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Final Geotechnical Engineering Report: Bridge 405/17.7 (SB I-405 over Renton Avenue) and Walls 03.63L, 03.65L, and 03.66L

WSDOT I-405 Renton to Bellevue Design-Build

Renton to Bellevue, Washington

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Prepared for:
Flatiron-Lane Joint Venture

Prepared by:
GeoEngineers, Inc.
17425 NE Union Hill Road, Suite 250
Redmond, Washington 98052
T: (425)861-6000

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FLATIRON | LANE | wood.

In Association with

Mikayla S. Hatch, P.E.
Geotechnical Engineer
Direct Tel.: (425) 861-6021
E-mail: mhatch@geoengineers.com

Ivy A. Harmon, P.E.
Geotechnical Engineer
Direct Tel.: (225) 663-1510
E-mail: iharmon@geoengineers.com

Reviewed By:

Benjamin M. Upsall, P.E.
Principal Geotechnical Engineer
Direct Tel.: (206) 239-3223
E-mail: bupsall@geoengineers.com

David S. Phelps, PE
Principal Geotechnical Engineer
Direct Tel.: (253) 722-2412
Email: dphelps@geoengineers.com

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List of abbreviations and acronyms

3D	three-dimensional
AASHTO	The American Association of State Highway and Transportation Officials
CALTRANS	State of California Department of Transportation
CDR	capacity to demand ratio
CIP	cast-in-place
ESU	engineering stratigraphic unit
FEA	Finite Element Analysis
FEE	functional evaluation earthquake
FEMA	Federal Emergency Management Agency
ft/s	feet per second
FHWA	Federal Highway Association
FS	factor of safety
GDM	Geotechnical Design Manual
GDR	Geotechnical Data Report
HS	Hardening-Soil
H:V	horizontal to vertical
I-405	Interstate 405
ISRM	International Society for Rock Mechanics
ksf	kips per square foot
LRFD	Load and Resistance Factor Design
M_w	Mean Magnitude
NAVD	North American Vertical Datum
NB	Northbound
NCHRP	National Cooperative Highway Research Program
OSHA	Occupational Safety and Health Administration
pcf	pounds per cubic foot
PGA	peak ground acceleration
Project GDM	Project Geotechnical Design Manual, consisting of WSDOT's 2015 Geotechnical Design Manual, along with project-specific Chapters 6 (Seismic) and 15 (Retaining Walls) from Conformed Request for Proposal Appendix G5
psf	pounds per square foot
PSHA	probabilistic seismic hazard analysis
RFP	Request for Proposal
RFU	Released For Use

SB	Southbound
SE	Structural Earth
SEE	safety evaluation earthquake
SPM	Soil Properties Methodology
SPT	standard penetration test
TR	Technical Requirements
USCS	United States Soil Classification System
USGS	United States Geological Survey
WAC	Washington Administrative Code
WADNR	Washington State Department of Natural Resources
Wood	Wood Environment & Infrastructure Solutions, Inc.
WSDOT	Washington State Department of Transportation

1. Introduction

This report provides geotechnical design recommendations for Bridge 405/17.7 (Renton Avenue) and Walls 03.63L, 03.65L, and 03.66L which are part of the Washington State Department of Transportation (WSDOT) Interstate 405 (I-405) Renton to Bellevue Design-Build Project in Renton, Washington. Figure 1 presents a vicinity map.

Bridge 405/17.7 (Renton Avenue), referred to as Bridge 17.7 in the remainder of this report, is an existing urban bridge crossing allowing vehicular and pedestrian traffic to cross above the Northbound (NB) and Southbound (SB) lanes of I-405. Bridge 17.7 connects Renton Avenue on the west side of I-405 to South 3rd Street on the east side of I-405, and the western bridge approach connects to Mill Avenue South after it reaches the surrounding grade elevation. The western edge of Bridge 17.7 (Pier 1) will be moved westward to provide additional travel lane width for I-405 southbound traffic. In order to do this, the existing Pier 1 will be demolished and rebuilt in a location that is further west than the existing Pier 1; Piers 2 and 3 of the existing bridge will remain in place, and the girders spanning between Piers 1 and 2 will be extended westward to reach the new Pier 1 location.

Wall 03.63L is an existing Hilfiker wall that retains the earthen embankment that forms the western approach to Bridge 17.7. The maximum height of the existing wall is 47 feet. We understand that a portion of the existing Hilfiker wall along with a portion of the remaining western approach embankment will be deconstructed to create a working platform for the construction of the new Pier 1 of Bridge 17.7. Once the new Pier 1 and associated structural elements are constructed, Wall 03.63L will be reconstructed to a maximum height of approximately 45 feet. The portion of the existing Wall 03.63L that will support the new Bridge 17.7 Pier 1 foundation will be retrofitted in-place with a permanent soil nail wall. After construction of the new Pier 1 foundation, the portions of Wall 03.63L that were removed above the Pier 1 working and construction platform will be replaced with a new Hilfiker wall.

Wall 03.65L is a proposed Hilfiker type welded wire Structural Earth (SE) Wall located on the southwest side of the new Pier 1 stem wall, that acts as a wing wall for the Pier 1 abutment, but the wall face is lined up nearly parallel to the new Pier 1 stem wall. Wall 03.65L will have a maximum height of 21.5 feet and is approximately 50 feet long. Figure 2X shows the approximate location of Wall 03.65L.

Wall 03.66L is a proposed short structural wall that spans between wall 03.63L and Pier 1 of Bridge 18W. Figure 2X shows the location of Wall 03.66L.

The evaluations and design recommendations in this report are based on the proposed Bridge 17.7 lengthening, the subsurface conditions encountered in nearby explorations and by laboratory testing of soil samples. If the nature or location of the project elements are different than we have stated herein, we should be notified so we can revise or confirm our recommendations. The location of the proposed bridge lengthening and associated walls are shown on the Site Plans Figures 2X and 2X-2.

This report was prepared in accordance with the project specific conformed Request for Proposal (RFP), Technical Requirements (TR), and the requirements provided in the WSDOT project-specific Geotechnical Design Manual (Project GDM). The North American Vertical Datum (NAVD) 88 is used throughout this report. The basis of our recommendations related to Bridge 17.7 is based on communication with the structural engineering team.

Due to their proximity, the subsurface conditions for Bridges 17.7 and 18W as well as Walls 03.63L, 03.65L, and 03.66L have been addressed and presented together. The design recommendations for Bridge 18W are presented in our Released For Use (RFU) geotechnical report dated April 22, 2021 and the subsequent RFU geotechnical report addendum dated September 21, 2021. Appendix A provides copies of relevant exploration logs of borings completed for this study as well as historic borings in the vicinity of Bridges 17.7 and 18W as well as Walls 03.63L, 03.65L, and 03.66L. Appendix B provides the laboratory data associated with the explorations. Appendix C presents the subsurface properties and material behaviors, including the Engineering Stratigraphic Units (ESUs) and the seismic design parameters.

The remaining appendices present the design calculation packages for each structural element. Appendix D presents the geotechnical calculation package associated with Bridge 17.7 and Wall 03.63L. Appendix E presents assumptions, applications, approach, and results of a Finite Element Analysis (FEA) which was required to adequately model the seismic inertial effects and lateral soil springs associated with Pier 1 of Bridge 17.7 and its interaction with Wall 03.63L. Appendices F and G present the geotechnical calculation packages associated with Walls 03.65L and 03.66L, respectively.

2. Description of Structures and Construction Sequence

Existing Bridge 17.7 is a two-span structure supported by shallow spread footings at Piers 1 and 2 and by a drilled shaft secant pile wall at Pier 3 on the eastern end. The footings at Piers 1 and 2 are isolated spread footings that are rectangular in shape.

Bridge 17.7 is located immediately south of Bridge 18W and supports traffic on Renton Avenue (South 3rd Street) crossing over all lanes of I-405 in the east-west direction. The southern abutment (Pier 1) of Bridge 18W begins about 70 feet north of the centerline of Bridge 17.7 as shown on Figures 2X and 2X-2. Wall 03.66L is located at the southwest corner of Bridge 18W and connects to the northeast corner of Bridge 17.7 as shown on Figure 2X. Wall 03.63L extends along the north side of the western approach embankment to Bridge 17.7 as shown on Figures 2X and 2X-2. Wall 03.65L extends to the south of the proposed new Bridge 17.7 Pier 1. The design of Walls 03.63L, 03.65L, and 03.66L are closely linked to the Bridge 17.7 modification plan and therefore are being addressed herein.

Bridge 17.7 site topography slopes down steeply from east to west. Ground surface at Pier 3 (east) is about Elevation 111 feet, and Pier 1 (west) is about 94 feet. NB and SB I-405 lanes between Piers 1 and 3 and are at approximately Elevation 75 and 71 feet, respectively. At the end of the western approach embankment, the surrounding ground surface is at about Elevation 50 feet. Representative cross-sections are presented in Appendix C.1 on Figures C.1-2 through C.1-5. The approximate structure stationing for Bridge 17.7 and Walls 03.63L, 03.65L, and 03.66L are presented in Table 1.

Table 1: Summary of Structure Stationing

Structure	Feature	Design Station
Bridge 17.7	Existing Pier 1	Bridge 17.7 R-Line Station 15+22.69
	Proposed Pier 1	Bridge 17.7 R-Line Station 15+10.02
	Pier 2	Bridge 17.7 R-Line Station 15+86.44
	Pier 3	Bridge 17.7 R-Line Station 16+63.07
Wall 03.63L	Beginning of Wall	Bridge 17.7 R-Line Station 14+75.00
	End of Wall	Bridge 17.7 R-Line Station 15+26+00
Wall 03.65L	Beginning of Wall	SB I-405 Station 5497+33.13
	End of Wall	SB I-405 Station 5497+80.84
Wall 03.66L	Beginning of Wall	SB I-405 Station 5498+20.39
	End of Wall	SB I-405 Station 5498+50.64

2.1 Bridge 17.7 Pier 1 and Wall 03.63L

To accommodate widening southbound I-405 under the existing Bridge 17.7 between Piers 1 and 2, portions of the existing Hilfiker wall (Wall 03.63L) approach embankment along with portions of the existing Bridge 17.7 Pier 1 stem wall need to be removed and/or replaced. A new Pier 1 bridge footing will be constructed with a bottom of footing elevation of 66.5 feet, resting on top of a portion of the existing Hilfiker wall. The existing Hilfiker wall is not internally stable with the anticipated increase in vertical loading due to the new Pier 1 bridge footing loads; therefore, a new permanent soil nail wall will be drilled through the face of the existing Hilfiker wall (Wall 03.63L) that will remain below the new Pier 1 footing location. The soil nail wall will extend far enough laterally to cover the proposed Pier 1 footing's zone of influence.

2.2 Bridge 17.7 Piers 2 and 3

The existing Bridge 17.7 Piers 2 and 3 will remain in place as they currently exist.

2.3 Construction Sequence

The construction sequence for this bridge lengthening project is generally as follows:

1) Install a temporary lateral restraint (e.g., deadman anchor or other) at the existing Pier 3 on the east side of I-405 to resist the temporarily unbalanced earth pressure loading condition that will be created when the earthen embankment behind the existing Pier 1 abutment wall is removed.

2) Remove portions of the existing earthen embankment (Hilfiker Wall that also creates Wall 03.63L) behind the existing Pier 1 abutment wall.
3) Install soil nails through the face of existing Wall 03.63L that will remain below the proposed new Pier 1 footing elevation.
4) Construct the new Pier 1 bridge footing and stem wall to the west of the existing Pier 1 stem wall.
5) Extend the bridge girders that had spanned between the existing Pier 2 and the existing Pier 1 so that they span between the existing Pier 2 and the proposed Pier 1 (a longer span).
6) Backfill behind the new Pier 1 stem wall with a new Hilfiker Wall system, which also reconstructs any necessary portions of Wall 03.63L that were removed to facilitate construction of the new Pier 1 footing.
7) Demolish existing Pier 1 stem wall down to below I-405 roadway elevation.
8) Decommission the temporary lateral restraint at Pier 3 on the east side of I-405.

Due to the depth of the existing Pier 1 footing, a portion of the existing Pier 1 stem wall and the entire existing Pier 1 footing will remain buried in place. To install the new Pier 1 footing, the existing approach embankment will be removed using an open cut slope excavation technique. The portions of the existing Hilfiker wall which are below this cut slope will remain in place.

Figure 3 shows the location of each design section where we evaluated conditions for the construction of the new Pier 1 and subsequent portions of Wall 03.63L. Section Ea-Ea' represents the tallest portion of the existing Hilfiker wall and is in front of the toe of the new Pier 1 footing, placing it under the widened portion of SB I-405 in the final condition. Section Fa-Fa' is cut through the stem wall of the new Pier 1 footing and Section Ga-Ga' is cut behind the proposed Pier 1 footing. Finally, Section Ha-Ha' represents a portion of Wall 03.63L within the excavation slope cut of the existing Hilfiker wall. In the final condition, Section Ha-Ha' represents a section of Wall 03.63L that is partially existing Hilfiker wall (lower portion) and partially new Hilfiker wall (upper portion). See Figure 4 and the mark up presented in Appendix D.1 for clarity on the construction sequence at each critical cross-section.

3. Exploration and Laboratory Testing

Previous geotechnical investigation borings and laboratory data is provided in the RFP's Geotechnical Data Report (GDR). An additional geotechnical exploration was completed as part of this project's Subsurface Investigation Plans to supplement existing boreholes at the project site. Exploration locations are shown on the Site Plan Figures 2X and 2X-2. Soil boring logs in the vicinity and associated laboratory testing are included in Appendices A and B, respectively.

The explorations and laboratory testing associated with Bridge 17.7 as well as Bridge 18W and Walls 03.63L, 03.65L, and 03.66L are:

- Soil boring W-134-20 (drilled on August 17, 2020 by the design-build team) with standard penetration test (SPT) data;
- Previous subsurface explorations R2B-03-17, TH-3, H-6, HE-7-90, HE-8-90, HE-9-90, HE-10-90, HE-11-90, HQ-106-89, HQ-12-89, HQ-13-89, HQ-14-89, HQ-18-89, HQ-13B-89, HQ-15-89, HQ-83-90, HQ-81-90, HQ-20-89, and MW-28 as provided in the contract documents; and
- Laboratory testing consisting of moisture content, fines content, and Atterberg Limits determination.

4. Subsurface Conditions

4.1 Regional and Site Geology

Geologic maps available through the Washington State Department of Natural Resources (WADNR) show surficial soils at the southernmost portion of Bridge 18W and Bridge 17.7 share a deposit of continental glacial drift. Undifferentiated deposits of glacial and non-glacial gravel, sand and clay, as well as sedimentary rock also converge at the Bridge 18W and Bridge 17.7 sites. Bridge 17.7 approach embankments consist of imported granular fill materials placed on top of the naturally deposited materials during previous bridge construction phases. Glacial drift is a unit which can contain glacially derived and non-

glacially derived soils that were deposited during the Quaternary (Pleistocene) Age. This unit is generally dense to very dense. Undifferentiated glacial and non-glacial deposits consist of glaciofluvial sand and gravel, glaciolacustrine clay and sand, and nonglacial sand and clay deposited during the middle to upper Pleistocene age. This unit is generally medium dense to very dense.

GeoEngineers simplified the descriptions of geologic units encountered at this site and converted them into ESUs, which were used for the bridge design.

4.2 Engineering Stratigraphic Units

The subsurface conditions at the site, along with the geologic setting and history, is summarized below. Our interpretation of the subsurface conditions at Bridge 17.7 was developed in conjunction with the subsurface conditions at Bridge 18W, as well as with Walls 03.63L, 03.65L, and 03.66L due to the proximity of these structures. Incorporating borings applicable to each of these structures allowed for a more robust evaluation and statistically significant analysis of the selected soil properties. Profiles and cross sections are presented in Appendix C.

- **ESU 1 – Existing Fill.** Existing fill consists of soils placed during previous development including roadway, wall, embankment, and bridge construction. The composition of fill soil encountered varies slightly by location and the following ESU subunits characterize the types of fill soil encountered.
    - **ESU 1A – Existing Granular Fill.** Medium dense to dense silty sand (fill) was encountered in boring R2B-03-17. This fill soil was encountered in the upper portion of the Bridge 17.7 Hilfiker Wall Embankment, above approximately Elevation 72 feet. ESU 1A increases in thickness up to about 24 feet as it approaches the Bridge 17.7 west abutment.
    - **ESU 1B – Existing Gravelly Granular Fill.** ESU 1B is fill soil that was used as backfill at Bridges 18W and 17.7, as well as at Walls 03.63L and 03.66L. This medium dense to dense gravel and sand backfill was encountered in boring R2B-03-17. This subunit is described as “well-graded” and is generally consistent with WSDOT Gravel Borrow material (WSDOT Standard Specification 9-03.14(1)). ESU 1B extends from about station 5497+50 to 5498+85 and is assumed to be backfill placed in accordance with WSDOT specifications at the time of construction of Bridge 18W and 17.7. The borings H-6, HQ-106-89, HQ-12-89, HQ-13-89, HQ-14-89, and HQ-13B-89 were located such that the upper soil encountered at these borings was removed and replaced by ESU 1B during construction activities.
    - **ESU 1C – Existing Gravelly Granular Fill.** ESU 1C is fill soil that was used to backfill around Piers 2, 3, 4, and 5 of Bridge 18W located between about stations 5435+00 to 5504+60. Much of the soil encountered in the explorations adjacent to these piers has subsequently been removed by the construction of Bridge 18W. This backfilled, replacement fill soil would have been placed and compacted within the same construction timeframe as the ESU 1A and 1B backfilled soils placed in the vicinity of Bridges 18W and 17.7. It is also assumed to have been placed and compacted in accordance with the WSDOT Standard Specifications at the time of construction (approximately 1990).
- **ESU 2 – Cohesionless Native Deposits.** This ESU consists of coarse-grained and fine-grained cohesionless soil. These soils have not been glacially over-ridden. The composition of deposits encountered varies slightly by location and the following ESU subunits characterize the types of deposits encountered at Bridge 18W, Bridge 17.7, and Walls 03.63L, 03.65L, and 03.66L.
    - **ESU 2A –Native Sand and Gravel.** Loose to very dense glacial sand, gravel, and silt were encountered in borings HE-7-90, R2B-03-17, HQ-18-89, HQ-14-89 and HE-9-90 located under I-405 and Bridge 17.7 northward toward the southern-most section of Bridge 18W, to approximate station 5498+20.
    - **ESU 2B –Native Sand and Gravel.** Medium dense to very dense sand and gravel was encountered in borings HE-8-90, HQ-15-89, HQ-81-90, HQ-83-90, MW-28, and HQ-20-89. This ESU subunit extends northward from approximately station 5498+20 and underlies Bridge 18W. ESU 2B increases in thickness from about 15 feet to more than 50 feet as the deposit progresses northward. ESU 2B is encountered at the ground surface at Pier 2 of Bridge 18W.

- **ESU 2C –Native Silt.** Very loose to loose silt was encountered in boring W-134-20. This ESU subunit extends from south of Bridge 17.7 to approximately station 5497+35.

- **ESU 7 - Bedrock.** The condition of the bedrock encountered varies slightly by location. The following ESU subunit characterizes the type of bedrock encountered in the vicinity of Bridges 17.7 and 18W.

  - **ESU 7A – Weathered Sandstone**. Sedimentary bedrock was encountered underlying the site. Borings R2B-03-17, HE-8-90, HE-9-90, HE-11-90, TH-3, HQ-13-89, HQ-12-89, H-6, HQ-18-89, HQ-14-89, HQ-15-89, HQ-81-90, HQ-83-90, and MW-28 noted the presence of sandstone in the exploration logs. The variation in descriptions of material above the logged sandstone suggests the layer is highly weathered. Strength testing was performed on samples from boring HQ-18-89. Results indicate the sandstone is extremely weak to weak. The depth to ESU 7A increases from south to north, beginning at about Elevation 42 feet at station 5497+38, and sloping to about Elevation -16 feet at station 5504+60.

4.3 Site Groundwater Conditions

Piezometers were installed at exploration locations HQ-13-89, HQ-13B-89, HQ-14-89, HQ-18-89, HQ-20-89, HQ-106-89 and a monitoring well was installed at MW-28. Groundwater measurements were recorded in borings HE-7-90, HE-9-90, R2B-03-17, and HQ-83-90 during exploration. Boreholes advanced using mud rotary drilling techniques prevented an accurate determination of the groundwater level at the time of drilling.

The groundwater level reported in R2B-03-17 was observed during a bail and recharge test, with the recharged water in the borehole reaching Elevation 68.5 feet (21.6 feet below ground surface). The groundwater level observed at R2B-03-17 was recorded at Elevation 79 feet at the beginning of a bail and recharge test. The boring was bailed to Elevation 63 feet, and after 30 minutes the water level in the boring was observed at Elevation 69 feet. The results of the recharge test and observed elevation of the groundwater in the boring are inconsistent with the groundwater observations of the adjacent borings, thus groundwater elevation data from R2B-03-17 was excluded from the groundwater level determination.

The Ordinary High Water Level in Cedar River at Bridge 18W is at Elevation 35 feet. Historical plans show the inclusion of seal slabs below Pier 2 and Pier 3 footings, indicating the presence of groundwater during construction.

Groundwater levels, if observed, are reported on the boring logs in Appendix A.

Based on available groundwater level observations and supporting information, the design groundwater at the western embankment of Bridge 17.7 is assumed to be at Elevation 43 feet. Along the alignment of Bridge 17.7 towards the east, the groundwater increases in elevation to about 80 feet, seeming to follow along the approximate interface between the native sand and gravel (ESU 2A) and the weathered sandstone (ESU 7A). North of Bridge 17.7, the groundwater slopes downward from Elevation 43 feet at Bridge 18W Pier 1 to 35 feet at Pier 3, aligning with the Cedar River Ordinary High Water Level. The design groundwater level declines from Elevation 35 feet to Elevation 26 feet between the river and Bridge 18W Pier 4 and then remains consistent at Elevation 26 feet under Pier 5. The groundwater levels used in design are shown on the design ESU sections in Appendix C.

5. Design Soil Properties

5.1 Selection of ESU Soil Properties

We selected engineering properties for each ESU based on the subsurface conditions described in the GDR, RFP reference documents and explorations completed by the design-build team. Soil properties were developed in accordance with the procedures outlined in the Soil Properties Methodology (SPM) memorandum prepared by Wood dated March 6, 2020. Young's Modulus and Poisson's ratio values were determined using the correlations in Table C10.4.6.3-1 (AASHTO 2017).

The analyses completed for determination of the soil properties used in this memo are presented in Appendix C. The selected static and pseudo-static engineering soil properties for use in design of Bridge 17.7, Walls 03.63L, 03.65L, and 03.66L are presented in Table 2. The applicable pseudo-static engineering soil properties are presented in parentheses under the static properties.

No existing explorations or historic data are available to help define the properties of the backfill soils that make up ESU 1C.This backfilled, fill soil would have been placed and compacted within the same construction timeframe as the

ESU 1A and 1B backfilled soils placed in the vicinity of Bridges 18W and 17.7. It is assumed to have been placed and compacted in accordance with the WSDOT Standard Specifications at the time of construction (approximately 1990). The soil properties for ESU 1C are assumed to be consistent with the properties of ESU 1B.

Table 11-2 from the FHWA-NHI-11-032 Geotechnical Engineering Circular No. 3 provides recommendations for applying apparent cohesion for the pseudo-static analysis scenarios. Apparent cohesion values were applied in accordance with GDM Section 5.10. Specific values for apparent cohesion were developed when applicable by following the guidance provided in FHWA-NHI-11-032.

Table 2: Bridge 17.7 ESU Units and Descriptions

ESU No.	Description	Total Unit Weight, γ (pcf)	$(N_1)_{60}$	Φ' (deg)	C (psf)	S_u (psf)	S_r (psf)	E_s (ksf)	ν
1A	Existing Granular Fill	120	30	40	0	-	-	800	0.28
1B	Existing Gravelly Granular Fill	125	21	38	0	- -	- -	1720	0.25
1C[1]	Existing Gravelly Granular Fill	125	21	38	0	- -	- -	1720	0.25
2A	Native Sand and Gravel (pseudo-static)	120 (120)	29 (29)	39 (39)	0 (50)	-	-	979 (979)	0.35 (0.35)
2B	Native Sand and Gravel	135	37	41	0	-	-	1330	0.36
2C	Native Silt (pseudo-static)	110 (110)	9 (9)	29 (29)	0 (200)	-	-	112 (112)	0.43 (0.43)
7A	Weathered Sandstone	135	50	42	0	-	-	1107	0.32

Abbreviations:
ESU = Engineering Stratigraphic Unit
γ = total unit weight
pcf = pounds per cubic foot
$(N_1)_{60}$ = SPT N-value corrected for effective overburden stress
Φ' = effective friction angle
deg = degrees
c = cohesion
psf = pounds per square foot
S_u = Undrained Shear Strength
S_r = Residual Strength
E_s = Young's Modulus
ksf = kips per square foot
ν = Poisson's Ratio
Notes:

1. The design values for ESU 1C have been assumed to match those calculated for ESU 1B as discussed in more detail above.

5.2 Soil Parameters for Standard WSDOT Materials

Table 3 presents the design soil properties to be used for WSDOT Standard Specification Materials used for backfill. Table values were determined using ranges provided in WSDOT GDM Table 5-2: presumptive Property Ranges for Compacted

Borrow and other WSDOT Standard Specification Materials. Young's Modulus and Poisson's ratio values were determined using the correlations in Table C10.4.6.3-1 (AASHTO 2017).

The National Cooperative Highway Research Program (NCHRP) Report 611 (FHWA-NHI-11-032 Table 11-2) provides recommendations for applying apparent cohesion for the pseudo-static analysis scenarios. Pseudo-static properties were developed for specified backfill by following this guidance. The applicable pseudo-static properties are presented in parentheses under the static properties in Table 3. In accordance with GDM Section 5.12 pertaining to Select Borrow, we reduced the friction angle of the Select Borrow when applying apparent cohesion so as to not increase the overall shear strength of that soil unit.

Table 3: WSDOT Specified Backfill Engineering Soil Parameters

Material	WSDOT Standard Specification	Soil Type (USCS classification)	Soil Friction Angle (degree)	Cohesion (psf)	Wet Unit Weight (pcf)	E_s (psf)	ν
Common Borrow (Pseudo-Static)	9-03.14(3)	ML, SM, GM	32 (32)	0 (200)	120 (120)	300 (300)	0.31 (0.31)
Select Borrow (Pseudo-Static)	9-03.14(2)	GP, GP-GM, SP, SP-SM	36 (35)	0 (50)	125 (125)	900 (900)	0.35 (0.35)
Gravel Borrow (Pseudo-Static)	9-03.14(1)	GW, GW-GM, SW, SW-SM	38 (38)	0 (50)	130 (130)	1400 (1400)	0.40 (0.40)
Gravel Backfill for Wall	9-03.12(2)	GW, GP, SW, SP	38	0	130	1400	0.35

Source: Project GDM 5.2 - Presumptive Design Ranges for Compacted Borrow and WSDOT Standard Specifications (WSDOT 2018d).

Abbreviations:
pcf = pounds per cubic foot
psf = pounds per square foot
E_s = Young's Modulus
USCS = Unified Soil Classification System
WSDOT = Washington State Department of Transportation
ν = Poisson's Ratio

6. Seismic Setting and Design Values

6.1 Regional Seismic Setting

The regional seismic setting of this project is discussed in detail in the report titled "I-405 R2B Segment 1a Site Specific Hazard Analysis" dated March 25, 2021 (Submittal 1197) by Hart Crowser.

6.2 Seismic Design Criteria

The applicable seismic design criteria are set forth in the WSDOT GDM Section 6-1.2.1. Bridge 17.7 is an overpass bridge classified as normal. In accordance with the RFP, it is being designed for the Safety Evaluation Earthquake (SEE) hazard level, which has a 975-year return interval. A site-specific hazard analysis was performed to develop design spectra for use in seismic design. The results of this probabilistic seismic hazard analysis (PSHA), which was completed by Hart Crowser, and the recommend design spectra results in both tabular and graphical format are published in the report titled "I-405 R2B Segment 1a Site Specific Hazard Analysis" dated March 25, 2021 (Submittal 1197). Note that the appropriate spectra results must match the seismic site class for each structural element as defined in Section 6.3 below.

6.3 Seismic Site Class

To select the appropriate seismic design parameters and response spectra for Bridge 17.7, we first evaluated the seismic site class at each relevant boring in the vicinity using a spreadsheet developed by GeoEngineers in accordance with American Association of State Highway and Transportation Officials (AASHTO) Load and Resistance Factor Design (LRFD) Section 3.10.3.1. Because the explorations did not extend to 100 feet below ground surface, we extrapolated soil conditions beyond the

base of the borings. Next, we selected a representative site class for each structural element (i.e., bridge), considering the distribution of site classes represented by the borings as well as the depths of the borings (amount of extrapolation to 100 feet deep). The representative design site class and site class adjusted peak ground acceleration (As) are summarized in Table 4 below. Bridge 17.7 and its associated walls (Wall 03.63L, Wall 03.65L, and Wall 03.66L) are characterized by seismic site class C. Site class calculations are provided in Appendix C. We used the recommended SEE response spectrum site class adjusted peak ground acceleration (As) and Mean Magnitude (M_w) in our analyses.

Table 4: Seismic Site Class and Design Parameters for Bridge 17.7

Parameter	Return Period
	1,000-year (SEE)
Site Class	C
Site Class Adjusted Peak Ground Acceleration (A_s)	0.51g
Mean Earthquake Magnitude (Mw)	6.97
Recommended Response Spectrum (g) at a period of 0.1 (s)	1.07
Recommended Response Spectrum (g) at a period of 0.2 (s)	1.26
Recommended Response Spectrum (g) at a period of 0.3 (s)	1.09
Recommended Response Spectrum (g) at a period of 0.4 (s)	0.90
Recommended Response Spectrum (g) at a period of 0.5 (s)	0.75
Recommended Response Spectrum (g) at a period of 0.6 (s)	0.64
Recommended Response Spectrum (g) at a period of 0.7 (s)	0.55
Recommended Response Spectrum (g) at a period of 0.8 (s)	0.49
Recommended Response Spectrum (g) at a period of 0.9 (s)	0.43
Recommended Response Spectrum (g) at a period of 1.0 (s)	0.38
Recommended Response Spectrum (g) at a period of 1.5 (s)	0.24
Recommended Response Spectrum (g) at a period of 2.0 (s)	0.17
Recommended Response Spectrum (g) at a period of 3.0 (s)	0.10
Recommended Response Spectrum (g) at a period of 4.0 (s)	0.071
Recommended Response Spectrum (g) at a period of 5.0 (s)	0.056

Abbreviations:
SEE = safety evaluation earthquake

6.4 Liquefaction Assessment

Liquefaction is a phenomenon where soils experience a rapid loss of internal strength as a consequence of strong ground motions. Ground settlement, lateral spreading and/or sand boils may result from soil liquefaction. Structures supported on liquefied soils could suffer foundation settlement or lateral movement that could severely damage the structure.

The potential for liquefaction was evaluated in accordance with the Project GDM using a spreadsheet developed by GeoEngineers. Borings HE-7-90, HQ-18-89, HQ-83-90, and HQ-20-89 each contained soil samples that have potential for liquefaction under the SEE event. However, these liquefiable soil samples have either been removed, are no longer representative of the current conditions at the site or are located away from the area of concern and therefore the impacts of liquefaction potential are considered to have been mitigated. Specifically:

- Boring HE-7-90 is located under the existing 40- to 50-foot-tall western approach embankment of Bridge 17.7. This boring was drilled prior to the construction of that embankment and so the data and soil samples contained in that historic boring are no longer representative of the current stress, density, and consolidation characteristics that currently exist.

- The potentially liquefiable soil layers that were identified in boring HQ-18-89 have subsequently been removed during the past construction activities at Bridge 17.7.
- The potentially liquefiable soil layers that were identified in boring HQ-83-90 have subsequently been removed during the past construction activities at Pier 3 of Bridge 18W.
- Boring HQ-20-89 identifies two potentially liquefiable layers. The uppermost sample is a wood fragment and thus is not susceptible to liquefaction. The lower potentially liquefiable layer ranging from Elevation 0.8 feet to 10.8 feet consists of clean gravel (GP and GW) in the 31 to 36 blow count range and could potentially liquefy under the design SEE event. However, that boring is located between Piers 4 and 5 of Bridge 18W as shown on Figure 2. The focus of our report is Bridge 17.7, thus the liquefaction potential identified in this boring does not influence our design.

6.5 Fault Rupture

Surface fault rupture is defined as physical fault displacement observed at the ground surface. Surface fault rupture is generally observed as a result of larger-magnitude earthquakes (magnitudes of about 6 or larger) that are associated with faults that have mapped traces at or near the ground surface. The amount of surface fault displacement is dependent on many factors including but not limited to the earthquake magnitude.

The closest active faults to the project site are the various roughly east-west trending splays of the Seattle Fault. According to the United States Geological Survey (USGS) Interactive Fault Mapping tool (https://www.usgs.gov/natural-hazards/earthquake-hazards/faults), the closest known splay of the Seattle Fault is approximately 3.3 miles to the north of Bridge 17.7. As such, the potential for fault rupture hazard at the Bridge 17.7 site is estimated to be negligible.

7. Engineering Analysis Methodology

The following sections describe the engineering analyses completed for the design of Bridge 17.7 and its associated walls (03.63L, 03.65L, and 03.66L), including evaluation of liquefaction potential, global slope stability, compound slope stability, soil nail evaluation, consolidation settlement, foundation bearing resistance and elastic settlement, lateral earth pressures, coefficients of sliding friction, seismic springs on shallow and deep foundations, and secant pile wall analyses. Our methodology for each of these analyses is described in the following sections.

7.1 Liquefaction Potential

The potential for liquefaction and liquefaction induced settlement was evaluated in accordance with the Project GDM using a spreadsheet developed by GeoEngineers. Our evaluation indicates that there was some liquefaction potential at the Bridge 17.7 site. However, previous earthwork at the site and the distance to locations with liquefaction potential have mitigated the liquefaction potential.

7.2 Global Slope Stability

Global slope stability was evaluated using the limit equilibrium analysis method following the procedure outlined in the Project GDM. Global slope stability of Bridge 17.7, Wall 03.63L, and Wall 03.65L was evaluated using the commercially available computer design software Slope/W (Geo Slope International, Ltd. 2021). Global stability was evaluated using both the Spencer method and the Morgenstern and Price method to allow for comparison of results between the two analysis methods. Entry and exit search limits and circular failure surfaces were also used in the models. Groundwater levels were modeled using a piezometric surface based on the design groundwater levels.

Static analyses were conducted using Strength Limit State loading conditions as required by Section 15-4.12 of the Project GDM. The target static factor of safety (FS) is 1.3, which was determined from the prescribed resistance factor of 0.75. A traffic surcharge of 250 pounds per square foot (psf) was also included in the static analyses. A Strength Limit State load factor for nonstructural surcharge loads of 1.0 was applied to this traffic surcharge per Project GDM Section 15-4.12.

Pseudostatic analyses (stability analyses using non-liquefied soil properties in conjunction with a horizontal seismic acceleration) were performed using Extreme Limit State loading conditions as required by Section 15-4.12 of the Project GDM. The target static FS is 1.1, which was determined from the prescribed resistance factor of 0.9. A traffic surcharge of 250 psf was also included in the seismic analyses. A load factor of 0.5 was applied to this traffic surcharge for the pseudostatic

cases. A horizontal seismic acceleration value (K_h) equal to 50 percent of the total site-class adjusted horizontal seismic acceleration was included in the pseudostatic analyses. When applicable, apparent cohesion was incorporated into the soil properties and wave scattering reductions to the horizontal seismic coefficient were also incorporated in the pseudostatic cases when applicable.

Post-seismic analyses (stability analyses using liquefied soil properties without the addition of a horizontal seismic coefficient) were not performed at this site due to the absence of liquefiable soils.

7.3 Compound Stability

We evaluated compound stability of each design section at Wall 03.63L (existing and new design) and 03.65L using the computer design software Slope/W. We performed limit equilibrium analyses following the procedures outlined in Project GDM Section 15-5.3.4. Factors of safety were calculated using both Spencer's method and the Morgenstern-Price method with entry and exit search limits for a circular failure surface.

Steel reinforcement corrosion rates were accounted for by following AASHTO LRFD Section 11.10.6.4.2a and Federal Highway Association (FHWA) Geotechnical Engineering Circular No. 11 Tables 3-7 and 3-8.

We applied the resistance factors presented in AASHTO LRFD Section 11.5 and FHWA Geotechnical Engineering Circular No. 11 Table 4-7 to calculate the pullout resistance and tensile capacity of the welded wire reinforcement mats at Walls 03.63L and 03.65L. For the existing welded wire mats at Wall 03.63L pullout resistance and tensile capacity was calculated according to AASHTO LRFD Section 11.10.6.3.2 and FHWA Geotechnical Engineering Circular No. 11 Section 3.4.2 equations 3-6 and 3-7. For Wall 03.65L, we selected a welded wire mat section that may be used and calculated the pullout resistance and tensile capacity in the same fashion. The wall designer may choose a different welded wire mat section in the final design. The calculated tensile capacity and interface shear friction angles were input into Slope/W to model the reinforced zone.

For pseudo-static analyses of each wall, we used an apparent cohesion in the native soils above the groundwater table based on the fines content ranges presented in Table 11-2 of the FHWA Geotechnical Engineering Circular No. 3.

Per Project GDM Section 15-5.3.4 and AASHTO LRFD Table 3.4.1-1, a strength limit state load factor of 1.75 was applied to the standard traffic surcharge of 250 psf, resulting in a uniform traffic surcharge of 437.5 psf in the static compound stability analysis. Per AASHTO LRFD Section 3.4.1, an extreme limit state load factor of 0.5 was applied to the standard traffic surcharge of 250 psf, resulting in a uniform traffic surcharge of 125 psf for the seismic (pseudo-static and post-seismic) compound stability analyses. No traffic surcharge loads were applied to the model for Wall 03.65L because that wall supports a side slope as opposed to a traffic lane.

Groundwater levels were modeled using a piezometric surface. The piezometric surface was based on measured or observed groundwater levels at the project site, as discussed in Section 4.3.

The results of our compound stability analyses are presented in Section 8.6. Compound stability models showing FS for critical failures at the design sections are provided in Appendix D and F for Wall 03.63L and Wall 03.65L, respectively.

7.4 Wall 03.63L Internal Stability of Existing Wall

Internal stability was evaluated using the procedure outlined in Project GDM 15-5.3.10. We evaluated internal stability of the existing portion of Wall 03.63L that will not be replaced or converted into a soil nail wall (design section Ha-Ha') using the computer design software MSEW Version 3.0 (ADAMA Engineering 1998-2010). MSEW analyzes internal stability (connection strength, pullout, and internal sliding) and external stability (sliding and overturning) of SE Walls using design guidelines from AASHTO 2007-2010. We analyzed the bearing resistance using GeoEngineers spreadsheet, see Section 7.7.Appendix D presents the internal stability output reports from the design software MSEW.

7.5 Soil Nail Wall Evaluation

Soil nail wall design was completed in accordance with procedures and recommendations outlined in the FHWA Geotechnical Engineering Circular No. 7 and the Project GDM Section 15-5.7 for the permanent soil nail wall portion of Wall 03.63L. Soil nail wall design was completed using the design software SNAIL 2018 V. 2.2.1 (SNAIL) developed by CALTRANS. The program uses an iterative bi-linear wedge analysis for determining the FS in a multilayer soil system with interslice forces included. The program considers the limiting pullout capacity of the soil nails on both the wall and the non-wall sides of the

assumed failure surface. SNAIL also includes options for modeling surcharges, water levels, slopes above and below the wall, and varying reinforcement parameters.

We understand that the structural capacity of the wall facing will be analyzed by the project structural engineers using the procedure presented in FHWA Geotechnical Circular No. 7 and the results of our analyses. Therefore, we used a reasonable yet high wall facing capacity in our analysis so that wall facing capacity did not control the failure.

The height of the soil nail portion of Wall 03.63L used in design was calculated as the vertical distance between the proposed Pier 1 bottom of footing (Elevation 66.5 feet) and the existing ground surface (Elevation 50 feet), which is 16.5 feet. The permanent soil nail wall will be installed through the existing Hilfiker wall. There is no temporary soil nail construction case because the existing Hilfiker wall is stable on its own and will be unloaded (with the removal of the existing Hilfiker wall down to bottom of footing elevation). The purpose of the permanent soil nail wall is to support the proposed Pier 1 foundation footing loads.

Nominal bond strengths were developed in accordance with FHWA Geotechnical Engineering Circular No. 7 for rotary drilled soil nails based on the soil type and density/consistency of each ESU. Nominal bond strengths will be confirmed in the field during soil nail verification testing.

Soil nail recommendations are presented in Section 8.9. Soil nail calculations and SNAIL output reports for Walls 03.63L are provided in Appendix D.

7.6 Consolidation Settlement

No soils susceptible to long-term consolidation settlement such as organic soil or normally-consolidated to lightly-over-consolidated high plasticity silts or clays were encountered in the explorations in the vicinity of Bridge 17.7 and its associated walls. We do not anticipate long-term consolidation settlement to occur.

7.7 Foundation Bearing Resistance and Elastic Settlement

Bearing resistance for the Nominal (unfactored), Service, Strength, and Extreme Limit States were calculated using a spreadsheet developed by GeoEngineers. Service and Strength Limit State bearing resistance was calculated using the methodology described in AASHTO LRFD 10.6.3. Settlement used to determine the Service Limit State bearing resistance was calculated using AASHTO LRFD 10.6.2.4 methodology. Shallow foundation and SE Wall bearing resistance factors were obtained from AASHTO Sections 10.5.5 and 11.5 respectively. The resistance factors used to determine the factored bearing resistance values are summarized in Table 5 below.

Table 5: Resistance Factors for Shallow Foundations and SE Walls

Parameter	Shallow Foundation Resistance Factors		SE Wall Bearing Resistance Factors
	Bearing Resistance (Clay)	Bearing Resistance (Sand)	
Service	1.00	1.00	1.00
Strength	0.55	0.45	0.65
Extreme Event	0.90	0.90	0.90

A staged elastic settlement analysis was completed for the proposed Bridge 17.7 Pier 1 footing and the existing Pier 2 footing as requested by the structural engineer. Cumulative elastic settlement values were calculated per AASHTO Section 10.6.2.4.2 for each stage of loading during construction. Loading stages included footing weight, substructure weight, backfill soil weight, girder placement, and superstructure placement.

7.8 SE Wall Minimum Embedment and Strap Length

Representatives subcontracted to Hilfiker (the SE Wall manufacturer) will be completing the design for Wall 03.65L and the new portions of Wall 03.63L. The new portions of Wall 03.63L are anticipated to have the same strap lengths as are currently in place.

For Wall 03.63L, we have determined minimum strap lengths and minimum wall embedment depths to satisfy the requirements set forth in the Project GDM and to achieve global stability, compound stability, and bearing capacity design requirements. These analyses were completed in accordance with the methodology described in Sections 7.2, 7.3, and 7.7 of this report.

7.9 Lateral Earth Pressures

Active, at-rest and seismic lateral earth pressures were developed considering the soil retained behind each pier stem wall and associated footing. Passive lateral earth pressures were developed considering the soil present in front of the toe of the foundations. Static and seismic lateral earth pressures were developed for the soil retained behind Wall 03.63L and Wall 03.65L. Passive earth pressures are ignored for the embedded portion of the SE Walls.

Lateral earth pressures were calculated using a spreadsheet developed by GeoEngineers based on Rankine and Coulomb earth pressure theory. The earth pressure loads and resistances presented in this report do not include load or resistance factors. See Table 6 below for load and resistance factors associated with lateral earth pressures on permanent structures (AASHTO LRFD Section 11.5.7 and Table 3.4.1-2).

Table 6: Load and Resistance Factors for Lateral Earth Pressures on Permanent Structures

Parameter	Load Factor	Resistance Factor
	Active Earth Pressure	Passive Earth Pressure Component of Sliding Resistance
Service	1.00	1.00
Strength	1.50	0.50
Extreme Event	1.00	1.00

Due to the geometry of Bridge 17.7, we assumed Pier 1, Pier 2, and Pier 3 are fully restrained and therefore used the site-class adjusted Peak Ground Acceleration (A_s) as the horizontal seismic coefficient (K_h) per Project GDM Section 6-4.3.2. Pier 1 and Pier 3 walls are 20-feet or greater in height, therefore we reduced the wall height-dependent seismic coefficient (wave scatter coefficient), **α** (k_h = **α** * A_s) for wave scattering effects. Finally, because each pier is restrained by Bridge 17.7, at-rest static (K_o) earth pressure coefficients were used. For Pier 1 and Pier 2, at-rest seismic (K_{oe}) earth pressure coefficients were used. Active seismic (K_{ae}) earth pressure coefficients were used for Pier 3 because we calculate that 3 to 4 inches of horizontal displacement could occur during the SEE event. Applicable earth pressures are summarized for each bridge pier on Figures 5 through 8.

For Walls 03.63L and 03.65L we have assumed that the walls can deform enough under seismic loading to allow for the use of a horizontal seismic acceleration value (K_h) equal to 50 percent of the site-class adjusted horizontal seismic acceleration that would be used for a fully restrained wall, per Project GDM Section 6-4.3.2. Seismic earth pressures were developed using this reduced horizontal seismic acceleration. Wall 03.66L is a mass concrete structural extension of the existing wall, so no lateral earth pressures are provided.

7.10 Coefficients of Sliding Friction

Coefficients of sliding friction at the bottom of bridge footings, SE Walls, and other structures such as concrete barriers were determined using AASHTO Equation 10.6.3.4-2. For bridge footings, SE Wall fascia footings, and other concrete structures a

modifying coefficient of 1.0 was used for situations where concrete was to be cast directly against soil and a modifying coefficient of 0.8 for situations where precast concrete would be set directly on the soil after curing. For SE Walls with continuous reinforcements (e.g., grids and sheets) the angle of sliding friction was taken as the minimum of the reinforced fill friction angle, foundation soil friction angle, or the soil-reinforcement interface angle (taken as $^2/_3$ of the lesser of the foundation or reinforced soil friction angle in absence of specific information) per AASHTO Section 11.10.5.3.

The sliding resistance coefficients throughout this report do not include resistance factors. Table 7 below provides resistance factors to be applied. Shallow foundation and SE Wall sliding resistance factors were obtained from AASHTO Sections 10.5.5 and 11.5 respectively.

Table 7: Resistance Factors for Passive Earth Pressures of Sliding Resistance

Parameter	Sliding Resistance Factors	
	Shallow Foundations	SE Walls
Service	1.00	1.00
Strength	0.80 – 0.90[1]	1.00
Extreme Event	1.00	1.00

Notes:
1. Value varies depending on construction method and soil type. Confirm value using AASHTO Table 10.5.5.2.2-1.

7.11 Seismic Springs on Shallow Foundations

Seismic structural springs were developed for shallow foundations for each of the bridge pier footings per Project GDM Section 6-5.1.1. The initial shear modulus, G_o, and effective shear modulus, G, were developed in accordance with Federal Emergency Management Agency (FEMA) 356 (ASCE 2000) as referenced in Project GDM Section 6-5.1.1. Initial shear modulus, G_o, was correlated using Equation 4-5 (FEMA 356) by using the standard penetration blow count normalized for overburden pressure and hammer efficiency. The Effective Shear Modulus, (G/G_o) was calculated using Table 4-7 (FEMA 356) considering the effective peak acceleration ($S_{XS}/2.5$). Spring constants were developed for the SEE hazard level.

7.12 Lateral Analysis of Secant Pile Wall

Lateral performance of Pier 3 secant pile wall under static and seismic conditions was analyzed using software PYWALL (Ensoft Inc. PYWALL Version 2019.6.2). The secant pile wall was modeled assuming linear elastic section properties.

Per Section 15-5.1 of the Project GDM, active earth pressures may be used for abutment walls if they can move sufficiently to develop active pressures. If the pier is not free to deform, at-rest lateral earth pressures are used. Based on the known construction sequence of the existing bridge, we have assumed that Pier 3 has not experienced enough displacement to date to mobilize an active earth pressure condition. Additionally, the bridge structure is being used to brace against displacement so the lateral earth pressures in the static condition are calculated using at-rest coefficients. However, in the seismic case, we use seismic active earth pressures because Pier 3 will likely deform enough to develop active earth pressures. Therefore, we used the site-class adjusted Peak Ground Acceleration (A_s) as the horizontal seismic coefficient (K_h) per Project GDM Section 6-4.3.2.

8. Conclusions and Recommendations

Geotechnical recommendations and conclusions for Bridge 17.7, Wall 03.63L, Wall 03.65L, and Wall 03.66L are presented below. The methods used for these analyses are described in Section 7.0. Calculations are included in Appendix D, Appendix E, Appendix F, and Appendix G.

8.1 Bridge 17.7 Pier 1 and Wall 03.63L

The design of Bridge 17.7 Pier 1 is presented together with Wall 03.63L because the design of each element is dependent on the other. To accommodate widening southbound I-405 under the existing Bridge 17.7, portions of the existing Hilfiker wall (Wall 03.63L) approach embankment along with the existing Bridge 17.7 Pier 1 footing need to be removed and/or replaced. A new Pier 1 bridge footing will be constructed with a bottom of footing at Elevation 66.5 feet, resting on top of a portion of the

existing Hilfiker wall. The existing Hilfiker wall is not internally stable with the addition of the anticipated new Pier 1 bridge footing loads. Therefore, a new permanent soil nail wall will be constructed through the face of the existing Hilfiker wall (Wall 03.63L). The soil nail wall will extend laterally to cover the proposed Pier 1 footing's zone of influence. For details on the construction of Bridge 17.7 Pier 1 and Wall 03.63L see Section 2.1 and Appendix D.

Figure 3 shows the location of each design section that we used to evaluate conditions for the construction of the new Pier 1 and subsequent portions of Wall 03.63L. Section Ea-Ea' represents the tallest portion of the existing Hilfiker wall and is directly in front of the toe of the new Pier 1 footing, placing it under the widened portion of I-405 pavement in the final condition. Section Fa-Fa' is cut through the stem wall of the new Pier 1 footing and Section Ga-Ga' is cut behind the proposed Pier 1 footing. Finally, Section Ha-Ha' represents a portion of Wall 03.63L within the excavation slope cut. In the final condition, Section Ha-Ha' represents a section of Wall 03.63L that is partially existing Hilfiker wall (lower portion) and partially new Hilfiker wall (upper portion). See Figure 4 and the mark up presented in Appendix D.1 for a description of the construction sequence at each critical cross-section.

8.1.1 Pier 1 and Wall 03.63L Global Stability

We completed global stability analyses for the following critical cross sections:

- Cross-section D-D' shown on Figure 3: Longitudinal Stability of Pier 1,
- Cross-section Ea-Ea' shown on Figure 3: Maximum height of existing Hilfiker wall,
- Cross-section Fa-Fa' shown on Figure 3: Transverse Stability of Wall 03.63L with proposed Pier 1 footing load,
- Cross-section Ga-Ga' shown on Figure 3: Transverse Stability of Wall 03.63L behind proposed Pier 1 footing, and
- Cross-section Ha-Ha' shown on Figure 3: Transverse Stability of Wall 03.63L where a portion of the wall will be excavated and then replaced with new Hilfiker wall.

We calculated the global stability FS values for static conditions using the Spencer and Morgenstern-Price Method in Slope/W. We used static soil strength parameters for the static analysis. We modeled the SE Wall as a "High Strength" material (in the global stability analyses only) having a unit weight of 130 pounds per cubic foot (pcf). We used design backfill properties within the suggested range in the Project GDM Table 5-2.

We used a horizontal seismic acceleration coefficient (k_h) to estimate seismic lateral earth pressures and evaluate pseudo-static global stability. For our analyses, k_h is reduced to 50 percent of A_s ($k_h = 0.5 * A_s$) for flexible wall displacements of 1- to 2-inches and reduced for the wall height-dependent seismic coefficient (wave scatter coefficient), $\boldsymbol{\alpha}$ ($k_h = \boldsymbol{\alpha} * A_s$) for wave scattering effects where applicable.

For sections Ea-Ea', Fa-Fa', and Ga-Ga' the final condition includes a permanent soil nail wall below either the proposed Pier 1 footing or the new portions of the Hilfiker wall, as applicable. The existing Hilfiker wall reinforcements were modeled as described in Section 8.1.2 in this report and Appendix D. The soil nails were modeled using the results of the SNAIL analysis described in Section 8.1.5 of this report and Appendix D. The top row of the soil nail wall is modeled in Slope/W as being 45 feet long, however the limiting soil nail design for the top row is 46 feet long, as described in Section 8.1.5 and Appendix D.

A summary of global stability analysis results is presented in Table 8 below. Appendix D presents the global stability figures and detailed input and output reports. Strap lengths and embedment depths were modeled based on existing Hilfiker design documents dated September 1990 (Wall 6), see Appendix D.1.

Table 8: Global Slope Stability Results – Bridge 17.7 Pier 1 and Wall 03.63L

Wall	Section	Scenario	Loading Type	Minimum Required Factor of Safety	Calculated FS (Spencer/ Morgenstern & Price)	Minimum Required Strap Length/ Minimum Wall Embedment2
Pier 1	(D-D')	Final	Static	1.3	4.1 / 4.1	Not applicable
			Pseudo-Static	1.1	3.2 / 3.2	
Wall 03.63L Bridge 17.7	(Ea-Ea')	Existing	Static	1.3	2.4 / 2.4	34-feet / 1-foot
			Pseudo-Static	1.1	1.8 / 1.8	
		Final	Static	1.3	4.3 / 4.3	
			Pseudo-Static	1.1	2.0 / 2.0	
	(Fa-Fa')	Existing	Static	1.3	2.4 / 2.5	34-feet / 1-foot
			Pseudo-Static	1.1	1.8 / 1.8	
		Construction	Static	1.3	4.2 / 4.2	
		Final	Static	1.3	1.8 / 1.8	
			Pseudo-Static	1.1	1.5 / 1.5	
	(Ga-Ga')	Existing	Static	1.3	2.5 / 2.5	32-feet / 3-feet
			Pseudo-Static	1.1	1.8 / 1.8	
		Construction	Static	1.3	3.9 / 3.9	
		Final	Static	1.3	2.6 / 2.6	
			Pseudo-Static	1.1	1.9 / 1.9	
	(Ha-Ha')	Existing	Static	1.3	2.5 / 2.5	32-feet / 3-feet
			Pseudo-Static	1.1	1.8 / 1.8	
		Construction	Static	1.3	2.9 / 2.9	
		Final	Static	1.3	2.5 / 2.5	
			Pseudo-Static	1.1	1.8 / 1.8	

8.1.2 Pier 1 and Wall 03.63L Compound Stability

We evaluated compound stability at each Wall 03.63L design section using the computer program Slope/. Limit equilibrium analyses were completed following the procedures outlined in Project GDM Section 15-5.3.4. Stability factors of safety were determined using both Spencer's and Morgenstern-Price methods with entry and exit search limits for a circular failure surface.

We modeled the soil reinforcements as inextensible welded steel wire grid mats connected to cast in place concrete facing as shown in the design documents for the existing Hilfiker wall (Wall 6) dated September 1990 (Appendix D.1). Based on discussions with the Hilfiker design team, we understand galvanization was applied to the welded wire mats. We calculated the corrosion losses in the steel wires over the 30-year in-place life to date and also over the 75-year full design life using the prescribed steel corrosion rates presented in AASHTO LRFD Section 11.10.6.4.2a and FHWA Geotechnical Engineering Circular No. 11 Tables 3-7 and 3-8. See Appendix D for details on corrosion loss calculations.

For compound stability involving the portions of the Hilfiker Wall 03.63L that will be reconstructed, we modeled the reinforcement properties as equivalent to those of the existing Hilfiker wall reinforcements at a corrosion design life of 45 years. This matches the approximately 45 years of remaining design life of the existing Hilfiker wall reinforcement lower in the wall. The new portion of the wall will not be an exact one-to-one replacement of the existing wall and that the design of the new upper portions of the wall will be designed by others. The new wall will be designed to the current required corrosion rate and design life. The calculation provided was used to verify compound stability and is based on the existing wall exposed to corrosion for 45 years. The new wall designer should make certain that greater than or equal amounts of steel area used in this design remain at the end of the new wall design life in order to satisfy compound stability.

We applied resistance factors presented in AASHTO LRFD Section 11.5 and FHWA Geotechnical Engineering Circular No. 11 Table 4-7 to calculate the pullout resistance and tensile capacity of the steel grid reinforcements at Wall 03.63L. We modeled the reinforced fill as Gravel Backfill for SE Walls. Using the thickness of the transverse bar and the transverse bar spacing we calculated the pullout resistance factor F* in accordance with AASHTO LRFD Section 11.10.6.3.2 and FHWA Geotechnical Engineering Circular No. 11 Section 3.4.2 equations 3-6 and 3-7. We used the pullout resistance to calculate an interface shear friction angle at each reinforcing grid, considering the grid wire size and spacing. The calculated tensile capacity and interface shear friction angles were input into Slope/W to model the reinforced zone.

We applied resistance factors presented in AASHTO LRFD Section 11.5 and FHWA Geotechnical Engineering Circular No. 11 Table 4-7 to calculate the pullout resistance and tensile capacity of the reinforcing welded wire grid.

Slope/W does not have a specific welded-wire grid reinforcement input option. Therefore, the tensile strength of the grids were modeled as a continuous reinforcement. The calculated allowable tensile grid capacity was converted to a continuous reinforcement tensile capacity by distributing the capacity over the tributary width. The longitudinal wires are spaced every 6 inches, therefore two bars exist within each 1-foot representative width of grid.

For pseudo-static analyses, we used an apparent cohesion in the native soils above the groundwater table based on the fines content ranges presented in Table 11-2 of the FHWA Geotechnical Engineering Circular No. 3.

Groundwater levels were modeled using a piezometric surface. The piezometric surface was based on measured or observed groundwater levels at Bridge 17.7 as discussed in Appendix C.

Per Project GDM Section 15-5.3.4 and AASHTO LRFD Table 3.4.1-1, a strength limit state load factor of 1.75 was applied to the standard traffic surcharge of 250 psf, resulting in a uniform traffic surcharge of 437.5 psf in the static compound stability analysis. Per AASHTO LRFD Section 3.4.1, an extreme limit state load factor of 0.5 was applied to the standard traffic surcharge of 250 psf, resulting in a uniform traffic surcharge of 125 psf for the seismic (pseudo-static and post-seismic) compound stability analyses.

Per Project GDM Sections 15-4.12 and 6-4.3.2, a static resistance factor of 0.75 (FS = 1.3) and seismic resistance factor of 0.9 (FS = 1.1) shall be used for compound stability. The required minimum static and pseudo-static FSs were met at each design section at Bridge 17.7 Pier 1 and Wall 03.63L.

When modeling the new Pier 1 footing, we modeled the factored footing load as a high strength "material" with a unit weight and thickness corresponding to the design footing load. We modeled the footing load with an upper limit of 9.0 kips per square foot (ksf) for both the static (Strength Limit State) and pseudo-static case (Extreme Limit State). The footing was modeled with a unit weight of 2,250 pcf and a thickness of 4 feet, which corresponds to a factored load of 9,000 psf. This factored foundation

load does not include soil vertical load. The soil weight of the Hilfiker wall on top of the Pier 1 footing is taken into account by the soil unit modeled above the footing elevation within the Slope/W model.

Structural loads were not included in our analyses. Any structural foundation loads applied to the wall shall include the appropriate load factors in AASHTO LRFD Table 3.4.1-1 consistent with Strength Limit State and Extreme Event Limit State design.

The results of our compound stability analyses for Wall 03.63L are summarized in Table 9. See Appendix D for the compound stability figures and detailed input and output Slope/W reports.

Table 9: Compound Stability Results – Bridge 17.7 Pier 1 and Wall 03.63L

Wall	Section	Scenario	Loading Type	Minimum Required Factor of Safety	Calculated FS (Spencer/ Morgenstern & Price)	Minimum Required Strap Length/ Minimum Wall Embedment2
Wall 03.63L Bridge 17.7	(Ea-Ea')	Existing	Static	1.3	2.7 / 2.6	34-feet / 1-foot
			Pseudo-Static	1.1	2.0 / 2.0	
	(Fa-Fa')	Existing	Static	1.3	3.3 / 3.3	34-feet / 1-foot
			Pseudo-Static	1.1	2.1 / 2.1	
		Construction	Static	1.3	5.9 / 5.9	
		Final	Static	1.3	4.8 / 4.8	
			Pseudo-Static	1.1	2.3 / 2.3	
	(Ga-Ga')	Existing	Static	1.3	2.7 / 3.2	32-feet / 3-feet
			Pseudo-Static	1.1	2.2 / 2.2	
		Construction	Static	1.3	5.8 / 5.8	
		Final	Static	1.3	4.3 / 4.2	
			Pseudo-Static	1.1	2.3 / 2.3	
	(Ha-Ha')	Existing	Static	1.3	3.2 / 3.2	32-feet / 3-feet
			Pseudo-Static	1.1	2.2 / 2.2	
		Construction	Static	1.3	2.9 / 2.9	
		Final	Static	1.3	8.2 / 8.2	
			Pseudo-Static	1.1	2.4 / 2.5	

8.1.3 Wall 03.63L Internal Stability of Existing Wall

Internal stability was evaluated using the procedure outlined in Project GDM 15-5.3.10. We evaluated internal stability of the existing portion of Wall 03.63L that will not be replaced or converted into a soil nail wall (e.g., design section Ha-Ha') using the computer design software MSEW. MSEW analyzes internal stability (connection strength, pullout, and internal sliding) and external stability (sliding and overturning) of SE Walls using design guidelines from AASHTO 2007-2010. We analyzed our bearing capacity using GeoEngineers internal spreadsheet, see Section 8.1.5.

Design section Ha-Ha' was selected as being representative of the entire sloped cut excavation portion of Wall 03.63L. This portion of the wall consists of the existing Hilfiker wall that is to remain in place below the newly replaced portion of Wall 03.63L, which will also be a Hilfiker wall. For our design analyses, we assumed a 2H:1V (horizontal to vertical) slope cut that begins at the bottom and back (west side) of the proposed Pier 1 footing. It is likely that the bottom of this slope cut will be located further to the west in order to accommodate a slightly larger work bench or platform, however it is more conservative to assume the slope cut starts behind the proposed footing without any extended portion of work bench because design cross-sections that are closer to the proposed Pier 1 footing yield taller sections of the existing wall to remain in place. It is also likely that due to the geometry of the existing wall and the welded wire mats that need to be removed, that portions of this slope cut may need to be steeper than 2H:1V. In accordance with Occupational Safety and Health Administration (OSHA) guidelines for temporary open slope cuts in angular gravel type backfill, in combination with local experience in these soil types, a temporary slope cut as steep as (but not exceeding) 1.5H:1V is acceptable.

Section Ha-Ha' was cut approximately halfway up the slope cut. We analyzed the internal stability of both the existing wall at 75 years of total design life corrosion and the final condition at Section Ha-Ha'. The existing condition analysis is used to evaluate the wall portions within this area that will not be removed, the final condition at section Ha-Ha' represents a mix of new (upper) and existing (lower) wall portions, and Section Ga-Ga' (right behind proposed Pier 1) represents the tallest portion of new Hilfiker wall that will be constructed over the existing wall.

We calculated the corrosion loss over 75 years for the full design life of the existing welded wire mats using steel corrosion rates presented in AASHTO LRFD Section 11.10.6.4.2a and FHWA Geotechnical Engineering Circular No. 11 Tables 3-7 and 3-8. The static analyses found that all portions of the existing Hilfiker wall are internally stable at Section Ha-Ha' with 75 years of corrosion losses considered. However, the seismic analyses found that portions of the existing Hilfiker wall were not internally stable with 75 years of corrosion losses considered. Those weaker portions of the existing wall are not located below the proposed Pier 1 footing elevation but rather within the upper reaches of Wall 03.63L. Referring to the MSEW results for the existing condition included in Appendix D.6 (see page 7), there are three welded-wire layers that do not meet the minimum capacity to demand ratios (CDR) for metal mat tensile strength (see layers 15, 16, and 17 on that page with CDR ratios of 0.899, 0.917, and 0.956 respectively).Our proposed bottom of the new Pier 1 footing falls just above layer #9, which is lower in elevation, so for the majority of our work area these three weaker layers of welded-wire mats will be removed and replaced with new material designed to current seismic standards. The only areas where the three weaker layers will remain will be either 1) within the slope cut portion of the excavation where depths of cut are less than or equal to about 14 feet, or 2) within portions of the existing Hilfiker approach embankment that are outside of our construction area and will remain essentially untouched. All three of these layers have CDR ratios that reduce the FS against tensile failure (which has a resistance factor of 0.85 for the seismic case per AASHTO Table 11.5.6-1) but do not reduce those FSs to a point below 1.0. The minimum CDR value of 0.899 results in a factor of safety of 1.057 (0.899 divided by 0.85) for the seismic case tensile failure. Within the portions of the wall where the three weaker layers will remain, the proposed work will do no harm to the existing condition, and in all cases within the area of construction influence, overall condition of the wall will be improved by replacing upper layers of existing welded-wire mats with new welded-wire mats.

8.1.4 Wall 03.63L Soil Nail Wall Recommendations

8.1.4.1 General

We used the design software SNAIL to evaluate the LRFD soil nail capacity of Wall 03.63L. We varied the soil nail length and spacing to target a minimum CDR of 1.0. Using this process, we calculated the maximum allowable factored footing loads as 7,000 psf and 12,000 psf for the permanent static and seismic conditions, respectively. These loads include the weight of the soil of the new Hilfiker wall above the footing.

We considered a 6-inch-diameter drilled hole to calculate the design load transfer of each soil nail row. Soil nail bars consist of Grade 65 or higher deformed steel reinforcing rods, threaded at the proximal end (closest to the face). Minimum bar sizes and nail lengths are provided in Table 10. A minimum drill hole diameter of 6 inches is used to maintain grout cover over the soil nail bar and to develop the minimum design load transfer presented in Table 10.

Table 10. Wall 03.63L Soil Nail Layout

Soil Nail Row	Depth (feet)	Horizontal Spacing (feet)	Length (feet)	Declination (degrees)	Bar Size/ Grade	Nominal Design Load Transfer (lbs/ft)
1	2	4	46	10	#11/65	2,827
2	6	4	45	10	#11/65	2,827
3	10	4	40	10	#10/65	2,827
4	14	4	40	10	#10/65	2,827

Abbreviations:
lbs/ft = pounds per foot

Centralizers shall be installed along the soil nail bars at a maximum spacing of 7 feet, including one centralizer within 3 feet of the distal (furthest from the face) end of the bars. Centralizers shall provide at least 1 inch of grout cover over the bar. Openings between the centralizer support arms shall allow unobstructed tremie pipe insertion and grout flow.

The permanent soil nail wall portion of Wall 03.63L underpins Bridge 17.7 Pier 1. Therefore, per Project GDM Section 15-5.7 the walls shall have double corrosion protection (encapsulated) nails within the zone of influence of the bridge structure. To avoid obstructions or structures, soil nails may be installed at an inclination angle of +/-3 degrees of the angle shown in Table 10.

A detailed description of our soil nail evaluation methodology, assumptions, figures, and SNAIL reports are presented in Appendix D. The results of our analyses of the Wall 03.63L soil nail layout and design is presented in Table 11.

Table 11. Wall 03.63L Overall Stability CDR and Soil Nail Service Loads

Condition	Wall Height (feet)	Minimum Required CDR	Calculated CDR	Maximum Service Load (kips)
Permanent Static	16.5	1.0	1.00	32.9
Seismic	16.5	1.0	1.08	44.5

8.1.4.2 Soil Nail Wall Facing and Drainage

Structural capacity of the wall facing will be analyzed by the project structural engineer using the procedure outlined in the FHWA Geotechnical Circular No. 7. The structural engineer shall use the maximum service loads presented in Table 11 for Wall 03.63L.

We propose to install the soil nail portion of Wall 03.63L through the existing Hilfiker wall system. We assume the existing wall drainage in place for the existing Wall 03.63L will remain adequate for the soil nail wall.

8.1.4.3 Soil Nail Wall Performance

Soil nail reinforcement is typically mobilized through lateral wall deflections as the cut wall construction proceeds downward in stages. However, this soil nail wall will be installed through an existing SE Wall. We anticipate that the reinforcement will be mobilized as loads are applied during construction of the proposed Pier 1 footing and stem wall, the Bridge 17.7 superstructure, and reconstruction of the western approach embankment. Soil nail walls are typically designed for deflections less than 1 inch under static conditions and less than 1.5 inches under seismic conditions. However, soil conditions may vary locally. Therefore, it is important that the special inspection program defined in the specifications and the applicable Geotechnical Special Inspection Plan be completed and that GeoEngineers be provided the data as soon as it is obtained.

8.1.4.4 Soil Nail Load Testing

For simplicity during construction, the soil-grout bond stress stated in the report was converted to a design load transfer, consistent with WSDOT standard plans and specifications. The design load transfer represents the allowable (resistance factor applied) force per foot of nail (pounds per foot). The testing procedure in the WSDOT Standard Specifications lists testing steps in proportion to the design load transfer. WSDOT Standard Specifications shall be followed for verification and proof testing of soil nails. Further details about the verification and proof testing are listed below.

8.1.4.5 Verification Testing

Prior to installing any production nails, sacrificial nails shall be installed, and verification tests performed to verify the installation methods and design soil-grout bond stress. We recommend a minimum of one verification test at Wall 03.63L installed in ESU 1B.

8.1.4.6 Proof Testing

During construction of the wall, sacrificial nails shall be installed for proof testing to confirm that the required pullout resistance is available. At least one soil nail in each row shall be tested and at least 5 percent of all nails shall be tested. Test nails will need to be selected at the time of installation so that the grouting is stopped short to create an unbonded zone for testing purposes. FHWA Geotechnical Engineering Circular No. 7 and the WSDOT Standard Specifications outline the testing procedure for the soil nails.

8.1.4.7 Soil Nail Locations

Careful layout of all soil nails will be needed and should extend past the zone of influence of the proposed Bridge 17.7 Pier 1 footing load. During construction the nail locations can be modified by up to 1 foot without significant change in stability.

8.1.4.8 Soil Nail Pattern

The nails can be laid out using a squared (grid) pattern for construction simplicity, or a staggered pattern to reduce the total number of nails. The recommended spacing may be modified slightly to avoid the existing utilities that run through the lower reaches of the western approach embankment and other obstructions, as necessary. Where spacing is to be modified, the nail spacing must still meet minimum and maximum spacing requirements specified in Project GDM Section 15-5.7. The specific spacing for Wall 03.63L is provided in Table 10.

8.1.4.9 Drilling Conditions

The soil nails for Wall 03.63L will be installed through the existing Hilfiker wall. Holes will need to be cored through the existing facing. The soils include gravel fill with welded wire mesh reinforcement layers at an approximately 2-foot vertical spacing. These welded wire mats will likely need to be cored through using a casing advance system.

Soil nail drilling is expected to encounter caving ground conditions in the backfill soils, so the drilling contractor must use temporary casing to install the soil nails. Caving soils and the existing Hilfiker wall could represent difficult slow drilling conditions.

8.1.4.10 Maintenance

The retaining wall structure will require typical maintenance throughout its lifetime. The walls will have the existing Hilfiker wall drainage to prevent hydrostatic pressure build-up behind the wall. These drainage systems shall be maintained.

8.1.5 Pier 1 and Wall 03.63L Bearing Capacity and Elastic Settlement

We evaluated the bearing capacity for the proposed Pier 1 foundation at Bridge 17.7, existing Pier 1 foundation, and the lower portion of Wall 03.63L that will remain in place. Bearing capacity was not calculated for the new upper portions of Wall 03.63L because a majority of the newly constructed wall will bear directly on the proposed Pier 1 footing and therefore is accounted for in the Pier 1 bearing resistance analysis. Additionally, the new Wall 03.63L is replacing the existing wall with an approximate one to one replacement.

We evaluated the shallow foundation bearing resistance based on AASHTO LRFD Section 10.6.3.1.2 and using the Shallow Foundation Resistance and Elastic Settlement spread sheet developed by GeoEngineers.

Bearing capacity was evaluated by using the maximum height of the existing Wall 03.63L over ESU 1B. Portions of Wall 03.63L likely also bears on ESU 2A, however the extent of that ESU contact is difficult to confirm. Therefore, in the bearing

capacity calculation, we assumed the wall bears entirely on ESU 1B because it is weaker than ESU 2A. We evaluated strap width of 32- and 34-feet per the existing Hilfiker wall design sheets (see appendix D.1). Bearing resistance results and calculations are presented in Appendix D. A summary of the bearing capacity results is presented in Table 12.

Table 12. Bearing Resistance Summary

Scenario	Maximum Bearing Resistance Limited by Global and Compound Stability[5]		Maximum Bearing Resistance Limited by Soil Nail Capacity (SNAIL)[6]		Maximum Bearing Resistance Limited by Bearing Resistance Calculation				
	Factored Strength Limit State	Factored Extreme Limit State	Factored Strength Limit State	Factored Extreme Limit State	Unfactored Bearing Resistance	Factored Extreme Event Resistance[1]	Factored Strength Bearing Resistance[2]	Factored Service Limit State[3]	
								1" Deflection	1.5" Deflection
	(ksf) [4]	(ksf) [4]	(ksf) [4]	(ksf) [4]	(ksf) [4]	(ksf) [4]	(ksf) [4]	(ksf) [4]	(ksf) [4]
Wall 03.63L **B = 32ft L=70ft** (ESU 1B)	Not Applicable				72	64.8	46.8	3.6	5.4
Wall 03.63L **B = 34ft L=70 ft** (ESU 1B)	Not Applicable				75.2	67.7	48.9	3.5	5.2
Pier 1 Proposed Footing **B=24.7ft L=38.7ft** (ESU 1B)	9.0	9.0	7.0	12.0	100.4	90.3	45.2	5.4	8.0
								0.25" Deflection	0.5" Deflection
Pier 1 Existing Footing **B=12ft L=41.7ft** (ESU 7A)	Not Applicable				578.3	520.5	260.3	1.3[7]	2.7[8]

Notes:

1. Resistance factor of 0.9 included in the factored bearing resistance values presented for Extreme Limit State load cases (AASHTO 11.5.8) for SE Walls.
2. Strength Limit State factor (0.65) SE Walls from AASHTO 11.5.7.1.
3. Resistance factor of 1.0 included in the factored bearing resistance values presented for Service Limit State load cases.
4. ksf = kips per square foot
5. Bearing resistance limiting values to meet global and compound stability requirements. See Appendix D.4 and D.5 for details.
6. Bearing resistance limiting values to meet soil nail wall capacity requirements. See Appendix D.7 for details.
7. Bearing resistance value limiting the existing pier 1 foundation settlement to 0.25-inches of settlement. The bearing resistance values are exclusive of loads that the existing footing is already under.

8. Bearing resistance value limiting the existing pier 1 foundation settlement to 0.50-inches of settlement. The bearing resistance values are exclusive of loads that the existing footing is already under.

All final settlement values were less than 1.0 inch and are anticipated to be elastic and occur immediately as the loads are placed. Because the anticipated settlement of Pier 1 is less than 2 inches settlement instrumentation and monitoring is not required as outlined in RFP 2.6.7.5. We anticipate post-construction settlement to be negligible. Cumulative elastic settlement values for each loading case are presented below in Table 13. A summary of calculations, assumptions, and results are also presented in Appendix D.

Table 13: Bridge 17.7 Proposed Pier 1 Cumulative Settlement Values for Staged Loading

	Proposed Pier 1 – Bridge 17.7				
	Stage 1	**Stage 2**	**Stage 2.5**	**Stage 3**	**Case 4**
q_o(ksf)[1]	0.00	1.18	1.46	0.48	0.09
ν[2]	0.25	0.25	0.25	0.25	0.25
A (ft^2)[3]	956	956	956	956	956
E_s (ksf)[4]	1720	1720	1720	1720	1720
L/B	1.6	1.6	1.6	1.6	1.6
β_z[5]	1.091	1.091	1.091	1.091	1.091
S_e (in.) [6] per Stage	0.00	0.22	0.27	0.09	0.02
Cumulative S_e (in.)	0.00	0.22	0.49	0.58	0.59

Notes:
1. Load intensity at bottom of foundation
2. Poisson's Ratio
3. Area of bottom of footing
4. Young's Modulus of subgrade soil
5. Shape factor
6. Predicted elastic settlement in inches

8.1.6 Pier 1 and Wall 03.63L Lateral Earth Pressures and Sliding

Lateral earth pressures were calculated using a spreadsheet developed by GeoEngineers based on Rankine and Coulomb earth pressure theory per AASHTO Section 3.11.5. Seismic lateral earth pressure coefficients were developed using the Mononobe-Okabe Method per AASHTO Section A11.3.1. We recommend lateral earth pressures be applied using a triangular distribution and additional loads be applied as either point loads or with a rectangular distribution as presented on Figure 5.

Active static lateral earth pressure coefficients, ka, and active seismic earth pressure coefficients, k_{ae}, and the corresponding lateral earth pressures on the back of Wall 03.63L are presented in Appendix D.

The analysis methods, input parameters, additional discussion, and results of the lateral earth pressure calculations are included in Appendix D. Nominal lateral earth pressure coefficients for Bridge 17.7 Pier 1 are presented in Figure 5.

Coefficients of friction against sliding were calculated for Wall 03.63L, the proposed Pier 1 footing. Coefficients of friction were determined using AASHTO Equation 10.6.3.4-2 for concrete structures (such as footings or wall fascia footings) and for soil-to-soil resistance to sliding at the base of the SE Walls. Friction coefficients are provided for native soils and each of the approved import materials. A coefficient of 1.0 was used for concrete cast against soil and 0.8 for precast concrete. For sliding coefficients for SE Walls with discontinuous reinforcements (e.g., strips) the angle of sliding friction was taken as the lesser of the friction angle of the reinforced fill or the friction angle of the foundation soil (AASHTO 11.10.5.3). For sliding coefficients for SE Walls with continuous reinforcements (e.g., grids and sheets) the angle of sliding friction was taken as the minimum of the reinforced fill friction angle, foundation soil friction angle, or the soil-reinforcement interface angle (taken as $^2/_3$ of the lesser of the foundation or reinforced soil friction angle in absence of specific information) per AASHTO Section 11.10.5.3.

The analysis methods, input parameters, additional discussion, and results of the Bridge 17.7 Pier 1 and Wall 03.63L sliding coefficients are included in Appendix D.

8.1.7 Pier 1 Seismic Spread Footing Springs

We calculated the seismic structural footing springs for each of the existing and proposed Bridge 17.7 pier 1 footing. Per FEMA 356 (ASCE 2000) as referenced in Project GDM Section 6-5.1.1 the initial shear modulus (G_o) was correlated the corrected SPT blowcount, $(N_1)_{60}$.

Spring constants were developed for the SEE hazard levels. A summary of the calculated spring constants is presented in Table 14 below. The analysis methods, input parameters, additional discussion, and results of the Bridge 17.7 Pier 1 seismic spring constants are included in Appendix D.

Table 14: Summary of the 6-Degree-of-Freedom Structural Seismic Spring Constants Proposed Pier 1

Results Summary[1]							
Pier		$K_{x,emb}$	$K_{y,emb}$	$K_{z,emb}$	$K_{xx,emb}$	$K_{yy,emb}$	$K_{zz,emb}$
		kips/in	kips/in	kips/in	kip-in	kip-in	kip-in
SEE	Pier 1 – Existing (ESU 7A)	13,800	15,350	13,510	138,100,000	647,500,000	730,300,000
	Pier 1 – Proposed (ESU 1B)	5,647	5,870	5,793	160,200,000	320,600,000	357,000,000

Notes:
1. Spring values calculated using equations presented in Figure 4-4 (FEMA)

8.2 Bridge 17.7 Pier 2

8.2.1 Pier 2 Shallow Foundation Bearing Resistance and Settlement

We evaluated Bridge 17.7 Pier 2 existing shallow foundation bearing resistance based on AASHTO LRFD Section 10.6.3.1.2 and using the Shallow Foundation Resistance and Elastic Settlement spread sheet developed by GeoEngineers.

Bearing resistance results and calculations are presented in Appendix D. A summary of the bearing resistance results is presented in Table 15. It should be noted that the deflection estimates and bearing resistance values reported for the Service Limit State are exclusive of the existing footing loads and only consider loads added to the existing footing and the resulting deformation estimate from the additional loads.

Table 15. Bridge 17.7 Pier 2 Bearing Resistance Summary

Scenario	Maximum Bearing Resistance Limited by Bearing Resistance Calculation				
	Unfactored Bearing Resistance	Factored Extreme Event Resistance[1]	Factored Strength Bearing Resistance[2]	Factored Service Limit State[3]	
				0.25" Deflection	0.5" Deflection
	(ksf)[4]	(ksf)[4]	(ksf)[4]	(ksf)[4]	(ksf)[4]
Pier 2 Existing Footing **B=14ft L=28ft** (ESU 2A)	106.5	95.9	47.9	1.3[5]	2.6[5]

Notes:

1. Resistance factor of 0.9 included in the factored bearing resistance values presented for Extreme Limit State load cases (AASHTO 11.5.8) for SE Walls.
2. Strength Limit State factor (0.65) SE Walls from AASHTO 11.5.7.1.
3. Resistance factor of 1.0 included in the factored bearing resistance values presented for Service Limit State load cases.
4. ksf = kips per square foot
5. The bearing resistance values are exclusive of loads that the existing footing is already under.

A staged elastic settlement analysis was completed as requested by the structural engineer. Cumulative elastic settlement values were calculated per AASHTO Section 10.6.2.4.2 for each stage of loading during construction. Loading stages included the existing condition footing weight, substructure weight, backfill soil weight, girder placement, and superstructure placement. Applied loads were provided by the structural engineer (COWI).

All final settlement values were less than 0.25 inches and are anticipated to be elastic and occur immediately as the loads are placed. Because the anticipated settlement of Pier 2 is less than 2-inches settlement instrumentation and monitoring is not required as outlined in RFP 2.6.7.5. We anticipate post-construction settlement to be negligible. Cumulative elastic settlement values for each loading stage are presented below in Table 16.

Table 16: Bridge 17.7 Pier 2 Cumulative Settlement Values for Staged Loading

	Existing Pier 2 – Bridge 17.7			
	Stage 1	Stage 2	Stage 3	Stage 4
q_o(ksf)[1]	0.00	-0.02	0.20	0.01
ν[2]	0.35	0.35	0.35	0.35
A (ft^2)[3]	392	392	392	392
E_s (ksf)[4]	979	979	979	979
L/B	2.0	2.0	2.0	2.0
β_z[5]	1.10	1.10	1.10	1.10
S_e (in.) [6] per Stage	0.00	0.00	0.04	0.00
Cumulative S_e (in.)	0.00	0.00	0.04	0.04

Notes:

1. Load intensity at bottom of foundation
2. Poisson's Ratio
3. Area of bottom of footing
4. Young's Modulus of subgrade soil
5. Shape factor
6. Predicted elastic settlement in inches

8.2.2 Pier 2 Lateral Earth Pressure and Sliding

Lateral earth pressures were calculated using a spreadsheet developed by GeoEngineers based on Rankine and Coulomb earth pressure theory per AASHTO Section 3.11.5. Seismic lateral earth pressure coefficients were developed using the Mononobe-Okabe Method per AASHTO Section A11.3.1. Lateral earth pressure calculations are presented in Appendix D and applicable earth pressures for Pier 2 are presented on Figure 6.

Due to the geometry and construction history of Bridge 17.7, we have assumed Pier 2 is fully restrained and therefore used the site-class adjusted Peak Ground Acceleration (A_s) as the horizontal seismic coefficient (K_h) without any reductions for flexibility, per Project GDM Section 6-4.3.2. At Pier 2 in the seismic condition, at-rest seismic (K_{oe}) earth pressure coefficients are considered for design.

Coefficients of friction against sliding were calculated for the existing Pier 2 footing. Coefficients of friction were determined using AASHTO Equation 10.6.3.4-2 for concrete structures. Friction coefficients are provided for native soils and each of the approved import materials. A coefficient of 1.0 was used for concrete cast against soil and 0.8 for precast concrete. A summary of coefficients of friction against sliding are presented on Figure 6 and in Appendix D.

8.2.3 Pier 2 Seismic Spread Footing Seismic Springs

We calculated the seismic structural footing springs for the existing Bridge 17.7 Pier 2. Per FEMA 356 (ASCE 2000) as referenced in Project GDM Section 6-5.1.1 the initial shear modulus (G_o) was correlated the corrected SPT blow count, $(N_1)_{60}$. Calculations are presented in Appendix D.

Using the shear modulus values correlated, the Effective Shear Modulus, (G/G_o) was calculated using Table 4-7 (FEMA 356) by using the effective peak acceleration ($S_{XS}/2.5$). Spring constants were developed for the SEE hazard levels. A summary of the calculated spring constants is presented in Table 17 below. Calculations for these values are presented in Appendix D.

Table 17: Bridge 17.7 Pier 2 Summary of the 6-Degree-of-Freedom Structural Seismic Spring Constants

Results Summary[1]							
Pier		$K_{x,emb}$	$K_{y,emb}$	$K_{z,emb}$	$K_{xx,emb}$	$K_{yy,emb}$	$K_{zz,emb}$
		kips/in	kips/in	kips/in	kip-in	kip-in	kip-in
SEE	Pier 2 – Existing (ESU 2A)	11,380	12,070	10,080	119,100,000	278,500,000	333,400,000

Notes:
1. Spring values calculated using equations presented in Figure 4-4 (FEMA)

8.3 Bridge 17.7 Pier 3 Secant Pile Wall and Cast-In-Place Wall

8.3.1 Pier 3 Global Stability

We completed global stability analyses for the following critical cross section:

- Cross-section D-D' on Figure 3: Longitudinal Stability of Pier 3

We calculated the global stability FS values for static conditions using the Spencer and Morgenstern-Price Method in Slope/W. We used static soil strength parameters for the static analysis. We used a horizontal seismic acceleration coefficient (k_h) to estimate seismic lateral earth pressures and evaluate pseudo-static global stability.

For our global stability analyses, the site-class adjusted horizontal seismic acceleration was based on the assumption that Pier 3 remains fully restrained in the seismic condition. Later analyses have updated this assumption as we have found that Pier 3 is expected to deform up to 3 or 4 inches during the SEE seismic event. We did not apply the wall height-dependent seismic coefficient (wave scatter coefficient, α) for wave scattering effects in the global stability analysis.

A summary of global stability analysis results is presented in Table 18. See Appendix D.16 for the global stability results figures (Figures D.16-1 through D.16-42) and the detailed input/output reports from Slope/W in Appendix D.16 after the results figures.

Table 18: Global Slope Stability Results – Bridge 17.7 Pier 3

Wall	Section	Scenario	Loading Type	Minimum Required Factor of Safety	Calculated FS (Spencer/ Morgenstern & Price)	Minimum Required Strap Length/ Minimum Wall Embedment
Pier 3	D-D'	Existing	Static	1.3	3.9 / 3.9	Not applicable
			Pseudo-Static	1.1	1.6 / 1.6	

8.3.2 Pier 3 Lateral Earth Pressure

Lateral earth pressures at Pier 3 were calculated using a spreadsheet developed by GeoEngineers based on Rankine and Coulomb earth pressure theory per AASHTO Section 3.11.5. Seismic lateral earth pressure coefficients were developed using the Mononobe-Okabe Method per AASHTO Section A11.3.1. We recommend lateral earth pressures be applied using a triangular distribution and additional loads be applied as either point loads or with a rectangular distribution.

At-rest static lateral earth pressure coefficients, ko, and active seismic earth pressure coefficients, k_{ae}, and the corresponding lateral earth pressures on the Pier 3 are presented in Appendix D.

The analysis methods, input parameters, additional discussion, and results of the lateral earth pressure calculations are included in Appendix D. Nominal lateral earth pressure coefficients for Bridge 17.7 Pier 3 are presented in Figures 7 and 8 for seismic and static conditions, respectively.

8.3.3 Pier 3 CIP Spread Footing Sliding

Coefficient of friction against sliding was calculated for the Pier 3 cast-in-place (CIP) wall spread footing. Coefficients of friction were determined using AASHTO Equation 10.6.3.4-2 for concrete structures (such as footings or wall fascia footings) and for soil-to-soil resistance to sliding at the base of the SE Walls. A coefficient of 1.0 was used for concrete cast against soil. Calculations for these coefficients are presented in Appendix D. Sliding friction coefficients are presented in Table 19, below.

Table 19: Sliding Friction Coefficient for Pier 3 CIP Wall

Soil Type	φ'	Cast-In-Place Concrete
ESU 2A	39	0.81

8.3.4 Pier 3 CIP Wall Seismic Spread Footing Springs

We calculated the seismic structural footing springs for the existing Pier 3 CIP wall west of Bridge 17.7 Pier 3. Per FEMA 356 (ASCE 2000) as referenced in Project GDM Section 6-5.1.1 the initial shear modulus (G_o) was correlated to the corrected SPT blow count, $(N_1)_{60}$. Correlated G_o values are presented in Table D-19 below. Calculations are presented in Appendix D.

8.3.5 Pier 3 CIP Wall Seismic Spread Footing Seismic Springs

We calculated the seismic structural footing springs for the existing CIP at Bridge 17.7 Pier 3. Per FEMA 356 (ASCE 2000) as referenced in Project GDM Section 6-5.1.1 the initial shear modulus (G_o) was correlated the corrected SPT blow count, $(N_1)_{60}$. Calculations are presented in Appendix D.

Using the correlated shear modulus values, the Effective Shear Modulus, (G/G_o) was calculated using Table 4-7 (FEMA 356) and the effective peak acceleration ($S_{XS}/2.5$). Spring constants were developed for the SEE hazard levels. A summary of the calculated spring constants is presented in Table 20 below. Calculations for these values are presented in Appendix D.

Table 20: Bridge 17.7 Pier 3 Summary of the 6-Degree-of-Freedom Structural Seismic Spring Constants

Results Summary[1]							
Pier		$K_{x,emb}$	$K_{y,emb}$	$K_{z,emb}$	$K_{xx,emb}$	$K_{yy,emb}$	$K_{zz,emb}$
		kips/in	kips/in	kips/in	kip-in	kip-in	kip-in
SEE	Pier 3 CIP Wall – Existing (ESU 2A)	7,439	8,214	7,903	74,880,000	361,500,000	390,300,000

Notes:

1. Spring values calculated using equations presented in Figure 4-4 (FEMA)

8.3.6 Pier 3 Secant Pile Wall

We used the analysis software PYWALL to model the soil-structural-interaction and lateral performance of Pier 3. The secant pile wall was modeled assuming linear elastic section properties.

The p-y model was iterated in conjunction with the structural reaction model developed by COWI. The models were refined until deformation and forces calculated matched well. Model inputs and calculations are presented in Appendix D.

8.4 Wall 03.65L

8.4.1 Wall 03.65L Global Stability

We performed global stability analyses for the following critical cross section:

- Wall 03.65L Sta. 1+49 (Cross-section D-D' on Figure 3) where the wall is at its maximum height.

We estimated the global stability factor of safety for static conditions using Slope/W and the Spencer and Morgenstern-Price Method. We used static strength soil parameters. We modeled the Structural Earth Wall as a "High Strength" material having a

unit weight of 130 pcf consistent with Gravel Borrow backfill. Design backfill properties are within the suggested range presented in the Project GDM Table 5-2.

We used a horizontal seismic acceleration coefficient (k_h) to estimate seismic lateral earth pressures and to evaluate pseudo-static global stability. For our analyses, k_h is reduced to 50 percent of A_s ($k_h = 0.5 * A_s$) for assumed flexible wall displacements of 1- to 2-inches and reduced for the wall height-dependent seismic coefficient (wave scatter coefficient), **α** ($k_h = \alpha * A_s$) for wave scattering effects.

A summary of global stability results is presented in Table 21. The analysis methods, input parameters, additional discussion, and results of the Wall 03.65L global stability are included in Appendix F.

To meet global stability analysis minimum static and pseudo static factor of safety requirements, Wall 03.65L is required to have a minimum embedment of 2 feet and a minimum strap length of 0.7* Height of the wall plus embedment (H) or 8 feet at a minimum.

Table 21: Wall 03.65L Global Slope Stability Results

Wall	Wall Station Analyzed	Loading Type	Minimum Required Factor of Safety	Calculated FS (Spencer/ Morgenstern & Price)	Minimum Required Strap Length/ Minimum Wall Embedment[1]
Wall 03.65L	Sta 1+49	Static	1.3	2.5 / 2.5	The greater of 0.7H or 8 feet / 2 feet Embedment
		Pseudo-Static	1.1	1.7 / 1.7	The greater of 0.7H or 8 feet / 2 feet Embedment

Notes:

H represents the wall face height plus 2 feet of embedment.

8.4.2 Wall 03.65L Compound Stability

We evaluated compound stability of the design section at Wall 03.65L using the computer design software Slope/W. We completed limit equilibrium analyses following the procedures outlined in Project GDM Section 15-5.3.4. Factors of safety were developed using both Spencer's method and the Morgenstern-Price method with entry and exit search limits for a circular failure surface.

We modeled the soil reinforcements as inextensible welded wire mats (Hilfiker type) connected to CIP concrete facing panels. The welded wire reinforcing rows consist of W7.0xW3.5 welded wire mats with 6-inch longitudinal bar spacing and 12-inch transverse bar spacing. All reinforcing mats have galvanized corrosion protection. The pre-corrosion gross steel reinforcement wire diameter of the longitudinal wires in the W7.0xW3.5 mats are 0.299 inches. We calculated the corrosion losses in the steel wires over the full 75-year design life using the prescribed steel corrosion rates presented in AASHTO LRFD Section 11.10.6.4.2a and FHWA Geotechnical Engineering Circular No. 11 Tables 3-7 and 3-8.

We applied resistance factors presented in AASHTO LRFD Section 11.5 and FHWA Geotechnical Engineering Circular No. 11 Table 4-7 to calculate the pullout resistance and tensile capacity of the steel grid reinforcements at Wall 03.63L. We modeled the reinforced fill as Gravel Backfill for structural earth walls. Using the thickness of the transverse bar and the transverse bar spacing we calculated the pullout resistance factor F* in accordance with AASHTO LRFD Section 11.10.6.3.2 and FHWA Geotechnical Engineering Circular No. 11 Section 3.4.2 equations 3-6 and 3-7. We used the pullout resistance to calculate an interface shear friction angle at each reinforcing grid, considering the grid wire size and spacing. The calculated tensile capacity and interface shear friction angles were input into Slope/W to model the reinforced zone.

Slope/W does not have a specific welded-wire grid reinforcement input option. Therefore, the tensile strength of the grids were modeled as continuous reinforcement. The calculated allowable tensile grid capacity was converted to a continuous reinforcement tensile capacity by distributing the capacity over the tributary width. The longitudinal wires are spaced every 6 inches; therefore, two bars exist within each 1-foot representative width of grid.

For pseudo-static analyses, we used an apparent cohesion in the native soils above the groundwater table based on the fines content ranges presented in Table 11-2 of the FHWA Geotechnical Engineering Circular No. 3. We used the horizontal seismic coefficients, k_h, for compound stability presented in Table F-1 for the pseudo-static analyses. We applied the apparent cohesion

values to applicable ESUs in the pseudo-static analyses for ESU layers above the groundwater. The amount of apparent cohesion was dependent on the ESU's fines content per FHWA-NHI-11-032, Table 11-2.

Groundwater levels were modeled using a piezometric surface. The piezometric surface was based on measured or observed groundwater levels at Bridge 17.7 as discussed in Appendix C.

We used the results of the global stability analyses to model and evaluate compound stability of Wall 03.65L at the design section presented in Table 22. Per Project GDM Sections 15-4.12 and 6-4.3.2, a static resistance factor of 0.75 (FS = 1.3) and seismic resistance factor of 0.9 (FS = 1.1) shall be used for compound stability. The required minimum static and pseudo-static FSs were met at Wall 03.65L.

Structural loads were not included in our analyses. Any structural foundation loads applied to the wall shall include the appropriate load factors in AASHTO LRFD Table 3.4.1-1 consistent with Strength Limit State and Extreme Event Limit State design.

The results of our compound stability analyses for Wall 03.65L are summarized in Table 22. The analysis methods, input parameters, additional discussion, and results of the Wall 03.65L compound stability are included in Appendix F.

Table 22. Wall 03.65L Compound Stability Results

Design Section	Loading Type	Minimum Required Factor of Safety	Calculated Factor of Safety (Spencer/ Morgenstern-Price)	Number of Reinforcement Rows
Station 1+49	Static	1.3	2.2 / 2.2	10
	Pseudo-Static	1.1	1.5 / 1.5	

8.4.3 Wall 03.65L Shallow Foundation Bearing Resistance and Settlement

Per Project GDM Section 15-4.5, the minimum embedment of Wall 03.65L was verified by calculating the bearing capacity. We evaluated the shallow foundation bearing resistance based on AASHTO LRFD Section 10.6.3.1.2 and using the Shallow Foundation Resistance and Elastic Settlement spread sheet developed by GeoEngineers.

A summary of the bearing capacity results is presented in Table 23. The analysis methods, input parameters, additional discussion, and results of the Wall 03.65L bearing capacity are included in Appendix F.

Table 23. Wall 03.65L Bearing Resistance Summary

Scenario	Wall Load Pressure	Wall Width	Footing Length	Unfactored Bearing Resistance	Factored Extreme Event Resistance[1]	Factored Strength Bearing Resistance[2]	Factored Service Limit State[3]	
							1" Deflection	2" Deflection
	(ksf)	(feet)	(feet)	(ksf)[5]	(ksf)	(ksf)	(ksf)	(ksf)
Wall 03.65L **Sta. 1+49 H=21.5ft** (ESU 1A)	2.8	15	48	79.2	71.3	51.5	6.6	13.2

Notes:

1. Resistance factor of 0.9 included in the factored bearing resistance values presented for Extreme Limit State load cases (AASHTO 11.5.8) for SE Walls.
2. Strength Limit State factor (0.65) SE Walls from AASHTO 11.5.7.1.
3. Resistance factor of 1.0 included in the factored bearing resistance values presented for Service Limit State load cases.
4. Maximum Height of wall
5. ksf = kips per square foot

8.4.4 Wall 03.65L Lateral Earth Pressure and Sliding

Lateral earth pressures were calculated using a spreadsheet developed by GeoEngineers based on Rankine and Coulomb earth pressure theory per AASHTO Section 3.11.5. Seismic active lateral earth pressure coefficients were developed using the Mononobe-Okabe Method per AASHTO Section A11.3.1. Lateral earth pressure calculations are presented in Appendix F. Active static lateral earth pressure coefficients, k_a, and active static plus seismic earth pressure coefficients, k_{ae}, and the corresponding lateral earth pressures on Wall 03.65L are presented in Appendix F. We recommend lateral earth pressures be applied using a triangular distribution.

Coefficients of friction against sliding were calculated for Wall 03.65L using AASHTO Equation 10.6.3.4-2 for concrete structures (such as fascia wall footings) and for soil-to-soil resistance to sliding at the base of the SE Wall. Friction coefficients are provided for native soils and each of the approved import materials. A coefficient of 1.0 was used for concrete cast against soil and 0.8 for precast concrete. For SE Wall sliding coefficients with discontinuous reinforcements (e.g., strips) the angle of sliding friction was taken as the lesser of the friction angle of the reinforced fill and the friction angle of the foundation soil (AASHTO 11.10.5.3). For sliding coefficients for the SE wall with continuous reinforcements (e.g., grids and sheets) the angle of sliding friction was taken as the minimum of the reinforced fill friction angle, foundation soil friction angle, and the soil-reinforcement interface angle (taken as $^2/_3$ of the lesser of the foundation or reinforced soil friction angle in absence of specific information) per AASHTO Section 11.10.5.3. Calculations for these coefficients are presented in Appendix F.

8.5 Wall 03.66L

8.5.1 Wall 03.66L Shallow Foundation Bearing Resistance and Settlement

We evaluated the bearing capacity for the existing Bridge 17.7 Pier 1 foundation because the new Wall 03.66L will bear on the existing bridge foundation which will no longer carry the bridge load.

We evaluated the shallow foundation bearing resistance based on AASHTO LRFD Section 10.6.3.1.2 and using the Shallow Foundation Resistance and Elastic Settlement spread sheet developed by GeoEngineers.

We evaluated the estimated Service Limit State loads that will cause ¼-inch and ½-inch of additional settlement for the existing footing dimensions. This is exclusive of any existing loads that the footings are currently experiencing and any settlement that the footings have already experienced. This is a calculation of the settlement that is expected to occur from the new additional loads on the existing footings only. All settlement is anticipated to occur immediately as the load is applied.

Bearing resistance results and calculations are presented in Appendix G. A summary of the bearing capacity results is presented in Table 24.

Table 24. Wall 03.66L Bearing Resistance Summary at Existing Bridge 17.7 Pier 1

Scenario	Maximum Bearing Resistance Limited by Bearing Resistance Calculation				
	Unfactored Bearing Resistance	Factored Extreme Event Resistance[1]	Factored Strength Bearing Resistance[2]	Factored Service Limit State[3]	
				1/4-inches Deflection	1/2-inches Deflection
	(ksf)[4]	(ksf)[4]	(ksf)[4]	(ksf)[4]	(ksf)[4]
Pier 1 Existing Footing **B=12ft** **L=41.7ft** (ESU 7A)	578.3	520.5	260.3	1.3	2.7

Notes:

1. Resistance factor of 0.9 included in the factored bearing resistance values presented for Extreme Limit State load cases (AASHTO 11.5.8) for SE Walls.
2. Strength Limit State factor (0.65) SE Walls from AASHTO 11.5.7.1.
3. Resistance factor of 1.0 included in the factored bearing resistance values presented for Service Limit State load cases.
4. ksf = kips per square foot

8.5.2 Wall 03.66L Seismic Spread Footing Springs

We calculated the seismic structural footing springs for each of the existing Bridge 17.7 Pier 1 footing. Per FEMA 356 (ASCE 2000) as referenced in Project GDM Section 6-5.1.1 the initial shear modulus (G_o) was correlated the corrected SPT blowcount, $(N_1)_{60}$.

Spring constants were developed for the SEE hazard levels. A summary of the calculated spring constants is presented in Table 25 below. The analysis methods, input parameters, additional discussion, and results of the Bridge 17.7 Pier 1 seismic spring constants are included in Appendix G.

Table 25: Summary of the 6-Degree-of-Freedom Structural Seismic Spring Constants for Pier 1

Results Summary[1]						
Pier	$K_{x,emb}$	$K_{y,emb}$	$K_{z,emb}$	$K_{xx,emb}$	$K_{yy,emb}$	$K_{zz,emb}$
	kips/in	kips/in	kips/in	kip-in	kip-in	kip-in
Pier 1 – Existing (ESU 7A) (SEE)	13,800	15,350	13,510	138,100,000	647,500,000	730,300,000

9. Construction Considerations

9.1 Backfill

We recommend that, if needed, roadway embankment fill be placed and compacted in accordance with Compaction Method C as described in WSDOT Standard Specifications Section 2-03.3(14)C. Any SE Walls should be backfilled with the WSDOT Standard Specification material Gravel Backfill for SE Walls.

Compaction of fills with higher fines contents, including imported fills, and portions of the excavated native soil to be reused as fill, are more susceptible to changes in water content and when over wet can be difficult or impossible to compact as specified. Necessary precautions should be taken to control moisture content and protect moisture-sensitive fill materials particularly during wet weather months or periods of extended wet weather.

When structural fill is placed against an existing slope that is 2H:1V or steeper, the existing slope shall be terraced in accordance with 2018 WSDOT Standard Specification 2-03.3(14) for Hillside Terraces. Structural fill placed behind walls shall meet the requirements of WSDOT Standard Specification 9-03.12(2).

9.2 Excavation

We anticipate that the site soils can be excavated with conventional excavation equipment, such as trackhoes or dozers. Although not currently anticipated, excavations extending into weathered sandstone (ESU 7A) may be difficult. Large cobbles and boulders could be encountered at this site, even though the explorations at the site did not encounter any.

We do not anticipate any required excavation below the groundwater table. Surface water will need to be managed if seepage occurs, or if seasonal high groundwater conditions or stormwater events are encountered during construction. Excessive groundwater flow into excavations could cause lateral movement of the granular soils into the excavations, possibly destabilizing the excavations.

All temporary cut slopes and shoring must comply with the provisions of Title 296 Washington Administrative Code (WAC), Part N, “Excavation, Trenching and Shoring.” The contractor performing the work has the primary responsibility for the protection of workers and adjacent improvements.

9.3 Utilities

If new utilities are to be installed in the vicinity of or below the elevation of the bottom of any bridge or wall footings, the utilities should be installed and backfilled prior to the construction of the bridge of wall foundation elements. There are existing utilities that run under and/or through the existing western approach embankment. Care should be taken not to disturb the existing utilities that are to remain in service, particularly during installation of soil nail elements for Wall 03.66L.

9.4 Temporary Shoring

Temporary shoring is anticipated for this project in the form of; 1) temporary lateral restraint needed at Bridge 17.7 Pier 3 as discussed in this report, and 2) temporary shoring parallel to SB I-405 behind a temporary barrier to facilitate the removal of the existing Bridge 17.7 Pier 1 stem wall down to an elevation of 66.5 feet. GeoEngineers or a shoring designer should be retained to provide the design of the temporary shoring.

9.5 Temporary Slopes

Temporary slopes and excavation sidewalls on site should be comply with OSHA Standards. Flatter slopes may be necessary if seepage is present on the face of the cut slopes or if localized sloughing occurs. All temporary cut slopes and shoring must comply with the provisions of Title 296 WAC, Part N, "Excavation, Trenching and Shoring." The contractor performing the work has the primary responsibility for the protection of workers and adjacent improvements.

Some sloughing and raveling of the cut slopes should be expected. Temporary covering, such as heavy plastic sheeting, should be used to protect these slopes during periods of rainfall. Surface water runoff from above cut slopes should be prevented from flowing over the slope face by using curbs, berms, drainage ditches, swales or other appropriate methods.

If temporary cut slopes experience excessive sloughing or raveling during construction, it may become necessary to modify the cut slopes to maintain safe working conditions and protect adjacent facilities or structures. Slopes experiencing excessive sloughing or raveling should be flattened or regraded to add intermediate slope benches. We recommend all construction equipment be staged and operated at least 5 feet from the crest of the temporary slope to prevent localized soughing.

9.6 Permanent Slopes

Permanent slope cuts should be inclined no steeper than 2H:1V. Permanent slopes should be planted or hydroseeded as soon as practicable after grading. Temporary erosion control measures, such as erosion control blankets, should be incorporated until permanent vegetation and erosion control has been established.

9.7 Welded Wire Reinforcement

Welded wire reinforcement materials shall be furnished, placed, and handled in accordance with WSDOT Standard Specifications and the manufacturer's requirements.

9.8 Clearing and Grubbing

Work areas should be cleared of asphalt, trees, shrubs and associated stumps and root wads, sod, organic-rich soil, and other deleterious material. Based on the explorations, we anticipate that stripping depths, if needed, would typically be less than about 1 foot. Existing voids and areas of loose soil or debris should be cleaned and backfilled with compacted structural fill.

9.9 Bearing Surface Preparation

The bearing surface for proposed Bridge 17.7 Pier 1 should be evaluated by GeoEngineers when excavated and before construction to identify any soft or unsuitable soils. Based on adjacent borings we expect to encounter ESU 1B at or near the proposed foundation bearing elevations.

9.10 Sedimentation and Erosion Control

In our opinion, the erosion potential of the undisturbed on-site soils is low to moderate as most of the adjacent areas are vegetated or paved. However, where earthwork is planned the ground surface is likely to be heavily disturbed by construction equipment. Given the proximity of the work area to the Cedar River, the potential for runoff should be evaluated and temporary erosion and sediment control plans should be in place before construction begins.

The amount of erosion and related potential impacts are in part a function of the time of year construction occurs. Wet weather construction will increase the erosion potential. We expect that exposed soils will have moderate erosion potential during wet weather. It will, therefore, be necessary to put in place effective erosion and sedimentation controls during and after construction.

Effective erosion and sedimentation control may include interceptor swales and silt fences to prevent water from flowing off site. If the runoff is silty, collected water should be passed through a temporary de-silting facility prior to discharging the

water. Erosion risk can also be reduced by completing initial clearing and grading activities during the drier months and limiting the disturbance of the existing ground surface and vegetation where possible. Material stockpiles should be covered during wet weather to prevent erosion and soil loss. All areas disturbed during construction should be seeded and planted as soon as practical to reduce the potential for erosion. Erosion and sedimentation control measures should be installed and maintained in accordance with applicable regulatory standards.

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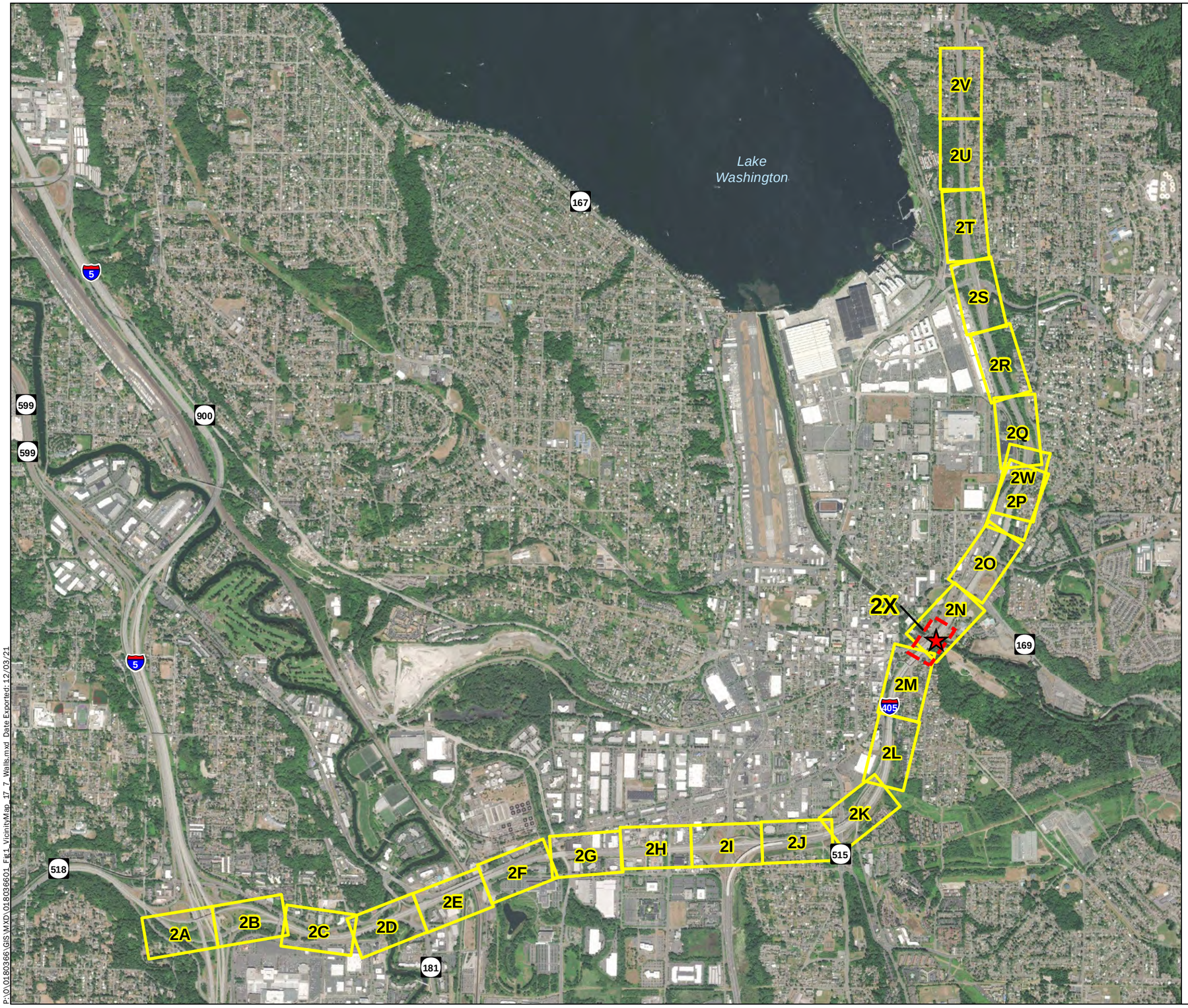
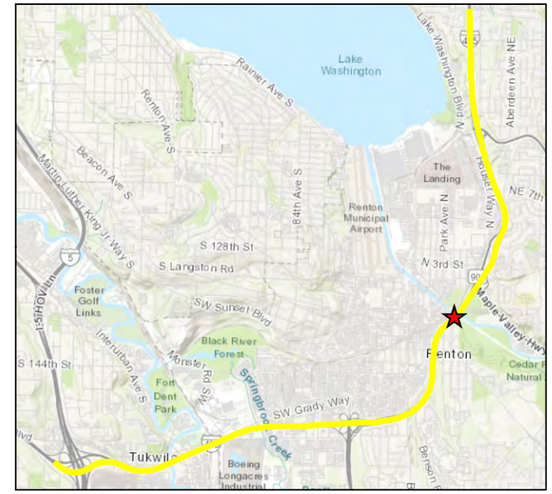
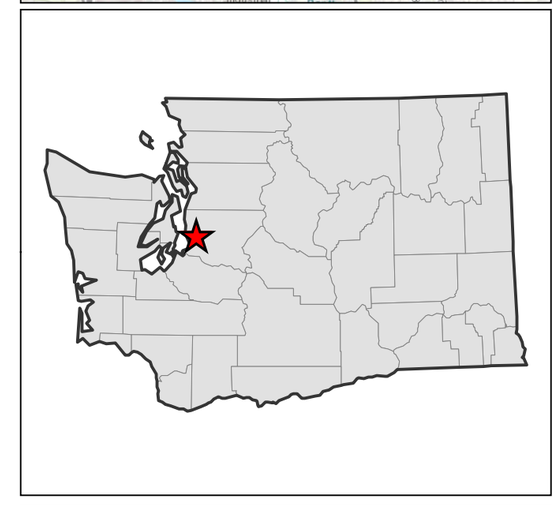


Legend

- Bridge 17.7 and Associated Walls Approximate Location
- Site Plan Index
- Site Plan Included in this Report
- Segment 1A





Vicinity Map

I-405 Renton to Bellevue
Segment 1A - Bridge 17.7 and Walls
King County, Washington

GeoEngineers

Figure 1

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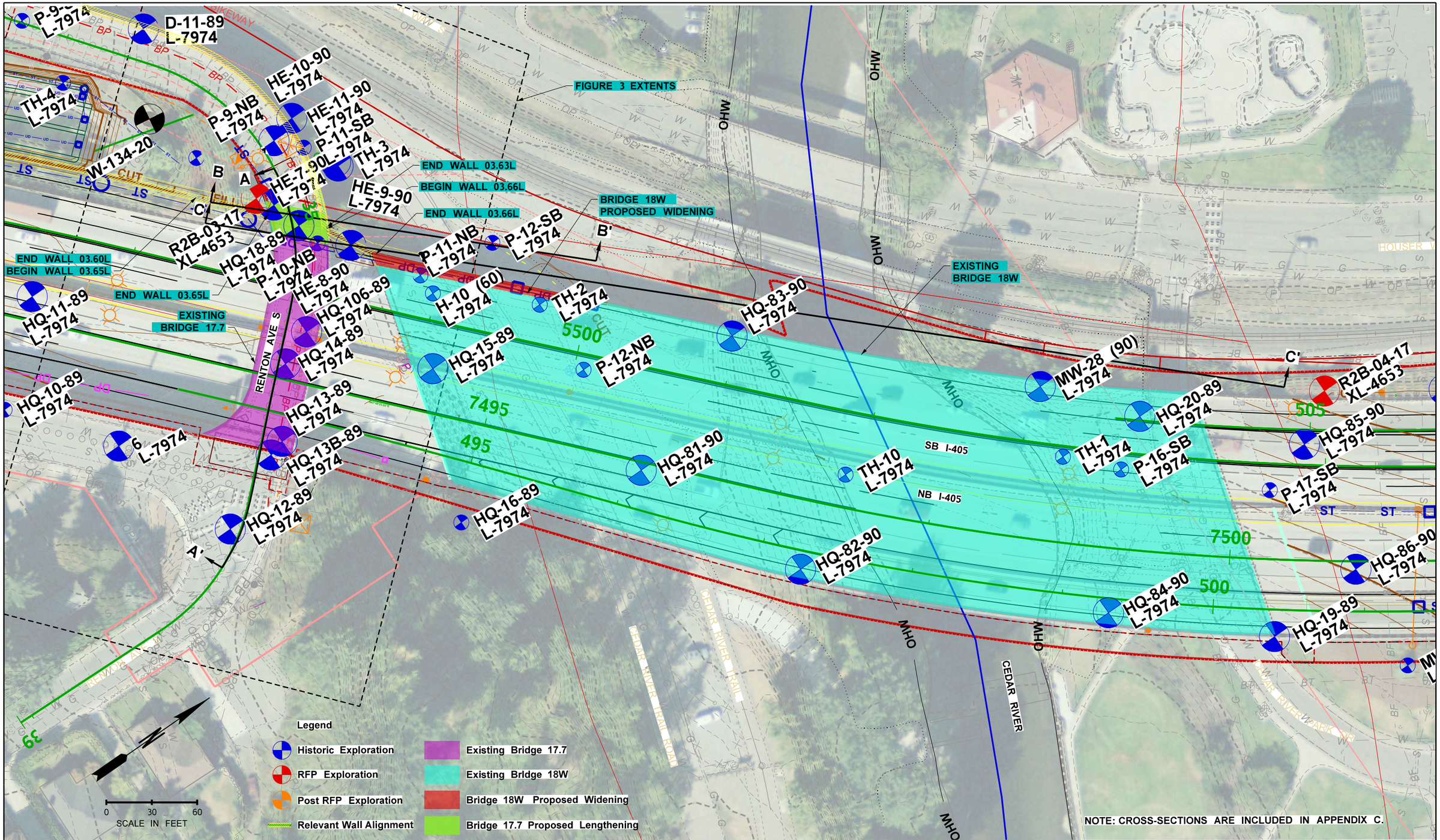

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I-405; RENTON TO BELLEVUE WIDENING AND EXPRESS TOLL LANES PROJECT

BRIDGE 17.7-18W AND ASSOCIATED WALLS
FIGURE 2X

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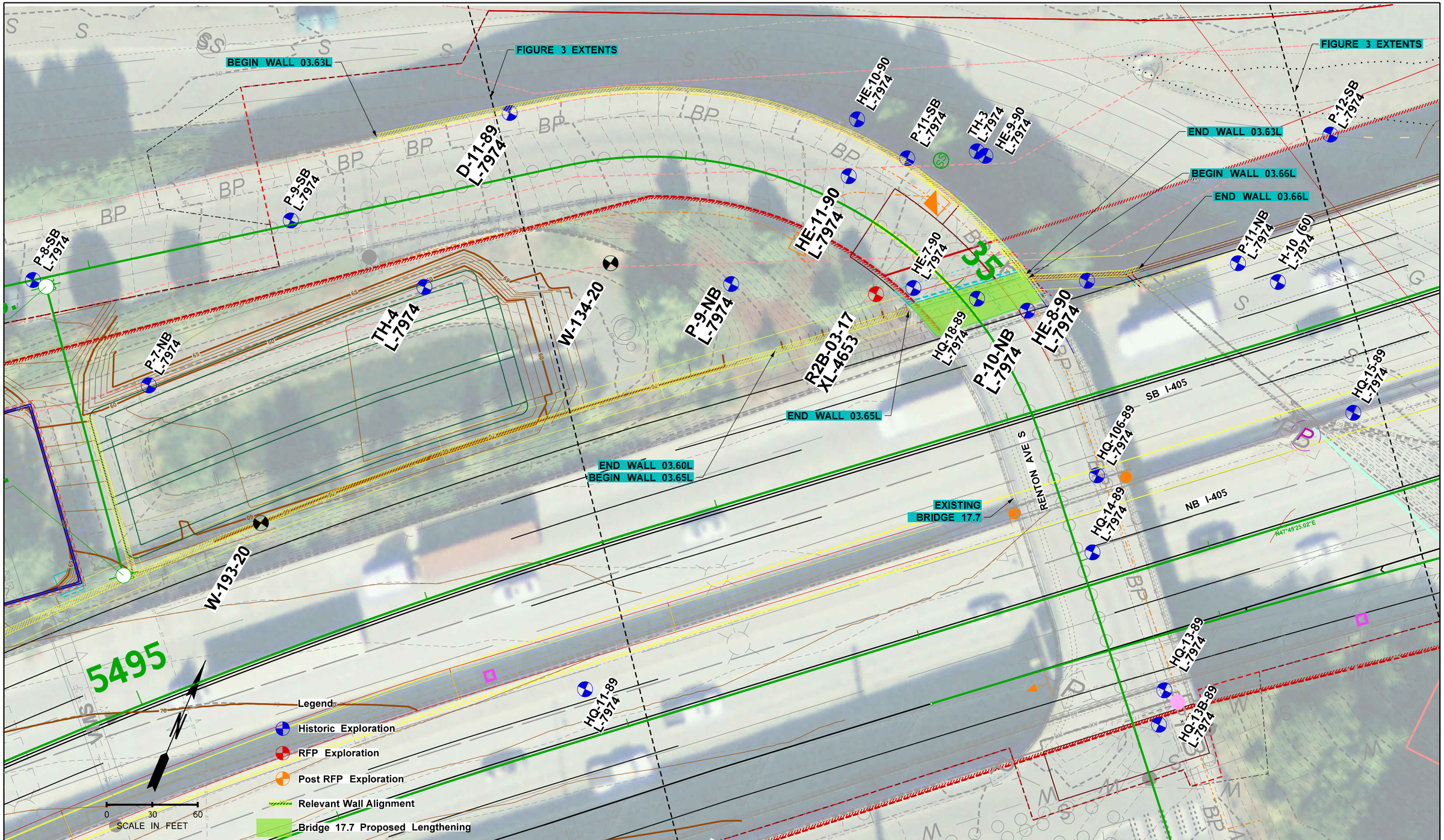

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BRIDGE 17.7 AND ASSOCIATED WALLS FIGURE 2X - 2

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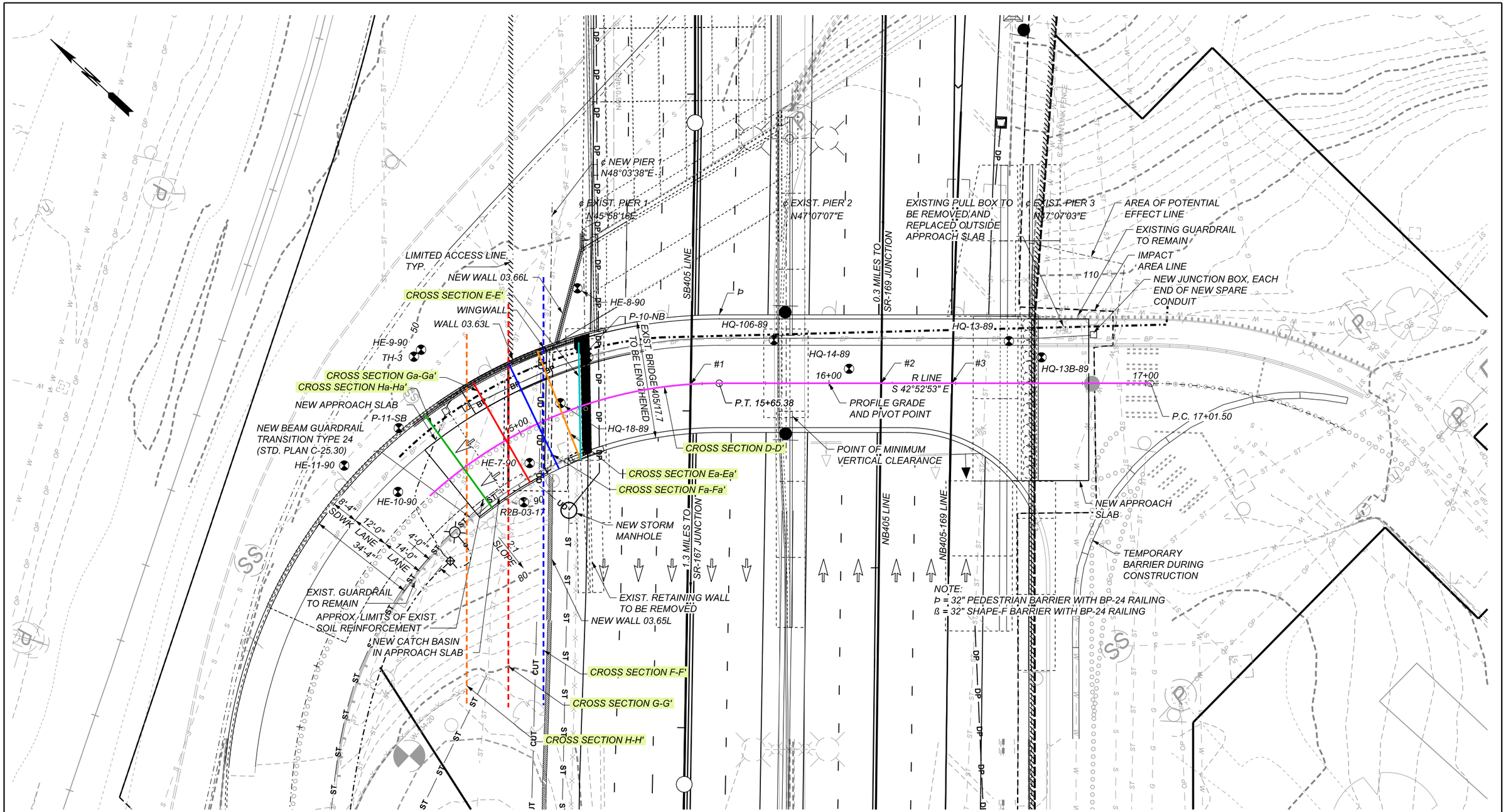

PLAN

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I-405; RENTON TO BELLEVUE WIDENING AND EXPRESS TOLL LANES PROJECT

BRIDGE PLAN WITH ANALYSIS CROSS SECTIONS BRIDGE 17.7 AND WALLS 03.63L, 03.35L

PLAN REF NO

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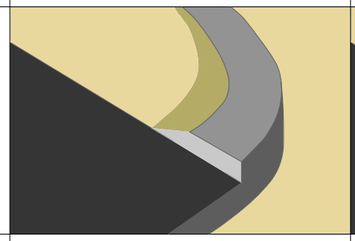
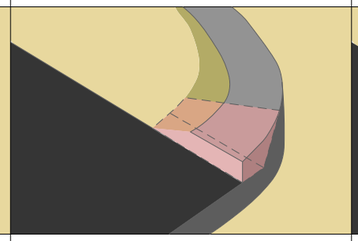
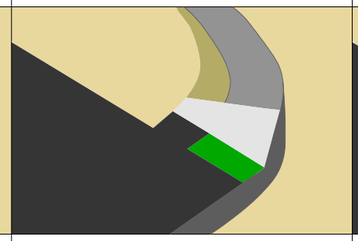
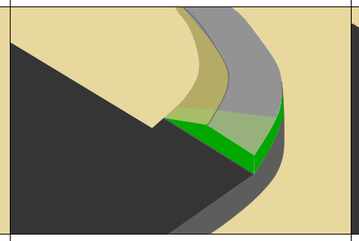
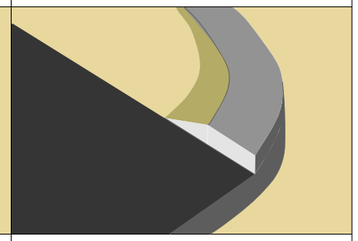
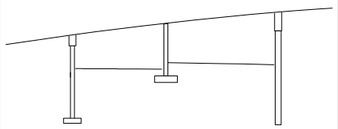
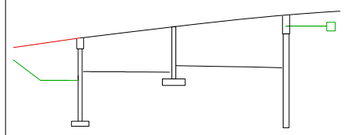
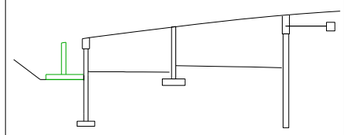
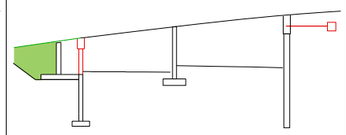
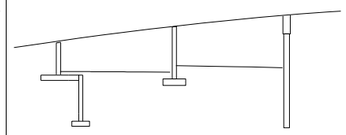
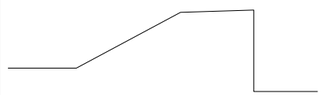
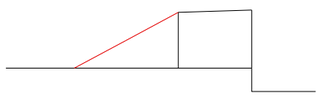
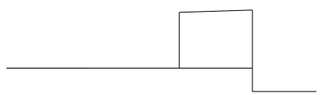
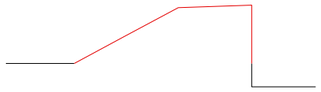
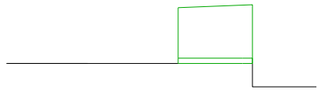
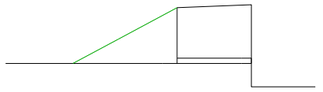
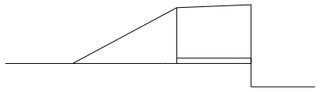
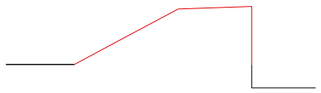
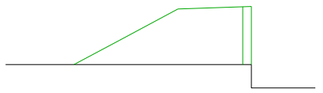
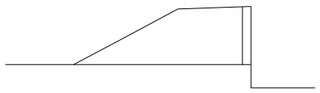
SEQUENCE STEP	1	2	3	4	5
STEP DESCRIPTION	EXISTING CONDITIONS OF BRIDGE 17.7 AND ASSOCIATED WALLS	DECONSTRUCTION OF WALL 03.63L, WINGWALL AND SOIL SLOPE PIER 3 DEADMAN INSTALLED	FOOTING FOR NEW PIER 1 AND STEM WALL CONSTRUCTED	GIRDER EXTENSIONS CONSTRUCTED, DECONSTRUCTION OF EXISTING PIER 1 AND EXCAVATION BACKFILLED	FINAL CONDITIONS
ISOMETRIC RENDERING					
D-D'					
E-E'					
F-F'					
G-G'					

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FEATURE TO BE ADDED

FEATURE TO BE REMOVED

NOTES:
1. ALL FEATURES SHOWN ARE APPROXIMATE AND SHOULD NOT BE USED FOR CONSTRUCTION
2. REFER TO FIGURE 3 FOR CROSS-SECTION LOCATIONS

NOT TO SCALE

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I-405; RENTON TO BELLEVUE WIDENING AND EXPRESS TOLL LANES PROJECT

BRIDGE 17.7 AND WALL 03.63L CONSTRUCTION SEQUENCE

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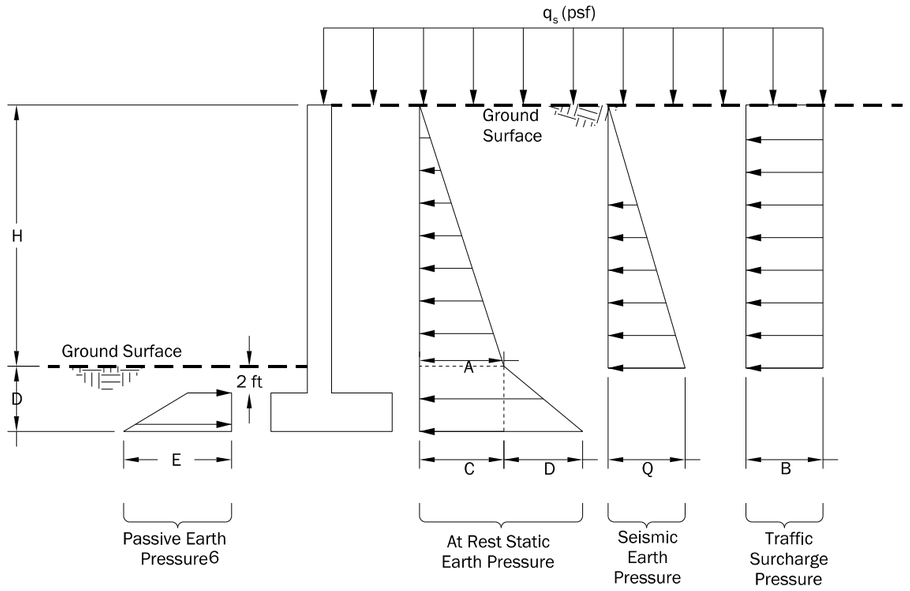

Legend

H = Height of Wall, Feet

D = Footing Embedment Depth, Feet

Notes:

1. Seismic earth pressure where wall is restrained and not permitted to move laterally and 1 to 2 inches of deformation is not acceptable during design seismic event.
2. Earth pressures assume drained conditions.
3. At-rest earth pressure is a nominal (unfactored) value.
4. Passive earth pressure is a nominal (unfactored) value.
5. Passive earth pressures assume a flat foreslope.
6. The entire passive pressure triangle extending up to the ground surface is to be applied for seismic case. The upper 2-feet of the passive pressure triangle is to be excluded for the static case. (AASHTO 11.8.6.3)
7. EFD - Equivalent fluid weight (earth pressure coefficient * unit weight)
8. Kpe - Seismic passive earth pressure coefficient
9. Koe - Seismic at rest earth pressure coefficient
10. Ko - At-rest earth pressure coefficient (for braced or rigid walls)
11. Kp - Passive earth pressure coefficient
12. pcf - pounds per cubic foot
13. ESU - Engineering Soil Unit
14. Value varies depending on construction method and soil type. Confirm value using AASHTO Table 10.5.5.2.2-1.
15. Load and resistance factors associated with lateral earth pressures on permanent structures. (AASHTO LRFD Section 11.5.7 and Table 3.4.1-2)

Interval	Layer Description	Elevation, Top of Layer ft	Elevation, Bottom of Layer ft	Friction Angle deg	Soil Total Unit Weight pcf	Soil Effective Unit Weight pcf	Active Lateral Earth Pressure Coefficient	At Rest Lateral Earth Pressure Coefficient	Passive Lateral Earth Pressure Coefficient	Seismic Lateral Earth Pressure Coefficient
Stratum 1	ESU 1A, above water table	94	72	40	120	120	0.20	0.36	4.60	0.45
Stratum 2	ESU 1B, above water table	72	66.5	38	125	125	0.22	0.38	4.20	0.47

Sliding Friction Coefficients			
Soil Type	φ'	Concrete Structure Sliding Friction Coefficient	
		Cast-In-Place Concrete	Precast Concrete
ESU 1B	38	0.78	0.63
Common Borrow	32	0.62	0.50
Select Borrow	36	0.73	0.58
Gravel Borrow	38	0.78	0.63

	Static (At-Rest)(psf)				Seismic (psf)	Passive (psf)
	A	B	C	D	Q	E
Stratum	1	1	2	2	1	2
Description	Earth Pressure * H_1	Traffic Surcharge	Earth Pressure * H_1	Earth Pressure * D_1	Seismic Earth Pressure * H_1	Earth Pressure * D_1
Recommended Earth Pressures	943	89	6005	264	1188	2890
To calculate	42.87 * H1	89	48.04 * H1	48.04 * D1	53.98 * H1	525.47 * D1

Limit State	Resistance Factor[15]			Load Factor[15]
	Passive Earth Pressure Component of Sliding Resistance	At-rest Pressure	Shear Resistance to Sliding	At-rest Pressure
Strength	0.5	1.0	0.8 - 0.9[14]	1.35
Service	1.0	1.0	1.0	1.0
Extreme	1.0	1.0	1.0	1.0

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I-405; RENTON TO BELLEVUE WIDENING AND EXPRESS TOLL LANES PROJECT

EARTH PRESSURES AND SLIDING FOR BRIDGE 17.7 PIER 1

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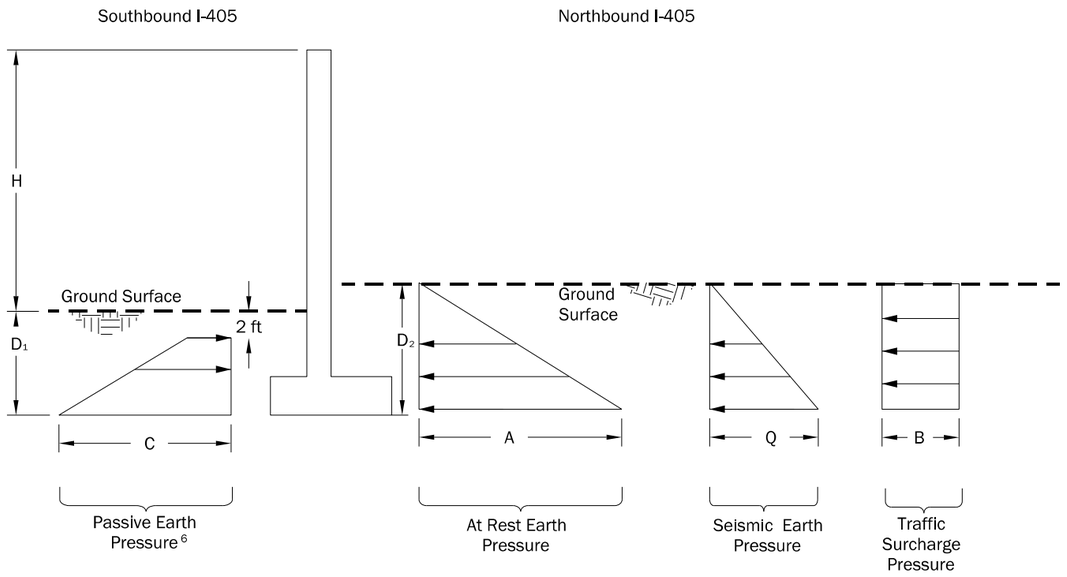

Legend

H = Height of Wall, Feet

D = Footing Embedment Depth, Feet

Notes:

1. Seismic earth pressure where wall is restrained and not permitted to move laterally and 1 to 2 inches of deformation is not acceptable during design seismic event.
2. Earth pressures assume drained conditions.
3. At-rest earth pressure is a nominal (unfactored) value.
4. Passive earth pressure is a nominal (unfactored) value.
5. Passive earth pressures assume a flat foreslope.
6. The entire passive pressure triangle extending up to the ground surface is to be applied for seismic case. The upper 2-feet of the passive pressure triangle is to be excluded for the static case. (AASHTO 11.8.6.3)
7. EFD - Equivalent fluid weight (earth pressure coefficient * unit weight)
8. Kpe - Seismic passive earth pressure coefficient
9. Koe - Seismic at rest earth pressure coefficient
10. Ko - At-rest earth pressure coefficient (for braced or rigid walls)
11. Kp - Passive earth pressure coefficient
12. pcf - pounds per cubic foot
13. ESU - Engineering Soil Unit
14. Value varies depending on construction method and soil type. Confirm value using AASHTO Table 10.5.5.2.2-1.
15. Load and resistance factors associated with lateral earth pressures on permanent structures. (AASHTO LRFD Section 11.5.7 and Table 3.4.1-2)

Interval	Layer Description	Elevation, Top of NB I-405 ft	Elevation, Top of SB I-405 ft	Friction Angle deg	Soil Total Unit Weight pcf	Soil Effective Unit Weight pcf	Active Lateral Earth Pressure Coefficient	At Rest Lateral Earth Pressure Coefficient	Passive Lateral Earth Pressure Coefficient	Seismic Lateral Earth Pressure Coefficient
Stratum 1	ESU 1B, above water table	75.5	71	38	125	125	0.22	0.38	4.20	0.54

	Static (At-Rest)(psf)		Seismic (psf)	Passive (psf)
	A	B	Q	C
Stratum	1	1	1	1
Description	Earth Pressure * D_2	Traffic Surcharge	Seismic Earth Pressure * D_2	Earth Pressure * D_1
Recommended Earth Pressures	577	96	813	3941
To calculate	48.04 * D2	96	67.75 * D2	525.47 * D1

Soil Type	φ'	Sliding Friction Coefficient: Cast-In-Place Concrete	Sliding Friction Coefficient: Precast Concrete
Pier 2 - Existing Foundation			
ESU 2A	39	0.81	0.65

Limit State	Resistance Factor[15]: Passive Earth Pressure Component of Sliding Resistance	Resistance Factor[15]: At-rest Pressure	Resistance Factor[15]: Shear Resistance to Sliding	Load Factor[15]: At-rest Pressure
Strength	0.5	1.0	0.8 - 0.9[14]	1.35
Service	1.0	1.0	1.0	1.0
Extreme	1.0	1.0	1.0	1.0

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CHECKED BY	
PROJ. ENGR.	
REGIONAL ADM.	

REVISION	DATE	BY

REGION NO. 10 | STATE WASH | FED.AID PROJ.NO.

JOB NUMBER

CONTRACT NO. | LOCATION NO.

P.E. STAMP BOX — DATE

P.E. STAMP BOX — DATE

Washington State Department of Transportation

FLATIRON LANE

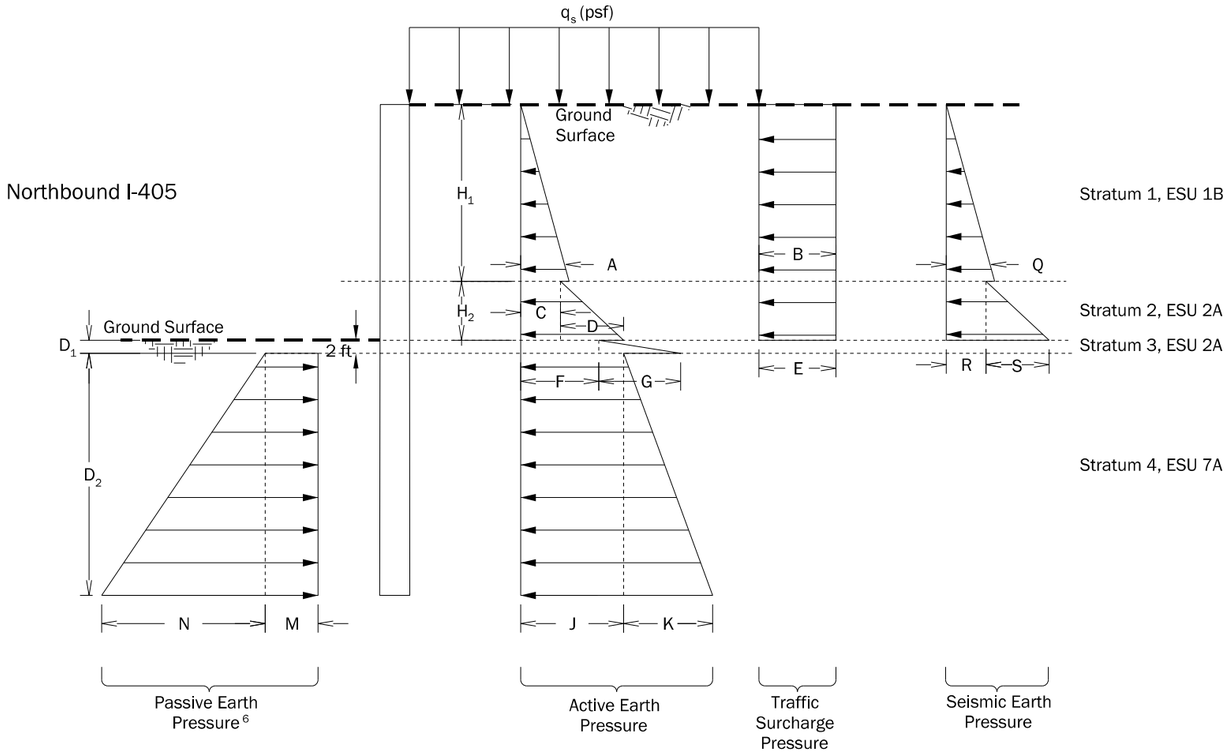
wood.

I-405; RENTON TO BELLEVUE WIDENING AND EXPRESS TOLL LANES PROJECT

EARTH PRESSURES AND SLIDING FOR BRIDGE 17.7 PIER 2

PLAN REF NO

SHEET OF SHEETS



Legend

H = Height of Wall, Feet

D = Footing Embedment Depth, Feet

Notes:

1. Seismic earth pressure where wall is restrained and not permitted to move laterally and 1 to 2 inches of deformation is not acceptable during design seismic event.
2. Earth pressures assume drained conditions.
3. At-rest earth pressure is a nominal (unfactored) value.
4. Passive earth pressure is a nominal (unfactored) value.
5. Passive earth pressures assume a flat foreslope as specified in the tables.
6. The entire passive pressure triangle extending up to the ground surface is to be applied for seismic case. The upper 2-feet of the passive pressure triangle is to be excluded for the static case. (AASHTO 11.8.6.3)
7. EFD - Equivalent fluid weight (earth pressure coefficient * unit weight)
8. Kpe - Seismic passive earth pressure coefficient
9. Kae - Seismic active pressure coefficient
10. Ko - At-rest earth pressure coefficient (for braced or rigid walls)
11. Kp - Passive earth pressure coefficient
12. pcf - pounds per cubic foot
13. ESU - Engineering Soil Unit
14. Value varies depending on construction method and soil type. Confirm value using AASHTO Table 10.5.5.2.2-1.
15. Load and resistance factors associated with lateral earth pressures on permanent structures. (AASHTO LRFD Section 11.5.7 and Table 3.4.1-2)
16. To calculate LEP for each stratum, sum the areas indicated. For Example, for a point within Stratum 2: C+D+E+R+S = LEP

Interval	Layer Description	Elevation, Top of Layer ft	Elevation, Bottom of Layer ft	Friction Angle deg	Soil Total Unit Weight pcf	Soil Effective Unit Weight pcf	Active Lateral Earth Pressure Coefficient	At Rest Lateral Earth Pressure Coefficient	Passive Lateral Earth Pressure Coefficient	Seismic Lateral Earth Pressure Coefficient
Stratum 1	ESU 1B, above water table	110	83	38	125	125	0.22	0.38	4.20	0.41
Stratum 2	ESU 2A, above water table	83	74	39	120	120	0.21	0.37	4.40	0.40
Stratum 3	ESU 2A, above water table	74	72	39	120	120	0.21	0.37	4.40	0.40
Stratum 4	ESU 7A, below water table	72	35	42	135	72.6	0.18	0.33	5.04	0.38

	Seismic (Active) (psf)								
	A	B	C	D	E	F	G	J	K
Stratum	1	1	2	2	2	3	3	4	4
Description	Earth Pressure * H_1	Traffic Surcharge	Earth Pressure * H_1	Earth Pressure * H_2	Traffic Surcharge	(Earth Pressure * H_1) + (Earth Pressure * H_2)	Earth Pressure * D_1	(Earth Pressure * H_2) + (Earth Pressure * H_2) + (Earth Pressure * D_1)	Earth Pressure * D_2
Recommended Earth Pressures	732	27	703	225	26	927	89	864	494
To Calculate	27.1 * H1	27	26.02 * H1	24.98 * H2	26	26.02 * H1 + 24.98 * H2	24.98 * D1	23 * H1 + 22.08 * H2 + 22.08 * D1	13.36 * D2

	Passive (psf)		Seismic (psf)		
	M	N	Q	R	S
Stratum	4	4	1	2	2
Description	Earth Pressure * D_1	Earth Pressure * D_2	Seismic Earth Pressure * H_1	Seismic Earth Pressure * H_1	Seismic Earth Pressure * H_2
Recommended Earth Pressures	1211	13551	1384	1350	432
To Calculate	605.36 * D1	366.24 * D2	51.25 * H1	50 * H1	48 * H2

	Resistance Factor[15]			Load Factor[15]
Limit State	Passive Earth Pressure Component of Sliding Resistance	At-rest Pressure	Shear Resistance to Sliding	At-rest Pressure
Strength	0.5	1.0	0.8 - 0.9[14]	1.35
Service	1.0	1.0	1.0	1.0
Extreme	1.0	1.0	1.0	1.0

FILE NAME	\\geoengineers.com\WAN\Projects\0\0180366\CAD\01\Bridges\17.7 - BR2 - Renton Avenue Bridge\IRCR Report\018036601_F07 Pier 3 Seismic LEP.dgn
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DATE	12/6/2021
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CHECKED BY	
PROJ. ENGR.	
REGIONAL ADM.	

REVISION	DATE	BY

REGION NO. 10 | STATE WASH | FED.AID PROJ.NO.

JOB NUMBER

CONTRACT NO. | LOCATION NO.

P.E. STAMP BOX DATE

P.E. STAMP BOX DATE

Washington State Department of Transportation

FLATIRON LANE

wood.

I-405; RENTON TO BELLEVUE WIDENING AND EXPRESS TOLL LANES PROJECT

SEISMIC EARTH PRESSURES AND SLIDING FOR BRIDGE 17.7 PIER 3

PLAN REF NO

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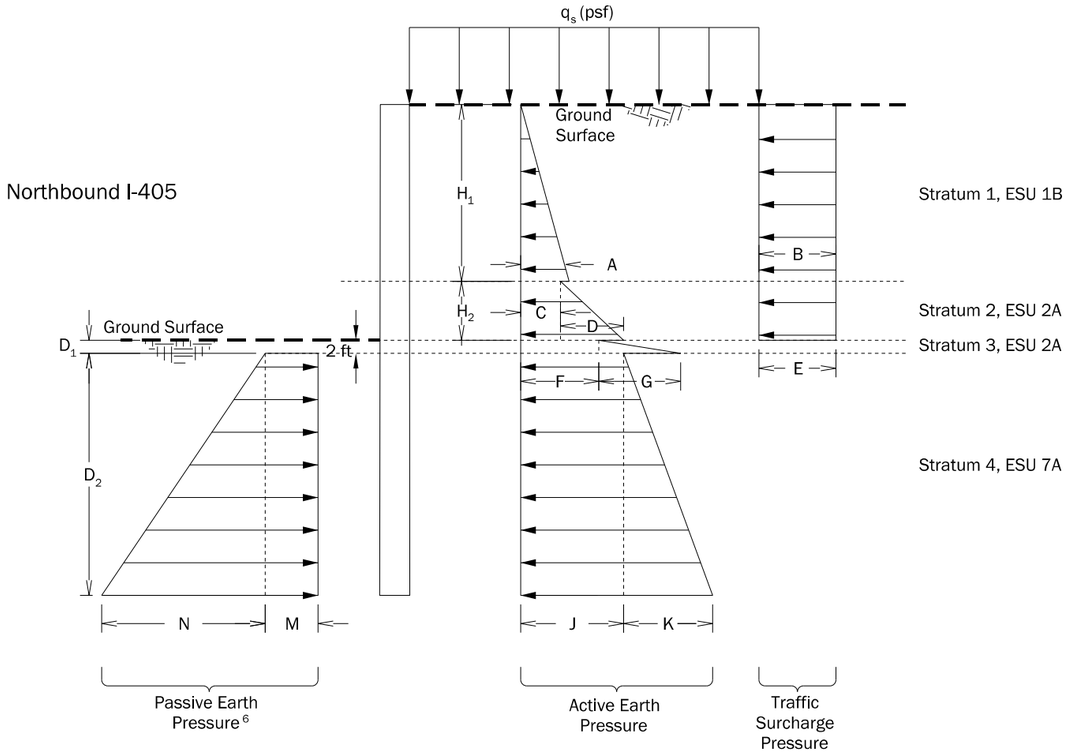

Legend

H = Height of Wall, Feet

D = Footing Embedment Depth, Feet

Notes:

1. Seismic earth pressure where wall is restrained and not permitted to move laterally and 1 to 2 inches of deformation is not acceptable during design seismic event.
2. Earth pressures assume drained conditions.
3. At-rest earth pressure is a nominal (unfactored) value.
4. Passive earth pressure is a nominal (unfactored) value.
5. Passive earth pressures assume a flat foreslope as specified in the tables.
6. The entire passive pressure triangle extending up to the ground surface is to be applied for seismic case. The upper 2-feet of the passive pressure triangle is to be excluded for the static case. (AASHTO 11.8.6.3)
7. EFD - Equivalent fluid weight (earth pressure coefficient * unit weight)
8. Kpe - Seismic passive earth pressure coefficient
9. Kae - Seismic active pressure coefficient
10. Ko - At-rest earth pressure coefficient (for braced or rigid walls)
11. Kp - Passive earth pressure coefficient
12. pcf - pounds per cubic foot
13. ESU - Engineering Soil Unit
14. Value varies depending on construction method and soil type. Confirm value using AASHTO Table 10.5.5.2.2-1.
15. Load and resistance factors associated with lateral earth pressures on permanent structures. (AASHTO LRFD Section 11.5.7 and Table 3.4.1-2)
16. To calculate LEP for each stratum, sum the areas indicated. For Example, for a point within Stratum 2: C+D+E+R+S = LEP

Layer Description	Elevation, Top of Layer ft	Elevation, Bottom of Layer ft	Friction Angle deg	Soil Total Unit Weight pcf	Soil Effective Unit Weight pcf	Active Lateral Earth Pressure Coefficient	At Rest Lateral Earth Pressure Coefficient	Passive Lateral Earth Pressure Coefficient	Seismic Lateral Earth Pressure Coefficient
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ESU 2A, above water table	83	74	39	120	120	0.21	0.37	4.40	0.40
ESU 2A, above water table	74	72	39	120	120	0.21	0.37	4.40	0.40
ESU 7A, below water table	72	35	42	135	72.6	0.18	0.33	5.04	0.38

	Static (At-Rest) (psf)								
	A	B	C	D	E	F	G	J	K
Stratum	1	1	2	2	2	3	3	4	4
Description	Earth Pressure * H_1	Traffic Surcharge	Earth Pressure * H_1	Earth Pressure * H_2	Traffic Surcharge	(Earth Pressure * H_1)+ (Earth Pressure * H_1)	Earth Pressure * D_1	(Earth Pressure * H_2)+ (Earth Pressure * H_2)+ (Earth Pressure * D_1)	Earth Pressure * D_2
Recommended Earth Pressures	1297	96	1251	400	93	1651	89	1553	889
To Calculate	48.04 * H1	96	46.33 * H1	44.48 * H2	93	46.33 * H1 + 44.48 * H2	44.48 * D1	41.36 * H1 + 39.7 * H2 + 39.7 * D1	24.02 * D2

	Static, Passive (psf)	
	M	N
Stratum	4	4
Description	Earth Pressure * D_1	Earth Pressure * D_2
Recommended Earth Pressures	1211	13551
To Calculate	605.36 * D1	366.24 * D2

	Resistance Factor[15]			Load Factor[15]
Limit State	Passive Earth Pressure Component of Sliding Resistance	At-rest Pressure	Shear Resistance to Sliding	At-rest Pressure
Strength	0.5	1.0	0.8 - 0.9[14]	1.35
Service	1.0	1.0	1.0	1.0
Extreme	1.0	1.0	1.0	1.0

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PROJ. ENGR.	
REGIONAL ADM.	

REVISION	DATE	BY

REGION NO. 10 | STATE WASH | FED.AID PROJ.NO.

JOB NUMBER

CONTRACT NO. | LOCATION NO.

P.E. STAMP BOX — DATE

P.E. STAMP BOX — DATE

Washington State Department of Transportation

FLATIRON LANE

wood.

I-405; RENTON TO BELLEVUE WIDENING AND EXPRESS TOLL LANES PROJECT

STATIC EARTH PRESSURES AND SLIDING FOR BRIDGE 17.7 PIER 3

PLAN REF NO

SHEET OF SHEETS

In Association with

Appendix A
Field Exploration Logs

Bridge 17.7 Field Exploration Logs

wood.
4020 Lake Washington Blvd Suite 200
Kirkland, WA 98033

PROJECT NAME I-405 Renton to Bellevue Widening **PROJECT NUMBER** 20316 **BORING NUMBER** W-134-20

CLIENT WSDOT **PROJECT LOCATION** Renton, WA

DATE STARTED 8/17/20 **COMPLETED** 8/17/20 **GROUND ELEVATION** 65.7 ft NAVD88 **HOLE SIZE** 6 inches

DRILLING CONTRACTOR Gregory Drilling **DRILL RIG** LAR ID: #309 **SPT HAMMER EFFICIENCY** 80%

DRILLING METHOD HSA **STATION (FT)** 5496+96.21 **OFFSET (FT)** 85.9 L

LOGGED BY Jeana Lopez **CHECKED BY** Pat Reed **NORTHING** 178108.595 **EASTING** 1302081.49

NOTES **GW LEVEL (ATD)** Dry

ELEVATION (ft) / DEPTH	GRAPHIC LOG	SOIL & ROCK DESCRIPTION	RECOVERY % (RQD)	SAMPLE TYPE NUMBER	SPT N VALUE / PL MC LL / FINES CONTENT (%)	TESTS AND REMARKS
0 / 65		Weeds and well graded gravel over Silty SAND with gravel, medium dense, yellowish brown, moist, [FILL] (GM)				
			44	SPT-1 6 5 6	11	MC = 9% Fines = 19%
5 / 60		Becomes loose, dark brown, trace burnt wood pieces and gravel	44	SPT-2 3 4 6	10	
		Silty SAND, loose, yellowish brown, moist, [Qal] (SP)	89	SPT-3 2 2 3	5	MC = 7% Fines = 17%
		Sandy SILT, loose, olive gray with brownish yellow, moist, stratified, [Qal] (ML)				MC = 18% Fines = 57% MC = 22% LL = NP PL = NP Fines = 63%
10 / 55		Becomes stratified to laminated	94	SPT-4 2 2 3	5	
15 / 50		Silty SAND, dense, mottled grayish brown with highly oxidized reddish brown, extremely weathered sandstone, [Renton Fm] (SM)	89	SPT-5 5 17 20	37	MC = 11% Fines = 29%
20		Silty gravel with sand, volcanic rock fragments				Coarse gravel in sampler

(Continued Next Page)

Figure A.1-2

WSDOT GEOTECH DRILLING - I405 WSDOT.GDT - 11/4/20 14:11 - C:\USERS\CHELSEA.FOSTER\DOCUMENTS\PROJECTWISE\WORKINGDIR\WSDOT\DMS08721\I405 WSDOT - SEG. 1.GPJ

wood.
4020 Lake Washington Blvd Suite 200
Kirkland, WA 98033

PROJECT NAME I-405 Renton to Bellevue Widening **PROJECT NUMBER** 20316 **BORING NUMBER** W-134-20

CLIENT WSDOT **PROJECT LOCATION** Renton, WA

ELEVATION (ft) / DEPTH	GRAPHIC LOG	SOIL & ROCK DESCRIPTION	RECOVERY % (RQD)	SAMPLE TYPE NUMBER	▲ SPT N VALUE ▲ / PL MC LL / ☐ FINES CONTENT (%) ☐	TESTS AND REMARKS
20 45		Silty SAND, dense, moist, fine to medium grained, mottled grayish brown with highly oxidized reddish brown, extremely weathered sandstone, [Renton Fm] (SM)	94	SPT-6 9 12 15	20 40 60 80 27	MC = 13% Fines = 32%

Bottom of borehole at 21.5 feet.

WSDOT GEOTECH DRILLING - I405 WSDOT.GDT - 11/4/20 14:11 - C:\USERS\CHELSEA.FOSTER\DOCUMENTS\PROJECTWISE\WORKINGDIR\WSDOT\DMS08721\I405 WSDOT - SEG. 1.GPJ

Figure A.1-3

WSDOT

LOG OF TEST BORING

Start Card SE-60498 / AE-40625

Job No. XL-4653 SR 405 Elevation 90.1 ft

HOLE No. R2B-03-17

Sheet 1 of 3

Project I-405 Renton to Bellevue - ETL - Envir & Traff

Driller Henderson, Ted Lic# 2902

Component Cut Wall 03.65L

Inspector Haller, Robert #2779

Start February 22, 2017 Completion February 24, 2017 Well ID# N/A

Equipment CME 45C (9A4-7)

Station SB405 5497+42.377 Offset 49.7 feet left Hole Dia (inches) 4

Historical SPT Efficiency 88.4%

Northing 178136.573 Easting 1302164.821 Collected by Region Survey Crew

Method Casing Advancer

Lat 47.4801082 Long -122.2012758 Datum NAD 83/91 HARN, NAVD88, SPN (ft)

Drill Fluid Bentonite

Depth (ft)	Elevation (ft)	Blows/6" (N) and/or RQD FF	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
	90.0	4 4 5 (9)		D-1		Well graded SAND with gravel and organics, sub-rounded, loose, dark gray, moist, homogeneous. HCl not tested. Recovered: 0.5 ft Retained: 0.5 ft		
5	85.0	11 12 14 (26)		D-2		Well graded SAND with gravel, sub-rounded, dense, dark gray, moist, homogeneous. HCl not tested. Recovered: 0.8 ft Retained: 0.8 ft		
		8 8 11 (19)		D-3		Silty SAND with gravel, sub-rounded, medium dense, dark gray, moist, homogeneous. HCl not tested. Recovered: 1.1 ft Retained: 1.1 ft		
10	80.0	9 11 19 (30)		D-4	MC GS	MC=8% Poorly graded SAND with silt and gravel, sub-rounded, dense, dark gray, moist, homogeneous. HCl not tested. Recovered: 0.7 ft Retained: 0.7 ft		
		5 5 5 (10)		D-5		Silty SAND with gravel, sub-rounded, loose, dark gray, wet, homogeneous. HCl not tested. Recovered: 0.4 ft Retained: 0.4 ft		
15	75.0							
		11 12		D-6	MC GS	GW, MC=6% Well graded GRAVEL with sand, sub-rounded, medium		
20								

SPT Efficiency
Field SPT (N)
Moisture Content
RQD
20 40 60 80

ENTERPRISE BORING LOG XL-5467 (OLD XL-4653) 405 RENTON TO BELLEVUE ETL - ENVIRO AND TRAFF.GPJ ENTERPRISE DATA TEMPLATE.GDT 5/11/18

Figure A.1-4

WSDOT

LOG OF TEST BORING

Job No. XL-4653 SR 405 Elevation 90.1 ft HOLE No. R2B-03-17

Sheet 2 of 3

Project I-405 Renton to Bellevue - ETL - Envir & Traff Driller Henderson, Ted

SPT Efficiency
Field SPT (N)
Moisture Content
RQD

Depth (ft)	Elevation (ft)	Blows/6" (N) and/or RQD FF	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
	70	9 (21)				dense, gray, wet, homogeneous. HCl not tested. Recovered: 0.5 ft Retained: 0.5 ft		
25	65	7 10 8 (18)		D-7		Well graded GRAVEL with sand, sub-rounded, medium dense, gray, wet, homogeneous. HCl not tested. Recovered: 0.2 ft Retained: 0.2 ft		
30	60	7 5 7 (12)		D-8		Well graded GRAVEL with sand, sub-rounded, medium dense, dark brown, wet, homogeneous. HCl not tested. Recovered: 0.4 ft Retained: 0.4 ft		
35	55	6 6 11 (17)		D-9		Silty GRAVEL with sand, sub-rounded, medium dense, dark brown, wet, homogeneous. HCl not tested. Recovered: 0.5 ft Retained: 0.5 ft		
40	50	14 20 14 (34)		D-10		Well graded SAND with gravel, sub-rounded, dense, dark brown, moist, homogeneous. HCl not tested. Recovered: 0.9 ft Retained: 0.9 ft		
45		12 18		D-11	MC GS	CL-ML, MC=15%, PI=6 Sandy silty CLAY, hard, grayish brown, moist,		

ENTERPRISE BORING LOG XL-5467 (OLD XL-4653) 405 RENTON TO BELLEVUE ETL - ENVIRO AND TRAFF.GPJ ENTERPRISE DATA TEMPLATE.GDT 5/11/18

Figure A.1-5

WSDOT

LOG OF TEST BORING

Job No. XL-4653 SR 405 Elevation 90.1 ft HOLE No. R2B-03-17

Sheet 3 of 3

Project I-405 Renton to Bellevue - ETL - Envir & Traff Driller Henderson, Ted

Depth (ft)	Elevation (ft)	Profile	SPT Efficiency / Field SPT (N) / Moisture Content / RQD (20 40 60 80)	Blows/6" (N) and/or RQD FF	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
	45			18 (36)			AL	homogeneous. HCl not tested. Recovered: 1.5 ft Retained: 1.5 ft		
								Drilling behavior indicated SANDSTONE at 46 ft.		
				33 32 30 (62)		D-12		SANDSTONE, grayish brown, coarse grained, very dense, moist. HCl not tested. FeO stains. Recovered: 1.5 ft Retained: 1.5 ft		
50	40									
55	35							The implied accuracy of the borehole location information displayed on this boring log is typically sub-meter in (X,Y) when collected by the HQ Geotech Office and sub-centimeter in (X,Y,Z) when collected by the Region Survey Crew.		
								End of test hole boring at 50.5 ft below ground elevation. This is a summary Log of Test Boring. Soil/Rock descriptions are derived from visual field identifications and laboratory test data. Note: REF = SPT Refusal		
60	30							Bail/Recharge test: Hole Diameter: 4 inches Depth of boring during bail test: 50.5 ft. Depth of casing during bail test: 45 ft. Water depth before bailing: 11.1 ft. Bailed bore hole water level to 28 ft. Recharge after 5 minutes: 25.9 ft. Recharge after 10 minutes: 24 ft. Recharge after 15 minutes: 23 ft. Recharge after 20 minutes: 21.9 ft. Recharge after 25 minutes: 21.6 ft. Recharge after 30 minutes: 21.6 ft.		
65	25									
70										

ENTERPRISE BORING LOG XL-5467 (OLD XL-4653) 405 RENTON TO BELLEVUE ETL - ENVIRO AND TRAFF.GPJ ENTERPRISE DATA TEMPLATE.GDT 5/11/18

Figure A.1-6

LOG OF TEST BORING **WASHINGTON STATE DEPARTMENT OF TRANSPORTATION**

S.H. ____ S.R. 405 SECTION S. Renton I/C to Sunset Blvd HOV Lanes Job No. L-7974

Hole No. HQ-83-90 Sub Section Cedar River Bridge No. 405/18 Cont. Sec. 1743

Station I.S 260+00 Offset 40' Lt. Ground El. 38'

Type of Boring HW Casing Advancer Casing HW W.T. El. 25'

Inspector ____ Date May 24, 1990 Sheet 1 of 3

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
				Large blocks of concrete on surface
	25		3 STD 11 PEN 14 1 12	GP-GM, M.C. = 15.3% Dense, weak red to reddish black, moist, silty, fine to coarse sandy GRAVEL with rock fragments.
5				
	7		3 STD 4 PEN	Loose, weak red to reddish black, wet, silty, fine to coarse
			3 2 4	sandy GRAVEL. Changed to silty sand at 7'.
10				
	43		21 STD 30 PEN 13 3 16	Dense, dark grayish brown, wet, slightly silty, gravelly, fine to coarse SAND with cobbles.
	37		14 STD 17 PEN 20 4 20	Dense, dark grayish brown, wet, slightly silty, fine to coarse sandy GRAVEL.
15	35		14 STD 17 PEN 18 5 23	SW Dense, dark grayish brown, wet, slightly silty, gravelly, fine to coarse SAND with cobbles.
	54		14 STD 17 PEN 37 6 50	GP Very dense, dark grayish brown, wet, slightly silty, fine to coarse sandy GRAVEL.
	40		17 STD 24 PEN 16 7 17	Dense, dark grayish brown, wet, slightly silty, fine to coarse sandy GRAVEL with cobbles.

DOT FORM 351-003 REVISED 12/79

Original to Materials Engineer
Copy to Bridge Engineer
Copy to District Administrator

Copy to ____

Figure A.1-7

Hole No. HQ-83-90 Sub Section Cedar River Bridge No. 405/18 Sheet 2 of 3

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
			7 STD	
	24		12 PEN	Medium dense, dark grayish brown, wet, slightly silty,
			12 8	gravelly, fine to coarse SAND.
			16	
			13 STD	
	35		16 PEN	Dense, dark grayish brown, wet, slightly silty, gravelly,
			19 9	fine to coarse SAND with cobbles.
			20	
			17 STD	
25	26		14 PEN	Dense, dark grayish brown, wet, slightly silty, gravelly,
			12 10	fine to coarse SAND with cobbles.
			13	
			27 STD	SM, M.C. = 15.2%
	64		32 PEN	Very dense, dark brown to strong brown, moist, silty,
			32 11	gravelly, fine to coarse SAND with weathered rock fragments.
			35	
			23 STD	
30	38		22 PEN	Dense, dark brown to strong brown, moist, silty, gravelly,
			16 12	fine to coarse SAND with weathered rock fragments.
			18	Changed to weathered sandstone at 30'.
				Light gray/brown, ash laminae inclined 15°, poorly cemented,
				moderately weathered SANDSTONE. RQD = 41%. Recovered 75%.
			C-13	
35				
			50/ STD	
	50/4"		4" PEN	Very dense, light brownish gray, moderately weathered
			14	SANDSTONE.
			C-15	Light gray, discontinuous ash laminae, well cemented, fresh
				SANDSTONE. RQD = 100%. Recovered 100%.
40				
			50/ STD	
	50/4"		4" PEN	Very dense, light gray, poorly cemented, fresh SANDSTONE.
			16	
			C-17	Light gray/dark gray, discontinuous, carbonaceous laminae, 8"
				siltstone bed, poorly to well cemented, fresh SANDSTONE.
				RQD = 75%. Recovered 100%.
45				

DOT FORM 351-003A (X) REVISED 4/80

Figure A.1-8

Hole No. HQ-83-90 Sub Section Cedar River Bridge No. 405/18 Sheet 3 of 3

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
				Light gray, discontinuous carbonaceous laminae, fresh, poorly cemented SANDSTONE. RQD = 50%. Recovered 50%.
			C-18	2' of sandstone core was in bottom of hole when we tried to take a drive sample.
50				
				Stopped test boring 50' below ground elevation.
55				
				This is a summary Log of Test Boring. Soil/Rock descriptions are derived from visual field identification and laboratory test data.

DOT FORM 351-003A (X) REVISED 4/80

Figure A.1-9

LOG OF TEST BORING WASHINGTON STATE DEPARTMENT OF TRANSPORTATION

S.H. ____ S.R. 405 SECTION S. Renton I/C to Sunset Blvd HOV Lanes Job No. L-7974

Hole No. HQ-81-90 Sub Section Cedar River Bridge No. 405/18 Cont. Sec. 1743

Station LN 258+75 Offset 14' Rt. LN ℄ Ground El. 48.6'

Type of Boring HW HQ Wire Line Casing HW W.T. El. Not determined

Inspector ____ Date May 3, 1990 Sheet 1 of 3

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.		DESCRIPTION OF MATERIAL
			8	STD	GP-GM
	27		13	PEN	Dense, very dark gray, moist, silty, fine to coarse sandy,
			14	1	subangular and subrounded GRAVEL. Retained 1.5'.
			11		
			3	STD	
	7		5	PEN	Loose, very dark gray, wet, silty, fine to coarse sandy
			3	2	subangular and subrounded GRAVEL. Retained 1.0'.
			3		
			3	STD	
5	4		2	PEN	Very loose, dark gray, wet, silty, fine to coarse sandy,
			2	3	subangular and subrounded GRAVEL. Retained 0.7'.
			2		
			1	STD	
	2		1	PEN	Very loose, very dark gray, wet, slightly silty subangular
			1	4	gravelly, fine to coarse SAND. Retained 0.4'.
			2		
			6	STD	
	10		5	PEN	Loose, dark gray, wet, slightly silty, gravelly, fine to
			5	5	coarse SAND. (Gravel is subrounded and subangular).
10			4		Retained 0.6'.
			3	STD	
	7		4	PEN	No recovery, pushing a rock.
			3	6	
			3		
			12	STD	SP
	52		20	PEN	Very dense, grayish brown, wet, slightly silty, gravelly,
			32	7	fine to coarse SAND. (Gravel is subangular).
			30		Retained 1.5'.
			16	STD	
15	57		25	PEN	Very dense, light yellowish brown to reddish brown, moist,
			32	8	very silty, fine to medium SAND. Retained 2.0'.
			38		
			15	STD	SM, M.C. = 12.1%
	65		24	PEN	Very dense, yellowish brown, moist, very silty, fine to
			41	9	medium SAND. Retained 2.0'.
			52		

DOT FORM 351-003 REVISED 12/79

Original to Materials Engineer
Copy to Bridge Engineer
Copy to District Administrator

Copy to ____

Figure A.1-10

Hole No. HQ-81-90 Sub Section Cedar River Bridge No. 405/18 Sheet 2 of 3

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
	76		15 STD 36 PEN 40 10	Very dense, light yellowish brown, moist, very silty, fine to medium SAND. Retained 1.5'.
25				
	76		24 STD 26 PEN 50 11	SP-SM, M.C. = 12.8% Very dense, dark gray, moist, silty, gravelly, fine to coarse SAND with carbonaceous laminae. Retained 1.5'.
30	50/4"		18 STD 50/ PEN 4" 12	Very dense, light gray, wet, silty, medium to coarse SAND with angular to subangular gravel. Retained 0.2'. (Field I.D.). (Found valve stem of tire in sample).
35	73		21 STD 23 PEN 50 13	Very dense, dark gray, wet, silty, fine to coarse sandy subangular GRAVEL with carbonaceous laminae. Retained 1.0'.
40	44		23 STD 23 PEN 21 14	SP-SM, M.C. = 22.0% Dense, greenish gray, moist, silty, gravelly, fine to coarse SAND with carbonaceous laminae and cobbles. Gravel is subangular. Retained 1.0'.
45	76		14 STD 30 PEN 46 15	Very dense, dark gray, wet, silty, gravelly, fine to coarse SAND with carbonaceous laminae and cobbles. Retained 1.0'.

DOT FORM 351-003A (X) REVISED 4/80

Figure A.1-11

Hole No. HQ-81-90 Sub Section Cedar River Bridge No. 405/18 Sheet 3 of 3

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
			C-18	Cored a gray sandstone boulder 2.8'.
50	50/1"		50/1" STD PEN 16	No recovery, on a boulder.
			C-19	Cored a gray sandstone boulder 1.0'.
55	98		44 28 70 STD PEN 17	Very dense, dark gray, wet, silty, gravelly, fine to coarse SAND with cobbles and boulders. Gravel is subrounded and subangular. Retained 1.6'.
60	100/2"		100/2" STD PEN 18	No recovery, on a boulder.
				Stopped test boring at 59.2' below ground elevation.
				This is a summary Log of Test Boring. Soil/Rock descriptions are derived from visual field identification and laboratory test data.

DOT FORM 351-003A (X) REVISED 4/80

Figure A.1-12

LOG OF TEST BORING WASHINGTON STATE DEPARTMENT OF TRANSPORTATION

S.H. ____ S.R. 405 SECTION So. Renton I/C to Sunset Blvd Job No. L-7974

Hole No. HE-11-90 Sub Section Wall 6 & Renton Ave. Br. #405/17B Cont. Sec. 1743

Station R 14+61.1 Offset 7.1' Lt Ground El. 47.9'

Type of Boring Power Augers Casing Augers to 22' W.T. El. Not determined

Inspector ____ Date March 30, 1990 Sheet 1 of 2

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
	11		6 STD 5 PEN 6 8 1	Medium dense, very dark grayish brown, moist, gravelly, silty, fine to coarse SAND.
5				
	36/6"		25 STD 36 PEN 2	* Very dense, very dark grayish brown, moist, silty, fine to coarse sandy GRAVEL.
10				
	14		4 STD 6 PEN 8 3 14	Medium dense, grayish brown, dry, slightly silty, gravelly, fine to coarse SAND.
15				
	37		8 STD 18 PEN 19 4 16	* Dense, grayish brown, dry, slightly silty, fine to coarse sandy GRAVEL.

DOT FORM 351-003 REVISED 12/79

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Figure A.1-13

Hole No. HE-11-90 Sub Section Wall 6 & Renton Ave. Br. #405/17B Sheet 2 of 2

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
	50/6"		50 STD PEN 5	Highly weathered sandstone. Very dense, grayish brown, moist, very silty, fine to medium SAND with a trace of mica).
25				
				Stopped test boring 22.5' below ground elevation
				This is a summary Log of Test Boring. Soil/Rock descriptions are derived from visual field identification and laboratory test data.
				*Laboratory test results reflect the finer fraction of soil observed in the field.

DOT FORM 351-003A (X) REVISED 4/80

Figure A.1-14

LOG OF TEST BORING WASHINGTON STATE DEPARTMENT OF TRANSPORTATION

S.H. ____ S.R. 405 SECTION So. Renton I/C to Sunset Blvd. Job No. L-7974

Hole No. HE-8-90 Sub Section Wall 6 & Renton Ave. Br. #405/17B Cont. Sec. 1743

Station R 15+29.3 Offset 36' Lt. 'R' line Ground El. 48.5

Type of Boring Power Augers Casing ____ W.T. El. Not determined

Inspector ____ Date March 29, 1990 Sheet 1 of 1

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
	45		17 STD 21 PEN 24 1	Dense, very dark grayish brown, dry, silty, gravelly, fine to coarse SAND with wood fragments.
5				
	32/6"		19 STD 32 PEN 2	SM, M.C. = 10.8% Very dense, dark grayish brown, moist, gravelly, silty, fine to coarse SAND.
10				
	24		7 STD 9 PEN 15 30 3	Medium dense, grayish brown, moist, very silty, fine to medium SAND with a trace of mica .
15				
	50/6"		50 STD PEN 4	Highly weathered SANDSTONE (Very dense, grayish brown, moist, very silty, fine to medium SAND with a trace of mica). Stopped test boring 17.5' below ground elevation.
20				This is a summary Log of Test Boring. Soil/Rock descriptions are derived from visual field identification and laboratory test data.

DOT FORM 351-003 REVISED 12/79

Original to Materials Engineer
Copy to Bridge Engineer
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Figure A.1-15

LOG OF TEST BORING — **WASHINGTON STATE DEPARTMENT OF TRANSPORTATION**

S.H. ____ S.R. 405 SECTION So. Renton I/C to Sunset Blvd Job No. L-7974

Hole No. HE-9-90 Sub Section Wall 6 & Renton Ave. Br. #405/17B Cont. Sec. 1743

Station R 14+88.8 Offset 37.8' Lt. 'R' line Ground El. 47.6'

Type of Boring Power Augers Casing ____ W.T. El. 25.1'

Inspector ____ Date March 29, 1990 Sheet 1 of 2

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
	29		14 STD 19 PEN 10 6 1	Dense, grayish brown, dry, slightly silty, gravelly, fine to coarse SAND.
5				
	6		3 STD 3 PEN 3 2 2	SM, M.C. = 13.8% Loose, brown, moist, gravelly, silty, fine to coarse SAND.
10				
	31		10 STD 15 PEN 16 26 3	* Dense, dark grayish brown, dry, slightly silty, fine to coarse sandy GRAVEL.
15				
	13		6 STD 10 PEN 3 5 4	*SP, M.C. = 3.0% Medium dense, grayish brown, dry, slightly silty, fine to coarse SAND and GRAVEL.
2				

DOT FORM 351-003 REVISED 12/79

Original to Materials Engineer
Copy to Bridge Engineer
Copy to District Administrator

Copy to ____

Figure A.1-16

Hole No. HE-9-90 Sub Section Wall 6 & Renton Ave. Br. #405/17B Sheet 2 of 2

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
			6 STD	
	50/6"		50 PEN	Very dense, reddish brown and gray, wet, slightly silty, gravelly,
			5	fine to coarse SAND. Changed at 22.5 to gray highly weathered sandstone.
25				
				Stopped test boring 23' below ground elevation.
				*Laboratory test result reflects the finer fraction of soil observed in the field.
30				
				This is a summary Log of Test Boring. Soil/Rock descriptions are derived from visual field identification and laboratory test data.

DOT FORM 351-003A (X) REVISED 4/80

Figure A.1-17

LOG OF TEST BORING WASHINGTON STATE DEPARTMENT OF TRANSPORTATION

S.H. ____ S.R. 405 SECTION So. Renton I/C to Sunset Blvd. Job No. L-7974

Hole No. HE-10-90 Sub Section Wall 6 & Renton Ave. Br. #405/17B Cont. Sec. 1743

Station R 14+51.9 Offset 27.3' Lt. 'R' line Ground El. 46.8'

Type of Boring Power Augers Casing ____ W.T. El. Not determined

Inspector ____ Date March 29, 1990 Sheet 1 of 1

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
	28		24 STD 14 PEN 14 1	Dense, very dark grayish brown, moist, gravelly, silty, fine to coarse SAND.
5				
	11		5 STD 5 PEN 6 2 11	Medium dense, dark grayish brown, moist, gravelly, silty, fine to coarse SAND with silt layers.
10				
	65		13 STD 27 PEN 38 3	Very dense, dark grayish brown, dry, slightly silty, GRAVEL and fine to coarse SAND.
15				
	45/6"		35 STD 45 PEN 4	Very dense, dark grayish brown, dry, slightly silty, GRAVEL and fine to coarse SAND. Stopped test boring 18' below ground elevation.
				This is a summary Log of Test Boring. Soil/Rock descriptions are derived from visual field identification and laboratory test data.

DOT FORM 351-003 REVISED 12/79

Original to Materials Engineer
Copy to Bridge Engineer
Copy to District Administrator

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Figure A.1-18

LOG OF TEST BORING WASHINGTON STATE DEPARTMENT OF TRANSPORTATION

S.H. ____ S.R. 405 SECTION So. Renton I/C to Sunset BLVD HOV Job No. L-7974

Hole No. HE-7-90 Sub Section Wall 6 & Renton Ave. Br. #405/17B Cont. Sec. 1743

Station R 14+99.0 Offset 9.7' Rt. R line Ground El. 52.0'

Type of Boring CME 45 Augers Casing ____ W.T. El. 49.0'

Inspector ____ Date March 28, 1990 Sheet 1 of 2

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
0			1 STD 4 PEN	Medium dense, dark brown, dry silty, gravelly, fine to coarse
	18		14 1	SAND with organic material to 0.3'. Retained 1.0'.
			5 STD 4 PEN	SP-SM, M.C. = 9.9% Medium dense, dark brown, dry, silty, gravelly, fine to coarse
5	18		14 2	SAND with a trace of wood fragments. Retained 0.5.
			11 STD 15 PEN	*SP-SM Dense, brown, wet, silty, fine to coarse sandy GRAVEL. (Sand
10	25		10 3	in tip of sampler). Retained 1.1'.
			5 STD 10 PEN	Medium dense, light brown and gray, wet, very silty, fine to
15	20		10 4	medium SAND, with a trace of mica. Retained 1.1'.
			2 STD 3 PEN	SM Dense, light brown and gray, wet, very silty, fine to medium
	42		39 5	SAND, with a trace of mica. Retained 1.1' End of boring -19.5' below ground elevation.

DOT FORM 351-003 REVISED 12/79

Original to Materials Engineer
Copy to Bridge Engineer
Copy to District Administrator

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Figure A.1-19

Hole No. HE-7-90 Sub Section Wall 6 & Renton Ave. Br. #405/17B Sheet 2 of 2

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
				This is a summary Log of Test Boring. Soil/Rock descriptions are derived from visual field identification and laboratory test data.
				*Laboratory test result reflects the finer fraction of soil observed in the field.

DOT FORM 351-003A (X) REVISED 4/80

Figure A.1-20

LOG OF TEST BORING WASHINGTON STATE DEPARTMENT OF TRANSPORTATION

S.H. ____ S.R. 405 SECTION Cedar River Monitoring Job No. L-7974

Hole No. MW-28 Sub Section Wells Cont. Sec. 1743

Station LS 262+05 Offset 45' LT C_L Ground El. 41.0'

Type of Boring Cable Tool Casing 8"x72.0' W.T. El. Note bottom Log

Inspector ____ Date February 26, 1990 Sheet 1 of 2

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
				0-0' to 8.0' fill material - slightly silty, fine to coarse sand, gravel, and cobbles, large blocks concrete, and basalt fragments.
10				Slightly silty, fine to coarse sandy gravel with cobbles.
20				
30				

DOT FORM 351-003 REVISED 12/79

Original to Materials Engineer
Copy to Bridge Engineer
Copy to District Administrator

Copy to ____

Figure A.1-21

Hole No. MW-28 Sub Section Cedar River Monitoring Well Sheet 2 of 2

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
50				
60				
70				71.0' to 73.0'
				Sandstone - multicolored, light brown, rusty oxidized brown, light gray. Very hard driving 71' to 72'.
80				Water table approximately 17.5' below ground surface.
				With casing seated in sandstone, bailed hole water was bailed to 27.4' below ground surface.
90				Cut off approximate 67' to 68' below ground surface.

DOT FORM 351-003A (X) REVISED 4/80

Figure A.1-22

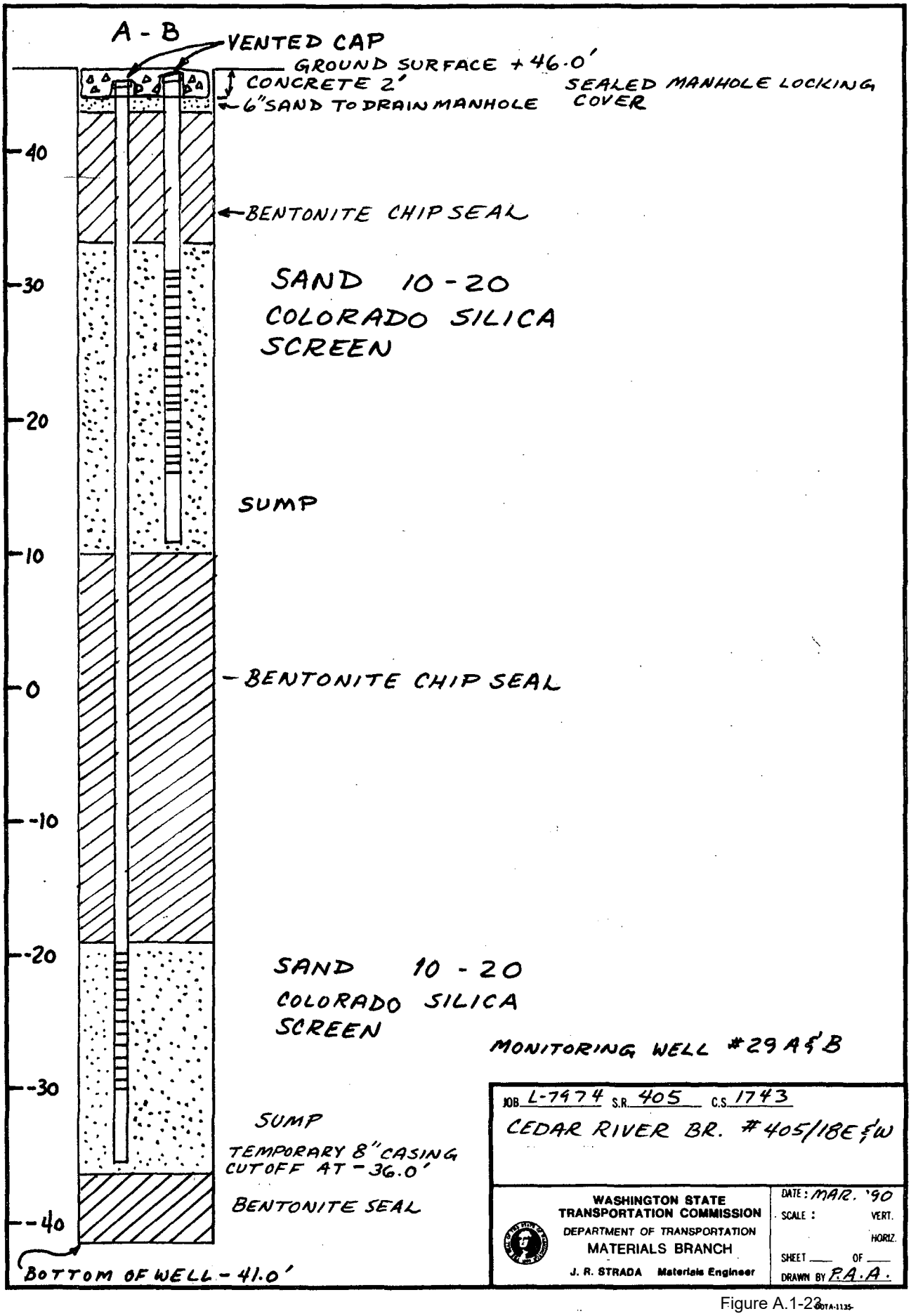
A - B
VENTED CAP
GROUND SURFACE +46.0'
CONCRETE 2'
SEALED MANHOLE LOCKING COVER
6" SAND TO DRAIN MANHOLE
40
BENTONITE CHIP SEAL
30
SAND 10-20
COLORADO SILICA
SCREEN
20
SUMP
10
0
BENTONITE CHIP SEAL
-10
-20
SAND 10-20
COLORADO SILICA
SCREEN
MONITORING WELL #29 A & B
-30
SUMP
TEMPORARY 8" CASING
CUTOFF AT -36.0'
BENTONITE SEAL
-40
BOTTOM OF WELL - 41.0'
JOB L-7974 S.R. 405 C.S. 1743
CEDAR RIVER BR. #405/18E & W
WASHINGTON STATE
TRANSPORTATION COMMISSION
DEPARTMENT OF TRANSPORTATION
MATERIALS BRANCH
J. R. STRADA Materials Engineer
DATE: MAR. '90
SCALE: VERT.
HORIZ.
SHEET ___ OF ___
DRAWN BY P.A.A.

Figure A.1-23

LOG OF TEST BORING WASHINGTON STATE DEPARTMENT OF TRANSPORTATION

S.H. ____ S.R. 405 SECTIONS. Renton I/C to Sunset Blvd HOV Lanes Job No. L-7974

Hole No. HQ-106-89 Sub Section Renton Ave. S. U'Xing No. 405/17B Cont. Sec. 1743

Station LN 256+43 Offset 29.0' Lt. Ground El. 75.8'

Type of Boring Wet Rotary Casing 25' x 3" W.T. El. See Piezo Data

Inspector ____ Date June 8-12, 1989 Sheet 1 of 2

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
5				
	12		8 STD 6 PEN 6 1	GP Medium dense, brown, wet, slightly silty, fine to coarse sandy GRAVEL. Retained 0.2'.
10				
	21		9 STD 11 PEN 10 2	SW Medium dense, brown, wet, slightly silty, gravelly, fine to coarse SAND (fines may have been washed from sample). Retained 0.9'. (drilling became dense at -11.5' with signs of cobbles to -13.0')
15				
	50		16 STD 22 PEN 28 3	Dense, brown, wet, slightly silty, gravelly, fine to coarse SAND (fines may have been washed from sample). Retained 0.8'.

DOT FORM 351-003 REVISED 12/79

Original to Materials Engineer
Copy to Bridge Engineer
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Figure A.1-24

Hole No. HQ-106-89 Sub Section Renton Ave. S. U'Xing No. 405/17B Sheet 2 of 2

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
	50/4"		42 STD 50/4" PEN 4	Very dense, brown, wet, slightly silty, gravelly, fine to coarse SAND (fines may have been washed from sample). Retained 0.6'.
25		? ? ?		
	43		20 STD 22 PEN 21 5	SM Dense, brown red gray, wet, gravelly, very silty, fine to coarse SAND (clasts of highly weathered sandstone). Retained 0.6'.
30				Stopped test boring 26.5' below ground elevation. This is a summary Log of Test Boring. Soil/Rock descriptions are derived from visual field identifications and laboratory test data.

DOT FORM 351-003A (X) REVISED 4/80

Figure A.1-25

PIEZOMETRIC DATA
TEST HOLE HQ-106-89

Pump Tests

- none completed

Water Level Readings

DATE	PIEZOMETER
11/30/89	dry

Instrumentation Diagram

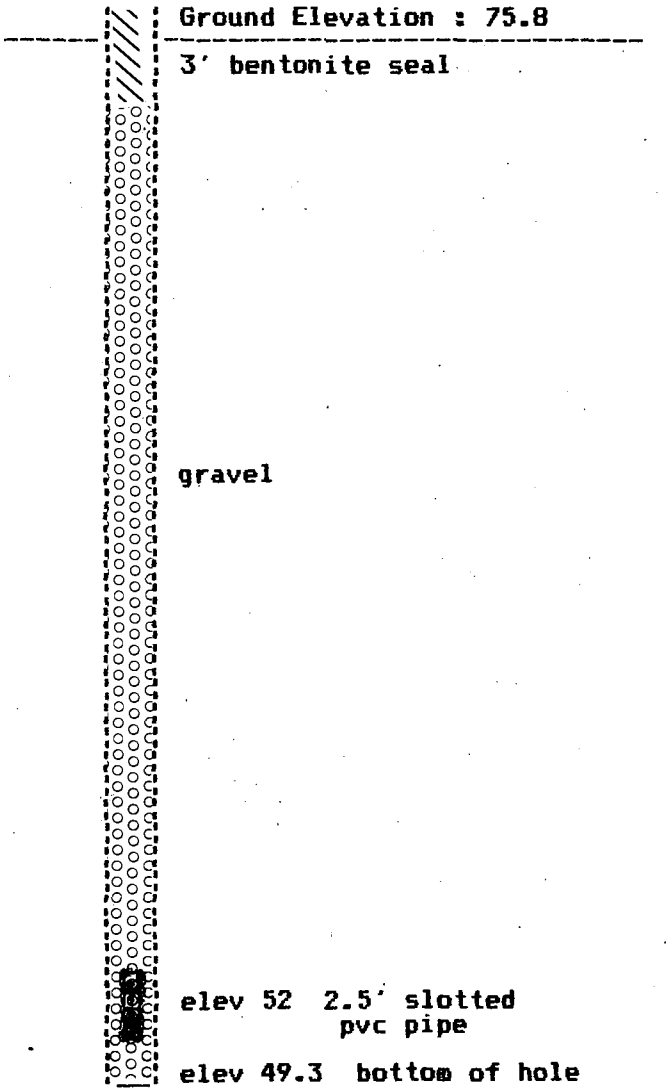

Figure A.1-26

LOG OF TEST BORING **WASHINGTON STATE DEPARTMENT OF TRANSPORTATION**

S.H. ____ S.R. 405 SECTION S. Renton I/C to Sunset Blvd HOV Lanes Job No. L-7974

Hole No. HQ-13B-89 Sub Section ____ Cont. Sec. 1743

Station LN 256+37 Offset 56' Rt. Ground El. 90.5'

Type of Boring Wet Rotary Casing HW x 40' W.T. El. See Piezo Data

Inspector ____ Date June 6, 1989 Sheet 1 of 2

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
			1 STD	GW/GM, M.C. = 10.1%
	5		2 PEN	Loose, dark reddish brown, moist, silty, fine to coarse
5			3 1	sandy, GRAVEL. Massive. Retained 0.4'.
			2 STD	
	6		2 PEN	Loose, light olive brown, moist, very silty, fine SAND.
10			4 2	Laminated. Retained 1.5'.
			12 STD	
	34		11 PEN	No recovery.
15			23 3	
			10 STD	SW, M.C. = 16.3%
	31		14 PEN	Dense, olive brown, moist, slightly silty, gravelly, fine
			17 4	to coarse SAND. Laminated. Retained 1.5'.

DOT FORM 351-003 REVISED 12/79

Original to Materials Engineer
Copy to Bridge Engineer
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Figure A.1-27

Hole No. HQ-13B-89 Sub Section S. Renton I/C to Sunset Blvd HOV Lanes Sheet 2 of 2

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
			17 STD	SP, M.C. = 11.1%
	24		13 PEN	Medium dense, olive brown, moist, slightly silt, gravelly,
25			11 5	fine to coarse SAND. Massive. Retained 1.3'.
		? ?		
30				
			6 STD	SM, M.C. = 17.5%
	23		10 PEN	Medium dense, yellowish brown, moist, very silty, fine
			13 6	SAND. Laminated. Retained 1.5'.
35				
				Stopped test boring 31.5' below ground elevation.
				This is a summary Log of Test Boring. Soil/Rock descriptions are derived from visual field identifications and laboratory test data.

DOT FORM 351-003A (X) REVISED 4/80

Figure A.1-28

PIEZOMETRIC DATA
TEST HOLE HQ-13B-89

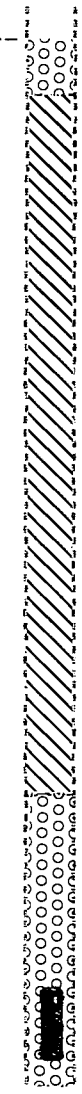
Pump Tests

- none completed

Water Level Readings

DATE	PIEZOMETER
06/15/89	dry
11/03/89	dry

Instrumentation Diagram



Ground Elevation : 90.5

3' cement seal

bentonite

elev 65 gravel

elev 61 2.5'slotted pvc pipe

elev 59.0 bottom of hole

Figure A.1-29

LOG OF TEST BORING WASHINGTON STATE DEPARTMENT OF TRANSPORTATION

S.H. ____ S.R. 405 SECTION S Renton to Sunset Blvd. HOV Job No. L-7974

Hole No. HQ-20-89 Sub Section Cedar R. & BNRR OC Br. # 405/18 and Wall #15 Cont. Sec. 1743

Station LN 262+01.5 Offset 79.2' Lt. Ground El. 37.2'

Type of Boring Mobile B-61 Rotary Casing 4" x 75.0' W.T. El. See Piezo Data

Inspector ____ Date April 11, 1989 Sheet 1 of 4

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
5	36		9 STD 15 PEN 21 1	*SW/SM Dense, brown, wet, slightly silty, fine to coarse sandy, subrounded GRAVEL with cobbles. Retained 0.6'.
10	51		20 STD 22 PEN 29 2	*SW/SM Very dense, dark grayish brown, wet, slightly silty, fine to coarse sandy, subrounded GRAVEL. Retained 0.4'.
15	16		26 STD 8 PEN 8 3	M.C.=220.4% (Wood) Medium dense, dark brown, saturated, silty, fine to coarse sandy, subrounded GRAVEL with 0.5' of wood. Retained 0.7'.

DOT FORM 351-003 REVISED 12/79

Original to Materials Engineer
Copy to Bridge Engineer
Copy to District Administrator

Copy to ____

Figure A.1-30

Hole No. HQ-20-89 Sub Section Cedar R & BNRR OC Br # 405/18 and Wall # 15 Sheet 2 of 4

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
	51		13 STD	GW
	51		25 PEN	Very dense, light brownish gray, wet slightly silty, fine to
			26 4	coarse sandy, subrounded GRAVEL with cobbles. Retained 0.2'.
25				
	46		21 STD	GW
			25 PEN	Dense, dark gray, wet, slightly silty, medium to coarse sandy,
			21 5	subrounded fine to coarse GRAVEL with cobbles. Retained 0.3'.
30				
	31		16 STD	GW
			14 PEN	Dense, yellowish brown, wet slightly silty, fine to coarse sandy,
			17 6	subrounded GRAVEL with cobbles. Retained 0.3'.
35				
	34		22 STD	GP
			17 PEN	Dense, brown, wet, slightly silty, fine to coarse sandy,
			17 7	subrounded GRAVEL with cobbles. Retained 0.3'.
40				
	36		21 STD	GW
			17 PEN	Dense, yellowish brown, wet slightly silty, fine to coarse
			19 8	sandy, subrounded GRAVEL with cobbles.
45				

DOT FORM 351-003A (X) REVISED 4/80

Figure A.1-31

Hole No. HQ-20-89 Sub Section Cedar R & BNRR OC Br. # 405/18 and Wall # 15 Sheet 3 of 4

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
			26 ↑ STD	GP
	53		27 PEN	Very dense, dark grayish brown, wet, slightly silty, fine to
			26 ↓ 9	coarse sandy, subrounded GRAVEL with cobbles. Retained 0.4'.
50				
			34 ↑ STD	GW
	84		50 PEN	Very dense, dark yellowish brown, wet slightly silty, fine to
			34 ↓ 10	coarse sandy, subrounded GRAVEL with cobbles. Retained 0.3'.
55				
			32 ↑ STD	Dense, dark yellowish brown, wet slightly silty, fine to coarse
	44		27 PEN	sandy, subrounded GRAVEL with cobbles. Retained 0.2'.
			17 ↓ 11	
60				
			44 ↑ STD	GW
	52		26 PEN	Very dense, dark yellowish brown, wet slightly silty, fine to
			26 ↓ 12	sandy, subrounded GRAVEL with cobbles. Retained 0.3'.
65				
			67 ↑ STD	GW
	102		51 PEN	Very dense, yellowish brown, wet, slightly silty, fine to coarse
			51 ↓ 13	sandy, subrounded GRAVEL with cobbles. Retained 0.8'.
70				

DOT FORM 351-003A (X) REVISED 4/80

Figure A.1-32

Hole No. HQ-20-89 Sub Section Cedar R & BNRR OC Br. # 405/18 and Wall # 15 Sheet 4 of 4

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
			33 STD	GW
	104		67 PEN	Very dense, yellowish brown, wet, slightly silty, fine to coarse
			37 14	sandy, subrounded GRAVEL with cobbles. Retained 0.5'.
75			29 STD	GW
	74		35 PEN	Very dense, light yellowish brown, wet, slightly silty, fine to
			39 15	coarse sandy, subrounded GRAVEL with cobbles. Retained 0.5'.
				End of boring at 76.5' below ground elevation. Water elevation 19.4' ATD (at time of drilling). Installed piezometer to elevation - 37.1' below sea level.
80				NOTE: Hole drilled hard; the best drilling fluid return was 50%, which often went to 0% return.
				This is a summary Log of Test Boring. Soil/Rock descriptions are derived from visual field identifications and laboratory test data.

DOT FORM 351-003A (X) REVISED 4/80

Figure A.1-33

PIEZOMETRIC DATA
TEST HOLE HQ-20-89

Pump Tests

- none completed

Water Level Readings

DATE	PIEZOMETER
05/12/89	-17.4 ft
01/17/90	-15.0 ft

Instrumentation Diagram

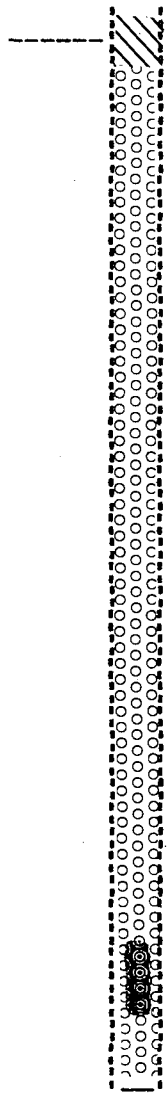


Figure A.1-34

LOG OF TEST BORING WASHINGTON STATE DEPARTMENT OF TRANSPORTATION

S.H. ____ S.R. 405 SECTION S. Renton I/C to Sunset Blvd. HOV Lanes Job No. L-7974

Hole No. HQ-14-89 Sub Section Renton Ave S. U'Xing 405/17B & Wall 3 Cont. Sec. 1743

Station LN 256+34.1 Offset 2.8' Lt. Ground El. 84.7'

Type of Boring Wet Rotary Casing 30' X HW W.T. El. See Piezo Data

Inspector ____ Date March 24-28, 1989 Sheet 1 of 3

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
1				
2				
3		? ?		
4				
5				
	8		4 STD 4 PEN 4 1	GW Loose, brown, wet, slightly silty, fine to coarse sandy GRAVEL. Massive. Retained 0.2'.
10				
	11		2 STD 5 PEN 6 2	SM, M.C.=18.6% Medium dense, olive brown, moist, very silty, fine to medium SAND with fine sand laminae. Retained 1.1'.
		? ?		
15				
	52		3 STD 25 PEN 27 3	SM, M.C.=16.6% Very dense, yellowish brown, moist, slightly clayey, very silty, gravelly, fine to coarse SAND with shallowly inclined silty laminae. Retained 0.9'.

DOT FORM 351-003 REVISED 12/79

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Figure A.1-35

Hole No. HQ-14-89 Sub Section Renton Ave. S. U'Xing No. 405/17B & Wall 3 Sheet 2 of 3

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
			16 STD	SW/SM, M.C.=13.6%
	41		19 PEN	Dense, olive brown, moist, slightly silty, gravelly, fine to
			22 4	coarse SAND. Massive. Retained 1.5'.
25				
			5 STD	
	25		9 PEN	Dense, light olive brown/dark grayish brown, moist, slightly
			16 5	silty, gravelly, fine to coarse SAND. 1 shallowly inclined
				sand laminae. Retained 1.1'.
30				
			10 STD	SM, M.C.=16.3%
	45		21 PEN	Dense, very pale orange/dark yellowish orange, very silty,
			24 6	fine to medium SAND. Massive. Retained 1.5'.
			C-7	Very pale orange/dark, yellowish orange, slightly gravelly SAND.
				Massive. Retained 2.0'.
35				
			C-8	Dark yellowish orange/dark yellowish brown, slightly gravelly
				SAND. Massive. Retained 3.0'.
40				
			C-9	Dark yellowish brown, gravelly sandy SILT. Thickly bedded.
				Turning dark gray at 44.9'. Retained 1.0'.
45				

DOT FORM 351-003A (X) REVISED 4/80

Figure A.1-36

Hole No. HQ-14-89 Sub Section Renton Ave. S. U'Xing 405/17B & Wall 3 Sheet 3 of 3

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
			C-10	Dark gray, gravel, cobbles and boulders (up to 4') with silty sand matrix. Retained 4.6'.
50				
			C-11	Dark gray, gravel, cobbles and boulders (up to 4') with silty sand matrix. Retained 3.2'.
55				
	50/0"		50/0" STD PEN 12	No recovery. Bouncing on cobble/boulder.
			C-13	Dark gray, gravel and cobbles (up to 6") with silty sand matrix. Retained 1.5'.
60				
	50/2"		37/50/2" STD PEN 14	*SW/SM Very dense, dark gray, wet, silty, fine to coarse sandy, GRAVEL. Massive. Retained 0.5'.
			C-15	Dark gray, gravel, cobbles and boulders (up to 4') with silty sand matrix. Retained 4.8'.
65				
	50/4"		20/50/4" STD PEN 16	GW/GM Very dense, dark gray, wet, silty fine to coarse sandy, GRAVEL. Massive. Retained 0.5'.
			C-17	Dark gray, gravel & cobbles (up to 4") with silty sand matrix. Retained 1.7'.
			50/5" STD PEN 18	Very dense, dark gray, wet silty, sandy GRAVEL. Massive. Retained 0.2'.
				Test boring stopped 67.9' below ground elevation.
70				*Laboratory test result reflects the finer fraction of soil observed in the field.

This is a summary Log of Test Boring. Soil/Rock descriptions are derived from visual field identifications and laboratory test data

DOT FORM 351-003A (X) REVISED 4/80

Figure A.1-37

PIEZOMETRIC DATA
TEST HOLE HQ-14-89

Pump Tests

- none completed

Water Level Readings

DATE	PIEZOMETER
05/12/89	-34.0 ft
06/15/89	-34.7 ft
11/03/89	-37.2 ft

Instrumentation Diagram

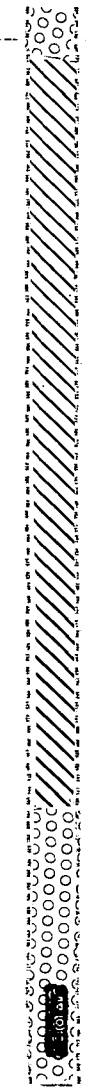

Figure A.1-38

LOG OF TEST BORING WASHINGTON STATE DEPARTMENT OF TRANSPORTATION

S.H. ____ S.R. 405 SECTION S. Renton I/C to Sunset Blvd. HOV Lanes Job No. L-7974

Hole No. HQ-13-89 Sub Section Renton Ave. S. U'Xing No. 405/17B & Wall 2B Cont. Sec. 1743

Station LN 256+42.9 Offset 46.4' Rt. Ground El. 89.7'

Type of Boring HW/HQ Wire Line Casing HW to 30' HQ to 80' W.T. El. See Piezo Data

Inspector ____ Date March 17, 1989 Sheet 1 of 4

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
				Brown, moist, organic, SILT, with same sand. No sample submitted.
5				
	4		3 STD 2 PEN 2 1 2	*SP Very loose, brown, wet, slightly silty, fine to coarse sandy GRAVEL. (Some fines may have been washed from sample.)
10				
	71		4 STD 20 PEN 51 2	*SM, M.C.=16.8% Very dense, gray , moist, very silty, fine to coarse sandy GRAVEL. (Some fines may have been washed from sample.)
15				
	40		15 STD 20 PEN 20 3	*SW/SM Dense, gray, moist, silty, fine to coarse sandy GRAVEL. (Some fines may have been washed from sample.)

DOT FORM 351-003 REVISED 12/79

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Figure A.1-39

Hole No. HQ-13-89 Sub Section Renton Ave. S. U'Xing No. 405/17B & Wall 2B Sheet 2 of 4

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
	47		17 STD 22 PEN 25 4	Dense, brown, wet, silty, gravelly, fine to coarse SAND.
25				
	28		15 STD 14 PEN 14 5	SM, M.C.=12.4% Dense, orange brown to gray, moist, gravelly, very silty, fine to medium SAND.
30				
	110/6"		110 STD PEN 6 C-7	Very dense, orange brown and gray, moist, gravelly, very silty, fine to medium SAND. (weathered sandstone). GRAVEL and COBBLES (sandstone & volcanics) Retained 1.3'
35				
	53/6"		16 STD 53 PEN 8 C-9	*SM, M.C.=10.8% Very dense, gray, moist, very silty, fine to coarse sandy GRAVEL. No recovery.
40				
	82		22 STD 40 PEN 42 10	ML, M.C.=19.5% Very hard, gray, moist SILT.
			C-11	No recovery.
45				

DOT FORM 351-003A (X) REVISED 4/80

Figure A.1-40

Hole No. HQ-13-89 Sub Section Renton Ave. S. U'Xing No. 405/17B & Wall 2B Sheet 3 of 4

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.		DESCRIPTION OF MATERIAL
	69		22 26 43	STD PEN 12	Very hard, gray, moist, SILT.
				C-13	Gray, sandy SILT. Discontinuous sand laminae, shallowly inclined. Retained 1.4'.
50					
	56/6"		24 56	STD PEN 14	No recovery.
				C-15	No recovery.
55		? ?			
	70/6"		70	STD PEN 16	ML, M.C.=15.7% Very hard, light gray, moist, SILT. (weathered sandstone)
				C-17	No recovery.
60					
				C-18	Medium light, gray, fresh, massive SANDSTONE. RQD=20% Retained 1.2'.
65		0° 70° 0°			
		70° 60° 80° 0°		C-19	Medium light gray, fresh SANDSTONE with thin silt laminae inclined 80° RQD=48%. Retained 4.7'.
70					

DOT FORM 351-003A (X) REVISED 4/80

Figure A.1-41

Hole No. HQ-13-89 Sub Section Renton Ave. S. U'Xing No. 405/17B & Wall 2B Sheet 4 of 4

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
		80°		
		80°	C-20	Medium light gray, fresh SANDSTONE with thin silt laminae inclined 80°. RQD=60% Retained 4.5'.
		30°		
		70°		
75		80°		
			C-21	No recovery.
				From 76.0' to 79.0' large quatities of coarse, sand washed up in the water return.
80				
		*	60 STD 50 PEN 2" 22	No recovery.
				Test coring stopped 80' 8" below ground elevation.
85				
				*Laboratory test result reflects the finer fraction of soil observed in the field.
				This is a summary Log of Test Boring. Soil/Rock descriptions are derived from visual field identifications and laboratory test data.

DOT FORM 351-003A (X) REVISED 4/80

Figure A.1-42

PIEZOMETRIC DATA
TEST HOLE HQ-13-89

Pump Tests

- none completed

Water Level Readings

DATE	PIEZOMETER
05/12/89	-34.0 ft
06/15/89	-34.7 ft
11/03/89	-36.2 ft

Instrumentation Diagram

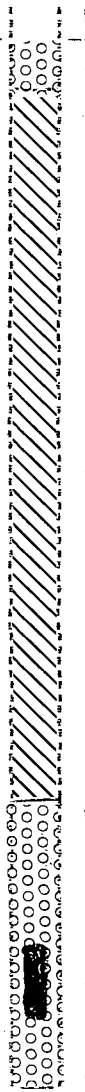

Figure A.1-43

LOG OF TEST BORING WASHINGTON STATE DEPARTMENT OF TRANSPORTATION

S.H. ____ S.R. 405 SECTION S Renton I/C to Sunset Blvd HOV Lanes Job No. L-7974

Hole No. HQ-18-89 Sub Section Renton Ave. S. U'Xing 405/17B & Wall 6 Cont. Sec. 1743

Station LN 256+22.2 Offset 93.4' Lt. Ground El. 51.0'

Type of Boring HW Advancer hq Core Casing HW x 22.0' HQ x 42.0' W.T. El. See Piezo Data

Inspector ____ Date March 14, 1989 Sheet 1 of 3

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
5	3		1 STD 2 PEN 2 1	SM, M.C.=17.6% Very loose, very dark olive gray, moist, silty, gravelly, fine to coarse SAND; gravel is sub rounded. Retained 0.6'.
10	5		2 STD 2 PEN 3 2	SM, M.C.=15.6% Loose very dark olive gray, moist, gravelly, very silty, fine to coarse SAND; gravel is sub rounded. Retained 1.2'.
15	1		0 STD 0 PEN 1 3	SM, M.C.=20.2% Very loose, very pale brown, moist, gravelly, silty, fine to coarse SAND; gravel is sub rounded. Retained 1.3'.

DOT FORM 351-003 REVISED 12/79

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Figure A.1-44

Hole No. HQ-18-89 Sub Section Renton Ave. S. U'Xing No. 405/17B & Wall 6 Sheet 2 of 3

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
	100/5"		100/5" STD PEN 5	SM, M.C.=17.5% Completely weathered SANDSTONE. (Very dense, light gray, moist, very silty fine to medium SAND.) Retained 0.4'.
			C-6	Light gray, slightly weathered, massive, silt infilled fractures, SANDSTONE. Retained 4.0'. RQD=62%
25			C-7	Light gray/greenish gray, slightly weathered to fresh, 10°-20° inclined laminae, silt infilled fractures, SANDSTONE. Retained 4.7'. RQD=76%
30			C-8	Light greenish gray, fresh, 10°-30° laminae, SANDSTONE. Retained 4.5' RQD=56%.
35			C-9	Light greenish gray, fresh, massive SANDSTONE with small Fe-stained pockets. Retained 4.5'. RQD=60%.
40			C-10	Light greenish gray/light gray/black, discontinuous organic laminae inclined 5°-15°, change to light gray at 46', fresh SANDSTONE. Retained 4.1'. RQD=20%.
45				

DOT FORM 351-003A (X) REVISED 4/80

Figure A.1-45

Hole No. HQ-18-89 Sub Section Renton Ave. S. U'Xing No. 405/17B & Wall 6 Sheet 3 of 3

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
			C-11	Light gray, light greenish gray 48'-50', discontinuous organic laminae inclined 5°, fresh SANDSTONE. Retained 4.8'. RQD=90%
50				
55				Stopped test boring 52.0' below ground elevation.
				This is a summary Log of Test Boring. Soil/Rock descriptions are derived from visual field identifications and laboratory test data.

DOT FORM 351-003A (X) REVISED 4/80

Figure A.1-46

PIEZOMETRIC DATA
TEST HOLE HQ-18-89

Pump Tests

- pump test performed in rock; overburden isolated by 22' of HW casing

- performed in HQ-sized borehole

0 min	-50.3 ft	
5 min	-47.2 ft	0.36 gal/min
10 min	-45.0 ft	0.31 gal/min
15 min	-42.5 ft	0.30 gal/min
20 min	-40.5 ft	0.29 gal/min
25 min	-38.5 ft	0.28 gal/min
30 min	-36.4 ft	0.27 gal/min

Water Level Readings

DATE	PIEZOMETER
05/12/89	-12.2 ft
11/03/89	dry

DATE	PIEZOMETER
05/12/89	-21.0 ft
11/03/89	-22.5 ft

Instrumentation Diagram

Ground Elevation : 51.0

3' cement seal

bentonite

elev 40 gravel

elev 35 2.5' slotted pvc pip

elev 33 bentonite

elev 7 gravel

elev 4 2.5' slotted pvc pipe

elev -1.0 bottom to hole

Figure A.1-47

LOG OF TEST BORING WASHINGTON STATE DEPARTMENT OF TRANSPORTATION

S.H. ____ S.R. 405 SECTION S. Renton I/C to Sunset Blvd HOV Lanes Job No. L-7974

Hole No. HQ-12-89 Sub Section ____ Cont. Sec. 1743

Station LN 256+22.6 Offset 112.9' Rt. Ground El. 105.7'

Type of Boring Wet Rotary Casing HW x 35' W.T. El. Not Determined

Inspector ____ Date March 9, 1989 Sheet 1 of 4

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
5	1 / 12"		STD	SP/SM, M.C. = 19.2%
	1		PEN	Very loose, brown, moist, gravelly, silty, fine to coarse
	1 / 12"		1	SAND with a 2" layer of organic silty gravel.
10	22		STD	GW/GM
	21		PEN	Very dense, gray and brown, moist, slightly silty, fine to
	71 / 50		2	coarse sandy GRAVEL. (Some fines may have been washed from sample.)
15	7		STD	GP
	13		PEN	Dense, gray, moist, fine to coarse sandy GRAVEL. (Some
	35 / 22		3	fines may have been washed from sample.)

DOT FORM 351-003 REVISED 12/79

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Figure A.1-48

Hole No. HQ-12-89 Sub Section S. Renton I/C to Sunset Blvd HOV Lanes Sheet 2 of 4

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
	35		12 STD 17 PEN 18 4	*SP/SM, M.C. = 15.0% Dense, gray and brown, moist, silty, fine to coarse sandy GRAVEL, with a 2" fine sand layer.
25				
	65/6"		40 STD 65 PEN 5	SM, M.C. = 11.3% Very dense, gray, moist, gravelly, very silty, fine to medium SAND.
30				
	58/6"		32 STD 58 PEN 6	Very dense, gray, moist, gravelly, very silty, fine to medium SAND.
35				
	65		10 STD 20 PEN 45 7	SM, M.C. = 12.9% Very dense, gray, moist, gravelly, very silty, fine to coarse SAND.
		0°		
		0° 20°	C-8	Light gray/yellowish brown/black, continuous organic laminae inclined 10°-20°, moderately to highly weathered, smooth fractures, SANDSTONE. RQD = 0%. Retained 2.4'.
40		20° 20° 20° 0° 15° 20° 20°		
			C-9	Light gray/yellowish brown, moderately weathered to fresh, several sandy silt laminae inclined 5°-10°, SANDSTONE. RQD = 60%. Retained 4.5'.
45				

DOT FORM 351-003A (X) REVISED 4/80

Figure A.1-49

Hole No. HQ-12-89 Sub Section S. Renton I/C to Sunset Blvd HOV Lanes Sheet 3 of 4

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
		20° 10° 0° 0° 30° 30° 30°	C-10	Light to medium gray, 8" mudstone bed inclined 5°-10° at 45', fresh, trace discontinuous organic laminae SANDSTONE. RQD = 50%. Retained 3.4'.
50				
		0° 0° 0° 0° 0°	C-11	Light to medium gray/black, discontinuous mudstone and organic laminae inclined 5°-10°, fresh SANDSTONE. RQD = 82%. Retained 5.1'.
55		70° 70°	C-12	Light gray/black, discontinuous organic laminae inclined 30°, one steeply inclined, smooth fracture (no infilling) SANDSTONE. RQD = 50%. Retained 5.0'.
60		0° 0° 0° 0° 0° 0° 0° 0°		
		0° 0° 0° 0° 30° 0° 0° 70° 0°	C-13	Light gray/black, discontinuous organic laminae inclined 30°, one steeply inclined, smooth fracture with silt infilling, fresh SANDSTONE. RQD = 63%. Retained 4.8'.
65		0° 70° 0° 0°	C-14	Light gray, massive, fresh, SANDSTONE. RQD = 80%. Retained 4.6'.
70				

DOT FORM 351-003A (X) REVISED 4/80

Figure A.1-50

Hole No. HQ-12-89 Sub Section S. Renton I/C to Sunset Blvd HOV Lanes Sheet 4 of 4

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
			C-15	Light gray, massive, fresh, SANDSTONE. RQD = 30%. Retained 4.0'.
75			C-16	Light gray, one organic and one mudstone laminae inclined 10°-20°, fresh SANDSTONE. RQD = 81%. Retained 4.8'.
80			C-17	Light gray, one organic discontinuous laminae, fresh SANDSTONE. RQD = 72%. Retained 5.2'.
85			C-18	Light gray, several discontinuous laminae, fresh SANDSTONE. RQD = 60%. Retained 5.0'.
90				Stopped test boring 90.0' below ground elevation.
				*Laboratory test result reflects the finer fraction of soil observed in the field.
				This is a summary Log of Test Boring. Soil/Rock descriptions are derived from visual field identifications and laboratory test data.

DOT FORM 351-003A (X) REVISED 4/80

Figure A.1-51

LOG OF TEST BORING WASHINGTON STATE DEPARTMENT OF TRANSPORTATION

S.H. ____ S.R. 405 SECTION S. Renton I/C to Sunset Blvd. HOV Lanes Job No. L-7974

Hole No. HQ-15-89 Sub Section Cedar R. & BNRR OC Br. #405/18 and Wall 3 Cont. Sec. 1743

Station LN 257+29.6 Offset 19.6' Lt. Ground El. 49.4'

Type of Boring HW/HQ Wireline Casing ____ W.T. El. Not determined

Inspector ____ Date March 3, 1989 Sheet 1 of 3

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
	42		14 STD 20 PEN 22 1	*~~SP~~ GP Dense, brown, moist, slightly silty, fine to coarse sandy GRAVEL.
5				
		? ?		
			8 STD 9 PEN 15 2	SM, M.C.=14.3% Medium dense, yellowish brown, completely weathered, SANDSTONE. (Moist, very silty, fine to medium SAND)
10	24			
			C-3	Yellowish brown, massive, SAND. Retained 2.5'.
15				
			C-4	Yellowish brown to gray, massive, SAND. Retained 3.9'.
		? ?		

DOT FORM 351-003 REVISED 12/79

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Figure A.1-52

Hole No. HQ-15-89 Sub Section Cedar R. & BNRR OC Br. #405/18 and Wall 3 Sheet 2 of 3

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
			C-5	Medium gray, greenish gray, highly fractured, CONGLOMERATE; fresh. Retained 4.7'. RQD=20%
25			C-6	Medium gray/greenish gray, fresh, highly fractured, CONGLOMERATE with 1.0' interbed of foreign cobbles Retained 3.5'. RQD=5%
30			C-7	Greenish gray/medium gray, sandy SILTSTONE with foreign gravel; highly fractured; fresh. Retained 3.0'. RQD=0%
35			C-8	Medium gray, highly fractured, fresh, CONGLOMERATE. Retained 4.5'. RQD=0%
40			C-9	Medium gray, highly fractured, silty SANDSTONE. Retained 2.9' RQD=0%
45				

DOT FORM 351-003A (X) REVISED 4/80

Figure A.1-53

Hole No. HQ-15-89 Sub Section Cedar R & BNRR OC Br. # 405/18 and Wall 3 Sheet 3 of 3

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
			C-10	Medium gray, highly fractured, fresh silty SANDSTONE. Retained 5.5'. RQD=0%
50				
				Test coring stopped 49.5' below ground elevation.
				*Laboratory test result reflects the finer fraction of soil observed in the field.
				This is a summary Log of Test Boring. Soil/Rock descriptions are derived from visual field identifications and laboratory test data.

DOT FORM 351-003A (X) REVISED 4/80

Figure A.1-54

LOG OF TEST BORING WASHINGTON STATE DEPARTMENT OF TRANSPORTATION

S.H. ____ S.R. 405 SECTION South Renton I/C To Sunset Blvd. HOV Lanes Job No. L-7974

Hole No. D-11-89 Sub Section Wall 6 Cont. Sec. 1743

Station LN 254+96.3 Offset 198.5' Lt. Ground El. 46.4'

Type of Boring HW/HQ Wire Line Casing HQ to 40' W.T. El. 36.0'

Inspector ____ Date February 28, 1989 Sheet 1 of 2

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
			6 STD	SM, M.C.=15.4%
5	30		14 PEN	Dense, yellowish, orange brown, moist, very silty,
			16 1	fine to medium SAND
			13 STD	SM, M.C.=12.6%
10	33		16 PEN	Dense, yellowish, orange brown, moist gravelly, very
			17 2	silty, fine to medium SAND
			C-3	No recovery.
15			C-4	Yellowish orange, brown, discontinuous organic laminae, highly to completely weathered SANDSTONE. RQD=90% Retained 4.5'.
20				

DOT FORM 351-003 REVISED 12/79

Original to Materials Engineer
Copy to Bridge Engineer
Copy to District Administrator

Copy to ____

Figure A.1-55

Hole No. D-11-89 Sub Section Wall 6 Sheet 2 of 2

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
			C-5	Yellowish orange brown, discontinuous organic laminae, slightly weathered SANDSTONE. RQD=74% Retained 4.3'.
		0° 0° 0°		
		20°		
		45° 35°		
25				
		0° 0°	C-6	Light gray, continuous organic laminae inclined 15°, fresh SANDSTONE. Several 2"-3" mudstone beds at 27'. RQD=80% Retained 4.0'.
		0° 0°		
		0°		
		0°		
		0°		
		0°		
30				
			C-7	Light gray, mudstone laminae inclined 5°, fresh SANDSTONE. RQD=92% Retained 5'0'.
35				
			C-8	Light gray, stratified inclined 5°, fresh SANDSTONE. Retained 5'0'. RQD=90%
40				
				Test coring stopped 40' below ground elevation.
				This is a summary Log of Test Boring. Soil/Rock descriptions are derived from visual field identifications and laboratory test data.

DOT FORM 351-003A (X) REVISED 4/80

Figure A.1-56

LOG OF TEST BORING WASHINGTON STATE DEPARTMENT OF TRANSPORTATION

S.H. ____ S.R. 405 SECTION S. Renton to Sunset Blvd. H.O.V. Job No. L-7974

Hole No. 6 Sub Section ____ Cont. Sec. 1743

Station 255+36 L^N Line Offset 75.0' Rt. ℄ Ground El. 97.9'

Type of Boring Augers, coring, tri-cone Casing 23.0' x 4.0" W.T. El. Not encountered

Inspector ____ Date February 18 - 21, 1986 Sheet 1 of 3

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
				ACP Brown, moist, silty, fine to coarse sandy GRAVEL with cobbles (Fill)
			4 STD	SM, M.C. = 10.6%
	30		11 PEN	Dense, brown, moist, gravelly, very silty, fine to medium SAND.
			19 1 21	Retained 0.8'.
5				
	10		2 STD 5 PEN	SM, M.C. = 15.2% Loose, brown, moist, gravelly, very silty, fine to coarse SAND.
			5 2 7	Retained 0.4'.
10				
	22		2 STD 2 PEN	SP/SM, M.C. = 8.3% Medium dense, brown, dry, gravelly, silty, fine to coarse SAND.
			20 3 24	Retained 0.6'.
15				
	58		16 STD 28 PEN	Very dense, brown, dry, gravelly, silty, fine to coarse SAND.
			30 4	Retained 0.7'.

DOT FORM 351-003 REVISED 12/79

Original to Materials Engineer
Copy to Bridge Engineer
Copy to District Administrator

Copy to ____

Figure A.1-57

Hole No. 6 Sub Section S. Renton to Sunset Blvd. H.O.V. Sheet 2 of 3

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
	69		8 STD 29 PEN 40 5	SM, M.C. = 11.2% Very dense, red-brown, moist, gravelly, very silty, fine to medium SAND. (Weathered SANDSTONE). Retained 1.5'.
25				
	169/11"		26 STD 69 PEN 100/5" 6	SM, M.C. = 7.2% Very dense, brown, dry, gravelly, very silty, fine to medium SAND with cobbles. Retained 1.1'.
30				
	100/5"		45 STD 100/5" PEN 7	SM, M.C. = 3.3% Very dense, tan, dry, gravelly, silty, fine to coarse SAND with cobbles. Retained 0.9'.
35				
	100/4"		100/4" STD PEN 8	Very dense, tan, dry, silty, fine to coarse SAND. (Visual I.D. only - small sample). Retained 0.3'.
40				
	100/4"		100/4" STD PEN 9 C- 1	No recovery. Light tan to white SANDSTONE. Retained 2.7'. RQD = 64%, F.S. (Fracture Spacing) = 5".
45				

DOT FORM 351-003A (X) REVISED 4/80

Figure A.1-58

Hole No. 6 Sub Section S. Renton to Sunset Blvd. H.O.V. Sheet 3 of 3

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
	100/4"		100/4" STD PEN 10	SM, M.C. = 26.4% Very dense, gray, moist, silty, fine to medium SAND. (Sandstone) Retained 0.3'.
				Light tan to white SANDSTONE. Retained 3.3'.
50				End of boring 50.0' below ground elevation.
				This is a summary Log of Test Boring. Soil/Rock descriptions are derived from visual field identifications and laboratory test data.

DOT FORM 351-003A (X) REVISED 4/80

Figure A.1-59

LOG OF TEST BORING WASHINGTON STATE DEPARTMENT OF TRANSPORTATION

S.H. ____ S.R. 405 SECTION S. Renton - I/C to Sunset Blvd. HOV Lanes Job No. L-7974

Hole No. TH-3 Sub Section ____ Cont. Sec. 1743

Station LN 256+38 Offset 140' Lt. Ground El. 47.8'

Type of Boring Wash & Rotary Casing 22' W.T. El. Not encountered

Inspector ____ Date May 12, 1959 Sheet 1 of 2

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
				Fill - Brown and black SAND and GRAVEL; edge of road.
5				
	4		3 STD 2 PEN 2 1 4	Soft, brown, slightly fine sandy SILT.
			U-2	Brown, very fine and fine SAND.
10				
				Coarser SAND at 13.0' - quite clean.
15				
	17		12 STD 9 PEN 8 3 7	No recovery.
20				

DOT FORM 351-003 REVISED 12/79

Original to Materials Engineer
Copy to Bridge Engineer
Copy to District Administrator

Copy to ____

Figure A.1-60

Hole No. TH-3 Sub Section _____ Sheet 2 of 2

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
			23 STD	
	55/6"		55 PEN 4	Very dense, decomposed, brownish SANDSTONE.
			C-5	
25				Gray SANDSTONE.
				Total depth drilled 28.5' below ground elevation.
30				Lost water intermittently to 21.0'
				Soil/Rock descriptions are based on field observations.

DOT FORM 351-003A (X) REVISED 4/80

Figure A.1-61

Appendix B
Laboratory Test Results

Job No. **XL-4653** Date **May 7, 2018**

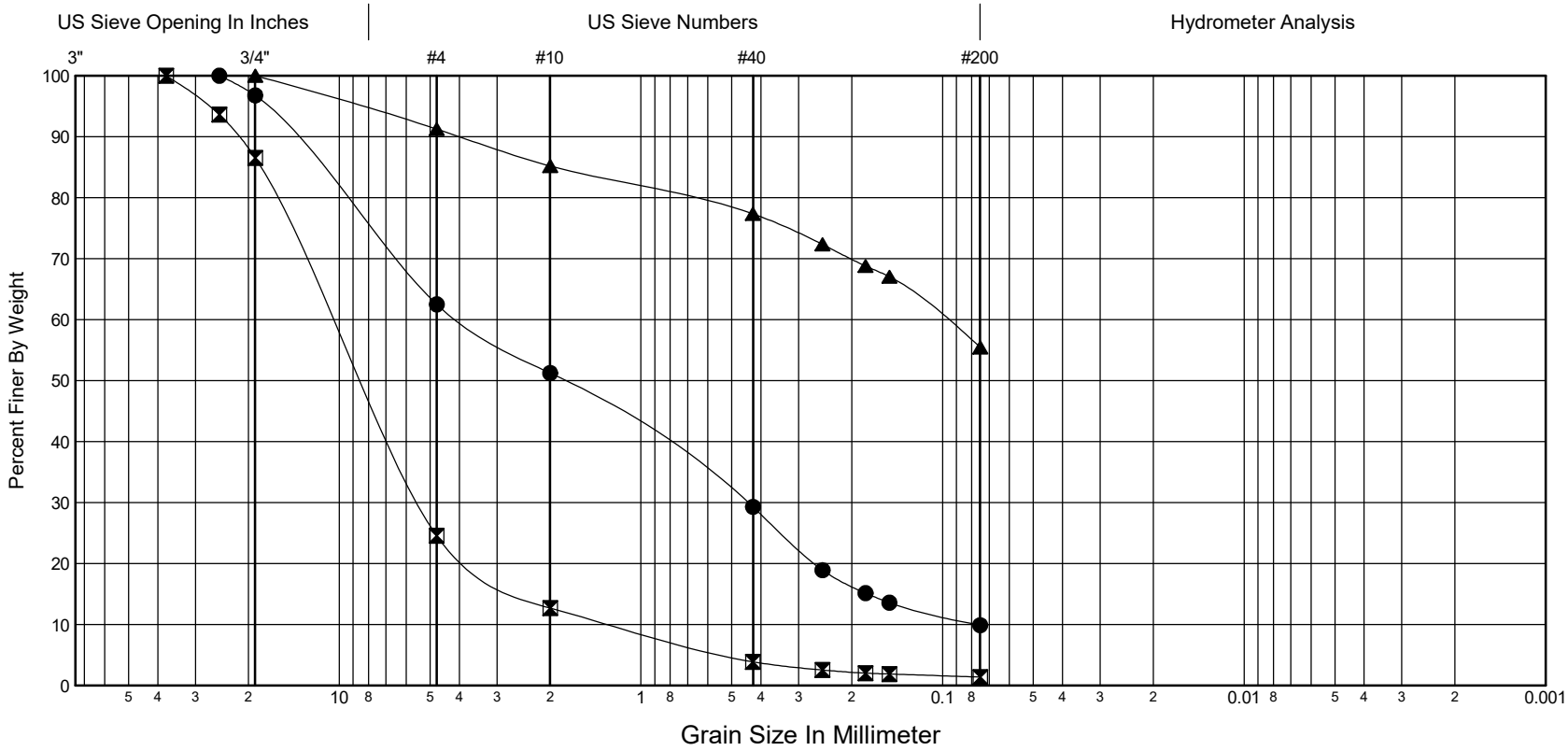
Hole No. **R2B-03-17** Sheet **1**

Project **I-405 Renton to Bellevue - ETL - Envir & Traff**

Laboratory Summary

WSDOT

	Depth (ft)	Sample No.	USCS	Description	MC%	LL	PL	PI	Moist Density (lbs/ft^3)	Specific Gravity	Gravel (%)	Sand (%)	Fines (%)	Cc	Cu	D60	D50	D30	D20	D10
●	9.0	D-4		MC & Sieve Only	8						37.5	52.6	9.9	0.7	51.2	3.920	1.83	0.45	0.26	0.077
⊠	19.0	D-6	GW	WELL-GRADED GRAVEL with SAND	6						75.4	23.2	1.4	2.2	8.4	10.494	8.39	5.36	3.41	1.246
▲	44.0	D-11	CL-ML	SANDY SILTY CLAY	15	25	19	6			8.8	35.8	55.5			0.098				



Gravel	Sand			Silt			Clay
	Coarse	Medium	Fine	Coarse	Medium	Fine	

XL-5467 (OLD XL-4653) 405 RENTON TO BELLEVUE ETL - ENVIRO AND TRAFF.GPJ PUBLIC-COMMON LIBRARY.GLB 5/7/18

Figure B.1-1

SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

JOB NO.: L-7974

SAMPLE NO.: E-9034-1

HOLE NO.: HQ-83-90

DATE: 09-11-90

LAB. TECH.: P.A.A.

SIEVE ANALYSIS

DRY WT.: 47.7g.

WET WT.: 55.0g.

% H_2O: 15.3%

WT. OF SAMPLE: 273.2g.

	WT.	% PASS
-1½"	72.8g.	100.0
-1"	14.5g.	73.4
-¾"	53.2g.	68.0
-#4	27.6g.	48.6
-#10	42.9g.	38.5
-#40	43.4g.	22.8
-#200	18.8g.	6.9

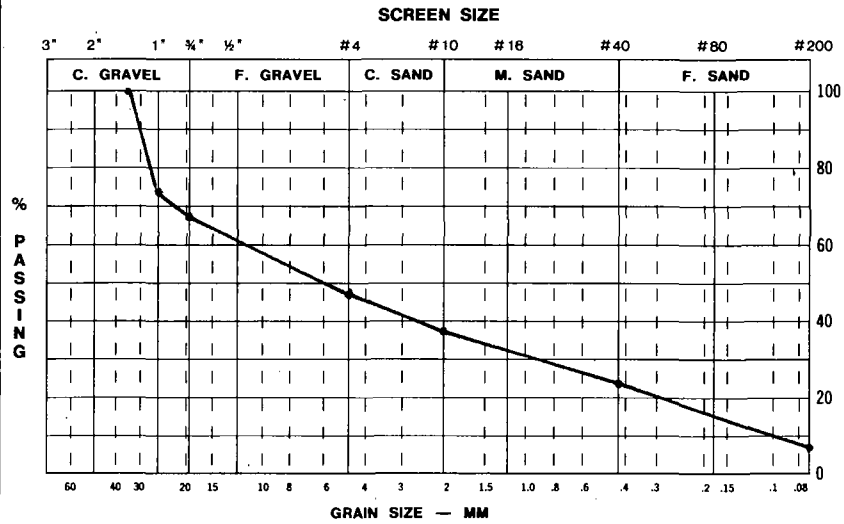
SAMPLE DESCRIPTION

CLASS. GP-GM WEAK RED TO REDDISH BLACK, MOIST, ~~SLIGHTLY~~ SILTY, FINE TO COARSE SANDY GRAVEL

SOIL FIELD IDENTIFICATION

TEST	GRAVEL	SAND	SILT	CLAY
VISUAL	✓	✓	✓	
DRIED CAST				
DILITANCY				
BITE				
TOUGHNESS				

GRAIN SIZE CURVE



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=

PLASTICITY CHART

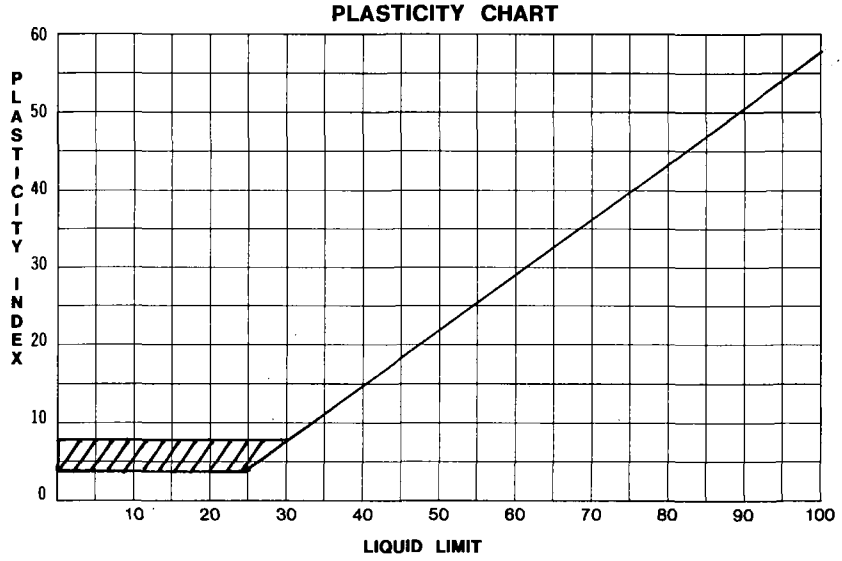


Figure B.1-2

SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

JOB NO.: L-7974

SAMPLE NO.: E-9034-5

HOLE NO.: HQ-83-90

DATE: 09-11-90

LAB. TECH.: P.A.A.

SIEVE ANALYSIS

DRY WT.: 96.8g.

WET WT.: 101.0g.

% H_2O: 4.3%

WT. OF SAMPLE: 636.0g.

	WT.	% PASS
-1½"	26.2g.	100.0
-1"	26.7g.	95.9
-¾"	243.3g.	91.7
-#4	129.5g.	53.4
-#10	85.6g.	33.1
-#40	97.1g.	19.6
-#200	27.6g.	4.3

SAMPLE DESCRIPTION

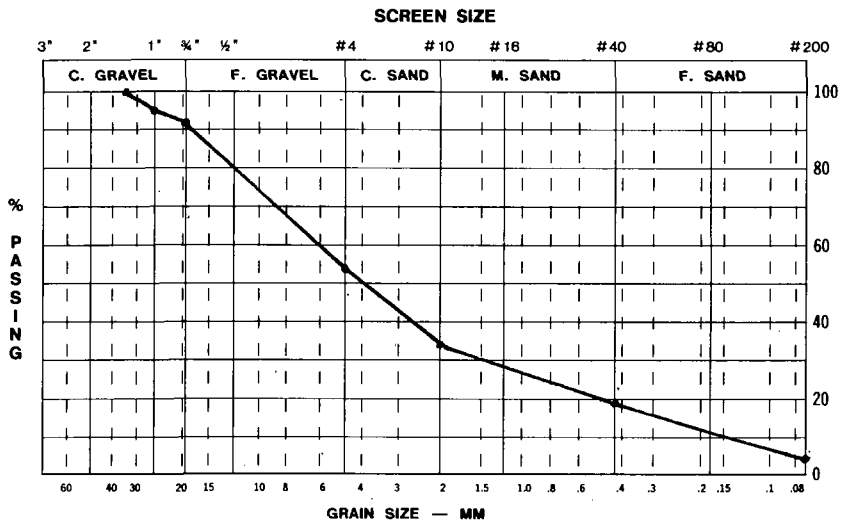
CLASS. SW

DARK GRAYISH BROWN, DRY, SLIGHTLY SILTY, GRAVELLY, FINE TO COARSE SAND

SOIL FIELD IDENTIFICATION

TEST	GRAVEL	SAND	SILT	CLAY
VISUAL	✓	✓	✓	
DRIED CAST				
DILITANCY				
BITE				
TOUGHNESS				

GRAIN SIZE CURVE



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=

PLASTICITY CHART

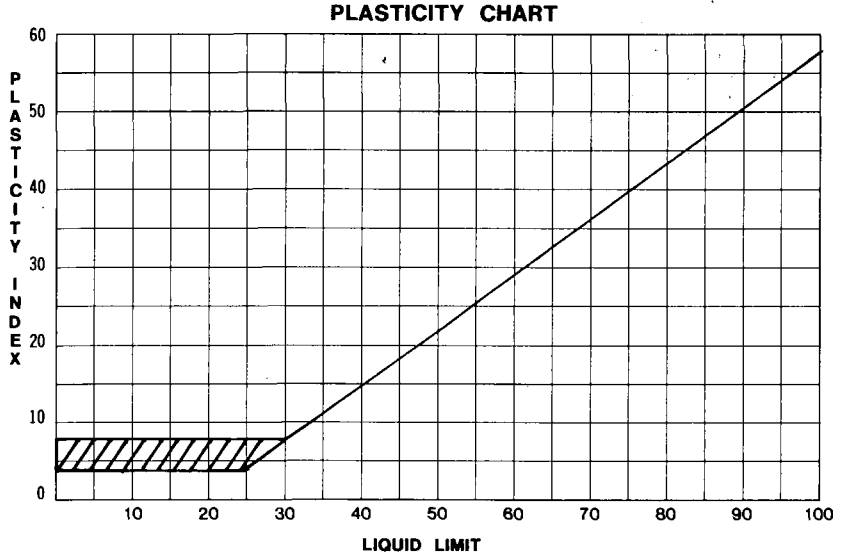


Figure B.1-3

SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

JOB NO.: L-7974

SAMPLE NO.: E-9034-6

HOLE NO.: HQ-83-90

DATE: 09-11-90

LAB. TECH.: P.A.A.

SIEVE ANALYSIS

DRY WT.: 41.1g.

WET WT.: 44.0g.

% H_2O: 7.1%

WT. OF SAMPLE: 604.4g.

	WT.	% PASS
-1½"	111.2g.	100.0
-1"	84.6g	81.6
-¾"	190.8g.	67.6
-#4	60.1g.	36.0
-#10	66.0g.	26.1
-#40	67.9g.	15.2
-#200	23.8g.	3.9

SAMPLE DESCRIPTION

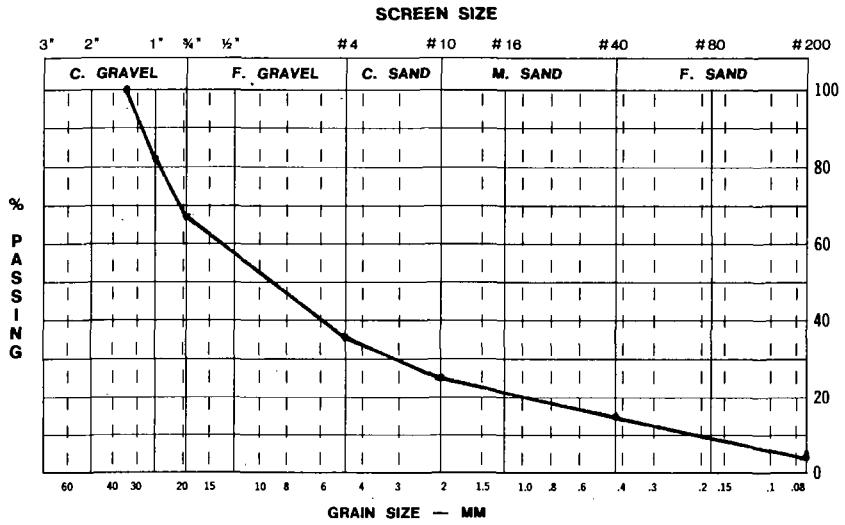
CLASS. GP

DARK GRAYISH BROWN, DRY, SLIGHTLY SILTY, FINE TO COARSE SANDY GRAVEL

SOIL FIELD IDENTIFICATION

TEST	GRAVEL	SAND	SILT	CLAY
VISUAL	✓	✓	✓	
DRIED CAST				
DILITANCY				
BITE				
TOUGHNESS				

GRAIN SIZE CURVE



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=

PLASTICITY CHART

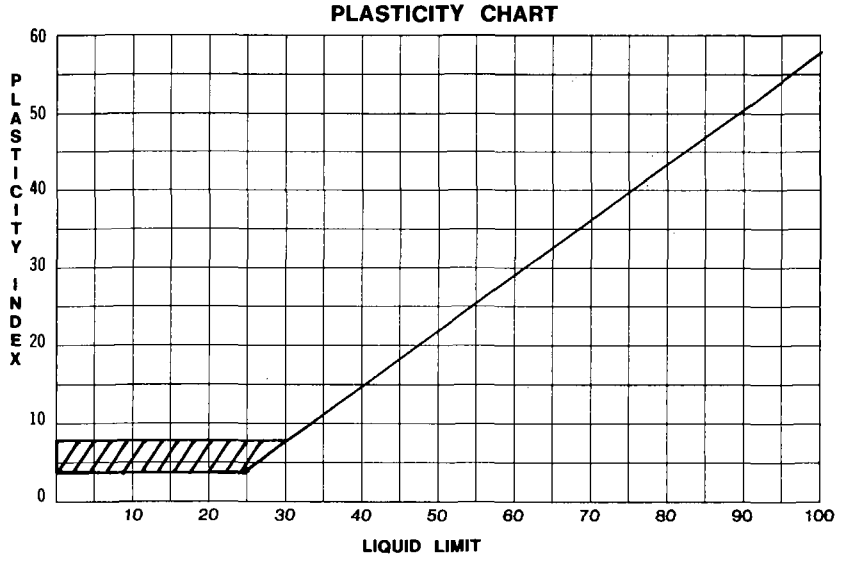


Figure B.1-4

SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

JOB NO.: L-7974

SAMPLE NO.: E-9034-11

HOLE NO.: HQ-83-90

DATE: 09-11-90

LAB. TECH.: P.A.A.

SIEVE ANALYSIS

DRY WT.: 73.6g.

WET WT.: 84.8g.

% H_2O: 15.2%

WT. OF SAMPLE: 620.3g.

	WT.	% PASS
-1½"	Ø	100.0
-1"	56.3g.	100.0
-¾"	138.0g.	90.9
-#4	78.2g.	68.7
-#10	118.4g.	56.1
-#40	148.0g.	37.0
-#200	81.4g.	13.1

SAMPLE DESCRIPTION

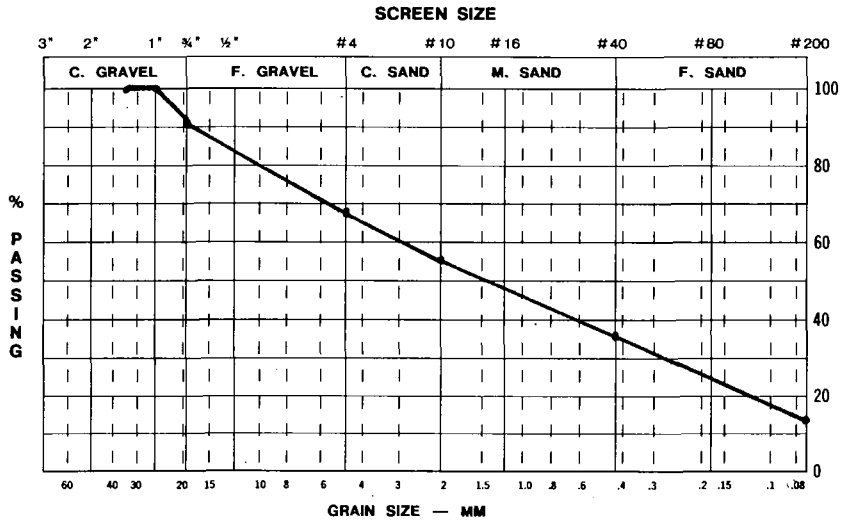
CLASS. SM

DARK BROWN TO STRONG BROWN, MOIST, SILTY, GRAVELLY, FINE TO COARSE SAND

SOIL FIELD IDENTIFICATION

TEST	GRAVEL	SAND	SILT	CLAY
VISUAL	✓	✓	✓	
DRIED CAST				
DILITANCY				
BITE				
TOUGHNESS				

GRAIN SIZE CURVE



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=

PLASTICITY CHART

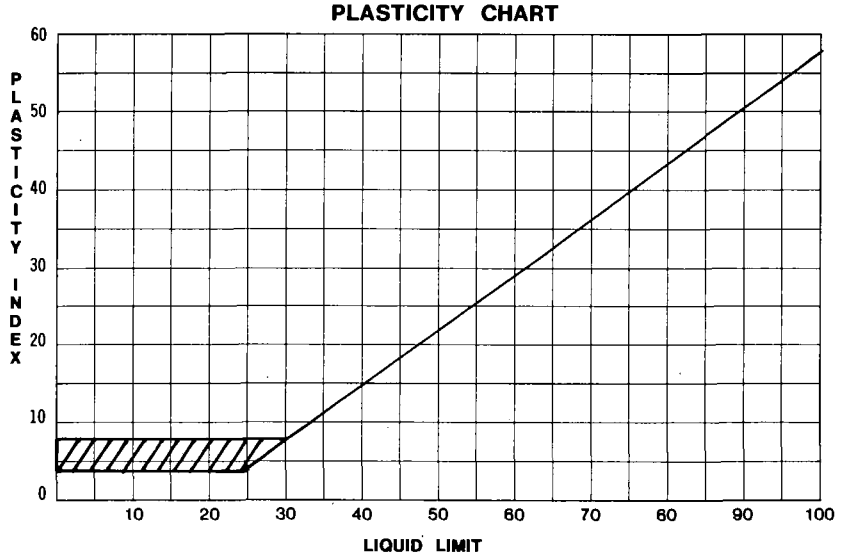


Figure B.1-5

SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

JOB NO.:	L-7974
SAMPLE NO.:	E-8998-1
HOLE NO.:	HQ-81-90
DATE:	09-11-90
LAB. TECH.:	P.A.A.

SIEVE ANALYSIS

DRY WT.:	63.3g.
WET WT.:	68.4g.
% H_2O:	7.9%
WT. OF SAMPLE:	372.0g.

	WT.	% PASS
-1½"	28.3g.	100.0
-1"	46.1g.	92.4
-¾"	100.2g.	80.0
-#4	35.8g.	53.1
-#10	72.1g.	43.4
-#40	64.2g.	24.1
-#200	25.3g.	6.8

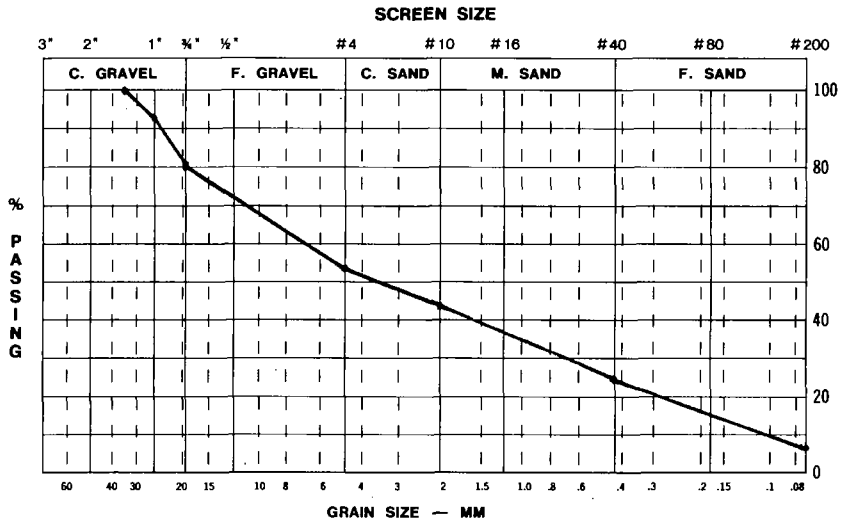
SAMPLE DESCRIPTION

CLASS. GP-GM VERY DARK GRAYISH BROWN, DRY, SILTY, FINE TO COARSE SANDY GRAVEL

SOIL FIELD IDENTIFICATION

TEST	GRAVEL	SAND	SILT	CLAY
VISUAL	✓	✓	✓	
DRIED CAST				
DILITANCY				
BITE				
TOUGHNESS				

GRAIN SIZE CURVE



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=

PLASTICITY CHART

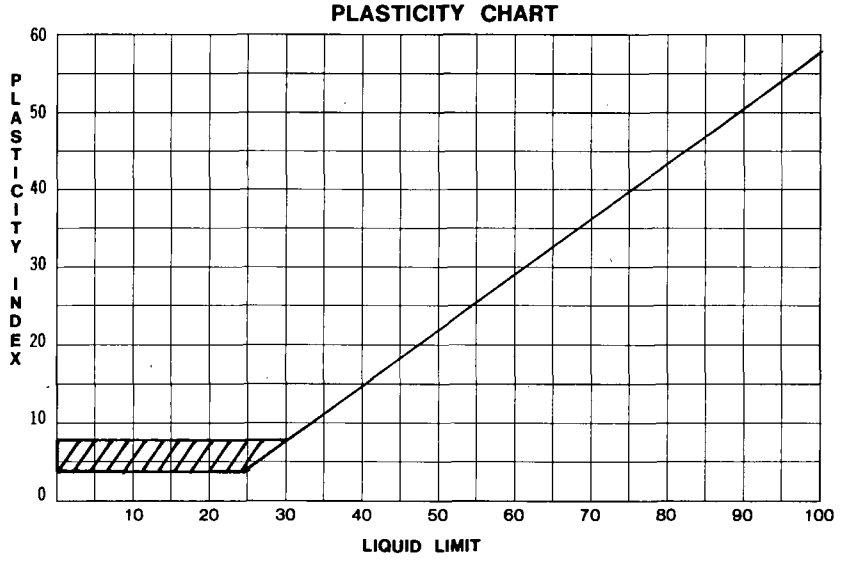


Figure B.1-6

SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

JOB NO.: L-7974

SAMPLE NO.: E-8998-7

HOLE NO.: HQ-81-90

DATE: 09-11-90

LAB. TECH.: P.A.A.

SIEVE ANALYSIS

DRY WT.: 68.2g.

WET WT.: 71.0g.

% H_2O: 4.1%

WT. OF SAMPLE: 238.8g.

	WT.	% PASS
-1½"	Ø	100.0
-1"	Ø	100.0
-¾"	64.7g.	100.0
-#4	25.5g.	72.9
-#10	72.5g.	62.2
-#40	65.7g.	31.9
-#200	10.4g.	4.4

SAMPLE DESCRIPTION

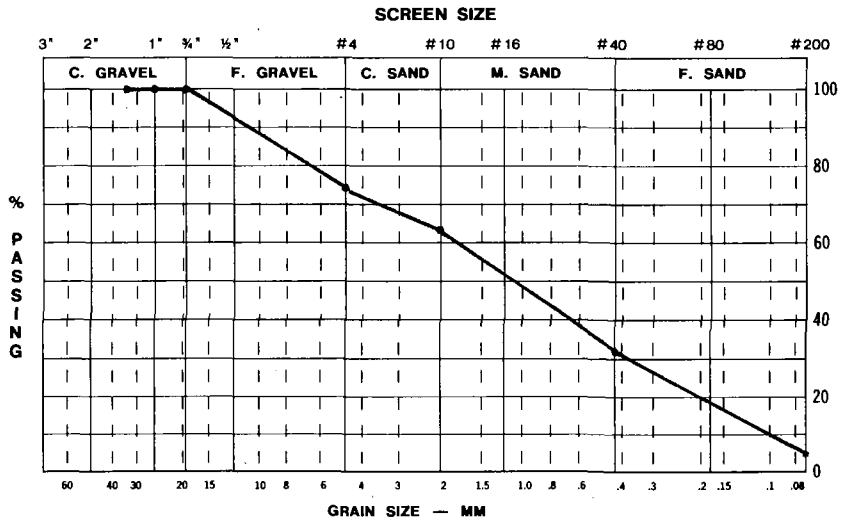
CLASS. SP

OLIVE, DRY, SLIGHTLY SILTY, GRAVELLY, FINE TO COARSE SAND

SOIL FIELD IDENTIFICATION

TEST	GRAVEL	SAND	SILT	CLAY
VISUAL	✓	✓	✓	
DRIED CAST				
DILITANCY				
BITE				
TOUGHNESS				

GRAIN SIZE CURVE



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=

PLASTICITY CHART

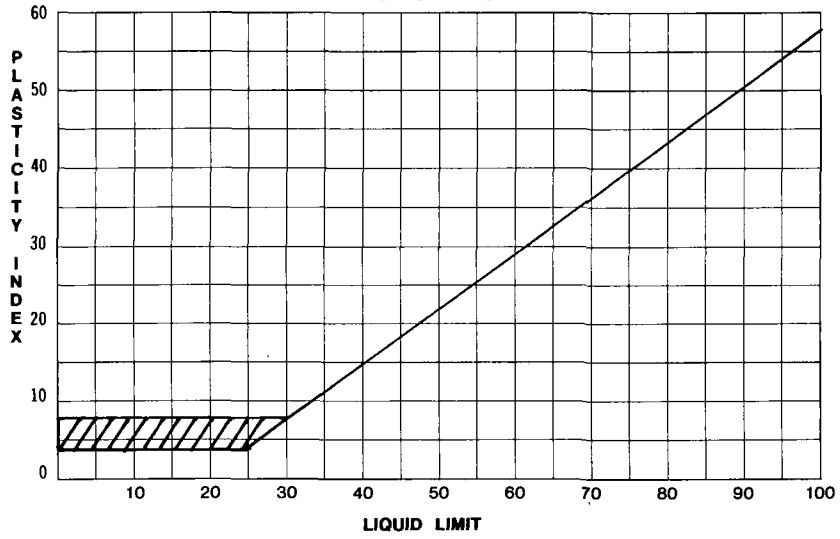


Figure B.1-7

SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

JOB NO.: L-7974

SAMPLE NO.: E-8998-9

HOLE NO.: HQ-81-90

DATE: 09-11-90

LAB. TECH.: P.A.A.

SIEVE ANALYSIS

DRY WT.: 67.0g.

WET WT.: 75.1g.

% H_2O: 12.1%

WT. OF SAMPLE: 484.5g.

	WT.	% PASS
-1½"	Ø	100.0
-1"	Ø	100.0
-¾"	Ø	100.0
-#4	Ø	100.0
-#10	31.5g.	100.0
-#40	346.2g.	93.5
-#200	106.8g.	22.0

SAMPLE DESCRIPTION

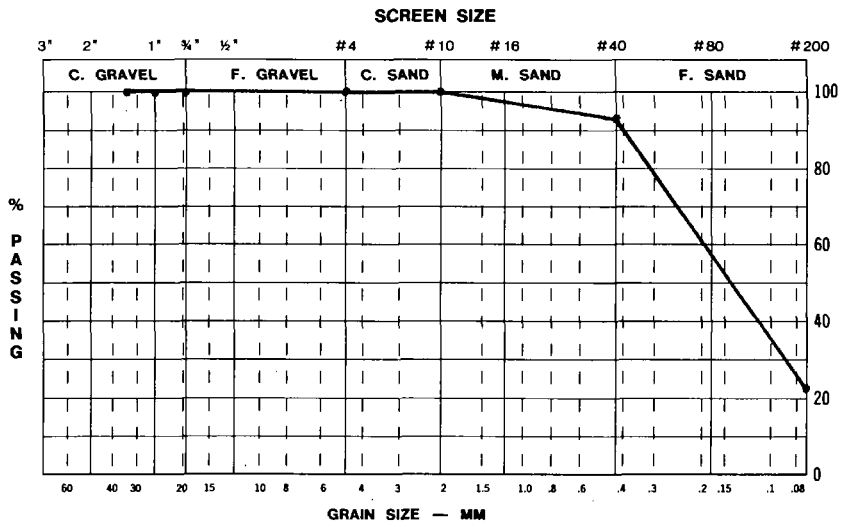
CLASS. SM

OLIVE YELLOW, MOIST, VERY SILTY, FINE TO MEDIUM SAND

SOIL FIELD IDENTIFICATION

TEST	GRAVEL	SAND	SILT	CLAY
VISUAL		✓	✓	
DRIED CAST				
DILITANCY				
BITE				
TOUGHNESS				

GRAIN SIZE CURVE



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=

PLASTICITY CHART

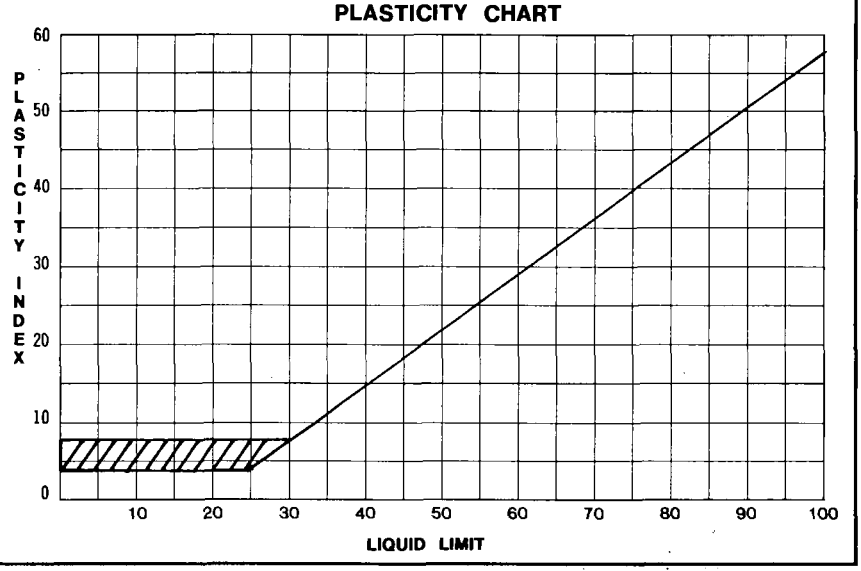


Figure B.1-8

SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

JOB NO.: L-7974

SAMPLE NO.: E-8998-11

HOLE NO.: HQ-81-90

DATE: 9-11-90

LAB. TECH.: P.A.A.

SOIL FIELD IDENTIFICATION

TEST	GRAVEL	SAND	SILT	CLAY
VISUAL	✓	✓	✓	
DRIED CAST				
DILITANCY				
BITE				
TOUGHNESS				

SIEVE ANALYSIS

DRY WT.: 52.5g.

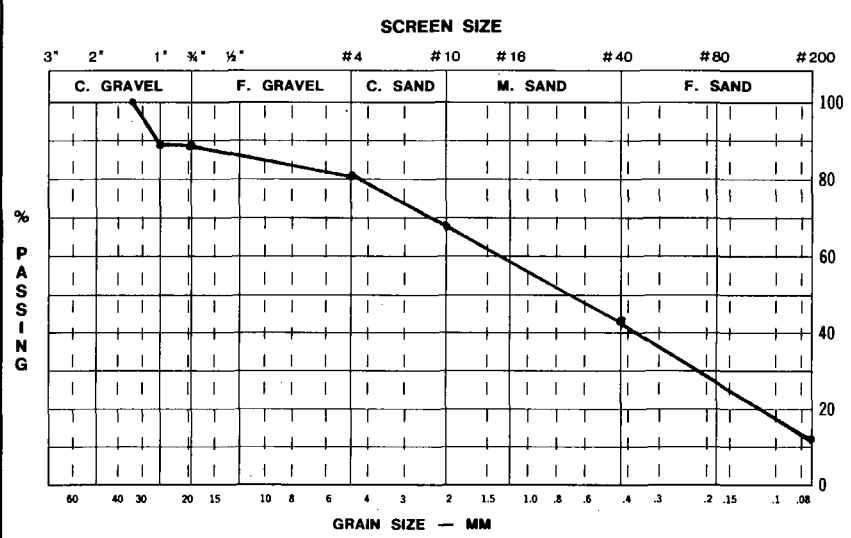
WET WT.: 59.2g.

% H_2O: 12.8%

WT. OF SAMPLE: 377.9g.

	WT.	% PASS
-1½"	39.2g.	100.0
-1"	Ø	89.6
-¾"	35.1g.	89.6
-#4	46.7g.	80.3
-#10	92.0g.	68.0
-#40	120.6g.	43.6
-#200	44.3g.	11.7

GRAIN SIZE CURVE



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=

SAMPLE DESCRIPTION

CLASS. SP-SM GREY, MOIST, SILTY, GRAVELLY, FINE TO COARSE SAND

PLASTICITY CHART

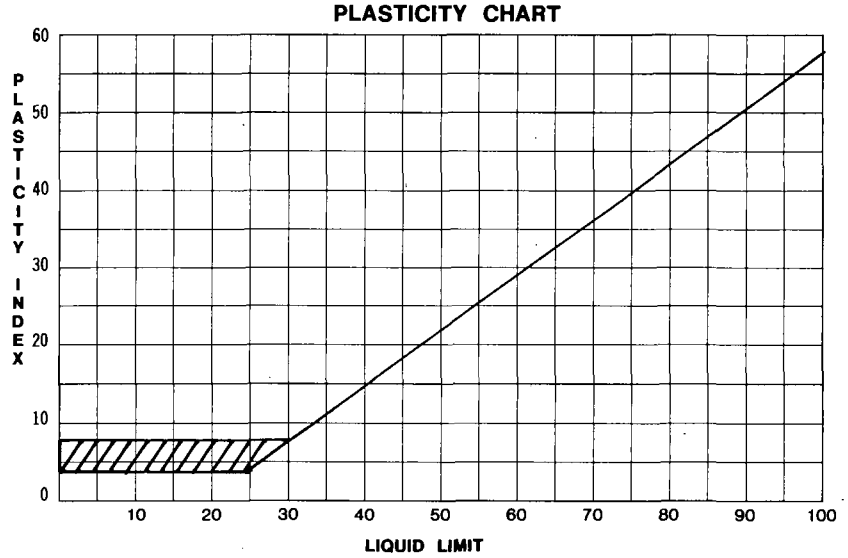


Figure B.1-9

SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

JOB NO.: L-7974

SAMPLE NO.: E-8998-14

HOLE NO.: HQ-81-90

DATE: 09-11-90

LAB. TECH.: PAA

SIEVE ANALYSIS

DRY WT.: 57.4g.

WET WT.: 70.0g.

% H_2O: 22.0%

WT. OF SAMPLE: 444.4g.

	WT.	% PASS
-1½"	63.8g.	100.0
-1"	Ø	85.6
-¾"	69.1g.	85.6
-#4	53.7g.	70.1
-#10	95.5g.	58.0
-#40	119.8g.	36.5
-#200	42.5g.	9.6

SAMPLE DESCRIPTION

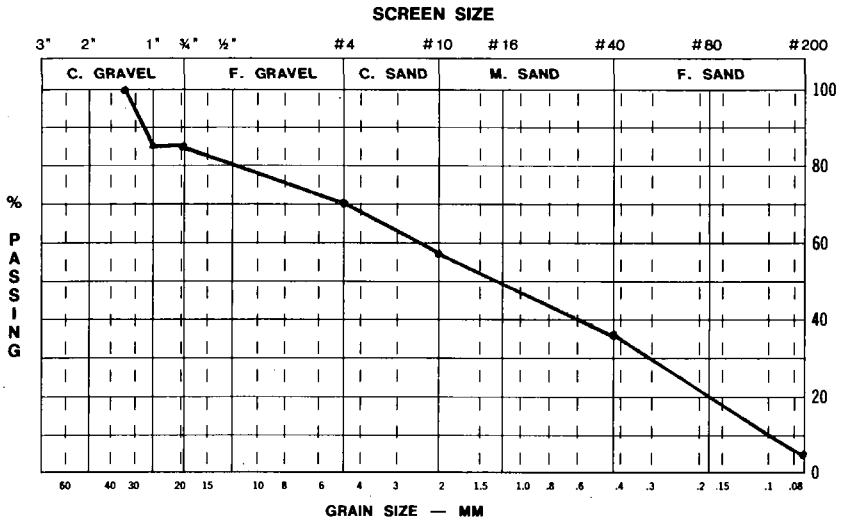
CLASS. SP-SM

DARK GREENISH GRAY, MOIST, SILTY, GRAVELLY, FINE TO COARSE SAND

SOIL FIELD IDENTIFICATION

TEST	GRAVEL	SAND	SILT	CLAY
VISUAL	✓	✓	✓	
DRIED CAST				
DILITANCY				
BITE				
TOUGHNESS				

GRAIN SIZE CURVE



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=

PLASTICITY CHART

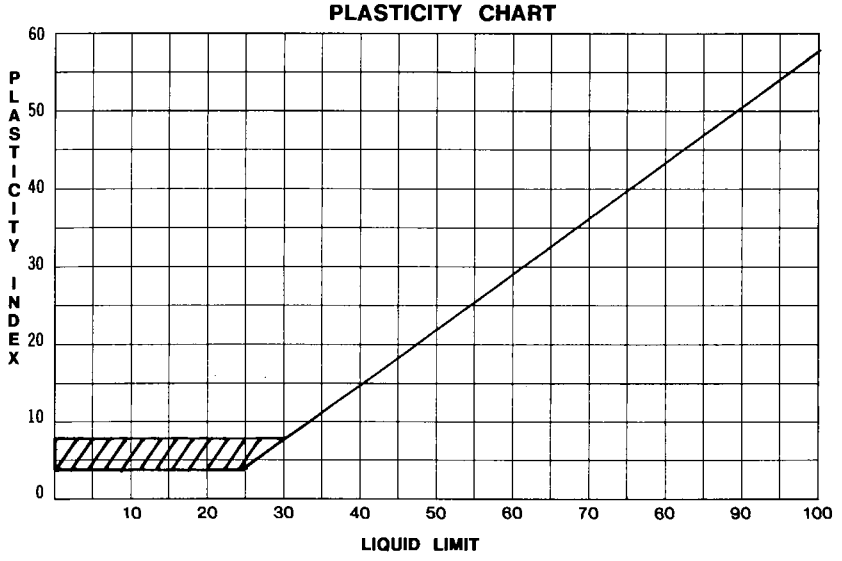


Figure B.1-10

SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

JOB NO.: L-7974

SAMPLE NO.: E-8911-2

HOLE NO.: HE-8-90

DATE: 5-30-90

LAB. TECH.: P.A.A.

SIEVE ANALYSIS

DRY WT.: 74.4g.

WET WT.: 82.4g.

% H_2O: 10.8%

WT. OF SAMPLE: 424.7g.

	WT.	% PASS
-1½"	Ø	100.0
-1"	Ø	100.0
-¾"	31.8g.	100.0
-#4	16.7g.	92.5
-#10	98.9g.	88.6
-#40	202.7g.	65.3
-#200	74.6g.	17.6

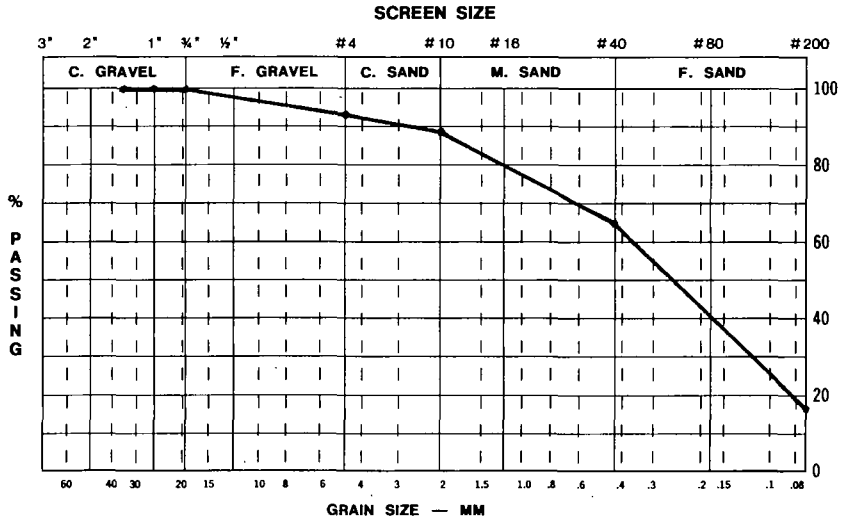
SAMPLE DESCRIPTION

CLASS. SM BROWN, MOIST, GRAVELLY, SILTY, FINE TO COARSE SAND

SOIL FIELD IDENTIFICATION

TEST	GRAVEL	SAND	SILT	CLAY
VISUAL	✓	✓	✓	
DRIED CAST				
DILITANCY				
BITE				
TOUGHNESS				

GRAIN SIZE CURVE



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=

PLASTICITY CHART

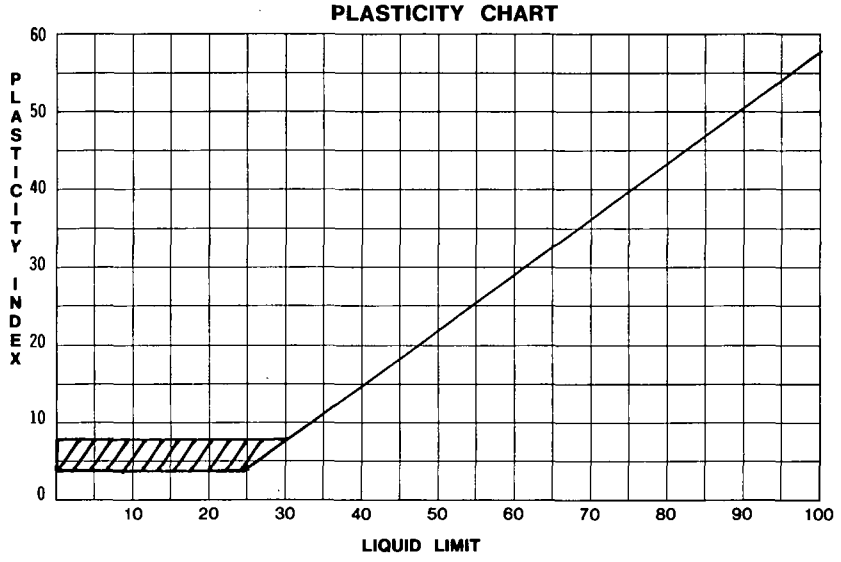


Figure B.1-11

SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

JOB NO.: L-7974

SAMPLE NO.: E-8912-2

HOLE NO.: HE-9-90

DATE: 5-30-90

LAB. TECH.: P.A.A.

SIEVE ANALYSIS

DRY WT.: 52.1g.

WET WT.: 59.3g.

% H_2O: 13.8%

WT. OF SAMPLE: 205.4g.

	WT.	% PASS
-1½"	Ø	100.0
-1"	Ø	100.0
-¾"	18.0g.	100.0
-#4	17.9g.	91.2
-#10	54.9g.	82.5
-#40	81.7g.	55.8
-#200	32.9g.	16.0

SAMPLE DESCRIPTION

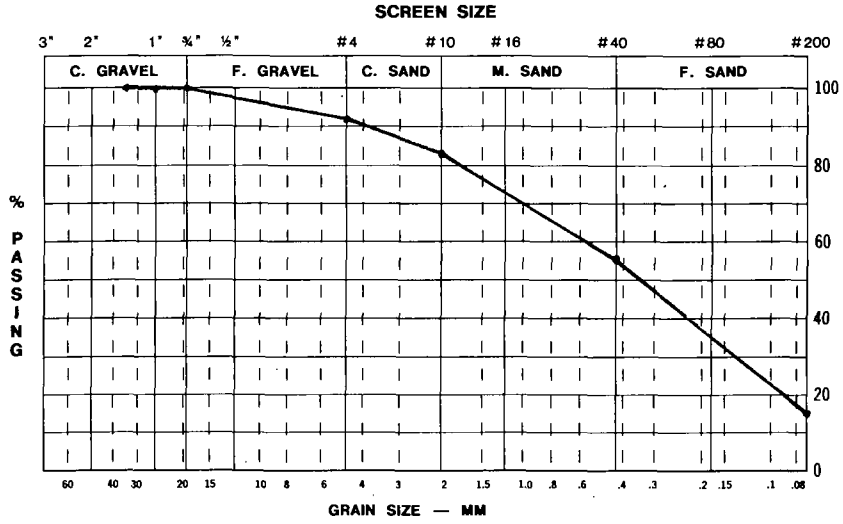
CLASS. SM

BROWN, MOIST, GRAVELLY, SILTY, FINE TO COARSE SAND

SOIL FIELD IDENTIFICATION

TEST	GRAVEL	SAND	SILT	CLAY
VISUAL	✓	✓	✓	
DRIED CAST				
DILITANCY				
BITE				
TOUGHNESS				

GRAIN SIZE CURVE



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=

PLASTICITY CHART

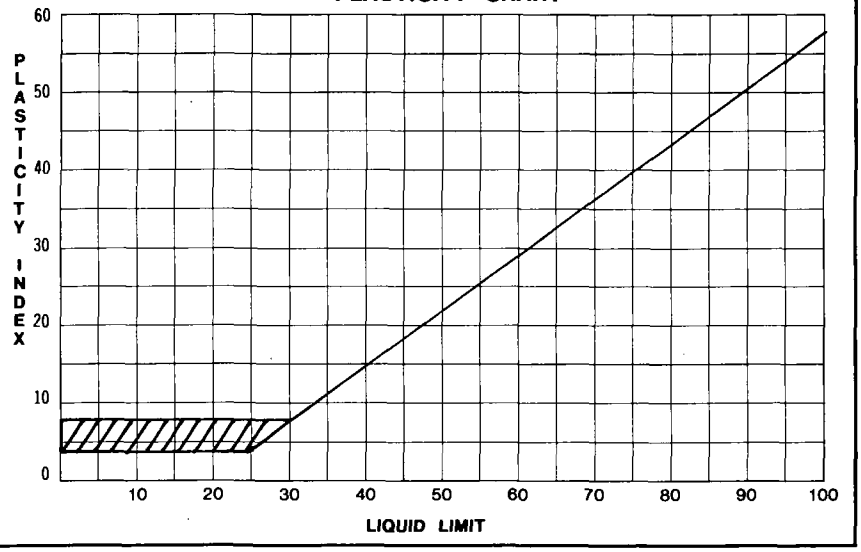


Figure B.1-12

SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

JOB NO.: L-7974

SAMPLE NO.: E-8912-4

HOLE NO.: HE-9-90

DATE: 5-30-90

LAB. TECH.: P.A.A.

SOIL FIELD IDENTIFICATION

TEST	GRAVEL	SAND	SILT	CLAY
VISUAL	✓	✓	✓	
DRIED CAST				
DILITANCY				
BITE				
TOUGHNESS				

SIEVE ANALYSIS

DRY WT.: 76.9g.

WET WT.: 79.2g.

% H_2O: 3.0 %

WT. OF SAMPLE: 207.4g.

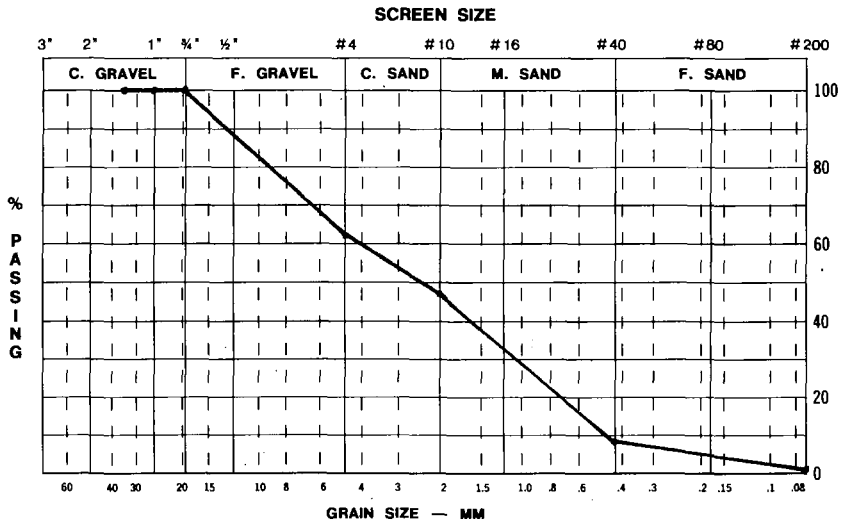
	WT.	% PASS
-1½"	Ø	100.0
-1"	Ø	100.0
-¾"	79.1g.	100.0
-#4	28.2g.	61.9
-#10	70.6g.	48.3
-#40	24.6g.	14.2
-#200	4.9g.	2.4

SAMPLE DESCRIPTION

CLASS. SP

BROWN, DRY, SLIGHTLY SILTY, GRAVELLY, FINE TO COARSE SAND

GRAIN SIZE CURVE



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=

PLASTICITY CHART

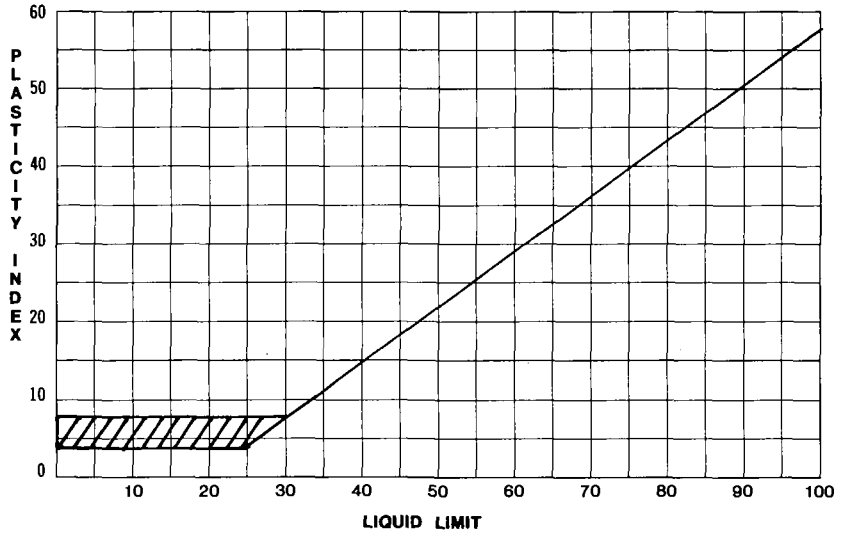


Figure B.1-13

SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

JOB NO.: L-7974

SAMPLE NO.: E-8910-2

HOLE NO.: HE-7-90

DATE: 5-30-90

LAB. TECH.: P.A.A.

SOIL FIELD IDENTIFICATION

TEST	GRAVEL	SAND	SILT	CLAY
VISUAL	✓	✓	✓	
DRIED CAST				
DILITANCY				
BITE				
TOUGHNESS				

SIEVE ANALYSIS

DRY WT.: 64.7g.

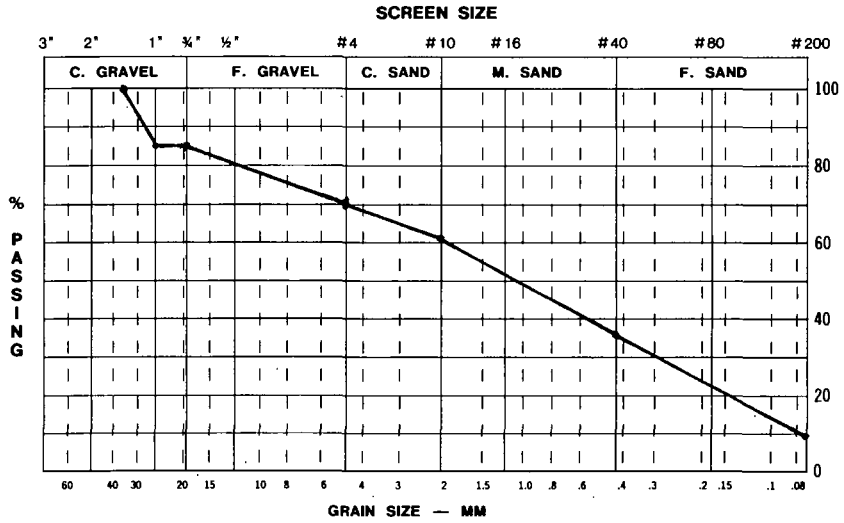
WET WT.: 71.1g.

% H_2O: 9.9%

WT. OF SAMPLE: 225.2g.

	WT.	% PASS
-1½"	33.3g.	100.0
-1"	Ø	85.2
-¾"	33.9g.	85.2
-#4	20.8g.	70.2
-#10	55.5g.	60.9
-#40	59.6g.	36.3
-#200	22.1g.	9.8

GRAIN SIZE CURVE



SAMPLE DESCRIPTION

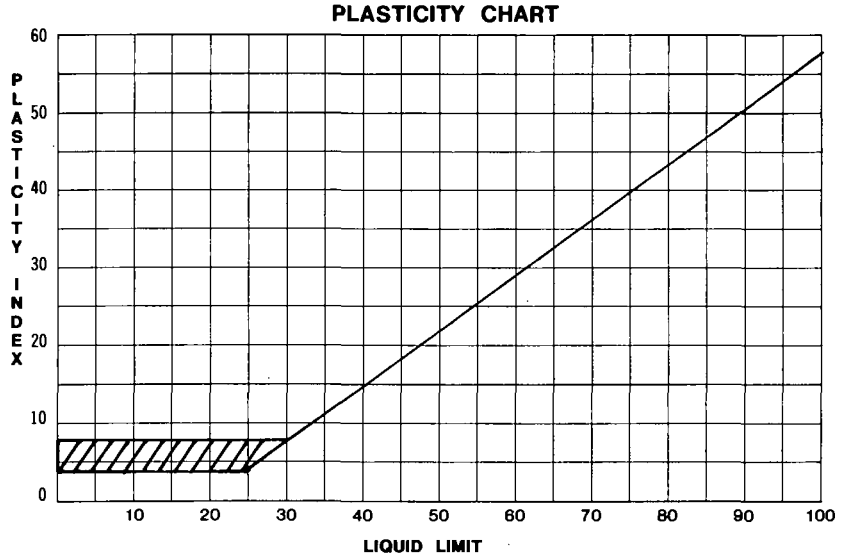
CLASS. SP-SM

BROWN, DRY, SILTY, GRAVELLY, FINE TO COARSE SAND WITH A TRACE OF WOOD FRAGMENTS

LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=

PLASTICITY CHART



DOT FORM 351-019 REVISED 4/87 -1272-

Figure B.1-14

SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

JOB NO.: L-7974

SAMPLE NO.: E-8910-3

HOLE NO.: HE-7-90

DATE: 5-30-90

LAB. TECH.: P.A.A.

SIEVE ANALYSIS

DRY WT.: 89.0g.

WET WT.: 92.3g.

% H_2O: 3.7%

WT. OF SAMPLE: 520.8g.

	WT.	% PASS
-1½"	Ø	100.0
-1"	15.5g.	100.0
-¾"	177.0g.	97.0
-#4	73.2g.	63.0
-#10	97.7g.	49.0
-#40	110.1g.	30.2
-#200	47.3g.	9.1

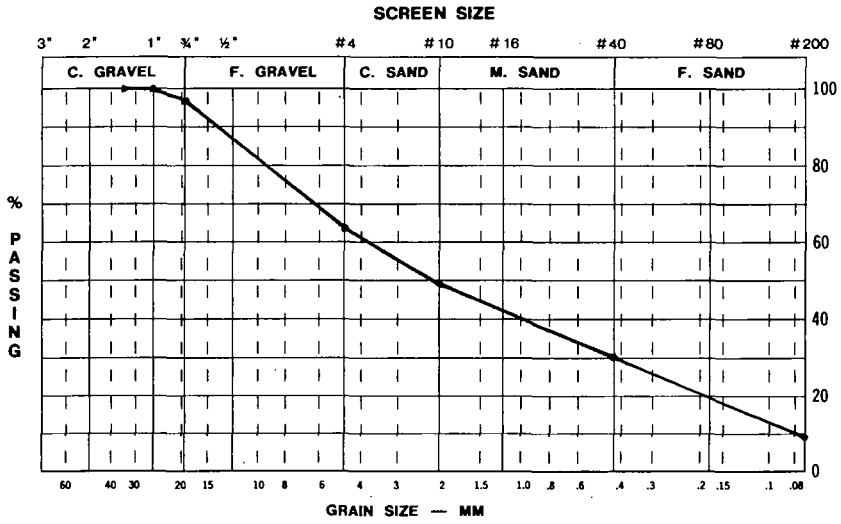
SAMPLE DESCRIPTION

CLASS. SP-SM BROWN, DRY, SILTY, GRAVELLY, FINE TO COARSE SAND

SOIL FIELD IDENTIFICATION

TEST	GRAVEL	SAND	SILT	CLAY
VISUAL	✓	✓	✓	
DRIED CAST				
DILITANCY				
BITE				
TOUGHNESS				

GRAIN SIZE CURVE



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=

PLASTICITY CHART

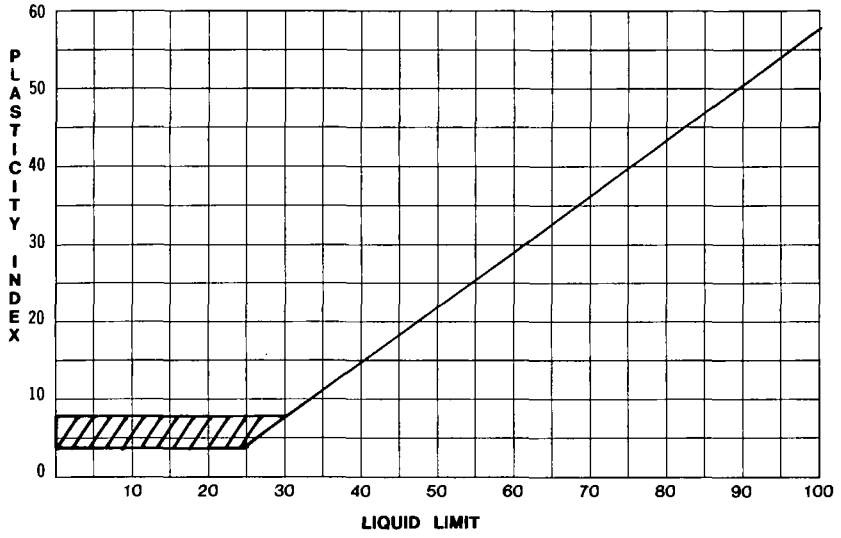


Figure B.1-15

SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

JOB NO.: L-7974

SAMPLE NO.: E-8910-5

HOLE NO.: HE-7-90

DATE: 5-30-90

LAB. TECH.: P.A.A.

SIEVE ANALYSIS

DRY WT.: NOT RECORDED*

WET WT.: 73.7g.

% H_2O: *

WT. OF SAMPLE: 434.9g.

	WT.	% PASS
-1½"	Ø	100.0
-1"	Ø	100.0
-¾"	Ø	100.0
-#4	Ø	100.0
-#10	52.4g.	100.0
-#40	290.3g.	88.0
-#200	92.2g.	21.2

SAMPLE DESCRIPTION

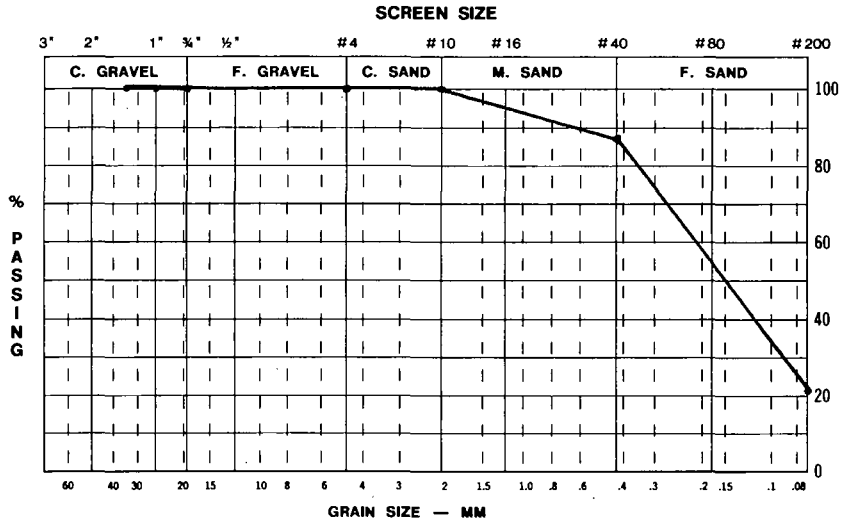
CLASS. SM

BROWN AND WHITE, VERY SILTY, FINE TO MEDIUM SAND WITH A TRACE OF MICACEOUS MATERIAL

SOIL FIELD IDENTIFICATION

TEST	GRAVEL	SAND	SILT	CLAY
VISUAL		✓	✓	
DRIED CAST				
DILITANCY				
BITE				
TOUGHNESS				

GRAIN SIZE CURVE



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=

PLASTICITY CHART

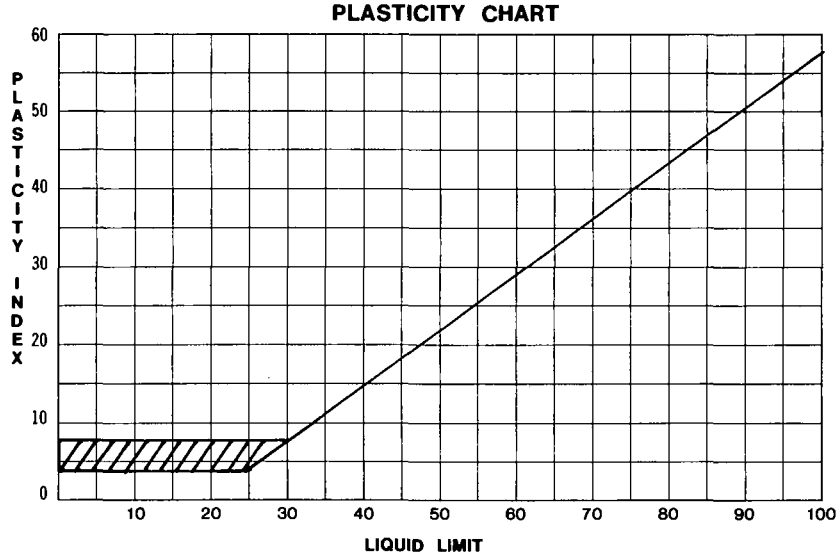


Figure B.1-16

SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

JOB NO.: L-7974

SAMPLE NO.: B678-1

HOLE NO.: HQ-106-89

DATE: 7-24-89

LAB. TECH.: JM

SIEVE ANALYSIS

DRY WT.: 21.8

WET WT.: 23.1

% H_2O: 6.0%

WT. OF SAMPLE: 108.0

	WT.	% PASS
-1½"	67.3	100
-1"	0	37.7
-¾"	7.9	37.7
-#4	5.6	30.4
-#10	11.1	25.2
-#40	13.8	14.9
-#200	2.3	2.1

SAMPLE DESCRIPTION

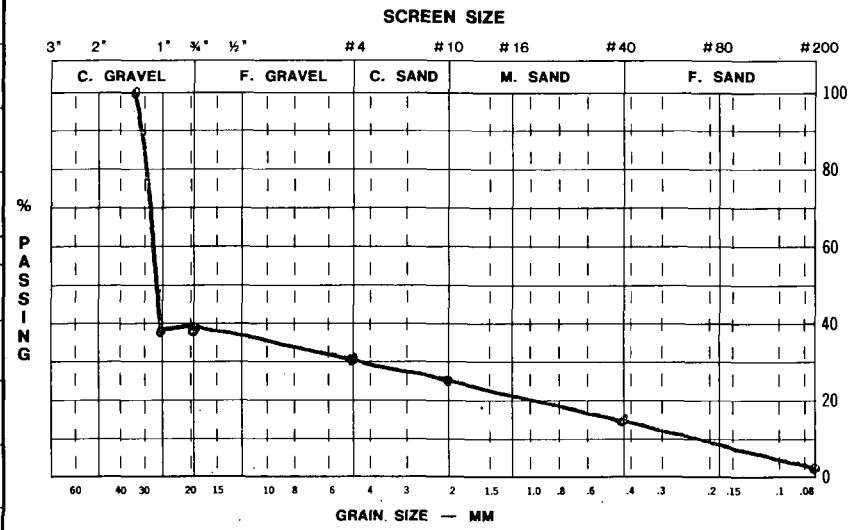
CLASS. GP — SUB RND.

GREY, DRY, SL. SILTY, F-C SANDY, F-C SUB. RND. GRAVEL.

SOIL FIELD IDENTIFICATION

TEST	GRAVEL	SAND	SILT	CLAY
VISUAL				
DRIED CAST				
DILITANCY				
BITE				
TOUGHNESS				

GRAIN SIZE CURVE



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=

PLASTICITY CHART

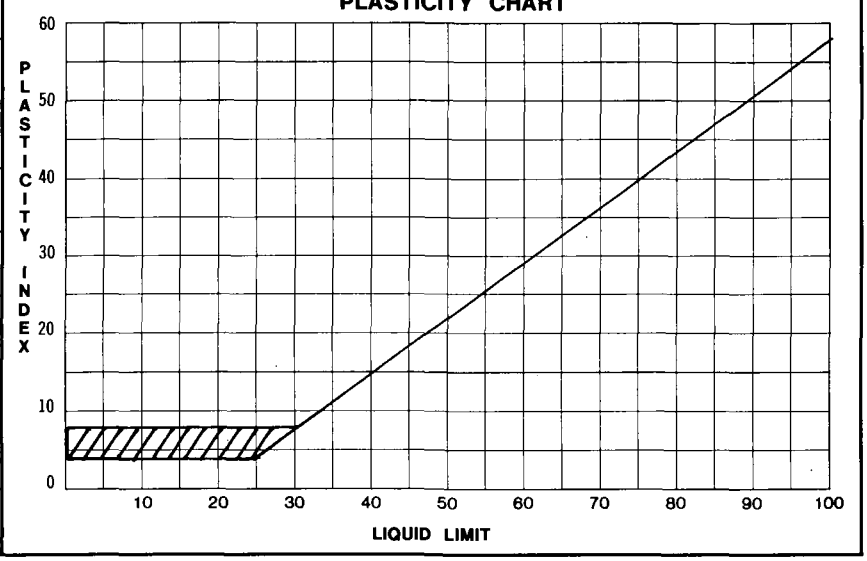


Figure B.1-17

SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

JOB NO.: L-7974

SAMPLE NO.: B67B-2

HOLE NO.: HQ-106-89

DATE: 7-21-89

LAB. TECH.: JM

SIEVE ANALYSIS

DRY WT.: 74.2

WET WT.: 77.5

% H_2O: 4.4%

WT. OF SAMPLE: 318.9

	WT.	% PASS
-1½"		
-1"	16.9	100
-¾"	33.2	94.7
-#4	62.1	84.3
-#10	140.0	64.8
-#40	56.1	20.9
-#200	10.6	3.3

SAMPLE DESCRIPTION

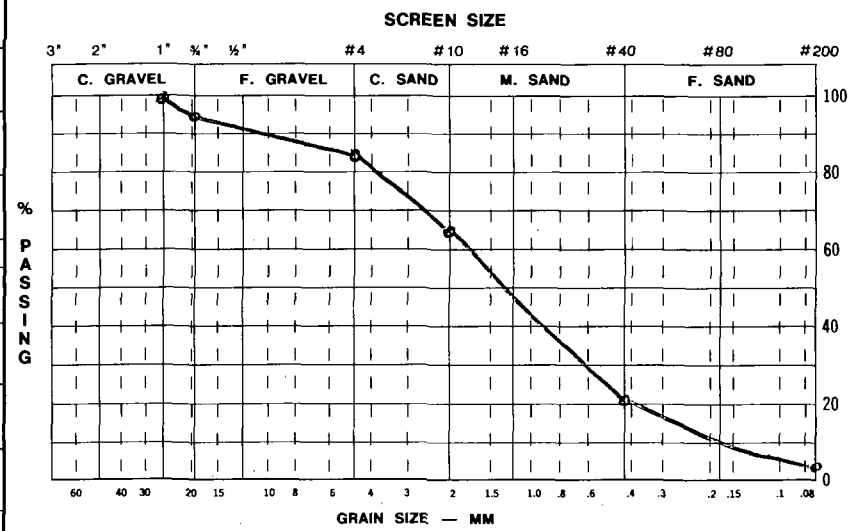
CLASS. SW

GREY, DRY, SL. SILTY, GRAVELLY, F-C SAND.

SOIL FIELD IDENTIFICATION

TEST	GRAVEL	SAND	SILT	CLAY
VISUAL				
DRIED CAST				
DILITANCY				
BITE				
TOUGHNESS				

GRAIN SIZE CURVE



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=

PLASTICITY CHART

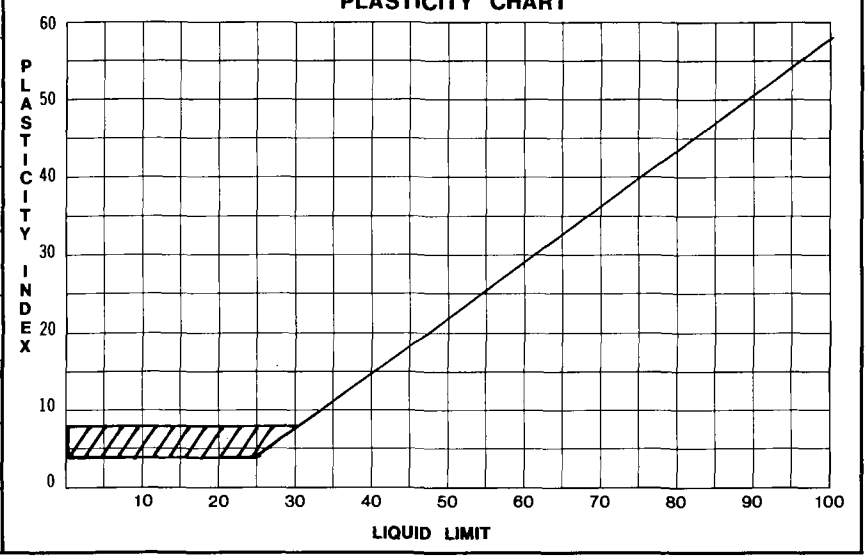


Figure B.1-18

SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

JOB NO.: L-7974

SAMPLE NO.: B678-5

HOLE NO.: HQ-106-89

DATE: 7-24-89

LAB. TECH.: JM

SIEVE ANALYSIS

DRY WT.: 57.9

WET WT.: 67.0

% H_2O: 15.7%

WT. OF SAMPLE: 297.9

	WT.	% PASS
-1½"	30.2	100
-1"	0	89.9
-¾"	22.9	89.9
-#4	11.1	82.2
-#10	51.1	78.4
-#40	119.5	61.3
-#200	63.1	21.2

SAMPLE DESCRIPTION

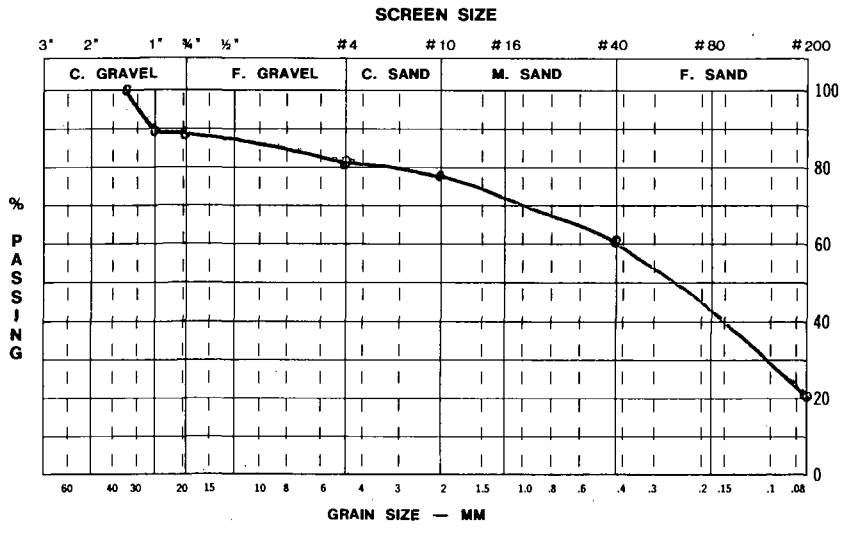
CLASS. SM

GREY, MOIST, V. SILTY, GRADUELLY, F-C SAND.

SOIL FIELD IDENTIFICATION

TEST	GRAVEL	SAND	SILT	CLAY
VISUAL				
DRIED CAST				
DILITANCY				
BITE				
TOUGHNESS				

GRAIN SIZE CURVE



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=

PLASTICITY CHART

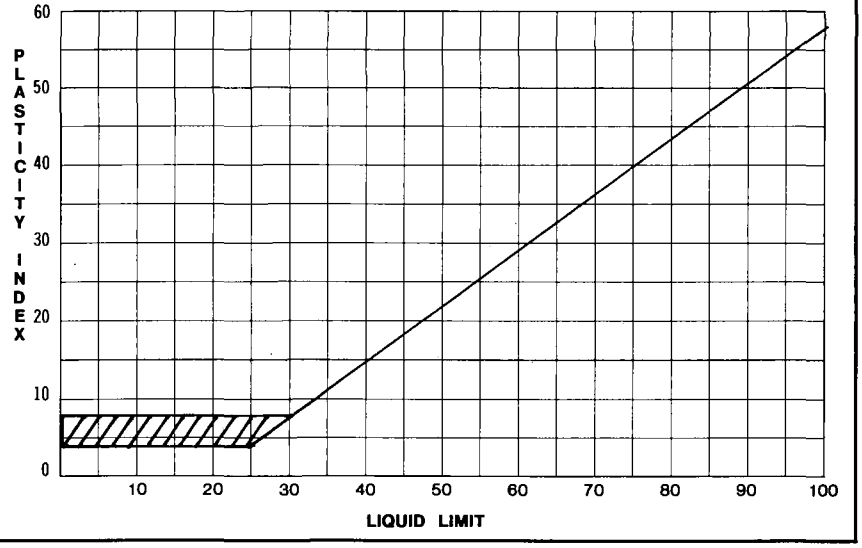


Figure B.1-19

SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

JOB NO.: L-7974

SAMPLE NO.: 0674-1

HOLE NO.: HQ-13B

DATE: 7-24-89

LAB. TECH.: Jm

SIEVE ANALYSIS

DRY WT.: 58.2

WET WT.: 64.1

% H_2O: 10.1%

WT. OF SAMPLE: 307.7

	WT.	% PASS
-1½"	44.6	100
-1"	14.4	85.5
-¾"	116.1	80.8
-#4	23.8	43.1
-#10	42.0	35.4
-#40	41.9	21.7
-#200	24.9	8.1

SAMPLE DESCRIPTION

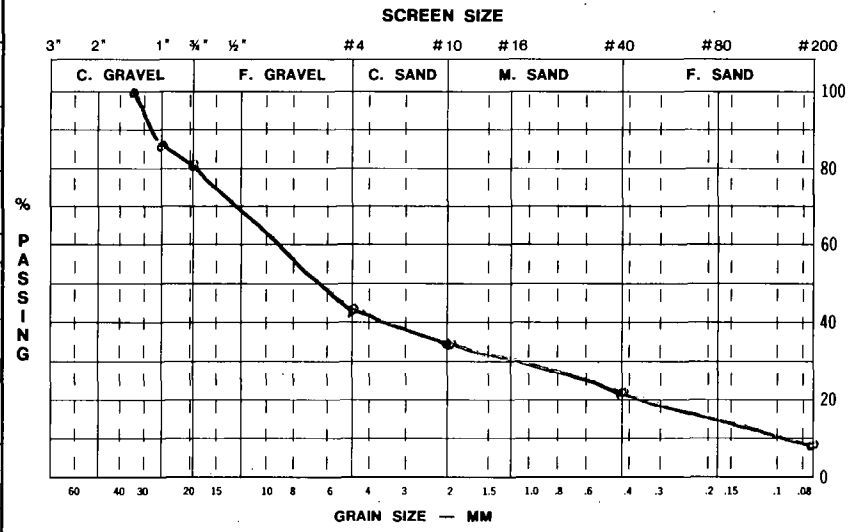
CLASS. GW-GM

BRN., MOIST, SILTY, F-C SANDY, F-C GRAVEL.

SOIL FIELD IDENTIFICATION

TEST	GRAVEL	SAND	SILT	CLAY
VISUAL				
DRIED CAST				
DILITANCY				
BITE				
TOUGHNESS				

GRAIN SIZE CURVE



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=

PLASTICITY CHART

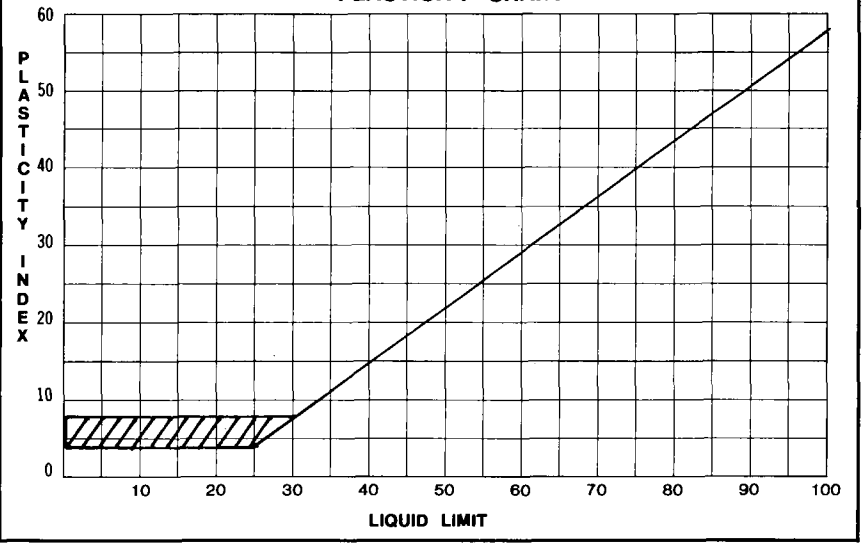


Figure B.1-20

SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

JOB NO.: L-7974

SAMPLE NO.: B674-2

HOLE NO.: HQ13B

DATE: 7-24-09

LAB. TECH.: JM

SOIL FIELD IDENTIFICATION

TEST	GRAVEL	SAND	SILT	CLAY
VISUAL				
DRIED CAST				
DILITANCY				
BITE				
TOUGHNESS				

SIEVE ANALYSIS

DRY WT.: 72.9

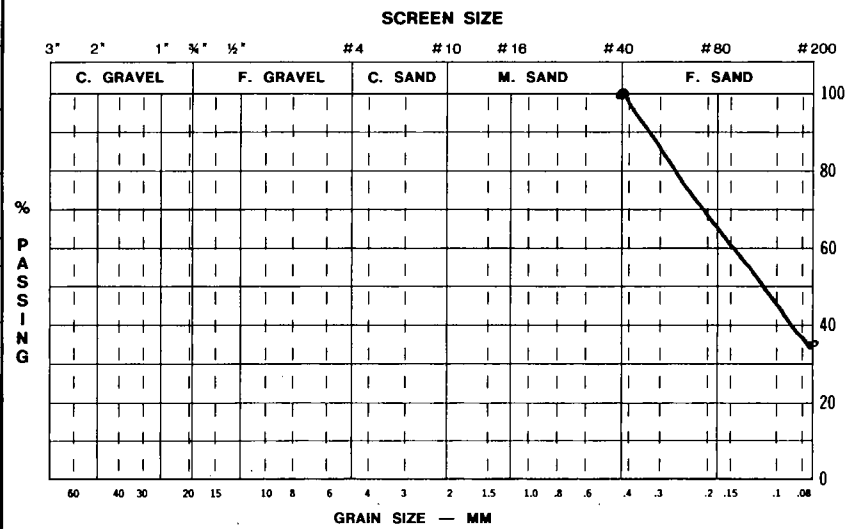
WET WT.: 89.6

% H_2O: 22.9%

WT. OF SAMPLE: 527.2

	WT.	% PASS
-1½"		
-1"		
-¾"		
-#4		
-#10		
-#40	344.2	100
-#200	183.0	34.7

GRAIN SIZE CURVE



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=

SAMPLE DESCRIPTION

CLASS. SM

LOOSE, MOIST, V. SILTY, F. SAND

PLASTICITY CHART

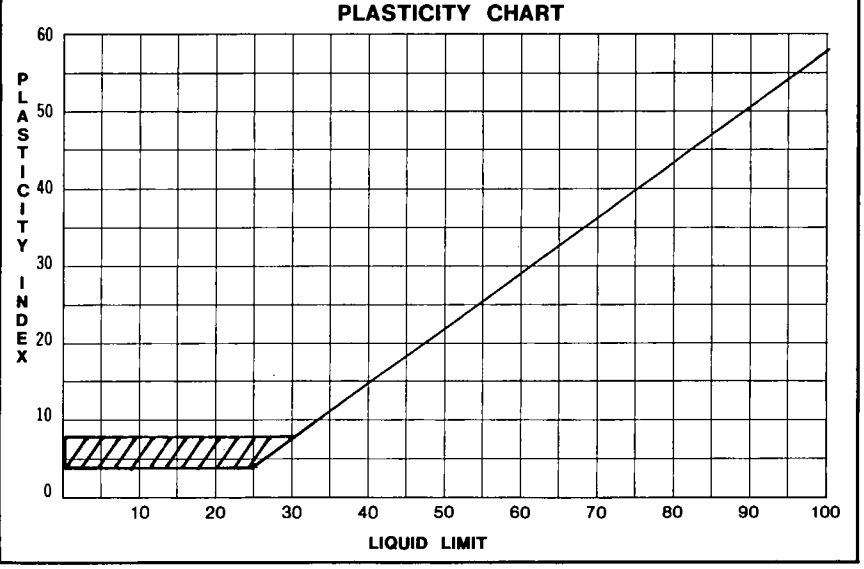


Figure B.1-21

SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

JOB NO.: L-7974

SAMPLE NO.: B674-3

HOLE NO.: HQ-13B

DATE: 7-21-89

LAB. TECH.: JM

SIEVE ANALYSIS

DRY WT.: 52.7

WET WT.: 61.3

% H_2O: 16.3%

WT. OF SAMPLE: 6289

	WT.	% PASS
-1½"		
-1"		
-¾"	12.1	100
-#4	36.7	98.1
-#10	403.9	92.2
-#40	148.7	28.0
-#200	27.5	4.4

SAMPLE DESCRIPTION

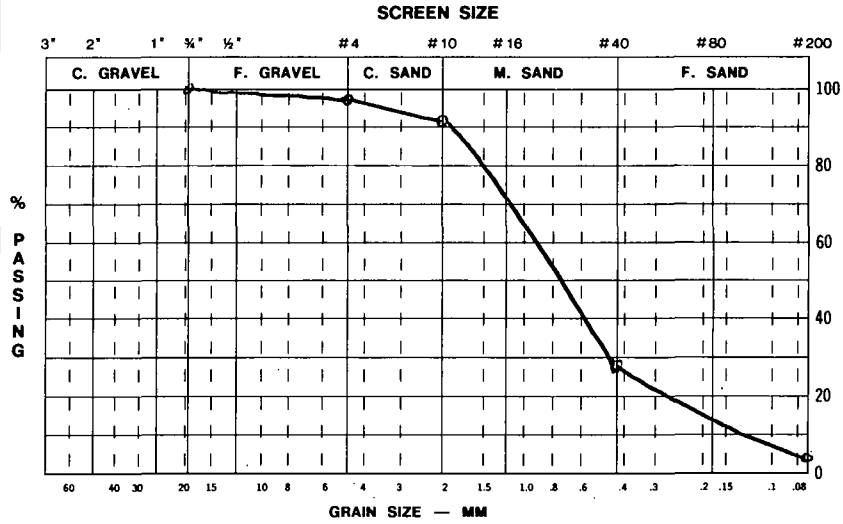
CLASS. SW

COREY, MOIST, SL. SILTY, GRAVELLY, F-C SAND.

SOIL FIELD IDENTIFICATION

TEST	GRAVEL	SAND	SILT	CLAY
VISUAL				
DRIED CAST				
DILITANCY				
BITE				
TOUGHNESS				

GRAIN SIZE CURVE



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=

PLASTICITY CHART

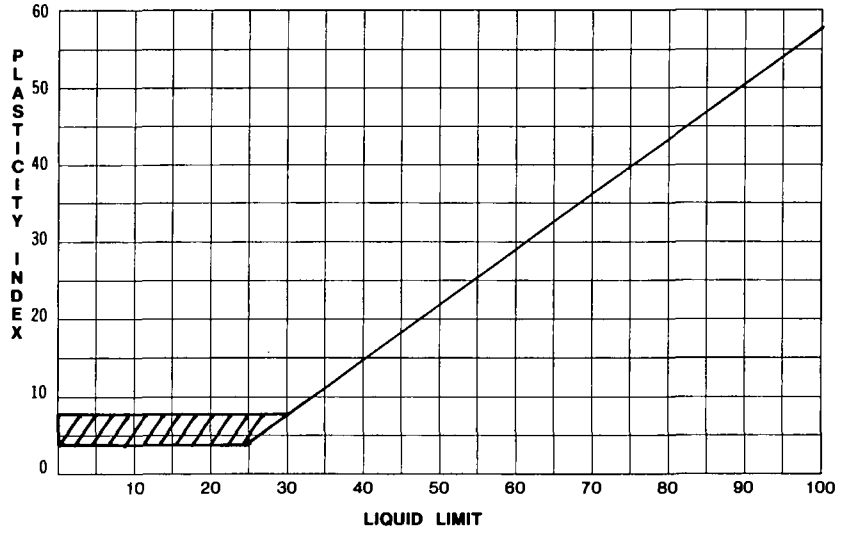


Figure B.1-22

SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

JOB NO.: L-7974

SAMPLE NO.: B674-4

HOLE NO.: HQ-13B

DATE: 7-24-89

LAB. TECH.: JM

SIEVE ANALYSIS

DRY WT.: 82.0

WET WT.: 91.1

% H_2O: 11.1

WT. OF SAMPLE: 752.9

	WT.	% PASS
-1½"	29.0	100
-1"	27.6	96.1
-¾"	216.4	92.5
-#4	89.3	63.7
-#10	176.3	51.9
-#40	177.5	28.5
-#200	36.8	4.9

SAMPLE DESCRIPTION

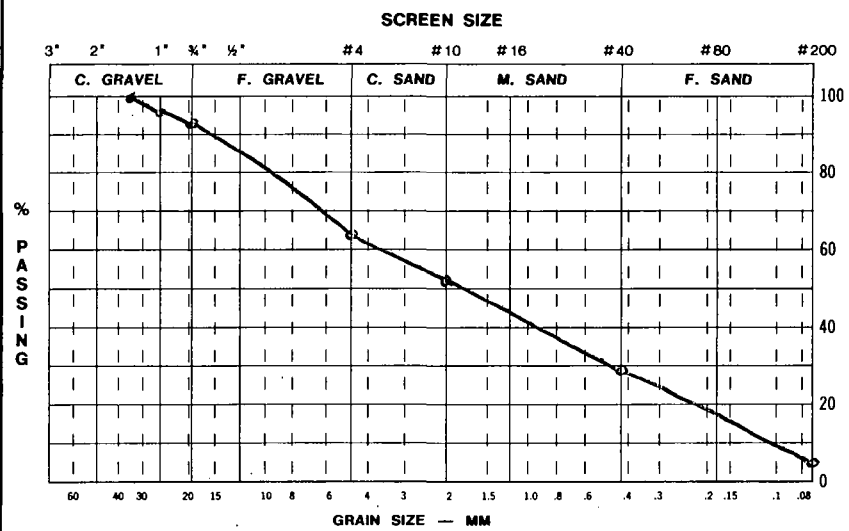
CLASS. SP

CREEY, MOIST, SL. SILTY, GRAVELLY, F-C SAND.

SOIL FIELD IDENTIFICATION

TEST	GRAVEL	SAND	SILT	CLAY
VISUAL				
DRIED CAST				
DILITANCY				
BITE				
TOUGHNESS				

GRAIN SIZE CURVE



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=

PLASTICITY CHART

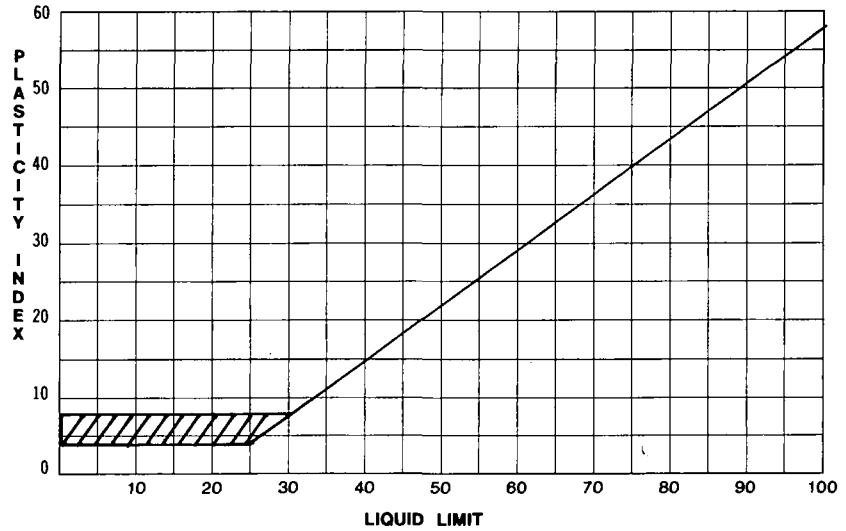


Figure B.1-23

SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

JOB NO.: L-7974

SAMPLE NO.: B674-5

HOLE NO.: HQ-13B

DATE: 7-24-99

LAB. TECH.: JM

SIEVE ANALYSIS

DRY WT.: 68.5

WET WT.: 80.5

% H_2O: 17.5%

WT. OF SAMPLE: 349.8

	WT.	% PASS
-1½"		
-1"		
-¾"		
-#4		
-#10		
-#40	242.0	100
-#200	107.8	30.8

SAMPLE DESCRIPTION

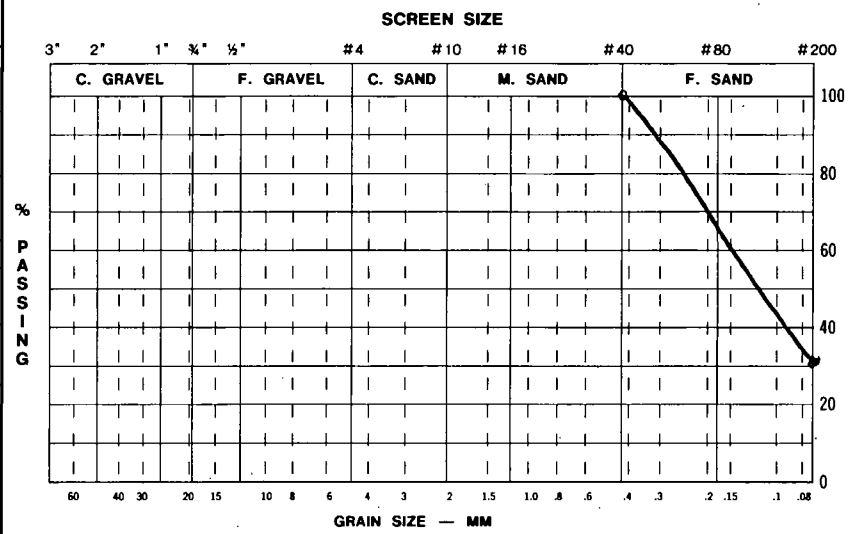
CLASS. SM

TAN, MOIST, V. SILTY, F. SAND.

SOIL FIELD IDENTIFICATION

TEST	GRAVEL	SAND	SILT	CLAY
VISUAL				
DRIED CAST				
DILITANCY				
BITE				
TOUGHNESS				

GRAIN SIZE CURVE



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=

PLASTICITY CHART

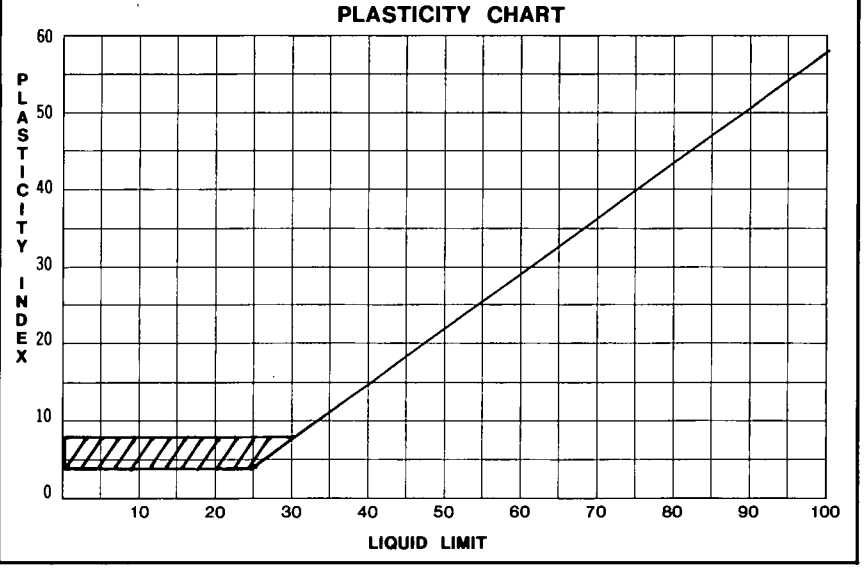


Figure B.1-24

SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

JOB NO.: L-7974

SAMPLE NO.: 8624-1

HOLE NO.: HQ-20-89

DATE: 5-12-89

LAB. TECH.: JM

SIEVE ANALYSIS

DRY WT.: 69.5

WET WT.: 75.1

% H_2O: 8.1%

WT. OF SAMPLE: 218.6

	WT.	% PASS
-1½"		
-1"		
-¾"	69.5	100.
-#4	34.1	59.1
-#10	54.2	43.5
-#40	28.7	18.7
-#200	12.1	5.5

SAMPLE DESCRIPTION

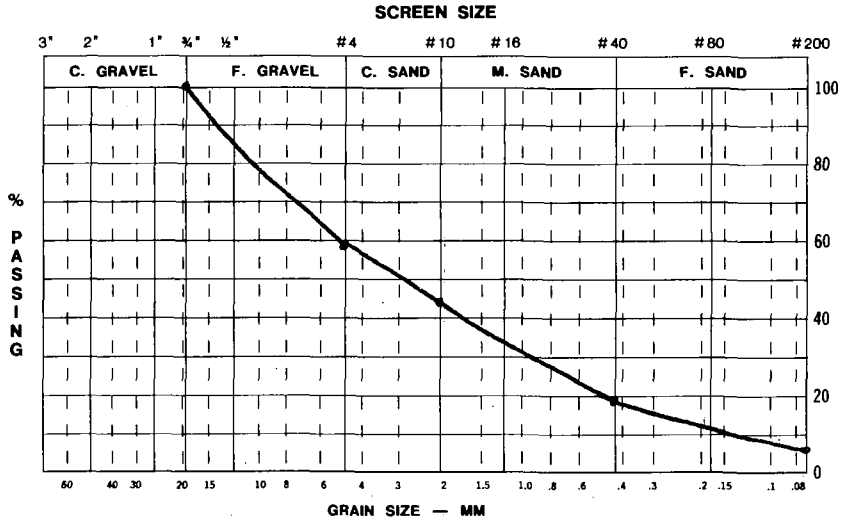
CLASS. SW-SM

GREY, DRY, SL. SILTY, GRAVELLY, F-C SAND.

SOIL FIELD IDENTIFICATION

TEST	GRAVEL	SAND	SILT	CLAY
VISUAL				
DRIED CAST				
DILITANCY				
BITE				
TOUGHNESS				

GRAIN SIZE CURVE



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=

PLASTICITY CHART

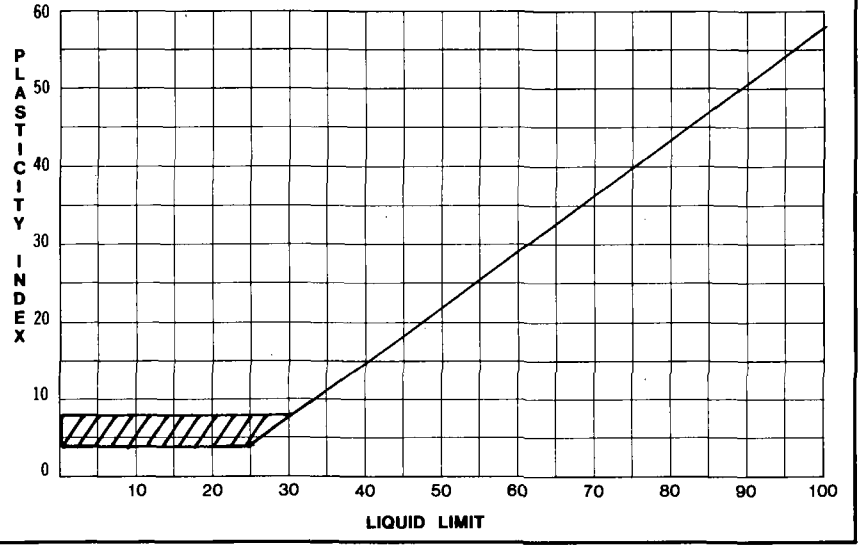


Figure B.1-25

SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

JOB NO.: L-7974

SAMPLE NO.: 8624-2

HOLE NO.: HQ-20-89

DATE: 5-12-89

LAB. TECH.: JM

SIEVE ANALYSIS

DRY WT.: 95.0

WET WT.: 90.0

% H_2O: 5.9%

WT. OF SAMPLE: 247.9

	WT.	% PASS
-1½"		
-1"		
-¾"	92.1	100
-#4	57.6	62.8
-#10	51.0	39.6
-#40	33.2	19.0
-#200	14.0	5.6

SAMPLE DESCRIPTION

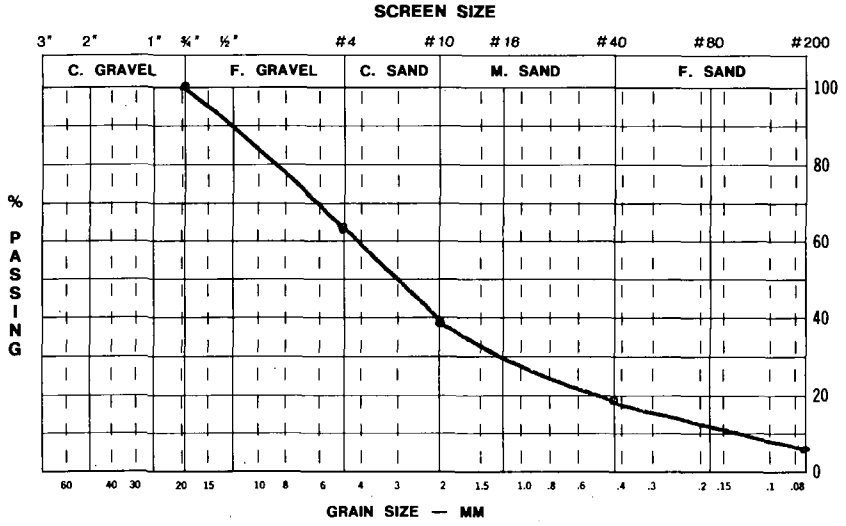
CLASS. SW-SM

GREY, DRY, SL. SILTY, GRAVELLY, F-C SAND.

SOIL FIELD IDENTIFICATION

TEST	GRAVEL	SAND	SILT	CLAY
VISUAL				
DRIED CAST				
DILITANCY				
BITE				
TOUGHNESS				

GRAIN SIZE CURVE



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=

PLASTICITY CHART

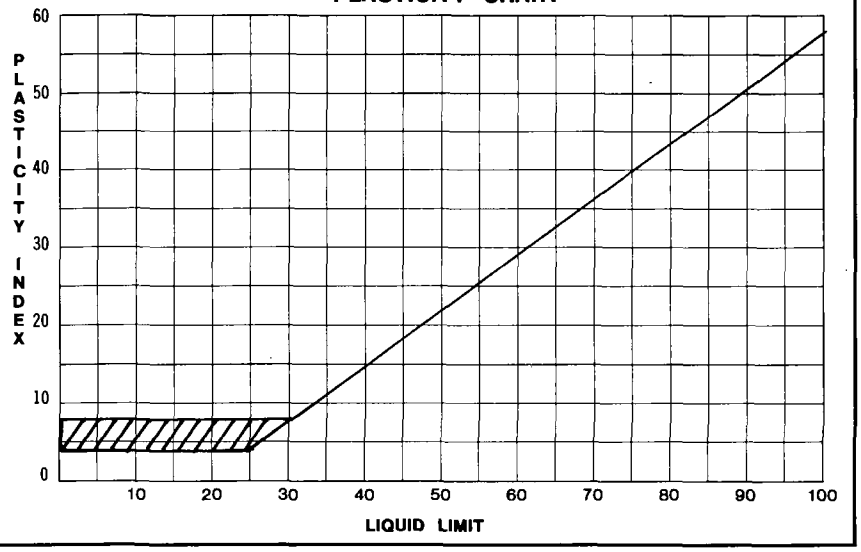


Figure B.1-26

SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

JOB NO.: L-7974

SAMPLE NO.: 0624-3

HOLE NO.: HQ-20-89

DATE: 5-12-89

LAB. TECH.: JM

SIEVE ANALYSIS

DRY WT.: 14.2

WET WT.: 45.5

% H_2O: 220.4%

WT. OF SAMPLE:

	WT.	% PASS
-1½"		
-1"		
-¾"		
-#4		
-#10		
-#40		
-#200		

SAMPLE DESCRIPTION

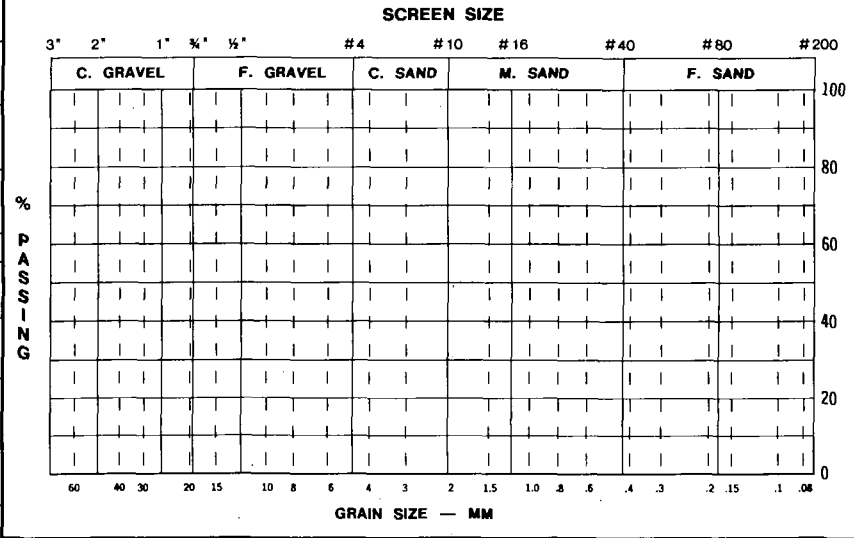
CLASS.

WOOD CHUNKS ONLY, IN SAMPLE

SOIL FIELD IDENTIFICATION

TEST	GRAVEL	SAND	SILT	CLAY
VISUAL				
DRIED CAST				
DILITANCY				
BITE				
TOUGHNESS				

GRAIN SIZE CURVE



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=

PLASTICITY CHART

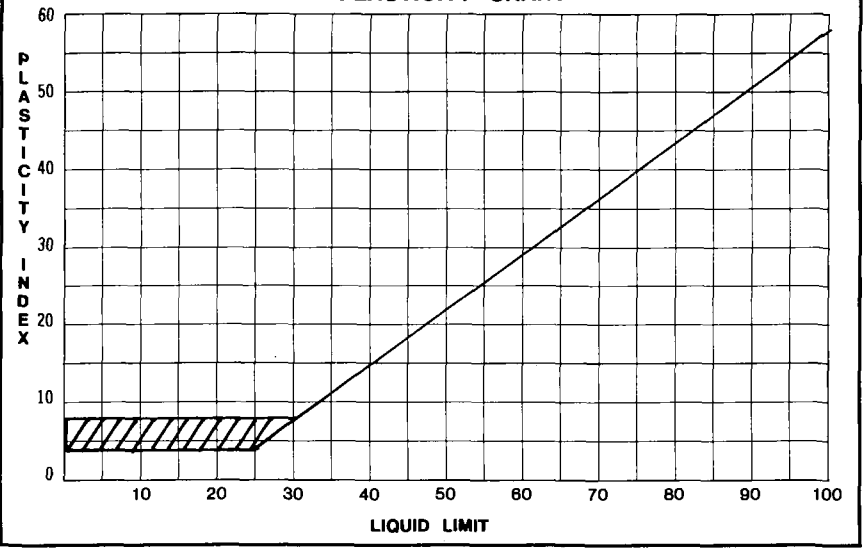


Figure B.1-27

SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

JOB NO.: L-7974

SAMPLE NO.: B624-4

HOLE NO.: HQ-20-89

DATE: 5-12-89

LAB. TECH.: JM

SIEVE ANALYSIS

DRY WT.:

WET WT.:

% H_2O: 0%

WT. OF SAMPLE: 90.6

	WT.	% PASS
-1½"	33.1	100
-1"	0	63.5
-¾"	23.5	63.5
-#4	9.8	37.5
-#10	13.3	26.7
-#40	7.0	12.0
-#200	3.9	4.3

SAMPLE DESCRIPTION

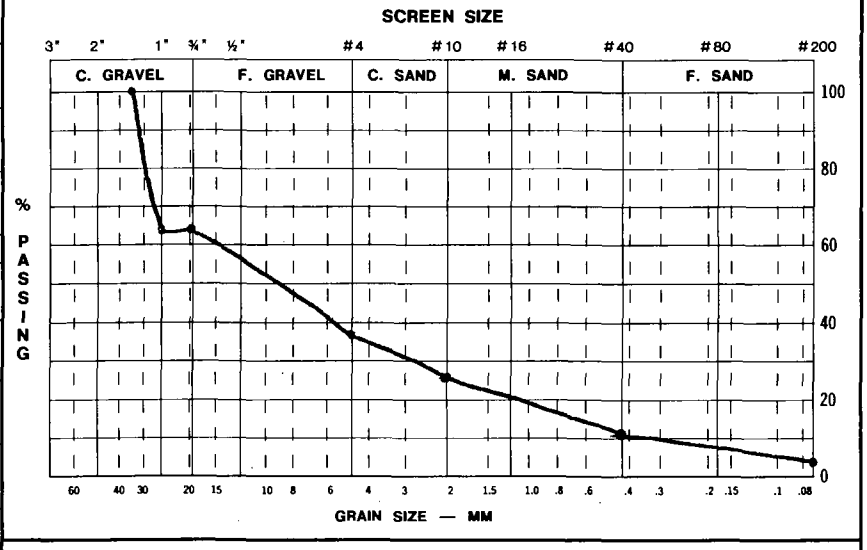
CLASS. GW

GREY, DRY, SL. SILTY, F-C SANDY, F-C GRAVEL.

SOIL FIELD IDENTIFICATION

TEST	GRAVEL	SAND	SILT	CLAY
VISUAL				
DRIED CAST				
DILITANCY				
BITE				
TOUGHNESS				

GRAIN SIZE CURVE



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=

PLASTICITY CHART

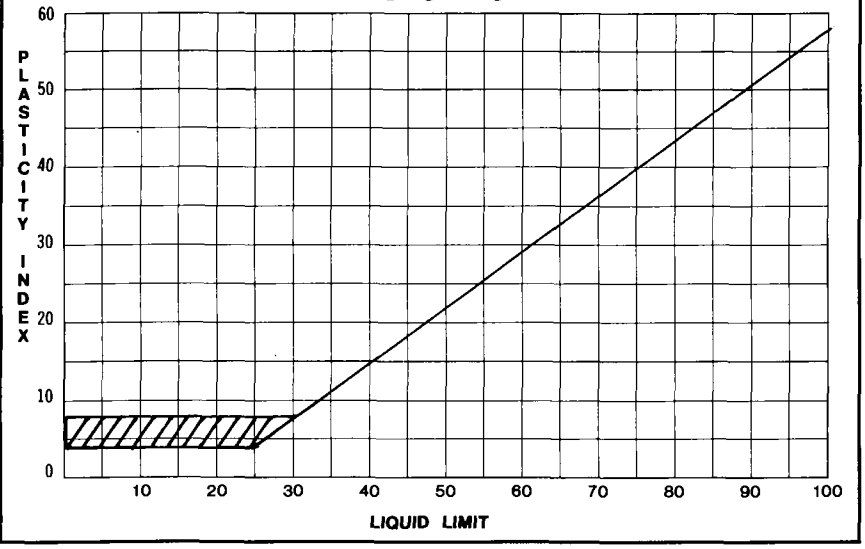


Figure B.1-28

SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

JOB NO.: L-7974

SAMPLE NO.: 06245

HOLE NO.: HQ-20-89

DATE: 5-12-89

LAB. TECH.: JM

SIEVE ANALYSIS

DRY WT.: 71.0

WET WT.: 73.5

% H_2O: 3.5%

WT. OF SAMPLE: 175.6

	WT.	% PASS
-1½"		
-1"	40.6	100
-¾"	81.3	76.9
-#4	21.6	30.6
-#10	29.4	18.3
-#40	2.4	1.5
-#200	.3	.2

SAMPLE DESCRIPTION

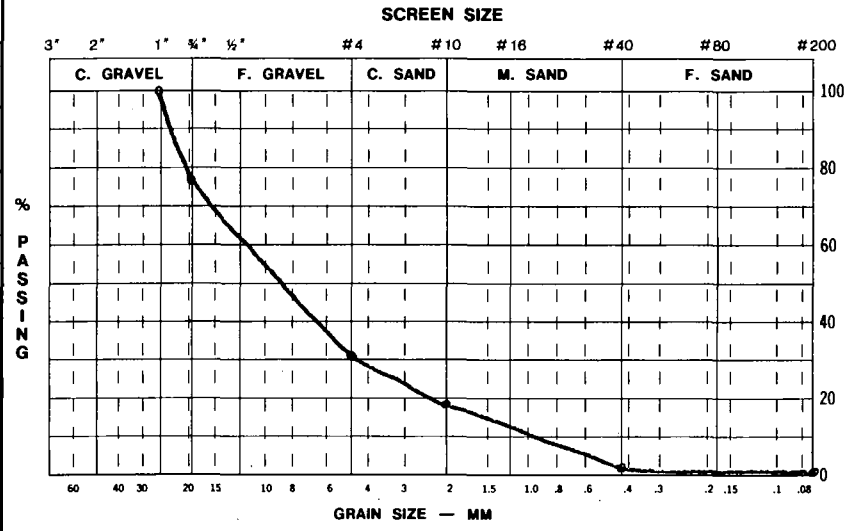
CLASS. GW

COBBLY, DRY, SL. SILTY, M-C SANDY, F-C GRAVEL.

SOIL FIELD IDENTIFICATION

TEST	GRAVEL	SAND	SILT	CLAY
VISUAL				
DRIED CAST				
DILITANCY				
BITE				
TOUGHNESS				

GRAIN SIZE CURVE



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=

PLASTICITY CHART

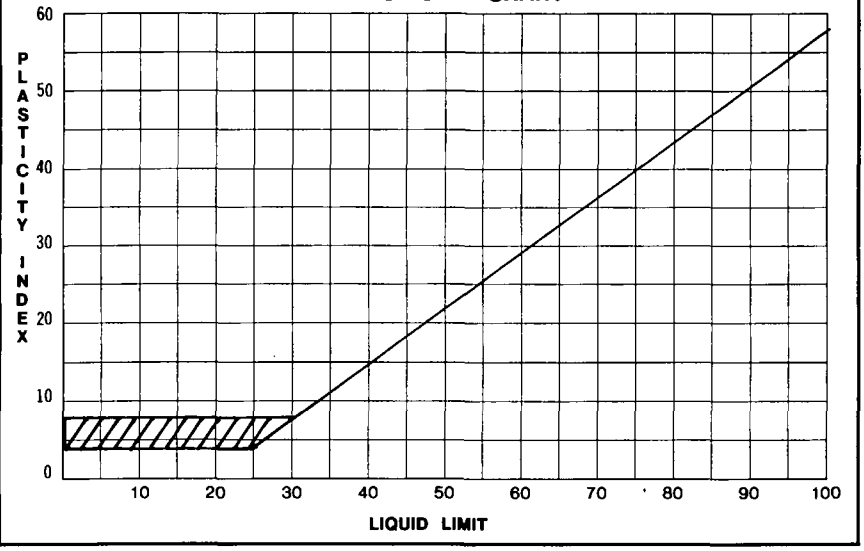


Figure B.1-29

SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

JOB NO.: L-7974

SAMPLE NO.: 8624-6

HOLE NO.: HQ-20-89

DATE: 5-12-89

LAB. TECH.: JM

SIEVE ANALYSIS

DRY WT.: 74.8

WET WT.: 75.9

% H_2O: 1.5%

WT. OF SAMPLE: 174.5

	WT.	% PASS
-1½"	56.1	100
-1"	14.6	67.9
-¾"	44.6	59.5
-#4	22.9	33.9
-#10	26.6	20.8
-#40	7.5	5.6
-#200	2.2	1.3

SAMPLE DESCRIPTION

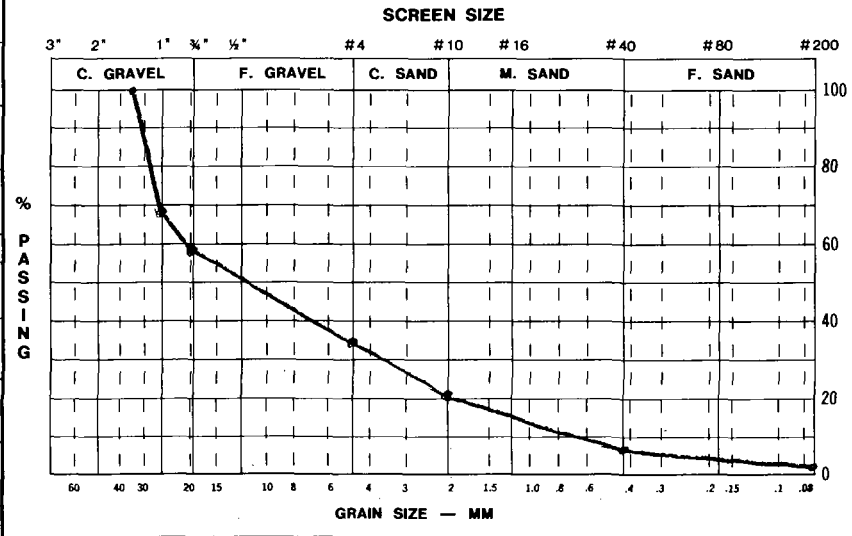
CLASS. GW

COREY, DRY, SL SILTY, F-C SANDY, F-C GRAVEL.

SOIL FIELD IDENTIFICATION

TEST	GRAVEL	SAND	SILT	CLAY
VISUAL				
DRIED CAST				
DILITANCY				
BITE				
TOUGHNESS				

GRAIN SIZE CURVE



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=

PLASTICITY CHART

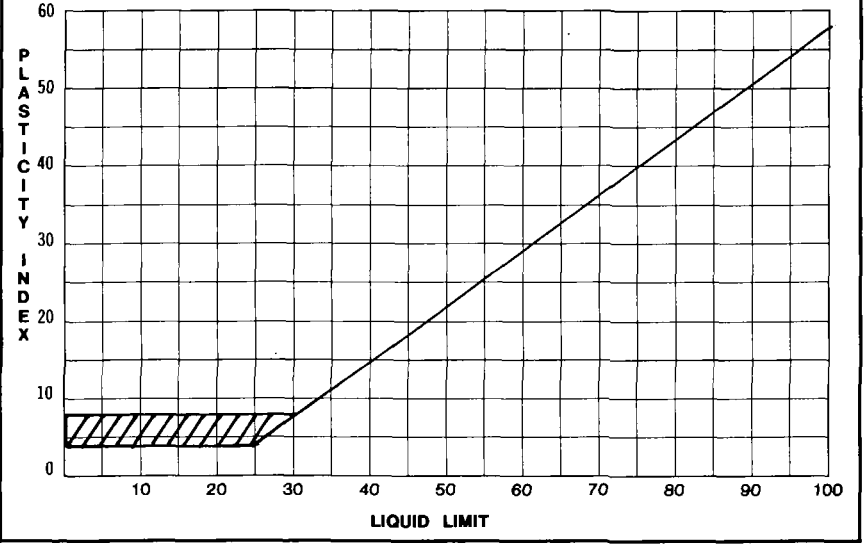


Figure B.1-30

SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

JOB NO.: L-7974

SAMPLE NO.: 0624-7

HOLE NO.: HQ-20-89

DATE: 5-12-09

LAB. TECH.: JM

SIEVE ANALYSIS

DRY WT.: 59.6

WET WT.: 60.6

% H_2O: 1.7%

WT. OF SAMPLE: 119.9

	WT.	% PASS
-1½"	35.2	100
-1"	12.8	70.6
-¾"	26.5	60.0
-#4	24.3	37.9
-#10	14.7	17.6
-#40	4.7	5.3
-#200	1.7	1.4

SAMPLE DESCRIPTION

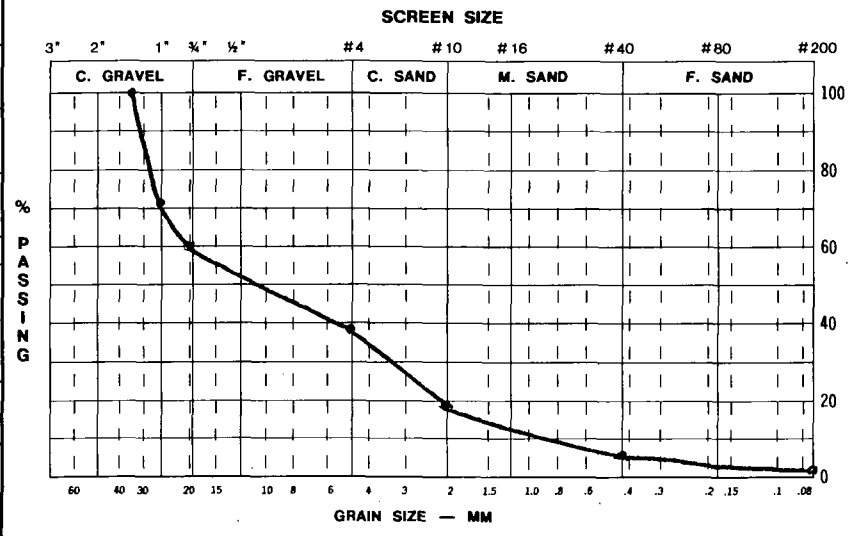
CLASS. GP

LOOSE, DRY, SL. SILTY, F-C SANDY, F-C GRAVEL.

SOIL FIELD IDENTIFICATION

TEST	GRAVEL	SAND	SILT	CLAY
VISUAL				
DRIED CAST				
DILITANCY				
BITE				
TOUGHNESS				

GRAIN SIZE CURVE



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=

PLASTICITY CHART

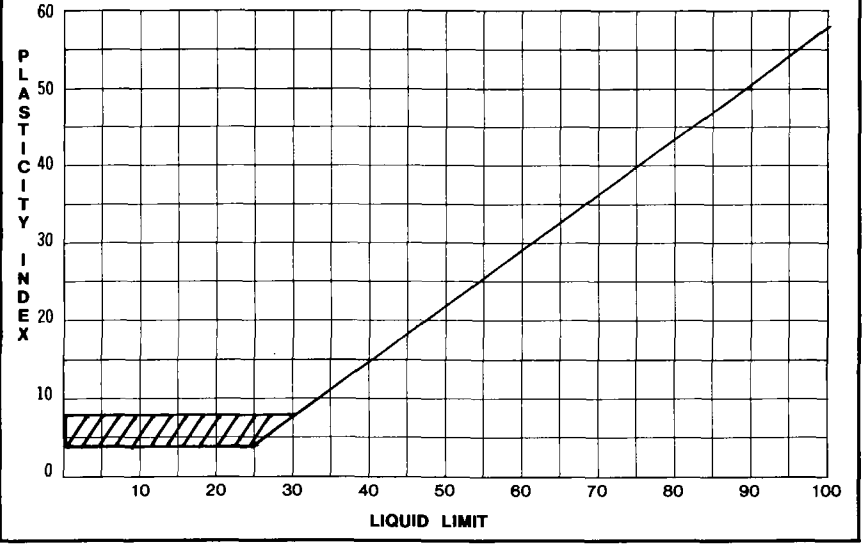


Figure B.1-31

SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

JOB NO.: L-7974

SAMPLE NO.: 0624-B

HOLE NO.: HQ-20-89

DATE: 5-12-89

LAB. TECH.: JM

SIEVE ANALYSIS

DRY WT.: 84.8

WET WT.: 91.7

% H_2O: 8.1%

WT. OF SAMPLE: 327.9

	WT.	% PASS
-1½"		
-1"	53.0	100
-¾"	106.5	83.8
-#4	51.3	51.4
-#10	70.9	35.7
-#40	31.8	14.1
-#200	14.4	4.4

SAMPLE DESCRIPTION

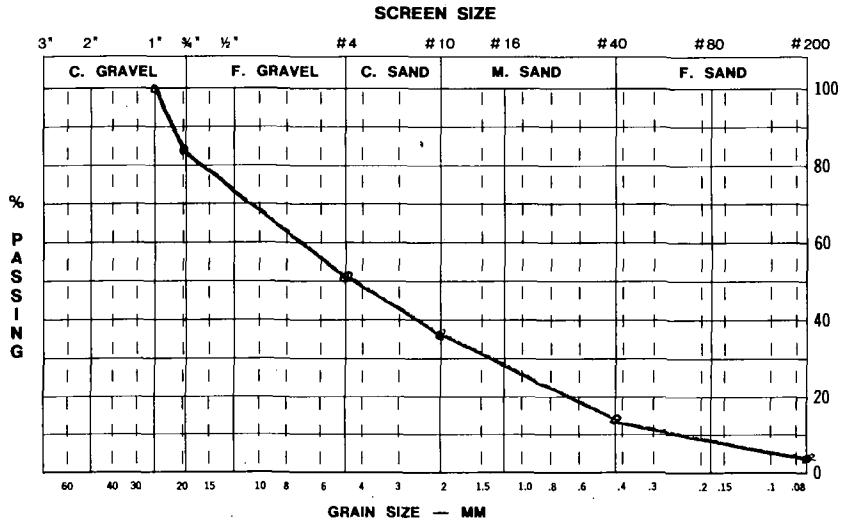
CLASS. GW

GREY, DRY, SL. SILTY, F-C SANDY, F-C GRAVEL.

SOIL FIELD IDENTIFICATION

TEST	GRAVEL	SAND	SILT	CLAY
VISUAL				
DRIED CAST				
DILITANCY				
BITE				
TOUGHNESS				

GRAIN SIZE CURVE



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=

PLASTICITY CHART

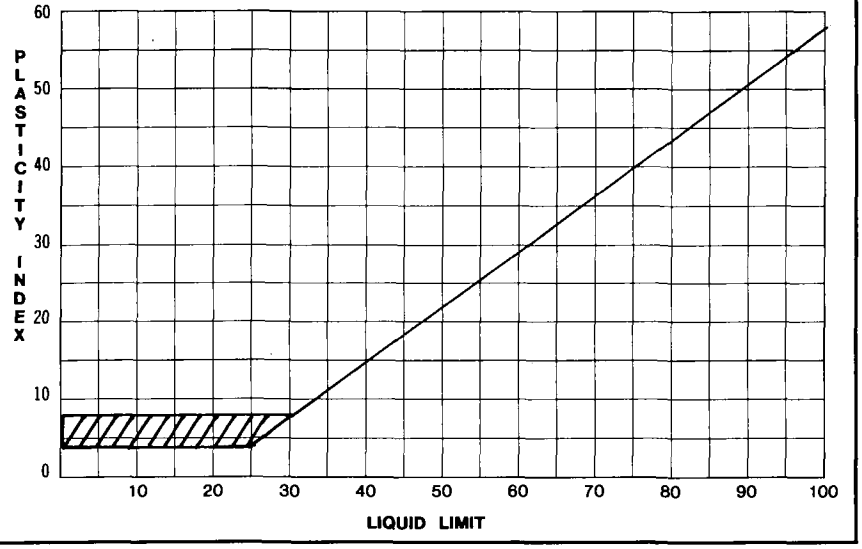


Figure B.1-32

SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

JOB NO.: L-7974

SAMPLE NO.: B624-9

HOLE NO.: HQ-20-89

DATE: 5-12-89

LAB. TECH.: JM

SIEVE ANALYSIS

DRY WT.: 54.9

WET WT.: 57.7

% H_2O: 5.1%

WT. OF SAMPLE: 308.7

	WT.	% PASS
-1½"	73.1	100
-1"	0	76.3
-¾"	118.2	76.3
-#4	48.5	38.0
-#10	31.1	22.3
-#40	27.0	12.2
-#200	10.8	3.5

SAMPLE DESCRIPTION

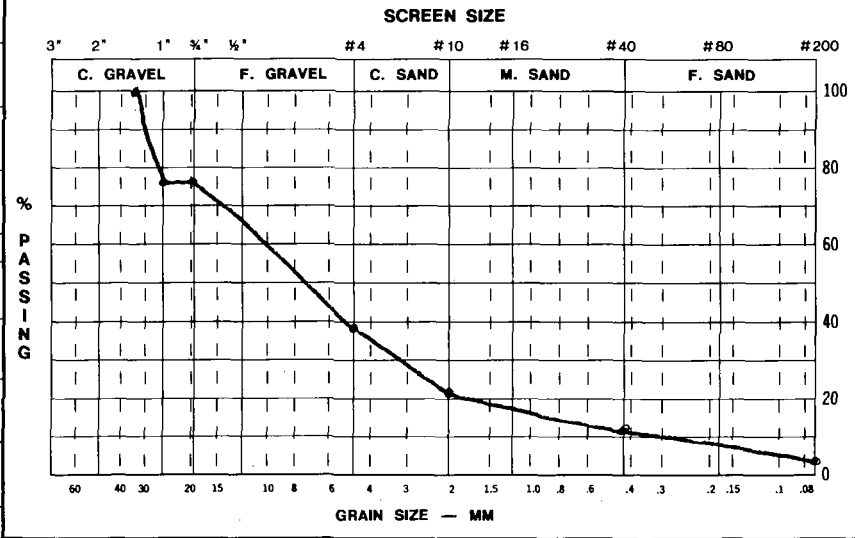
CLASS. GP

GREY, DRY, SL. SILTY, F-C SANDY, F-C GRAVEL.

SOIL FIELD IDENTIFICATION

TEST	GRAVEL	SAND	SILT	CLAY
VISUAL				
DRIED CAST				
DILITANCY				
BITE				
TOUGHNESS				

GRAIN SIZE CURVE



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=

PLASTICITY CHART

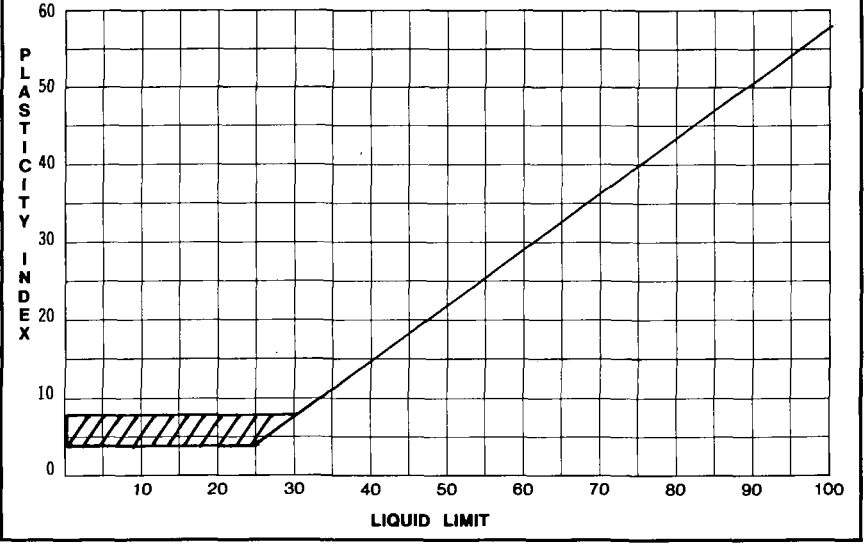


Figure B.1-33

SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

JOB NO.: L-7974

SAMPLE NO.: 0624-10

HOLE NO.: HQ-20-89

DATE: 5-12-89

LAB. TECH.: JM

SIEVE ANALYSIS

DRY WT.: 84.2

WET WT.: 87.7

% H_2O: 4.2%

WT. OF SAMPLE: 281.9

	WT.	% PASS
-1½"	78.7	100
-1"	22.3	72.1
-¾"	76.7	64.2
-#4	27.1	37.0
-#10	37.4	27.4
-#40	26.8	14.1
-#200	12.9	4.6

SAMPLE DESCRIPTION

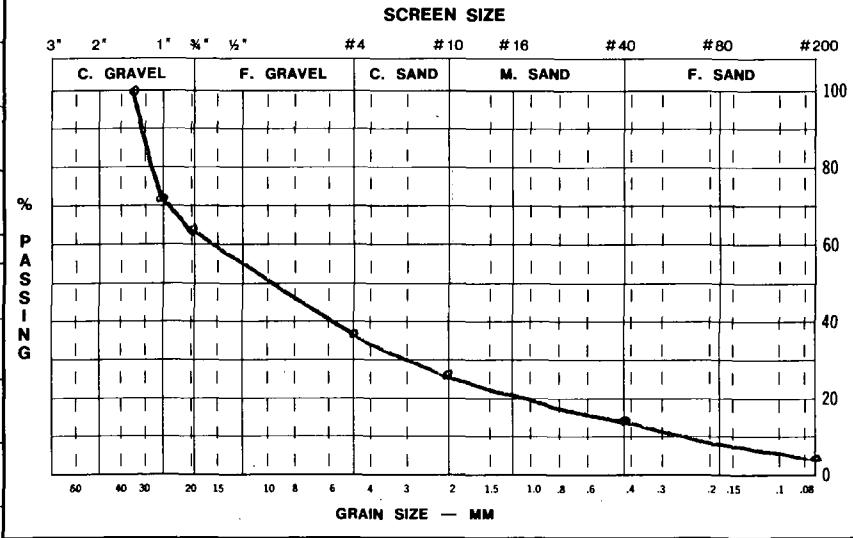
CLASS. GW

COREY, DRY, SL. SILTY, F-C SANDY, F-C GRAVEL.

SOIL FIELD IDENTIFICATION

TEST	GRAVEL	SAND	SILT	CLAY
VISUAL				
DRIED CAST				
DILITANCY				
BITE				
TOUGHNESS				

GRAIN SIZE CURVE



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=

PLASTICITY CHART

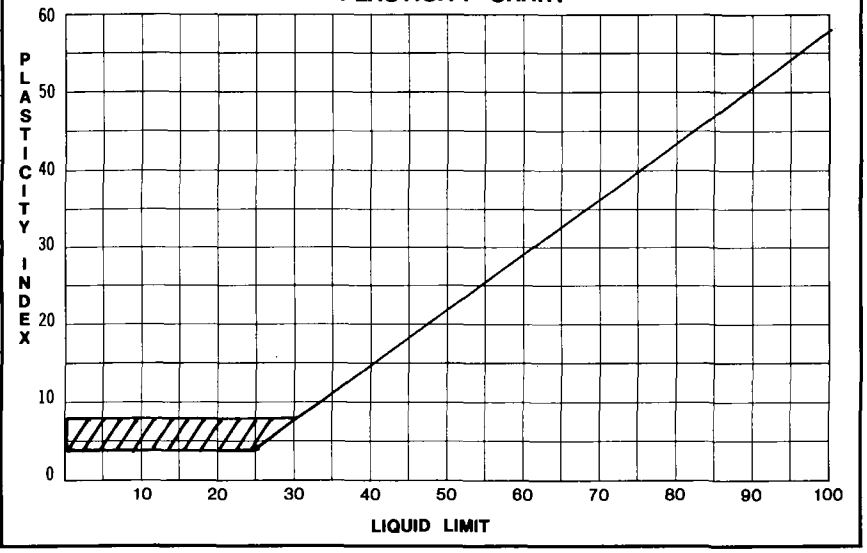


Figure B.1-34

SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

JOB NO.: L-7974

SAMPLE NO.: B624-11

HOLE NO.: HQ-20-89

DATE: 5-12-89

LAB. TECH.: JM

SIEVE ANALYSIS

DRY WT.:

WET WT.:

% H_2O:

WT. OF SAMPLE:

	WT.	% PASS
-1½"		
-1"		
-¾"		
-#4		
-#10		
-#40		
-#200		

SAMPLE DESCRIPTION

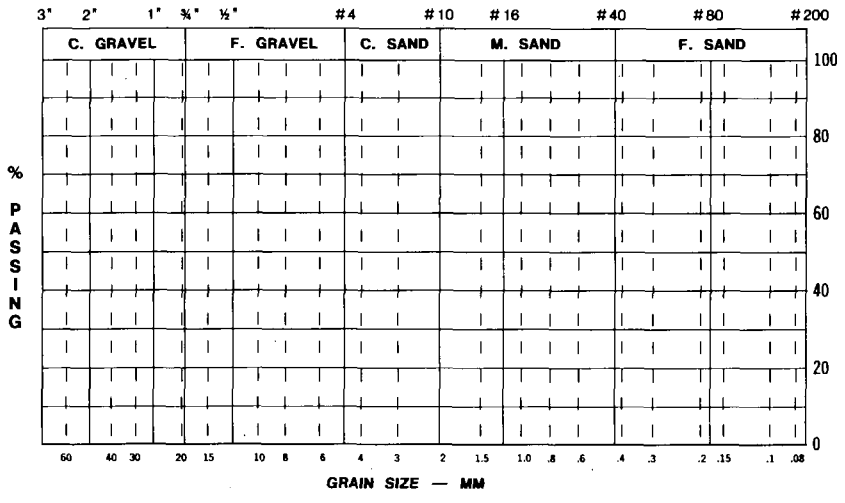
CLASS.

1½"- GRAVEL
(VISUAL ID ONLY,
SMALL SAMPLE)

SOIL FIELD IDENTIFICATION

TEST	GRAVEL	SAND	SILT	CLAY
VISUAL				
DRIED CAST				
DILITANCY				
BITE				
TOUGHNESS				

GRAIN SIZE CURVE



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=

PLASTICITY CHART

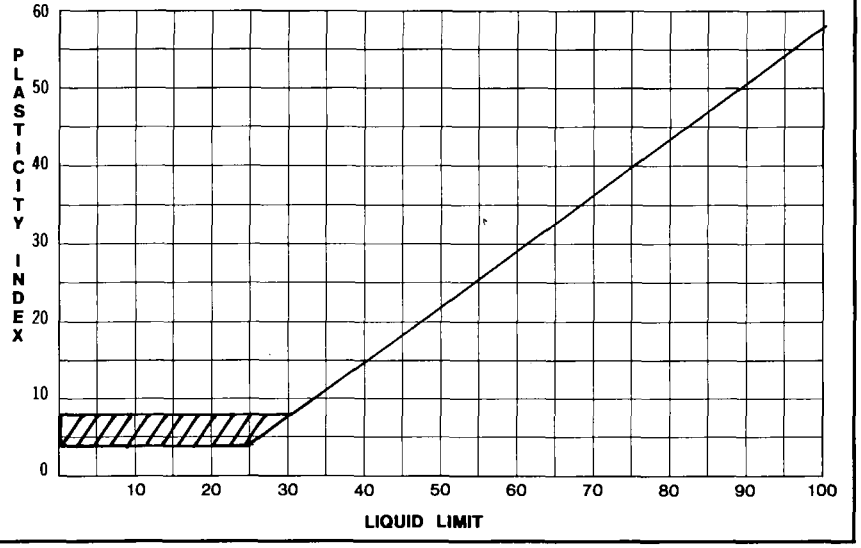


Figure B.1-35

SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

JOB NO.: L-7974

SAMPLE NO.: 0624-12

HOLE NO.: HQ-20

DATE: 5-12-89

LAB. TECH.: JM

SIEVE ANALYSIS

DRY WT.:

WET WT.:

% H_2O: 0% (DRY IN SAMPLE BAG)

WT. OF SAMPLE: 158.6

	WT.	% PASS
-1½"	29.5	100
-1"	31.7	81.4
-¾"	38.4	61.4
-#4	18.6	37.2
-#10	21.5	25.5
-#40	13.1	11.9
-#200	5.8	3.7

SAMPLE DESCRIPTION

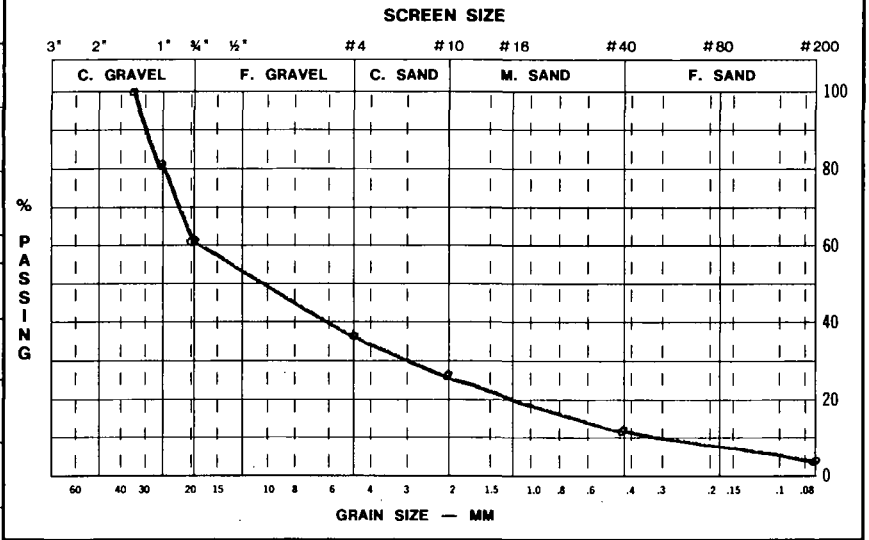
CLASS. GW

GREY, DRY, SL. SILTY, F-C SANDY, F-C GRAVEL.

SOIL FIELD IDENTIFICATION

TEST	GRAVEL	SAND	SILT	CLAY
VISUAL				
DRIED CAST				
DILITANCY				
BITE				
TOUGHNESS				

GRAIN SIZE CURVE



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=

PLASTICITY CHART

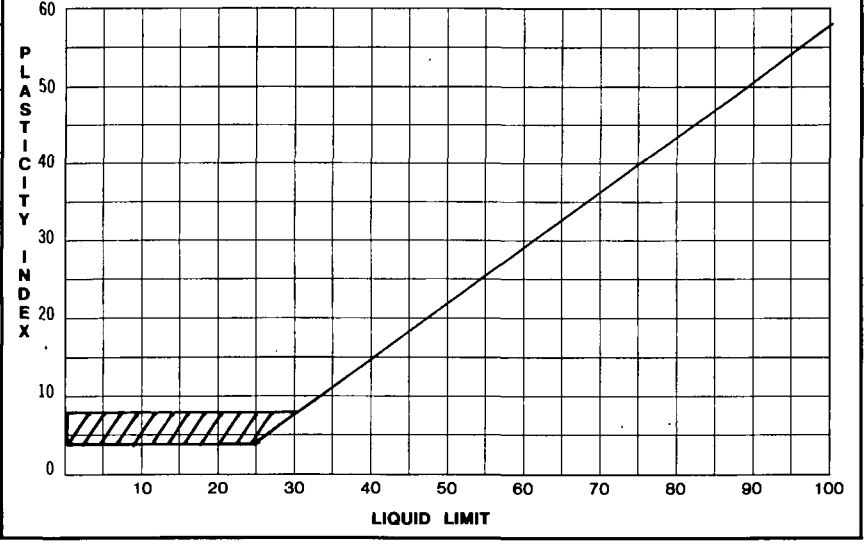


Figure B.1-36

SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

JOB NO.: L-7974

SAMPLE NO.: 8624-13

HOLE NO.: HQ-20-89

DATE: 5-12-89

LAB. TECH.: JM

SIEVE ANALYSIS

DRY WT.: 92.6

WET WT.: 97.9

% H_2O: 5.7%

WT. OF SAMPLE: 400.4

	WT.	% PASS
-1½"	30.9	100
-1"	43.3	92.4
-¾"	170.6	81.8
-#4	43.4	40.1
-#10	55.4	29.4
-#40	45.6	15.9
-#200	19.2	4.7

SAMPLE DESCRIPTION

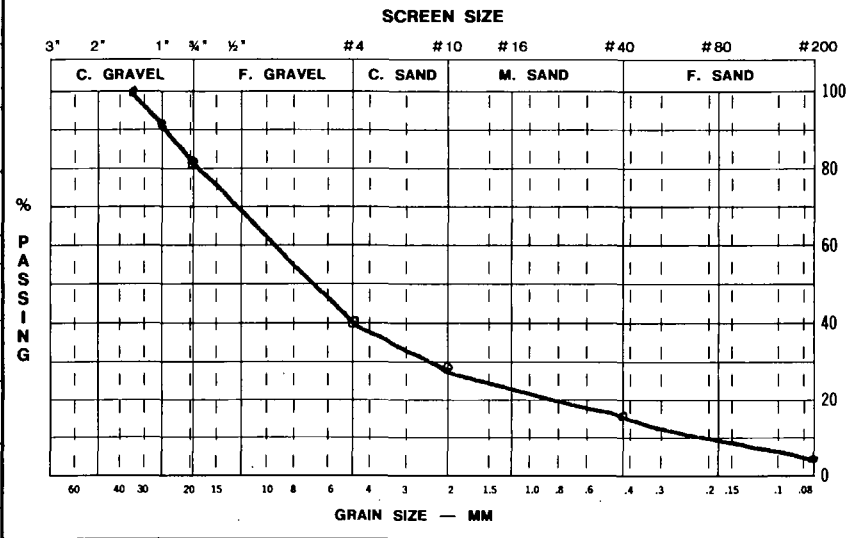
CLASS. GW

GREY, DRY, SL. SILTY, F-C SANDY, F-C GRAVEL.

SOIL FIELD IDENTIFICATION

TEST	GRAVEL	SAND	SILT	CLAY
VISUAL				
DRIED CAST				
DILITANCY				
BITE				
TOUGHNESS				

GRAIN SIZE CURVE



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=

PLASTICITY CHART

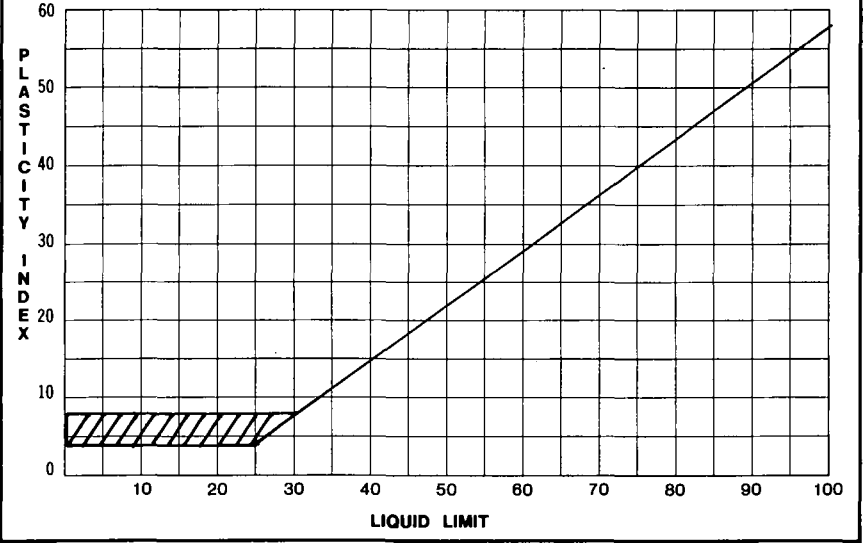


Figure B.1-37

SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

JOB NO.: L-7974

SAMPLE NO.: 0624-14

HOLE NO.: HQ-20-89

DATE: 5-12-09

LAB. TECH.: JM

SIEVE ANALYSIS

DRY WT.: 74.4

WET WT.: 77.7

% H_2O: 4.4%

WT. OF SAMPLE: 265.2

	WT.	% PASS
-1½"	76.0	100
-1"	32.8	71.3
-¾"	62.4	59.0
-#4	27.5	35.4
-#10	32.2	25.1
-#40	23.2	12.9
-#200	11.10	4.2

SAMPLE DESCRIPTION

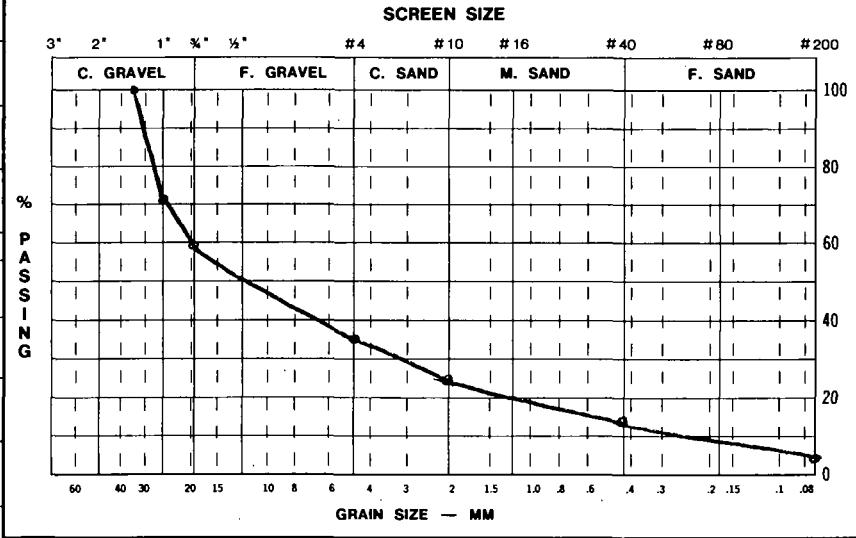
CLASS. GW

GREY, DRY, SL. SILTY, F-C SANDY, F-C GRAVEL.

SOIL FIELD IDENTIFICATION

TEST	GRAVEL	SAND	SILT	CLAY
VISUAL				
DRIED CAST				
DILITANCY				
BITE				
TOUGHNESS				

GRAIN SIZE CURVE



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=

PLASTICITY CHART

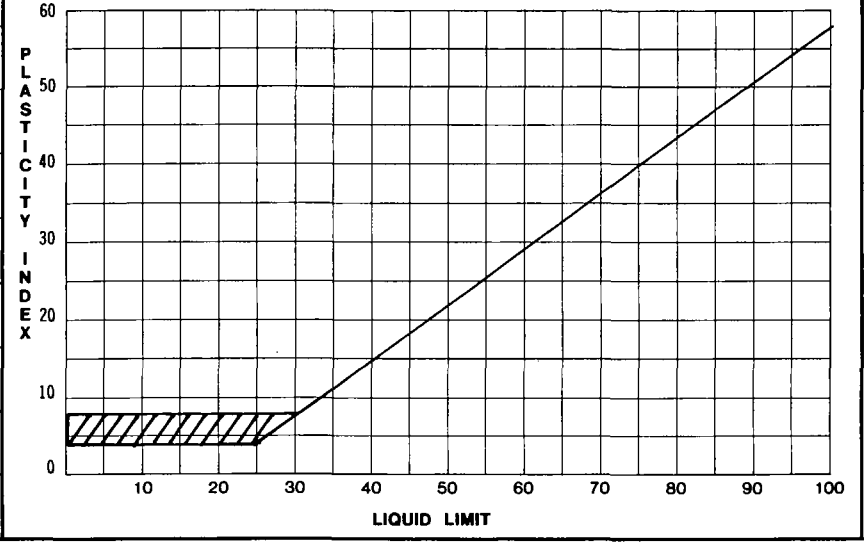


Figure B.1-38

SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

JOB NO.: L-7974

SAMPLE NO.: B624-15

HOLE NO.: HQ-20-89

DATE: 5-12-89

LAB. TECH.: JM

SIEVE ANALYSIS

DRY WT.: 71,7

WET WT.: 75,5

% H_2O: 5,3%

WT. OF SAMPLE: 352.1

	WT.	% PASS
-1½"	43,2	100
-1"	75,2	87,7
-¾"	88,2	66,4
-#4	53,7	41,3
-#10	58,9	26,1
-#40	22,6	9,3
-#200	10,3	2,9

SAMPLE DESCRIPTION

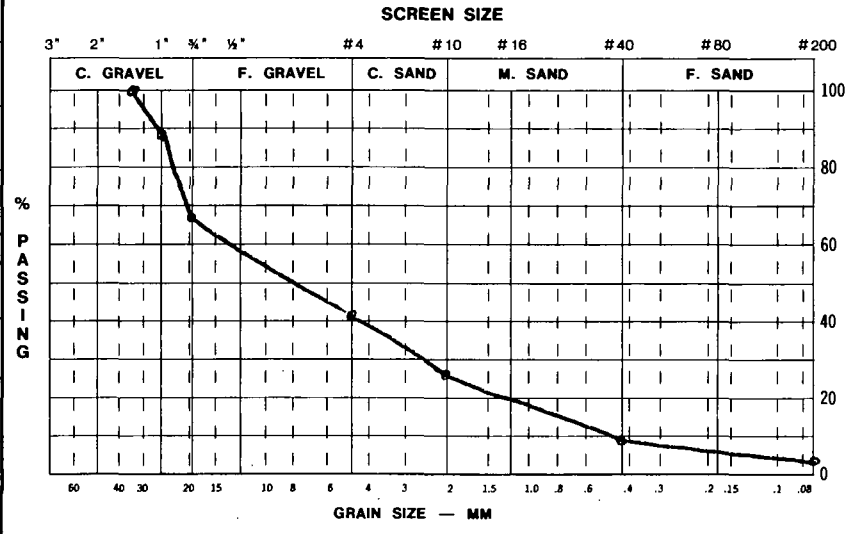
CLASS. GW

COBBLY, DRY, SL. SILTY, F-C SANDY, F-C GRAVEL.

SOIL FIELD IDENTIFICATION

TEST	GRAVEL	SAND	SILT	CLAY
VISUAL				
DRIED CAST				
DILITANCY				
BITE				
TOUGHNESS				

GRAIN SIZE CURVE



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=

PLASTICITY CHART

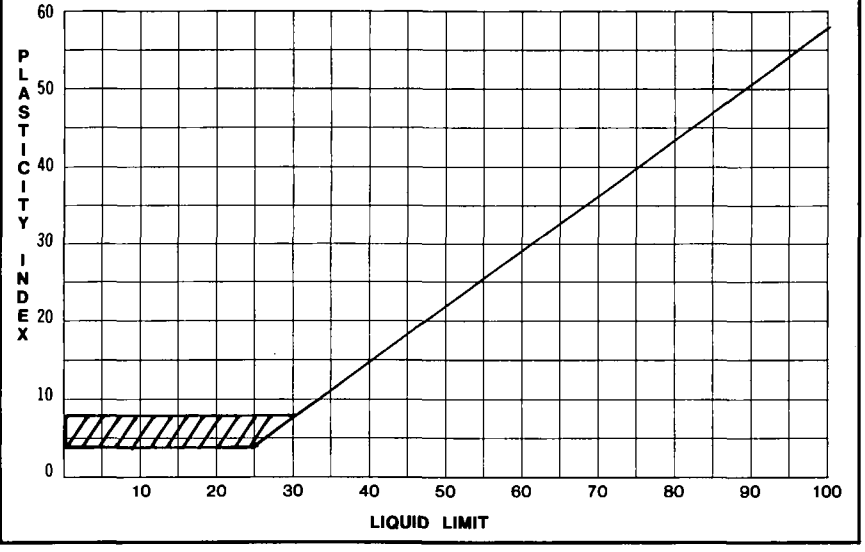


Figure B.1-39

SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

JOB NO.: L-7974

SAMPLE NO.: B572-1

HOLE NO.: HQ-13-89

DATE: 4-21-89

LAB. TECH.: JM

SIEVE ANALYSIS

DRY WT.: 84.4

WET WT.: 97.9

% H_2O: 16.0%

WT. OF SAMPLE: 207.5

	WT.	% PASS
-1½"	49.1	100
-1"	0	76.3
-¾"	50.2	76.3
-#4	20.6	52.1
-#10	41.4	42.2
-#40	39.4	22.3
-#200	6.8	3.3

SAMPLE DESCRIPTION

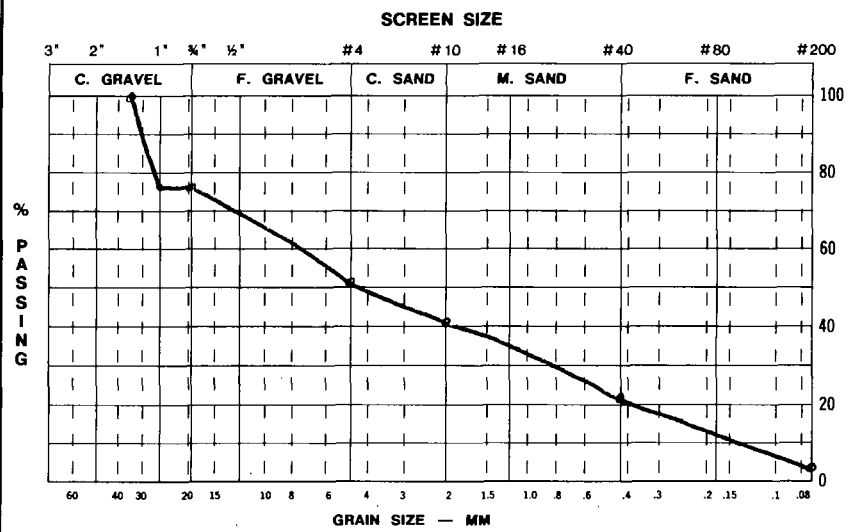
CLASS. SP

LOOSE, MOIST, SL. SILTY, GRAVELLY, F-C SAND.

SOIL FIELD IDENTIFICATION

TEST	GRAVEL	SAND	SILT	CLAY
VISUAL				
DRIED CAST				
DILITANCY				
BITE				
TOUGHNESS				

GRAIN SIZE CURVE



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=

PLASTICITY CHART

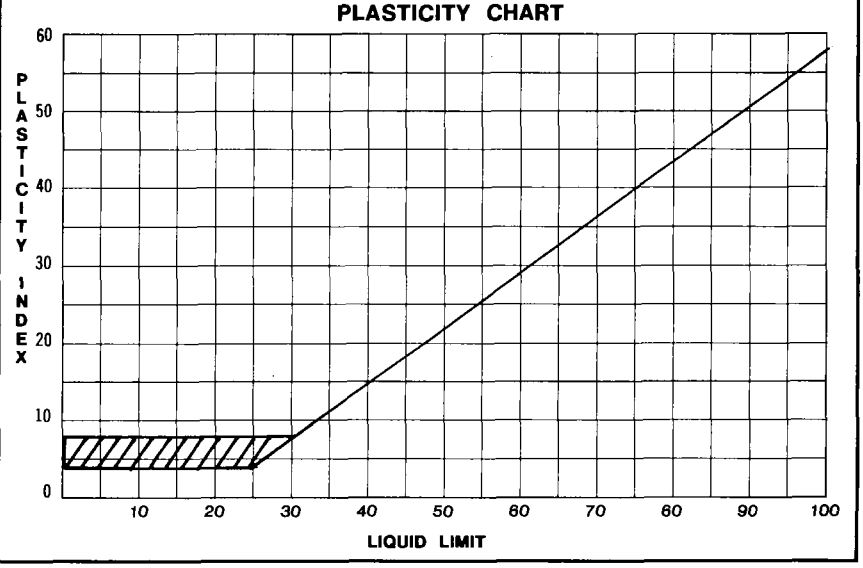


Figure B.1-40

SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

JOB NO.: L-7974

SAMPLE NO.: 0572-2

HOLE NO.: HA-13-89

DATE: 4-19-89

LAB. TECH.: JM

SIEVE ANALYSIS

DRY WT.: 76.0

WET WT.: 88.8

% H_2O: 16.8%

WT. OF SAMPLE: 372.1

	WT.	% PASS
-1½"		
-1"	34.3	100
-¾"	72.3	90.8
-#4	29.1	71.4
-#10	51.2	63.5
-#40	83.8	49.8
-#200	101.4	27.3

SAMPLE DESCRIPTION

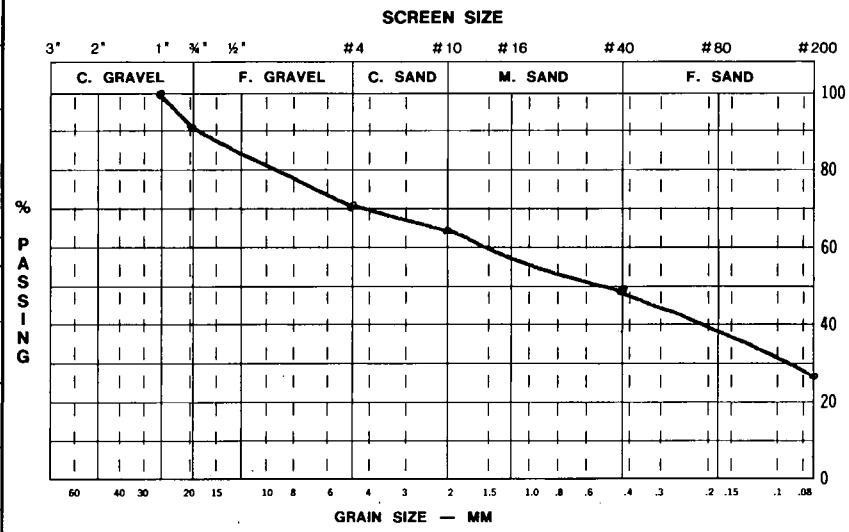
CLASS. SM

GREY, MOIST, U. SILTY, GRAVELLY, F-C SAND.

SOIL FIELD IDENTIFICATION

TEST	GRAVEL	SAND	SILT	CLAY
VISUAL				
DRIED CAST				
DILITANCY				
BITE				
TOUGHNESS				

GRAIN SIZE CURVE



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=

PLASTICITY CHART

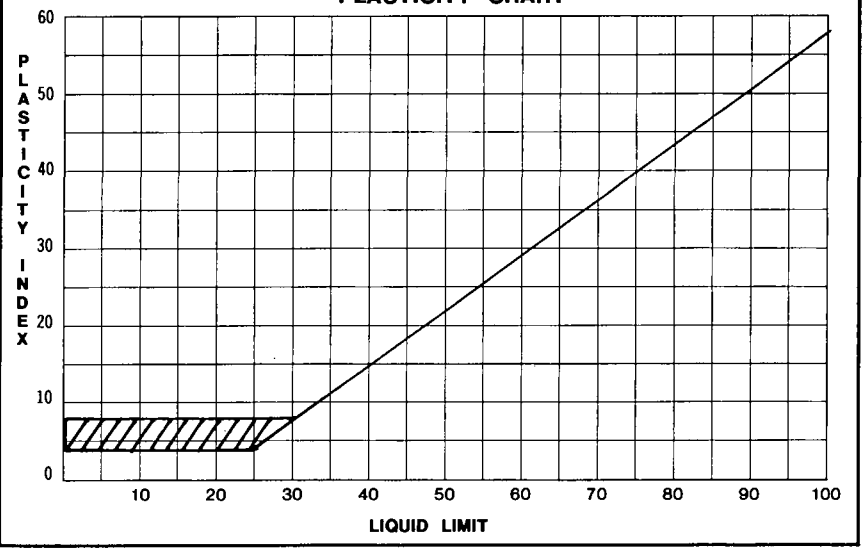


Figure B.1-41

SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

JOB NO.: L-7974

SAMPLE NO.: B572-3

HOLE NO.: HQ-13-89

DATE: 4-21-89

LAB. TECH.: JM

SIEVE ANALYSIS

DRY WT.: 73.2

WET WT.: 83.0

% H_2O: 13.4%

WT. OF SAMPLE: 517.9

	WT.	% PASS
-1½"		
-1"		
-¾"	100.4	100
-#4	98.6	80.6
-#10	190.6	61.6
-#40	93.0	24.8
-#200	35.3	6.8

SAMPLE DESCRIPTION

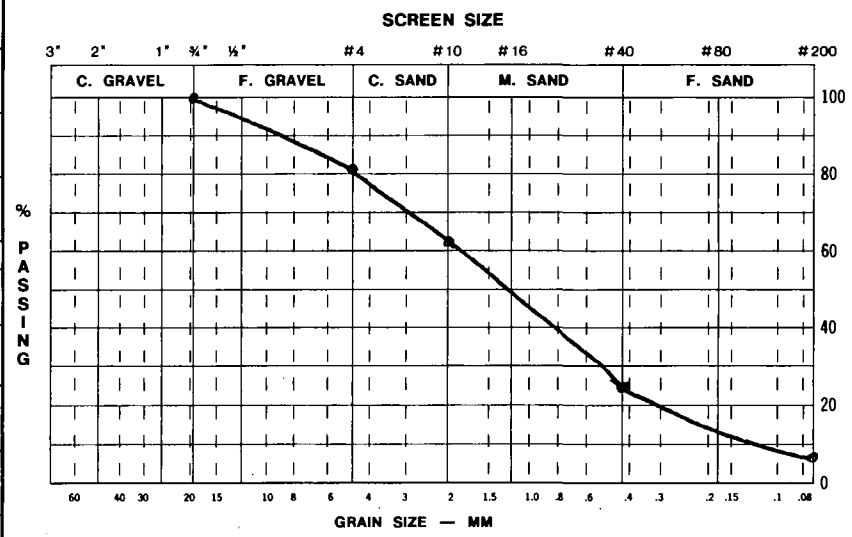
CLASS. SW-SM

GREY, MOIST, SILTY, GRAVELLY, F-C SAND.

SOIL FIELD IDENTIFICATION

TEST	GRAVEL	SAND	SILT	CLAY
VISUAL				
DRIED CAST				
DILITANCY				
BITE				
TOUGHNESS				

GRAIN SIZE CURVE



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=

PLASTICITY CHART

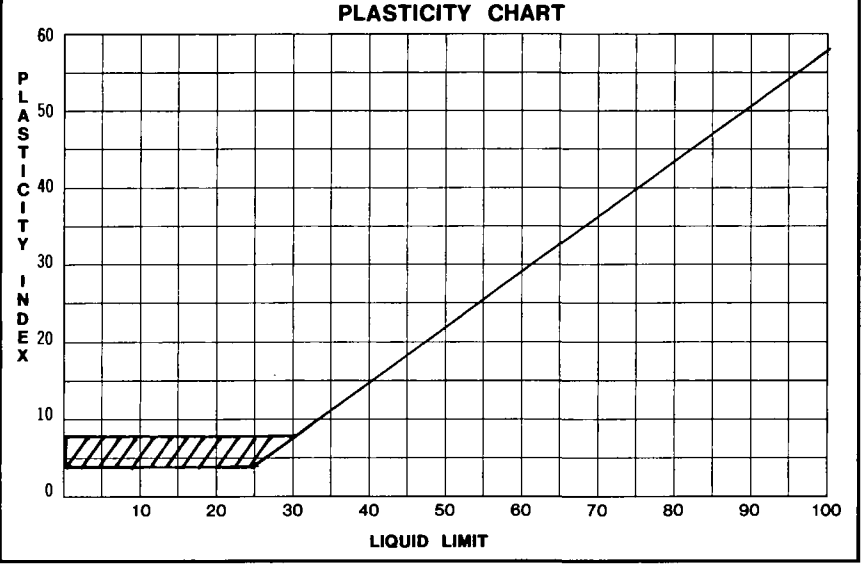


Figure B.1-42

SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

JOB NO.: L-7974

SAMPLE NO.: 8572-5

HOLE NO.: HQ-13-89

DATE: 4-20-89

LAB. TECH.: JM

SIEVE ANALYSIS

DRY WT.: 93.8

WET WT.: 105.4

% H_2O: 12.4%

WT. OF SAMPLE: 396.8

	WT.	% PASS
-1½"		
-1"		
-¾"	23.1	100
-#4	2.7	94.2
-#10	50.3	93.5
-#40	225.4	80.8
-#200	95.3	24.0

SAMPLE DESCRIPTION

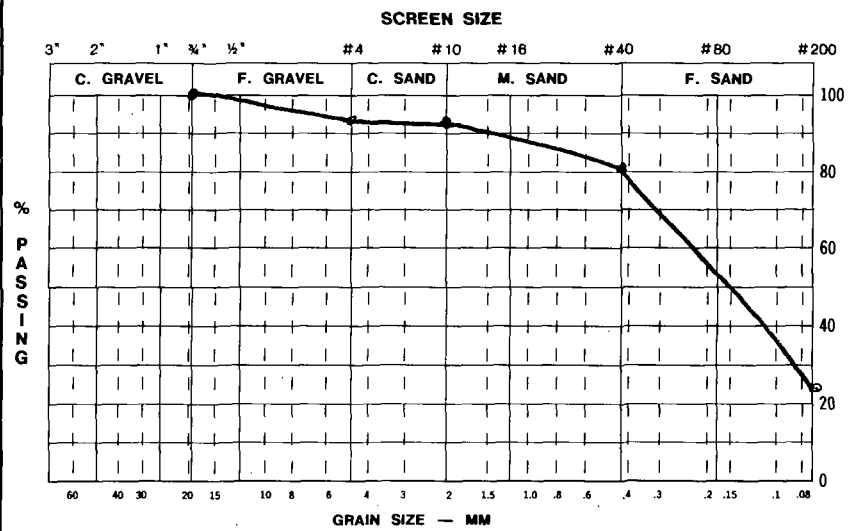
CLASS. SM

GREY-TAN, MOIST, V. SILTY, GRAVELLY, F-M SAND.

SOIL FIELD IDENTIFICATION

TEST	GRAVEL	SAND	SILT	CLAY
VISUAL				
DRIED CAST				
DILITANCY				
BITE				
TOUGHNESS				

GRAIN SIZE CURVE



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=

PLASTICITY CHART

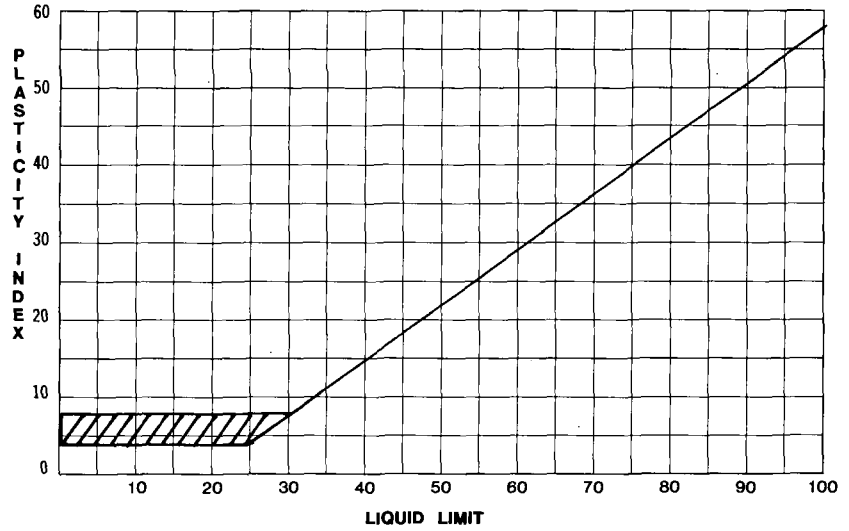


Figure B.1-43

SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

JOB NO.: L-7974

SAMPLE NO.: B587-1

HOLE NO.: HQ-14-89

DATE: 4-20-89

LAB. TECH.: JM

SIEVE ANALYSIS

DRY WT.: 00 SAMPLE WAS TOTALLY DRY WHEN SUBMITTED

WET WT.: 00

% H_2O:

WT. OF SAMPLE: 152.1

	WT.	% PASS
-1½"	53.8	100
-1"	17.7	64.6
-¾"	58.0	53.0
-#4	6.0	14.9
-#10	10.9	10.9
-#40	3.7	3.7
-#200	2.0	1.3

SAMPLE DESCRIPTION

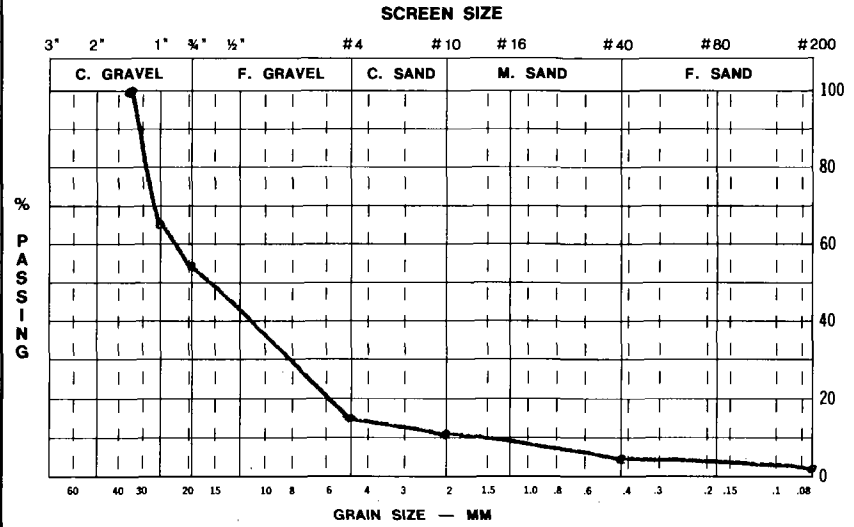
CLASS. GW

GREY, DRY, SL. SILTY, F-C SANDY, F-C GRAVEL.

SOIL FIELD IDENTIFICATION

TEST	GRAVEL	SAND	SILT	CLAY
VISUAL				
DRIED CAST				
DILITANCY				
BITE				
TOUGHNESS				

GRAIN SIZE CURVE



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=

PLASTICITY CHART

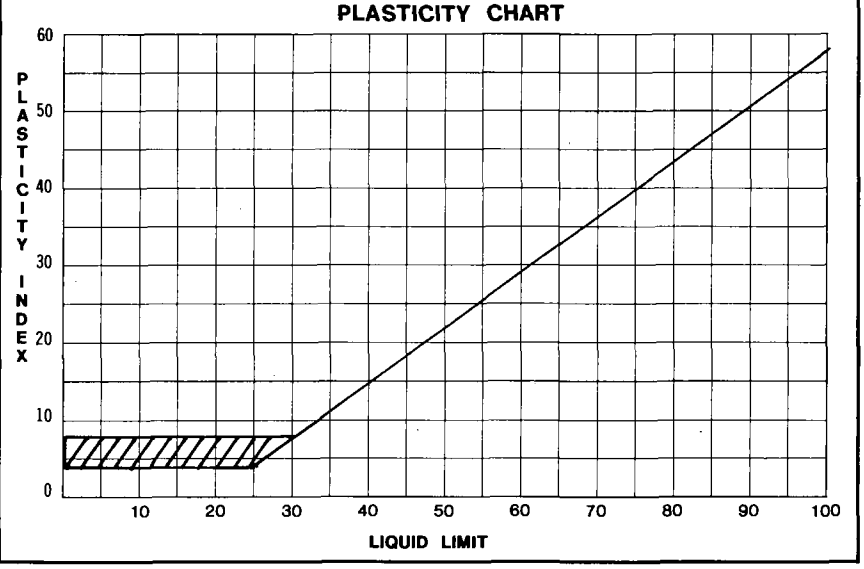


Figure B.1-44

SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

JOB NO.: L-7974

SAMPLE NO.: B587-2

HOLE NO.: HQ-14-89

DATE: 4-21-89

LAB. TECH.: JM

SOIL FIELD IDENTIFICATION

TEST	GRAVEL	SAND	SILT	CLAY
VISUAL				
DRIED CAST				
DILITANCY				
BITE				
TOUGHNESS				

SIEVE ANALYSIS

DRY WT.: 42.4

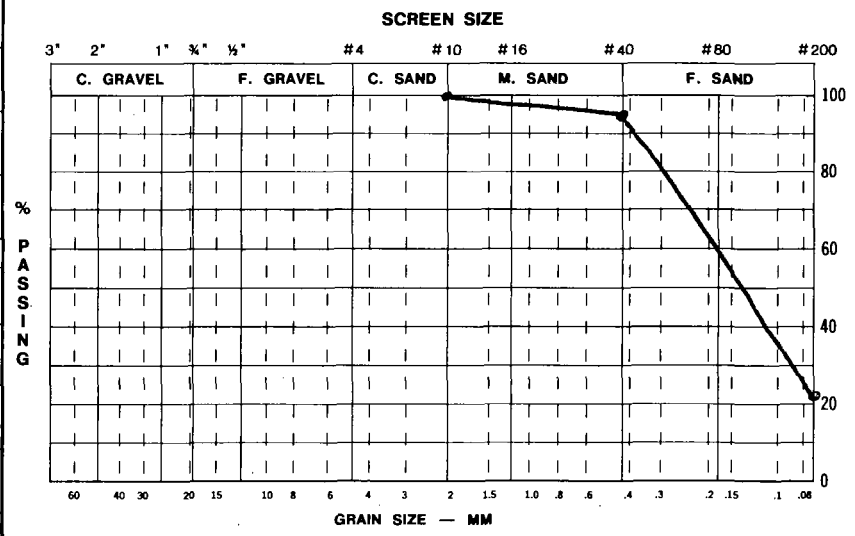
WET WT.: 50.3

% H_2O: 18.6%

WT. OF SAMPLE: 417.2

	WT.	% PASS
-1½"		
-1"		
-¾"		
-#4		
-#10	20.9	100
-#40	306.1	95.0
-#200	90.2	21.6

GRAIN SIZE CURVE



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=

SAMPLE DESCRIPTION

CLASS. SM

CLAYEY, MOIST, V. SILTY, F-M SAND.

PLASTICITY CHART

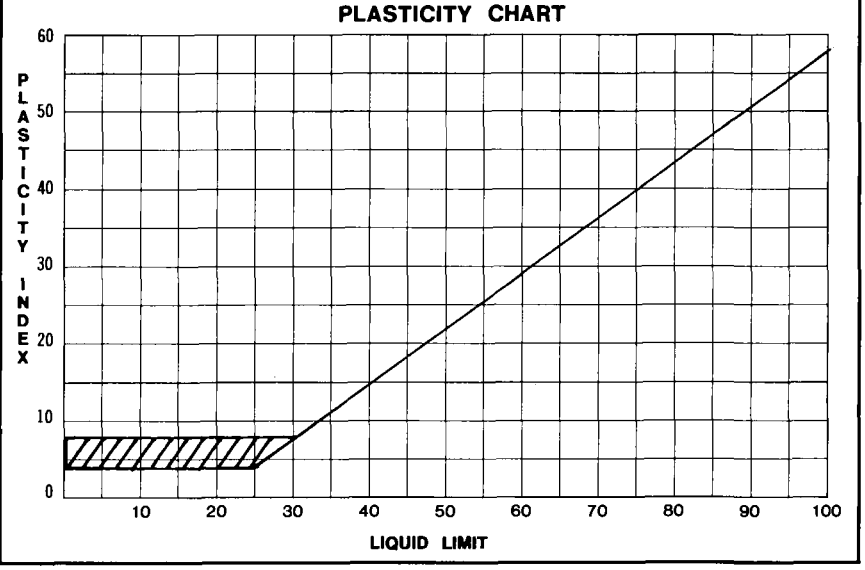


Figure B.1-45

SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

JOB NO.: L-7974

SAMPLE NO.: 0587-3

HOLE NO.: HQ+14-89

DATE: 4-20-89

LAB. TECH.: JM

SIEVE ANALYSIS

DRY WT.: 75.3

WET WT.: 87.8

% H_2O: 16.6%

WT. OF SAMPLE: 517.3

	WT.	% PASS
-1½"		
-1"	52.6	100
-¾"	118.4	89.8
-#4	46.8	66.9
-#10	46.4	57.9
-#40	131.5	40.9
-#200	121.6	23.5

SAMPLE DESCRIPTION

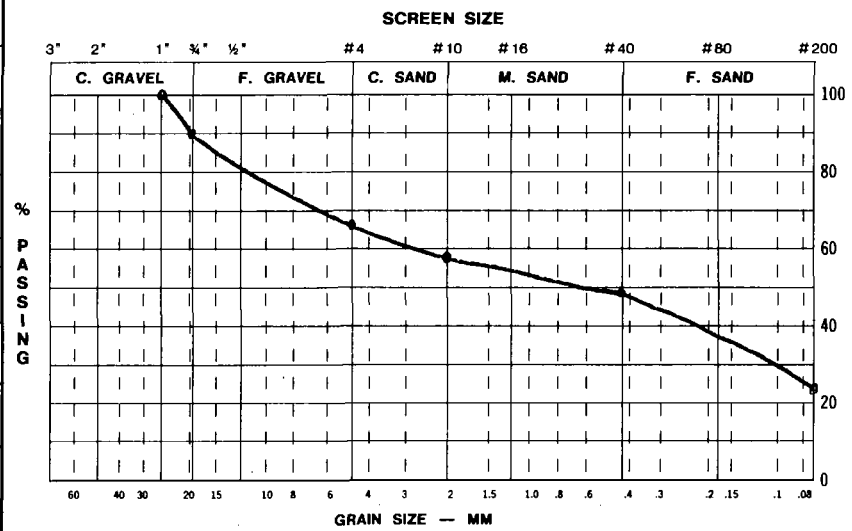
CLASS. SM

COREY, MOIST, V. SILTY, GRAVELLY, F-C SAND.

SOIL FIELD IDENTIFICATION

TEST	GRAVEL	SAND	SILT	CLAY
VISUAL				
DRIED CAST				
DILITANCY				
BITE				
TOUGHNESS				

GRAIN SIZE CURVE



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=

PLASTICITY CHART

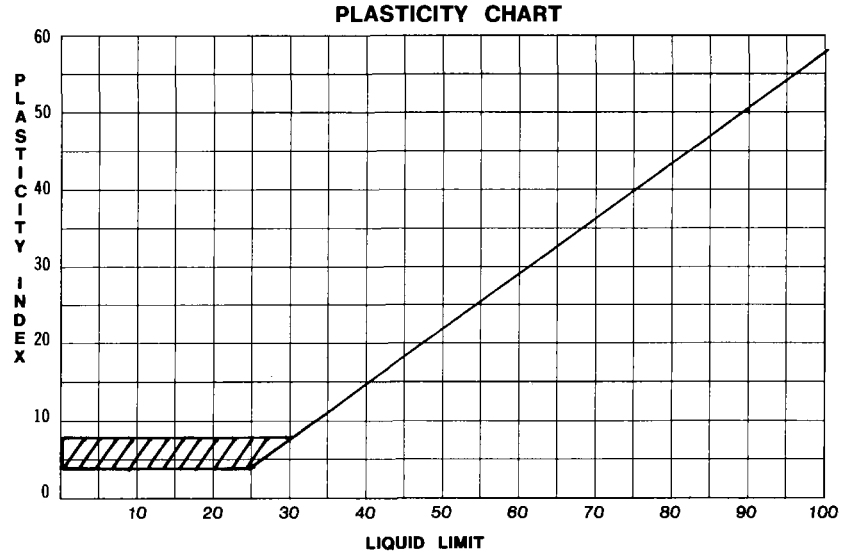


Figure B.1-46

SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

JOB NO.: L-7974

SAMPLE NO.: BSB7-4

HOLE NO.: HQ+14-89

DATE: 4-20-89

LAB. TECH.: JM

SIEVE ANALYSIS

DRY WT.: 84.8

WET WT.: 96.3

% H_2O: 13.6%

WT. OF SAMPLE: 618.6

	WT.	% PASS
-1½"		
-1"		
-¾"	37.0	100
-#4	123.1	94.0
-#10	297.2	74.1
-#40	127.4	26.1
-#200	33.9	5.5

SAMPLE DESCRIPTION

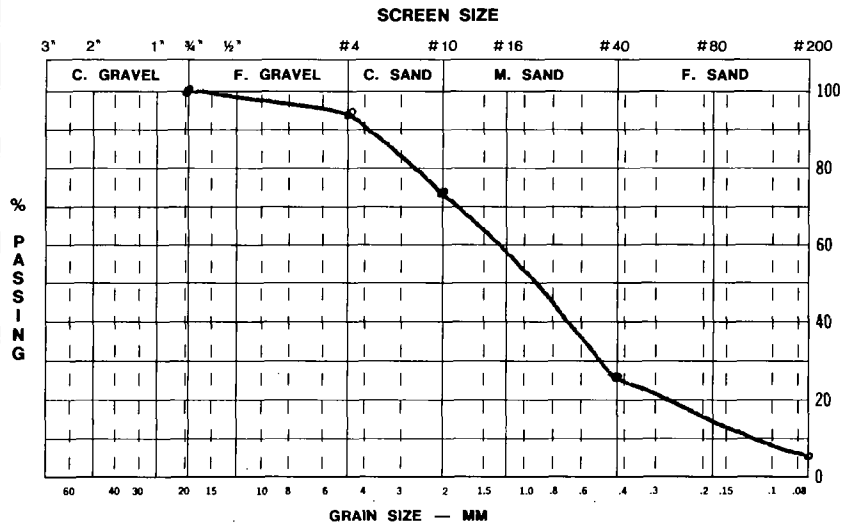
CLASS. SW-SM

COREY, MOIST, SL. SILTY, COARSELY, F-C SAND.

SOIL FIELD IDENTIFICATION

TEST	GRAVEL	SAND	SILT	CLAY
VISUAL				
DRIED CAST				
DILITANCY				
BITE				
TOUGHNESS				

GRAIN SIZE CURVE



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=

PLASTICITY CHART

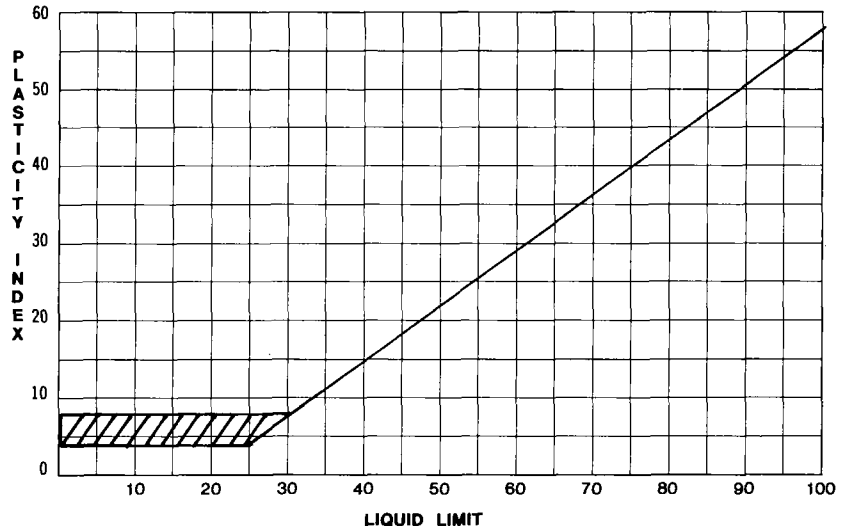


Figure B.1-47

SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

JOB NO.: L-7974

SAMPLE NO.: B587-6

HOLE NO.: HA-14-89

DATE: 4-19-89

LAB. TECH.: JM

SOIL FIELD IDENTIFICATION

TEST	GRAVEL	SAND	SILT	CLAY
VISUAL				
DRIED CAST				
DILITANCY				
BITE				
TOUGHNESS				

SIEVE ANALYSIS

DRY WT.: 52.1

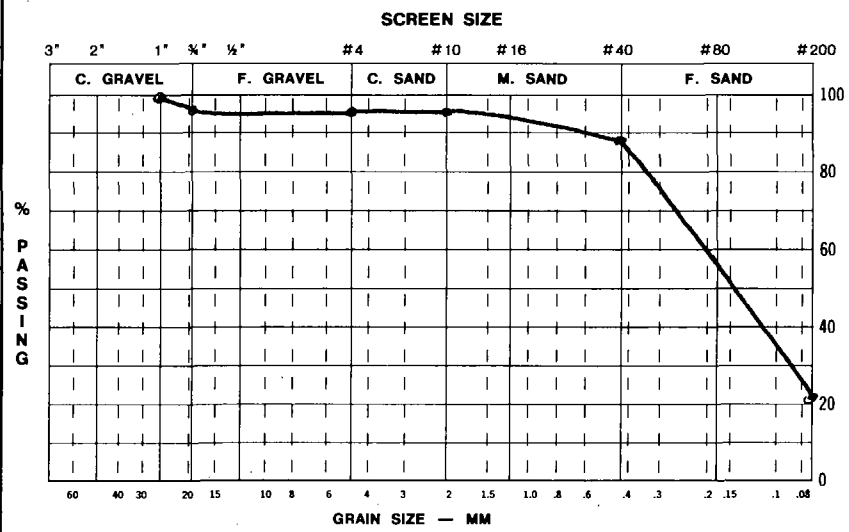
WET WT.: 60.6

% H_2O: 16.3%

WT. OF SAMPLE: 526.9

	WT.	% PASS
-1½"		
-1"	16.8	100
-¾"	3.6	96.8
-#4	2.6	96.1
-#10	38.8	95.6
-#40	347.2	88.3
-#200	117.9	22.4

GRAIN SIZE CURVE



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=

SAMPLE DESCRIPTION

CLASS. SM

TAN, MOIST, V. SILTY, COARSELY, F-M SAND

PLASTICITY CHART

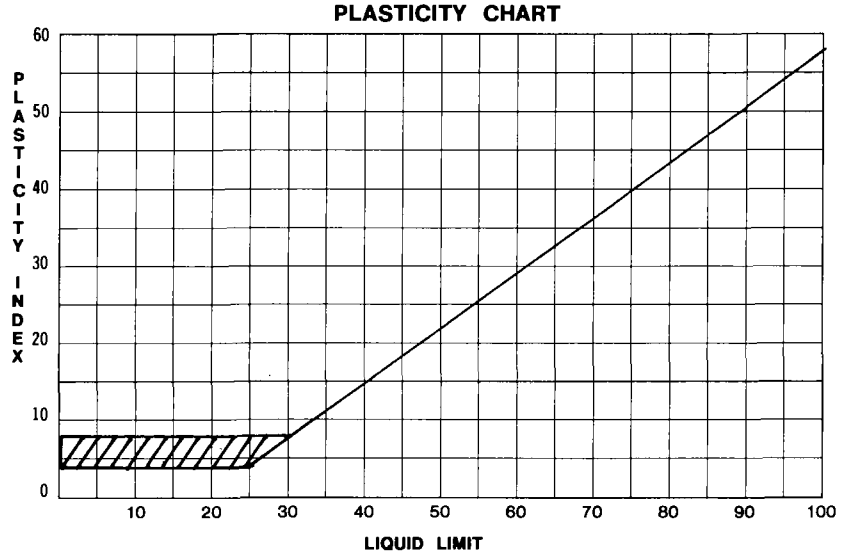


Figure B.1-48

SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

JOB NO.: L-7974

SAMPLE NO.: 0587-14

HOLE NO.: HQ-14-09

DATE: 4-21-09

LAB. TECH.: JM

SIEVE ANALYSIS

DRY WT.: 54.7

WET WT.: 61.9

% H_2O: 13.2%

WT. OF SAMPLE: 299.0

	WT.	% PASS
-1½"		
-1"	20.2	100
-¾"	118.3	93.2
-#4	37.9	53.7
-#10	63.5	41.0
-#40	39.1	19.8
-#200	20.0	6.7

SAMPLE DESCRIPTION

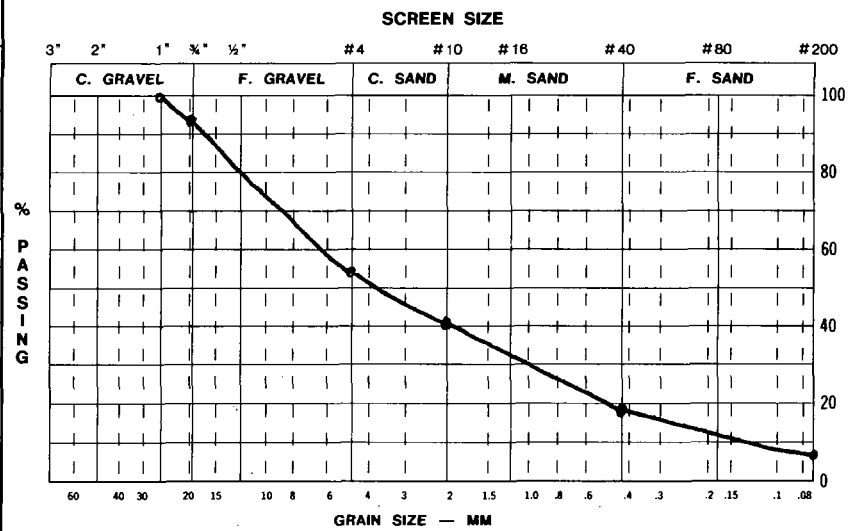
CLASS. SW-SM

COREY, MOIST, SILTY, GRAVELLY, F-C SAND.

SOIL FIELD IDENTIFICATION

TEST	GRAVEL	SAND	SILT	CLAY
VISUAL				
DRIED CAST				
DILITANCY				
BITE				
TOUGHNESS				

GRAIN SIZE CURVE



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=

PLASTICITY CHART

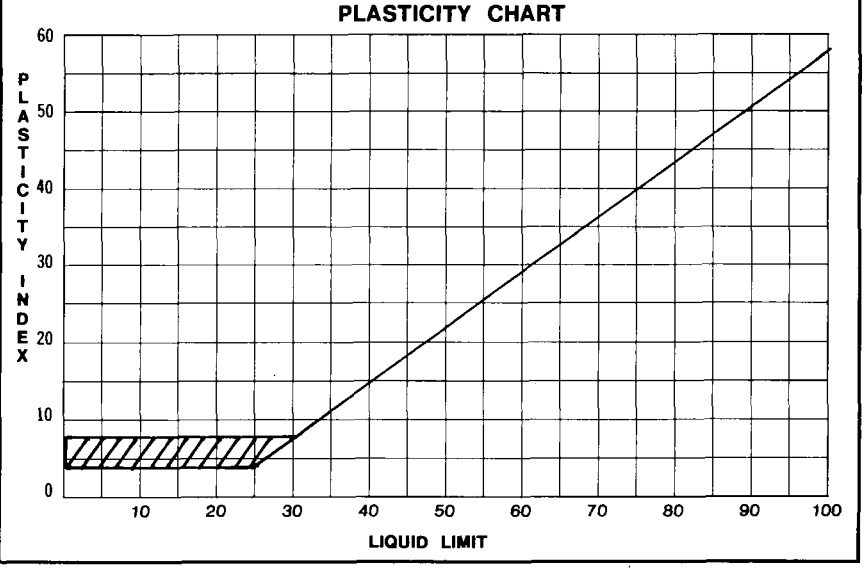


Figure B.1-49

SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

JOB NO.: L-7974

SAMPLE NO.: 0587-16

HOLE NO.: HQ-14-89

DATE: 4-21-89

LAB. TECH.: JM

SIEVE ANALYSIS

DRY WT.: 74.9

WET WT.: 87.9

% H_2O: 17.4%

WT. OF SAMPLE: 407.3

	WT.	% PASS
-1½"	92.4	100
-1"	14.3	77.3
-¾"	113.8	73.8
-#4	37.7	45.9
-#10	61.1	36.6
-#40	57.9	21.6
-#200	30.1	7.4

SAMPLE DESCRIPTION

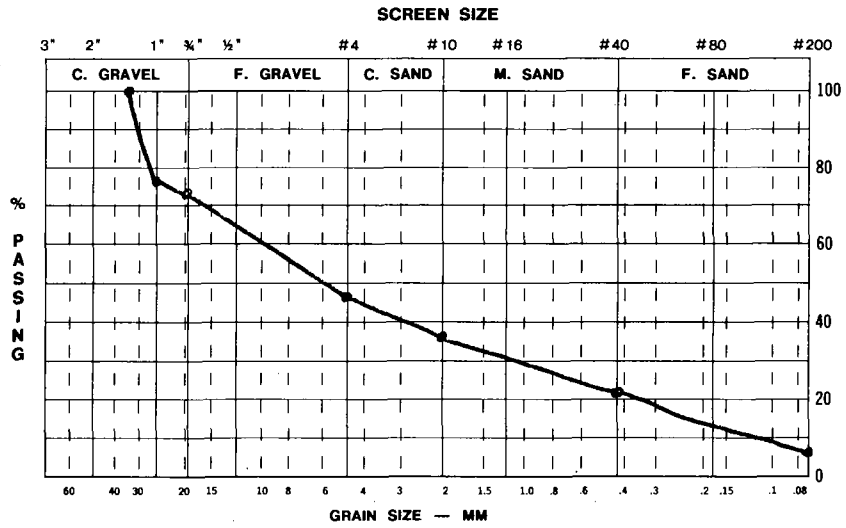
CLASS. GW-GM

COBBLEY, MOIST, SILTY, F-C SANDY, F-C GRAVEL

SOIL FIELD IDENTIFICATION

TEST	GRAVEL	SAND	SILT	CLAY
VISUAL				
DRIED CAST				
DILITANCY				
BITE				
TOUGHNESS				

GRAIN SIZE CURVE



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=

PLASTICITY CHART

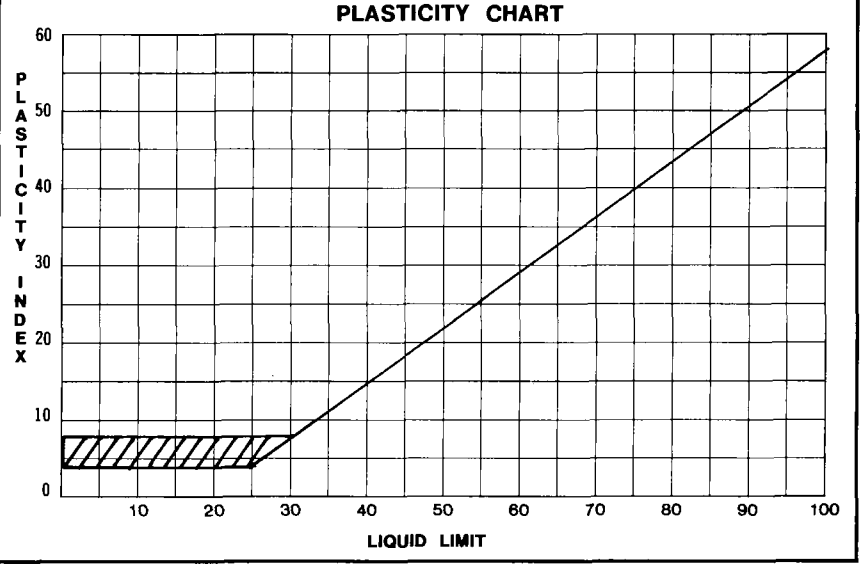


Figure B.1-50

SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

JOB NO.: L-7974

SAMPLE NO.: B572-B

HOLE NO.: HQ-13-89

DATE: 4-19-89

LAB. TECH.: JM

SIEVE ANALYSIS

DRY WT.: 94.8

WET WT.: 105.0

% H_2O: 10.8%

WT. OF SAMPLE: 521.9

	WT.	% PASS
-1½"	12.6	100
-1"	19.8	97.6
-¾"	39.0	93.8
-#4	36.7	86.3
-#10	84.2	79.3
-#40	212.8	63.2
-#200	116.8	22.4

SAMPLE DESCRIPTION

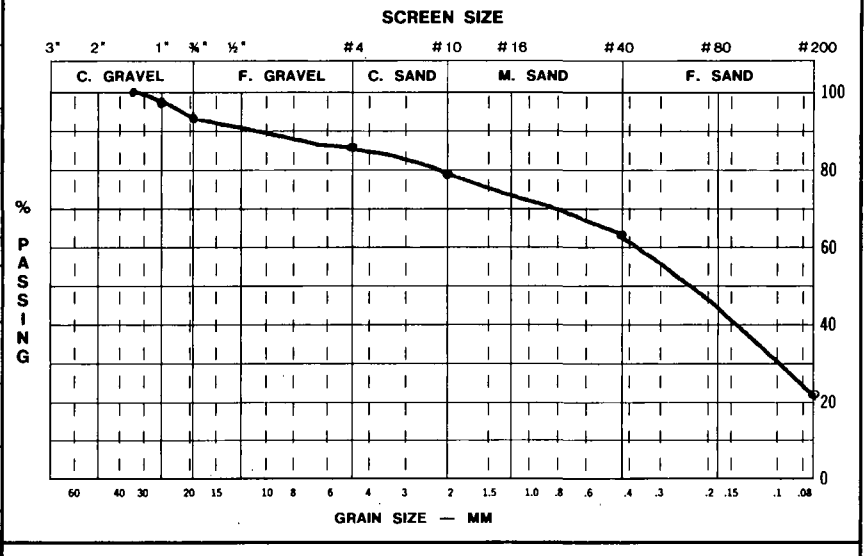
CLASS. SM

GREY, MOIST, V. SILTY, GRAVELLY, F-C SAND.

SOIL FIELD IDENTIFICATION

TEST	GRAVEL	SAND	SILT	CLAY
VISUAL				
DRIED CAST				
DILITANCY				
BITE				
TOUGHNESS				

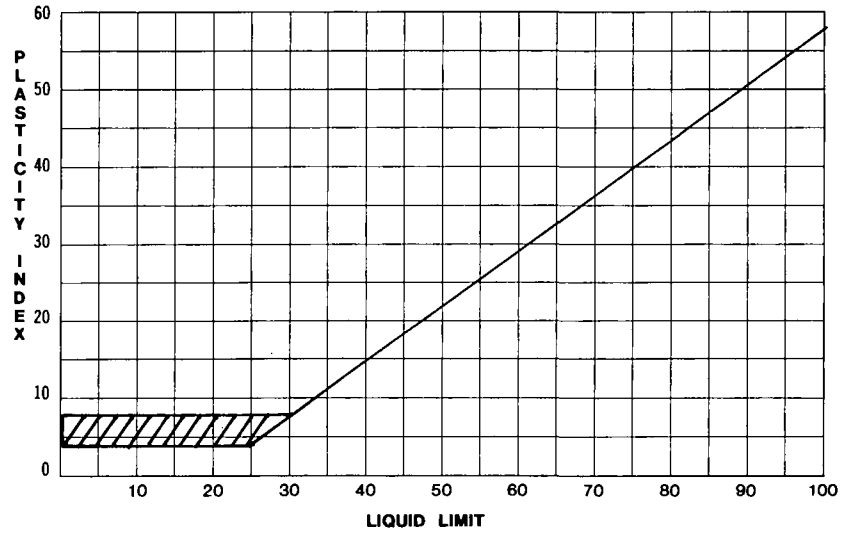
GRAIN SIZE CURVE



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=

PLASTICITY CHART



SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

JOB NO.: L-7974

SAMPLE NO.: 8572-9

HOLE NO.: HQ-13-89

DATE: 4-21-89

LAB. TECH.: JM

SOIL FIELD IDENTIFICATION

TEST	GRAVEL	SAND	SILT	CLAY
VISUAL				
DRIED CAST				
DILITANCY				
BITE				
TOUGHNESS				

SIEVE ANALYSIS

DRY WT.: 72.7

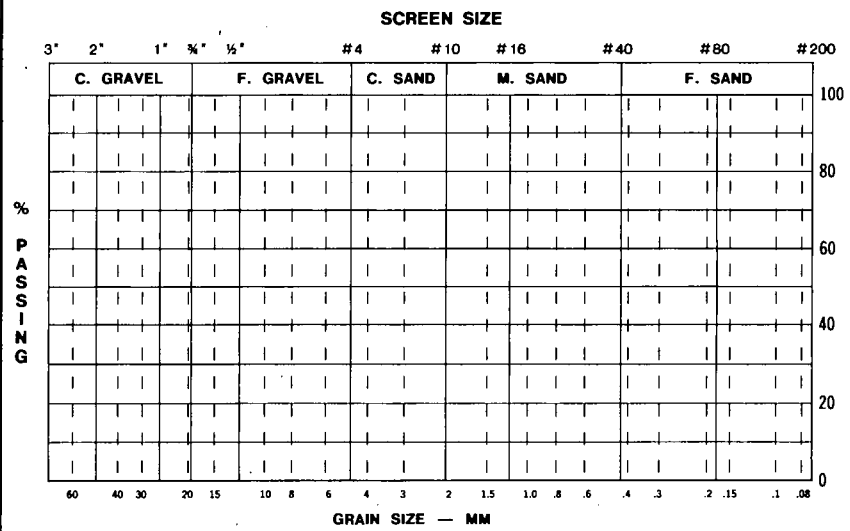
WET WT.: 86.9

% H_2O: 19.5%

WT. OF SAMPLE: 172.3

	WT.	% PASS
-1½"		
-1"		
-¾"		
-#4		
-#10		
-#40		
-#200	172.3	100%

GRAIN SIZE CURVE



LIQUID LIMIT DETERMINATION

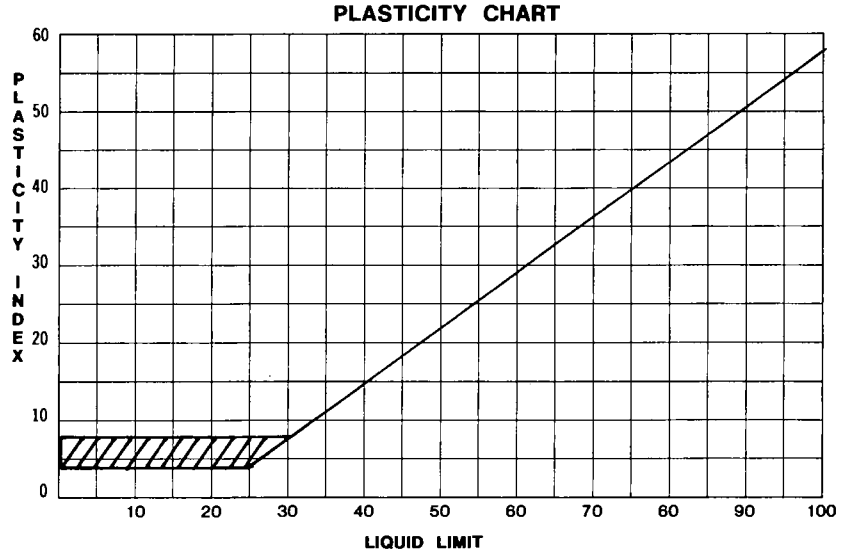
	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=

SAMPLE DESCRIPTION

CLASS. ML

COREY, MOIST, SILT.

PLASTICITY CHART



SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

JOB NO.: L-7974

SAMPLE NO.: S572-12

HOLE NO.: WB-13-89

DATE: 4-20-89

LAB. TECH.: JM

SOIL FIELD IDENTIFICATION

TEST	GRAVEL	SAND	SILT	CLAY
VISUAL				
DRIED CAST				
DILITANCY				
BITE				
TOUGHNESS				

SIEVE ANALYSIS

DRY WT.: 61.6

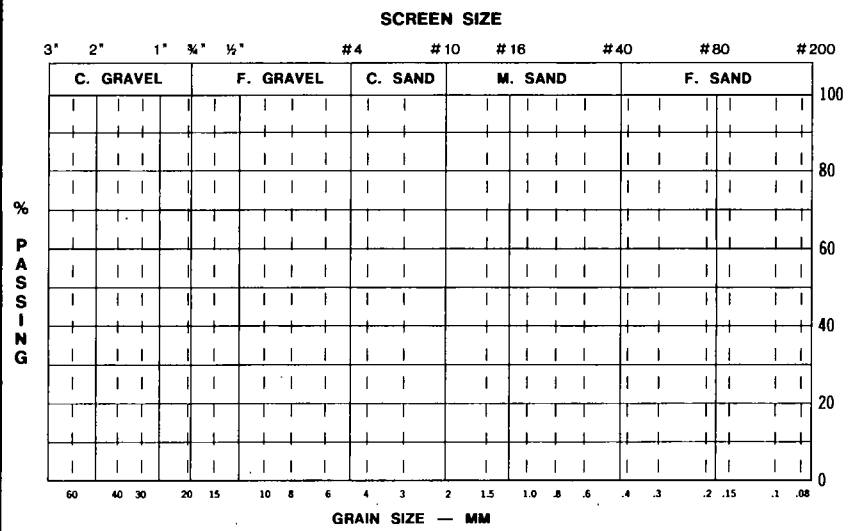
WET WT.: 71.3

% H_2O: 15.7%

WT. OF SAMPLE: 144.5

	WT.	% PASS
-1½"		
-1"		
-¾"		
-#4		
-#10		
-#40		
-#200	144.5	100%

GRAIN SIZE CURVE



LIQUID LIMIT DETERMINATION

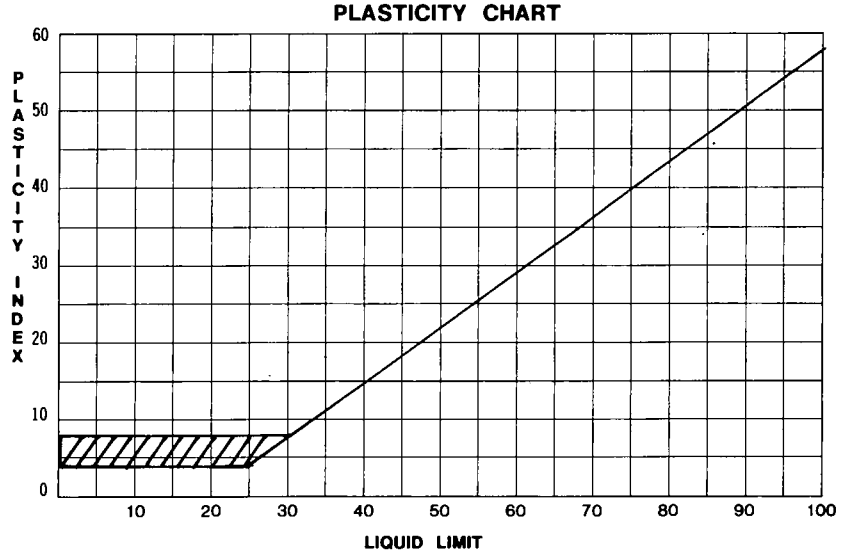
	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=

SAMPLE DESCRIPTION

CLASS. ML

COREX, MOIST, SILT.

PLASTICITY CHART



SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

JOB NO.: L-7974

SAMPLE NO.: 0570-1

HOLE NO.: HQ-18-89

DATE: 4-20-89

LAB. TECH.: JM

SIEVE ANALYSIS

DRY WT.: 73.3

WET WT.: 86.2

% H_2O: 17.6%

WT. OF SAMPLE: 251.4

	WT.	% PASS
-1½"		
-1"		
-¾"	40.3	100
-#4	22.0	84.0
-#10	61.5	75.2
-#40	88.7	50.8
-#200	38.9	15.5

SAMPLE DESCRIPTION

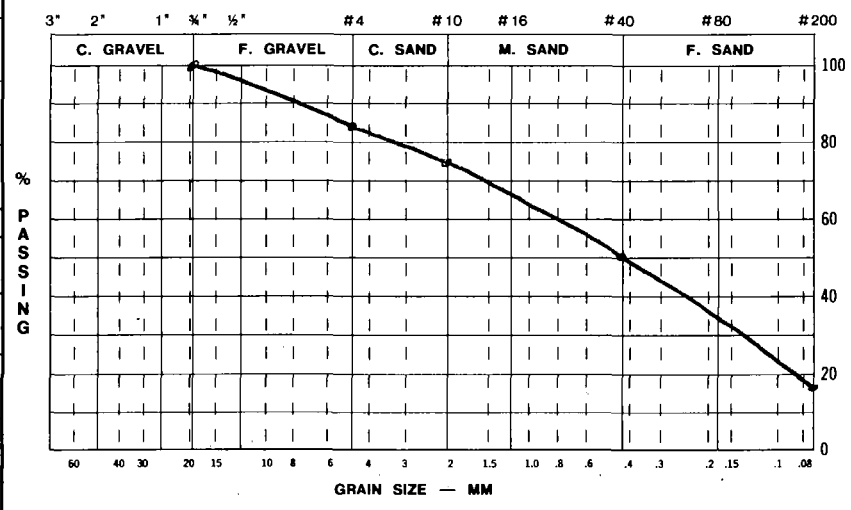
CLASS. SM

GREY, MOIST, SILTY, GRAVELLY, F-C SAND.

SOIL FIELD IDENTIFICATION

TEST	GRAVEL	SAND	SILT	CLAY
VISUAL				
DRIED CAST				
DILITANCY				
BITE				
TOUGHNESS				

GRAIN SIZE CURVE



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=

PLASTICITY CHART

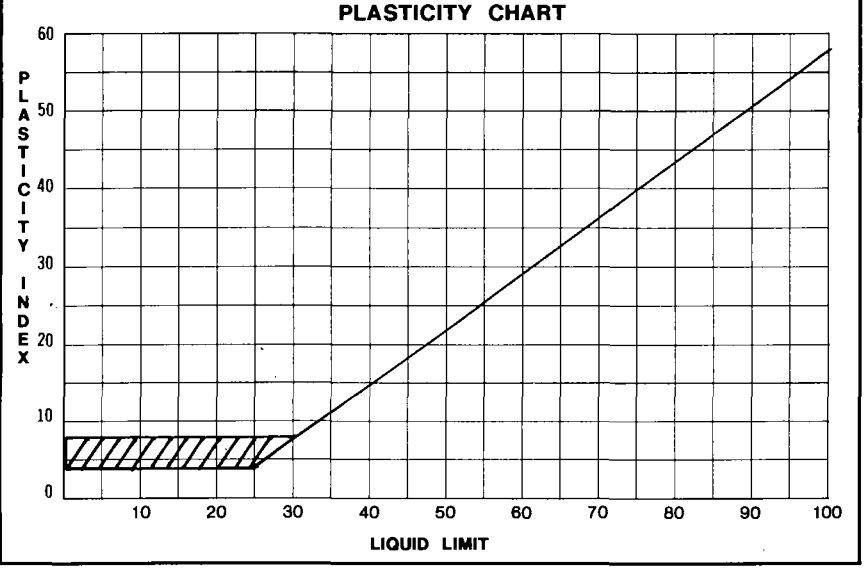


Figure B.1-54

SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

JOB NO.: L-7974

SAMPLE NO.: 0570-2

HOLE NO.: HQ-18-89

DATE: 4-20-89

LAB. TECH.: jm

SIEVE ANALYSIS

DRY WT.: 67.2

WET WT.: 77.7

% H_2O: 15.6%

WT. OF SAMPLE: 588.7

	WT.	% PASS
-1½"		
-1"		
-¾"	53.4	100
-#4	20.1	90.9
-#10	77.4	87.5
-#40	300.6	74.4
-#200	137.2	23.3

SAMPLE DESCRIPTION

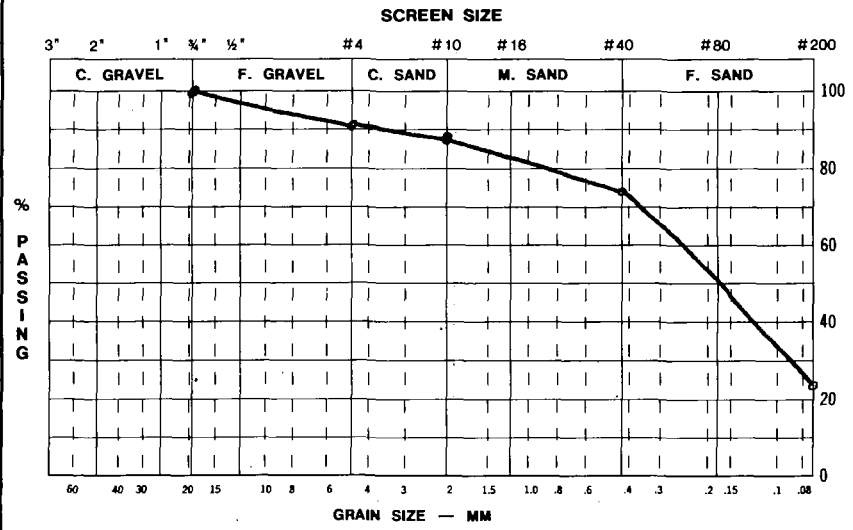
CLASS. SM

GREY, MOIST, V. SILTY, GRAVELLY, F-C SAND.

SOIL FIELD IDENTIFICATION

TEST	GRAVEL	SAND	SILT	CLAY
VISUAL				
DRIED CAST				
DILITANCY				
BITE				
TOUGHNESS				

GRAIN SIZE CURVE



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=

PLASTICITY CHART

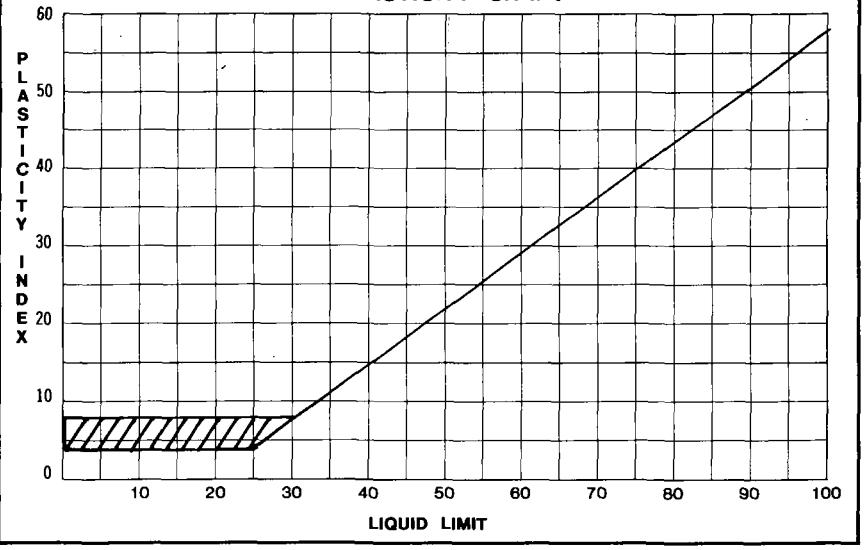


Figure B.1-55

SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

JOB NO.: L-7974

SAMPLE NO.: B570-3

HOLE NO.: HQ-18-89

DATE: 4-21-89

LAB. TECH.: JM

SIEVE ANALYSIS

DRY WT.: 44,5

WET WT.: 53,5

% H_2O: 20,2%

WT. OF SAMPLE: 424,2

	WT.	% PASS
-1½"		
-1"		
-¾"	18,1	100
-#4	9,5	95,7
-#10	135,9	93,5
-#40	180,3	61,5
-#200	80,4	19,0

SAMPLE DESCRIPTION

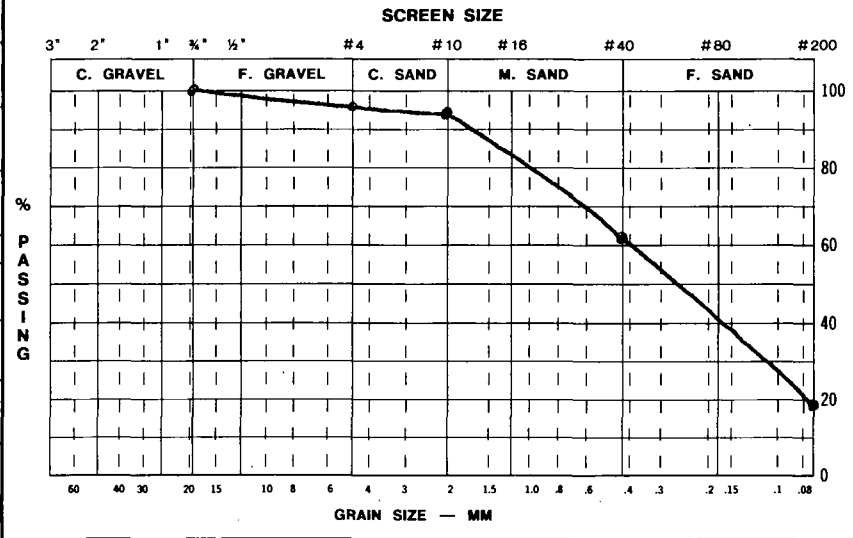
CLASS. SM

TAN-GREY, MOIST, SILTY, GRAVELLY, F-C SAND.

SOIL FIELD IDENTIFICATION

TEST	GRAVEL	SAND	SILT	CLAY
VISUAL				
DRIED CAST				
DILITANCY				
BITE				
TOUGHNESS				

GRAIN SIZE CURVE



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=

PLASTICITY CHART

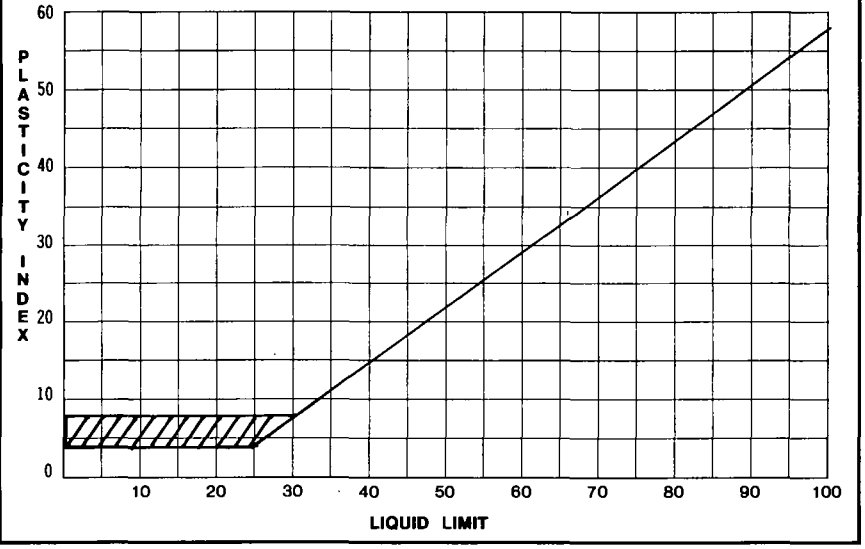


Figure B.1-56

SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

JOB NO.: L-7974

SAMPLE NO.: B570-4

HOLE NO.: HQ-18-09

DATE: 4-20-09

LAB. TECH.: JM

SIEVE ANALYSIS

DRY WT.: 45.1

WET WT.: 53.0

% H_2O: 17.5%

WT. OF SAMPLE: 125.8

	WT.	% PASS
-1½"		
-1"		
-¾"		
-#4		
-#10	7.0	100
-#40	82.1	94.4
-#200	36.7	29.2

SAMPLE DESCRIPTION

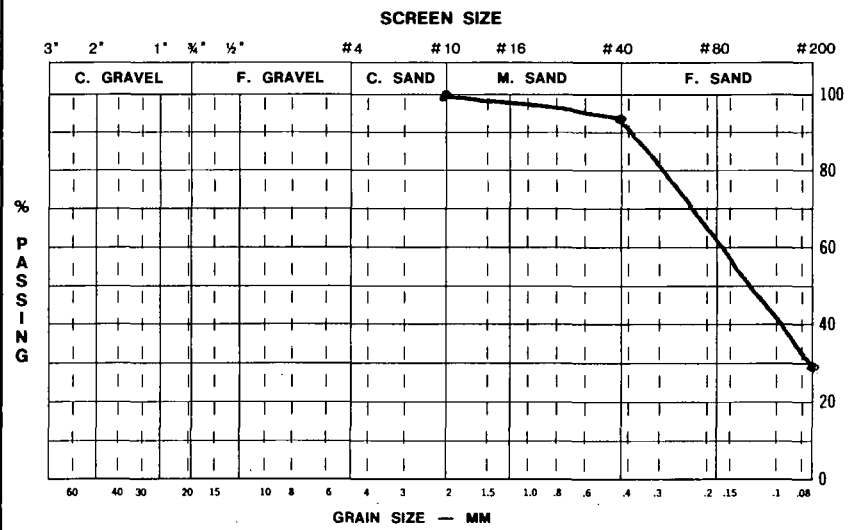
CLASS. SM

COREY, MOIST, V. SILTY, F-M SAND.

SOIL FIELD IDENTIFICATION

TEST	GRAVEL	SAND	SILT	CLAY
VISUAL				
DRIED CAST				
DILITANCY				
BITE				
TOUGHNESS				

GRAIN SIZE CURVE



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=

PLASTICITY CHART

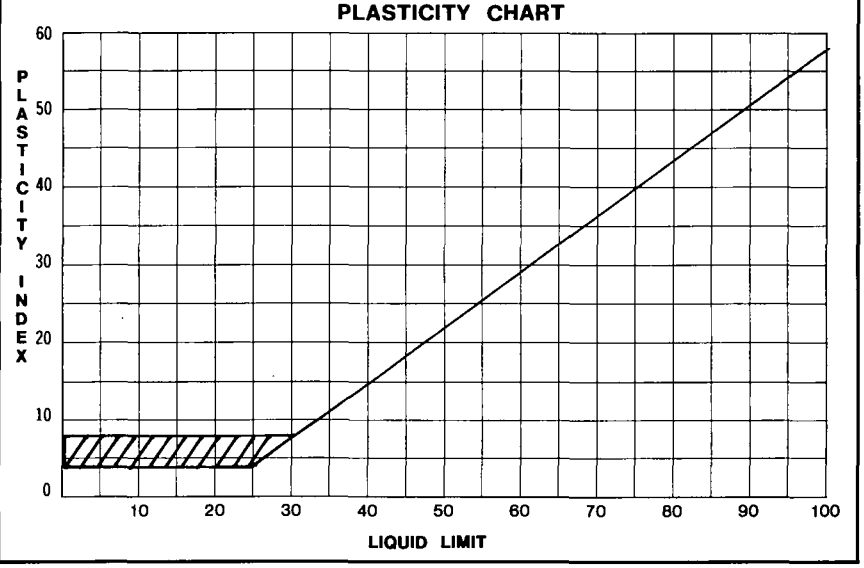


Figure B.1-57

Washington State Department of Transportation
Materials Headquarters
Point Load Test Results

PROJECT NO.: L-7974
PROJECT TITLE: SO. RENTON I/C TO SUNSET BLVD.

ENGINEER: TCB DATE: 08/06/90

BOREHOLE HQ-18-89

DEPTH (FT)	ROCK TYPE	TEST TYPE (Note 1)	"L" SAMPLE LENGTH (Note 2) (mm)	"D" PLATEN SEPAR. (Note 3) (mm)	"P" GAUAGE READING AT FAILURE (ft-lbs)	COMMENTS	"De^2" (Note 4) (sq in)	"Is" (Note 5) (psi)	"I50" (Note 6) (psi)	UCS (Note 7) (psi)	ROCK STRENGTH
25	sandstone	D	120	59	20		5.40	4	4	96	EXTREMELY WEAK
30	sandstone	D	150	58	120		5.21	23	25	590	VERY WEAK
33	sandstone	D	150	59	235		5.40	44	47	1126	WEAK
40	sandstone	D	180	57	130		5.04	26	27	657	VERY WEAK
46	sandstone	D	180	58	260		5.21	50	53	1279	WEAK
51	sandstone	D	180	59	305		5.40	57	61	1462	WEAK
							0.00		0	0	
							0.00		0	0	
							0.00		0	0	
							0.00		0	0	
							0.00		0	0	
							0.00		0	0	
							0.00		0	0	
							0.00		0	0	
							0.00		0	0	
							0.00		0	0	

Note 1: "A" = axial "D" = diametral "L" = lump
Note 2: If diametral "D"/"L" should be >0.7. If axial or lump, "D"/"L" should be approx 1.0 to 1.4
Note 3: Should not be measureduntil first indication of resistance
Note 4: "De^2" = ("D")^2 for diametral
Note 5: "Is" = "P"/"De^2"
Note 6: "I50 (psi)" = "F" * ("Is") where "F" = ("De"/50)^0.45
Note 7: Approximate Uniaxial Compressive Strength (HQ Core) = "I50" * 24

Figure B.1-58

Washington State Department of Transportation

WASHINGTON STATE DEPARTMENT OF TRANSPORTATION

Project So. Renton I/C To Sunset Blvd. Sheet No. ____ of ____ sheets

S.R. 405 Made by JM Check by ____ Date 4-11-89 Supv. ____

UNIAXIAL CORE COMPRESSION

JOB #: L-7974

SAMPLE #: ____

TEST HOLE: HQ-10-89

DEPTH: 32'

ROCK TYPE: SANDSTONE

LENGTH: (IN.) 4.50"

DIAMETER: (IN.) 2.25"

AREA: (IN^2) 3.98

DATE: 4-11-89

TESTED BY: JM/P.A.

TEST METHOD: ASTM D 3148-80, D 2938-79

LOAD (LB.)	READING x .001" DEFLECTION (IN.)	STRESS (P.S.I.)
00	.000	
~~5,000~~ 1000	15	
~~10,000~~ 2000	23	
~~15,000~~ 2700	34	678.39
20,000		
25,000		
30,000		
35,000		
40,000		
45,000		
50,000		
55,000		
60,000		
65,000		
70,000		
75,000		
80,000		
85,000		
90,000		
95,000		
100,000		
105,000		
110,000		

DOT FORM 232-007A REVISED 6/83 -615-

WASHINGTON STATE DEPARTMENT OF TRANSPORTATION

Project So. Renton I/C To Sunset Blvd. Sheet No. ..... of ..... sheets

S.R. 405 Made by Jm Check by ..... Date 4-11-09 Supv. .....

UNIAXIAL CORE COMPRESSION

JOB #: L-7974

SAMPLE #:

TEST HOLE: HQ-18-09

DEPTH: 48'

ROCK TYPE: SANDSTONE

LENGTH: (IN.) 4.50"

DIAMETER: (IN.) 2.25"

AREA: (IN^2) 3.98

DATE: 4-11-09

TESTED BY: Jm/P.D.

TEST METHOD: ASTM D 3148-80, D 2938-79

LOAD (LB.)	READING x .001" DEFLECTION (IN.)	STRESS (P.S.I.)
00	.000	
~~5,000~~ 400	45	100.50
10,000		
15,000		
20,000		
25,000		
30,000		
35,000		
40,000		
45,000		
50,000		
55,000		
60,000		
65,000		
70,000		
75,000		
80,000		
85,000		
90,000		
95,000		
100,000		
105,000		
110,000		

SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

JOB NO.: L-7974

SAMPLE NO.: 8555-1

HOLE NO.: HQ-12-89

DATE: 3-29-89

LAB. TECH.: JM

SOIL FIELD IDENTIFICATION

TEST	GRAVEL	SAND	SILT	CLAY
VISUAL				
DRIED CAST				
DILITANCY				
BITE				
TOUGHNESS				

SIEVE ANALYSIS

DRY WT.: 62.4

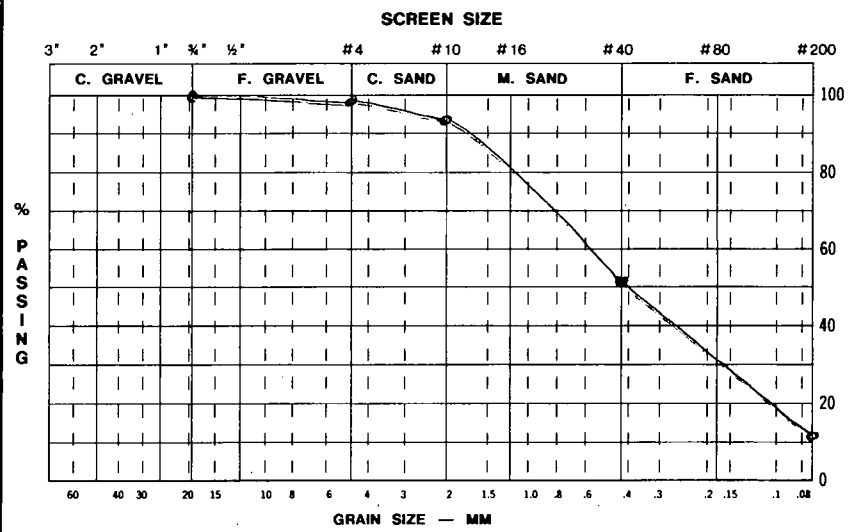
WET WT.: 74.4

% H_2O: 19.2%

WT. OF SAMPLE: 317.8

	WT.	% PASS
-1½"		
-1"		
-¾"	4.6	100
-#4	16.8	98.6
-#10	130.5	93.3
-#40	128.5	52.2
-#200	37.4	11.8

GRAIN SIZE CURVE



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=

SAMPLE DESCRIPTION

CLASS. SP-SM

LOOSE, MOIST, SILTY, GRAVELLY, F-C SAND.

PLASTICITY CHART

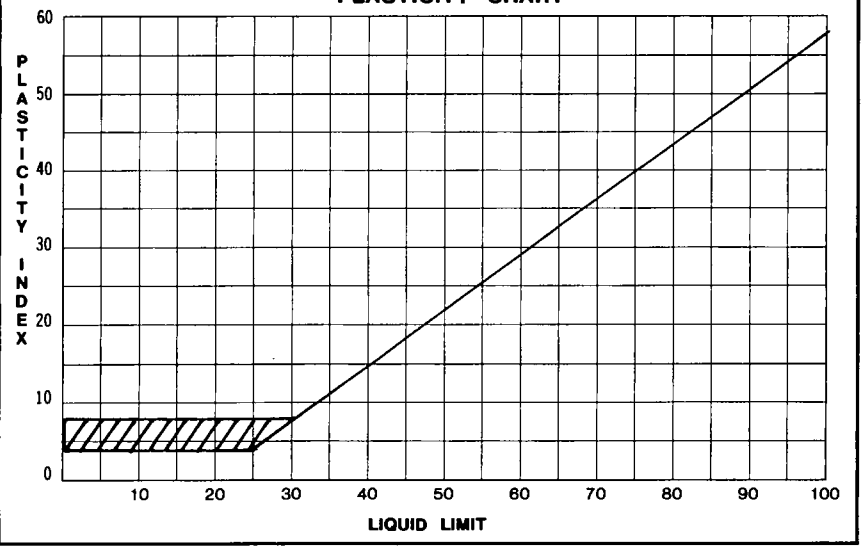


Figure B.1-61

SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

JOB NO.: L-7974

SAMPLE NO.: 0555-2

HOLE NO.: HQ-12-89

DATE: 3-29-89

LAB. TECH.: JM

SOIL FIELD IDENTIFICATION

TEST	GRAVEL	SAND	SILT	CLAY
VISUAL				
DRIED CAST				
DILITANCY				
BITE				
TOUGHNESS				

SIEVE ANALYSIS

DRY WT.: 73.8

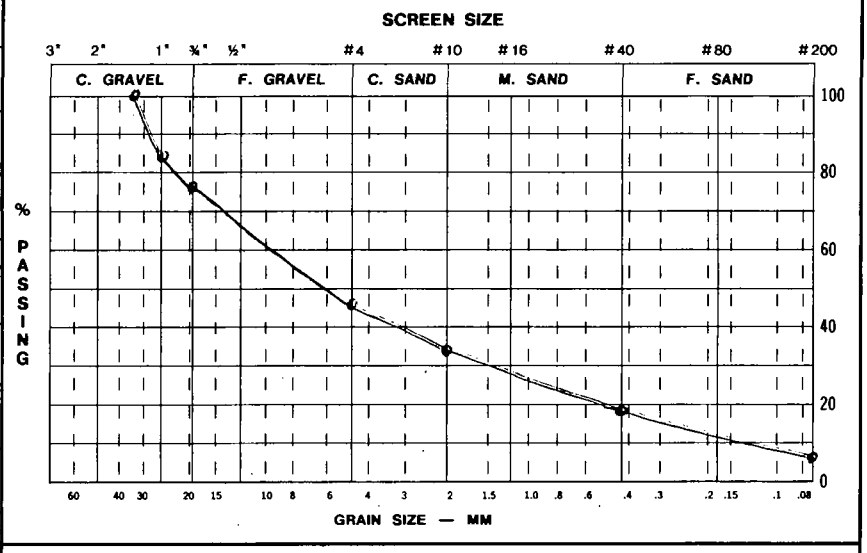
WET WT.: 78.5

% H_2O: 6.4%

WT. OF SAMPLE: 254.0

	WT.	% PASS
-1½"	41.2	100
-1"	18.2	83.8
-¾"	77.0	76.6
-#4	30.2	46.3
-#10	37.1	34.4
-#40	36.3	19.8
-#200	14.0	5.5

GRAIN SIZE CURVE



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=

SAMPLE DESCRIPTION

CLASS. GW-GM

GREY, DRY, SL. SILTY, F-C SANDY, F-C GRAVEL

PLASTICITY CHART

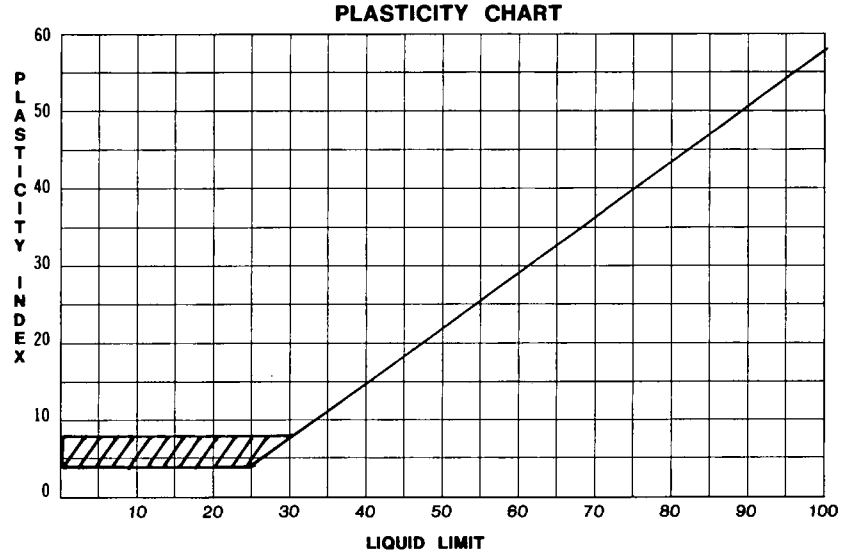


Figure B.1-62

SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

JOB NO.: L-7974

SAMPLE NO.: B555-3

HOLE NO.: HQ-12-89

DATE: 3-29-89

LAB. TECH.: JM

SIEVE ANALYSIS

DRY WT.: 36.7

WET WT.: 38.4

% H_2O: 4.6%

WT. OF SAMPLE: 292.6

	WT.	% PASS
-1½"	192.4	100
-1"	340.	34.2
-¾"	26.8	22.6
-#4	15.2	13.5
-#10	13.8	8.3
-#40	8.5	3.6
-#200	1.9	.6

SAMPLE DESCRIPTION

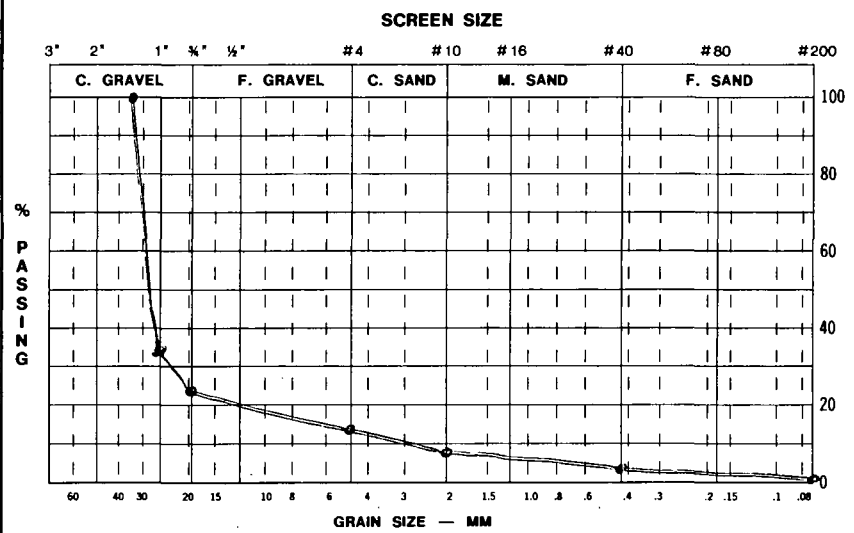
CLASS. GP — ANG. & SUB. RND.

COBBLEY, DRY, SL. SILTY, F-C SANDY, F-C ANG. AND SUB RND. GRAVEL.

SOIL FIELD IDENTIFICATION

TEST	GRAVEL	SAND	SILT	CLAY
VISUAL				
DRIED CAST				
DILITANCY				
BITE				
TOUGHNESS				

GRAIN SIZE CURVE



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=

PLASTICITY CHART

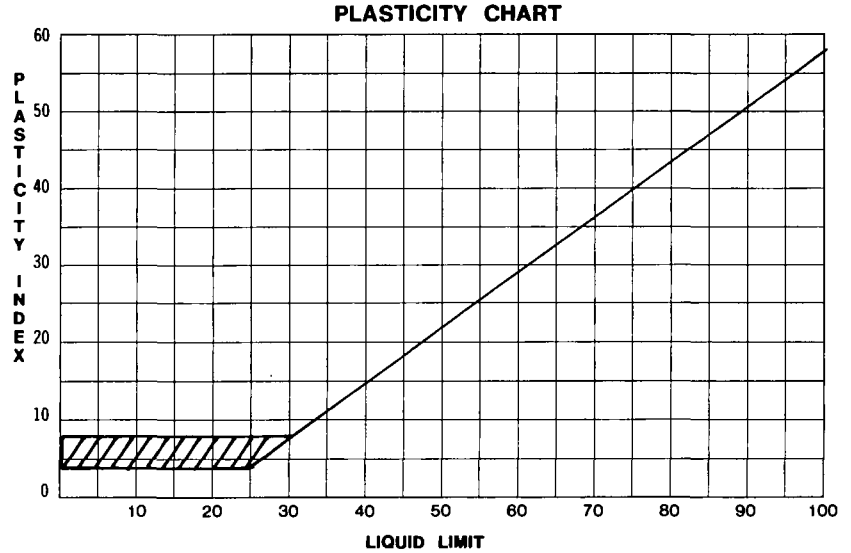


Figure B.1-63

SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

JOB NO.: L-7974

SAMPLE NO.: B555-4

HOLE NO.: HQ-12-89

DATE: 3-29-89

LAB. TECH.: JM

SIEVE ANALYSIS

DRY WT.: 55.5

WET WT.: 63.8

% H_2O: 15.0%

WT. OF SAMPLE: 489.4

	WT.	% PASS
-1½"	30.6	100
-1"	17.5	93.7
-¾"	133.7	90.2
-#4	53.8	62.9
-#10	81.7	51.9
-#40	138.3	35.2
-#200	33.8	6.9

SAMPLE DESCRIPTION

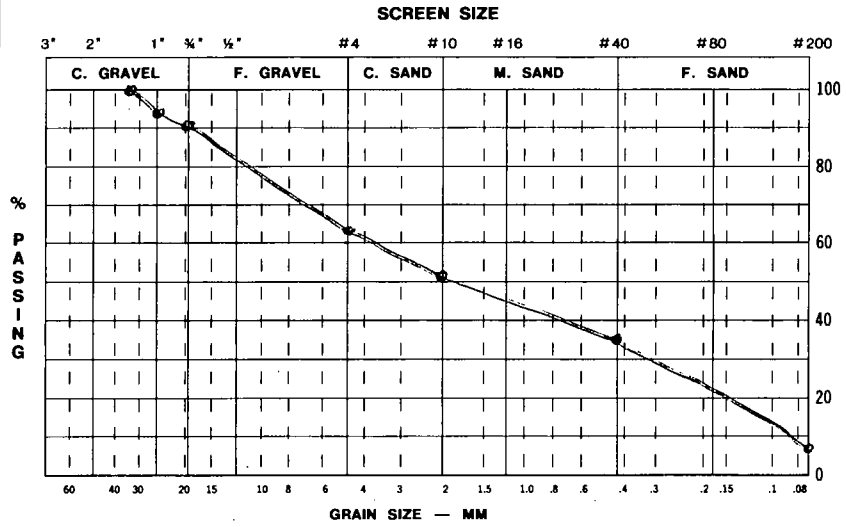
CLASS. SP-SM

GREY, MOIST, SILTY, GRAVELLY, F-C SAND.

SOIL FIELD IDENTIFICATION

TEST	GRAVEL	SAND	SILT	CLAY
VISUAL				
DRIED CAST				
DILITANCY				
BITE				
TOUGHNESS				

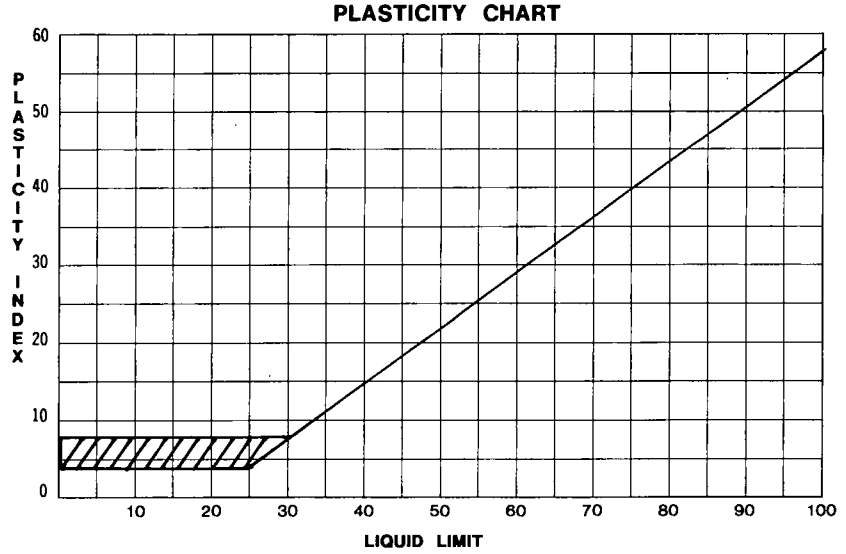
GRAIN SIZE CURVE



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=

PLASTICITY CHART



SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

JOB NO.: L-7974

SAMPLE NO.: 8555-5

HOLE NO.: HQ-12-89

DATE: 3-29-89

LAB. TECH.: JM

SIEVE ANALYSIS

DRY WT.: 71.9

WET WT.: 80.0

% H_2O: 11.3%

WT. OF SAMPLE: 516.3

	WT.	% PASS
-1½"	27.0	100
-1"	35.8	94.8
-¾"	29.9	87.8
-#4	7.5	82.0
-#10	50.3	80.6
-#40	204.1	70.9
-#200	161.7	31.3

SAMPLE DESCRIPTION

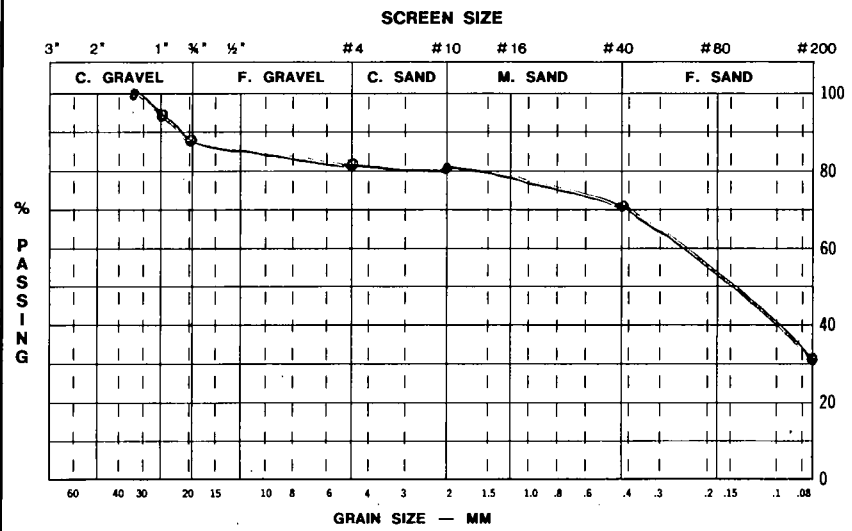
CLASS. SM

COREY, MOIST, V. SILTY, GRAVELLY, F-M SAND.

SOIL FIELD IDENTIFICATION

TEST	GRAVEL	SAND	SILT	CLAY
VISUAL				
DRIED CAST				
DILITANCY				
BITE				
TOUGHNESS				

GRAIN SIZE CURVE



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=

PLASTICITY CHART

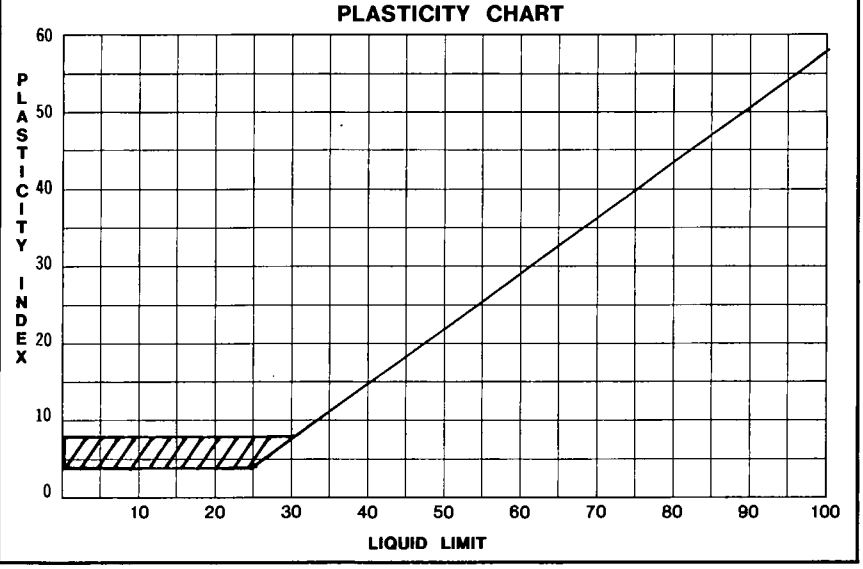


Figure B.1-65

SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

JOB NO.: L-7974

SAMPLE NO.: B555-7

HOLE NO.: HQ-12-89

DATE: 3-29-89

LAB. TECH.: JM

SIEVE ANALYSIS

DRY WT.: 55.9

WET WT.: 63.1

% H_2O: 12.9%

WT. OF SAMPLE: 457.6

	WT.	% PASS
-1½"		
-1"	16.5	100
-¾"	34.3	96.4
-#4	15.5	88.9
-#10	38.9	85.5
-#40	214.3	77.0
-#200	138.1	30.2

SAMPLE DESCRIPTION

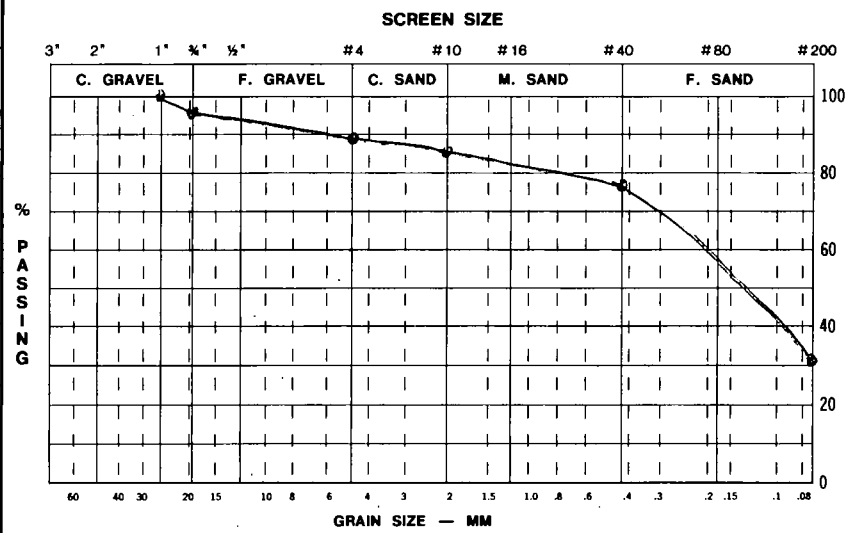
CLASS. SM

COREY, MOIST, V. SILTY, GRAVELLY, F-C SAND.

SOIL FIELD IDENTIFICATION

TEST	GRAVEL	SAND	SILT	CLAY
VISUAL				
DRIED CAST				
DILITANCY				
BITE				
TOUGHNESS				

GRAIN SIZE CURVE



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=

PLASTICITY CHART

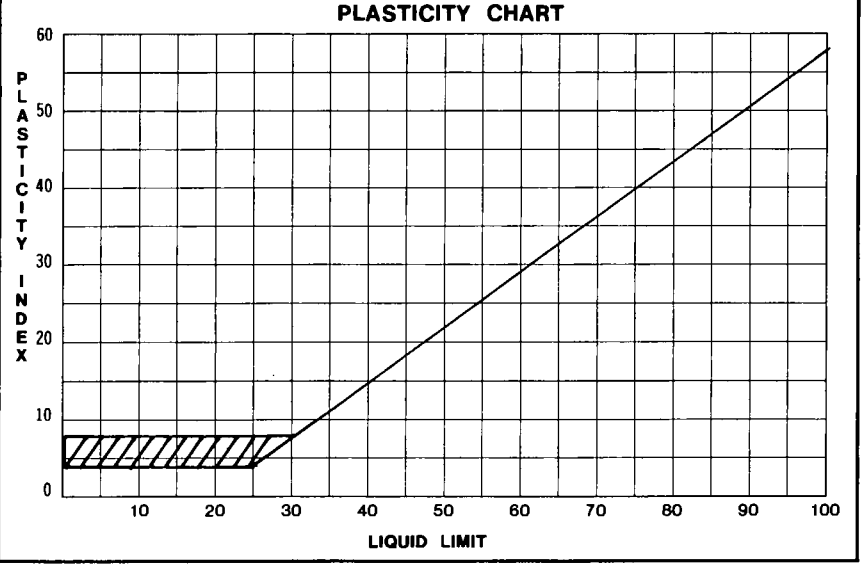


Figure B.1-66

SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

JOB NO.: L-7974

SAMPLE NO.: B540-1

HOLE NO.: HQ-15-89

DATE: 3-29-89

LAB. TECH.: JM

SIEVE ANALYSIS

DRY WT.: 61.1

WET WT.: 67.0

% H_2O: 9.7%

WT. OF SAMPLE: 496.7

	WT.	% PASS
-1½"		
-1"	35.3	100
-¾"	168.3	92.9
-#4	46.6	59.0
-#10	100.1	49.6
-#40	122.6	29.5
-#200	23.8	4.8

SAMPLE DESCRIPTION

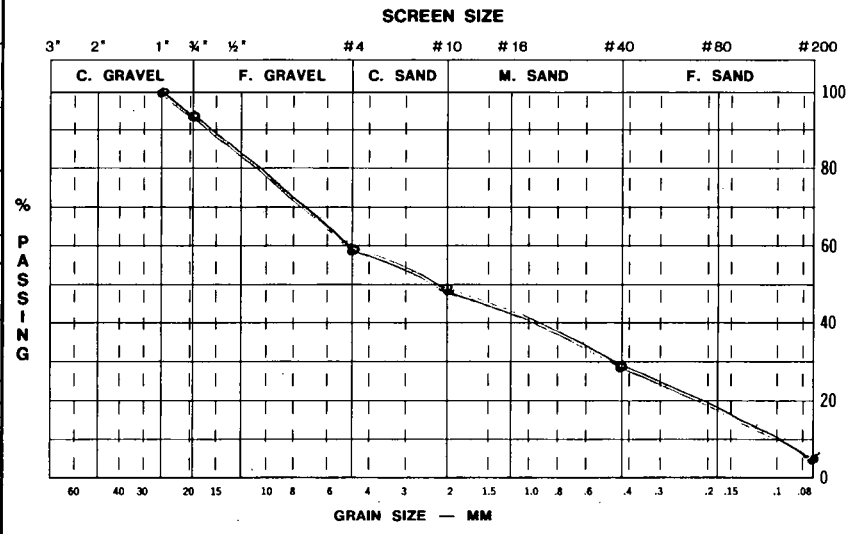
CLASS. SP

GREY, DRY, SL. SILTY, GRAVELLY, F-C SAND

SOIL FIELD IDENTIFICATION

TEST	GRAVEL	SAND	SILT	CLAY
VISUAL				
DRIED CAST				
DILITANCY				
BITE				
TOUGHNESS				

GRAIN SIZE CURVE



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=

PLASTICITY CHART

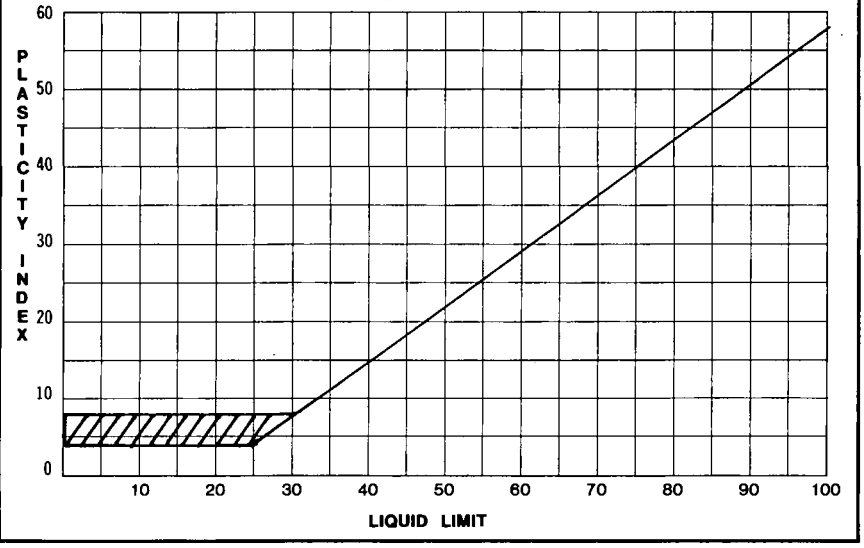


Figure B.1-67

SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

JOB NO.: L-7974

SAMPLE NO.: B540-2

HOLE NO.: HQ-15-89

DATE: 3-29-89

LAB. TECH.: JM

SIEVE ANALYSIS

DRY WT.: 46.3

WET WT.: 52.9

% H_2O: 14.3%

WT. OF SAMPLE: 525.3

	WT.	% PASS
-1½"		
-1"		
-¾"		
-#4		
-#10	60.7	100
-#40	341.1	88.4
-#200	123.5	23.5

SAMPLE DESCRIPTION

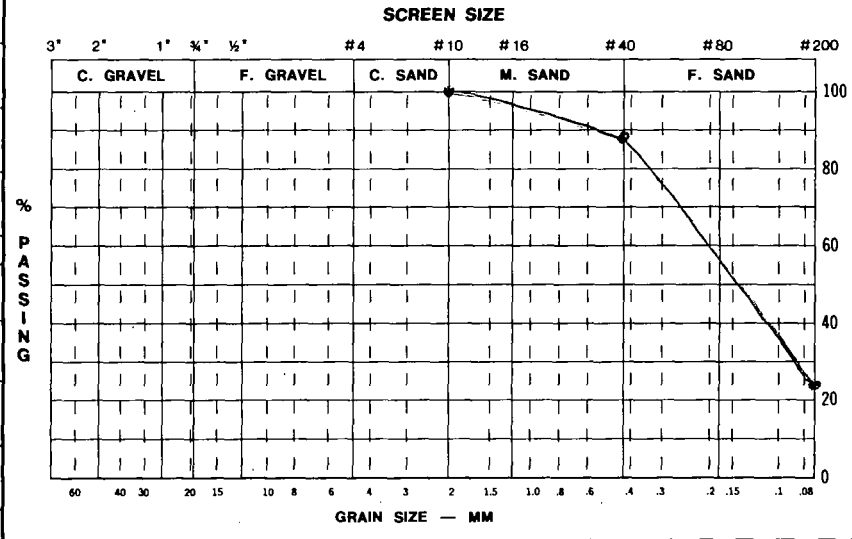
CLASS. SM

TAN, MOIST, V. SILTY, F-M SAND.

SOIL FIELD IDENTIFICATION

TEST	GRAVEL	SAND	SILT	CLAY
VISUAL				
DRIED CAST				
DILITANCY				
BITE				
TOUGHNESS				

GRAIN SIZE CURVE



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=

PLASTICITY CHART

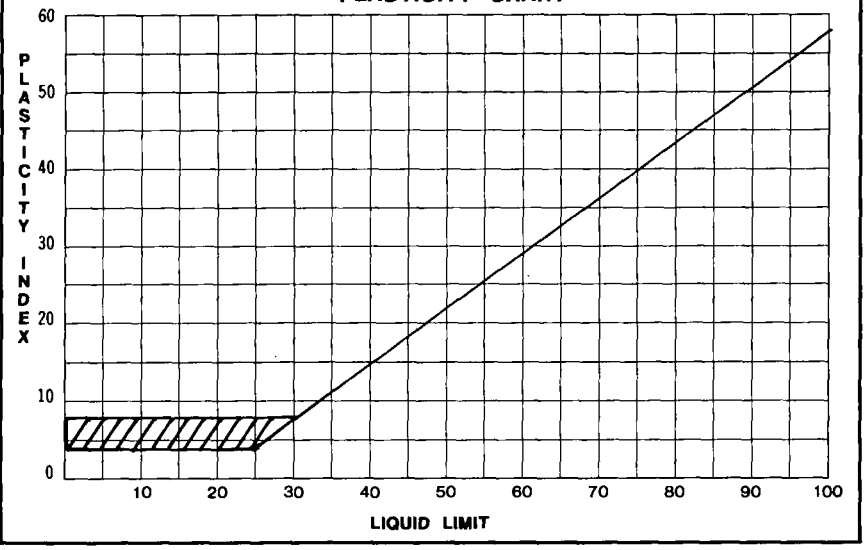


Figure B.1-68

SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

JOB NO.: L-7974

SAMPLE NO.: 8541-1

HOLE NO.: A11-89

DATE: 3-29-89

LAB. TECH.: JM

SIEVE ANALYSIS

DRY WT.: 50.1

WET WT.: 57.8

% H_2O: 15.4%

WT. OF SAMPLE: 349.2

	WT.	% PASS
-1½"		
-1"		
-¾"		
-#4		
-#10	21.3	100
-#40	235.9	93.9
-#200	92.0	26.3

SAMPLE DESCRIPTION

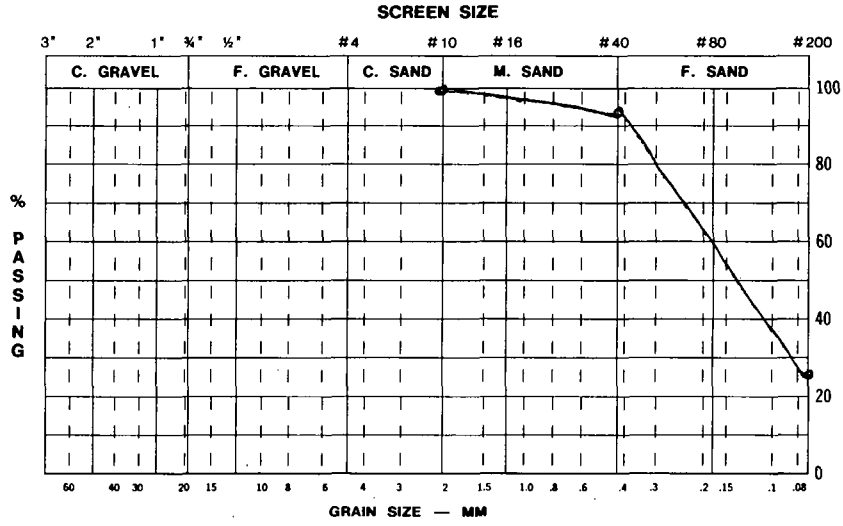
CLASS. SM

TAN, MOIST, V. SILTY, F-M SAND.

SOIL FIELD IDENTIFICATION

TEST	GRAVEL	SAND	SILT	CLAY
VISUAL				
DRIED CAST				
DILITANCY				
BITE				
TOUGHNESS				

GRAIN SIZE CURVE



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=

PLASTICITY CHART

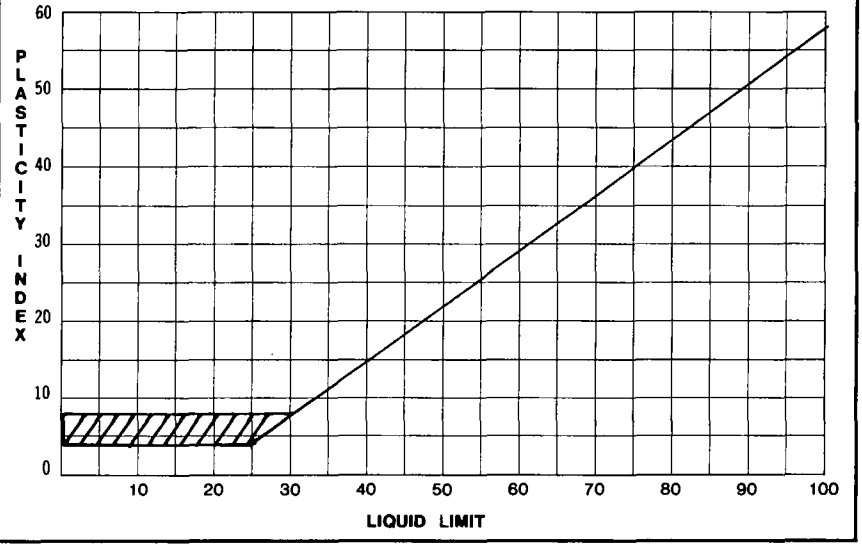


Figure B.1-69

SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

JOB NO.: L-7974

SAMPLE NO.: 8541-2

HOLE NO.: D-11-89

DATE: 3-29-89

LAB. TECH.: JM

SIEVE ANALYSIS

DRY WT.: 76.0

WET WT.: 85.6

% H_2O: 12.6%

WT. OF SAMPLE: 481.6

	WT.	% PASS
-1½"		
-1"		
-¾"	17.7	100
-#4	2.2	96.3
-#10	59.0	95.9
-#40	296.3	83.6
-#200	106.4	22.1

SAMPLE DESCRIPTION

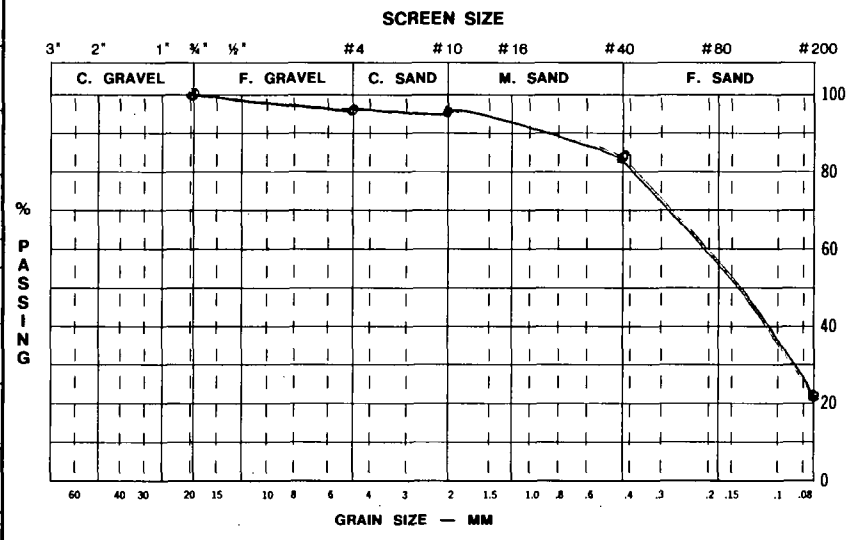
CLASS. SM

TAN, MOIST, V. SILTY, GRAVELLY, F-M SAND.

SOIL FIELD IDENTIFICATION

TEST	GRAVEL	SAND	SILT	CLAY
VISUAL				
DRIED CAST				
DILITANCY				
BITE				
TOUGHNESS				

GRAIN SIZE CURVE



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=

PLASTICITY CHART

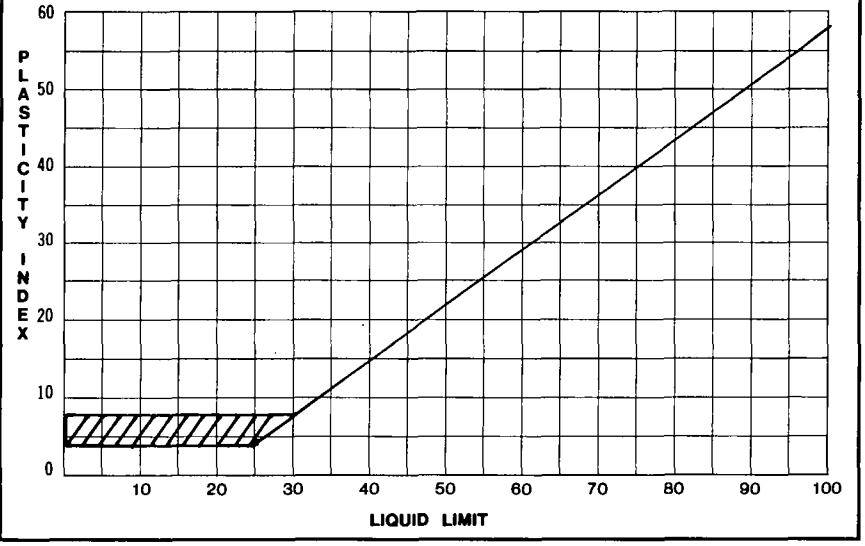


Figure B.1-70

SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

A-LINE

SAMPLE NO. 6644-1 JOB NO. L-7974 HOLE NO. 6

DATE 8-23-86 OPERATOR JM

SOIL FIELD IDENTIFICATION

TEST	SAND	SILT	CLAY
VISUAL	✓	✓	
DRIED CAST			
DILATANCY			
BITE			
TOUGHNESS			

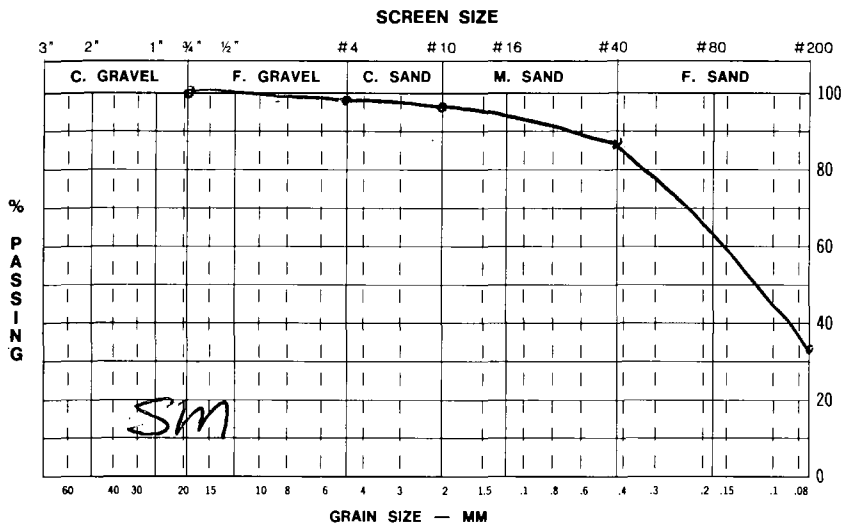
DESCRIPTION: BRN., MOIST, V. SILTY, GRAVELLY, F-M SAND.

47.2 52.2 W20 = 10.6 %

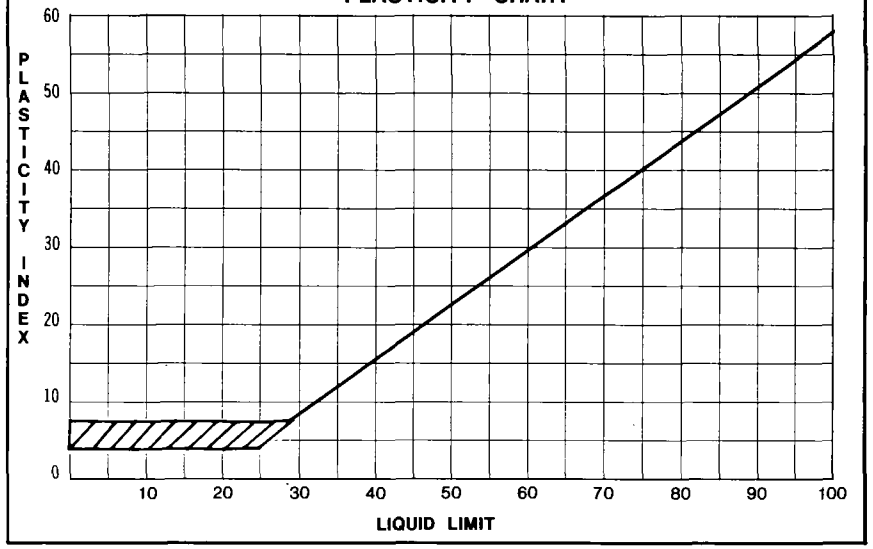
SIEVE ANALYSIS % Passing 141.6

			-40 76.3	87.1
-¾ 2.3		100	-80	
-4 1.4		98.4	-140	
-10 14.5		97.4	-200 47.10	33.1

GRAIN SIZE CURVE



PLASTICITY CHART



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=

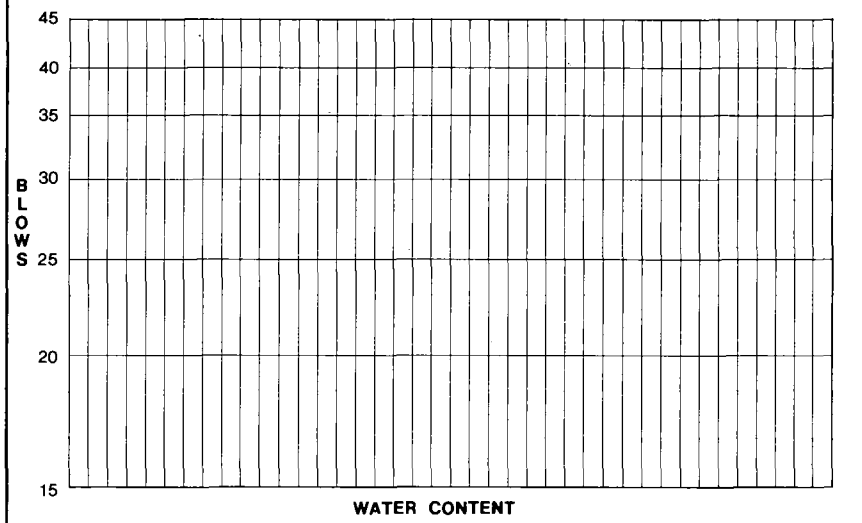


Figure B.1-71

SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

A-LINE

SAMPLE NO. 6644-2 JOB NO. L-7974 HOLE NO. 6

DATE 8-23-96 OPERATOR JM

SOIL FIELD IDENTIFICATION

TEST	SAND	SILT	CLAY
VISUAL	✓	✓	
DRIED CAST			
DILATANCY			
BITE			
TOUGHNESS			

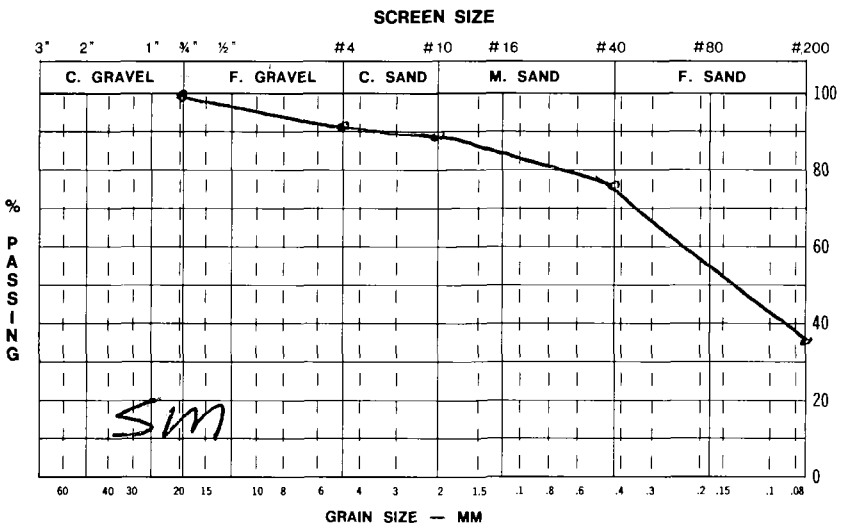
DESCRIPTION: BRN, MOIST, GRAVELLY, V. SILTY, F-C SAND.

33.5 38.6 W20 = 15.2 %

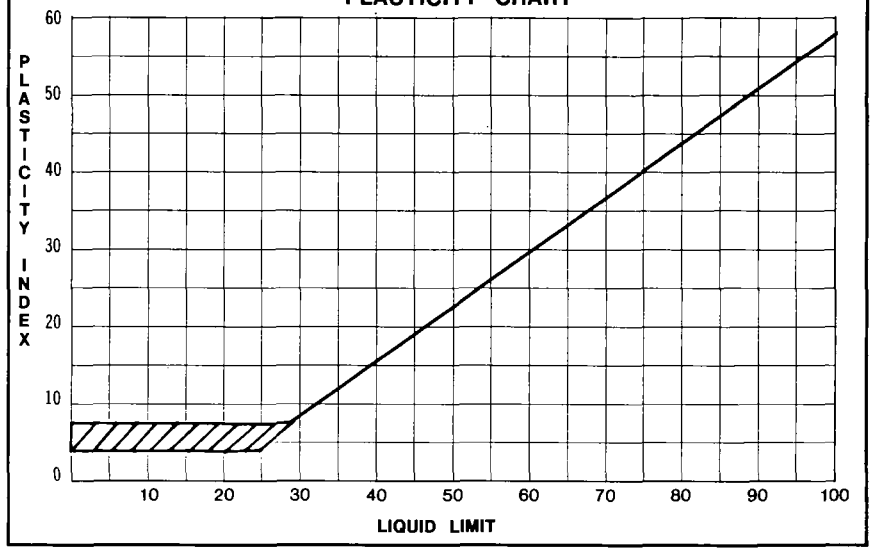
SIEVE ANALYSIS % Passing 110.0

			-40	44.7	75.6
-¾	9.7	100	-80		
-4	2.3	91.2	-140		
-10	14.8	89.1	-200	38.50	35.0

GRAIN SIZE CURVE



PLASTICITY CHART



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=

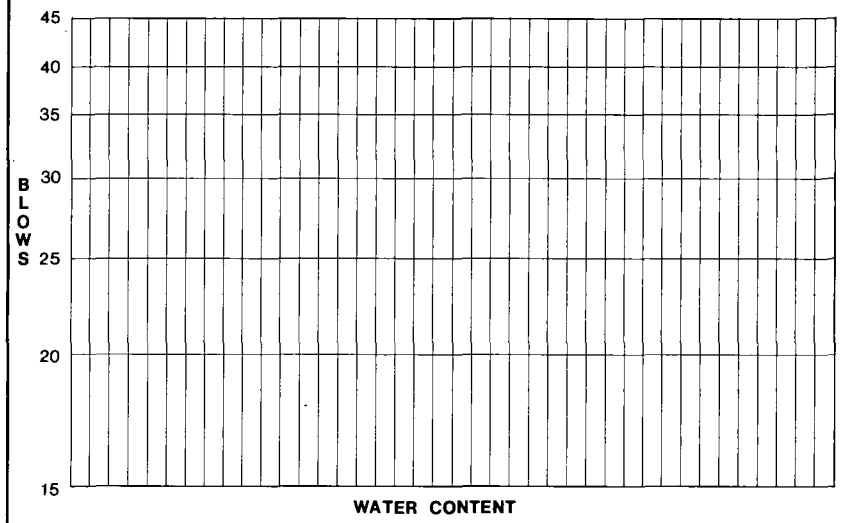


Figure B.1-72

SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

A-LINE

SAMPLE NO. 6644-3 JOB NO. L-7974 HOLE NO. 6

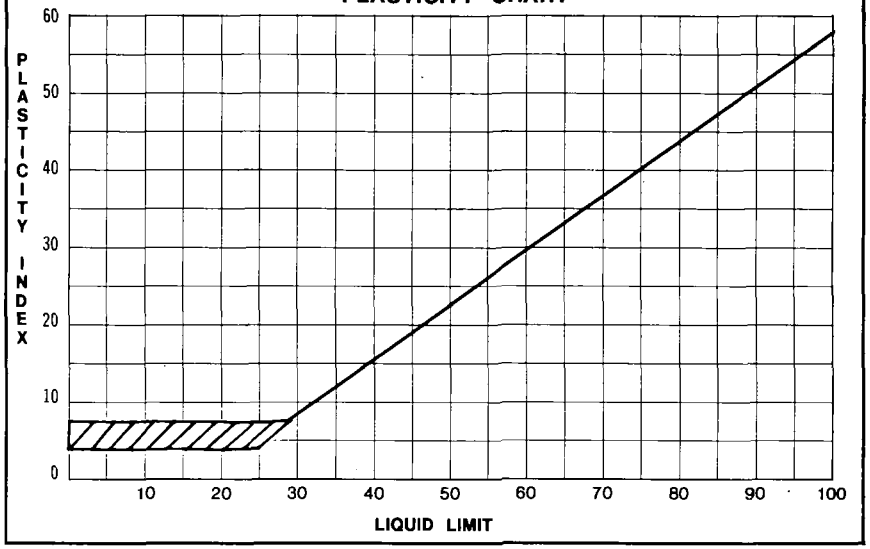
DATE 8-23-86 OPERATOR Jm

SOIL FIELD IDENTIFICATION

TEST	SAND	SILT	CLAY
VISUAL	✓	✓	
DRIED CAST			
DILATANCY			
BITE			
TOUGHNESS			

DESCRIPTION: BRN., DRY, GRAVELLY, SILTY, F-C SAND

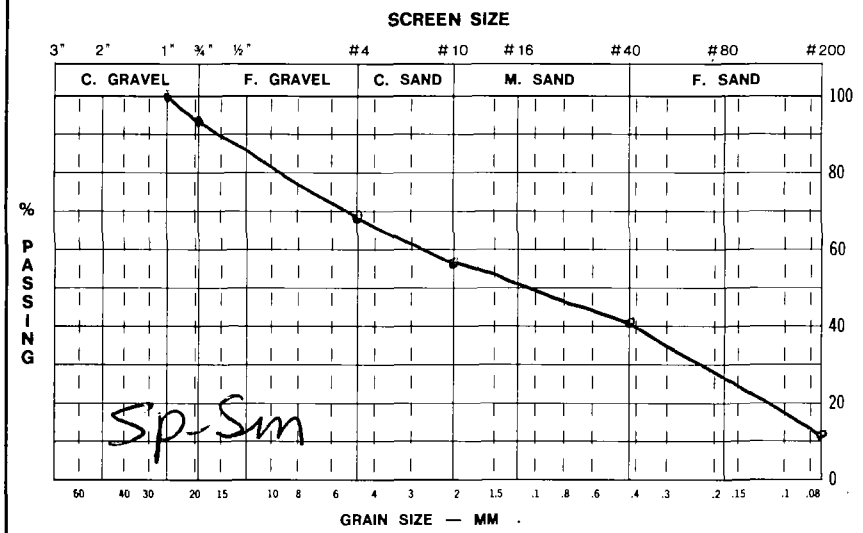
PLASTICITY CHART



48.4 52.4 H_2O = 8.3 %

SIEVE ANALYSIS			% Passing 210.0		
-1"	14.6	100	-40	64.0	41.0
-¾	52.5	93.0	-80		
-4	24.9	68.0	-140		
-10	32.0	56.2	-200	22.0	10.5

GRAIN SIZE CURVE



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=

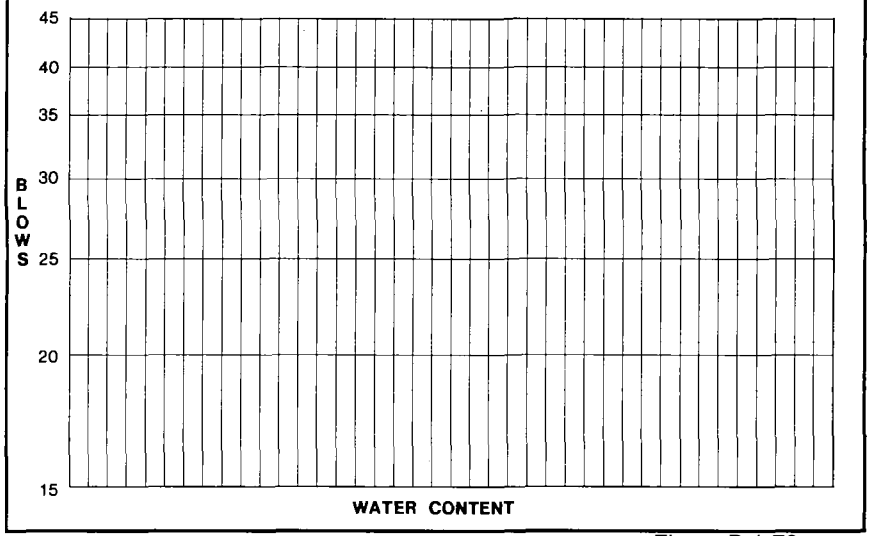


Figure B.1-73

DOT FORM 351-019 5/80 -790-

SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

A-LINE

SAMPLE NO. 6644-5 JOB NO L-7974 HOLE NO. 6

DATE 8-23-06 OPERATOR JM

SOIL FIELD IDENTIFICATION

TEST	SAND	SILT	CLAY
VISUAL	✓	✓	
DRIED CAST			
DILATANCY			
BITE			
TOUGHNESS			

DESCRIPTION: RED-BRN., MOIST, V. SILTY, F-M SAND.

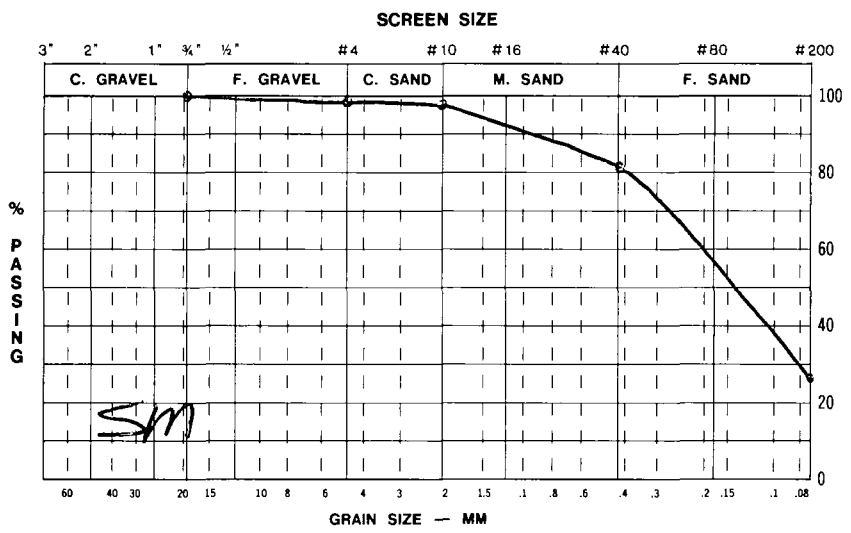
52.5 58.4 H20=11.2 %

SIEVE ANALYSIS

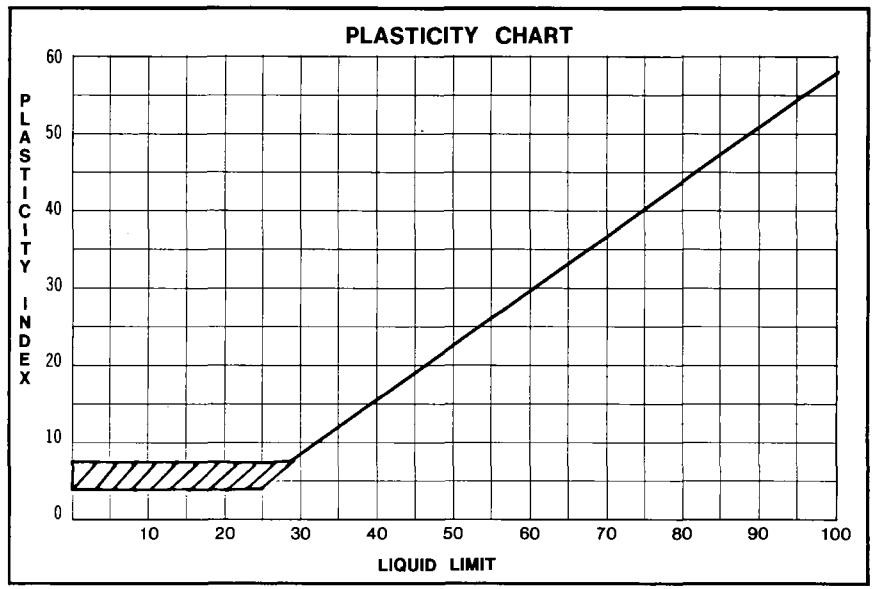
% Passing 310.7

			-40	173.7	82.4
-¾	3.4	100	-80		
-4	3.2	99.9	-140		
-10	48.2	97.9	-200	82.20	26.5

GRAIN SIZE CURVE



PLASTICITY CHART



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=

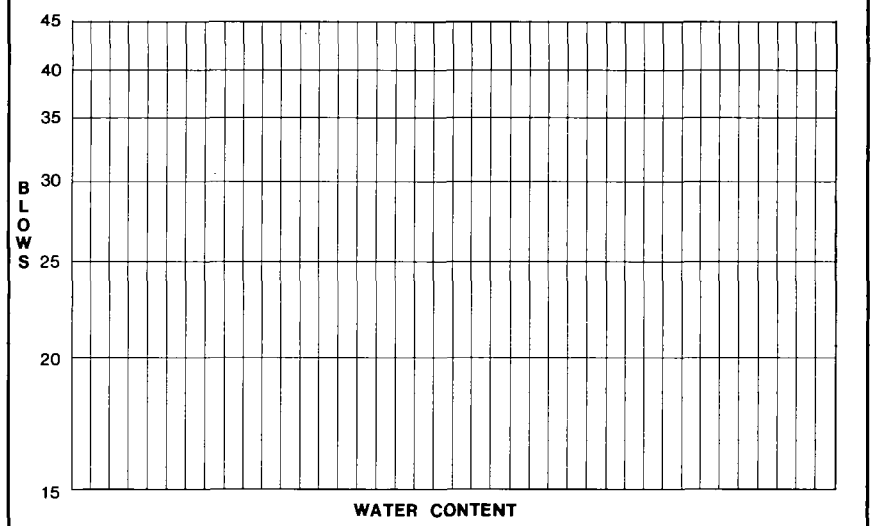


Figure B.1-74

SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

A-LINE

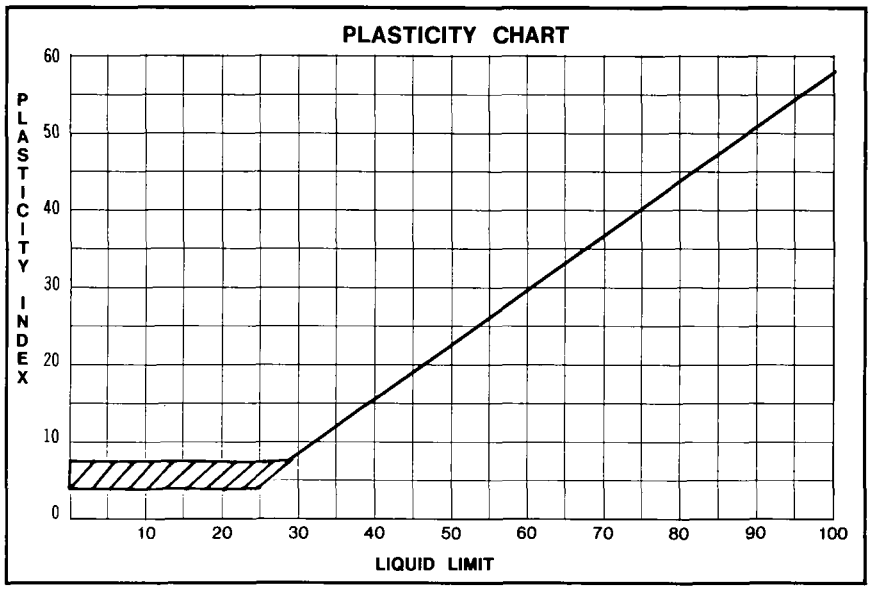
SAMPLE NO. 66446 JOB NO. L-7974 HOLE NO. 6

DATE 8-23-96 OPERATOR JM

SOIL FIELD IDENTIFICATION

TEST	SAND	SILT	CLAY
VISUAL	✓	✓	
DRIED CAST			
DILATANCY			
BITE			
TOUGHNESS			

DESCRIPTION: BRN, DRY, CRUMBLY, V. SILTY, F-M SAND.

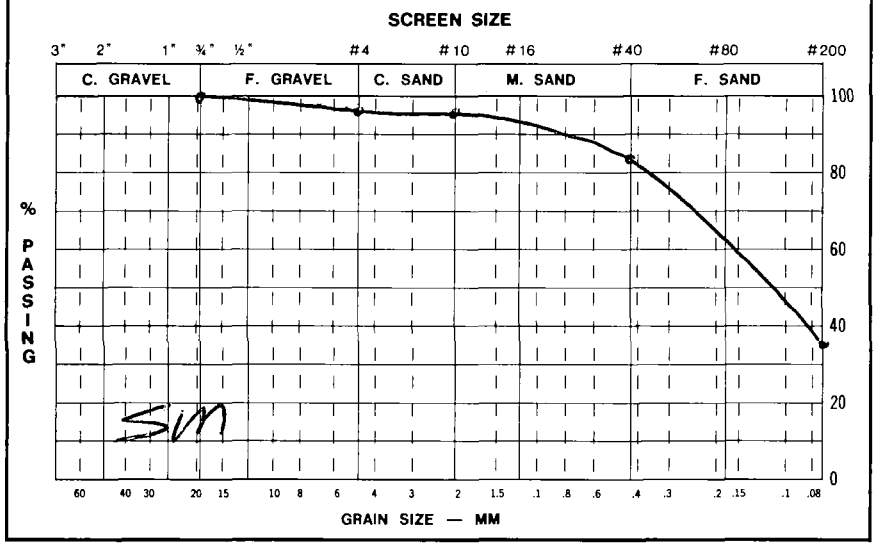


71.2 76.3 H20 = 7.2 %

SIEVE ANALYSIS — % Passing 250.6

			-40	121.2	83.1
-¾	6.5	100	-80		
-4	2.9	97.4	-140		
-10	32.9	96.2	-200	97.10	34.8

GRAIN SIZE CURVE



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=

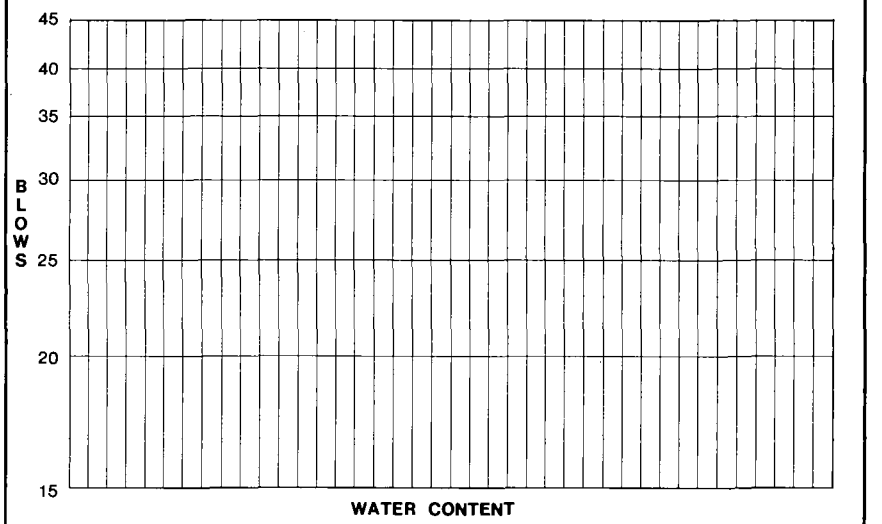


Figure B.1-75

SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

A-LINE

SAMPLE NO. 6644-7 JOB NO. L-7974 HOLE NO. 6

DATE 8-23-86 OPERATOR JM

SOIL FIELD IDENTIFICATION

TEST	SAND	SILT	CLAY
VISUAL	✓	✓	
DRIED CAST			
DILATANCY			
BITE			
TOUGHNESS			

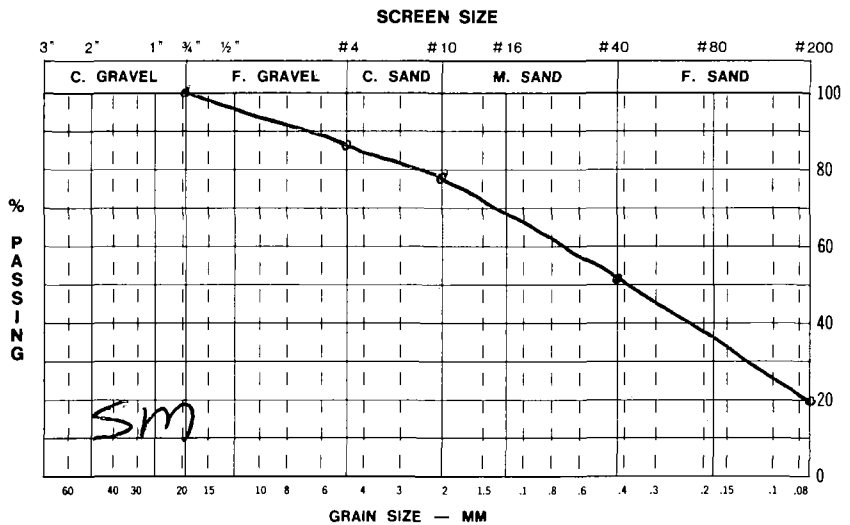
DESCRIPTION: TAN, DRY, LOOSE, SILTY, F-C SAND

51.9 53.6 H20 = 3.3 %

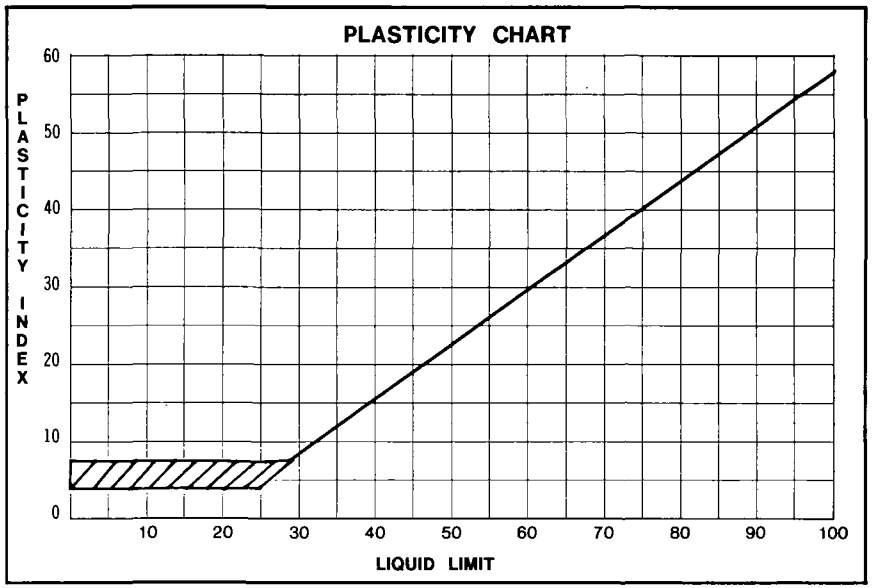
SIEVE ANALYSIS % Passing 202.2

			-40	65.2	51.7
-¾	29.0	100	-80		
-4	14.8	85.7	-140		
-10	53.8	78.3	-200	39.40	19.5

GRAIN SIZE CURVE



PLASTICITY CHART



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL =
Blows					PI =

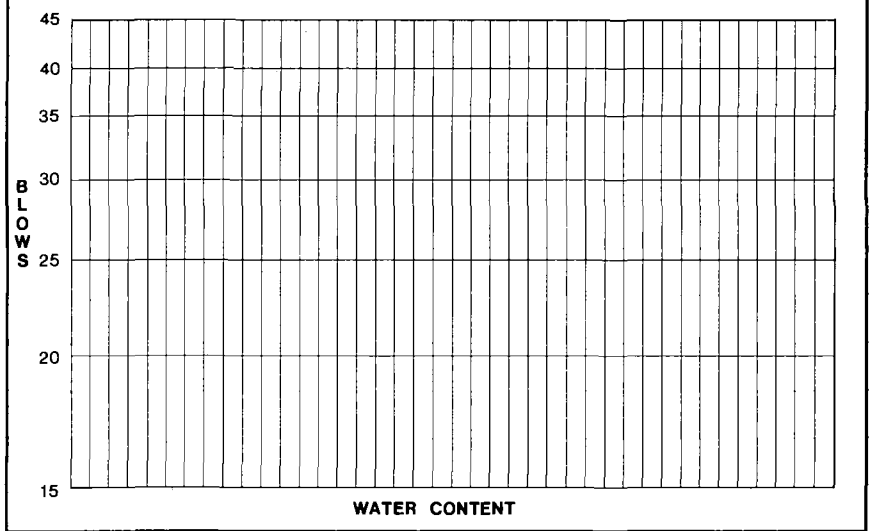


Figure B.1-76

SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

A-LINE

SAMPLE NO. 6644-B JOB NO. L-7974 HOLE NO. 6

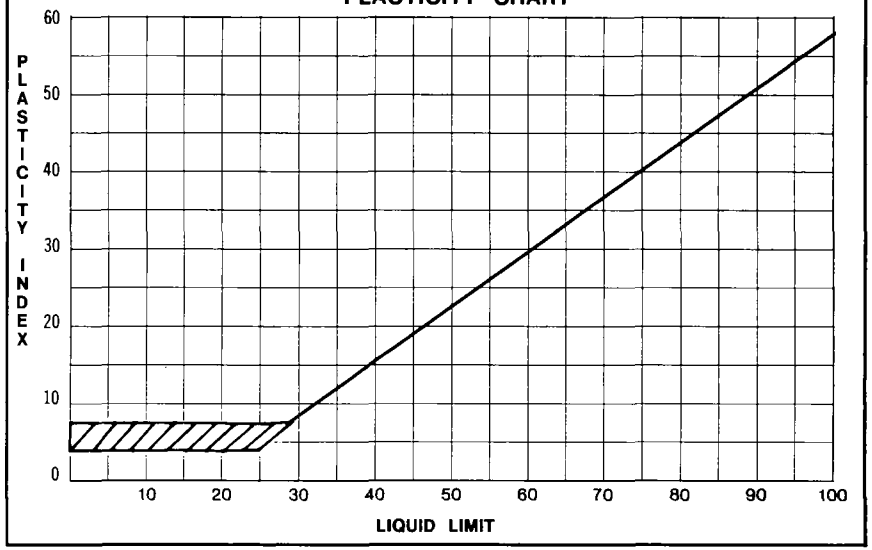
DATE 8-23-86 OPERATOR JM

SOIL FIELD IDENTIFICATION

TEST	SAND	SILT	CLAY
VISUAL	✓	✓	
DRIED CAST			
DILATANCY			
BITE			
TOUGHNESS			

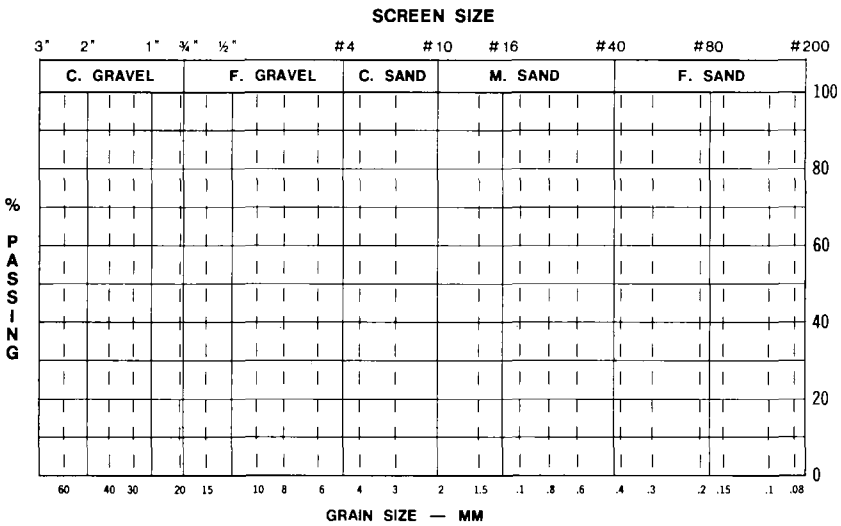
DESCRIPTION: TAN, DRY, SILTY, F-C SAND
VISUAL ID ONLY (Small Sample)

PLASTICITY CHART



SIEVE ANALYSIS	% Passing
	-40
-¾	-80
-4	-140
-10	-200

GRAIN SIZE CURVE



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=

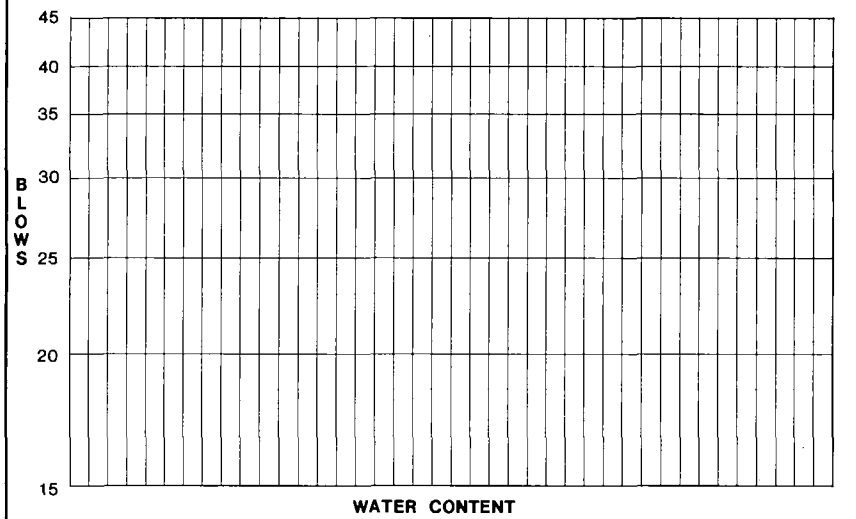


Figure B.1-77

SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

A-LINE

SAMPLE NO. 66449 JOB NO. C-7974 HOLE NO. 6

DATE 8-23-96 OPERATOR JM

SOIL FIELD IDENTIFICATION

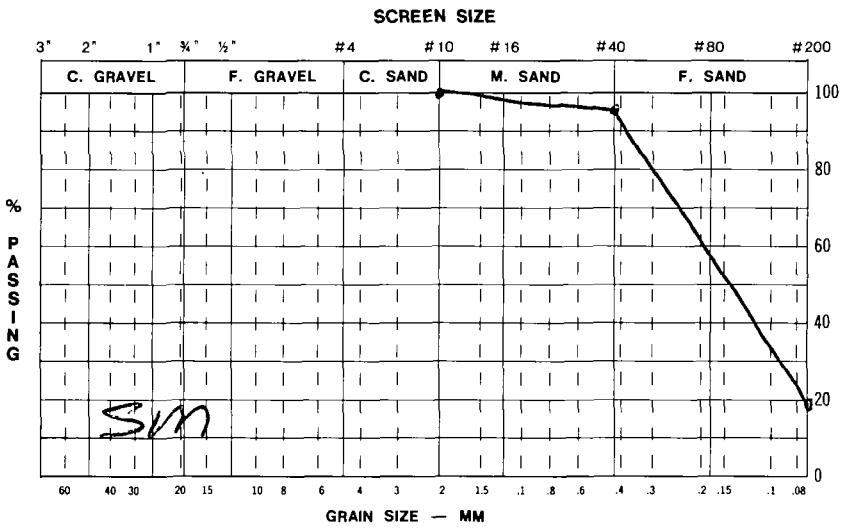
TEST	SAND	SILT	CLAY
VISUAL	✓	✓	
DRIED CAST			
DILATANCY			
BITE			
TOUGHNESS			

DESCRIPTION: DRY, MOIST, SILTY, F-M SAND

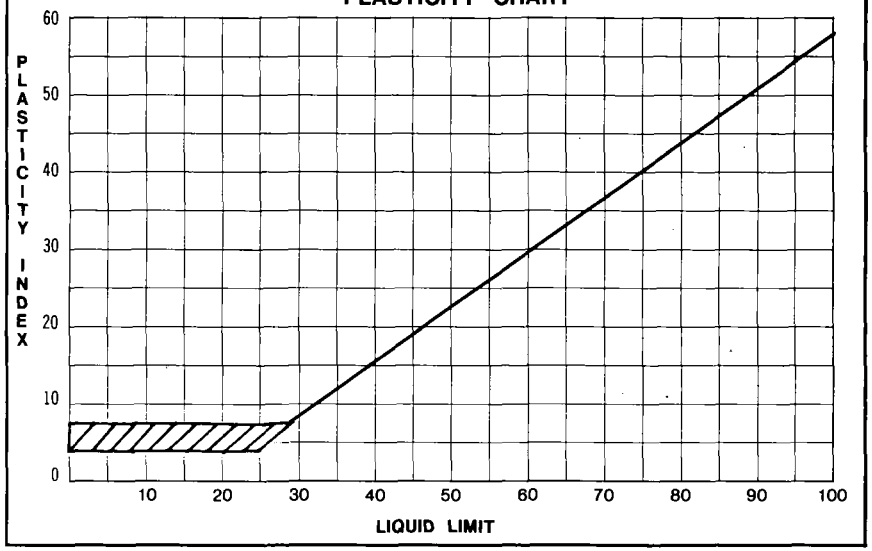
62.6 79.1 H20=26.4%

SIEVE ANALYSIS	% Passing		265.6
	-40	202.0	95.5
-¾	-80		
-4	-140		
-10 12.0 100	-200	51.60	19.40

GRAIN SIZE CURVE



PLASTICITY CHART



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=

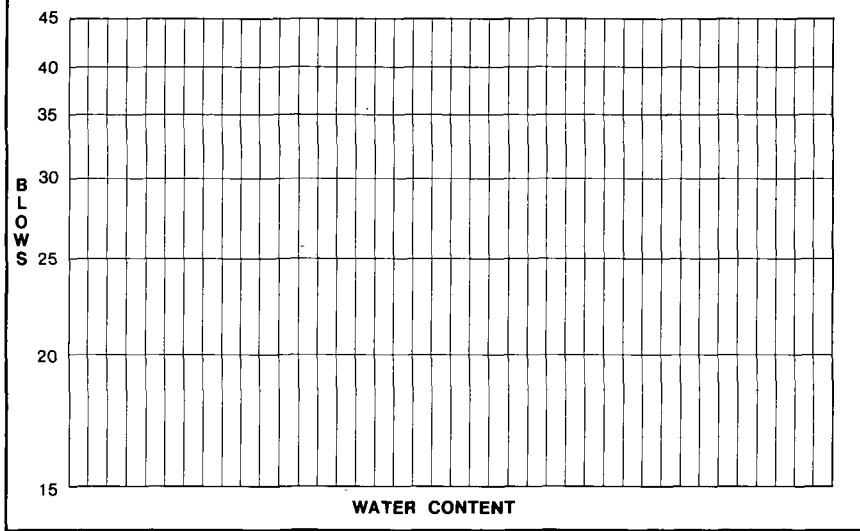


Figure B.1-78

FLATIRON | LANE | wood.

In Association with

Appendix C
Bridge 17.7, 18W, and Walls 03.63L, 03.65L, and 03.66L Subsurface Properties

APPENDIX C – Bridges 17.7, Walls 03.63L, 03.65L, and 03.66L – ESU's and Seismic Design Parameters

1.0 ESU Properties

The selected engineering stratigraphic unit (ESU) properties and selection process details for the properties described in Sections 1.1 through 1.3 are presented in Appendix C.1 (Figures C.1-1 through C.1-23) at the end of this text.

1.1 Calculation of $N1_{60}$ and Friction Angle

We calculated $(N_1)_{60}$ (field blow counts corrected for overburden pressure and hammer efficiency) and friction angle in accordance with Section 3.10.3.1 of American Association of State Highway and Transportation Officials (AASHTO) utilizing the Residual Strength spreadsheet developed by GeoEngineers. The average, geomean, and standard deviation for $(N_1)_{60}$ were calculated for each ESU. The covariance was verified to be between 15 and 45 percent as presented in Sabatini (2002) and Duncan (2000) per the Load and Resistance Factor Design (LRFD) Bridge Design Specifications (AASHTO 2017). The range of effective friction angle values was determined in accordance with Table 5-1 in the Project Geotechnical Design Manual (Project GDM). The effective friction angle was assigned to the ESU group by considering the fines content and consolidation history. For normally consolidated soil units, the lower limit friction angle was assigned to soil with fines content greater than 30 percent passing US No. 200 sieve and the upper limit friction angle was selected for the soil with fines content less than 5 percent passing US No. 200 sieve. For normally consolidated soils containing fines content between 5 percent and 30 percent, the effective friction angle was selected by interpolation between the upper and lower values of the friction angle range. Soil units that were either glacially over-consolidated or lightly cemented (e.g., weathered sandstone) were assigned the upper bound effective friction angle regardless of fines content.

1.2 Calculation of Unit Weight

Individual sample unit weights for each ESU were correlated using State of California Department of Transportation (CALTRANS) Geotechnical Manual (2014) method of United States Soil Classification System (USCS) classification with blow counts. The value for unit weight was verified with applicable ranges presented in Coduto (2001), as specified in Geotechnical Soil Properties Methodology (Wood 2020). The covariance was verified to be between 3 and 7 percent presented in Sabatini (2002) and Duncan (2000). The geometric mean of the unit weights was rounded to the nearest 5 pounds per cubic foot (pcf) and assigned to each ESU.

1.3 Elastic Modulus and Poisson's Ratio

Elastic modulus and Poisson's ratio were estimated from suggested ranges presented in Table C10.4.6.3-1 (AASHTO 2017) by soil type and relative density estimated from the raw blowcount, N. The elastic modulus and Poisson's ratios used for design are presented in Table C-1.

Table C-1: Bridge 17.7, Wall 03.63L, 03.65L, and 03.66L Elastic Modulus and Poisson's Ratio

Soil	Elastic Modulus (ksf)	Poisson's Ratio
1A	800	0.28
1B	1720	0.25
1C[1]	1720	0.25
2A	979	0.35
2B	1330	0.36
2C	112	0.43
7A	1107	0.32

Notes:

1. The design values for ESU 1C have been assumed to match those calculated for ESU 1B as discussed in more detail above.

1.4 Groundwater for Design

Piezometers were installed at exploration locations HQ-13-89, HQ-13B-89, HQ-14-89, HQ-18-89, HQ-20-89, HQ-106-89 and a monitoring well was installed at MW-28. Groundwater measurements were recorded in borings HE-7-90, HE-9-90, R2B-03-17, and HQ-83-90 during exploration. Boreholes advanced using mud rotary drilling techniques prevented an accurate determination of the groundwater level at the time of drilling.

The groundwater level reported in R2B-03-17 was observed during a bail and recharge test, with the recharged water in the borehole reaching Elevation 68.5 feet (21.6 feet below ground surface). The groundwater level observed at R2B-03-17 was recorded at Elevation 79 feet at the beginning of a bail and recharge test. The boring was bailed to Elevation 63 feet, and after 30 minutes the water level in the boring was observed at Elevation 69 feet. The results of the recharge test and observed elevation of the groundwater in the boring are inconsistent with the groundwater observations of the adjacent borings, thus groundwater elevation data from R2B-03-17 was excluded from the groundwater level determination.

The Ordinary High Water Level in Cedar River at Bridge 18W is at Elevation 35 feet. Historical plans show the inclusion of seal slabs below Pier 2 and Pier 3 footings, indicating the presence of groundwater during construction.

Groundwater levels, if observed, are reported on the boring logs in Appendix A.

Based on available groundwater level observations and supporting information, the design groundwater under Pier 1 at Bridge 18W and at the western embankment of Bridge 17.7 is assumed to be at Elevation 43 feet. Along the alignment of Bridge 17.7 towards the east, the groundwater increases in elevation to about 80 feet, seeming to follow along the approximate interface between the native sand and gravel (ESU 2A) and the weathered sandstone (ESU 7A). North of Bridge 17.7, the groundwater slopes downward from 43 feet at Bridge 18W Pier 1 to 35 feet at Pier 3, aligning with the Cedar River Ordinary High Water Level. The design groundwater level declines from Elevation 35 feet to Elevation 26 feet between the river and Bridge 18W Pier 4 and then remains consistent at Elevation 26 feet under Pier 5. The groundwater levels used in design are shown on the design section in Appendix C.1, Figures C.1-2 through C.1-5.

1.3 Calculation of Residual Strengths

The potential for liquefaction was evaluated using a spreadsheet developed by GeoEngineers in accordance with the Project GDM. The borings HQ-18-89, HQ-83-90, and HQ-20-89 each contained soil samples that have potential for liquefaction under the safety evaluation earthquake (SEE). However, these liquefiable soil samples have either been removed, or are no longer representative of the current conditions at the site and/or are located away from the work that we will be performing and therefore liquefaction potential for the design being considered at Bridge 17.7 is considered to have been mitigated. Thus, no residual strengths were calculated for the ESU groups.

2.0 Site Class Designation

Seismic Site Class was evaluated in accordance with Section 3.10.3.1 of AASHTO utilizing the Site Class spreadsheet developed by GeoEngineers. The average SPT blow count N for the upper 100 feet of the soil profile (N_{ave}) was used to determine the site class. Soil layers that have subsequently been removed from the soil profile due to construction activities were not included in the determination of the Seismic Site Class.

The borings selected as representative of the soil conditions in the vicinity of Bridge 17.7, and Walls 03.63L, 03.65L, and 03.66L are those within within approximately 50 feet of the footprint of the walls and bridge. Borings that were removed from the site class evaluation were done so because they are not representative of Bridge 17.7, and Walls 03.63L, 03.65L, and 03.66L due to their distance from the structure (outside the footprint or more than 50 feet away) and the likelihood for soil conditions presented in the borings to have changed between the time of drilling and now through earthwork activities associated with the original construction of Bridges 17.7 and 18W. Of the borings that were considered, five had a Seismic Site Class designation of D. To achieve a site class rating of C the N_{ave} must be equal to or greater than 50, and at HE-7-90 and HQ-106-89 the Nave was 38 and 46, respectively. Borings TH-3, HQ-13B-89, and W-134-20 have N_{ave} values greater than 20. This high N_{ave} and combined with the other explorations being classified as Seismic Site Class C led us to select Seismic Site Class C as representative for Bridge 17.7, and Walls 03.63L, 03.65L, and 03.66L.

The results of the analysis are summarized below in Table C-2 and calculations are included in Appendix C.2 (beginning at Figure C.2-1). Bridge 17.7 and Walls 03.63L, 03.65L, and 03.66L are classified as Site Class C for seismic hazard evaluations.

Table C-2. Bridge 17.7, Wall 03.63L, 03.65L, and 03.66L Site Class Summary

Name	N_{ave}	Calculated Site Class
R2B-03-17	51	C
HQ-12-89	81	C
HQ-13-89	77	C
HQ-14-89	62	C
HQ-18-89	100	C
HE-7-90	38	D
TH-3	26	D
HE-9-90	66	C
HE-11-90	62	C
HE-10-90	62	C
HQ-106-89	46	D
HQ-13B-89	24	D
H-6	91	C
W-134-20	29	D

3.0 Seismic Design Parameters

The design functional evaluation earthquake (FEE) and SEE response spectra for Seismic Site Class C at Bridge 17.7 and Walls 03.63L, 03.65L, and 03.66L was developed and provided by Hart Crowser and is included in the following report:

- Segment 1A Site Specific Hazard Analysis Geotech Report dated January 27, 2021 (Submittal 964).

It is our understanding that these analyses were completed in accordance with the Project GDM and will be finalized at a later date. No changes to the seismic design parameters or deaggregation information are anticipated. The ground motion parameters for design are based on the projected ground motion at the project site that has either a 30 percent (FEE) or 7 percent (SEE) probability of exceedance in a 75-year period (approximate 210 and 975-year return periods). Further details about the determination of the seismic parameters are included in the above referenced report.

We used the recommended SEE response spectrum site class adjusted peak ground acceleration (A_s) and Mean Magnitude (M_w) in our analyses.

3.1 Liquefaction Analysis

As discussed in section C1.3, the potentially liquefiable soil samples have either been removed, are no longer representative of the current conditions at the site or are located away from the work that we will be performing and therefore liquefaction potential for the design being considered at Bridge 17.7 and Walls 03.63L, 03.65L, and 03.66L has been mitigated. Specifically:

- The potentially liquefiable soil layers that were identified in boring HQ-18-89 have subsequently been removed during the original construction activities at Bridge 17.7.
- The potentially liquefiable soil layers that were identified in boring HQ-83-90 have subsequently been removed during the original construction activities at Pier 3 of Bridge 18W.
- Boring HQ-20-89 identifies two potentially liquefiable layers. The uppermost sample is a wood fragment and thus is not susceptible to liquefaction. The lower potentially liquefiable layer ranging from Elevation 0.8 feet to 10.8 feet consists of clean gravel (GP and GW) in the 31 to 36 blow count range and could potentially liquefy under the design SEE event. However, that boring is located between Piers 4 and 5 of Bridge 18W as shown on Figure 2. The focus of our report is Bridge 17.7, thus the liquefaction potential identified in this boring does not influence our design.

Appendix C.1
ESU Properties

Bridge 17.7 and Bridge 18W
Walls 03.63L, 03.64L, 03.65L, 03.66L
Soil Properties Summary

ESU	Description	Total No. of Samples [c]	USCS [b]	Fines (%)	Plasticity Index, PI [g] (%)	Raw N (bpf)	N_{60} [d] (bpf)		$(N_1)_{60}$ [d] (bpf)		Saturated Unit Weight [e] (pcf)		ϕ' [f] (deg)		Residual Shear Strength, Sr (psf)	Undrained Shear Strength, Su (psf)	
				Value	Value	Value	Value	COV [a]	Value	COV [a]	Value	COV [a]	Value	COV [a]	Value	Value	COV
1A	Existing Granular Fill	4	SM	8	-	20	23	42%	30	43%	120	8%	40	6%	-	-	-
1B	Existing Gravelly Granular Fill	7	GW	4	-	16	21	56%	21	38%	125	9%	38	5%	-	-	-
1C [h]	Existing Gravelly Granular Fill	0	GW	4	-	16	21	56%	21	38%	125	9%	38	5%	-	-	-
2A	Native Sand and Gravel	16	SM	11	-	29	28	44%	29	41%	120	7%	39	6%	-	-	-
2B	Native Sand and Gravel	21	SM	5	-	41	38	36%	37	32%	135	6%	41	3%	-	-	-
2C	Native Silt	2	ML	63	-	5	6	0%	9	9%	110	0%	29	1%	-	-	-
7A	Weathered Sandstone	17	SM(SS)	14	-	59	61	36%	50	31%	135	6%	42	3%	-	-	-

Notes:

a. Coefficient of Variation (COV) percentage calculated to verify the variability and reliability of sample data within ESU (WSDOT GDM Section 5.11.2 (2015)). Calculated COV percentage compared to ranges presented in Table 52 (Sabatini et al. 2002) (below).

b. Predominant USCS classification of all samples in ESU. Sandstone denoted as SM(SS), SS, and SSTN depending on historical boring notations.

c. Number of samples excludes outliers.

d. Corrected blow counts (N_{60} and $(N_1)_{60}$) were calculated following WSDOT GDM Section 5.5 (2015).

e. Individual sample unit weights were correlated using CALTRANS Geotechnical Manual (2014), verified with applicable ranges presented in Codotu (2001), as specified in WOOD SPM. The geometric mean of the unit weights was rounded to the nearest 5pcf, as specified in WOOD SPM. Unit weight data variability and quality were evaluated by comparing the calculated COV percentage to the applicable Sabatini range.

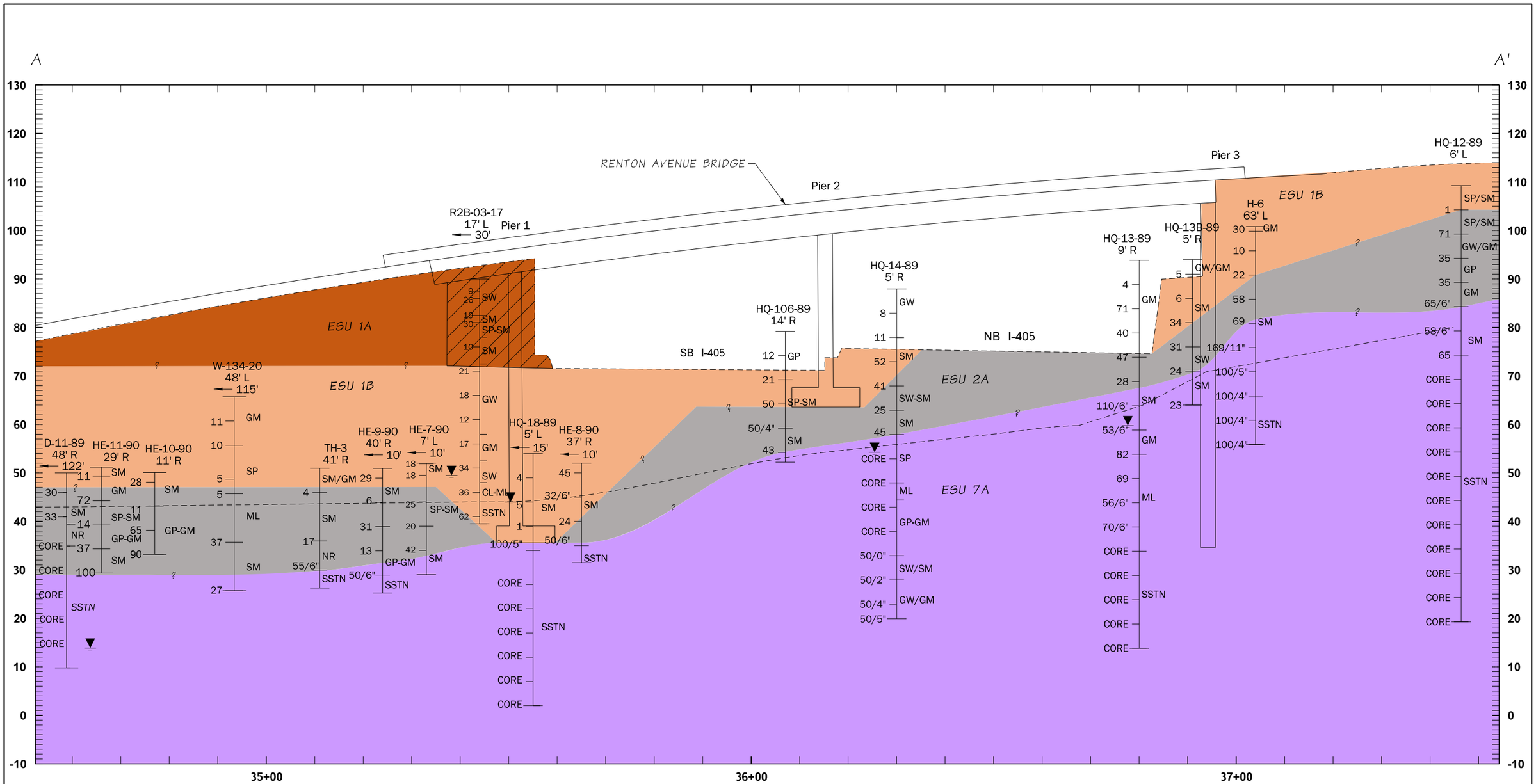
f. High and low range friction angles were calculated using the data presented in the WSDOT GDM Section 5.8.3 and Table 5-1 of the WSDOT GDM (2015). Friction angle data variability and quality were evaluated by comparing the calculated COV percentage to the applicable Sabatini range. Per established WOOD practice, the design friction angle was selected based on fines content of the ESU.

g. Not enough lab data to develop representative design plasticity index values.

h. No current information was available to develop ESU 1C. ESU 1C was assumed to be the same material type as ESU 1B. Refer to geotechnical report for additional discussion.

Measured or interpreted parameter value	Coefficient of Variation, V (%)
Unit weight, γ	3 to 7 %
Buoyant unit weight, γ_b	0 to 10 %
Effective stress friction angle, ϕ'	2 to 13 %
Undrained shear strength, s_u	13 to 40 %
Undrained strength ratio (s_u/σ_v')	5 to 15 %
Compression index, C_c	10 to 37 %
Preconsolidation stress, σ_p'	10 to 35 %
Hydraulic conductivity of saturated clay, k	68 to 90 %
Hydraulic conductivity of partly-saturated clay, k	130 to 240 %
Coefficient of consolidation, c_v	33 to 68 %
Standard penetration blowcount, N	15 to 45 %
Electric cone penetration test, q_c	5 to 15 %
Mechanical cone penetration test, q_c	15 to 37 %
Vane shear test undrained strength, s_{uVST}	10 to 20 %

Source: Table 52 (Sabatini et al. 2002)



BRIDGE 17.7 STATIONING

THE ESU STRATIFICATION HAVE BEEN INTERPRETED, INTERPOLATED BETWEEN EXPLORATIONS, AND EXTRAPOLATED BEYOND EXPLORATIONS FOR ENGINEERING DESIGN PURPOSES, THE STRATA MAY NOT REPRESENT ACTUAL SUBSURFACE CONDITIONS. SEE THE EXPLORATION LOGS FOR DETAILED SUBSURFACE CONDITIONS AT THE LOCATION EXPLORED.

Figure C.1-2

FILE NAME	c:\users\tbyrd\documents\projectwise\workingdir\wsdot\dms17077\XL5467_BR-17.7_XS-1.dgn						Washington State Department of Transportation	I-405; RENTON TO BELLEVUE WIDENING AND EXPRESS TOLL LANES PROJECT
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DATE	2/24/2021							
PLOTTED BY	tbyrd				JOB NUMBER			SHEET OF SHEETS
DESIGNED BY								
ENTERED BY								
CHECKED BY					CONTRACT NO.	LOCATION NO.		
PROJ. ENGR.								
REGIONAL ADM.		REVISION	DATE	BY				

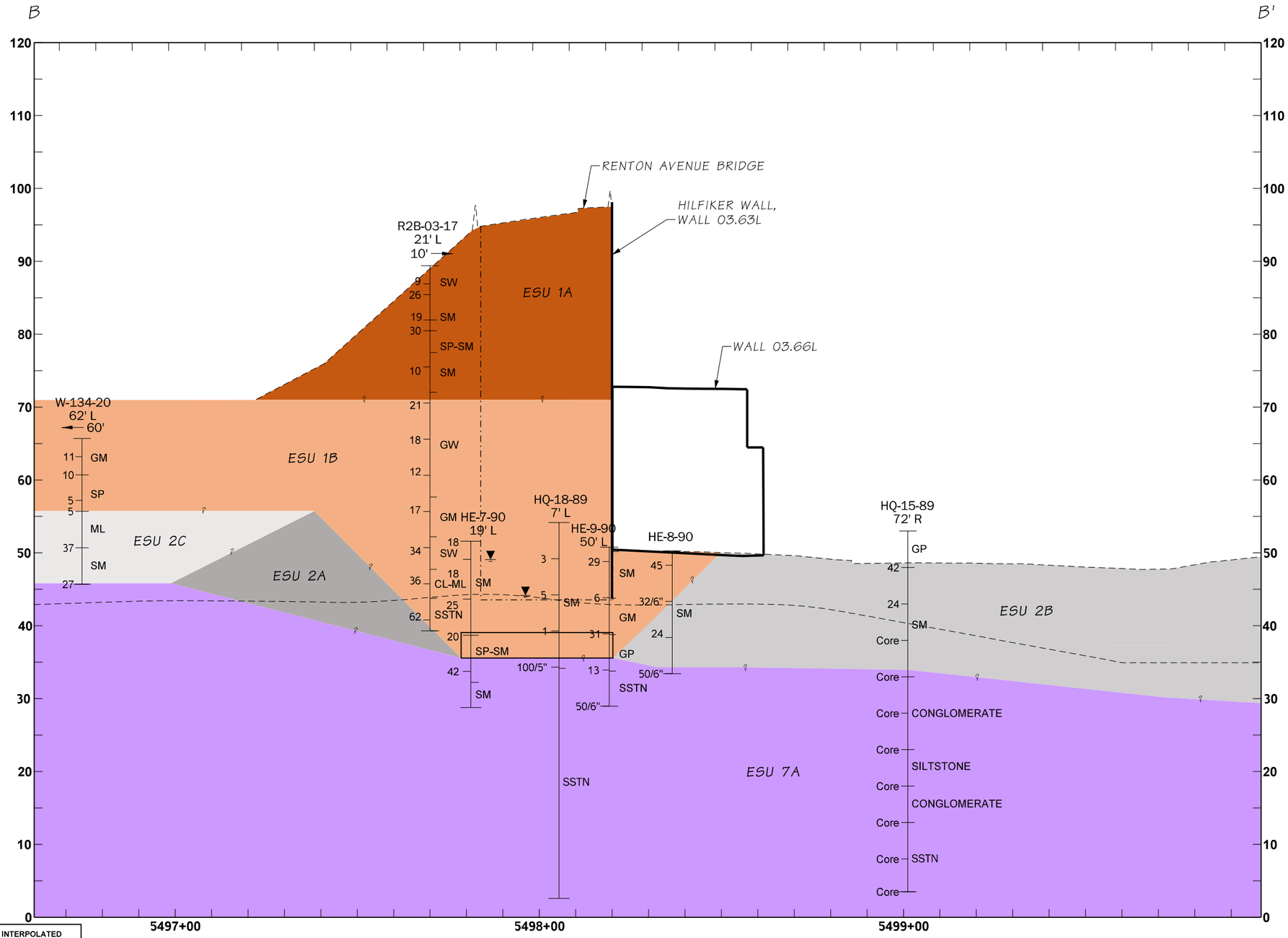
P.E. STAMP BOX — DATE

P.E. STAMP BOX — DATE

FLATIRON LANE

wood.

BRIDGE CROSS SECTION A-A'
BRIDGE 17.7 - RENTON AVENUE BRIDGE



THE ESU STRATIFICATION HAVE BEEN INTERPRETED, INTERPOLATED BETWEEN EXPLORATIONS, AND EXTRAPOLATED BEYOND EXPLORATIONS FOR ENGINEERING DESIGN PURPOSES, THE STRATA MAY NOT REPRESENT ACTUAL SUBSURFACE CONDITIONS. SEE THE EXPLORATION LOGS FOR DETAILED SUBSURFACE CONDITIONS AT THE LOCATION EXPLORED.

I-405 SB STATIONING

Figure C.1-3

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REGIONAL ADM.		REVISION	DATE	BY			

REGION NO.	STATE
10	WASH

JOB NUMBER

CONTRACT NO.

FED.AID PROJ.NO.

LOCATION NO.

P.E. STAMP BOX DATE

P.E. STAMP BOX DATE

Washington State Department of Transportation

FLATIRON LANE

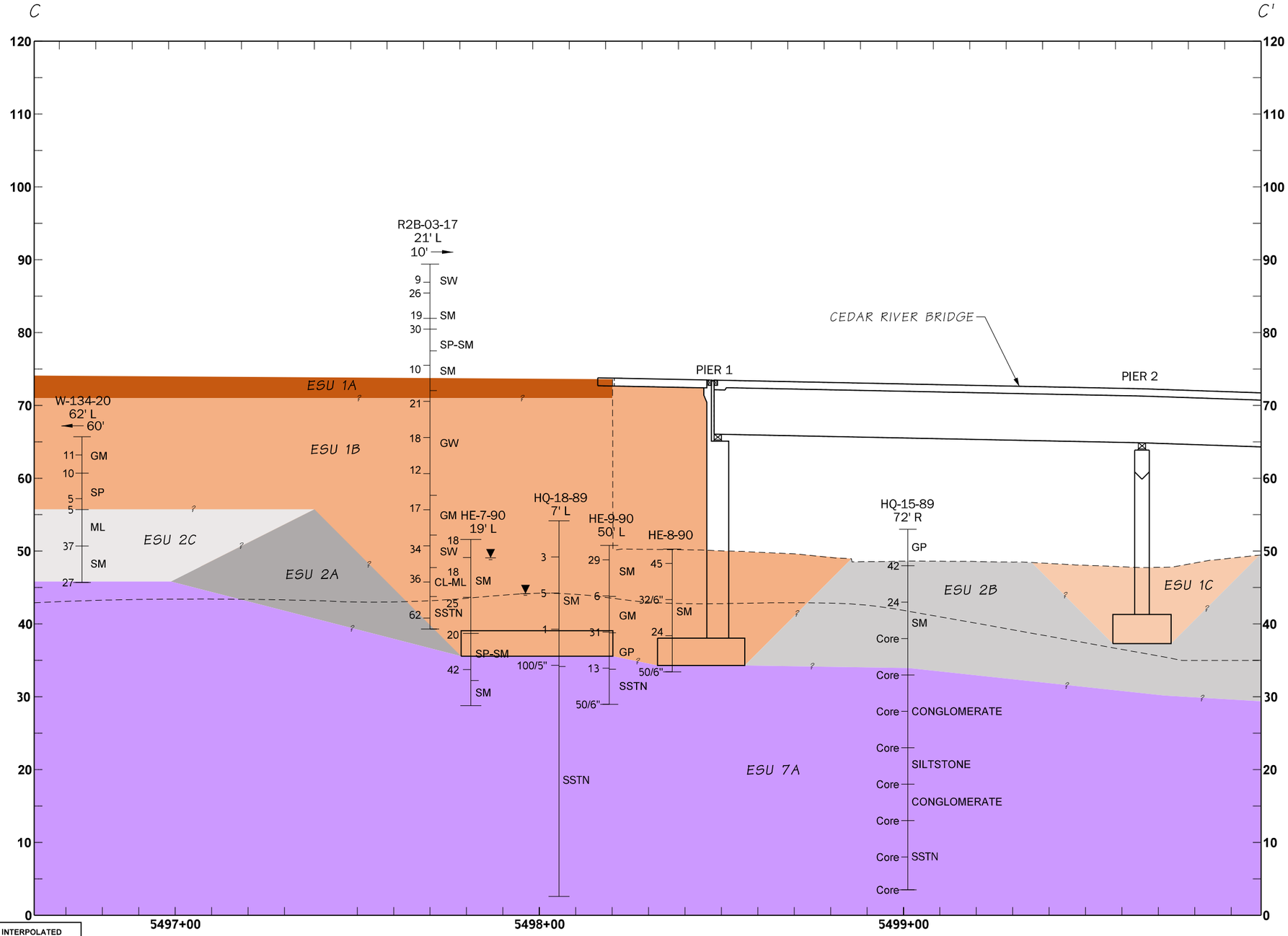
wood.

I-405; RENTON TO BELLEVUE WIDENING AND EXPRESS TOLL LANES PROJECT

BRIDGE CROSS SECTION B-B'
BRIDGE 17.7 AND WALLS 03.63L, 03.66L

PLAN REF NO

SHEET 1 OF 1 SHEETS



THE ESU STRATIFICATION HAVE BEEN INTERPRETED, INTERPOLATED BETWEEN EXPLORATIONS, AND EXTRAPOLATED BEYOND EXPLORATIONS FOR ENGINEERING DESIGN PURPOSES. THE STRATA MAY NOT REPRESENT ACTUAL SUBSURFACE CONDITIONS. SEE THE EXPLORATION LOGS FOR DETAILED SUBSURFACE CONDITIONS AT THE LOCATION EXPLORED.

I-405 SB STATIONING

Figure C.1-4

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REGION NO.	STATE	FED.AID PROJ.NO.
10	WASH	
JOB NUMBER		
CONTRACT NO.		LOCATION NO.

P.E. STAMP BOX — DATE

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Washington State Department of Transportation

FLATIRON LANE

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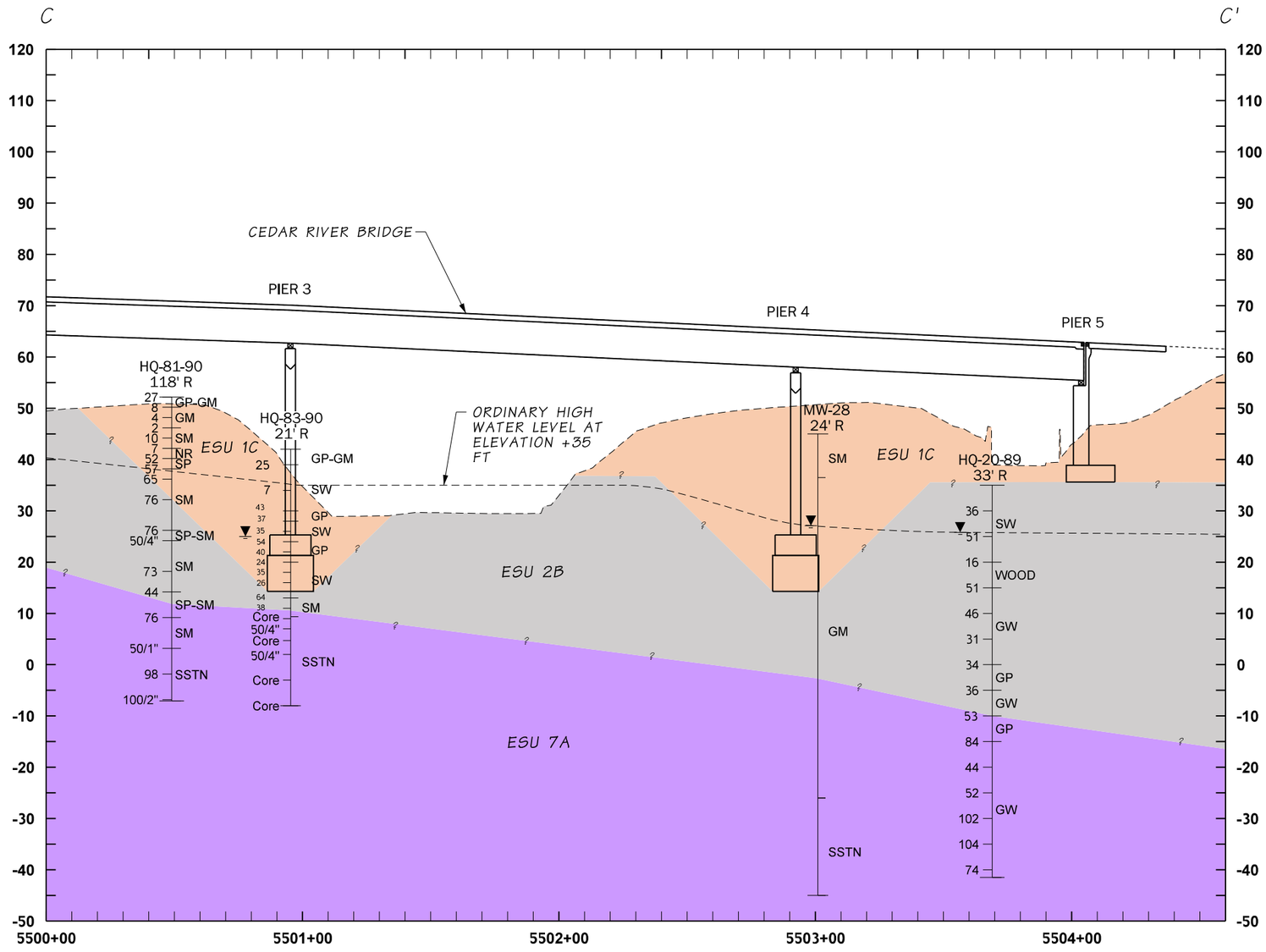
I-405; RENTON TO BELLEVUE WIDENING AND EXPRESS TOLL LANES PROJECT

BRIDGE CROSS SECTION C-C'
BRIDGE 18W - BW1 - CEDAR RIVER BRIDGE

PLAN REF NO

SHEET 1 OF 2 SHEETS



I-405 SB STATIONING

THE ESU STRATIFICATION HAVE BEEN INTERPRETED, INTERPOLATED BETWEEN EXPLORATIONS, AND EXTRAPOLATED BEYOND EXPLORATIONS FOR ENGINEERING DESIGN PURPOSES, THE STRATA MAY NOT REPRESENT ACTUAL SUBSURFACE CONDITIONS. SEE THE EXPLORATION LOGS FOR DETAILED SUBSURFACE CONDITIONS AT THE LOCATION EXPLORED.

Figure C.1-5

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PROJ. ENGR.							
REGIONAL ADM.		REVISION	DATE	BY			

REGION NO.	STATE	FED.AID PROJ.NO.
10	WASH	
JOB NUMBER		
CONTRACT NO.	LOCATION NO.	

P.E. STAMP BOX — DATE

P.E. STAMP BOX — DATE

Washington State Department of Transportation

FLATIRON LANE

wood.

I-405; RENTON TO BELLEVUE WIDENING AND EXPRESS TOLL LANES PROJECT

BRIDGE CROSS SECTION C-C'
BRIDGE 18W - BW1 - CEDAR RIVER BRIDGE

PLAN REF NO

SHEET 2 OF 2 SHEETS

	ESU Name:	ESU 1A - Existing Granular Fill							
		N	N_{60}	$(N_1)_{60}$	%F (Lab)	PI (Lab)	ϕ' (high) (deg)	ϕ' (low) (deg)	Sat. Unit Weight
	GeoMean:	20	23	30	8	-	40	35	120
	Average:	21	25	33	9	-	40	35	125
	St. Dev.:	8.8	10.6	14.2	2.5	-	2.3	2.3	10.4
	COV:	0.41	0.42	0.43	0.28	-	0.06	0.06	0.08

Boring	Elevation	N	N_{60}	$(N_1)_{60}$	%F (Lab)	PI (Lab)	ϕ' (high) (deg)	ϕ' (low) (deg)	USCS	Sat. Unit Weight	Explaination for Sample Removal
R2B-03-17	76.1	10	13	14	10	-	37	32	SM	110	
R2B-03-17	81.1	30	38	45	10	-	42	37	SM	125	
R2B-03-17	82.6	19	22	30	10	-	40	35	SM	120	
R2B-03-17	86.1	26	29	43	5	-	42	37	SW	135	
R2B-03-17	87.6								SW		Sample at ground surface, likely included surficial disturbed soil.

Notes:

1. Highlighted cells represent samples that were removed as outliers.
2. Friction angle, unit weight, and corrected blow count values were correlated using specified methodology in the WOOD Geotechnical SPM.
3. Not enough lab testing to generate representative design plasticity index values.
4. Fines content percentage highlighted is from lab testing.

ESU 1A - Existing Granular Fill

1. Check N160 COV is between 15 and 45%

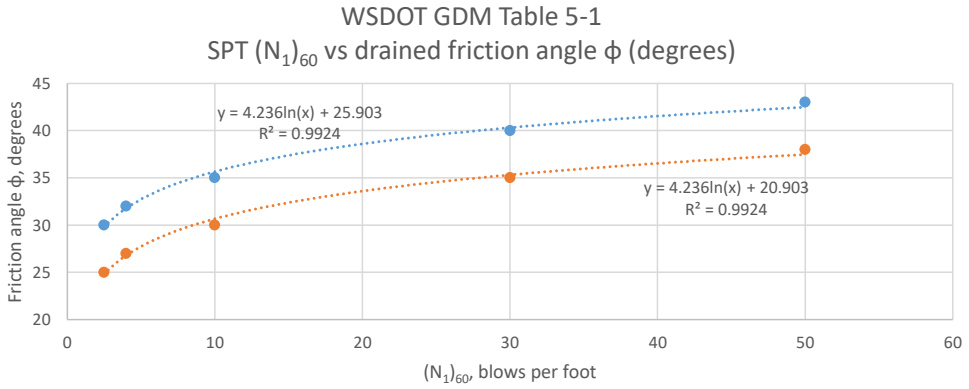
Selected Design N160:	30
Coefficient of Variation (COV):	0.43

* 15 and 45% come from GEC 5 Sabatini (2002)

2. Check Phi' is between 2 to 13%

$(N_1)_{60}$ (blows per foot)	Friction angle ϕ (degrees)
2.5	25
2.5	30
4	27
4	32
10	30
10	35
30	35
30	40
50	38
50	43

* Phi' Developed from WSDOT Correlation
* 2 to 13% comes from GEC 5 Sabatini (2002)

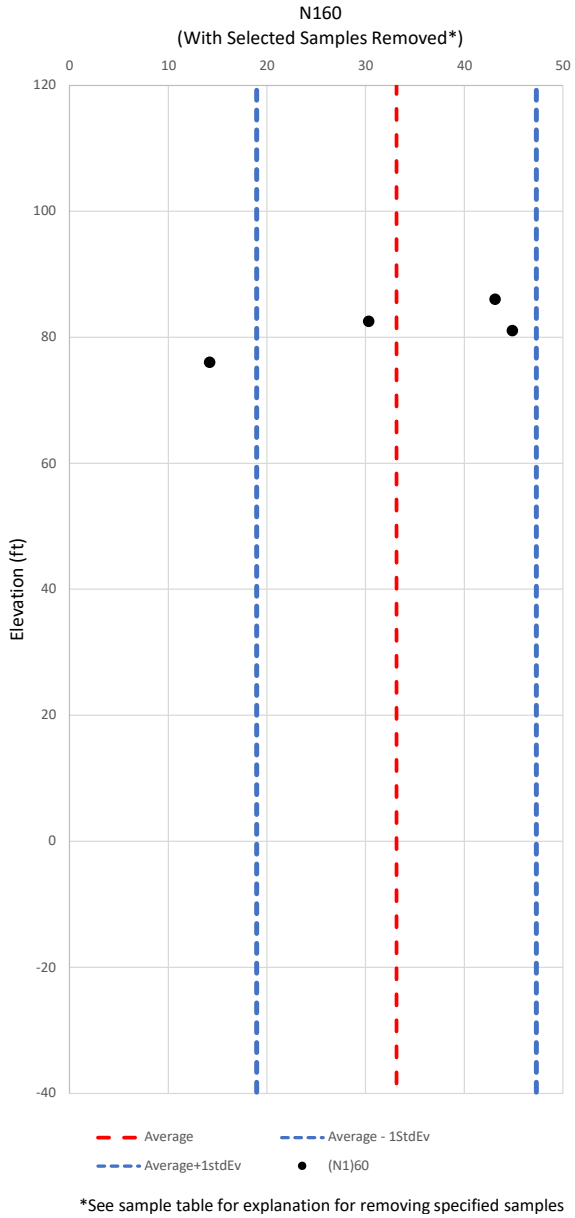


	ϕ (high)	ϕ (low)	ϕ (avg)	ϕ' COV	% Fines
GeoMean:	40	35	38	0.06	8

Selected Design Phi' (deg):	40
Notes on Selection:	The fines content test data was used to interpolate between the high friction angle (at <5% fines) and the low friction angle (at >30% fines).

Pick Representative USCS:	SM	*Using Predominant USCS Classification
Pick Representative Unit Weight:	120	
Notes on Selection:	Individual sample unit weights were correlated using CALTRANS Geotechnical Manual (2014), verified with applicable ranges presented in Codotu (2001), as specified in WOOD SPM. The geometric mean of the unit weights was rounded to the nearest 5pcf, as specified in WOOD SPM. Data set COV was 8%.	

ESU 1A - Existing Granular Fill



*See sample table for explanation for removing specified samples

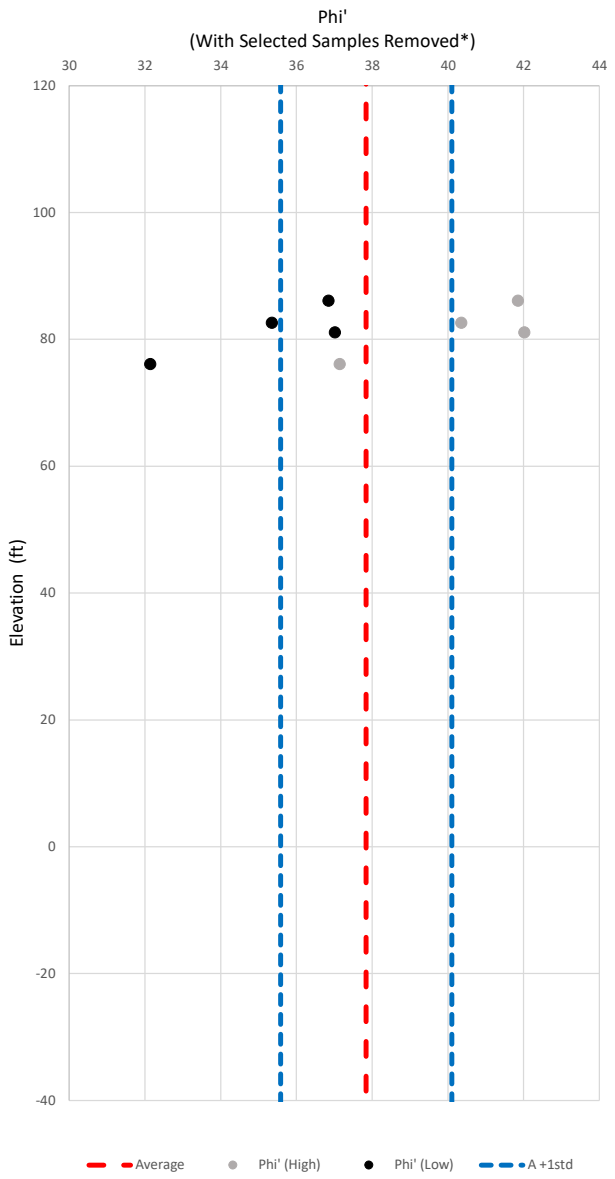


Figure C.1-8

	ESU Name:	ESU 1B - Existing Gravelly Granular Fill							
		N	N_{60}	$(N_1)_{60}$	%F (Lab)	PI (Lab)	ϕ' (high) (deg)	ϕ' (low) (deg)	Sat. Unit Weight
	GeoMean:	16	21	21	4	-	38	33	125
	Average:	18	24	23	7	-	38	33	125
	St. Dev.:	8.3	13.5	8.5	8.2	-	1.8	1.8	11.1
	COV:	0.47	0.56	0.38	1.11	-	0.05	0.06	0.09

Boring	Elevation	N	N_{60}	$(N_1)_{60}$	%F (Lab)	PI (Lab)	ϕ' (high) (deg)	ϕ' (low) (deg)	USCS	Sat. Unit Weight	Explanation for Sample Removal
R2B-03-17	51.1	34	50	39	5	-	41	36	SW	135	
R2B-03-17	56.1	17	25	18	5	-	38	33	GM	115	
R2B-03-17	61.1	12	18	13	1	-	37	32	GW	130	
R2B-03-17	66.1	18	25	22	1	-	39	34	GW	135	
R2B-03-17	71.1	21	29	28	1	-	40	35	GW	140	
HQ-106-89	74.39								GP		Soil has since been removed.
H-6	91.49								SM		Soil has since been removed.
H-6	96.49								SM		Soil has since been removed.
H-6	100.49								GM		Cobbles in sample, artifically high blowcount.
HQ-12-89	104.29								SM		Sample at ground surface, likely included surficial disturbed soil.
HQ-13-89	89.09								GM		Soil has since been removed.
HQ-14-89	78.29								SM		Soil has since been removed.
HQ-14-89	83.29								GW		Soil has since been removed.
HQ-13B-89	86.09								SM		Soil has since been removed.
HQ-13B-89	91.09								GW/GM		Soil has since been removed.
W-134-20	60.7	10	11	18	19	-	36	31	GM	115	
W-134-20	63.2	11	11	19	19	-	37	32	GM	115	

Notes:

1. Highlighted cells represent samples that were removed as outliers.
2. Friction angle, unit weight, and corrected blow count values were correlated using specified methodology in the WOOD Geotechnical SPM.
3. Not enough lab testing to generate representative design plasticity index values.
4. Fines content percentage highlighted is from lab testing.

ESU 1B - Existing Gravelly Granular Fill

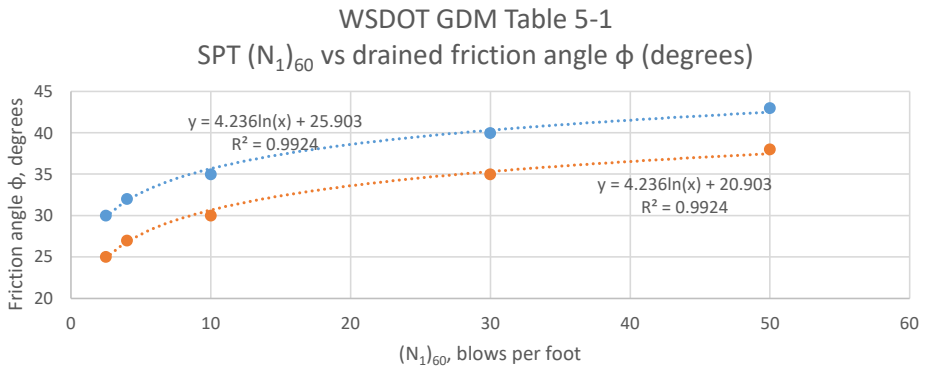
1. Check N160 COV is between 15 and 45%

Selected Design N160:	21
Coefficient of Variation (COV):	0.38

* 15 and 45% come from GEC 5 Sabatini (2002)

2. Check Phi' is between 2 to 13%

$(N_1)_{60}$ (blows per foot)	Friction angle ϕ (degrees)
2.5	25
2.5	30
4	27
4	32
10	30
10	35
30	35
30	40
50	38
50	43



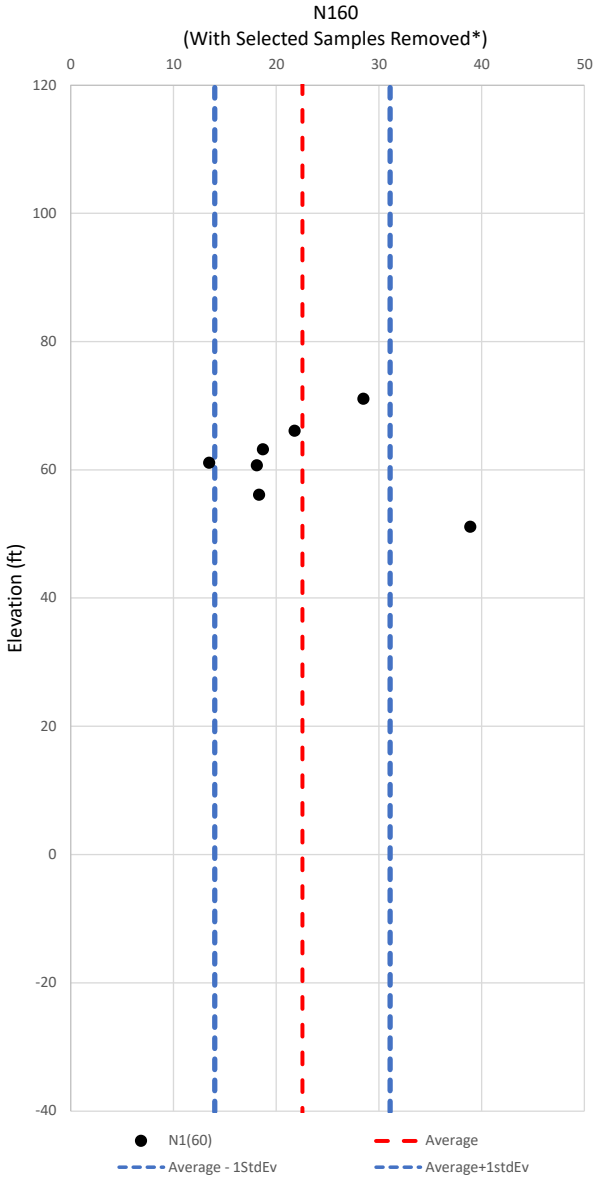
* Phi' Developed from WSDOT Correlation
* 2 to 13% comes from GEC 5 Sabatini (2002)

	ϕ (high)	ϕ (low)	ϕ (avg)	ϕ' COV	% Fines
GeoMean:	38	33	36	0.05	4

Selected Design Phi' (deg):	38
Notes on Selection:	The low fines content supports the use of the upper bound of the friction angle range.

Pick Representative USCS:	GW	*Using Predominant USCS Classification
Pick Representative Unit Weight:	125	
Notes on Selection:	Individual sample unit weights were correlated using CALTRANS Geotechnical Manual (2014), verified with applicable ranges presented in Codotu (2001), as specified in WOOD SPM. The geometric mean of the unit weights was rounded to the nearest 5pcf, as specified in WOOD SPM. Data set COV was 9%.	

ESU 1B - Existing Gravelly Granular Fill



*See sample table for explanation for removing specified samples

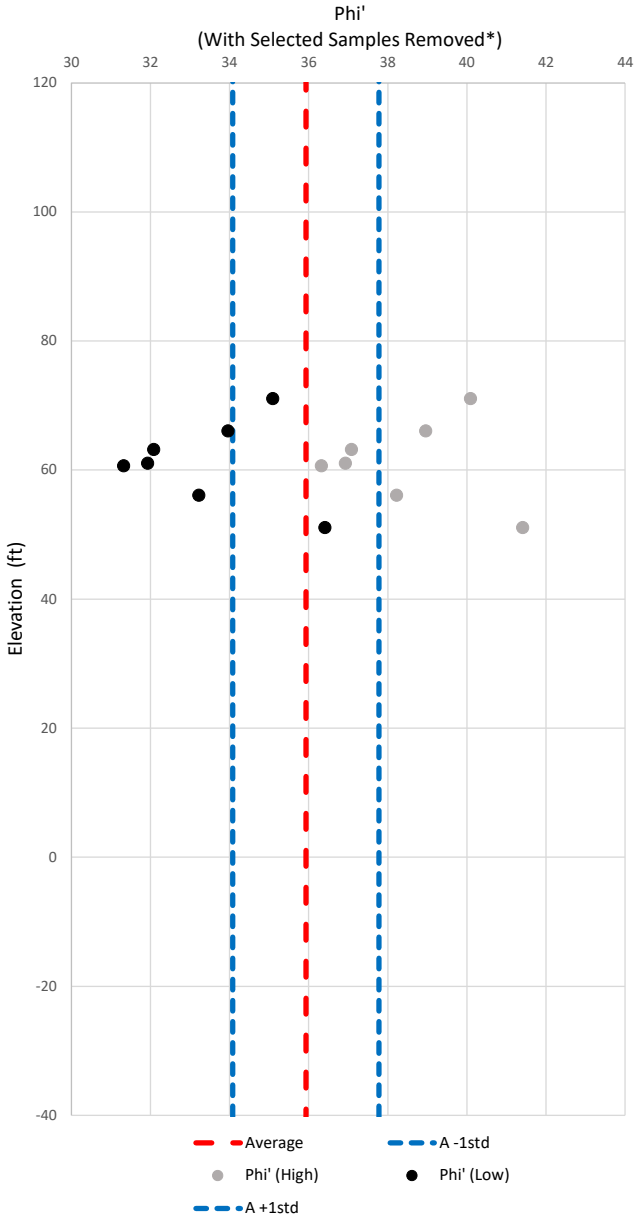


Figure C.1-11

	ESU Name:	ESU 2A - Native Sand and Gravel							
		N	N_{60}	$(N_1)_{60}$	%F (Lab)	PI (Lab)	ϕ' (high) (deg)	ϕ' (low) (deg)	Sat. Unit Weight
	GeoMean:	29	28	29	11	-	40	35	120
	Average:	33	32	32	18	6	40	35	120
	St. Dev.:	13.1	14.0	13.2	14.6	-	2.1	2.1	8.1
	COV:	0.40	0.44	0.41	0.83	-	0.05	0.06	0.07

Boring	Elevation	N	N_{60}	$(N_1)_{60}$	%F (Lab)	PI (Lab)	ϕ' (high) (deg)	ϕ' (low) (deg)	USCS	Sat. Unit Weight	Explanation for Sample Removal
D-11-89	40.99								SM		Beneath existing embankment.
D-11-89	45.99								SM		Beneath existing embankment.
H-6	86.49	58	55	58	30	-	43	38	SM	130	
HE-10-90	33.39								GP-GM		Beneath existing embankment.
HE-10-90	38.39								GP-GM		Beneath existing embankment.
HE-10-90	43.39								SM		Beneath existing embankment.
HE-10-90	48.39								SM		Beneath existing embankment.
HE-11-90	34.49								GP-GM		Beneath existing embankment.
HE-11-90	39.49								SP-SM		Beneath existing embankment.
HE-11-90	44.49								GM		Beneath existing embankment.
HE-11-90	49.49								SM		Beneath existing embankment.
HE-7-90	42.59								SP-SM		Beneath existing embankment.
HE-7-90	47.59								GP-GM		Beneath existing embankment.
HE-7-90	53.09								SP-SM		Beneath existing embankment.
HE-7-90	55.59								SM		Beneath existing embankment.
HE-8-90	40.09								SM		Soil has since been removed.
HE-8-90	45.09								SM		Soil has since been removed.
HE-8-90	50.09								SM		Soil has since been removed.
HE-9-90	34.19	13	12	13	30	-	37	32	GM	110	
HE-9-90	39.19	31	26	31	30	-	40	35	GM	120	
HE-9-90	44.19	6	5	8	16	-	35	30	SM	110	
HE-9-90	49.19	29	22	37	16	-	41	36	SM	120	
HQ-106-89	59.39								SP-SM		Refusal blowcount, artificially high.
HQ-106-89	64.39								SP-SM		Soil has since been removed.
HQ-106-89	69.39								SW		Soil has since been removed.
HQ-12-89	89.29	35	33	32	7	-	41	36	GM	120	
HQ-12-89	94.29	35	33	36	1	-	41	36	GP	135	
HQ-12-89	99.29								GM		Outlier high blowcount. Conservative to remove.
HQ-13-89	69.09	28	27	23	24	-	39	34	SM	115	
HQ-13-89	74.09	47	45	43	24	-	42	37	SM	125	
HQ-13-89	79.09								GM		Soil has since been removed.
HQ-13-89	84.09								GM		Soil has since been removed.
HQ-13B-89	71.09	24	23	20	5	-	39	34	SP	125	
HQ-13B-89	76.09	31	29	29	5	-	40	35	SP	130	
HQ-13B-89	81.09	34	29	33	4	-	41	36	SP	130	
HQ-14-89	63.29	25	24	20	6	-	39	34	SW-SM	115	
HQ-14-89	68.29	41	39	37	6	-	41	36	SW-SM	120	
HQ-14-89	73.29	52	49	51	24	-	43	38	SM	130	
HQ-18-89	39.59								SM		Beneath existing embankment.
HQ-18-89	44.59								SM		Beneath existing embankment.
HQ-18-89	49.59								SM		Beneath existing embankment.
R2B-03-17	46.1	36	53	41	55	6	42	37	ML	110	
TH-3	36.39								NR		Poor quality boring, use HE-9-91
TH-3	46.39								SM		Poor quality boring, use HE-9-92

Notes:

1. Highlighted cells represent samples that were removed as outliers.
2. Friction angle, unit weight, and corrected blow count values were correlated using specified methodology in the WOOD Geotechnical SPM.
3. Not enough lab testing to generate representative design plasticity index values.
4. Fines content percentage highlighted is from lab testing.

Figure C.1-12

ESU 2A - Native Sand and Gravel

1. Check N160 COV is between 15 and 45%

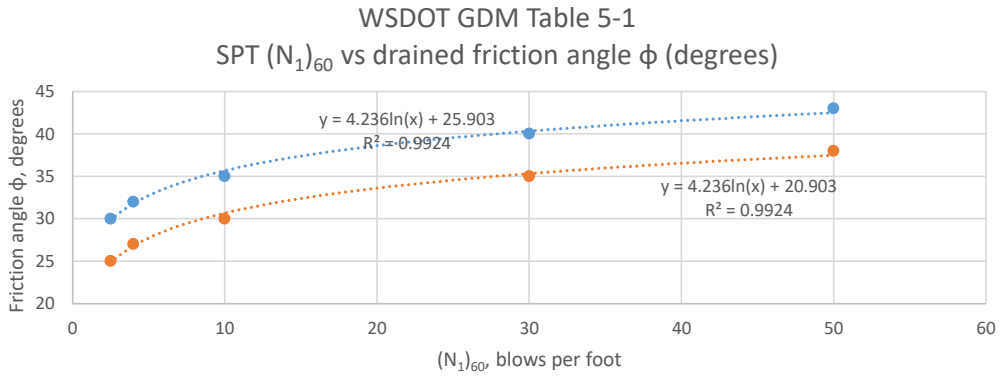
Selected Design N160:	29
Coefficient of Variation (COV):	0.41

* 15 and 45% come from GEC 5 Sabatini (2002)

2. Check Phi' is between 2 to 13%

$(N_1)_{60}$ (blows per foot)	Friction angle ϕ (degrees)
2.5	25
2.5	30
4	27
4	32
10	30
10	35
30	35
30	40
50	38
50	43

* Phi' Developed from WSDOT Correlation
* 2 to 13% comes from GEC 5 Sabatini (2002)



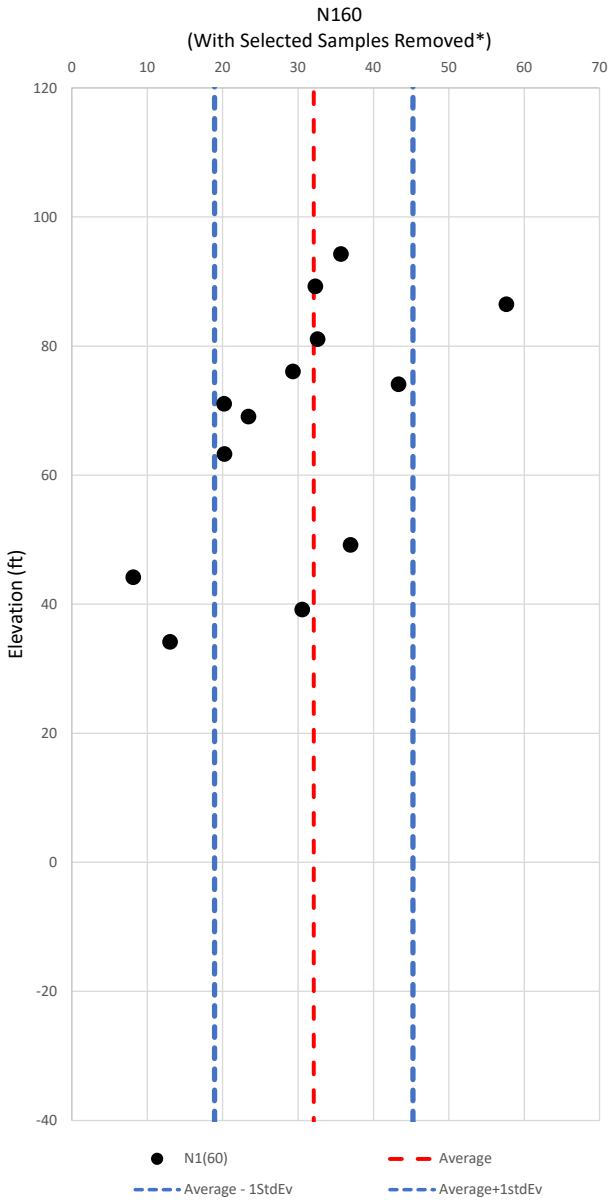
	ϕ (high)	ϕ (low)	ϕ (avg)	ϕ' COV	% Fines
GeoMean:	40	35	38	0.06	11

Selected Design Phi' (deg):	39
Notes on Selection:	The fines content test data was used to interpolate between the high friction angle (at <5% fines) and the low friction angle (at >30% fines).

Pick Representative USCS:	SM
Pick Representative Unit Weight:	120
Notes on Selection:	Individual sample unit weights were correlated using CALTRANS Geotechnical Manual (2014), verified with applicable ranges presented in Codotu (2001), as specified in WOOD SPM. The geometric mean of the unit weights was rounded to the nearest 5pcf, as specified in WOOD SPM. Data set COV was 7%.

*Using Predominant USCS Classification

Figure C.1-13



*See sample table for explanation for removing specified samples

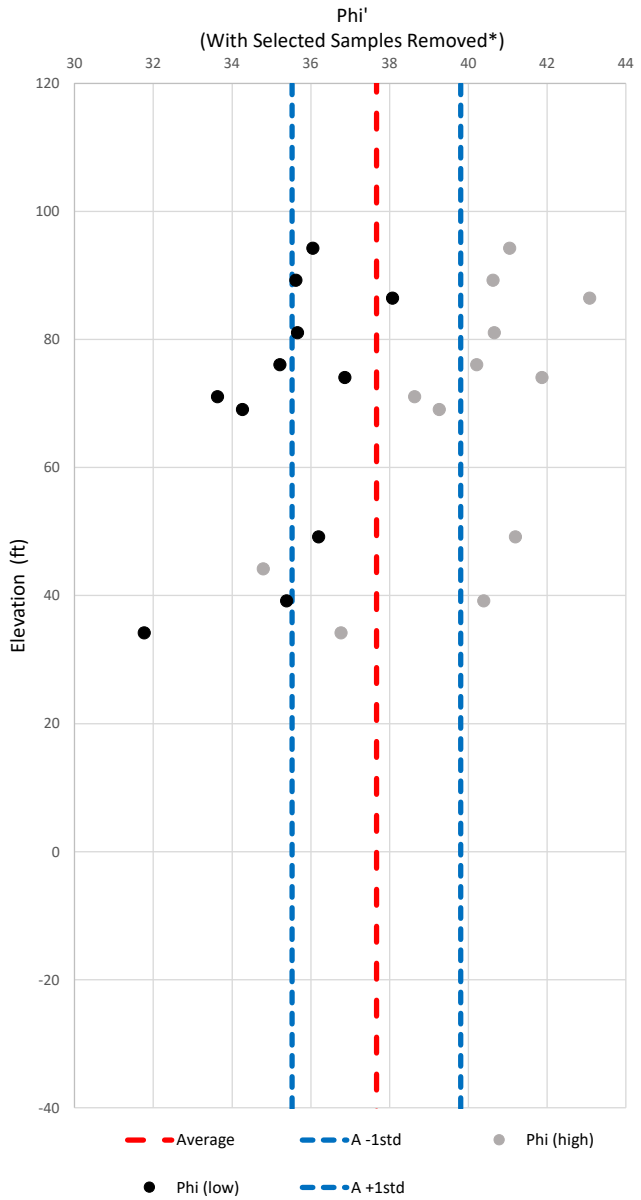


Figure C.1-14

	ESU Name:	ESU 2B - Native Sand and Gravel							
		N	N_{60}	$(N_1)_{60}$	%F (Lab)	PI (Lab)	ϕ' (high) (deg)	ϕ' (low) (deg)	Sat. Unit Weight
	GeoMean:	41	38	37	5	-	41	36	135
	Average:	43	40	39	8	-	41	36	135
	St. Dev.:	14.5	14.5	12.5	7.3	-	1.3	1.3	7.8
	COV:	0.34	0.36	0.32	0.95	-	0.03	0.04	0.06

Boring	Elevation	N	N_{60}	$(N_1)_{60}$	%F (Lab)	PI (Lab)	ϕ' (high) (deg)	ϕ' (low) (deg)	USCS	Sat. Unit Weight	Explanation for Sample Removal
HQ-15-89	37.99								SM		Core
HQ-15-89	42.49								SM		Core
HQ-15-89	43.99	24	20	26	24	-	40	35	SM	120	
HQ-20-89	0.79	36	36	28	4	-	40	35	GW	140	
HQ-20-89	5.79	34	34	28	1	-	40	35	GP	130	
HQ-20-89	10.79	31	31	26	1	-	40	35	GW	140	
HQ-20-89	15.79	46	44	40	0	-	42	37	GW	145	
HQ-20-89	20.79	51	48	47	4	-	42	37	GW	150	
HQ-20-89	25.79								wood		Wood in sample.
HQ-20-89	30.79	51	43	49	6	-	42	37	SW	140	
HQ-20-89	35.79	36	29	40	6	-	42	37	SW	135	
HQ-81-90	14.19	44	44	34	10	-	41	36	SP-SM	125	
HQ-81-90	18.19	73	73	61	30	-	43	38	SM	130	
HQ-81-90	24.19								SM		Refusal blowcount, artificially high.
HQ-81-90	26.19	76	72	65	12	-	44	39	SP-SM	135	
HQ-83-90	12.59	38	38	35	13	-	41	36	SM	120	
HQ-83-90	14.59	64	61	57	13	-	43	38	SM	130	
HQ-83-90	17.59	26	25	23	5	-	39	34	SW	130	
HQ-83-90	19.59	35	33	32	5	-	41	36	SW	130	
HQ-83-90	21.59	24	23	22	5	-	39	34	SW	125	
HQ-83-90	23.59	40	38	38	4	-	41	36	GP	135	
HQ-83-90	25.59	54	51	53	4	-	43	38	GP	140	
HQ-83-90	27.59	35	30	32	4	-	41	36	SW	130	
HQ-83-90	29.59	37	31	35	5	-	41	36	GW	140	
HQ-83-90	31.59	43	37	42	5	-	42	37	SW	135	
MW-28	36.59								GM		Visual classification only.

Notes:

1. Highlighted cells represent samples that were removed as outliers.
2. Friction angle, unit weight, and corrected blow count values were correlated using specified methodology in the WOOD Geotechnical SPM.
3. Not enough lab testing to generate representative design plasticity index values.
4. Fines content percentage highlighted is from lab testing.

ESU 2B - Native Sand and Gravel

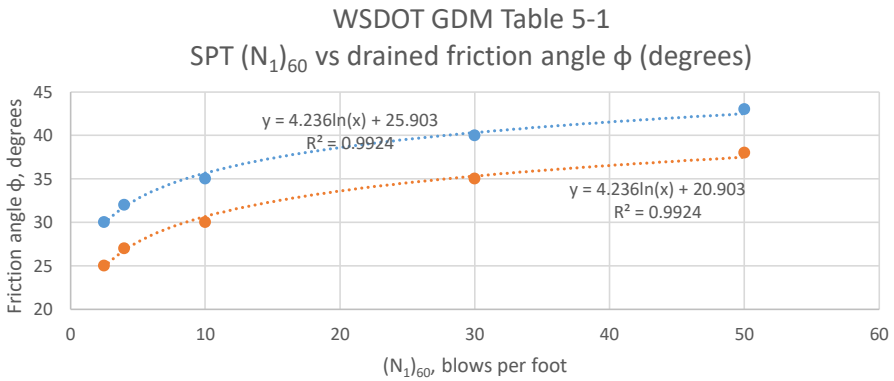
1. Check N160 COV is between 15 and 45%

Selected Design N160:	37
Coefficient of Variation (COV):	0.32

* 15 and 45% come from GEC 5 Sabatini (2002)

2. Check Phi' is between 2 to 13%

$(N_1)_{60}$ (blows per foot)	Friction angle ϕ (degrees)
2.5	25
2.5	30
4	27
4	32
10	30
10	35
30	35
30	40
50	38
50	43



* Phi' Developed from WSDOT Correlation
* 2 to 13% comes from GEC 5 Sabatini (2002)

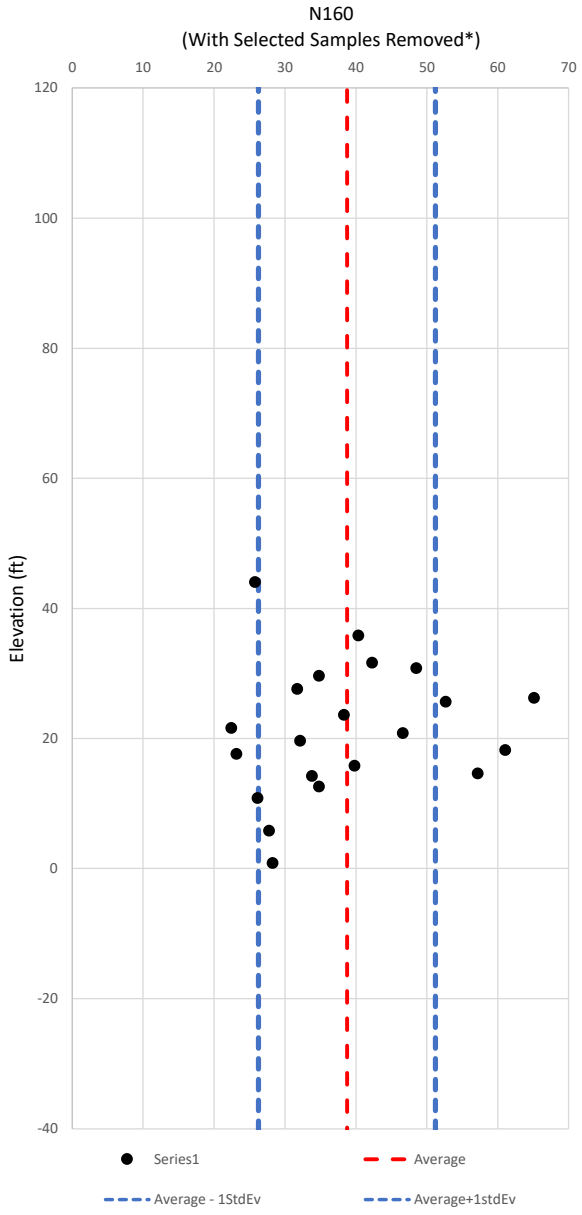
	ϕ (high)	ϕ (low)	ϕ (avg)	ϕ' COV	% Fines
GeoMean:	41	36	39	0.03	5

Selected Design Phi' (deg):	41
Notes on Selection:	The low fines content supports the use of the upper bound of the friction angle range.

Pick Representative USCS:	SM
Pick Representative Unit Weight:	135
Notes on Selection:	Individual sample unit weights were correlated using CALTRANS Geotechnical Manual (2014), verified with applicable ranges presented in Codotu (2001), as specified in WOOD SPM. The geometric mean of the unit weights was rounded to the nearest 5pcf, as specified in WOOD SPM. Data set COV was 6%.

*Using Predominant USCS Classification

ESU 2B - Native Sand and Gravel



*See sample table for explanation for removing specified samples

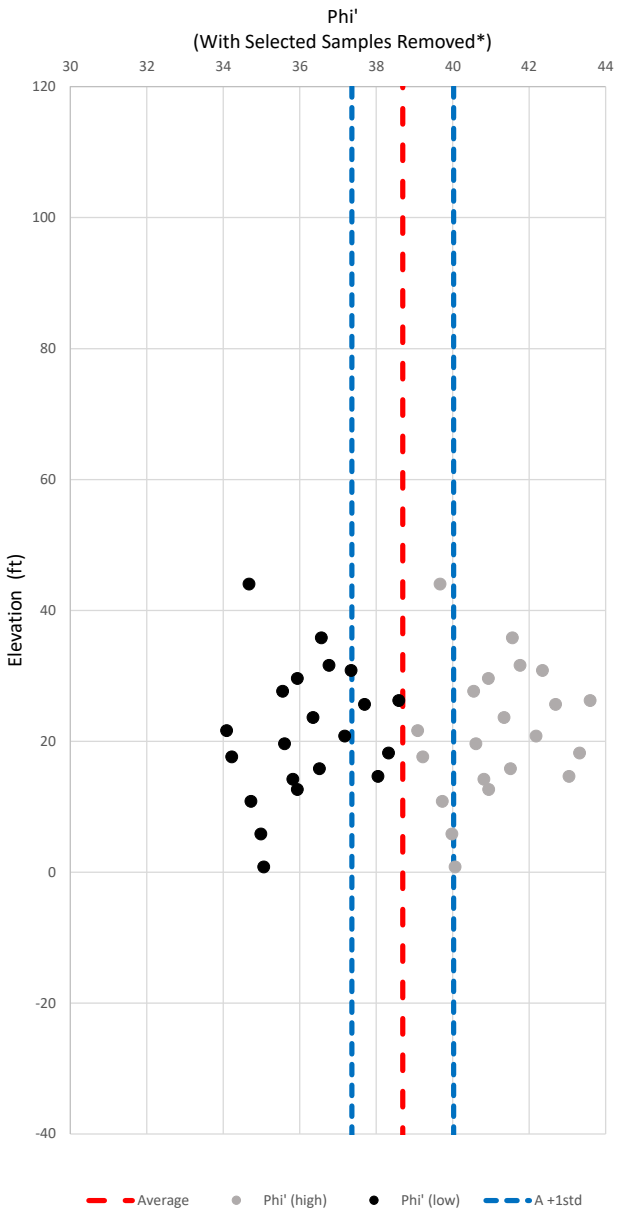


Figure C.1-17

	ESU Name:	ESU 2C - Native Silt							
		N	N_{60}	$(N_1)_{60}$	%F (Lab)	PI (Lab)	ϕ' (high) (deg)	ϕ' (low) (deg)	Sat. Unit Weight
	GeoMean:	5	6	9	63	-	34	29	110
	Average:	5	6	9	63	-	34	29	110
	St. Dev.:	0.0	0.0	0.7	0.0	-	0.2	0.2	0.0
	COV:	0.00	0.00	0.09	0.00	-	0.01	0.01	0.00

Boring	Elevation	N	N_{60}	$(N_1)_{60}$	%F (Lab)	PI (Lab)	ϕ' (high) (deg)	ϕ' (low) (deg)	USCS	Sat. Unit Weight	Explanation for Sample Removal
W-134-20	55.7	5	6	8	63	-	33	28	ML	110	
W-134-20	57.2	5	6	9	63	NP	34	29	ML	110	

Notes:
1. Highlighted cells represent samples that were removed as outliers.
2. Friction angle, unit weight, and corrected blow count values were correlated using specified methodology in the WOOD Geotechnical SPM.
3. Not enough lab testing to generate representative design plasticity index values.
4. Fines content percentage highlighted is from lab testing.

ESU 2C - Native Silt

1. Check N160 COV is between 15 and 45%

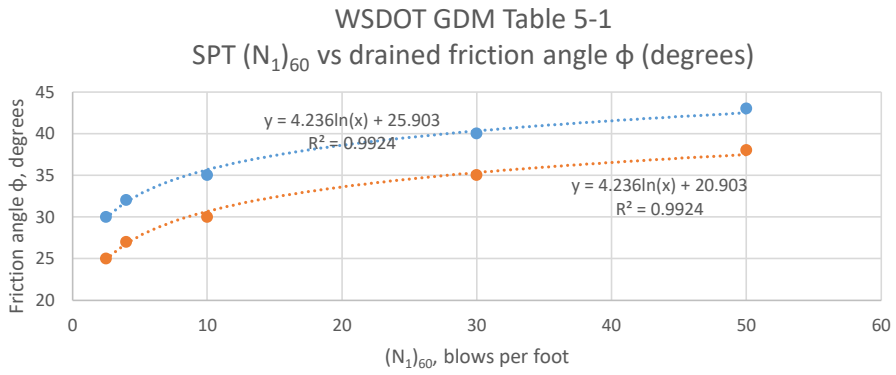
Selected Design N160:	9
Coefficient of Variation (COV):	0.09

* 15 and 45% come from GEC 5 Sabatini (2002)

2. Check Phi' is between 2 to 13%

$(N_1)_{60}$ (blows per foot)	Friction angle ϕ (degrees)
2.5	25
2.5	30
4	27
4	32
10	30
10	35
30	35
30	40
50	38
50	43

* Phi' Developed from WSDOT Correlation
* 2 to 13% comes from GEC 5 Sabatini (2002)

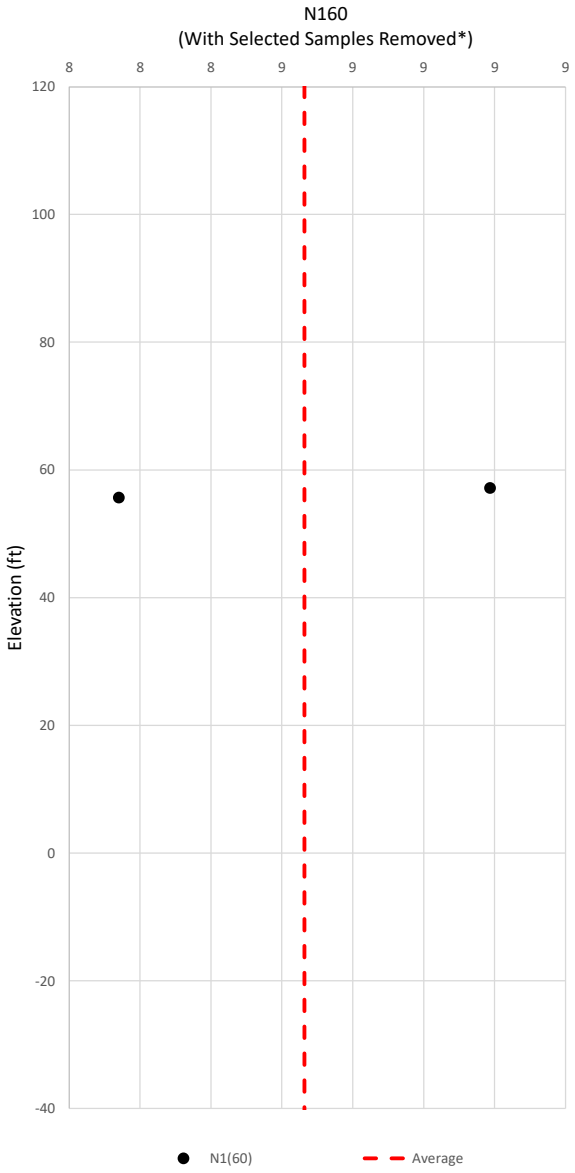


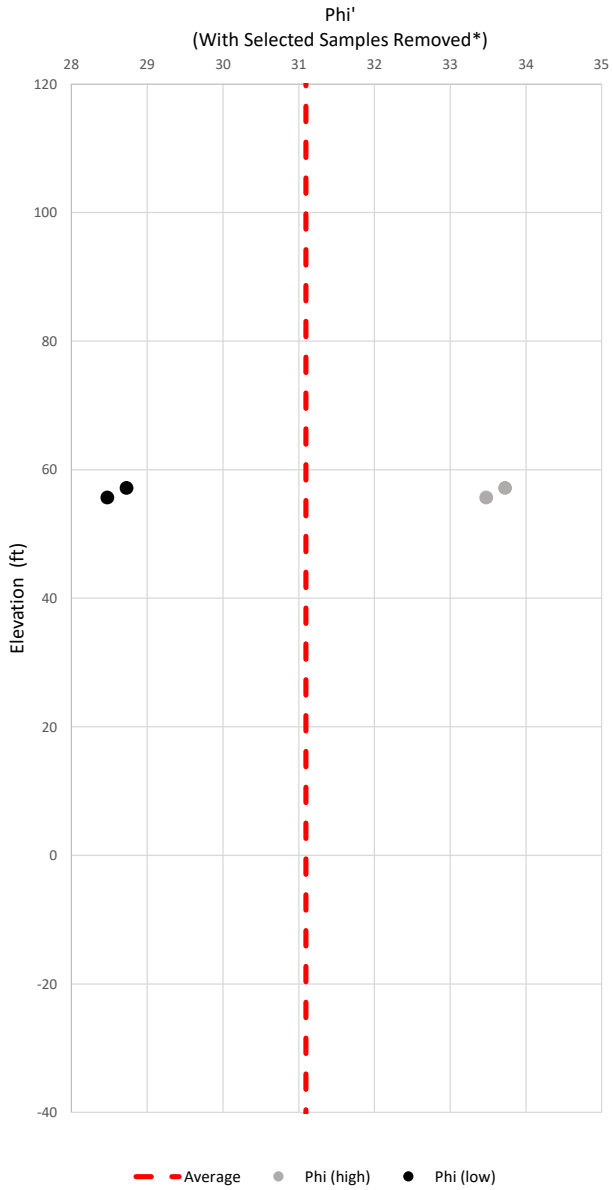
	ϕ (high)	ϕ (low)	ϕ (avg)	ϕ' COV	% Fines
GeoMean:	34	29	31	0.01	63

Selected Design Phi' (deg):	29
Notes on Selection:	The high fines content supports the use of the lower bound of the friction angle range.

Pick Representative USCS:	ML	*Using Predominant USCS Classification
Pick Representative Unit Weight:	110	
Notes on Selection:	Individual sample unit weights were correlated using CALTRANS Geotechnical Manual (2014), verified with applicable ranges presented in Codotu (2001), as specified in WOOD SPM. The geometric mean of the unit weights was rounded to the nearest 5pcf, as specified in WOOD SPM. Data set COV was 0%.	

ESU 2C - Native Silt





*See sample table for explanation for removing specified samples

Figure C.1-20

	ESU Name:	ESU 7A - Weathered Sandstone							
		N	N_{60}	$(N_1)_{60}$	%F (Lab)	PI (Lab)	Φ' (high) (deg)	Φ' (low) (deg)	Sat. Unit Weight
	GeoMean:	59	61	50	14	-	42	37	135
	Average:	64	65	53	23	-	42	37	135
	St. Dev.:	24	23	17	21	-	1.0	1.0	7.6
	COV:	0.38	0.36	0.31	0.89	-	0.02	0.03	0.06

Boring	Elevation	N	N_{60}	$(N_1)_{60}$	%F (Lab)	PI (Lab)	Φ' (high) (deg)	Φ' (low) (deg)	USCS	Sat. Unit Weight	Explanation for Sample Removal
HE-8-90	35.09								SM(SS)		Refusal blowcount.
R2B-03-17	41.1	62	91	70	30	-	44	39	SS	135	
HQ-15-89	32.99								Conglomerate		Core
HQ-15-89	27.99								Conglomerate		Core
HQ-15-89	22.99								Siltstone		Core
HQ-15-89	17.99								Conglomerate		Core
HQ-15-89	12.99								SM(SS)		Core
HQ-15-89	7.99								SM(SS)		Core
HQ-83-90	10.59								SM(SS)		Core
HQ-83-90	6.59								SM(SS)		Refusal blowcount.
HQ-83-90	6.09								SM(SS)		Core
HQ-83-90	1.59								SM(SS)		Refusal blowcount.
HQ-83-90	1.09								SM(SS)		Core
HQ-83-90	-3.41								SM(SS)		Core
HE-9-90	29.19								SM(SS)		Refusal blowcount.
HQ-106-89	54.39	43	41	36	21	-	41	36	SM	120	
TH-3	30.39								SS		Poor quality sample, use HE-9-90.
H-6	81.49	69	66	63	27	-	43	38	SM	130	
H-6	76.49								SM		Refusal blowcount.
H-6	71.49								SM		Refusal blowcount.
H-6	66.49								SM		Refusal blowcount.
H-6	61.49								SM		Refusal blowcount.
H-6	56.49								SM(SS)		Refusal blowcount.
HE-7-90	37.59								SM		Beneath existing embankment.
HE-11-90	29.49								SM		Beneath existing embankment.
HQ-12-89	84.29								SM		Refusal blowcount.
HQ-12-89	79.29								SM		Refusal blowcount.
HQ-12-89	74.29	65	65	54	30	-	43	38	SM(SS)	135	
HQ-12-89	69.29								SM(SS)		Core
HQ-12-89	64.29								SM(SS)		Core
HQ-12-89	59.29								SM(SS)		Core
HQ-12-89	54.29								SM(SS)		Core
HQ-12-89	49.29								SM(SS)		Core
HQ-12-89	44.29								SM(SS)		Core
HQ-12-89	39.29								SM(SS)		Core
HQ-12-89	34.29								SM(SS)		Core
HQ-12-89	29.29								SM(SS)		Core
HQ-12-89	24.29								SM(SS)		Core
HQ-13-89	64.09								SM		Refusal blowcount.
HQ-13-89	59.09								GM		Refusal blowcount.
HQ-13-89	54.09	82	82	67	70	-	44	39	ML	130	
HQ-13-89	49.09	69	69	55	70	-	43	38	ML	130	
HQ-13-89	44.09								ML		Refusal blowcount.
HQ-13-89	39.09								SM(SS)		Refusal blowcount.
HQ-13-89	34.09								SM(SS)		Core
HQ-13-89	29.09								SM(SS)		Core
HQ-13-89	24.09								SM(SS)		Core
HQ-13-89	19.09								SM(SS)		Core
HQ-13-89	14.09								SM(SS)		Core
HQ-14-89	58.29	45	45	39	22	-	41	36	SM	125	
HQ-14-89	53.29								SP		Core
HQ-14-89	48.29								ML		Core
HQ-14-89	43.29								GP-GM		Core
HQ-14-89	38.29								GP-GM		Core
HQ-14-89	33.29								GP-GM		Refusal blowcount.
HQ-14-89	28.29								GP-GM		Refusal blowcount.
HQ-14-89	23.29								GW/GM		Refusal blowcount.
HQ-18-89	34.59								SS		Beneath existing embankment.
HQ-18-89	29.59								SS		Beneath existing embankment.
HQ-18-89	24.59								SS		Beneath existing embankment.
HQ-18-89	19.59								SS		Beneath existing embankment.
HQ-18-89	14.59								SS		Beneath existing embankment.
HQ-18-89	9.59								SS		Beneath existing embankment.
HQ-18-89	4.59								SS		Beneath existing embankment.
HQ-13B-89	64.09	23	23	19	31	-	38	33	SM	115	
HQ-81-90	9.19	76	76	60	30	-	43	38	SM	130	
HQ-81-90	3.19								SS		Refusal blowcount.
HQ-81-90	-1.81	98	98	72	-	-	44	39	SS	135	
HQ-81-90	-6.81								SS		Refusal blowcount.
HQ-20-89	-4.21	53	53	43	4	-	42	37	GP	135	
HQ-20-89	-9.21	84	84	68	5	-	44	39	GW	150	
HQ-20-89	-14.21	44	44	32	5	-	41	36	GW	140	
HQ-20-89	-19.21	52	52	38	4	-	41	36	GW	145	
HQ-20-89	-24.21	102	100	76	5	-	44	39	GW	150	
HQ-20-89	-29.21	104	100	74	4	-	44	39	GW	150	
HQ-20-89	-34.21	74	74	54	3	-	43	38	GW	150	
MW-28	-26.41								SM(SS)	135	Visual classification only.
MW-28	-28.41								SM(SS)	135	Visual classification only.
MW-28	-45.41								SM(SS)	135	Visual classification only.
D-11-89	39.49								SSTN	135	Core
D-11-89	34.99								SSTN	135	Core
D-11-89	29.99								SSTN	135	Core
D-11-89	24.99								SSTN	135	Core
D-11-89	19.99								SSTN	135	Core
D-11-89	14.99								SSTN	135	Core
D-11-89	9.99								SSTN	135	Core
W-134-20	50.7	37	47	50	29	-	43	38	SM	130	
W-134-20	45.7	27	34	34	32	-	40	35	SM	120	

Notes:
1. Highlighted cells represent samples that were removed as outliers.
2. Friction angle, unit weight, and corrected blow count values were correlated using specified methodology in the WOOD Geotechnical SPM.
3. Not enough lab testing to generate representative design plasticity index values.
4. Fines content percentage highlighted is from lab testing.

Figure C.1-21

ESU 7A - Weathered Sandstone

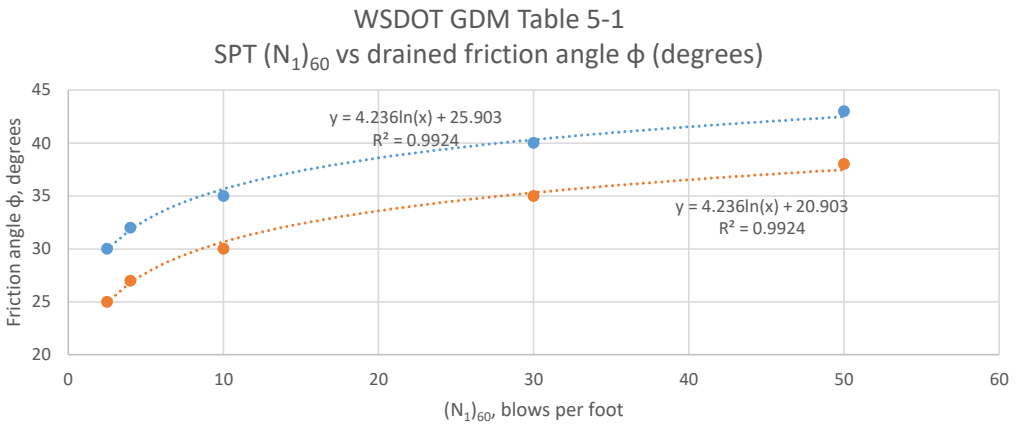
1. Check N160 COV is between 15 and 45%

Selected Design N160:	50
Coefficient of Variation (COV):	0.31

* 15 and 45% come from GEC 5 Sabatini (2002)

2. Check Phi' is between 2 to 13%

$(N_1)_{60}$ (blows per foot)	Friction angle ϕ (degrees)
2.5	25
2.5	30
4	27
4	32
10	30
10	35
30	35
30	40
50	38
50	43



* Phi' Developed from WSDOT Correlation

* 2 to 13% comes from GEC 5 Sabatini (2002)

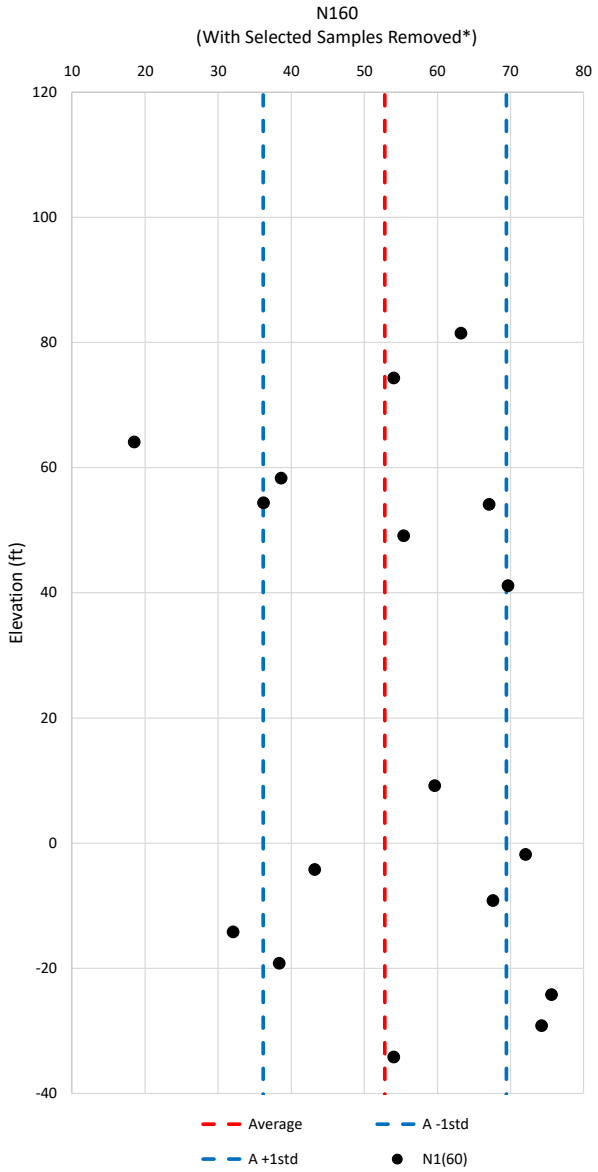
	ϕ (high)	ϕ (low)	ϕ (avg)	ϕ' COV	% Fines
GeoMean:	42	37	40	0.03	14

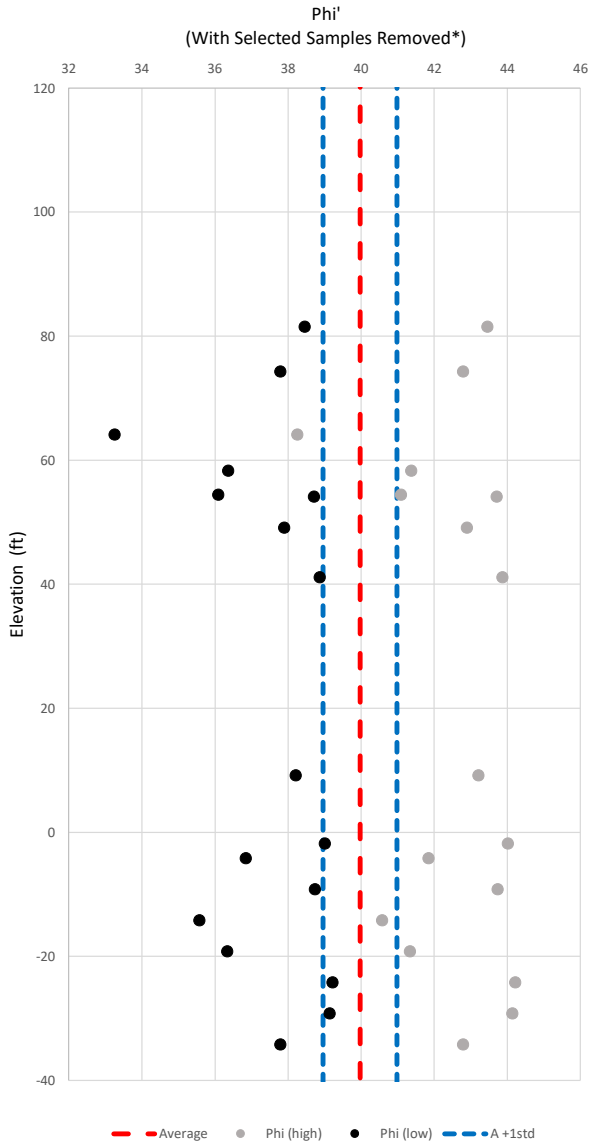
Selected Design Phi' (deg):	42
Notes on Selection:	The soil is weathered sandstone, this supports the use of the upper bound friction angle.

Pick Representative USCS:	SM(SS)	*Using Predominant USCS Classification
Pick Representative Unit Weight:	135	
Notes on Selection:	Individual sample unit weights were correlated using CALTRANS Geotechnical Manual (2014), verified with applicable ranges presented in Codotu (2001), as specified in WOOD SPM. The geometric mean of the unit weights was rounded to the nearest 5pcf, as specified in WOOD SPM. Data set COV was 6%.	

Figure C.1-22

ESU 7A - Weathered Sandstone





*See sample table for explanation for removing specified samples

Figure C.1-23

Appendix C.2
Site Class Designation

Seismic Site Class Summary Bridges 17.7, Walls 03.63L, 03.65L, and 03.66L			
Boring	Navg	Calculated Site Class	Site Class
R2B-03-17	51	C	C
HQ-12-89	81	C	C
HQ-13-89	77	C	C
HQ-14-89	62	C	C
HQ-18-89	100	C	C
HE-7-90	38	D	D
TH-3	26	D	D
HE-9-90	66	C	C
HE-11-90	62	C	C
HE-10-90	62	C	C
HQ-106-89	46	D	D
HQ-13B-89	24	D	D
H-6	91	C	C
W-134-20	29	D	D

Boring Designation: **R2B-03-17**

Depth (feet)	Field N-value	Hammer Energy (%)	Energy Corrected N-value N_i	Layer thickness d_i (feet)	d_i/N_i	Notes
		88%			End of Data	Above proposed footing depth
		88%			End of Data	Above proposed footing depth
		88%			End of Data	Above proposed footing depth
		88%			End of Data	Above proposed footing depth
		88%			End of Data	Above proposed footing depth
19	**21**	88%	31	12	0.39	
24	**18**	88%	27	5	0.19	
29	**12**	88%	18	5	0.28	
34	**17**	88%	25	5	0.20	
39	**34**	88%	50	5	0.10	
44	**36**	88%	53	5	0.09	Clay (CL-ML) with PI = 6
49	**62**	88%	91	63	0.69	End of boring at 50.5'. Bail/Recharge test done after
		88%			End of Data	R2B-03-17 assume water table is consistent with area, not as indicated in log, so no liquefaction.
		88%			End of Data	
		88%			End of Data	
		88%			End of Data	
		88%			End of Data	
		88%			End of Data	
		88%			End of Data	
		88%			End of Data	
		88%			End of Data	
		88%			End of Data	
		88%			End of Data	
		88%			End of Data	
		88%			End of Data	
		88%			End of Data	
		88%			End of Data	
		88%			End of Data	

Sum	**100**	**1.94**
N_{ave}	**51.5**	
Calculated Site Class	**C**	
Site Class E (>10' Soft Clay)?		
Site Class F (>10' Peat)?		
Site Class F (>25' High PI Clay)?		
Site Class F (Liquefaction)?		

Boring Designation: **HQ-12-89**

Depth (feet)	Field N-value	Hammer Energy (%)	Energy Corrected N-value N_i	Layer thickness d_i (feet)	d_i/N_i	Notes
		60%			End of Data	Material subsequently removed after drilling
10	71	60%	71	7.5	0.11	
15	35	60%	35	5	0.14	
20	35	60%	35	5	0.14	
25	100	60%	100	5	0.05	
30	100	60%	100	5	0.05	
35	65	60%	65	3.25	0.05	
36.5	100	60%	100	27.5	0.28	Coring begins at 36.5'
90	100	60%	100	41.75	0.42	Coring ends at 90'
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
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		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	

Sum	**100**	**1.23**
N_{ave}	**81.0**	
Calculated Site Class	**C**	
Site Class E (>10' Soft Clay)?		
Site Class F (>10' Peat)?		
Site Class F (>25' High PI Clay)?		
Site Class F (Liquefaction)?		

Boring Designation: **HQ-13-89**

Depth (feet)	Field N-value	Hammer Energy (%)	Energy Corrected N-value N_i	Layer thickness d_i (feet)	d_i/N_i	Notes
		60%			End of Data	Material subsequently removed after drilling
		60%			End of Data	Material subsequently removed after drilling
		60%			End of Data	Material subsequently removed after drilling
20	**47**	60%	47	12.5	0.27	
25	**28**	60%	28	5	0.18	
30	**100**	60%	100	5	0.05	
35	**100**	60%	100	5	0.05	
40	**82**	60%	82	5	0.06	
45	**69**	60%	69	5	0.07	Coring begins at 41.5'
50	**100**	60%	100	5	0.05	
55	**100**	60%	100	15.5	0.16	
81	**100**	60%	100	42	0.42	Coring ends at 80' 8"
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
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		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	

Sum	**100**	**1.30**
N_{ave}	**76.7**	
Calculated Site Class	**C**	
Site Class E (>10' Soft Clay)?		
Site Class F (>10' Peat)?		
Site Class F (>25' High PI Clay)?		
Site Class F (Liquefaction)?		

Boring Designation: **HQ-14-89**

Depth (feet)	Field N-value	Hammer Energy (%)	Energy Corrected N-value N_i	Layer thickness d_i (feet)	d_i/N_i	Notes
		60%			End of Data	Material subsequently removed after drilling
		60%			End of Data	Material subsequently removed after drilling
		60%			End of Data	Above proposed footing depth
		60%			End of Data	Above proposed footing depth
25	**25**	60%	25	15	0.60	
30	**45**	60%	45	12.5	0.28	
50	**100**	60%	100	12.5	0.13	
55	**100**	60%	100	5	0.05	
60	**100**	60%	100	5	0.05	
65	**100**	60%	100	50	0.50	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
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		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	

Sum	**100**	**1.60**
N_{ave}	**62.4**	
Calculated Site Class	**C**	
Site Class E (>10' Soft Clay)?		
Site Class F (>10' Peat)?		
Site Class F (>25' High PI Clay)?		
Site Class F (Liquefaction)?		

Boring Designation: **HQ-18-89**

Depth (feet)	Field N-value	Hammer Energy (%)	Energy Corrected N-value N_i	Layer thickness d_i (feet)	d_i/N_i	Notes
		60%			End of Data	Material subsequently removed after drilling
		60%			End of Data	Material subsequently removed after drilling
		60%			End of Data	Material subsequently removed after drilling
20	**100**	60%	100	100	1.00	Sandstone the rest of the way down
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
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		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	

Sum	**100**	**1.00**
N_{ave}	**100.0**	
Calculated Site Class	**C**	
Site Class E (>10' Soft Clay)?		
Site Class F (>10' Peat)?		
Site Class F (>25' High PI Clay)?		
Site Class F (Liquefaction)?		

Boring Designation: **HE-7-90**

Depth (feet)	Field N-value	Hammer Energy (%)	Energy Corrected N-value N_i	Layer thickness d_i (feet)	d_i/N_i	Notes
		60%			End of Data	Material subsequently removed after drilling
		60%			End of Data	Material subsequently removed after drilling
8	**25**	60%	25	6.5	0.26	
13	**20**	60%	20	5	0.25	
18	**42**	60%	42	88.5	2.11	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
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		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	

Sum	**100**	**2.62**
N_{ave}	**38.2**	
Calculated Site Class	**D**	
Site Class E (>10' Soft Clay)?		
Site Class F (>10' Peat)?		
Site Class F (>25' High PI Clay)?		
Site Class F (Liquefaction)?		

Boring Designation: **TH-3**

Depth (feet)	Field N-value	Hammer Energy (%)	Energy Corrected N-value N_i	Layer thickness d_i (feet)	d_i/N_i	Notes
5	**4**	**60%**	4	10	2.50	
15	**17**	60%	17	8	0.47	
21	**110**	60%	100	82	0.82	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
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		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	

Sum	**100**	**3.79**
N_{ave}	**26.4**	
Calculated Site Class	**D**	
Site Class E (>10' Soft Clay)?		
Site Class F (>10' Peat)?		
Site Class F (>25' High PI Clay)?		
Site Class F (Liquefaction)?		

Boring Designation: **HE-9-90**

Depth (feet)	Field N-value	Hammer Energy (%)	Energy Corrected N-value N_i	Layer thickness d_i (feet)	d_i/N_i	Notes
		60%			End of Data	Material subsequently removed after drilling
		60%			End of Data	Material subsequently removed after drilling
12	**31**	60%	31	8.5	0.27	
17	**13**	60%	13	5	0.38	
22	**100**	60%	100	86.5	0.87	Sandstone
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
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		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	

Sum	**100**	**1.52**
N_{ave}	**65.6**	
Calculated Site Class	**C**	
Site Class E (>10' Soft Clay)?		
Site Class F (>10' Peat)?		
Site Class F (>25' High PI Clay)?		
Site Class F (Liquefaction)?		

Boring Designation: **HE-11-90**

Depth (feet)	Field N-value	Hammer Energy (%)	Energy Corrected N-value N_i	Layer thickness d_i (feet)	d_i/N_i	Notes
		60%			End of Data	Material subsequently removed after drilling
12	**14**	60%	14	8.5	0.61	
17	**37**	60%	37	5	0.14	
22	**100**	60%	100	86.5	0.87	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
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		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	

Sum	**100**	**1.61**
N_{ave}	**62.2**	
Calculated Site Class	**C**	
Site Class E (>10' Soft Clay)?		
Site Class F (>10' Peat)?		
Site Class F (>25' High PI Clay)?		
Site Class F (Liquefaction)?		

Boring Designation: **HE-10-90**

Depth (feet)	Field N-value	Hammer Energy (%)	Energy Corrected N-value N_i	Layer thickness d_i (feet)	d_i/N_i	Notes
		60%			End of Data	Material subsequently removed after drilling
7	**11**	60%	11	6	0.55	
12	**65**	60%	65	5	0.08	
17	**90**	60%	90	89	0.99	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
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		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	

Sum	**100**	**1.61**
N_{ave}	**62.1**	
Calculated Site Class	**C**	
Site Class E (>10' Soft Clay)?		
Site Class F (>10' Peat)?		
Site Class F (>25' High PI Clay)?		
Site Class F (Liquefaction)?		

Boring Designation: **HQ-106-89**

Depth (feet)	Field N-value	Hammer Energy (%)	Energy Corrected N-value N_i	Layer thickness d_i (feet)	d_i/N_i	Notes
		60%			End of Data	Material subsequently removed after drilling
		60%			End of Data	Material subsequently removed after drilling
		60%			End of Data	Material subsequently removed after drilling
20	**100**	60%	100	12.5	0.13	
25	**43**	60%	43	87.5	2.03	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
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		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	

Sum	**100**	**2.16**
N_{ave}	**46.3**	
Calculated Site Class	**D**	
Site Class E (>10' Soft Clay)?		
Site Class F (>10' Peat)?		
Site Class F (>25' High PI Clay)?		
Site Class F (Liquefaction)?		

Boring Designation: **HQ-13B-89**

Depth (feet)	Field N-value	Hammer Energy (%)	Energy Corrected N-value N_i	Layer thickness d_i (feet)	d_i/N_i	Notes
		60%			End of Data	Material subsequently removed after drilling
		60%			End of Data	Material subsequently removed after drilling
13	**34**	60%	34	9	0.26	
18	**31**	60%	31	5	0.16	
23	**24**	60%	24	6	0.25	
30	**23**	60%	23	80	3.48	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	

Sum	**100**	**4.15**
N_{ave}	**24.1**	
Calculated Site Class	**D**	
Site Class E (>10' Soft Clay)?		
Site Class F (>10' Peat)?		
Site Class F (>25' High PI Clay)?		
Site Class F (Liquefaction)?		

Boring Designation: **H-6**

Depth (feet)	Field N-value	Hammer Energy (%)	Energy Corrected N-value N_i	Layer thickness d_i (feet)	d_i/N_i	Notes
		60%			End of Data	Material subsequently removed after drilling
		60%			End of Data	Material subsequently removed after drilling
		60%			End of Data	Material subsequently removed after drilling
15	**58**	60%	58	10	0.17	
20	**69**	60%	69	5	0.07	
25	**100**	60%	100	5	0.05	
30	**100**	60%	100	5	0.05	
35	**100**	60%	100	5	0.05	
40	**100**	60%	100	5	0.05	
45	**100**	60%	100	65	0.65	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	
		60%			End of Data	

Sum	**100**	**1.09**
N_{ave}	**91.3**	
Calculated Site Class	**C**	
Site Class E (>10' Soft Clay)?		
Site Class F (>10' Peat)?		
Site Class F (>25' High PI Clay)?		
Site Class F (Liquefaction)?		

Boring Designation: **W-134-20**

Depth (feet)	Field N-value	Hammer Energy (%)	Energy Corrected N-value N_i	Layer thickness d_i (feet)	d_i/N_i	Notes
2.5	**11**	**88%**	16	3.75	0.23	
5	**10**	88%	15	2.5	0.17	
7.5	**5**	88%	7	2.5	0.34	
10	**5**	88%	7	3.75	0.51	
15	**37**	88%	55	5	0.09	
20	**27**	88%	40	82.5	2.07	End at 21.5' below ground surface
		88%			End of Data	
		88%			End of Data	
		88%			End of Data	
		88%			End of Data	
		88%			End of Data	
		88%			End of Data	
		88%			End of Data	
		88%			End of Data	
		88%			End of Data	
		88%			End of Data	
		88%			End of Data	
		88%			End of Data	
		88%			End of Data	
		88%			End of Data	
		88%			End of Data	
		88%			End of Data	
		88%			End of Data	
		88%			End of Data	
		88%			End of Data	
		88%			End of Data	

Sum	**100**	**3.42**
N_{ave}	**29.3**	
Calculated Site Class	**D**	
Site Class E (>10' Soft Clay)?		
Site Class F (>10' Peat)?		
Site Class F (>25' High PI Clay)?		
Site Class F (>25' High PI Clay)?		

In Association with

Appendix D
Bridge 17.7 and Wall 03.63L Calculations

APPENDIX D – Bridge 17.7 and Wall 03.63L Calculation Package

This appendix presents the detailed geotechnical calculations for Bridge 17.7 and Wall 03.63L including:

- Engineering Stratigraphic Unit (ESU) Soil Properties
- Global Stability
- Compound Stability
- Internal Stability
- Soil Nail Evaluations
- Bearing Resistance
- Settlement
- Lateral Earth Pressure and Sliding
- Slope Stability
- Seismic Springs
- Wall Lateral Deflections

Cross-sections depicting subsurface conditions for Bridge 17.7 and Wall 03.63L can be found in Appendix C and are also contained within the slope stability models in Appendix D.4 and D.5. Design properties of the existing Hilfiker Wall 03.63L were selected based on the existing design drawings provided by Hilfiker dated September 1990 (Wall 6). Relevant pages of these design drawings are attached in Appendix D.1 with markups pertinent to understanding our analyses. Locations of selected design sections are presented on Figure 3 of this report.

Bridge 17.7 is supported mid-span by an existing spread footing, Pier 2. An existing secant pile wall exists at Bridge 17.7 Pier 3, and a Cast-In-Place (CIP) wall is between traffic lanes and Pier 3. The historical plan sheets for the existing Pier 2, Pier 3, and the CIP wall in front of Pier 3 are dated between September and October 1990 with some sheets having as-built markups dated July 2, 1997. These historical plan sheets are presented in Appendix D.2.

1.0 ESU Properties

The selected ESU properties and selection process details for the properties for Bridge 17.7 and Wall 03.63L are presented and described in Appendix C.

2.0 Seismic Design Parameters

The design functional evaluation earthquake (FEE) and safety evaluation earthquake (SEE) response spectra for Seismic Site Class C and D at Bridge 17.7 use the probabilistic seismic hazard analysis (PSHA) results available at Bridge 18W. The design FEE and SEE response spectra for Seismic Site Class C and D at Bridge 18W were developed and provided by Hart Crowser and is included in the following report:

- "I-405 R2B Segment 1a Site Specific Hazard Analysis" dated March 25, 2021 (Submittal 1197) by Hart Crowser.

These analyses were completed in accordance with the Project Geotechnical Design Manual (Project GDM). The ground motion parameters for design are based on the projected ground motion at the project site that has either a 30 percent (FEE) or 7 percent (SEE) probability of exceedance in a 75-year period (approximate 210- and 975-year return periods). Further details about the determination of the seismic parameters are included in the above referenced report.

We used the recommended the SEE response spectra peak ground acceleration (PGA) and Mean Magnitude (Mw) in our analyses.

3.0 Bridge 17.7 Pier 1 and Wall 03.63L Design Analyses

To accommodate widening southbound Interstate 405 (I-405) under the existing Bridge 17.7, portions of the existing Hilfiker wall (Wall 03.63L) approach embankment along with portions of the existing Bridge 17.7 Pier 1 stem wall need to be removed and/or replaced. A new Pier 1 bridge footing will be constructed with a bottom of footing elevation of 66.5 feet, resting on top

of a portion of the existing Hilfiker wall. The existing Hilfiker wall is not internally stable with the addition of the anticipated new Pier 1 bridge footing loads. Therefore, a new permanent soil nail wall will be drilled through the face of the existing Hilfiker wall (Wall 03.63L) that will remain beneath the new Pier 1 footing location. The soil nail wall will extend laterally to cover the proposed Pier 1 footing's zone of influence.

The construction sequence for the new western bridge abutment is generally as follows:

1) Install a temporary lateral restraint at Pier 3 on the east side of I-405 to resist the temporarily unbalanced earth pressure loading condition that will be created when the earthen embankment behind the existing Pier 1 abutment wall is removed.
2) Remove portions of the existing earthen embankment (Hilfiker Wall that also creates Wall 03.63L) behind the existing Pier 1 abutment wall.
3) Install soil nails through the face of the existing Wall 03.63L that remains below the proposed new Pier 1 footing elevation.
4) Construct the new Pier 1 bridge footing and stem wall to the west of the existing Pier 1 stem wall.
5) Extend the bridge girders that had spanned between the existing Pier 2 and the existing Pier 1 so that they span between the existing Pier 2 and the proposed Pier 1 (a longer span).
6) Backfill behind the new Pier 1 stem wall with a Hilfiker Wall, which also reconstructs any necessary portions of Wall 03.63L that were removed to facilitate construction of the new Pier 1 footing.
7) Demolish the existing Pier 1 stem wall down to below I-405 roadway elevation.
8) Decommission the temporary lateral restraint at Pier 3 on the east side of I-405.

Due to the depth of the existing Pier 1 footing, a portion of the existing Pier 1 stem wall and the entire existing Pier 1 footing will remain buried in place. To install the new Pier 1 footing, the existing approach embankment will be removed using an open cut slope excavation technique. The portions of the existing Hilfiker wall which are below this cut slope will be preserved in their current condition and will remain in place.

Figure 3 shows the location of each design section that we used to evaluate conditions for the construction of the new Pier 1 and subsequent portions of Wall 03.63L. Section Ea-Ea' represents the tallest portion of the existing Hilfiker wall and is right in front of the toe of the new Pier 1 footing, which places it under the widened portion of I-405 pavement in the final condition. Section Fa-Fa' is cut through the stem wall of the new Pier 1 footing and Section Ga-Ga' is cut right behind the proposed Pier 1 footing. Finally, Section Ha-Ha' represents a portion of Wall 03.63L within the excavation slope cut of the existing Hilfiker wall. In the final condition, Section Ha-Ha' represents a section of Wall 03.63L that is partially existing Hilfiker wall (lower portion) and partially new Hilfiker wall (upper portion). See Figure 4 and the mark up presented in Appendix D.1 for clarity on the construction sequence at each critical cross-section.

3.1 Pier 1/Wall 03.63L Wave Scattering Evaluations

Per the National Cooperative Highway Research Program (NCHRP) Report 611 the PGA can be adjusted to account for variations in the average ground acceleration behind retaining walls and/or slopes greater than 20 feet in height by applying a scaling factor (or alpha value) to the PGA. The normalized SEE spectral shape developed by Hart Crowser falls in the mid-spectral shape range because the PSHA results typically peak at about 0.3 second (NCHRP Figure 5-4). Using the mid-spectral shape curve, the PGA was scaled for qualifying wall and slope heights. We did not apply wave scattering effects to calculate seismic lateral earth pressure analyses. For global and compound pseudo-static analyses, wave scatter was based on the height of the failure surface mobilized in the design seismic event. Wave scatter reductions were not applied for heights less than or equal to 20 feet.

Calculations of these corrected PGAs are presented in Appendix D.3 and the results are presented in Table D-1.

Table D-1: Wave Scattering Scaling Factors and Corrected PGAs

Wall Section/Structure	Seismic Analysis	Condition	Design Height (ft.)	Scaling Factor α	Corrected PGA (SEE)	Kh (g)
Bridge 17.7 Pier 1 – Longitudinal Section D-D'	Global Stability	Final	62	0.672	0.343	0.171
Wall 03.63L Section Ea-Ea'	Global Stability	Existing	66	0.661	0.337	0.169
	Compound Stability	Existing	54	0.698	0.356	0.178
	Global Stability	Final	30.6	0.799	0.407	0.204
Wall 03.63L/Pier 1 Section Fa-Fa'	Global Stability	Existing	63	0.669	0.341	0.171
	Compound Stability	Existing	51.5	0.707	0.361	0.18
	Global Stability	Final	60	0.678	0.346	0.173
	Compound Stability	Final	16.5	1.000 (N/A)	0.51 (Full PGA)	0.255
Wall 03.63L Section Ga-Ga'	Global Stability	Existing	60	0.678	0.346	0.173
	Compound Stability	Existing	43	0.740	0.377	0.189
	Global Stability	Final	57.5	0.686	0.35	0.175
	Compound Stability	Final	27	0.818	0.417	0.209
Wall 03.63L Section Ha-Ha'	Global Stability	Existing	55	0.695	0.354	0.177
	Compound Stability	Existing	41	0.749	0.382	0.191
	Global Stability	Final	55	0.695	0.354	0.177
	Compound Stability	Final	10.75	1.000 (N/A)	0.51 (Full PGA)	0.255

Abbreviations:
SEE = safety evaluation earthquake

3.2 Pier 1/Wall 03.63L Global Stability Analysis

We performed global stability analyses for the following critical cross sections:

- Cross-section D-D' on Figure 3: Longitudinal Stability of Pier 1,
- Cross-section Ea-Ea' on Figure 3: Maximum height of existing Hilfiker wall,
- Cross-section Fa-Fa' on Figure 3: Transverse Stability of Wall 03.63L with proposed Pier 1 footing load,
- Cross-section Ga-Ga' on Figure 3: Transverse Stability of Wall 03.63L behind proposed Pier 1 footing, and
- Cross-section Ha-Ha' on Figure 3: Transverse Stability of Wall 03.63L where a portion of the wall will be excavated and then replaced with new Hilfiker wall.

We calculated the global stability factor of safety (FS) values for static conditions using the Spencer and Morgenstern-Price Method in SLOPE/W (Geo-Slope International 2021 version 11.01). We used static soil strength parameters for the static analysis. We modeled the structural earth (SE) Wall as a "High Strength" material (in the global stability analyses only) having a unit weight of 130 pounds per cubic foot (pcf) for Gravel Borrow backfill. We used design backfill properties within the suggested range in the Project GDM Table 5-2.

We used a horizontal seismic acceleration coefficient (k_h) to estimate seismic lateral earth pressures and evaluate pseudo-static global stability. For our analyses, k_h is reduced to 50 percent of A_s ($k_h = 0.5 * A_s$) for flexible wall displacements of 1- to 2-inches and reduced for the wall height-dependent seismic coefficient (wave scatter coefficient), **α** ($k_h = \boldsymbol{\alpha} * A_s$) for wave scattering effects. This horizontal acceleration was corrected by the wave scattering reduction factors presented in Table D-1, above.

For sections Ea-Ea', Fa-Fa', and Ga-Ga' the final condition contains a permanent soil nail wall below either the proposed Pier 1 footing or the new portions of the Hilfiker wall, as applicable. The existing Hilfiker wall reinforcements were modeled as described in Section 7.3 in this report and Section 3.3 in this appendix. The soil nails were modeled using the results of the SNAIL analysis described in Section 7.5 of this report and section 3.5 of this appendix. The top row of the soil nail wall is modeled in SlopeW as being 45 feet long, however the limiting soil nail design for the top row is actually 46 feet long, as described in Section 4.5 of this appendix.

A summary of global stability analysis results is presented in Table D-2. See Appendix D.4 for the global stability results figures (Figures D.4-1 through D.4-42) and the detailed input/output reports from Slope/W in Appendix D.4 after the results figures. Strap lengths and embedment depths were modeled based on existing Hilfiker design documents dated September 1990 (Wall 6), see Appendix D.1.

Table D-2: Global Slope Stability Results – Bridge 17.7 Pier 1 and Wall 03.63L

Wall	Section	Scenario	Loading Type	Minimum Required Factor of Safety	Calculated FS (Spencer/ Morgenstern & Price)	Minimum Required Strap Length/ Minimum Wall Embedment2
Pier 1	(D-D')	Final	Static	1.3	4.1 / 4.1	Not applicable
			Pseudo-Static	1.1	3.2 / 3.2	
Wall 03.63L Bridge 17.7	(Ea-Ea')	Existing	Static	1.3	2.4 / 2.4	34-feet / 1-foot
			Pseudo-Static	1.1	1.8 / 1.8	
		Final	Static	1.3	4.3 / 4.3	
			Pseudo-Static	1.1	2.0 / 2.0	
	(Fa-Fa')	Existing	Static	1.3	2.4 / 2.5	34-feet / 1-foot
			Pseudo-Static	1.1	1.8 / 1.8	
		Construction	Static	1.3	4.2 / 4.2	
		Final	Static	1.3	1.8 / 1.8	
			Pseudo-Static	1.1	1.5 / 1.5	

Wall	Section	Scenario	Loading Type	Minimum Required Factor of Safety	Calculated FS (Spencer/ Morgenstern & Price)	Minimum Required Strap Length/ Minimum Wall Embedment2
	(Ga-Ga')	Existing	Static	1.3	2.5 / 2.5	32-feet / 3-feet
			Pseudo-Static	1.1	1.8 / 1.8	
		Construction	Static	1.3	3.9 / 3.9	
		Final	Static	1.3	2.6 / 2.6	
			Pseudo-Static	1.1	1.9 / 1.9	
	(Ha-Ha')	Existing	Static	1.3	2.5 / 2.5	32-feet / 3-feet
			Pseudo-Static	1.1	1.8 / 1.8	
		Construction	Static	1.3	2.9 / 2.9	
		Final	Static	1.3	2.5 / 2.5	
			Pseudo-Static	1.1	1.8 / 1.8	

3.3 Pier 1/Wall 03.63L Compound Stability

We evaluated Wall 03.63L compound stability at each design section using the computer design software Slope/W (Geo Slope International, Ltd. 2020). Limit equilibrium analyses were performed following the procedures outlined in Project GDM Section 15-5.3.4. Factors of safety were determined using both Spencer's and Morgenstern-Price methods with entry and exit search limits for a circular failure surface.

We modeled the soil reinforcements as inextensible welded steel wire grid mats connected to cast in place concrete facing as shown in the design documents for the existing Hilfiker wall (Wall 6) dated September 1990 (Appendix D.1). Per Section A of the historical design documents, the welded wire mats consist of either W4.5xW3.5, W7.0xW3.5, or W9.5x4.0 each with 6-inch longitudinal bar spacing and 12-inch transverse bar spacing, see Appendix D.1. The pre-corrosion gross steel reinforcement wire diameter of the W4.5xW3.5, W7.0xW3.5, and W9.5x4.0 consisted of 0.239, 0.299, and 0.348 inches, respectively. Based on discussions with the Hilfiker design team, we understand galvanization was applied to the welded wire mats. We calculated the corrosion losses in the steel wires over the 30-year in-place life to date and also over the 75-year full design life of the existing welded wire mats using the prescribed steel corrosion rates presented in American Association of

State Highway and Transportation Officials (AASHTO) Load and Resistance Factor Design (LRFD) Section 11.10.6.4.2a and Federal Highway Association (FHWA) Geotechnical Engineering Circular No. 11 Tables 3-7 and 3-8.

For compound stability involving the portions of the Hilfiker Wall 03.63L that will be reconstructed, we modeled the reinforcement properties as equal to those of the existing Hilfiker wall reinforcements at a corrosion design life of 45 years. This matches the approximately 45 years of remaining design life of the existing Hilfiker wall reinforcement lower in the wall. We understand the new portion of the wall will not be an exact one-to-one replacement of the existing wall and that the design of the new upper portions of the wall will be an independent design. We also understand that the new wall will be designed to the current required corrosion rate and design life duration. The calculation provided here was used to verify compound stability and is based on the existing wall as originally designed exposed to corrosion for 45 years. For the final design, the wall designer should make certain that greater than or equal amounts of steel area used in this design remain at the end of the total new wall design life in order to satisfy compound stability.

We applied resistance factors presented in AASHTO LRFD Section 11.5 and FHWA Geotechnical Engineering Circular No. 11 Table 4-7 to calculate the pullout resistance and tensile capacity of the steel grid reinforcements at Wall 03.63L. We modeled the reinforced fill as Gravel Backfill for SE Walls. Using the thickness of the transverse bar and the transverse bar spacing we calculated the pullout resistance factor F* in accordance with AASHTO LRFD Section 11.10.6.3.2 and FHWA Geotechnical Engineering Circular No. 11 Section 3.4.2 equations 3-6 and 3-7. We used the pullout resistance to calculate an interface shear friction angle at each reinforcing grid, considering the grid wire size and spacing. The calculated tensile capacity and interface shear friction angles were input into Slope/W to model the reinforced zone.

We applied resistance factors presented in AASHTO LRFD Section 11.5 and FHWA Geotechnical Engineering Circular No. 11 Table 4-7 to calculate the pullout resistance and tensile capacity of the reinforcing welded wire grid.

Slope/W does not have a specific welded-wire grid reinforcement input option. Therefore, the tensile strength of the grids were modeled as continuous reinforcement. The calculated allowable tensile grid capacity was converted to a continuous reinforcement tensile capacity by distributing the capacity over the tributary width. The longitudinal wires are spaced every 6 inches, therefore two bars exist within each 1-foot representative width of grid.

For pseudo-static analyses, we used an apparent cohesion in the native soils above the groundwater table based on the fines content ranges presented in Table 11-2 of the FHWA Geotechnical Engineering Circular No. 3. We used the horizontal seismic coefficients, k_h, for compound stability presented in Table D-1 for the pseudo-static analyses.

Groundwater levels were modeled using a piezometric surface. The piezometric surface was based on measured or observed groundwater levels at Bridge 17.7 as discussed in Appendix C.

Per Project GDM Section 15-5.3.4 and AASHTO LRFD Table 3.4.1-1, a strength limit state load factor of 1.75 was applied to the standard traffic surcharge of 250 pounds per square foot (psf), resulting in a uniform traffic surcharge of 437.5 psf in the static compound stability analysis. Per AASHTO LRFD Section 3.4.1, an extreme limit state load factor of 0.5 was applied to the standard traffic surcharge of 250 psf, resulting in a uniform traffic surcharge of 125 psf for the seismic (pseudo-static and post-seismic) compound stability analyses.

Per Project GDM Sections 15-4.12 and 6-4.3.2, a static resistance factor of 0.75 (FS = 1.3) and seismic resistance factor of 0.9 (FS = 1.1) shall be used for compound stability. The required minimum static and pseudo-static FSs were met at each design section at Bridge 17.7 Pier 1 and Wall 03.63L.

When modeling the new Pier 1 footing, we modeled the factored footing load as a high strength material with a unit weight and thickness corresponding to the design footing load. We modeled the footing load with an upper limit of 9.0 kips per square foot (ksf) for both the static (Strength Limit State) and pseudo-static case (Extreme Limit State). The footing was modeled with a unit weight of 2,250 pcf and a thickness of four feet, which corresponds to a factored load of 9,000 pounds per square foot (psf). This factored foundation load does not include soil vertical load. The soil weight of the Hilfiker wall on top of the Pier 1 footing is taken into account by the soil unit modeled above the footing elevation.

Structural loads were not included in our analyses. Any structural foundation loads applied to the wall shall include the appropriate load factors in AASHTO LRFD Table 3.4.1-1 consistent with Strength Limit State and Extreme Event Limit State design.

The results of our compound stability analyses for Wall 03.63L are summarized in Table D-3. Compound stability models showing FS for critical failures at the design sections are provided in Appendix D.5. Compound stability Slope/W reports are also provided in Appendix D.5 after the Slope/W figures.

Table D-3: Compound Stability Results – Bridge 17.7 Pier 1 and Wall 03.63L

Wall	Section	Scenario	Loading Type	Minimum Required Factor of Safety	Calculated FS (Spencer/ Morgenstern & Price)	Minimum Required Strap Length/ Minimum Wall Embedment2
Wall 03.63L Bridge 17.7	(Ea-Ea')	Existing	Static	1.3	2.7 / 2.6	34-feet / 1-foot
			Pseudo-Static	1.1	2.0 / 2.0	
	(Fa-Fa')	Existing	Static	1.3	3.3 / 3.3	34-feet / 1-foot
			Pseudo-Static	1.1	2.1 / 2.1	
		Construction	Static	1.3	5.9 / 5.9	
		Final	Static	1.3	4.8 / 4.8	
			Pseudo-Static	1.1	2.3 / 2.3	
	(Ga-Ga')	Existing	Static	1.3	2.7 / 3.2	32-feet / 3-feet
			Pseudo-Static	1.1	2.2 / 2.2	
		Construction	Static	1.3	5.8 / 5.8	
		Final	Static	1.3	4.3 / 4.2	
			Pseudo-Static	1.1	2.3 / 2.3	
	(Ha-Ha')	Existing	Static	1.3	3.2 / 3.2	32-feet / 3-feet
			Pseudo-Static	1.1	2.2 / 2.2	

Wall	Section	Scenario	Loading Type	Minimum Required Factor of Safety	Calculated FS (Spencer/ Morgenstern & Price)	Minimum Required Strap Length/ Minimum Wall Embedment2
		Construction	Static	1.3	2.9 / 2.9	
		Final	Static	1.3	8.2 / 8.2	
			Pseudo-Static	1.1	2.4 / 2.5	

3.4 Wall 03.63L Internal Stability of Existing Wall

Internal stability was evaluated using the procedure outlined in Project GDM 15-5.3.10. We evaluated internal stability of the existing portion of Wall 03.63L that will not be replaced or converted into a soil nail wall (design section Ha-Ha') using the computer design software MSEW Version 3.0 (ADAMA Engineering 1998-2010). MSEW analyzes internal stability (connection strength, pullout, and internal sliding) and external stability (sliding and overturning) of SEWs using design guidelines from AASHTO 2007-2010. We analyzed bearing capacity using GeoEngineers internal spreadsheet, see Section 3.6 of this appendix. Internal stability output reports for the design software MSEW are presented in Appendix D.6.

Design section Ha-Ha' was selected as representative of the entire sloped cut excavation portion of Wall 03.63L. This portion of the wall consists of the existing Hilfiker wall that is to remain in place below the newly replaced portion of Wall 03.63L, which will also be a Hilfiker wall. For our design analyses, we assumed a 2H:1V (horizontal to vertical) slope cut that begins at the bottom and back (west side) of the proposed Pier 1 footing. It is likely that the bottom of this slope cut will be located further to the west in order to accommodate a work bench or platform, however it is more conservative to assume the slope cut starts behind the proposed footing without any extended portion of work bench because design cross-sections that are closer to the proposed Pier 1 footing yield taller sections of the existing wall to remain in place. Section Ha-Ha' was cut approximately halfway up the 2H:1V slope cut. We analyzed the internal stability of the existing wall considering the corrosion condition at 75 years life and the final condition shown on Section Ha-Ha'. The existing condition analysis is used to evaluate the wall portions that will not be removed, the final condition at section Ha-Ha' represents a mix of new (upper) and existing (lower) wall portions. Section Ga-Ga' (behind proposed pier 1) represents the tallest portion of new Hilfiker wall that will be constructed over the existing wall.

We calculated the corrosion loss over 75 years design life of the existing welded wire mats using steel corrosion rates presented in AASHTO LRFD Section 11.10.6.4.2a and FHWA Geotechnical Engineering Circular No. 11 Tables 3-7 and 3-8. The static analyses found that all portions of the existing Hilfiker wall were internally stable at Section Ha-Ha' with 75 years of corrosion losses considered. However, the seismic analyses found that portions of the existing Hilfiker wall were not internally stable at Section Ha-Ha' considering 75 years of corrosion losses. Those weaker portions of the existing wall are not located below the proposed Pier 1 footing elevation but rather within the upper reaches of wall 03.63L. Referring to the MSEW results for the existing condition included in Appendix D.6 (page 7), there are three welded-wire layers that do not meet the minimum capacity to demand ratios (CDR) for metal mat tensile strength (see layers 15, 16, and 17 with CDR ratios of 0.899, 0.917, and 0.956 respectively). Our proposed bottom of the new Pier 1 footing falls just above layer #9, which is lower in elevation, so for the majority of our work area these three weaker layers of welded-wire mats will be removed and replaced with new material designed to current seismic standards. The only areas where the three weaker layers will remain will be either 1) within the slope cut portion of the excavation where depths of cut are less than or equal to about 14 feet, or 2) within portions of the existing Hilfiker approach embankment that are outside of our construction area and will remain. All three of these layers have CDR ratios that reduce the actual factor of safety against tensile failure (which has a resistance factor of 0.85 for the seismic case per AASHTO Table 11.5.6-1) but do not reduce those factors of safety to a point below 1.0. The minimum CDR value of

0.899 calculates to a factor of safety of 1.057 (0.899 divided by 0.85) in the seismic case against tensile failure. Within these portions of the wall where the three weaker layers will remain, the proposed work will do no harm to the existing condition, and in all cases within the area of our construction influence, we will be improving the overall condition of the wall by replacing the upper layers of existing welded-wire mats with new welded-wire mats.

3.5 Wall 03.63L Soil Nail Wall

We used the design software SNAIL to evaluate the LRFD soil nail capacity of the soil nail retrofitted portion of Wall 03.63L. This is specific to the portions of wall 03.63L that will remain below the proposed new Pier 1 footing as those additional loads were predicting failure within the existing Hilfiker wall reinforcement. We varied the soil nail length and spacing to target a minimum Capacity Demand Ratio of 1.0. Using this process, we calculated the maximum allowable factored footing loads as 7,000 psf and 12,000 psf for the permanent static and seismic conditions, respectively. These loads include the weight of the soil of the new Hilfiker wall to be constructed above the footing.

We used a 6-inch-diameter drilled hole to calculate the design load transfer of each soil nail row. The design was completed for Grade 65 or higher deformed steel reinforcing rods, threaded at the proximal end (closest to the face). Minimum bar sizes and nail lengths are provided in Table D-4.

Nominal bond strengths were developed by referencing FHWA Geotechnical Engineering Circular No. 7 for rotary drilled soil nails based on the soil type and density/consistency for ESU 1B. Table 4-4a from FHWA is presented in Figure D-1 below. For ESU 1B we selected the nominal bond strength as 12.5 psi. Nominal bond strengths will be confirmed in the field during soil nail verification testing.

Table 4.4a: Estimated Bond Strength for Soil Nails in Coarse-Grained Soils (Modified after Elias and Juran 1991)

Drill-Hole Drilling Method	Soil Type	Bond Strength, q_u (psi)
Rotary Drilled	Sand/gravel	15 - 26
Rotary Drilled	Silty sand	15 - 22
Rotary Drilled	Silt	9 - 11
Rotary Drilled	Piedmont residual	6 - 17
Rotary Drilled	Fine Colluvium	11 - 22
Driven Casing	Sand/gravel w/low overburden (1)	28 - 35
Driven Casing	Sand/gravel w/high overburden (1)	41 - 62
Driven Casing	Dense Moraine	55 - 70
Driven Casing	Colluvium	15 - 26
Augered	Silty sand fill	3 - 6
Augered	Silty fine sand	8 - 13
Augered	Silty clayey sand	9 - 20

Note: (1) Low and high overburden are defined as effective overburden pressure being, respectively, less than and greater than 1.5 tsf.

Figure D-1: FHWA Geotechnical Engineering Circular No. 7 Table 4-4a

The Wall 03.63L soil nail layout analysis is presented in Table D-4. SNAIL reports are presented in Appendix D.7.

Table D-4. Wall 03.63L Soil Nail Layout

Soil Nail Row	Depth (feet)	Horizontal Spacing (feet)	Length (feet)	Declination (degrees)	Bar Size/ Grade	Nominal Design Load Transfer (lbs/ft)
1	2	4	46	10	#11/65	2,827
2	6	4	45	10	#11/65	2,827
3	10	4	40	10	#10/65	2,827
4	14	4	40	10	#10/65	2,827

Abbreviations:
lbs/ft = pounds per foot

Table D-5. Wall 03.63L Overall Stability CDR and Soil Nail Service Loads

Condition	Wall Height (feet)	Minimum Required CDR	Calculated CDR	Maximum Service Load (kips)
Permanent Static	16.5	1.0	1.00	32.9
Seismic	16.5	1.0	1.08	44.5

It is our understanding that structural capacity of the wall facing will be analyzed by the wall designer using the procedure outlined in the FHWA Geotechnical Circular No. 7 or other approved methods. The wall designer shall use the maximum service loads presented in Table D-5.

Soil nails will be installed through the existing Hilfiker wall facing. We assume the wall drainage system for the existing Wall 03.63L will be adequate for the soil nail wall.

3.6 Pier 1/Wall 03.63L Shallow Foundation Bearing Resistance and Settlement

We evaluated the bearing resistance for the proposed bridge Pier 1 foundation, existing Pier 1 bridge foundation, and the lower portion of Wall 03.63L that will remain in place. Bearing resistance was not analyzed for the new portions of Wall 03.63L because a majority of it will be supported by the proposed Pier 1 footing and therefore is accounted for in the Pier 1 bearing resistance analysis. Additionally, the new Wall 03.63L is replacing the current existing wall with an approximate one to one replacement on a 2H:1V slope cut.

We evaluated the shallow foundation bearing resistance based on AASHTO LRFD Section 10.6.3.1.2 and by using the Shallow Foundation Resistance and Elastic Settlement spreadsheet developed by GeoEngineers.

Bearing resistance was evaluated considering the maximum height of the existing Wall 03.63L over ESU 1B. Portions of Wall 03.63L likely also bears on ESU 2A, however the exact limits of the ESU contact between ESU 2A and ESU 1B is difficult to confirm. We have assumed the wall bears entirely on ESU 1B because it is a weaker soil unit than ESU 2A. We evaluated strap width of 32- and 34-feet per the existing Hilfiker wall design sheets (see Appendix D.1). Bearing resistance results and calculations are presented in Appendix D.8 (Figures D.8-1 through D.8-6). A summary of the bearing resistance results is presented in Table D-6.

Table D-6. Bearing Resistance Summary

Scenario	Maximum Bearing Resistance Limited by Global and Compound Stability[5]		Maximum Bearing Resistance Limited by Soil Nail Capacity (SNAIL)[6]		Maximum Bearing Resistance Limited by Bearing Resistance Calculation				
	Factored Strength Limit State	Factored Extreme Limit State	Factored Strength Limit State	Factored Extreme Limit State	Unfactored Bearing Resistance	Factored Extreme Event Resistance[1]	Factored Strength Bearing Resistance[2]	Factored Service Limit State[3]	
								1" Deflection	1.5" Deflection
	(ksf) [4]	(ksf) [4]	(ksf) [4]	(ksf) [4]	(ksf) [4]	(ksf) [4]	(ksf) [4]	(ksf) [4]	(ksf) [4]
Wall 03.63L **B = 32ft L=70ft** (ESU 1B)	Not Applicable				72	64.8	46.8	3.6	5.4
Wall 03.63L **B = 34ft L=70 ft** (ESU 1B)	Not Applicable				75.2	67.7	48.9	3.5	5.2
Pier 1 Proposed Footing **B=24.7ft L=38.7ft** (ESU 1B)	9.0	9.0	7.0	12.0	100.4	90.3	45.2	5.4	8.0
Pier 1 Existing Footing **B=12ft L=41.7ft** (ESU 7A)	Not Applicable				578.3	520.5	260.3	1.3[7]	2.7[8]

Notes:

1. Resistance factor of 0.9 included in the factored bearing resistance values presented for Extreme Limit State load cases (AASHTO 11.5.8) for MSE Walls.
2. Strength Limit State factor (0.65) MSE Walls from AASHTO 11.5.7.1.
3. Resistance factor of 1.0 included in the factored bearing resistance values presented for Service Limit State load cases.
4. ksf = kips per square foot
5. Bearing resistance limiting values to meet global and compound stability requirements. See Appendix D.4 and D.5 for details.
6. Bearing resistance limiting values to meet soil nail wall capacity requirements. See Appendix D.7 for details.
7. Bearing resistance value limiting the existing pier 1 foundation settlement to 0.25-inches of settlement. The bearing resistance values are exclusive of loads that the existing footing is already under.
8. Bearing resistance value limiting the existing pier 1 foundation settlement to 0.50-inches of settlement. The bearing resistance values are exclusive of loads that the existing footing is already under.

A staged elastic settlement analysis was completed as requested by the structural engineer. Elastic settlement values were calculated per load stage and in a cumulative manner in accordance with AASHTO Section 10.6.2.4.2. Loading stages included: 1) the existing conditions with the existing Hilfiker Wall backfill removed, 2) excavate existing wall, construct the

new Pier 1 footing, add and post-tension the girder extensions, 2.5) add the new Hilfiker Wall and backfill between the new Pier 1 abutment and Wall 03.63L, 3) demolish existing Pier 1, and 4) final conditions. Loads applied were supplied by the structural engineer and are summarized below in Table D-7. the existing condition footing weight and each stage of the bridge extension construction sequence, as described in report Section 2.1. Loads applied were supplied by the structural engineer and are summarized below in Table D-7.

Table D-7: Bridge 17.7 Pier 1 Staged Settlement Analysis Loading Inputs

		Pier 1		
		Cumulative Load (kips)	Cumulative Pressure (ksf)	Δ Pressure Per Stage (ksf)
Stage 1	**Existing Condition (Existing Hilfiker wall backfill removed)**	-	3.2	0.00
Stage 2	**Extension + DC1[1] + PT[2] (New footing, girder extension, and post-tensioning)**	1127	1.18	1.18
Stage 2.5	**Build New Hilfiker Wall (27-feet tall)**	2522	2.64	1.46
Stage 3	**Extension+DC1+PT+Pier 1 Removal (Demolish existing Pier 1)**	2979	3.12	0.48
Stage 4	**Extension+DC1+PT+Pier 1 Removal+DC2[3] (Final condition)**	3065	3.21	0.09
	Footing Size (ft2)	956		
	Total Dead Load (kips)	3065		
	Final Total Pressure Increase (ksf)	3.2		

All final settlement values were less than 1.0-inch and are anticipated to be elastic occurring immediately as the loads are placed. Because the anticipated settlement of Pier 1 is less than 2-inches, settlement instrumentation and monitoring is not required as outlined in RFP Section 2.6.7.5. We anticipate post-construction settlement will be negligible. Cumulative elastic settlement values for each loading case are presented below in Table D-8.

Table D-8: Bridge 17.7 Pier 1 Cumulative Settlement Values for Staged Loading

	Pier 1				
	Stage 1	**Stage 2**	**Stage 2.5**	**Stage 3**	**Stage 4**
q_o (ksf)[1]	0.00	1.18	1.46	0.48	0.09
ν[2]	.025	0.25	0.25	0.25	0.25
A (ft^2)[3]	956	956	956	956	956
E_s (ksf)[4]	1720	1720	1720	1720	1720

	Pier 1				
	Stage 1	Stage 2	Stage 2.5	Stage 3	Stage 4
L/B	1.6	1.6	1.6	1.6	1.6
β_z [5]	1.091	1.091	1.091	1.091	1.091
S_e (in.) [6] per Stage	0.00	0.22	0.27	0.09	0.02
Cumulative S_e (in.)	0.00	0.22	0.49	0.58	0.59

Notes:

1. Load intensity at bottom of foundation
2. Poissons Ratio
3. Area of bottom of footing
4. Young's Modulus of subgrade soil
5. Shape factor
6. Predicted elastic settlement in inches

3.7 Pier 1/Wall 03.63L Lateral Earth Pressure

Lateral earth pressures were calculated using a spreadsheet developed by GeoEngineers based on Rankine and Coulomb earth pressure theory per AASHTO Section 3.11.5. Seismic active lateral earth pressure coefficients were developed using the Mononobe-Okabe Method per AASHTO Section A11.3.1. Lateral earth pressure calculations are presented in Appendix D.9 (Figures D.9-1 through D.9-2).

Coefficients of friction against sliding were calculated for Wall 03.63L and the proposed Pier 1 footing. Coefficients of friction were determined using AASHTO Equation 10.6.3.4-2 for concrete structures (such as footings or wall fascia footings) and for soil-to-soil resistance to sliding at the base of the SE walls. Friction coefficients are provided for native soils and each of the approved import materials. A coefficient of 1.0 was used for concrete cast against soil and 0.8 for precast concrete. For sliding coefficients for SE walls with discontinuous reinforcements (e.g., strips) the angle of sliding friction was taken as the lesser of the friction angle of the reinforced fill and the friction angle of the foundation soil (AASHTO 11.10.5.3). For sliding coefficients for SE walls with continuous reinforcements (e.g., grids and sheets) the angle of sliding friction was taken as the minimum of the reinforced fill friction angle, foundation soil friction angle, and the soil-reinforcement interface angle (taken as $^2/_3$ of the lesser of the foundation or reinforced soil friction angle in absence of specific information) per AASHTO Section 11.10.5.3. Calculations for these coefficients are presented in Appendix D.9. Sliding friction coefficients are presented on Figure D.9-3.

3.8 Pier 1 Seismic Spread Footing Springs

We calculated seismic structural footing spring values for the existing and proposed Bridge 17.7 Pier 1 footings. Per Federal Emergency Management Agency (FEMA) 356 (ASCE 2000) as referenced in Project GDM Section 6-5.1.1 the initial shear modulus (Go) was correlated the corrected standard penetration test (SPT) blow count, $(N_1)_{60}$. Correlated Go values are presented in Table D-9 below. Calculations are presented in Appendix D.10.

Table D-9: Foundation Spring Inputs and Shear Modulus Summary

Property		Proposed Pier 1 (ESU 1B)	Existing Pier 1 (ESU 7A)
SEE	Footing Width (ft.)	24.7	12
	Footing Length (ft.)	38.7	41.7
	Embedment (ft.)	6	8.5 [5]
	Footing Thickness (ft.)	4	3.5
	σ_o' (psf)	750	680
	$S_{XS}/2.5$ [1]	0.51	0.51
	G/G_o [2]	0.34	0.71
	G_o [3] (ksf)	1511	2018
	G [4] (ksf)	514	1430

Notes:
1. Effective peak acceleration
2. Effective shear modulus ratio from FEMA Table 4-7
3. The initial shear modulus calculated using Go = 20,000 * $(N_1)_{60}$1/3 * Sqrt(σ_o') (Equation 4-5, FEMA)
4. Effective shear modulus
5. Embedment with historic ground surface

Using the shear modulus values presented in Table D-8, The Effective Shear Modulus, (G/G_o) was calculated using Table 4-7 (FEMA 356) by using the effective peak acceleration ($S_{XS}/2.5$). Spring constants were developed for the SEE hazard level. A summary of the calculated spring constants is presented in Table D-10 below. Calculations for these values are presented in Appendix D.10.

Table D-10: Summary of the 6-Degree-of-Freedom Structural Seismic Spring Constants for Pier 1

Results Summary[1]							
Pier		$K_{x,emb}$	$K_{y,emb}$	$K_{z,emb}$	$K_{xx,emb}$	$K_{yy,emb}$	$K_{zz,emb}$
		kips/in	kips/in	kips/in	kip-in	kip-in	kip-in
SEE	Pier 1 – Existing (ESU 7A)	1380	15,350	13,510	138,100,000	647,500,000	730,300,000
	Pier 1 - Proposed (ESU 1B)	5,647	5,870	5,793	160,200,000	320,600,000	357,000,000

Notes:
1. Spring values calculated using equations presented in Figure 4-4 (FEMA)

4.0 Bridge 17.7 Pier 2 Analyses

4.1 Pier 2 Shallow Foundation Bearing Resistance and Settlement

We evaluated Bridge 17.7 Pier 2 existing shallow foundation bearing resistance based on AASHTO LRFD Section 10.6.3.1.2 and using the Shallow Foundation Resistance and Elastic Settlement spread sheet developed by GeoEngineers.

Bearing resistance results and calculations are presented in Appendix D.8 (Figures D.8-1 through D.8-6). A summary of the bearing resistance results is presented in Table D-11. It should be noted that the deflection estimates and bearing resistance values reported for the Service Limit State are exclusive of the existing footing loads and only consider loads added to the existing footing and the resulting deformation estimate from the additional loads.

Table D-11. Bridge 17.7 Pier 2 Bearing Resistance Summary

Scenario	Maximum Bearing Resistance Limited by Bearing Resistance Calculation				
	Unfactored Bearing Resistance	Factored Extreme Event Resistance[1]	Factored Strength Bearing Resistance[2]	Factored Service Limit State[3]	
				0.25" Deflection	0.5" Deflection
	(ksf) [4]	(ksf) [4]	(ksf) [4]	(ksf) [4]	(ksf) [4]
Pier 2 Existing Footing **B=14ft L=28ft** (ESU 2A)	106.5	95.9	47.9	1.3[5]	2.6[5]

Notes:

1. Resistance factor of 0.9 included in the factored bearing resistance values presented for Extreme Limit State load cases (AASHTO 11.5.8) for MSE Walls.
2. Strength Limit State factor (0.65) MSE Walls from AASHTO 11.5.7.1.
3. Resistance factor of 1.0 included in the factored bearing resistance values presented for Service Limit State load cases.
4. ksf = kips per square foot
5. The bearing resistance values are exclusive of loads that the existing footing is already under.

A staged elastic settlement analysis was completed as requested by the structural engineer. Cumulative elastic settlement values were calculated per AASHTO Section 10.6.2.4.2 for each stage of loading during construction. Loading stages included the existing condition footing weight, substructure weight, backfill soil weight, girder placement, and superstructure placement. Applied loads were provided by the structural engineer (COWI) and are summarized below in Table D-12.

Table D-12: Bridge 17.7 Pier 2 Staged Settlement Analysis Loading Inputs

		Pier 2		
		Cumulative Load (kips)	Cumulative Pressure (ksf)	Δ Pressure Per Stage (ksf)
Stage 1	**Existing Conditions**	1592	4.06	0.00
Stage 2	**Existing +DC1+PT (Girder extension, and post-tensioning)**	1583	4.04	-0.02
Stage 3	**Extension+DC1+PT+Pier 1 Removal (Demolish existing Pier 1)**	1661	4.24	0.20
Stage 4	**Extension+DC1+PT+Pier 1 Removal+DC2 (Final condition)**	1664	4.24	0.01
	Footing Size (ft2)	392		
	Total Dead Load (kips)	1664		
	Final Total Pressure Increase (ksf)	0.18		

All final settlement values were less than 0.25-inches and are anticipated to be elastic and occur immediately as the loads are placed. Because the anticipated settlement of Pier 2 is less than 2-inches, settlement instrumentation and monitoring is not required as required in Request for Proposal (RFP) Section 2.6.7.5. We anticipate post-construction settlement to be negligible. Cumulative elastic settlement values for each loading case are presented below in Table D-13.

Table D-13: Bridge 17.7 Pier 2 Cumulative Settlement Values for Staged Loading

	Pier 2			
	Stage 1	Stage 2	Stage 3	Stage 4
q_o (ksf)[1]	0.00	-0.02	0.20	0.01
ν[2]	0.35	0.35	0.35	0.35
A (ft^2)[3]	392	392	392	392
E_s (ksf)[4]	979	979	979	979
L/B	2.0	2.0	2.0	2.0
β_z[5]	1.10	1.10	1.10	1.10
S_e (in.) [6] per Stage	0.00	0.00	0.04	0.00
Cumulative S_e (in.)	0.00	0.00	0.04	0.04

Notes:

1. Load intensity at bottom of foundation
2. Poissons Ratio
3. Area of bottom of footing
4. Young's Modulus of subgrade soil
5. Shape factor
6. Predicted elastic settlement in inches

4.2 Pier 2 Lateral Earth Pressures and Sliding

Lateral earth pressures were calculated using a spreadsheet developed by GeoEngineers based on Rankine and Coulomb earth pressure theory per AASHTO Section 3.11.5. Seismic lateral earth pressure coefficients were developed using the Mononobe-Okabe Method per AASHTO Section A11.3.1. Lateral earth pressure calculations are presented in Appendix D.12 (Figures D.12-1 through D.12-2). Applicable earth pressures for Pier 2 are presented on Figure 6.

Based on the construction sequence presented in Section 5.0 below, Pier 2 has not previously experienced displacement and is braced between Pier 1 and Pier 3. Therefore Pier 2 is not free to deform and lateral earth pressures in the static condition must be calculated considering at-rest conditions.

Due to the geometry and construction history of Bridge 17.7, we have assumed Pier 2 is fully restrained and therefore used the site-class adjusted Peak Ground Acceleration (A_s) as the horizontal seismic coefficient (K_h) without any reductions for

flexibility, per Project GDM Section 6-4.3.2. At Pier 2 in the seismic condition, at-rest seismic (K_{oe}) earth pressure coefficients are provided for design.

Coefficients of friction against sliding were calculated for the existing Pier 2 footing. Coefficients of friction were determined using AASHTO Equation 10.6.3.4-2 for concrete structures. Friction coefficients are provided for native soils and each of the approved import materials. A coefficient of 1.0 was used for concrete cast against soil and 0.8 for precast concrete. A summary of coefficients of friction against sliding are presented on Figure 6 and in Appendix D.12.

4.3 Pier 2 Seismic Spread Footing Springs

We calculated the seismic structural footing springs for the existing Bridge 17.7 Pier 2. Per FEMA 356 (ASCE 2000) as referenced in Project GDM Section 6-5.1.1 the initial shear modulus (G_o) was correlated the corrected SPT blow count, $(N_1)_{60}$. Correlated G_o values are presented in Table D-14 below. Calculations are presented in Appendix D.10.

Table D-14: Bridge 17.7 Pier 2 Foundation Spring Inputs and Shear Modulus Summary

Property		Existing Pier 2 (ESU 2A)
SEE	Footing Width (ft.)	14
	Footing Length (ft.)	28
	Embedment (ft.)	8.4[5]
	Footing Thickness (ft.)	4
	σ_o' (psf)	1008
	$S_{XS}/2.5$[1]	0.51
	G/G_o [2]	0.34
	G_o [3] (ksf)	1951
	G [4] (ksf)	663

Notes:
1. Effective peak acceleration
2. Effective shear modulus ratio from FEMA Table 4-7
3. The initial shear modulus calculated using Go = 20,000 * $(N_1)_{60}$1/3 * Sqrt(σ_o') (Equation 4-5, FEMA)
4. Effective shear modulus
5. Embedment with historic ground surface

Using the shear modulus values presented in Table D-14, the Effective Shear Modulus, (G/G_o) was calculated using Table 4-7 (FEMA 356) by using the effective peak acceleration ($S_{XS}/2.5$). Spring constants were developed for the SEE hazard levels. A summary of the calculated spring constants is presented in Table D-15 below. Calculations for these values are presented in Appendix D.10.

Table D-15: Bridge 17.7 Pier 2 Summary of the 6-Degree-of-Freedom Structural Seismic Spring Constants

Results Summary[1]							
Pier		$K_{x,emb}$	$K_{y,emb}$	$K_{z,emb}$	$K_{xx,emb}$	$K_{yy,emb}$	$K_{zz,emb}$
		kips/in	kips/in	kips/in	kip-in	kip-in	kip-in
SEE	Pier 2 – Existing (ESU 2A)	1.138E+04	1.207E+04	1.008E+04	1.191E+08	2.785E+08	3.334E+08

Notes:
1. Spring values calculated using equations presented in Figure 4-4 (FEMA)

5.0 Bridge 17.7 Pier 3 Analyses

To accommodate widening southbound I-405 under the existing Bridge 17.7, portions of the existing Hilfiker wall (Wall 03.63L) approach embankment along with the existing Bridge 17.7 Pier 1 footing need to be removed and/or replaced. The existing Bridge 17.7 girders will be extended to extend over the widened lane and connect to the new Pier 1.

Bridge 17.7 was constructed between 1990 and 1992 in two phases. Appendix D.2 contains the as-built plans for Bridge 17.7. During construction Phase 1, drilled shaft secant piles were installed at the eastern pier of the bridge (what will become Pier 3 in the new configuration). A spread footing shallow foundation (what will become Pier 2 in the current configuration), was also constructed. The girders were installed, followed by construction of a temporary earthen approach embankment placed against the west side of Pier 2. Finally, after the Phase 1 bridge structure was installed, the northbound lanes for I-405 were cut into the slope between Pier 3 and Pier 2, and a CIP wall was constructed in front of Pier 3.

Phase 2 construction placed a spread footing and pier at the western side of the bridge. Once the current Pier 1 was installed, the girders of the bridge were placed between Pier 2 and Pier 1. At the time the girders were placed, the temporary approach embankment remained on the west side of Pier 2. Wall 03.63L approach embankment was constructed west of Pier 1. Finally, the southbound lanes for I-405 were cut between Pier 1 and Pier 2, removing native and temporary embankment material. See the annotations in Appendix D.1 and D.2 for clarity.

Pier 3 was not allowed to displace during construction. In Phase 1, the lateral pressures and movement of Pier 3 into the I-405 northbound cut were resisted by Pier 2 and the temporary embankment on the west side of Pier 2 through the superstructure. In Phase 2, Wall 03.63L behind Pier 1 imposed lateral loads that were carried through the girders to Pier 2, and Pier 2 was restricted from moving into the I-405 northbound cut by the superstructure between Pier 2 and Pier 3. This lack of displacement resulted in at-rest lateral earth pressures at Pier 3, and the superstructure of Bridge 17.7 is in a state of compression between Pier 1 and Pier 3.

A portion of the existing embankment and Wall 03.63L behind the existing Pier 1 will be removed to construct the new Pier 1 footing and stem wall. The removal of the lateral load on Pier 1 creates unbalanced lateral forces exerted by the soil retained behind Pier 3 which will cause Pier 3 to displace toward Pier 2. To counteract this displacement, the lateral forces will be balanced by a temporary deadman or bracing system that must be in place before the removal of Wall 3.63L and embankment. Figure 3 presents the location of each design section, with Section D-D' along the centerline of the bridge. See Figure 4 for proposed construction sequencing.

5.1 Wave Scattering Evaluations

Per the NCHRP Report 611 the PGA can be adjusted to account for variations in the average ground acceleration behind retaining walls and/or slopes greater than 20 feet in height by applying a scaling factor (or alpha value) to the PGA. The normalized SEE spectral shape developed by Hart Crowser falls in the mid-spectral shape range because the PSHA results typically peak at about 0.3 second (NCHRP Figure 5-4). Using the mid-spectral shape curve, the PGA was scaled for qualifying wall and slope heights. Bridge 17.7 is characterized by Seismic Site Class C.

Calculations of these corrected PGAs are presented in Appendix D.15 and the results are presented in Table D-16.

Table D-16: Wave Scattering Scaling Factors and Corrected PGAs

Wall Section/Structure	Seismic Analysis	Condition	Design Height (ft.)	Scaling Factor α	Initial PGA (SEE)	Corrected PGA (SEE)	Kh (g)
Bridge 17.7 Pier 3 – Longitudinal Section D-D'	Global Stability	Existing	36	N/A	0.51	0.51	N/A
Bridge 17.7 Pier 3	Lateral Earth Pressure	Existing	36	0.79	0.56	0.442	0.442

Abbreviations:
SEE = safety evaluation earthquake
N/A = not applicable

For global stability analyses, wave scatter was not applied to the Pier 3 secant pile wall. For Lateral Earth Pressure analyses, the full PGA was applied.

5.2 Global Stability Analysis

We completed global stability analyses for the following critical cross section:

- Cross-section D-D' on Figure 3: Longitudinal Stability of Pier 3

We calculated the global stability FS values for static conditions using the Spencer and Morgenstern-Price Method in SLOPE/W (Geo-Slope International 2021 version 11.01). We used static soil strength parameters for the static analysis. We modeled the Pier 3 secant pile wall as a "High Strength" material having a unit weight of 130 pcf and neglected the presence of the CIP wall. We used the established ESU soil properties. We used a horizontal seismic acceleration coefficient (kh) to estimate seismic lateral earth pressures and evaluate pseudo-static global stability.

For our global stability analyses, the site-class adjusted horizontal seismic acceleration was based on the assumption that Pier 3 remains fully restrained in the seismic condition. Later analyses have updated this assumption as we have found that Pier 3 is expected to deform up to 3 or 4 inches during the SEE seismic event. We did not apply the wall height-dependent seismic coefficient (wave scatter coefficient, α) for wave scattering effects in the global stability analysis.

A summary of global stability analysis results is presented in Table D-17. See Appendix D.16 for the global stability results figures (Figures D.16-1 through D.16-42) and the detailed input/output reports from Slope/W in Appendix D.16 after the results figures.

Table D-17: Global Slope Stability Results – Bridge 17.7 Pier 3

Wall	Section	Scenario	Loading Type	Minimum Required Factor of Safety	Calculated FS (Spencer/ Morgenstern & Price)	Minimum Required Strap Length/ Minimum Wall Embedment
Pier 3	D-D'	Existing	Static	1.3	3.9 / 3.9	Not applicable
			Pseudo-Static	1.1	1.6 / 1.6	

5.3 Pier 3 Lateral Earth Pressure

Lateral earth pressures were calculated using a spreadsheet developed by GeoEngineers based on Rankine and Coulomb earth pressure theory per AASHTO Section 3.11.5. Seismic lateral earth pressure coefficients were developed using the Mononobe-Okabe Method per AASHTO Section A11.3.1. Lateral earth pressure calculations are presented in Appendix D.17 (Figures D.17-1 through D.17-2). Figure 7 presents the lateral earth pressures at Pier 3.

Per Section 15-4.8 of the Project GDM, at-rest earth pressures shall be used where bridge abutment walls and wing walls connect. Active earth pressures apply at distances away from the bridge abutment equal to or greater than the height of the abutment wall. Per Section 15-5.1 of the Project GDM, active earth pressures may be used for abutment walls if they can move sufficiently to develop active pressures. To be consistent with Section 15-4.8 and 15-5.1, if the pier is not free to deform, at-rest lateral earth pressures shall be used. Based on the construction sequence presented in Section 5.0, Pier 3 has not experienced displacement and is braced to prevent displacement, and as such, the lateral earth pressures in the static condition have been calculated using at-rest earth pressure coefficients.

We have estimated that, in the seismic case, lateral deformations at Pier 3 could be up to about 3 or 4 inches and, therefore, we use the site-class adjusted Peak Ground Acceleration (A_s) as the horizontal seismic coefficient (K_h) per Project GDM Section 6-4.3.2. At Pier 3 in the seismic condition, active seismic (K_{ae}) earth pressure coefficients are recommended. We applied the wall height-dependent seismic coefficient (wave scatter coefficient, α) for wave scattering effects. This horizontal acceleration was corrected by the wave scattering reduction factors presented in Table D-1, above.

5.4 Pier 3 CIP Spread Footing Sliding

Coefficient of friction against sliding was calculated for the Pier 3 CIP wall spread footing. Coefficients of friction were determined using AASHTO Equation 10.6.3.4-2 for concrete structures (such as footings or wall fascia footings) and for soil-to-soil resistance to sliding at the base of the SE walls. Friction coefficients are provided for native soils. A coefficient of 1.0 was used for concrete cast against soil. Calculations for these coefficients are presented in Appendix D.9. Sliding friction coefficients are presented in Table D-18, below.

Table D-18: Sliding Friction Coefficient for Pier 3 CIP Wall

Soil Type	φ'	Cast-In-Place Concrete
ESU 2A	39	0.81

5.5 Pier 3 CIP Wall Seismic Spread Footing Springs

We calculated the seismic structural footing springs for the existing Pier 3 CIP wall west of Bridge 17.7 Pier 3. Per FEMA 356 (ASCE 2000) as referenced in Project GDM Section 6-5.1.1 the initial shear modulus (G_o) was correlated the corrected SPT blow count, $(N_1)_{60}$. Correlated G_o values are presented in Table D-19 below. Calculations are presented in Appendix D.10.

Table D-19: Foundation Spring Inputs and Shear Modulus Summary

	Property	Existing Pier 3 CIP Wall (ESU 2A)
SEE	Footing Width (ft.)	12.5
	Footing Length (ft.)	40
	Embedment (ft.)	4 [5]
	Footing Thickness (ft.)	2.5
	σ_o' (psf)	480
	$S_{XS}/2.5$ [1]	0.51
	G/G_o [2]	0.71
	G_o [3] (ksf)	1346
	G [4] (ksf)	956

Notes:

1. Effective peak acceleration
2. Effective shear modulus ratio from FEMA Table 4-7
3. The initial shear modulus calculated using Go = 20,000 * $(N_1)_{60}$1/3 * Sqrt(σ_o') (Equation 4-5, FEMA)
4. Effective shear modulus
5. Embedment with historic ground surface

Using the shear modulus values presented in Table D-19, the Effective Shear Modulus, (G/G_o) was calculated using Table 4-7 (FEMA 356) by using the effective peak acceleration ($S_{XS}/2.5$). Spring constants were developed for the SEE hazard levels. A summary of the calculated spring constants is presented in Table D-20 below. Calculations for these values are presented in Appendix D.10.

Table D-20: Summary of the 6-Degree-of-Freedom Structural Seismic Spring Constants for Pier 3 CIP Wall

Results Summary[1]							
Pier		$K_{x,emb}$	$K_{y,emb}$	$K_{z,emb}$	$K_{xx,emb}$	$K_{yy,emb}$	$K_{zz,emb}$
		kips/in	kips/in	kips/in	kip-in	kip-in	kip-in
SEE	Pier 3 CIP Wall – Existing (ESU 2A)	7,439	8,214	7,903	74,879,275	361,525,394	390,290,262

Notes:

1. Spring values calculated using equations presented in Figure 4-4 (FEMA)

5.6 Pier 3 Secant Pile Wall

The secant pile wall at Pier 3 is constructed of eight reinforced drilled shafts, each 48-inches in diameter at 6-foot-on-center spacing. The shafts extend from the bottom of the shear key, at approximately elevation 107 feet, down to an elevation of approximately 34 feet, where they are embedded about 5 feet into the ESU 7A sandstone formation. Unreinforced lean concrete shafts provide lagging between the reinforced shafts down to about elevation 75 feet.

We used the analysis software PYWALL (Ensoft Inc. PYWALLVersion 2019.6.2) to model the soil-structural-interaction and lateral performance of Pier 3. The secant pile wall was modeled assuming linear elastic section properties. The moment of inertia for each section of the drilled shaft was defined for the intact (static) case and the cracked (seismic) case. The static model restricts the deformation of Pier 3 by assigning the pile a pinned-head condition. The seismic case was evaluated with a free-head condition.

Per Section 15-5.1 of the Project GDM, active earth pressures may be used for abutment walls if they can move sufficiently to develop active pressures. To be consistent with Section 15-5.1 of the GDM, if the pier is not free to deform, at-rest lateral earth pressures should be used. Based on the construction sequence presented in Section 5.0 above, Pier 3 has not experienced displacement and is braced against displacement, and the lateral earth pressures in the static condition must be calculated using at-rest coefficients.

We estimate that in the seismic case, Pier 3 deformations will be on the order of 3 to 4 inches and therefore use the site-class adjusted Peak Ground Acceleration (A_s) as the horizontal seismic coefficient (K_h) per Project GDM Section 6-4.3.2. At Pier 3 in the seismic condition, active seismic (K_{ae}) earth pressure coefficients shall be used. We applied the wall height-dependent seismic coefficient (wave scatter coefficient, α) for wave scattering effects. This horizontal acceleration was corrected by the wave scattering reduction factors presented in Table D-1, above.

The earth pressures were input directly into the pile model based on the results of the lateral earth pressure analysis presented in Section 5.3 above. Additional lateral and axial loads, including the deadweight of the bridge structure and the reaction forces from Pier 1 delivered to Pier 3 during a seismic event were quantified and applied at the appropriate depth along the piles.

Iterating the model refined the assumption that Pier 3 can tolerate 3 to 4 inches of lateral movement during a seismic event. This movement transitions the soil behind Pier 3 from an at-rest state during static conditions to an active seismic state during shaking.

The p-y model was iterated in conjunction with the structural reaction model developed by COWI. The models were refined until deformation and forces calculated matched well. Model inputs and calculations are presented in Appendix D.18.

FLATIRON | LANE | wood.

In Association with

Appendix D.1
Existing Hilfiker Wall Design Plan Markup

Hillfiker Retaining Wall
SR 405
South Renton to Sunset Blvd HOV
Retaining Wall 6
Revised 1991
File: AsBuilt_014052_Vol_3.pdf

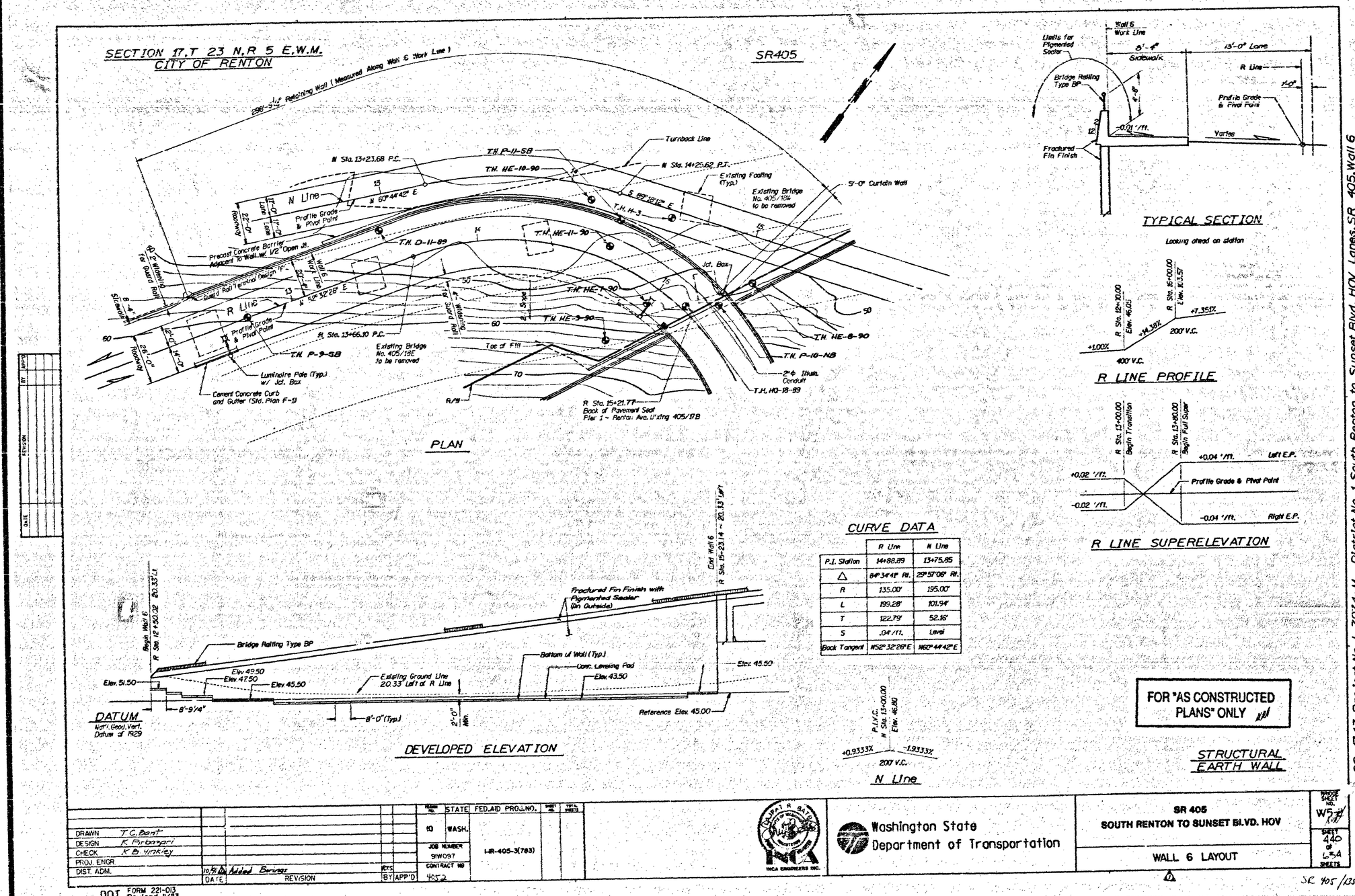
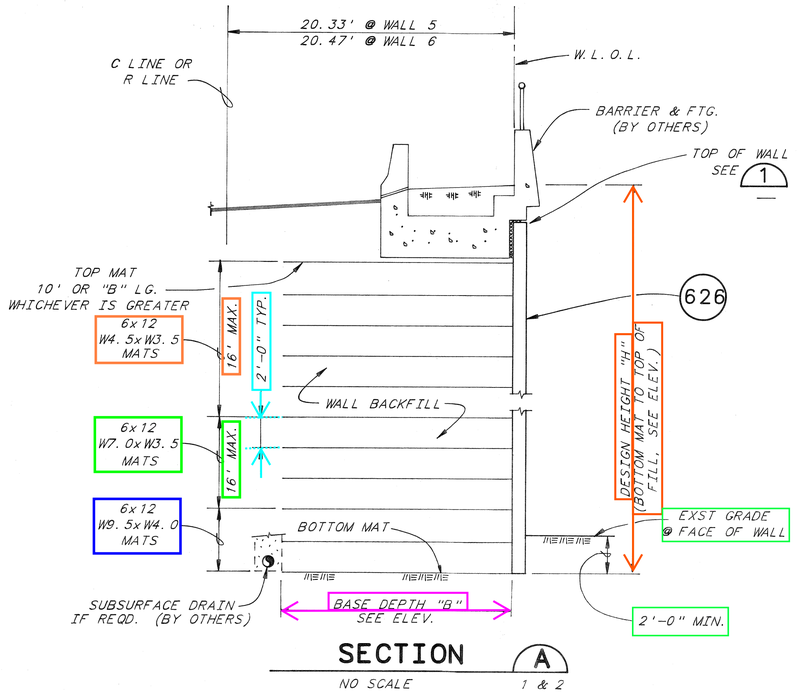


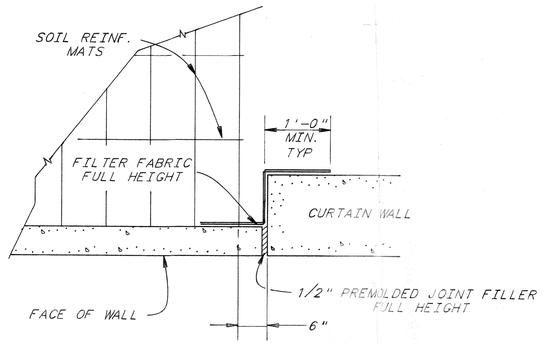
Figure D.1-1



SECTION A

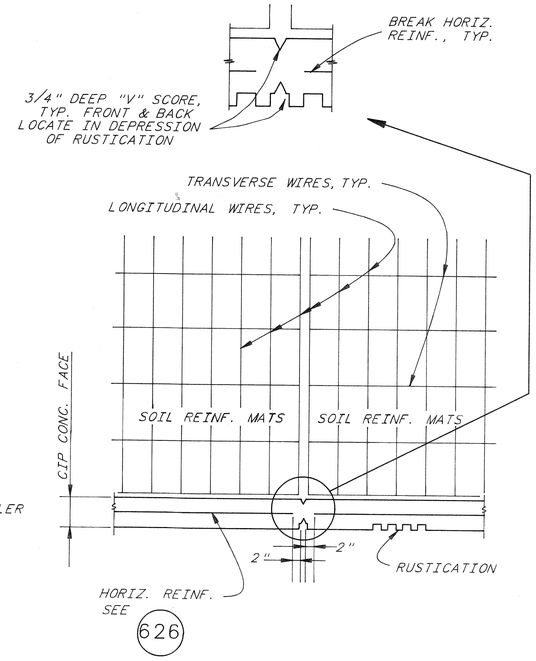
NO SCALE

1 & 2



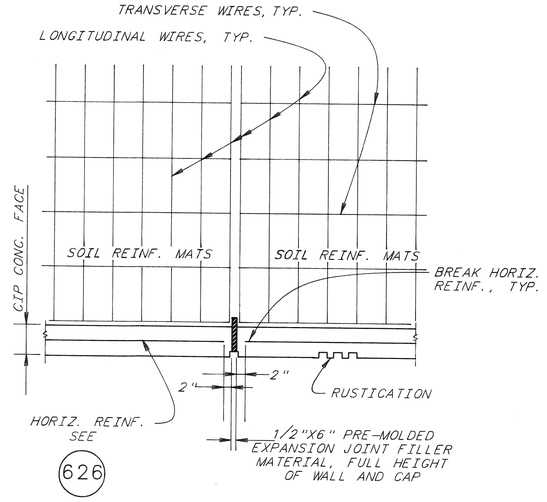
E.R.S. TO CURTAIN WALL JOINT 609

NO SCALE



DEEP SCORE JOINT 600

NO SCALE



EXPANSION JOINT 601

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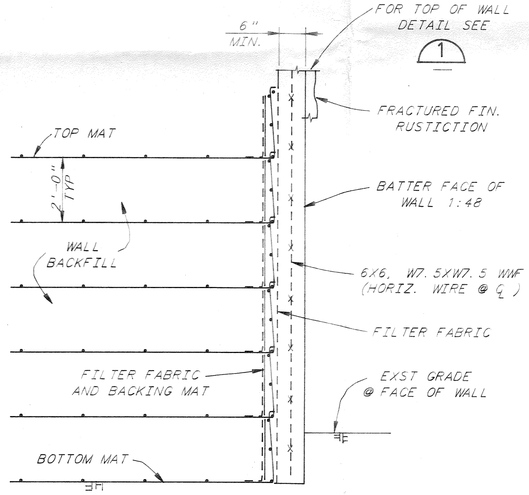
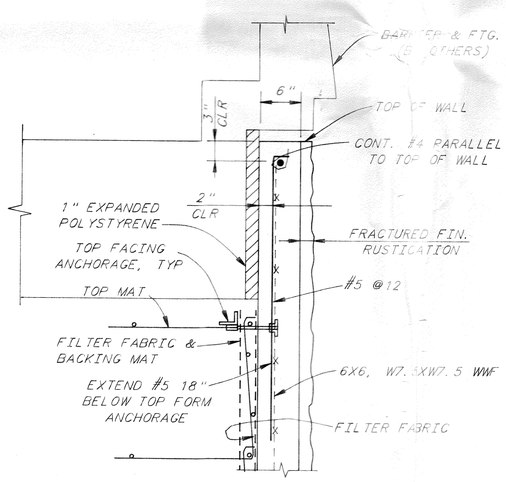


C.I.P. CONC. FACING 626

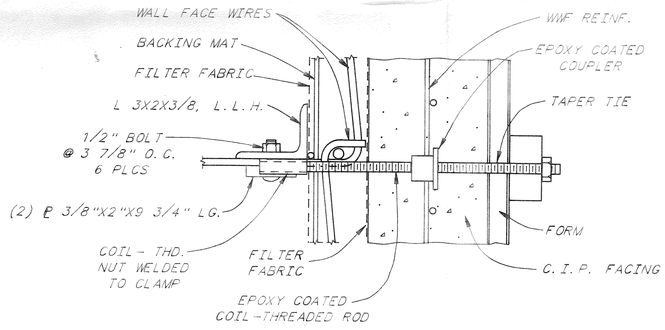
NO SCALE

NOTE: AT CONTRACTOR'S OPTION THE WALL FACE MAY BE PRE-CAST



DETAIL 1

NO SCALE



FACING ANCHORAGE 627

NO SCALE

NOTES:

1. ANCHORAGES TO BE PLACED AT 8'-0"X4'-0" (HORIZ. X VERT.) MAXIMUM SPACING.
2. ANCHORAGES TO BE PLACED ALONG TOP MATS, TYP.
3. THREADED ROD, COUPLER & TAPER TIE SIZES TO BE BASED ON FINAL ANCHORAGE SPACINGS.

CAD FILE: 90081S4EG07

DRAWN	R.D. WALKER				REGION NO.	STATE	FED. AID PROJ. NO	SHEET NO.	TOTAL SHEETS
CHECKED	K.J. NELSON				10	WASH.			
PROJ. ENG.					JOB NUMBER				
DIST. ADM.					CONTRACT NO.				
	DATE	REVISION	BY	APP'D					

SHN — SELVAGE • HEBER • NELSON & ASSOCIATES
CONSULTING ENGINEERS (707) 444-0427
2630 HARRISON AVE. EUREKA, CA., 95501

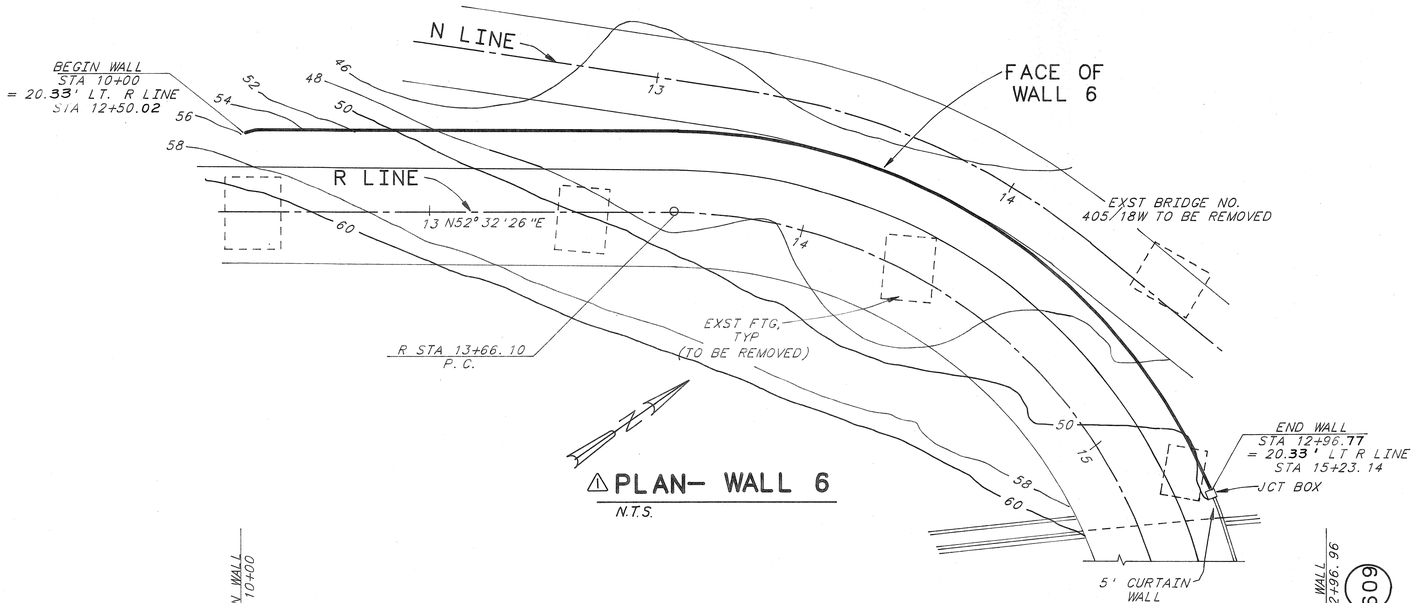
E.R.S.
HILFIKER RETAINING WALLS
(707) 443-5093 P.O. BOX 2012
EUREKA, CALIFORNIA 95502-2012

JUN 28 1990

Figure D.1-2

SECTIONS AND DETAILS

SHEET OF SHEETS



⚠ PLAN– WALL 6

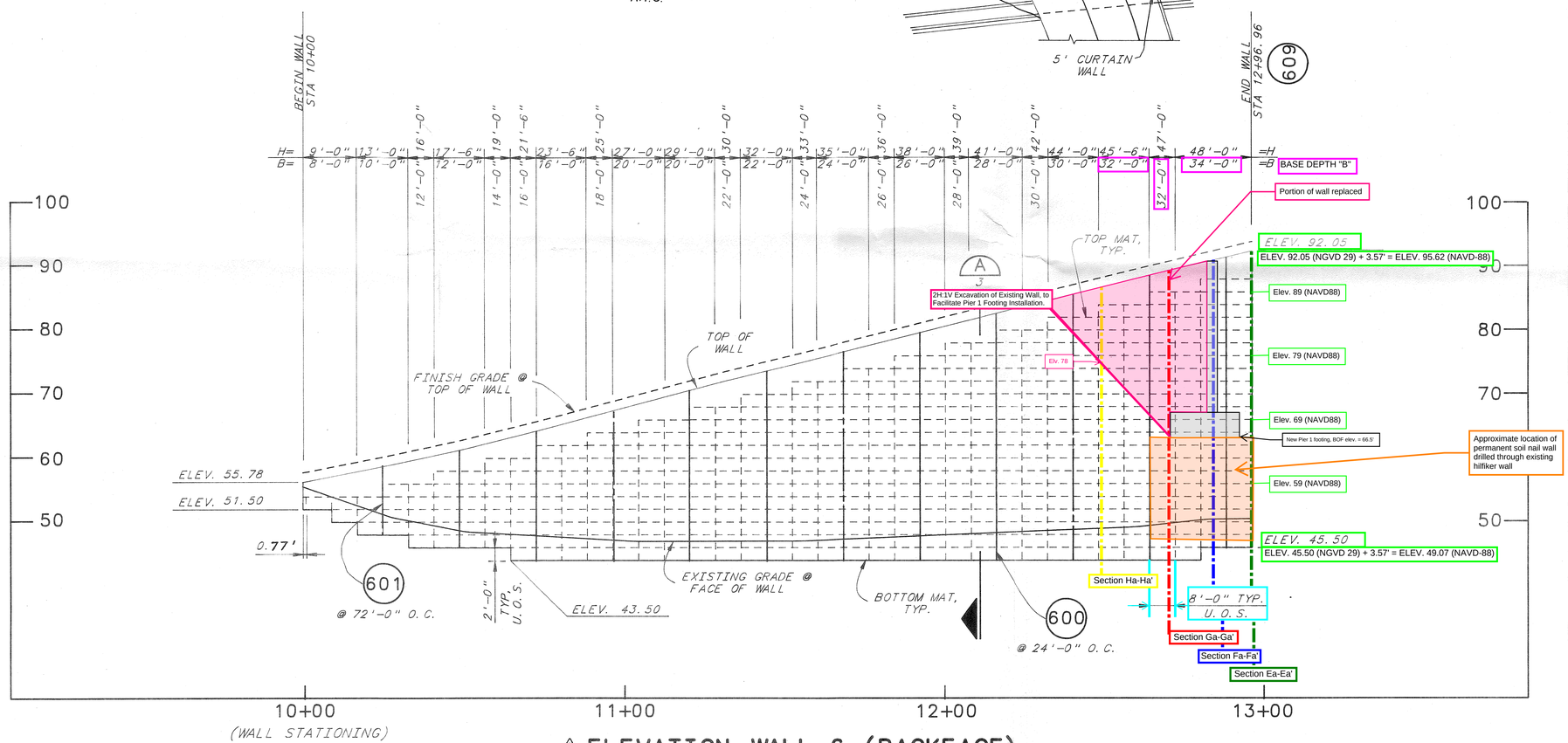
N.T.S.

CURVE DATA

	R LINE	N LINE
P.I. STATION	14+88.89	13+75.85
△	84°34'41" RT.	29°57'06" RT.
R	135.00'	195.00'
L	199.28'	101.94'
T	122.79'	52.16'
S	.04'/FT	LEVEL
BK. TAN	N52°32'26"E	N60°44'42"E

TOP OF WALL 6

STATION	ELEVATION
10+00	55.78
10+25	58.23
10+50	60.88
10+76.67	64.22
11+00	67.35
11+32.11	71.63
11+55.14	74.44
12+70.30	88.82
12+96.96	92.05



⚠ ELEVATION–WALL 6 (BACKFACE)

SCALE: HORIZ. ....1"=20'
VERT. .....1"=10'

8644 FT² WALL FACE*
U.O.S. =UNLESS OTHERWISE STATED
*(BOTTOM MAT TO TOP OF WALL)

THE DESIGN CONTAINED ON THESE DRAWINGS IS BASED ON INFORMATION PROVIDED BY THE OWNER. ON THE BASIS OF THIS INFORMATION, THE HILFIKER COMPANY HAS DESIGNED, AND IS RESPONSIBLE FOR THE INTERNAL STABILITY OF THE STRUCTURE ONLY. EXTERNAL STABILITY, INCLUDING FOUNDATION AND SLOPE STABILITY, IS THE RESPONSIBILITY OF THE OWNER.

SHN
SELVAGE • HEBER • NELSON & ASSOCIATES
CONSULTING ENGINEERS (707) 444-0427
2630 HARRISON AVE. EUREKA, CA., 95501

E.R.S.
HILFIKER RETAINING WALLS
(707) 443-5093 P.O. BOX 2012
EUREKA, CALIFORNIA 95502-2012

DRAWN R. WALKER				
CHECKED T. LARK/J. NELSON				
PROJ. ENGR.				
DIST. ADM.	9/90	⚠ REVISED PER INCA REVIEW	T.L.	
	DATE	REVISION	BY	APP'D

REGION NO.	STATE	FED. AID PROJ. NO.	SHEET NO.	TOTAL SHEETS
10	WASH.			
JOB NUMBER				
CONTRACT NO.				

HILFIKER RETAINING WALLS

Figure D.1-3

RETAINING WALL 6

SHEET OF SHEETS

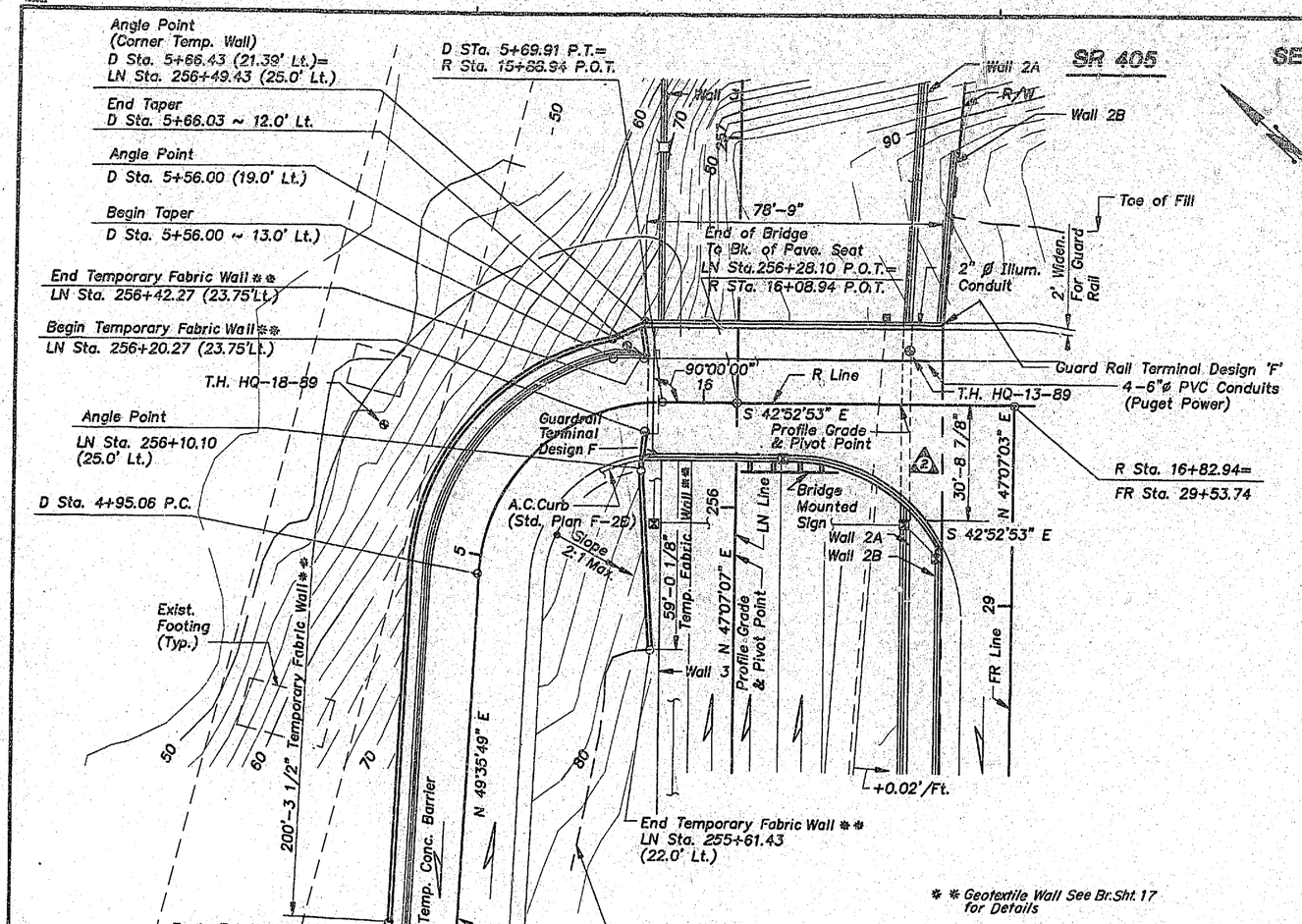
CAD FILE: 90131S2[G0]

FLATIRON | LANE | wood.

In Association with

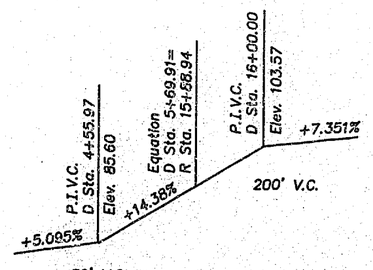
Appendix D.2
Existing Bridge 17.7 As-Built Plan Markup

135062

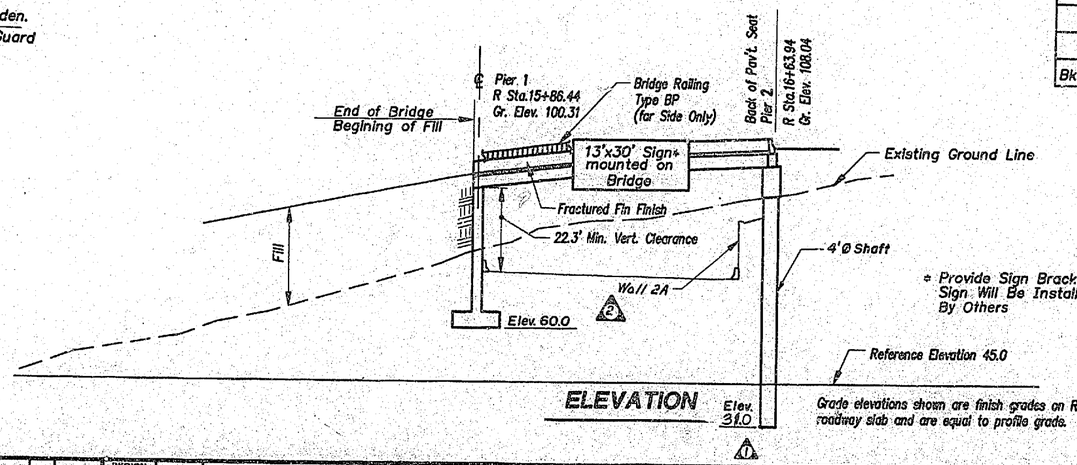


** Geotextile Wall See Br.Sht. 17 for Details

PLAN



D LINE / R LINE PROFILE



ELEVATION

* Provide Sign Bracket. Sign Will Be Installed By Others

Grade elevations shown are finish grades on R Line at top of roadway slab and are equal to profile grade.

SECTION 17, T 23 N, R 5 E, W.M.
CITY OF RENTON

R LINE CURVE DATA

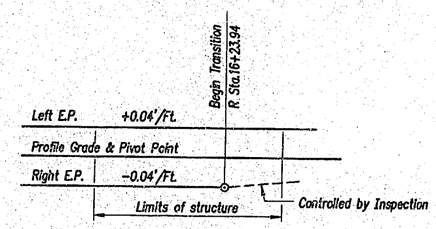
	R line
P.I. Station	Sta.17+56.47
Δ	44°18'38" Rt.
R	135.00'
L	104.40'
T	54.97'
S	0.04'/Ft.
Bk. Tangent	S 42°52'53" E

ROADWAY ELEVATION AT SOUTH CURB LINE

R Station	Offset Rt.	Elevation
16+23.94	14.00'	103.75
16+34.84	15.34'	104.78
16+44.04	18.74'	105.56
16+52.40	24.14'	106.23
16+59.36	31.24'	106.76
16+64.61	39.74'	107.12
16+67.85	49.14'	107.14

R LINE - SOUTH CURB LINE CURVE DATA

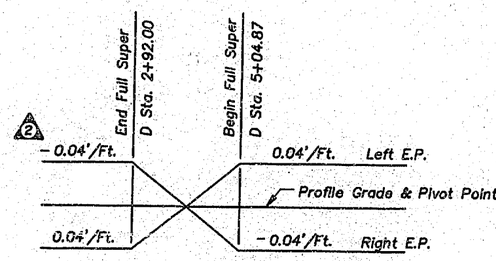
PC Sta.	Δ	R	L	T
R Sta.16+23.94	89°59'56" Rt.	45.00'	70.69'	45.00'



R LINE SUPERELEVATION

D LINE CURVE DATA

P.I. Station	5+41.99
Δ	87°31'18" Rt.
R	49.00'
L	74.85'
T	46.93'
S	0.04'/Ft.
Bk. Tangent	N49°35'49"E



D LINE SUPERELEVATION

LEGEND: (B/15) Identifies Section, View or Detail — Taken or shown on Bridge Sheet 15

(B/—) Used where Section, View or Detail is taken and shown on the same sheet.

Structural Design Approved
By
Bridge & Structures Branch
7/20

C.I.P. CONCRETE BOX GIRDER

GENERAL NOTES

1. ALL MATERIAL AND WORK SHALL BE IN ACCORDANCE WITH THE REQUIREMENTS OF THE STATE OF WASHINGTON, DEPARTMENT OF TRANSPORTATION, STANDARD SPECIFICATIONS FOR ROAD, BRIDGE AND MUNICIPAL CONSTRUCTION, 1988. THIS STRUCTURE HAS BEEN DESIGNED IN ACCORDANCE WITH THE REQUIREMENTS FOR LOAD FACTOR DESIGN, OF 1989 AASHTO STANDARD SPECIFICATIONS FOR HIGHWAY BRIDGES, FOURTEENTH EDITION AND APPLICABLE REQUIREMENTS OF AASHTO GUIDE SPECIFICATIONS FOR SEISMIC DESIGN OF HIGHWAY BRIDGES.
2. LOADING: HS20 OR TWO 24^{k} AXLE AT 4 FT. CENTERS
3. CONCRETE STRENGTH:
   - A. TRAFFIC BARRIERS — CLASS 4000
   - B. SUPERSTRUCTURE — CLASS 5000
   - C. DRILLED SHAFTS — CLASS 4000 OR CLASS 4000W IF PLACED UNDERWATER
   - D. DRILLED SHAFTS LEAN CONCRETE — (SEE SPECIFICATIONS)
   - E. ALL OTHERS — CLASS 4000
4. UNLESS OTHERWISE SHOWN ON THE PLANS, CONCRETE COVER MEASURED FROM THE FACE OF THE CONCRETE TO THE FACE OF ANY REINFORCEMENT BAR SHALL BE AS FOLLOWS:
   - A. 1) TOP SLAB — TOP 2-1/2 INCHES; BOTTOM 1 INCH
   - 2) BOTTOM SLAB — TOP 1 INCH; BOTTOM 1 INCH
   - 3) WEB 1-1/2 INCHES
   - B. CONCRETE EXPOSED TO EARTH OR WEATHER (SIDES AND TOPS):
     - 1) PRIMARY REINFORCEMENT 2 INCHES
     - 2) SECONDARY REINFORCEMENT (STIRRUPS AND TIES) 1-1/2 INCHES
   - C. CONCRETE CAST AGAINST EARTH (BOTTOM) 3 INCHES
5. FOOTING ELEVATIONS AND SUBSTRUCTURE DETAILS ARE SUBJECT TO CHANGE DEPENDING UPON FOUNDATION MATERIAL ENCOUNTERED. REINFORCING STEEL FOR THE FOOTINGS, COLUMNS AND ABUTMENT WALLS SHALL NOT BE CUT UNTIL FINAL FOOTING ELEVATIONS HAVE BEEN DETERMINED IN THE FIELD AND SUBSTRUCTURE DETAILS HAVE BEEN MODIFIED AS REQUIRED.
6. FALSEWORK SHALL NOT BE RELEASED UNTIL ALL CONCRETE, EXCEPT THAT IN THE TRAFFIC BARRIER, HAS BEEN IN PLACE THE REQUIRED LENGTH OF TIME AND HAS DEVELOPED SUFFICIENT STRENGTH AS OUTLINED IN THE SPECIFICATIONS. FALSEWORK SHALL BE CAREFULLY RELEASED TO PREVENT IMPACT OF UNDUE STRESSES IN THE STRUCTURE. THE TRAFFIC BARRIER SHALL NOT BE POURED UNTIL THE FALSEWORK HAS BEEN RELEASED FOR THE ENTIRE BRIDGE.
7. SHAFT SPIRALS MAY BE #5 DEFORMED BARS, 5/8" DIAMETER PLAIN BARS, OR W31 COLD DRAWN WIRE.
8. FOUNDATION CAPACITY AT PIER 2 = 4 TONS PER SQUARE FOOT.

DATUM

Nat'l. Geod. Vert. Datum of 1929

DATE	REVISION	BY	APP'D
10-6-90	(2) Added Note, Revised Number	MRW	
9-7-90	(1) Revised Shaft Elev.	KTS	JT
9-3-90	Del. "2-2"ø PVC Conduit"		

REGION NO.	STATE	FED. AID PROJ. NO.	SHEET NO.	TOTAL SHEETS
10	WASH	ACI-405-3(780)		

JOB NUMBER 90W069
CONTRACT NO. 2854

APPROVED

DOT FORM 221-012 Revised 10/83

Washington State Department of Transportation
INCA ENGINEERS INC.

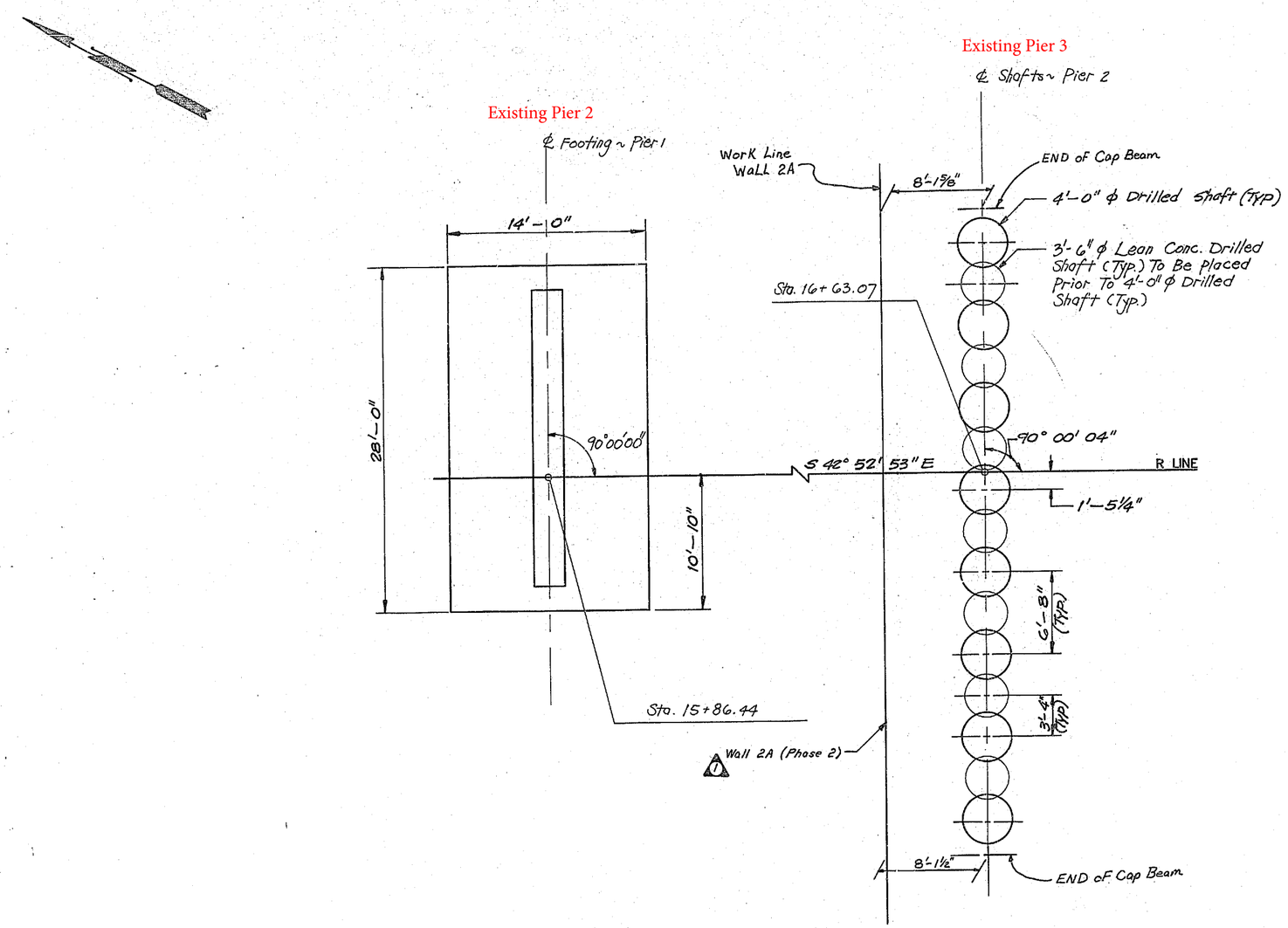
SR 405
TUKWILA TO SUNSET BLVD
CEDAR RIVER PIPELINES-RELOCATION
RENTON AVENUE U'XING 405/17B

RENTON AVE. S. U-XING BRIDGE LAYOUT

SHEET 1
SHEETS 268 OF 317

SR 405/131

200/24



SEQUENCE OF CONSTRUCTION

PHASE 1

1) CONSTRUCT PIER 1 & 2.
2) CONSTRUCT SUPERSTRUCTURE.
3) CONSTRUCT TEMPORARY APPROACH AT PIER 1.
4) EXCAVATE FOR LN LINE ROADWAY.

PHASE 2

5) CONSTRUCT WALL 2A UNDER BRIDGE. 1

FOUNDATION LAYOUT

DRAWN	P. Lee				REGION NO.	STATE	FED. AID PROJ. NO.	SHEET NO.	TOTAL SHEETS	
DESIGN	K. Pirbazari				10	WASH	ACI-405-3(780)			
CHECK	K. Pirbazari				JOB NUMBER 90W069					
PROJ. ENGR.										
DIST. ADM.		10-6-90	1 Added Wall 2A To Sequence	MRW	CONTRACT NO. 3854					
		DATE	REVISION	BY	APP'D					

APPROVED

Washington State Department of Transportation

INCA ENGINEERS, INC.

SR 405
TUKWILA TO SUNSET BLVD
CEDAR RIVER PIPELINES-RELOCATION
RENTON AVENUE U'XING 405/17B

FDN. LAYOUT CONSTR. SEQUENCE

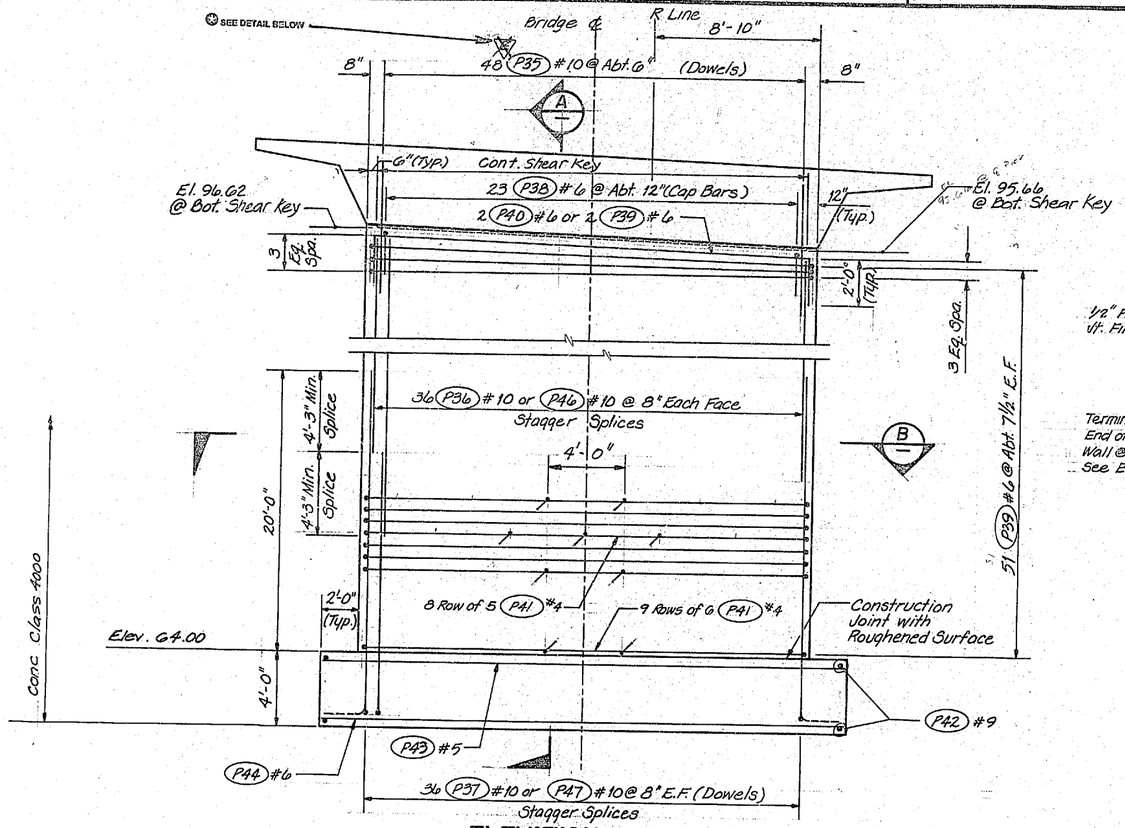
2

SHEET 269 OF 317 SHEETS

200/23

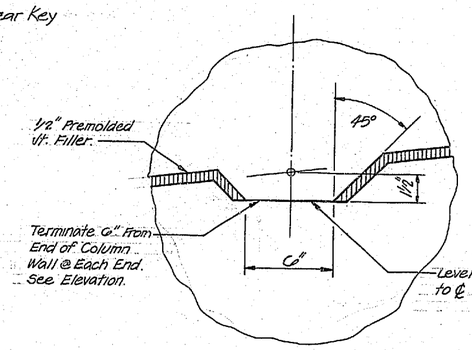
SR 405/131

DOT FORM 221-012
Revised 10/83

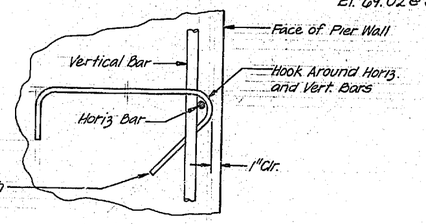


ELEVATION

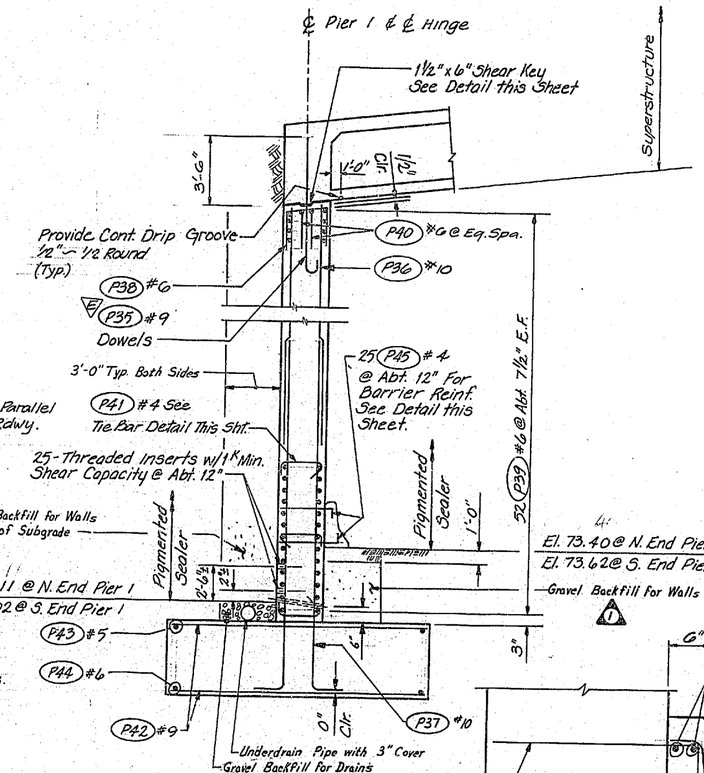
Looking Forward on Stations.
All Dimensions and Elevations at ℄ Pier



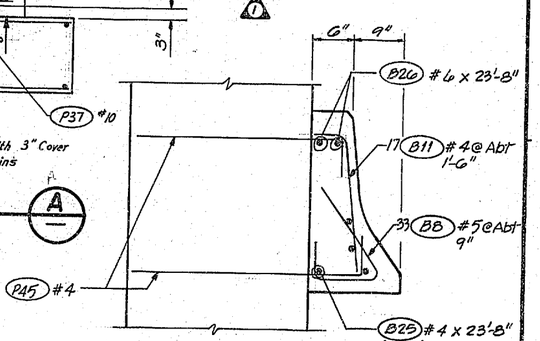
SHEAR KEY DETAIL



TIE BAR DETAIL

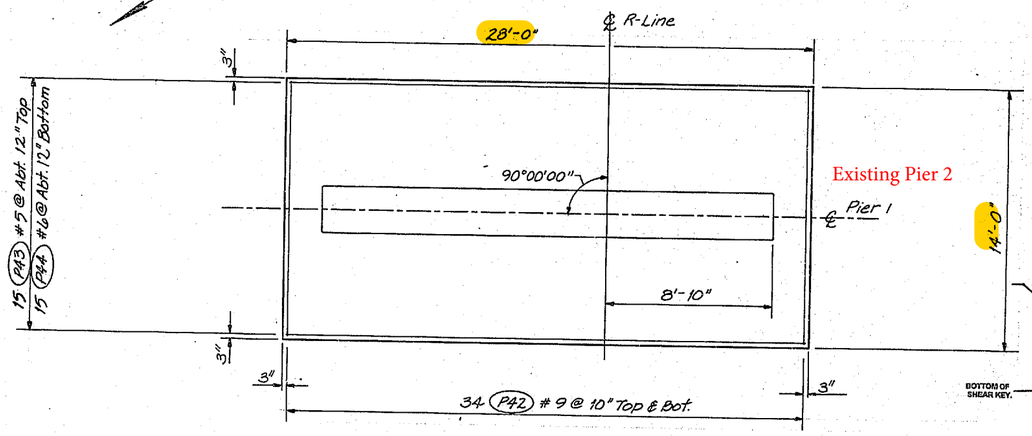


SECTION A

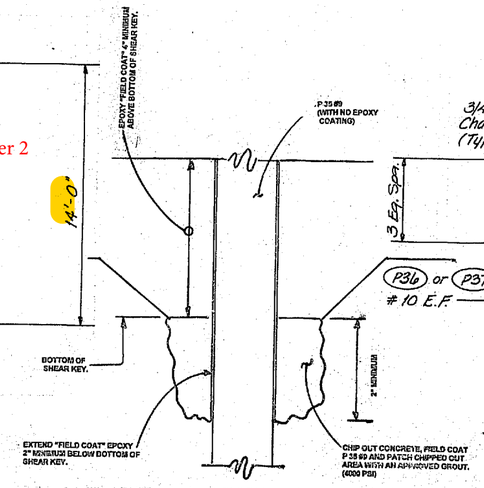


BARRIER DETAIL

For Dimensions, Reinforcing, and Bar Lengths See Bridge Sheet 13

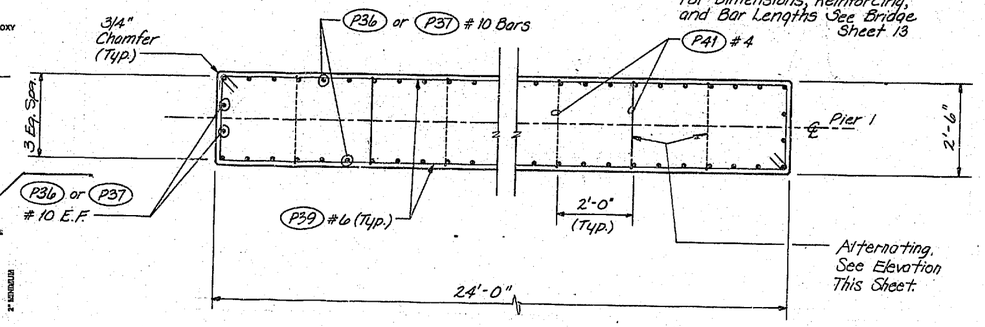


FOOTING PLAN



BAR NO. P 35, EPOXY COATING REPAIR PROCEDURE DETAIL A

NO SCALE



SECTION B

AS BUILT CHANGES 7/2/07

DRAWN	T. Bant					REGION NO.	STATE	FED. AID PROJ. NO.	SHEET NO.	TOTAL SHEETS
DESIGN	L. Pierce					10	WASH	ACI-405-3(780)		
CHECK	K. Pirbazari					JOB NUMBER				
PROJ. ENGR.						90W069				
DIST. ADM.		10-8-90	1	Added Drainage Detail	HPR	CONTRACT NO.				
		DATE		REVISION	BY APP'D	3854				

APPROVED

Washington State Department of Transportation

INCA ENGINEERS INC.

SR 405
TUKWILA TO SUNSET BLVD
CEDAR RIVER PIPELINES-RELOCATION
RENTON AVENUE U'XING 405/175

PIER 1

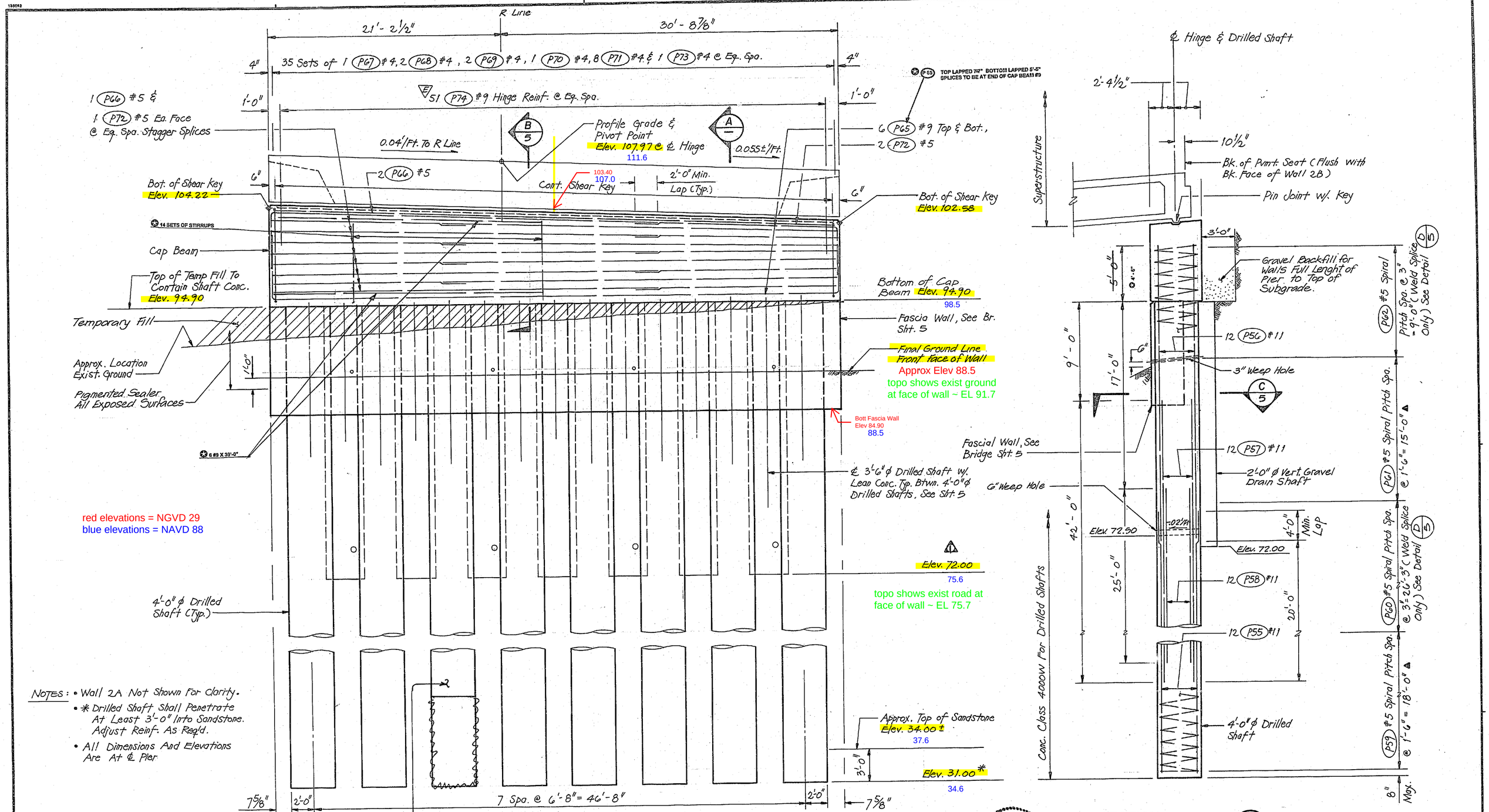
3

SHEET 270 OF 317 SHEETS

200/22

DOT FORM 221-012 Revised 10/83

SR 405/131



NOTES:
- Wall 2A Not Shown For Clarity.
- * Drilled Shaft Shall Penetrate At Least 3'-0" Into Sandstone. Adjust Reinf. As Req'd.
- All Dimensions And Elevations Are At ℄ Pier

ELEVATION - PIER 2

(Looking Ahead On Station)
Top of CapBeam Follows the Roadway Slab Slope.

SECTION A

Cap Beam Reinf. Not Shown For Clarity

NOTE: Either Lap or Weld Splice May Be Used In This Region, See Either Section C/5 Or Detail D/5.

AS BUILT CHANGES 7/2/97

DRAWN	P. Lee				
DESIGN	J. King				
CHECK	K. Pirbazari				
PROJ. ENGR.					
DIST. ADM.	9-7-90	1 Revised Elev.	RTS	CK	
	DATE	REVISION	BY	APP'D	

REGION NO.	STATE	FED. AID PROJ. NO.	SHEET NO.	TOTAL SHEETS
10	WASH	ACI-405-3(780)		

JOB NUMBER 90W069
CONTRACT NO. 3854

APPROVED

Washington State Department of Transportation
INCA ENGINEERS INC.

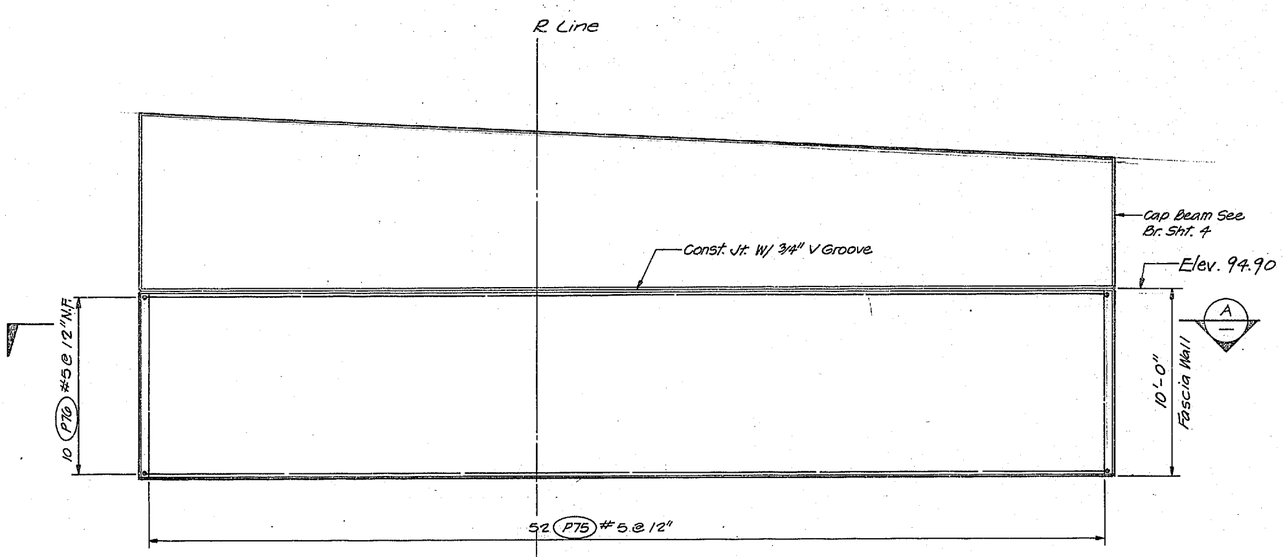
SR 405
TUKWILA TO SUNSET BLVD
CEDAR RIVER PIPELINES-RELOCATION
RENTON AVENUE U'XING 405/17B

PIER 2

4
SHEET 271 OF 317 SHEETS

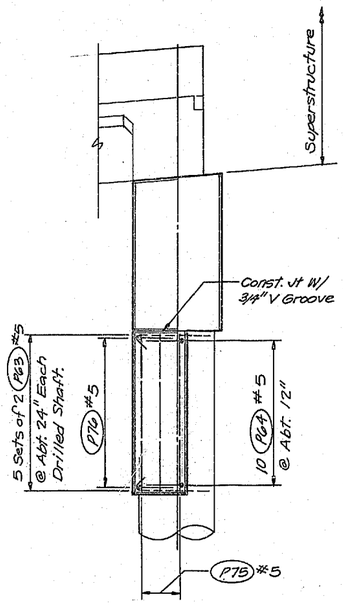
DOT FORM 221-012 Revised 10/83

SR 405/131



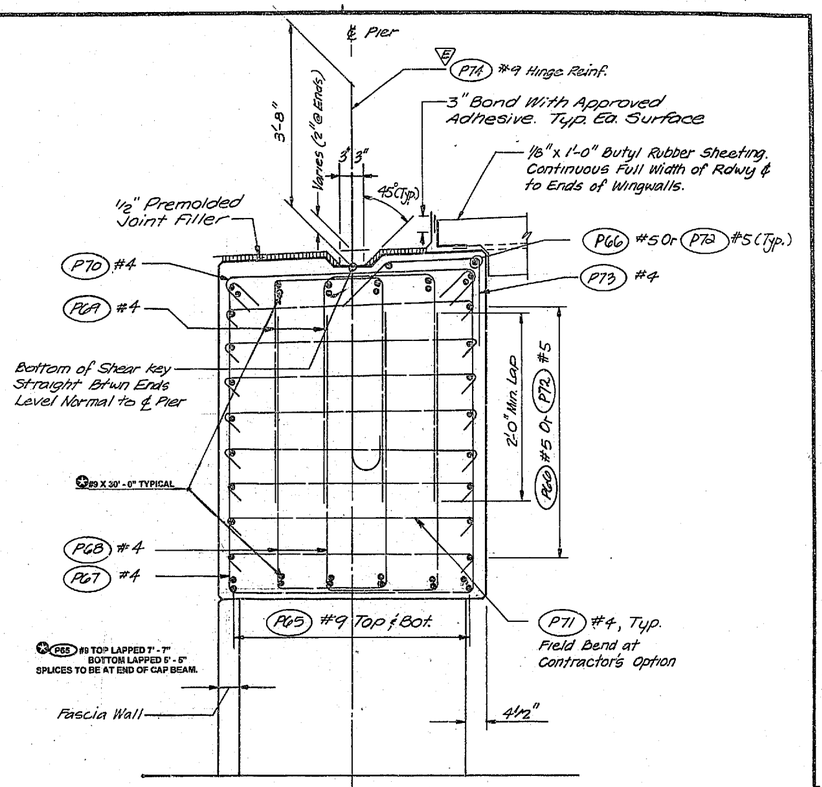
FRONT ELEVATION

Fascia Wall Only

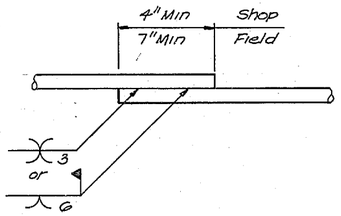


SOUTH ELEVATION

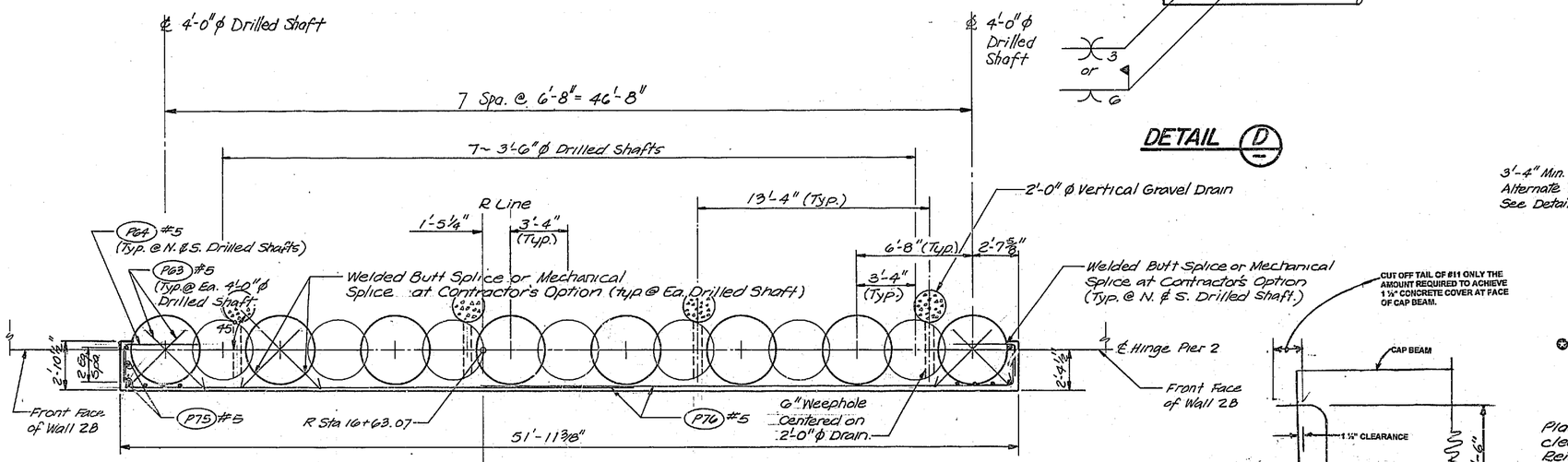
Fascia Wall Only. North Elevation Similar and Opposite Hand.



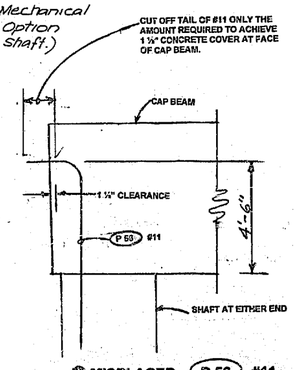
SECTION (B/4)



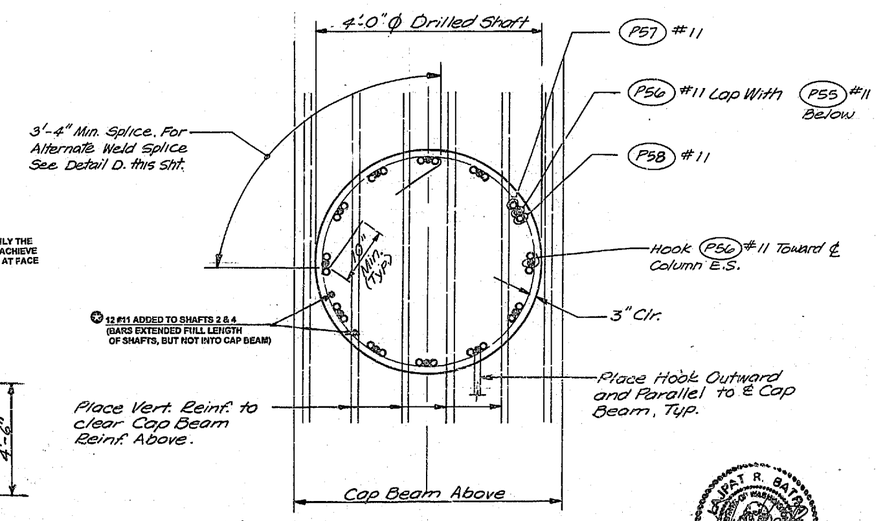
DETAIL (D)



SECTION (A/—)



MISPLACED (P56) #11



SECTION (C/4)

AS BUILT CHANGES 7/2/97

DRAWN	T. Bant				REGION NO.	STATE	FED. AID PROJ. NO.	SHEET NO.	TOTAL SHEETS
DESIGN	J. King				10	WASH	ACI-405-3(780)		
CHECK	K. Pirbazari				JOB NUMBER				
PROJ. ENGR.					90W069				
DIST. ADM.					CONTRACT NO.				
	DATE	REVISION	BY	APP'D	3854				

APPROVED

Washington State Department of Transportation

SR 405
TUKWILA TO SUNSET BLVD
CEDAR RIVER PIPELINES-RELOCATION
RENTON AVENUE U'XING 405/173

PIER 2 WALL & DETAILS

5

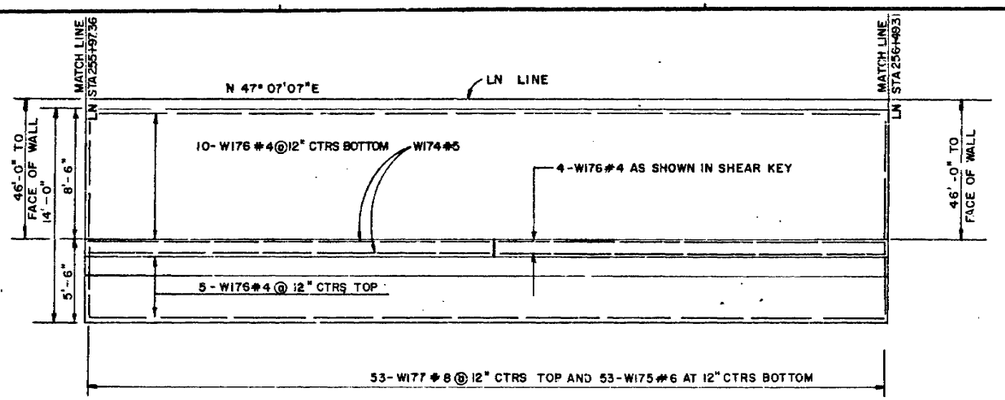
SHEET 272 OF 317 SHEETS

DOT FORM 221-012 Revised 10/83

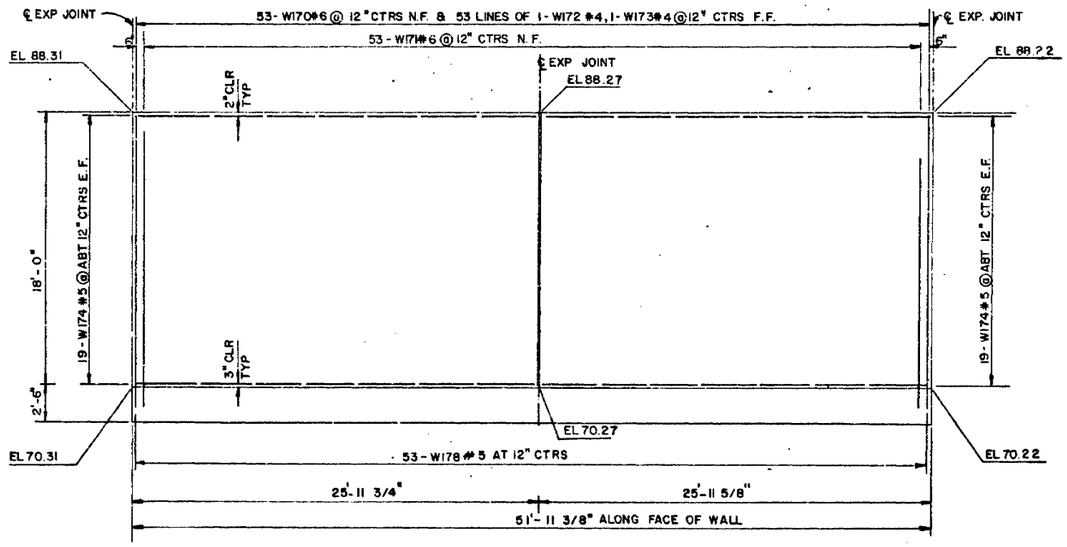
SR 405/131

200/20

Existing CIP Wall at Pier 3



WALL 2A SEGMENT R PLAN



WALL 2A SEGMENT R ELEVATION

NOTES
N.F. DENOTES NEAR FACE
E.F. DENOTES EACH FACE
F.F. DENOTES FAR FACE
FOR EXPANSION JOINT DETAIL SEE A/W36

FOR "AS CONSTRUCTED PLANS" ONLY

L-7974
SR-405 KING COUNTY
CEDAR RIVER PIPE LINES RELOCATIONS
CS 1743
PLAN & ELEVATION SEGMENT R
SHEET 1 OF 1

DRAWN	TAB/OL/TL				REGION NO. 10	STATE WASH	FED. AID PROJ. NO. ACI-405-3(780)	SHEET NO.	TOTAL SHEETS	HIGHWAY DIVISION
CHECKED	DR/SJ/RGD				JOB NUMBER 90W069					
PROJ. ENGR.	J.E. JOHNSON				CONTRACT NO. 3854					APPROVED
DIST. ADM.	R.Q. ANDERSON	DATE	REVISION	BY	APP'D					

Washington State Department of Transportation

SR 405
TUKWILA TO SUNSET BLVD
CEDAR RIVER PIPELINES - RELOCATION

PLAN & ELEVATION
WALL 2A SEGMENT R

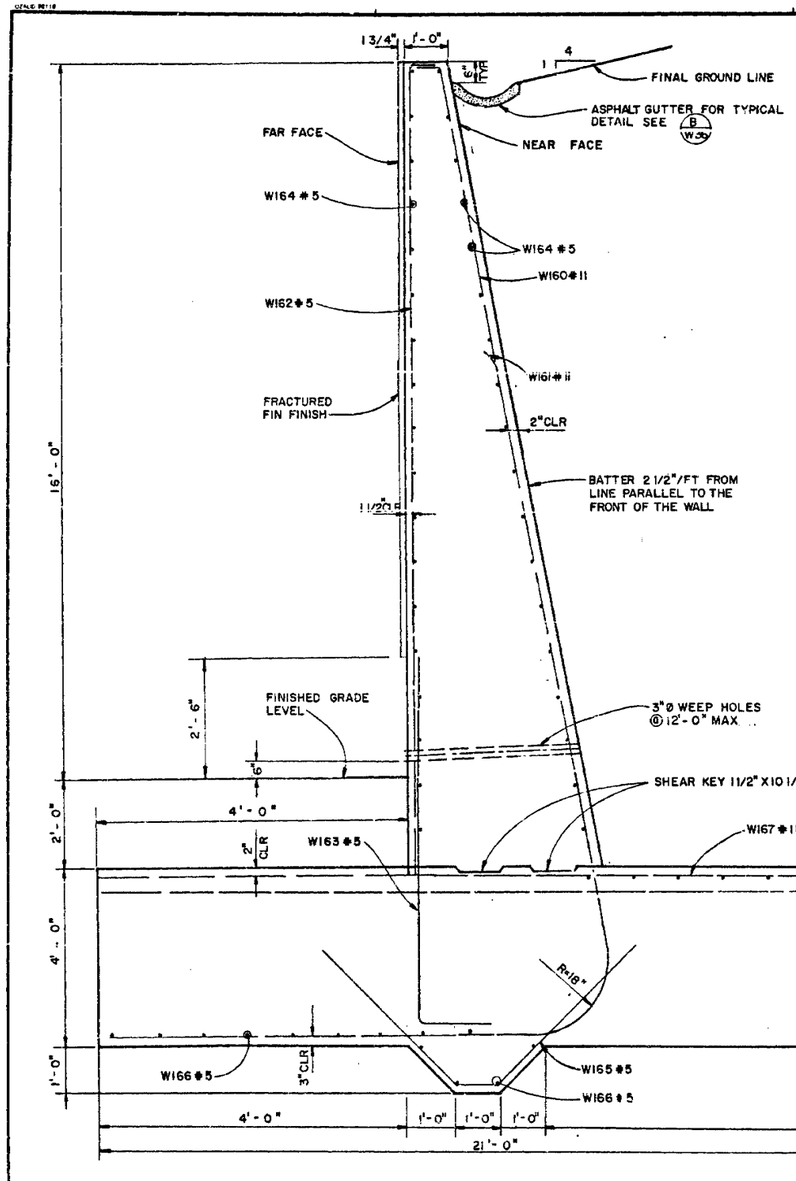
W30

SHEET 181 OF 317 SHEETS

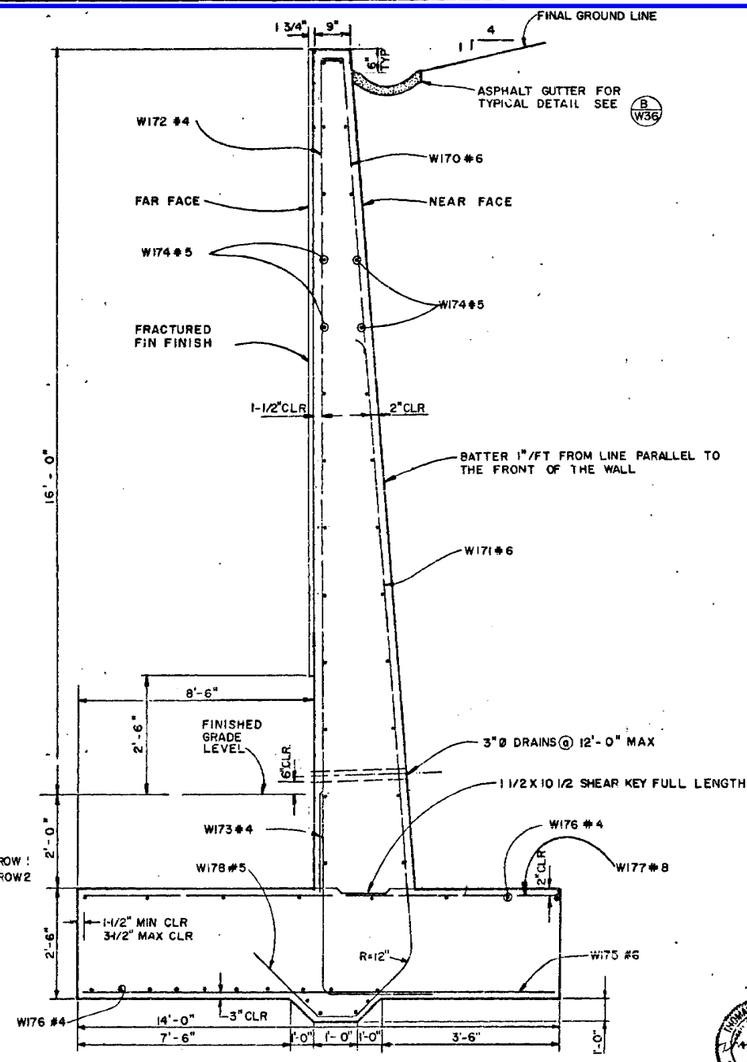
DOT FORM 221-011 Revised 9/82

SR405/131

Existing CIP Wall at Pier 3



Q W29 TYPICAL SECTION SEGMENT Q
LN STA 255+50 TO LN STA 255+97.00



R W30 TYPICAL SECTION SEGMENT R
LN STA 255+97.00 TO 256+49.31

FOR "AS CONSTRUCTED PLANS" ONLY

DRAWN JL/PK/TAB				REGION NO. 10	STATE WASH	FED. AID PROJ. NO. ACI-405-3(790)	SHEET NO.	TOTAL SHEETS	HIGHWAY DIVISION
CHECKED DR/SJ/RGD				JOB NUMBER 90W069					
PROJ. ENGR. J.E. JOHNSON	12-10-90	Rev Reinforc. Steel in Footing Detail R		CONTRACT NO. 3854					APPROVED
DIST. ADM. R.Q. ANDERSON	9-1-90	REV. LEADER LINE W171 # 8	C.L.						
	DATE	REVISION	BY APP'D						

Washington State Department of Transportation

SR 405
TUKWILA TO SUNSET BLVD
CEDAR RIVER PIPELINES - RELOCATION

W37

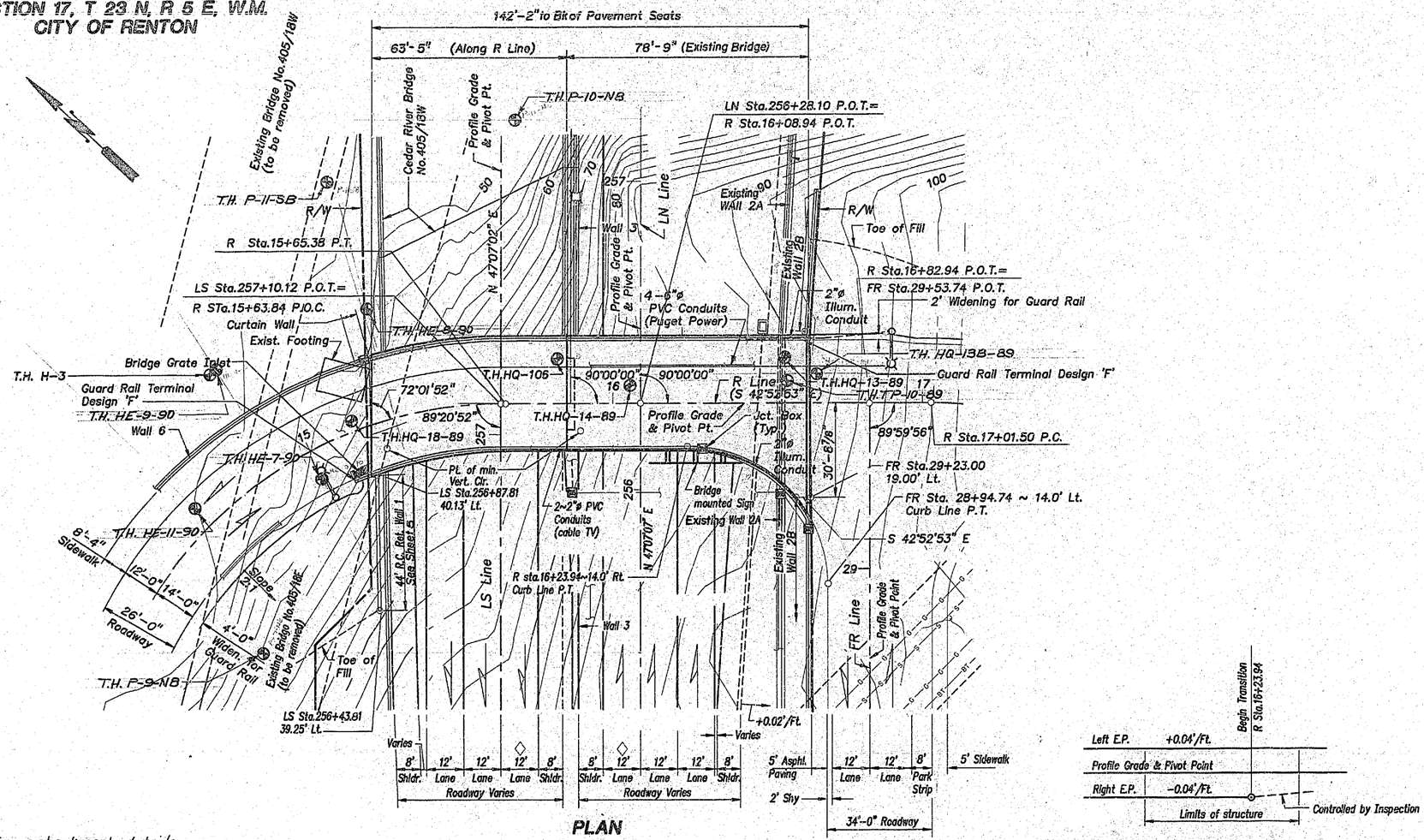
TYPICAL SECTIONS
WALL 2A SEGMENTS Q & R

SHEET 188 OF 317 SHEETS

DOT FORM 221-011 Revised 9/82

SR405/131

SECTION 17, T 23 N, R 5 E, W.M.
CITY OF RENTON

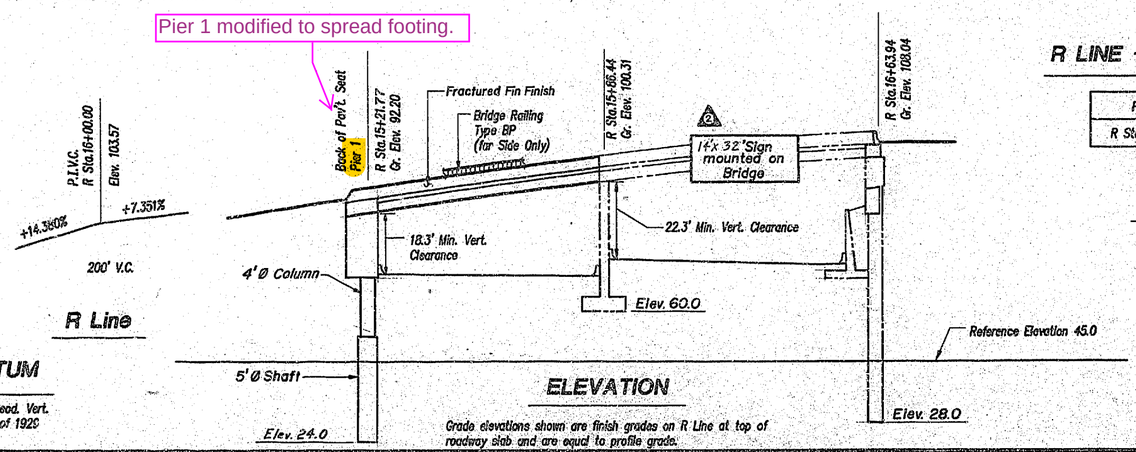


PLAN

For embankment details, see Standard Plan H-9.

R LINE SUPERELEVATION

Pier 1 modified to spread footing.



DATUM

Nat'l. Geod. Vert. Datum of 1929

ELEVATION

Grade elevations shown are finish grades on R Line at top of roadway slab and are equal to profile grade.

R LINE - SOUTH CURB LINE CURVE DATA

PC Sta.	Δ	R	L	T
R Sta.16+23.94	89°59'56" Rt.	45.00'	70.69'	45.00'

ROADWAY ELEVATION AT SOUTH CURB LINE

R Station	Offset Rt.	Elevation
16+23.94	14.00'	103.75
16+34.84	15.34'	105.19
16+44.04	18.74'	105.86
16+52.40	24.14'	106.39
16+59.36	31.24'	106.63
16+64.61	39.74'	106.66
16+67.85	49.14'	106.51

R LINE CURVE DATA

P.I. Station	R line Sta.14+88.89	R line Sta.17+56.47
Δ	84°34'41" Rt.	44°18'38" Rt.
R	135.00'	135.00'
L	199.28'	104.40'
T	122.79'	54.97'
S	0.04'/Ft.	0.04'/Ft.
Bk. Tangent	N 52°32'26" E	S 42°52'53" E

Structural Design Approved By Bridge & Structures Branch
Allen Wallen 10/13/89

JASRAT R. BATRA
REGISTERED PROFESSIONAL ENGINEER

GENERAL NOTES

1. ALL MATERIAL AND WORK SHALL BE IN ACCORDANCE WITH THE REQUIREMENTS OF THE STATE OF WASHINGTON, DEPARTMENT OF TRANSPORTATION, STANDARD SPECIFICATIONS FOR ROAD, BRIDGE AND MUNICIPAL CONSTRUCTION, 1991. THIS STRUCTURE HAS BEEN DESIGNED IN ACCORDANCE WITH THE REQUIREMENTS FOR LOAD FACTOR DESIGN, OF 1989 AASHTO STANDARD SPECIFICATIONS FOR HIGHWAY BRIDGES, FOURTEENTH EDITION AND APPLICABLE REQUIREMENTS OF AASHTO GUIDE SPECIFICATIONS FOR SEISMIC DESIGN OF HIGHWAY BRIDGES.
2. LOADING: HS20 OR TWO 24^k AXLE AT 4 FT. CENTERS
3. CONCRETE STRENGTH
   A. TRAFFIC BARRIERS — CLASS 4000
   B. SUPERSTRUCTURE — CLASS 5000
   C. DRILLED SHAFTS — CLASS 4000 OR CLASS 4000W IF PLACED UNDERWATER
   D. ALL OTHERS — CLASS 4000
4. UNLESS OTHERWISE SHOWN ON THE PLANS, CONCRETE COVER MEASURED FROM THE FACE OF THE CONCRETE TO THE FACE OF ANY REINFORCEMENT BAR SHALL BE AS FOLLOWS:
   A. 1) TOP SLAB - TOP 2-1/2 INCHES; BOTTOM 1 INCH
      2) BOTTOM SLAB - TOP 1 INCH; BOTTOM 1 INCH
      3) WEB 1-1/2 INCHES
   B. CONCRETE EXPOSED TO EARTH OR WEATHER (SIDES AND TOPS):
      1) PRIMARY REINFORCEMENT 2 INCHES
      2) SECONDARY REINFORCEMENT (STIRRUPS AND TIES) 1-1/2 INCHES
   C. CONCRETE CAST AGAINST EARTH (BOTTOM) 3 INCHES
5. FOOTING ELEVATIONS AND SUBSTRUCTURE DETAILS ARE SUBJECT TO CHANGE DEPENDING UPON FOUNDATION MATERIAL ENCOUNTERED. REINFORCING STEEL FOR THE FOOTINGS, COLUMNS AND ABUTMENT WALLS SHALL NOT BE CUT UNTIL FINAL FOOTING ELEVATIONS HAVE BEEN DETERMINED IN THE FIELD AND SUBSTRUCTURE DETAILS HAVE BEEN MODIFIED AS REQUIRED.
6. FALSEWORK SHALL NOT BE RELEASED UNTIL ALL CONCRETE, EXCEPT THAT IN THE TRAFFIC BARRIER, HAS BEEN IN PLACE THE REQUIRED LENGTH OF TIME AND HAS DEVELOPED SUFFICIENT STRENGTH AS OUTLINED IN THE SPECIFICATIONS. FALSEWORK SHALL BE CAREFULLY RELEASED TO PREVENT IMPACT OF UNDUE STRESSES IN THE STRUCTURE. THE TRAFFIC BARRIER SHALL NOT BE POURED UNTIL THE FALSEWORK HAS BEEN RELEASED FOR THE ENTIRE BRIDGE.
7. SHAFT SPIRALS MAY BE #5 DEFORMED BARS, 5/8" DIAMETER PLAIN BARS, OR W31 COLD DRAWN WIRE.
8. FOUNDATION CAPACITY AT PIER 2 = 4 TONS PER SQUARE FOOT.

DESIGN K. Pirbazari						
DRAWN P. Lee						
CHECKED K. Pirbazari						
PROJ. ENGR.	2/92	(2) Rev'd Size of Sign	RTS	MAC		
DIST. ADM.	10/89	(1) Added Borings	RDS	MAC		
	DATE	REVISION	BY	APP'D		

REGION NO.	STATE	FED. AID PROJ. NO.	SHEET NO.	TOTAL SHEETS
10	WASH			
JOB NUMBER 91W097		I-IR-405-3(783)		
CONTRACT NO. 405				

APPROVED

Washington State Department of Transportation
INCA ENGINEERS INC.

SR 405
SOUTH RENTON TO SUNSET BLVD. HOV
RENTON AVE. U'XING STAGE 2
405/17.7
RENTON AVE. S. U-XING BRIDGE LAYOUT

SHEET 328 OF 634 SHEETS

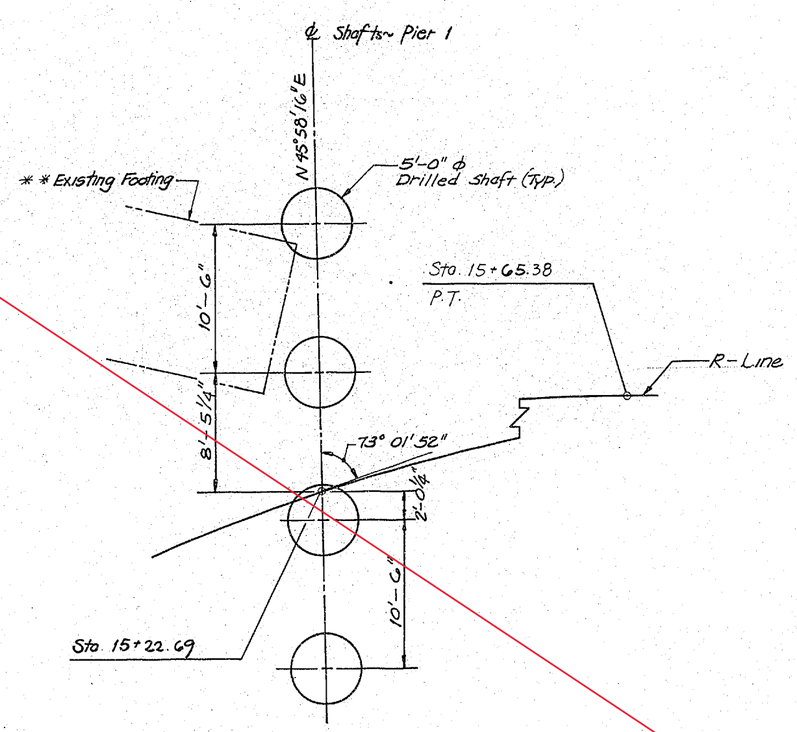
(1) SR 405 / 135

265/185

135082

CONSTRUCTION SEQUENCE

1) CONSTRUCT PIER 1.
2) CONSTRUCT SUPERSTRUCTURE (7 FT. DEPTH OF TEMPORARY APPROACH FILL MAY BE REMOVED TO FACILITATE CONSTRUCTION).
3) BACKFILL TO EL 65.5 AND CONSTRUCT 44.0' R.C. WALL AT SOUTHWEST CORNER OF BRIDGE.
4) CONSTRUCT WALL 6 AND APPROACH AT PIER 1.
5) EXCAVATE AND PLACE FILL AS REQUIRED FOR LS LINE ROADWAY.



FOUNDATION LAYOUT

** Drill Shaft Through Existing Footing Locate in Field.

THIS SHEET DELETED PER CHANGE ORDER NO. 158

AS BUILT CHANGES 10/8/97

DRAWN P. Lee					REGION NO. 10	STATE WASH	FED. AID PROJ. NO. I-IR-405-3(783)	SHEET NO.	TOTAL SHEETS	Washington State Department of Transportation
DESIGN K. Pirbazari					JOB NUMBER 91W097					INCA ENGINEERS INC.
CHECK K. Pirbazari					CONTRACT NO. 4052					APPROVED
PROJ. ENGR.										
DIST. ADM.										
	DATE	REVISION	BY	APP'D						

SR 405
SOUTH RENTON TO SUNSET BLVD. HOV
RENTON AVE. U'XING STAGE 2

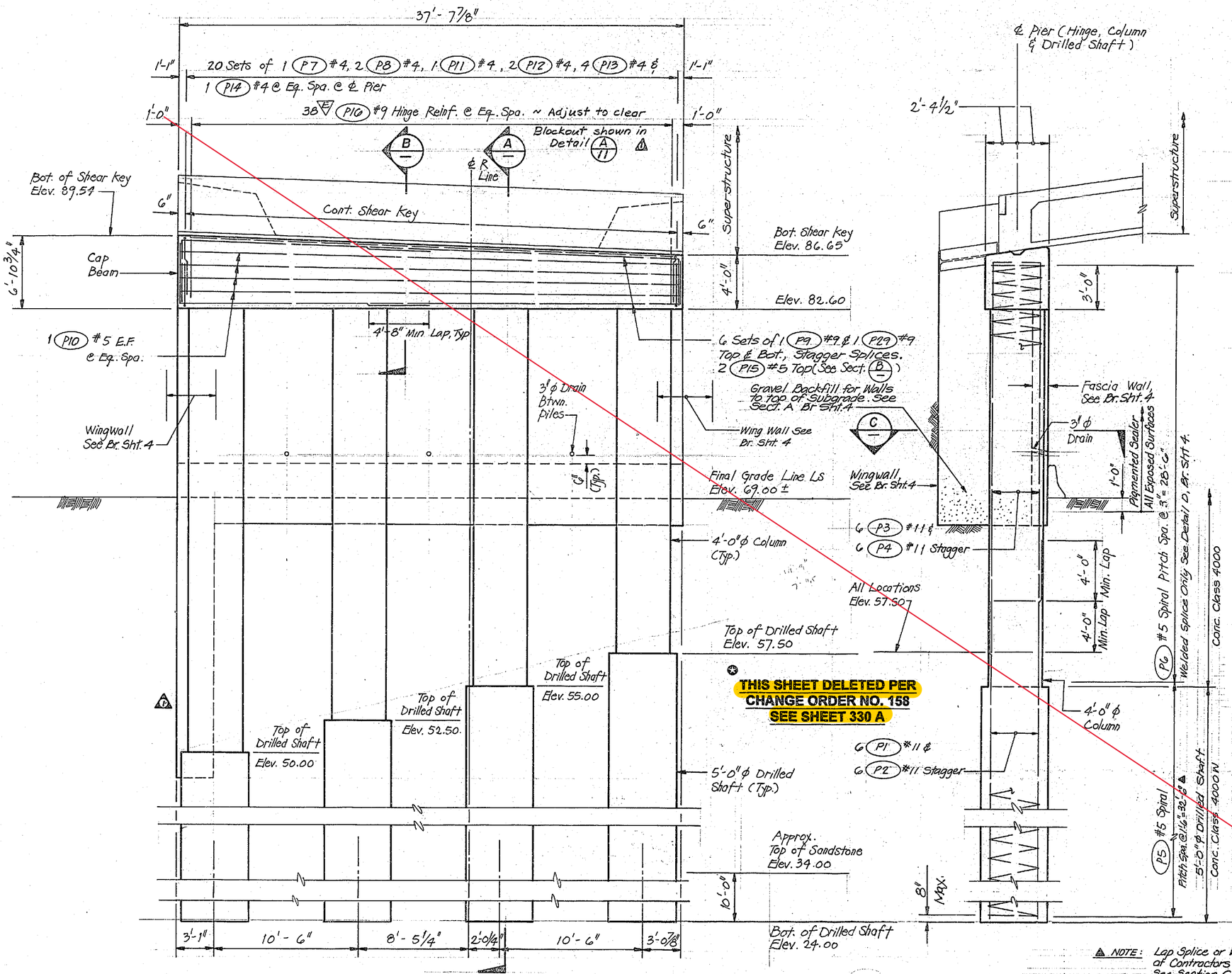
FDN. LAYOUT CONSTR. SEQUENCE

SHEET 2 OF 634 SHEETS

DOT FORM 221-012

SR 405/135

205/104



SECTION B

SECTION C

ELEVATION
(Looking Ahead On Station)
Wingwall Not Shown For Clarity

SECTION A
Cap Beam Reinf. Not Shown For Clarity

Note: All Dimensions And Elevations Are At ℄ Pier.

* = Drilled Shaft Shall Penetrate At Least 10'-0" Into Sandstone Adjust Reinf. As Req'd.

⚠ NOTE: Lap Splice or Welded Splice at Contractors Option See Section C this Sht and Detail D, Br. Sht 4.

Note: For Additional Dimensions & Details, See Br. Sht 4

✪ AS BUILT CHANGES 10/8/07

LAJPAT R. BATRA — REGISTERED PROFESSIONAL ENGINEER

DRAWN	P. Lee			REGION NO.	STATE	FED. AID PROJ. NO.	SHEET NO. / TOTAL SHEETS
DESIGN	J. King			10	WASH		
CHECK	K. Pirbazari			JOB NUMBER 91W097		I-IR-405-3(783)	
PROJ. ENGR.				CONTRACT NO. 4052			
DIST. ADM.							
	2/10/92	⚠ Added note, Extended North Wingwall	MML				
	DATE	REVISION	BY APP'D				

APPROVED

Washington State Department of Transportation

INCA ENGINEERS INC.

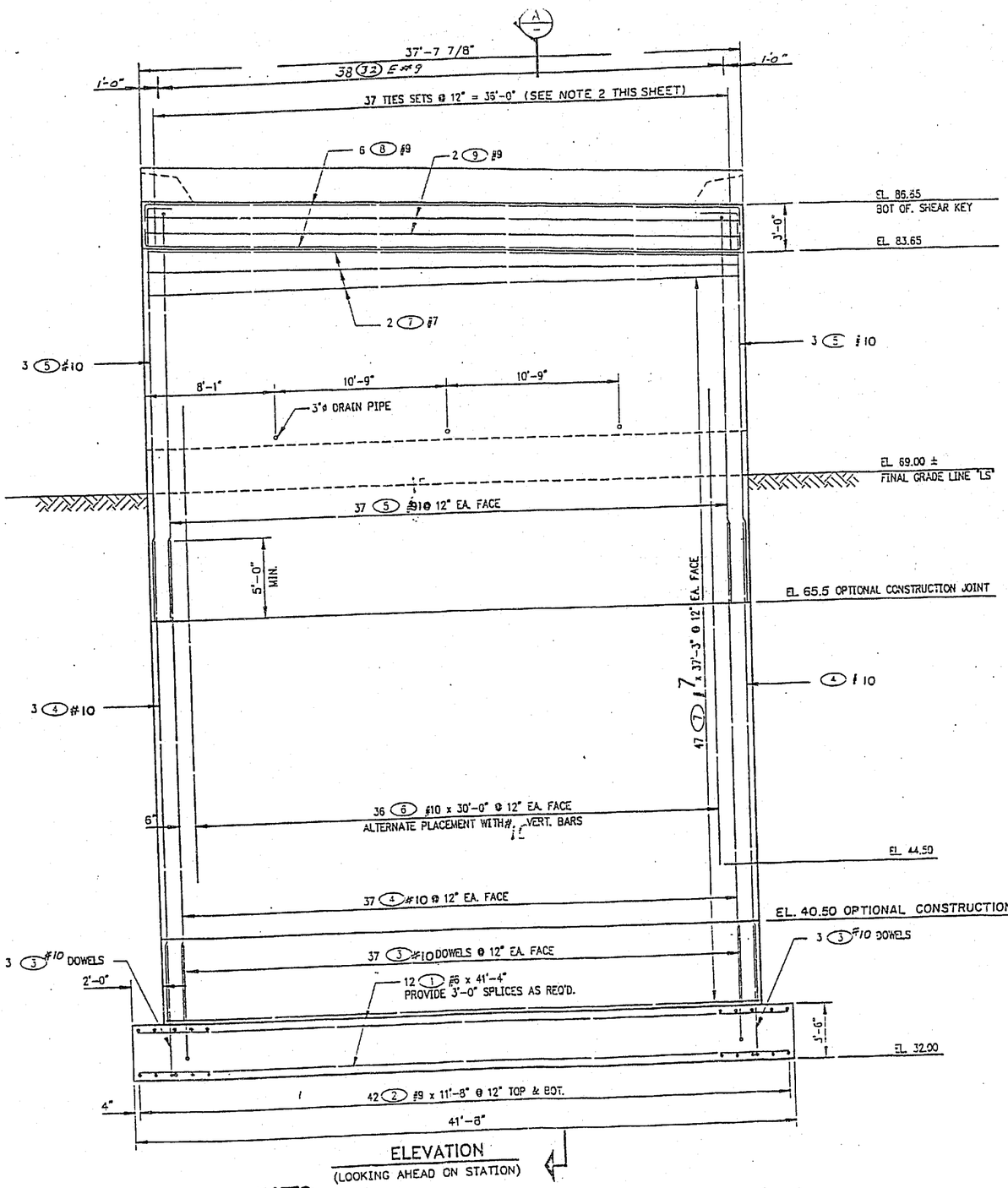
SR 405
SOUTH RENTON TO SUNSET BLVD. HOV
RENTON AVE. U'XING STAGE 2

PIER 1

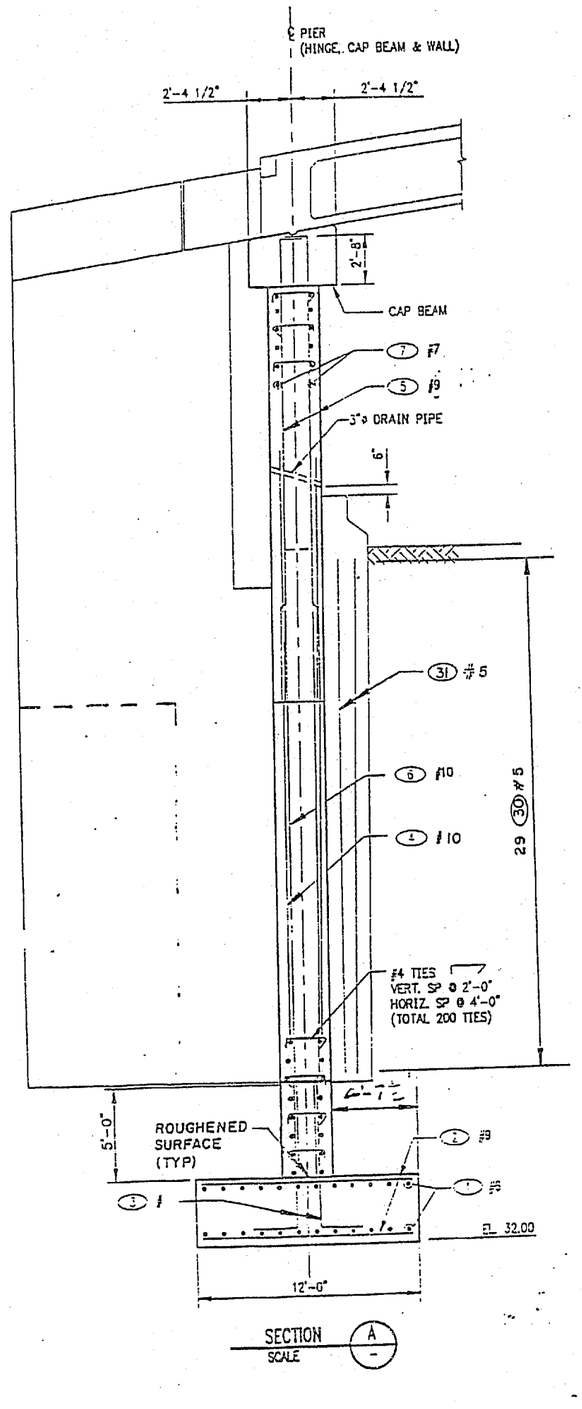
SHEET 3 — SHEET 330 OF 634 SHEETS

DOT FORM 221-012 Revised 10/83

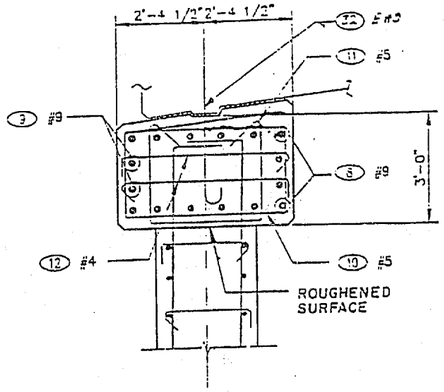
SR 405/135



ELEVATION
(LOOKING AHEAD ON STATION)



SECTION A
SCALE



CAP BEAM DETAIL

NOTES:

1. WING WALLS ARE NOT SHOWN FOR CLARITY.
2. EACH CAP BEAM TIE SET CONSISTS OF 1 (10) #5, 1 (11) #5 AND 2 (12) #4, TOTAL 4 BARS.
3. UNLESS OTHERWISE NOTED, ALL HOOKS SHALL BE 90°, 135° OR 180° STANDARD HOOKS.
4. SEE CONTRACT DRAWINGS FOR REMAINING DETAILS NOT SHOWN.

☆AS BUILT BY REGION™

3/4/94

SHEET 330A

PIER 1.

SOUTH RENTON TO SUNSET BLVD. HOV
RENTON AVE. INTG. STAGE 2

Approved By:

INCA ENGINEERS INC.
Bellevue, Washington

Drawn By T.C. Date 02-11-94
Designed By Date
Checked By W.L. Date 02-11-94
Approved By Date

Scale: Horiz. N/A Vert. N/A
Job No.

Sheet —

3-24-94 USRegion 1 added bar list, made corrected dims on REF drawings

EXPIRES 2/27/94

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Appendix D.3
Pier 1/Wall 03.63L Wave Scattering Calculations

Calculating Corrected PGA for Wave Scattering Effects

(Wall 03.63L)

Per the National Cooperative Highway Research Program (NCHRP) Report 611 the Peak Ground Acceleration (PGA) can be adjusted to account for variations in the average ground acceleration due to wave scattering behind tall retaining walls or slopes by applying a scaling factor (or alpha value) to the PGA.

For Wall 03.63L, we will be applying the Mid Spectral shape curve to calculate our alpha scaling factor. This was determined by using Figure 5-4 in Report 611 (see below) and comparing it to the spectral shape developed by the PSHA provided by Hart Crowser ("I-405 R2B Segment 1a Site Specific Hazard Analysis RFU" (released for use) dated March 25, 2021 [Submittal 1197]). At Wall 03.63L, the design seismic site class of C was selected.

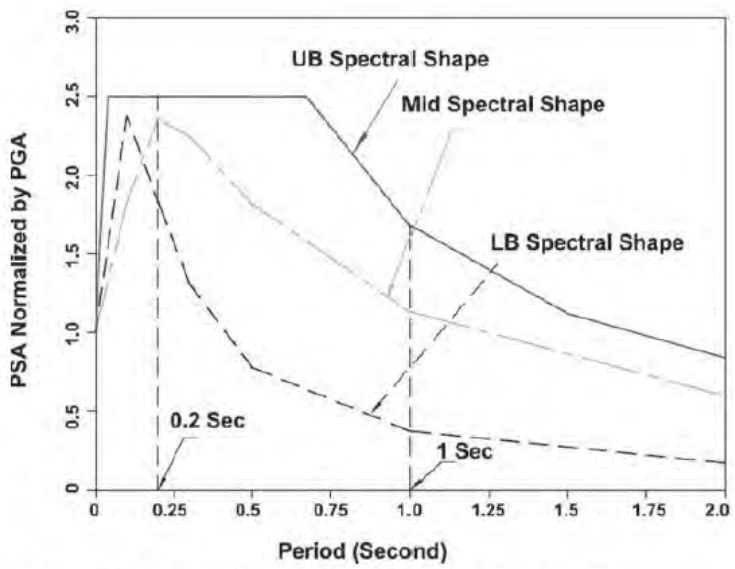

Figure 5-4. Spectral curve shapes adopted for further ground motion studies.

The alpha factor for global stability calculations is selected using the applicable design height. For global and compound analyses, the deisgn height consists of the veritcal height of the critical pseudo-static failure surface. For lateral earth pressure calculations, the design height consists of the vertical distance from the back of the bottom reinforcement layer to the ground surface.

Wall design heights for each analysed section of Wall 03.63L are presented below:

Section D-D' Final Condition

$H\_Wall_{global\_D\_Final} := 62\ ft$ — Height of failure surface for Wall 03.63L global stability pseudo-static analysis

Section Ea-Ea' Existing Condition

$H\_Wall_{global\_Ea\_Existing} := 66\ ft$ Height of failure surface for Wall 03.63L global stability pseudo-static analysis

$H\_Wall_{compound\_Ea\_Existing} := 54\ ft$ Height of failure surface for Wall 03.63L compound stability pseudo-static analysis

Section Ea-Ea' Final Condition

$H\_Wall_{global\_Ea\_Final} := 30.6\ ft$ Height of failure surface for Wall 03.63L global stability pseudo-static analysis

Section Fa-Fa' Existing Condition

$H\_Wall_{global\_Fa\_Existing} := 63\ ft$ Height of failure surface for Wall 03.63L global stability pseudo-static analysis

$H\_Wall_{compound\_Fa\_Existing} := 51.5\ ft$ Height of failure surface for Wall 03.63L compound stability pseudo-static analysis

Section Fa-Fa' Final Condition

$H\_Wall_{global\_Fa\_Final} := 60\ ft$ Height of failure surface for Wall 03.63L global stability pseudo-static analysis

$H\_Wall_{compound\_Fa\_Final} := 16.5\ ft$ Height of failure surface for Wall 03.63L compound stability pseudo-static analysis

Section Ga-Ga' Existing Condition

$H\_Wall_{global\_Ga\_Existing} := 60\ ft$ Height of failure surface for Wall 03.63L global stability pseudo-static analysis

$H\_Wall_{compound\_Ga\_Existing} := 43\ ft$ Height of failure surface for Wall 03.63L compound stability pseudo-static analysis

Section Ga-Ga' Final Condition

$H\_Wall_{global\_Ga\_Final} := 57.5\ ft$ Height of failure surface for Wall 03.63L global stability pseudo-static analysis

$H\_Wall_{compound\_Ga\_Final} := 27\ ft$ Height of failure surface for Wall 03.63L compound stability pseudo-static analysis

Section Ha-Ha' Existing Condition

$H\_Wall_{global\_Ha\_Existing} := 55\ ft$ Height of failure surface for Wall 03.63L global stability pseudo-static analysis

$H\_Wall_{compound\_Ha\_Existing} := 41\ ft$ Height of failure surface for Wall 03.63L compound stability pseudo-static analysis

Section Ha-Ha' Final Condition

$H\_Wall_{global\_Ha\_Final} := 55\ ft$ Height of failure surface for Wall 03.63L global stability pseudo-static analysis

$H\_Wall_{compound\_Ha\_Final} := 10.75\ ft$ Height of failure surface for Wall 03.63L global stability pseudo-static analysis

Using the slope and/or wall heights, the alpha scaling factor was selected from Figure 6-13

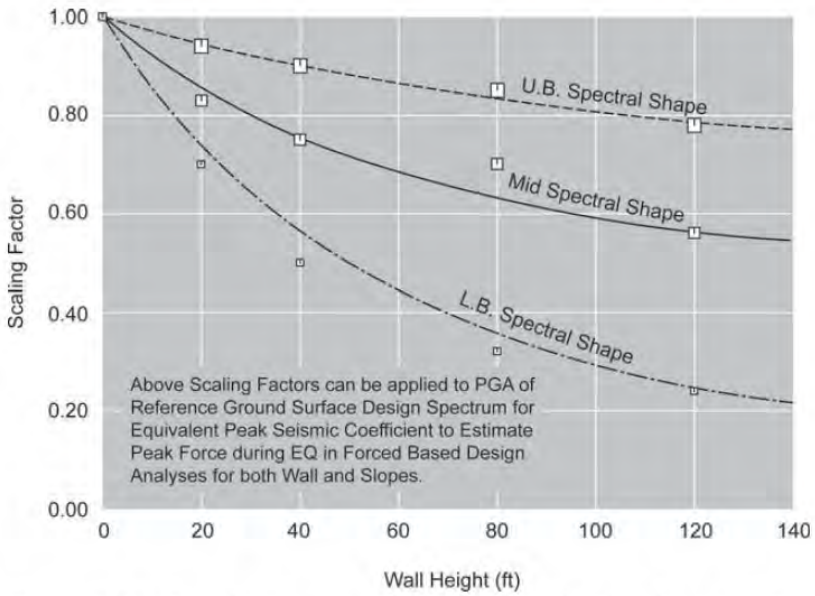

Figure 6-13. Resultant wave scattering α coefficients for retaining wall design.

$PGA := 0.51$

Section D-D' Final Condition

$H\_Wall_{global\_D\_Final} = 62\ ft$

$\alpha_1 := 0.672$

Reduced PGA to be used for Wall 03.63L global stability analyses

$PGAr := PGA \cdot \alpha_1 = 0.343$

Horizontal seismic coefficient to be used for Wall 03.63L global stability analyses

$$k_h := \frac{PGAr}{2} = 0.171$$

Section Ea-Ea' Existing Condition

$H\_Wall_{global\_Ea\_Existing} = 66\ ft$

$\alpha_1 := 0.661$

Reduced PGA to be used for Wall 03.63L global stability analyses

$PGAr := PGA \cdot \alpha_1 = 0.337$

Horizontal seismic coefficient to be used for Wall 03.63L global stability analyses

$$k_h := \frac{PGAr}{2} = 0.169$$

$H\_Wall_{compound\_Ea\_Existing} = 54\ ft$

$\alpha_1 := 0.698$

Reduced PGA to be used for Wall 03.63L compound stability analyses

$PGAr := PGA \cdot \alpha_1 = 0.356$

Horizontal seismic coefficient to be used for Wall 03.63L global stability analyses

$$k_h := \frac{PGAr}{2} = 0.178$$

Section Ea-Ea' Final Condition

$H\_Wall_{global\_Ea\_Final} = 30.6\ ft$

$\alpha_1 := 0.799$

Reduced PGA to be used for Wall 03.63L global stability analyses

$PGAr := PGA \cdot \alpha_1 = 0.407$

Horizontal seismic coefficient to be used for Wall 03.63L global stability analyses

$$k_h := \frac{PGAr}{2} = 0.204$$

Section Fa-Fa' Existing Condition

$H\_Wall_{global\_Fa\_Existing} = 63\ ft$ $\alpha_1 := 0.669$

Reduced PGA to be used for Wall 03.63L global stability analyses

$$PGAr := PGA \cdot \alpha_1 = 0.341$$

Horizontal seismic coefficient to be used for Wall 03.63L global stability analyses

$$k_h := \frac{PGAr}{2} = 0.171$$

$H\_Wall_{compound\_Fa\_Existing} = 51.5\ ft$ $\alpha_1 := 0.707$

Reduced PGA to be used for Wall 03.63L compound stability analyses

$$PGAr := PGA \cdot \alpha_1 = 0.361$$

Horizontal seismic coefficient to be used for Wall 03.63L global stability analyses

$$k_h := \frac{PGAr}{2} = 0.18$$

Section Fa-Fa' Final Condition

$H\_Wall_{global\_Fa\_Final} = 60\ ft$ $\alpha_1 := 0.678$

Reduced PGA to be used for Wall 03.63L global stability analyses

$$PGAr := PGA \cdot \alpha_1 = 0.346$$

Horizontal seismic coefficient to be used for Wall 03.63L global stability analyses

$$k_h := \frac{PGAr}{2} = 0.173$$

$H\_Wall_{compound\_Fa\_Final} = 16.5\ ft$ $\alpha_1 := 1.000$

Reduced PGA to be used for Wall 03.63L compound stability analyses

$$PGAr := PGA \cdot \alpha_1 = 0.51$$

Horizontal seismic coefficient to be used for Wall 03.63L global stability analyses

$$k_h := \frac{PGAr}{2} = 0.255$$

Section Ga-Ga' Existing Condition

$H\_Wall_{global\_Ga\_Existing} = 60\ ft$ $\alpha_1 := 0.678$

Reduced PGA to be used for Wall 03.63L global stability analyses

$$PGAr := PGA \cdot \alpha_1 = 0.346$$

Horizontal seismic coefficient to be used for Wall 03.63L global stability analyses

$$k_h := \frac{PGAr}{2} = 0.173$$

$H\_Wall_{compound\_Ga\_Existing} = 43\ ft$ $\alpha_1 := 0.740$

Reduced PGA to be used for Wall 03.63L compound stability analyses

$$PGAr := PGA \cdot \alpha_1 = 0.377$$

Horizontal seismic coefficient to be used for Wall 03.63L global stability analyses

$$k_h := \frac{PGAr}{2} = 0.189$$

Section Ga-Ga' Final Condition

$H\_Wall_{global\_Ga\_Final} = 57.5\ ft$ $\alpha_1 := 0.686$

Reduced PGA to be used for Wall 03.63L global stability analyses

$$PGAr := PGA \cdot \alpha_1 = 0.35$$

Horizontal seismic coefficient to be used for Wall 03.63L global stability analyses

$$k_h := \frac{PGAr}{2} = 0.175$$

$H\_Wall_{compound\_Ga\_Final} = 27\ ft$ $\alpha_1 := 0.818$

Reduced PGA to be used for Wall 03.63L compound stability analyses

$$PGAr := PGA \cdot \alpha_1 = 0.417$$

Horizontal seismic coefficient to be used for Wall 03.63L global stability analyses

$$k_h := \frac{PGAr}{2} = 0.209$$

Section Ha-Ha' Existing Condition

$H\_Wall_{global\_Ha\_Existing} = 55\ ft$ $\alpha_1 := 0.695$

Reduced PGA to be used for Wall 03.63L global stability analyses

$$PGAr := PGA \cdot \alpha_1 = 0.354$$

Horizontal seismic coefficient to be used for Wall 03.63L global stability analyses

$$k_h := \frac{PGAr}{2} = 0.177$$

$H\_Wall_{compound\_Ha\_Existing} = 41\ ft$ $\alpha_1 := 0.749$

Reduced PGA to be used for Wall 03.63L compound stability analyses

$$PGAr := PGA \cdot \alpha_1 = 0.382$$

Horizontal seismic coefficient to be used for Wall 03.63L global stability analyses

$$k_h := \frac{PGAr}{2} = 0.191$$

Section Ha-Ha' Final Condition

$H\_Wall_{global\_Ha\_Final} = 55\ ft$ $\alpha_1 := 0.695$

Reduced PGA to be used for Wall 03.63L global stability analyses

$$PGAr := PGA \cdot \alpha_1 = 0.354$$

Horizontal seismic coefficient to be used for Wall 03.63L global stability analyses

$$k_h := \frac{PGAr}{2} = 0.177$$

$H\_Wall_{compound\_Ha\_Final} = 10.75\ ft$ $\alpha_1 := 1.000$

Reduced PGA to be used for Wall 03.63L global stability analyses

$$PGAr := PGA \cdot \alpha_1 = 0.51$$

Horizontal seismic coefficient to be used for Wall 03.63L global stability analyses

$$k_h := \frac{PGAr}{2} = 0.255$$

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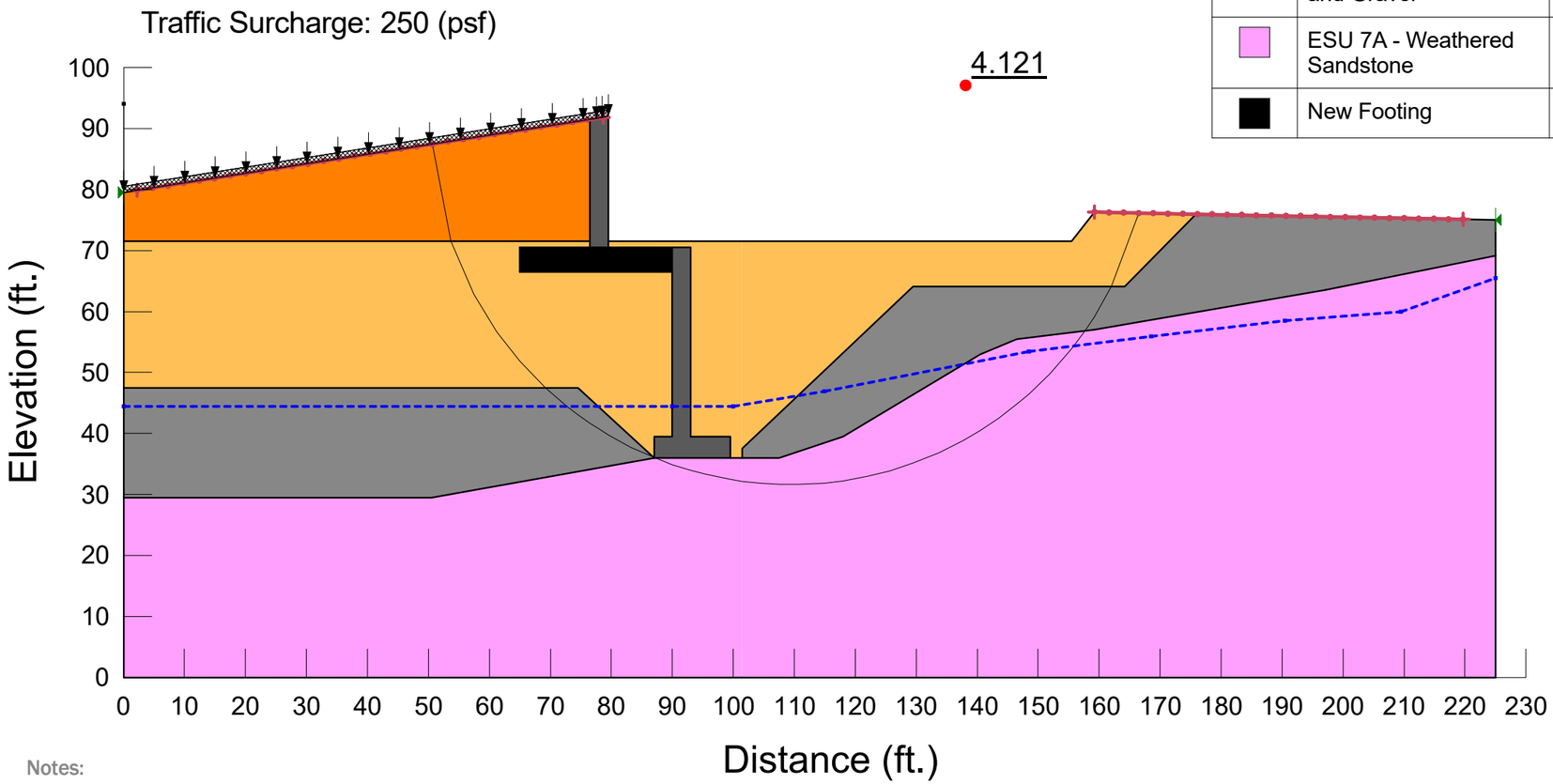
In Association with

Appendix D.4
Pier 1/Wall 03.63L Global Stability Analyses

Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Concrete	High Strength	150		
	ESU 1A - Existing Granular Fill	Mohr-Coulomb	120	0	40
	ESU 1B - Existing Silty Granular Fill	Mohr-Coulomb	125	0	38
	ESU 2A - Native Sand and Gravel	Mohr-Coulomb	120	0	39
	ESU 7A - Weathered Sandstone	Mohr-Coulomb	135	0	43
	New Footing	High Strength	2,250		



Notes:

1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document.
3. GeoEngineers, Inc. cannot guarantee the accuracy and context of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

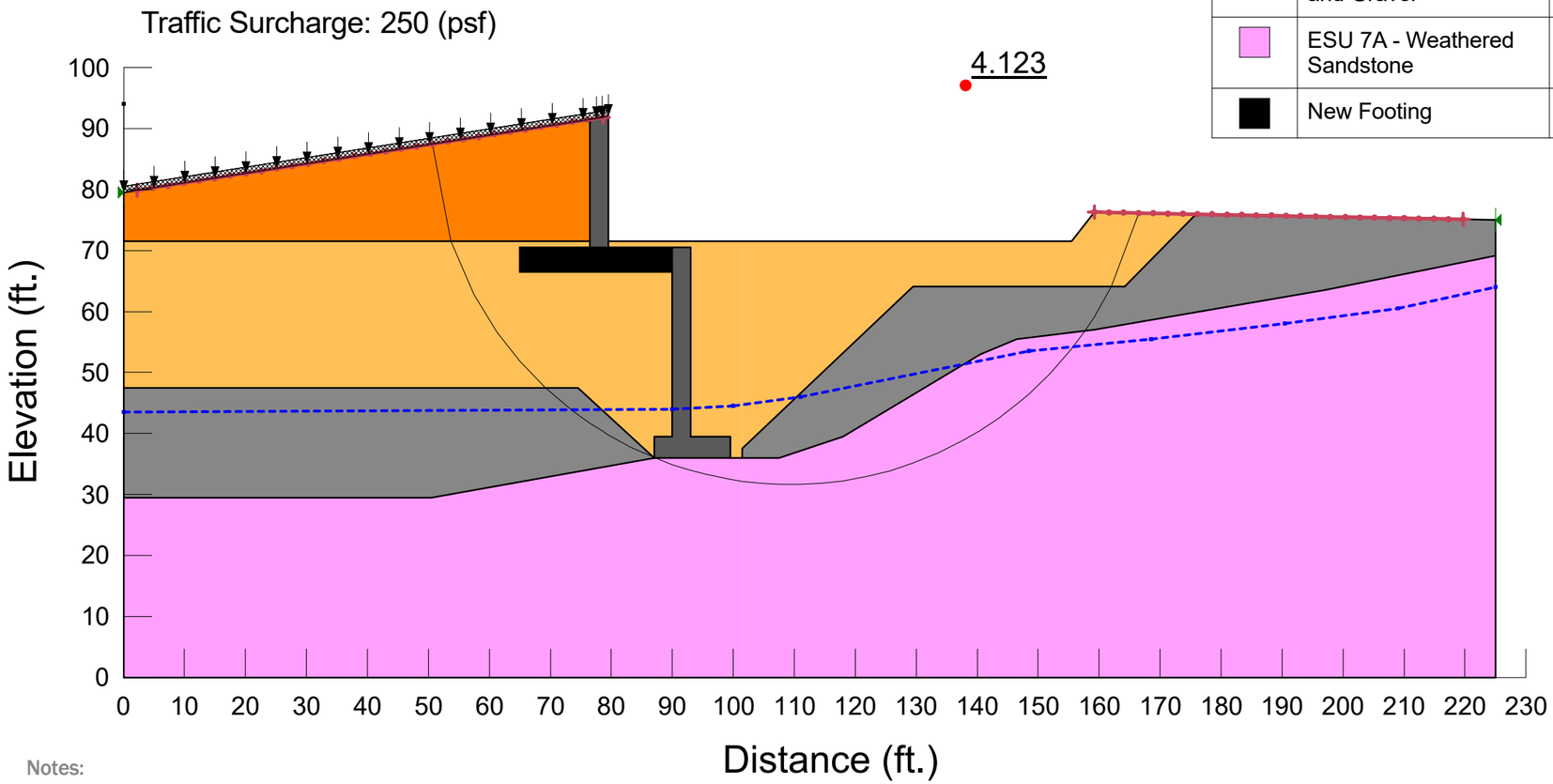
Bridge 17.7 - Wall 03.63L Section D-D'
Static Global Stability (Spencer) - Final Condition

WSDOT I-405 Renton to Bellevue
King County, Washington

GeoEngineers

Figure D.4-1

Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Concrete	High Strength	150		
	ESU 1A - Existing Granular Fill	Mohr-Coulomb	120	0	40
	ESU 1B - Existing Silty Granular Fill	Mohr-Coulomb	125	0	38
	ESU 2A - Native Sand and Gravel	Mohr-Coulomb	120	0	39
	ESU 7A - Weathered Sandstone	Mohr-Coulomb	135	0	43
	New Footing	High Strength	2,250		



Notes:

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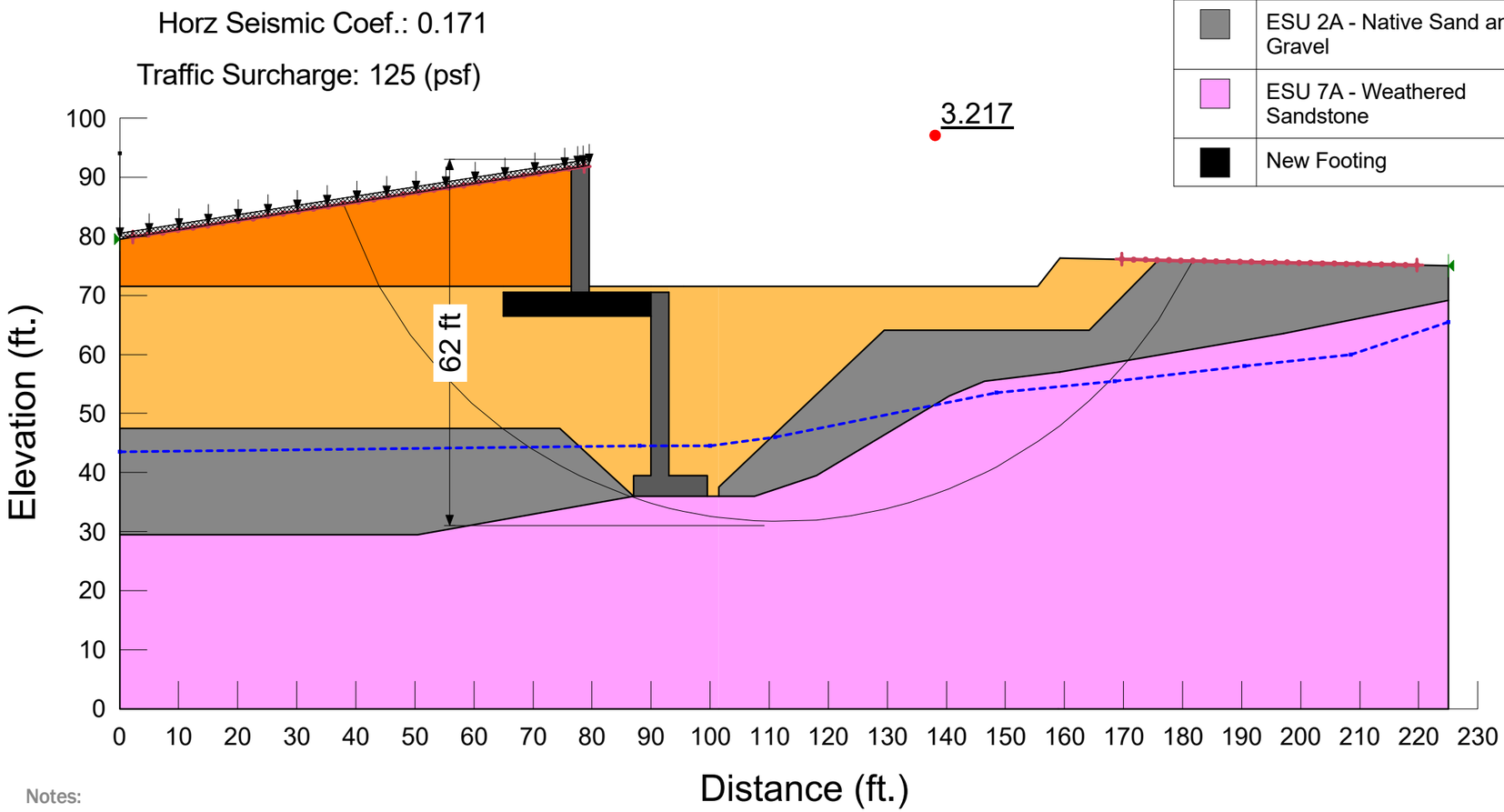
Bridge 17.7 - Wall 03.63L Section D-D'
Static Global Stability (M-P) - Final Condition

WSDOT I-405 Renton to Bellevue
King County, Washington

GeoEngineers

Figure D.4-2

Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Concrete	High Strength	150		
	ESU 1A - Existing Granular Fill (Pseudo-Static)	Mohr-Coulomb	120	50	40
	ESU 1B - Existing Silty Granular Fill	Mohr-Coulomb	125	0	38
	ESU 2A - Native Sand and Gravel	Mohr-Coulomb	120	0	39
	ESU 7A - Weathered Sandstone	Mohr-Coulomb	135	0	43
	New Footing	High Strength	2,250		



Notes:

1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document.
3. GeoEngineers, Inc. cannot guarantee the accuracy and context of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

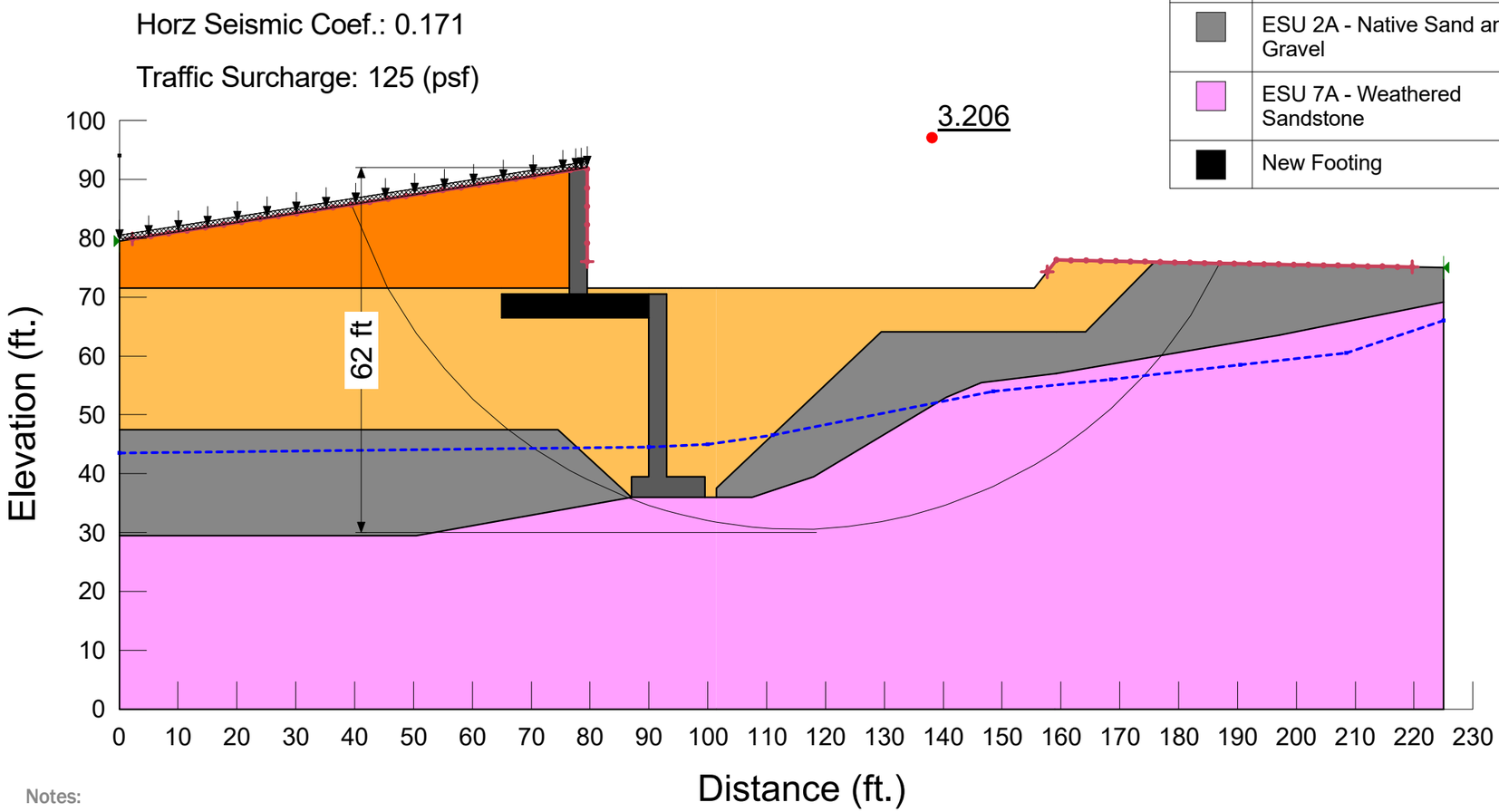
Bridge 17.7 - Wall 03.63L Section D-D'
Pseudo-Static Global Stability (Spencer) - Final Condition

WSDOT I-405 Renton to Bellevue
King County, Washington

GeoEngineers

Figure D.4-3

Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Concrete	High Strength	150		
	ESU 1A - Existing Granular Fill (Pseudo-Static)	Mohr-Coulomb	120	50	40
	ESU 1B - Existing Silty Granular Fill	Mohr-Coulomb	125	0	38
	ESU 2A - Native Sand and Gravel	Mohr-Coulomb	120	0	39
	ESU 7A - Weathered Sandstone	Mohr-Coulomb	135	0	43
	New Footing	High Strength	2,250		



Notes:

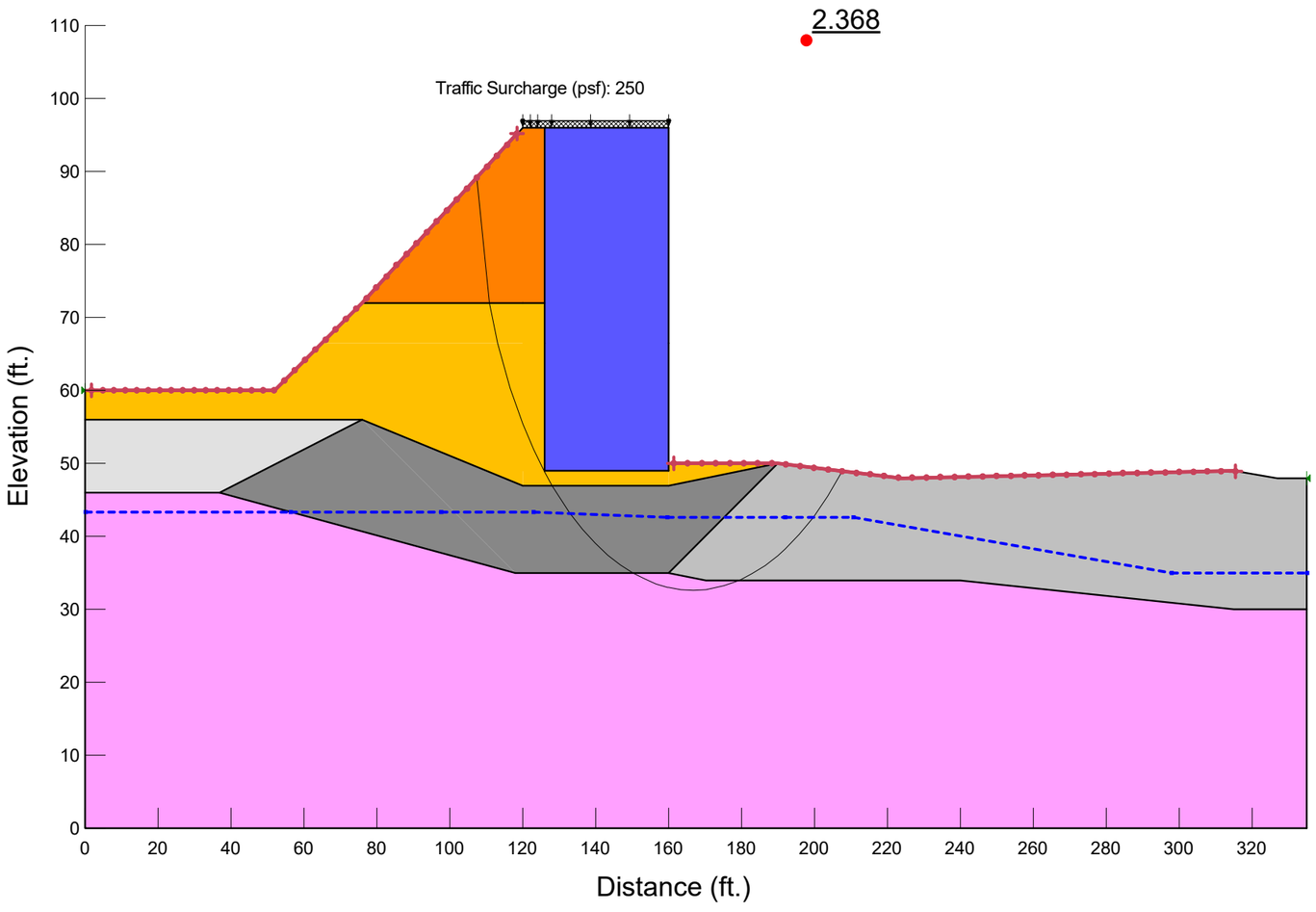
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document.
3. GeoEngineers, Inc. cannot guarantee the accuracy and context of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Bridge 17.7 - Wall 03.63L Section D-D'
Pseudo-Static Global Stability (M-P) - Final Condition

WSDOT I-405 Renton to Bellevue
King County, Washington

GeoEngineers

Figure D.4-4



Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	ESU 1A - Existing Granular Fill	Mohr-Coulomb	120	0	40
	ESU 1B - Existing Gravelly Granular Fill	Mohr-Coulomb	125	0	38
	ESU 2A - Native Sand and Gravel	Mohr-Coulomb	120	0	39
	ESU 2B - Native Sand and Gravel	Mohr-Coulomb	135	0	41
	ESU 2C - Native Silt	Mohr-Coulomb	110	0	29
	ESU 7A - Weathered Sandstone	Mohr-Coulomb	135	0	42
	Hilfiker Wall	High Strength	130		

Notes:

1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document.
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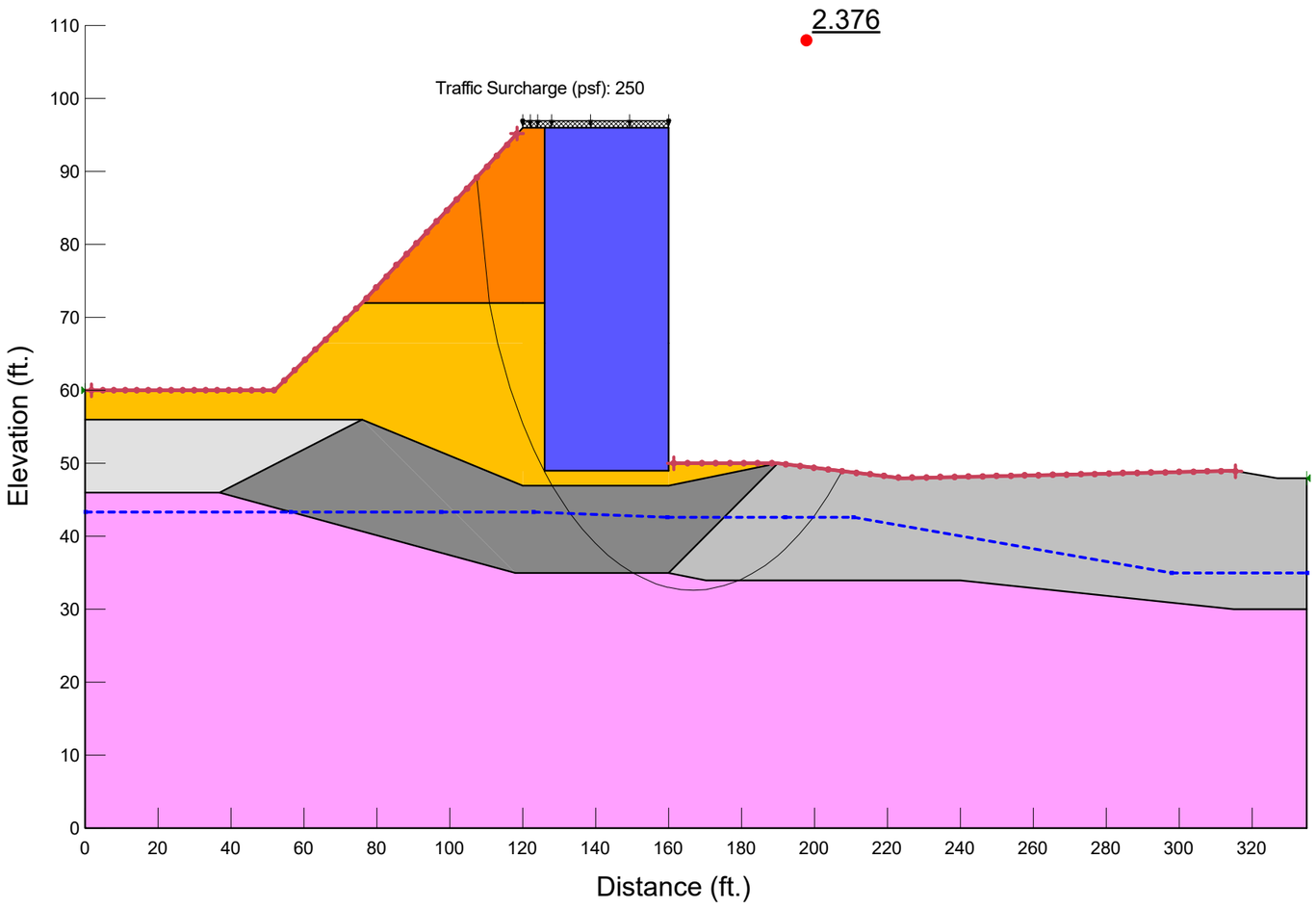
Bridge 17.7 - Wall 03.63L Section Ea-Ea'
Static Global Stability (Spencer) - Existing Condition

WSDOT I-405 Renton to Bellevue
King County, Washington

GeoEngineers

Figure D.4-5



Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	ESU 1A - Existing Granular Fill	Mohr-Coulomb	120	0	40
	ESU 1B - Existing Gravelly Granular Fill	Mohr-Coulomb	125	0	38
	ESU 2A - Native Sand and Gravel	Mohr-Coulomb	120	0	39
	ESU 2B - Native Sand and Gravel	Mohr-Coulomb	135	0	41
	ESU 2C - Native Silt	Mohr-Coulomb	110	0	29
	ESU 7A - Weathered Sandstone	Mohr-Coulomb	135	0	42
	Hilfiker Wall	High Strength	130		

Notes:

1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document.
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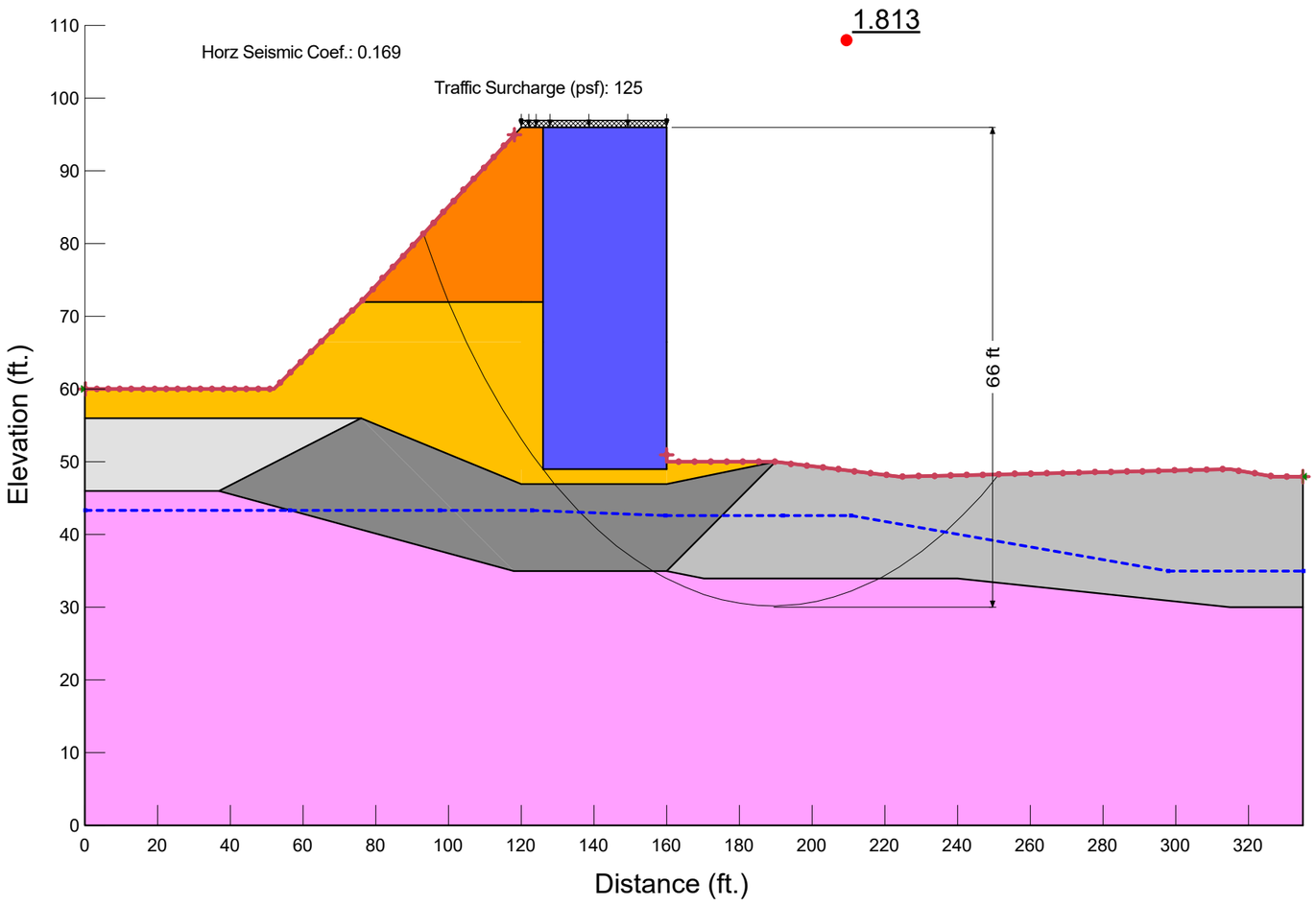
Bridge 17.7 - Wall 03.63L Section Ea-Ea'
Static Global Stability (M-P) - Existing Condition

WSDOT I-405 Renton to Bellevue
King County, Washington

GeoEngineers

Figure D.4-6



Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	ESU 1A - Existing Granular Fill (Pseudo-Static)	Mohr-Coulomb	120	50	40
	ESU 1B - Existing Gravelly Granular Fill	Mohr-Coulomb	125	0	38
	ESU 2A - Native Sand and Gravel	Mohr-Coulomb	120	0	39
	ESU 2B - Native Sand and Gravel	Mohr-Coulomb	135	0	41
	ESU 2C - Native Silt (Pseudo-Static)	Mohr-Coulomb	110	200	29
	ESU 7A - Weathered Sandstone	Mohr-Coulomb	135	0	42
	Hilfiker Wall	High Strength	130		

Notes:

1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document.
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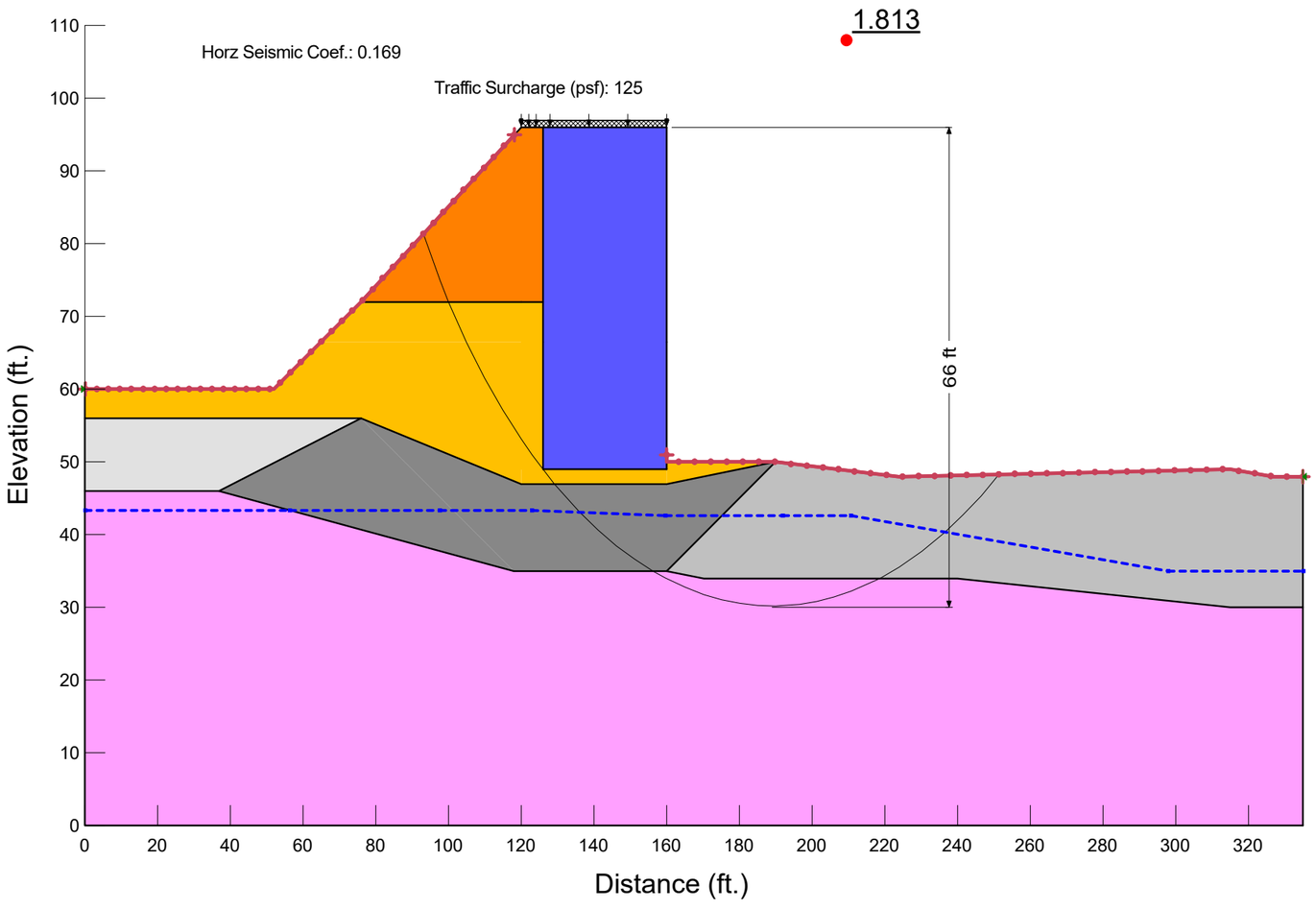
Bridge 17.7 - Wall 03.63L Section Ea-Ea'
Pseudo-Static Global Stability (Spencer) - Existing Condition

WSDOT I-405 Renton to Bellevue
King County, Washington

GeoEngineers

Figure D.4-7



Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	ESU 1A - Existing Granular Fill (Pseudo-Static)	Mohr-Coulomb	120	50	40
	ESU 1B - Existing Gravelly Granular Fill	Mohr-Coulomb	125	0	38
	ESU 2A - Native Sand and Gravel	Mohr-Coulomb	120	0	39
	ESU 2B - Native Sand and Gravel	Mohr-Coulomb	135	0	41
	ESU 2C - Native Silt (Pseudo-Static)	Mohr-Coulomb	110	200	29
	ESU 7A - Weathered Sandstone	Mohr-Coulomb	135	0	42
	Hilfiker Wall	High Strength	130		

Notes:

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2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document.
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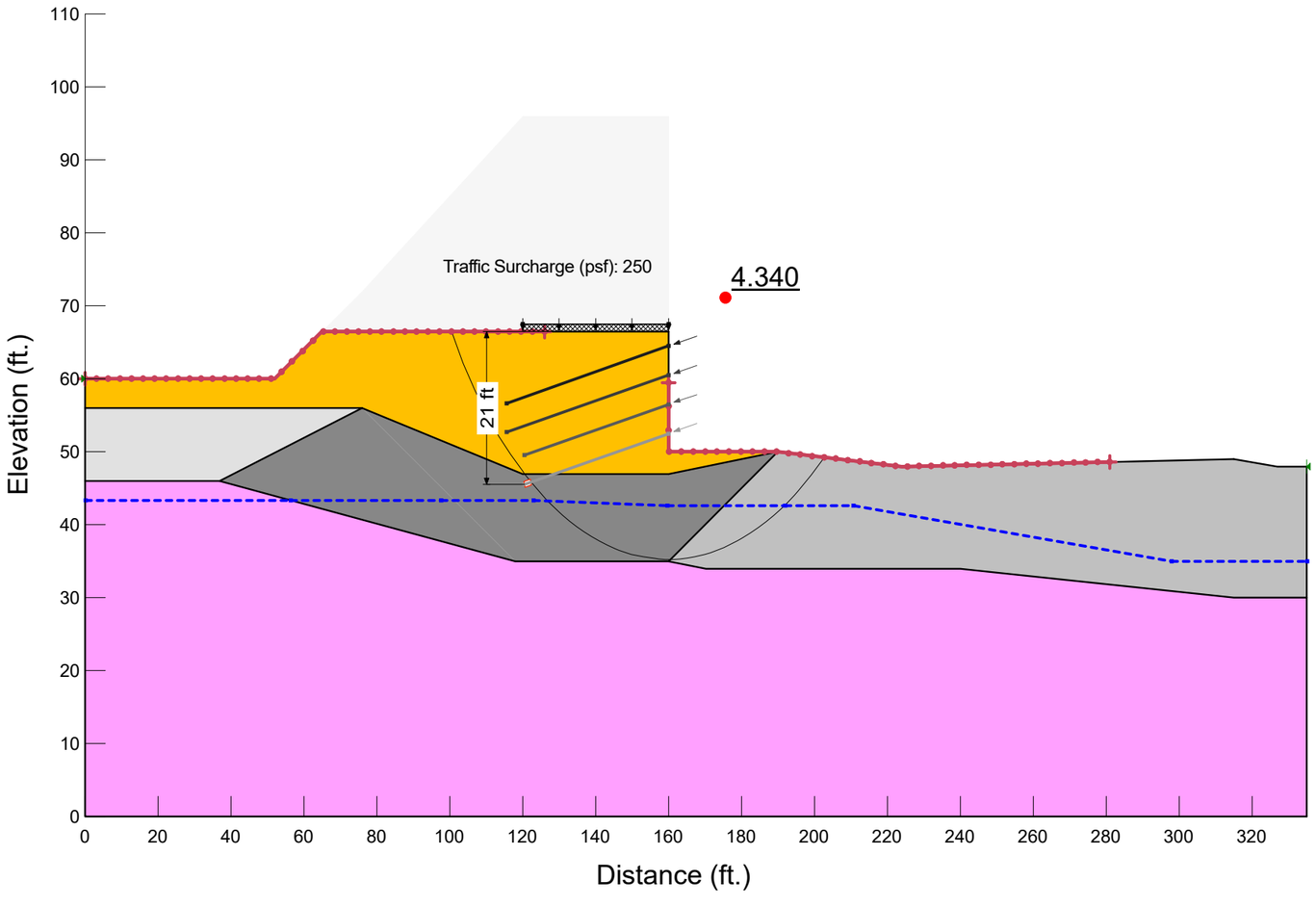
Bridge 17.7 - Wall 03.63L Section Ea-Ea'
Pseudo-Static Global Stability (M-P) - Existing Condition

WSDOT I-405 Renton to Bellevue
King County, Washington

GeoEngineers

Figure D.4-8



Color	Name	Slope Stability Material Model	Unit Weight	Effective Cohesion	Effective Friction Angle
	ESU 1B - Existing Gravelly Granular Fill	Mohr-Coulomb	125	0	38
	ESU 2A - Native Sand and Gravel	Mohr-Coulomb	120	0	39
	ESU 2B - Native Sand and Gravel	Mohr-Coulomb	135	0	41
	ESU 2C - Native Silt	Mohr-Coulomb	110	0	29
	ESU 7A - Weathered Sandstone	Mohr-Coulomb	135	0	42

Color	Name	Type	Pullout Resistance (psf)	Tensile Capacity (lbf)	Bond Length (ft)	Bond Diameter (ft)	Out-of-Plane Spacing (ft)
	Soil Nail_Row 1	Anchor	1,800	82,550	45	0.5	4
	Soil Nail_Row 2	Anchor	1,800	82,550	45	0.5	4
	Soil Nail_Row 3	Anchor	1,800	82,550	40	0.5	4
	Soil Nail_Row 4	Anchor	1,800	82,550	40	0.5	4

Notes:

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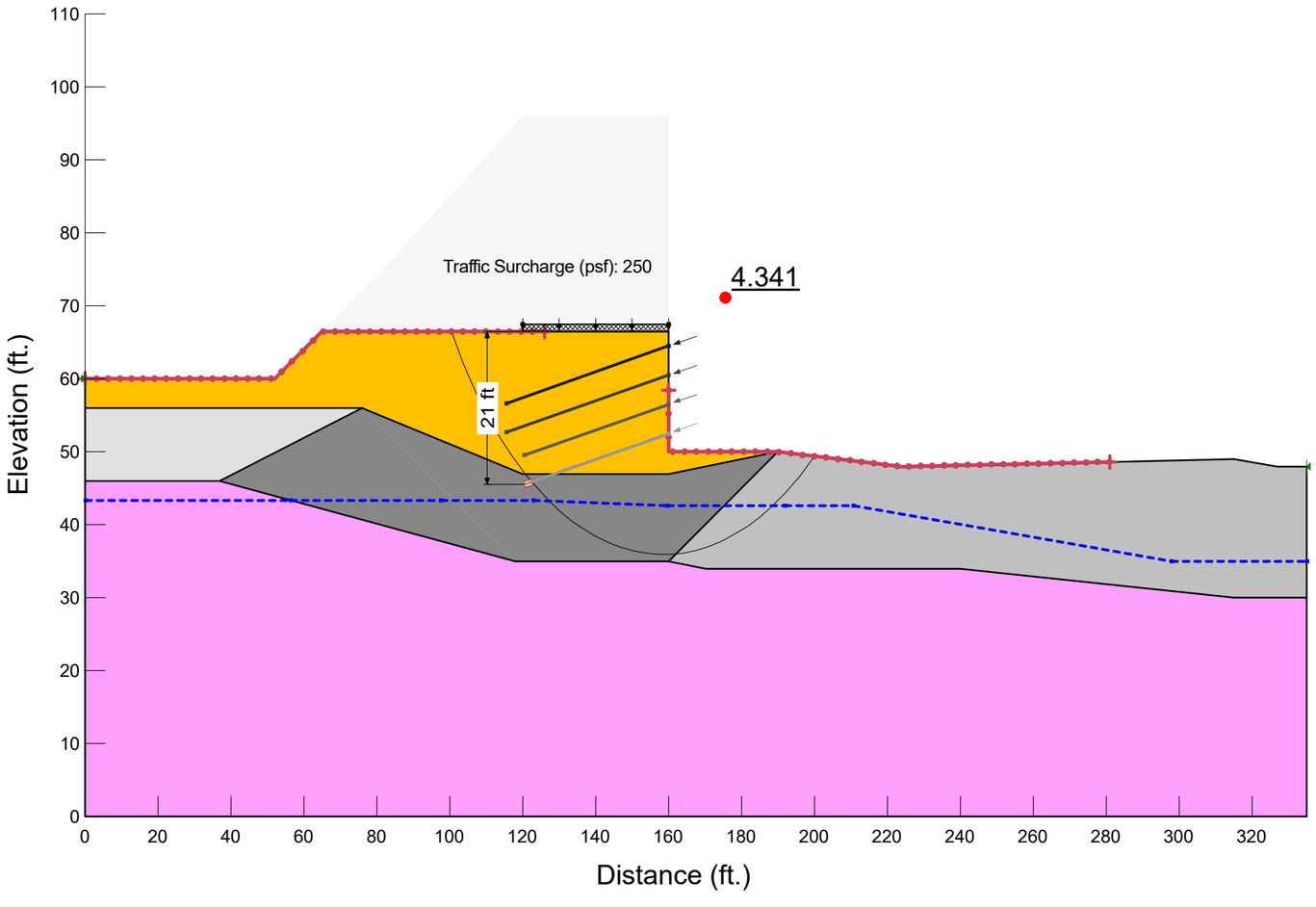
Bridge 17.7 - Wall 03.63L Section Ea-Ea'
Static Global Stability (Spencer) - Final Condition

WSDOT I-405 Renton to Bellevue
King County, Washington

GeoEngineers

Figure D.4-9



Color	Name	Slope Stability Material Model	Unit Weight	Effective Cohesion	Effective Friction Angle
	ESU 1B - Existing Gravelly Granular Fill	Mohr-Coulomb	125	0	38
	ESU 2A - Native Sand and Gravel	Mohr-Coulomb	120	0	39
	ESU 2B - Native Sand and Gravel	Mohr-Coulomb	135	0	41
	ESU 2C - Native Silt	Mohr-Coulomb	110	0	29
	ESU 7A - Weathered Sandstone	Mohr-Coulomb	135	0	42

Color	Name	Type	Pullout Resistance (psf)	Tensile Capacity (lbf)	Bond Length (ft)	Bond Diameter (ft)	Out-of-Plane Spacing (ft)
	Soil Nail_Row 1	Anchor	1,800	82,550	45	0.5	4
	Soil Nail_Row 2	Anchor	1,800	82,550	45	0.5	4
	Soil Nail_Row 3	Anchor	1,800	82,550	40	0.5	4
	Soil Nail_Row 4	Anchor	1,800	82,550	40	0.5	4

Notes:

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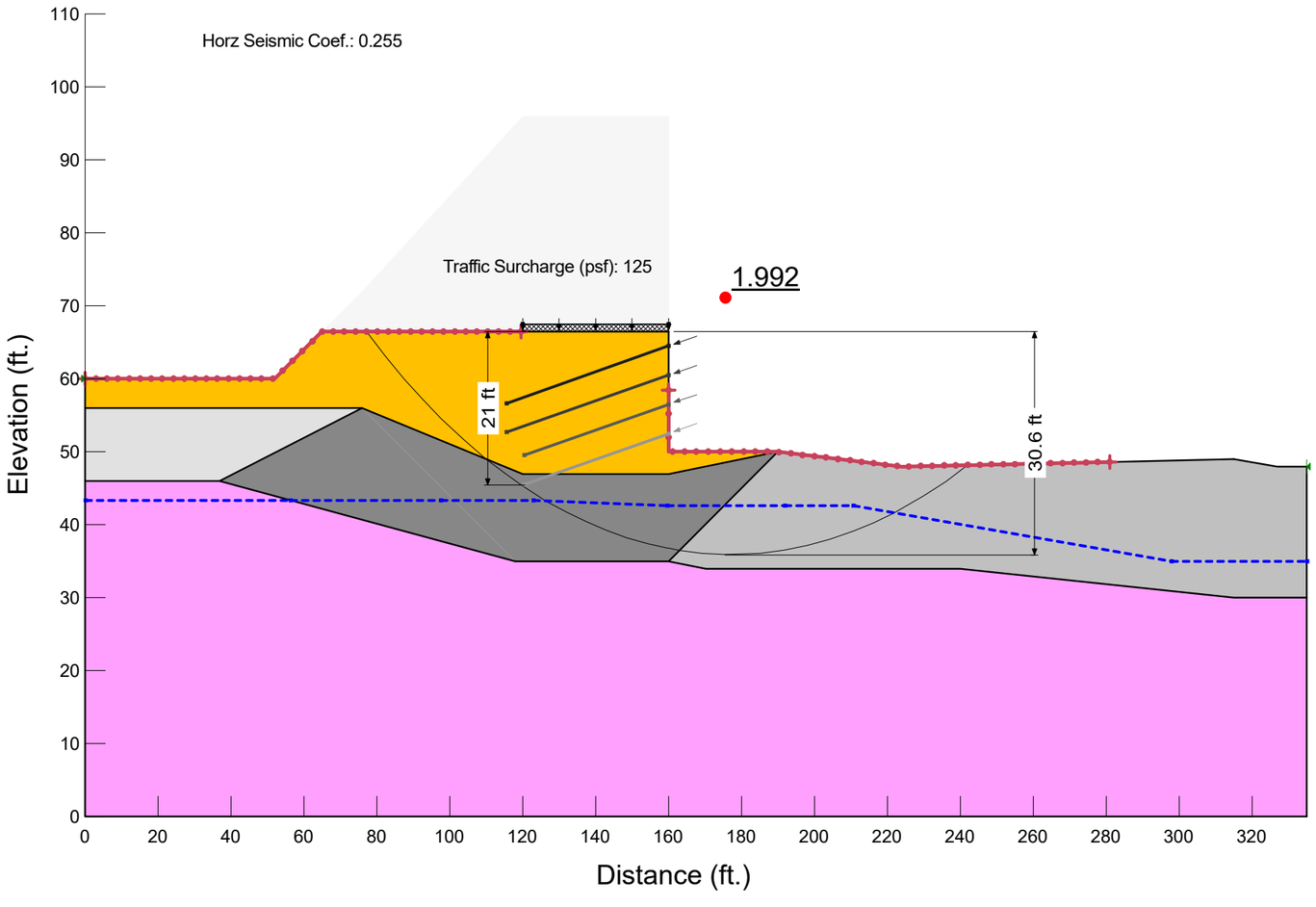
Bridge 17.7 - Wall 03.63L Section Ea-Ea'
Static Global Stability (M-P) - Final Condition

WSDOT I-405 Renton to Bellevue
King County, Washington

GeoEngineers

Figure D.4-10



Color	Name	Slope Stability Material Model	Unit Weight	Effective Cohesion	Effective Friction Angle
	ESU 1B - Existing Gravelly Granular Fill	Mohr-Coulomb	125	0	38
	ESU 2A - Native Sand and Gravel	Mohr-Coulomb	120	0	39
	ESU 2B - Native Sand and Gravel	Mohr-Coulomb	135	0	41
	ESU 2C - Native Silt (Pseudo-Static)	Mohr-Coulomb	110	200	29
	ESU 7A - Weathered Sandstone	Mohr-Coulomb	135	0	42

Color	Name	Type	Pullout Resistance (psf)	Tensile Capacity (lbf)	Bond Length (ft)	Bond Diameter (ft)	Out-of-Plane Spacing (ft)
	Soil Nail_Row 1	Anchor	1,800	82,550	45	0.5	4
	Soil Nail_Row 2	Anchor	1,800	82,550	45	0.5	4
	Soil Nail_Row 3	Anchor	1,800	82,550	40	0.5	4
	Soil Nail_Row 4	Anchor	1,800	82,550	40	0.5	4

Notes:

1. The locations of all features shown are approximate.
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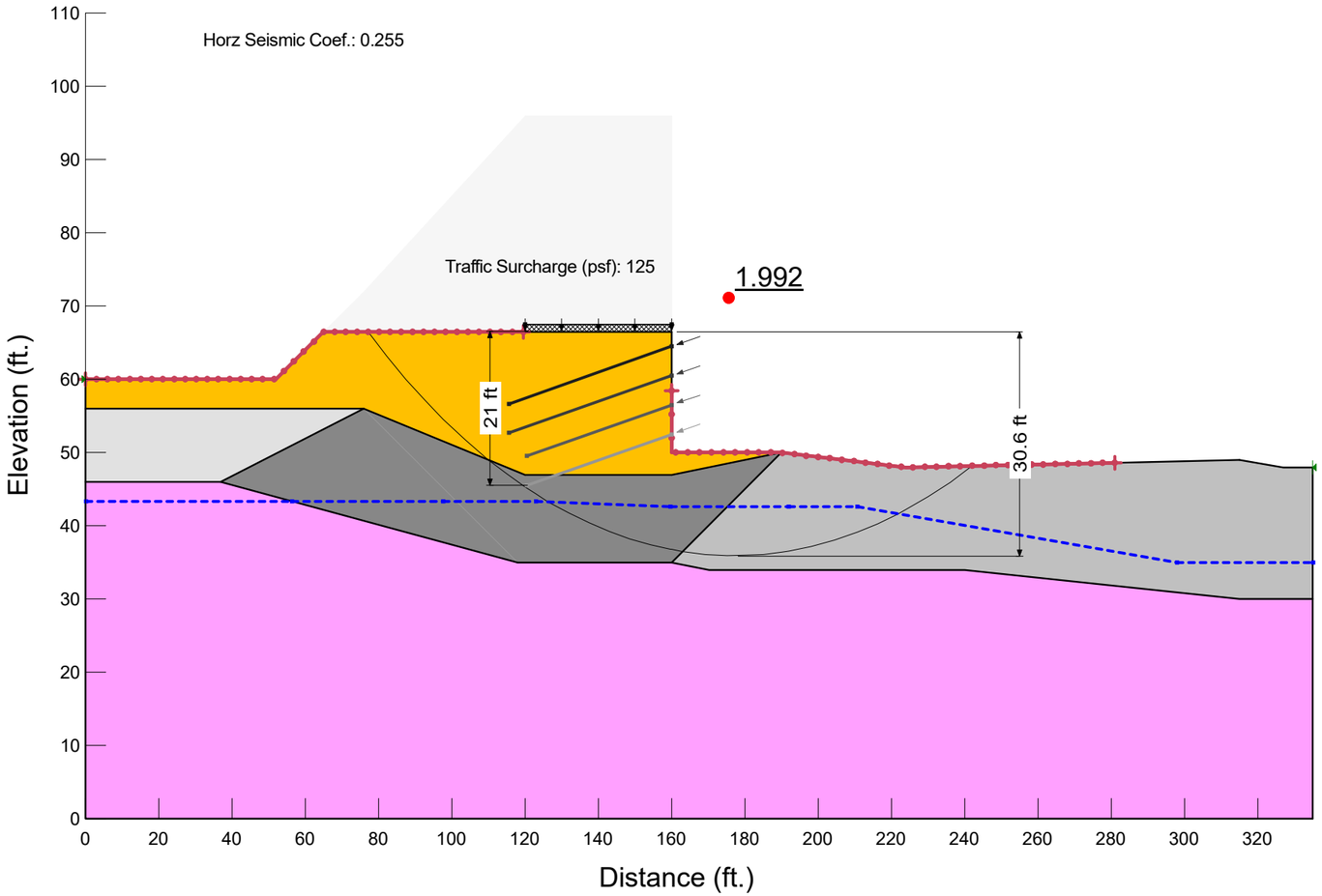
Bridge 17.7 - Wall 03.63L Section Ea-Ea'
Pseudo-Static Global Stability (Spencer) - Final Condition

WSDOT I-405 Renton to Bellevue
King County, Washington

GeoEngineers

Figure D.4-11



Color	Name	Slope Stability Material Model	Unit Weight	Effective Cohesion	Effective Friction Angle
	ESU 1B - Existing Gravelly Granular Fill	Mohr-Coulomb	125	0	38
	ESU 2A - Native Sand and Gravel	Mohr-Coulomb	120	0	39
	ESU 2B - Native Sand and Gravel	Mohr-Coulomb	135	0	41
	ESU 2C - Native Silt (Pseudo-Static)	Mohr-Coulomb	110	200	29
	ESU 7A - Weathered Sandstone	Mohr-Coulomb	135	0	42

Color	Name	Type	Pullout Resistance (psf)	Tensile Capacity (lbf)	Bond Length (ft)	Bond Diameter (ft)	Out-of-Plane Spacing (ft)
	Soil Nail_Row 1	Anchor	1,800	82,550	45	0.5	4
	Soil Nail_Row 2	Anchor	1,800	82,550	45	0.5	4
	Soil Nail_Row 3	Anchor	1,800	82,550	40	0.5	4
	Soil Nail_Row 4	Anchor	1,800	82,550	40	0.5	4

Notes:

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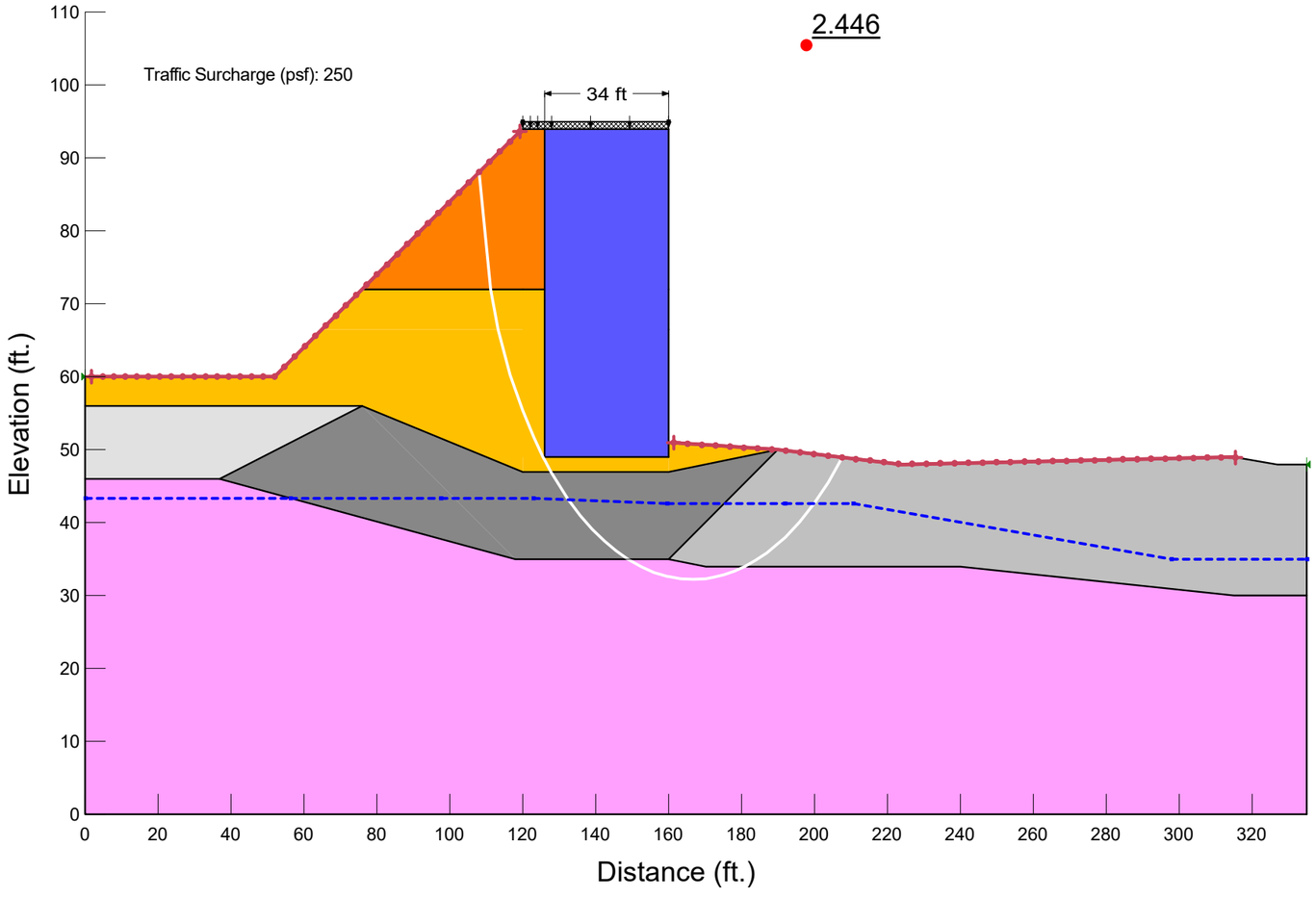
Bridge 17.7 - Wall 03.63L Section Ea-Ea'
Pseudo-Static Global Stability (M-P) - Final Condition

WSDOT I-405 Renton to Bellevue
King County, Washington

GeoEngineers

Figure D.4-12



Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	ESU 1A - Existing Granular Fill	Mohr-Coulomb	120	0	40
	ESU 1B - Existing Gravelly Granular Fill	Mohr-Coulomb	125	0	38
	ESU 2A - Native Sand and Gravel	Mohr-Coulomb	120	0	39
	ESU 2B - Native Sand and Gravel	Mohr-Coulomb	135	0	41
	ESU 2C - Native Silt	Mohr-Coulomb	110	0	29
	ESU 7A - Weathered Sandstone	Mohr-Coulomb	135	0	42
	Hilfiker Wall	High Strength	130		

Notes:

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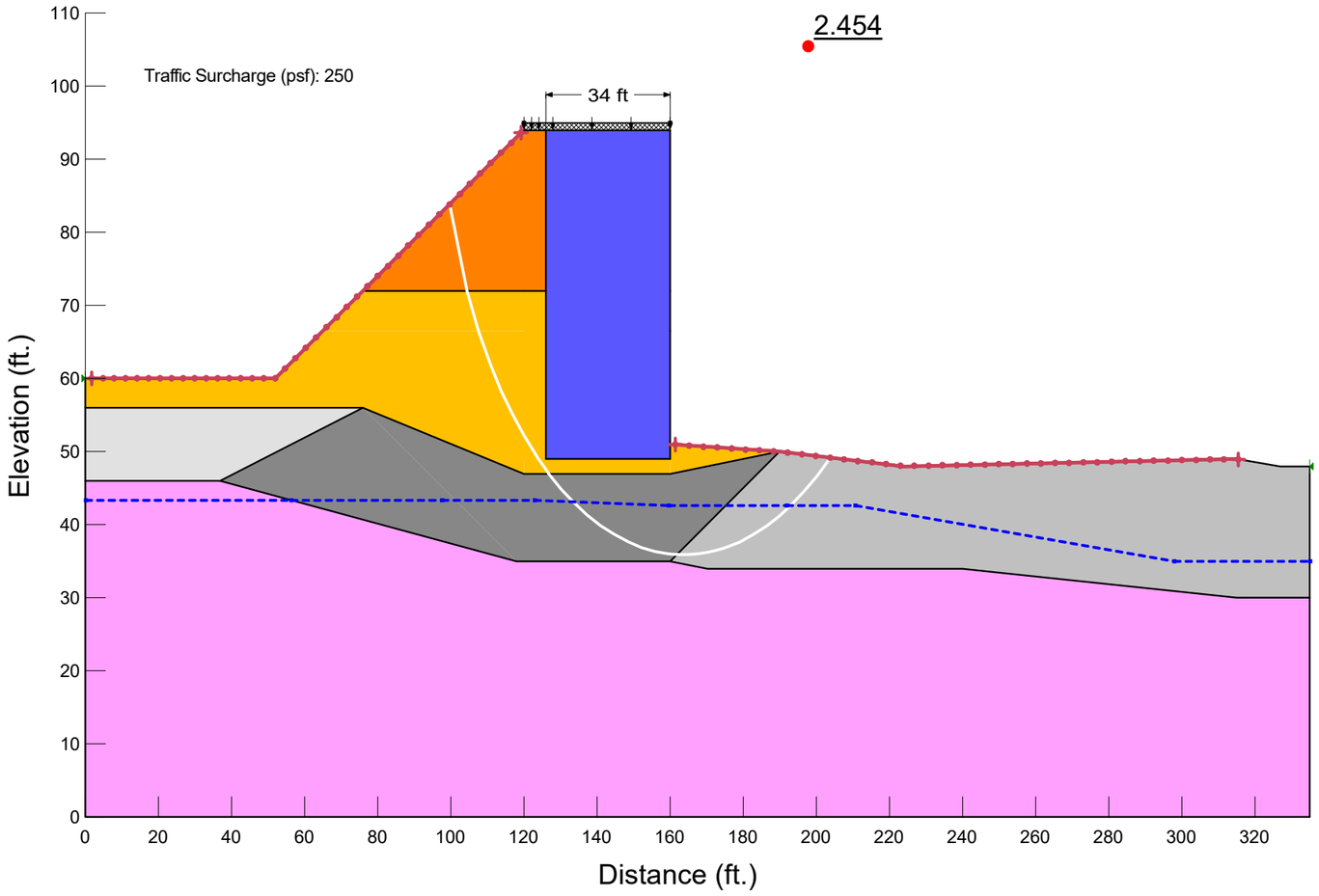
Bridge 17.7 - Wall 03.63L Section Fa-Fa'
Static Global Stability (Spencer) - Existing Condition

WSDOT I-405 Renton to Bellevue
King County, Washington

GeoEngineers

Figure D.4-13



Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	ESU 1A - Existing Granular Fill	Mohr-Coulomb	120	0	40
	ESU 1B - Existing Gravelly Granular Fill	Mohr-Coulomb	125	0	38
	ESU 2A - Native Sand and Gravel	Mohr-Coulomb	120	0	39
	ESU 2B - Native Sand and Gravel	Mohr-Coulomb	135	0	41
	ESU 2C - Native Silt	Mohr-Coulomb	110	0	29
	ESU 7A - Weathered Sandstone	Mohr-Coulomb	135	0	42
	Hilfiker Wall	High Strength	130		

Notes:

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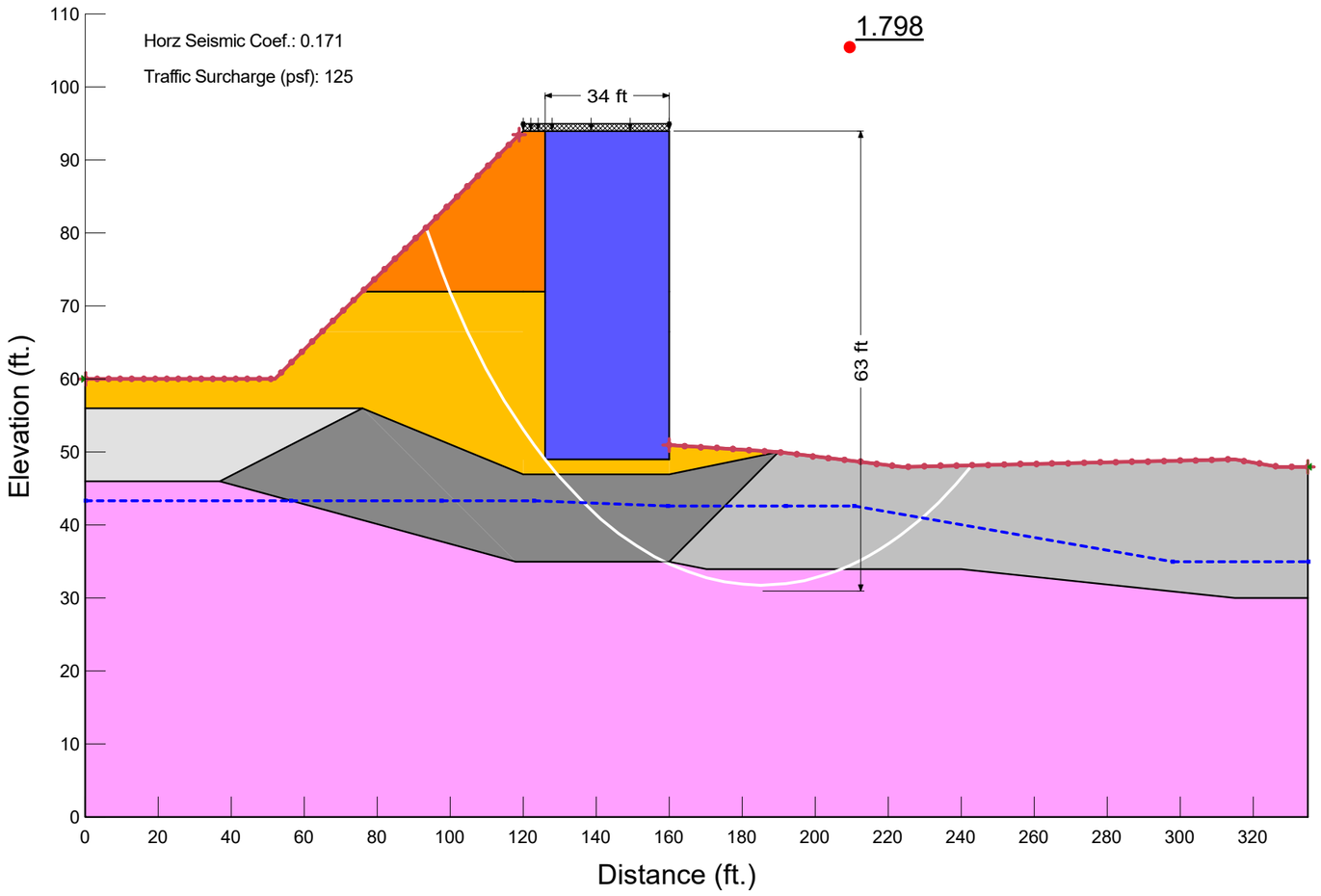
Bridge 17.7 - Wall 03.63L Section Fa-Fa'
Static Global Stability (M-P) - Existing Condition

WSDOT I-405 Renton to Bellevue
King County, Washington

GeoEngineers

Figure D.4-14



Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	ESU 1A - Existing Granular Fill (Pseudo-Static)	Mohr-Coulomb	120	50	40
	ESU 1B - Existing Gravelly Granular Fill	Mohr-Coulomb	125	0	38
	ESU 2A - Native Sand and Gravel	Mohr-Coulomb	120	0	39
	ESU 2B - Native Sand and Gravel	Mohr-Coulomb	135	0	41
	ESU 2C - Native Silt (Pseudo-Static)	Mohr-Coulomb	110	200	29
	ESU 7A - Weathered Sandstone	Mohr-Coulomb	135	0	42
	Hilfiker Wall	High Strength	130		

Notes:

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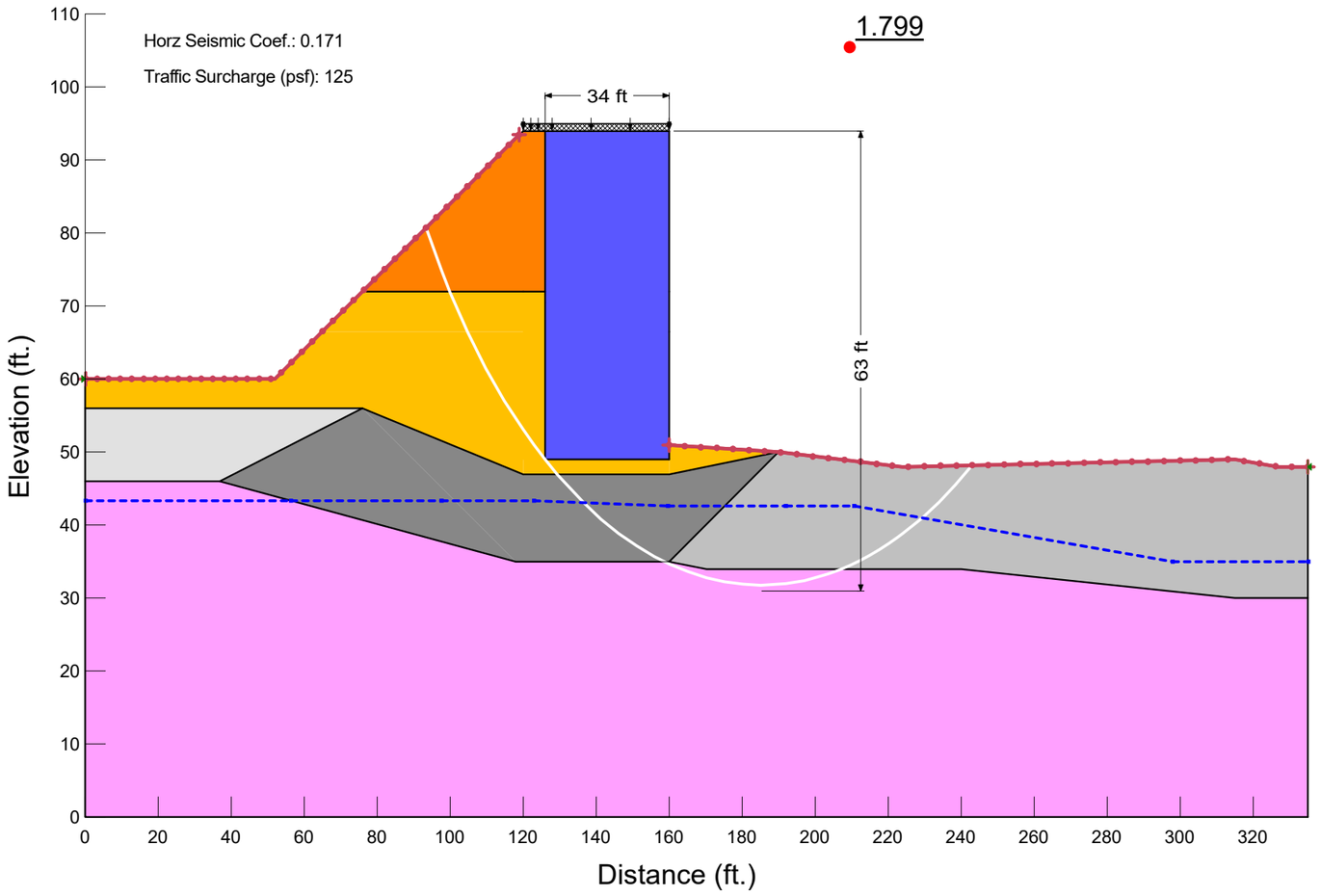
Bridge 17.7 - Wall 03.63L Section Fa-Fa'
Pseudo-Static Global Stability (Spencer) - Existing Condition

WSDOT I-405 Renton to Bellevue
King County, Washington

GeoEngineers

Figure D.4-15



Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	ESU 1A - Existing Granular Fill (Pseudo-Static)	Mohr-Coulomb	120	50	40
	ESU 1B - Existing Gravelly Granular Fill	Mohr-Coulomb	125	0	38
	ESU 2A - Native Sand and Gravel	Mohr-Coulomb	120	0	39
	ESU 2B - Native Sand and Gravel	Mohr-Coulomb	135	0	41
	ESU 2C - Native Silt (Pseudo-Static)	Mohr-Coulomb	110	200	29
	ESU 7A - Weathered Sandstone	Mohr-Coulomb	135	0	42
	Hilfiker Wall	High Strength	130		

Notes:

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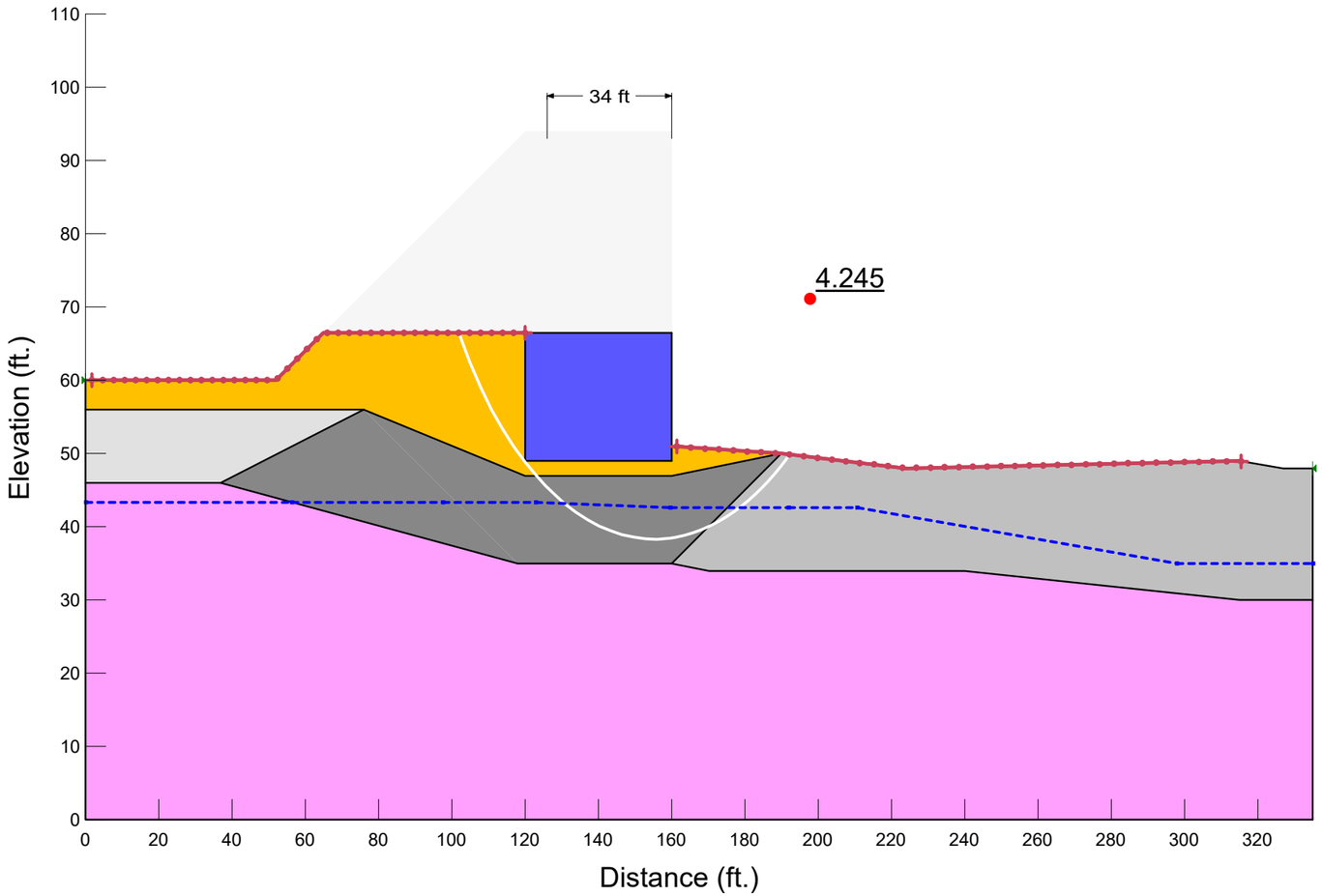
Bridge 17.7 - Wall 03.63L Section Fa-Fa'
Pseudo-Static Gobal Stability (M-P) - Existing Condition

WSDOT I-405 Renton to Bellevue
King County, Washington

GeoEngineers

Figure D.4-16



Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	ESU 1B - Existing Gravelly Granular Fill	Mohr-Coulomb	125	0	38
	ESU 2A - Native Sand and Gravel	Mohr-Coulomb	120	0	39
	ESU 2B - Native Sand and Gravel	Mohr-Coulomb	135	0	41
	ESU 2C - Native Silt	Mohr-Coulomb	110	0	29
	ESU 7A - Weathered Sandstone	Mohr-Coulomb	135	0	42
	Hilfiker Wall	High Strength	130		

Notes:

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2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document.
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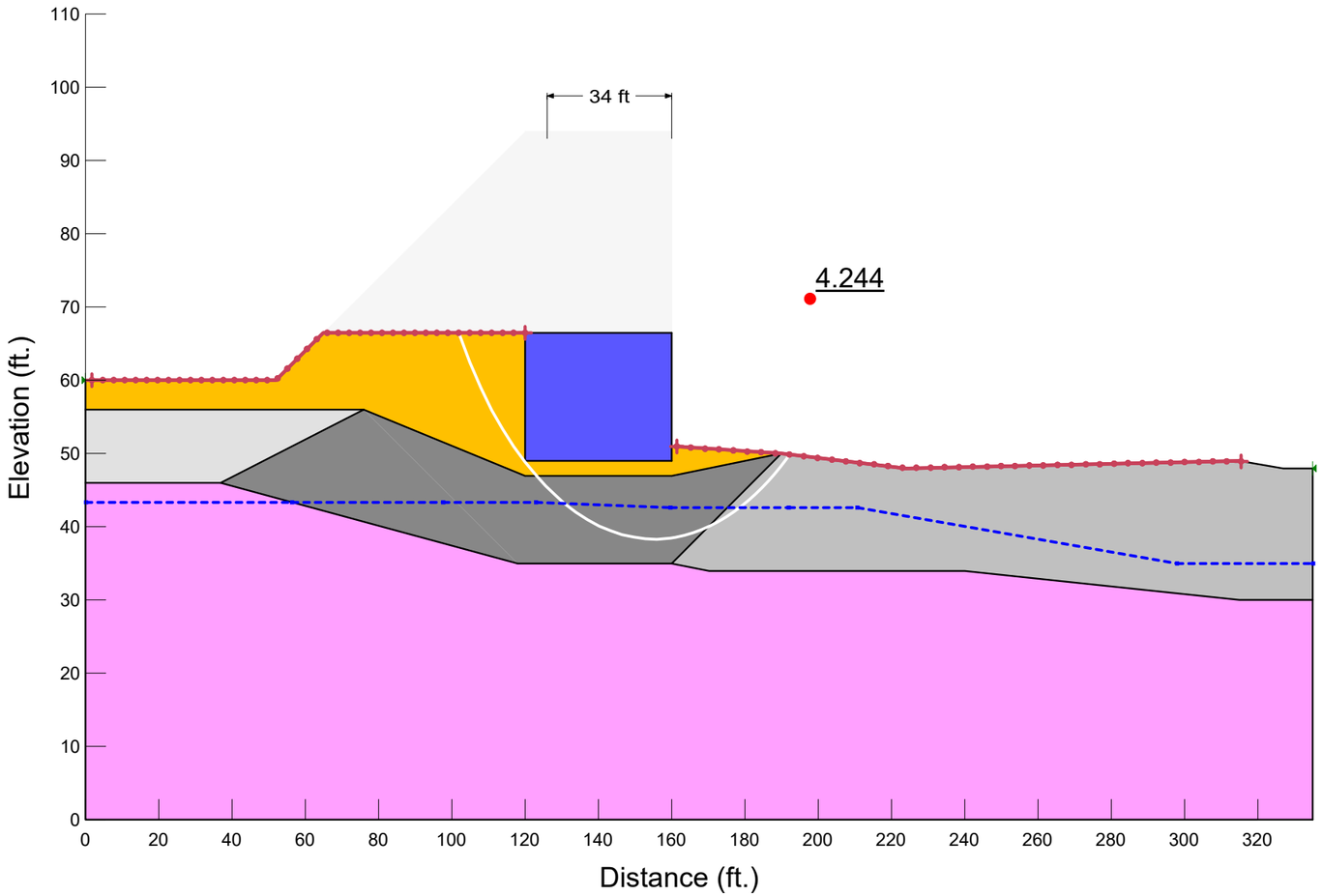
Bridge 17.7 - Wall 03.63L Section Fa-Fa'
Static Global Stability (Spencer) - Construction Condition

WSDOT I-405 Renton to Bellevue
King County, Washington

GeoEngineers

Figure D.4-17



Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	ESU 1B - Existing Gravelly Granular Fill	Mohr-Coulomb	125	0	38
	ESU 2A - Native Sand and Gravel	Mohr-Coulomb	120	0	39
	ESU 2B - Native Sand and Gravel	Mohr-Coulomb	135	0	41
	ESU 2C - Native Silt	Mohr-Coulomb	110	0	29
	ESU 7A - Weathered Sandstone	Mohr-Coulomb	135	0	42
	Hilfiker Wall	High Strength	130		

Notes:

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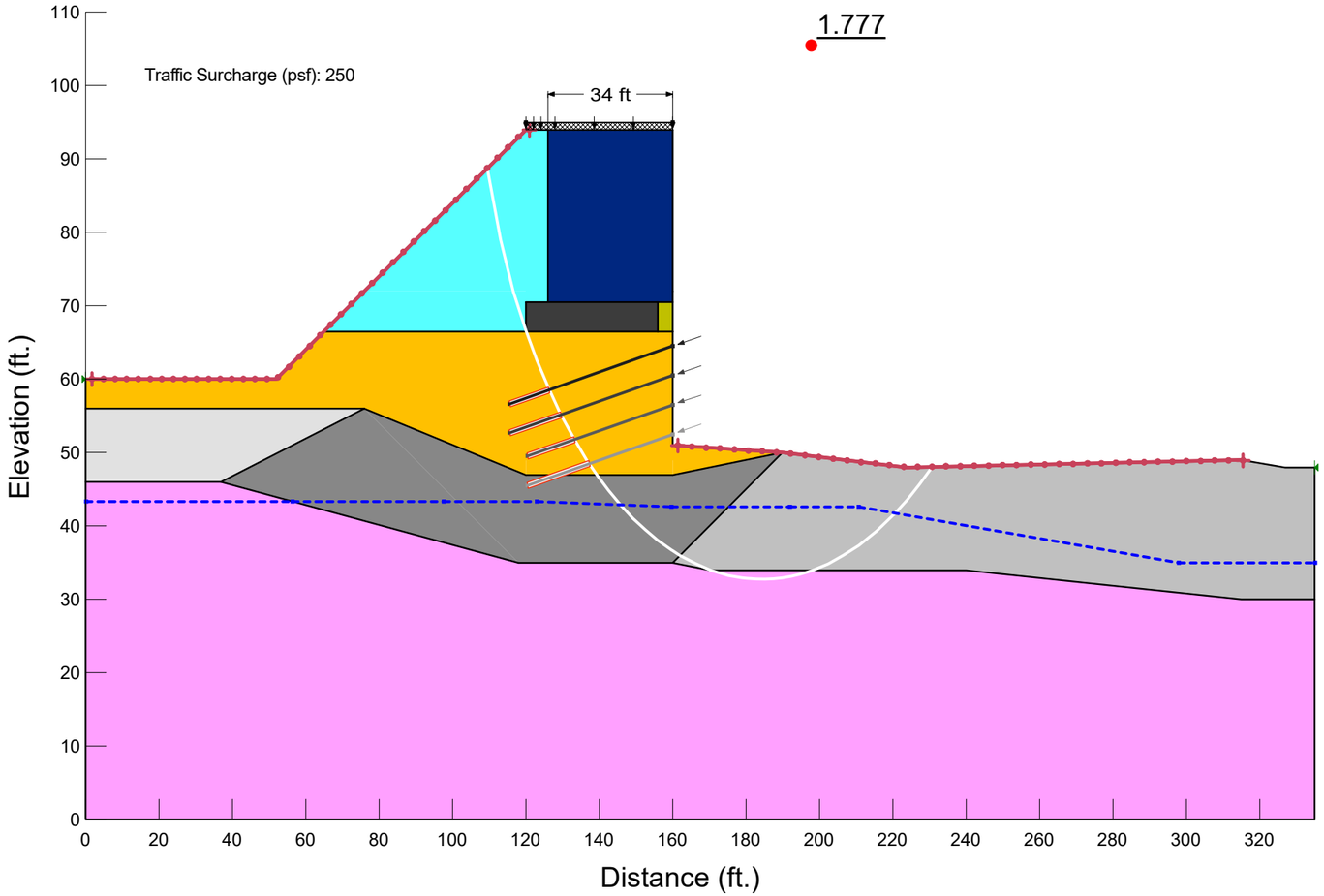
Bridge 17.7 - Wall 03.63L Section Fa-Fa'
Static Global Stability (M-P) - Construction Condition

WSDOT I-405 Renton to Bellevue
King County, Washington

GeoEngineers

Figure D.4-18



Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Common Borrow	Mohr-Coulomb	120	0	32
	ESU 1B - Existing Gravelly Granular Fill	Mohr-Coulomb	125	0	38
	ESU 2A - Native Sand and Gravel	Mohr-Coulomb	120	0	39
	ESU 2B - Native Sand and Gravel	Mohr-Coulomb	135	0	41
	ESU 2C - Native Silt	Mohr-Coulomb	110	0	29
	ESU 7A - Weathered Sandstone	Mohr-Coulomb	135	0	42
	Gravel Borrow	Mohr-Coulomb	130	0	38
	New Hilfiker Wall	High Strength	130		
	New Pier 1 Footing	High Strength	2,250		

Color	Name	Type	Pullout Resistance (psf)	Tensile Capacity (lbf)	Bond Length (ft)	Bond Diameter (ft)	Out-of-Plane Spacing (ft)	Factored Tensile Capacity
	Soil Nail_Row 1	Anchor	1,800	82,550	45	0.5	4	20,638 lbf/ft
	Soil Nail_Row 2	Anchor	1,800	82,550	45	0.5	4	20,638 lbf/ft
	Soil Nail_Row 3	Anchor	1,800	82,550	40	0.5	4	20,638 lbf/ft
	Soil Nail_Row 4	Anchor	1,800	82,550	40	0.5	4	20,638 lbf/ft

Notes:

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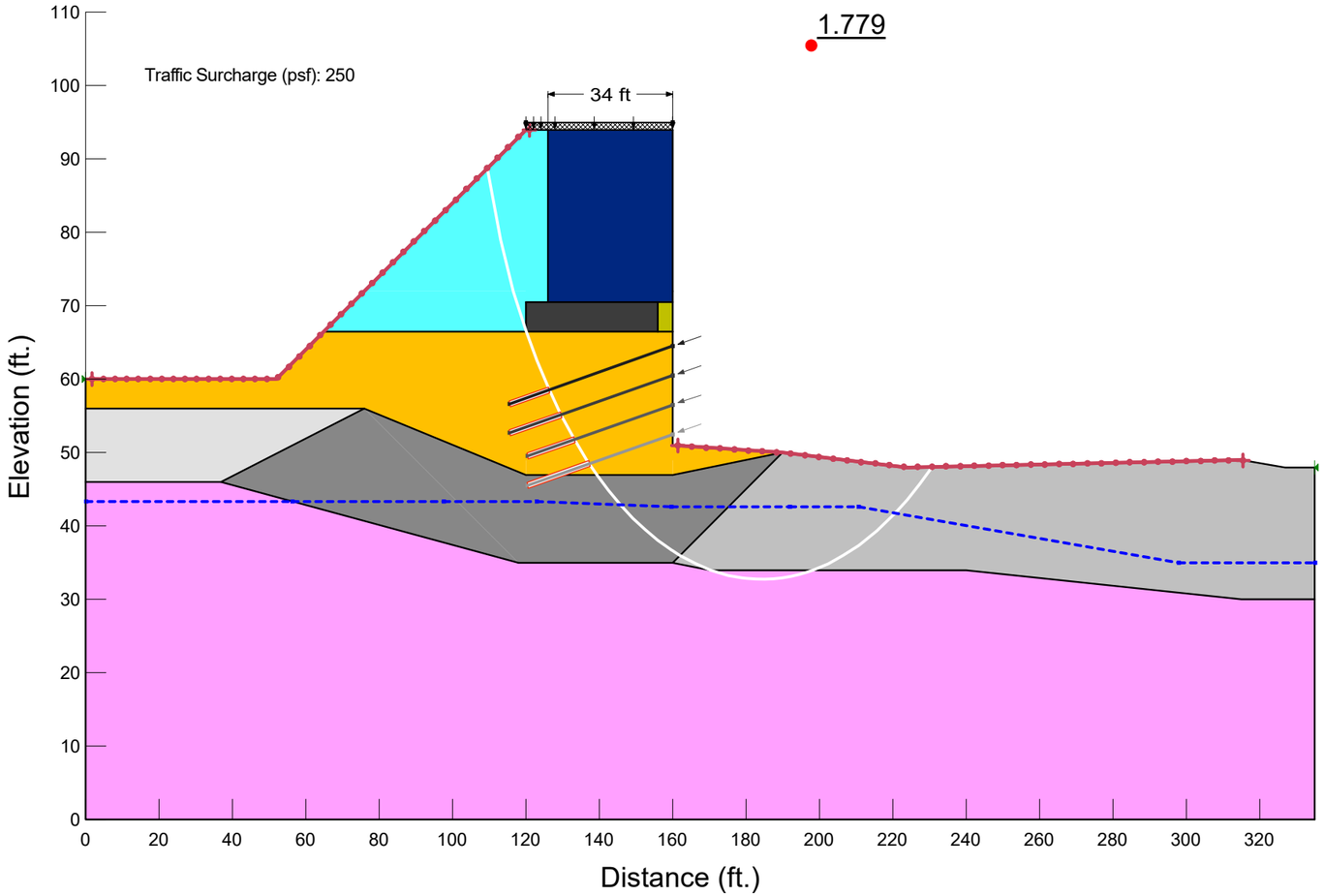
Bridge 17.7 - Wall 03.63L Section Fa-Fa'
Static Global Stability (Spencer) - Final Condition

WSDOT I-405 Renton to Bellevue
King County, Washington

GeoEngineers

Figure D.4-19



Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Common Borrow	Mohr-Coulomb	120	0	32
	ESU 1B - Existing Gravelly Granular Fill	Mohr-Coulomb	125	0	38
	ESU 2A - Native Sand and Gravel	Mohr-Coulomb	120	0	39
	ESU 2B - Native Sand and Gravel	Mohr-Coulomb	135	0	41
	ESU 2C - Native Silt	Mohr-Coulomb	110	0	29
	ESU 7A - Weathered Sandstone	Mohr-Coulomb	135	0	42
	Gravel Borrow	Mohr-Coulomb	130	0	38
	New Hilfiker Wall	High Strength	130		
	New Pier 1 Footing	High Strength	2,250		

Color	Name	Type	Pullout Resistance (psf)	Tensile Capacity (lbf)	Bond Length (ft)	Bond Diameter (ft)	Out-of-Plane Spacing (ft)	Factored Tensile Capacity
	Soil Nail_Row 1	Anchor	1,800	82,550	45	0.5	4	20,638 lbf/ft
	Soil Nail_Row 2	Anchor	1,800	82,550	45	0.5	4	20,638 lbf/ft
	Soil Nail_Row 3	Anchor	1,800	82,550	40	0.5	4	20,638 lbf/ft
	Soil Nail_Row 4	Anchor	1,800	82,550	40	0.5	4	20,638 lbf/ft

Notes:

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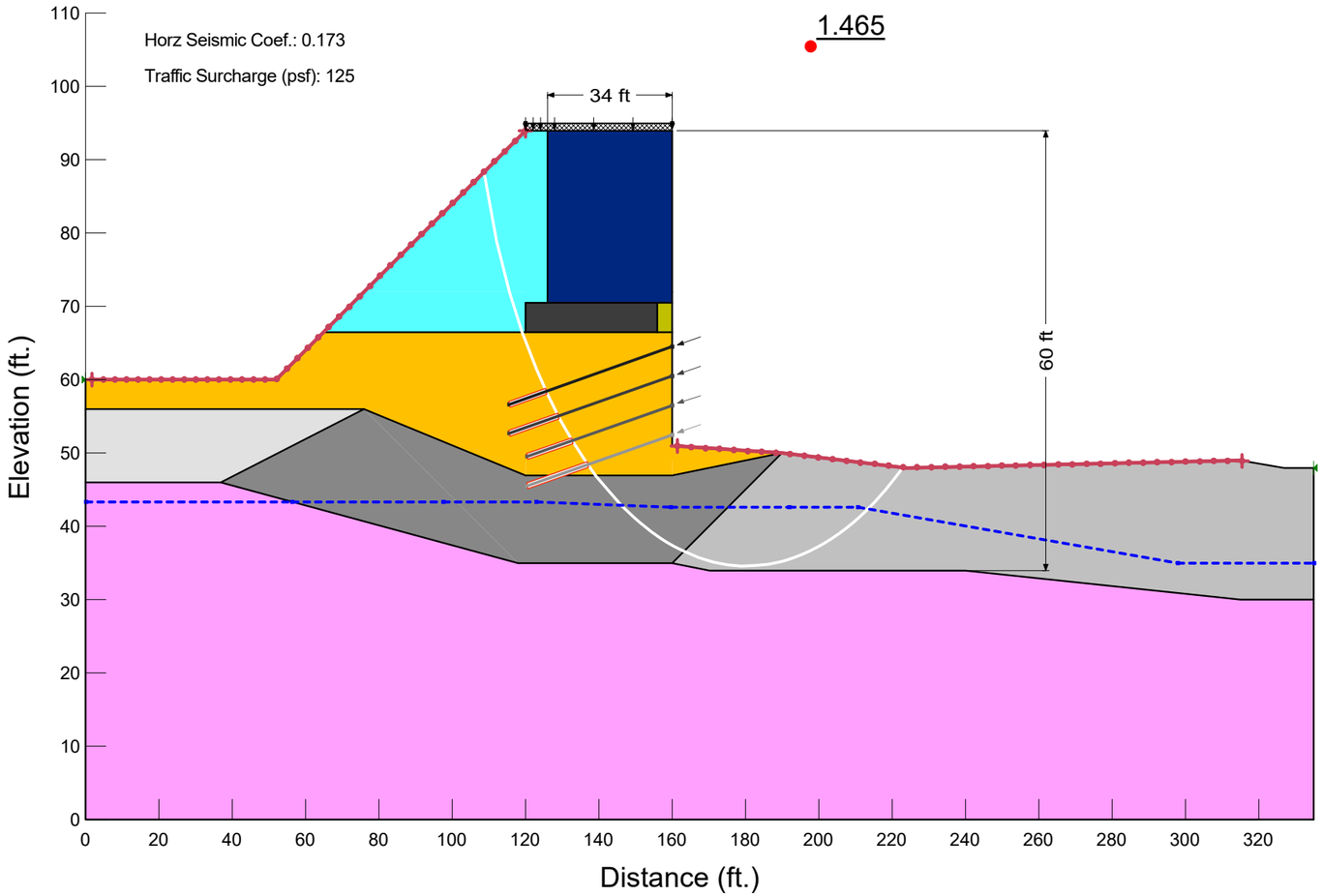
Bridge 17.7 - Wall 03.63L Section Fa-Fa'
Static Global Stability (M-P) - Final Condition

WSDOT I-405 Renton to Bellevue
King County, Washington

GeoEngineers

Figure D.4-20



Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Common Borrow	Mohr-Coulomb	120	0	32
	ESU 1B - Existing Gravelly Granular Fill	Mohr-Coulomb	125	0	38
	ESU 2A - Native Sand and Gravel	Mohr-Coulomb	120	0	39
	ESU 2B - Native Sand and Gravel	Mohr-Coulomb	135	0	41
	ESU 2C - Native Silt (Pseudo-Static)	Mohr-Coulomb	110	200	29
	ESU 7A - Weathered Sandstone	Mohr-Coulomb	135	0	42
	Gravel Borrow	Mohr-Coulomb	130	0	38
	New Hilfiker Wall	High Strength	130		
	New Pier 1 Footing	High Strength	2,250		

Color	Name	Type	Pullout Resistance (psf)	Tensile Capacity (lbf)	Bond Length (ft)	Bond Diameter (ft)	Out-of-Plane Spacing (ft)	Factored Tensile Capacity
	Soil Nail_Row 1	Anchor	1,800	82,550	45	0.5	4	20,638 lbf/ft
	Soil Nail_Row 2	Anchor	1,800	82,550	45	0.5	4	20,638 lbf/ft
	Soil Nail_Row 3	Anchor	1,800	82,550	40	0.5	4	20,638 lbf/ft
	Soil Nail_Row 4	Anchor	1,800	82,550	40	0.5	4	20,638 lbf/ft

Notes:

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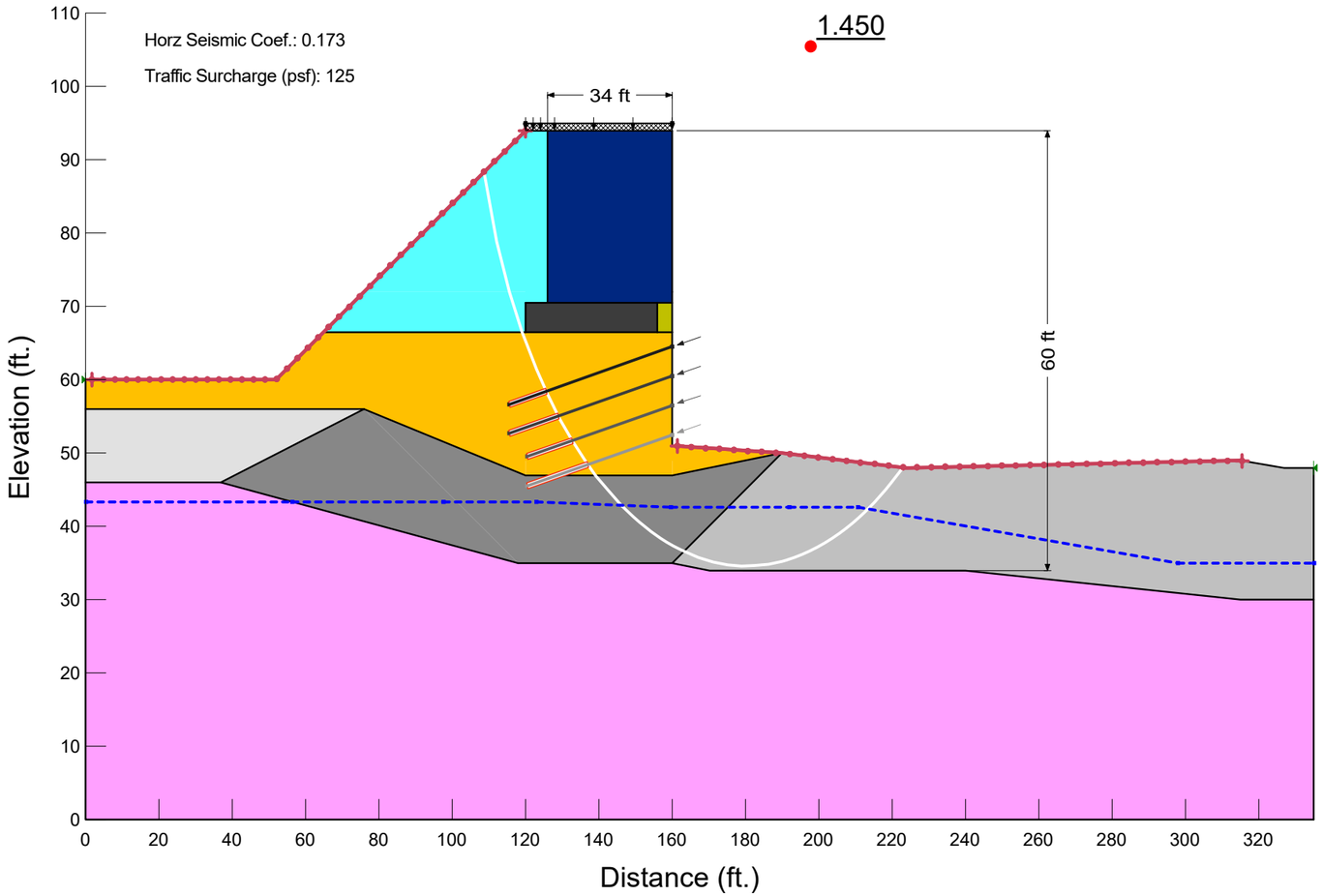
Bridge 17.7 - Wall 03.63L Section Fa-Fa'
Pseudo-Static Global Stability (Spencer) - Final Condition

WSDOT I-405 Renton to Bellevue
King County, Washington

GeoEngineers

Figure D.4-21



Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Common Borrow	Mohr-Coulomb	120	0	32
	ESU 1B - Existing Gravelly Granular Fill	Mohr-Coulomb	125	0	38
	ESU 2A - Native Sand and Gravel	Mohr-Coulomb	120	0	39
	ESU 2B - Native Sand and Gravel	Mohr-Coulomb	135	0	41
	ESU 2C - Native Silt (Pseudo-Static)	Mohr-Coulomb	110	200	29
	ESU 7A - Weathered Sandstone	Mohr-Coulomb	135	0	42
	Gravel Borrow	Mohr-Coulomb	130	0	38
	New Hilfiker Wall	High Strength	130		
	New Pier 1 Footing	High Strength	2,250		

Color	Name	Type	Pullout Resistance (psf)	Tensile Capacity (lbf)	Bond Length (ft)	Bond Diameter (ft)	Out-of-Plane Spacing (ft)	Factored Tensile Capacity
	Soil Nail_Row 1	Anchor	1,800	82,550	45	0.5	4	20,638 lbf/ft
	Soil Nail_Row 2	Anchor	1,800	82,550	45	0.5	4	20,638 lbf/ft
	Soil Nail_Row 3	Anchor	1,800	82,550	40	0.5	4	20,638 lbf/ft
	Soil Nail_Row 4	Anchor	1,800	82,550	40	0.5	4	20,638 lbf/ft

Notes:

1. The locations of all features shown are approximate.
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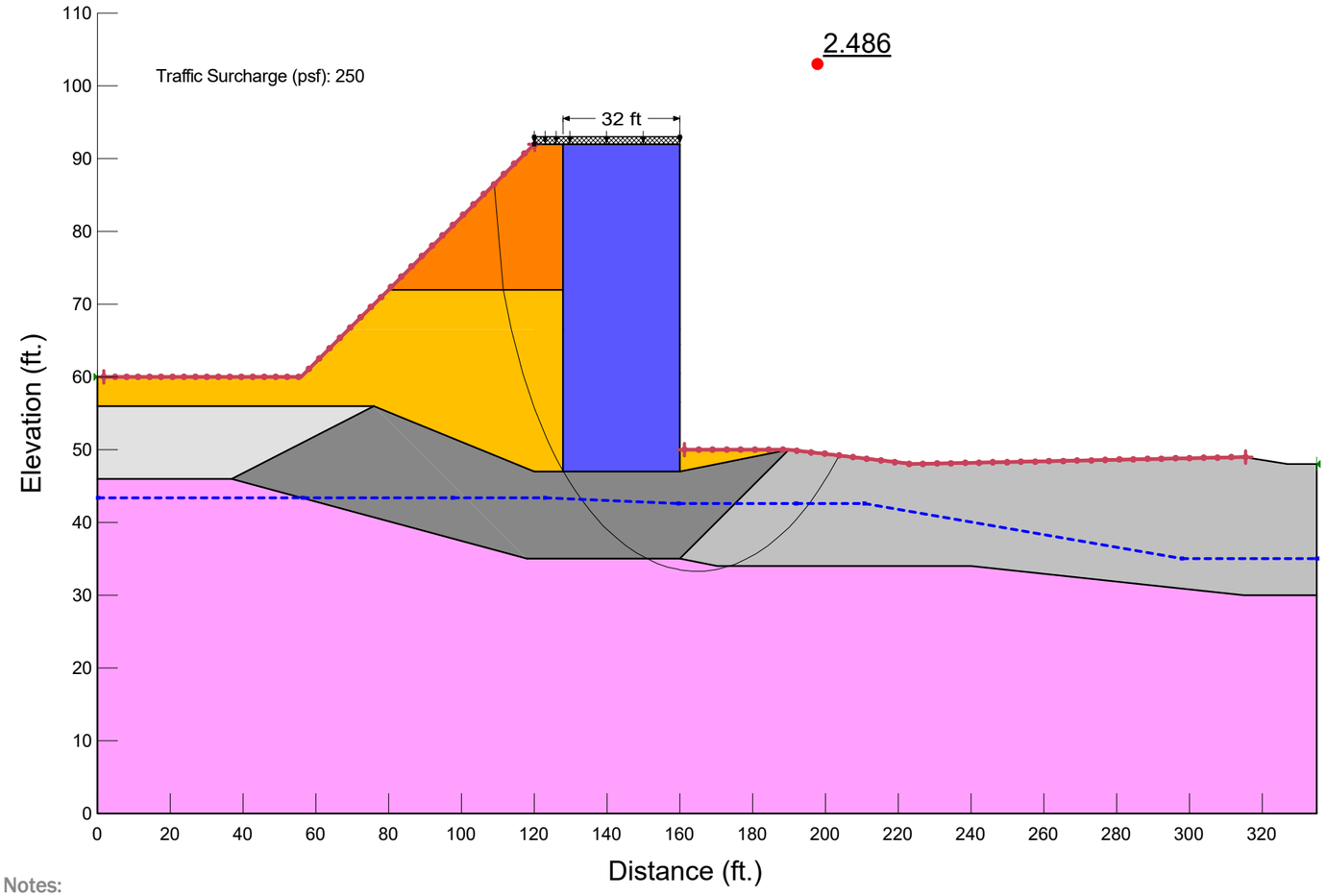
Bridge 17.7 - Wall 03.63L Section Fa-Fa'
Pseudo-Static Global Stability (M-P) - Final Condition

WSDOT I-405 Renton to Bellevue
King County, Washington

GeoEngineers

Figure D.4-22



Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	ESU 1A - Existing Granular Fill	Mohr-Coulomb	120	0	40
	ESU 1B - Existing Gravelly Granular Fill	Mohr-Coulomb	125	0	38
	ESU 2A - Native Sand and Gravel	Mohr-Coulomb	120	0	39
	ESU 2B - Native Sand and Gravel	Mohr-Coulomb	135	0	41
	ESU 2C - Native Silt	Mohr-Coulomb	110	0	29
	ESU 7A - Weathered Sandstone	Mohr-Coulomb	135	0	43
	Hilfiker Wall	High Strength	130		

Notes:

1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document.
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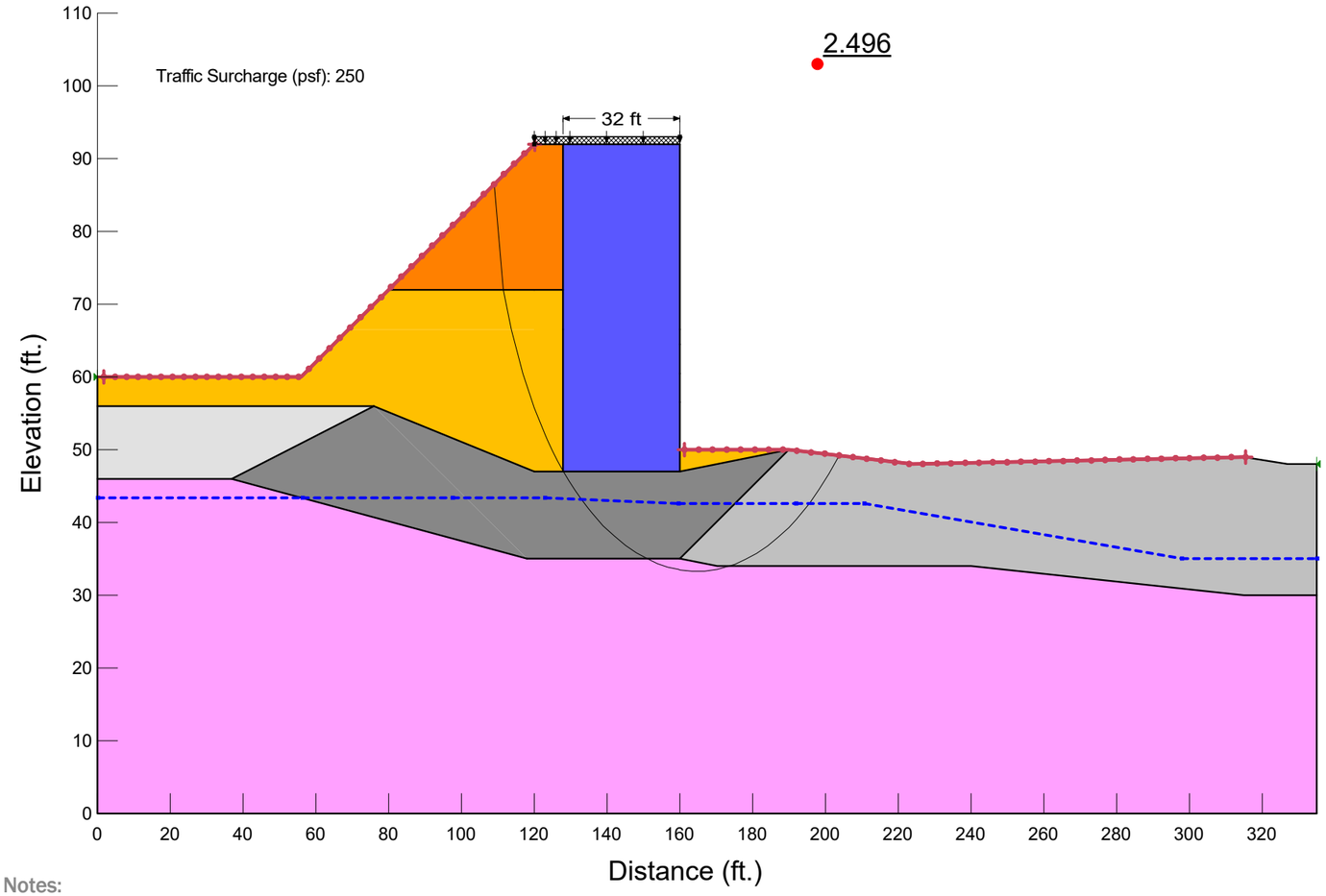
Bridge 17.7 - Wall 03.63L Section Ga-Ga'
Static Global Stability (Spencer) - Existing Condition

WSDOT I-405 Renton to Bellevue
King County, Washington

GeoEngineers

Figure D.4-23



Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	ESU 1A - Existing Granular Fill	Mohr-Coulomb	120	0	40
	ESU 1B - Existing Gravelly Granular Fill	Mohr-Coulomb	125	0	38
	ESU 2A - Native Sand and Gravel	Mohr-Coulomb	120	0	39
	ESU 2B - Native Sand and Gravel	Mohr-Coulomb	135	0	41
	ESU 2C - Native Silt	Mohr-Coulomb	110	0	29
	ESU 7A - Weathered Sandstone	Mohr-Coulomb	135	0	43
	Hilfiker Wall	High Strength	130		

Notes:

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2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document.
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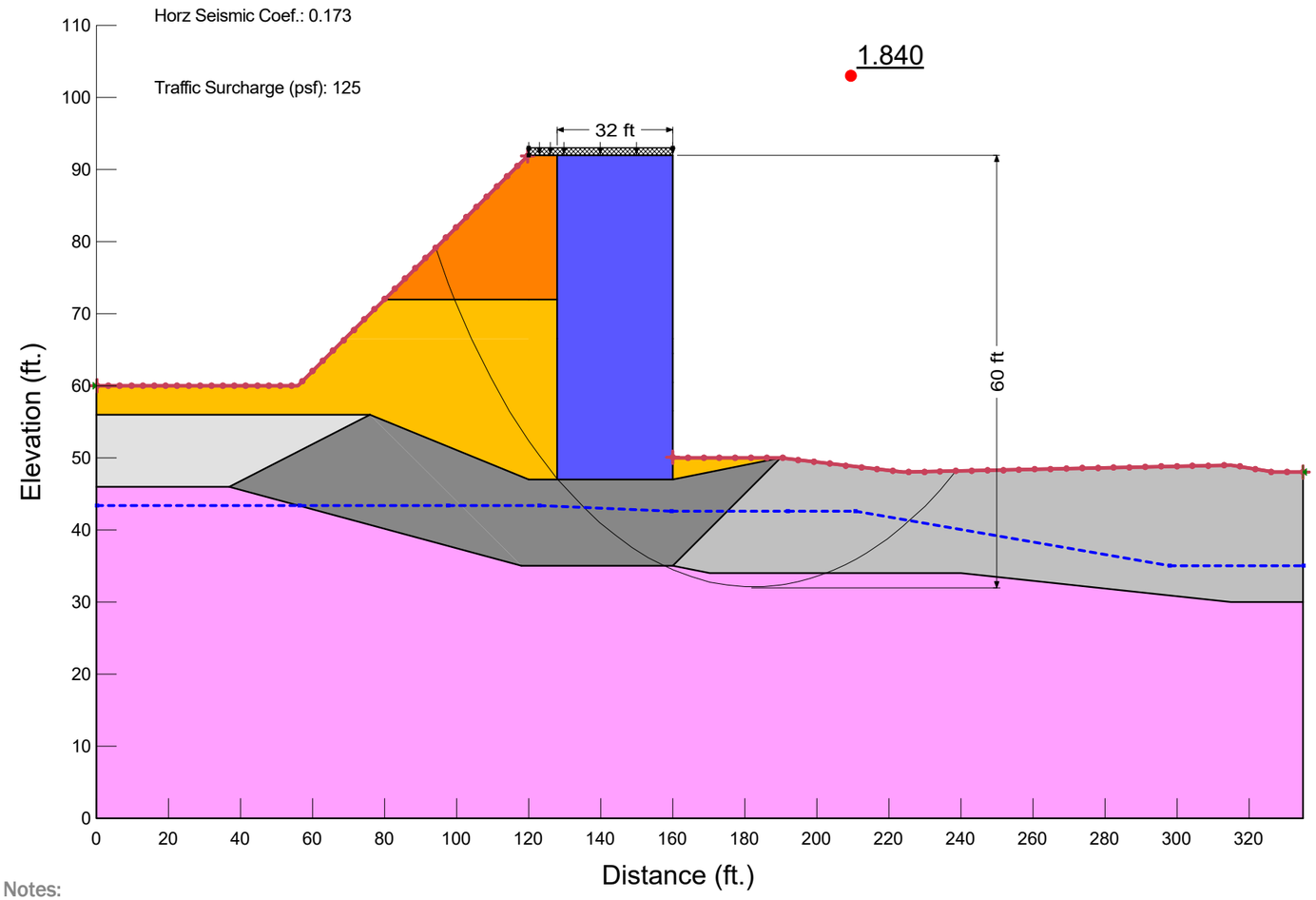
Bridge 17.7 - Wall 03.63L Section Ga-Ga'
Static Global Stability (M-P) - Existing Condition

WSDOT I-405 Renton to Bellevue
King County, Washington

GeoEngineers

Figure D.4-24



Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	ESU 1A - Existing Granular Fill (Pseudo-Static)	Mohr-Coulomb	120	50	40
	ESU 1B - Existing Gravelly Granular Fill	Mohr-Coulomb	125	0	38
	ESU 2A - Native Sand and Gravel	Mohr-Coulomb	120	0	39
	ESU 2B - Native Sand and Gravel	Mohr-Coulomb	135	0	41
	ESU 2C - Native Silt (Pseudo-Static)	Mohr-Coulomb	110	200	29
	ESU 7A - Weathered Sandstone	Mohr-Coulomb	135	0	43
	Hilfiker Wall	High Strength	130		

Notes:

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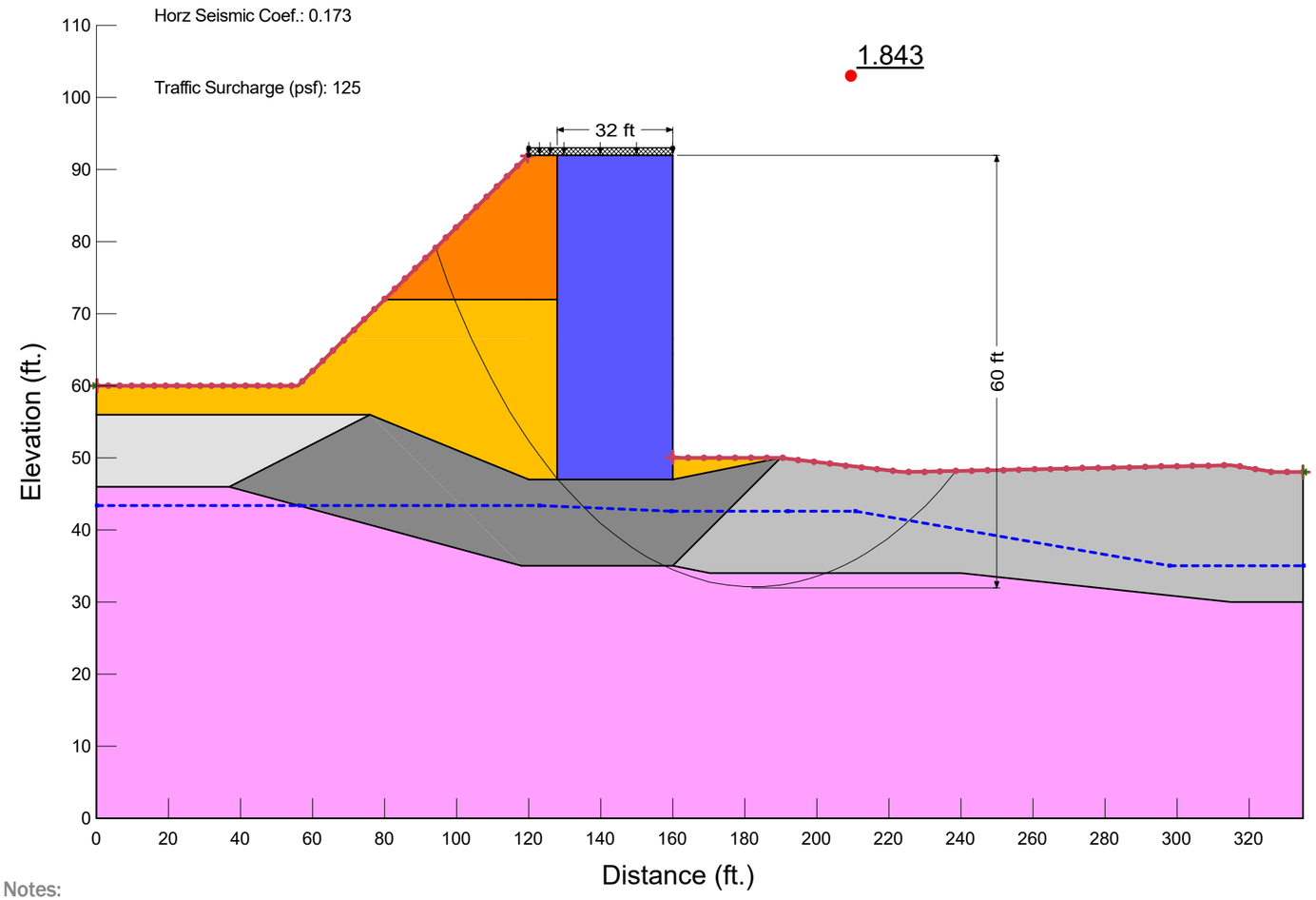
Bridge 17.7 - Wall 03.63L Section Ga-Ga'
Pseudo-Static Global Stability (Spencer) - Existing Condition

WSDOT I-405 Renton to Bellevue
King County, Washington

GeoEngineers

Figure D.4-25



Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	ESU 1A - Existing Granular Fill (Pseudo-Static)	Mohr-Coulomb	120	50	40
	ESU 1B - Existing Gravelly Granular Fill	Mohr-Coulomb	125	0	38
	ESU 2A - Native Sand and Gravel	Mohr-Coulomb	120	0	39
	ESU 2B - Native Sand and Gravel	Mohr-Coulomb	135	0	41
	ESU 2C - Native Silt (Pseudo-Static)	Mohr-Coulomb	110	200	29
	ESU 7A - Weathered Sandstone	Mohr-Coulomb	135	0	43
	Hilfiker Wall	High Strength	130		

Notes:

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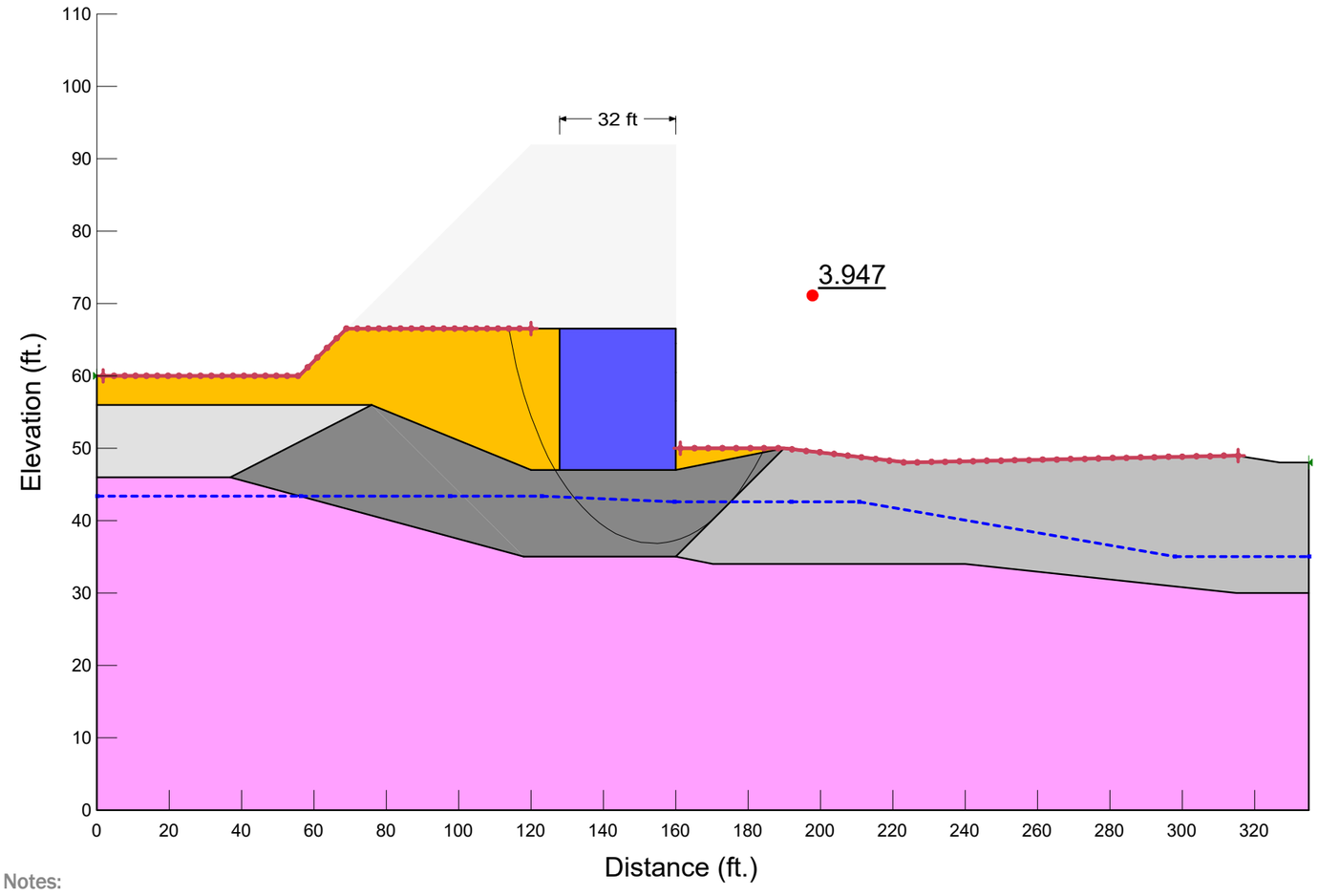
Bridge 17.7 - Wall 03.63L Section Ga-Ga'
Pseudo-Static Global Stability (M-P) - Existing Condition

WSDOT I-405 Renton to Bellevue
King County, Washington

GeoEngineers

Figure D.4-26



Color	Name	Slope Stability Material Model	Unit Weight	Effective Cohesion	Effective Friction Angle
	ESU 1B - Existing Gravelly Granular Fill	Mohr-Coulomb	125	0	38
	ESU 2A - Native Sand and Gravel	Mohr-Coulomb	120	0	39
	ESU 2B - Native Sand and Gravel	Mohr-Coulomb	135	0	41
	ESU 2C - Native Silt	Mohr-Coulomb	110	0	29
	ESU 7A - Weathered Sandstone	Mohr-Coulomb	135	0	43
	Hilfiker Wall	High Strength	130		

Notes:

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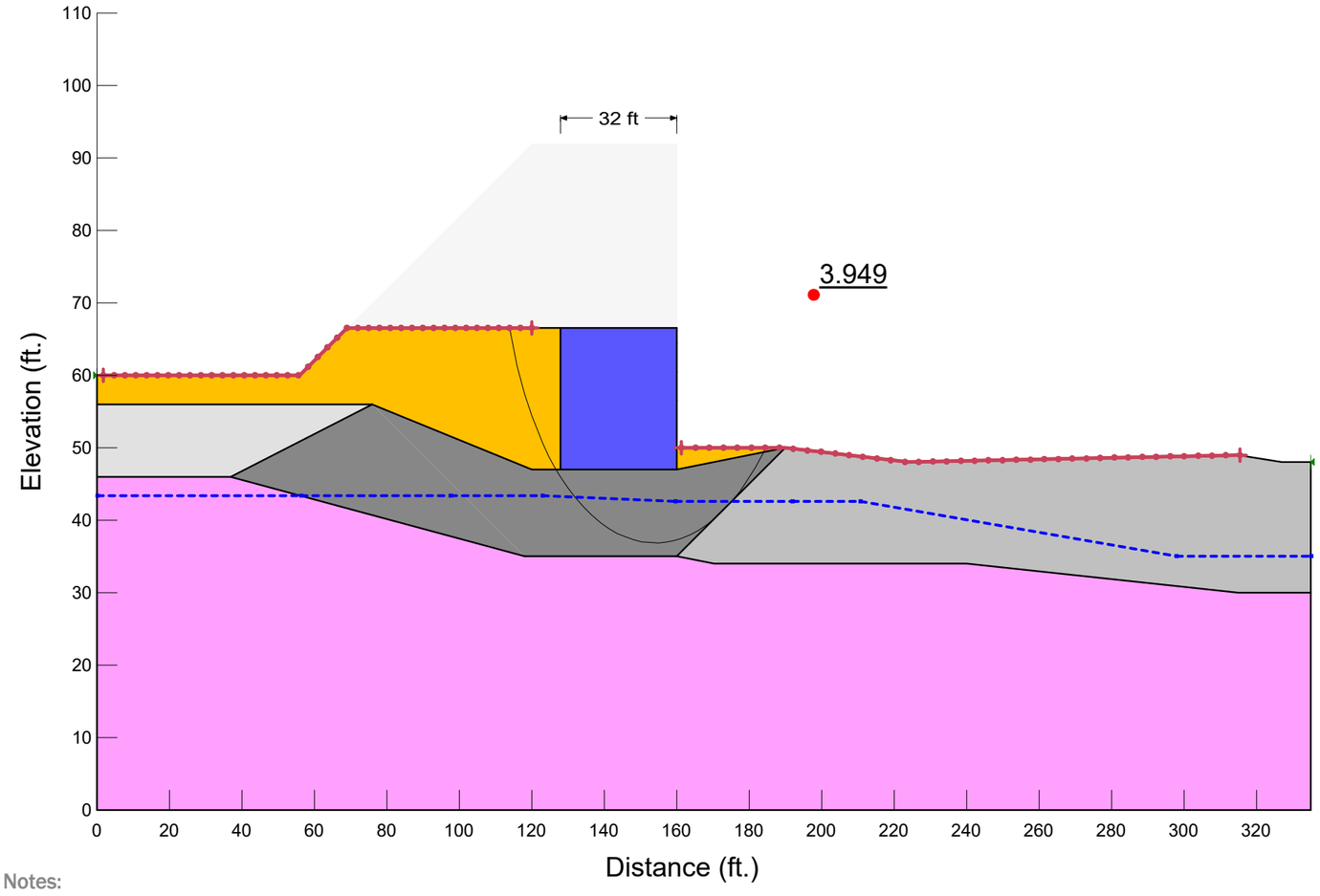
Bridge 17.7 - Wall 03.63L Section Ga-Ga'
Static Global Stability (Spencer) - Construction Condition

WSDOT I-405 Renton to Bellevue
King County, Washington

GeoEngineers

Figure D.4-27



Color	Name	Slope Stability Material Model	Unit Weight	Effective Cohesion	Effective Friction Angle
	ESU 1B - Existing Gravelly Granular Fill	Mohr-Coulomb	125	0	38
	ESU 2A - Native Sand and Gravel	Mohr-Coulomb	120	0	39
	ESU 2B - Native Sand and Gravel	Mohr-Coulomb	135	0	41
	ESU 2C - Native Silt	Mohr-Coulomb	110	0	29
	ESU 7A - Weathered Sandstone	Mohr-Coulomb	135	0	43
	Hilfiker Wall	High Strength	130		

Notes:

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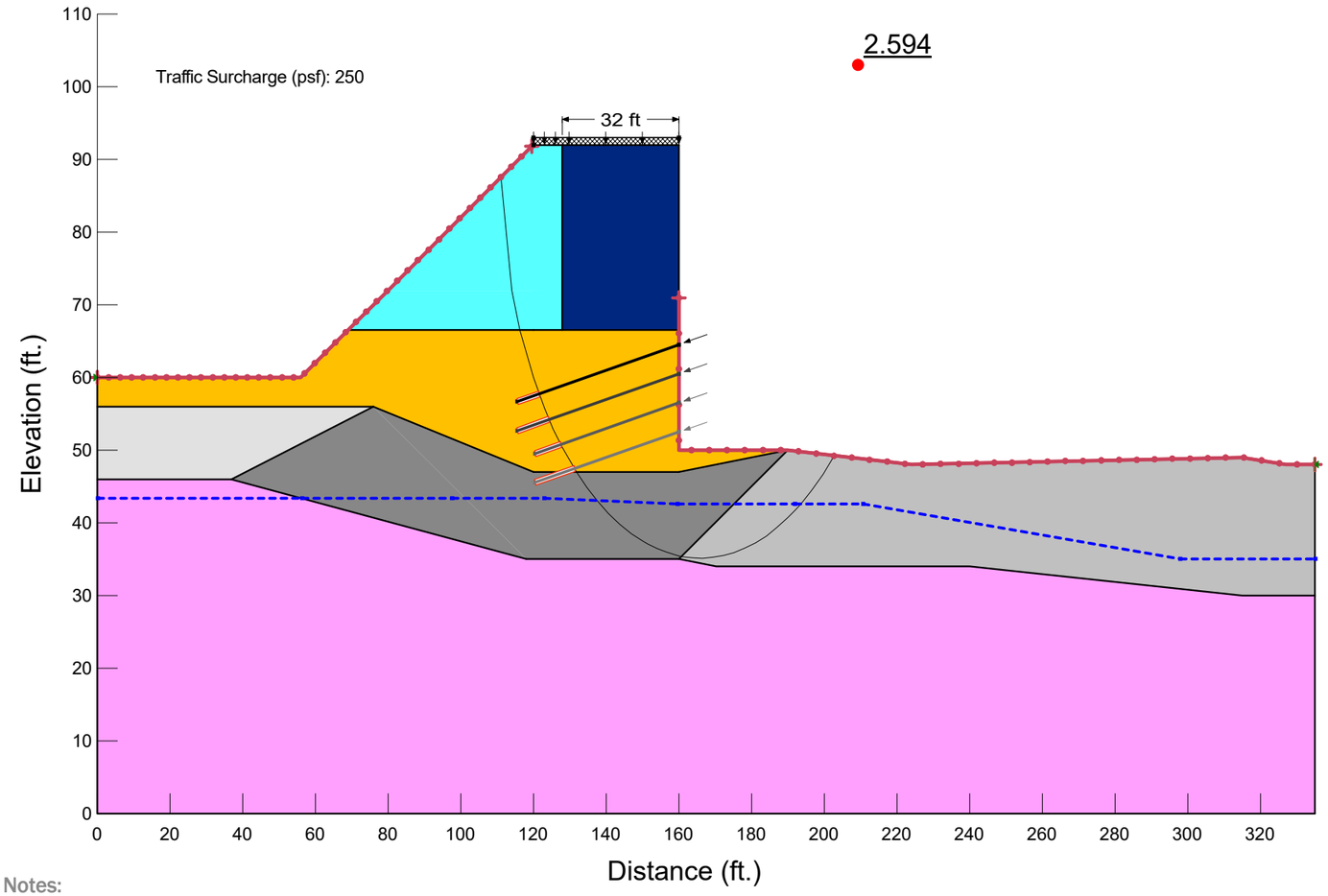
Bridge 17.7 - Wall 03.63L Section Ga-Ga'
Static Global Stability (M-P) - Construction Condition

WSDOT I-405 Renton to Bellevue
King County, Washington

GeoEngineers

Figure D.4-28



Color	Name	Slope Stability Material Model	Unit Weight	Effective Cohesion	Effective Friction Angle
	Common Borrow	Mohr-Coulomb	120	0	32
	ESU 1B - Existing Gravelly Granular Fill	Mohr-Coulomb	125	0	38
	ESU 2A - Native Sand and Gravel	Mohr-Coulomb	120	0	39
	ESU 2B - Native Sand and Gravel	Mohr-Coulomb	135	0	41
	ESU 2C - Native Silt	Mohr-Coulomb	110	0	29
	ESU 7A - Weathered Sandstone	Mohr-Coulomb	135	0	43
	New Hilfiker Wall	High Strength	130		

Color	Name	Type	Pullout Resistance (psf)	Tensile Capacity (lbf)	Bond Length (ft)	Bond Diameter (ft)	Out-of-Plane Spacing (ft)
	Soil Nail_Row 1	Anchor	1,800	82,550	45	0.5	4
	Soil Nail_Row 2	Anchor	1,800	82,550	45	0.5	4
	Soil Nail_Row 3	Anchor	1,800	82,550	40	0.5	4
	Soil Nail_Row 4	Anchor	1,800	82,550	40	0.5	4

Notes:

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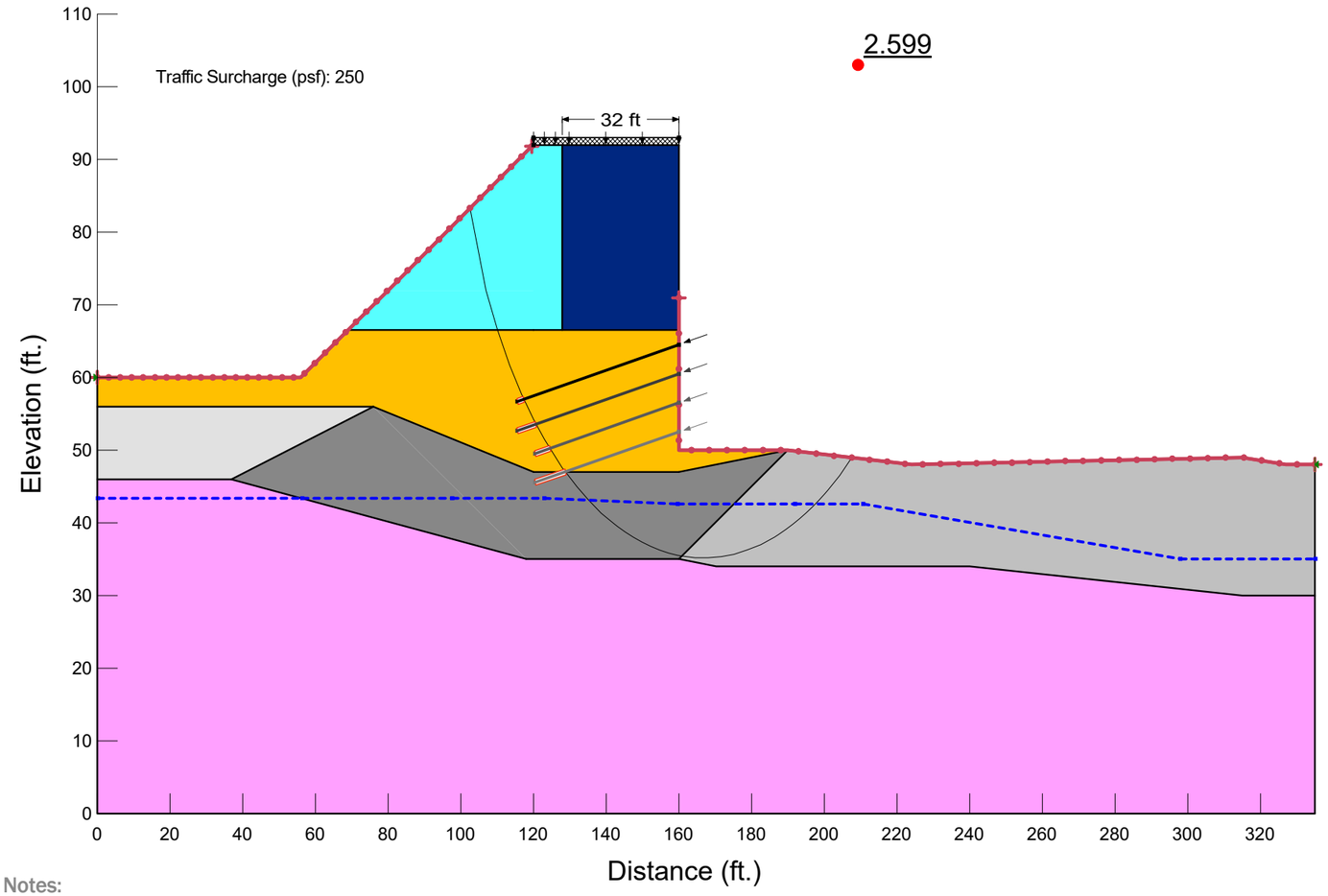
Bridge 17.7 - Wall 03.63L Section Ga-Ga'
Static Global Stability (Spencer) - Final Condition

WSDOT I-405 Renton to Bellevue
King County, Washington

GeoEngineers

Figure D.4-29



Color	Name	Slope Stability Material Model	Unit Weight	Effective Cohesion	Effective Friction Angle
	Common Borrow	Mohr-Coulomb	120	0	32
	ESU 1B - Existing Gravelly Granular Fill	Mohr-Coulomb	125	0	38
	ESU 2A - Native Sand and Gravel	Mohr-Coulomb	120	0	39
	ESU 2B - Native Sand and Gravel	Mohr-Coulomb	135	0	41
	ESU 2C - Native Silt	Mohr-Coulomb	110	0	29
	ESU 7A - Weathered Sandstone	Mohr-Coulomb	135	0	43
	New Hilfiker Wall	High Strength	130		

Color	Name	Type	Pullout Resistance (psf)	Tensile Capacity (lbf)	Bond Length (ft)	Bond Diameter (ft)	Out-of-Plane Spacing (ft)
	Soil Nail_Row 1	Anchor	1,800	82,550	45	0.5	4
	Soil Nail_Row 2	Anchor	1,800	82,550	45	0.5	4
	Soil Nail_Row 3	Anchor	1,800	82,550	40	0.5	4
	Soil Nail_Row 4	Anchor	1,800	82,550	40	0.5	4

Notes:

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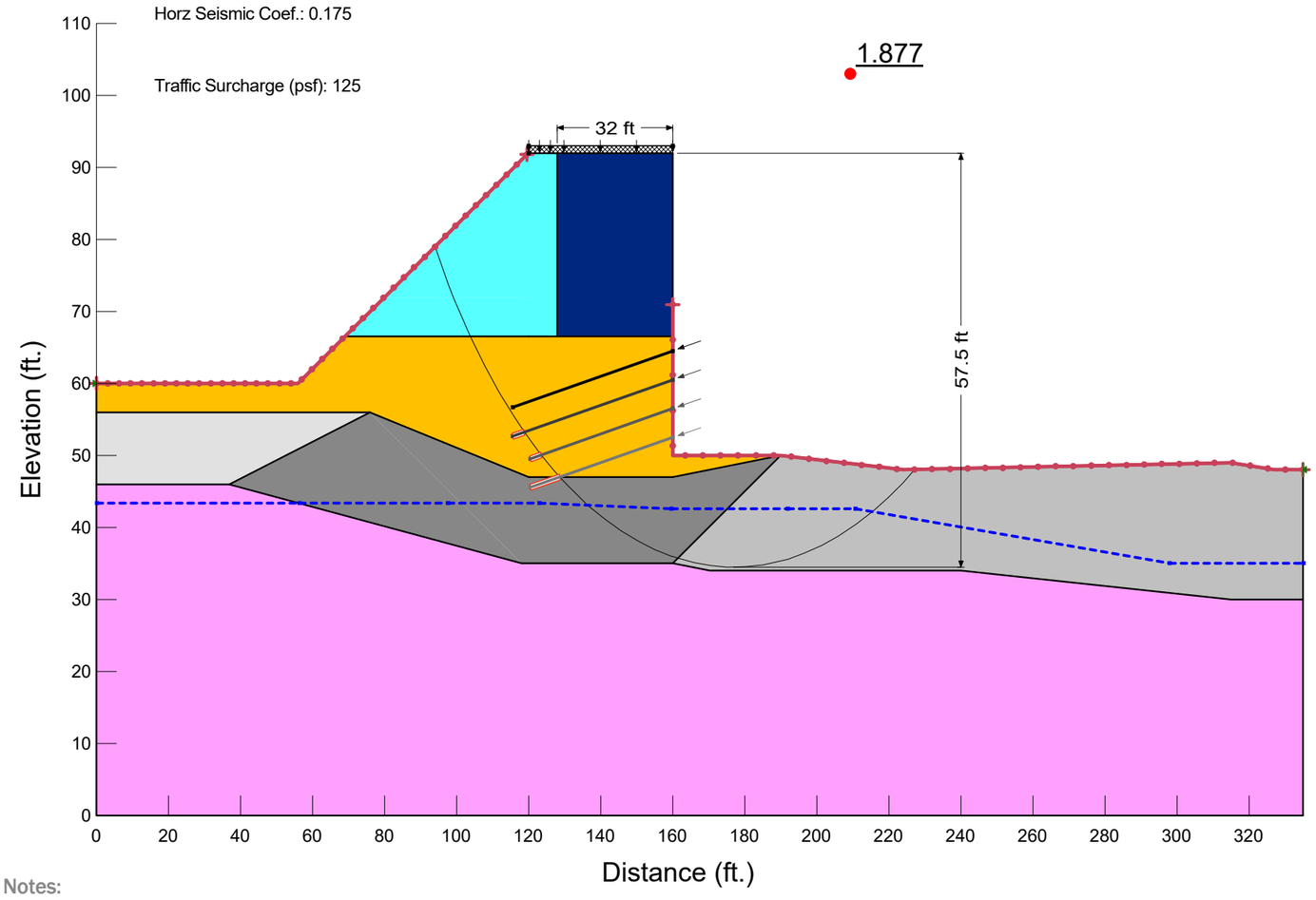
Bridge 17.7 - Wall 03.63L Section Ga-Ga'
Static Global Stability (M-P) - Final Condition

WSDOT I-405 Renton to Bellevue
King County, Washington

GeoEngineers

Figure D.4-30



Color	Name	Slope Stability Material Model	Unit Weight	Effective Cohesion	Effective Friction Angle
	Common Borrow	Mohr-Coulomb	120	0	32
	ESU 1B - Existing Gravelly Granular Fill	Mohr-Coulomb	125	0	38
	ESU 2A - Native Sand and Gravel	Mohr-Coulomb	120	0	39
	ESU 2B - Native Sand and Gravel	Mohr-Coulomb	135	0	41
	ESU 2C - Native Silt (Pseudo-Static)	Mohr-Coulomb	110	200	29
	ESU 7A - Weathered Sandstone	Mohr-Coulomb	135	0	43
	New Hilfiker Wall	High Strength	130		

Color	Name	Type	Pullout Resistance (psf)	Tensile Capacity (lbf)	Bond Length (ft)	Bond Diameter (ft)	Out-of-Plane Spacing (ft)
	Soil Nail_Row 1	Anchor	1,800	82,550	45	0.5	4
	Soil Nail_Row 2	Anchor	1,800	82,550	45	0.5	4
	Soil Nail_Row 3	Anchor	1,800	82,550	40	0.5	4
	Soil Nail_Row 4	Anchor	1,800	82,550	40	0.5	4

Notes:

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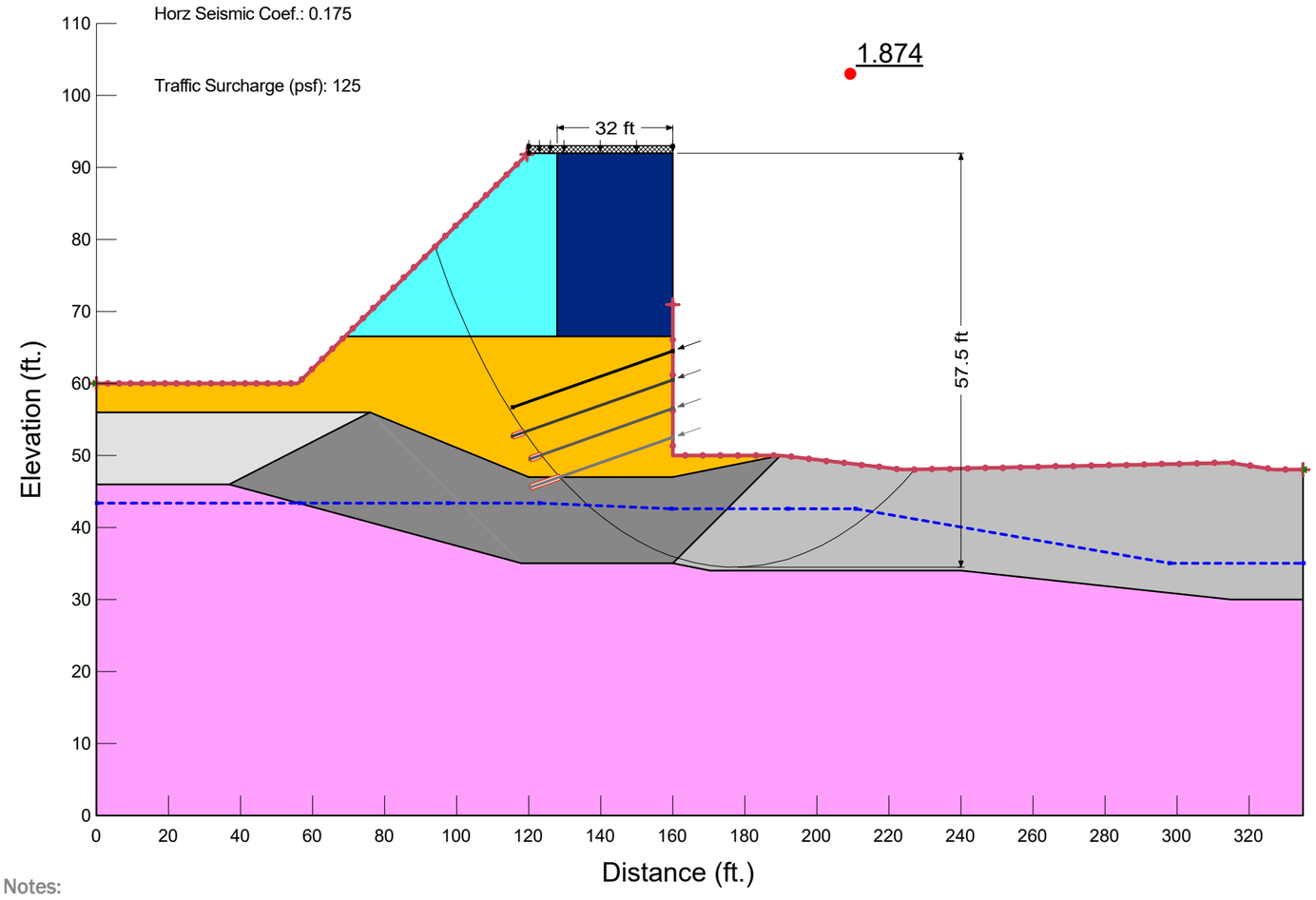
Bridge 17.7 - Wall 03.63L Section Ga-Ga'
Pseudo-Static Global Stability (Spencer) - Final Condition

WSDOT I-405 Renton to Bellevue
King County, Washington

GeoEngineers

Figure D.4-31



Color	Name	Slope Stability Material Model	Unit Weight	Effective Cohesion	Effective Friction Angle
	Common Borrow	Mohr-Coulomb	120	0	32
	ESU 1B - Existing Gravelly Granular Fill	Mohr-Coulomb	125	0	38
	ESU 2A - Native Sand and Gravel	Mohr-Coulomb	120	0	39
	ESU 2B - Native Sand and Gravel	Mohr-Coulomb	135	0	41
	ESU 2C - Native Silt (Pseudo-Static)	Mohr-Coulomb	110	200	29
	ESU 7A - Weathered Sandstone	Mohr-Coulomb	135	0	43
	New Hilfiker Wall	High Strength	130		

Color	Name	Type	Pullout Resistance (psf)	Tensile Capacity (lbf)	Bond Length (ft)	Bond Diameter (ft)	Out-of-Plane Spacing (ft)
	Soil Nail_Row 1	Anchor	1,800	82,550	45	0.5	4
	Soil Nail_Row 2	Anchor	1,800	82,550	45	0.5	4
	Soil Nail_Row 3	Anchor	1,800	82,550	40	0.5	4
	Soil Nail_Row 4	Anchor	1,800	82,550	40	0.5	4

Notes:

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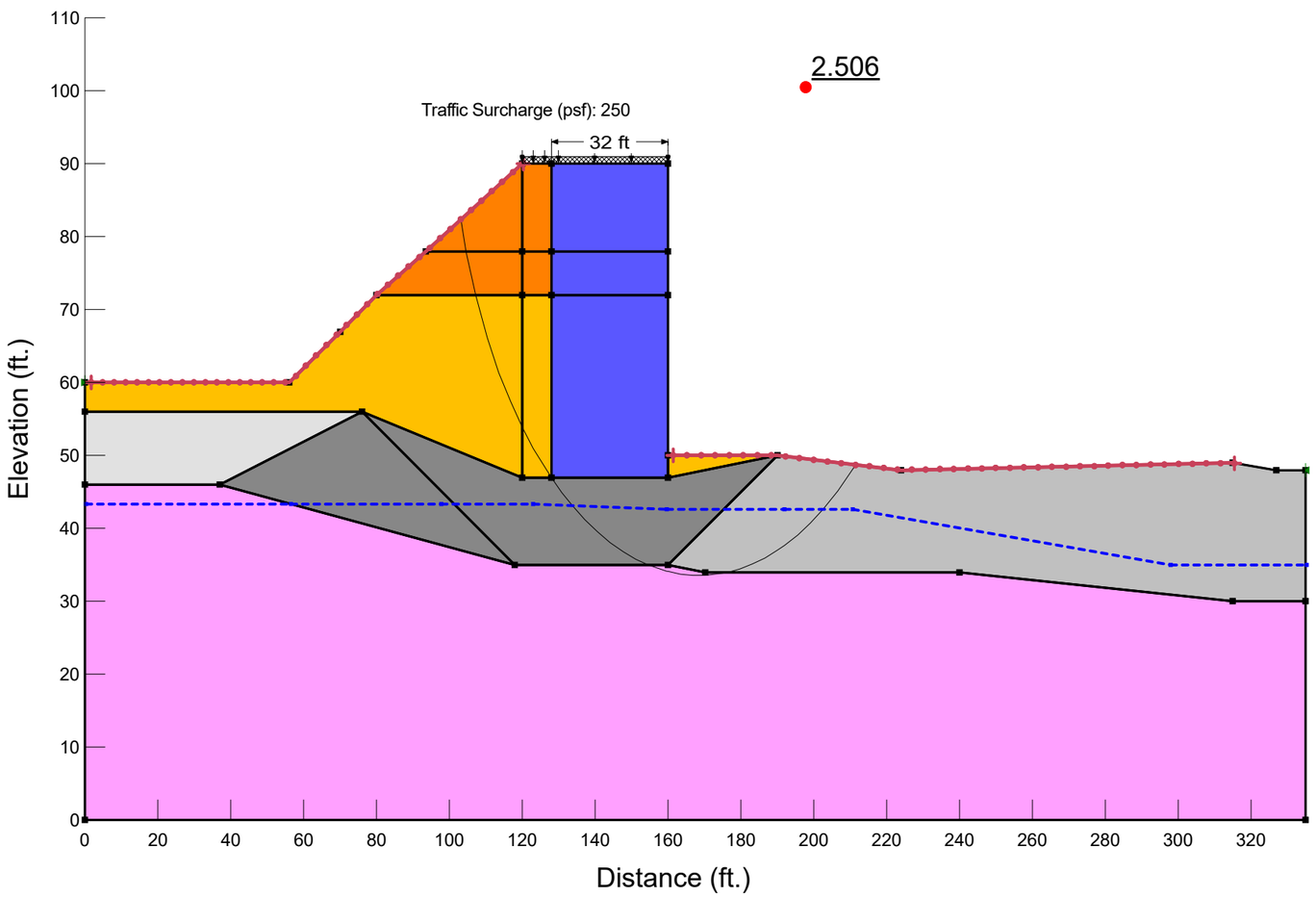
Bridge 17.7 - Wall 03.63L Section Ga-Ga'
Pseudo-Static Global Stability (M-P) - Final Condition

WSDOT I-405 Renton to Bellevue
King County, Washington

GeoEngineers

Figure D.4-32



Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	ESU 1A - Existing Granular Fill	Mohr-Coulomb	120	0	40
	ESU 1B - Existing Gravelly Granular Fill	Mohr-Coulomb	125	0	38
	ESU 2A - Native Sand and Gravel	Mohr-Coulomb	120	0	39
	ESU 2B - Native Sand and Gravel	Mohr-Coulomb	135	0	41
	ESU 2C - Native Silt	Mohr-Coulomb	110	0	29
	ESU 7A - Weathered Sandstone	Mohr-Coulomb	135	0	43
	Hilfiker Wall	High Strength	130		

Notes:

1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document.
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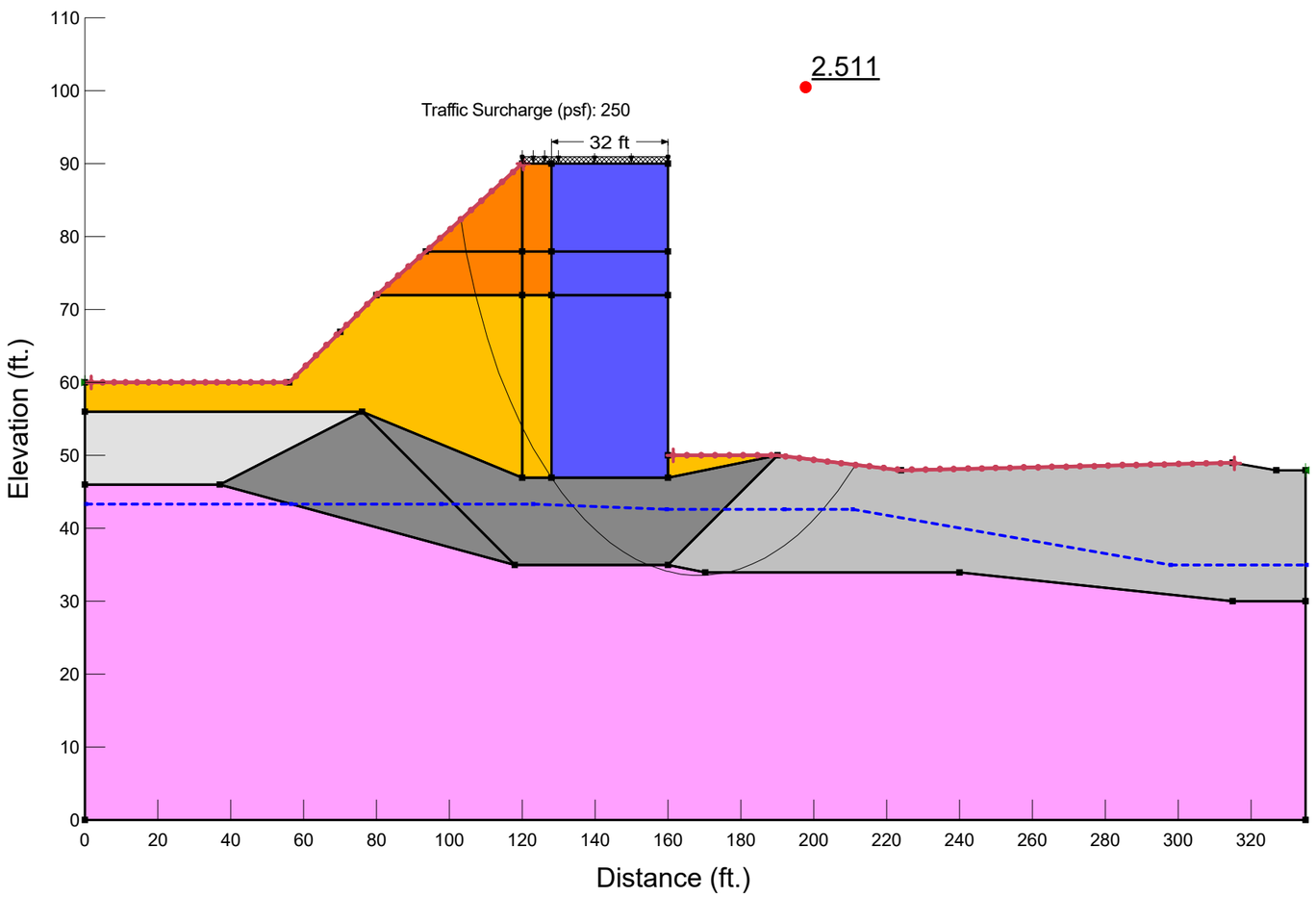
Bridge 17.7 - Wall 03.63L Section Ha-Ha'
Static Global Stability (Spencer) - Existing Condition

WSDOT I-405 Renton to Bellevue
King County, Washington

GeoEngineers

Figure D.4-33



Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	ESU 1A - Existing Granular Fill	Mohr-Coulomb	120	0	40
	ESU 1B - Existing Gravelly Granular Fill	Mohr-Coulomb	125	0	38
	ESU 2A - Native Sand and Gravel	Mohr-Coulomb	120	0	39
	ESU 2B - Native Sand and Gravel	Mohr-Coulomb	135	0	41
	ESU 2C - Native Silt	Mohr-Coulomb	110	0	29
	ESU 7A - Weathered Sandstone	Mohr-Coulomb	135	0	43
	Hilfiker Wall	High Strength	130		

Notes:

1. The locations of all features shown are approximate.
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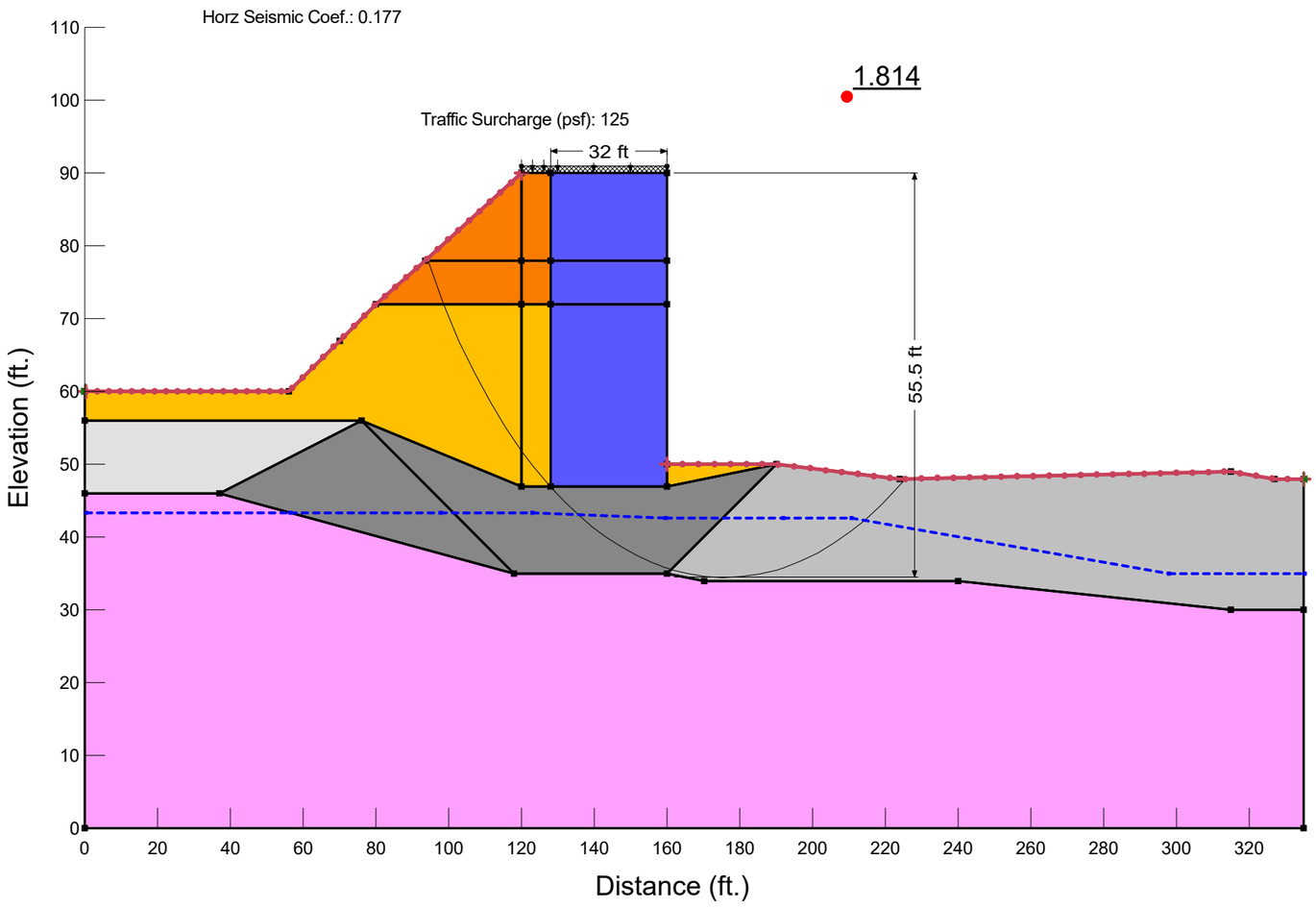
Bridge 17.7 - Wall 03.63L Section Ha-Ha'
Static Global Stability (M-P) - Existing Condition

WSDOT I-405 Renton to Bellevue
King County, Washington

GeoEngineers

Figure D.4-34



Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	ESU 1A - Existing Granular Fill (Pseudo-Static)	Mohr-Coulomb	120	50	40
	ESU 1B - Existing Gravelly Granular Fill	Mohr-Coulomb	125	0	38
	ESU 2A - Native Sand and Gravel	Mohr-Coulomb	120	0	39
	ESU 2B - Native Sand and Gravel	Mohr-Coulomb	135	0	41
	ESU 2C - Native Silt (Pseudo-Static)	Mohr-Coulomb	110	200	29
	ESU 7A - Weathered Sandstone	Mohr-Coulomb	135	0	43
	Hilfiker Wall	High Strength	130		

Notes:

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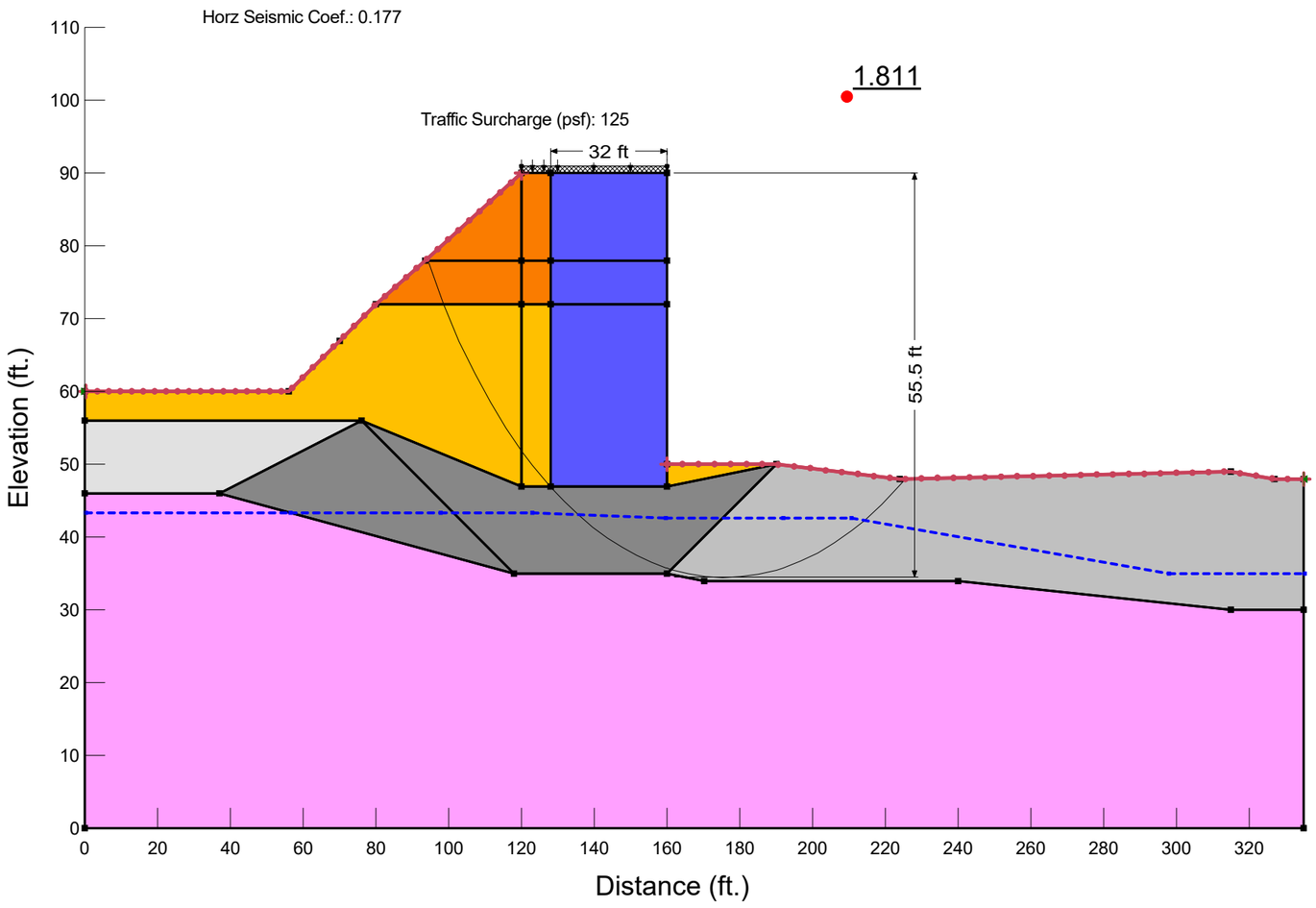
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document.
3. GeoEngineers, Inc. cannot guarantee the accuracy and context of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Bridge 17.7 - Wall 03.63L Section Ha-Ha'
Pseudo-Static Global Stability (Spencer) - Existing Condition

WSDOT I-405 Renton to Bellevue
King County, Washington

GeoEngineers

Figure D.4-35



Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	ESU 1A - Existing Granular Fill (Pseudo-Static)	Mohr-Coulomb	120	50	40
	ESU 1B - Existing Gravelly Granular Fill	Mohr-Coulomb	125	0	38
	ESU 2A - Native Sand and Gravel	Mohr-Coulomb	120	0	39
	ESU 2B - Native Sand and Gravel	Mohr-Coulomb	135	0	41
	ESU 2C - Native Silt (Pseudo-Static)	Mohr-Coulomb	110	200	29
	ESU 7A - Weathered Sandstone	Mohr-Coulomb	135	0	43
	Hilfiker Wall	High Strength	130		

Notes:

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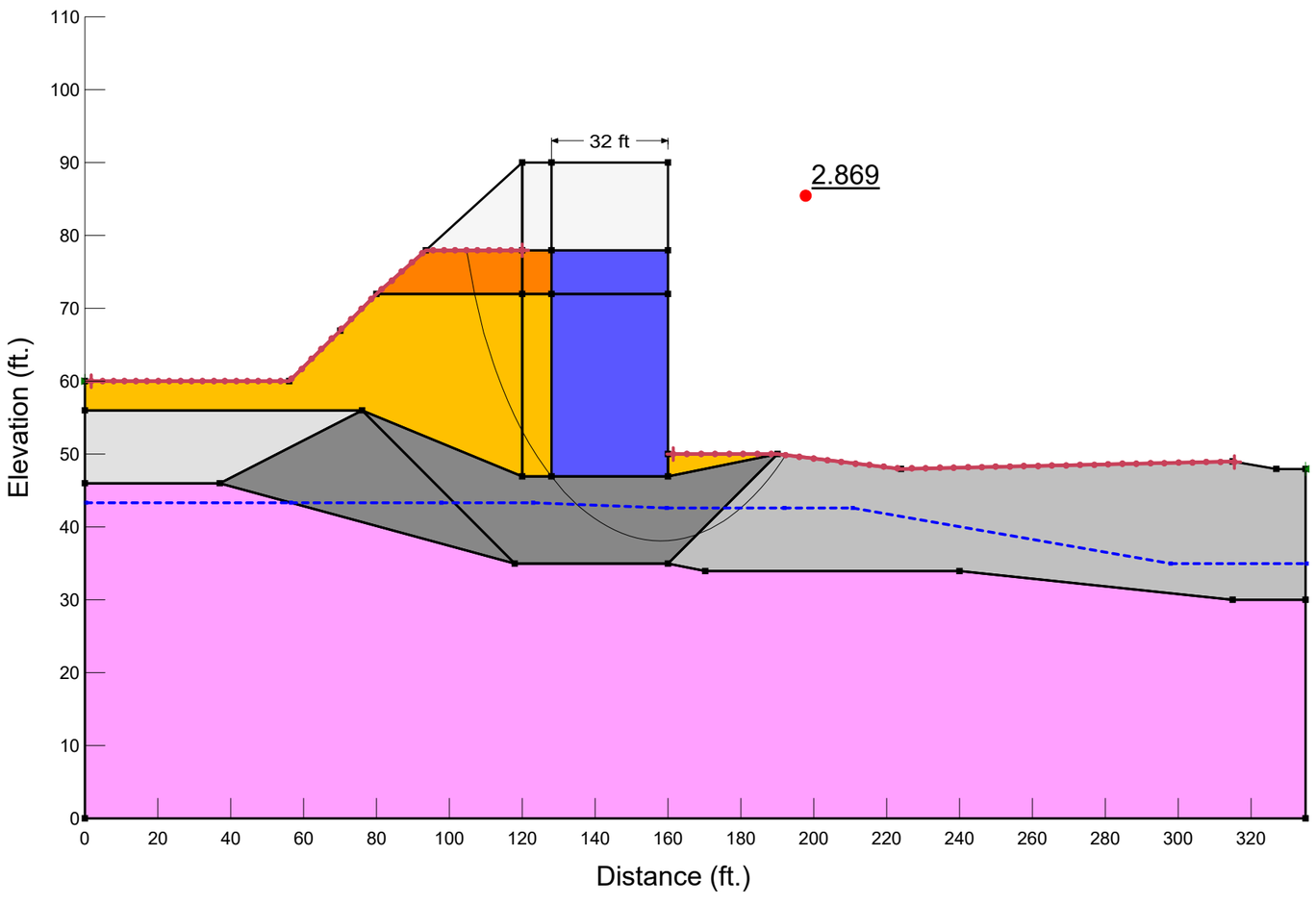
Bridge 17.7 - Wall 03.63L Section Ha-Ha'
Pseudo-Static Global Stability (M-P) - Existing Condition

WSDOT I-405 Renton to Bellevue
King County, Washington

GeoEngineers

Figure D.4-36



Color	Name	Slope Stability Material Model	Unit Weight	Effective Cohesion	Effective Friction Angle
	ESU 1A - Existing Granular Fill	Mohr-Coulomb	120	0	40
	ESU 1B - Existing Gravelly Granular Fill	Mohr-Coulomb	125	0	38
	ESU 2A - Native Sand and Gravel	Mohr-Coulomb	120	0	39
	ESU 2B - Native Sand and Gravel	Mohr-Coulomb	135	0	41
	ESU 2C - Native Silt	Mohr-Coulomb	110	0	29
	ESU 7A - Weathered Sandstone	Mohr-Coulomb	135	0	43
	Hilfiker Wall	High Strength	130		

Notes:

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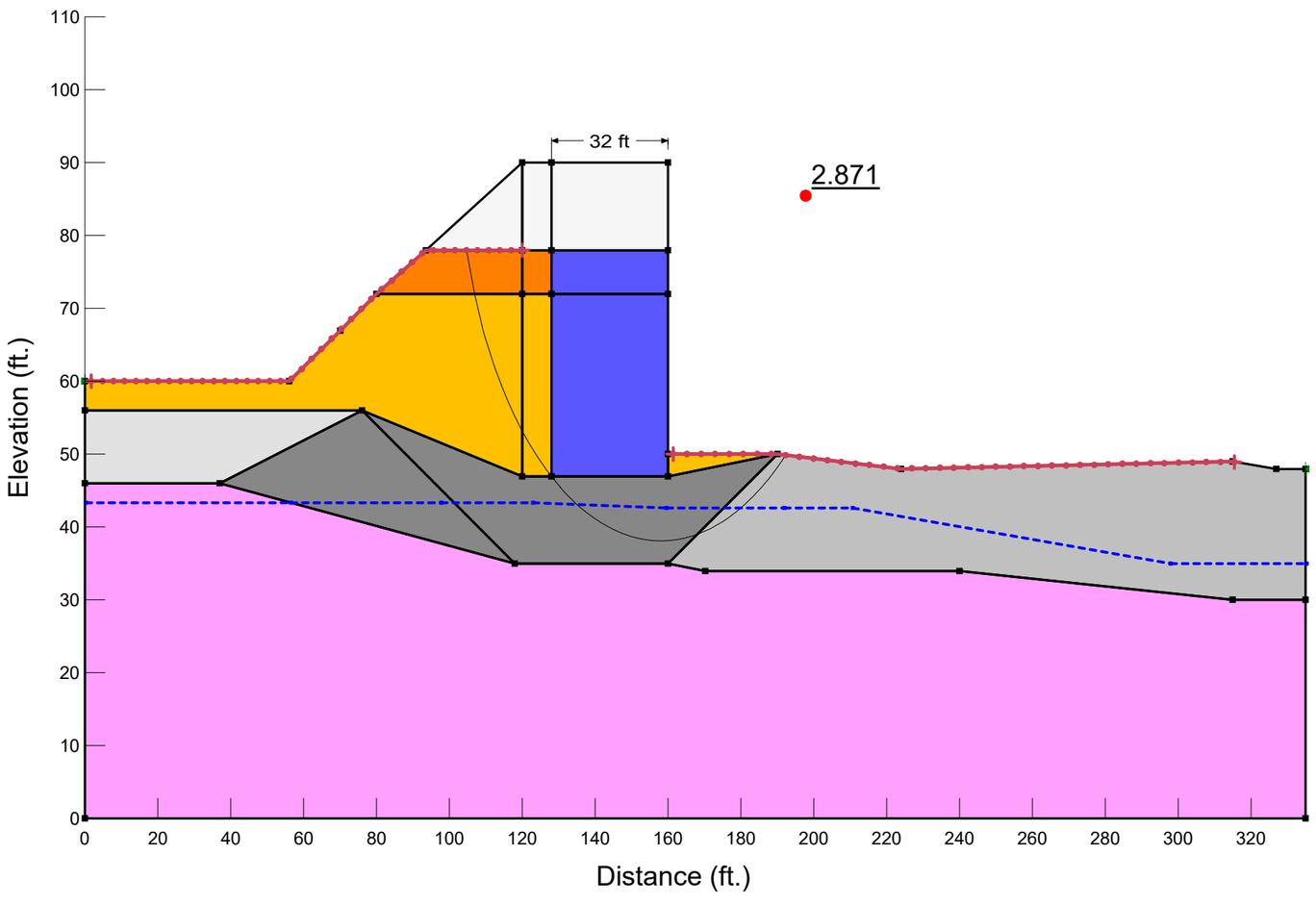
Bridge 17.7 - Wall 03.63L Section Ha-Ha'
Static Global Stability (Spencer) - Construction Condition

WSDOT I-405 Renton to Bellevue
King County, Washington

GeoEngineers

Figure D.4-37



Color	Name	Slope Stability Material Model	Unit Weight	Effective Cohesion	Effective Friction Angle
	ESU 1A - Existing Granular Fill	Mohr-Coulomb	120	0	40
	ESU 1B - Existing Gravelly Granular Fill	Mohr-Coulomb	125	0	38
	ESU 2A - Native Sand and Gravel	Mohr-Coulomb	120	0	39
	ESU 2B - Native Sand and Gravel	Mohr-Coulomb	135	0	41
	ESU 2C - Native Silt	Mohr-Coulomb	110	0	29
	ESU 7A - Weathered Sandstone	Mohr-Coulomb	135	0	43
	Hilfiker Wall	High Strength	130		

Notes:

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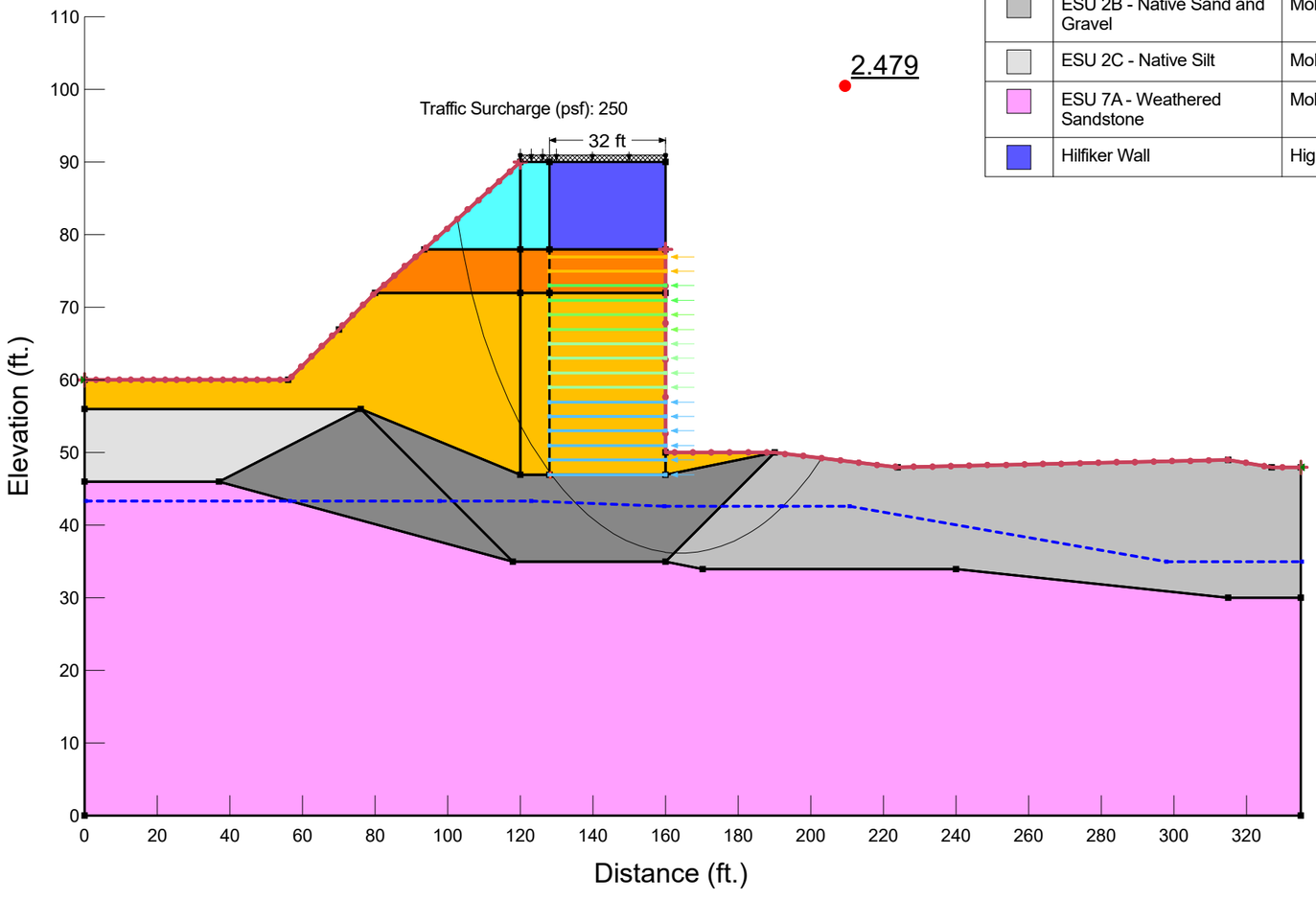
Bridge 17.7 - Wall 03.63L Section Ha-Ha'
Static Global Stability (M-P) - Construction Condition

WSDOT I-405 Renton to Bellevue
King County, Washington

GeoEngineers

Figure D.4-38



Color	Name	Slope Stability Material Model	Unit Weight	Effective Cohesion	Effective Friction Angle
	Common Borrow	Mohr-Coulomb	120	0	32
	ESU 1A - Existing Granular Fill	Mohr-Coulomb	120	0	40
	ESU 1B - Existing Gravelly Granular Fill	Mohr-Coulomb	125	0	38
	ESU 2A - Native Sand and Gravel	Mohr-Coulomb	120	0	39
	ESU 2B - Native Sand and Gravel	Mohr-Coulomb	135	0	41
	ESU 2C - Native Silt	Mohr-Coulomb	110	0	29
	ESU 7A - Weathered Sandstone	Mohr-Coulomb	135	0	43
	Hilfiker Wall	High Strength	130		

Color	Name	Type	Interface Adhesion	Interface Shear Angle	Factored Tensile Capacity
	EL47_W9.5xW4 (75 yrs)	Geosynthetic	0	12.4	5,680 lbf/ft
	EL49_W9.5xW4 (75 yrs)	Geosynthetic	0	12.4	5,680 lbf/ft
	EL51_W9.5xW4 (75 yrs)	Geosynthetic	0	12.4	5,680 lbf/ft
	EL53_W9.5xW4 (75 yrs)	Geosynthetic	0	12.4	5,680 lbf/ft
	EL55_W9.5xW4 (75 yrs)	Geosynthetic	0	12.4	5,680 lbf/ft
	EL57_W9.5xW4 (75 yrs)	Geosynthetic	0	12.4	5,680 lbf/ft
	EL59_W7.0xW3.5 (75 yrs)	Geosynthetic	0	10.4	3,936 lbf/ft
	EL61_W7.0xW3.5 (75 yrs)	Geosynthetic	0	10.4	3,936 lbf/ft
	EL63_W7.0xW3.5 (75 yrs)	Geosynthetic	0	10.4	3,936 lbf/ft
	EL65_W7.0xW3.5 (75 yrs)	Geosynthetic	0	10.4	3,936 lbf/ft
	EL67_W7.0xW3.5 (75 yrs)	Geosynthetic	0	10.4	3,936 lbf/ft
	EL69_W7.0xW3.5 (75 yrs)	Geosynthetic	0	10.4	3,936 lbf/ft
	EL71_W7.0xW3.5 (75 yrs)	Geosynthetic	0	20.1	3,936 lbf/ft
	EL73_W7.0xW3.5 (75 yrs)	Geosynthetic	0	20.1	3,936 lbf/ft
	EL75_W7.0xW3.5 (75 yrs)	Geosynthetic	0	15.4	2,236 lbf/ft
	EL77_W4.5xW3.5 (75 yrs)	Geosynthetic	0	15.4	2,236 lbf/ft

Notes:

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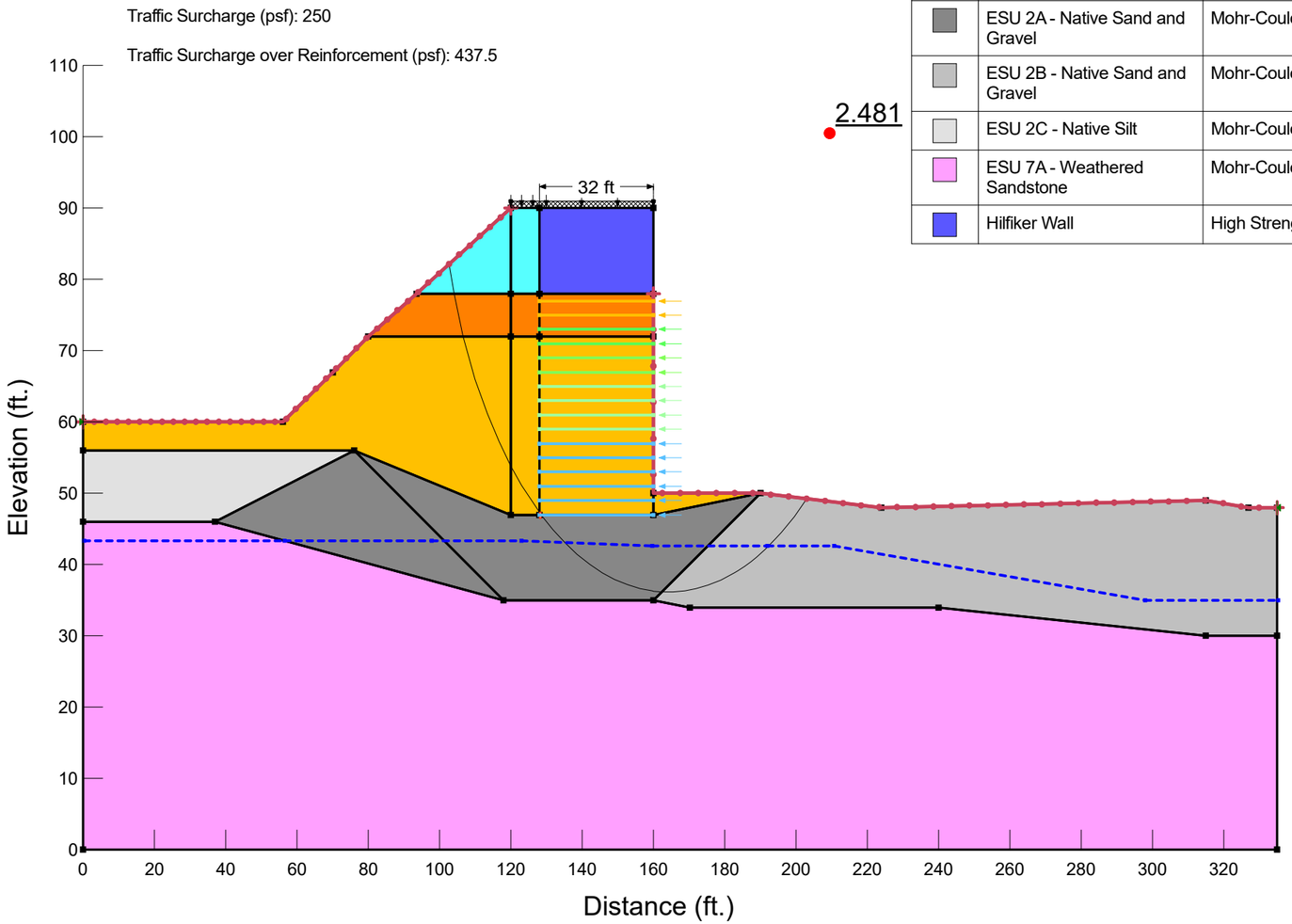
Bridge 17.7 - Wall 03.63L Section Ha-Ha'
Static Global Stability (Spencer) - Final Condition

WSDOT I-405 Renton to Bellevue
King County, Washington

GeoEngineers

Figure D.4-39



Color	Name	Slope Stability Material Model	Unit Weight	Effective Cohesion	Effective Friction Angle
	Common Borrow	Mohr-Coulomb	120	0	32
	ESU 1A - Existing Granular Fill	Mohr-Coulomb	120	0	40
	ESU 1B - Existing Gravelly Granular Fill	Mohr-Coulomb	125	0	38
	ESU 2A - Native Sand and Gravel	Mohr-Coulomb	120	0	39
	ESU 2B - Native Sand and Gravel	Mohr-Coulomb	135	0	41
	ESU 2C - Native Silt	Mohr-Coulomb	110	0	29
	ESU 7A - Weathered Sandstone	Mohr-Coulomb	135	0	43
	Hilfiker Wall	High Strength	130		

Color	Name	Type	Interface Adhesion	Interface Shear Angle	Factored Tensile Capacity
	EL47_W9.5xW4 (75 yrs)	Geosynthetic	0	12.4	5,680 lbf/ft
	EL49_W9.5xW4 (75 yrs)	Geosynthetic	0	12.4	5,680 lbf/ft
	EL51_W9.5xW4 (75 yrs)	Geosynthetic	0	12.4	5,680 lbf/ft
	EL53_W9.5xW4 (75 yrs)	Geosynthetic	0	12.4	5,680 lbf/ft
	EL55_W9.5xW4 (75 yrs)	Geosynthetic	0	12.4	5,680 lbf/ft
	EL57_W9.5xW4 (75 yrs)	Geosynthetic	0	12.4	5,680 lbf/ft
	EL59_W7.0xW3.5 (75 yrs)	Geosynthetic	0	10.4	3,936 lbf/ft
	EL61_W7.0xW3.5 (75 yrs)	Geosynthetic	0	10.4	3,936 lbf/ft
	EL63_W7.0xW3.5 (75 yrs)	Geosynthetic	0	10.4	3,936 lbf/ft
	EL65_W7.0xW3.5 (75 yrs)	Geosynthetic	0	10.4	3,936 lbf/ft
	EL67_W7.0xW3.5 (75 yrs)	Geosynthetic	0	10.4	3,936 lbf/ft
	EL69_W7.0xW3.5 (75 yrs)	Geosynthetic	0	10.4	3,936 lbf/ft
	EL71_W7.0xW3.5 (75 yrs)	Geosynthetic	0	20.1	3,936 lbf/ft
	EL73_W7.0xW3.5 (75 yrs)	Geosynthetic	0	20.1	3,936 lbf/ft
	EL75_W7.0xW3.5 (75 yrs)	Geosynthetic	0	15.4	2,236 lbf/ft
	EL77_W4.5xW3.5 (75 yrs)	Geosynthetic	0	15.4	2,236 lbf/ft

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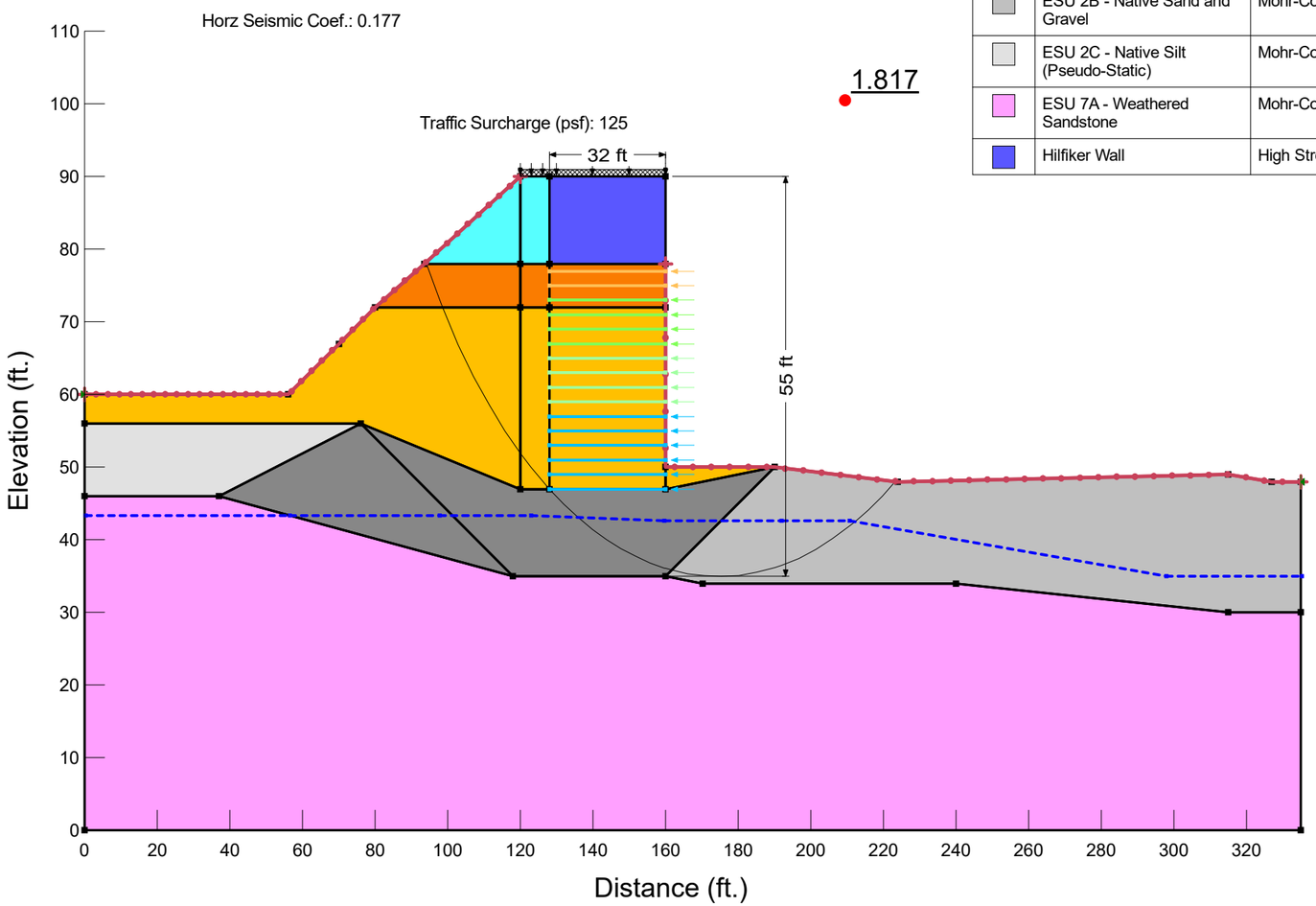
Bridge 17.7 - Wall 03.63L Section Ha-Ha'
Static Global Stability (M-P) - Final Condition

WSDOT I-405 Renton to Bellevue
King County, Washington

GeoEngineers

Figure D.4-40



Color	Name	Slope Stability Material Model	Unit Weight	Effective Cohesion	Effective Friction Angle
	Common Borrow	Mohr-Coulomb	120	0	32
	ESU 1A - Existing Granular Fill (Pseudo-Static)	Mohr-Coulomb	120	50	40
	ESU 1B - Existing Gravelly Granular Fill	Mohr-Coulomb	125	0	38
	ESU 2A - Native Sand and Gravel	Mohr-Coulomb	120	0	39
	ESU 2B - Native Sand and Gravel	Mohr-Coulomb	135	0	41
	ESU 2C - Native Silt (Pseudo-Static)	Mohr-Coulomb	110	200	29
	ESU 7A - Weathered Sandstone	Mohr-Coulomb	135	0	43
	Hilfiker Wall	High Strength	130		

Color	Name	Type	Interface Adhesion	Interface Shear Angle	Factored Tensile Capacity
	EQ_EL47_W9.5xW4 75 yrs)	Geosynthetic	0	16.3	7,427 lbf/ft
	EQ_EL49_W9.5xW4 (75 yrs)	Geosynthetic	0	16.3	7,427 lbf/ft
	EQ_EL51_W9.5xW4 (75 yrs)	Geosynthetic	0	16.3	7,427 lbf/ft
	EQ_EL53_W9.5xW4 (75 yrs)	Geosynthetic	0	16.3	7,427 lbf/ft
	EQ_EL55_W9.5xW4 (75 yrs)	Geosynthetic	0	16.3	7,427 lbf/ft
	EQ_EL57_W9.5xW4 (75 yrs)	Geosynthetic	0	16.3	7,427 lbf/ft
	EQ_EL59_W7.0xW3.5 (75 yrs)	Geosynthetic	0	13.7	5,147 lbf/ft
	EQ_EL61_W7.0xW3.5 (75 yrs)	Geosynthetic	0	13.7	5,147 lbf/ft
	EQ_EL63_W7.0xW3.5 (75 yrs)	Geosynthetic	0	13.7	5,147 lbf/ft
	EQ_EL65_W7.0xW3.5 (75 yrs)	Geosynthetic	0	13.7	5,147 lbf/ft
	EQ_EL67_W7.0xW3.5 (75 yrs)	Geosynthetic	0	13.7	5,147 lbf/ft
	EQ_EL69_W7.0xW3.5 (75 yrs)	Geosynthetic	0	13.7	5,147 lbf/ft
	EQ_EL71_W7.0xW3.5 (75 yrs)	Geosynthetic	0	26	5,147 lbf/ft
	EQ_EL73_W7.0xW3.5 (75 yrs)	Geosynthetic	0	26	5,147 lbf/ft
	EQ_EL75_W7.0xW3.5 (75 yrs)	Geosynthetic	0	20.2	2,924 lbf/ft
	EQ_EL77_W4.5xW3.5 (75 yrs)	Geosynthetic	0	20.2	2,924 lbf/ft

Notes:

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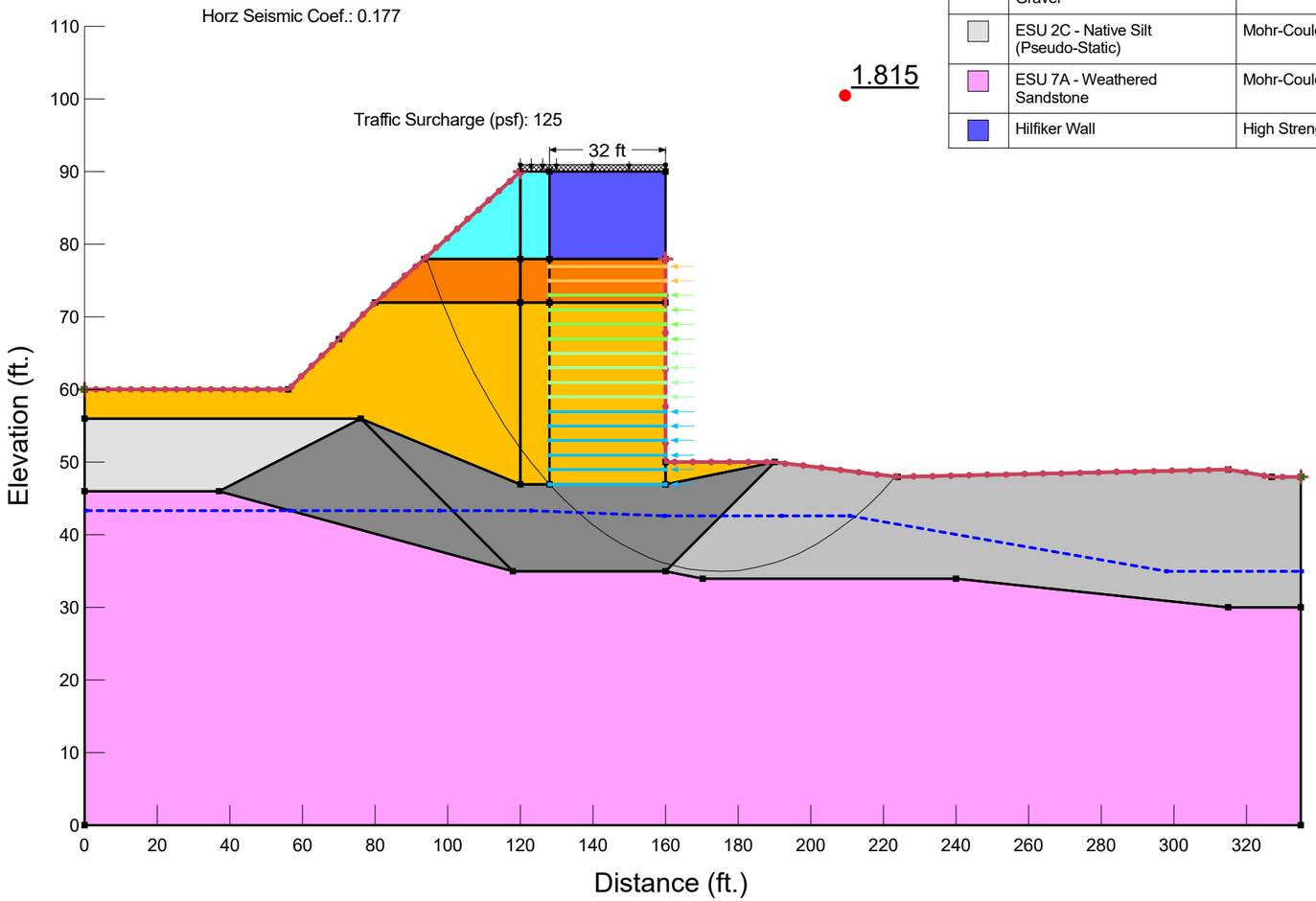
Bridge 17.7 - Wall 03.63L Section Ha-Ha'
Pseudo-Static Global Stability (Spencer) - Final Condition

WSDOT I-405 Renton to Bellevue
King County, Washington

GeoEngineers

Figure D.4-41



Color	Name	Slope Stability Material Model	Unit Weight	Effective Cohesion	Effective Friction Angle
	Common Borrow	Mohr-Coulomb	120	0	32
	ESU 1A - Existing Granular Fill (Pseudo-Static)	Mohr-Coulomb	120	50	40
	ESU 1B - Existing Gravelly Granular Fill	Mohr-Coulomb	125	0	38
	ESU 2A - Native Sand and Gravel	Mohr-Coulomb	120	0	39
	ESU 2B - Native Sand and Gravel	Mohr-Coulomb	135	0	41
	ESU 2C - Native Silt (Pseudo-Static)	Mohr-Coulomb	110	200	29
	ESU 7A - Weathered Sandstone	Mohr-Coulomb	135	0	43
	Hilfiker Wall	High Strength	130		

Color	Name	Type	Interface Adhesion	Interface Shear Angle	Factored Tensile Capacity
	EQ_EL47_W9.5xW4 75 yrs)	Geosynthetic	0	16.3	7,427 lbf/ft
	EQ_EL49_W9.5xW4 (75 yrs)	Geosynthetic	0	16.3	7,427 lbf/ft
	EQ_EL51_W9.5xW4 (75 yrs)	Geosynthetic	0	16.3	7,427 lbf/ft
	EQ_EL53_W9.5xW4 (75 yrs)	Geosynthetic	0	16.3	7,427 lbf/ft
	EQ_EL55_W9.5xW4 (75 yrs)	Geosynthetic	0	16.3	7,427 lbf/ft
	EQ_EL57_W9.5xW4 (75 yrs)	Geosynthetic	0	16.3	7,427 lbf/ft
	EQ_EL59_W7.0xW3.5 (75 yrs)	Geosynthetic	0	13.7	5,147 lbf/ft
	EQ_EL61_W7.0xW3.5 (75 yrs)	Geosynthetic	0	13.7	5,147 lbf/ft
	EQ_EL63_W7.0xW3.5 (75 yrs)	Geosynthetic	0	13.7	5,147 lbf/ft
	EQ_EL65_W7.0xW3.5 (75 yrs)	Geosynthetic	0	13.7	5,147 lbf/ft
	EQ_EL67_W7.0xW3.5 (75 yrs)	Geosynthetic	0	13.7	5,147 lbf/ft
	EQ_EL69_W7.0xW3.5 (75 yrs)	Geosynthetic	0	13.7	5,147 lbf/ft
	EQ_EL71_W7.0xW3.5 (75 yrs)	Geosynthetic	0	26	5,147 lbf/ft
	EQ_EL73_W7.0xW3.5 (75 yrs)	Geosynthetic	0	26	5,147 lbf/ft
	EQ_EL75_W7.0xW3.5 (75 yrs)	Geosynthetic	0	20.2	2,924 lbf/ft
	EQ_EL77_W4.5xW3.5 (75 yrs)	Geosynthetic	0	20.2	2,924 lbf/ft

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Bridge 17.7 - Wall 03.63L Section Ha-Ha'

Pseudo-Static Global Stability (M-P) - Final Condition

WSDOT I-405 Renton to Bellevue
King County, Washington

GeoEngineers

Figure D.4-42

1.1 Static - Spencer Section D-D' - Final Condition - Global Stability

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File Informa on

File Version: 11.02
Title: Bridge 17.7 Pier 3
Created By: Mikayla S. Hatch
Last Edited By: Valerie R. Yanez
Revision Number: 281
Date: 11/29/2021
Time: 04:03:20 PM
Tool Version: 11.2.2.23310
File Name: Bridge 17.7 D-D' - Pier 1.gsz
Directory: P:\0\0180366\01\Analysis\Bridge 17.7\SlopeW\
Last Solved Date: 11/29/2021
Last Solved Time: 04:03:25 PM

Project Se ngs

Unit System: U.S. Customary Units

Analysis Se ngs

1.1 Sta c - Spencer

Descrip on: Spencer Method
Kind: SLOPE/W
Parent: B17.7 Pier 3
Analysis Type: Spencer
Se ngs
PWP Condi ons from: Piezometric Line
Apply Phrea c Correc on: No
Use Staged Rapid Drawdown: No
Unit Weight of Water: 62.4 pcf
Slip Surface
Direc on of movement: Le. to Right
Use Passive Mode: No
Slip Surface Op on: Entry and Exit
Cri cal slip surfaces saved: 1
Op mize Cri cal Slip Surface Loca on: No
Tension Crack Op on: (none)
Distribu on
F of S Calcula on Op on: Constant
Advanced
Geometry Se ngs
Minimum Slip Surface Depth: 2 ft
Number of Slices: 30
Factor of Safety Convergence Se ngs
Maximum Number of Itera ons: 100
Tolerable difference in F of S: 0.001

Figure D.4-43

Solu□on Se□ ngs
Search Method: Root Finder
Tolerable difference between star□ng and converged F of S: 3
Maximum itera□ons to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

ESU 1A - Exis ng Granular Fill

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 40 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Concrete

Slope Stability Material Model: High Strength
Unit Weight: 150 pcf
Pore Water Pressure
Piezometric Line: 1

ESU 2A - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 39 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1B - Exis ng Silty Granular Fill

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 7A - Weathered Sandstone

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 43 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

New Foo ng

Slope Stability Material Model: High Strength

Unit Weight: 2,250 pcf
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (2.22265, 79.849107) ft
Left-Zone Right Coordinate: (78.67362, 91.857103) ft
Left-Zone Increment: 30
Right Type: Range
Right-Zone Left Coordinate: (159.2, 76.3) ft
Right-Zone Right Coordinate: (219.71591, 75.103568) ft
Right-Zone Increment: 25
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 79.5) ft
Right Coordinate: (225, 75) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	0 ft	44.460364 ft
Coordinate 2	90 ft	44.460364 ft
Coordinate 3	100 ft	44.460364 ft
Coordinate 4	115 ft	46.960364 ft
Coordinate 5	148.5 ft	53.460364 ft
Coordinate 6	168.5 ft	55.960364 ft
Coordinate 7	190.5 ft	58.5 ft
Coordinate 8	209.5 ft	59.960364 ft
Coordinate 9	225 ft	65.460364 ft

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 250 pcf
Direc□on: Ver□cal

Coordinates

	X	Y
	0 ft	94 ft
	0 ft	80.5 ft
	79.5 ft	93 ft

Figure D.4-45

Geometry

Name: Default Geometry

Se ngs

View: 2D

Element Thickness: 1 ft

Points

	X	Y
Point 1	225 ft	75 ft
Point 2	159.2 ft	76.3 ft
Point 3	159 ft	0 ft
Point 4	159.2 ft	64.1 ft
Point 5	164.2 ft	64.1 ft
Point 6	175.9 ft	75.96236 ft
Point 7	159.2 ft	57 ft
Point 8	197.1 ft	63.5 ft
Point 9	155.5 ft	71.5 ft
Point 10	101.5 ft	71.5 ft
Point 11	101.5 ft	0 ft
Point 12	129.5 ft	64.1 ft
Point 13	101.5 ft	37.5 ft
Point 14	101.5 ft	36 ft
Point 15	107.5 ft	36 ft
Point 16	118 ft	39.5 ft
Point 17	140.5 ft	53 ft
Point 18	146.5 ft	55.5 ft
Point 19	87 ft	36 ft
Point 20	74.5 ft	47.5 ft
Point 21	0.5 ft	47.5 ft
Point 22	0 ft	29.5 ft
Point 23	50.5 ft	29.5 ft
Point 24	95.5 ft	71.5 ft
Point 25	225 ft	0 ft
Point 26	225 ft	69.13637 ft
Point 27	0 ft	0 ft
Point 28	0 ft	47.5 ft
Point 29	0 ft	71.5 ft
Point 30	0 ft	79.5 ft
Point 31	79.5 ft	71.497532 ft
Point 32	76.5 ft	71.497532 ft
Point 33	65 ft	71.497532 ft
Point 34	65 ft	66.502713 ft
Point 35	90 ft	71.497532 ft
Point 36	90 ft	66.502713 ft
Point 37	76.5 ft	91.5157 ft
Point 38	79.5 ft	91.9869 ft
Point 39	93 ft	71.5 ft
Point 40	93 ft	39.5 ft

Figure D.4-46

Point 41	90 ft	39.5 ft
Point 42	87 ft	39.5 ft
Point 43	99.5 ft	39.5 ft
Point 44	99.5 ft	36 ft
Point 45	65 ft	70.5 ft
Point 46	90 ft	70.5 ft
Point 47	76.5 ft	70.5 ft
Point 48	79.5 ft	70.5 ft
Point 49	93 ft	70.5 ft

Regions

	Material	Points	Area
Region 1	ESU 2A - Na□ve Sand and Gravel	8,26,1,6,5,4,12,13,14,15,16,17,18,7	1,345.5 ft²
Region 2	ESU 1B - Exis□ng Silty Granular Fill	5,6,2,9,10,13,12,4	939.79 ft²
Region 3	ESU 7A - Weathered Sandstone	8,7,18,17,16,15,14,11,3,25,26	6,826.6 ft²
Region 4	ESU 7A - Weathered Sandstone	11,14,44,19,23,22,27	3,207.1 ft²
Region 5	ESU 2A - Na□ve Sand and Gravel	28,22,23,19,20,21	1,375.5 ft²
Region 6	Concrete	37,32,31,38	60.761 ft²
Region 7	ESU 1B - Exis□ng Silty Granular Fill	35,46,49,39	2.9963 ft²
Region 8	ESU 1B - Exis□ng Silty Granular Fill	29,28,21,20,19,42,41,36,34,45,33	2,130.9 ft²
Region 9	ESU 1B - Exis□ng Silty Granular Fill	14,13,10,24,39,49,40,43,44	279 ft²
Region 10	ESU 1A - Exis□ng Granular Fill	30,29,33,32,37	1,071.7 ft²
Region 11	ESU 1B - Exis□ng Silty Granular Fill	33,45,47,32	11.472 ft²
Region 12	New Foo□ng	34,36,46,48,47,45	99.932 ft²
Region 13	ESU 1B - Exis□ng Silty Granular Fill	46,35,31,48	10.474 ft²
Region 14	Concrete	32,47,48,31	2.9926 ft²
Region 15	Concrete	36,41,42,19,44,43,40,49,46	136.75 ft²

Slip Results

Slip Surfaces Analysed: 946 of 4030 converged

Current Slip Surface

Slip Surface: 2,490
Factor of Safety: 4.121
Volume: 3,780.0592 ft³
Weight: 689,223.02 lbf
Resis□ng Moment: 39,223,082 lbf·ft
Ac□va□ng Moment: 9,517,786.3 lbf·ft
Resis□ng Force: 534,372.49 lbf
Ac□va□ng Force: 129,669.07 lbf
Slip Rank: 1 of 4,030 slip surfaces
Exit: (166.46184, 76.15318) ft
Entry: (50.641597, 87.454173) ft
Radius: 58.829722 ft
Center: (109.39512, 90.447424) ft

Slip Slices

	X	Y	PWP	Base	Fric□onal	Cohesive	Suc□on	Base

				Normal Stress	Strength	Strength	Strength	Material
Slice 1	52.171214 ft	79.476067 ft	-2,184.9799 psf	566.87263 psf	475.66261 psf	0 psf	0 psf	ESU 1A - Exis□ng Granular Fill
Slice 2	55.584026 ft	67.148536 ft	-1,415.7419 psf	1,882.1825 psf	1,470.5221 psf	0 psf	0 psf	ESU 1B - Exis□ng Silty Granular Fill
Slice 3	59.350415 ft	59.730924 ft	-952.88296 psf	2,828.8728 psf	2,210.1577 psf	0 psf	0 psf	ESU 1B - Exis□ng Silty Granular Fill
Slice 4	63.116805 ft	54.254762 ft	-611.17042 psf	3,591.5969 psf	2,806.063 psf	0 psf	0 psf	ESU 1B - Exis□ng Silty Granular Fill
Slice 5	67.094981 ft	49.673393 ft	-325.29298 psf	11,253.363 psf	8,792.091 psf	0 psf	0 psf	ESU 1B - Exis□ng Silty Granular Fill
Slice 6	70.947743 ft	45.980182 ft	-94.836643 psf	11,993.226 psf	9,711.9229 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 7	73.602763 ft	43.772326 ft	42.933568 psf	12,491.638 psf	10,080.762 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 8	75.5 ft	42.379143 ft	129.8682 psf	12,829.61 psf	10,284.048 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 9	77.151976 ft	41.246732 ft	200.53064 psf	13,664.634 psf	10,903.016 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 10	78.651976 ft	40.299585 ft	259.6326 psf	13,920.067 psf	11,062.002 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 11	81.351788 ft	38.774719 ft	354.78426 psf	11,307.078 psf	8,868.9929 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 12	85.101788 ft	36.908419 ft	471.24134 psf	11,733.258 psf	9,119.8015 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 13	88.5 ft	35.476932 ft	560.56614 psf	12,052.288 psf	10,716.204 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 14	91.5 ft	34.427595 ft	626.04476 psf	5,168.5258 psf	4,235.9321 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 15	94.25 ft	33.61532 ft	676.73072 psf	4,601.9578 psf	3,660.3335 psf	0 psf	0 psf	ESU 7A - Weathered

								Sandstone
Slice 16	97.5 ft	32.869029 ft	723.29928 psf	4,757.3762 psf	3,761.8376 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 17	99.75 ft	32.414299 ft	751.67444 psf	4,773.1703 psf	3,750.1056 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 18	100.75 ft	32.261316 ft	769.02058 psf	4,811.1971 psf	3,769.3906 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 19	103 ft	31.985798 ft	809.6129 psf	4,873.6319 psf	3,789.759 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 20	106 ft	31.734974 ft	856.46435 psf	4,946.505 psf	3,814.0246 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 21	109.10236 ft	31.640257 ft	894.6392 psf	5,007.9628 psf	3,835.7363 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 22	112.85236 ft	31.758794 ft	926.24253 psf	5,060.6553 psf	3,855.4022 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 23	116.5 ft	32.067859 ft	947.45348 psf	5,086.5896 psf	3,859.8069 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 24	119.91667 ft	32.599017 ft	955.67639 psf	5,086.8823 psf	3,852.4119 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 25	123.75 ft	33.43017 ft	950.22437 psf	5,063.7361 psf	3,835.9117 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 26	127.58333 ft	34.536219 ft	927.61886 psf	5,004.9347 psf	3,802.1585 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 27	131.57761 ft	36.006262 ft	884.24881 psf	4,913.5688 psf	3,757.4016 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 28	135.73284 ft	37.894022 ft	816.76187 psf	4,783.8115 psf	3,699.3336 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 29	139.15523 ft	39.72424 ft	743.99264 psf	4,642.8923 psf	3,635.7827 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 30	142 ft	41.512679 ft	666.83702 psf	4,487.3911 psf	3,562.7243 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 31	145 ft	43.653448 ft	569.57546 psf	4,287.2956 psf	3,466.8301 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 32	147.5 ft	45.645291 ft	475.55308 psf	4,089.73 psf	3,370.2745 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 33	150.25 ft	48.187628 ft	342.66875 psf	3,821.3367 psf	3,243.9104 psf	0 psf	0 psf	ESU 7A - Weathered

								Sandstone
Slice 34	153.75 ft	51.892719 ft	138.77102 psf	3,427.5406 psf	3,066.8272 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 35	155.68666 ft	54.14401 ft	13.396483 psf	3,234.7117 psf	3,003.925 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 36	156.76953 ft	55.600408 ft	-69.036452 psf	3,316.209 psf	3,092.4149 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 37	158.43286 ft	57.977353 ft	-204.38377 psf	3,227.8825 psf	2,613.8877 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 38	160.59751 ft	61.61796 ft	-414.67338 psf	3,018.1199 psf	2,444.0253 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 39	164.22843 ft	70.12659 ft	-917.29073 psf	1,816.3717 psf	1,419.1051 psf	0 psf	0 psf	ESU 1B - Exis□ng Silty Granular Fill

1.2 Static - M-P Section D-D' - Final Condition - Global Stability

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File Informa on

File Version: 11.02
Title: Bridge 17.7 Pier 3
Created By: Mikayla S. Hatch
Last Edited By: Valerie R. Yanez
Revision Number: 281
Date: 11/29/2021
Time: 04:03:20 PM
Tool Version: 11.2.2.23310
File Name: Bridge 17.7 D-D' - Pier 1.gsz
Directory: P:\0\0180366\01\Analysis\Bridge 17.7\SlopeW\
Last Solved Date: 11/29/2021
Last Solved Time: 04:03:27 PM

Project Se ngs

Unit System: U.S. Customary Units

Analysis Se ngs

1.2 Sta c - M-P

Descrip on: Spencer Method
Kind: SLOPE/W
Parent: B17.7 Pier 3
Analysis Type: Morgenstern-Price
Se ngs
Side Func on
Interslice force func on op on: Half-Sine
PWP Condi ons from: Piezometric Line
Apply Phrea c Correc on: No
Use Staged Rapid Drawdown: No
Unit Weight of Water: 62.4 pcf
Slip Surface
Direc on of movement: Le. to Right
Use Passive Mode: No
Slip Surface Op on: Entry and Exit
Cri cal slip surfaces saved: 1
Op mize Cri cal Slip Surface Loca on: No
Tension Crack Op on: (none)
Distribu on
F of S Calcula on Op on: Constant
Advanced
Geometry Se ngs
Minimum Slip Surface Depth: 2 ft
Number of Slices: 30
Factor of Safety Convergence Se ngs

Figure D.4-51

Maximum Number of Itera□ons: 100
Tolerable difference in F of S: 0.001
Solu□on Se□ ngs
Search Method: Root Finder
Tolerable difference between star□ng and converged F of S: 3
Maximum itera□ons to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

ESU 1A - Exis ng Granular Fill

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 40 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Concrete

Slope Stability Material Model: High Strength
Unit Weight: 150 pcf
Pore Water Pressure
Piezometric Line: 1

ESU 2A - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 39 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1B - Exis ng Silty Granular Fill

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 7A - Weathered Sandstone

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 43 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

New Foo ng

Slope Stability Material Model: High Strength
Unit Weight: 2,250 pcf
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (2.22265, 79.849107) ft
Left-Zone Right Coordinate: (78.67362, 91.857103) ft
Left-Zone Increment: 30
Right Type: Range
Right-Zone Left Coordinate: (159.2, 76.3) ft
Right-Zone Right Coordinate: (219.71591, 75.103568) ft
Right-Zone Increment: 25
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 79.5) ft
Right Coordinate: (225, 75) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	0 ft	43.5 ft
Coordinate 2	90 ft	44 ft
Coordinate 3	100 ft	44.5 ft
Coordinate 4	111 ft	46.025 ft
Coordinate 5	148.5 ft	53.5 ft
Coordinate 6	168.5 ft	55.5 ft
Coordinate 7	190.5 ft	58 ft
Coordinate 8	209 ft	60.490524 ft
Coordinate 9	225 ft	64 ft

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 250 pcf
Direc□on: Ver□cal

Coordinates

	X	Y
	0 ft	94 ft

Figure D.4-53

	0 ft	80.5 ft
	79.5 ft	93 ft

Geometry

Name: Default Geometry

Se ngs

View: 2D

Element Thickness: 1 ft

Points

	X	Y
Point 1	225 ft	75 ft
Point 2	159.2 ft	76.3 ft
Point 3	159 ft	0 ft
Point 4	159.2 ft	64.1 ft
Point 5	164.2 ft	64.1 ft
Point 6	175.9 ft	75.96236 ft
Point 7	159.2 ft	57 ft
Point 8	197.1 ft	63.5 ft
Point 9	155.5 ft	71.5 ft
Point 10	101.5 ft	71.5 ft
Point 11	101.5 ft	0 ft
Point 12	129.5 ft	64.1 ft
Point 13	101.5 ft	37.5 ft
Point 14	101.5 ft	36 ft
Point 15	107.5 ft	36 ft
Point 16	118 ft	39.5 ft
Point 17	140.5 ft	53 ft
Point 18	146.5 ft	55.5 ft
Point 19	87 ft	36 ft
Point 20	74.5 ft	47.5 ft
Point 21	0.5 ft	47.5 ft
Point 22	0 ft	29.5 ft
Point 23	50.5 ft	29.5 ft
Point 24	95.5 ft	71.5 ft
Point 25	225 ft	0 ft
Point 26	225 ft	69.13637 ft
Point 27	0 ft	0 ft
Point 28	0 ft	47.5 ft
Point 29	0 ft	71.5 ft
Point 30	0 ft	79.5 ft
Point 31	79.5 ft	71.497532 ft
Point 32	76.5 ft	71.497532 ft
Point 33	65 ft	71.497532 ft
Point 34	65 ft	66.502713 ft
Point 35	90 ft	71.497532 ft
Point 36	90 ft	66.502713 ft

Figure D.4-54

Point 37	76.5 ft	91.5157 ft
Point 38	79.5 ft	91.9869 ft
Point 39	93 ft	71.5 ft
Point 40	93 ft	39.5 ft
Point 41	90 ft	39.5 ft
Point 42	87 ft	39.5 ft
Point 43	99.5 ft	39.5 ft
Point 44	99.5 ft	36 ft
Point 45	65 ft	70.5 ft
Point 46	90 ft	70.5 ft
Point 47	76.5 ft	70.5 ft
Point 48	79.5 ft	70.5 ft
Point 49	93 ft	70.5 ft

Regions

	Material	Points	Area
Region 1	ESU 2A - Na□ve Sand and Gravel	8,26,1,6,5,4,12,13,14,15,16,17,18,7	1,345.5 ft²
Region 2	ESU 1B - Exis□ng Silty Granular Fill	5,6,2,9,10,13,12,4	939.79 ft²
Region 3	ESU 7A - Weathered Sandstone	8,7,18,17,16,15,14,11,3,25,26	6,826.6 ft²
Region 4	ESU 7A - Weathered Sandstone	11,14,44,19,23,22,27	3,207.1 ft²
Region 5	ESU 2A - Na□ve Sand and Gravel	28,22,23,19,20,21	1,375.5 ft²
Region 6	Concrete	37,32,31,38	60.761 ft²
Region 7	ESU 1B - Exis□ng Silty Granular Fill	35,46,49,39	2.9963 ft²
Region 8	ESU 1B - Exis□ng Silty Granular Fill	29,28,21,20,19,42,41,36,34,45,33	2,130.9 ft²
Region 9	ESU 1B - Exis□ng Silty Granular Fill	14,13,10,24,39,49,40,43,44	279 ft²
Region 10	ESU 1A - Exis□ng Granular Fill	30,29,33,32,37	1,071.7 ft²
Region 11	ESU 1B - Exis□ng Silty Granular Fill	33,45,47,32	11.472 ft²
Region 12	New Foo□ng	34,36,46,48,47,45	99.932 ft²
Region 13	ESU 1B - Exis□ng Silty Granular Fill	46,35,31,48	10.474 ft²
Region 14	Concrete	32,47,48,31	2.9926 ft²
Region 15	Concrete	36,41,42,19,44,43,40,49,46	136.75 ft²

Slip Results

Slip Surfaces Analysed: 919 of 4030 converged

Current Slip Surface

Slip Surface: 2,490
Factor of Safety: 4.123
Volume: 3,780.0061 ft³
Weight: 689,217.18 lbf
Resis□ng Moment: 39,238,494 lbf·ft
Ac□va□ng Moment: 9,517,712.5 lbf·ft
Resis□ng Force: 535,617.05 lbf
Ac□va□ng Force: 129,911.77 lbf
Slip Rank: 1 of 4,030 slip surfaces
Exit: (166.46184, 76.15318) ft
Entry: (50.641597, 87.454173) ft
Radius: 58.829722 ft

Figure D.4-55

Center: (109.39512, 90.447424) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Fric□onal Strength	Cohesive Strength	Suc□on Strength	Base Material
Slice 1	52.171214 ft	79.476067 ft	-2,226.8206 psf	595.6084 psf	499.77479 psf	0 psf	0 psf	ESU 1A - Exis□ng Granular Fill
Slice 2	55.584026 ft	67.148536 ft	-1,456.3995 psf	1,921.0599 psf	1,500.8965 psf	0 psf	0 psf	ESU 1B - Exis□ng Silty Granular Fill
Slice 3	59.350415 ft	59.730924 ft	-992.23487 psf	2,847.0049 psf	2,224.324 psf	0 psf	0 psf	ESU 1B - Exis□ng Silty Granular Fill
Slice 4	63.116805 ft	54.254762 ft	-649.21664 psf	3,583.9118 psf	2,800.0588 psf	0 psf	0 psf	ESU 1B - Exis□ng Silty Granular Fill
Slice 5	67.094981 ft	49.673393 ft	-361.9601 psf	11,240.061 psf	8,781.6981 psf	0 psf	0 psf	ESU 1B - Exis□ng Silty Granular Fill
Slice 6	71.299472 ft	45.703914 ft	-112.80707 psf	11,979.967 psf	9,701.1864 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 7	73.954492 ft	43.496058 ft	25.883545 psf	12,445.699 psf	10,057.368 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 8	75.5 ft	42.379143 ft	96.114822 psf	12,705.826 psf	10,211.143 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 9	77.437275 ft	41.06741 ft	178.63852 psf	13,575.389 psf	10,848.475 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 10	78.937275 ft	40.120263 ft	238.26048 psf	13,822.607 psf	11,000.387 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 11	81.351788 ft	38.774719 ft	323.0595 psf	11,161.399 psf	8,776.714 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 12	85.101788 ft	36.908419 ft	440.81658 psf	11,589.283 psf	9,027.85 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 13	88.5 ft	35.476932 ft	531.31943 psf	11,923.672 psf	10,623.54 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice	91.5 ft	34.427595	601.99804	5,065.1382	4,161.9455	0 psf	0 psf	ESU 7A -

14		ft	psf	psf	psf			Weathered Sandstone
Slice 15	94.25 ft	33.61532 ft	661.26401 psf	4,515.0275 psf	3,593.6926 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 16	97.5 ft	32.869029 ft	717.97257 psf	4,691.3363 psf	3,705.2216 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 17	99.75 ft	32.414299 ft	753.36773 psf	4,722.5897 psf	3,701.3593 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 18	100.75 ft	32.261316 ft	770.18204 psf	4,767.682 psf	3,727.7291 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 19	103 ft	31.985798 ft	806.83891 psf	4,846.4629 psf	3,767.0103 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 20	106 ft	31.734974 ft	848.44309 psf	4,942.0315 psf	3,817.3329 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 21	108.94188 ft	31.637122 ft	879.99895 psf	5,023.8242 psf	3,864.1796 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 22	110.69188 ft	31.632803 ft	895.40754 psf	5,070.0241 psf	3,892.8929 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 23	112.75 ft	31.739601 ft	913.17609 psf	5,109.0645 psf	3,912.7292 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 24	116.25 ft	32.045008 ft	937.65307 psf	5,158.2974 psf	3,935.8145 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 25	119.91667 ft	32.599017 ft	948.69038 psf	5,184.6689 psf	3,950.1139 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 26	123.75 ft	33.43017 ft	944.50696 psf	5,183.3998 psf	3,952.8315 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 27	127.58333 ft	34.536219 ft	923.17004 psf	5,141.2995 psf	3,933.4694 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 28	131.56697 ft	36.001447 ft	881.28992 psf	5,060.8378 psf	3,897.4915 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 29	135.70092 ft	37.877477 ft	815.64527 psf	4,934.374 psf	3,840.7767 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 30	139.13394 ft	39.712511 ft	743.84057 psf	4,787.6264 psf	3,770.8913 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 31	142 ft	41.512679 ft	667.15922 psf	4,620.5118 psf	3,686.5609 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice	145 ft	43.653448	570.89047	4,403.1869	3,573.6742	0 psf	0 psf	ESU 7A -

32		ft	psf	psf	psf			Weathered Sandstone
Slice 33	147.5 ft	45.645291 ft	477.69542 psf	4,186.4444 psf	3,458.4644 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 34	150.25 ft	48.187628 ft	342.41203 psf	3,892.341 psf	3,310.3623 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 35	153.75 ft	51.892719 ft	133.05431 psf	3,458.8917 psf	3,101.3936 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 36	155.62557 ft	54.065552 ft	9.1731259 psf	3,233.8858 psf	3,007.0932 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 37	156.70843 ft	55.52195 ft	-74.949073 psf	3,287.9738 psf	3,066.0851 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 38	158.43286 ft	57.977353 ft	-217.40575 psf	3,170.7482 psf	2,567.6213 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 39	160.59751 ft	61.61796 ft	-431.07221 psf	2,902.3935 psf	2,350.3119 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 40	164.22843 ft	70.12659 ft	-939.3538 psf	1,601.5415 psf	1,251.2613 psf	0 psf	0 psf	ESU 1B - Exis□ng Silty Granular Fill

1.3 Pseudo-Static - Spencer Section D-D' - Final Condition - Global Stability

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File Informa on

File Version: 11.02
Title: Bridge 17.7 Pier 3
Created By: Mikayla S. Hatch
Last Edited By: Valerie R. Yanez
Revision Number: 281
Date: 11/29/2021
Time: 04:03:20 PM
Tool Version: 11.2.2.23310
File Name: Bridge 17.7 D-D' - Pier 1.gsz
Directory: P:\0\0180366\01\Analysis\Bridge 17.7\SlopeW\
Last Solved Date: 11/29/2021
Last Solved Time: 04:03:28 PM

Project Se ngs

Unit System: U.S. Customary Units

Analysis Se ngs

1.3 Pseudo-Sta c - Spencer

Descrip on: Spencer Method
Kind: SLOPE/W
Parent: B17.7 Pier 3
Analysis Type: Spencer
Se ngs
PWP Condi ons from: Piezometric Line
Apply Phrea c Correc on: No
Use Staged Rapid Drawdown: No
Unit Weight of Water: 62.4 pcf
Slip Surface
Direc on of movement: Le. to Right
Use Passive Mode: No
Slip Surface Op on: Entry and Exit
Cri cal slip surfaces saved: 1
Op mize Cri cal Slip Surface Loca on: No
Tension Crack Op on: (none)
Distribu on
F of S Calcula on Op on: Constant
Advanced
Geometry Se ngs
Minimum Slip Surface Depth: 2 ft
Number of Slices: 30
Factor of Safety Convergence Se ngs
Maximum Number of Itera ons: 100
Tolerable difference in F of S: 0.001

Solu□on Se□ ngs
Search Method: Root Finder
Tolerable difference between star□ng and converged F of S: 3
Maximum itera□ons to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Concrete

Slope Stability Material Model: High Strength
Unit Weight: 150 pcf
Pore Water Pressure
Piezometric Line: 1

ESU 1A - Exis ng Granular Fill (Pseudo-Sta c)

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 50 psf
Effec□ve Fric□on Angle: 40 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2A - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 39 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1B - Exis ng Silty Granular Fill

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 7A - Weathered Sandstone

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 43 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

New Foo ng

Slope Stability Material Model: High Strength

Unit Weight: 2,250 pcf
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (2.22265, 79.849107) ft
Left-Zone Right Coordinate: (78.67362, 91.857103) ft
Left-Zone Increment: 30
Right Type: Range
Right-Zone Left Coordinate: (169.70696, 76.087571) ft
Right-Zone Right Coordinate: (219.71591, 75.103568) ft
Right-Zone Increment: 25
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 79.5) ft
Right Coordinate: (225, 75) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	0 ft	43.5 ft
Coordinate 2	88 ft	44.5 ft
Coordinate 3	100 ft	44.5 ft
Coordinate 4	111 ft	46.025 ft
Coordinate 5	148.5 ft	53.5 ft
Coordinate 6	168.5 ft	55.5 ft
Coordinate 7	190.5 ft	58 ft
Coordinate 8	208.5 ft	60 ft
Coordinate 9	225 ft	65.5 ft

Seismic Coefficients

Horz Seismic Coef.: 0.171

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 125 pcf
Direc□on: Ver□cal

Coordinates

Figure D.4-61

	X	Y
	0 ft	94 ft
	0 ft	80.5 ft
	79.5 ft	93 ft

Geometry

Name: Default Geometry

Se ngs

View: 2D

Element Thickness: 1 ft

Points

	X	Y
Point 1	225 ft	75 ft
Point 2	159.2 ft	76.3 ft
Point 3	159 ft	0 ft
Point 4	159.2 ft	64.1 ft
Point 5	164.2 ft	64.1 ft
Point 6	175.9 ft	75.96236 ft
Point 7	159.2 ft	57 ft
Point 8	197.1 ft	63.5 ft
Point 9	155.5 ft	71.5 ft
Point 10	101.5 ft	71.5 ft
Point 11	101.5 ft	0 ft
Point 12	129.5 ft	64.1 ft
Point 13	101.5 ft	37.5 ft
Point 14	101.5 ft	36 ft
Point 15	107.5 ft	36 ft
Point 16	118 ft	39.5 ft
Point 17	140.5 ft	53 ft
Point 18	146.5 ft	55.5 ft
Point 19	87 ft	36 ft
Point 20	74.5 ft	47.5 ft
Point 21	0.5 ft	47.5 ft
Point 22	0 ft	29.5 ft
Point 23	50.5 ft	29.5 ft
Point 24	95.5 ft	71.5 ft
Point 25	225 ft	0 ft
Point 26	225 ft	69.13637 ft
Point 27	0 ft	0 ft
Point 28	0 ft	47.5 ft
Point 29	0 ft	71.5 ft
Point 30	0 ft	79.5 ft
Point 31	79.5 ft	71.497532 ft
Point 32	76.5 ft	71.497532 ft
Point 33	65 ft	71.497532 ft
Point 34	65 ft	66.502713 ft

Figure D.4-62

Point 35	90 ft	71.497532 ft
Point 36	90 ft	66.502713 ft
Point 37	76.5 ft	91.5157 ft
Point 38	79.5 ft	91.9869 ft
Point 39	93 ft	71.5 ft
Point 40	93 ft	39.5 ft
Point 41	90 ft	39.5 ft
Point 42	87 ft	39.5 ft
Point 43	99.5 ft	39.5 ft
Point 44	99.5 ft	36 ft
Point 45	65 ft	70.5 ft
Point 46	90 ft	70.5 ft
Point 47	76.5 ft	70.5 ft
Point 48	79.5 ft	70.5 ft
Point 49	93 ft	70.5 ft

Regions

	Material	Points	Area
Region 1	ESU 2A - Na□ve Sand and Gravel	8,26,1,6,5,4,12,13,14,15,16,17,18,7	1,345.5 ft²
Region 2	ESU 1B - Exis□ng Silty Granular Fill	5,6,2,9,10,13,12,4	939.79 ft²
Region 3	ESU 7A - Weathered Sandstone	8,7,18,17,16,15,14,11,3,25,26	6,826.6 ft²
Region 4	ESU 7A - Weathered Sandstone	11,14,44,19,23,22,27	3,207.1 ft²
Region 5	ESU 2A - Na□ve Sand and Gravel	28,22,23,19,20,21	1,375.5 ft²
Region 6	Concrete	37,32,31,38	60.761 ft²
Region 7	ESU 1B - Exis□ng Silty Granular Fill	35,46,49,39	2.9963 ft²
Region 8	ESU 1B - Exis□ng Silty Granular Fill	29,28,21,20,19,42,41,36,34,45,33	2,130.9 ft²
Region 9	ESU 1B - Exis□ng Silty Granular Fill	14,13,10,24,39,49,40,43,44	279 ft²
Region 10	ESU 1A - Exis□ng Granular Fill (Pseudo-Sta□c)	30,29,33,32,37	1,071.7 ft²
Region 11	ESU 1B - Exis□ng Silty Granular Fill	33,45,47,32	11.472 ft²
Region 12	New Foo□ng	34,36,46,48,47,45	99.932 ft²
Region 13	ESU 1B - Exis□ng Silty Granular Fill	46,35,31,48	10.474 ft²
Region 14	Concrete	32,47,48,31	2.9926 ft²
Region 15	Concrete	36,41,42,19,44,43,40,49,46	136.75 ft²

Slip Results

Slip Surfaces Analysed: 523 of 4030 converged

Current Slip Surface

Slip Surface: 1,854
Factor of Safety: 3.217
Volume: 4,603.2947 ft³
Weight: 793,876.31 lbf
Resis□ng Moment: 56,996,002 lbf·ft
Ac□va□ng Moment: 17,718,394 lbf·ft
Resis□ng Force: 627,875.84 lbf
Ac□va□ng Force: 195,175.3 lbf
Slip Rank: 1 of 4,030 slip surfaces
Exit: (181.70905, 75.848503) ft

Figure D.4-63

Entry: (37.899769, 85.45284) ft
Radius: 77.566834 ft
Center: (111.7164, 109.27968) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Fric□onal Strength	Cohesive Strength	Suc□on Strength	Base Material
Slice 1	40.93633 ft	78.475585 ft	-2,153.4489 psf	529.16675 psf	444.02362 psf	50 psf	0 psf	ESU 1A - Exis□ng Granular Fill (Pseudo-Sta□c)
Slice 2	46.577963 ft	67.442372 ft	-1,460.976 psf	1,587.6955 psf	1,240.4437 psf	0 psf	0 psf	ESU 1B - Exis□ng Silty Granular Fill
Slice 3	51.788107 ft	60.205179 ft	-1,005.6807 psf	2,421.2778 psf	1,891.7095 psf	0 psf	0 psf	ESU 1B - Exis□ng Silty Granular Fill
Slice 4	56.998252 ft	54.425338 ft	-641.32416 psf	3,172.6858 psf	2,478.7738 psf	0 psf	0 psf	ESU 1B - Exis□ng Silty Granular Fill
Slice 5	62.208396 ft	49.663367 ft	-340.48267 psf	3,857.818 psf	3,014.0578 psf	0 psf	0 psf	ESU 1B - Exis□ng Silty Granular Fill
Slice 6	67.094541 ft	45.89418 ft	-101.82068 psf	11,205.104 psf	9,073.7145 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 7	71.937807 ft	42.756261 ft	97.419786 psf	11,965.569 psf	9,610.6377 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 8	75.5 ft	40.6961 ft	228.49975 psf	12,507.065 psf	9,942.9864 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 9	77.192899 ft	39.823628 ft	284.1424 psf	13,290.621 psf	10,532.438 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 10	78.692899 ft	39.099435 ft	330.39566 psf	13,515.98 psf	10,677.476 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 11	83.014516 ft	37.31789 ft	444.62849 psf	11,223.991 psf	8,728.9554 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 12	86.764516 ft	35.836125 ft	539.74972 psf	11,533.864 psf	10,252.178 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone

Slice 13	87.5 ft	35.591804 ft	555.5169 psf	11,689.161 psf	10,382.291 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 14	89 ft	35.121164 ft	585.23937 psf	11,841.036 psf	10,496.2 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 15	91.5 ft	34.409811 ft	629.6278 psf	5,051.7596 psf	4,123.7046 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 16	94.25 ft	33.715845 ft	672.93125 psf	4,491.3069 psf	3,560.6929 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 17	97.5 ft	33.053903 ft	714.23645 psf	4,645.5036 psf	3,665.9659 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 18	99.75 ft	32.64186 ft	739.94796 psf	4,664.6358 psf	3,659.8306 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 19	100.75 ft	32.495708 ft	755.55601 psf	4,705.3333 psf	3,683.2269 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 20	104.5 ft	32.108058 ft	812.18625 psf	4,817.3076 psf	3,734.8361 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 21	108.94188 ft	31.775908 ft	871.33872 psf	4,947.3591 psf	3,800.9505 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 22	110.69188 ft	31.72022 ft	889.9527 psf	4,995.3462 psf	3,828.3414 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 23	114.5 ft	31.841962 ft	928.55597 psf	5,068.3876 psf	3,860.4554 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 24	120.875 ft	32.309869 ft	978.6534 psf	5,171.8177 psf	3,910.1889 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 25	126.625 ft	33.215464 ft	993.66506 psf	5,218.7215 psf	3,939.9289 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 26	131.56697 ft	34.326379 ft	985.81417 psf	5,229.4175 psf	3,957.2241 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 27	135.70092 ft	35.546152 ft	961.11999 psf	5,215.6212 psf	3,967.3866 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 28	139.13394 ft	36.734796 ft	929.65 psf	5,183.2162 psf	3,966.5146 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 29	143.5 ft	38.60014 ft	867.55929 psf	5,087.0016 psf	3,934.6936 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 30	147.5 ft	40.469229 ft	800.68172 psf	4,970.42 psf	3,888.3438 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone

Slice 31	152 ft	43.120368 ft	669.52906 psf	4,751.3396 psf	3,806.3499 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 32	157.35 ft	46.598321 ft	485.88876 psf	4,889.8333 psf	4,106.7447 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 33	161.7 ft	50.055085 ft	297.33071 psf	5,057.0641 psf	4,438.5232 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 34	165.85885 ft	53.783386 ft	90.635937 psf	4,744.8542 psf	4,340.1288 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 35	168.00885 ft	55.919912 ft	-29.26727 psf	4,536.4083 psf	4,230.2692 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 36	169.63332 ft	57.71089 ft	-129.92322 psf	4,302.1886 psf	4,011.8557 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 37	173.33332 ft	62.353961 ft	-393.41449 psf	3,296.8404 psf	2,669.7287 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 38	178.80453 ft	70.786349 ft	-880.79974 psf	1,800.6334 psf	1,458.1241 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel

1.4 Pseudo-Static - M-P Section D-D' - Final Condition - Global Stability

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File Informa on

File Version: 11.02
Title: Bridge 17.7 Pier 3
Created By: Mikayla S. Hatch
Last Edited By: Valerie R. Yanez
Revision Number: 281
Date: 11/29/2021
Time: 04:03:20 PM
Tool Version: 11.2.2.23310
File Name: Bridge 17.7 D-D' - Pier 1.gsz
Directory: P:\0\0180366\01\Analysis\Bridge 17.7\SlopeW\
Last Solved Date: 11/29/2021
Last Solved Time: 04:03:29 PM

Project Se ngs

Unit System: U.S. Customary Units

Analysis Se ngs

1.4 Pseudo-Sta c - M-P

Descrip on: Spencer Method
Kind: SLOPE/W
Parent: B17.7 Pier 3
Analysis Type: Morgenstern-Price
Se ngs
Side Func on
Interslice force func on op on: Half-Sine
PWP Condi ons from: Piezometric Line
Apply Phrea c Correc on: No
Use Staged Rapid Drawdown: No
Unit Weight of Water: 62.4 pcf
Slip Surface
Direc on of movement: Le. to Right
Use Passive Mode: No
Slip Surface Op on: Entry and Exit
Cri cal slip surfaces saved: 1
Op mize Cri cal Slip Surface Loca on: No
Tension Crack Op on: (none)
Distribu on
F of S Calcula on Op on: Constant
Advanced
Geometry Se ngs
Minimum Slip Surface Depth: 2 ft
Number of Slices: 30
Factor of Safety Convergence Se ngs

Maximum Number of Itera□ons: 100
Tolerable difference in F of S: 0.001
Solu□on Se□ ngs
Search Method: Root Finder
Tolerable difference between star□ng and converged F of S: 3
Maximum itera□ons to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Concrete

Slope Stability Material Model: High Strength
Unit Weight: 150 pcf
Pore Water Pressure
Piezometric Line: 1

ESU 1A - Exis ng Granular Fill (Pseudo-Sta c)

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 50 psf
Effec□ve Fric□on Angle: 40 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2A - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 39 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1B - Exis ng Silty Granular Fill

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 7A - Weathered Sandstone

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 43 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

New Foo ng

Slope Stability Material Model: High Strength
Unit Weight: 2,250 pcf
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (2.22265, 79.849107) ft
Left-Zone Right Coordinate: (79.5, 76) ft
Left-Zone Increment: 30
Right Type: Range
Right-Zone Left Coordinate: (157.67588, 74.322762) ft
Right-Zone Right Coordinate: (219.71591, 75.103568) ft
Right-Zone Increment: 25
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 79.5) ft
Right Coordinate: (225, 75) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	0 ft	43.5 ft
Coordinate 2	90 ft	44.5 ft
Coordinate 3	100 ft	45 ft
Coordinate 4	111 ft	46.525 ft
Coordinate 5	148.5 ft	54 ft
Coordinate 6	168.5 ft	56 ft
Coordinate 7	190.5 ft	58.5 ft
Coordinate 8	208.5 ft	60.5 ft
Coordinate 9	225 ft	66 ft

Seismic Coefficients

Horz Seismic Coef.: 0.171

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 125 pcf
Direc on: Ver cal

Figure D.4-69

Coordinates

	X	Y
	0 ft	94 ft
	0 ft	80.5 ft
	79.5 ft	93 ft

Geometry

Name: Default Geometry

Se ngs

View: 2D

Element Thickness: 1 ft

Points

	X	Y
Point 1	225 ft	75 ft
Point 2	159.2 ft	76.3 ft
Point 3	159 ft	0 ft
Point 4	159.2 ft	64.1 ft
Point 5	164.2 ft	64.1 ft
Point 6	175.9 ft	75.96236 ft
Point 7	159.2 ft	57 ft
Point 8	197.1 ft	63.5 ft
Point 9	155.5 ft	71.5 ft
Point 10	101.5 ft	71.5 ft
Point 11	101.5 ft	0 ft
Point 12	129.5 ft	64.1 ft
Point 13	101.5 ft	37.5 ft
Point 14	101.5 ft	36 ft
Point 15	107.5 ft	36 ft
Point 16	118 ft	39.5 ft
Point 17	140.5 ft	53 ft
Point 18	146.5 ft	55.5 ft
Point 19	87 ft	36 ft
Point 20	74.5 ft	47.5 ft
Point 21	0.5 ft	47.5 ft
Point 22	0 ft	29.5 ft
Point 23	50.5 ft	29.5 ft
Point 24	95.5 ft	71.5 ft
Point 25	225 ft	0 ft
Point 26	225 ft	69.13637 ft
Point 27	0 ft	0 ft
Point 28	0 ft	47.5 ft
Point 29	0 ft	71.5 ft
Point 30	0 ft	79.5 ft
Point 31	79.5 ft	71.497532 ft
Point 32	76.5 ft	71.497532 ft
Point 33	65 ft	71.497532 ft

Figure D.4-70

Point 34	65 ft	66.502713 ft
Point 35	90 ft	71.497532 ft
Point 36	90 ft	66.502713 ft
Point 37	76.5 ft	91.5157 ft
Point 38	79.5 ft	91.9869 ft
Point 39	93 ft	71.5 ft
Point 40	93 ft	39.5 ft
Point 41	90 ft	39.5 ft
Point 42	87 ft	39.5 ft
Point 43	99.5 ft	39.5 ft
Point 44	99.5 ft	36 ft
Point 45	65 ft	70.5 ft
Point 46	90 ft	70.5 ft
Point 47	76.5 ft	70.5 ft
Point 48	79.5 ft	70.5 ft
Point 49	93 ft	70.5 ft

Regions

	Material	Points	Area
Region 1	ESU 2A - Na□ve Sand and Gravel	8,26,1,6,5,4,12,13,14,15,16,17,18,7	1,345.5 ft²
Region 2	ESU 1B - Exis□ng Silty Granular Fill	5,6,2,9,10,13,12,4	939.79 ft²
Region 3	ESU 7A - Weathered Sandstone	8,7,18,17,16,15,14,11,3,25,26	6,826.6 ft²
Region 4	ESU 7A - Weathered Sandstone	11,14,44,19,23,22,27	3,207.1 ft²
Region 5	ESU 2A - Na□ve Sand and Gravel	28,22,23,19,20,21	1,375.5 ft²
Region 6	Concrete	37,32,31,38	60.761 ft²
Region 7	ESU 1B - Exis□ng Silty Granular Fill	35,46,49,39	2.9963 ft²
Region 8	ESU 1B - Exis□ng Silty Granular Fill	29,28,21,20,19,42,41,36,34,45,33	2,130.9 ft²
Region 9	ESU 1B - Exis□ng Silty Granular Fill	14,13,10,24,39,49,40,43,44	279 ft²
Region 10	ESU 1A - Exis□ng Granular Fill (Pseudo-Sta□c)	30,29,33,32,37	1,071.7 ft²
Region 11	ESU 1B - Exis□ng Silty Granular Fill	33,45,47,32	11.472 ft²
Region 12	New Foo□ng	34,36,46,48,47,45	99.932 ft²
Region 13	ESU 1B - Exis□ng Silty Granular Fill	46,35,31,48	10.474 ft²
Region 14	Concrete	32,47,48,31	2.9926 ft²
Region 15	Concrete	36,41,42,19,44,43,40,49,46	136.75 ft²

Slip Results

Slip Surfaces Analysed: 402 of 4030 converged

Current Slip Surface

Slip Surface: 1,624
Factor of Safety: 3.206
Volume: 4,821.9602 ft³
Weight: 821,360.13 lbf
Resis□ng Moment: 60,003,644 lbf·ft
Ac□va□ng Moment: 18,719,375 lbf·ft
Resis□ng Force: 643,785.8 lbf
Ac□va□ng Force: 200,783.12 lbf
Slip Rank: 1 of 4,030 slip surfaces

Figure D.4-71

Exit: (186.94961, 75.745788) ft
Entry: (39.450899, 85.696473) ft
Radius: 79.580331 ft
Center: (115.18482, 110.13829) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Fric□onal Strength	Cohesive Strength	Suc□on Strength	Base Material
Slice 1	42.532885 ft	78.59737 ft	-2,160.5864 psf	604.71608 psf	507.41704 psf	50 psf	0 psf	ESU 1A - Exis□ng Granular Fill (Pseudo-Sta□c)
Slice 2	48.038011 ft	67.667274 ft	-1,474.7315 psf	1,686.0356 psf	1,317.2754 psf	0 psf	0 psf	ESU 1B - Exis□ng Silty Granular Fill
Slice 3	52.884294 ft	60.777897 ft	-1,041.4743 psf	2,430.7016 psf	1,899.0722 psf	0 psf	0 psf	ESU 1B - Exis□ng Silty Granular Fill
Slice 4	57.730576 ft	55.186046 ft	-689.18276 psf	3,079.2239 psf	2,405.7534 psf	0 psf	0 psf	ESU 1B - Exis□ng Silty Granular Fill
Slice 5	62.576859 ft	50.514562 ft	-394.32203 psf	3,661.3736 psf	2,860.5786 psf	0 psf	0 psf	ESU 1B - Exis□ng Silty Granular Fill
Slice 6	65.549214 ft	47.938273 ft	-231.50075 psf	10,718.175 psf	8,373.9558 psf	0 psf	0 psf	ESU 1B - Exis□ng Silty Granular Fill
Slice 7	68.302402 ft	45.891702 ft	-101.88588 psf	11,012.26 psf	8,917.5525 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 8	72.503188 ft	43.013717 ft	80.612917 psf	11,548.075 psf	9,286.1674 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 9	75.5 ft	41.168635 ft	197.82384 psf	11,935.544 psf	9,505.0187 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 10	77.203461 ft	40.211151 ft	258.75193 psf	12,681.211 psf	10,059.509 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 11	78.703461 ft	39.418162 ft	309.27439 psf	12,883.574 psf	10,182.467 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel

Slice 12	82.996935 ft	37.458565 ft	434.53007 psf	10,618.691 psf	8,246.9707 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 13	86.746935 ft	35.813041 ft	539.81078 psf	10,929.952 psf	9,688.9635 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 14	88.5 ft	35.182206 ft	580.39036 psf	11,197.47 psf	9,900.5865 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 15	91.5 ft	34.180473 ft	648.61846 psf	4,654.3124 psf	3,735.3701 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 16	94.25 ft	33.371865 ft	707.65561 psf	4,151.8454 psf	3,211.759 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 17	97.5 ft	32.57497 ft	767.52185 psf	4,363.003 psf	3,352.8404 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 18	99.75 ft	32.069533 ft	806.08111 psf	4,426.9699 psf	3,376.5334 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 19	100.75 ft	31.881765 ft	825.06604 psf	4,488.0489 psf	3,415.7868 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 20	104.5 ft	31.33665 ft	891.52216 psf	4,682.8017 psf	3,535.4253 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 21	109.25 ft	30.79897 ft	966.16516 psf	4,935.2812 psf	3,701.2606 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 22	114.5 ft	30.637916 ft	1,034.8885 psf	5,187.1935 psf	3,872.0871 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 23	120.875 ft	30.813999 ft	1,103.1956 psf	5,467.1576 psf	4,069.4603 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 24	126.625 ft	31.438154 ft	1,135.7692 psf	5,672.6081 psf	4,230.6707 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 25	131.87895 ft	32.366732 ft	1,143.1766 psf	5,817.8098 psf	4,359.1659 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 26	136.63686 ft	33.543667 ft	1,128.9166 psf	5,904.5216 psf	4,453.3237 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 27	139.7579 ft	34.450879 ft	1,111.1275 psf	5,934.4283 psf	4,497.8008 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 28	143.5 ft	35.83504 ft	1,071.3015 psf	5,902.1835 psf	4,504.8703 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 29	147.5 ft	37.422673 ft	1,021.9868 psf	5,829.0982 psf	4,482.7039 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone

Slice 30	152 ft	39.696286 ft	914.39173 psf	5,629.1168 psf	4,396.5523 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 31	157.35 ft	42.68188 ft	761.47468 psf	5,718.0629 psf	4,622.0933 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 32	161.7 ft	45.641262 ft	603.95323 psf	5,763.7362 psf	4,811.5755 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 33	166.35 ft	49.250959 ft	407.72414 psf	5,252.9063 psf	4,518.2055 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 34	171.29799 ft	53.846783 ft	154.20103 psf	4,534.0952 psf	4,084.3174 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 35	174.99799 ft	57.664072 ft	-57.761472 psf	3,879.1596 psf	3,617.3749 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 36	176.46575 ft	59.375205 ft	-154.12841 psf	3,541.8629 psf	3,302.8405 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 37	179.51102 ft	63.476347 ft	-388.44588 psf	2,554.5426 psf	2,068.6278 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 38	184.47008 ft	71.320155 ft	-842.73526 psf	1,044.2003 psf	845.57672 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel

1.1 Static (Spencer) Section Ea-Ea' - Existing Condition - Global Stability

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File Informa on

File Version: 11.01
Created By: Mikayla S. Hatch
Last Edited By: Mikayla S. Hatch
Revision Number: 432
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Time: 03:09:03 PM
Tool Version: 11.1.1.22085
File Name: Wall 03.63L - Bridge 17.7 Ea-Ea' - All Condi ons.gsz
Directory: \\red\WAN\Projects\0\0180366\01\Analysis\Bridge 17.7\SlopeW\
Last Solved Date: 11/12/2021
Last Solved Time: 03:09:16 PM

Project Se ngs

Unit System: U.S. Customary Units

Analysis Se ngs

1.1 Sta c (Spencer)

Kind: SLOPE/W
Parent: 1. Global Stability
Analysis Type: Spencer
Se ngs
PWP Condi ons from: Piezometric Line
Apply Phrea c Correc on: No
Use Staged Rapid Drawdown: No
Cri cal Slip Surface Source from: (none)
Unit Weight of Water: 62.4 pcf
Slip Surface
Direc on of movement: Le. to Right
Use Passive Mode: No
Slip Surface Op on: Entry and Exit
Cri cal slip surfaces saved: 1
Op mize Cri cal Slip Surface Loca on: No
Tension Crack Op on: (none)
Distribu on
F of S Calcula on Op on: Constant
Advanced
Geometry Se ngs
Minimum Slip Surface Depth: 2 ft
Number of Slices: 30
Factor of Safety Convergence Se ngs
Maximum Number of Itera ons: 100
Tolerable difference in F of S: 0.001
Solu on Se ngs

Figure D.4-75

Search Method: Root Finder
Tolerable difference between star□ng and converged F of S: 3
Maximum itera□ons to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Hilfiker Wall

Material Model: High Strength
Unit Weight: 130 pcf
Pore Water Pressure
Piezometric Line: 1

ESU 2A - Na ve Sand and Gravel

Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 39 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2B - Na ve Sand and Gravel

Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 41 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 7A - Weathered Sandstone

Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 42 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2C - Na ve Silt

Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 29 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1A - Exis ng Granular Fill

Material Model: Mohr-Coulomb
Unit Weight: 120 pcf

Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 40 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1B - Exis ng Gravelly Granular Fill

Material Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (1.75, 60) ft
Left-Zone Right Coordinate: (118.53905, 95.203118) ft
Left-Zone Increment: 40
Right Type: Range
Right-Zone Left Coordinate: (161.44853, 50) ft
Right-Zone Right Coordinate: (315.5, 48.958333) ft
Right-Zone Increment: 40
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 60) ft
Right Coordinate: (335, 48) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	0.25 ft	43.375 ft
Coordinate 2	56.5 ft	43.375 ft
Coordinate 3	97.75 ft	43.375 ft
Coordinate 4	123 ft	43.375 ft
Coordinate 5	159.75 ft	42.625 ft
Coordinate 6	192 ft	42.625 ft
Coordinate 7	210.75 ft	42.625 ft
Coordinate 8	298 ft	35 ft
Coordinate 9	335.25 ft	35 ft

Surcharge Loads

Figure D.4-77

Surcharge Load 1

Surcharge (Unit Weight): 250 pcf
Direc□on: Ver□cal

Coordinates

	X	Y
	120 ft	97 ft
	160 ft	97 ft

Geometry

Name: Ea-Ea'

Se ngs

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	0 ft	56 ft
Point 2	76 ft	56 ft
Point 3	118 ft	35 ft
Point 4	160 ft	35 ft
Point 5	0 ft	46 ft
Point 6	37 ft	46 ft
Point 7	190 ft	50 ft
Point 8	160 ft	50 ft
Point 9	170.25 ft	34 ft
Point 10	240 ft	34 ft
Point 11	315 ft	30 ft
Point 12	335 ft	30 ft
Point 13	335 ft	48 ft
Point 14	327 ft	48 ft
Point 15	315 ft	49 ft
Point 16	224 ft	48 ft
Point 17	0 ft	0 ft
Point 18	335 ft	0 ft
Point 19	160 ft	96 ft
Point 20	120 ft	96 ft
Point 21	120 ft	72 ft
Point 22	76 ft	72 ft
Point 23	52 ft	60 ft
Point 24	0 ft	60 ft
Point 25	160 ft	47 ft
Point 26	120 ft	47 ft
Point 27	65 ft	66.5 ft
Point 28	120 ft	66.5 ft
Point 29	120 ft	49 ft
Point 30	160 ft	49 ft

Figure D.4-78

Point 31	160 ft	66.5 ft
Point 32	160 ft	72 ft
Point 33	281 ft	48.626374 ft
Point 34	126 ft	49 ft
Point 35	126 ft	96 ft
Point 36	126 ft	66.5 ft
Point 37	126 ft	72 ft

Regions

	Material	Points	Area
Region 1	ESU 2C - Na□ve Silt	5,6,2,1	565 ft²
Region 2	Hilfiker Wall	19,35,37,32	816 ft²
Region 3	ESU 1A - Exis□ng Granular Fill	20,22,21	528 ft²
Region 4	ESU 2A - Na□ve Sand and Gravel	6,2,3	619.5 ft²
Region 5	ESU 2B - Na□ve Sand and Gravel	7,16,33,15,14,13,12,11,10,9,4	2,595.4 ft²
Region 6	ESU 7A - Weathered Sandstone	18,17,5,6,3,4,9,10,11,12	12,178 ft²
Region 7	ESU 1B - Exis□ng Gravelly Granular Fill	8,30,25,7	45 ft²
Region 8	ESU 2A - Na□ve Sand and Gravel	4,7,25,26,2,3	945 ft²
Region 9	ESU 1B - Exis□ng Gravelly Granular Fill	21,22,27,28	272.25 ft²
Region 10	ESU 1B - Exis□ng Gravelly Granular Fill	23,24,1,2,26,29,28,27	1,077.8 ft²
Region 11	ESU 1B - Exis□ng Gravelly Granular Fill	29,26,25,30,34	80 ft²
Region 12	ESU 1B - Exis□ng Gravelly Granular Fill	29,34,36,28	105 ft²
Region 13	ESU 1B - Exis□ng Gravelly Granular Fill	28,36,37,21	33 ft²
Region 14	Hilfiker Wall	30,8,31,36,34	595 ft²
Region 15	Hilfiker Wall	31,32,37,36	187 ft²
Region 16	ESU 1A - Exis□ng Granular Fill	20,21,37,35	144 ft²

Slip Results

Slip Surfaces Analysed: 3853 of 8405 converged

Current Slip Surface

Slip Surface: 7,445
Factor of Safety: 2.368
Volume: 3,128.6352 ft³
Weight: 398,879.97 lbf
Resis□ng Moment: 19,926,951 lbf·ft
Ac□va□ng Moment: 8,416,740.4 lbf·ft
Resis□ng Force: 287,042.86 lbf
Ac□va□ng Force: 121,239.75 lbf
Slip Rank: 1 of 8,405 slip surfaces
Exit: (207.65326, 48.961573) ft
Entry: (107.51808, 89.191679) ft
Radius: 59.337893 ft
Center: (166.79009, 91.987002) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Fric□onal Strength	Cohesive Strength	Suc□on Strength	Base Material

Figure D.4-79

Slice 1	109.21887 ft	80.59584 ft	-2,322.5804 psf	279.00054 psf	234.10925 psf	0 psf	0 psf	ESU 1A - Exis□ng Granular Fill
Slice 2	112.06216 ft	69.25 ft	-1,614.6 psf	1,141.302 psf	891.68285 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 3	114.9035 ft	63.414934 ft	-1,250.4919 psf	1,800.2293 psf	1,406.4932 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 4	118.30117 ft	57.91239 ft	-907.13311 psf	2,556.1421 psf	1,997.0771 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 5	121.5 ft	53.719635 ft	-645.50523 psf	3,328.7211 psf	2,600.682 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 6	124.5 ft	50.418327 ft	-441.4138 psf	3,819.1052 psf	2,983.812 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 7	127.0485 ft	47.946147 ft	-290.39523 psf	4,458.0854 psf	3,483.038 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 8	130.57746 ft	45.084868 ft	-116.34544 psf	4,945.367 psf	4,004.6793 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 9	134.77745 ft	42.067035 ft	66.61882 psf	5,537.28 psf	4,430.0541 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 10	138.21651 ft	40.018883 ft	190.04393 psf	5,993.7615 psf	4,699.7578 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 11	141.65558 ft	38.26887 ft	294.86521 psf	6,425.116 psf	4,964.1792 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 12	145.09465 ft	36.788454 ft	382.86359 psf	6,835.3719 psf	5,225.1382 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 13	148.53372 ft	35.556301 ft	455.3704 psf	7,227.9251 psf	5,484.3067 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 14	151.83604 ft	34.587641 ft	511.60938 psf	7,601.5067 psf	6,383.7722 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone

Figure D.4-80

Slice 15	155.00163 ft	33.854315 ft	553.33766 psf	7,966.2791 psf	6,674.6425 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 16	158.16721 ft	33.300785 ft	583.84665 psf	8,323.2039 psf	6,968.5486 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 17	159.875 ft	33.053555 ft	597.25816 psf	8,516.4824 psf	7,130.5015 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 18	161.70833 ft	32.891983 ft	607.34025 psf	2,173.4632 psf	1,410.1435 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 19	165.125 ft	32.697102 ft	619.50085 psf	2,303.1144 psf	1,515.9324 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 20	168.54167 ft	32.699596 ft	619.34524 psf	2,414.1862 psf	1,616.0821 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 21	172.75 ft	33.002672 ft	600.43329 psf	2,520.216 psf	1,728.5801 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 22	177.31475 ft	33.627639 ft	561.43535 psf	2,607.2545 psf	1,842.0638 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 23	181.14958 ft	34.441695 ft	510.63821 psf	2,629.4375 psf	1,841.8442 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 24	184.68975 ft	35.443738 ft	448.11072 psf	2,635.2671 psf	1,901.2661 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 25	188.22992 ft	36.69039 ft	370.31967 psf	2,611.3714 psf	1,948.1165 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 26	191 ft	37.823673 ft	299.60278 psf	2,548.8507 psf	1,955.2414 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 27	193.93 ft	39.26415 ft	209.71706 psf	2,393.9523 psf	1,898.7267 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 28	197.78999 ft	41.441323 ft	73.861441 psf	2,124.0911 psf	1,782.2374 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 29	201.70331 ft	44.070083 ft	-90.173178 psf	1,648.5089 psf	1,433.0269 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 30	205.66994 ft	47.23837 ft	-287.87426 psf	732.4844 psf	636.73897 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel

Figure D.4-81

1.2 Static (M-P) Section Ea-Ea' - Existing Condition - Global Stability

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File Informa on

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Last Solved Date: 11/12/2021
Last Solved Time: 03:09:20 PM

Project Se ngs

Unit System: U.S. Customary Units

Analysis Se ngs

1.2 Sta c (M-P)

Kind: SLOPE/W
Parent: 1. Global Stability
Analysis Type: Morgenstern-Price
Se ngs
Side Func on
Interslice force func on op on: Half-Sine
PWP Condi ons from: Piezometric Line
Apply Phrea c Correc on: No
Use Staged Rapid Drawdown: No
Unit Weight of Water: 62.4 pcf
Slip Surface
Direc on of movement: Le. to Right
Use Passive Mode: No
Slip Surface Op on: Entry and Exit
Cri cal slip surfaces saved: 1
Op mize Cri cal Slip Surface Loca on: No
Tension Crack Op on: (none)
Distribu on
F of S Calcula on Op on: Constant
Advanced
Geometry Se ngs
Minimum Slip Surface Depth: 2 ft
Number of Slices: 30
Factor of Safety Convergence Se ngs
Maximum Number of Itera ons: 100
Tolerable difference in F of S: 0.001

Figure D.4-82

Solu□on Se□ ngs
Search Method: Root Finder
Tolerable difference between star□ng and converged F of S: 3
Maximum itera□ons to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Hilfiker Wall

Slope Stability Material Model: High Strength
Unit Weight: 130 pcf
Pore Water Pressure
Piezometric Line: 1

ESU 2A - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 39 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2B - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 41 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 7A - Weathered Sandstone

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 42 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2C - Na ve Silt

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 29 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1A - Exis ng Granular Fill

Slope Stability Material Model: Mohr-Coulomb

Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 40 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1B - Exis ng Gravelly Granular Fill

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (1.75, 60) ft
Left-Zone Right Coordinate: (118.53905, 95.203118) ft
Left-Zone Increment: 40
Right Type: Range
Right-Zone Left Coordinate: (161.44853, 50) ft
Right-Zone Right Coordinate: (315.5, 48.958333) ft
Right-Zone Increment: 40
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 60) ft
Right Coordinate: (335, 48) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	0.25 ft	43.375 ft
Coordinate 2	56.5 ft	43.375 ft
Coordinate 3	97.75 ft	43.375 ft
Coordinate 4	123 ft	43.375 ft
Coordinate 5	159.75 ft	42.625 ft
Coordinate 6	192 ft	42.625 ft
Coordinate 7	210.75 ft	42.625 ft
Coordinate 8	298 ft	35 ft
Coordinate 9	335.25 ft	35 ft

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 250 pcf
Direc□on: Ver□cal

Coordinates

	X	Y
	120 ft	97 ft
	160 ft	97 ft

Geometry

Name: Ea-Ea'

Se ngs

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	0 ft	56 ft
Point 2	76 ft	56 ft
Point 3	118 ft	35 ft
Point 4	160 ft	35 ft
Point 5	0 ft	46 ft
Point 6	37 ft	46 ft
Point 7	190 ft	50 ft
Point 8	160 ft	50 ft
Point 9	170.25 ft	34 ft
Point 10	240 ft	34 ft
Point 11	315 ft	30 ft
Point 12	335 ft	30 ft
Point 13	335 ft	48 ft
Point 14	327 ft	48 ft
Point 15	315 ft	49 ft
Point 16	224 ft	48 ft
Point 17	0 ft	0 ft
Point 18	335 ft	0 ft
Point 19	160 ft	96 ft
Point 20	120 ft	96 ft
Point 21	120 ft	72 ft
Point 22	76 ft	72 ft
Point 23	52 ft	60 ft
Point 24	0 ft	60 ft
Point 25	160 ft	47 ft
Point 26	120 ft	47 ft
Point 27	65 ft	66.5 ft
Point 28	120 ft	66.5 ft

Figure D.4-85

Point 29	120 ft	49 ft
Point 30	160 ft	49 ft
Point 31	160 ft	66.5 ft
Point 32	160 ft	72 ft
Point 33	281 ft	48.626374 ft
Point 34	126 ft	49 ft
Point 35	126 ft	96 ft
Point 36	126 ft	66.5 ft
Point 37	126 ft	72 ft

Regions

	Material	Points	Area
Region 1	ESU 2C - Na□ve Silt	5,6,2,1	565 ft²
Region 2	Hilfiker Wall	19,35,37,32	816 ft²
Region 3	ESU 1A - Exis□ng Granular Fill	20,22,21	528 ft²
Region 4	ESU 2A - Na□ve Sand and Gravel	6,2,3	619.5 ft²
Region 5	ESU 2B - Na□ve Sand and Gravel	7,16,33,15,14,13,12,11,10,9,4	2,595.4 ft²
Region 6	ESU 7A - Weathered Sandstone	18,17,5,6,3,4,9,10,11,12	12,178 ft²
Region 7	ESU 1B - Exis□ng Gravelly Granular Fill	8,30,25,7	45 ft²
Region 8	ESU 2A - Na□ve Sand and Gravel	4,7,25,26,2,3	945 ft²
Region 9	ESU 1B - Exis□ng Gravelly Granular Fill	21,22,27,28	272.25 ft²
Region 10	ESU 1B - Exis□ng Gravelly Granular Fill	23,24,1,2,26,29,28,27	1,077.8 ft²
Region 11	ESU 1B - Exis□ng Gravelly Granular Fill	29,26,25,30,34	80 ft²
Region 12	ESU 1B - Exis□ng Gravelly Granular Fill	29,34,36,28	105 ft²
Region 13	ESU 1B - Exis□ng Gravelly Granular Fill	28,36,37,21	33 ft²
Region 14	Hilfiker Wall	30,8,31,36,34	595 ft²
Region 15	Hilfiker Wall	31,32,37,36	187 ft²
Region 16	ESU 1A - Exis□ng Granular Fill	20,21,37,35	144 ft²

Slip Results

Slip Surfaces Analysed: 4406 of 8405 converged

Current Slip Surface

Slip Surface: 7,445
Factor of Safety: 2.376
Volume: 3,128.6352 ft³
Weight: 398,879.97 lbf
Resis□ng Moment: 19,994,788 lbf·ft
Ac□va□ng Moment: 8,416,740.4 lbf·ft
Resis□ng Force: 287,879.57 lbf
Ac□va□ng Force: 121,180.19 lbf
Slip Rank: 1 of 8,405 slip surfaces
Exit: (207.65326, 48.961573) ft
Entry: (107.51808, 89.191679) ft
Radius: 59.337893 ft
Center: (166.79009, 91.987002) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Fric□onal Strength	Cohesive Strength	Suc□on Strength	Base Material
Slice 1	109.21887 ft	80.59584 ft	-2,322.5804 psf	383.27887 psf	321.60916 psf	0 psf	0 psf	ESU 1A - Exis□ng Granular Fill
Slice 2	112.06216 ft	69.25 ft	-1,614.6 psf	1,358.0041 psf	1,060.9891 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 3	114.9035 ft	63.414934 ft	-1,250.4919 psf	1,969.5646 psf	1,538.7925 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 4	118.30117 ft	57.91239 ft	-907.13311 psf	2,615.6803 psf	2,043.5934 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 5	121.5 ft	53.719635 ft	-645.50523 psf	3,270.8136 psf	2,555.4397 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 6	124.5 ft	50.418327 ft	-441.4138 psf	3,640.4116 psf	2,844.2012 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 7	127.0485 ft	47.946147 ft	-290.39523 psf	4,194.483 psf	3,277.0893 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 8	130.57746 ft	45.084868 ft	-116.34544 psf	4,585.7044 psf	3,713.4302 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 9	134.77745 ft	42.067035 ft	66.61882 psf	5,109.3033 psf	4,083.4854 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 10	138.21651 ft	40.018883 ft	190.04393 psf	5,553.7329 psf	4,343.4297 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 11	141.65558 ft	38.26887 ft	294.86521 psf	6,012.3608 psf	4,629.9367 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 12	145.09465 ft	36.788454 ft	382.86359 psf	6,489.003 psf	4,944.6542 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 13	148.53372 ft	35.556301 ft	455.3704 psf	6,984.4807 psf	5,287.1693 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel

Slice 14	151.83604 ft	34.587641 ft	511.60938 psf	7,514.6117 psf	6,305.5316 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 15	155.00163 ft	33.854315 ft	553.33766 psf	8,027.9084 psf	6,730.1337 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 16	158.16721 ft	33.300785 ft	583.84665 psf	8,541.4143 psf	7,165.0261 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 17	159.875 ft	33.053555 ft	597.25816 psf	8,819.1914 psf	7,403.062 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 18	161.70833 ft	32.891983 ft	607.34025 psf	2,333.5906 psf	1,554.3228 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 19	165.125 ft	32.697102 ft	619.50085 psf	2,575.7295 psf	1,761.3962 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 20	168.54167 ft	32.699596 ft	619.34524 psf	2,791.372 psf	1,955.7017 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 21	172.75 ft	33.002672 ft	600.43329 psf	2,997.4922 psf	2,158.3216 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 22	177.31475 ft	33.627639 ft	561.43535 psf	3,138.9588 psf	2,320.8125 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 23	181.14958 ft	34.441695 ft	510.63821 psf	3,136.6448 psf	2,282.7527 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 24	184.68975 ft	35.443738 ft	448.11072 psf	3,063.3196 psf	2,273.3664 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 25	188.22992 ft	36.69039 ft	370.31967 psf	2,895.7774 psf	2,195.3469 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 26	191 ft	37.823673 ft	299.60278 psf	2,680.5535 psf	2,069.7289 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 27	193.93 ft	39.26415 ft	209.71706 psf	2,340.2785 psf	1,852.0688 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 28	197.78999 ft	41.441323 ft	73.861441 psf	1,814.4786 psf	1,513.0954 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 29	201.70331 ft	44.070083 ft	-90.173178 psf	1,165.0476 psf	1,012.7604 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 30	205.66994 ft	47.23837 ft	-287.87426 psf	399.36001 psf	347.15836 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel

1.3 Pseudo-static (Spencer) Section Ea-Ea' - Existing Condition - Global Stability

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File Informa on

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Last Solved Time: 03:11:54 PM

Project Se ngs

Unit System: U.S. Customary Units

Analysis Se ngs

1.3 Pseudo-sta c (Spencer)

Kind: SLOPE/W
Parent: 1. Global Stability
Analysis Type: Spencer
Se ngs
PWP Condi ons from: Piezometric Line
Apply Phrea c Correc on: No
Use Staged Rapid Drawdown: No
Unit Weight of Water: 62.4 pcf
Slip Surface
Direc on of movement: Le. to Right
Use Passive Mode: No
Slip Surface Op on: Entry and Exit
Cri cal slip surfaces saved: 1
Op mize Cri cal Slip Surface Loca on: No
Tension Crack Op on: (none)
Distribu on
F of S Calcula on Op on: Constant
Advanced
Geometry Se ngs
Minimum Slip Surface Depth: 2 ft
Number of Slices: 30
Factor of Safety Convergence Se ngs
Maximum Number of Itera ons: 100
Tolerable difference in F of S: 0.001
Solu on Se ngs
Search Method: Root Finder

Tolerable difference between star□ng and converged F of S: 3
Maximum itera□ons to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Hilfiker Wall

Slope Stability Material Model: High Strength
Unit Weight: 130 pcf
Pore Water Pressure
Piezometric Line: 1

ESU 1A - Exis ng Granular Fill (Pseudo-Sta c)

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 50 psf
Effec□ve Fric□on Angle: 40 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2A - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 39 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2B - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 41 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 7A - Weathered Sandstone

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 42 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1B - Exis ng Gravelly Granular Fill

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effec□ve Cohesion: 0 psf

Effec□ve Fric□on Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2C - Na ve Silt (Pseudo-Sta c)

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effec□ve Cohesion: 200 psf
Effec□ve Fric□on Angle: 29 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (0.25, 60) ft
Left-Zone Right Coordinate: (118.13955, 94.985209) ft
Left-Zone Increment: 40
Right Type: Range
Right-Zone Left Coordinate: (160, 50.99889) ft
Right-Zone Right Coordinate: (335, 48) ft
Right-Zone Increment: 40
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 60) ft
Right Coordinate: (335, 48) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	0.25 ft	43.375 ft
Coordinate 2	56.5 ft	43.375 ft
Coordinate 3	97.75 ft	43.375 ft
Coordinate 4	123 ft	43.375 ft
Coordinate 5	159.75 ft	42.625 ft
Coordinate 6	192 ft	42.625 ft
Coordinate 7	210.75 ft	42.625 ft
Coordinate 8	298 ft	35 ft
Coordinate 9	335.25 ft	35 ft

Seismic Coefficients

Horz Seismic Coef.: 0.169

Figure D.4-91

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 125 pcf
Direc□on: Ver□cal

Coordinates

	X	Y
	120 ft	97 ft
	160 ft	97 ft

Geometry

Name: Ea-Ea'

Se ngs

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	0 ft	56 ft
Point 2	76 ft	56 ft
Point 3	118 ft	35 ft
Point 4	160 ft	35 ft
Point 5	0 ft	46 ft
Point 6	37 ft	46 ft
Point 7	190 ft	50 ft
Point 8	160 ft	50 ft
Point 9	170.25 ft	34 ft
Point 10	240 ft	34 ft
Point 11	315 ft	30 ft
Point 12	335 ft	30 ft
Point 13	335 ft	48 ft
Point 14	327 ft	48 ft
Point 15	315 ft	49 ft
Point 16	224 ft	48 ft
Point 17	0 ft	0 ft
Point 18	335 ft	0 ft
Point 19	160 ft	96 ft
Point 20	120 ft	96 ft
Point 21	120 ft	72 ft
Point 22	76 ft	72 ft
Point 23	52 ft	60 ft
Point 24	0 ft	60 ft
Point 25	160 ft	47 ft
Point 26	120 ft	47 ft
Point 27	65 ft	66.5 ft
Point 28	120 ft	66.5 ft

Figure D.4-92

Point 29	120 ft	49 ft
Point 30	160 ft	49 ft
Point 31	160 ft	66.5 ft
Point 32	160 ft	72 ft
Point 33	281 ft	48.626374 ft
Point 34	126 ft	49 ft
Point 35	126 ft	96 ft
Point 36	126 ft	66.5 ft
Point 37	126 ft	72 ft

Regions

	Material	Points	Area
Region 1	ESU 2C - Na□ve Silt (Pseudo-Sta□c)	5,6,2,1	565 ft²
Region 2	Hilfiker Wall	19,35,37,32	816 ft²
Region 3	ESU 1A - Exis□ng Granular Fill (Pseudo-Sta□c)	20,22,21	528 ft²
Region 4	ESU 2A - Na□ve Sand and Gravel	6,2,3	619.5 ft²
Region 5	ESU 2B - Na□ve Sand and Gravel	7,16,33,15,14,13,12,11,10,9,4	2,595.4 ft²
Region 6	ESU 7A - Weathered Sandstone	18,17,5,6,3,4,9,10,11,12	12,178 ft²
Region 7	ESU 1B - Exis□ng Gravelly Granular Fill	8,30,25,7	45 ft²
Region 8	ESU 2A - Na□ve Sand and Gravel	4,7,25,26,2,3	945 ft²
Region 9	ESU 1B - Exis□ng Gravelly Granular Fill	21,22,27,28	272.25 ft²
Region 10	ESU 1B - Exis□ng Gravelly Granular Fill	23,24,1,2,26,29,28,27	1,077.8 ft²
Region 11	ESU 1B - Exis□ng Gravelly Granular Fill	29,26,25,30,34	80 ft²
Region 12	ESU 1B - Exis□ng Gravelly Granular Fill	29,34,36,28	105 ft²
Region 13	ESU 1B - Exis□ng Gravelly Granular Fill	28,36,37,21	33 ft²
Region 14	Hilfiker Wall	30,8,31,36,34	595 ft²
Region 15	Hilfiker Wall	31,32,37,36	187 ft²
Region 16	ESU 1A - Exis□ng Granular Fill (Pseudo-Sta□c)	20,21,37,35	144 ft²

Slip Results

Slip Surfaces Analysed: 3827 of 8405 converged

Current Slip Surface

Slip Surface: 6,463
Factor of Safety: 1.813
Volume: 4,098.7378 ft³
Weight: 526,501.06 lbf
Resis□ng Moment: 46,327,484 lbf·ft
Ac□va□ng Moment: 25,554,421 lbf·ft
Resis□ng Force: 363,338.74 lbf
Ac□va□ng Force: 200,399.73 lbf
Slip Rank: 1 of 8,405 slip surfaces
Exit: (251.39568, 48.301052) ft
Entry: (93.135962, 81.346889) ft
Radius: 115.88442 ft
Center: (189.23792, 146.105) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Fric□onal Strength	Cohesive Strength	Suc□on Strength	Base Material
Slice 1	95.442981 ft	78.162059 ft	-2,170.7125 psf	238.5534 psf	200.17007 psf	50 psf	0 psf	ESU 1A - Exis□ng Granular Fill (Pseudo-Sta□c)
Slice 2	98.94722 ft	73.488615 ft	-1,879.0896 psf	652.55672 psf	547.5601 psf	50 psf	0 psf	ESU 1A - Exis□ng Granular Fill (Pseudo-Sta□c)
Slice 3	102.58345 ft	69.25 ft	-1,614.6 psf	1,120.3835 psf	875.33954 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 4	107.51872 ft	64.015019 ft	-1,287.9372 psf	1,752.1861 psf	1,368.9578 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 5	112.51123 ft	59.323019 ft	-995.15637 psf	2,405.954 psf	1,879.7373 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 6	117.50374 ft	55.147316 ft	-734.59255 psf	3,071.4042 psf	2,399.6439 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 7	121.5 ft	52.097792 ft	-544.3022 psf	3,637.8631 psf	2,842.2101 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 8	124.5 ft	50.006458 ft	-415.71316 psf	3,914.4523 psf	3,058.3053 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 9	127.58815 ft	47.997982 ft	-294.31697 psf	4,442.8616 psf	3,471.1439 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 10	132.65232 ft	45.053537 ft	-117.03266 psf	4,881.0363 psf	3,952.5852 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 11	138.64986 ft	41.883163 ft	73.161018 psf	5,415.2781 psf	4,325.9611 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel

Slice 12	143.69288 ft	39.581161 ft	210.38379 psf	5,851.4379 psf	4,568.0356 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 13	148.7359 ft	37.562187 ft	329.94567 psf	6,274.6381 psf	4,813.917 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 14	153.77892 ft	35.810651 ft	432.81936 psf	6,686.4578 psf	5,064.0965 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 15	158.02522 ft	34.517552 ft	508.10124 psf	7,061.6469 psf	5,900.839 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 16	159.875 ft	34.002362 ft	538.05261 psf	7,222.6585 psf	6,018.8462 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 17	162.5625 ft	33.363317 ft	577.92904 psf	1,847.9012 psf	1,143.4881 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 18	167.6875 ft	32.27189 ft	646.03405 psf	2,080.3055 psf	1,291.4238 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 19	172.75 ft	31.427328 ft	698.73475 psf	2,294.6892 psf	1,437.0038 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 20	177.70833 ft	30.822026 ft	736.50555 psf	2,489.5651 psf	1,578.4619 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 21	182.625 ft	30.435621 ft	760.61728 psf	2,667.6935 psf	1,717.1392 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 22	187.54167 ft	30.25908 ft	771.63342 psf	2,830.5211 psf	1,853.8308 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 23	191 ft	30.238292 ft	772.93059 psf	2,921.2962 psf	1,934.3971 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 24	194.34375 ft	30.356886 ft	765.5303 psf	2,951.8131 psf	1,968.5378 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 25	199.03125 ft	30.659094 ft	746.67253 psf	2,978.5614 psf	2,009.6018 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 26	203.71875 ft	31.153165 ft	715.84252 psf	2,980.2378 psf	2,038.8706 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 27	208.40625 ft	31.841591 ft	672.8847 psf	2,954.2668 psf	2,054.1656 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 28	214.67105 ft	33.117384 ft	571.89257 psf	2,872.8844 psf	2,071.8223 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 29	221.29605 ft	34.778643 ft	432.10193 psf	2,694.9323 psf	1,967.0484 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel

Slice 30	227.16165 ft	36.652754 ft	283.17059 psf	2,543.1758 psf	1,964.5926 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 31	233.48494 ft	39.055027 ft	98.786008 psf	2,349.1674 psf	1,956.2267 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 32	239.10477 ft	41.534067 ft	-86.552709 psf	2,005.4148 psf	1,743.2805 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 33	244.02113 ft	44.025541 ft	-268.83107 psf	1,438.1337 psf	1,250.1506 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 34	248.9375 ft	46.822915 ft	-470.19761 psf	579.58881 psf	503.82887 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel

1.4 Pseudo-static (M-P) Section Ea-Ea' - Existing Condition - Global Stability

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File Informa on

File Version: 11.01
Created By: Mikayla S. Hatch
Last Edited By: Mikayla S. Hatch
Revision Number: 433
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Tool Version: 11.1
File Name: Wall 03.63L - Bridge 17.7 Ea-Ea' - All Condi ons.gsz
Directory: P:\0\0180366\01\Analysis\Bridge 17.7\SlopeW\
Last Solved Date: 11/12/2021
Last Solved Time: 03:11:48 PM

Project Se ngs

Unit System: U.S. Customary Units

Analysis Se ngs

1.4 Pseudo-sta c (M-P)

Kind: SLOPE/W
Parent: 1. Global Stability
Analysis Type: Morgenstern-Price
Se ngs
- Side Func on
  - Interslice force func on op on: Half-Sine
- PWP Condi ons from: Piezometric Line
- Apply Phrea c Correc on: No
- Use Staged Rapid Drawdown: No
- Unit Weight of Water: 62.4 pcf

Slip Surface
- Direc on of movement: Le. to Right
- Use Passive Mode: No
- Slip Surface Op on: Entry and Exit
- Cri cal slip surfaces saved: 1
- Op mize Cri cal Slip Surface Loca on: No
- Tension Crack Op on: (none)

Distribu on
- F of S Calcula on Op on: Constant

Advanced
- Geometry Se ngs
  - Minimum Slip Surface Depth: 2 ft
  - Number of Slices: 30
- Factor of Safety Convergence Se ngs
  - Maximum Number of Itera ons: 100
  - Tolerable difference in F of S: 0.001

Figure D.4-97

Solu□on Se□ ngs
Search Method: Root Finder
Tolerable difference between star□ng and converged F of S: 3
Maximum itera□ons to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Hilfiker Wall

Slope Stability Material Model: High Strength
Unit Weight: 130 pcf
Pore Water Pressure
Piezometric Line: 1

ESU 1A - Exis ng Granular Fill (Pseudo-Sta c)

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 50 psf
Effec□ve Fric□on Angle: 40 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2A - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 39 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2B - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 41 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 7A - Weathered Sandstone

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 42 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1B - Exis ng Gravelly Granular Fill

Slope Stability Material Model: Mohr-Coulomb

Unit Weight: 125 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2C - Na ve Silt (Pseudo-Sta c)

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effec□ve Cohesion: 200 psf
Effec□ve Fric□on Angle: 29 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (0.25, 60) ft
Left-Zone Right Coordinate: (118.13955, 94.985209) ft
Left-Zone Increment: 40
Right Type: Range
Right-Zone Left Coordinate: (160, 50.99889) ft
Right-Zone Right Coordinate: (335, 48) ft
Right-Zone Increment: 40
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 60) ft
Right Coordinate: (335, 48) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	0.25 ft	43.375 ft
Coordinate 2	56.5 ft	43.375 ft
Coordinate 3	97.75 ft	43.375 ft
Coordinate 4	123 ft	43.375 ft
Coordinate 5	159.75 ft	42.625 ft
Coordinate 6	192 ft	42.625 ft
Coordinate 7	210.75 ft	42.625 ft
Coordinate 8	298 ft	35 ft
Coordinate 9	335.25 ft	35 ft

Seismic Coefficients

Horz Seismic Coef.: 0.169

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 125 pcf
Direc□on: Ver□cal

Coordinates

	X	Y
	120 ft	97 ft
	160 ft	97 ft

Geometry

Name: Ea-Ea'

Se ngs

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	0 ft	56 ft
Point 2	76 ft	56 ft
Point 3	118 ft	35 ft
Point 4	160 ft	35 ft
Point 5	0 ft	46 ft
Point 6	37 ft	46 ft
Point 7	190 ft	50 ft
Point 8	160 ft	50 ft
Point 9	170.25 ft	34 ft
Point 10	240 ft	34 ft
Point 11	315 ft	30 ft
Point 12	335 ft	30 ft
Point 13	335 ft	48 ft
Point 14	327 ft	48 ft
Point 15	315 ft	49 ft
Point 16	224 ft	48 ft
Point 17	0 ft	0 ft
Point 18	335 ft	0 ft
Point 19	160 ft	96 ft
Point 20	120 ft	96 ft
Point 21	120 ft	72 ft
Point 22	76 ft	72 ft
Point 23	52 ft	60 ft
Point 24	0 ft	60 ft

Figure D.4-100

Point 25	160 ft	47 ft
Point 26	120 ft	47 ft
Point 27	65 ft	66.5 ft
Point 28	120 ft	66.5 ft
Point 29	120 ft	49 ft
Point 30	160 ft	49 ft
Point 31	160 ft	66.5 ft
Point 32	160 ft	72 ft
Point 33	281 ft	48.626374 ft
Point 34	126 ft	49 ft
Point 35	126 ft	96 ft
Point 36	126 ft	66.5 ft
Point 37	126 ft	72 ft

Regions

	Material	Points	Area
Region 1	ESU 2C - Na□ve Silt (Pseudo-Sta□c)	5,6,2,1	565 ft²
Region 2	Hilfiker Wall	19,35,37,32	816 ft²
Region 3	ESU 1A - Exis□ng Granular Fill (Pseudo-Sta□c)	20,22,21	528 ft²
Region 4	ESU 2A - Na□ve Sand and Gravel	6,2,3	619.5 ft²
Region 5	ESU 2B - Na□ve Sand and Gravel	7,16,33,15,14,13,12,11,10,9,4	2,595.4 ft²
Region 6	ESU 7A - Weathered Sandstone	18,17,5,6,3,4,9,10,11,12	12,178 ft²
Region 7	ESU 1B - Exis□ng Gravelly Granular Fill	8,30,25,7	45 ft²
Region 8	ESU 2A - Na□ve Sand and Gravel	4,7,25,26,2,3	945 ft²
Region 9	ESU 1B - Exis□ng Gravelly Granular Fill	21,22,27,28	272.25 ft²
Region 10	ESU 1B - Exis□ng Gravelly Granular Fill	23,24,1,2,26,29,28,27	1,077.8 ft²
Region 11	ESU 1B - Exis□ng Gravelly Granular Fill	29,26,25,30,34	80 ft²
Region 12	ESU 1B - Exis□ng Gravelly Granular Fill	29,34,36,28	105 ft²
Region 13	ESU 1B - Exis□ng Gravelly Granular Fill	28,36,37,21	33 ft²
Region 14	Hilfiker Wall	30,8,31,36,34	595 ft²
Region 15	Hilfiker Wall	31,32,37,36	187 ft²
Region 16	ESU 1A - Exis□ng Granular Fill (Pseudo-Sta□c)	20,21,37,35	144 ft²

Slip Results

Slip Surfaces Analysed: 3986 of 8405 converged

Current Slip Surface

Slip Surface: 6,463
Factor of Safety: 1.813
Volume: 4,098.7378 ft³
Weight: 526,501.06 lbf
Resis□ng Moment: 46,333,011 lbf·ft
Ac□va□ng Moment: 25,554,421 lbf·ft
Resis□ng Force: 364,095.96 lbf
Ac□va□ng Force: 200,809.6 lbf
Slip Rank: 1 of 8,405 slip surfaces
Exit: (251.39568, 48.301052) ft
Entry: (93.135962, 81.346889) ft

Figure D.4-101

Radius: 115.88442 ft
Center: (189.23792, 146.105) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Fric□onal Strength	Cohesive Strength	Suc□on Strength	Base Material
Slice 1	95.442981 ft	78.162059 ft	-2,170.7125 psf	293.1714 psf	246.00001 psf	50 psf	0 psf	ESU 1A - Exis□ng Granular Fill (Pseudo-Sta□c)
Slice 2	98.94722 ft	73.488615 ft	-1,879.0896 psf	775.01797 psf	650.31729 psf	50 psf	0 psf	ESU 1A - Exis□ng Granular Fill (Pseudo-Sta□c)
Slice 3	102.58345 ft	69.25 ft	-1,614.6 psf	1,286.0261 psf	1,004.7537 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 4	107.51872 ft	64.015019 ft	-1,287.9372 psf	1,904.5517 psf	1,487.9989 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 5	112.51123 ft	59.323019 ft	-995.15637 psf	2,501.0594 psf	1,954.0418 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 6	117.50374 ft	55.147316 ft	-734.59255 psf	3,082.1964 psf	2,408.0757 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 7	121.5 ft	52.097792 ft	-544.3022 psf	3,570.4095 psf	2,789.5096 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 8	124.5 ft	50.006458 ft	-415.71316 psf	3,783.9285 psf	2,956.329 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 9	127.58815 ft	47.997982 ft	-294.31697 psf	4,257.2359 psf	3,326.1172 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 10	132.65232 ft	45.053537 ft	-117.03266 psf	4,609.9174 psf	3,733.0375 psf	0 psf	0 psf	ESU 2A - Na□ve Sand

								and Gravel
Slice 11	138.64986 ft	41.883163 ft	73.161018 psf	5,077.4283 psf	4,052.3758 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 12	143.69288 ft	39.581161 ft	210.38379 psf	5,489.1448 psf	4,274.6564 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 13	148.7359 ft	37.562187 ft	329.94567 psf	5,918.9252 psf	4,525.8664 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 14	153.77892 ft	35.810651 ft	432.81936 psf	6,370.7378 psf	4,808.4315 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 15	158.02522 ft	34.517552 ft	508.10124 psf	6,833.6788 psf	5,695.5756 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 16	159.875 ft	34.002362 ft	538.05261 psf	7,031.6786 psf	5,846.8871 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 17	162.5625 ft	33.363317 ft	577.92904 psf	1,671.2593 psf	984.43901 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 18	167.6875 ft	32.27189 ft	646.03405 psf	1,992.4747 psf	1,212.3406 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 19	172.75 ft	31.427328 ft	698.73475 psf	2,310.6115 psf	1,451.3404 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 20	177.70833 ft	30.822026 ft	736.50555 psf	2,618.7537 psf	1,694.7839 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 21	182.625 ft	30.435621 ft	760.61728 psf	2,914.2049 psf	1,939.099 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 22	187.54167 ft	30.25908 ft	771.63342 psf	3,190.3724 psf	2,177.8424 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 23	191 ft	30.238292 ft	772.93059 psf	3,353.0653 psf	2,323.1637 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 24	194.34375 ft	30.356886 ft	765.5303 psf	3,438.2527 psf	2,406.53 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 25	199.03125 ft	30.659094 ft	746.67253 psf	3,517.9606 psf	2,495.279 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 26	203.71875 ft	31.153165 ft	715.84252 psf	3,534.9432 psf	2,538.3297 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 27	208.40625 ft	31.841591 ft	672.8847 psf	3,479.4791 psf	2,527.0689 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 28	214.67105 ft	33.117384 ft	571.89257 psf	3,278.6921 psf	2,437.2133 psf	0 psf	0 psf	ESU 7A - Weathered

								Sandstone
Slice 29	221.29605 ft	34.778643 ft	432.10193 psf	2,896.4059 psf	2,142.1867 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 30	227.16165 ft	36.652754 ft	283.17059 psf	2,500.2562 psf	1,927.2831 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 31	233.48494 ft	39.055027 ft	98.786008 psf	2,001.0119 psf	1,653.5797 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 32	239.10477 ft	41.534067 ft	-86.552709 psf	1,447.1385 psf	1,257.9783 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 33	244.02113 ft	44.025541 ft	-268.83107 psf	880.80593 psf	765.67291 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 34	248.9375 ft	46.822915 ft	-470.19761 psf	294.02628 psf	255.59314 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel

6.1 Static (Spencer) Section Ea-Ea' - Final Condition - Global Stability

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File Informa on

File Version: 11.01
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Directory: P:\0\0180366\01\Analysis\Bridge 17.7\SlopeW\
Last Solved Date: 11/12/2021
Last Solved Time: 02:34:48 PM

Project Se ngs

Unit System: U.S. Customary Units

Analysis Se ngs

6.1 Sta c (Spencer)

Kind: SLOPE/W
Parent: FINAL CONDITION
Analysis Type: Spencer
Se ngs
PWP Condi ons from: Piezometric Line
Apply Phrea c Correc on: No
Use Staged Rapid Drawdown: No
Unit Weight of Water: 62.4 pcf
Slip Surface
Direc on of movement: Le. to Right
Use Passive Mode: No
Slip Surface Op□on: Entry and Exit
Cri□cal slip surfaces saved: 1
Op□mize Cri□cal Slip Surface Loca□on: No
Tension Crack Op□on: (none)
Distribu□on
F of S Calcula□on Op□on: Constant
Advanced
Geometry Se□ ngs
Minimum Slip Surface Depth: 2 ft
Number of Slices: 30
Factor of Safety Convergence Se□ ngs
Maximum Number of Itera□ons: 100
Tolerable difference in F of S: 0.001
Solu□on Se□ ngs
Search Method: Root Finder

Figure D.4-105

Tolerable difference between star□ng and converged F of S: 3
Maximum itera□ons to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

ESU 2A - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 39 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2B - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 41 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 7A - Weathered Sandstone

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 42 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2C - Na ve Silt

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 29 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1B - Exis ng Gravelly Granular Fill

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Reinforcements

Soil Nail_Row 1

Type: Anchor
Pullout Resistance: 1,800 psf
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 82,550 lbf
Tensile Capacity Reduc□on Factor: 1
Shear Force: 0 lbf
Shear Force Reduc□on Factor: 1
Apply Shear: Parallel to Slip
F of S Dependent: No
Force Distribu□on: Distributed
Bond Length: 45 ft
Bond Diameter: 0.5 ft
Out-of-Plane Spacing: 4 ft
Face Anchorage: Yes
Factored Pullout Resistance: 706.86 lbf/ft/ft
Factored Tensile Capacity: 20,638 lbf/ft

Soil Nail_Row 2

Type: Anchor
Pullout Resistance: 1,800 psf
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 82,550 lbf
Tensile Capacity Reduc□on Factor: 1
Shear Force: 0 lbf
Shear Force Reduc□on Factor: 1
Apply Shear: Parallel to Slip
F of S Dependent: No
Force Distribu□on: Distributed
Bond Length: 45 ft
Bond Diameter: 0.5 ft
Out-of-Plane Spacing: 4 ft
Face Anchorage: Yes
Factored Pullout Resistance: 706.86 lbf/ft/ft
Factored Tensile Capacity: 20,638 lbf/ft

Soil Nail_Row 3

Type: Anchor
Pullout Resistance: 1,800 psf
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 82,550 lbf
Tensile Capacity Reduc□on Factor: 1
Shear Force: 0 lbf
Shear Force Reduc□on Factor: 1
Apply Shear: Parallel to Slip
F of S Dependent: No
Force Distribu□on: Distributed
Bond Length: 40 ft
Bond Diameter: 0.5 ft
Out-of-Plane Spacing: 4 ft
Face Anchorage: Yes

Figure D.4-107

Factored Pullout Resistance: 706.86 lbf/ft/ft
Factored Tensile Capacity: 20,638 lbf/ft

Soil Nail_Row 4

Type: Anchor
Pullout Resistance: 1,800 psf
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 82,550 lbf
Tensile Capacity Reduc□on Factor: 1
Shear Force: 0 lbf
Shear Force Reduc□on Factor: 1
Apply Shear: Parallel to Slip
F of S Dependent: No
Force Distribu□on: Distributed
Bond Length: 40 ft
Bond Diameter: 0.5 ft
Out-of-Plane Spacing: 4 ft
Face Anchorage: Yes
Factored Pullout Resistance: 706.86 lbf/ft/ft
Factored Tensile Capacity: 20,638 lbf/ft

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (0.05, 60) ft
Left-Zone Right Coordinate: (126, 66.5) ft
Left-Zone Increment: 40
Right Type: Range
Right-Zone Left Coordinate: (160, 59.5) ft
Right-Zone Right Coordinate: (281, 48.626374) ft
Right-Zone Increment: 40
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 60) ft
Right Coordinate: (335, 48) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	0.25 ft	43.375 ft
Coordinate 2	56.5 ft	43.375 ft
Coordinate 3	97.75 ft	43.375 ft
Coordinate 4	123 ft	43.375 ft
Coordinate 5	159.75 ft	42.625 ft
Coordinate 6	192 ft	42.625 ft

Figure D.4-108

Coordinate 7	210.75 ft	42.625 ft
Coordinate 8	298 ft	35 ft
Coordinate 9	335.25 ft	35 ft

Reinforcement Lines

Reinforcement Line 1

Reinforcement: Soil Nail_Row 1
Lock to Ground Surface: Yes
Outside Point: (160, 64.5) ft
Inside Point: (115.68365, 56.685832) ft
Length: 45.000001 ft
Orienta□on: -170 °
Max. Pullout Force: 0 lbf
Bond Length: 45 ft
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 2

Reinforcement: Soil Nail_Row 2
Lock to Ground Surface: Yes
Outside Point: (160, 60.5) ft
Inside Point: (115.68365, 52.685832) ft
Length: 45.000001 ft
Orienta□on: -170 °
Max. Pullout Force: 0 lbf
Bond Length: 45 ft
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 3

Reinforcement: Soil Nail_Row 3
Lock to Ground Surface: Yes
Outside Point: (160, 56.5) ft
Inside Point: (120.60769, 49.554073) ft
Length: 40 ft
Orienta□on: -170 °
Max. Pullout Force: 0 lbf
Bond Length: 40 ft
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 4

Reinforcement: Soil Nail_Row 4
Lock to Ground Surface: Yes
Outside Point: (160, 52.5) ft
Inside Point: (120.60769, 45.554073) ft
Length: 40 ft
Orienta□on: -170 °
Slip Surface Intersec□on: (122.34375, 45.860188) ft
Max. Pullout Force: 20,637.5 lbf
Bond Length: 40 ft
Available Length: 1.7628445 ft
Required Length: 1.7628445 ft
Pullout Force: 1,246.0814 lbf
Pullout Force per Length: 706.85835 lbf/ft
Governing Component: Pullout Resistance

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 250 pcf
Direc□on: Ver□cal

Coordinates

	X	Y
	120 ft	67.5 ft
	160 ft	67.5 ft

Geometry

Name: Ea-Ea'

Se ngs

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	0 ft	56 ft
Point 2	76 ft	56 ft
Point 3	118 ft	35 ft
Point 4	160 ft	35 ft
Point 5	0 ft	46 ft
Point 6	37 ft	46 ft
Point 7	190 ft	50 ft
Point 8	160 ft	50 ft
Point 9	170.25 ft	34 ft
Point 10	240 ft	34 ft
Point 11	315 ft	30 ft
Point 12	335 ft	30 ft
Point 13	335 ft	48 ft
Point 14	327 ft	48 ft

Figure D.4-110

Point 15	315 ft	49 ft
Point 16	224 ft	48 ft
Point 17	0 ft	0 ft
Point 18	335 ft	0 ft
Point 19	160 ft	96 ft
Point 20	120 ft	96 ft
Point 21	120 ft	72 ft
Point 22	76 ft	72 ft
Point 23	52 ft	60 ft
Point 24	0 ft	60 ft
Point 25	160 ft	47 ft
Point 26	120 ft	47 ft
Point 27	65 ft	66.5 ft
Point 28	120 ft	66.5 ft
Point 29	120 ft	49 ft
Point 30	160 ft	49 ft
Point 31	160 ft	66.5 ft
Point 32	160 ft	72 ft
Point 33	160 ft	64.5 ft
Point 34	160 ft	60.5 ft
Point 35	160 ft	56.5 ft
Point 36	160 ft	52.5 ft
Point 37	281 ft	48.626374 ft

Regions

	Material	Points	Area
Region 1	ESU 2C - Na□ve Silt	5,6,2,1	565 ft²
Region 2		19,20,21,32	960 ft²
Region 3		20,22,21	528 ft²
Region 4	ESU 2A - Na□ve Sand and Gravel	6,2,3	619.5 ft²
Region 5	ESU 2B - Na□ve Sand and Gravel	7,16,37,15,14,13,12,11,10,9,4	2,595.4 ft²
Region 6	ESU 7A - Weathered Sandstone	18,17,5,6,3,4,9,10,11,12	12,178 ft²
Region 7	ESU 1B - Exis□ng Gravelly Granular Fill	8,30,25,7	45 ft²
Region 8	ESU 2A - Na□ve Sand and Gravel	4,7,25,26,2,3	945 ft²
Region 9		21,22,27,28	272.25 ft²
Region 10	ESU 1B - Exis□ng Gravelly Granular Fill	23,24,1,2,26,29,28,27	1,077.8 ft²
Region 11	ESU 1B - Exis□ng Gravelly Granular Fill	29,26,25,30	80 ft²
Region 12	ESU 1B - Exis□ng Gravelly Granular Fill	29,30,8,36,35,34,33,31,28	700 ft²
Region 13		28,31,32,21	220 ft²

Slip Results

Slip Surfaces Analysed: 4932 of 8405 converged

Current Slip Surface

Slip Surface: 6,643
Factor of Safety: 4.340
Volume: 1,736.2673 ft³

Weight: 216,644.25 lbf
Resis□ng Moment: 12,798,710 lbf·ft
Ac□va□ng Moment: 2,948,732.9 lbf·ft
Resis□ng Force: 164,144.76 lbf
Ac□va□ng Force: 37,817.194 lbf
Slip Rank: 1 of 8,405 slip surfaces
Exit: (202.70293, 49.252769) ft
Entry: (100.50311, 66.5) ft
Radius: 72.2532 ft
Center: (159.98134, 107.52275) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Fric□onal Strength	Cohesive Strength	Suc□on Strength	Base Material
Slice 1	102.12785 ft	64.324079 ft	-1,307.2225 psf	193.23271 psf	150.96994 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 2	105.37733 ft	60.270626 ft	-1,054.2871 psf	577.57785 psf	451.25328 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 3	108.62682 ft	56.749745 ft	-834.5841 psf	936.4231 psf	731.61391 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 4	111.8763 ft	53.655456 ft	-641.50045 psf	1,271.0281 psf	993.03599 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 5	115.12578 ft	50.917037 ft	-470.62312 psf	1,582.8077 psf	1,236.6249 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 6	118.37526 ft	48.484552 ft	-318.83607 psf	1,873.0814 psf	1,463.4116 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 7	120.25794 ft	47.169773 ft	-236.79385 psf	2,245.8662 psf	1,754.663 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 8	121.75794 ft	46.225485 ft	-177.87023 psf	2,368.3359 psf	1,917.8406 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 9	124.94214 ft	44.373349 ft	-64.770233 psf	2,603.2067 psf	2,108.0352 psf	0 psf	0 psf	ESU 2A - Na□ve Sand

								and Gravel
Slice 10	128.52757 ft	42.500805 ft	47.51061 psf	2,859.42 psf	2,277.0394 psf	0 psf	0 psf	ESU 2A - Naïve Sand and Gravel
Slice 11	131.81414 ft	41.009972 ft	136.35319 psf	3,074.958 psf	2,379.6353 psf	0 psf	0 psf	ESU 2A - Naïve Sand and Gravel
Slice 12	135.10071 ft	39.71113 ft	213.21561 psf	3,271.4916 psf	2,476.543 psf	0 psf	0 psf	ESU 2A - Naïve Sand and Gravel
Slice 13	138.38728 ft	38.59339 ft	278.77723 psf	3,449.836 psf	2,567.8728 psf	0 psf	0 psf	ESU 2A - Naïve Sand and Gravel
Slice 14	141.67386 ft	37.648037 ft	333.58194 psf	3,610.6386 psf	2,653.7081 psf	0 psf	0 psf	ESU 2A - Naïve Sand and Gravel
Slice 15	144.96043 ft	36.868132 ft	378.06263 psf	3,754.4038 psf	2,734.1071 psf	0 psf	0 psf	ESU 2A - Naïve Sand and Gravel
Slice 16	148.247 ft	36.248232 ft	412.55905 psf	3,881.5114 psf	2,809.1022 psf	0 psf	0 psf	ESU 2A - Naïve Sand and Gravel
Slice 17	151.53357 ft	35.784179 ft	437.33062 psf	3,992.2296 psf	2,878.7004 psf	0 psf	0 psf	ESU 2A - Naïve Sand and Gravel
Slice 18	154.82014 ft	35.472955 ft	452.56565 psf	4,086.724 psf	2,942.8834 psf	0 psf	0 psf	ESU 2A - Naïve Sand and Gravel
Slice 19	158.10671 ft	35.312579 ft	458.38773 psf	4,165.0625 psf	3,001.6061 psf	0 psf	0 psf	ESU 2A - Naïve Sand and Gravel
Slice 20	159.875 ft	35.269735 ft	458.96856 psf	4,317.446 psf	3,124.5334 psf	0 psf	0 psf	ESU 2A - Naïve Sand and Gravel
Slice 21	160.27173 ft	35.270643 ft	458.91189 psf	1,820.9761 psf	1,102.9778 psf	0 psf	0 psf	ESU 2A - Naïve Sand and Gravel
Slice 22	162.38179 ft	35.332862 ft	455.02938 psf	1,844.8043 psf	1,208.1129 psf	0 psf	0 psf	ESU 2B - Naïve Sand and Gravel
Slice 23	166.05842 ft	35.549208 ft	441.52941 psf	1,871.3 psf	1,242.8806 psf	0 psf	0 psf	ESU 2B - Naïve Sand and Gravel
Slice 24	169.73505 ft	35.954964 ft	416.21025 psf	1,872.5682 psf	1,265.9927 psf	0 psf	0 psf	ESU 2B - Naïve Sand and Gravel
Slice 25	173.41168 ft	36.553387 ft	378.86864 psf	1,847.3365 psf	1,276.5197 psf	0 psf	0 psf	ESU 2B - Naïve Sand and Gravel
Slice 26	177.09375 ft	37.350898 ft	329.10398 psf	1,793.8513 psf	1,273.2854 psf	0 psf	0 psf	ESU 2B - Naïve Sand and Gravel
Slice 27	180.78125 ft	38.354969 ft	266.44991 psf	1,709.9301 psf	1,254.7982 psf	0 psf	0 psf	ESU 2B - Naïve Sand

								and Gravel
Slice 28	184.46875 ft	39.573867 ft	190.39073 psf	1,592.9058 psf	1,219.1878 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 29	188.15625 ft	41.019444 ft	100.18671 psf	1,439.2648 psf	1,164.0428 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 30	190.87153 ft	42.212785 ft	25.722207 psf	1,287.7623 psf	1,097.0748 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 31	191.87153 ft	42.68819 ft	-3.9430868 psf	1,212.2335 psf	1,053.7785 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 32	193.78382 ft	43.69609 ft	-66.835988 psf	1,040.4797 psf	904.47517 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 33	197.35146 ft	45.719407 ft	-193.09099 psf	680.66806 psf	591.69571 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 34	200.91911 ft	48.025392 ft	-336.98448 psf	244.86207 psf	212.85535 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel

6.2 Static (M-P) Section Ea-Ea' - Final Condition - Global Stability

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File Informa on

File Version: 11.01
Created By: Mikayla S. Hatch
Last Edited By: Mikayla S. Hatch
Revision Number: 426
Date: 11/12/2021
Time: 02:34:29 PM
Tool Version: 11.1
File Name: Wall 03.63L - Bridge 17.7 Ea-Ea' - All Condi ons.gsz
Directory: P:\0\0180366\01\Analysis\Bridge 17.7\SlopeW\
Last Solved Date: 11/12/2021
Last Solved Time: 02:35:14 PM

Project Se ngs

Unit System: U.S. Customary Units

Analysis Se ngs

6.2 Sta c (M-P)

Kind: SLOPE/W
Parent: FINAL CONDITION
Analysis Type: Morgenstern-Price
Se ngs
Side Func on
Interslice force func on op on: Half-Sine
PWP Condi ons from: Piezometric Line
Apply Phrea c Correc on: No
Use Staged Rapid Drawdown: No
Unit Weight of Water: 62.4 pcf
Slip Surface
Direc on of movement: Le. to Right
Use Passive Mode: No
Slip Surface Op on: Entry and Exit
Cri cal slip surfaces saved: 1
Op mize Cri cal Slip Surface Loca on: No
Tension Crack Op on: (none)
Distribu on
F of S Calcula on Op on: Constant
Advanced
Geometry Se ngs
Minimum Slip Surface Depth: 2 ft
Number of Slices: 30
Factor of Safety Convergence Se ngs
Maximum Number of Itera ons: 100
Tolerable difference in F of S: 0.001

Figure D.4-115

Solu□on Se□ ngs
Search Method: Root Finder
Tolerable difference between star□ng and converged F of S: 3
Maximum itera□ons to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

ESU 2A - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 39 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2B - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 41 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 7A - Weathered Sandstone

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 42 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2C - Na ve Silt

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 29 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1B - Exis ng Gravelly Granular Fill

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Reinforcements

Soil Nail_Row 1

Type: Anchor
Pullout Resistance: 1,800 psf
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 82,550 lbf
Tensile Capacity Reduc□on Factor: 1
Shear Force: 0 lbf
Shear Force Reduc□on Factor: 1
Apply Shear: Parallel to Slip
F of S Dependent: No
Force Distribu□on: Distributed
Bond Length: 45 ft
Bond Diameter: 0.5 ft
Out-of-Plane Spacing: 4 ft
Face Anchorage: Yes
Factored Pullout Resistance: 706.86 lbf/ft/ft
Factored Tensile Capacity: 20,638 lbf/ft

Soil Nail_Row 2

Type: Anchor
Pullout Resistance: 1,800 psf
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 82,550 lbf
Tensile Capacity Reduc□on Factor: 1
Shear Force: 0 lbf
Shear Force Reduc□on Factor: 1
Apply Shear: Parallel to Slip
F of S Dependent: No
Force Distribu□on: Distributed
Bond Length: 45 ft
Bond Diameter: 0.5 ft
Out-of-Plane Spacing: 4 ft
Face Anchorage: Yes
Factored Pullout Resistance: 706.86 lbf/ft/ft
Factored Tensile Capacity: 20,638 lbf/ft

Soil Nail_Row 3

Type: Anchor
Pullout Resistance: 1,800 psf
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 82,550 lbf
Tensile Capacity Reduc□on Factor: 1
Shear Force: 0 lbf
Shear Force Reduc□on Factor: 1
Apply Shear: Parallel to Slip
F of S Dependent: No
Force Distribu□on: Distributed
Bond Length: 40 ft
Bond Diameter: 0.5 ft
Out-of-Plane Spacing: 4 ft
Face Anchorage: Yes

Factored Pullout Resistance: 706.86 lbf/ft/ft
Factored Tensile Capacity: 20,638 lbf/ft

Soil Nail_Row 4

Type: Anchor
Pullout Resistance: 1,800 psf
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 82,550 lbf
Tensile Capacity Reduc□on Factor: 1
Shear Force: 0 lbf
Shear Force Reduc□on Factor: 1
Apply Shear: Parallel to Slip
F of S Dependent: No
Force Distribu□on: Distributed
Bond Length: 40 ft
Bond Diameter: 0.5 ft
Out-of-Plane Spacing: 4 ft
Face Anchorage: Yes
Factored Pullout Resistance: 706.86 lbf/ft/ft
Factored Tensile Capacity: 20,638 lbf/ft

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (0.05, 60) ft
Left-Zone Right Coordinate: (126, 66.5) ft
Left-Zone Increment: 40
Right Type: Range
Right-Zone Left Coordinate: (160, 58.5) ft
Right-Zone Right Coordinate: (281, 48.626374) ft
Right-Zone Increment: 40
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 60) ft
Right Coordinate: (335, 48) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	0.25 ft	43.375 ft
Coordinate 2	56.5 ft	43.375 ft
Coordinate 3	97.75 ft	43.375 ft
Coordinate 4	123 ft	43.375 ft
Coordinate 5	159.75 ft	42.625 ft
Coordinate 6	192 ft	42.625 ft

Coordinate 7	210.75 ft	42.625 ft
Coordinate 8	298 ft	35 ft
Coordinate 9	335.25 ft	35 ft

Reinforcement Lines

Reinforcement Line 1

Reinforcement: Soil Nail_Row 1
Lock to Ground Surface: Yes
Outside Point: (160, 64.5) ft
Inside Point: (115.68365, 56.685832) ft
Length: 45.000001 ft
Orienta□on: -170 °
Max. Pullout Force: 0 lbf
Bond Length: 45 ft
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 2

Reinforcement: Soil Nail_Row 2
Lock to Ground Surface: Yes
Outside Point: (160, 60.5) ft
Inside Point: (115.68365, 52.685832) ft
Length: 45.000001 ft
Orienta□on: -170 °
Max. Pullout Force: 0 lbf
Bond Length: 45 ft
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 3

Reinforcement: Soil Nail_Row 3
Lock to Ground Surface: Yes
Outside Point: (160, 56.5) ft
Inside Point: (120.60769, 49.554073) ft
Length: 40 ft
Orienta□on: -170 °
Max. Pullout Force: 0 lbf
Bond Length: 40 ft
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 4

Reinforcement: Soil Nail_Row 4
Lock to Ground Surface: Yes
Outside Point: (160, 52.5) ft
Inside Point: (120.60769, 45.554073) ft
Length: 40 ft
Orienta□on: -170 °
Slip Surface Intersec□on: (122.52968, 45.892972) ft
Max. Pullout Force: 20,637.5 lbf
Bond Length: 40 ft
Available Length: 1.9516426 ft
Required Length: 1.9516426 ft
Pullout Force: 1,379.5349 lbf
Pullout Force per Length: 706.85835 lbf/ft
Governing Component: Pullout Resistance

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 250 pcf
Direc□on: Ver□cal

Coordinates

	X	Y
	120 ft	67.5 ft
	160 ft	67.5 ft

Geometry

Name: Ea-Ea'

Se ngs

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	0 ft	56 ft
Point 2	76 ft	56 ft
Point 3	118 ft	35 ft
Point 4	160 ft	35 ft
Point 5	0 ft	46 ft
Point 6	37 ft	46 ft
Point 7	190 ft	50 ft
Point 8	160 ft	50 ft
Point 9	170.25 ft	34 ft
Point 10	240 ft	34 ft
Point 11	315 ft	30 ft
Point 12	335 ft	30 ft
Point 13	335 ft	48 ft
Point 14	327 ft	48 ft

Figure D.4-120

Point 15	315 ft	49 ft
Point 16	224 ft	48 ft
Point 17	0 ft	0 ft
Point 18	335 ft	0 ft
Point 19	160 ft	96 ft
Point 20	120 ft	96 ft
Point 21	120 ft	72 ft
Point 22	76 ft	72 ft
Point 23	52 ft	60 ft
Point 24	0 ft	60 ft
Point 25	160 ft	47 ft
Point 26	120 ft	47 ft
Point 27	65 ft	66.5 ft
Point 28	120 ft	66.5 ft
Point 29	120 ft	49 ft
Point 30	160 ft	49 ft
Point 31	160 ft	66.5 ft
Point 32	160 ft	72 ft
Point 33	160 ft	64.5 ft
Point 34	160 ft	60.5 ft
Point 35	160 ft	56.5 ft
Point 36	160 ft	52.5 ft
Point 37	281 ft	48.626374 ft

Regions

	Material	Points	Area
Region 1	ESU 2C - Na□ve Silt	5,6,2,1	565 ft²
Region 2		19,20,21,32	960 ft²
Region 3		20,22,21	528 ft²
Region 4	ESU 2A - Na□ve Sand and Gravel	6,2,3	619.5 ft²
Region 5	ESU 2B - Na□ve Sand and Gravel	7,16,37,15,14,13,12,11,10,9,4	2,595.4 ft²
Region 6	ESU 7A - Weathered Sandstone	18,17,5,6,3,4,9,10,11,12	12,178 ft²
Region 7	ESU 1B - Exis□ng Gravelly Granular Fill	8,30,25,7	45 ft²
Region 8	ESU 2A - Na□ve Sand and Gravel	4,7,25,26,2,3	945 ft²
Region 9		21,22,27,28	272.25 ft²
Region 10	ESU 1B - Exis□ng Gravelly Granular Fill	23,24,1,2,26,29,28,27	1,077.8 ft²
Region 11	ESU 1B - Exis□ng Gravelly Granular Fill	29,26,25,30	80 ft²
Region 12	ESU 1B - Exis□ng Gravelly Granular Fill	29,30,8,36,35,34,33,31,28	700 ft²
Region 13		28,31,32,21	220 ft²

Slip Results

Slip Surfaces Analysed: 5412 of 8405 converged

Current Slip Surface

Slip Surface: 6,638
Factor of Safety: 4.341
Volume: 1,668.3162 ft³

Weight: 207,722.58 lbf
Resis□ng Moment: 12,089,243 lbf·ft
Ac□va□ng Moment: 2,784,775.2 lbf·ft
Resis□ng Force: 158,975.11 lbf
Ac□va□ng Force: 36,619.091 lbf
Slip Rank: 1 of 8,405 slip surfaces
Exit: (200.06843, 49.40774) ft
Entry: (100.50311, 66.5) ft
Radius: 70.565559 ft
Center: (158.62301, 106.51969) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Fric□onal Strength	Cohesive Strength	Suc□on Strength	Base Material
Slice 1	102.12785 ft	64.324628 ft	-1,307.2568 psf	215.24226 psf	168.16568 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 2	105.37733 ft	60.278408 ft	-1,054.7726 psf	621.06342 psf	485.22792 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 3	108.62682 ft	56.774617 ft	-836.13613 psf	976.98938 psf	763.30776 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 4	111.8763 ft	53.703641 ft	-644.5072 psf	1,294.6596 psf	1,011.4989 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 5	115.12578 ft	50.992858 ft	-475.35434 psf	1,582.4661 psf	1,236.358 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 6	118.37526 ft	48.591265 ft	-325.49496 psf	1,846.6164 psf	1,442.7349 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 7	120.35824 ft	47.231211 ft	-240.62755 psf	2,215.364 psf	1,730.8321 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 8	121.85824 ft	46.302912 ft	-182.70173 psf	2,327.4188 psf	1,884.7066 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 9	125.14979 ft	44.446539 ft	-69.601729 psf	2,545.0578 psf	2,060.9472 psf	0 psf	0 psf	ESU 2A - Na□ve Sand

								and Gravel
Slice 10	128.92211 ft	42.53411 ft	44.929915 psf	2,796.8279 psf	2,228.4431 psf	0 psf	0 psf	ESU 2A - Naïve Sand and Gravel
Slice 11	132.16715 ft	41.124569 ft	128.75278 psf	2,999.826 psf	2,324.9493 psf	0 psf	0 psf	ESU 2A - Naïve Sand and Gravel
Slice 12	135.41219 ft	39.90285 ft	200.85564 psf	3,191.2994 psf	2,421.6136 psf	0 psf	0 psf	ESU 2A - Naïve Sand and Gravel
Slice 13	138.65723 ft	38.858744 ft	261.87536 psf	3,371.8134 psf	2,518.3782 psf	0 psf	0 psf	ESU 2A - Naïve Sand and Gravel
Slice 14	141.90227 ft	37.984113 ft	312.3199 psf	3,541.2511 psf	2,614.7369 psf	0 psf	0 psf	ESU 2A - Naïve Sand and Gravel
Slice 15	145.14731 ft	37.272517 ft	352.59102 psf	3,698.8664 psf	2,709.7604 psf	0 psf	0 psf	ESU 2A - Naïve Sand and Gravel
Slice 16	148.39236 ft	36.718958 ft	383.00063 psf	3,843.3321 psf	2,802.1212 psf	0 psf	0 psf	ESU 2A - Naïve Sand and Gravel
Slice 17	151.6374 ft	36.319689 ft	403.78255 psf	3,972.7931 psf	2,890.1277 psf	0 psf	0 psf	ESU 2A - Naïve Sand and Gravel
Slice 18	154.88244 ft	36.072081 ft	415.10086 psf	4,084.9313 psf	2,971.7701 psf	0 psf	0 psf	ESU 2A - Naïve Sand and Gravel
Slice 19	158.12748 ft	35.974532 ft	417.05541 psf	4,177.0497 psf	3,044.7833 psf	0 psf	0 psf	ESU 2A - Naïve Sand and Gravel
Slice 20	159.875 ft	35.965354 ft	415.56194 psf	4,363.1039 psf	3,196.6565 psf	0 psf	0 psf	ESU 2A - Naïve Sand and Gravel
Slice 21	161.03874 ft	36.003157 ft	413.20303 psf	1,807.1916 psf	1,128.8297 psf	0 psf	0 psf	ESU 2A - Naïve Sand and Gravel
Slice 22	163.72405 ft	36.158113 ft	403.53373 psf	1,832.9468 psf	1,242.5698 psf	0 psf	0 psf	ESU 2B - Naïve Sand and Gravel
Slice 23	167.01718 ft	36.474809 ft	383.7719 psf	1,847.2158 psf	1,272.1524 psf	0 psf	0 psf	ESU 2B - Naïve Sand and Gravel
Slice 24	170.31031 ft	36.948742 ft	354.19853 psf	1,833.5323 psf	1,285.9652 psf	0 psf	0 psf	ESU 2B - Naïve Sand and Gravel
Slice 25	173.60344 ft	37.583161 ft	314.61078 psf	1,789.867 psf	1,282.4207 psf	0 psf	0 psf	ESU 2B - Naïve Sand and Gravel
Slice 26	176.9153 ft	38.388079 ft	264.38387 psf	1,713.8747 psf	1,260.0232 psf	0 psf	0 psf	ESU 2B - Naïve Sand and Gravel
Slice 27	180.2459 ft	39.371442 ft	203.02203 psf	1,603.7801 psf	1,217.6604 psf	0 psf	0 psf	ESU 2B - Naïve Sand

								and Gravel
Slice 28	183.5765 ft	40.537489 ft	130.26069 psf	1,458.9478 psf	1,155.0101 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 29	186.9071 ft	41.89614 ft	45.480842 psf	1,279.0207 psf	1,072.2998 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 30	189.2862 ft	42.96941 ft	-21.491214 psf	1,129.5402 psf	981.89436 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 31	191 ft	43.830288 ft	-75.209952 psf	985.54131 psf	856.71799 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 32	194.01711 ft	45.517092 ft	-180.46657 psf	682.80496 psf	593.55329 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 33	198.05132 ft	48.047585 ft	-338.36931 psf	236.52865 psf	205.61122 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel

6.3 Pseudo-Static (Spencer) Section Ea-Ea' - Final Condition - Global Stability

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File Informa on

File Version: 11.01
Created By: Mikayla S. Hatch
Last Edited By: Mikayla S. Hatch
Revision Number: 426
Date: 11/12/2021
Time: 02:34:29 PM
Tool Version: 11.1
File Name: Wall 03.63L - Bridge 17.7 Ea-Ea' - All Condi ons.gsz
Directory: P:\0\0180366\01\Analysis\Bridge 17.7\SlopeW\
Last Solved Date: 11/12/2021
Last Solved Time: 02:35:02 PM

Project Se ngs

Unit System: U.S. Customary Units

Analysis Se ngs

6.3 Pseudo-Sta c (Spencer)

Kind: SLOPE/W
Parent: FINAL CONDITION
Analysis Type: Spencer
Se ngs
PWP Condi ons from: Piezometric Line
Apply Phrea c Correc on: No
Use Staged Rapid Drawdown: No
Unit Weight of Water: 62.4 pcf
Slip Surface
Direc on of movement: Le. to Right
Use Passive Mode: No
Slip Surface Op□on: Entry and Exit
Cri□cal slip surfaces saved: 1
Op□mize Cri□cal Slip Surface Loca□on: No
Tension Crack Op□on: (none)
Distribu□on
F of S Calcula□on Op□on: Constant
Advanced
Geometry Se□ ngs
Minimum Slip Surface Depth: 2 ft
Number of Slices: 30
Factor of Safety Convergence Se□ ngs
Maximum Number of Itera□ons: 100
Tolerable difference in F of S: 0.001
Solu□on Se□ ngs
Search Method: Root Finder

Tolerable difference between star□ng and converged F of S: 3
Maximum itera□ons to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

ESU 2A - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 39 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2B - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 41 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 7A - Weathered Sandstone

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 42 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1B - Exis ng Gravelly Granular Fill

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2C - Na ve Silt (Pseudo-Sta c)

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effec□ve Cohesion: 200 psf
Effec□ve Fric□on Angle: 29 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Reinforcements

Soil Nail_Row 1

Type: Anchor
Pullout Resistance: 1,800 psf
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 82,550 lbf
Tensile Capacity Reduc□on Factor: 1
Shear Force: 0 lbf
Shear Force Reduc□on Factor: 1
Apply Shear: Parallel to Slip
F of S Dependent: No
Force Distribu□on: Distributed
Bond Length: 45 ft
Bond Diameter: 0.5 ft
Out-of-Plane Spacing: 4 ft
Face Anchorage: Yes
Factored Pullout Resistance: 706.86 lbf/ft/ft
Factored Tensile Capacity: 20,638 lbf/ft

Soil Nail_Row 2

Type: Anchor
Pullout Resistance: 1,800 psf
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 82,550 lbf
Tensile Capacity Reduc□on Factor: 1
Shear Force: 0 lbf
Shear Force Reduc□on Factor: 1
Apply Shear: Parallel to Slip
F of S Dependent: No
Force Distribu□on: Distributed
Bond Length: 45 ft
Bond Diameter: 0.5 ft
Out-of-Plane Spacing: 4 ft
Face Anchorage: Yes
Factored Pullout Resistance: 706.86 lbf/ft/ft
Factored Tensile Capacity: 20,638 lbf/ft

Soil Nail_Row 3

Type: Anchor
Pullout Resistance: 1,800 psf
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 82,550 lbf
Tensile Capacity Reduc□on Factor: 1
Shear Force: 0 lbf
Shear Force Reduc□on Factor: 1
Apply Shear: Parallel to Slip
F of S Dependent: No
Force Distribu□on: Distributed
Bond Length: 40 ft
Bond Diameter: 0.5 ft
Out-of-Plane Spacing: 4 ft
Face Anchorage: Yes

Figure D.4-127

Factored Pullout Resistance: 706.86 lbf/ft/ft
Factored Tensile Capacity: 20,638 lbf/ft

Soil Nail_Row 4

Type: Anchor
Pullout Resistance: 1,800 psf
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 82,550 lbf
Tensile Capacity Reduc□on Factor: 1
Shear Force: 0 lbf
Shear Force Reduc□on Factor: 1
Apply Shear: Parallel to Slip
F of S Dependent: No
Force Distribu□on: Distributed
Bond Length: 40 ft
Bond Diameter: 0.5 ft
Out-of-Plane Spacing: 4 ft
Face Anchorage: Yes
Factored Pullout Resistance: 706.86 lbf/ft/ft
Factored Tensile Capacity: 20,638 lbf/ft

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (0.05, 60) ft
Left-Zone Right Coordinate: (119.58945, 66.5) ft
Left-Zone Increment: 40
Right Type: Range
Right-Zone Left Coordinate: (160, 58.5) ft
Right-Zone Right Coordinate: (281, 48.626374) ft
Right-Zone Increment: 40
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 60) ft
Right Coordinate: (335, 48) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	0.25 ft	43.375 ft
Coordinate 2	56.5 ft	43.375 ft
Coordinate 3	97.75 ft	43.375 ft
Coordinate 4	123 ft	43.375 ft
Coordinate 5	159.75 ft	42.625 ft
Coordinate 6	192 ft	42.625 ft

Coordinate 7	210.75 ft	42.625 ft
Coordinate 8	298 ft	35 ft
Coordinate 9	335.25 ft	35 ft

Seismic Coefficients

Horz Seismic Coef.: 0.255

Reinforcement Lines

Reinforcement Line 1

Reinforcement: Soil Nail_Row 1
Lock to Ground Surface: Yes
Outside Point: (160, 64.5) ft
Inside Point: (115.68365, 56.685832) ft
Length: 45.000001 ft
Orienta□on: -170 °
Max. Pullout Force: 0 lbf
Bond Length: 45 ft
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 2

Reinforcement: Soil Nail_Row 2
Lock to Ground Surface: Yes
Outside Point: (160, 60.5) ft
Inside Point: (115.68365, 52.685832) ft
Length: 45.000001 ft
Orienta□on: -170 °
Max. Pullout Force: 0 lbf
Bond Length: 45 ft
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 3

Reinforcement: Soil Nail_Row 3
Lock to Ground Surface: Yes
Outside Point: (160, 56.5) ft
Inside Point: (120.60769, 49.554073) ft
Length: 40 ft
Orienta□on: -170 °
Max. Pullout Force: 0 lbf
Bond Length: 40 ft
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf

Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 4

Reinforcement: Soil Nail_Row 4
Lock to Ground Surface: Yes
Outside Point: (160, 52.5) ft
Inside Point: (120.60769, 45.554073) ft
Length: 40 ft
Orienta□on: -170 °
Max. Pullout Force: 0 lbf
Bond Length: 40 ft
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 125 pcf
Direc□on: Ver□cal

Coordinates

	X	Y
	120 ft	67.5 ft
	160 ft	67.5 ft

Geometry

Name: Ea-Ea'

Se ngs

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	0 ft	56 ft
Point 2	76 ft	56 ft
Point 3	118 ft	35 ft
Point 4	160 ft	35 ft
Point 5	0 ft	46 ft
Point 6	37 ft	46 ft
Point 7	190 ft	50 ft
Point 8	160 ft	50 ft
Point 9	170.25 ft	34 ft
Point 10	240 ft	34 ft
Point 11	315 ft	30 ft

Figure D.4-130

Point 12	335 ft	30 ft
Point 13	335 ft	48 ft
Point 14	327 ft	48 ft
Point 15	315 ft	49 ft
Point 16	224 ft	48 ft
Point 17	0 ft	0 ft
Point 18	335 ft	0 ft
Point 19	160 ft	96 ft
Point 20	120 ft	96 ft
Point 21	120 ft	72 ft
Point 22	76 ft	72 ft
Point 23	52 ft	60 ft
Point 24	0 ft	60 ft
Point 25	160 ft	47 ft
Point 26	120 ft	47 ft
Point 27	65 ft	66.5 ft
Point 28	120 ft	66.5 ft
Point 29	120 ft	49 ft
Point 30	160 ft	49 ft
Point 31	160 ft	66.5 ft
Point 32	160 ft	72 ft
Point 33	160 ft	64.5 ft
Point 34	160 ft	60.5 ft
Point 35	160 ft	56.5 ft
Point 36	160 ft	52.5 ft
Point 37	281 ft	48.626374 ft

Regions

	Material	Points	Area
Region 1	ESU 2C - Na□ve Silt (Pseudo-Sta□c)	5,6,2,1	565 ft²
Region 2		19,20,21,32	960 ft²
Region 3		20,22,21	528 ft²
Region 4	ESU 2A - Na□ve Sand and Gravel	6,2,3	619.5 ft²
Region 5	ESU 2B - Na□ve Sand and Gravel	7,16,37,15,14,13,12,11,10,9,4	2,595.4 ft²
Region 6	ESU 7A - Weathered Sandstone	18,17,5,6,3,4,9,10,11,12	12,178 ft²
Region 7	ESU 1B - Exis□ng Gravelly Granular Fill	8,30,25,7	45 ft²
Region 8	ESU 2A - Na□ve Sand and Gravel	4,7,25,26,2,3	945 ft²
Region 9		21,22,27,28	272.25 ft²
Region 10	ESU 1B - Exis□ng Gravelly Granular Fill	23,24,1,2,26,29,28,27	1,077.8 ft²
Region 11	ESU 1B - Exis□ng Gravelly Granular Fill	29,26,25,30	80 ft²
Region 12	ESU 1B - Exis□ng Gravelly Granular Fill	29,30,8,36,35,34,33,31,28	700 ft²
Region 13		28,31,32,21	220 ft²

Slip Results

Slip Surfaces Analysed: 5910 of 8405 converged

Current Slip Surface

Figure D.4-131

Slip Surface: 5,472
Factor of Safety: 1.992
Volume: 2,369.2432 ft³
Weight: 299,829.64 lbf
Resis□ng Moment: 40,460,698 lbf·ft
Ac□va□ng Moment: 20,313,207 lbf·ft
Resis□ng Force: 219,472.15 lbf
Ac□va□ng Force: 110,157.88 lbf
Slip Rank: 1 of 8,405 slip surfaces
Exit: (242.13368, 48.199271) ft
Entry: (77.213588, 66.5) ft
Radius: 178.72464 ft
Center: (177.13266, 214.6846) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Fric□onal Strength	Cohesive Strength	Suc□on Strength	Base Material
Slice 1	79.780639 ft	64.832307 ft	-1,338.9359 psf	141.32751 psf	110.41716 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 2	84.914742 ft	61.618043 ft	-1,138.3659 psf	424.74675 psf	331.84853 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 3	90.048845 ft	58.638889 ft	-952.46668 psf	701.54288 psf	548.10537 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 4	95.182948 ft	55.881587 ft	-780.41104 psf	971.26221 psf	758.8332 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 5	100.81485 ft	53.109234 ft	-607.41619 psf	1,257.4977 psf	982.46485 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 6	106.94454 ft	50.352567 ft	-435.40017 psf	1,559.3761 psf	1,218.3182 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 7	112.50704 ft	48.074731 ft	-293.26319 psf	1,821.498 psf	1,475.02 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 8	117.50235 ft	46.221837 ft	-177.64264 psf	2,047.0472 psf	1,657.6661 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice	121.5 ft	44.846405	-91.815662	2,335.1043	1,890.9302	0 psf	0 psf	ESU 2A -

9		ft	psf	psf	psf			Na□ve Sand and Gravel
Slice 10	124.71092 ft	43.830114 ft	-30.577896 psf	2,470.5716 psf	2,000.6294 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 11	129.19919 ft	42.531854 ft	44.717822 psf	2,651.7401 psf	2,111.125 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 12	134.75389 ft	41.080559 ft	128.2049 psf	2,865.8029 psf	2,216.8632 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 13	140.30858 ft	39.817713 ft	199.93276 psf	3,067.1076 psf	2,321.7924 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 14	145.86327 ft	38.739254 ft	260.15489 psf	3,255.6041 psf	2,425.667 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 15	151.41796 ft	37.841804 ft	309.08203 psf	3,431.2055 psf	2,528.2458 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 16	156.97265 ft	37.122616 ft	346.88561 psf	3,593.7861 psf	2,629.2882 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 17	159.875 ft	36.795156 ft	363.78229 psf	3,675.9324 psf	2,682.1263 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 18	161.51692 ft	36.649977 ft	372.84145 psf	1,550.1049 psf	953.32918 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 19	166.08789 ft	36.327803 ft	392.94511 psf	1,650.8926 psf	1,093.5171 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 20	172.19596 ft	36.054278 ft	410.01303 psf	1,775.8866 psf	1,187.3358 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 21	177.70833 ft	35.977795 ft	414.78561 psf	1,872.0019 psf	1,266.7388 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 22	182.625 ft	36.061303 ft	409.57469 psf	1,941.6124 psf	1,331.78 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 23	187.54167 ft	36.280324 ft	395.9078 psf	1,996.3346 psf	1,391.2298 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 24	191 ft	36.501582 ft	382.1013 psf	2,010.1931 psf	1,415.2786 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 25	195.125 ft	36.89566 ft	357.51083 psf	1,957.4105 psf	1,390.7716 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 26	201.375 ft	37.639811 ft	311.07582 psf	1,852.4983 psf	1,339.9381 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice	207.625 ft	38.608889	250.60533	1,707.9041	1,266.8105	0 psf	0 psf	ESU 2B -

27		ft	psf	psf	psf			Na□ve Sand and Gravel
Slice 28	213.53251 ft	39.728974 ft	165.53818 psf	1,536.9909 psf	1,192.1857 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 29	219.09752 ft	40.980099 ft	57.120314 psf	1,342.0875 psf	1,117.0049 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 30	222.94001 ft	41.933388 ft	-23.319171 psf	1,177.092 psf	1,023.2305 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 31	227.02228 ft	43.093176 ft	-117.95171 psf	979.27222 psf	851.26835 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 32	233.06684 ft	44.967958 ft	-267.90091 psf	652.59706 psf	567.29397 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 33	239.1114 ft	47.081647 ft	-432.75787 psf	238.59714 psf	207.40933 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel

6.4 Pseudo-Static (M-P) Section Ea-Ea' - Final Condition - Global Stability

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File Informa on

File Version: 11.01
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Last Edited By: Mikayla S. Hatch
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Directory: P:\0\0180366\01\Analysis\Bridge 17.7\SlopeW\
Last Solved Date: 11/12/2021
Last Solved Time: 02:35:22 PM

Project Se ngs

Unit System: U.S. Customary Units

Analysis Se ngs

6.4 Pseudo-Sta c (M-P)

Kind: SLOPE/W
Parent: FINAL CONDITION
Analysis Type: Morgenstern-Price
Se ngs
Side Func on
Interslice force func on op on: Half-Sine
PWP Condi ons from: Piezometric Line
Apply Phrea c Correc on: No
Use Staged Rapid Drawdown: No
Unit Weight of Water: 62.4 pcf
Slip Surface
Direc on of movement: Le. to Right
Use Passive Mode: No
Slip Surface Op on: Entry and Exit
Cri cal slip surfaces saved: 1
Op mize Cri cal Slip Surface Loca on: No
Tension Crack Op on: (none)
Distribu on
F of S Calcula on Op on: Constant
Advanced
Geometry Se ngs
Minimum Slip Surface Depth: 2 ft
Number of Slices: 30
Factor of Safety Convergence Se ngs
Maximum Number of Itera ons: 100
Tolerable difference in F of S: 0.001

Solu□on Se□ ngs
Search Method: Root Finder
Tolerable difference between star□ng and converged F of S: 3
Maximum itera□ons to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

ESU 2A - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 39 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2B - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 41 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 7A - Weathered Sandstone

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 42 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1B - Exis ng Gravelly Granular Fill

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2C - Na ve Silt (Pseudo-Sta c)

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effec□ve Cohesion: 200 psf
Effec□ve Fric□on Angle: 29 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Reinforcements

Soil Nail_Row 1

Type: Anchor
Pullout Resistance: 1,800 psf
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 82,550 lbf
Tensile Capacity Reduc□on Factor: 1
Shear Force: 0 lbf
Shear Force Reduc□on Factor: 1
Apply Shear: Parallel to Slip
F of S Dependent: No
Force Distribu□on: Distributed
Bond Length: 45 ft
Bond Diameter: 0.5 ft
Out-of-Plane Spacing: 4 ft
Face Anchorage: Yes
Factored Pullout Resistance: 706.86 lbf/ft/ft
Factored Tensile Capacity: 20,638 lbf/ft

Soil Nail_Row 2

Type: Anchor
Pullout Resistance: 1,800 psf
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 82,550 lbf
Tensile Capacity Reduc□on Factor: 1
Shear Force: 0 lbf
Shear Force Reduc□on Factor: 1
Apply Shear: Parallel to Slip
F of S Dependent: No
Force Distribu□on: Distributed
Bond Length: 45 ft
Bond Diameter: 0.5 ft
Out-of-Plane Spacing: 4 ft
Face Anchorage: Yes
Factored Pullout Resistance: 706.86 lbf/ft/ft
Factored Tensile Capacity: 20,638 lbf/ft

Soil Nail_Row 3

Type: Anchor
Pullout Resistance: 1,800 psf
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 82,550 lbf
Tensile Capacity Reduc□on Factor: 1
Shear Force: 0 lbf
Shear Force Reduc□on Factor: 1
Apply Shear: Parallel to Slip
F of S Dependent: No
Force Distribu□on: Distributed
Bond Length: 40 ft
Bond Diameter: 0.5 ft
Out-of-Plane Spacing: 4 ft
Face Anchorage: Yes

Factored Pullout Resistance: 706.86 lbf/ft/ft
Factored Tensile Capacity: 20,638 lbf/ft

Soil Nail_Row 4

Type: Anchor
Pullout Resistance: 1,800 psf
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 82,550 lbf
Tensile Capacity Reduc□on Factor: 1
Shear Force: 0 lbf
Shear Force Reduc□on Factor: 1
Apply Shear: Parallel to Slip
F of S Dependent: No
Force Distribu□on: Distributed
Bond Length: 40 ft
Bond Diameter: 0.5 ft
Out-of-Plane Spacing: 4 ft
Face Anchorage: Yes
Factored Pullout Resistance: 706.86 lbf/ft/ft
Factored Tensile Capacity: 20,638 lbf/ft

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (0.05, 60) ft
Left-Zone Right Coordinate: (119.58945, 66.5) ft
Left-Zone Increment: 40
Right Type: Range
Right-Zone Left Coordinate: (160, 58.5) ft
Right-Zone Right Coordinate: (281, 48.626374) ft
Right-Zone Increment: 40
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 60) ft
Right Coordinate: (335, 48) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	0.25 ft	43.375 ft
Coordinate 2	56.5 ft	43.375 ft
Coordinate 3	97.75 ft	43.375 ft
Coordinate 4	123 ft	43.375 ft
Coordinate 5	159.75 ft	42.625 ft
Coordinate 6	192 ft	42.625 ft

Coordinate 7	210.75 ft	42.625 ft
Coordinate 8	298 ft	35 ft
Coordinate 9	335.25 ft	35 ft

Seismic Coefficients

Horz Seismic Coef.: 0.255

Reinforcement Lines

Reinforcement Line 1

Reinforcement: Soil Nail_Row 1
Lock to Ground Surface: Yes
Outside Point: (160, 64.5) ft
Inside Point: (115.68365, 56.685832) ft
Length: 45.000001 ft
Orienta□on: -170 °
Max. Pullout Force: 0 lbf
Bond Length: 45 ft
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 2

Reinforcement: Soil Nail_Row 2
Lock to Ground Surface: Yes
Outside Point: (160, 60.5) ft
Inside Point: (115.68365, 52.685832) ft
Length: 45.000001 ft
Orienta□on: -170 °
Max. Pullout Force: 0 lbf
Bond Length: 45 ft
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 3

Reinforcement: Soil Nail_Row 3
Lock to Ground Surface: Yes
Outside Point: (160, 56.5) ft
Inside Point: (120.60769, 49.554073) ft
Length: 40 ft
Orienta□on: -170 °
Max. Pullout Force: 0 lbf
Bond Length: 40 ft
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf

Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 4

Reinforcement: Soil Nail_Row 4
Lock to Ground Surface: Yes
Outside Point: (160, 52.5) ft
Inside Point: (120.60769, 45.554073) ft
Length: 40 ft
Orienta□on: -170 °
Max. Pullout Force: 0 lbf
Bond Length: 40 ft
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 125 pcf
Direc□on: Ver□cal

Coordinates

	X	Y
	120 ft	67.5 ft
	160 ft	67.5 ft

Geometry

Name: Ea-Ea'

Se ngs

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	0 ft	56 ft
Point 2	76 ft	56 ft
Point 3	118 ft	35 ft
Point 4	160 ft	35 ft
Point 5	0 ft	46 ft
Point 6	37 ft	46 ft
Point 7	190 ft	50 ft
Point 8	160 ft	50 ft
Point 9	170.25 ft	34 ft
Point 10	240 ft	34 ft
Point 11	315 ft	30 ft

Figure D.4-140

Point 12	335 ft	30 ft
Point 13	335 ft	48 ft
Point 14	327 ft	48 ft
Point 15	315 ft	49 ft
Point 16	224 ft	48 ft
Point 17	0 ft	0 ft
Point 18	335 ft	0 ft
Point 19	160 ft	96 ft
Point 20	120 ft	96 ft
Point 21	120 ft	72 ft
Point 22	76 ft	72 ft
Point 23	52 ft	60 ft
Point 24	0 ft	60 ft
Point 25	160 ft	47 ft
Point 26	120 ft	47 ft
Point 27	65 ft	66.5 ft
Point 28	120 ft	66.5 ft
Point 29	120 ft	49 ft
Point 30	160 ft	49 ft
Point 31	160 ft	66.5 ft
Point 32	160 ft	72 ft
Point 33	160 ft	64.5 ft
Point 34	160 ft	60.5 ft
Point 35	160 ft	56.5 ft
Point 36	160 ft	52.5 ft
Point 37	281 ft	48.626374 ft

Regions

	Material	Points	Area
Region 1	ESU 2C - Na□ve Silt (Pseudo-Sta□c)	5,6,2,1	565 ft²
Region 2		19,20,21,32	960 ft²
Region 3		20,22,21	528 ft²
Region 4	ESU 2A - Na□ve Sand and Gravel	6,2,3	619.5 ft²
Region 5	ESU 2B - Na□ve Sand and Gravel	7,16,37,15,14,13,12,11,10,9,4	2,595.4 ft²
Region 6	ESU 7A - Weathered Sandstone	18,17,5,6,3,4,9,10,11,12	12,178 ft²
Region 7	ESU 1B - Exis□ng Gravelly Granular Fill	8,30,25,7	45 ft²
Region 8	ESU 2A - Na□ve Sand and Gravel	4,7,25,26,2,3	945 ft²
Region 9		21,22,27,28	272.25 ft²
Region 10	ESU 1B - Exis□ng Gravelly Granular Fill	23,24,1,2,26,29,28,27	1,077.8 ft²
Region 11	ESU 1B - Exis□ng Gravelly Granular Fill	29,26,25,30	80 ft²
Region 12	ESU 1B - Exis□ng Gravelly Granular Fill	29,30,8,36,35,34,33,31,28	700 ft²
Region 13		28,31,32,21	220 ft²

Slip Results

Slip Surfaces Analysed: 6051 of 8405 converged

Current Slip Surface

Figure D.4-141

Slip Surface: 5,472
Factor of Safety: 1.992
Volume: 2,369.2432 ft³
Weight: 299,829.64 lbf
Resis□ng Moment: 40,469,252 lbf·ft
Ac□va□ng Moment: 20,313,207 lbf·ft
Resis□ng Force: 219,583.04 lbf
Ac□va□ng Force: 110,203.36 lbf
Slip Rank: 1 of 8,405 slip surfaces
Exit: (242.13368, 48.199271) ft
Entry: (77.213588, 66.5) ft
Radius: 178.72464 ft
Center: (177.13266, 214.6846) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Fric□onal Strength	Cohesive Strength	Suc□on Strength	Base Material
Slice 1	79.780639 ft	64.832307 ft	-1,338.9359 psf	162.96985 psf	127.32601 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 2	84.914742 ft	61.618043 ft	-1,138.3659 psf	473.26991 psf	369.75897 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 3	90.048845 ft	58.638889 ft	-952.46668 psf	756.34224 psf	590.91932 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 4	95.182948 ft	55.881587 ft	-780.41104 psf	1,017.0434 psf	794.60141 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 5	100.81485 ft	53.109234 ft	-607.41619 psf	1,281.3623 psf	1,001.1099 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 6	106.94454 ft	50.352567 ft	-435.40017 psf	1,551.7013 psf	1,212.3219 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 7	112.50704 ft	48.074731 ft	-293.26319 psf	1,781.7444 psf	1,442.8282 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 8	117.50235 ft	46.221837 ft	-177.64264 psf	1,982.9594 psf	1,605.7689 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice	121.5 ft	44.846405	-91.815662	2,254.3881	1,825.5675	0 psf	0 psf	ESU 2A -

9		ft	psf	psf	psf			Na□ve Sand and Gravel
Slice 10	124.71092 ft	43.830114 ft	-30.577896 psf	2,379.9103 psf	1,927.2134 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 11	129.19919 ft	42.531854 ft	44.717822 psf	2,552.3371 psf	2,030.63 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 12	134.75389 ft	41.080559 ft	128.2049 psf	2,763.1685 psf	2,133.7515 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 13	140.30858 ft	39.817713 ft	199.93276 psf	2,971.1816 psf	2,244.1131 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 14	145.86327 ft	38.739254 ft	260.15489 psf	3,177.0274 psf	2,362.0368 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 15	151.41796 ft	37.841804 ft	309.08203 psf	3,380.0842 psf	2,486.8485 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 16	156.97265 ft	37.122616 ft	346.88561 psf	3,578.3118 psf	2,616.7574 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 17	159.875 ft	36.795156 ft	363.78229 psf	3,681.2662 psf	2,686.4455 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 18	161.51692 ft	36.649977 ft	372.84145 psf	1,553.4239 psf	956.0168 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 19	166.08789 ft	36.327803 ft	392.94511 psf	1,687.1922 psf	1,125.0718 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 20	172.19596 ft	36.054278 ft	410.01303 psf	1,852.1579 psf	1,253.6374 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 21	177.70833 ft	35.977795 ft	414.78561 psf	1,980.9669 psf	1,361.4606 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 22	182.625 ft	36.061303 ft	409.57469 psf	2,072.9746 psf	1,445.9715 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 23	187.54167 ft	36.280324 ft	395.9078 psf	2,140.3026 psf	1,516.3792 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 24	191 ft	36.501582 ft	382.1013 psf	2,155.9438 psf	1,541.9778 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 25	195.125 ft	36.89566 ft	357.51083 psf	2,095.271 psf	1,510.6118 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 26	201.375 ft	37.639811 ft	311.07582 psf	1,962.1198 psf	1,435.2306 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice	207.625 ft	38.608889	250.60533	1,770.3088	1,321.058	0 psf	0 psf	ESU 2B -

27		ft	psf	psf	psf			Na□ve Sand and Gravel
Slice 28	213.53251 ft	39.728974 ft	165.53818 psf	1,540.8974 psf	1,195.5815 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 29	219.09752 ft	40.980099 ft	57.120314 psf	1,283.6418 psf	1,066.1989 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 30	222.94001 ft	41.933388 ft	-23.319171 psf	1,080.9279 psf	939.63625 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 31	227.02228 ft	43.093176 ft	-117.95171 psf	862.10491 psf	749.41636 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 32	233.06684 ft	44.967958 ft	-267.90091 psf	534.42999 psf	464.5729 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 33	239.1114 ft	47.081647 ft	-432.75787 psf	180.92666 psf	157.27715 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel

1.1 Static (Spencer) Section Fa-Fa' - Existing Condition - Global Stability

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File Informa on

File Version: 11.01
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Last Solved Date: 11/12/2021
Last Solved Time: 03:13:06 PM

Project Se ngs

Unit System: U.S. Customary Units

Analysis Se ngs

1.1 Sta c (Spencer)

Kind: SLOPE/W
Parent: 1. Global Stability
Analysis Type: Spencer
Se ngs
PWP Condi ons from: Piezometric Line
Apply Phrea c Correc on: No
Use Staged Rapid Drawdown: No
Unit Weight of Water: 62.4 pcf
Slip Surface
Direc on of movement: Le. to Right
Use Passive Mode: No
Slip Surface Op□on: Entry and Exit
Cri□cal slip surfaces saved: 1
Op□mize Cri□cal Slip Surface Loca□on: No
Tension Crack Op□on: (none)
Distribu□on
F of S Calcula□on Op□on: Constant
Advanced
Geometry Se□ ngs
Minimum Slip Surface Depth: 2 ft
Number of Slices: 30
Factor of Safety Convergence Se□ ngs
Maximum Number of Itera□ons: 100
Tolerable difference in F of S: 0.001
Solu□on Se□ ngs
Search Method: Root Finder

Tolerable difference between star□ng and converged F of S: 3
Maximum itera□ons to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Hilfiker Wall

Slope Stability Material Model: High Strength
Unit Weight: 130 pcf
Pore Water Pressure
Piezometric Line: 1

ESU 2A - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 39 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2B - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 41 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 7A - Weathered Sandstone

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 42 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2C - Na ve Silt

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 29 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1A - Exis ng Granular Fill

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf

Effec□ve Fric□on Angle: 40 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1B - Exis ng Gravelly Granular Fill

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (1.75, 60) ft
Left-Zone Right Coordinate: (119.36773, 93.683865) ft
Left-Zone Increment: 40
Right Type: Range
Right-Zone Left Coordinate: (161.44853, 50.951716) ft
Right-Zone Right Coordinate: (315.5, 48.958333) ft
Right-Zone Increment: 40
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 60) ft
Right Coordinate: (335, 48) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	0.25 ft	43.375 ft
Coordinate 2	56.5 ft	43.375 ft
Coordinate 3	97.75 ft	43.375 ft
Coordinate 4	123 ft	43.375 ft
Coordinate 5	159.75 ft	42.625 ft
Coordinate 6	192 ft	42.625 ft
Coordinate 7	210.75 ft	42.625 ft
Coordinate 8	298 ft	35 ft
Coordinate 9	335.25 ft	35 ft

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 250 pcf
Direc□on: Ver□cal

Coordinates

	X	Y
	120 ft	95 ft
	160 ft	95 ft

Geometry

Name: Fa-Fa'

Se ngs

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	0 ft	56 ft
Point 2	76 ft	56 ft
Point 3	118 ft	35 ft
Point 4	160 ft	35 ft
Point 5	0 ft	46 ft
Point 6	37 ft	46 ft
Point 7	190 ft	50 ft
Point 8	160 ft	51 ft
Point 9	170.25 ft	34 ft
Point 10	240 ft	34 ft
Point 11	315 ft	30 ft
Point 12	335 ft	30 ft
Point 13	335 ft	48 ft
Point 14	327 ft	48 ft
Point 15	315 ft	49 ft
Point 16	224 ft	48 ft
Point 17	0 ft	0 ft
Point 18	335 ft	0 ft
Point 19	160 ft	94 ft
Point 20	120 ft	94 ft
Point 21	120 ft	72 ft
Point 22	76 ft	72 ft
Point 23	52 ft	60 ft
Point 24	0 ft	60 ft
Point 25	160 ft	47 ft
Point 26	120 ft	47 ft
Point 27	65 ft	66.5 ft
Point 28	160 ft	66.5 ft
Point 29	120 ft	66.5 ft
Point 30	120 ft	49 ft

Figure D.4-148

Point 31	160 ft	49 ft
Point 32	160 ft	72 ft
Point 33	160 ft	70.5 ft
Point 34	120 ft	70.5 ft
Point 35	156 ft	70.5 ft
Point 36	156 ft	66.5 ft
Point 37	126 ft	49 ft
Point 38	126 ft	94 ft
Point 39	126 ft	66.5 ft
Point 40	126 ft	70.5 ft
Point 41	126 ft	72 ft

Regions

	Material	Points	Area
Region 1	ESU 2C - Na□ve Silt	5,6,2,1	565 ft²
Region 2	Hilfiker Wall	19,38,41,32	748 ft²
Region 3	ESU 1A - Exis□ng Granular Fill	20,22,21	484 ft²
Region 4	ESU 2A - Na□ve Sand and Gravel	6,2,3	619.5 ft²
Region 5	ESU 2B - Na□ve Sand and Gravel	7,16,15,14,13,12,11,10,9,4	2,595.4 ft²
Region 6	ESU 7A - Weathered Sandstone	18,17,5,6,3,4,9,10,11,12	12,178 ft²
Region 7	ESU 1B - Exis□ng Gravelly Granular Fill	8,31,25,7	60 ft²
Region 8	ESU 2A - Na□ve Sand and Gravel	4,7,25,26,2,3	945 ft²
Region 9	ESU 1B - Exis□ng Gravelly Granular Fill	21,22,27,29,34	272.25 ft²
Region 10	ESU 1B - Exis□ng Gravelly Granular Fill	23,24,1,2,26,30,29,27	1,077.8 ft²
Region 11	ESU 1B - Exis□ng Gravelly Granular Fill	29,30,37,39	105 ft²
Region 12	ESU 1B - Exis□ng Gravelly Granular Fill	30,26,25,31,37	80 ft²
Region 13	ESU 1B - Exis□ng Gravelly Granular Fill	29,39,40,34	24 ft²
Region 14	Hilfiker Wall	32,41,40,35,33	51 ft²
Region 15	Hilfiker Wall	28,33,35,36	16 ft²
Region 16	Hilfiker Wall	31,8,28,36,39,37	595 ft²
Region 17	Hilfiker Wall	36,35,40,39	120 ft²
Region 18	ESU 1B - Exis□ng Gravelly Granular Fill	21,34,40,41	9 ft²
Region 19	ESU 1A - Exis□ng Granular Fill	20,21,41,38	132 ft²

Slip Results

Slip Surfaces Analysed: 3857 of 8405 converged

Current Slip Surface

Slip Surface: 7,445
Factor of Safety: 2.446
Volume: 3,063.2126 ft³
Weight: 390,698.85 lbf
Resis□ng Moment: 19,374,017 lbf·ft
Ac□va□ng Moment: 7,921,567.5 lbf·ft
Resis□ng Force: 282,736.52 lbf
Ac□va□ng Force: 115,602.6 lbf
Slip Rank: 1 of 8,405 slip surfaces
Exit: (207.64217, 48.962225) ft

Entry: (108.13646, 88.06823) ft
Radius: 58.590896 ft
Center: (166.66189, 90.837154) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Fric□onal Strength	Cohesive Strength	Suc□on Strength	Base Material
Slice 1	109.65907 ft	80.034115 ft	-2,287.5288 psf	255.053 psf	214.01488 psf	0 psf	0 psf	ESU 1A - Exis□ng Granular Fill
Slice 2	112.27316 ft	69.25 ft	-1,614.6 psf	1,052.1745 psf	822.04885 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 3	115.02349 ft	63.380216 ft	-1,248.3255 psf	1,692.8677 psf	1,322.6132 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 4	118.34116 ft	57.831845 ft	-902.10711 psf	2,429.4757 psf	1,898.1144 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 5	121.5 ft	53.584775 ft	-637.08995 psf	3,191.6328 psf	2,493.5768 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 6	124.32152 ft	50.383146 ft	-438.99121 psf	3,656.5332 psf	2,856.7968 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 7	125.82152 ft	48.826495 ft	-343.76642 psf	3,895.258 psf	3,043.3091 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 8	126.89389 ft	47.826495 ft	-282.73204 psf	4,285.4875 psf	3,348.1898 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 9	130.1834 ft	45.089755 ft	-116.14854 psf	4,736.5206 psf	3,835.5588 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 10	134.21219 ft	42.092302 ft	65.761955 psf	5,302.9908 psf	4,241.0243 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 11	137.47852 ft	40.066341 ft	188.02237 psf	5,734.979 psf	4,491.8369 psf	0 psf	0 psf	ESU 2A - Na□ve Sand

								and Gravel
Slice 12	140.74485 ft	38.3216 ft	292.73461 psf	6,142.223 psf	4,736.8223 psf	0 psf	0 psf	ESU 2A - Naïve Sand and Gravel
Slice 13	144.01118 ft	36.830652 ft	381.61019 psf	6,528.4084 psf	4,977.579 psf	0 psf	0 psf	ESU 2A - Naïve Sand and Gravel
Slice 14	147.27752 ft	35.572845 ft	455.93777 psf	6,896.5864 psf	5,215.5345 psf	0 psf	0 psf	ESU 2A - Naïve Sand and Gravel
Slice 15	150.68301 ft	34.497339 ft	518.71258 psf	7,266.9537 psf	6,076.1436 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 16	154.22767 ft	33.609592 ft	569.59399 psf	7,664.2377 psf	6,388.0459 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 17	157.875 ft	32.939942 ft	606.73535 psf	8,059.6509 psf	6,710.6353 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 18	159.875 ft	32.640802 ft	623.01399 psf	8,276.8519 psf	6,891.5466 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 19	161.70833 ft	32.481212 ft	632.9724 psf	2,347.154 psf	1,543.456 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 20	165.125 ft	32.291354 ft	644.81953 psf	2,464.984 psf	1,638.8834 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 21	168.54167 ft	32.301368 ft	644.19463 psf	2,562.7175 psf	1,727.4458 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 22	171.5 ft	32.459824 ft	634.30699 psf	2,632.2587 psf	1,798.9638 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 23	174 ft	32.721253 ft	617.99382 psf	2,676.9675 psf	1,853.9082 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 24	176.65993 ft	33.123335 ft	592.90388 psf	2,710.6583 psf	1,906.8347 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 25	179.47979 ft	33.683792 ft	557.93137 psf	2,731.1676 psf	1,956.7907 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 26	182.4081 ft	34.423813 ft	511.75405 psf	2,712.4134 psf	1,913.004 psf	0 psf	0 psf	ESU 2B - Naïve Sand and Gravel
Slice 27	185.44486 ft	35.361722 ft	453.22853 psf	2,689.868 psf	1,944.281 psf	0 psf	0 psf	ESU 2B - Naïve Sand and Gravel
Slice 28	188.48162 ft	36.485377 ft	383.11246 psf	2,642.3847 psf	1,963.9554 psf	0 psf	0 psf	ESU 2B - Naïve Sand and Gravel
Slice 29	191 ft	37.551686 ft	316.57479 psf	2,566.7822 psf	1,956.0755 psf	0 psf	0 psf	ESU 2B - Naïve Sand

								and Gravel
Slice 30	193.98894 ft	39.058124 ft	222.57308 psf	2,402.0118 psf	1,894.5571 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 31	197.96682 ft	41.366406 ft	78.536272 psf	2,111.7279 psf	1,767.4265 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 32	201.87736 ft	44.072023 ft	-90.294209 psf	1,622.5063 psf	1,410.4232 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 33	205.72057 ft	47.240635 ft	-288.01563 psf	715.55933 psf	622.02624 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel

1.2 Static (M-P) Section Fa-Fa' - Existing Condition - Global Stability

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File Informa on

File Version: 11.01
Created By: Mikayla S. Hatch
Last Edited By: Mikayla S. Hatch
Revision Number: 397
Date: 11/12/2021
Time: 03:12:52 PM
Tool Version: 11.1
File Name: Wall 03.63L - Bridge 17.7 Fa-Fa' - All Condi ons.gsz
Directory: P:\0\0180366\01\Analysis\Bridge 17.7\SlopeW\
Last Solved Date: 11/12/2021
Last Solved Time: 03:13:10 PM

Project Se ngs

Unit System: U.S. Customary Units

Analysis Se ngs

1.2 Sta c (M-P)

Kind: SLOPE/W
Parent: 1. Global Stability
Analysis Type: Morgenstern-Price
Se ngs
Side Func on
Interslice force func on op on: Half-Sine
PWP Condi ons from: Piezometric Line
Apply Phrea c Correc on: No
Use Staged Rapid Drawdown: No
Unit Weight of Water: 62.4 pcf
Slip Surface
Direc on of movement: Le. to Right
Use Passive Mode: No
Slip Surface Op on: Entry and Exit
Cri cal slip surfaces saved: 1
Op mize Cri cal Slip Surface Loca on: No
Tension Crack Op on: (none)
Distribu on
F of S Calcula on Op on: Constant
Advanced
Geometry Se ngs
Minimum Slip Surface Depth: 2 ft
Number of Slices: 30
Factor of Safety Convergence Se ngs
Maximum Number of Itera ons: 100
Tolerable difference in F of S: 0.001

Solu□on Se□ ngs
Search Method: Root Finder
Tolerable difference between star□ng and converged F of S: 3
Maximum itera□ons to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Hilfiker Wall

Slope Stability Material Model: High Strength
Unit Weight: 130 pcf
Pore Water Pressure
Piezometric Line: 1

ESU 2A - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 39 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2B - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 41 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 7A - Weathered Sandstone

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 42 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2C - Na ve Silt

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 29 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1A - Exis ng Granular Fill

Slope Stability Material Model: Mohr-Coulomb

Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 40 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1B - Exis ng Gravelly Granular Fill

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (1.75, 60) ft
Left-Zone Right Coordinate: (119.36773, 93.683865) ft
Left-Zone Increment: 40
Right Type: Range
Right-Zone Left Coordinate: (161.44853, 50.951716) ft
Right-Zone Right Coordinate: (315.5, 48.958333) ft
Right-Zone Increment: 40
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 60) ft
Right Coordinate: (335, 48) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	0.25 ft	43.375 ft
Coordinate 2	56.5 ft	43.375 ft
Coordinate 3	97.75 ft	43.375 ft
Coordinate 4	123 ft	43.375 ft
Coordinate 5	159.75 ft	42.625 ft
Coordinate 6	192 ft	42.625 ft
Coordinate 7	210.75 ft	42.625 ft
Coordinate 8	298 ft	35 ft
Coordinate 9	335.25 ft	35 ft

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 250 pcf
Direc□on: Ver□cal

Coordinates

	X	Y
	120 ft	95 ft
	160 ft	95 ft

Geometry

Name: Fa-Fa'

Se ngs

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	0 ft	56 ft
Point 2	76 ft	56 ft
Point 3	118 ft	35 ft
Point 4	160 ft	35 ft
Point 5	0 ft	46 ft
Point 6	37 ft	46 ft
Point 7	190 ft	50 ft
Point 8	160 ft	51 ft
Point 9	170.25 ft	34 ft
Point 10	240 ft	34 ft
Point 11	315 ft	30 ft
Point 12	335 ft	30 ft
Point 13	335 ft	48 ft
Point 14	327 ft	48 ft
Point 15	315 ft	49 ft
Point 16	224 ft	48 ft
Point 17	0 ft	0 ft
Point 18	335 ft	0 ft
Point 19	160 ft	94 ft
Point 20	120 ft	94 ft
Point 21	120 ft	72 ft
Point 22	76 ft	72 ft
Point 23	52 ft	60 ft
Point 24	0 ft	60 ft
Point 25	160 ft	47 ft
Point 26	120 ft	47 ft
Point 27	65 ft	66.5 ft
Point 28	160 ft	66.5 ft

Figure D.4-156

Point 29	120 ft	66.5 ft
Point 30	120 ft	49 ft
Point 31	160 ft	49 ft
Point 32	160 ft	72 ft
Point 33	160 ft	70.5 ft
Point 34	120 ft	70.5 ft
Point 35	156 ft	70.5 ft
Point 36	156 ft	66.5 ft
Point 37	126 ft	49 ft
Point 38	126 ft	94 ft
Point 39	126 ft	66.5 ft
Point 40	126 ft	70.5 ft
Point 41	126 ft	72 ft

Regions

	Material	Points	Area
Region 1	ESU 2C - Na□ve Silt	5,6,2,1	565 ft²
Region 2	Hilfiker Wall	19,38,41,32	748 ft²
Region 3	ESU 1A - Exis□ng Granular Fill	20,22,21	484 ft²
Region 4	ESU 2A - Na□ve Sand and Gravel	6,2,3	619.5 ft²
Region 5	ESU 2B - Na□ve Sand and Gravel	7,16,15,14,13,12,11,10,9,4	2,595.4 ft²
Region 6	ESU 7A - Weathered Sandstone	18,17,5,6,3,4,9,10,11,12	12,178 ft²
Region 7	ESU 1B - Exis□ng Gravelly Granular Fill	8,31,25,7	60 ft²
Region 8	ESU 2A - Na□ve Sand and Gravel	4,7,25,26,2,3	945 ft²
Region 9	ESU 1B - Exis□ng Gravelly Granular Fill	21,22,27,29,34	272.25 ft²
Region 10	ESU 1B - Exis□ng Gravelly Granular Fill	23,24,1,2,26,30,29,27	1,077.8 ft²
Region 11	ESU 1B - Exis□ng Gravelly Granular Fill	29,30,37,39	105 ft²
Region 12	ESU 1B - Exis□ng Gravelly Granular Fill	30,26,25,31,37	80 ft²
Region 13	ESU 1B - Exis□ng Gravelly Granular Fill	29,39,40,34	24 ft²
Region 14	Hilfiker Wall	32,41,40,35,33	51 ft²
Region 15	Hilfiker Wall	28,33,35,36	16 ft²
Region 16	Hilfiker Wall	31,8,28,36,39,37	595 ft²
Region 17	Hilfiker Wall	36,35,40,39	120 ft²
Region 18	ESU 1B - Exis□ng Gravelly Granular Fill	21,34,40,41	9 ft²
Region 19	ESU 1A - Exis□ng Granular Fill	20,21,41,38	132 ft²

Slip Results

Slip Surfaces Analysed: 4402 of 8405 converged

Current Slip Surface

Slip Surface: 6,824
Factor of Safety: 2.454
Volume: 3,041.6924 ft³
Weight: 385,730.56 lbf
Resis□ng Moment: 21,066,771 lbf·ft
Ac□va□ng Moment: 8,586,273.5 lbf·ft
Resis□ng Force: 279,542.66 lbf
Ac□va□ng Force: 113,906.5 lbf

Slip Rank: 1 of 8,405 slip surfaces
Exit: (203.79549, 49.188501) ft
Entry: (99.713008, 83.856504) ft
Radius: 66.807443 ft
Center: (163.80623, 102.70573) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Fric□onal Strength	Cohesive Strength	Suc□on Strength	Base Material
Slice 1	102.09317 ft	77.928252 ft	-2,156.1229 psf	433.73409 psf	363.94611 psf	0 psf	0 psf	ESU 1A - Exis□ng Granular Fill
Slice 2	106.06675 ft	69.25 ft	-1,614.6 psf	1,250.5334 psf	977.02376 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 3	109.20265 ft	64.306595 ft	-1,306.1315 psf	1,787.198 psf	1,396.3121 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 4	112.28761 ft	60.241805 ft	-1,052.4887 psf	2,274.3471 psf	1,776.9147 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 5	115.37257 ft	56.74495 ft	-834.28486 psf	2,738.5756 psf	2,139.6098 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 6	118.45752 ft	53.692331 ft	-643.80144 psf	3,191.8242 psf	2,493.7264 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 7	121.5 ft	51.036986 ft	-478.10793 psf	3,752.7262 psf	2,931.9511 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 8	123.53524 ft	49.404395 ft	-376.91586 psf	3,966.9014 psf	3,099.2831 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 9	125.03524 ft	48.312333 ft	-310.68138 psf	4,122.4981 psf	3,220.8485 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice	126.46331	47.312333	-250.09998	4,528.13	3,537.7629	0 psf	0 psf	ESU 1B -

10	ft	ft	psf	psf	psf			Exis□ng Gravelly Granular Fill
Slice 11	128.57358 ft	45.977113 ft	-169.46964 psf	4,736.1717 psf	3,835.2762 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 12	131.86751 ft	44.057323 ft	-53.869427 psf	5,097.3995 psf	4,127.7927 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 13	135.38827 ft	42.279193 ft	52.602266 psf	5,498.7178 psf	4,410.1774 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 14	139.13585 ft	40.653001 ft	149.30423 psf	5,941.01 psf	4,690.0309 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 15	142.88344 ft	39.289814 ft	229.59465 psf	6,394.4921 psf	4,992.2355 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 16	146.63103 ft	38.17289 ft	294.51829 psf	6,856.2555 psf	5,313.59 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 17	150.37862 ft	37.289562 ft	344.86548 psf	7,319.8978 psf	5,648.2698 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 18	154.12621 ft	36.630428 ft	381.223 psf	7,775.2369 psf	5,987.5544 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 19	157.875 ft	36.188727 ft	404.01122 psf	8,208.2833 psf	6,319.7749 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 20	159.875 ft	36.014167 ft	412.51598 psf	8,429.7428 psf	6,492.2223 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 21	160.92682 ft	35.966811 ft	415.47096 psf	2,101.2869 psf	1,365.1468 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 22	163.52819 ft	35.919853 ft	418.40118 psf	2,212.5375 psf	1,559.6189 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 23	166.87728 ft	35.989964 ft	414.02625 psf	2,322.578 psf	1,659.0787 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 24	170.22637 ft	36.228768 ft	399.12485 psf	2,394.553 psf	1,734.5992 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 25	173.57546 ft	36.638101 ft	373.58252 psf	2,421.5578 psf	1,780.2777 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 26	177.09375 ft	37.260049 ft	334.77292 psf	2,393.8016 psf	1,789.8863 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 27	180.78125 ft	38.118972 ft	281.17615 psf	2,299.4138 psf	1,754.4272 psf	0 psf	0 psf	ESU 2B - Na□ve Sand

								and Gravel
Slice 28	184.46875 ft	39.20348 ft	213.50286 psf	2,134.2702 psf	1,669.6975 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 29	188.15625 ft	40.525422 ft	131.01364 psf	1,899.3243 psf	1,537.169 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 30	191 ft	41.693149 ft	58.147511 psf	1,662.5347 psf	1,394.6725 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 31	192.51082 ft	42.381928 ft	15.167678 psf	1,507.134 psf	1,296.9465 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 32	194.81729 ft	43.566588 ft	-58.755092 psf	1,230.8518 psf	1,069.9632 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 33	198.40857 ft	45.596143 ft	-185.39934 psf	762.70414 psf	663.00859 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 34	201.99985 ft	47.936305 ft	-331.42546 psf	258.36559 psf	224.59378 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel

1.3 Pseudo-static (Spencer)

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File Informa on

File Version: 11.01
Created By: Mikayla S. Hatch
Last Edited By: Mikayla S. Hatch
Revision Number: 398
Date: 11/12/2021
Time: 03:15:20 PM
Tool Version: 11.1
File Name: Wall 03.63L - Bridge 17.7 Fa-Fa' - All Condi ons.gsz
Directory: P:\0\0180366\01\Analysis\Bridge 17.7\SlopeW\
Last Solved Date: 11/12/2021
Last Solved Time: 03:15:32 PM

Project Se ngs

Unit System: U.S. Customary Units

Analysis Se ngs

1.3 Pseudo-sta c (Spencer)

Kind: SLOPE/W
Parent: 1. Global Stability
Analysis Type: Spencer
Se ngs
PWP Condi ons from: Piezometric Line
Apply Phrea c Correc on: No
Use Staged Rapid Drawdown: No
Unit Weight of Water: 62.4 pcf
Slip Surface
Direc on of movement: Le. to Right
Use Passive Mode: No
Slip Surface Op□on: Entry and Exit
Cri□cal slip surfaces saved: 1
Op□mize Cri□cal Slip Surface Loca□on: No
Tension Crack Op□on: (none)
Distribu□on
F of S Calcula□on Op□on: Constant
Advanced
Geometry Se□ ngs
Minimum Slip Surface Depth: 2 ft
Number of Slices: 30
Factor of Safety Convergence Se□ ngs
Maximum Number of Itera□ons: 100
Tolerable difference in F of S: 0.001
Solu□on Se□ ngs
Search Method: Root Finder

Tolerable difference between star□ng and converged F of S: 3
Maximum itera□ons to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Hilfiker Wall

Slope Stability Material Model: High Strength
Unit Weight: 130 pcf
Pore Water Pressure
Piezometric Line: 1

ESU 1A - Exis ng Granular Fill (Pseudo-Sta c)

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 50 psf
Effec□ve Fric□on Angle: 40 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2A - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 39 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2B - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 41 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 7A - Weathered Sandstone

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 42 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1B - Exis ng Gravelly Granular Fill

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effec□ve Cohesion: 0 psf

Effec□ve Fric□on Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2C - Na ve Silt (Pseudo-Sta c)

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effec□ve Cohesion: 200 psf
Effec□ve Fric□on Angle: 29 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (0.25, 60) ft
Left-Zone Right Coordinate: (118.96045, 93.480225) ft
Left-Zone Increment: 40
Right Type: Range
Right-Zone Left Coordinate: (160.0333, 50.99889) ft
Right-Zone Right Coordinate: (335, 48) ft
Right-Zone Increment: 40
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 60) ft
Right Coordinate: (335, 48) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	0.25 ft	43.375 ft
Coordinate 2	56.5 ft	43.375 ft
Coordinate 3	97.75 ft	43.375 ft
Coordinate 4	123 ft	43.375 ft
Coordinate 5	159.75 ft	42.625 ft
Coordinate 6	192 ft	42.625 ft
Coordinate 7	210.75 ft	42.625 ft
Coordinate 8	298 ft	35 ft
Coordinate 9	335.25 ft	35 ft

Seismic Coefficients

Horz Seismic Coef.: 0.171

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 125 pcf
Direc□on: Ver□cal

Coordinates

	X	Y
	120 ft	95 ft
	160 ft	95 ft

Geometry

Name: Fa-Fa'

Se ngs

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	0 ft	56 ft
Point 2	76 ft	56 ft
Point 3	118 ft	35 ft
Point 4	160 ft	35 ft
Point 5	0 ft	46 ft
Point 6	37 ft	46 ft
Point 7	190 ft	50 ft
Point 8	160 ft	51 ft
Point 9	170.25 ft	34 ft
Point 10	240 ft	34 ft
Point 11	315 ft	30 ft
Point 12	335 ft	30 ft
Point 13	335 ft	48 ft
Point 14	327 ft	48 ft
Point 15	315 ft	49 ft
Point 16	224 ft	48 ft
Point 17	0 ft	0 ft
Point 18	335 ft	0 ft
Point 19	160 ft	94 ft
Point 20	120 ft	94 ft
Point 21	120 ft	72 ft
Point 22	76 ft	72 ft
Point 23	52 ft	60 ft
Point 24	0 ft	60 ft
Point 25	160 ft	47 ft
Point 26	120 ft	47 ft
Point 27	65 ft	66.5 ft
Point 28	160 ft	66.5 ft

Point 29	120 ft	66.5 ft
Point 30	120 ft	49 ft
Point 31	160 ft	49 ft
Point 32	160 ft	72 ft
Point 33	160 ft	70.5 ft
Point 34	120 ft	70.5 ft
Point 35	156 ft	70.5 ft
Point 36	156 ft	66.5 ft
Point 37	126 ft	49 ft
Point 38	126 ft	94 ft
Point 39	126 ft	66.5 ft
Point 40	126 ft	70.5 ft
Point 41	126 ft	72 ft

Regions

	Material	Points	Area
Region 1	ESU 2C - Na□ve Silt (Pseudo-Sta□c)	5,6,2,1	565 ft²
Region 2	Hilfiker Wall	19,38,41,32	748 ft²
Region 3	ESU 1A - Exis□ng Granular Fill (Pseudo-Sta□c)	20,22,21	484 ft²
Region 4	ESU 2A - Na□ve Sand and Gravel	6,2,3	619.5 ft²
Region 5	ESU 2B - Na□ve Sand and Gravel	7,16,15,14,13,12,11,10,9,4	2,595.4 ft²
Region 6	ESU 7A - Weathered Sandstone	18,17,5,6,3,4,9,10,11,12	12,178 ft²
Region 7	ESU 1B - Exis□ng Gravelly Granular Fill	8,31,25,7	60 ft²
Region 8	ESU 2A - Na□ve Sand and Gravel	4,7,25,26,2,3	945 ft²
Region 9	ESU 1B - Exis□ng Gravelly Granular Fill	21,22,27,29,34	272.25 ft²
Region 10	ESU 1B - Exis□ng Gravelly Granular Fill	23,24,1,2,26,30,29,27	1,077.8 ft²
Region 11	ESU 1B - Exis□ng Gravelly Granular Fill	29,30,37,39	105 ft²
Region 12	ESU 1B - Exis□ng Gravelly Granular Fill	30,26,25,31,37	80 ft²
Region 13	ESU 1B - Exis□ng Gravelly Granular Fill	29,39,40,34	24 ft²
Region 14	Hilfiker Wall	32,41,40,35,33	51 ft²
Region 15	Hilfiker Wall	28,33,35,36	16 ft²
Region 16	Hilfiker Wall	31,8,28,36,39,37	595 ft²
Region 17	Hilfiker Wall	36,35,40,39	120 ft²
Region 18	ESU 1B - Exis□ng Gravelly Granular Fill	21,34,40,41	9 ft²
Region 19	ESU 1A - Exis□ng Granular Fill (Pseudo-Sta□c)	20,21,41,38	132 ft²

Slip Results

Slip Surfaces Analysed: 3856 of 8405 converged

Current Slip Surface

Slip Surface: 6,453
Factor of Safety: 1.798
Volume: 3,776.0829 ft³
Weight: 483,975.13 lbf
Resis□ng Moment: 40,674,423 lbf·ft
Ac□va□ng Moment: 22,619,855 lbf·ft
Resis□ng Force: 335,850.37 lbf
Ac□va□ng Force: 186,749.16 lbf

Slip Rank: 1 of 8,405 slip surfaces
Exit: (243.1241, 48.210155) ft
Entry: (93.479862, 80.739931) ft
Radius: 110.4308 ft
Center: (185.20513, 142.23332) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Fric□onal Strength	Cohesive Strength	Suc□on Strength	Base Material
Slice 1	95.614931 ft	77.772526 ft	-2,146.4056 psf	210.6032 psf	176.71707 psf	50 psf	0 psf	ESU 1A - Exis□ng Granular Fill (Pseudo-Sta□c)
Slice 2	98.868169 ft	73.402561 ft	-1,873.7198 psf	579.4927 psf	486.25211 psf	50 psf	0 psf	ESU 1A - Exis□ng Granular Fill (Pseudo-Sta□c)
Slice 3	102.41046 ft	69.25 ft	-1,614.6 psf	1,016.6259 psf	794.27517 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 4	107.36215 ft	63.985506 ft	-1,286.0956 psf	1,626.5744 psf	1,270.8192 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 5	112.41729 ft	59.253879 ft	-990.84205 psf	2,264.8861 psf	1,769.523 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 6	117.47243 ft	55.072568 ft	-729.92827 psf	2,915.4616 psf	2,277.8082 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 7	121.5 ft	52.048811 ft	-541.24579 psf	3,473.9512 psf	2,714.1482 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 8	124.5 ft	50.001956 ft	-415.43225 psf	3,748.5848 psf	2,928.7155 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 9	127.64914 ft	48.007341 ft	-294.97858 psf	4,266.972 psf	3,333.7239 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly

								Granular Fill
Slice 10	132.92455 ft	45.049226 ft	-117.11033 psf	4,724.1985 psf	3,825.5806 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 11	138.98198 ft	41.977567 ft	66.847254 psf	5,262.743 psf	4,207.5534 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 12	143.84427 ft	39.874313 ft	191.89831 psf	5,681.653 psf	4,445.5157 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 13	148.70656 ft	38.04032 ft	300.14751 psf	6,089.9128 psf	4,688.4595 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 14	153.56885 ft	36.461541 ft	392.47133 psf	6,489.1368 psf	4,936.9823 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 15	157.41187 ft	35.367193 ft	455.86466 psf	6,801.642 psf	5,138.7091 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 16	159.28687 ft	34.888179 ft	483.36742 psf	7,003.0688 psf	5,870.3655 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 17	159.875 ft	34.7469 ft	491.59342 psf	7,054.4014 psf	5,909.1788 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 18	162.5625 ft	34.180467 ft	526.93884 psf	1,889.0845 psf	1,226.4814 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 19	167.6875 ft	33.231673 ft	586.14362 psf	2,095.9527 psf	1,359.4382 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 20	172.75 ft	32.536002 ft	629.5535 psf	2,283.4405 psf	1,489.1666 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 21	177.70833 ft	32.084833 ft	657.70641 psf	2,450.1465 psf	1,613.9203 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 22	182.625 ft	31.86005 ft	671.73289 psf	2,598.2965 psf	1,734.6857 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 23	187.54167 ft	31.854622 ft	672.07162 psf	2,728.7955 psf	1,851.8825 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 24	191 ft	31.95921 ft	665.54529 psf	2,799.615 psf	1,921.525 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 25	194.52095 ft	32.225241 ft	648.94494 psf	2,819.242 psf	1,954.1443 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 26	199.56285 ft	32.76938 ft	614.99067 psf	2,827.0309 psf	1,991.73 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice	204.60475	33.550019	566.27882	2,801.5301	2,012.6292	0 psf	0 psf	ESU 7A -

27	ft	ft	psf	psf	psf			Weathered Sandstone
Slice 28	208.93785 ft	34.398827 ft	513.3132 psf	2,713.1172 psf	1,912.2605 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 29	212.95833 ft	35.371181 ft	440.59561 psf	2,636.3307 psf	1,908.7234 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 30	217.375 ft	36.61735 ft	338.74925 psf	2,523.9478 psf	1,899.5641 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 31	221.79167 ft	38.06562 ft	224.29186 psf	2,367.7776 psf	1,863.3037 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 32	226.66512 ft	39.921236 ft	81.925024 psf	2,179.7809 psf	1,823.6383 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 33	231.62922 ft	42.066729 ft	-79.024427 psf	1,879.0897 psf	1,633.4677 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 34	236.22717 ft	44.330342 ft	-245.34786 psf	1,354.7423 psf	1,177.6595 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 35	240.82513 ft	46.869303 ft	-428.85303 psf	550.11849 psf	478.21071 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel

1.4 Pseudo-static (M-P) Section Fa-Fa' - Existing Condition - Global Stability

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File Informa on

File Version: 11.01
Created By: Mikayla S. Hatch
Last Edited By: Mikayla S. Hatch
Revision Number: 398
Date: 11/12/2021
Time: 03:15:20 PM
Tool Version: 11.1
File Name: Wall 03.63L - Bridge 17.7 Fa-Fa' - All Condi ons.gsz
Directory: P:\0\0180366\01\Analysis\Bridge 17.7\SlopeW\
Last Solved Date: 11/12/2021
Last Solved Time: 03:15:28 PM

Project Se ngs

Unit System: U.S. Customary Units

Analysis Se ngs

1.4 Pseudo-sta c (M-P)

Kind: SLOPE/W
Parent: 1. Global Stability
Analysis Type: Morgenstern-Price
Se ngs
Side Func on
Interslice force func on op on: Half-Sine
PWP Condi ons from: Piezometric Line
Apply Phrea c Correc on: No
Use Staged Rapid Drawdown: No
Unit Weight of Water: 62.4 pcf
Slip Surface
Direc on of movement: Le. to Right
Use Passive Mode: No
Slip Surface Op on: Entry and Exit
Cri cal slip surfaces saved: 1
Op mize Cri cal Slip Surface Loca on: No
Tension Crack Op on: (none)
Distribu on
F of S Calcula on Op on: Constant
Advanced
Geometry Se ngs
Minimum Slip Surface Depth: 2 ft
Number of Slices: 30
Factor of Safety Convergence Se ngs
Maximum Number of Itera ons: 100
Tolerable difference in F of S: 0.001

Solu□on Se□ ngs
Search Method: Root Finder
Tolerable difference between star□ng and converged F of S: 3
Maximum itera□ons to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Hilfiker Wall

Slope Stability Material Model: High Strength
Unit Weight: 130 pcf
Pore Water Pressure
Piezometric Line: 1

ESU 1A - Exis ng Granular Fill (Pseudo-Sta c)

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 50 psf
Effec□ve Fric□on Angle: 40 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2A - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 39 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2B - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 41 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 7A - Weathered Sandstone

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 42 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1B - Exis ng Gravelly Granular Fill

Slope Stability Material Model: Mohr-Coulomb

Unit Weight: 125 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2C - Na ve Silt (Pseudo-Sta c)

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effec□ve Cohesion: 200 psf
Effec□ve Fric□on Angle: 29 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (0.25, 60) ft
Left-Zone Right Coordinate: (118.96045, 93.480225) ft
Left-Zone Increment: 40
Right Type: Range
Right-Zone Left Coordinate: (160.0333, 50.99889) ft
Right-Zone Right Coordinate: (335, 48) ft
Right-Zone Increment: 40
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 60) ft
Right Coordinate: (335, 48) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	0.25 ft	43.375 ft
Coordinate 2	56.5 ft	43.375 ft
Coordinate 3	97.75 ft	43.375 ft
Coordinate 4	123 ft	43.375 ft
Coordinate 5	159.75 ft	42.625 ft
Coordinate 6	192 ft	42.625 ft
Coordinate 7	210.75 ft	42.625 ft
Coordinate 8	298 ft	35 ft
Coordinate 9	335.25 ft	35 ft

Seismic Coefficients

Horz Seismic Coef.: 0.171

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 125 pcf
Direc□on: Ver□cal

Coordinates

	X	Y
	120 ft	95 ft
	160 ft	95 ft

Geometry

Name: Fa-Fa'

Se ngs

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	0 ft	56 ft
Point 2	76 ft	56 ft
Point 3	118 ft	35 ft
Point 4	160 ft	35 ft
Point 5	0 ft	46 ft
Point 6	37 ft	46 ft
Point 7	190 ft	50 ft
Point 8	160 ft	51 ft
Point 9	170.25 ft	34 ft
Point 10	240 ft	34 ft
Point 11	315 ft	30 ft
Point 12	335 ft	30 ft
Point 13	335 ft	48 ft
Point 14	327 ft	48 ft
Point 15	315 ft	49 ft
Point 16	224 ft	48 ft
Point 17	0 ft	0 ft
Point 18	335 ft	0 ft
Point 19	160 ft	94 ft
Point 20	120 ft	94 ft
Point 21	120 ft	72 ft
Point 22	76 ft	72 ft
Point 23	52 ft	60 ft
Point 24	0 ft	60 ft

Point 25	160 ft	47 ft
Point 26	120 ft	47 ft
Point 27	65 ft	66.5 ft
Point 28	160 ft	66.5 ft
Point 29	120 ft	66.5 ft
Point 30	120 ft	49 ft
Point 31	160 ft	49 ft
Point 32	160 ft	72 ft
Point 33	160 ft	70.5 ft
Point 34	120 ft	70.5 ft
Point 35	156 ft	70.5 ft
Point 36	156 ft	66.5 ft
Point 37	126 ft	49 ft
Point 38	126 ft	94 ft
Point 39	126 ft	66.5 ft
Point 40	126 ft	70.5 ft
Point 41	126 ft	72 ft

Regions

	Material	Points	Area
Region 1	ESU 2C - Na□ve Silt (Pseudo-Sta□c)	5,6,2,1	565 ft²
Region 2	Hilfiker Wall	19,38,41,32	748 ft²
Region 3	ESU 1A - Exis□ng Granular Fill (Pseudo-Sta□c)	20,22,21	484 ft²
Region 4	ESU 2A - Na□ve Sand and Gravel	6,2,3	619.5 ft²
Region 5	ESU 2B - Na□ve Sand and Gravel	7,16,15,14,13,12,11,10,9,4	2,595.4 ft²
Region 6	ESU 7A - Weathered Sandstone	18,17,5,6,3,4,9,10,11,12	12,178 ft²
Region 7	ESU 1B - Exis□ng Gravelly Granular Fill	8,31,25,7	60 ft²
Region 8	ESU 2A - Na□ve Sand and Gravel	4,7,25,26,2,3	945 ft²
Region 9	ESU 1B - Exis□ng Gravelly Granular Fill	21,22,27,29,34	272.25 ft²
Region 10	ESU 1B - Exis□ng Gravelly Granular Fill	23,24,1,2,26,30,29,27	1,077.8 ft²
Region 11	ESU 1B - Exis□ng Gravelly Granular Fill	29,30,37,39	105 ft²
Region 12	ESU 1B - Exis□ng Gravelly Granular Fill	30,26,25,31,37	80 ft²
Region 13	ESU 1B - Exis□ng Gravelly Granular Fill	29,39,40,34	24 ft²
Region 14	Hilfiker Wall	32,41,40,35,33	51 ft²
Region 15	Hilfiker Wall	28,33,35,36	16 ft²
Region 16	Hilfiker Wall	31,8,28,36,39,37	595 ft²
Region 17	Hilfiker Wall	36,35,40,39	120 ft²
Region 18	ESU 1B - Exis□ng Gravelly Granular Fill	21,34,40,41	9 ft²
Region 19	ESU 1A - Exis□ng Granular Fill (Pseudo-Sta□c)	20,21,41,38	132 ft²

Slip Results

Slip Surfaces Analysed: 3994 of 8405 converged

Current Slip Surface

Slip Surface: 6,453
Factor of Safety: 1.799
Volume: 3,776.0829 ft³

Weight: 483,975.13 lbf
Resis□ng Moment: 40,684,148 lbf·ft
Ac□va□ng Moment: 22,619,855 lbf·ft
Resis□ng Force: 336,605.64 lbf
Ac□va□ng Force: 187,142.8 lbf
Slip Rank: 1 of 8,405 slip surfaces
Exit: (243.1241, 48.210155) ft
Entry: (93.479862, 80.739931) ft
Radius: 110.4308 ft
Center: (185.20513, 142.23332) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Fric□onal Strength	Cohesive Strength	Suc□on Strength	Base Material
Slice 1	95.614931 ft	77.772526 ft	-2,146.4056 psf	262.00178 psf	219.8456 psf	50 psf	0 psf	ESU 1A - Exis□ng Granular Fill (Pseudo-Sta□c)
Slice 2	98.868169 ft	73.402561 ft	-1,873.7198 psf	696.74959 psf	584.64233 psf	50 psf	0 psf	ESU 1A - Exis□ng Granular Fill (Pseudo-Sta□c)
Slice 3	102.41046 ft	69.25 ft	-1,614.6 psf	1,177.5621 psf	920.01232 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 4	107.36215 ft	63.985506 ft	-1,286.0956 psf	1,772.3797 psf	1,384.7348 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 5	112.41729 ft	59.253879 ft	-990.84205 psf	2,347.9368 psf	1,834.4092 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 6	117.47243 ft	55.072568 ft	-729.92827 psf	2,907.6684 psf	2,271.7195 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 7	121.5 ft	52.048811 ft	-541.24579 psf	3,383.911 psf	2,643.801 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 8	124.5 ft	50.001956 ft	-415.43225 psf	3,594.5523 psf	2,808.3721 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly

								Granular Fill
Slice 9	127.64914 ft	48.007341 ft	-294.97858 psf	4,055.7862 psf	3,168.7275 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 10	132.92455 ft	45.049226 ft	-117.11033 psf	4,429.6466 psf	3,587.0571 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 11	138.98198 ft	41.977567 ft	66.847254 psf	4,912.2942 psf	3,923.7656 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 12	143.84427 ft	39.874313 ft	191.89831 psf	5,321.6575 psf	4,153.9971 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 13	148.70656 ft	38.04032 ft	300.14751 psf	5,753.7091 psf	4,416.2071 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 14	153.56885 ft	36.461541 ft	392.47133 psf	6,211.7242 psf	4,712.3381 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 15	157.41187 ft	35.367193 ft	455.86466 psf	6,594.3669 psf	4,970.8611 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 16	159.28687 ft	34.888179 ft	483.36742 psf	6,872.756 psf	5,753.0313 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 17	159.875 ft	34.7469 ft	491.59342 psf	6,939.5375 psf	5,805.7549 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 18	162.5625 ft	34.180467 ft	526.93884 psf	1,774.9683 psf	1,123.7308 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 19	167.6875 ft	33.231673 ft	586.14362 psf	2,089.1393 psf	1,353.3034 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 20	172.75 ft	32.536002 ft	629.5535 psf	2,397.3749 psf	1,591.7536 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 21	177.70833 ft	32.084833 ft	657.70641 psf	2,689.4974 psf	1,829.4328 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 22	182.625 ft	31.86005 ft	671.73289 psf	2,958.6662 psf	2,059.164 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 23	187.54167 ft	31.854622 ft	672.07162 psf	3,193.5771 psf	2,270.3738 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 24	191 ft	31.95921 ft	665.54529 psf	3,321.0072 psf	2,390.9886 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 25	194.52095 ft	32.225241 ft	648.94494 psf	3,372.0858 psf	2,451.927 psf	0 psf	0 psf	ESU 7A - Weathered

								Sandstone
Slice 26	199.56285 ft	32.76938 ft	614.99067 psf	3,381.3836 psf	2,490.8714 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 27	204.60475 ft	33.550019 ft	566.27882 psf	3,294.3014 psf	2,456.3226 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 28	208.93785 ft	34.398827 ft	513.3132 psf	3,102.7226 psf	2,250.9393 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 29	212.95833 ft	35.371181 ft	440.59561 psf	2,894.5888 psf	2,133.2237 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 30	217.375 ft	36.61735 ft	338.74925 psf	2,599.8397 psf	1,965.5359 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 31	221.79167 ft	38.06562 ft	224.29186 psf	2,236.7437 psf	1,749.3977 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 32	226.66512 ft	39.921236 ft	81.925024 psf	1,805.8968 psf	1,498.6258 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 33	231.62922 ft	42.066729 ft	-79.024427 psf	1,316.0503 psf	1,144.0251 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 34	236.22717 ft	44.330342 ft	-245.34786 psf	796.78419 psf	692.63393 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 35	240.82513 ft	46.869303 ft	-428.85303 psf	264.66978 psf	230.07393 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel

3.1 Static (Spencer) Section Fa-Fa' - Construction Condition - Global Stability

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File Informa on

File Version: 11.01
Created By: Mikayla S. Hatch
Last Edited By: Amy Nguyen
Revision Number: 377
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Time: 05:25:56 PM
Tool Version: 11.1
File Name: Wall 03.63L - Bridge 17.7 Fa-Fa' - All Condi ons.gsz
Directory: P:\0\0180366\01\Analysis\Bridge 17.7\SlopeW\
Last Solved Date: 11/10/2021
Last Solved Time: 05:31:48 PM

Project Se ngs

Unit System: U.S. Customary Units

Analysis Se ngs

3.1 Sta c (Spencer)

Kind: SLOPE/W
Parent: 3. Global Stability
Analysis Type: Spencer
Se ngs
PWP Condi ons from: Piezometric Line
Apply Phrea c Correc on: No
Use Staged Rapid Drawdown: No
Unit Weight of Water: 62.4 pcf
Slip Surface
Direc on of movement: Le. to Right
Use Passive Mode: No
Slip Surface Op□on: Entry and Exit
Cri□cal slip surfaces saved: 1
Op□mize Cri□cal Slip Surface Loca□on: No
Tension Crack Op□on: (none)
Distribu□on
F of S Calcula□on Op□on: Constant
Advanced
Geometry Se□ ngs
Minimum Slip Surface Depth: 2 ft
Number of Slices: 30
Factor of Safety Convergence Se□ ngs
Maximum Number of Itera□ons: 100
Tolerable difference in F of S: 0.001
Solu□on Se□ ngs
Search Method: Root Finder

Tolerable difference between star□ng and converged F of S: 3
Maximum itera□ons to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Hilfiker Wall

Slope Stability Material Model: High Strength
Unit Weight: 130 pcf
Pore Water Pressure
Piezometric Line: 1

ESU 2A - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 39 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2B - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 41 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 7A - Weathered Sandstone

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 42 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2C - Na ve Silt

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 29 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1B - Exis ng Gravelly Granular Fill

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effec□ve Cohesion: 0 psf

Effec□ve Fric□on Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (1.75, 60) ft
Left-Zone Right Coordinate: (120, 66.5) ft
Left-Zone Increment: 40
Right Type: Range
Right-Zone Left Coordinate: (161.44853, 50.951716) ft
Right-Zone Right Coordinate: (315.5, 48.958333) ft
Right-Zone Increment: 40
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 60) ft
Right Coordinate: (335, 48) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	0.25 ft	43.375 ft
Coordinate 2	56.5 ft	43.375 ft
Coordinate 3	97.75 ft	43.375 ft
Coordinate 4	123 ft	43.375 ft
Coordinate 5	159.75 ft	42.625 ft
Coordinate 6	192 ft	42.625 ft
Coordinate 7	210.75 ft	42.625 ft
Coordinate 8	298 ft	35 ft
Coordinate 9	335.25 ft	35 ft

Geometry

Name: Ga-Ga'

Se ngs

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	0 ft	56 ft

Figure D.4-179

Point 2	76 ft	56 ft
Point 3	118 ft	35 ft
Point 4	160 ft	35 ft
Point 5	0 ft	46 ft
Point 6	37 ft	46 ft
Point 7	190 ft	50 ft
Point 8	160 ft	51 ft
Point 9	170.25 ft	34 ft
Point 10	240 ft	34 ft
Point 11	315 ft	30 ft
Point 12	335 ft	30 ft
Point 13	335 ft	48 ft
Point 14	327 ft	48 ft
Point 15	315 ft	49 ft
Point 16	224 ft	48 ft
Point 17	0 ft	0 ft
Point 18	335 ft	0 ft
Point 19	160 ft	94 ft
Point 20	120 ft	94 ft
Point 21	120 ft	72 ft
Point 22	76 ft	72 ft
Point 23	52 ft	60 ft
Point 24	0 ft	60 ft
Point 25	160 ft	47 ft
Point 26	120 ft	47 ft
Point 27	65 ft	66.5 ft
Point 28	160 ft	66.5 ft
Point 29	120 ft	66.5 ft
Point 30	120 ft	49 ft
Point 31	160 ft	49 ft
Point 32	160 ft	72 ft
Point 33	160 ft	70.5 ft
Point 34	120 ft	70.5 ft
Point 35	156 ft	70.5 ft
Point 36	156 ft	66.5 ft

Regions

	Material	Points	Area
Region 1	ESU 2C - Na□ve Silt	5,6,2,1	565 ft²
Region 2		19,20,21,32	880 ft²
Region 3		20,22,21	484 ft²
Region 4	ESU 2A - Na□ve Sand and Gravel	6,2,3	619.5 ft²
Region 5	ESU 2B - Na□ve Sand and Gravel	7,16,15,14,13,12,11,10,9,4	2,595.4 ft²
Region 6	ESU 7A - Weathered Sandstone	18,17,5,6,3,4,9,10,11,12	12,178 ft²
Region 7	ESU 1B - Exis□ng Gravelly Granular Fill	8,31,25,7	60 ft²
Region 8	ESU 2A - Na□ve Sand and Gravel	4,7,25,26,2,3	945 ft²
Region 9		21,22,27,29,34	272.25 ft²
Region 10	ESU 1B - Exis□ng Gravelly Granular Fill	23,24,1,2,26,30,29,27	1,077.8 ft²
Region 11	Hilfiker Wall	29,30,31,8,28,36	700 ft²

Region 12	ESU 1B - Exis□ng Gravelly Granular Fill	30,26,25,31	80 ft²
Region 13		29,36,35,34	144 ft²
Region 14		32,21,34,35,33	60 ft²
Region 15		28,33,35,36	16 ft²

Slip Results

Slip Surfaces Analysed: 4733 of 8405 converged

Current Slip Surface

Slip Surface: 7,013
Factor of Safety: 4.245
Volume: 1,438.7057 ft³
Weight: 181,687.62 lbf
Resis□ng Moment: 9,422,340.8 lbf·ft
Ac□va□ng Moment: 2,219,587.6 lbf·ft
Resis□ng Force: 135,805.89 lbf
Ac□va□ng Force: 31,990.362 lbf
Slip Rank: 1 of 8,405 slip surfaces
Exit: (192.25544, 49.867327) ft
Entry: (102.03233, 66.5) ft
Radius: 64.648195 ft
Center: (155.40264, 102.98287) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Fric□onal Strength	Cohesive Strength	Suc□on Strength	Base Material
Slice 1	103.52964 ft	64.482617 ft	-1,317.1153 psf	173.64312 psf	135.66487 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 2	106.52425 ft	60.733018 ft	-1,083.1403 psf	520.93138 psf	406.9962 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 3	109.51886 ft	57.49061 ft	-880.81405 psf	846.42601 psf	661.30048 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 4	112.51347 ft	54.651706 ft	-703.66645 psf	1,150.8415 psf	899.13589 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 5	115.50808 ft	52.147929 ft	-547.43078 psf	1,435.1993 psf	1,121.3005 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill

Slice 6	118.50269 ft	49.931413 ft	-409.12019 psf	1,700.5192 psf	1,328.5912 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 7	121.5 ft	47.965634 ft	-286.45558 psf	2,021.4915 psf	1,579.3622 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 8	124.31669 ft	46.318968 ft	-185.38037 psf	2,232.5661 psf	1,807.8964 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 9	126.91436 ft	44.967607 ft	-104.3635 psf	2,415.1795 psf	1,955.7738 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 10	129.47631 ft	43.777636 ft	-33.371896 psf	2,583.6258 psf	2,092.1789 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 11	132.33496 ft	42.613843 ft	35.608417 psf	2,758.8486 psf	2,205.2364 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 12	135.4903 ft	41.500041 ft	101.09144 psf	2,937.6224 psf	2,296.9775 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 13	138.64564 ft	40.565531 ft	155.38661 psf	3,098.8446 psf	2,383.5653 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 14	141.80098 ft	39.802334 ft	198.99186 psf	3,243.0418 psf	2,465.023 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 15	144.95632 ft	39.204283 ft	232.29207 psf	3,370.6005 psf	2,541.3521 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 16	148.11165 ft	38.76675 ft	255.57591 psf	3,481.7826 psf	2,612.5307 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 17	151.26699 ft	38.48646 ft	269.04774 psf	3,576.7348 psf	2,678.5122 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 18	154.42233 ft	38.361363 ft	272.83555 psf	3,655.4942 psf	2,739.223 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 19	157.875 ft	38.409219 ft	265.45249 psf	3,722.0601 psf	2,799.1057 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 20	159.875 ft	38.489676 ft	258.04421 psf	3,755.5226 psf	2,832.2021 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 21	161.66931 ft	38.66098 ft	247.35488 psf	1,590.0874 psf	1,087.3233 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 22	165.00792 ft	39.074508 ft	221.55072 psf	1,551.3777 psf	1,076.8727 psf	0 psf	0 psf	ESU 2A - Na□ve Sand

								and Gravel
Slice 23	168.34654 ft	39.666662 ft	184.6003 psf	1,489.1663 psf	1,056.4167 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 24	171.32438 ft	40.340513 ft	142.55201 psf	1,428.0859 psf	1,117.4976 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 25	173.94146 ft	41.064891 ft	97.350782 psf	1,354.3128 psf	1,092.6604 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 26	176.90558 ft	42.04084 ft	36.451584 psf	1,245.4954 psf	1,051.0058 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 27	179.99102 ft	43.213222 ft	-36.705033 psf	1,099.5597 psf	955.83266 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 28	182.85073 ft	44.472206 ft	-115.26566 psf	924.24612 psf	803.4349 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 29	185.71044 ft	45.90217 ft	-204.49541 psf	710.07196 psf	617.25614 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 30	188.57015 ft	47.516387 ft	-305.22254 psf	449.75519 psf	390.96622 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 31	191 ft	49.031203 ft	-399.74709 psf	172.30154 psf	149.77944 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 32	192.12772 ft	49.779166 ft	-446.41994 psf	18.414897 psf	16.007826 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel

3.2 Static (M-P) Section Fa-Fa' - Construction Condition - Global Stability

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File Informa on

File Version: 11.01
Created By: Mikayla S. Hatch
Last Edited By: Amy Nguyen
Revision Number: 377
Date: 11/10/2021
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Tool Version: 11.1
File Name: Wall 03.63L - Bridge 17.7 Fa-Fa' - All Condi ons.gsz
Directory: P:\0\0180366\01\Analysis\Bridge 17.7\SlopeW\
Last Solved Date: 11/10/2021
Last Solved Time: 05:32:10 PM

Project Se ngs

Unit System: U.S. Customary Units

Analysis Se ngs

3.2 Sta c (M-P)

Kind: SLOPE/W
Parent: 3. Global Stability
Analysis Type: Morgenstern-Price
Se ngs
Side Func on
Interslice force func on op on: Half-Sine
PWP Condi ons from: Piezometric Line
Apply Phrea c Correc on: No
Use Staged Rapid Drawdown: No
Unit Weight of Water: 62.4 pcf
Slip Surface
Direc on of movement: Le. to Right
Use Passive Mode: No
Slip Surface Op on: Entry and Exit
Cri cal slip surfaces saved: 1
Op mize Cri cal Slip Surface Loca on: No
Tension Crack Op on: (none)
Distribu on
F of S Calcula on Op on: Constant
Advanced
Geometry Se ngs
Minimum Slip Surface Depth: 2 ft
Number of Slices: 30
Factor of Safety Convergence Se ngs
Maximum Number of Itera ons: 100
Tolerable difference in F of S: 0.001

Figure D.4-184

Solu□on Se□ ngs
Search Method: Root Finder
Tolerable difference between star□ng and converged F of S: 3
Maximum itera□ons to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Hilfiker Wall

Slope Stability Material Model: High Strength
Unit Weight: 130 pcf
Pore Water Pressure
Piezometric Line: 1

ESU 2A - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 39 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2B - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 41 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 7A - Weathered Sandstone

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 42 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2C - Na ve Silt

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 29 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1B - Exis ng Gravelly Granular Fill

Slope Stability Material Model: Mohr-Coulomb

Unit Weight: 125 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (1.75, 60) ft
Left-Zone Right Coordinate: (120, 66.5) ft
Left-Zone Increment: 40
Right Type: Range
Right-Zone Left Coordinate: (161.44853, 50.951716) ft
Right-Zone Right Coordinate: (315.5, 48.958333) ft
Right-Zone Increment: 40
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 60) ft
Right Coordinate: (335, 48) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	0.25 ft	43.375 ft
Coordinate 2	56.5 ft	43.375 ft
Coordinate 3	97.75 ft	43.375 ft
Coordinate 4	123 ft	43.375 ft
Coordinate 5	159.75 ft	42.625 ft
Coordinate 6	192 ft	42.625 ft
Coordinate 7	210.75 ft	42.625 ft
Coordinate 8	298 ft	35 ft
Coordinate 9	335.25 ft	35 ft

Geometry

Name: Ga-Ga'

Se ngs

View: 2D
Element Thickness: 1 ft

Points

	X	Y

Figure D.4-186

Point 1	0 ft	56 ft
Point 2	76 ft	56 ft
Point 3	118 ft	35 ft
Point 4	160 ft	35 ft
Point 5	0 ft	46 ft
Point 6	37 ft	46 ft
Point 7	190 ft	50 ft
Point 8	160 ft	51 ft
Point 9	170.25 ft	34 ft
Point 10	240 ft	34 ft
Point 11	315 ft	30 ft
Point 12	335 ft	30 ft
Point 13	335 ft	48 ft
Point 14	327 ft	48 ft
Point 15	315 ft	49 ft
Point 16	224 ft	48 ft
Point 17	0 ft	0 ft
Point 18	335 ft	0 ft
Point 19	160 ft	94 ft
Point 20	120 ft	94 ft
Point 21	120 ft	72 ft
Point 22	76 ft	72 ft
Point 23	52 ft	60 ft
Point 24	0 ft	60 ft
Point 25	160 ft	47 ft
Point 26	120 ft	47 ft
Point 27	65 ft	66.5 ft
Point 28	160 ft	66.5 ft
Point 29	120 ft	66.5 ft
Point 30	120 ft	49 ft
Point 31	160 ft	49 ft
Point 32	160 ft	72 ft
Point 33	160 ft	70.5 ft
Point 34	120 ft	70.5 ft
Point 35	156 ft	70.5 ft
Point 36	156 ft	66.5 ft

Regions

	Material	Points	Area
Region 1	ESU 2C - Na□ve Silt	5,6,2,1	565 ft²
Region 2		19,20,21,32	880 ft²
Region 3		20,22,21	484 ft²
Region 4	ESU 2A - Na□ve Sand and Gravel	6,2,3	619.5 ft²
Region 5	ESU 2B - Na□ve Sand and Gravel	7,16,15,14,13,12,11,10,9,4	2,595.4 ft²
Region 6	ESU 7A - Weathered Sandstone	18,17,5,6,3,4,9,10,11,12	12,178 ft²
Region 7	ESU 1B - Exis□ng Gravelly Granular Fill	8,31,25,7	60 ft²
Region 8	ESU 2A - Na□ve Sand and Gravel	4,7,25,26,2,3	945 ft²
Region 9		21,22,27,29,34	272.25 ft²
Region 10	ESU 1B - Exis□ng Gravelly Granular Fill	23,24,1,2,26,30,29,27	1,077.8 ft²

Region 11	Hilfiker Wall	29,30,31,8,28,36	700 ft²
Region 12	ESU 1B - Exis□ng Gravelly Granular Fill	30,26,25,31	80 ft²
Region 13		29,36,35,34	144 ft²
Region 14		32,21,34,35,33	60 ft²
Region 15		28,33,35,36	16 ft²

Slip Results

Slip Surfaces Analysed: 5207 of 8405 converged

Current Slip Surface

Slip Surface: 7,013
Factor of Safety: 4.244
Volume: 1,438.7057 ft³
Weight: 181,687.62 lbf
Resis□ng Moment: 9,420,836.1 lbf·ft
Ac□va□ng Moment: 2,219,587.6 lbf·ft
Resis□ng Force: 135,775.94 lbf
Ac□va□ng Force: 31,988.106 lbf
Slip Rank: 1 of 8,405 slip surfaces
Exit: (192.25544, 49.867327) ft
Entry: (102.03233, 66.5) ft
Radius: 64.648195 ft
Center: (155.40264, 102.98287) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Fric□onal Strength	Cohesive Strength	Suc□on Strength	Base Material
Slice 1	103.52964 ft	64.482617 ft	-1,317.1153 psf	197.79484 psf	154.53427 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 2	106.52425 ft	60.733018 ft	-1,083.1403 psf	568.96939 psf	444.52761 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 3	109.51886 ft	57.49061 ft	-880.81405 psf	892.57086 psf	697.35278 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 4	112.51347 ft	54.651706 ft	-703.66645 psf	1,180.5351 psf	922.33513 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 5	115.50808 ft	52.147929 ft	-547.43078 psf	1,441.359 psf	1,126.1131 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly

								Granular Fill
Slice 6	118.50269 ft	49.931413 ft	-409.12019 psf	1,681.2708 psf	1,313.5527 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 7	121.5 ft	47.965634 ft	-286.45558 psf	1,979.3836 psf	1,546.464 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 8	124.31669 ft	46.318968 ft	-185.38037 psf	2,171.2707 psf	1,758.2603 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 9	126.91436 ft	44.967607 ft	-104.3635 psf	2,341.7052 psf	1,896.2755 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 10	129.47631 ft	43.777636 ft	-33.371896 psf	2,503.5923 psf	2,027.3691 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 11	132.33496 ft	42.613843 ft	35.608417 psf	2,678.1944 psf	2,139.924 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 12	135.4903 ft	41.500041 ft	101.09144 psf	2,863.9471 psf	2,237.3164 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 13	138.64564 ft	40.565531 ft	155.38661 psf	3,039.8566 psf	2,335.7977 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 14	141.80098 ft	39.802334 ft	198.99186 psf	3,205.2791 psf	2,434.4434 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 15	144.95632 ft	39.204283 ft	232.29207 psf	3,358.7579 psf	2,531.7621 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 16	148.11165 ft	38.76675 ft	255.57591 psf	3,498.0806 psf	2,625.7285 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 17	151.26699 ft	38.48646 ft	269.04774 psf	3,620.3567 psf	2,713.8365 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 18	154.42233 ft	38.361363 ft	272.83555 psf	3,722.127 psf	2,793.1811 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 19	157.875 ft	38.409219 ft	265.45249 psf	3,804.2059 psf	2,865.626 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 20	159.875 ft	38.489676 ft	258.04421 psf	3,841.1736 psf	2,901.561 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 21	161.66931 ft	38.66098 ft	247.35488 psf	1,664.0916 psf	1,147.2508 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel

Slice 22	165.00792 ft	39.074508 ft	221.55072 psf	1,626.5662 psf	1,137.7591 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 23	168.34654 ft	39.666662 ft	184.6003 psf	1,556.6768 psf	1,111.0857 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 24	171.32438 ft	40.340513 ft	142.55201 psf	1,480.6315 psf	1,163.1747 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 25	173.94146 ft	41.064891 ft	97.350782 psf	1,387.4634 psf	1,121.4778 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 26	176.90558 ft	42.04084 ft	36.451584 psf	1,251.5652 psf	1,056.2821 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 27	179.99102 ft	43.213222 ft	-36.705033 psf	1,075.8383 psf	935.21193 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 28	182.85073 ft	44.472206 ft	-115.26566 psf	877.18936 psf	762.52907 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 29	185.71044 ft	45.90217 ft	-204.49541 psf	649.54408 psf	564.64006 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 30	188.57015 ft	47.516387 ft	-305.22254 psf	393.87443 psf	342.38982 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 31	191 ft	49.031203 ft	-399.74709 psf	144.59239 psf	125.69224 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 32	192.12772 ft	49.779166 ft	-446.41994 psf	15.073666 psf	13.103338 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel

5.1 Static (Spencer) Section Fa-Fa' - Final Condition - Global Stability

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File Informa on

File Version: 11.01
Created By: Mikayla S. Hatch
Last Edited By: Mikayla S. Hatch
Revision Number: 403
Date: 11/12/2021
Time: 03:57:57 PM
Tool Version: 11.1
File Name: Wall 03.63L - Bridge 17.7 Fa-Fa' - All Condi ons.gsz
Directory: P:\0\0180366\01\Analysis\Bridge 17.7\SlopeW\
Last Solved Date: 11/12/2021
Last Solved Time: 03:58:10 PM

Project Se ngs

Unit System: U.S. Customary Units

Analysis Se ngs

5.1 Sta c (Spencer)

Kind: SLOPE/W
Parent: 5. Global Stability
Analysis Type: Spencer
Se ngs
PWP Condi ons from: Piezometric Line
Apply Phrea c Correc on: No
Use Staged Rapid Drawdown: No
Unit Weight of Water: 62.4 pcf
Slip Surface
Direc on of movement: Le. to Right
Use Passive Mode: No
Slip Surface Op on: Entry and Exit
Cri cal slip surfaces saved: 1
Op mize Cri cal Slip Surface Loca on: No
Tension Crack Op on: (none)
Distribu on
F of S Calcula on Op on: Constant
Advanced
Geometry Se ngs
Minimum Slip Surface Depth: 2 ft
Number of Slices: 30
Factor of Safety Convergence Se ngs
Maximum Number of Itera ons: 100
Tolerable difference in F of S: 0.001
Solu on Se ngs
Search Method: Root Finder

Tolerable difference between star□ng and converged F of S: 3
Maximum itera□ons to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Gravel Borrow

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2A - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 39 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2B - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 41 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 7A - Weathered Sandstone

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 42 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2C - Na ve Silt

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 29 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1B - Exis ng Gravelly Granular Fill

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Common Borrow

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

New Hilfiker Wall

Slope Stability Material Model: High Strength
Unit Weight: 130 pcf
Pore Water Pressure
Piezometric Line: 1

New Pier 1 Foo ng

Slope Stability Material Model: High Strength
Unit Weight: 2,250 pcf
Pore Water Pressure
Piezometric Line: 1

Reinforcements

Soil Nail_Row 2

Type: Anchor
Pullout Resistance: 1,800 psf
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 82,550 lbf
Tensile Capacity Reduc□on Factor: 1
Shear Force: 0 lbf
Shear Force Reduc□on Factor: 1
Apply Shear: Parallel to Slip
F of S Dependent: No
Force Distribu□on: Distributed
Bond Length: 45 ft
Bond Diameter: 0.5 ft
Out-of-Plane Spacing: 4 ft
Face Anchorage: Yes
Factored Pullout Resistance: 706.86 lbf/ft/ft
Factored Tensile Capacity: 20,638 lbf/ft

Soil Nail_Row 1

Type: Anchor
Pullout Resistance: 1,800 psf

Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 82,550 lbf
Tensile Capacity Reduc□on Factor: 1
Shear Force: 0 lbf
Shear Force Reduc□on Factor: 1
Apply Shear: Parallel to Slip
F of S Dependent: No
Force Distribu□on: Distributed
Bond Length: 45 ft
Bond Diameter: 0.5 ft
Out-of-Plane Spacing: 4 ft
Face Anchorage: Yes
Factored Pullout Resistance: 706.86 lbf/ft/ft
Factored Tensile Capacity: 20,638 lbf/ft

Soil Nail_Row 3

Type: Anchor
Pullout Resistance: 1,800 psf
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 82,550 lbf
Tensile Capacity Reduc□on Factor: 1
Shear Force: 0 lbf
Shear Force Reduc□on Factor: 1
Apply Shear: Parallel to Slip
F of S Dependent: No
Force Distribu□on: Distributed
Bond Length: 40 ft
Bond Diameter: 0.5 ft
Out-of-Plane Spacing: 4 ft
Face Anchorage: Yes
Factored Pullout Resistance: 706.86 lbf/ft/ft
Factored Tensile Capacity: 20,638 lbf/ft

Soil Nail_Row 4

Type: Anchor
Pullout Resistance: 1,800 psf
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 82,550 lbf
Tensile Capacity Reduc□on Factor: 1
Shear Force: 0 lbf
Shear Force Reduc□on Factor: 1
Apply Shear: Parallel to Slip
F of S Dependent: No
Force Distribu□on: Distributed
Bond Length: 40 ft
Bond Diameter: 0.5 ft
Out-of-Plane Spacing: 4 ft
Face Anchorage: Yes
Factored Pullout Resistance: 706.86 lbf/ft/ft
Factored Tensile Capacity: 20,638 lbf/ft

Slip Surface Entry and Exit

Left Type: Range

Left-Zone Left Coordinate: (1.75, 60) ft
Left-Zone Right Coordinate: (121, 94) ft
Left-Zone Increment: 40
Right Type: Range
Right-Zone Left Coordinate: (161.44853, 50.951716) ft
Right-Zone Right Coordinate: (315.5, 48.958333) ft
Right-Zone Increment: 40
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 60) ft
Right Coordinate: (335, 48) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	0.25 ft	43.375 ft
Coordinate 2	56.5 ft	43.375 ft
Coordinate 3	97.75 ft	43.375 ft
Coordinate 4	123 ft	43.375 ft
Coordinate 5	159.75 ft	42.625 ft
Coordinate 6	192 ft	42.625 ft
Coordinate 7	210.75 ft	42.625 ft
Coordinate 8	298 ft	35 ft
Coordinate 9	335.25 ft	35 ft

Reinforcement Lines

Reinforcement Line 1

Reinforcement: Soil Nail_Row 1
Lock to Ground Surface: Yes
Outside Point: (160, 64.5) ft
Inside Point: (115.68365, 56.685832) ft
Length: 45.000001 ft
Orienta□on: -170 °
Slip Surface Intersec□on: (126.38574, 58.5729) ft
Max. Pullout Force: 20,637.5 lbf
Bond Length: 45 ft
Available Length: 10.867192 ft
Required Length: 10.867192 ft
Pullout Force: 7,681.5652 lbf
Pullout Force per Length: 706.85835 lbf/ft
Governing Component: Pullout Resistance

Reinforcement Line 2

Reinforcement: Soil Nail_Row 2
Lock to Ground Surface: Yes
Outside Point: (160, 60.5) ft
Inside Point: (115.68365, 52.685832) ft
Length: 45.000001 ft
Orienta□on: -170 °
Slip Surface Intersec□on: (129.64464, 55.147531) ft
Max. Pullout Force: 20,637.5 lbf
Bond Length: 45 ft
Available Length: 14.176362 ft
Required Length: 14.176362 ft
Pullout Force: 10,020.68 lbf
Pullout Force per Length: 706.85835 lbf/ft
Governing Component: Pullout Resistance

Reinforcement Line 3

Reinforcement: Soil Nail_Row 3
Lock to Ground Surface: Yes
Outside Point: (160, 56.5) ft
Inside Point: (120.60769, 49.554073) ft
Length: 40 ft
Orienta□on: -170 °
Slip Surface Intersec□on: (133.28607, 51.789613) ft
Max. Pullout Force: 20,637.5 lbf
Bond Length: 40 ft
Available Length: 12.87396 ft
Required Length: 12.87396 ft
Pullout Force: 9,100.0664 lbf
Pullout Force per Length: 706.85835 lbf/ft
Governing Component: Pullout Resistance

Reinforcement Line 4

Reinforcement: Soil Nail_Row 4
Lock to Ground Surface: Yes
Outside Point: (160, 52.5) ft
Inside Point: (120.60769, 45.554073) ft
Length: 40 ft
Orienta□on: -170 °
Slip Surface Intersec□on: (137.35633, 48.50731) ft
Max. Pullout Force: 20,637.5 lbf
Bond Length: 40 ft
Available Length: 17.007013 ft
Required Length: 17.007013 ft
Pullout Force: 12,021.549 lbf
Pullout Force per Length: 706.85835 lbf/ft
Governing Component: Pullout Resistance

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 250 pcf
Direc□on: Ver□cal

Coordinates

	X	Y
	120 ft	95 ft
	160 ft	95 ft

Geometry

Name: Fa-Fa'

Se ngs

View: 2D

Element Thickness: 1 ft

Points

	X	Y
Point 1	0 ft	56 ft
Point 2	76 ft	56 ft
Point 3	118 ft	35 ft
Point 4	160 ft	35 ft
Point 5	0 ft	46 ft
Point 6	37 ft	46 ft
Point 7	190 ft	50 ft
Point 8	160 ft	51 ft
Point 9	170.25 ft	34 ft
Point 10	240 ft	34 ft
Point 11	315 ft	30 ft
Point 12	335 ft	30 ft
Point 13	335 ft	48 ft
Point 14	327 ft	48 ft
Point 15	315 ft	49 ft
Point 16	224 ft	48 ft
Point 17	0 ft	0 ft
Point 18	335 ft	0 ft
Point 19	160 ft	94 ft
Point 20	120 ft	94 ft
Point 21	120 ft	72 ft
Point 22	76 ft	72 ft
Point 23	52 ft	60 ft
Point 24	0 ft	60 ft
Point 25	160 ft	47 ft
Point 26	120 ft	47 ft
Point 27	65 ft	66.5 ft
Point 28	160 ft	66.5 ft
Point 29	120 ft	66.5 ft
Point 30	120 ft	49 ft
Point 31	160 ft	49 ft
Point 32	160 ft	72 ft
Point 33	160 ft	70.5 ft
Point 34	120 ft	70.5 ft

Point 35	156 ft	70.5 ft
Point 36	156 ft	66.5 ft
Point 37	126 ft	49 ft
Point 38	126 ft	94 ft
Point 39	126 ft	66.5 ft
Point 40	126 ft	70.5 ft
Point 41	126 ft	72 ft

Regions

	Material	Points	Area
Region 1	ESU 2C - Na□ve Silt	5,6,2,1	565 ft²
Region 2	New Hilfiker Wall	19,38,41,32	748 ft²
Region 3	Common Borrow	20,22,21	484 ft²
Region 4	ESU 2A - Na□ve Sand and Gravel	6,2,3	619.5 ft²
Region 5	ESU 2B - Na□ve Sand and Gravel	7,16,15,14,13,12,11,10,9,4	2,595.4 ft²
Region 6	ESU 7A - Weathered Sandstone	18,17,5,6,3,4,9,10,11,12	12,178 ft²
Region 7	ESU 1B - Exis□ng Gravelly Granular Fill	8,31,25,7	60 ft²
Region 8	ESU 2A - Na□ve Sand and Gravel	4,7,25,26,2,3	945 ft²
Region 9	Common Borrow	21,22,27,29,34	272.25 ft²
Region 10	ESU 1B - Exis□ng Gravelly Granular Fill	23,24,1,2,26,30,29,27	1,077.8 ft²
Region 11	ESU 1B - Exis□ng Gravelly Granular Fill	29,30,37,39	105 ft²
Region 12	ESU 1B - Exis□ng Gravelly Granular Fill	30,26,25,31,37	80 ft²
Region 13	New Pier 1 Foo□ng	29,39,40,34	24 ft²
Region 14	New Hilfiker Wall	32,41,40,35,33	51 ft²
Region 15	Gravel Borrow	28,33,35,36	16 ft²
Region 16	ESU 1B - Exis□ng Gravelly Granular Fill	31,8,28,36,39,37	595 ft²
Region 17	New Pier 1 Foo□ng	36,35,40,39	120 ft²
Region 18	Common Borrow	21,34,40,41	9 ft²
Region 19	Common Borrow	20,21,41,38	132 ft²

Slip Results

Slip Surfaces Analysed: 4528 of 8405 converged

Current Slip Surface

Slip Surface: 7,474
Factor of Safety: 1.777
Volume: 2,915.9591 ft³
Weight: 677,979.93 lbf
Resis□ng Moment: 41,132,607 lbf·ft
Ac□va□ng Moment: 23,150,763 lbf·ft
Resis□ng Force: 438,578.15 lbf
Ac□va□ng Force: 246,778.68 lbf
Slip Rank: 1 of 8,405 slip surfaces
Exit: (230.73349, 48.073994) ft
Entry: (109.51049, 88.755244) ft
Radius: 77.974101 ft
Center: (184.32339, 110.73229) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Fric□onal Strength	Cohesive Strength	Suc□on Strength	Base Material
Slice 1	111.29521 ft	83.898173 ft	-2,528.646 psf	268.00804 psf	167.47001 psf	0 psf	0 psf	Common Borrow
Slice 2	114.86466 ft	75.520551 ft	-2,005.8824 psf	902.94667 psf	564.2237 psf	0 psf	0 psf	Common Borrow
Slice 3	118.32469 ft	69.329459 ft	-1,619.5583 psf	1,518.8544 psf	949.08559 psf	0 psf	0 psf	Common Borrow
Slice 4	121.5 ft	64.615517 ft	-1,325.4083 psf	6,601.9721 psf	5,158.0259 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 5	124.5 ft	60.77585 ft	-1,087.7232 psf	7,419.8975 psf	5,797.0593 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 6	127.78141 ft	57.101473 ft	-862.62088 psf	8,357.2885 psf	6,529.4294 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 7	131.34424 ft	53.572248 ft	-646.9344 psf	9,208.8727 psf	7,194.7599 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 8	134.90707 ft	50.460567 ft	-457.30266 psf	10,030.759 psf	7,836.8878 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 9	138.04399 ft	48 ft	-307.75806 psf	10,903.914 psf	8,519.0711 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 10	141.01309 ft	45.921708 ft	-181.85368 psf	11,349.376 psf	9,190.5435 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 11	144.24025 ft	43.876005 ft	-58.311546 psf	11,962.202 psf	9,686.8006 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 12	147.54486 ft	42.003681 ft	54.313161 psf	12,560.722 psf	10,127.49 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 13	150.92692 ft	40.296977 ft	156.50455 psf	13,184.039 psf	10,549.489 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 14	154.30897 ft	38.789692 ft	246.25223 psf	13,794.175 psf	10,970.892 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel

Slice 15	157.875 ft	37.407877 ft	327.93626 psf	6,940.3702 psf	5,354.6434 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 16	159.875 ft	36.690283 ft	370.32636 psf	13,184.165 psf	10,376.442 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 17	161.01378 ft	36.331394 ft	392.72103 psf	1,614.2602 psf	989.18294 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 18	164.13637 ft	35.448312 ft	447.82535 psf	1,762.8726 psf	1,143.1532 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 19	168.354 ft	34.441422 ft	510.65527 psf	1,967.8193 psf	1,266.6934 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 20	172.85641 ft	33.643951 ft	560.41749 psf	2,165.7829 psf	1,445.4775 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 21	177.09375 ft	33.116163 ft	593.35143 psf	2,332.7327 psf	1,566.1459 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 22	180.78125 ft	32.860559 ft	609.30113 psf	2,458.9644 psf	1,665.4443 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 23	184.46875 ft	32.780131 ft	614.31985 psf	2,568.744 psf	1,759.7714 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 24	188.15625 ft	32.874335 ft	608.44151 psf	2,661.5229 psf	1,848.6028 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 25	191 ft	33.051049 ft	597.41452 psf	2,709.966 psf	1,902.1499 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 26	193.54599 ft	33.321184 ft	580.5581 psf	2,716.8997 psf	1,923.5707 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 27	196.63797 ft	33.752685 ft	553.63245 psf	2,711.3748 psf	1,942.8399 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 28	200.2783 ft	34.437975 ft	510.87035 psf	2,654.118 psf	1,863.0968 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 29	204.46698 ft	35.436239 ft	448.57867 psf	2,578.9753 psf	1,851.9255 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 30	208.65566 ft	36.684736 ft	370.6725 psf	2,459.4907 psf	1,815.782 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 31	213.23425 ft	38.365409 ft	252.25113 psf	2,272.2245 psf	1,755.936 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 32	218.20274 ft	40.557229 ft	88.386947 psf	1,989.3629 psf	1,652.4932 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel

Slice 33	222.34349 ft	42.682083 ft	-66.784718 psf	1,604.6837 psf	1,394.9303 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 34	225.68337 ft	44.661365 ft	-208.50528 psf	1,116.8693 psf	970.87966 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 35	229.05012 ft	46.89457 ft	-366.21712 psf	446.39051 psf	388.04135 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel

5.2 Static (M-P) Section Fa-Fa' - Final Condition - Global Stability

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File Informa on

File Version: 11.01
Created By: Mikayla S. Hatch
Last Edited By: Mikayla S. Hatch
Revision Number: 403
Date: 11/12/2021
Time: 03:57:57 PM
Tool Version: 11.1
File Name: Wall 03.63L - Bridge 17.7 Fa-Fa' - All Condi ons.gsz
Directory: P:\0\0180366\01\Analysis\Bridge 17.7\SlopeW\
Last Solved Date: 11/12/2021
Last Solved Time: 03:58:26 PM

Project Se ngs

Unit System: U.S. Customary Units

Analysis Se ngs

5.2 Sta c (M-P)

Kind: SLOPE/W
Parent: 5. Global Stability
Analysis Type: Morgenstern-Price
Se ngs
Side Func on
Interslice force func on op on: Half-Sine
PWP Condi ons from: Piezometric Line
Apply Phrea c Correc on: No
Use Staged Rapid Drawdown: No
Unit Weight of Water: 62.4 pcf
Slip Surface
Direc on of movement: Le. to Right
Use Passive Mode: No
Slip Surface Op on: Entry and Exit
Cri cal slip surfaces saved: 1
Op mize Cri cal Slip Surface Loca on: No
Tension Crack Op on: (none)
Distribu on
F of S Calcula on Op on: Constant
Advanced
Geometry Se ngs
Minimum Slip Surface Depth: 2 ft
Number of Slices: 30
Factor of Safety Convergence Se ngs
Maximum Number of Itera ons: 100
Tolerable difference in F of S: 0.001

Figure D.4-202

Solu□on Se□ ngs
Search Method: Root Finder
Tolerable difference between star□ng and converged F of S: 3
Maximum itera□ons to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Gravel Borrow

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2A - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 39 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2B - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 41 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 7A - Weathered Sandstone

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 42 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2C - Na ve Silt

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 29 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1B - Exis ng Gravelly Granular Fill

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effec ve Cohesion: 0 psf
Effec ve Fric on Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Common Borrow

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec ve Cohesion: 0 psf
Effec ve Fric on Angle: 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

New Hilfiker Wall

Slope Stability Material Model: High Strength
Unit Weight: 130 pcf
Pore Water Pressure
Piezometric Line: 1

New Pier 1 Foo ng

Slope Stability Material Model: High Strength
Unit Weight: 2,250 pcf
Pore Water Pressure
Piezometric Line: 1

Reinforcements

Soil Nail_Row 2

Type: Anchor
Pullout Resistance: 1,800 psf
Pullout Resistance Reduc on Factor: 1
Tensile Capacity: 82,550 lbf
Tensile Capacity Reduc on Factor: 1
Shear Force: 0 lbf
Shear Force Reduc on Factor: 1
Apply Shear: Parallel to Slip
F of S Dependent: No
Force Distribu on: Distributed
Bond Length: 45 ft
Bond Diameter: 0.5 ft
Out-of-Plane Spacing: 4 ft
Face Anchorage: Yes
Factored Pullout Resistance: 706.86 lbf/ft/ft
Factored Tensile Capacity: 20,638 lbf/ft

Soil Nail_Row 1

Type: Anchor

Pullout Resistance: 1,800 psf
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 82,550 lbf
Tensile Capacity Reduc□on Factor: 1
Shear Force: 0 lbf
Shear Force Reduc□on Factor: 1
Apply Shear: Parallel to Slip
F of S Dependent: No
Force Distribu□on: Distributed
Bond Length: 45 ft
Bond Diameter: 0.5 ft
Out-of-Plane Spacing: 4 ft
Face Anchorage: Yes
Factored Pullout Resistance: 706.86 lbf/ft/ft
Factored Tensile Capacity: 20,638 lbf/ft

Soil Nail_Row 3

Type: Anchor
Pullout Resistance: 1,800 psf
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 82,550 lbf
Tensile Capacity Reduc□on Factor: 1
Shear Force: 0 lbf
Shear Force Reduc□on Factor: 1
Apply Shear: Parallel to Slip
F of S Dependent: No
Force Distribu□on: Distributed
Bond Length: 40 ft
Bond Diameter: 0.5 ft
Out-of-Plane Spacing: 4 ft
Face Anchorage: Yes
Factored Pullout Resistance: 706.86 lbf/ft/ft
Factored Tensile Capacity: 20,638 lbf/ft

Soil Nail_Row 4

Type: Anchor
Pullout Resistance: 1,800 psf
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 82,550 lbf
Tensile Capacity Reduc□on Factor: 1
Shear Force: 0 lbf
Shear Force Reduc□on Factor: 1
Apply Shear: Parallel to Slip
F of S Dependent: No
Force Distribu□on: Distributed
Bond Length: 40 ft
Bond Diameter: 0.5 ft
Out-of-Plane Spacing: 4 ft
Face Anchorage: Yes
Factored Pullout Resistance: 706.86 lbf/ft/ft
Factored Tensile Capacity: 20,638 lbf/ft

Slip Surface Entry and Exit

Figure D.4-205

Left Type: Range
Left-Zone Left Coordinate: (1.75, 60) ft
Left-Zone Right Coordinate: (121, 94) ft
Left-Zone Increment: 40
Right Type: Range
Right-Zone Left Coordinate: (161.44853, 50.951716) ft
Right-Zone Right Coordinate: (315.5, 48.958333) ft
Right-Zone Increment: 40
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 60) ft
Right Coordinate: (335, 48) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	0.25 ft	43.375 ft
Coordinate 2	56.5 ft	43.375 ft
Coordinate 3	97.75 ft	43.375 ft
Coordinate 4	123 ft	43.375 ft
Coordinate 5	159.75 ft	42.625 ft
Coordinate 6	192 ft	42.625 ft
Coordinate 7	210.75 ft	42.625 ft
Coordinate 8	298 ft	35 ft
Coordinate 9	335.25 ft	35 ft

Reinforcement Lines

Reinforcement Line 1

Reinforcement: Soil Nail_Row 1
Lock to Ground Surface: Yes
Outside Point: (160, 64.5) ft
Inside Point: (115.68365, 56.685832) ft
Length: 45.000001 ft
Orienta□on: -170 °
Slip Surface Intersec□on: (126.38574, 58.5729) ft
Max. Pullout Force: 20,637.5 lbf
Bond Length: 45 ft
Available Length: 10.867192 ft
Required Length: 10.867192 ft
Pullout Force: 7,681.5652 lbf
Pullout Force per Length: 706.85835 lbf/ft
Governing Component: Pullout Resistance

Reinforcement Line 2

Reinforcement: Soil Nail_Row 2
Lock to Ground Surface: Yes
Outside Point: (160, 60.5) ft
Inside Point: (115.68365, 52.685832) ft
Length: 45.000001 ft
Orienta□on: -170 °
Slip Surface Intersec□on: (129.64464, 55.147531) ft
Max. Pullout Force: 20,637.5 lbf
Bond Length: 45 ft
Available Length: 14.176362 ft
Required Length: 14.176362 ft
Pullout Force: 10,020.68 lbf
Pullout Force per Length: 706.85835 lbf/ft
Governing Component: Pullout Resistance

Reinforcement Line 3

Reinforcement: Soil Nail_Row 3
Lock to Ground Surface: Yes
Outside Point: (160, 56.5) ft
Inside Point: (120.60769, 49.554073) ft
Length: 40 ft
Orienta□on: -170 °
Slip Surface Intersec□on: (133.28607, 51.789613) ft
Max. Pullout Force: 20,637.5 lbf
Bond Length: 40 ft
Available Length: 12.87396 ft
Required Length: 12.87396 ft
Pullout Force: 9,100.0664 lbf
Pullout Force per Length: 706.85835 lbf/ft
Governing Component: Pullout Resistance

Reinforcement Line 4

Reinforcement: Soil Nail_Row 4
Lock to Ground Surface: Yes
Outside Point: (160, 52.5) ft
Inside Point: (120.60769, 45.554073) ft
Length: 40 ft
Orienta□on: -170 °
Slip Surface Intersec□on: (137.35633, 48.50731) ft
Max. Pullout Force: 20,637.5 lbf
Bond Length: 40 ft
Available Length: 17.007013 ft
Required Length: 17.007013 ft
Pullout Force: 12,021.549 lbf
Pullout Force per Length: 706.85835 lbf/ft
Governing Component: Pullout Resistance

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 250 pcf

Direc□on: Ver□cal

Coordinates

	X	Y
	120 ft	95 ft
	160 ft	95 ft

Geometry

Name: Fa-Fa'

Se ngs

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	0 ft	56 ft
Point 2	76 ft	56 ft
Point 3	118 ft	35 ft
Point 4	160 ft	35 ft
Point 5	0 ft	46 ft
Point 6	37 ft	46 ft
Point 7	190 ft	50 ft
Point 8	160 ft	51 ft
Point 9	170.25 ft	34 ft
Point 10	240 ft	34 ft
Point 11	315 ft	30 ft
Point 12	335 ft	30 ft
Point 13	335 ft	48 ft
Point 14	327 ft	48 ft
Point 15	315 ft	49 ft
Point 16	224 ft	48 ft
Point 17	0 ft	0 ft
Point 18	335 ft	0 ft
Point 19	160 ft	94 ft
Point 20	120 ft	94 ft
Point 21	120 ft	72 ft
Point 22	76 ft	72 ft
Point 23	52 ft	60 ft
Point 24	0 ft	60 ft
Point 25	160 ft	47 ft
Point 26	120 ft	47 ft
Point 27	65 ft	66.5 ft
Point 28	160 ft	66.5 ft
Point 29	120 ft	66.5 ft
Point 30	120 ft	49 ft
Point 31	160 ft	49 ft
Point 32	160 ft	72 ft

Point 33	160 ft	70.5 ft
Point 34	120 ft	70.5 ft
Point 35	156 ft	70.5 ft
Point 36	156 ft	66.5 ft
Point 37	126 ft	49 ft
Point 38	126 ft	94 ft
Point 39	126 ft	66.5 ft
Point 40	126 ft	70.5 ft
Point 41	126 ft	72 ft

Regions

	Material	Points	Area
Region 1	ESU 2C - Na□ve Silt	5,6,2,1	565 ft²
Region 2	New Hilfiker Wall	19,38,41,32	748 ft²
Region 3	Common Borrow	20,22,21	484 ft²
Region 4	ESU 2A - Na□ve Sand and Gravel	6,2,3	619.5 ft²
Region 5	ESU 2B - Na□ve Sand and Gravel	7,16,15,14,13,12,11,10,9,4	2,595.4 ft²
Region 6	ESU 7A - Weathered Sandstone	18,17,5,6,3,4,9,10,11,12	12,178 ft²
Region 7	ESU 1B - Exis□ng Gravelly Granular Fill	8,31,25,7	60 ft²
Region 8	ESU 2A - Na□ve Sand and Gravel	4,7,25,26,2,3	945 ft²
Region 9	Common Borrow	21,22,27,29,34	272.25 ft²
Region 10	ESU 1B - Exis□ng Gravelly Granular Fill	23,24,1,2,26,30,29,27	1,077.8 ft²
Region 11	ESU 1B - Exis□ng Gravelly Granular Fill	29,30,37,39	105 ft²
Region 12	ESU 1B - Exis□ng Gravelly Granular Fill	30,26,25,31,37	80 ft²
Region 13	New Pier 1 Foo□ng	29,39,40,34	24 ft²
Region 14	New Hilfiker Wall	32,41,40,35,33	51 ft²
Region 15	Gravel Borrow	28,33,35,36	16 ft²
Region 16	ESU 1B - Exis□ng Gravelly Granular Fill	31,8,28,36,39,37	595 ft²
Region 17	New Pier 1 Foo□ng	36,35,40,39	120 ft²
Region 18	Common Borrow	21,34,40,41	9 ft²
Region 19	Common Borrow	20,21,41,38	132 ft²

Slip Results

Slip Surfaces Analysed: 5191 of 8405 converged

Current Slip Surface

Slip Surface: 7,474
Factor of Safety: 1.779
Volume: 2,915.9591 ft³
Weight: 677,979.93 lbf
Resis□ng Moment: 41,184,551 lbf·ft
Ac□va□ng Moment: 23,150,763 lbf·ft
Resis□ng Force: 439,411.78 lbf
Ac□va□ng Force: 246,936.62 lbf
Slip Rank: 1 of 8,405 slip surfaces
Exit: (230.73349, 48.073994) ft
Entry: (109.51049, 88.755244) ft
Radius: 77.974101 ft

Center: (184.32339, 110.73229) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Fric?onal Strength	Cohesive Strength	Suc?on Strength	Base Material
Slice 1	111.29521 ft	83.898173 ft	-2,528.646 psf	339.29514 psf	212.01513 psf	0 psf	0 psf	Common Borrow
Slice 2	114.86466 ft	75.520551 ft	-2,005.8824 psf	1,047.3746 psf	654.47228 psf	0 psf	0 psf	Common Borrow
Slice 3	118.32469 ft	69.329459 ft	-1,619.5583 psf	1,657.2738 psf	1,035.5796 psf	0 psf	0 psf	Common Borrow
Slice 4	121.5 ft	64.615517 ft	-1,325.4083 psf	7,017.0826 psf	5,482.3457 psf	0 psf	0 psf	ESU 1B - Exis?ng Gravelly Granular Fill
Slice 5	124.5 ft	60.77585 ft	-1,087.7232 psf	7,628.4804 psf	5,960.0221 psf	0 psf	0 psf	ESU 1B - Exis?ng Gravelly Granular Fill
Slice 6	127.78141 ft	57.101473 ft	-862.62088 psf	8,351.72 psf	6,525.0788 psf	0 psf	0 psf	ESU 1B - Exis?ng Gravelly Granular Fill
Slice 7	131.34424 ft	53.572248 ft	-646.9344 psf	9,002.0416 psf	7,033.1657 psf	0 psf	0 psf	ESU 1B - Exis?ng Gravelly Granular Fill
Slice 8	134.90707 ft	50.460567 ft	-457.30266 psf	9,677.0643 psf	7,560.5512 psf	0 psf	0 psf	ESU 1B - Exis?ng Gravelly Granular Fill
Slice 9	138.04399 ft	48 ft	-307.75806 psf	10,463.443 psf	8,174.9376 psf	0 psf	0 psf	ESU 1B - Exis?ng Gravelly Granular Fill
Slice 10	141.01309 ft	45.921708 ft	-181.85368 psf	10,888.947 psf	8,817.6953 psf	0 psf	0 psf	ESU 2A - Na?ve Sand and Gravel
Slice 11	144.24025 ft	43.876005 ft	-58.311546 psf	11,511.937 psf	9,322.1827 psf	0 psf	0 psf	ESU 2A - Na?ve Sand and Gravel
Slice 12	147.54486 ft	42.003681 ft	54.313161 psf	12,155.672 psf	9,799.4874 psf	0 psf	0 psf	ESU 2A - Na?ve Sand and Gravel
Slice 13	150.92692 ft	40.296977 ft	156.50455 psf	12,860.226 psf	10,287.271 psf	0 psf	0 psf	ESU 2A - Na?ve Sand and Gravel
Slice	154.30897	38.789692	246.25223	13,583.322	10,800.146	0 psf	0 psf	ESU 2A -

14	ft	ft	psf	psf	psf			Na□ve Sand and Gravel
Slice 15	157.875 ft	37.407877 ft	327.93626 psf	6,818.1584 psf	5,255.6782 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 16	159.875 ft	36.690283 ft	370.32636 psf	14,324.796 psf	11,300.106 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 17	161.01378 ft	36.331394 ft	392.72103 psf	1,454.6531 psf	859.93563 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 18	164.13637 ft	35.448312 ft	447.82535 psf	1,665.5812 psf	1,058.579 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 19	168.354 ft	34.441422 ft	510.65527 psf	1,961.0395 psf	1,260.7998 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 20	172.85641 ft	33.643951 ft	560.41749 psf	2,267.8086 psf	1,537.3419 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 21	177.09375 ft	33.116163 ft	593.35143 psf	2,537.7914 psf	1,750.7816 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 22	180.78125 ft	32.860559 ft	609.30113 psf	2,748.9508 psf	1,926.5492 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 23	184.46875 ft	32.780131 ft	614.31985 psf	2,932.5924 psf	2,087.382 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 24	188.15625 ft	32.874335 ft	608.44151 psf	3,080.8088 psf	2,226.1295 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 25	191 ft	33.051049 ft	597.41452 psf	3,155.2293 psf	2,303.0668 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 26	193.54599 ft	33.321184 ft	580.5581 psf	3,167.855 psf	2,329.6126 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 27	196.63797 ft	33.752685 ft	553.63245 psf	3,148.0634 psf	2,336.0361 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 28	200.2783 ft	34.437975 ft	510.87035 psf	3,037.5171 psf	2,196.3805 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 29	204.46698 ft	35.436239 ft	448.57867 psf	2,865.0714 psf	2,100.6251 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 30	208.65566 ft	36.684736 ft	370.6725 psf	2,605.5241 psf	1,942.7269 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 31	213.23425 ft	38.365409 ft	252.25113 psf	2,228.2892 psf	1,717.7436 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice	218.20274	40.557229	88.386947	1,724.6309	1,422.3652	0 psf	0 psf	ESU 2B -

32	ft	ft	psf	psf	psf			Na□ve Sand and Gravel
Slice 33	222.34349 ft	42.682083 ft	-66.784718 psf	1,210.7523 psf	1,052.4909 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 34	225.68337 ft	44.661365 ft	-208.50528 psf	738.98676 psf	642.39139 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 35	229.05012 ft	46.89457 ft	-366.21712 psf	252.40131 psf	219.40911 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel

5.3 Pseudo-Static (Spencer) Section Fa-Fa' - Final Condition - Global Stability

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File Informa on

File Version: 11.01
Created By: Mikayla S. Hatch
Last Edited By: Mikayla S. Hatch
Revision Number: 403
Date: 11/12/2021
Time: 03:57:57 PM
Tool Version: 11.1
File Name: Wall 03.63L - Bridge 17.7 Fa-Fa' - All Condi ons.gsz
Directory: P:\0\0180366\01\Analysis\Bridge 17.7\SlopeW\
Last Solved Date: 11/12/2021
Last Solved Time: 03:58:22 PM

Project Se ngs

Unit System: U.S. Customary Units

Analysis Se ngs

5.3 Pseudo-Sta c (Spencer)

Kind: SLOPE/W
Parent: 5. Global Stability
Analysis Type: Spencer
Se ngs
PWP Condi ons from: Piezometric Line
Apply Phrea c Correc on: No
Use Staged Rapid Drawdown: No
Unit Weight of Water: 62.4 pcf
Slip Surface
Direc on of movement: Le. to Right
Use Passive Mode: No
Slip Surface Op□on: Entry and Exit
Cri□cal slip surfaces saved: 1
Op□mize Cri□cal Slip Surface Loca□on: No
Tension Crack Op□on: (none)
Distribu□on
F of S Calcula□on Op□on: Constant
Advanced
Geometry Se□ ngs
Minimum Slip Surface Depth: 2 ft
Number of Slices: 30
Factor of Safety Convergence Se□ ngs
Maximum Number of Itera□ons: 100
Tolerable difference in F of S: 0.001
Solu□on Se□ ngs
Search Method: Root Finder

Tolerable difference between star□ng and converged F of S: 3
Maximum itera□ons to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Gravel Borrow

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2A - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 39 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2B - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 41 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 7A - Weathered Sandstone

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 42 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1B - Exis ng Gravelly Granular Fill

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2C - Na ve Silt (Pseudo-Sta c)

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effec□ve Cohesion: 200 psf
Effec□ve Fric□on Angle: 29 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Common Borrow

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

New Hilfiker Wall

Slope Stability Material Model: High Strength
Unit Weight: 130 pcf
Pore Water Pressure
Piezometric Line: 1

New Pier 1 Foo ng

Slope Stability Material Model: High Strength
Unit Weight: 2,250 pcf
Pore Water Pressure
Piezometric Line: 1

Reinforcements

Soil Nail_Row 2

Type: Anchor
Pullout Resistance: 1,800 psf
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 82,550 lbf
Tensile Capacity Reduc□on Factor: 1
Shear Force: 0 lbf
Shear Force Reduc□on Factor: 1
Apply Shear: Parallel to Slip
F of S Dependent: No
Force Distribu□on: Distributed
Bond Length: 45 ft
Bond Diameter: 0.5 ft
Out-of-Plane Spacing: 4 ft
Face Anchorage: Yes
Factored Pullout Resistance: 706.86 lbf/ft/ft
Factored Tensile Capacity: 20,638 lbf/ft

Soil Nail_Row 1

Type: Anchor
Pullout Resistance: 1,800 psf

Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 82,550 lbf
Tensile Capacity Reduc□on Factor: 1
Shear Force: 0 lbf
Shear Force Reduc□on Factor: 1
Apply Shear: Parallel to Slip
F of S Dependent: No
Force Distribu□on: Distributed
Bond Length: 45 ft
Bond Diameter: 0.5 ft
Out-of-Plane Spacing: 4 ft
Face Anchorage: Yes
Factored Pullout Resistance: 706.86 lbf/ft/ft
Factored Tensile Capacity: 20,638 lbf/ft

Soil Nail_Row 3

Type: Anchor
Pullout Resistance: 1,800 psf
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 82,550 lbf
Tensile Capacity Reduc□on Factor: 1
Shear Force: 0 lbf
Shear Force Reduc□on Factor: 1
Apply Shear: Parallel to Slip
F of S Dependent: No
Force Distribu□on: Distributed
Bond Length: 40 ft
Bond Diameter: 0.5 ft
Out-of-Plane Spacing: 4 ft
Face Anchorage: Yes
Factored Pullout Resistance: 706.86 lbf/ft/ft
Factored Tensile Capacity: 20,638 lbf/ft

Soil Nail_Row 4

Type: Anchor
Pullout Resistance: 1,800 psf
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 82,550 lbf
Tensile Capacity Reduc□on Factor: 1
Shear Force: 0 lbf
Shear Force Reduc□on Factor: 1
Apply Shear: Parallel to Slip
F of S Dependent: No
Force Distribu□on: Distributed
Bond Length: 40 ft
Bond Diameter: 0.5 ft
Out-of-Plane Spacing: 4 ft
Face Anchorage: Yes
Factored Pullout Resistance: 706.86 lbf/ft/ft
Factored Tensile Capacity: 20,638 lbf/ft

Slip Surface Entry and Exit

Left Type: Range

Left-Zone Left Coordinate: (1.75, 60) ft
Left-Zone Right Coordinate: (120, 94) ft
Left-Zone Increment: 40
Right Type: Range
Right-Zone Left Coordinate: (161.44853, 50.951716) ft
Right-Zone Right Coordinate: (315.5, 48.958333) ft
Right-Zone Increment: 40
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 60) ft
Right Coordinate: (335, 48) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	0.25 ft	43.375 ft
Coordinate 2	56.5 ft	43.375 ft
Coordinate 3	97.75 ft	43.375 ft
Coordinate 4	123 ft	43.375 ft
Coordinate 5	159.75 ft	42.625 ft
Coordinate 6	192 ft	42.625 ft
Coordinate 7	210.75 ft	42.625 ft
Coordinate 8	298 ft	35 ft
Coordinate 9	335.25 ft	35 ft

Seismic Coefficients

Horz Seismic Coef.: 0.173

Reinforcement Lines

Reinforcement Line 1

Reinforcement: Soil Nail_Row 1
Lock to Ground Surface: Yes
Outside Point: (160, 64.5) ft
Inside Point: (115.68365, 56.685832) ft
Length: 45.000001 ft
Orienta□on: -170 °
Slip Surface Intersec□on: (125.69203, 58.45058) ft
Max. Pullout Force: 20,637.5 lbf
Bond Length: 45 ft
Available Length: 10.162777 ft
Required Length: 10.162777 ft
Pullout Force: 7,183.6436 lbf

Pullout Force per Length: 706.85835 lbf/ft
Governing Component: Pullout Resistance

Reinforcement Line 2

Reinforcement: Soil Nail_Row 2
Lock to Ground Surface: Yes
Outside Point: (160, 60.5) ft
Inside Point: (115.68365, 52.685832) ft
Length: 45.000001 ft
Orienta□on: -170 °
Slip Surface Intersec□on: (129.06992, 55.046193) ft
Max. Pullout Force: 20,637.5 lbf
Bond Length: 45 ft
Available Length: 13.592776 ft
Required Length: 13.592776 ft
Pullout Force: 9,608.1671 lbf
Pullout Force per Length: 706.85835 lbf/ft
Governing Component: Pullout Resistance

Reinforcement Line 3

Reinforcement: Soil Nail_Row 3
Lock to Ground Surface: Yes
Outside Point: (160, 56.5) ft
Inside Point: (120.60769, 49.554073) ft
Length: 40 ft
Orienta□on: -170 °
Slip Surface Intersec□on: (132.82549, 51.7084) ft
Max. Pullout Force: 20,637.5 lbf
Bond Length: 40 ft
Available Length: 12.406275 ft
Required Length: 12.406275 ft
Pullout Force: 8,769.4792 lbf
Pullout Force per Length: 706.85835 lbf/ft
Governing Component: Pullout Resistance

Reinforcement Line 4

Reinforcement: Soil Nail_Row 4
Lock to Ground Surface: Yes
Outside Point: (160, 52.5) ft
Inside Point: (120.60769, 45.554073) ft
Length: 40 ft
Orienta□on: -170 °
Slip Surface Intersec□on: (137.08452, 48.459383) ft
Max. Pullout Force: 20,637.5 lbf
Bond Length: 40 ft
Available Length: 16.731016 ft
Required Length: 16.731016 ft
Pullout Force: 11,826.458 lbf
Pullout Force per Length: 706.85835 lbf/ft
Governing Component: Pullout Resistance

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 125 pcf
Direc□on: Ver□cal

Coordinates

	X	Y
	120 ft	95 ft
	160 ft	95 ft

Geometry

Name: Fa-Fa'

Se ngs

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	0 ft	56 ft
Point 2	76 ft	56 ft
Point 3	118 ft	35 ft
Point 4	160 ft	35 ft
Point 5	0 ft	46 ft
Point 6	37 ft	46 ft
Point 7	190 ft	50 ft
Point 8	160 ft	51 ft
Point 9	170.25 ft	34 ft
Point 10	240 ft	34 ft
Point 11	315 ft	30 ft
Point 12	335 ft	30 ft
Point 13	335 ft	48 ft
Point 14	327 ft	48 ft
Point 15	315 ft	49 ft
Point 16	224 ft	48 ft
Point 17	0 ft	0 ft
Point 18	335 ft	0 ft
Point 19	160 ft	94 ft
Point 20	120 ft	94 ft
Point 21	120 ft	72 ft
Point 22	76 ft	72 ft
Point 23	52 ft	60 ft
Point 24	0 ft	60 ft
Point 25	160 ft	47 ft
Point 26	120 ft	47 ft
Point 27	65 ft	66.5 ft
Point 28	160 ft	66.5 ft
Point 29	120 ft	66.5 ft
Point 30	120 ft	49 ft

Point 31	160 ft	49 ft
Point 32	160 ft	72 ft
Point 33	160 ft	70.5 ft
Point 34	120 ft	70.5 ft
Point 35	156 ft	70.5 ft
Point 36	156 ft	66.5 ft
Point 37	126 ft	49 ft
Point 38	126 ft	94 ft
Point 39	126 ft	66.5 ft
Point 40	126 ft	70.5 ft
Point 41	126 ft	72 ft

Regions

	Material	Points	Area
Region 1	ESU 2C - Na□ve Silt (Pseudo-Sta□c)	5,6,2,1	565 ft²
Region 2	New Hilfiker Wall	19,38,41,32	748 ft²
Region 3	Common Borrow	20,22,21	484 ft²
Region 4	ESU 2A - Na□ve Sand and Gravel	6,2,3	619.5 ft²
Region 5	ESU 2B - Na□ve Sand and Gravel	7,16,15,14,13,12,11,10,9,4	2,595.4 ft²
Region 6	ESU 7A - Weathered Sandstone	18,17,5,6,3,4,9,10,11,12	12,178 ft²
Region 7	ESU 1B - Exis□ng Gravelly Granular Fill	8,31,25,7	60 ft²
Region 8	ESU 2A - Na□ve Sand and Gravel	4,7,25,26,2,3	945 ft²
Region 9	Common Borrow	21,22,27,29,34	272.25 ft²
Region 10	ESU 1B - Exis□ng Gravelly Granular Fill	23,24,1,2,26,30,29,27	1,077.8 ft²
Region 11	ESU 1B - Exis□ng Gravelly Granular Fill	29,30,37,39	105 ft²
Region 12	ESU 1B - Exis□ng Gravelly Granular Fill	30,26,25,31,37	80 ft²
Region 13	New Pier 1 Foo□ng	29,39,40,34	24 ft²
Region 14	New Hilfiker Wall	32,41,40,35,33	51 ft²
Region 15	Gravel Borrow	28,33,35,36	16 ft²
Region 16	ESU 1B - Exis□ng Gravelly Granular Fill	31,8,28,36,39,37	595 ft²
Region 17	New Pier 1 Foo□ng	36,35,40,39	120 ft²
Region 18	Common Borrow	21,34,40,41	9 ft²
Region 19	Common Borrow	20,21,41,38	132 ft²

Slip Results

Slip Surfaces Analysed: 4378 of 8405 converged

Current Slip Surface

Slip Surface: 7,464
Factor of Safety: 1.465
Volume: 2,763.994 ft³
Weight: 657,654.94 lbf
Resis□ng Moment: 37,909,075 lbf·ft
Ac□va□ng Moment: 25,879,737 lbf·ft
Resis□ng Force: 433,327.35 lbf
Ac□va□ng Force: 295,822.02 lbf
Slip Rank: 1 of 8,405 slip surfaces
Exit: (223.02891, 48.057123) ft

Figure D.4-220

Entry: (108.7055, 88.352752) ft
Radius: 74.603797 ft
Center: (180.32802, 109.23196) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Fric□onal Strength	Cohesive Strength	Suc□on Strength	Base Material
Slice 1	110.44886 ft	83.599947 ft	-2,510.0367 psf	194.29484 psf	121.40889 psf	0 psf	0 psf	Common Borrow
Slice 2	113.93556 ft	75.423571 ft	-1,999.8308 psf	678.97824 psf	424.2727 psf	0 psf	0 psf	Common Borrow
Slice 3	117.4269 ft	69.25 ft	-1,614.6 psf	1,185.5063 psf	740.78656 psf	0 psf	0 psf	Common Borrow
Slice 4	119.58744 ft	65.921412 ft	-1,406.8961 psf	1,441.4625 psf	1,126.1939 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 5	121.5 ft	63.416781 ft	-1,250.6071 psf	5,620.3491 psf	4,391.098 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 6	124.5 ft	59.796761 ft	-1,026.6281 psf	6,366.9557 psf	4,974.411 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 7	127.71786 ft	56.392386 ft	-818.29293 psf	7,280.2597 psf	5,687.9622 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 8	131.15357 ft	53.175041 ft	-621.90589 psf	8,129.3632 psf	6,351.3546 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 9	134.58929 ft	50.334048 ft	-449.0032 psf	8,873.1642 psf	6,932.4756 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 10	137.74509 ft	48 ft	-307.37742 psf	9,828.001 psf	7,678.4759 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 11	140.9324 ft	45.911609 ft	-181.12076 psf	10,385.11 psf	8,409.696 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 12	144.43113 ft	43.862573 ft	-57.716463 psf	11,144.628 psf	9,024.742 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel

Slice 13	147.81708 ft	42.109248 ft	47.379132 psf	11,926.586 psf	9,619.5917 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 14	151.09025 ft	40.619175 ft	136.19143 psf	12,656.416 psf	10,138.678 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 15	154.36342 ft	39.314023 ft	213.46462 psf	13,398.471 psf	10,677.007 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 16	157.875 ft	38.114295 ft	283.85572 psf	6,803.0666 psf	5,279.1529 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 17	159.875 ft	37.486692 ft	320.63041 psf	15,595.977 psf	12,369.732 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 18	161.61425 ft	37.032651 ft	348.96255 psf	1,503.5849 psf	934.99471 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 19	165.23208 ft	36.200097 ft	400.91393 psf	1,682.1896 psf	1,113.7959 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 20	169.23925 ft	35.484686 ft	445.55557 psf	1,881.5735 psf	1,248.3114 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 21	173.24642 ft	34.992305 ft	476.28019 psf	2,072.6948 psf	1,387.7421 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 22	177.09375 ft	34.721155 ft	493.19995 psf	2,249.915 psf	1,527.0891 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 23	180.78125 ft	34.652328 ft	497.49473 psf	2,414.0247 psf	1,666.0141 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 24	184.46875 ft	34.766056 ft	490.39812 psf	2,574.5353 psf	1,811.7128 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 25	188.15625 ft	35.063179 ft	471.85761 psf	2,733.5981 psf	1,966.101 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 26	191 ft	35.402329 ft	450.69468 psf	2,842.933 psf	2,079.541 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 27	193.875 ft	35.893224 ft	420.06285 psf	2,913.9824 psf	2,167.9312 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 28	197.625 ft	36.686626 ft	370.55455 psf	3,006.5496 psf	2,291.4356 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 29	201.375 ft	37.685253 ft	308.24023 psf	3,099.1596 psf	2,426.1092 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 30	205.125 ft	38.897873 ft	232.5727 psf	3,201.0425 psf	2,580.4514 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel

Slice 31	208.875 ft	40.335826 ft	142.84447 psf	3,332.1618 psf	2,772.4313 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 32	212.1044 ft	41.7505 ft	47.182875 psf	3,525.3624 psf	3,023.5354 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 33	215.05381 ft	43.227431 ft	-61.06166 psf	3,656.7201 psf	3,178.7383 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 34	218.24385 ft	45.008244 ft	-189.58062 psf	3,575.5081 psf	3,108.1418 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 35	221.43389 ft	47.00351 ft	-331.48146 psf	2,528.87 psf	2,198.3132 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel

5.4 Pseudo-Static (M-P) Section Fa-Fa' - Final Condition - Global Stability

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File Informa on

File Version: 11.01
Created By: Mikayla S. Hatch
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Revision Number: 403
Date: 11/12/2021
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File Name: Wall 03.63L - Bridge 17.7 Fa-Fa' - All Condi ons.gsz
Directory: P:\0\0180366\01\Analysis\Bridge 17.7\SlopeW\
Last Solved Date: 11/12/2021
Last Solved Time: 03:58:34 PM

Project Se ngs

Unit System: U.S. Customary Units

Analysis Se ngs

5.4 Pseudo-Sta c (M-P)

Kind: SLOPE/W
Parent: 5. Global Stability
Analysis Type: Morgenstern-Price
Se ngs
Side Func on
Interslice force func on op on: Half-Sine
PWP Condi ons from: Piezometric Line
Apply Phrea c Correc on: No
Use Staged Rapid Drawdown: No
Unit Weight of Water: 62.4 pcf
Slip Surface
Direc on of movement: Le. to Right
Use Passive Mode: No
Slip Surface Op on: Entry and Exit
Cri cal slip surfaces saved: 1
Op mize Cri cal Slip Surface Loca on: No
Tension Crack Op on: (none)
Distribu on
F of S Calcula on Op on: Constant
Advanced
Geometry Se ngs
Minimum Slip Surface Depth: 2 ft
Number of Slices: 30
Factor of Safety Convergence Se ngs
Maximum Number of Itera ons: 100
Tolerable difference in F of S: 0.001

Figure D.4-224

Solu□on Se□ ngs
Search Method: Root Finder
Tolerable difference between star□ng and converged F of S: 3
Maximum itera□ons to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Gravel Borrow

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2A - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 39 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2B - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 41 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 7A - Weathered Sandstone

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 42 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1B - Exis ng Gravelly Granular Fill

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2C - Na ve Silt (Pseudo-Sta c)

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effec□ve Cohesion: 200 psf
Effec□ve Fric□on Angle: 29 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Common Borrow

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

New Hilfiker Wall

Slope Stability Material Model: High Strength
Unit Weight: 130 pcf
Pore Water Pressure
Piezometric Line: 1

New Pier 1 Foo ng

Slope Stability Material Model: High Strength
Unit Weight: 2,250 pcf
Pore Water Pressure
Piezometric Line: 1

Reinforcements

Soil Nail_Row 2

Type: Anchor
Pullout Resistance: 1,800 psf
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 82,550 lbf
Tensile Capacity Reduc□on Factor: 1
Shear Force: 0 lbf
Shear Force Reduc□on Factor: 1
Apply Shear: Parallel to Slip
F of S Dependent: No
Force Distribu□on: Distributed
Bond Length: 45 ft
Bond Diameter: 0.5 ft
Out-of-Plane Spacing: 4 ft
Face Anchorage: Yes
Factored Pullout Resistance: 706.86 lbf/ft/ft
Factored Tensile Capacity: 20,638 lbf/ft

Soil Nail_Row 1

Type: Anchor

Pullout Resistance: 1,800 psf
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 82,550 lbf
Tensile Capacity Reduc□on Factor: 1
Shear Force: 0 lbf
Shear Force Reduc□on Factor: 1
Apply Shear: Parallel to Slip
F of S Dependent: No
Force Distribu□on: Distributed
Bond Length: 45 ft
Bond Diameter: 0.5 ft
Out-of-Plane Spacing: 4 ft
Face Anchorage: Yes
Factored Pullout Resistance: 706.86 lbf/ft/ft
Factored Tensile Capacity: 20,638 lbf/ft

Soil Nail_Row 3

Type: Anchor
Pullout Resistance: 1,800 psf
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 82,550 lbf
Tensile Capacity Reduc□on Factor: 1
Shear Force: 0 lbf
Shear Force Reduc□on Factor: 1
Apply Shear: Parallel to Slip
F of S Dependent: No
Force Distribu□on: Distributed
Bond Length: 40 ft
Bond Diameter: 0.5 ft
Out-of-Plane Spacing: 4 ft
Face Anchorage: Yes
Factored Pullout Resistance: 706.86 lbf/ft/ft
Factored Tensile Capacity: 20,638 lbf/ft

Soil Nail_Row 4

Type: Anchor
Pullout Resistance: 1,800 psf
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 82,550 lbf
Tensile Capacity Reduc□on Factor: 1
Shear Force: 0 lbf
Shear Force Reduc□on Factor: 1
Apply Shear: Parallel to Slip
F of S Dependent: No
Force Distribu□on: Distributed
Bond Length: 40 ft
Bond Diameter: 0.5 ft
Out-of-Plane Spacing: 4 ft
Face Anchorage: Yes
Factored Pullout Resistance: 706.86 lbf/ft/ft
Factored Tensile Capacity: 20,638 lbf/ft

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (1.75, 60) ft
Left-Zone Right Coordinate: (120, 94) ft
Left-Zone Increment: 40
Right Type: Range
Right-Zone Left Coordinate: (161.44853, 50.951716) ft
Right-Zone Right Coordinate: (315.5, 48.958333) ft
Right-Zone Increment: 40
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 60) ft
Right Coordinate: (335, 48) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	0.25 ft	43.375 ft
Coordinate 2	56.5 ft	43.375 ft
Coordinate 3	97.75 ft	43.375 ft
Coordinate 4	123 ft	43.375 ft
Coordinate 5	159.75 ft	42.625 ft
Coordinate 6	192 ft	42.625 ft
Coordinate 7	210.75 ft	42.625 ft
Coordinate 8	298 ft	35 ft
Coordinate 9	335.25 ft	35 ft

Seismic Coefficients

Horz Seismic Coef.: 0.173

Reinforcement Lines

Reinforcement Line 1

Reinforcement: Soil Nail_Row 1
Lock to Ground Surface: Yes
Outside Point: (160, 64.5) ft
Inside Point: (115.68365, 56.685832) ft
Length: 45.000001 ft
Orienta□on: -170 °
Slip Surface Intersec□on: (125.69203, 58.45058) ft
Max. Pullout Force: 20,637.5 lbf
Bond Length: 45 ft
Available Length: 10.162777 ft
Required Length: 10.162777 ft

Figure D.4-228

Pullout Force: 7,183.6436 lbf
Pullout Force per Length: 706.85835 lbf/ft
Governing Component: Pullout Resistance

Reinforcement Line 2

Reinforcement: Soil Nail_Row 2
Lock to Ground Surface: Yes
Outside Point: (160, 60.5) ft
Inside Point: (115.68365, 52.685832) ft
Length: 45.000001 ft
Orienta□on: -170 °
Slip Surface Intersec□on: (129.06992, 55.046193) ft
Max. Pullout Force: 20,637.5 lbf
Bond Length: 45 ft
Available Length: 13.592776 ft
Required Length: 13.592776 ft
Pullout Force: 9,608.1671 lbf
Pullout Force per Length: 706.85835 lbf/ft
Governing Component: Pullout Resistance

Reinforcement Line 3

Reinforcement: Soil Nail_Row 3
Lock to Ground Surface: Yes
Outside Point: (160, 56.5) ft
Inside Point: (120.60769, 49.554073) ft
Length: 40 ft
Orienta□on: -170 °
Slip Surface Intersec□on: (132.82549, 51.7084) ft
Max. Pullout Force: 20,637.5 lbf
Bond Length: 40 ft
Available Length: 12.406275 ft
Required Length: 12.406275 ft
Pullout Force: 8,769.4792 lbf
Pullout Force per Length: 706.85835 lbf/ft
Governing Component: Pullout Resistance

Reinforcement Line 4

Reinforcement: Soil Nail_Row 4
Lock to Ground Surface: Yes
Outside Point: (160, 52.5) ft
Inside Point: (120.60769, 45.554073) ft
Length: 40 ft
Orienta□on: -170 °
Slip Surface Intersec□on: (137.08452, 48.459383) ft
Max. Pullout Force: 20,637.5 lbf
Bond Length: 40 ft
Available Length: 16.731016 ft
Required Length: 16.731016 ft
Pullout Force: 11,826.458 lbf
Pullout Force per Length: 706.85835 lbf/ft
Governing Component: Pullout Resistance

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 125 pcf
Direc□on: Ver□cal

Coordinates

	X	Y
	120 ft	95 ft
	160 ft	95 ft

Geometry

Name: Fa-Fa'

Se ngs

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	0 ft	56 ft
Point 2	76 ft	56 ft
Point 3	118 ft	35 ft
Point 4	160 ft	35 ft
Point 5	0 ft	46 ft
Point 6	37 ft	46 ft
Point 7	190 ft	50 ft
Point 8	160 ft	51 ft
Point 9	170.25 ft	34 ft
Point 10	240 ft	34 ft
Point 11	315 ft	30 ft
Point 12	335 ft	30 ft
Point 13	335 ft	48 ft
Point 14	327 ft	48 ft
Point 15	315 ft	49 ft
Point 16	224 ft	48 ft
Point 17	0 ft	0 ft
Point 18	335 ft	0 ft
Point 19	160 ft	94 ft
Point 20	120 ft	94 ft
Point 21	120 ft	72 ft
Point 22	76 ft	72 ft
Point 23	52 ft	60 ft
Point 24	0 ft	60 ft
Point 25	160 ft	47 ft
Point 26	120 ft	47 ft
Point 27	65 ft	66.5 ft
Point 28	160 ft	66.5 ft
Point 29	120 ft	66.5 ft
Point 30	120 ft	49 ft

Point 31	160 ft	49 ft
Point 32	160 ft	72 ft
Point 33	160 ft	70.5 ft
Point 34	120 ft	70.5 ft
Point 35	156 ft	70.5 ft
Point 36	156 ft	66.5 ft
Point 37	126 ft	49 ft
Point 38	126 ft	94 ft
Point 39	126 ft	66.5 ft
Point 40	126 ft	70.5 ft
Point 41	126 ft	72 ft

Regions

	Material	Points	Area
Region 1	ESU 2C - Na□ve Silt (Pseudo-Sta□c)	5,6,2,1	565 ft²
Region 2	New Hilfiker Wall	19,38,41,32	748 ft²
Region 3	Common Borrow	20,22,21	484 ft²
Region 4	ESU 2A - Na□ve Sand and Gravel	6,2,3	619.5 ft²
Region 5	ESU 2B - Na□ve Sand and Gravel	7,16,15,14,13,12,11,10,9,4	2,595.4 ft²
Region 6	ESU 7A - Weathered Sandstone	18,17,5,6,3,4,9,10,11,12	12,178 ft²
Region 7	ESU 1B - Exis□ng Gravelly Granular Fill	8,31,25,7	60 ft²
Region 8	ESU 2A - Na□ve Sand and Gravel	4,7,25,26,2,3	945 ft²
Region 9	Common Borrow	21,22,27,29,34	272.25 ft²
Region 10	ESU 1B - Exis□ng Gravelly Granular Fill	23,24,1,2,26,30,29,27	1,077.8 ft²
Region 11	ESU 1B - Exis□ng Gravelly Granular Fill	29,30,37,39	105 ft²
Region 12	ESU 1B - Exis□ng Gravelly Granular Fill	30,26,25,31,37	80 ft²
Region 13	New Pier 1 Foo□ng	29,39,40,34	24 ft²
Region 14	New Hilfiker Wall	32,41,40,35,33	51 ft²
Region 15	Gravel Borrow	28,33,35,36	16 ft²
Region 16	ESU 1B - Exis□ng Gravelly Granular Fill	31,8,28,36,39,37	595 ft²
Region 17	New Pier 1 Foo□ng	36,35,40,39	120 ft²
Region 18	Common Borrow	21,34,40,41	9 ft²
Region 19	Common Borrow	20,21,41,38	132 ft²

Slip Results

Slip Surfaces Analysed: 4446 of 8405 converged

Current Slip Surface

Slip Surface: 7,464
Factor of Safety: 1.450
Volume: 2,763.994 ft³
Weight: 657,654.94 lbf
Resis□ng Moment: 37,534,612 lbf·ft
Ac□va□ng Moment: 25,879,737 lbf·ft
Resis□ng Force: 432,207.93 lbf
Ac□va□ng Force: 298,078.77 lbf
Slip Rank: 1 of 8,405 slip surfaces
Exit: (223.02891, 48.057123) ft

Figure D.4-231

Entry: (108.7055, 88.352752) ft
Radius: 74.603797 ft
Center: (180.32802, 109.23196) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Fric□onal Strength	Cohesive Strength	Suc□on Strength	Base Material
Slice 1	110.44886 ft	83.599947 ft	-2,510.0367 psf	288.27871 psf	180.13653 psf	0 psf	0 psf	Common Borrow
Slice 2	113.93556 ft	75.423571 ft	-1,999.8308 psf	874.09622 psf	546.19594 psf	0 psf	0 psf	Common Borrow
Slice 3	117.4269 ft	69.25 ft	-1,614.6 psf	1,367.8428 psf	854.72303 psf	0 psf	0 psf	Common Borrow
Slice 4	119.58744 ft	65.921412 ft	-1,406.8961 psf	1,541.2927 psf	1,204.1898 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 5	121.5 ft	63.416781 ft	-1,250.6071 psf	6,135.9258 psf	4,793.9106 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 6	124.5 ft	59.796761 ft	-1,026.6281 psf	6,512.505 psf	5,088.1266 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 7	127.71786 ft	56.392386 ft	-818.29293 psf	7,074.1043 psf	5,526.896 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 8	131.15357 ft	53.175041 ft	-621.90589 psf	7,595.1475 psf	5,933.9796 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 9	134.58929 ft	50.334048 ft	-449.0032 psf	8,089.1094 psf	6,319.9049 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 10	137.74509 ft	48 ft	-307.37742 psf	8,889.6475 psf	6,945.3538 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 11	140.9324 ft	45.911609 ft	-181.12076 psf	9,377.6861 psf	7,593.9005 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 12	144.43113 ft	43.862573 ft	-57.716463 psf	10,142.342 psf	8,213.1066 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel

Slice 13	147.81708 ft	42.109248 ft	47.379132 psf	11,026.287 psf	8,890.544 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 14	151.09025 ft	40.619175 ft	136.19143 psf	11,934.921 psf	9,554.4229 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 15	154.36342 ft	39.314023 ft	213.46462 psf	12,941.878 psf	10,307.266 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 16	157.875 ft	38.114295 ft	283.85572 psf	6,614.4615 psf	5,126.4235 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 17	159.875 ft	37.486692 ft	320.63041 psf	18,922.709 psf	15,063.666 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 18	161.61425 ft	37.032651 ft	348.96255 psf	1,264.1279 psf	741.08625 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 19	165.23208 ft	36.200097 ft	400.91393 psf	1,677.1575 psf	1,109.4216 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 20	169.23925 ft	35.484686 ft	445.55557 psf	2,168.1809 psf	1,497.4553 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 21	173.24642 ft	34.992305 ft	476.28019 psf	2,680.7295 psf	1,916.2986 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 22	177.09375 ft	34.721155 ft	493.19995 psf	3,174.0275 psf	2,330.4078 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 23	180.78125 ft	34.652328 ft	497.49473 psf	3,620.93 psf	2,715.1608 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 24	184.46875 ft	34.766056 ft	490.39812 psf	4,013.9351 psf	3,062.964 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 25	188.15625 ft	35.063179 ft	471.85761 psf	4,321.1241 psf	3,346.1163 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 26	191 ft	35.402329 ft	450.69468 psf	4,468.3993 psf	3,492.5373 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 27	193.875 ft	35.893224 ft	420.06285 psf	4,483.9139 psf	3,532.6518 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 28	197.625 ft	36.686626 ft	370.55455 psf	4,367.395 psf	3,474.4004 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 29	201.375 ft	37.685253 ft	308.24023 psf	4,076.3916 psf	3,275.604 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 30	205.125 ft	38.897873 ft	232.5727 psf	3,614.3399 psf	2,939.7254 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel

Slice 31	208.875 ft	40.335826 ft	142.84447 psf	3,000.7997 psf	2,484.3825 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 32	212.1044 ft	41.7505 ft	47.182875 psf	2,385.0113 psf	2,032.2433 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 33	215.05381 ft	43.227431 ft	-61.06166 psf	1,737.2245 psf	1,510.1462 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 34	218.24385 ft	45.008244 ft	-189.58062 psf	993.29553 psf	863.45863 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 35	221.43389 ft	47.00351 ft	-331.48146 psf	305.99003 psf	265.99307 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel

1.1 Static (Spencer) Section Ga-Ga' - Existing Condition - Global Stability

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File Informa on

File Version: 11.01
Created By: Mikayla S. Hatch
Last Edited By: Mikayla S. Hatch
Revision Number: 323
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Time: 04:47:21 PM
Tool Version: 11.1
File Name: Wall 03.63L - Bridge 17.7 Ga-Ga' - All Condi ons.gsz
Directory: P:\0\0180366\01\Analysis\Bridge 17.7\SlopeW\
Last Solved Date: 11/12/2021
Last Solved Time: 04:47:40 PM

Project Se ngs

Unit System: U.S. Customary Units

Analysis Se ngs

1.1 Sta c (Spencer)

Kind: SLOPE/W
Parent: 1. Global Stability
Analysis Type: Spencer
Se ngs
PWP Condi ons from: Piezometric Line
Apply Phrea c Correc on: No
Use Staged Rapid Drawdown: No
Unit Weight of Water: 62.4 pcf
Slip Surface
Direc on of movement: Le. to Right
Use Passive Mode: No
Slip Surface Op on: Entry and Exit
Cri cal slip surfaces saved: 1
Op mize Cri cal Slip Surface Loca on: No
Tension Crack Op on: (none)
Distribu on
F of S Calcula on Op on: Constant
Advanced
Geometry Se ngs
Minimum Slip Surface Depth: 2 ft
Number of Slices: 30
Factor of Safety Convergence Se ngs
Maximum Number of Itera ons: 100
Tolerable difference in F of S: 0.001
Solu on Se ngs
Search Method: Root Finder

Tolerable difference between star□ng and converged F of S: 3
Maximum itera□ons to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Hilfiker Wall

Slope Stability Material Model: High Strength
Unit Weight: 130 pcf
Pore Water Pressure
Piezometric Line: 1

ESU 2A - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 39 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2B - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 41 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 7A - Weathered Sandstone

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 43 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2C - Na ve Silt

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 29 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1A - Exis ng Granular Fill

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf

Effec□ve Fric□on Angle: 40 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1B - Exis ng Gravelly Granular Fill

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (1.75, 60) ft
Left-Zone Right Coordinate: (120.29262, 92) ft
Left-Zone Increment: 40
Right Type: Range
Right-Zone Left Coordinate: (161.41681, 50) ft
Right-Zone Right Coordinate: (315.5, 48.958333) ft
Right-Zone Increment: 40
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 60) ft
Right Coordinate: (335, 48) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	0.25 ft	43.375 ft
Coordinate 2	56.5 ft	43.375 ft
Coordinate 3	97.75 ft	43.375 ft
Coordinate 4	123 ft	43.375 ft
Coordinate 5	159.75 ft	42.625 ft
Coordinate 6	192 ft	42.625 ft
Coordinate 7	210.75 ft	42.625 ft
Coordinate 8	298 ft	35 ft
Coordinate 9	335.25 ft	35 ft

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 250 pcf
Direc□on: Ver□cal

Coordinates

	X	Y
	120 ft	92 ft
	120 ft	93 ft
	160 ft	93 ft

Geometry

Name: Ga-Ga'

Se ngs

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	0 ft	56 ft
Point 2	76 ft	56 ft
Point 3	118 ft	35 ft
Point 4	160 ft	35 ft
Point 5	0 ft	46 ft
Point 6	37 ft	46 ft
Point 7	190 ft	50 ft
Point 8	160 ft	50 ft
Point 9	170.25 ft	34 ft
Point 10	240 ft	34 ft
Point 11	315 ft	30 ft
Point 12	335 ft	30 ft
Point 13	335 ft	48 ft
Point 14	327 ft	48 ft
Point 15	315 ft	49 ft
Point 16	224 ft	48 ft
Point 17	0 ft	0 ft
Point 18	335 ft	0 ft
Point 19	160 ft	92 ft
Point 20	120 ft	92 ft
Point 21	120 ft	72 ft
Point 22	80 ft	72 ft
Point 23	56 ft	60 ft
Point 24	0 ft	60 ft
Point 25	160 ft	47 ft
Point 26	120 ft	47 ft
Point 27	69 ft	66.5 ft
Point 28	160 ft	66.5 ft
Point 29	120 ft	66.5 ft

Point 30	160 ft	72 ft
Point 31	128 ft	47 ft
Point 32	128 ft	92 ft
Point 33	128 ft	66.5 ft
Point 34	128 ft	72 ft
Point 35	160 ft	64.5 ft
Point 36	160 ft	60.5 ft
Point 37	160 ft	56.5 ft
Point 38	160 ft	52.5 ft

Regions

	Material	Points	Area
Region 1	ESU 2C - Na□ve Silt	5,6,2,1	565 ft²
Region 2	Hilfiker Wall	19,32,34,30	640 ft²
Region 3	ESU 1A - Exis□ng Granular Fill	20,22,21	400 ft²
Region 4	ESU 2A - Na□ve Sand and Gravel	6,2,3	619.5 ft²
Region 5	ESU 2B - Na□ve Sand and Gravel	7,16,15,14,13,12,11,10,9,4	2,595.4 ft²
Region 6	ESU 7A - Weathered Sandstone	18,17,5,6,3,4,9,10,11,12	12,178 ft²
Region 7	ESU 1B - Exis□ng Gravelly Granular Fill	8,7,25	45 ft²
Region 8	ESU 2A - Na□ve Sand and Gravel	4,7,25,31,26,2,3	945 ft²
Region 9	ESU 1B - Exis□ng Gravelly Granular Fill	21,22,27,29	250.25 ft²
Region 10	ESU 1B - Exis□ng Gravelly Granular Fill	23,24,1,2,26,29,27	1,051.8 ft²
Region 11	ESU 1B - Exis□ng Gravelly Granular Fill	26,31,33,29	156 ft²
Region 12	ESU 1B - Exis□ng Gravelly Granular Fill	29,33,34,21	44 ft²
Region 13	Hilfiker Wall	25,8,38,37,36,35,28,33,31	624 ft²
Region 14	Hilfiker Wall	28,30,34,33	176 ft²
Region 15	ESU 1A - Exis□ng Granular Fill	20,21,34,32	160 ft²

Slip Results

Slip Surfaces Analysed: 3602 of 8405 converged

Current Slip Surface

Slip Surface: 7,440
Factor of Safety: 2.486
Volume: 2,824.2332 ft³
Weight: 359,461.29 lbf
Resis□ng Moment: 17,193,969 lbf·ft
Ac□va□ng Moment: 6,916,433.6 lbf·ft
Resis□ng Force: 264,417.42 lbf
Ac□va□ng Force: 106,337.55 lbf
Slip Rank: 1 of 8,405 slip surfaces
Exit: (203.78401, 49.189176) ft
Entry: (108.98329, 86.491644) ft
Radius: 55.83986 ft
Center: (164.76078, 89.1301) ft

Slip Slices

	X	Y	PWP	Base	Fric□onal	Cohesive	Suc□on	Base

				Normal Stress	Strength	Strength	Strength	Material
Slice 1	110.29832 ft	79.245822 ft	-2,238.3393 psf	221.64546 psf	185.98262 psf	0 psf	0 psf	ESU 1A - Exis□ng Granular Fill
Slice 2	112.66272 ft	69.25 ft	-1,614.6 psf	938.82293 psf	733.48886 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 3	115.28407 ft	63.469088 ft	-1,253.8711 psf	1,555.4504 psf	1,215.2511 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 4	118.42802 ft	58.091604 ft	-918.31609 psf	2,258.2497 psf	1,764.338 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 5	121.5 ft	53.902954 ft	-656.94433 psf	3,003.6387 psf	2,346.6997 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 6	124.25 ft	50.741765 ft	-461.27795 psf	3,459.9341 psf	2,703.1968 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 7	126.75 ft	48.260102 ft	-309.60589 psf	3,846.6264 psf	3,005.3139 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 8	129.28974 ft	46.035956 ft	-174.05342 psf	4,427.1783 psf	3,585.0583 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 9	131.81331 ft	44.072158 ft	-54.726166 psf	4,782.8052 psf	3,873.0393 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 10	134.54726 ft	42.204093 ft	58.359504 psf	5,154.1039 psf	4,126.4525 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 11	137.54751 ft	40.400478 ft	167.08438 psf	5,546.3004 psf	4,356.0033 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 12	140.54777 ft	38.840458 ft	260.60889 psf	5,917.333 psf	4,580.7249 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 13	143.54802 ft	37.501826 ft	340.3188 psf	6,270.2259 psf	4,801.9441 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice	146.54828	36.367649	407.27071	6,607.5195	5,020.8625	0 psf	0 psf	ESU 2A -

14	ft	ft	psf	psf	psf			Na□ve Sand and Gravel
Slice 15	149.54853 ft	35.424918 ft	462.27637 psf	6,931.4448 psf	5,238.6293 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 16	152.49888 ft	34.673456 ft	505.41044 psf	7,259.0337 psf	6,297.8556 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 17	155.39933 ft	34.100206 ft	537.48761 psf	7,581.1877 psf	6,568.3566 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 18	158.29978 ft	33.684507 ft	559.73357 psf	7,896.9445 psf	6,842.0599 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 19	159.875 ft	33.504535 ft	569.117 psf	8,069.2432 psf	6,993.9808 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 20	161.70833 ft	33.399987 ft	575.64079 psf	2,138.9232 psf	1,457.7845 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 21	165.125 ft	33.317567 ft	580.78383 psf	2,257.8308 psf	1,563.8716 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 22	168.54167 ft	33.444706 ft	572.85032 psf	2,356.4577 psf	1,663.2408 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 23	171.94279 ft	33.780349 ft	551.90623 psf	2,433.6854 psf	1,754.7875 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 24	174.44279 ft	34.14213 ft	529.33112 psf	2,451.5128 psf	1,670.9271 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 25	176.725 ft	34.60793 ft	500.26519 psf	2,472.6765 psf	1,714.591 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 26	179.675 ft	35.340574 ft	454.54821 psf	2,485.5869 psf	1,765.555 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 27	182.625 ft	36.247818 ft	397.93614 psf	2,477.4102 psf	1,807.6592 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 28	185.575 ft	37.338873 ft	329.85433 psf	2,445.8276 psf	1,839.3875 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 29	188.525 ft	38.625699 ft	249.55636 psf	2,387.6507 psf	1,858.617 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 30	191 ft	39.852217 ft	173.02166 psf	2,291.7084 psf	1,841.7463 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 31	193.83488 ft	41.504846 ft	69.897623 psf	2,087.3291 psf	1,753.7265 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice	197.02214	43.582894	-59.772612	1,748.3659	1,519.8312	0 psf	0 psf	ESU 2B -

32	ft	ft	psf	psf	psf			Na□ve Sand and Gravel
Slice 33	199.72689 ft	45.627794 ft	-187.37436 psf	1,269.1875 psf	1,103.2878 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 34	202.43164 ft	47.951988 ft	-332.40404 psf	530.26763 psf	460.95462 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel

1.2 Static (M-P) Section Ga-Ga' - Existing Condition - Global Stability

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File Informa on

File Version: 11.01
Created By: Mikayla S. Hatch
Last Edited By: Mikayla S. Hatch
Revision Number: 323
Date: 11/12/2021
Time: 04:47:21 PM
Tool Version: 11.1
File Name: Wall 03.63L - Bridge 17.7 Ga-Ga' - All Condi ons.gsz
Directory: P:\0\0180366\01\Analysis\Bridge 17.7\SlopeW\
Last Solved Date: 11/12/2021
Last Solved Time: 04:47:44 PM

Project Se ngs

Unit System: U.S. Customary Units

Analysis Se ngs

1.2 Sta c (M-P)

Kind: SLOPE/W
Parent: 1. Global Stability
Analysis Type: Morgenstern-Price
Se ngs
Side Func on
Interslice force func on op on: Half-Sine
PWP Condi ons from: Piezometric Line
Apply Phrea c Correc on: No
Use Staged Rapid Drawdown: No
Unit Weight of Water: 62.4 pcf
Slip Surface
Direc on of movement: Le. to Right
Use Passive Mode: No
Slip Surface Op on: Entry and Exit
Cri cal slip surfaces saved: 1
Op mize Cri cal Slip Surface Loca on: No
Tension Crack Op on: (none)
Distribu on
F of S Calcula on Op on: Constant
Advanced
Geometry Se ngs
Minimum Slip Surface Depth: 2 ft
Number of Slices: 30
Factor of Safety Convergence Se ngs
Maximum Number of Itera ons: 100
Tolerable difference in F of S: 0.001

Solu□on Se□ ngs
Search Method: Root Finder
Tolerable difference between star□ng and converged F of S: 3
Maximum itera□ons to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Hilfiker Wall

Slope Stability Material Model: High Strength
Unit Weight: 130 pcf
Pore Water Pressure
Piezometric Line: 1

ESU 2A - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 39 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2B - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 41 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 7A - Weathered Sandstone

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 43 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2C - Na ve Silt

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 29 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1A - Exis ng Granular Fill

Slope Stability Material Model: Mohr-Coulomb

Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 40 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1B - Exis ng Gravelly Granular Fill

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (1.75, 60) ft
Left-Zone Right Coordinate: (120.29262, 92) ft
Left-Zone Increment: 40
Right Type: Range
Right-Zone Left Coordinate: (161.41681, 50) ft
Right-Zone Right Coordinate: (315.5, 48.958333) ft
Right-Zone Increment: 40
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 60) ft
Right Coordinate: (335, 48) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	0.25 ft	43.375 ft
Coordinate 2	56.5 ft	43.375 ft
Coordinate 3	97.75 ft	43.375 ft
Coordinate 4	123 ft	43.375 ft
Coordinate 5	159.75 ft	42.625 ft
Coordinate 6	192 ft	42.625 ft
Coordinate 7	210.75 ft	42.625 ft
Coordinate 8	298 ft	35 ft
Coordinate 9	335.25 ft	35 ft

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 250 pcf
Direc□on: Ver□cal

Coordinates

	X	Y
	120 ft	92 ft
	120 ft	93 ft
	160 ft	93 ft

Geometry

Name: Ga-Ga'

Se ngs

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	0 ft	56 ft
Point 2	76 ft	56 ft
Point 3	118 ft	35 ft
Point 4	160 ft	35 ft
Point 5	0 ft	46 ft
Point 6	37 ft	46 ft
Point 7	190 ft	50 ft
Point 8	160 ft	50 ft
Point 9	170.25 ft	34 ft
Point 10	240 ft	34 ft
Point 11	315 ft	30 ft
Point 12	335 ft	30 ft
Point 13	335 ft	48 ft
Point 14	327 ft	48 ft
Point 15	315 ft	49 ft
Point 16	224 ft	48 ft
Point 17	0 ft	0 ft
Point 18	335 ft	0 ft
Point 19	160 ft	92 ft
Point 20	120 ft	92 ft
Point 21	120 ft	72 ft
Point 22	80 ft	72 ft
Point 23	56 ft	60 ft
Point 24	0 ft	60 ft
Point 25	160 ft	47 ft
Point 26	120 ft	47 ft
Point 27	69 ft	66.5 ft

Point 28	160 ft	66.5 ft
Point 29	120 ft	66.5 ft
Point 30	160 ft	72 ft
Point 31	128 ft	47 ft
Point 32	128 ft	92 ft
Point 33	128 ft	66.5 ft
Point 34	128 ft	72 ft
Point 35	160 ft	64.5 ft
Point 36	160 ft	60.5 ft
Point 37	160 ft	56.5 ft
Point 38	160 ft	52.5 ft

Regions

	Material	Points	Area
Region 1	ESU 2C - Na□ve Silt	5,6,2,1	565 ft²
Region 2	Hilfiker Wall	19,32,34,30	640 ft²
Region 3	ESU 1A - Exis□ng Granular Fill	20,22,21	400 ft²
Region 4	ESU 2A - Na□ve Sand and Gravel	6,2,3	619.5 ft²
Region 5	ESU 2B - Na□ve Sand and Gravel	7,16,15,14,13,12,11,10,9,4	2,595.4 ft²
Region 6	ESU 7A - Weathered Sandstone	18,17,5,6,3,4,9,10,11,12	12,178 ft²
Region 7	ESU 1B - Exis□ng Gravelly Granular Fill	8,7,25	45 ft²
Region 8	ESU 2A - Na□ve Sand and Gravel	4,7,25,31,26,2,3	945 ft²
Region 9	ESU 1B - Exis□ng Gravelly Granular Fill	21,22,27,29	250.25 ft²
Region 10	ESU 1B - Exis□ng Gravelly Granular Fill	23,24,1,2,26,29,27	1,051.8 ft²
Region 11	ESU 1B - Exis□ng Gravelly Granular Fill	26,31,33,29	156 ft²
Region 12	ESU 1B - Exis□ng Gravelly Granular Fill	29,33,34,21	44 ft²
Region 13	Hilfiker Wall	25,8,38,37,36,35,28,33,31	624 ft²
Region 14	Hilfiker Wall	28,30,34,33	176 ft²
Region 15	ESU 1A - Exis□ng Granular Fill	20,21,34,32	160 ft²

Slip Results

Slip Surfaces Analysed: 4205 of 8405 converged

Current Slip Surface

Slip Surface: 7,440
Factor of Safety: 2.496
Volume: 2,824.2332 ft³
Weight: 359,461.29 lbf
Resis□ng Moment: 17,261,810 lbf·ft
Ac□va□ng Moment: 6,916,433.6 lbf·ft
Resis□ng Force: 265,322.25 lbf
Ac□va□ng Force: 106,306.95 lbf
Slip Rank: 1 of 8,405 slip surfaces
Exit: (203.78401, 49.189176) ft
Entry: (108.98329, 86.491644) ft
Radius: 55.83986 ft
Center: (164.76078, 89.1301) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Fric□onal Strength	Cohesive Strength	Suc□on Strength	Base Material
Slice 1	110.29832 ft	79.245822 ft	-2,238.3393 psf	313.34596 psf	262.92848 psf	0 psf	0 psf	ESU 1A - Exis□ng Granular Fill
Slice 2	112.66272 ft	69.25 ft	-1,614.6 psf	1,147.8444 psf	896.79433 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 3	115.28407 ft	63.469088 ft	-1,253.8711 psf	1,734.3078 psf	1,354.9898 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 4	118.42802 ft	58.091604 ft	-918.31609 psf	2,341.7797 psf	1,829.5988 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 5	121.5 ft	53.902954 ft	-656.94433 psf	2,976.3502 psf	2,325.3796 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 6	124.25 ft	50.741765 ft	-461.27795 psf	3,318.2784 psf	2,592.5232 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 7	126.75 ft	48.260102 ft	-309.60589 psf	3,614.0593 psf	2,823.6126 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 8	129.28974 ft	46.035956 ft	-174.05342 psf	4,120.9096 psf	3,337.0468 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 9	131.81331 ft	44.072158 ft	-54.726166 psf	4,417.4857 psf	3,577.2094 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 10	134.54726 ft	42.204093 ft	58.359504 psf	4,749.2034 psf	3,798.5705 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 11	137.54751 ft	40.400478 ft	167.08438 psf	5,126.224 psf	4,015.8321 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 12	140.54777 ft	38.840458 ft	260.60889 psf	5,513.2723 psf	4,253.523 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 13	143.54802 ft	37.501826 ft	340.3188 psf	5,913.4873 psf	4,513.0629 psf	0 psf	0 psf	ESU 2A - Na□ve Sand

								and Gravel
Slice 14	146.54828 ft	36.367649 ft	407.27071 psf	6,328.0236 psf	4,794.5311 psf	0 psf	0 psf	ESU 2A - Naïve Sand and Gravel
Slice 15	149.54853 ft	35.424918 ft	462.27637 psf	6,755.9935 psf	5,096.5516 psf	0 psf	0 psf	ESU 2A - Naïve Sand and Gravel
Slice 16	152.49888 ft	34.673456 ft	505.41044 psf	7,243.0934 psf	6,282.991 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 17	155.39933 ft	34.100206 ft	537.48761 psf	7,706.0037 psf	6,684.7494 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 18	158.29978 ft	33.684507 ft	559.73357 psf	8,164.2893 psf	7,091.3629 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 19	159.875 ft	33.504535 ft	569.117 psf	8,411.7111 psf	7,313.3373 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 20	161.70833 ft	33.399987 ft	575.64079 psf	2,336.1578 psf	1,641.7087 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 21	165.125 ft	33.317567 ft	580.78383 psf	2,563.0677 psf	1,848.5096 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 22	168.54167 ft	33.444706 ft	572.85032 psf	2,755.7136 psf	2,035.553 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 23	171.94279 ft	33.780349 ft	551.90623 psf	2,900.3379 psf	2,189.9479 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 24	174.44279 ft	34.14213 ft	529.33112 psf	2,934.0061 psf	2,090.3521 psf	0 psf	0 psf	ESU 2B - Naïve Sand and Gravel
Slice 25	176.725 ft	34.60793 ft	500.26519 psf	2,957.1937 psf	2,135.7754 psf	0 psf	0 psf	ESU 2B - Naïve Sand and Gravel
Slice 26	179.675 ft	35.340574 ft	454.54821 psf	2,938.9695 psf	2,159.6745 psf	0 psf	0 psf	ESU 2B - Naïve Sand and Gravel
Slice 27	182.625 ft	36.247818 ft	397.93614 psf	2,855.8394 psf	2,136.6227 psf	0 psf	0 psf	ESU 2B - Naïve Sand and Gravel
Slice 28	185.575 ft	37.338873 ft	329.85433 psf	2,703.9544 psf	2,063.7737 psf	0 psf	0 psf	ESU 2B - Naïve Sand and Gravel
Slice 29	188.525 ft	38.625699 ft	249.55636 psf	2,482.629 psf	1,941.1805 psf	0 psf	0 psf	ESU 2B - Naïve Sand and Gravel
Slice 30	191 ft	39.852217 ft	173.02166 psf	2,226.0765 psf	1,784.6933 psf	0 psf	0 psf	ESU 2B - Naïve Sand and Gravel
Slice 31	193.83488 ft	41.504846 ft	69.897623 psf	1,835.2982 psf	1,534.6393 psf	0 psf	0 psf	ESU 2B - Naïve Sand

								and Gravel
Slice 32	197.02214 ft	43.582894 ft	-59.772612 psf	1,324.85 psf	1,151.6745 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 33	199.72689 ft	45.627794 ft	-187.37436 psf	819.59413 psf	712.46231 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 34	202.43164 ft	47.951988 ft	-332.40404 psf	278.76661 psf	242.32812 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel

1.3 Pseudo-static (Spencer) Section Ga-Ga' - Existing Condition - Global Stability

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File Informa on

File Version: 11.01
Created By: Mikayla S. Hatch
Last Edited By: Mikayla S. Hatch
Revision Number: 323
Date: 11/12/2021
Time: 04:47:21 PM
Tool Version: 11.1
File Name: Wall 03.63L - Bridge 17.7 Ga-Ga' - All Condi ons.gsz
Directory: P:\0\0180366\01\Analysis\Bridge 17.7\SlopeW\
Last Solved Date: 11/12/2021
Last Solved Time: 04:47:50 PM

Project Se ngs

Unit System: U.S. Customary Units

Analysis Se ngs

1.3 Pseudo-sta c (Spencer)

Kind: SLOPE/W
Parent: 1. Global Stability
Analysis Type: Spencer
Se ngs
PWP Condi ons from: Piezometric Line
Apply Phrea c Correc on: No
Use Staged Rapid Drawdown: No
Unit Weight of Water: 62.4 pcf
Slip Surface
Direc on of movement: Le. to Right
Use Passive Mode: No
Slip Surface Op on: Entry and Exit
Cri cal slip surfaces saved: 1
Op mize Cri cal Slip Surface Loca on: No
Tension Crack Op on: (none)
Distribu on
F of S Calcula on Op on: Constant
Advanced
Geometry Se ngs
Minimum Slip Surface Depth: 2 ft
Number of Slices: 30
Factor of Safety Convergence Se ngs
Maximum Number of Itera ons: 100
Tolerable difference in F of S: 0.001
Solu on Se ngs
Search Method: Root Finder

Figure D.4-251

Tolerable difference between star□ng and converged F of S: 3
Maximum itera□ons to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Hilfiker Wall

Slope Stability Material Model: High Strength
Unit Weight: 130 pcf
Pore Water Pressure
Piezometric Line: 1

ESU 1A - Exis ng Granular Fill (Pseudo-Sta c)

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 50 psf
Effec□ve Fric□on Angle: 40 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2A - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 39 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2B - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 41 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 7A - Weathered Sandstone

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 43 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1B - Exis ng Gravelly Granular Fill

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effec□ve Cohesion: 0 psf

Effec□ve Fric□on Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2C - Na ve Silt (Pseudo-Sta c)

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effec□ve Cohesion: 200 psf
Effec□ve Fric□on Angle: 29 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (0.25, 60) ft
Left-Zone Right Coordinate: (119.82159, 91.910795) ft
Left-Zone Increment: 40
Right Type: Range
Right-Zone Left Coordinate: (160, 50.069336) ft
Right-Zone Right Coordinate: (335, 48) ft
Right-Zone Increment: 40
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 60) ft
Right Coordinate: (335, 48) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	0.25 ft	43.375 ft
Coordinate 2	56.5 ft	43.375 ft
Coordinate 3	97.75 ft	43.375 ft
Coordinate 4	123 ft	43.375 ft
Coordinate 5	159.75 ft	42.625 ft
Coordinate 6	192 ft	42.625 ft
Coordinate 7	210.75 ft	42.625 ft
Coordinate 8	298 ft	35 ft
Coordinate 9	335.25 ft	35 ft

Seismic Coefficients

Horz Seismic Coef.: 0.173

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 125 pcf
Direc□on: Ver□cal

Coordinates

	X	Y
	120 ft	92 ft
	120 ft	93 ft
	160 ft	93 ft

Geometry

Name: Ga-Ga'

Se ngs

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	0 ft	56 ft
Point 2	76 ft	56 ft
Point 3	118 ft	35 ft
Point 4	160 ft	35 ft
Point 5	0 ft	46 ft
Point 6	37 ft	46 ft
Point 7	190 ft	50 ft
Point 8	160 ft	50 ft
Point 9	170.25 ft	34 ft
Point 10	240 ft	34 ft
Point 11	315 ft	30 ft
Point 12	335 ft	30 ft
Point 13	335 ft	48 ft
Point 14	327 ft	48 ft
Point 15	315 ft	49 ft
Point 16	224 ft	48 ft
Point 17	0 ft	0 ft
Point 18	335 ft	0 ft
Point 19	160 ft	92 ft
Point 20	120 ft	92 ft
Point 21	120 ft	72 ft
Point 22	80 ft	72 ft
Point 23	56 ft	60 ft
Point 24	0 ft	60 ft
Point 25	160 ft	47 ft
Point 26	120 ft	47 ft
Point 27	69 ft	66.5 ft

Point 28	160 ft	66.5 ft
Point 29	120 ft	66.5 ft
Point 30	160 ft	72 ft
Point 31	128 ft	47 ft
Point 32	128 ft	92 ft
Point 33	128 ft	66.5 ft
Point 34	128 ft	72 ft
Point 35	160 ft	64.5 ft
Point 36	160 ft	60.5 ft
Point 37	160 ft	56.5 ft
Point 38	160 ft	52.5 ft

Regions

	Material	Points	Area
Region 1	ESU 2C - Na□ve Silt (Pseudo-Sta□c)	5,6,2,1	565 ft²
Region 2	Hilfiker Wall	19,32,34,30	640 ft²
Region 3	ESU 1A - Exis□ng Granular Fill (Pseudo-Sta□c)	20,22,21	400 ft²
Region 4	ESU 2A - Na□ve Sand and Gravel	6,2,3	619.5 ft²
Region 5	ESU 2B - Na□ve Sand and Gravel	7,16,15,14,13,12,11,10,9,4	2,595.4 ft²
Region 6	ESU 7A - Weathered Sandstone	18,17,5,6,3,4,9,10,11,12	12,178 ft²
Region 7	ESU 1B - Exis□ng Gravelly Granular Fill	8,7,25	45 ft²
Region 8	ESU 2A - Na□ve Sand and Gravel	4,7,25,31,26,2,3	945 ft²
Region 9	ESU 1B - Exis□ng Gravelly Granular Fill	21,22,27,29	250.25 ft²
Region 10	ESU 1B - Exis□ng Gravelly Granular Fill	23,24,1,2,26,29,27	1,051.8 ft²
Region 11	ESU 1B - Exis□ng Gravelly Granular Fill	26,31,33,29	156 ft²
Region 12	ESU 1B - Exis□ng Gravelly Granular Fill	29,33,34,21	44 ft²
Region 13	Hilfiker Wall	25,8,38,37,36,35,28,33,31	624 ft²
Region 14	Hilfiker Wall	28,30,34,33	176 ft²
Region 15	ESU 1A - Exis□ng Granular Fill (Pseudo-Sta□c)	20,21,34,32	160 ft²

Slip Results

Slip Surfaces Analysed: 3764 of 8405 converged

Current Slip Surface

Slip Surface: 6,448
Factor of Safety: 1.840
Volume: 3,593.9376 ft³
Weight: 460,060.61 lbf
Resis□ng Moment: 37,699,308 lbf·ft
Ac□va□ng Moment: 20,487,401 lbf·ft
Resis□ng Force: 324,269.26 lbf
Ac□va□ng Force: 176,201.64 lbf
Slip Rank: 1 of 8,405 slip surfaces
Exit: (238.69984, 48.161537) ft
Entry: (94.242261, 79.121131) ft
Radius: 106.30643 ft
Center: (182.4915, 138.3928) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Fric□onal Strength	Cohesive Strength	Suc□on Strength	Base Material
Slice 1	95.996131 ft	76.663597 ft	-2,077.2085 psf	171.277 psf	143.71847 psf	50 psf	0 psf	ESU 1A - Exis□ng Granular Fill (Pseudo-Sta□c)
Slice 2	98.608538 ft	73.103032 ft	-1,855.0292 psf	465.52591 psf	390.62262 psf	50 psf	0 psf	ESU 1A - Exis□ng Granular Fill (Pseudo-Sta□c)
Slice 3	101.8242 ft	69.25 ft	-1,614.6 psf	859.17896 psf	671.26417 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 4	106.81777 ft	63.82447 ft	-1,276.047 psf	1,469.9536 psf	1,148.4537 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 5	112.09066 ft	58.816487 ft	-963.54879 psf	2,133.6699 psf	1,667.0056 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 6	117.36355 ft	54.43879 ft	-690.3805 psf	2,811.0576 psf	2,196.2389 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 7	121.5 ft	51.342576 ft	-497.17674 psf	3,383.985 psf	2,643.8589 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 8	125.5 ft	48.703032 ft	-335.65287 psf	3,745.1023 psf	2,925.9946 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 9	131.66175 ft	45.118979 ft	-119.85479 psf	4,510.4745 psf	3,652.5102 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 10	137.56849 ft	42.076416 ft	62.479134 psf	5,036.505 psf	4,027.8867 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 11	142.05845 ft	40.105797 ft	179.72792 psf	5,422.8323 psf	4,245.7822 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel

Slice 12	146.54842 ft	38.375486 ft	281.98149 psf	5,799.4491 psf	4,467.9572 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 13	151.03838 ft	36.873163 ft	370.00862 psf	6,167.7026 psf	4,694.88 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 14	155.52835 ft	35.588808 ft	444.43454 psf	6,528.9523 psf	4,927.1453 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 15	158.76166 ft	34.773661 ft	491.18217 psf	6,862.1227 psf	5,940.9982 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 16	159.875 ft	34.520105 ft	505.74542 psf	6,960.432 psf	6,019.0926 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 17	162.5625 ft	34.00368 ft	537.97036 psf	1,828.4741 psf	1,203.4142 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 18	167.6875 ft	33.154003 ft	590.9902 psf	2,047.6252 psf	1,358.3341 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 19	172.75 ft	32.563412 ft	627.84307 psf	2,248.6179 psf	1,511.397 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 20	177.70833 ft	32.222537 ft	649.11368 psf	2,430.0157 psf	1,660.718 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 21	182.625 ft	32.114873 ft	655.83194 psf	2,594.3577 psf	1,807.7045 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 22	187.54167 ft	32.234909 ft	648.34166 psf	2,742.9281 psf	1,953.2335 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 23	191 ft	32.432156 ft	636.03344 psf	2,822.1094 psf	2,038.5488 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 24	194.64285 ft	32.816635 ft	612.04195 psf	2,834.7422 psf	2,072.7015 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 25	199.92855 ft	33.560408 ft	565.63055 psf	2,829.2688 psf	2,110.8768 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 26	204.61605 ft	34.435148 ft	511.04675 psf	2,716.5019 psf	1,917.1729 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 27	208.70535 ft	35.390656 ft	451.42306 psf	2,643.0634 psf	1,905.1639 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 28	212.95833 ft	36.571792 ft	365.67746 psf	2,537.4453 psf	1,887.889 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 29	217.375 ft	37.999898 ft	252.47828 psf	2,391.9825 psf	1,859.8426 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel

Slice 30	221.79167 ft	39.646121 ft	125.66855 psf	2,192.1294 psf	1,796.347 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 31	224.90151 ft	40.917247 ft	29.391432 psf	2,033.2359 psf	1,741.9154 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 32	227.95249 ft	42.326664 ft	-75.194078 psf	1,796.7265 psf	1,561.8705 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 33	232.25143 ft	44.482786 ft	-233.17949 psf	1,289.7395 psf	1,121.1535 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 34	236.55037 ft	46.89163 ft	-406.93473 psf	521.0898 psf	452.97645 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel

1.4 Pseudo-static (M-P) Section Ga-Ga' - Existing Condition - Global Stability

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File Informa on

File Version: 11.01
Created By: Mikayla S. Hatch
Last Edited By: Mikayla S. Hatch
Revision Number: 323
Date: 11/12/2021
Time: 04:47:21 PM
Tool Version: 11.1
File Name: Wall 03.63L - Bridge 17.7 Ga-Ga' - All Condi ons.gsz
Directory: P:\0\0180366\01\Analysis\Bridge 17.7\SlopeW\
Last Solved Date: 11/12/2021
Last Solved Time: 04:47:30 PM

Project Se ngs

Unit System: U.S. Customary Units

Analysis Se ngs

1.4 Pseudo-sta c (M-P)

Kind: SLOPE/W
Parent: 1. Global Stability
Analysis Type: Morgenstern-Price
Se ngs
Side Func on
Interslice force func on op on: Half-Sine
PWP Condi ons from: Piezometric Line
Apply Phrea c Correc on: No
Use Staged Rapid Drawdown: No
Unit Weight of Water: 62.4 pcf
Slip Surface
Direc on of movement: Le. to Right
Use Passive Mode: No
Slip Surface Op on: Entry and Exit
Cri cal slip surfaces saved: 1
Op mize Cri cal Slip Surface Loca on: No
Tension Crack Op on: (none)
Distribu on
F of S Calcula on Op on: Constant
Advanced
Geometry Se ngs
Minimum Slip Surface Depth: 2 ft
Number of Slices: 30
Factor of Safety Convergence Se ngs
Maximum Number of Itera ons: 100
Tolerable difference in F of S: 0.001

Solu□on Se□ ngs
Search Method: Root Finder
Tolerable difference between star□ng and converged F of S: 3
Maximum itera□ons to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Hilfiker Wall

Slope Stability Material Model: High Strength
Unit Weight: 130 pcf
Pore Water Pressure
Piezometric Line: 1

ESU 1A - Exis ng Granular Fill (Pseudo-Sta c)

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 50 psf
Effec□ve Fric□on Angle: 40 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2A - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 39 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2B - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 41 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 7A - Weathered Sandstone

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 43 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1B - Exis ng Gravelly Granular Fill

Slope Stability Material Model: Mohr-Coulomb

Unit Weight: 125 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2C - Na ve Silt (Pseudo-Sta c)

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effec□ve Cohesion: 200 psf
Effec□ve Fric□on Angle: 29 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (0.25, 60) ft
Left-Zone Right Coordinate: (119.82159, 91.910795) ft
Left-Zone Increment: 40
Right Type: Range
Right-Zone Left Coordinate: (160, 50.069336) ft
Right-Zone Right Coordinate: (335, 48) ft
Right-Zone Increment: 40
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 60) ft
Right Coordinate: (335, 48) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	0.25 ft	43.375 ft
Coordinate 2	56.5 ft	43.375 ft
Coordinate 3	97.75 ft	43.375 ft
Coordinate 4	123 ft	43.375 ft
Coordinate 5	159.75 ft	42.625 ft
Coordinate 6	192 ft	42.625 ft
Coordinate 7	210.75 ft	42.625 ft
Coordinate 8	298 ft	35 ft
Coordinate 9	335.25 ft	35 ft

Seismic Coefficients

Horz Seismic Coef.: 0.173

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 125 pcf
Direc□on: Ver□cal

Coordinates

	X	Y
	120 ft	92 ft
	120 ft	93 ft
	160 ft	93 ft

Geometry

Name: Ga-Ga'

Se ngs

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	0 ft	56 ft
Point 2	76 ft	56 ft
Point 3	118 ft	35 ft
Point 4	160 ft	35 ft
Point 5	0 ft	46 ft
Point 6	37 ft	46 ft
Point 7	190 ft	50 ft
Point 8	160 ft	50 ft
Point 9	170.25 ft	34 ft
Point 10	240 ft	34 ft
Point 11	315 ft	30 ft
Point 12	335 ft	30 ft
Point 13	335 ft	48 ft
Point 14	327 ft	48 ft
Point 15	315 ft	49 ft
Point 16	224 ft	48 ft
Point 17	0 ft	0 ft
Point 18	335 ft	0 ft
Point 19	160 ft	92 ft
Point 20	120 ft	92 ft
Point 21	120 ft	72 ft
Point 22	80 ft	72 ft
Point 23	56 ft	60 ft

Point 24	0 ft	60 ft
Point 25	160 ft	47 ft
Point 26	120 ft	47 ft
Point 27	69 ft	66.5 ft
Point 28	160 ft	66.5 ft
Point 29	120 ft	66.5 ft
Point 30	160 ft	72 ft
Point 31	128 ft	47 ft
Point 32	128 ft	92 ft
Point 33	128 ft	66.5 ft
Point 34	128 ft	72 ft
Point 35	160 ft	64.5 ft
Point 36	160 ft	60.5 ft
Point 37	160 ft	56.5 ft
Point 38	160 ft	52.5 ft

Regions

	Material	Points	Area
Region 1	ESU 2C - Na□ve Silt (Pseudo-Sta□c)	5,6,2,1	565 ft²
Region 2	Hilfiker Wall	19,32,34,30	640 ft²
Region 3	ESU 1A - Exis□ng Granular Fill (Pseudo-Sta□c)	20,22,21	400 ft²
Region 4	ESU 2A - Na□ve Sand and Gravel	6,2,3	619.5 ft²
Region 5	ESU 2B - Na□ve Sand and Gravel	7,16,15,14,13,12,11,10,9,4	2,595.4 ft²
Region 6	ESU 7A - Weathered Sandstone	18,17,5,6,3,4,9,10,11,12	12,178 ft²
Region 7	ESU 1B - Exis□ng Gravelly Granular Fill	8,7,25	45 ft²
Region 8	ESU 2A - Na□ve Sand and Gravel	4,7,25,31,26,2,3	945 ft²
Region 9	ESU 1B - Exis□ng Gravelly Granular Fill	21,22,27,29	250.25 ft²
Region 10	ESU 1B - Exis□ng Gravelly Granular Fill	23,24,1,2,26,29,27	1,051.8 ft²
Region 11	ESU 1B - Exis□ng Gravelly Granular Fill	26,31,33,29	156 ft²
Region 12	ESU 1B - Exis□ng Gravelly Granular Fill	29,33,34,21	44 ft²
Region 13	Hilfiker Wall	25,8,38,37,36,35,28,33,31	624 ft²
Region 14	Hilfiker Wall	28,30,34,33	176 ft²
Region 15	ESU 1A - Exis□ng Granular Fill (Pseudo-Sta□c)	20,21,34,32	160 ft²

Slip Results

Slip Surfaces Analysed: 3928 of 8405 converged

Current Slip Surface

Slip Surface: 6,448
Factor of Safety: 1.843
Volume: 3,593.9376 ft³
Weight: 460,060.61 lbf
Resis□ng Moment: 37,759,066 lbf·ft
Ac□va□ng Moment: 20,487,401 lbf·ft
Resis□ng Force: 325,469.05 lbf
Ac□va□ng Force: 176,588.29 lbf
Slip Rank: 1 of 8,405 slip surfaces
Exit: (238.69984, 48.161537) ft

Figure D.4-263

Entry: (94.242261, 79.121131) ft
Radius: 106.30643 ft
Center: (182.4915, 138.3928) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Fric□onal Strength	Cohesive Strength	Suc□on Strength	Base Material
Slice 1	95.996131 ft	76.663597 ft	-2,077.2085 psf	215.14776 psf	180.53041 psf	50 psf	0 psf	ESU 1A - Exis□ng Granular Fill (Pseudo-Sta□c)
Slice 2	98.608538 ft	73.103032 ft	-1,855.0292 psf	569.98786 psf	478.2766 psf	50 psf	0 psf	ESU 1A - Exis□ng Granular Fill (Pseudo-Sta□c)
Slice 3	101.8242 ft	69.25 ft	-1,614.6 psf	1,014.541 psf	792.64632 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 4	106.81777 ft	63.82447 ft	-1,276.047 psf	1,621.5487 psf	1,266.8927 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 5	112.09066 ft	58.816487 ft	-963.54879 psf	2,223.7773 psf	1,737.4053 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 6	117.36355 ft	54.43879 ft	-690.3805 psf	2,805.1218 psf	2,191.6013 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 7	121.5 ft	51.342576 ft	-497.17674 psf	3,291.1715 psf	2,571.345 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 8	125.5 ft	48.703032 ft	-335.65287 psf	3,566.8872 psf	2,786.7577 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 9	131.66175 ft	45.118979 ft	-119.85479 psf	4,228.4209 psf	3,424.1078 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 10	137.56849 ft	42.076416 ft	62.479134 psf	4,690.8438 psf	3,747.9758 psf	0 psf	0 psf	ESU 2A - Na□ve Sand

								and Gravel
Slice 11	142.05845 ft	40.105797 ft	179.72792 psf	5,061.5146 psf	3,953.1929 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 12	146.54842 ft	38.375486 ft	281.98149 psf	5,452.2074 psf	4,186.7664 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 13	151.03838 ft	36.873163 ft	370.00862 psf	5,866.1761 psf	4,450.7086 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 14	155.52835 ft	35.588808 ft	444.43454 psf	6,304.6324 psf	4,745.4946 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 15	158.76166 ft	34.773661 ft	491.18217 psf	6,758.983 psf	5,844.8188 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 16	159.875 ft	34.520105 ft	505.74542 psf	6,889.3899 psf	5,952.8448 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 17	162.5625 ft	34.00368 ft	537.97036 psf	1,746.6971 psf	1,127.1559 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 18	167.6875 ft	33.154003 ft	590.9902 psf	2,083.3002 psf	1,391.6016 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 19	172.75 ft	32.563412 ft	627.84307 psf	2,414.3261 psf	1,665.9224 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 20	177.70833 ft	32.222537 ft	649.11368 psf	2,727.085 psf	1,937.7396 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 21	182.625 ft	32.114873 ft	655.83194 psf	3,012.1189 psf	2,197.2731 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 22	187.54167 ft	32.234909 ft	648.34166 psf	3,254.9882 psf	2,430.7372 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 23	191 ft	32.432156 ft	636.03344 psf	3,376.2251 psf	2,555.27 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 24	194.64285 ft	32.816635 ft	612.04195 psf	3,396.9934 psf	2,597.0092 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 25	199.92855 ft	33.560408 ft	565.63055 psf	3,343.642 psf	2,590.5376 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 26	204.61605 ft	34.435148 ft	511.04675 psf	3,123.3472 psf	2,270.8382 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 27	208.70535 ft	35.390656 ft	451.42306 psf	2,922.8208 psf	2,148.3532 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 28	212.95833 ft	36.571792 ft	365.67746 psf	2,644.8559 psf	1,981.2596 psf	0 psf	0 psf	ESU 2B - Na□ve Sand

								and Gravel
Slice 29	217.375 ft	37.999898 ft	252.47828 psf	2,289.4105 psf	1,770.6782 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 30	221.79167 ft	39.646121 ft	125.66855 psf	1,872.1548 psf	1,518.1973 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 31	224.90151 ft	40.917247 ft	29.391432 psf	1,564.863 psf	1,334.7651 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 32	227.95249 ft	42.326664 ft	-75.194078 psf	1,240.3924 psf	1,078.2567 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 33	232.25143 ft	44.482786 ft	-233.17949 psf	750.10805 psf	652.05898 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 34	236.55037 ft	46.89163 ft	-406.93473 psf	249.03141 psf	216.4797 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel

3.1 Static (Spencer) Section Ga-Ga' - Construction Condition - Global Stability

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File Informa on

File Version: 11.01
Created By: Mikayla S. Hatch
Last Edited By: Mikayla S. Hatch
Revision Number: 323
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Tool Version: 11.1
File Name: Wall 03.63L - Bridge 17.7 Ga-Ga' - All Condi ons.gsz
Directory: P:\0\0180366\01\Analysis\Bridge 17.7\SlopeW\
Last Solved Date: 11/12/2021
Last Solved Time: 04:48:02 PM

Project Se ngs

Unit System: U.S. Customary Units

Analysis Se ngs

3.1 Sta c (Spencer)

Kind: SLOPE/W
Parent: 3. Global Stability
Analysis Type: Spencer
Se ngs
PWP Condi ons from: Piezometric Line
Apply Phrea c Correc on: No
Use Staged Rapid Drawdown: No
Unit Weight of Water: 62.4 pcf
Slip Surface
Direc on of movement: Le. to Right
Use Passive Mode: No
Slip Surface Op on: Entry and Exit
Cri cal slip surfaces saved: 1
Op mize Cri cal Slip Surface Loca on: No
Tension Crack Op on: (none)
Distribu on
F of S Calcula on Op on: Constant
Advanced
Geometry Se ngs
Minimum Slip Surface Depth: 2 ft
Number of Slices: 30
Factor of Safety Convergence Se ngs
Maximum Number of Itera ons: 100
Tolerable difference in F of S: 0.001
Solu on Se ngs
Search Method: Root Finder

Tolerable difference between star□ng and converged F of S: 3
Maximum itera□ons to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Hilfiker Wall

Slope Stability Material Model: High Strength
Unit Weight: 130 pcf
Pore Water Pressure
Piezometric Line: 1

ESU 2A - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 39 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2B - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 41 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 7A - Weathered Sandstone

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 43 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2C - Na ve Silt

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 29 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1B - Exis ng Gravelly Granular Fill

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effec□ve Cohesion: 0 psf

Effec□ve Fric□on Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (1.75, 60) ft
Left-Zone Right Coordinate: (120, 66.5) ft
Left-Zone Increment: 40
Right Type: Range
Right-Zone Left Coordinate: (161.41681, 50) ft
Right-Zone Right Coordinate: (315.5, 48.958333) ft
Right-Zone Increment: 40
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 60) ft
Right Coordinate: (335, 48) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	0.25 ft	43.375 ft
Coordinate 2	56.5 ft	43.375 ft
Coordinate 3	97.75 ft	43.375 ft
Coordinate 4	123 ft	43.375 ft
Coordinate 5	159.75 ft	42.625 ft
Coordinate 6	192 ft	42.625 ft
Coordinate 7	210.75 ft	42.625 ft
Coordinate 8	298 ft	35 ft
Coordinate 9	335.25 ft	35 ft

Geometry

Name: Ga-Ga'

Se ngs

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	0 ft	56 ft

Figure D.4-269

Point 2	76 ft	56 ft
Point 3	118 ft	35 ft
Point 4	160 ft	35 ft
Point 5	0 ft	46 ft
Point 6	37 ft	46 ft
Point 7	190 ft	50 ft
Point 8	160 ft	50 ft
Point 9	170.25 ft	34 ft
Point 10	240 ft	34 ft
Point 11	315 ft	30 ft
Point 12	335 ft	30 ft
Point 13	335 ft	48 ft
Point 14	327 ft	48 ft
Point 15	315 ft	49 ft
Point 16	224 ft	48 ft
Point 17	0 ft	0 ft
Point 18	335 ft	0 ft
Point 19	160 ft	92 ft
Point 20	120 ft	92 ft
Point 21	120 ft	72 ft
Point 22	80 ft	72 ft
Point 23	56 ft	60 ft
Point 24	0 ft	60 ft
Point 25	160 ft	47 ft
Point 26	120 ft	47 ft
Point 27	69 ft	66.5 ft
Point 28	160 ft	66.5 ft
Point 29	120 ft	66.5 ft
Point 30	160 ft	72 ft
Point 31	128 ft	47 ft
Point 32	128 ft	92 ft
Point 33	128 ft	66.5 ft
Point 34	128 ft	72 ft
Point 35	160 ft	64.5 ft
Point 36	160 ft	60.5 ft
Point 37	160 ft	56.5 ft
Point 38	160 ft	52.5 ft

Regions

	Material	Points	Area
Region 1	ESU 2C - Na□ve Silt	5,6,2,1	565 ft²
Region 2		19,32,34,30	640 ft²
Region 3		20,22,21	400 ft²
Region 4	ESU 2A - Na□ve Sand and Gravel	6,2,3	619.5 ft²
Region 5	ESU 2B - Na□ve Sand and Gravel	7,16,15,14,13,12,11,10,9,4	2,595.4 ft²
Region 6	ESU 7A - Weathered Sandstone	18,17,5,6,3,4,9,10,11,12	12,178 ft²
Region 7	ESU 1B - Exis□ng Gravelly Granular Fill	8,7,25	45 ft²
Region 8	ESU 2A - Na□ve Sand and Gravel	4,7,25,31,26,2,3	945 ft²
Region 9		21,22,27,29	250.25 ft²

Region 10	ESU 1B - Exis□ng Gravelly Granular Fill	23,24,1,2,26,29,27	1,051.8 ft²
Region 11	ESU 1B - Exis□ng Gravelly Granular Fill	26,31,33,29	156 ft²
Region 12		29,33,34,21	44 ft²
Region 13	Hilfiker Wall	25,8,38,37,36,35,28,33,31	624 ft²
Region 14		28,30,34,33	176 ft²
Region 15		20,21,34,32	160 ft²

Slip Results

Slip Surfaces Analysed: 4789 of 8405 converged

Current Slip Surface

Slip Surface: 7,824
Factor of Safety: 3.947
Volume: 1,244.4141 ft³
Weight: 156,657.4 lbf
Resis□ng Moment: 5,320,254.6 lbf·ft
Ac□va□ng Moment: 1,348,002.4 lbf·ft
Resis□ng Force: 113,575.22 lbf
Ac□va□ng Force: 28,776.598 lbf
Slip Rank: 1 of 8,405 slip surfaces
Exit: (184.53919, 50) ft
Entry: (114.01078, 66.5) ft
Radius: 41.90606 ft
Center: (154.07763, 78.778658) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Fric□onal Strength	Cohesive Strength	Suc□on Strength	Base Material
Slice 1	115.00898 ft	63.882056 ft	-1,279.6403 psf	163.96027 psf	128.0998 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 2	117.00539 ft	59.358578 ft	-997.37524 psf	520.78904 psf	406.885 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 3	119.0018 ft	55.921249 ft	-782.88595 psf	844.21207 psf	659.57076 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 4	121.5 ft	52.527929 ft	-571.14277 psf	1,204.0108 psf	940.67634 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 5	123.94008 ft	49.692343 ft	-395.3994 psf	1,533.8081 psf	1,198.3422 psf	0 psf	0 psf	ESU 1B - Exis□ng

								Gravelly Granular Fill
Slice 6	125.82025 ft	47.859142 ft	-283.40198 psf	1,763.1609 psf	1,377.5323 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 7	127.38016 ft	46.487536 ft	-199.80028 psf	1,934.5982 psf	1,566.6068 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 8	128.98691 ft	45.23682 ft	-123.8017 psf	2,179.6229 psf	1,765.0238 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 9	130.96074 ft	43.845481 ft	-39.495759 psf	2,377.5111 psf	1,925.2705 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 10	133.10609 ft	42.52233 ft	40.336812 psf	2,580.1126 psf	2,056.6699 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 11	135.42295 ft	41.276035 ft	115.15519 psf	2,784.8974 psf	2,161.9146 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 12	137.73981 ft	40.2091 ft	178.78146 psf	2,972.3874 psf	2,262.2175 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 13	140.05667 ft	39.306904 ft	232.12804 psf	3,143.948 psf	2,357.9453 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 14	142.37353 ft	38.558309 ft	275.88989 psf	3,300.6536 psf	2,449.4053 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 15	144.6904 ft	37.954831 ft	310.59646 psf	3,443.3586 psf	2,536.8608 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 16	147.00726 ft	37.490083 ft	336.6463 psf	3,572.7473 psf	2,620.5429 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 17	149.32412 ft	37.159401 ft	354.33041 psf	3,689.3695 psf	2,700.6614 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 18	151.64098 ft	36.959594 ft	363.8479 psf	3,793.668 psf	2,777.4136 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 19	153.95784 ft	36.888784 ft	365.316 psf	3,886.0012 psf	2,850.9946 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 20	156.27471 ft	36.946314 ft	358.7757 psf	3,966.6613 psf	2,921.6082 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 21	158.59157 ft	37.132716 ft	344.19372 psf	4,035.8943 psf	2,989.4802 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice	159.875 ft	37.275738	333.79396	4,071.3878	3,026.6438	0 psf	0 psf	ESU 2A -

22		ft	psf	psf	psf			Na□ve Sand and Gravel
Slice 23	161.27213 ft	37.515 ft	318.864 psf	1,672.8665 psf	1,096.4496 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 24	163.81639 ft	38.040917 ft	286.04678 psf	1,647.1483 psf	1,102.1983 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 25	166.36065 ft	38.735249 ft	242.72045 psf	1,600.1439 psf	1,099.2198 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 26	168.90491 ft	39.606993 ft	188.32361 psf	1,529.6788 psf	1,086.208 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 27	171.44528 ft	40.666455 ft	122.2132 psf	1,450.8508 psf	1,154.967 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 28	173.99075 ft	41.934695 ft	43.075053 psf	1,325.5715 psf	1,114.8572 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 29	176.39236 ft	43.332848 ft	-44.169707 psf	1,141.4215 psf	924.30492 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 30	178.59006 ft	44.815349 ft	-136.67776 psf	937.32165 psf	759.02811 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 31	180.73671 ft	46.4758 ft	-240.28994 psf	680.50359 psf	551.06094 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 32	182.88336 ft	48.378633 ft	-359.02673 psf	342.08124 psf	277.01193 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 33	184.24793 ft	49.697834 ft	-441.34484 psf	68.42755 psf	53.461461 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill

3.2 Static (M-P) Section Ga-Ga' - Construction Condition - Global Stability

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File Informa on

File Version: 11.01
Created By: Mikayla S. Hatch
Last Edited By: Mikayla S. Hatch
Revision Number: 323
Date: 11/12/2021
Time: 04:47:21 PM
Tool Version: 11.1
File Name: Wall 03.63L - Bridge 17.7 Ga-Ga' - All Condi ons.gsz
Directory: P:\0\0180366\01\Analysis\Bridge 17.7\SlopeW\
Last Solved Date: 11/12/2021
Last Solved Time: 04:48:14 PM

Project Se ngs

Unit System: U.S. Customary Units

Analysis Se ngs

3.2 Sta c (M-P)

Kind: SLOPE/W
Parent: 3. Global Stability
Analysis Type: Morgenstern-Price
Se ngs
Side Func on
Interslice force func on op on: Half-Sine
PWP Condi ons from: Piezometric Line
Apply Phrea c Correc on: No
Use Staged Rapid Drawdown: No
Unit Weight of Water: 62.4 pcf
Slip Surface
Direc on of movement: Le. to Right
Use Passive Mode: No
Slip Surface Op on: Entry and Exit
Cri cal slip surfaces saved: 1
Op mize Cri cal Slip Surface Loca on: No
Tension Crack Op on: (none)
Distribu on
F of S Calcula on Op on: Constant
Advanced
Geometry Se ngs
Minimum Slip Surface Depth: 2 ft
Number of Slices: 30
Factor of Safety Convergence Se ngs
Maximum Number of Itera ons: 100
Tolerable difference in F of S: 0.001

Solu□on Se□ ngs
Search Method: Root Finder
Tolerable difference between star□ng and converged F of S: 3
Maximum itera□ons to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Hilfiker Wall

Slope Stability Material Model: High Strength
Unit Weight: 130 pcf
Pore Water Pressure
Piezometric Line: 1

ESU 2A - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 39 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2B - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 41 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 7A - Weathered Sandstone

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 43 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2C - Na ve Silt

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 29 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1B - Exis ng Gravelly Granular Fill

Slope Stability Material Model: Mohr-Coulomb

Unit Weight: 125 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (1.75, 60) ft
Left-Zone Right Coordinate: (120, 66.5) ft
Left-Zone Increment: 40
Right Type: Range
Right-Zone Left Coordinate: (161.41681, 50) ft
Right-Zone Right Coordinate: (315.5, 48.958333) ft
Right-Zone Increment: 40
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 60) ft
Right Coordinate: (335, 48) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	0.25 ft	43.375 ft
Coordinate 2	56.5 ft	43.375 ft
Coordinate 3	97.75 ft	43.375 ft
Coordinate 4	123 ft	43.375 ft
Coordinate 5	159.75 ft	42.625 ft
Coordinate 6	192 ft	42.625 ft
Coordinate 7	210.75 ft	42.625 ft
Coordinate 8	298 ft	35 ft
Coordinate 9	335.25 ft	35 ft

Geometry

Name: Ga-Ga'

Se ngs

View: 2D
Element Thickness: 1 ft

Points

	X	Y

Figure D.4-276

Point 1	0 ft	56 ft
Point 2	76 ft	56 ft
Point 3	118 ft	35 ft
Point 4	160 ft	35 ft
Point 5	0 ft	46 ft
Point 6	37 ft	46 ft
Point 7	190 ft	50 ft
Point 8	160 ft	50 ft
Point 9	170.25 ft	34 ft
Point 10	240 ft	34 ft
Point 11	315 ft	30 ft
Point 12	335 ft	30 ft
Point 13	335 ft	48 ft
Point 14	327 ft	48 ft
Point 15	315 ft	49 ft
Point 16	224 ft	48 ft
Point 17	0 ft	0 ft
Point 18	335 ft	0 ft
Point 19	160 ft	92 ft
Point 20	120 ft	92 ft
Point 21	120 ft	72 ft
Point 22	80 ft	72 ft
Point 23	56 ft	60 ft
Point 24	0 ft	60 ft
Point 25	160 ft	47 ft
Point 26	120 ft	47 ft
Point 27	69 ft	66.5 ft
Point 28	160 ft	66.5 ft
Point 29	120 ft	66.5 ft
Point 30	160 ft	72 ft
Point 31	128 ft	47 ft
Point 32	128 ft	92 ft
Point 33	128 ft	66.5 ft
Point 34	128 ft	72 ft
Point 35	160 ft	64.5 ft
Point 36	160 ft	60.5 ft
Point 37	160 ft	56.5 ft
Point 38	160 ft	52.5 ft

Regions

	Material	Points	Area
Region 1	ESU 2C - Na□ve Silt	5,6,2,1	565 ft²
Region 2		19,32,34,30	640 ft²
Region 3		20,22,21	400 ft²
Region 4	ESU 2A - Na□ve Sand and Gravel	6,2,3	619.5 ft²
Region 5	ESU 2B - Na□ve Sand and Gravel	7,16,15,14,13,12,11,10,9,4	2,595.4 ft²
Region 6	ESU 7A - Weathered Sandstone	18,17,5,6,3,4,9,10,11,12	12,178 ft²
Region 7	ESU 1B - Exis□ng Gravelly Granular Fill	8,7,25	45 ft²
Region 8	ESU 2A - Na□ve Sand and Gravel	4,7,25,31,26,2,3	945 ft²

Region 9		21,22,27,29	250.25 ft²
Region 10	ESU 1B - Exis□ng Gravelly Granular Fill	23,24,1,2,26,29,27	1,051.8 ft²
Region 11	ESU 1B - Exis□ng Gravelly Granular Fill	26,31,33,29	156 ft²
Region 12		29,33,34,21	44 ft²
Region 13	Hilfiker Wall	25,8,38,37,36,35,28,33,31	624 ft²
Region 14		28,30,34,33	176 ft²
Region 15		20,21,34,32	160 ft²

Slip Results

Slip Surfaces Analysed: 5316 of 8405 converged

Current Slip Surface

Slip Surface: 7,824
Factor of Safety: 3.949
Volume: 1,244.4141 ft³
Weight: 156,657.4 lbf
Resis□ng Moment: 5,323,200.2 lbf·ft
Ac□va□ng Moment: 1,348,002.4 lbf·ft
Resis□ng Force: 113,581.51 lbf
Ac□va□ng Force: 28,762.259 lbf
Slip Rank: 1 of 8,405 slip surfaces
Exit: (184.53919, 50) ft
Entry: (114.01078, 66.5) ft
Radius: 41.90606 ft
Center: (154.07763, 78.778658) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Fric□onal Strength	Cohesive Strength	Suc□on Strength	Base Material
Slice 1	115.00898 ft	63.882056 ft	-1,279.6403 psf	207.70861 psf	162.27975 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 2	117.00539 ft	59.358578 ft	-997.37524 psf	604.5807 psf	472.35021 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 3	119.0018 ft	55.921249 ft	-782.88595 psf	921.99899 psf	720.34456 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 4	121.5 ft	52.527929 ft	-571.14277 psf	1,246.2397 psf	973.66916 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice	123.94008	49.692343	-395.3994	1,530.5426	1,195.7909	0 psf	0 psf	ESU 1B -

5	ft	ft	psf	psf	psf			Exis□ng Gravelly Granular Fill
Slice 6	125.82025 ft	47.859142 ft	-283.40198 psf	1,724.0567 psf	1,346.9807 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 7	127.38016 ft	46.487536 ft	-199.80028 psf	1,867.1904 psf	1,512.021 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 8	128.98691 ft	45.23682 ft	-123.8017 psf	2,088.3459 psf	1,691.1091 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 9	130.96074 ft	43.845481 ft	-39.495759 psf	2,260.382 psf	1,830.4213 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 10	133.10609 ft	42.52233 ft	40.336812 psf	2,443.9631 psf	1,946.4182 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 11	135.42295 ft	41.276035 ft	115.15519 psf	2,638.9869 psf	2,043.7586 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 12	137.73981 ft	40.2091 ft	178.78146 psf	2,828.5413 psf	2,145.7332 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 13	140.05667 ft	39.306904 ft	232.12804 psf	3,013.9726 psf	2,252.6933 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 14	142.37353 ft	38.558309 ft	275.88989 psf	3,195.6195 psf	2,364.3504 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 15	144.6904 ft	37.954831 ft	310.59646 psf	3,372.881 psf	2,479.7891 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 16	147.00726 ft	37.490083 ft	336.6463 psf	3,544.2471 psf	2,597.4639 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 17	149.32412 ft	37.159401 ft	354.33041 psf	3,707.3171 psf	2,715.1951 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 18	151.64098 ft	36.959594 ft	363.8479 psf	3,858.8268 psf	2,830.1781 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 19	153.95784 ft	36.888784 ft	365.316 psf	3,994.7048 psf	2,939.0211 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 20	156.27471 ft	36.946314 ft	358.7757 psf	4,110.1754 psf	3,037.8236 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 21	158.59157 ft	37.132716 ft	344.19372 psf	4,199.9243 psf	3,122.3091 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel

Slice 22	159.875 ft	37.275738 ft	333.79396 psf	4,239.4841 psf	3,162.7655 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 23	161.27213 ft	37.515 ft	318.864 psf	1,812.2805 psf	1,209.3448 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 24	163.81639 ft	38.040917 ft	286.04678 psf	1,789.0125 psf	1,217.0777 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 25	166.36065 ft	38.735249 ft	242.72045 psf	1,728.9973 psf	1,203.5632 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 26	168.90491 ft	39.606993 ft	188.32361 psf	1,629.0811 psf	1,166.7024 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 27	171.44528 ft	40.666455 ft	122.2132 psf	1,503.4278 psf	1,200.6715 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 28	173.99075 ft	41.934695 ft	43.075053 psf	1,318.1025 psf	1,108.3645 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 29	176.39236 ft	43.332848 ft	-44.169707 psf	1,080.6551 psf	875.09725 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 30	178.59006 ft	44.815349 ft	-136.67776 psf	835.90785 psf	676.90483 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 31	180.73671 ft	46.4758 ft	-240.28994 psf	563.55984 psf	456.36176 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 32	182.88336 ft	48.378633 ft	-359.02673 psf	258.17736 psf	209.0679 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 33	184.24793 ft	49.697834 ft	-441.34484 psf	48.03558 psf	37.529508 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill

5.1 Static (Spencer) Section Ga-Ga' - Final Condition - Global Stability

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File Informa on

File Version: 11.01
Created By: Mikayla S. Hatch
Last Edited By: Mikayla S. Hatch
Revision Number: 323
Date: 11/12/2021
Time: 04:47:21 PM
Tool Version: 11.1
File Name: Wall 03.63L - Bridge 17.7 Ga-Ga' - All Condi ons.gsz
Directory: P:\0\0180366\01\Analysis\Bridge 17.7\SlopeW\
Last Solved Date: 11/12/2021
Last Solved Time: 04:48:40 PM

Project Se ngs

Unit System: U.S. Customary Units

Analysis Se ngs

5.1 Sta c (Spencer)

Kind: SLOPE/W
Parent: 5. Global Stability
Analysis Type: Spencer
Se ngs
PWP Condi ons from: Piezometric Line
Apply Phrea c Correc on: No
Use Staged Rapid Drawdown: No
Unit Weight of Water: 62.4 pcf
Slip Surface
Direc on of movement: Le. to Right
Use Passive Mode: No
Slip Surface Op□on: Entry and Exit
Cri□cal slip surfaces saved: 1
Op□mize Cri□cal Slip Surface Loca□on: No
Tension Crack Op□on: (none)
Distribu□on
F of S Calcula□on Op□on: Constant
Advanced
Geometry Se□ ngs
Minimum Slip Surface Depth: 2 ft
Number of Slices: 30
Factor of Safety Convergence Se□ ngs
Maximum Number of Itera□ons: 100
Tolerable difference in F of S: 0.001
Solu□on Se□ ngs
Search Method: Root Finder

Tolerable difference between star□ng and converged F of S: 3
Maximum itera□ons to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

ESU 2A - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 39 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2B - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 41 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 7A - Weathered Sandstone

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 43 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2C - Na ve Silt

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 29 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1B - Exis ng Gravelly Granular Fill

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Common Borrow

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

New Hilfiker Wall

Slope Stability Material Model: High Strength
Unit Weight: 130 pcf
Pore Water Pressure
Piezometric Line: 1

Reinforcements

Soil Nail_Row 1

Type: Anchor
Pullout Resistance: 1,800 psf
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 82,550 lbf
Tensile Capacity Reduc□on Factor: 1
Shear Force: 0 lbf
Shear Force Reduc□on Factor: 1
Apply Shear: Parallel to Slip
F of S Dependent: No
Force Distribu□on: Distributed
Bond Length: 45 ft
Bond Diameter: 0.5 ft
Out-of-Plane Spacing: 4 ft
Face Anchorage: Yes
Factored Pullout Resistance: 706.86 lbf/ft/ft
Factored Tensile Capacity: 20,638 lbf/ft

Soil Nail_Row 2

Type: Anchor
Pullout Resistance: 1,800 psf
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 82,550 lbf
Tensile Capacity Reduc□on Factor: 1
Shear Force: 0 lbf
Shear Force Reduc□on Factor: 1
Apply Shear: Parallel to Slip
F of S Dependent: No
Force Distribu□on: Distributed
Bond Length: 45 ft
Bond Diameter: 0.5 ft
Out-of-Plane Spacing: 4 ft
Face Anchorage: Yes
Factored Pullout Resistance: 706.86 lbf/ft/ft
Factored Tensile Capacity: 20,638 lbf/ft

Soil Nail_Row 3

Type: Anchor
Pullout Resistance: 1,800 psf
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 82,550 lbf
Tensile Capacity Reduc□on Factor: 1
Shear Force: 0 lbf
Shear Force Reduc□on Factor: 1
Apply Shear: Parallel to Slip
F of S Dependent: No
Force Distribu□on: Distributed
Bond Length: 40 ft
Bond Diameter: 0.5 ft
Out-of-Plane Spacing: 4 ft
Face Anchorage: Yes
Factored Pullout Resistance: 706.86 lbf/ft/ft
Factored Tensile Capacity: 20,638 lbf/ft

Soil Nail_Row 4

Type: Anchor
Pullout Resistance: 1,800 psf
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 82,550 lbf
Tensile Capacity Reduc□on Factor: 1
Shear Force: 0 lbf
Shear Force Reduc□on Factor: 1
Apply Shear: Parallel to Slip
F of S Dependent: No
Force Distribu□on: Distributed
Bond Length: 40 ft
Bond Diameter: 0.5 ft
Out-of-Plane Spacing: 4 ft
Face Anchorage: Yes
Factored Pullout Resistance: 706.86 lbf/ft/ft
Factored Tensile Capacity: 20,638 lbf/ft

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (0.05, 60) ft
Left-Zone Right Coordinate: (119.5945, 91.79725) ft
Left-Zone Increment: 40
Right Type: Range
Right-Zone Left Coordinate: (160, 70.95212) ft
Right-Zone Right Coordinate: (335, 48) ft
Right-Zone Increment: 40
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 60) ft
Right Coordinate: (335, 48) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	0.25 ft	43.375 ft
Coordinate 2	56.5 ft	43.375 ft
Coordinate 3	97.75 ft	43.375 ft
Coordinate 4	123 ft	43.375 ft
Coordinate 5	159.75 ft	42.625 ft
Coordinate 6	192 ft	42.625 ft
Coordinate 7	210.75 ft	42.625 ft
Coordinate 8	298 ft	35 ft
Coordinate 9	335.25 ft	35 ft

Reinforcement Lines

Reinforcement Line 1

Reinforcement: Soil Nail_Row 1
Lock to Ground Surface: Yes
Outside Point: (160, 64.5) ft
Inside Point: (115.68365, 56.685832) ft
Length: 45.000001 ft
Orienta□on: -170 °
Slip Surface Intersec□on: (121.63098, 57.734506) ft
Max. Pullout Force: 20,637.5 lbf
Bond Length: 45 ft
Available Length: 6.0390732 ft
Required Length: 6.0390732 ft
Pullout Force: 4,268.7693 lbf
Pullout Force per Length: 706.85835 lbf/ft
Governing Component: Pullout Resistance

Reinforcement Line 2

Reinforcement: Soil Nail_Row 2
Lock to Ground Surface: Yes
Outside Point: (160, 60.5) ft
Inside Point: (115.68365, 52.685832) ft
Length: 45.000001 ft
Orienta□on: -170 °
Slip Surface Intersec□on: (124.38902, 54.220823) ft
Max. Pullout Force: 20,637.5 lbf
Bond Length: 45 ft
Available Length: 8.8396634 ft
Required Length: 8.8396634 ft
Pullout Force: 6,248.3899 lbf
Pullout Force per Length: 706.85835 lbf/ft
Governing Component: Pullout Resistance

Reinforcement Line 3

Reinforcement: Soil Nail_Row 3
Lock to Ground Surface: Yes
Outside Point: (160, 56.5) ft
Inside Point: (120.60769, 49.554073) ft
Length: 40 ft
Orienta□on: -170 °
Slip Surface Intersec□on: (127.59531, 50.78618) ft
Max. Pullout Force: 20,637.5 lbf
Bond Length: 40 ft
Available Length: 7.0954189 ft
Required Length: 7.0954189 ft
Pullout Force: 5,015.4561 lbf
Pullout Force per Length: 706.85835 lbf/ft
Governing Component: Pullout Resistance

Reinforcement Line 4

Reinforcement: Soil Nail_Row 4
Lock to Ground Surface: Yes
Outside Point: (160, 52.5) ft
Inside Point: (120.60769, 45.554073) ft
Length: 40 ft
Orienta□on: -170 °
Slip Surface Intersec□on: (131.36016, 47.450023) ft
Max. Pullout Force: 20,637.5 lbf
Bond Length: 40 ft
Available Length: 10.918343 ft
Required Length: 10.918343 ft
Pullout Force: 7,717.7219 lbf
Pullout Force per Length: 706.85835 lbf/ft
Governing Component: Pullout Resistance

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 250 pcf
Direc□on: Ver□cal

Coordinates

	X	Y
	120 ft	92 ft
	120 ft	93 ft
	160 ft	93 ft

Geometry

Name: Ga-Ga'

Se ngs

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	0 ft	56 ft
Point 2	76 ft	56 ft
Point 3	118 ft	35 ft
Point 4	160 ft	35 ft
Point 5	0 ft	46 ft
Point 6	37 ft	46 ft
Point 7	190 ft	50 ft
Point 8	160 ft	50 ft
Point 9	170.25 ft	34 ft
Point 10	240 ft	34 ft
Point 11	315 ft	30 ft
Point 12	335 ft	30 ft
Point 13	335 ft	48 ft
Point 14	327 ft	48 ft
Point 15	315 ft	49 ft
Point 16	224 ft	48 ft
Point 17	0 ft	0 ft
Point 18	335 ft	0 ft
Point 19	160 ft	92 ft
Point 20	120 ft	92 ft
Point 21	120 ft	72 ft
Point 22	80 ft	72 ft
Point 23	56 ft	60 ft
Point 24	0 ft	60 ft
Point 25	160 ft	47 ft
Point 26	120 ft	47 ft
Point 27	69 ft	66.5 ft
Point 28	160 ft	66.5 ft
Point 29	120 ft	66.5 ft
Point 30	160 ft	72 ft
Point 31	128 ft	47 ft
Point 32	128 ft	92 ft
Point 33	128 ft	66.5 ft
Point 34	128 ft	72 ft
Point 35	160 ft	64.5 ft
Point 36	160 ft	60.5 ft
Point 37	160 ft	56.5 ft
Point 38	160 ft	52.5 ft

Regions

	Material	Points	Area
Region 1	ESU 2C - Na□ve Silt	5,6,2,1	565 ft²
Region 2	New Hilfiker Wall	19,32,34,30	640 ft²
Region 3	Common Borrow	20,22,21	400 ft²
Region 4	ESU 2A - Na□ve Sand and Gravel	6,2,3	619.5 ft²
Region 5	ESU 2B - Na□ve Sand and Gravel	7,16,15,14,13,12,11,10,9,4	2,595.4 ft²
Region 6	ESU 7A - Weathered Sandstone	18,17,5,6,3,4,9,10,11,12	12,178 ft²

Region 7	ESU 1B - Exis□ng Gravelly Granular Fill	8,7,25	45 ft²
Region 8	ESU 2A - Na□ve Sand and Gravel	4,7,25,31,26,2,3	945 ft²
Region 9	Common Borrow	21,22,27,29	250.25 ft²
Region 10	ESU 1B - Exis□ng Gravelly Granular Fill	23,24,1,2,26,29,27	1,051.8 ft²
Region 11	ESU 1B - Exis□ng Gravelly Granular Fill	26,31,33,29	156 ft²
Region 12	Common Borrow	29,33,34,21	44 ft²
Region 13	ESU 1B - Exis□ng Gravelly Granular Fill	25,8,38,37,36,35,28,33,31	624 ft²
Region 14	New Hilfiker Wall	28,30,34,33	176 ft²
Region 15	Common Borrow	20,21,34,32	160 ft²

Slip Results

Slip Surfaces Analysed: 4872 of 8405 converged

Current Slip Surface

Slip Surface: 7,655
Factor of Safety: 2.594
Volume: 2,575.3595 ft³
Weight: 324,658.85 lbf
Resis□ng Moment: 15,126,296 lbf·ft
Ac□va□ng Moment: 5,832,150.9 lbf·ft
Resis□ng Force: 234,568.71 lbf
Ac□va□ng Force: 90,444.167 lbf
Slip Rank: 1 of 8,405 slip surfaces
Exit: (202.74469, 49.250312) ft
Entry: (111.07167, 87.535836) ft
Radius: 54.966509 ft
Center: (165.97787, 90.110046) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Fric□onal Strength	Cohesive Strength	Suc□on Strength	Base Material
Slice 1	112.57606 ft	79.767918 ft	-2,270.9181 psf	296.46222 psf	185.25016 psf	0 psf	0 psf	Common Borrow
Slice 2	115.2104 ft	69.25 ft	-1,614.6 psf	1,149.9502 psf	718.56863 psf	0 psf	0 psf	Common Borrow
Slice 3	118.17018 ft	63.243876 ft	-1,239.8179 psf	1,768.2435 psf	1,381.5033 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 4	121.5 ft	57.915454 ft	-907.32431 psf	2,632.2737 psf	2,056.5576 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 5	124.25 ft	54.383193 ft	-688.50311 psf	3,167.2946 psf	2,474.5617 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill

Slice 6	126.75 ft	51.648332 ft	-521.03141 psf	3,617.2565 psf	2,826.1105 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 7	129.93871 ft	48.686716 ft	-340.2873 psf	4,277.6769 psf	3,342.0875 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 8	133.29026 ft	45.954105 ft	-174.04048 psf	4,795.8278 psf	3,883.5848 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 9	136.11594 ft	43.993352 ft	-55.287924 psf	5,172.0767 psf	4,188.2651 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 10	139.11602 ft	42.188786 ft	53.496484 psf	5,529.6079 psf	4,434.4676 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 11	142.29048 ft	40.5406 ft	152.3007 psf	5,914.92 psf	4,666.4771 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 12	145.46494 ft	39.143299 ft	235.44971 psf	6,278.0189 psf	4,893.1761 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 13	148.63939 ft	37.976598 ft	304.20932 psf	6,621.9723 psf	5,116.0236 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 14	151.81385 ft	37.025217 ft	359.53292 psf	6,949.4077 psf	5,336.3754 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 15	154.98831 ft	36.277691 ft	402.13596 psf	7,262.6898 psf	5,555.5669 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 16	158.16277 ft	35.725581 ft	432.54504 psf	7,564.063 psf	5,774.9894 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 17	159.875 ft	35.48353 ft	445.62776 psf	10,682.54 psf	8,289.6881 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 18	160.38988 ft	35.429721 ft	448.98539 psf	1,778.0243 psf	1,076.2345 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 19	162.22678 ft	35.290863 ft	457.65013 psf	1,842.4609 psf	1,203.7976 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 20	165.12083 ft	35.169276 ft	465.2372 psf	1,933.6113 psf	1,276.4382 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 21	168.01488 ft	35.200384 ft	463.29604 psf	2,008.5576 psf	1,343.2754 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 22	170.90893 ft	35.384449 ft	451.81037 psf	2,066.641 psf	1,403.7508 psf	0 psf	0 psf	ESU 2B - Na□ve Sand

								and Gravel
Slice 23	173.80298 ft	35.723029 ft	430.68301 psf	2,106.9986 psf	1,457.1989 psf	0 psf	0 psf	ESU 2B - Naïve Sand and Gravel
Slice 24	176.725 ft	36.225408 ft	399.33452 psf	2,128.5031 psf	1,503.1433 psf	0 psf	0 psf	ESU 2B - Naïve Sand and Gravel
Slice 25	179.675 ft	36.899276 ft	357.28515 psf	2,129.313 psf	1,540.4003 psf	0 psf	0 psf	ESU 2B - Naïve Sand and Gravel
Slice 26	182.625 ft	37.747897 ft	304.33125 psf	2,106.9831 psf	1,567.0214 psf	0 psf	0 psf	ESU 2B - Naïve Sand and Gravel
Slice 27	185.575 ft	38.779968 ft	239.92999 psf	2,058.7903 psf	1,581.1111 psf	0 psf	0 psf	ESU 2B - Naïve Sand and Gravel
Slice 28	188.525 ft	40.006874 ft	163.37108 psf	1,980.9759 psf	1,580.0197 psf	0 psf	0 psf	ESU 2B - Naïve Sand and Gravel
Slice 29	191 ft	41.182052 ft	90.039975 psf	1,867.5467 psf	1,545.163 psf	0 psf	0 psf	ESU 2B - Naïve Sand and Gravel
Slice 30	192.83169 ft	42.159229 ft	29.064082 psf	1,734.6581 psf	1,482.6503 psf	0 psf	0 psf	ESU 2B - Naïve Sand and Gravel
Slice 31	195.17693 ft	43.574693 ft	-59.260844 psf	1,492.6532 psf	1,297.5436 psf	0 psf	0 psf	ESU 2B - Naïve Sand and Gravel
Slice 32	198.20404 ft	45.620739 ft	-186.93411 psf	1,057.7362 psf	919.47602 psf	0 psf	0 psf	ESU 2B - Naïve Sand and Gravel
Slice 33	201.23114 ft	47.983702 ft	-334.383 psf	423.59656 psf	368.22687 psf	0 psf	0 psf	ESU 2B - Naïve Sand and Gravel

5.2 Static (M-P) Section Ga-Ga' - Final Condition - Global Stability

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File Informa on

File Version: 11.01
Created By: Mikayla S. Hatch
Last Edited By: Mikayla S. Hatch
Revision Number: 323
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Tool Version: 11.1
File Name: Wall 03.63L - Bridge 17.7 Ga-Ga' - All Condi ons.gsz
Directory: P:\0\0180366\01\Analysis\Bridge 17.7\SlopeW\
Last Solved Date: 11/12/2021
Last Solved Time: 04:48:52 PM

Project Se ngs

Unit System: U.S. Customary Units

Analysis Se ngs

5.2 Sta c (M-P)

Kind: SLOPE/W
Parent: 5. Global Stability
Analysis Type: Morgenstern-Price
Se ngs
Side Func on
Interslice force func on op on: Half-Sine
PWP Condi ons from: Piezometric Line
Apply Phrea c Correc on: No
Use Staged Rapid Drawdown: No
Unit Weight of Water: 62.4 pcf
Slip Surface
Direc on of movement: Le. to Right
Use Passive Mode: No
Slip Surface Op on: Entry and Exit
Cri cal slip surfaces saved: 1
Op mize Cri cal Slip Surface Loca on: No
Tension Crack Op on: (none)
Distribu on
F of S Calcula on Op on: Constant
Advanced
Geometry Se ngs
Minimum Slip Surface Depth: 2 ft
Number of Slices: 30
Factor of Safety Convergence Se ngs
Maximum Number of Itera ons: 100
Tolerable difference in F of S: 0.001

Solu□on Se□ ngs
Search Method: Root Finder
Tolerable difference between star□ng and converged F of S: 3
Maximum itera□ons to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

ESU 2A - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 39 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2B - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 41 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 7A - Weathered Sandstone

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 43 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2C - Na ve Silt

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 29 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1B - Exis ng Gravelly Granular Fill

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Common Borrow

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

New Hilfiker Wall

Slope Stability Material Model: High Strength
Unit Weight: 130 pcf
Pore Water Pressure
Piezometric Line: 1

Reinforcements

Soil Nail_Row 1

Type: Anchor
Pullout Resistance: 1,800 psf
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 82,550 lbf
Tensile Capacity Reduc□on Factor: 1
Shear Force: 0 lbf
Shear Force Reduc□on Factor: 1
Apply Shear: Parallel to Slip
F of S Dependent: No
Force Distribu□on: Distributed
Bond Length: 45 ft
Bond Diameter: 0.5 ft
Out-of-Plane Spacing: 4 ft
Face Anchorage: Yes
Factored Pullout Resistance: 706.86 lbf/ft/ft
Factored Tensile Capacity: 20,638 lbf/ft

Soil Nail_Row 2

Type: Anchor
Pullout Resistance: 1,800 psf
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 82,550 lbf
Tensile Capacity Reduc□on Factor: 1
Shear Force: 0 lbf
Shear Force Reduc□on Factor: 1
Apply Shear: Parallel to Slip
F of S Dependent: No
Force Distribu□on: Distributed
Bond Length: 45 ft
Bond Diameter: 0.5 ft
Out-of-Plane Spacing: 4 ft
Face Anchorage: Yes
Factored Pullout Resistance: 706.86 lbf/ft/ft
Factored Tensile Capacity: 20,638 lbf/ft

Soil Nail_Row 3

Type: Anchor
Pullout Resistance: 1,800 psf
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 82,550 lbf
Tensile Capacity Reduc□on Factor: 1
Shear Force: 0 lbf
Shear Force Reduc□on Factor: 1
Apply Shear: Parallel to Slip
F of S Dependent: No
Force Distribu□on: Distributed
Bond Length: 40 ft
Bond Diameter: 0.5 ft
Out-of-Plane Spacing: 4 ft
Face Anchorage: Yes
Factored Pullout Resistance: 706.86 lbf/ft/ft
Factored Tensile Capacity: 20,638 lbf/ft

Soil Nail_Row 4

Type: Anchor
Pullout Resistance: 1,800 psf
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 82,550 lbf
Tensile Capacity Reduc□on Factor: 1
Shear Force: 0 lbf
Shear Force Reduc□on Factor: 1
Apply Shear: Parallel to Slip
F of S Dependent: No
Force Distribu□on: Distributed
Bond Length: 40 ft
Bond Diameter: 0.5 ft
Out-of-Plane Spacing: 4 ft
Face Anchorage: Yes
Factored Pullout Resistance: 706.86 lbf/ft/ft
Factored Tensile Capacity: 20,638 lbf/ft

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (0.05, 60) ft
Left-Zone Right Coordinate: (119.5945, 91.79725) ft
Left-Zone Increment: 40
Right Type: Range
Right-Zone Left Coordinate: (160, 70.95212) ft
Right-Zone Right Coordinate: (335, 48) ft
Right-Zone Increment: 40
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 60) ft
Right Coordinate: (335, 48) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	0.25 ft	43.375 ft
Coordinate 2	56.5 ft	43.375 ft
Coordinate 3	97.75 ft	43.375 ft
Coordinate 4	123 ft	43.375 ft
Coordinate 5	159.75 ft	42.625 ft
Coordinate 6	192 ft	42.625 ft
Coordinate 7	210.75 ft	42.625 ft
Coordinate 8	298 ft	35 ft
Coordinate 9	335.25 ft	35 ft

Reinforcement Lines

Reinforcement Line 1

Reinforcement: Soil Nail_Row 1
Lock to Ground Surface: Yes
Outside Point: (160, 64.5) ft
Inside Point: (115.68365, 56.685832) ft
Length: 45.000001 ft
Orienta□on: -170 °
Slip Surface Intersec□on: (117.41689, 56.99145) ft
Max. Pullout Force: 20,637.5 lbf
Bond Length: 45 ft
Available Length: 1.7599826 ft
Required Length: 1.7599826 ft
Pullout Force: 1,244.0584 lbf
Pullout Force per Length: 706.85835 lbf/ft
Governing Component: Pullout Resistance

Reinforcement Line 2

Reinforcement: Soil Nail_Row 2
Lock to Ground Surface: Yes
Outside Point: (160, 60.5) ft
Inside Point: (115.68365, 52.685832) ft
Length: 45.000001 ft
Orienta□on: -170 °
Slip Surface Intersec□on: (120.76042, 53.581003) ft
Max. Pullout Force: 20,637.5 lbf
Bond Length: 45 ft
Available Length: 5.1550837 ft
Required Length: 5.1550837 ft
Pullout Force: 3,643.914 lbf
Pullout Force per Length: 706.85835 lbf/ft
Governing Component: Pullout Resistance

Reinforcement Line 3

Reinforcement: Soil Nail_Row 3
Lock to Ground Surface: Yes
Outside Point: (160, 56.5) ft
Inside Point: (120.60769, 49.554073) ft
Length: 40 ft
Orienta□on: -170 °
Slip Surface Intersec□on: (124.6066, 50.259188) ft
Max. Pullout Force: 20,637.5 lbf
Bond Length: 40 ft
Available Length: 4.0605982 ft
Required Length: 4.0605982 ft
Pullout Force: 2,870.2677 lbf
Pullout Force per Length: 706.85835 lbf/ft
Governing Component: Pullout Resistance

Reinforcement Line 4

Reinforcement: Soil Nail_Row 4
Lock to Ground Surface: Yes
Outside Point: (160, 52.5) ft
Inside Point: (120.60769, 45.554073) ft
Length: 40 ft
Orienta□on: -170 °
Slip Surface Intersec□on: (128.84011, 47.005671) ft
Max. Pullout Force: 20,637.5 lbf
Bond Length: 40 ft
Available Length: 8.359421 ft
Required Length: 8.359421 ft
Pullout Force: 5,908.9265 lbf
Pullout Force per Length: 706.85835 lbf/ft
Governing Component: Pullout Resistance

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 250 pcf
Direc□on: Ver□cal

Coordinates

	X	Y
	120 ft	92 ft
	120 ft	93 ft
	160 ft	93 ft

Geometry

Name: Ga-Ga'

Se ngs

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	0 ft	56 ft
Point 2	76 ft	56 ft
Point 3	118 ft	35 ft
Point 4	160 ft	35 ft
Point 5	0 ft	46 ft
Point 6	37 ft	46 ft
Point 7	190 ft	50 ft
Point 8	160 ft	50 ft
Point 9	170.25 ft	34 ft
Point 10	240 ft	34 ft
Point 11	315 ft	30 ft
Point 12	335 ft	30 ft
Point 13	335 ft	48 ft
Point 14	327 ft	48 ft
Point 15	315 ft	49 ft
Point 16	224 ft	48 ft
Point 17	0 ft	0 ft
Point 18	335 ft	0 ft
Point 19	160 ft	92 ft
Point 20	120 ft	92 ft
Point 21	120 ft	72 ft
Point 22	80 ft	72 ft
Point 23	56 ft	60 ft
Point 24	0 ft	60 ft
Point 25	160 ft	47 ft
Point 26	120 ft	47 ft
Point 27	69 ft	66.5 ft
Point 28	160 ft	66.5 ft
Point 29	120 ft	66.5 ft
Point 30	160 ft	72 ft
Point 31	128 ft	47 ft
Point 32	128 ft	92 ft
Point 33	128 ft	66.5 ft
Point 34	128 ft	72 ft
Point 35	160 ft	64.5 ft
Point 36	160 ft	60.5 ft
Point 37	160 ft	56.5 ft
Point 38	160 ft	52.5 ft

Regions

	Material	Points	Area
Region 1	ESU 2C - Na□ve Silt	5,6,2,1	565 ft²
Region 2	New Hilfiker Wall	19,32,34,30	640 ft²
Region 3	Common Borrow	20,22,21	400 ft²
Region 4	ESU 2A - Na□ve Sand and Gravel	6,2,3	619.5 ft²
Region 5	ESU 2B - Na□ve Sand and Gravel	7,16,15,14,13,12,11,10,9,4	2,595.4 ft²
Region 6	ESU 7A - Weathered Sandstone	18,17,5,6,3,4,9,10,11,12	12,178 ft²

Region 7	ESU 1B - Exis□ng Gravelly Granular Fill	8,7,25	45 ft²
Region 8	ESU 2A - Na□ve Sand and Gravel	4,7,25,31,26,2,3	945 ft²
Region 9	Common Borrow	21,22,27,29	250.25 ft²
Region 10	ESU 1B - Exis□ng Gravelly Granular Fill	23,24,1,2,26,29,27	1,051.8 ft²
Region 11	ESU 1B - Exis□ng Gravelly Granular Fill	26,31,33,29	156 ft²
Region 12	Common Borrow	29,33,34,21	44 ft²
Region 13	ESU 1B - Exis□ng Gravelly Granular Fill	25,8,38,37,36,35,28,33,31	624 ft²
Region 14	New Hilfiker Wall	28,30,34,33	176 ft²
Region 15	Common Borrow	20,21,34,32	160 ft²

Slip Results

Slip Surfaces Analysed: 5463 of 8405 converged

Current Slip Surface

Slip Surface: 7,044
Factor of Safety: 2.599
Volume: 2,885.6916 ft³
Weight: 363,117.84 lbf
Resis□ng Moment: 19,994,191 lbf·ft
Ac□va□ng Moment: 7,694,193.4 lbf·ft
Resis□ng Force: 262,463.63 lbf
Ac□va□ng Force: 100,983.58 lbf
Slip Rank: 1 of 8,405 slip surfaces
Exit: (207.63768, 48.962489) ft
Entry: (102.54884, 83.274422) ft
Radius: 67.08278 ft
Center: (166.89116, 102.25245) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Fric□onal Strength	Cohesive Strength	Suc□on Strength	Base Material
Slice 1	104.78303 ft	77.637211 ft	-2,137.962 psf	474.00675 psf	296.19229 psf	0 psf	0 psf	Common Borrow
Slice 2	108.57347 ft	69.25 ft	-1,614.6 psf	1,295.1035 psf	809.27047 psf	0 psf	0 psf	Common Borrow
Slice 3	111.77477 ft	64.122127 ft	-1,294.6207 psf	1,768.5366 psf	1,381.7322 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 4	115.06486 ft	59.738856 ft	-1,021.1046 psf	2,303.3526 psf	1,799.5763 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 5	118.35495 ft	56.006926 ft	-788.2322 psf	2,815.1393 psf	2,199.4279 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill

Slice 6	121.5 ft	52.900772 ft	-594.40815 psf	3,425.4854 psf	2,676.2825 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 7	125.5 ft	49.557435 ft	-388.9676 psf	3,840.7015 psf	3,000.6849 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 8	128.42411 ft	47.296861 ft	-251.63155 psf	4,734.027 psf	3,698.6272 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 9	130.43684 ft	45.971024 ft	-171.4625 psf	4,623.7169 psf	3,744.2121 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 10	133.61409 ft	44.034007 ft	-54.638734 psf	4,966.9624 psf	4,022.1669 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 11	136.95609 ft	42.251192 ft	52.352965 psf	5,323.2033 psf	4,268.2504 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 12	140.46285 ft	40.624507 ft	149.39239 psf	5,716.4544 psf	4,508.1179 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 13	143.9696 ft	39.234834 ft	231.64224 psf	6,112.6291 psf	4,762.3293 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 14	147.47636 ft	38.066714 ft	300.06716 psf	6,510.4625 psf	5,029.079 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 15	150.98311 ft	37.108185 ft	355.41362 psf	6,906.5255 psf	5,304.9858 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 16	154.48987 ft	36.35007 ft	398.25425 psf	7,295.1391 psf	5,584.9872 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 17	157.99662 ft	35.78549 ft	429.01829 psf	7,668.3195 psf	5,862.2705 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 18	159.875 ft	35.537709 ft	442.24696 psf	10,088.545 psf	7,811.4185 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 19	160.43961 ft	35.482087 ft	445.71779 psf	1,871.7359 psf	1,154.7667 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 20	162.67557 ft	35.32646 ft	455.42887 psf	1,981.0143 psf	1,326.1712 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 21	166.26826 ft	35.196624 ft	463.53068 psf	2,134.5749 psf	1,452.6166 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel

Slice 22	169.86096 ft	35.259569 ft	459.60289 psf	2,256.4863 psf	1,562.0069 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 23	173.45365 ft	35.515844 ft	443.61136 psf	2,339.671 psf	1,648.2195 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 24	177.09375 ft	35.976314 ft	414.87801 psf	2,376.8683 psf	1,705.5321 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 25	180.78125 ft	36.650524 ft	372.80727 psf	2,359.8115 psf	1,727.2764 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 26	184.46875 ft	37.541731 ft	317.19599 psf	2,281.8614 psf	1,707.8576 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 27	188.15625 ft	38.659089 ft	247.47282 psf	2,139.7357 psf	1,644.919 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 28	191 ft	39.660801 ft	184.96604 psf	1,970.1299 psf	1,551.8193 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 29	193.40665 ft	40.651453 ft	123.14934 psf	1,762.0009 psf	1,424.6319 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 30	196.21994 ft	41.940964 ft	42.68383 psf	1,489.1607 psf	1,257.4032 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 31	199.2951 ft	43.545963 ft	-57.4681 psf	1,139.6073 psf	990.6455 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 32	202.63213 ft	45.518042 ft	-180.52579 psf	708.4594 psf	615.85436 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 33	205.96917 ft	47.765823 ft	-320.78736 psf	241.25283 psf	209.71788 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel

5.3 Pseudo-Static (Spencer) Section Ga-Ga' - Final Condition - Global Stability

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File Informa on

File Version: 11.01
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Last Solved Date: 11/12/2021
Last Solved Time: 04:49:12 PM

Project Se ngs

Unit System: U.S. Customary Units

Analysis Se ngs

5.3 Pseudo-Sta c (Spencer)

Kind: SLOPE/W
Parent: 5. Global Stability
Analysis Type: Spencer
Se ngs
PWP Condi ons from: Piezometric Line
Apply Phrea c Correc on: No
Use Staged Rapid Drawdown: No
Unit Weight of Water: 62.4 pcf
Slip Surface
Direc on of movement: Le. to Right
Use Passive Mode: No
Slip Surface Op□on: Entry and Exit
Cri□cal slip surfaces saved: 1
Op□mize Cri□cal Slip Surface Loca□on: No
Tension Crack Op□on: (none)
Distribu□on
F of S Calcula□on Op□on: Constant
Advanced
Geometry Se□ ngs
Minimum Slip Surface Depth: 2 ft
Number of Slices: 30
Factor of Safety Convergence Se□ ngs
Maximum Number of Itera□ons: 100
Tolerable difference in F of S: 0.001
Solu□on Se□ ngs
Search Method: Root Finder

Tolerable difference between star□ng and converged F of S: 3
Maximum itera□ons to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

ESU 2A - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 39 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2B - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 41 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 7A - Weathered Sandstone

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 43 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1B - Exis ng Gravelly Granular Fill

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2C - Na ve Silt (Pseudo-Sta c)

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effec□ve Cohesion: 200 psf
Effec□ve Fric□on Angle: 29 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Common Borrow

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

New Hilfiker Wall

Slope Stability Material Model: High Strength
Unit Weight: 130 pcf
Pore Water Pressure
Piezometric Line: 1

Reinforcements

Soil Nail_Row 1

Type: Anchor
Pullout Resistance: 1,800 psf
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 82,550 lbf
Tensile Capacity Reduc□on Factor: 1
Shear Force: 0 lbf
Shear Force Reduc□on Factor: 1
Apply Shear: Parallel to Slip
F of S Dependent: No
Force Distribu□on: Distributed
Bond Length: 45 ft
Bond Diameter: 0.5 ft
Out-of-Plane Spacing: 4 ft
Face Anchorage: Yes
Factored Pullout Resistance: 706.86 lbf/ft/ft
Factored Tensile Capacity: 20,638 lbf/ft

Soil Nail_Row 2

Type: Anchor
Pullout Resistance: 1,800 psf
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 82,550 lbf
Tensile Capacity Reduc□on Factor: 1
Shear Force: 0 lbf
Shear Force Reduc□on Factor: 1
Apply Shear: Parallel to Slip
F of S Dependent: No
Force Distribu□on: Distributed
Bond Length: 45 ft
Bond Diameter: 0.5 ft
Out-of-Plane Spacing: 4 ft
Face Anchorage: Yes
Factored Pullout Resistance: 706.86 lbf/ft/ft
Factored Tensile Capacity: 20,638 lbf/ft

Soil Nail_Row 3

Type: Anchor
Pullout Resistance: 1,800 psf
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 82,550 lbf
Tensile Capacity Reduc□on Factor: 1
Shear Force: 0 lbf
Shear Force Reduc□on Factor: 1
Apply Shear: Parallel to Slip
F of S Dependent: No
Force Distribu□on: Distributed
Bond Length: 40 ft
Bond Diameter: 0.5 ft
Out-of-Plane Spacing: 4 ft
Face Anchorage: Yes
Factored Pullout Resistance: 706.86 lbf/ft/ft
Factored Tensile Capacity: 20,638 lbf/ft

Soil Nail_Row 4

Type: Anchor
Pullout Resistance: 1,800 psf
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 82,550 lbf
Tensile Capacity Reduc□on Factor: 1
Shear Force: 0 lbf
Shear Force Reduc□on Factor: 1
Apply Shear: Parallel to Slip
F of S Dependent: No
Force Distribu□on: Distributed
Bond Length: 40 ft
Bond Diameter: 0.5 ft
Out-of-Plane Spacing: 4 ft
Face Anchorage: Yes
Factored Pullout Resistance: 706.86 lbf/ft/ft
Factored Tensile Capacity: 20,638 lbf/ft

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (0.05, 60) ft
Left-Zone Right Coordinate: (119.5945, 91.79725) ft
Left-Zone Increment: 40
Right Type: Range
Right-Zone Left Coordinate: (160, 70.95212) ft
Right-Zone Right Coordinate: (335, 48) ft
Right-Zone Increment: 40
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 60) ft
Right Coordinate: (335, 48) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	0.25 ft	43.375 ft
Coordinate 2	56.5 ft	43.375 ft
Coordinate 3	97.75 ft	43.375 ft
Coordinate 4	123 ft	43.375 ft
Coordinate 5	159.75 ft	42.625 ft
Coordinate 6	192 ft	42.625 ft
Coordinate 7	210.75 ft	42.625 ft
Coordinate 8	298 ft	35 ft
Coordinate 9	335.25 ft	35 ft

Seismic Coefficients

Horz Seismic Coef.: 0.175

Reinforcement Lines

Reinforcement Line 1

Reinforcement: Soil Nail_Row 1
Lock to Ground Surface: Yes
Outside Point: (160, 64.5) ft
Inside Point: (115.68365, 56.685832) ft
Length: 45.000001 ft
Orienta□on: -170 °
Max. Pullout Force: 0 lbf
Bond Length: 45 ft
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 2

Reinforcement: Soil Nail_Row 2
Lock to Ground Surface: Yes
Outside Point: (160, 60.5) ft
Inside Point: (115.68365, 52.685832) ft
Length: 45.000001 ft
Orienta□on: -170 °
Slip Surface Intersec□on: (118.88902, 53.251025) ft
Max. Pullout Force: 20,637.5 lbf
Bond Length: 45 ft
Available Length: 3.2548156 ft
Required Length: 3.2548156 ft
Pullout Force: 2,300.6936 lbf

Pullout Force per Length: 706.85835 lbf/ft
Governing Component: Pullout Resistance

Reinforcement Line 3

Reinforcement: Soil Nail_Row 3
Lock to Ground Surface: Yes
Outside Point: (160, 56.5) ft
Inside Point: (120.60769, 49.554073) ft
Length: 40 ft
Orienta□on: -170 °
Slip Surface Intersec□on: (123.56744, 50.075957) ft
Max. Pullout Force: 20,637.5 lbf
Bond Length: 40 ft
Available Length: 3.0054121 ft
Required Length: 3.0054121 ft
Pullout Force: 2,124.4007 lbf
Pullout Force per Length: 706.85835 lbf/ft
Governing Component: Pullout Resistance

Reinforcement Line 4

Reinforcement: Soil Nail_Row 4
Lock to Ground Surface: Yes
Outside Point: (160, 52.5) ft
Inside Point: (120.60769, 45.554073) ft
Length: 40 ft
Orienta□on: -170 °
Slip Surface Intersec□on: (128.73226, 46.986654) ft
Max. Pullout Force: 20,637.5 lbf
Bond Length: 40 ft
Available Length: 8.2499079 ft
Required Length: 8.2499079 ft
Pullout Force: 5,831.5163 lbf
Pullout Force per Length: 706.85835 lbf/ft
Governing Component: Pullout Resistance

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 125 pcf
Direc□on: Ver□cal

Coordinates

	X	Y
	120 ft	92 ft
	120 ft	93 ft
	160 ft	93 ft

Geometry

Name: Ga-Ga'

Se ngs

View: 2D

Element Thickness: 1 ft

Points

	X	Y
Point 1	0 ft	56 ft
Point 2	76 ft	56 ft
Point 3	118 ft	35 ft
Point 4	160 ft	35 ft
Point 5	0 ft	46 ft
Point 6	37 ft	46 ft
Point 7	190 ft	50 ft
Point 8	160 ft	50 ft
Point 9	170.25 ft	34 ft
Point 10	240 ft	34 ft
Point 11	315 ft	30 ft
Point 12	335 ft	30 ft
Point 13	335 ft	48 ft
Point 14	327 ft	48 ft
Point 15	315 ft	49 ft
Point 16	224 ft	48 ft
Point 17	0 ft	0 ft
Point 18	335 ft	0 ft
Point 19	160 ft	92 ft
Point 20	120 ft	92 ft
Point 21	120 ft	72 ft
Point 22	80 ft	72 ft
Point 23	56 ft	60 ft
Point 24	0 ft	60 ft
Point 25	160 ft	47 ft
Point 26	120 ft	47 ft
Point 27	69 ft	66.5 ft
Point 28	160 ft	66.5 ft
Point 29	120 ft	66.5 ft
Point 30	160 ft	72 ft
Point 31	128 ft	47 ft
Point 32	128 ft	92 ft
Point 33	128 ft	66.5 ft
Point 34	128 ft	72 ft
Point 35	160 ft	64.5 ft
Point 36	160 ft	60.5 ft
Point 37	160 ft	56.5 ft
Point 38	160 ft	52.5 ft

Regions

	Material	Points	Area
Region 1	ESU 2C - Na□ve Silt (Pseudo-Sta□c)	5,6,2,1	565 ft²
Region 2	New Hilfiker Wall	19,32,34,30	640 ft²

Figure D.4-307

Region 3	Common Borrow	20,22,21	400 ft²
Region 4	ESU 2A - Na□ve Sand and Gravel	6,2,3	619.5 ft²
Region 5	ESU 2B - Na□ve Sand and Gravel	7,16,15,14,13,12,11,10,9,4	2,595.4 ft²
Region 6	ESU 7A - Weathered Sandstone	18,17,5,6,3,4,9,10,11,12	12,178 ft²
Region 7	ESU 1B - Exis□ng Gravelly Granular Fill	8,7,25	45 ft²
Region 8	ESU 2A - Na□ve Sand and Gravel	4,7,25,31,26,2,3	945 ft²
Region 9	Common Borrow	21,22,27,29	250.25 ft²
Region 10	ESU 1B - Exis□ng Gravelly Granular Fill	23,24,1,2,26,29,27	1,051.8 ft²
Region 11	ESU 1B - Exis□ng Gravelly Granular Fill	26,31,33,29	156 ft²
Region 12	Common Borrow	29,33,34,21	44 ft²
Region 13	ESU 1B - Exis□ng Gravelly Granular Fill	25,8,38,37,36,35,28,33,31	624 ft²
Region 14	New Hilfiker Wall	28,30,34,33	176 ft²
Region 15	Common Borrow	20,21,34,32	160 ft²

Slip Results

Slip Surfaces Analysed: 5334 of 8405 converged

Current Slip Surface

Slip Surface: 6,448
Factor of Safety: 1.877
Volume: 3,308.6235 ft³
Weight: 418,034.11 lbf
Resis□ng Moment: 31,994,385 lbf·ft
Ac□va□ng Moment: 17,043,316 lbf·ft
Resis□ng Force: 294,798.42 lbf
Ac□va□ng Force: 157,012.34 lbf
Slip Rank: 1 of 8,405 slip surfaces
Exit: (227.215, 48.03533) ft
Entry: (94.026017, 79.013009) ft
Radius: 99.67289 ft
Center: (177.05028, 134.16422) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Fric□onal Strength	Cohesive Strength	Suc□on Strength	Base Material
Slice 1	95.888009 ft	76.396935 ft	-2,060.5688 psf	200.63732 psf	125.37211 psf	0 psf	0 psf	Common Borrow
Slice 2	98.444094 ft	72.890431 ft	-1,841.7629 psf	495.56472 psf	309.6632 psf	0 psf	0 psf	Common Borrow
Slice 3	101.50107 ft	69.25 ft	-1,614.6 psf	845.55419 psf	528.3609 psf	0 psf	0 psf	Common Borrow
Slice 4	105.88096 ft	64.441156 ft	-1,314.5282 psf	1,338.6747 psf	1,045.8873 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 5	109.91497 ft	60.543002 ft	-1,071.2833 psf	1,836.1856 psf	1,434.5854 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly

								Granular Fill
Slice 6	113.94898 ft	57.053142 ft	-853.51607 psf	2,344.3511 psf	1,831.6078 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 7	117.98299 ft	53.917926 ft	-657.87856 psf	2,882.2985 psf	2,251.8984 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 8	121.5 ft	51.426159 ft	-502.39235 psf	3,380.763 psf	2,641.3416 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 9	125.5 ft	48.907442 ft	-348.40805 psf	3,752.1542 psf	2,931.5041 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 10	128.35345 ft	47.197912 ft	-245.36715 psf	4,431.3143 psf	3,462.1221 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 11	130.66301 ft	45.971133 ft	-171.75731 psf	4,500.2651 psf	3,644.2428 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 12	134.57524 ft	44.020558 ft	-55.023539 psf	4,855.3012 psf	3,931.7454 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 13	138.85322 ft	42.13515 ft	57.178038 psf	5,213.9629 psf	4,175.8821 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 14	143.49695 ft	40.341098 ft	163.21326 psf	5,622.0075 psf	4,420.4444 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 15	148.14068 ft	38.806823 ft	253.03836 psf	6,023.545 psf	4,672.8641 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 16	152.78441 ft	37.519917 ft	327.42764 psf	6,420.597 psf	4,934.1512 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 17	157.42814 ft	36.470578 ft	386.99276 psf	6,815.3625 psf	5,205.5912 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 18	159.875 ft	35.982356 ft	414.501 psf	9,798.5019 psf	7,599.0141 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 19	160.721 ft	35.840747 ft	423.3374 psf	1,603.3327 psf	955.54138 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice	163.74334	35.410901	450.15975	1,726.9793	1,109.9223	0 psf	0 psf	ESU 2B -

20	ft	ft	psf	psf	psf			Na□ve Sand and Gravel
Slice 21	168.346 ft	34.899001 ft	482.10231 psf	1,902.259 psf	1,234.5234 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 22	172.94867 ft	34.602397 ft	500.61042 psf	2,063.7524 psf	1,358.8186 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 23	177.70833 ft	34.523825 ft	505.5133 psf	2,215.2256 psf	1,486.2303 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 24	182.625 ft	34.677813 ft	495.90445 psf	2,355.5312 psf	1,616.5489 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 25	187.54167 ft	35.075852 ft	471.06684 psf	2,477.99 psf	1,744.5917 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 26	191 ft	35.477491 ft	446.00453 psf	2,536.1098 psf	1,816.9008 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 27	194.34375 ft	36.031875 ft	411.41103 psf	2,521.192 psf	1,834.0046 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 28	199.03125 ft	36.974982 ft	352.56111 psf	2,474.7381 psf	1,844.7803 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 29	203.71875 ft	38.156091 ft	278.85993 psf	2,385.8806 psf	1,831.6051 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 30	208.40625 ft	39.584141 ft	189.74963 psf	2,243.7743 psf	1,785.5364 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 31	213.12879 ft	41.285191 ft	70.631813 psf	2,040.4027 psf	1,712.2957 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 32	217.63068 ft	43.155911 ft	-70.651245 psf	1,694.7061 psf	1,473.1856 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 33	221.87689 ft	45.172037 ft	-219.61334 psf	1,107.0551 psf	962.34828 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 34	225.6075 ft	47.138402 ft	-362.65865 psf	383.83208 psf	333.66014 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel

5.4 Pseudo-Static (M-P) Section Ga-Ga' - Final Condition - Global Stability

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File Informa on

File Version: 11.01
Created By: Mikayla S. Hatch
Last Edited By: Mikayla S. Hatch
Revision Number: 323
Date: 11/12/2021
Time: 04:47:21 PM
Tool Version: 11.1
File Name: Wall 03.63L - Bridge 17.7 Ga-Ga' - All Condi ons.gsz
Directory: P:\0\0180366\01\Analysis\Bridge 17.7\SlopeW\
Last Solved Date: 11/12/2021
Last Solved Time: 04:49:00 PM

Project Se ngs

Unit System: U.S. Customary Units

Analysis Se ngs

5.4 Pseudo-Sta c (M-P)

Kind: SLOPE/W
Parent: 5. Global Stability
Analysis Type: Morgenstern-Price
Se ngs
- Side Func on
  - Interslice force func on op on: Half-Sine
- PWP Condi ons from: Piezometric Line
- Apply Phrea c Correc on: No
- Use Staged Rapid Drawdown: No
- Unit Weight of Water: 62.4 pcf

Slip Surface
- Direc on of movement: Le. to Right
- Use Passive Mode: No
- Slip Surface Op on: Entry and Exit
- Cri cal slip surfaces saved: 1
- Op mize Cri cal Slip Surface Loca on: No
- Tension Crack Op on: (none)

Distribu on
- F of S Calcula on Op on: Constant

Advanced
- Geometry Se ngs
  - Minimum Slip Surface Depth: 2 ft
  - Number of Slices: 30
- Factor of Safety Convergence Se ngs
  - Maximum Number of Itera ons: 100
  - Tolerable difference in F of S: 0.001

Solu□on Se□ ngs
Search Method: Root Finder
Tolerable difference between star□ng and converged F of S: 3
Maximum itera□ons to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

ESU 2A - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 39 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2B - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 41 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 7A - Weathered Sandstone

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 43 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1B - Exis ng Gravelly Granular Fill

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2C - Na ve Silt (Pseudo-Sta c)

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effec□ve Cohesion: 200 psf
Effec□ve Fric□on Angle: 29 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Common Borrow

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

New Hilfiker Wall

Slope Stability Material Model: High Strength
Unit Weight: 130 pcf
Pore Water Pressure
Piezometric Line: 1

Reinforcements

Soil Nail_Row 1

Type: Anchor
Pullout Resistance: 1,800 psf
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 82,550 lbf
Tensile Capacity Reduc□on Factor: 1
Shear Force: 0 lbf
Shear Force Reduc□on Factor: 1
Apply Shear: Parallel to Slip
F of S Dependent: No
Force Distribu□on: Distributed
Bond Length: 45 ft
Bond Diameter: 0.5 ft
Out-of-Plane Spacing: 4 ft
Face Anchorage: Yes
Factored Pullout Resistance: 706.86 lbf/ft/ft
Factored Tensile Capacity: 20,638 lbf/ft

Soil Nail_Row 2

Type: Anchor
Pullout Resistance: 1,800 psf
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 82,550 lbf
Tensile Capacity Reduc□on Factor: 1
Shear Force: 0 lbf
Shear Force Reduc□on Factor: 1
Apply Shear: Parallel to Slip
F of S Dependent: No
Force Distribu□on: Distributed
Bond Length: 45 ft
Bond Diameter: 0.5 ft
Out-of-Plane Spacing: 4 ft
Face Anchorage: Yes
Factored Pullout Resistance: 706.86 lbf/ft/ft
Factored Tensile Capacity: 20,638 lbf/ft

Soil Nail_Row 3

Type: Anchor
Pullout Resistance: 1,800 psf
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 82,550 lbf
Tensile Capacity Reduc□on Factor: 1
Shear Force: 0 lbf
Shear Force Reduc□on Factor: 1
Apply Shear: Parallel to Slip
F of S Dependent: No
Force Distribu□on: Distributed
Bond Length: 40 ft
Bond Diameter: 0.5 ft
Out-of-Plane Spacing: 4 ft
Face Anchorage: Yes
Factored Pullout Resistance: 706.86 lbf/ft/ft
Factored Tensile Capacity: 20,638 lbf/ft

Soil Nail_Row 4

Type: Anchor
Pullout Resistance: 1,800 psf
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 82,550 lbf
Tensile Capacity Reduc□on Factor: 1
Shear Force: 0 lbf
Shear Force Reduc□on Factor: 1
Apply Shear: Parallel to Slip
F of S Dependent: No
Force Distribu□on: Distributed
Bond Length: 40 ft
Bond Diameter: 0.5 ft
Out-of-Plane Spacing: 4 ft
Face Anchorage: Yes
Factored Pullout Resistance: 706.86 lbf/ft/ft
Factored Tensile Capacity: 20,638 lbf/ft

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (0.05, 60) ft
Left-Zone Right Coordinate: (119.5945, 91.79725) ft
Left-Zone Increment: 40
Right Type: Range
Right-Zone Left Coordinate: (160, 70.95212) ft
Right-Zone Right Coordinate: (335, 48) ft
Right-Zone Increment: 40
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 60) ft
Right Coordinate: (335, 48) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	0.25 ft	43.375 ft
Coordinate 2	56.5 ft	43.375 ft
Coordinate 3	97.75 ft	43.375 ft
Coordinate 4	123 ft	43.375 ft
Coordinate 5	159.75 ft	42.625 ft
Coordinate 6	192 ft	42.625 ft
Coordinate 7	210.75 ft	42.625 ft
Coordinate 8	298 ft	35 ft
Coordinate 9	335.25 ft	35 ft

Seismic Coefficients

Horz Seismic Coef.: 0.175

Reinforcement Lines

Reinforcement Line 1

Reinforcement: Soil Nail_Row 1
Lock to Ground Surface: Yes
Outside Point: (160, 64.5) ft
Inside Point: (115.68365, 56.685832) ft
Length: 45.000001 ft
Orienta□on: -170 °
Max. Pullout Force: 0 lbf
Bond Length: 45 ft
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 2

Reinforcement: Soil Nail_Row 2
Lock to Ground Surface: Yes
Outside Point: (160, 60.5) ft
Inside Point: (115.68365, 52.685832) ft
Length: 45.000001 ft
Orienta□on: -170 °
Slip Surface Intersec□on: (118.88902, 53.251025) ft
Max. Pullout Force: 20,637.5 lbf
Bond Length: 45 ft
Available Length: 3.2548156 ft
Required Length: 3.2548156 ft
Pullout Force: 2,300.6936 lbf

Figure D.4-315

Pullout Force per Length: 706.85835 lbf/ft
Governing Component: Pullout Resistance

Reinforcement Line 3

Reinforcement: Soil Nail_Row 3
Lock to Ground Surface: Yes
Outside Point: (160, 56.5) ft
Inside Point: (120.60769, 49.554073) ft
Length: 40 ft
Orienta□on: -170 °
Slip Surface Intersec□on: (123.56744, 50.075957) ft
Max. Pullout Force: 20,637.5 lbf
Bond Length: 40 ft
Available Length: 3.0054121 ft
Required Length: 3.0054121 ft
Pullout Force: 2,124.4007 lbf
Pullout Force per Length: 706.85835 lbf/ft
Governing Component: Pullout Resistance

Reinforcement Line 4

Reinforcement: Soil Nail_Row 4
Lock to Ground Surface: Yes
Outside Point: (160, 52.5) ft
Inside Point: (120.60769, 45.554073) ft
Length: 40 ft
Orienta□on: -170 °
Slip Surface Intersec□on: (128.73226, 46.986654) ft
Max. Pullout Force: 20,637.5 lbf
Bond Length: 40 ft
Available Length: 8.2499079 ft
Required Length: 8.2499079 ft
Pullout Force: 5,831.5163 lbf
Pullout Force per Length: 706.85835 lbf/ft
Governing Component: Pullout Resistance

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 125 pcf
Direc□on: Ver□cal

Coordinates

	X	Y
	120 ft	92 ft
	120 ft	93 ft
	160 ft	93 ft

Geometry

Name: Ga-Ga'

Se ngs

View: 2D

Element Thickness: 1 ft

Points

	X	Y
Point 1	0 ft	56 ft
Point 2	76 ft	56 ft
Point 3	118 ft	35 ft
Point 4	160 ft	35 ft
Point 5	0 ft	46 ft
Point 6	37 ft	46 ft
Point 7	190 ft	50 ft
Point 8	160 ft	50 ft
Point 9	170.25 ft	34 ft
Point 10	240 ft	34 ft
Point 11	315 ft	30 ft
Point 12	335 ft	30 ft
Point 13	335 ft	48 ft
Point 14	327 ft	48 ft
Point 15	315 ft	49 ft
Point 16	224 ft	48 ft
Point 17	0 ft	0 ft
Point 18	335 ft	0 ft
Point 19	160 ft	92 ft
Point 20	120 ft	92 ft
Point 21	120 ft	72 ft
Point 22	80 ft	72 ft
Point 23	56 ft	60 ft
Point 24	0 ft	60 ft
Point 25	160 ft	47 ft
Point 26	120 ft	47 ft
Point 27	69 ft	66.5 ft
Point 28	160 ft	66.5 ft
Point 29	120 ft	66.5 ft
Point 30	160 ft	72 ft
Point 31	128 ft	47 ft
Point 32	128 ft	92 ft
Point 33	128 ft	66.5 ft
Point 34	128 ft	72 ft
Point 35	160 ft	64.5 ft
Point 36	160 ft	60.5 ft
Point 37	160 ft	56.5 ft
Point 38	160 ft	52.5 ft

Regions

	Material	Points	Area
Region 1	ESU 2C - Na□ve Silt (Pseudo-Sta□c)	5,6,2,1	565 ft²
Region 2	New Hilfiker Wall	19,32,34,30	640 ft²

Figure D.4-317

Region 3	Common Borrow	20,22,21	400 ft²
Region 4	ESU 2A - Na□ve Sand and Gravel	6,2,3	619.5 ft²
Region 5	ESU 2B - Na□ve Sand and Gravel	7,16,15,14,13,12,11,10,9,4	2,595.4 ft²
Region 6	ESU 7A - Weathered Sandstone	18,17,5,6,3,4,9,10,11,12	12,178 ft²
Region 7	ESU 1B - Exis□ng Gravelly Granular Fill	8,7,25	45 ft²
Region 8	ESU 2A - Na□ve Sand and Gravel	4,7,25,31,26,2,3	945 ft²
Region 9	Common Borrow	21,22,27,29	250.25 ft²
Region 10	ESU 1B - Exis□ng Gravelly Granular Fill	23,24,1,2,26,29,27	1,051.8 ft²
Region 11	ESU 1B - Exis□ng Gravelly Granular Fill	26,31,33,29	156 ft²
Region 12	Common Borrow	29,33,34,21	44 ft²
Region 13	ESU 1B - Exis□ng Gravelly Granular Fill	25,8,38,37,36,35,28,33,31	624 ft²
Region 14	New Hilfiker Wall	28,30,34,33	176 ft²
Region 15	Common Borrow	20,21,34,32	160 ft²

Slip Results

Slip Surfaces Analysed: 5682 of 8405 converged

Current Slip Surface

Slip Surface: 6,448
Factor of Safety: 1.874
Volume: 3,308.6235 ft³
Weight: 418,034.11 lbf
Resis□ng Moment: 31,947,448 lbf·ft
Ac□va□ng Moment: 17,043,316 lbf·ft
Resis□ng Force: 294,928.65 lbf
Ac□va□ng Force: 157,382.13 lbf
Slip Rank: 1 of 8,405 slip surfaces
Exit: (227.215, 48.03533) ft
Entry: (94.026017, 79.013009) ft
Radius: 99.67289 ft
Center: (177.05028, 134.16422) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Fric□onal Strength	Cohesive Strength	Suc□on Strength	Base Material
Slice 1	95.888009 ft	76.396935 ft	-2,060.5688 psf	276.75355 psf	172.93481 psf	0 psf	0 psf	Common Borrow
Slice 2	98.444094 ft	72.890431 ft	-1,841.7629 psf	647.49584 psf	404.60031 psf	0 psf	0 psf	Common Borrow
Slice 3	101.50107 ft	69.25 ft	-1,614.6 psf	1,031.0023 psf	644.24176 psf	0 psf	0 psf	Common Borrow
Slice 4	105.88096 ft	64.441156 ft	-1,314.5282 psf	1,481.9835 psf	1,157.8524 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 5	109.91497 ft	60.543002 ft	-1,071.2833 psf	1,928.0419 psf	1,506.3514 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly

								Granular Fill
Slice 6	113.94898 ft	57.053142 ft	-853.51607 psf	2,357.8307 psf	1,842.1392 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 7	117.98299 ft	53.917926 ft	-657.87856 psf	2,799.7371 psf	2,187.3943 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 8	121.5 ft	51.426159 ft	-502.39235 psf	3,214.4868 psf	2,511.4324 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 9	125.5 ft	48.907442 ft	-348.40805 psf	3,497.1004 psf	2,732.2343 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 10	128.35345 ft	47.197912 ft	-245.36715 psf	4,116.2303 psf	3,215.9516 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 11	130.66301 ft	45.971133 ft	-171.75731 psf	4,163.2216 psf	3,371.3104 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 12	134.57524 ft	44.020558 ft	-55.023539 psf	4,490.9281 psf	3,636.6819 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 13	138.85322 ft	42.13515 ft	57.178038 psf	4,846.8149 psf	3,878.5715 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 14	143.49695 ft	40.341098 ft	163.21326 psf	5,287.9542 psf	4,149.9334 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 15	148.14068 ft	38.806823 ft	253.03836 psf	5,762.4957 psf	4,461.4706 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 16	152.78441 ft	37.519917 ft	327.42764 psf	6,271.0191 psf	4,813.0254 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 17	157.42814 ft	36.470578 ft	386.99276 psf	6,809.4071 psf	5,200.7686 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 18	159.875 ft	35.982356 ft	414.501 psf	10,614.985 psf	8,260.1893 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 19	160.721 ft	35.840747 ft	423.3374 psf	1,597.1198 psf	950.51023 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice	163.74334	35.410901	450.15975	1,803.0735	1,176.0699	0 psf	0 psf	ESU 2B -

20	ft	ft	psf	psf	psf			Na□ve Sand and Gravel
Slice 21	168.346 ft	34.899001 ft	482.10231 psf	2,103.6944 psf	1,409.6285 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 22	172.94867 ft	34.602397 ft	500.61042 psf	2,392.6441 psf	1,644.7198 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 23	177.70833 ft	34.523825 ft	505.5133 psf	2,662.6427 psf	1,875.164 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 24	182.625 ft	34.677813 ft	495.90445 psf	2,890.7817 psf	2,081.835 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 25	187.54167 ft	35.075852 ft	471.06684 psf	3,041.9923 psf	2,234.8714 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 26	191 ft	35.477491 ft	446.00453 psf	3,075.9912 psf	2,286.2126 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 27	194.34375 ft	36.031875 ft	411.41103 psf	2,993.0641 psf	2,244.1968 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 28	199.03125 ft	36.974982 ft	352.56111 psf	2,791.0369 psf	2,119.7346 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 29	203.71875 ft	38.156091 ft	278.85993 psf	2,483.528 psf	1,916.4887 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 30	208.40625 ft	39.584141 ft	189.74963 psf	2,085.1884 psf	1,647.6798 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 31	213.12879 ft	41.285191 ft	70.631813 psf	1,619.7951 psf	1,346.6671 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 32	217.63068 ft	43.155911 ft	-70.651245 psf	1,114.7071 psf	969.00013 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 33	221.87689 ft	45.172037 ft	-219.61334 psf	597.67717 psf	519.55284 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 34	225.6075 ft	47.138402 ft	-362.65865 psf	169.34606 psf	147.21029 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel

1.1 Static (Spencer) Section Ha-Ha' - Existing Condition - Global Stability

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File Informa on

File Version: 11.01
Created By: Mikayla S. Hatch
Last Edited By: Mikayla S. Hatch
Revision Number: 305
Date: 11/15/2021
Time: 01:36:51 PM
Tool Version: 11.1
File Name: Wall 03.63L - Bridge 17.7 Ha-Ha' - All Condi ons.gsz
Directory: P:\0\0180366\01\Analysis\Bridge 17.7\SlopeW\
Last Solved Date: 11/15/2021
Last Solved Time: 01:37:28 PM

Project Se ngs

Unit System: U.S. Customary Units

Analysis Se ngs

1.1 Sta c (Spencer)

Kind: SLOPE/W
Parent: 1. Global Stability
Analysis Type: Spencer
Se ngs
PWP Condi ons from: Piezometric Line
Apply Phrea c Correc on: No
Use Staged Rapid Drawdown: No
Unit Weight of Water: 62.4 pcf
Slip Surface
Direc on of movement: Le. to Right
Use Passive Mode: No
Slip Surface Op□on: Entry and Exit
Cri□cal slip surfaces saved: 1
Op□mize Cri□cal Slip Surface Loca□on: No
Tension Crack Op□on: (none)
Distribu□on
F of S Calcula□on Op□on: Constant
Advanced
Geometry Se□ ngs
Minimum Slip Surface Depth: 2 ft
Number of Slices: 30
Factor of Safety Convergence Se□ ngs
Maximum Number of Itera□ons: 100
Tolerable difference in F of S: 0.001
Solu□on Se□ ngs
Search Method: Root Finder

Tolerable difference between star□ng and converged F of S: 3
Maximum itera□ons to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Hilfiker Wall

Slope Stability Material Model: High Strength
Unit Weight: 130 pcf
Pore Water Pressure
Piezometric Line: 1

ESU 2A - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 39 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2B - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 41 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 7A - Weathered Sandstone

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 43 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2C - Na ve Silt

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 29 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1A - Exis ng Granular Fill

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf

Effec□ve Fric□on Angle: 40 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1B - Exis ng Gravelly Granular Fill

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (1.75, 60) ft
Left-Zone Right Coordinate: (120.29189, 90) ft
Left-Zone Increment: 40
Right Type: Range
Right-Zone Left Coordinate: (161.41681, 50) ft
Right-Zone Right Coordinate: (315.5, 48.958333) ft
Right-Zone Increment: 40
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 60) ft
Right Coordinate: (335, 48) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	0.25 ft	43.375 ft
Coordinate 2	56.5 ft	43.375 ft
Coordinate 3	97.75 ft	43.375 ft
Coordinate 4	123 ft	43.375 ft
Coordinate 5	159.75 ft	42.625 ft
Coordinate 6	192 ft	42.625 ft
Coordinate 7	210.75 ft	42.625 ft
Coordinate 8	298 ft	35 ft
Coordinate 9	335.25 ft	35 ft

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 250 pcf
Direc□on: Ver□cal

Coordinates

	X	Y
	120 ft	91 ft
	160 ft	91 ft

Geometry

Name: Ga-Ga'

Se ngs

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	0 ft	56 ft
Point 2	76 ft	56 ft
Point 3	118 ft	35 ft
Point 4	160 ft	35 ft
Point 5	0 ft	46 ft
Point 6	37 ft	46 ft
Point 7	190 ft	50 ft
Point 8	160 ft	50 ft
Point 9	170.25 ft	34 ft
Point 10	240 ft	34 ft
Point 11	315 ft	30 ft
Point 12	335 ft	30 ft
Point 13	335 ft	48 ft
Point 14	327 ft	48 ft
Point 15	315 ft	49 ft
Point 16	224 ft	48 ft
Point 17	0 ft	0 ft
Point 18	335 ft	0 ft
Point 19	160 ft	90 ft
Point 20	120 ft	90 ft
Point 21	120 ft	72 ft
Point 22	80 ft	72 ft
Point 23	56 ft	60 ft
Point 24	0 ft	60 ft
Point 25	160 ft	47 ft
Point 26	120 ft	47 ft
Point 27	70 ft	67 ft
Point 28	160 ft	78 ft
Point 29	93.5 ft	78 ft
Point 30	120 ft	78 ft

Figure D.4-324

Point 31	160 ft	72 ft
Point 32	128 ft	90 ft
Point 33	128 ft	47 ft
Point 34	128 ft	78 ft
Point 35	128 ft	72 ft

Regions

	Material	Points	Area
Region 1	ESU 2C - Na□ve Silt	5,6,2,1	565 ft²
Region 2	ESU 1A - Exis□ng Granular Fill	20,29,30	159 ft²
Region 3	ESU 2A - Na□ve Sand and Gravel	6,2,3	619.5 ft²
Region 4	ESU 2B - Na□ve Sand and Gravel	7,16,15,14,13,12,11,10,9,4	2,595.4 ft²
Region 5	ESU 7A - Weathered Sandstone	18,17,5,6,3,4,9,10,11,12	12,178 ft²
Region 6	ESU 1B - Exis□ng Gravelly Granular Fill	8,7,25	45 ft²
Region 7	ESU 2A - Na□ve Sand and Gravel	4,7,25,33,26,2,3	945 ft²
Region 8	ESU 1B - Exis□ng Gravelly Granular Fill	23,24,1,2,26,21,22,27	1,302 ft²
Region 9	ESU 1B - Exis□ng Gravelly Granular Fill	26,33,35,21	200 ft²
Region 10	Hilfiker Wall	19,32,34,28	384 ft²
Region 11	ESU 1A - Exis□ng Granular Fill	22,21,30,29	199.5 ft²
Region 12	Hilfiker Wall	28,34,35,31	192 ft²
Region 13	ESU 1A - Exis□ng Granular Fill	20,30,34,32	96 ft²
Region 14	ESU 1A - Exis□ng Granular Fill	30,21,35,34	48 ft²
Region 15	Hilfiker Wall	25,8,31,35,33	800 ft²

Slip Results

Slip Surfaces Analysed: 3636 of 8405 converged

Current Slip Surface

Slip Surface: 7,039
Factor of Safety: 2.506
Volume: 2,923.7019 ft³
Weight: 372,360.97 lbf
Resis□ng Moment: 20,995,895 lbf·ft
Ac□va□ng Moment: 8,380,567 lbf·ft
Resis□ng Force: 270,478.46 lbf
Ac□va□ng Force: 107,926.23 lbf
Slip Rank: 1 of 8,405 slip surfaces
Exit: (211.47817, 48.736578) ft
Entry: (103.15294, 82.371141) ft
Radius: 68.242487 ft
Center: (168.57056, 101.80233) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Fric□onal Strength	Cohesive Strength	Suc□on Strength	Base Material
Slice 1	103.8833 ft	80.18557 ft	-2,296.9796 psf	112.74939 psf	94.607969 psf	0 psf	0 psf	ESU 1A - Exis□ng

								Granular Fill
Slice 2	105.8966 ft	75 ft	-1,973.4 psf	450.67966 psf	378.16514 psf	0 psf	0 psf	ESU 1A - Exis□ng Granular Fill
Slice 3	108.78209 ft	69.072559 ft	-1,603.5277 psf	979.85576 psf	765.54722 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 4	111.98721 ft	63.761419 ft	-1,272.1125 psf	1,561.8452 psf	1,220.2472 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 5	115.19233 ft	59.362137 ft	-997.59734 psf	2,129.5923 psf	1,663.8199 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 6	118.39744 ft	55.60604 ft	-763.21687 psf	2,683.4665 psf	2,096.5538 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 7	121.5 ft	52.435302 ft	-565.36286 psf	3,323.5113 psf	2,596.6116 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 8	125.5 ft	48.967113 ft	-352.13153 psf	3,825.4817 psf	2,988.7939 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 9	129.41846 ft	45.935082 ft	-167.92284 psf	4,511.323 psf	3,653.1973 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 10	132.25538 ft	44.049092 ft	-53.849793 psf	4,834.5589 psf	3,914.9486 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 11	135.41975 ft	42.186314 ft	58.357826 psf	5,183.5891 psf	4,150.3305 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 12	138.91157 ft	40.372517 ft	167.09205 psf	5,554.458 psf	4,362.6029 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 13	142.40339 ft	38.804381 ft	260.497 psf	5,905.1055 psf	4,570.9138 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 14	145.89521 ft	37.463864 ft	339.69853 psf	6,237.6373 psf	4,776.0567 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice	149.38703	36.336928	405.57259	6,553.8675	4,978.7911	0 psf	0 psf	ESU 2A -

15	ft	ft	psf	psf	psf			Na□ve Sand and Gravel
Slice 16	152.87885 ft	35.412659 ft	458.80025 psf	6,855.415 psf	5,179.8765 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 17	157.18738 ft	34.566145 ft	506.13599 psf	7,240.2371 psf	6,279.6509 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 18	159.875 ft	34.116231 ft	530.9472 psf	7,480.962 psf	6,480.9936 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 19	161.70833 ft	33.927458 ft	542.72664 psf	2,003.6613 psf	1,362.3436 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 20	165.125 ft	33.668352 ft	558.89483 psf	2,122.0911 psf	1,457.7041 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 21	168.54167 ft	33.581237 ft	564.33079 psf	2,223.1127 psf	1,546.8391 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 22	172.75 ft	33.734015 ft	554.79744 psf	2,319.0725 psf	1,645.2131 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 23	175.77941 ft	33.943758 ft	541.70947 psf	2,379.4099 psf	1,713.6833 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 24	178.02022 ft	34.239364 ft	523.26371 psf	2,383.5255 psf	1,617.1009 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 25	181.44302 ft	34.807557 ft	487.80844 psf	2,406.4656 psf	1,667.8632 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 26	184.86581 ft	35.557364 ft	441.02048 psf	2,406.1279 psf	1,708.2418 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 27	188.2886 ft	36.495059 ft	382.50834 psf	2,380.2766 psf	1,736.6334 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 28	191 ft	37.359829 ft	328.54666 psf	2,321.2316 psf	1,732.2146 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 29	193.75951 ft	38.406989 ft	263.20387 psf	2,194.4314 psf	1,678.7905 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 30	197.27852 ft	39.922383 ft	168.6433 psf	1,993.4922 psf	1,586.3169 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 31	200.79753 ft	41.681835 ft	58.853486 psf	1,733.6074 psf	1,455.8414 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 32	204.60528 ft	43.899688 ft	-79.540509 psf	1,317.4147 psf	1,145.2111 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice	208.70176	46.665173	-252.10682	636.84804	553.60355	0 psf	0 psf	ESU 2B -

33	ft	ft	psf	psf	psf			Na□ve Sand and Gravel
Slice 34	211.11408 ft	48.446275 ft	-365.23301 psf	97.391194 psf	84.660873 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel

Figure D.4-328

1.2 Static (M-P) Section Ha-Ha' - Existing Condition - Global Stability

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File Informa on

File Version: 11.01
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Last Edited By: Mikayla S. Hatch
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Last Solved Date: 11/15/2021
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Project Se ngs

Unit System: U.S. Customary Units

Analysis Se ngs

1.2 Sta c (M-P)

Kind: SLOPE/W
Parent: 1. Global Stability
Analysis Type: Morgenstern-Price
Se ngs
- Side Func on
  - Interslice force func on op on: Half-Sine
- PWP Condi ons from: Piezometric Line
- Apply Phrea c Correc on: No
- Use Staged Rapid Drawdown: No
- Unit Weight of Water: 62.4 pcf

Slip Surface
- Direc on of movement: Le. to Right
- Use Passive Mode: No
- Slip Surface Op on: Entry and Exit
- Cri cal slip surfaces saved: 1
- Op mize Cri cal Slip Surface Loca on: No
- Tension Crack Op on: (none)

Distribu on
- F of S Calcula on Op on: Constant

Advanced
- Geometry Se ngs
  - Minimum Slip Surface Depth: 2 ft
  - Number of Slices: 30
- Factor of Safety Convergence Se ngs
  - Maximum Number of Itera ons: 100
  - Tolerable difference in F of S: 0.001

Solu□on Se□ ngs
Search Method: Root Finder
Tolerable difference between star□ng and converged F of S: 3
Maximum itera□ons to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Hilfiker Wall

Slope Stability Material Model: High Strength
Unit Weight: 130 pcf
Pore Water Pressure
Piezometric Line: 1

ESU 2A - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 39 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2B - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 41 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 7A - Weathered Sandstone

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 43 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2C - Na ve Silt

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 29 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1A - Exis ng Granular Fill

Slope Stability Material Model: Mohr-Coulomb

Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 40 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1B - Exis ng Gravelly Granular Fill

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (1.75, 60) ft
Left-Zone Right Coordinate: (120.29262, 90) ft
Left-Zone Increment: 40
Right Type: Range
Right-Zone Left Coordinate: (161.41681, 50) ft
Right-Zone Right Coordinate: (315.5, 48.958333) ft
Right-Zone Increment: 40
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 60) ft
Right Coordinate: (335, 48) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	0.25 ft	43.375 ft
Coordinate 2	56.5 ft	43.375 ft
Coordinate 3	97.75 ft	43.375 ft
Coordinate 4	123 ft	43.375 ft
Coordinate 5	159.75 ft	42.625 ft
Coordinate 6	192 ft	42.625 ft
Coordinate 7	210.75 ft	42.625 ft
Coordinate 8	298 ft	35 ft
Coordinate 9	335.25 ft	35 ft

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 250 pcf
Direc□on: Ver□cal

Coordinates

	X	Y
	120 ft	91 ft
	160 ft	91 ft

Geometry

Name: Ga-Ga'

Se ngs

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	0 ft	56 ft
Point 2	76 ft	56 ft
Point 3	118 ft	35 ft
Point 4	160 ft	35 ft
Point 5	0 ft	46 ft
Point 6	37 ft	46 ft
Point 7	190 ft	50 ft
Point 8	160 ft	50 ft
Point 9	170.25 ft	34 ft
Point 10	240 ft	34 ft
Point 11	315 ft	30 ft
Point 12	335 ft	30 ft
Point 13	335 ft	48 ft
Point 14	327 ft	48 ft
Point 15	315 ft	49 ft
Point 16	224 ft	48 ft
Point 17	0 ft	0 ft
Point 18	335 ft	0 ft
Point 19	160 ft	90 ft
Point 20	120 ft	90 ft
Point 21	120 ft	72 ft
Point 22	80 ft	72 ft
Point 23	56 ft	60 ft
Point 24	0 ft	60 ft
Point 25	160 ft	47 ft
Point 26	120 ft	47 ft
Point 27	70 ft	67 ft
Point 28	160 ft	78 ft

Figure D.4-332

Point 29	93.5 ft	78 ft
Point 30	120 ft	78 ft
Point 31	160 ft	72 ft
Point 32	128 ft	90 ft
Point 33	128 ft	47 ft
Point 34	128 ft	78 ft
Point 35	128 ft	72 ft

Regions

	Material	Points	Area
Region 1	ESU 2C - Na□ve Silt	5,6,2,1	565 ft²
Region 2	ESU 1A - Exis□ng Granular Fill	20,29,30	159 ft²
Region 3	ESU 2A - Na□ve Sand and Gravel	6,2,3	619.5 ft²
Region 4	ESU 2B - Na□ve Sand and Gravel	7,16,15,14,13,12,11,10,9,4	2,595.4 ft²
Region 5	ESU 7A - Weathered Sandstone	18,17,5,6,3,4,9,10,11,12	12,178 ft²
Region 6	ESU 1B - Exis□ng Gravelly Granular Fill	8,7,25	45 ft²
Region 7	ESU 2A - Na□ve Sand and Gravel	4,7,25,33,26,2,3	945 ft²
Region 8	ESU 1B - Exis□ng Gravelly Granular Fill	23,24,1,2,26,21,22,27	1,302 ft²
Region 9	ESU 1B - Exis□ng Gravelly Granular Fill	26,33,35,21	200 ft²
Region 10	Hilfiker Wall	19,32,34,28	384 ft²
Region 11	ESU 1A - Exis□ng Granular Fill	22,21,30,29	199.5 ft²
Region 12	Hilfiker Wall	28,34,35,31	192 ft²
Region 13	ESU 1A - Exis□ng Granular Fill	20,30,34,32	96 ft²
Region 14	ESU 1A - Exis□ng Granular Fill	30,21,35,34	48 ft²
Region 15	Hilfiker Wall	25,8,31,35,33	800 ft²

Slip Results

Slip Surfaces Analysed: 4254 of 8405 converged

Current Slip Surface

Slip Surface: 7,039
Factor of Safety: 2.511
Volume: 2,923.6487 ft³
Weight: 372,354.31 lbf
Resis□ng Moment: 21,039,540 lbf·ft
Ac□va□ng Moment: 8,380,520 lbf·ft
Resis□ng Force: 271,055.43 lbf
Ac□va□ng Force: 107,931.72 lbf
Slip Rank: 1 of 8,405 slip surfaces
Exit: (211.47817, 48.736578) ft
Entry: (103.1535, 82.371397) ft
Radius: 68.242352 ft
Center: (168.57101, 101.80252) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Fric□onal Strength	Cohesive Strength	Suc□on Strength	Base Material
Slice	103.88391	80.185698	-2,296.9876	148.11541	124.28358	0 psf	0 psf	ESU 1A -

1	ft	ft	psf	psf	psf			Exis□ng Granular Fill
Slice 2	105.89727 ft	75 ft	-1,973.4 psf	552.29745 psf	463.43259 psf	0 psf	0 psf	ESU 1A - Exis□ng Granular Fill
Slice 3	108.78269 ft	69.072725 ft	-1,603.538 psf	1,123.4612 psf	877.74407 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 4	111.98764 ft	63.761861 ft	-1,272.1401 psf	1,686.9673 psf	1,318.0033 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 5	115.19258 ft	59.36277 ft	-997.63684 psf	2,201.4865 psf	1,719.9898 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 6	118.39753 ft	55.606811 ft	-763.26499 psf	2,685.6416 psf	2,098.2532 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 7	121.5 ft	52.436101 ft	-565.41268 psf	3,257.3613 psf	2,544.9295 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 8	125.5 ft	48.967838 ft	-352.17679 psf	3,668.2168 psf	2,865.9251 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 9	129.41872 ft	45.93557 ft	-167.95363 psf	4,286.0593 psf	3,470.7824 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 10	132.25617 ft	44.049228 ft	-53.859259 psf	4,576.461 psf	3,705.9451 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 11	135.42088 ft	42.186273 ft	58.358949 psf	4,908.0201 psf	3,927.1782 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 12	138.91286 ft	40.372446 ft	167.09483 psf	5,281.8996 psf	4,141.8872 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 13	142.40484 ft	38.804298 ft	260.50031 psf	5,659.527 psf	4,372.0456 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 14	145.89681 ft	37.463786 ft	339.70134 psf	6,041.8986 psf	4,617.5483 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel

Slice 15	149.38879 ft	36.336871 ft	405.57392 psf	6,428.1391 psf	4,876.9771 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 16	152.88077 ft	35.412638 ft	458.79915 psf	6,815.4311 psf	5,147.499 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 17	157.18838 ft	34.566335 ft	506.12284 psf	7,346.6268 psf	6,378.8732 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 18	159.875 ft	34.116611 ft	530.9235 psf	7,663.9986 psf	6,651.7001 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 19	161.70833 ft	33.927825 ft	542.70373 psf	2,104.1913 psf	1,456.1107 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 20	165.125 ft	33.668696 ft	558.87335 psf	2,288.1168 psf	1,612.5456 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 21	168.54167 ft	33.581559 ft	564.31071 psf	2,449.1329 psf	1,757.6251 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 22	172.75 ft	33.73431 ft	554.77906 psf	2,602.2095 psf	1,909.2597 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 23	175.77822 ft	33.943898 ft	541.70079 psf	2,690.0008 psf	2,003.3221 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 24	178.01814 ft	34.23934 ft	523.26515 psf	2,695.2155 psf	1,888.0476 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 25	181.44153 ft	34.807517 ft	487.81092 psf	2,709.7255 psf	1,931.4808 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 26	184.86492 ft	35.557369 ft	441.0202 psf	2,671.7241 psf	1,939.1213 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 27	188.28831 ft	36.49517 ft	382.50138 psf	2,577.0131 psf	1,907.6599 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 28	191 ft	37.360004 ft	328.53577 psf	2,443.5064 psf	1,838.5159 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 29	193.75948 ft	38.407133 ft	263.19489 psf	2,228.1816 psf	1,708.1369 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 30	197.27844 ft	39.922476 ft	168.63751 psf	1,904.3744 psf	1,508.8531 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 31	200.7974 ft	41.681868 ft	58.851454 psf	1,526.0607 psf	1,275.4256 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 32	204.60516 ft	43.899687 ft	-79.540481 psf	1,037.6922 psf	902.0521 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel

Slice 33	208.70172 ft	46.665177 ft	-252.10704 psf	433.57244 psf	376.89877 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 34	211.11408 ft	48.446279 ft	-365.23326 psf	58.803634 psf	51.117219 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel

1.3 Pseudo-static (Spencer) Section Ha-Ha' - Existing Condition - Global Stability

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File Informa on

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Last Solved Date: 11/15/2021
Last Solved Time: 01:37:36 PM

Project Se ngs

Unit System: U.S. Customary Units

Analysis Se ngs

1.3 Pseudo-sta c (Spencer)

Kind: SLOPE/W
Parent: 1. Global Stability
Analysis Type: Spencer
Se ngs
PWP Condi ons from: Piezometric Line
Apply Phrea c Correc on: No
Use Staged Rapid Drawdown: No
Unit Weight of Water: 62.4 pcf
Slip Surface
Direc on of movement: Le. to Right
Use Passive Mode: No
Slip Surface Op□on: Entry and Exit
Cri□cal slip surfaces saved: 1
Op□mize Cri□cal Slip Surface Loca□on: No
Tension Crack Op□on: (none)
Distribu□on
F of S Calcula□on Op□on: Constant
Advanced
Geometry Se□ ngs
Minimum Slip Surface Depth: 2 ft
Number of Slices: 30
Factor of Safety Convergence Se□ ngs
Maximum Number of Itera□ons: 100
Tolerable difference in F of S: 0.001
Solu□on Se□ ngs
Search Method: Root Finder

Tolerable difference between star□ng and converged F of S: 3
Maximum itera□ons to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Hilfiker Wall

Slope Stability Material Model: High Strength
Unit Weight: 130 pcf
Pore Water Pressure
Piezometric Line: 1

ESU 1A - Exis ng Granular Fill (Pseudo-Sta c)

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 50 psf
Effec□ve Fric□on Angle: 40 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2A - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 39 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2B - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 41 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 7A - Weathered Sandstone

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 43 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1B - Exis ng Gravelly Granular Fill

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effec□ve Cohesion: 0 psf

Effec□ve Fric□on Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2C - Na ve Silt (Pseudo-Sta c)

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effec□ve Cohesion: 200 psf
Effec□ve Fric□on Angle: 29 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (0.25, 60) ft
Left-Zone Right Coordinate: (120, 90) ft
Left-Zone Increment: 40
Right Type: Range
Right-Zone Left Coordinate: (160, 50.069336) ft
Right-Zone Right Coordinate: (335, 48) ft
Right-Zone Increment: 40
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 60) ft
Right Coordinate: (335, 48) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	0.25 ft	43.375 ft
Coordinate 2	56.5 ft	43.375 ft
Coordinate 3	97.75 ft	43.375 ft
Coordinate 4	123 ft	43.375 ft
Coordinate 5	159.75 ft	42.625 ft
Coordinate 6	192 ft	42.625 ft
Coordinate 7	210.75 ft	42.625 ft
Coordinate 8	298 ft	35 ft
Coordinate 9	335.25 ft	35 ft

Seismic Coefficients

Horz Seismic Coef.: 0.177

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 125 pcf
Direc□on: Ver□cal

Coordinates

	X	Y
	120 ft	91 ft
	160 ft	91 ft

Geometry

Name: Ga-Ga'

Se ngs

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	0 ft	56 ft
Point 2	76 ft	56 ft
Point 3	118 ft	35 ft
Point 4	160 ft	35 ft
Point 5	0 ft	46 ft
Point 6	37 ft	46 ft
Point 7	190 ft	50 ft
Point 8	160 ft	50 ft
Point 9	170.25 ft	34 ft
Point 10	240 ft	34 ft
Point 11	315 ft	30 ft
Point 12	335 ft	30 ft
Point 13	335 ft	48 ft
Point 14	327 ft	48 ft
Point 15	315 ft	49 ft
Point 16	224 ft	48 ft
Point 17	0 ft	0 ft
Point 18	335 ft	0 ft
Point 19	160 ft	90 ft
Point 20	120 ft	90 ft
Point 21	120 ft	72 ft
Point 22	80 ft	72 ft
Point 23	56 ft	60 ft
Point 24	0 ft	60 ft
Point 25	160 ft	47 ft
Point 26	120 ft	47 ft
Point 27	70 ft	67 ft
Point 28	160 ft	78 ft

Point 29	93.5 ft	78 ft
Point 30	120 ft	78 ft
Point 31	160 ft	72 ft
Point 32	128 ft	90 ft
Point 33	128 ft	47 ft
Point 34	128 ft	78 ft
Point 35	128 ft	72 ft

Regions

	Material	Points	Area
Region 1	ESU 2C - Na□ve Silt (Pseudo-Sta□c)	5,6,2,1	565 ft²
Region 2	ESU 1A - Exis□ng Granular Fill (Pseudo-Sta□c)	20,29,30	159 ft²
Region 3	ESU 2A - Na□ve Sand and Gravel	6,2,3	619.5 ft²
Region 4	ESU 2B - Na□ve Sand and Gravel	7,16,15,14,13,12,11,10,9,4	2,595.4 ft²
Region 5	ESU 7A - Weathered Sandstone	18,17,5,6,3,4,9,10,11,12	12,178 ft²
Region 6	ESU 1B - Exis□ng Gravelly Granular Fill	8,7,25	45 ft²
Region 7	ESU 2A - Na□ve Sand and Gravel	4,7,25,33,26,2,3	945 ft²
Region 8	ESU 1B - Exis□ng Gravelly Granular Fill	23,24,1,2,26,21,22,27	1,302 ft²
Region 9	ESU 1B - Exis□ng Gravelly Granular Fill	26,33,35,21	200 ft²
Region 10	Hilfiker Wall	19,32,34,28	384 ft²
Region 11	ESU 1A - Exis□ng Granular Fill (Pseudo-Sta□c)	22,21,30,29	199.5 ft²
Region 12	Hilfiker Wall	28,34,35,31	192 ft²
Region 13	ESU 1A - Exis□ng Granular Fill (Pseudo-Sta□c)	20,30,34,32	96 ft²
Region 14	ESU 1A - Exis□ng Granular Fill (Pseudo-Sta□c)	30,21,35,34	48 ft²
Region 15	Hilfiker Wall	25,8,31,35,33	800 ft²

Slip Results

Slip Surfaces Analysed: 3804 of 8405 converged

Current Slip Surface

Slip Surface: 6,433
Factor of Safety: 1.814
Volume: 3,206.5395 ft³
Weight: 408,807.8 lbf
Resis□ng Moment: 30,797,316 lbf·ft
Ac□va□ng Moment: 16,981,190 lbf·ft
Resis□ng Force: 288,182.76 lbf
Ac□va□ng Force: 158,865.18 lbf
Slip Rank: 1 of 8,405 slip surfaces
Exit: (225.5625, 48.01717) ft
Entry: (94.082937, 78.263971) ft
Radius: 98.162458 ft
Center: (175.81045, 132.63751) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Fric□onal Strength	Cohesive Strength	Suc□on Strength	Base Material
Slice	94.171055	78.131986	-2,168.8359	-4.6326317	-3.8872396	50 psf	0 psf	ESU 1A -

1	ft	ft	psf	psf	psf			Exis□ng Granular Fill (Pseudo-Sta□c)
Slice 2	96.004587 ft	75.559579 ft	-2,008.3177 psf	178.66049 psf	149.91395 psf	50 psf	0 psf	ESU 1A - Exis□ng Granular Fill (Pseudo-Sta□c)
Slice 3	98.183073 ft	72.559579 ft	-1,821.1177 psf	412.76851 psf	346.3539 psf	50 psf	0 psf	ESU 1A - Exis□ng Granular Fill (Pseudo-Sta□c)
Slice 4	100.75453 ft	69.45958 ft	-1,627.6778 psf	712.87513 psf	556.95909 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 5	105.0313 ft	64.691607 ft	-1,330.1563 psf	1,209.2137 psf	944.74132 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 6	109.30807 ft	60.492906 ft	-1,068.1573 psf	1,719.3888 psf	1,343.3338 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 7	113.58484 ft	56.767928 ft	-835.71872 psf	2,240.7208 psf	1,750.643 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 8	117.86161 ft	53.449259 ft	-628.63373 psf	2,771.7649 psf	2,165.5401 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 9	121.5 ft	50.887892 ft	-468.80445 psf	3,268.618 psf	2,553.7243 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 10	125.5 ft	48.398283 ft	-316.63651 psf	3,628.383 psf	2,834.8035 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 11	129.88302 ft	45.908052 ft	-166.82774 psf	4,235.5641 psf	3,429.8922 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel

Slice 12	133.64905 ft	44.015073 ft	-53.501823 psf	4,572.3431 psf	3,702.6104 psf	0 psf	0 psf	ESU 2A - Naïve Sand and Gravel
Slice 13	137.55023 ft	42.264834 ft	50.745094 psf	4,917.4529 psf	3,940.9823 psf	0 psf	0 psf	ESU 2A - Naïve Sand and Gravel
Slice 14	141.58655 ft	40.659491 ft	145.77835 psf	5,268.9806 psf	4,148.6874 psf	0 psf	0 psf	ESU 2A - Naïve Sand and Gravel
Slice 15	145.62287 ft	39.256143 ft	228.20712 psf	5,615.1339 psf	4,362.2473 psf	0 psf	0 psf	ESU 2A - Naïve Sand and Gravel
Slice 16	149.6592 ft	38.045779 ft	298.59374 psf	5,957.2439 psf	4,582.2845 psf	0 psf	0 psf	ESU 2A - Naïve Sand and Gravel
Slice 17	153.69552 ft	37.021053 ft	357.39652 psf	6,296.7285 psf	4,809.5762 psf	0 psf	0 psf	ESU 2A - Naïve Sand and Gravel
Slice 18	157.73184 ft	36.176037 ft	404.98538 psf	6,635.1435 psf	5,045.0826 psf	0 psf	0 psf	ESU 2A - Naïve Sand and Gravel
Slice 19	159.875 ft	35.777232 ft	427.30072 psf	6,817.5255 psf	5,174.702 psf	0 psf	0 psf	ESU 2A - Naïve Sand and Gravel
Slice 20	160.57576 ft	35.666213 ft	434.22834 psf	1,638.3936 psf	975.1138 psf	0 psf	0 psf	ESU 2A - Naïve Sand and Gravel
Slice 21	163.50126 ft	35.278677 ft	458.41057 psf	1,759.8696 psf	1,131.3411 psf	0 psf	0 psf	ESU 2B - Naïve Sand and Gravel
Slice 22	168.20076 ft	34.798837 ft	488.35256 psf	1,938.5028 psf	1,260.5963 psf	0 psf	0 psf	ESU 2B - Naïve Sand and Gravel
Slice 23	172.90025 ft	34.546366 ft	504.10679 psf	2,102.8043 psf	1,389.7265 psf	0 psf	0 psf	ESU 2B - Naïve Sand and Gravel
Slice 24	177.70833 ft	34.524206 ft	505.48954 psf	2,255.217 psf	1,521.0149 psf	0 psf	0 psf	ESU 2B - Naïve Sand and Gravel
Slice 25	182.625 ft	34.742887 ft	491.84386 psf	2,394.8156 psf	1,654.2281 psf	0 psf	0 psf	ESU 2B - Naïve Sand and Gravel

Slice 26	187.54167 ft	35.210021 ft	462.69467 psf	2,516.7994 psf	1,785.606 psf	0 psf	0 psf	ESU 2B - Naïve Sand and Gravel
Slice 27	191 ft	35.662663 ft	434.44986 psf	2,574.3077 psf	1,860.1501 psf	0 psf	0 psf	ESU 2B - Naïve Sand and Gravel
Slice 28	194.34375 ft	36.270044 ft	396.54924 psf	2,556.7066 psf	1,877.7962 psf	0 psf	0 psf	ESU 2B - Naïve Sand and Gravel
Slice 29	199.03125 ft	37.291595 ft	332.80446 psf	2,505.5354 psf	1,888.7262 psf	0 psf	0 psf	ESU 2B - Naïve Sand and Gravel
Slice 30	203.71875 ft	38.55766 ft	253.80204 psf	2,409.7443 psf	1,874.132 psf	0 psf	0 psf	ESU 2B - Naïve Sand and Gravel
Slice 31	208.40625 ft	40.0783 ft	158.9141 psf	2,256.6801 psf	1,823.5601 psf	0 psf	0 psf	ESU 2B - Naïve Sand and Gravel
Slice 32	212.50463 ft	41.610998 ft	53.70523 psf	2,072.3527 psf	1,754.7835 psf	0 psf	0 psf	ESU 2B - Naïve Sand and Gravel
Slice 33	216.69445 ft	43.434422 ft	-82.924764 psf	1,709.6115 psf	1,486.1426 psf	0 psf	0 psf	ESU 2B - Naïve Sand and Gravel
Slice 34	221.56482 ft	45.834122 ft	-259.22557 psf	949.72989 psf	825.5876 psf	0 psf	0 psf	ESU 2B - Naïve Sand and Gravel
Slice 35	224.78125 ft	47.567443 ft	-384.92497 psf	210.39081 psf	182.88994 psf	0 psf	0 psf	ESU 2B - Naïve Sand and Gravel

1.4 Pseudo-static (M-P) Section Ha-Ha' - Existing Condition - Global Stability

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File Informa on

File Version: 11.01
Created By: Mikayla S. Hatch
Last Edited By: Mikayla S. Hatch
Revision Number: 305
Date: 11/15/2021
Time: 01:36:51 PM
Tool Version: 11.1
File Name: Wall 03.63L - Bridge 17.7 Ha-Ha' - All Condi ons.gsz
Directory: P:\0\0180366\01\Analysis\Bridge 17.7\SlopeW\
Last Solved Date: 11/15/2021
Last Solved Time: 01:37:24 PM

Project Se ngs

Unit System: U.S. Customary Units

Analysis Se ngs

1.4 Pseudo-sta c (M-P)

Kind: SLOPE/W
Parent: 1. Global Stability
Analysis Type: Morgenstern-Price
Se ngs
- Side Func on
  - Interslice force func on op on: Half-Sine
- PWP Condi ons from: Piezometric Line
- Apply Phrea c Correc on: No
- Use Staged Rapid Drawdown: No
- Unit Weight of Water: 62.4 pcf

Slip Surface
- Direc on of movement: Le. to Right
- Use Passive Mode: No
- Slip Surface Op on: Entry and Exit
- Cri cal slip surfaces saved: 1
- Op mize Cri cal Slip Surface Loca on: No
- Tension Crack Op on: (none)

Distribu on
- F of S Calcula on Op on: Constant

Advanced
- Geometry Se ngs
  - Minimum Slip Surface Depth: 2 ft
  - Number of Slices: 30
- Factor of Safety Convergence Se ngs
  - Maximum Number of Itera ons: 100
  - Tolerable difference in F of S: 0.001

Solu□on Se□ ngs
Search Method: Root Finder
Tolerable difference between star□ng and converged F of S: 3
Maximum itera□ons to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Hilfiker Wall

Slope Stability Material Model: High Strength
Unit Weight: 130 pcf
Pore Water Pressure
Piezometric Line: 1

ESU 1A - Exis ng Granular Fill (Pseudo-Sta c)

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 50 psf
Effec□ve Fric□on Angle: 40 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2A - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 39 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2B - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 41 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 7A - Weathered Sandstone

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 43 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1B - Exis ng Gravelly Granular Fill

Slope Stability Material Model: Mohr-Coulomb

Unit Weight: 125 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2C - Na ve Silt (Pseudo-Sta c)

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effec□ve Cohesion: 200 psf
Effec□ve Fric□on Angle: 29 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (0.25, 60) ft
Left-Zone Right Coordinate: (120, 90) ft
Left-Zone Increment: 40
Right Type: Range
Right-Zone Left Coordinate: (160, 50.069336) ft
Right-Zone Right Coordinate: (335, 48) ft
Right-Zone Increment: 40
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 60) ft
Right Coordinate: (335, 48) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	0.25 ft	43.375 ft
Coordinate 2	56.5 ft	43.375 ft
Coordinate 3	97.75 ft	43.375 ft
Coordinate 4	123 ft	43.375 ft
Coordinate 5	159.75 ft	42.625 ft
Coordinate 6	192 ft	42.625 ft
Coordinate 7	210.75 ft	42.625 ft
Coordinate 8	298 ft	35 ft
Coordinate 9	335.25 ft	35 ft

Seismic Coefficients

Horz Seismic Coef.: 0.177

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 125 pcf

Direc□on: Ver□cal

Coordinates

	X	Y
	120 ft	91 ft
	160 ft	91 ft

Geometry

Name: Ga-Ga'

Se ngs

View: 2D

Element Thickness: 1 ft

Points

	X	Y
Point 1	0 ft	56 ft
Point 2	76 ft	56 ft
Point 3	118 ft	35 ft
Point 4	160 ft	35 ft
Point 5	0 ft	46 ft
Point 6	37 ft	46 ft
Point 7	190 ft	50 ft
Point 8	160 ft	50 ft
Point 9	170.25 ft	34 ft
Point 10	240 ft	34 ft
Point 11	315 ft	30 ft
Point 12	335 ft	30 ft
Point 13	335 ft	48 ft
Point 14	327 ft	48 ft
Point 15	315 ft	49 ft
Point 16	224 ft	48 ft
Point 17	0 ft	0 ft
Point 18	335 ft	0 ft
Point 19	160 ft	90 ft
Point 20	120 ft	90 ft
Point 21	120 ft	72 ft
Point 22	80 ft	72 ft
Point 23	56 ft	60 ft
Point 24	0 ft	60 ft

Point 25	160 ft	47 ft
Point 26	120 ft	47 ft
Point 27	70 ft	67 ft
Point 28	160 ft	78 ft
Point 29	93.5 ft	78 ft
Point 30	120 ft	78 ft
Point 31	160 ft	72 ft
Point 32	128 ft	90 ft
Point 33	128 ft	47 ft
Point 34	128 ft	78 ft
Point 35	128 ft	72 ft

Regions

	Material	Points	Area
Region 1	ESU 2C - Na□ve Silt (Pseudo-Sta□c)	5,6,2,1	565 ft²
Region 2	ESU 1A - Exis□ng Granular Fill (Pseudo-Sta□c)	20,29,30	159 ft²
Region 3	ESU 2A - Na□ve Sand and Gravel	6,2,3	619.5 ft²
Region 4	ESU 2B - Na□ve Sand and Gravel	7,16,15,14,13,12,11,10,9,4	2,595.4 ft²
Region 5	ESU 7A - Weathered Sandstone	18,17,5,6,3,4,9,10,11,12	12,178 ft²
Region 6	ESU 1B - Exis□ng Gravelly Granular Fill	8,7,25	45 ft²
Region 7	ESU 2A - Na□ve Sand and Gravel	4,7,25,33,26,2,3	945 ft²
Region 8	ESU 1B - Exis□ng Gravelly Granular Fill	23,24,1,2,26,21,22,27	1,302 ft²
Region 9	ESU 1B - Exis□ng Gravelly Granular Fill	26,33,35,21	200 ft²
Region 10	Hilfiker Wall	19,32,34,28	384 ft²
Region 11	ESU 1A - Exis□ng Granular Fill (Pseudo-Sta□c)	22,21,30,29	199.5 ft²
Region 12	Hilfiker Wall	28,34,35,31	192 ft²
Region 13	ESU 1A - Exis□ng Granular Fill (Pseudo-Sta□c)	20,30,34,32	96 ft²
Region 14	ESU 1A - Exis□ng Granular Fill (Pseudo-Sta□c)	30,21,35,34	48 ft²
Region 15	Hilfiker Wall	25,8,31,35,33	800 ft²

Slip Results

Slip Surfaces Analysed: 3951 of 8405 converged

Current Slip Surface

Slip Surface: 6,433
Factor of Safety: 1.811
Volume: 3,206.5395 ft³
Weight: 408,807.8 lbf
Resis□ng Moment: 30,759,851 lbf·ft
Ac□va□ng Moment: 16,981,190 lbf·ft
Resis□ng Force: 288,433.42 lbf
Ac□va□ng Force: 159,228.22 lbf
Slip Rank: 1 of 8,405 slip surfaces
Exit: (225.5625, 48.01717) ft
Entry: (94.082937, 78.263971) ft
Radius: 98.162458 ft
Center: (175.81045, 132.63751) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Fric□onal Strength	Cohesive Strength	Suc□on Strength	Base Material
Slice 1	94.171055 ft	78.131986 ft	-2,168.8359 psf	-12.17938 psf	-10.219713 psf	50 psf	0 psf	ESU 1A - Exis□ng Granular Fill (Pseudo-Sta□c)
Slice 2	96.004587 ft	75.559579 ft	-2,008.3177 psf	228.84145 psf	192.02078 psf	50 psf	0 psf	ESU 1A - Exis□ng Granular Fill (Pseudo-Sta□c)
Slice 3	98.183073 ft	72.559579 ft	-1,821.1177 psf	515.31915 psf	432.40411 psf	50 psf	0 psf	ESU 1A - Exis□ng Granular Fill (Pseudo-Sta□c)
Slice 4	100.75453 ft	69.45958 ft	-1,627.6778 psf	861.1438 psf	672.79927 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 5	105.0313 ft	64.691607 ft	-1,330.1563 psf	1,358.6091 psf	1,061.4617 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 6	109.30807 ft	60.492906 ft	-1,068.1573 psf	1,821.2369 psf	1,422.9062 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 7	113.58484 ft	56.767928 ft	-835.71872 psf	2,264.5897 psf	1,769.2914 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 8	117.86161 ft	53.449259 ft	-628.63373 psf	2,701.9711 psf	2,111.0112 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 9	121.5 ft	50.887892 ft	-468.80445 psf	3,115.4779 psf	2,434.0781 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 10	125.5 ft	48.398283 ft	-316.63651 psf	3,389.7057 psf	2,648.3283 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly

								Granular Fill
Slice 11	129.88302 ft	45.908052 ft	-166.82774 psf	3,923.4017 psf	3,177.1081 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 12	133.64905 ft	44.015073 ft	-53.501823 psf	4,220.1422 psf	3,417.4037 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 13	137.55023 ft	42.264834 ft	50.745094 psf	4,549.7671 psf	3,643.2362 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 14	141.58655 ft	40.659491 ft	145.77835 psf	4,913.5108 psf	3,860.8336 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 15	145.62287 ft	39.256143 ft	228.20712 psf	5,303.3549 psf	4,109.7736 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 16	149.6592 ft	38.045779 ft	298.59374 psf	5,721.1695 psf	4,391.1153 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 17	153.69552 ft	37.021053 ft	357.39652 psf	6,166.4185 psf	4,704.0533 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 18	157.73184 ft	36.176037 ft	404.98538 psf	6,635.4849 psf	5,045.359 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 19	159.875 ft	35.777232 ft	427.30072 psf	6,894.7609 psf	5,237.246 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 20	160.57576 ft	35.666213 ft	434.22834 psf	1,651.5385 psf	985.75832 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 21	163.50126 ft	35.278677 ft	458.41057 psf	1,859.9977 psf	1,218.3811 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 22	168.20076 ft	34.798837 ft	488.35256 psf	2,176.2496 psf	1,467.2665 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 23	172.90025 ft	34.546366 ft	504.10679 psf	2,477.8263 psf	1,715.7282 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 24	177.70833 ft	34.524206 ft	505.48954 psf	2,752.0649 psf	1,952.9182 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 25	182.625 ft	34.742887 ft	491.84386 psf	2,973.6149 psf	2,157.3706 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 26	187.54167 ft	35.210021 ft	462.69467 psf	3,108.7248 psf	2,300.1589 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 27	191 ft	35.662663 ft	434.44986 psf	3,125.3606 psf	2,339.173 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice	194.34375	36.270044	396.54924	3,020.0252	2,280.5529	0 psf	0 psf	ESU 2B -

28	ft	ft	psf	psf	psf			Na□ve Sand and Gravel
Slice 29	199.03125 ft	37.291595 ft	332.80446 psf	2,782.2813 psf	2,129.2978 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 30	203.71875 ft	38.55766 ft	253.80204 psf	2,437.0327 psf	1,897.8535 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 31	208.40625 ft	40.0783 ft	158.9141 psf	2,003.004 psf	1,603.0429 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 32	212.50463 ft	41.610998 ft	53.70523 psf	1,576.6159 psf	1,323.8461 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 33	216.69445 ft	43.434422 ft	-82.924764 psf	1,080.2979 psf	939.08863 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 34	221.56482 ft	45.834122 ft	-259.22557 psf	469.39578 psf	408.03953 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 35	224.78125 ft	47.567443 ft	-384.92497 psf	84.65413 psf	73.588712 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel

3.1 Static (Spencer) Section Ha-Ha' - Construction Condition - Global Stability

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File Informa on

File Version: 11.01
Created By: Mikayla S. Hatch
Last Edited By: Mikayla S. Hatch
Revision Number: 306
Date: 11/15/2021
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Tool Version: 11.1
File Name: Wall 03.63L - Bridge 17.7 Ha-Ha' - All Condi ons.gsz
Directory: P:\0\0180366\01\Analysis\Bridge 17.7\SlopeW\
Last Solved Date: 11/15/2021
Last Solved Time: 01:40:46 PM

Project Se ngs

Unit System: U.S. Customary Units

Analysis Se ngs

3.1 Sta c (Spencer)

Kind: SLOPE/W
Parent: 3. Global Stability
Analysis Type: Spencer
Se ngs
PWP Condi ons from: Piezometric Line
Apply Phrea c Correc on: No
Use Staged Rapid Drawdown: No
Unit Weight of Water: 62.4 pcf
Slip Surface
Direc on of movement: Le. to Right
Use Passive Mode: No
Slip Surface Op on: Entry and Exit
Cri cal slip surfaces saved: 1
Op mize Cri cal Slip Surface Loca on: No
Tension Crack Op on: (none)
Distribu on
F of S Calcula on Op on: Constant
Advanced
Geometry Se ngs
Minimum Slip Surface Depth: 2 ft
Number of Slices: 30
Factor of Safety Convergence Se ngs
Maximum Number of Itera ons: 100
Tolerable difference in F of S: 0.001
Solu on Se ngs
Search Method: Root Finder

Figure D.4-353

Tolerable difference between star□ng and converged F of S: 3
Maximum itera□ons to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Hilfiker Wall

Slope Stability Material Model: High Strength
Unit Weight: 130 pcf
Pore Water Pressure
Piezometric Line: 1

ESU 2A - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 39 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2B - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 41 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 7A - Weathered Sandstone

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 43 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2C - Na ve Silt

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 29 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1A - Exis ng Granular Fill

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf

Effec□ve Fric□on Angle: 40 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1B - Exis ng Gravelly Granular Fill

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (1.75, 60) ft
Left-Zone Right Coordinate: (120.00682, 78) ft
Left-Zone Increment: 40
Right Type: Range
Right-Zone Left Coordinate: (161.41681, 50) ft
Right-Zone Right Coordinate: (315.5, 48.958333) ft
Right-Zone Increment: 40
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 60) ft
Right Coordinate: (335, 48) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	0.25 ft	43.375 ft
Coordinate 2	56.5 ft	43.375 ft
Coordinate 3	97.75 ft	43.375 ft
Coordinate 4	123 ft	43.375 ft
Coordinate 5	159.75 ft	42.625 ft
Coordinate 6	192 ft	42.625 ft
Coordinate 7	210.75 ft	42.625 ft
Coordinate 8	298 ft	35 ft
Coordinate 9	335.25 ft	35 ft

Geometry

Name: Ga-Ga'

Se ngs

View: 2D

Element Thickness: 1 ft

Points

	X	Y
Point 1	0 ft	56 ft
Point 2	76 ft	56 ft
Point 3	118 ft	35 ft
Point 4	160 ft	35 ft
Point 5	0 ft	46 ft
Point 6	37 ft	46 ft
Point 7	190 ft	50 ft
Point 8	160 ft	50 ft
Point 9	170.25 ft	34 ft
Point 10	240 ft	34 ft
Point 11	315 ft	30 ft
Point 12	335 ft	30 ft
Point 13	335 ft	48 ft
Point 14	327 ft	48 ft
Point 15	315 ft	49 ft
Point 16	224 ft	48 ft
Point 17	0 ft	0 ft
Point 18	335 ft	0 ft
Point 19	160 ft	90 ft
Point 20	120 ft	90 ft
Point 21	120 ft	72 ft
Point 22	80 ft	72 ft
Point 23	56 ft	60 ft
Point 24	0 ft	60 ft
Point 25	160 ft	47 ft
Point 26	120 ft	47 ft
Point 27	70 ft	67 ft
Point 28	160 ft	78 ft
Point 29	93.5 ft	78 ft
Point 30	120 ft	78 ft
Point 31	160 ft	72 ft
Point 32	128 ft	90 ft
Point 33	128 ft	47 ft
Point 34	128 ft	78 ft
Point 35	128 ft	72 ft

Regions

	Material	Points	Area
Region 1	ESU 2C - Na□ve Silt	5,6,2,1	565 ft²
Region 2		20,29,30	159 ft²
Region 3	ESU 2A - Na□ve Sand and Gravel	6,2,3	619.5 ft²
Region 4	ESU 2B - Na□ve Sand and Gravel	7,16,15,14,13,12,11,10,9,4	2,595.4 ft²
Region 5	ESU 7A - Weathered Sandstone	18,17,5,6,3,4,9,10,11,12	12,178 ft²

Figure D.4-356

Region 6	ESU 1B - Exis□ng Gravelly Granular Fill	8,7,25	45 ft²
Region 7	ESU 2A - Na□ve Sand and Gravel	4,7,25,33,26,2,3	945 ft²
Region 8	ESU 1B - Exis□ng Gravelly Granular Fill	23,24,1,2,26,21,22,27	1,302 ft²
Region 9	ESU 1B - Exis□ng Gravelly Granular Fill	26,33,35,21	200 ft²
Region 10		19,32,34,28	384 ft²
Region 11	ESU 1A - Exis□ng Granular Fill	22,21,30,29	199.5 ft²
Region 12	Hilfiker Wall	28,34,35,31	192 ft²
Region 13		20,30,34,32	96 ft²
Region 14	ESU 1A - Exis□ng Granular Fill	30,21,35,34	48 ft²
Region 15	Hilfiker Wall	25,8,31,35,33	800 ft²

Slip Results

Slip Surfaces Analysed: 4118 of 8405 converged

Current Slip Surface

Slip Surface: 7,219
Factor of Safety: 2.869
Volume: 1,895.0945 ft³
Weight: 239,767.75 lbf
Resis□ng Moment: 10,826,331 lbf·ft
Ac□va□ng Moment: 3,772,921.3 lbf·ft
Resis□ng Force: 174,394.74 lbf
Ac□va□ng Force: 60,775.334 lbf
Slip Rank: 1 of 8,405 slip surfaces
Exit: (192.24277, 49.868072) ft
Entry: (104.71145, 78) ft
Radius: 55.638318 ft
Center: (158.06717, 93.77309) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Fric□onal Strength	Cohesive Strength	Suc□on Strength	Base Material
Slice 1	105.78875 ft	75 ft	-1,973.4 psf	143.80571 psf	120.66732 psf	0 psf	0 psf	ESU 1A - Exis□ng Granular Fill
Slice 2	108.17944 ft	69.320441 ft	-1,618.9955 psf	516.22529 psf	403.3194 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 3	110.80623 ft	64.519045 ft	-1,319.3884 psf	914.14297 psf	714.20676 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 4	113.43302 ft	60.628524 ft	-1,076.6199 psf	1,287.604 psf	1,005.9865 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly

								Granular Fill
Slice 5	116.05981 ft	57.345275 ft	-871.74513 psf	1,638.9142 psf	1,280.4601 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 6	118.6866 ft	54.513275 ft	-695.02837 psf	1,970.4023 psf	1,539.447 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 7	121.5 ft	51.886339 ft	-531.10754 psf	2,304.4934 psf	1,800.4676 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 8	124.23395 ft	49.631065 ft	-391.94982 psf	2,614.1531 psf	2,042.4002 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 9	126.73395 ft	47.821992 ft	-282.24734 psf	2,881.6154 psf	2,251.3647 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 10	129.75672 ft	45.919408 ft	-167.37553 psf	3,321.5957 psf	2,689.7752 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 11	133.27016 ft	44.004839 ft	-52.380673 psf	3,657.2135 psf	2,961.5531 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 12	136.57208 ft	42.481993 ft	38.440028 psf	3,956.4183 psf	3,172.7163 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 13	139.66247 ft	41.292539 ft	108.72642 psf	4,219.8466 psf	3,329.1194 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 14	142.75286 ft	40.308047 ft	166.22323 psf	4,467.2374 psf	3,482.8926 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 15	145.84325 ft	39.517312 ft	211.62953 psf	4,699.8874 psf	3,634.5196 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 16	148.93364 ft	38.911926 ft	245.4701 psf	4,918.9552 psf	3,784.5136 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 17	152.02403 ft	38.485779 ft	268.12618 psf	5,125.5221 psf	3,933.4417 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 18	155.11442 ft	38.234731 ft	279.85607 psf	5,320.6501 psf	4,081.9545 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice	158.20481	38.156403	280.80821	5,505.4434	4,230.8262	0 psf	0 psf	ESU 2A -

19	ft	ft	psf	psf	psf			Na□ve Sand and Gravel
Slice 20	159.875 ft	38.164291 ft	278.34826 psf	5,604.0844 psf	4,312.6961 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 21	161.34833 ft	38.248031 ft	273.12284 psf	1,573.1075 psf	1,052.7068 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 22	164.04498 ft	38.473461 ft	259.05605 psf	1,587.4617 psf	1,075.7217 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 23	166.74163 ft	38.832096 ft	236.67721 psf	1,586.0526 psf	1,092.7026 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 24	169.87997 ft	39.434111 ft	199.11147 psf	1,588.4431 psf	1,207.7276 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 25	173.45999 ft	40.338893 ft	142.65311 psf	1,552.8041 psf	1,225.8256 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 26	176.42864 ft	41.266711 ft	84.757221 psf	1,495.6986 psf	1,226.5126 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 27	178.78591 ft	42.15194 ft	29.518929 psf	1,425.1351 psf	1,213.1906 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 28	181.63712 ft	43.407731 ft	-48.842407 psf	1,287.9398 psf	1,119.5889 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 29	184.98227 ft	45.115655 ft	-155.41688 psf	1,046.9926 psf	910.13677 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 30	188.32742 ft	47.125855 ft	-280.85335 psf	695.62024 psf	604.69345 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 31	191 ft	48.945517 ft	-394.40027 psf	273.60991 psf	237.84546 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 32	192.12139 ft	49.774123 ft	-446.10525 psf	29.126501 psf	25.319281 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel

3.2 Static (M-P) Section Ha-Ha' - Construction Condition - Global Stability

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File Informa on

File Version: 11.01
Created By: Mikayla S. Hatch
Last Edited By: Mikayla S. Hatch
Revision Number: 306
Date: 11/15/2021
Time: 01:39:23 PM
Tool Version: 11.1
File Name: Wall 03.63L - Bridge 17.7 Ha-Ha' - All Condi ons.gsz
Directory: P:\0\0180366\01\Analysis\Bridge 17.7\SlopeW\
Last Solved Date: 11/15/2021
Last Solved Time: 01:40:52 PM

Project Se ngs

Unit System: U.S. Customary Units

Analysis Se ngs

3.2 Sta c (M-P)

Kind: SLOPE/W
Parent: 3. Global Stability
Analysis Type: Morgenstern-Price
Se ngs
Side Func on
Interslice force func on op on: Half-Sine
PWP Condi ons from: Piezometric Line
Apply Phrea c Correc on: No
Use Staged Rapid Drawdown: No
Unit Weight of Water: 62.4 pcf
Slip Surface
Direc on of movement: Le. to Right
Use Passive Mode: No
Slip Surface Op on: Entry and Exit
Cri cal slip surfaces saved: 1
Op mize Cri cal Slip Surface Loca on: No
Tension Crack Op on: (none)
Distribu on
F of S Calcula on Op on: Constant
Advanced
Geometry Se ngs
Minimum Slip Surface Depth: 2 ft
Number of Slices: 30
Factor of Safety Convergence Se ngs
Maximum Number of Itera ons: 100
Tolerable difference in F of S: 0.001

Solu□on Se□ ngs
Search Method: Root Finder
Tolerable difference between star□ng and converged F of S: 3
Maximum itera□ons to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Hilfiker Wall

Slope Stability Material Model: High Strength
Unit Weight: 130 pcf
Pore Water Pressure
Piezometric Line: 1

ESU 2A - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 39 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2B - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 41 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 7A - Weathered Sandstone

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 43 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2C - Na ve Silt

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 29 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1A - Exis ng Granular Fill

Slope Stability Material Model: Mohr-Coulomb

Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 40 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1B - Exis ng Gravelly Granular Fill

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (1.75, 60) ft
Left-Zone Right Coordinate: (120.00682, 78) ft
Left-Zone Increment: 40
Right Type: Range
Right-Zone Left Coordinate: (161.41681, 50) ft
Right-Zone Right Coordinate: (315.5, 48.958333) ft
Right-Zone Increment: 40
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 60) ft
Right Coordinate: (335, 48) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	0.25 ft	43.375 ft
Coordinate 2	56.5 ft	43.375 ft
Coordinate 3	97.75 ft	43.375 ft
Coordinate 4	123 ft	43.375 ft
Coordinate 5	159.75 ft	42.625 ft
Coordinate 6	192 ft	42.625 ft
Coordinate 7	210.75 ft	42.625 ft
Coordinate 8	298 ft	35 ft
Coordinate 9	335.25 ft	35 ft

Geometry

Name: Ga-Ga'

Se ngs

View: 2D

Element Thickness: 1 ft

Points

	X	Y
Point 1	0 ft	56 ft
Point 2	76 ft	56 ft
Point 3	118 ft	35 ft
Point 4	160 ft	35 ft
Point 5	0 ft	46 ft
Point 6	37 ft	46 ft
Point 7	190 ft	50 ft
Point 8	160 ft	50 ft
Point 9	170.25 ft	34 ft
Point 10	240 ft	34 ft
Point 11	315 ft	30 ft
Point 12	335 ft	30 ft
Point 13	335 ft	48 ft
Point 14	327 ft	48 ft
Point 15	315 ft	49 ft
Point 16	224 ft	48 ft
Point 17	0 ft	0 ft
Point 18	335 ft	0 ft
Point 19	160 ft	90 ft
Point 20	120 ft	90 ft
Point 21	120 ft	72 ft
Point 22	80 ft	72 ft
Point 23	56 ft	60 ft
Point 24	0 ft	60 ft
Point 25	160 ft	47 ft
Point 26	120 ft	47 ft
Point 27	70 ft	67 ft
Point 28	160 ft	78 ft
Point 29	93.5 ft	78 ft
Point 30	120 ft	78 ft
Point 31	160 ft	72 ft
Point 32	128 ft	90 ft
Point 33	128 ft	47 ft
Point 34	128 ft	78 ft
Point 35	128 ft	72 ft

Regions

	Material	Points	Area
Region 1	ESU 2C - Na ve Silt	5,6,2,1	565 ft²
Region 2		20,29,30	159 ft²

Figure D.4-363

Region 3	ESU 2A - Na□ve Sand and Gravel	6,2,3	619.5 ft²
Region 4	ESU 2B - Na□ve Sand and Gravel	7,16,15,14,13,12,11,10,9,4	2,595.4 ft²
Region 5	ESU 7A - Weathered Sandstone	18,17,5,6,3,4,9,10,11,12	12,178 ft²
Region 6	ESU 1B - Exis□ng Gravelly Granular Fill	8,7,25	45 ft²
Region 7	ESU 2A - Na□ve Sand and Gravel	4,7,25,33,26,2,3	945 ft²
Region 8	ESU 1B - Exis□ng Gravelly Granular Fill	23,24,1,2,26,21,22,27	1,302 ft²
Region 9	ESU 1B - Exis□ng Gravelly Granular Fill	26,33,35,21	200 ft²
Region 10		19,32,34,28	384 ft²
Region 11	ESU 1A - Exis□ng Granular Fill	22,21,30,29	199.5 ft²
Region 12	Hilfiker Wall	28,34,35,31	192 ft²
Region 13		20,30,34,32	96 ft²
Region 14	ESU 1A - Exis□ng Granular Fill	30,21,35,34	48 ft²
Region 15	Hilfiker Wall	25,8,31,35,33	800 ft²

Slip Results

Slip Surfaces Analysed: 4668 of 8405 converged

Current Slip Surface

Slip Surface: 7,219
Factor of Safety: 2.871
Volume: 1,895.0945 ft³
Weight: 239,767.75 lbf
Resis□ng Moment: 10,832,068 lbf·ft
Ac□va□ng Moment: 3,772,921.3 lbf·ft
Resis□ng Force: 174,401.73 lbf
Ac□va□ng Force: 60,732.489 lbf
Slip Rank: 1 of 8,405 slip surfaces
Exit: (192.24277, 49.868072) ft
Entry: (104.71145, 78) ft
Radius: 55.638318 ft
Center: (158.06717, 93.77309) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Fric□onal Strength	Cohesive Strength	Suc□on Strength	Base Material
Slice 1	105.78875 ft	75 ft	-1,973.4 psf	191.04709 psf	160.30754 psf	0 psf	0 psf	ESU 1A - Exis□ng Granular Fill
Slice 2	108.17944 ft	69.320441 ft	-1,618.9955 psf	625.34311 psf	488.57158 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 3	110.80623 ft	64.519045 ft	-1,319.3884 psf	1,022.9799 psf	799.2395 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill

Slice 4	113.43302 ft	60.628524 ft	-1,076.6199 psf	1,360.3869 psf	1,062.8507 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 5	116.05981 ft	57.345275 ft	-871.74513 psf	1,659.3506 psf	1,296.4267 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 6	118.6866 ft	54.513275 ft	-695.02837 psf	1,933.4255 psf	1,510.5575 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 7	121.5 ft	51.886339 ft	-531.10754 psf	2,208.6852 psf	1,725.614 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 8	124.23395 ft	49.631065 ft	-391.94982 psf	2,468.7885 psf	1,928.829 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 9	126.73395 ft	47.821992 ft	-282.24734 psf	2,701.3439 psf	2,110.5211 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 10	129.75672 ft	45.919408 ft	-167.37553 psf	3,115.7996 psf	2,523.1248 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 11	133.27016 ft	44.004839 ft	-52.380673 psf	3,445.2187 psf	2,789.8831 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 12	136.57208 ft	42.481993 ft	38.440028 psf	3,763.5005 psf	3,016.4945 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 13	139.66247 ft	41.292539 ft	108.72642 psf	4,065.5242 psf	3,204.1517 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 14	142.75286 ft	40.308047 ft	166.22323 psf	4,369.5325 psf	3,403.7728 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 15	145.84325 ft	39.517312 ft	211.62953 psf	4,672.8758 psf	3,612.646 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 16	148.93364 ft	38.911926 ft	245.4701 psf	4,970.7059 psf	3,826.4205 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 17	152.02403 ft	38.485779 ft	268.12618 psf	5,255.8883 psf	4,039.0102 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice	155.11442	38.234731	279.85607	5,519.024	4,242.5945	0 psf	0 psf	ESU 2A -

18	ft	ft	psf	psf	psf			Na□ve Sand and Gravel
Slice 19	158.20481 ft	38.156403 ft	280.80821 psf	5,748.6695 psf	4,427.7867 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 20	159.875 ft	38.164291 ft	278.34826 psf	5,858.9383 psf	4,519.0727 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 21	161.34833 ft	38.248031 ft	273.12284 psf	1,755.178 psf	1,200.1446 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 22	164.04498 ft	38.473461 ft	259.05605 psf	1,786.1408 psf	1,236.6088 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 23	166.74163 ft	38.832096 ft	236.67721 psf	1,787.4699 psf	1,255.8071 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 24	169.87997 ft	39.434111 ft	199.11147 psf	1,772.7892 psf	1,367.9771 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 25	173.45999 ft	40.338893 ft	142.65311 psf	1,683.3959 psf	1,339.3473 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 26	176.42864 ft	41.266711 ft	84.757221 psf	1,558.178 psf	1,280.8252 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 27	178.78591 ft	42.15194 ft	29.518929 psf	1,420.9347 psf	1,209.5393 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 28	181.63712 ft	43.407731 ft	-48.842407 psf	1,201.7627 psf	1,044.6764 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 29	184.98227 ft	45.115655 ft	-155.41688 psf	885.69222 psf	769.9205 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 30	188.32742 ft	47.125855 ft	-280.85335 psf	519.17118 psf	451.30862 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 31	191 ft	48.945517 ft	-394.40027 psf	180.00933 psf	156.47973 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 32	192.12139 ft	49.774123 ft	-446.10525 psf	17.904753 psf	15.564365 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel

5.1 Static (Spencer) Section Ha-Ha' - Final Condition - Global Stability

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File Informa on

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Project Se ngs

Unit System: U.S. Customary Units

Analysis Se ngs

5.1 Sta c (Spencer)

Kind: SLOPE/W
Parent: 5. Global Stability
Analysis Type: Spencer
Se ngs
PWP Condi ons from: Piezometric Line
Apply Phrea c Correc on: No
Use Staged Rapid Drawdown: No
Unit Weight of Water: 62.4 pcf
Slip Surface
Direc on of movement: Le. to Right
Use Passive Mode: No
Slip Surface Op□on: Entry and Exit
Cri□cal slip surfaces saved: 1
Op□mize Cri□cal Slip Surface Loca□on: No
Tension Crack Op□on: (none)
Distribu□on
F of S Calcula□on Op□on: Constant
Advanced
Geometry Se□ ngs
Minimum Slip Surface Depth: 2 ft
Number of Slices: 30
Factor of Safety Convergence Se□ ngs
Maximum Number of Itera□ons: 100
Tolerable difference in F of S: 0.001
Solu□on Se□ ngs
Search Method: Root Finder

Tolerable difference between star□ng and converged F of S: 3
Maximum itera□ons to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Hilfiker Wall

Slope Stability Material Model: High Strength
Unit Weight: 130 pcf
Pore Water Pressure
Piezometric Line: 1

ESU 2A - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 39 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2B - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 41 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 7A - Weathered Sandstone

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 43 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2C - Na ve Silt

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 29 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1A - Exis ng Granular Fill

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf

Effec□ve Fric□on Angle: 40 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1B - Exis ng Gravelly Granular Fill

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Common Borrow

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Reinforcements

EL47_W9.5xW4 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 12.4 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,680 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,680 lbf/ft

EL49_W9.5xW4 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 12.4 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,680 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,680 lbf/ft

EL51_W9.5xW4 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 12.4 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,680 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,680 lbf/ft

EL53_W9.5xW4 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 12.4 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,680 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,680 lbf/ft

EL55_W9.5xW4 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 12.4 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,680 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,680 lbf/ft

EL57_W9.5xW4 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 12.4 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,680 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,680 lbf/ft

EL59_W7.0xW3.5 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf

Interface Shear Angle: 10.4 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,936 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,936 lbf/ft

EL61_W7.0xW3.5 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 10.4 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,936 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,936 lbf/ft

EL63_W7.0xW3.5 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 10.4 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,936 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,936 lbf/ft

EL65_W7.0xW3.5 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 10.4 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,936 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,936 lbf/ft

EL67_W7.0xW3.5 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 10.4 °
Surface Area Factor: 2

Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,936 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,936 lbf/ft

EL69_W7.0xW3.5 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 10.4 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,936 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,936 lbf/ft

EL71_W7.0xW3.5 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 20.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,936 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,936 lbf/ft

EL73_W7.0xW3.5 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 20.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,936 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,936 lbf/ft

EL75_W7.0xW3.5 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 15.4 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 2,236 lbf

Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 2,236 lbf/ft

EL77_W4.5xW3.5 (75 yrs)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 15.4 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 2,236 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 2,236 lbf/ft

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (0.05, 60) ft
Left-Zone Right Coordinate: (120, 90) ft
Left-Zone Increment: 40
Right Type: Range
Right-Zone Left Coordinate: (160, 78) ft
Right-Zone Right Coordinate: (335, 48) ft
Right-Zone Increment: 40
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 60) ft
Right Coordinate: (335, 48) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	0.25 ft	43.375 ft
Coordinate 2	56.5 ft	43.375 ft
Coordinate 3	97.75 ft	43.375 ft
Coordinate 4	123 ft	43.375 ft
Coordinate 5	159.75 ft	42.625 ft
Coordinate 6	192 ft	42.625 ft
Coordinate 7	210.75 ft	42.625 ft
Coordinate 8	298 ft	35 ft

Coordinate 9	335.25 ft	35 ft

Reinforcement Lines

Reinforcement Line 1

Reinforcement: EL47_W9.5xW4 (75 yrs)
Lock to Ground Surface: No
Outside Point: (160, 47) ft
Inside Point: (128, 47) ft
Length: 32 ft
Orienta□on: 180 °
Slip Surface Intersec□on: (128.52717, 47) ft
Max. Pullout Force: 5,680 lbf
Available Length: 0.52716903 ft
Required Length: 0.52716903 ft
Pullout Force: 1,305.7211 lbf
Pullout Force per Length: 2,476.8548 lbf/ft
Governing Component: Pullout Resistance

Reinforcement Line 2

Reinforcement: EL49_W9.5xW4 (75 yrs)
Lock to Ground Surface: No
Outside Point: (160, 49) ft
Inside Point: (128, 49) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 3

Reinforcement: EL51_W9.5xW4 (75 yrs)
Lock to Ground Surface: No
Outside Point: (160, 51) ft
Inside Point: (128, 51) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 4

Reinforcement: EL53_W9.5xW4 (75 yrs)
Lock to Ground Surface: No
Outside Point: (160, 53) ft
Inside Point: (128, 53) ft

Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 5

Reinforcement: EL55_W9.5xW4 (75 yrs)
Lock to Ground Surface: No
Outside Point: (160, 55) ft
Inside Point: (128, 55) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 6

Reinforcement: EL57_W9.5xW4 (75 yrs)
Lock to Ground Surface: No
Outside Point: (160, 57) ft
Inside Point: (128, 57) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 7

Reinforcement: EL59_W7.0xW3.5 (75 yrs)
Lock to Ground Surface: No
Outside Point: (160, 59) ft
Inside Point: (128, 59) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 8

Reinforcement: EL61_W7.0xW3.5 (75 yrs)
Lock to Ground Surface: No

Outside Point: (160, 61) ft
Inside Point: (128, 61) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 9

Reinforcement: EL63_W7.0xW3.5 (75 yrs)
Lock to Ground Surface: No
Outside Point: (160, 63) ft
Inside Point: (128, 63) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 10

Reinforcement: EL65_W7.0xW3.5 (75 yrs)
Lock to Ground Surface: No
Outside Point: (160, 65) ft
Inside Point: (128, 65) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 11

Reinforcement: EL67_W7.0xW3.5 (75 yrs)
Lock to Ground Surface: Yes
Outside Point: (160, 67) ft
Inside Point: (128, 67) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 12

Reinforcement: EL69_W7.0xW3.5 (75 yrs)
Lock to Ground Surface: Yes
Outside Point: (160, 69) ft
Inside Point: (128, 69) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 13

Reinforcement: EL71_W7.0xW3.5 (75 yrs)
Lock to Ground Surface: Yes
Outside Point: (160, 71) ft
Inside Point: (128, 71) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 14

Reinforcement: EL73_W7.0xW3.5 (75 yrs)
Lock to Ground Surface: Yes
Outside Point: (160, 73) ft
Inside Point: (128, 73) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 15

Reinforcement: EL75_W7.0xW3.5 (75 yrs)
Lock to Ground Surface: Yes
Outside Point: (160, 75) ft
Inside Point: (128, 75) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 16

Reinforcement: EL77_W4.5xW3.5 (75 yrs)
Lock to Ground Surface: Yes
Outside Point: (160, 77) ft
Inside Point: (128, 77) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 250 pcf
Direc□on: Ver□cal

Coordinates

	X	Y
	120 ft	91 ft
	160 ft	91 ft

Geometry

Name: Ga-Ga'

Se ngs

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	0 ft	56 ft
Point 2	76 ft	56 ft
Point 3	118 ft	35 ft
Point 4	160 ft	35 ft
Point 5	0 ft	46 ft
Point 6	37 ft	46 ft
Point 7	190 ft	50 ft
Point 8	160 ft	50 ft
Point 9	170.25 ft	34 ft
Point 10	240 ft	34 ft
Point 11	315 ft	30 ft
Point 12	335 ft	30 ft
Point 13	335 ft	48 ft
Point 14	327 ft	48 ft

Point 15	315 ft	49 ft
Point 16	224 ft	48 ft
Point 17	0 ft	0 ft
Point 18	335 ft	0 ft
Point 19	160 ft	90 ft
Point 20	120 ft	90 ft
Point 21	120 ft	72 ft
Point 22	80 ft	72 ft
Point 23	56 ft	60 ft
Point 24	0 ft	60 ft
Point 25	160 ft	47 ft
Point 26	120 ft	47 ft
Point 27	70 ft	67 ft
Point 28	160 ft	78 ft
Point 29	93.5 ft	78 ft
Point 30	120 ft	78 ft
Point 31	160 ft	72 ft
Point 32	128 ft	90 ft
Point 33	128 ft	47 ft
Point 34	128 ft	78 ft
Point 35	128 ft	72 ft

Regions

	Material	Points	Area
Region 1	ESU 2C - Na□ve Silt	5,6,2,1	565 ft²
Region 2	Common Borrow	20,29,30	159 ft²
Region 3	ESU 2A - Na□ve Sand and Gravel	6,2,3	619.5 ft²
Region 4	ESU 2B - Na□ve Sand and Gravel	7,16,15,14,13,12,11,10,9,4	2,595.4 ft²
Region 5	ESU 7A - Weathered Sandstone	18,17,5,6,3,4,9,10,11,12	12,178 ft²
Region 6	ESU 1B - Exis□ng Gravelly Granular Fill	8,7,25	45 ft²
Region 7	ESU 2A - Na□ve Sand and Gravel	4,7,25,33,26,2,3	945 ft²
Region 8	ESU 1B - Exis□ng Gravelly Granular Fill	23,24,1,2,26,21,22,27	1,302 ft²
Region 9	ESU 1B - Exis□ng Gravelly Granular Fill	26,33,35,21	200 ft²
Region 10	Hilfiker Wall	19,32,34,28	384 ft²
Region 11	ESU 1A - Exis□ng Granular Fill	22,21,30,29	199.5 ft²
Region 12	ESU 1A - Exis□ng Granular Fill	28,34,35,31	192 ft²
Region 13	Common Borrow	20,30,34,32	96 ft²
Region 14	ESU 1A - Exis□ng Granular Fill	30,21,35,34	48 ft²
Region 15	ESU 1B - Exis□ng Gravelly Granular Fill	25,8,31,35,33	800 ft²

Slip Results

Slip Surfaces Analysed: 5754 of 8405 converged

Current Slip Surface

Slip Surface: 7,044
Factor of Safety: 2.479
Volume: 2,697.7124 ft³

Weight: 336,407.22 lbf
Resis□ng Moment: 17,729,638 lbf·ft
Ac□va□ng Moment: 7,152,789 lbf·ft
Resis□ng Force: 244,290.14 lbf
Ac□va□ng Force: 98,528.174 lbf
Slip Rank: 1 of 8,405 slip surfaces
Exit: (203.06447, 49.231502) ft
Entry: (102.69463, 82.163606) ft
Radius: 64.156243 ft
Center: (164.23347, 100.30182) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Fric□onal Strength	Cohesive Strength	Suc□on Strength	Base Material
Slice 1	103.38643 ft	80.081803 ft	-2,290.5045 psf	114.09721 psf	71.295849 psf	0 psf	0 psf	Common Borrow
Slice 2	105.3677 ft	75 ft	-1,973.4 psf	429.38304 psf	360.29515 psf	0 psf	0 psf	ESU 1A - Exis□ng Granular Fill
Slice 3	108.32502 ft	69.019202 ft	-1,600.1982 psf	962.0965 psf	751.67216 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 4	111.66073 ft	63.646304 ft	-1,264.9294 psf	1,559.8908 psf	1,218.7202 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 5	114.99644 ft	59.253624 ft	-990.82611 psf	2,143.294 psf	1,674.5248 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 6	118.33215 ft	55.54263 ft	-759.26012 psf	2,712.9247 psf	2,119.5691 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 7	121.5 ft	52.491498 ft	-568.86945 psf	3,360.3105 psf	2,625.3623 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 8	125.5 ft	49.253863 ft	-370.0247 psf	3,854.9646 psf	3,011.8284 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 9	128.26358 ft	47.178473 ft	-244.03976 psf	4,333.5579 psf	3,385.7465 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly

								Granular Fill
Slice 10	130.17741 ft	45.965682 ft	-170.79876 psf	4,493.3499 psf	3,638.643 psf	0 psf	0 psf	ESU 2A - Naïve Sand and Gravel
Slice 11	133.47791 ft	44.029425 ft	-54.179421 psf	4,856.6813 psf	3,932.863 psf	0 psf	0 psf	ESU 2A - Naïve Sand and Gravel
Slice 12	136.88685 ft	42.29832 ft	49.500366 psf	5,217.4557 psf	4,184.9277 psf	0 psf	0 psf	ESU 2A - Naïve Sand and Gravel
Slice 13	140.40426 ft	40.765241 ft	140.68518 psf	5,574.72 psf	4,400.3947 psf	0 psf	0 psf	ESU 2A - Naïve Sand and Gravel
Slice 14	143.92167 ft	39.474057 ft	216.77575 psf	5,914.019 psf	4,613.5366 psf	0 psf	0 psf	ESU 2A - Naïve Sand and Gravel
Slice 15	147.43908 ft	38.409563 ft	278.72087 psf	6,237.428 psf	4,825.2659 psf	0 psf	0 psf	ESU 2A - Naïve Sand and Gravel
Slice 16	150.95648 ft	37.560175 ft	327.24336 psf	6,546.8409 psf	5,036.5308 psf	0 psf	0 psf	ESU 2A - Naïve Sand and Gravel
Slice 17	154.47389 ft	36.917215 ft	362.88477 psf	6,844.0717 psf	5,248.3617 psf	0 psf	0 psf	ESU 2A - Naïve Sand and Gravel
Slice 18	157.9913 ft	36.474423 ft	386.03566 psf	7,130.9497 psf	5,461.9237 psf	0 psf	0 psf	ESU 2A - Naïve Sand and Gravel
Slice 19	159.875 ft	36.293914 ft	395.05975 psf	7,413.2539 psf	5,683.2216 psf	0 psf	0 psf	ESU 2A - Naïve Sand and Gravel
Slice 20	161.17332 ft	36.229364 ft	399.0877 psf	1,745.0421 psf	1,089.9324 psf	0 psf	0 psf	ESU 2A - Naïve Sand and Gravel
Slice 21	163.95957 ft	36.166437 ft	403.01435 psf	1,819.1665 psf	1,231.0423 psf	0 psf	0 psf	ESU 2B - Naïve Sand and Gravel
Slice 22	167.18541 ft	36.233864 ft	398.80689 psf	1,892.9722 psf	1,298.8581 psf	0 psf	0 psf	ESU 2B - Naïve Sand and Gravel
Slice 23	170.41124 ft	36.464267 ft	384.42975 psf	1,948.4156 psf	1,359.5522 psf	0 psf	0 psf	ESU 2B - Naïve Sand and Gravel
Slice 24	173.63708 ft	36.859426 ft	359.77183 psf	1,984.3247 psf	1,412.2023 psf	0 psf	0 psf	ESU 2B - Naïve Sand and Gravel
Slice 25	177.09375 ft	37.475908 ft	321.30337 psf	1,998.3722 psf	1,457.8537 psf	0 psf	0 psf	ESU 2B - Naïve Sand and Gravel
Slice 26	180.78125 ft	38.345763 ft	267.02438 psf	1,984.9973 psf	1,493.411 psf	0 psf	0 psf	ESU 2B - Naïve Sand and Gravel
Slice	184.46875	39.451331	198.03695	1,937.3188	1,511.9347	0 psf	0 psf	ESU 2B -

27	ft	ft	psf	psf	psf			Naïve Sand and Gravel
Slice 28	188.15625 ft	40.805808 ft	113.51759 psf	1,849.6433 psf	1,509.191 psf	0 psf	0 psf	ESU 2B - Naïve Sand and Gravel
Slice 29	191 ft	42.006315 ft	38.605959 psf	1,729.6633 psf	1,470.0137 psf	0 psf	0 psf	ESU 2B - Naïve Sand and Gravel
Slice 30	192.16494 ft	42.545234 ft	4.9774186 psf	1,651.5071 psf	1,431.3064 psf	0 psf	0 psf	ESU 2B - Naïve Sand and Gravel
Slice 31	194.11898 ft	43.567428 ft	-58.807535 psf	1,463.4725 psf	1,272.1772 psf	0 psf	0 psf	ESU 2B - Naïve Sand and Gravel
Slice 32	197.69717 ft	45.604422 ft	-185.91592 psf	1,028.3422 psf	893.92426 psf	0 psf	0 psf	ESU 2B - Naïve Sand and Gravel
Slice 33	201.27537 ft	47.965244 ft	-333.23124 psf	404.74403 psf	351.83862 psf	0 psf	0 psf	ESU 2B - Naïve Sand and Gravel

5.2 Static (M-P) Section Ha-Ha' - Final Condition - Global Stability

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File Informa on

File Version: 11.01
Created By: Mikayla S. Hatch
Last Edited By: Mikayla S. Hatch
Revision Number: 321
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Time: 02:50:16 PM
Tool Version: 11.1
File Name: Wall 03.63L - Bridge 17.7 Ha-Ha' - All Condi ons.gsz
Directory: P:\0\0180366\01\Analysis\Bridge 17.7\SlopeW\
Last Solved Date: 11/15/2021
Last Solved Time: 02:50:50 PM

Project Se ngs

Unit System: U.S. Customary Units

Analysis Se ngs

5.2 Sta c (M-P)

Kind: SLOPE/W
Parent: 5. Global Stability
Analysis Type: Morgenstern-Price
Se ngs
Side Func on
Interslice force func on op on: Half-Sine
PWP Condi ons from: Piezometric Line
Apply Phrea c Correc on: No
Use Staged Rapid Drawdown: No
Unit Weight of Water: 62.4 pcf
Slip Surface
Direc on of movement: Le. to Right
Use Passive Mode: No
Slip Surface Op on: Entry and Exit
Cri cal slip surfaces saved: 1
Op mize Cri cal Slip Surface Loca on: No
Tension Crack Op on: (none)
Distribu on
F of S Calcula on Op on: Constant
Advanced
Geometry Se ngs
Minimum Slip Surface Depth: 2 ft
Number of Slices: 30
Factor of Safety Convergence Se ngs
Maximum Number of Itera ons: 100
Tolerable difference in F of S: 0.001

Solu□on Se□ ngs
Search Method: Root Finder
Tolerable difference between star□ng and converged F of S: 3
Maximum itera□ons to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Hilfiker Wall

Slope Stability Material Model: High Strength
Unit Weight: 130 pcf
Pore Water Pressure
Piezometric Line: 1

ESU 2A - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 39 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2B - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 41 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 7A - Weathered Sandstone

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 43 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2C - Na ve Silt

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 29 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1A - Exis ng Granular Fill

Slope Stability Material Model: Mohr-Coulomb

Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 40 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1B - Exis ng Gravelly Granular Fill

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Common Borrow

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Reinforcements

EL47_W9.5xW4 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 12.4 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,680 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,680 lbf/ft

EL49_W9.5xW4 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 12.4 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,680 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,680 lbf/ft

EL51_W9.5xW4 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 12.4 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,680 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,680 lbf/ft

EL53_W9.5xW4 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 12.4 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,680 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,680 lbf/ft

EL55_W9.5xW4 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 12.4 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,680 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,680 lbf/ft

EL57_W9.5xW4 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 12.4 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,680 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,680 lbf/ft

EL59_W7.0xW3.5 (75 yrs)

Type: Geosynthe□c

Interface Adhesion: 0 psf
Interface Shear Angle: 10.4 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,936 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,936 lbf/ft

EL61_W7.0xW3.5 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 10.4 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,936 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,936 lbf/ft

EL63_W7.0xW3.5 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 10.4 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,936 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,936 lbf/ft

EL65_W7.0xW3.5 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 10.4 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,936 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,936 lbf/ft

EL67_W7.0xW3.5 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 10.4 °

Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,936 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,936 lbf/ft

EL69_W7.0xW3.5 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 10.4 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,936 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,936 lbf/ft

EL71_W7.0xW3.5 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 20.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,936 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,936 lbf/ft

EL73_W7.0xW3.5 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 20.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,936 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,936 lbf/ft

EL75_W7.0xW3.5 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 15.4 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1

Tensile Capacity: 2,236 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 2,236 lbf/ft

EL77_W4.5xW3.5 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 15.4 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 2,236 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 2,236 lbf/ft

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (0.05, 60) ft
Left-Zone Right Coordinate: (120, 90) ft
Left-Zone Increment: 40
Right Type: Range
Right-Zone Left Coordinate: (160, 78) ft
Right-Zone Right Coordinate: (335, 48) ft
Right-Zone Increment: 40
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 60) ft
Right Coordinate: (335, 48) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	0.25 ft	43.375 ft
Coordinate 2	56.5 ft	43.375 ft
Coordinate 3	97.75 ft	43.375 ft
Coordinate 4	123 ft	43.375 ft
Coordinate 5	159.75 ft	42.625 ft
Coordinate 6	192 ft	42.625 ft
Coordinate 7	210.75 ft	42.625 ft

Coordinate 8	298 ft	35 ft
Coordinate 9	335.25 ft	35 ft

Reinforcement Lines

Reinforcement Line 1

Reinforcement: EL47_W9.5xW4 (75 yrs)
Lock to Ground Surface: No
Outside Point: (160, 47) ft
Inside Point: (128, 47) ft
Length: 32 ft
Orienta□on: 180 °
Slip Surface Intersec□on: (128.52717, 47) ft
Max. Pullout Force: 5,680 lbf
Available Length: 0.52716903 ft
Required Length: 0.52716903 ft
Pullout Force: 1,305.7211 lbf
Pullout Force per Length: 2,476.8548 lbf/ft
Governing Component: Pullout Resistance

Reinforcement Line 2

Reinforcement: EL49_W9.5xW4 (75 yrs)
Lock to Ground Surface: No
Outside Point: (160, 49) ft
Inside Point: (128, 49) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 3

Reinforcement: EL51_W9.5xW4 (75 yrs)
Lock to Ground Surface: No
Outside Point: (160, 51) ft
Inside Point: (128, 51) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 4

Reinforcement: EL53_W9.5xW4 (75 yrs)
Lock to Ground Surface: No
Outside Point: (160, 53) ft

Inside Point: (128, 53) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 5

Reinforcement: EL55_W9.5xW4 (75 yrs)
Lock to Ground Surface: No
Outside Point: (160, 55) ft
Inside Point: (128, 55) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 6

Reinforcement: EL57_W9.5xW4 (75 yrs)
Lock to Ground Surface: No
Outside Point: (160, 57) ft
Inside Point: (128, 57) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 7

Reinforcement: EL59_W7.0xW3.5 (75 yrs)
Lock to Ground Surface: No
Outside Point: (160, 59) ft
Inside Point: (128, 59) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 8

Reinforcement: EL61_W7.0xW3.5 (75 yrs)

Lock to Ground Surface: No
Outside Point: (160, 61) ft
Inside Point: (128, 61) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 9

Reinforcement: EL63_W7.0xW3.5 (75 yrs)
Lock to Ground Surface: No
Outside Point: (160, 63) ft
Inside Point: (128, 63) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 10

Reinforcement: EL65_W7.0xW3.5 (75 yrs)
Lock to Ground Surface: No
Outside Point: (160, 65) ft
Inside Point: (128, 65) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 11

Reinforcement: EL67_W7.0xW3.5 (75 yrs)
Lock to Ground Surface: Yes
Outside Point: (160, 67) ft
Inside Point: (128, 67) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 12

Reinforcement: EL69_W7.0xW3.5 (75 yrs)
Lock to Ground Surface: Yes
Outside Point: (160, 69) ft
Inside Point: (128, 69) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 13

Reinforcement: EL71_W7.0xW3.5 (75 yrs)
Lock to Ground Surface: Yes
Outside Point: (160, 71) ft
Inside Point: (128, 71) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 14

Reinforcement: EL73_W7.0xW3.5 (75 yrs)
Lock to Ground Surface: Yes
Outside Point: (160, 73) ft
Inside Point: (128, 73) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 15

Reinforcement: EL75_W7.0xW3.5 (75 yrs)
Lock to Ground Surface: Yes
Outside Point: (160, 75) ft
Inside Point: (128, 75) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft

Governing Component: (none)

Reinforcement Line 16

Reinforcement: EL77_W4.5xW3.5 (75 yrs)
Lock to Ground Surface: Yes
Outside Point: (160, 77) ft
Inside Point: (128, 77) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 250 pcf
Direc□on: Ver□cal

Coordinates

	X	Y
	120 ft	91 ft
	160 ft	91 ft

Geometry

Name: Ga-Ga'

Se ngs

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	0 ft	56 ft
Point 2	76 ft	56 ft
Point 3	118 ft	35 ft
Point 4	160 ft	35 ft
Point 5	0 ft	46 ft
Point 6	37 ft	46 ft
Point 7	190 ft	50 ft
Point 8	160 ft	50 ft
Point 9	170.25 ft	34 ft
Point 10	240 ft	34 ft
Point 11	315 ft	30 ft
Point 12	335 ft	30 ft
Point 13	335 ft	48 ft

Point 14	327 ft	48 ft
Point 15	315 ft	49 ft
Point 16	224 ft	48 ft
Point 17	0 ft	0 ft
Point 18	335 ft	0 ft
Point 19	160 ft	90 ft
Point 20	120 ft	90 ft
Point 21	120 ft	72 ft
Point 22	80 ft	72 ft
Point 23	56 ft	60 ft
Point 24	0 ft	60 ft
Point 25	160 ft	47 ft
Point 26	120 ft	47 ft
Point 27	70 ft	67 ft
Point 28	160 ft	78 ft
Point 29	93.5 ft	78 ft
Point 30	120 ft	78 ft
Point 31	160 ft	72 ft
Point 32	128 ft	90 ft
Point 33	128 ft	47 ft
Point 34	128 ft	78 ft
Point 35	128 ft	72 ft

Regions

	Material	Points	Area
Region 1	ESU 2C - Na□ve Silt	5,6,2,1	565 ft²
Region 2	Common Borrow	20,29,30	159 ft²
Region 3	ESU 2A - Na□ve Sand and Gravel	6,2,3	619.5 ft²
Region 4	ESU 2B - Na□ve Sand and Gravel	7,16,15,14,13,12,11,10,9,4	2,595.4 ft²
Region 5	ESU 7A - Weathered Sandstone	18,17,5,6,3,4,9,10,11,12	12,178 ft²
Region 6	ESU 1B - Exis□ng Gravelly Granular Fill	8,7,25	45 ft²
Region 7	ESU 2A - Na□ve Sand and Gravel	4,7,25,33,26,2,3	945 ft²
Region 8	ESU 1B - Exis□ng Gravelly Granular Fill	23,24,1,2,26,21,22,27	1,302 ft²
Region 9	ESU 1B - Exis□ng Gravelly Granular Fill	26,33,35,21	200 ft²
Region 10	Hilfiker Wall	19,32,34,28	384 ft²
Region 11	ESU 1A - Exis□ng Granular Fill	22,21,30,29	199.5 ft²
Region 12	ESU 1A - Exis□ng Granular Fill	28,34,35,31	192 ft²
Region 13	Common Borrow	20,30,34,32	96 ft²
Region 14	ESU 1A - Exis□ng Granular Fill	30,21,35,34	48 ft²
Region 15	ESU 1B - Exis□ng Gravelly Granular Fill	25,8,31,35,33	800 ft²

Slip Results

Slip Surfaces Analysed: 6354 of 8405 converged

Current Slip Surface

Slip Surface: 7,044

Factor of Safety: 2.481

Volume: 2,697.7124 ft³
Weight: 336,407.22 lbf
Resis□ng Moment: 17,746,991 lbf·ft
Ac□va□ng Moment: 7,152,789 lbf·ft
Resis□ng Force: 244,478.88 lbf
Ac□va□ng Force: 98,508.856 lbf
Slip Rank: 1 of 8,405 slip surfaces
Exit: (203.06447, 49.231502) ft
Entry: (102.69463, 82.163606) ft
Radius: 64.156243 ft
Center: (164.23347, 100.30182) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Fric□onal Strength	Cohesive Strength	Suc□on Strength	Base Material
Slice 1	103.38643 ft	80.081803 ft	-2,290.5045 psf	159.46909 psf	99.647347 psf	0 psf	0 psf	Common Borrow
Slice 2	105.3677 ft	75 ft	-1,973.4 psf	531.27121 psf	445.78947 psf	0 psf	0 psf	ESU 1A - Exis□ng Granular Fill
Slice 3	108.32502 ft	69.019202 ft	-1,600.1982 psf	1,102.8659 psf	861.65324 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 4	111.66073 ft	63.646304 ft	-1,264.9294 psf	1,671.539 psf	1,305.9494 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 5	114.99644 ft	59.253624 ft	-990.82611 psf	2,188.9058 psf	1,710.1606 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 6	118.33215 ft	55.54263 ft	-759.26012 psf	2,677.795 psf	2,092.1228 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 7	121.5 ft	52.491498 ft	-568.86945 psf	3,250.5548 psf	2,539.6118 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 8	125.5 ft	49.253863 ft	-370.0247 psf	3,657.2364 psf	2,857.3462 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 9	128.26358 ft	47.178473 ft	-244.03976 psf	4,087.8318 psf	3,193.7643 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly

								Granular Fill
Slice 10	130.17741 ft	45.965682 ft	-170.79876 psf	4,231.3664 psf	3,426.493 psf	0 psf	0 psf	ESU 2A - Naïve Sand and Gravel
Slice 11	133.47791 ft	44.029425 ft	-54.179421 psf	4,580.9269 psf	3,709.5614 psf	0 psf	0 psf	ESU 2A - Naïve Sand and Gravel
Slice 12	136.88685 ft	42.29832 ft	49.500366 psf	4,953.8843 psf	3,971.4918 psf	0 psf	0 psf	ESU 2A - Naïve Sand and Gravel
Slice 13	140.40426 ft	40.765241 ft	140.68518 psf	5,350.2059 psf	4,218.5867 psf	0 psf	0 psf	ESU 2A - Naïve Sand and Gravel
Slice 14	143.92167 ft	39.474057 ft	216.77575 psf	5,753.9271 psf	4,483.8967 psf	0 psf	0 psf	ESU 2A - Naïve Sand and Gravel
Slice 15	147.43908 ft	38.409563 ft	278.72087 psf	6,162.9225 psf	4,764.9326 psf	0 psf	0 psf	ESU 2A - Naïve Sand and Gravel
Slice 16	150.95648 ft	37.560175 ft	327.24336 psf	6,572.2719 psf	5,057.1244 psf	0 psf	0 psf	ESU 2A - Naïve Sand and Gravel
Slice 17	154.47389 ft	36.917215 ft	362.88477 psf	6,974.0602 psf	5,353.6243 psf	0 psf	0 psf	ESU 2A - Naïve Sand and Gravel
Slice 18	157.9913 ft	36.474423 ft	386.03566 psf	7,357.264 psf	5,645.1894 psf	0 psf	0 psf	ESU 2A - Naïve Sand and Gravel
Slice 19	159.875 ft	36.293914 ft	395.05975 psf	7,726.6925 psf	5,937.0391 psf	0 psf	0 psf	ESU 2A - Naïve Sand and Gravel
Slice 20	161.17332 ft	36.229364 ft	399.0877 psf	1,905.34 psf	1,219.7391 psf	0 psf	0 psf	ESU 2A - Naïve Sand and Gravel
Slice 21	163.95957 ft	36.166437 ft	403.01435 psf	2,029.6888 psf	1,414.0465 psf	0 psf	0 psf	ESU 2B - Naïve Sand and Gravel
Slice 22	167.18541 ft	36.233864 ft	398.80689 psf	2,146.9671 psf	1,519.6525 psf	0 psf	0 psf	ESU 2B - Naïve Sand and Gravel
Slice 23	170.41124 ft	36.464267 ft	384.42975 psf	2,229.7751 psf	1,604.1342 psf	0 psf	0 psf	ESU 2B - Naïve Sand and Gravel
Slice 24	173.63708 ft	36.859426 ft	359.77183 psf	2,271.5904 psf	1,661.9185 psf	0 psf	0 psf	ESU 2B - Naïve Sand and Gravel
Slice 25	177.09375 ft	37.475908 ft	321.30337 psf	2,262.7763 psf	1,687.6967 psf	0 psf	0 psf	ESU 2B - Naïve Sand and Gravel
Slice 26	180.78125 ft	38.345763 ft	267.02438 psf	2,188.8942 psf	1,670.6559 psf	0 psf	0 psf	ESU 2B - Naïve Sand and Gravel
Slice	184.46875	39.451331	198.03695	2,043.2318	1,604.0034	0 psf	0 psf	ESU 2B -

27	ft	ft	psf	psf	psf			Na□ve Sand and Gravel
Slice 28	188.15625 ft	40.805808 ft	113.51759 psf	1,825.9416 psf	1,488.5874 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 29	191 ft	42.006315 ft	38.605959 psf	1,595.779 psf	1,353.6298 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 30	192.16494 ft	42.545234 ft	4.9774186 psf	1,475.3319 psf	1,278.1596 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 31	194.11898 ft	43.567428 ft	-58.807535 psf	1,237.375 psf	1,075.6337 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 32	197.69717 ft	45.604422 ft	-185.91592 psf	769.57689 psf	668.98299 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 33	201.27537 ft	47.965244 ft	-333.23124 psf	261.4623 psf	227.28571 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel

5.3 Pseudo-Static (Spencer) Section Ha-Ha' - Final Condition - Global Stability

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File Informa on

File Version: 11.01
Created By: Mikayla S. Hatch
Last Edited By: Mikayla S. Hatch
Revision Number: 321
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File Name: Wall 03.63L - Bridge 17.7 Ha-Ha' - All Condi ons.gsz
Directory: P:\0\0180366\01\Analysis\Bridge 17.7\SlopeW\
Last Solved Date: 11/15/2021
Last Solved Time: 02:50:30 PM

Project Se ngs

Unit System: U.S. Customary Units

Analysis Se ngs

5.3 Pseudo-Sta c (Spencer)

Kind: SLOPE/W
Parent: 5. Global Stability
Analysis Type: Spencer
Se ngs
PWP Condi ons from: Piezometric Line
Apply Phrea c Correc on: No
Use Staged Rapid Drawdown: No
Unit Weight of Water: 62.4 pcf
Slip Surface
Direc on of movement: Le. to Right
Use Passive Mode: No
Slip Surface Op on: Entry and Exit
Cri cal slip surfaces saved: 1
Op mize Cri cal Slip Surface Loca on: No
Tension Crack Op on: (none)
Distribu on
F of S Calcula on Op on: Constant
Advanced
Geometry Se ngs
Minimum Slip Surface Depth: 2 ft
Number of Slices: 30
Factor of Safety Convergence Se ngs
Maximum Number of Itera ons: 100
Tolerable difference in F of S: 0.001
Solu on Se ngs
Search Method: Root Finder

Tolerable difference between star□ng and converged F of S: 3
Maximum itera□ons to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Hilfiker Wall

Slope Stability Material Model: High Strength
Unit Weight: 130 pcf
Pore Water Pressure
Piezometric Line: 1

ESU 1A - Exis ng Granular Fill (Pseudo-Sta c)

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 50 psf
Effec□ve Fric□on Angle: 40 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2A - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 39 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2B - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 41 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 7A - Weathered Sandstone

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 43 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1B - Exis ng Gravelly Granular Fill

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effec□ve Cohesion: 0 psf

Effec□ve Fric□on Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2C - Na ve Silt (Pseudo-Sta c)

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effec□ve Cohesion: 200 psf
Effec□ve Fric□on Angle: 29 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Common Borrow

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Reinforcements

EQ_EL47_W9.5xW4 75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 16.3 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,427 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,427 lbf/ft

EQ_EL49_W9.5xW4 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 16.3 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,427 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,427 lbf/ft

EQ_EL51_W9.5xW4 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 16.3 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,427 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,427 lbf/ft

EQ_EL53_W9.5xW4 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 16.3 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,427 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,427 lbf/ft

EQ_EL55_W9.5xW4 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 16.3 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,427 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,427 lbf/ft

EQ_EL57_W9.5xW4 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 16.3 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,427 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,427 lbf/ft

EQ_EL59_W7.0xW3.5 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf

Interface Shear Angle: 13.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,147 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,147 lbf/ft

EQ_EL61_W7.0xW3.5 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 13.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,147 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,147 lbf/ft

EQ_EL63_W7.0xW3.5 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 13.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,147 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,147 lbf/ft

EQ_EL65_W7.0xW3.5 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 13.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,147 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,147 lbf/ft

EQ_EL67_W7.0xW3.5 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 13.7 °
Surface Area Factor: 2

Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,147 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,147 lbf/ft

EQ_EL69_W7.0xW3.5 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 13.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,147 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,147 lbf/ft

EQ_EL71_W7.0xW3.5 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 26 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,147 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,147 lbf/ft

EQ_EL73_W7.0xW3.5 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 26 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,147 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,147 lbf/ft

EQ_EL75_W7.0xW3.5 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 20.2 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 2,924 lbf

Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 2,924 lbf/ft

EQ_EL77_W4.5xW3.5 (75 yrs)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 20.2 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 2,924 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 2,924 lbf/ft

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (0.05, 60) ft
Left-Zone Right Coordinate: (120, 90) ft
Left-Zone Increment: 40
Right Type: Range
Right-Zone Left Coordinate: (160, 78) ft
Right-Zone Right Coordinate: (335, 48) ft
Right-Zone Increment: 40
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 60) ft
Right Coordinate: (335, 48) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	0.25 ft	43.375 ft
Coordinate 2	56.5 ft	43.375 ft
Coordinate 3	97.75 ft	43.375 ft
Coordinate 4	123 ft	43.375 ft
Coordinate 5	159.75 ft	42.625 ft
Coordinate 6	192 ft	42.625 ft
Coordinate 7	210.75 ft	42.625 ft
Coordinate 8	298 ft	35 ft

Figure D.4-405

Coordinate 9	335.25 ft	35 ft

Seismic Coefficients

Horz Seismic Coef.: 0.177

Reinforcement Lines

Reinforcement Line 1

Reinforcement: EQ_EL47_W9.5xW4 75 yrs)
Lock to Ground Surface: No
Outside Point: (160, 47) ft
Inside Point: (128, 47) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 2

Reinforcement: EQ_EL49_W9.5xW4 (75 yrs)
Lock to Ground Surface: No
Outside Point: (160, 49) ft
Inside Point: (128, 49) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 3

Reinforcement: EQ_EL51_W9.5xW4 (75 yrs)
Lock to Ground Surface: No
Outside Point: (160, 51) ft
Inside Point: (128, 51) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 4

Reinforcement: EQ_EL53_W9.5xW4 (75 yrs)

Lock to Ground Surface: No
Outside Point: (160, 53) ft
Inside Point: (128, 53) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 5

Reinforcement: EQ_EL55_W9.5xW4 (75 yrs)
Lock to Ground Surface: No
Outside Point: (160, 55) ft
Inside Point: (128, 55) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 6

Reinforcement: EQ_EL57_W9.5xW4 (75 yrs)
Lock to Ground Surface: No
Outside Point: (160, 57) ft
Inside Point: (128, 57) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 7

Reinforcement: EQ_EL59_W7.0xW3.5 (75 yrs)
Lock to Ground Surface: No
Outside Point: (160, 59) ft
Inside Point: (128, 59) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 8

Reinforcement: EQ_EL61_W7.0xW3.5 (75 yrs)
Lock to Ground Surface: No
Outside Point: (160, 61) ft
Inside Point: (128, 61) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 9

Reinforcement: EQ_EL63_W7.0xW3.5 (75 yrs)
Lock to Ground Surface: No
Outside Point: (160, 63) ft
Inside Point: (128, 63) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 10

Reinforcement: EQ_EL65_W7.0xW3.5 (75 yrs)
Lock to Ground Surface: No
Outside Point: (160, 65) ft
Inside Point: (128, 65) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 11

Reinforcement: EQ_EL67_W7.0xW3.5 (75 yrs)
Lock to Ground Surface: Yes
Outside Point: (160, 67) ft
Inside Point: (128, 67) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft

Governing Component: (none)

Reinforcement Line 12

Reinforcement: EQ_EL69_W7.0xW3.5 (75 yrs)
Lock to Ground Surface: Yes
Outside Point: (160, 69) ft
Inside Point: (128, 69) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 13

Reinforcement: EQ_EL71_W7.0xW3.5 (75 yrs)
Lock to Ground Surface: Yes
Outside Point: (160, 71) ft
Inside Point: (128, 71) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 14

Reinforcement: EQ_EL73_W7.0xW3.5 (75 yrs)
Lock to Ground Surface: Yes
Outside Point: (160, 73) ft
Inside Point: (128, 73) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 15

Reinforcement: EQ_EL75_W7.0xW3.5 (75 yrs)
Lock to Ground Surface: Yes
Outside Point: (160, 75) ft
Inside Point: (128, 75) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft

Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 16

Reinforcement: EQ_EL77_W4.5xW3.5 (75 yrs)
Lock to Ground Surface: Yes
Outside Point: (160, 77) ft
Inside Point: (128, 77) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 125 pcf
Direc□on: Ver□cal

Coordinates

	X	Y
	120 ft	91 ft
	160 ft	91 ft

Geometry

Name: Ga-Ga'

Se ngs

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	0 ft	56 ft
Point 2	76 ft	56 ft
Point 3	118 ft	35 ft
Point 4	160 ft	35 ft
Point 5	0 ft	46 ft
Point 6	37 ft	46 ft
Point 7	190 ft	50 ft
Point 8	160 ft	50 ft
Point 9	170.25 ft	34 ft
Point 10	240 ft	34 ft
Point 11	315 ft	30 ft

Figure D.4-410

Point 12	335 ft	30 ft
Point 13	335 ft	48 ft
Point 14	327 ft	48 ft
Point 15	315 ft	49 ft
Point 16	224 ft	48 ft
Point 17	0 ft	0 ft
Point 18	335 ft	0 ft
Point 19	160 ft	90 ft
Point 20	120 ft	90 ft
Point 21	120 ft	72 ft
Point 22	80 ft	72 ft
Point 23	56 ft	60 ft
Point 24	0 ft	60 ft
Point 25	160 ft	47 ft
Point 26	120 ft	47 ft
Point 27	70 ft	67 ft
Point 28	160 ft	78 ft
Point 29	93.5 ft	78 ft
Point 30	120 ft	78 ft
Point 31	160 ft	72 ft
Point 32	128 ft	90 ft
Point 33	128 ft	47 ft
Point 34	128 ft	78 ft
Point 35	128 ft	72 ft

Regions

	Material	Points	Area
Region 1	ESU 2C - Na□ve Silt (Pseudo-Sta□c)	5,6,2,1	565 ft²
Region 2	Common Borrow	20,29,30	159 ft²
Region 3	ESU 2A - Na□ve Sand and Gravel	6,2,3	619.5 ft²
Region 4	ESU 2B - Na□ve Sand and Gravel	7,16,15,14,13,12,11,10,9,4	2,595.4 ft²
Region 5	ESU 7A - Weathered Sandstone	18,17,5,6,3,4,9,10,11,12	12,178 ft²
Region 6	ESU 1B - Exis□ng Gravelly Granular Fill	8,7,25	45 ft²
Region 7	ESU 2A - Na□ve Sand and Gravel	4,7,25,33,26,2,3	945 ft²
Region 8	ESU 1B - Exis□ng Gravelly Granular Fill	23,24,1,2,26,21,22,27	1,302 ft²
Region 9	ESU 1B - Exis□ng Gravelly Granular Fill	26,33,35,21	200 ft²
Region 10	Hilfiker Wall	19,32,34,28	384 ft²
Region 11	ESU 1A - Exis□ng Granular Fill (Pseudo-Sta□c)	22,21,30,29	199.5 ft²
Region 12	ESU 1A - Exis□ng Granular Fill (Pseudo-Sta□c)	28,34,35,31	192 ft²
Region 13	Common Borrow	20,30,34,32	96 ft²
Region 14	ESU 1A - Exis□ng Granular Fill (Pseudo-Sta□c)	30,21,35,34	48 ft²
Region 15	ESU 1B - Exis□ng Gravelly Granular Fill	25,8,31,35,33	800 ft²

Slip Results

Slip Surfaces Analysed: 5750 of 8405 converged

Current Slip Surface

Figure D.4-411

Slip Surface: 6,448
Factor of Safety: 1.817
Volume: 3,153.6793 ft³
Weight: 395,844.66 lbf
Resis□ng Moment: 29,532,764 lbf·ft
Ac□va□ng Moment: 16,251,245 lbf·ft
Resis□ng Force: 280,231.98 lbf
Ac□va□ng Force: 154,170.63 lbf
Slip Rank: 1 of 8,405 slip surfaces
Exit: (223.34001, 48.038823) ft
Entry: (94.041944, 78.245408) ft
Radius: 96.854303 ft
Center: (174.73399, 131.81359) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Fric□onal Strength	Cohesive Strength	Suc□on Strength	Base Material
Slice 1	94.123671 ft	78.122704 ft	-2,168.2567 psf	8.6347508 psf	5.3955912 psf	0 psf	0 psf	Common Borrow
Slice 2	95.9777 ft	75.520481 ft	-2,005.878 psf	179.3141 psf	150.46239 psf	50 psf	0 psf	ESU 1A - Exis□ng Granular Fill (Pseudo-Sta□c)
Slice 3	98.152984 ft	72.520481 ft	-1,818.678 psf	412.62942 psf	346.23719 psf	50 psf	0 psf	ESU 1A - Exis□ng Granular Fill (Pseudo-Sta□c)
Slice 4	100.70037 ft	69.454148 ft	-1,627.3388 psf	708.96088 psf	553.90095 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 5	104.98918 ft	64.680468 ft	-1,329.4612 psf	1,205.7148 psf	942.00762 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 6	109.27798 ft	60.484795 ft	-1,067.6512 psf	1,716.7503 psf	1,341.2723 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 7	113.56679 ft	56.769092 ft	-835.79132 psf	2,239.3531 psf	1,749.5744 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 8	117.8556 ft	53.464481 ft	-629.58359 psf	2,772.0848 psf	2,165.79 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly

								Granular Fill
Slice 9	121.5 ft	50.920609 ft	-470.846 psf	3,270.4089 psf	2,555.1234 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 10	125.5 ft	48.456884 ft	-320.29327 psf	3,630.7864 psf	2,836.6812 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 11	129.95928 ft	45.958483 ft	-170.07177 psf	4,112.9441 psf	3,330.5964 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 12	133.87785 ft	44.024852 ft	-54.403392 psf	4,459.1282 psf	3,610.9308 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 13	137.82988 ft	42.291541 ft	48.722428 psf	4,804.5624 psf	3,851.2033 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 14	141.81535 ft	40.749711 ft	139.85725 psf	5,147.1369 psf	4,054.8151 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 15	145.80083 ft	39.405427 ft	218.66518 psf	5,484.8382 psf	4,264.4628 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 16	149.78631 ft	38.250155 ft	285.67877 psf	5,818.9846 psf	4,480.7827 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 17	153.77178 ft	37.276951 ft	341.33136 psf	6,150.9936 psf	4,704.5717 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 18	157.75726 ft	36.480226 ft	385.97157 psf	6,482.4345 psf	4,936.8184 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 19	159.875 ft	36.105958 ft	406.78825 psf	6,661.4154 psf	5,064.8972 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 20	160.84238 ft	35.964464 ft	415.61748 psf	1,621.7981 psf	976.74584 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 21	163.94563 ft	35.588895 ft	439.05294 psf	1,746.4674 psf	1,136.518 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 22	168.46738 ft	35.188785 ft	464.01983 psf	1,913.9312 psf	1,260.3887 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 23	172.98913 ft	35.001407 ft	475.71218 psf	2,067.9767 psf	1,384.1344 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 24	177.70833 ft	35.036213 ft	473.54029 psf	2,213.2623 psf	1,512.3173 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel

Slice 25	182.625 ft	35.312789 ft	456.28197 psf	2,348.5879 psf	1,644.9564 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 26	187.54167 ft	35.841882 ft	423.26659 psf	2,465.9592 psf	1,775.6856 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 27	191 ft	36.340325 ft	392.16372 psf	2,519.5555 psf	1,849.3134 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 28	194.34375 ft	36.995419 ft	351.28588 psf	2,495.8394 psf	1,864.2319 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 29	199.03125 ft	38.087728 ft	283.12578 psf	2,434.1096 psf	1,869.8217 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 30	203.71875 ft	39.430658 ft	199.32697 psf	2,323.7842 psf	1,846.7625 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 31	208.40625 ft	41.035364 ft	99.193293 psf	2,149.3119 psf	1,782.1409 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 32	211.47406 ft	42.201587 ft	22.472476 psf	1,999.4762 psf	1,718.5832 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 33	214.0551 ft	43.323607 ft	-61.616753 psf	1,766.3919 psf	1,535.5011 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 34	217.76906 ft	45.070051 ft	-190.84819 psf	1,265.9826 psf	1,100.5019 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 35	221.48303 ft	47.015078 ft	-332.47123 psf	511.3945 psf	444.54845 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel

5.4 Pseudo-Static (M-P) Section Ha-Ha' - Final Condition - Global Stability

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File Informa on

File Version: 11.01
Created By: Mikayla S. Hatch
Last Edited By: Mikayla S. Hatch
Revision Number: 321
Date: 11/15/2021
Time: 02:50:16 PM
Tool Version: 11.1
File Name: Wall 03.63L - Bridge 17.7 Ha-Ha' - All Condi ons.gsz
Directory: P:\0\0180366\01\Analysis\Bridge 17.7\SlopeW\
Last Solved Date: 11/15/2021
Last Solved Time: 02:51:00 PM

Project Se ngs

Unit System: U.S. Customary Units

Analysis Se ngs

5.4 Pseudo-Sta c (M-P)

Kind: SLOPE/W
Parent: 5. Global Stability
Analysis Type: Morgenstern-Price
Se ngs
- Side Func on
  - Interslice force func on op on: Half-Sine
- PWP Condi ons from: Piezometric Line
- Apply Phrea c Correc on: No
- Use Staged Rapid Drawdown: No
- Unit Weight of Water: 62.4 pcf

Slip Surface
- Direc on of movement: Le. to Right
- Use Passive Mode: No
- Slip Surface Op on: Entry and Exit
- Cri cal slip surfaces saved: 1
- Op mize Cri cal Slip Surface Loca on: No
- Tension Crack Op on: (none)

Distribu on
- F of S Calcula on Op on: Constant

Advanced
- Geometry Se ngs
  - Minimum Slip Surface Depth: 2 ft
  - Number of Slices: 30
- Factor of Safety Convergence Se ngs
  - Maximum Number of Itera ons: 100
  - Tolerable difference in F of S: 0.001

Solu□on Se□ ngs
Search Method: Root Finder
Tolerable difference between star□ng and converged F of S: 3
Maximum itera□ons to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Hilfiker Wall

Slope Stability Material Model: High Strength
Unit Weight: 130 pcf
Pore Water Pressure
Piezometric Line: 1

ESU 1A - Exis ng Granular Fill (Pseudo-Sta c)

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 50 psf
Effec□ve Fric□on Angle: 40 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2A - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 39 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2B - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 41 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 7A - Weathered Sandstone

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 43 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1B - Exis ng Gravelly Granular Fill

Slope Stability Material Model: Mohr-Coulomb

Unit Weight: 125 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2C - Na ve Silt (Pseudo-Sta c)

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effec□ve Cohesion: 200 psf
Effec□ve Fric□on Angle: 29 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Common Borrow

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Reinforcements

EQ_EL47_W9.5xW4 75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 16.3 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,427 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,427 lbf/ft

EQ_EL49_W9.5xW4 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 16.3 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,427 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,427 lbf/ft

EQ_EL51_W9.5xW4 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 16.3 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,427 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,427 lbf/ft

EQ_EL53_W9.5xW4 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 16.3 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,427 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,427 lbf/ft

EQ_EL55_W9.5xW4 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 16.3 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,427 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,427 lbf/ft

EQ_EL57_W9.5xW4 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 16.3 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,427 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,427 lbf/ft

EQ_EL59_W7.0xW3.5 (75 yrs)

Type: Geosynthe□c

Interface Adhesion: 0 psf
Interface Shear Angle: 13.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,147 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,147 lbf/ft

EQ_EL61_W7.0xW3.5 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 13.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,147 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,147 lbf/ft

EQ_EL63_W7.0xW3.5 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 13.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,147 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,147 lbf/ft

EQ_EL65_W7.0xW3.5 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 13.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,147 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,147 lbf/ft

EQ_EL67_W7.0xW3.5 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 13.7 °

Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,147 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,147 lbf/ft

EQ_EL69_W7.0xW3.5 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 13.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,147 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,147 lbf/ft

EQ_EL71_W7.0xW3.5 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 26 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,147 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,147 lbf/ft

EQ_EL73_W7.0xW3.5 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 26 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,147 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,147 lbf/ft

EQ_EL75_W7.0xW3.5 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 20.2 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1

Tensile Capacity: 2,924 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 2,924 lbf/ft

EQ_EL77_W4.5xW3.5 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 20.2 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 2,924 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 2,924 lbf/ft

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (0.05, 60) ft
Left-Zone Right Coordinate: (120, 90) ft
Left-Zone Increment: 40
Right Type: Range
Right-Zone Left Coordinate: (160, 78) ft
Right-Zone Right Coordinate: (335, 48) ft
Right-Zone Increment: 40
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 60) ft
Right Coordinate: (335, 48) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	0.25 ft	43.375 ft
Coordinate 2	56.5 ft	43.375 ft
Coordinate 3	97.75 ft	43.375 ft
Coordinate 4	123 ft	43.375 ft
Coordinate 5	159.75 ft	42.625 ft
Coordinate 6	192 ft	42.625 ft
Coordinate 7	210.75 ft	42.625 ft

Figure D.4-421

Coordinate 8	298 ft	35 ft
Coordinate 9	335.25 ft	35 ft

Seismic Coefficients

Horz Seismic Coef.: 0.177

Reinforcement Lines

Reinforcement Line 1

Reinforcement: EQ_EL47_W9.5xW4 75 yrs)
Lock to Ground Surface: No
Outside Point: (160, 47) ft
Inside Point: (128, 47) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 2

Reinforcement: EQ_EL49_W9.5xW4 (75 yrs)
Lock to Ground Surface: No
Outside Point: (160, 49) ft
Inside Point: (128, 49) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 3

Reinforcement: EQ_EL51_W9.5xW4 (75 yrs)
Lock to Ground Surface: No
Outside Point: (160, 51) ft
Inside Point: (128, 51) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 4

Reinforcement: EQ_EL53_W9.5xW4 (75 yrs)
Lock to Ground Surface: No
Outside Point: (160, 53) ft
Inside Point: (128, 53) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 5

Reinforcement: EQ_EL55_W9.5xW4 (75 yrs)
Lock to Ground Surface: No
Outside Point: (160, 55) ft
Inside Point: (128, 55) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 6

Reinforcement: EQ_EL57_W9.5xW4 (75 yrs)
Lock to Ground Surface: No
Outside Point: (160, 57) ft
Inside Point: (128, 57) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 7

Reinforcement: EQ_EL59_W7.0xW3.5 (75 yrs)
Lock to Ground Surface: No
Outside Point: (160, 59) ft
Inside Point: (128, 59) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 8

Reinforcement: EQ_EL61_W7.0xW3.5 (75 yrs)
Lock to Ground Surface: No
Outside Point: (160, 61) ft
Inside Point: (128, 61) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 9

Reinforcement: EQ_EL63_W7.0xW3.5 (75 yrs)
Lock to Ground Surface: No
Outside Point: (160, 63) ft
Inside Point: (128, 63) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 10

Reinforcement: EQ_EL65_W7.0xW3.5 (75 yrs)
Lock to Ground Surface: No
Outside Point: (160, 65) ft
Inside Point: (128, 65) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 11

Reinforcement: EQ_EL67_W7.0xW3.5 (75 yrs)
Lock to Ground Surface: Yes
Outside Point: (160, 67) ft
Inside Point: (128, 67) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft

Governing Component: (none)

Reinforcement Line 12

Reinforcement: EQ_EL69_W7.0xW3.5 (75 yrs)
Lock to Ground Surface: Yes
Outside Point: (160, 69) ft
Inside Point: (128, 69) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 13

Reinforcement: EQ_EL71_W7.0xW3.5 (75 yrs)
Lock to Ground Surface: Yes
Outside Point: (160, 71) ft
Inside Point: (128, 71) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 14

Reinforcement: EQ_EL73_W7.0xW3.5 (75 yrs)
Lock to Ground Surface: Yes
Outside Point: (160, 73) ft
Inside Point: (128, 73) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 15

Reinforcement: EQ_EL75_W7.0xW3.5 (75 yrs)
Lock to Ground Surface: Yes
Outside Point: (160, 75) ft
Inside Point: (128, 75) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft

Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 16

Reinforcement: EQ_EL77_W4.5xW3.5 (75 yrs)
Lock to Ground Surface: Yes
Outside Point: (160, 77) ft
Inside Point: (128, 77) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 125 pcf
Direc□on: Ver□cal

Coordinates

	X	Y
	120 ft	91 ft
	160 ft	91 ft

Geometry

Name: Ga-Ga'

Se ngs

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	0 ft	56 ft
Point 2	76 ft	56 ft
Point 3	118 ft	35 ft
Point 4	160 ft	35 ft
Point 5	0 ft	46 ft
Point 6	37 ft	46 ft
Point 7	190 ft	50 ft
Point 8	160 ft	50 ft
Point 9	170.25 ft	34 ft
Point 10	240 ft	34 ft
Point 11	315 ft	30 ft

Point 12	335 ft	30 ft
Point 13	335 ft	48 ft
Point 14	327 ft	48 ft
Point 15	315 ft	49 ft
Point 16	224 ft	48 ft
Point 17	0 ft	0 ft
Point 18	335 ft	0 ft
Point 19	160 ft	90 ft
Point 20	120 ft	90 ft
Point 21	120 ft	72 ft
Point 22	80 ft	72 ft
Point 23	56 ft	60 ft
Point 24	0 ft	60 ft
Point 25	160 ft	47 ft
Point 26	120 ft	47 ft
Point 27	70 ft	67 ft
Point 28	160 ft	78 ft
Point 29	93.5 ft	78 ft
Point 30	120 ft	78 ft
Point 31	160 ft	72 ft
Point 32	128 ft	90 ft
Point 33	128 ft	47 ft
Point 34	128 ft	78 ft
Point 35	128 ft	72 ft

Regions

	Material	Points	Area
Region 1	ESU 2C - Na□ve Silt (Pseudo-Sta□c)	5,6,2,1	565 ft²
Region 2	Common Borrow	20,29,30	159 ft²
Region 3	ESU 2A - Na□ve Sand and Gravel	6,2,3	619.5 ft²
Region 4	ESU 2B - Na□ve Sand and Gravel	7,16,15,14,13,12,11,10,9,4	2,595.4 ft²
Region 5	ESU 7A - Weathered Sandstone	18,17,5,6,3,4,9,10,11,12	12,178 ft²
Region 6	ESU 1B - Exis□ng Gravelly Granular Fill	8,7,25	45 ft²
Region 7	ESU 2A - Na□ve Sand and Gravel	4,7,25,33,26,2,3	945 ft²
Region 8	ESU 1B - Exis□ng Gravelly Granular Fill	23,24,1,2,26,21,22,27	1,302 ft²
Region 9	ESU 1B - Exis□ng Gravelly Granular Fill	26,33,35,21	200 ft²
Region 10	Hilfiker Wall	19,32,34,28	384 ft²
Region 11	ESU 1A - Exis□ng Granular Fill (Pseudo-Sta□c)	22,21,30,29	199.5 ft²
Region 12	ESU 1A - Exis□ng Granular Fill (Pseudo-Sta□c)	28,34,35,31	192 ft²
Region 13	Common Borrow	20,30,34,32	96 ft²
Region 14	ESU 1A - Exis□ng Granular Fill (Pseudo-Sta□c)	30,21,35,34	48 ft²
Region 15	ESU 1B - Exis□ng Gravelly Granular Fill	25,8,31,35,33	800 ft²

Slip Results

Slip Surfaces Analysed: 5887 of 8405 converged

Current Slip Surface

Figure D.4-427

Slip Surface: 6,448
Factor of Safety: 1.815
Volume: 3,153.6793 ft³
Weight: 395,844.66 lbf
Resis□ng Moment: 29,496,307 lbf·ft
Ac□va□ng Moment: 16,251,245 lbf·ft
Resis□ng Force: 280,475.04 lbf
Ac□va□ng Force: 154,526.8 lbf
Slip Rank: 1 of 8,405 slip surfaces
Exit: (223.34001, 48.038823) ft
Entry: (94.041944, 78.245408) ft
Radius: 96.854303 ft
Center: (174.73399, 131.81359) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Fric□onal Strength	Cohesive Strength	Suc□on Strength	Base Material
Slice 1	94.123671 ft	78.122704 ft	-2,168.2567 psf	12.606603 psf	7.87748 psf	0 psf	0 psf	Common Borrow
Slice 2	95.9777 ft	75.520481 ft	-2,005.878 psf	230.42073 psf	193.34595 psf	50 psf	0 psf	ESU 1A - Exis□ng Granular Fill (Pseudo-Sta□c)
Slice 3	98.152984 ft	72.520481 ft	-1,818.678 psf	516.43965 psf	433.34432 psf	50 psf	0 psf	ESU 1A - Exis□ng Granular Fill (Pseudo-Sta□c)
Slice 4	100.70037 ft	69.454148 ft	-1,627.3388 psf	857.74745 psf	670.14575 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 5	104.98918 ft	64.680468 ft	-1,329.4612 psf	1,353.7453 psf	1,057.6617 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 6	109.27798 ft	60.484795 ft	-1,067.6512 psf	1,814.2965 psf	1,417.4838 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 7	113.56679 ft	56.769092 ft	-835.79132 psf	2,255.7587 psf	1,762.3918 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 8	117.8556 ft	53.464481 ft	-629.58359 psf	2,692.0718 psf	2,103.277 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly

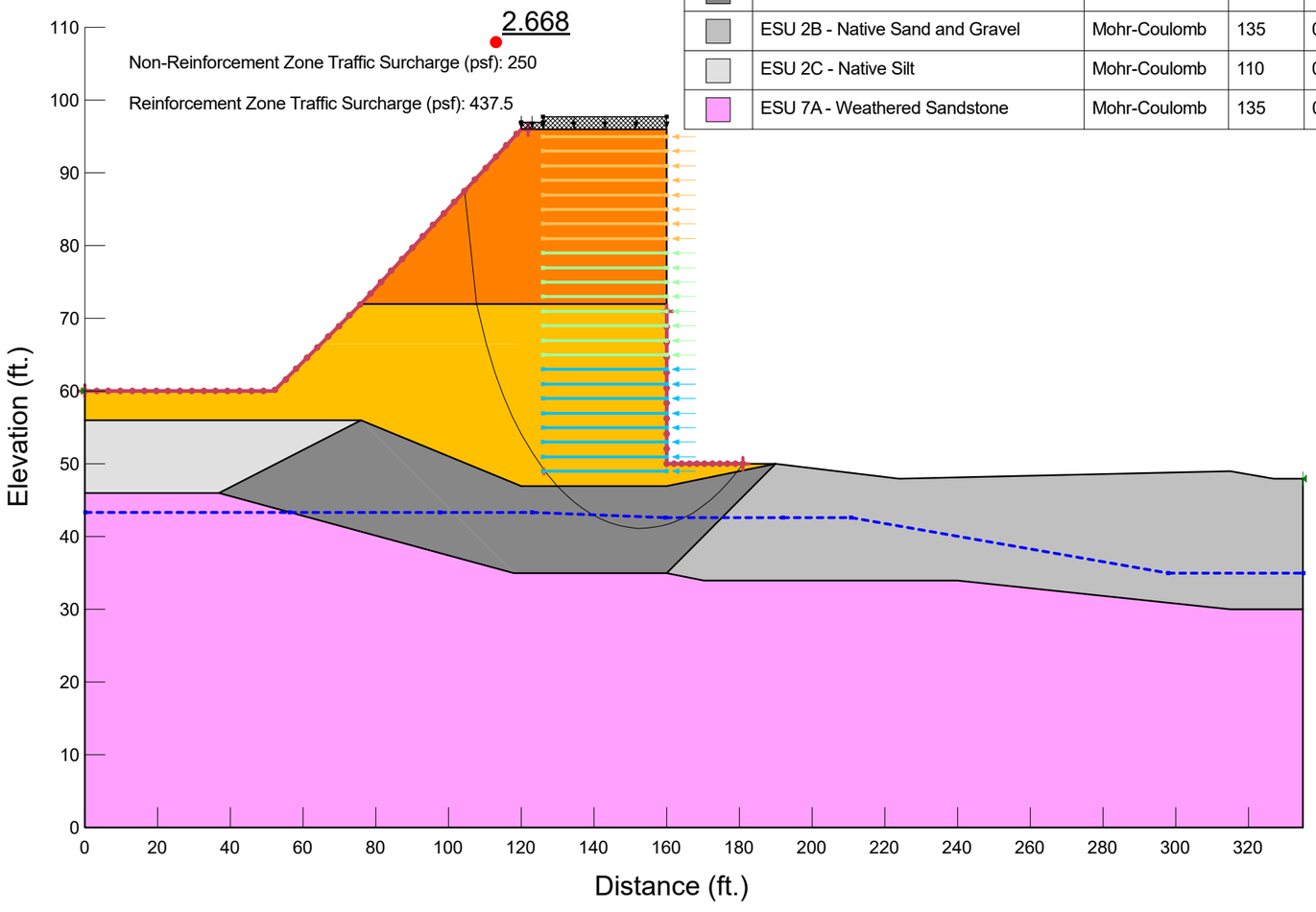
								Granular Fill
Slice 9	121.5 ft	50.920609 ft	-470.846 psf	3,105.4925 psf	2,426.2767 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 10	125.5 ft	48.456884 ft	-320.29327 psf	3,380.2437 psf	2,640.9359 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 11	129.95928 ft	45.958483 ft	-170.07177 psf	3,789.9065 psf	3,069.0057 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 12	133.87785 ft	44.024852 ft	-54.403392 psf	4,100.4184 psf	3,320.4534 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 13	137.82988 ft	42.291541 ft	48.722428 psf	4,437.5807 psf	3,554.0273 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 14	141.81535 ft	40.749711 ft	139.85725 psf	4,800.5968 psf	3,774.1925 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 15	145.80083 ft	39.405427 ft	218.66518 psf	5,190.167 psf	4,025.8428 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 16	149.78631 ft	38.250155 ft	285.67877 psf	5,607.7266 psf	4,309.7093 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 17	153.77178 ft	37.276951 ft	341.33136 psf	6,052.1467 psf	4,624.5271 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 18	157.75726 ft	36.480226 ft	385.97157 psf	6,519.0202 psf	4,966.4448 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 19	159.875 ft	36.105958 ft	406.78825 psf	6,776.5586 psf	5,158.1383 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 20	160.84238 ft	35.964464 ft	415.61748 psf	1,672.2524 psf	1,017.6029 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 21	163.94563 ft	35.588895 ft	439.05294 psf	1,893.2769 psf	1,264.1376 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 22	168.46738 ft	35.188785 ft	464.01983 psf	2,196.127 psf	1,505.6978 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 23	172.98913 ft	35.001407 ft	475.71218 psf	2,480.7097 psf	1,742.9177 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 24	177.70833 ft	35.036213 ft	473.54029 psf	2,737.7777 psf	1,968.2716 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel

Slice 25	182.625 ft	35.312789 ft	456.28197 psf	2,939.0515 psf	2,158.2387 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 26	187.54167 ft	35.841882 ft	423.26659 psf	3,044.3943 psf	2,278.5116 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 27	191 ft	36.340325 ft	392.16372 psf	3,034.8787 psf	2,297.2771 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 28	194.34375 ft	36.995419 ft	351.28588 psf	2,900.9931 psf	2,216.4267 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 29	199.03125 ft	38.087728 ft	283.12578 psf	2,622.6051 psf	2,033.6783 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 30	203.71875 ft	39.430658 ft	199.32697 psf	2,240.6567 psf	1,774.5009 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 31	208.40625 ft	41.035364 ft	99.193293 psf	1,778.6657 psf	1,459.9431 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 32	211.47406 ft	42.201587 ft	22.472476 psf	1,451.4964 psf	1,242.2315 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 33	214.0551 ft	43.323607 ft	-61.616753 psf	1,141.3344 psf	992.14687 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 34	217.76906 ft	45.070051 ft	-190.84819 psf	679.21162 psf	590.42965 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 35	221.48303 ft	47.015078 ft	-332.47123 psf	222.49867 psf	193.41515 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel

FLATIRON | LANE | wood.

In Association with

Appendix D.5
Pier 1/Wall 03.63L Compound Stability Analyses



Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	ESU 1A - Existing Granular Fill	Mohr-Coulomb	120	0	40
	ESU 1B - Existing Gravelly Granular Fill	Mohr-Coulomb	125	0	38
	ESU 2A - Native Sand and Gravel	Mohr-Coulomb	120	0	39
	ESU 2B - Native Sand and Gravel	Mohr-Coulomb	135	0	41
	ESU 2C - Native Silt	Mohr-Coulomb	110	0	29
	ESU 7A - Weathered Sandstone	Mohr-Coulomb	135	0	42

Color	Name	Type	Interface Adhesion	Interface Shear Angle	Factored Tensile Capacity
	EL49_W9.5xW4	Geosynthetic	0	14.1	7,441 lbf/ft
	EL51_W9.5xW4	Geosynthetic	0	14.1	7,441 lbf/ft
	EL53_W9.5xW4	Geosynthetic	0	14.1	7,441 lbf/ft
	EL55_W9.5xW4	Geosynthetic	0	14.1	7,441 lbf/ft
	EL57_W9.5xW4	Geosynthetic	0	14.1	7,441 lbf/ft
	EL59_W9.5xW4	Geosynthetic	0	14.1	7,441 lbf/ft
	EL61_W9.5xW4.0	Geosynthetic	0	14.1	7,441 lbf/ft
	EL63_W9.5xW4.0	Geosynthetic	0	14.1	7,441 lbf/ft
	EL65_W7.0xW3.5	Geosynthetic	0	12.1	5,422 lbf/ft
	EL67_W7.0xW3.5	Geosynthetic	0	12.1	5,422 lbf/ft
	EL69_W7.0xW3.5	Geosynthetic	0	12.1	5,422 lbf/ft
	EL71_W7.0xW3.5	Geosynthetic	0	12.1	5,422 lbf/ft
	EL73_W7.0xW3.5	Geosynthetic	0	12.1	5,422 lbf/ft
	EL75_W7.0xW3.5	Geosynthetic	0	12.1	5,422 lbf/ft
	EL77_W7.0xW3.5	Geosynthetic	0	23.2	5,422 lbf/ft
	EL79_W4.5xW3.5	Geosynthetic	0	23.2	5,422 lbf/ft
	EL81_W4.5xW3.5	Geosynthetic	0	18.7	3,385 lbf/ft
	EL83_W4.5xW3.5	Geosynthetic	0	18.7	3,385 lbf/ft
	EL85_W4.5xW3.5	Geosynthetic	0	18.7	3,385 lbf/ft
	EL87_W4.5xW3.5	Geosynthetic	0	18.7	3,385 lbf/ft
	EL89_W4.5xW3.5	Geosynthetic	0	18.7	3,385 lbf/ft
	EL91_W4.5xW3.5	Geosynthetic	0	18.7	3,385 lbf/ft
	EL93_W4.5xW3.5	Geosynthetic	0	18.7	3,385 lbf/ft
	EL95_W4.5xW3.5	Geosynthetic	0	18.7	3,385 lbf/ft

Notes:

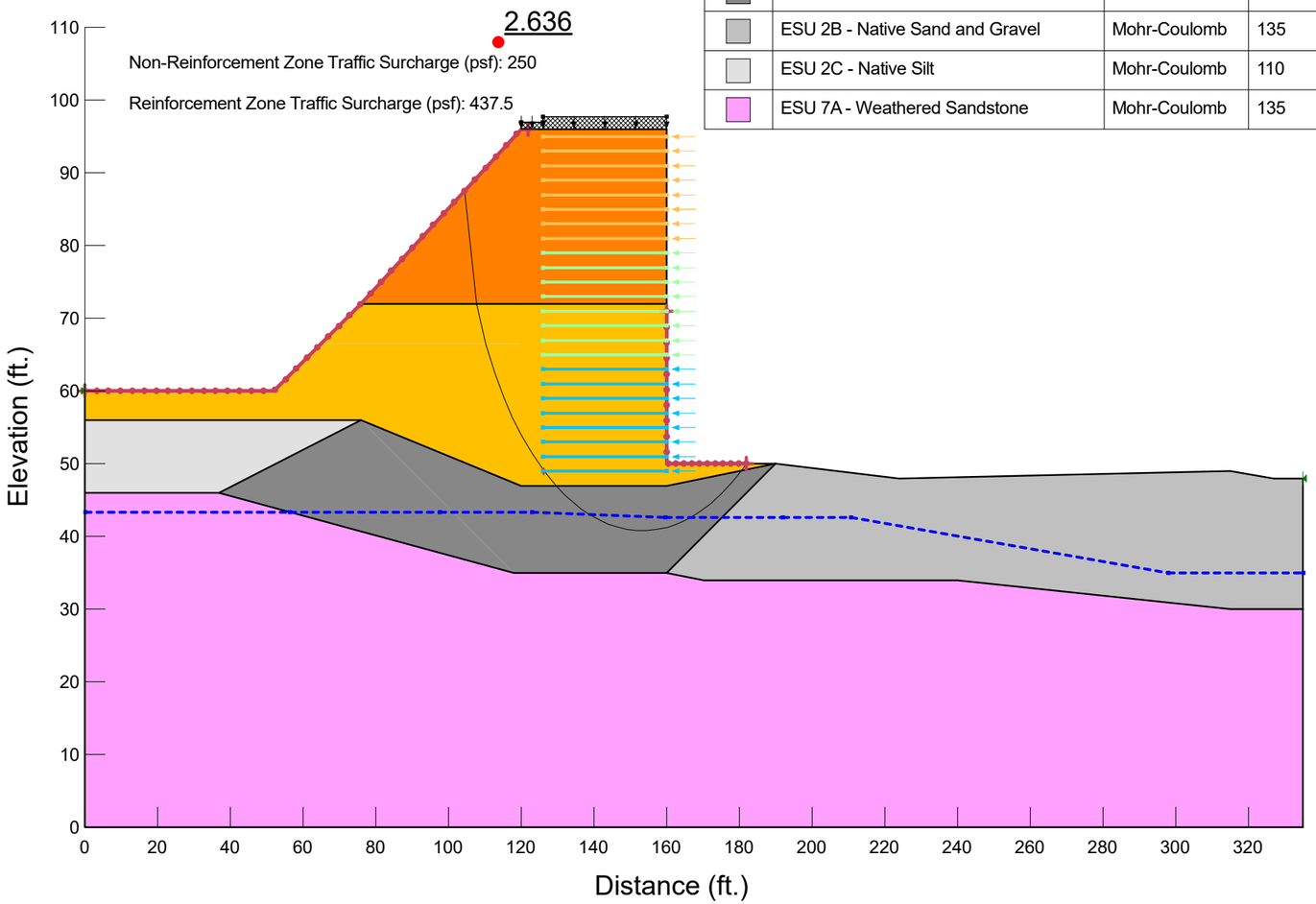
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document.
3. GeoEngineers, Inc. cannot guarantee the accuracy and context of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Bridge 17.7 - Wall 03.63L Section Ea-Ea'
Static Compound Stability (Spencer) - Existing Condition

WSDOT I-405 Renton to Bellevue
King County, Washington

GeoEngineers

Figure D.5-1



Color	Name	Slope Stability Material Model	Unit Weight	Effective Cohesion	Effective Friction Angle
	ESU 1A - Existing Granular Fill	Mohr-Coulomb	120	0	40
	ESU 1B - Existing Gravelly Granular Fill	Mohr-Coulomb	125	0	38
	ESU 2A - Native Sand and Gravel	Mohr-Coulomb	120	0	39
	ESU 2B - Native Sand and Gravel	Mohr-Coulomb	135	0	41
	ESU 2C - Native Silt	Mohr-Coulomb	110	0	29
	ESU 7A - Weathered Sandstone	Mohr-Coulomb	135	0	42

Color	Name	Type	Interface Adhesion	Interface Shear Angle	Factored Tensile Capacity
	EL47_W9.5xW4	Geosynthetic	0	14.1	7,441 lbf/ft
	EL51_W9.5xW4	Geosynthetic	0	14.1	7,441 lbf/ft
	EL53_W9.5xW4	Geosynthetic	0	14.1	7,441 lbf/ft
	EL55_W9.5xW4	Geosynthetic	0	14.1	7,441 lbf/ft
	EL57_W9.5xW4	Geosynthetic	0	14.1	7,441 lbf/ft
	EL59_W9.5xW4	Geosynthetic	0	14.1	7,441 lbf/ft
	EL61_W9.5xW4.0	Geosynthetic	0	14.1	7,441 lbf/ft
	EL63_W9.5xW4.0	Geosynthetic	0	14.1	7,441 lbf/ft
	EL65_W7.0xW3.5	Geosynthetic	0	12.1	5,422 lbf/ft
	EL67_W7.0xW3.5	Geosynthetic	0	12.1	5,422 lbf/ft
	EL69_W7.0xW3.5	Geosynthetic	0	12.1	5,422 lbf/ft
	EL71_W7.0xW3.5	Geosynthetic	0	12.1	5,422 lbf/ft
	EL73_W7.0xW3.5	Geosynthetic	0	12.1	5,422 lbf/ft
	EL75_W7.0xW3.5	Geosynthetic	0	12.1	5,422 lbf/ft
	EL77_W7.0xW3.5	Geosynthetic	0	23.2	5,422 lbf/ft
	EL79_W4.5xW3.5	Geosynthetic	0	23.2	5,422 lbf/ft
	EL81_W4.5xW3.5	Geosynthetic	0	18.7	3,385 lbf/ft
	EL83_W4.5xW3.5	Geosynthetic	0	18.7	3,385 lbf/ft
	EL85_W4.5xW3.5	Geosynthetic	0	18.7	3,385 lbf/ft
	EL87_W4.5xW3.5	Geosynthetic	0	18.7	3,385 lbf/ft
	EL89_W4.5xW3.5	Geosynthetic	0	18.7	3,385 lbf/ft
	EL91_W4.5xW3.5	Geosynthetic	0	18.7	3,385 lbf/ft
	EL93_W4.5xW3.5	Geosynthetic	0	18.7	3,385 lbf/ft
	EL95_W4.5xW3.5	Geosynthetic	0	18.7	3,385 lbf/ft

Notes:

1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document.
3. GeoEngineers, Inc. cannot guarantee the accuracy and context of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

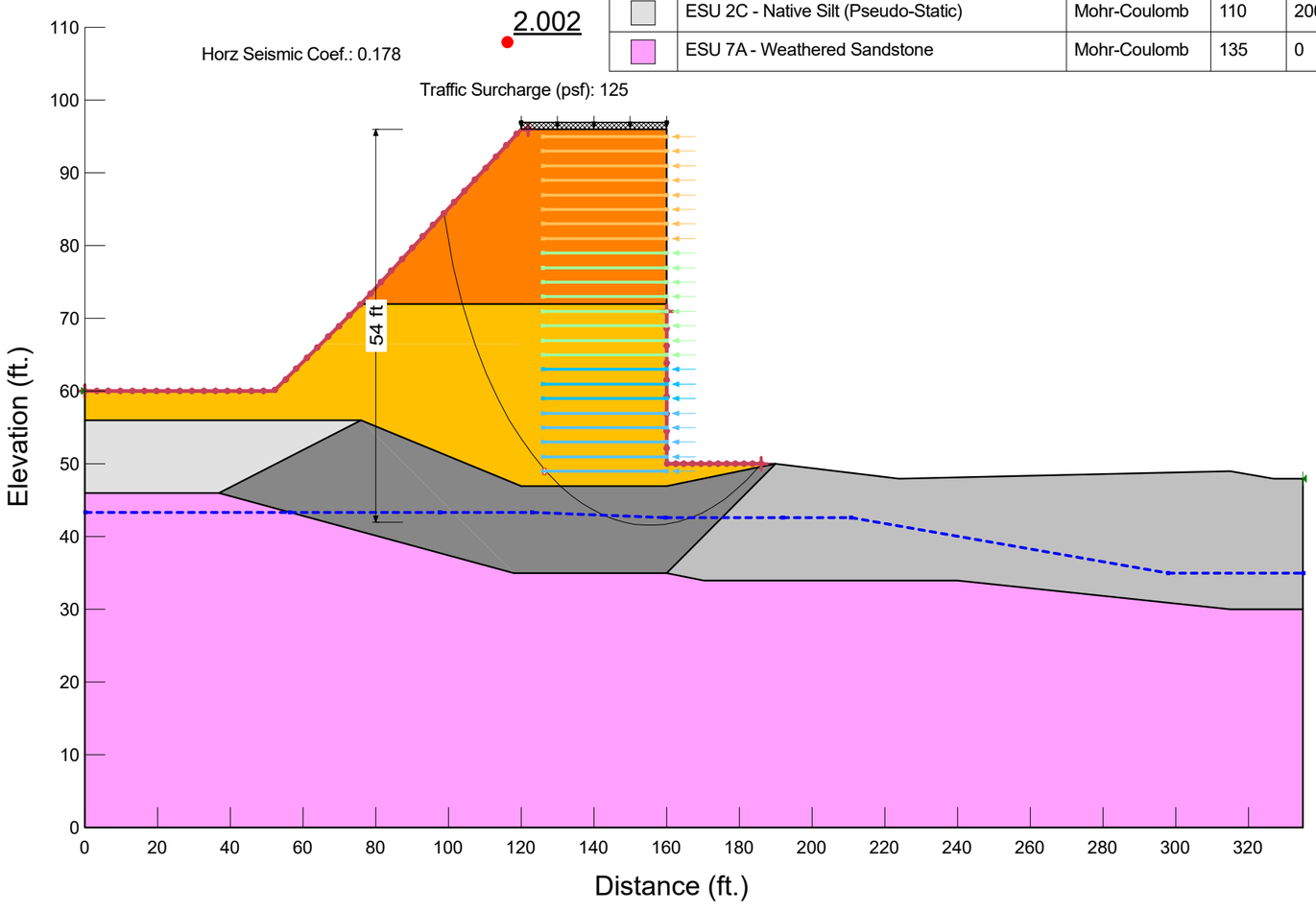
Bridge 17.7 - Wall 03.63L Section Ea-Ea'
Static Compound Stability (M-P) - Existing Condition

WSDOT I-405 Renton to Bellevue
King County, Washington

GeoEngineers

Figure D.5-2

Color	Name	Slope Stability Material Model	Unit Weight	Effective Cohesion	Effective Friction Angle
	ESU 1A - Existing Granular Fill (Pseudo-Static)	Mohr-Coulomb	120	50	40
	ESU 1B - Existing Gravelly Granular Fill	Mohr-Coulomb	125	0	38
	ESU 2A - Native Sand and Gravel	Mohr-Coulomb	120	0	39
	ESU 2B - Native Sand and Gravel	Mohr-Coulomb	135	0	41
	ESU 2C - Native Silt (Pseudo-Static)	Mohr-Coulomb	110	200	29
	ESU 7A - Weathered Sandstone	Mohr-Coulomb	135	0	42



Color	Name	Type	Interface Adhesion	Interface Shear Angle	Factored Tensile Capacity
	EQ_EL49_W9.5xW4	Geosynthetic	0	18.5	9,730 lbf/ft
	EQ_EL51_W9.5xW4	Geosynthetic	0	18.5	9,730 lbf/ft
	EQ_EL53_W9.5xW4	Geosynthetic	0	18.5	9,730 lbf/ft
	EQ_EL55_W9.5xW4	Geosynthetic	0	18.5	9,730 lbf/ft
	EQ_EL57_W9.5xW4	Geosynthetic	0	18.5	9,730 lbf/ft
	EQ_EL59_W9.5xW4	Geosynthetic	0	18.5	9,730 lbf/ft
	EQ_EL61_W7.0xW3.5	Geosynthetic	0	18.5	9,730 lbf/ft
	EQ_EL63_W7.0xW3.5	Geosynthetic	0	18.5	9,730 lbf/ft
	EQ_EL65_W7.0xW3.5	Geosynthetic	0	16	7,091 lbf/ft
	EQ_EL67_W7.0xW3.5	Geosynthetic	0	16	7,091 lbf/ft
	EQ_EL69_W7.0xW3.5	Geosynthetic	0	16	7,091 lbf/ft
	EQ_EL71_W7.0xW3.5	Geosynthetic	0	16	7,091 lbf/ft
	EQ_EL73_W7.0xW3.5	Geosynthetic	0	16	7,091 lbf/ft
	EQ_EL75_W7.0xW3.5	Geosynthetic	0	16	7,091 lbf/ft
	EQ_EL77_W7.0xW3.5	Geosynthetic	0	29.8	7,091 lbf/ft
	EQ_EL79_W7.0xW3.5	Geosynthetic	0	29.8	7,091 lbf/ft
	EQ_EL81_W4.5xW3.5	Geosynthetic	0	24.3	4,426 lbf/ft
	EQ_EL83_W4.5xW3.5	Geosynthetic	0	24.3	4,426 lbf/ft
	EQ_EL85_W4.5xW3.5	Geosynthetic	0	24.3	4,426 lbf/ft
	EQ_EL87_W4.5xW3.5	Geosynthetic	0	24.3	4,426 lbf/ft
	EQ_EL89_W4.5xW3.5	Geosynthetic	0	24.3	4,426 lbf/ft
	EQ_EL91_W4.5xW3.5	Geosynthetic	0	24.3	4,426 lbf/ft
	EQ_EL93_W4.5xW3.5	Geosynthetic	0	24.3	4,426 lbf/ft
	EQ_EL95_W4.5xW3.5	Geosynthetic	0	24.3	4,426 lbf/ft

Notes:

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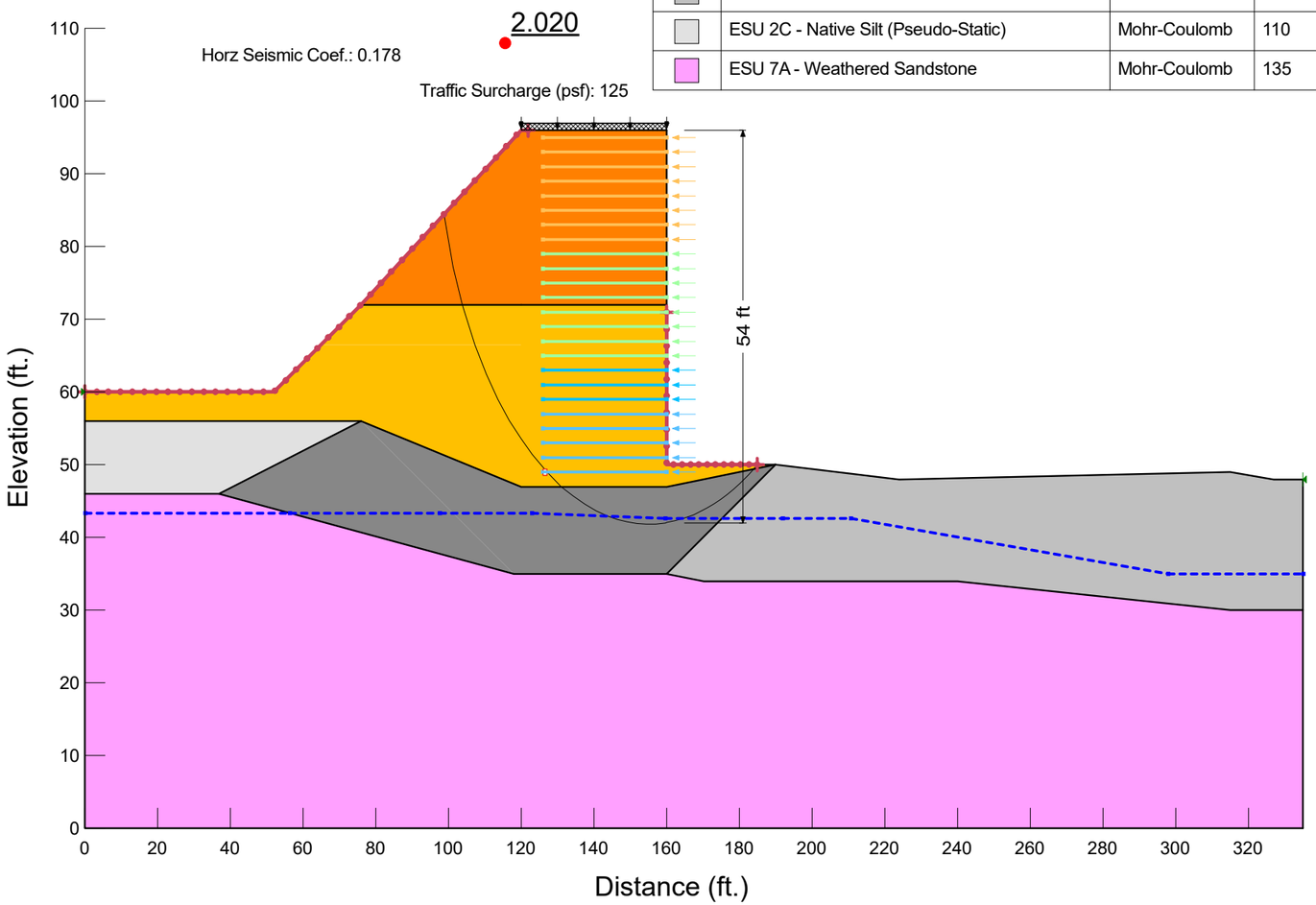
Bridge 17.7 - Wall 03.63L Section Ea-Ea'
Pseudo-Static Compound Stability (Spencer) - Existing Condition

WSDOT I-405 Renton to Bellevue
King County, Washington

GeoEngineers

Figure D.5-3

Color	Name	Slope Stability Material Model	Unit Weight	Effective Cohesion	Effective Friction Angle
	ESU 1A - Existing Granular Fill (Pseudo-Static)	Mohr-Coulomb	120	50	40
	ESU 1B - Existing Gravelly Granular Fill	Mohr-Coulomb	125	0	38
	ESU 2A - Native Sand and Gravel	Mohr-Coulomb	120	0	39
	ESU 2B - Native Sand and Gravel	Mohr-Coulomb	135	0	41
	ESU 2C - Native Silt (Pseudo-Static)	Mohr-Coulomb	110	200	29
	ESU 7A - Weathered Sandstone	Mohr-Coulomb	135	0	42



Color	Name	Type	Interface Adhesion	Interface Shear Angle	Factored Tensile Capacity
	EQ_EL49_W9.5xW4	Geosynthetic	0	18.5	9,730 lbf/ft
	EQ_EL51_W9.5xW4	Geosynthetic	0	18.5	9,730 lbf/ft
	EQ_EL53_W9.5xW4	Geosynthetic	0	18.5	9,730 lbf/ft
	EQ_EL55_W9.5xW4	Geosynthetic	0	18.5	9,730 lbf/ft
	EQ_EL57_W9.5xW4	Geosynthetic	0	18.5	9,730 lbf/ft
	EQ_EL59_W9.5xW4	Geosynthetic	0	18.5	9,730 lbf/ft
	EQ_EL61_W7.0xW3.5	Geosynthetic	0	18.5	9,730 lbf/ft
	EQ_EL63_W7.0xW3.5	Geosynthetic	0	18.5	9,730 lbf/ft
	EQ_EL65_W7.0xW3.5	Geosynthetic	0	16	7,091 lbf/ft
	EQ_EL67_W7.0xW3.5	Geosynthetic	0	16	7,091 lbf/ft
	EQ_EL69_W7.0xW3.5	Geosynthetic	0	16	7,091 lbf/ft
	EQ_EL71_W7.0xW3.5	Geosynthetic	0	16	7,091 lbf/ft
	EQ_EL73_W7.0xW3.5	Geosynthetic	0	16	7,091 lbf/ft
	EQ_EL75_W7.0xW3.5	Geosynthetic	0	16	7,091 lbf/ft
	EQ_EL77_W7.0xW3.5	Geosynthetic	0	29.8	7,091 lbf/ft
	EQ_EL79_W7.0xW3.5	Geosynthetic	0	29.8	7,091 lbf/ft
	EQ_EL81_W4.5xW3.5	Geosynthetic	0	24.3	4,426 lbf/ft
	EQ_EL83_W4.5xW3.5	Geosynthetic	0	24.3	4,426 lbf/ft
	EQ_EL85_W4.5xW3.5	Geosynthetic	0	24.3	4,426 lbf/ft
	EQ_EL87_W4.5xW3.5	Geosynthetic	0	24.3	4,426 lbf/ft
	EQ_EL89_W4.5xW3.5	Geosynthetic	0	24.3	4,426 lbf/ft
	EQ_EL91_W4.5xW3.5	Geosynthetic	0	24.3	4,426 lbf/ft
	EQ_EL93_W4.5xW3.5	Geosynthetic	0	24.3	4,426 lbf/ft
	EQ_EL95_W4.5xW3.5	Geosynthetic	0	24.3	4,426 lbf/ft

Notes:

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Bridge 17.7 - Wall 03.63L Section Ea-Ea'
Pseudo-Static Compound Stability (M-P) - Existing Condition

WSDOT I-405 Renton to Bellevue
King County, Washington

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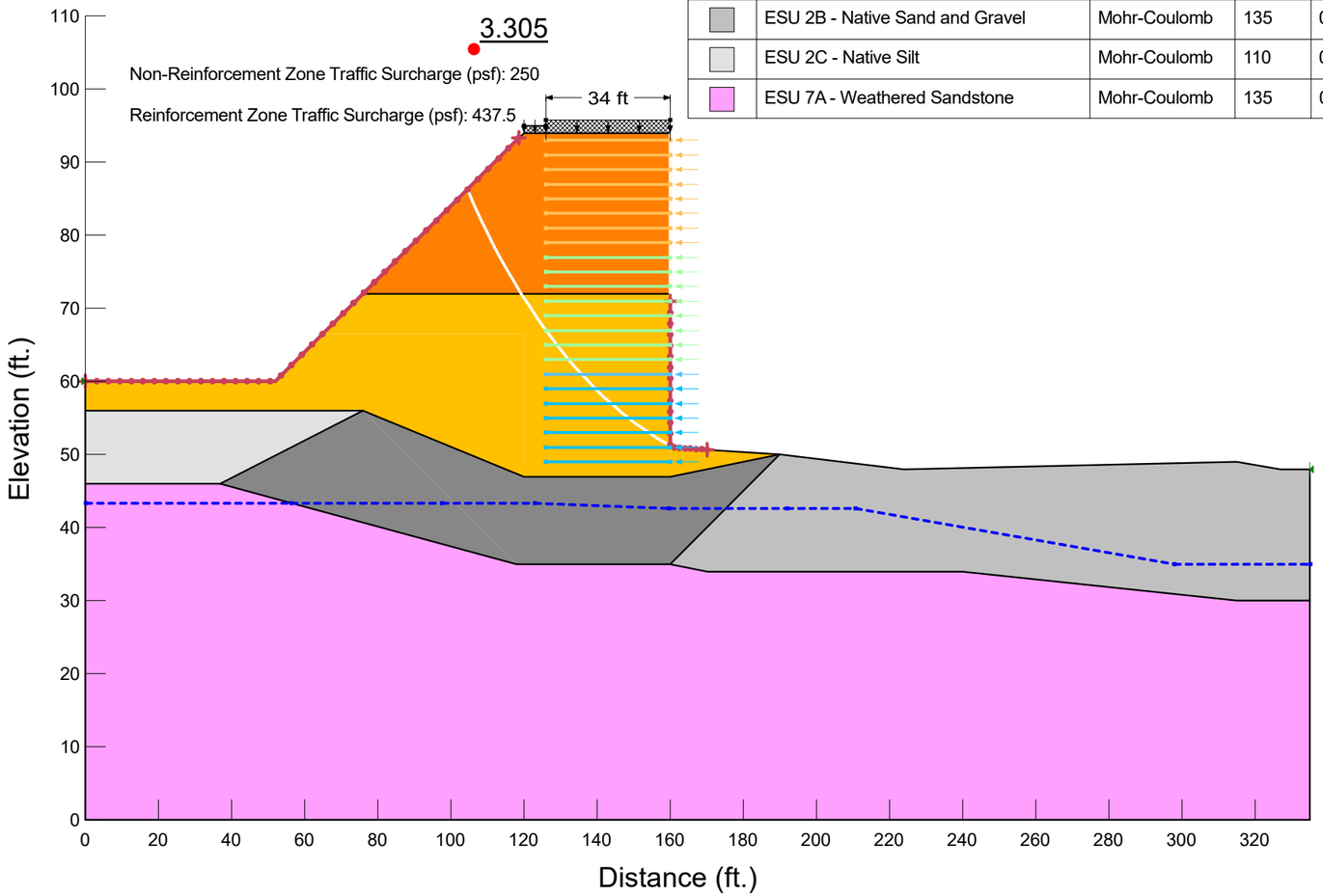
Figure D.5-4



Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	ESU 1A - Existing Granular Fill	Mohr-Coulomb	120	0	40
	ESU 1B - Existing Gravelly Granular Fill	Mohr-Coulomb	125	0	38
	ESU 2A - Native Sand and Gravel	Mohr-Coulomb	120	0	39
	ESU 2B - Native Sand and Gravel	Mohr-Coulomb	135	0	41
	ESU 2C - Native Silt	Mohr-Coulomb	110	0	29
	ESU 7A - Weathered Sandstone	Mohr-Coulomb	135	0	42

Color	Name	Type	Interface Adhesion	Interface Shear Angle	Factored Tensile Capacity
	EL49_W9.5xW4.0	Geosynthetic	0	14.1	7,441 lbf/ft
	EL51_W9.5xW4.0	Geosynthetic	0	14.1	7,441 lbf/ft
	EL53_W9.5xW4.0	Geosynthetic	0	14.1	7,441 lbf/ft
	EL55_W9.5xW4.0	Geosynthetic	0	14.1	7,441 lbf/ft
	EL57_W9.5xW4.0	Geosynthetic	0	14.1	7,441 lbf/ft
	EL59_W9.5xW4.0	Geosynthetic	0	14.1	7,441 lbf/ft
	EL61_W9.5xW4.0	Geosynthetic	0	14.1	7,441 lbf/ft
	EL63_W7.0xW3.5	Geosynthetic	0	12.1	5,422 lbf/ft
	EL65_W7.0xW3.5	Geosynthetic	0	12.1	5,422 lbf/ft
	EL67_W7.0xW3.5	Geosynthetic	0	12.1	5,422 lbf/ft
	EL69_W7.0xW3.5	Geosynthetic	0	12.1	5,422 lbf/ft
	EL71_W7.0xW3.5	Geosynthetic	0	12.1	5,422 lbf/ft
	EL73_W7.0xW3.5	Geosynthetic	0	12.1	5,422 lbf/ft
	EL75_W7.0xW3.5	Geosynthetic	0	23.2	5,422 lbf/ft
	EL77_W7.0xW3.5	Geosynthetic	0	23.2	5,422 lbf/ft
	EL79_W4.5xW3.5	Geosynthetic	0	18.7	3,385 lbf/ft
	EL81_W4.5xW3.5	Geosynthetic	0	18.7	3,385 lbf/ft
	EL83_W4.5xW3.5	Geosynthetic	0	18.7	3,385 lbf/ft
	EL85_W4.5xW3.5	Geosynthetic	0	18.7	3,385 lbf/ft
	EL87_W4.5xW3.5	Geosynthetic	0	18.7	3,385 lbf/ft
	EL89_W4.5xW3.5	Geosynthetic	0	18.7	3,385 lbf/ft
	EL91_W4.5xW3.5	Geosynthetic	0	18.7	3,385 lbf/ft
	EL93_W4.5xW3.5	Geosynthetic	0	18.7	3,385 lbf/ft

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Bridge 17.7 - Wall 03.63L Section Fa-Fa'
Static Compound Stability (Spencer) - Existing Condition

WSDOT I-405 Renton to Bellevue
King County, Washington

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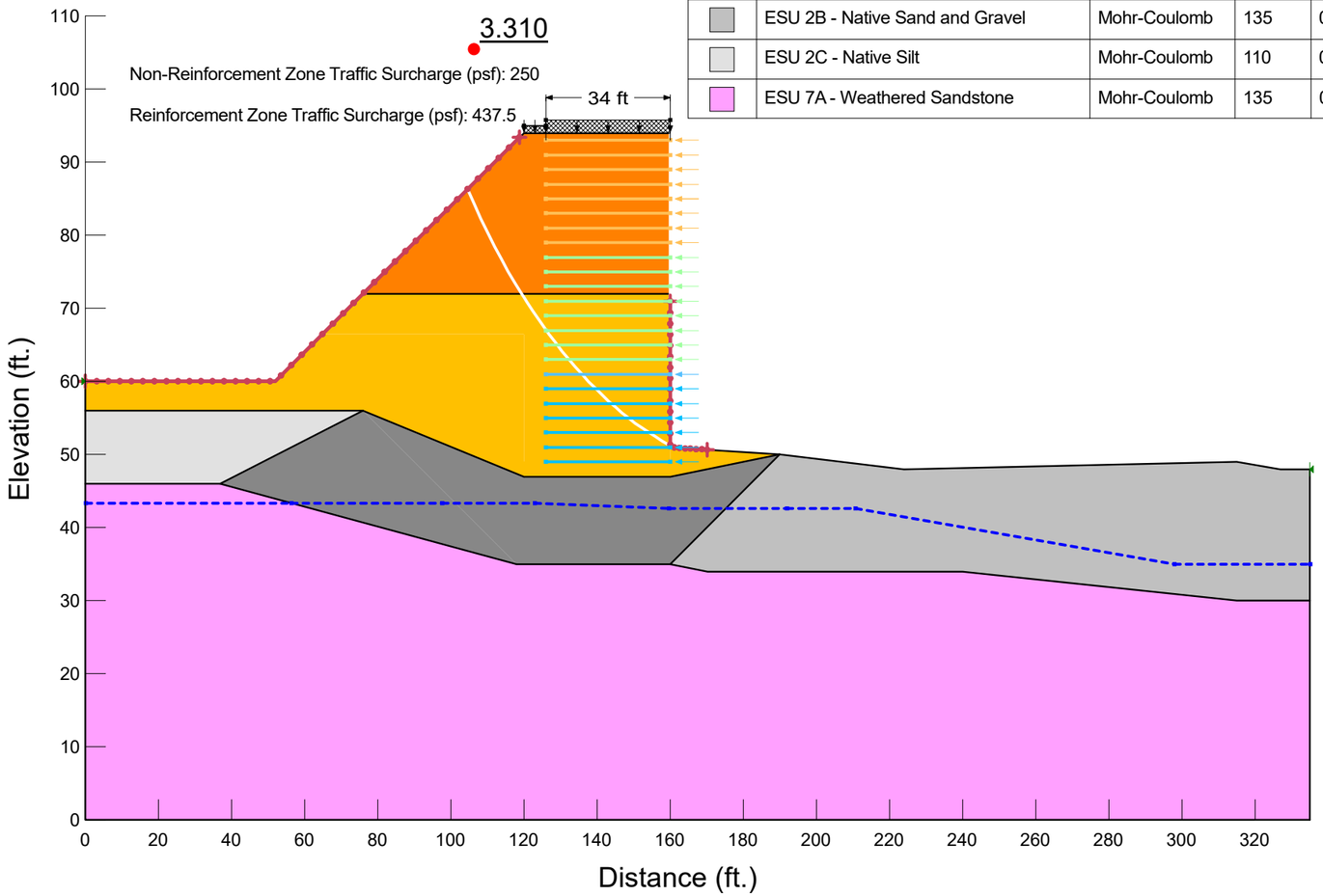
Figure D.5-5



Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	ESU 1A - Existing Granular Fill	Mohr-Coulomb	120	0	40
	ESU 1B - Existing Gravelly Granular Fill	Mohr-Coulomb	125	0	38
	ESU 2A - Native Sand and Gravel	Mohr-Coulomb	120	0	39
	ESU 2B - Native Sand and Gravel	Mohr-Coulomb	135	0	41
	ESU 2C - Native Silt	Mohr-Coulomb	110	0	29
	ESU 7A - Weathered Sandstone	Mohr-Coulomb	135	0	42

Color	Name	Type	Interface Adhesion	Interface Shear Angle	Factored Tensile Capacity
	EL49_W9.5xW4.0	Geosynthetic	0	14.1	7,441 lbf/ft
	EL51_W9.5xW4.0	Geosynthetic	0	14.1	7,441 lbf/ft
	EL53_W9.5xW4.0	Geosynthetic	0	14.1	7,441 lbf/ft
	EL55_W9.5xW4.0	Geosynthetic	0	14.1	7,441 lbf/ft
	EL57_W9.5xW4.0	Geosynthetic	0	14.1	7,441 lbf/ft
	EL59_W9.5xW4.0	Geosynthetic	0	14.1	7,441 lbf/ft
	EL61_W9.5xW4.0	Geosynthetic	0	14.1	7,441 lbf/ft
	EL63_W7.0xW3.5	Geosynthetic	0	12.1	5,422 lbf/ft
	EL65_W7.0xW3.5	Geosynthetic	0	12.1	5,422 lbf/ft
	EL67_W7.0xW3.5	Geosynthetic	0	12.1	5,422 lbf/ft
	EL69_W7.0xW3.5	Geosynthetic	0	12.1	5,422 lbf/ft
	EL71_W7.0xW3.5	Geosynthetic	0	12.1	5,422 lbf/ft
	EL73_W7.0xW3.5	Geosynthetic	0	12.1	5,422 lbf/ft
	EL75_W7.0xW3.5	Geosynthetic	0	23.2	5,422 lbf/ft
	EL77_W7.0xW3.5	Geosynthetic	0	23.2	5,422 lbf/ft
	EL79_W4.5xW3.5	Geosynthetic	0	18.7	3,385 lbf/ft
	EL81_W4.5xW3.5	Geosynthetic	0	18.7	3,385 lbf/ft
	EL83_W4.5xW3.5	Geosynthetic	0	18.7	3,385 lbf/ft
	EL85_W4.5xW3.5	Geosynthetic	0	18.7	3,385 lbf/ft
	EL87_W4.5xW3.5	Geosynthetic	0	18.7	3,385 lbf/ft
	EL89_W4.5xW3.5	Geosynthetic	0	18.7	3,385 lbf/ft
	EL91_W4.5xW3.5	Geosynthetic	0	18.7	3,385 lbf/ft
	EL93_W4.5xW3.5	Geosynthetic	0	18.7	3,385 lbf/ft

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Bridge 17.7 - Wall 03.63L Section Fa-Fa'
Static Compound Stability (M-P) - Existing Condition

WSDOT I-405 Renton to Bellevue
King County, Washington

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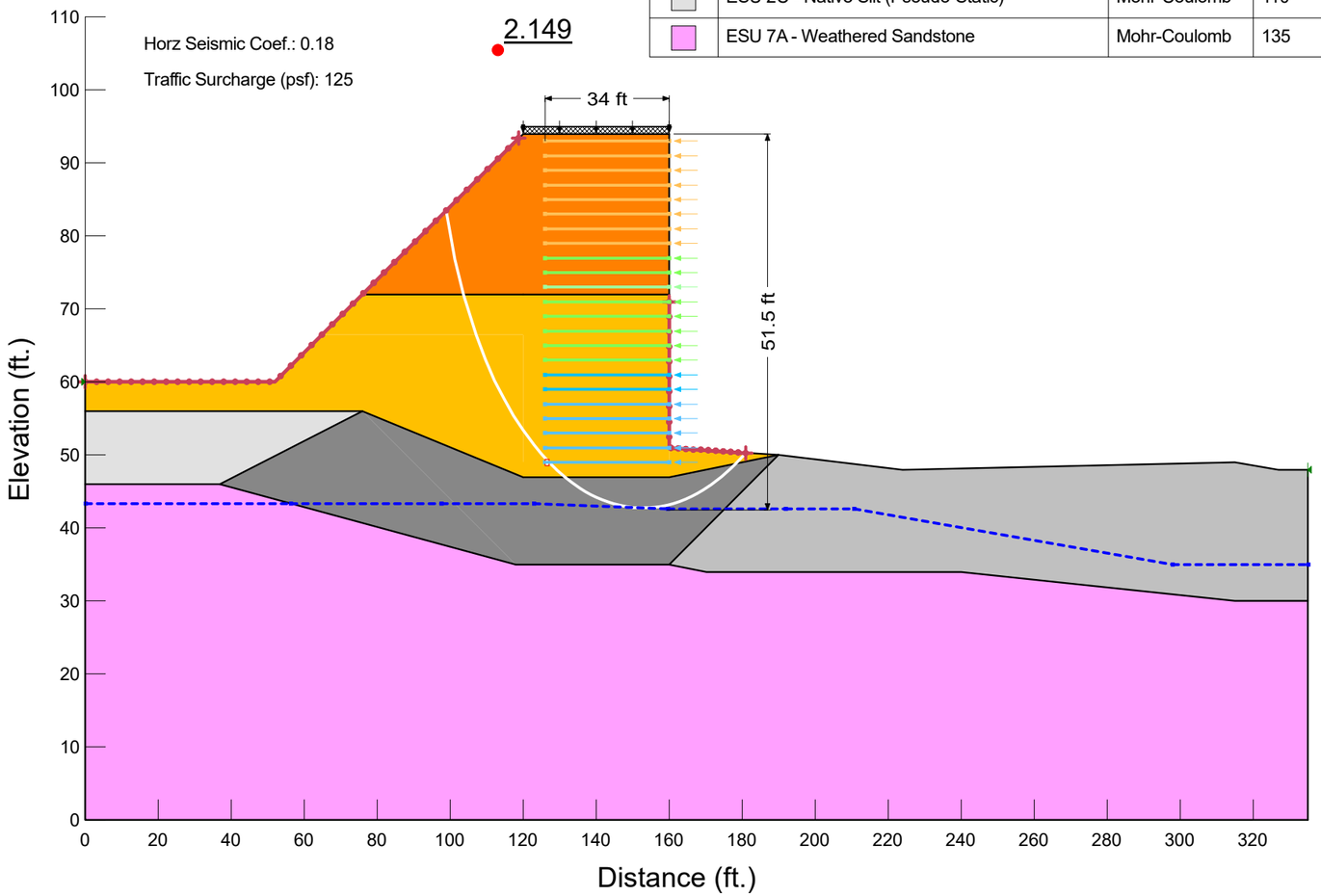
Figure D.5-6

Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	ESU 1A - Existing Granular Fill (Pseudo-Static)	Mohr-Coulomb	120	50	40
	ESU 1B - Existing Gravelly Granular Fill	Mohr-Coulomb	125	0	38
	ESU 2A - Native Sand and Gravel	Mohr-Coulomb	120	0	39
	ESU 2B - Native Sand and Gravel	Mohr-Coulomb	135	0	41
	ESU 2C - Native Silt (Pseudo-Static)	Mohr-Coulomb	110	200	29
	ESU 7A - Weathered Sandstone	Mohr-Coulomb	135	0	42



Color	Name	Type	Interface Adhesion	Interface Shear Angle	Factored Tensile Capacity
	EQ_EL49_W9.5xW4.0	Geosynthetic	0	18.5	9,730 lbf/ft
	EQ_EL51_W9.5xW4.0	Geosynthetic	0	18.5	9,730 lbf/ft
	EQ_EL53_W9.5xW4.0	Geosynthetic	0	18.5	9,730 lbf/ft
	EQ_EL55_W9.5xW4.0	Geosynthetic	0	18.5	9,730 lbf/ft
	EQ_EL57_W9.5xW4.0	Geosynthetic	0	18.5	9,730 lbf/ft
	EQ_EL59_W9.5xW4.0	Geosynthetic	0	18.5	9,730 lbf/ft
	EQ_EL61_W9.5xW4.0	Geosynthetic	0	18.5	9,730 lbf/ft
	EQ_EL63_W7.0xW3.5	Geosynthetic	0	16	7,091 lbf/ft
	EQ_EL65_W7.0xW3.5	Geosynthetic	0	16	7,091 lbf/ft
	EQ_EL67_W7.0xW3.5	Geosynthetic	0	16	7,091 lbf/ft
	EQ_EL69_W7.0xW3.5	Geosynthetic	0	16	7,091 lbf/ft
	EQ_EL71_W7.0xW3.5	Geosynthetic	0	16	7,091 lbf/ft
	EQ_EL73_W7.0xW3.5	Geosynthetic	0	16	7,091 lbf/ft
	EQ_EL75_W7.0xW3.5	Geosynthetic	0	29.8	7,091 lbf/ft
	EQ_EL77_W7.0xW3.5	Geosynthetic	0	29.8	7,091 lbf/ft
	EQ_EL79_W4.5xW3.5	Geosynthetic	0	24.3	4,426 lbf/ft
	EQ_EL81_W4.5xW3.5	Geosynthetic	0	24.3	4,426 lbf/ft
	EQ_EL83_W4.5xW3.5	Geosynthetic	0	24.3	4,426 lbf/ft
	EQ_EL85_W4.5xW3.5	Geosynthetic	0	24.3	4,426 lbf/ft
	EQ_EL87_W4.5xW3.5	Geosynthetic	0	24.3	4,426 lbf/ft
	EQ_EL89_W4.5xW3.5	Geosynthetic	0	24.3	4,426 lbf/ft
	EQ_EL91_W4.5xW3.5	Geosynthetic	0	24.3	4,426 lbf/ft
	EQ_EL93_W4.5xW3.5	Geosynthetic	0	24.3	4,426 lbf/ft

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Bridge 17.7 - Wall 03.63L Section Fa-Fa'
Pseudo-Static Compound Stability (Spencer) - Existing Condition

WSDOT I-405 Renton to Bellevue
King County, Washington

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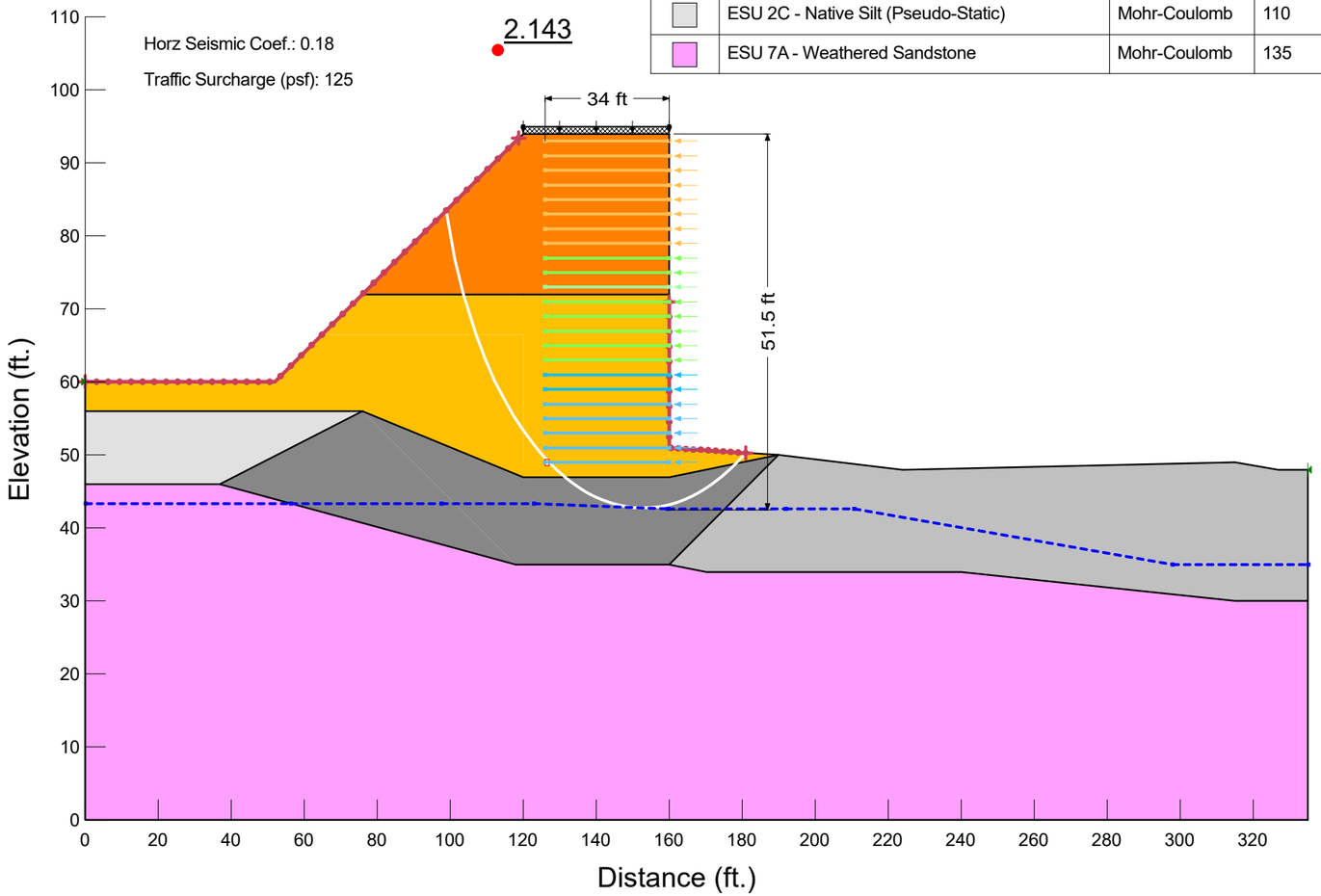
Figure D.5-7

Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	ESU 1A - Existing Granular Fill (Pseudo-Static)	Mohr-Coulomb	120	50	40
	ESU 1B - Existing Gravelly Granular Fill	Mohr-Coulomb	125	0	38
	ESU 2A - Native Sand and Gravel	Mohr-Coulomb	120	0	39
	ESU 2B - Native Sand and Gravel	Mohr-Coulomb	135	0	41
	ESU 2C - Native Silt (Pseudo-Static)	Mohr-Coulomb	110	200	29
	ESU 7A - Weathered Sandstone	Mohr-Coulomb	135	0	42



Color	Name	Type	Interface Adhesion	Interface Shear Angle	Factored Tensile Capacity
	EQ_EL49_W9.5xW4.0	Geosynthetic	0	18.5	9,730 lbf/ft
	EQ_EL51_W9.5xW4.0	Geosynthetic	0	18.5	9,730 lbf/ft
	EQ_EL53_W9.5xW4.0	Geosynthetic	0	18.5	9,730 lbf/ft
	EQ_EL55_W9.5xW4.0	Geosynthetic	0	18.5	9,730 lbf/ft
	EQ_EL57_W9.5xW4.0	Geosynthetic	0	18.5	9,730 lbf/ft
	EQ_EL59_W9.5xW4.0	Geosynthetic	0	18.5	9,730 lbf/ft
	EQ_EL61_W9.5xW4.0	Geosynthetic	0	18.5	9,730 lbf/ft
	EQ_EL63_W7.0xW3.5	Geosynthetic	0	16	7,091 lbf/ft
	EQ_EL65_W7.0xW3.5	Geosynthetic	0	16	7,091 lbf/ft
	EQ_EL67_W7.0xW3.5	Geosynthetic	0	16	7,091 lbf/ft
	EQ_EL69_W7.0xW3.5	Geosynthetic	0	16	7,091 lbf/ft
	EQ_EL71_W7.0xW3.5	Geosynthetic	0	16	7,091 lbf/ft
	EQ_EL73_W7.0xW3.5	Geosynthetic	0	16	7,091 lbf/ft
	EQ_EL75_W7.0xW3.5	Geosynthetic	0	29.8	7,091 lbf/ft
	EQ_EL77_W7.0xW3.5	Geosynthetic	0	29.8	7,091 lbf/ft
	EQ_EL79_W4.5xW3.5	Geosynthetic	0	24.3	4,426 lbf/ft
	EQ_EL81_W4.5xW3.5	Geosynthetic	0	24.3	4,426 lbf/ft
	EQ_EL83_W4.5xW3.5	Geosynthetic	0	24.3	4,426 lbf/ft
	EQ_EL85_W4.5xW3.5	Geosynthetic	0	24.3	4,426 lbf/ft
	EQ_EL87_W4.5xW3.5	Geosynthetic	0	24.3	4,426 lbf/ft
	EQ_EL89_W4.5xW3.5	Geosynthetic	0	24.3	4,426 lbf/ft
	EQ_EL91_W4.5xW3.5	Geosynthetic	0	24.3	4,426 lbf/ft
	EQ_EL93_W4.5xW3.5	Geosynthetic	0	24.3	4,426 lbf/ft

Notes:

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Bridge 17.7 - Wall 03.63L Section Fa-Fa'
Pseudo-Static Compound Stability (M-P) - Existing Condition

WSDOT I-405 Renton to Bellevue
King County, Washington

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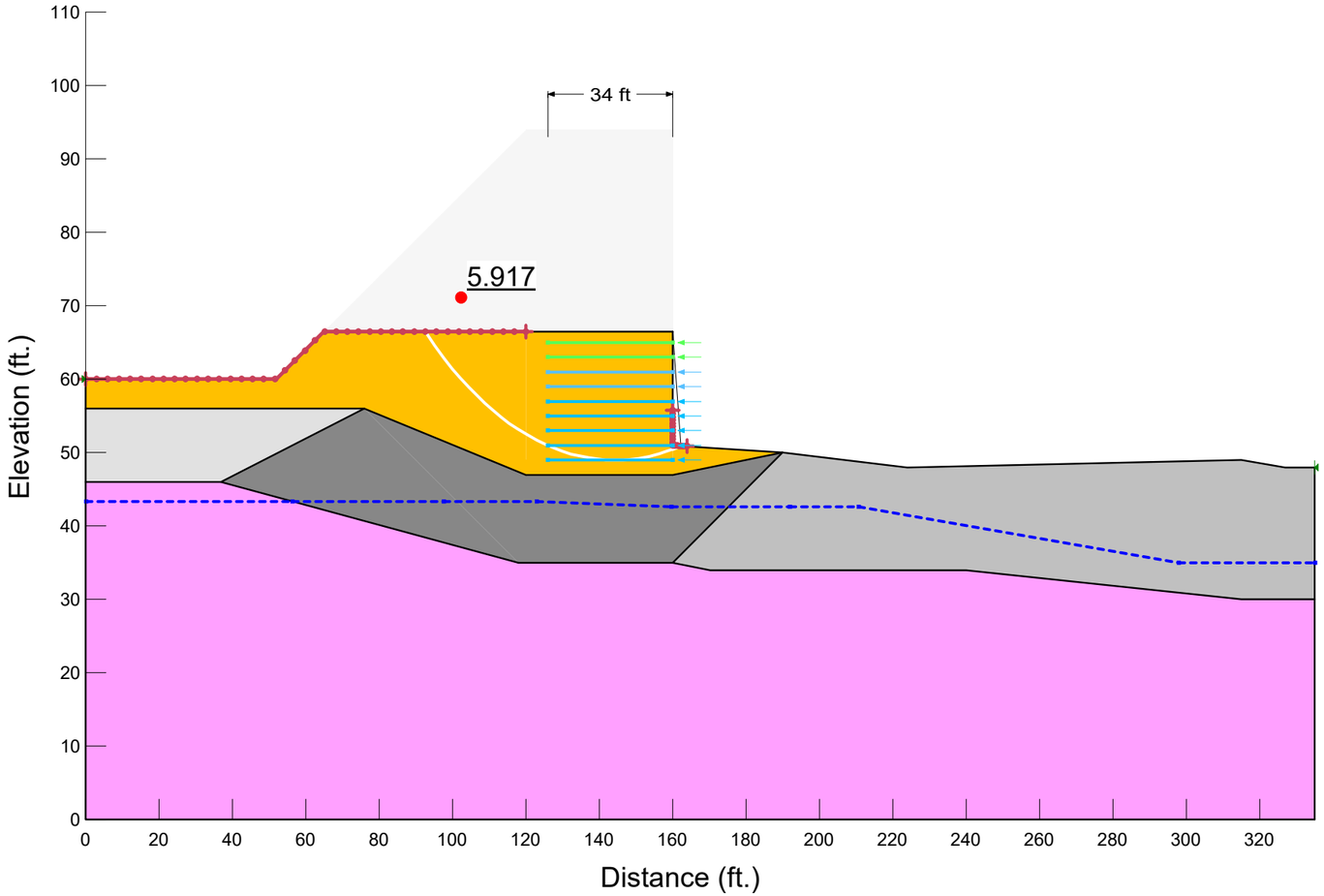
Figure D.5-8



Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	ESU 1B - Existing Gravelly Granular Fill	Mohr-Coulomb	125	0	38
	ESU 2A - Native Sand and Gravel	Mohr-Coulomb	120	0	39
	ESU 2B - Native Sand and Gravel	Mohr-Coulomb	135	0	41
	ESU 2C - Native Silt	Mohr-Coulomb	110	0	29
	ESU 7A - Weathered Sandstone	Mohr-Coulomb	135	0	42

Color	Name	Type	Interface Adhesion	Interface Shear Angle	Factored Tensile Capacity
	Con_EL49_W9.5xW4.0	Geosynthetic	0	26.7	7,441 lbf/ft
	Con_EL51_W9.5xW4.0	Geosynthetic	0	26.7	7,441 lbf/ft
	Con_EL53_W9.5xW4.0	Geosynthetic	0	26.7	7,441 lbf/ft
	Con_EL55_W9.5xW4.0	Geosynthetic	0	26.7	7,441 lbf/ft
	Con_EL57_W9.5xW4.0	Geosynthetic	0	26.7	7,441 lbf/ft
	Con_EL59_W9.5xW4.0	Geosynthetic	0	26.7	7,441 lbf/ft
	Con_EL61_W9.5xW4.0	Geosynthetic	0	26.7	7,441 lbf/ft
	Con_EL63_W7.0xW3.5	Geosynthetic	0	23.2	5,422 lbf/ft
	Con_EL65_W7.0xW3.5	Geosynthetic	0	23.2	5,422 lbf/ft

Notes:

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Bridge 17.7 - Wall 03.63L Section Fa-Fa'
Static Compound Stability (Spencer) - Construction Condition

WSDOT I-405 Renton to Bellevue
King County, Washington

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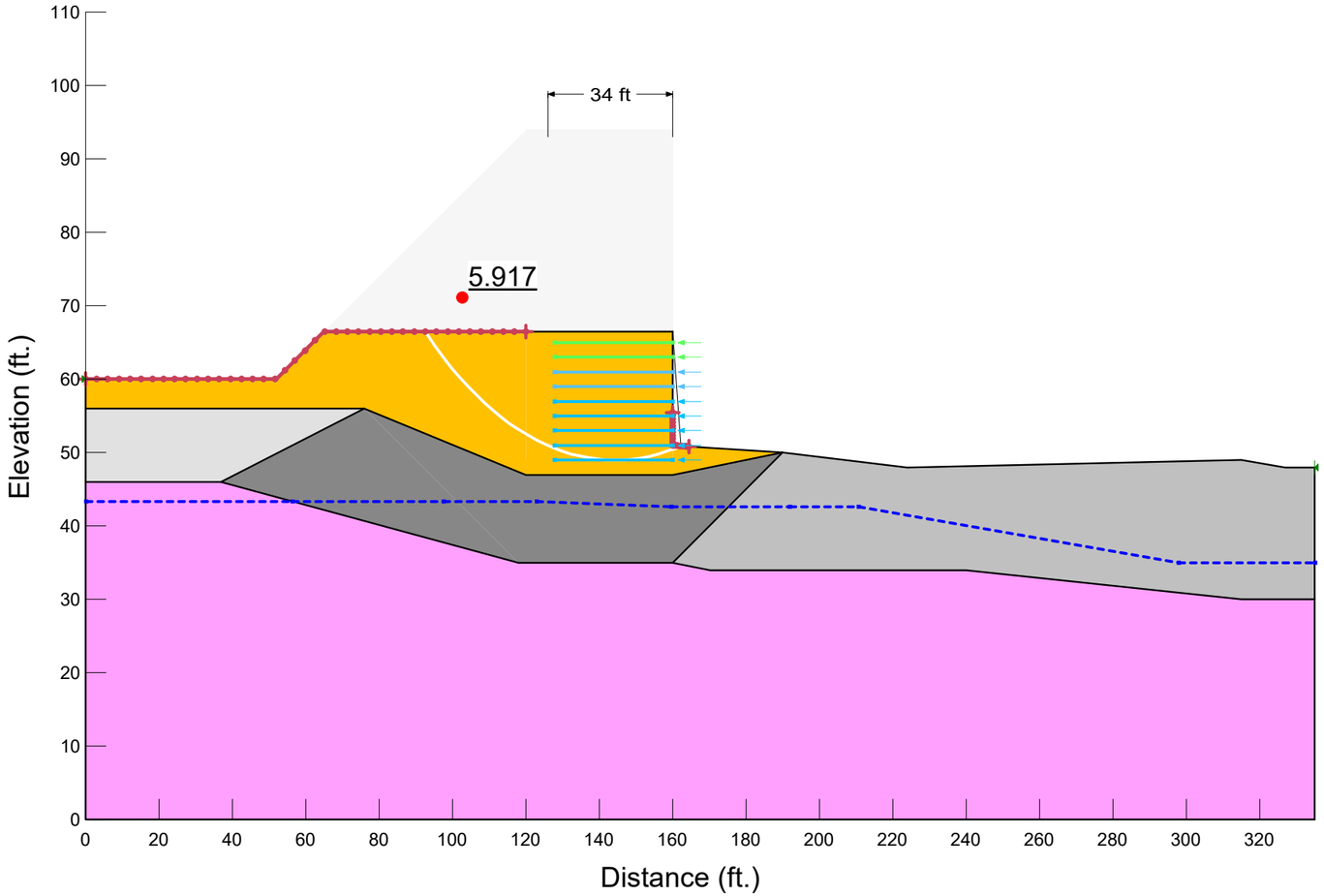
Figure D.5-9



Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	ESU 1B - Existing Gravelly Granular Fill	Mohr-Coulomb	125	0	38
	ESU 2A - Native Sand and Gravel	Mohr-Coulomb	120	0	39
	ESU 2B - Native Sand and Gravel	Mohr-Coulomb	135	0	41
	ESU 2C - Native Silt	Mohr-Coulomb	110	0	29
	ESU 7A - Weathered Sandstone	Mohr-Coulomb	135	0	42

Color	Name	Type	Interface Adhesion	Interface Shear Angle	Factored Tensile Capacity
	Con_EL49_W9.5xW4.0	Geosynthetic	0	26.7	7,441 lbf/ft
	Con_EL51_W9.5xW4.0	Geosynthetic	0	26.7	7,441 lbf/ft
	Con_EL53_W9.5xW4.0	Geosynthetic	0	26.7	7,441 lbf/ft
	Con_EL55_W9.5xW4.0	Geosynthetic	0	26.7	7,441 lbf/ft
	Con_EL57_W9.5xW4.0	Geosynthetic	0	26.7	7,441 lbf/ft
	Con_EL59_W9.5xW4.0	Geosynthetic	0	26.7	7,441 lbf/ft
	Con_EL61_W9.5xW4.0	Geosynthetic	0	26.7	7,441 lbf/ft
	Con_EL63_W7.0xW3.5	Geosynthetic	0	23.2	5,422 lbf/ft
	Con_EL65_W7.0xW3.5	Geosynthetic	0	23.2	5,422 lbf/ft

Notes:

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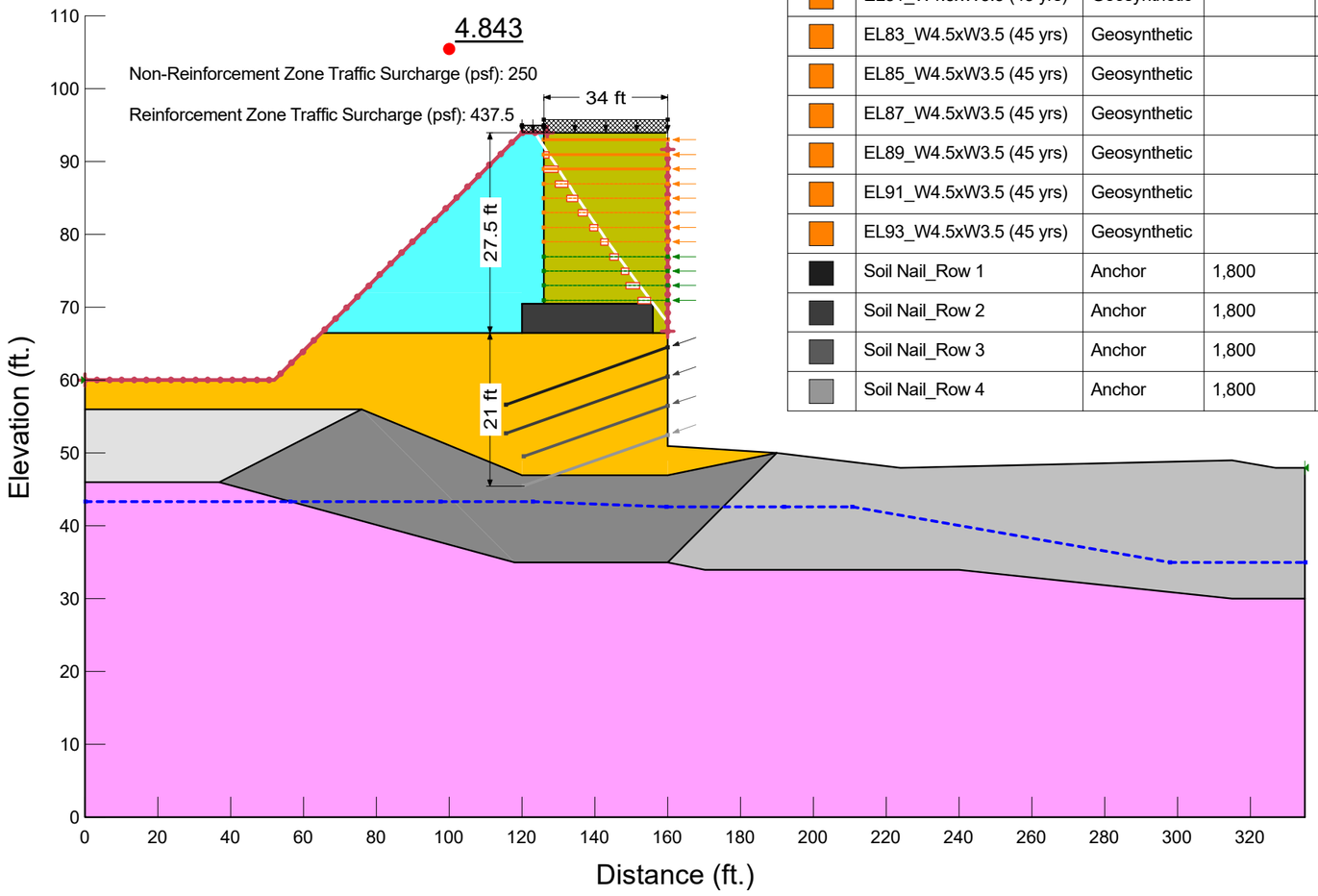
Bridge 17.7 - Wall 03.63L Section Fa-Fa'
Static Compound Stability (M-P) - Construction Condition

WSDOT I-405 Renton to Bellevue
King County, Washington

GeoEngineers

Figure D.5-10



Color	Name	Type	Pullout Resistance (psf)	Tensile Capacity (lbf)	Bond Length (ft)	Bond Diameter (ft)	Out-of-Plane Spacing (ft)	Interface Adhesion (psf)	Interface Shear Angle (°)	Factored Tensile Capacity
	EL71_W7.0xW3.5 (45 yrs)	Geosynthetic						0	11.5	4,901 lbf/ft
	EL73_W7.0xW3.5 (45 yrs)	Geosynthetic						0	11.5	4,901 lbf/ft
	EL75_W7.0xW3.5 (45 yrs)	Geosynthetic						0	22.2	4,901 lbf/ft
	EL77_W7.0xW3.5 (45 yrs)	Geosynthetic						0	22.2	4,901 lbf/ft
	EL79_W4.5xW3.5 (45 yrs)	Geosynthetic						0	17.6	2,975 lbf/ft
	EL81_W4.5xW3.5 (45 yrs)	Geosynthetic						0	17.6	2,975 lbf/ft
	EL83_W4.5xW3.5 (45 yrs)	Geosynthetic						0	17.6	2,975 lbf/ft
	EL85_W4.5xW3.5 (45 yrs)	Geosynthetic						0	17.6	2,975 lbf/ft
	EL87_W4.5xW3.5 (45 yrs)	Geosynthetic						0	17.6	2,975 lbf/ft
	EL89_W4.5xW3.5 (45 yrs)	Geosynthetic						0	17.6	2,975 lbf/ft
	EL91_W4.5xW3.5 (45 yrs)	Geosynthetic						0	17.6	2,975 lbf/ft
	EL93_W4.5xW3.5 (45 yrs)	Geosynthetic						0	17.6	2,975 lbf/ft
	Soil Nail_Row 1	Anchor	1,800	82,550	45	0.5	4			20,638 lbf/ft
	Soil Nail_Row 2	Anchor	1,800	82,550	45	0.5	4			20,638 lbf/ft
	Soil Nail_Row 3	Anchor	1,800	82,550	40	0.5	4			20,638 lbf/ft
	Soil Nail_Row 4	Anchor	1,800	82,550	40	0.5	4			20,638 lbf/ft

Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Common Borrow	Mohr-Coulomb	120	0	32
	ESU 1B - Existing Gravelly Granular Fill	Mohr-Coulomb	125	0	38
	ESU 2A - Native Sand and Gravel	Mohr-Coulomb	120	0	39
	ESU 2B - Native Sand and Gravel	Mohr-Coulomb	135	0	41
	ESU 2C - Native Silt	Mohr-Coulomb	110	0	29
	ESU 7A - Weathered Sandstone	Mohr-Coulomb	135	0	42
	Gravel Borrow	Mohr-Coulomb	130	0	38
	New Pier 1 Footing	High Strength	2,250		

Notes:

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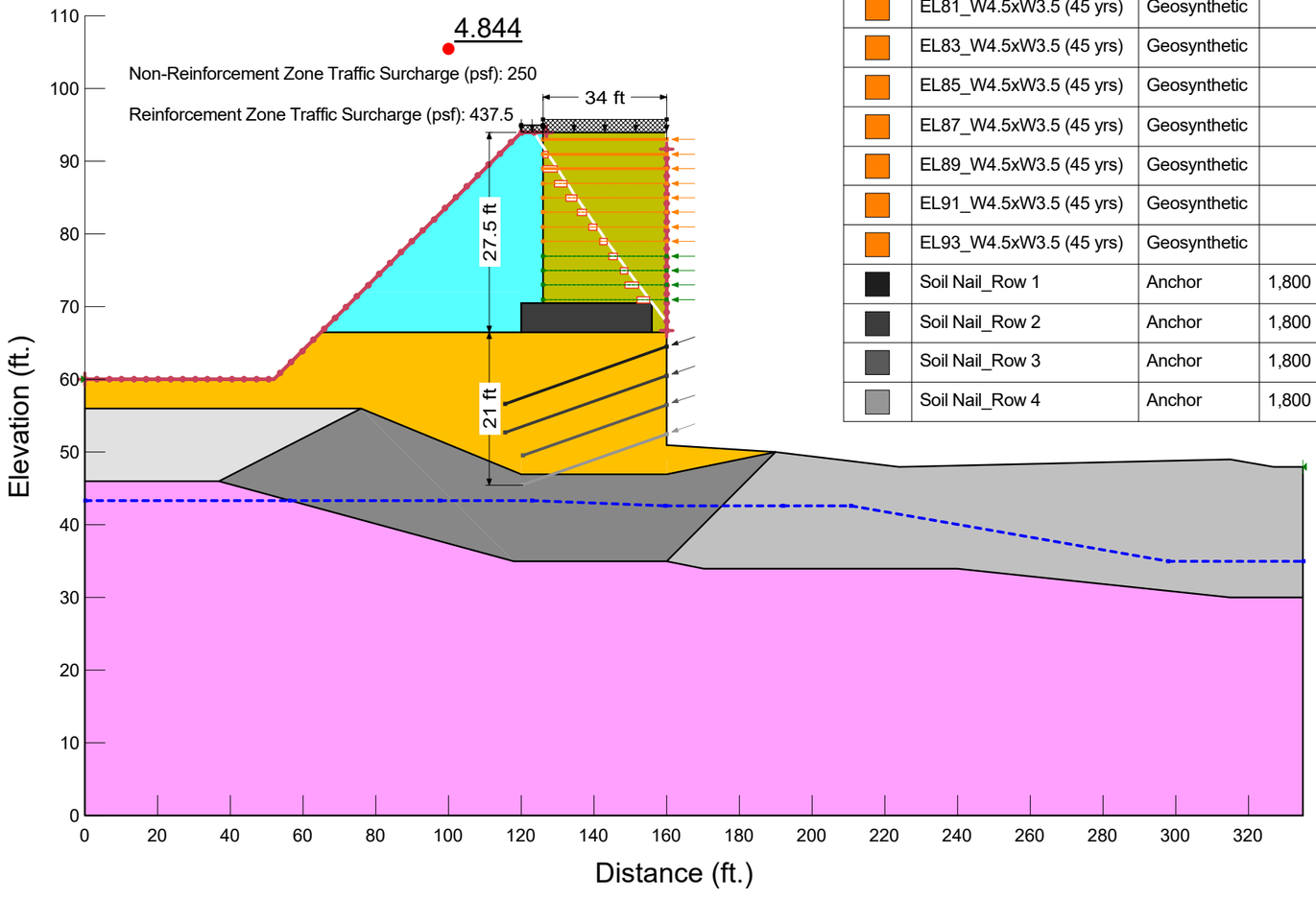
Bridge 17.7 - Wall 03.63L Section Fa-Fa'
Static Compound Stability (Spencer) - Final Condition

WSDOT I-405 Renton to Bellevue
King County, Washington

GeoEngineers

Figure D.5-11



Color	Name	Type	Pullout Resistance (psf)	Tensile Capacity (lbf)	Bond Length (ft)	Bond Diameter (ft)	Out-of-Plane Spacing (ft)	Interface Adhesion (psf)	Interface Shear Angle (°)	Factored Tensile Capacity
	EL71_W7.0xW3.5 (45 yrs)	Geosynthetic						0	11.5	4,901 lbf/ft
	EL73_W7.0xW3.5 (45 yrs)	Geosynthetic						0	11.5	4,901 lbf/ft
	EL75_W7.0xW3.5 (45 yrs)	Geosynthetic						0	22.2	4,901 lbf/ft
	EL77_W7.0xW3.5 (45 yrs)	Geosynthetic						0	22.2	4,901 lbf/ft
	EL79_W4.5xW3.5 (45 yrs)	Geosynthetic						0	17.6	2,975 lbf/ft
	EL81_W4.5xW3.5 (45 yrs)	Geosynthetic						0	17.6	2,975 lbf/ft
	EL83_W4.5xW3.5 (45 yrs)	Geosynthetic						0	17.6	2,975 lbf/ft
	EL85_W4.5xW3.5 (45 yrs)	Geosynthetic						0	17.6	2,975 lbf/ft
	EL87_W4.5xW3.5 (45 yrs)	Geosynthetic						0	17.6	2,975 lbf/ft
	EL89_W4.5xW3.5 (45 yrs)	Geosynthetic						0	17.6	2,975 lbf/ft
	EL91_W4.5xW3.5 (45 yrs)	Geosynthetic						0	17.6	2,975 lbf/ft
	EL93_W4.5xW3.5 (45 yrs)	Geosynthetic						0	17.6	2,975 lbf/ft
	Soil Nail_Row 1	Anchor	1,800	82,550	45	0.5	4			20,638 lbf/ft
	Soil Nail_Row 2	Anchor	1,800	82,550	45	0.5	4			20,638 lbf/ft
	Soil Nail_Row 3	Anchor	1,800	82,550	40	0.5	4			20,638 lbf/ft
	Soil Nail_Row 4	Anchor	1,800	82,550	40	0.5	4			20,638 lbf/ft

Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Common Borrow	Mohr-Coulomb	120	0	32
	ESU 1B - Existing Gravelly Granular Fill	Mohr-Coulomb	125	0	38
	ESU 2A - Native Sand and Gravel	Mohr-Coulomb	120	0	39
	ESU 2B - Native Sand and Gravel	Mohr-Coulomb	135	0	41
	ESU 2C - Native Silt	Mohr-Coulomb	110	0	29
	ESU 7A - Weathered Sandstone	Mohr-Coulomb	135	0	42
	Gravel Borrow	Mohr-Coulomb	130	0	38
	New Pier 1 Footing	High Strength	2,250		

Notes:

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Bridge 17.7 - Wall 03.63L Section Fa-Fa'
Static Compound Stability (M-P) - Final Condition

WSDOT I-405 Renton to Bellevue
King County, Washington

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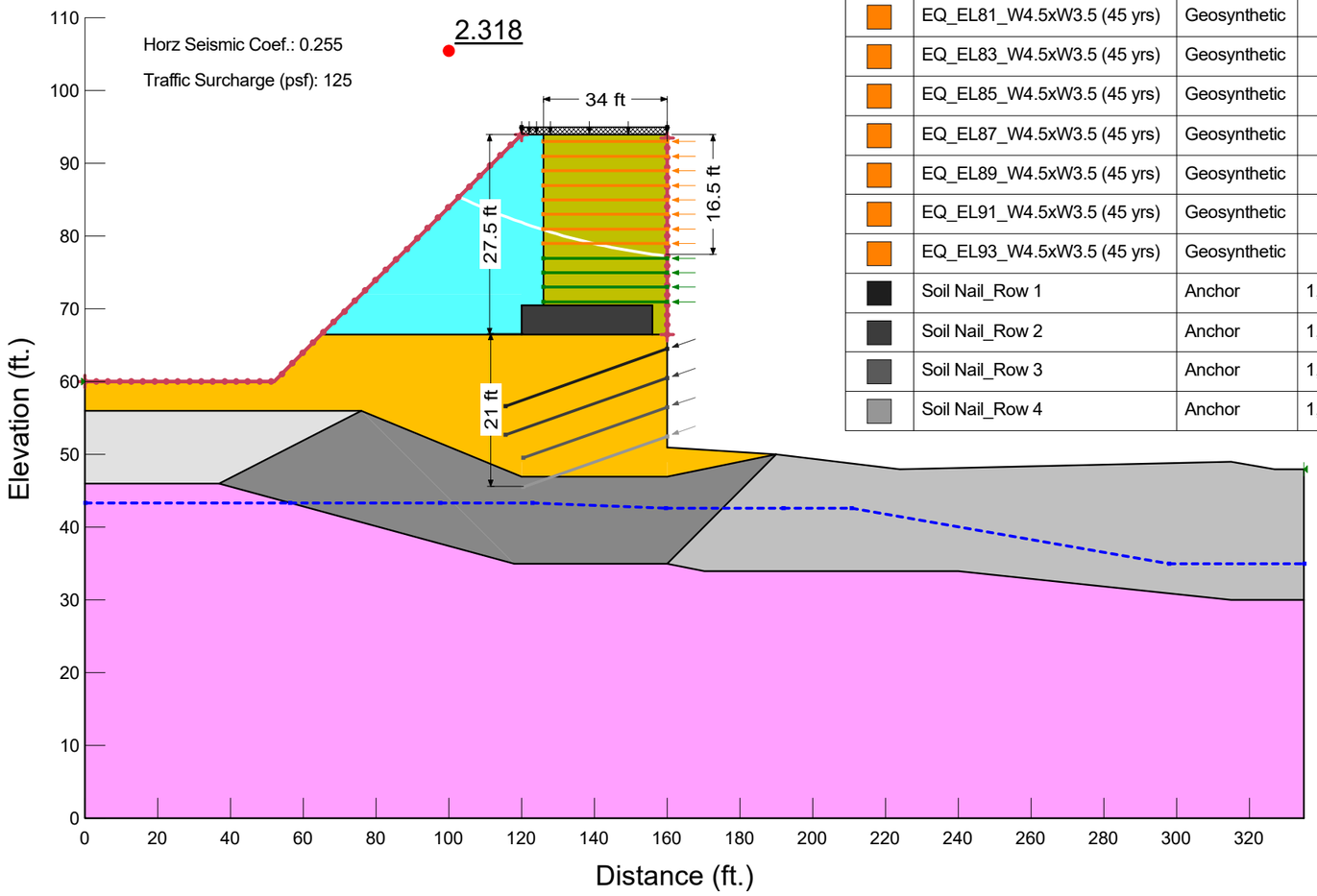
Figure D.5-12



Color	Name	Type	Pullout Resistance (psf)	Tensile Capacity (lbf)	Bond Length (ft)	Bond Diameter (ft)	Out-of-Plane Spacing (ft)	Interface Adhesion (psf)	Interface Shear Angle (°)	Factored Tensile Capacity
	EQ_EL71_W7.0xW3.5 (45 yrs)	Geosynthetic						0	15.2	6,409 lbf/ft
	EQ_EL73_W7.0xW3.5 (45 yrs)	Geosynthetic						0	15.2	6,409 lbf/ft
	EQ_EL75_W7.0xW3.5 (45 yrs)	Geosynthetic						0	28.5	6,409 lbf/ft
	EQ_EL77_W7.0xW3.5 (45 yrs)	Geosynthetic						0	28.5	6,409 lbf/ft
	EQ_EL79_W4.5xW3.5 (45 yrs)	Geosynthetic						0	23	3,891 lbf/ft
	EQ_EL81_W4.5xW3.5 (45 yrs)	Geosynthetic						0	23	3,891 lbf/ft
	EQ_EL83_W4.5xW3.5 (45 yrs)	Geosynthetic						0	23	3,891 lbf/ft
	EQ_EL85_W4.5xW3.5 (45 yrs)	Geosynthetic						0	23	3,891 lbf/ft
	EQ_EL87_W4.5xW3.5 (45 yrs)	Geosynthetic						0	23	3,891 lbf/ft
	EQ_EL89_W4.5xW3.5 (45 yrs)	Geosynthetic						0	23	3,891 lbf/ft
	EQ_EL91_W4.5xW3.5 (45 yrs)	Geosynthetic						0	23	3,891 lbf/ft
	EQ_EL93_W4.5xW3.5 (45 yrs)	Geosynthetic						0	23	3,891 lbf/ft
	Soil Nail_Row 1	Anchor	1,800	82,550	45	0.5	4			20,638 lbf/ft
	Soil Nail_Row 2	Anchor	1,800	82,550	45	0.5	4			20,638 lbf/ft
	Soil Nail_Row 3	Anchor	1,800	82,550	40	0.5	4			20,638 lbf/ft
	Soil Nail_Row 4	Anchor	1,800	82,550	40	0.5	4			20,638 lbf/ft

Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Common Borrow	Mohr-Coulomb	120	0	32
	ESU 1B - Existing Gravelly Granular Fill	Mohr-Coulomb	125	0	38
	ESU 2A - Native Sand and Gravel	Mohr-Coulomb	120	0	39
	ESU 2B - Native Sand and Gravel	Mohr-Coulomb	135	0	41
	ESU 2C - Native Silt (Pseudo-Static)	Mohr-Coulomb	110	200	29
	ESU 7A - Weathered Sandstone	Mohr-Coulomb	135	0	42
	Gravel Borrow	Mohr-Coulomb	130	0	38
	New Pier 1 Footing	High Strength	2,250		

Notes:

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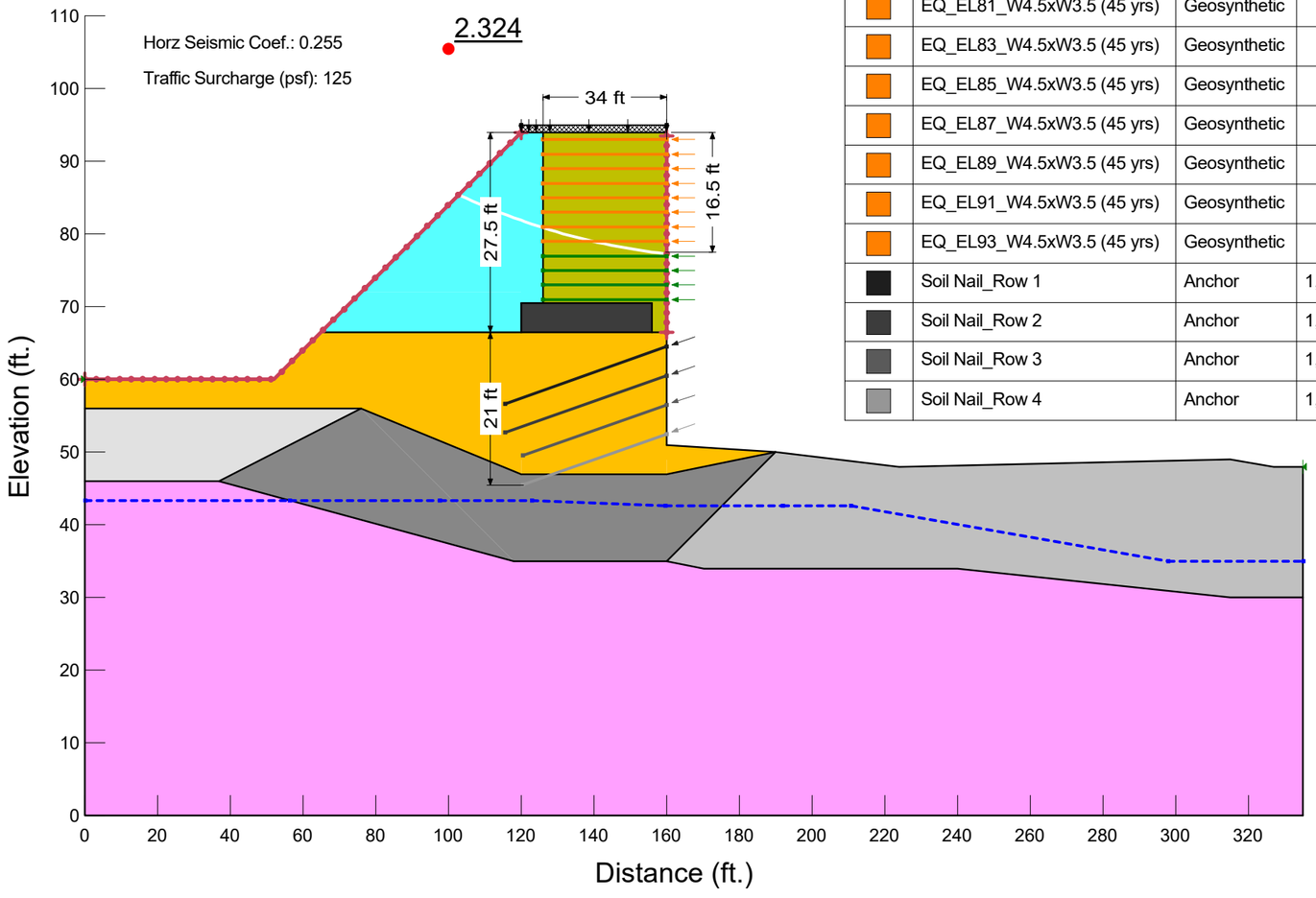
Bridge 17.7 - Wall 03.63L Section Fa-Fa'
Pseudo-Static Compound Stability (Spencer) - Final Condition

WSDOT I-405 Renton to Bellevue
King County, Washington

GeoEngineers

Figure D.5-13



Color	Name	Type	Pullout Resistance (psf)	Tensile Capacity (lbf)	Bond Length (ft)	Bond Diameter (ft)	Out-of-Plane Spacing (ft)	Interface Adhesion (psf)	Interface Shear Angle (°)	Factored Tensile Capacity
	EQ_EL71_W7.0xW3.5 (45 yrs)	Geosynthetic						0	15.2	6,409 lbf/ft
	EQ_EL73_W7.0xW3.5 (45 yrs)	Geosynthetic						0	15.2	6,409 lbf/ft
	EQ_EL75_W7.0xW3.5 (45 yrs)	Geosynthetic						0	28.5	6,409 lbf/ft
	EQ_EL77_W7.0xW3.5 (45 yrs)	Geosynthetic						0	28.5	6,409 lbf/ft
	EQ_EL79_W4.5xW3.5 (45 yrs)	Geosynthetic						0	23	3,891 lbf/ft
	EQ_EL81_W4.5xW3.5 (45 yrs)	Geosynthetic						0	23	3,891 lbf/ft
	EQ_EL83_W4.5xW3.5 (45 yrs)	Geosynthetic						0	23	3,891 lbf/ft
	EQ_EL85_W4.5xW3.5 (45 yrs)	Geosynthetic						0	23	3,891 lbf/ft
	EQ_EL87_W4.5xW3.5 (45 yrs)	Geosynthetic						0	23	3,891 lbf/ft
	EQ_EL89_W4.5xW3.5 (45 yrs)	Geosynthetic						0	23	3,891 lbf/ft
	EQ_EL91_W4.5xW3.5 (45 yrs)	Geosynthetic						0	23	3,891 lbf/ft
	EQ_EL93_W4.5xW3.5 (45 yrs)	Geosynthetic						0	23	3,891 lbf/ft
	Soil Nail_Row 1	Anchor	1,800	82,550	45	0.5	4			20,638 lbf/ft
	Soil Nail_Row 2	Anchor	1,800	82,550	45	0.5	4			20,638 lbf/ft
	Soil Nail_Row 3	Anchor	1,800	82,550	40	0.5	4			20,638 lbf/ft
	Soil Nail_Row 4	Anchor	1,800	82,550	40	0.5	4			20,638 lbf/ft

Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Common Borrow	Mohr-Coulomb	120	0	32
	ESU 1B - Existing Gravelly Granular Fill	Mohr-Coulomb	125	0	38
	ESU 2A - Native Sand and Gravel	Mohr-Coulomb	120	0	39
	ESU 2B - Native Sand and Gravel	Mohr-Coulomb	135	0	41
	ESU 2C - Native Silt (Pseudo-Static)	Mohr-Coulomb	110	200	29
	ESU 7A - Weathered Sandstone	Mohr-Coulomb	135	0	42
	Gravel Borrow	Mohr-Coulomb	130	0	38
	New Pier 1 Footing	High Strength	2,250		

Notes:

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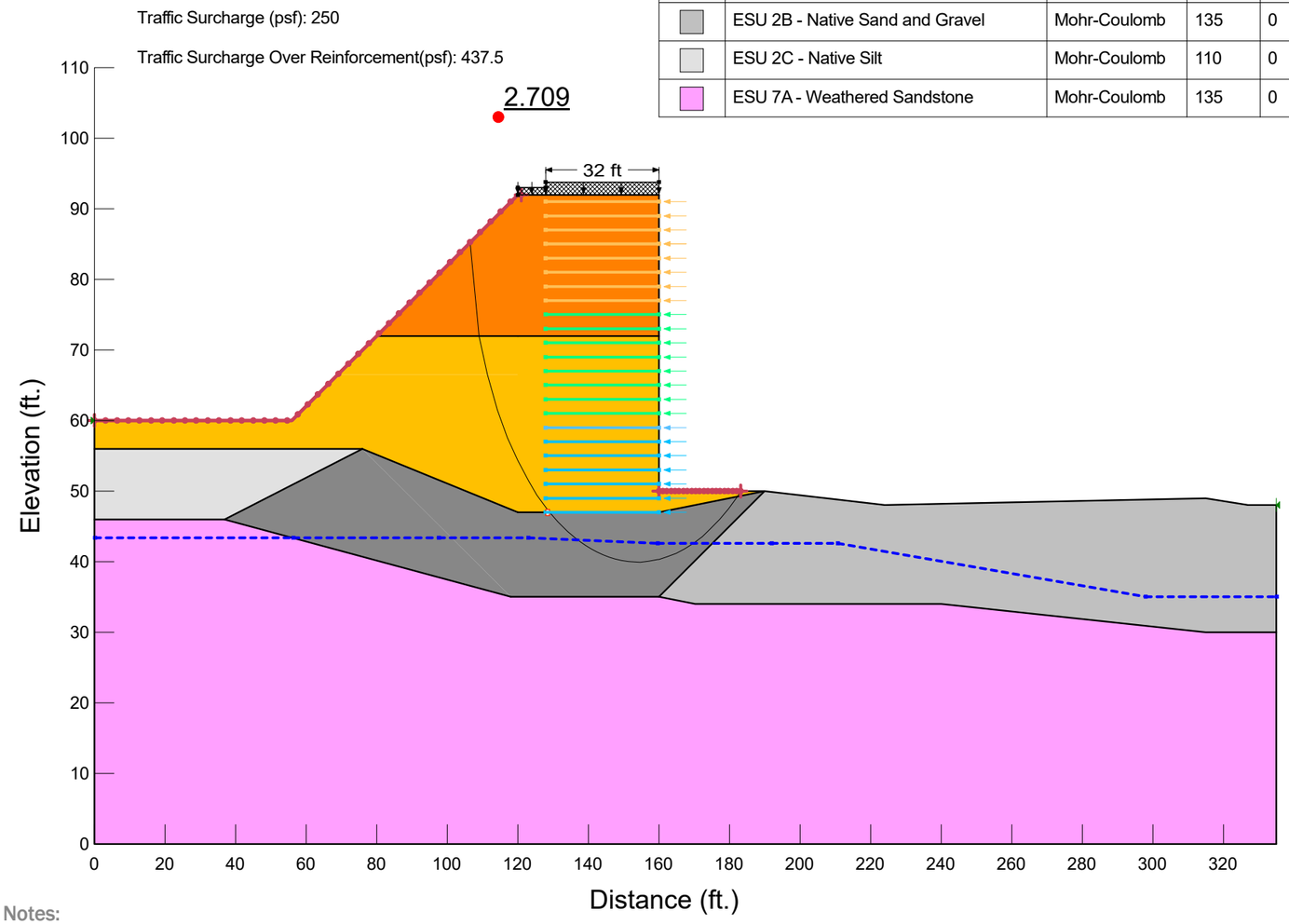
Bridge 17.7 - Wall 03.63L Section Fa-Fa'
Pseudo-Static Compound Stability (M-P) - Final Condition

WSDOT I-405 Renton to Bellevue
King County, Washington

GeoEngineers

Figure D.5-14

Color	Name	Slope Stability Material Model	Unit Weight	Effective Cohesion	Effective Friction Angle
	ESU 1A - Existing Granular Fill	Mohr-Coulomb	120	0	40
	ESU 1B - Existing Gravelly Granular Fill	Mohr-Coulomb	125	0	38
	ESU 2A - Native Sand and Gravel	Mohr-Coulomb	120	0	39
	ESU 2B - Native Sand and Gravel	Mohr-Coulomb	135	0	41
	ESU 2C - Native Silt	Mohr-Coulomb	110	0	29
	ESU 7A - Weathered Sandstone	Mohr-Coulomb	135	0	43



Color	Name	Type	Interface Adhesion	Interface Shear Angle	Factored Tensile Capacity
	EL47_W9.5xW4	Geosynthetic	0	14.1	7,441 lbf/ft
	EL49_W9.5xW4	Geosynthetic	0	14.1	7,441 lbf/ft
	EL51_W9.5xW4	Geosynthetic	0	14.1	7,441 lbf/ft
	EL53_W9.5xW4	Geosynthetic	0	14.1	7,441 lbf/ft
	EL55_W9.5xW4	Geosynthetic	0	14.1	7,441 lbf/ft
	EL57_W9.5xW4	Geosynthetic	0	14.1	7,441 lbf/ft
	EL59_W7.0xW3.5	Geosynthetic	0	14.1	7,441 lbf/ft
	EL61_W7.0xW3.5	Geosynthetic	0	12.1	5,422 lbf/ft
	EL63_W7.0xW3.5	Geosynthetic	0	12.1	5,422 lbf/ft
	EL65_W7.0xW3.5	Geosynthetic	0	12.1	5,422 lbf/ft
	EL67_W7.0xW3.5	Geosynthetic	0	12.1	5,422 lbf/ft
	EL69_W7.0xW3.5	Geosynthetic	0	12.1	5,422 lbf/ft
	EL71_W7.0xW3.5	Geosynthetic	0	12.1	5,422 lbf/ft
	EL73_W7.0xW3.5	Geosynthetic	0	23.2	5,422 lbf/ft
	EL75_W7.0xW3.5	Geosynthetic	0	23.2	5,422 lbf/ft
	EL77_W4.5xW3.5	Geosynthetic	0	18.7	3,385 lbf/ft
	EL79_W4.5xW3.5	Geosynthetic	0	18.7	3,385 lbf/ft
	EL81_W4.5xW3.5	Geosynthetic	0	18.7	3,385 lbf/ft
	EL83_W4.5xW3.5	Geosynthetic	0	18.7	3,385 lbf/ft
	EL85_W4.5xW3.5	Geosynthetic	0	18.7	3,385 lbf/ft
	EL87_W4.5xW3.5	Geosynthetic	0	18.7	3,385 lbf/ft
	EL89_W4.5xW3.5	Geosynthetic	0	18.7	3,385 lbf/ft
	EL91_W4.5xW3.5	Geosynthetic	0	18.7	3,385 lbf/ft

Notes:

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2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document.
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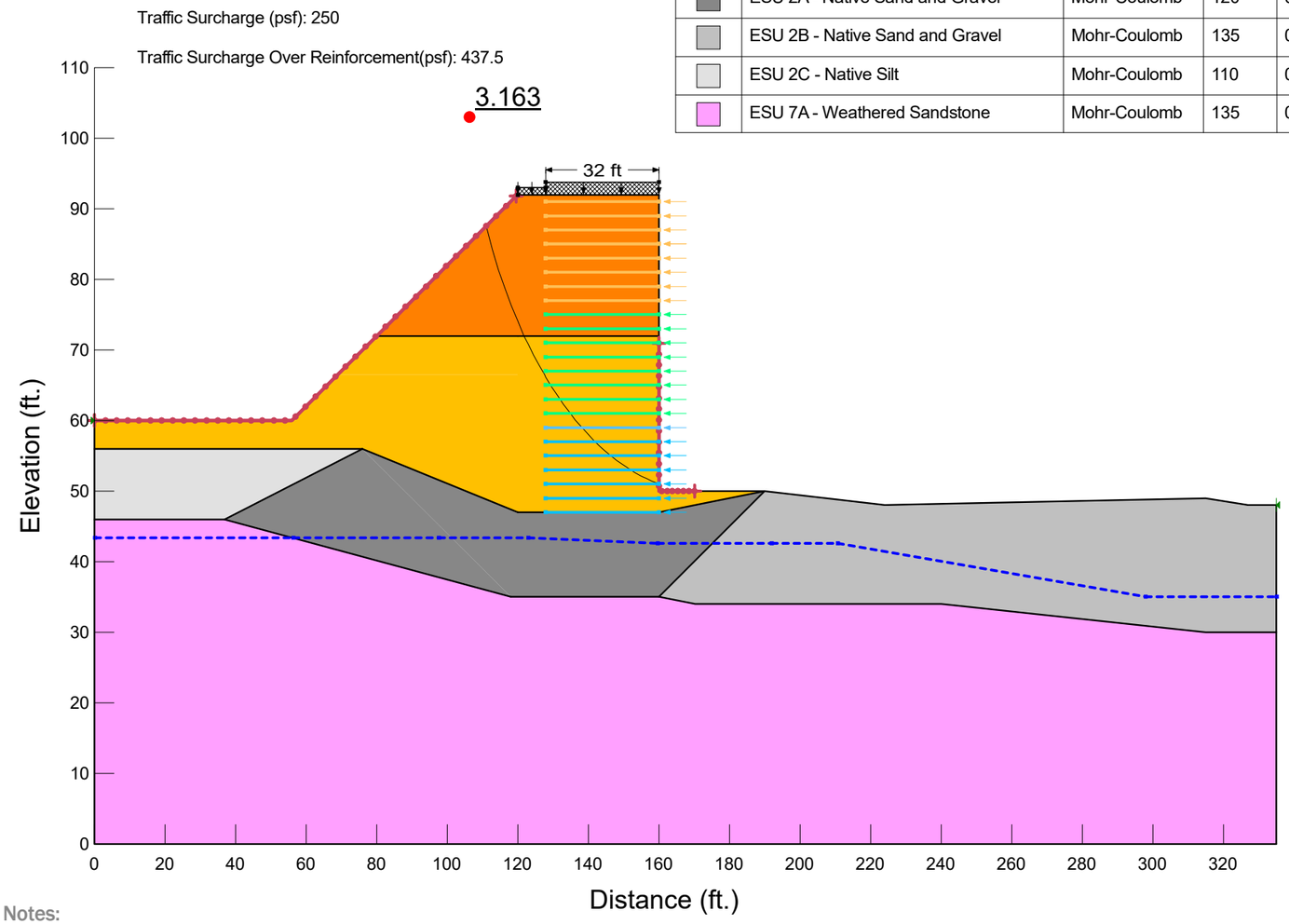
Bridge 17.7 - Wall 03.63L Section Ga-Ga'
Static Compound Stability (Spencer) - Existing Condition

WSDOT I-405 Renton to Bellevue
King County, Washington

GeoEngineers

Figure D.5-15



Color	Name	Slope Stability Material Model	Unit Weight	Effective Cohesion	Effective Friction Angle
	ESU 1A - Existing Granular Fill	Mohr-Coulomb	120	0	40
	ESU 1B - Existing Gravelly Granular Fill	Mohr-Coulomb	125	0	38
	ESU 2A - Native Sand and Gravel	Mohr-Coulomb	120	0	39
	ESU 2B - Native Sand and Gravel	Mohr-Coulomb	135	0	41
	ESU 2C - Native Silt	Mohr-Coulomb	110	0	29
	ESU 7A - Weathered Sandstone	Mohr-Coulomb	135	0	43

Color	Name	Type	Interface Adhesion	Interface Shear Angle	Factored Tensile Capacity
	EL47_W9.5xW4	Geosynthetic	0	14.1	7,441 lbf/ft
	EL49_W9.5xW4	Geosynthetic	0	14.1	7,441 lbf/ft
	EL51_W9.5xW4	Geosynthetic	0	14.1	7,441 lbf/ft
	EL53_W9.5xW4	Geosynthetic	0	14.1	7,441 lbf/ft
	EL55_W9.5xW4	Geosynthetic	0	14.1	7,441 lbf/ft
	EL57_W9.5xW4	Geosynthetic	0	14.1	7,441 lbf/ft
	EL59_W7.0xW3.5	Geosynthetic	0	14.1	7,441 lbf/ft
	EL61_W7.0xW3.5	Geosynthetic	0	12.1	5,422 lbf/ft
	EL63_W7.0xW3.5	Geosynthetic	0	12.1	5,422 lbf/ft
	EL65_W7.0xW3.5	Geosynthetic	0	12.1	5,422 lbf/ft
	EL67_W7.0xW3.5	Geosynthetic	0	12.1	5,422 lbf/ft
	EL69_W7.0xW3.5	Geosynthetic	0	12.1	5,422 lbf/ft
	EL71_W7.0xW3.5	Geosynthetic	0	12.1	5,422 lbf/ft
	EL73_W7.0xW3.5	Geosynthetic	0	23.2	5,422 lbf/ft
	EL75_W7.0xW3.5	Geosynthetic	0	23.2	5,422 lbf/ft
	EL77_W4.5xW3.5	Geosynthetic	0	18.7	3,385 lbf/ft
	EL79_W4.5xW3.5	Geosynthetic	0	18.7	3,385 lbf/ft
	EL81_W4.5xW3.5	Geosynthetic	0	18.7	3,385 lbf/ft
	EL83_W4.5xW3.5	Geosynthetic	0	18.7	3,385 lbf/ft
	EL85_W4.5xW3.5	Geosynthetic	0	18.7	3,385 lbf/ft
	EL87_W4.5xW3.5	Geosynthetic	0	18.7	3,385 lbf/ft
	EL89_W4.5xW3.5	Geosynthetic	0	18.7	3,385 lbf/ft
	EL91_W4.5xW3.5	Geosynthetic	0	18.7	3,385 lbf/ft

Notes:

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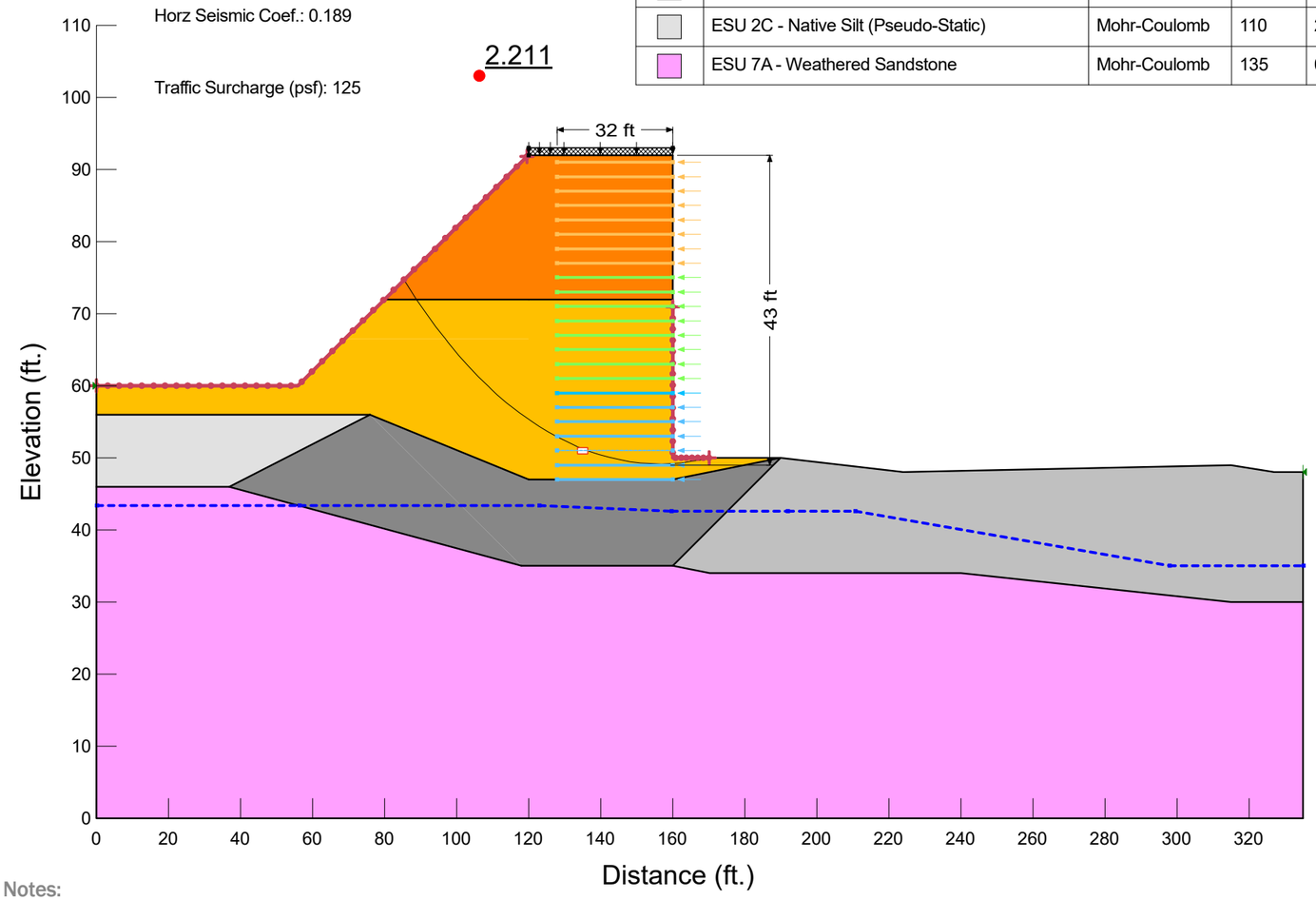
Bridge 17.7 - Wall 03.63L Section Ga-Ga'
Static Compound Stability (M-P) - Existing Condition

WSDOT I-405 Renton to Bellevue
King County, Washington

GeoEngineers

Figure D.5-16

Color	Name	Slope Stability Material Model	Unit Weight	Effective Cohesion	Effective Friction Angle
	ESU 1A - Existing Granular Fill (Pseudo-Static)	Mohr-Coulomb	120	50	40
	ESU 1B - Existing Gravelly Granular Fill	Mohr-Coulomb	125	0	38
	ESU 2A - Native Sand and Gravel	Mohr-Coulomb	120	0	39
	ESU 2B - Native Sand and Gravel	Mohr-Coulomb	135	0	41
	ESU 2C - Native Silt (Pseudo-Static)	Mohr-Coulomb	110	200	29
	ESU 7A - Weathered Sandstone	Mohr-Coulomb	135	0	43



Color	Name	Type	Interface Adhesion	Interface Shear Angle	Factored Tensile Capacity
	EQ_EL47_W9.5xW4	Geosynthetic	0	18.5	9,730 lbf/ft
	EQ_EL49_W9.5xW4	Geosynthetic	0	18.5	9,730 lbf/ft
	EQ_EL51_W9.5xW4	Geosynthetic	0	18.5	9,730 lbf/ft
	EQ_EL53_W9.5xW4	Geosynthetic	0	18.5	9,730 lbf/ft
	EQ_EL55_W9.5xW4	Geosynthetic	0	18.5	9,730 lbf/ft
	EQ_EL57_W9.5xW4	Geosynthetic	0	18.5	9,730 lbf/ft
	EQ_EL59_W7.0xW3.5	Geosynthetic	0	18.5	9,730 lbf/ft
	EQ_EL61_W7.0xW3.5	Geosynthetic	0	16	7,091 lbf/ft
	EQ_EL63_W7.0xW3.5	Geosynthetic	0	16	7,091 lbf/ft
	EQ_EL65_W7.0xW3.5	Geosynthetic	0	16	7,091 lbf/ft
	EQ_EL67_W7.0xW3.5	Geosynthetic	0	16	7,091 lbf/ft
	EQ_EL69_W7.0xW3.5	Geosynthetic	0	16	7,091 lbf/ft
	EQ_EL71_W7.0xW3.5	Geosynthetic	0	16	7,091 lbf/ft
	EQ_EL73_W7.0xW3.5	Geosynthetic	0	29.8	7,091 lbf/ft
	EQ_EL75_W7.0xW3.5	Geosynthetic	0	29.8	7,091 lbf/ft
	EQ_EL77_W4.5xW3.5	Geosynthetic	0	24.3	4,426 lbf/ft
	EQ_EL79_W4.5xW3.5	Geosynthetic	0	24.3	4,426 lbf/ft
	EQ_EL81_W4.5xW3.5	Geosynthetic	0	24.3	4,426 lbf/ft
	EQ_EL83_W4.5xW3.5	Geosynthetic	0	24.3	4,426 lbf/ft
	EQ_EL85_W4.5xW3.5	Geosynthetic	0	24.3	4,426 lbf/ft
	EQ_EL87_W4.5xW3.5	Geosynthetic	0	24.3	4,426 lbf/ft
	EQ_EL89_W4.5xW3.5	Geosynthetic	0	24.3	4,426 lbf/ft
	EQ_EL91_W4.5xW3.5	Geosynthetic	0	24.3	4,426 lbf/ft

Notes:

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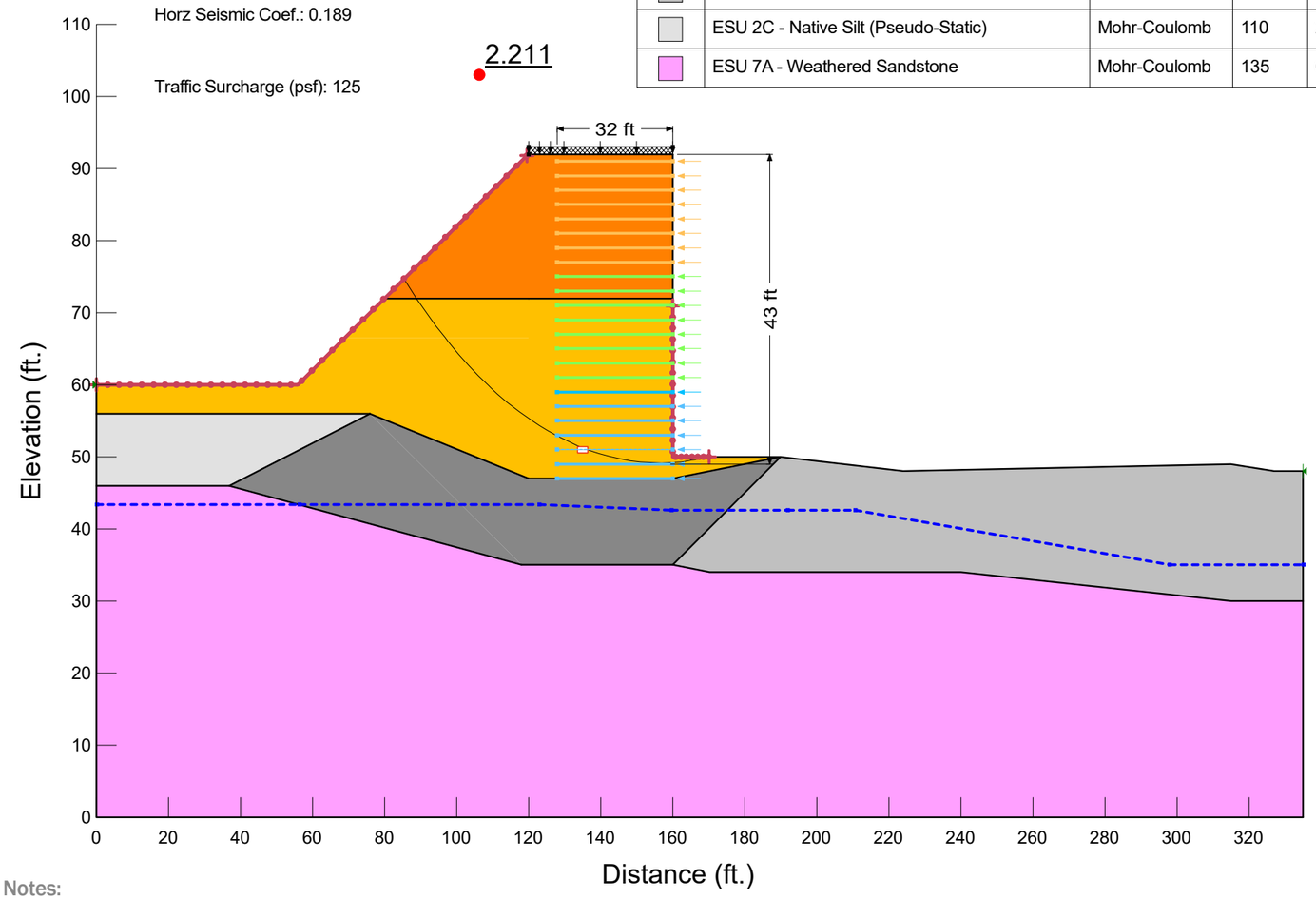
Bridge 17.7 - Wall 03.63L Section Ga-Ga'
Pseudo-Static Compound Stability (Spencer) - Existing Condition

WSDOT I-405 Renton to Bellevue
King County, Washington

GeoEngineers

Figure D.5-17

Color	Name	Slope Stability Material Model	Unit Weight	Effective Cohesion	Effective Friction Angle
	ESU 1A - Existing Granular Fill (Pseudo-Static)	Mohr-Coulomb	120	50	40
	ESU 1B - Existing Gravelly Granular Fill	Mohr-Coulomb	125	0	38
	ESU 2A - Native Sand and Gravel	Mohr-Coulomb	120	0	39
	ESU 2B - Native Sand and Gravel	Mohr-Coulomb	135	0	41
	ESU 2C - Native Silt (Pseudo-Static)	Mohr-Coulomb	110	200	29
	ESU 7A - Weathered Sandstone	Mohr-Coulomb	135	0	43



Color	Name	Type	Interface Adhesion	Interface Shear Angle	Factored Tensile Capacity
	EQ_EL47_W9.5xW4	Geosynthetic	0	18.5	9,730 lbf/ft
	EQ_EL49_W9.5xW4	Geosynthetic	0	18.5	9,730 lbf/ft
	EQ_EL51_W9.5xW4	Geosynthetic	0	18.5	9,730 lbf/ft
	EQ_EL53_W9.5xW4	Geosynthetic	0	18.5	9,730 lbf/ft
	EQ_EL55_W9.5xW4	Geosynthetic	0	18.5	9,730 lbf/ft
	EQ_EL57_W9.5xW4	Geosynthetic	0	18.5	9,730 lbf/ft
	EQ_EL59_W7.0xW3.5	Geosynthetic	0	18.5	9,730 lbf/ft
	EQ_EL61_W7.0xW3.5	Geosynthetic	0	16	7,091 lbf/ft
	EQ_EL63_W7.0xW3.5	Geosynthetic	0	16	7,091 lbf/ft
	EQ_EL65_W7.0xW3.5	Geosynthetic	0	16	7,091 lbf/ft
	EQ_EL67_W7.0xW3.5	Geosynthetic	0	16	7,091 lbf/ft
	EQ_EL69_W7.0xW3.5	Geosynthetic	0	16	7,091 lbf/ft
	EQ_EL71_W7.0xW3.5	Geosynthetic	0	16	7,091 lbf/ft
	EQ_EL73_W7.0xW3.5	Geosynthetic	0	29.8	7,091 lbf/ft
	EQ_EL75_W7.0xW3.5	Geosynthetic	0	29.8	7,091 lbf/ft
	EQ_EL77_W4.5xW3.5	Geosynthetic	0	24.3	4,426 lbf/ft
	EQ_EL79_W4.5xW3.5	Geosynthetic	0	24.3	4,426 lbf/ft
	EQ_EL81_W4.5xW3.5	Geosynthetic	0	24.3	4,426 lbf/ft
	EQ_EL83_W4.5xW3.5	Geosynthetic	0	24.3	4,426 lbf/ft
	EQ_EL85_W4.5xW3.5	Geosynthetic	0	24.3	4,426 lbf/ft
	EQ_EL87_W4.5xW3.5	Geosynthetic	0	24.3	4,426 lbf/ft
	EQ_EL89_W4.5xW3.5	Geosynthetic	0	24.3	4,426 lbf/ft
	EQ_EL91_W4.5xW3.5	Geosynthetic	0	24.3	4,426 lbf/ft

Notes:

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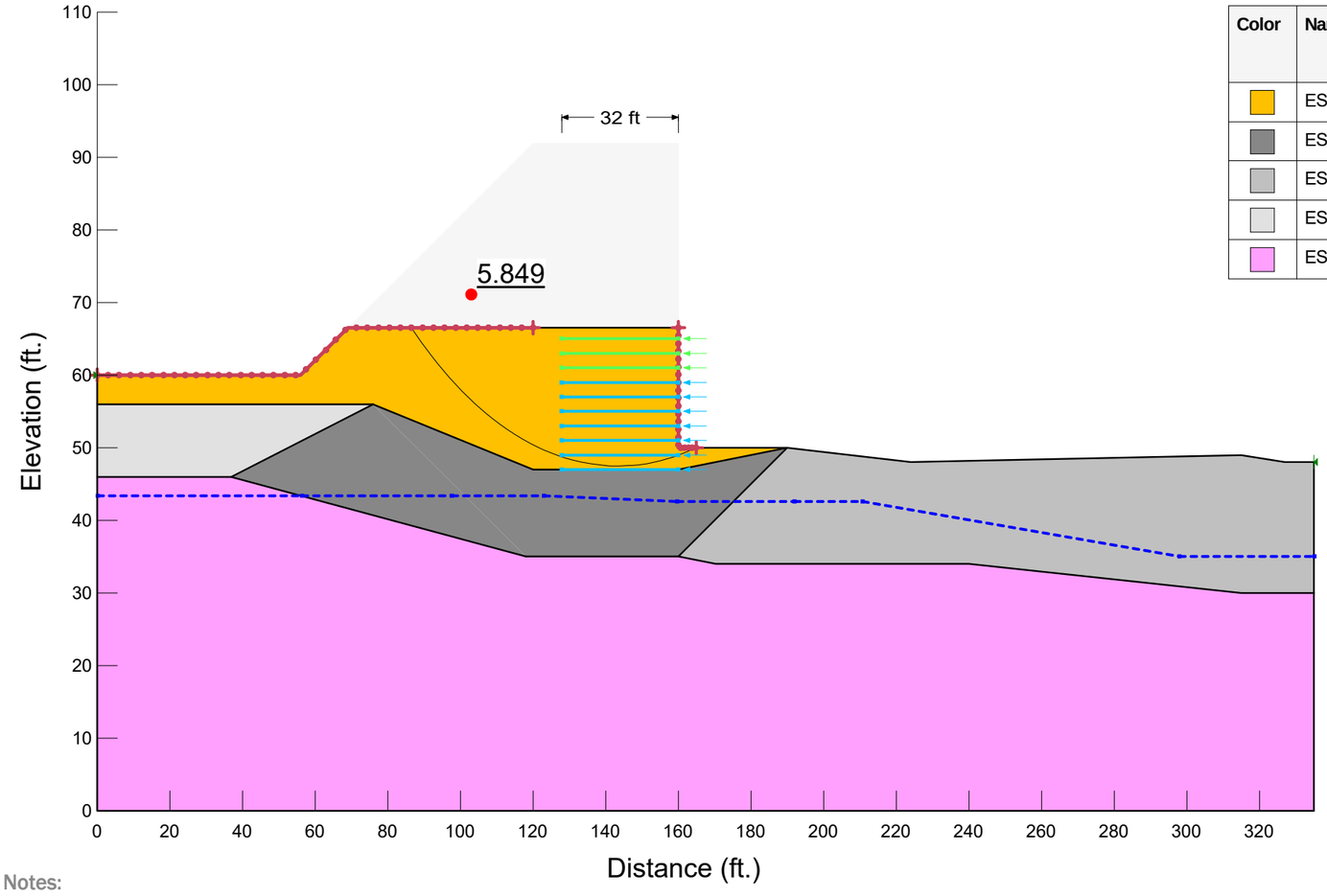
Bridge 17.7 - Wall 03.63L Section Ga-Ga'
Pseudo-Static Compound Stability (M-P) - Existing Condition

WSDOT I-405 Renton to Bellevue
King County, Washington

GeoEngineers

Figure D.5-18



Color	Name	Slope Stability Material Model	Unit Weight	Effective Cohesion	Effective Friction Angle
	ESU 1B - Existing Gravelly Granular Fill	Mohr-Coulomb	125	0	38
	ESU 2A - Native Sand and Gravel	Mohr-Coulomb	120	0	39
	ESU 2B - Native Sand and Gravel	Mohr-Coulomb	135	0	41
	ESU 2C - Native Silt	Mohr-Coulomb	110	0	29
	ESU 7A - Weathered Sandstone	Mohr-Coulomb	135	0	43

Color	Name	Type	Interface Adhesion	Interface Shear Angle	Factored Tensile Capacity
	Con_EL47_W9.5xW4	Geosynthetic	0	26.7	7,441 lbf/ft
	Con_EL49_W9.5xW4	Geosynthetic	0	26.7	7,441 lbf/ft
	Con_EL51_W9.5xW4	Geosynthetic	0	26.7	7,441 lbf/ft
	Con_EL53_W9.5xW4	Geosynthetic	0	26.7	7,441 lbf/ft
	Con_EL55_W9.5xW4	Geosynthetic	0	26.7	7,441 lbf/ft
	Con_EL57_W9.5xW4	Geosynthetic	0	26.7	7,441 lbf/ft
	Con_EL59_W7.0xW3.5	Geosynthetic	0	26.7	7,441 lbf/ft
	Con_EL61_W7.0xW3.5	Geosynthetic	0	23.2	5,422 lbf/ft
	Con_EL63_W7.0xW3.5	Geosynthetic	0	23.2	5,422 lbf/ft
	Con_EL65_W7.0xW3.5	Geosynthetic	0	23.2	5,422 lbf/ft

Notes:

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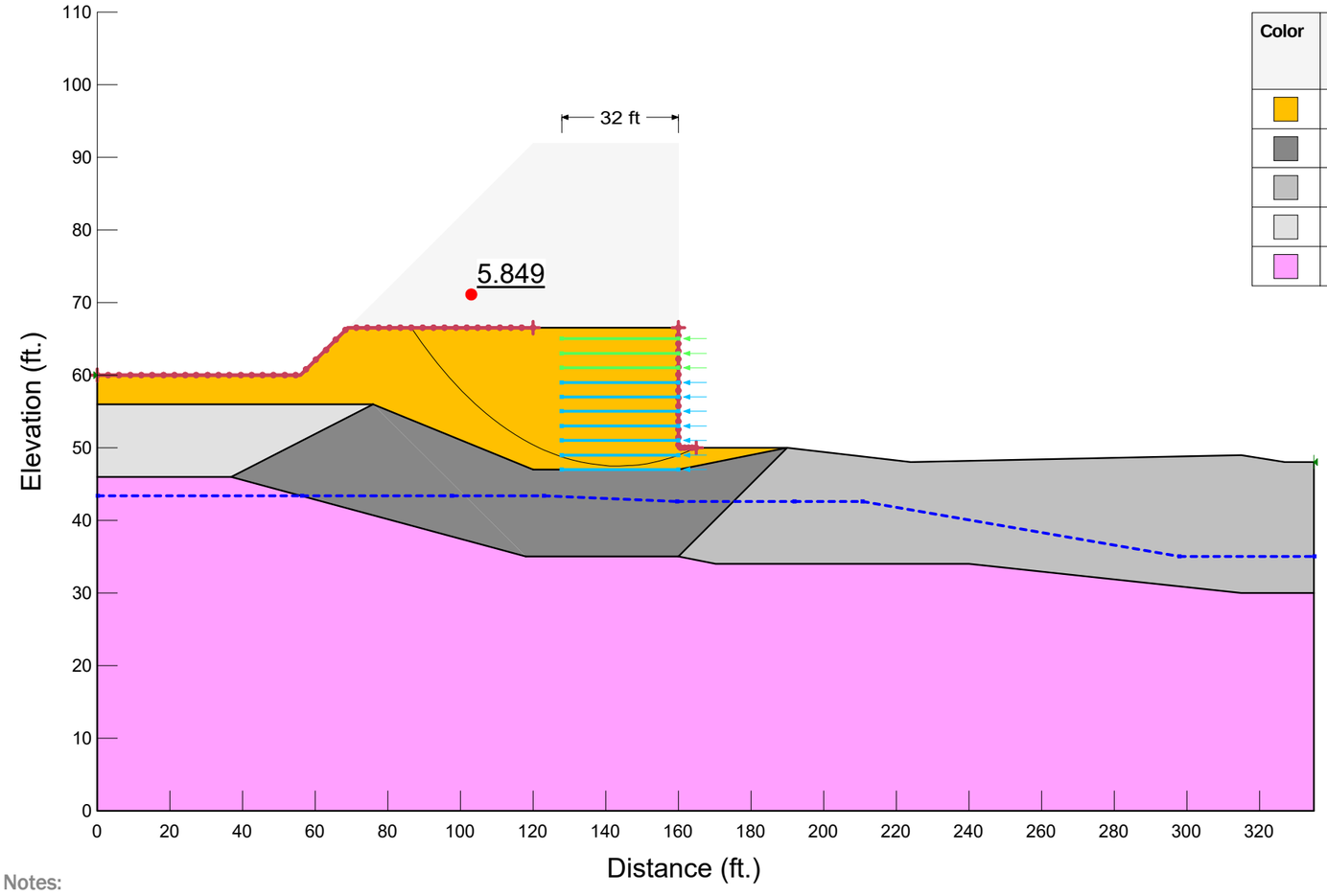
Bridge 17.7 - Wall 03.63L Section Ga-Ga'
Static Compound Stability (Spencer) - Construction Condition

WSDOT I-405 Renton to Bellevue
King County, Washington

GeoEngineers

Figure D.5-19



Color	Name	Slope Stability Material Model	Unit Weight	Effective Cohesion	Effective Friction Angle
	ESU 1B - Existing Gravelly Granular Fill	Mohr-Coulomb	125	0	38
	ESU 2A - Native Sand and Gravel	Mohr-Coulomb	120	0	39
	ESU 2B - Native Sand and Gravel	Mohr-Coulomb	135	0	41
	ESU 2C - Native Silt	Mohr-Coulomb	110	0	29
	ESU 7A - Weathered Sandstone	Mohr-Coulomb	135	0	43

Color	Name	Type	Interface Adhesion	Interface Shear Angle	Factored Tensile Capacity
	Con_EL47_W9.5xW4	Geosynthetic	0	26.7	7,441 lbf/ft
	Con_EL49_W9.5xW4	Geosynthetic	0	26.7	7,441 lbf/ft
	Con_EL51_W9.5xW4	Geosynthetic	0	26.7	7,441 lbf/ft
	Con_EL53_W9.5xW4	Geosynthetic	0	26.7	7,441 lbf/ft
	Con_EL55_W9.5xW4	Geosynthetic	0	26.7	7,441 lbf/ft
	Con_EL57_W9.5xW4	Geosynthetic	0	26.7	7,441 lbf/ft
	Con_EL59_W7.0xW3.5	Geosynthetic	0	26.7	7,441 lbf/ft
	Con_EL61_W7.0xW3.5	Geosynthetic	0	23.2	5,422 lbf/ft
	Con_EL63_W7.0xW3.5	Geosynthetic	0	23.2	5,422 lbf/ft
	Con_EL65_W7.0xW3.5	Geosynthetic	0	23.2	5,422 lbf/ft

Notes:

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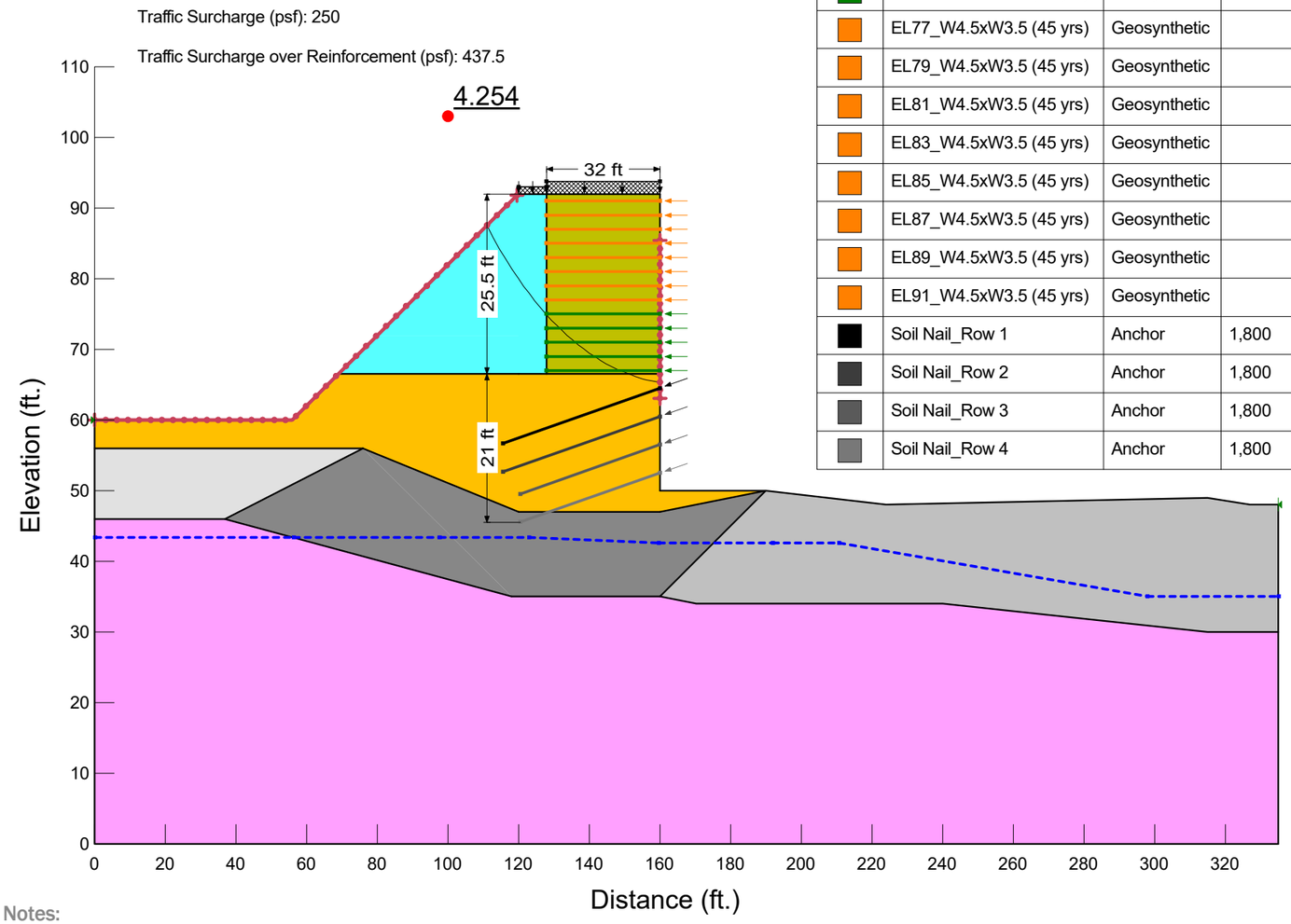
Bridge 17.7 - Wall 03.63L Section Ga-Ga'
Static Compound Stability (M-P) - Construction Condition

WSDOT I-405 Renton to Bellevue
King County, Washington

GeoEngineers

Figure D.5-20



Color	Name	Type	Pullout Resistance (psf)	Tensile Capacity (lbf)	Bond Length (ft)	Bond Diameter (ft)	Out-of-Plane Spacing (ft)	Interface Adhesion (psf)	Interface Shear Angle (°)	Factored Tensile Capacity
	EL67_W7.0xW3.5 (45 yrs)	Geosynthetic						0	11.5	4,901 lbf/ft
	EL69_W7.0xW3.5 (45 yrs)	Geosynthetic						0	11.5	4,901 lbf/ft
	EL71_W7.0xW3.5 (45 yrs)	Geosynthetic						0	11.5	4,901 lbf/ft
	EL73_W7.0xW3.5 (45 yrs)	Geosynthetic						0	22.2	4,901 lbf/ft
	EL75_W7.0xW3.5 (45 yrs)	Geosynthetic						0	22.2	4,901 lbf/ft
	EL77_W4.5xW3.5 (45 yrs)	Geosynthetic						0	17.6	2,975 lbf/ft
	EL79_W4.5xW3.5 (45 yrs)	Geosynthetic						0	17.6	2,975 lbf/ft
	EL81_W4.5xW3.5 (45 yrs)	Geosynthetic						0	17.6	2,975 lbf/ft
	EL83_W4.5xW3.5 (45 yrs)	Geosynthetic						0	17.6	2,975 lbf/ft
	EL85_W4.5xW3.5 (45 yrs)	Geosynthetic						0	17.6	2,975 lbf/ft
	EL87_W4.5xW3.5 (45 yrs)	Geosynthetic						0	17.6	2,975 lbf/ft
	EL89_W4.5xW3.5 (45 yrs)	Geosynthetic						0	17.6	2,975 lbf/ft
	EL91_W4.5xW3.5 (45 yrs)	Geosynthetic						0	17.6	2,975 lbf/ft
	Soil Nail_Row 1	Anchor	1,800	82,550	45	0.5	4			20,638 lbf/ft
	Soil Nail_Row 2	Anchor	1,800	82,550	45	0.5	4			20,638 lbf/ft
	Soil Nail_Row 3	Anchor	1,800	82,550	40	0.5	4			20,638 lbf/ft
	Soil Nail_Row 4	Anchor	1,800	82,550	40	0.5	4			20,638 lbf/ft

Color	Name	Slope Stability Material Model	Unit Weight	Effective Cohesion	Effective Friction Angle
	Common Borrow	Mohr-Coulomb	120	0	32
	ESU 1B - Existing Gravelly Granular Fill	Mohr-Coulomb	125	0	38
	ESU 2A - Native Sand and Gravel	Mohr-Coulomb	120	0	39
	ESU 2B - Native Sand and Gravel	Mohr-Coulomb	135	0	41
	ESU 2C - Native Silt	Mohr-Coulomb	110	0	29
	ESU 7A - Weathered Sandstone	Mohr-Coulomb	135	0	43
	Gravel Borrow	Mohr-Coulomb	130	0	38

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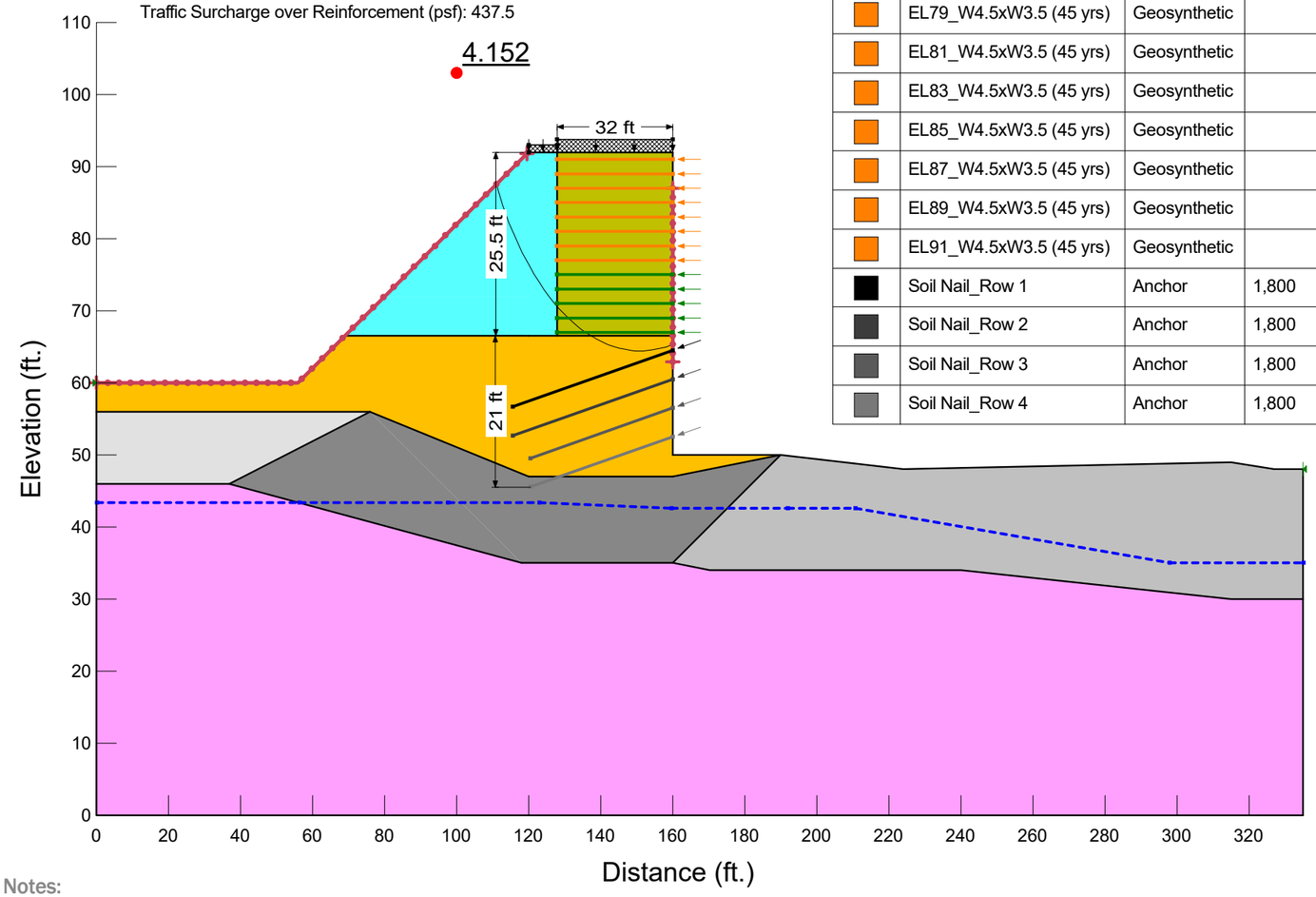
Bridge 17.7 - Wall 03.63L Section Ga-Ga'
Static Compound Stability (Spencer) - Final Condition

WSDOT I-405 Renton to Bellevue
King County, Washington

GeoEngineers

Figure D.5-21



Color	Name	Type	Pullout Resistance (psf)	Tensile Capacity (lbf)	Bond Length (ft)	Bond Diameter (ft)	Out-of-Plane Spacing (ft)	Interface Adhesion (psf)	Interface Shear Angle (°)	Factored Tensile Capacity
	EL67_W7.0xW3.5 (45 yrs)	Geosynthetic						0	11.5	4,901 lbf/ft
	EL69_W7.0xW3.5 (45 yrs)	Geosynthetic						0	11.5	4,901 lbf/ft
	EL71_W7.0xW3.5 (45 yrs)	Geosynthetic						0	11.5	4,901 lbf/ft
	EL73_W7.0xW3.5 (45 yrs)	Geosynthetic						0	22.2	4,901 lbf/ft
	EL75_W7.0xW3.5 (45 yrs)	Geosynthetic						0	22.2	4,901 lbf/ft
	EL77_W4.5xW3.5 (45 yrs)	Geosynthetic						0	17.6	2,975 lbf/ft
	EL79_W4.5xW3.5 (45 yrs)	Geosynthetic						0	17.6	2,975 lbf/ft
	EL81_W4.5xW3.5 (45 yrs)	Geosynthetic						0	17.6	2,975 lbf/ft
	EL83_W4.5xW3.5 (45 yrs)	Geosynthetic						0	17.6	2,975 lbf/ft
	EL85_W4.5xW3.5 (45 yrs)	Geosynthetic						0	17.6	2,975 lbf/ft
	EL87_W4.5xW3.5 (45 yrs)	Geosynthetic						0	17.6	2,975 lbf/ft
	EL89_W4.5xW3.5 (45 yrs)	Geosynthetic						0	17.6	2,975 lbf/ft
	EL91_W4.5xW3.5 (45 yrs)	Geosynthetic						0	17.6	2,975 lbf/ft
	Soil Nail_Row 1	Anchor	1,800	82,550	45	0.5	4			20,638 lbf/ft
	Soil Nail_Row 2	Anchor	1,800	82,550	45	0.5	4			20,638 lbf/ft
	Soil Nail_Row 3	Anchor	1,800	82,550	40	0.5	4			20,638 lbf/ft
	Soil Nail_Row 4	Anchor	1,800	82,550	40	0.5	4			20,638 lbf/ft

Color	Name	Slope Stability Material Model	Unit Weight	Effective Cohesion	Effective Friction Angle
	Common Borrow	Mohr-Coulomb	120	0	32
	ESU 1B - Existing Gravelly Granular Fill	Mohr-Coulomb	125	0	38
	ESU 2A - Native Sand and Gravel	Mohr-Coulomb	120	0	39
	ESU 2B - Native Sand and Gravel	Mohr-Coulomb	135	0	41
	ESU 2C - Native Silt	Mohr-Coulomb	110	0	29
	ESU 7A - Weathered Sandstone	Mohr-Coulomb	135	0	43
	Gravel Borrow	Mohr-Coulomb	130	0	38

Notes:

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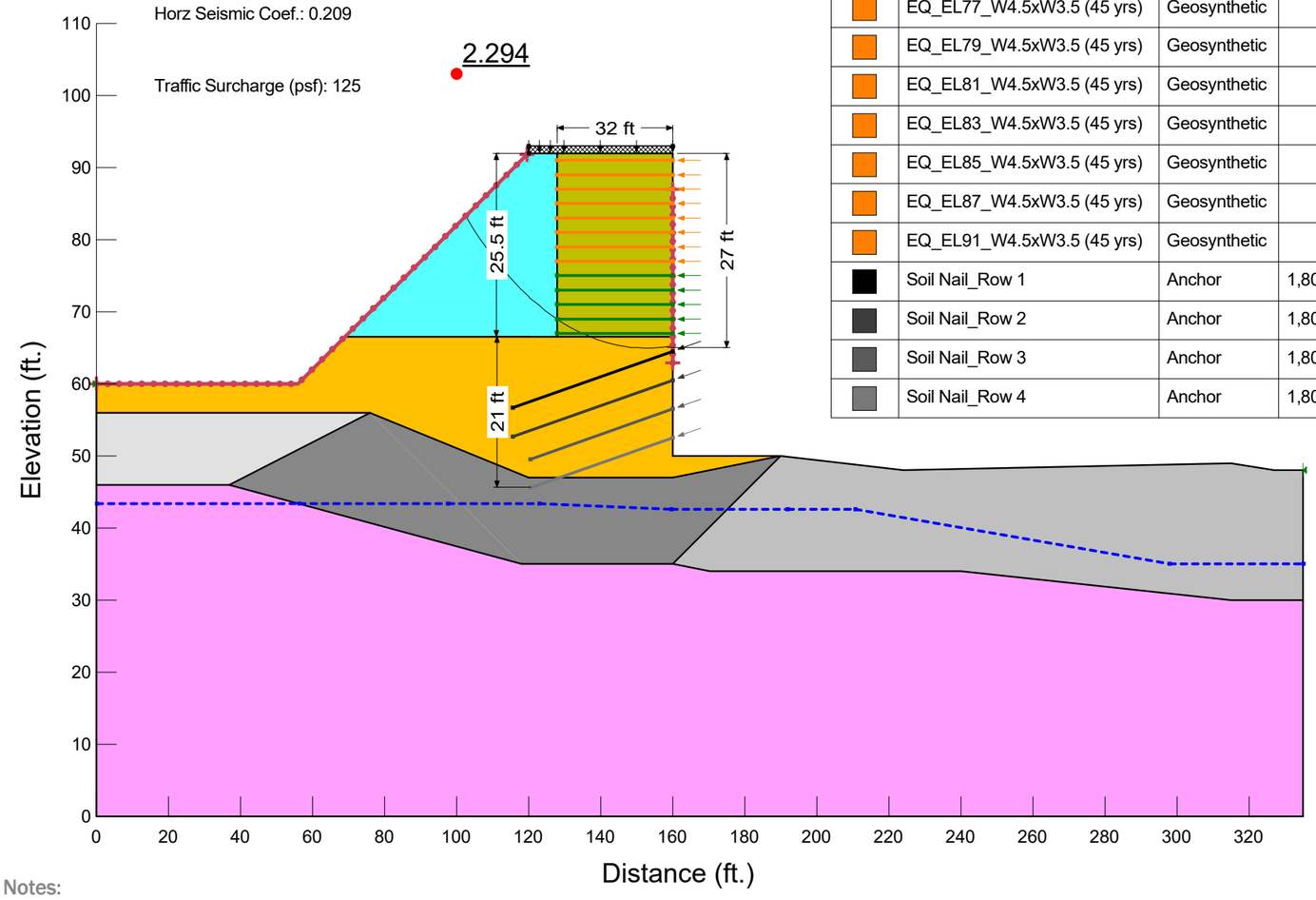
Bridge 17.7 - Wall 03.63L Section Ga-Ga'
Static Compound Stability (M-P) - Final Condition

WSDOT I-405 Renton to Bellevue
King County, Washington

GeoEngineers

Figure D.5-22



Color	Name	Type	Pullout Resistance (psf)	Tensile Capacity (lbf)	Bond Length (ft)	Bond Diameter (ft)	Out-of-Plane Spacing (ft)	Interface Adhesion (psf)	Interface Shear Angle (°)	Factored Tensile Capacity
	EQ_EL67_W7.0xW3.5 (45 yrs)	Geosynthetic						0	15.2	6,409 lbf/ft
	EQ_EL69_W7.0xW3.5 (45 yrs)	Geosynthetic						0	15.2	6,409 lbf/ft
	EQ_EL71_W7.0xW3.5 (45 yrs)	Geosynthetic						0	15.2	6,409 lbf/ft
	EQ_EL73_W7.0xW3.5 (45 yrs)	Geosynthetic						0	28.5	6,409 lbf/ft
	EQ_EL75_W7.0xW3.5 (45 yrs)	Geosynthetic						0	28.5	6,409 lbf/ft
	EQ_EL77_W4.5xW3.5 (45 yrs)	Geosynthetic						0	23	3,891 lbf/ft
	EQ_EL79_W4.5xW3.5 (45 yrs)	Geosynthetic						0	23	3,891 lbf/ft
	EQ_EL81_W4.5xW3.5 (45 yrs)	Geosynthetic						0	23	3,891 lbf/ft
	EQ_EL83_W4.5xW3.5 (45 yrs)	Geosynthetic						0	23	3,891 lbf/ft
	EQ_EL85_W4.5xW3.5 (45 yrs)	Geosynthetic						0	23	3,891 lbf/ft
	EQ_EL87_W4.5xW3.5 (45 yrs)	Geosynthetic						0	23	3,891 lbf/ft
	EQ_EL91_W4.5xW3.5 (45 yrs)	Geosynthetic						0	23	3,891 lbf/ft
	Soil Nail_Row 1	Anchor	1,800	82,550	45	0.5	4			20,638 lbf/ft
	Soil Nail_Row 2	Anchor	1,800	82,550	45	0.5	4			20,638 lbf/ft
	Soil Nail_Row 3	Anchor	1,800	82,550	40	0.5	4			20,638 lbf/ft
	Soil Nail_Row 4	Anchor	1,800	82,550	40	0.5	4			20,638 lbf/ft

Color	Name	Slope Stability Material Model	Unit Weight	Effective Cohesion	Effective Friction Angle
	Common Borrow	Mohr-Coulomb	120	0	32
	ESU 1B - Existing Gravelly Granular Fill	Mohr-Coulomb	125	0	38
	ESU 2A - Native Sand and Gravel	Mohr-Coulomb	120	0	39
	ESU 2B - Native Sand and Gravel	Mohr-Coulomb	135	0	41
	ESU 2C - Native Silt (Pseudo-Static)	Mohr-Coulomb	110	200	29
	ESU 7A - Weathered Sandstone	Mohr-Coulomb	135	0	43
	Gravel Borrow	Mohr-Coulomb	130	0	38

Notes:

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Bridge 17.7 - Wall 03.63L Section Ga-Ga'
Pseudo-Static Compound Stability (Spencer) - Final Condition

WSDOT I-405 Renton to Bellevue
King County, Washington

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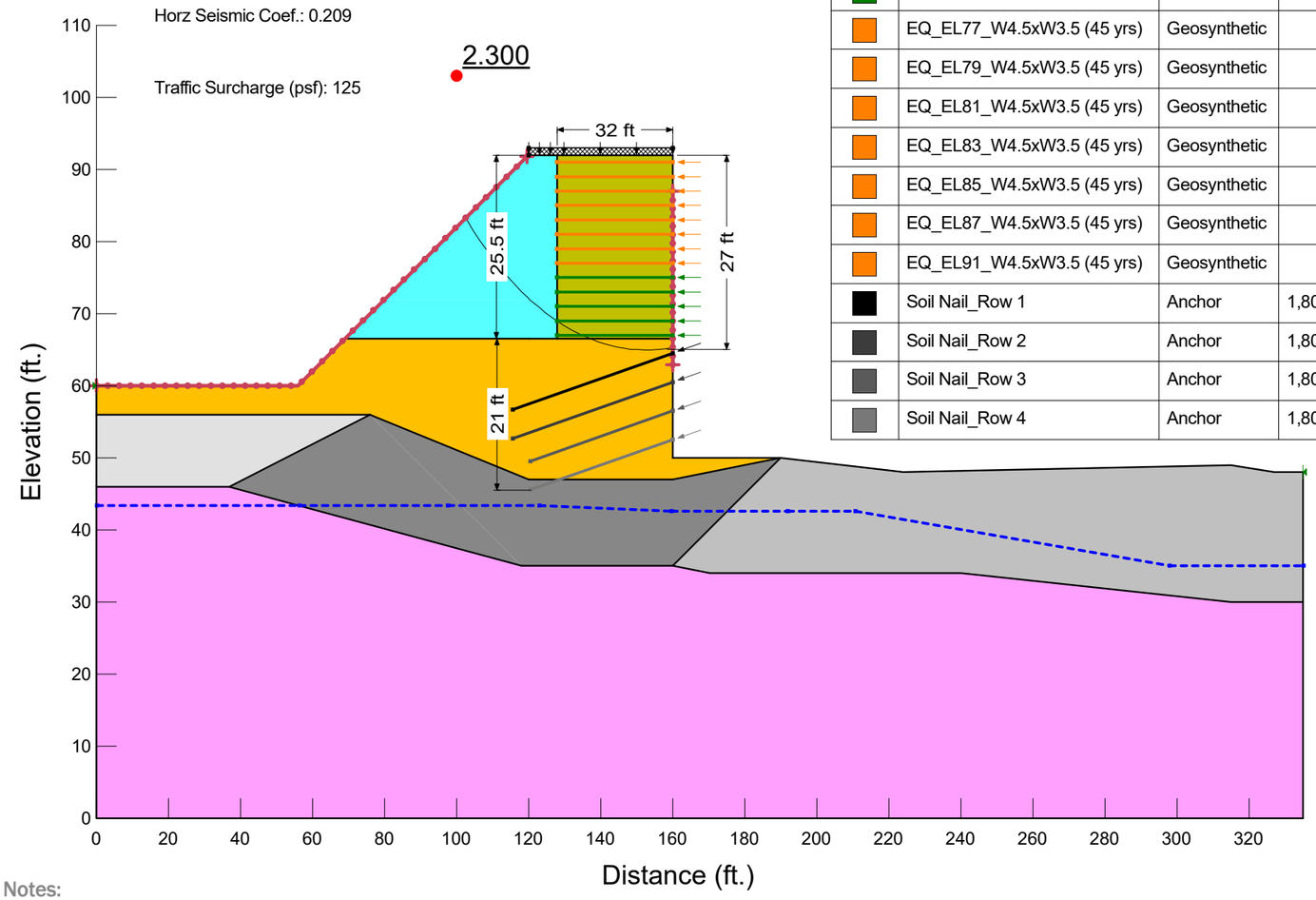
Figure D.5-23



Color	Name	Type	Pullout Resistance (psf)	Tensile Capacity (lbf)	Bond Length (ft)	Bond Diameter (ft)	Out-of-Plane Spacing (ft)	Interface Adhesion (psf)	Interface Shear Angle (°)	Factored Tensile Capacity
	EQ_EL67_W7.0xW3.5 (45 yrs)	Geosynthetic						0	15.2	6,409 lbf/ft
	EQ_EL69_W7.0xW3.5 (45 yrs)	Geosynthetic						0	15.2	6,409 lbf/ft
	EQ_EL71_W7.0xW3.5 (45 yrs)	Geosynthetic						0	15.2	6,409 lbf/ft
	EQ_EL73_W7.0xW3.5 (45 yrs)	Geosynthetic						0	28.5	6,409 lbf/ft
	EQ_EL75_W7.0xW3.5 (45 yrs)	Geosynthetic						0	28.5	6,409 lbf/ft
	EQ_EL77_W4.5xW3.5 (45 yrs)	Geosynthetic						0	23	3,891 lbf/ft
	EQ_EL79_W4.5xW3.5 (45 yrs)	Geosynthetic						0	23	3,891 lbf/ft
	EQ_EL81_W4.5xW3.5 (45 yrs)	Geosynthetic						0	23	3,891 lbf/ft
	EQ_EL83_W4.5xW3.5 (45 yrs)	Geosynthetic						0	23	3,891 lbf/ft
	EQ_EL85_W4.5xW3.5 (45 yrs)	Geosynthetic						0	23	3,891 lbf/ft
	EQ_EL87_W4.5xW3.5 (45 yrs)	Geosynthetic						0	23	3,891 lbf/ft
	EQ_EL91_W4.5xW3.5 (45 yrs)	Geosynthetic						0	23	3,891 lbf/ft
	Soil Nail_Row 1	Anchor	1,800	82,550	45	0.5	4			20,638 lbf/ft
	Soil Nail_Row 2	Anchor	1,800	82,550	45	0.5	4			20,638 lbf/ft
	Soil Nail_Row 3	Anchor	1,800	82,550	40	0.5	4			20,638 lbf/ft
	Soil Nail_Row 4	Anchor	1,800	82,550	40	0.5	4			20,638 lbf/ft

Color	Name	Slope Stability Material Model	Unit Weight	Effective Cohesion	Effective Friction Angle
	Common Borrow	Mohr-Coulomb	120	0	32
	ESU 1B - Existing Gravelly Granular Fill	Mohr-Coulomb	125	0	38
	ESU 2A - Native Sand and Gravel	Mohr-Coulomb	120	0	39
	ESU 2B - Native Sand and Gravel	Mohr-Coulomb	135	0	41
	ESU 2C - Native Silt (Pseudo-Static)	Mohr-Coulomb	110	200	29
	ESU 7A - Weathered Sandstone	Mohr-Coulomb	135	0	43
	Gravel Borrow	Mohr-Coulomb	130	0	38

Notes:

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Bridge 17.7 - Wall 03.63L Section Ga-Ga'
Pseudo-Static Compound Stability (M-P) - Final Condition

WSDOT I-405 Renton to Bellevue
King County, Washington

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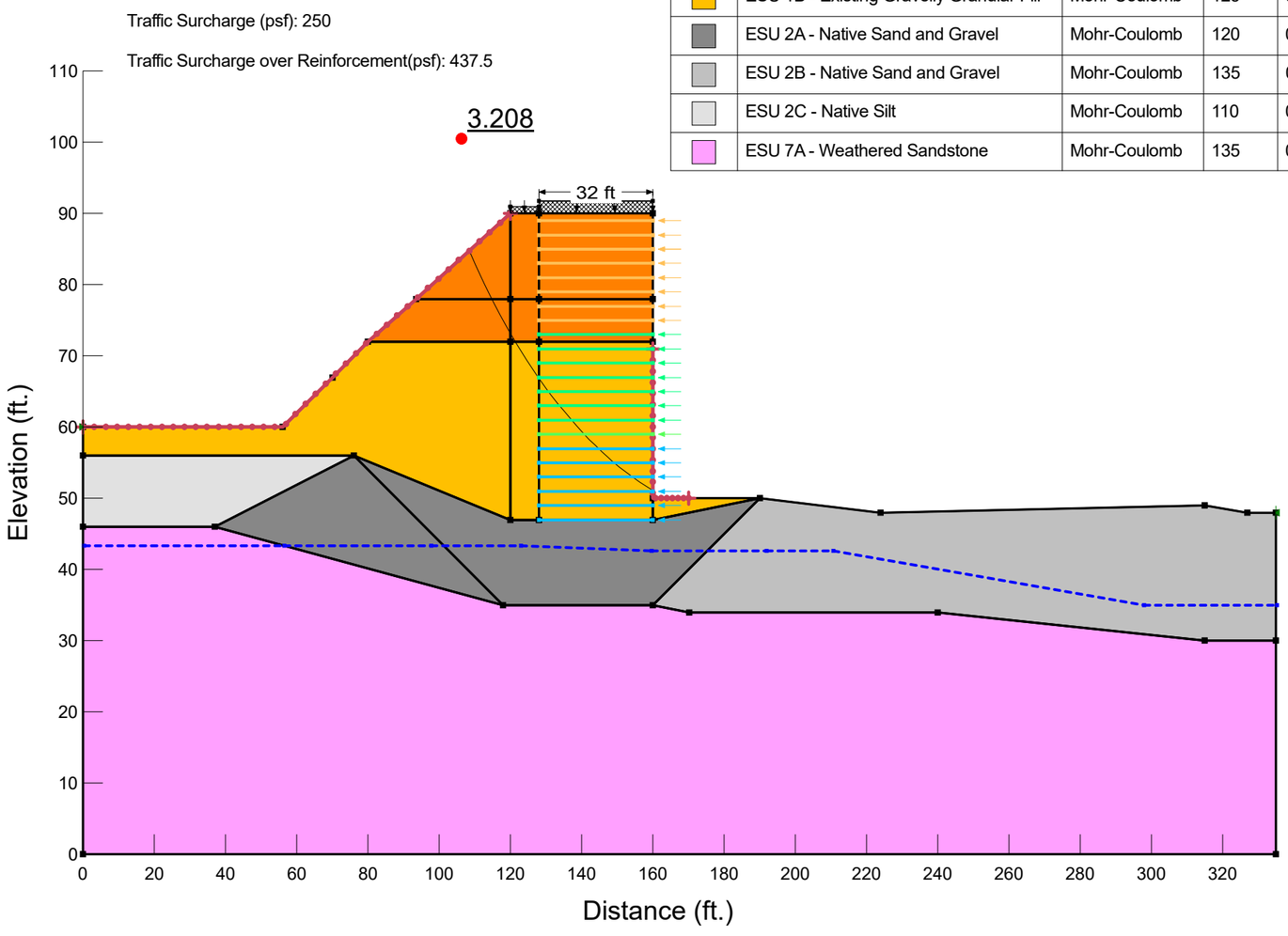
Figure D.5-24



Color	Name	Slope Stability Material Model	Unit Weight	Effective Cohesion	Effective Friction Angle
	ESU 1A - Existing Granular Fill	Mohr-Coulomb	120	0	40
	ESU 1B - Existing Gravelly Granular Fill	Mohr-Coulomb	125	0	38
	ESU 2A - Native Sand and Gravel	Mohr-Coulomb	120	0	39
	ESU 2B - Native Sand and Gravel	Mohr-Coulomb	135	0	41
	ESU 2C - Native Silt	Mohr-Coulomb	110	0	29
	ESU 7A - Weathered Sandstone	Mohr-Coulomb	135	0	43

Color	Name	Type	Interface Adhesion	Interface Shear Angle	Factored Tensile Capacity
	EL47_W9.5xW4	Geosynthetic	0	14.1	7,441 lbf/ft
	EL49_W9.5xW4	Geosynthetic	0	14.1	7,441 lbf/ft
	EL51_W9.5xW4	Geosynthetic	0	14.1	7,441 lbf/ft
	EL53_W9.5xW4	Geosynthetic	0	14.1	7,441 lbf/ft
	EL55_W9.5xW4	Geosynthetic	0	14.1	7,441 lbf/ft
	EL57_W9.5xW4	Geosynthetic	0	14.1	7,441 lbf/ft
	EL59_W7.0xW3.5	Geosynthetic	0	12.1	5,422 lbf/ft
	EL61_W7.0xW3.5	Geosynthetic	0	12.1	5,422 lbf/ft
	EL63_W7.0xW3.5	Geosynthetic	0	12.1	5,422 lbf/ft
	EL65_W7.0xW3.5	Geosynthetic	0	12.1	5,422 lbf/ft
	EL67_W7.0xW3.5	Geosynthetic	0	12.1	5,422 lbf/ft
	EL69_W7.0xW3.5	Geosynthetic	0	12.1	5,422 lbf/ft
	EL71_W7.0xW3.5	Geosynthetic	0	23.2	5,422 lbf/ft
	EL73_W7.0xW3.5	Geosynthetic	0	23.2	5,422 lbf/ft
	EL75_W7.0xW3.5	Geosynthetic	0	18.7	3,385 lbf/ft
	EL77_W4.5xW3.5	Geosynthetic	0	18.7	3,385 lbf/ft
	EL79_W4.5xW3.5	Geosynthetic	0	18.7	3,385 lbf/ft
	EL81_W4.5xW3.5	Geosynthetic	0	18.7	3,385 lbf/ft
	EL83_W4.5xW3.5	Geosynthetic	0	18.7	3,385 lbf/ft
	EL85_W4.5xW3.5	Geosynthetic	0	18.7	3,385 lbf/ft
	EL87_W4.5xW3.5	Geosynthetic	0	18.7	3,385 lbf/ft
	EL89_W4.5xW3.5	Geosynthetic	0	18.7	3,385 lbf/ft

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Bridge 17.7 - Wall 03.63L Section Ha-Ha'
Static Compound Stability (Spencer) - Existing Condition

WSDOT I-405 Renton to Bellevue
King County, Washington

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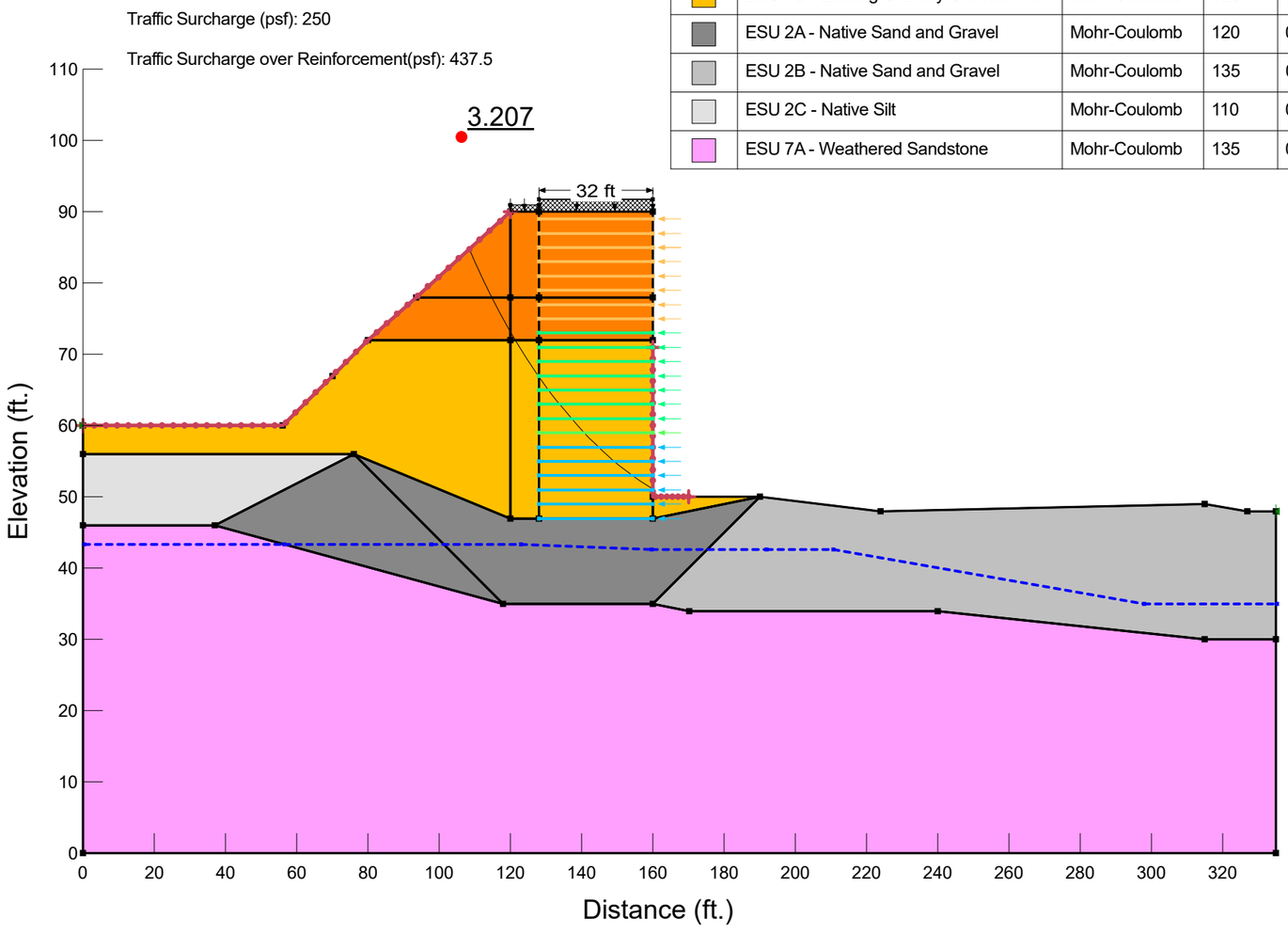
Figure D.5-25



Color	Name	Slope Stability Material Model	Unit Weight	Effective Cohesion	Effective Friction Angle
	ESU 1A - Existing Granular Fill	Mohr-Coulomb	120	0	40
	ESU 1B - Existing Gravelly Granular Fill	Mohr-Coulomb	125	0	38
	ESU 2A - Native Sand and Gravel	Mohr-Coulomb	120	0	39
	ESU 2B - Native Sand and Gravel	Mohr-Coulomb	135	0	41
	ESU 2C - Native Silt	Mohr-Coulomb	110	0	29
	ESU 7A - Weathered Sandstone	Mohr-Coulomb	135	0	43

Color	Name	Type	Interface Adhesion	Interface Shear Angle	Factored Tensile Capacity
	EL47_W9.5xW4	Geosynthetic	0	14.1	7,441 lbf/ft
	EL49_W9.5xW4	Geosynthetic	0	14.1	7,441 lbf/ft
	EL51_W9.5xW4	Geosynthetic	0	14.1	7,441 lbf/ft
	EL53_W9.5xW4	Geosynthetic	0	14.1	7,441 lbf/ft
	EL55_W9.5xW4	Geosynthetic	0	14.1	7,441 lbf/ft
	EL57_W9.5xW4	Geosynthetic	0	14.1	7,441 lbf/ft
	EL59_W7.0xW3.5	Geosynthetic	0	12.1	5,422 lbf/ft
	EL61_W7.0xW3.5	Geosynthetic	0	12.1	5,422 lbf/ft
	EL63_W7.0xW3.5	Geosynthetic	0	12.1	5,422 lbf/ft
	EL65_W7.0xW3.5	Geosynthetic	0	12.1	5,422 lbf/ft
	EL67_W7.0xW3.5	Geosynthetic	0	12.1	5,422 lbf/ft
	EL69_W7.0xW3.5	Geosynthetic	0	12.1	5,422 lbf/ft
	EL71_W7.0xW3.5	Geosynthetic	0	23.2	5,422 lbf/ft
	EL73_W7.0xW3.5	Geosynthetic	0	23.2	5,422 lbf/ft
	EL75_W7.0xW3.5	Geosynthetic	0	18.7	3,385 lbf/ft
	EL77_W4.5xW3.5	Geosynthetic	0	18.7	3,385 lbf/ft
	EL79_W4.5xW3.5	Geosynthetic	0	18.7	3,385 lbf/ft
	EL81_W4.5xW3.5	Geosynthetic	0	18.7	3,385 lbf/ft
	EL83_W4.5xW3.5	Geosynthetic	0	18.7	3,385 lbf/ft
	EL85_W4.5xW3.5	Geosynthetic	0	18.7	3,385 lbf/ft
	EL87_W4.5xW3.5	Geosynthetic	0	18.7	3,385 lbf/ft
	EL89_W4.5xW3.5	Geosynthetic	0	18.7	3,385 lbf/ft

Notes:

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Bridge 17.7 - Wall 03.63L Section Ha-Ha'
Static Compound Stability (M-P) - Existing Condition

WSDOT I-405 Renton to Bellevue
King County, Washington

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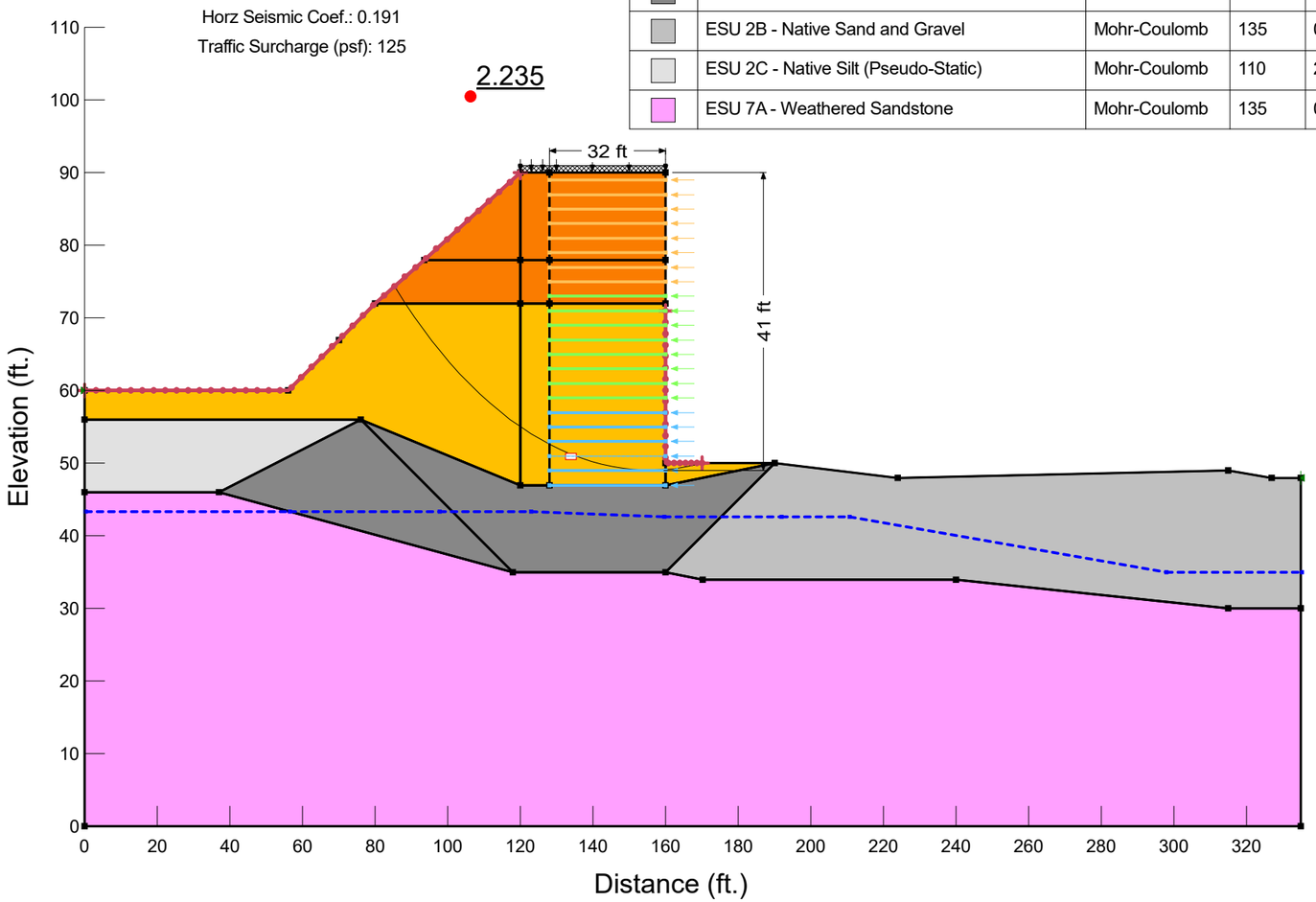
Figure D.5-26



Color	Name	Slope Stability Material Model	Unit Weight	Effective Cohesion	Effective Friction Angle
	ESU 1A - Existing Granular Fill (Pseudo-Static)	Mohr-Coulomb	120	50	40
	ESU 1B - Existing Gravelly Granular Fill	Mohr-Coulomb	125	0	38
	ESU 2A - Native Sand and Gravel	Mohr-Coulomb	120	0	39
	ESU 2B - Native Sand and Gravel	Mohr-Coulomb	135	0	41
	ESU 2C - Native Silt (Pseudo-Static)	Mohr-Coulomb	110	200	29
	ESU 7A - Weathered Sandstone	Mohr-Coulomb	135	0	43

Color	Name	Type	Interface Adhesion	Interface Shear Angle	Factored Tensile Capacity
	EQ_EL47_W9.5xW4	Geosynthetic	0	18.5	9,730 lbf/ft
	EQ_EL49_W9.5xW4	Geosynthetic	0	18.5	9,730 lbf/ft
	EQ_EL51_W9.5xW4	Geosynthetic	0	18.5	9,730 lbf/ft
	EQ_EL53_W9.5xW4	Geosynthetic	0	18.5	9,730 lbf/ft
	EQ_EL55_W9.5xW4	Geosynthetic	0	18.5	9,730 lbf/ft
	EQ_EL57_W9.5xW4	Geosynthetic	0	18.5	9,730 lbf/ft
	EQ_EL59_W7.0xW3.5	Geosynthetic	0	16	7,091 lbf/ft
	EQ_EL61_W7.0xW3.5	Geosynthetic	0	16	7,091 lbf/ft
	EQ_EL63_W7.0xW3.5	Geosynthetic	0	16	7,091 lbf/ft
	EQ_EL65_W7.0xW3.5	Geosynthetic	0	16	7,091 lbf/ft
	EQ_EL67_W7.0xW3.5	Geosynthetic	0	16	7,091 lbf/ft
	EQ_EL69_W7.0xW3.5	Geosynthetic	0	16	7,091 lbf/ft
	EQ_EL71_W7.0xW3.5	Geosynthetic	0	29.8	7,091 lbf/ft
	EQ_EL73_W7.0xW3.5	Geosynthetic	0	29.8	7,091 lbf/ft
	EQ_EL75_W7.0xW3.5	Geosynthetic	0	24.3	4,426 lbf/ft
	EQ_EL77_W4.5xW3.5	Geosynthetic	0	24.3	4,426 lbf/ft
	EQ_EL79_W4.5xW3.5	Geosynthetic	0	24.3	4,426 lbf/ft
	EQ_EL81_W4.5xW3.5	Geosynthetic	0	24.3	4,426 lbf/ft
	EQ_EL83_W4.5xW3.5	Geosynthetic	0	24.3	4,426 lbf/ft
	EQ_EL85_W4.5xW3.5	Geosynthetic	0	24.3	4,426 lbf/ft
	EQ_EL87_W4.5xW3.5	Geosynthetic	0	24.3	4,426 lbf/ft
	EQ_EL89_W4.5xW3.5	Geosynthetic	0	24.3	4,426 lbf/ft

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Bridge 17.7 - Wall 03.63L Section Ha-Ha'
Pseudo-Static Compound Stability (Spencer) - Existing Condition

WSDOT I-405 Renton to Bellevue
King County, Washington

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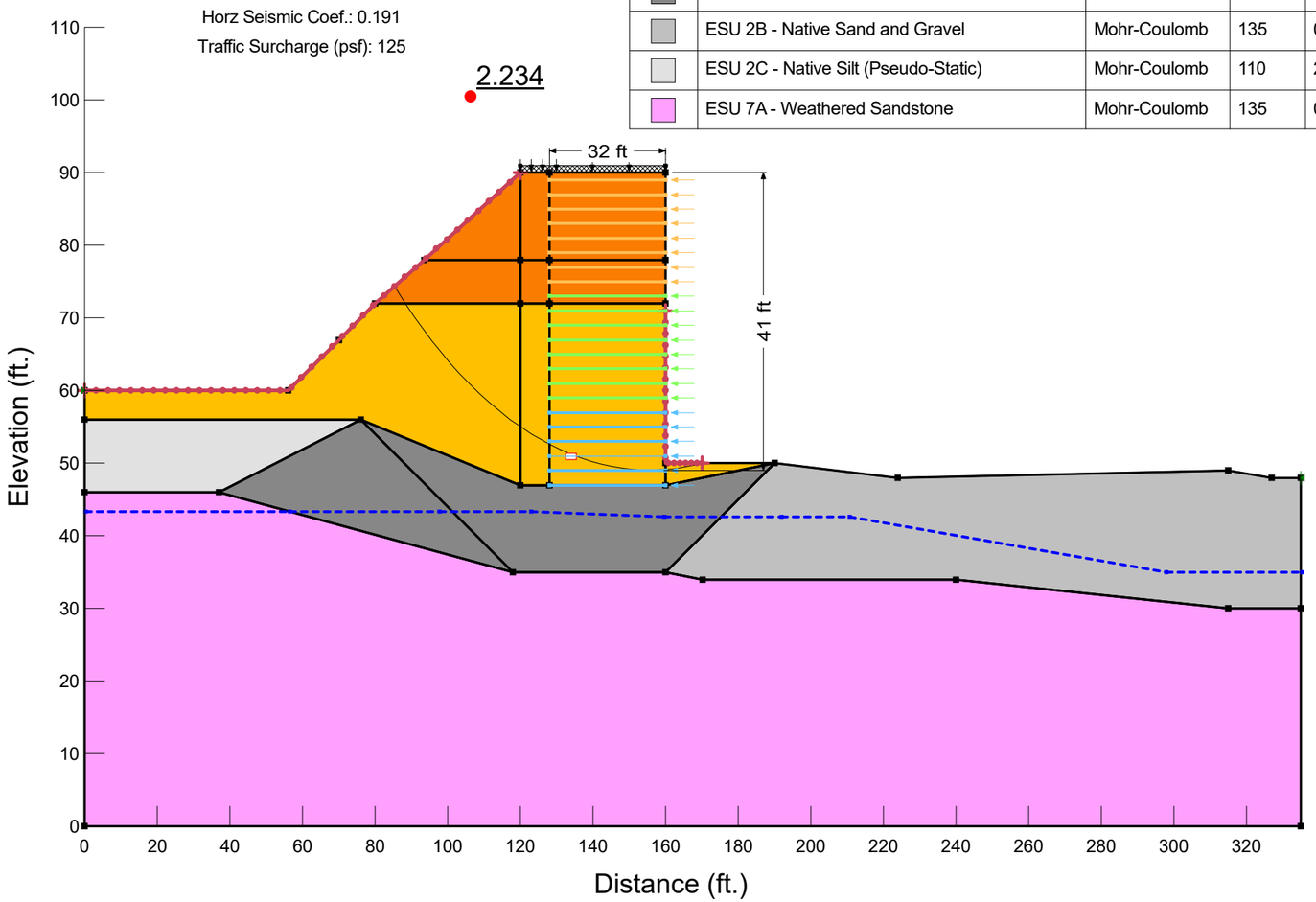
Figure D.5-27



Color	Name	Slope Stability Material Model	Unit Weight	Effective Cohesion	Effective Friction Angle
	ESU 1A - Existing Granular Fill (Pseudo-Static)	Mohr-Coulomb	120	50	40
	ESU 1B - Existing Gravelly Granular Fill	Mohr-Coulomb	125	0	38
	ESU 2A - Native Sand and Gravel	Mohr-Coulomb	120	0	39
	ESU 2B - Native Sand and Gravel	Mohr-Coulomb	135	0	41
	ESU 2C - Native Silt (Pseudo-Static)	Mohr-Coulomb	110	200	29
	ESU 7A - Weathered Sandstone	Mohr-Coulomb	135	0	43

Color	Name	Type	Interface Adhesion	Interface Shear Angle	Factored Tensile Capacity
	EQ_EL47_W9.5xW4	Geosynthetic	0	18.5	9,730 lbf/ft
	EQ_EL49_W9.5xW4	Geosynthetic	0	18.5	9,730 lbf/ft
	EQ_EL51_W9.5xW4	Geosynthetic	0	18.5	9,730 lbf/ft
	EQ_EL53_W9.5xW4	Geosynthetic	0	18.5	9,730 lbf/ft
	EQ_EL55_W9.5xW4	Geosynthetic	0	18.5	9,730 lbf/ft
	EQ_EL57_W9.5xW4	Geosynthetic	0	18.5	9,730 lbf/ft
	EQ_EL59_W7.0xW3.5	Geosynthetic	0	16	7,091 lbf/ft
	EQ_EL61_W7.0xW3.5	Geosynthetic	0	16	7,091 lbf/ft
	EQ_EL63_W7.0xW3.5	Geosynthetic	0	16	7,091 lbf/ft
	EQ_EL65_W7.0xW3.5	Geosynthetic	0	16	7,091 lbf/ft
	EQ_EL67_W7.0xW3.5	Geosynthetic	0	16	7,091 lbf/ft
	EQ_EL69_W7.0xW3.5	Geosynthetic	0	16	7,091 lbf/ft
	EQ_EL71_W7.0xW3.5	Geosynthetic	0	29.8	7,091 lbf/ft
	EQ_EL73_W7.0xW3.5	Geosynthetic	0	29.8	7,091 lbf/ft
	EQ_EL75_W7.0xW3.5	Geosynthetic	0	24.3	4,426 lbf/ft
	EQ_EL77_W4.5xW3.5	Geosynthetic	0	24.3	4,426 lbf/ft
	EQ_EL79_W4.5xW3.5	Geosynthetic	0	24.3	4,426 lbf/ft
	EQ_EL81_W4.5xW3.5	Geosynthetic	0	24.3	4,426 lbf/ft
	EQ_EL83_W4.5xW3.5	Geosynthetic	0	24.3	4,426 lbf/ft
	EQ_EL85_W4.5xW3.5	Geosynthetic	0	24.3	4,426 lbf/ft
	EQ_EL87_W4.5xW3.5	Geosynthetic	0	24.3	4,426 lbf/ft
	EQ_EL89_W4.5xW3.5	Geosynthetic	0	24.3	4,426 lbf/ft

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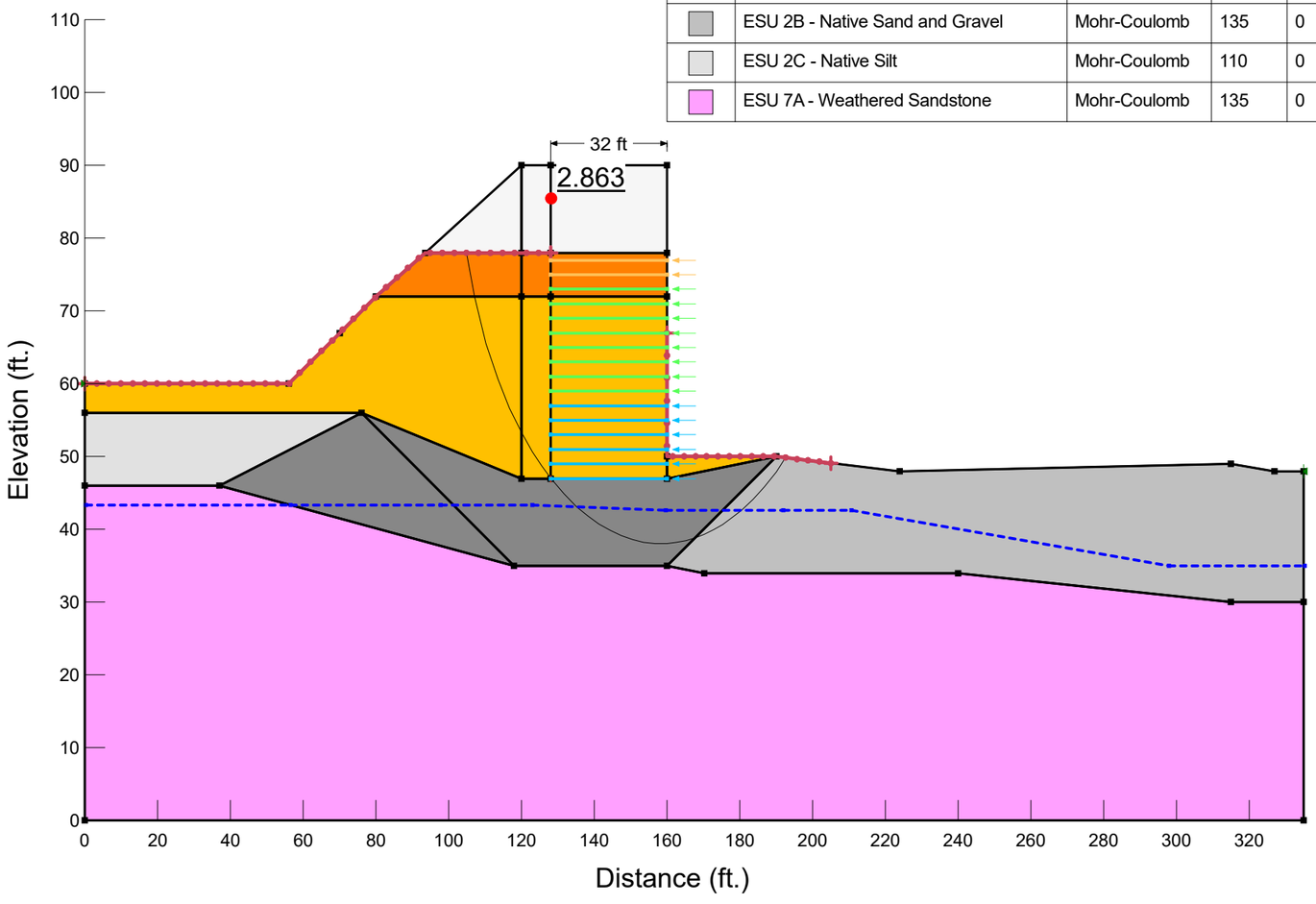
Bridge 17.7 - Wall 03.63L Section Ha-Ha'
Pseudo-Static Compound Stability (M-P) - Existing Condition

WSDOT I-405 Renton to Bellevue
King County, Washington

GeoEngineers

Figure D.5-28

Color	Name	Slope Stability Material Model	Unit Weight	Effective Cohesion	Effective Friction Angle
	ESU 1A - Existing Granular Fill	Mohr-Coulomb	120	0	40
	ESU 1B - Existing Gravelly Granular Fill	Mohr-Coulomb	125	0	38
	ESU 2A - Native Sand and Gravel	Mohr-Coulomb	120	0	39
	ESU 2B - Native Sand and Gravel	Mohr-Coulomb	135	0	41
	ESU 2C - Native Silt	Mohr-Coulomb	110	0	29
	ESU 7A - Weathered Sandstone	Mohr-Coulomb	135	0	43



Color	Name	Type	Interface Adhesion	Interface Shear Angle	Factored Tensile Capacity
	Con_EL47_W9.5xW4	Geosynthetic	0	14.1	7,441 lbf/ft
	Con_EL49_W9.5xW4	Geosynthetic	0	14.1	7,441 lbf/ft
	Con_EL51_W9.5xW4	Geosynthetic	0	14.1	7,441 lbf/ft
	Con_EL53_W9.5xW4	Geosynthetic	0	14.1	7,441 lbf/ft
	Con_EL55_W9.5xW4	Geosynthetic	0	14.1	7,441 lbf/ft
	Con_EL57_W9.5xW4	Geosynthetic	0	14.1	7,441 lbf/ft
	Con_EL59_W7.0xW3.5	Geosynthetic	0	23.2	5,422 lbf/ft
	Con_EL61_W7.0xW3.5	Geosynthetic	0	23.2	5,422 lbf/ft
	Con_EL63_W7.0xW3.5	Geosynthetic	0	23.2	5,422 lbf/ft
	Con_EL65_W7.0xW3.5	Geosynthetic	0	23.2	5,422 lbf/ft
	Con_EL67_W7.0xW3.5	Geosynthetic	0	23.2	5,422 lbf/ft
	Con_EL69_W7.0xW3.5	Geosynthetic	0	23.2	5,422 lbf/ft
	Con_EL71_W7.0xW3.5	Geosynthetic	0	23.2	5,422 lbf/ft
	Con_EL73_W7.0xW3.5	Geosynthetic	0	23.2	5,422 lbf/ft
	Con_EL75_W4.5xW3.5	Geosynthetic	0	18.7	3,385 lbf/ft
	Con_EL77_W4.5xW3.5	Geosynthetic	0	18.7	3,385 lbf/ft

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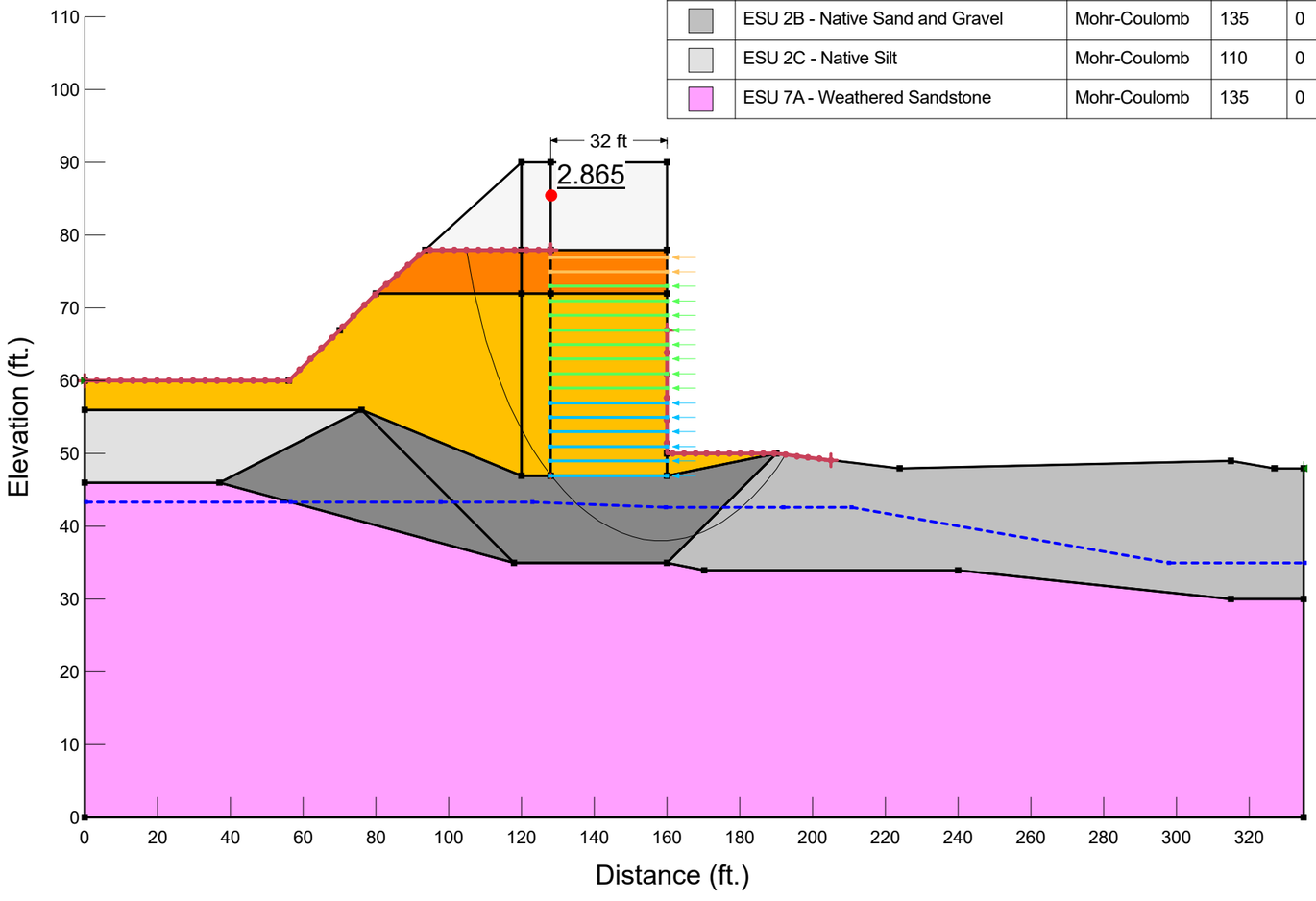
Bridge 17.7 - Wall 03.63L Section Ha-Ha'
Static Compound Stability (Spencer) - Construction Condition

WSDOT I-405 Renton to Bellevue
King County, Washington

GeoEngineers

Figure D.5-29

Color	Name	Slope Stability Material Model	Unit Weight	Effective Cohesion	Effective Friction Angle
	ESU 1A - Existing Granular Fill	Mohr-Coulomb	120	0	40
	ESU 1B - Existing Gravelly Granular Fill	Mohr-Coulomb	125	0	38
	ESU 2A - Native Sand and Gravel	Mohr-Coulomb	120	0	39
	ESU 2B - Native Sand and Gravel	Mohr-Coulomb	135	0	41
	ESU 2C - Native Silt	Mohr-Coulomb	110	0	29
	ESU 7A - Weathered Sandstone	Mohr-Coulomb	135	0	43



Color	Name	Type	Interface Adhesion	Interface Shear Angle	Factored Tensile Capacity
	Con_EL47_W9.5xW4	Geosynthetic	0	14.1	7,441 lbf/ft
	Con_EL49_W9.5xW4	Geosynthetic	0	14.1	7,441 lbf/ft
	Con_EL51_W9.5xW4	Geosynthetic	0	14.1	7,441 lbf/ft
	Con_EL53_W9.5xW4	Geosynthetic	0	14.1	7,441 lbf/ft
	Con_EL55_W9.5xW4	Geosynthetic	0	14.1	7,441 lbf/ft
	Con_EL57_W9.5xW4	Geosynthetic	0	14.1	7,441 lbf/ft
	Con_EL59_W7.0xW3.5	Geosynthetic	0	23.2	5,422 lbf/ft
	Con_EL61_W7.0xW3.5	Geosynthetic	0	23.2	5,422 lbf/ft
	Con_EL63_W7.0xW3.5	Geosynthetic	0	23.2	5,422 lbf/ft
	Con_EL65_W7.0xW3.5	Geosynthetic	0	23.2	5,422 lbf/ft
	Con_EL67_W7.0xW3.5	Geosynthetic	0	23.2	5,422 lbf/ft
	Con_EL69_W7.0xW3.5	Geosynthetic	0	23.2	5,422 lbf/ft
	Con_EL71_W7.0xW3.5	Geosynthetic	0	23.2	5,422 lbf/ft
	Con_EL73_W7.0xW3.5	Geosynthetic	0	23.2	5,422 lbf/ft
	Con_EL75_W4.5xW3.5	Geosynthetic	0	18.7	3,385 lbf/ft
	Con_EL77_W4.5xW3.5	Geosynthetic	0	18.7	3,385 lbf/ft

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Bridge 17.7 - Wall 03.63L Section Ha-Ha'
Static Compound Stability (M-P) - Construction Condition

WSDOT I-405 Renton to Bellevue
King County, Washington

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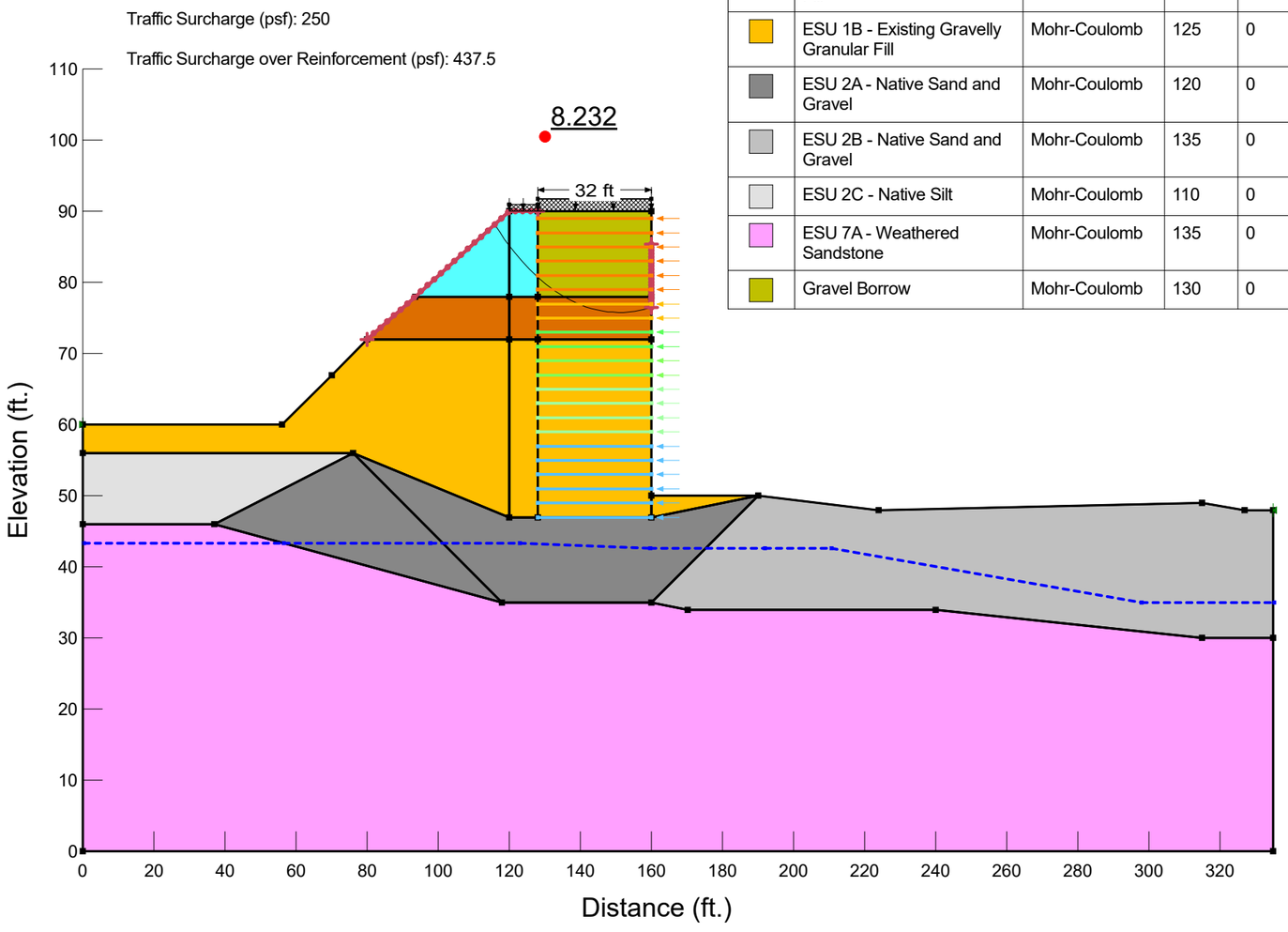
Figure D.5-30



Color	Name	Slope Stability Material Model	Unit Weight	Effective Cohesion	Effective Friction Angle
	Common Borrow	Mohr-Coulomb	120	0	32
	ESU 1A - Existing Granular Fill	Mohr-Coulomb	120	0	40
	ESU 1B - Existing Gravelly Granular Fill	Mohr-Coulomb	125	0	38
	ESU 2A - Native Sand and Gravel	Mohr-Coulomb	120	0	39
	ESU 2B - Native Sand and Gravel	Mohr-Coulomb	135	0	41
	ESU 2C - Native Silt	Mohr-Coulomb	110	0	29
	ESU 7A - Weathered Sandstone	Mohr-Coulomb	135	0	43
	Gravel Borrow	Mohr-Coulomb	130	0	38

Color	Name	Type	Interface Adhesion	Interface Shear Angle	Factored Tensile Capacity
	EL47_W9.5xW4 (75 yrs)	Geosynthetic	0	12.4	5,680 lbf/ft
	EL49_W9.5xW4 (75 yrs)	Geosynthetic	0	12.4	5,680 lbf/ft
	EL51_W9.5xW4 (75 yrs)	Geosynthetic	0	12.4	5,680 lbf/ft
	EL53_W9.5xW4 (75 yrs)	Geosynthetic	0	12.4	5,680 lbf/ft
	EL55_W9.5xW4 (75 yrs)	Geosynthetic	0	12.4	5,680 lbf/ft
	EL57_W9.5xW4 (75 yrs)	Geosynthetic	0	12.4	5,680 lbf/ft
	EL59_W7.0xW3.5 (75 yrs)	Geosynthetic	0	10.4	3,936 lbf/ft
	EL61_W7.0xW3.5 (75 yrs)	Geosynthetic	0	10.4	3,936 lbf/ft
	EL63_W7.0xW3.5 (75 yrs)	Geosynthetic	0	10.4	3,936 lbf/ft
	EL65_W7.0xW3.5 (75 yrs)	Geosynthetic	0	10.4	3,936 lbf/ft
	EL67_W7.0xW3.5 (75 yrs)	Geosynthetic	0	10.4	3,936 lbf/ft
	EL69_W7.0xW3.5 (75 yrs)	Geosynthetic	0	10.4	3,936 lbf/ft
	EL71_W7.0xW3.5 (75 yrs)	Geosynthetic	0	20.1	3,936 lbf/ft
	EL73_W7.0xW3.5 (75 yrs)	Geosynthetic	0	20.1	3,936 lbf/ft
	EL75_W7.0xW3.5 (75 yrs)	Geosynthetic	0	15.4	2,236 lbf/ft
	EL77_W4.5xW3.5 (75 yrs)	Geosynthetic	0	15.4	2,236 lbf/ft
	EL79_W4.5xW3.5 (45 yrs)	Geosynthetic	0	17.6	2,975 lbf/ft
	EL81_W4.5xW3.5 (45 yrs)	Geosynthetic	0	17.6	2,975 lbf/ft
	EL83_W4.5xW3.5 (45 yrs)	Geosynthetic	0	17.6	2,975 lbf/ft
	EL85_W4.5xW3.5 (45 yrs)	Geosynthetic	0	17.6	2,975 lbf/ft
	EL87_W4.5xW3.5 (45 yrs)	Geosynthetic	0	17.6	2,975 lbf/ft
	EL89_W4.5xW3.5 (45 yrs)	Geosynthetic	0	17.6	2,975 lbf/ft

Notes:

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Bridge 17.7 - Wall 03.63L Section Ha-Ha'
Static Compound Stability (Spencer) - Final Condition

WSDOT I-405 Renton to Bellevue
King County, Washington

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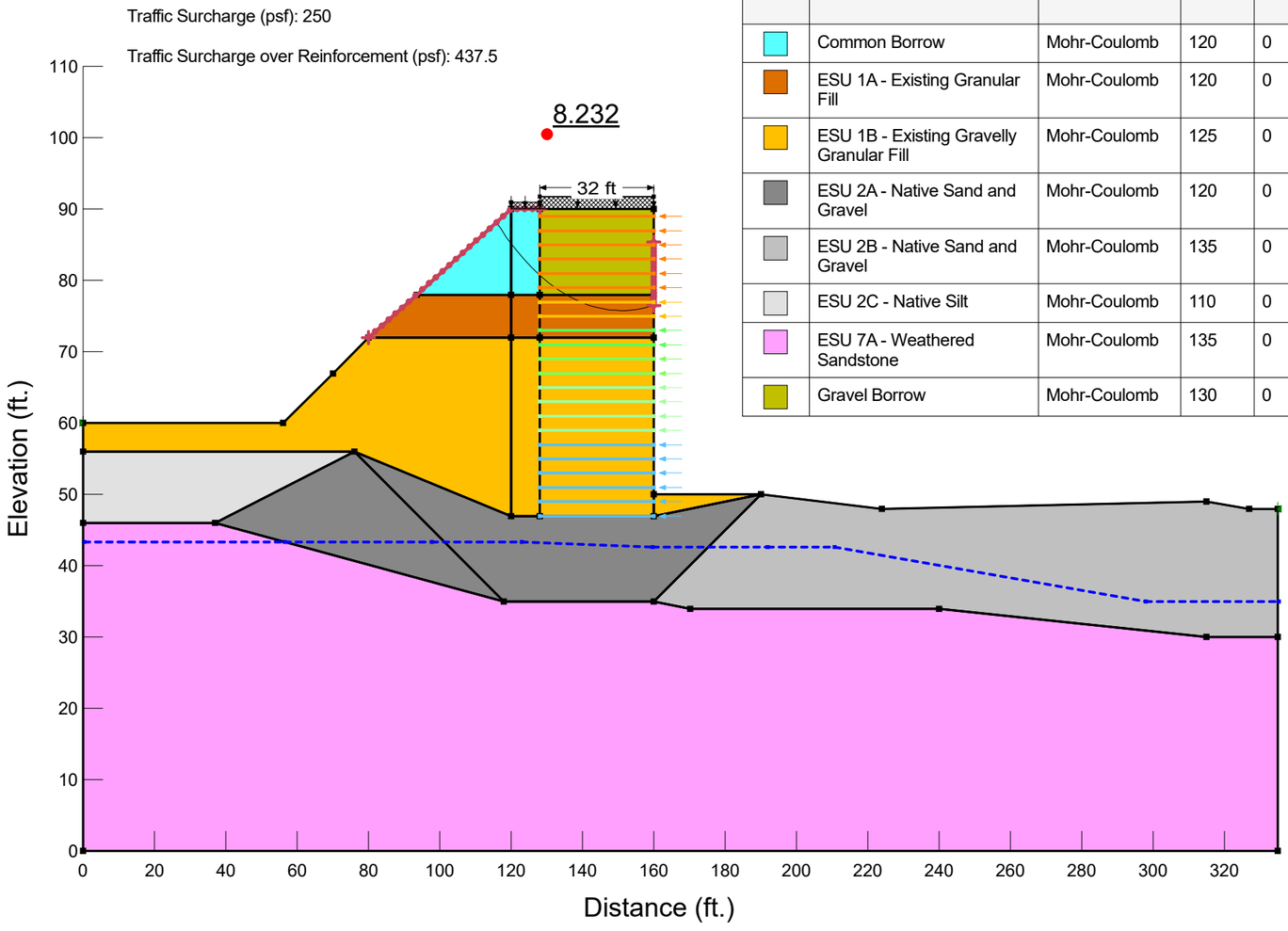
Figure D.5-31



Color	Name	Slope Stability Material Model	Unit Weight	Effective Cohesion	Effective Friction Angle
	Common Borrow	Mohr-Coulomb	120	0	32
	ESU 1A - Existing Granular Fill	Mohr-Coulomb	120	0	40
	ESU 1B - Existing Gravelly Granular Fill	Mohr-Coulomb	125	0	38
	ESU 2A - Native Sand and Gravel	Mohr-Coulomb	120	0	39
	ESU 2B - Native Sand and Gravel	Mohr-Coulomb	135	0	41
	ESU 2C - Native Silt	Mohr-Coulomb	110	0	29
	ESU 7A - Weathered Sandstone	Mohr-Coulomb	135	0	43
	Gravel Borrow	Mohr-Coulomb	130	0	38

Color	Name	Type	Interface Adhesion	Interface Shear Angle	Factored Tensile Capacity
	EL47_W9.5xW4 (75 yrs)	Geosynthetic	0	12.4	5,680 lbf/ft
	EL49_W9.5xW4 (75 yrs)	Geosynthetic	0	12.4	5,680 lbf/ft
	EL51_W9.5xW4 (75 yrs)	Geosynthetic	0	12.4	5,680 lbf/ft
	EL53_W9.5xW4 (75 yrs)	Geosynthetic	0	12.4	5,680 lbf/ft
	EL55_W9.5xW4 (75 yrs)	Geosynthetic	0	12.4	5,680 lbf/ft
	EL57_W9.5xW4 (75 yrs)	Geosynthetic	0	12.4	5,680 lbf/ft
	EL59_W7.0xW3.5 (75 yrs)	Geosynthetic	0	10.4	3,936 lbf/ft
	EL61_W7.0xW3.5 (75 yrs)	Geosynthetic	0	10.4	3,936 lbf/ft
	EL63_W7.0xW3.5 (75 yrs)	Geosynthetic	0	10.4	3,936 lbf/ft
	EL65_W7.0xW3.5 (75 yrs)	Geosynthetic	0	10.4	3,936 lbf/ft
	EL67_W7.0xW3.5 (75 yrs)	Geosynthetic	0	10.4	3,936 lbf/ft
	EL69_W7.0xW3.5 (75 yrs)	Geosynthetic	0	10.4	3,936 lbf/ft
	EL71_W7.0xW3.5 (75 yrs)	Geosynthetic	0	20.1	3,936 lbf/ft
	EL73_W7.0xW3.5 (75 yrs)	Geosynthetic	0	20.1	3,936 lbf/ft
	EL75_W7.0xW3.5 (75 yrs)	Geosynthetic	0	15.4	2,236 lbf/ft
	EL77_W4.5xW3.5 (75 yrs)	Geosynthetic	0	15.4	2,236 lbf/ft
	EL79_W4.5xW3.5 (45 yrs)	Geosynthetic	0	17.6	2,975 lbf/ft
	EL81_W4.5xW3.5 (45 yrs)	Geosynthetic	0	17.6	2,975 lbf/ft
	EL83_W4.5xW3.5 (45 yrs)	Geosynthetic	0	17.6	2,975 lbf/ft
	EL85_W4.5xW3.5 (45 yrs)	Geosynthetic	0	17.6	2,975 lbf/ft
	EL87_W4.5xW3.5 (45 yrs)	Geosynthetic	0	17.6	2,975 lbf/ft
	EL89_W4.5xW3.5 (45 yrs)	Geosynthetic	0	17.6	2,975 lbf/ft

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Bridge 17.7 - Wall 03.63L Section Ha-Ha'
Static Compound Stability (M-P) - Final Condition

WSDOT I-405 Renton to Bellevue
King County, Washington

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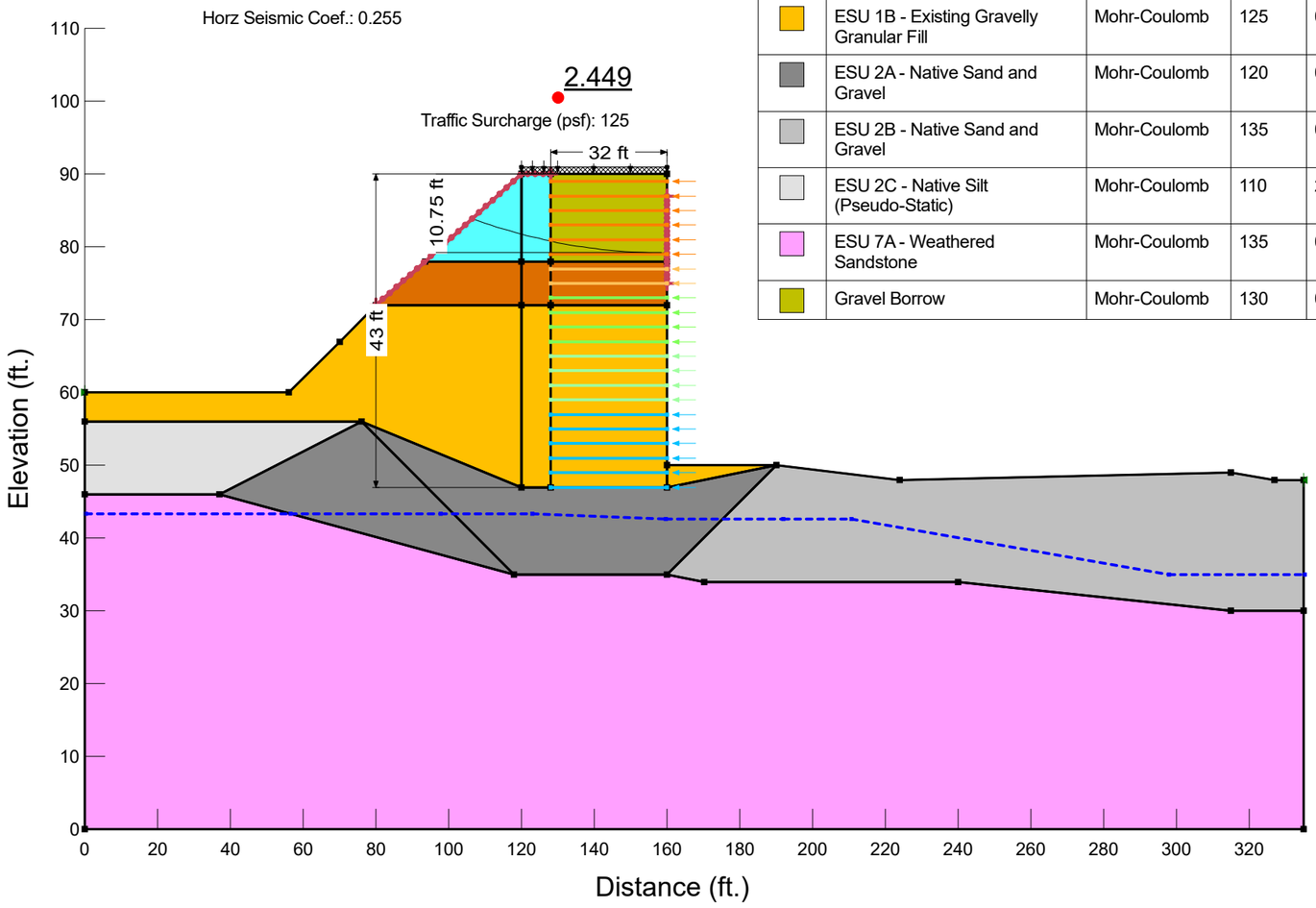
Figure D.5-32



Color	Name	Slope Stability Material Model	Unit Weight	Effective Cohesion	Effective Friction Angle
	Common Borrow	Mohr-Coulomb	120	0	32
	ESU 1A - Existing Granular Fill (Pseudo-Static)	Mohr-Coulomb	120	50	40
	ESU 1B - Existing Gravelly Granular Fill	Mohr-Coulomb	125	0	38
	ESU 2A - Native Sand and Gravel	Mohr-Coulomb	120	0	39
	ESU 2B - Native Sand and Gravel	Mohr-Coulomb	135	0	41
	ESU 2C - Native Silt (Pseudo-Static)	Mohr-Coulomb	110	200	29
	ESU 7A - Weathered Sandstone	Mohr-Coulomb	135	0	43
	Gravel Borrow	Mohr-Coulomb	130	0	38

Color	Name	Type	Interface Adhesion	Interface Shear Angle	Factored Tensile Capacity
	EQ_EL47_W9.5xW4 75 yrs)	Geosynthetic	0	16.3	7,427 lbf/ft
	EQ_EL49_W9.5xW4 (75 yrs)	Geosynthetic	0	16.3	7,427 lbf/ft
	EQ_EL51_W9.5xW4 (75 yrs)	Geosynthetic	0	16.3	7,427 lbf/ft
	EQ_EL53_W9.5xW4 (75 yrs)	Geosynthetic	0	16.3	7,427 lbf/ft
	EQ_EL55_W9.5xW4 (75 yrs)	Geosynthetic	0	16.3	7,427 lbf/ft
	EQ_EL57_W9.5xW4 (75 yrs)	Geosynthetic	0	16.3	7,427 lbf/ft
	EQ_EL59_W7.0xW3.5 (75 yrs)	Geosynthetic	0	13.7	5,147 lbf/ft
	EQ_EL61_W7.0xW3.5 (75 yrs)	Geosynthetic	0	13.7	5,147 lbf/ft
	EQ_EL63_W7.0xW3.5 (75 yrs)	Geosynthetic	0	13.7	5,147 lbf/ft
	EQ_EL65_W7.0xW3.5 (75 yrs)	Geosynthetic	0	13.7	5,147 lbf/ft
	EQ_EL67_W7.0xW3.5 (75 yrs)	Geosynthetic	0	13.7	5,147 lbf/ft
	EQ_EL69_W7.0xW3.5 (75 yrs)	Geosynthetic	0	13.7	5,147 lbf/ft
	EQ_EL71_W7.0xW3.5 (75 yrs)	Geosynthetic	0	26	5,147 lbf/ft
	EQ_EL73_W7.0xW3.5 (75 yrs)	Geosynthetic	0	26	5,147 lbf/ft
	EQ_EL75_W7.0xW3.5 (75 yrs)	Geosynthetic	0	20.2	2,924 lbf/ft
	EQ_EL77_W4.5xW3.5 (75 yrs)	Geosynthetic	0	20.2	2,924 lbf/ft
	EQ_EL79_W4.5xW3.5 (45 yrs)	Geosynthetic	0	23	3,891 lbf/ft
	EQ_EL81_W4.5xW3.5 (45 yrs)	Geosynthetic	0	23	3,891 lbf/ft
	EQ_EL83_W4.5xW3.5 (45 yrs)	Geosynthetic	0	23	3,891 lbf/ft
	EQ_EL85_W4.5xW3.5 (45 yrs)	Geosynthetic	0	23	3,891 lbf/ft
	EQ_EL87_W4.5xW3.5 (45 yrs)	Geosynthetic	0	23	3,891 lbf/ft

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Bridge 17.7 - Wall 03.63L Section Ha-Ha'
Pseudo-Static Compound Stability (Spencer) - Final Condition

WSDOT I-405 Renton to Bellevue
King County, Washington

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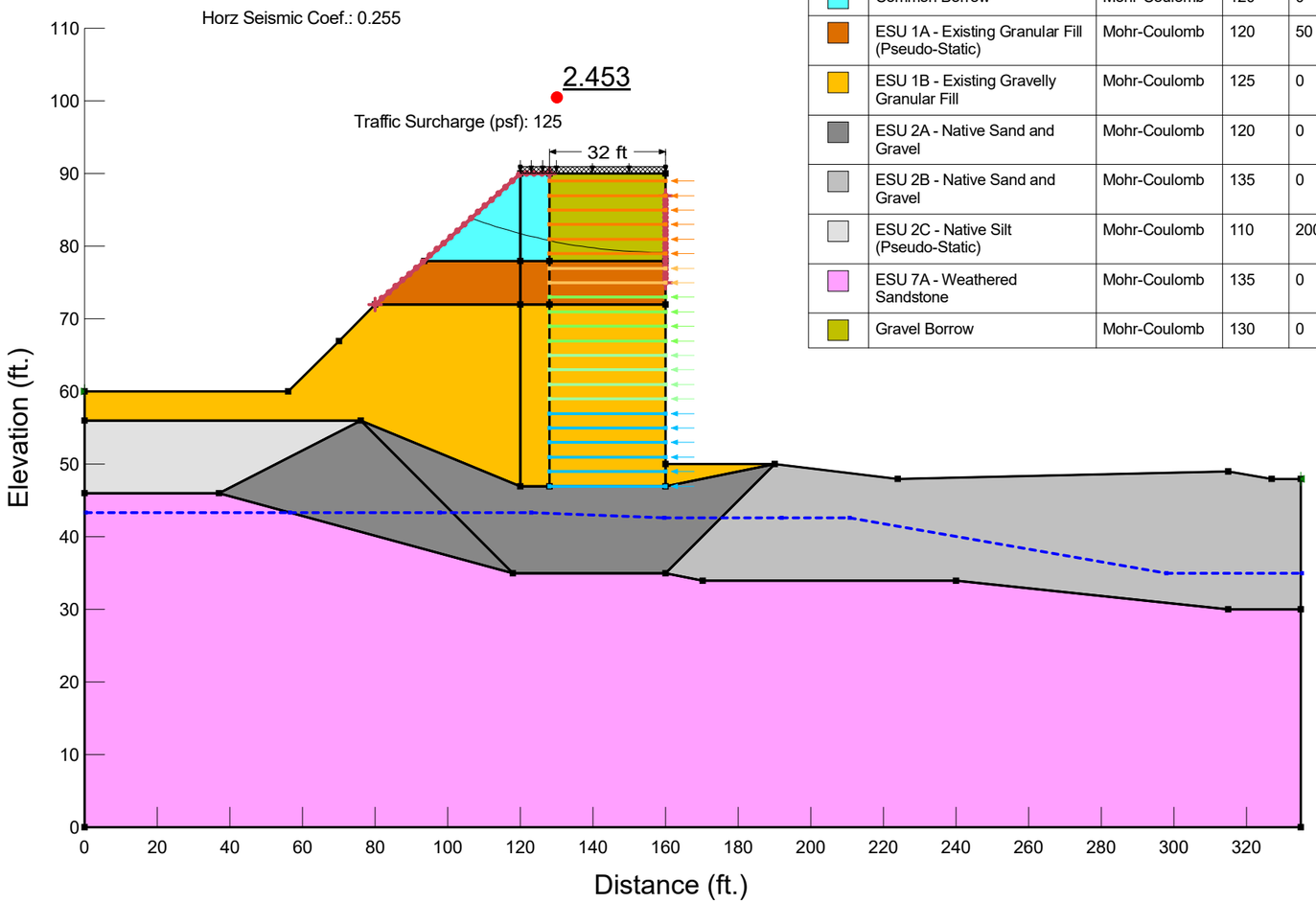
Figure D.5-33



Color	Name	Slope Stability Material Model	Unit Weight	Effective Cohesion	Effective Friction Angle
	Common Borrow	Mohr-Coulomb	120	0	32
	ESU 1A - Existing Granular Fill (Pseudo-Static)	Mohr-Coulomb	120	50	40
	ESU 1B - Existing Gravelly Granular Fill	Mohr-Coulomb	125	0	38
	ESU 2A - Native Sand and Gravel	Mohr-Coulomb	120	0	39
	ESU 2B - Native Sand and Gravel	Mohr-Coulomb	135	0	41
	ESU 2C - Native Silt (Pseudo-Static)	Mohr-Coulomb	110	200	29
	ESU 7A - Weathered Sandstone	Mohr-Coulomb	135	0	43
	Gravel Borrow	Mohr-Coulomb	130	0	38

Color	Name	Type	Interface Adhesion	Interface Shear Angle	Factored Tensile Capacity
	EQ_EL47_W9.5xW4 75 yrs)	Geosynthetic	0	16.3	7,427 lbf/ft
	EQ_EL49_W9.5xW4 (75 yrs)	Geosynthetic	0	16.3	7,427 lbf/ft
	EQ_EL51_W9.5xW4 (75 yrs)	Geosynthetic	0	16.3	7,427 lbf/ft
	EQ_EL53_W9.5xW4 (75 yrs)	Geosynthetic	0	16.3	7,427 lbf/ft
	EQ_EL55_W9.5xW4 (75 yrs)	Geosynthetic	0	16.3	7,427 lbf/ft
	EQ_EL57_W9.5xW4 (75 yrs)	Geosynthetic	0	16.3	7,427 lbf/ft
	EQ_EL59_W7.0xW3.5 (75 yrs)	Geosynthetic	0	13.7	5,147 lbf/ft
	EQ_EL61_W7.0xW3.5 (75 yrs)	Geosynthetic	0	13.7	5,147 lbf/ft
	EQ_EL63_W7.0xW3.5 (75 yrs)	Geosynthetic	0	13.7	5,147 lbf/ft
	EQ_EL65_W7.0xW3.5 (75 yrs)	Geosynthetic	0	13.7	5,147 lbf/ft
	EQ_EL67_W7.0xW3.5 (75 yrs)	Geosynthetic	0	13.7	5,147 lbf/ft
	EQ_EL69_W7.0xW3.5 (75 yrs)	Geosynthetic	0	13.7	5,147 lbf/ft
	EQ_EL71_W7.0xW3.5 (75 yrs)	Geosynthetic	0	26	5,147 lbf/ft
	EQ_EL73_W7.0xW3.5 (75 yrs)	Geosynthetic	0	26	5,147 lbf/ft
	EQ_EL75_W7.0xW3.5 (75 yrs)	Geosynthetic	0	20.2	2,924 lbf/ft
	EQ_EL77_W4.5xW3.5 (75 yrs)	Geosynthetic	0	20.2	2,924 lbf/ft
	EQ_EL79_W4.5xW3.5 (45 yrs)	Geosynthetic	0	23	3,891 lbf/ft
	EQ_EL81_W4.5xW3.5 (45 yrs)	Geosynthetic	0	23	3,891 lbf/ft
	EQ_EL83_W4.5xW3.5 (45 yrs)	Geosynthetic	0	23	3,891 lbf/ft
	EQ_EL85_W4.5xW3.5 (45 yrs)	Geosynthetic	0	23	3,891 lbf/ft
	EQ_EL87_W4.5xW3.5 (45 yrs)	Geosynthetic	0	23	3,891 lbf/ft

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Bridge 17.7 - Wall 03.63L Section Ha-Ha'
Pseudo-Static Compound Stability (M-P) - Final Condition

WSDOT I-405 Renton to Bellevue
King County, Washington

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Figure D.5-34

Calculating MSE Strip Properties for Slope/W
Bridge 17.7 - Section Ea-Ea' (Tallest Existing Wall) Existing Condition

For global stability analyses, the MSE wall is modeled as a high strength material and the failure is forced outside of the reinforced zone. To check for compound stability, the high strength material is replaced with gravel borrow and welded wire grids modeled after existing wall design drawings dated June 28, 1990 provided by Hilfiker. Relevant pages of these plans are provided within this appendix. The properties of the metal grids are calculated based on FHWA NHI-10-024 and NHI-10-025. The reinforcement properties are converted to per unit width basis, and implemented as a continous layer in Slope/W.

Input Soil Properties:

Backfill meeting WSDOT standard specifications 9-03.14(4), Gravel Borrow for Structural Earth Wall.

$\phi_{ESU1A} := 40\ deg$	Elevation 72 and above
$\phi_{ESU1B} := 38\ deg$	Elevation 72 and below

Input Grid Properties:

$d_{W4.5xW3.5} := 0.239\ in$	Gross Diameter (no corrosion)
$d_{W7.0xW3.5} := 0.299\ in$	Gross Diameter (no corrosion)
$d_{W9.5xW4.0} := 0.348\ in$	Gross Diameter (no corrosion)
$f_y := 65.0\ ksi$	Yield stress
$s_t := 12\ in$	Spacing of Transverse Bars
$s_l := 6\ in$	Spacing of Longitudinal Bars
$w := 1\ ft$	Gross Grid Width
$TWE := 96\ ft$	Top of Wall Elevation

Calculate Corrosion Reduction:

Bridge 17.7 was constructed in 1990. Calculate new cross-sectional area of steel grid after 30 years of corrosion exposure.

Table 3-7. Minimum Galvanization Thickness by Steel Thickness
(after AASHTO M 111 and ASTM A123).

Category	Steel Thickness	Minimum Galvanization Thickness
Strip	< ¼ in. (6.4 mm)	3.4 mils (85 µm)
	> ¼ in. (6.4 mm)	3.9 mils (100 µm)
Wire*	All diameters	3.4 mils (85 µm)

* For bar mats fabricated from uncoated steel wire.

The corrosion rates presented in Table 3-8 are suitable for conservative design. **These rates assume a moderately corrosive backfill material having the controlled electrochemical property limits** that are discussed under electrochemical properties in this chapter.

Table 3-8 Steel Corrosion Rates for Moderately Corrosive Reinforced Fill.

For zinc/side:	0.58 mils/yr (15 µm/year) (first 2 years)
	0.16 mils/yr (4 µm/year) (thereafter)
For residual carbon steel/side:	0.47 mils/yr (12 µm/year) (thereafter)

Calculate time (in years) to corrode through galvinization.

$$0.58 \cdot 2 + 0.16 \cdot \left(t_g - 2\right) = 3.4$$

$$t_g := \frac{3.4 - 0.58 \cdot 2}{0.16}\ yr + 2\ yr = 16\ yr$$ years to corrode through galvenization

Calculate the new diameter after 30 years of corrosion exposure:

$$years := 30\ yr$$

$$dc_{W4.5xW3.5} := d_{W4.5xW3.5} - \left(2 \cdot 0.00047\ \frac{in}{yr} \cdot \left(years - t_g\right)\right) = 0.226\ in$$

$$dc_{W7.0xW3.5} := d_{W7.0xW3.5} - \left(2 \cdot 0.00047\ \frac{in}{yr} \cdot \left(years - t_g\right)\right) = 0.286\ in$$

$$dc_{W9.5xW4.0} := d_{W9.5xW4.0} - \left(2 \cdot 0.00047\ \frac{in}{yr} \cdot \left(years - t_g\right)\right) = 0.335\ in$$

Calculate cross-sectional area after 30 years of corrosion exposure:

$$A_{sW4.5xW3.5} := \pi \cdot \left(\frac{dc_{W4.5xW3.5}}{2}\right)^2 = 0.04\ in^2$$

$$A_{sW7.0xW3.5} := \pi \cdot \left(\frac{dc_{W7.0xW3.5}}{2}\right)^2 = 0.064\ in^2$$

$$A_{sW9.5xW4.0} := \pi \cdot \left(\frac{dc_{W9.5xW4.0}}{2} \right)^2 = 0.088 \ in^2$$

LRFD Resistance Factors for Tensile and Pullout Resistance for MSE Walls with Metal Straps:

Table 4-7. Resistance Factors, ϕ, for Tensile and Pullout Resistance for MSE Walls
(after Table 11.5.6-1, AASHTO {2007}).

Reinforcement Type and Loading Condition			Resistance Factor
Metallic reinforcement and connectors	Strip reinforcements [A]		
		Static loading	0.75
		Combined static/earthquake loading	1.00
		Combined static/traffic barrier impact [B]	1.00
	Grid reinforcements [A, C]		
		Static loading	0.65
		Combined static/earthquake loading	0.85
		Combined static/traffic barrier impact [B]	0.85
Geosynthetic reinforcement and connectors		Static loading	0.90
		Combined static/earthquake loading	1.20
		Combined static/traffic barrier impact [B]	1.20
Pullout resistance of tensile reinforcement (metallic and geosynthetic)		Static loading	0.90
		Combined static/earthquake loading	1.20
		Combined static/traffic barrier impact [B]	1.00

Notes:
A. Apply to gross cross-section less sacrificial area. For sections with holes, reduce gross area in accordance with AASHTO (2007) Article 6.8.3 and apply to net section less sacrificial area.
B. Combined static/traffic barrier impact resistance factors are not presented in AASHTO.
C. Applies to grid reinforcements connected to rigid facing element, e.g., a concrete panel or block. For grid reinforcements connected to a flexible facing mat or which are continuous with the facing mat, use the resistance factor for strip reinforcements.

Resistance Factors:

$$\Phi_{static} := 0.65 \qquad \Phi_{pullout\_static} := 0.9$$

$$\Phi_{seismic} := 0.85 \qquad \Phi_{pullout\_seismic} := 1.2$$

Calculate Slope/W Reinforcement Inputs:

$$H_{wall} := 47 \ ft$$

Based on the existing Hilfiker wall design drawings dated June 28, 1990, the vertical (s_v) spacing of the steel grids within each SE wall panel was determined. For calculation efficiency, the calculations are performed using matrices.

$$s_v := \begin{bmatrix} 0 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \end{bmatrix} ft \qquad t := \begin{bmatrix} dc_{W9.5xW4.0} \\ dc_{W9.5xW4.0} \\ dc_{W9.5xW4.0} \\ dc_{W9.5xW4.0} \\ dc_{W9.5xW4.0} \\ dc_{W9.5xW4.0} \\ dc_{W9.5xW4.0} \\ dc_{W9.5xW4.0} \\ dc_{W9.5xW4.0} \\ dc_{W7.0xW3.5} \\ dc_{W7.0xW3.5} \\ dc_{W7.0xW3.5} \\ dc_{W7.0xW3.5} \\ dc_{W7.0xW3.5} \\ dc_{W7.0xW3.5} \\ dc_{W7.0xW3.5} \\ dc_{W7.0xW3.5} \\ dc_{W7.0xW3.5} \\ dc_{W4.5xW3.5} \\ dc_{W4.5xW3.5} \\ dc_{W4.5xW3.5} \\ dc_{W4.5xW3.5} \\ dc_{W4.5xW3.5} \\ dc_{W4.5xW3.5} \\ dc_{W4.5xW3.5} \\ dc_{W4.5xW3.5} \end{bmatrix}$$

The matrix respresents the same order of the SE Wall reinforcement. Top row of the matrix represents the bottom row (Row 1) of the SE Wall reinforcement and the bottom row of the matrix represents the row of reinforcement closest to the ground surface (Row 24).

t represents the claculated thickness of each row of reinforcement for the existing Hilfiker wall after 30 years of corrosion exposure. This thickness is applied below in the grid capacity calculations.

$i := 0 .. \text{length}\left(s_v\right) - 1$ Calculate number of elements

Calculate each grid's vertical elevation and depth from the top of the wall, with the base of the wall as elevation 0 ft. Top row of the matrix represents the bottom reinforcement row.

$$elevation_i := \sum_{j=0}^{i} s_{v_j} = \begin{bmatrix} 0 \\ 2 \\ 4 \\ 6 \\ 8 \\ 10 \\ 12 \\ 14 \\ 16 \\ 18 \\ 20 \\ 22 \\ 24 \\ 26 \\ 28 \\ 30 \\ 32 \\ 34 \\ 36 \\ 38 \\ 40 \\ 42 \\ 44 \\ 46 \end{bmatrix} ft \qquad depth_i := H_{wall} - elevation_i = \begin{bmatrix} 47 \\ 45 \\ 43 \\ 41 \\ 39 \\ 37 \\ 35 \\ 33 \\ 31 \\ 29 \\ 27 \\ 25 \\ 23 \\ 21 \\ 19 \\ 17 \\ 15 \\ 13 \\ 11 \\ 9 \\ 7 \\ 5 \\ 3 \\ 1 \end{bmatrix} ft$$

Calculate Pullout Resistance Slope/W Input:

For design and comparison purposes, a normalized definition of pullout resistance will be used throughout the manual. The pullout resistance, P_r, at each of the reinforcement levels per unit width of reinforcement is given by:

$$P_r = F^* \alpha \sigma_v' L_e C \qquad (3\text{-}2)$$

where:

- $L_e C$ = the total surface area per unit width of the reinforcement in the resistive zone behind the failure surface
- L_e = the embedment or adherence length in the resisting zone behind the failure surface
- C = the reinforcement effective unit perimeter; e.g., C = 2 for and sheets, and because the edges are neglected C = 2 for strips and grids
- F^* = the pullout resistance (or friction-bearing-interaction) factor
- α = a scale effect correction factor to account for a non linear stress reduction over the embedded length of highly extensible reinforcements, based on laboratory data (generally 1.0 for metallic reinforcements and 0.6 to 1.0 for geosynthetic reinforcements, see Table 3-6).
- σ'_v = the effective vertical stress at the soil-reinforcement interfaces.

The factored pullout resistance is then given by:

$$P_r = \Phi_{pullout} \left(F \cdot \alpha \cdot \sigma_v' \cdot L_e \cdot C\right)$$

In Slope/W, pullout resistance per unit width of wall is given by:

$$P_r = \left(c + \sigma_v' \cdot tan\left(\phi_{interface}\right)\right) \cdot \alpha \cdot L_e \cdot C$$

Where α and C can be defined within the reinforcement properties, and are set to be the same as defined above. Overburden pressure, σ_v' and effective length, Le, are determined from the limit equilibrium analysis performed in Slope/W. Interface adhesion, c, is assumed to be negligable for metal grids in granular backfill.

To select a representative interface friction angle, $\phi_{interface}$, that will produce the same factored resistance per unit width of wall, the two expressions are set to be equal:

$$\Phi_{pullout} \left(F \cdot \alpha \cdot \sigma_v' \cdot L_e \cdot C\right) = \sigma_v' \cdot tan\left(\phi_{interface}\right) \cdot \alpha \cdot L_e \cdot C$$

Removing common constants and rearranging produces:

$$\phi_{interface} = atan\left(\Phi_{pullout} \cdot F\right)$$

Calculate Pullout Resistance Factor F*:

For steel grid reinforcements with transverse spacing of $S_t \geq 6$ inches (150 mm) (see Figure 3-4), F* is a function of a bearing or embedment factor, F_q, applied over the contributing bearing α_β, as follows:

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$F^* = F_q \alpha_\beta = 40 \alpha_\beta = 40 (t/2S_t) = 20 (t/S_t)$ at the top of the structure (3-6)

$F^* = F_q \alpha_\beta = 20 \alpha_\beta = 20 (t/2S_t) = 10 (t/S_t)$ at a depth of 20 ft (6 m) and below (3-7)

Where, t is the thickness of the transverse bar. S_t must be uniform throughout the length of the reinforcement rather than having transverse grid members concentrated only in the resistant zone. The maximum S_t distance is 24 in. (610 mm). For sloping backfills see Figure 4-15.

$$F_i := \begin{cases} \left\| 20 \cdot \left(\frac{t_i}{s_t} \right) \right\| & \text{if } depth_i \leq 20\ \textit{ft} \\ \left\| 10 \cdot \left(\frac{t_i}{s_t} \right) \right\| & \text{else} \end{cases}$$

$$F = \begin{bmatrix} 0.28 \\ 0.28 \\ 0.28 \\ 0.28 \\ 0.28 \\ 0.28 \\ 0.28 \\ 0.28 \\ 0.24 \\ 0.24 \\ 0.24 \\ 0.24 \\ 0.24 \\ 0.24 \\ 0.48 \\ 0.48 \\ 0.38 \\ 0.38 \\ 0.38 \\ 0.38 \\ 0.38 \\ 0.38 \\ 0.38 \\ 0.38 \end{bmatrix}$$

Calculated F* for each row of reinforcement. Top row of matrix represents the bottom row of reinforcement.

Calculate Interface Shear Angle (degrees):

$$\phi_{interface\_static} := \operatorname{atan}\left(\Phi_{pullout\_static} \cdot F\right) = \begin{bmatrix} 14.1 \\ 14.1 \\ 14.1 \\ 14.1 \\ 14.1 \\ 14.1 \\ 14.1 \\ 14.1 \\ 12.1 \\ 12.1 \\ 12.1 \\ 12.1 \\ 12.1 \\ 23.2 \\ 23.2 \\ 18.7 \\ 18.7 \\ 18.7 \\ 18.7 \\ 18.7 \\ 18.7 \\ 18.7 \\ 18.7 \end{bmatrix} \textit{deg}$$

Static interface shear angle for each row of reinforcement. Top row of matrix represents the bottom reinforcement row.

$$\phi_{interface\_seismic} := \operatorname{atan}\left(\Phi_{pullout\_seismic} \cdot F\right) = \begin{bmatrix} 18.5 \\ 18.5 \\ 18.5 \\ 18.5 \\ 18.5 \\ 18.5 \\ 18.5 \\ 18.5 \\ 16 \\ 16 \\ 16 \\ 16 \\ 16 \\ 16 \\ 29.8 \\ 29.8 \\ 24.3 \\ 24.3 \\ 24.3 \\ 24.3 \\ 24.3 \\ 24.3 \\ 24.3 \\ 24.3 \\ 24.3 \end{bmatrix} \textit{deg}$$

Seismic interface shear angle for each row of reinforcement. Top row of matrix represents the bottom reinforcement row.

Calculate Allowable Tensile Capacity of Steel Straps:

$$T_{capacity} = \Phi_{static} \cdot f_y \, A_s$$

Slope/W does not have grid reinforcement inputs. Therefore, the tensile strength of the grids were modeled as continuous reinforcement. The calculated allowable tensile grid capacity was converted to a continuous reinforcement tensile capacity by distributing the capacity over the tributary width. The longitudinal wires are spaced every 6 inches, therefore there are two bars within each 1 foot width of grid.

W9.5xW4.0:
(Rows 1 through 8)

$$T_{al\_static} := \frac{\Phi_{static} \cdot f_y \, A_{sW9.5xW4.0} \cdot \frac{1\ \textit{ft}}{s_l}}{w} = 7.44\ \frac{\textit{kip}}{\textit{ft}}$$

$$T_{al\_seismic} := \frac{\Phi_{seismic} \cdot f_y \, A_{sW9.5xW4.0} \cdot \frac{1\ \textit{ft}}{s_l}}{w} = 9.7\ \frac{\textit{kip}}{\textit{ft}}$$

W7.0xW3.5:
(Rows 9 through 16)

$$T_{al\_static} := \frac{\Phi_{static} \cdot f_y \, A_{sW7.0xW3.5} \cdot \frac{1\ ft}{s_l}}{w} = 5.42\ \frac{kip}{ft}$$

$$T_{al\_seismic} := \frac{\Phi_{seismic} \cdot f_y \, A_{sW7.0xW3.5} \cdot \frac{1\ ft}{s_l}}{w} = 7.1\ \frac{kip}{ft}$$

W4.5xW3.5:
(Rows 17 through 24)

$$T_{al\_static} := \frac{\Phi_{static} \cdot f_y \, A_{sW4.5xW3.5} \cdot \frac{1\ ft}{s_l}}{w} = 3.38\ \frac{kip}{ft}$$

$$T_{al\_seismic} := \frac{\Phi_{seismic} \cdot f_y \, A_{sW4.5xW3.5} \cdot \frac{1\ ft}{s_l}}{w} = 4.4\ \frac{kip}{ft}$$

Calculating MSE Strip Properties for Slope/W
Bridge 17.7 - Section Fa-Fa' (Proposed Footing Centerline) - Existing Condition

For global stability analyses, the MSE wall is modeled as a high strength material and the failure is forced outside of the reinforced zone. To check for compound stability, the high strength material is replaced with gravel borrow and welded wire grids modeled after existing wall design drawings dated June 28, 1990 provided by Hilfiker. Relevant pages of these plans are provided within this appendix. The properties of the metal grids are calculated based on FHWA NHI-10-024 and NHI-10-025. The reinforcement properties are converted to per unit width basis, and implemented as a continous layer in Slope/W.

Input Soil Properties:

Backfill meeting WSDOT standard specifications 9-03.14(4), Gravel Borrow for Structural Earth Wall.

$\phi_{ESU1A} := 40\ deg$ Elevation 72 and above

$\phi_{ESU1B} := 38\ deg$ Elevation 72 and below

Input Grid Properties:

$d_{W4.5xW3.5} := 0.239\ in$ Gross Diameter (no corrosion)

$d_{W7.0xW3.5} := 0.299\ in$ Gross Diameter (no corrosion)

$d_{W9.5xW4.0} := 0.348\ in$ Gross Diameter (no corrosion)

$f_y := 65.0\ ksi$ Yield stress

$s_t := 12\ in$ Spacing of Transverse Bars

$s_l := 6\ in$ Spacing of Longitudinal Bars

$w := 1\ ft$ Gross Grid Width

$TWE := 94\ ft$ Top of Wall Elevation

Calculate Corrosion Reduction:

Bridge 17.7 was constructed in 1990. Calculate new cross-sectional area of steel grid after 30 years of corrosion exposure.

Table 3-7. Minimum Galvanization Thickness by Steel Thickness
(after AASHTO M 111 and ASTM A123).

Category	Steel Thickness	Minimum Galvanization Thickness
Strip	< ¼ in. (6.4 mm)	3.4 mils (85 µm)
	> ¼ in. (6.4 mm)	3.9 mils (100 µm)
Wire*	All diameters	3.4 mils (85 µm)
* For bar mats fabricated from uncoated steel wire.		

The corrosion rates presented in Table 3-8 are suitable for conservative design. **These rates assume a moderately corrosive backfill material having the controlled electrochemical property limits** that are discussed under electrochemical properties in this chapter.

Table 3-8 Steel Corrosion Rates for Moderately Corrosive Reinforced Fill.

For zinc/side:	0.58 mils/yr (15 µm/year) (first 2 years)
	0.16 mils/yr (4 µm/year) (thereafter)
For residual carbon steel/side:	0.47 mils/yr (12 µm/year) (thereafter)

Calculate time (in years) to corrode through galvinization.

$$0.58 \cdot 2 + 0.16 \cdot \left(t_g - 2\right) = 3.4$$

$$t_g := \frac{3.4 - 0.58 \cdot 2}{0.16}\ yr + 2\ yr = 16\ yr$$ years to corrode through galvenization

Calculate the new diameter after 30 years of corrosion exposure:

$$years := 30\ yr$$

$$dc_{W4.5xW3.5} := d_{W4.5xW3.5} - \left(2 \cdot 0.00047\ \frac{in}{yr} \cdot \left(years - t_g\right)\right) = 0.226\ in$$

$$dc_{W7.0xW3.5} := d_{W7.0xW3.5} - \left(2 \cdot 0.00047\ \frac{in}{yr} \cdot \left(years - t_g\right)\right) = 0.286\ in$$

$$dc_{W9.5xW4.0} := d_{W9.5xW4.0} - \left(2 \cdot 0.00047\ \frac{in}{yr} \cdot \left(years - t_g\right)\right) = 0.335\ in$$

Calculate cross-sectional area after 30 years of corrosion exposure:

$$A_{sW4.5xW3.5} := \pi \cdot \left(\frac{dc_{W4.5xW3.5}}{2}\right)^2 = 0.04\ in^2$$

$$A_{sW7.0xW3.5} := \pi \cdot \left(\frac{dc_{W7.0xW3.5}}{2}\right)^2 = 0.064\ in^2$$

$$A_{sW9.5xW4.0} := \pi \cdot \left(\frac{dc_{W9.5xW4.0}}{2} \right)^2 = 0.088\ in^2$$

LRFD Resistance Factors for Tensile and Pullout Resistance for MSE Walls with Metal Straps:

Table 4-7. Resistance Factors, ϕ, for Tensile and Pullout Resistance for MSE Walls
(after Table 11.5.6-1, AASHTO {2007}).

Reinforcement Type and Loading Condition			Resistance Factor
Metallic reinforcement and connectors	Strip reinforcements (A)		
		Static loading	0.75
		Combined static/earthquake loading	1.00
		Combined static/traffic barrier impact (B)	1.00
	Grid reinforcements (A, C)		
		Static loading	0.65
		Combined static/earthquake loading	0.85
		Combined static/traffic barrier impact (B)	0.85
Geosynthetic reinforcement and connectors		Static loading	0.90
		Combined static/earthquake loading	1.20
		Combined static/traffic barrier impact (B)	1.20
Pullout resistance of tensile reinforcement (metallic and geosynthetic)		Static loading	0.90
		Combined static/earthquake loading	1.20
		Combined static/traffic barrier impact (B)	1.00

Notes:
A. Apply to gross cross-section less sacrificial area. For sections with holes, reduce gross area in accordance with AASHTO (2007) Article 6.8.3 and apply to net section less sacrificial area.
B. Combined static/traffic barrier impact resistance factors are not presented in AASHTO.
C. Applies to grid reinforcements connected to rigid facing element, e.g., a concrete panel or block. For grid reinforcements connected to a flexible facing mat or which are continuous with the facing mat, use the resistance factor for strip reinforcements.

Resistance Factors:

$$\Phi_{static} := 0.65 \qquad \Phi_{pullout\_static} := 0.9$$

$$\Phi_{seismic} := 0.85 \qquad \Phi_{pullout\_seismic} := 1.2$$

Calculate Slope/W Reinforcement Inputs:

$$H_{wall} := 45\ ft$$

Based on the existing Hilfiker wall design drawings dated June 28, 1990, the vertical (s_v) spacing of the steel grids within each SE wall panel was determined. For calculation efficiency, the calculations are performed using matrices.

$$s_v := \begin{bmatrix} 0 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 6 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \end{bmatrix} ft \qquad t := \begin{bmatrix} dc_{W9.5xW4.0} \\ dc_{W9.5xW4.0} \\ dc_{W9.5xW4.0} \\ dc_{W9.5xW4.0} \\ dc_{W9.5xW4.0} \\ dc_{W9.5xW4.0} \\ dc_{W9.5xW4.0} \\ dc_{W9.5xW4.0} \\ dc_{W7.0xW3.5} \\ dc_{W7.0xW3.5} \\ dc_{W7.0xW3.5} \\ dc_{W7.0xW3.5} \\ dc_{W7.0xW3.5} \\ dc_{W7.0xW3.5} \\ dc_{W4.5xW3.5} \\ dc_{W4.5xW3.5} \\ dc_{W4.5xW3.5} \\ dc_{W4.5xW3.5} \\ dc_{W4.5xW3.5} \\ dc_{W4.5xW3.5} \\ dc_{W4.5xW3.5} \\ dc_{W4.5xW3.5} \end{bmatrix}$$

The matrix respresents the same order of the SE Wall reinforcement. Top row of the matrix represents the bottom row (Row 1) of the SE Wall reinforcement and the bottom row of the matrix represents the row of reinforcement closest to the ground surface (Row 23).

t represents the claculated thickness of each row of reinforcement for the existing Hilfiker wall after 30 years of corrosion exposure. This thickness is applied below in the grid capacity calculations.

$i := 0 .. \text{length}\left(s_v\right) - 1$ Calculate number of elements

Calculate each grid's vertical elevation and depth from the top of the wall, with the base of the wall as elevation 0 ft. Top row of the matrix represents the bottom reinforcement row.

$$elevation_i := \sum_{j=0}^{i} s_{v_j} = \begin{bmatrix} 0 \\ 2 \\ 4 \\ 6 \\ 8 \\ 10 \\ 12 \\ 14 \\ 16 \\ 22 \\ 24 \\ 26 \\ 28 \\ 30 \\ 32 \\ 34 \\ 36 \\ 38 \\ 40 \\ 42 \\ 44 \end{bmatrix} ft \qquad depth_i := H_{wall} - elevation_i = \begin{bmatrix} 45 \\ 43 \\ 41 \\ 39 \\ 37 \\ 35 \\ 33 \\ 31 \\ 29 \\ 23 \\ 21 \\ 19 \\ 17 \\ 15 \\ 13 \\ 11 \\ 9 \\ 7 \\ 5 \\ 3 \\ 1 \end{bmatrix} ft$$

Calculate Pullout Resistance Slope/W Input:

For design and comparison purposes, a normalized definition of pullout resistance will be used throughout the manual. The pullout resistance, P_r, at each of the reinforcement levels per unit width of reinforcement is given by:

$$P_r = F^* \alpha \sigma_v' L_e C \qquad (3\text{-}2)$$

where:

- $L_e C$ = the total surface area per unit width of the reinforcement in the resistive zone behind the failure surface
- L_e = the embedment or adherence length in the resisting zone behind the failure surface
- C = the reinforcement effective unit perimeter; e.g., C = 2 for and sheets, and because the edges are neglected C = 2 for strips and grids
- F^* = the pullout resistance (or friction-bearing-interaction) factor
- α = a scale effect correction factor to account for a non linear stress reduction over the embedded length of highly extensible reinforcements, based on laboratory data (generally 1.0 for metallic reinforcements and 0.6 to 1.0 for geosynthetic reinforcements, see Table 3-6).
- σ'_v = the effective vertical stress at the soil-reinforcement interfaces.

The factored pullout resistance is then given by:

$$P_r = \Phi_{pullout} \left(F \cdot \alpha \cdot \sigma_v' \cdot L_e \cdot C\right)$$

In Slope/W, pullout resistance per unit width of wall is given by:

$$P_r = \left(c + \sigma_v' \cdot tan\left(\phi_{interface}\right)\right) \cdot \alpha \cdot L_e \cdot C$$

Where α and C can be defined within the reinforcement properties, and are set to be the same as defined above. Overburden pressure, σ_v' and effective length, Le, are determined from the limit equilibrium analysis performed in Slope/W. Interface adhesion, c, is assumed to be negligable for metal grids in granular backfill.

To select a representative interface friction angle, $\phi_{interface}$, that will produce the same factored resistance per unit width of wall, the two expressions are set to be equal:

$$\Phi_{pullout} \left(F \cdot \alpha \cdot \sigma_v' \cdot L_e \cdot C\right) = \sigma_v' \cdot tan\left(\phi_{interface}\right) \cdot \alpha \cdot L_e \cdot C$$

Removing common constants and rearranging produces:

$$\phi_{interface} = atan\left(\Phi_{pullout} \cdot F\right)$$

Calculate Pullout Resistance Factor F*:

For steel grid reinforcements with transverse spacing of $S_t \geq 6$ inches (150 mm) (see Figure 3-4), F* is a function of a bearing or embedment factor, F_q, applied over the contributing bearing α_β, as follows:

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$F^* = F_q\,\alpha_\beta = 40\,\alpha_\beta = 40\,(t/2S_t) = 20\,(t/S_t)$ at the top of the structure (3-6)

$F^* = F_q\,\alpha_\beta = 20\,\alpha_\beta = 20\,(t/2S_t) = 10\,(t/S_t)$ at a depth of 20 ft (6 m) and below (3-7)

Where, t is the thickness of the transverse bar. S_t must be uniform throughout the length of the reinforcement rather than having transverse grid members concentrated only in the resistant zone. The maximum S_t distance is 24 in. (610 mm). For sloping backfills see Figure 4-15.

$$F_i := \begin{cases} \text{if } depth_i < 20\ ft \\ \quad \left\| 20 \cdot \left(\frac{t_i}{s_t} \right) \right. \\ \text{else} \\ \quad \left\| 10 \cdot \left(\frac{t_i}{s_t} \right) \right. \end{cases}$$

$$F = \begin{bmatrix} 0.28 \\ 0.28 \\ 0.28 \\ 0.28 \\ 0.28 \\ 0.28 \\ 0.28 \\ 0.24 \\ 0.24 \\ 0.24 \\ 0.24 \\ 0.48 \\ 0.48 \\ 0.38 \\ 0.38 \\ 0.38 \\ 0.38 \\ 0.38 \\ 0.38 \\ 0.38 \\ 0.38 \end{bmatrix}$$

Calculated F* for each row of reinforcement. Top row of matrix represents the bottom row of reinforcement.

Calculate Interface Shear Angle (degrees):

$$\phi_{interface\_static} := \operatorname{atan}\left(\Phi_{pullout\_static} \cdot F\right) = \begin{bmatrix} 14.1 \\ 14.1 \\ 14.1 \\ 14.1 \\ 14.1 \\ 14.1 \\ 14.1 \\ 12.1 \\ 12.1 \\ 12.1 \\ 12.1 \\ 23.2 \\ 23.2 \\ 18.7 \\ 18.7 \\ 18.7 \\ 18.7 \\ 18.7 \\ 18.7 \\ 18.7 \\ 18.7 \end{bmatrix} \ deg$$

Static interface shear angle for each row of reinforcement. Top row of matrix represents the bottom reinforcement row.

$$\phi_{interface\_seismic} := \operatorname{atan}\left(\Phi_{pullout\_seismic} \cdot F\right) = \begin{bmatrix} 18.5 \\ 18.5 \\ 18.5 \\ 18.5 \\ 18.5 \\ 18.5 \\ 18.5 \\ 16 \\ 16 \\ 16 \\ 16 \\ 29.8 \\ 29.8 \\ 24.3 \\ 24.3 \\ 24.3 \\ 24.3 \\ 24.3 \\ 24.3 \\ 24.3 \\ 24.3 \end{bmatrix} \textit{deg}$$

Seismic interface shear angle for each row of reinforcement. Top row of matrix represents the bottom reinforcement row.

Calculate Allowable Tensile Capacity of Steel Straps:

$$T_{capacity} = \Phi_{static} \cdot f_y \, A_s$$

Slope/W does not have grid reinforcement inputs. Therefore, the tensile strength of the grids were modeled as continuous reinforcement. The calculated allowable tensile grid capacity was converted to a continuous reinforcement tensile capacity by distributing the capacity over the tributary width. The longitudinal wires are spaced every 6 inches, therefore there are two bars within each 1 foot width of grid.

W9.5xW4.0:
(Rows 1 through 6)

$$T_{al\_static} := \frac{\Phi_{static} \cdot f_y \, A_{sW9.5xW4.0} \cdot \frac{1\ \textit{ft}}{s_l}}{w} = 7.44\ \frac{\textit{kip}}{\textit{ft}}$$

$$T_{al\_seismic} := \frac{\Phi_{seismic} \cdot f_y \, A_{sW9.5xW4.0} \cdot \frac{1\ \textit{ft}}{s_l}}{w} = 9.7\ \frac{\textit{kip}}{\textit{ft}}$$

W7.0xW3.5:
(Rows 7 through 15)

$$T_{al\_static} := \frac{\Phi_{static} \cdot f_y \, A_{sW7.0xW3.5} \cdot \frac{1\ ft}{s_l}}{w} = 5.42\ \frac{kip}{ft}$$

$$T_{al\_seismic} := \frac{\Phi_{seismic} \cdot f_y \, A_{sW7.0xW3.5} \cdot \frac{1\ ft}{s_l}}{w} = 7.1\ \frac{kip}{ft}$$

W4.5xW3.5:
(Rows 16 through 23)

$$T_{al\_static} := \frac{\Phi_{static} \cdot f_y \, A_{sW4.5xW3.5} \cdot \frac{1\ ft}{s_l}}{w} = 3.38\ \frac{kip}{ft}$$

$$T_{al\_seismic} := \frac{\Phi_{seismic} \cdot f_y \, A_{sW4.5xW3.5} \cdot \frac{1\ ft}{s_l}}{w} = 4.4\ \frac{kip}{ft}$$

Wall 03.63L - Section Fa-Fa'
(Construction Condition)

For the construction condition the existing Hilfiker wall is cut down to elevation 66.5-feet in order to install the new footing for Bridge 17.7, prior to installing the new Hilfiker wall.

$TWE := 66.5\ ft$ Top of Wall Elevation During Construction

$BWE := 49\ ft$ Bottom of Wall Elevation

Calculate Slope/W Reinforcement Inputs:

$H_{wall} := TWE - BWE = 17.5\ ft$

Based on the existing Hilfiker wall design drawings dated June 28, 1990, the vertical (s_v) spacing of the steel grids within each SE wall panel was determined. For calculation efficiency, the calculations are performed using matrices.

$$s_v := \begin{bmatrix} 0 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \end{bmatrix} ft \qquad t := \begin{bmatrix} dc_{W9.5xW4.0} \\ dc_{W9.5xW4.0} \\ dc_{W9.5xW4.0} \\ dc_{W9.5xW4.0} \\ dc_{W9.5xW4.0} \\ dc_{W9.5xW4.0} \\ dc_{W9.5xW4.0} \\ dc_{W7.0xW3.5} \\ dc_{W7.0xW3.5} \end{bmatrix}$$

The matrix respresents the same order of the SE Wall reinforcement. Top row of the matrix represents the bottom row (Row 1) of the SE Wall reinforcement and the bottom row of the matrix represents the row of reinforcement closest to the ground surface (Row 10).

t represents the claculated thickness of each row of reinforcement for the existing Hilfiker wall after 30 years of corrosion exposure. This thickness is applied below in the grid capacity calculations.

$i := 0 .. \text{length}(s_v) - 1$ Calculate number of elements

Calculate each grid's vertical elevation and depth from the top of the wall, with the base of the wall as elevation 0 ft. Top row of the matrix represents the bottom reinforcement row.

$$elevation_i := \sum_{j=0}^{i} s_{v_j} = \begin{bmatrix} 0 \\ 2 \\ 4 \\ 6 \\ 8 \\ 10 \\ 12 \\ 14 \\ 16 \end{bmatrix} ft \qquad depth_i := H_{wall} - elevation_i = \begin{bmatrix} 17.5 \\ 15.5 \\ 13.5 \\ 11.5 \\ 9.5 \\ 7.5 \\ 5.5 \\ 3.5 \\ 1.5 \end{bmatrix} ft$$

Calculate Pullout Resistance Slope/W Input:

For design and comparison purposes, a normalized definition of pullout resistance will be used throughout the manual. The pullout resistance, P_r, at each of the reinforcement levels per unit width of reinforcement is given by:

$$P_r = F^* \alpha \sigma_v' L_e C \qquad (3\text{-}2)$$

where:

- $L_e C$ = the total surface area per unit width of the reinforcement in the resistive zone behind the failure surface
- L_e = the embedment or adherence length in the resisting zone behind the failure surface
- C = the reinforcement effective unit perimeter; e.g., C = 2 for and sheets, and because the edges are neglected C = 2 for strips and grids
- F^* = the pullout resistance (or friction-bearing-interaction) factor
- α = a scale effect correction factor to account for a non linear stress reduction over the embedded length of highly extensible reinforcements, based on laboratory data (generally 1.0 for metallic reinforcements and 0.6 to 1.0 for geosynthetic reinforcements, see Table 3-6).
- σ'_v = the effective vertical stress at the soil-reinforcement interfaces.

The factored pullout resistance is then given by:

$$P_r = \Phi_{pullout} \left(F \cdot \alpha \cdot \sigma_v' \cdot L_e \cdot C\right)$$

In Slope/W, pullout resistance per unit width of wall is given by:

$$P_r = \left(c + \sigma_v' \cdot \tan\left(\phi_{interface}\right)\right) \cdot \alpha \cdot L_e \cdot C$$

Where α and C can be defined within the reinforcement properties, and are set to be the same as defined above. Overburden pressure, σ_v' and effective length, Le, are determined from the limit equilibrium analysis performed in Slope/W. Interface adhesion, c, is assumed to be negligable for metal grids in granular backfill.

To select a representative interface friction angle, $\phi_{interface}$, that will produce the same factored resistance per unit width of wall, the two expressions are set to be equal:

$$\Phi_{pullout}\left(F\cdot\alpha\cdot\sigma_v'\cdot L_e\cdot C\right)=\sigma_v'\cdot tan\left(\phi_{interface}\right)\cdot\alpha\cdot L_e\cdot C$$

Removing common constants and rearranging produces:

$$\phi_{interface}=atan\left(\Phi_{pullout}\cdot F\right)$$

Calculate Pullout Resistance Factor F*:

For steel grid reinforcements with transverse spacing of $S_t \geq 6$ inches (150 mm) (see Figure 3-4), F* is a function of a bearing or embedment factor, F_q, applied over the contributing bearing α_β, as follows:

$F^* = F_q\,\alpha_\beta = 40\,\alpha_\beta = 40\,(t/2S_t) = 20\,(t/S_t)$ at the top of the structure (3-6)

$F^* = F_q\,\alpha_\beta = 20\,\alpha_\beta = 20\,(t/2S_t) = 10\,(t/S_t)$ at a depth of 20 ft (6 m) and below (3-7)

Where, t is the thickness of the transverse bar. S_t must be uniform throughout the length of the reinforcement rather than having transverse grid members concentrated only in the resistant zone. The maximum S_t distance is 24 in. (610 mm). For sloping backfills see Figure 4-15.

$$F\_construction_i := \begin{cases} \text{if } depth_i < 20\ ft \\ \quad 20\cdot\left(\frac{t_i}{s_t}\right) \\ \text{else} \\ \quad 10\cdot\left(\frac{t_i}{s_t}\right) \end{cases}$$

$$F\_construction = \begin{bmatrix} 0.56 \\ 0.56 \\ 0.56 \\ 0.56 \\ 0.56 \\ 0.56 \\ 0.56 \\ 0.48 \\ 0.48 \end{bmatrix}$$

Calculated F* for each row of reinforcement for hte construction case. Top row of matrix represents the bottom row of reinforcement.

Calculate Interface Shear Angle (degrees):

$$\phi_{interface\_static} := \operatorname{atan}\left(\Phi_{pullout\_static} \cdot F\_construction\right) = \begin{bmatrix} 26.7 \\ 26.7 \\ 26.7 \\ 26.7 \\ 26.7 \\ 26.7 \\ 26.7 \\ 23.2 \\ 23.2 \end{bmatrix} \ deg$$

Static interface shear angle for each row of reinforcement. Top row of matrix represents the bottom reinforcement row.

Calculate Allowable Tensile Capacity of Steel Straps:

$$T_{capacity} = \Phi_{static} \cdot f_y \, A_s$$

Slope/W does not have grid reinforcement inputs. Therefore, the tensile strength of the grids were modeled as continuous reinforcement. The calculated allowable tensile grid capacity was converted to a continuous reinforcement tensile capacity by distributing the capacity over the tributary width. The longitudinal wires are spaced every 6 inches, therefore there are two bars within each 1 foot width of grid.

W9.5xW4.0:
(Rows 1 through 7)

$$T_{al\_static} := \frac{\Phi_{static} \cdot f_y \, A_{sW9.5xW4.0} \cdot \frac{1\ ft}{s_l}}{w} = 7.44\ \frac{kip}{ft}$$

W7.0xW3.5:
(Rows 8 through 9)

$$T_{al\_static} := \frac{\Phi_{static} \cdot f_y \, A_{sW7.0xW3.5} \cdot \frac{1\ ft}{s_l}}{w} = 5.42\ \frac{kip}{ft}$$

Wall 03.63L - Section Fa-Fa' (Final Condition)

The final condition occurs after the construction phase. The new Bridge 17.7 footing has been installed, as well as the previously cut down Hilfiker wall has been replaced by a new Hilfiker wall.

$TWE := 94\ ft$ Top of Wall Elevation for Final Condition

$BWE := 71\ ft$ Bottom of Wall Elevation

$H_{wall} := TWE - BWE = 23\ ft$

Calculate Corrosion Reduction:

Calculate the cross-sectional area of steel remaining after corrosion exposure for the deisgn life of the new Hilfiker wall. We undestand the new portion of the wall will not be an exact one-to-one replacement of the existing wall. We also understand that the new wall will be designed to the current required corrosion rate and design life duration. The calculation provided here was used to verify compound stability and is based on the existing wall as originally designed exposed to 45 years of corrosion. For the final design, the wall designer should make certain that greater than or equal amounts of steel area remain at the end of the total new wall design life in order to satisfy compound stability.

The corrosion rates presented in Table 3-8 are suitable for conservative design. **These rates assume a moderately corrosive backfill material having the controlled electrochemical property limits** that are discussed under electrochemical properties in this chapter.

Table 3-8 Steel Corrosion Rates for Moderately Corrosive Reinforced Fill.

For zinc/side:	0.58 mils/yr (15 µm/year) (first 2 years)
	0.16 mils/yr (4 µm/year) (thereafter)
For residual carbon steel/side:	0.47 mils/yr (12 µm/year) (thereafter)

Calculate the new diameter (of NEW Hilfiker wall) after 45 years of corrosion exposure:

$years := 45\ yr$

$$dc_{W4.5xW3.5\_NEW} := d_{W4.5xW3.5} - \left(2 \cdot 0.00047\ \frac{in}{yr} \cdot \left(years - t_g\right)\right) = 0.212\ in$$

$$dc_{W7.0xW3.5\_NEW} := d_{W7.0xW3.5} - \left(2 \cdot 0.00047\ \frac{in}{yr} \cdot \left(years - t_g\right)\right) = 0.272\ in$$

Calculate cross-sectional (of NEW Hilfiker wall) after 45 years of corrosion exposure:

$$A_{sW4.5xW3.5\_NEW} := \pi \cdot \left(\frac{dc_{W4.5xW3.5\_NEW}}{2}\right)^2 = 0.035\ in^2$$

$$A_{sW7.0xW3.5\_NEW} := \pi \cdot \left(\frac{dc_{W7.0xW3.5\_NEW}}{2} \right)^2 = 0.058\ in^2$$

LRFD Resistance Factors for Tensile and Pullout Resistance for MSE Walls with Metal Straps:

Table 4-7. Resistance Factors, ϕ, for Tensile and Pullout Resistance for MSE Walls
(after Table 11.5.6-1, AASHTO {2007}).

Reinforcement Type and Loading Condition			Resistance Factor
Metallic reinforcement and connectors	Strip reinforcements (A)		
		Static loading	0.75
		Combined static/earthquake loading	1.00
		Combined static/traffic barrier impact (B)	1.00
	Grid reinforcements (A, C)		
		Static loading	0.65
		Combined static/earthquake loading	0.85
		Combined static/traffic barrier impact (B)	0.85
Geosynthetic reinforcement and connectors		Static loading	0.90
		Combined static/earthquake loading	1.20
		Combined static/traffic barrier impact (B)	1.20
Pullout resistance of tensile reinforcement (metallic and geosynthetic)		Static loading	0.90
		Combined static/earthquake loading	1.20
		Combined static/traffic barrier impact (B)	1.00

Notes:
A. Apply to gross cross-section less sacrificial area. For sections with holes, reduce gross area in accordance with AASHTO (2007) Article 6.8.3 and apply to net section less sacrificial area.
B. Combined static/traffic barrier impact resistance factors are not presented in AASHTO.
C. Applies to grid reinforcements connected to rigid facing element, e.g., a concrete panel or block. For grid reinforcements connected to a flexible facing mat or which are continuous with the facing mat, use the resistance factor for strip reinforcements.

Resistance Factors:

$$\Phi_{static} := 0.65 \qquad \Phi_{pullout\_static} := 0.9$$

$$\Phi_{seismic} := 0.85 \qquad \Phi_{pullout\_seismic} := 1.2$$

Calculate Slope/W Reinforcement Inputs:

$$H_{wall} := 23\ ft$$

Based on the existing Hilfiker wall design drawings dated June 28, 1990, the vertical (s_v) spacing of the steel grids within each SE wall panel was determined. For calculation efficiency, the calculations are performed using matrices.

$$s_v := \begin{bmatrix} 0 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \end{bmatrix} ft \qquad t := \begin{bmatrix} dc_{W7.0xW3.5\_NEW} \\ dc_{W7.0xW3.5\_NEW} \\ dc_{W7.0xW3.5\_NEW} \\ dc_{W7.0xW3.5\_NEW} \\ dc_{W4.5xW3.5\_NEW} \\ dc_{W4.5xW3.5\_NEW} \\ dc_{W4.5xW3.5\_NEW} \\ dc_{W4.5xW3.5\_NEW} \\ dc_{W4.5xW3.5\_NEW} \\ dc_{W4.5xW3.5\_NEW} \\ dc_{W4.5xW3.5\_NEW} \\ dc_{W4.5xW3.5\_NEW} \end{bmatrix}$$

The matrix respresents the same order of the SE Wall reinforcement. Top row of the matrix represents the bottom row (Row 1) of the SE Wall reinforcement and the bottom row of the matrix represents the row of reinforcement closest to the ground surface (Row 24).

t represents the claculated thickness of each row of reinforcement for the existing Hilfiker wall after 30 years of corrosion exposure. This thickness is applied below in the grid capacity calculations.

$i := 0 .. \text{length}\left(s_v\right) - 1$ Calculate number of elements

Calculate each strap's vertical elevation and depth from the top of the wall, with the base of the wall as elevation 0 ft. Top row of the matrix represents the bottom reinforcement row.

$$elevation_i := \sum_{j=0}^{i} s_{v_j} = \begin{bmatrix} 0 \\ 2 \\ 4 \\ 6 \\ 8 \\ 10 \\ 12 \\ 14 \\ 16 \\ 18 \\ 20 \\ 22 \end{bmatrix} ft \qquad depth_i := H_{wall} - elevation_i = \begin{bmatrix} 23 \\ 21 \\ 19 \\ 17 \\ 15 \\ 13 \\ 11 \\ 9 \\ 7 \\ 5 \\ 3 \\ 1 \end{bmatrix} ft$$

Calculate Pullout Resistance Slope/W Input:

For design and comparison purposes, a normalized definition of pullout resistance will be used throughout the manual. The pullout resistance, P_r, at each of the reinforcement levels per unit width of reinforcement is given by:

$$P_r = F^* \alpha \sigma'_v L_e C \qquad (3\text{-}2)$$

where:

- $L_e C$ = the total surface area per unit width of the reinforcement in the resistive zone behind the failure surface
- L_e = the embedment or adherence length in the resisting zone behind the failure surface
- C = the reinforcement effective unit perimeter; e.g., C = 2 for and sheets, and because the edges are neglected C = 2 for strips and grids
- F^* = the pullout resistance (or friction-bearing-interaction) factor
- α = a scale effect correction factor to account for a non linear stress reduction over the embedded length of highly extensible reinforcements, based on laboratory data (generally 1.0 for metallic reinforcements and 0.6 to 1.0 for geosynthetic reinforcements, see Table 3-6).
- σ'_v = the effective vertical stress at the soil-reinforcement interfaces.

The factored pullout resistance is then given by:

$$P_r = \Phi_{pullout} \left(F \cdot \alpha \cdot \sigma_v' \cdot L_e \cdot C\right)$$

In Slope/W, pullout resistance per unit width of wall is given by:

$$P_r = \left(c + \sigma_v' \cdot tan\left(\phi_{interface}\right)\right) \cdot \alpha \cdot L_e \cdot C$$

Where α and C can be defined within the reinforcement properties, and are set to be the same as defined above. Overburden pressure, σ_v' and effective length, Le, are determined from the limit equilibrium analysis performed in Slope/W. Interface adhesion, c, is assumed to be negligable for metal grids in granular backfill.

To select a representative interface friction angle, $\phi_{interface}$, that will produce the same factored resistance per unit width of wall, the two expressions are set to be equal:

$$\Phi_{pullout} \left(F \cdot \alpha \cdot \sigma_v' \cdot L_e \cdot C\right) = \sigma_v' \cdot tan\left(\phi_{interface}\right) \cdot \alpha \cdot L_e \cdot C$$

Removing common constants and rearranging produces:

$$\phi_{interface} = atan\left(\Phi_{pullout} \cdot F\right)$$

Calculate Pullout Resistance Factor F*:

For steel grid reinforcements with transverse spacing of $S_t \geq 6$ inches (150 mm) (see Figure 3-4), F* is a function of a bearing or embedment factor, F_q, applied over the contributing bearing α_β, as follows:

$F^* = F_q\,\alpha_\beta = 40\,\alpha_\beta = 40\,(t/2S_t) = 20\,(t/S_t)$ at the top of the structure (3-6)

$F^* = F_q\,\alpha_\beta = 20\,\alpha_\beta = 20\,(t/2S_t) = 10\,(t/S_t)$ at a depth of 20 ft (6 m) and below (3-7)

Where, t is the thickness of the transverse bar. S_t must be uniform throughout the length of the reinforcement rather than having transverse grid members concentrated only in the resistant zone. The maximum S_t distance is 24 in. (610 mm). For sloping backfills see Figure 4-15.

$$F\_final_i := \text{if } depth_i < 20\ ft \left\| 20 \cdot \left(\frac{t_i}{s_t}\right) \right. \text{else} \left\| 10 \cdot \left(\frac{t_i}{s_t}\right) \right.$$

$$F\_final = \begin{bmatrix} 0.23 \\ 0.23 \\ 0.45 \\ 0.45 \\ 0.35 \\ 0.35 \\ 0.35 \\ 0.35 \\ 0.35 \\ 0.35 \\ 0.35 \\ 0.35 \end{bmatrix}$$

Calculated F* for each row of reinforcement. Top row of matrix represents the bottom row of reinforcement.

Calculate Interface Shear Angle (degrees):

$$\phi_{interface\_static} := \operatorname{atan}\left(\Phi_{pullout\_static} \cdot F\_final\right) = \begin{bmatrix} 11.5 \\ 11.5 \\ 22.2 \\ 22.2 \\ 17.6 \\ 17.6 \\ 17.6 \\ 17.6 \\ 17.6 \\ 17.6 \\ 17.6 \\ 17.6 \end{bmatrix} \text{deg}$$

Static interface shear angle for each row of reinforcement. Top row of matrix represents the bottom reinforcement row.

$$\phi_{interface\_seismic} := \operatorname{atan}\left(\Phi_{pullout\_seismic} \cdot F\_final\right) = \begin{bmatrix} 15.2 \\ 15.2 \\ 28.5 \\ 28.5 \\ 23 \\ 23 \\ 23 \\ 23 \\ 23 \\ 23 \\ 23 \\ 23 \end{bmatrix} \text{deg}$$

Seismic interface shear angle for each row of reinforcement. Top row of matrix represents the bottom reinforcement row.

Calculate Allowable Tensile Capacity of Steel Straps:

$$T_{capacity} = \Phi_{static} \cdot f_y \, A_s$$

Slope/W does not have grid reinforcement inputs. Therefore, the tensile strength of the grids were modeled as continuous reinforcement. The calculated allowable tensile grid capacity was converted to a continuous reinforcement tensile capacity by distributing the capacity over the tributary width. The longitudinal wires are spaced every 6 inches, therefore there are two bars within each 1 foot width of grid.

W7.0xW3.5 (NEW):
(Rows 1 through 4)

$$T_{al\_static} := \frac{\Phi_{static} \cdot f_y \, A_{sW7.0xW3.5\_NEW} \cdot \frac{1\ ft}{s_l}}{w} = 4.9\ \frac{kip}{ft}$$

$$T_{al\_seismic} := \frac{\Phi_{seismic} \cdot f_y \, A_{sW7.0xW3.5\_NEW} \cdot \frac{1\ ft}{s_l}}{w} = 6.4\ \frac{kip}{ft}$$

W4.5xW3.5 (NEW):
(Rows 5 through 12)

$$T_{al\_static} := \frac{\Phi_{static} \cdot f_y \, A_{sW4.5xW3.5\_NEW} \cdot \frac{1\ ft}{s_l}}{w} = 2.98\ \frac{kip}{ft}$$

$$T_{al\_seismic} := \frac{\Phi_{seismic} \cdot f_y \, A_{sW4.5xW3.5\_NEW} \cdot \frac{1\ ft}{s_l}}{w} = 3.9\ \frac{kip}{ft}$$

Calculating MSE Strip Properties for Slope/W

Wall 03.63L - Section Ga-Ga' (Behind Proposed Footing) - Existing Condition

For global stability analyses, the MSE wall is modeled as a high strength material and the failure is forced outside of the reinforced zone. To check for compound stability, the high strength material is replaced with gravel borrow and welded wire grids modeled after existing wall design drawings dated June 28, 1990 provided by Hilfiker. Relevant pages of these plans are provided within this appendix. The properties of the metal grids are calculated based on FHWA NHI-10-024 and NHI-10-025. The reinforcement properties are converted to per unit width basis, and implemented as a continous layer in Slope/W.

Input Soil Properties:

Backfill meeting WSDOT standard specifications 9-03.14(4), Gravel Borrow for Structural Earth Wall.

$\phi_{ESU1A} := 40\ deg$	Elevation 72 and above
$\phi_{ESU1B} := 38\ deg$	Elevation 72 and below

Input Grid Properties:

$d_{W4.5xW3.5} := 0.239\ in$	Gross Diameter (no corrosion)
$d_{W7.0xW3.5} := 0.299\ in$	Gross Diameter (no corrosion)
$d_{W9.5xW4.0} := 0.348\ in$	Gross Diameter (no corrosion)
$f_y := 65.0\ ksi$	Yield stress
$s_t := 12\ in$	Spacing of Transverse Bars
$s_l := 6\ in$	Spacing of Longitudinal Bars
$w := 1\ ft$	Gross Grid Width
$TWE := 92\ ft$	Top of Wall Elevation

Calculate Corrosion Reduction:

Bridge 17.7 was constructed in 1990. Calculate new cross-sectional area of steel grid after 30 years of corrosion exposure.

The corrosion rates presented in Table 3-8 are suitable for conservative design. **These rates assume a moderately corrosive backfill material having the controlled electrochemical property limits** that are discussed under electrochemical properties in this chapter.

Table 3-8 Steel Corrosion Rates for Moderately Corrosive Reinforced Fill.

For zinc/side:	0.58 mils/yr (15 µm/year) (first 2 years)
	0.16 mils/yr (4 µm/year) (thereafter)
For residual carbon steel/side:	0.47 mils/yr (12 µm/year) (thereafter)

Calculate time (in years) to corrode through galvinization.

$$0.58 \cdot 2 + 0.16 \cdot (t_g - 2) = 3.4$$

$$t_g := \frac{3.4 - 0.58 \cdot 2}{0.16}\ yr + 2\ yr = 16\ yr$$ years to corrode through galvenization

Calculate the new diameter after 30 years of corrosion exposure:

$$years := 30\ yr$$

$$dc_{W4.5xW3.5} := d_{W4.5xW3.5} - \left(2 \cdot 0.00047\ \frac{in}{yr} \cdot (years - t_g)\right) = 0.226\ in$$

$$dc_{W7.0xW3.5} := d_{W7.0xW3.5} - \left(2 \cdot 0.00047\ \frac{in}{yr} \cdot (years - t_g)\right) = 0.286\ in$$

$$dc_{W9.5xW4.0} := d_{W9.5xW4.0} - \left(2 \cdot 0.00047\ \frac{in}{yr} \cdot (years - t_g)\right) = 0.335\ in$$

Calculate cross-sectional area after 30 years of corrosion exposure:

$$A_{sW4.5xW3.5} := \pi \cdot \left(\frac{dc_{W4.5xW3.5}}{2}\right)^2 = 0.04\ in^2$$

$$A_{sW7.0xW3.5} := \pi \cdot \left(\frac{dc_{W7.0xW3.5}}{2}\right)^2 = 0.064\ in^2$$

$$A_{sW9.5xW4.0} := \pi \cdot \left(\frac{dc_{W9.5xW4.0}}{2}\right)^2 = 0.088\ in^2$$

LRFD Resistance Factors for Tensile and Pullout Resistance for MSE Walls with Metal Straps:

Table 4-7. Resistance Factors, ϕ, for Tensile and Pullout Resistance for MSE Walls
(after Table 11.5.6-1, AASHTO {2007}).

Reinforcement Type and Loading Condition			Resistance Factor
Metallic reinforcement and connectors	Strip reinforcements [A]		
		Static loading	0.75
		Combined static/earthquake loading	1.00
		Combined static/traffic barrier impact [B]	1.00
	Grid reinforcements [A, C]		
		Static loading	0.65
		Combined static/earthquake loading	0.85
		Combined static/traffic barrier impact [B]	0.85
Geosynthetic reinforcement and connectors		Static loading	0.90
		Combined static/earthquake loading	1.20
		Combined static/traffic barrier impact [B]	1.20
Pullout resistance of tensile reinforcement (metallic and geosynthetic)		Static loading	0.90
		Combined static/earthquake loading	1.20
		Combined static/traffic barrier impact [B]	1.00

Notes:
A. Apply to gross cross-section less sacrificial area. For sections with holes, reduce gross area in accordance with AASHTO (2007) Article 6.8.3 and apply to net section less sacrificial area.
B. Combined static/traffic barrier impact resistance factors are not presented in AASHTO.
C. Applies to grid reinforcements connected to rigid facing element, e.g., a concrete panel or block. For grid reinforcements connected to a flexible facing mat or which are continuous with the facing mat, use the resistance factor for strip reinforcements.

Resistance Factors:

$$\Phi_{static} := 0.65 \qquad \Phi_{pullout\_static} := 0.9$$

$$\Phi_{seismic} := 0.85 \qquad \Phi_{pullout\_seismic} := 1.2$$

Calculate Slope/W Reinforcement Inputs:

$H_{wall} := 45\ ft$

Based on the existing Hilfiker wall design drawings dated June 28, 1990, the vertical (s_v) spacing of the steel grids within each SE wall panel was determined. For calculation efficiency, the calculations are performed using matrices.

$$s_v := \begin{bmatrix} 0 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \end{bmatrix} ft \qquad t := \begin{bmatrix} dc_{W9.5xW4.0} \\ dc_{W9.5xW4.0} \\ dc_{W9.5xW4.0} \\ dc_{W9.5xW4.0} \\ dc_{W9.5xW4.0} \\ dc_{W9.5xW4.0} \\ dc_{W9.5xW4.0} \\ dc_{W7.0xW3.5} \\ dc_{W7.0xW3.5} \\ dc_{W7.0xW3.5} \\ dc_{W7.0xW3.5} \\ dc_{W7.0xW3.5} \\ dc_{W7.0xW3.5} \\ dc_{W7.0xW3.5} \\ dc_{W7.0xW3.5} \\ dc_{W4.5xW3.5} \\ dc_{W4.5xW3.5} \\ dc_{W4.5xW3.5} \\ dc_{W4.5xW3.5} \\ dc_{W4.5xW3.5} \\ dc_{W4.5xW3.5} \\ dc_{W4.5xW3.5} \\ dc_{W4.5xW3.5} \end{bmatrix}$$

The matrix respresents the same order of the SE Wall reinforcement. Top row of the matrix represents the bottom row (Row 1) of the SE Wall reinforcement and the bottom row of the matrix represents the row of reinforcement closest to the ground surface (Row 23).

t represents the claculated thickness of each row of reinforcement for the existing Hilfiker wall after 30 years of corrosion exposure. This thickness is applied below in the grid capacity calculations.

$i := 0 .. \text{length}\left(s_v\right) - 1$ Calculate number of elements

Calculate each grid's vertical elevation and depth from the top of the wall, with the base of the wall as elevation 0 ft. Top row of the matrix represents the bottom reinforcement row.

$$elevation_i := \sum_{j=0}^{i} s_{v_j} = \begin{bmatrix} 0 \\ 2 \\ 4 \\ 6 \\ 8 \\ 10 \\ 12 \\ 14 \\ 16 \\ 18 \\ 20 \\ 22 \\ 24 \\ 26 \\ 28 \\ 30 \\ 32 \\ 34 \\ 36 \\ 38 \\ 40 \\ 42 \\ 44 \end{bmatrix} ft \qquad depth_i := H_{wall} - elevation_i = \begin{bmatrix} 45 \\ 43 \\ 41 \\ 39 \\ 37 \\ 35 \\ 33 \\ 31 \\ 29 \\ 27 \\ 25 \\ 23 \\ 21 \\ 19 \\ 17 \\ 15 \\ 13 \\ 11 \\ 9 \\ 7 \\ 5 \\ 3 \\ 1 \end{bmatrix} ft$$

Calculate Pullout Resistance Slope/W Input:

For design and comparison purposes, a normalized definition of pullout resistance will be used throughout the manual. The pullout resistance, P_r, at each of the reinforcement levels per unit width of reinforcement is given by:

$$P_r = F^* \alpha \sigma_v' L_e C \qquad (3\text{-}2)$$

where:

- $L_e C$ = the total surface area per unit width of the reinforcement in the resistive zone behind the failure surface
- L_e = the embedment or adherence length in the resisting zone behind the failure surface
- C = the reinforcement effective unit perimeter; e.g., C = 2 for and sheets, and because the edges are neglected C = 2 for strips and grids
- F^* = the pullout resistance (or friction-bearing-interaction) factor
- α = a scale effect correction factor to account for a non linear stress reduction over the embedded length of highly extensible reinforcements, based on laboratory data (generally 1.0 for metallic reinforcements and 0.6 to 1.0 for geosynthetic reinforcements, see Table 3-6).
- σ'_v = the effective vertical stress at the soil-reinforcement interfaces.

The factored pullout resistance is then given by:

$$P_r = \Phi_{pullout} \left(F \cdot \alpha \cdot \sigma_v' \cdot L_e \cdot C \right)$$

In Slope/W, pullout resistance per unit width of wall is given by:

$$P_r = \left(c + \sigma_v' \cdot tan\left(\phi_{interface}\right)\right) \cdot \alpha \cdot L_e \cdot C$$

Where α and C can be defined within the reinforcement properties, and are set to be the same as defined above. Overburden pressure, σ_v' and effective length, Le, are determined from the limit equilibrium analysis performed in Slope/W. Interface adhesion, c, is assumed to be negligable for metal grids in granular backfill.

To select a representative interface friction angle, $\phi_{interface}$, that will produce the same factored resistance per unit width of wall, the two expressions are set to be equal:

$$\Phi_{pullout}\left(F \cdot \alpha \cdot \sigma_v' \cdot L_e \cdot C\right) = \sigma_v' \cdot tan\left(\phi_{interface}\right) \cdot \alpha \cdot L_e \cdot C$$

Removing common constants and rearranging produces:

$$\phi_{interface} = atan\left(\Phi_{pullout} \cdot F\right)$$

Calculate Pullout Resistance Factor F*:

For steel grid reinforcements with transverse spacing of $S_t \geq 6$ inches (150 mm) (see Figure 3-4), F* is a function of a bearing or embedment factor, F_q, applied over the contributing bearing α_β, as follows:

$F^* = F_q\,\alpha_\beta = 40\,\alpha_\beta = 40\,(t/2S_t) = 20\,(t/S_t)$ at the top of the structure (3-6)

$F^* = F_q\,\alpha_\beta = 20\,\alpha_\beta = 20\,(t/2S_t) = 10\,(t/S_t)$ at a depth of 20 ft (6 m) and below (3-7)

Where, t is the thickness of the transverse bar. S_t must be uniform throughout the length of the reinforcement rather than having transverse grid members concentrated only in the resistant zone. The maximum S_t distance is 24 in. (610 mm). For sloping backfills see Figure 4-15.

$$F_i := \text{if } depth_i < 20\ ft \left\| 20 \cdot \left(\frac{t_i}{s_t} \right) \right. \text{else} \left\| 10 \cdot \left(\frac{t_i}{s_t} \right) \right.$$

$$F = \begin{bmatrix} 0.28 \\ 0.28 \\ 0.28 \\ 0.28 \\ 0.28 \\ 0.28 \\ 0.28 \\ 0.24 \\ 0.24 \\ 0.24 \\ 0.24 \\ 0.24 \\ 0.24 \\ 0.24 \\ 0.48 \\ 0.48 \\ 0.38 \\ 0.38 \\ 0.38 \\ 0.38 \\ 0.38 \\ 0.38 \\ 0.38 \\ 0.38 \end{bmatrix}$$

Calculated F* for each row of reinforcement. Top row of matrix represents the bottom row of reinforcement.

Calculate Interface Shear Angle (degrees):

$$\phi_{interface\_static} := \operatorname{atan}\left(\Phi_{pullout\_static} \cdot F\right) = \begin{bmatrix} 14.1 \\ 14.1 \\ 14.1 \\ 14.1 \\ 14.1 \\ 14.1 \\ 14.1 \\ 12.1 \\ 12.1 \\ 12.1 \\ 12.1 \\ 12.1 \\ 12.1 \\ 23.2 \\ 23.2 \\ 18.7 \\ 18.7 \\ 18.7 \\ 18.7 \\ 18.7 \\ 18.7 \\ 18.7 \\ 18.7 \end{bmatrix} \textit{deg}$$

Static interface shear angle for each row of reinforcement. Top row of matrix represents the bottom reinforcement row.

$$\phi_{interface\_seismic} := \operatorname{atan}\left(\Phi_{pullout\_seismic} \cdot F\right) = \begin{bmatrix} 18.5 \\ 18.5 \\ 18.5 \\ 18.5 \\ 18.5 \\ 18.5 \\ 18.5 \\ 16 \\ 16 \\ 16 \\ 16 \\ 16 \\ 16 \\ 29.8 \\ 29.8 \\ 24.3 \\ 24.3 \\ 24.3 \\ 24.3 \\ 24.3 \\ 24.3 \\ 24.3 \\ 24.3 \\ 24.3 \end{bmatrix} \ deg$$

Seismic interface shear angle for each row of reinforcement. Top row of matrix represents the bottom reinforcement row.

Calculate Allowable Tensile Capacity of Steel Straps:

$$T_{capacity} = \Phi_{static} \cdot f_y \ A_s$$

Slope/W does not have grid reinforcement inputs. Therefore, the tensile strength of the grids were modeled as continuous reinforcement. The calculated allowable tensile strap capacity was converted to a continuous reinforcement tensile capacity by distributing the capacity over the tributary width. The longitudinal wires are spaced every 6 inches, therefore there are two bars within each 1 foot width of grid.

W9.5xW4.0:
(Rows 1 through 7)

$$T_{al\_static} := \frac{\Phi_{static} \cdot f_y \ A_{sW9.5xW4.0} \cdot \frac{1 \ ft}{s_l}}{w} = 7.44 \ \frac{kip}{ft}$$

$$T_{al\_seismic} := \frac{\Phi_{seismic} \cdot f_y \ A_{sW9.5xW4.0} \cdot \frac{1 \ ft}{s_l}}{w} = 9.7 \ \frac{kip}{ft}$$

W7.0xW3.5:
(Rows 8 through 15)

$$T_{al\_static} := \frac{\Phi_{static} \cdot f_y \, A_{sW7.0xW3.5} \cdot \frac{1\ ft}{s_l}}{w} = 5.42\ \frac{kip}{ft}$$

$$T_{al\_seismic} := \frac{\Phi_{seismic} \cdot f_y \, A_{sW7.0xW3.5} \cdot \frac{1\ ft}{s_l}}{w} = 7.1\ \frac{kip}{ft}$$

W4.5xW3.5:
(Rows 16 through 23)

$$T_{al\_static} := \frac{\Phi_{static} \cdot f_y \, A_{sW4.5xW3.5} \cdot \frac{1\ ft}{s_l}}{w} = 3.38\ \frac{kip}{ft}$$

$$T_{al\_seismic} := \frac{\Phi_{seismic} \cdot f_y \, A_{sW4.5xW3.5} \cdot \frac{1\ ft}{s_l}}{w} = 4.4\ \frac{kip}{ft}$$

Wall 03.63L - Section Ga-Ga' (Construction Condition)

For the construction condition the existing Hilfiker wall is cut down to elevation 67-feet in order to install the new footing for Bridge 17.7, prior to installing the new Hilfiker wall.

$TWE := 66.5\ ft$ Top of Wall Elevation During Construction Condition

$BWE := 47\ ft$ Bottom of Wall Elevation

RFD Resistance Factors for Tensile and Pullout Resistance for MSE Walls with Metal Straps:

Table 4-7. Resistance Factors, ϕ, for Tensile and Pullout Resistance for MSE Walls
(after Table 11.5.6-1, AASHTO {2007}).

Reinforcement Type and Loading Condition			Resistance Factor
Metallic reinforcement and connectors	Strip reinforcements [A]		
		Static loading	0.75
		Combined static/earthquake loading	1.00
		Combined static/traffic barrier impact [B]	1.00
	Grid reinforcements [A, C]		
		Static loading	0.65
		Combined static/earthquake loading	0.85
		Combined static/traffic barrier impact [B]	0.85
Geosynthetic reinforcement and connectors		Static loading	0.90
		Combined static/earthquake loading	1.20
		Combined static/traffic barrier impact [B]	1.20
Pullout resistance of tensile reinforcement (metallic and geosynthetic)		Static loading	0.90
		Combined static/earthquake loading	1.20
		Combined static/traffic barrier impact [B]	1.00

Notes:
A. Apply to gross cross-section less sacrificial area. For sections with holes, reduce gross area in accordance with AASHTO (2007) Article 6.8.3 and apply to net section less sacrificial area.
B. Combined static/traffic barrier impact resistance factors are not presented in AASHTO.
C. Applies to grid reinforcements connected to rigid facing element, e.g., a concrete panel or block. For grid reinforcements connected to a flexible facing mat or which are continuous with the facing mat, use the resistance factor for strip reinforcements.

Resistance Factors:

$\Phi_{static} := 0.65$ $\Phi_{pullout\_static} := 0.9$

$\Phi_{seismic} := 0.85$ $\Phi_{pullout\_seismic} := 1.2$

Calculate Slope/W Reinforcement Inputs:

$H_{wall} := 19.5\ ft$

Based on the existing Hilfiker wall design drawings dated June 28, 1990, the vertical (s_v) spacing of the steel grids within each SE wall panel was determined. For calculation efficiency, the calculations are performed using matrices.

$$s_v := \begin{bmatrix} 0 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \end{bmatrix} ft \qquad t := \begin{bmatrix} dc_{W9.5xW4.0} \\ dc_{W9.5xW4.0} \\ dc_{W9.5xW4.0} \\ dc_{W9.5xW4.0} \\ dc_{W9.5xW4.0} \\ dc_{W9.5xW4.0} \\ dc_{W9.5xW4.0} \\ dc_{W7.0xW3.5} \\ dc_{W7.0xW3.5} \\ dc_{W7.0xW3.5} \end{bmatrix}$$

The matrix respresents the same order of the SE Wall reinforcement. Top row of the matrix represents the bottom row (Row 1) of the SE Wall reinforcement and the bottom row of the matrix represents the row of reinforcement closest to the ground surface (Row 10).

t represents the claculated thickness of each row of reinforcement for the existing Hilfiker wall after 30 years of corrosion exposure. This thickness is applied below in the grid capacity calculations.

$i := 0 .. \text{length}\left(s_v\right) - 1$

Calculate number of elements

Calculate each grids's vertical elevation and depth from the top of the wall, with the base of the wall as elevation 0 ft. Top row of the matrix represents the bottom reinforcement row.

$$elevation_i := \sum_{j=0}^{i} s_{v_j} = \begin{bmatrix} 0 \\ 2 \\ 4 \\ 6 \\ 8 \\ 10 \\ 12 \\ 14 \\ 16 \\ 18 \end{bmatrix} ft \qquad depth_i := H_{wall} - elevation_i = \begin{bmatrix} 19.5 \\ 17.5 \\ 15.5 \\ 13.5 \\ 11.5 \\ 9.5 \\ 7.5 \\ 5.5 \\ 3.5 \\ 1.5 \end{bmatrix} ft$$

Calculate Pullout Resistance Slope/W Input:

For design and comparison purposes, a normalized definition of pullout resistance will be used throughout the manual. The pullout resistance, P_r, at each of the reinforcement levels per unit width of reinforcement is given by:

$$P_r = F^* \alpha \sigma'_v L_e C \qquad (3\text{-}2)$$

where:

- $L_e C$ = the total surface area per unit width of the reinforcement in the resistive zone behind the failure surface
- L_e = the embedment or adherence length in the resisting zone behind the failure surface
- C = the reinforcement effective unit perimeter; e.g., C = 2 for and sheets, and because the edges are neglected C = 2 for strips and grids
- F^* = the pullout resistance (or friction-bearing-interaction) factor
- α = a scale effect correction factor to account for a non linear stress reduction over the embedded length of highly extensible reinforcements, based on laboratory data (generally 1.0 for metallic reinforcements and 0.6 to 1.0 for geosynthetic reinforcements, see Table 3-6).
- σ'_v = the effective vertical stress at the soil-reinforcement interfaces.

The factored pullout resistance is then given by:

$$P_r = \Phi_{pullout} \left(F \cdot \alpha \cdot \sigma_v' \cdot L_e \cdot C\right)$$

In Slope/W, pullout resistance per unit width of wall is given by:

$$P_r = \left(c + \sigma_v' \cdot tan\left(\phi_{interface}\right)\right) \cdot \alpha \cdot L_e \cdot C$$

Where α and C can be defined within the reinforcement properties, and are set to be the same as defined above. Overburden pressure, σ_v' and effective length, Le, are determined from the limit equilibrium analysis performed in Slope/W. Interface adhesion, c, is assumed to be negligable for metal grids in granular backfill.

To select a representative interface friction angle, $\phi_{interface}$, that will produce the same factored resistance per unit width of wall, the two expressions are set to be equal:

$$\Phi_{pullout} \left(F \cdot \alpha \cdot \sigma_v' \cdot L_e \cdot C\right) = \sigma_v' \cdot tan\left(\phi_{interface}\right) \cdot \alpha \cdot L_e \cdot C$$

Removing common constants and rearranging produces:

$$\phi_{interface} = atan\left(\Phi_{pullout} \cdot F\right)$$

Calculate Pullout Resistance Factor F*:

For steel grid reinforcements with transverse spacing of $S_t \geq 6$ inches (150 mm) (see Figure 3-4), F* is a function of a bearing or embedment factor, F_q, applied over the contributing bearing α_β, as follows:

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$F^* = F_q \alpha_\beta = 40 \alpha_\beta = 40 (t/2S_t) = 20 (t/S_t)$ at the top of the structure (3-6)

$F^* = F_q \alpha_\beta = 20 \alpha_\beta = 20 (t/2S_t) = 10 (t/S_t)$ at a depth of 20 ft (6 m) and below (3-7)

Where, t is the thickness of the transverse bar. S_t must be uniform throughout the length of the reinforcement rather than having transverse grid members concentrated only in the resistant zone. The maximum S_t distance is 24 in. (610 mm). For sloping backfills see Figure 4-15.

$$F\_construction_i := \begin{cases} \text{if } depth_i < 20\ ft \\ \quad 20 \cdot \left(\frac{t_i}{s_t}\right) \\ \text{else} \\ \quad 10 \cdot \left(\frac{t_i}{s_t}\right) \end{cases}$$

$$F\_construction = \begin{bmatrix} 0.56 \\ 0.56 \\ 0.56 \\ 0.56 \\ 0.56 \\ 0.56 \\ 0.56 \\ 0.48 \\ 0.48 \\ 0.48 \end{bmatrix}$$

Calculated F* for each row of reinforcement for the construction case. Top row of matrix represents the bottom row of reinforcement.

Calculate Interface Shear Angle (degrees):

$$\phi_{interface\_static} := \operatorname{atan}\left(\Phi_{pullout\_static} \cdot F\_construction\right) = \begin{bmatrix} 26.7 \\ 26.7 \\ 26.7 \\ 26.7 \\ 26.7 \\ 26.7 \\ 26.7 \\ 23.2 \\ 23.2 \\ 23.2 \end{bmatrix} deg$$

Static interface shear angle for each row of reinforcement. Top row of matrix represents the bottom reinforcement row.

Calculate Allowable Tensile Capacity of Steel Straps:

$$T_{capacity} = \Phi_{static} \cdot f_y \, A_s$$

Slope/W does not have grid reinforcement inputs. Therefore, the tensile strength of the grids were modeled as continuous reinforcement. The calculated allowable tensile grid capacity was converted to a continuous reinforcement tensile capacity by distributing the capacity over the tributary width. The longitudinal wires are spaced every 6 inches, therefore there are two bars within each 1 foot width of grid.

W9.5xW4.0:
(Rows 1 through 7)

$$T_{al\_static} := \frac{\Phi_{static} \cdot f_y \, A_{sW9.5xW4.0} \cdot \frac{1\ ft}{s_l}}{w} = 7.44\ \frac{kip}{ft}$$

W7.0xW3.5:
(Rows 8 through 10)

$$T_{al\_static} := \frac{\Phi_{static} \cdot f_y \, A_{sW7.0xW3.5} \cdot \frac{1\ ft}{s_l}}{w} = 5.42\ \frac{kip}{ft}$$

Wall 03.63L - Section Ga-Ga' (Final Condition)

The final condition occurs after the construction phase. The new Bridge 17.7 footing has been installed, as well as the previously cut down Hilfiker wall has been replaced by a new Hilfiker wall.

$TWE := 92\ ft$ Top of Wall Elevation for Final Condition

$BWE := 67\ ft$ Bottom of Wall Elevation

$H_{wall} := TWE - BWE = 25\ ft$

Calculate Corrosion Reduction:

Calculate the cross-sectional area of steel remaining after corrosion exposure for the deisgn life of the new Hilfiker wall. We undestand the new portion of the wall will not be an exact one-to-one replacement of the existing wall. We also understand that the new wall will be designed to the current required corrosion rate and design life duration. The calculation provided here was used to verify compound stability and is based on the existing wall as originally designed exposed to 45 years of corrosion. For the final design, the wall designer should make certain that greater than or equal amounts of steel area remain at the end of the total new wall design life in order to satisfy compound stability.

The corrosion rates presented in Table 3-8 are suitable for conservative design. **These rates assume a moderately corrosive backfill material having the controlled electrochemical property limits** that are discussed under electrochemical properties in this chapter.

Table 3-8 Steel Corrosion Rates for Moderately Corrosive Reinforced Fill.

For zinc/side:	0.58 mils/yr (15 µm/year) (first 2 years)
	0.16 mils/yr (4 µm/year) (thereafter)
For residual carbon steel/side:	0.47 mils/yr (12 µm/year) (thereafter)

Calculate the new diameter (of NEW Hilfiker wall) after 45 years of corrosion exposure:

$years := 45\ yr$

$$dc_{W4.5xW3.5\_NEW} := d_{W4.5xW3.5} - \left(2 \cdot 0.00047\ \frac{in}{yr} \cdot \left(years - t_g\right)\right) = 0.212\ in$$

$$dc_{W7.0xW3.5\_NEW} := d_{W7.0xW3.5} - \left(2 \cdot 0.00047\ \frac{in}{yr} \cdot \left(years - t_g\right)\right) = 0.272\ in$$

Calculate cross-sectional (of NEW Hilfiker wall) after 45 years of corrosion exposure:

$$A_{sW4.5xW3.5\_NEW} := \pi \cdot \left(\frac{dc_{W4.5xW3.5\_NEW}}{2} \right)^2 = 0.035\ in^2$$

$$A_{sW7.0xW3.5\_NEW} := \pi \cdot \left(\frac{dc_{W7.0xW3.5\_NEW}}{2} \right)^2 = 0.058\ in^2$$

LRFD Resistance Factors for Tensile and Pullout Resistance for MSE Walls with Metal Straps:

Table 4-7. Resistance Factors, ϕ, for Tensile and Pullout Resistance for MSE Walls
(after Table 11.5.6-1, AASHTO {2007}).

Reinforcement Type and Loading Condition			Resistance Factor
Metallic reinforcement and connectors	Strip reinforcements [A]		
		Static loading	0.75
		Combined static/earthquake loading	1.00
		Combined static/traffic barrier impact [B]	1.00
	Grid reinforcements [A, C]		
		Static loading	0.65
		Combined static/earthquake loading	0.85
		Combined static/traffic barrier impact [B]	0.85
Geosynthetic reinforcement and connectors		Static loading	0.90
		Combined static/earthquake loading	1.20
		Combined static/traffic barrier impact [B]	1.20
Pullout resistance of tensile reinforcement (metallic and geosynthetic)		Static loading	0.90
		Combined static/earthquake loading	1.20
		Combined static/traffic barrier impact [B]	1.00

Notes:
A. Apply to gross cross-section less sacrificial area. For sections with holes, reduce gross area in accordance with AASHTO (2007) Article 6.8.3 and apply to net section less sacrificial area.
B. Combined static/traffic barrier impact resistance factors are not presented in AASHTO.
C. Applies to grid reinforcements connected to rigid facing element, e.g., a concrete panel or block. For grid reinforcements connected to a flexible facing mat or which are continuous with the facing mat, use the resistance factor for strip reinforcements.

Resistance Factors:

$$\Phi_{static} := 0.65 \qquad \Phi_{pullout\_static} := 0.9$$

$$\Phi_{seismic} := 0.85 \qquad \Phi_{pullout\_seismic} := 1.2$$

Calculate Slope/W Reinforcement Inputs:

$H_{wall} := 25\ ft$

Based on the existing Hilfiker wall As-Builts, the vertical (s_v) spacing of the steel straps within each SE wall panel was determined. For calculation efficiency, the calculations are performed using matrices.

$$s_v := \begin{bmatrix} 0 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \end{bmatrix} ft \qquad t := \begin{bmatrix} dc_{W7.0xW3.5\_NEW} \\ dc_{W7.0xW3.5\_NEW} \\ dc_{W7.0xW3.5\_NEW} \\ dc_{W7.0xW3.5\_NEW} \\ dc_{W7.0xW3.5\_NEW} \\ dc_{W4.5xW3.5\_NEW} \\ dc_{W4.5xW3.5\_NEW} \\ dc_{W4.5xW3.5\_NEW} \\ dc_{W4.5xW3.5\_NEW} \\ dc_{W4.5xW3.5\_NEW} \\ dc_{W4.5xW3.5\_NEW} \\ dc_{W4.5xW3.5\_NEW} \\ dc_{W4.5xW3.5\_NEW} \end{bmatrix}$$

The matrix respresents the same order of the SE Wall reinforcement. Top row of the matrix represents the bottom row (Row 1) of the SE Wall reinforcement and the bottom row of the matrix represents the row of reinforcement closest to the ground surface (Row 13).

t represents the claculated thickness of each row of reinforcement for the existing Hilfiker wall after 45 years of corrosion exposure. This thickness is applied below in the grid capacity calculations.

$i := 0 .. \text{length}\left(s_v\right) - 1$ Calculate number of elements

Calculate each grid's vertical elevation and depth from the top of the wall, with the base of the new Hilfiker wall as elevation 0 ft. Top row of the matrix represents the bottom reinforcement row.

$$elevation_i := \sum_{j=0}^{i} s_{v_j} = \begin{bmatrix} 0 \\ 2 \\ 4 \\ 6 \\ 8 \\ 10 \\ 12 \\ 14 \\ 16 \\ 18 \\ 20 \\ 22 \\ 24 \end{bmatrix} ft \qquad depth_i := H_{wall} - elevation_i = \begin{bmatrix} 25 \\ 23 \\ 21 \\ 19 \\ 17 \\ 15 \\ 13 \\ 11 \\ 9 \\ 7 \\ 5 \\ 3 \\ 1 \end{bmatrix} ft$$

Calculate Pullout Resistance Slope/W Input:

For design and comparison purposes, a normalized definition of pullout resistance will be used throughout the manual. The pullout resistance, P_r, at each of the reinforcement levels per unit width of reinforcement is given by:

$$P_r = F^* \alpha \sigma_v' L_e C \qquad (3\text{-}2)$$

where:

- $L_e C$ = the total surface area per unit width of the reinforcement in the resistive zone behind the failure surface
- L_e = the embedment or adherence length in the resisting zone behind the failure surface
- C = the reinforcement effective unit perimeter; e.g., C = 2 for and sheets, and because the edges are neglected C = 2 for strips and grids
- F^* = the pullout resistance (or friction-bearing-interaction) factor
- α = a scale effect correction factor to account for a non linear stress reduction over the embedded length of highly extensible reinforcements, based on laboratory data (generally 1.0 for metallic reinforcements and 0.6 to 1.0 for geosynthetic reinforcements, see Table 3-6).
- σ'_v = the effective vertical stress at the soil-reinforcement interfaces.

The factored pullout resistance is then given by:

$$P_r = \Phi_{pullout} \left(F \cdot \alpha \cdot \sigma_v' \cdot L_e \cdot C \right)$$

In Slope/W, pullout resistance per unit width of wall is given by:

$$P_r = \left(c + \sigma_v' \cdot \tan\left(\phi_{interface} \right) \right) \cdot \alpha \cdot L_e \cdot C$$

Where α and C can be defined within the reinforcement properties, and are set to be the same as defined above. Overburden pressure, σ_v' and effective length, Le, are determined from the limit equilibrium analysis performed in Slope/W. Interface adhesion, c, is assumed to be negligable for metal grids in granular backfill.

To select a representative interface friction angle, $\phi_{interface}$, that will produce the same factored resistance per unit width of wall, the two expressions are set to be equal:

$$\Phi_{pullout}\left(F \cdot \alpha \cdot \sigma_v' \cdot L_e \cdot C\right) = \sigma_v' \cdot tan\left(\phi_{interface}\right) \cdot \alpha \cdot L_e \cdot C$$

Removing common constants and rearranging produces:

$$\phi_{interface} = atan\left(\Phi_{pullout} \cdot F\right)$$

Calculate Pullout Resistance Factor F*:

For steel grid reinforcements with transverse spacing of $S_t \geq 6$ inches (150 mm) (see Figure 3-4), F* is a function of a bearing or embedment factor, F_q, applied over the contributing bearing α_β, as follows:

$F^* = F_q\,\alpha_\beta = 40\,\alpha_\beta = 40\,(t/2S_t) = 20\,(t/S_t)$ at the top of the structure (3-6)

$F^* = F_q\,\alpha_\beta = 20\,\alpha_\beta = 20\,(t/2S_t) = 10\,(t/S_t)$ at a depth of 20 ft (6 m) and below (3-7)

Where, t is the thickness of the transverse bar. S_t must be uniform throughout the length of the reinforcement rather than having transverse grid members concentrated only in the resistant zone. The maximum S_t distance is 24 in. (610 mm). For sloping backfills see Figure 4-15.

$$F\_final_i := \text{if } depth_i < 20\ ft \left\| 20 \cdot \left(\frac{t_i}{s_t} \right) \right. \text{else} \left\| 10 \cdot \left(\frac{t_i}{s_t} \right) \right.$$

$$F\_final = \begin{bmatrix} 0.23 \\ 0.23 \\ 0.23 \\ 0.45 \\ 0.45 \\ 0.35 \\ 0.35 \\ 0.35 \\ 0.35 \\ 0.35 \\ 0.35 \\ 0.35 \\ 0.35 \end{bmatrix}$$

Calculated F* for each row of reinforcement. Top row of matrix represents the bottom row of reinforcement.

Calculate Interface Shear Angle (degrees):

$$\phi_{interface\_static} := \operatorname{atan}\left(\Phi_{pullout\_static} \cdot F\_final\right) = \begin{bmatrix} 11.5 \\ 11.5 \\ 11.5 \\ 22.2 \\ 22.2 \\ 17.6 \\ 17.6 \\ 17.6 \\ 17.6 \\ 17.6 \\ 17.6 \\ 17.6 \\ 17.6 \end{bmatrix} \textit{deg}$$

Static interface shear angle for each row of reinforcement. Top row of matrix represents the bottom reinforcement row.

$$\phi_{interface\_seismic} := \operatorname{atan}\left(\Phi_{pullout\_seismic} \cdot F\_final\right) = \begin{bmatrix} 15.2 \\ 15.2 \\ 15.2 \\ 28.5 \\ 28.5 \\ 23 \\ 23 \\ 23 \\ 23 \\ 23 \\ 23 \\ 23 \\ 23 \end{bmatrix} \textit{deg}$$

Seismic interface shear angle for each row of reinforcement. Top row of matrix represents the bottom reinforcement row.

Calculate Allowable Tensile Capacity of Steel Straps:

$$T_{capacity} = \Phi_{static} \cdot f_y \, A_s$$

Slope/W does not have grid reinforcement inputs. Therefore, the tensile strength of the grids were modeled as continuous reinforcement. The calculated allowable tensile grid capacity was converted to a continuous reinforcement tensile capacity by distributing the capacity over the tributary width. The longitudinal wires are spaced every 6 inches, therefore there are two bars within each 1 foot width of grid.

W7.0xW3.5 (NEW):
(Rows 1 through 5)

$$T_{al\_static} := \frac{\Phi_{static} \cdot f_y \, A_{sW7.0xW3.5\_NEW} \cdot \frac{1\ ft}{s_l}}{w} = 4.9\ \frac{kip}{ft}$$

$$T_{al\_seismic} := \frac{\Phi_{seismic} \cdot f_y \, A_{sW7.0xW3.5\_NEW} \cdot \frac{1\ ft}{s_l}}{w} = 6.4\ \frac{kip}{ft}$$

W4.5xW3.5 (NEW):
(Rows 6 through 13)

$$T_{al\_static} := \frac{\Phi_{static} \cdot f_y \, A_{sW4.5xW3.5\_NEW} \cdot \frac{1\ ft}{s_l}}{w} = 2.98\ \frac{kip}{ft}$$

$$T_{al\_seismic} := \frac{\Phi_{seismic} \cdot f_y \, A_{sW4.5xW3.5\_NEW} \cdot \frac{1\ ft}{s_l}}{w} = 3.9\ \frac{kip}{ft}$$

Calculating MSE Strip Properties for Slope/W
Wall 03.63L - Section Ha-Ha' (New Wall Over Old) - Existing Condition

For global stability analyses, the MSE wall is modeled as a high strength material and the failure is forced outside of the reinforced zone. To check for compound stability, the high strength material is replaced with gravel borrow and welded wire grids modeled after existing wall design drawings dated June 28, 1990 provided by Hilfiker. Relevant pages of these plans are provided within this appendix. The properties of the metal grids are calculated based on FHWA NHI-10-024 and NHI-10-025. The reinforcement properties are converted to per unit width basis, and implemented as a continous layer in Slope/W.

Input Soil Properties:

Backfill meeting WSDOT standard specifications 9-03.14(4), Gravel Borrow for Structural Earth Wall.

$\phi_{ESU1A} := 40\ deg$	Elevation 72 and above
$\phi_{ESU1B} := 38\ deg$	Elevation 72 and below

Input Grid Properties:

$d_{W4.5xW3.5} := 0.239\ in$	Gross Diameter (no corrosion)
$d_{W7.0xW3.5} := 0.299\ in$	Gross Diameter (no corrosion)
$d_{W9.5xW4.0} := 0.348\ in$	Gross Diameter (no corrosion)
$f_y := 65.0\ ksi$	Yield stress
$s_t := 12\ in$	Spacing of Transverse Bars
$s_l := 6\ in$	Spacing of Longitudinal Bars
$w := 1\ ft$	Gross Grid Width
$TWE := 90\ ft$	Top of Wall Elevation

Calculate Corrosion Reduction:

Bridge 17.7 was constructed in 1990. Calculate new cross-sectional area of steel grid after 30 years of corrosion exposure.

The corrosion rates presented in Table 3-8 are suitable for conservative design. **These rates assume a moderately corrosive backfill material having the controlled electrochemical property limits** that are discussed under electrochemical properties in this chapter.

Table 3-8 Steel Corrosion Rates for Moderately Corrosive Reinforced Fill.

For zinc/side:	0.58 mils/yr (15 μm/year) (first 2 years)
	0.16 mils/yr (4 μm/year) (thereafter)
For residual carbon steel/side:	0.47 mils/yr (12 μm/year) (thereafter)

Calculate time (in years) to corrode through galvinization.

$$0.58 \cdot 2 + 0.16 \cdot \left(t_g - 2\right) = 3.4$$

$$t_g := \frac{3.4 - 0.58 \cdot 2}{0.16}\ yr + 2\ yr = 16\ yr$$ years to corrode through galvenization

Calculate the new diameter after 30 years of corrosion exposure:

$$years := 30\ yr$$

$$dc_{W4.5xW3.5} := d_{W4.5xW3.5} - \left(2 \cdot 0.00047\ \frac{in}{yr} \cdot \left(years - t_g\right)\right) = 0.226\ in$$

$$dc_{W7.0xW3.5} := d_{W7.0xW3.5} - \left(2 \cdot 0.00047\ \frac{in}{yr} \cdot \left(years - t_g\right)\right) = 0.286\ in$$

$$dc_{W9.5xW4.0} := d_{W9.5xW4.0} - \left(2 \cdot 0.00047\ \frac{in}{yr} \cdot \left(years - t_g\right)\right) = 0.335\ in$$

Calculate cross-sectional area after 30 years of corrosion exposure:

$$A_{sW4.5xW3.5} := \pi \cdot \left(\frac{dc_{W4.5xW3.5}}{2}\right)^2 = 0.04\ in^2$$

$$A_{sW7.0xW3.5} := \pi \cdot \left(\frac{dc_{W7.0xW3.5}}{2}\right)^2 = 0.064\ in^2$$

$$A_{sW9.5xW4.0} := \pi \cdot \left(\frac{dc_{W9.5xW4.0}}{2}\right)^2 = 0.088\ in^2$$

LRFD Resistance Factors for Tensile and Pullout Resistance for MSE Walls with Metal Straps:

Table 4-7. Resistance Factors, ϕ, for Tensile and Pullout Resistance for MSE Walls
(after Table 11.5.6-1, AASHTO {2007}).

Reinforcement Type and Loading Condition			Resistance Factor
Metallic reinforcement and connectors	Strip reinforcements [A]		
		Static loading	0.75
		Combined static/earthquake loading	1.00
		Combined static/traffic barrier impact [B]	1.00
	Grid reinforcements [A, C]		
		Static loading	0.65
		Combined static/earthquake loading	0.85
		Combined static/traffic barrier impact [B]	0.85
Geosynthetic reinforcement and connectors		Static loading	0.90
		Combined static/earthquake loading	1.20
		Combined static/traffic barrier impact [B]	1.20
Pullout resistance of tensile reinforcement (metallic and geosynthetic)		Static loading	0.90
		Combined static/earthquake loading	1.20
		Combined static/traffic barrier impact [B]	1.00

Notes:
A. Apply to gross cross-section less sacrificial area. For sections with holes, reduce gross area in accordance with AASHTO (2007) Article 6.8.3 and apply to net section less sacrificial area.
B. Combined static/traffic barrier impact resistance factors are not presented in AASHTO.
C. Applies to grid reinforcements connected to rigid facing element, e.g., a concrete panel or block. For grid reinforcements connected to a flexible facing mat or which are continuous with the facing mat, use the resistance factor for strip reinforcements.

Resistance Factors:

$$\Phi_{static} := 0.65 \qquad \Phi_{pullout\_static} := 0.9$$

$$\Phi_{seismic} := 0.85 \qquad \Phi_{pullout\_seismic} := 1.2$$

Calculate Slope/W Reinforcement Inputs:

$H_{wall} := 43\ ft$

Based on the existing Hilfiker wall design drawings dated June 28, 1990, the vertical (s_v) spacing of the steel grids within each SE wall panel was determined. For calculation efficiency, the calculations are performed using matrices.

$$s_v := \begin{bmatrix} 0 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \end{bmatrix} ft \qquad t := \begin{bmatrix} dc_{W9.5xW4.0} \\ dc_{W9.5xW4.0} \\ dc_{W9.5xW4.0} \\ dc_{W9.5xW4.0} \\ dc_{W9.5xW4.0} \\ dc_{W9.5xW4.0} \\ dc_{W7.0xW3.5} \\ dc_{W7.0xW3.5} \\ dc_{W7.0xW3.5} \\ dc_{W7.0xW3.5} \\ dc_{W7.0xW3.5} \\ dc_{W7.0xW3.5} \\ dc_{W7.0xW3.5} \\ dc_{W7.0xW3.5} \\ dc_{W4.5xW3.5} \\ dc_{W4.5xW3.5} \\ dc_{W4.5xW3.5} \\ dc_{W4.5xW3.5} \\ dc_{W4.5xW3.5} \\ dc_{W4.5xW3.5} \\ dc_{W4.5xW3.5} \end{bmatrix}$$

The matrix respresents the same order of the SE Wall reinforcement. Top row of the matrix represents the bottom row (Row 1) of the SE Wall reinforcement and the bottom row of the matrix represents the row of reinforcement closest to the ground surface (Row 22).

t represents the claculated thickness of each row of reinforcement for the existing Hilfiker wall after 30 years of corrosion exposure. This thickness is applied below in the grid capacity calculations.

$i := 0 .. \text{length}\left(s_v\right) - 1$ Calculate number of elements

Calculate each grid's vertical elevation and depth from the top of the wall, with the base of the wall as elevation 0 ft. Top row of the matrix represents the bottom reinforcement row.

$$elevation_i := \sum_{j=0}^{i} s_{v_j} = \begin{bmatrix} 0 \\ 2 \\ 4 \\ 6 \\ 8 \\ 10 \\ 12 \\ 14 \\ 16 \\ 18 \\ 20 \\ 22 \\ 24 \\ 26 \\ 28 \\ 30 \\ 32 \\ 34 \\ 36 \\ 38 \\ 40 \\ 42 \end{bmatrix} ft \qquad depth_i := H_{wall} - elevation_i = \begin{bmatrix} 43 \\ 41 \\ 39 \\ 37 \\ 35 \\ 33 \\ 31 \\ 29 \\ 27 \\ 25 \\ 23 \\ 21 \\ 19 \\ 17 \\ 15 \\ 13 \\ 11 \\ 9 \\ 7 \\ 5 \\ 3 \\ 1 \end{bmatrix} ft$$

Calculate Pullout Resistance Slope/W Input:

For design and comparison purposes, a normalized definition of pullout resistance will be used throughout the manual. The pullout resistance, P_r, at each of the reinforcement levels per unit width of reinforcement is given by:

$$P_r = F^* \alpha \sigma_v' L_e C \qquad (3\text{-}2)$$

where:

- $L_e C$ = the total surface area per unit width of the reinforcement in the resistive zone behind the failure surface
- L_e = the embedment or adherence length in the resisting zone behind the failure surface
- C = the reinforcement effective unit perimeter; e.g., C = 2 for and sheets, and because the edges are neglected C = 2 for strips and grids
- F^* = the pullout resistance (or friction-bearing-interaction) factor
- α = a scale effect correction factor to account for a non linear stress reduction over the embedded length of highly extensible reinforcements, based on laboratory data (generally 1.0 for metallic reinforcements and 0.6 to 1.0 for geosynthetic reinforcements, see Table 3-6).
- σ'_v = the effective vertical stress at the soil-reinforcement interfaces.

The factored pullout resistance is then given by:

$$P_r = \Phi_{pullout} \left(F \cdot \alpha \cdot \sigma_v' \cdot L_e \cdot C \right)$$

In Slope/W, pullout resistance per unit width of wall is given by:

$$P_r = \left(c + \sigma_v' \cdot tan\left(\phi_{interface}\right)\right) \cdot \alpha \cdot L_e \cdot C$$

Where α and C can be defined within the reinforcement properties, and are set to be the same as defined above. Overburden pressure, σ_v' and effective length, Le, are determined from the limit equilibrium analysis performed in Slope/W. Interface adhesion, c, is assumed to be negligable for metal grids in granular backfill.

To select a representative interface friction angle, $\phi_{interface}$, that will produce the same factored resistance per unit width of wall, the two expressions are set to be equal:

$$\Phi_{pullout}\left(F \cdot \alpha \cdot \sigma_v' \cdot L_e \cdot C\right) = \sigma_v' \cdot tan\left(\phi_{interface}\right) \cdot \alpha \cdot L_e \cdot C$$

Removing common constants and rearranging produces:

$$\phi_{interface} = atan\left(\Phi_{pullout} \cdot F\right)$$

Calculate Pullout Resistance Factor F*:

For steel grid reinforcements with transverse spacing of $S_t \geq 6$ inches (150 mm) (see Figure 3-4), F* is a function of a bearing or embedment factor, F_q, applied over the contributing bearing α_β, as follows:

$F^* = F_q\,\alpha_\beta = 40\,\alpha_\beta = 40\,(t/2S_t) = 20\,(t/S_t)$ at the top of the structure (3-6)

$F^* = F_q\,\alpha_\beta = 20\,\alpha_\beta = 20\,(t/2S_t) = 10\,(t/S_t)$ at a depth of 20 ft (6 m) and below (3-7)

Where, t is the thickness of the transverse bar. S_t must be uniform throughout the length of the reinforcement rather than having transverse grid members concentrated only in the resistant zone. The maximum S_t distance is 24 in. (610 mm). For sloping backfills see Figure 4-15.

$$F_i := \text{if } depth_i < 20\ ft \left\| 20 \cdot \left(\frac{t_i}{s_t} \right) \right. \text{else} \left\| 10 \cdot \left(\frac{t_i}{s_t} \right) \right.$$

$$F = \begin{bmatrix} 0.28 \\ 0.28 \\ 0.28 \\ 0.28 \\ 0.28 \\ 0.28 \\ 0.24 \\ 0.24 \\ 0.24 \\ 0.24 \\ 0.24 \\ 0.24 \\ 0.48 \\ 0.48 \\ 0.38 \\ 0.38 \\ 0.38 \\ 0.38 \\ 0.38 \\ 0.38 \\ 0.38 \\ 0.38 \end{bmatrix}$$

Calculated F* for each row of reinforcement. Top row of matrix represents the bottom row of reinforcement.

Calculate Interface Shear Angle (degrees):

$$\phi_{interface\_static} := \operatorname{atan}\left(\Phi_{pullout\_static} \cdot F\right) = \begin{bmatrix} 14.1 \\ 14.1 \\ 14.1 \\ 14.1 \\ 14.1 \\ 14.1 \\ 12.1 \\ 12.1 \\ 12.1 \\ 12.1 \\ 12.1 \\ 12.1 \\ 23.2 \\ 23.2 \\ 18.7 \\ 18.7 \\ 18.7 \\ 18.7 \\ 18.7 \\ 18.7 \\ 18.7 \\ 18.7 \end{bmatrix} \textit{deg}$$

Static interface shear angle for each row of reinforcement. Top row of matrix represents the bottom reinforcement row.

$$\phi_{interface\_seismic} := \operatorname{atan}\left(\Phi_{pullout\_seismic} \cdot F\right) = \begin{bmatrix} 18.5 \\ 18.5 \\ 18.5 \\ 18.5 \\ 18.5 \\ 18.5 \\ 16 \\ 16 \\ 16 \\ 16 \\ 16 \\ 16 \\ 29.8 \\ 29.8 \\ 24.3 \\ 24.3 \\ 24.3 \\ 24.3 \\ 24.3 \\ 24.3 \\ 24.3 \\ 24.3 \\ 24.3 \end{bmatrix} \textit{deg}$$

Seismic interface shear angle for each row of reinforcement. Top row of matrix represents the bottom reinforcement row.

Calculate Allowable Tensile Capacity of Steel Straps:

$$T_{capacity} = \Phi_{static} \cdot f_y \, A_s$$

Slope/W does not have grid reinforcement inputs. Therefore, the tensile strength of the grids were modeled as continuous reinforcement. The calculated allowable tensile strap capacity was converted to a continuous reinforcement tensile capacity by distributing the capacity over the tributary width. The longitudinal wires are spaced every 6 inches, therefore there are two bars within each 1 foot width of grid.

W9.5xW4.0:
(Rows 1 through 6)

$$T_{al\_static} := \frac{\Phi_{static} \cdot f_y \, A_{sW9.5xW4.0} \cdot \frac{1\ \textit{ft}}{s_l}}{w} = 7.44\ \frac{\textit{kip}}{\textit{ft}}$$

$$T_{al\_seismic} := \frac{\Phi_{seismic} \cdot f_y \, A_{sW9.5xW4.0} \cdot \frac{1\ \textit{ft}}{s_l}}{w} = 9.7\ \frac{\textit{kip}}{\textit{ft}}$$

W7.0xW3.5:
(Rows 7 through 14)

$$T_{al\_static} := \frac{\Phi_{static} \cdot f_y \, A_{sW7.0xW3.5} \cdot \frac{1\ ft}{s_l}}{w} = 5.42\ \frac{kip}{ft}$$

$$T_{al\_seismic} := \frac{\Phi_{seismic} \cdot f_y \, A_{sW7.0xW3.5} \cdot \frac{1\ ft}{s_l}}{w} = 7.1\ \frac{kip}{ft}$$

W4.5xW3.5:
(Rows 15 through 22)

$$T_{al\_static} := \frac{\Phi_{static} \cdot f_y \, A_{sW4.5xW3.5} \cdot \frac{1\ ft}{s_l}}{w} = 3.38\ \frac{kip}{ft}$$

$$T_{al\_seismic} := \frac{\Phi_{seismic} \cdot f_y \, A_{sW4.5xW3.5} \cdot \frac{1\ ft}{s_l}}{w} = 4.4\ \frac{kip}{ft}$$

Wall 03.63L - Section Ha-Ha'
(Construction Condition)

For the construction condition the existing Hilfiker wall is cut down to elevation 78-feet in order to install the new footing for Bridge 17.7, prior to installing the new Hilfiker wall.

$TWE := 78\ ft$ Top of Wall Elevation During Construction Condition

$BWE := 47\ ft$ Bottom of Wall Elevation

RFD Resistance Factors for Tensile and Pullout Resistance for MSE Walls with Metal Straps:

Table 4-7. Resistance Factors, ϕ, for Tensile and Pullout Resistance for MSE Walls
(after Table 11.5.6-1, AASHTO {2007}).

Reinforcement Type and Loading Condition			Resistance Factor
Metallic reinforcement and connectors	Strip reinforcements [A]		
		Static loading	0.75
		Combined static/earthquake loading	1.00
		Combined static/traffic barrier impact [B]	1.00
	Grid reinforcements [A, C]		
		Static loading	0.65
		Combined static/earthquake loading	0.85
		Combined static/traffic barrier impact [B]	0.85
Geosynthetic reinforcement and connectors		Static loading	0.90
		Combined static/earthquake loading	1.20
		Combined static/traffic barrier impact [B]	1.20
Pullout resistance of tensile reinforcement (metallic and geosynthetic)		Static loading	0.90
		Combined static/earthquake loading	1.20
		Combined static/traffic barrier impact [B]	1.00

Notes:
A. Apply to gross cross-section less sacrificial area. For sections with holes, reduce gross area in accordance with AASHTO (2007) Article 6.8.3 and apply to net section less sacrificial area.
B. Combined static/traffic barrier impact resistance factors are not presented in AASHTO.
C. Applies to grid reinforcements connected to rigid facing element, e.g., a concrete panel or block. For grid reinforcements connected to a flexible facing mat or which are continuous with the facing mat, use the resistance factor for strip reinforcements.

Resistance Factors:

$\Phi_{static} := 0.65$ $\Phi_{pullout\_static} := 0.9$

$\Phi_{seismic} := 0.85$ $\Phi_{pullout\_seismic} := 1.2$

Calculate Slope/W Reinforcement Inputs:

$H_{wall} := 31\ ft$

Based on the existing Hilfiker wall design drawings dated June 28, 1990, the vertical (s_v) spacing of the steel grids within each SE wall panel was determined. For calculation efficiency, the calculations are performed using matrices.

$$s_v := \begin{bmatrix} 0 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \end{bmatrix} ft \qquad t := \begin{bmatrix} dc_{W9.5xW4.0} \\ dc_{W9.5xW4.0} \\ dc_{W9.5xW4.0} \\ dc_{W9.5xW4.0} \\ dc_{W9.5xW4.0} \\ dc_{W9.5xW4.0} \\ dc_{W7.0xW3.5} \\ dc_{W7.0xW3.5} \\ dc_{W7.0xW3.5} \\ dc_{W7.0xW3.5} \\ dc_{W7.0xW3.5} \\ dc_{W7.0xW3.5} \\ dc_{W7.0xW3.5} \\ dc_{W7.0xW3.5} \\ dc_{W4.5xW3.5} \\ dc_{W4.5xW3.5} \end{bmatrix}$$

The matrix respresents the same order of the SE Wall reinforcement. Top row of the matrix represents the bottom row (Row 1) of the SE Wall reinforcement and the bottom row of the matrix represents the row of reinforcement closest to the ground surface (Row 16).

t represents the claculated thickness of each row of reinforcement for the existing Hilfiker wall after 30 years of corrosion exposure. This thickness is applied below in the grid capacity calculations.

$i := 0 .. \text{length}\left(s_v\right) - 1$ Calculate number of elements

Calculate each grids's vertical elevation and depth from the top of the wall, with the base of the wall as elevation 0 ft. Top row of the matrix represents the bottom reinforcement row.

$$elevation_i := \sum_{j=0}^{i} s_{v_j} = \begin{bmatrix} 0 \\ 2 \\ 4 \\ 6 \\ 8 \\ 10 \\ 12 \\ 14 \\ 16 \\ 18 \\ 20 \\ 22 \\ 24 \\ 26 \\ 28 \\ 30 \end{bmatrix} ft \qquad depth_i := H_{wall} - elevation_i = \begin{bmatrix} 31 \\ 29 \\ 27 \\ 25 \\ 23 \\ 21 \\ 19 \\ 17 \\ 15 \\ 13 \\ 11 \\ 9 \\ 7 \\ 5 \\ 3 \\ 1 \end{bmatrix} ft$$

Calculate Pullout Resistance Slope/W Input:

For design and comparison purposes, a normalized definition of pullout resistance will be used throughout the manual. The pullout resistance, P_r, at each of the reinforcement levels per unit width of reinforcement is given by:

$$P_r = F^* \alpha \sigma_v' L_e C \quad (3\text{-}2)$$

where:

- $L_e C$ = the total surface area per unit width of the reinforcement in the resistive zone behind the failure surface
- L_e = the embedment or adherence length in the resisting zone behind the failure surface
- C = the reinforcement effective unit perimeter; e.g., C = 2 for and sheets, and because the edges are neglected C = 2 for strips and grids
- F^* = the pullout resistance (or friction-bearing-interaction) factor
- α = a scale effect correction factor to account for a non linear stress reduction over the embedded length of highly extensible reinforcements, based on laboratory data (generally 1.0 for metallic reinforcements and 0.6 to 1.0 for geosynthetic reinforcements, see Table 3-6).
- σ'_v = the effective vertical stress at the soil-reinforcement interfaces.

The factored pullout resistance is then given by:

$$P_r = \Phi_{pullout} \left(F \cdot \alpha \cdot \sigma_v' \cdot L_e \cdot C \right)$$

In Slope/W, pullout resistance per unit width of wall is given by:

$$P_r = \left(c + \sigma_v' \cdot tan\left(\phi_{interface} \right) \right) \cdot \alpha \cdot L_e \cdot C$$

Where α and C can be defined within the reinforcement properties, and are set to be the same as defined above. Overburden pressure, σ_v' and effective length, Le, are determined from the limit equilibrium analysis performed in Slope/W. Interface adhesion, c, is assumed to be negligable for metal grids in granular backfill.

To select a representative interface friction angle, $\phi_{interface}$, that will produce the same factored resistance per unit width of wall, the two expressions are set to be equal:

$$\Phi_{pullout} \left(F \cdot \alpha \cdot \sigma_v' \cdot L_e \cdot C \right) = \sigma_v' \cdot tan\left(\phi_{interface} \right) \cdot \alpha \cdot L_e \cdot C$$

Removing common constants and rearranging produces:

$$\phi_{interface} = atan\left(\Phi_{pullout} \cdot F \right)$$

Calculate Pullout Resistance Factor F*:

For steel grid reinforcements with transverse spacing of $S_t \geq 6$ inches (150 mm) (see Figure 3-4), F* is a function of a bearing or embedment factor, F_q, applied over the contributing bearing α_β, as follows:

$F^* = F_q\,\alpha_\beta = 40\,\alpha_\beta = 40\,(t/2S_t) = 20\,(t/S_t)$ at the top of the structure (3-6)

$F^* = F_q\,\alpha_\beta = 20\,\alpha_\beta = 20\,(t/2S_t) = 10\,(t/S_t)$ at a depth of 20 ft (6 m) and below (3-7)

Where, t is the thickness of the transverse bar. S_t must be uniform throughout the length of the reinforcement rather than having transverse grid members concentrated only in the resistant zone. The maximum S_t distance is 24 in. (610 mm). For sloping backfills see Figure 4-15.

$$F\_construction_i := \begin{cases} 20 \cdot \left(\frac{t_i}{s_t}\right) & \text{if } depth_i < 20\ ft \\ 10 \cdot \left(\frac{t_i}{s_t}\right) & \text{else} \end{cases}$$

$$F\_construction = \begin{bmatrix} 0.28 \\ 0.28 \\ 0.28 \\ 0.28 \\ 0.28 \\ 0.28 \\ 0.48 \\ 0.48 \\ 0.48 \\ 0.48 \\ 0.48 \\ 0.48 \\ 0.48 \\ 0.48 \\ 0.38 \\ 0.38 \end{bmatrix}$$

Calculated F* for each row of reinforcement for the construction case. Top row of matrix represents the bottom row of reinforcement.

Calculate Interface Shear Angle (degrees):

$$\phi_{interface\_static} := \operatorname{atan}\left(\Phi_{pullout\_static} \cdot F\_construction\right) = \begin{bmatrix} 14.1 \\ 14.1 \\ 14.1 \\ 14.1 \\ 14.1 \\ 14.1 \\ 23.2 \\ 23.2 \\ 23.2 \\ 23.2 \\ 23.2 \\ 23.2 \\ 23.2 \\ 23.2 \\ 18.7 \\ 18.7 \end{bmatrix} \textit{deg}$$

Static interface shear angle for each row of reinforcement. Top row of matrix represents the bottom reinforcement row.

Calculate Allowable Tensile Capacity of Steel Straps:

$$T_{capacity} = \Phi_{static} \cdot f_y \, A_s$$

Slope/W does not have grid reinforcement inputs. Therefore, the tensile strength of the grids were modeled as continuous reinforcement. The calculated allowable tensile grid capacity was converted to a continuous reinforcement tensile capacity by distributing the capacity over the tributary width. The longitudinal wires are spaced every 6 inches, therefore there are two bars within each 1 foot width of grid.

W9.5xW4.0:
(Rows 1 through 6)

$$T_{al\_static} := \frac{\Phi_{static} \cdot f_y \, A_{sW9.5xW4.0} \cdot \frac{1\ ft}{s_l}}{w} = 7.44\ \frac{kip}{ft}$$

W7.0xW3.5:
(Rows 7 through 14)

$$T_{al\_static} := \frac{\Phi_{static} \cdot f_y \, A_{sW7.0xW3.5} \cdot \frac{1\ ft}{s_l}}{w} = 5.42\ \frac{kip}{ft}$$

W4.5xW3.5:
(Rows 15 through 16)

$$T_{al\_static} := \frac{\Phi_{static} \cdot f_y \, A_{sW4.5xW3.5} \cdot \frac{1\ ft}{s_l}}{w} = 3.38\ \frac{kip}{ft}$$

Wall 03.63L - Section Ha-Ha' (Final Condition)

The final condition occurs after the construction phase. The new Bridge 17.7 footing has been installed, as well as the previously cut down Hilfiker wall has been replaced by a new Hilfiker wall.

$TWE := 90\ ft$ Top of Wall Elevation for Final Condition

$BWE := 47\ ft$ Bottom of Wall Elevation

Calculate Corrosion Reduction:

Calculate the cross-sectional area of steel remaining after corrosion exposure for the deisgn life of the new Hilfiker wall. We undestand the new portion of the wall will not be an exact one-to-one replacement of the existing wall. We also understand that the new wall will be designed to the current required corrosion rate and design life duration. The calculation provided here was used to verify compound stability and is based on the existing wall as originally designed exposed to 45 years of corrosion. For the final design, the wall designer should make certain that greater than or equal amounts of steel area remain at the end of the total new wall design life in order to satisfy compound stability.

The corrosion rates presented in Table 3-8 are suitable for conservative design. **These rates assume a moderately corrosive backfill material having the controlled electrochemical property limits** that are discussed under electrochemical properties in this chapter.

Table 3-8 Steel Corrosion Rates for Moderately Corrosive Reinforced Fill.

For zinc/side:	0.58 mils/yr (15 µm/year) (first 2 years)
	0.16 mils/yr (4 µm/year) (thereafter)
For residual carbon steel/side:	0.47 mils/yr (12 µm/year) (thereafter)

Calculate the new diameter (of the existing Hilfiker wall) after 75 years of corrosion exposure:

$years := 75\ yr$

$$dc_{W9.5xW4.0} := d_{W9.5xW4.0} - \left(2 \cdot 0.00047\ \frac{in}{yr} \cdot \left(years - t_g\right)\right) = 0.293\ in$$

$$dc_{W7.0xW3.5} := d_{W7.0xW3.5} - \left(2 \cdot 0.00047\ \frac{in}{yr} \cdot \left(years - t_g\right)\right) = 0.244\ in$$

$$dc_{W4.5xW3.5} := d_{W4.5xW3.5} - \left(2 \cdot 0.00047\ \frac{in}{yr} \cdot \left(years - t_g\right)\right) = 0.184\ in$$

Calculate the new diameter (of NEW Hilfiker wall) after 45 years of corrosion exposure:

$$years := 43\ yr$$

$$dc_{W4.5xW3.5\_NEW} := d_{W4.5xW3.5} - \left(2 \cdot 0.00047\ \frac{in}{yr} \cdot \left(years - t_g\right)\right) = 0.214\ in$$

Calculate cross-sectional (of the existing Hilfiker wall) after 75 years of corrosion exposure:

$$A_{sW9.5xW4.0} := \pi \cdot \left(\frac{dc_{W9.5xW4.0}}{2}\right)^2 = 0.067\ in^2$$

$$A_{sW7.0xW3.5} := \pi \cdot \left(\frac{dc_{W7.0xW3.5}}{2}\right)^2 = 0.047\ in^2$$

$$A_{sW4.5xW3.5} := \pi \cdot \left(\frac{dc_{W4.5xW3.5}}{2}\right)^2 = 0.026\ in^2$$

Calculate cross-sectional (of NEW Hilfiker wall) after 75 years of corrosion exposure:

$$A_{sW4.5xW3.5\_NEW} := \pi \cdot \left(\frac{dc_{W4.5xW3.5\_NEW}}{2}\right)^2 = 0.036\ in^2$$

LRFD Resistance Factors for Tensile and Pullout Resistance for MSE Walls with Metal Straps:

Table 4-7. Resistance Factors, ϕ, for Tensile and Pullout Resistance for MSE Walls
(after Table 11.5.6-1, AASHTO {2007}).

Reinforcement Type and Loading Condition			Resistance Factor
Metallic reinforcement and connectors	Strip reinforcements [A]		
		Static loading	0.75
		Combined static/earthquake loading	1.00
		Combined static/traffic barrier impact [B]	1.00
	Grid reinforcements [A, C]		
		Static loading	0.65
		Combined static/earthquake loading	0.85
		Combined static/traffic barrier impact [B]	0.85
Geosynthetic reinforcement and connectors		Static loading	0.90
		Combined static/earthquake loading	1.20
		Combined static/traffic barrier impact [B]	1.20
Pullout resistance of tensile reinforcement (metallic and geosynthetic)		Static loading	0.90
		Combined static/earthquake loading	1.20
		Combined static/traffic barrier impact [B]	1.00

Notes:
A. Apply to gross cross-section less sacrificial area. For sections with holes, reduce gross area in accordance with AASHTO (2007) Article 6.8.3 and apply to net section less sacrificial area.
B. Combined static/traffic barrier impact resistance factors are not presented in AASHTO.
C. Applies to grid reinforcements connected to rigid facing element, e.g., a concrete panel or block. For grid reinforcements connected to a flexible facing mat or which are continuous with the facing mat, use the resistance factor for strip reinforcements.

Resistance Factors:

$\Phi_{static} := 0.65$ $\Phi_{pullout\_static} := 0.9$

$\Phi_{seismic} := 0.85$ $\Phi_{pullout\_seismic} := 1.2$

Calculate Slope/W Reinforcement Inputs:

$H_{wall} := 43\ ft$

Based on the existing Hilfiker wall As-Builts, the vertical (s_v) spacing of the steel straps within each SE wall panel was determined. For calculation efficiency, the calculations are performed using matrices.

$$s_v := \begin{bmatrix} 0 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \end{bmatrix} ft \qquad t := \begin{bmatrix} dc_{W9.5xW4.0} \\ dc_{W9.5xW4.0} \\ dc_{W9.5xW4.0} \\ dc_{W9.5xW4.0} \\ dc_{W9.5xW4.0} \\ dc_{W9.5xW4.0} \\ dc_{W7.0xW3.5} \\ dc_{W7.0xW3.5} \\ dc_{W7.0xW3.5} \\ dc_{W7.0xW3.5} \\ dc_{W7.0xW3.5} \\ dc_{W7.0xW3.5} \\ dc_{W7.0xW3.5} \\ dc_{W7.0xW3.5} \\ dc_{W4.5xW3.5} \\ dc_{W4.5xW3.5} \\ dc_{W4.5xW3.5\_NEW} \\ dc_{W4.5xW3.5\_NEW} \\ dc_{W4.5xW3.5\_NEW} \\ dc_{W4.5xW3.5\_NEW} \\ dc_{W4.5xW3.5\_NEW} \\ dc_{W4.5xW3.5\_NEW} \end{bmatrix}$$

The matrix respresents the same order of the SE Wall reinforcement. Top row of the matrix represents the bottom row (Row 1) of the SE Wall reinforcement and the bottom row of the matrix represents the row of reinforcement closest to the ground surface (Row 22).

t represents the claculated thickness of each row of reinforcement for the existing Hilfiker wall after either 75 years of corrosion (existing wall left in place) or 45 years of corrosion (proposed new hilfiker wall). This thickness is applied below in the grid capacity calculations.

$i := 0 .. \text{length}\left(s_v\right) - 1$ Calculate number of elements

Calculate each grid's vertical elevation and depth from the top of the wall, with the base of the new Hilfiker wall as elevation 20 ft. Top row of the matrix represents the bottom reinforcement row.

$$elevation_i := \sum_{j=0}^{i} s_{v_j} = \begin{bmatrix} 0 \\ 2 \\ 4 \\ 6 \\ 8 \\ 10 \\ 12 \\ 14 \\ 16 \\ 18 \\ 20 \\ 22 \\ 24 \\ 26 \\ 28 \\ 30 \\ 32 \\ 34 \\ 36 \\ 38 \\ 40 \\ 42 \end{bmatrix} ft \qquad depth_i := H_{wall} - elevation_i = \begin{bmatrix} 43 \\ 41 \\ 39 \\ 37 \\ 35 \\ 33 \\ 31 \\ 29 \\ 27 \\ 25 \\ 23 \\ 21 \\ 19 \\ 17 \\ 15 \\ 13 \\ 11 \\ 9 \\ 7 \\ 5 \\ 3 \\ 1 \end{bmatrix} ft$$

Calculate Pullout Resistance Slope/W Input:

For design and comparison purposes, a normalized definition of pullout resistance will be used throughout the manual. The pullout resistance, P_r, at each of the reinforcement levels per unit width of reinforcement is given by:

$$P_r = F^* \alpha \sigma_v' L_e C \qquad (3\text{-}2)$$

where:

- $L_e C$ = the total surface area per unit width of the reinforcement in the resistive zone behind the failure surface
- L_e = the embedment or adherence length in the resisting zone behind the failure surface
- C = the reinforcement effective unit perimeter; e.g., C = 2 for and sheets, and because the edges are neglected C = 2 for strips and grids
- F^* = the pullout resistance (or friction-bearing-interaction) factor
- α = a scale effect correction factor to account for a non linear stress reduction over the embedded length of highly extensible reinforcements, based on laboratory data (generally 1.0 for metallic reinforcements and 0.6 to 1.0 for geosynthetic reinforcements, see Table 3-6).
- σ'_v = the effective vertical stress at the soil-reinforcement interfaces.

The factored pullout resistance is then given by:

$$P_r = \Phi_{pullout} \left(F \cdot \alpha \cdot \sigma_v' \cdot L_e \cdot C\right)$$

In Slope/W, pullout resistance per unit width of wall is given by:

$$P_r = \left(c + \sigma_v' \cdot tan\left(\phi_{interface}\right)\right) \cdot \alpha \cdot L_e \cdot C$$

Where α and C can be defined within the reinforcement properties, and are set to be the same as defined above. Overburden pressure, σ_v' and effective length, Le, are determined from the limit equilibrium analysis performed in Slope/W. Interface adhesion, c, is assumed to be negligable for metal grids in granular backfill.

To select a representative interface friction angle, $\phi_{interface}$, that will produce the same factored resistance per unit width of wall, the two expressions are set to be equal:

$$\Phi_{pullout} \left(F \cdot \alpha \cdot \sigma_v' \cdot L_e \cdot C\right) = \sigma_v' \cdot tan\left(\phi_{interface}\right) \cdot \alpha \cdot L_e \cdot C$$

Removing common constants and rearranging produces:

$$\phi_{interface} = atan\left(\Phi_{pullout} \cdot F\right)$$

Calculate Pullout Resistance Factor F*:

For steel grid reinforcements with transverse spacing of $S_t \geq 6$ inches (150 mm) (see Figure 3-4), F* is a function of a bearing or embedment factor, F_q, applied over the contributing bearing α_β, as follows:

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$F^* = F_q \alpha_\beta = 40 \alpha_\beta = 40 (t/2S_t) = 20 (t/S_t)$ at the top of the structure (3-6)

$F^* = F_q \alpha_\beta = 20 \alpha_\beta = 20 (t/2S_t) = 10 (t/S_t)$ at a depth of 20 ft (6 m) and below (3-7)

Where, t is the thickness of the transverse bar. S_t must be uniform throughout the length of the reinforcement rather than having transverse grid members concentrated only in the resistant zone. The maximum S_t distance is 24 in. (610 mm). For sloping backfills see Figure 4-15.

$$F\_final_i := \text{if } depth_i < 20\ ft \left\| 20 \cdot \left(\frac{t_i}{s_t} \right) \right\| \text{else} \left\| 10 \cdot \left(\frac{t_i}{s_t} \right) \right\|$$

$$F\_final = \begin{bmatrix} 0.24 \\ 0.24 \\ 0.24 \\ 0.24 \\ 0.24 \\ 0.24 \\ 0.2 \\ 0.2 \\ 0.2 \\ 0.2 \\ 0.2 \\ 0.2 \\ 0.41 \\ 0.41 \\ 0.31 \\ 0.31 \\ 0.36 \\ 0.36 \\ 0.36 \\ 0.36 \\ 0.36 \\ 0.36 \end{bmatrix}$$

Calculated F* for each row of reinforcement. Top row of matrix represents the bottom row of reinforcement.

Calculate Interface Shear Angle (degrees):

$$\phi_{interface\_static} := \operatorname{atan}\left(\Phi_{pullout\_static} \cdot F\_final\right) = \begin{bmatrix} 12.4 \\ 12.4 \\ 12.4 \\ 12.4 \\ 12.4 \\ 12.4 \\ 10.4 \\ 10.4 \\ 10.4 \\ 10.4 \\ 10.4 \\ 10.4 \\ 20.1 \\ 20.1 \\ 15.4 \\ 15.4 \\ 17.8 \\ 17.8 \\ 17.8 \\ 17.8 \\ 17.8 \\ 17.8 \end{bmatrix} \textit{deg}$$

Static interface shear angle for each row of reinforcement. Top row of matrix represents the bottom reinforcement row.

$$\phi_{interface\_seismic} := \operatorname{atan}\left(\Phi_{pullout\_seismic} \cdot F\_final\right) = \begin{bmatrix} 16.3 \\ 16.3 \\ 16.3 \\ 16.3 \\ 16.3 \\ 16.3 \\ 13.7 \\ 13.7 \\ 13.7 \\ 13.7 \\ 13.7 \\ 13.7 \\ 26 \\ 26 \\ 20.2 \\ 20.2 \\ 23.1 \\ 23.1 \\ 23.1 \\ 23.1 \\ 23.1 \\ 23.1 \end{bmatrix} \textit{deg}$$

Seismic interface shear angle for each row of reinforcement. Top row of matrix represents the bottom reinforcement row.

Calculate Allowable Tensile Capacity of Steel Straps:

$$T_{capacity} = \Phi_{static} \cdot f_y \, A_s$$

Slope/W does not have grid reinforcement inputs. Therefore, the tensile strength of the grids were modeled as continuous reinforcement. The calculated allowable tensile grid capacity was converted to a continuous reinforcement tensile capacity by distributing the capacity over the tributary width. The longitudinal wires are spaced every 6 inches, therefore there are two bars within each 1 foot width of grid.

W9.5xW4.0:
(Rows 1 through 6)

$$T_{al\_static} := \frac{\Phi_{static} \cdot f_y \, A_{sW9.5xW4.0} \cdot \frac{1\ \textit{ft}}{s_l}}{w} = 5.68\ \frac{\textit{kip}}{\textit{ft}}$$

$$T_{al\_seismic} := \frac{\Phi_{seismic} \cdot f_y \, A_{sW9.5xW4.0} \cdot \frac{1\ \textit{ft}}{s_l}}{w} = 7.4\ \frac{\textit{kip}}{\textit{ft}}$$

W7.0xW3.5:
(Rows 7 through 14)

$$T_{al\_static} := \frac{\Phi_{static} \cdot f_y \, A_{sW7.0xW3.5} \cdot \frac{1\ ft}{s_l}}{w} = 3.94\ \frac{kip}{ft}$$

$$T_{al\_seismic} := \frac{\Phi_{seismic} \cdot f_y \, A_{sW7.0xW3.5} \cdot \frac{1\ ft}{s_l}}{w} = 5.1\ \frac{kip}{ft}$$

W4.5xW3.5:
(Rows 15 through 16)

$$T_{al\_static} := \frac{\Phi_{static} \cdot f_y \, A_{sW4.5xW3.5} \cdot \frac{1\ ft}{s_l}}{w} = 2.24\ \frac{kip}{ft}$$

$$T_{al\_seismic} := \frac{\Phi_{seismic} \cdot f_y \, A_{sW4.5xW3.5} \cdot \frac{1\ ft}{s_l}}{w} = 2.9\ \frac{kip}{ft}$$

W4.5xW3.5 (NEW):
(Rows 17 through 22)

$$T_{al\_static} := \frac{\Phi_{static} \cdot f_y \, A_{sW4.5xW3.5\_NEW} \cdot \frac{1\ ft}{s_l}}{w} = 3.03\ \frac{kip}{ft}$$

$$T_{al\_seismic} := \frac{\Phi_{seismic} \cdot f_y \, A_{sW4.5xW3.5\_NEW} \cdot \frac{1\ ft}{s_l}}{w} = 4\ \frac{kip}{ft}$$

2.1 Static (Spencer) Section Ea-Ea' - Existing Condition - Compound Stability

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File Informa on

File Version: 11.01
Created By: Mikayla S. Hatch
Last Edited By: Amy Nguyen
Revision Number: 406
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Tool Version: 11.1
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Directory: P:\0\0180366\01\Analysis\Bridge 17.7\SlopeW\
Last Solved Date: 11/10/2021
Last Solved Time: 01:36:24 PM

Project Se ngs

Unit System: U.S. Customary Units

Analysis Se ngs

2.1 Sta c (Spencer)

Kind: SLOPE/W
Parent: 2. Compound Stability
Analysis Type: Spencer
Se ngs
PWP Condi ons from: Piezometric Line
Apply Phrea c Correc on: No
Use Staged Rapid Drawdown: No
Unit Weight of Water: 62.4 pcf
Slip Surface
Direc on of movement: Le. to Right
Use Passive Mode: No
Slip Surface Op□on: Entry and Exit
Cri□cal slip surfaces saved: 1
Op□mize Cri□cal Slip Surface Loca□on: No
Tension Crack Op□on: (none)
Distribu□on
F of S Calcula□on Op□on: Constant
Advanced
Geometry Se□ ngs
Minimum Slip Surface Depth: 2 ft
Number of Slices: 30
Factor of Safety Convergence Se□ ngs
Maximum Number of Itera□ons: 100
Tolerable difference in F of S: 0.001
Solu□on Se□ ngs
Search Method: Root Finder

Tolerable difference between star□ng and converged F of S: 3
Maximum itera□ons to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

ESU 2A - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 39 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2B - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 41 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 7A - Weathered Sandstone

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 42 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2C - Na ve Silt

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 29 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1A - Exis ng Granular Fill

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 40 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1B - Exis ng Gravelly Granular Fill

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Reinforcements

EL49_W9.5xW4

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 14.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,441 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,441 lbf/ft

EL51_W9.5xW4

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 14.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,441 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,441 lbf/ft

EL53_W9.5xW4

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 14.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,441 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,441 lbf/ft

EL55_W9.5xW4

Type: Geosynthe□c
Interface Adhesion: 0 psf

Interface Shear Angle: 14.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,441 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,441 lbf/ft

EL57_W9.5xW4

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 14.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,441 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,441 lbf/ft

EL59_W9.5xW4

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 14.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,441 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,441 lbf/ft

EL61_W9.5xW4.0

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 14.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,441 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,441 lbf/ft

EL63_W9.5xW4.0

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 14.1 °
Surface Area Factor: 2

Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,441 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,441 lbf/ft

EL65_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 12.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,422 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,422 lbf/ft

EL67_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 12.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,422 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,422 lbf/ft

EL69_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 12.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,422 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,422 lbf/ft

EL71_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 12.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,422 lbf

Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,422 lbf/ft

EL73_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 12.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,422 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,422 lbf/ft

EL75_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 12.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,422 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,422 lbf/ft

EL77_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 23.2 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,422 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,422 lbf/ft

EL79_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 23.2 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,422 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No

Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,422 lbf/ft

EL81_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,385 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,385 lbf/ft

EL89_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,385 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,385 lbf/ft

EL87_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,385 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,385 lbf/ft

EL85_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,385 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes

Factored Tensile Capacity: 3,385 lbf/ft

EL83_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,385 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,385 lbf/ft

EL91_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,385 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,385 lbf/ft

EL93_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,385 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,385 lbf/ft

EL95_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,385 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,385 lbf/ft

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (0.05, 60) ft
Left-Zone Right Coordinate: (122, 96) ft
Left-Zone Increment: 40
Right Type: Range
Right-Zone Left Coordinate: (160, 70.95212) ft
Right-Zone Right Coordinate: (181, 50) ft
Right-Zone Increment: 20
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 60) ft
Right Coordinate: (335, 48) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	0.25 ft	43.375 ft
Coordinate 2	56.5 ft	43.375 ft
Coordinate 3	97.75 ft	43.375 ft
Coordinate 4	123 ft	43.375 ft
Coordinate 5	159.75 ft	42.625 ft
Coordinate 6	192 ft	42.625 ft
Coordinate 7	210.75 ft	42.625 ft
Coordinate 8	298 ft	35 ft
Coordinate 9	335.25 ft	35 ft

Reinforcement Lines

Reinforcement Line 1

Reinforcement: EL49_W9.5xW4
Lock to Ground Surface: No
Outside Point: (160, 49) ft
Inside Point: (126, 49) ft
Length: 34 ft
Orienta□on: 180 °
Slip Surface Intersec□on: (126.61076, 49) ft
Max. Pullout Force: 7,441 lbf
Available Length: 0.61075678 ft
Required Length: 0.61075678 ft
Pullout Force: 1,892.2752 lbf
Pullout Force per Length: 3,098.2467 lbf/ft
Governing Component: Pullout Resistance

Reinforcement Line 2

Reinforcement: EL51_W9.5xW4
Lock to Ground Surface: No
Outside Point: (160, 51) ft
Inside Point: (126, 51) ft
Length: 34 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 3

Reinforcement: EL53_W9.5xW4
Lock to Ground Surface: No
Outside Point: (160, 53) ft
Inside Point: (126, 53) ft
Length: 34 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 4

Reinforcement: EL55_W9.5xW4
Lock to Ground Surface: No
Outside Point: (160, 55) ft
Inside Point: (126, 55) ft
Length: 34 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 5

Reinforcement: EL57_W9.5xW4
Lock to Ground Surface: No
Outside Point: (160, 57) ft
Inside Point: (126, 57) ft
Length: 34 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft

Governing Component: (none)

Reinforcement Line 6

Reinforcement: EL59_W9.5xW4
Lock to Ground Surface: No
Outside Point: (160, 59) ft
Inside Point: (126, 59) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 7

Reinforcement: EL61_W9.5xW4.0
Lock to Ground Surface: No
Outside Point: (160, 61) ft
Inside Point: (126, 61) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 8

Reinforcement: EL63_W9.5xW4.0
Lock to Ground Surface: No
Outside Point: (160, 63) ft
Inside Point: (126, 63) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 9

Reinforcement: EL65_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 65) ft
Inside Point: (126, 65) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft

Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 10

Reinforcement: EL67_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 67) ft
Inside Point: (126, 67) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 11

Reinforcement: EL69_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 69) ft
Inside Point: (126, 69) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 12

Reinforcement: EL71_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 71) ft
Inside Point: (126, 71) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 13

Reinforcement: EL73_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 73) ft
Inside Point: (126, 73) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf

Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 14

Reinforcement: EL75_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 75) ft
Inside Point: (126, 75) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 15

Reinforcement: EL77_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 77) ft
Inside Point: (126, 77) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 16

Reinforcement: EL79_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 79) ft
Inside Point: (126, 79) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 17

Reinforcement: EL81_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 81) ft
Inside Point: (126, 81) ft
Length: 34 ft

Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 18

Reinforcement: EL83_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 83) ft
Inside Point: (126, 83) ft
Length: 34 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 19

Reinforcement: EL85_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 85) ft
Inside Point: (126, 85) ft
Length: 34 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 20

Reinforcement: EL87_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 87) ft
Inside Point: (126, 87) ft
Length: 34 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 21

Reinforcement: EL91_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 91) ft

Inside Point: (126, 91) ft
Length: 34 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 22

Reinforcement: EL89_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 89) ft
Inside Point: (126, 89) ft
Length: 34 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 23

Reinforcement: EL93_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 93) ft
Inside Point: (126, 93) ft
Length: 34 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 24

Reinforcement: EL95_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 95) ft
Inside Point: (126, 95) ft
Length: 34 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 250 pcf
Direc□on: Ver□cal

Coordinates

	X	Y
	120 ft	97 ft
	126 ft	97 ft

Surcharge Load 2

Surcharge (Unit Weight): 250 pcf
Direc□on: Ver□cal

Coordinates

	X	Y
	126 ft	97.75 ft
	160 ft	97.75 ft

Geometry

Name: Ea-Ea'

Se ngs

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	0 ft	56 ft
Point 2	76 ft	56 ft
Point 3	118 ft	35 ft
Point 4	160 ft	35 ft
Point 5	0 ft	46 ft
Point 6	37 ft	46 ft
Point 7	190 ft	50 ft
Point 8	160 ft	50 ft
Point 9	170.25 ft	34 ft
Point 10	240 ft	34 ft
Point 11	315 ft	30 ft
Point 12	335 ft	30 ft
Point 13	335 ft	48 ft
Point 14	327 ft	48 ft
Point 15	315 ft	49 ft
Point 16	224 ft	48 ft
Point 17	0 ft	0 ft
Point 18	335 ft	0 ft
Point 19	160 ft	96 ft
Point 20	120 ft	96 ft
Point 21	120 ft	72 ft

Point 22	76 ft	72 ft
Point 23	52 ft	60 ft
Point 24	0 ft	60 ft
Point 25	160 ft	47 ft
Point 26	120 ft	47 ft
Point 27	65 ft	66.5 ft
Point 28	120 ft	66.5 ft
Point 29	120 ft	49 ft
Point 30	160 ft	49 ft
Point 31	160 ft	66.5 ft
Point 32	160 ft	72 ft

Regions

	Material	Points	Area
Region 1	ESU 2C - Na□ve Silt	5,6,2,1	565 ft²
Region 2	ESU 1A - Exis□ng Granular Fill	19,20,21,32	960 ft²
Region 3	ESU 1A - Exis□ng Granular Fill	20,22,21	528 ft²
Region 4	ESU 2A - Na□ve Sand and Gravel	6,2,3	619.5 ft²
Region 5	ESU 2B - Na□ve Sand and Gravel	7,16,15,14,13,12,11,10,9,4	2,595.4 ft²
Region 6	ESU 7A - Weathered Sandstone	18,17,5,6,3,4,9,10,11,12	12,178 ft²
Region 7	ESU 1B - Exis□ng Gravelly Granular Fill	8,30,25,7	45 ft²
Region 8	ESU 2A - Na□ve Sand and Gravel	4,7,25,26,2,3	945 ft²
Region 9	ESU 1B - Exis□ng Gravelly Granular Fill	21,22,27,28	272.25 ft²
Region 10	ESU 1B - Exis□ng Gravelly Granular Fill	23,24,1,2,26,29,28,27	1,077.8 ft²
Region 11	ESU 1B - Exis□ng Gravelly Granular Fill	29,26,25,30	80 ft²
Region 12	ESU 1B - Exis□ng Gravelly Granular Fill	29,30,8,31,28	700 ft²
Region 13	ESU 1B - Exis□ng Gravelly Granular Fill	28,31,32,21	220 ft²

Slip Results

Slip Surfaces Analysed: 1885 of 4305 converged

Current Slip Surface

Slip Surface: 3,675
Factor of Safety: 2.668
Volume: 2,570.1146 ft³
Weight: 314,077.59 lbf
Resis□ng Moment: 13,191,394 lbf·ft
Ac□va□ng Moment: 4,943,507.7 lbf·ft
Resis□ng Force: 242,079.1 lbf
Ac□va□ng Force: 90,739.814 lbf
Slip Rank: 1 of 4,305 slip surfaces
Exit: (181, 50) ft
Entry: (104.51796, 87.555251) ft
Radius: 48.597403 ft
Center: (153.06505, 89.76614) ft

Slip Slices

	X	Y	PWP	Base	Fric□onal	Cohesive	Suc□on	Base

				Normal Stress	Strength	Strength	Strength	Material
Slice 1	106.17474 ft	79.777625 ft	-2,271.5238 psf	248.23426 psf	208.29327 psf	0 psf	0 psf	ESU 1A - Exis□ng Granular Fill
Slice 2	109.11524 ft	69.25 ft	-1,614.6 psf	1,065.4561 psf	832.42555 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 3	111.5991 ft	64.528188 ft	-1,319.9589 psf	1,620.7654 psf	1,266.2807 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 4	113.99935 ft	60.930477 ft	-1,095.4618 psf	2,131.7931 psf	1,665.5393 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 5	116.39961 ft	57.922715 ft	-907.77741 psf	2,627.6427 psf	2,052.9395 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 6	118.79987 ft	55.346121 ft	-746.99798 psf	3,112.6123 psf	2,431.8393 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 7	121.5 ft	52.868188 ft	-592.37494 psf	3,749.5476 psf	2,929.4677 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 8	124.5 ft	50.493944 ft	-446.13232 psf	4,202.42 psf	3,283.2903 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 9	126.30538 ft	49.201452 ft	-367.77988 psf	4,670.3796 psf	3,648.9004 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 10	128.29705 ft	48 ft	-295.34563 psf	4,900.5895 psf	3,828.7601 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 11	131.20192 ft	46.385852 ft	-198.32206 psf	5,305.2493 psf	4,296.1061 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 12	133.63908 ft	45.240059 ft	-129.92822 psf	5,632.9493 psf	4,561.4724 psf	0 psf	0 psf	ESU 2A - Na□ve Sand

								and Gravel
Slice 13	136.07624 ft	44.253547 ft	-71.473511 psf	5,953.9118 psf	4,821.3827 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 14	138.51339 ft	43.416105 ft	-22.320806 psf	6,269.6252 psf	5,077.0424 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 15	140.9831 ft	42.712281 ft	18.45272 psf	6,584.3609 psf	5,316.9676 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 16	143.48535 ft	42.139379 ft	51.015306 psf	6,900.0858 psf	5,546.2679 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 17	145.98761 ft	41.703492 ft	75.028101 psf	7,214.6906 psf	5,781.5847 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 18	148.48986 ft	41.400905 ft	90.722943 psf	7,530.5926 psf	6,024.6876 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 19	150.99211 ft	41.22912 ft	98.255833 psf	7,850.5734 psf	6,277.703 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 20	153.49437 ft	41.186743 ft	97.713592 psf	8,177.9504 psf	6,543.2467 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 21	155.99662 ft	41.273435 ft	89.117445 psf	8,516.8101 psf	6,824.611 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 22	158.49887 ft	41.489894 ft	72.423889 psf	8,872.342 psf	7,126.0332 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 23	159.875 ft	41.648408 ft	60.939351 psf	9,308.6332 psf	7,488.6348 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 24	161.21817 ft	41.873477 ft	46.895012 psf	1,289.1648 psf	1,005.9702 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 25	163.65452 ft	42.352928 ft	16.977291 psf	1,280.7484 psf	1,023.3817 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 26	166.08593 ft	42.962525 ft	-21.06158 psf	1,248.4911 psf	1,011.0082 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 27	168.5124 ft	43.706946 ft	-67.513453 psf	1,185.4915 psf	959.99209 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 28	170.93887 ft	44.593897 ft	-122.8592 psf	1,089.8975 psf	882.58157 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 29	173.36534 ft	45.632003 ft	-187.63697 psf	952.41125 psf	771.24742 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 30	175.79182 ft	46.832272 ft	-262.53375 psf	758.31778 psf	614.07363 psf	0 psf	0 psf	ESU 2A - Na□ve Sand

								and Gravel
Slice 31	178.21829 ft	48.208822 ft	-348.43047 psf	482.54931 psf	390.76073 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 32	180.21576 ft	49.471576 ft	-427.22636 psf	156.8226 psf	122.52325 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill

2.2 Static (M-P) Section Ea-Ea' - Existing Condition - Compound Stability

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File Informa on

File Version: 11.01
Created By: Mikayla S. Hatch
Last Edited By: Amy Nguyen
Revision Number: 406
Date: 11/10/2021
Time: 01:34:24 PM
Tool Version: 11.1
File Name: Wall 03.63L - Bridge 17.7 Ea-Ea' - All Condi ons.gsz
Directory: P:\0\0180366\01\Analysis\Bridge 17.7\SlopeW\
Last Solved Date: 11/10/2021
Last Solved Time: 01:36:36 PM

Project Se ngs

Unit System: U.S. Customary Units

Analysis Se ngs

2.2 Sta c (M-P)

Kind: SLOPE/W
Parent: 2. Compound Stability
Analysis Type: Morgenstern-Price
Se ngs
Side Func on
Interslice force func on op on: Half-Sine
PWP Condi ons from: Piezometric Line
Apply Phrea c Correc on: No
Use Staged Rapid Drawdown: No
Unit Weight of Water: 62.4 pcf
Slip Surface
Direc on of movement: Le. to Right
Use Passive Mode: No
Slip Surface Op on: Entry and Exit
Cri cal slip surfaces saved: 1
Op mize Cri cal Slip Surface Loca on: No
Tension Crack Op on: (none)
Distribu on
F of S Calcula on Op on: Constant
Advanced
Geometry Se ngs
Minimum Slip Surface Depth: 2 ft
Number of Slices: 30
Factor of Safety Convergence Se ngs
Maximum Number of Itera ons: 100
Tolerable difference in F of S: 0.001

Solu□on Se□ ngs
Search Method: Root Finder
Tolerable difference between star□ng and converged F of S: 3
Maximum itera□ons to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

ESU 2A - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 39 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2B - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 41 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 7A - Weathered Sandstone

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 42 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2C - Na ve Silt

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 29 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1A - Exis ng Granular Fill

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 40 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1B - Exis ng Gravelly Granular Fill

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effec ve Cohesion: 0 psf
Effec ve Fric on Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Reinforcements

EL47_W9.5xW4

Type: Geosynthe c
Interface Adhesion: 0 psf
Interface Shear Angle: 14.1 °
Surface Area Factor: 2
Pullout Resistance Reduc on Factor: 1
Tensile Capacity: 7,441 lbf
Tensile Capacity Reduc on Factor: 1
F of S Dependent: No
Force Distribu on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,441 lbf/ft

EL51_W9.5xW4

Type: Geosynthe c
Interface Adhesion: 0 psf
Interface Shear Angle: 14.1 °
Surface Area Factor: 2
Pullout Resistance Reduc on Factor: 1
Tensile Capacity: 7,441 lbf
Tensile Capacity Reduc on Factor: 1
F of S Dependent: No
Force Distribu on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,441 lbf/ft

EL53_W9.5xW4

Type: Geosynthe c
Interface Adhesion: 0 psf
Interface Shear Angle: 14.1 °
Surface Area Factor: 2
Pullout Resistance Reduc on Factor: 1
Tensile Capacity: 7,441 lbf
Tensile Capacity Reduc on Factor: 1
F of S Dependent: No
Force Distribu on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,441 lbf/ft

EL55_W9.5xW4

Type: Geosynthe c

Interface Adhesion: 0 psf
Interface Shear Angle: 14.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,441 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,441 lbf/ft

EL57_W9.5xW4

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 14.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,441 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,441 lbf/ft

EL59_W9.5xW4

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 14.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,441 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,441 lbf/ft

EL61_W9.5xW4.0

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 14.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,441 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,441 lbf/ft

EL63_W9.5xW4.0

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 14.1 °

Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,441 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,441 lbf/ft

EL65_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 12.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,422 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,422 lbf/ft

EL67_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 12.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,422 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,422 lbf/ft

EL69_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 12.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,422 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,422 lbf/ft

EL71_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 12.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1

Tensile Capacity: 5,422 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,422 lbf/ft

EL73_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 12.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,422 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,422 lbf/ft

EL75_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 12.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,422 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,422 lbf/ft

EL77_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 23.2 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,422 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,422 lbf/ft

EL79_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 23.2 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,422 lbf
Tensile Capacity Reduc□on Factor: 1

F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,422 lbf/ft

EL81_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,385 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,385 lbf/ft

EL89_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,385 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,385 lbf/ft

EL87_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,385 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,385 lbf/ft

EL85_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,385 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed

Face Anchorage: Yes
Factored Tensile Capacity: 3,385 lbf/ft

EL83_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,385 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,385 lbf/ft

EL91_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,385 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,385 lbf/ft

EL93_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,385 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,385 lbf/ft

EL95_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,385 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,385 lbf/ft

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (0.05, 60) ft
Left-Zone Right Coordinate: (122, 96) ft
Left-Zone Increment: 40
Right Type: Range
Right-Zone Left Coordinate: (160, 70.95212) ft
Right-Zone Right Coordinate: (182, 50) ft
Right-Zone Increment: 20
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 60) ft
Right Coordinate: (335, 48) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	0.25 ft	43.375 ft
Coordinate 2	56.5 ft	43.375 ft
Coordinate 3	97.75 ft	43.375 ft
Coordinate 4	123 ft	43.375 ft
Coordinate 5	159.75 ft	42.625 ft
Coordinate 6	192 ft	42.625 ft
Coordinate 7	210.75 ft	42.625 ft
Coordinate 8	298 ft	35 ft
Coordinate 9	335.25 ft	35 ft

Reinforcement Lines

Reinforcement Line 1

Reinforcement: EL47_W9.5xW4
Lock to Ground Surface: No
Outside Point: (160, 49) ft
Inside Point: (126, 49) ft
Length: 34 ft
Orienta□on: 180 °
Slip Surface Intersec□on: (126.33395, 49) ft
Max. Pullout Force: 7,441 lbf
Available Length: 0.33395312 ft
Required Length: 0.33395312 ft
Pullout Force: 1,036.5457 lbf
Pullout Force per Length: 3,103.866 lbf/ft
Governing Component: Pullout Resistance

Reinforcement Line 2

Reinforcement: EL51_W9.5xW4
Lock to Ground Surface: No
Outside Point: (160, 51) ft
Inside Point: (126, 51) ft
Length: 34 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 3

Reinforcement: EL53_W9.5xW4
Lock to Ground Surface: No
Outside Point: (160, 53) ft
Inside Point: (126, 53) ft
Length: 34 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 4

Reinforcement: EL55_W9.5xW4
Lock to Ground Surface: No
Outside Point: (160, 55) ft
Inside Point: (126, 55) ft
Length: 34 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 5

Reinforcement: EL57_W9.5xW4
Lock to Ground Surface: No
Outside Point: (160, 57) ft
Inside Point: (126, 57) ft
Length: 34 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft

Governing Component: (none)

Reinforcement Line 6

Reinforcement: EL59_W9.5xW4
Lock to Ground Surface: No
Outside Point: (160, 59) ft
Inside Point: (126, 59) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 7

Reinforcement: EL61_W9.5xW4.0
Lock to Ground Surface: No
Outside Point: (160, 61) ft
Inside Point: (126, 61) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 8

Reinforcement: EL63_W9.5xW4.0
Lock to Ground Surface: No
Outside Point: (160, 63) ft
Inside Point: (126, 63) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 9

Reinforcement: EL65_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 65) ft
Inside Point: (126, 65) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft

Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 10

Reinforcement: EL67_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 67) ft
Inside Point: (126, 67) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 11

Reinforcement: EL69_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 69) ft
Inside Point: (126, 69) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 12

Reinforcement: EL71_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 71) ft
Inside Point: (126, 71) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 13

Reinforcement: EL73_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 73) ft
Inside Point: (126, 73) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf

Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 14

Reinforcement: EL75_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 75) ft
Inside Point: (126, 75) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 15

Reinforcement: EL77_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 77) ft
Inside Point: (126, 77) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 16

Reinforcement: EL79_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 79) ft
Inside Point: (126, 79) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 17

Reinforcement: EL81_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 81) ft
Inside Point: (126, 81) ft
Length: 34 ft

Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 18

Reinforcement: EL83_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 83) ft
Inside Point: (126, 83) ft
Length: 34 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 19

Reinforcement: EL85_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 85) ft
Inside Point: (126, 85) ft
Length: 34 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 20

Reinforcement: EL89_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 89) ft
Inside Point: (126, 89) ft
Length: 34 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 21

Reinforcement: EL87_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 87) ft

Inside Point: (126, 87) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 22

Reinforcement: EL91_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 91) ft
Inside Point: (126, 91) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 23

Reinforcement: EL85_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 85) ft
Inside Point: (126, 85) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 24

Reinforcement: EL93_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 93) ft
Inside Point: (126, 93) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 25

Reinforcement: EL95_W4.5xW3.5

Lock to Ground Surface: No
Outside Point: (160, 95) ft
Inside Point: (126, 95) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 250 pcf
Direc□on: Ver□cal

Coordinates

	X	Y
	120 ft	97 ft
	126 ft	97 ft

Surcharge Load 2

Surcharge (Unit Weight): 250 pcf
Direc□on: Ver□cal

Coordinates

	X	Y
	126 ft	97.75 ft
	160 ft	97.75 ft

Geometry

Name: Ea-Ea'

Se ngs

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	0 ft	56 ft
Point 2	76 ft	56 ft
Point 3	118 ft	35 ft
Point 4	160 ft	35 ft
Point 5	0 ft	46 ft
Point 6	37 ft	46 ft
Point 7	190 ft	50 ft

Point 8	160 ft	50 ft
Point 9	170.25 ft	34 ft
Point 10	240 ft	34 ft
Point 11	315 ft	30 ft
Point 12	335 ft	30 ft
Point 13	335 ft	48 ft
Point 14	327 ft	48 ft
Point 15	315 ft	49 ft
Point 16	224 ft	48 ft
Point 17	0 ft	0 ft
Point 18	335 ft	0 ft
Point 19	160 ft	96 ft
Point 20	120 ft	96 ft
Point 21	120 ft	72 ft
Point 22	76 ft	72 ft
Point 23	52 ft	60 ft
Point 24	0 ft	60 ft
Point 25	160 ft	47 ft
Point 26	120 ft	47 ft
Point 27	65 ft	66.5 ft
Point 28	120 ft	66.5 ft
Point 29	120 ft	49 ft
Point 30	160 ft	49 ft
Point 31	160 ft	66.5 ft
Point 32	160 ft	72 ft

Regions

	Material	Points	Area
Region 1	ESU 2C - Na□ve Silt	5,6,2,1	565 ft²
Region 2	ESU 1A - Exis□ng Granular Fill	19,20,21,32	960 ft²
Region 3	ESU 1A - Exis□ng Granular Fill	20,22,21	528 ft²
Region 4	ESU 2A - Na□ve Sand and Gravel	6,2,3	619.5 ft²
Region 5	ESU 2B - Na□ve Sand and Gravel	7,16,15,14,13,12,11,10,9,4	2,595.4 ft²
Region 6	ESU 7A - Weathered Sandstone	18,17,5,6,3,4,9,10,11,12	12,178 ft²
Region 7	ESU 1B - Exis□ng Gravelly Granular Fill	8,30,25,7	45 ft²
Region 8	ESU 2A - Na□ve Sand and Gravel	4,7,25,26,2,3	945 ft²
Region 9	ESU 1B - Exis□ng Gravelly Granular Fill	21,22,27,28	272.25 ft²
Region 10	ESU 1B - Exis□ng Gravelly Granular Fill	23,24,1,2,26,29,28,27	1,077.8 ft²
Region 11	ESU 1B - Exis□ng Gravelly Granular Fill	29,26,25,30	80 ft²
Region 12	ESU 1B - Exis□ng Gravelly Granular Fill	29,30,8,31,28	700 ft²
Region 13	ESU 1B - Exis□ng Gravelly Granular Fill	28,31,32,21	220 ft²

Slip Results

Slip Surfaces Analysed: 2001 of 4305 converged

Current Slip Surface

Slip Surface: 3,675

Figure D.5-152

Factor of Safety: 2.636
Volume: 2,593.7259 ft³
Weight: 316,930.58 lbf
Resis□ng Moment: 13,434,637 lbf·ft
Ac□va□ng Moment: 5,097,918.9 lbf·ft
Resis□ng Force: 243,577.32 lbf
Ac□va□ng Force: 92,412.051 lbf
Slip Rank: 1 of 4,305 slip surfaces
Exit: (182, 50) ft
Entry: (104.51796, 87.555251) ft
Radius: 48.976226 ft
Center: (153.44321, 89.7892) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Fric□onal Strength	Cohesive Strength	Suc□on Strength	Base Material
Slice 1	106.16494 ft	79.777625 ft	-2,271.5238 psf	370.74543 psf	311.09235 psf	0 psf	0 psf	ESU 1A - Exis□ng Granular Fill
Slice 2	109.08526 ft	69.25 ft	-1,614.6 psf	1,284.3499 psf	1,003.4441 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 3	111.56377 ft	64.503897 ft	-1,318.4432 psf	1,760.6837 psf	1,375.5968 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 4	113.97412 ft	60.863343 ft	-1,091.2726 psf	2,163.5896 psf	1,690.3814 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 5	116.38447 ft	57.821774 ft	-901.47867 psf	2,541.433 psf	1,985.5851 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 6	118.79482 ft	55.21683 ft	-738.93021 psf	2,912.3805 psf	2,275.401 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 7	121.5 ft	52.716548 ft	-582.91259 psf	3,438.2991 psf	2,686.2937 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 8	124.5 ft	50.324012 ft	-435.52855 psf	3,792.9946 psf	2,963.4122 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly

								Granular Fill
Slice 9	126.16698 ft	49.111967 ft	-362.01976 psf	4,204.4697 psf	3,284.8918 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 10	127.97478 ft	48 ft	-294.93523 psf	4,386.5491 psf	3,427.1477 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 11	130.76396 ft	46.399764 ft	-198.63246 psf	4,783.2321 psf	3,873.385 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 12	133.06067 ft	45.273724 ft	-131.29234 psf	5,135.2546 psf	4,158.4472 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 13	135.35739 ft	44.291436 ft	-72.922355 psf	5,511.0743 psf	4,462.78 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 14	137.6541 ft	43.443727 ft	-22.950085 psf	5,909.6584 psf	4,785.5471 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 15	140.11168 ft	42.681986 ft	21.452876 psf	6,354.4779 psf	5,128.3826 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 16	142.73012 ft	42.017868 ft	59.559322 psf	6,847.0344 psf	5,496.389 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 17	145.34857 ft	41.504781 ft	88.241472 psf	7,347.6023 psf	5,878.5145 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 18	147.96701 ft	41.13793 ft	107.79846 psf	7,841.4411 psf	6,262.5803 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 19	150.58545 ft	40.914013 ft	118.43639 psf	8,308.8916 psf	6,632.4998 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 20	153.20389 ft	40.831062 ft	120.27801 psf	8,725.6441 psf	6,968.4881 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 21	155.82234 ft	40.888358 ft	113.36819 psf	9,063.8303 psf	7,247.9413 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 22	158.44078 ft	41.086399 ft	97.675982 psf	9,294.1552 psf	7,447.162 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 23	159.875 ft	41.237302 ft	86.592386 psf	9,501.9106 psf	7,624.3744 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 24	161.10701 ft	41.429292 ft	74.612161 psf	1,573.4109 psf	1,213.7033 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel

Slice 25	163.32102 ft	41.832739 ft	49.437095 psf	1,537.5648 psf	1,205.0621 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 26	165.53503 ft	42.342877 ft	17.604485 psf	1,466.7201 psf	1,173.4707 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 27	168.04283 ft	43.062677 ft	-27.311047 psf	1,336.2852 psf	1,082.1024 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 28	170.84443 ft	44.033083 ft	-87.864369 psf	1,135.8595 psf	919.80087 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 29	173.64602 ft	45.200503 ft	-160.7114 psf	889.46786 psf	720.27687 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 30	176.44762 ft	46.580992 ft	-246.85388 psf	608.98566 psf	493.14686 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 31	179.24922 ft	48.195895 ft	-347.62385 psf	307.40212 psf	248.92933 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 32	181.32501 ft	49.532501 ft	-431.02805 psf	76.233461 psf	59.560108 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill

2.3 Pseudo-Static (Spencer) Section Ea-Ea' - Existing Condition - Compound Stability

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File Informa on

File Version: 11.01
Created By: Mikayla S. Hatch
Last Edited By: Amy Nguyen
Revision Number: 406
Date: 11/10/2021
Time: 01:34:24 PM
Tool Version: 11.1
File Name: Wall 03.63L - Bridge 17.7 Ea-Ea' - All Condi ons.gsz
Directory: P:\0\0180366\01\Analysis\Bridge 17.7\SlopeW\
Last Solved Date: 11/10/2021
Last Solved Time: 01:37:06 PM

Project Se ngs

Unit System: U.S. Customary Units

Analysis Se ngs

2.3 Pseudo-Sta c (Spencer)

Kind: SLOPE/W
Parent: 2. Compound Stability
Analysis Type: Spencer
Se ngs
PWP Condi ons from: Piezometric Line
Apply Phrea c Correc on: No
Use Staged Rapid Drawdown: No
Unit Weight of Water: 62.4 pcf
Slip Surface
Direc on of movement: Le. to Right
Use Passive Mode: No
Slip Surface Op□on: Entry and Exit
Cri□cal slip surfaces saved: 1
Op□mize Cri□cal Slip Surface Loca□on: No
Tension Crack Op□on: (none)
Distribu□on
F of S Calcula□on Op□on: Constant
Advanced
Geometry Se□ ngs
Minimum Slip Surface Depth: 2 ft
Number of Slices: 30
Factor of Safety Convergence Se□ ngs
Maximum Number of Itera□ons: 100
Tolerable difference in F of S: 0.001
Solu□on Se□ ngs
Search Method: Root Finder

Tolerable difference between star□ng and converged F of S: 3
Maximum itera□ons to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

ESU 1A - Exis ng Granular Fill (Pseudo-Sta c)

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 50 psf
Effec□ve Fric□on Angle: 40 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2A - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 39 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2B - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 41 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 7A - Weathered Sandstone

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 42 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1B - Exis ng Gravelly Granular Fill

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2C - Na ve Silt (Pseudo-Sta c)

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effec□ve Cohesion: 200 psf
Effec□ve Fric□on Angle: 29 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Reinforcements

EQ_EL49_W9.5xW4

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.5 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 9,730 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 9,730 lbf/ft

EQ_EL51_W9.5xW4

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.5 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 9,730 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 9,730 lbf/ft

EQ_EL53_W9.5xW4

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.5 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 9,730 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 9,730 lbf/ft

EQ_EL55_W9.5xW4

Type: Geosynthe□c
Interface Adhesion: 0 psf

Interface Shear Angle: 18.5 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 9,730 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 9,730 lbf/ft

EQ_EL57_W9.5xW4

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.5 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 9,730 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 9,730 lbf/ft

EQ_EL59_W9.5xW4

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.5 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 9,730 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 9,730 lbf/ft

EQ_EL61_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.5 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 9,730 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 9,730 lbf/ft

EQ_EL63_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.5 °
Surface Area Factor: 2

Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 9,730 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 9,730 lbf/ft

EQ_EL65_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 16 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,091 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,091 lbf/ft

EQ_EL67_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 16 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,091 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,091 lbf/ft

EQ_EL69_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 16 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,091 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,091 lbf/ft

EQ_EL71_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 16 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,091 lbf

Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,091 lbf/ft

EQ_EL73_W7.0xW3.5

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 16 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 7,091 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,091 lbf/ft

EQ_EL75_W7.0xW3.5

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 16 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 7,091 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,091 lbf/ft

EQ_EL77_W7.0xW3.5

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 29.8 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 7,091 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,091 lbf/ft

EQ_EL79_W7.0xW3.5

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 29.8 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 7,091 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No

Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,091 lbf/ft

EQ_EL81_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 24.3 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 4,426 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 4,426 lbf/ft

EQ_EL83_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 24.3 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 4,426 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 4,426 lbf/ft

EQ_EL85_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 24.3 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 4,426 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 4,426 lbf/ft

EQ_EL87_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 24.3 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 4,426 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes

Factored Tensile Capacity: 4,426 lbf/ft

EQ_EL89_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 24.3 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 4,426 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 4,426 lbf/ft

EQ_EL91_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 24.3 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 4,426 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 4,426 lbf/ft

EQ_EL93_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 24.3 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 4,426 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 4,426 lbf/ft

EQ_EL95_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 24.3 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 4,426 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 4,426 lbf/ft

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (0.05, 60) ft
Left-Zone Right Coordinate: (122, 96) ft
Left-Zone Increment: 40
Right Type: Range
Right-Zone Left Coordinate: (160, 70.95212) ft
Right-Zone Right Coordinate: (186, 50) ft
Right-Zone Increment: 20
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 60) ft
Right Coordinate: (335, 48) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	0.25 ft	43.375 ft
Coordinate 2	56.5 ft	43.375 ft
Coordinate 3	97.75 ft	43.375 ft
Coordinate 4	123 ft	43.375 ft
Coordinate 5	159.75 ft	42.625 ft
Coordinate 6	192 ft	42.625 ft
Coordinate 7	210.75 ft	42.625 ft
Coordinate 8	298 ft	35 ft
Coordinate 9	335.25 ft	35 ft

Seismic Coefficients

Horz Seismic Coef.: 0.178

Reinforcement Lines

Reinforcement Line 1

Reinforcement: EQ_EL49_W9.5xW4
Lock to Ground Surface: No
Outside Point: (160, 49) ft
Inside Point: (126, 49) ft
Length: 34 ft
Orienta□on: 180 °
Slip Surface Intersec□on: (126.90073, 49) ft
Max. Pullout Force: 9,730 lbf
Available Length: 0.90073318 ft

Figure D.5-164

Required Length: 0.90073318 ft
Pullout Force: 3,455.0528 lbf
Pullout Force per Length: 3,835.8228 lbf/ft
Governing Component: Pullout Resistance

Reinforcement Line 2

Reinforcement: EQ_EL51_W9.5xW4
Lock to Ground Surface: No
Outside Point: (160, 51) ft
Inside Point: (126, 51) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 3

Reinforcement: EQ_EL53_W9.5xW4
Lock to Ground Surface: No
Outside Point: (160, 53) ft
Inside Point: (126, 53) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 4

Reinforcement: EQ_EL55_W9.5xW4
Lock to Ground Surface: No
Outside Point: (160, 55) ft
Inside Point: (126, 55) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 5

Reinforcement: EQ_EL57_W9.5xW4
Lock to Ground Surface: No
Outside Point: (160, 57) ft
Inside Point: (126, 57) ft
Length: 34 ft
Orienta□on: 180 °

Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 6

Reinforcement: EQ_EL59_W9.5xW4
Lock to Ground Surface: No
Outside Point: (160, 59) ft
Inside Point: (126, 59) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 7

Reinforcement: EQ_EL61_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 61) ft
Inside Point: (126, 61) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 8

Reinforcement: EQ_EL63_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 63) ft
Inside Point: (126, 63) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 9

Reinforcement: EQ_EL65_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 65) ft
Inside Point: (126, 65) ft

Length: 34 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 10

Reinforcement: EQ_EL67_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 67) ft
Inside Point: (126, 67) ft
Length: 34 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 11

Reinforcement: EQ_EL69_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 69) ft
Inside Point: (126, 69) ft
Length: 34 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 12

Reinforcement: EQ_EL71_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 71) ft
Inside Point: (126, 71) ft
Length: 34 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 13

Reinforcement: EQ_EL73_W7.0xW3.5
Lock to Ground Surface: No

Outside Point: (160, 73) ft
Inside Point: (126, 73) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 14

Reinforcement: EQ_EL75_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 75) ft
Inside Point: (126, 75) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 15

Reinforcement: EQ_EL77_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 77) ft
Inside Point: (126, 77) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 16

Reinforcement: EQ_EL79_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 79) ft
Inside Point: (126, 79) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 17

Reinforcement: EQ_EL81_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 81) ft
Inside Point: (126, 81) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 18

Reinforcement: EQ_EL83_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 83) ft
Inside Point: (126, 83) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 19

Reinforcement: EQ_EL89_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 89) ft
Inside Point: (126, 89) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 20

Reinforcement: EQ_EL87_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 87) ft
Inside Point: (126, 87) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 21

Reinforcement: EQ_EL91_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 91) ft
Inside Point: (126, 91) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 22

Reinforcement: EQ_EL85_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 85) ft
Inside Point: (126, 85) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 23

Reinforcement: EQ_EL93_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 93) ft
Inside Point: (126, 93) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 24

Reinforcement: EQ_EL95_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 95) ft
Inside Point: (126, 95) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft

Governing Component: (none)

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 125 pcf
Direc□on: Ver□cal

Coordinates

	X	Y
	120 ft	97 ft
	160 ft	97 ft

Geometry

Name: Ea-Ea'

Se ngs

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	0 ft	56 ft
Point 2	76 ft	56 ft
Point 3	118 ft	35 ft
Point 4	160 ft	35 ft
Point 5	0 ft	46 ft
Point 6	37 ft	46 ft
Point 7	190 ft	50 ft
Point 8	160 ft	50 ft
Point 9	170.25 ft	34 ft
Point 10	240 ft	34 ft
Point 11	315 ft	30 ft
Point 12	335 ft	30 ft
Point 13	335 ft	48 ft
Point 14	327 ft	48 ft
Point 15	315 ft	49 ft
Point 16	224 ft	48 ft
Point 17	0 ft	0 ft
Point 18	335 ft	0 ft
Point 19	160 ft	96 ft
Point 20	120 ft	96 ft
Point 21	120 ft	72 ft
Point 22	76 ft	72 ft
Point 23	52 ft	60 ft
Point 24	0 ft	60 ft
Point 25	160 ft	47 ft

Point 26	120 ft	47 ft
Point 27	65 ft	66.5 ft
Point 28	120 ft	66.5 ft
Point 29	120 ft	49 ft
Point 30	160 ft	49 ft
Point 31	160 ft	66.5 ft
Point 32	160 ft	72 ft

Regions

	Material	Points	Area
Region 1	ESU 2C - Na□ve Silt (Pseudo-Sta□c)	5,6,2,1	565 ft²
Region 2	ESU 1A - Exis□ng Granular Fill (Pseudo-Sta□c)	19,20,21,32	960 ft²
Region 3	ESU 1A - Exis□ng Granular Fill (Pseudo-Sta□c)	20,22,21	528 ft²
Region 4	ESU 2A - Na□ve Sand and Gravel	6,2,3	619.5 ft²
Region 5	ESU 2B - Na□ve Sand and Gravel	7,16,15,14,13,12,11,10,9,4	2,595.4 ft²
Region 6	ESU 7A - Weathered Sandstone	18,17,5,6,3,4,9,10,11,12	12,178 ft²
Region 7	ESU 1B - Exis□ng Gravelly Granular Fill	8,30,25,7	45 ft²
Region 8	ESU 2A - Na□ve Sand and Gravel	4,7,25,26,2,3	945 ft²
Region 9	ESU 1B - Exis□ng Gravelly Granular Fill	21,22,27,28	272.25 ft²
Region 10	ESU 1B - Exis□ng Gravelly Granular Fill	23,24,1,2,26,29,28,27	1,077.8 ft²
Region 11	ESU 1B - Exis□ng Gravelly Granular Fill	29,26,25,30	80 ft²
Region 12	ESU 1B - Exis□ng Gravelly Granular Fill	29,30,8,31,28	700 ft²
Region 13	ESU 1B - Exis□ng Gravelly Granular Fill	28,31,32,21	220 ft²

Slip Results

Slip Surfaces Analysed: 1854 of 4305 converged

Current Slip Surface

Slip Surface: 3,464
Factor of Safety: 2.002
Volume: 2,703.4925 ft³
Weight: 330,321.37 lbf
Resis□ng Moment: 15,870,343 lbf·ft
Ac□va□ng Moment: 7,927,179.5 lbf·ft
Resis□ng Force: 247,072.91 lbf
Ac□va□ng Force: 123,405.91 lbf
Slip Rank: 1 of 4,305 slip surfaces
Exit: (186, 50) ft
Entry: (98.772016, 84.4211) ft
Radius: 59.087417 ft
Center: (155.58474, 100.65802) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Fric□onal Strength	Cohesive Strength	Suc□on Strength	Base Material
Slice 1	100.05709 ft	80.823487 ft	-2,336.7856 psf	121.03377 psf	101.5594 psf	50 psf	0 psf	ESU 1A - Exis□ng Granular

								Fill (Pseudo-Sta□c)
Slice 2	102.62723 ft	74.612937 ft	-1,949.2473 psf	396.68436 psf	332.8577 psf	50 psf	0 psf	ESU 1A - Exis□ng Granular Fill (Pseudo-Sta□c)
Slice 3	105.64171 ft	69.25 ft	-1,614.6 psf	768.27247 psf	600.24023 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 4	108.94973 ft	64.465898 ft	-1,316.072 psf	1,200.1914 psf	937.69232 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 5	112.10695 ft	60.713549 ft	-1,081.9254 psf	1,634.6026 psf	1,277.0915 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 6	115.26417 ft	57.519802 ft	-882.63563 psf	2,088.676 psf	1,631.8525 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 7	118.42139 ft	54.765945 ft	-710.79499 psf	2,562.261 psf	2,001.8577 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 8	121.5 ft	52.427531 ft	-564.87794 psf	3,071.2052 psf	2,399.4885 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 9	124.95037 ft	50.183737 ft	-427.3489 psf	3,538.5661 psf	2,764.6308 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 10	128.872 ft	48 ft	-296.07782 psf	4,043.9292 psf	3,159.4638 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 11	132.33748 ft	46.360266 ft	-198.17157 psf	4,540.7443 psf	3,677.0222 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 12	135.32588 ft	45.174944 ft	-128.01316 psf	4,958.7366 psf	4,015.5057 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice	138.31429	44.172505	-69.266561	5,397.172	4,370.5437	0 psf	0 psf	ESU 2A -

13	ft	ft	psf	psf	psf			Na□ve Sand and Gravel
Slice 14	141.3027 ft	43.343317 ft	-21.330886 psf	5,861.5223 psf	4,746.5672 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 15	144.20966 ft	42.693738 ft	15.50091 psf	6,345.4068 psf	5,125.8567 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 16	147.03518 ft	42.209841 ft	42.097836 psf	6,844.4489 psf	5,508.4353 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 17	149.86069 ft	41.865642 ft	59.977658 psf	7,391.8543 psf	5,937.2366 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 18	152.68621 ft	41.658689 ft	69.29331 psf	8,002.5043 psf	6,424.1876 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 19	155.51173 ft	41.587537 ft	70.135014 psf	8,696.9482 psf	6,985.8556 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 20	158.33724 ft	41.651692 ft	62.533497 psf	9,504.2867 psf	7,645.781 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 21	159.875 ft	41.726694 ft	56.054272 psf	11,322.709 psf	9,123.5569 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 22	161.67436 ft	41.909351 ft	44.656525 psf	1,507.6013 psf	1,184.6693 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 23	165.02307 ft	42.353953 ft	16.913313 psf	1,650.5125 psf	1,322.8626 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 24	168.23788 ft	42.962838 ft	-21.081079 psf	1,785.5679 psf	1,445.9244 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 25	171.31879 ft	43.726408 ft	-68.727852 psf	1,896.54 psf	1,535.7878 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 26	174.39971 ft	44.669814 ft	-127.5964 psf	1,991.2931 psf	1,612.5174 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 27	177.48062 ft	45.802368 ft	-198.26778 psf	2,033.2824 psf	1,646.5196 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 28	180.56153 ft	47.136125 ft	-281.49422 psf	1,914.7962 psf	1,550.5714 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 29	183.64244 ft	48.686646 ft	-378.24672 psf	1,317.1448 psf	1,066.6028 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 30	185.59145 ft	49.759145 ft	-445.17065 psf	298.92462 psf	233.54551 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly

								Granular Fill

Figure D.5-175

2.4 Pseudo-Static (M-P)

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File Informa on

File Version: 11.01
Created By: Mikayla S. Hatch
Last Edited By: Amy Nguyen
Revision Number: 406
Date: 11/10/2021
Time: 01:34:24 PM
Tool Version: 11.1
File Name: Wall 03.63L - Bridge 17.7 Ea-Ea' - All Condi ons.gsz
Directory: P:\0\0180366\01\Analysis\Bridge 17.7\SlopeW\
Last Solved Date: 11/10/2021
Last Solved Time: 01:35:30 PM

Project Se ngs

Unit System: U.S. Customary Units

Analysis Se ngs

2.4 Pseudo-Sta c (M&P)

Kind: SLOPE/W
Parent: 2. Compound Stability
Analysis Type: Morgenstern-Price
Se ngs
Side Func on
Interslice force func on op on: Half-Sine
PWP Condi ons from: Piezometric Line
Apply Phrea c Correc on: No
Use Staged Rapid Drawdown: No
Unit Weight of Water: 62.4 pcf
Slip Surface
Direc on of movement: Le. to Right
Use Passive Mode: No
Slip Surface Op on: Entry and Exit
Cri cal slip surfaces saved: 1
Op mize Cri cal Slip Surface Loca on: No
Tension Crack Op on: (none)
Distribu on
F of S Calcula on Op on: Constant
Advanced
Geometry Se ngs
Minimum Slip Surface Depth: 2 ft
Number of Slices: 30
Factor of Safety Convergence Se ngs
Maximum Number of Itera ons: 100
Tolerable difference in F of S: 0.001

Solu□on Se□ ngs
Search Method: Root Finder
Tolerable difference between star□ng and converged F of S: 3
Maximum itera□ons to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

ESU 1A - Exis ng Granular Fill (Pseudo-Sta c)

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 50 psf
Effec□ve Fric□on Angle: 40 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2A - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 39 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2B - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 41 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 7A - Weathered Sandstone

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 42 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1B - Exis ng Gravelly Granular Fill

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2C - Na ve Silt (Pseudo-Sta c)

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effec□ve Cohesion: 200 psf
Effec□ve Fric□on Angle: 29 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Reinforcements

EQ_EL49_W9.5xW4

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.5 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 9,730 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 9,730 lbf/ft

EQ_EL51_W9.5xW4

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.5 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 9,730 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 9,730 lbf/ft

EQ_EL53_W9.5xW4

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.5 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 9,730 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 9,730 lbf/ft

EQ_EL55_W9.5xW4

Type: Geosynthe□c

Interface Adhesion: 0 psf
Interface Shear Angle: 18.5 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 9,730 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 9,730 lbf/ft

EQ_EL57_W9.5xW4

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.5 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 9,730 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 9,730 lbf/ft

EQ_EL59_W9.5xW4

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.5 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 9,730 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 9,730 lbf/ft

EQ_EL61_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.5 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 9,730 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 9,730 lbf/ft

EQ_EL63_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.5 °

Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 9,730 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 9,730 lbf/ft

EQ_EL65_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 16 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,091 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,091 lbf/ft

EQ_EL67_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 16 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,091 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,091 lbf/ft

EQ_EL69_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 16 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,091 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,091 lbf/ft

EQ_EL71_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 16 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1

Tensile Capacity: 7,091 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,091 lbf/ft

EQ_EL73_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 16 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,091 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,091 lbf/ft

EQ_EL75_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 16 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,091 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,091 lbf/ft

EQ_EL77_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 29.8 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,091 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,091 lbf/ft

EQ_EL79_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 29.8 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,091 lbf
Tensile Capacity Reduc□on Factor: 1

F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,091 lbf/ft

EQ_EL81_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 24.3 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 4,426 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 4,426 lbf/ft

EQ_EL83_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 24.3 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 4,426 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 4,426 lbf/ft

EQ_EL85_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 24.3 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 4,426 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 4,426 lbf/ft

EQ_EL87_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 24.3 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 4,426 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed

Face Anchorage: Yes
Factored Tensile Capacity: 4,426 lbf/ft

EQ_EL89_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 24.3 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 4,426 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 4,426 lbf/ft

EQ_EL91_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 24.3 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 4,426 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 4,426 lbf/ft

EQ_EL93_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 24.3 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 4,426 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 4,426 lbf/ft

EQ_EL95_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 24.3 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 4,426 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 4,426 lbf/ft

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (0.05, 60) ft
Left-Zone Right Coordinate: (122, 96) ft
Left-Zone Increment: 40
Right Type: Range
Right-Zone Left Coordinate: (160, 70.95212) ft
Right-Zone Right Coordinate: (185, 50) ft
Right-Zone Increment: 20
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 60) ft
Right Coordinate: (335, 48) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	0.25 ft	43.375 ft
Coordinate 2	56.5 ft	43.375 ft
Coordinate 3	97.75 ft	43.375 ft
Coordinate 4	123 ft	43.375 ft
Coordinate 5	159.75 ft	42.625 ft
Coordinate 6	192 ft	42.625 ft
Coordinate 7	210.75 ft	42.625 ft
Coordinate 8	298 ft	35 ft
Coordinate 9	335.25 ft	35 ft

Seismic Coefficients

Horz Seismic Coef.: 0.178

Reinforcement Lines

Reinforcement Line 1

Reinforcement: EQ_EL49_W9.5xW4
Lock to Ground Surface: No
Outside Point: (160, 49) ft
Inside Point: (126, 49) ft
Length: 34 ft
Orienta□on: 180 °
Slip Surface Intersec□on: (127.1166, 49) ft
Max. Pullout Force: 9,730 lbf
Available Length: 1.1165961 ft

Figure D.5-184

Required Length: 1.1165961 ft
Pullout Force: 4,278.4502 lbf
Pullout Force per Length: 3,831.6902 lbf/ft
Governing Component: Pullout Resistance

Reinforcement Line 2

Reinforcement: EQ_EL51_W9.5xW4
Lock to Ground Surface: No
Outside Point: (160, 51) ft
Inside Point: (126, 51) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 3

Reinforcement: EQ_EL53_W9.5xW4
Lock to Ground Surface: No
Outside Point: (160, 53) ft
Inside Point: (126, 53) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 4

Reinforcement: EQ_EL55_W9.5xW4
Lock to Ground Surface: No
Outside Point: (160, 55) ft
Inside Point: (126, 55) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 5

Reinforcement: EQ_EL57_W9.5xW4
Lock to Ground Surface: No
Outside Point: (160, 57) ft
Inside Point: (126, 57) ft
Length: 34 ft
Orienta□on: 180 °

Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 6

Reinforcement: EQ_EL59_W9.5xW4
Lock to Ground Surface: No
Outside Point: (160, 59) ft
Inside Point: (126, 59) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 7

Reinforcement: EQ_EL61_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 61) ft
Inside Point: (126, 61) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 8

Reinforcement: EQ_EL63_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 63) ft
Inside Point: (126, 63) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 9

Reinforcement: EQ_EL65_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 65) ft
Inside Point: (126, 65) ft

Length: 34 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 10

Reinforcement: EQ_EL67_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 67) ft
Inside Point: (126, 67) ft
Length: 34 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 11

Reinforcement: EQ_EL69_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 69) ft
Inside Point: (126, 69) ft
Length: 34 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 12

Reinforcement: EQ_EL71_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 71) ft
Inside Point: (126, 71) ft
Length: 34 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 13

Reinforcement: EQ_EL73_W7.0xW3.5
Lock to Ground Surface: No

Outside Point: (160, 73) ft
Inside Point: (126, 73) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 14

Reinforcement: EQ_EL75_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 75) ft
Inside Point: (126, 75) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 15

Reinforcement: EQ_EL77_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 77) ft
Inside Point: (126, 77) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 16

Reinforcement: EQ_EL79_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 79) ft
Inside Point: (126, 79) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 17

Reinforcement: EQ_EL81_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 81) ft
Inside Point: (126, 81) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 18

Reinforcement: EQ_EL83_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 83) ft
Inside Point: (126, 83) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 19

Reinforcement: EQ_EL89_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 89) ft
Inside Point: (126, 89) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 20

Reinforcement: EQ_EL87_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 87) ft
Inside Point: (126, 87) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 21

Reinforcement: EQ_EL91_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 91) ft
Inside Point: (126, 91) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 22

Reinforcement: EQ_EL85_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 85) ft
Inside Point: (126, 85) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 23

Reinforcement: EQ_EL93_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 93) ft
Inside Point: (126, 93) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 24

Reinforcement: EQ_EL95_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 95) ft
Inside Point: (126, 95) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft

Governing Component: (none)

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 125 pcf
Direc□on: Ver□cal

Coordinates

	X	Y
	120 ft	97 ft
	160 ft	97 ft

Geometry

Name: Ea-Ea'

Se ngs

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	0 ft	56 ft
Point 2	76 ft	56 ft
Point 3	118 ft	35 ft
Point 4	160 ft	35 ft
Point 5	0 ft	46 ft
Point 6	37 ft	46 ft
Point 7	190 ft	50 ft
Point 8	160 ft	50 ft
Point 9	170.25 ft	34 ft
Point 10	240 ft	34 ft
Point 11	315 ft	30 ft
Point 12	335 ft	30 ft
Point 13	335 ft	48 ft
Point 14	327 ft	48 ft
Point 15	315 ft	49 ft
Point 16	224 ft	48 ft
Point 17	0 ft	0 ft
Point 18	335 ft	0 ft
Point 19	160 ft	96 ft
Point 20	120 ft	96 ft
Point 21	120 ft	72 ft
Point 22	76 ft	72 ft
Point 23	52 ft	60 ft
Point 24	0 ft	60 ft
Point 25	160 ft	47 ft

Point 26	120 ft	47 ft
Point 27	65 ft	66.5 ft
Point 28	120 ft	66.5 ft
Point 29	120 ft	49 ft
Point 30	160 ft	49 ft
Point 31	160 ft	66.5 ft
Point 32	160 ft	72 ft

Regions

	Material	Points	Area
Region 1	ESU 2C - Na□ve Silt (Pseudo-Sta□c)	5,6,2,1	565 ft²
Region 2	ESU 1A - Exis□ng Granular Fill (Pseudo-Sta□c)	19,20,21,32	960 ft²
Region 3	ESU 1A - Exis□ng Granular Fill (Pseudo-Sta□c)	20,22,21	528 ft²
Region 4	ESU 2A - Na□ve Sand and Gravel	6,2,3	619.5 ft²
Region 5	ESU 2B - Na□ve Sand and Gravel	7,16,15,14,13,12,11,10,9,4	2,595.4 ft²
Region 6	ESU 7A - Weathered Sandstone	18,17,5,6,3,4,9,10,11,12	12,178 ft²
Region 7	ESU 1B - Exis□ng Gravelly Granular Fill	8,30,25,7	45 ft²
Region 8	ESU 2A - Na□ve Sand and Gravel	4,7,25,26,2,3	945 ft²
Region 9	ESU 1B - Exis□ng Gravelly Granular Fill	21,22,27,28	272.25 ft²
Region 10	ESU 1B - Exis□ng Gravelly Granular Fill	23,24,1,2,26,29,28,27	1,077.8 ft²
Region 11	ESU 1B - Exis□ng Gravelly Granular Fill	29,26,25,30	80 ft²
Region 12	ESU 1B - Exis□ng Gravelly Granular Fill	29,30,8,31,28	700 ft²
Region 13	ESU 1B - Exis□ng Gravelly Granular Fill	28,31,32,21	220 ft²

Slip Results

Slip Surfaces Analysed: 2214 of 4305 converged

Current Slip Surface

Slip Surface: 3,464
Factor of Safety: 2.020
Volume: 2,684.0746 ft³
Weight: 327,978.56 lbf
Resis□ng Moment: 15,612,680 lbf·ft
Ac□va□ng Moment: 7,727,637.2 lbf·ft
Resis□ng Force: 245,976.19 lbf
Ac□va□ng Force: 121,739.08 lbf
Slip Rank: 1 of 4,305 slip surfaces
Exit: (185, 50) ft
Entry: (98.772016, 84.4211) ft
Radius: 58.653715 ft
Center: (155.17711, 100.50598) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Fric□onal Strength	Cohesive Strength	Suc□on Strength	Base Material
Slice 1	100.0581 ft	80.82016 ft	-2,336.578 psf	183.69029 psf	154.13445 psf	50 psf	0 psf	ESU 1A - Exis□ng Granular

								Fill (Pseudo-Sta□c)
Slice 2	102.63025 ft	74.609611 ft	-1,949.0397 psf	595.85764 psf	499.98393 psf	50 psf	0 psf	ESU 1A - Exis□ng Granular Fill (Pseudo-Sta□c)
Slice 3	105.65189 ft	69.25 ft	-1,614.6 psf	995.01308 psf	777.38942 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 4	108.96402 ft	64.477749 ft	-1,316.8115 psf	1,325.6451 psf	1,035.7075 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 5	112.11716 ft	60.747993 ft	-1,084.0748 psf	1,605.0252 psf	1,253.9831 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 6	115.27029 ft	57.574977 ft	-886.07855 psf	1,881.9452 psf	1,470.3368 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 7	118.42343 ft	54.840569 ft	-715.4515 psf	2,177.432 psf	1,701.1963 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 8	121.5 ft	52.518977 ft	-570.58417 psf	2,527.9688 psf	1,975.0657 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 9	125.0583 ft	50.233141 ft	-430.56918 psf	2,882.4608 psf	2,252.0252 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 10	129.13261 ft	48 ft	-296.40969 psf	3,350.7809 psf	2,617.917 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 11	132.74119 ft	46.340341 ft	-197.44238 psf	3,925.7513 psf	3,179.0107 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 12	135.92633 ft	45.127073 ft	-125.79063 psf	4,518.1144 psf	3,658.6969 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice	139.11148	44.119706	-66.987129	5,231.1225	4,236.0795	0 psf	0 psf	ESU 2A -

13	ft	ft	psf	psf	psf			Naïve Sand and Gravel
Slice 14	142.29663 ft	43.307319 ft	-20.350377 psf	6,070.3742 psf	4,915.6921 psf	0 psf	0 psf	ESU 2A - Naïve Sand and Gravel
Slice 15	145.21093 ft	42.720731 ft	12.541417 psf	6,962.7375 psf	5,628.1578 psf	0 psf	0 psf	ESU 2A - Naïve Sand and Gravel
Slice 16	147.8544 ft	42.326414 ft	33.780426 psf	7,805.534 psf	6,293.442 psf	0 psf	0 psf	ESU 2A - Naïve Sand and Gravel
Slice 17	150.49787 ft	42.054247 ft	47.397311 psf	8,670.5438 psf	6,982.8864 psf	0 psf	0 psf	ESU 2A - Naïve Sand and Gravel
Slice 18	153.14133 ft	41.902523 ft	53.49849 psf	9,503.2787 psf	7,652.2811 psf	0 psf	0 psf	ESU 2A - Naïve Sand and Gravel
Slice 19	155.7848 ft	41.870307 ft	52.142427 psf	10,233.037 psf	8,244.3261 psf	0 psf	0 psf	ESU 2A - Naïve Sand and Gravel
Slice 20	158.42827 ft	41.9574 ft	43.341457 psf	10,779.494 psf	8,693.9648 psf	0 psf	0 psf	ESU 2A - Naïve Sand and Gravel
Slice 21	159.875 ft	42.040838 ft	36.451679 psf	12,610.012 psf	10,181.868 psf	0 psf	0 psf	ESU 2A - Naïve Sand and Gravel
Slice 22	161.16666 ft	42.170668 ft	28.350296 psf	2,358.5661 psf	1,886.9716 psf	0 psf	0 psf	ESU 2A - Naïve Sand and Gravel
Slice 23	163.49997 ft	42.457727 ft	10.437835 psf	2,381.0865 psf	1,919.7134 psf	0 psf	0 psf	ESU 2A - Naïve Sand and Gravel
Slice 24	166.04408 ft	42.884779 ft	-16.210192 psf	2,300.2069 psf	1,862.6708 psf	0 psf	0 psf	ESU 2A - Naïve Sand and Gravel
Slice 25	168.79899 ft	43.473555 ft	-52.949831 psf	2,092.9428 psf	1,694.8316 psf	0 psf	0 psf	ESU 2A - Naïve Sand and Gravel
Slice 26	171.5539 ft	44.203213 ft	-98.480496 psf	1,781.9049 psf	1,442.9582 psf	0 psf	0 psf	ESU 2A - Naïve Sand and Gravel
Slice 27	174.30881 ft	45.079332 ft	-153.15032 psf	1,398.8745 psf	1,132.7863 psf	0 psf	0 psf	ESU 2A - Naïve Sand and Gravel
Slice 28	177.06372 ft	46.109009 ft	-217.40218 psf	987.24782 psf	799.45752 psf	0 psf	0 psf	ESU 2A - Naïve Sand and Gravel
Slice 29	179.81863 ft	47.30119 ft	-291.79423 psf	593.00019 psf	480.20209 psf	0 psf	0 psf	ESU 2A - Naïve Sand and Gravel
Slice 30	182.57354 ft	48.667125 ft	-377.02863 psf	251.76774 psf	203.8775 psf	0 psf	0 psf	ESU 2A - Naïve Sand and Gravel
Slice	184.4755	49.69755	-441.32712	50.886485	39.756879	0 psf	0 psf	ESU 1B -

31	ft	ft	psf	psf	psf			Exis□ng Gravelly Granular Fill

2.1 Static (Spencer) Section Fa-Fa' - Existing Condition - Global Stability

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File Informa on

File Version: 11.01
Created By: Mikayla S. Hatch
Last Edited By: Amy Nguyen
Revision Number: 377
Date: 11/10/2021
Time: 05:25:56 PM
Tool Version: 11.1
File Name: Wall 03.63L - Bridge 17.7 Fa-Fa' - All Condi ons.gsz
Directory: P:\0\0180366\01\Analysis\Bridge 17.7\SlopeW\
Last Solved Date: 11/10/2021
Last Solved Time: 05:31:34 PM

Project Se ngs

Unit System: U.S. Customary Units

Analysis Se ngs

2.1 Sta c (Spencer)

Kind: SLOPE/W
Parent: 2. Compound Stability
Analysis Type: Spencer
Se ngs
PWP Condi ons from: Piezometric Line
Apply Phrea c Correc on: No
Use Staged Rapid Drawdown: No
Unit Weight of Water: 62.4 pcf
Slip Surface
Direc on of movement: Le. to Right
Use Passive Mode: No
Slip Surface Op□on: Entry and Exit
Cri□cal slip surfaces saved: 1
Op□mize Cri□cal Slip Surface Loca□on: No
Tension Crack Op□on: (none)
Distribu□on
F of S Calcula□on Op□on: Constant
Advanced
Geometry Se□ ngs
Minimum Slip Surface Depth: 2 ft
Number of Slices: 30
Factor of Safety Convergence Se□ ngs
Maximum Number of Itera□ons: 100
Tolerable difference in F of S: 0.001
Solu□on Se□ ngs
Search Method: Root Finder

Tolerable difference between star□ng and converged F of S: 3
Maximum itera□ons to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

ESU 2A - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 39 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2B - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 41 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 7A - Weathered Sandstone

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 42 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2C - Na ve Silt

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 29 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1A - Exis ng Granular Fill

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 40 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1B - Exis ng Gravelly Granular Fill

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Reinforcements

EL49_W9.5xW4.0

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 14.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,441 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,441 lbf/ft

EL51_W9.5xW4.0

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 14.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,441 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,441 lbf/ft

EL53_W9.5xW4.0

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 14.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,441 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,441 lbf/ft

EL55_W9.5xW4.0

Type: Geosynthe□c
Interface Adhesion: 0 psf

Interface Shear Angle: 14.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,441 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,441 lbf/ft

EL57_W9.5xW4.0

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 14.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,441 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,441 lbf/ft

EL59_W9.5xW4.0

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 14.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,441 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,441 lbf/ft

EL61_W9.5xW4.0

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 14.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,441 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,441 lbf/ft

EL63_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 12.1 °
Surface Area Factor: 2

Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,422 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,422 lbf/ft

EL65_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 12.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,422 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,422 lbf/ft

EL67_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 12.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,422 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,422 lbf/ft

EL69_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 12.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,422 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,422 lbf/ft

EL71_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 12.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,422 lbf

Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,422 lbf/ft

EL73_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 12.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,422 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,422 lbf/ft

EL75_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 23.2 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,422 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,422 lbf/ft

EL77_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 23.2 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,422 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,422 lbf/ft

EL79_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,385 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No

Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,385 lbf/ft

EL81_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,385 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,385 lbf/ft

EL89_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,385 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,385 lbf/ft

EL87_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,385 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,385 lbf/ft

EL85_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,385 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes

Factored Tensile Capacity: 3,385 lbf/ft

EL83_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,385 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,385 lbf/ft

EL91_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,385 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,385 lbf/ft

EL93_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,385 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,385 lbf/ft

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (0.05, 60) ft
Left-Zone Right Coordinate: (118.7337, 93.36685) ft
Left-Zone Increment: 40
Right Type: Range
Right-Zone Left Coordinate: (160, 70.95212) ft
Right-Zone Right Coordinate: (170.17203, 50.660932) ft
Right-Zone Increment: 20
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 60) ft
Right Coordinate: (335, 48) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	0.25 ft	43.375 ft
Coordinate 2	56.5 ft	43.375 ft
Coordinate 3	97.75 ft	43.375 ft
Coordinate 4	123 ft	43.375 ft
Coordinate 5	159.75 ft	42.625 ft
Coordinate 6	192 ft	42.625 ft
Coordinate 7	210.75 ft	42.625 ft
Coordinate 8	298 ft	35 ft
Coordinate 9	335.25 ft	35 ft

Reinforcement Lines

Reinforcement Line 1

Reinforcement: EL49_W9.5xW4.0
Lock to Ground Surface: No
Outside Point: (160, 49) ft
Inside Point: (126, 49) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 2

Reinforcement: EL51_W9.5xW4.0
Lock to Ground Surface: No
Outside Point: (160, 51) ft
Inside Point: (126, 51) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 3

Reinforcement: EL53_W9.5xW4.0
Lock to Ground Surface: No
Outside Point: (160, 53) ft
Inside Point: (126, 53) ft
Length: 34 ft
Orienta□on: 180 °
Slip Surface Intersec□on: (154.25806, 53) ft
Max. Pullout Force: 7,441 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 4

Reinforcement: EL55_W9.5xW4.0
Lock to Ground Surface: No
Outside Point: (160, 55) ft
Inside Point: (126, 55) ft
Length: 34 ft
Orienta□on: 180 °
Slip Surface Intersec□on: (148.71352, 55) ft
Max. Pullout Force: 7,441 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 5

Reinforcement: EL57_W9.5xW4.0
Lock to Ground Surface: No
Outside Point: (160, 57) ft
Inside Point: (126, 57) ft
Length: 34 ft
Orienta□on: 180 °
Slip Surface Intersec□on: (143.93747, 57) ft
Max. Pullout Force: 7,441 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 6

Reinforcement: EL59_W9.5xW4.0
Lock to Ground Surface: No
Outside Point: (160, 59) ft
Inside Point: (126, 59) ft
Length: 34 ft
Orienta□on: 180 °
Slip Surface Intersec□on: (139.68083, 59) ft
Max. Pullout Force: 7,441 lbf

Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 7

Reinforcement: EL61_W9.5xW4.0
Lock to Ground Surface: No
Outside Point: (160, 61) ft
Inside Point: (126, 61) ft
Length: 34 ft
Orienta□on: 180 °
Slip Surface Intersec□on: (135.84183, 61) ft
Max. Pullout Force: 7,441 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 8

Reinforcement: EL63_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 63) ft
Inside Point: (126, 63) ft
Length: 34 ft
Orienta□on: 180 °
Slip Surface Intersec□on: (132.32934, 63) ft
Max. Pullout Force: 5,422 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 9

Reinforcement: EL65_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 65) ft
Inside Point: (126, 65) ft
Length: 34 ft
Orienta□on: 180 °
Slip Surface Intersec□on: (129.09397, 65) ft
Max. Pullout Force: 5,422 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 10

Reinforcement: EL67_W7.0xW3.5
Lock to Ground Surface: No

Outside Point: (160, 67) ft
Inside Point: (126, 67) ft
Length: 34 ft
Orientation: 180 °
Slip Surface Intersection: (126.07413, 67) ft
Max. Pullout Force: 5,422 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 11

Reinforcement: EL69_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 69) ft
Inside Point: (126, 69) ft
Length: 34 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 12

Reinforcement: EL71_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 71) ft
Inside Point: (126, 71) ft
Length: 34 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 13

Reinforcement: EL73_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 73) ft
Inside Point: (126, 73) ft
Length: 34 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 14

Reinforcement: EL75_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 75) ft
Inside Point: (126, 75) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 15

Reinforcement: EL77_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 77) ft
Inside Point: (126, 77) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 16

Reinforcement: EL79_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 79) ft
Inside Point: (126, 79) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 17

Reinforcement: EL81_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 81) ft
Inside Point: (126, 81) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft

Governing Component: (none)

Reinforcement Line 18

Reinforcement: EL83_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 83) ft
Inside Point: (126, 83) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 19

Reinforcement: EL93_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 93) ft
Inside Point: (126, 93) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 20

Reinforcement: EL89_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 89) ft
Inside Point: (126, 89) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 21

Reinforcement: EL87_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 87) ft
Inside Point: (126, 87) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft

Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 22

Reinforcement: EL91_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 91) ft
Inside Point: (126, 91) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 23

Reinforcement: EL85_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 85) ft
Inside Point: (126, 85) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 250 pcf
Direc□on: Ver□cal

Coordinates

	X	Y
	120 ft	95 ft
	126 ft	95 ft

Surcharge Load 2

Surcharge (Unit Weight): 250 pcf
Direc□on: Ver□cal

Coordinates

	X	Y
	126 ft	95.75 ft
	160 ft	95.75 ft

Geometry

Name: Ga-Ga'

Se ngs

View: 2D

Element Thickness: 1 ft

Points

	X	Y
Point 1	0 ft	56 ft
Point 2	76 ft	56 ft
Point 3	118 ft	35 ft
Point 4	160 ft	35 ft
Point 5	0 ft	46 ft
Point 6	37 ft	46 ft
Point 7	190 ft	50 ft
Point 8	160 ft	51 ft
Point 9	170.25 ft	34 ft
Point 10	240 ft	34 ft
Point 11	315 ft	30 ft
Point 12	335 ft	30 ft
Point 13	335 ft	48 ft
Point 14	327 ft	48 ft
Point 15	315 ft	49 ft
Point 16	224 ft	48 ft
Point 17	0 ft	0 ft
Point 18	335 ft	0 ft
Point 19	160 ft	94 ft
Point 20	120 ft	94 ft
Point 21	120 ft	72 ft
Point 22	76 ft	72 ft
Point 23	52 ft	60 ft
Point 24	0 ft	60 ft
Point 25	160 ft	47 ft
Point 26	120 ft	47 ft
Point 27	65 ft	66.5 ft
Point 28	160 ft	66.5 ft
Point 29	120 ft	66.5 ft
Point 30	120 ft	49 ft
Point 31	160 ft	49 ft
Point 32	160 ft	72 ft
Point 33	160 ft	70.5 ft
Point 34	120 ft	70.5 ft
Point 35	156 ft	70.5 ft
Point 36	156 ft	66.5 ft

Regions

	Material	Points	Area
Region 1	ESU 2C - Na□ve Silt	5,6,2,1	565 ft²

Figure D.5-211

Region 2	ESU 1A - Exis□ng Granular Fill	19,20,21,32	880 ft²
Region 3	ESU 1A - Exis□ng Granular Fill	20,22,21	484 ft²
Region 4	ESU 2A - Na□ve Sand and Gravel	6,2,3	619.5 ft²
Region 5	ESU 2B - Na□ve Sand and Gravel	7,16,15,14,13,12,11,10,9,4	2,595.4 ft²
Region 6	ESU 7A - Weathered Sandstone	18,17,5,6,3,4,9,10,11,12	12,178 ft²
Region 7	ESU 1B - Exis□ng Gravelly Granular Fill	8,31,25,7	60 ft²
Region 8	ESU 2A - Na□ve Sand and Gravel	4,7,25,26,2,3	945 ft²
Region 9	ESU 1B - Exis□ng Gravelly Granular Fill	21,22,27,29,34	272.25 ft²
Region 10	ESU 1B - Exis□ng Gravelly Granular Fill	23,24,1,2,26,30,29,27	1,077.8 ft²
Region 11	ESU 1B - Exis□ng Gravelly Granular Fill	29,30,31,8,28,36	700 ft²
Region 12	ESU 1B - Exis□ng Gravelly Granular Fill	30,26,25,31	80 ft²
Region 13	ESU 1B - Exis□ng Gravelly Granular Fill	29,36,35,34	144 ft²
Region 14	ESU 1B - Exis□ng Gravelly Granular Fill	32,21,34,35,33	60 ft²
Region 15	ESU 1B - Exis□ng Gravelly Granular Fill	28,33,35,36	16 ft²

Slip Results

Slip Surfaces Analysed: 1581 of 4305 converged

Current Slip Surface

Slip Surface: 3,747
Factor of Safety: 3.305
Volume: 1,553.5103 ft³
Weight: 188,885.85 lbf
Resis□ng Moment: 18,217,950 lbf·ft
Ac□va□ng Moment: 5,512,551 lbf·ft
Resis□ng Force: 144,079.78 lbf
Ac□va□ng Force: 43,597.769 lbf
Slip Rank: 1 of 4,305 slip surfaces
Exit: (160, 51.266129) ft
Entry: (104.5838, 86.2919) ft
Radius: 111.88901 ft
Center: (189.44885, 159.21017) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Fric□onal Strength	Cohesive Strength	Suc□on Strength	Base Material
Slice 1	105.50683 ft	85.24438 ft	-2,612.6493 psf	116.30448 psf	97.591048 psf	0 psf	0 psf	ESU 1A - Exis□ng Granular Fill
Slice 2	107.35288 ft	83.19993 ft	-2,485.0757 psf	351.92361 psf	295.29897 psf	0 psf	0 psf	ESU 1A - Exis□ng Granular Fill
Slice 3	109.19893 ft	81.252831 ft	-2,363.5767 psf	588.45905 psf	493.77577 psf	0 psf	0 psf	ESU 1A - Exis□ng Granular Fill
Slice	111.04499	79.395944	-2,247.7069	825.61442	692.77275	0 psf	0 psf	ESU 1A -

4	ft	ft	psf	psf	psf			Exis□ng Granular Fill
Slice 5	112.89104 ft	77.623099 ft	-2,137.0814 psf	1,063.1502 psf	892.0889 psf	0 psf	0 psf	ESU 1A - Exis□ng Granular Fill
Slice 6	114.73709 ft	75.928922 ft	-2,031.3647 psf	1,300.8716 psf	1,091.5609 psf	0 psf	0 psf	ESU 1A - Exis□ng Granular Fill
Slice 7	116.58315 ft	74.308697 ft	-1,930.2627 psf	1,538.6201 psf	1,291.0556 psf	0 psf	0 psf	ESU 1A - Exis□ng Granular Fill
Slice 8	118.4292 ft	72.75826 ft	-1,833.5154 psf	1,776.2658 psf	1,490.464 psf	0 psf	0 psf	ESU 1A - Exis□ng Granular Fill
Slice 9	119.67611 ft	71.741638 ft	-1,770.0782 psf	1,950.5513 psf	1,523.9377 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 10	120.63023 ft	70.991638 ft	-1,723.2782 psf	2,233.2364 psf	1,744.7955 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 11	122.13023 ft	69.844806 ft	-1,651.7159 psf	2,364.7985 psf	1,847.5831 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 12	123.75 ft	68.645534 ft	-1,577.8364 psf	2,505.3067 psf	1,957.3601 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 13	125.25 ft	67.576008 ft	-1,513.0082 psf	2,633.3417 psf	2,057.392 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 14	126.40361 ft	66.775279 ft	-1,464.5118 psf	2,877.1347 psf	2,247.864 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 15	127.71948 ft	65.896507 ft	-1,411.3522 psf	2,986.4341 psf	2,333.258 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 16	129.54403 ft	64.714683 ft	-1,339.9299 psf	3,176.4631 psf	2,481.725 psf	0 psf	0 psf	ESU 1B - Exis□ng

								Gravelly Granular Fill
Slice 17	131.36858 ft	63.582276 ft	-1,271.5912 psf	3,325.4862 psf	2,598.1546 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 18	133.19313 ft	62.497549 ft	-1,206.2277 psf	3,517.4583 psf	2,748.1396 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 19	135.01768 ft	61.458912 ft	-1,143.7403 psf	3,729.1449 psf	2,913.5273 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 20	136.84223 ft	60.464912 ft	-1,084.0382 psf	3,871.2886 psf	3,024.5821 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 21	138.66678 ft	59.514212 ft	-1,027.038 psf	4,010.7522 psf	3,133.5431 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 22	140.49133 ft	58.605584 ft	-972.66314 psf	4,234.7225 psf	3,308.5278 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 23	142.31588 ft	57.737898 ft	-920.843 psf	4,369.7587 psf	3,414.0296 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 24	144.14043 ft	56.91011 ft	-871.51257 psf	4,608.8824 psf	3,600.8536 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 25	145.96498 ft	56.12126 ft	-824.61183 psf	4,739.7051 psf	3,703.0634 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 26	147.78953 ft	55.37046 ft	-780.0854 psf	4,867.9093 psf	3,803.2275 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 27	149.61408 ft	54.656889 ft	-737.88209 psf	5,150.4857 psf	4,024.0004 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly

								Granular Fill
Slice 28	151.43863 ft	53.97979 ft	-697.95463 psf	5,274.9861 psf	4,121.2708 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 29	153.26318 ft	53.338463 ft	-660.25934 psf	5,396.9003 psf	4,216.5206 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 30	155.08773 ft	52.732262 ft	-624.75587 psf	5,798.8213 psf	4,530.5358 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 31	156.9375 ft	52.153162 ft	-590.97569 psf	5,897.4525 psf	4,607.5949 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 32	158.8125 ft	51.601552 ft	-558.94296 psf	6,017.2433 psf	4,701.1857 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 33	159.875 ft	51.300386 ft	-541.34412 psf	11,421.892 psf	8,923.7598 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill

2.2 Static (M-P) Section Fa-Fa' - Existing Condition - Global Stability

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Time: 05:25:56 PM
Tool Version: 11.1
File Name: Wall 03.63L - Bridge 17.7 Fa-Fa' - All Condi ons.gsz
Directory: P:\0\0180366\01\Analysis\Bridge 17.7\SlopeW\
Last Solved Date: 11/10/2021
Last Solved Time: 05:32:22 PM

Project Se ngs

Unit System: U.S. Customary Units

Analysis Se ngs

2.2 Sta c (M-P)

Kind: SLOPE/W
Parent: 2. Compound Stability
Analysis Type: Morgenstern-Price
Se ngs
Side Func on
Interslice force func on op on: Half-Sine
PWP Condi ons from: Piezometric Line
Apply Phrea c Correc on: No
Use Staged Rapid Drawdown: No
Unit Weight of Water: 62.4 pcf
Slip Surface
Direc on of movement: Le. to Right
Use Passive Mode: No
Slip Surface Op on: Entry and Exit
Cri cal slip surfaces saved: 1
Op mize Cri cal Slip Surface Loca on: No
Tension Crack Op on: (none)
Distribu on
F of S Calcula on Op on: Constant
Advanced
Geometry Se ngs
Minimum Slip Surface Depth: 2 ft
Number of Slices: 30
Factor of Safety Convergence Se ngs
Maximum Number of Itera ons: 100
Tolerable difference in F of S: 0.001

Solu□on Se□ ngs
Search Method: Root Finder
Tolerable difference between star□ng and converged F of S: 3
Maximum itera□ons to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

ESU 2A - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 39 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2B - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 41 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 7A - Weathered Sandstone

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 42 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2C - Na ve Silt

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 29 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1A - Exis ng Granular Fill

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 40 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1B - Exis ng Gravelly Granular Fill

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effec ve Cohesion: 0 psf
Effec ve Fric on Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Reinforcements

EL49_W9.5xW4.0

Type: Geosynthe c
Interface Adhesion: 0 psf
Interface Shear Angle: 14.1 °
Surface Area Factor: 2
Pullout Resistance Reduc on Factor: 1
Tensile Capacity: 7,441 lbf
Tensile Capacity Reduc on Factor: 1
F of S Dependent: No
Force Distribu on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,441 lbf/ft

EL51_W9.5xW4.0

Type: Geosynthe c
Interface Adhesion: 0 psf
Interface Shear Angle: 14.1 °
Surface Area Factor: 2
Pullout Resistance Reduc on Factor: 1
Tensile Capacity: 7,441 lbf
Tensile Capacity Reduc on Factor: 1
F of S Dependent: No
Force Distribu on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,441 lbf/ft

EL53_W9.5xW4.0

Type: Geosynthe c
Interface Adhesion: 0 psf
Interface Shear Angle: 14.1 °
Surface Area Factor: 2
Pullout Resistance Reduc on Factor: 1
Tensile Capacity: 7,441 lbf
Tensile Capacity Reduc on Factor: 1
F of S Dependent: No
Force Distribu on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,441 lbf/ft

EL55_W9.5xW4.0

Type: Geosynthe c

Interface Adhesion: 0 psf
Interface Shear Angle: 14.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,441 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,441 lbf/ft

EL57_W9.5xW4.0

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 14.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,441 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,441 lbf/ft

EL59_W9.5xW4.0

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 14.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,441 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,441 lbf/ft

EL61_W9.5xW4.0

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 14.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,441 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,441 lbf/ft

EL63_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 12.1 °

Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,422 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,422 lbf/ft

EL65_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 12.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,422 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,422 lbf/ft

EL67_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 12.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,422 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,422 lbf/ft

EL69_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 12.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,422 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,422 lbf/ft

EL71_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 12.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1

Tensile Capacity: 5,422 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,422 lbf/ft

EL73_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 12.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,422 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,422 lbf/ft

EL75_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 23.2 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,422 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,422 lbf/ft

EL77_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 23.2 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,422 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,422 lbf/ft

EL79_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,385 lbf
Tensile Capacity Reduc□on Factor: 1

F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,385 lbf/ft

EL81_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,385 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,385 lbf/ft

EL89_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,385 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,385 lbf/ft

EL87_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,385 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,385 lbf/ft

EL85_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,385 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed

Face Anchorage: Yes
Factored Tensile Capacity: 3,385 lbf/ft

EL83_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,385 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,385 lbf/ft

EL91_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,385 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,385 lbf/ft

EL93_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,385 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,385 lbf/ft

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (0.05, 60) ft
Left-Zone Right Coordinate: (118.7945, 93.39725) ft
Left-Zone Increment: 40
Right Type: Range
Right-Zone Left Coordinate: (160, 70.95212) ft
Right-Zone Right Coordinate: (170.17203, 50.660932) ft
Right-Zone Increment: 20
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 60) ft
Right Coordinate: (335, 48) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	0.25 ft	43.375 ft
Coordinate 2	56.5 ft	43.375 ft
Coordinate 3	97.75 ft	43.375 ft
Coordinate 4	123 ft	43.375 ft
Coordinate 5	159.75 ft	42.625 ft
Coordinate 6	192 ft	42.625 ft
Coordinate 7	210.75 ft	42.625 ft
Coordinate 8	298 ft	35 ft
Coordinate 9	335.25 ft	35 ft

Reinforcement Lines

Reinforcement Line 1

Reinforcement: EL49_W9.5xW4.0
Lock to Ground Surface: No
Outside Point: (160, 49) ft
Inside Point: (126, 49) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 2

Reinforcement: EL51_W9.5xW4.0
Lock to Ground Surface: No
Outside Point: (160, 51) ft
Inside Point: (126, 51) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 3

Reinforcement: EL53_W9.5xW4.0
Lock to Ground Surface: No
Outside Point: (160, 53) ft
Inside Point: (126, 53) ft
Length: 34 ft
Orienta□on: 180 °
Slip Surface Intersec□on: (154.28167, 53) ft
Max. Pullout Force: 7,441 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 4

Reinforcement: EL55_W9.5xW4.0
Lock to Ground Surface: No
Outside Point: (160, 55) ft
Inside Point: (126, 55) ft
Length: 34 ft
Orienta□on: 180 °
Slip Surface Intersec□on: (148.74999, 55) ft
Max. Pullout Force: 7,441 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 5

Reinforcement: EL57_W9.5xW4.0
Lock to Ground Surface: No
Outside Point: (160, 57) ft
Inside Point: (126, 57) ft
Length: 34 ft
Orienta□on: 180 °
Slip Surface Intersec□on: (143.98197, 57) ft
Max. Pullout Force: 7,441 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 6

Reinforcement: EL59_W9.5xW4.0
Lock to Ground Surface: No
Outside Point: (160, 59) ft
Inside Point: (126, 59) ft
Length: 34 ft
Orienta□on: 180 °
Slip Surface Intersec□on: (139.7317, 59) ft
Max. Pullout Force: 7,441 lbf

Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 7

Reinforcement: EL61_W9.5xW4.0
Lock to Ground Surface: No
Outside Point: (160, 61) ft
Inside Point: (126, 61) ft
Length: 34 ft
Orienta□on: 180 °
Slip Surface Intersec□on: (135.89683, 61) ft
Max. Pullout Force: 7,441 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 8

Reinforcement: EL63_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 63) ft
Inside Point: (126, 63) ft
Length: 34 ft
Orienta□on: 180 °
Slip Surface Intersec□on: (132.38838, 63) ft
Max. Pullout Force: 5,422 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 9

Reinforcement: EL65_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 65) ft
Inside Point: (126, 65) ft
Length: 34 ft
Orienta□on: 180 °
Slip Surface Intersec□on: (129.15583, 65) ft
Max. Pullout Force: 5,422 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 10

Reinforcement: EL67_W7.0xW3.5
Lock to Ground Surface: No

Outside Point: (160, 67) ft
Inside Point: (126, 67) ft
Length: 34 ft
Orientation: 180 °
Slip Surface Intersection: (126.13901, 67) ft
Max. Pullout Force: 5,422 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 11

Reinforcement: EL69_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 69) ft
Inside Point: (126, 69) ft
Length: 34 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 12

Reinforcement: EL71_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 71) ft
Inside Point: (126, 71) ft
Length: 34 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 13

Reinforcement: EL73_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 73) ft
Inside Point: (126, 73) ft
Length: 34 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 14

Reinforcement: EL75_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 75) ft
Inside Point: (126, 75) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 15

Reinforcement: EL77_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 77) ft
Inside Point: (126, 77) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 16

Reinforcement: EL79_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 79) ft
Inside Point: (126, 79) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 17

Reinforcement: EL81_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 81) ft
Inside Point: (126, 81) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft

Governing Component: (none)

Reinforcement Line 18

Reinforcement: EL83_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 83) ft
Inside Point: (126, 83) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 19

Reinforcement: EL85_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 85) ft
Inside Point: (126, 85) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 20

Reinforcement: EL89_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 89) ft
Inside Point: (126, 89) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 21

Reinforcement: EL87_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 87) ft
Inside Point: (126, 87) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft

Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 22

Reinforcement: EL91_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 91) ft
Inside Point: (126, 91) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 23

Reinforcement: EL85_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 85) ft
Inside Point: (126, 85) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 24

Reinforcement: EL93_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 93) ft
Inside Point: (126, 93) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 250 pcf
Direc□on: Ver□cal

Coordinates

	X	Y
	120 ft	95 ft
	126 ft	95 ft

Surcharge Load 2

Surcharge (Unit Weight): 250 pcf
Direc□on: Ver□cal

Coordinates

	X	Y
	126 ft	95.75 ft
	160 ft	95.75 ft

Geometry

Name: Ga-Ga'

Se ngs

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	0 ft	56 ft
Point 2	76 ft	56 ft
Point 3	118 ft	35 ft
Point 4	160 ft	35 ft
Point 5	0 ft	46 ft
Point 6	37 ft	46 ft
Point 7	190 ft	50 ft
Point 8	160 ft	51 ft
Point 9	170.25 ft	34 ft
Point 10	240 ft	34 ft
Point 11	315 ft	30 ft
Point 12	335 ft	30 ft
Point 13	335 ft	48 ft
Point 14	327 ft	48 ft
Point 15	315 ft	49 ft
Point 16	224 ft	48 ft
Point 17	0 ft	0 ft
Point 18	335 ft	0 ft
Point 19	160 ft	94 ft
Point 20	120 ft	94 ft
Point 21	120 ft	72 ft
Point 22	76 ft	72 ft
Point 23	52 ft	60 ft
Point 24	0 ft	60 ft
Point 25	160 ft	47 ft

Point 26	120 ft	47 ft
Point 27	65 ft	66.5 ft
Point 28	160 ft	66.5 ft
Point 29	120 ft	66.5 ft
Point 30	120 ft	49 ft
Point 31	160 ft	49 ft
Point 32	160 ft	72 ft
Point 33	160 ft	70.5 ft
Point 34	120 ft	70.5 ft
Point 35	156 ft	70.5 ft
Point 36	156 ft	66.5 ft

Regions

	Material	Points	Area
Region 1	ESU 2C - Na□ve Silt	5,6,2,1	565 ft²
Region 2	ESU 1A - Exis□ng Granular Fill	19,20,21,32	880 ft²
Region 3	ESU 1A - Exis□ng Granular Fill	20,22,21	484 ft²
Region 4	ESU 2A - Na□ve Sand and Gravel	6,2,3	619.5 ft²
Region 5	ESU 2B - Na□ve Sand and Gravel	7,16,15,14,13,12,11,10,9,4	2,595.4 ft²
Region 6	ESU 7A - Weathered Sandstone	18,17,5,6,3,4,9,10,11,12	12,178 ft²
Region 7	ESU 1B - Exis□ng Gravelly Granular Fill	8,31,25,7	60 ft²
Region 8	ESU 2A - Na□ve Sand and Gravel	4,7,25,26,2,3	945 ft²
Region 9	ESU 1B - Exis□ng Gravelly Granular Fill	21,22,27,29,34	272.25 ft²
Region 10	ESU 1B - Exis□ng Gravelly Granular Fill	23,24,1,2,26,30,29,27	1,077.8 ft²
Region 11	ESU 1B - Exis□ng Gravelly Granular Fill	29,30,31,8,28,36	700 ft²
Region 12	ESU 1B - Exis□ng Gravelly Granular Fill	30,26,25,31	80 ft²
Region 13	ESU 1B - Exis□ng Gravelly Granular Fill	29,36,35,34	144 ft²
Region 14	ESU 1B - Exis□ng Gravelly Granular Fill	32,21,34,35,33	60 ft²
Region 15	ESU 1B - Exis□ng Gravelly Granular Fill	28,33,35,36	16 ft²

Slip Results

Slip Surfaces Analysed: 1667 of 4305 converged

Current Slip Surface

Slip Surface: 3,747
Factor of Safety: 3.310
Volume: 1,551.403 ft³
Weight: 188,627.67 lbf
Resis□ng Moment: 18,205,113 lbf·ft
Ac□va□ng Moment: 5,500,234.8 lbf·ft
Resis□ng Force: 143,890.03 lbf
Ac□va□ng Force: 43,475.061 lbf
Slip Rank: 1 of 4,305 slip surfaces
Exit: (160, 51.267383) ft
Entry: (104.637, 86.3185) ft
Radius: 111.93289 ft
Center: (189.57135, 159.22343) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Fric□onal Strength	Cohesive Strength	Suc□on Strength	Base Material
Slice 1	105.56101 ft	85.268849 ft	-2,614.1762 psf	136.90989 psf	114.88104 psf	0 psf	0 psf	ESU 1A - Exis□ng Granular Fill
Slice 2	107.40904 ft	83.220306 ft	-2,486.3471 psf	396.93497 psf	333.06799 psf	0 psf	0 psf	ESU 1A - Exis□ng Granular Fill
Slice 3	109.25706 ft	81.269425 ft	-2,364.6121 psf	637.14688 psf	534.62971 psf	0 psf	0 psf	ESU 1A - Exis□ng Granular Fill
Slice 4	111.10508 ft	79.409032 ft	-2,248.5236 psf	862.61385 psf	723.81896 psf	0 psf	0 psf	ESU 1A - Exis□ng Granular Fill
Slice 5	112.9531 ft	77.632927 ft	-2,137.6947 psf	1,077.7457 psf	904.33604 psf	0 psf	0 psf	ESU 1A - Exis□ng Granular Fill
Slice 6	114.80113 ft	75.93571 ft	-2,031.7883 psf	1,286.4099 psf	1,079.4261 psf	0 psf	0 psf	ESU 1A - Exis□ng Granular Fill
Slice 7	116.64915 ft	74.312643 ft	-1,930.5089 psf	1,492.0221 psf	1,251.9552 psf	0 psf	0 psf	ESU 1A - Exis□ng Granular Fill
Slice 8	118.49717 ft	72.759547 ft	-1,833.5957 psf	1,697.6158 psf	1,424.4688 psf	0 psf	0 psf	ESU 1A - Exis□ng Granular Fill
Slice 9	119.71059 ft	71.768814 ft	-1,771.774 psf	1,846.8418 psf	1,442.911 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 10	120.66411 ft	71.018814 ft	-1,724.974 psf	2,111.6111 psf	1,649.7714 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 11	122.16411 ft	69.869416 ft	-1,653.2515 psf	2,221.709 psf	1,735.7893 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 12	123.75 ft	68.693531 ft	-1,580.8314 psf	2,343.6463 psf	1,831.0572 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly

								Granular Fill
Slice 13	125.25 ft	67.621592 ft	-1,515.8527 psf	2,464.6537 psf	1,925.5985 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 14	126.43548 ft	66.797477 ft	-1,465.9375 psf	2,709.0925 psf	2,116.575 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 15	127.78125 ft	65.897313 ft	-1,411.4811 psf	2,826.0827 psf	2,207.9778 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 16	129.60181 ft	64.717002 ft	-1,340.1481 psf	3,046.2762 psf	2,380.0118 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 17	131.42238 ft	63.585913 ft	-1,271.8866 psf	3,228.1366 psf	2,522.0967 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 18	133.24294 ft	62.502318 ft	-1,206.5887 psf	3,477.3625 psf	2,716.8134 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 19	135.06351 ft	61.464638 ft	-1,144.1559 psf	3,761.2037 psf	2,938.5744 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 20	136.88407 ft	60.471423 ft	-1,084.4977 psf	3,963.1927 psf	3,096.3855 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 21	138.70464 ft	59.521345 ft	-1,027.5313 psf	4,167.5468 psf	3,256.0444 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 22	140.5252 ft	58.61318 ft	-973.18023 psf	4,471.2134 psf	3,493.2947 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 23	142.34577 ft	57.745803 ft	-921.37434 psf	4,664.1387 psf	3,644.0245 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly

								Granular Fill
Slice 24	144.16633 ft	56.918176 ft	-872.04883 psf	4,955.2058 psf	3,871.4311 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 25	145.98689 ft	56.12934 ft	-825.14395 psf	5,113.2812 psf	3,994.9331 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 26	147.80746 ft	55.378413 ft	-780.60451 psf	5,255.673 psf	4,106.1818 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 27	149.62802 ft	54.664576 ft	-738.37952 psf	5,487.0246 psf	4,286.9335 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 28	151.44859 ft	53.987075 ft	-698.42186 psf	5,555.0161 psf	4,340.0542 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 29	153.26915 ft	53.345211 ft	-660.688 psf	5,597.7587 psf	4,373.4484 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 30	155.08972 ft	52.73834 ft	-625.1377 psf	5,700.1112 psf	4,453.4149 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 31	156.9375 ft	52.157824 ft	-591.26655 psf	5,611.015 psf	4,383.8054 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 32	158.8125 ft	51.604123 ft	-559.10339 psf	5,504.0737 psf	4,300.2537 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 33	159.875 ft	51.301779 ft	-541.43099 psf	5,434.1465 psf	4,245.6205 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill

2.3 Pseudo-Static (Spencer) Section Fa-Fa' - Existing Condition - Global Stability

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File Informa on

File Version: 11.01
Created By: Mikayla S. Hatch
Last Edited By: Amy Nguyen
Revision Number: 377
Date: 11/10/2021
Time: 05:25:56 PM
Tool Version: 11.1
File Name: Wall 03.63L - Bridge 17.7 Fa-Fa' - All Condi ons.gsz
Directory: P:\0\0180366\01\Analysis\Bridge 17.7\SlopeW\
Last Solved Date: 11/10/2021
Last Solved Time: 05:32:46 PM

Project Se ngs

Unit System: U.S. Customary Units

Analysis Se ngs

2.3 Pseudo-Sta c (Spencer)

Kind: SLOPE/W
Parent: 2. Compound Stability
Analysis Type: Spencer
Se ngs
PWP Condi ons from: Piezometric Line
Apply Phrea c Correc on: No
Use Staged Rapid Drawdown: No
Unit Weight of Water: 62.4 pcf
Slip Surface
Direc on of movement: Le. to Right
Use Passive Mode: No
Slip Surface Op□on: Entry and Exit
Cri□cal slip surfaces saved: 1
Op□mize Cri□cal Slip Surface Loca□on: No
Tension Crack Op□on: (none)
Distribu□on
F of S Calcula□on Op□on: Constant
Advanced
Geometry Se□ ngs
Minimum Slip Surface Depth: 2 ft
Number of Slices: 30
Factor of Safety Convergence Se□ ngs
Maximum Number of Itera□ons: 100
Tolerable difference in F of S: 0.001
Solu□on Se□ ngs
Search Method: Root Finder

Tolerable difference between star□ng and converged F of S: 3
Maximum itera□ons to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

ESU 1A - Exis ng Granular Fill (Pseudo-Sta c)

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 50 psf
Effec□ve Fric□on Angle: 40 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2A - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 39 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2B - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 41 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 7A - Weathered Sandstone

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 42 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1B - Exis ng Gravelly Granular Fill

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2C - Na ve Silt (Pseudo-Sta c)

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effec□ve Cohesion: 200 psf
Effec□ve Fric□on Angle: 29 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Reinforcements

EQ_EL49_W9.5xW4.0

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.5 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 9,730 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 9,730 lbf/ft

EQ_EL51_W9.5xW4.0

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.5 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 9,730 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 9,730 lbf/ft

EQ_EL53_W9.5xW4.0

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.5 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 9,730 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 9,730 lbf/ft

EQ_EL55_W9.5xW4.0

Type: Geosynthe□c
Interface Adhesion: 0 psf

Interface Shear Angle: 18.5 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 9,730 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 9,730 lbf/ft

EQ_EL57_W9.5xW4.0

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.5 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 9,730 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 9,730 lbf/ft

EQ_EL59_W9.5xW4.0

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.5 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 9,730 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 9,730 lbf/ft

EQ_EL61_W9.5xW4.0

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.5 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 9,730 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 9,730 lbf/ft

EQ_EL63_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 16 °
Surface Area Factor: 2

Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,091 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,091 lbf/ft

EQ_EL65_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 16 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,091 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,091 lbf/ft

EQ_EL67_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 16 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,091 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,091 lbf/ft

EQ_EL69_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 16 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,091 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,091 lbf/ft

EQ_EL71_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 16 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,091 lbf

Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,091 lbf/ft

EQ_EL73_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 16 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,091 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,091 lbf/ft

EQ_EL75_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 29.8 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,091 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,091 lbf/ft

EQ_EL77_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 29.8 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,091 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,091 lbf/ft

EQ_EL79_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 24.3 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 4,426 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No

Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 4,426 lbf/ft

EQ_EL81_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 24.3 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 4,426 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 4,426 lbf/ft

EQ_EL83_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 24.3 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 4,426 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 4,426 lbf/ft

EQ_EL85_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 24.3 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 4,426 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 4,426 lbf/ft

EQ_EL87_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 24.3 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 4,426 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes

Factored Tensile Capacity: 4,426 lbf/ft

EQ_EL89_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 24.3 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 4,426 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 4,426 lbf/ft

EQ_EL91_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 24.3 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 4,426 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 4,426 lbf/ft

EQ_EL93_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 24.3 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 4,426 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 4,426 lbf/ft

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (0.05, 60) ft
Left-Zone Right Coordinate: (118.7945, 93.39725) ft
Left-Zone Increment: 40
Right Type: Range
Right-Zone Left Coordinate: (160, 70.95212) ft
Right-Zone Right Coordinate: (181, 50.3) ft
Right-Zone Increment: 20
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 60) ft
Right Coordinate: (335, 48) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	0.25 ft	43.375 ft
Coordinate 2	56.5 ft	43.375 ft
Coordinate 3	97.75 ft	43.375 ft
Coordinate 4	123 ft	43.375 ft
Coordinate 5	159.75 ft	42.625 ft
Coordinate 6	192 ft	42.625 ft
Coordinate 7	210.75 ft	42.625 ft
Coordinate 8	298 ft	35 ft
Coordinate 9	335.25 ft	35 ft

Seismic Coefficients

Horz Seismic Coef.: 0.18

Reinforcement Lines

Reinforcement Line 1

Reinforcement: EQ_EL49_W9.5xW4.0
Lock to Ground Surface: No
Outside Point: (160, 49) ft
Inside Point: (126, 49) ft
Length: 34 ft
Orienta□on: 180 °
Slip Surface Intersec□on: (127.18986, 49) ft
Max. Pullout Force: 9,730 lbf
Available Length: 1.1898595 ft
Required Length: 1.1898595 ft
Pullout Force: 4,434.162 lbf
Pullout Force per Length: 3,726.6266 lbf/ft
Governing Component: Pullout Resistance

Reinforcement Line 2

Reinforcement: EQ_EL51_W9.5xW4.0
Lock to Ground Surface: No
Outside Point: (160, 51) ft
Inside Point: (126, 51) ft
Length: 34 ft
Orienta□on: 180 °

Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 3

Reinforcement: EQ_EL53_W9.5xW4.0
Lock to Ground Surface: No
Outside Point: (160, 53) ft
Inside Point: (126, 53) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 4

Reinforcement: EQ_EL55_W9.5xW4.0
Lock to Ground Surface: No
Outside Point: (160, 55) ft
Inside Point: (126, 55) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 5

Reinforcement: EQ_EL57_W9.5xW4.0
Lock to Ground Surface: No
Outside Point: (160, 57) ft
Inside Point: (126, 57) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 6

Reinforcement: EQ_EL59_W9.5xW4.0
Lock to Ground Surface: No
Outside Point: (160, 59) ft
Inside Point: (126, 59) ft

Length: 34 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 7

Reinforcement: EQ_EL61_W9.5xW4.0
Lock to Ground Surface: No
Outside Point: (160, 61) ft
Inside Point: (126, 61) ft
Length: 34 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 8

Reinforcement: EQ_EL63_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 63) ft
Inside Point: (126, 63) ft
Length: 34 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 9

Reinforcement: EQ_EL65_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 65) ft
Inside Point: (126, 65) ft
Length: 34 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 10

Reinforcement: EQ_EL67_W7.0xW3.5
Lock to Ground Surface: No

Outside Point: (160, 67) ft
Inside Point: (126, 67) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 11

Reinforcement: EQ_EL69_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 69) ft
Inside Point: (126, 69) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 12

Reinforcement: EQ_EL71_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 71) ft
Inside Point: (126, 71) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 13

Reinforcement: EQ_EL73_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 73) ft
Inside Point: (126, 73) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 14

Reinforcement: EQ_EL75_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 75) ft
Inside Point: (126, 75) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 15

Reinforcement: EQ_EL77_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 77) ft
Inside Point: (126, 77) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 16

Reinforcement: EQ_EL79_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 79) ft
Inside Point: (126, 79) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 17

Reinforcement: EQ_EL81_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 81) ft
Inside Point: (126, 81) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 18

Reinforcement: EQ_EL83_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 83) ft
Inside Point: (126, 83) ft
Length: 34 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 19

Reinforcement: EQ_EL89_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 89) ft
Inside Point: (126, 89) ft
Length: 34 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 20

Reinforcement: EQ_EL87_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 87) ft
Inside Point: (126, 87) ft
Length: 34 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 21

Reinforcement: EQ_EL91_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 91) ft
Inside Point: (126, 91) ft
Length: 34 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft

Governing Component: (none)

Reinforcement Line 22

Reinforcement: EQ_EL85_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 85) ft
Inside Point: (126, 85) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 23

Reinforcement: EQ_EL93_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 93) ft
Inside Point: (126, 93) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 125 pcf
Direc□on: Ver□cal

Coordinates

	X	Y
	120 ft	95 ft
	160 ft	95 ft

Geometry

Name: Ga-Ga'

Se ngs

View: 2D
Element Thickness: 1 ft

Points

	X	Y

Figure D.5-250

Point 1	0 ft	56 ft
Point 2	76 ft	56 ft
Point 3	118 ft	35 ft
Point 4	160 ft	35 ft
Point 5	0 ft	46 ft
Point 6	37 ft	46 ft
Point 7	190 ft	50 ft
Point 8	160 ft	51 ft
Point 9	170.25 ft	34 ft
Point 10	240 ft	34 ft
Point 11	315 ft	30 ft
Point 12	335 ft	30 ft
Point 13	335 ft	48 ft
Point 14	327 ft	48 ft
Point 15	315 ft	49 ft
Point 16	224 ft	48 ft
Point 17	0 ft	0 ft
Point 18	335 ft	0 ft
Point 19	160 ft	94 ft
Point 20	120 ft	94 ft
Point 21	120 ft	72 ft
Point 22	76 ft	72 ft
Point 23	52 ft	60 ft
Point 24	0 ft	60 ft
Point 25	160 ft	47 ft
Point 26	120 ft	47 ft
Point 27	65 ft	66.5 ft
Point 28	160 ft	66.5 ft
Point 29	120 ft	66.5 ft
Point 30	120 ft	49 ft
Point 31	160 ft	49 ft
Point 32	160 ft	72 ft
Point 33	160 ft	70.5 ft
Point 34	120 ft	70.5 ft
Point 35	156 ft	70.5 ft
Point 36	156 ft	66.5 ft

Regions

	Material	Points	Area
Region 1	ESU 2C - Na□ve Silt (Pseudo-Sta□c)	5,6,2,1	565 ft²
Region 2	ESU 1A - Exis□ng Granular Fill (Pseudo-Sta□c)	19,20,21,32	880 ft²
Region 3	ESU 1A - Exis□ng Granular Fill (Pseudo-Sta□c)	20,22,21	484 ft²
Region 4	ESU 2A - Na□ve Sand and Gravel	6,2,3	619.5 ft²
Region 5	ESU 2B - Na□ve Sand and Gravel	7,16,15,14,13,12,11,10,9,4	2,595.4 ft²
Region 6	ESU 7A - Weathered Sandstone	18,17,5,6,3,4,9,10,11,12	12,178 ft²
Region 7	ESU 1B - Exis□ng Gravelly Granular Fill	8,31,25,7	60 ft²
Region 8	ESU 2A - Na□ve Sand and Gravel	4,7,25,26,2,3	945 ft²
Region 9	ESU 1B - Exis□ng Gravelly Granular Fill	21,22,27,29,34	272.25 ft²
Region 10	ESU 1B - Exis□ng Gravelly Granular Fill	23,24,1,2,26,30,29,27	1,077.8 ft²

Region 11	ESU 1B - Exis□ng Gravelly Granular Fill	29,30,31,8,28,36	700 ft²
Region 12	ESU 1B - Exis□ng Gravelly Granular Fill	30,26,25,31	80 ft²
Region 13	ESU 1B - Exis□ng Gravelly Granular Fill	29,36,35,34	144 ft²
Region 14	ESU 1B - Exis□ng Gravelly Granular Fill	32,21,34,35,33	60 ft²
Region 15	ESU 1B - Exis□ng Gravelly Granular Fill	28,33,35,36	16 ft²

Slip Results

Slip Surfaces Analysed: 1880 of 4305 converged

Current Slip Surface

Slip Surface: 3,569
Factor of Safety: 2.149
Volume: 2,534.8698 ft³
Weight: 310,149.22 lbf
Resis□ng Moment: 14,289,291 lbf·ft
Ac□va□ng Moment: 6,650,487.1 lbf·ft
Resis□ng Force: 235,927.65 lbf
Ac□va□ng Force: 109,799.45 lbf
Slip Rank: 1 of 4,305 slip surfaces
Exit: (181, 50.3) ft
Entry: (98.974001, 83.487001) ft
Radius: 56.071909 ft
Center: (152.90687, 98.826643) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Fric□onal Strength	Cohesive Strength	Suc□on Strength	Base Material
Slice 1	100.14769 ft	80.168226 ft	-2,295.8973 psf	90.286862 psf	75.759673 psf	50 psf	0 psf	ESU 1A - Exis□ng Granular Fill (Pseudo-Sta□c)
Slice 2	102.49508 ft	74.424726 ft	-1,937.5029 psf	343.18886 psf	287.96965 psf	50 psf	0 psf	ESU 1A - Exis□ng Granular Fill (Pseudo-Sta□c)
Slice 3	105.38014 ft	69.25 ft	-1,614.6 psf	697.73581 psf	545.13096 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 4	108.38236 ft	64.810384 ft	-1,337.568 psf	1,087.552 psf	849.68871 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice	110.96406	61.663884	-1,141.2264	1,432.1168	1,118.8922	0 psf	0 psf	ESU 1B -

5	ft	ft	psf	psf	psf			Exis□ng Gravelly Granular Fill
Slice 6	113.54576 ft	58.93337 ft	-970.8423 psf	1,787.9966 psf	1,396.9361 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 7	116.12745 ft	56.537084 ft	-821.31402 psf	2,155.2562 psf	1,683.8707 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 8	118.70915 ft	54.420332 ft	-689.2287 psf	2,534.4961 psf	1,980.1654 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 9	121.5 ft	52.411265 ft	-563.86293 psf	2,990.2028 psf	2,336.2025 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 10	124.04746 ft	50.767295 ft	-462.61315 psf	3,303.5849 psf	2,581.0434 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 11	126.14239 ft	49.569149 ft	-390.51663 psf	3,653.5998 psf	2,854.505 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 12	128.26854 ft	48.472204 ft	-324.77485 psf	3,922.7433 psf	3,064.7829 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 13	130.4259 ft	47.472204 ft	-265.12218 psf	4,203.9943 psf	3,284.5203 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 14	132.84051 ft	46.487814 ft	-206.77117 psf	4,526.1341 psf	3,665.1911 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 15	135.51236 ft	45.539541 ft	-151.00146 psf	4,897.0528 psf	3,965.5552 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 16	138.18422 ft	44.739809 ft	-104.50071 psf	5,285.2467 psf	4,279.9084 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 17	140.85608 ft	44.082089 ft	-66.861526 psf	5,695.0724 psf	4,611.7787 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel

Slice 18	143.52793 ft	43.561297 ft	-37.76665 psf	6,132.0557 psf	4,965.6408 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 19	146.19979 ft	43.17358 ft	-16.975603 psf	6,603.3475 psf	5,347.2854 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 20	148.87165 ft	42.916161 ft	-4.315213 psf	7,118.402 psf	5,764.3683 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 21	151.76322 ft	42.787995 ft	0 psf	7,720.5817 psf	6,252.0038 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 22	154.65944 ft	42.79818 ft	-4.3237662 psf	8,451.6828 psf	6,844.0378 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 23	157.875 ft	43.006994 ft	-21.448666 psf	9,341.4842 psf	7,564.5848 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 24	159.875 ft	43.18953 ft	-35.226692 psf	11,761.264 psf	9,524.084 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 25	161.30641 ft	43.403175 ft	-48.558142 psf	1,526.5366 psf	1,236.165 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 26	163.91924 ft	43.862914 ft	-77.245848 psf	1,592.2131 psf	1,289.3487 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 27	166.53207 ft	44.452025 ft	-114.00634 psf	1,650.5656 psf	1,336.6017 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 28	169.14489 ft	45.174779 ft	-159.10621 psf	1,699.9043 psf	1,376.5553 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 29	171.75772 ft	46.036681 ft	-212.88892 psf	1,737.131 psf	1,406.701 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 30	174.37055 ft	47.044701 ft	-275.78932 psf	1,755.2675 psf	1,421.3876 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 31	176.98338 ft	48.207595 ft	-348.35392 psf	1,731.9257 psf	1,402.4858 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 32	179.64489 ft	49.564489 ft	-433.02414 psf	1,100.9296 psf	860.14045 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill

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File Informa on

File Version: 11.01
Created By: Mikayla S. Hatch
Last Edited By: Amy Nguyen
Revision Number: 377
Date: 11/10/2021
Time: 05:25:56 PM
Tool Version: 11.1
File Name: Wall 03.63L - Bridge 17.7 Fa-Fa' - All Condi ons.gsz
Directory: P:\0\0180366\01\Analysis\Bridge 17.7\SlopeW\
Last Solved Date: 11/10/2021
Last Solved Time: 05:30:50 PM

Project Se ngs

Unit System: U.S. Customary Units

Analysis Se ngs

2.4 Pseudo-Sta c (M&P)

Kind: SLOPE/W
Parent: 2. Compound Stability
Analysis Type: Morgenstern-Price
Se ngs
Side Func on
Interslice force func on op on: Half-Sine
PWP Condi ons from: Piezometric Line
Apply Phrea c Correc on: No
Use Staged Rapid Drawdown: No
Unit Weight of Water: 62.4 pcf
Slip Surface
Direc on of movement: Le. to Right
Use Passive Mode: No
Slip Surface Op on: Entry and Exit
Cri cal slip surfaces saved: 1
Op mize Cri cal Slip Surface Loca on: No
Tension Crack Op on: (none)
Distribu on
F of S Calcula on Op on: Constant
Advanced
Geometry Se ngs
Minimum Slip Surface Depth: 2 ft
Number of Slices: 30
Factor of Safety Convergence Se ngs
Maximum Number of Itera ons: 100
Tolerable difference in F of S: 0.001

Solu□on Se□ ngs
Search Method: Root Finder
Tolerable difference between star□ng and converged F of S: 3
Maximum itera□ons to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

ESU 1A - Exis ng Granular Fill (Pseudo-Sta c)

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 50 psf
Effec□ve Fric□on Angle: 40 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2A - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 39 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2B - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 41 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 7A - Weathered Sandstone

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 42 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1B - Exis ng Gravelly Granular Fill

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2C - Na ve Silt (Pseudo-Sta c)

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effec□ve Cohesion: 200 psf
Effec□ve Fric□on Angle: 29 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Reinforcements

EQ_EL49_W9.5xW4.0

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.5 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 9,730 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 9,730 lbf/ft

EQ_EL51_W9.5xW4.0

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.5 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 9,730 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 9,730 lbf/ft

EQ_EL53_W9.5xW4.0

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.5 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 9,730 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 9,730 lbf/ft

EQ_EL55_W9.5xW4.0

Type: Geosynthe□c

Interface Adhesion: 0 psf
Interface Shear Angle: 18.5 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 9,730 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 9,730 lbf/ft

EQ_EL57_W9.5xW4.0

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.5 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 9,730 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 9,730 lbf/ft

EQ_EL59_W9.5xW4.0

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.5 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 9,730 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 9,730 lbf/ft

EQ_EL61_W9.5xW4.0

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.5 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 9,730 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 9,730 lbf/ft

EQ_EL63_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 16 °

Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,091 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,091 lbf/ft

EQ_EL65_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 16 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,091 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,091 lbf/ft

EQ_EL67_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 16 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,091 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,091 lbf/ft

EQ_EL69_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 16 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,091 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,091 lbf/ft

EQ_EL71_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 16 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1

Tensile Capacity: 7,091 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,091 lbf/ft

EQ_EL73_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 16 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,091 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,091 lbf/ft

EQ_EL75_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 29.8 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,091 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,091 lbf/ft

EQ_EL77_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 29.8 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,091 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,091 lbf/ft

EQ_EL79_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 24.3 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 4,426 lbf
Tensile Capacity Reduc□on Factor: 1

F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 4,426 lbf/ft

EQ_EL81_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 24.3 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 4,426 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 4,426 lbf/ft

EQ_EL83_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 24.3 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 4,426 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 4,426 lbf/ft

EQ_EL85_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 24.3 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 4,426 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 4,426 lbf/ft

EQ_EL87_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 24.3 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 4,426 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed

Face Anchorage: Yes
Factored Tensile Capacity: 4,426 lbf/ft

EQ_EL89_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 24.3 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 4,426 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 4,426 lbf/ft

EQ_EL91_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 24.3 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 4,426 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 4,426 lbf/ft

EQ_EL93_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 24.3 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 4,426 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 4,426 lbf/ft

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (0.05, 60) ft
Left-Zone Right Coordinate: (118.7945, 93.39725) ft
Left-Zone Increment: 40
Right Type: Range
Right-Zone Left Coordinate: (160, 70.95212) ft
Right-Zone Right Coordinate: (181, 50.3) ft
Right-Zone Increment: 20
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 60) ft
Right Coordinate: (335, 48) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	0.25 ft	43.375 ft
Coordinate 2	56.5 ft	43.375 ft
Coordinate 3	97.75 ft	43.375 ft
Coordinate 4	123 ft	43.375 ft
Coordinate 5	159.75 ft	42.625 ft
Coordinate 6	192 ft	42.625 ft
Coordinate 7	210.75 ft	42.625 ft
Coordinate 8	298 ft	35 ft
Coordinate 9	335.25 ft	35 ft

Seismic Coefficients

Horz Seismic Coef.: 0.18

Reinforcement Lines

Reinforcement Line 1

Reinforcement: EQ_EL49_W9.5xW4.0
Lock to Ground Surface: No
Outside Point: (160, 49) ft
Inside Point: (126, 49) ft
Length: 34 ft
Orienta□on: 180 °
Slip Surface Intersec□on: (127.18986, 49) ft
Max. Pullout Force: 9,730 lbf
Available Length: 1.1898595 ft
Required Length: 1.1898595 ft
Pullout Force: 4,434.162 lbf
Pullout Force per Length: 3,726.6266 lbf/ft
Governing Component: Pullout Resistance

Reinforcement Line 2

Reinforcement: EQ_EL51_W9.5xW4.0
Lock to Ground Surface: No
Outside Point: (160, 51) ft
Inside Point: (126, 51) ft
Length: 34 ft
Orienta□on: 180 °

Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 3

Reinforcement: EQ_EL53_W9.5xW4.0
Lock to Ground Surface: No
Outside Point: (160, 53) ft
Inside Point: (126, 53) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 4

Reinforcement: EQ_EL55_W9.5xW4.0
Lock to Ground Surface: No
Outside Point: (160, 55) ft
Inside Point: (126, 55) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 5

Reinforcement: EQ_EL57_W9.5xW4.0
Lock to Ground Surface: No
Outside Point: (160, 57) ft
Inside Point: (126, 57) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 6

Reinforcement: EQ_EL59_W9.5xW4.0
Lock to Ground Surface: No
Outside Point: (160, 59) ft
Inside Point: (126, 59) ft

Length: 34 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 7

Reinforcement: EQ_EL61_W9.5xW4.0
Lock to Ground Surface: No
Outside Point: (160, 61) ft
Inside Point: (126, 61) ft
Length: 34 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 8

Reinforcement: EQ_EL63_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 63) ft
Inside Point: (126, 63) ft
Length: 34 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 9

Reinforcement: EQ_EL65_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 65) ft
Inside Point: (126, 65) ft
Length: 34 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 10

Reinforcement: EQ_EL67_W7.0xW3.5
Lock to Ground Surface: No

Outside Point: (160, 67) ft
Inside Point: (126, 67) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 11

Reinforcement: EQ_EL69_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 69) ft
Inside Point: (126, 69) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 12

Reinforcement: EQ_EL71_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 71) ft
Inside Point: (126, 71) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 13

Reinforcement: EQ_EL73_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 73) ft
Inside Point: (126, 73) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 14

Reinforcement: EQ_EL75_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 75) ft
Inside Point: (126, 75) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 15

Reinforcement: EQ_EL77_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 77) ft
Inside Point: (126, 77) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 16

Reinforcement: EQ_EL79_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 79) ft
Inside Point: (126, 79) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 17

Reinforcement: EQ_EL81_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 81) ft
Inside Point: (126, 81) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 18

Reinforcement: EQ_EL83_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 83) ft
Inside Point: (126, 83) ft
Length: 34 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 19

Reinforcement: EQ_EL89_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 89) ft
Inside Point: (126, 89) ft
Length: 34 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 20

Reinforcement: EQ_EL87_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 87) ft
Inside Point: (126, 87) ft
Length: 34 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 21

Reinforcement: EQ_EL91_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 91) ft
Inside Point: (126, 91) ft
Length: 34 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft

Governing Component: (none)

Reinforcement Line 22

Reinforcement: EQ_EL85_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 85) ft
Inside Point: (126, 85) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 23

Reinforcement: EQ_EL93_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 93) ft
Inside Point: (126, 93) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 125 pcf
Direc□on: Ver□cal

Coordinates

	X	Y
	120 ft	95 ft
	160 ft	95 ft

Geometry

Name: Ga-Ga'

Se ngs

View: 2D
Element Thickness: 1 ft

Points

	X	Y

Figure D.5-269

Point 1	0 ft	56 ft
Point 2	76 ft	56 ft
Point 3	118 ft	35 ft
Point 4	160 ft	35 ft
Point 5	0 ft	46 ft
Point 6	37 ft	46 ft
Point 7	190 ft	50 ft
Point 8	160 ft	51 ft
Point 9	170.25 ft	34 ft
Point 10	240 ft	34 ft
Point 11	315 ft	30 ft
Point 12	335 ft	30 ft
Point 13	335 ft	48 ft
Point 14	327 ft	48 ft
Point 15	315 ft	49 ft
Point 16	224 ft	48 ft
Point 17	0 ft	0 ft
Point 18	335 ft	0 ft
Point 19	160 ft	94 ft
Point 20	120 ft	94 ft
Point 21	120 ft	72 ft
Point 22	76 ft	72 ft
Point 23	52 ft	60 ft
Point 24	0 ft	60 ft
Point 25	160 ft	47 ft
Point 26	120 ft	47 ft
Point 27	65 ft	66.5 ft
Point 28	160 ft	66.5 ft
Point 29	120 ft	66.5 ft
Point 30	120 ft	49 ft
Point 31	160 ft	49 ft
Point 32	160 ft	72 ft
Point 33	160 ft	70.5 ft
Point 34	120 ft	70.5 ft
Point 35	156 ft	70.5 ft
Point 36	156 ft	66.5 ft

Regions

	Material	Points	Area
Region 1	ESU 2C - Na□ve Silt (Pseudo-Sta□c)	5,6,2,1	565 ft²
Region 2	ESU 1A - Exis□ng Granular Fill (Pseudo-Sta□c)	19,20,21,32	880 ft²
Region 3	ESU 1A - Exis□ng Granular Fill (Pseudo-Sta□c)	20,22,21	484 ft²
Region 4	ESU 2A - Na□ve Sand and Gravel	6,2,3	619.5 ft²
Region 5	ESU 2B - Na□ve Sand and Gravel	7,16,15,14,13,12,11,10,9,4	2,595.4 ft²
Region 6	ESU 7A - Weathered Sandstone	18,17,5,6,3,4,9,10,11,12	12,178 ft²
Region 7	ESU 1B - Exis□ng Gravelly Granular Fill	8,31,25,7	60 ft²
Region 8	ESU 2A - Na□ve Sand and Gravel	4,7,25,26,2,3	945 ft²
Region 9	ESU 1B - Exis□ng Gravelly Granular Fill	21,22,27,29,34	272.25 ft²
Region 10	ESU 1B - Exis□ng Gravelly Granular Fill	23,24,1,2,26,30,29,27	1,077.8 ft²

Region 11	ESU 1B - Exis□ng Gravelly Granular Fill	29,30,31,8,28,36	700 ft²
Region 12	ESU 1B - Exis□ng Gravelly Granular Fill	30,26,25,31	80 ft²
Region 13	ESU 1B - Exis□ng Gravelly Granular Fill	29,36,35,34	144 ft²
Region 14	ESU 1B - Exis□ng Gravelly Granular Fill	32,21,34,35,33	60 ft²
Region 15	ESU 1B - Exis□ng Gravelly Granular Fill	28,33,35,36	16 ft²

Slip Results

Slip Surfaces Analysed: 2217 of 4305 converged

Current Slip Surface

Slip Surface: 3,569
Factor of Safety: 2.143
Volume: 2,534.8698 ft³
Weight: 310,149.22 lbf
Resis□ng Moment: 14,251,232 lbf·ft
Ac□va□ng Moment: 6,650,487.1 lbf·ft
Resis□ng Force: 236,063.05 lbf
Ac□va□ng Force: 110,160.71 lbf
Slip Rank: 1 of 4,305 slip surfaces
Exit: (181, 50.3) ft
Entry: (98.974001, 83.487001) ft
Radius: 56.071909 ft
Center: (152.90687, 98.826643) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Fric□onal Strength	Cohesive Strength	Suc□on Strength	Base Material
Slice 1	100.14769 ft	80.168226 ft	-2,295.8973 psf	169.67008 psf	142.3701 psf	50 psf	0 psf	ESU 1A - Exis□ng Granular Fill (Pseudo-Sta□c)
Slice 2	102.49508 ft	74.424726 ft	-1,937.5029 psf	548.44357 psf	460.1988 psf	50 psf	0 psf	ESU 1A - Exis□ng Granular Fill (Pseudo-Sta□c)
Slice 3	105.38014 ft	69.25 ft	-1,614.6 psf	923.42329 psf	721.45734 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 4	108.38236 ft	64.810384 ft	-1,337.568 psf	1,218.1745 psf	951.74223 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice	110.96406	61.663884	-1,141.2264	1,435.8055	1,121.7742	0 psf	0 psf	ESU 1B -

5	ft	ft	psf	psf	psf			Exis□ng Gravelly Granular Fill
Slice 6	113.54576 ft	58.93337 ft	-970.8423 psf	1,644.9144 psf	1,285.148 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 7	116.12745 ft	56.537084 ft	-821.31402 psf	1,859.2838 psf	1,452.6317 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 8	118.70915 ft	54.420332 ft	-689.2287 psf	2,090.7333 psf	1,633.4599 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 9	121.5 ft	52.411265 ft	-563.86293 psf	2,404.941 psf	1,878.9458 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 10	124.04746 ft	50.767295 ft	-462.61315 psf	2,617.0898 psf	2,044.6946 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 11	126.14239 ft	49.569149 ft	-390.51663 psf	2,927.523 psf	2,287.2316 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 12	128.26854 ft	48.472204 ft	-324.77485 psf	3,184.5012 psf	2,488.005 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 13	130.4259 ft	47.472204 ft	-265.12218 psf	3,490.7067 psf	2,727.239 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 14	132.84051 ft	46.487814 ft	-206.77117 psf	3,892.6966 psf	3,152.2435 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 15	135.51236 ft	45.539541 ft	-151.00146 psf	4,419.4194 psf	3,578.7753 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 16	138.18422 ft	44.739809 ft	-104.50071 psf	5,038.3921 psf	4,080.0094 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 17	140.85608 ft	44.082089 ft	-66.861526 psf	5,751.7772 psf	4,657.6973 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel

Slice 18	143.52793 ft	43.561297 ft	-37.76665 psf	6,552.5125 psf	5,306.12 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 19	146.19979 ft	43.17358 ft	-16.975603 psf	7,419.1125 psf	6,007.8789 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 20	148.87165 ft	42.916161 ft	-4.315213 psf	8,310.0863 psf	6,729.3752 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 21	151.76322 ft	42.787995 ft	0 psf	9,198.3633 psf	7,448.6877 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 22	154.65944 ft	42.79818 ft	-4.3237662 psf	9,984.0169 psf	8,084.8975 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 23	157.875 ft	43.006994 ft	-21.448666 psf	10,421.327 psf	8,439.0244 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 24	159.875 ft	43.18953 ft	-35.226692 psf	12,086.922 psf	9,787.7965 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 25	161.30641 ft	43.403175 ft	-48.558142 psf	2,163.069 psf	1,751.6188 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 26	163.91924 ft	43.862914 ft	-77.245848 psf	2,019.3328 psf	1,635.2235 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 27	166.53207 ft	44.452025 ft	-114.00634 psf	1,776.1327 psf	1,438.2839 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 28	169.14489 ft	45.174779 ft	-159.10621 psf	1,460.4186 psf	1,182.6236 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 29	171.75772 ft	46.036681 ft	-212.88892 psf	1,109.2056 psf	898.21698 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 30	174.37055 ft	47.044701 ft	-275.78932 psf	758.7191 psf	614.39862 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 31	176.98338 ft	48.207595 ft	-348.35392 psf	434.19016 psf	351.60026 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 32	179.64489 ft	49.564489 ft	-433.02414 psf	136.05452 psf	106.29744 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill

4.1 Static (Spencer) Section Fa-Fa' - Construction Condition - Compound Stability

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File Informa on

File Version: 11.01
Created By: Mikayla S. Hatch
Last Edited By: Amy Nguyen
Revision Number: 377
Date: 11/10/2021
Time: 05:25:56 PM
Tool Version: 11.1
File Name: Wall 03.63L - Bridge 17.7 Fa-Fa' - All Condi ons.gsz
Directory: P:\0\0180366\01\Analysis\Bridge 17.7\SlopeW\
Last Solved Date: 11/10/2021
Last Solved Time: 05:32:00 PM

Project Se ngs

Unit System: U.S. Customary Units

Analysis Se ngs

4.1 Sta c (Spencer)

Kind: SLOPE/W
Parent: 4. Compound Stability
Analysis Type: Spencer
Se ngs
PWP Condi ons from: Piezometric Line
Apply Phrea c Correc on: No
Use Staged Rapid Drawdown: No
Unit Weight of Water: 62.4 pcf
Slip Surface
Direc on of movement: Le. to Right
Use Passive Mode: No
Slip Surface Op on: Entry and Exit
Cri cal slip surfaces saved: 1
Op mize Cri cal Slip Surface Loca on: No
Tension Crack Op on: (none)
Distribu on
F of S Calcula on Op on: Constant
Advanced
Geometry Se ngs
Minimum Slip Surface Depth: 2 ft
Number of Slices: 30
Factor of Safety Convergence Se ngs
Maximum Number of Itera ons: 100
Tolerable difference in F of S: 0.001
Solu on Se ngs
Search Method: Root Finder

Tolerable difference between star□ng and converged F of S: 3
Maximum itera□ons to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

ESU 2A - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 39 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2B - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 41 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 7A - Weathered Sandstone

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 42 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2C - Na ve Silt

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 29 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1B - Exis ng Gravelly Granular Fill

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Reinforcements

Con_EL49_W9.5xW4.0

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 26.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,441 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,441 lbf/ft

Con_EL51_W9.5xW4.0

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 26.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,441 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,441 lbf/ft

Con_EL53_W9.5xW4.0

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 26.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,441 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,441 lbf/ft

Con_EL55_W9.5xW4.0

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 26.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,441 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,441 lbf/ft

Con_EL57_W9.5xW4.0

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 26.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,441 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,441 lbf/ft

Con_EL59_W9.5xW4.0

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 26.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,441 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,441 lbf/ft

Con_EL61_W9.5xW4.0

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 26.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,441 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,441 lbf/ft

Con_EL63_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 23.2 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,422 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,422 lbf/ft

Con_EL65_W7.0xW3.5

Type: Geosynthe□c

Interface Adhesion: 0 psf
Interface Shear Angle: 23.2 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,422 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,422 lbf/ft

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (0.05, 60) ft
Left-Zone Right Coordinate: (120, 66.5) ft
Left-Zone Increment: 40
Right Type: Range
Right-Zone Left Coordinate: (160, 55.75) ft
Right-Zone Right Coordinate: (164, 50.866667) ft
Right-Zone Increment: 20
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 60) ft
Right Coordinate: (335, 48) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	0.25 ft	43.375 ft
Coordinate 2	56.5 ft	43.375 ft
Coordinate 3	97.75 ft	43.375 ft
Coordinate 4	123 ft	43.375 ft
Coordinate 5	159.75 ft	42.625 ft
Coordinate 6	192 ft	42.625 ft
Coordinate 7	210.75 ft	42.625 ft
Coordinate 8	298 ft	35 ft
Coordinate 9	335.25 ft	35 ft

Reinforcement Lines

Reinforcement Line 1

Reinforcement: Con_EL49_W9.5xW4.0
Lock to Ground Surface: No

Outside Point: (160, 49) ft
Inside Point: (126, 49) ft
Length: 34 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 2

Reinforcement: Con_EL51_W9.5xW4.0
Lock to Ground Surface: No
Outside Point: (160, 51) ft
Inside Point: (126, 51) ft
Length: 34 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 3

Reinforcement: Con_EL53_W9.5xW4.0
Lock to Ground Surface: No
Outside Point: (160, 53) ft
Inside Point: (126, 53) ft
Length: 34 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 4

Reinforcement: Con_EL55_W9.5xW4.0
Lock to Ground Surface: No
Outside Point: (160, 55) ft
Inside Point: (126, 55) ft
Length: 34 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 5

Reinforcement: Con_EL57_W9.5xW4.0
Lock to Ground Surface: No
Outside Point: (160, 57) ft
Inside Point: (126, 57) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 6

Reinforcement: Con_EL59_W9.5xW4.0
Lock to Ground Surface: No
Outside Point: (160, 59) ft
Inside Point: (126, 59) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 7

Reinforcement: Con_EL61_W9.5xW4.0
Lock to Ground Surface: No
Outside Point: (160, 61) ft
Inside Point: (126, 61) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 8

Reinforcement: Con_EL63_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 63) ft
Inside Point: (126, 63) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 9

Reinforcement: Con_EL65_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 65) ft
Inside Point: (126, 65) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Geometry

Name: Ga-Ga'

Se ngs

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	0 ft	56 ft
Point 2	76 ft	56 ft
Point 3	118 ft	35 ft
Point 4	160 ft	35 ft
Point 5	0 ft	46 ft
Point 6	37 ft	46 ft
Point 7	190 ft	50 ft
Point 8	160 ft	51 ft
Point 9	170.25 ft	34 ft
Point 10	240 ft	34 ft
Point 11	315 ft	30 ft
Point 12	335 ft	30 ft
Point 13	335 ft	48 ft
Point 14	327 ft	48 ft
Point 15	315 ft	49 ft
Point 16	224 ft	48 ft
Point 17	0 ft	0 ft
Point 18	335 ft	0 ft
Point 19	160 ft	94 ft
Point 20	120 ft	94 ft
Point 21	120 ft	72 ft
Point 22	76 ft	72 ft
Point 23	52 ft	60 ft
Point 24	0 ft	60 ft
Point 25	160 ft	47 ft
Point 26	120 ft	47 ft

Point 27	65 ft	66.5 ft
Point 28	160 ft	66.5 ft
Point 29	120 ft	66.5 ft
Point 30	120 ft	49 ft
Point 31	160 ft	49 ft
Point 32	160 ft	72 ft
Point 33	160 ft	70.5 ft
Point 34	120 ft	70.5 ft
Point 35	156 ft	70.5 ft
Point 36	156 ft	66.5 ft

Regions

	Material	Points	Area
Region 1	ESU 2C - Na□ve Silt	5,6,2,1	565 ft²
Region 2		19,20,21,32	880 ft²
Region 3		20,22,21	484 ft²
Region 4	ESU 2A - Na□ve Sand and Gravel	6,2,3	619.5 ft²
Region 5	ESU 2B - Na□ve Sand and Gravel	7,16,15,14,13,12,11,10,9,4	2,595.4 ft²
Region 6	ESU 7A - Weathered Sandstone	18,17,5,6,3,4,9,10,11,12	12,178 ft²
Region 7	ESU 1B - Exis□ng Gravelly Granular Fill	8,31,25,7	60 ft²
Region 8	ESU 2A - Na□ve Sand and Gravel	4,7,25,26,2,3	945 ft²
Region 9		21,22,27,29,34	272.25 ft²
Region 10	ESU 1B - Exis□ng Gravelly Granular Fill	23,24,1,2,26,30,29,27	1,077.8 ft²
Region 11	ESU 1B - Exis□ng Gravelly Granular Fill	29,30,31,8,28,36	700 ft²
Region 12	ESU 1B - Exis□ng Gravelly Granular Fill	30,26,25,31	80 ft²
Region 13		29,36,35,34	144 ft²
Region 14		32,21,34,35,33	60 ft²
Region 15		28,33,35,36	16 ft²

Slip Results

Slip Surfaces Analysed: 1357 of 4305 converged

Current Slip Surface

Slip Surface: 3,337
Factor of Safety: 5.917
Volume: 883.36939 ft³
Weight: 110,421.17 lbf
Resis□ng Moment: 7,409,244.7 lbf·ft
Ac□va□ng Moment: 1,252,121 lbf·ft
Resis□ng Force: 84,792.108 lbf
Ac□va□ng Force: 14,329.971 lbf
Slip Rank: 1 of 4,305 slip surfaces
Exit: (162.25053, 50.924982) ft
Entry: (92.666001, 66.5) ft
Radius: 84.86366 ft
Center: (144.27933, 133.86398) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Fric□onal Strength	Cohesive Strength	Suc□on Strength	Base Material
Slice 1	93.937 ft	65.563187 ft	-1,384.5428 psf	97.609333 psf	76.260769 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 2	96.479 ft	63.759747 ft	-1,272.0082 psf	289.53207 psf	226.20724 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 3	98.8625 ft	62.188192 ft	-1,173.9432 psf	461.24421 psf	360.36347 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 4	101.0875 ft	60.825381 ft	-1,088.9038 psf	613.71914 psf	479.48994 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 5	103.3125 ft	59.554179 ft	-1,009.5807 psf	759.12856 psf	593.09624 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 6	105.5375 ft	58.36995 ft	-935.68488 psf	897.56868 psf	701.25751 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 7	107.7625 ft	57.268656 ft	-866.96411 psf	1,029.1271 psf	804.04219 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 8	109.9875 ft	56.246761 ft	-803.19788 psf	1,153.8817 psf	901.51121 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 9	112.2125 ft	55.301164 ft	-744.19262 psf	1,271.9004 psf	993.7175 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 10	114.4375 ft	54.429136 ft	-689.77811 psf	1,383.2402 psf	1,080.7057 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 11	116.6625 ft	53.628278 ft	-639.80452 psf	1,487.9474 psf	1,162.5119 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly

								Granular Fill
Slice 12	118.8875 ft	52.896474 ft	-594.13995 psf	1,586.0574 psf	1,239.1638 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 13	121.5 ft	52.129539 ft	-546.28323 psf	1,692.0685 psf	1,321.9888 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 14	124.17857 ft	51.424127 ft	-503.76639 psf	1,792.8684 psf	1,400.7423 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 15	126.53571 ft	50.884747 ft	-473.11086 psf	1,873.1105 psf	1,463.4343 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 16	128.89286 ft	50.415423 ft	-446.82677 psf	1,945.9715 psf	1,520.3596 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 17	131.25 ft	50.014976 ft	-424.84064 psf	2,011.4188 psf	1,571.4926 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 18	133.60714 ft	49.682423 ft	-407.09108 psf	2,069.4043 psf	1,616.7958 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 19	135.96429 ft	49.416961 ft	-393.52801 psf	2,119.8635 psf	1,656.2189 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 20	138.32143 ft	49.217959 ft	-384.112 psf	2,162.7152 psf	1,689.6983 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 21	140.67857 ft	49.084947 ft	-378.81382 psf	2,197.8597 psf	1,717.1562 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 22	143.03571 ft	49.017616 ft	-377.61411 psf	2,225.1783 psf	1,738.4998 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly

								Granular Fill
Slice 23	145.39286 ft	49.015809 ft	-380.50309 psf	2,244.5318 psf	1,753.6204 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 24	147.75 ft	49.079521 ft	-387.48049 psf	2,255.7581 psf	1,762.3914 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 25	150.10714 ft	49.208901 ft	-398.55557 psf	2,258.6709 psf	1,764.6671 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 26	152.46429 ft	49.404251 ft	-413.74716 psf	2,253.0567 psf	1,760.2808 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 27	154.82143 ft	49.666031 ft	-433.08393 psf	2,238.672 psf	1,749.0423 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 28	156.9375 ft	49.955023 ft	-453.81178 psf	2,218.4733 psf	1,733.2613 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 29	158.8125 ft	50.259418 ft	-475.19381 psf	2,193.9432 psf	1,714.0963 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 30	159.875 ft	50.445756 ft	-488.01514 psf	2,178.0756 psf	1,701.6992 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 31	161.12526 ft	50.697054 ft	-503.69616 psf	36.196381 psf	28.279712 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill

4.2 Static (M-P) Section Fa-Fa' - Construction Condition - Compound Stability

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File Informa on

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File Name: Wall 03.63L - Bridge 17.7 Fa-Fa' - All Condi ons.gsz
Directory: P:\0\0180366\01\Analysis\Bridge 17.7\SlopeW\
Last Solved Date: 11/10/2021
Last Solved Time: 05:32:56 PM

Project Se ngs

Unit System: U.S. Customary Units

Analysis Se ngs

4.2 Sta c (M-P)

Kind: SLOPE/W
Parent: 4. Compound Stability
Analysis Type: Morgenstern-Price
Se ngs
Side Func on
Interslice force func on op on: Half-Sine
PWP Condi ons from: Piezometric Line
Apply Phrea c Correc on: No
Use Staged Rapid Drawdown: No
Unit Weight of Water: 62.4 pcf
Slip Surface
Direc on of movement: Le. to Right
Use Passive Mode: No
Slip Surface Op on: Entry and Exit
Cri cal slip surfaces saved: 1
Op mize Cri cal Slip Surface Loca on: No
Tension Crack Op on: (none)
Distribu on
F of S Calcula on Op on: Constant
Advanced
Geometry Se ngs
Minimum Slip Surface Depth: 2 ft
Number of Slices: 30
Factor of Safety Convergence Se ngs
Maximum Number of Itera ons: 100
Tolerable difference in F of S: 0.001

Solu□on Se□ ngs
Search Method: Root Finder
Tolerable difference between star□ng and converged F of S: 3
Maximum itera□ons to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

ESU 2A - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 39 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2B - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 41 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 7A - Weathered Sandstone

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 42 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2C - Na ve Silt

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 29 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1B - Exis ng Gravelly Granular Fill

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Reinforcements

Con_EL49_W9.5xW4.0

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 26.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,441 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,441 lbf/ft

Con_EL51_W9.5xW4.0

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 26.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,441 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,441 lbf/ft

Con_EL53_W9.5xW4.0

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 26.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,441 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,441 lbf/ft

Con_EL55_W9.5xW4.0

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 26.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,441 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,441 lbf/ft

Con_EL57_W9.5xW4.0

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 26.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,441 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,441 lbf/ft

Con_EL59_W9.5xW4.0

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 26.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,441 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,441 lbf/ft

Con_EL61_W9.5xW4.0

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 26.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,441 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,441 lbf/ft

Con_EL63_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 23.2 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,422 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,422 lbf/ft

Con_EL65_W7.0xW3.5

Type: Geosynthe□c

Interface Adhesion: 0 psf
Interface Shear Angle: 23.2 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,422 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,422 lbf/ft

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (0.05, 60) ft
Left-Zone Right Coordinate: (120, 66.5) ft
Left-Zone Increment: 40
Right Type: Range
Right-Zone Left Coordinate: (160, 55.5) ft
Right-Zone Right Coordinate: (164.5, 50.85) ft
Right-Zone Increment: 20
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 60) ft
Right Coordinate: (335, 48) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	0.25 ft	43.375 ft
Coordinate 2	56.5 ft	43.375 ft
Coordinate 3	97.75 ft	43.375 ft
Coordinate 4	123 ft	43.375 ft
Coordinate 5	159.75 ft	42.625 ft
Coordinate 6	192 ft	42.625 ft
Coordinate 7	210.75 ft	42.625 ft
Coordinate 8	298 ft	35 ft
Coordinate 9	335.25 ft	35 ft

Reinforcement Lines

Reinforcement Line 1

Reinforcement: Con_EL49_W9.5xW4.0
Lock to Ground Surface: No

Outside Point: (160, 49) ft
Inside Point: (128, 49) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 2

Reinforcement: Con_EL51_W9.5xW4.0
Lock to Ground Surface: No
Outside Point: (160, 51) ft
Inside Point: (128, 51) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 3

Reinforcement: Con_EL53_W9.5xW4.0
Lock to Ground Surface: No
Outside Point: (160, 53) ft
Inside Point: (128, 53) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 4

Reinforcement: Con_EL55_W9.5xW4.0
Lock to Ground Surface: No
Outside Point: (160, 55) ft
Inside Point: (128, 55) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 5

Reinforcement: Con_EL57_W9.5xW4.0
Lock to Ground Surface: No
Outside Point: (160, 57) ft
Inside Point: (128, 57) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 6

Reinforcement: Con_EL59_W9.5xW4.0
Lock to Ground Surface: No
Outside Point: (160, 59) ft
Inside Point: (128, 59) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 7

Reinforcement: Con_EL61_W9.5xW4.0
Lock to Ground Surface: No
Outside Point: (160, 61) ft
Inside Point: (128, 61) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 8

Reinforcement: Con_EL63_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 63) ft
Inside Point: (128, 63) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 9

Reinforcement: Con_EL65_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 65) ft
Inside Point: (128, 65) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Geometry

Name: Ga-Ga'

Se ngs

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	0 ft	56 ft
Point 2	76 ft	56 ft
Point 3	118 ft	35 ft
Point 4	160 ft	35 ft
Point 5	0 ft	46 ft
Point 6	37 ft	46 ft
Point 7	190 ft	50 ft
Point 8	160 ft	51 ft
Point 9	170.25 ft	34 ft
Point 10	240 ft	34 ft
Point 11	315 ft	30 ft
Point 12	335 ft	30 ft
Point 13	335 ft	48 ft
Point 14	327 ft	48 ft
Point 15	315 ft	49 ft
Point 16	224 ft	48 ft
Point 17	0 ft	0 ft
Point 18	335 ft	0 ft
Point 19	160 ft	94 ft
Point 20	120 ft	94 ft
Point 21	120 ft	72 ft
Point 22	76 ft	72 ft
Point 23	52 ft	60 ft
Point 24	0 ft	60 ft
Point 25	160 ft	47 ft
Point 26	120 ft	47 ft

Point 27	65 ft	66.5 ft
Point 28	160 ft	66.5 ft
Point 29	120 ft	66.5 ft
Point 30	120 ft	49 ft
Point 31	160 ft	49 ft
Point 32	160 ft	72 ft
Point 33	160 ft	70.5 ft
Point 34	120 ft	70.5 ft
Point 35	156 ft	70.5 ft
Point 36	156 ft	66.5 ft

Regions

	Material	Points	Area
Region 1	ESU 2C - Na□ve Silt	5,6,2,1	565 ft²
Region 2		19,20,21,32	880 ft²
Region 3		20,22,21	484 ft²
Region 4	ESU 2A - Na□ve Sand and Gravel	6,2,3	619.5 ft²
Region 5	ESU 2B - Na□ve Sand and Gravel	7,16,15,14,13,12,11,10,9,4	2,595.4 ft²
Region 6	ESU 7A - Weathered Sandstone	18,17,5,6,3,4,9,10,11,12	12,178 ft²
Region 7	ESU 1B - Exis□ng Gravelly Granular Fill	8,31,25,7	60 ft²
Region 8	ESU 2A - Na□ve Sand and Gravel	4,7,25,26,2,3	945 ft²
Region 9		21,22,27,29,34	272.25 ft²
Region 10	ESU 1B - Exis□ng Gravelly Granular Fill	23,24,1,2,26,30,29,27	1,077.8 ft²
Region 11	ESU 1B - Exis□ng Gravelly Granular Fill	29,30,31,8,28,36	700 ft²
Region 12	ESU 1B - Exis□ng Gravelly Granular Fill	30,26,25,31	80 ft²
Region 13		29,36,35,34	144 ft²
Region 14		32,21,34,35,33	60 ft²
Region 15		28,33,35,36	16 ft²

Slip Results

Slip Surfaces Analysed: 1479 of 4305 converged

Current Slip Surface

Slip Surface: 3,332
Factor of Safety: 5.917
Volume: 883.36985 ft³
Weight: 110,421.23 lbf
Resis□ng Moment: 7,408,746.9 lbf·ft
Ac□va□ng Moment: 1,252,125.9 lbf·ft
Resis□ng Force: 84,791.991 lbf
Ac□va□ng Force: 14,330.856 lbf
Slip Rank: 1 of 4,305 slip surfaces
Exit: (162.25062, 50.924979) ft
Entry: (92.666001, 66.5) ft
Radius: 84.863753 ft
Center: (144.27937, 133.86406) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Fric□onal Strength	Cohesive Strength	Suc□on Strength	Base Material
Slice 1	93.937 ft	65.563187 ft	-1,384.5429 psf	105.31387 psf	82.280215 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 2	96.479 ft	63.759747 ft	-1,272.0082 psf	305.45649 psf	238.64877 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 3	98.8625 ft	62.188193 ft	-1,173.9433 psf	477.29962 psf	372.90733 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 4	101.0875 ft	60.825382 ft	-1,088.9038 psf	625.32056 psf	488.55397 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 5	103.3125 ft	59.554179 ft	-1,009.5808 psf	763.60958 psf	596.59719 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 6	105.5375 ft	58.369951 ft	-935.68493 psf	893.64576 psf	698.19259 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 7	107.7625 ft	57.268656 ft	-866.96415 psf	1,016.668 psf	794.30811 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 8	109.9875 ft	56.246761 ft	-803.1979 psf	1,133.691 psf	885.7365 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 9	112.2125 ft	55.301164 ft	-744.19261 psf	1,245.5171 psf	973.10462 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 10	114.4375 ft	54.429136 ft	-689.77808 psf	1,352.7453 psf	1,056.8805 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 11	116.6625 ft	53.628277 ft	-639.80446 psf	1,455.7782 psf	1,137.3786 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly

								Granular Fill
Slice 12	118.8875 ft	52.896472 ft	-594.13985 psf	1,554.8273 psf	1,214.7642 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 13	121.5 ft	52.129537 ft	-546.28309 psf	1,665.3448 psf	1,301.1099 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 14	124.17857 ft	51.424124 ft	-503.7662 psf	1,774.0464 psf	1,386.0369 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 15	126.53571 ft	50.884744 ft	-473.11062 psf	1,863.667 psf	1,456.0563 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 16	128.89286 ft	50.415418 ft	-446.82647 psf	1,947.4666 psf	1,521.5277 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 17	131.25 ft	50.014971 ft	-424.84028 psf	2,024.6206 psf	1,581.8069 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 18	133.60714 ft	49.682417 ft	-407.09066 psf	2,094.1619 psf	1,636.1386 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 19	135.96429 ft	49.416954 ft	-393.52753 psf	2,155.0203 psf	1,683.6864 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 20	138.32143 ft	49.21795 ft	-384.11145 psf	2,206.0699 psf	1,723.5707 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 21	140.67857 ft	49.084937 ft	-378.8132 psf	2,246.1838 psf	1,754.9112 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 22	143.03571 ft	49.017605 ft	-377.61341 psf	2,274.2948 psf	1,776.8739 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly

								Granular Fill
Slice 23	145.39286 ft	49.015796 ft	-380.5023 psf	2,289.4567 psf	1,788.7196 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 24	147.75 ft	49.079507 ft	-387.47962 psf	2,290.9044 psf	1,789.8506 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 25	150.10714 ft	49.208886 ft	-398.55461 psf	2,278.106 psf	1,779.8515 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 26	152.46429 ft	49.404235 ft	-413.7461 psf	2,250.8038 psf	1,758.5207 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 27	154.82143 ft	49.666012 ft	-433.08278 psf	2,209.0376 psf	1,725.8893 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 28	156.9375 ft	49.955003 ft	-453.81053 psf	2,159.9638 psf	1,687.5487 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 29	158.8125 ft	50.259397 ft	-475.19247 psf	2,106.9009 psf	1,646.0914 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 30	159.875 ft	50.445733 ft	-488.01375 psf	2,073.9394 psf	1,620.339 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 31	161.12531 ft	50.697041 ft	-503.69536 psf	34.345435 psf	26.833595 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill

6.1 Static (Spencer) Section Fa-Fa' - Final Condition - Compound Stability

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File Informa on

File Version: 11.01
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Directory: P:\0\0180366\01\Analysis\Bridge 17.7\SlopeW\
Last Solved Date: 11/12/2021
Last Solved Time: 03:58:12 PM

Project Se ngs

Unit System: U.S. Customary Units

Analysis Se ngs

6.1 Sta c (Spencer)

Kind: SLOPE/W
Parent: 6. Compound Stability
Analysis Type: Spencer
Se ngs
PWP Condi ons from: Piezometric Line
Apply Phrea c Correc on: No
Use Staged Rapid Drawdown: No
Unit Weight of Water: 62.4 pcf
Slip Surface
Direc on of movement: Le. to Right
Use Passive Mode: No
Slip Surface Op□on: Entry and Exit
Cri□cal slip surfaces saved: 1
Op□mize Cri□cal Slip Surface Loca□on: No
Tension Crack Op□on: (none)
Distribu□on
F of S Calcula□on Op□on: Constant
Advanced
Geometry Se□ ngs
Minimum Slip Surface Depth: 2 ft
Number of Slices: 30
Factor of Safety Convergence Se□ ngs
Maximum Number of Itera□ons: 100
Tolerable difference in F of S: 0.001
Solu□on Se□ ngs
Search Method: Root Finder

Tolerable difference between star□ng and converged F of S: 3
Maximum itera□ons to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Gravel Borrow

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2A - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 39 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2B - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 41 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 7A - Weathered Sandstone

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 42 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2C - Na ve Silt

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 29 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1B - Exis ng Gravelly Granular Fill

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Common Borrow

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

New Pier 1 Foo ng

Slope Stability Material Model: High Strength
Unit Weight: 2,250 pcf
Pore Water Pressure
Piezometric Line: 1

Reinforcements

EL71_W7.0xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 11.5 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 4,901 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 4,901 lbf/ft

EL73_W7.0xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 11.5 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 4,901 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 4,901 lbf/ft

EL75_W7.0xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 22.2 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 4,901 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 4,901 lbf/ft

EL77_W7.0xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 22.2 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 4,901 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 4,901 lbf/ft

EL79_W4.5xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 17.6 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 2,975 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 2,975 lbf/ft

EL81_W4.5xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 17.6 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 2,975 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 2,975 lbf/ft

EL83_W4.5xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf

Interface Shear Angle: 17.6 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 2,975 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 2,975 lbf/ft

EL85_W4.5xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 17.6 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 2,975 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 2,975 lbf/ft

EL87_W4.5xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 17.6 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 2,975 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 2,975 lbf/ft

EL89_W4.5xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 17.6 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 2,975 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 2,975 lbf/ft

EL91_W4.5xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 17.6 °
Surface Area Factor: 2

Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 2,975 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 2,975 lbf/ft

EL93_W4.5xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 17.6 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 2,975 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 2,975 lbf/ft

Soil Nail_Row 2

Type: Anchor
Pullout Resistance: 1,800 psf
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 82,550 lbf
Tensile Capacity Reduc□on Factor: 1
Shear Force: 0 lbf
Shear Force Reduc□on Factor: 1
Apply Shear: Parallel to Slip
F of S Dependent: No
Force Distribu□on: Distributed
Bond Length: 45 ft
Bond Diameter: 0.5 ft
Out-of-Plane Spacing: 4 ft
Face Anchorage: Yes
Factored Pullout Resistance: 706.86 lbf/ft/ft
Factored Tensile Capacity: 20,638 lbf/ft

Soil Nail_Row 1

Type: Anchor
Pullout Resistance: 1,800 psf
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 82,550 lbf
Tensile Capacity Reduc□on Factor: 1
Shear Force: 0 lbf
Shear Force Reduc□on Factor: 1
Apply Shear: Parallel to Slip
F of S Dependent: No
Force Distribu□on: Distributed
Bond Length: 45 ft
Bond Diameter: 0.5 ft
Out-of-Plane Spacing: 4 ft
Face Anchorage: Yes

Factored Pullout Resistance: 706.86 lbf/ft/ft
Factored Tensile Capacity: 20,638 lbf/ft

Soil Nail_Row 3

Type: Anchor
Pullout Resistance: 1,800 psf
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 82,550 lbf
Tensile Capacity Reduc□on Factor: 1
Shear Force: 0 lbf
Shear Force Reduc□on Factor: 1
Apply Shear: Parallel to Slip
F of S Dependent: No
Force Distribu□on: Distributed
Bond Length: 40 ft
Bond Diameter: 0.5 ft
Out-of-Plane Spacing: 4 ft
Face Anchorage: Yes
Factored Pullout Resistance: 706.86 lbf/ft/ft
Factored Tensile Capacity: 20,638 lbf/ft

Soil Nail_Row 4

Type: Anchor
Pullout Resistance: 1,800 psf
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 82,550 lbf
Tensile Capacity Reduc□on Factor: 1
Shear Force: 0 lbf
Shear Force Reduc□on Factor: 1
Apply Shear: Parallel to Slip
F of S Dependent: No
Force Distribu□on: Distributed
Bond Length: 40 ft
Bond Diameter: 0.5 ft
Out-of-Plane Spacing: 4 ft
Face Anchorage: Yes
Factored Pullout Resistance: 706.86 lbf/ft/ft
Factored Tensile Capacity: 20,638 lbf/ft

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (0.05, 60) ft
Left-Zone Right Coordinate: (127, 94) ft
Left-Zone Increment: 40
Right Type: Range
Right-Zone Left Coordinate: (160, 91.7) ft
Right-Zone Right Coordinate: (160, 66.75) ft
Right-Zone Increment: 20
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 60) ft
Right Coordinate: (335, 48) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	0.25 ft	43.375 ft
Coordinate 2	56.5 ft	43.375 ft
Coordinate 3	97.75 ft	43.375 ft
Coordinate 4	123 ft	43.375 ft
Coordinate 5	159.75 ft	42.625 ft
Coordinate 6	192 ft	42.625 ft
Coordinate 7	210.75 ft	42.625 ft
Coordinate 8	298 ft	35 ft
Coordinate 9	335.25 ft	35 ft

Reinforcement Lines

Reinforcement Line 1

Reinforcement: EL71_W7.0xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 71) ft
Inside Point: (126, 71) ft
Length: 34 ft
Orienta□on: 180 °
Slip Surface Intersec□on: (155.3732, 71) ft
Max. Pullout Force: 4,901 lbf
Available Length: 29.373204 ft
Required Length: 3.4973535 ft
Pullout Force: 4,901 lbf
Pullout Force per Length: 1,401.3453 lbf/ft
Governing Component: Tensile Capacity

Reinforcement Line 2

Reinforcement: EL73_W7.0xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 73) ft
Inside Point: (126, 73) ft
Length: 34 ft
Orienta□on: 180 °
Slip Surface Intersec□on: (152.36036, 73) ft
Max. Pullout Force: 4,901 lbf
Available Length: 26.360362 ft
Required Length: 3.8361666 ft
Pullout Force: 4,901 lbf
Pullout Force per Length: 1,277.5775 lbf/ft

Governing Component: Tensile Capacity

Reinforcement Line 3

Reinforcement: EL75_W7.0xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 75) ft
Inside Point: (126, 75) ft
Length: 34 ft
Orienta□on: 180 °
Slip Surface Intersec□on: (149.40111, 75) ft
Max. Pullout Force: 4,901 lbf
Available Length: 23.401108 ft
Required Length: 2.0516131 ft
Pullout Force: 4,901 lbf
Pullout Force per Length: 2,388.852 lbf/ft
Governing Component: Tensile Capacity

Reinforcement Line 4

Reinforcement: EL77_W7.0xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 77) ft
Inside Point: (126, 77) ft
Length: 34 ft
Orienta□on: 180 °
Slip Surface Intersec□on: (146.49253, 77) ft
Max. Pullout Force: 4,901 lbf
Available Length: 20.492532 ft
Required Length: 2.3080428 ft
Pullout Force: 4,901 lbf
Pullout Force per Length: 2,123.4442 lbf/ft
Governing Component: Tensile Capacity

Reinforcement Line 5

Reinforcement: EL79_W4.5xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 79) ft
Inside Point: (126, 79) ft
Length: 34 ft
Orienta□on: 180 °
Slip Surface Intersec□on: (143.635, 79) ft
Max. Pullout Force: 2,975 lbf
Available Length: 17.634996 ft
Required Length: 1.9694823 ft
Pullout Force: 2,975 lbf
Pullout Force per Length: 1,510.5493 lbf/ft
Governing Component: Tensile Capacity

Reinforcement Line 6

Reinforcement: EL81_W4.5xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 81) ft
Inside Point: (126, 81) ft
Length: 34 ft
Orienta□on: 180 °

Slip Surface Intersec□on: (140.82441, 81) ft
Max. Pullout Force: 2,975 lbf
Available Length: 14.824413 ft
Required Length: 2.1739766 ft
Pullout Force: 2,975 lbf
Pullout Force per Length: 1,368.46 lbf/ft
Governing Component: Tensile Capacity

Reinforcement Line 7

Reinforcement: EL83_W4.5xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 83) ft
Inside Point: (126, 83) ft
Length: 34 ft
Orienta□on: 180 °
Slip Surface Intersec□on: (138.05991, 83) ft
Max. Pullout Force: 2,975 lbf
Available Length: 12.059911 ft
Required Length: 2.5837385 ft
Pullout Force: 2,975 lbf
Pullout Force per Length: 1,151.4323 lbf/ft
Governing Component: Tensile Capacity

Reinforcement Line 8

Reinforcement: EL85_W4.5xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 85) ft
Inside Point: (126, 85) ft
Length: 34 ft
Orienta□on: 180 °
Slip Surface Intersec□on: (135.34166, 85) ft
Max. Pullout Force: 2,975 lbf
Available Length: 9.3416635 ft
Required Length: 2.9628355 ft
Pullout Force: 2,975 lbf
Pullout Force per Length: 1,004.1057 lbf/ft
Governing Component: Tensile Capacity

Reinforcement Line 9

Reinforcement: EL87_W4.5xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 87) ft
Inside Point: (126, 87) ft
Length: 34 ft
Orienta□on: 180 °
Slip Surface Intersec□on: (132.66642, 87) ft
Max. Pullout Force: 2,975 lbf
Available Length: 6.6664205 ft
Required Length: 3.4810469 ft
Pullout Force: 2,975 lbf
Pullout Force per Length: 854.62795 lbf/ft
Governing Component: Tensile Capacity

Reinforcement Line 10

Reinforcement: EL89_W4.5xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 89) ft
Inside Point: (126, 89) ft
Length: 34 ft
Orienta□on: 180 °
Slip Surface Intersec□on: (130.03306, 89) ft
Max. Pullout Force: 2,975 lbf
Available Length: 4.0330551 ft
Required Length: 4.0330551 ft
Pullout Force: 2,835.0974 lbf
Pullout Force per Length: 702.9652 lbf/ft
Governing Component: Pullout Resistance

Reinforcement Line 11

Reinforcement: EL91_W4.5xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 91) ft
Inside Point: (126, 91) ft
Length: 34 ft
Orienta□on: 180 °
Slip Surface Intersec□on: (127.44047, 91) ft
Max. Pullout Force: 2,975 lbf
Available Length: 1.4404742 ft
Required Length: 1.4404742 ft
Pullout Force: 790.93896 lbf
Pullout Force per Length: 549.08236 lbf/ft
Governing Component: Pullout Resistance

Reinforcement Line 12

Reinforcement: EL93_W4.5xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 93) ft
Inside Point: (126, 93) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 13

Reinforcement: Soil Nail_Row 1
Lock to Ground Surface: Yes
Outside Point: (160, 64.5) ft
Inside Point: (115.68365, 56.685832) ft
Length: 45.000001 ft
Orienta□on: -170 °
Max. Pullout Force: 0 lbf
Bond Length: 45 ft
Available Length: 0 ft
Required Length: 0 ft

Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 14

Reinforcement: Soil Nail_Row 2
Lock to Ground Surface: Yes
Outside Point: (160, 60.5) ft
Inside Point: (115.68365, 52.685832) ft
Length: 45.000001 ft
Orienta□on: -170 °
Max. Pullout Force: 0 lbf
Bond Length: 45 ft
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 15

Reinforcement: Soil Nail_Row 3
Lock to Ground Surface: Yes
Outside Point: (160, 56.5) ft
Inside Point: (120.60769, 49.554073) ft
Length: 40 ft
Orienta□on: -170 °
Max. Pullout Force: 0 lbf
Bond Length: 40 ft
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 16

Reinforcement: Soil Nail_Row 4
Lock to Ground Surface: Yes
Outside Point: (160, 52.5) ft
Inside Point: (120.60769, 45.554073) ft
Length: 40 ft
Orienta□on: -170 °
Max. Pullout Force: 0 lbf
Bond Length: 40 ft
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 250 pcf
Direc□on: Ver□cal

Coordinates

	X	Y
	120 ft	95 ft
	126 ft	95 ft

Surcharge Load 2

Surcharge (Unit Weight): 250 pcf
Direc□on: Ver□cal

Coordinates

	X	Y
	126 ft	95.75 ft
	160 ft	95.75 ft

Geometry

Name: Fa-Fa'

Se ngs

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	0 ft	56 ft
Point 2	76 ft	56 ft
Point 3	118 ft	35 ft
Point 4	160 ft	35 ft
Point 5	0 ft	46 ft
Point 6	37 ft	46 ft
Point 7	190 ft	50 ft
Point 8	160 ft	51 ft
Point 9	170.25 ft	34 ft
Point 10	240 ft	34 ft
Point 11	315 ft	30 ft
Point 12	335 ft	30 ft
Point 13	335 ft	48 ft
Point 14	327 ft	48 ft
Point 15	315 ft	49 ft
Point 16	224 ft	48 ft
Point 17	0 ft	0 ft
Point 18	335 ft	0 ft
Point 19	160 ft	94 ft
Point 20	120 ft	94 ft
Point 21	120 ft	72 ft
Point 22	76 ft	72 ft

Figure D.5-310

Point 23	52 ft	60 ft
Point 24	0 ft	60 ft
Point 25	160 ft	47 ft
Point 26	120 ft	47 ft
Point 27	65 ft	66.5 ft
Point 28	160 ft	66.5 ft
Point 29	120 ft	66.5 ft
Point 30	120 ft	49 ft
Point 31	160 ft	49 ft
Point 32	160 ft	72 ft
Point 33	160 ft	70.5 ft
Point 34	120 ft	70.5 ft
Point 35	156 ft	70.5 ft
Point 36	156 ft	66.5 ft
Point 37	126 ft	49 ft
Point 38	126 ft	94 ft
Point 39	126 ft	66.5 ft
Point 40	126 ft	70.5 ft
Point 41	126 ft	72 ft

Regions

	Material	Points	Area
Region 1	ESU 2C - Na□ve Silt	5,6,2,1	565 ft²
Region 2	Gravel Borrow	19,38,41,32	748 ft²
Region 3	Common Borrow	20,22,21	484 ft²
Region 4	ESU 2A - Na□ve Sand and Gravel	6,2,3	619.5 ft²
Region 5	ESU 2B - Na□ve Sand and Gravel	7,16,15,14,13,12,11,10,9,4	2,595.4 ft²
Region 6	ESU 7A - Weathered Sandstone	18,17,5,6,3,4,9,10,11,12	12,178 ft²
Region 7	ESU 1B - Exis□ng Gravelly Granular Fill	8,31,25,7	60 ft²
Region 8	ESU 2A - Na□ve Sand and Gravel	4,7,25,26,2,3	945 ft²
Region 9	Common Borrow	21,22,27,29,34	272.25 ft²
Region 10	ESU 1B - Exis□ng Gravelly Granular Fill	23,24,1,2,26,30,29,27	1,077.8 ft²
Region 11	ESU 1B - Exis□ng Gravelly Granular Fill	29,30,37,39	105 ft²
Region 12	ESU 1B - Exis□ng Gravelly Granular Fill	30,26,25,31,37	80 ft²
Region 13	New Pier 1 Foo□ng	29,39,40,34	24 ft²
Region 14	Gravel Borrow	32,41,40,35,33	51 ft²
Region 15	Gravel Borrow	28,33,35,36	16 ft²
Region 16	ESU 1B - Exis□ng Gravelly Granular Fill	31,8,28,36,39,37	595 ft²
Region 17	New Pier 1 Foo□ng	36,35,40,39	120 ft²
Region 18	Common Borrow	21,34,40,41	9 ft²
Region 19	Common Borrow	20,21,41,38	132 ft²

Slip Results

Slip Surfaces Analysed: 274 of 4305 converged

Current Slip Surface

Slip Surface: 4,191

Factor of Safety: 4.843
Volume: 490.03564 ft³
Weight: 63,682.326 lbf
Resis□ng Moment: 29,406,469 lbf·ft
Ac□va□ng Moment: 6,071,761.4 lbf·ft
Resis□ng Force: 55,473.71 lbf
Ac□va□ng Force: 11,455.11 lbf
Slip Rank: 1 of 4,305 slip surfaces
Exit: (160, 67.9975) ft
Entry: (123.62559, 94) ft
Radius: 434.91589 ft
Center: (394.40197, 434.34098) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Fric□onal Strength	Cohesive Strength	Suc□on Strength	Base Material
Slice 1	124.21919 ft	93.529414 ft	-3,131.1881 psf	308.57854 psf	192.82127 psf	0 psf	0 psf	Common Borrow
Slice 2	125.4064 ft	92.591597 ft	-3,074.1801 psf	421.80596 psf	263.57362 psf	0 psf	0 psf	Common Borrow
Slice 3	126.60563 ft	91.65109 ft	-3,017.0197 psf	725.36755 psf	566.71924 psf	0 psf	0 psf	Gravel Borrow
Slice 4	127.8169 ft	90.707973 ft	-2,959.7117 psf	841.32825 psf	657.31767 psf	0 psf	0 psf	Gravel Borrow
Slice 5	129.02817 ft	89.771697 ft	-2,902.8306 psf	960.16012 psf	750.1593 psf	0 psf	0 psf	Gravel Borrow
Slice 6	130.23944 ft	88.842204 ft	-2,846.3727 psf	1,063.6779 psf	831.03627 psf	0 psf	0 psf	Gravel Borrow
Slice 7	131.45071 ft	87.91944 ft	-2,790.3348 psf	1,180.7872 psf	922.53203 psf	0 psf	0 psf	Gravel Borrow
Slice 8	132.66197 ft	87.003351 ft	-2,734.7134 psf	1,280.6202 psf	1,000.5302 psf	0 psf	0 psf	Gravel Borrow
Slice 9	133.87324 ft	86.093886 ft	-2,679.5052 psf	1,396.0344 psf	1,090.7016 psf	0 psf	0 psf	Gravel Borrow
Slice 10	135.08451 ft	85.190991 ft	-2,624.7071 psf	1,492.6933 psf	1,166.2198 psf	0 psf	0 psf	Gravel Borrow
Slice 11	136.29578 ft	84.294617 ft	-2,570.3159 psf	1,606.439 psf	1,255.0877 psf	0 psf	0 psf	Gravel Borrow
Slice 12	137.50704 ft	83.404713 ft	-2,516.3284 psf	1,699.6513 psf	1,327.9131 psf	0 psf	0 psf	Gravel Borrow
Slice 13	138.71831 ft	82.521231 ft	-2,462.7416 psf	1,811.7543 psf	1,415.4976 psf	0 psf	0 psf	Gravel Borrow
Slice 14	139.92958 ft	81.644121 ft	-2,409.5525 psf	1,923.0452 psf	1,502.4476 psf	0 psf	0 psf	Gravel Borrow
Slice 15	141.14085 ft	80.773337 ft	-2,356.758 psf	2,010.3442 psf	1,570.6531 psf	0 psf	0 psf	Gravel Borrow
Slice 16	142.35212 ft	79.908831 ft	-2,304.3554 psf	2,120.0294 psf	1,656.3485 psf	0 psf	0 psf	Gravel Borrow
Slice 17	143.56338 ft	79.050559 ft	-2,252.3417 psf	2,202.6438 psf	1,720.894 psf	0 psf	0 psf	Gravel Borrow
Slice 18	144.77465 ft	78.198475 ft	-2,200.7142 psf	2,310.7467 psf	1,805.3532 psf	0 psf	0 psf	Gravel Borrow

Slice 19	145.98592 ft	77.352534 ft	-2,149.47 psf	2,368.1212 psf	1,850.1791 psf	0 psf	0 psf	Gravel Borrow
Slice 20	147.19719 ft	76.512693 ft	-2,098.6064 psf	2,474.665 psf	1,933.4202 psf	0 psf	0 psf	Gravel Borrow
Slice 21	148.40846 ft	75.67891 ft	-2,048.1209 psf	2,580.4372 psf	2,016.0585 psf	0 psf	0 psf	Gravel Borrow
Slice 22	149.61972 ft	74.851142 ft	-1,998.0107 psf	2,620.5167 psf	2,047.372 psf	0 psf	0 psf	Gravel Borrow
Slice 23	150.83099 ft	74.029347 ft	-1,948.2732 psf	2,724.7627 psf	2,128.8179 psf	0 psf	0 psf	Gravel Borrow
Slice 24	152.04226 ft	73.213485 ft	-1,898.9059 psf	2,747.0973 psf	2,146.2677 psf	0 psf	0 psf	Gravel Borrow
Slice 25	153.25353 ft	72.403516 ft	-1,849.9064 psf	2,849.8384 psf	2,226.5378 psf	0 psf	0 psf	Gravel Borrow
Slice 26	154.4279 ft	71.623722 ft	-1,802.7427 psf	2,928.1396 psf	2,287.7134 psf	0 psf	0 psf	Gravel Borrow
Slice 27	155.56538 ft	70.873722 ft	-1,757.3913 psf	2,885.0017 psf	2,254.0104 psf	0 psf	0 psf	Gravel Borrow
Slice 28	156.73676 ft	70.106769 ft	-1,711.0251 psf	3,009.0946 psf	2,350.9623 psf	0 psf	0 psf	Gravel Borrow
Slice 29	157.94206 ft	69.32314 ft	-1,663.6616 psf	3,108.4851 psf	2,428.6147 psf	0 psf	0 psf	Gravel Borrow
Slice 30	159.14735 ft	68.545162 ft	-1,616.6507 psf	3,207.1562 psf	2,505.7051 psf	0 psf	0 psf	Gravel Borrow
Slice 31	159.875 ft	68.07754 ft	-1,588.2385 psf	1,547.959 psf	1,209.3981 psf	0 psf	0 psf	Gravel Borrow

6.2 Static (M-P) Section Fa-Fa' - Final Condition - Compound Stability

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File Informa on

File Version: 11.01
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Last Edited By: Mikayla S. Hatch
Revision Number: 403
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Directory: P:\0\0180366\01\Analysis\Bridge 17.7\SlopeW\
Last Solved Date: 11/12/2021
Last Solved Time: 03:58:36 PM

Project Se ngs

Unit System: U.S. Customary Units

Analysis Se ngs

6.2 Sta c (M-P)

Kind: SLOPE/W
Parent: 6. Compound Stability
Analysis Type: Morgenstern-Price
Se ngs
Side Func on
Interslice force func on op on: Half-Sine
PWP Condi ons from: Piezometric Line
Apply Phrea c Correc on: No
Use Staged Rapid Drawdown: No
Unit Weight of Water: 62.4 pcf
Slip Surface
Direc on of movement: Le. to Right
Use Passive Mode: No
Slip Surface Op on: Entry and Exit
Cri cal slip surfaces saved: 1
Op mize Cri cal Slip Surface Loca on: No
Tension Crack Op on: (none)
Distribu on
F of S Calcula on Op on: Constant
Advanced
Geometry Se ngs
Minimum Slip Surface Depth: 2 ft
Number of Slices: 30
Factor of Safety Convergence Se ngs
Maximum Number of Itera ons: 100
Tolerable difference in F of S: 0.001

Solu□on Se□ ngs
Search Method: Root Finder
Tolerable difference between star□ng and converged F of S: 3
Maximum itera□ons to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Gravel Borrow

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2A - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 39 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2B - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 41 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 7A - Weathered Sandstone

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 42 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2C - Na ve Silt

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 29 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1B - Exis ng Gravelly Granular Fill

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effec ve Cohesion: 0 psf
Effec ve Fric on Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Common Borrow

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec ve Cohesion: 0 psf
Effec ve Fric on Angle: 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

New Pier 1 Foo ng

Slope Stability Material Model: High Strength
Unit Weight: 2,250 pcf
Pore Water Pressure
Piezometric Line: 1

Reinforcements

EL71_W7.0xW3.5 (45 yrs)

Type: Geosynthe c
Interface Adhesion: 0 psf
Interface Shear Angle: 11.5 °
Surface Area Factor: 2
Pullout Resistance Reduc on Factor: 1
Tensile Capacity: 4,901 lbf
Tensile Capacity Reduc on Factor: 1
F of S Dependent: No
Force Distribu on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 4,901 lbf/ft

EL73_W7.0xW3.5 (45 yrs)

Type: Geosynthe c
Interface Adhesion: 0 psf
Interface Shear Angle: 11.5 °
Surface Area Factor: 2
Pullout Resistance Reduc on Factor: 1
Tensile Capacity: 4,901 lbf
Tensile Capacity Reduc on Factor: 1
F of S Dependent: No
Force Distribu on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 4,901 lbf/ft

EL75_W7.0xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 22.2 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 4,901 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 4,901 lbf/ft

EL77_W7.0xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 22.2 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 4,901 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 4,901 lbf/ft

EL79_W4.5xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 17.6 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 2,975 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 2,975 lbf/ft

EL81_W4.5xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 17.6 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 2,975 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 2,975 lbf/ft

EL83_W4.5xW3.5 (45 yrs)

Type: Geosynthe□c

Interface Adhesion: 0 psf
Interface Shear Angle: 17.6 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 2,975 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 2,975 lbf/ft

EL85_W4.5xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 17.6 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 2,975 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 2,975 lbf/ft

EL87_W4.5xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 17.6 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 2,975 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 2,975 lbf/ft

EL89_W4.5xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 17.6 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 2,975 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 2,975 lbf/ft

EL91_W4.5xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 17.6 °

Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 2,975 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 2,975 lbf/ft

EL93_W4.5xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 17.6 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 2,975 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 2,975 lbf/ft

Soil Nail_Row 2

Type: Anchor
Pullout Resistance: 1,800 psf
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 82,550 lbf
Tensile Capacity Reduc□on Factor: 1
Shear Force: 0 lbf
Shear Force Reduc□on Factor: 1
Apply Shear: Parallel to Slip
F of S Dependent: No
Force Distribu□on: Distributed
Bond Length: 45 ft
Bond Diameter: 0.5 ft
Out-of-Plane Spacing: 4 ft
Face Anchorage: Yes
Factored Pullout Resistance: 706.86 lbf/ft/ft
Factored Tensile Capacity: 20,638 lbf/ft

Soil Nail_Row 1

Type: Anchor
Pullout Resistance: 1,800 psf
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 82,550 lbf
Tensile Capacity Reduc□on Factor: 1
Shear Force: 0 lbf
Shear Force Reduc□on Factor: 1
Apply Shear: Parallel to Slip
F of S Dependent: No
Force Distribu□on: Distributed
Bond Length: 45 ft
Bond Diameter: 0.5 ft
Out-of-Plane Spacing: 4 ft

Face Anchorage: Yes
Factored Pullout Resistance: 706.86 lbf/ft/ft
Factored Tensile Capacity: 20,638 lbf/ft

Soil Nail_Row 3

Type: Anchor
Pullout Resistance: 1,800 psf
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 82,550 lbf
Tensile Capacity Reduc□on Factor: 1
Shear Force: 0 lbf
Shear Force Reduc□on Factor: 1
Apply Shear: Parallel to Slip
F of S Dependent: No
Force Distribu□on: Distributed
Bond Length: 40 ft
Bond Diameter: 0.5 ft
Out-of-Plane Spacing: 4 ft
Face Anchorage: Yes
Factored Pullout Resistance: 706.86 lbf/ft/ft
Factored Tensile Capacity: 20,638 lbf/ft

Soil Nail_Row 4

Type: Anchor
Pullout Resistance: 1,800 psf
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 82,550 lbf
Tensile Capacity Reduc□on Factor: 1
Shear Force: 0 lbf
Shear Force Reduc□on Factor: 1
Apply Shear: Parallel to Slip
F of S Dependent: No
Force Distribu□on: Distributed
Bond Length: 40 ft
Bond Diameter: 0.5 ft
Out-of-Plane Spacing: 4 ft
Face Anchorage: Yes
Factored Pullout Resistance: 706.86 lbf/ft/ft
Factored Tensile Capacity: 20,638 lbf/ft

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (0.05, 60) ft
Left-Zone Right Coordinate: (127, 94) ft
Left-Zone Increment: 40
Right Type: Range
Right-Zone Left Coordinate: (160, 91.7) ft
Right-Zone Right Coordinate: (160, 66.75) ft
Right-Zone Increment: 20
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 60) ft
Right Coordinate: (335, 48) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	0.25 ft	43.375 ft
Coordinate 2	56.5 ft	43.375 ft
Coordinate 3	97.75 ft	43.375 ft
Coordinate 4	123 ft	43.375 ft
Coordinate 5	159.75 ft	42.625 ft
Coordinate 6	192 ft	42.625 ft
Coordinate 7	210.75 ft	42.625 ft
Coordinate 8	298 ft	35 ft
Coordinate 9	335.25 ft	35 ft

Reinforcement Lines

Reinforcement Line 1

Reinforcement: EL71_W7.0xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 71) ft
Inside Point: (126, 71) ft
Length: 34 ft
Orienta□on: 180 °
Slip Surface Intersec□on: (155.3732, 71) ft
Max. Pullout Force: 4,901 lbf
Available Length: 29.373204 ft
Required Length: 3.4973535 ft
Pullout Force: 4,901 lbf
Pullout Force per Length: 1,401.3453 lbf/ft
Governing Component: Tensile Capacity

Reinforcement Line 2

Reinforcement: EL73_W7.0xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 73) ft
Inside Point: (126, 73) ft
Length: 34 ft
Orienta□on: 180 °
Slip Surface Intersec□on: (152.36036, 73) ft
Max. Pullout Force: 4,901 lbf
Available Length: 26.360362 ft
Required Length: 3.8361666 ft
Pullout Force: 4,901 lbf

Pullout Force per Length: 1,277.5775 lbf/ft
Governing Component: Tensile Capacity

Reinforcement Line 3

Reinforcement: EL75_W7.0xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 75) ft
Inside Point: (126, 75) ft
Length: 34 ft
Orienta□on: 180 °
Slip Surface Intersec□on: (149.40111, 75) ft
Max. Pullout Force: 4,901 lbf
Available Length: 23.401108 ft
Required Length: 2.0516131 ft
Pullout Force: 4,901 lbf
Pullout Force per Length: 2,388.852 lbf/ft
Governing Component: Tensile Capacity

Reinforcement Line 4

Reinforcement: EL77_W7.0xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 77) ft
Inside Point: (126, 77) ft
Length: 34 ft
Orienta□on: 180 °
Slip Surface Intersec□on: (146.49253, 77) ft
Max. Pullout Force: 4,901 lbf
Available Length: 20.492532 ft
Required Length: 2.3080428 ft
Pullout Force: 4,901 lbf
Pullout Force per Length: 2,123.4442 lbf/ft
Governing Component: Tensile Capacity

Reinforcement Line 5

Reinforcement: EL79_W4.5xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 79) ft
Inside Point: (126, 79) ft
Length: 34 ft
Orienta□on: 180 °
Slip Surface Intersec□on: (143.635, 79) ft
Max. Pullout Force: 2,975 lbf
Available Length: 17.634996 ft
Required Length: 1.9694823 ft
Pullout Force: 2,975 lbf
Pullout Force per Length: 1,510.5493 lbf/ft
Governing Component: Tensile Capacity

Reinforcement Line 6

Reinforcement: EL81_W4.5xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 81) ft
Inside Point: (126, 81) ft
Length: 34 ft

Orientation: 180 °
Slip Surface Intersection: (140.82441, 81) ft
Max. Pullout Force: 2,975 lbf
Available Length: 14.824413 ft
Required Length: 2.1739766 ft
Pullout Force: 2,975 lbf
Pullout Force per Length: 1,368.46 lbf/ft
Governing Component: Tensile Capacity

Reinforcement Line 7

Reinforcement: EL83_W4.5xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 83) ft
Inside Point: (126, 83) ft
Length: 34 ft
Orientation: 180 °
Slip Surface Intersection: (138.05991, 83) ft
Max. Pullout Force: 2,975 lbf
Available Length: 12.059911 ft
Required Length: 2.5837385 ft
Pullout Force: 2,975 lbf
Pullout Force per Length: 1,151.4323 lbf/ft
Governing Component: Tensile Capacity

Reinforcement Line 8

Reinforcement: EL85_W4.5xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 85) ft
Inside Point: (126, 85) ft
Length: 34 ft
Orientation: 180 °
Slip Surface Intersection: (135.34166, 85) ft
Max. Pullout Force: 2,975 lbf
Available Length: 9.3416635 ft
Required Length: 2.9628355 ft
Pullout Force: 2,975 lbf
Pullout Force per Length: 1,004.1057 lbf/ft
Governing Component: Tensile Capacity

Reinforcement Line 9

Reinforcement: EL87_W4.5xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 87) ft
Inside Point: (126, 87) ft
Length: 34 ft
Orientation: 180 °
Slip Surface Intersection: (132.66642, 87) ft
Max. Pullout Force: 2,975 lbf
Available Length: 6.6664205 ft
Required Length: 3.4810469 ft
Pullout Force: 2,975 lbf
Pullout Force per Length: 854.62795 lbf/ft
Governing Component: Tensile Capacity

Reinforcement Line 10

Reinforcement: EL89_W4.5xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 89) ft
Inside Point: (126, 89) ft
Length: 34 ft
Orienta□on: 180 °
Slip Surface Intersec□on: (130.03306, 89) ft
Max. Pullout Force: 2,975 lbf
Available Length: 4.0330551 ft
Required Length: 4.0330551 ft
Pullout Force: 2,835.0974 lbf
Pullout Force per Length: 702.9652 lbf/ft
Governing Component: Pullout Resistance

Reinforcement Line 11

Reinforcement: EL91_W4.5xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 91) ft
Inside Point: (126, 91) ft
Length: 34 ft
Orienta□on: 180 °
Slip Surface Intersec□on: (127.44047, 91) ft
Max. Pullout Force: 2,975 lbf
Available Length: 1.4404742 ft
Required Length: 1.4404742 ft
Pullout Force: 790.93896 lbf
Pullout Force per Length: 549.08236 lbf/ft
Governing Component: Pullout Resistance

Reinforcement Line 12

Reinforcement: EL93_W4.5xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 93) ft
Inside Point: (126, 93) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 13

Reinforcement: Soil Nail_Row 1
Lock to Ground Surface: Yes
Outside Point: (160, 64.5) ft
Inside Point: (115.68365, 56.685832) ft
Length: 45.000001 ft
Orienta□on: -170 °
Max. Pullout Force: 0 lbf
Bond Length: 45 ft
Available Length: 0 ft

Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 14

Reinforcement: Soil Nail_Row 2
Lock to Ground Surface: Yes
Outside Point: (160, 60.5) ft
Inside Point: (115.68365, 52.685832) ft
Length: 45.000001 ft
Orienta□on: -170 °
Max. Pullout Force: 0 lbf
Bond Length: 45 ft
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 15

Reinforcement: Soil Nail_Row 3
Lock to Ground Surface: Yes
Outside Point: (160, 56.5) ft
Inside Point: (120.60769, 49.554073) ft
Length: 40 ft
Orienta□on: -170 °
Max. Pullout Force: 0 lbf
Bond Length: 40 ft
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 16

Reinforcement: Soil Nail_Row 4
Lock to Ground Surface: Yes
Outside Point: (160, 52.5) ft
Inside Point: (120.60769, 45.554073) ft
Length: 40 ft
Orienta□on: -170 °
Max. Pullout Force: 0 lbf
Bond Length: 40 ft
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 250 pcf
Direc□on: Ver□cal

Coordinates

	X	Y
	120 ft	95 ft
	126 ft	95 ft

Surcharge Load 2

Surcharge (Unit Weight): 250 pcf
Direc□on: Ver□cal

Coordinates

	X	Y
	126 ft	95.75 ft
	160 ft	95.75 ft

Geometry

Name: Fa-Fa'

Se ngs

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	0 ft	56 ft
Point 2	76 ft	56 ft
Point 3	118 ft	35 ft
Point 4	160 ft	35 ft
Point 5	0 ft	46 ft
Point 6	37 ft	46 ft
Point 7	190 ft	50 ft
Point 8	160 ft	51 ft
Point 9	170.25 ft	34 ft
Point 10	240 ft	34 ft
Point 11	315 ft	30 ft
Point 12	335 ft	30 ft
Point 13	335 ft	48 ft
Point 14	327 ft	48 ft
Point 15	315 ft	49 ft
Point 16	224 ft	48 ft
Point 17	0 ft	0 ft
Point 18	335 ft	0 ft
Point 19	160 ft	94 ft
Point 20	120 ft	94 ft
Point 21	120 ft	72 ft

Point 22	76 ft	72 ft
Point 23	52 ft	60 ft
Point 24	0 ft	60 ft
Point 25	160 ft	47 ft
Point 26	120 ft	47 ft
Point 27	65 ft	66.5 ft
Point 28	160 ft	66.5 ft
Point 29	120 ft	66.5 ft
Point 30	120 ft	49 ft
Point 31	160 ft	49 ft
Point 32	160 ft	72 ft
Point 33	160 ft	70.5 ft
Point 34	120 ft	70.5 ft
Point 35	156 ft	70.5 ft
Point 36	156 ft	66.5 ft
Point 37	126 ft	49 ft
Point 38	126 ft	94 ft
Point 39	126 ft	66.5 ft
Point 40	126 ft	70.5 ft
Point 41	126 ft	72 ft

Regions

	Material	Points	Area
Region 1	ESU 2C - Na□ve Silt	5,6,2,1	565 ft²
Region 2	Gravel Borrow	19,38,41,32	748 ft²
Region 3	Common Borrow	20,22,21	484 ft²
Region 4	ESU 2A - Na□ve Sand and Gravel	6,2,3	619.5 ft²
Region 5	ESU 2B - Na□ve Sand and Gravel	7,16,15,14,13,12,11,10,9,4	2,595.4 ft²
Region 6	ESU 7A - Weathered Sandstone	18,17,5,6,3,4,9,10,11,12	12,178 ft²
Region 7	ESU 1B - Exis□ng Gravelly Granular Fill	8,31,25,7	60 ft²
Region 8	ESU 2A - Na□ve Sand and Gravel	4,7,25,26,2,3	945 ft²
Region 9	Common Borrow	21,22,27,29,34	272.25 ft²
Region 10	ESU 1B - Exis□ng Gravelly Granular Fill	23,24,1,2,26,30,29,27	1,077.8 ft²
Region 11	ESU 1B - Exis□ng Gravelly Granular Fill	29,30,37,39	105 ft²
Region 12	ESU 1B - Exis□ng Gravelly Granular Fill	30,26,25,31,37	80 ft²
Region 13	New Pier 1 Foo□ng	29,39,40,34	24 ft²
Region 14	Gravel Borrow	32,41,40,35,33	51 ft²
Region 15	Gravel Borrow	28,33,35,36	16 ft²
Region 16	ESU 1B - Exis□ng Gravelly Granular Fill	31,8,28,36,39,37	595 ft²
Region 17	New Pier 1 Foo□ng	36,35,40,39	120 ft²
Region 18	Common Borrow	21,34,40,41	9 ft²
Region 19	Common Borrow	20,21,41,38	132 ft²

Slip Results

Slip Surfaces Analysed: 274 of 4305 converged

Current Slip Surface

Figure D.5-327

Slip Surface: 4,191
Factor of Safety: 4.844
Volume: 490.03564 ft³
Weight: 63,682.326 lbf
Resis□ng Moment: 29,412,116 lbf·ft
Ac□va□ng Moment: 6,071,761.4 lbf·ft
Resis□ng Force: 55,483.773 lbf
Ac□va□ng Force: 11,454.923 lbf
Slip Rank: 1 of 4,305 slip surfaces
Exit: (160, 67.9975) ft
Entry: (123.62559, 94) ft
Radius: 434.91589 ft
Center: (394.40197, 434.34098) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Fric□onal Strength	Cohesive Strength	Suc□on Strength	Base Material
Slice 1	124.21919 ft	93.529414 ft	-3,131.1881 psf	281.81561 psf	176.09794 psf	0 psf	0 psf	Common Borrow
Slice 2	125.4064 ft	92.591597 ft	-3,074.1801 psf	394.56185 psf	246.54961 psf	0 psf	0 psf	Common Borrow
Slice 3	126.60563 ft	91.65109 ft	-3,017.0197 psf	693.56656 psf	541.87358 psf	0 psf	0 psf	Gravel Borrow
Slice 4	127.8169 ft	90.707973 ft	-2,959.7117 psf	823.14318 psf	643.10994 psf	0 psf	0 psf	Gravel Borrow
Slice 5	129.02817 ft	89.771697 ft	-2,902.8306 psf	956.07681 psf	746.96907 psf	0 psf	0 psf	Gravel Borrow
Slice 6	130.23944 ft	88.842204 ft	-2,846.3727 psf	1,079.668 psf	843.52906 psf	0 psf	0 psf	Gravel Borrow
Slice 7	131.45071 ft	87.91944 ft	-2,790.3348 psf	1,211.4195 psf	946.46462 psf	0 psf	0 psf	Gravel Borrow
Slice 8	132.66197 ft	87.003351 ft	-2,734.7134 psf	1,326.8801 psf	1,036.6724 psf	0 psf	0 psf	Gravel Borrow
Slice 9	133.87324 ft	86.093886 ft	-2,679.5052 psf	1,453.7803 psf	1,135.8176 psf	0 psf	0 psf	Gravel Borrow
Slice 10	135.08451 ft	85.190991 ft	-2,624.7071 psf	1,557.8431 psf	1,217.1204 psf	0 psf	0 psf	Gravel Borrow
Slice 11	136.29578 ft	84.294617 ft	-2,570.3159 psf	1,676.7989 psf	1,310.0589 psf	0 psf	0 psf	Gravel Borrow
Slice 12	137.50704 ft	83.404713 ft	-2,516.3284 psf	1,766.7734 psf	1,380.3547 psf	0 psf	0 psf	Gravel Borrow
Slice 13	138.71831 ft	82.521231 ft	-2,462.7416 psf	1,875.7932 psf	1,465.5303 psf	0 psf	0 psf	Gravel Borrow
Slice 14	139.92958 ft	81.644121 ft	-2,409.5525 psf	1,980.234 psf	1,547.1284 psf	0 psf	0 psf	Gravel Borrow
Slice 15	141.14085 ft	80.773337 ft	-2,356.758 psf	2,047.8288 psf	1,599.9392 psf	0 psf	0 psf	Gravel Borrow
Slice 16	142.35212 ft	79.908831 ft	-2,304.3554 psf	2,141.5092 psf	1,673.1303 psf	0 psf	0 psf	Gravel Borrow
Slice 17	143.56338 ft	79.050559 ft	-2,252.3417 psf	2,195.2146 psf	1,715.0896 psf	0 psf	0 psf	Gravel Borrow
Slice	144.77465	78.198475	-2,200.7142	2,280.7006	1,781.8786	0 psf	0 psf	Gravel

18	ft	ft	psf	psf	psf			Borrow
Slice 19	145.98592 ft	77.352534 ft	-2,149.47 psf	2,300.4883 psf	1,797.3384 psf	0 psf	0 psf	Gravel Borrow
Slice 20	147.19719 ft	76.512693 ft	-2,098.6064 psf	2,384.7811 psf	1,863.1952 psf	0 psf	0 psf	Gravel Borrow
Slice 21	148.40846 ft	75.67891 ft	-2,048.1209 psf	2,467.1416 psf	1,927.5423 psf	0 psf	0 psf	Gravel Borrow
Slice 22	149.61972 ft	74.851142 ft	-1,998.0107 psf	2,483.4828 psf	1,940.3094 psf	0 psf	0 psf	Gravel Borrow
Slice 23	150.83099 ft	74.029347 ft	-1,948.2732 psf	2,575.6404 psf	2,012.3108 psf	0 psf	0 psf	Gravel Borrow
Slice 24	152.04226 ft	73.213485 ft	-1,898.9059 psf	2,605.2626 psf	2,035.4542 psf	0 psf	0 psf	Gravel Borrow
Slice 25	153.25353 ft	72.403516 ft	-1,849.9064 psf	2,716.6426 psf	2,122.4738 psf	0 psf	0 psf	Gravel Borrow
Slice 26	154.4279 ft	71.623722 ft	-1,802.7427 psf	2,814.5322 psf	2,198.9535 psf	0 psf	0 psf	Gravel Borrow
Slice 27	155.56538 ft	70.873722 ft	-1,757.3913 psf	2,867.9585 psf	2,240.6948 psf	0 psf	0 psf	Gravel Borrow
Slice 28	156.73676 ft	70.106769 ft	-1,711.0251 psf	3,024.3816 psf	2,362.9059 psf	0 psf	0 psf	Gravel Borrow
Slice 29	157.94206 ft	69.32314 ft	-1,663.6616 psf	3,170.1656 psf	2,476.8048 psf	0 psf	0 psf	Gravel Borrow
Slice 30	159.14735 ft	68.545162 ft	-1,616.6507 psf	3,314.4064 psf	2,589.4981 psf	0 psf	0 psf	Gravel Borrow
Slice 31	159.875 ft	68.07754 ft	-1,588.2385 psf	3,400.4989 psf	2,656.7609 psf	0 psf	0 psf	Gravel Borrow

6.3 Pseudo-Static (Spencer) Section Fa-Fa' - Final Condition - Compound Stability

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File Informa on

File Version: 11.01
Created By: Mikayla S. Hatch
Last Edited By: Mikayla S. Hatch
Revision Number: 403
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Tool Version: 11.1
File Name: Wall 03.63L - Bridge 17.7 Fa-Fa' - All Condi ons.gsz
Directory: P:\0\0180366\01\Analysis\Bridge 17.7\SlopeW\
Last Solved Date: 11/12/2021
Last Solved Time: 03:58:14 PM

Project Se ngs

Unit System: U.S. Customary Units

Analysis Se ngs

6.3 Pseudo-Sta c (Spencer)

Kind: SLOPE/W
Parent: 6. Compound Stability
Analysis Type: Spencer
Se ngs
PWP Condi ons from: Piezometric Line
Apply Phrea c Correc on: No
Use Staged Rapid Drawdown: No
Unit Weight of Water: 62.4 pcf
Slip Surface
Direc on of movement: Le. to Right
Use Passive Mode: No
Slip Surface Op□on: Entry and Exit
Cri□cal slip surfaces saved: 1
Op□mize Cri□cal Slip Surface Loca□on: No
Tension Crack Op□on: (none)
Distribu□on
F of S Calcula□on Op□on: Constant
Advanced
Geometry Se□ ngs
Minimum Slip Surface Depth: 2 ft
Number of Slices: 30
Factor of Safety Convergence Se□ ngs
Maximum Number of Itera□ons: 100
Tolerable difference in F of S: 0.001
Solu□on Se□ ngs
Search Method: Root Finder

Tolerable difference between star□ng and converged F of S: 3
Maximum itera□ons to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Gravel Borrow

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2A - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 39 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2B - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 41 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 7A - Weathered Sandstone

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 42 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1B - Exis ng Gravelly Granular Fill

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2C - Na ve Silt (Pseudo-Sta c)

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effec□ve Cohesion: 200 psf
Effec□ve Fric□on Angle: 29 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Common Borrow

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

New Pier 1 Foo ng

Slope Stability Material Model: High Strength
Unit Weight: 2,250 pcf
Pore Water Pressure
Piezometric Line: 1

Reinforcements

EQ_EL71_W7.0xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 15.2 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 6,409 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 6,409 lbf/ft

EQ_EL73_W7.0xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 15.2 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 6,409 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 6,409 lbf/ft

EQ_EL75_W7.0xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 28.5 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 6,409 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 6,409 lbf/ft

EQ_EL77_W7.0xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 28.5 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 6,409 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 6,409 lbf/ft

EQ_EL79_W4.5xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 23 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,891 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,891 lbf/ft

EQ_EL81_W4.5xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 23 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,891 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,891 lbf/ft

EQ_EL83_W4.5xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf

Interface Shear Angle: 23 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,891 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,891 lbf/ft

EQ_EL85_W4.5xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 23 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,891 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,891 lbf/ft

EQ_EL87_W4.5xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 23 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,891 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,891 lbf/ft

EQ_EL89_W4.5xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 23 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,891 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,891 lbf/ft

EQ_EL91_W4.5xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 23 °
Surface Area Factor: 2

Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,891 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,891 lbf/ft

Soil Nail_Row 2

Type: Anchor
Pullout Resistance: 1,800 psf
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 82,550 lbf
Tensile Capacity Reduc□on Factor: 1
Shear Force: 0 lbf
Shear Force Reduc□on Factor: 1
Apply Shear: Parallel to Slip
F of S Dependent: No
Force Distribu□on: Distributed
Bond Length: 45 ft
Bond Diameter: 0.5 ft
Out-of-Plane Spacing: 4 ft
Face Anchorage: Yes
Factored Pullout Resistance: 706.86 lbf/ft/ft
Factored Tensile Capacity: 20,638 lbf/ft

EQ_EL93_W4.5xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 23 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,891 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,891 lbf/ft

Soil Nail_Row 1

Type: Anchor
Pullout Resistance: 1,800 psf
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 82,550 lbf
Tensile Capacity Reduc□on Factor: 1
Shear Force: 0 lbf
Shear Force Reduc□on Factor: 1
Apply Shear: Parallel to Slip
F of S Dependent: No
Force Distribu□on: Distributed
Bond Length: 45 ft
Bond Diameter: 0.5 ft
Out-of-Plane Spacing: 4 ft
Face Anchorage: Yes

Factored Pullout Resistance: 706.86 lbf/ft/ft
Factored Tensile Capacity: 20,638 lbf/ft

Soil Nail_Row 3

Type: Anchor
Pullout Resistance: 1,800 psf
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 82,550 lbf
Tensile Capacity Reduc□on Factor: 1
Shear Force: 0 lbf
Shear Force Reduc□on Factor: 1
Apply Shear: Parallel to Slip
F of S Dependent: No
Force Distribu□on: Distributed
Bond Length: 40 ft
Bond Diameter: 0.5 ft
Out-of-Plane Spacing: 4 ft
Face Anchorage: Yes
Factored Pullout Resistance: 706.86 lbf/ft/ft
Factored Tensile Capacity: 20,638 lbf/ft

Soil Nail_Row 4

Type: Anchor
Pullout Resistance: 1,800 psf
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 82,550 lbf
Tensile Capacity Reduc□on Factor: 1
Shear Force: 0 lbf
Shear Force Reduc□on Factor: 1
Apply Shear: Parallel to Slip
F of S Dependent: No
Force Distribu□on: Distributed
Bond Length: 40 ft
Bond Diameter: 0.5 ft
Out-of-Plane Spacing: 4 ft
Face Anchorage: Yes
Factored Pullout Resistance: 706.86 lbf/ft/ft
Factored Tensile Capacity: 20,638 lbf/ft

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (0.05, 60) ft
Left-Zone Right Coordinate: (120, 94) ft
Left-Zone Increment: 40
Right Type: Range
Right-Zone Left Coordinate: (160, 93.5) ft
Right-Zone Right Coordinate: (160, 66.5) ft
Right-Zone Increment: 20
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 60) ft
Right Coordinate: (335, 48) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	0.25 ft	43.375 ft
Coordinate 2	56.5 ft	43.375 ft
Coordinate 3	97.75 ft	43.375 ft
Coordinate 4	123 ft	43.375 ft
Coordinate 5	159.75 ft	42.625 ft
Coordinate 6	192 ft	42.625 ft
Coordinate 7	210.75 ft	42.625 ft
Coordinate 8	298 ft	35 ft
Coordinate 9	335.25 ft	35 ft

Seismic Coefficients

Horz Seismic Coef.: 0.255

Reinforcement Lines

Reinforcement Line 1

Reinforcement: EQ_EL71_W7.0xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 71) ft
Inside Point: (126, 71) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 2

Reinforcement: EQ_EL73_W7.0xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 73) ft
Inside Point: (126, 73) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft

Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 3

Reinforcement: EQ_EL75_W7.0xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 75) ft
Inside Point: (126, 75) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 4

Reinforcement: EQ_EL77_W7.0xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 77) ft
Inside Point: (126, 77) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 5

Reinforcement: EQ_EL79_W4.5xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 79) ft
Inside Point: (126, 79) ft
Length: 34 ft
Orienta□on: 180 °
Slip Surface Intersec□on: (139.93758, 79) ft
Max. Pullout Force: 3,891 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 6

Reinforcement: EQ_EL81_W4.5xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 81) ft
Inside Point: (126, 81) ft
Length: 34 ft
Orienta□on: 180 °

Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 7

Reinforcement: EQ_EL83_W4.5xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 83) ft
Inside Point: (126, 83) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 8

Reinforcement: EQ_EL85_W4.5xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 85) ft
Inside Point: (126, 85) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 9

Reinforcement: EQ_EL87_W4.5xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 87) ft
Inside Point: (126, 87) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 10

Reinforcement: EQ_EL89_W4.5xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 89) ft
Inside Point: (126, 89) ft

Length: 34 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 11

Reinforcement: EQ_EL91_W4.5xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 91) ft
Inside Point: (126, 91) ft
Length: 34 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 12

Reinforcement: EQ_EL93_W4.5xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 93) ft
Inside Point: (126, 93) ft
Length: 34 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 13

Reinforcement: Soil Nail_Row 1
Lock to Ground Surface: Yes
Outside Point: (160, 64.5) ft
Inside Point: (115.68365, 56.685832) ft
Length: 45.000001 ft
Orientation: -170 °
Max. Pullout Force: 0 lbf
Bond Length: 45 ft
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 14

Reinforcement: Soil Nail_Row 2

Lock to Ground Surface: Yes
Outside Point: (160, 60.5) ft
Inside Point: (115.68365, 52.685832) ft
Length: 45.000001 ft
Orienta□on: -170 °
Max. Pullout Force: 0 lbf
Bond Length: 45 ft
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 15

Reinforcement: Soil Nail_Row 3
Lock to Ground Surface: Yes
Outside Point: (160, 56.5) ft
Inside Point: (120.60769, 49.554073) ft
Length: 40 ft
Orienta□on: -170 °
Max. Pullout Force: 0 lbf
Bond Length: 40 ft
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 16

Reinforcement: Soil Nail_Row 4
Lock to Ground Surface: Yes
Outside Point: (160, 52.5) ft
Inside Point: (120.60769, 45.554073) ft
Length: 40 ft
Orienta□on: -170 °
Max. Pullout Force: 0 lbf
Bond Length: 40 ft
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 125 pcf
Direc□on: Ver□cal

Coordinates

	X	Y
	120 ft	95 ft

	160 ft	95 ft

Geometry

Name: Fa-Fa'

Se ngs

View: 2D

Element Thickness: 1 ft

Points

	X	Y
Point 1	0 ft	56 ft
Point 2	76 ft	56 ft
Point 3	118 ft	35 ft
Point 4	160 ft	35 ft
Point 5	0 ft	46 ft
Point 6	37 ft	46 ft
Point 7	190 ft	50 ft
Point 8	160 ft	51 ft
Point 9	170.25 ft	34 ft
Point 10	240 ft	34 ft
Point 11	315 ft	30 ft
Point 12	335 ft	30 ft
Point 13	335 ft	48 ft
Point 14	327 ft	48 ft
Point 15	315 ft	49 ft
Point 16	224 ft	48 ft
Point 17	0 ft	0 ft
Point 18	335 ft	0 ft
Point 19	160 ft	94 ft
Point 20	120 ft	94 ft
Point 21	120 ft	72 ft
Point 22	76 ft	72 ft
Point 23	52 ft	60 ft
Point 24	0 ft	60 ft
Point 25	160 ft	47 ft
Point 26	120 ft	47 ft
Point 27	65 ft	66.5 ft
Point 28	160 ft	66.5 ft
Point 29	120 ft	66.5 ft
Point 30	120 ft	49 ft
Point 31	160 ft	49 ft
Point 32	160 ft	72 ft
Point 33	160 ft	70.5 ft
Point 34	120 ft	70.5 ft
Point 35	156 ft	70.5 ft
Point 36	156 ft	66.5 ft
Point 37	126 ft	49 ft

Figure D.5-342

Point 38	126 ft	94 ft
Point 39	126 ft	66.5 ft
Point 40	126 ft	70.5 ft
Point 41	126 ft	72 ft

Regions

	Material	Points	Area
Region 1	ESU 2C - Na□ve Silt (Pseudo-Sta□c)	5,6,2,1	565 ft²
Region 2	Gravel Borrow	19,38,41,32	748 ft²
Region 3	Common Borrow	20,22,21	484 ft²
Region 4	ESU 2A - Na□ve Sand and Gravel	6,2,3	619.5 ft²
Region 5	ESU 2B - Na□ve Sand and Gravel	7,16,15,14,13,12,11,10,9,4	2,595.4 ft²
Region 6	ESU 7A - Weathered Sandstone	18,17,5,6,3,4,9,10,11,12	12,178 ft²
Region 7	ESU 1B - Exis□ng Gravelly Granular Fill	8,31,25,7	60 ft²
Region 8	ESU 2A - Na□ve Sand and Gravel	4,7,25,26,2,3	945 ft²
Region 9	Common Borrow	21,22,27,29,34	272.25 ft²
Region 10	ESU 1B - Exis□ng Gravelly Granular Fill	23,24,1,2,26,30,29,27	1,077.8 ft²
Region 11	ESU 1B - Exis□ng Gravelly Granular Fill	29,30,37,39	105 ft²
Region 12	ESU 1B - Exis□ng Gravelly Granular Fill	30,26,25,31,37	80 ft²
Region 13	New Pier 1 Foo□ng	29,39,40,34	24 ft²
Region 14	Gravel Borrow	32,41,40,35,33	51 ft²
Region 15	Gravel Borrow	28,33,35,36	16 ft²
Region 16	ESU 1B - Exis□ng Gravelly Granular Fill	31,8,28,36,39,37	595 ft²
Region 17	New Pier 1 Foo□ng	36,35,40,39	120 ft²
Region 18	Common Borrow	21,34,40,41	9 ft²
Region 19	Common Borrow	20,21,41,38	132 ft²

Slip Results

Slip Surfaces Analysed: 367 of 4305 converged

Current Slip Surface

Slip Surface: 3,631
Factor of Safety: 2.318
Volume: 697.27375 ft³
Weight: 88,838.065 lbf
Resis□ng Moment: 22,816,442 lbf·ft
Ac□va□ng Moment: 9,844,000.6 lbf·ft
Resis□ng Force: 67,975.311 lbf
Ac□va□ng Force: 29,331.487 lbf
Slip Rank: 1 of 4,305 slip surfaces
Exit: (160, 77.3) ft
Entry: (102.83018, 85.415088) ft
Radius: 333.21743 ft
Center: (178.06877, 410.02718) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Fric□onal Strength	Cohesive Strength	Suc□on Strength	Base Material

Slice 1	103.78406 ft	85.196948 ft	-2,609.6895 psf	60.122344 psf	37.56861 psf	0 psf	0 psf	Common Borrow
Slice 2	105.69181 ft	84.76655 ft	-2,582.8327 psf	181.29766 psf	113.28735 psf	0 psf	0 psf	Common Borrow
Slice 3	107.59957 ft	84.347896 ft	-2,556.7087 psf	303.38668 psf	189.57704 psf	0 psf	0 psf	Common Borrow
Slice 4	109.50733 ft	83.940941 ft	-2,531.3147 psf	426.40457 psf	266.44715 psf	0 psf	0 psf	Common Borrow
Slice 5	111.41509 ft	83.545641 ft	-2,506.648 psf	550.36721 psf	343.9076 psf	0 psf	0 psf	Common Borrow
Slice 6	113.32285 ft	83.161954 ft	-2,482.7059 psf	675.29117 psf	421.96876 psf	0 psf	0 psf	Common Borrow
Slice 7	115.2306 ft	82.789838 ft	-2,459.4859 psf	801.19381 psf	500.64146 psf	0 psf	0 psf	Common Borrow
Slice 8	117.13836 ft	82.429255 ft	-2,436.9855 psf	928.09322 psf	579.93701 psf	0 psf	0 psf	Common Borrow
Slice 9	119.04612 ft	82.080166 ft	-2,415.2024 psf	1,056.0083 psf	659.86723 psf	0 psf	0 psf	Common Borrow
Slice 10	120.75 ft	81.777526 ft	-2,396.3176 psf	1,268.1708 psf	792.44109 psf	0 psf	0 psf	Common Borrow
Slice 11	122.25 ft	81.519124 ft	-2,380.1934 psf	1,300.6624 psf	812.74409 psf	0 psf	0 psf	Common Borrow
Slice 12	123.75 ft	81.26777 ft	-2,365.4639 psf	1,332.8987 psf	832.88756 psf	0 psf	0 psf	Common Borrow
Slice 13	125.25 ft	81.023446 ft	-2,352.1283 psf	1,364.8753 psf	852.86876 psf	0 psf	0 psf	Common Borrow
Slice 14	126.9375 ft	80.757458 ft	-2,337.6797 psf	1,610.494 psf	1,258.2558 psf	0 psf	0 psf	Gravel Borrow
Slice 15	128.8125 ft	80.471756 ft	-2,322.2396 psf	1,657.5466 psf	1,295.0173 psf	0 psf	0 psf	Gravel Borrow
Slice 16	130.6875 ft	80.196959 ft	-2,307.48 psf	1,704.2179 psf	1,331.4809 psf	0 psf	0 psf	Gravel Borrow
Slice 17	132.5625 ft	79.933041 ft	-2,293.3993 psf	1,750.4979 psf	1,367.6388 psf	0 psf	0 psf	Gravel Borrow
Slice 18	134.4375 ft	79.679977 ft	-2,279.9959 psf	1,796.3759 psf	1,403.4827 psf	0 psf	0 psf	Gravel Borrow
Slice 19	136.3125 ft	79.43774 ft	-2,267.2681 psf	1,841.841 psf	1,439.0039 psf	0 psf	0 psf	Gravel Borrow
Slice 20	138.1875 ft	79.206308 ft	-2,255.2145 psf	1,886.8816 psf	1,474.1935 psf	0 psf	0 psf	Gravel Borrow
Slice 21	140.0625 ft	78.985658 ft	-2,243.8336 psf	2,154.2113 psf	1,683.0543 psf	0 psf	0 psf	Gravel Borrow
Slice 22	141.9375 ft	78.775767 ft	-2,233.1242 psf	2,200.5128 psf	1,719.229 psf	0 psf	0 psf	Gravel Borrow
Slice 23	143.8125 ft	78.576616 ft	-2,223.0849 psf	2,246.3856 psf	1,755.0688 psf	0 psf	0 psf	Gravel Borrow
Slice 24	145.6875 ft	78.388185 ft	-2,213.7146 psf	2,291.8168 psf	1,790.5635 psf	0 psf	0 psf	Gravel Borrow
Slice 25	147.5625 ft	78.210457 ft	-2,205.0121 psf	2,336.7929 psf	1,825.7027 psf	0 psf	0 psf	Gravel Borrow
Slice 26	149.4375 ft	78.043413 ft	-2,196.9763 psf	2,381.2998 psf	1,860.4753 psf	0 psf	0 psf	Gravel Borrow

Slice 27	151.3125 ft	77.887038 ft	-2,189.6063 psf	2,425.3227 psf	1,894.8698 psf	0 psf	0 psf	Gravel Borrow
Slice 28	153.1875 ft	77.741316 ft	-2,182.901 psf	2,468.8462 psf	1,928.874 psf	0 psf	0 psf	Gravel Borrow
Slice 29	155.0625 ft	77.606234 ft	-2,176.8596 psf	2,511.8539 psf	1,962.4753 psf	0 psf	0 psf	Gravel Borrow
Slice 30	156.9375 ft	77.481779 ft	-2,171.4814 psf	2,554.3287 psf	1,995.6603 psf	0 psf	0 psf	Gravel Borrow
Slice 31	158.8125 ft	77.367938 ft	-2,166.7655 psf	2,596.2527 psf	2,028.4149 psf	0 psf	0 psf	Gravel Borrow
Slice 32	159.875 ft	77.306835 ft	-2,164.1465 psf	4,226.5975 psf	3,302.1799 psf	0 psf	0 psf	Gravel Borrow

6.4 Pseudo-Static (M-P) Section Fa-Fa' - Final Condition - Compound Stability

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File Informa on

File Version: 11.01
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Last Edited By: Mikayla S. Hatch
Revision Number: 403
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Directory: P:\0\0180366\01\Analysis\Bridge 17.7\SlopeW\
Last Solved Date: 11/12/2021
Last Solved Time: 03:58:38 PM

Project Se ngs

Unit System: U.S. Customary Units

Analysis Se ngs

6.4 Pseudo-Sta c (M-P)

Kind: SLOPE/W
Parent: 6. Compound Stability
Analysis Type: Morgenstern-Price
Se ngs
Side Func on
Interslice force func on op on: Half-Sine
PWP Condi ons from: Piezometric Line
Apply Phrea c Correc on: No
Use Staged Rapid Drawdown: No
Unit Weight of Water: 62.4 pcf
Slip Surface
Direc on of movement: Le. to Right
Use Passive Mode: No
Slip Surface Op on: Entry and Exit
Cri cal slip surfaces saved: 1
Op mize Cri cal Slip Surface Loca on: No
Tension Crack Op on: (none)
Distribu on
F of S Calcula on Op on: Constant
Advanced
Geometry Se ngs
Minimum Slip Surface Depth: 2 ft
Number of Slices: 30
Factor of Safety Convergence Se ngs
Maximum Number of Itera ons: 100
Tolerable difference in F of S: 0.001

Solu□on Se□ ngs
Search Method: Root Finder
Tolerable difference between star□ng and converged F of S: 3
Maximum itera□ons to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Gravel Borrow

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2A - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 39 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2B - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 41 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 7A - Weathered Sandstone

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 42 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1B - Exis ng Gravelly Granular Fill

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2C - Na ve Silt (Pseudo-Sta c)

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effec□ve Cohesion: 200 psf
Effec□ve Fric□on Angle: 29 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Common Borrow

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

New Pier 1 Foo ng

Slope Stability Material Model: High Strength
Unit Weight: 2,250 pcf
Pore Water Pressure
Piezometric Line: 1

Reinforcements

EQ_EL71_W7.0xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 15.2 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 6,409 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 6,409 lbf/ft

EQ_EL73_W7.0xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 15.2 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 6,409 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 6,409 lbf/ft

EQ_EL75_W7.0xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 28.5 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 6,409 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 6,409 lbf/ft

EQ_EL77_W7.0xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 28.5 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 6,409 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 6,409 lbf/ft

EQ_EL79_W4.5xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 23 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,891 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,891 lbf/ft

EQ_EL81_W4.5xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 23 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,891 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,891 lbf/ft

EQ_EL83_W4.5xW3.5 (45 yrs)

Type: Geosynthe□c

Interface Adhesion: 0 psf
Interface Shear Angle: 23 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,891 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,891 lbf/ft

EQ_EL85_W4.5xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 23 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,891 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,891 lbf/ft

EQ_EL87_W4.5xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 23 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,891 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,891 lbf/ft

EQ_EL89_W4.5xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 23 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,891 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,891 lbf/ft

EQ_EL91_W4.5xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 23 °

Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,891 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,891 lbf/ft

Soil Nail_Row 2

Type: Anchor
Pullout Resistance: 1,800 psf
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 82,550 lbf
Tensile Capacity Reduc□on Factor: 1
Shear Force: 0 lbf
Shear Force Reduc□on Factor: 1
Apply Shear: Parallel to Slip
F of S Dependent: No
Force Distribu□on: Distributed
Bond Length: 45 ft
Bond Diameter: 0.5 ft
Out-of-Plane Spacing: 4 ft
Face Anchorage: Yes
Factored Pullout Resistance: 706.86 lbf/ft/ft
Factored Tensile Capacity: 20,638 lbf/ft

EQ_EL93_W4.5xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 23 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,891 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,891 lbf/ft

Soil Nail_Row 1

Type: Anchor
Pullout Resistance: 1,800 psf
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 82,550 lbf
Tensile Capacity Reduc□on Factor: 1
Shear Force: 0 lbf
Shear Force Reduc□on Factor: 1
Apply Shear: Parallel to Slip
F of S Dependent: No
Force Distribu□on: Distributed
Bond Length: 45 ft
Bond Diameter: 0.5 ft
Out-of-Plane Spacing: 4 ft

Face Anchorage: Yes
Factored Pullout Resistance: 706.86 lbf/ft/ft
Factored Tensile Capacity: 20,638 lbf/ft

Soil Nail_Row 3

Type: Anchor
Pullout Resistance: 1,800 psf
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 82,550 lbf
Tensile Capacity Reduc□on Factor: 1
Shear Force: 0 lbf
Shear Force Reduc□on Factor: 1
Apply Shear: Parallel to Slip
F of S Dependent: No
Force Distribu□on: Distributed
Bond Length: 40 ft
Bond Diameter: 0.5 ft
Out-of-Plane Spacing: 4 ft
Face Anchorage: Yes
Factored Pullout Resistance: 706.86 lbf/ft/ft
Factored Tensile Capacity: 20,638 lbf/ft

Soil Nail_Row 4

Type: Anchor
Pullout Resistance: 1,800 psf
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 82,550 lbf
Tensile Capacity Reduc□on Factor: 1
Shear Force: 0 lbf
Shear Force Reduc□on Factor: 1
Apply Shear: Parallel to Slip
F of S Dependent: No
Force Distribu□on: Distributed
Bond Length: 40 ft
Bond Diameter: 0.5 ft
Out-of-Plane Spacing: 4 ft
Face Anchorage: Yes
Factored Pullout Resistance: 706.86 lbf/ft/ft
Factored Tensile Capacity: 20,638 lbf/ft

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (0.05, 60) ft
Left-Zone Right Coordinate: (120, 94) ft
Left-Zone Increment: 40
Right Type: Range
Right-Zone Left Coordinate: (160, 93.5) ft
Right-Zone Right Coordinate: (160, 66.5) ft
Right-Zone Increment: 20
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 60) ft
Right Coordinate: (335, 48) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	0.25 ft	43.375 ft
Coordinate 2	56.5 ft	43.375 ft
Coordinate 3	97.75 ft	43.375 ft
Coordinate 4	123 ft	43.375 ft
Coordinate 5	159.75 ft	42.625 ft
Coordinate 6	192 ft	42.625 ft
Coordinate 7	210.75 ft	42.625 ft
Coordinate 8	298 ft	35 ft
Coordinate 9	335.25 ft	35 ft

Seismic Coefficients

Horz Seismic Coef.: 0.255

Reinforcement Lines

Reinforcement Line 1

Reinforcement: EQ_EL71_W7.0xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 71) ft
Inside Point: (126, 71) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 2

Reinforcement: EQ_EL73_W7.0xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 73) ft
Inside Point: (126, 73) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf

Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 3

Reinforcement: EQ_EL75_W7.0xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 75) ft
Inside Point: (126, 75) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 4

Reinforcement: EQ_EL77_W7.0xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 77) ft
Inside Point: (126, 77) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 5

Reinforcement: EQ_EL79_W4.5xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 79) ft
Inside Point: (126, 79) ft
Length: 34 ft
Orienta□on: 180 °
Slip Surface Intersec□on: (139.93758, 79) ft
Max. Pullout Force: 3,891 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 6

Reinforcement: EQ_EL81_W4.5xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 81) ft
Inside Point: (126, 81) ft

Length: 34 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 7

Reinforcement: EQ_EL83_W4.5xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 83) ft
Inside Point: (126, 83) ft
Length: 34 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 8

Reinforcement: EQ_EL85_W4.5xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 85) ft
Inside Point: (126, 85) ft
Length: 34 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 9

Reinforcement: EQ_EL87_W4.5xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 87) ft
Inside Point: (126, 87) ft
Length: 34 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 10

Reinforcement: EQ_EL89_W4.5xW3.5 (45 yrs)
Lock to Ground Surface: No

Outside Point: (160, 89) ft
Inside Point: (126, 89) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 11

Reinforcement: EQ_EL91_W4.5xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 91) ft
Inside Point: (126, 91) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 12

Reinforcement: EQ_EL93_W4.5xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 93) ft
Inside Point: (126, 93) ft
Length: 34 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 13

Reinforcement: Soil Nail_Row 1
Lock to Ground Surface: Yes
Outside Point: (160, 64.5) ft
Inside Point: (115.68365, 56.685832) ft
Length: 45.000001 ft
Orienta□on: -170 °
Max. Pullout Force: 0 lbf
Bond Length: 45 ft
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 14

Reinforcement: Soil Nail_Row 2
Lock to Ground Surface: Yes
Outside Point: (160, 60.5) ft
Inside Point: (115.68365, 52.685832) ft
Length: 45.000001 ft
Orienta□on: -170 °
Max. Pullout Force: 0 lbf
Bond Length: 45 ft
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 15

Reinforcement: Soil Nail_Row 3
Lock to Ground Surface: Yes
Outside Point: (160, 56.5) ft
Inside Point: (120.60769, 49.554073) ft
Length: 40 ft
Orienta□on: -170 °
Max. Pullout Force: 0 lbf
Bond Length: 40 ft
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 16

Reinforcement: Soil Nail_Row 4
Lock to Ground Surface: Yes
Outside Point: (160, 52.5) ft
Inside Point: (120.60769, 45.554073) ft
Length: 40 ft
Orienta□on: -170 °
Max. Pullout Force: 0 lbf
Bond Length: 40 ft
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 125 pcf
Direc□on: Ver□cal

Coordinates

	X	Y
	120 ft	95 ft
	160 ft	95 ft

Geometry

Name: Fa-Fa'

Se ngs

View: 2D

Element Thickness: 1 ft

Points

	X	Y
Point 1	0 ft	56 ft
Point 2	76 ft	56 ft
Point 3	118 ft	35 ft
Point 4	160 ft	35 ft
Point 5	0 ft	46 ft
Point 6	37 ft	46 ft
Point 7	190 ft	50 ft
Point 8	160 ft	51 ft
Point 9	170.25 ft	34 ft
Point 10	240 ft	34 ft
Point 11	315 ft	30 ft
Point 12	335 ft	30 ft
Point 13	335 ft	48 ft
Point 14	327 ft	48 ft
Point 15	315 ft	49 ft
Point 16	224 ft	48 ft
Point 17	0 ft	0 ft
Point 18	335 ft	0 ft
Point 19	160 ft	94 ft
Point 20	120 ft	94 ft
Point 21	120 ft	72 ft
Point 22	76 ft	72 ft
Point 23	52 ft	60 ft
Point 24	0 ft	60 ft
Point 25	160 ft	47 ft
Point 26	120 ft	47 ft
Point 27	65 ft	66.5 ft
Point 28	160 ft	66.5 ft
Point 29	120 ft	66.5 ft
Point 30	120 ft	49 ft
Point 31	160 ft	49 ft
Point 32	160 ft	72 ft
Point 33	160 ft	70.5 ft
Point 34	120 ft	70.5 ft
Point 35	156 ft	70.5 ft

Point 36	156 ft	66.5 ft
Point 37	126 ft	49 ft
Point 38	126 ft	94 ft
Point 39	126 ft	66.5 ft
Point 40	126 ft	70.5 ft
Point 41	126 ft	72 ft

Regions

	Material	Points	Area
Region 1	ESU 2C - Na□ve Silt (Pseudo-Sta□c)	5,6,2,1	565 ft²
Region 2	Gravel Borrow	19,38,41,32	748 ft²
Region 3	Common Borrow	20,22,21	484 ft²
Region 4	ESU 2A - Na□ve Sand and Gravel	6,2,3	619.5 ft²
Region 5	ESU 2B - Na□ve Sand and Gravel	7,16,15,14,13,12,11,10,9,4	2,595.4 ft²
Region 6	ESU 7A - Weathered Sandstone	18,17,5,6,3,4,9,10,11,12	12,178 ft²
Region 7	ESU 1B - Exis□ng Gravelly Granular Fill	8,31,25,7	60 ft²
Region 8	ESU 2A - Na□ve Sand and Gravel	4,7,25,26,2,3	945 ft²
Region 9	Common Borrow	21,22,27,29,34	272.25 ft²
Region 10	ESU 1B - Exis□ng Gravelly Granular Fill	23,24,1,2,26,30,29,27	1,077.8 ft²
Region 11	ESU 1B - Exis□ng Gravelly Granular Fill	29,30,37,39	105 ft²
Region 12	ESU 1B - Exis□ng Gravelly Granular Fill	30,26,25,31,37	80 ft²
Region 13	New Pier 1 Foo□ng	29,39,40,34	24 ft²
Region 14	Gravel Borrow	32,41,40,35,33	51 ft²
Region 15	Gravel Borrow	28,33,35,36	16 ft²
Region 16	ESU 1B - Exis□ng Gravelly Granular Fill	31,8,28,36,39,37	595 ft²
Region 17	New Pier 1 Foo□ng	36,35,40,39	120 ft²
Region 18	Common Borrow	21,34,40,41	9 ft²
Region 19	Common Borrow	20,21,41,38	132 ft²

Slip Results

Slip Surfaces Analysed: 381 of 4305 converged

Current Slip Surface

Slip Surface: 3,631
Factor of Safety: 2.324
Volume: 697.27375 ft³
Weight: 88,838.065 lbf
Resis□ng Moment: 22,871,403 lbf·ft
Ac□va□ng Moment: 9,844,000.6 lbf·ft
Resis□ng Force: 68,144.044 lbf
Ac□va□ng Force: 29,318.269 lbf
Slip Rank: 1 of 4,305 slip surfaces
Exit: (160, 77.3) ft
Entry: (102.83018, 85.415088) ft
Radius: 333.21743 ft
Center: (178.06877, 410.02718) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Fric□onal Strength	Cohesive Strength	Suc□on Strength	Base Material
Slice 1	103.78406 ft	85.196948 ft	-2,609.6895 psf	76.182862 psf	47.604336 psf	0 psf	0 psf	Common Borrow
Slice 2	105.69181 ft	84.76655 ft	-2,582.8327 psf	219.05357 psf	136.87986 psf	0 psf	0 psf	Common Borrow
Slice 3	107.59957 ft	84.347896 ft	-2,556.7087 psf	348.2403 psf	217.60469 psf	0 psf	0 psf	Common Borrow
Slice 4	109.50733 ft	83.940941 ft	-2,531.3147 psf	465.29163 psf	290.74648 psf	0 psf	0 psf	Common Borrow
Slice 5	111.41509 ft	83.545641 ft	-2,506.648 psf	572.09963 psf	357.48753 psf	0 psf	0 psf	Common Borrow
Slice 6	113.32285 ft	83.161954 ft	-2,482.7059 psf	670.89875 psf	419.22407 psf	0 psf	0 psf	Common Borrow
Slice 7	115.2306 ft	82.789838 ft	-2,459.4859 psf	764.26152 psf	477.5636 psf	0 psf	0 psf	Common Borrow
Slice 8	117.13836 ft	82.429255 ft	-2,436.9855 psf	855.08456 psf	534.31613 psf	0 psf	0 psf	Common Borrow
Slice 9	119.04612 ft	82.080166 ft	-2,415.2024 psf	946.55675 psf	591.4743 psf	0 psf	0 psf	Common Borrow
Slice 10	120.75 ft	81.777526 ft	-2,396.3176 psf	1,130.602 psf	706.47851 psf	0 psf	0 psf	Common Borrow
Slice 11	122.25 ft	81.519124 ft	-2,380.1934 psf	1,145.7439 psf	715.94028 psf	0 psf	0 psf	Common Borrow
Slice 12	123.75 ft	81.26777 ft	-2,365.4639 psf	1,168.0745 psf	729.89399 psf	0 psf	0 psf	Common Borrow
Slice 13	125.25 ft	81.023446 ft	-2,352.1283 psf	1,198.2628 psf	748.7577 psf	0 psf	0 psf	Common Borrow
Slice 14	126.9375 ft	80.757458 ft	-2,337.6797 psf	1,468.3616 psf	1,147.2098 psf	0 psf	0 psf	Gravel Borrow
Slice 15	128.8125 ft	80.471756 ft	-2,322.2396 psf	1,546.3105 psf	1,208.1102 psf	0 psf	0 psf	Gravel Borrow
Slice 16	130.6875 ft	80.196959 ft	-2,307.48 psf	1,635.0502 psf	1,277.4412 psf	0 psf	0 psf	Gravel Borrow
Slice 17	132.5625 ft	79.933041 ft	-2,293.3993 psf	1,733.0156 psf	1,353.9802 psf	0 psf	0 psf	Gravel Borrow
Slice 18	134.4375 ft	79.679977 ft	-2,279.9959 psf	1,837.8535 psf	1,435.8886 psf	0 psf	0 psf	Gravel Borrow
Slice 19	136.3125 ft	79.43774 ft	-2,267.2681 psf	1,946.5217 psf	1,520.7894 psf	0 psf	0 psf	Gravel Borrow
Slice 20	138.1875 ft	79.206308 ft	-2,255.2145 psf	2,055.476 psf	1,605.9138 psf	0 psf	0 psf	Gravel Borrow
Slice 21	140.0625 ft	78.985658 ft	-2,243.8336 psf	2,414.4819 psf	1,886.4 psf	0 psf	0 psf	Gravel Borrow
Slice 22	141.9375 ft	78.775767 ft	-2,233.1242 psf	2,472.3687 psf	1,931.6261 psf	0 psf	0 psf	Gravel Borrow
Slice 23	143.8125 ft	78.576616 ft	-2,223.0849 psf	2,511.6605 psf	1,962.3242 psf	0 psf	0 psf	Gravel Borrow
Slice 24	145.6875 ft	78.388185 ft	-2,213.7146 psf	2,532.1721 psf	1,978.3496 psf	0 psf	0 psf	Gravel Borrow
Slice 25	147.5625 ft	78.210457 ft	-2,205.0121 psf	2,534.7722 psf	1,980.3811 psf	0 psf	0 psf	Gravel Borrow

Slice 26	149.4375 ft	78.043413 ft	-2,196.9763 psf	2,521.2667 psf	1,969.8294 psf	0 psf	0 psf	Gravel Borrow
Slice 27	151.3125 ft	77.887038 ft	-2,189.6063 psf	2,494.1773 psf	1,948.6649 psf	0 psf	0 psf	Gravel Borrow
Slice 28	153.1875 ft	77.741316 ft	-2,182.901 psf	2,456.446 psf	1,919.1859 psf	0 psf	0 psf	Gravel Borrow
Slice 29	155.0625 ft	77.606234 ft	-2,176.8596 psf	2,411.1122 psf	1,883.7673 psf	0 psf	0 psf	Gravel Borrow
Slice 30	156.9375 ft	77.481779 ft	-2,171.4814 psf	2,361.0126 psf	1,844.6252 psf	0 psf	0 psf	Gravel Borrow
Slice 31	158.8125 ft	77.367938 ft	-2,166.7655 psf	2,308.5513 psf	1,803.638 psf	0 psf	0 psf	Gravel Borrow
Slice 32	159.875 ft	77.306835 ft	-2,164.1465 psf	2,278.5889 psf	1,780.2288 psf	0 psf	0 psf	Gravel Borrow

2.1 Static (Spencer) Section Ga-Ga' - Existing Condition - Compound Stability

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File Informa on

File Version: 11.01
Created By: Mikayla S. Hatch
Last Edited By: Mikayla S. Hatch
Revision Number: 323
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Tool Version: 11.1
File Name: Wall 03.63L - Bridge 17.7 Ga-Ga' - All Condi ons.gsz
Directory: P:\0\0180366\01\Analysis\Bridge 17.7\SlopeW\
Last Solved Date: 11/12/2021
Last Solved Time: 04:47:56 PM

Project Se ngs

Unit System: U.S. Customary Units

Analysis Se ngs

2.1 Sta c (Spencer)

Kind: SLOPE/W
Parent: 2. Compound Stability - 30 Years Corrosion
Analysis Type: Spencer
Se ngs
PWP Condi ons from: Piezometric Line
Apply Phrea c Correc on: No
Use Staged Rapid Drawdown: No
Unit Weight of Water: 62.4 pcf
Slip Surface
Direc on of movement: Le. to Right
Use Passive Mode: No
Slip Surface Op on: Entry and Exit
Cri cal slip surfaces saved: 1
Op mize Cri cal Slip Surface Loca on: No
Tension Crack Op on: (none)
Distribu on
F of S Calcula on Op on: Constant
Advanced
Geometry Se ngs
Minimum Slip Surface Depth: 2 ft
Number of Slices: 30
Factor of Safety Convergence Se ngs
Maximum Number of Itera ons: 100
Tolerable difference in F of S: 0.001
Solu on Se ngs
Search Method: Root Finder

Tolerable difference between star□ng and converged F of S: 3
Maximum itera□ons to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

ESU 2A - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 39 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2B - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 41 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 7A - Weathered Sandstone

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 43 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2C - Na ve Silt

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 29 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1A - Exis ng Granular Fill

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 40 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1B - Exis ng Gravelly Granular Fill

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Reinforcements

EL47_W9.5xW4

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 14.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,441 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,441 lbf/ft

EL49_W9.5xW4

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 14.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,441 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,441 lbf/ft

EL51_W9.5xW4

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 14.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,441 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,441 lbf/ft

EL53_W9.5xW4

Type: Geosynthe□c
Interface Adhesion: 0 psf

Interface Shear Angle: 14.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,441 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,441 lbf/ft

EL55_W9.5xW4

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 14.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,441 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,441 lbf/ft

EL57_W9.5xW4

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 14.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,441 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,441 lbf/ft

EL59_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 14.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,441 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,441 lbf/ft

EL61_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 12.1 °
Surface Area Factor: 2

Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,422 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,422 lbf/ft

EL63_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 12.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,422 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,422 lbf/ft

EL65_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 12.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,422 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,422 lbf/ft

EL67_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 12.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,422 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,422 lbf/ft

EL69_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 12.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,422 lbf

Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,422 lbf/ft

EL71_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 12.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,422 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,422 lbf/ft

EL73_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 23.2 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,422 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,422 lbf/ft

EL75_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 23.2 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,422 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,422 lbf/ft

EL77_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,385 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No

Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,385 lbf/ft

EL79_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,385 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,385 lbf/ft

EL81_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,385 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,385 lbf/ft

EL89_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,385 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,385 lbf/ft

EL87_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,385 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes

Factored Tensile Capacity: 3,385 lbf/ft

EL85_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,385 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,385 lbf/ft

EL83_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,385 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,385 lbf/ft

EL91_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,385 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,385 lbf/ft

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (0.05, 60) ft
Left-Zone Right Coordinate: (121.05, 92) ft
Left-Zone Increment: 40
Right Type: Range
Right-Zone Left Coordinate: (160, 50) ft
Right-Zone Right Coordinate: (183.3, 50) ft
Right-Zone Increment: 20
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 60) ft
Right Coordinate: (335, 48) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	0.25 ft	43.375 ft
Coordinate 2	56.5 ft	43.375 ft
Coordinate 3	97.75 ft	43.375 ft
Coordinate 4	123 ft	43.375 ft
Coordinate 5	159.75 ft	42.625 ft
Coordinate 6	192 ft	42.625 ft
Coordinate 7	210.75 ft	42.625 ft
Coordinate 8	298 ft	35 ft
Coordinate 9	335.25 ft	35 ft

Reinforcement Lines

Reinforcement Line 1

Reinforcement: EL47_W9.5xW4
Lock to Ground Surface: No
Outside Point: (160, 47) ft
Inside Point: (128, 47) ft
Length: 32 ft
Orienta□on: 180 °
Slip Surface Intersec□on: (129.12021, 47) ft
Max. Pullout Force: 7,441 lbf
Available Length: 1.1202113 ft
Required Length: 1.1202113 ft
Pullout Force: 3,330.3921 lbf
Pullout Force per Length: 2,973.0034 lbf/ft
Governing Component: Pullout Resistance

Reinforcement Line 2

Reinforcement: EL49_W9.5xW4
Lock to Ground Surface: No
Outside Point: (160, 49) ft
Inside Point: (128, 49) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft

Governing Component: (none)

Reinforcement Line 3

Reinforcement: EL51_W9.5xW4
Lock to Ground Surface: No
Outside Point: (160, 51) ft
Inside Point: (128, 51) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 4

Reinforcement: EL53_W9.5xW4
Lock to Ground Surface: No
Outside Point: (160, 53) ft
Inside Point: (128, 53) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 5

Reinforcement: EL55_W9.5xW4
Lock to Ground Surface: No
Outside Point: (160, 55) ft
Inside Point: (128, 55) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 6

Reinforcement: EL57_W9.5xW4
Lock to Ground Surface: No
Outside Point: (160, 57) ft
Inside Point: (128, 57) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft

Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 7

Reinforcement: EL59_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 59) ft
Inside Point: (128, 59) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 8

Reinforcement: EL61_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 61) ft
Inside Point: (128, 61) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 9

Reinforcement: EL63_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 63) ft
Inside Point: (128, 63) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 10

Reinforcement: EL65_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 65) ft
Inside Point: (128, 65) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf

Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 11

Reinforcement: EL67_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 67) ft
Inside Point: (128, 67) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 12

Reinforcement: EL69_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 69) ft
Inside Point: (128, 69) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 13

Reinforcement: EL71_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 71) ft
Inside Point: (128, 71) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 14

Reinforcement: EL73_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 73) ft
Inside Point: (128, 73) ft
Length: 32 ft

Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 15

Reinforcement: EL75_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 75) ft
Inside Point: (128, 75) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 16

Reinforcement: EL77_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 77) ft
Inside Point: (128, 77) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 17

Reinforcement: EL79_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 79) ft
Inside Point: (128, 79) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 18

Reinforcement: EL81_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 81) ft

Inside Point: (128, 81) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 19

Reinforcement: EL83_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 83) ft
Inside Point: (128, 83) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 20

Reinforcement: EL85_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 85) ft
Inside Point: (128, 85) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 21

Reinforcement: EL89_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 89) ft
Inside Point: (128, 89) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 22

Reinforcement: EL87_W4.5xW3.5

Lock to Ground Surface: No
Outside Point: (160, 87) ft
Inside Point: (128, 87) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 23

Reinforcement: EL91_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 91) ft
Inside Point: (128, 91) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 24

Reinforcement: EL85_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 85) ft
Inside Point: (128, 85) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 250 pcf
Direction: Vertical

Coordinates

	X	Y
	120 ft	92 ft
	120 ft	93 ft
	128 ft	93 ft

Surcharge Load 2

Surcharge (Unit Weight): 250 pcf
Direc□on: Ver□cal

Coordinates

	X	Y
	128 ft	93.75 ft
	160 ft	93.75 ft

Geometry

Name: Ga-Ga'

Se ngs

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	0 ft	56 ft
Point 2	76 ft	56 ft
Point 3	118 ft	35 ft
Point 4	160 ft	35 ft
Point 5	0 ft	46 ft
Point 6	37 ft	46 ft
Point 7	190 ft	50 ft
Point 8	160 ft	50 ft
Point 9	170.25 ft	34 ft
Point 10	240 ft	34 ft
Point 11	315 ft	30 ft
Point 12	335 ft	30 ft
Point 13	335 ft	48 ft
Point 14	327 ft	48 ft
Point 15	315 ft	49 ft
Point 16	224 ft	48 ft
Point 17	0 ft	0 ft
Point 18	335 ft	0 ft
Point 19	160 ft	92 ft
Point 20	120 ft	92 ft
Point 21	120 ft	72 ft
Point 22	80 ft	72 ft
Point 23	56 ft	60 ft
Point 24	0 ft	60 ft
Point 25	160 ft	47 ft
Point 26	120 ft	47 ft
Point 27	69 ft	66.5 ft
Point 28	160 ft	66.5 ft
Point 29	120 ft	66.5 ft
Point 30	160 ft	72 ft

Point 31	128 ft	47 ft
Point 32	128 ft	92 ft
Point 33	128 ft	66.5 ft
Point 34	128 ft	72 ft
Point 35	160 ft	64.5 ft
Point 36	160 ft	60.5 ft
Point 37	160 ft	56.5 ft
Point 38	160 ft	52.5 ft

Regions

	Material	Points	Area
Region 1	ESU 2C - Na□ve Silt	5,6,2,1	565 ft²
Region 2	ESU 1A - Exis□ng Granular Fill	19,32,34,30	640 ft²
Region 3	ESU 1A - Exis□ng Granular Fill	20,22,21	400 ft²
Region 4	ESU 2A - Na□ve Sand and Gravel	6,2,3	619.5 ft²
Region 5	ESU 2B - Na□ve Sand and Gravel	7,16,15,14,13,12,11,10,9,4	2,595.4 ft²
Region 6	ESU 7A - Weathered Sandstone	18,17,5,6,3,4,9,10,11,12	12,178 ft²
Region 7	ESU 1B - Exis□ng Gravelly Granular Fill	8,7,25	45 ft²
Region 8	ESU 2A - Na□ve Sand and Gravel	4,7,25,31,26,2,3	945 ft²
Region 9	ESU 1B - Exis□ng Gravelly Granular Fill	21,22,27,29	250.25 ft²
Region 10	ESU 1B - Exis□ng Gravelly Granular Fill	23,24,1,2,26,29,27	1,051.8 ft²
Region 11	ESU 1B - Exis□ng Gravelly Granular Fill	26,31,33,29	156 ft²
Region 12	ESU 1B - Exis□ng Gravelly Granular Fill	29,33,34,21	44 ft²
Region 13	ESU 1B - Exis□ng Gravelly Granular Fill	25,8,38,37,36,35,28,33,31	624 ft²
Region 14	ESU 1B - Exis□ng Gravelly Granular Fill	28,30,34,33	176 ft²
Region 15	ESU 1A - Exis□ng Granular Fill	20,21,34,32	160 ft²

Slip Results

Slip Surfaces Analysed: 2304 of 4305 converged

Current Slip Surface

Slip Surface: 3,780
Factor of Safety: 2.709
Volume: 2,388.7398 ft³
Weight: 292,263.68 lbf
Resis□ng Moment: 12,030,880 lbf·ft
Ac□va□ng Moment: 4,440,670.3 lbf·ft
Resis□ng Force: 224,579.04 lbf
Ac□va□ng Force: 82,918.03 lbf
Slip Rank: 1 of 4,305 slip surfaces
Exit: (183.3, 50) ft
Entry: (106.56635, 85.283177) ft
Radius: 47.536231 ft
Center: (154.0521, 87.473374) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Fric□onal Strength	Cohesive Strength	Suc□on Strength	Base Material

Slice 1	107.83553 ft	78.641589 ft	-2,200.6351 psf	197.25928 psf	165.52019 psf	0 psf	0 psf	ESU 1A - Exis□ng Granular Fill
Slice 2	110.24879 ft	69.25 ft	-1,614.6 psf	872.25265 psf	681.47846 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 3	112.82739 ft	63.982518 ft	-1,285.9091 psf	1,450.998 psf	1,133.6439 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 4	115.69643 ft	59.498217 ft	-1,006.0887 psf	2,063.1168 psf	1,611.8835 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 5	118.56548 ft	55.91815 ft	-782.69254 psf	2,647.3022 psf	2,068.2991 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 6	121.5 ft	52.892888 ft	-593.91619 psf	3,330.3966 psf	2,601.991 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 7	124.25 ft	50.474027 ft	-444.57115 psf	3,751.9761 psf	2,931.365 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 8	126.75 ft	48.589501 ft	-330.16038 psf	4,113.9782 psf	3,214.192 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 9	128.56011 ft	47.35591 ft	-255.48942 psf	4,572.047 psf	3,572.0746 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 10	130.43882 ft	46.244779 ft	-188.54729 psf	4,783.2998 psf	3,873.4398 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 11	133.07604 ft	44.840775 ft	-104.29591 psf	5,133.4254 psf	4,156.9659 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 12	135.71326 ft	43.640314 ft	-32.74557 psf	5,472.7817 psf	4,431.7713 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 13	138.29399 ft	42.644975 ft	26.077156 psf	5,797.7344 psf	4,673.7959 psf	0 psf	0 psf	ESU 2A - Na□ve Sand

								and Gravel
Slice 14	140.81823 ft	41.835332 ft	73.384334 psf	6,106.133 psf	4,885.2236 psf	0 psf	0 psf	ESU 2A - Naïve Sand and Gravel
Slice 15	143.34246 ft	41.177384 ft	111.22573 psf	6,408.2981 psf	5,099.2687 psf	0 psf	0 psf	ESU 2A - Naïve Sand and Gravel
Slice 16	145.8667 ft	40.664713 ft	140.00188 psf	6,706.2503 psf	5,317.2431 psf	0 psf	0 psf	ESU 2A - Naïve Sand and Gravel
Slice 17	148.39094 ft	40.292567 ft	160.00924 psf	7,002.1373 psf	5,540.646 psf	0 psf	0 psf	ESU 2A - Naïve Sand and Gravel
Slice 18	150.91517 ft	40.057628 ft	171.4549 psf	7,298.3493 psf	5,771.2453 psf	0 psf	0 psf	ESU 2A - Naïve Sand and Gravel
Slice 19	153.43941 ft	39.957854 ft	174.46624 psf	7,597.6605 psf	6,011.1842 psf	0 psf	0 psf	ESU 2A - Naïve Sand and Gravel
Slice 20	155.96365 ft	39.992391 ft	169.09658 psf	7,903.4159 psf	6,263.1283 psf	0 psf	0 psf	ESU 2A - Naïve Sand and Gravel
Slice 21	158.48788 ft	40.161535 ft	155.32751 psf	8,219.7922 psf	6,530.4747 psf	0 psf	0 psf	ESU 2A - Naïve Sand and Gravel
Slice 22	159.875 ft	40.295294 ft	145.37366 psf	8,794.7106 psf	7,004.095 psf	0 psf	0 psf	ESU 2A - Naïve Sand and Gravel
Slice 23	161.22627 ft	40.498 ft	132.72478 psf	1,440.0351 psf	1,058.639 psf	0 psf	0 psf	ESU 2A - Naïve Sand and Gravel
Slice 24	163.67881 ft	40.938961 ft	105.20884 psf	1,440.8176 psf	1,081.5547 psf	0 psf	0 psf	ESU 2A - Naïve Sand and Gravel
Slice 25	166.13135 ft	41.514944 ft	69.267501 psf	1,424.8399 psf	1,097.7209 psf	0 psf	0 psf	ESU 2A - Naïve Sand and Gravel
Slice 26	168.5839 ft	42.231122 ft	24.577969 psf	1,389.9502 psf	1,105.6566 psf	0 psf	0 psf	ESU 2A - Naïve Sand and Gravel
Slice 27	171.0575 ft	43.103053 ft	-29.830533 psf	1,321.8616 psf	1,070.4224 psf	0 psf	0 psf	ESU 2A - Naïve Sand and Gravel
Slice 28	173.55216 ft	44.142439 ft	-94.688211 psf	1,208.0958 psf	978.29671 psf	0 psf	0 psf	ESU 2A - Naïve Sand and Gravel
Slice 29	176.04683 ft	45.355146 ft	-170.36112 psf	1,044.3861 psf	845.72723 psf	0 psf	0 psf	ESU 2A - Naïve Sand and Gravel
Slice 30	178.54149 ft	46.75674 ft	-257.82058 psf	810.27387 psf	656.14685 psf	0 psf	0 psf	ESU 2A - Naïve Sand and Gravel
Slice 31	181.03616 ft	48.367654 ft	-358.34163 psf	467.94716 psf	378.93614 psf	0 psf	0 psf	ESU 2A - Naïve Sand

								and Gravel
Slice 32	182.79175 ft	49.614175 ft	-436.12449 psf	122.45054 psf	95.66885 psf	0 psf	0 psf	ESU 1B - Existing Gravelly Granular Fill

2.2 Static (M-P) Section Ga-Ga' - Existing Condition - Compound Stability

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File Informa on

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Last Edited By: Mikayla S. Hatch
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Tool Version: 11.1
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Directory: P:\0\0180366\01\Analysis\Bridge 17.7\SlopeW\
Last Solved Date: 11/12/2021
Last Solved Time: 04:48:18 PM

Project Se ngs

Unit System: U.S. Customary Units

Analysis Se ngs

2.2 Sta c (M-P)

Kind: SLOPE/W
Parent: 2. Compound Stability - 30 Years Corrosion
Analysis Type: Morgenstern-Price
Se ngs
Side Func on
Interslice force func on op on: Half-Sine
PWP Condi ons from: Piezometric Line
Apply Phrea c Correc on: No
Use Staged Rapid Drawdown: No
Unit Weight of Water: 62.4 pcf
Slip Surface
Direc on of movement: Le. to Right
Use Passive Mode: No
Slip Surface Op on: Entry and Exit
Cri cal slip surfaces saved: 1
Op mize Cri cal Slip Surface Loca on: No
Tension Crack Op on: (none)
Distribu on
F of S Calcula on Op on: Constant
Advanced
Geometry Se ngs
Minimum Slip Surface Depth: 2 ft
Number of Slices: 30
Factor of Safety Convergence Se ngs
Maximum Number of Itera ons: 100
Tolerable difference in F of S: 0.001

Solu□on Se□ ngs
Search Method: Root Finder
Tolerable difference between star□ng and converged F of S: 3
Maximum itera□ons to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

ESU 2A - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 39 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2B - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 41 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 7A - Weathered Sandstone

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 43 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2C - Na ve Silt

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 29 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1A - Exis ng Granular Fill

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 40 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1B - Exis ng Gravelly Granular Fill

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effec ve Cohesion: 0 psf
Effec ve Fric on Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Reinforcements

EL47_W9.5xW4

Type: Geosynthe c
Interface Adhesion: 0 psf
Interface Shear Angle: 14.1 °
Surface Area Factor: 2
Pullout Resistance Reduc on Factor: 1
Tensile Capacity: 7,441 lbf
Tensile Capacity Reduc on Factor: 1
F of S Dependent: No
Force Distribu on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,441 lbf/ft

EL49_W9.5xW4

Type: Geosynthe c
Interface Adhesion: 0 psf
Interface Shear Angle: 14.1 °
Surface Area Factor: 2
Pullout Resistance Reduc on Factor: 1
Tensile Capacity: 7,441 lbf
Tensile Capacity Reduc on Factor: 1
F of S Dependent: No
Force Distribu on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,441 lbf/ft

EL51_W9.5xW4

Type: Geosynthe c
Interface Adhesion: 0 psf
Interface Shear Angle: 14.1 °
Surface Area Factor: 2
Pullout Resistance Reduc on Factor: 1
Tensile Capacity: 7,441 lbf
Tensile Capacity Reduc on Factor: 1
F of S Dependent: No
Force Distribu on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,441 lbf/ft

EL53_W9.5xW4

Type: Geosynthe c

Interface Adhesion: 0 psf
Interface Shear Angle: 14.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,441 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,441 lbf/ft

EL55_W9.5xW4

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 14.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,441 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,441 lbf/ft

EL57_W9.5xW4

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 14.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,441 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,441 lbf/ft

EL59_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 14.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,441 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,441 lbf/ft

EL61_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 12.1 °

Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,422 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,422 lbf/ft

EL63_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 12.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,422 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,422 lbf/ft

EL65_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 12.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,422 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,422 lbf/ft

EL67_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 12.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,422 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,422 lbf/ft

EL69_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 12.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1

Tensile Capacity: 5,422 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,422 lbf/ft

EL71_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 12.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,422 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,422 lbf/ft

EL73_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 23.2 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,422 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,422 lbf/ft

EL75_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 23.2 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,422 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,422 lbf/ft

EL77_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,385 lbf
Tensile Capacity Reduc□on Factor: 1

F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,385 lbf/ft

EL79_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,385 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,385 lbf/ft

EL81_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,385 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,385 lbf/ft

EL89_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,385 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,385 lbf/ft

EL87_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,385 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed

Face Anchorage: Yes
Factored Tensile Capacity: 3,385 lbf/ft

EL85_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,385 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,385 lbf/ft

EL83_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,385 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,385 lbf/ft

EL91_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,385 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,385 lbf/ft

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (0.05, 60) ft
Left-Zone Right Coordinate: (119.5945, 91.79725) ft
Left-Zone Increment: 40
Right Type: Range
Right-Zone Left Coordinate: (160, 70.95212) ft
Right-Zone Right Coordinate: (170.15, 50) ft
Right-Zone Increment: 20
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 60) ft
Right Coordinate: (335, 48) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	0.25 ft	43.375 ft
Coordinate 2	56.5 ft	43.375 ft
Coordinate 3	97.75 ft	43.375 ft
Coordinate 4	123 ft	43.375 ft
Coordinate 5	159.75 ft	42.625 ft
Coordinate 6	192 ft	42.625 ft
Coordinate 7	210.75 ft	42.625 ft
Coordinate 8	298 ft	35 ft
Coordinate 9	335.25 ft	35 ft

Reinforcement Lines

Reinforcement Line 1

Reinforcement: EL47_W9.5xW4
Lock to Ground Surface: No
Outside Point: (160, 47) ft
Inside Point: (128, 47) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 2

Reinforcement: EL49_W9.5xW4
Lock to Ground Surface: No
Outside Point: (160, 49) ft
Inside Point: (128, 49) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 3

Reinforcement: EL51_W9.5xW4
Lock to Ground Surface: No
Outside Point: (160, 51) ft
Inside Point: (128, 51) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 4

Reinforcement: EL53_W9.5xW4
Lock to Ground Surface: No
Outside Point: (160, 53) ft
Inside Point: (128, 53) ft
Length: 32 ft
Orienta□on: 180 °
Slip Surface Intersec□on: (152.06103, 53) ft
Max. Pullout Force: 7,441 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 5

Reinforcement: EL55_W9.5xW4
Lock to Ground Surface: No
Outside Point: (160, 55) ft
Inside Point: (128, 55) ft
Length: 32 ft
Orienta□on: 180 °
Slip Surface Intersec□on: (146.42783, 55) ft
Max. Pullout Force: 7,441 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 6

Reinforcement: EL57_W9.5xW4
Lock to Ground Surface: No
Outside Point: (160, 57) ft
Inside Point: (128, 57) ft
Length: 32 ft
Orienta□on: 180 °
Slip Surface Intersec□on: (141.97655, 57) ft
Max. Pullout Force: 7,441 lbf
Available Length: 0 ft

Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 7

Reinforcement: EL59_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 59) ft
Inside Point: (128, 59) ft
Length: 32 ft
Orienta□on: 180 °
Slip Surface Intersec□on: (138.20195, 59) ft
Max. Pullout Force: 7,441 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 8

Reinforcement: EL61_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 61) ft
Inside Point: (128, 61) ft
Length: 32 ft
Orienta□on: 180 °
Slip Surface Intersec□on: (134.92154, 61) ft
Max. Pullout Force: 5,422 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 9

Reinforcement: EL63_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 63) ft
Inside Point: (128, 63) ft
Length: 32 ft
Orienta□on: 180 °
Slip Surface Intersec□on: (132.01187, 63) ft
Max. Pullout Force: 5,422 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 10

Reinforcement: EL65_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 65) ft

Inside Point: (128, 65) ft
Length: 32 ft
Orientation: 180 °
Slip Surface Intersection: (129.38205, 65) ft
Max. Pullout Force: 5,422 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 11

Reinforcement: EL67_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 67) ft
Inside Point: (128, 67) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 12

Reinforcement: EL69_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 69) ft
Inside Point: (128, 69) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 13

Reinforcement: EL71_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 71) ft
Inside Point: (128, 71) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 14

Reinforcement: EL73_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 73) ft
Inside Point: (128, 73) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 15

Reinforcement: EL75_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 75) ft
Inside Point: (128, 75) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 16

Reinforcement: EL77_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 77) ft
Inside Point: (128, 77) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 17

Reinforcement: EL79_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 79) ft
Inside Point: (128, 79) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 18

Reinforcement: EL81_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 81) ft
Inside Point: (128, 81) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 19

Reinforcement: EL83_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 83) ft
Inside Point: (128, 83) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 20

Reinforcement: EL85_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 85) ft
Inside Point: (128, 85) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 21

Reinforcement: EL89_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 89) ft
Inside Point: (128, 89) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft

Governing Component: (none)

Reinforcement Line 22

Reinforcement: EL87_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 87) ft
Inside Point: (128, 87) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 23

Reinforcement: EL91_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 91) ft
Inside Point: (128, 91) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 24

Reinforcement: EL85_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 85) ft
Inside Point: (128, 85) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 250 pcf
Direc□on: Ver□cal

Coordinates

	X	Y

	120 ft	92 ft
	120 ft	93 ft
	128 ft	93 ft

Surcharge Load 2

Surcharge (Unit Weight): 250 pcf
Direc□on: Ver□cal

Coordinates

	X	Y
	128 ft	93.75 ft
	160 ft	93.75 ft

Geometry

Name: Ga-Ga'

Se ngs

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	0 ft	56 ft
Point 2	76 ft	56 ft
Point 3	118 ft	35 ft
Point 4	160 ft	35 ft
Point 5	0 ft	46 ft
Point 6	37 ft	46 ft
Point 7	190 ft	50 ft
Point 8	160 ft	50 ft
Point 9	170.25 ft	34 ft
Point 10	240 ft	34 ft
Point 11	315 ft	30 ft
Point 12	335 ft	30 ft
Point 13	335 ft	48 ft
Point 14	327 ft	48 ft
Point 15	315 ft	49 ft
Point 16	224 ft	48 ft
Point 17	0 ft	0 ft
Point 18	335 ft	0 ft
Point 19	160 ft	92 ft
Point 20	120 ft	92 ft
Point 21	120 ft	72 ft
Point 22	80 ft	72 ft
Point 23	56 ft	60 ft
Point 24	0 ft	60 ft
Point 25	160 ft	47 ft
Point 26	120 ft	47 ft

Point 27	69 ft	66.5 ft
Point 28	160 ft	66.5 ft
Point 29	120 ft	66.5 ft
Point 30	160 ft	72 ft
Point 31	128 ft	47 ft
Point 32	128 ft	92 ft
Point 33	128 ft	66.5 ft
Point 34	128 ft	72 ft
Point 35	160 ft	64.5 ft
Point 36	160 ft	60.5 ft
Point 37	160 ft	56.5 ft
Point 38	160 ft	52.5 ft

Regions

	Material	Points	Area
Region 1	ESU 2C - Na□ve Silt	5,6,2,1	565 ft²
Region 2	ESU 1A - Exis□ng Granular Fill	19,32,34,30	640 ft²
Region 3	ESU 1A - Exis□ng Granular Fill	20,22,21	400 ft²
Region 4	ESU 2A - Na□ve Sand and Gravel	6,2,3	619.5 ft²
Region 5	ESU 2B - Na□ve Sand and Gravel	7,16,15,14,13,12,11,10,9,4	2,595.4 ft²
Region 6	ESU 7A - Weathered Sandstone	18,17,5,6,3,4,9,10,11,12	12,178 ft²
Region 7	ESU 1B - Exis□ng Gravelly Granular Fill	8,7,25	45 ft²
Region 8	ESU 2A - Na□ve Sand and Gravel	4,7,25,31,26,2,3	945 ft²
Region 9	ESU 1B - Exis□ng Gravelly Granular Fill	21,22,27,29	250.25 ft²
Region 10	ESU 1B - Exis□ng Gravelly Granular Fill	23,24,1,2,26,29,27	1,051.8 ft²
Region 11	ESU 1B - Exis□ng Gravelly Granular Fill	26,31,33,29	156 ft²
Region 12	ESU 1B - Exis□ng Gravelly Granular Fill	29,33,34,21	44 ft²
Region 13	ESU 1B - Exis□ng Gravelly Granular Fill	25,8,38,37,36,35,28,33,31	624 ft²
Region 14	ESU 1B - Exis□ng Gravelly Granular Fill	28,30,34,33	176 ft²
Region 15	ESU 1A - Exis□ng Granular Fill	20,21,34,32	160 ft²

Slip Results

Slip Surfaces Analysed: 1629 of 4305 converged

Current Slip Surface

Slip Surface: 3,988
Factor of Safety: 3.163
Volume: 1,385.2654 ft³
Weight: 168,743.91 lbf
Resis□ng Moment: 10,121,777 lbf·ft
Ac□va□ng Moment: 3,200,159.9 lbf·ft
Resis□ng Force: 128,589.96 lbf
Ac□va□ng Force: 40,658.482 lbf
Slip Rank: 1 of 4,305 slip surfaces
Exit: (160, 51.063341) ft
Entry: (111.07167, 87.535836) ft
Radius: 68.50611 ft
Center: (172.19299, 118.47564) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Fric⍰onal Strength	Cohesive Strength	Suc⍰on Strength	Base Material
Slice 1	111.96451 ft	85.885813 ft	-2,652.6747 psf	159.68478 psf	133.99144 psf	0 psf	0 psf	ESU 1A - Exis⍰ng Granular Fill
Slice 2	113.75017 ft	82.774232 ft	-2,458.5121 psf	454.593 psf	381.44882 psf	0 psf	0 psf	ESU 1A - Exis⍰ng Granular Fill
Slice 3	115.53584 ft	79.998006 ft	-2,285.2755 psf	712.39282 psf	597.76855 psf	0 psf	0 psf	ESU 1A - Exis⍰ng Granular Fill
Slice 4	117.3215 ft	77.48807 ft	-2,128.6556 psf	946.7271 psf	794.39836 psf	0 psf	0 psf	ESU 1A - Exis⍰ng Granular Fill
Slice 5	119.10717 ft	75.197634 ft	-1,985.7323 psf	1,167.4657 psf	979.62003 psf	0 psf	0 psf	ESU 1A - Exis⍰ng Granular Fill
Slice 6	120.93153 ft	73.051232 ft	-1,851.7969 psf	1,511.1867 psf	1,268.0362 psf	0 psf	0 psf	ESU 1A - Exis⍰ng Granular Fill
Slice 7	122.43153 ft	71.399108 ft	-1,748.7044 psf	1,648.7763 psf	1,288.1652 psf	0 psf	0 psf	ESU 1B - Exis⍰ng Gravelly Granular Fill
Slice 8	123.7609 ft	70.03741 ft	-1,664.7033 psf	1,761.2296 psf	1,376.0234 psf	0 psf	0 psf	ESU 1B - Exis⍰ng Gravelly Granular Fill
Slice 9	125.28271 ft	68.56149 ft	-1,574.544 psf	1,895.4381 psf	1,480.8785 psf	0 psf	0 psf	ESU 1B - Exis⍰ng Gravelly Granular Fill
Slice 10	126.80452 ft	67.173189 ft	-1,489.8519 psf	2,036.7349 psf	1,591.2717 psf	0 psf	0 psf	ESU 1B - Exis⍰ng Gravelly Granular Fill
Slice 11	127.78271 ft	66.314997 ft	-1,437.5465 psf	2,132.4177 psf	1,666.0273 psf	0 psf	0 psf	ESU 1B - Exis⍰ng Gravelly Granular Fill
Slice 12	128.83553 ft	65.44685 ft	-1,384.7148 psf	2,387.5646 psf	1,865.3699 psf	0 psf	0 psf	ESU 1B - Exis⍰ng

								Gravelly Granular Fill
Slice 13	130.50658 ft	64.122891 ft	-1,304.2278 psf	2,570.7301 psf	2,008.4745 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 14	132.17763 ft	62.880691 ft	-1,228.8426 psf	2,827.5757 psf	2,209.1442 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 15	133.84868 ft	61.714874 ft	-1,158.2236 psf	3,041.5583 psf	2,376.3258 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 16	135.51974 ft	60.620814 ft	-1,092.0823 psf	3,339.5474 psf	2,609.1404 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 17	137.19079 ft	59.594504 ft	-1,030.1686 psf	3,578.65 psf	2,795.9478 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 18	138.86184 ft	58.632454 ft	-972.2647 psf	3,939.3048 psf	3,077.7222 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 19	140.53289 ft	57.731606 ft	-918.17984 psf	4,188.4866 psf	3,272.4043 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 20	142.20395 ft	56.889272 ft	-867.74623 psf	4,563.9177 psf	3,565.7233 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 21	143.875 ft	56.103078 ft	-820.81576 psf	4,795.6876 psf	3,746.8018 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 22	145.54605 ft	55.370924 ft	-777.25738 psf	5,013.6292 psf	3,917.0764 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 23	147.21711 ft	54.690947 ft	-736.95484 psf	5,354.1113 psf	4,183.0902 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly

								Granular Fill
Slice 24	148.88816 ft	54.061493 ft	-699.80494 psf	5,499.4083 psf	4,296.6087 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 25	150.55921 ft	53.481093 ft	-665.716 psf	5,610.2745 psf	4,383.2268 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 26	152.23026 ft	52.948442 ft	-634.60663 psf	5,821.6296 psf	4,548.3556 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 27	153.90132 ft	52.462384 ft	-606.40463 psf	5,792.0873 psf	4,525.2746 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 28	155.57237 ft	52.021895 ft	-581.04617 psf	5,715.9776 psf	4,465.8111 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 29	157.24342 ft	51.626074 ft	-558.47499 psf	5,596.267 psf	4,372.2829 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 30	158.91447 ft	51.274132 ft	-538.64181 psf	5,437.9021 psf	4,248.5548 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 31	159.875 ft	51.08619 ft	-527.97823 psf	5,333.3696 psf	4,166.885 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill

2.3 Pseudo-Static (Spencer) Section Ga-Ga' - Existing Condition - Compound Stability

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File Informa on

File Version: 11.01
Created By: Mikayla S. Hatch
Last Edited By: Mikayla S. Hatch
Revision Number: 323
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Tool Version: 11.1
File Name: Wall 03.63L - Bridge 17.7 Ga-Ga' - All Condi ons.gsz
Directory: P:\0\0180366\01\Analysis\Bridge 17.7\SlopeW\
Last Solved Date: 11/12/2021
Last Solved Time: 04:48:28 PM

Project Se ngs

Unit System: U.S. Customary Units

Analysis Se ngs

2.3 Pseudo-Sta c (Spencer)

Kind: SLOPE/W
Parent: 2. Compound Stability - 30 Years Corrosion
Analysis Type: Spencer
Se ngs
PWP Condi ons from: Piezometric Line
Apply Phrea c Correc on: No
Use Staged Rapid Drawdown: No
Unit Weight of Water: 62.4 pcf
Slip Surface
Direc on of movement: Le. to Right
Use Passive Mode: No
Slip Surface Op on: Entry and Exit
Cri cal slip surfaces saved: 1
Op mize Cri cal Slip Surface Loca on: No
Tension Crack Op on: (none)
Distribu on
F of S Calcula on Op on: Constant
Advanced
Geometry Se ngs
Minimum Slip Surface Depth: 2 ft
Number of Slices: 30
Factor of Safety Convergence Se ngs
Maximum Number of Itera ons: 100
Tolerable difference in F of S: 0.001
Solu on Se ngs
Search Method: Root Finder

Tolerable difference between star□ng and converged F of S: 3
Maximum itera□ons to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

ESU 1A - Exis ng Granular Fill (Pseudo-Sta c)

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 50 psf
Effec□ve Fric□on Angle: 40 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2A - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 39 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2B - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 41 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 7A - Weathered Sandstone

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 43 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1B - Exis ng Gravelly Granular Fill

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2C - Na ve Silt (Pseudo-Sta c)

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effec□ve Cohesion: 200 psf
Effec□ve Fric□on Angle: 29 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Reinforcements

EQ_EL47_W9.5xW4

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.5 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 9,730 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 9,730 lbf/ft

EQ_EL49_W9.5xW4

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.5 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 9,730 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 9,730 lbf/ft

EQ_EL51_W9.5xW4

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.5 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 9,730 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 9,730 lbf/ft

EQ_EL53_W9.5xW4

Type: Geosynthe□c
Interface Adhesion: 0 psf

Interface Shear Angle: 18.5 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 9,730 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 9,730 lbf/ft

EQ_EL55_W9.5xW4

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.5 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 9,730 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 9,730 lbf/ft

EQ_EL57_W9.5xW4

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.5 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 9,730 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 9,730 lbf/ft

EQ_EL59_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.5 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 9,730 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 9,730 lbf/ft

EQ_EL61_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 16 °
Surface Area Factor: 2

Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,091 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,091 lbf/ft

EQ_EL63_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 16 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,091 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,091 lbf/ft

EQ_EL65_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 16 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,091 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,091 lbf/ft

EQ_EL67_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 16 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,091 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,091 lbf/ft

EQ_EL69_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 16 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,091 lbf

Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,091 lbf/ft

EQ_EL71_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 16 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,091 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,091 lbf/ft

EQ_EL73_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 29.8 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,091 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,091 lbf/ft

EQ_EL75_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 29.8 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,091 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,091 lbf/ft

EQ_EL77_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 24.3 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 4,426 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No

Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 4,426 lbf/ft

EQ_EL79_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 24.3 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 4,426 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 4,426 lbf/ft

EQ_EL81_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 24.3 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 4,426 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 4,426 lbf/ft

EQ_EL83_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 24.3 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 4,426 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 4,426 lbf/ft

EQ_EL85_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 24.3 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 4,426 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes

Factored Tensile Capacity: 4,426 lbf/ft

EQ_EL87_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 24.3 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 4,426 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 4,426 lbf/ft

EQ_EL89_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 24.3 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 4,426 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 4,426 lbf/ft

EQ_EL91_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 24.3 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 4,426 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 4,426 lbf/ft

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (0.05, 60) ft
Left-Zone Right Coordinate: (119.5945, 91.79725) ft
Left-Zone Increment: 40
Right Type: Range
Right-Zone Left Coordinate: (160, 70.95212) ft
Right-Zone Right Coordinate: (170.15, 50) ft
Right-Zone Increment: 20
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 60) ft
Right Coordinate: (335, 48) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	0.25 ft	43.375 ft
Coordinate 2	56.5 ft	43.375 ft
Coordinate 3	97.75 ft	43.375 ft
Coordinate 4	123 ft	43.375 ft
Coordinate 5	159.75 ft	42.625 ft
Coordinate 6	192 ft	42.625 ft
Coordinate 7	210.75 ft	42.625 ft
Coordinate 8	298 ft	35 ft
Coordinate 9	335.25 ft	35 ft

Seismic Coefficients

Horz Seismic Coef.: 0.189

Reinforcement Lines

Reinforcement Line 1

Reinforcement: EQ_EL47_W9.5xW4
Lock to Ground Surface: No
Outside Point: (160, 47) ft
Inside Point: (128, 47) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 2

Reinforcement: EQ_EL49_W9.5xW4
Lock to Ground Surface: No
Outside Point: (160, 49) ft
Inside Point: (128, 49) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf

Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 3

Reinforcement: EQ_EL51_W9.5xW4
Lock to Ground Surface: No
Outside Point: (160, 51) ft
Inside Point: (128, 51) ft
Length: 32 ft
Orienta□on: 180 °
Slip Surface Intersec□on: (136.47126, 51) ft
Max. Pullout Force: 9,730 lbf
Available Length: 8.4712569 ft
Required Length: 2.8401803 ft
Pullout Force: 9,730 lbf
Pullout Force per Length: 3,425.8389 lbf/ft
Governing Component: Tensile Capacity

Reinforcement Line 4

Reinforcement: EQ_EL53_W9.5xW4
Lock to Ground Surface: No
Outside Point: (160, 53) ft
Inside Point: (128, 53) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 5

Reinforcement: EQ_EL55_W9.5xW4
Lock to Ground Surface: No
Outside Point: (160, 55) ft
Inside Point: (128, 55) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 6

Reinforcement: EQ_EL57_W9.5xW4
Lock to Ground Surface: No
Outside Point: (160, 57) ft
Inside Point: (128, 57) ft

Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 7

Reinforcement: EQ_EL59_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 59) ft
Inside Point: (128, 59) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 8

Reinforcement: EQ_EL61_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 61) ft
Inside Point: (128, 61) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 9

Reinforcement: EQ_EL63_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 63) ft
Inside Point: (128, 63) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 10

Reinforcement: EQ_EL65_W7.0xW3.5
Lock to Ground Surface: No

Outside Point: (160, 65) ft
Inside Point: (128, 65) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 11

Reinforcement: EQ_EL67_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 67) ft
Inside Point: (128, 67) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 12

Reinforcement: EQ_EL69_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 69) ft
Inside Point: (128, 69) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 13

Reinforcement: EQ_EL71_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 71) ft
Inside Point: (128, 71) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 14

Reinforcement: EQ_EL73_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 73) ft
Inside Point: (128, 73) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 15

Reinforcement: EQ_EL75_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 75) ft
Inside Point: (128, 75) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 16

Reinforcement: EQ_EL77_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 77) ft
Inside Point: (128, 77) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 17

Reinforcement: EQ_EL79_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 79) ft
Inside Point: (128, 79) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 18

Reinforcement: EQ_EL81_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 81) ft
Inside Point: (128, 81) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 19

Reinforcement: EQ_EL83_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 83) ft
Inside Point: (128, 83) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 20

Reinforcement: EQ_EL89_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 89) ft
Inside Point: (128, 89) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 21

Reinforcement: EQ_EL87_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 87) ft
Inside Point: (128, 87) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft

Governing Component: (none)

Reinforcement Line 22

Reinforcement: EQ_EL91_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 91) ft
Inside Point: (128, 91) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 23

Reinforcement: EQ_EL85_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 85) ft
Inside Point: (128, 85) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 125 pcf
Direc□on: Ver□cal

Coordinates

	X	Y
	120 ft	92 ft
	120 ft	93 ft
	160 ft	93 ft

Geometry

Name: Ga-Ga'

Se ngs

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	0 ft	56 ft
Point 2	76 ft	56 ft
Point 3	118 ft	35 ft
Point 4	160 ft	35 ft
Point 5	0 ft	46 ft
Point 6	37 ft	46 ft
Point 7	190 ft	50 ft
Point 8	160 ft	50 ft
Point 9	170.25 ft	34 ft
Point 10	240 ft	34 ft
Point 11	315 ft	30 ft
Point 12	335 ft	30 ft
Point 13	335 ft	48 ft
Point 14	327 ft	48 ft
Point 15	315 ft	49 ft
Point 16	224 ft	48 ft
Point 17	0 ft	0 ft
Point 18	335 ft	0 ft
Point 19	160 ft	92 ft
Point 20	120 ft	92 ft
Point 21	120 ft	72 ft
Point 22	80 ft	72 ft
Point 23	56 ft	60 ft
Point 24	0 ft	60 ft
Point 25	160 ft	47 ft
Point 26	120 ft	47 ft
Point 27	69 ft	66.5 ft
Point 28	160 ft	66.5 ft
Point 29	120 ft	66.5 ft
Point 30	160 ft	72 ft
Point 31	128 ft	47 ft
Point 32	128 ft	92 ft
Point 33	128 ft	66.5 ft
Point 34	128 ft	72 ft
Point 35	160 ft	64.5 ft
Point 36	160 ft	60.5 ft
Point 37	160 ft	56.5 ft
Point 38	160 ft	52.5 ft

Regions

	Material	Points	Area
Region 1	ESU 2C - Na□ve Silt (Pseudo-Sta□c)	5,6,2,1	565 ft²
Region 2	ESU 1A - Exis□ng Granular Fill (Pseudo-Sta□c)	19,32,34,30	640 ft²
Region 3	ESU 1A - Exis□ng Granular Fill (Pseudo-Sta□c)	20,22,21	400 ft²
Region 4	ESU 2A - Na□ve Sand and Gravel	6,2,3	619.5 ft²
Region 5	ESU 2B - Na□ve Sand and Gravel	7,16,15,14,13,12,11,10,9,4	2,595.4 ft²
Region 6	ESU 7A - Weathered Sandstone	18,17,5,6,3,4,9,10,11,12	12,178 ft²
Region 7	ESU 1B - Exis□ng Gravelly Granular Fill	8,7,25	45 ft²

Region 8	ESU 2A - Na□ve Sand and Gravel	4,7,25,31,26,2,3	945 ft²
Region 9	ESU 1B - Exis□ng Gravelly Granular Fill	21,22,27,29	250.25 ft²
Region 10	ESU 1B - Exis□ng Gravelly Granular Fill	23,24,1,2,26,29,27	1,051.8 ft²
Region 11	ESU 1B - Exis□ng Gravelly Granular Fill	26,31,33,29	156 ft²
Region 12	ESU 1B - Exis□ng Gravelly Granular Fill	29,33,34,21	44 ft²
Region 13	ESU 1B - Exis□ng Gravelly Granular Fill	25,8,38,37,36,35,28,33,31	624 ft²
Region 14	ESU 1B - Exis□ng Gravelly Granular Fill	28,30,34,33	176 ft²
Region 15	ESU 1A - Exis□ng Granular Fill (Pseudo-Sta□c)	20,21,34,32	160 ft²

Slip Results

Slip Surfaces Analysed: 1670 of 4305 converged

Current Slip Surface

Slip Surface: 3,042
Factor of Safety: 2.211
Volume: 2,322.0169 ft³
Weight: 284,313.8 lbf
Resis□ng Moment: 24,384,709 lbf·ft
Ac□va□ng Moment: 11,027,716 lbf·ft
Resis□ng Force: 211,877.63 lbf
Ac□va□ng Force: 95,803.04 lbf
Slip Rank: 1 of 4,305 slip surfaces
Exit: (170.15, 50) ft
Entry: (85.50319, 74.751595) ft
Radius: 111.51913 ft
Center: (156.57461, 160.68977) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Fric□onal Strength	Cohesive Strength	Suc□on Strength	Base Material
Slice 1	87.23564 ft	73.375797 ft	-1,872.0498 psf	127.60776 psf	107.07563 psf	50 psf	0 psf	ESU 1A - Exis□ng Granular Fill (Pseudo-Sta□c)
Slice 2	90.284847 ft	71.026497 ft	-1,725.4534 psf	355.70986 psf	277.911 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 3	92.918361 ft	69.137454 ft	-1,607.5771 psf	566.57094 psf	442.65373 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 4	95.551874 ft	67.360957 ft	-1,496.7237 psf	785.18411 psf	613.45306 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly

								Granular Fill
Slice 5	97.309315 ft	66.223528 ft	-1,425.7481 psf	936.21862 psf	731.45415 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 6	99.140625 ft	65.111415 ft	-1,356.3523 psf	1,095.5382 psf	855.92827 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 7	101.92188 ft	63.493834 ft	-1,255.4152 psf	1,346.2912 psf	1,051.8379 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 8	104.70312 ft	61.981118 ft	-1,161.0218 psf	1,606.1923 psf	1,254.895 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 9	107.48438 ft	60.568509 ft	-1,072.875 psf	1,875.6093 psf	1,465.3866 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 10	110.26562 ft	59.25182 ft	-990.71355 psf	2,155.0102 psf	1,683.6785 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 11	113.04688 ft	58.027355 ft	-914.30693 psf	2,444.9688 psf	1,910.219 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 12	115.82812 ft	56.891847 ft	-843.45125 psf	2,746.1725 psf	2,145.5451 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 13	118.60938 ft	55.842404 ft	-777.96598 psf	3,059.4355 psf	2,390.293 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 14	121.5 ft	54.841807 ft	-715.52873 psf	3,446.9194 psf	2,693.0286 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 15	124.25 ft	53.966153 ft	-662.47978 psf	3,660.643 psf	2,860.0078 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly

								Granular Fill
Slice 16	126.75 ft	53.240589 ft	-620.38828 psf	3,859.4431 psf	3,015.3274 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 17	129.44318 ft	52.531606 ft	-579.57741 psf	4,079.09 psf	3,186.9344 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 18	132.32955 ft	51.848108 ft	-540.60283 psf	4,322.2968 psf	3,376.9484 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 19	135.21591 ft	51.244987 ft	-506.6438 psf	4,964.8905 psf	3,878.9976 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 20	138.10227 ft	50.720921 ft	-477.61773 psf	5,244.1464 psf	4,097.1762 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 21	140.98864 ft	50.274781 ft	-453.45432 psf	5,536.2764 psf	4,325.4132 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 22	143.875 ft	49.905627 ft	-434.0948 psf	5,843.2228 psf	4,565.226 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 23	146.76136 ft	49.61269 ft	-419.49122 psf	6,167.2669 psf	4,818.397 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 24	149.64773 ft	49.395368 ft	-409.606 psf	6,511.087 psf	5,087.0187 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 25	152.53409 ft	49.253218 ft	-404.41154 psf	6,877.827 psf	5,373.5474 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 26	155.42045 ft	49.185952 ft	-403.88986 psf	7,271.1777 psf	5,680.8666 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly

								Granular Fill
Slice 27	158.30682 ft	49.193435 ft	-408.03251 psf	7,695.4725 psf	6,012.3621 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 28	159.875 ft	49.219558 ft	-411.50039 psf	14,199.846 psf	11,094.136 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 29	161.26875 ft	49.276715 ft	-415.06699 psf	126.64502 psf	98.945935 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 30	163.80625 ft	49.412624 ft	-423.54771 psf	108.73442 psf	84.952642 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 31	166.34375 ft	49.606656 ft	-435.65535 psf	77.200807 psf	60.315881 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 32	168.88125 ft	49.859118 ft	-451.40896 psf	29.405837 psf	22.974358 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill

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File Informa on

File Version: 11.01
Created By: Mikayla S. Hatch
Last Edited By: Mikayla S. Hatch
Revision Number: 324
Date: 11/12/2021
Time: 04:53:13 PM
Tool Version: 11.1
File Name: Wall 03.63L - Bridge 17.7 Ga-Ga' - All Condi ons.gsz
Directory: P:\0\0180366\01\Analysis\Bridge 17.7\SlopeW\
Last Solved Date: 11/12/2021
Last Solved Time: 04:54:42 PM

Project Se ngs

Unit System: U.S. Customary Units

Analysis Se ngs

2.4 Pseudo-Sta c (M&P)

Kind: SLOPE/W
Parent: 2. Compound Stability - 30 Years Corrosion
Analysis Type: Morgenstern-Price
Se ngs
Side Func on
Interslice force func on op on: Half-Sine
PWP Condi ons from: Piezometric Line
Apply Phrea c Correc on: No
Use Staged Rapid Drawdown: No
Unit Weight of Water: 62.4 pcf
Slip Surface
Direc on of movement: Le. to Right
Use Passive Mode: No
Slip Surface Op on: Entry and Exit
Cri cal slip surfaces saved: 1
Op mize Cri cal Slip Surface Loca on: No
Tension Crack Op on: (none)
Distribu on
F of S Calcula on Op on: Constant
Advanced
Geometry Se ngs
Minimum Slip Surface Depth: 2 ft
Number of Slices: 30
Factor of Safety Convergence Se ngs
Maximum Number of Itera ons: 100
Tolerable difference in F of S: 0.001

Solu□on Se□ ngs
Search Method: Root Finder
Tolerable difference between star□ng and converged F of S: 3
Maximum itera□ons to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

ESU 1A - Exis ng Granular Fill (Pseudo-Sta c)

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 50 psf
Effec□ve Fric□on Angle: 40 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2A - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 39 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2B - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 41 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 7A - Weathered Sandstone

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 43 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1B - Exis ng Gravelly Granular Fill

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2C - Na ve Silt (Pseudo-Sta c)

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effec□ve Cohesion: 200 psf
Effec□ve Fric□on Angle: 29 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Reinforcements

EQ_EL47_W9.5xW4

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.5 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 9,730 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 9,730 lbf/ft

EQ_EL49_W9.5xW4

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.5 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 9,730 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 9,730 lbf/ft

EQ_EL51_W9.5xW4

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.5 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 9,730 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 9,730 lbf/ft

EQ_EL53_W9.5xW4

Type: Geosynthe□c

Interface Adhesion: 0 psf
Interface Shear Angle: 18.5 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 9,730 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 9,730 lbf/ft

EQ_EL55_W9.5xW4

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.5 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 9,730 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 9,730 lbf/ft

EQ_EL57_W9.5xW4

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.5 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 9,730 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 9,730 lbf/ft

EQ_EL59_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.5 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 9,730 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 9,730 lbf/ft

EQ_EL61_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 16 °

Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,091 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,091 lbf/ft

EQ_EL63_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 16 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,091 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,091 lbf/ft

EQ_EL65_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 16 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,091 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,091 lbf/ft

EQ_EL67_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 16 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,091 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,091 lbf/ft

EQ_EL69_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 16 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1

Tensile Capacity: 7,091 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,091 lbf/ft

EQ_EL71_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 16 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,091 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,091 lbf/ft

EQ_EL73_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 29.8 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,091 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,091 lbf/ft

EQ_EL75_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 29.8 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,091 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,091 lbf/ft

EQ_EL77_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 24.3 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 4,426 lbf
Tensile Capacity Reduc□on Factor: 1

F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 4,426 lbf/ft

EQ_EL79_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 24.3 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 4,426 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 4,426 lbf/ft

EQ_EL81_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 24.3 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 4,426 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 4,426 lbf/ft

EQ_EL83_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 24.3 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 4,426 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 4,426 lbf/ft

EQ_EL85_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 24.3 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 4,426 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed

Face Anchorage: Yes
Factored Tensile Capacity: 4,426 lbf/ft

EQ_EL87_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 24.3 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 4,426 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 4,426 lbf/ft

EQ_EL89_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 24.3 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 4,426 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 4,426 lbf/ft

EQ_EL91_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 24.3 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 4,426 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 4,426 lbf/ft

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (0.05, 60) ft
Left-Zone Right Coordinate: (119.5945, 91.79725) ft
Left-Zone Increment: 40
Right Type: Range
Right-Zone Left Coordinate: (160, 70.95212) ft
Right-Zone Right Coordinate: (170.15, 50) ft
Right-Zone Increment: 20
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 60) ft
Right Coordinate: (335, 48) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	0.25 ft	43.375 ft
Coordinate 2	56.5 ft	43.375 ft
Coordinate 3	97.75 ft	43.375 ft
Coordinate 4	123 ft	43.375 ft
Coordinate 5	159.75 ft	42.625 ft
Coordinate 6	192 ft	42.625 ft
Coordinate 7	210.75 ft	42.625 ft
Coordinate 8	298 ft	35 ft
Coordinate 9	335.25 ft	35 ft

Seismic Coefficients

Horz Seismic Coef.: 0.189

Reinforcement Lines

Reinforcement Line 1

Reinforcement: EQ_EL47_W9.5xW4
Lock to Ground Surface: No
Outside Point: (160, 47) ft
Inside Point: (128, 47) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 2

Reinforcement: EQ_EL49_W9.5xW4
Lock to Ground Surface: No
Outside Point: (160, 49) ft
Inside Point: (128, 49) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf

Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 3

Reinforcement: EQ_EL51_W9.5xW4
Lock to Ground Surface: No
Outside Point: (160, 51) ft
Inside Point: (128, 51) ft
Length: 32 ft
Orienta□on: 180 °
Slip Surface Intersec□on: (136.47126, 51) ft
Max. Pullout Force: 9,730 lbf
Available Length: 8.4712569 ft
Required Length: 2.8401803 ft
Pullout Force: 9,730 lbf
Pullout Force per Length: 3,425.8389 lbf/ft
Governing Component: Tensile Capacity

Reinforcement Line 4

Reinforcement: EQ_EL53_W9.5xW4
Lock to Ground Surface: No
Outside Point: (160, 53) ft
Inside Point: (128, 53) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 5

Reinforcement: EQ_EL55_W9.5xW4
Lock to Ground Surface: No
Outside Point: (160, 55) ft
Inside Point: (128, 55) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 6

Reinforcement: EQ_EL57_W9.5xW4
Lock to Ground Surface: No
Outside Point: (160, 57) ft
Inside Point: (128, 57) ft

Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 7

Reinforcement: EQ_EL59_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 59) ft
Inside Point: (128, 59) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 8

Reinforcement: EQ_EL61_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 61) ft
Inside Point: (128, 61) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 9

Reinforcement: EQ_EL63_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 63) ft
Inside Point: (128, 63) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 10

Reinforcement: EQ_EL65_W7.0xW3.5
Lock to Ground Surface: No

Outside Point: (160, 65) ft
Inside Point: (128, 65) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 11

Reinforcement: EQ_EL67_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 67) ft
Inside Point: (128, 67) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 12

Reinforcement: EQ_EL69_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 69) ft
Inside Point: (128, 69) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 13

Reinforcement: EQ_EL71_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 71) ft
Inside Point: (128, 71) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 14

Reinforcement: EQ_EL73_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 73) ft
Inside Point: (128, 73) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 15

Reinforcement: EQ_EL75_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 75) ft
Inside Point: (128, 75) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 16

Reinforcement: EQ_EL77_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 77) ft
Inside Point: (128, 77) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 17

Reinforcement: EQ_EL79_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 79) ft
Inside Point: (128, 79) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 18

Reinforcement: EQ_EL81_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 81) ft
Inside Point: (128, 81) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 19

Reinforcement: EQ_EL83_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 83) ft
Inside Point: (128, 83) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 20

Reinforcement: EQ_EL89_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 89) ft
Inside Point: (128, 89) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 21

Reinforcement: EQ_EL87_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 87) ft
Inside Point: (128, 87) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft

Governing Component: (none)

Reinforcement Line 22

Reinforcement: EQ_EL91_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 91) ft
Inside Point: (128, 91) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 23

Reinforcement: EQ_EL85_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 85) ft
Inside Point: (128, 85) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 125 pcf
Direc□on: Ver□cal

Coordinates

	X	Y
	120 ft	92 ft
	120 ft	93 ft
	160 ft	93 ft

Geometry

Name: Ga-Ga'

Se ngs

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	0 ft	56 ft
Point 2	76 ft	56 ft
Point 3	118 ft	35 ft
Point 4	160 ft	35 ft
Point 5	0 ft	46 ft
Point 6	37 ft	46 ft
Point 7	190 ft	50 ft
Point 8	160 ft	50 ft
Point 9	170.25 ft	34 ft
Point 10	240 ft	34 ft
Point 11	315 ft	30 ft
Point 12	335 ft	30 ft
Point 13	335 ft	48 ft
Point 14	327 ft	48 ft
Point 15	315 ft	49 ft
Point 16	224 ft	48 ft
Point 17	0 ft	0 ft
Point 18	335 ft	0 ft
Point 19	160 ft	92 ft
Point 20	120 ft	92 ft
Point 21	120 ft	72 ft
Point 22	80 ft	72 ft
Point 23	56 ft	60 ft
Point 24	0 ft	60 ft
Point 25	160 ft	47 ft
Point 26	120 ft	47 ft
Point 27	69 ft	66.5 ft
Point 28	160 ft	66.5 ft
Point 29	120 ft	66.5 ft
Point 30	160 ft	72 ft
Point 31	128 ft	47 ft
Point 32	128 ft	92 ft
Point 33	128 ft	66.5 ft
Point 34	128 ft	72 ft
Point 35	160 ft	64.5 ft
Point 36	160 ft	60.5 ft
Point 37	160 ft	56.5 ft
Point 38	160 ft	52.5 ft

Regions

	Material	Points	Area
Region 1	ESU 2C - Na□ve Silt (Pseudo-Sta□c)	5,6,2,1	565 ft²
Region 2	ESU 1A - Exis□ng Granular Fill (Pseudo-Sta□c)	19,32,34,30	640 ft²
Region 3	ESU 1A - Exis□ng Granular Fill (Pseudo-Sta□c)	20,22,21	400 ft²
Region 4	ESU 2A - Na□ve Sand and Gravel	6,2,3	619.5 ft²
Region 5	ESU 2B - Na□ve Sand and Gravel	7,16,15,14,13,12,11,10,9,4	2,595.4 ft²
Region 6	ESU 7A - Weathered Sandstone	18,17,5,6,3,4,9,10,11,12	12,178 ft²
Region 7	ESU 1B - Exis□ng Gravelly Granular Fill	8,7,25	45 ft²

Region 8	ESU 2A - Na□ve Sand and Gravel	4,7,25,31,26,2,3	945 ft²
Region 9	ESU 1B - Exis□ng Gravelly Granular Fill	21,22,27,29	250.25 ft²
Region 10	ESU 1B - Exis□ng Gravelly Granular Fill	23,24,1,2,26,29,27	1,051.8 ft²
Region 11	ESU 1B - Exis□ng Gravelly Granular Fill	26,31,33,29	156 ft²
Region 12	ESU 1B - Exis□ng Gravelly Granular Fill	29,33,34,21	44 ft²
Region 13	ESU 1B - Exis□ng Gravelly Granular Fill	25,8,38,37,36,35,28,33,31	624 ft²
Region 14	ESU 1B - Exis□ng Gravelly Granular Fill	28,30,34,33	176 ft²
Region 15	ESU 1A - Exis□ng Granular Fill (Pseudo-Sta□c)	20,21,34,32	160 ft²

Slip Results

Slip Surfaces Analysed: 1909 of 4305 converged

Current Slip Surface

Slip Surface: 3,042
Factor of Safety: 2.211
Volume: 2,322.0169 ft³
Weight: 284,313.8 lbf
Resis□ng Moment: 24,379,052 lbf·ft
Ac□va□ng Moment: 11,027,716 lbf·ft
Resis□ng Force: 211,884.89 lbf
Ac□va□ng Force: 95,832.617 lbf
Slip Rank: 1 of 4,305 slip surfaces
Exit: (170.15, 50) ft
Entry: (85.50319, 74.751595) ft
Radius: 111.51913 ft
Center: (156.57461, 160.68977) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Fric□onal Strength	Cohesive Strength	Suc□on Strength	Base Material
Slice 1	87.23564 ft	73.375797 ft	-1,872.0498 psf	180.31797 psf	151.30474 psf	50 psf	0 psf	ESU 1A - Exis□ng Granular Fill (Pseudo-Sta□c)
Slice 2	90.284847 ft	71.026497 ft	-1,725.4534 psf	499.36281 psf	390.14499 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 3	92.918361 ft	69.137454 ft	-1,607.5771 psf	719.29603 psf	561.97565 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 4	95.551874 ft	67.360957 ft	-1,496.7237 psf	912.11818 psf	712.62483 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly

								Granular Fill
Slice 5	97.309315 ft	66.223528 ft	-1,425.7481 psf	1,031.9973 psf	806.28466 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 6	99.140625 ft	65.111415 ft	-1,356.3523 psf	1,148.5062 psf	897.31135 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 7	101.92188 ft	63.493834 ft	-1,255.4152 psf	1,322.8708 psf	1,033.5399 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 8	104.70312 ft	61.981118 ft	-1,161.0218 psf	1,498.7595 psf	1,170.9593 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 9	107.48438 ft	60.568509 ft	-1,072.875 psf	1,684.2349 psf	1,315.8685 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 10	110.26562 ft	59.25182 ft	-990.71355 psf	1,887.2346 psf	1,474.4693 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 11	113.04688 ft	58.027355 ft	-914.30693 psf	2,115.7465 psf	1,653.0023 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 12	115.82812 ft	56.891847 ft	-843.45125 psf	2,377.8426 psf	1,857.7742 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 13	118.60938 ft	55.842404 ft	-777.96598 psf	2,681.5335 psf	2,095.0436 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 14	121.5 ft	54.841807 ft	-715.52873 psf	3,100.6201 psf	2,422.4699 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 15	124.25 ft	53.966153 ft	-662.47978 psf	3,388.1768 psf	2,647.1338 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly

								Granular Fill
Slice 16	126.75 ft	53.240589 ft	-620.38828 psf	3,691.3137 psf	2,883.9703 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 17	129.44318 ft	52.531606 ft	-579.57741 psf	4,060.2934 psf	3,172.2489 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 18	132.32955 ft	51.848108 ft	-540.60283 psf	4,498.3529 psf	3,514.4985 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 19	135.21591 ft	51.244987 ft	-506.6438 psf	5,417.1031 psf	4,232.3048 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 20	138.10227 ft	50.720921 ft	-477.61773 psf	5,871.4685 psf	4,587.294 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 21	140.98864 ft	50.274781 ft	-453.45432 psf	6,286.4673 psf	4,911.5266 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 22	143.875 ft	49.905627 ft	-434.0948 psf	6,630.1126 psf	5,180.0117 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 23	146.76136 ft	49.61269 ft	-419.49122 psf	6,871.4901 psf	5,368.5964 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 24	149.64773 ft	49.395368 ft	-409.606 psf	6,986.1056 psf	5,458.1439 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 25	152.53409 ft	49.253218 ft	-404.41154 psf	6,960.9948 psf	5,438.5252 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 26	155.42045 ft	49.185952 ft	-403.88986 psf	6,797.9935 psf	5,311.1746 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly

								Granular Fill
Slice 27	158.30682 ft	49.193435 ft	-408.03251 psf	6,513.8657 psf	5,089.1896 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 28	159.875 ft	49.219558 ft	-411.50039 psf	8,317.5024 psf	6,498.3451 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 29	161.26875 ft	49.276715 ft	-415.06699 psf	111.67104 psf	87.246978 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 30	163.80625 ft	49.412624 ft	-423.54771 psf	86.376539 psf	67.484748 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 31	166.34375 ft	49.606656 ft	-435.65535 psf	55.207426 psf	43.132769 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 32	168.88125 ft	49.859118 ft	-451.40896 psf	19.005912 psf	14.849046 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill

4.1 Static (Spencer) Section Ga-Ga' - Construction Condition - Compound Stability

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File Informa on

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Project Se ngs

Unit System: U.S. Customary Units

Analysis Se ngs

4.1 Sta c (Spencer)

Kind: SLOPE/W
Parent: 4. Compound Stability
Analysis Type: Spencer
Se ngs
PWP Condi ons from: Piezometric Line
Apply Phrea c Correc on: No
Use Staged Rapid Drawdown: No
Unit Weight of Water: 62.4 pcf
Slip Surface
Direc on of movement: Le. to Right
Use Passive Mode: No
Slip Surface Op□on: Entry and Exit
Cri□cal slip surfaces saved: 1
Op□mize Cri□cal Slip Surface Loca□on: No
Tension Crack Op□on: (none)
Distribu□on
F of S Calcula□on Op□on: Constant
Advanced
Geometry Se□ ngs
Minimum Slip Surface Depth: 2 ft
Number of Slices: 30
Factor of Safety Convergence Se□ ngs
Maximum Number of Itera□ons: 100
Tolerable difference in F of S: 0.001
Solu□on Se□ ngs
Search Method: Root Finder

Tolerable difference between star□ng and converged F of S: 3
Maximum itera□ons to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

ESU 2A - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 39 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2B - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 41 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 7A - Weathered Sandstone

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 43 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2C - Na ve Silt

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 29 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1B - Exis ng Gravelly Granular Fill

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Reinforcements

Con_EL47_W9.5xW4

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 26.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,441 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,441 lbf/ft

Con_EL49_W9.5xW4

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 26.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,441 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,441 lbf/ft

Con_EL51_W9.5xW4

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 26.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,441 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,441 lbf/ft

Con_EL53_W9.5xW4

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 26.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,441 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,441 lbf/ft

Con_EL55_W9.5xW4

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 26.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,441 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,441 lbf/ft

Con_EL57_W9.5xW4

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 26.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,441 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,441 lbf/ft

Con_EL59_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 26.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,441 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,441 lbf/ft

Con_EL61_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 23.2 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,422 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,422 lbf/ft

Con_EL63_W7.0xW3.5

Type: Geosynthe□c

Interface Adhesion: 0 psf
Interface Shear Angle: 23.2 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,422 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,422 lbf/ft

Con_EL65_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 23.2 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,422 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,422 lbf/ft

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (0.05, 60) ft
Left-Zone Right Coordinate: (120, 66.5) ft
Left-Zone Increment: 40
Right Type: Range
Right-Zone Left Coordinate: (160, 66.5) ft
Right-Zone Right Coordinate: (165, 50) ft
Right-Zone Increment: 20
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 60) ft
Right Coordinate: (335, 48) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	0.25 ft	43.375 ft
Coordinate 2	56.5 ft	43.375 ft
Coordinate 3	97.75 ft	43.375 ft
Coordinate 4	123 ft	43.375 ft

Coordinate 5	159.75 ft	42.625 ft
Coordinate 6	192 ft	42.625 ft
Coordinate 7	210.75 ft	42.625 ft
Coordinate 8	298 ft	35 ft
Coordinate 9	335.25 ft	35 ft

Reinforcement Lines

Reinforcement Line 1

Reinforcement: Con_EL47_W9.5xW4
Lock to Ground Surface: No
Outside Point: (160, 47) ft
Inside Point: (128, 47) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 2

Reinforcement: Con_EL49_W9.5xW4
Lock to Ground Surface: No
Outside Point: (160, 49) ft
Inside Point: (128, 49) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 3

Reinforcement: Con_EL51_W9.5xW4
Lock to Ground Surface: No
Outside Point: (160, 51) ft
Inside Point: (128, 51) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 4

Reinforcement: Con_EL53_W9.5xW4

Lock to Ground Surface: No
Outside Point: (160, 53) ft
Inside Point: (128, 53) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 5

Reinforcement: Con_EL55_W9.5xW4
Lock to Ground Surface: No
Outside Point: (160, 55) ft
Inside Point: (128, 55) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 6

Reinforcement: Con_EL57_W9.5xW4
Lock to Ground Surface: No
Outside Point: (160, 57) ft
Inside Point: (128, 57) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 7

Reinforcement: Con_EL59_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 59) ft
Inside Point: (128, 59) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 8

Reinforcement: Con_EL61_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 61) ft
Inside Point: (128, 61) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 9

Reinforcement: Con_EL63_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 63) ft
Inside Point: (128, 63) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 10

Reinforcement: Con_EL65_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 65) ft
Inside Point: (128, 65) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Geometry

Name: Ga-Ga'

Se ngs

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	0 ft	56 ft

Point 2	76 ft	56 ft
Point 3	118 ft	35 ft
Point 4	160 ft	35 ft
Point 5	0 ft	46 ft
Point 6	37 ft	46 ft
Point 7	190 ft	50 ft
Point 8	160 ft	50 ft
Point 9	170.25 ft	34 ft
Point 10	240 ft	34 ft
Point 11	315 ft	30 ft
Point 12	335 ft	30 ft
Point 13	335 ft	48 ft
Point 14	327 ft	48 ft
Point 15	315 ft	49 ft
Point 16	224 ft	48 ft
Point 17	0 ft	0 ft
Point 18	335 ft	0 ft
Point 19	160 ft	92 ft
Point 20	120 ft	92 ft
Point 21	120 ft	72 ft
Point 22	80 ft	72 ft
Point 23	56 ft	60 ft
Point 24	0 ft	60 ft
Point 25	160 ft	47 ft
Point 26	120 ft	47 ft
Point 27	69 ft	66.5 ft
Point 28	160 ft	66.5 ft
Point 29	120 ft	66.5 ft
Point 30	160 ft	72 ft
Point 31	128 ft	47 ft
Point 32	128 ft	92 ft
Point 33	128 ft	66.5 ft
Point 34	128 ft	72 ft
Point 35	160 ft	64.5 ft
Point 36	160 ft	60.5 ft
Point 37	160 ft	56.5 ft
Point 38	160 ft	52.5 ft

Regions

	Material	Points	Area
Region 1	ESU 2C - Na□ve Silt	5,6,2,1	565 ft²
Region 2		19,32,34,30	640 ft²
Region 3		20,22,21	400 ft²
Region 4	ESU 2A - Na□ve Sand and Gravel	6,2,3	619.5 ft²
Region 5	ESU 2B - Na□ve Sand and Gravel	7,16,15,14,13,12,11,10,9,4	2,595.4 ft²
Region 6	ESU 7A - Weathered Sandstone	18,17,5,6,3,4,9,10,11,12	12,178 ft²
Region 7	ESU 1B - Exis□ng Gravelly Granular Fill	8,7,25	45 ft²
Region 8	ESU 2A - Na□ve Sand and Gravel	4,7,25,31,26,2,3	945 ft²
Region 9		21,22,27,29	250.25 ft²

Figure D.5-450

Region 10	ESU 1B - Exis□ng Gravelly Granular Fill	23,24,1,2,26,29,27	1,051.8 ft²
Region 11	ESU 1B - Exis□ng Gravelly Granular Fill	26,31,33,29	156 ft²
Region 12		29,33,34,21	44 ft²
Region 13	ESU 1B - Exis□ng Gravelly Granular Fill	25,8,38,37,36,35,28,33,31	624 ft²
Region 14		28,30,34,33	176 ft²
Region 15		20,21,34,32	160 ft²

Slip Results

Slip Surfaces Analysed: 928 of 4305 converged

Current Slip Surface

Slip Surface: 3,147
Factor of Safety: 5.849
Volume: 1,046.0791 ft³
Weight: 130,759.89 lbf
Resis□ng Moment: 9,734,020.1 lbf·ft
Ac□va□ng Moment: 1,664,057.9 lbf·ft
Resis□ng Force: 100,370.08 lbf
Ac□va□ng Force: 17,159.149 lbf
Slip Rank: 1 of 4,305 slip surfaces
Exit: (165, 50) ft
Entry: (86.591778, 66.5) ft
Radius: 94.235348 ft
Center: (143.36047, 141.71713) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Fric□onal Strength	Cohesive Strength	Suc□on Strength	Base Material
Slice 1	87.986556 ft	65.486829 ft	-1,379.7782 psf	105.71943 psf	82.597068 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 2	90.776112 ft	63.535542 ft	-1,258.0178 psf	313.60879 psf	245.01804 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 3	93.565667 ft	61.729135 ft	-1,145.2981 psf	511.29137 psf	399.4646 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 4	96.355222 ft	60.057974 ft	-1,041.0176 psf	698.92884 psf	546.06306 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 5	98.986111 ft	58.595208 ft	-949.741 psf	867.18671 psf	677.52051 psf	0 psf	0 psf	ESU 1B - Exis□ng

								Gravelly Granular Fill
Slice 6	101.45833 ft	57.321589 ft	-870.26715 psf	1,017.036 psf	794.59561 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 7	103.93056 ft	56.138333 ft	-796.43196 psf	1,159.3118 psf	905.75366 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 8	106.40278 ft	55.041734 ft	-728.0042 psf	1,294.092 psf	1,011.0555 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 9	108.875 ft	54.028538 ft	-664.78078 psf	1,421.4432 psf	1,110.5532 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 10	111.34722 ft	53.095882 ft	-606.58301 psf	1,541.4205 psf	1,204.2897 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 11	113.81944 ft	52.241243 ft	-553.25356 psf	1,654.067 psf	1,292.2988 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 12	116.29167 ft	51.462404 ft	-504.65401 psf	1,759.4138 psf	1,374.6047 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 13	118.76389 ft	50.757416 ft	-460.66275 psf	1,857.4797 psf	1,451.2222 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 14	121.5 ft	50.065382 ft	-417.47982 psf	1,957.0305 psf	1,528.9998 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 15	124.25 ft	49.448709 ft	-380.59128 psf	2,049.0812 psf	1,600.9177 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 16	126.75 ft	48.965953 ft	-353.65099 psf	2,124.4855 psf	1,659.83 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly

								Granular Fill
Slice 17	129.32292 ft	48.542786 ft	-330.52189 psf	2,194.1224 psf	1,714.2363 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 18	131.96875 ft	48.182357 ft	-311.4005 psf	2,257.5116 psf	1,763.7613 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 19	134.61458 ft	47.897914 ft	-297.02065 psf	2,312.3523 psf	1,806.6077 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 20	137.26042 ft	47.688767 ft	-287.33928 psf	2,358.5453 psf	1,842.6975 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 21	139.90625 ft	47.554414 ft	-282.32504 psf	2,395.9696 psf	1,871.9366 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 22	142.55208 ft	47.494535 ft	-281.95796 psf	2,424.4819 psf	1,894.2128 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 23	145.19792 ft	47.508987 ft	-286.22917 psf	2,443.9141 psf	1,909.395 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 24	147.84375 ft	47.597805 ft	-295.1408 psf	2,454.0716 psf	1,917.3309 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 25	150.48958 ft	47.7612 ft	-308.70604 psf	2,454.7305 psf	1,917.8457 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 26	153.13542 ft	47.999563 ft	-326.94924 psf	2,445.6344 psf	1,910.739 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 27	155.78125 ft	48.313467 ft	-349.90623 psf	2,426.4909 psf	1,895.7825 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly

								Granular Fill
Slice 28	158.42708 ft	48.703678 ft	-377.62479 psf	2,396.967 psf	1,872.7159 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 29	159.875 ft	48.940218 ft	-394.06962 psf	2,377.5727 psf	1,857.5634 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 30	161.25 ft	49.204185 ft	-410.54115 psf	108.30002 psf	84.61325 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 31	163.75 ft	49.722951 ft	-442.91213 psf	38.05849 psf	29.734551 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill

4.2 Static (M-P) Section Ga-Ga' - Construction Condition - Compound Stability

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File Informa on

File Version: 11.01
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Last Solved Date: 11/12/2021
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Project Se ngs

Unit System: U.S. Customary Units

Analysis Se ngs

4.2 Sta c (M-P)

Kind: SLOPE/W
Parent: 4. Compound Stability
Analysis Type: Morgenstern-Price
Se ngs
Side Func on
Interslice force func on op on: Half-Sine
PWP Condi ons from: Piezometric Line
Apply Phrea c Correc on: No
Use Staged Rapid Drawdown: No
Unit Weight of Water: 62.4 pcf
Slip Surface
Direc on of movement: Le. to Right
Use Passive Mode: No
Slip Surface Op on: Entry and Exit
Cri cal slip surfaces saved: 1
Op mize Cri cal Slip Surface Loca on: No
Tension Crack Op on: (none)
Distribu on
F of S Calcula on Op on: Constant
Advanced
Geometry Se ngs
Minimum Slip Surface Depth: 2 ft
Number of Slices: 30
Factor of Safety Convergence Se ngs
Maximum Number of Itera ons: 100
Tolerable difference in F of S: 0.001

Solu□on Se□ ngs
Search Method: Root Finder
Tolerable difference between star□ng and converged F of S: 3
Maximum itera□ons to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

ESU 2A - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 39 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2B - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 41 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 7A - Weathered Sandstone

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 43 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2C - Na ve Silt

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 29 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1B - Exis ng Gravelly Granular Fill

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Reinforcements

Con_EL47_W9.5xW4

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 26.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,441 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,441 lbf/ft

Con_EL49_W9.5xW4

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 26.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,441 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,441 lbf/ft

Con_EL51_W9.5xW4

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 26.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,441 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,441 lbf/ft

Con_EL53_W9.5xW4

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 26.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,441 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,441 lbf/ft

Con_EL55_W9.5xW4

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 26.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,441 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,441 lbf/ft

Con_EL57_W9.5xW4

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 26.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,441 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,441 lbf/ft

Con_EL59_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 26.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,441 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,441 lbf/ft

Con_EL61_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 23.2 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,422 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,422 lbf/ft

Con_EL63_W7.0xW3.5

Type: Geosynthe□c

Interface Adhesion: 0 psf
Interface Shear Angle: 23.2 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,422 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,422 lbf/ft

Con_EL65_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 23.2 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,422 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,422 lbf/ft

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (0.05, 60) ft
Left-Zone Right Coordinate: (120, 66.5) ft
Left-Zone Increment: 40
Right Type: Range
Right-Zone Left Coordinate: (160, 66.5) ft
Right-Zone Right Coordinate: (165, 50) ft
Right-Zone Increment: 20
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 60) ft
Right Coordinate: (335, 48) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	0.25 ft	43.375 ft
Coordinate 2	56.5 ft	43.375 ft
Coordinate 3	97.75 ft	43.375 ft
Coordinate 4	123 ft	43.375 ft

Coordinate 5	159.75 ft	42.625 ft
Coordinate 6	192 ft	42.625 ft
Coordinate 7	210.75 ft	42.625 ft
Coordinate 8	298 ft	35 ft
Coordinate 9	335.25 ft	35 ft

Reinforcement Lines

Reinforcement Line 1

Reinforcement: Con_EL47_W9.5xW4
Lock to Ground Surface: No
Outside Point: (160, 47) ft
Inside Point: (128, 47) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 2

Reinforcement: Con_EL49_W9.5xW4
Lock to Ground Surface: No
Outside Point: (160, 49) ft
Inside Point: (128, 49) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 3

Reinforcement: Con_EL51_W9.5xW4
Lock to Ground Surface: No
Outside Point: (160, 51) ft
Inside Point: (128, 51) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 4

Reinforcement: Con_EL53_W9.5xW4

Lock to Ground Surface: No
Outside Point: (160, 53) ft
Inside Point: (128, 53) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 5

Reinforcement: Con_EL55_W9.5xW4
Lock to Ground Surface: No
Outside Point: (160, 55) ft
Inside Point: (128, 55) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 6

Reinforcement: Con_EL57_W9.5xW4
Lock to Ground Surface: No
Outside Point: (160, 57) ft
Inside Point: (128, 57) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 7

Reinforcement: Con_EL59_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 59) ft
Inside Point: (128, 59) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 8

Reinforcement: Con_EL61_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 61) ft
Inside Point: (128, 61) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 9

Reinforcement: Con_EL63_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 63) ft
Inside Point: (128, 63) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 10

Reinforcement: Con_EL65_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 65) ft
Inside Point: (128, 65) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Geometry

Name: Ga-Ga'

Se ngs

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	0 ft	56 ft

Point 2	76 ft	56 ft
Point 3	118 ft	35 ft
Point 4	160 ft	35 ft
Point 5	0 ft	46 ft
Point 6	37 ft	46 ft
Point 7	190 ft	50 ft
Point 8	160 ft	50 ft
Point 9	170.25 ft	34 ft
Point 10	240 ft	34 ft
Point 11	315 ft	30 ft
Point 12	335 ft	30 ft
Point 13	335 ft	48 ft
Point 14	327 ft	48 ft
Point 15	315 ft	49 ft
Point 16	224 ft	48 ft
Point 17	0 ft	0 ft
Point 18	335 ft	0 ft
Point 19	160 ft	92 ft
Point 20	120 ft	92 ft
Point 21	120 ft	72 ft
Point 22	80 ft	72 ft
Point 23	56 ft	60 ft
Point 24	0 ft	60 ft
Point 25	160 ft	47 ft
Point 26	120 ft	47 ft
Point 27	69 ft	66.5 ft
Point 28	160 ft	66.5 ft
Point 29	120 ft	66.5 ft
Point 30	160 ft	72 ft
Point 31	128 ft	47 ft
Point 32	128 ft	92 ft
Point 33	128 ft	66.5 ft
Point 34	128 ft	72 ft
Point 35	160 ft	64.5 ft
Point 36	160 ft	60.5 ft
Point 37	160 ft	56.5 ft
Point 38	160 ft	52.5 ft

Regions

	Material	Points	Area
Region 1	ESU 2C - Na□ve Silt	5,6,2,1	565 ft²
Region 2		19,32,34,30	640 ft²
Region 3		20,22,21	400 ft²
Region 4	ESU 2A - Na□ve Sand and Gravel	6,2,3	619.5 ft²
Region 5	ESU 2B - Na□ve Sand and Gravel	7,16,15,14,13,12,11,10,9,4	2,595.4 ft²
Region 6	ESU 7A - Weathered Sandstone	18,17,5,6,3,4,9,10,11,12	12,178 ft²
Region 7	ESU 1B - Exis□ng Gravelly Granular Fill	8,7,25	45 ft²
Region 8	ESU 2A - Na□ve Sand and Gravel	4,7,25,31,26,2,3	945 ft²
Region 9		21,22,27,29	250.25 ft²

Region 10	ESU 1B - Exis□ng Gravelly Granular Fill	23,24,1,2,26,29,27	1,051.8 ft²
Region 11	ESU 1B - Exis□ng Gravelly Granular Fill	26,31,33,29	156 ft²
Region 12		29,33,34,21	44 ft²
Region 13	ESU 1B - Exis□ng Gravelly Granular Fill	25,8,38,37,36,35,28,33,31	624 ft²
Region 14		28,30,34,33	176 ft²
Region 15		20,21,34,32	160 ft²

Slip Results

Slip Surfaces Analysed: 947 of 4305 converged

Current Slip Surface

Slip Surface: 3,147
Factor of Safety: 5.849
Volume: 1,046.0791 ft³
Weight: 130,759.89 lbf
Resis□ng Moment: 9,733,765.9 lbf·ft
Ac□va□ng Moment: 1,664,057.9 lbf·ft
Resis□ng Force: 100,370.03 lbf
Ac□va□ng Force: 17,159.534 lbf
Slip Rank: 1 of 4,305 slip surfaces
Exit: (165, 50) ft
Entry: (86.591778, 66.5) ft
Radius: 94.235348 ft
Center: (143.36047, 141.71713) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Fric□onal Strength	Cohesive Strength	Suc□on Strength	Base Material
Slice 1	87.986556 ft	65.486829 ft	-1,379.7782 psf	114.01597 psf	89.07904 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 2	90.776112 ft	63.535542 ft	-1,258.0178 psf	331.04018 psf	258.63693 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 3	93.565667 ft	61.729135 ft	-1,145.2981 psf	529.15115 psf	413.41818 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 4	96.355222 ft	60.057974 ft	-1,041.0176 psf	711.42379 psf	555.82518 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 5	98.986111 ft	58.595208 ft	-949.741 psf	871.518 psf	680.90449 psf	0 psf	0 psf	ESU 1B - Exis□ng

								Gravelly Granular Fill
Slice 6	101.45833 ft	57.321589 ft	-870.26715 psf	1,012.4746 psf	791.03184 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 7	103.93056 ft	56.138333 ft	-796.43196 psf	1,145.8878 psf	895.2657 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 8	106.40278 ft	55.041734 ft	-728.0042 psf	1,272.7744 psf	994.40035 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 9	108.875 ft	54.028538 ft	-664.78078 psf	1,393.9297 psf	1,089.0573 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 10	111.34722 ft	53.095882 ft	-606.58301 psf	1,509.9368 psf	1,179.6919 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 11	113.81944 ft	52.241243 ft	-553.25356 psf	1,621.1728 psf	1,266.599 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 12	116.29167 ft	51.462404 ft	-504.65401 psf	1,727.8152 psf	1,349.9172 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 13	118.76389 ft	50.757416 ft	-460.66275 psf	1,829.8474 psf	1,429.6335 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 14	121.5 ft	50.065382 ft	-417.47982 psf	1,936.6777 psf	1,513.0984 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 15	124.25 ft	49.448709 ft	-380.59128 psf	2,038.4821 psf	1,592.6367 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 16	126.75 ft	48.965953 ft	-353.65099 psf	2,124.3325 psf	1,659.7104 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly

								Granular Fill
Slice 17	129.32292 ft	48.542786 ft	-330.52189 psf	2,205.4824 psf	1,723.1117 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 18	131.96875 ft	48.182357 ft	-311.4005 psf	2,280.5758 psf	1,781.7811 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 19	134.61458 ft	47.897914 ft	-297.02065 psf	2,345.9208 psf	1,832.8342 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 20	137.26042 ft	47.688767 ft	-287.33928 psf	2,400.2974 psf	1,875.3179 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 21	139.90625 ft	47.554414 ft	-282.32504 psf	2,442.4797 psf	1,908.2743 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 22	142.55208 ft	47.494535 ft	-281.95796 psf	2,471.3001 psf	1,930.7913 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 23	145.19792 ft	47.508987 ft	-286.22917 psf	2,485.7173 psf	1,942.0552 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 24	147.84375 ft	47.597805 ft	-295.1408 psf	2,484.881 psf	1,941.4018 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 25	150.48958 ft	47.7612 ft	-308.70604 psf	2,468.1902 psf	1,928.3615 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 26	153.13542 ft	47.999563 ft	-326.94924 psf	2,435.3384 psf	1,902.6949 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 27	155.78125 ft	48.313467 ft	-349.90623 psf	2,386.3418 psf	1,864.4145 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly

								Granular Fill
Slice 28	158.42708 ft	48.703678 ft	-377.62479 psf	2,321.5466 psf	1,813.791 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 29	159.875 ft	48.940218 ft	-394.06962 psf	2,281.0299 psf	1,782.1359 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 30	161.25 ft	49.204185 ft	-410.54115 psf	103.82696 psf	81.118511 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 31	163.75 ft	49.722951 ft	-442.91213 psf	35.961462 psf	28.096174 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill

6.1 Static (Spencer) Section Ga-Ga' - Final Condition - Compound Stability

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File Informa on

File Version: 11.01
Created By: Mikayla S. Hatch
Last Edited By: Mikayla S. Hatch
Revision Number: 323
Date: 11/12/2021
Time: 04:47:21 PM
Tool Version: 11.1
File Name: Wall 03.63L - Bridge 17.7 Ga-Ga' - All Condi ons.gsz
Directory: P:\0\0180366\01\Analysis\Bridge 17.7\SlopeW\
Last Solved Date: 11/12/2021
Last Solved Time: 04:48:44 PM

Project Se ngs

Unit System: U.S. Customary Units

Analysis Se ngs

6.1 Sta c (Spencer)

Kind: SLOPE/W
Parent: 6. Compound Stability
Analysis Type: Spencer
Se ngs
PWP Condi ons from: Piezometric Line
Apply Phrea c Correc on: No
Use Staged Rapid Drawdown: No
Unit Weight of Water: 62.4 pcf
Slip Surface
Direc on of movement: Le. to Right
Use Passive Mode: No
Slip Surface Op□on: Entry and Exit
Cri□cal slip surfaces saved: 1
Op□mize Cri□cal Slip Surface Loca□on: No
Tension Crack Op□on: (none)
Distribu□on
F of S Calcula□on Op□on: Constant
Advanced
Geometry Se□ ngs
Minimum Slip Surface Depth: 2 ft
Number of Slices: 30
Factor of Safety Convergence Se□ ngs
Maximum Number of Itera□ons: 100
Tolerable difference in F of S: 0.001
Solu□on Se□ ngs
Search Method: Root Finder

Tolerable difference between star□ng and converged F of S: 3
Maximum itera□ons to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Gravel Borrow

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2A - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 39 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2B - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 41 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 7A - Weathered Sandstone

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 43 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2C - Na ve Silt

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 29 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1B - Exis ng Gravelly Granular Fill

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Common Borrow

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Reinforcements

EL67_W7.0xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 11.5 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 4,901 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 4,901 lbf/ft

EL69_W7.0xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 11.5 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 4,901 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 4,901 lbf/ft

EL71_W7.0xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 11.5 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 4,901 lbf

Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 4,901 lbf/ft

EL73_W7.0xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 22.2 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 4,901 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 4,901 lbf/ft

EL75_W7.0xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 22.2 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 4,901 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 4,901 lbf/ft

EL77_W4.5xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 17.6 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 2,975 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 2,975 lbf/ft

EL79_W4.5xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 17.6 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 2,975 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No

Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 2,975 lbf/ft

EL81_W4.5xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 17.6 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 2,975 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 2,975 lbf/ft

EL83_W4.5xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 17.6 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 2,975 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 2,975 lbf/ft

EL85_W4.5xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 17.6 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 2,975 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 2,975 lbf/ft

EL87_W4.5xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 17.6 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 2,975 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes

Factored Tensile Capacity: 2,975 lbf/ft

EL89_W4.5xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 17.6 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 2,975 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 2,975 lbf/ft

EL91_W4.5xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 17.6 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 2,975 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 2,975 lbf/ft

Soil Nail_Row 1

Type: Anchor
Pullout Resistance: 1,800 psf
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 82,550 lbf
Tensile Capacity Reduc□on Factor: 1
Shear Force: 0 lbf
Shear Force Reduc□on Factor: 1
Apply Shear: Parallel to Slip
F of S Dependent: No
Force Distribu□on: Distributed
Bond Length: 45 ft
Bond Diameter: 0.5 ft
Out-of-Plane Spacing: 4 ft
Face Anchorage: Yes
Factored Pullout Resistance: 706.86 lbf/ft/ft
Factored Tensile Capacity: 20,638 lbf/ft

Soil Nail_Row 2

Type: Anchor
Pullout Resistance: 1,800 psf
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 82,550 lbf
Tensile Capacity Reduc□on Factor: 1
Shear Force: 0 lbf
Shear Force Reduc□on Factor: 1

Apply Shear: Parallel to Slip
F of S Dependent: No
Force Distribu□on: Distributed
Bond Length: 45 ft
Bond Diameter: 0.5 ft
Out-of-Plane Spacing: 4 ft
Face Anchorage: Yes
Factored Pullout Resistance: 706.86 lbf/ft/ft
Factored Tensile Capacity: 20,638 lbf/ft

Soil Nail_Row 3

Type: Anchor
Pullout Resistance: 1,800 psf
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 82,550 lbf
Tensile Capacity Reduc□on Factor: 1
Shear Force: 0 lbf
Shear Force Reduc□on Factor: 1
Apply Shear: Parallel to Slip
F of S Dependent: No
Force Distribu□on: Distributed
Bond Length: 40 ft
Bond Diameter: 0.5 ft
Out-of-Plane Spacing: 4 ft
Face Anchorage: Yes
Factored Pullout Resistance: 706.86 lbf/ft/ft
Factored Tensile Capacity: 20,638 lbf/ft

Soil Nail_Row 4

Type: Anchor
Pullout Resistance: 1,800 psf
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 82,550 lbf
Tensile Capacity Reduc□on Factor: 1
Shear Force: 0 lbf
Shear Force Reduc□on Factor: 1
Apply Shear: Parallel to Slip
F of S Dependent: No
Force Distribu□on: Distributed
Bond Length: 40 ft
Bond Diameter: 0.5 ft
Out-of-Plane Spacing: 4 ft
Face Anchorage: Yes
Factored Pullout Resistance: 706.86 lbf/ft/ft
Factored Tensile Capacity: 20,638 lbf/ft

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (0.05, 60) ft
Left-Zone Right Coordinate: (119.5945, 91.79725) ft
Left-Zone Increment: 40
Right Type: Range
Right-Zone Left Coordinate: (160, 85.4) ft

Figure D.5-474

Right-Zone Right Coordinate: (160, 63.1) ft
Right-Zone Increment: 20
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 60) ft
Right Coordinate: (335, 48) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	0.25 ft	43.375 ft
Coordinate 2	56.5 ft	43.375 ft
Coordinate 3	97.75 ft	43.375 ft
Coordinate 4	123 ft	43.375 ft
Coordinate 5	159.75 ft	42.625 ft
Coordinate 6	192 ft	42.625 ft
Coordinate 7	210.75 ft	42.625 ft
Coordinate 8	298 ft	35 ft
Coordinate 9	335.25 ft	35 ft

Reinforcement Lines

Reinforcement Line 1

Reinforcement: EL67_W7.0xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 67) ft
Inside Point: (128, 67) ft
Length: 32 ft
Orienta□on: 180 °
Slip Surface Intersec□on: (148.80714, 67) ft
Max. Pullout Force: 4,901 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 2

Reinforcement: EL69_W7.0xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 69) ft
Inside Point: (128, 69) ft
Length: 32 ft
Orienta□on: 180 °

Slip Surface Intersec□on: (141.52787, 69) ft
Max. Pullout Force: 4,901 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 3

Reinforcement: EL71_W7.0xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 71) ft
Inside Point: (128, 71) ft
Length: 32 ft
Orienta□on: 180 °
Slip Surface Intersec□on: (136.11873, 71) ft
Max. Pullout Force: 4,901 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 4

Reinforcement: EL73_W7.0xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 73) ft
Inside Point: (128, 73) ft
Length: 32 ft
Orienta□on: 180 °
Slip Surface Intersec□on: (131.66025, 73) ft
Max. Pullout Force: 4,901 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 5

Reinforcement: EL75_W7.0xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 75) ft
Inside Point: (128, 75) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 6

Reinforcement: EL77_W4.5xW3.5 (45 yrs)

Lock to Ground Surface: No
Outside Point: (160, 77) ft
Inside Point: (128, 77) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 7

Reinforcement: EL79_W4.5xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 79) ft
Inside Point: (128, 79) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 8

Reinforcement: EL81_W4.5xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 81) ft
Inside Point: (128, 81) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 9

Reinforcement: EL83_W4.5xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 83) ft
Inside Point: (128, 83) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 10

Reinforcement: EL85_W4.5xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 85) ft
Inside Point: (128, 85) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 11

Reinforcement: EL89_W4.5xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 89) ft
Inside Point: (128, 89) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 12

Reinforcement: EL87_W4.5xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 87) ft
Inside Point: (128, 87) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 13

Reinforcement: EL91_W4.5xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 91) ft
Inside Point: (128, 91) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft

Governing Component: (none)

Reinforcement Line 14

Reinforcement: Soil Nail_Row 1
Lock to Ground Surface: Yes
Outside Point: (160, 64.5) ft
Inside Point: (115.68365, 56.685832) ft
Length: 45.000001 ft
Orienta□on: -170 °
Max. Pullout Force: 0 lbf
Bond Length: 45 ft
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 15

Reinforcement: Soil Nail_Row 2
Lock to Ground Surface: Yes
Outside Point: (160, 60.5) ft
Inside Point: (115.68365, 52.685832) ft
Length: 45.000001 ft
Orienta□on: -170 °
Max. Pullout Force: 0 lbf
Bond Length: 45 ft
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 16

Reinforcement: Soil Nail_Row 3
Lock to Ground Surface: Yes
Outside Point: (160, 56.5) ft
Inside Point: (120.60769, 49.554073) ft
Length: 40 ft
Orienta□on: -170 °
Max. Pullout Force: 0 lbf
Bond Length: 40 ft
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 17

Reinforcement: Soil Nail_Row 4
Lock to Ground Surface: Yes
Outside Point: (160, 52.5) ft
Inside Point: (120.60769, 45.554073) ft
Length: 40 ft
Orienta□on: -170 °

Max. Pullout Force: 0 lbf
Bond Length: 40 ft
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 250 pcf
Direc□on: Ver□cal

Coordinates

	X	Y
	120 ft	93 ft
	128 ft	93 ft

Surcharge Load 2

Surcharge (Unit Weight): 250 pcf
Direc□on: Ver□cal

Coordinates

	X	Y
	128 ft	93.75 ft
	160 ft	93.75 ft

Geometry

Name: Ga-Ga'

Se ngs

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	0 ft	56 ft
Point 2	76 ft	56 ft
Point 3	118 ft	35 ft
Point 4	160 ft	35 ft
Point 5	0 ft	46 ft
Point 6	37 ft	46 ft
Point 7	190 ft	50 ft
Point 8	160 ft	50 ft
Point 9	170.25 ft	34 ft
Point 10	240 ft	34 ft
Point 11	315 ft	30 ft

Point 12	335 ft	30 ft
Point 13	335 ft	48 ft
Point 14	327 ft	48 ft
Point 15	315 ft	49 ft
Point 16	224 ft	48 ft
Point 17	0 ft	0 ft
Point 18	335 ft	0 ft
Point 19	160 ft	92 ft
Point 20	120 ft	92 ft
Point 21	120 ft	72 ft
Point 22	80 ft	72 ft
Point 23	56 ft	60 ft
Point 24	0 ft	60 ft
Point 25	160 ft	47 ft
Point 26	120 ft	47 ft
Point 27	69 ft	66.5 ft
Point 28	160 ft	66.5 ft
Point 29	120 ft	66.5 ft
Point 30	160 ft	72 ft
Point 31	128 ft	47 ft
Point 32	128 ft	92 ft
Point 33	128 ft	66.5 ft
Point 34	128 ft	72 ft
Point 35	160 ft	64.5 ft
Point 36	160 ft	60.5 ft
Point 37	160 ft	56.5 ft
Point 38	160 ft	52.5 ft

Regions

	Material	Points	Area
Region 1	ESU 2C - Na□ve Silt	5,6,2,1	565 ft²
Region 2	Gravel Borrow	19,32,34,30	640 ft²
Region 3	Common Borrow	20,22,21	400 ft²
Region 4	ESU 2A - Na□ve Sand and Gravel	6,2,3	619.5 ft²
Region 5	ESU 2B - Na□ve Sand and Gravel	7,16,15,14,13,12,11,10,9,4	2,595.4 ft²
Region 6	ESU 7A - Weathered Sandstone	18,17,5,6,3,4,9,10,11,12	12,178 ft²
Region 7	ESU 1B - Exis□ng Gravelly Granular Fill	8,7,25	45 ft²
Region 8	ESU 2A - Na□ve Sand and Gravel	4,7,25,31,26,2,3	945 ft²
Region 9	Common Borrow	21,22,27,29	250.25 ft²
Region 10	ESU 1B - Exis□ng Gravelly Granular Fill	23,24,1,2,26,29,27	1,051.8 ft²
Region 11	ESU 1B - Exis□ng Gravelly Granular Fill	26,31,33,29	156 ft²
Region 12	Common Borrow	29,33,34,21	44 ft²
Region 13	ESU 1B - Exis□ng Gravelly Granular Fill	25,8,38,37,36,35,28,33,31	624 ft²
Region 14	Gravel Borrow	28,30,34,33	176 ft²
Region 15	Common Borrow	20,21,34,32	160 ft²

Slip Results

Slip Surfaces Analysed: 481 of 4305 converged

Current Slip Surface

Slip Surface: 3,977
Factor of Safety: 4.254
Volume: 913.12366 ft³
Weight: 116,950.65 lbf
Resisting Moment: 7,936,784.2 lbf·ft
Activating Moment: 1,866,031.3 lbf·ft
Resisting Force: 95,322.351 lbf
Activating Force: 22,407.278 lbf
Slip Rank: 1 of 4,305 slip surfaces
Exit: (160, 65.33) ft
Entry: (111.07167, 87.535836) ft
Radius: 78.191138 ft
Center: (165.88285, 143.29952) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength	Suction Strength	Base Material
Slice 1	111.96451 ft	86.685515 ft	-2,702.5762 psf	116.08492 psf	72.537911 psf	0 psf	0 psf	Common Borrow
Slice 2	113.75017 ft	85.036307 ft	-2,599.6655 psf	349.59135 psf	218.44892 psf	0 psf	0 psf	Common Borrow
Slice 3	115.53584 ft	83.485894 ft	-2,502.9198 psf	581.35234 psf	363.26926 psf	0 psf	0 psf	Common Borrow
Slice 4	117.3215 ft	82.026759 ft	-2,411.8698 psf	811.18489 psf	506.88458 psf	0 psf	0 psf	Common Borrow
Slice 5	119.10717 ft	80.652512 ft	-2,326.1167 psf	1,038.9569 psf	649.21235 psf	0 psf	0 psf	Common Borrow
Slice 6	120.75 ft	79.45568 ft	-2,251.4344 psf	1,411.7633 psf	882.16762 psf	0 psf	0 psf	Common Borrow
Slice 7	122.25 ft	78.421086 ft	-2,186.8758 psf	1,528.3526 psf	955.0207 psf	0 psf	0 psf	Common Borrow
Slice 8	123.83333 ft	77.385069 ft	-2,123.2896 psf	1,647.8009 psf	1,029.6603 psf	0 psf	0 psf	Common Borrow
Slice 9	125.5 ft	76.350793 ft	-2,060.8732 psf	1,769.8902 psf	1,105.9501 psf	0 psf	0 psf	Common Borrow
Slice 10	127.16667 ft	75.373157 ft	-2,001.9911 psf	1,888.1247 psf	1,179.8313 psf	0 psf	0 psf	Common Borrow
Slice 11	128.7232 ft	74.507524 ft	-1,949.9578 psf	2,282.3593 psf	1,783.1745 psf	0 psf	0 psf	Gravel Borrow
Slice 12	130.16961 ft	73.745533 ft	-1,904.2515 psf	2,388.9867 psf	1,866.4809 psf	0 psf	0 psf	Gravel Borrow
Slice 13	131.61601 ft	73.02157 ft	-1,860.9182 psf	2,530.83 psf	1,977.3011 psf	0 psf	0 psf	Gravel Borrow
Slice 14	133.06242 ft	72.334472 ft	-1,819.8852 psf	2,632.0221 psf	2,056.361 psf	0 psf	0 psf	Gravel Borrow
Slice 15	134.57702 ft	71.654191 ft	-1,779.3645 psf	2,731.4575 psf	2,134.0485 psf	0 psf	0 psf	Gravel Borrow
Slice 16	136.15984 ft	70.983103 ft	-1,739.5043 psf	2,878.1855 psf	2,248.685 psf	0 psf	0 psf	Gravel Borrow
Slice	137.74265	70.352531	-1,702.1722	2,979.3514	2,327.7244	0 psf	0 psf	Gravel

17	ft	ft	psf	psf	psf			Borrow
Slice 18	139.32546 ft	69.761429 ft	-1,667.3032 psf	3,077.1358 psf	2,404.1219 psf	0 psf	0 psf	Gravel Borrow
Slice 19	140.90827 ft	69.208855 ft	-1,634.8382 psf	3,225.4848 psf	2,520.0249 psf	0 psf	0 psf	Gravel Borrow
Slice 20	142.49108 ft	68.69395 ft	-1,604.7238 psf	3,317.0499 psf	2,591.5634 psf	0 psf	0 psf	Gravel Borrow
Slice 21	144.07389 ft	68.21594 ft	-1,576.9116 psf	3,405.2659 psf	2,660.4853 psf	0 psf	0 psf	Gravel Borrow
Slice 22	145.6567 ft	67.774123 ft	-1,551.3579 psf	3,490.1381 psf	2,726.7948 psf	0 psf	0 psf	Gravel Borrow
Slice 23	147.23951 ft	67.367868 ft	-1,528.0232 psf	3,571.6685 psf	2,790.4933 psf	0 psf	0 psf	Gravel Borrow
Slice 24	148.82233 ft	66.996606 ft	-1,506.8721 psf	3,741.5907 psf	2,923.2511 psf	0 psf	0 psf	Gravel Borrow
Slice 25	150.40514 ft	66.659828 ft	-1,487.8729 psf	3,817.2545 psf	2,982.366 psf	0 psf	0 psf	Gravel Borrow
Slice 26	152.05189 ft	66.346267 ft	-1,470.4037 psf	3,873.8668 psf	3,026.5964 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 27	153.76258 ft	66.058318 ft	-1,454.6142 psf	3,946.5058 psf	3,083.3483 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 28	155.47327 ft	65.809199 ft	-1,441.2478 psf	4,015.3607 psf	3,137.1436 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 29	157.18396 ft	65.598539 ft	-1,430.281 psf	4,080.4109 psf	3,187.9664 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 30	158.89465 ft	65.426023 ft	-1,421.6946 psf	4,141.6306 psf	3,235.7965 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 31	159.875 ft	65.339633 ft	-1,417.3931 psf	5,514.2072 psf	4,308.1708 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill

6.2 Static (M-P) Section Ga-Ga' - Final Condition - Compound Stability

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File Informa on

File Version: 11.01
Created By: Mikayla S. Hatch
Last Edited By: Mikayla S. Hatch
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File Name: Wall 03.63L - Bridge 17.7 Ga-Ga' - All Condi ons.gsz
Directory: P:\0\0180366\01\Analysis\Bridge 17.7\SlopeW\
Last Solved Date: 11/12/2021
Last Solved Time: 04:49:16 PM

Project Se ngs

Unit System: U.S. Customary Units

Analysis Se ngs

6.2 Sta c (M-P)

Kind: SLOPE/W
Parent: 6. Compound Stability
Analysis Type: Morgenstern-Price
Se ngs
Side Func on
Interslice force func on op on: Half-Sine
PWP Condi ons from: Piezometric Line
Apply Phrea c Correc on: No
Use Staged Rapid Drawdown: No
Unit Weight of Water: 62.4 pcf
Slip Surface
Direc on of movement: Le. to Right
Use Passive Mode: No
Slip Surface Op on: Entry and Exit
Cri cal slip surfaces saved: 1
Op mize Cri cal Slip Surface Loca on: No
Tension Crack Op on: (none)
Distribu on
F of S Calcula on Op on: Constant
Advanced
Geometry Se ngs
Minimum Slip Surface Depth: 2 ft
Number of Slices: 30
Factor of Safety Convergence Se ngs
Maximum Number of Itera ons: 100
Tolerable difference in F of S: 0.001

Solu□on Se□ ngs
Search Method: Root Finder
Tolerable difference between star□ng and converged F of S: 3
Maximum itera□ons to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Gravel Borrow

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2A - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 39 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2B - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 41 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 7A - Weathered Sandstone

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 43 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2C - Na ve Silt

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 29 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1B - Exis ng Gravelly Granular Fill

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effec ve Cohesion: 0 psf
Effec ve Fric on Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Common Borrow

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec ve Cohesion: 0 psf
Effec ve Fric on Angle: 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Reinforcements

EL67_W7.0xW3.5 (45 yrs)

Type: Geosynthe c
Interface Adhesion: 0 psf
Interface Shear Angle: 11.5 °
Surface Area Factor: 2
Pullout Resistance Reduc on Factor: 1
Tensile Capacity: 4,901 lbf
Tensile Capacity Reduc on Factor: 1
F of S Dependent: No
Force Distribu on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 4,901 lbf/ft

EL69_W7.0xW3.5 (45 yrs)

Type: Geosynthe c
Interface Adhesion: 0 psf
Interface Shear Angle: 11.5 °
Surface Area Factor: 2
Pullout Resistance Reduc on Factor: 1
Tensile Capacity: 4,901 lbf
Tensile Capacity Reduc on Factor: 1
F of S Dependent: No
Force Distribu on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 4,901 lbf/ft

EL71_W7.0xW3.5 (45 yrs)

Type: Geosynthe c
Interface Adhesion: 0 psf
Interface Shear Angle: 11.5 °
Surface Area Factor: 2
Pullout Resistance Reduc on Factor: 1

Tensile Capacity: 4,901 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 4,901 lbf/ft

EL73_W7.0xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 22.2 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 4,901 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 4,901 lbf/ft

EL75_W7.0xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 22.2 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 4,901 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 4,901 lbf/ft

EL77_W4.5xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 17.6 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 2,975 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 2,975 lbf/ft

EL79_W4.5xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 17.6 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 2,975 lbf
Tensile Capacity Reduc□on Factor: 1

F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 2,975 lbf/ft

EL81_W4.5xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 17.6 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 2,975 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 2,975 lbf/ft

EL83_W4.5xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 17.6 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 2,975 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 2,975 lbf/ft

EL85_W4.5xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 17.6 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 2,975 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 2,975 lbf/ft

EL87_W4.5xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 17.6 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 2,975 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed

Face Anchorage: Yes
Factored Tensile Capacity: 2,975 lbf/ft

EL89_W4.5xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 17.6 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 2,975 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 2,975 lbf/ft

EL91_W4.5xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 17.6 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 2,975 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 2,975 lbf/ft

Soil Nail_Row 1

Type: Anchor
Pullout Resistance: 1,800 psf
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 82,550 lbf
Tensile Capacity Reduc□on Factor: 1
Shear Force: 0 lbf
Shear Force Reduc□on Factor: 1
Apply Shear: Parallel to Slip
F of S Dependent: No
Force Distribu□on: Distributed
Bond Length: 45 ft
Bond Diameter: 0.5 ft
Out-of-Plane Spacing: 4 ft
Face Anchorage: Yes
Factored Pullout Resistance: 706.86 lbf/ft/ft
Factored Tensile Capacity: 20,638 lbf/ft

Soil Nail_Row 2

Type: Anchor
Pullout Resistance: 1,800 psf
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 82,550 lbf
Tensile Capacity Reduc□on Factor: 1
Shear Force: 0 lbf

Shear Force Reduc□on Factor: 1
Apply Shear: Parallel to Slip
F of S Dependent: No
Force Distribu□on: Distributed
Bond Length: 45 ft
Bond Diameter: 0.5 ft
Out-of-Plane Spacing: 4 ft
Face Anchorage: Yes
Factored Pullout Resistance: 706.86 lbf/ft/ft
Factored Tensile Capacity: 20,638 lbf/ft

Soil Nail_Row 3

Type: Anchor
Pullout Resistance: 1,800 psf
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 82,550 lbf
Tensile Capacity Reduc□on Factor: 1
Shear Force: 0 lbf
Shear Force Reduc□on Factor: 1
Apply Shear: Parallel to Slip
F of S Dependent: No
Force Distribu□on: Distributed
Bond Length: 40 ft
Bond Diameter: 0.5 ft
Out-of-Plane Spacing: 4 ft
Face Anchorage: Yes
Factored Pullout Resistance: 706.86 lbf/ft/ft
Factored Tensile Capacity: 20,638 lbf/ft

Soil Nail_Row 4

Type: Anchor
Pullout Resistance: 1,800 psf
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 82,550 lbf
Tensile Capacity Reduc□on Factor: 1
Shear Force: 0 lbf
Shear Force Reduc□on Factor: 1
Apply Shear: Parallel to Slip
F of S Dependent: No
Force Distribu□on: Distributed
Bond Length: 40 ft
Bond Diameter: 0.5 ft
Out-of-Plane Spacing: 4 ft
Face Anchorage: Yes
Factored Pullout Resistance: 706.86 lbf/ft/ft
Factored Tensile Capacity: 20,638 lbf/ft

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (0.05, 60) ft
Left-Zone Right Coordinate: (119.5945, 91.79725) ft
Left-Zone Increment: 40
Right Type: Range

Right-Zone Left Coordinate: (160, 86.975) ft
Right-Zone Right Coordinate: (160, 62.925) ft
Right-Zone Increment: 20
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 60) ft
Right Coordinate: (335, 48) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	0.25 ft	43.375 ft
Coordinate 2	56.5 ft	43.375 ft
Coordinate 3	97.75 ft	43.375 ft
Coordinate 4	123 ft	43.375 ft
Coordinate 5	159.75 ft	42.625 ft
Coordinate 6	192 ft	42.625 ft
Coordinate 7	210.75 ft	42.625 ft
Coordinate 8	298 ft	35 ft
Coordinate 9	335.25 ft	35 ft

Reinforcement Lines

Reinforcement Line 1

Reinforcement: EL67_W7.0xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 67) ft
Inside Point: (128, 67) ft
Length: 32 ft
Orienta□on: 180 °
Slip Surface Intersec□on: (135.83818, 67) ft
Max. Pullout Force: 4,901 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 2

Reinforcement: EL69_W7.0xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 69) ft
Inside Point: (128, 69) ft
Length: 32 ft

Orientation: 180 °
Slip Surface Intersection: (131.00523, 69) ft
Max. Pullout Force: 4,901 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 3

Reinforcement: EL71_W7.0xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 71) ft
Inside Point: (128, 71) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 4

Reinforcement: EL73_W7.0xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 73) ft
Inside Point: (128, 73) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 5

Reinforcement: EL75_W7.0xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 75) ft
Inside Point: (128, 75) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 6

Reinforcement: EL77_W4.5xW3.5 (45 yrs)
Lock to Ground Surface: No

Outside Point: (160, 77) ft
Inside Point: (128, 77) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 7

Reinforcement: EL79_W4.5xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 79) ft
Inside Point: (128, 79) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 8

Reinforcement: EL81_W4.5xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 81) ft
Inside Point: (128, 81) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 9

Reinforcement: EL83_W4.5xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 83) ft
Inside Point: (128, 83) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 10

Reinforcement: EL85_W4.5xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 85) ft
Inside Point: (128, 85) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 11

Reinforcement: EL89_W4.5xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 89) ft
Inside Point: (128, 89) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 12

Reinforcement: EL87_W4.5xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 87) ft
Inside Point: (128, 87) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 13

Reinforcement: EL91_W4.5xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 91) ft
Inside Point: (128, 91) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 14

Reinforcement: Soil Nail_Row 1
Lock to Ground Surface: Yes
Outside Point: (160, 64.5) ft
Inside Point: (115.68365, 56.685832) ft
Length: 45.000001 ft
Orienta□on: -170 °
Max. Pullout Force: 0 lbf
Bond Length: 45 ft
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 15

Reinforcement: Soil Nail_Row 2
Lock to Ground Surface: Yes
Outside Point: (160, 60.5) ft
Inside Point: (115.68365, 52.685832) ft
Length: 45.000001 ft
Orienta□on: -170 °
Max. Pullout Force: 0 lbf
Bond Length: 45 ft
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 16

Reinforcement: Soil Nail_Row 3
Lock to Ground Surface: Yes
Outside Point: (160, 56.5) ft
Inside Point: (120.60769, 49.554073) ft
Length: 40 ft
Orienta□on: -170 °
Max. Pullout Force: 0 lbf
Bond Length: 40 ft
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 17

Reinforcement: Soil Nail_Row 4
Lock to Ground Surface: Yes
Outside Point: (160, 52.5) ft
Inside Point: (120.60769, 45.554073) ft
Length: 40 ft
Orienta□on: -170 °
Max. Pullout Force: 0 lbf
Bond Length: 40 ft

Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 250 pcf
Direc□on: Ver□cal

Coordinates

	X	Y
	120 ft	92 ft
	120 ft	93 ft
	128 ft	93 ft

Surcharge Load 2

Surcharge (Unit Weight): 0 pcf
Direc□on: Ver□cal

Coordinates

	X	Y
	128 ft	93.75 ft
	160 ft	93.75 ft

Geometry

Name: Ga-Ga'

Se ngs

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	0 ft	56 ft
Point 2	76 ft	56 ft
Point 3	118 ft	35 ft
Point 4	160 ft	35 ft
Point 5	0 ft	46 ft
Point 6	37 ft	46 ft
Point 7	190 ft	50 ft
Point 8	160 ft	50 ft
Point 9	170.25 ft	34 ft
Point 10	240 ft	34 ft
Point 11	315 ft	30 ft
Point 12	335 ft	30 ft

Point 13	335 ft	48 ft
Point 14	327 ft	48 ft
Point 15	315 ft	49 ft
Point 16	224 ft	48 ft
Point 17	0 ft	0 ft
Point 18	335 ft	0 ft
Point 19	160 ft	92 ft
Point 20	120 ft	92 ft
Point 21	120 ft	72 ft
Point 22	80 ft	72 ft
Point 23	56 ft	60 ft
Point 24	0 ft	60 ft
Point 25	160 ft	47 ft
Point 26	120 ft	47 ft
Point 27	69 ft	66.5 ft
Point 28	160 ft	66.5 ft
Point 29	120 ft	66.5 ft
Point 30	160 ft	72 ft
Point 31	128 ft	47 ft
Point 32	128 ft	92 ft
Point 33	128 ft	66.5 ft
Point 34	128 ft	72 ft
Point 35	160 ft	64.5 ft
Point 36	160 ft	60.5 ft
Point 37	160 ft	56.5 ft
Point 38	160 ft	52.5 ft

Regions

	Material	Points	Area
Region 1	ESU 2C - Na□ve Silt	5,6,2,1	565 ft²
Region 2	Gravel Borrow	19,32,34,30	640 ft²
Region 3	Common Borrow	20,22,21	400 ft²
Region 4	ESU 2A - Na□ve Sand and Gravel	6,2,3	619.5 ft²
Region 5	ESU 2B - Na□ve Sand and Gravel	7,16,15,14,13,12,11,10,9,4	2,595.4 ft²
Region 6	ESU 7A - Weathered Sandstone	18,17,5,6,3,4,9,10,11,12	12,178 ft²
Region 7	ESU 1B - Exis□ng Gravelly Granular Fill	8,7,25	45 ft²
Region 8	ESU 2A - Na□ve Sand and Gravel	4,7,25,31,26,2,3	945 ft²
Region 9	Common Borrow	21,22,27,29	250.25 ft²
Region 10	ESU 1B - Exis□ng Gravelly Granular Fill	23,24,1,2,26,29,27	1,051.8 ft²
Region 11	ESU 1B - Exis□ng Gravelly Granular Fill	26,31,33,29	156 ft²
Region 12	Common Borrow	29,33,34,21	44 ft²
Region 13	ESU 1B - Exis□ng Gravelly Granular Fill	25,8,38,37,36,35,28,33,31	624 ft²
Region 14	Gravel Borrow	28,30,34,33	176 ft²
Region 15	Common Borrow	20,21,34,32	160 ft²

Slip Results

Slip Surfaces Analysed: 462 of 4305 converged

Current Slip Surface

Slip Surface: 3,978
Factor of Safety: 4.152
Volume: 1,057.6612 ft³
Weight: 135,080.31 lbf
Resis□ng Moment: 4,888,858.7 lbf·ft
Ac□va□ng Moment: 1,177,371.8 lbf·ft
Resis□ng Force: 99,518.863 lbf
Ac□va□ng Force: 23,966.551 lbf
Slip Rank: 1 of 4,305 slip surfaces
Exit: (160, 65.33) ft
Entry: (111.07167, 87.535836) ft
Radius: 46.023606 ft
Center: (150.97924, 110.4609) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Fric□onal Strength	Cohesive Strength	Suc□on Strength	Base Material
Slice 1	111.96451 ft	86.105608 ft	-2,666.3899 psf	172.91376 psf	108.04851 psf	0 psf	0 psf	Common Borrow
Slice 2	113.75017 ft	83.445017 ft	-2,500.3691 psf	489.27028 psf	305.73 psf	0 psf	0 psf	Common Borrow
Slice 3	115.53584 ft	81.135553 ft	-2,356.2585 psf	762.2384 psf	476.29941 psf	0 psf	0 psf	Common Borrow
Slice 4	117.3215 ft	79.098281 ft	-2,229.1327 psf	1,008.0335 psf	629.88924 psf	0 psf	0 psf	Common Borrow
Slice 5	119.10717 ft	77.282433 ft	-2,115.8238 psf	1,237.5295 psf	773.29425 psf	0 psf	0 psf	Common Borrow
Slice 6	120.75 ft	75.771192 ft	-2,021.5224 psf	1,599.7297 psf	999.62206 psf	0 psf	0 psf	Common Borrow
Slice 7	122.25 ft	74.518149 ft	-1,943.3325 psf	1,712.1044 psf	1,069.8416 psf	0 psf	0 psf	Common Borrow
Slice 8	123.67554 ft	73.420707 ft	-1,875.7124 psf	1,820.191 psf	1,137.3816 psf	0 psf	0 psf	Common Borrow
Slice 9	125.02661 ft	72.461372 ft	-1,817.5705 psf	1,924.6772 psf	1,202.6718 psf	0 psf	0 psf	Common Borrow
Slice 10	126.85107 ft	71.292252 ft	-1,746.9408 psf	2,069.6947 psf	1,293.2888 psf	0 psf	0 psf	Common Borrow
Slice 11	128.77961 ft	70.155111 ft	-1,678.4391 psf	2,192.47 psf	1,712.9453 psf	0 psf	0 psf	Gravel Borrow
Slice 12	130.33883 ft	69.334451 ft	-1,629.2155 psf	2,374.3342 psf	1,855.0332 psf	0 psf	0 psf	Gravel Borrow
Slice 13	131.89804 ft	68.587922 ft	-1,584.6177 psf	2,529.3656 psf	1,976.157 psf	0 psf	0 psf	Gravel Borrow
Slice 14	133.45726 ft	67.911614 ft	-1,544.4017 psf	2,687.9811 psf	2,100.081 psf	0 psf	0 psf	Gravel Borrow
Slice 15	135.01648 ft	67.30222 ft	-1,508.3611 psf	2,849.228 psf	2,226.0609 psf	0 psf	0 psf	Gravel Borrow
Slice 16	136.5757 ft	66.756936 ft	-1,476.321 psf	3,076.3404 psf	2,403.5006 psf	0 psf	0 psf	Gravel Borrow
Slice	138.15511	66.267907	-1,447.817	3,235.4968	2,527.8471	0 psf	0 psf	ESU 1B -

17	ft	ft	psf	psf	psf			Exis□ng Gravelly Granular Fill
Slice 18	139.75474 ft	65.834644 ft	-1,422.8185 psf	3,392.9422 psf	2,650.8569 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 19	141.35436 ft	65.4624 ft	-1,401.6275 psf	3,541.8423 psf	2,767.1905 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 20	142.95398 ft	65.149668 ft	-1,384.1501 psf	3,678.5679 psf	2,874.0122 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 21	144.5536 ft	64.895222 ft	-1,370.3097 psf	3,799.2554 psf	2,968.3036 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 22	146.15322 ft	64.698087 ft	-1,360.0456 psf	3,900.0027 psf	3,047.016 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 23	147.75284 ft	64.557525 ft	-1,353.3116 psf	3,977.1077 psf	3,107.2571 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 24	149.35246 ft	64.473017 ft	-1,350.0753 psf	4,027.3335 psf	3,146.4978 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 25	150.95208 ft	64.444252 ft	-1,350.3175 psf	4,048.1766 psf	3,162.7822 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 26	152.5517 ft	64.471127 ft	-1,354.0315 psf	4,038.1051 psf	3,154.9135 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 27	154.15133 ft	64.553739 ft	-1,361.2236 psf	3,996.7366 psf	3,122.5928 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 28	155.75095 ft	64.692391 ft	-1,371.9125 psf	3,924.9261 psf	3,066.4883 psf	0 psf	0 psf	ESU 1B - Exis□ng

								Gravelly Granular Fill
Slice 29	157.35057 ft	64.887594 ft	-1,386.1303 psf	3,824.748 psf	2,988.2206 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 30	158.95019 ft	65.14008 ft	-1,403.9225 psf	3,699.3689 psf	2,890.2638 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 31	159.875 ft	65.305375 ft	-1,415.2554 psf	3,618.2304 psf	2,826.8714 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill

6.3 Pseudo-Static (Spencer) Section Ga-Ga' - Final Condition - Compound Stability

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File Informa on

File Version: 11.01
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Last Edited By: Mikayla S. Hatch
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Directory: P:\0\0180366\01\Analysis\Bridge 17.7\SlopeW\
Last Solved Date: 11/12/2021
Last Solved Time: 04:49:20 PM

Project Se ngs

Unit System: U.S. Customary Units

Analysis Se ngs

6.3 Pseudo-Sta c (Spencer)

Kind: SLOPE/W
Parent: 6. Compound Stability
Analysis Type: Spencer
Se ngs
PWP Condi ons from: Piezometric Line
Apply Phrea c Correc on: No
Use Staged Rapid Drawdown: No
Unit Weight of Water: 62.4 pcf
Slip Surface
Direc on of movement: Le. to Right
Use Passive Mode: No
Slip Surface Op□on: Entry and Exit
Cri□cal slip surfaces saved: 1
Op□mize Cri□cal Slip Surface Loca□on: No
Tension Crack Op□on: (none)
Distribu□on
F of S Calcula□on Op□on: Constant
Advanced
Geometry Se□ ngs
Minimum Slip Surface Depth: 2 ft
Number of Slices: 30
Factor of Safety Convergence Se□ ngs
Maximum Number of Itera□ons: 100
Tolerable difference in F of S: 0.001
Solu□on Se□ ngs
Search Method: Root Finder

Tolerable difference between star□ng and converged F of S: 3
Maximum itera□ons to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Gravel Borrow

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2A - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 39 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2B - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 41 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 7A - Weathered Sandstone

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 43 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1B - Exis ng Gravelly Granular Fill

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2C - Na ve Silt (Pseudo-Sta c)

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effec□ve Cohesion: 200 psf
Effec□ve Fric□on Angle: 29 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Common Borrow

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Reinforcements

EQ_EL67_W7.0xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 15.2 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 6,409 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 6,409 lbf/ft

EQ_EL69_W7.0xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 15.2 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 6,409 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 6,409 lbf/ft

EQ_EL71_W7.0xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 15.2 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 6,409 lbf

Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 6,409 lbf/ft

EQ_EL73_W7.0xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 28.5 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 6,409 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 6,409 lbf/ft

EQ_EL75_W7.0xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 28.5 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 6,409 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 6,409 lbf/ft

EQ_EL77_W4.5xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 23 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,891 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,891 lbf/ft

EQ_EL79_W4.5xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 23 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,891 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No

Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,891 lbf/ft

EQ_EL81_W4.5xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 23 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,891 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,891 lbf/ft

EQ_EL83_W4.5xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 23 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,891 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,891 lbf/ft

EQ_EL85_W4.5xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 23 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,891 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,891 lbf/ft

EQ_EL87_W4.5xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 23 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,891 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes

Factored Tensile Capacity: 3,891 lbf/ft

EQ_EL91_W4.5xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 23 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,891 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,891 lbf/ft

Soil Nail_Row 1

Type: Anchor
Pullout Resistance: 1,800 psf
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 82,550 lbf
Tensile Capacity Reduc□on Factor: 1
Shear Force: 0 lbf
Shear Force Reduc□on Factor: 1
Apply Shear: Parallel to Slip
F of S Dependent: No
Force Distribu□on: Distributed
Bond Length: 45 ft
Bond Diameter: 0.5 ft
Out-of-Plane Spacing: 4 ft
Face Anchorage: Yes
Factored Pullout Resistance: 706.86 lbf/ft/ft
Factored Tensile Capacity: 20,638 lbf/ft

Soil Nail_Row 2

Type: Anchor
Pullout Resistance: 1,800 psf
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 82,550 lbf
Tensile Capacity Reduc□on Factor: 1
Shear Force: 0 lbf
Shear Force Reduc□on Factor: 1
Apply Shear: Parallel to Slip
F of S Dependent: No
Force Distribu□on: Distributed
Bond Length: 45 ft
Bond Diameter: 0.5 ft
Out-of-Plane Spacing: 4 ft
Face Anchorage: Yes
Factored Pullout Resistance: 706.86 lbf/ft/ft
Factored Tensile Capacity: 20,638 lbf/ft

Soil Nail_Row 3

Type: Anchor
Pullout Resistance: 1,800 psf

Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 82,550 lbf
Tensile Capacity Reduc□on Factor: 1
Shear Force: 0 lbf
Shear Force Reduc□on Factor: 1
Apply Shear: Parallel to Slip
F of S Dependent: No
Force Distribu□on: Distributed
Bond Length: 40 ft
Bond Diameter: 0.5 ft
Out-of-Plane Spacing: 4 ft
Face Anchorage: Yes
Factored Pullout Resistance: 706.86 lbf/ft/ft
Factored Tensile Capacity: 20,638 lbf/ft

Soil Nail_Row 4

Type: Anchor
Pullout Resistance: 1,800 psf
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 82,550 lbf
Tensile Capacity Reduc□on Factor: 1
Shear Force: 0 lbf
Shear Force Reduc□on Factor: 1
Apply Shear: Parallel to Slip
F of S Dependent: No
Force Distribu□on: Distributed
Bond Length: 40 ft
Bond Diameter: 0.5 ft
Out-of-Plane Spacing: 4 ft
Face Anchorage: Yes
Factored Pullout Resistance: 706.86 lbf/ft/ft
Factored Tensile Capacity: 20,638 lbf/ft

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (0.05, 60) ft
Left-Zone Right Coordinate: (119.5945, 91.79725) ft
Left-Zone Increment: 40
Right Type: Range
Right-Zone Left Coordinate: (160, 86.975) ft
Right-Zone Right Coordinate: (160, 62.925) ft
Right-Zone Increment: 20
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 60) ft
Right Coordinate: (335, 48) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	0.25 ft	43.375 ft
Coordinate 2	56.5 ft	43.375 ft
Coordinate 3	97.75 ft	43.375 ft
Coordinate 4	123 ft	43.375 ft
Coordinate 5	159.75 ft	42.625 ft
Coordinate 6	192 ft	42.625 ft
Coordinate 7	210.75 ft	42.625 ft
Coordinate 8	298 ft	35 ft
Coordinate 9	335.25 ft	35 ft

Seismic Coefficients

Horz Seismic Coef.: 0.209

Reinforcement Lines

Reinforcement Line 1

Reinforcement: EQ_EL67_W7.0xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 67) ft
Inside Point: (128, 67) ft
Length: 32 ft
Orienta□on: 180 °
Slip Surface Intersec□on: (134.95945, 67) ft
Max. Pullout Force: 6,409 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 2

Reinforcement: EQ_EL69_W7.0xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 69) ft
Inside Point: (128, 69) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 3

Reinforcement: EQ_EL71_W7.0xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 71) ft
Inside Point: (128, 71) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 4

Reinforcement: EQ_EL73_W7.0xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 73) ft
Inside Point: (128, 73) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 5

Reinforcement: EQ_EL75_W7.0xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 75) ft
Inside Point: (128, 75) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 6

Reinforcement: EQ_EL77_W4.5xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 77) ft
Inside Point: (128, 77) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 7

Reinforcement: EQ_EL79_W4.5xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 79) ft
Inside Point: (128, 79) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 8

Reinforcement: EQ_EL81_W4.5xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 81) ft
Inside Point: (128, 81) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 9

Reinforcement: EQ_EL83_W4.5xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 83) ft
Inside Point: (128, 83) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 10

Reinforcement: EQ_EL85_W4.5xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 85) ft
Inside Point: (128, 85) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft

Governing Component: (none)

Reinforcement Line 11

Reinforcement: EQ_EL87_W4.5xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 89) ft
Inside Point: (128, 89) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 12

Reinforcement: EQ_EL87_W4.5xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 87) ft
Inside Point: (128, 87) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 13

Reinforcement: EQ_EL91_W4.5xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 91) ft
Inside Point: (128, 91) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 14

Reinforcement: Soil Nail_Row 1
Lock to Ground Surface: Yes
Outside Point: (160, 64.5) ft
Inside Point: (115.68365, 56.685832) ft
Length: 45.000001 ft
Orienta□on: -170 °
Max. Pullout Force: 0 lbf
Bond Length: 45 ft
Available Length: 0 ft

Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 15

Reinforcement: Soil Nail_Row 2
Lock to Ground Surface: Yes
Outside Point: (160, 60.5) ft
Inside Point: (115.68365, 52.685832) ft
Length: 45.000001 ft
Orienta□on: -170 °
Max. Pullout Force: 0 lbf
Bond Length: 45 ft
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 16

Reinforcement: Soil Nail_Row 3
Lock to Ground Surface: Yes
Outside Point: (160, 56.5) ft
Inside Point: (120.60769, 49.554073) ft
Length: 40 ft
Orienta□on: -170 °
Max. Pullout Force: 0 lbf
Bond Length: 40 ft
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 17

Reinforcement: Soil Nail_Row 4
Lock to Ground Surface: Yes
Outside Point: (160, 52.5) ft
Inside Point: (120.60769, 45.554073) ft
Length: 40 ft
Orienta□on: -170 °
Max. Pullout Force: 0 lbf
Bond Length: 40 ft
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 125 pcf
Direc□on: Ver□cal

Coordinates

	X	Y
	120 ft	92 ft
	120 ft	93 ft
	160 ft	93 ft

Geometry

Name: Ga-Ga'

Se ngs

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	0 ft	56 ft
Point 2	76 ft	56 ft
Point 3	118 ft	35 ft
Point 4	160 ft	35 ft
Point 5	0 ft	46 ft
Point 6	37 ft	46 ft
Point 7	190 ft	50 ft
Point 8	160 ft	50 ft
Point 9	170.25 ft	34 ft
Point 10	240 ft	34 ft
Point 11	315 ft	30 ft
Point 12	335 ft	30 ft
Point 13	335 ft	48 ft
Point 14	327 ft	48 ft
Point 15	315 ft	49 ft
Point 16	224 ft	48 ft
Point 17	0 ft	0 ft
Point 18	335 ft	0 ft
Point 19	160 ft	92 ft
Point 20	120 ft	92 ft
Point 21	120 ft	72 ft
Point 22	80 ft	72 ft
Point 23	56 ft	60 ft
Point 24	0 ft	60 ft
Point 25	160 ft	47 ft
Point 26	120 ft	47 ft
Point 27	69 ft	66.5 ft
Point 28	160 ft	66.5 ft
Point 29	120 ft	66.5 ft

Point 30	160 ft	72 ft
Point 31	128 ft	47 ft
Point 32	128 ft	92 ft
Point 33	128 ft	66.5 ft
Point 34	128 ft	72 ft
Point 35	160 ft	64.5 ft
Point 36	160 ft	60.5 ft
Point 37	160 ft	56.5 ft
Point 38	160 ft	52.5 ft

Regions

	Material	Points	Area
Region 1	ESU 2C - Na□ve Silt (Pseudo-Sta□c)	5,6,2,1	565 ft²
Region 2	Gravel Borrow	19,32,34,30	640 ft²
Region 3	Common Borrow	20,22,21	400 ft²
Region 4	ESU 2A - Na□ve Sand and Gravel	6,2,3	619.5 ft²
Region 5	ESU 2B - Na□ve Sand and Gravel	7,16,15,14,13,12,11,10,9,4	2,595.4 ft²
Region 6	ESU 7A - Weathered Sandstone	18,17,5,6,3,4,9,10,11,12	12,178 ft²
Region 7	ESU 1B - Exis□ng Gravelly Granular Fill	8,7,25	45 ft²
Region 8	ESU 2A - Na□ve Sand and Gravel	4,7,25,31,26,2,3	945 ft²
Region 9	Common Borrow	21,22,27,29	250.25 ft²
Region 10	ESU 1B - Exis□ng Gravelly Granular Fill	23,24,1,2,26,29,27	1,051.8 ft²
Region 11	ESU 1B - Exis□ng Gravelly Granular Fill	26,31,33,29	156 ft²
Region 12	Common Borrow	29,33,34,21	44 ft²
Region 13	ESU 1B - Exis□ng Gravelly Granular Fill	25,8,38,37,36,35,28,33,31	624 ft²
Region 14	Gravel Borrow	28,30,34,33	176 ft²
Region 15	Common Borrow	20,21,34,32	160 ft²

Slip Results

Slip Surfaces Analysed: 745 of 4305 converged

Current Slip Surface

Slip Surface: 3,662
Factor of Safety: 2.294
Volume: 1,186.4941 ft³
Weight: 150,564.66 lbf
Resis□ng Moment: 8,874,409.1 lbf·ft
Ac□va□ng Moment: 3,869,576.4 lbf·ft
Resis□ng Force: 111,621.79 lbf
Ac□va□ng Force: 48,664.976 lbf
Slip Rank: 1 of 4,305 slip surfaces
Exit: (160, 65.33) ft
Entry: (102.54884, 83.274422) ft
Radius: 77.456568 ft
Center: (152.5529, 142.42773) ft

Slip Slices

	X	Y	PWP	Base	Fric□onal	Cohesive	Suc□on	Base

				Normal Stress	Strength	Strength	Strength	Material
Slice 1	103.51835 ft	82.48139 ft	-2,440.2387 psf	75.255225 psf	47.024684 psf	0 psf	0 psf	Common Borrow
Slice 2	105.45737 ft	80.945709 ft	-2,344.4122 psf	230.697 psf	144.15548 psf	0 psf	0 psf	Common Borrow
Slice 3	107.39639 ft	79.507267 ft	-2,254.6535 psf	390.45752 psf	243.98494 psf	0 psf	0 psf	Common Borrow
Slice 4	109.33541 ft	78.159523 ft	-2,170.5542 psf	554.37803 psf	346.41384 psf	0 psf	0 psf	Common Borrow
Slice 5	111.27442 ft	76.89687 ft	-2,091.7647 psf	722.34082 psf	451.36864 psf	0 psf	0 psf	Common Borrow
Slice 6	113.21344 ft	75.714468 ft	-2,017.9828 psf	894.27356 psf	558.80414 psf	0 psf	0 psf	Common Borrow
Slice 7	115.15246 ft	74.608114 ft	-1,948.9463 psf	1,070.1493 psf	668.70351 psf	0 psf	0 psf	Common Borrow
Slice 8	117.09147 ft	73.574137 ft	-1,884.4261 psf	1,249.9849 psf	781.07728 psf	0 psf	0 psf	Common Borrow
Slice 9	119.03049 ft	72.609317 ft	-1,824.2214 psf	1,433.8393 psf	895.96222 psf	0 psf	0 psf	Common Borrow
Slice 10	120.15617 ft	72.07191 ft	-1,790.6872 psf	1,634.5318 psf	1,021.3688 psf	0 psf	0 psf	Common Borrow
Slice 11	121.65617 ft	71.415313 ft	-1,749.7155 psf	1,723.0551 psf	1,076.6843 psf	0 psf	0 psf	Common Borrow
Slice 12	123.83333 ft	70.497899 ft	-1,693.5301 psf	1,854.2163 psf	1,158.6429 psf	0 psf	0 psf	Common Borrow
Slice 13	125.5 ft	69.854533 ft	-1,655.5065 psf	1,953.9761 psf	1,220.9797 psf	0 psf	0 psf	Common Borrow
Slice 14	127.16667 ft	69.254782 ft	-1,620.2045 psf	2,053.7555 psf	1,283.3289 psf	0 psf	0 psf	Common Borrow
Slice 15	128.92395 ft	68.669674 ft	-1,585.9316 psf	2,405.0155 psf	1,879.004 psf	0 psf	0 psf	Gravel Borrow
Slice 16	130.77186 ft	68.102912 ft	-1,552.9189 psf	2,535.4275 psf	1,980.8931 psf	0 psf	0 psf	Gravel Borrow
Slice 17	132.61977 ft	67.586062 ft	-1,523.0207 psf	2,667.0031 psf	2,083.6912 psf	0 psf	0 psf	Gravel Borrow
Slice 18	134.46768 ft	67.118096 ft	-1,496.1729 psf	2,994.3145 psf	2,339.4149 psf	0 psf	0 psf	Gravel Borrow
Slice 19	136.31558 ft	66.698106 ft	-1,472.3188 psf	3,134.8694 psf	2,449.2284 psf	0 psf	0 psf	Gravel Borrow
Slice 20	138.17747 ft	66.322834 ft	-1,451.2729 psf	3,274.6901 psf	2,558.4683 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 21	140.05335 ft	65.992286 ft	-1,433.0355 psf	3,420.2818 psf	2,672.217 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 22	141.92922 ft	65.709023 ft	-1,417.7488 psf	3,568.7975 psf	2,788.2502 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly

								Granular Fill
Slice 23	143.80509 ft	65.472523 ft	-1,405.38 psf	3,720.6704 psf	2,906.9063 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 24	145.68096 ft	65.282354 ft	-1,395.9024 psf	3,876.3992 psf	3,028.575 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 25	147.55683 ft	65.138176 ft	-1,389.2946 psf	4,036.5578 psf	3,153.7046 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 26	149.4327 ft	65.03973 ft	-1,385.5404 psf	4,201.8071 psf	3,282.8115 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 27	151.30858 ft	64.986843 ft	-1,384.6291 psf	4,372.9083 psf	3,416.4904 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 28	153.18445 ft	64.979421 ft	-1,386.5548 psf	4,550.7385 psf	3,555.4266 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 29	155.06032 ft	65.01745 ft	-1,391.3167 psf	4,736.3085 psf	3,700.4098 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 30	156.93619 ft	65.100998 ft	-1,398.919 psf	4,930.7847 psf	3,852.3512 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 31	158.81206 ft	65.230213 ft	-1,409.3709 psf	5,135.5137 psf	4,012.303 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 32	159.875 ft	65.31813 ft	-1,416.0513 psf	7,304.9094 psf	5,707.2207 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill

6.4 Pseudo-Static (M-P) Section Ga-Ga' - Final Condition - Compound Stability

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File Informa on

File Version: 11.01
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Last Edited By: Mikayla S. Hatch
Revision Number: 323
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Directory: P:\0\0180366\01\Analysis\Bridge 17.7\SlopeW\
Last Solved Date: 11/12/2021
Last Solved Time: 04:49:22 PM

Project Se ngs

Unit System: U.S. Customary Units

Analysis Se ngs

6.4 Pseudo-Sta c (M-P)

Kind: SLOPE/W
Parent: 6. Compound Stability
Analysis Type: Morgenstern-Price
Se ngs
Side Func on
Interslice force func on op on: Half-Sine
PWP Condi ons from: Piezometric Line
Apply Phrea c Correc on: No
Use Staged Rapid Drawdown: No
Unit Weight of Water: 62.4 pcf
Slip Surface
Direc on of movement: Le. to Right
Use Passive Mode: No
Slip Surface Op on: Entry and Exit
Cri cal slip surfaces saved: 1
Op mize Cri cal Slip Surface Loca on: No
Tension Crack Op on: (none)
Distribu on
F of S Calcula on Op on: Constant
Advanced
Geometry Se ngs
Minimum Slip Surface Depth: 2 ft
Number of Slices: 30
Factor of Safety Convergence Se ngs
Maximum Number of Itera ons: 100
Tolerable difference in F of S: 0.001

Solu□on Se□ ngs
Search Method: Root Finder
Tolerable difference between star□ng and converged F of S: 3
Maximum itera□ons to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Gravel Borrow

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2A - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 39 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2B - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 41 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 7A - Weathered Sandstone

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 43 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1B - Exis ng Gravelly Granular Fill

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2C - Na ve Silt (Pseudo-Sta c)

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effec□ve Cohesion: 200 psf
Effec□ve Fric□on Angle: 29 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Common Borrow

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Reinforcements

EQ_EL67_W7.0xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 15.2 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 6,409 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 6,409 lbf/ft

EQ_EL69_W7.0xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 15.2 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 6,409 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 6,409 lbf/ft

EQ_EL71_W7.0xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 15.2 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1

Tensile Capacity: 6,409 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 6,409 lbf/ft

EQ_EL73_W7.0xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 28.5 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 6,409 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 6,409 lbf/ft

EQ_EL75_W7.0xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 28.5 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 6,409 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 6,409 lbf/ft

EQ_EL77_W4.5xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 23 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,891 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,891 lbf/ft

EQ_EL79_W4.5xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 23 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,891 lbf
Tensile Capacity Reduc□on Factor: 1

F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,891 lbf/ft

EQ_EL81_W4.5xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 23 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,891 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,891 lbf/ft

EQ_EL83_W4.5xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 23 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,891 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,891 lbf/ft

EQ_EL85_W4.5xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 23 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,891 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,891 lbf/ft

EQ_EL87_W4.5xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 23 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,891 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed

Face Anchorage: Yes
Factored Tensile Capacity: 3,891 lbf/ft

EQ_EL91_W4.5xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 23 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,891 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,891 lbf/ft

Soil Nail_Row 1

Type: Anchor
Pullout Resistance: 1,800 psf
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 82,550 lbf
Tensile Capacity Reduc□on Factor: 1
Shear Force: 0 lbf
Shear Force Reduc□on Factor: 1
Apply Shear: Parallel to Slip
F of S Dependent: No
Force Distribu□on: Distributed
Bond Length: 45 ft
Bond Diameter: 0.5 ft
Out-of-Plane Spacing: 4 ft
Face Anchorage: Yes
Factored Pullout Resistance: 706.86 lbf/ft/ft
Factored Tensile Capacity: 20,638 lbf/ft

Soil Nail_Row 2

Type: Anchor
Pullout Resistance: 1,800 psf
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 82,550 lbf
Tensile Capacity Reduc□on Factor: 1
Shear Force: 0 lbf
Shear Force Reduc□on Factor: 1
Apply Shear: Parallel to Slip
F of S Dependent: No
Force Distribu□on: Distributed
Bond Length: 45 ft
Bond Diameter: 0.5 ft
Out-of-Plane Spacing: 4 ft
Face Anchorage: Yes
Factored Pullout Resistance: 706.86 lbf/ft/ft
Factored Tensile Capacity: 20,638 lbf/ft

Soil Nail_Row 3

Type: Anchor

Pullout Resistance: 1,800 psf
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 82,550 lbf
Tensile Capacity Reduc□on Factor: 1
Shear Force: 0 lbf
Shear Force Reduc□on Factor: 1
Apply Shear: Parallel to Slip
F of S Dependent: No
Force Distribu□on: Distributed
Bond Length: 40 ft
Bond Diameter: 0.5 ft
Out-of-Plane Spacing: 4 ft
Face Anchorage: Yes
Factored Pullout Resistance: 706.86 lbf/ft/ft
Factored Tensile Capacity: 20,638 lbf/ft

Soil Nail_Row 4

Type: Anchor
Pullout Resistance: 1,800 psf
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 82,550 lbf
Tensile Capacity Reduc□on Factor: 1
Shear Force: 0 lbf
Shear Force Reduc□on Factor: 1
Apply Shear: Parallel to Slip
F of S Dependent: No
Force Distribu□on: Distributed
Bond Length: 40 ft
Bond Diameter: 0.5 ft
Out-of-Plane Spacing: 4 ft
Face Anchorage: Yes
Factored Pullout Resistance: 706.86 lbf/ft/ft
Factored Tensile Capacity: 20,638 lbf/ft

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (0.05, 60) ft
Left-Zone Right Coordinate: (119.5945, 91.79725) ft
Left-Zone Increment: 40
Right Type: Range
Right-Zone Left Coordinate: (160, 86.975) ft
Right-Zone Right Coordinate: (160, 62.925) ft
Right-Zone Increment: 20
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 60) ft
Right Coordinate: (335, 48) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	0.25 ft	43.375 ft
Coordinate 2	56.5 ft	43.375 ft
Coordinate 3	97.75 ft	43.375 ft
Coordinate 4	123 ft	43.375 ft
Coordinate 5	159.75 ft	42.625 ft
Coordinate 6	192 ft	42.625 ft
Coordinate 7	210.75 ft	42.625 ft
Coordinate 8	298 ft	35 ft
Coordinate 9	335.25 ft	35 ft

Seismic Coefficients

Horz Seismic Coef.: 0.209

Reinforcement Lines

Reinforcement Line 1

Reinforcement: EQ_EL67_W7.0xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 67) ft
Inside Point: (128, 67) ft
Length: 32 ft
Orienta□on: 180 °
Slip Surface Intersec□on: (134.95945, 67) ft
Max. Pullout Force: 6,409 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 2

Reinforcement: EQ_EL69_W7.0xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 69) ft
Inside Point: (128, 69) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 3

Reinforcement: EQ_EL71_W7.0xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 71) ft
Inside Point: (128, 71) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 4

Reinforcement: EQ_EL73_W7.0xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 73) ft
Inside Point: (128, 73) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 5

Reinforcement: EQ_EL75_W7.0xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 75) ft
Inside Point: (128, 75) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 6

Reinforcement: EQ_EL77_W4.5xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 77) ft
Inside Point: (128, 77) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 7

Reinforcement: EQ_EL79_W4.5xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 79) ft
Inside Point: (128, 79) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 8

Reinforcement: EQ_EL81_W4.5xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 81) ft
Inside Point: (128, 81) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 9

Reinforcement: EQ_EL83_W4.5xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 83) ft
Inside Point: (128, 83) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 10

Reinforcement: EQ_EL85_W4.5xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 85) ft
Inside Point: (128, 85) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft

Governing Component: (none)

Reinforcement Line 11

Reinforcement: EQ_EL87_W4.5xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 89) ft
Inside Point: (128, 89) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 12

Reinforcement: EQ_EL87_W4.5xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 87) ft
Inside Point: (128, 87) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 13

Reinforcement: EQ_EL91_W4.5xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 91) ft
Inside Point: (128, 91) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 14

Reinforcement: Soil Nail_Row 1
Lock to Ground Surface: Yes
Outside Point: (160, 64.5) ft
Inside Point: (115.68365, 56.685832) ft
Length: 45.000001 ft
Orienta□on: -170 °
Max. Pullout Force: 0 lbf
Bond Length: 45 ft
Available Length: 0 ft

Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 15

Reinforcement: Soil Nail_Row 2
Lock to Ground Surface: Yes
Outside Point: (160, 60.5) ft
Inside Point: (115.68365, 52.685832) ft
Length: 45.000001 ft
Orienta□on: -170 °
Max. Pullout Force: 0 lbf
Bond Length: 45 ft
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 16

Reinforcement: Soil Nail_Row 3
Lock to Ground Surface: Yes
Outside Point: (160, 56.5) ft
Inside Point: (120.60769, 49.554073) ft
Length: 40 ft
Orienta□on: -170 °
Max. Pullout Force: 0 lbf
Bond Length: 40 ft
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 17

Reinforcement: Soil Nail_Row 4
Lock to Ground Surface: Yes
Outside Point: (160, 52.5) ft
Inside Point: (120.60769, 45.554073) ft
Length: 40 ft
Orienta□on: -170 °
Max. Pullout Force: 0 lbf
Bond Length: 40 ft
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 125 pcf
Direc□on: Ver□cal

Coordinates

	X	Y
	120 ft	92 ft
	120 ft	93 ft
	160 ft	93 ft

Geometry

Name: Ga-Ga'

Se ngs

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	0 ft	56 ft
Point 2	76 ft	56 ft
Point 3	118 ft	35 ft
Point 4	160 ft	35 ft
Point 5	0 ft	46 ft
Point 6	37 ft	46 ft
Point 7	190 ft	50 ft
Point 8	160 ft	50 ft
Point 9	170.25 ft	34 ft
Point 10	240 ft	34 ft
Point 11	315 ft	30 ft
Point 12	335 ft	30 ft
Point 13	335 ft	48 ft
Point 14	327 ft	48 ft
Point 15	315 ft	49 ft
Point 16	224 ft	48 ft
Point 17	0 ft	0 ft
Point 18	335 ft	0 ft
Point 19	160 ft	92 ft
Point 20	120 ft	92 ft
Point 21	120 ft	72 ft
Point 22	80 ft	72 ft
Point 23	56 ft	60 ft
Point 24	0 ft	60 ft
Point 25	160 ft	47 ft
Point 26	120 ft	47 ft
Point 27	69 ft	66.5 ft
Point 28	160 ft	66.5 ft
Point 29	120 ft	66.5 ft

Point 30	160 ft	72 ft
Point 31	128 ft	47 ft
Point 32	128 ft	92 ft
Point 33	128 ft	66.5 ft
Point 34	128 ft	72 ft
Point 35	160 ft	64.5 ft
Point 36	160 ft	60.5 ft
Point 37	160 ft	56.5 ft
Point 38	160 ft	52.5 ft

Regions

	Material	Points	Area
Region 1	ESU 2C - Na□ve Silt (Pseudo-Sta□c)	5,6,2,1	565 ft²
Region 2	Gravel Borrow	19,32,34,30	640 ft²
Region 3	Common Borrow	20,22,21	400 ft²
Region 4	ESU 2A - Na□ve Sand and Gravel	6,2,3	619.5 ft²
Region 5	ESU 2B - Na□ve Sand and Gravel	7,16,15,14,13,12,11,10,9,4	2,595.4 ft²
Region 6	ESU 7A - Weathered Sandstone	18,17,5,6,3,4,9,10,11,12	12,178 ft²
Region 7	ESU 1B - Exis□ng Gravelly Granular Fill	8,7,25	45 ft²
Region 8	ESU 2A - Na□ve Sand and Gravel	4,7,25,31,26,2,3	945 ft²
Region 9	Common Borrow	21,22,27,29	250.25 ft²
Region 10	ESU 1B - Exis□ng Gravelly Granular Fill	23,24,1,2,26,29,27	1,051.8 ft²
Region 11	ESU 1B - Exis□ng Gravelly Granular Fill	26,31,33,29	156 ft²
Region 12	Common Borrow	29,33,34,21	44 ft²
Region 13	ESU 1B - Exis□ng Gravelly Granular Fill	25,8,38,37,36,35,28,33,31	624 ft²
Region 14	Gravel Borrow	28,30,34,33	176 ft²
Region 15	Common Borrow	20,21,34,32	160 ft²

Slip Results

Slip Surfaces Analysed: 825 of 4305 converged

Current Slip Surface

Slip Surface: 3,662
Factor of Safety: 2.300
Volume: 1,186.4941 ft³
Weight: 150,564.66 lbf
Resis□ng Moment: 8,899,111.4 lbf·ft
Ac□va□ng Moment: 3,869,576.4 lbf·ft
Resis□ng Force: 112,043.43 lbf
Ac□va□ng Force: 48,715.482 lbf
Slip Rank: 1 of 4,305 slip surfaces
Exit: (160, 65.33) ft
Entry: (102.54884, 83.274422) ft
Radius: 77.456568 ft
Center: (152.5529, 142.42773) ft

Slip Slices

	X	Y	PWP	Base	Fric□onal	Cohesive	Suc□on	Base

				Normal Stress	Strength	Strength	Strength	Material
Slice 1	103.51835 ft	82.48139 ft	-2,440.2387 psf	116.26452 psf	72.650135 psf	0 psf	0 psf	Common Borrow
Slice 2	105.45737 ft	80.945709 ft	-2,344.4122 psf	317.80879 psf	198.58897 psf	0 psf	0 psf	Common Borrow
Slice 3	107.39639 ft	79.507267 ft	-2,254.6535 psf	481.15195 psf	300.65711 psf	0 psf	0 psf	Common Borrow
Slice 4	109.33541 ft	78.159523 ft	-2,170.5542 psf	618.49902 psf	386.48108 psf	0 psf	0 psf	Common Borrow
Slice 5	111.27442 ft	76.89687 ft	-2,091.7647 psf	739.16145 psf	461.87933 psf	0 psf	0 psf	Common Borrow
Slice 6	113.21344 ft	75.714468 ft	-2,017.9828 psf	850.6747 psf	531.56055 psf	0 psf	0 psf	Common Borrow
Slice 7	115.15246 ft	74.608114 ft	-1,948.9463 psf	959.52003 psf	599.57466 psf	0 psf	0 psf	Common Borrow
Slice 8	117.09147 ft	73.574137 ft	-1,884.4261 psf	1,071.59 psf	669.60374 psf	0 psf	0 psf	Common Borrow
Slice 9	119.03049 ft	72.609317 ft	-1,824.2214 psf	1,192.4796 psf	745.14394 psf	0 psf	0 psf	Common Borrow
Slice 10	120.15617 ft	72.07191 ft	-1,790.6872 psf	1,359.3427 psf	849.4116 psf	0 psf	0 psf	Common Borrow
Slice 11	121.65617 ft	71.415313 ft	-1,749.7155 psf	1,416.163 psf	884.91685 psf	0 psf	0 psf	Common Borrow
Slice 12	123.83333 ft	70.497899 ft	-1,693.5301 psf	1,521.2319 psf	950.57118 psf	0 psf	0 psf	Common Borrow
Slice 13	125.5 ft	69.854533 ft	-1,655.5065 psf	1,623.2069 psf	1,014.2923 psf	0 psf	0 psf	Common Borrow
Slice 14	127.16667 ft	69.254782 ft	-1,620.2045 psf	1,745.4989 psf	1,090.7088 psf	0 psf	0 psf	Common Borrow
Slice 15	128.92395 ft	68.669674 ft	-1,585.9316 psf	2,156.3552 psf	1,684.7293 psf	0 psf	0 psf	Gravel Borrow
Slice 16	130.77186 ft	68.102912 ft	-1,552.9189 psf	2,371.7164 psf	1,852.988 psf	0 psf	0 psf	Gravel Borrow
Slice 17	132.61977 ft	67.586062 ft	-1,523.0207 psf	2,615.5994 psf	2,043.5302 psf	0 psf	0 psf	Gravel Borrow
Slice 18	134.46768 ft	67.118096 ft	-1,496.1729 psf	3,142.2116 psf	2,454.9647 psf	0 psf	0 psf	Gravel Borrow
Slice 19	136.31558 ft	66.698106 ft	-1,472.3188 psf	3,425.1638 psf	2,676.0313 psf	0 psf	0 psf	Gravel Borrow
Slice 20	138.17747 ft	66.322834 ft	-1,451.2729 psf	3,706.9039 psf	2,896.1507 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 21	140.05335 ft	65.992286 ft	-1,433.0355 psf	3,983.0547 psf	3,111.9034 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 22	141.92922 ft	65.709023 ft	-1,417.7488 psf	4,233.683 psf	3,307.7157 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly

								Granular Fill
Slice 23	143.80509 ft	65.472523 ft	-1,405.38 psf	4,443.5163 psf	3,471.6554 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 24	145.68096 ft	65.282354 ft	-1,395.9024 psf	4,598.4199 psf	3,592.6794 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 25	147.55683 ft	65.138176 ft	-1,389.2946 psf	4,687.4241 psf	3,662.217 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 26	149.4327 ft	65.03973 ft	-1,385.5404 psf	4,704.5052 psf	3,675.5623 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 27	151.30858 ft	64.986843 ft	-1,384.6291 psf	4,649.6452 psf	3,632.7009 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 28	153.18445 ft	64.979421 ft	-1,386.5548 psf	4,528.8316 psf	3,538.311 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 29	155.06032 ft	65.01745 ft	-1,391.3167 psf	4,352.9513 psf	3,400.8983 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 30	156.93619 ft	65.100998 ft	-1,398.919 psf	4,135.8729 psf	3,231.2981 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 31	158.81206 ft	65.230213 ft	-1,409.3709 psf	3,892.2908 psf	3,040.9909 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 32	159.875 ft	65.31813 ft	-1,416.0513 psf	3,748.3315 psf	2,928.5175 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill

2.1 Static (Spencer) Section Ha-Ha' - Existing Condition - Compound Stability

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File Informa on

File Version: 11.01
Created By: Mikayla S. Hatch
Last Edited By: Mikayla S. Hatch
Revision Number: 306
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Tool Version: 11.1
File Name: Wall 03.63L - Bridge 17.7 Ha-Ha' - All Condi ons.gsz
Directory: P:\0\0180366\01\Analysis\Bridge 17.7\SlopeW\
Last Solved Date: 11/15/2021
Last Solved Time: 01:39:36 PM

Project Se ngs

Unit System: U.S. Customary Units

Analysis Se ngs

2.1 Sta c (Spencer)

Kind: SLOPE/W
Parent: 2. Compound Stability - 30 Years Corrosion
Analysis Type: Spencer
Se ngs
PWP Condi ons from: Piezometric Line
Apply Phrea c Correc on: No
Use Staged Rapid Drawdown: No
Unit Weight of Water: 62.4 pcf
Slip Surface
Direc on of movement: Le. to Right
Use Passive Mode: No
Slip Surface Op on: Entry and Exit
Cri cal slip surfaces saved: 1
Op mize Cri cal Slip Surface Loca on: No
Tension Crack Op on: (none)
Distribu on
F of S Calcula on Op on: Constant
Advanced
Geometry Se ngs
Minimum Slip Surface Depth: 2 ft
Number of Slices: 30
Factor of Safety Convergence Se ngs
Maximum Number of Itera ons: 100
Tolerable difference in F of S: 0.001
Solu on Se ngs
Search Method: Root Finder

Tolerable difference between star□ng and converged F of S: 3
Maximum itera□ons to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

ESU 2A - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 39 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2B - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 41 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 7A - Weathered Sandstone

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 43 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2C - Na ve Silt

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 29 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1A - Exis ng Granular Fill

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 40 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1B - Exis ng Gravelly Granular Fill

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Reinforcements

EL47_W9.5xW4

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 14.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,441 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,441 lbf/ft

EL49_W9.5xW4

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 14.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,441 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,441 lbf/ft

EL51_W9.5xW4

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 14.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,441 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,441 lbf/ft

EL53_W9.5xW4

Type: Geosynthe□c
Interface Adhesion: 0 psf

Interface Shear Angle: 14.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,441 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,441 lbf/ft

EL55_W9.5xW4

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 14.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,441 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,441 lbf/ft

EL57_W9.5xW4

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 14.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,441 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,441 lbf/ft

EL59_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 12.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,422 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,422 lbf/ft

EL61_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 12.1 °
Surface Area Factor: 2

Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,422 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,422 lbf/ft

EL63_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 12.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,422 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,422 lbf/ft

EL65_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 12.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,422 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,422 lbf/ft

EL67_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 12.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,422 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,422 lbf/ft

EL69_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 12.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,422 lbf

Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,422 lbf/ft

EL71_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 23.2 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,422 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,422 lbf/ft

EL73_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 23.2 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,422 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,422 lbf/ft

EL75_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,385 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,385 lbf/ft

EL77_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,385 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No

Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,385 lbf/ft

EL79_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,385 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,385 lbf/ft

EL81_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,385 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,385 lbf/ft

EL89_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,385 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,385 lbf/ft

EL87_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,385 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes

Factored Tensile Capacity: 3,385 lbf/ft

EL85_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,385 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,385 lbf/ft

EL83_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,385 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,385 lbf/ft

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (0.05, 60) ft
Left-Zone Right Coordinate: (120, 90) ft
Left-Zone Increment: 40
Right Type: Range
Right-Zone Left Coordinate: (160, 70.95212) ft
Right-Zone Right Coordinate: (170.15, 50) ft
Right-Zone Increment: 20
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 60) ft
Right Coordinate: (335, 48) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y

Coordinate 1	0.25 ft	43.375 ft
Coordinate 2	56.5 ft	43.375 ft
Coordinate 3	97.75 ft	43.375 ft
Coordinate 4	123 ft	43.375 ft
Coordinate 5	159.75 ft	42.625 ft
Coordinate 6	192 ft	42.625 ft
Coordinate 7	210.75 ft	42.625 ft
Coordinate 8	298 ft	35 ft
Coordinate 9	335.25 ft	35 ft

Reinforcement Lines

Reinforcement Line 1

Reinforcement: EL47_W9.5xW4
Lock to Ground Surface: No
Outside Point: (160, 47) ft
Inside Point: (128, 47) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 2

Reinforcement: EL49_W9.5xW4
Lock to Ground Surface: No
Outside Point: (160, 49) ft
Inside Point: (128, 49) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 3

Reinforcement: EL51_W9.5xW4
Lock to Ground Surface: No
Outside Point: (160, 51) ft
Inside Point: (128, 51) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft

Governing Component: (none)

Reinforcement Line 4

Reinforcement: EL53_W9.5xW4
Lock to Ground Surface: No
Outside Point: (160, 53) ft
Inside Point: (128, 53) ft
Length: 32 ft
Orientation: 180 °
Slip Surface Intersection: (154.3565, 53) ft
Max. Pullout Force: 7,441 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 5

Reinforcement: EL55_W9.5xW4
Lock to Ground Surface: No
Outside Point: (160, 55) ft
Inside Point: (128, 55) ft
Length: 32 ft
Orientation: 180 °
Slip Surface Intersection: (149.26148, 55) ft
Max. Pullout Force: 7,441 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 6

Reinforcement: EL57_W9.5xW4
Lock to Ground Surface: No
Outside Point: (160, 57) ft
Inside Point: (128, 57) ft
Length: 32 ft
Orientation: 180 °
Slip Surface Intersection: (144.80501, 57) ft
Max. Pullout Force: 7,441 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 7

Reinforcement: EL59_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 59) ft
Inside Point: (128, 59) ft
Length: 32 ft
Orientation: 180 °

Slip Surface Intersec□on: (140.80313, 59) ft
Max. Pullout Force: 5,422 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 8

Reinforcement: EL61_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 61) ft
Inside Point: (128, 61) ft
Length: 32 ft
Orienta□on: 180 °
Slip Surface Intersec□on: (137.16576, 61) ft
Max. Pullout Force: 5,422 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 9

Reinforcement: EL63_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 63) ft
Inside Point: (128, 63) ft
Length: 32 ft
Orienta□on: 180 °
Slip Surface Intersec□on: (133.82693, 63) ft
Max. Pullout Force: 5,422 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 10

Reinforcement: EL65_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 65) ft
Inside Point: (128, 65) ft
Length: 32 ft
Orienta□on: 180 °
Slip Surface Intersec□on: (130.73441, 65) ft
Max. Pullout Force: 5,422 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 11

Reinforcement: EL67_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 67) ft
Inside Point: (128, 67) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 12

Reinforcement: EL69_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 69) ft
Inside Point: (128, 69) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 13

Reinforcement: EL71_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 71) ft
Inside Point: (128, 71) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 14

Reinforcement: EL73_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 73) ft
Inside Point: (128, 73) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 15

Reinforcement: EL75_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 75) ft
Inside Point: (128, 75) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 16

Reinforcement: EL77_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 77) ft
Inside Point: (128, 77) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 17

Reinforcement: EL79_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 79) ft
Inside Point: (128, 79) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 18

Reinforcement: EL81_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 81) ft
Inside Point: (128, 81) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft

Governing Component: (none)

Reinforcement Line 19

Reinforcement: EL83_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 83) ft
Inside Point: (128, 83) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 20

Reinforcement: EL85_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 85) ft
Inside Point: (128, 85) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 21

Reinforcement: EL89_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 89) ft
Inside Point: (128, 89) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 22

Reinforcement: EL87_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 87) ft
Inside Point: (128, 87) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft

Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 23

Reinforcement: EL85_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 85) ft
Inside Point: (128, 85) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 250 pcf
Direc□on: Ver□cal

Coordinates

	X	Y
	120 ft	91 ft
	128 ft	91 ft

Surcharge Load 2

Surcharge (Unit Weight): 250 pcf
Direc□on: Ver□cal

Coordinates

	X	Y
	128 ft	91.75 ft
	160 ft	91.75 ft

Geometry

Name: Ga-Ga'

Se ngs

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	0 ft	56 ft
Point 2	76 ft	56 ft

Point 3	118 ft	35 ft
Point 4	160 ft	35 ft
Point 5	0 ft	46 ft
Point 6	37 ft	46 ft
Point 7	190 ft	50 ft
Point 8	160 ft	50 ft
Point 9	170.25 ft	34 ft
Point 10	240 ft	34 ft
Point 11	315 ft	30 ft
Point 12	335 ft	30 ft
Point 13	335 ft	48 ft
Point 14	327 ft	48 ft
Point 15	315 ft	49 ft
Point 16	224 ft	48 ft
Point 17	0 ft	0 ft
Point 18	335 ft	0 ft
Point 19	160 ft	90 ft
Point 20	120 ft	90 ft
Point 21	120 ft	72 ft
Point 22	80 ft	72 ft
Point 23	56 ft	60 ft
Point 24	0 ft	60 ft
Point 25	160 ft	47 ft
Point 26	120 ft	47 ft
Point 27	70 ft	67 ft
Point 28	160 ft	78 ft
Point 29	93.5 ft	78 ft
Point 30	120 ft	78 ft
Point 31	160 ft	72 ft
Point 32	128 ft	90 ft
Point 33	128 ft	47 ft
Point 34	128 ft	78 ft
Point 35	128 ft	72 ft

Regions

	Material	Points	Area
Region 1	ESU 2C - Na□ve Silt	5,6,2,1	565 ft²
Region 2	ESU 1A - Exis□ng Granular Fill	20,29,30	159 ft²
Region 3	ESU 2A - Na□ve Sand and Gravel	6,2,3	619.5 ft²
Region 4	ESU 2B - Na□ve Sand and Gravel	7,16,15,14,13,12,11,10,9,4	2,595.4 ft²
Region 5	ESU 7A - Weathered Sandstone	18,17,5,6,3,4,9,10,11,12	12,178 ft²
Region 6	ESU 1B - Exis□ng Gravelly Granular Fill	8,7,25	45 ft²
Region 7	ESU 2A - Na□ve Sand and Gravel	4,7,25,33,26,2,3	945 ft²
Region 8	ESU 1B - Exis□ng Gravelly Granular Fill	23,24,1,2,26,21,22,27	1,302 ft²
Region 9	ESU 1B - Exis□ng Gravelly Granular Fill	26,33,35,21	200 ft²
Region 10	ESU 1A - Exis□ng Granular Fill	19,32,34,28	384 ft²
Region 11	ESU 1A - Exis□ng Granular Fill	22,21,30,29	199.5 ft²
Region 12	ESU 1A - Exis□ng Granular Fill	28,34,35,31	192 ft²
Region 13	ESU 1A - Exis□ng Granular Fill	20,30,34,32	96 ft²

Region 14	ESU 1A - Exis□ng Granular Fill	30,21,35,34	48 ft²
Region 15	ESU 1B - Exis□ng Gravelly Granular Fill	25,8,31,35,33	800 ft²

Slip Results

Slip Surfaces Analysed: 1472 of 4305 converged

Current Slip Surface

Slip Surface: 3,862
Factor of Safety: 3.208
Volume: 1,287.2195 ft³
Weight: 156,805.38 lbf
Resis□ng Moment: 15,083,364 lbf·ft
Ac□va□ng Moment: 4,701,613.7 lbf·ft
Resis□ng Force: 120,237.67 lbf
Ac□va□ng Force: 37,480.212 lbf
Slip Rank: 1 of 4,305 slip surfaces
Exit: (160, 51.115355) ft
Entry: (108.46309, 84.775737) ft
Radius: 110.04979 ft
Center: (192.00871, 156.40732) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Fric□onal Strength	Cohesive Strength	Suc□on Strength	Base Material
Slice 1	109.25353 ft	83.873899 ft	-2,527.1313 psf	96.079377 psf	80.62017 psf	0 psf	0 psf	ESU 1A - Exis□ng Granular Fill
Slice 2	110.83442 ft	82.108469 ft	-2,416.9685 psf	290.43697 psf	243.70556 psf	0 psf	0 psf	ESU 1A - Exis□ng Granular Fill
Slice 3	112.41531 ft	80.416955 ft	-2,311.418 psf	485.4559 psf	407.34587 psf	0 psf	0 psf	ESU 1A - Exis□ng Granular Fill
Slice 4	113.9962 ft	78.794516 ft	-2,210.1778 psf	680.93728 psf	571.37422 psf	0 psf	0 psf	ESU 1A - Exis□ng Granular Fill
Slice 5	115.65554 ft	77.16281 ft	-2,108.3594 psf	886.3005 psf	743.69443 psf	0 psf	0 psf	ESU 1A - Exis□ng Granular Fill
Slice 6	117.39332 ft	75.524061 ft	-2,006.1014 psf	1,101.6993 psf	924.43545 psf	0 psf	0 psf	ESU 1A - Exis□ng Granular Fill
Slice 7	119.13111 ft	73.954513 ft	-1,908.1616 psf	1,317.1338 psf	1,105.2065 psf	0 psf	0 psf	ESU 1A - Exis□ng

								Granular Fill
Slice 8	120.69728 ft	72.593262 ft	-1,823.2196 psf	1,662.2233 psf	1,394.771 psf	0 psf	0 psf	ESU 1A - Exis□ng Granular Fill
Slice 9	122.19728 ft	71.341226 ft	-1,745.0925 psf	1,805.304 psf	1,410.4581 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 10	123.83333 ft	70.024763 ft	-1,664.0064 psf	1,949.1985 psf	1,522.8807 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 11	125.5 ft	68.734904 ft	-1,585.6417 psf	2,093.6525 psf	1,635.7406 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 12	127.16667 ft	67.494999 ft	-1,510.3941 psf	2,235.9002 psf	1,746.8767 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 13	128.88194 ft	66.269607 ft	-1,436.1139 psf	2,522.6566 psf	1,970.9153 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 14	130.64583 ft	65.059503 ft	-1,362.8497 psf	2,701.031 psf	2,110.2767 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 15	132.40972 ft	63.89886 ft	-1,292.6718 psf	2,846.3945 psf	2,223.8471 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 16	134.17361 ft	62.785838 ft	-1,225.4655 psf	3,036.7396 psf	2,372.561 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 17	135.9375 ft	61.718756 ft	-1,161.1259 psf	3,177.6679 psf	2,482.6663 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 18	137.70139 ft	60.696078 ft	-1,099.557 psf	3,371.599 psf	2,634.1819 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill

Slice 19	139.46528 ft	59.716392 ft	-1,040.6709 psf	3,508.1829 psf	2,740.8929 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 20	141.22917 ft	58.778405 ft	-984.38676 psf	3,708.4361 psf	2,897.3478 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 21	142.99306 ft	57.880925 ft	-930.63023 psf	3,840.796 psf	3,000.7587 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 22	144.75694 ft	57.022853 ft	-879.33281 psf	4,081.8991 psf	3,189.1291 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 23	146.52083 ft	56.203177 ft	-830.43129 psf	4,210.503 psf	3,289.6055 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 24	148.28472 ft	55.420961 ft	-783.86731 psf	4,336.6733 psf	3,388.1805 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 25	150.04861 ft	54.675342 ft	-739.58692 psf	4,624.0938 psf	3,612.738 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 26	151.8125 ft	53.965519 ft	-697.54024 psf	4,747.0255 psf	3,708.7828 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 27	153.57639 ft	53.290754 ft	-657.68113 psf	5,101.1743 psf	3,985.4742 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 28	155.34028 ft	52.650361 ft	-619.96688 psf	5,221.5346 psf	4,079.51 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 29	157.10417 ft	52.043708 ft	-584.358 psf	5,339.5019 psf	4,171.6761 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice	158.86806	51.47021	-550.81797	5,455.084	4,261.9787	0 psf	0 psf	ESU 1B -

30	ft	ft	psf	psf	psf			Exis□ng Gravelly Granular Fill
Slice 31	159.875 ft	51.153517 ft	-532.17945 psf	10,140.809 psf	7,922.8686 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill

2.2 Static (M-P) Section Ha-Ha' - Existing Condition - Compound Stability

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File Informa on

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Last Edited By: Mikayla S. Hatch
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Tool Version: 11.1
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Directory: P:\0\0180366\01\Analysis\Bridge 17.7\SlopeW\
Last Solved Date: 11/15/2021
Last Solved Time: 01:39:40 PM

Project Se ngs

Unit System: U.S. Customary Units

Analysis Se ngs

2.2 Sta c (M-P)

Kind: SLOPE/W
Parent: 2. Compound Stability - 30 Years Corrosion
Analysis Type: Morgenstern-Price
Se ngs
Side Func on
Interslice force func on op on: Half-Sine
PWP Condi ons from: Piezometric Line
Apply Phrea c Correc on: No
Use Staged Rapid Drawdown: No
Unit Weight of Water: 62.4 pcf
Slip Surface
Direc on of movement: Le. to Right
Use Passive Mode: No
Slip Surface Op on: Entry and Exit
Cri cal slip surfaces saved: 1
Op mize Cri cal Slip Surface Loca on: No
Tension Crack Op on: (none)
Distribu on
F of S Calcula on Op on: Constant
Advanced
Geometry Se ngs
Minimum Slip Surface Depth: 2 ft
Number of Slices: 30
Factor of Safety Convergence Se ngs
Maximum Number of Itera ons: 100
Tolerable difference in F of S: 0.001

Solu□on Se□ ngs
Search Method: Root Finder
Tolerable difference between star□ng and converged F of S: 3
Maximum itera□ons to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

ESU 2A - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 39 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2B - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 41 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 7A - Weathered Sandstone

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 43 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2C - Na ve Silt

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 29 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1A - Exis ng Granular Fill

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 40 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1B - Exis ng Gravelly Granular Fill

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effec ve Cohesion: 0 psf
Effec ve Fric on Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Reinforcements

EL47_W9.5xW4

Type: Geosynthe c
Interface Adhesion: 0 psf
Interface Shear Angle: 14.1 °
Surface Area Factor: 2
Pullout Resistance Reduc on Factor: 1
Tensile Capacity: 7,441 lbf
Tensile Capacity Reduc on Factor: 1
F of S Dependent: No
Force Distribu on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,441 lbf/ft

EL49_W9.5xW4

Type: Geosynthe c
Interface Adhesion: 0 psf
Interface Shear Angle: 14.1 °
Surface Area Factor: 2
Pullout Resistance Reduc on Factor: 1
Tensile Capacity: 7,441 lbf
Tensile Capacity Reduc on Factor: 1
F of S Dependent: No
Force Distribu on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,441 lbf/ft

EL51_W9.5xW4

Type: Geosynthe c
Interface Adhesion: 0 psf
Interface Shear Angle: 14.1 °
Surface Area Factor: 2
Pullout Resistance Reduc on Factor: 1
Tensile Capacity: 7,441 lbf
Tensile Capacity Reduc on Factor: 1
F of S Dependent: No
Force Distribu on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,441 lbf/ft

EL53_W9.5xW4

Type: Geosynthe c

Interface Adhesion: 0 psf
Interface Shear Angle: 14.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,441 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,441 lbf/ft

EL55_W9.5xW4

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 14.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,441 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,441 lbf/ft

EL57_W9.5xW4

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 14.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,441 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,441 lbf/ft

EL59_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 12.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,422 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,422 lbf/ft

EL61_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 12.1 °

Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,422 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,422 lbf/ft

EL63_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 12.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,422 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,422 lbf/ft

EL65_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 12.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,422 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,422 lbf/ft

EL67_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 12.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,422 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,422 lbf/ft

EL69_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 12.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1

Tensile Capacity: 5,422 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,422 lbf/ft

EL71_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 23.2 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,422 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,422 lbf/ft

EL73_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 23.2 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,422 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,422 lbf/ft

EL75_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,385 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,385 lbf/ft

EL77_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,385 lbf
Tensile Capacity Reduc□on Factor: 1

F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,385 lbf/ft

EL79_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,385 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,385 lbf/ft

EL81_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,385 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,385 lbf/ft

EL89_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,385 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,385 lbf/ft

EL87_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,385 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed

Face Anchorage: Yes
Factored Tensile Capacity: 3,385 lbf/ft

EL85_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,385 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,385 lbf/ft

EL83_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,385 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,385 lbf/ft

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (0.05, 60) ft
Left-Zone Right Coordinate: (120, 90) ft
Left-Zone Increment: 40
Right Type: Range
Right-Zone Left Coordinate: (160, 70.95212) ft
Right-Zone Right Coordinate: (170.15, 50) ft
Right-Zone Increment: 20
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 60) ft
Right Coordinate: (335, 48) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	0.25 ft	43.375 ft
Coordinate 2	56.5 ft	43.375 ft
Coordinate 3	97.75 ft	43.375 ft
Coordinate 4	123 ft	43.375 ft
Coordinate 5	159.75 ft	42.625 ft
Coordinate 6	192 ft	42.625 ft
Coordinate 7	210.75 ft	42.625 ft
Coordinate 8	298 ft	35 ft
Coordinate 9	335.25 ft	35 ft

Reinforcement Lines

Reinforcement Line 1

Reinforcement: EL47_W9.5xW4
Lock to Ground Surface: No
Outside Point: (160, 47) ft
Inside Point: (128, 47) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 2

Reinforcement: EL49_W9.5xW4
Lock to Ground Surface: No
Outside Point: (160, 49) ft
Inside Point: (128, 49) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 3

Reinforcement: EL51_W9.5xW4
Lock to Ground Surface: No
Outside Point: (160, 51) ft
Inside Point: (128, 51) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft

Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 4

Reinforcement: EL53_W9.5xW4
Lock to Ground Surface: No
Outside Point: (160, 53) ft
Inside Point: (128, 53) ft
Length: 32 ft
Orienta□on: 180 °
Slip Surface Intersec□on: (154.3565, 53) ft
Max. Pullout Force: 7,441 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 5

Reinforcement: EL55_W9.5xW4
Lock to Ground Surface: No
Outside Point: (160, 55) ft
Inside Point: (128, 55) ft
Length: 32 ft
Orienta□on: 180 °
Slip Surface Intersec□on: (149.26148, 55) ft
Max. Pullout Force: 7,441 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 6

Reinforcement: EL57_W9.5xW4
Lock to Ground Surface: No
Outside Point: (160, 57) ft
Inside Point: (128, 57) ft
Length: 32 ft
Orienta□on: 180 °
Slip Surface Intersec□on: (144.80501, 57) ft
Max. Pullout Force: 7,441 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 7

Reinforcement: EL59_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 59) ft
Inside Point: (128, 59) ft

Length: 32 ft
Orientation: 180 °
Slip Surface Intersection: (140.80313, 59) ft
Max. Pullout Force: 5,422 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 8

Reinforcement: EL61_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 61) ft
Inside Point: (128, 61) ft
Length: 32 ft
Orientation: 180 °
Slip Surface Intersection: (137.16576, 61) ft
Max. Pullout Force: 5,422 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 9

Reinforcement: EL63_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 63) ft
Inside Point: (128, 63) ft
Length: 32 ft
Orientation: 180 °
Slip Surface Intersection: (133.82693, 63) ft
Max. Pullout Force: 5,422 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 10

Reinforcement: EL65_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 65) ft
Inside Point: (128, 65) ft
Length: 32 ft
Orientation: 180 °
Slip Surface Intersection: (130.73441, 65) ft
Max. Pullout Force: 5,422 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 11

Reinforcement: EL67_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 67) ft
Inside Point: (128, 67) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 12

Reinforcement: EL69_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 69) ft
Inside Point: (128, 69) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 13

Reinforcement: EL71_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 71) ft
Inside Point: (128, 71) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 14

Reinforcement: EL73_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 73) ft
Inside Point: (128, 73) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft

Governing Component: (none)

Reinforcement Line 15

Reinforcement: EL75_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 75) ft
Inside Point: (128, 75) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 16

Reinforcement: EL77_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 77) ft
Inside Point: (128, 77) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 17

Reinforcement: EL79_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 79) ft
Inside Point: (128, 79) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 18

Reinforcement: EL81_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 81) ft
Inside Point: (128, 81) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft

Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 19

Reinforcement: EL83_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 83) ft
Inside Point: (128, 83) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 20

Reinforcement: EL85_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 85) ft
Inside Point: (128, 85) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 21

Reinforcement: EL89_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 89) ft
Inside Point: (128, 89) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 22

Reinforcement: EL87_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 87) ft
Inside Point: (128, 87) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf

Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 23

Reinforcement: EL85_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 85) ft
Inside Point: (128, 85) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 250 pcf
Direc□on: Ver□cal

Coordinates

	X	Y
	120 ft	91 ft
	128 ft	91 ft

Surcharge Load 2

Surcharge (Unit Weight): 250 pcf
Direc□on: Ver□cal

Coordinates

	X	Y
	128 ft	91.75 ft
	160 ft	91.75 ft

Geometry

Name: Ga-Ga'

Se ngs

View: 2D
Element Thickness: 1 ft

Points

	X	Y

Point 1	0 ft	56 ft
Point 2	76 ft	56 ft
Point 3	118 ft	35 ft
Point 4	160 ft	35 ft
Point 5	0 ft	46 ft
Point 6	37 ft	46 ft
Point 7	190 ft	50 ft
Point 8	160 ft	50 ft
Point 9	170.25 ft	34 ft
Point 10	240 ft	34 ft
Point 11	315 ft	30 ft
Point 12	335 ft	30 ft
Point 13	335 ft	48 ft
Point 14	327 ft	48 ft
Point 15	315 ft	49 ft
Point 16	224 ft	48 ft
Point 17	0 ft	0 ft
Point 18	335 ft	0 ft
Point 19	160 ft	90 ft
Point 20	120 ft	90 ft
Point 21	120 ft	72 ft
Point 22	80 ft	72 ft
Point 23	56 ft	60 ft
Point 24	0 ft	60 ft
Point 25	160 ft	47 ft
Point 26	120 ft	47 ft
Point 27	70 ft	67 ft
Point 28	160 ft	78 ft
Point 29	93.5 ft	78 ft
Point 30	120 ft	78 ft
Point 31	160 ft	72 ft
Point 32	128 ft	90 ft
Point 33	128 ft	47 ft
Point 34	128 ft	78 ft
Point 35	128 ft	72 ft

Regions

	Material	Points	Area
Region 1	ESU 2C - Na□ve Silt	5,6,2,1	565 ft²
Region 2	ESU 1A - Exis□ng Granular Fill	20,29,30	159 ft²
Region 3	ESU 2A - Na□ve Sand and Gravel	6,2,3	619.5 ft²
Region 4	ESU 2B - Na□ve Sand and Gravel	7,16,15,14,13,12,11,10,9,4	2,595.4 ft²
Region 5	ESU 7A - Weathered Sandstone	18,17,5,6,3,4,9,10,11,12	12,178 ft²
Region 6	ESU 1B - Exis□ng Gravelly Granular Fill	8,7,25	45 ft²
Region 7	ESU 2A - Na□ve Sand and Gravel	4,7,25,33,26,2,3	945 ft²
Region 8	ESU 1B - Exis□ng Gravelly Granular Fill	23,24,1,2,26,21,22,27	1,302 ft²
Region 9	ESU 1B - Exis□ng Gravelly Granular Fill	26,33,35,21	200 ft²
Region 10	ESU 1A - Exis□ng Granular Fill	19,32,34,28	384 ft²
Region 11	ESU 1A - Exis□ng Granular Fill	22,21,30,29	199.5 ft²

Region 12	ESU 1A - Exis□ng Granular Fill	28,34,35,31	192 ft²
Region 13	ESU 1A - Exis□ng Granular Fill	20,30,34,32	96 ft²
Region 14	ESU 1A - Exis□ng Granular Fill	30,21,35,34	48 ft²
Region 15	ESU 1B - Exis□ng Gravelly Granular Fill	25,8,31,35,33	800 ft²

Slip Results

Slip Surfaces Analysed: 1612 of 4305 converged

Current Slip Surface

Slip Surface: 3,862
Factor of Safety: 3.207
Volume: 1,287.2195 ft³
Weight: 156,805.38 lbf
Resis□ng Moment: 15,080,614 lbf·ft
Ac□va□ng Moment: 4,701,613.7 lbf·ft
Resis□ng Force: 120,236.57 lbf
Ac□va□ng Force: 37,487.973 lbf
Slip Rank: 1 of 4,305 slip surfaces
Exit: (160, 51.115355) ft
Entry: (108.46309, 84.775737) ft
Radius: 110.04979 ft
Center: (192.00871, 156.40732) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Fric□onal Strength	Cohesive Strength	Suc□on Strength	Base Material
Slice 1	109.25353 ft	83.873899 ft	-2,527.1313 psf	113.38853 psf	95.144278 psf	0 psf	0 psf	ESU 1A - Exis□ng Granular Fill
Slice 2	110.83442 ft	82.108469 ft	-2,416.9685 psf	329.34321 psf	276.35177 psf	0 psf	0 psf	ESU 1A - Exis□ng Granular Fill
Slice 3	112.41531 ft	80.416955 ft	-2,311.418 psf	529.57071 psf	444.36259 psf	0 psf	0 psf	ESU 1A - Exis□ng Granular Fill
Slice 4	113.9962 ft	78.794516 ft	-2,210.1778 psf	717.69076 psf	602.21405 psf	0 psf	0 psf	ESU 1A - Exis□ng Granular Fill
Slice 5	115.65554 ft	77.16281 ft	-2,108.3594 psf	905.42507 psf	759.74184 psf	0 psf	0 psf	ESU 1A - Exis□ng Granular Fill
Slice 6	117.39332 ft	75.524061 ft	-2,006.1014 psf	1,095.2683 psf	919.03926 psf	0 psf	0 psf	ESU 1A - Exis□ng Granular Fill

Slice 7	119.13111 ft	73.954513 ft	-1,908.1616 psf	1,281.2239 psf	1,075.0745 psf	0 psf	0 psf	ESU 1A - Exis□ng Granular Fill
Slice 8	120.69728 ft	72.593262 ft	-1,823.2196 psf	1,600.2629 psf	1,342.78 psf	0 psf	0 psf	ESU 1A - Exis□ng Granular Fill
Slice 9	122.19728 ft	71.341226 ft	-1,745.0925 psf	1,714.528 psf	1,339.5361 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 10	123.83333 ft	70.024763 ft	-1,664.0064 psf	1,831.9691 psf	1,431.2911 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 11	125.5 ft	68.734904 ft	-1,585.6417 psf	1,956.9453 psf	1,528.9332 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 12	127.16667 ft	67.494999 ft	-1,510.3941 psf	2,088.3923 psf	1,631.6309 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 13	128.88194 ft	66.269607 ft	-1,436.1139 psf	2,370.1367 psf	1,851.7537 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 14	130.64583 ft	65.059503 ft	-1,362.8497 psf	2,566.1271 psf	2,004.8782 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 15	132.40972 ft	63.89886 ft	-1,292.6718 psf	2,735.1418 psf	2,136.927 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 16	134.17361 ft	62.785838 ft	-1,225.4655 psf	2,974.3119 psf	2,323.7872 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 17	135.9375 ft	61.718756 ft	-1,161.1259 psf	3,162.1063 psf	2,470.5082 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 18	137.70139 ft	60.696078 ft	-1,099.557 psf	3,425.9108 psf	2,676.6149 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly

								Granular Fill
Slice 19	139.46528 ft	59.716392 ft	-1,040.6709 psf	3,623.6579 psf	2,831.1118 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 20	141.22917 ft	58.778405 ft	-984.38676 psf	3,900.189 psf	3,047.1616 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 21	142.99306 ft	57.880925 ft	-930.63023 psf	4,093.5803 psf	3,198.2555 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 22	144.75694 ft	57.022853 ft	-879.33281 psf	4,395.0653 psf	3,433.8013 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 23	146.52083 ft	56.203177 ft	-830.43129 psf	4,558.8771 psf	3,561.7852 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 24	148.28472 ft	55.420961 ft	-783.86731 psf	4,709.47 psf	3,679.4412 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 25	150.04861 ft	54.675342 ft	-739.58692 psf	4,959.0549 psf	3,874.4383 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 26	151.8125 ft	53.965519 ft	-697.54024 psf	5,036.9916 psf	3,935.3291 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 27	153.57639 ft	53.290754 ft	-657.68113 psf	5,194.5857 psf	4,058.4551 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 28	155.34028 ft	52.650361 ft	-619.96688 psf	5,160.2687 psf	4,031.6438 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 29	157.10417 ft	52.043708 ft	-584.358 psf	5,097.6905 psf	3,982.7523 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly

								Granular Fill
Slice 30	158.86806 ft	51.47021 ft	-550.81797 psf	5,009.9299 psf	3,914.1862 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 31	159.875 ft	51.153517 ft	-532.17945 psf	4,951.0919 psf	3,868.2169 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill

2.3 Pseudo-Static (Spencer) Section Ha-Ha' - Existing Condition - Compound Stability

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File Informa on

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Last Edited By: Mikayla S. Hatch
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File Name: Wall 03.63L - Bridge 17.7 Ha-Ha' - All Condi ons.gsz
Directory: P:\0\0180366\01\Analysis\Bridge 17.7\SlopeW\
Last Solved Date: 11/15/2021
Last Solved Time: 01:39:46 PM

Project Se ngs

Unit System: U.S. Customary Units

Analysis Se ngs

2.3 Pseudo-Sta c (Spencer)

Kind: SLOPE/W
Parent: 2. Compound Stability - 30 Years Corrosion
Analysis Type: Spencer
Se ngs
PWP Condi ons from: Piezometric Line
Apply Phrea c Correc on: No
Use Staged Rapid Drawdown: No
Unit Weight of Water: 62.4 pcf
Slip Surface
Direc on of movement: Le. to Right
Use Passive Mode: No
Slip Surface Op on: Entry and Exit
Cri cal slip surfaces saved: 1
Op mize Cri cal Slip Surface Loca on: No
Tension Crack Op on: (none)
Distribu on
F of S Calcula on Op on: Constant
Advanced
Geometry Se ngs
Minimum Slip Surface Depth: 2 ft
Number of Slices: 30
Factor of Safety Convergence Se ngs
Maximum Number of Itera ons: 100
Tolerable difference in F of S: 0.001
Solu on Se ngs
Search Method: Root Finder

Tolerable difference between star□ng and converged F of S: 3
Maximum itera□ons to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

ESU 1A - Exis ng Granular Fill (Pseudo-Sta c)

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 50 psf
Effec□ve Fric□on Angle: 40 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2A - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 39 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2B - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 41 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 7A - Weathered Sandstone

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 43 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1B - Exis ng Gravelly Granular Fill

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2C - Na ve Silt (Pseudo-Sta c)

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effec□ve Cohesion: 200 psf
Effec□ve Fric□on Angle: 29 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Reinforcements

EQ_EL47_W9.5xW4

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.5 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 9,730 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 9,730 lbf/ft

EQ_EL49_W9.5xW4

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.5 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 9,730 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 9,730 lbf/ft

EQ_EL51_W9.5xW4

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.5 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 9,730 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 9,730 lbf/ft

EQ_EL53_W9.5xW4

Type: Geosynthe□c
Interface Adhesion: 0 psf

Interface Shear Angle: 18.5 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 9,730 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 9,730 lbf/ft

EQ_EL55_W9.5xW4

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.5 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 9,730 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 9,730 lbf/ft

EQ_EL57_W9.5xW4

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.5 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 9,730 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 9,730 lbf/ft

EQ_EL59_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 16 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,091 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,091 lbf/ft

EQ_EL61_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 16 °
Surface Area Factor: 2

Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,091 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,091 lbf/ft

EQ_EL63_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 16 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,091 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,091 lbf/ft

EQ_EL65_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 16 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,091 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,091 lbf/ft

EQ_EL67_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 16 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,091 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,091 lbf/ft

EQ_EL69_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 16 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,091 lbf

Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,091 lbf/ft

EQ_EL71_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 29.8 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,091 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,091 lbf/ft

EQ_EL73_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 29.8 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,091 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,091 lbf/ft

EQ_EL75_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 24.3 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 4,426 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 4,426 lbf/ft

EQ_EL77_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 24.3 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 4,426 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No

Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 4,426 lbf/ft

EQ_EL79_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 24.3 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 4,426 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 4,426 lbf/ft

EQ_EL81_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 24.3 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 4,426 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 4,426 lbf/ft

EQ_EL83_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 24.3 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 4,426 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 4,426 lbf/ft

EQ_EL85_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 24.3 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 4,426 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes

Factored Tensile Capacity: 4,426 lbf/ft

EQ_EL87_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 24.3 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 4,426 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 4,426 lbf/ft

EQ_EL89_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 24.3 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 4,426 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 4,426 lbf/ft

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (0.05, 60) ft
Left-Zone Right Coordinate: (120, 90) ft
Left-Zone Increment: 40
Right Type: Range
Right-Zone Left Coordinate: (160, 70.95212) ft
Right-Zone Right Coordinate: (170.15, 50) ft
Right-Zone Increment: 20
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 60) ft
Right Coordinate: (335, 48) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y

Coordinate 1	0.25 ft	43.375 ft
Coordinate 2	56.5 ft	43.375 ft
Coordinate 3	97.75 ft	43.375 ft
Coordinate 4	123 ft	43.375 ft
Coordinate 5	159.75 ft	42.625 ft
Coordinate 6	192 ft	42.625 ft
Coordinate 7	210.75 ft	42.625 ft
Coordinate 8	298 ft	35 ft
Coordinate 9	335.25 ft	35 ft

Seismic Coefficients

Horz Seismic Coef.: 0.191

Reinforcement Lines

Reinforcement Line 1

Reinforcement: EQ_EL47_W9.5xW4
Lock to Ground Surface: No
Outside Point: (160, 47) ft
Inside Point: (128, 47) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 2

Reinforcement: EQ_EL49_W9.5xW4
Lock to Ground Surface: No
Outside Point: (160, 49) ft
Inside Point: (128, 49) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 3

Reinforcement: EQ_EL51_W9.5xW4
Lock to Ground Surface: No
Outside Point: (160, 51) ft
Inside Point: (128, 51) ft
Length: 32 ft
Orienta□on: 180 °

Slip Surface Intersec□on: (135.45871, 51) ft
Max. Pullout Force: 9,730 lbf
Available Length: 7.4587092 ft
Required Length: 2.9647733 ft
Pullout Force: 9,730 lbf
Pullout Force per Length: 3,281.8698 lbf/ft
Governing Component: Tensile Capacity

Reinforcement Line 4

Reinforcement: EQ_EL53_W9.5xW4
Lock to Ground Surface: No
Outside Point: (160, 53) ft
Inside Point: (128, 53) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 5

Reinforcement: EQ_EL55_W9.5xW4
Lock to Ground Surface: No
Outside Point: (160, 55) ft
Inside Point: (128, 55) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 6

Reinforcement: EQ_EL57_W9.5xW4
Lock to Ground Surface: No
Outside Point: (160, 57) ft
Inside Point: (128, 57) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 7

Reinforcement: EQ_EL59_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 59) ft

Inside Point: (128, 59) ft
Length: 32 ft
Orientaon: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 8

Reinforcement: EQ_EL61_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 61) ft
Inside Point: (128, 61) ft
Length: 32 ft
Orientaon: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 9

Reinforcement: EQ_EL63_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 63) ft
Inside Point: (128, 63) ft
Length: 32 ft
Orientaon: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 10

Reinforcement: EQ_EL65_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 65) ft
Inside Point: (128, 65) ft
Length: 32 ft
Orientaon: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 11

Reinforcement: EQ_EL67_W7.0xW3.5

Lock to Ground Surface: No
Outside Point: (160, 67) ft
Inside Point: (128, 67) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 12

Reinforcement: EQ_EL69_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 69) ft
Inside Point: (128, 69) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 13

Reinforcement: EQ_EL71_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 71) ft
Inside Point: (128, 71) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 14

Reinforcement: EQ_EL73_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 73) ft
Inside Point: (128, 73) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 15

Reinforcement: EQ_EL75_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 75) ft
Inside Point: (128, 75) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 16

Reinforcement: EQ_EL77_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 77) ft
Inside Point: (128, 77) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 17

Reinforcement: EQ_EL79_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 79) ft
Inside Point: (128, 79) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 18

Reinforcement: EQ_EL81_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 81) ft
Inside Point: (128, 81) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft

Governing Component: (none)

Reinforcement Line 19

Reinforcement: EQ_EL83_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 83) ft
Inside Point: (128, 83) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 20

Reinforcement: EQ_EL89_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 89) ft
Inside Point: (128, 89) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 21

Reinforcement: EQ_EL87_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 87) ft
Inside Point: (128, 87) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 22

Reinforcement: EQ_EL85_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 85) ft
Inside Point: (128, 85) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft

Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 125 pcf
Direc□on: Ver□cal

Coordinates

	X	Y
	120 ft	91 ft
	160 ft	91 ft

Geometry

Name: Ga-Ga'

Se ngs

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	0 ft	56 ft
Point 2	76 ft	56 ft
Point 3	118 ft	35 ft
Point 4	160 ft	35 ft
Point 5	0 ft	46 ft
Point 6	37 ft	46 ft
Point 7	190 ft	50 ft
Point 8	160 ft	50 ft
Point 9	170.25 ft	34 ft
Point 10	240 ft	34 ft
Point 11	315 ft	30 ft
Point 12	335 ft	30 ft
Point 13	335 ft	48 ft
Point 14	327 ft	48 ft
Point 15	315 ft	49 ft
Point 16	224 ft	48 ft
Point 17	0 ft	0 ft
Point 18	335 ft	0 ft
Point 19	160 ft	90 ft
Point 20	120 ft	90 ft
Point 21	120 ft	72 ft
Point 22	80 ft	72 ft
Point 23	56 ft	60 ft

Point 24	0 ft	60 ft
Point 25	160 ft	47 ft
Point 26	120 ft	47 ft
Point 27	70 ft	67 ft
Point 28	160 ft	78 ft
Point 29	93.5 ft	78 ft
Point 30	120 ft	78 ft
Point 31	160 ft	72 ft
Point 32	128 ft	90 ft
Point 33	128 ft	47 ft
Point 34	128 ft	78 ft
Point 35	128 ft	72 ft

Regions

	Material	Points	Area
Region 1	ESU 2C - Na□ve Silt (Pseudo-Sta□c)	5,6,2,1	565 ft²
Region 2	ESU 1A - Exis□ng Granular Fill (Pseudo-Sta□c)	20,29,30	159 ft²
Region 3	ESU 2A - Na□ve Sand and Gravel	6,2,3	619.5 ft²
Region 4	ESU 2B - Na□ve Sand and Gravel	7,16,15,14,13,12,11,10,9,4	2,595.4 ft²
Region 5	ESU 7A - Weathered Sandstone	18,17,5,6,3,4,9,10,11,12	12,178 ft²
Region 6	ESU 1B - Exis□ng Gravelly Granular Fill	8,7,25	45 ft²
Region 7	ESU 2A - Na□ve Sand and Gravel	4,7,25,33,26,2,3	945 ft²
Region 8	ESU 1B - Exis□ng Gravelly Granular Fill	23,24,1,2,26,21,22,27	1,302 ft²
Region 9	ESU 1B - Exis□ng Gravelly Granular Fill	26,33,35,21	200 ft²
Region 10	ESU 1A - Exis□ng Granular Fill (Pseudo-Sta□c)	19,32,34,28	384 ft²
Region 11	ESU 1A - Exis□ng Granular Fill (Pseudo-Sta□c)	22,21,30,29	199.5 ft²
Region 12	ESU 1A - Exis□ng Granular Fill (Pseudo-Sta□c)	28,34,35,31	192 ft²
Region 13	ESU 1A - Exis□ng Granular Fill (Pseudo-Sta□c)	20,30,34,32	96 ft²
Region 14	ESU 1A - Exis□ng Granular Fill (Pseudo-Sta□c)	30,21,35,34	48 ft²
Region 15	ESU 1B - Exis□ng Gravelly Granular Fill	25,8,31,35,33	800 ft²

Slip Results

Slip Surfaces Analysed: 1799 of 4305 converged

Current Slip Surface

Slip Surface: 3,042
Factor of Safety: 2.235
Volume: 2,221.5752 ft³
Weight: 272,354.25 lbf
Resis□ng Moment: 23,315,773 lbf·ft
Ac□va□ng Moment: 10,434,769 lbf·ft
Resis□ng Force: 203,492.76 lbf
Ac□va□ng Force: 91,050.169 lbf
Slip Rank: 1 of 4,305 slip surfaces
Exit: (170.15, 50) ft
Entry: (85.363817, 74.383919) ft
Radius: 111.08602 ft
Center: (155.93553, 160.17283) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Fric⍰onal Strength	Cohesive Strength	Suc⍰on Strength	Base Material
Slice 1	86.864855 ft	73.191959 ft	-1,860.5783 psf	107.59807 psf	90.285499 psf	50 psf	0 psf	ESU 1A - Exis⍰ng Granular Fill (Pseudo-Sta⍰c)
Slice 2	89.649419 ft	71.045412 ft	-1,726.6337 psf	309.22165 psf	241.59043 psf	0 psf	0 psf	ESU 1B - Exis⍰ng Gravelly Granular Fill
Slice 3	92.216473 ft	69.191897 ft	-1,610.9744 psf	507.07334 psf	396.16911 psf	0 psf	0 psf	ESU 1B - Exis⍰ng Gravelly Granular Fill
Slice 4	94.5625 ft	67.588652 ft	-1,510.9319 psf	694.39858 psf	542.52363 psf	0 psf	0 psf	ESU 1B - Exis⍰ng Gravelly Granular Fill
Slice 5	96.6875 ft	66.214344 ft	-1,425.1751 psf	869.13649 psf	679.04385 psf	0 psf	0 psf	ESU 1B - Exis⍰ng Gravelly Granular Fill
Slice 6	99.140625 ft	64.716954 ft	-1,331.7379 psf	1,076.0395 psf	840.69416 psf	0 psf	0 psf	ESU 1B - Exis⍰ng Gravelly Granular Fill
Slice 7	101.92188 ft	63.11565 ft	-1,231.8166 psf	1,318.4948 psf	1,030.121 psf	0 psf	0 psf	ESU 1B - Exis⍰ng Gravelly Granular Fill
Slice 8	104.70312 ft	61.618844 ft	-1,138.4159 psf	1,568.9995 psf	1,225.8368 psf	0 psf	0 psf	ESU 1B - Exis⍰ng Gravelly Granular Fill
Slice 9	107.48438 ft	60.221836 ft	-1,051.2426 psf	1,827.8479 psf	1,428.0713 psf	0 psf	0 psf	ESU 1B - Exis⍰ng Gravelly Granular Fill
Slice 10	110.26562 ft	58.92049 ft	-970.03857 psf	2,095.4221 psf	1,637.1231 psf	0 psf	0 psf	ESU 1B - Exis⍰ng Gravelly Granular Fill

Slice 11	113.04688 ft	57.711157 ft	-894.57619 psf	2,372.1961 psf	1,853.3627 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 12	115.82812 ft	56.590611 ft	-824.65411 psf	2,658.7426 psf	2,077.2374 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 13	118.60938 ft	55.555996 ft	-760.09415 psf	2,955.7428 psf	2,309.2794 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 14	121.5 ft	54.570705 ft	-698.61198 psf	3,330.4288 psf	2,602.0162 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 15	124.25 ft	53.709549 ft	-646.46772 psf	3,535.26 psf	2,762.0478 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 16	126.75 ft	52.997132 ft	-605.19654 psf	3,725.1128 psf	2,910.3771 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 17	129.44318 ft	52.302302 ft	-565.26882 psf	3,934.0977 psf	3,073.654 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 18	132.32955 ft	51.633989 ft	-527.24181 psf	4,164.555 psf	3,253.7069 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 19	135.21591 ft	51.0461 ft	-494.23322 psf	4,776.2346 psf	3,731.6035 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 20	138.10227 ft	50.537339 ft	-466.16225 psf	5,038.1132 psf	3,936.2054 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 21	140.98864 ft	50.106609 ft	-442.9604 psf	5,310.6958 psf	4,149.1703 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice	143.875 ft	49.752996	-424.57062	5,595.5946	4,371.7576	0 psf	0 psf	ESU 1B -

22		ft	psf	psf	psf			Exis□ng Gravelly Granular Fill
Slice 23	146.76136 ft	49.47576 ft	-410.94679 psf	5,894.699 psf	4,605.4436 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 24	149.64773 ft	49.274328 ft	-402.05312 psf	6,210.223 psf	4,851.9579 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 25	152.53409 ft	49.148287 ft	-397.86386 psf	6,544.7603 psf	5,113.3271 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 26	155.42045 ft	49.09738 ft	-398.36297 psf	6,901.3494 psf	5,391.9251 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 27	158.30682 ft	49.121504 ft	-403.54402 psf	7,283.5505 psf	5,690.5333 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 28	159.875 ft	49.156756 ft	-407.5816 psf	13,402.522 psf	10,471.198 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 29	161.26875 ft	49.222179 ft	-411.66396 psf	134.35324 psf	104.96826 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 30	163.80625 ft	49.373292 ft	-421.09343 psf	114.16214 psf	89.193239 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 31	166.34375 ft	49.582828 ft	-434.16845 psf	80.356042 psf	62.781021 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 32	168.88125 ft	49.851118 ft	-450.90978 psf	30.412261 psf	23.760663 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill

2.4 Pseudo-Static (M-P)

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File Informa on

File Version: 11.01
Created By: Mikayla S. Hatch
Last Edited By: Mikayla S. Hatch
Revision Number: 306
Date: 11/15/2021
Time: 01:39:23 PM
Tool Version: 11.1
File Name: Wall 03.63L - Bridge 17.7 Ha-Ha' - All Condi ons.gsz
Directory: P:\0\0180366\01\Analysis\Bridge 17.7\SlopeW\
Last Solved Date: 11/15/2021
Last Solved Time: 01:39:32 PM

Project Se ngs

Unit System: U.S. Customary Units

Analysis Se ngs

2.4 Pseudo-Sta c (M&P)

Kind: SLOPE/W
Parent: 2. Compound Stability - 30 Years Corrosion
Analysis Type: Morgenstern-Price
Se ngs
Side Func on
Interslice force func on op on: Half-Sine
PWP Condi ons from: Piezometric Line
Apply Phrea c Correc on: No
Use Staged Rapid Drawdown: No
Unit Weight of Water: 62.4 pcf
Slip Surface
Direc on of movement: Le. to Right
Use Passive Mode: No
Slip Surface Op on: Entry and Exit
Cri cal slip surfaces saved: 1
Op mize Cri cal Slip Surface Loca on: No
Tension Crack Op on: (none)
Distribu on
F of S Calcula on Op on: Constant
Advanced
Geometry Se ngs
Minimum Slip Surface Depth: 2 ft
Number of Slices: 30
Factor of Safety Convergence Se ngs
Maximum Number of Itera ons: 100
Tolerable difference in F of S: 0.001

Solu□on Se□ ngs
Search Method: Root Finder
Tolerable difference between star□ng and converged F of S: 3
Maximum itera□ons to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

ESU 1A - Exis ng Granular Fill (Pseudo-Sta c)

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 50 psf
Effec□ve Fric□on Angle: 40 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2A - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 39 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2B - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 41 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 7A - Weathered Sandstone

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 43 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1B - Exis ng Gravelly Granular Fill

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2C - Na ve Silt (Pseudo-Sta c)

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effec□ve Cohesion: 200 psf
Effec□ve Fric□on Angle: 29 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Reinforcements

EQ_EL47_W9.5xW4

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.5 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 9,730 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 9,730 lbf/ft

EQ_EL49_W9.5xW4

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.5 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 9,730 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 9,730 lbf/ft

EQ_EL51_W9.5xW4

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.5 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 9,730 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 9,730 lbf/ft

EQ_EL53_W9.5xW4

Type: Geosynthe□c

Interface Adhesion: 0 psf
Interface Shear Angle: 18.5 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 9,730 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 9,730 lbf/ft

EQ_EL55_W9.5xW4

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.5 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 9,730 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 9,730 lbf/ft

EQ_EL57_W9.5xW4

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.5 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 9,730 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 9,730 lbf/ft

EQ_EL59_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 16 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,091 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,091 lbf/ft

EQ_EL61_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 16 °

Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,091 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,091 lbf/ft

EQ_EL63_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 16 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,091 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,091 lbf/ft

EQ_EL65_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 16 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,091 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,091 lbf/ft

EQ_EL67_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 16 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,091 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,091 lbf/ft

EQ_EL69_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 16 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1

Tensile Capacity: 7,091 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,091 lbf/ft

EQ_EL71_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 29.8 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,091 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,091 lbf/ft

EQ_EL73_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 29.8 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,091 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,091 lbf/ft

EQ_EL75_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 24.3 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 4,426 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 4,426 lbf/ft

EQ_EL77_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 24.3 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 4,426 lbf
Tensile Capacity Reduc□on Factor: 1

F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 4,426 lbf/ft

EQ_EL79_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 24.3 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 4,426 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 4,426 lbf/ft

EQ_EL81_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 24.3 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 4,426 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 4,426 lbf/ft

EQ_EL83_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 24.3 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 4,426 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 4,426 lbf/ft

EQ_EL85_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 24.3 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 4,426 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed

Face Anchorage: Yes
Factored Tensile Capacity: 4,426 lbf/ft

EQ_EL87_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 24.3 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 4,426 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 4,426 lbf/ft

EQ_EL89_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 24.3 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 4,426 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 4,426 lbf/ft

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (0.05, 60) ft
Left-Zone Right Coordinate: (120, 90) ft
Left-Zone Increment: 40
Right Type: Range
Right-Zone Left Coordinate: (160, 70.95212) ft
Right-Zone Right Coordinate: (170.15, 50) ft
Right-Zone Increment: 20
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 60) ft
Right Coordinate: (335, 48) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	0.25 ft	43.375 ft
Coordinate 2	56.5 ft	43.375 ft
Coordinate 3	97.75 ft	43.375 ft
Coordinate 4	123 ft	43.375 ft
Coordinate 5	159.75 ft	42.625 ft
Coordinate 6	192 ft	42.625 ft
Coordinate 7	210.75 ft	42.625 ft
Coordinate 8	298 ft	35 ft
Coordinate 9	335.25 ft	35 ft

Seismic Coefficients

Horz Seismic Coef.: 0.191

Reinforcement Lines

Reinforcement Line 1

Reinforcement: EQ_EL47_W9.5xW4
Lock to Ground Surface: No
Outside Point: (160, 47) ft
Inside Point: (128, 47) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 2

Reinforcement: EQ_EL49_W9.5xW4
Lock to Ground Surface: No
Outside Point: (160, 49) ft
Inside Point: (128, 49) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 3

Reinforcement: EQ_EL51_W9.5xW4
Lock to Ground Surface: No
Outside Point: (160, 51) ft
Inside Point: (128, 51) ft
Length: 32 ft

Orientation: 180 °
Slip Surface Intersection: (135.45871, 51) ft
Max. Pullout Force: 9,730 lbf
Available Length: 7.4587092 ft
Required Length: 2.9647733 ft
Pullout Force: 9,730 lbf
Pullout Force per Length: 3,281.8698 lbf/ft
Governing Component: Tensile Capacity

Reinforcement Line 4

Reinforcement: EQ_EL53_W9.5xW4
Lock to Ground Surface: No
Outside Point: (160, 53) ft
Inside Point: (128, 53) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 5

Reinforcement: EQ_EL55_W9.5xW4
Lock to Ground Surface: No
Outside Point: (160, 55) ft
Inside Point: (128, 55) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 6

Reinforcement: EQ_EL57_W9.5xW4
Lock to Ground Surface: No
Outside Point: (160, 57) ft
Inside Point: (128, 57) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 7

Reinforcement: EQ_EL59_W7.0xW3.5
Lock to Ground Surface: No

Outside Point: (160, 59) ft
Inside Point: (128, 59) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 8

Reinforcement: EQ_EL61_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 61) ft
Inside Point: (128, 61) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 9

Reinforcement: EQ_EL63_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 63) ft
Inside Point: (128, 63) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 10

Reinforcement: EQ_EL65_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 65) ft
Inside Point: (128, 65) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 11

Reinforcement: EQ_EL67_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 67) ft
Inside Point: (128, 67) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 12

Reinforcement: EQ_EL69_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 69) ft
Inside Point: (128, 69) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 13

Reinforcement: EQ_EL71_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 71) ft
Inside Point: (128, 71) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 14

Reinforcement: EQ_EL73_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 73) ft
Inside Point: (128, 73) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 15

Reinforcement: EQ_EL75_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 75) ft
Inside Point: (128, 75) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 16

Reinforcement: EQ_EL77_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 77) ft
Inside Point: (128, 77) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 17

Reinforcement: EQ_EL79_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 79) ft
Inside Point: (128, 79) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 18

Reinforcement: EQ_EL81_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 81) ft
Inside Point: (128, 81) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft

Governing Component: (none)

Reinforcement Line 19

Reinforcement: EQ_EL83_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 83) ft
Inside Point: (128, 83) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 20

Reinforcement: EQ_EL89_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 89) ft
Inside Point: (128, 89) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 21

Reinforcement: EQ_EL87_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 87) ft
Inside Point: (128, 87) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 22

Reinforcement: EQ_EL85_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 85) ft
Inside Point: (128, 85) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft

Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 125 pcf
Direc□on: Ver□cal

Coordinates

	X	Y
	120 ft	91 ft
	160 ft	91 ft

Geometry

Name: Ga-Ga'

Se ngs

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	0 ft	56 ft
Point 2	76 ft	56 ft
Point 3	118 ft	35 ft
Point 4	160 ft	35 ft
Point 5	0 ft	46 ft
Point 6	37 ft	46 ft
Point 7	190 ft	50 ft
Point 8	160 ft	50 ft
Point 9	170.25 ft	34 ft
Point 10	240 ft	34 ft
Point 11	315 ft	30 ft
Point 12	335 ft	30 ft
Point 13	335 ft	48 ft
Point 14	327 ft	48 ft
Point 15	315 ft	49 ft
Point 16	224 ft	48 ft
Point 17	0 ft	0 ft
Point 18	335 ft	0 ft
Point 19	160 ft	90 ft
Point 20	120 ft	90 ft
Point 21	120 ft	72 ft
Point 22	80 ft	72 ft
Point 23	56 ft	60 ft

Figure D.5-606

Point 24	0 ft	60 ft
Point 25	160 ft	47 ft
Point 26	120 ft	47 ft
Point 27	70 ft	67 ft
Point 28	160 ft	78 ft
Point 29	93.5 ft	78 ft
Point 30	120 ft	78 ft
Point 31	160 ft	72 ft
Point 32	128 ft	90 ft
Point 33	128 ft	47 ft
Point 34	128 ft	78 ft
Point 35	128 ft	72 ft

Regions

	Material	Points	Area
Region 1	ESU 2C - Na□ve Silt (Pseudo-Sta□c)	5,6,2,1	565 ft²
Region 2	ESU 1A - Exis□ng Granular Fill (Pseudo-Sta□c)	20,29,30	159 ft²
Region 3	ESU 2A - Na□ve Sand and Gravel	6,2,3	619.5 ft²
Region 4	ESU 2B - Na□ve Sand and Gravel	7,16,15,14,13,12,11,10,9,4	2,595.4 ft²
Region 5	ESU 7A - Weathered Sandstone	18,17,5,6,3,4,9,10,11,12	12,178 ft²
Region 6	ESU 1B - Exis□ng Gravelly Granular Fill	8,7,25	45 ft²
Region 7	ESU 2A - Na□ve Sand and Gravel	4,7,25,33,26,2,3	945 ft²
Region 8	ESU 1B - Exis□ng Gravelly Granular Fill	23,24,1,2,26,21,22,27	1,302 ft²
Region 9	ESU 1B - Exis□ng Gravelly Granular Fill	26,33,35,21	200 ft²
Region 10	ESU 1A - Exis□ng Granular Fill (Pseudo-Sta□c)	19,32,34,28	384 ft²
Region 11	ESU 1A - Exis□ng Granular Fill (Pseudo-Sta□c)	22,21,30,29	199.5 ft²
Region 12	ESU 1A - Exis□ng Granular Fill (Pseudo-Sta□c)	28,34,35,31	192 ft²
Region 13	ESU 1A - Exis□ng Granular Fill (Pseudo-Sta□c)	20,30,34,32	96 ft²
Region 14	ESU 1A - Exis□ng Granular Fill (Pseudo-Sta□c)	30,21,35,34	48 ft²
Region 15	ESU 1B - Exis□ng Gravelly Granular Fill	25,8,31,35,33	800 ft²

Slip Results

Slip Surfaces Analysed: 1970 of 4305 converged

Current Slip Surface

Slip Surface: 3,042
Factor of Safety: 2.234
Volume: 2,221.5752 ft³
Weight: 272,354.25 lbf
Resis□ng Moment: 23,310,317 lbf·ft
Ac□va□ng Moment: 10,434,769 lbf·ft
Resis□ng Force: 203,493.42 lbf
Ac□va□ng Force: 91,083.949 lbf
Slip Rank: 1 of 4,305 slip surfaces
Exit: (170.15, 50) ft
Entry: (85.363817, 74.383919) ft
Radius: 111.08602 ft
Center: (155.93553, 160.17283) ft

Figure D.5-607

Slip Slices

	X	Y	PWP	Base Normal Stress	Fric□onal Strength	Cohesive Strength	Suc□on Strength	Base Material
Slice 1	86.864855 ft	73.191959 ft	-1,860.5783 psf	149.70366 psf	125.61628 psf	50 psf	0 psf	ESU 1A - Exis□ng Granular Fill (Pseudo-Sta□c)
Slice 2	89.649419 ft	71.045412 ft	-1,726.6337 psf	437.58089 psf	341.87566 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 3	92.216473 ft	69.191897 ft	-1,610.9744 psf	651.4477 psf	508.96673 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 4	94.5625 ft	67.588652 ft	-1,510.9319 psf	824.68187 psf	644.31209 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 5	96.6875 ft	66.214344 ft	-1,425.1751 psf	968.24751 psf	756.47786 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 6	99.140625 ft	64.716954 ft	-1,331.7379 psf	1,123.2677 psf	877.59293 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 7	101.92188 ft	63.11565 ft	-1,231.8166 psf	1,293.9028 psf	1,010.9076 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 8	104.70312 ft	61.618844 ft	-1,138.4159 psf	1,465.8468 psf	1,145.245 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 9	107.48438 ft	60.221836 ft	-1,051.2426 psf	1,646.6512 psf	1,286.5049 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 10	110.26562 ft	58.92049 ft	-970.03857 psf	1,843.7086 psf	1,440.463 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill

Slice 11	113.04688 ft	57.711157 ft	-894.57619 psf	2,064.3967 psf	1,612.8835 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 12	115.82812 ft	56.590611 ft	-824.65411 psf	2,316.0904 psf	1,809.5282 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 13	118.60938 ft	55.555996 ft	-760.09415 psf	2,606.0086 psf	2,036.0371 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 14	121.5 ft	54.570705 ft	-698.61198 psf	3,011.9239 psf	2,353.1728 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 15	124.25 ft	53.709549 ft	-646.46772 psf	3,286.6812 psf	2,567.8368 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 16	126.75 ft	52.997132 ft	-605.19654 psf	3,574.1474 psf	2,792.43 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 17	129.44318 ft	52.302302 ft	-565.26882 psf	3,921.8039 psf	3,064.049 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 18	132.32955 ft	51.633989 ft	-527.24181 psf	4,332.1154 psf	3,384.6195 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 19	135.21591 ft	51.0461 ft	-494.23322 psf	5,198.5344 psf	4,061.5402 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 20	138.10227 ft	50.537339 ft	-466.16225 psf	5,618.7199 psf	4,389.8251 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 21	140.98864 ft	50.106609 ft	-442.9604 psf	6,000.7815 psf	4,688.3243 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice	143.875 ft	49.752996	-424.57062	6,316.0423	4,934.6331	0 psf	0 psf	ESU 1B -

22		ft	psf	psf	psf			Exis□ng Gravelly Granular Fill
Slice 23	146.76136 ft	49.47576 ft	-410.94679 psf	6,536.9627 psf	5,107.235 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 24	149.64773 ft	49.274328 ft	-402.05312 psf	6,641.7792 psf	5,189.1266 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 25	152.53409 ft	49.148287 ft	-397.86386 psf	6,618.9034 psf	5,171.2541 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 26	155.42045 ft	49.09738 ft	-398.36297 psf	6,469.7401 psf	5,054.7149 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 27	158.30682 ft	49.121504 ft	-403.54402 psf	6,208.8353 psf	4,850.8737 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 28	159.875 ft	49.156756 ft	-407.5816 psf	7,932.6963 psf	6,197.7016 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 29	161.26875 ft	49.222179 ft	-411.66396 psf	118.47922 psf	92.566112 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 30	163.80625 ft	49.373292 ft	-421.09343 psf	91.519047 psf	71.502516 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 31	166.34375 ft	49.582828 ft	-434.16845 psf	58.414131 psf	45.638121 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 32	168.88125 ft	49.851118 ft	-450.90978 psf	20.092841 psf	15.698248 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill

4.1 Static (Spencer) Section Ha-Ha' - Construction Condition - Compound Stability

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File Informa on

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Last Solved Date: 11/15/2021
Last Solved Time: 01:46:24 PM

Project Se ngs

Unit System: U.S. Customary Units

Analysis Se ngs

4.1 Sta c (Spencer)

Kind: SLOPE/W
Parent: 4. Compound Stability
Analysis Type: Spencer
Se ngs
PWP Condi ons from: Piezometric Line
Apply Phrea c Correc on: No
Use Staged Rapid Drawdown: No
Unit Weight of Water: 62.4 pcf
Slip Surface
Direc on of movement: Le. to Right
Use Passive Mode: No
Slip Surface Op□on: Entry and Exit
Cri□cal slip surfaces saved: 1
Op□mize Cri□cal Slip Surface Loca□on: No
Tension Crack Op□on: (none)
Distribu□on
F of S Calcula□on Op□on: Constant
Advanced
Geometry Se□ ngs
Minimum Slip Surface Depth: 2 ft
Number of Slices: 30
Factor of Safety Convergence Se□ ngs
Maximum Number of Itera□ons: 100
Tolerable difference in F of S: 0.001
Solu□on Se□ ngs
Search Method: Root Finder

Tolerable difference between star□ng and converged F of S: 3
Maximum itera□ons to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

ESU 2A - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 39 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2B - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 41 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 7A - Weathered Sandstone

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 43 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2C - Na ve Silt

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 29 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1A - Exis ng Granular Fill

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 40 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1B - Exis ng Gravelly Granular Fill

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Reinforcements

Con_EL47_W9.5xW4

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 14.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,441 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,441 lbf/ft

Con_EL49_W9.5xW4

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 14.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,441 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,441 lbf/ft

Con_EL51_W9.5xW4

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 14.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,441 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,441 lbf/ft

Con_EL53_W9.5xW4

Type: Geosynthe□c
Interface Adhesion: 0 psf

Interface Shear Angle: 14.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,441 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,441 lbf/ft

Con_EL55_W9.5xW4

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 14.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,441 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,441 lbf/ft

Con_EL57_W9.5xW4

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 14.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,441 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,441 lbf/ft

Con_EL59_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 23.2 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,422 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,422 lbf/ft

Con_EL61_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 23.2 °
Surface Area Factor: 2

Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,422 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,422 lbf/ft

Con_EL63_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 23.2 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,422 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,422 lbf/ft

Con_EL65_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 23.2 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,422 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,422 lbf/ft

Con_EL67_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 23.2 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,422 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,422 lbf/ft

Con_EL69_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 23.2 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,422 lbf

Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,422 lbf/ft

Con_EL71_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 23.2 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,422 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,422 lbf/ft

Con_EL73_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 23.2 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,422 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,422 lbf/ft

Con_EL75_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,385 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,385 lbf/ft

Con_EL77_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,385 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No

Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,385 lbf/ft

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (0.05, 60) ft
Left-Zone Right Coordinate: (128, 78) ft
Left-Zone Increment: 40
Right Type: Range
Right-Zone Left Coordinate: (160, 67) ft
Right-Zone Right Coordinate: (205, 49.117647) ft
Right-Zone Increment: 20
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 60) ft
Right Coordinate: (335, 48) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	0.25 ft	43.375 ft
Coordinate 2	56.5 ft	43.375 ft
Coordinate 3	97.75 ft	43.375 ft
Coordinate 4	123 ft	43.375 ft
Coordinate 5	159.75 ft	42.625 ft
Coordinate 6	192 ft	42.625 ft
Coordinate 7	210.75 ft	42.625 ft
Coordinate 8	298 ft	35 ft
Coordinate 9	335.25 ft	35 ft

Reinforcement Lines

Reinforcement Line 1

Reinforcement: Con_EL47_W9.5xW4
Lock to Ground Surface: No
Outside Point: (160, 47) ft
Inside Point: (128, 47) ft
Length: 32 ft
Orienta□on: 180 °
Slip Surface Intersec□on: (128.07878, 47) ft
Max. Pullout Force: 7,441 lbf
Available Length: 0.078783219 ft

Figure D.5-617

Required Length: 0.078783219 ft
Pullout Force: 157.05308 lbf
Pullout Force per Length: 1,993.4839 lbf/ft
Governing Component: Pullout Resistance

Reinforcement Line 2

Reinforcement: Con_EL49_W9.5xW4
Lock to Ground Surface: No
Outside Point: (160, 49) ft
Inside Point: (128, 49) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 3

Reinforcement: Con_EL51_W9.5xW4
Lock to Ground Surface: No
Outside Point: (160, 51) ft
Inside Point: (128, 51) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 4

Reinforcement: Con_EL53_W9.5xW4
Lock to Ground Surface: No
Outside Point: (160, 53) ft
Inside Point: (128, 53) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 5

Reinforcement: Con_EL55_W9.5xW4
Lock to Ground Surface: No
Outside Point: (160, 55) ft
Inside Point: (128, 55) ft
Length: 32 ft
Orienta□on: 180 °

Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 6

Reinforcement: Con_EL57_W9.5xW4
Lock to Ground Surface: No
Outside Point: (160, 57) ft
Inside Point: (128, 57) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 7

Reinforcement: Con_EL59_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 59) ft
Inside Point: (128, 59) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 8

Reinforcement: Con_EL61_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 61) ft
Inside Point: (128, 61) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 9

Reinforcement: Con_EL63_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 63) ft
Inside Point: (128, 63) ft

Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 10

Reinforcement: Con_EL65_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 65) ft
Inside Point: (128, 65) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 11

Reinforcement: Con_EL67_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 67) ft
Inside Point: (128, 67) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 12

Reinforcement: Con_EL69_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 69) ft
Inside Point: (128, 69) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 13

Reinforcement: Con_EL71_W7.0xW3.5
Lock to Ground Surface: No

Outside Point: (160, 71) ft
Inside Point: (128, 71) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 14

Reinforcement: Con_EL73_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 73) ft
Inside Point: (128, 73) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 15

Reinforcement: Con_EL75_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 75) ft
Inside Point: (128, 75) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 16

Reinforcement: Con_EL77_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 77) ft
Inside Point: (128, 77) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Geometry

Name: Ga-Ga'

Se ngs

View: 2D

Element Thickness: 1 ft

Points

	X	Y
Point 1	0 ft	56 ft
Point 2	76 ft	56 ft
Point 3	118 ft	35 ft
Point 4	160 ft	35 ft
Point 5	0 ft	46 ft
Point 6	37 ft	46 ft
Point 7	190 ft	50 ft
Point 8	160 ft	50 ft
Point 9	170.25 ft	34 ft
Point 10	240 ft	34 ft
Point 11	315 ft	30 ft
Point 12	335 ft	30 ft
Point 13	335 ft	48 ft
Point 14	327 ft	48 ft
Point 15	315 ft	49 ft
Point 16	224 ft	48 ft
Point 17	0 ft	0 ft
Point 18	335 ft	0 ft
Point 19	160 ft	90 ft
Point 20	120 ft	90 ft
Point 21	120 ft	72 ft
Point 22	80 ft	72 ft
Point 23	56 ft	60 ft
Point 24	0 ft	60 ft
Point 25	160 ft	47 ft
Point 26	120 ft	47 ft
Point 27	70 ft	67 ft
Point 28	160 ft	78 ft
Point 29	93.5 ft	78 ft
Point 30	120 ft	78 ft
Point 31	160 ft	72 ft
Point 32	128 ft	90 ft
Point 33	128 ft	47 ft
Point 34	128 ft	78 ft
Point 35	128 ft	72 ft

Regions

	Material	Points	Area
Region 1	ESU 2C - Na ve Silt	5,6,2,1	565 ft²
Region 2		20,29,30	159 ft²

Figure D.5-622

Region 3	ESU 2A - Na□ve Sand and Gravel	6,2,3	619.5 ft²
Region 4	ESU 2B - Na□ve Sand and Gravel	7,16,15,14,13,12,11,10,9,4	2,595.4 ft²
Region 5	ESU 7A - Weathered Sandstone	18,17,5,6,3,4,9,10,11,12	12,178 ft²
Region 6	ESU 1B - Exis□ng Gravelly Granular Fill	8,7,25	45 ft²
Region 7	ESU 2A - Na□ve Sand and Gravel	4,7,25,33,26,2,3	945 ft²
Region 8	ESU 1B - Exis□ng Gravelly Granular Fill	23,24,1,2,26,21,22,27	1,302 ft²
Region 9	ESU 1B - Exis□ng Gravelly Granular Fill	26,33,35,21	200 ft²
Region 10		19,32,34,28	384 ft²
Region 11	ESU 1A - Exis□ng Granular Fill	22,21,30,29	199.5 ft²
Region 12	ESU 1A - Exis□ng Granular Fill	28,34,35,31	192 ft²
Region 13		20,30,34,32	96 ft²
Region 14	ESU 1A - Exis□ng Granular Fill	30,21,35,34	48 ft²
Region 15	ESU 1B - Exis□ng Gravelly Granular Fill	25,8,31,35,33	800 ft²

Slip Results

Slip Surfaces Analysed: 2143 of 4305 converged

Current Slip Surface

Slip Surface: 3,549
Factor of Safety: 2.863
Volume: 1,895.3064 ft³
Weight: 233,926.24 lbf
Resis□ng Moment: 10,587,561 lbf·ft
Ac□va□ng Moment: 3,697,439.6 lbf·ft
Resis□ng Force: 169,863.2 lbf
Ac□va□ng Force: 59,320.083 lbf
Slip Rank: 1 of 4,305 slip surfaces
Exit: (192.61622, 49.846105) ft
Entry: (104.89018, 78) ft
Radius: 55.740737 ft
Center: (158.34324, 93.805088) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Fric□onal Strength	Cohesive Strength	Suc□on Strength	Base Material
Slice 1	105.9673 ft	75 ft	-1,973.4 psf	143.92367 psf	120.7663 psf	0 psf	0 psf	ESU 1A - Exis□ng Granular Fill
Slice 2	108.66387 ft	68.784522 ft	-1,585.5542 psf	557.63865 psf	435.67506 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 3	111.90277 ft	63.118227 ft	-1,231.9774 psf	1,043.8434 psf	815.53982 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill

Slice 4	115.14166 ft	58.675833 ft	-954.77196 psf	1,492.7002 psf	1,166.2252 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 5	118.38055 ft	55.015818 ft	-726.38705 psf	1,909.4561 psf	1,491.8306 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 6	121.5 ft	52.024637 ft	-539.73736 psf	2,285.2449 psf	1,785.429 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 7	124.25 ft	49.734878 ft	-398.44823 psf	2,597.8632 psf	2,029.6732 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 8	126.75 ft	47.907437 ft	-287.59959 psf	2,866.4554 psf	2,239.5204 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 9	129.80091 ft	45.972387 ft	-170.7377 psf	3,163.0968 psf	2,561.4253 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 10	133.36645 ft	44.012595 ft	-52.987286 psf	3,498.3262 psf	2,832.8887 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 11	136.66976 ft	42.477704 ft	38.583281 psf	3,792.5763 psf	3,039.9236 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 12	139.74712 ft	41.283188 ft	109.20213 psf	4,050.0551 psf	3,191.2398 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 13	142.82449 ft	40.292178 ft	167.12223 psf	4,291.5362 psf	3,339.8846 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 14	145.90185 ft	39.493487 ft	213.04159 psf	4,518.2454 psf	3,486.2853 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 15	148.97922 ft	38.878696 ft	247.48565 psf	4,731.2687 psf	3,630.8959 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 16	152.05659 ft	38.441655 ft	270.83804 psf	4,931.6087 psf	3,774.2176 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 17	155.13395 ft	38.178163 ft	283.36103 psf	5,120.2372 psf	3,916.8251 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 18	158.21132 ft	38.085749 ft	285.20874 psf	5,298.1505 psf	4,059.4002 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel

Slice 19	159.875 ft	38.085542 ft	283.26217 psf	5,408.7401 psf	4,150.5302 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 20	161.28601 ft	38.156985 ft	278.80415 psf	1,578.7273 psf	1,052.657 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 21	163.85802 ft	38.352886 ft	266.57991 psf	1,594.6305 psf	1,075.4341 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 22	166.43003 ft	38.669401 ft	246.82941 psf	1,596.3864 psf	1,092.8497 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 23	168.9717 ft	39.101987 ft	219.83601 psf	1,607.0687 psf	1,205.903 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 24	171.48302 ft	39.650621 ft	185.60124 psf	1,594.91 psf	1,225.0934 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 25	173.99434 ft	40.322746 ft	143.66068 psf	1,564.594 psf	1,235.1985 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 26	176.54389 ft	41.137337 ft	92.830168 psf	1,512.9882 psf	1,234.5245 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 27	179.13166 ft	42.104736 ft	32.46449 psf	1,436.6207 psf	1,220.6144 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 28	182.02129 ft	43.374225 ft	-46.751657 psf	1,299.4706 psf	1,129.6126 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 29	185.21277 ft	45.00202 ft	-148.32603 psf	1,071.333 psf	931.29556 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 30	188.40426 ft	46.903358 ft	-266.96955 psf	744.76497 psf	647.41431 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 31	191 ft	48.64933 ft	-375.91821 psf	349.62665 psf	303.92581 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 32	192.30811 ft	49.609319 ft	-435.82149 psf	72.803846 psf	63.287418 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel

4.2 Static (M-P) Section Ha-Ha' - Construction Condition - Compound Stability

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File Informa on

File Version: 11.01
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Last Edited By: Mikayla S. Hatch
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Directory: P:\0\0180366\01\Analysis\Bridge 17.7\SlopeW\
Last Solved Date: 11/15/2021
Last Solved Time: 01:46:28 PM

Project Se ngs

Unit System: U.S. Customary Units

Analysis Se ngs

4.2 Sta c (M-P)

Kind: SLOPE/W
Parent: 4. Compound Stability
Analysis Type: Morgenstern-Price
Se ngs
Side Func on
Interslice force func on op on: Half-Sine
PWP Condi ons from: Piezometric Line
Apply Phrea c Correc on: No
Use Staged Rapid Drawdown: No
Unit Weight of Water: 62.4 pcf
Slip Surface
Direc on of movement: Le. to Right
Use Passive Mode: No
Slip Surface Op on: Entry and Exit
Cri cal slip surfaces saved: 1
Op mize Cri cal Slip Surface Loca on: No
Tension Crack Op on: (none)
Distribu on
F of S Calcula on Op on: Constant
Advanced
Geometry Se ngs
Minimum Slip Surface Depth: 2 ft
Number of Slices: 30
Factor of Safety Convergence Se ngs
Maximum Number of Itera ons: 100
Tolerable difference in F of S: 0.001

Solu□on Se□ ngs
Search Method: Root Finder
Tolerable difference between star□ng and converged F of S: 3
Maximum itera□ons to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

ESU 2A - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 39 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2B - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 41 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 7A - Weathered Sandstone

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 43 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2C - Na ve Silt

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 29 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1A - Exis ng Granular Fill

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 40 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1B - Exis ng Gravelly Granular Fill

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effec ve Cohesion: 0 psf
Effec ve Fric on Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Reinforcements

Con_EL47_W9.5xW4

Type: Geosynthe c
Interface Adhesion: 0 psf
Interface Shear Angle: 14.1 °
Surface Area Factor: 2
Pullout Resistance Reduc on Factor: 1
Tensile Capacity: 7,441 lbf
Tensile Capacity Reduc on Factor: 1
F of S Dependent: No
Force Distribu on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,441 lbf/ft

Con_EL49_W9.5xW4

Type: Geosynthe c
Interface Adhesion: 0 psf
Interface Shear Angle: 14.1 °
Surface Area Factor: 2
Pullout Resistance Reduc on Factor: 1
Tensile Capacity: 7,441 lbf
Tensile Capacity Reduc on Factor: 1
F of S Dependent: No
Force Distribu on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,441 lbf/ft

Con_EL51_W9.5xW4

Type: Geosynthe c
Interface Adhesion: 0 psf
Interface Shear Angle: 14.1 °
Surface Area Factor: 2
Pullout Resistance Reduc on Factor: 1
Tensile Capacity: 7,441 lbf
Tensile Capacity Reduc on Factor: 1
F of S Dependent: No
Force Distribu on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,441 lbf/ft

Con_EL53_W9.5xW4

Type: Geosynthe c

Interface Adhesion: 0 psf
Interface Shear Angle: 14.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,441 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,441 lbf/ft

Con_EL55_W9.5xW4

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 14.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,441 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,441 lbf/ft

Con_EL57_W9.5xW4

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 14.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,441 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,441 lbf/ft

Con_EL59_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 23.2 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,422 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,422 lbf/ft

Con_EL61_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 23.2 °

Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,422 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,422 lbf/ft

Con_EL63_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 23.2 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,422 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,422 lbf/ft

Con_EL65_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 23.2 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,422 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,422 lbf/ft

Con_EL67_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 23.2 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,422 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,422 lbf/ft

Con_EL69_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 23.2 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1

Tensile Capacity: 5,422 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,422 lbf/ft

Con_EL71_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 23.2 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,422 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,422 lbf/ft

Con_EL73_W7.0xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 23.2 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,422 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,422 lbf/ft

Con_EL75_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,385 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,385 lbf/ft

Con_EL77_W4.5xW3.5

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 18.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,385 lbf
Tensile Capacity Reduc□on Factor: 1

F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,385 lbf/ft

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (0.05, 60) ft
Left-Zone Right Coordinate: (128, 78) ft
Left-Zone Increment: 40
Right Type: Range
Right-Zone Left Coordinate: (160, 67) ft
Right-Zone Right Coordinate: (205, 49.117647) ft
Right-Zone Increment: 20
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 60) ft
Right Coordinate: (335, 48) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	0.25 ft	43.375 ft
Coordinate 2	56.5 ft	43.375 ft
Coordinate 3	97.75 ft	43.375 ft
Coordinate 4	123 ft	43.375 ft
Coordinate 5	159.75 ft	42.625 ft
Coordinate 6	192 ft	42.625 ft
Coordinate 7	210.75 ft	42.625 ft
Coordinate 8	298 ft	35 ft
Coordinate 9	335.25 ft	35 ft

Reinforcement Lines

Reinforcement Line 1

Reinforcement: Con_EL47_W9.5xW4
Lock to Ground Surface: No
Outside Point: (160, 47) ft
Inside Point: (128, 47) ft
Length: 32 ft
Orienta□on: 180 °
Slip Surface Intersec□on: (128.07878, 47) ft
Max. Pullout Force: 7,441 lbf

Available Length: 0.078783219 ft
Required Length: 0.078783219 ft
Pullout Force: 157.05308 lbf
Pullout Force per Length: 1,993.4839 lbf/ft
Governing Component: Pullout Resistance

Reinforcement Line 2

Reinforcement: Con_EL49_W9.5xW4
Lock to Ground Surface: No
Outside Point: (160, 49) ft
Inside Point: (128, 49) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 3

Reinforcement: Con_EL51_W9.5xW4
Lock to Ground Surface: No
Outside Point: (160, 51) ft
Inside Point: (128, 51) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 4

Reinforcement: Con_EL53_W9.5xW4
Lock to Ground Surface: No
Outside Point: (160, 53) ft
Inside Point: (128, 53) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 5

Reinforcement: Con_EL55_W9.5xW4
Lock to Ground Surface: No
Outside Point: (160, 55) ft
Inside Point: (128, 55) ft
Length: 32 ft

Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 6

Reinforcement: Con_EL57_W9.5xW4
Lock to Ground Surface: No
Outside Point: (160, 57) ft
Inside Point: (128, 57) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 7

Reinforcement: Con_EL59_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 59) ft
Inside Point: (128, 59) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 8

Reinforcement: Con_EL61_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 61) ft
Inside Point: (128, 61) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 9

Reinforcement: Con_EL63_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 63) ft

Inside Point: (128, 63) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 10

Reinforcement: Con_EL65_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 65) ft
Inside Point: (128, 65) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 11

Reinforcement: Con_EL67_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 67) ft
Inside Point: (128, 67) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 12

Reinforcement: Con_EL69_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 69) ft
Inside Point: (128, 69) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 13

Reinforcement: Con_EL71_W7.0xW3.5

Lock to Ground Surface: No
Outside Point: (160, 71) ft
Inside Point: (128, 71) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 14

Reinforcement: Con_EL73_W7.0xW3.5
Lock to Ground Surface: No
Outside Point: (160, 73) ft
Inside Point: (128, 73) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 15

Reinforcement: Con_EL75_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 75) ft
Inside Point: (128, 75) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 16

Reinforcement: Con_EL77_W4.5xW3.5
Lock to Ground Surface: No
Outside Point: (160, 77) ft
Inside Point: (128, 77) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Geometry

Name: Ga-Ga'

Se ngs

View: 2D

Element Thickness: 1 ft

Points

	X	Y
Point 1	0 ft	56 ft
Point 2	76 ft	56 ft
Point 3	118 ft	35 ft
Point 4	160 ft	35 ft
Point 5	0 ft	46 ft
Point 6	37 ft	46 ft
Point 7	190 ft	50 ft
Point 8	160 ft	50 ft
Point 9	170.25 ft	34 ft
Point 10	240 ft	34 ft
Point 11	315 ft	30 ft
Point 12	335 ft	30 ft
Point 13	335 ft	48 ft
Point 14	327 ft	48 ft
Point 15	315 ft	49 ft
Point 16	224 ft	48 ft
Point 17	0 ft	0 ft
Point 18	335 ft	0 ft
Point 19	160 ft	90 ft
Point 20	120 ft	90 ft
Point 21	120 ft	72 ft
Point 22	80 ft	72 ft
Point 23	56 ft	60 ft
Point 24	0 ft	60 ft
Point 25	160 ft	47 ft
Point 26	120 ft	47 ft
Point 27	70 ft	67 ft
Point 28	160 ft	78 ft
Point 29	93.5 ft	78 ft
Point 30	120 ft	78 ft
Point 31	160 ft	72 ft
Point 32	128 ft	90 ft
Point 33	128 ft	47 ft
Point 34	128 ft	78 ft
Point 35	128 ft	72 ft

Regions

	Material	Points	Area
Region 1	ESU 2C - Na ve Silt	5,6,2,1	565 ft²
Region 2		20,29,30	159 ft²

Figure D.5-637

Region 3	ESU 2A - Na□ve Sand and Gravel	6,2,3	619.5 ft²
Region 4	ESU 2B - Na□ve Sand and Gravel	7,16,15,14,13,12,11,10,9,4	2,595.4 ft²
Region 5	ESU 7A - Weathered Sandstone	18,17,5,6,3,4,9,10,11,12	12,178 ft²
Region 6	ESU 1B - Exis□ng Gravelly Granular Fill	8,7,25	45 ft²
Region 7	ESU 2A - Na□ve Sand and Gravel	4,7,25,33,26,2,3	945 ft²
Region 8	ESU 1B - Exis□ng Gravelly Granular Fill	23,24,1,2,26,21,22,27	1,302 ft²
Region 9	ESU 1B - Exis□ng Gravelly Granular Fill	26,33,35,21	200 ft²
Region 10		19,32,34,28	384 ft²
Region 11	ESU 1A - Exis□ng Granular Fill	22,21,30,29	199.5 ft²
Region 12	ESU 1A - Exis□ng Granular Fill	28,34,35,31	192 ft²
Region 13		20,30,34,32	96 ft²
Region 14	ESU 1A - Exis□ng Granular Fill	30,21,35,34	48 ft²
Region 15	ESU 1B - Exis□ng Gravelly Granular Fill	25,8,31,35,33	800 ft²

Slip Results

Slip Surfaces Analysed: 2312 of 4305 converged

Current Slip Surface

Slip Surface: 3,549
Factor of Safety: 2.865
Volume: 1,895.3064 ft³
Weight: 233,926.24 lbf
Resis□ng Moment: 10,593,501 lbf·ft
Ac□va□ng Moment: 3,697,439.6 lbf·ft
Resis□ng Force: 169,878.87 lbf
Ac□va□ng Force: 59,278.573 lbf
Slip Rank: 1 of 4,305 slip surfaces
Exit: (192.61622, 49.846105) ft
Entry: (104.89018, 78) ft
Radius: 55.740737 ft
Center: (158.34324, 93.805088) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Fric□onal Strength	Cohesive Strength	Suc□on Strength	Base Material
Slice 1	105.9673 ft	75 ft	-1,973.4 psf	190.90569 psf	160.1889 psf	0 psf	0 psf	ESU 1A - Exis□ng Granular Fill
Slice 2	108.66387 ft	68.784522 ft	-1,585.5542 psf	667.38251 psf	521.41637 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 3	111.90277 ft	63.118227 ft	-1,231.9774 psf	1,142.1045 psf	892.30986 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill

Slice 4	115.14166 ft	58.675833 ft	-954.77196 psf	1,536.0723 psf	1,200.1112 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 5	118.38055 ft	55.015818 ft	-726.38705 psf	1,883.5071 psf	1,471.557 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 6	121.5 ft	52.024637 ft	-539.73736 psf	2,193.43 psf	1,713.6953 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 7	124.25 ft	49.734878 ft	-398.44823 psf	2,455.6893 psf	1,918.5948 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 8	126.75 ft	47.907437 ft	-287.59959 psf	2,688.6408 psf	2,100.5964 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 9	129.80091 ft	45.972387 ft	-170.7377 psf	2,959.4885 psf	2,396.5465 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 10	133.36645 ft	44.012595 ft	-52.987286 psf	3,288.7764 psf	2,663.1986 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 11	136.66976 ft	42.477704 ft	38.583281 psf	3,601.5472 psf	2,885.2313 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 12	139.74712 ft	41.283188 ft	109.20213 psf	3,896.0692 psf	3,066.5445 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 13	142.82449 ft	40.292178 ft	167.12223 psf	4,191.9153 psf	3,259.2132 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 14	145.90185 ft	39.493487 ft	213.04159 psf	4,486.7222 psf	3,460.7583 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 15	148.97922 ft	38.878696 ft	247.48565 psf	4,776.0404 psf	3,667.1513 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 16	152.05659 ft	38.441655 ft	270.83804 psf	5,053.2514 psf	3,872.722 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 17	155.13395 ft	38.178163 ft	283.36103 psf	5,309.5822 psf	4,070.1536 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 18	158.21132 ft	38.085749 ft	285.20874 psf	5,534.2983 psf	4,250.6289 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel

Slice 19	159.875 ft	38.085542 ft	283.26217 psf	5,662.6103 psf	4,356.1102 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 20	161.28601 ft	38.156985 ft	278.80415 psf	1,759.3368 psf	1,198.9117 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 21	163.85802 ft	38.352886 ft	266.57991 psf	1,793.2105 psf	1,236.2411 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 22	166.43003 ft	38.669401 ft	246.82941 psf	1,800.7848 psf	1,258.3682 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 23	168.9717 ft	39.101987 ft	219.83601 psf	1,804.9059 psf	1,377.8802 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 24	171.48302 ft	39.650621 ft	185.60124 psf	1,766.5854 psf	1,374.3286 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 25	173.99434 ft	40.322746 ft	143.66068 psf	1,693.5814 psf	1,347.3255 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 26	176.54389 ft	41.137337 ft	92.830168 psf	1,582.9054 psf	1,295.3026 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 27	179.13166 ft	42.104736 ft	32.46449 psf	1,433.6371 psf	1,218.0208 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 28	182.02129 ft	43.374225 ft	-46.751657 psf	1,212.5123 psf	1,054.0208 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 29	185.21277 ft	45.00202 ft	-148.32603 psf	910.91942 psf	791.85017 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 30	188.40426 ft	46.903358 ft	-266.96955 psf	562.92899 psf	489.34671 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 31	191 ft	48.64933 ft	-375.91821 psf	234.43653 psf	203.79257 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel
Slice 32	192.30811 ft	49.609319 ft	-435.82149 psf	45.387911 psf	39.455109 psf	0 psf	0 psf	ESU 2B - Na□ve Sand and Gravel

6.1 Static (Spencer) Section Ha-Ha' - Final Condition - Compound Stability

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File Informa on

File Version: 11.01
Created By: Mikayla S. Hatch
Last Edited By: Mikayla S. Hatch
Revision Number: 329
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Tool Version: 11.1
File Name: Wall 03.63L - Bridge 17.7 Ha-Ha' - All Condi ons.gsz
Directory: P:\0\0180366\01\Analysis\Bridge 17.7\SlopeW\
Last Solved Date: 11/15/2021
Last Solved Time: 03:28:16 PM

Project Se ngs

Unit System: U.S. Customary Units

Analysis Se ngs

6.1 Sta c (Spencer)

Kind: SLOPE/W
Parent: 6. Compound Stability
Analysis Type: Spencer
Se ngs
PWP Condi ons from: Piezometric Line
Apply Phrea c Correc on: No
Use Staged Rapid Drawdown: No
Unit Weight of Water: 62.4 pcf
Slip Surface
Direc on of movement: Le. to Right
Use Passive Mode: No
Slip Surface Op□on: Entry and Exit
Cri□cal slip surfaces saved: 1
Op□mize Cri□cal Slip Surface Loca□on: No
Tension Crack Op□on: (none)
Distribu□on
F of S Calcula□on Op□on: Constant
Advanced
Geometry Se□ ngs
Minimum Slip Surface Depth: 2 ft
Number of Slices: 30
Factor of Safety Convergence Se□ ngs
Maximum Number of Itera□ons: 100
Tolerable difference in F of S: 0.001
Solu□on Se□ ngs
Search Method: Root Finder

Tolerable difference between star□ng and converged F of S: 3
Maximum itera□ons to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Gravel Borrow

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2A - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 39 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2B - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 41 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 7A - Weathered Sandstone

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 43 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2C - Na ve Silt

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 29 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1A - Exis ng Granular Fill

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 40 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1B - Exis ng Gravelly Granular Fill

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Common Borrow

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Reinforcements

EL79_W4.5xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 17.6 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 2,975 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 2,975 lbf/ft

EL81_W4.5xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 17.6 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 2,975 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes

Factored Tensile Capacity: 2,975 lbf/ft

EL83_W4.5xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 17.6 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 2,975 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 2,975 lbf/ft

EL85_W4.5xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 17.6 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 2,975 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 2,975 lbf/ft

EL87_W4.5xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 17.6 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 2,975 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 2,975 lbf/ft

EL89_W4.5xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 17.6 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 2,975 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 2,975 lbf/ft

EL47_W9.5xW4 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 12.4 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,680 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,680 lbf/ft

EL49_W9.5xW4 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 12.4 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,680 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,680 lbf/ft

EL51_W9.5xW4 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 12.4 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,680 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,680 lbf/ft

EL53_W9.5xW4 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 12.4 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,680 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,680 lbf/ft

EL55_W9.5xW4 (75 yrs)

Type: Geosynthe□c

Interface Adhesion: 0 psf
Interface Shear Angle: 12.4 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,680 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,680 lbf/ft

EL57_W9.5xW4 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 12.4 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,680 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,680 lbf/ft

EL59_W7.0xW3.5 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 10.4 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,936 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,936 lbf/ft

EL61_W7.0xW3.5 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 10.4 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,936 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,936 lbf/ft

EL63_W7.0xW3.5 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 10.4 °

Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,936 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,936 lbf/ft

EL65_W7.0xW3.5 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 10.4 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,936 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,936 lbf/ft

EL67_W7.0xW3.5 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 10.4 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,936 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,936 lbf/ft

EL69_W7.0xW3.5 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 10.4 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,936 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,936 lbf/ft

EL71_W7.0xW3.5 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 20.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1

Tensile Capacity: 3,936 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,936 lbf/ft

EL73_W7.0xW3.5 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 20.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,936 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,936 lbf/ft

EL75_W7.0xW3.5 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 15.4 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 2,236 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 2,236 lbf/ft

EL77_W4.5xW3.5 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 15.4 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 2,236 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 2,236 lbf/ft

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (80, 72) ft
Left-Zone Right Coordinate: (128, 90) ft
Left-Zone Increment: 25
Right Type: Range
Right-Zone Left Coordinate: (160, 85.4) ft

Right-Zone Right Coordinate: (160, 76.5) ft
Right-Zone Increment: 20
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 60) ft
Right Coordinate: (335, 48) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	0.25 ft	43.375 ft
Coordinate 2	56.5 ft	43.375 ft
Coordinate 3	97.75 ft	43.375 ft
Coordinate 4	123 ft	43.375 ft
Coordinate 5	159.75 ft	42.625 ft
Coordinate 6	192 ft	42.625 ft
Coordinate 7	210.75 ft	42.625 ft
Coordinate 8	298 ft	35 ft
Coordinate 9	335.25 ft	35 ft

Reinforcement Lines

Reinforcement Line 1

Reinforcement: EL47_W9.5xW4 (75 yrs)
Lock to Ground Surface: No
Outside Point: (160, 47) ft
Inside Point: (128, 47) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 2

Reinforcement: EL49_W9.5xW4 (75 yrs)
Lock to Ground Surface: No
Outside Point: (160, 49) ft
Inside Point: (128, 49) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf

Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 3

Reinforcement: EL51_W9.5xW4 (75 yrs)
Lock to Ground Surface: No
Outside Point: (160, 51) ft
Inside Point: (128, 51) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 4

Reinforcement: EL53_W9.5xW4 (75 yrs)
Lock to Ground Surface: No
Outside Point: (160, 53) ft
Inside Point: (128, 53) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 5

Reinforcement: EL55_W9.5xW4 (75 yrs)
Lock to Ground Surface: No
Outside Point: (160, 55) ft
Inside Point: (128, 55) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 6

Reinforcement: EL57_W9.5xW4 (75 yrs)
Lock to Ground Surface: No
Outside Point: (160, 57) ft
Inside Point: (128, 57) ft
Length: 32 ft

Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 7

Reinforcement: EL59_W7.0xW3.5 (75 yrs)
Lock to Ground Surface: No
Outside Point: (160, 59) ft
Inside Point: (128, 59) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 8

Reinforcement: EL61_W7.0xW3.5 (75 yrs)
Lock to Ground Surface: No
Outside Point: (160, 61) ft
Inside Point: (128, 61) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 9

Reinforcement: EL63_W7.0xW3.5 (75 yrs)
Lock to Ground Surface: No
Outside Point: (160, 63) ft
Inside Point: (128, 63) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 10

Reinforcement: EL65_W7.0xW3.5 (75 yrs)
Lock to Ground Surface: No
Outside Point: (160, 65) ft

Inside Point: (128, 65) ft
Length: 32 ft
Orientaon: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 11

Reinforcement: EL67_W7.0xW3.5 (75 yrs)
Lock to Ground Surface: No
Outside Point: (160, 67) ft
Inside Point: (128, 67) ft
Length: 32 ft
Orientaon: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 12

Reinforcement: EL69_W7.0xW3.5 (75 yrs)
Lock to Ground Surface: No
Outside Point: (160, 69) ft
Inside Point: (128, 69) ft
Length: 32 ft
Orientaon: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 13

Reinforcement: EL71_W7.0xW3.5 (75 yrs)
Lock to Ground Surface: No
Outside Point: (160, 71) ft
Inside Point: (128, 71) ft
Length: 32 ft
Orientaon: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 14

Reinforcement: EL73_W7.0xW3.5 (75 yrs)

Lock to Ground Surface: No
Outside Point: (160, 73) ft
Inside Point: (128, 73) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 15

Reinforcement: EL75_W7.0xW3.5 (75 yrs)
Lock to Ground Surface: No
Outside Point: (160, 75) ft
Inside Point: (128, 75) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 16

Reinforcement: EL77_W4.5xW3.5 (75 yrs)
Lock to Ground Surface: No
Outside Point: (160, 77) ft
Inside Point: (128, 77) ft
Length: 32 ft
Orientation: 180 °
Slip Surface Intersection: (139.58929, 77) ft
Max. Pullout Force: 2,236 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 17

Reinforcement: EL79_W4.5xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 79) ft
Inside Point: (128, 79) ft
Length: 32 ft
Orientation: 180 °
Slip Surface Intersection: (132.43216, 79) ft
Max. Pullout Force: 2,975 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft

Governing Component: (none)

Reinforcement Line 18

Reinforcement: EL81_W4.5xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 81) ft
Inside Point: (128, 81) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 19

Reinforcement: EL83_W4.5xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 83) ft
Inside Point: (128, 83) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 20

Reinforcement: EL85_W4.5xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 85) ft
Inside Point: (128, 85) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 21

Reinforcement: EL89_W4.5xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 89) ft
Inside Point: (128, 89) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft

Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 22

Reinforcement: EL87_W4.5xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 87) ft
Inside Point: (128, 87) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 250 pcf
Direc□on: Ver□cal

Coordinates

	X	Y
	120 ft	91 ft
	128 ft	91 ft

Surcharge Load 2

Surcharge (Unit Weight): 250 pcf
Direc□on: Ver□cal

Coordinates

	X	Y
	128 ft	91.75 ft
	160 ft	91.75 ft

Geometry

Name: Ga-Ga'

Se ngs

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	0 ft	56 ft
Point 2	76 ft	56 ft

Point 3	118 ft	35 ft
Point 4	160 ft	35 ft
Point 5	0 ft	46 ft
Point 6	37 ft	46 ft
Point 7	190 ft	50 ft
Point 8	160 ft	50 ft
Point 9	170.25 ft	34 ft
Point 10	240 ft	34 ft
Point 11	315 ft	30 ft
Point 12	335 ft	30 ft
Point 13	335 ft	48 ft
Point 14	327 ft	48 ft
Point 15	315 ft	49 ft
Point 16	224 ft	48 ft
Point 17	0 ft	0 ft
Point 18	335 ft	0 ft
Point 19	160 ft	90 ft
Point 20	120 ft	90 ft
Point 21	120 ft	72 ft
Point 22	80 ft	72 ft
Point 23	56 ft	60 ft
Point 24	0 ft	60 ft
Point 25	160 ft	47 ft
Point 26	120 ft	47 ft
Point 27	70 ft	67 ft
Point 28	160 ft	78 ft
Point 29	93.5 ft	78 ft
Point 30	120 ft	78 ft
Point 31	160 ft	72 ft
Point 32	128 ft	90 ft
Point 33	128 ft	47 ft
Point 34	128 ft	78 ft
Point 35	128 ft	72 ft

Regions

	Material	Points	Area
Region 1	ESU 2C - Na□ve Silt	5,6,2,1	565 ft²
Region 2	Common Borrow	20,29,30	159 ft²
Region 3	ESU 2A - Na□ve Sand and Gravel	6,2,3	619.5 ft²
Region 4	ESU 2B - Na□ve Sand and Gravel	7,16,15,14,13,12,11,10,9,4	2,595.4 ft²
Region 5	ESU 7A - Weathered Sandstone	18,17,5,6,3,4,9,10,11,12	12,178 ft²
Region 6	ESU 1B - Exis□ng Gravelly Granular Fill	8,7,25	45 ft²
Region 7	ESU 2A - Na□ve Sand and Gravel	4,7,25,33,26,2,3	945 ft²
Region 8	ESU 1B - Exis□ng Gravelly Granular Fill	23,24,1,2,26,21,22,27	1,302 ft²
Region 9	ESU 1B - Exis□ng Gravelly Granular Fill	26,33,35,21	200 ft²
Region 10	Gravel Borrow	19,32,34,28	384 ft²
Region 11	ESU 1A - Exis□ng Granular Fill	22,21,30,29	199.5 ft²
Region 12	ESU 1A - Exis□ng Granular Fill	28,34,35,31	192 ft²
Region 13	Common Borrow	20,30,34,32	96 ft²

Region 14	ESU 1A - Exis□ng Granular Fill	30,21,35,34	48 ft²
Region 15	ESU 1B - Exis□ng Gravelly Granular Fill	25,8,31,35,33	800 ft²

Slip Results

Slip Surfaces Analysed: 289 of 2730 converged

Current Slip Surface

Slip Surface: 2,097
Factor of Safety: 8.232
Volume: 481.66647 ft³
Weight: 61,542.576 lbf
Resis□ng Moment: 3,563,876.7 lbf·ft
Ac□va□ng Moment: 432,923.43 lbf·ft
Resis□ng Force: 61,456.834 lbf
Ac□va□ng Force: 7,465.4729 lbf
Slip Rank: 1 of 2,730 slip surfaces
Exit: (160, 76.5) ft
Entry: (115.94873, 88.165464) ft
Radius: 56.236745 ft
Center: (151.13598, 132.03378) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Fric□onal Strength	Cohesive Strength	Suc□on Strength	Base Material
Slice 1	116.62394 ft	87.640543 ft	-2,762.1699 psf	84.979856 psf	53.101308 psf	0 psf	0 psf	Common Borrow
Slice 2	117.97437 ft	86.622549 ft	-2,698.6471 psf	254.11709 psf	158.78998 psf	0 psf	0 psf	Common Borrow
Slice 3	119.32479 ft	85.666236 ft	-2,638.9731 psf	419.86733 psf	262.36223 psf	0 psf	0 psf	Common Borrow
Slice 4	120.75 ft	84.721316 ft	-2,580.0101 psf	774.42198 psf	483.91256 psf	0 psf	0 psf	Common Borrow
Slice 5	122.25 ft	83.790567 ft	-2,521.9314 psf	880.32801 psf	550.08999 psf	0 psf	0 psf	Common Borrow
Slice 6	123.83333 ft	82.878634 ft	-2,466.088 psf	986.14429 psf	616.21135 psf	0 psf	0 psf	Common Borrow
Slice 7	125.5 ft	81.988886 ft	-2,412.6902 psf	1,091.4982 psf	682.0438 psf	0 psf	0 psf	Common Borrow
Slice 8	127.16667 ft	81.169304 ft	-2,363.6707 psf	1,190.61 psf	743.97567 psf	0 psf	0 psf	Common Borrow
Slice 9	128.755 ft	80.449034 ft	-2,320.7485 psf	1,531.6891 psf	1,196.6867 psf	0 psf	0 psf	Gravel Borrow
Slice 10	130.26501 ft	79.819674 ft	-2,283.3994 psf	1,619.3058 psf	1,265.1404 psf	0 psf	0 psf	Gravel Borrow
Slice 11	131.77501 ft	79.240999 ft	-2,249.2131 psf	1,716.605 psf	1,341.1588 psf	0 psf	0 psf	Gravel Borrow
Slice 12	133.28501 ft	78.711358 ft	-2,218.0864 psf	1,794.098 psf	1,401.703 psf	0 psf	0 psf	Gravel Borrow
Slice	134.79502	78.229302	-2,189.929	1,866.5635	1,458.3192	0 psf	0 psf	Gravel

13	ft	ft	psf	psf	psf			Borrow
Slice 14	136.30627 ft	77.793237 ft	-2,164.6431 psf	1,930.6898 psf	1,620.0411 psf	0 psf	0 psf	ESU 1A - Exis□ng Granular Fill
Slice 15	137.81877 ft	77.402127 ft	-2,142.164 psf	1,989.9196 psf	1,669.7408 psf	0 psf	0 psf	ESU 1A - Exis□ng Granular Fill
Slice 16	139.33127 ft	77.055402 ft	-2,122.4545 psf	2,060.0083 psf	1,728.5522 psf	0 psf	0 psf	ESU 1A - Exis□ng Granular Fill
Slice 17	140.84376 ft	76.752227 ft	-2,105.4624 psf	2,110.2918 psf	1,770.745 psf	0 psf	0 psf	ESU 1A - Exis□ng Granular Fill
Slice 18	142.35626 ft	76.491886 ft	-2,091.1433 psf	2,156.0604 psf	1,809.1495 psf	0 psf	0 psf	ESU 1A - Exis□ng Granular Fill
Slice 19	143.86876 ft	76.273781 ft	-2,079.4597 psf	2,197.3118 psf	1,843.7635 psf	0 psf	0 psf	ESU 1A - Exis□ng Granular Fill
Slice 20	145.38126 ft	76.097416 ft	-2,070.3806 psf	2,234.0345 psf	1,874.5775 psf	0 psf	0 psf	ESU 1A - Exis□ng Granular Fill
Slice 21	146.89376 ft	75.962397 ft	-2,063.8816 psf	2,266.2073 psf	1,901.5737 psf	0 psf	0 psf	ESU 1A - Exis□ng Granular Fill
Slice 22	148.40626 ft	75.868427 ft	-2,059.9439 psf	2,293.7995 psf	1,924.7263 psf	0 psf	0 psf	ESU 1A - Exis□ng Granular Fill
Slice 23	149.91876 ft	75.815298 ft	-2,058.5548 psf	2,316.7703 psf	1,944.0011 psf	0 psf	0 psf	ESU 1A - Exis□ng Granular Fill
Slice 24	151.43126 ft	75.802895 ft	-2,059.707 psf	2,335.0683 psf	1,959.355 psf	0 psf	0 psf	ESU 1A - Exis□ng Granular Fill
Slice 25	152.94376 ft	75.831191 ft	-2,063.3988 psf	2,348.6312 psf	1,970.7356 psf	0 psf	0 psf	ESU 1A - Exis□ng Granular Fill
Slice 26	154.45625 ft	75.900248 ft	-2,069.634 psf	2,357.3847 psf	1,978.0807 psf	0 psf	0 psf	ESU 1A - Exis□ng Granular Fill
Slice 27	155.96875 ft	76.010216 ft	-2,078.4222 psf	2,361.242 psf	1,981.3173 psf	0 psf	0 psf	ESU 1A - Exis□ng

								Granular Fill
Slice 28	157.48125 ft	76.161338 ft	-2,089.7783 psf	2,360.1023 psf	1,980.361 psf	0 psf	0 psf	ESU 1A - Exis□ng Granular Fill
Slice 29	158.99375 ft	76.353948 ft	-2,103.7233 psf	2,353.85 psf	1,975.1147 psf	0 psf	0 psf	ESU 1A - Exis□ng Granular Fill
Slice 30	159.875 ft	76.480336 ft	-2,112.573 psf	2,520.0043 psf	2,114.5347 psf	0 psf	0 psf	ESU 1A - Exis□ng Granular Fill

6.2 Static (M-P) Section Ha-Ha' - Final Condition - Compound Stability

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File Informa on

File Version: 11.01
Created By: Mikayla S. Hatch
Last Edited By: Mikayla S. Hatch
Revision Number: 329
Date: 11/15/2021
Time: 03:28:09 PM
Tool Version: 11.1
File Name: Wall 03.63L - Bridge 17.7 Ha-Ha' - All Condi ons.gsz
Directory: P:\0\0180366\01\Analysis\Bridge 17.7\SlopeW\
Last Solved Date: 11/15/2021
Last Solved Time: 03:28:20 PM

Project Se ngs

Unit System: U.S. Customary Units

Analysis Se ngs

6.2 Sta c (M-P)

Kind: SLOPE/W
Parent: 6. Compound Stability
Analysis Type: Morgenstern-Price
Se ngs
Side Func on
Interslice force func on op on: Half-Sine
PWP Condi ons from: Piezometric Line
Apply Phrea c Correc on: No
Use Staged Rapid Drawdown: No
Unit Weight of Water: 62.4 pcf
Slip Surface
Direc on of movement: Le. to Right
Use Passive Mode: No
Slip Surface Op on: Entry and Exit
Cri cal slip surfaces saved: 1
Op mize Cri cal Slip Surface Loca on: No
Tension Crack Op on: (none)
Distribu on
F of S Calcula on Op on: Constant
Advanced
Geometry Se ngs
Minimum Slip Surface Depth: 2 ft
Number of Slices: 30
Factor of Safety Convergence Se ngs
Maximum Number of Itera ons: 100
Tolerable difference in F of S: 0.001

Solu□on Se□ ngs
Search Method: Root Finder
Tolerable difference between star□ng and converged F of S: 3
Maximum itera□ons to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Gravel Borrow

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2A - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 39 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2B - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 41 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 7A - Weathered Sandstone

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 43 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2C - Na ve Silt

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 29 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1A - Exis ng Granular Fill

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec ve Cohesion: 0 psf
Effec ve Fric on Angle: 40 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1B - Exis ng Gravelly Granular Fill

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effec ve Cohesion: 0 psf
Effec ve Fric on Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Common Borrow

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec ve Cohesion: 0 psf
Effec ve Fric on Angle: 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Reinforcements

EL79_W4.5xW3.5 (45 yrs)

Type: Geosynthe c
Interface Adhesion: 0 psf
Interface Shear Angle: 17.6 °
Surface Area Factor: 2
Pullout Resistance Reduc on Factor: 1
Tensile Capacity: 2,975 lbf
Tensile Capacity Reduc on Factor: 1
F of S Dependent: No
Force Distribu on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 2,975 lbf/ft

EL81_W4.5xW3.5 (45 yrs)

Type: Geosynthe c
Interface Adhesion: 0 psf
Interface Shear Angle: 17.6 °
Surface Area Factor: 2
Pullout Resistance Reduc on Factor: 1
Tensile Capacity: 2,975 lbf
Tensile Capacity Reduc on Factor: 1
F of S Dependent: No
Force Distribu on: Distributed

Face Anchorage: Yes
Factored Tensile Capacity: 2,975 lbf/ft

EL83_W4.5xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 17.6 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 2,975 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 2,975 lbf/ft

EL85_W4.5xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 17.6 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 2,975 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 2,975 lbf/ft

EL87_W4.5xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 17.6 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 2,975 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 2,975 lbf/ft

EL89_W4.5xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 17.6 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 2,975 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 2,975 lbf/ft

EL47_W9.5xW4 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 12.4 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,680 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,680 lbf/ft

EL49_W9.5xW4 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 12.4 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,680 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,680 lbf/ft

EL51_W9.5xW4 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 12.4 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,680 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,680 lbf/ft

EL53_W9.5xW4 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 12.4 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,680 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,680 lbf/ft

EL55_W9.5xW4 (75 yrs)

Type: Geosynthe□c

Interface Adhesion: 0 psf
Interface Shear Angle: 12.4 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,680 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,680 lbf/ft

EL57_W9.5xW4 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 12.4 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,680 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,680 lbf/ft

EL59_W7.0xW3.5 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 10.4 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,936 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,936 lbf/ft

EL61_W7.0xW3.5 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 10.4 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,936 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,936 lbf/ft

EL63_W7.0xW3.5 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 10.4 °

Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,936 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,936 lbf/ft

EL65_W7.0xW3.5 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 10.4 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,936 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,936 lbf/ft

EL67_W7.0xW3.5 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 10.4 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,936 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,936 lbf/ft

EL69_W7.0xW3.5 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 10.4 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,936 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,936 lbf/ft

EL71_W7.0xW3.5 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 20.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1

Tensile Capacity: 3,936 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,936 lbf/ft

EL73_W7.0xW3.5 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 20.1 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,936 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,936 lbf/ft

EL75_W7.0xW3.5 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 15.4 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 2,236 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 2,236 lbf/ft

EL77_W4.5xW3.5 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 15.4 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 2,236 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 2,236 lbf/ft

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (80, 72) ft
Left-Zone Right Coordinate: (128, 90) ft
Left-Zone Increment: 25
Right Type: Range
Right-Zone Left Coordinate: (160, 85.4) ft

Right-Zone Right Coordinate: (160, 76.5) ft
Right-Zone Increment: 20
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 60) ft
Right Coordinate: (335, 48) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	0.25 ft	43.375 ft
Coordinate 2	56.5 ft	43.375 ft
Coordinate 3	97.75 ft	43.375 ft
Coordinate 4	123 ft	43.375 ft
Coordinate 5	159.75 ft	42.625 ft
Coordinate 6	192 ft	42.625 ft
Coordinate 7	210.75 ft	42.625 ft
Coordinate 8	298 ft	35 ft
Coordinate 9	335.25 ft	35 ft

Reinforcement Lines

Reinforcement Line 1

Reinforcement: EL47_W9.5xW4 (75 yrs)
Lock to Ground Surface: No
Outside Point: (160, 47) ft
Inside Point: (128, 47) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 2

Reinforcement: EL49_W9.5xW4 (75 yrs)
Lock to Ground Surface: No
Outside Point: (160, 49) ft
Inside Point: (128, 49) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf

Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 3

Reinforcement: EL51_W9.5xW4 (75 yrs)
Lock to Ground Surface: No
Outside Point: (160, 51) ft
Inside Point: (128, 51) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 4

Reinforcement: EL53_W9.5xW4 (75 yrs)
Lock to Ground Surface: No
Outside Point: (160, 53) ft
Inside Point: (128, 53) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 5

Reinforcement: EL55_W9.5xW4 (75 yrs)
Lock to Ground Surface: No
Outside Point: (160, 55) ft
Inside Point: (128, 55) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 6

Reinforcement: EL57_W9.5xW4 (75 yrs)
Lock to Ground Surface: No
Outside Point: (160, 57) ft
Inside Point: (128, 57) ft
Length: 32 ft

Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 7

Reinforcement: EL59_W7.0xW3.5 (75 yrs)
Lock to Ground Surface: No
Outside Point: (160, 59) ft
Inside Point: (128, 59) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 8

Reinforcement: EL61_W7.0xW3.5 (75 yrs)
Lock to Ground Surface: No
Outside Point: (160, 61) ft
Inside Point: (128, 61) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 9

Reinforcement: EL63_W7.0xW3.5 (75 yrs)
Lock to Ground Surface: No
Outside Point: (160, 63) ft
Inside Point: (128, 63) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 10

Reinforcement: EL65_W7.0xW3.5 (75 yrs)
Lock to Ground Surface: No
Outside Point: (160, 65) ft

Inside Point: (128, 65) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 11

Reinforcement: EL67_W7.0xW3.5 (75 yrs)
Lock to Ground Surface: No
Outside Point: (160, 67) ft
Inside Point: (128, 67) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 12

Reinforcement: EL69_W7.0xW3.5 (75 yrs)
Lock to Ground Surface: No
Outside Point: (160, 69) ft
Inside Point: (128, 69) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 13

Reinforcement: EL71_W7.0xW3.5 (75 yrs)
Lock to Ground Surface: No
Outside Point: (160, 71) ft
Inside Point: (128, 71) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 14

Reinforcement: EL73_W7.0xW3.5 (75 yrs)

Lock to Ground Surface: No
Outside Point: (160, 73) ft
Inside Point: (128, 73) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 15

Reinforcement: EL75_W7.0xW3.5 (75 yrs)
Lock to Ground Surface: No
Outside Point: (160, 75) ft
Inside Point: (128, 75) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 16

Reinforcement: EL77_W4.5xW3.5 (75 yrs)
Lock to Ground Surface: No
Outside Point: (160, 77) ft
Inside Point: (128, 77) ft
Length: 32 ft
Orientation: 180 °
Slip Surface Intersection: (139.58929, 77) ft
Max. Pullout Force: 2,236 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 17

Reinforcement: EL79_W4.5xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 79) ft
Inside Point: (128, 79) ft
Length: 32 ft
Orientation: 180 °
Slip Surface Intersection: (132.43216, 79) ft
Max. Pullout Force: 2,975 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft

Governing Component: (none)

Reinforcement Line 18

Reinforcement: EL81_W4.5xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 81) ft
Inside Point: (128, 81) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 19

Reinforcement: EL83_W4.5xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 83) ft
Inside Point: (128, 83) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 20

Reinforcement: EL85_W4.5xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 85) ft
Inside Point: (128, 85) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 21

Reinforcement: EL89_W4.5xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 89) ft
Inside Point: (128, 89) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft

Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 22

Reinforcement: EL87_W4.5xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 87) ft
Inside Point: (128, 87) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 250 pcf
Direc□on: Ver□cal

Coordinates

	X	Y
	120 ft	91 ft
	128 ft	91 ft

Surcharge Load 2

Surcharge (Unit Weight): 250 pcf
Direc□on: Ver□cal

Coordinates

	X	Y
	128 ft	91.75 ft
	160 ft	91.75 ft

Geometry

Name: Ga-Ga'

Se ngs

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	0 ft	56 ft
Point 2	76 ft	56 ft

Point 3	118 ft	35 ft
Point 4	160 ft	35 ft
Point 5	0 ft	46 ft
Point 6	37 ft	46 ft
Point 7	190 ft	50 ft
Point 8	160 ft	50 ft
Point 9	170.25 ft	34 ft
Point 10	240 ft	34 ft
Point 11	315 ft	30 ft
Point 12	335 ft	30 ft
Point 13	335 ft	48 ft
Point 14	327 ft	48 ft
Point 15	315 ft	49 ft
Point 16	224 ft	48 ft
Point 17	0 ft	0 ft
Point 18	335 ft	0 ft
Point 19	160 ft	90 ft
Point 20	120 ft	90 ft
Point 21	120 ft	72 ft
Point 22	80 ft	72 ft
Point 23	56 ft	60 ft
Point 24	0 ft	60 ft
Point 25	160 ft	47 ft
Point 26	120 ft	47 ft
Point 27	70 ft	67 ft
Point 28	160 ft	78 ft
Point 29	93.5 ft	78 ft
Point 30	120 ft	78 ft
Point 31	160 ft	72 ft
Point 32	128 ft	90 ft
Point 33	128 ft	47 ft
Point 34	128 ft	78 ft
Point 35	128 ft	72 ft

Regions

	Material	Points	Area
Region 1	ESU 2C - Na□ve Silt	5,6,2,1	565 ft²
Region 2	Common Borrow	20,29,30	159 ft²
Region 3	ESU 2A - Na□ve Sand and Gravel	6,2,3	619.5 ft²
Region 4	ESU 2B - Na□ve Sand and Gravel	7,16,15,14,13,12,11,10,9,4	2,595.4 ft²
Region 5	ESU 7A - Weathered Sandstone	18,17,5,6,3,4,9,10,11,12	12,178 ft²
Region 6	ESU 1B - Exis□ng Gravelly Granular Fill	8,7,25	45 ft²
Region 7	ESU 2A - Na□ve Sand and Gravel	4,7,25,33,26,2,3	945 ft²
Region 8	ESU 1B - Exis□ng Gravelly Granular Fill	23,24,1,2,26,21,22,27	1,302 ft²
Region 9	ESU 1B - Exis□ng Gravelly Granular Fill	26,33,35,21	200 ft²
Region 10	Gravel Borrow	19,32,34,28	384 ft²
Region 11	ESU 1A - Exis□ng Granular Fill	22,21,30,29	199.5 ft²
Region 12	ESU 1A - Exis□ng Granular Fill	28,34,35,31	192 ft²
Region 13	Common Borrow	20,30,34,32	96 ft²

Region 14	ESU 1A - Exis□ng Granular Fill	30,21,35,34	48 ft²
Region 15	ESU 1B - Exis□ng Gravelly Granular Fill	25,8,31,35,33	800 ft²

Slip Results

Slip Surfaces Analysed: 291 of 2730 converged

Current Slip Surface

Slip Surface: 2,097
Factor of Safety: 8.232
Volume: 481.66647 ft³
Weight: 61,542.576 lbf
Resis□ng Moment: 3,564,101.3 lbf·ft
Ac□va□ng Moment: 432,923.43 lbf·ft
Resis□ng Force: 61,469.841 lbf
Ac□va□ng Force: 7,467.4016 lbf
Slip Rank: 1 of 2,730 slip surfaces
Exit: (160, 76.5) ft
Entry: (115.94873, 88.165464) ft
Radius: 56.236745 ft
Center: (151.13598, 132.03378) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Fric□onal Strength	Cohesive Strength	Suc□on Strength	Base Material
Slice 1	116.62394 ft	87.640543 ft	-2,762.1699 psf	92.905709 psf	58.05393 psf	0 psf	0 psf	Common Borrow
Slice 2	117.97437 ft	86.622549 ft	-2,698.6471 psf	271.84533 psf	169.86781 psf	0 psf	0 psf	Common Borrow
Slice 3	119.32479 ft	85.666236 ft	-2,638.9731 psf	439.97412 psf	274.92635 psf	0 psf	0 psf	Common Borrow
Slice 4	120.75 ft	84.721316 ft	-2,580.0101 psf	798.91444 psf	499.21715 psf	0 psf	0 psf	Common Borrow
Slice 5	122.25 ft	83.790567 ft	-2,521.9314 psf	890.22991 psf	556.27739 psf	0 psf	0 psf	Common Borrow
Slice 6	123.83333 ft	82.878634 ft	-2,466.088 psf	980.93238 psf	612.95458 psf	0 psf	0 psf	Common Borrow
Slice 7	125.5 ft	81.988886 ft	-2,412.6902 psf	1,071.9339 psf	669.81864 psf	0 psf	0 psf	Common Borrow
Slice 8	127.16667 ft	81.169304 ft	-2,363.6707 psf	1,159.3497 psf	724.44208 psf	0 psf	0 psf	Common Borrow
Slice 9	128.755 ft	80.449034 ft	-2,320.7485 psf	1,492.2265 psf	1,165.8551 psf	0 psf	0 psf	Gravel Borrow
Slice 10	130.26501 ft	79.819674 ft	-2,283.3994 psf	1,574.4479 psf	1,230.0935 psf	0 psf	0 psf	Gravel Borrow
Slice 11	131.77501 ft	79.240999 ft	-2,249.2131 psf	1,672.8683 psf	1,306.9879 psf	0 psf	0 psf	Gravel Borrow
Slice 12	133.28501 ft	78.711358 ft	-2,218.0864 psf	1,754.3615 psf	1,370.6574 psf	0 psf	0 psf	Gravel Borrow
Slice	134.79502	78.229302	-2,189.929	1,834.1456	1,432.9916	0 psf	0 psf	Gravel

13	ft	ft	psf	psf	psf			Borrow
Slice 14	136.30627 ft	77.793237 ft	-2,164.6431 psf	1,909.1323 psf	1,601.9522 psf	0 psf	0 psf	ESU 1A - Exis□ng Granular Fill
Slice 15	137.81877 ft	77.402127 ft	-2,142.164 psf	1,981.1101 psf	1,662.3487 psf	0 psf	0 psf	ESU 1A - Exis□ng Granular Fill
Slice 16	139.33127 ft	77.055402 ft	-2,122.4545 psf	2,069.4325 psf	1,736.46 psf	0 psf	0 psf	ESU 1A - Exis□ng Granular Fill
Slice 17	140.84376 ft	76.752227 ft	-2,105.4624 psf	2,134.1145 psf	1,790.7347 psf	0 psf	0 psf	ESU 1A - Exis□ng Granular Fill
Slice 18	142.35626 ft	76.491886 ft	-2,091.1433 psf	2,193.4836 psf	1,840.5513 psf	0 psf	0 psf	ESU 1A - Exis□ng Granular Fill
Slice 19	143.86876 ft	76.273781 ft	-2,079.4597 psf	2,246.5424 psf	1,885.0729 psf	0 psf	0 psf	ESU 1A - Exis□ng Granular Fill
Slice 20	145.38126 ft	76.097416 ft	-2,070.3806 psf	2,292.2666 psf	1,923.44 psf	0 psf	0 psf	ESU 1A - Exis□ng Granular Fill
Slice 21	146.89376 ft	75.962397 ft	-2,063.8816 psf	2,329.6516 psf	1,954.8098 psf	0 psf	0 psf	ESU 1A - Exis□ng Granular Fill
Slice 22	148.40626 ft	75.868427 ft	-2,059.9439 psf	2,357.7632 psf	1,978.3983 psf	0 psf	0 psf	ESU 1A - Exis□ng Granular Fill
Slice 23	149.91876 ft	75.815298 ft	-2,058.5548 psf	2,375.7902 psf	1,993.5247 psf	0 psf	0 psf	ESU 1A - Exis□ng Granular Fill
Slice 24	151.43126 ft	75.802895 ft	-2,059.707 psf	2,383.0941 psf	1,999.6534 psf	0 psf	0 psf	ESU 1A - Exis□ng Granular Fill
Slice 25	152.94376 ft	75.831191 ft	-2,063.3988 psf	2,379.2545 psf	1,996.4316 psf	0 psf	0 psf	ESU 1A - Exis□ng Granular Fill
Slice 26	154.45625 ft	75.900248 ft	-2,069.634 psf	2,364.1024 psf	1,983.7175 psf	0 psf	0 psf	ESU 1A - Exis□ng Granular Fill
Slice 27	155.96875 ft	76.010216 ft	-2,078.4222 psf	2,337.7417 psf	1,961.5982 psf	0 psf	0 psf	ESU 1A - Exis□ng

								Granular Fill
Slice 28	157.48125 ft	76.161338 ft	-2,089.7783 psf	2,300.5534 psf	1,930.3935 psf	0 psf	0 psf	ESU 1A - Exis□ng Granular Fill
Slice 29	158.99375 ft	76.353948 ft	-2,103.7233 psf	2,253.1838 psf	1,890.6457 psf	0 psf	0 psf	ESU 1A - Exis□ng Granular Fill
Slice 30	159.875 ft	76.480336 ft	-2,112.573 psf	2,221.9881 psf	1,864.4694 psf	0 psf	0 psf	ESU 1A - Exis□ng Granular Fill

6.3 Pseudo-Static (Spencer) Section Ha-Ha' - Final Condition - Compound Stability

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File Informa on

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Last Edited By: Mikayla S. Hatch
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Directory: P:\0\0180366\01\Analysis\Bridge 17.7\SlopeW\
Last Solved Date: 11/15/2021
Last Solved Time: 03:28:18 PM

Project Se ngs

Unit System: U.S. Customary Units

Analysis Se ngs

6.3 Pseudo-Sta c (Spencer)

Kind: SLOPE/W
Parent: 6. Compound Stability
Analysis Type: Spencer
Se ngs
PWP Condi ons from: Piezometric Line
Apply Phrea c Correc on: No
Use Staged Rapid Drawdown: No
Unit Weight of Water: 62.4 pcf
Slip Surface
Direc on of movement: Le. to Right
Use Passive Mode: No
Slip Surface Op□on: Entry and Exit
Cri□cal slip surfaces saved: 1
Op□mize Cri□cal Slip Surface Loca□on: No
Tension Crack Op□on: (none)
Distribu□on
F of S Calcula□on Op□on: Constant
Advanced
Geometry Se□ ngs
Minimum Slip Surface Depth: 2 ft
Number of Slices: 30
Factor of Safety Convergence Se□ ngs
Maximum Number of Itera□ons: 100
Tolerable difference in F of S: 0.001
Solu□on Se□ ngs
Search Method: Root Finder

Tolerable difference between star□ng and converged F of S: 3
Maximum itera□ons to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Gravel Borrow

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1A - Exis ng Granular Fill (Pseudo-Sta c)

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 50 psf
Effec□ve Fric□on Angle: 40 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2A - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 39 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2B - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 41 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 7A - Weathered Sandstone

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 43 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1B - Exis ng Gravelly Granular Fill

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2C - Na ve Silt (Pseudo-Sta c)

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effec□ve Cohesion: 200 psf
Effec□ve Fric□on Angle: 29 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Common Borrow

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Reinforcements

EQ_EL47_W9.5xW4 75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 16.3 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,427 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,427 lbf/ft

EQ_EL49_W9.5xW4 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 16.3 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,427 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes

Factored Tensile Capacity: 7,427 lbf/ft

EQ_EL51_W9.5xW4 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 16.3 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,427 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,427 lbf/ft

EQ_EL53_W9.5xW4 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 16.3 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,427 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,427 lbf/ft

EQ_EL55_W9.5xW4 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 16.3 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,427 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,427 lbf/ft

EQ_EL57_W9.5xW4 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 16.3 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,427 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,427 lbf/ft

EQ_EL59_W7.0xW3.5 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 13.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,147 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,147 lbf/ft

EQ_EL61_W7.0xW3.5 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 13.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,147 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,147 lbf/ft

EQ_EL63_W7.0xW3.5 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 13.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,147 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,147 lbf/ft

EQ_EL65_W7.0xW3.5 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 13.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,147 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,147 lbf/ft

EQ_EL79_W4.5xW3.5 (45 yrs)

Type: Geosynthe□c

Interface Adhesion: 0 psf
Interface Shear Angle: 23 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,891 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,891 lbf/ft

EQ_EL81_W4.5xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 23 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,891 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,891 lbf/ft

EQ_EL83_W4.5xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 23 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,891 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,891 lbf/ft

EQ_EL85_W4.5xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 23 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,891 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,891 lbf/ft

EQ_EL87_W4.5xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 23 °

Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,891 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,891 lbf/ft

EQ_EL67_W7.0xW3.5 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 13.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,147 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,147 lbf/ft

EQ_EL69_W7.0xW3.5 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 13.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,147 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,147 lbf/ft

EQ_EL71_W7.0xW3.5 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 26 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,147 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,147 lbf/ft

EQ_EL73_W7.0xW3.5 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 26 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1

Tensile Capacity: 5,147 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,147 lbf/ft

EQ_EL75_W7.0xW3.5 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 20.2 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 2,924 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 2,924 lbf/ft

EQ_EL77_W4.5xW3.5 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 20.2 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 2,924 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 2,924 lbf/ft

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (80, 72) ft
Left-Zone Right Coordinate: (128, 90) ft
Left-Zone Increment: 25
Right Type: Range
Right-Zone Left Coordinate: (160, 86.975) ft
Right-Zone Right Coordinate: (160, 75) ft
Right-Zone Increment: 20
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 60) ft
Right Coordinate: (335, 48) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	0.25 ft	43.375 ft
Coordinate 2	56.5 ft	43.375 ft
Coordinate 3	97.75 ft	43.375 ft
Coordinate 4	123 ft	43.375 ft
Coordinate 5	159.75 ft	42.625 ft
Coordinate 6	192 ft	42.625 ft
Coordinate 7	210.75 ft	42.625 ft
Coordinate 8	298 ft	35 ft
Coordinate 9	335.25 ft	35 ft

Seismic Coefficients

Horz Seismic Coef.: 0.255

Reinforcement Lines

Reinforcement Line 1

Reinforcement: EQ_EL47_W9.5xW4 75 yrs)
Lock to Ground Surface: No
Outside Point: (160, 47) ft
Inside Point: (128, 47) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 2

Reinforcement: EQ_EL49_W9.5xW4 (75 yrs)
Lock to Ground Surface: No
Outside Point: (160, 49) ft
Inside Point: (128, 49) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 3

Reinforcement: EQ_EL51_W9.5xW4 (75 yrs)

Lock to Ground Surface: No
Outside Point: (160, 51) ft
Inside Point: (128, 51) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 4

Reinforcement: EQ_EL53_W9.5xW4 (75 yrs)
Lock to Ground Surface: No
Outside Point: (160, 53) ft
Inside Point: (128, 53) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 5

Reinforcement: EQ_EL55_W9.5xW4 (75 yrs)
Lock to Ground Surface: No
Outside Point: (160, 55) ft
Inside Point: (128, 55) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 6

Reinforcement: EQ_EL57_W9.5xW4 (75 yrs)
Lock to Ground Surface: No
Outside Point: (160, 57) ft
Inside Point: (128, 57) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 7

Reinforcement: EQ_EL59_W7.0xW3.5 (75 yrs)
Lock to Ground Surface: No
Outside Point: (160, 59) ft
Inside Point: (128, 59) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 8

Reinforcement: EQ_EL61_W7.0xW3.5 (75 yrs)
Lock to Ground Surface: No
Outside Point: (160, 61) ft
Inside Point: (128, 61) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 9

Reinforcement: EQ_EL63_W7.0xW3.5 (75 yrs)
Lock to Ground Surface: No
Outside Point: (160, 63) ft
Inside Point: (128, 63) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 10

Reinforcement: EQ_EL65_W7.0xW3.5 (75 yrs)
Lock to Ground Surface: No
Outside Point: (160, 65) ft
Inside Point: (128, 65) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft

Governing Component: (none)

Reinforcement Line 11

Reinforcement: EQ_EL67_W7.0xW3.5 (75 yrs)
Lock to Ground Surface: No
Outside Point: (160, 67) ft
Inside Point: (128, 67) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 12

Reinforcement: EQ_EL69_W7.0xW3.5 (75 yrs)
Lock to Ground Surface: No
Outside Point: (160, 69) ft
Inside Point: (128, 69) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 13

Reinforcement: EQ_EL71_W7.0xW3.5 (75 yrs)
Lock to Ground Surface: No
Outside Point: (160, 71) ft
Inside Point: (128, 71) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 14

Reinforcement: EQ_EL73_W7.0xW3.5 (75 yrs)
Lock to Ground Surface: No
Outside Point: (160, 73) ft
Inside Point: (128, 73) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft

Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 15

Reinforcement: EQ_EL75_W7.0xW3.5 (75 yrs)
Lock to Ground Surface: No
Outside Point: (160, 75) ft
Inside Point: (128, 75) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 16

Reinforcement: EQ_EL77_W4.5xW3.5 (75 yrs)
Lock to Ground Surface: No
Outside Point: (160, 77) ft
Inside Point: (128, 77) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 17

Reinforcement: EQ_EL79_W4.5xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 79) ft
Inside Point: (128, 79) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 18

Reinforcement: EQ_EL81_W4.5xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 81) ft
Inside Point: (128, 81) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf

Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 19

Reinforcement: EQ_EL83_W4.5xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 83) ft
Inside Point: (128, 83) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 20

Reinforcement: EQ_EL85_W4.5xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 85) ft
Inside Point: (128, 85) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 21

Reinforcement: EQ_EL87_W4.5xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 89) ft
Inside Point: (128, 89) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 22

Reinforcement: EQ_EL87_W4.5xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 87) ft
Inside Point: (128, 87) ft
Length: 32 ft

Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 125 pcf
Direction: Vertical

Coordinates

	X	Y
	120 ft	91 ft
	160 ft	91 ft

Geometry

Name: Ga-Ga'

Settings

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	0 ft	56 ft
Point 2	76 ft	56 ft
Point 3	118 ft	35 ft
Point 4	160 ft	35 ft
Point 5	0 ft	46 ft
Point 6	37 ft	46 ft
Point 7	190 ft	50 ft
Point 8	160 ft	50 ft
Point 9	170.25 ft	34 ft
Point 10	240 ft	34 ft
Point 11	315 ft	30 ft
Point 12	335 ft	30 ft
Point 13	335 ft	48 ft
Point 14	327 ft	48 ft
Point 15	315 ft	49 ft
Point 16	224 ft	48 ft
Point 17	0 ft	0 ft
Point 18	335 ft	0 ft
Point 19	160 ft	90 ft
Point 20	120 ft	90 ft

Point 21	120 ft	72 ft
Point 22	80 ft	72 ft
Point 23	56 ft	60 ft
Point 24	0 ft	60 ft
Point 25	160 ft	47 ft
Point 26	120 ft	47 ft
Point 27	70 ft	67 ft
Point 28	160 ft	78 ft
Point 29	93.5 ft	78 ft
Point 30	120 ft	78 ft
Point 31	160 ft	72 ft
Point 32	128 ft	90 ft
Point 33	128 ft	47 ft
Point 34	128 ft	78 ft
Point 35	128 ft	72 ft

Regions

	Material	Points	Area
Region 1	ESU 2C - Na□ve Silt (Pseudo-Sta□c)	5,6,2,1	565 ft²
Region 2	Common Borrow	20,29,30	159 ft²
Region 3	ESU 2A - Na□ve Sand and Gravel	6,2,3	619.5 ft²
Region 4	ESU 2B - Na□ve Sand and Gravel	7,16,15,14,13,12,11,10,9,4	2,595.4 ft²
Region 5	ESU 7A - Weathered Sandstone	18,17,5,6,3,4,9,10,11,12	12,178 ft²
Region 6	ESU 1B - Exis□ng Gravelly Granular Fill	8,7,25	45 ft²
Region 7	ESU 2A - Na□ve Sand and Gravel	4,7,25,33,26,2,3	945 ft²
Region 8	ESU 1B - Exis□ng Gravelly Granular Fill	23,24,1,2,26,21,22,27	1,302 ft²
Region 9	ESU 1B - Exis□ng Gravelly Granular Fill	26,33,35,21	200 ft²
Region 10	Gravel Borrow	19,32,34,28	384 ft²
Region 11	ESU 1A - Exis□ng Granular Fill (Pseudo-Sta□c)	22,21,30,29	199.5 ft²
Region 12	ESU 1A - Exis□ng Granular Fill (Pseudo-Sta□c)	28,34,35,31	192 ft²
Region 13	Common Borrow	20,30,34,32	96 ft²
Region 14	ESU 1A - Exis□ng Granular Fill (Pseudo-Sta□c)	30,21,35,34	48 ft²
Region 15	ESU 1B - Exis□ng Gravelly Granular Fill	25,8,31,35,33	800 ft²

Slip Results

Slip Surfaces Analysed: 929 of 2730 converged

Current Slip Surface

Slip Surface: 1,536
Factor of Safety: 2.449
Volume: 455.41432 ft³
Weight: 57,942.544 lbf
Resis□ng Moment: 13,593,927 lbf·ft
Ac□va□ng Moment: 5,549,476.5 lbf·ft
Resis□ng Force: 46,143.538 lbf
Ac□va□ng Force: 18,839.93 lbf
Slip Rank: 1 of 2,730 slip surfaces
Exit: (160, 79.19125) ft

Figure D.5-694

Entry: (106.49965, 83.886633) ft
Radius: 293.74432 ft
Center: (158.82363, 372.93322) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Fric□onal Strength	Cohesive Strength	Suc□on Strength	Base Material
Slice 1	107.34342 ft	83.736432 ft	-2,518.5534 psf	49.006633 psf	30.622743 psf	0 psf	0 psf	Common Borrow
Slice 2	109.03096 ft	83.441103 ft	-2,500.1248 psf	147.7163 psf	92.303387 psf	0 psf	0 psf	Common Borrow
Slice 3	110.71851 ft	83.155902 ft	-2,482.3283 psf	247.05239 psf	154.37546 psf	0 psf	0 psf	Common Borrow
Slice 4	112.40605 ft	82.880799 ft	-2,465.1619 psf	347.02608 psf	216.84596 psf	0 psf	0 psf	Common Borrow
Slice 5	114.0936 ft	82.615767 ft	-2,448.6238 psf	447.64907 psf	279.72219 psf	0 psf	0 psf	Common Borrow
Slice 6	115.78114 ft	82.360776 ft	-2,432.7124 psf	548.93362 psf	343.01179 psf	0 psf	0 psf	Common Borrow
Slice 7	117.46868 ft	82.115802 ft	-2,417.426 psf	650.89252 psf	406.72279 psf	0 psf	0 psf	Common Borrow
Slice 8	119.15623 ft	81.880818 ft	-2,402.7631 psf	753.53916 psf	470.86353 psf	0 psf	0 psf	Common Borrow
Slice 9	120.75 ft	81.667782 ft	-2,389.4696 psf	955.57108 psf	597.10708 psf	0 psf	0 psf	Common Borrow
Slice 10	122.25 ft	81.47563 ft	-2,377.4793 psf	981.6072 psf	613.37625 psf	0 psf	0 psf	Common Borrow
Slice 11	123.83333 ft	81.281539 ft	-2,366.4292 psf	1,008.6227 psf	630.25743 psf	0 psf	0 psf	Common Borrow
Slice 12	125.5 ft	81.08641 ft	-2,356.3756 psf	1,036.5811 psf	647.72776 psf	0 psf	0 psf	Common Borrow
Slice 13	127.16667 ft	80.900923 ft	-2,346.9237 psf	1,064.0121 psf	664.86854 psf	0 psf	0 psf	Common Borrow
Slice 14	128.88194 ft	80.720219 ft	-2,337.8321 psf	1,254.2921 psf	979.9604 psf	0 psf	0 psf	Gravel Borrow
Slice 15	130.64583 ft	80.544856 ft	-2,329.1358 psf	1,287.913 psf	1,006.2279 psf	0 psf	0 psf	Gravel Borrow
Slice 16	132.40972 ft	80.380234 ft	-2,321.1096 psf	1,320.8883 psf	1,031.9911 psf	0 psf	0 psf	Gravel Borrow
Slice 17	134.17361 ft	80.226333 ft	-2,313.7524 psf	1,353.1991 psf	1,057.235 psf	0 psf	0 psf	Gravel Borrow
Slice 18	135.9375 ft	80.083137 ft	-2,307.0633 psf	1,384.8256 psf	1,081.9443 psf	0 psf	0 psf	Gravel Borrow
Slice 19	137.70139 ft	79.950631 ft	-2,301.0411 psf	1,415.747 psf	1,106.1028 psf	0 psf	0 psf	Gravel Borrow
Slice 20	139.46528 ft	79.828799 ft	-2,295.6851 psf	1,445.9419 psf	1,129.6936 psf	0 psf	0 psf	Gravel Borrow
Slice 21	141.22917 ft	79.717629 ft	-2,290.9943 psf	1,475.3876 psf	1,152.6991 psf	0 psf	0 psf	Gravel Borrow
Slice 22	142.99306 ft	79.617108 ft	-2,286.9681 psf	1,504.0605 psf	1,175.1009 psf	0 psf	0 psf	Gravel Borrow
Slice	144.75694	79.527226	-2,283.6057	1,531.9359	1,196.8795	0 psf	0 psf	Gravel

23	ft	ft	psf	psf	psf			Borrow
Slice 24	146.52083 ft	79.447972 ft	-2,280.9065 psf	1,558.9878 psf	1,218.0148 psf	0 psf	0 psf	Gravel Borrow
Slice 25	148.28472 ft	79.379339 ft	-2,278.87 psf	1,585.1891 psf	1,238.4854 psf	0 psf	0 psf	Gravel Borrow
Slice 26	150.04861 ft	79.321318 ft	-2,277.4958 psf	1,610.5113 psf	1,258.2693 psf	0 psf	0 psf	Gravel Borrow
Slice 27	151.8125 ft	79.273903 ft	-2,276.7834 psf	1,634.9245 psf	1,277.343 psf	0 psf	0 psf	Gravel Borrow
Slice 28	153.57639 ft	79.237089 ft	-2,276.7325 psf	1,658.3973 psf	1,295.682 psf	0 psf	0 psf	Gravel Borrow
Slice 29	155.34028 ft	79.210873 ft	-2,277.3428 psf	1,680.8969 psf	1,313.2606 psf	0 psf	0 psf	Gravel Borrow
Slice 30	157.10417 ft	79.195251 ft	-2,278.6143 psf	1,702.3886 psf	1,330.0517 psf	0 psf	0 psf	Gravel Borrow
Slice 31	158.86806 ft	79.190222 ft	-2,280.5467 psf	1,722.8361 psf	1,346.0271 psf	0 psf	0 psf	Gravel Borrow
Slice 32	159.875 ft	79.190803 ft	-2,281.7061 psf	1,734.212 psf	1,354.9149 psf	0 psf	0 psf	Gravel Borrow

6.4 Pseudo-Static (M-P) Section Ha-Ha' - Final Condition - Compound Stability

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File Informa on

File Version: 11.01
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Last Edited By: Mikayla S. Hatch
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Directory: P:\0\0180366\01\Analysis\Bridge 17.7\SlopeW\
Last Solved Date: 11/15/2021
Last Solved Time: 03:28:22 PM

Project Se ngs

Unit System: U.S. Customary Units

Analysis Se ngs

6.4 Pseudo-Sta c (M-P)

Kind: SLOPE/W
Parent: 6. Compound Stability
Analysis Type: Morgenstern-Price
Se ngs
- Side Func on
  - Interslice force func on op on: Half-Sine
- PWP Condi ons from: Piezometric Line
- Apply Phrea c Correc on: No
- Use Staged Rapid Drawdown: No
- Unit Weight of Water: 62.4 pcf

Slip Surface
- Direc on of movement: Le. to Right
- Use Passive Mode: No
- Slip Surface Op on: Entry and Exit
- Cri cal slip surfaces saved: 1
- Op mize Cri cal Slip Surface Loca on: No
- Tension Crack Op on: (none)

Distribu on
- F of S Calcula on Op on: Constant

Advanced
- Geometry Se ngs
  - Minimum Slip Surface Depth: 2 ft
  - Number of Slices: 30
- Factor of Safety Convergence Se ngs
  - Maximum Number of Itera ons: 100
  - Tolerable difference in F of S: 0.001

Solu□on Se□ ngs
Search Method: Root Finder
Tolerable difference between star□ng and converged F of S: 3
Maximum itera□ons to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Gravel Borrow

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1A - Exis ng Granular Fill (Pseudo-Sta c)

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 50 psf
Effec□ve Fric□on Angle: 40 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2A - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 39 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2B - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 41 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 7A - Weathered Sandstone

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 43 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1B - Exis ng Gravelly Granular Fill

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effec ve Cohesion: 0 psf
Effec ve Fric on Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2C - Na ve Silt (Pseudo-Sta c)

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effec ve Cohesion: 200 psf
Effec ve Fric on Angle: 29 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Common Borrow

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec ve Cohesion: 0 psf
Effec ve Fric on Angle: 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Reinforcements

EQ_EL47_W9.5xW4 75 yrs)

Type: Geosynthe c
Interface Adhesion: 0 psf
Interface Shear Angle: 16.3 °
Surface Area Factor: 2
Pullout Resistance Reduc on Factor: 1
Tensile Capacity: 7,427 lbf
Tensile Capacity Reduc on Factor: 1
F of S Dependent: No
Force Distribu on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,427 lbf/ft

EQ_EL49_W9.5xW4 (75 yrs)

Type: Geosynthe c
Interface Adhesion: 0 psf
Interface Shear Angle: 16.3 °
Surface Area Factor: 2
Pullout Resistance Reduc on Factor: 1
Tensile Capacity: 7,427 lbf
Tensile Capacity Reduc on Factor: 1
F of S Dependent: No
Force Distribu on: Distributed

Face Anchorage: Yes
Factored Tensile Capacity: 7,427 lbf/ft

EQ_EL51_W9.5xW4 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 16.3 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,427 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,427 lbf/ft

EQ_EL53_W9.5xW4 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 16.3 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,427 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,427 lbf/ft

EQ_EL55_W9.5xW4 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 16.3 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,427 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,427 lbf/ft

EQ_EL57_W9.5xW4 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 16.3 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 7,427 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,427 lbf/ft

EQ_EL59_W7.0xW3.5 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 13.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,147 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,147 lbf/ft

EQ_EL61_W7.0xW3.5 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 13.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,147 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,147 lbf/ft

EQ_EL63_W7.0xW3.5 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 13.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,147 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,147 lbf/ft

EQ_EL65_W7.0xW3.5 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 13.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,147 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,147 lbf/ft

EQ_EL79_W4.5xW3.5 (45 yrs)

Type: Geosynthe□c

Interface Adhesion: 0 psf
Interface Shear Angle: 23 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,891 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,891 lbf/ft

EQ_EL81_W4.5xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 23 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,891 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,891 lbf/ft

EQ_EL83_W4.5xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 23 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,891 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,891 lbf/ft

EQ_EL85_W4.5xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 23 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,891 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,891 lbf/ft

EQ_EL87_W4.5xW3.5 (45 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 23 °

Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 3,891 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,891 lbf/ft

EQ_EL67_W7.0xW3.5 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 13.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,147 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,147 lbf/ft

EQ_EL69_W7.0xW3.5 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 13.7 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,147 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,147 lbf/ft

EQ_EL71_W7.0xW3.5 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 26 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 5,147 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,147 lbf/ft

EQ_EL73_W7.0xW3.5 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 26 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1

Tensile Capacity: 5,147 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,147 lbf/ft

EQ_EL75_W7.0xW3.5 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 20.2 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 2,924 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 2,924 lbf/ft

EQ_EL77_W4.5xW3.5 (75 yrs)

Type: Geosynthe□c
Interface Adhesion: 0 psf
Interface Shear Angle: 20.2 °
Surface Area Factor: 2
Pullout Resistance Reduc□on Factor: 1
Tensile Capacity: 2,924 lbf
Tensile Capacity Reduc□on Factor: 1
F of S Dependent: No
Force Distribu□on: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 2,924 lbf/ft

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (80, 72) ft
Left-Zone Right Coordinate: (128, 90) ft
Left-Zone Increment: 25
Right Type: Range
Right-Zone Left Coordinate: (160, 86.975) ft
Right-Zone Right Coordinate: (160, 75) ft
Right-Zone Increment: 20
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (0, 60) ft
Right Coordinate: (335, 48) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	0.25 ft	43.375 ft
Coordinate 2	56.5 ft	43.375 ft
Coordinate 3	97.75 ft	43.375 ft
Coordinate 4	123 ft	43.375 ft
Coordinate 5	159.75 ft	42.625 ft
Coordinate 6	192 ft	42.625 ft
Coordinate 7	210.75 ft	42.625 ft
Coordinate 8	298 ft	35 ft
Coordinate 9	335.25 ft	35 ft

Seismic Coefficients

Horz Seismic Coef.: 0.255

Reinforcement Lines

Reinforcement Line 1

Reinforcement: EQ_EL47_W9.5xW4 75 yrs)
Lock to Ground Surface: No
Outside Point: (160, 47) ft
Inside Point: (128, 47) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 2

Reinforcement: EQ_EL49_W9.5xW4 (75 yrs)
Lock to Ground Surface: No
Outside Point: (160, 49) ft
Inside Point: (128, 49) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 3

Reinforcement: EQ_EL51_W9.5xW4 (75 yrs)

Lock to Ground Surface: No
Outside Point: (160, 51) ft
Inside Point: (128, 51) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 4

Reinforcement: EQ_EL53_W9.5xW4 (75 yrs)
Lock to Ground Surface: No
Outside Point: (160, 53) ft
Inside Point: (128, 53) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 5

Reinforcement: EQ_EL55_W9.5xW4 (75 yrs)
Lock to Ground Surface: No
Outside Point: (160, 55) ft
Inside Point: (128, 55) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 6

Reinforcement: EQ_EL57_W9.5xW4 (75 yrs)
Lock to Ground Surface: No
Outside Point: (160, 57) ft
Inside Point: (128, 57) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 7

Reinforcement: EQ_EL59_W7.0xW3.5 (75 yrs)
Lock to Ground Surface: No
Outside Point: (160, 59) ft
Inside Point: (128, 59) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 8

Reinforcement: EQ_EL61_W7.0xW3.5 (75 yrs)
Lock to Ground Surface: No
Outside Point: (160, 61) ft
Inside Point: (128, 61) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 9

Reinforcement: EQ_EL63_W7.0xW3.5 (75 yrs)
Lock to Ground Surface: No
Outside Point: (160, 63) ft
Inside Point: (128, 63) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 10

Reinforcement: EQ_EL65_W7.0xW3.5 (75 yrs)
Lock to Ground Surface: No
Outside Point: (160, 65) ft
Inside Point: (128, 65) ft
Length: 32 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft

Governing Component: (none)

Reinforcement Line 11

Reinforcement: EQ_EL67_W7.0xW3.5 (75 yrs)
Lock to Ground Surface: No
Outside Point: (160, 67) ft
Inside Point: (128, 67) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 12

Reinforcement: EQ_EL69_W7.0xW3.5 (75 yrs)
Lock to Ground Surface: No
Outside Point: (160, 69) ft
Inside Point: (128, 69) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 13

Reinforcement: EQ_EL71_W7.0xW3.5 (75 yrs)
Lock to Ground Surface: No
Outside Point: (160, 71) ft
Inside Point: (128, 71) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 14

Reinforcement: EQ_EL73_W7.0xW3.5 (75 yrs)
Lock to Ground Surface: No
Outside Point: (160, 73) ft
Inside Point: (128, 73) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft

Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 15

Reinforcement: EQ_EL75_W7.0xW3.5 (75 yrs)
Lock to Ground Surface: No
Outside Point: (160, 75) ft
Inside Point: (128, 75) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 16

Reinforcement: EQ_EL77_W4.5xW3.5 (75 yrs)
Lock to Ground Surface: No
Outside Point: (160, 77) ft
Inside Point: (128, 77) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 17

Reinforcement: EQ_EL79_W4.5xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 79) ft
Inside Point: (128, 79) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 18

Reinforcement: EQ_EL81_W4.5xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 81) ft
Inside Point: (128, 81) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf

Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 19

Reinforcement: EQ_EL83_W4.5xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 83) ft
Inside Point: (128, 83) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 20

Reinforcement: EQ_EL85_W4.5xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 85) ft
Inside Point: (128, 85) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 21

Reinforcement: EQ_EL87_W4.5xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 89) ft
Inside Point: (128, 89) ft
Length: 32 ft
Orienta□on: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 22

Reinforcement: EQ_EL87_W4.5xW3.5 (45 yrs)
Lock to Ground Surface: No
Outside Point: (160, 87) ft
Inside Point: (128, 87) ft
Length: 32 ft

Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 125 pcf
Direction: Vertical

Coordinates

	X	Y
	120 ft	91 ft
	160 ft	91 ft

Geometry

Name: Ga-Ga'

Settings

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	0 ft	56 ft
Point 2	76 ft	56 ft
Point 3	118 ft	35 ft
Point 4	160 ft	35 ft
Point 5	0 ft	46 ft
Point 6	37 ft	46 ft
Point 7	190 ft	50 ft
Point 8	160 ft	50 ft
Point 9	170.25 ft	34 ft
Point 10	240 ft	34 ft
Point 11	315 ft	30 ft
Point 12	335 ft	30 ft
Point 13	335 ft	48 ft
Point 14	327 ft	48 ft
Point 15	315 ft	49 ft
Point 16	224 ft	48 ft
Point 17	0 ft	0 ft
Point 18	335 ft	0 ft
Point 19	160 ft	90 ft
Point 20	120 ft	90 ft

Figure D.5-711

Point 21	120 ft	72 ft
Point 22	80 ft	72 ft
Point 23	56 ft	60 ft
Point 24	0 ft	60 ft
Point 25	160 ft	47 ft
Point 26	120 ft	47 ft
Point 27	70 ft	67 ft
Point 28	160 ft	78 ft
Point 29	93.5 ft	78 ft
Point 30	120 ft	78 ft
Point 31	160 ft	72 ft
Point 32	128 ft	90 ft
Point 33	128 ft	47 ft
Point 34	128 ft	78 ft
Point 35	128 ft	72 ft

Regions

	Material	Points	Area
Region 1	ESU 2C - Na□ve Silt (Pseudo-Sta□c)	5,6,2,1	565 ft²
Region 2	Common Borrow	20,29,30	159 ft²
Region 3	ESU 2A - Na□ve Sand and Gravel	6,2,3	619.5 ft²
Region 4	ESU 2B - Na□ve Sand and Gravel	7,16,15,14,13,12,11,10,9,4	2,595.4 ft²
Region 5	ESU 7A - Weathered Sandstone	18,17,5,6,3,4,9,10,11,12	12,178 ft²
Region 6	ESU 1B - Exis□ng Gravelly Granular Fill	8,7,25	45 ft²
Region 7	ESU 2A - Na□ve Sand and Gravel	4,7,25,33,26,2,3	945 ft²
Region 8	ESU 1B - Exis□ng Gravelly Granular Fill	23,24,1,2,26,21,22,27	1,302 ft²
Region 9	ESU 1B - Exis□ng Gravelly Granular Fill	26,33,35,21	200 ft²
Region 10	Gravel Borrow	19,32,34,28	384 ft²
Region 11	ESU 1A - Exis□ng Granular Fill (Pseudo-Sta□c)	22,21,30,29	199.5 ft²
Region 12	ESU 1A - Exis□ng Granular Fill (Pseudo-Sta□c)	28,34,35,31	192 ft²
Region 13	Common Borrow	20,30,34,32	96 ft²
Region 14	ESU 1A - Exis□ng Granular Fill (Pseudo-Sta□c)	30,21,35,34	48 ft²
Region 15	ESU 1B - Exis□ng Gravelly Granular Fill	25,8,31,35,33	800 ft²

Slip Results

Slip Surfaces Analysed: 958 of 2730 converged

Current Slip Surface

Slip Surface: 1,536
Factor of Safety: 2.453
Volume: 455.41432 ft³
Weight: 57,942.544 lbf
Resis□ng Moment: 13,615,126 lbf·ft
Ac□va□ng Moment: 5,549,476.5 lbf·ft
Resis□ng Force: 46,216.711 lbf
Ac□va□ng Force: 18,840.239 lbf
Slip Rank: 1 of 2,730 slip surfaces
Exit: (160, 79.19125) ft

Figure D.5-712

Entry: (106.49965, 83.886633) ft
Radius: 293.74432 ft
Center: (158.82363, 372.93322) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Fric□onal Strength	Cohesive Strength	Suc□on Strength	Base Material
Slice 1	107.34342 ft	83.736432 ft	-2,518.5534 psf	59.722533 psf	37.318781 psf	0 psf	0 psf	Common Borrow
Slice 2	109.03096 ft	83.441103 ft	-2,500.1248 psf	173.54764 psf	108.4446 psf	0 psf	0 psf	Common Borrow
Slice 3	110.71851 ft	83.155902 ft	-2,482.3283 psf	279.1456 psf	174.42953 psf	0 psf	0 psf	Common Borrow
Slice 4	112.40605 ft	82.880799 ft	-2,465.1619 psf	377.39027 psf	235.81962 psf	0 psf	0 psf	Common Borrow
Slice 5	114.0936 ft	82.615767 ft	-2,448.6238 psf	469.34924 psf	293.28195 psf	0 psf	0 psf	Common Borrow
Slice 6	115.78114 ft	82.360776 ft	-2,432.7124 psf	556.28472 psf	347.60527 psf	0 psf	0 psf	Common Borrow
Slice 7	117.46868 ft	82.115802 ft	-2,417.426 psf	639.652 psf	399.69893 psf	0 psf	0 psf	Common Borrow
Slice 8	119.15623 ft	81.880818 ft	-2,402.7631 psf	721.0916 psf	450.58804 psf	0 psf	0 psf	Common Borrow
Slice 9	120.75 ft	81.667782 ft	-2,389.4696 psf	900.95584 psf	562.97969 psf	0 psf	0 psf	Common Borrow
Slice 10	122.25 ft	81.47563 ft	-2,377.4793 psf	911.83466 psf	569.77753 psf	0 psf	0 psf	Common Borrow
Slice 11	123.83333 ft	81.281539 ft	-2,366.4292 psf	927.42101 psf	579.51696 psf	0 psf	0 psf	Common Borrow
Slice 12	125.5 ft	81.08641 ft	-2,356.3756 psf	948.98411 psf	592.99109 psf	0 psf	0 psf	Common Borrow
Slice 13	127.16667 ft	80.900923 ft	-2,346.9237 psf	976.40368 psf	610.12474 psf	0 psf	0 psf	Common Borrow
Slice 14	128.88194 ft	80.720219 ft	-2,337.8321 psf	1,187.2863 psf	927.60974 psf	0 psf	0 psf	Gravel Borrow
Slice 15	130.64583 ft	80.544856 ft	-2,329.1358 psf	1,242.1976 psf	970.51113 psf	0 psf	0 psf	Gravel Borrow
Slice 16	132.40972 ft	80.380234 ft	-2,321.1096 psf	1,300.6886 psf	1,016.2093 psf	0 psf	0 psf	Gravel Borrow
Slice 17	134.17361 ft	80.226333 ft	-2,313.7524 psf	1,361.1755 psf	1,063.4668 psf	0 psf	0 psf	Gravel Borrow
Slice 18	135.9375 ft	80.083137 ft	-2,307.0633 psf	1,421.6791 psf	1,110.7374 psf	0 psf	0 psf	Gravel Borrow
Slice 19	137.70139 ft	79.950631 ft	-2,301.0411 psf	1,479.9547 psf	1,156.2674 psf	0 psf	0 psf	Gravel Borrow
Slice 20	139.46528 ft	79.828799 ft	-2,295.6851 psf	1,533.6711 psf	1,198.2352 psf	0 psf	0 psf	Gravel Borrow
Slice 21	141.22917 ft	79.717629 ft	-2,290.9943 psf	1,580.6197 psf	1,234.9155 psf	0 psf	0 psf	Gravel Borrow
Slice 22	142.99306 ft	79.617108 ft	-2,286.9681 psf	1,618.9279 psf	1,264.8451 psf	0 psf	0 psf	Gravel Borrow
Slice	144.75694	79.527226	-2,283.6057	1,647.2448	1,286.9687	0 psf	0 psf	Gravel

23	ft	ft	psf	psf	psf			Borrow
Slice 24	146.52083 ft	79.447972 ft	-2,280.9065 psf	1,664.8707 psf	1,300.7396 psf	0 psf	0 psf	Gravel Borrow
Slice 25	148.28472 ft	79.379339 ft	-2,278.87 psf	1,671.8074 psf	1,306.1591 psf	0 psf	0 psf	Gravel Borrow
Slice 26	150.04861 ft	79.321318 ft	-2,277.4958 psf	1,668.7192 psf	1,303.7463 psf	0 psf	0 psf	Gravel Borrow
Slice 27	151.8125 ft	79.273903 ft	-2,276.7834 psf	1,656.8102 psf	1,294.442 psf	0 psf	0 psf	Gravel Borrow
Slice 28	153.57639 ft	79.237089 ft	-2,276.7325 psf	1,637.6374 psf	1,279.4626 psf	0 psf	0 psf	Gravel Borrow
Slice 29	155.34028 ft	79.210873 ft	-2,277.3428 psf	1,612.8919 psf	1,260.1292 psf	0 psf	0 psf	Gravel Borrow
Slice 30	157.10417 ft	79.195251 ft	-2,278.6143 psf	1,584.1872 psf	1,237.7027 psf	0 psf	0 psf	Gravel Borrow
Slice 31	158.86806 ft	79.190222 ft	-2,280.5467 psf	1,552.8924 psf	1,213.2525 psf	0 psf	0 psf	Gravel Borrow
Slice 32	159.875 ft	79.190803 ft	-2,281.7061 psf	1,534.4286 psf	1,198.827 psf	0 psf	0 psf	Gravel Borrow

FLATIRON | LANE | wood.

In Association with

Appendix D.6
Internal Stability of Existing Wall 03.63L

AASHTO 2007-2010 (LRFD)
Bridge 17.7 - Existing Condition

MSEW(3.0): Update # 14.981

PROJECT IDENTIFICATION

Title: Bridge 17.7 - Existing Condition
Project Number: 00180-366-01
Client:
Designer: MSH
Station Number: Section Ha-Ha'

Description:

Company's information:

Name: GeoEngineers, Inc.
Street:

,
Telephone #:
Fax #:
E-Mail:

Original file path and name: P:\0\0180366\01\Analysis\Bridge 17.7\Appendix E - Wall .....
.....ition - 75 years.BEN

Original date and time of creating this file: Thu May 27 11:37:30 2021

PROGRAM MODE:

ANALYSIS
of a SIMPLE STRUCTURE
using METAL MATS/GRIDS as reinforcing material.

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Figure D.6-1

SOIL DATA

REINFORCED SOIL

Unit weight, γ	130.0 lb/ft ^{3}
Design value of internal angle of friction, ϕ	38.0 °

RETAINED SOIL

Unit weight, γ	125.0 lb/ft ^{3}
Design value of internal angle of friction, ϕ	38.0 °

FOUNDATION SOIL (Considered as an equivalent uniform soil)

Equivalent unit weight, $\gamma_{equiv.}$	125.0 lb/ft ^{3}
Equivalent internal angle of friction, $\phi_{equiv.}$	38.0 °
Equivalent cohesion, $c_{equiv.}$	0.0 lb/ft ^{2}

Water table is at wall base elevation

LATERAL EARTH PRESSURE COEFFICIENTS

Ka (internal stability) = 0.2379 (if batter is less than 10°, Ka is calculated from eq. 15. Otherwise, eq. 38 is utilized)
Ka (external stability) = 0.2379 (if batter is less than 10°, Ka is calculated from eq. 16. Otherwise, eq. 17 is utilized)

BEARING CAPACITY

Bearing capacity is controlled by general shear.
Bearing capacity factors (calculated by MSEW): Nc = 61.35   N γ= 78.02

SEISMICITY

Maximum ground acceleration coefficient, A = 0.510
Design acceleration coefficient in Internal Stability: Kh = Am = 0.510
Design acceleration coefficient in External Stability: Kh_d = 0.510 => Kh = Am = 0.510

Kae (Kh > 0) = 0.6539   Kae (Kh = 0) = 0.2379 Δ Kae = 0.4160
Seismic soil-metal mats friction coefficient, F* is 80.0% of its specified static value.

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INPUT DATA: Metal mats/grids (Analysis)

D A T A	Metal mats type #1	Metal mats type #2	Metal mats type #3	Metal mats type #4	Metal mats type #5
Yield strength of steel, Fy [kips/in ²]	65.0	65.0	65.0	N/A	N/A
Gross width of grid, b [in]	12.0	12.0	12.0	N/A	N/A
Vertical spacing, Sv [ft]	Varies	Varies	Varies	N/A	N/A
Design cross section area, Ac [in ²]	0.05	0.09	0.13	N/A	N/A
Thickness of transverse element, t [in]	0.2	0.2	0.2	N/A	N/A
Distance between transverse bars, St [in]	12.0	12.0	12.0	N/A	N/A
Friction angle along reinforcement-soil interface, ρ					
@ the top	38.00	38.00	38.00	N/A	N/A
@ 19.7 ft or below	38.00	38.00	38.00	N/A	N/A
Pullout resistance factor, F*					
@ the top	0.35	0.35	0.35	N/A	N/A
@ 19.7 ft or below	0.18	0.18	0.18	N/A	N/A
Scale-effect correction factor, α	1.00	1.00	1.00	N/A	N/A

Variation of Lateral Earth Pressure Coefficient With Depth

Z	K / Ka
0 ft	2.50
3.3 ft	2.30
6.6 ft	2.05
9.8 ft	1.85
13.1 ft	1.65
16.4 ft	1.40
19.7 ft	1.20

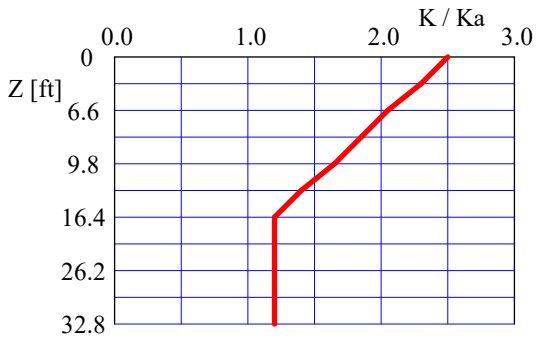

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Figure D.6-3

INPUT DATA: Facia and Connection (Analysis)

FACIA type: Full height precast concrete panels.
Depth of panel is 1.31 ft. Horizontal distance to Center of Gravity of panel is 0.66 ft.
Average unit weight of panel is γ_f = 152.78 lb/ft ^{3}

Z / Hd	To-static / Tmax or To-seismic / Tmd
0.00	1.00
0.25	1.00
0.50	1.00
0.75	1.00
1.00	1.00

D A T A (for connection only)	Type #1	Type #2	Type #3	Type #4	Type #5
Product Name	W4.5xW3.5	W7.0xW3.5	W9.5xW4.0	N/A	N/A
Strength reduction at the connection, CRu = Fyc / Fy	1.00	1.00	1.00	N/A	N/A

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Figure D.6-4

INPUT DATA: Geometry and Surcharge loads (of a SIMPLE STRUCTURE)

Design height, Hd	43.00	[ft]	{ Embedded depth is E = 3.00 ft, and height above top of finished bottom grade is H = 40.00 ft }
Batter, ω	0.0	[deg]	
Backslope, β	0.0	[deg]	
Backslope rise	0.0	[ft]	Broken back equivalent angle, I = 0.00° (see Fig. 25 in DEMO 82)

U N I F O R M   S U R C H A R G E

Uniformly distributed dead load is 0.0 [lb/ft ²], and live load is 250.0 [lb/ft ²]

ANALYZED REINFORCEMENT LAYOUT:

SCALE:

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Figure D.6-5

AASHTO 2007-2010 (LRFD) Input Data

INTERNAL STABILITY

Load factor for vertical earth pressure, EV, from Table 3.4.1-2:	$\gamma_{p\text{-}EV}$	1.35		
Load factor for earthquake loads, EQ, from Table 3.4.1-1:	$\gamma_{p\text{-}EQ}$	1.00		
Load factor for live load surcharge, LS, from Figure C11.5.5-3(b): (Same as in External Stability).	$\gamma_{p\text{-}LS}$	1.75		
Load factor for dead load surcharge, ES: (Same as in External Stability).	$\gamma_{p\text{-}ES}$	1.50		

Resistance factor for reinforcement tension from Table 11.5.6-1:	ϕ	Static	Combined static/seismic
Metal Mats:		0.65	0.85

Resistance factor for reinforcement tension in connectors from Table 11.5.6-1:	ϕ	Static	Combined static/seismic
Metal Mats:		0.65	0.85

Resistance factor for reinforcement pullout from Table 11.5.6-1:	ϕ	0.90	1.20

EXTERNAL STABILITY

Load factor for vertical earth pressure, EV, from Table 3.4.1-2 and Figure C11.5.5-2:		Static	Combined Static/Seismic	
Sliding and Eccentricity	$\gamma_{p\text{-}EV}$	1.00	$\gamma_{p\text{-}EQ}$	1.00
Bearing Capacity	$\gamma_{p\text{-}EV}$	1.35	$\gamma_{p\text{-}EQ}$	1.35

Load factor of active lateral earth pressure, EH, from Table 3.4.1-2 and Figure C11.5.5-2:	$\gamma_{p\text{-}EH}$	1.50
Load factor of active lateral earth pressure during earthquake (does not multiply P_{AE} and P_{IR}):	$(\gamma_{p\text{-}EH})_{EQ}$	1.50
Load factor for earthquake loads, EQ, from Table 3.4.1-1 (multiplies P_{AE} and P_{IR}):	$\gamma_{p\text{-}EQ}$	1.00

Resistance factor for shear resistance along common interfaces from Table 11.5.6-1:		Static	Combined Static/Seismic	
Reinforced Soil and Foundation	ϕ_τ	1.00		1.00
Reinforced Soil and Reinforcement	ϕ_τ	1.00		1.00

Resistance factor for bearing capacity of shallow foundation from Table 11.5.6-1:		Static	Combined Static/Seismic
	ϕ_b	0.65	0.65

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Figure D.6-6

ANALYSIS: CALCULATED FACTORS (Static conditiorBearing capacity, CDR = 4.40, factored bearing load = 9598 lb/ft².
Foundation Interface: Direct sliding, CDR = 3.057, Eccentricity, e/L = 0.1201, CDR-overturning = 4.16

METAL MATS				CONNECTION							
#	Elevation [ft]	Length [ft]	Type #	CDR [pullout resistance]	CDR [connection break]	CDR [metal mats strength]	Metal mats strength CDR	Pullout resistance CDR	Direct sliding CDR	Eccentricity e/L	Product name
1	0.00	32.00	3	N/A	2.51	2.51	2.512	24.994	3.057	0.1201	W9.5xW4.0
2	2.00	32.00	3	N/A	1.30	1.30	1.299	11.866	3.191	0.1099	W9.5xW4.0
3	4.00	32.00	3	N/A	1.36	1.36	1.362	11.367	3.337	0.1002	W9.5xW4.0
4	6.00	32.00	3	N/A	1.43	1.43	1.431	10.872	3.498	0.0909	W9.5xW4.0
5	8.00	32.00	3	N/A	1.51	1.51	1.507	10.377	3.674	0.0821	W9.5xW4.0
6	10.00	32.00	3	N/A	1.59	1.59	1.592	9.875	3.869	0.0737	W9.5xW4.0
7	12.00	32.00	2	N/A	1.17	1.17	1.171	9.378	4.086	0.0658	W7.0xW3.5
8	14.00	32.00	2	N/A	1.25	1.25	1.245	8.880	4.329	0.0583	W7.0xW3.5
9	16.00	32.00	2	N/A	1.33	1.33	1.330	8.376	4.602	0.0513	W7.0xW3.5
10	18.00	32.00	2	N/A	1.43	1.43	1.426	7.875	4.912	0.0447	W7.0xW3.5
11	20.00	32.00	2	N/A	1.54	1.54	1.538	7.373	5.268	0.0385	W7.0xW3.5
12	22.00	32.00	2	N/A	1.67	1.67	1.669	6.976	5.678	0.0328	W7.0xW3.5
13	24.00	32.00	2	N/A	1.75	1.75	1.753	6.860	6.158	0.0276	W7.0xW3.5
14	26.00	32.00	2	N/A	1.77	1.77	1.771	6.812	6.726	0.0228	W7.0xW3.5
15	28.00	32.00	1	N/A	1.02	1.02	1.020	6.623	7.410	0.0184	W4.5xW3.5
16	30.00	32.00	1	N/A	1.05	1.05	1.051	6.403	8.249	0.0145	W4.5xW3.5
17	32.00	32.00	1	N/A	1.12	1.12	1.120	6.210	9.302	0.0111	W4.5xW3.5
18	34.00	32.00	1	N/A	1.23	1.23	1.231	5.979	10.664	0.0080	W4.5xW3.5
19	36.00	32.00	1	N/A	1.40	1.40	1.398	5.632	12.492	0.0055	W4.5xW3.5
20	38.00	32.00	1	N/A	1.66	1.66	1.658	5.066	15.076	0.0034	W4.5xW3.5
21	40.00	32.00	1	N/A	2.12	2.12	2.123	4.120	19.009	0.0017	W4.5xW3.5
22	42.00	32.00	1	N/A	3.17	3.17	3.171	2.164	25.718	0.0004	W4.5xW3.5

ANALYSIS: CALCULATED FACTORS (Seismic conditiBearing capacity, CDR = 0.81, factored bearing load = 22315 lb/ft².
Foundation Interface: Direct sliding, CDR = 1.066, Eccentricity, e/L = 0.4586, Fs-overturning = 1.09

METAL MATS				CONNECTION							
#	Elevation [ft]	Length [ft]	Type #	CDR [pullout resistance]	CDR [connection break]	CDR [metal mats strength]	Metal mats strength CDR	Pullout resistance CDR	Direct sliding CDR	Eccentricity e/L	Product name
1	0.00	32.00	3	N/A	1.84	1.84	1.836	14.900	1.066	0.4586	W9.5xW4.0
2	2.00	32.00	3	N/A	1.22	1.22	1.220	9.086	1.117	0.4177	W9.5xW4.0
3	4.00	32.00	3	N/A	1.28	1.28	1.276	8.686	1.172	0.3787	W9.5xW4.0
4	6.00	32.00	3	N/A	1.34	1.34	1.337	8.289	1.233	0.3416	W9.5xW4.0
5	8.00	32.00	3	N/A	1.41	1.41	1.405	7.891	1.300	0.3064	W9.5xW4.0
6	10.00	32.00	3	N/A	1.48	1.48	1.480	7.489	1.375	0.2731	W9.5xW4.0
7	12.00	32.00	2	N/A	1.09	1.09	1.085	7.090	1.460	0.2417	W7.0xW3.5
8	14.00	32.00	2	N/A	1.15	1.15	1.150	6.690	1.556	0.2123	W7.0xW3.5
9	16.00	32.00	2	N/A	1.22	1.22	1.223	6.286	1.665	0.1847	W7.0xW3.5
10	18.00	32.00	2	N/A	1.31	1.31	1.306	5.883	1.790	0.1591	W7.0xW3.5
11	20.00	32.00	2	N/A	1.40	1.40	1.401	5.479	1.936	0.1354	W7.0xW3.5
12	22.00	32.00	2	N/A	1.50	1.50	1.504	5.128	2.108	0.1136	W7.0xW3.5
13	24.00	32.00	2	N/A	1.56	1.56	1.555	4.965	2.314	0.0937	W7.0xW3.5
14	26.00	32.00	2	N/A	1.57	1.57	1.566	4.914	2.564	0.0757	W7.0xW3.5
15	28.00	32.00	1	N/A	0.90	0.90	0.899	4.761	2.874	0.0596	W4.5xW3.5
16	30.00	32.00	1	N/A	0.92	0.92	0.917	4.557	3.270	0.0455	W4.5xW3.5
17	32.00	32.00	1	N/A	0.96	0.96	0.956	4.326	3.792	0.0332	W4.5xW3.5
18	34.00	32.00	1	N/A	1.02	1.02	1.016	4.027	4.513	0.0229	W4.5xW3.5
19	36.00	32.00	1	N/A	1.10	1.10	1.099	3.612	5.573	0.0144	W4.5xW3.5
20	38.00	32.00	1	N/A	1.21	1.21	1.214	3.025	7.282	0.0079	W4.5xW3.5
21	40.00	32.00	1	N/A	1.38	1.38	1.383	2.190	10.504	0.0033	W4.5xW3.5
22	42.00	32.00	1	N/A	1.66	1.66	1.656	0.922	18.839	0.0006	W4.5xW3.5

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Figure D.6-7

DIRECT SLIDING for GIVEN LAYOUT (for METAL MATS/GRIDS reinforcements)

Along reinforced and foundation soils interface: CDR-static = 3.057 and CDR-seismic = 1.066

#	Metal Mats Elevation [ft]	Metal Mats Length [ft]	CDR Static	CDR Seismic	Metal Mats Type #	Product name
1	0.00	32.00	3.057	1.066	3	W9.5xW4.0
2	2.00	32.00	3.191	1.117	3	W9.5xW4.0
3	4.00	32.00	3.337	1.172	3	W9.5xW4.0
4	6.00	32.00	3.498	1.233	3	W9.5xW4.0
5	8.00	32.00	3.674	1.300	3	W9.5xW4.0
6	10.00	32.00	3.869	1.375	3	W9.5xW4.0
7	12.00	32.00	4.086	1.460	2	W7.0xW3.5
8	14.00	32.00	4.329	1.556	2	W7.0xW3.5
9	16.00	32.00	4.602	1.665	2	W7.0xW3.5
10	18.00	32.00	4.912	1.790	2	W7.0xW3.5
11	20.00	32.00	5.268	1.936	2	W7.0xW3.5
12	22.00	32.00	5.678	2.108	2	W7.0xW3.5
13	24.00	32.00	6.158	2.314	2	W7.0xW3.5
14	26.00	32.00	6.726	2.564	2	W7.0xW3.5
15	28.00	32.00	7.410	2.874	1	W4.5xW3.5
16	30.00	32.00	8.249	3.270	1	W4.5xW3.5
17	32.00	32.00	9.302	3.792	1	W4.5xW3.5
18	34.00	32.00	10.664	4.513	1	W4.5xW3.5
19	36.00	32.00	12.492	5.573	1	W4.5xW3.5
20	38.00	32.00	15.076	7.282	1	W4.5xW3.5
21	40.00	32.00	19.009	10.504	1	W4.5xW3.5
22	42.00	32.00	25.718	18.839	1	W4.5xW3.5

ECCENTRICITY for GIVEN LAYOUT (for Simplified Method)

At interface with foundation: e/L static = 0.1201, e/L seismic = 0.4586; Overturning: CDR-static = 4.16, CDR-seismic = 1.09

#	Metal Mats Elevation [ft]	Metal Mats Length [ft]	e / L Static	e / L Seismic	Metal Mats Type #	Product name
1	0.00	32.00	0.1201	0.4586	3	W9.5xW4.0
2	2.00	32.00	0.1099	0.4177	3	W9.5xW4.0
3	4.00	32.00	0.1002	0.3787	3	W9.5xW4.0
4	6.00	32.00	0.0909	0.3416	3	W9.5xW4.0
5	8.00	32.00	0.0821	0.3064	3	W9.5xW4.0
6	10.00	32.00	0.0737	0.2731	3	W9.5xW4.0
7	12.00	32.00	0.0658	0.2417	2	W7.0xW3.5
8	14.00	32.00	0.0583	0.2123	2	W7.0xW3.5
9	16.00	32.00	0.0513	0.1847	2	W7.0xW3.5
10	18.00	32.00	0.0447	0.1591	2	W7.0xW3.5
11	20.00	32.00	0.0385	0.1354	2	W7.0xW3.5
12	22.00	32.00	0.0328	0.1136	2	W7.0xW3.5
13	24.00	32.00	0.0276	0.0937	2	W7.0xW3.5
14	26.00	32.00	0.0228	0.0757	2	W7.0xW3.5
15	28.00	32.00	0.0184	0.0596	1	W4.5xW3.5
16	30.00	32.00	0.0145	0.0455	1	W4.5xW3.5
17	32.00	32.00	0.0111	0.0332	1	W4.5xW3.5
18	34.00	32.00	0.0080	0.0229	1	W4.5xW3.5
19	36.00	32.00	0.0055	0.0144	1	W4.5xW3.5
20	38.00	32.00	0.0034	0.0079	1	W4.5xW3.5
21	40.00	32.00	0.0017	0.0033	1	W4.5xW3.5
22	42.00	32.00	0.0004	0.0006	1	W4.5xW3.5

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Figure D.6-8

RESULTS for STRENGTH [Note: Actual CDR = (Yield stress) / (Actual stress)] For Simplified Method
Live Load included in calculating Tmax

#	Metal Mats Elevation [ft]	Coverage ratio, Rc=b/Sh	Horizontal spacing, Sh [ft]	Long-term strength Fy·Ac·Rc/b [lb/ft]	Tmax [lb/ft]	Tmd [lb/ft]	Specified minimum CDR static	Actual calculated CDR static	Specified minimum CDR seismic	Actual calculated CDR seismic
1	0.00	1.000	1.000	5662	2254.06	1779.15	N/A	2.512	N/A	1.836
2	2.00	1.000	1.000	5662	4357.83	1712.43	N/A	1.299	N/A	1.220
3	4.00	1.000	1.000	5662	4157.43	1645.72	N/A	1.362	N/A	1.276
4	6.00	1.000	1.000	5662	3957.04	1579.00	N/A	1.431	N/A	1.337
5	8.00	1.000	1.000	5662	3756.65	1512.28	N/A	1.507	N/A	1.405
6	10.00	1.000	1.000	5662	3556.26	1445.56	N/A	1.592	N/A	1.480
7	12.00	1.000	1.000	3929	3355.86	1378.84	N/A	1.171	N/A	1.085
8	14.00	1.000	1.000	3929	3155.47	1312.12	N/A	1.245	N/A	1.150
9	16.00	1.000	1.000	3929	2955.08	1245.41	N/A	1.330	N/A	1.223
10	18.00	1.000	1.000	3929	2754.69	1178.69	N/A	1.426	N/A	1.306
11	20.00	1.000	1.000	3929	2554.29	1111.97	N/A	1.538	N/A	1.401
12	22.00	1.000	1.000	3929	2353.90	1061.93	N/A	1.669	N/A	1.504
13	24.00	1.000	1.000	3929	2241.39	1061.93	N/A	1.753	N/A	1.555
14	26.00	1.000	1.000	3929	2219.19	1061.93	N/A	1.771	N/A	1.566
15	28.00	1.000	1.000	2239	2194.76	1061.93	N/A	1.020	N/A	0.899
16	30.00	1.000	1.000	2239	2129.89	1061.93	N/A	1.051	N/A	0.917
17	32.00	1.000	1.000	2239	1999.65	1061.93	N/A	1.120	N/A	0.956
18	34.00	1.000	1.000	2239	1819.49	1061.93	N/A	1.231	N/A	1.016
19	36.00	1.000	1.000	2239	1601.65	1061.93	N/A	1.398	N/A	1.099
20	38.00	1.000	1.000	2239	1350.63	1061.93	N/A	1.658	N/A	1.214
21	40.00	1.000	1.000	2239	1054.66	1061.93	N/A	2.123	N/A	1.383
22	42.00	1.000	1.000	2239	706.24	1061.93	N/A	3.171	N/A	1.656

RESULTS for PULLOUT Live Load included in calculating Tmax

NOTE: Live load is not included in calculating the overburden pressure used to assess pullout resistance.

#	Metal Mats Elevation [ft]	Coverage Ratio Rc=b/Sh	Tmax [lb/ft]	Tmd [lb/ft]	Le [ft] (see NOTE)	La [ft]	Avail.Static Pullout, Pr [lb/ft]	Specified Static CDR	Actual Static CDR	Avail.Seism. Pullout, Pr [lb/ft]	Specified Seismic CDR	Actual Seismic CDR
1	0.00	1.000	2254.1	1779.2	32.00	0.00	56337.9	N/A	24.994	60093.8	N/A	14.900
2	2.00	1.000	4357.8	1712.4	30.80	1.20	51709.6	N/A	11.866	55156.9	N/A	9.086
3	4.00	1.000	4157.4	1645.7	29.60	2.40	47255.8	N/A	11.367	50406.2	N/A	8.686
4	6.00	1.000	3957.0	1579.0	28.40	3.60	43020.4	N/A	10.872	45888.4	N/A	8.289
5	8.00	1.000	3756.6	1512.3	27.20	4.80	38980.9	N/A	10.377	41579.6	N/A	7.891
6	10.00	1.000	3556.3	1445.6	26.00	6.00	35119.1	N/A	9.875	37460.4	N/A	7.489
7	12.00	1.000	3355.9	1378.8	24.80	7.20	31472.5	N/A	9.378	33570.7	N/A	7.090
8	14.00	1.000	3155.5	1312.1	23.60	8.40	28021.8	N/A	8.880	29889.9	N/A	6.690
9	16.00	1.000	2955.1	1245.4	22.40	9.60	24752.1	N/A	8.376	26402.2	N/A	6.286
10	18.00	1.000	2754.7	1178.7	21.20	10.80	21694.3	N/A	7.875	23140.5	N/A	5.883
11	20.00	1.000	2554.3	1112.0	20.00	12.00	18832.3	N/A	7.373	20087.8	N/A	5.479
12	22.00	1.000	2353.9	1061.9	19.10	12.90	16420.5	N/A	6.976	17515.2	N/A	5.128
13	24.00	1.000	2241.4	1061.9	19.10	12.90	15376.6	N/A	6.860	16401.7	N/A	4.965
14	26.00	1.000	2219.2	1061.9	19.10	12.90	15116.3	N/A	6.812	16124.0	N/A	4.914
15	28.00	1.000	2194.8	1061.9	19.10	12.90	14536.4	N/A	6.623	15505.5	N/A	4.761
16	30.00	1.000	2129.9	1061.9	19.10	12.90	13636.9	N/A	6.403	14546.0	N/A	4.557
17	32.00	1.000	1999.7	1061.9	19.10	12.90	12417.8	N/A	6.210	13245.6	N/A	4.326
18	34.00	1.000	1819.5	1061.9	19.10	12.90	10879.1	N/A	5.979	11604.3	N/A	4.027
19	36.00	1.000	1601.6	1061.9	19.10	12.90	9020.8	N/A	5.632	9622.2	N/A	3.612
20	38.00	1.000	1350.6	1061.9	19.10	12.90	6842.9	N/A	5.066	7299.1	N/A	3.025
21	40.00	1.000	1054.7	1061.9	19.10	12.90	4345.4	N/A	4.120	4635.1	N/A	2.190
22	42.00	1.000	706.2	1061.9	19.10	12.90	1528.4	N/A	2.164	1630.3	N/A	0.922

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Figure D.6-9

RESULTS for CONNECTION (static conditions)

Live Load included in calculating Tmax

#	Metal Mats Elevation [ft]	Coverage ratio Rc=b/Sh	Horizontal spacing, Sh [ft]	Connection force, To [lb/ft]	Reduction factor for connection break, CRu	Long-term connection strength,Tac (break criterion) [lb/ft]	Metal Mats long-term strength, [lb/ft]	CDR connection break Specified	CDR connection break Actual	CDR Metal Mats strength Specified	CDR Metal Mats strength Actual	Product name
1	0.00	1.000	1.000	2254	1.00	5662	5662	N/A	2.51	N/A	2.51	W9.5xW4.0
2	2.00	1.000	1.000	4358	1.00	5662	5662	N/A	1.30	N/A	1.30	W9.5xW4.0
3	4.00	1.000	1.000	4157	1.00	5662	5662	N/A	1.36	N/A	1.36	W9.5xW4.0
4	6.00	1.000	1.000	3957	1.00	5662	5662	N/A	1.43	N/A	1.43	W9.5xW4.0
5	8.00	1.000	1.000	3757	1.00	5662	5662	N/A	1.51	N/A	1.51	W9.5xW4.0
6	10.00	1.000	1.000	3556	1.00	5662	5662	N/A	1.59	N/A	1.59	W9.5xW4.0
7	12.00	1.000	1.000	3356	1.00	3929	3929	N/A	1.17	N/A	1.17	W7.0xW3.5
8	14.00	1.000	1.000	3155	1.00	3929	3929	N/A	1.25	N/A	1.25	W7.0xW3.5
9	16.00	1.000	1.000	2955	1.00	3929	3929	N/A	1.33	N/A	1.33	W7.0xW3.5
10	18.00	1.000	1.000	2755	1.00	3929	3929	N/A	1.43	N/A	1.43	W7.0xW3.5
11	20.00	1.000	1.000	2554	1.00	3929	3929	N/A	1.54	N/A	1.54	W7.0xW3.5
12	22.00	1.000	1.000	2354	1.00	3929	3929	N/A	1.67	N/A	1.67	W7.0xW3.5
13	24.00	1.000	1.000	2241	1.00	3929	3929	N/A	1.75	N/A	1.75	W7.0xW3.5
14	26.00	1.000	1.000	2219	1.00	3929	3929	N/A	1.77	N/A	1.77	W7.0xW3.5
15	28.00	1.000	1.000	2195	1.00	2239	2239	N/A	1.02	N/A	1.02	W4.5xW3.5
16	30.00	1.000	1.000	2130	1.00	2239	2239	N/A	1.05	N/A	1.05	W4.5xW3.5
17	32.00	1.000	1.000	2000	1.00	2239	2239	N/A	1.12	N/A	1.12	W4.5xW3.5
18	34.00	1.000	1.000	1819	1.00	2239	2239	N/A	1.23	N/A	1.23	W4.5xW3.5
19	36.00	1.000	1.000	1602	1.00	2239	2239	N/A	1.40	N/A	1.40	W4.5xW3.5
20	38.00	1.000	1.000	1351	1.00	2239	2239	N/A	1.66	N/A	1.66	W4.5xW3.5
21	40.00	1.000	1.000	1055	1.00	2239	2239	N/A	2.12	N/A	2.12	W4.5xW3.5
22	42.00	1.000	1.000	706	1.00	2239	2239	N/A	3.17	N/A	3.17	W4.5xW3.5

RESULTS for CONNECTION (seismic conditions)

Live Load included in calculating Tmax

#	Metal Mats Elevation [ft]	Coverage ratio Rc=b/Sh	Horizontal spacing, Sh [ft]	Connection force, To [lb/ft]	Reduction factor for connection break, CRu	Long-term connection strength,Tac (break criterion) [lb/ft]	Metal Mats long-term strength, [lb/ft]	CDR connection break Specified	CDR connection break Actual	CDR Metal Mats strength Specified	CDR Metal Mats strength Actual	Product name
1	0.00	1.000	1.000	4033	1.00	7404	5662	N/A	1.84	N/A	1.84	W9.5xW4.0
2	2.00	1.000	1.000	6070	1.00	7404	5662	N/A	1.22	N/A	1.22	W9.5xW4.0
3	4.00	1.000	1.000	5803	1.00	7404	5662	N/A	1.28	N/A	1.28	W9.5xW4.0
4	6.00	1.000	1.000	5536	1.00	7404	5662	N/A	1.34	N/A	1.34	W9.5xW4.0
5	8.00	1.000	1.000	5269	1.00	7404	5662	N/A	1.41	N/A	1.41	W9.5xW4.0
6	10.00	1.000	1.000	5002	1.00	7404	5662	N/A	1.48	N/A	1.48	W9.5xW4.0
7	12.00	1.000	1.000	4735	1.00	5138	3929	N/A	1.09	N/A	1.09	W7.0xW3.5
8	14.00	1.000	1.000	4468	1.00	5138	3929	N/A	1.15	N/A	1.15	W7.0xW3.5
9	16.00	1.000	1.000	4200	1.00	5138	3929	N/A	1.22	N/A	1.22	W7.0xW3.5
10	18.00	1.000	1.000	3933	1.00	5138	3929	N/A	1.31	N/A	1.31	W7.0xW3.5
11	20.00	1.000	1.000	3666	1.00	5138	3929	N/A	1.40	N/A	1.40	W7.0xW3.5
12	22.00	1.000	1.000	3416	1.00	5138	3929	N/A	1.50	N/A	1.50	W7.0xW3.5
13	24.00	1.000	1.000	3303	1.00	5138	3929	N/A	1.56	N/A	1.56	W7.0xW3.5
14	26.00	1.000	1.000	3281	1.00	5138	3929	N/A	1.57	N/A	1.57	W7.0xW3.5
15	28.00	1.000	1.000	3257	1.00	2928	2239	N/A	0.90	N/A	0.90	W4.5xW3.5
16	30.00	1.000	1.000	3192	1.00	2928	2239	N/A	0.92	N/A	0.92	W4.5xW3.5
17	32.00	1.000	1.000	3062	1.00	2928	2239	N/A	0.96	N/A	0.96	W4.5xW3.5
18	34.00	1.000	1.000	2881	1.00	2928	2239	N/A	1.02	N/A	1.02	W4.5xW3.5
19	36.00	1.000	1.000	2664	1.00	2928	2239	N/A	1.10	N/A	1.10	W4.5xW3.5
20	38.00	1.000	1.000	2413	1.00	2928	2239	N/A	1.21	N/A	1.21	W4.5xW3.5
21	40.00	1.000	1.000	2117	1.00	2928	2239	N/A	1.38	N/A	1.38	W4.5xW3.5
22	42.00	1.000	1.000	1768	1.00	2928	2239	N/A	1.66	N/A	1.66	W4.5xW3.5

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Figure D.6-10

AASHTO 2007-2010 (LRFD)
Bridge 17.7 - Final Condition

MSEW(3.0): Update # 14.981

PROJECT IDENTIFICATION

Title: Bridge 17.7 - Final Condition
Project Number: 00180-366-01
Client:
Designer: MSH
Station Number: Section Ha-Ha'

Description:

Company's information:

Name: GeoEngineers, Inc.
Street:

,
Telephone #:
Fax #:
E-Mail:

Original file path and name: P:\0\0180366\01\Analysis\Bridge 17.7\Appendix E - Wall .....
.....ion - 75-45years.BEN

Original date and time of creating this file: Thu May 27 11:37:30 2021

PROGRAM MODE:

ANALYSIS
of a SIMPLE STRUCTURE
using METAL MATS/GRIDS as reinforcing material.

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Figure D.6-11

SOIL DATA

REINFORCED SOIL

Unit weight, γ	130.0 lb/ft ^{3}
Design value of internal angle of friction, ϕ	38.0 °

RETAINED SOIL

Unit weight, γ	125.0 lb/ft ^{3}
Design value of internal angle of friction, ϕ	38.0 °

FOUNDATION SOIL (Considered as an equivalent uniform soil)

Equivalent unit weight, $\gamma_{equiv.}$	125.0 lb/ft ^{3}
Equivalent internal angle of friction, $\phi_{equiv.}$	38.0 °
Equivalent cohesion, $c_{equiv.}$	0.0 lb/ft ^{2}

Water table is at wall base elevation

LATERAL EARTH PRESSURE COEFFICIENTS

Ka (internal stability) = 0.2379 (if batter is less than 10°, Ka is calculated from eq. 15. Otherwise, eq. 38 is utilized)
Ka (external stability) = 0.2379 (if batter is less than 10°, Ka is calculated from eq. 16. Otherwise, eq. 17 is utilized)

BEARING CAPACITY

Bearing capacity is controlled by general shear.
Bearing capacity factors (calculated by MSEW): Nc = 61.35 N γ= 78.02

SEISMICITY

Maximum ground acceleration coefficient, A = 0.510
Design acceleration coefficient in Internal Stability: Kh = Am = 0.510
Design acceleration coefficient in External Stability: Kh_d = 0.510 => Kh = Am = 0.510

Kae (Kh > 0) = 0.6539 Kae (Kh = 0) = 0.2379 Δ Kae = 0.4160
Seismic soil-metal mats friction coefficient, F* is 80.0% of its specified static value.

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Figure D.6-12

INPUT DATA: Metal mats/grids (Analysis)

D A T A	Metal mats type #1	Metal mats type #2	Metal mats type #3	Metal mats type #4	Metal mats type #5
Yield strength of steel, Fy [kips/in ²]	65.0	65.0	65.0	65.0	N/A
Gross width of grid, b [in]	12.0	12.0	12.0	12.0	N/A
Vertical spacing, Sv [ft]	Varies	Varies	Varies	Varies	N/A
Design cross section area, Ac [in ²]	0.05	0.09	0.13	0.07	N/A
Thickness of transverse element, t [in]	0.2	0.2	0.2	0.2	N/A
Distance between transverse bars, St [in]	12.0	12.0	12.0	12.0	N/A
Friction angle along reinforcement-soil interface, ρ					
@ the top	38.00	38.00	38.00	38.00	N/A
@ 19.7 ft or below	38.00	38.00	38.00	38.00	N/A
Pullout resistance factor, F*					
@ the top	0.35	0.35	0.35	0.38	N/A
@ 19.7 ft or below	0.18	0.18	0.18	0.19	N/A
Scale-effect correction factor, α	1.00	1.00	1.00	1.00	N/A

Variation of Lateral Earth Pressure Coefficient With Depth

Z	K / Ka
0 ft	2.50
3.3 ft	2.30
6.6 ft	2.05
9.8 ft	1.85
13.1 ft	1.65
16.4 ft	1.40
19.7 ft	1.20

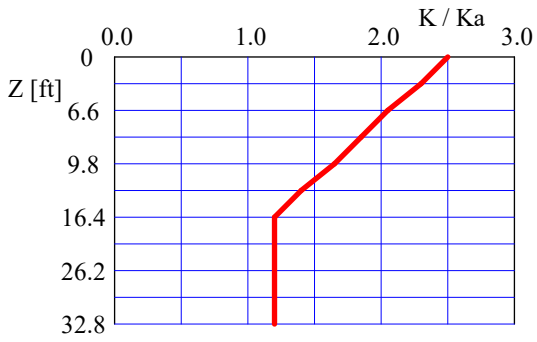

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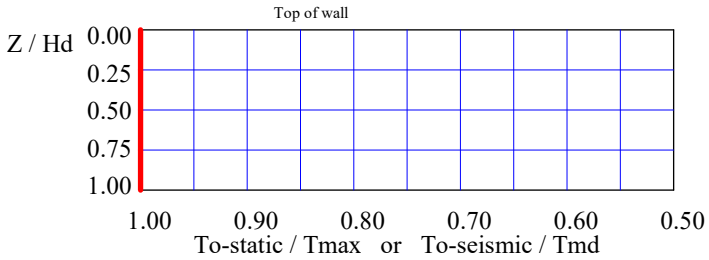
Figure D.6-13

INPUT DATA: Facia and Connection (Analysis)

FACIA type: Full height precast concrete panels.
Depth of panel is 1.31 ft. Horizontal distance to Center of Gravity of panel is 0.66 ft.
Average unit weight of panel is γ_f = 152.78 lb/ft ^{3}

Z / Hd	To-static / Tmax or To-seismic / Tmd
0.00	1.00
0.25	1.00
0.50	1.00
0.75	1.00
1.00	1.00



D A T A (for connection only)	Type #1	Type #2	Type #3	Type #4	Type #5
Product Name	W4.5xW3.5..	W7.0xW3.5..	W9.5xW4.0..	W4.5xW3.5..	N/A
Strength reduction at the connection, CRu = Fyc / Fy	1.00	1.00	1.00	1.00	N/A

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Figure D.6-14

INPUT DATA: Geometry and Surcharge loads (of a SIMPLE STRUCTURE)

Design height, Hd	43.00	[ft]	{ Embedded depth is E = 3.00 ft, and height above top of finished bottom grade is H = 40.00 ft }
Batter, ω	0.0	[deg]	
Backslope, β	0.0	[deg]	
Backslope rise	0.0	[ft]	Broken back equivalent angle, I = 0.00° (see Fig. 25 in DEMO 82)

U N I F O R M S U R C H A R G E

Uniformly distributed dead load is 0.0 [lb/ft ²], and live load is 250.0 [lb/ft ²]

ANALYZED REINFORCEMENT LAYOUT:

SCALE:

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Figure D.6-15

AASHTO 2007-2010 (LRFD) Input Data

INTERNAL STABILITY

Load factor for vertical earth pressure, EV, from Table 3.4.1-2:	$\gamma_{p\text{-}EV}$	1.35	
Load factor for earthquake loads, EQ, from Table 3.4.1-1:	$\gamma_{p\text{-}EQ}$	1.00	
Load factor for live load surcharge, LS, from Figure C11.5.5-3(b): (Same as in External Stability).	$\gamma_{p\text{-}LS}$	1.75	
Load factor for dead load surcharge, ES: (Same as in External Stability).	$\gamma_{p\text{-}ES}$	1.50	
Resistance factor for reinforcement tension from Table 11.5.6-1:	ϕ	Static	Combined static/seismic
Metal Mats:		0.65	0.85
Resistance factor for reinforcement tension in connectors from Table 11.5.6-1:	ϕ	Static	Combined static/seismic
Metal Mats:		0.65	0.85
Resistance factor for reinforcement pullout from Table 11.5.6-1:	ϕ	0.90	1.20

EXTERNAL STABILITY

Load factor for vertical earth pressure, EV, from Table 3.4.1-2 and Figure C11.5.5-2:		Static		Combined Static/Seismic
Sliding and Eccentricity	$\gamma_{p\text{-}EV}$	1.00	$\gamma_{p\text{-}EQ}$	1.00
Bearing Capacity	$\gamma_{p\text{-}EV}$	1.35	$\gamma_{p\text{-}EQ}$	1.35

Load factor of active lateral earth pressure, EH, from Table 3.4.1-2 and Figure C11.5.5-2:	$\gamma_{p\text{-}EH}$	1.50
Load factor of active lateral earth pressure during earthquake (does not multiply P_{AE} and P_{IR}):	$(\gamma_{p\text{-}EH})_{EQ}$	1.50
Load factor for earthquake loads, EQ, from Table 3.4.1-1 (multiplies P_{AE} and P_{IR}):	$\gamma_{p\text{-}EQ}$	1.00

Resistance factor for shear resistance along common interfaces from Table 11.5.6-1:		Static	Combined Static/Seismic
Reinforced Soil and Foundation	ϕ_τ	1.00	1.00
Reinforced Soil and Reinforcement	ϕ_τ	1.00	1.00
Resistance factor for bearing capacity of shallow foundation from Table 11.5.6-1:		Static	Combined Static/Seismic
	ϕ_b	0.65	0.65

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Figure D.6-16

ANALYSIS: CALCULATED FACTORS (Static conditiorBearing capacity, CDR = 4.40, factored bearing load = 9598 lb/ft².
Foundation Interface: Direct sliding, CDR = 3.057, Eccentricity, e/L = 0.1201, CDR-overturning = 4.16

METAL MATS				CONNECTION							
#	Elevation [ft]	Length [ft]	Type #	CDR [pullout resistance]	CDR [connection break]	CDR [metal mats strength]	Metal mats strength CDR	Pullout resistance CDR	Direct sliding CDR	Eccentricity e/L	Product name
1	0.00	32.00	3	N/A	2.51	2.51	2.512	24.994	3.057	0.1201	W9.5xW4.0 ..
2	2.00	32.00	3	N/A	1.30	1.30	1.299	11.866	3.191	0.1099	W9.5xW4.0 ..
3	4.00	32.00	3	N/A	1.36	1.36	1.362	11.367	3.337	0.1002	W9.5xW4.0 ..
4	6.00	32.00	3	N/A	1.43	1.43	1.431	10.872	3.498	0.0909	W9.5xW4.0 ..
5	8.00	32.00	3	N/A	1.51	1.51	1.507	10.377	3.674	0.0821	W9.5xW4.0 ..
6	10.00	32.00	3	N/A	1.59	1.59	1.592	9.875	3.869	0.0737	W9.5xW4.0 ..
7	12.00	32.00	2	N/A	1.17	1.17	1.171	9.378	4.086	0.0658	W7.0xW3.5 ..
8	14.00	32.00	2	N/A	1.25	1.25	1.245	8.880	4.329	0.0583	W7.0xW3.5 ..
9	16.00	32.00	2	N/A	1.33	1.33	1.330	8.376	4.602	0.0513	W7.0xW3.5 ..
10	18.00	32.00	2	N/A	1.43	1.43	1.426	7.875	4.912	0.0447	W7.0xW3.5 ..
11	20.00	32.00	2	N/A	1.54	1.54	1.538	7.373	5.268	0.0385	W7.0xW3.5 ..
12	22.00	32.00	2	N/A	1.67	1.67	1.669	6.976	5.678	0.0328	W7.0xW3.5 ..
13	24.00	32.00	2	N/A	1.75	1.75	1.753	6.860	6.158	0.0276	W7.0xW3.5 ..
14	26.00	32.00	2	N/A	1.77	1.77	1.771	6.812	6.726	0.0228	W7.0xW3.5 ..
15	28.00	32.00	1	N/A	1.02	1.02	1.020	6.623	7.410	0.0184	W4.5xW3.5 ..
16	30.00	32.00	1	N/A	1.05	1.05	1.051	6.403	8.249	0.0145	W4.5xW3.5 ..
17	32.00	32.00	4	N/A	1.48	1.48	1.479	6.635	9.302	0.0111	W4.5xW3.5 ..
18	34.00	32.00	4	N/A	1.63	1.63	1.625	6.388	10.664	0.0080	W4.5xW3.5 ..
19	36.00	32.00	4	N/A	1.85	1.85	1.847	6.018	12.492	0.0055	W4.5xW3.5 ..
20	38.00	32.00	4	N/A	2.19	2.19	2.190	5.413	15.076	0.0034	W4.5xW3.5 ..
21	40.00	32.00	4	N/A	2.80	2.80	2.804	4.402	19.009	0.0017	W4.5xW3.5 ..
22	42.00	32.00	4	N/A	4.19	4.19	4.188	2.312	25.718	0.0004	W4.5xW3.5 ..

ANALYSIS: CALCULATED FACTORS (Seismic conditiBearing capacity, CDR = 0.81, factored bearing load = 22315 lb/ft².
Foundation Interface: Direct sliding, CDR = 1.066, Eccentricity, e/L = 0.4586, Fs-overturning = 1.09

METAL MATS				CONNECTION							
#	Elevation [ft]	Length [ft]	Type #	CDR [pullout resistance]	CDR [connection break]	CDR [metal mats strength]	Metal mats strength CDR	Pullout resistance CDR	Direct sliding CDR	Eccentricity e/L	Product name
1	0.00	32.00	3	N/A	1.84	1.84	1.836	14.900	1.066	0.4586	W9.5xW4.0 ..
2	2.00	32.00	3	N/A	1.22	1.22	1.220	9.086	1.117	0.4177	W9.5xW4.0 ..
3	4.00	32.00	3	N/A	1.28	1.28	1.276	8.686	1.172	0.3787	W9.5xW4.0 ..
4	6.00	32.00	3	N/A	1.34	1.34	1.337	8.289	1.233	0.3416	W9.5xW4.0 ..
5	8.00	32.00	3	N/A	1.41	1.41	1.405	7.891	1.300	0.3064	W9.5xW4.0 ..
6	10.00	32.00	3	N/A	1.48	1.48	1.480	7.489	1.375	0.2731	W9.5xW4.0 ..
7	12.00	32.00	2	N/A	1.09	1.09	1.085	7.090	1.460	0.2417	W7.0xW3.5 ..
8	14.00	32.00	2	N/A	1.15	1.15	1.150	6.690	1.556	0.2123	W7.0xW3.5 ..
9	16.00	32.00	2	N/A	1.22	1.22	1.223	6.286	1.665	0.1847	W7.0xW3.5 ..
10	18.00	32.00	2	N/A	1.31	1.31	1.306	5.883	1.790	0.1591	W7.0xW3.5 ..
11	20.00	32.00	2	N/A	1.40	1.40	1.401	5.479	1.936	0.1354	W7.0xW3.5 ..
12	22.00	32.00	2	N/A	1.50	1.50	1.504	5.128	2.108	0.1136	W7.0xW3.5 ..
13	24.00	32.00	2	N/A	1.56	1.56	1.555	4.965	2.314	0.0937	W7.0xW3.5 ..
14	26.00	32.00	2	N/A	1.57	1.57	1.566	4.914	2.564	0.0757	W7.0xW3.5 ..
15	28.00	32.00	1	N/A	0.90	0.90	0.899	4.761	2.874	0.0596	W4.5xW3.5 ..
16	30.00	32.00	1	N/A	0.92	0.92	0.917	4.557	3.270	0.0455	W4.5xW3.5 ..
17	32.00	32.00	4	N/A	1.26	1.26	1.263	4.623	3.792	0.0332	W4.5xW3.5 ..
18	34.00	32.00	4	N/A	1.34	1.34	1.342	4.303	4.513	0.0229	W4.5xW3.5 ..
19	36.00	32.00	4	N/A	1.45	1.45	1.452	3.860	5.573	0.0144	W4.5xW3.5 ..
20	38.00	32.00	4	N/A	1.60	1.60	1.603	3.232	7.282	0.0079	W4.5xW3.5 ..
21	40.00	32.00	4	N/A	1.83	1.83	1.827	2.340	10.504	0.0033	W4.5xW3.5 ..
22	42.00	32.00	4	N/A	2.19	2.19	2.187	0.985	18.839	0.0006	W4.5xW3.5 ..

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Figure D.6-17

DIRECT SLIDING for GIVEN LAYOUT (for METAL MATS/GRIDS reinforcements)

Along reinforced and foundation soils interface: CDR-static = 3.057 and CDR-seismic = 1.066

#	Metal Mats Elevation [ft]	Metal Mats Length [ft]	CDR Static	CDR Seismic	Metal Mats Type #	Product name
1	0.00	32.00	3.057	1.066	3	W9.5xW4.0 (75 yr)
2	2.00	32.00	3.191	1.117	3	W9.5xW4.0 (75 yr)
3	4.00	32.00	3.337	1.172	3	W9.5xW4.0 (75 yr)
4	6.00	32.00	3.498	1.233	3	W9.5xW4.0 (75 yr)
5	8.00	32.00	3.674	1.300	3	W9.5xW4.0 (75 yr)
6	10.00	32.00	3.869	1.375	3	W9.5xW4.0 (75 yr)
7	12.00	32.00	4.086	1.460	2	W7.0xW3.5 (75 yr)
8	14.00	32.00	4.329	1.556	2	W7.0xW3.5 (75 yr)
9	16.00	32.00	4.602	1.665	2	W7.0xW3.5 (75 yr)
10	18.00	32.00	4.912	1.790	2	W7.0xW3.5 (75 yr)
11	20.00	32.00	5.268	1.936	2	W7.0xW3.5 (75 yr)
12	22.00	32.00	5.678	2.108	2	W7.0xW3.5 (75 yr)
13	24.00	32.00	6.158	2.314	2	W7.0xW3.5 (75 yr)
14	26.00	32.00	6.726	2.564	2	W7.0xW3.5 (75 yr)
15	28.00	32.00	7.410	2.874	1	W4.5xW3.5 (75 yr)
16	30.00	32.00	8.249	3.270	1	W4.5xW3.5 (75 yr)
17	32.00	32.00	9.302	3.792	4	W4.5xW3.5 (45 yr)
18	34.00	32.00	10.664	4.513	4	W4.5xW3.5 (45 yr)
19	36.00	32.00	12.492	5.573	4	W4.5xW3.5 (45 yr)
20	38.00	32.00	15.076	7.282	4	W4.5xW3.5 (45 yr)
21	40.00	32.00	19.009	10.504	4	W4.5xW3.5 (45 yr)
22	42.00	32.00	25.718	18.839	4	W4.5xW3.5 (45 yr)

ECCENTRICITY for GIVEN LAYOUT (for Simplified Method)

At interface with foundation: e/L static = 0.1201, e/L seismic = 0.4586; Overturning: CDR-static = 4.16, CDR-seismic = 1.09

#	Metal Mats Elevation [ft]	Metal Mats Length [ft]	e / L Static	e / L Seismic	Metal Mats Type #	Product name
1	0.00	32.00	0.1201	0.4586	3	W9.5xW4.0 (75 yr)
2	2.00	32.00	0.1099	0.4177	3	W9.5xW4.0 (75 yr)
3	4.00	32.00	0.1002	0.3787	3	W9.5xW4.0 (75 yr)
4	6.00	32.00	0.0909	0.3416	3	W9.5xW4.0 (75 yr)
5	8.00	32.00	0.0821	0.3064	3	W9.5xW4.0 (75 yr)
6	10.00	32.00	0.0737	0.2731	3	W9.5xW4.0 (75 yr)
7	12.00	32.00	0.0658	0.2417	2	W7.0xW3.5 (75 yr)
8	14.00	32.00	0.0583	0.2123	2	W7.0xW3.5 (75 yr)
9	16.00	32.00	0.0513	0.1847	2	W7.0xW3.5 (75 yr)
10	18.00	32.00	0.0447	0.1591	2	W7.0xW3.5 (75 yr)
11	20.00	32.00	0.0385	0.1354	2	W7.0xW3.5 (75 yr)
12	22.00	32.00	0.0328	0.1136	2	W7.0xW3.5 (75 yr)
13	24.00	32.00	0.0276	0.0937	2	W7.0xW3.5 (75 yr)
14	26.00	32.00	0.0228	0.0757	2	W7.0xW3.5 (75 yr)
15	28.00	32.00	0.0184	0.0596	1	W4.5xW3.5 (75 yr)
16	30.00	32.00	0.0145	0.0455	1	W4.5xW3.5 (75 yr)
17	32.00	32.00	0.0111	0.0332	4	W4.5xW3.5 (45 yr)
18	34.00	32.00	0.0080	0.0229	4	W4.5xW3.5 (45 yr)
19	36.00	32.00	0.0055	0.0144	4	W4.5xW3.5 (45 yr)
20	38.00	32.00	0.0034	0.0079	4	W4.5xW3.5 (45 yr)
21	40.00	32.00	0.0017	0.0033	4	W4.5xW3.5 (45 yr)
22	42.00	32.00	0.0004	0.0006	4	W4.5xW3.5 (45 yr)

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RESULTS for STRENGTH [Note: Actual CDR = (Yield stress) / (Actual stress)] For Simplified Method

Live Load included in calculating Tmax

#	Metal Mats Elevation [ft]	Coverage ratio, Rc=b/Sh	Horizontal spacing, Sh [ft]	Long-term strength Fy·Ac·Rc/b [lb/ft]	Tmax [lb/ft]	Tmd [lb/ft]	Specified minimum CDR static	Actual calculated CDR static	Specified minimum CDR seismic	Actual calculated CDR seismic
1	0.00	1.000	1.000	5662	2254.06	1779.15	N/A	2.512	N/A	1.836
2	2.00	1.000	1.000	5662	4357.83	1712.43	N/A	1.299	N/A	1.220
3	4.00	1.000	1.000	5662	4157.43	1645.72	N/A	1.362	N/A	1.276
4	6.00	1.000	1.000	5662	3957.04	1579.00	N/A	1.431	N/A	1.337
5	8.00	1.000	1.000	5662	3756.65	1512.28	N/A	1.507	N/A	1.405
6	10.00	1.000	1.000	5662	3556.26	1445.56	N/A	1.592	N/A	1.480
7	12.00	1.000	1.000	3929	3355.86	1378.84	N/A	1.171	N/A	1.085
8	14.00	1.000	1.000	3929	3155.47	1312.12	N/A	1.245	N/A	1.150
9	16.00	1.000	1.000	3929	2955.08	1245.41	N/A	1.330	N/A	1.223
10	18.00	1.000	1.000	3929	2754.69	1178.69	N/A	1.426	N/A	1.306
11	20.00	1.000	1.000	3929	2554.29	1111.97	N/A	1.538	N/A	1.401
12	22.00	1.000	1.000	3929	2353.90	1061.93	N/A	1.669	N/A	1.504
13	24.00	1.000	1.000	3929	2241.39	1061.93	N/A	1.753	N/A	1.555
14	26.00	1.000	1.000	3929	2219.19	1061.93	N/A	1.771	N/A	1.566
15	28.00	1.000	1.000	2239	2194.76	1061.93	N/A	1.020	N/A	0.899
16	30.00	1.000	1.000	2239	2129.89	1061.93	N/A	1.051	N/A	0.917
17	32.00	1.000	1.000	2958	1999.65	1061.93	N/A	1.479	N/A	1.263
18	34.00	1.000	1.000	2958	1819.49	1061.93	N/A	1.625	N/A	1.342
19	36.00	1.000	1.000	2958	1601.65	1061.93	N/A	1.847	N/A	1.452
20	38.00	1.000	1.000	2958	1350.63	1061.93	N/A	2.190	N/A	1.603
21	40.00	1.000	1.000	2958	1054.66	1061.93	N/A	2.804	N/A	1.827
22	42.00	1.000	1.000	2958	706.24	1061.93	N/A	4.188	N/A	2.187

RESULTS for PULLOUT Live Load included in calculating Tmax

NOTE: Live load is not included in calculating the overburden pressure used to assess pullout resistance.

#	Metal Mats Elevation [ft]	Coverage Ratio Rc=b/Sh	Tmax [lb/ft]	Tmd [lb/ft]	Le [ft] (see NOTE)	La [ft]	Avail.Static Pullout, Pr [lb/ft]	Specified Static CDR	Actual Static CDR	Avail.Seism. Pullout, Pr [lb/ft]	Specified Seismic CDR	Actual Seismic CDR
1	0.00	1.000	2254.1	1779.2	32.00	0.00	56337.9	N/A	24.994	60093.8	N/A	14.900
2	2.00	1.000	4357.8	1712.4	30.80	1.20	51709.6	N/A	11.866	55156.9	N/A	9.086
3	4.00	1.000	4157.4	1645.7	29.60	2.40	47255.8	N/A	11.367	50406.2	N/A	8.686
4	6.00	1.000	3957.0	1579.0	28.40	3.60	43020.4	N/A	10.872	45888.4	N/A	8.289
5	8.00	1.000	3756.6	1512.3	27.20	4.80	38980.9	N/A	10.377	41579.6	N/A	7.891
6	10.00	1.000	3556.3	1445.6	26.00	6.00	35119.1	N/A	9.875	37460.4	N/A	7.489
7	12.00	1.000	3355.9	1378.8	24.80	7.20	31472.5	N/A	9.378	33570.7	N/A	7.090
8	14.00	1.000	3155.5	1312.1	23.60	8.40	28021.8	N/A	8.880	29889.9	N/A	6.690
9	16.00	1.000	2955.1	1245.4	22.40	9.60	24752.1	N/A	8.376	26402.2	N/A	6.286
10	18.00	1.000	2754.7	1178.7	21.20	10.80	21694.3	N/A	7.875	23140.5	N/A	5.883
11	20.00	1.000	2554.3	1112.0	20.00	12.00	18832.3	N/A	7.373	20087.8	N/A	5.479
12	22.00	1.000	2353.9	1061.9	19.10	12.90	16420.5	N/A	6.976	17515.2	N/A	5.128
13	24.00	1.000	2241.4	1061.9	19.10	12.90	15376.6	N/A	6.860	16401.7	N/A	4.965
14	26.00	1.000	2219.2	1061.9	19.10	12.90	15116.3	N/A	6.812	16124.0	N/A	4.914
15	28.00	1.000	2194.8	1061.9	19.10	12.90	14536.4	N/A	6.623	15505.5	N/A	4.761
16	30.00	1.000	2129.9	1061.9	19.10	12.90	13636.9	N/A	6.403	14546.0	N/A	4.557
17	32.00	1.000	1999.7	1061.9	19.10	12.90	13267.8	N/A	6.635	14152.3	N/A	4.623
18	34.00	1.000	1819.5	1061.9	19.10	12.90	11623.6	N/A	6.388	12398.5	N/A	4.303
19	36.00	1.000	1601.6	1061.9	19.10	12.90	9638.0	N/A	6.018	10280.5	N/A	3.860
20	38.00	1.000	1350.6	1061.9	19.10	12.90	7311.0	N/A	5.413	7798.4	N/A	3.232
21	40.00	1.000	1054.7	1061.9	19.10	12.90	4642.6	N/A	4.402	4952.1	N/A	2.340
22	42.00	1.000	706.2	1061.9	19.10	12.90	1632.9	N/A	2.312	1741.7	N/A	0.985

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Figure D.6-19

Version 3.0 MSEW Version 3.0 MSEW Version 3.0 MSEW Version 3.0 MSEW Version 3.0 MSEW Version 3.0 MSEW Version 3.0 MSEW Version 3.0

RESULTS for CONNECTION (static conditions)

Live Load included in calculating Tmax

#	Metal Mats Elevation [ft]	Coverage ratio Rc=b/Sh	Horizontal spacing, Sh [ft]	Connection force, To [lb/ft]	Reduction factor for connection break, CRu	Long-term connection strength,Tac (break criterion) [lb/ft]	Metal Mats long-term strength, [lb/ft]	CDR connection break Specified	CDR connection break Actual	CDR Metal Mats strength Specified	CDR Metal Mats strength Actual	Product name
1	0.00	1.000	1.000	2254	1.00	5662	5662	N/A	2.51	N/A	2.51	W9.5xW4.0 ..
2	2.00	1.000	1.000	4358	1.00	5662	5662	N/A	1.30	N/A	1.30	W9.5xW4.0 ..
3	4.00	1.000	1.000	4157	1.00	5662	5662	N/A	1.36	N/A	1.36	W9.5xW4.0 ..
4	6.00	1.000	1.000	3957	1.00	5662	5662	N/A	1.43	N/A	1.43	W9.5xW4.0 ..
5	8.00	1.000	1.000	3757	1.00	5662	5662	N/A	1.51	N/A	1.51	W9.5xW4.0 ..
6	10.00	1.000	1.000	3556	1.00	5662	5662	N/A	1.59	N/A	1.59	W9.5xW4.0 ..
7	12.00	1.000	1.000	3356	1.00	3929	3929	N/A	1.17	N/A	1.17	W7.0xW3.5 ..
8	14.00	1.000	1.000	3155	1.00	3929	3929	N/A	1.25	N/A	1.25	W7.0xW3.5 ..
9	16.00	1.000	1.000	2955	1.00	3929	3929	N/A	1.33	N/A	1.33	W7.0xW3.5 ..
10	18.00	1.000	1.000	2755	1.00	3929	3929	N/A	1.43	N/A	1.43	W7.0xW3.5 ..
11	20.00	1.000	1.000	2554	1.00	3929	3929	N/A	1.54	N/A	1.54	W7.0xW3.5 ..
12	22.00	1.000	1.000	2354	1.00	3929	3929	N/A	1.67	N/A	1.67	W7.0xW3.5 ..
13	24.00	1.000	1.000	2241	1.00	3929	3929	N/A	1.75	N/A	1.75	W7.0xW3.5 ..
14	26.00	1.000	1.000	2219	1.00	3929	3929	N/A	1.77	N/A	1.77	W7.0xW3.5 ..
15	28.00	1.000	1.000	2195	1.00	2239	2239	N/A	1.02	N/A	1.02	W4.5xW3.5 ..
16	30.00	1.000	1.000	2130	1.00	2239	2239	N/A	1.05	N/A	1.05	W4.5xW3.5 ..
17	32.00	1.000	1.000	2000	1.00	2958	2958	N/A	1.48	N/A	1.48	W4.5xW3.5 ..
18	34.00	1.000	1.000	1819	1.00	2958	2958	N/A	1.63	N/A	1.63	W4.5xW3.5 ..
19	36.00	1.000	1.000	1602	1.00	2958	2958	N/A	1.85	N/A	1.85	W4.5xW3.5 ..
20	38.00	1.000	1.000	1351	1.00	2958	2958	N/A	2.19	N/A	2.19	W4.5xW3.5 ..
21	40.00	1.000	1.000	1055	1.00	2958	2958	N/A	2.80	N/A	2.80	W4.5xW3.5 ..
22	42.00	1.000	1.000	706	1.00	2958	2958	N/A	4.19	N/A	4.19	W4.5xW3.5 ..

RESULTS for CONNECTION (seismic conditions)

Live Load included in calculating Tmax

#	Metal Mats Elevation [ft]	Coverage ratio Rc=b/Sh	Horizontal spacing, Sh [ft]	Connection force, To [lb/ft]	Reduction factor for connection break, CRu	Long-term connection strength,Tac (break criterion) [lb/ft]	Metal Mats long-term strength, [lb/ft]	CDR connection break Specified	CDR connection break Actual	CDR Metal Mats strength Specified	CDR Metal Mats strength Actual	Product name
1	0.00	1.000	1.000	4033	1.00	7404	5662	N/A	1.84	N/A	1.84	W9.5xW4.0 ..
2	2.00	1.000	1.000	6070	1.00	7404	5662	N/A	1.22	N/A	1.22	W9.5xW4.0 ..
3	4.00	1.000	1.000	5803	1.00	7404	5662	N/A	1.28	N/A	1.28	W9.5xW4.0 ..
4	6.00	1.000	1.000	5536	1.00	7404	5662	N/A	1.34	N/A	1.34	W9.5xW4.0 ..
5	8.00	1.000	1.000	5269	1.00	7404	5662	N/A	1.41	N/A	1.41	W9.5xW4.0 ..
6	10.00	1.000	1.000	5002	1.00	7404	5662	N/A	1.48	N/A	1.48	W9.5xW4.0 ..
7	12.00	1.000	1.000	4735	1.00	5138	3929	N/A	1.09	N/A	1.09	W7.0xW3.5 ..
8	14.00	1.000	1.000	4468	1.00	5138	3929	N/A	1.15	N/A	1.15	W7.0xW3.5 ..
9	16.00	1.000	1.000	4200	1.00	5138	3929	N/A	1.22	N/A	1.22	W7.0xW3.5 ..
10	18.00	1.000	1.000	3933	1.00	5138	3929	N/A	1.31	N/A	1.31	W7.0xW3.5 ..
11	20.00	1.000	1.000	3666	1.00	5138	3929	N/A	1.40	N/A	1.40	W7.0xW3.5 ..
12	22.00	1.000	1.000	3416	1.00	5138	3929	N/A	1.50	N/A	1.50	W7.0xW3.5 ..
13	24.00	1.000	1.000	3303	1.00	5138	3929	N/A	1.56	N/A	1.56	W7.0xW3.5 ..
14	26.00	1.000	1.000	3281	1.00	5138	3929	N/A	1.57	N/A	1.57	W7.0xW3.5 ..
15	28.00	1.000	1.000	3257	1.00	2928	2239	N/A	0.90	N/A	0.90	W4.5xW3.5 ..
16	30.00	1.000	1.000	3192	1.00	2928	2239	N/A	0.92	N/A	0.92	W4.5xW3.5 ..
17	32.00	1.000	1.000	3062	1.00	3868	2958	N/A	1.26	N/A	1.26	W4.5xW3.5 ..
18	34.00	1.000	1.000	2881	1.00	3868	2958	N/A	1.34	N/A	1.34	W4.5xW3.5 ..
19	36.00	1.000	1.000	2664	1.00	3868	2958	N/A	1.45	N/A	1.45	W4.5xW3.5 ..
20	38.00	1.000	1.000	2413	1.00	3868	2958	N/A	1.60	N/A	1.60	W4.5xW3.5 ..
21	40.00	1.000	1.000	2117	1.00	3868	2958	N/A	1.83	N/A	1.83	W4.5xW3.5 ..
22	42.00	1.000	1.000	1768	1.00	3868	2958	N/A	2.19	N/A	2.19	W4.5xW3.5 ..

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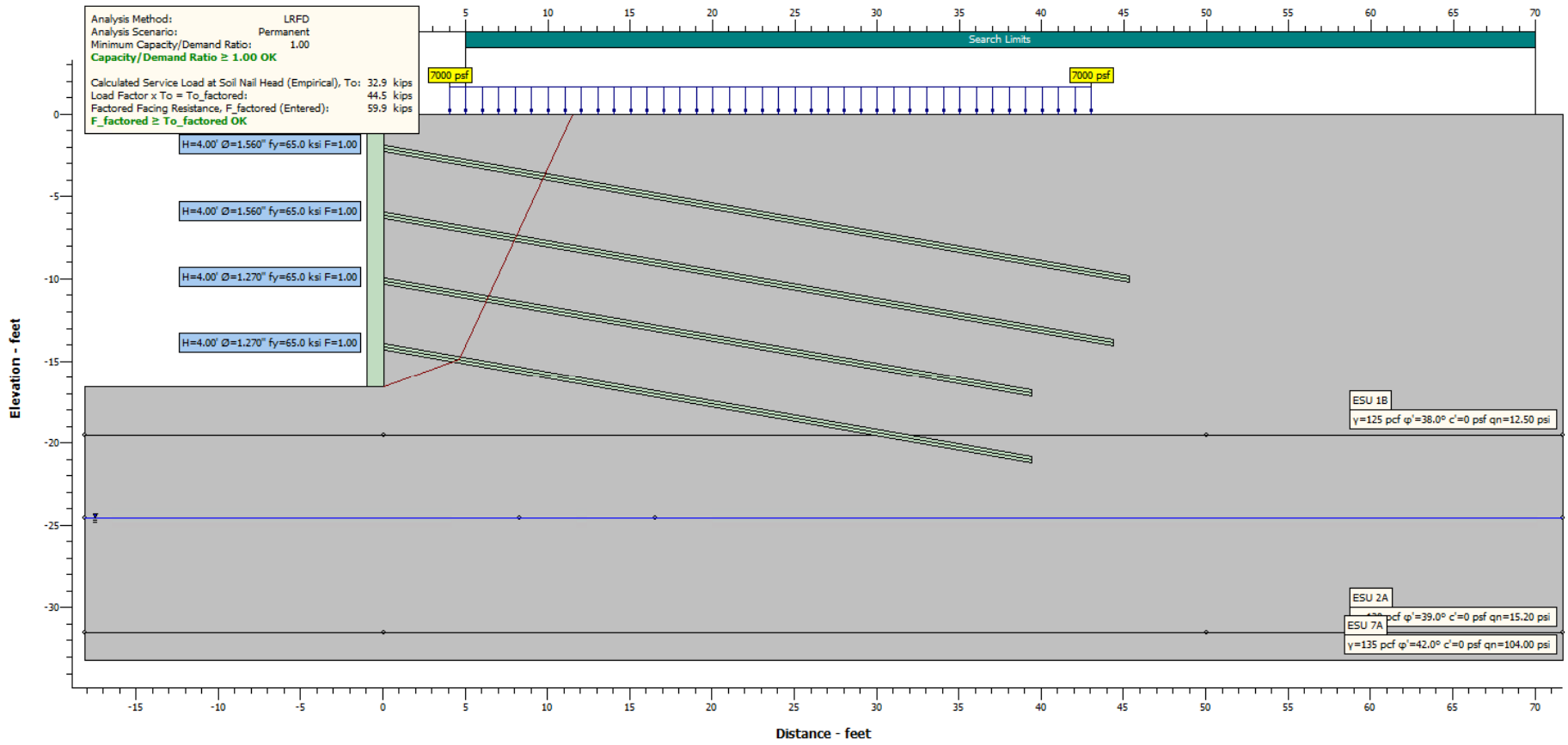
Figure D.6-20

FLATIRON | LANE | wood.

In Association with

Appendix D.7
Wall 03.63L Soil Nail Wall Calculations

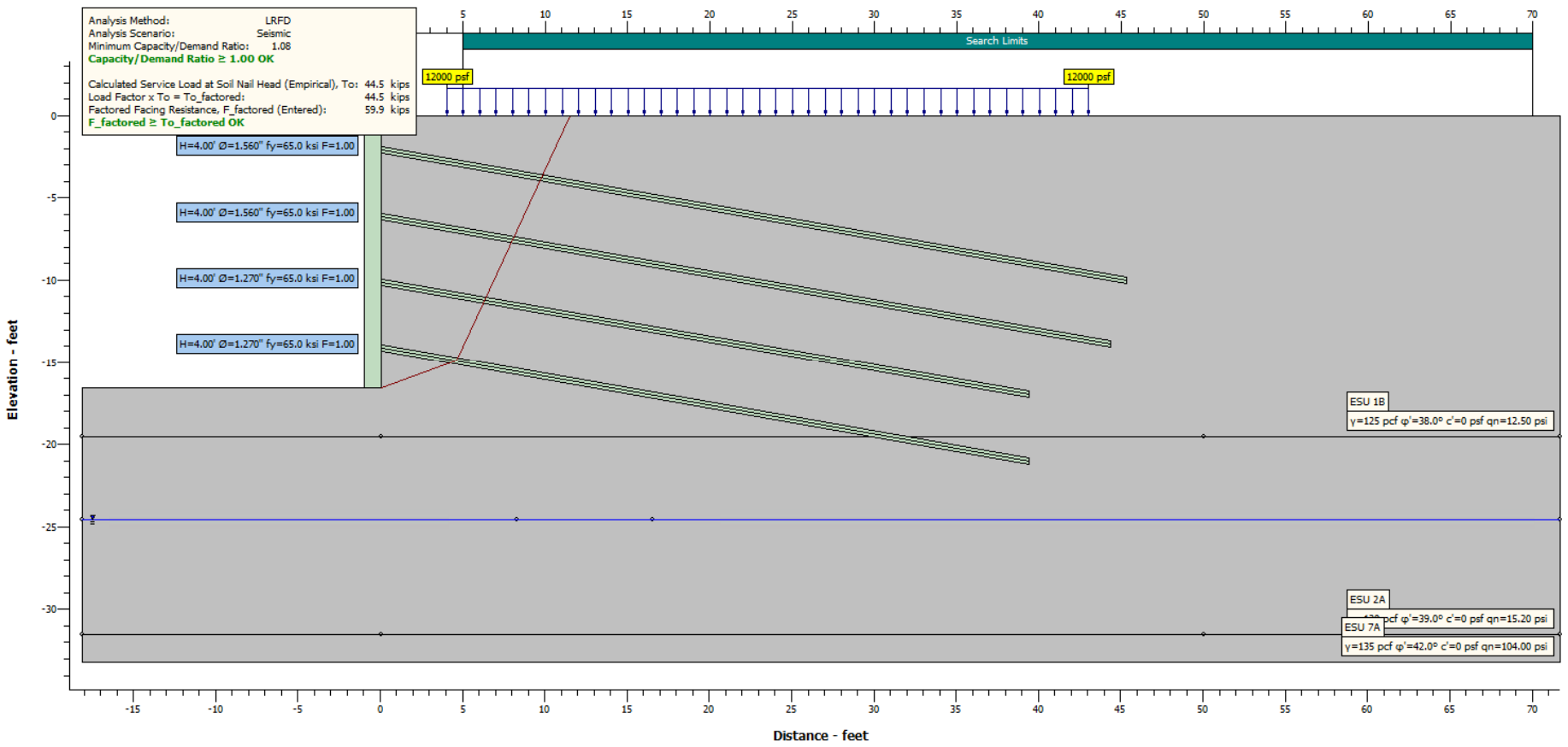


Soil Nail Wall 03.63L – Section Fa-Fa' Permanent - Static

I-405/Renton to Bellevue Corridor Widening
King County, Washington

GeoEngineers

Figure D.7-1



Soil Nail Wall 03.63L – Section Fa-Fa' Permanent - Seismic

I-405/Renton to Bellevue Corridor Widening
King County, Washington

GeoEngineers

Figure D.7-2

SNAIL

Version: 2.2.1

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File Information

File Name: Soil Nail Support - Wall 03.63L Static - Strength Limit Load 7ksf.snz
Run Date: 11/22/21
Run Time: 10:07:03

Project Information

Description: Bridge 17.7 Pier 1
Location:
EA:
Project ID: 00180-366-01
Wall No.: Wall 03.63L
Structure No.:
Station: Section Fa-Fa'
Engineer: MSH
Designer

Comments:

Maximum bearing capacity for Static Conditions

Geometry

Layout:

Reference Point:

At: Top of Wall
Distance From Origin: 0.00 feet
Elevation Above Origin: 0.00 feet

Wall Dimensions:

Wall Height: 16.50 feet
Facing Angle: 90.00 degrees
Facing Batter: 0.000 :12 H:V

Ground Surface:

Number of lines that define the ground surface above the wall: 1

No.	Angle degrees	Distance feet
1	0	

Number of lines that define the ground surface in front of the toe: 1

No.	Angle degrees	Distance feet
1	0	

Soil Layers:

Number of Layers: 3

Layers Below the Top Layer:

Coordinates of the Top of the Layer: feet

Layer	Point 1 Distance	Point 1 Elevation	Point 2 Distance	Point 2 Elevation
2	0.00	-19.50	50.00	-19.50
3	0.00	-31.50	50.00	-31.50

Ground Water:

Figure D.7-3

Include Ground Water: Yes
Phreatic Correction: No
Number of Points: 1

No.	Distance feet	Elevation feet
1		-24.50

Soil Nails

Dimensions and Properties:

Maximum Vertical Spacing: 4.00 feet
Number of Soil Nail Rows: 4
Soil Nail Design Parameters: Varying

No.	Soil Nail Length feet	Inclination From Horizontal degrees	Vertical Spacing feet	Horizontal Spacing H feet	Nail Bar Diameter Ø inches	Nail Bar Yield Strength fy ksi	Bond Strength Factor F
1	46.00	10	2.00	4.00	1.560	65.0	1.00
2	45.00	10	4.00	4.00	1.560	65.0	1.00
3	40.00	10	4.00	4.00	1.270	65.0	1.00
4	40.00	10	4.00	4.00	1.270	65.0	1.00

Facing Resistance:

	Temporary	Permanent	Seismic
LRFD Factored Facing Resistance:	56.0	59.9	59.9 kips

Soil Properties

Layer	Description	Unit Weight γ pcf	Friction Angle φ' degrees	Cohesion c' psf
1	ESU 1B	125	38.0	0
2	ESU 2A	120	39.0	0
3	ESU 7A	135	42.0	0

Loads

Applied Loads:

Seismic:

Horizontal Seismic Coefficient Kh0.26:

External Load:

Apply external load: No

Surcharges:

Apply surcharges: Yes

No.	Distance from Top of Wall Begin feet	End feet	Load Begin psf	Load End psf
1	4.00	43.00	7000	7000

Load and Resistance Factors

Load Factors:

Apply Load Factors to: Soil Nail Tensile Force (FHWA GEC No. 7 2015)

	Temporary	Permanent	Seismic
Soil Nail Tensile Force:	1.35	1.35	1.00

Resistance Factors:

	Temporary	Permanent	Seismic

Figure D.7-4

Pullout (Distal):	0.65	0.65	0.65
Pullout (Proximal):	0.65	0.65	0.65
Nail Bar Yield:	0.75	0.75	0.75
Cohesion:	0.75	0.65	0.90
Friction Angle:	0.75	0.65	0.90

Search Options

Search Limits:

Begin: 5.00 feet
End: 70.00 feet

Below Toe Searches (BTS):

Perform below Toe Search: No

Advanced Search Options:

Use Advanced Search Options: No

Results

Analysis:

Method: LRFD
Scenario: Permanent

Capacity/Demand Ratio:

Minimum: 1.00
Found at Search Point: 2
Found at Grid Point: 12
Found at Search Level: Toe of the wall

Load at Soil Nail Head:

Calculated Service Load at Soil Nail Head (Empirical), To: 32.9 kips
Load Factor x To = To_factored: 44.5 kips
Factored Facing Resistance, F_factored (Entered): 59.9 kips
F_factored ≥ To_factored OK

Nominal Pullout Resistance:

Layer	Description	Nominal Pullout Resistance klf
1	ESU 1B	2.827
2	ESU 2A	3.438
3	ESU 7A	23.524

Results by Search Level:

** Indicates Minimum Capacity/Demand Ratio:

Search Level: At the toe of the wall Facing Design Force = 32.9 kips (Clouterre)

Search Point	Minimum Capacity Demand Ratio	Distance From Toe of Wall feet	Failure Planes: Lower Angle degrees	Lower Length feet	Upper Angle degrees	Upper Length feet	Reinforcement: Level	Stress ksi	Controlling Resistance Failure Mode
1	1.81	5.00	22.42	4.33	86.15	14.88	1	26.7	Facing
							2	26.5	Facing
							3	36.1	Bar Yield
							4	36.1	Bar Yield
** 2	1.00	11.50	19.73	4.89	65.08	16.37	1	25.7	Pullout
							2	26.2	Pullout
							3	36.1	Pullout
							4	36.1	Bar Yield
3	1.02	18.00	0.00	3.60	48.89	21.90	1	22.6	Pullout
							2	24.1	Pullout
							3	34.2	Pullout
							4	36.1	Bar Yield
4	1.19	24.50	0.00	4.90	40.09	25.62	1	19.5	Pullout

Figure D.7-5

							2	21.7	Pullout
							3	31.6	Pullout
							4	36.1	Bar Yield
5	1.39	31.00	0.00	3.10	30.60	32.41	1	17.4	Pullout
							2	20.4	Pullout
							3	31.1	Pullout
							4	36.1	Bar Yield
6	1.57	37.50	0.00	3.75	26.05	37.57	1	15.0	Pullout
							2	18.6	Pullout
							3	29.3	Pullout
							4	36.1	Bar Yield
7	1.79	44.00	0.00	4.40	22.62	42.90	1	12.8	Pullout
							2	17.0	Pullout
							3	27.7	Pullout
							4	36.1	Bar Yield
8	2.13	50.50	0.00	5.05	19.95	48.35	1	10.9	Pullout
							2	15.5	Pullout
							3	26.1	Pullout
							4	36.1	Bar Yield
9	2.47	57.00	0.00	5.70	17.83	53.89	1	9.0	Pullout
							2	14.1	Pullout
							3	24.7	Pullout
							4	35.4	Pullout
10	2.83	63.50	0.00	6.35	16.10	59.48	1	7.4	Pullout
							2	12.9	Pullout
							3	23.4	Pullout
							4	34.8	Pullout
11	3.19	70.00	0.00	7.00	14.68	65.12	1	5.8	Pullout
							2	11.7	Pullout
							3	22.2	Pullout
							4	34.1	Pullout

END OF REPORT

Figure D.7-6

SNAIL

Version: 2.2.1

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File Information

File Name: Soil Nail Support - Wall 03.63L Seismic - Extreme Limit Load 7ksf.snz
Run Date: 12/02/21
Run Time: 10:16:33

Project Information

Description: Bridge 17.7 Pier 1
Location:
EA:
Project ID: 00180-366-01
Wall No.: Wall 03.63L
Structure No.:
Station: Section Fa-Fa'
Engineer: MSH
Designer

Comments:

Maximum bearing capacity for Static Conditions

Geometry

Layout:

Reference Point:

At: Top of Wall
Distance From Origin: 0.00 feet
Elevation Above Origin: 0.00 feet

Wall Dimensions:

Wall Height: 16.50 feet
Facing Angle: 90.00 degrees
Facing Batter: 0.000 :12 H:V

Ground Surface:

Number of lines that define the ground surface above the wall: 1

No.	Angle degrees	Distance feet
1	0	

Number of lines that define the ground surface in front of the toe: 1

No.	Angle degrees	Distance feet
1	0	

Soil Layers:

Number of Layers: 3

Layers Below the Top Layer:

Coordinates of the Top of the Layer: feet

Layer	Point 1 Distance	Point 1 Elevation	Point 2 Distance	Point 2 Elevation
2	0.00	-19.50	50.00	-19.50
3	0.00	-31.50	50.00	-31.50

Ground Water:

Figure D.7-7

Include Ground Water: Yes
Phreatic Correction: No
Number of Points: 1

No.	Distance feet	Elevation feet
1		-24.50

Soil Nails

Dimensions and Properties:

Maximum Vertical Spacing: 4.00 feet
Number of Soil Nail Rows: 4
Soil Nail Design Parameters: Varying

No.	Soil Nail Length feet	Inclination From Horizontal degrees	Vertical Spacing feet	Horizontal Spacing H feet	Nail Bar Diameter Ø inches	Nail Bar Yield Strength fy ksi	Bond Strength Factor F
1	46.00	10	2.00	4.00	1.560	65.0	1.00
2	45.00	10	4.00	4.00	1.560	65.0	1.00
3	40.00	10	4.00	4.00	1.270	65.0	1.00
4	40.00	10	4.00	4.00	1.270	65.0	1.00

Facing Resistance:

	Temporary	Permanent	Seismic
LRFD Factored Facing Resistance:	56.0	59.9	59.9 kips

Soil Properties

Layer	Description	Unit Weight γ pcf	Friction Angle φ' degrees	Cohesion c' psf
1	ESU 1B	125	38.0	0
2	ESU 2A	120	39.0	0
3	ESU 7A	135	42.0	0

Loads

Applied Loads:

Seismic:

Horizontal Seismic Coefficient Kh0.26:

External Load:

Apply external load: No

Surcharges:

Apply surcharges: Yes

No.	Distance from Top of Wall Begin feet	End feet	Load Begin psf	Load End psf
1	4.00	43.00	12000	12000

Load and Resistance Factors

Load Factors:

Apply Load Factors to: Soil Nail Tensile Force (FHWA GEC No. 7 2015)

	Temporary	Permanent	Seismic
Soil Nail Tensile Force:	1.35	1.35	1.00

Resistance Factors:

	Temporary	Permanent	Seismic

Figure D.7-8

Pullout (Distal):	0.65	0.65	0.65
Pullout (Proximal):	0.65	0.65	0.65
Nail Bar Yield:	0.75	0.75	0.75
Cohesion:	0.75	0.65	0.90
Friction Angle:	0.75	0.65	0.90

Search Options

Search Limits:

Begin: 5.00 feet
End: 70.00 feet

Below Toe Searches (BTS):

Perform below Toe Search: No

Advanced Search Options:

Use Advanced Search Options: No

Results

Analysis:

Method: LRFD
Scenario: Seismic

Capacity/Demand Ratio:

Minimum: 1.08
Found at Search Point: 2
Found at Grid Point: 12
Found at Search Level: Toe of the wall

Load at Soil Nail Head:

Calculated Service Load at Soil Nail Head (Empirical), To: 44.5 kips
Load Factor x To = To_factored: 44.5 kips
Factored Facing Resistance, F_factored (Entered): 59.9 kips
F_factored ≥ To_factored OK

Nominal Pullout Resistance:

Layer	Description	Nominal Pullout Resistance klf
1	ESU 1B	2.827
2	ESU 2A	3.438
3	ESU 7A	23.524

Results by Search Level:

** Indicates Minimum Capacity/Demand Ratio:

Search Level: At the toe of the wall Facing Design Force = 44.5 kips (Clouterre)

Search Point	Minimum Capacity Demand Ratio	Distance From Toe of Wall feet	Failure Planes: Lower Angle degrees	Lower Length feet	Upper Angle degrees	Upper Length feet	Reinforcement: Level	Stress ksi	Controlling Resistance Failure Mode
1	2.12	5.00	22.42	4.33	86.15	14.88	1	36.0	Facing
							2	35.8	Facing
							3	48.8	Bar Yield
							4	48.8	Bar Yield
** 2	1.08	11.50	19.73	4.89	65.08	16.37	1	34.7	Pullout
							2	35.4	Pullout
							3	48.7	Pullout
							4	48.8	Bar Yield
3	1.15	18.00	0.00	3.60	48.89	21.90	1	30.5	Pullout
							2	32.5	Pullout
							3	46.2	Pullout
							4	48.8	Bar Yield
4	1.36	24.50	0.00	4.90	40.09	25.62	1	26.4	Pullout

Figure D.7-9

							2	29.2	Pullout
							3	42.7	Pullout
							4	48.8	Bar Yield
5	1.62	31.00	0.00	6.20	33.64	29.79	1	22.6	Pullout
							2	26.3	Pullout
							3	39.4	Pullout
							4	48.8	Bar Yield
6	1.85	37.50	0.00	3.75	26.05	37.57	1	20.3	Pullout
							2	25.2	Pullout
							3	39.6	Pullout
							4	48.8	Bar Yield
7	2.11	44.00	0.00	4.40	22.62	42.90	1	17.3	Pullout
							2	23.0	Pullout
							3	37.3	Pullout
							4	48.8	Bar Yield
8	2.44	50.50	0.00	5.05	19.95	48.35	1	14.7	Pullout
							2	20.9	Pullout
							3	35.3	Pullout
							4	48.8	Bar Yield
9	2.76	57.00	0.00	5.70	17.83	53.89	1	12.2	Pullout
							2	19.1	Pullout
							3	33.4	Pullout
							4	47.8	Pullout
10	3.06	63.50	0.00	6.35	16.10	59.48	1	9.9	Pullout
							2	17.4	Pullout
							3	31.6	Pullout
							4	46.9	Pullout
11	3.34	70.00	0.00	7.00	14.68	65.12	1	7.8	Pullout
							2	15.8	Pullout
							3	30.0	Pullout
							4	46.1	Pullout

END OF REPORT

Figure D.7-10

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In Association with

Appendix D.8
Pier 1/Wall 03.63L Bearing Capacity Calculations

LRFD Foundation Design — **Spreadsheet Reference Section 10.6.3.1.2 of The 2014 AASHTO LRFD Bridge Design Specifications**

Date/Time:	11/24/2021
Project Name:	**Bridge 17.7 - PROPOSED Pier 1 - Strip Footing - Fill ESU 1B**
Project No.:	**00180-366-01**

Foundation Soil Conditions	
Unit Weight, γ (pcf)	**125**
Friction angle, Φ (degrees)	**38**
Friction angle, Φ (rad)	0.663
Cohesion, C (psf)	**0**
Embedment, D_f (ft)	**6**
Depth to Groundwater, D_w (ft)	**23.5**
Footing Length, L (ft)	**38.7**
Footing Width, B (ft)	**24.7**
Poissons Ration, ν	**0.25**
Young's Modulus, E_s (ksf)	**1720**

Bearing Capacity Factors	
N_γ	78
N_c	61
N_q	49

Footing Width, B	**Water Depth Factors**		**Shape Factors**			**Unfactored Bearing Resistance**	**Extreme Event Resistance** Resistance Factor (0.9) bearing resistance for seismic loading (Section 8.10; 2014 WSDOT GDM)	**Working Bearing Resistance** Resistance Factor (0.45) Theoretical method in sand (0.50) Theoretical method in clay (Table 10.5.5.2.2-1)	Deflection from Elastic Settlement Spreadsheet	Deflection from Elastic Settlement Spreadsheet
	C_{wq}	$C_{w\gamma}$	Sc	S_γ	Sq				**1" Deflection**	**1.5" Deflection**
(ft)						(ksf)	(ksf)	(ksf)	(ksf)	(ksf)
15.0	1.0	0.5	1.31	0.84	1.30	78.7	70.8	35.4	7.2	10.7
17.0	1.0	0.5	1.35	0.82	1.34	83.4	75.1	37.5	6.6	10.0
19.0	1.0	0.5	1.39	0.80	1.38	88.0	79.2	39.6	6.2	9.3
21.0	1.0	0.5	1.43	0.78	1.42	92.3	83.1	41.5	5.9	8.8
23.0	1.0	0.5	1.47	0.76	1.46	96.4	86.8	43.4	5.6	8.4
25.0	1.0	0.5	1.51	0.74	1.50	100.4	90.3	45.2	5.4	8.0
27.0	1.0	0.5	1.56	0.72	1.55	104.1	93.7	46.9	5.1	7.7
29.0	1.0	0.5	1.60	0.70	1.59	107.6	96.9	48.4	5.0	7.4
31.0	1.0	0.5	1.64	0.68	1.63	111.0	99.9	49.9	4.8	7.2
33.0	1.0	0.5	1.68	0.66	1.67	114.1	102.7	51.3	4.6	7.0
35.0	1.0	0.5	1.72	0.64	1.71	117.0	105.3	52.7	4.5	6.7

Note: Depth and inclination modifier were taken as 1 because the load is applied axially and during construction the soils above the footing were excavated.

Figure D.8-1

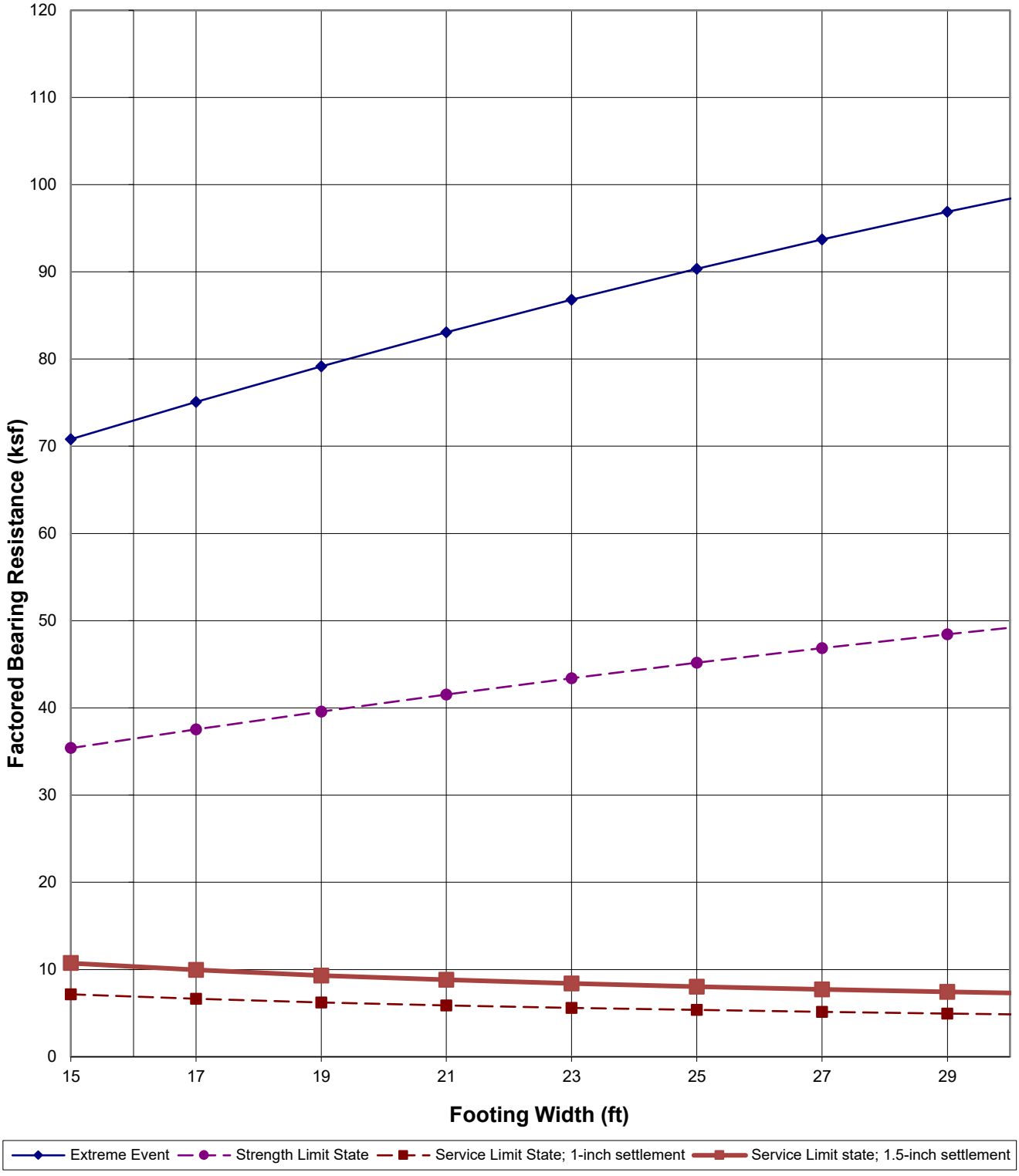
Bridge 17.7 - Proposed Pier 1 (ESU 1B)
Bearing Capacity Summary

Footing Width	Footing Length	Unfactored Bearing Resistance	Extreme Event Resistance[a]	Strength Bearing Resistance[b]	Service Limit State	
					1" Deflection	1.5" Deflection
(ft)	(ft)	(ksf)	(ksf)	(ksf)	(ksf)	(ksf)
15.0	38.7	78.7	70.8	35.4	7.2	10.7
17.0	38.7	83.4	75.1	37.5	6.6	10.0
19.0	38.7	88.0	79.2	39.6	6.2	9.3
21.0	38.7	92.3	83.1	41.5	5.9	8.8
23.0	38.7	96.4	86.8	43.4	5.6	8.4
25.0	38.7	100.4	90.3	45.2	5.4	8.0
27.0	38.7	104.1	93.7	46.9	5.1	7.7
29.0	38.7	107.6	96.9	48.4	5.0	7.4
31.0	38.7	111.0	99.9	49.9	4.8	7.2
33.0	38.7	114.1	102.7	51.3	4.6	7.0
35.0	38.7	117.0	105.3	52.7	4.5	6.7

Notes:
a. Resistance Factor (0.9) bearing resistance for seismic loading (Section 8.10; 2014 WSDOT GDM)
b. Resistance Factor (0.45) Theoretical method in sand (0.50) Theoretical method in clay (Table 10.5.5.2.2-1)

Figure D.8-2

Shallow Foundation Bearing Resistance
Bridge 17.7 - Proposed Pier 1 - ESU 1B



*Assumes Footing Length of 38.7 feet

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Shallow Strip Foundation Design

Figure D.8-3

LRFD Foundation Design — **Spreadsheet Reference Section 10.6.3.1.2 of The 2014 AASHTO LRFD Bridge Design Specifications**

Date/Time:	12/1/21 11:55 AM
Project Name:	**Existing Wall 03.63L - ESU 1B**
Project No.:	**00180-366-01**

Foundation Soil Conditions	
Unit Weight, γ (pcf)	**125**
Friction angle, Φ (degrees)	**38**
Friction angle, Φ (rad)	0.663
Cohesion, C (psf)	**0**
Embedment, D_f (ft)	**1**
Depth to Groundwater, D_w (ft)	**4**
Footing Length, L (ft)	**70**
Footing Width, B (ft)	**32**
Poissons Ration, ν	**0.25**
Young's Modulus, E_s (ksf)	**1720**

Bearing Capacity Factors	
N_γ	78
N_c	61
N_q	49

Footing Width, B	**Water Depth Factors**		**Shape Factors**			**Unfactored Bearing Resistance**	**Extreme Event Resistance** Resistance Factor (0.9) Bearing Resistance for Seismic Loading (AASHTO 11.5.8 for MSE Wall)	**Working Bearing Resistance** Resistance Factor (0.65) Bearing Resistance for MSE Wall (AASHTO Table 11.5.7.1)	Deflection from Elastic Settlement Spreadsheet **1" Deflection**	Deflection from Elastic Settlement Spreadsheet **1.5" Deflection**
	C_{wq}	$C_{w\gamma}$	Sc	S_γ	Sq					
(ft)						(ksf)	(ksf)	(ksf)	(ksf)	(ksf)
24.0	1.0	0.5	1.27	0.86	1.27	58.2	52.4	37.8	4.3	6.4
26.0	1.0	0.5	1.30	0.85	1.29	61.8	55.7	40.2	4.1	6.1
28.0	1.0	0.5	1.32	0.84	1.31	65.4	58.8	42.5	3.9	5.8
30.0	1.0	0.5	1.34	0.83	1.33	68.7	61.9	44.7	3.7	5.6
32.0	1.0	0.5	1.36	0.82	1.36	72.0	64.8	46.8	3.6	5.4
34.0	1.0	0.5	1.39	0.81	1.38	75.2	67.7	48.9	3.5	5.2
36.0	1.0	0.5	1.41	0.79	1.40	78.3	70.4	50.9	3.3	5.0
38.0	1.0	0.5	1.43	0.78	1.42	81.2	73.1	52.8	3.3	4.9
40.0	1.0	0.5	1.46	0.77	1.45	84.1	75.7	54.6	3.2	4.7
42.0	1.0	0.5	1.48	0.76	1.47	86.8	78.1	56.4	3.1	4.6
44.0	1.0	0.5	1.50	0.75	1.49	89.4	80.5	58.1	3.0	4.5

Note: Depth and inclination modifier were taken as 1 because the load is applied axially and during construction the soils above the wall are to be excavated.

Figure D.8-4

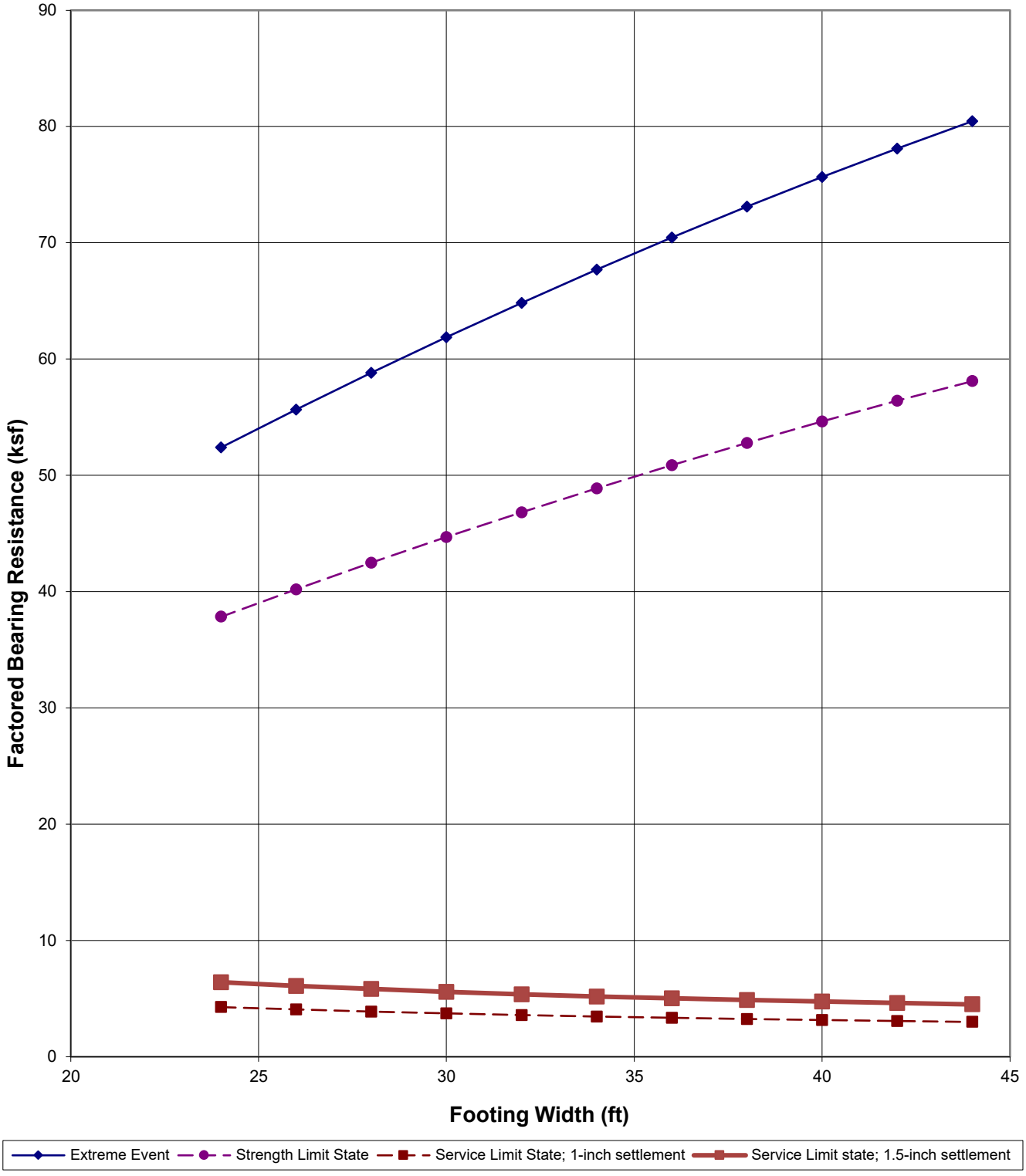
Existing Wall 03.63L
Bearing Capacity Summary

Footing Width	Footing Length	Unfactored Bearing Resistance	Factored Bearing Resistance		Service Limit State	
			Extreme Event[a]	Strength[b]	1" Deflection	1.5" Deflection
(ft)	(ft)	(ksf)	(ksf)	(ksf)	(ksf)	(ksf)
24.0	70.0	58.2	52.4	37.8	4.3	6.4
26.0	70.0	61.8	55.7	40.2	4.1	6.1
28.0	70.0	65.4	58.8	42.5	3.9	5.8
30.0	70.0	68.7	61.9	44.7	3.7	5.6
32.0	70.0	72.0	64.8	46.8	3.6	5.4
34.0	70.0	75.2	67.7	48.9	3.5	5.2
36.0	70.0	78.3	70.4	50.9	3.3	5.0
38.0	70.0	81.2	73.1	52.8	3.3	4.9
40.0	70.0	84.1	75.7	54.6	3.2	4.7
42.0	70.0	86.8	78.1	56.4	3.1	4.6
44.0	70.0	89.4	80.5	58.1	3.0	4.5

Notes:
a. Resistance Factor (0.9) bearing resistance for seismic loading (Section 8.10; 2015 WSDOT *Geotechnical Design Manual* M 46-03.11)
b. Resistance Factor (0.45) Theoretical method in sand (0.50) Theoretical method in clay (2017 AASHTO Table 10.5.5.2.2-1)

Figure D.8-5

Shallow Foundation Factored Bearing Resistance
Existing Wall 03.63L



*Assumes Footing Length of 70 feet

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Shallow Strip Foundation Design

Figure D.8-6

		Pier 1		
		Cumulative Load (kips)	Cumulative Pressure (ksf)	Δ Pressure per Stage (ksf)
1	Existing (Existing Hilfiker Wall, 27-feet)	-	3.2	0.00
2	Extension+DC1+PT	1127	1.18	1.18
2.5	Build New Hilfiker Wall (27-feet Tall)	2522	2.64	1.46
3	Extension+DC1+PT+Pier 1 Removal	2979	3.12	0.48
4	Extension+DC1+PT+Pier 1 Removal+DC2	3065	3.21	0.09
	Footing Length (ft)	38.7		
	Footing Width (ft)	24.7		
	Footing Size (ft^2)	956		
	Final Total Pressure Increase (ksf)	3.2		

	Pier 1				
	Stage 1	Stage 2	Stage 2.5	Stage 3	Stage 4
q_o (ksf)	0.00	1.18	1.46	0.48	0.09
ν	0.25	0.25	0.25	0.25	0.25
A (ft^2)	956	956	956	956	956
E_s (ksf)	1720	1720	1720	1720	1720
L/B	1.6	1.6	1.6	1.6	1.6
β_z	1.091	1.091	1.091	1.091	1.091
S_e(in.) per Stage	0.00	0.22	0.27	0.09	0.02
Cumulative S_e (in.)	0.00	0.22	0.49	0.58	0.59

		Pier 2		
		Cumulative Load (kips)	Cumulative Pressure (ksf)	Δ Pressure per Stage (ksf)
1	Existing	1592	4.06	0.00
2	Extension+DC1+PT	1583	4.04	-0.02
3	Extension+DCI+PT+Pier 1 Removal	1661	4.24	0.20
4	Extension+DCI+PT+Pier 1 Removal+DC2	1664	4.24	0.01
	Footing Length (ft)	28.0		
	Footing Width (ft)	14.0		
	Footing Size (ft^2)	392		
	Final Total Pressure Increase (ksf)	0.18		

	Pier 2			
	Stage 1	Stage 2	Stage 3	Stage 4
q_o (ksf)	0.00	-0.02	0.20	0.01
ν	0.35	0.35	0.35	0.35
A (ft^2)	392	392	392	392
E_s (ksf)	979	979	979	979
L/B	2.0	2.0	2.0	2.0
β_z	1.10	1.10	1.10	1.10
S_e(in.) per Stage	0.00	0.00	0.04	0.00
Cumulative S_e (in.)	0.00	0.00	0.03	0.04

Variable Key	
Variables	Description
q_o (ksf)	Load intensity at bottom of foundation
ν	Poisson's Ratio
A (ft^2)	Area of bottom of foundation
E_s (ksf)	Young's Modulus of Subgrade soil
β_z	Shape factor
S_e (in.)	Predicted cumulative elastic settlement

Figure D.8-7

LRFD Foundation Design — **Spreadsheet Reference Section 10.6.3.1.2 of The 2014 AASHTO LRFD Bridge Design Specifications**

Date/Time:	12/6/2021
Project Name:	**Bridge 17.7W - Existing Pier 1 - Strip Footing - ESU 7A**
Project No.:	**00180-366-01**

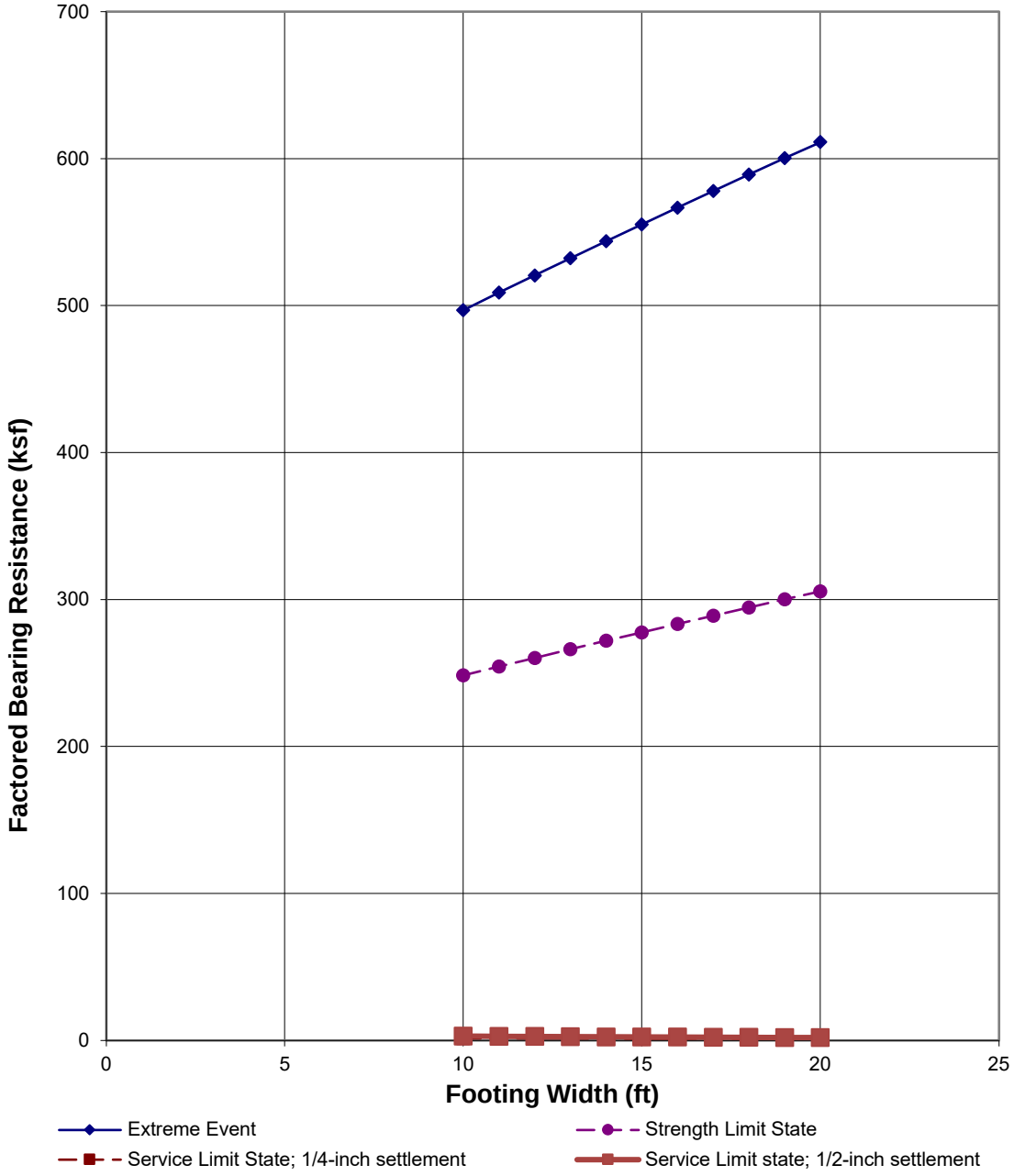
Foundation Soil Conditions	
Unit Weight, γ (pcf)	**135**
Friction angle, Φ (degrees)	**42**
Friction angle, Φ (rad)	0.733
Cohesion, C (psf)	**0**
Embedment, D_f (ft)	**36**
Depth to Groundwater, D_w (ft)	**29**
Footing Length, L (ft)	**41.7**
Footing Width, B (ft)	**12**
Poissons Ration, ν	**0.32**
Young's Modulus, E_s (ksf)	**1107**

Bearing Capacity Factors	
N_γ	156
N_c	94
N_q	85

Footing Width, B	**Water Depth Factors**		**Shape Factors**			**Unfactored Bearing Resistance**	**Extreme Event Resistance** Resistance Factor (0.9) bearing resistance for seismic loading (Section 8.10; 2014 WSDOT GDM)	**Working Bearing Resistance** Resistance Factor (0.45) Theoretical method in sand (0.50) Theoretical method in clay (Table 10.5.5.2.2-1)	Deflection from Elastic Settlement Spreadsheet **1/4" Deflection**	Deflection from Elastic Settlement Spreadsheet **1/2" Deflection**
	C_{wq}	$C_{w\gamma}$	Sc	S_γ	Sq					
(ft)						(ksf)	(ksf)	(ksf)	(ksf)	(ksf)
10.0	1.0	0.5	1.22	0.90	1.22	552.1	496.9	248.5	1.5	3.0
11.0	1.0	0.5	1.24	0.89	1.24	565.3	508.8	254.4	1.4	2.8
12.0	1.0	0.5	1.26	0.88	1.26	578.3	520.5	260.3	1.3	2.7
13.0	1.0	0.5	1.28	0.88	1.28	591.3	532.2	266.1	1.3	2.6
14.0	1.0	0.5	1.31	0.87	1.30	604.2	543.7	271.9	1.2	2.4
15.0	1.0	0.5	1.33	0.86	1.32	616.9	555.2	277.6	1.2	2.3
16.0	1.0	0.5	1.35	0.85	1.35	629.6	566.6	283.3	1.1	2.2
17.0	1.0	0.5	1.37	0.84	1.37	642.1	577.9	288.9	1.1	2.2
18.0	1.0	0.5	1.39	0.83	1.39	654.6	589.1	294.5	1.0	2.1
19.0	1.0	0.5	1.42	0.82	1.41	666.9	600.2	300.1	1.0	2.0
20.0	1.0	0.5	1.44	0.81	1.43	679.2	611.2	305.6	1.0	2.0

Note: Depth and inclination modifier were taken as 1 because the load is applied axially and during construction the soils above the footing were excavated.

Figure D.8-8



*Assumes Footing Length of 41.7 feet

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Shallow Strip Foundation Design

Figure D.8-9

Bridge 17.7 - Existing Pier 1 (ESU 7A)
Bearing Capacity Summary

Footing Width	Footing Length	Unfactored Bearing Resistance	Extreme Event Resistance[a]	Strength Bearing Resistance[b]	Service Limit State	
					1/4" Deflection	1/2" Deflection
(ft)	(ft)	(ksf)	(ksf)	(ksf)	(ksf)	(ksf)
10.0	41.7	552.1	496.9	248.5	1.5	3.0
11.0	41.7	565.3	508.8	254.4	1.4	2.8
12.0	41.7	578.3	520.5	260.3	1.3	2.7
13.0	41.7	591.3	532.2	266.1	1.3	2.6
14.0	41.7	604.2	543.7	271.9	1.2	2.4
15.0	41.7	616.9	555.2	277.6	1.2	2.3
16.0	41.7	629.6	566.6	283.3	1.1	2.2
17.0	41.7	642.1	577.9	288.9	1.1	2.2
18.0	41.7	654.6	589.1	294.5	1.0	2.1
19.0	41.7	666.9	600.2	300.1	1.0	2.0
20.0	41.7	679.2	611.2	305.6	1.0	2.0

Notes:
a. Resistance Factor (0.9) bearing resistance for seismic loading (Section 8.10; 2014 WSDOT GDM)
b. Resistance Factor (0.45) Theoretical method in sand (0.50) Theoretical method in clay (Table 10.5.5.2.2-1)

Figure D.8-10

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Appendix D.9
Pier 1/Wall 03.63L Lateral Earth Pressures and Sliding Calculations

Lateral Earth Pressures for Cohesionless Soils

Project Information

Project:	I-405/Renton to Bellevue Corridor Widening
Owner:	WSDOT
Job Number:	00180-366-01
Analysis by:	MSH
Date/Time:	12/1/2021 11:02 AM
Checked by:	BU

Input Parameters

Material	ϕ Friction Angle (deg)	β_2 (-) Foreslope (deg)	i (+) Backslope (deg)	δ Wall Friction - Active (deg)	δ Wall Friction - Passive (deg)	β Wall Batter (deg)	γ_m (pcf)	γ_b (pcf)	Passive Factor of Safety	k_h (g)	k_v (g)
Wall 03.63L Section Ea-Ea'											
ESU 1B	38	0	0	25	0	0	125	62.6	1	0.255	0
Wall 03.63L Section Fa-Fa' / Ga-Ga' / Ha-Ha'											
Common Borrow	32	-27	0	21.3	0	0	120	57.6	1	0.255	0
Select Borrow	36	-27	0	24.0	0	0	125	62.6	1	0.255	0
Gravel Borrow	38	-27	0	25.3	0	0	130	67.6	1	0.255	0

Lateral Earth Pressures

Output

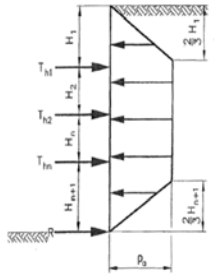
Material	Active			Passive					At Rest			Apparent EP Trapezoid		Seismic				Seismic Pressure - Rectangular
	K_a	γ_a (pcf)	γ'_a (pcf)	K_p	$\gamma_{p(all)}$ (pcf)	$\gamma'_{p(all)}$ (pcf)	$\gamma_{pe(all)}$ (pcf)	$\gamma'_{pe(all)}$ (pcf)	K_o	γ_o (pcf)	γ'_o (pcf)	Single Tieback (psf * H)	Mult. Tiebacks[1], **X**	K_{ae}	γ_{ae} (pcf)	γ'_{ae} (pcf)	K_{pe}	(psf * H)
Wall 03.63L Section Ea-Ea'																		
ESU 1B	0.22	27.10	13.57	4.20	525.47	263.15	939.75	470.63	0.38	48.04	24.06	27.10	27.10	0.18	49.60	24.84	7.52	11.25
Wall 03.63L Section Fa-Fa' / Ga-Ga' / Ha-Ha'																		
Common Borrow	0.28	33.00	15.84	1.24	148.72	71.39	570.60	273.89	0.47	56.41	27.08	33.00	33.00	0.21	57.74	27.71	4.76	12.37
Select Borrow	0.23	29.36	14.70	1.45	181.84	91.07	800.00	400.64	0.41	51.53	25.80	29.36	29.36	0.19	52.85	26.47	6.40	11.75
Gravel Borrow	0.22	28.18	14.65	1.53	199.01	103.48	977.34	508.22	0.38	49.96	25.98	28.18	28.18	0.18	51.58	26.82	7.52	11.70

Notes:

[1] "X" to be used in the following equation:

$$\frac{X \cdot H^2}{1.5H - 0.5H_1 - 0.5H_{n+1}}$$

where H_1 and H_{n+1} are represented by this diagram:



Recommended Lateral Earth Pressures

Figure D.9-2

Lateral Earth Pressures for Cohesionless Soils

Project Information

Project:	Renton to Bellevue - Bridge 17.7 Pier 1
Owner:	WSDOT
Job Number:	00183-366-00
Analysis by:	IAH
Date/Time:	12/2/2021 11:51 AM
Checked by:	MSH

Input Parameters

Run No.	ϕ Friction Angle (deg)	β_2 (-) Foreslope (deg)	i (+) Backslope (deg)	δ Wall Friction - Active (deg)	δ Wall Friction - Passive (deg)	β Wall Batter (deg)	γ_m (pcf)	γ_b (pcf)	Passive Factor of Safety	k_h (g)	k_v (g)
ESU 1A	40	0	0	26.7	0	0	120	57.6	1	0.476	0
ESU 1B	38	0	0	25.3	0	0	125	62.6	1	0.476	0
Common Borrow	32	0	0	21.3	0	0	120	57.6	1	0.476	0
Select Borrow	36	0	0	24.0	0	0	125	62.6	1	0.476	0
Gravel Borrow	38	0	0	25.3	0	0	130	67.6	1	0.476	0

Figure D.9-3

Lateral Earth Pressures

Output

Run No.	Active			Passive					At Rest			Apparent EP Trapezoid		Seismic	Seismic	Seismic Pressure - Rectangular
	K_a	γ_a (pcf)	γ'_a (pcf)	K_p	$\gamma_{p(all)}$ (pcf)	$\gamma'_{p(all)}$ (pcf)	$\gamma_{pe(all)}$ (pcf)	$\gamma'_{pe(all)}$ (pcf)	K_o	γ_o (pcf)	γ'_o (pcf)	Single Tieback (psf * H)	Mult. Tiebacks[1], **X**	K_e	K_{pe}	(psf * H)
ESU 1A	0.20	23.98	11.51	4.60	551.87	264.90	896.16	430.16	0.36	42.87	20.58	23.98	23.98	0.45	7.47	26.99
ESU 1B	0.22	27.10	13.57	4.20	525.47	263.15	783.50	392.38	0.38	48.04	24.06	27.10	27.10	0.47	6.27	29.64
Common Borrow	0.28	33.00	15.84	3.25	390.55	187.46	442.08	212.20	0.47	56.41	27.08	33.00	33.00	0.58	3.68	34.88
Select Borrow	0.23	29.36	14.70	3.85	481.48	241.13	654.20	327.62	0.41	51.53	25.80	29.36	29.36	0.50	5.23	31.44
Gravel Borrow	0.22	28.18	14.65	4.20	546.49	284.17	814.84	423.72	0.38	49.96	25.98	28.18	28.18	0.47	6.27	30.83

Notes:

[1] "X" to be used in the following equation:

$$\frac{X \cdot H^2}{1.5H - 0.5H_1 - 0.5H_{n+1}}$$

where H_1 and H_{n+1} are represented by this diagram:

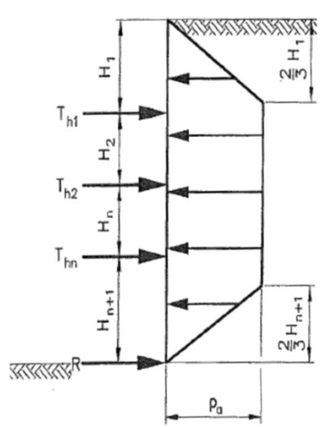


Figure D.9-4

Bridge 17.7
Proposed Pier 1

Lateral Earth Pressures

Ground Surface Elevation at Top of Wall	94	ft
Elevation of Change in Stratum	72	ft
Bottom of Footing Elevation	66.5	ft
Groundwater Level Elevation	43	ft
Traffic Surcharge, Static	250	psf
Traffic Surcharge, Seismic	125	psf

H1	22	ft
D1	5.5	ft

Interval	Layer Description	Elevation, Top of Layer ft	Elevation, Bottom of Layer ft	Friction Angle deg	Soil Total Unit Weight pcf	Soil Effective Unit Weight pcf	Active Lateral Earth Pressure Coefficient	At Rest Lateral Earth Pressure Coefficient	Passive Lateral Earth Pressure Coefficient	Seismic Lateral Earth Pressure Coefficient
Stratum 1	ESU 1A, above water table	94	72	40	120	120	0.20	0.36	4.60	0.45
Stratum 2	ESU 1B, above water table	72	66.5	38	125	125	0.22	0.38	4.20	0.47

	Static (At-Rest)(psf)				Seismic (psf)	Passive (psf)
	A	B	C	D	Q	E
Stratum	1	1	2	2	1	2
Description	Earth Pressure * H_1	Traffic Surcharge	Earth Pressure * H_1	Earth Pressure * D_1	Seismic Earth Pressure * H_1	Earth Pressure * D_1
Recommended Earth Pressures	943	89	6005	264	1188	2890
To calculate	42.87 * H1	89	48.04 * H1	48.04 * D1	53.98 * H1	525.47 * D1

Recommended Lateral Earth Pressures

See Report Figures for detailed lateral earth pressure figures.

Sliding Friction Coefficients					
Soil Type	φ'	Soil-to-Soil Sliding Friction Coefficient		Concrete Structure Sliding Friction Coefficient	
		Discontinuous Reinforcements	Continuous Reinforcements	Cast-In-Place Concrete	Precast Concrete
Wall 03.63L and/or Bridge 17.7 Pier 1 Footing					
ESU 1A	40	0.78	0.47	0.84	0.67
ESU 1B	38	0.78	0.47	0.78	0.63
Common Borrow	32	0.62	0.39	0.62	0.50
Select Borrow	36	0.73	0.45	0.73	0.58
Gravel Borrow	38	0.78	0.47	0.78	0.63

Notes:
Sliding coefficients calculated according to AASHTO Equation 10.6.3.4-2
Structural Earth Walls (SEW) are termed Mechanically Stabilized Earth (MSE) walls in AASHTO.

Coefficient of Friction for Discontinuous Reinforcements, e.g., Strips:
Coefficient of friction = 1.0*tan(Phi')
Phi' = lesser of friction angle of foundation soil and friction angle of reinforced fill per AASHTO 11.10.5.3

Coefficient of Friction for Continuous Reinforcements, e.g., Grids and Sheets:
Coefficient of friction = 1.0*tan(Phi')
Phi' = lesser of friction angle of foundation soil, friction angle of reinforced fill, and soil-reinforcement interface friction angle per AASHTO 11.10.5.3
In the absence of specific data, a maximum friction angle of 2/3 of friction angle of foundation soil or 2/3 of friction angle of reinforced fill should be used.

Cast-In-Place Concrete Coefficient of Friction:
Coefficient of friction = 1.0*tan(Phi')

Precast Concrete Coefficient of Friction:
Coefficient of friction = 0.8*tan(Phi')

AASHTO 10.6.3.4:

$$R_\tau = CV \tan \phi_f \qquad (10.6.3.4\text{-}2)$$

for which:

C = 1.0 for concrete cast against soil
= 0.8 for precast concrete footing
= 1.0 for MSE Wall per AASHTO Table 11.5.7-1

where:

ϕ_f = internal friction angle of drained soil (degrees)
V = total vertical force (kips)

Figure D.9-6

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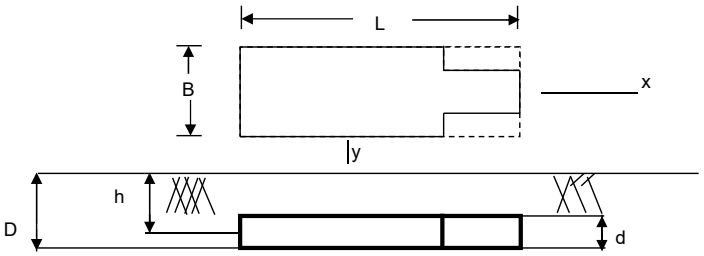
Appendix D.10
Pier 1 Shallow Foundation Seismic Springs

Foundation Spring Constants

Project:	**WSDOT I-405 Renton to Bellevue Widening**
Owner:	**WSDOT**
Job Number:	**00180-366-01**
Analysis by:	**MSH**
Date/Time:	**11/16/2021**
Foundation soil:	**ESU 1B**
Foundation:	**Pier 1 Proposed Spread Footing - 38.7 x 24.7**
EQ Return Interval	**SEE**
FEMA 356	

B	24.7	ft
L	38.7	ft
D	6	ft
d	4	ft
h	4	ft
υ	0.36	
G_0	1511.1	ksf
$(N_1)_{60}$	21	
γ	125	pcf
D_w	29	ft
σ'_o	750	psf
Site Class	C	
$S_{XS}/2.5$	0.51	
G/G_0	0.34	*From Table 4-7 (FEMA 356)
G	513.8	ksf



h	Distance of the effective sidewall centroid from ground surf
Vso	Shear wave velocity
υ	Poissons ratio
G_o	Initial Shear Modulus
$S_{XS}/2.5$	Effective Peak Acceleration
S_{XS}	Spectral response acceleration at short periods for the sele hazard level and damping adjusted for site class

Foundation on surface of homogeneous halfspace

Lateral x		
$K_{x,sur}$	4.451E+04	kips/ft
	3.709E+03	kips/in
Lateral y		
$K_{y,sur}$	4.627E+04	kips/ft
	3.856E+03	kips/in
Vertical		
$K_{z,sur}$	5.890E+04	kips/ft
	4.909E+03	kips/in
Rocking rx		
$K_{xx,sur}$	8.791E+06	kip-ft
	1.055E+08	kip-in
Rocking ry		
$K_{yy,sur}$	1.712E+07	kip-ft
	2.054E+08	kip-in
Torsional		
$K_{zz,sur}$	1.628E+07	kip-ft
	1.953E+08	kip-in

Foundation embedded in homogeneous halfspace

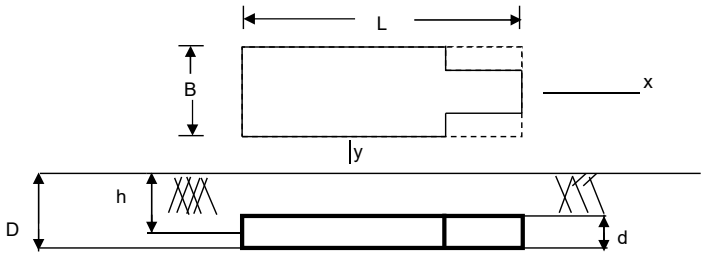
Lateral x		
Beta	1.52	
$K_{x,emb}$	6.777E+04	kips/ft
$K_{x,emb}$	5.647E+03	kips/in
Lateral y		
Beta	1.52	
$K_{y,emb}$	7.044E+04	kips/ft
$K_{y,emb}$	5.870E+03	kips/in
Vertical		
Beta	1.18	
$K_{z,emb}$	6.951E+04	kips/ft
$K_{z,emb}$	5.793E+03	kips/in
Rocking rx		
Beta	1.52	
$K_{xx,emb}$	1.335E+07	kip-ft
$K_{xx,emb}$	1.602E+08	kip-in
Rocking ry		
Beta	1.56	
$K_{yy,emb}$	2.671E+07	kip-ft
$K_{yy,emb}$	3.206E+08	kip-in
Torsional		
Beta	1.83	
$K_{zz,emb}$	2.975E+07	kip-ft
$K_{zz,emb}$	3.570E+08	kip-in

Figure D.10-1

Foundation Spring Constants

Project:	**WSDOT I-405 Renton to Bellevue Widening**
Owner:	**WSDOT**
Job Number:	**00180-366-01**
Analysis by:	**IAH**
Date/Time:	**10/18/2021**
Foundation soil:	**ESU 7A**
Foundation:	**Pier 1 Existing Spread Footing**
EQ Return Interval	**SEE**
FEMA 356	

B	12	ft
L	41.7	ft
D	8.5	ft
d	3.5	ft
h	6.75	ft



ESU	7A	
υ	0.36	
G_0	2018.1	ksf
$(N_1)_{60}$	58	
γ_{total}	135	pcf
D_w	1	ft
σ'_o	679.5	psf
Site Class	C	
$S_{XS}/2.5$	0.51	
G/G_0	0.71	*From Table 4-7 (FEMA 356)
G	1430.3	ksf

h	Distance of the effective sidewall centroid from ground surf
Vso	Shear wave velocity
υ	Poissons ratio
G_o	Initial Shear Modulus
$S_{XS}/2.5$	Effective Peak Acceleration
S_{XS}	Spectral response acceleration at short periods for the sele hazard level and damping adjusted for site class

Foundation on surface of homogeneous halfspace

Lateral x		
$K_{x,sur}$	9.248E+04	kips/ft
	7.706E+03	kips/in
Lateral y		
$K_{y,sur}$	1.028E+05	kips/ft
	8.569E+03	kips/in
Vertical		
$K_{z,sur}$	1.272E+05	kips/ft
	1.060E+04	kips/in
Rocking rx		
$K_{xx,sur}$	5.750E+06	kip-ft
	6.900E+07	kip-in
Rocking ry		
$K_{yy,sur}$	3.613E+07	kip-ft
	4.336E+08	kip-in
Torsional		
$K_{zz,sur}$	2.891E+07	kip-ft
	3.470E+08	kip-in

Foundation embedded in homogeneous halfspace

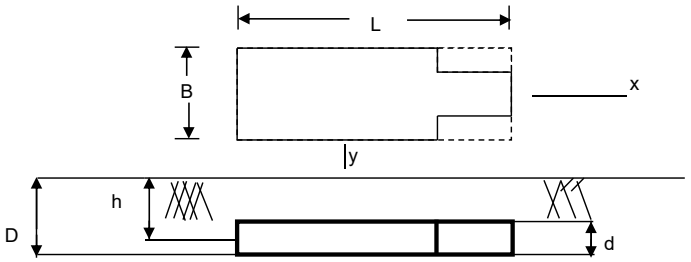
Lateral x		
Beta	1.79	
$K_{x,emb}$	1.656E+05	kips/ft
$K_{x,emb}$	1.380E+04	kips/in
Lateral y		
Beta	1.79	
$K_{y,emb}$	1.842E+05	kips/ft
$K_{y,emb}$	1.535E+04	kips/in
Vertical		
Beta	1.27	
$K_{z,emb}$	1.621E+05	kips/ft
$K_{z,emb}$	1.351E+04	kips/in
Rocking rx		
Beta	2.00	
$K_{xx,emb}$	1.151E+07	kip-ft
$K_{xx,emb}$	1.381E+08	kip-in
Rocking ry		
Beta	1.49	
$K_{yy,emb}$	5.395E+07	kip-ft
$K_{yy,emb}$	6.475E+08	kip-in
Torsional		
Beta	2.10	
$K_{zz,emb}$	6.086E+07	kip-ft
$K_{zz,emb}$	7.303E+08	kip-in

Figure D.10-2

Foundation Spring Constants

Project:	**WSDOT I-405 Renton to Bellevue Widening**
Owner:	**WSDOT**
Job Number:	**00180-366-01**
Analysis by:	**IAH**
Date/Time:	**5/13/2021 0:00**
Foundation soil:	**ESU 2A**
Foundation:	**Pier 2 Spread Footing**
EQ Return Interval	**SEE**
FEMA 356	

B	14	ft
L	28	ft
D	8.4	ft
d	4	ft
h	6.4	ft



υ	0.33	
G_0	1950.9	ksf
$(N_1)_{60}$	29	
γ	120	pcf
D_w	17	ft
σ'_o	1008	psf
Site Class	D	
$S_{XS}/2.5$	0.27	
G/G_0	0.6733333	*From Table 4-7 (FEMA 356)
G	1313.6	ksf

h	Distance of the effective sidewall centroid from ground s
Vso	Shear wave velocity
υ	Poissons ratio
G_o	Initial Shear Modulus
S_{XS}	Spectral response acceleration at short periods for the s hazard level and damping adjusted for site class

Foundation on surface of homogeneous halfspace

Lateral x		
$K_{x,sur}$	7.197E+04	kips/ft
	5.997E+03	kips/in
Lateral y		
$K_{y,sur}$	7.637E+04	kips/ft
	6.364E+03	kips/in
Vertical		
$K_{z,sur}$	9.351E+04	kips/ft
	7.792E+03	kips/in
Rocking rx		
$K_{xx,sur}$	4.842E+06	kip-ft
	5.810E+07	kip-in
Rocking ry		
$K_{yy,sur}$	1.353E+07	kip-ft
	1.623E+08	kip-in
Torsional		
$K_{zz,sur}$	1.228E+07	kip-ft
	1.473E+08	kip-in

Foundation embedded in homogeneous halfspace

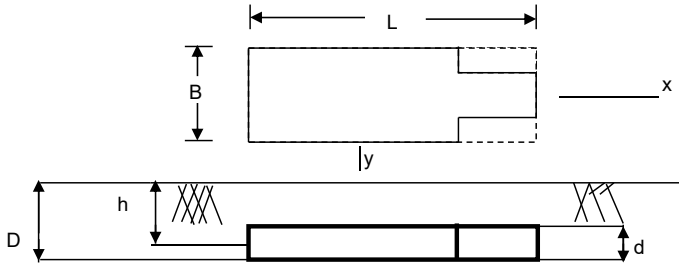
Lateral x		
Beta	1.90	
$K_{x,emb}$	1.365E+05	kips/ft
$K_{x,emb}$	1.138E+04	kips/in
Lateral y		
Beta	1.90	
$K_{y,emb}$	1.449E+05	kips/ft
$K_{y,emb}$	1.207E+04	kips/in
Vertical		
Beta	1.29	
$K_{z,emb}$	1.209E+05	kips/ft
$K_{z,emb}$	1.008E+04	kips/in
Rocking rx		
Beta	2.05	
$K_{xx,emb}$	9.921E+06	kip-ft
$K_{xx,emb}$	1.191E+08	kip-in
Rocking ry		
Beta	1.72	
$K_{yy,emb}$	2.321E+07	kip-ft
$K_{yy,emb}$	2.785E+08	kip-in
Torsional		
Beta	2.26	
$K_{zz,emb}$	2.778E+07	kip-ft
$K_{zz,emb}$	3.334E+08	kip-in

Figure D.10-3

Foundation Spring Constants

Project:	**WSDOT I-405 Renton to Bellevue Widening**
Owner:	**WSDOT**
Job Number:	**00180-366-01**
Analysis by:	**IAH**
Date/Time:	**8/1/2021 0:00**
Foundation soil:	**ESU 2A**
Foundation:	**Pier 3 CIP Wall Shallow Foundation**
EQ Return Interval	**SEE**
FEMA 356	

B	12.5	ft
L	40	ft
D	4	ft
d	2.5	ft
h	2.75	ft



υ	0.33	
G_0	1346.2	ksf
$(N_1)_{60}$	29	
γ	120	pcf
d_w	7	ft
σ'_o	480	psf
$S_{XS}/2.5$	0.51	
G/G_0	0.71	*From Table 4-7 (FEMA 356)
G	955.8	ksf

h	Distance of the effective sidewall centroid from ground surface
Vso	Shear wave velocity
υ	Poissons ratio
G_o	Initial Shear Modulus
S_{XS}	Spectral response acceleration at short periods for the selected hazard level and damping adjusted for site class

Foundation on surface of homogeneous halfspace

Lateral x

$K_{x,sur}$	6.039E+04	kips/ft
	5.033E+03	kips/in

Lateral y

$K_{y,sur}$	6.669E+04	kips/ft
	5.557E+03	kips/in

Vertical

$K_{z,sur}$	8.040E+04	kips/ft
	6.700E+03	kips/in

Rocking rx

$K_{xx,sur}$	3.845E+06	kip-ft
	4.614E+07	kip-in

Rocking ry

$K_{yy,sur}$	2.145E+07	kip-ft
	2.574E+08	kip-in

Torsional

$K_{zz,sur}$	1.805E+07	kip-ft
	2.166E+08	kip-in

Foundation embedded in homogeneous halfspace

Lateral x

Beta	1.48	
$K_{x,emb}$	8.927E+04	kips/ft
$K_{x,emb}$	7.439E+03	kips/in

Lateral y

Beta	1.48	
$K_{y,emb}$	9.857E+04	kips/ft
$K_{y,emb}$	8.214E+03	kips/in

Vertical

Beta	1.18	
$K_{z,emb}$	9.484E+04	kips/ft
$K_{z,emb}$	7.903E+03	kips/in

Rocking rx

Beta	1.62	
$K_{xx,emb}$	6.240E+06	kip-ft
$K_{xx,emb}$	7.488E+07	kip-in

Rocking ry

Beta	1.40	
$K_{yy,emb}$	3.013E+07	kip-ft
$K_{yy,emb}$	3.615E+08	kip-in

Torsional

Beta	1.80	
$K_{zz,emb}$	3.252E+07	kip-ft
$K_{zz,emb}$	3.903E+08	kip-in

Figure D.10-4

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Appendix D.11
Pier 2 Bearing Capacity Calculations

LRFD Foundation Design

Spreadsheet Reference Section 10.6.3.1.2 of The 2014 AASHTO LRFD Bridge Design Specifications

Date/Time:	2/4/2021
Project Name:	**Bridge 17.7W - Pier 2 - Strip Footing - Native Soil ESU 2A**
Project No.:	**00180-366-01**

Foundation Soil Conditions	
Unit Weight, γ (pcf)	**120**
Friction angle, Φ (degrees)	**39**
Friction angle, Φ (rad)	0.681
Cohesion, C (psf)	**0**
Embedment, D_f (ft)	**8**
Depth to Groundwater, D_w (ft)	**17**
Footing Length, L (ft)	**28**
Footing Width, B (ft)	**14**
Poissons Ration, ν	**0.35**
Young's Modulus, E_s (ksf)	**979**

Bearing Capacity Factors	
N_γ	92
N_c	68
N_q	56

Footing Width, B	**Water Depth Factors**		**Shape Factors**			**Unfactored Bearing Resistance**	**Extreme Event Resistance** Resistance Factor (0.9) bearing resistance for seismic loading (Section 8.10; 2014 WSDOT GDM)	**Working Bearing Resistance** Resistance Factor (0.45) Theoretical method in sand (0.50) Theoretical method in clay (Table 10.5.5.2.2-1)	Deflection from Elastic Settlement Spreadsheet **1/4" Deflection**	Deflection from Elastic Settlement Spreadsheet **1/2" Deflection**
	C_{wq}	$C_{w\gamma}$	Sc	S_γ	Sq					
(ft)						(ksf)	(ksf)	(ksf)	(ksf)	(ksf)
10.0	1.0	0.5	1.29	0.86	1.29	93.0	83.7	41.9	1.6	3.2
11.0	1.0	0.5	1.32	0.84	1.32	96.5	86.9	43.4	1.5	3.0
12.0	1.0	0.5	1.35	0.83	1.35	99.9	90.0	45.0	1.4	2.8
13.0	1.0	0.5	1.38	0.81	1.38	103.3	93.0	46.5	1.3	2.7
14.0	1.0	0.5	1.41	0.80	1.40	106.5	95.9	47.9	1.3	2.6
15.0	1.0	0.5	1.44	0.79	1.43	109.7	98.7	49.4	1.2	2.5
16.0	1.0	0.5	1.47	0.77	1.46	112.8	101.5	50.8	1.2	2.4
17.0	1.0	0.5	1.50	0.76	1.49	115.8	104.2	52.1	1.2	2.3
18.0	1.0	0.5	1.53	0.74	1.52	118.8	106.9	53.4	1.1	2.3
19.0	1.0	0.5	1.56	0.73	1.55	121.6	109.5	54.7	1.1	2.2
20.0	1.0	0.5	1.59	0.71	1.58	124.4	112.0	56.0	1.1	2.1

Note: Depth and inclination modifier were taken as 1 because the load is applied axially and during construction the soils above the footing were excavated.

Figure D.11-1

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Appendix D.12
Pier 2 Lateral Earth Pressures and Sliding Calculations

Lateral Earth Pressures for Cohesionless Soils

Project Information

Project:	Renton to Bellevue
Owner:	WSDOT
Job Number:	00180-366-01
Analysis:	Pier 2 - Existing Foundation in ESU 1B
Analysis by:	IAH
Date/Time:	2/24/2021 12:00 AM
Checked by:	BU

Input Parameters

Run No.	ϕ Friction Angle (deg)	β_2 (-) Foreslope (deg)	i (+) Backslope (deg)	δ Wall Friction - Active (deg)	δ Wall Friction - Passive (deg)	β Wall Batter (deg)	γ_m (pcf)	γ_b (pcf)	Passive Factor of Safety	k_h (g)	k_v (g)
ESU 1B	38	0	0	25.3	0	0	125	62.6	1	0.51	0

Figure D.12-1

Lateral Earth Pressures

Output

Run No.	Active			Passive					At Rest			Apparent EP Trapezoid		Seismic	Seismic	Seismic Pressure - Rectangular (psf * H)
	K_a	γ_a (pcf)	γ'_a (pcf)	K_p	$\gamma_{p(all)}$ (pcf)	$\gamma'_{p(all)}$ (pcf)	$\gamma_{pe(all)}$ (pcf)	$\gamma'_{pe(all)}$ (pcf)	K_o	γ_o (pcf)	γ'_o (pcf)	Single Tieback (psf * H)	Mult. Tiebacks[1], **X**	K_e	K_{pe}	
ESU 1B	0.22	27.10	13.57	4.20	525.47	263.15	752.50	376.85	0.38	48.04	24.06	27.10	27.10	0.54	6.02	33.87

Notes:

[1] "X" to be used in the following equation:

$$\frac{X \cdot H^2}{1.5H - 0.5H_1 - 0.5H_{n+1}}$$

where H_1 and H_{n+1} are represented by this diagram:

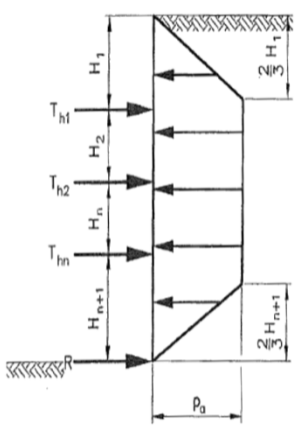

Figure D.12-2

Bridge 17.7
Existing Pier 2

Lateral Earth Pressures

Ground Surface Elevation on NB I-405 Side	75.5	ft
Ground Surface Elevation on SB I-405 Side	71	ft
Bottom of Footing Elevation	63.5	ft
Groundwater Level Elevation	54	ft
Traffic Surcharge, Static	250	psf
Traffic Surcharge, Seismic	125	psf

D_1	7.5	ft
D_2	12	ft

Interval	Layer Description	Elevation, Top of NB I-405 ft	Elevation, Top of SB I-405 ft	Friction Angle deg	Soil Total Unit Weight pcf	Soil Effective Unit Weight pcf	Active Lateral Earth Pressure Coefficient	At Rest Lateral Earth Pressure Coefficient	Passive Lateral Earth Pressure Coefficient	Seismic Lateral Earth Pressure Coefficient
Stratum 1	ESU 1B, above water table	75.5	71	38	125	125	0.22	0.38	4.20	0.54

	Static (At-Rest)(psf)		Seismic (psf)	Passive (psf)
	A	B	Q	C
Stratum	1	1	1	1
Description	Earth Pressure * D_2	Traffic Surcharge	Seismic Earth Pressure * D_2	Earth Pressure * D_1
Recommended Earth Pressures	577	96	813	3941
To calculate	48.04 * D2	96	67.75 * D2	525.47 * D1

Figure D.12-3

Bridge 17.7

Soil Type	φ'	Sliding Friction Coefficient	
		Cast-In-Place Concrete	Precast Concrete
Pier 2 - Existing Foundation			
ESU 2A	39	0.81	0.65

Notes:
Sliding coefficients calculated according to AASHTO Equation 10.6.3.4-2

Cast-In-Place Concrete Coefficient of Friction:
Coefficient of friction = 1.0*tan(Phi')

Precast Concrete Coefficient of Friction:
Coefficient of friction = 0.8*tan(Phi')

AASHTO 10.6.3.4:

$$R_\tau = CV \tan \phi_f \qquad (10.6.3.4\text{-}2)$$

for which:

C = 1.0 for concrete cast against soil
= 0.8 for precast concrete footing

where:

ϕ_f = internal friction angle of drained soil (degrees)
V = total vertical force (kips)

Figure D.12-4

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In Association with

Appendix D.13
Pier 3/CIP Bearing Capacity Calculations

LRFD Foundation Design

Spreadsheet Reference Section 10.6.3.1.2 of The 2014 AASHTO LRFD Bridge Design Specifications

Date/Time:	12/1/2021
Project Name:	**Bridge 17.7W - Pier 3 CIP Wall - Native Soil ESU 2A**
Project No.:	**00180-366-01**

Foundation Soil Conditions	
Unit Weight, γ (pcf)	**120**
Friction angle, Φ (degrees)	**39**
Friction angle, Φ (rad)	0.681
Cohesion, C (psf)	**0**
Embedment, D_f (ft)	**4**
Depth to Groundwater, D_w (ft)	**7**
Footing Length, L (ft)	**40**
Footing Width, B (ft)	**12.5**
Poissons Ration, ν	**0.33**
Young's Modulus, E_s (ksf)	**1000**

Bearing Capacity Factors	
N_γ	92
N_c	68
N_q	56

Footing Width, B	Water Depth Factors		Shape Factors			Unfactored Bearing Resistance	Extreme Event Resistance	Working Bearing Resistance	Deflection from Elastic Settlement Spreadsheet	Deflection from Elastic Settlement Spreadsheet
	C_{wq}	$C_{w\gamma}$	Sc	S_γ	Sq		Resistance Factor (0.9) bearing resistance for seismic loading (Section 8.10; 2014 WSDOT GDM)	Resistance Factor (0.45) Theoretical method in sand (0.50) Theoretical method in clay (Table 10.5.5.2.2-1)	**1/4" Deflection**	**1/2" Deflection**
(ft)						(ksf)	(ksf)	(ksf)	(ksf)	(ksf)
10.0	1.0	0.5	1.21	0.90	1.20	57.2	51.5	25.8	1.4	2.8
11.0	1.0	0.5	1.23	0.89	1.22	60.0	54.0	27.0	1.3	2.6
12.0	1.0	0.5	1.25	0.88	1.24	62.7	56.4	28.2	1.2	2.5
12.5	1.0	0.5	1.26	0.88	1.25	64.0	57.6	28.8	1.2	2.4
13.0	1.0	0.5	1.27	0.87	1.26	65.3	58.7	29.4	1.2	2.4
14.0	1.0	0.5	1.29	0.86	1.28	67.8	61.1	30.5	1.1	2.3
15.0	1.0	0.5	1.31	0.85	1.30	70.3	63.3	31.7	1.1	2.2
16.0	1.0	0.5	1.33	0.84	1.32	72.8	65.5	32.8	1.0	2.1
17.0	1.0	0.5	1.35	0.83	1.34	75.2	67.7	33.8	1.0	2.0
18.0	1.0	0.5	1.37	0.82	1.36	77.5	69.8	34.9	1.0	1.9
19.0	1.0	0.5	1.39	0.81	1.38	79.8	71.9	35.9	0.9	1.9

Note: Depth and inclination modifier were taken as 1 because the load is applied axially and during construction the soils above the footing were excavated.

Figure D.13-1

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In Association with

Appendix D.14
Pier 3/CIP Sliding Calculations

Bridge 17.7

Soil Type	φ'	Sliding Friction Coefficient	
		Cast-In-Place Concrete	Precast Concrete
Pier 3 - Existing Foundation			
ESU 2A	39	0.81	0.65

Notes:
Sliding coefficients calculated according to AASHTO Equation 10.6.3.4-2

Cast-In-Place Concrete Coefficient of Friction:
Coefficient of friction = 1.0*tan(Phi')

Precast Concrete Coefficient of Friction:
Coefficient of friction = 0.8*tan(Phi')

AASHTO 10.6.3.4:

$$R_\tau = CV \tan \phi_f \qquad (10.6.3.4\text{-}2)$$

for which:

C = 1.0 for concrete cast against soil
= 0.8 for precast concrete footing

where:

ϕ_f = internal friction angle of drained soil (degrees)
V = total vertical force (kips)

Figure D.14-1

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In Association with

Appendix D.15
Pier 3 Wave Scattering Calculations

Calculating Corrected PGA for Wave Scattering Effects

Per the National Cooperative Highway Research Program (NCHRP) Report 611 the Peak Ground Acceleration (PGA) can be adjusted to account for variations in the average ground acceleration due to wave scattering behind tall retaining walls or slopes by applying a scaling factor (or alpha value) to the PGA.

For Bridge 17.7, we will be applying the Mid Spectral shape curve to calculate our alpha scaling factor. This was determined by using figure 5-4 in Report 611 (see below) and comparing it to the spetral shape developed by the PSHA provided by Hart Crowser (Draft Bridge 18 PSHA Spectra dated October 10, 2020.) The eastern portion of Bridge 17.7, where the proposed widening will occur, is less than 50 feet south of Bridge 18.

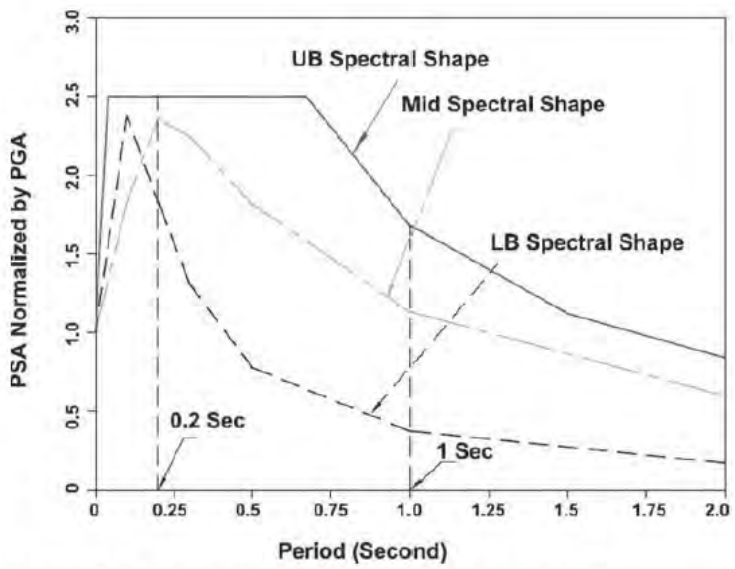

Figure 5-4. Spectral curve shapes adopted for further ground motion studies.

The alpha factor is selected using the exposed height of the walls associated with Bridge 17.7.
The Hilfiker wall is at it's maximum height at Pier 1 of Bridge 17.7.
Wall heights are presented below:

$H\_Pier1_{transverse} := 18\ ft$ Proposed exposed height of wall facing I-405 at Pier 1, maximum

$H\_Pier3 := 36\ ft$ Height of exposed existing wall at Pier 3, maximum

Created with PTC Mathcad Express. See www.mathcad.com for more information.

Using the slope and/or wall heights, the alpha scaling factor was selected from Figure 6-13

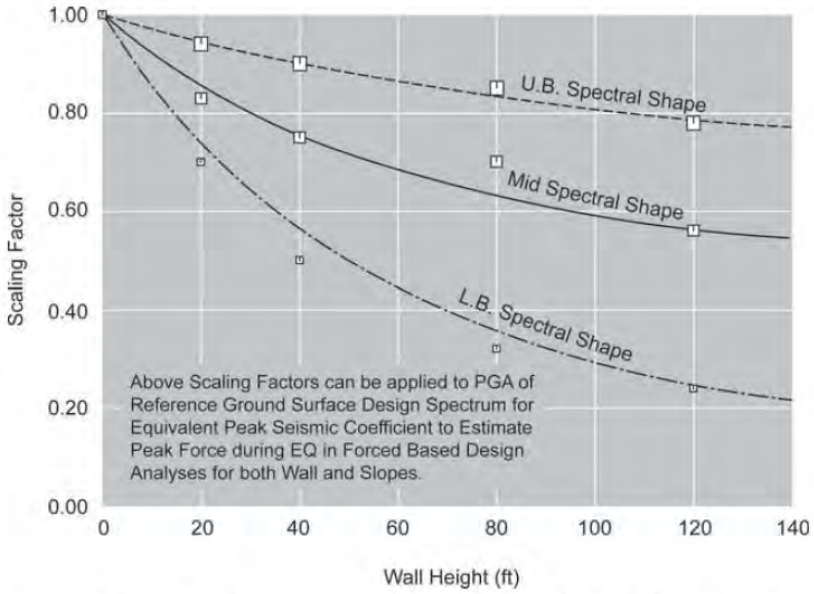

Figure 6-13. Resultant wave scattering α coefficients for retaining wall design.

$PGA := 0.56$ Preliminary site class assumed as Site Class D.

$\alpha_3 := 0.85$ $H\_Pier1_{transverse} = 18\ ft$

$PGAr := PGA \cdot \alpha_3 = 0.476$ Reduced PGA for Pier 1 Wall

$\alpha_3 := 0.79$ $H\_Pier3 = 36\ ft$

$PGAr := PGA \cdot \alpha_3 = 0.442$ Reduced PGA for Pier 3 Wall

Figure D.15-2

Created with PTC Mathcad Express. See www.mathcad.com for more information.

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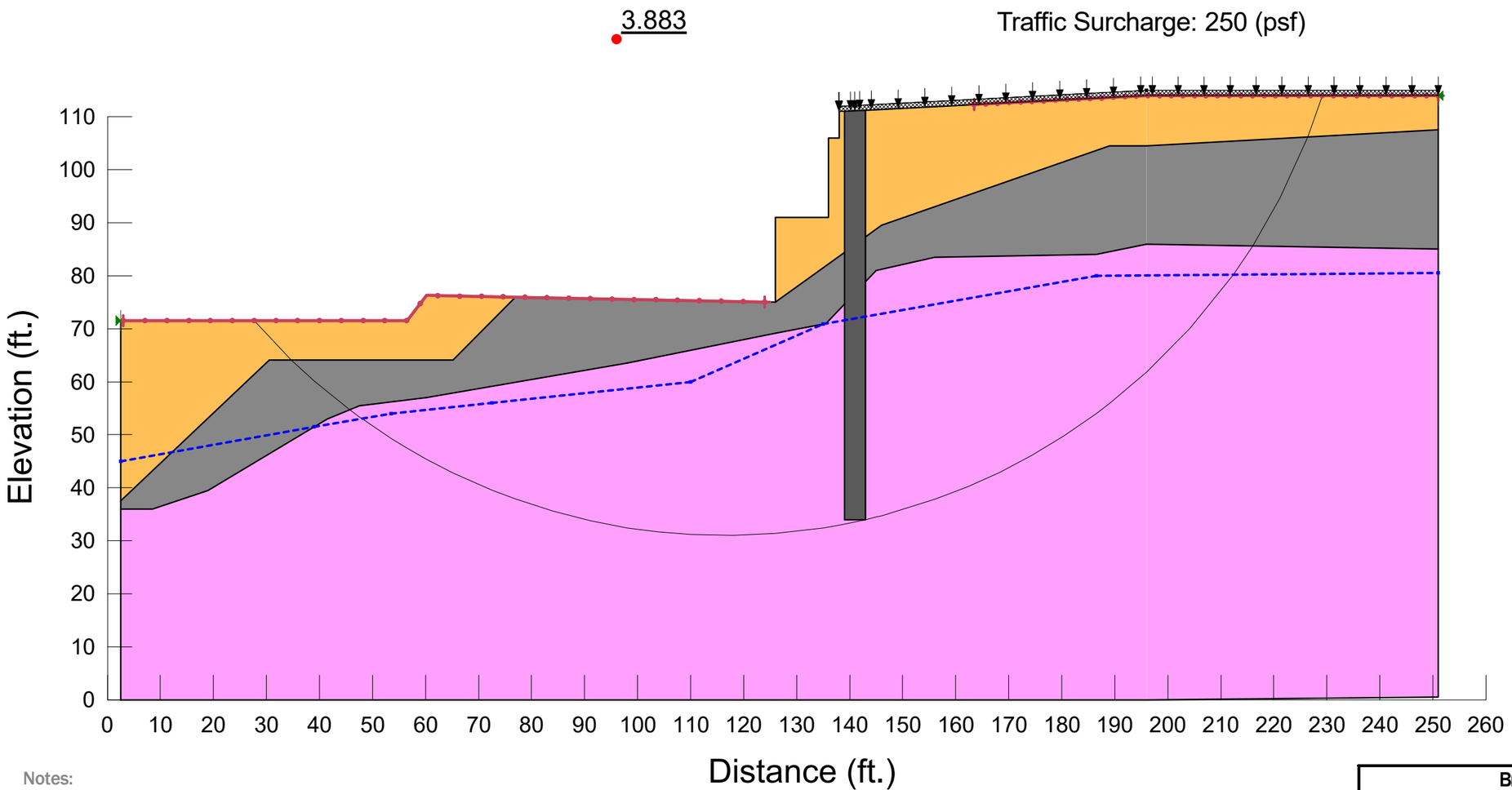
Appendix D.16
Pier 3 Global Stability Analyses

Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Concrete 48-in Dia Drilled Shaft	High Strength	150		
	ESU 1B - Existing Silty Granular Fill	Mohr-Coulomb	125	0	38
	ESU 2A - Native Sand and Gravel	Mohr-Coulomb	120	0	39
	ESU 7A - Weathered Sandstone	Mohr-Coulomb	135	0	43



Notes:

1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document.
3. GeoEngineers, Inc. cannot guarantee the accuracy and context of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

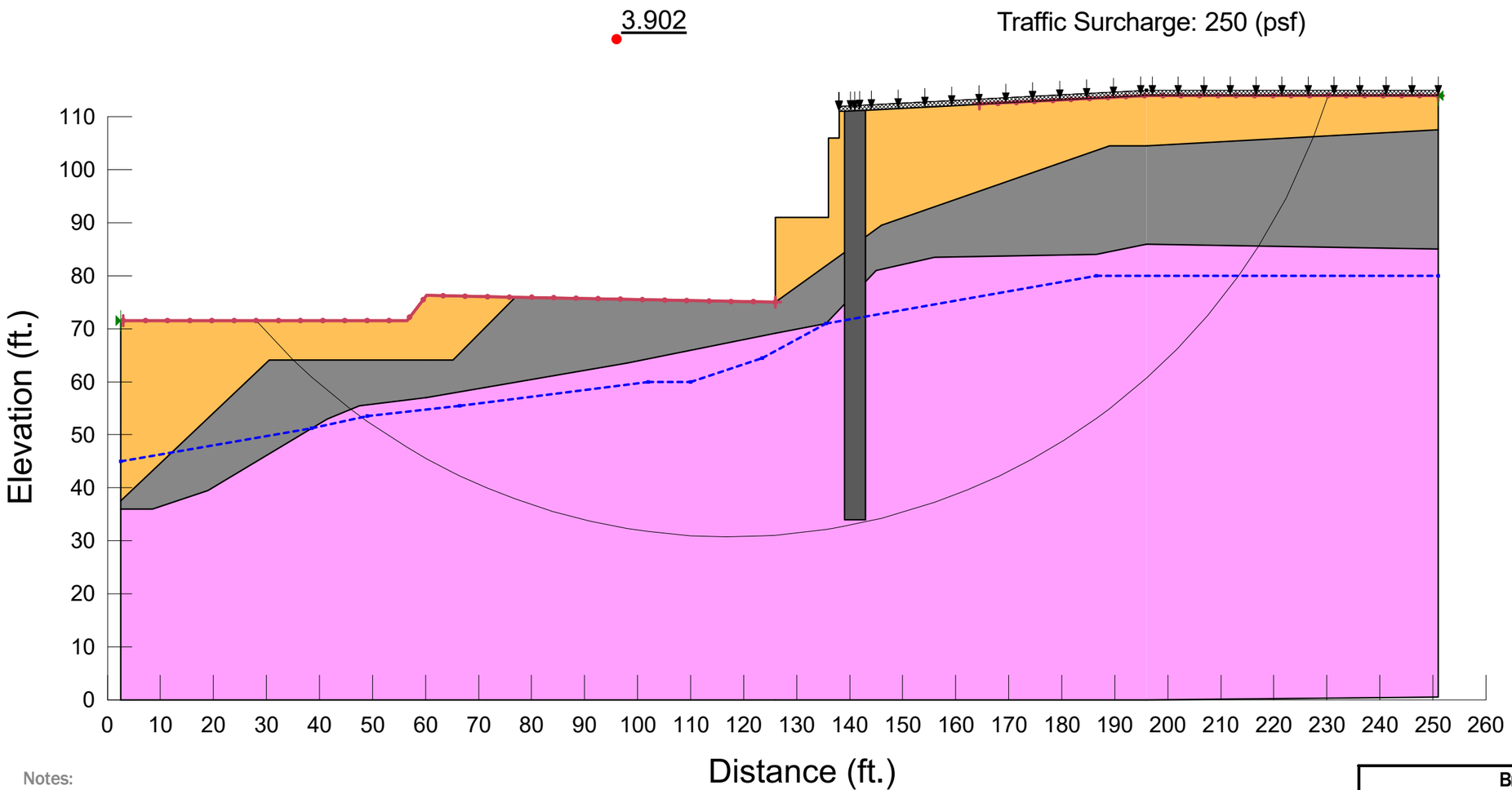
Bridge 17.7 - Pier 3 Section D-D'
Static Global Stability (Spencer) - Final Condition

WSDOT I-405 Renton to Bellevue
King County, Washington

GeoEngineers

Figure D.16-1

Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Concrete 48-in Dia Drilled Shaft	High Strength	150		
	ESU 1B - Existing Silty Granular Fill	Mohr-Coulomb	125	0	38
	ESU 2A - Native Sand and Gravel	Mohr-Coulomb	120	0	39
	ESU 7A - Weathered Sandstone	Mohr-Coulomb	135	0	43



Notes:

1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document.
3. GeoEngineers, Inc. cannot guarantee the accuracy and context of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

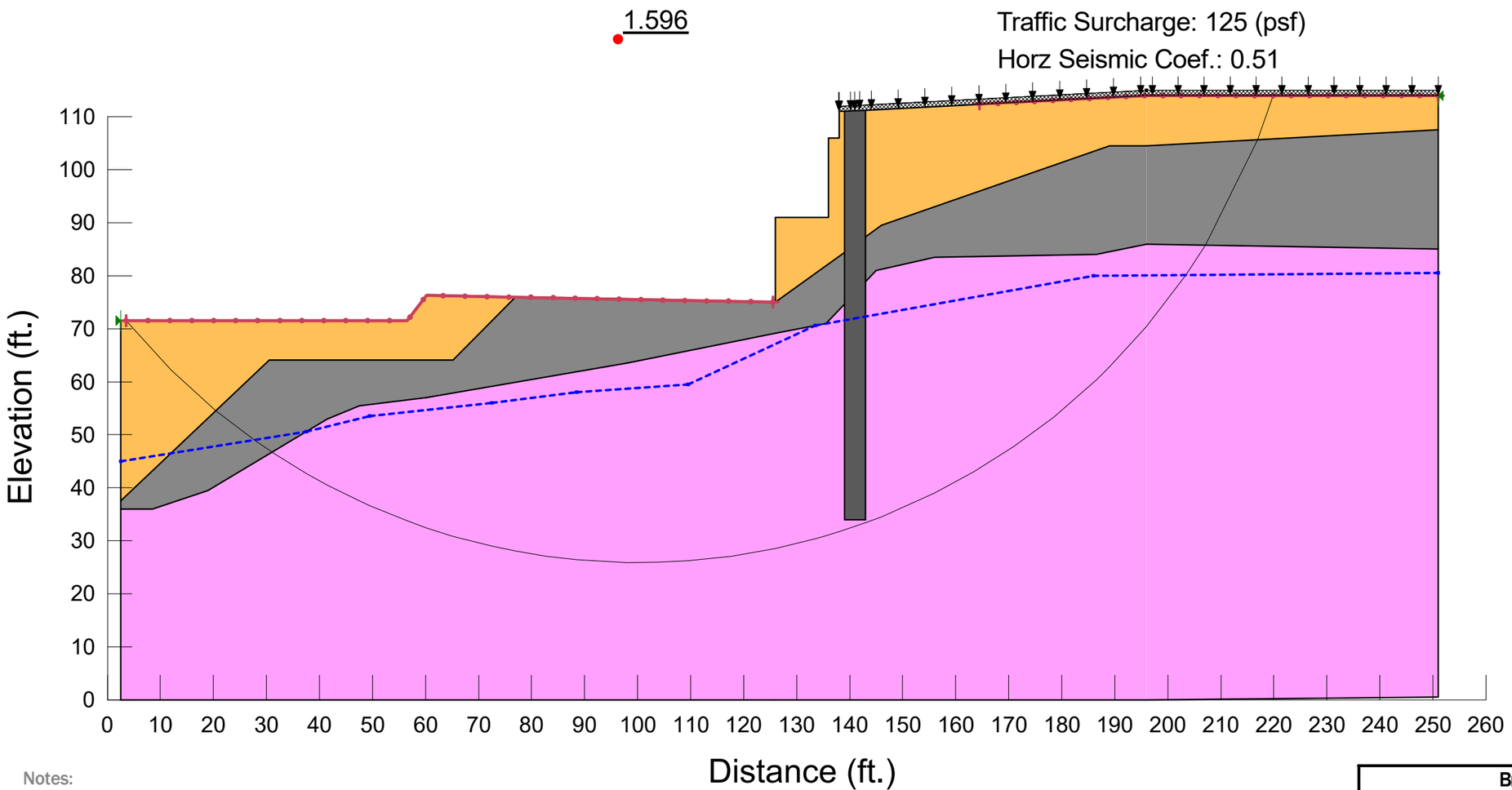
Bridge 17.7 - Pier 3 Section D-D'
Static Global Stability (M-P) - Final Condition

WSDOT I-405 Renton to Bellevue
King County, Washington

GeoEngineers

Figure D.16-2

Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Concrete 48-in Dia Drilled Shaft	High Strength	150		
	ESU 1B - Existing Silty Granular Fill	Mohr-Coulomb	125	0	38
	ESU 2A - Native Sand and Gravel	Mohr-Coulomb	120	0	39
	ESU 7A - Weathered Sandstone	Mohr-Coulomb	135	0	43



Notes:

1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document.
3. GeoEngineers, Inc. cannot guarantee the accuracy and context of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

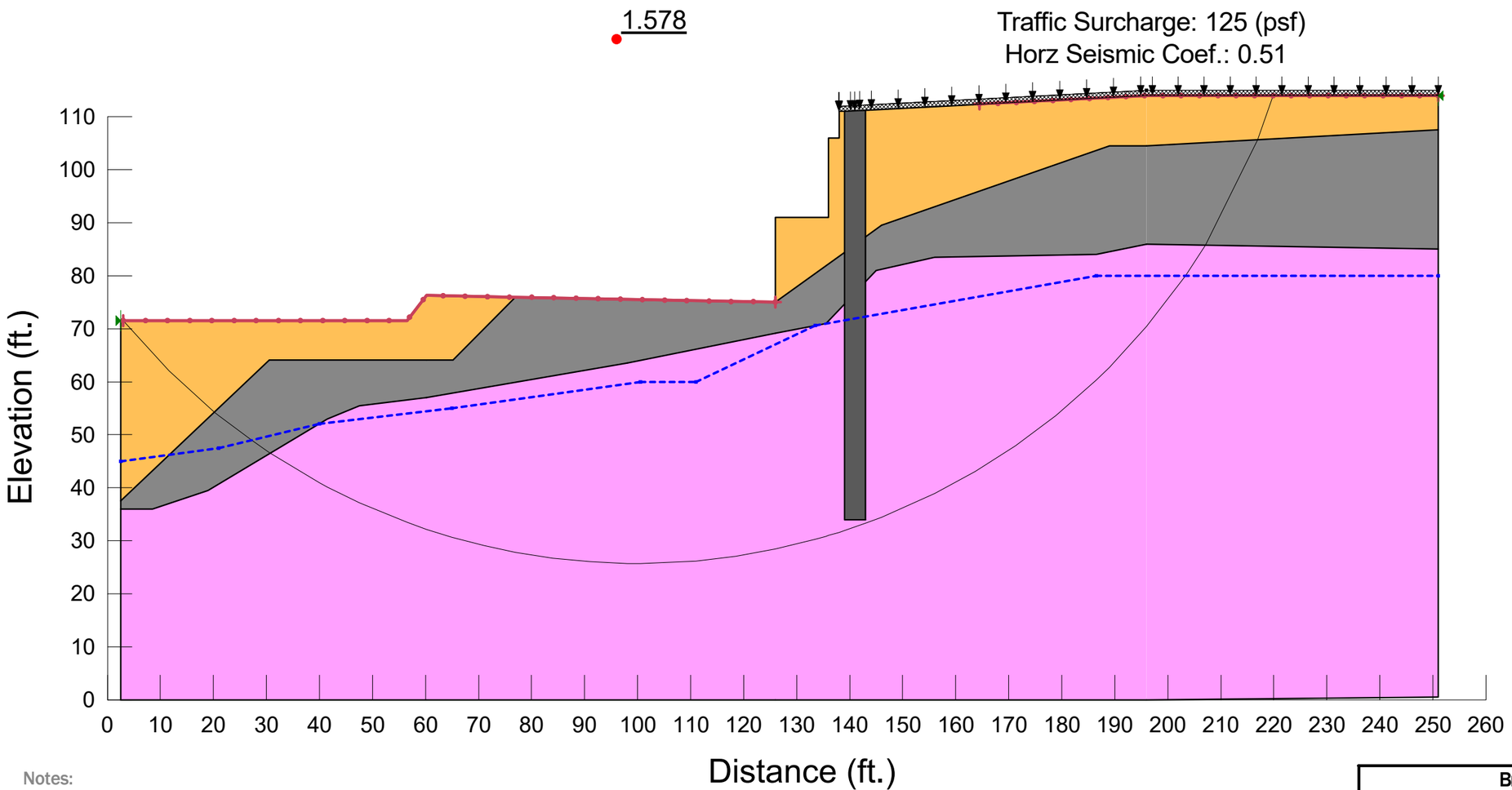
Bridge 17.7 - Pier 3 Section D-D'
Pseudo-Static Global Stability (Spencer) - Final Condition

WSDOT I-405 Renton to Bellevue
King County, Washington

GeoEngineers

Figure D.16-3

Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Concrete 48-in Dia Drilled Shaft	High Strength	150		
	ESU 1B - Existing Silty Granular Fill	Mohr-Coulomb	125	0	38
	ESU 2A - Native Sand and Gravel	Mohr-Coulomb	120	0	39
	ESU 7A - Weathered Sandstone	Mohr-Coulomb	135	0	43



Notes:

1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document.
3. GeoEngineers, Inc. cannot guarantee the accuracy and context of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Bridge 17.7 - Pier 3 Section D-D'
Pseudo-Static Global Stability (M-P) - Final Condition

WSDOT I-405 Renton to Bellevue
King County, Washington

GeoEngineers

Figure D.16-4

1.1 Static - Spencer Final Condition - Global Stability

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File Informa on

File Version: 11.02
Title: Bridge 17.7 Pier 3
Created By: Mikayla S. Hatch
Last Edited By: Valerie R. Yanez
Revision Number: 310
Date: 12/02/2021
Time: 02:52:28 PM
Tool Version: 11.2.2.23310
File Name: Bridge 17.7 D-D' - Pier 3 - All Condi ons.gsz
Directory: \\geoengineers.com\WAN\Projects\0\0180366\01\Analysis\Bridge 17.7\SlopeW\
Last Solved Date: 12/02/2021
Last Solved Time: 03:02:35 PM

Project Se ngs

Unit System: U.S. Customary Units

Analysis Se ngs

1.1 Sta c - Spencer

Descrip on: Spencer Method
Kind: SLOPE/W
Parent: B17.7 Pier 3
Analysis Type: Spencer
Se ngs
PWP Condi ons from: Piezometric Line
Apply Phrea c Correc on: No
Use Staged Rapid Drawdown: No
Unit Weight of Water: 62.4 pcf
Slip Surface
Direc on of movement: Right to Le.
Use Passive Mode: No
Slip Surface Op□on: Entry and Exit
Cri□cal slip surfaces saved: 1
Op□mize Cri□cal Slip Surface Loca□on: No
Tension Crack Op□on: (none)
Distribu□on
F of S Calcula□on Op□on: Constant
Advanced
Geometry Se□ ngs
Minimum Slip Surface Depth: 2 ft
Number of Slices: 30
Factor of Safety Convergence Se□ ngs
Maximum Number of Itera□ons: 100
Tolerable difference in F of S: 0.001

Solu□on Se□ ngs
Search Method: Root Finder
Tolerable difference between star□ng and converged F of S: 3
Maximum itera□ons to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Concrete 48-in Dia Drilled Sha.

Slope Stability Material Model: High Strength
Unit Weight: 150 pcf
Pore Water Pressure
Piezometric Line: 1

ESU 2A - Na□ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 39 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1B - Exis□ng Silty Granular Fill

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 7A - Weathered Sandstone

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 43 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (3, 71.5) ft
Left-Zone Right Coordinate: (124, 75.0392) ft
Left-Zone Increment: 30
Right Type: Range
Right-Zone Left Coordinate: (163.5, 112.31897) ft
Right-Zone Right Coordinate: (251, 114) ft
Right-Zone Increment: 40
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (2.5, 71.5) ft
Right Coordinate: (251, 114) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	2.5 ft	45 ft
Coordinate 2	39 ft	51.5 ft
Coordinate 3	53.5 ft	54 ft
Coordinate 4	72.5 ft	56 ft
Coordinate 5	110 ft	60 ft
Coordinate 6	135 ft	70.90191 ft
Coordinate 7	186.5 ft	80 ft
Coordinate 8	251 ft	80.5 ft

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 250 pcf
Direc□on: Ver□cal

Coordinates

	X	Y
	138 ft	112 ft
	196 ft	115 ft
	251 ft	115 ft

Geometry

Name: Default Geometry

Se□ ngs

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	126 ft	75 ft
Point 2	60.2 ft	76.3 ft
Point 3	60 ft	0 ft
Point 4	60.2 ft	64.1 ft
Point 5	65.2 ft	64.1 ft
Point 6	76.9 ft	75.96236 ft

Figure D.16-7

Point 7	60.2 ft	57 ft
Point 8	98.1 ft	63.5 ft
Point 9	56.5 ft	71.5 ft
Point 10	2.5 ft	71.5 ft
Point 11	2.5 ft	0 ft
Point 12	30.5 ft	64.1 ft
Point 13	2.5 ft	37.5 ft
Point 14	2.5 ft	36 ft
Point 15	8.5 ft	36 ft
Point 16	19 ft	39.5 ft
Point 17	41.5 ft	53 ft
Point 18	47.5 ft	55.5 ft
Point 19	126 ft	0 ft
Point 20	126 ft	69.13637 ft
Point 21	196 ft	114 ft
Point 22	138 ft	111 ft
Point 23	138 ft	106 ft
Point 24	136 ft	106 ft
Point 25	136 ft	91 ft
Point 26	126 ft	91 ft
Point 27	146 ft	89.5 ft
Point 28	189 ft	104.5 ft
Point 29	196 ft	104.5 ft
Point 30	135.5 ft	71 ft
Point 31	145 ft	81 ft
Point 32	156 ft	83.5 ft
Point 33	186.5 ft	84 ft
Point 34	196 ft	86 ft
Point 35	196 ft	0 ft
Point 36	139 ft	111.05172 ft
Point 37	139 ft	34 ft
Point 38	139 ft	84.425 ft
Point 39	139 ft	74.68421 ft
Point 40	143 ft	34 ft
Point 41	143 ft	78.89474 ft
Point 42	143 ft	87.325 ft
Point 43	143 ft	111.25862 ft
Point 44	251 ft	114 ft
Point 45	251 ft	107.5 ft
Point 46	251 ft	85 ft
Point 47	251 ft	0.5 ft

Regions

	Material	Points	Area
Region 1	ESU 2A - Na□ve Sand and Gravel	6,5,4,12,13,14,15,16,17,18,7,8,20,30,39,38,1	1,461.2 ft²
Region 2	ESU 1B - Exis□ng Silty Granular Fill	5,6,2,9,10,13,12,4	939.79 ft²
Region	ESU 7A - Weathered	8,7,18,17,16,15,14,11,3,19,35,34,33,32,31,41,40,37,39,30,20	12,310

3	Sandstone		ft²
Region 4	ESU 1B - Exis□ng Silty Granular Fill	21,43,42,27,28,29	801.62 ft²
Region 5	ESU 1B - Exis□ng Silty Granular Fill	22,23,24,25,26,1,38,36	196.76 ft²
Region 6	ESU 2A - Na□ve Sand and Gravel	31,32,33,34,29,28,27,42,41	741.22 ft²
Region 7	Concrete 48-in Dia Drilled Shaft	42,43,36,38,39,37,40,41	308.62 ft²
Region 8	ESU 1B - Exis□ng Silty Granular Fill	44,21,29,45	440 ft²
Region 9	ESU 2A - Na□ve Sand and Gravel	45,46,34,29	1,127.5 ft²
Region 10	ESU 7A - Weathered Sandstone	34,35,47,46	4,688.8 ft²

Slip Results

Slip Surfaces Analysed: 531 of 6355 converged

Current Slip Surface

Slip Surface: 1,384
Factor of Safety: 3.883
Volume: 8,893.9171 ft³
Weight: 1,155,537 lbf
Resis□ng Moment: 1.1011508e+08 lbf·ft
Ac□va□ng Moment: 28,363,242 lbf·ft
Resis□ng Force: 817,832.93 lbf
Ac□va□ng Force: 210,603.01 lbf
Slip Rank: 1 of 6,355 slip surfaces
Exit: (27.674597, 71.5) ft
Entry: (229.11414, 114) ft
Radius: 117.7951 ft
Center: (116.57209, 148.78468) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Fric□onal Strength	Cohesive Strength	Suc□on Strength	Base Material
Slice 1	31.183782 ft	67.8 ft	-1,103.9764 psf	786.23742 psf	614.276 psf	0 psf	0 psf	ESU 1B - Exis□ng Silty Granular Fill
Slice 2	36.846483 ft	62.118935 ft	-686.55216 psf	1,849.2691 psf	1,497.5086 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 3	42.326581 ft	57.434178 ft	-334.50326 psf	2,581.6633 psf	2,090.5897 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 4	46.576581 ft	54.048222 ft	-77.495482 psf	3,219.6181 psf	3,002.3424 psf	0 psf	0 psf	ESU 7A - Weathered

								Sandstone
Slice 5	47.72428 ft	53.204407 ft	-12.493792 psf	3,362.3873 psf	3,135.4769 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 6	50.72428 ft	51.170433 ft	146.70206 psf	3,635.49 psf	3,253.3474 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 7	55 ft	48.378169 ft	360.6549 psf	3,995.2908 psf	3,389.3528 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 8	58.35 ft	46.406241 ft	505.70738 psf	4,648.0067 psf	3,862.7566 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 9	62.7 ft	44.068017 ft	680.18524 psf	5,304.7242 psf	4,312.4524 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 10	68.85 ft	41.163372 ft	901.83084 psf	5,563.4337 psf	4,347.015 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 11	74.7 ft	38.708009 ft	1,093.6635 psf	5,749.7415 psf	4,341.8631 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 12	80.433333 ft	36.731598 ft	1,255.1525 psf	5,894.0777 psf	4,325.8677 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 13	87.5 ft	34.691716 ft	1,429.4769 psf	6,034.4625 psf	4,294.2185 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 14	94.566667 ft	33.119167 ft	1,574.6397 psf	6,111.606 psf	4,230.7895 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 15	101.075 ft	32.051996 ft	1,684.5506 psf	6,134.3339 psf	4,149.49 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 16	107.025 ft	31.415051 ft	1,763.8992 psf	6,113.1958 psf	4,055.7847 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 17	114 ft	31.085646 ft	1,913.1004 psf	6,032.1611 psf	3,841.0863 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 18	122 ft	31.182853 ft	2,124.724 psf	5,883.2938 psf	3,504.9231 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 19	130.5 ft	31.903708 ft	2,311.0376 psf	7,633.2157 psf	4,963.0114 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 20	135.25 ft	32.480091 ft	2,400.2775 psf	7,453.6164 psf	4,712.3148 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 21	135.75 ft	32.561492 ft	2,400.7099 psf	7,435.4135 psf	4,694.9371 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 22	137 ft	32.778838 ft	2,400.9271 psf	9,212.6914 psf	6,352.0729 psf	0 psf	0 psf	ESU 7A - Weathered

								Sandstone
Slice 23	138.5 ft	33.049665 ft	2,400.5631 psf	10,001.594 psf	7,088.0759 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 24	141 ft	33.568434 ft	2,395.7511 psf	11,383.269 psf	8,380.9959 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 25	144 ft	34.231904 ft	2,387.4217 psf	9,785.9064 psf	6,899.1986 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 26	145.5 ft	34.598009 ft	2,381.1124 psf	9,716.1465 psf	6,840.03 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 27	151 ft	36.254395 ft	2,338.3842 psf	9,388.3827 psf	6,574.23 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 28	159.05 ft	38.963831 ft	2,258.0563 psf	8,875.9882 psf	6,171.3213 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 29	165.15 ft	41.524892 ft	2,165.4906 psf	8,420.5878 psf	5,832.9724 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 30	171.25 ft	44.505477 ft	2,046.7467 psf	7,920.6604 psf	5,477.5131 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 31	177.35 ft	47.942972 ft	1,899.4917 psf	7,372.8411 psf	5,103.9809 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 32	183.45 ft	51.886292 ft	1,720.673 psf	6,772.8255 psf	4,711.2084 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 33	187.75 ft	54.939435 ft	1,564.3839 psf	6,325.2057 psf	4,439.5381 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 34	192.5 ft	58.842149 ft	1,323.1522 psf	5,780.6449 psf	4,156.6791 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 35	200.0855 ft	65.913969 ft	885.53995 psf	4,799.8168 psf	3,650.1222 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 36	208.25649 ft	75.115737 ft	315.30206 psf	3,566.63 psf	3,031.9124 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 37	214.17613 ft	82.918251 ft	-168.71135 psf	2,615.9904 psf	2,439.4505 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 38	218.60364 ft	90.148851 ft	-617.75912 psf	1,962.9607 psf	1,589.5743 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 39	223.79035 ft	100.40941 ft	-1,255.509 psf	1,078.1209 psf	873.04512 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 40	227.74893 ft	110.07865 ft	-1,856.9546 psf	369.54176 psf	288.71767 psf	0 psf	0 psf	ESU 1B - Exis□ng

								Silty Granular Fill

Figure D.16-12

1.2 Static - M-P Final Condition - Global Stability

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File Informa on

File Version: 11.02
Title: Bridge 17.7 Pier 3
Created By: Mikayla S. Hatch
Last Edited By: Valerie R. Yanez
Revision Number: 310
Date: 12/02/2021
Time: 02:52:28 PM
Tool Version: 11.2.2.23310
File Name: Bridge 17.7 D-D' - Pier 3 - All Condi ons.gsz
Directory: \\geoengineers.com\WAN\Projects\0\0180366\01\Analysis\Bridge 17.7\SlopeW\
Last Solved Date: 12/02/2021
Last Solved Time: 03:02:36 PM

Project Se ngs

Unit System: U.S. Customary Units

Analysis Se ngs

1.2 Sta c - M-P

Descrip on: MP Method
Kind: SLOPE/W
Parent: B17.7 Pier 3
Analysis Type: Morgenstern-Price
Se ngs
Side Func on
Interslice force func on op on: Half-Sine
PWP Condi ons from: Piezometric Line
Apply Phrea c Correc on: No
Use Staged Rapid Drawdown: No
Unit Weight of Water: 62.4 pcf
Slip Surface
Direc on of movement: Right to Le.
Use Passive Mode: No
Slip Surface Op□on: Entry and Exit
Cri□cal slip surfaces saved: 1
Op□mize Cri□cal Slip Surface Loca□on: No
Tension Crack Op□on: (none)
Distribu□on
F of S Calcula□on Op□on: Constant
Advanced
Geometry Se□ ngs
Minimum Slip Surface Depth: 2 ft
Number of Slices: 30
Factor of Safety Convergence Se□ ngs

Maximum Number of Itera□ons: 100
Tolerable difference in F of S: 0.001
Solu□on Se□ ngs
Search Method: Root Finder
Tolerable difference between star□ng and converged F of S: 3
Maximum itera□ons to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Concrete 48-in Dia Drilled Sha.

Slope Stability Material Model: High Strength
Unit Weight: 150 pcf
Pore Water Pressure
Piezometric Line: 1

ESU 2A - Na□ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 39 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1B - Exis□ng Silty Granular Fill

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 7A - Weathered Sandstone

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 43 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (3, 71.5) ft
Left-Zone Right Coordinate: (126, 75) ft
Left-Zone Increment: 30
Right Type: Range
Right-Zone Left Coordinate: (164.5, 112.37069) ft
Right-Zone Right Coordinate: (251, 114) ft

Right-Zone Increment: 25
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (2.5, 71.5) ft
Right Coordinate: (251, 114) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	2.5 ft	45 ft
Coordinate 2	38.5 ft	51.2 ft
Coordinate 3	49 ft	53.5 ft
Coordinate 4	66.5 ft	55.5 ft
Coordinate 5	102 ft	60 ft
Coordinate 6	110 ft	60 ft
Coordinate 7	123.5 ft	64.5 ft
Coordinate 8	135.5 ft	71 ft
Coordinate 9	186.5 ft	80 ft
Coordinate 10	251 ft	80 ft

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 250 pcf
Direc□on: Ver□cal

Coordinates

	X	Y
	138 ft	112 ft
	196 ft	115 ft
	251 ft	115 ft

Geometry

Name: Default Geometry

Se□ ngs

View: 2D
Element Thickness: 1 ft

Points

	X	Y

Point 1	126 ft	75 ft
Point 2	60.2 ft	76.3 ft
Point 3	60 ft	0 ft
Point 4	60.2 ft	64.1 ft
Point 5	65.2 ft	64.1 ft
Point 6	76.9 ft	75.96236 ft
Point 7	60.2 ft	57 ft
Point 8	98.1 ft	63.5 ft
Point 9	56.5 ft	71.5 ft
Point 10	2.5 ft	71.5 ft
Point 11	2.5 ft	0 ft
Point 12	30.5 ft	64.1 ft
Point 13	2.5 ft	37.5 ft
Point 14	2.5 ft	36 ft
Point 15	8.5 ft	36 ft
Point 16	19 ft	39.5 ft
Point 17	41.5 ft	53 ft
Point 18	47.5 ft	55.5 ft
Point 19	126 ft	0 ft
Point 20	126 ft	69.13637 ft
Point 21	196 ft	114 ft
Point 22	138 ft	111 ft
Point 23	138 ft	106 ft
Point 24	136 ft	106 ft
Point 25	136 ft	91 ft
Point 26	126 ft	91 ft
Point 27	146 ft	89.5 ft
Point 28	189 ft	104.5 ft
Point 29	196 ft	104.5 ft
Point 30	135.5 ft	71 ft
Point 31	145 ft	81 ft
Point 32	156 ft	83.5 ft
Point 33	186.5 ft	84 ft
Point 34	196 ft	86 ft
Point 35	196 ft	0 ft
Point 36	139 ft	111.05172 ft
Point 37	139 ft	34 ft
Point 38	139 ft	84.425 ft
Point 39	139 ft	74.68421 ft
Point 40	143 ft	34 ft
Point 41	143 ft	78.89474 ft
Point 42	143 ft	87.325 ft
Point 43	143 ft	111.25862 ft
Point 44	251 ft	114 ft
Point 45	251 ft	107.5 ft
Point 46	251 ft	85 ft
Point 47	251 ft	0.5 ft

Regions

Figure D.16-16

	Material	Points	Area
Region 1	ESU 2A - Na□ve Sand and Gravel	6,5,4,12,13,14,15,16,17,18,7,8,20,30,39,38,1	1,461.2 ft²
Region 2	ESU 1B - Exis□ng Silty Granular Fill	5,6,2,9,10,13,12,4	939.79 ft²
Region 3	ESU 7A - Weathered Sandstone	8,7,18,17,16,15,14,11,3,19,35,34,33,32,31,41,40,37,39,30,20	12,310 ft²
Region 4	ESU 1B - Exis□ng Silty Granular Fill	21,43,42,27,28,29	801.62 ft²
Region 5	ESU 1B - Exis□ng Silty Granular Fill	22,23,24,25,26,1,38,36	196.76 ft²
Region 6	ESU 2A - Na□ve Sand and Gravel	31,32,33,34,29,28,27,42,41	741.22 ft²
Region 7	Concrete 48-in Dia Drilled Shaft	42,43,36,38,39,37,40,41	308.62 ft²
Region 8	ESU 1B - Exis□ng Silty Granular Fill	44,21,29,45	440 ft²
Region 9	ESU 2A - Na□ve Sand and Gravel	45,46,34,29	1,127.5 ft²
Region 10	ESU 7A - Weathered Sandstone	34,35,47,46	4,688.8 ft²

Slip Results

Slip Surfaces Analysed: 341 of 4030 converged

Current Slip Surface

Slip Surface: 879
Factor of Safety: 3.902
Volume: 8,994.986 ft³
Weight: 1,168,829.1 lbf
Resis□ng Moment: 1.1166982e+08 lbf·ft
Ac□va□ng Moment: 28,620,770 lbf·ft
Resis□ng Force: 826,805.4 lbf
Ac□va□ng Force: 211,907.24 lbf
Slip Rank: 1 of 4,030 slip surfaces
Exit: (28.074674, 71.5) ft
Entry: (230.22989, 114) ft
Radius: 118.15384 ft
Center: (117.34778, 148.89924) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Fric□onal Strength	Cohesive Strength	Suc□on Strength	Base Material
Slice 1	31.572989 ft	67.8 ft	-1,110.2823 psf	609.21707 psf	475.97254 psf	0 psf	0 psf	ESU 1B - Exis□ng Silty Granular Fill
Slice 2	36.785652 ft	62.501446 ft	-723.63375 psf	1,478.2879 psf	1,197.094 psf	0 psf	0 psf	ESU 2A - Na□ve Sand

								and Gravel
Slice 3	42.183848 ft	57.861382 ft	-365.31733 psf	2,224.043 psf	1,800.9945 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 4	46.683848 ft	54.210797 ft	-76.012199 psf	2,916.7574 psf	2,719.9203 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 5	47.726864 ft	53.436268 ft	-13.425092 psf	3,065.4608 psf	2,858.5885 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 6	48.476864 ft	52.895531 ft	30.568352 psf	3,158.3967 psf	2,916.7472 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 7	52.75 ft	50.069153 ft	240.82772 psf	3,633.0348 psf	3,163.2843 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 8	58.35 ft	46.551637 ft	500.25671 psf	4,598.4435 psf	3,821.621 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 9	62.7 ft	44.18058 ft	679.23236 psf	5,356.4326 psf	4,361.5598 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 10	65.85 ft	42.561163 ft	802.74802 psf	5,598.362 psf	4,471.9824 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 11	69.1 ft	41.08288 ft	920.19395 psf	5,791.4503 psf	4,542.5201 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 12	74.3 ft	38.901863 ft	1,097.4206 psf	6,053.2012 psf	4,621.3401 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 13	80.433333 ft	36.721627 ft	1,281.9812 psf	6,292.3683 psf	4,672.2616 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 14	87.5 ft	34.635934 ft	1,468.0248 psf	6,482.0727 psf	4,675.6754 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 15	94.566667 ft	33.018338 ft	1,624.8591 psf	6,562.5057 psf	4,604.43 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 16	100.05 ft	32.035086 ft	1,729.5864 psf	6,564.295 psf	4,508.4387 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 17	106 ft	31.360276 ft	1,787.1188 psf	6,494.5152 psf	4,389.7182 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 18	113.375 ft	30.860505 ft	1,888.5045 psf	6,341.4051 psf	4,152.397 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 19	120.125 ft	30.826299 ft	2,031.039 psf	6,131.1819 psf	3,823.4451 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 20	124.75 ft	30.984153 ft	2,133.6389 psf	5,963.7158 psf	3,571.6045 psf	0 psf	0 psf	ESU 7A - Weathered

								Sandstone
Slice 21	130.75 ft	31.605367 ft	2,297.6751 psf	7,687.1727 psf	5,025.7879 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 22	135.75 ft	32.187529 ft	2,424.6511 psf	7,423.8213 psf	4,661.8016 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 23	137 ft	32.395631 ft	2,425.4303 psf	9,195.0268 psf	6,312.7509 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 24	138.5 ft	32.655296 ft	2,425.7448 psf	9,966.5691 psf	7,031.9324 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 25	141 ft	33.154976 ft	2,422.0942 psf	11,318.748 psf	8,296.2639 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 26	144 ft	33.795223 ft	2,415.1781 psf	9,673.6194 psf	6,768.606 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 27	145.5 ft	34.14944 ft	2,409.5926 psf	9,584.8762 psf	6,691.0602 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 28	151 ft	35.759302 ft	2,369.7019 psf	9,199.3323 psf	6,368.7334 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 29	159.05 ft	38.397536 ft	2,293.7208 psf	8,630.4078 psf	5,909.0562 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 30	165.15 ft	40.898537 ft	2,204.8301 psf	8,161.9482 psf	5,555.1024 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 31	171.25 ft	43.812944 ft	2,090.1429 psf	7,675.3129 psf	5,208.2553 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 32	177.35 ft	47.176463 ft	1,947.4311 psf	7,167.125 psf	4,867.4433 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 33	183.45 ft	51.035668 ft	1,773.7885 psf	6,631.7046 psf	4,530.0801 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 34	187.75 ft	54.023355 ft	1,620.9426 psf	6,242.0303 psf	4,309.2339 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 35	192.5 ft	57.839486 ft	1,382.8161 psf	5,774.5513 psf	4,095.3593 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 36	198.88889 ft	63.48598 ft	1,030.4749 psf	5,085.2149 psf	3,781.1063 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 37	204.66666 ft	69.417646 ft	660.33892 psf	4,356.8993 psf	3,447.0983 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 38	210.44443 ft	76.295695 ft	231.14861 psf	3,527.4981 psf	3,073.8956 psf	0 psf	0 psf	ESU 7A - Weathered

								Sandstone
Slice 39	215.2293 ft	82.807952 ft	-175.21621 psf	2,790.2455 psf	2,601.9461 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 40	219.72492 ft	90.145749 ft	-633.09475 psf	2,171.1926 psf	1,758.1971 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 41	224.92421 ft	100.44754 ft	-1,275.9264 psf	1,258.808 psf	1,019.3626 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 42	228.87687 ft	110.10974 ft	-1,878.8479 psf	460.25966 psf	359.59425 psf	0 psf	0 psf	ESU 1B - Exis□ng Silty Granular Fill

1.3 Pseudo-Static - Spencer Final Condition - Global Stability

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File Informa on

File Version: 11.02
Title: Bridge 17.7 Pier 3
Created By: Mikayla S. Hatch
Last Edited By: Valerie R. Yanez
Revision Number: 310
Date: 12/02/2021
Time: 02:52:28 PM
Tool Version: 11.2.2.23310
File Name: Bridge 17.7 D-D' - Pier 3 - All Condi ons.gsz
Directory: \\geoengineers.com\WAN\Projects\0\0180366\01\Analysis\Bridge 17.7\SlopeW\
Last Solved Date: 12/02/2021
Last Solved Time: 03:02:37 PM

Project Se ngs

Unit System: U.S. Customary Units

Analysis Se ngs

1.3 Pseudo-Sta c - Spencer

Descrip on: Spencer Method
Kind: SLOPE/W
Parent: B17.7 Pier 3
Analysis Type: Spencer
Se ngs
PWP Condi ons from: Piezometric Line
Apply Phrea c Correc on: No
Use Staged Rapid Drawdown: No
Unit Weight of Water: 62.4 pcf
Slip Surface
Direc on of movement: Right to Le.
Use Passive Mode: No
Slip Surface Op on: Entry and Exit
Cri cal slip surfaces saved: 1
Op mize Cri cal Slip Surface Loca on: No
Tension Crack Op on: (none)
Distribu on
F of S Calcula on Op on: Constant
Advanced
Geometry Se ngs
Minimum Slip Surface Depth: 2 ft
Number of Slices: 30
Factor of Safety Convergence Se ngs
Maximum Number of Itera ons: 100
Tolerable difference in F of S: 0.001

Solu□on Se□ ngs
Search Method: Root Finder
Tolerable difference between star□ng and converged F of S: 3
Maximum itera□ons to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Concrete 48-in Dia Drilled Sha.

Slope Stability Material Model: High Strength
Unit Weight: 150 pcf
Pore Water Pressure
Piezometric Line: 1

ESU 2A - Na□ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 39 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1B - Exis□ng Silty Granular Fill

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 7A - Weathered Sandstone

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 43 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (3.5, 71.5) ft
Left-Zone Right Coordinate: (125.5, 75.0098) ft
Left-Zone Increment: 30
Right Type: Range
Right-Zone Left Coordinate: (164.5, 112.37069) ft
Right-Zone Right Coordinate: (251, 114) ft
Right-Zone Increment: 25
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (2.5, 71.5) ft
Right Coordinate: (251, 114) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	2.5 ft	45 ft
Coordinate 2	37.5 ft	50.6 ft
Coordinate 3	49.5 ft	53.5 ft
Coordinate 4	72.5 ft	56 ft
Coordinate 5	88.5 ft	58 ft
Coordinate 6	109.5 ft	59.5 ft
Coordinate 7	133.5 ft	70.60766 ft
Coordinate 8	186 ft	80 ft
Coordinate 9	251 ft	80.5 ft

Seismic Coefficients

Horz Seismic Coef.: 0.51

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 125 pcf
Direc□on: Ver□cal

Coordinates

	X	Y
	138 ft	112 ft
	196 ft	115 ft
	251 ft	115 ft

Geometry

Name: Default Geometry

Se□ ngs

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	126 ft	75 ft

Point 2	60.2 ft	76.3 ft
Point 3	60 ft	0 ft
Point 4	60.2 ft	64.1 ft
Point 5	65.2 ft	64.1 ft
Point 6	76.9 ft	75.96236 ft
Point 7	60.2 ft	57 ft
Point 8	98.1 ft	63.5 ft
Point 9	56.5 ft	71.5 ft
Point 10	2.5 ft	71.5 ft
Point 11	2.5 ft	0 ft
Point 12	30.5 ft	64.1 ft
Point 13	2.5 ft	37.5 ft
Point 14	2.5 ft	36 ft
Point 15	8.5 ft	36 ft
Point 16	19 ft	39.5 ft
Point 17	41.5 ft	53 ft
Point 18	47.5 ft	55.5 ft
Point 19	126 ft	0 ft
Point 20	126 ft	69.13637 ft
Point 21	196 ft	114 ft
Point 22	138 ft	111 ft
Point 23	138 ft	106 ft
Point 24	136 ft	106 ft
Point 25	136 ft	91 ft
Point 26	126 ft	91 ft
Point 27	146 ft	89.5 ft
Point 28	189 ft	104.5 ft
Point 29	196 ft	104.5 ft
Point 30	135.5 ft	71 ft
Point 31	145 ft	81 ft
Point 32	156 ft	83.5 ft
Point 33	186.5 ft	84 ft
Point 34	196 ft	86 ft
Point 35	196 ft	0 ft
Point 36	139 ft	111.05172 ft
Point 37	139 ft	34 ft
Point 38	139 ft	84.425 ft
Point 39	139 ft	74.68421 ft
Point 40	143 ft	34 ft
Point 41	143 ft	78.89474 ft
Point 42	143 ft	87.325 ft
Point 43	143 ft	111.25862 ft
Point 44	251 ft	114 ft
Point 45	251 ft	107.5 ft
Point 46	251 ft	85 ft
Point 47	251 ft	0.5 ft

Regions

	Material	Points	Area

Region 1	ESU 2A - Na□ve Sand and Gravel	6,5,4,12,13,14,15,16,17,18,7,8,20,30,39,38,1	1,461.2 ft²
Region 2	ESU 1B - Exis□ng Silty Granular Fill	5,6,2,9,10,13,12,4	939.79 ft²
Region 3	ESU 7A - Weathered Sandstone	8,7,18,17,16,15,14,11,3,19,35,34,33,32,31,41,40,37,39,30,20	12,310 ft²
Region 4	ESU 1B - Exis□ng Silty Granular Fill	21,43,42,27,28,29	801.62 ft²
Region 5	ESU 1B - Exis□ng Silty Granular Fill	22,23,24,25,26,1,38,36	196.76 ft²
Region 6	ESU 2A - Na□ve Sand and Gravel	31,32,33,34,29,28,27,42,41	741.22 ft²
Region 7	Concrete 48-in Dia Drilled Shaft	42,43,36,38,39,37,40,41	308.62 ft²
Region 8	ESU 1B - Exis□ng Silty Granular Fill	44,21,29,45	440 ft²
Region 9	ESU 2A - Na□ve Sand and Gravel	45,46,34,29	1,127.5 ft²
Region 10	ESU 7A - Weathered Sandstone	34,35,47,46	4,688.8 ft²

Slip Results

Slip Surfaces Analysed: 76 of 4030 converged

Current Slip Surface

Slip Surface: 84
Factor of Safety: 1.596
Volume: 9,641.2255 ft³
Weight: 1,253,733 lbf
Resis□ng Moment: 1.3470232e+08 lbf·ft
Ac□va□ng Moment: 84,413,745 lbf·ft
Resis□ng Force: 925,712.19 lbf
Ac□va□ng Force: 580,006.07 lbf
Slip Rank: 1 of 4,030 slip surfaces
Exit: (3.5, 71.5) ft
Entry: (219.84484, 114) ft
Radius: 125.29128 ft
Center: (100.19531, 151.17385) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Fric□onal Strength	Cohesive Strength	Suc□on Strength	Base Material
Slice 1	7.7353828 ft	66.855651 ft	-1,311.5225 psf	8,504.4022 psf	6,644.3672 psf	0 psf	0 psf	ESU 1B - Exis□ng Silty Granular Fill
Slice 2	16.206148 ft	58.377878 ft	-697.93739 psf	7,215.8729 psf	5,637.6578 psf	0 psf	0 psf	ESU 1B - Exis□ng Silty

								Granular Fill
Slice 3	24.044383 ft	51.784006 ft	-208.22286 psf	7,459.3423 psf	6,040.4563 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 4	29.073618 ft	48.039917 ft	75.620172 psf	7,153.1092 psf	5,731.2376 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 5	30.759235 ft	46.883679 ft	164.59863 psf	6,996.1864 psf	5,532.1107 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 6	34.259235 ft	44.704095 ft	335.54867 psf	8,236.5319 psf	7,367.786 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 7	39.5 ft	41.589373 ft	592.42313 psf	7,827.5676 psf	6,746.8814 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 8	44.5 ft	38.992214 ft	829.88583 psf	7,534.6761 psf	6,252.3181 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 9	48.5 ft	37.049816 ft	1,011.4115 psf	7,354.3876 psf	5,914.9209 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 10	53 ft	35.172857 ft	1,167.3528 psf	7,173.8056 psf	5,601.1079 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 11	58.35 ft	33.093271 ft	1,333.406 psf	7,486.5982 psf	5,737.9446 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 12	62.7 ft	31.653383 ft	1,452.7593 psf	7,773.7909 psf	5,894.4573 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 13	68.85 ft	29.925493 ft	1,602.2927 psf	7,501.2937 psf	5,500.9074 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 14	74.7 ft	28.524572 ft	1,731.6267 psf	7,251.6062 psf	5,147.4641 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 15	79.8 ft	27.588666 ft	1,829.8072 psf	7,052.6634 psf	4,870.3922 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 16	85.6 ft	26.769845 ft	1,926.1417 psf	6,845.0969 psf	4,587 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 17	93.3 ft	26.164851 ft	2,007.9076 psf	6,558.3249 psf	4,243.3328 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 18	100.95 ft	25.917261 ft	2,057.4543 psf	6,276.039 psf	3,933.8938 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 19	106.65 ft	26.081491 ft	2,072.6121 psf	6,048.217 psf	3,707.3115 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice	113.625 ft	26.673508	2,167.5027	5,738.1006	3,329.6364	0 psf	0 psf	ESU 7A -

20		ft	psf	psf	psf			Weathered Sandstone
Slice 21	121.875 ft	27.843582 ft	2,332.7494 psf	5,355.2454 psf	2,818.5231 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 22	129.75 ft	29.479422 ft	2,458.1023 psf	6,621.3813 psf	3,882.3204 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 23	134.5 ft	30.674835 ft	2,502.9717 psf	6,332.0407 psf	3,570.6646 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 24	135.75 ft	31.03351 ft	2,494.5448 psf	6,255.8696 psf	3,507.4921 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 25	137 ft	31.414818 ft	2,484.7055 psf	7,658.2751 psf	4,824.4317 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 26	138.5 ft	31.882692 ft	2,472.2553 psf	8,160.7233 psf	5,304.5822 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 27	141 ft	32.73227 ft	2,447.1503 psf	9,175.5835 psf	6,274.3654 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 28	144 ft	33.794486 ft	2,414.3585 psf	7,798.6057 psf	5,020.8917 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 29	145.5 ft	34.361596 ft	2,395.716 psf	7,692.758 psf	4,939.5715 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 30	151 ft	36.776044 ft	2,306.4535 psf	7,251.1802 psf	4,611.0322 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 31	159.75 ft	41.024084 ft	2,139.0561 psf	6,535.755 psf	4,099.988 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 32	167.25 ft	45.429551 ft	1,947.881 psf	5,868.1281 psf	3,655.6896 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 33	174.75 ft	50.586995 ft	1,709.7825 psf	5,157.7102 psf	3,215.2446 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 34	182.25 ft	56.620795 ft	1,416.9994 psf	4,396.3535 psf	2,778.2927 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 35	186.25 ft	60.111359 ft	1,241.1712 psf	3,980.203 psf	2,554.1885 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 36	187.75 ft	61.569011 ft	1,150.9337 psf	3,810.5812 psf	2,480.1613 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 37	192.5 ft	66.610833 ft	838.60404 psf	3,247.3432 psf	2,246.1856 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice	199.70004	75.282551	300.94485	2,318.7458	1,881.6298	0 psf	0 psf	ESU 7A -

38	ft	ft	psf	psf	psf			Weathered Sandstone
Slice 39	205.2392 ft	82.966211 ft	-175.85677 psf	1,602.7629 psf	1,494.6006 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 40	211.99921 ft	95.719836 ft	-968.43813 psf	858.45626 psf	695.16417 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 41	218.38246 ft	109.82055 ft	-1,845.2586 psf	192.58176 psf	150.46136 psf	0 psf	0 psf	ESU 1B - Exis□ng Silty Granular Fill

1.4 Pseudo-Static - M-P Final Condition - Global Stability

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File Informa on

File Version: 11.02
Title: Bridge 17.7 Pier 3
Created By: Mikayla S. Hatch
Last Edited By: Valerie R. Yanez
Revision Number: 310
Date: 12/02/2021
Time: 02:52:28 PM
Tool Version: 11.2.2.23310
File Name: Bridge 17.7 D-D' - Pier 3 - All Condi ons.gsz
Directory: \\geoengineers.com\WAN\Projects\0\0180366\01\Analysis\Bridge 17.7\SlopeW\
Last Solved Date: 12/02/2021
Last Solved Time: 03:02:37 PM

Project Se ngs

Unit System: U.S. Customary Units

Analysis Se ngs

1.4 Pseudo-Sta c - M-P

Descrip on: MP Method
Kind: SLOPE/W
Parent: B17.7 Pier 3
Analysis Type: Morgenstern-Price
Se ngs
Side Func on
Interslice force func on op on: Half-Sine
PWP Condi ons from: Piezometric Line
Apply Phrea c Correc on: No
Use Staged Rapid Drawdown: No
Unit Weight of Water: 62.4 pcf
Slip Surface
Direc on of movement: Right to Le.
Use Passive Mode: No
Slip Surface Op on: Entry and Exit
Cri cal slip surfaces saved: 1
Op mize Cri cal Slip Surface Loca on: No
Tension Crack Op on: (none)
Distribu on
F of S Calcula on Op on: Constant
Advanced
Geometry Se ngs
Minimum Slip Surface Depth: 2 ft
Number of Slices: 30
Factor of Safety Convergence Se ngs

Maximum Number of Itera□ons: 100
Tolerable difference in F of S: 0.001
Solu□on Se□ ngs
Search Method: Root Finder
Tolerable difference between star□ng and converged F of S: 3
Maximum itera□ons to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Concrete 48-in Dia Drilled Sha.

Slope Stability Material Model: High Strength
Unit Weight: 150 pcf
Pore Water Pressure
Piezometric Line: 1

ESU 2A - Na□ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 39 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1B - Exis□ng Silty Granular Fill

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 7A - Weathered Sandstone

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 43 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (3, 71.5) ft
Left-Zone Right Coordinate: (126, 75) ft
Left-Zone Increment: 30
Right Type: Range
Right-Zone Left Coordinate: (164.5, 112.37069) ft
Right-Zone Right Coordinate: (251, 114) ft

Right-Zone Increment: 25
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (2.5, 71.5) ft
Right Coordinate: (251, 114) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	2.5 ft	45 ft
Coordinate 2	21 ft	47.5 ft
Coordinate 3	40 ft	52.1 ft
Coordinate 4	65 ft	55 ft
Coordinate 5	100.5 ft	60 ft
Coordinate 6	111 ft	60 ft
Coordinate 7	133.5 ft	70.60766 ft
Coordinate 8	186.5 ft	80 ft
Coordinate 9	251 ft	80 ft

Seismic Coefficients

Horz Seismic Coef.: 0.51

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 125 pcf
Direc□on: Ver□cal

Coordinates

	X	Y
	138 ft	112 ft
	196 ft	115 ft
	251 ft	115 ft

Geometry

Name: Default Geometry

Se□ ngs

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	126 ft	75 ft
Point 2	60.2 ft	76.3 ft
Point 3	60 ft	0 ft
Point 4	60.2 ft	64.1 ft
Point 5	65.2 ft	64.1 ft
Point 6	76.9 ft	75.96236 ft
Point 7	60.2 ft	57 ft
Point 8	98.1 ft	63.5 ft
Point 9	56.5 ft	71.5 ft
Point 10	2.5 ft	71.5 ft
Point 11	2.5 ft	0 ft
Point 12	30.5 ft	64.1 ft
Point 13	2.5 ft	37.5 ft
Point 14	2.5 ft	36 ft
Point 15	8.5 ft	36 ft
Point 16	19 ft	39.5 ft
Point 17	41.5 ft	53 ft
Point 18	47.5 ft	55.5 ft
Point 19	126 ft	0 ft
Point 20	126 ft	69.13637 ft
Point 21	196 ft	114 ft
Point 22	138 ft	111 ft
Point 23	138 ft	106 ft
Point 24	136 ft	106 ft
Point 25	136 ft	91 ft
Point 26	126 ft	91 ft
Point 27	146 ft	89.5 ft
Point 28	189 ft	104.5 ft
Point 29	196 ft	104.5 ft
Point 30	135.5 ft	71 ft
Point 31	145 ft	81 ft
Point 32	156 ft	83.5 ft
Point 33	186.5 ft	84 ft
Point 34	196 ft	86 ft
Point 35	196 ft	0 ft
Point 36	139 ft	111.05172 ft
Point 37	139 ft	34 ft
Point 38	139 ft	84.425 ft
Point 39	139 ft	74.68421 ft
Point 40	143 ft	34 ft
Point 41	143 ft	78.89474 ft
Point 42	143 ft	87.325 ft
Point 43	143 ft	111.25862 ft
Point 44	251 ft	114 ft
Point 45	251 ft	107.5 ft
Point 46	251 ft	85 ft

Point 47	251 ft	0.5 ft

Regions

	Material	Points	Area
Region 1	ESU 2A - Na□ve Sand and Gravel	6,5,4,12,13,14,15,16,17,18,7,8,20,30,39,38,1	1,461.2 ft²
Region 2	ESU 1B - Exis□ng Silty Granular Fill	5,6,2,9,10,13,12,4	939.79 ft²
Region 3	ESU 7A - Weathered Sandstone	8,7,18,17,16,15,14,11,3,19,35,34,33,32,31,41,40,37,39,30,20	12,310 ft²
Region 4	ESU 1B - Exis□ng Silty Granular Fill	21,43,42,27,28,29	801.62 ft²
Region 5	ESU 1B - Exis□ng Silty Granular Fill	22,23,24,25,26,1,38,36	196.76 ft²
Region 6	ESU 2A - Na□ve Sand and Gravel	31,32,33,34,29,28,27,42,41	741.22 ft²
Region 7	Concrete 48-in Dia Drilled Shaft	42,43,36,38,39,37,40,41	308.62 ft²
Region 8	ESU 1B - Exis□ng Silty Granular Fill	44,21,29,45	440 ft²
Region 9	ESU 2A - Na□ve Sand and Gravel	45,46,34,29	1,127.5 ft²
Region 10	ESU 7A - Weathered Sandstone	34,35,47,46	4,688.8 ft²

Slip Results

Slip Surfaces Analysed: 84 of 4030 converged

Current Slip Surface

Slip Surface: 84
Factor of Safety: 1.578
Volume: 9,680.7463 ft³
Weight: 1,258,930 lbf
Resis□ng Moment: 1.3388797e+08 lbf·ft
Ac□va□ng Moment: 84,872,472 lbf·ft
Resis□ng Force: 942,461.05 lbf
Ac□va□ng Force: 597,426.45 lbf
Slip Rank: 1 of 4,030 slip surfaces
Exit: (3, 71.5) ft
Entry: (219.84484, 114) ft
Radius: 125.54359 ft
Center: (99.956044, 151.25411) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Fric□onal Strength	Cohesive Strength	Suc□on Strength	Base Material
Slice 1	7.2978362 ft	66.785472 ft	-1,318.956 psf	1,543.5511 psf	1,205.9543 psf	0 psf	0 psf	ESU 1B - Exis□ng Silty

								Granular Fill
Slice 2	15.893508 ft	58.18886 ft	-710.04502 psf	4,176.7485 psf	3,263.2336 psf	0 psf	0 psf	ESU 1B - Exis□ng Silty Granular Fill
Slice 3	20.595672 ft	53.97692 ft	-407.56927 psf	5,615.9048 psf	4,547.67 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 4	24.069084 ft	51.316573 ft	-191.78835 psf	6,391.7931 psf	5,175.972 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 5	28.819084 ft	47.829919 ft	97.538828 psf	7,239.343 psf	5,783.319 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 6	35.25 ft	43.813082 ft	445.34369 psf	9,393.1446 psf	8,343.9594 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 7	40.75 ft	40.551294 ft	726.06808 psf	10,121.556 psf	8,761.4346 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 8	44.5 ft	38.672424 ft	870.45355 psf	10,443.248 psf	8,926.7752 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 9	52 ft	35.333039 ft	1,133.1192 psf	10,697.31 psf	8,918.7523 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 10	58.35 ft	32.821493 ft	1,335.8035 psf	11,126.684 psf	9,130.1435 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 11	62.6 ft	31.423401 ft	1,453.8076 psf	11,369.096 psf	9,246.1557 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 12	68.025 ft	29.879413 ft	1,594.1106 psf	10,870.773 psf	8,650.628 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 13	73.975 ft	28.4647 ft	1,734.6816 psf	10,179.119 psf	7,874.5651 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 14	80.433333 ft	27.289348 ft	1,864.7841 psf	9,351.5716 psf	6,981.5422 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 15	87.5 ft	26.38045 ft	1,983.6064 psf	8,420.8108 psf	6,002.7902 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 16	94.566667 ft	25.876123 ft	2,077.1835 psf	7,490.5313 psf	5,048.0285 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 17	99.3 ft	25.717971 ft	2,128.6521 psf	6,896.6419 psf	4,446.2224 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 18	105.75 ft	25.954464 ft	2,124.4414 psf	6,128.014 psf	3,733.3918 psf	0 psf	0 psf	ESU 7A - Weathered

								Sandstone
Slice 19	114.75 ft	26.64243 ft	2,191.832 psf	5,162.267 psf	2,769.9754 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 20	122.25 ft	27.764632 ft	2,342.446 psf	4,441.2259 psf	1,957.1439 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 21	129.75 ft	29.358211 ft	2,463.6459 psf	5,402.8321 psf	2,740.8355 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 22	134.5 ft	30.561004 ft	2,509.9695 psf	5,010.9162 psf	2,332.1705 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 23	135.75 ft	30.921582 ft	2,501.2921 psf	4,917.632 psf	2,253.2734 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 24	137 ft	31.304777 ft	2,491.2034 psf	6,231.2057 psf	3,487.6086 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 25	138.5 ft	31.774907 ft	2,478.4546 psf	6,699.7439 psf	3,936.416 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 26	141 ft	32.628196 ft	2,452.8547 psf	7,645.0443 psf	4,841.7952 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 27	144 ft	33.694839 ft	2,419.4706 psf	6,337.455 psf	3,653.5796 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 28	145.5 ft	34.264141 ft	2,400.5334 psf	6,240.496 psf	3,580.823 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 29	151 ft	36.686468 ft	2,310.2 psf	5,874.8429 psf	3,324.0833 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 30	159.8125 ft	40.983628 ft	2,139.5072 psf	5,352.4786 psf	2,996.1443 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 31	167.4375 ft	45.485524 ft	1,942.9073 psf	4,914.9578 psf	2,771.482 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 32	175.0625 ft	50.767506 ft	1,697.63 psf	4,468.2247 psf	2,583.6213 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 33	182.6875 ft	56.962149 ft	1,395.4027 psf	3,976.2197 psf	2,406.6508 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 34	187.75 ft	61.530338 ft	1,152.5069 psf	3,616.8179 psf	2,298.0072 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 35	192.5 ft	66.578693 ft	837.48954 psf	3,199.7479 psf	2,202.8416 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 36	199.65985 ft	75.201967 ft	299.39726 psf	2,433.474 psf	1,990.0587 psf	0 psf	0 psf	ESU 7A - Weathered

								Sandstone
Slice 37	205.20266 ft	82.899222 ft	-180.91142 psf	1,777.5026 psf	1,657.548 psf	0 psf	0 psf	ESU 7A - Weathered Sandstone
Slice 38	212.00298 ft	95.719776 ft	-980.91404 psf	1,046.4949 psf	847.43487 psf	0 psf	0 psf	ESU 2A - Na□ve Sand and Gravel
Slice 39	218.38259 ft	109.82055 ft	-1,860.8026 psf	261.30286 psf	204.15217 psf	0 psf	0 psf	ESU 1B - Exis□ng Silty Granular Fill

FLATIRON | LANE | wood.

In Association with

Appendix D.17
Pier 3 Lateral Earth Pressures

Lateral Earth Pressures for Cohesionless Soils

Project Information

Project:	Renton to Bellevue - Bridge 17.7 Pier 3
Owner:	WSDOT
Job Number:	00183-366-00
Analysis by:	IAH
Date/Time:	12/3/2021 7:31 AM
Checked by:	MH

Input Parameters

Run No.	ϕ Friction Angle (deg)	β_2 (-) Foreslope (deg)	i (+) Backslope (deg)	δ Wall Friction - Active (deg)	δ Wall Friction - Passive (deg)	β Wall Batter (deg)	γ_m (pcf)	γ_b (pcf)	Passive Factor of Safety	k_h (g)	k_v (g)
ESU 1B	38	0	0	25.3	0	0	125	62.6	1	0.442	0
ESU 2A	39	0	0	26.0	0	0	120	57.6	1	0.442	0
ESU 7A	42	0	0	28.0	0	0	135	72.6	1	0.442	0
Common Borrow	32	0	0	21.3	0	0	120	57.6	1	0.442	0
Select Borrow	36	0	0	24.0	0	0	125	62.6	1	0.442	0
Gravel Borrow	38	0	0	25.3	0	0	130	67.6	1	0.442	0

Figure D.17-1

Lateral Earth Pressures

Output

Run No.	Active			Passive					At Rest			Apparent EP Trapezoid		Seismic	Seismic	Seismic Pressure - Rectangular (psf * H)
	K_a	γ_a (pcf)	γ'_a (pcf)	K_p	$\gamma_{p(all)}$ (pcf)	$\gamma'_{p(all)}$ (pcf)	$\gamma_{pe(all)}$ (pcf)	$\gamma'_{pe(all)}$ (pcf)	K_o	γ_o (pcf)	γ'_o (pcf)	Single Tieback (psf * H)	Mult. Tiebacks[1], **X**	K_e	K_{pe}	
ESU 1B	0.22	27.10	13.57	4.20	525.47	263.15	813.25	407.28	0.38	48.04	24.06	27.10	27.10	0.41	6.51	25.91
ESU 2A	0.21	24.98	11.99	4.40	527.46	253.18	852.72	409.31	0.37	44.48	21.35	24.98	24.98	0.40	7.11	24.25
ESU 7A	0.18	24.84	13.36	5.04	681.03	366.24	1040.31	559.46	0.33	44.67	24.02	24.84	24.84	0.38	7.71	25.42
Common Borrow	0.28	33.00	15.84	3.25	390.55	187.46	466.56	223.95	0.47	56.41	27.08	33.00	33.00	0.50	3.89	29.91
Select Borrow	0.23	29.36	14.70	3.85	481.48	241.13	681.40	341.25	0.41	51.53	25.80	29.36	29.36	0.44	5.45	27.37
Gravel Borrow	0.22	28.18	14.65	4.20	546.49	284.17	845.78	439.81	0.38	49.96	25.98	28.18	28.18	0.41	6.51	26.95

Notes:

[1] "X" to be used in the following equation:

$$\frac{X \cdot H^2}{1.5H - 0.5H_1 - 0.5H_{n+1}}$$

where H_1 and H_{n+1} are represented by this diagram:

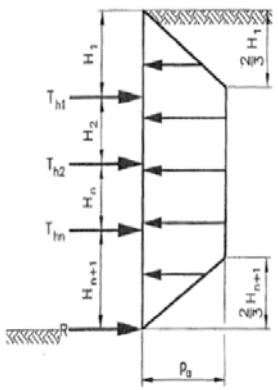


Figure D.17-2

Pier 3 Lateral Earth Pressures

Ground Surface Elevation at Top of Wall	110	ft	H_1	27	ft
Ground Surface Elevation at NB 405	74	ft	H_2	9	ft
Wall Toe Elevation	35	ft	D_1	2	ft
Groundwater Level Elevation	72	ft	D_2	37	ft
Traffic Surcharge, Static	250	psf			
Traffic Surcharge, Seismic	125	psf			

Interval	Layer Description	Elevation, Top of Layer ft	Elevation, Bottom of Layer ft	Friction Angle deg	Soil Total Unit Weight pcf	Soil Effective Unit Weight pcf	Active Lateral Earth Pressure Coefficient	At Rest Lateral Earth Pressure Coefficient	Passive Lateral Earth Pressure Coefficient	Seismic Lateral Earth Pressure Coefficient
Stratum 1	ESU 1B, above water table	110	83	38	125	125	0.22	0.38	4.20	0.41
Stratum 2	ESU 2A, above water table	83	74	39	120	120	0.21	0.37	4.40	0.40
Stratum 3	ESU 2A, above water table	74	72	39	120	120	0.21	0.37	4.40	0.40
Stratum 4	ESU 7A, below water table	72	35	42	135	72.6	0.18	0.33	5.04	0.38

	Static (At-Rest) (psf)								
	A	B	C	D	E	F	G	J	K
Stratum	1	1	2	2	2	3	3	4	4
Description	Earth Pressure * H_1	Traffic Surcharge	Earth Pressure * H_1	Earth Pressure * H_2	Traffic Surcharge	(Earth Pressure * H_1) + (Earth Pressure * H_2)	Earth Pressure * D_1	(Earth Pressure * H_1) + (Earth Pressure * H_2) + (Earth Pressure * D_1)	Earth Pressure * D_2
Recommended Earth Pressures	1297	96	1251	400	93	1651	89	1553	889
To Calculate	48.04 * H1	96	46.33 * H1	44.48 * H2	93	46.33 * H1 + 44.48 * H2	44.48 * D1	41.36 * H1 + 39.7 * H2 + 39.7 * D1	24.02 * D2

	Static, Passive (psf)	
	M	N
Stratum	4	4
Description	Earth Pressure * D_1	Earth Pressure * D_2
Recommended Earth Pressures	1211	13551
To Calculate	605.36 * D1	366.24 * D2

Figure D.17-3

	Seismic (Active) (psf)								
	A	B	C	D	E	F	G	J	K
Stratum	1	1	2	2	2	3	3	4	4
Description	Earth Pressure * H_1	Traffic Surcharge	Earth Pressure * H_1	Earth Pressure * H_2	Traffic Surcharge	(Earth Pressure * H_1) + (Earth Pressure * H_2)	Earth Pressure * D_1	(Earth Pressure * H_1) + (Earth Pressure * H_2) + (Earth Pressure * D_1)	Earth Pressure * D_2
Recommended Earth Pressures	732	27	703	225	26	927	89	864	494
To Calculate	27.1 * H1	27	26.02 * H1	24.98 * H2	26	26.02 * H1 + 24.98 * H2	24.98 * D1	23 * H1 + 22.08 * H2 + 22.08 * D1	13.36 * D2

	Passive (psf)		Seismic (psf)		
	M	N	Q	R	S
Stratum	4	4	1	2	2
Description	Earth Pressure * D_1	Earth Pressure * D_2	Seismic Earth Pressure * H_1	Seismic Earth Pressure * H_1	Seismic Earth Pressure * H_2
Recommended Earth Pressures	1211	13551	1384	1350	432
To Calculate	605.36 * D1	366.24 * D2	51.25 * H1	50 * H1	48 * H2

Figure D.17-4

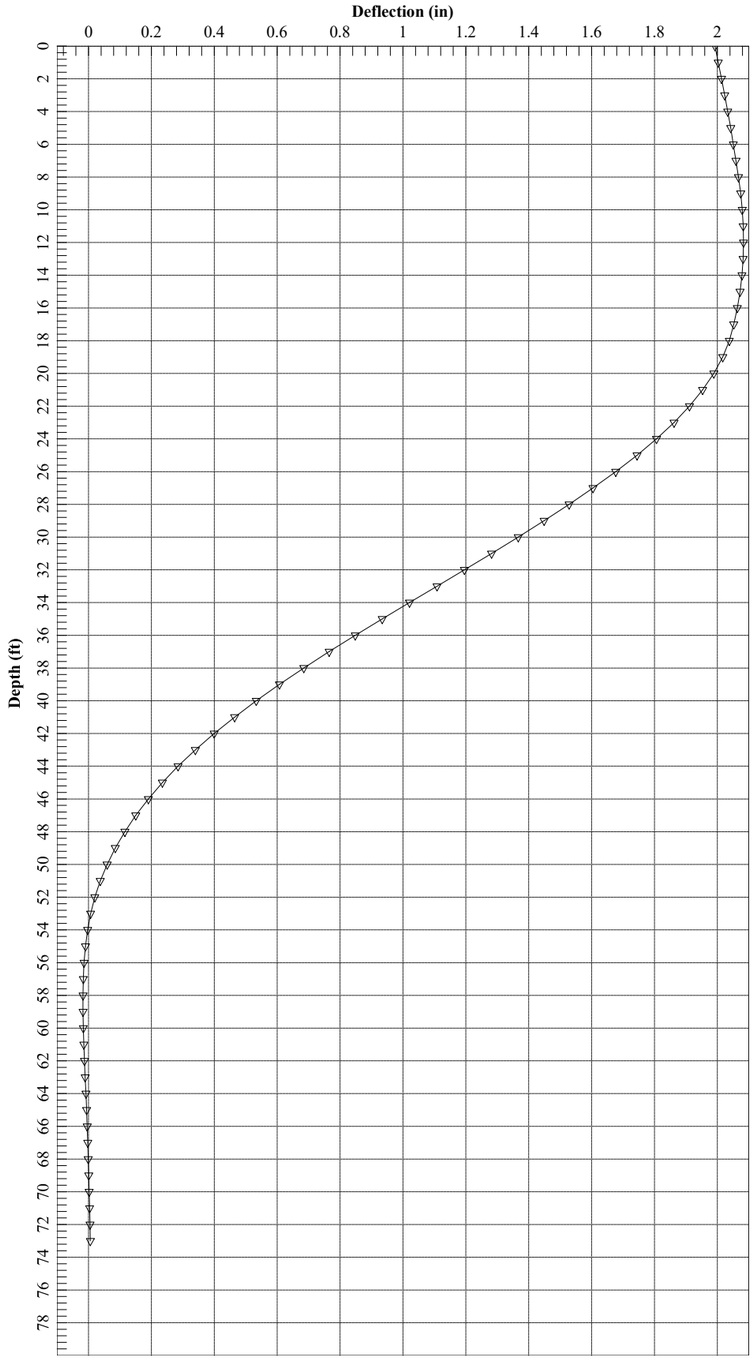
FLATIRON | LANE | wood.

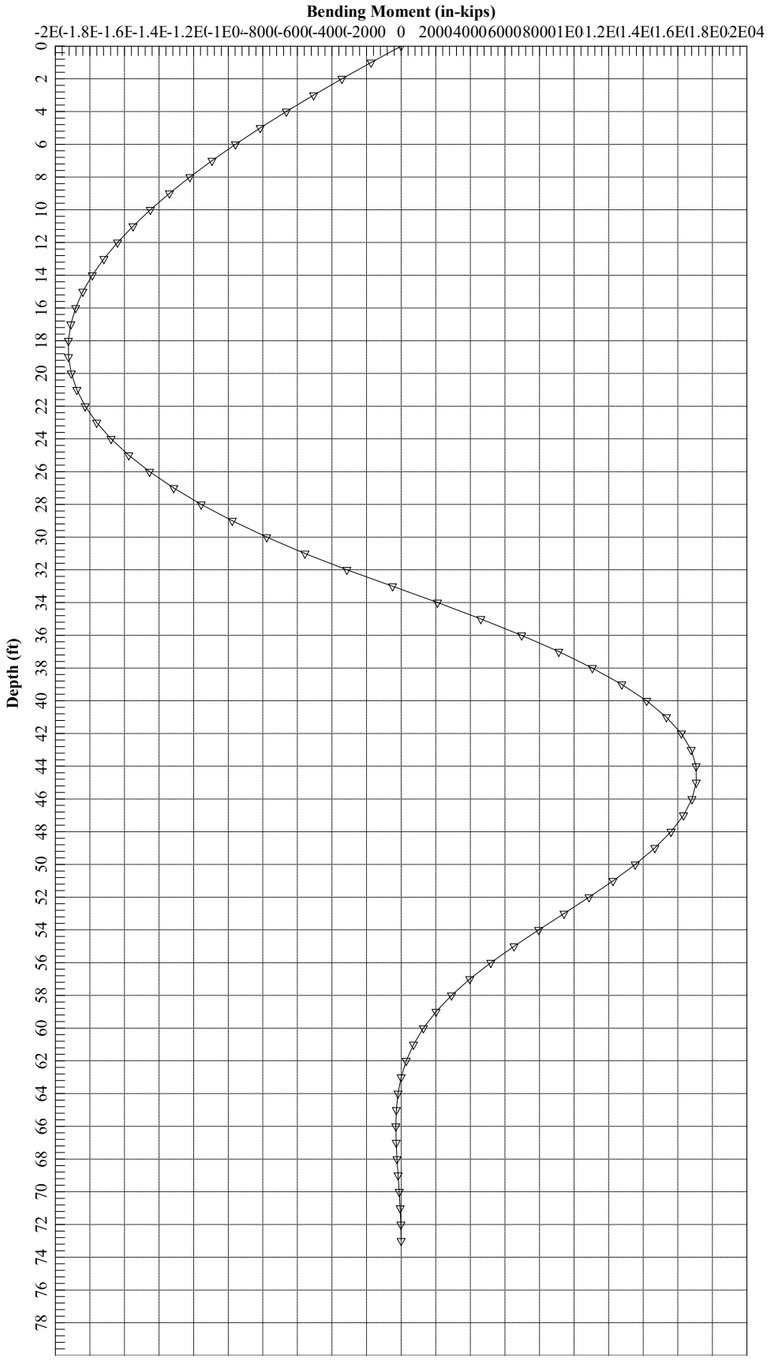
In Association with

Appendix D.18
Pier 3 Secant Pile Wall Analyses

Pier 3 Drilled Shaft Secant Pile Wall Results

Seismic Case





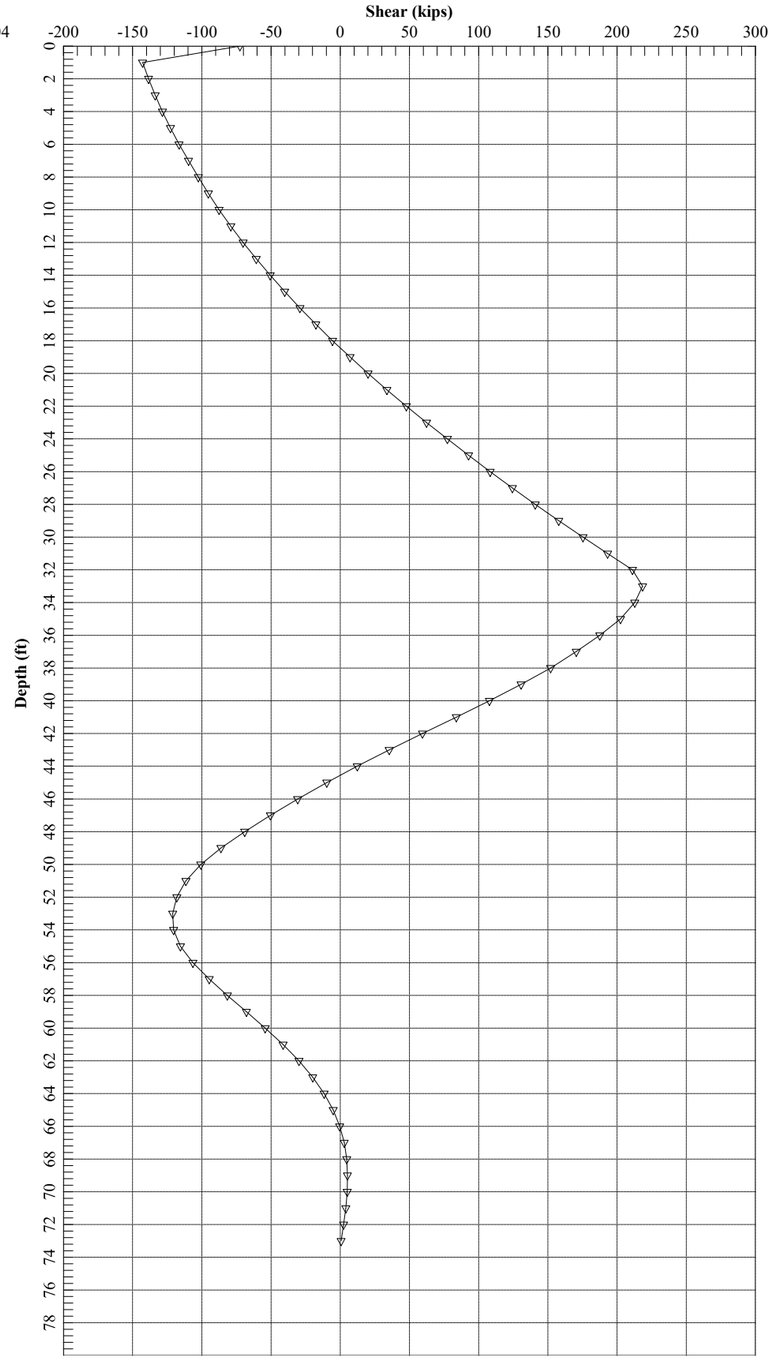


Figure D.18-1

Pier 3 Drilled Shaft Secant Pile Wall Results

Seismic Case

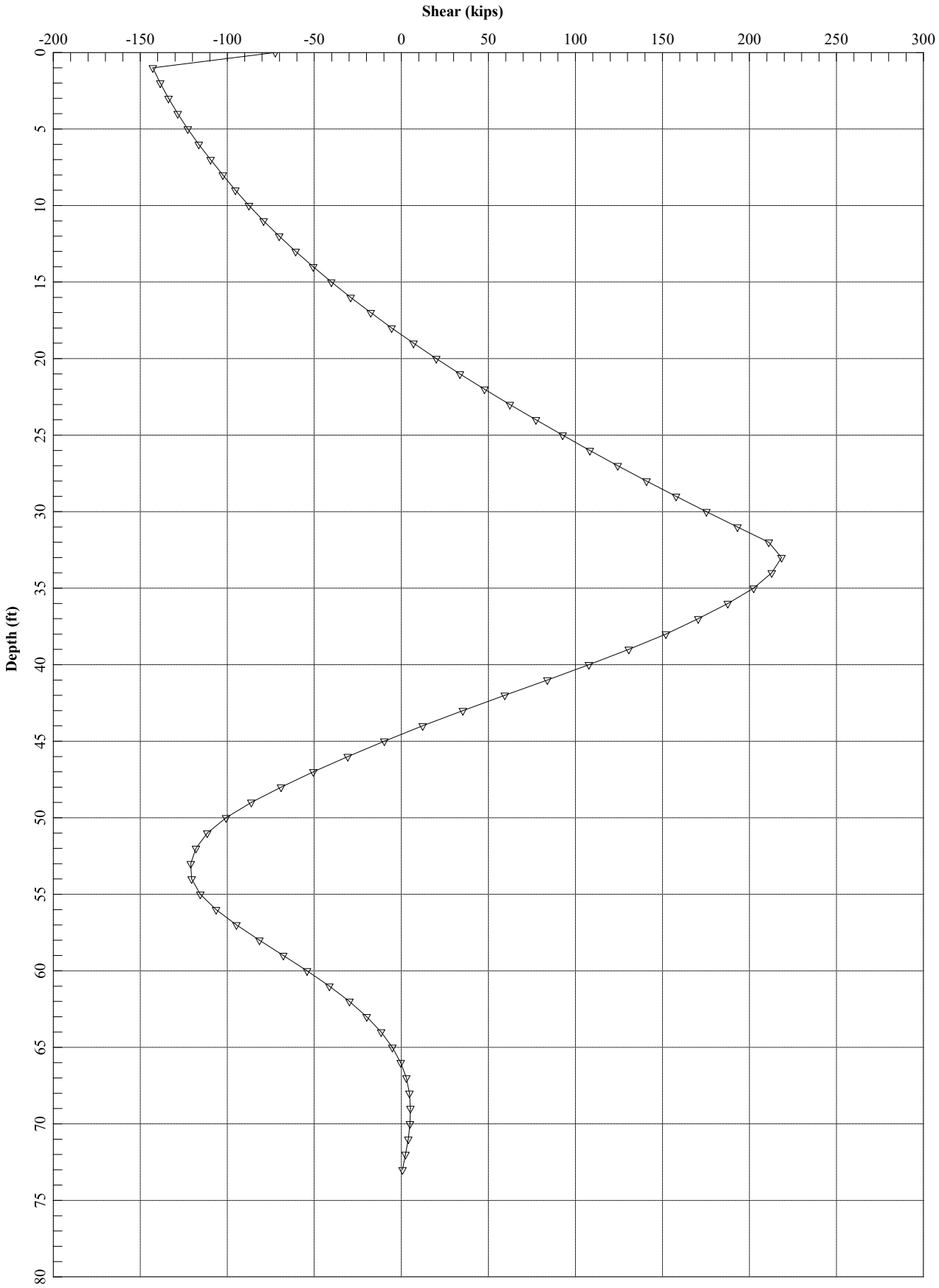
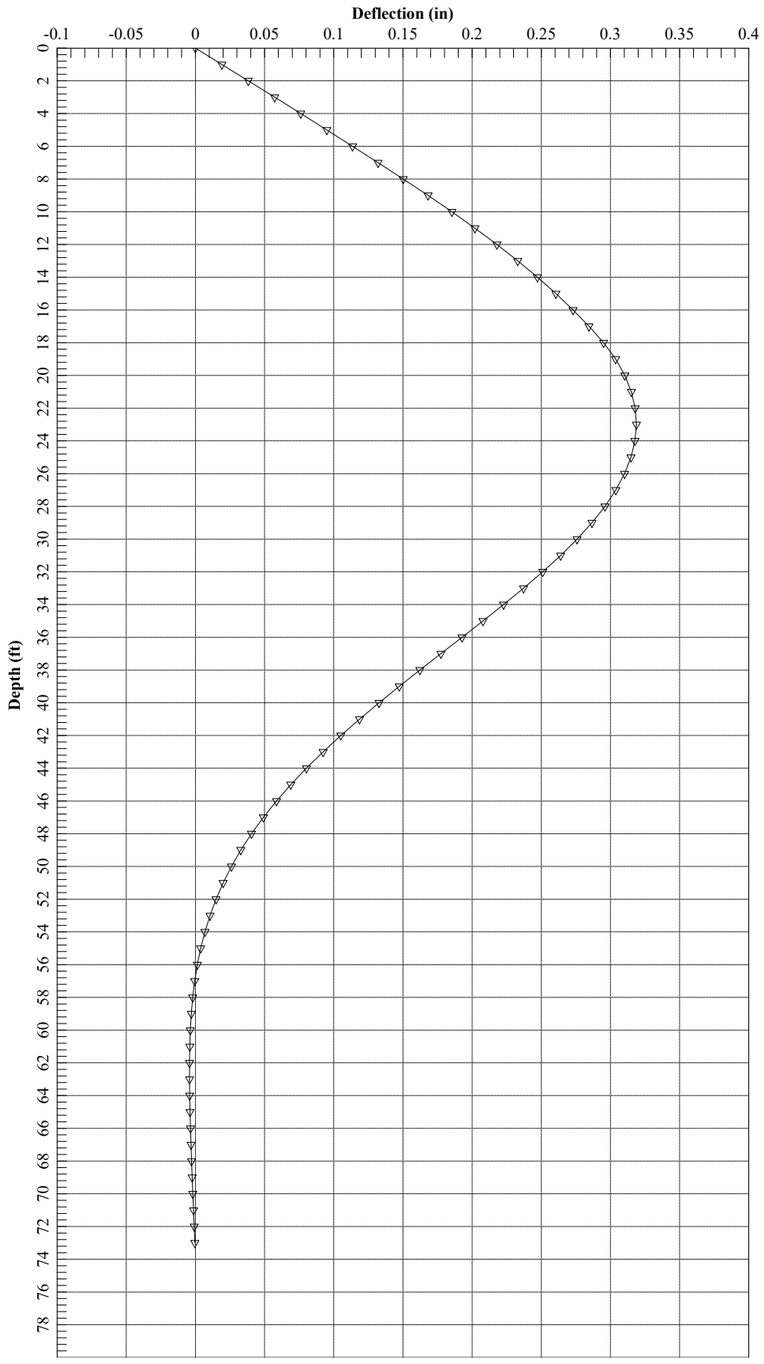
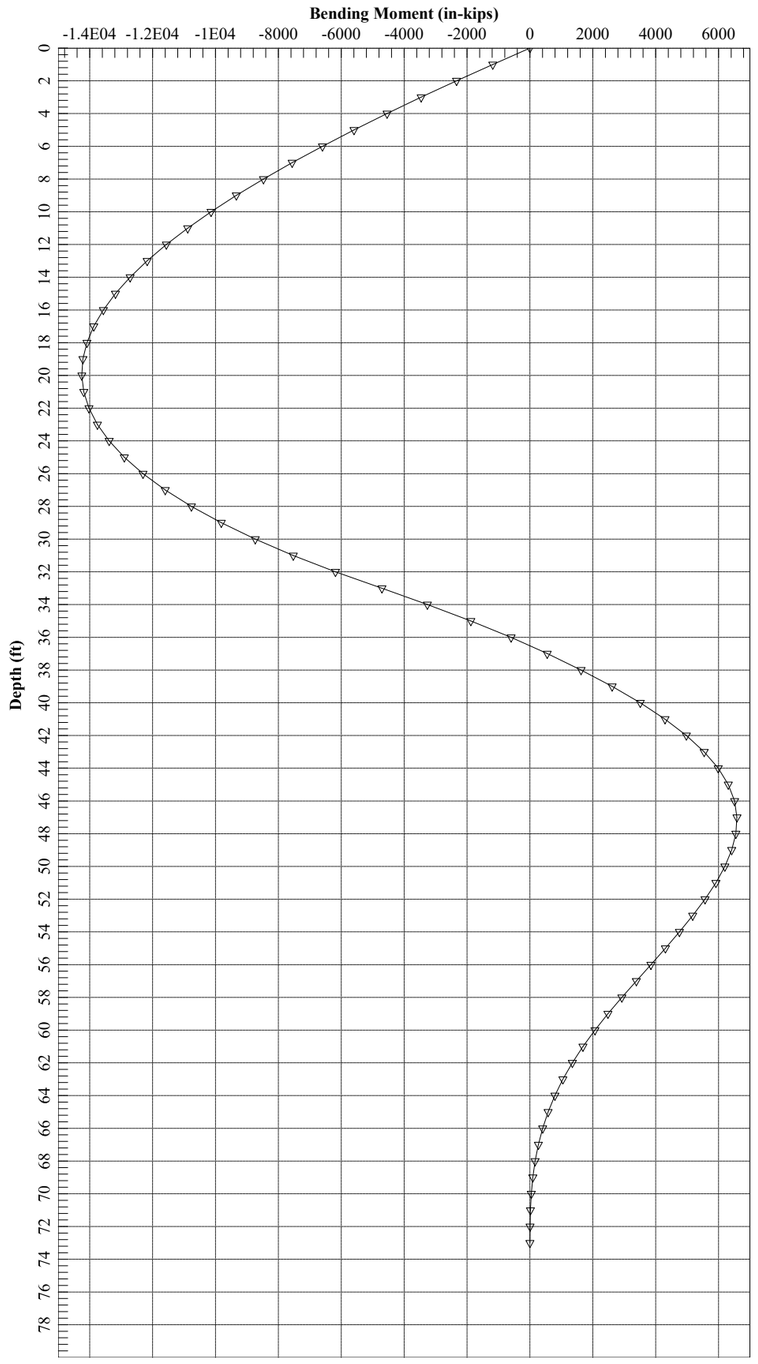


Figure D.18-2

Static Case





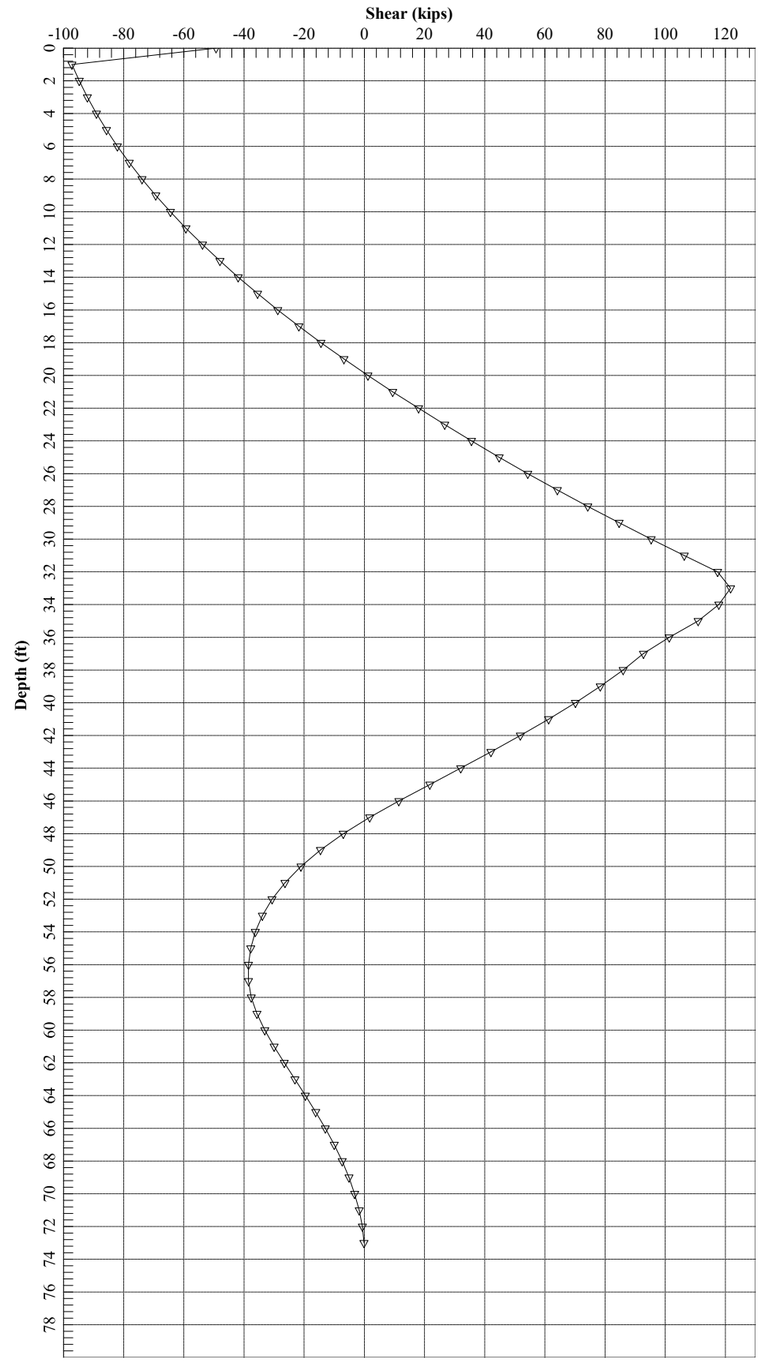


Figure D.18-3

Static Case

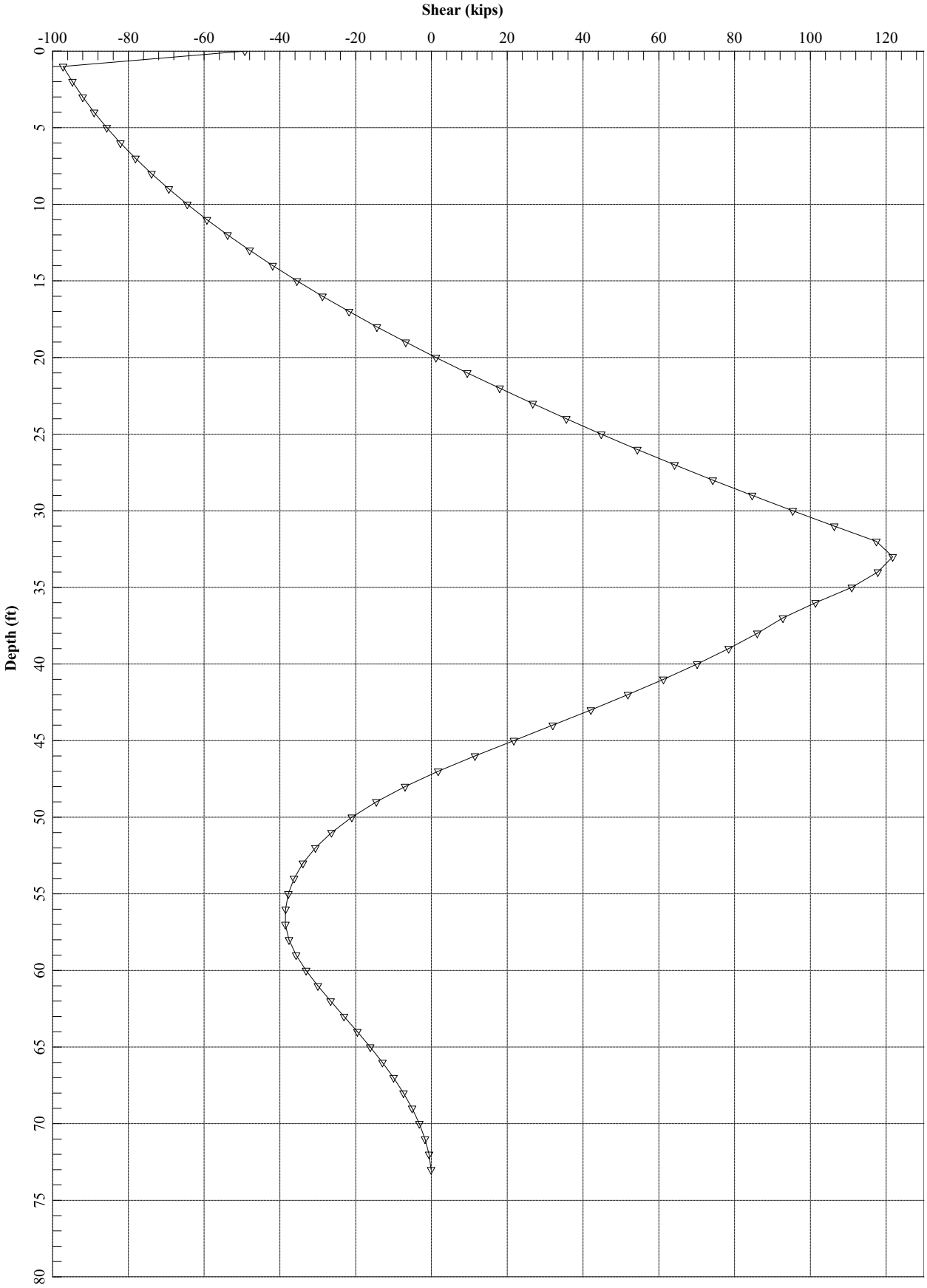


Figure D.18-4

Pier 3 Drilled Shaft Secant Pile Wall Analysis
PY Wall Model

WSDOT I-405 Renton to Bellevue Widening
00180-366-01
By IAH

Wall Properties and Wall Configuration

Total Height (ft)*	73
Increment Length (in)	12
Deflection Closure Tolerance (in)	1.00E-05

Free Height of Wall (ft)	32
Depth to Water Table in Backfill Side (ft)	38
Depth to Water Table in Excavation Side (ft)	38

Width for Active Earth Pressure Calculation (in) (Center-to-Center Spacing of Piles)	78
Width of Pile (in)	48

Note: Total Height is assumed at 73 feet to allow for application of loads along a 1-foot interval

Seismic Case

Elevation, Top (feet, NAVD88)	Elevation, Bottom (feet, NAVD88)	Depth, Top (ft)	Depth, Bottom (ft)	Cross Section Index
107	98.50	0	8.50	1
98.50	89.5	8.5	17.50	2
89.50	81.5	17.5	25.50	3
81.50	56.5	25.5	50.50	4
56.50	47.5	50.5	59.50	5
47.50	34	59.5	73.00	6

Static Case

Elevation, Top (feet, NAVD88)	Elevation, Bottom (feet, NAVD88)	Depth, Top (ft)	Depth, Bottom (ft)	Cross Section Index
107	98.50	0	8.50	1
98.50	89.5	8.5	17.50	2
89.5	34	17.5	73.00	3

Seismic Analysis, Free Head, Specified LEPs

Soil Layers

ESU	Elevation, Top (feet, NAVD88)	Elevation, Bottom (feet, NAVD88)	(N1)60 (bpf)	Soil Type	Depth at Bottom of the Layer (ft)	Total Unit Weight (lbs/ft^3)	Friction Angle (deg)	k(py) (lbs/in^3)	Optional Earth Pressure Coefficient
1B	110	83	21	Sand	27	125	38	95	0.63
2A	83	74	29	Sand	36	120	39	131	0.61
2A (Below GWT)	74	72	29	Sand	38	120	39	80	0.58
7A (Below GWT)	72	10	50	Sand	100	135	42	125	0.66

Earth Pressures Specified?

Yes Seismic lateral earth pressures. Applied to soil layers above I-405. Automatic calculation of LEP below I-405

Distributed Loads - Seismic - Calculated from LEPs

Depth Measured from top of Wall (ft)	Lateral Distributed Line Load (lbs/ft)	Elevation
0	2200	107
24	14500	83
24	14000	83
32	17800	75

Apply Concentrated Loads to Wall?

Yes

Concentrated Loads on Wall

Depth, Top, Measured from top of Wall (ft)	Depth, Bottom, Measured from top of Wall (ft)	Node Number*, Top	Node Number*, Bottom	Lateral Load (lbs)	Moment (lbs-in)	Axial Load (lbs)	
0	0	0	0	0	0	123000	Super structure axial load
0	8	0	16	1100	0	0	Inertial load
9	31	18	62	700	0	0	Inertial load
32	73	64	146	450	0	0	Inertial load
0	0	0	0	-174000	0	0	Resisting super structure force
0	23	0	46	179	0	0	active traffic surcharge
24	32	48	64	171	0	0	active traffic surcharge
0	0	0	0	4600	0	0	LEP above top of wall

Apply Restraints on Deflection or Slope?

No

Boundary Condition Specification

Specify	Depth, Measured from top of Wall (ft)	Node Number *	Deflection (in)	Slope (rad)
Deflection	NA	NA	NA	NA

* Node Number is based on the increment length specified in the pile model.

Static Analysis, Pinned Head, Specified LEP's

Soil Layers

ESU	Elevation, Top (feet, NAVD88)	Elevation, Bottom (feet, NAVD88)	(N1)60 (bpf)	Soil Type	Depth at Bottom of the Layer (ft)	Total Unit Weight (lbs/ft^3)	Friction Angle (deg)	k(py) (lbs/in^3)	Optional Earth Pressure Coefficient
1B	110	83	21	Sand	27	125	38	95	0.38
2A	83	74	29	Sand	36	120	39	131	0.37
2A (Below GWT)	74	72	29	Sand	38	120	39	80	0.37
7A (Below GWT)	72	10	50	Sand	100	135	42	125	0.33

Earth Pressures Specified?

Yes At rest lateral earth pressures. Applied to soil layers above I-405. Automatic calculation of LEP below I-405

Distributed Loads - Static - Calculated from LEPs

Depth Measured from top of Wall (ft)	Lateral Distributed Line Load (lbs/ft)	Elevation
0	1320	107
24	8720	83
24	8500	83
32	10800	75

Apply Concentrated Loads to Wall?

Yes

Concentrated Loads on Wall

Depth, Top, Measured from top of Wall (ft)	Depth, Bottom, Measured from top of Wall (ft)	Node Number*, Top	Node Number*, Bottom	Lateral Load (lbs)	Moment (lbs-in)	Axial Load (lbs)	
0	0	0	0	0	0	123000	Super structure axial load
0	0	0	0	2788	0	0	LEP above top of wall
0	24	0	48	618	0	0	traffic surcharge
24.5	32	49	64	602	0	0	traffic surcharge, 2A

Apply Restraints on Deflection or Slope?

Yes

Boundary Condition Specification

Specify	Depth, Measured from top of Wall (ft)	Node Number *	Deflection (in)	Slope (rad)
Deflection	0	0	0	0

* Node Number is based on the increment length specified in the pile model.

PY Wall

Elastic Modulus Parameter

Es = Young's Modulus of Elasticity

From PY Wall Users Manual:

K (py) Values

This is the value for the constant k used in the equation $E_s = k\,x$. This constant is in units of force per cubic length and depends on the type of soil and lateral loading imposed to the wall. It has two different uses: i) to define the initial (maximum) value of E_s on internally-generated p-y curves of stiff clays with free water and/or sands; and ii) to initialize the E_s array for the first iteration of analysis. Suggested values of the parameter k used for sands are given in Table 3.5.

Water Table	Relative Density		
	Loose	Medium	Dense
Submerged Sand	20 lb/in.^{3} 5,430 KPa/m	60 lb/in.^{3} 16,300 Kpa/m	125 lb/in.^{3} 33,900 Kpa/m
Sand Above WT	25 lb/in.^{3} 6,790 KPa/m	90 lb/in.^{3} 24,430 Kpa/m	225 lb/in.^{3} 61,000 Kpa/m

Table 3.5 Soil-Modulus Parameter k(py) for Sands

	Blowcount (low)	Blowcount (high)	Blowcount, Average	k (Below WT)	k (Below WT)	k (Above WT)	k (Above WT)
Density Description	0	0	0	0	0	0	0
Loose	4	10	7	0	20	0	25
Medium	10	30	20	20	60	25	90
Dense	30	50	50	60	125	90	225

		(N1)60	k
	ESU 1B	21	**95**
	ESU 2A	29	**131**
Below GWT	ESU 2A	29	**80**
Below GWT	ESU 7A	50	**125**

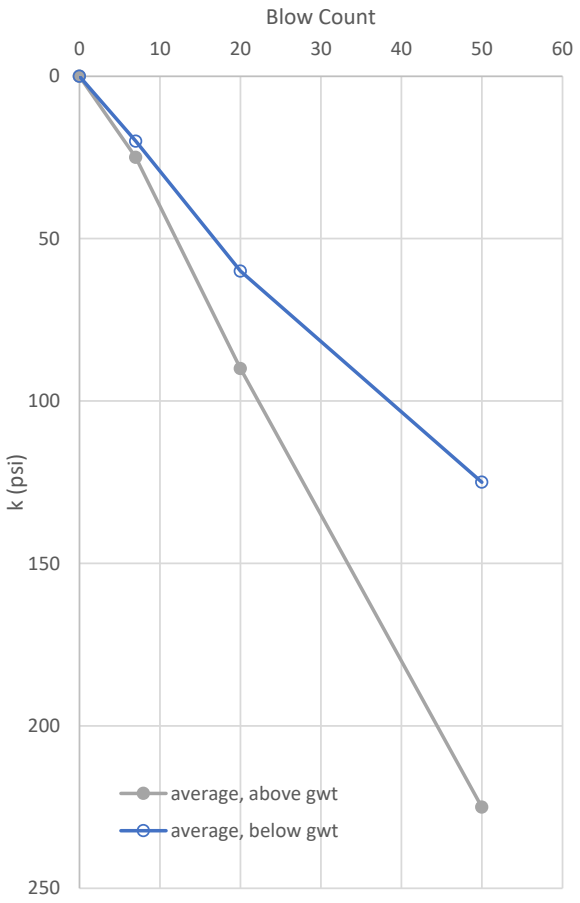


Figure D.18-8

PY Wall
Model Inputs - Wall Sections Details

Seismic Case

Analysis Case	Section Index	Section Name	Section Type	Model	Diameter	Width	Depth	Inertia (Seismic, Cracked Case) (in^4)	Es (lbs/in^2)
Seismic	1	Shaft Cap 107 - 98.5	elastic	Rectangle	N/A	78	57	601000	4030000
Seismic	2	98.5 - 89.5	elastic	Circle	48	N/A	N/A	259000	4030000
Seismic	3	89.5 - 81.5	elastic	Circle	48	N/A	N/A	96000	4030000
Seismic	4	81.5 - 56.5	elastic	Circle	48	N/A	N/A	120000	4030000
Seismic	5	56.5 - 47.5	elastic	Circle	48	N/A	N/A	96000	4030000
Seismic	6	47.5 - 34	elastic	Circle	48	N/A	N/A	59000	4030000

Static Case

Analysis Case	Section Index	Section Name	Section Type	Model	Diameter	Width	Depth	Inertia (in^4)	Es (lbs/in^2)
Static	1	107 - 98.5	elastic	Rectangle	N/A	78	57	1202000	4030000
Static	2	98.5 - 89.5	elastic	Circle	48	N/A	N/A	520000	4030000
Static	3	89.5 - 34	elastic	Circle	48	N/A	N/A	260600	4030000

```
     ============================================================================

                     PYWALL for Windows, Version 2019.6.2

                      Serial Number :  239146531

                      A Program for the Analysis of
                      Flexible Retaining Walls
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                          All Rights Reserved

     ============================================================================


     This program is licensed to :

     GeoEngineers, Inc.
     Baton Rouge, LA

     Path to file locations      : P:\0\0180366\01\Analysis\Bridge 17.7\Appendix D -
Bridge 17.7 - Analysis\Pier 3 PY-Wall\Final\
     Name of input data file     : PY Wall Pier 3 - Point Of Fixity_0in - Free head -
SEISMIC - inertia.py6d
     Name of output file         : PY Wall Pier 3 - Point Of Fixity_0in - Free head -
SEISMIC - inertia.py6o
     Name of plot output file    : PY Wall Pier 3 - Point Of Fixity_0in - Free head -
SEISMIC - inertia.py6p

     ----------------------------------------------------------------------------
                          Time and Date of Analysis
     ----------------------------------------------------------------------------

               Date:  November 30, 2021     Time:  18:58:53


      Bridge 17.7 Pier 3 - Seismic - Specified LEPs


      ************************************************
      *        PROGRAM CONTROL PARAMETERS            *
      ************************************************

      NO OF POINTS FOR SPECIFIED DEFLECTIONS AND SLOPES  =  0
      NO OF WALL SECTIONS                                =  6
      NO OF CROSS SECTIONS                               =  6
      GENERATE EARTH PRESSURE INTERNALLY                 =  0
      GENERATE SOIL RESISTANCE (P-Y) CURVES INTERNALLY   =  1
      NO OF P-Y MODIFICATION FACTORS FOR GEN. P-Y CURVES =  0
      NO OF USER-SPECIFIED SOIL RESISTANCE (P-Y) CURVES  =  0
      NO OF TIE BACKS                                    =  0


      HEIGHT OF WALL                                     =     73.000 FT
      NUMBER OF INCREMENTS                               =         73
      INCREMENT LENGTH                                   =     12.000 IN
      MAXIMUM ALLOWABLE DEFLECTION                       =     72.000 IN
```

```
 DEFLECTION CLOSURE TOLERANCE                        =  1.000E-05 IN
 MAXIMUM NUMBER OF ITERATIONS                        =         500



* WALL SECTIONS *

  SECT          TOP        BOTTOM     SECTION
                FT            FT
    1        0.00000       8.50000       1
    2        8.50000       17.5000       2
    3        17.5000       25.5000       3
    4        25.5000       50.5000       4
    5        50.5000       59.5000       5
    6        59.5000       73.0000       6


* CROSS SECTIONS *

 CROSS SECTION       :     1
 SECTION NAME        : Shaft
 TYPE                :  ELASTIC
 CROSS SECTION TYPE  : RECTANGULAR PIPE
 EQUIVALENT DIAMETER :       1.00000 IN
 EXTERNAL WIDTH      :       78.0000 IN
 EXTERNAL DEPTH      :       57.0000 IN
 INTERNAL WIDTH      :       0.00000 IN
 INTERNAL DEPTH      :       0.00000 IN
 YOUNG MODULUS       :   4.03000E+06 LBS/IN**2

 CROSS SECTION       :     2
 SECTION NAME        : 98.5
 TYPE                :  ELASTIC
 CROSS SECTION TYPE  : GENERAL SECTION
 EQUIVALENT DIAMETER :       48.0000 IN
 YOUNG MODULUS       :   4.03000E+06 LBS/IN**2

 CROSS SECTION       :     3
 SECTION NAME        : 89.5
 TYPE                :  ELASTIC
 CROSS SECTION TYPE  : GENERAL SECTION
 EQUIVALENT DIAMETER :       48.0000 IN
 YOUNG MODULUS       :   4.03000E+06 LBS/IN**2

 CROSS SECTION       :     4
 SECTION NAME        : 81.5
 TYPE                :  ELASTIC
 CROSS SECTION TYPE  : GENERAL SECTION
 EQUIVALENT DIAMETER :       48.0000 IN
 YOUNG MODULUS       :   4.03000E+06 LBS/IN**2

 CROSS SECTION       :     5
 SECTION NAME        : 56.5
 TYPE                :  ELASTIC
 CROSS SECTION TYPE  : GENERAL SECTION
 EQUIVALENT DIAMETER :       48.0000 IN
```


Figure D.18-11

```
 YOUNG MODULUS       :   4.03000E+06 LBS/IN**2

 CROSS SECTION       :     6
 SECTION NAME        : 47.5
 TYPE                :  ELASTIC
 CROSS SECTION TYPE  : GENERAL SECTION
 EQUIVALENT DIAMETER :       48.0000 IN
 YOUNG MODULUS       :   4.03000E+06 LBS/IN**2


* CROSS SECTIONS PROPERTIES *

         ELASTIC SECTIONS

  SECT           DIAM,IN       I,IN**4
    1             1.00000   6.01000E+05
    2             48.0000   2.59000E+05
    3             48.0000       96000.0
    4             48.0000   1.20000E+05
    5             48.0000       96000.0
    6             48.0000       59000.0




 ***********************************************
 *        STIFFNESS AND LOAD DATA                *
 ***********************************************

 EI - FLEXURAL RIGIDITY,  Q - TRANSVERSE LOAD,
 S - STIFFNESS OF TRANSVERSE RESISTANCE,
 T - TORQUE,              P - AXIAL LOAD,
 R - STIFFNESS OF TORSIONAL RESISTANCE.


FROM TO CONTD     EI          Q         S         T          R          P
              LBS-IN**2     LBS     LBS/IN    IN-LBS    IN-LBS      LBS
   0      1  2.422E+12 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
       9  0  2.422E+12 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
   9      1  1.044E+12 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
      18  0  1.044E+12 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  18      1  3.869E+11 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
      26  0  3.869E+11 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  26      1  4.836E+11 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
      51  0  4.836E+11 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  51      1  3.869E+11 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
      60  0  3.869E+11 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  60      1  2.378E+11 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
      73  0  2.378E+11 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
   0   0  0  1.211E+12 0.000E+00 0.000E+00 0.000E+00 0.000E+00 1.230E+05
   0   8  0  1.211E+12 1.100E+03 0.000E+00 0.000E+00 0.000E+00 0.000E+00
   9  31  0  1.733E+12 7.000E+02 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  32  73  0  4.836E+11 4.500E+02 0.000E+00 0.000E+00 0.000E+00 0.000E+00
   0   0  0  1.211E+12-1.500E+05 0.000E+00 0.000E+00 0.000E+00 0.000E+00
   0  23  0  1.211E+12 1.790E+02 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  24  32  0  3.869E+11 1.710E+02 0.000E+00 0.000E+00 0.000E+00 0.000E+00
```

```
  0   0  0  1.211E+12 4.600E+03 0.000E+00 0.000E+00 0.000E+00 0.000E+00


************************************************
*        SPECIFIED ACTIVE EARTH PRESSURE         *
************************************************



   DEPTH         ACTIVE EARTH PRESSURE
    IN                  LBS/IN
  --------       ------------------------
 0.000E+00           1.833E+02
 2.880E+02           1.208E+03
 2.880E+02           1.167E+03
 3.840E+02           1.483E+03


************************************************
*        SOIL LAYERS AND STRENGTH DATA           *
************************************************


   X AT THE SURFACE OF EXCAVATION SIDE     =      32.00 FT

   3 LAYER(S) OF SOIL

   LAYER  1
   THE SOIL IS A SAND

   LAYER  2
   THE SOIL IS A SAND

   LAYER  3
   THE SOIL IS A SAND


   DISTRIBUTION OF EFFECTIVE UNIT WEIGHT WITH DEPTH
                     6 POINTS

              X,FT   WEIGHT,LBS/IN**3
           32.0000     6.9444E-02
           36.0000     6.9444E-02
           36.0000     6.9444E-02
           38.0000     6.9444E-02
           38.0000     4.2125E-02
          150.0000     4.2125E-02


   DISTRIBUTION OF STRENGTH PARAMETERS WITH DEPTH
                     6 POINTS

               X,FT     S,LBS/IN**2      PHI,DEGREES      E50
             32.00     0.0000E+00         39.000       -----
             36.00     0.0000E+00         39.000       -----
             36.00     0.0000E+00         39.000       -----
```


Figure D.18-13

38.00	0.0000E+00	39.000	-----
38.00	0.0000E+00	42.000	-----
75.00	0.0000E+00	42.000	-----

P-Y CURVES DATA

AT THE EXCAVATION SIDE

DEPTH BELOW GS FT	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	PCT	PCD
0.01	42.53	39.00	6.94E-02	2.83	2.14	1.23E+00	2.69E+01

Y IN	P LBS/IN
0.000	0.000
0.065	0.635
0.130	1.271
0.188	1.397
0.246	1.498
0.304	1.582
0.362	1.654
0.419	1.719
0.477	1.777
0.535	1.831
0.593	1.880
0.651	1.925
0.709	1.968
1.004	2.180
1.299	2.392
1.595	2.603
1.914	2.603

P-Multiplier = 7.459E-01 Y-Multiplier = 1.000E+00

AT THE BACKFILL SIDE

DEPTH BELOW GS FT	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	PCT	PCD
32.01	42.53	39.00	6.94E-02	0.88	0.50	4.81E+04	1.03E+05

Y IN	P LBS/IN
0.000	0.000
0.035	1330.135
0.071	2660.270
0.135	5054.512
0.198	7448.755
0.262	9793.259
0.326	11179.371
0.390	12462.384

Figure D.18-14

0.454	13665.264
0.517	14803.380
0.581	15887.641
0.645	16926.134
0.709	17925.059
1.004	22466.074
1.299	27007.089
1.595	31548.104
1.914	31548.104

P-Multiplier = 7.459E-01 Y-Multiplier = 1.000E+00

AT THE EXCAVATION SIDE

DEPTH BELOW GS	DIAM	PHI	GAMMA AVG	A	B	PCT	PCD
FT	IN		LBS/IN**3				
1.00	42.53	39.00	6.94E-02	2.63	1.97	1.90E+02	3.22E+03

Y	P
IN	LBS/IN
0.000	0.000
0.035	41.556
0.071	83.112
0.135	157.912
0.198	197.070
0.262	212.575
0.326	225.530
0.390	236.750
0.454	246.703
0.517	255.683
0.581	263.888
0.645	271.462
0.709	278.509
1.004	310.040
1.299	341.572
1.595	373.104
1.914	373.104

P-Multiplier = 7.459E-01 Y-Multiplier = 1.000E+00

AT THE BACKFILL SIDE

DEPTH BELOW GS	DIAM	PHI	GAMMA AVG	A	B	PCT	PCD
FT	IN		LBS/IN**3				
33.00	42.53	39.00	6.94E-02	0.88	0.50	5.09E+04	1.06E+05

Y	P
IN	LBS/IN
0.000	0.000
0.035	1371.344
0.071	2742.689
0.135	5211.109

Figure D.18-15

0.198	7679.529
0.262	10147.949
0.326	11847.681
0.390	13207.393
0.454	14482.183
0.517	15688.337
0.581	16837.415
0.645	17937.989
0.709	18996.631
1.004	23809.111
1.299	28621.591
1.595	33434.071
1.914	33434.071

P-Multiplier = 7.459E-01 Y-Multiplier = 1.000E+00

AT THE EXCAVATION SIDE

DEPTH BELOW GS	DIAM	PHI	GAMMA AVG	A	B	PCT	PCD
FT	IN		LBS/IN**3				
2.00	42.53	39.00	6.94E-02	2.43	1.79	4.65E+02	6.45E+03

Y	P
IN	LBS/IN
0.000	0.000
0.035	83.112
0.071	166.224
0.135	315.825
0.198	431.976
0.262	467.751
0.326	497.746
0.390	523.796
0.454	546.955
0.517	567.890
0.581	587.054
0.645	604.769
0.709	621.272
1.004	695.171
1.299	769.070
1.595	842.969
1.914	842.969

P-Multiplier = 7.459E-01 Y-Multiplier = 1.000E+00

AT THE BACKFILL SIDE

DEPTH BELOW GS	DIAM	PHI	GAMMA AVG	A	B	PCT	PCD
FT	IN		LBS/IN**3				
34.00	42.53	39.00	6.94E-02	0.88	0.50	5.39E+04	1.10E+05

Y	P
IN	LBS/IN

Figure D.18-16

Y	P
IN	LBS/IN
0.000	0.000
0.035	1412.900
0.071	2825.801
0.135	5369.021
0.198	7912.242
0.262	10455.463
0.326	12541.202
0.390	13980.507
0.454	15329.918
0.517	16606.676
0.581	17823.017
0.645	18988.015
0.709	20108.626
1.004	25202.812
1.299	30296.997
1.595	35391.182
1.914	35391.182

P-Multiplier = 7.459E-01 Y-Multiplier = 1.000E+00

AT THE EXCAVATION SIDE

DEPTH BELOW GS	DIAM	PHI	GAMMA AVG	A	B	PCT	PCD
FT	IN		LBS/IN**3				
3.00	42.53	39.00	6.94E-02	2.22	1.63	8.24E+02	9.67E+03

Y	P
IN	LBS/IN
0.000	0.000
0.035	124.668
0.071	249.335
0.135	473.737
0.198	690.273
0.262	748.796
0.326	797.943
0.390	840.681
0.454	878.717
0.517	913.132
0.581	944.661
0.645	973.827
0.709	1001.016
1.004	1122.799
1.299	1244.582
1.595	1366.365
1.914	1366.365

P-Multiplier = 7.459E-01 Y-Multiplier = 1.000E+00

AT THE BACKFILL SIDE

DEPTH BELOW GS	DIAM	PHI	GAMMA AVG	A	B	PCT	PCD
FT	IN		LBS/IN**3				

Figure D.18-17

35.00	42.53	39.00	6.94E-02	0.88	0.50	5.70E+04	1.13E+05

Y	P
IN	LBS/IN
0.000	0.000
0.035	1454.456
0.071	2908.912
0.135	5526.934
0.198	8144.955
0.262	10762.976
0.326	13254.400
0.390	14775.555
0.454	16201.705
0.517	17551.070
0.581	18836.583
0.645	20067.832
0.709	21252.171
1.004	26636.054
1.299	32019.937
1.595	37403.820
1.914	37403.820

P-Multiplier = 7.459E-01 Y-Multiplier = 1.000E+00

AT THE EXCAVATION SIDE

DEPTH BELOW GS	DIAM	PHI	GAMMA AVG	A	B	PCT	PCD
FT	IN		LBS/IN**3				
3.99	42.53	39.00	6.94E-02	2.02	1.47	1.26E+03	1.29E+04

Y	P
IN	LBS/IN
0.000	0.000
0.035	165.877
0.071	331.755
0.135	630.334
0.198	928.913
0.262	1030.584
0.326	1099.868
0.390	1160.198
0.454	1213.951
0.517	1262.635
0.581	1307.274
0.645	1348.598
0.709	1387.148
1.004	1559.872
1.299	1732.596
1.595	1905.320
1.914	1905.320

P-Multiplier = 7.459E-01 Y-Multiplier = 1.000E+00

AT THE BACKFILL SIDE

Figure D.18-18

DEPTH BELOW GS	DIAM	PHI	GAMMA AVG	A	B	PCT	PCD
FT	IN		LBS/IN**3				
35.99	42.53	39.00	6.94E-02	0.88	0.50	6.01E+04	1.16E+05

Y	P
IN	LBS/IN
0.000	0.000
0.035	1495.666
0.071	2991.332
0.135	5683.530
0.198	8375.729
0.262	11067.927
0.326	13760.126
0.390	15585.640
0.454	17089.979
0.517	18513.324
0.581	19869.317
0.645	21168.071
0.709	22417.342
1.004	28096.402
1.299	33775.461
1.595	39454.521
1.914	39454.521

P-Multiplier = 7.459E-01 Y-Multiplier = 1.000E+00

AT THE EXCAVATION SIDE

DEPTH BELOW GS	DIAM	PHI	GAMMA AVG	A	B	PCT	PCD
FT	IN		LBS/IN**3				
4.01	42.53	39.00	6.94E-02	2.02	1.47	1.11E+03	1.18E+04

Y	P
IN	LBS/IN
0.000	0.000
0.035	93.042
0.071	186.085
0.135	353.561
0.198	521.038
0.262	688.514
0.326	855.990
0.390	1017.483
0.454	1064.641
0.517	1107.353
0.581	1146.516
0.645	1182.772
0.709	1216.593
1.004	1368.135
1.299	1519.676
1.595	1671.217
1.914	1671.217

Figure D.18-19

P-Multiplier = 7.459E-01 Y-Multiplier = 1.000E+00

AT THE BACKFILL SIDE

DEPTH BELOW GS FT	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	PCT	PCD
36.01	42.53	39.00	6.94E-02	0.88	0.50	5.91E+04	1.15E+05

Y IN	P LBS/IN
0.000	0.000
0.035	905.127
0.071	1810.254
0.135	3439.483
0.198	5068.711
0.262	6697.940
0.326	8327.169
0.390	9956.398
0.454	11585.626
0.517	13214.855
0.581	14844.084
0.645	16473.312
0.709	18102.541
1.004	25645.266
1.299	33187.992
1.595	38775.696
1.914	38775.696

P-Multiplier = 7.459E-01 Y-Multiplier = 1.000E+00

AT THE EXCAVATION SIDE

DEPTH BELOW GS FT	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	PCT	PCD
4.50	42.53	39.00	6.94E-02	1.92	1.39	1.35E+03	1.34E+04

Y IN	P LBS/IN
0.000	0.000
0.035	105.520
0.071	211.040
0.135	400.975
0.198	590.911
0.262	780.846
0.326	970.782
0.390	1160.717
0.454	1222.729
0.517	1272.340
0.581	1317.848
0.645	1359.993
0.709	1399.321
1.004	1575.562

Figure D.18-20

1.299	1751.804
1.595	1928.046
1.914	1928.046

P-Multiplier = 7.459E-01 Y-Multiplier = 1.000E+00

AT THE BACKFILL SIDE

DEPTH BELOW GS FT	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	PCT	PCD
36.50	42.53	39.00	6.94E-02	0.88	0.50	6.06E+04	1.17E+05

Y IN	P LBS/IN
0.000	0.000
0.035	917.604
0.071	1835.209
0.135	3486.897
0.198	5138.585
0.262	6790.272
0.326	8441.960
0.390	10093.648
0.454	11745.336
0.517	13397.024
0.581	15048.712
0.645	16700.400
0.709	18352.088
1.004	25998.791
1.299	33645.494
1.595	39803.796
1.914	39803.796

P-Multiplier = 7.459E-01 Y-Multiplier = 1.000E+00

AT THE EXCAVATION SIDE

DEPTH BELOW GS FT	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	PCT	PCD
5.00	42.53	39.00	6.94E-02	1.82	1.32	1.61E+03	1.50E+04

Y IN	P LBS/IN
0.000	0.000
0.035	118.209
0.071	236.417
0.135	449.193
0.198	661.968
0.262	874.744
0.326	1087.519
0.390	1300.295
0.454	1377.231
0.517	1433.822

Figure D.18-21

0.581	1485.757
0.645	1533.873
0.709	1578.791
1.004	1780.117
1.299	1981.443
1.595	2182.769
1.914	2182.769

P-Multiplier = 7.459E-01 Y-Multiplier = 1.000E+00

AT THE BACKFILL SIDE

DEPTH BELOW GS FT	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	PCT	PCD
37.00	42.53	39.00	6.94E-02	0.88	0.50	6.23E+04	1.18E+05

Y IN	P LBS/IN
0.000	0.000
0.035	930.293
0.071	1860.586
0.135	3535.114
0.198	5209.642
0.262	6884.170
0.326	8558.698
0.390	10233.225
0.454	11907.753
0.517	13582.281
0.581	15256.809
0.645	16931.336
0.709	18605.864
1.004	26358.308
1.299	34110.751
1.595	40863.087
1.914	40863.087

P-Multiplier = 7.459E-01 Y-Multiplier = 1.000E+00

AT THE EXCAVATION SIDE

DEPTH BELOW GS FT	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	PCT	PCD
5.50	42.53	39.00	6.94E-02	1.73	1.25	1.89E+03	1.66E+04

Y IN	P LBS/IN
0.000	0.000
0.035	130.897
0.071	261.795
0.135	497.410
0.198	733.026
0.262	968.641

Figure D.18-22

0.326	1204.256
0.390	1439.872
0.454	1528.532
0.517	1592.234
0.581	1650.727
0.645	1704.945
0.709	1755.580
1.004	1982.576
1.299	2209.572
1.595	2436.568
1.914	2436.568

P-Multiplier = 7.459E-01 Y-Multiplier = 1.000E+00

AT THE BACKFILL SIDE

DEPTH BELOW GS FT	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	PCT	PCD
37.50	42.53	39.00	6.94E-02	0.88	0.50	6.39E+04	1.20E+05

Y IN	P LBS/IN
0.000	0.000
0.035	942.982
0.071	1885.964
0.135	3583.332
0.198	5280.699
0.262	6978.067
0.326	8675.435
0.390	10372.802
0.454	12070.170
0.517	13767.538
0.581	15464.905
0.645	17162.273
0.709	18859.641
1.004	26717.824
1.299	34576.008
1.595	41936.260
1.914	41936.260

P-Multiplier = 7.459E-01 Y-Multiplier = 1.000E+00

AT THE EXCAVATION SIDE

DEPTH BELOW GS FT	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	PCT	PCD
5.99	42.53	39.00	6.94E-02	1.65	1.19	2.18E+03	1.82E+04

Y IN	P LBS/IN
0.000	0.000
0.035	143.375

Figure D.18-23

0.071	286.750
0.135	544.824
0.198	802.899
0.262	1060.973
0.326	1319.048
0.390	1577.122
0.454	1679.231
0.517	1750.306
0.581	1815.607
0.645	1876.166
0.709	1932.750
1.004	2186.473
1.299	2440.196
1.595	2693.919
1.914	2693.919

P-Multiplier = 7.459E-01 Y-Multiplier = 1.000E+00

AT THE BACKFILL SIDE

DEPTH BELOW GS FT	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	PCT	PCD
37.99	42.53	39.00	6.94E-02	0.88	0.50	6.55E+04	1.21E+05

Y IN	P LBS/IN
0.000	0.000
0.035	955.459
0.071	1910.919
0.135	3630.746
0.198	5350.572
0.262	7070.399
0.326	8790.226
0.390	10510.053
0.454	12229.880
0.517	13949.707
0.581	15669.534
0.645	17389.361
0.709	19109.187
1.004	27071.349
1.299	35033.510
1.595	42995.672
1.914	43005.083

P-Multiplier = 7.459E-01 Y-Multiplier = 1.000E+00

AT THE EXCAVATION SIDE

DEPTH BELOW GS FT	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	PCT	PCD
6.01	42.53	42.00	6.94E-02	1.65	1.18	2.14E+03	2.36E+04

Figure D.18-24

Y	P
IN	LBS/IN
0.000	0.000
0.035	192.709
0.071	385.418
0.135	732.294
0.198	1079.171
0.262	1382.097
0.326	1480.286
0.390	1566.062
0.454	1642.694
0.517	1712.260
0.581	1776.176
0.645	1835.453
0.709	1890.839
1.004	2139.193
1.299	2387.548
1.595	2635.902
1.914	2635.902

P-Multiplier = 7.459E-01 Y-Multiplier = 1.000E+00

AT THE BACKFILL SIDE

DEPTH BELOW GS	DIAM	PHI	GAMMA AVG	A	B	PCT	PCD
FT	IN		LBS/IN**3				
38.01	42.53	42.00	6.94E-02	0.88	0.50	8.15E+04	1.79E+05

Y	P
IN	LBS/IN
0.000	0.000
0.035	1461.591
0.071	2923.183
0.135	5554.047
0.198	8184.911
0.262	10815.775
0.326	13446.640
0.390	16077.504
0.454	18708.368
0.517	21339.232
0.581	23970.097
0.645	26600.961
0.709	29231.825
1.004	38092.071
1.299	45791.532
1.595	53490.993
1.914	53490.993

P-Multiplier = 7.459E-01 Y-Multiplier = 1.000E+00

AT THE EXCAVATION SIDE

Figure D.18-25

DEPTH BELOW GS FT	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	PCT	PCD
15.25	42.53	42.00	5.29E-02	0.89	0.52	1.02E+04	5.23E+04

Y IN	P LBS/IN
0.000	0.000
0.031	495.646
0.063	991.291
0.127	1486.408
0.192	1880.046
0.257	2219.819
0.321	2524.524
0.386	2803.950
0.450	3063.986
0.515	3308.508
0.580	3540.235
0.644	3761.164
0.709	3972.812
1.004	4921.147
1.299	5869.482
1.595	6817.817
1.914	6817.817

P-Multiplier = 7.459E-01 Y-Multiplier = 1.000E+00

AT THE BACKFILL SIDE

DEPTH BELOW GS FT	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	PCT	PCD
47.25	42.53	42.00	5.29E-02	0.88	0.50	9.56E+04	1.71E+05

Y IN	P LBS/IN
0.000	0.000
0.035	1828.047
0.071	3656.094
0.135	6946.579
0.198	10237.064
0.262	13527.548
0.326	16818.033
0.390	20108.518
0.454	23399.003
0.517	26689.487
0.581	29979.972
0.645	33270.457
0.709	35654.672
1.004	44687.189
1.299	53719.706
1.595	62752.223
1.914	62752.223

P-Multiplier = 7.459E-01 Y-Multiplier = 1.000E+00

Figure D.18-26

AT THE EXCAVATION SIDE

DEPTH BELOW GS FT	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	PCT	PCD
24.50	42.53	42.00	4.88E-02	0.88	0.50	2.40E+04	7.99E+04

Y IN	P LBS/IN
0.000	0.000
0.056	1454.772
0.111	2909.543
0.171	3777.768
0.231	4532.265
0.291	5213.020
0.350	5840.629
0.410	6427.423
0.470	6981.510
0.530	7508.569
0.589	8012.770
0.649	8497.287
0.709	8964.604
1.004	11235.637
1.299	13506.670
1.595	15777.703
1.914	15777.703

P-Multiplier = 7.459E-01 Y-Multiplier = 1.000E+00

AT THE BACKFILL SIDE

DEPTH BELOW GS FT	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	PCT	PCD
56.50	42.53	42.00	4.88E-02	0.88	0.50	1.26E+05	1.89E+05

Y IN	P LBS/IN
0.000	0.000
0.035	2194.833
0.071	4389.667
0.135	8340.367
0.198	12291.067
0.262	16241.767
0.326	20192.467
0.390	24143.167
0.454	28093.867
0.517	32044.567
0.581	35995.267
0.645	39945.967
0.709	43896.667
1.004	58847.572
1.299	70742.294
1.595	82637.016

Figure D.18-27

1.914	82637.016

P-Multiplier = 7.459E-01 Y-Multiplier = 1.000E+00

AT THE EXCAVATION SIDE

DEPTH BELOW GS FT	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	PCT	PCD
33.75	42.53	42.00	4.70E-02	0.88	0.50	4.36E+04	1.07E+05

Y IN	P LBS/IN
0.000	0.000
0.035	1292.737
0.071	2585.475
0.135	4912.402
0.198	7239.329
0.262	8882.086
0.326	10139.232
0.390	11302.872
0.454	12393.836
0.517	13426.061
0.581	14409.441
0.645	15351.311
0.709	16257.296
1.004	20375.810
1.299	24494.325
1.595	28612.840
1.914	28612.840

P-Multiplier = 7.459E-01 Y-Multiplier = 1.000E+00

AT THE BACKFILL SIDE

DEPTH BELOW GS FT	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	PCT	PCD
65.75	42.53	42.00	4.70E-02	0.88	0.50	1.64E+05	2.13E+05

Y IN	P LBS/IN
0.000	0.000
0.035	2561.620
0.071	5123.239
0.135	9734.155
0.198	14345.070
0.262	18955.985
0.326	23566.900
0.390	28177.816
0.454	32788.731
0.517	37399.646
0.581	42010.562
0.645	46621.477

Figure D.18-28

0.709	51232.392
1.004	72579.222
1.299	92037.271
1.595	107512.564
1.914	107512.564

P-Multiplier = 7.459E-01 Y-Multiplier = 1.000E+00

AT THE EXCAVATION SIDE

DEPTH BELOW GS FT	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	PCT	PCD
42.99	42.53	42.00	4.59E-02	0.88	0.50	6.89E+04	1.35E+05

Y IN	P LBS/IN
0.000	0.000
0.035	1659.193
0.071	3318.386
0.135	6304.934
0.198	9291.482
0.262	12278.030
0.326	15264.578
0.390	17856.038
0.454	19579.518
0.517	21210.205
0.581	22763.728
0.645	24251.675
0.709	25682.930
1.004	32189.273
1.299	38695.615
1.595	45201.957
1.914	45201.957

P-Multiplier = 7.459E-01 Y-Multiplier = 1.000E+00

AT THE BACKFILL SIDE

DEPTH BELOW GS FT	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	PCT	PCD
74.99	42.53	42.00	4.59E-02	0.88	0.50	2.08E+05	2.38E+05

Y IN	P LBS/IN
0.000	0.000
0.035	2928.075
0.071	5856.151
0.135	11126.687
0.198	16397.222
0.262	21667.758
0.326	26938.294
0.390	32208.830

Figure D.18-29

0.454	37479.366
0.517	42749.901
0.581	48020.437
0.645	53290.973
0.709	58561.509
1.004	82962.137
1.299	107362.766
1.595	131763.395
1.914	136564.056

P-Multiplier = 7.459E-01 Y-Multiplier = 1.000E+00

Bridge 17.7 Pier 3 - Seismic - Specified LEPs

RESULTS

NUMBER OF ITERATIONS : 6

STA I	X	DEFL.	SLOPE	MOMENT	SHEAR	SOIL_REACT	NET_FORCE/STA	EI
	FT	IN	RAD	LBS-IN	LBS	LBS/IN	LBS	LBS-IN**2
0	0.000E+00	1.993E+00	8.640E-04	-6.377E+02	-7.243E+04	0.000E+00	-1.448E+05	2.422E+12
1	1.000E+00	2.003E+00	8.597E-04	-1.738E+06	-1.428E+05	0.000E+00	4.045E+03	2.422E+12
2	2.000E+00	2.013E+00	8.469E-04	-3.428E+06	-1.385E+05	0.000E+00	4.504E+03	2.422E+12
3	3.000E+00	2.023E+00	8.259E-04	-5.063E+06	-1.338E+05	0.000E+00	5.016E+03	2.422E+12
4	4.000E+00	2.033E+00	7.969E-04	-6.638E+06	-1.285E+05	0.000E+00	5.529E+03	2.422E+12
5	5.000E+00	2.042E+00	7.603E-04	-8.146E+06	-1.227E+05	0.000E+00	6.041E+03	2.422E+12
6	6.000E+00	2.051E+00	7.164E-04	-9.583E+06	-1.164E+05	0.000E+00	6.554E+03	2.422E+12
7	7.000E+00	2.060E+00	6.655E-04	-1.094E+07	-1.096E+05	0.000E+00	7.066E+03	2.422E+12
8	8.000E+00	2.067E+00	6.082E-04	-1.221E+07	-1.025E+05	0.000E+00	7.029E+03	2.422E+12
9	9.000E+00	2.074E+00	5.009E-04	-1.340E+07	-9.536E+04	0.000E+00	7.341E+03	1.044E+12
10	1.000E+01	2.079E+00	3.405E-04	-1.450E+07	-8.759E+04	0.000E+00	8.204E+03	1.044E+12
11	1.100E+01	2.082E+00	1.680E-04	-1.550E+07	-7.912E+04	0.000E+00	8.716E+03	1.044E+12
12	1.200E+01	2.083E+00	-1.539E-05	-1.640E+07	-7.015E+04	0.000E+00	9.229E+03	1.044E+12
13	1.300E+01	2.082E+00	-2.085E-04	-1.719E+07	-6.067E+04	0.000E+00	9.741E+03	1.044E+12
14	1.400E+01	2.078E+00	-4.099E-04	-1.786E+07	-5.067E+04	0.000E+00	1.025E+04	1.044E+12
15	1.500E+01	2.072E+00	-6.183E-04	-1.840E+07	-4.016E+04	0.000E+00		

```
1.077E+04   1.044E+12
    16   1.600E+01   2.063E+00  -8.323E-04  -1.882E+07  -2.914E+04   0.000E+00
1.128E+04   1.044E+12
    17   1.700E+01   2.052E+00  -1.050E-03  -1.910E+07  -1.760E+04   0.000E+00
1.179E+04   1.044E+12
    18   1.800E+01   2.038E+00  -1.459E-03  -1.924E+07  -5.553E+03   0.000E+00
1.230E+04   3.869E+11
    19   1.900E+01   2.017E+00  -2.055E-03  -1.924E+07   7.007E+03   0.000E+00
1.282E+04   3.869E+11
    20   2.000E+01   1.989E+00  -2.649E-03  -1.907E+07   2.008E+04   0.000E+00
1.333E+04   3.869E+11
    21   2.100E+01   1.954E+00  -3.236E-03  -1.875E+07   3.367E+04   0.000E+00
1.384E+04   3.869E+11
    22   2.200E+01   1.911E+00  -3.810E-03  -1.827E+07   4.776E+04   0.000E+00
1.435E+04   3.869E+11
    23   2.300E+01   1.862E+00  -4.367E-03  -1.761E+07   6.233E+04   0.000E+00
1.478E+04   3.869E+11
    24   2.400E+01   1.806E+00  -4.900E-03  -1.677E+07   7.736E+04   0.000E+00
1.529E+04   3.869E+11
    25   2.500E+01   1.745E+00  -5.404E-03  -1.575E+07   9.268E+04   0.000E+00
1.535E+04   3.869E+11
    26   2.600E+01   1.677E+00  -5.829E-03  -1.455E+07   1.083E+05   0.000E+00
1.582E+04   4.836E+11
    27   2.700E+01   1.605E+00  -6.172E-03  -1.315E+07   1.243E+05   0.000E+00
1.630E+04   4.836E+11
    28   2.800E+01   1.529E+00  -6.479E-03  -1.156E+07   1.409E+05   0.000E+00
1.677E+04   4.836E+11
    29   2.900E+01   1.449E+00  -6.744E-03  -9.772E+06   1.579E+05   0.000E+00
1.725E+04   4.836E+11
    30   3.000E+01   1.367E+00  -6.961E-03  -7.774E+06   1.753E+05   0.000E+00
1.772E+04   4.836E+11
    31   3.100E+01   1.282E+00  -7.127E-03  -5.564E+06   1.931E+05   0.000E+00
1.785E+04   4.836E+11
    32   3.200E+01   1.196E+00  -7.235E-03  -3.139E+06   2.111E+05  -1.159E+00
1.810E+04   4.836E+11
    33   3.300E+01   1.108E+00  -7.280E-03  -4.973E+05   2.184E+05  -3.212E+02
-3.404E+03   4.836E+11
    34   3.400E+01   1.021E+00  -7.260E-03   2.104E+06   2.128E+05  -6.995E+02
-7.943E+03   4.836E+11
    35   3.500E+01   9.342E-01  -7.177E-03   4.609E+06   2.025E+05  -1.094E+03
-1.268E+04   4.836E+11
    36   3.600E+01   8.487E-01  -7.033E-03   6.963E+06   1.875E+05  -1.469E+03
-1.718E+04   4.836E+11
    37   3.700E+01   7.654E-01  -6.834E-03   9.110E+06   1.706E+05  -1.433E+03
-1.674E+04   4.836E+11
    38   3.800E+01   6.847E-01  -6.584E-03   1.106E+07   1.520E+05  -1.737E+03
-2.039E+04   4.836E+11
    39   3.900E+01   6.074E-01  -6.288E-03   1.276E+07   1.307E+05  -1.891E+03
-2.224E+04   4.836E+11
    40   4.000E+01   5.338E-01  -5.954E-03   1.419E+07   1.078E+05  -2.000E+03
-2.355E+04   4.836E+11
    41   4.100E+01   4.645E-01  -5.587E-03   1.534E+07   8.384E+04  -2.066E+03
-2.434E+04   4.836E+11
    42   4.200E+01   3.997E-01  -5.196E-03   1.620E+07   5.942E+04  -2.079E+03
-2.450E+04   4.836E+11
    43   4.300E+01   3.398E-01  -4.787E-03   1.677E+07   3.537E+04  -2.005E+03
```

```
-2.361E+04   4.836E+11
    44   4.400E+01   2.848E-01  -4.367E-03   1.705E+07   1.227E+04  -1.919E+03
-2.258E+04   4.836E+11
    45   4.500E+01   2.350E-01  -3.944E-03   1.707E+07  -9.778E+03  -1.831E+03
-2.152E+04   4.836E+11
    46   4.600E+01   1.902E-01  -3.523E-03   1.682E+07  -3.075E+04  -1.739E+03
-2.042E+04   4.836E+11
    47   4.700E+01   1.504E-01  -3.112E-03   1.633E+07  -5.049E+04  -1.626E+03
-1.906E+04   4.836E+11
    48   4.800E+01   1.155E-01  -2.716E-03   1.561E+07  -6.911E+04  -1.552E+03
-1.818E+04   4.836E+11
    49   4.900E+01   8.521E-02  -2.340E-03   1.467E+07  -8.623E+04  -1.375E+03
-1.605E+04   4.836E+11
    50   5.000E+01   5.931E-02  -1.990E-03   1.354E+07  -1.007E+05  -1.120E+03
-1.299E+04   4.836E+11
    51   5.100E+01   3.744E-02  -1.632E-03   1.225E+07  -1.115E+05  -7.458E+02
-8.499E+03   3.869E+11
    52   5.200E+01   2.013E-02  -1.274E-03   1.086E+07  -1.180E+05  -4.218E+02
-4.612E+03   3.869E+11
    53   5.300E+01   6.865E-03  -9.594E-04   9.418E+06  -1.210E+05  -1.510E+02
-1.362E+03   3.869E+11
    54   5.400E+01  -2.896E-03  -6.900E-04   7.957E+06  -1.205E+05   1.703E+02
2.494E+03   3.869E+11
    55   5.500E+01  -9.694E-03  -4.653E-04   6.526E+06  -1.155E+05   5.803E+02
7.414E+03   3.869E+11
    56   5.600E+01  -1.406E-02  -2.837E-04   5.185E+06  -1.064E+05   8.565E+02
1.073E+04   3.869E+11
    57   5.700E+01  -1.650E-02  -1.417E-04   3.972E+06  -9.472E+04   1.022E+03
1.272E+04   3.869E+11
    58   5.800E+01  -1.746E-02  -3.496E-05   2.911E+06  -8.153E+04   1.102E+03
1.367E+04   3.869E+11
    59   5.900E+01  -1.734E-02   4.144E-05   2.015E+06  -6.778E+04   1.114E+03
1.382E+04   3.869E+11
    60   6.000E+01  -1.647E-02   1.051E-04   1.285E+06  -5.419E+04   1.077E+03
1.337E+04   2.378E+11
    61   6.100E+01  -1.482E-02   1.556E-04   7.147E+05  -4.136E+04   9.861E+02
1.228E+04   2.378E+11
    62   6.200E+01  -1.274E-02   1.810E-04   2.921E+05  -2.982E+04   8.621E+02
1.080E+04   2.378E+11
    63   6.300E+01  -1.048E-02   1.883E-04  -9.851E+02  -1.987E+04   7.212E+02
9.104E+03   2.378E+11
    64   6.400E+01  -8.217E-03   1.836E-04  -1.848E+05  -1.164E+04   5.751E+02
7.351E+03   2.378E+11
    65   6.500E+01  -6.070E-03   1.719E-04  -2.804E+05  -5.150E+03   4.318E+02
5.632E+03   2.378E+11
    66   6.600E+01  -4.092E-03   1.570E-04  -3.084E+05  -3.342E+02   2.958E+02
4.000E+03   2.378E+11
    67   6.700E+01  -2.301E-03   1.420E-04  -2.884E+05   2.904E+03   1.690E+02
2.478E+03   2.378E+11
    68   6.800E+01  -6.844E-04   1.287E-04  -2.387E+05   4.674E+03   5.105E+01
1.063E+03   2.378E+11
    69   6.900E+01   7.874E-04   1.182E-04  -1.762E+05   5.242E+03  -3.144E+01
7.274E+01   2.378E+11
    70   7.000E+01   2.152E-03   1.109E-04  -1.129E+05   4.973E+03  -8.841E+01
-6.109E+02   2.378E+11
    71   7.100E+01   3.449E-03   1.066E-04  -5.686E+04   4.019E+03  -1.456E+02
```

```
-1.298E+03   2.378E+11
    72   7.200E+01   4.712E-03   1.048E-04  -1.642E+04   2.369E+03  -2.043E+02
-2.002E+03   2.378E+11
    73   7.300E+01   5.964E-03   1.044E-04  -1.432E-09   6.840E+02  -1.327E+02
-1.368E+03   2.378E+11


     END OF ANALYSIS
```


Figure D.18-33

```
     ========================================================================

                     PYWALL for Windows, Version 2019.6.2

                      Serial Number :  239146531

                      A Program for the Analysis of
                      Flexible Retaining Walls
                    (c) Copyright ENSOFT, Inc., 1987-2019
                         All Rights Reserved

     ========================================================================


     This program is licensed to :

     GeoEngineers, Inc.
     Baton Rouge, LA

     Path to file locations      : P:\0\0180366\01\Analysis\Bridge 17.7\Appendix D -
Bridge 17.7 - Analysis\Pier 3 PY-Wall\Final\
     Name of input data file     : PY Wall Pier 3 - Point Of Fixity_0in - Pinned - Static
- inertia.py6d
     Name of output file         : PY Wall Pier 3 - Point Of Fixity_0in - Pinned - Static
- inertia.py6o
     Name of plot output file    : PY Wall Pier 3 - Point Of Fixity_0in - Pinned - Static
- inertia.py6p

     ------------------------------------------------------------------------
                          Time and Date of Analysis
     ------------------------------------------------------------------------

               Date:  November 30, 2021     Time:  19:00:44


      Bridge 17.7 - Pier 3, COWI Modeled LEP


      ************************************************
      *        PROGRAM CONTROL PARAMETERS            *
      ************************************************

      NO OF POINTS FOR SPECIFIED DEFLECTIONS AND SLOPES  =  1
      NO OF WALL SECTIONS                                =  3
      NO OF CROSS SECTIONS                               =  3
      GENERATE EARTH PRESSURE INTERNALLY                 =  0
      GENERATE SOIL RESISTANCE (P-Y) CURVES INTERNALLY   =  1
      NO OF P-Y MODIFICATION FACTORS FOR GEN. P-Y CURVES =  0
      NO OF USER-SPECIFIED SOIL RESISTANCE (P-Y) CURVES  =  0
      NO OF TIE BACKS                                    =  0


      HEIGHT OF WALL                                     =     73.000 FT
      NUMBER OF INCREMENTS                               =         73
      INCREMENT LENGTH                                   =     12.000 IN
      MAXIMUM ALLOWABLE DEFLECTION                       =     72.000 IN
```

```
 DEFLECTION CLOSURE TOLERANCE                        =  1.000E-05 IN
 MAXIMUM NUMBER OF ITERATIONS                        =         500


 ************************************************
 *        SPECIFIED DEFLECTIONS AND SLOPES        *
 ************************************************

     STA      CASE       DEFLECTION        SLOPE
                            FT              RAD
       0         1         0.000E+00         NONE

* WALL SECTIONS *

  SECT          TOP        BOTTOM     SECTION
                FT            FT
    1        0.00000       8.50000       1
    2        8.50000       17.5000       2
    3        17.5000       73.0000       3


* CROSS SECTIONS *

 CROSS SECTION       :     1
 SECTION NAME        : Shaft
 TYPE                :  ELASTIC
 CROSS SECTION TYPE  : RECTANGULAR PIPE
 EQUIVALENT DIAMETER :       1.00000 IN
 EXTERNAL WIDTH      :       78.0000 IN
 EXTERNAL DEPTH      :       57.0000 IN
 INTERNAL WIDTH      :       0.00000 IN
 INTERNAL DEPTH      :       0.00000 IN
 YOUNG MODULUS       :   4.03000E+06 LBS/IN**2

 CROSS SECTION       :     2
 SECTION NAME        : 98.5
 TYPE                :  ELASTIC
 CROSS SECTION TYPE  : GENERAL SECTION
 EQUIVALENT DIAMETER :       48.0000 IN
 YOUNG MODULUS       :   4.03000E+06 LBS/IN**2

 CROSS SECTION       :     3
 SECTION NAME        : 89.5
 TYPE                :  ELASTIC
 CROSS SECTION TYPE  : GENERAL SECTION
 EQUIVALENT DIAMETER :       48.0000 IN
 YOUNG MODULUS       :   4.03000E+06 LBS/IN**2


* CROSS SECTIONS PROPERTIES *

         ELASTIC SECTIONS

  SECT          DIAM,IN       I,IN**4
    1            1.00000   1.20200E+06
    2            48.0000   5.20000E+05
```


Figure D.18-35

```
    3             48.0000   2.60600E+05



 ************************************************
 *        STIFFNESS AND LOAD DATA                *
 ************************************************

 EI - FLEXURAL RIGIDITY,  Q - TRANSVERSE LOAD,
 S - STIFFNESS OF TRANSVERSE RESISTANCE,
 T - TORQUE,              P - AXIAL LOAD,
 R - STIFFNESS OF TORSIONAL RESISTANCE.


FROM TO CONTD     EI          Q         S         T          R          P
              LBS-IN**2     LBS     LBS/IN    IN-LBS    IN-LBS     LBS
   0      1  4.844E+12 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
       9  0  4.844E+12 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
   9      1  2.096E+12 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
      18  0  2.096E+12 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  18      1  1.050E+12 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
      73  0  1.050E+12 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
   0   0  0  2.422E+12 0.000E+00 0.000E+00 0.000E+00 0.000E+00 1.230E+05
   0   0  0  2.422E+12 2.788E+03 0.000E+00 0.000E+00 0.000E+00 0.000E+00
   0  23  0  2.422E+12 6.180E+02 0.000E+00 0.000E+00 0.000E+00 0.000E+00
  24  32  0  1.050E+12 6.020E+02 0.000E+00 0.000E+00 0.000E+00 0.000E+00


 ************************************************
 *        SPECIFIED ACTIVE EARTH PRESSURE        *
 ************************************************



    DEPTH         ACTIVE EARTH PRESSURE
     IN                  LBS/IN
   --------       ----------------------
  0.000E+00           1.100E+02
  2.880E+02           7.267E+02
  2.880E+02           7.083E+02
  3.840E+02           9.000E+02


 ************************************************
 *        SOIL LAYERS AND STRENGTH DATA          *
 ************************************************


    X AT THE SURFACE OF EXCAVATION SIDE     =      32.00 FT

    3 LAYER(S) OF SOIL

    LAYER  1
    THE SOIL IS A SAND
```


Figure D.18-36

LAYER 2
THE SOIL IS A SAND

LAYER 3
THE SOIL IS A SAND

DISTRIBUTION OF EFFECTIVE UNIT WEIGHT WITH DEPTH
6 POINTS

X,FT	WEIGHT,LBS/IN**3
32.0000	6.9444E-02
36.0000	6.9444E-02
36.0000	6.9444E-02
38.0000	6.9444E-02
38.0000	4.2125E-02
100.0000	4.2125E-02

DISTRIBUTION OF STRENGTH PARAMETERS WITH DEPTH
6 POINTS

X,FT	S,LBS/IN**2	PHI,DEGREES	E50
32.00	0.0000E+00	39.000	-----
36.00	0.0000E+00	39.000	-----
36.00	0.0000E+00	39.000	-----
38.00	0.0000E+00	39.000	-----
38.00	0.0000E+00	42.000	-----
75.00	0.0000E+00	42.000	-----

P-Y CURVES DATA

AT THE EXCAVATION SIDE

DEPTH BELOW GS FT	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	PCT	PCD
0.01	42.53	39.00	6.94E-02	2.83	2.14	1.23E+00	2.69E+01

Y IN	P LBS/IN
0.000	0.000
0.065	0.635
0.130	1.271
0.188	1.397
0.246	1.498
0.304	1.582
0.362	1.654
0.419	1.719
0.477	1.777
0.535	1.831
0.593	1.880
0.651	1.925

Figure D.18-37

0.709	1.968
1.004	2.180
1.299	2.392
1.595	2.603
1.914	2.603

P-Multiplier = 7.459E-01 Y-Multiplier = 1.000E+00

AT THE BACKFILL SIDE

DEPTH BELOW GS FT	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	PCT	PCD
32.01	42.53	39.00	6.94E-02	0.88	0.50	4.81E+04	1.03E+05

Y IN	P LBS/IN
0.000	0.000
0.035	1330.135
0.071	2660.270
0.135	5054.512
0.198	7448.755
0.262	9793.259
0.326	11179.371
0.390	12462.384
0.454	13665.264
0.517	14803.380
0.581	15887.641
0.645	16926.134
0.709	17925.059
1.004	22466.074
1.299	27007.089
1.595	31548.104
1.914	31548.104

P-Multiplier = 7.459E-01 Y-Multiplier = 1.000E+00

AT THE EXCAVATION SIDE

DEPTH BELOW GS FT	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	PCT	PCD
1.00	42.53	39.00	6.94E-02	2.63	1.97	1.90E+02	3.22E+03

Y IN	P LBS/IN
0.000	0.000
0.035	41.556
0.071	83.112
0.135	157.912
0.198	197.070
0.262	212.575
0.326	225.530
0.390	236.750

Figure D.18-38

0.454	246.703
0.517	255.683
0.581	263.888
0.645	271.462
0.709	278.509
1.004	310.040
1.299	341.572
1.595	373.104
1.914	373.104

P-Multiplier = 7.459E-01 Y-Multiplier = 1.000E+00

AT THE BACKFILL SIDE

DEPTH BELOW GS FT	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	PCT	PCD
33.00	42.53	39.00	6.94E-02	0.88	0.50	5.09E+04	1.06E+05

Y IN	P LBS/IN
0.000	0.000
0.035	1371.344
0.071	2742.689
0.135	5211.109
0.198	7679.529
0.262	10147.949
0.326	11847.681
0.390	13207.393
0.454	14482.183
0.517	15688.337
0.581	16837.415
0.645	17937.989
0.709	18996.631
1.004	23809.111
1.299	28621.591
1.595	33434.071
1.914	33434.071

P-Multiplier = 7.459E-01 Y-Multiplier = 1.000E+00

AT THE EXCAVATION SIDE

DEPTH BELOW GS FT	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	PCT	PCD
2.00	42.53	39.00	6.94E-02	2.43	1.79	4.65E+02	6.45E+03

Y IN	P LBS/IN
0.000	0.000
0.035	83.112
0.071	166.224
0.135	315.825

Figure D.18-39

0.198	431.976
0.262	467.751
0.326	497.746
0.390	523.796
0.454	546.955
0.517	567.890
0.581	587.054
0.645	604.769
0.709	621.272
1.004	695.171
1.299	769.070
1.595	842.969
1.914	842.969

P-Multiplier = 7.459E-01 Y-Multiplier = 1.000E+00

AT THE BACKFILL SIDE

DEPTH BELOW GS	DIAM	PHI	GAMMA AVG	A	B	PCT	PCD
FT	IN		LBS/IN**3				
34.00	42.53	39.00	6.94E-02	0.88	0.50	5.39E+04	1.10E+05

Y	P
IN	LBS/IN
0.000	0.000
0.035	1412.900
0.071	2825.801
0.135	5369.021
0.198	7912.242
0.262	10455.463
0.326	12541.202
0.390	13980.507
0.454	15329.918
0.517	16606.676
0.581	17823.017
0.645	18988.015
0.709	20108.626
1.004	25202.812
1.299	30296.997
1.595	35391.182
1.914	35391.182

P-Multiplier = 7.459E-01 Y-Multiplier = 1.000E+00

AT THE EXCAVATION SIDE

DEPTH BELOW GS	DIAM	PHI	GAMMA AVG	A	B	PCT	PCD
FT	IN		LBS/IN**3				
3.00	42.53	39.00	6.94E-02	2.22	1.63	8.24E+02	9.67E+03

Y	P
IN	LBS/IN

Figure D.18-40

0.000	0.000
0.035	124.668
0.071	249.335
0.135	473.737
0.198	690.273
0.262	748.796
0.326	797.943
0.390	840.681
0.454	878.717
0.517	913.132
0.581	944.661
0.645	973.827
0.709	1001.016
1.004	1122.799
1.299	1244.582
1.595	1366.365
1.914	1366.365

P-Multiplier = 7.459E-01 Y-Multiplier = 1.000E+00

AT THE BACKFILL SIDE

DEPTH BELOW GS	DIAM	PHI	GAMMA AVG	A	B	PCT	PCD
FT	IN		LBS/IN**3				
35.00	42.53	39.00	6.94E-02	0.88	0.50	5.70E+04	1.13E+05

Y	P
IN	LBS/IN
0.000	0.000
0.035	1454.456
0.071	2908.912
0.135	5526.934
0.198	8144.955
0.262	10762.976
0.326	13254.400
0.390	14775.555
0.454	16201.705
0.517	17551.070
0.581	18836.583
0.645	20067.832
0.709	21252.171
1.004	26636.054
1.299	32019.937
1.595	37403.820
1.914	37403.820

P-Multiplier = 7.459E-01 Y-Multiplier = 1.000E+00

AT THE EXCAVATION SIDE

DEPTH BELOW GS	DIAM	PHI	GAMMA AVG	A	B	PCT	PCD
FT	IN		LBS/IN**3				

Figure D.18-41

3.99	42.53	39.00	6.94E-02	2.02	1.47	1.26E+03	1.29E+04

Y	P
IN	LBS/IN
0.000	0.000
0.035	165.877
0.071	331.755
0.135	630.334
0.198	928.913
0.262	1030.584
0.326	1099.868
0.390	1160.198
0.454	1213.951
0.517	1262.635
0.581	1307.274
0.645	1348.598
0.709	1387.148
1.004	1559.872
1.299	1732.596
1.595	1905.320
1.914	1905.320

P-Multiplier = 7.459E-01 Y-Multiplier = 1.000E+00

AT THE BACKFILL SIDE

DEPTH BELOW GS	DIAM	PHI	GAMMA AVG	A	B	PCT	PCD
FT	IN		LBS/IN**3				
35.99	42.53	39.00	6.94E-02	0.88	0.50	6.01E+04	1.16E+05

Y	P
IN	LBS/IN
0.000	0.000
0.035	1495.666
0.071	2991.332
0.135	5683.530
0.198	8375.729
0.262	11067.927
0.326	13760.126
0.390	15585.640
0.454	17089.979
0.517	18513.324
0.581	19869.317
0.645	21168.071
0.709	22417.342
1.004	28096.402
1.299	33775.461
1.595	39454.521
1.914	39454.521

P-Multiplier = 7.459E-01 Y-Multiplier = 1.000E+00

AT THE EXCAVATION SIDE

Figure D.18-42

DEPTH BELOW GS	DIAM	PHI	GAMMA AVG	A	B	PCT	PCD
FT	IN		LBS/IN**3				
4.01	42.53	39.00	6.94E-02	2.02	1.47	1.11E+03	1.18E+04

Y	P
IN	LBS/IN
0.000	0.000
0.035	93.042
0.071	186.085
0.135	353.561
0.198	521.038
0.262	688.514
0.326	855.990
0.390	1017.483
0.454	1064.641
0.517	1107.353
0.581	1146.516
0.645	1182.772
0.709	1216.593
1.004	1368.135
1.299	1519.676
1.595	1671.217
1.914	1671.217

P-Multiplier = 7.459E-01 Y-Multiplier = 1.000E+00

AT THE BACKFILL SIDE

DEPTH BELOW GS	DIAM	PHI	GAMMA AVG	A	B	PCT	PCD
FT	IN		LBS/IN**3				
36.01	42.53	39.00	6.94E-02	0.88	0.50	5.91E+04	1.15E+05

Y	P
IN	LBS/IN
0.000	0.000
0.035	905.127
0.071	1810.254
0.135	3439.483
0.198	5068.711
0.262	6697.940
0.326	8327.169
0.390	9956.398
0.454	11585.626
0.517	13214.855
0.581	14844.084
0.645	16473.312
0.709	18102.541
1.004	25645.266
1.299	33187.992
1.595	38775.696
1.914	38775.696

Figure D.18-43

P-Multiplier = 7.459E-01 Y-Multiplier = 1.000E+00

AT THE EXCAVATION SIDE

DEPTH BELOW GS FT	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	PCT	PCD
4.50	42.53	39.00	6.94E-02	1.92	1.39	1.35E+03	1.34E+04

Y IN	P LBS/IN
0.000	0.000
0.035	105.520
0.071	211.040
0.135	400.975
0.198	590.911
0.262	780.846
0.326	970.782
0.390	1160.717
0.454	1222.729
0.517	1272.340
0.581	1317.848
0.645	1359.993
0.709	1399.321
1.004	1575.562
1.299	1751.804
1.595	1928.046
1.914	1928.046

P-Multiplier = 7.459E-01 Y-Multiplier = 1.000E+00

AT THE BACKFILL SIDE

DEPTH BELOW GS FT	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	PCT	PCD
36.50	42.53	39.00	6.94E-02	0.88	0.50	6.06E+04	1.17E+05

Y IN	P LBS/IN
0.000	0.000
0.035	917.604
0.071	1835.209
0.135	3486.897
0.198	5138.585
0.262	6790.272
0.326	8441.960
0.390	10093.648
0.454	11745.336
0.517	13397.024
0.581	15048.712
0.645	16700.400
0.709	18352.088
1.004	25998.791

Figure D.18-44

1.299	33645.494
1.595	39803.796
1.914	39803.796

P-Multiplier = 7.459E-01 Y-Multiplier = 1.000E+00

AT THE EXCAVATION SIDE

DEPTH BELOW GS FT	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	PCT	PCD
5.00	42.53	39.00	6.94E-02	1.82	1.32	1.61E+03	1.50E+04

Y IN	P LBS/IN
0.000	0.000
0.035	118.209
0.071	236.417
0.135	449.193
0.198	661.968
0.262	874.744
0.326	1087.519
0.390	1300.295
0.454	1377.231
0.517	1433.822
0.581	1485.757
0.645	1533.873
0.709	1578.791
1.004	1780.117
1.299	1981.443
1.595	2182.769
1.914	2182.769

P-Multiplier = 7.459E-01 Y-Multiplier = 1.000E+00

AT THE BACKFILL SIDE

DEPTH BELOW GS FT	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	PCT	PCD
37.00	42.53	39.00	6.94E-02	0.88	0.50	6.23E+04	1.18E+05

Y IN	P LBS/IN
0.000	0.000
0.035	930.293
0.071	1860.586
0.135	3535.114
0.198	5209.642
0.262	6884.170
0.326	8558.698
0.390	10233.225
0.454	11907.753
0.517	13582.281

Figure D.18-45

0.581	15256.809
0.645	16931.336
0.709	18605.864
1.004	26358.308
1.299	34110.751
1.595	40863.087
1.914	40863.087

P-Multiplier = 7.459E-01 Y-Multiplier = 1.000E+00

AT THE EXCAVATION SIDE

DEPTH BELOW GS FT	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	PCT	PCD
5.50	42.53	39.00	6.94E-02	1.73	1.25	1.89E+03	1.66E+04

Y IN	P LBS/IN
0.000	0.000
0.035	130.897
0.071	261.795
0.135	497.410
0.198	733.026
0.262	968.641
0.326	1204.256
0.390	1439.872
0.454	1528.532
0.517	1592.234
0.581	1650.727
0.645	1704.945
0.709	1755.580
1.004	1982.576
1.299	2209.572
1.595	2436.568
1.914	2436.568

P-Multiplier = 7.459E-01 Y-Multiplier = 1.000E+00

AT THE BACKFILL SIDE

DEPTH BELOW GS FT	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	PCT	PCD
37.50	42.53	39.00	6.94E-02	0.88	0.50	6.39E+04	1.20E+05

Y IN	P LBS/IN
0.000	0.000
0.035	942.982
0.071	1885.964
0.135	3583.332
0.198	5280.699
0.262	6978.067

Figure D.18-46

0.326	8675.435
0.390	10372.802
0.454	12070.170
0.517	13767.538
0.581	15464.905
0.645	17162.273
0.709	18859.641
1.004	26717.824
1.299	34576.008
1.595	41936.260
1.914	41936.260

P-Multiplier = 7.459E-01 Y-Multiplier = 1.000E+00

AT THE EXCAVATION SIDE

DEPTH BELOW GS FT	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	PCT	PCD
5.99	42.53	39.00	6.94E-02	1.65	1.19	2.18E+03	1.82E+04

Y IN	P LBS/IN
0.000	0.000
0.035	143.375
0.071	286.750
0.135	544.824
0.198	802.899
0.262	1060.973
0.326	1319.048
0.390	1577.122
0.454	1679.231
0.517	1750.306
0.581	1815.607
0.645	1876.166
0.709	1932.750
1.004	2186.473
1.299	2440.196
1.595	2693.919
1.914	2693.919

P-Multiplier = 7.459E-01 Y-Multiplier = 1.000E+00

AT THE BACKFILL SIDE

DEPTH BELOW GS FT	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	PCT	PCD
37.99	42.53	39.00	6.94E-02	0.88	0.50	6.55E+04	1.21E+05

Y IN	P LBS/IN
0.000	0.000
0.035	955.459

Figure D.18-47

0.071	1910.919
0.135	3630.746
0.198	5350.572
0.262	7070.399
0.326	8790.226
0.390	10510.053
0.454	12229.880
0.517	13949.707
0.581	15669.534
0.645	17389.361
0.709	19109.187
1.004	27071.349
1.299	35033.510
1.595	42995.672
1.914	43005.083

P-Multiplier = 7.459E-01 Y-Multiplier = 1.000E+00

AT THE EXCAVATION SIDE

DEPTH BELOW GS FT	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	PCT	PCD
6.01	42.53	42.00	6.94E-02	1.65	1.18	2.14E+03	2.36E+04

Y IN	P LBS/IN
0.000	0.000
0.035	192.709
0.071	385.418
0.135	732.294
0.198	1079.171
0.262	1382.097
0.326	1480.286
0.390	1566.062
0.454	1642.694
0.517	1712.260
0.581	1776.176
0.645	1835.453
0.709	1890.839
1.004	2139.193
1.299	2387.548
1.595	2635.902
1.914	2635.902

P-Multiplier = 7.459E-01 Y-Multiplier = 1.000E+00

AT THE BACKFILL SIDE

DEPTH BELOW GS FT	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	PCT	PCD
38.01	42.53	42.00	6.94E-02	0.88	0.50	8.15E+04	1.79E+05

Figure D.18-48

Y	P
IN	LBS/IN
0.000	0.000
0.035	1461.591
0.071	2923.183
0.135	5554.047
0.198	8184.911
0.262	10815.775
0.326	13446.640
0.390	16077.504
0.454	18708.368
0.517	21339.232
0.581	23970.097
0.645	26600.961
0.709	29231.825
1.004	38092.071
1.299	45791.532
1.595	53490.993
1.914	53490.993

P-Multiplier = 7.459E-01 Y-Multiplier = 1.000E+00

AT THE EXCAVATION SIDE

DEPTH BELOW GS	DIAM	PHI	GAMMA AVG	A	B	PCT	PCD
FT	IN		LBS/IN**3				
15.25	42.53	42.00	5.29E-02	0.89	0.52	1.02E+04	5.23E+04

Y	P
IN	LBS/IN
0.000	0.000
0.031	495.646
0.063	991.291
0.127	1486.408
0.192	1880.046
0.257	2219.819
0.321	2524.524
0.386	2803.950
0.450	3063.986
0.515	3308.508
0.580	3540.235
0.644	3761.164
0.709	3972.812
1.004	4921.147
1.299	5869.482
1.595	6817.817
1.914	6817.817

P-Multiplier = 7.459E-01 Y-Multiplier = 1.000E+00

AT THE BACKFILL SIDE

Figure D.18-49

DEPTH BELOW GS FT	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	PCT	PCD
47.25	42.53	42.00	5.29E-02	0.88	0.50	9.56E+04	1.71E+05

Y IN	P LBS/IN
0.000	0.000
0.035	1828.047
0.071	3656.094
0.135	6946.579
0.198	10237.064
0.262	13527.548
0.326	16818.033
0.390	20108.518
0.454	23399.003
0.517	26689.487
0.581	29979.972
0.645	33270.457
0.709	35654.672
1.004	44687.189
1.299	53719.706
1.595	62752.223
1.914	62752.223

P-Multiplier = 7.459E-01 Y-Multiplier = 1.000E+00

AT THE EXCAVATION SIDE

DEPTH BELOW GS FT	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	PCT	PCD
24.50	42.53	42.00	4.88E-02	0.88	0.50	2.40E+04	7.99E+04

Y IN	P LBS/IN
0.000	0.000
0.056	1454.772
0.111	2909.543
0.171	3777.768
0.231	4532.265
0.291	5213.020
0.350	5840.629
0.410	6427.423
0.470	6981.510
0.530	7508.569
0.589	8012.770
0.649	8497.287
0.709	8964.604
1.004	11235.637
1.299	13506.670
1.595	15777.703
1.914	15777.703

P-Multiplier = 7.459E-01 Y-Multiplier = 1.000E+00

Figure D.18-50

AT THE BACKFILL SIDE

DEPTH BELOW GS FT	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	PCT	PCD
56.50	42.53	42.00	4.88E-02	0.88	0.50	1.26E+05	1.89E+05

Y IN	P LBS/IN
0.000	0.000
0.035	2194.833
0.071	4389.667
0.135	8340.367
0.198	12291.067
0.262	16241.767
0.326	20192.467
0.390	24143.167
0.454	28093.867
0.517	32044.567
0.581	35995.267
0.645	39945.967
0.709	43896.667
1.004	58847.572
1.299	70742.294
1.595	82637.016
1.914	82637.016

P-Multiplier = 7.459E-01 Y-Multiplier = 1.000E+00

AT THE EXCAVATION SIDE

DEPTH BELOW GS FT	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	PCT	PCD
33.75	42.53	42.00	4.70E-02	0.88	0.50	4.36E+04	1.07E+05

Y IN	P LBS/IN
0.000	0.000
0.035	1292.737
0.071	2585.475
0.135	4912.402
0.198	7239.329
0.262	8882.086
0.326	10139.232
0.390	11302.872
0.454	12393.836
0.517	13426.061
0.581	14409.441
0.645	15351.311
0.709	16257.296
1.004	20375.810
1.299	24494.325
1.595	28612.840

Figure D.18-51

1.914	28612.840

P-Multiplier = 7.459E-01 Y-Multiplier = 1.000E+00

AT THE BACKFILL SIDE

DEPTH BELOW GS FT	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	PCT	PCD
65.75	42.53	42.00	4.70E-02	0.88	0.50	1.64E+05	2.13E+05

Y IN	P LBS/IN
0.000	0.000
0.035	2561.620
0.071	5123.239
0.135	9734.155
0.198	14345.070
0.262	18955.985
0.326	23566.900
0.390	28177.816
0.454	32788.731
0.517	37399.646
0.581	42010.562
0.645	46621.477
0.709	51232.392
1.004	72579.222
1.299	92037.271
1.595	107512.564
1.914	107512.564

P-Multiplier = 7.459E-01 Y-Multiplier = 1.000E+00

AT THE EXCAVATION SIDE

DEPTH BELOW GS FT	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	PCT	PCD
42.99	42.53	42.00	4.59E-02	0.88	0.50	6.89E+04	1.35E+05

Y IN	P LBS/IN
0.000	0.000
0.035	1659.193
0.071	3318.386
0.135	6304.934
0.198	9291.482
0.262	12278.030
0.326	15264.578
0.390	17856.038
0.454	19579.518
0.517	21210.205
0.581	22763.728
0.645	24251.675

Figure D.18-52

0.709	25682.930
1.004	32189.273
1.299	38695.615
1.595	45201.957
1.914	45201.957

P-Multiplier = 7.459E-01 Y-Multiplier = 1.000E+00

AT THE BACKFILL SIDE

DEPTH BELOW GS FT	DIAM IN	PHI	GAMMA AVG LBS/IN**3	A	B	PCT	PCD
74.99	42.53	42.00	4.59E-02	0.88	0.50	2.08E+05	2.38E+05

Y IN	P LBS/IN
0.000	0.000
0.035	2928.075
0.071	5856.151
0.135	11126.687
0.198	16397.222
0.262	21667.758
0.326	26938.294
0.390	32208.830
0.454	37479.366
0.517	42749.901
0.581	48020.437
0.645	53290.973
0.709	58561.509
1.004	82962.137
1.299	107362.766
1.595	131763.395
1.914	136564.056

P-Multiplier = 7.459E-01 Y-Multiplier = 1.000E+00

Bridge 17.7 - Pier 3, COWI Modeled LEP

RESULTS

NUMBER OF ITERATIONS : 5

STA	I	X FT	DEFL. IN	SLOPE RAD	MOMENT LBS-IN	SHEAR LBS	SOIL_REACT LBS/IN	NET_FORCE/STA LBS	EI LBS-IN**2
0		0.000E+00	0.000E+00	1.594E-03	-1.176E+03	-4.924E+04	0.000E+00	-9.828E+04	4.844E+12
1		1.000E+00	1.913E-02	1.592E-03	-1.182E+06	-9.721E+04	0.000E+00	2.344E+03	4.844E+12
2		2.000E+00	3.822E-02	1.588E-03	-2.334E+06	-9.476E+04	0.000E+00		

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2.555E+03   4.844E+12
     3   3.000E+00   5.724E-02   1.581E-03  -3.456E+06  -9.205E+04   0.000E+00
2.863E+03   4.844E+12
     4   4.000E+00   7.616E-02   1.571E-03  -4.543E+06  -8.903E+04   0.000E+00
3.171E+03   4.844E+12
     5   5.000E+00   9.494E-02   1.558E-03  -5.593E+06  -8.571E+04   0.000E+00
3.480E+03   4.844E+12
     6   6.000E+00   1.136E-01   1.543E-03  -6.600E+06  -8.207E+04   0.000E+00
3.788E+03   4.844E+12
     7   7.000E+00   1.320E-01   1.526E-03  -7.562E+06  -7.813E+04   0.000E+00
4.096E+03   4.844E+12
     8   8.000E+00   1.502E-01   1.506E-03  -8.475E+06  -7.388E+04   0.000E+00
4.405E+03   4.844E+12
     9   9.000E+00   1.681E-01   1.469E-03  -9.335E+06  -6.932E+04   0.000E+00
4.713E+03   2.096E+12
    10   1.000E+01   1.854E-01   1.413E-03  -1.014E+07  -6.445E+04   0.000E+00
5.021E+03   2.096E+12
    11   1.100E+01   2.020E-01   1.353E-03  -1.088E+07  -5.928E+04   0.000E+00
5.330E+03   2.096E+12
    12   1.200E+01   2.179E-01   1.288E-03  -1.156E+07  -5.379E+04   0.000E+00
5.638E+03   2.096E+12
    13   1.300E+01   2.329E-01   1.220E-03  -1.217E+07  -4.800E+04   0.000E+00
5.946E+03   2.096E+12
    14   1.400E+01   2.472E-01   1.149E-03  -1.271E+07  -4.190E+04   0.000E+00
6.255E+03   2.096E+12
    15   1.500E+01   2.605E-01   1.075E-03  -1.318E+07  -3.549E+04   0.000E+00
6.563E+03   2.096E+12
    16   1.600E+01   2.730E-01   9.985E-04  -1.357E+07  -2.878E+04   0.000E+00
6.871E+03   2.096E+12
    17   1.700E+01   2.845E-01   9.199E-04  -1.387E+07  -2.175E+04   0.000E+00
7.180E+03   2.096E+12
    18   1.800E+01   2.951E-01   7.997E-04  -1.409E+07  -1.442E+04   0.000E+00
7.488E+03   1.050E+12
    19   1.900E+01   3.037E-01   6.381E-04  -1.422E+07  -6.774E+03   0.000E+00
7.796E+03   1.050E+12
    20   2.000E+01   3.104E-01   4.754E-04  -1.425E+07   1.177E+03   0.000E+00
8.105E+03   1.050E+12
    21   2.100E+01   3.151E-01   3.130E-04  -1.419E+07   9.435E+03   0.000E+00
8.413E+03   1.050E+12
    22   2.200E+01   3.179E-01   1.518E-04  -1.402E+07   1.800E+04   0.000E+00
8.721E+03   1.050E+12
    23   2.300E+01   3.187E-01  -6.923E-06  -1.376E+07   2.672E+04   0.000E+00
8.721E+03   1.050E+12
    24   2.400E+01   3.177E-01  -1.620E-04  -1.338E+07   3.559E+04   0.000E+00
9.021E+03   1.050E+12
    25   2.500E+01   3.149E-01  -3.121E-04  -1.290E+07   4.480E+04   0.000E+00
9.389E+03   1.050E+12
    26   2.600E+01   3.102E-01  -4.561E-04  -1.231E+07   5.433E+04   0.000E+00
9.677E+03   1.050E+12
    27   2.700E+01   3.039E-01  -5.927E-04  -1.160E+07   6.415E+04   0.000E+00
9.964E+03   1.050E+12
    28   2.800E+01   2.960E-01  -7.205E-04  -1.077E+07   7.426E+04   0.000E+00
1.025E+04   1.050E+12
    29   2.900E+01   2.866E-01  -8.381E-04  -9.815E+06   8.466E+04   0.000E+00
1.054E+04   1.050E+12
    30   3.000E+01   2.759E-01  -9.441E-04  -8.736E+06   9.534E+04   0.000E+00
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1.083E+04   1.050E+12
    31   3.100E+01   2.640E-01  -1.037E-03  -7.527E+06   1.063E+05   0.000E+00
1.111E+04   1.050E+12
    32   3.200E+01   2.510E-01  -1.115E-03  -6.184E+06   1.174E+05  -7.528E-01
1.109E+04   1.050E+12
    33   3.300E+01   2.372E-01  -1.178E-03  -4.709E+06   1.217E+05  -2.065E+02
-2.478E+03   1.050E+12
    34   3.400E+01   2.227E-01  -1.223E-03  -3.263E+06   1.178E+05  -4.456E+02
-5.347E+03   1.050E+12
    35   3.500E+01   2.078E-01  -1.252E-03  -1.881E+06   1.109E+05  -6.989E+02
-8.386E+03   1.050E+12
    36   3.600E+01   1.927E-01  -1.267E-03  -6.003E+05   1.013E+05  -9.017E+02
-1.082E+04   1.050E+12
    37   3.700E+01   1.774E-01  -1.267E-03   5.509E+05   9.276E+04  -5.282E+02
-6.338E+03   1.050E+12
    38   3.800E+01   1.623E-01  -1.254E-03   1.626E+06   8.600E+04  -5.992E+02
-7.191E+03   1.050E+12
    39   3.900E+01   1.473E-01  -1.230E-03   2.615E+06   7.843E+04  -6.622E+02
-7.947E+03   1.050E+12
    40   4.000E+01   1.327E-01  -1.195E-03   3.508E+06   7.014E+04  -7.187E+02
-8.625E+03   1.050E+12
    41   4.100E+01   1.186E-01  -1.151E-03   4.298E+06   6.124E+04  -7.651E+02
-9.181E+03   1.050E+12
    42   4.200E+01   1.051E-01  -1.098E-03   4.978E+06   5.185E+04  -8.003E+02
-9.604E+03   1.050E+12
    43   4.300E+01   9.230E-02  -1.038E-03   5.542E+06   4.208E+04  -8.277E+02
-9.932E+03   1.050E+12
    44   4.400E+01   8.023E-02  -9.717E-04   5.988E+06   3.202E+04  -8.485E+02
-1.018E+04   1.050E+12
    45   4.500E+01   6.898E-02  -9.014E-04   6.311E+06   2.175E+04  -8.643E+02
-1.037E+04   1.050E+12
    46   4.600E+01   5.859E-02  -8.282E-04   6.510E+06   1.148E+04  -8.458E+02
-1.015E+04   1.050E+12
    47   4.700E+01   4.910E-02  -7.534E-04   6.587E+06   1.762E+03  -7.747E+02
-9.297E+03   1.050E+12
    48   4.800E+01   4.051E-02  -6.783E-04   6.552E+06  -6.974E+03  -6.812E+02
-8.174E+03   1.050E+12
    49   4.900E+01   3.282E-02  -6.042E-04   6.419E+06  -1.458E+04  -5.859E+02
-7.030E+03   1.050E+12
    50   5.000E+01   2.601E-02  -5.321E-04   6.202E+06  -2.104E+04  -4.912E+02
-5.895E+03   1.050E+12
    51   5.100E+01   2.005E-02  -4.629E-04   5.914E+06  -2.638E+04  -3.994E+02
-4.793E+03   1.050E+12
    52   5.200E+01   1.490E-02  -3.973E-04   5.569E+06  -3.065E+04  -3.123E+02
-3.748E+03   1.050E+12
    53   5.300E+01   1.052E-02  -3.359E-04   5.179E+06  -3.391E+04  -2.313E+02
-2.776E+03   1.050E+12
    54   5.400E+01   6.843E-03  -2.791E-04   4.755E+06  -3.625E+04  -1.576E+02
-1.891E+03   1.050E+12
    55   5.500E+01   3.820E-03  -2.273E-04   4.309E+06  -3.774E+04  -9.191E+01
-1.103E+03   1.050E+12
    56   5.600E+01   1.387E-03  -1.807E-04   3.849E+06  -3.851E+04  -3.482E+01
-4.178E+02   1.050E+12
    57   5.700E+01  -5.173E-04  -1.394E-04   3.385E+06  -3.852E+04   3.204E+01
3.845E+02   1.050E+12
    58   5.800E+01  -1.958E-03  -1.033E-04   2.925E+06  -3.759E+04   1.235E+02
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1.482E+03   1.050E+12
    59   5.900E+01  -2.998E-03  -7.245E-05   2.482E+06  -3.569E+04   1.926E+02
2.311E+03   1.050E+12
    60   6.000E+01  -3.697E-03  -4.646E-05   2.068E+06  -3.309E+04   2.417E+02
2.901E+03   1.050E+12
    61   6.100E+01  -4.113E-03  -2.499E-05   1.688E+06  -2.999E+04   2.736E+02
3.284E+03   1.050E+12
    62   6.200E+01  -4.297E-03  -7.646E-06   1.348E+06  -2.661E+04   2.908E+02
3.490E+03   1.050E+12
    63   6.300E+01  -4.296E-03   6.054E-06   1.050E+06  -2.309E+04   2.957E+02
3.549E+03   1.050E+12
    64   6.400E+01  -4.151E-03   1.659E-05   7.941E+05  -1.957E+04   2.906E+02
3.487E+03   1.050E+12
    65   6.500E+01  -3.898E-03   2.444E-05   5.802E+05  -1.616E+04   2.773E+02
3.328E+03   1.050E+12
    66   6.600E+01  -3.565E-03   3.008E-05   4.062E+05  -1.295E+04   2.577E+02
3.092E+03   1.050E+12
    67   6.700E+01  -3.176E-03   3.393E-05   2.693E+05  -1.001E+04   2.332E+02
2.799E+03   1.050E+12
    68   6.800E+01  -2.750E-03   3.642E-05   1.660E+05  -7.377E+03   2.051E+02
2.462E+03   1.050E+12
    69   6.900E+01  -2.302E-03   3.790E-05   9.226E+04  -5.100E+03   1.743E+02
2.092E+03   1.050E+12
    70   7.000E+01  -1.841E-03   3.867E-05   4.361E+04  -3.205E+03   1.415E+02
1.698E+03   1.050E+12
    71   7.100E+01  -1.374E-03   3.901E-05   1.535E+04  -1.712E+03   1.072E+02
1.286E+03   1.050E+12
    72   7.200E+01  -9.046E-04   3.911E-05   2.516E+03  -6.395E+02   7.163E+01
8.595E+02   1.050E+12
    73   7.300E+01  -4.351E-04   3.913E-05  -9.390E-10  -1.049E+02   1.748E+01
2.097E+02   1.050E+12


     END OF ANALYSIS
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Figure D.18-56

Appendix E
Bridge 17.7 Pier 1 and Wall 03.63L Finite Element Analysis

APPENDIX E – Numerical Modeling Plaxis 3D Analyses

1.0 Introduction

This appendix presents numerical modeling analyses completed to define soil-structure springs by estimating the deformation of the Bridge 17.7 West (Pier 1) abutment under seismic lateral load from the bridge superstructure for the Interstate 405 (I-405) Renton to Bellevue Widening and Express Toll Lane Project in King County, Washington.

As a basis for the numerical modeling evaluation, we reviewed the following documents:

- Geotechnical package titled "Geotechnical Soil Properties Methodology," prepared by Wood, dated 2021.
- Geotechnical package titled "Bridge 17.7 and Bridge 18W Walls 03.63L, 03.64L, 03.65L, 03.66L, Soil Properties Summary," prepared by GeoEngineers, dated 2021.
- Design Drawing Set titled "Contract Plans Bridge 405/17.7 Renton Ave Over NB I-405" prepared by COWI International, dated June 04, 2021.
- Design Drawing Set titled "Historical Plans for Bridge 17.7 – SR 405 Tukwila to Sunset Blvd, Cedar River Pipelines-Relocation" prepared by WSDOT, dated October 1983.
- Design Package titled "Hilfiker Retaining Walls." Prepared by Cesaretti Engineered Solutions, dated May 26, 2021.

2.0 Project Description

GeoEngineers understands that a structural earth (SE), Hilfiker type, wall structure is being designed to provide lateral support for Bridge 17.7 as a part of the I-405 widening project. The existing girders for Bridge 17.7 are to remain and post-tensioned girder extensions are being designed and added. As a result, Piers 2 and 3 of the existing bridge will remain in service. To accommodate the girder extension the existing Pier 1 will be removed, and a new Pier 1 abutment wall and footing will be constructed. The structural design of the Bridge 17.7 extension will be completed by COWI International.

We understand that the bridge superstructure transmits load into the western approach embankment through the new proposed Pier 1 abutment of Bridge 17.7. Lateral soil springs were needed for the structural analysis model used to estimate the deformation of the abutment wall and bridge structure. Three-dimensional numerical modeling was used to develop lateral soil springs considering the geometry of the west abutment and Bridge 17.7 superstructure.

GeoEngineers' numerical modeling analyses summarized in this report were completed to provide lateral soil springs behind the new Pier 1 abutment wall by simulating the sequence of the construction of the new Pier 1 footing, abutment, and approach embankment and then the loading of the new pier wall in stages. The numerical analyses were completed using the three-dimensional finite element program, Plaxis 3D V21 (Bentley 2021).

2.1 Subsurface Conditions

GeoEngineers' understanding of subsurface conditions is based on our review of existing geotechnical information from near the project site and borings completed for this study. The locations of the explorations in the site vicinity are presented on Figure E-1. The boring logs are presented in Appendix A and laboratory test results are presented in Appendix B. Geologic cross-sections are presented on Figures E-2 and E-3.

The soils encountered at the site consist of existing fill (ESU 1), cohesionless native deposits (ESU 2) and bedrock (ESU 7). The existing fill, ESU 1 consists of soils placed during previous development including roadway, wall, embankment, and bridge construction. The cohesionless native deposits, ESU 2 consists of coarse-grained and fine-grained cohesionless soil. These soils have not been glacially over-ridden. Sedimentary sandstone bedrock, ESU 7A, was encountered underlying the site of Bridge 17.7 as shown in the exploration logs and cross sections. The variation in descriptions of material above the logged sandstone suggests the layer is highly weathered. Strength testing was performed on samples from boring HQ-18-89. Results indicate the sandstone is extremely weak, International Society for Rock Mechanics (ISRM), R0 to weak, ISRM, R2.

2.2 Groundwater Conditions

Based on available groundwater information, the design groundwater under the western embankment of Bridge 17.7 is assumed to be at Elevation 43 feet. Along the alignment of Bridge 17.7 towards the east, the groundwater increases in elevation to about 80 feet, seeming to follow the approximate interface between the native sand and gravel (ESU 2A) and the weathered sandstone (ESU 7A). North of Bridge 17.7, the groundwater slopes downward from 43 feet at Bridge 18W Pier 1 to 35 feet at Bridge 18W Pier 3, aligning with the Ordinary High-Water Level of the Cedar River.

2.3 Existing West Abutment Structure

Figures E-4 through E-7 present the Plaxis 3D components considered for the existing Bridge 17.7 West abutment model. The existing Bridge 17.7 West abutment consists of a pier wall and curved approaching ramp road supported by a Hilfiker type welded-wire wall. We modeled the individual lifts and welded-wire mats in the Hilfiker wall located within 100 feet of the existing pier wall. The approach ramp is supported by an existing vertical wall (Wall 03.63L) on one side (north and west sides) and by a soil slope on the other side (south and east sides). At the location of existing pier wall, the vertical wall 03.63L is about 50 feet high and the soil slope to the south slopes downward at about 30-degrees.

2.4 New West Abutment Structures

Figures E-8 through E-11 present the Plaxis 3D model components for the proposed excavation and construction of new Bridge 17.7 West abutment. As shown in Figures E-8 and E-9, soil zones of the ramp road and embankment behind the existing pier wall are excavated to elevation 67 feet. The bottom width of the excavation is about 22 feet and the cut into the existing ramp road and embankment follows a 1.5H:1V (horizontal to vertical) slope. The existing pier wall above I-405 road elevation, the wing wall intersecting excavated soil zones, and the welded-wire mats inside the excavation zone limits are removed. As shown in Figures E-10 and E-11, the new pier wall is to be constructed 13 feet west of the existing pier wall and a new Hilfiker wall with welded-wire mats constructed behind the new pier wall in both the ramp road and embankment zones.

3.0 Numerical Analysis

3.1 PLAXIS 3D Model

The three-dimensional (3D) numerical modeling analyses for Bridge 17.7 West abutment was completed using the computer program PLAXIS 3D V21 (Bentley 2021). PLAXIS 3D is a 3D, finite element application written for soil and rock mechanics analyses. Because PLAXIS is a 3D program, we explicitly modeled the complex 3D geometry considering existing and new pier walls, Hilfiker walls, wing walls, footings, and embankment slopes. As opposed to limit equilibrium analyses, which result in a factor of safety (FS) against failure, PLAXIS 3D calculates forces and displacements of the model. The forces and displacements calculated by PLAXIS 3D are dependent on the properties and constitutive models of the soil and structural elements. The following sections summarize the PLAXIS 3D analysis completed and the estimated performance of the Bridge 17.7 West abutment.

3.1.1 PLAXIS 3D Modeling Approach

We used the computer program PLAXIS 3D to evaluate the response of Bridge 17.7 West new abutment pier wall performance under lateral loads from the bridge superstructure. The loading conditions considered in our PLAXIS analysis is the static short-term condition that occurs immediately after applying bridge superstructure loads. We modeled a staged construction sequence in detail for the Bridge 17.7 West abutment as noted in the construction sequence simulation section below.

The general steps in our PLAXIS 3D modeling were as follows:

1. Develop a PLAXIS 3D mesh that represents the main components in the area near the Bridge 17.7 West abutment. This includes the soil units, groundwater levels, existing pier wall/footing, wing wall, new pier wall/footing, existing Hilfiker wall in the ramp road and new Hilfiker wall behind the proposed new pier wall.
2. Develop appropriate soil properties that represent anticipated subsurface conditions under the short-term static condition that occurs immediately after the excavations and new pier construction are completed. For this project, a more advanced soil model (Hardening-Soil [HS] Model; Schanz et al. 1999) that can capture the nonlinear stress-strain behavior of the soils was used in the simulation of the construction stages identified for this project.
3. Simulate the construction sequence developed by the project design and construction team in stages to evaluate the response of the Bridge 17.7 West abutment to build reasonable model states.

4. Model the new pier wall considering displacement loads as a basis for developing soil spring properties behind the new pier wall. These properties are used by the structural engineer to evaluate the resistance of the lateral loads imparted by the bridge superstructure through the new abutment wall and footing.

3.1.2 PLAXIS Mesh

Figure E-4 shows the 3D soil model mesh developed in PLAXIS 3D to model existing conditions at the Bridge 17.7 West abutment. Figure E-5 presents the 3D structural models for different structural elements including existing pier wall/footing, existing wing wall and existing welded-wire mats in the Hilfiker wall. Figures E-6 and E-7 provide zoomed-in views of the area near the Bridge 17.7 West abutment to show the relative locations of various soil units and structural elements in the PLAXIS 3D model. Figures E-8 and E-9 show the PLAXIS 3D models after excavation at the existing pier, ramp road and embankments. Figures E-10 and E-11 present the PLAXIS 3D after construction of new pier wall/footing, new Hilfiker wall and backfills.

3.1.3 Soil Constitutive Model

The soils were represented using the HS model in PLAXIS. The HS model is formulated using the classical theory of plasticity in an elastoplastic framework. The HS model calculates soil strain using a stress dependent soil stiffness relationship. Schanz et al. (1999) provides a detailed description of the HS model.

The HS model is a shear and volumetric hardening constitutive model for the simulation of soil behavior. The selection of strength-based parameters (friction angle and cohesion) and stiffness-based parameters are important to give reasonable soil response under complex loading conditions. The strength-related parameters (friction angle and cohesion) are determined from Standard Penetration Test (SPT)-based correlations. The selection of friction angle for each soil unit is presented in Appendix C. The dilation angles are also used to consider the amount of plastic volumetric strain that develops during plastic shearing in the Plastic Hardening model. The dilation angle for each soil unit is estimated as friction angle minus 30 degrees.

For a hardening soil model, the soil stiffness parameters are the reference unload-reload stiffness ($E_{ur,ref}$), primary deviatoric loading modulus ($E_{50,ref}$), primary compression modulus ($E_{oed,ref}$) and small strain shear modulus ($G_{0,ref}$). These stiffness parameters can be related to small strain shear modulus G_0 and Young's modulus E_0, which can be evaluated via shear wave velocity measurements.

Typically, the small-strain shear modulus, G_0, is calculated as:

$$G_0 = \rho v_s^2$$

where ρ is the soil density and v_s is the shear wave velocity at the site.

The small strain Young's modulus, E_0, is calculated as:

$$E_0 = 2(1+\nu)G_0$$

where ν is the Poisson ratio.

In the analysis presented in this appendix, we estimated small strain shear modulus via equations presented in Table 6-2 in Washington State Department of Transportation (WSDOT) Geotechnical Design Manual (GDM) for cohesionless soils and Table 4 in Geotechnical package titled "Geotechnical Soil Properties Methodology," prepared by Wood for fine-grained soils. These correlations are developed based field measurement of N_{60} or $N_{1,60}$ values for each soil unit.

The unloading-reloading modulus, E_{ur}, is calculated based on E_0 as:

$$E_{ur} = E_0/k_1$$

where k_1 is the model parameter, which represents the relationship between small-strain modulus and unloading-reloading modulus. The typical range for k_1 is 1.0 to 3.0. Based on G_{max}, E_{50}, E_{ur} correlation proposed by Wichtmann and Triantafyllidis (2009) based triaxial compression tests and P-wave measurements for dense sand, k_1 can be selected as 3 for shallow fill or loose compacted material with v_s less than 600 feet per second (ft/s), as 2 for compacted soil with shear wave velocity about 900 ft/s and as 1.5 for densely compacted soil or glacially consolidated soils with shear wave greater than 1,100 ft/s.

In our numerical modeling, we used k_1 equal to 3 for each soil unit as an initial, conservative, approach, which is Case 1. Then, we ran a parametric study case by using k_1 equal to 2 for the soil zones behind the Bridge 17.7 West abutment pier walls. The unloading-reloading soil stiffness behind the Pier 1 abutment is equivalent to a 662 ft/s material and 937 ft/s material for case 1 and 2, respectively.

The secant modulus for primary deviatoric loading modulus, E_{50}, is calculated based on E_{ur}, as:

$$E_{50} = E_{ur}/k_2$$

where k_2 is the model parameter, which represents the relationship between secant modulus and unloading-reloading modulus. The typical range for k_2 is 2.0 to 5.0. The default value recommended in PLAXIS 3D is 3.0 as listed in Plaxis Material Model manual, which is used in this analysis.

The primary compression modulus (E_{oed}) is related to primary deviatoric loading modulus (E_{50}) following the following equation as:

$$E_{50} = 1.25E_{oed}$$

which is recommended by PLAXIS 3D manual.

The stress dependent unloading-reloading modulus is calculated as:

$$E_{ur} = E_{ur}^{ref} Z^m$$

$$Z = (ccot\phi - \sigma_3)/(ccot\phi + p_{ref})$$

where m is the model parameter; c is the soil cohesion, p_{ref} is the reference pressure as 1 atmosphere (atm) (= 2,116 pounds per square foot [psf]). Model parameter m reflects the effect of stress state (normalized by reference pressure) on the soil stiffness (e.g., m = 1 means soil stiffness is linearly related to soil stress). In this report, we used m as 0.5 for cohesionless soils (sand and gravel) (Janbu 1963).

Table E-1 summarizes the plastic hardening soil model input parameters developed for the soil units encountered at the Bridge 17.7 West abutment area. We understand that Gravel Backfill for SE Walls (which is a similar material to ESU 1A) will be used to construct the new Hilfiker wall behind the new pier wall. The soil stiffness of the backfill material depends on the construction/compaction techniques of the Hilfiker wall. We developed two sets of soil stiffness parameters for the Gravel Backfill for SE Walls soil unit as Case 1 and Case 2, which are equivalent to 662 ft/s material and 937 ft/s material. The tension cut-off is used and set to zero to avoid tension resistance development in each of the soil units. Figures E-12 and E-13 presents elements of triaxial compression test of ESU 1A at various confining pressure compared to the laboratory test of similar material presented in WSDOT SR-18 project by Yu et al. (2016).

Table E-1. Hardening Soil Model Input Parameters

Parameter	Gravel Backfill for SE Walls (Case 1)	Gravel Backfill for SE Walls (Case 2)	ESU-1B	ESU-2A	ESU-7A
Drained Type	Drained	Drained	Drained	Drained	Drained
Soil Unit Weight (pcf)	120	120	125	120	135
Friction Angle (degree)	40	40	38	39	42
Dilation Angle (degree)	10	10	8	9	12
Soil Deviatoric Stiffness, E50,ref (ksf)	1400	2810	908	955	1270
Soil Compression Stiffness, EOED, ref (ksf)	1120	2250	726	764	1020
Unload/Reload Stiffness, Eur,ref (ksf)	4210	8430	2720	2870	3810
PH Model Parameter, m	0.5	0.5	0.5	0.5	0.5
Reference Pressure Pref (psf)	2116	2116	2116	2116	2116
Small Strain Shear Modulus, G0,ref (ksf)	4860	4860	3140	3310	4390
Horizontal Stress Ratio, K0,nc	0.36	0.36	0.38	0.37	0.33
Interface Friction Coefficient, Rinter	1.0	1.0	1.0	-	-
Rf	0.9	0.9	0.9	0.9	0.9
Tension Cut-off	on	on	on	on	on

Notes:
pcf – pounds per cubic foot
ksf – kips per square foot

3.1.4 Structural Elements

The structural elements modeled for Bridge 17.7 West abutment include existing pier wall/footing, existing wing wall, existing geogrid in Hilfiker wall, new pier wall/footing and new geogrid in new Hilfiker wall. In PLAXIS 3D, all the walls/footings are modeled as plate elements and all the geogrids are modeled as geogrid elements.

3.1.4.1 Plate Elements Input Parameters

The walls/footings were modeled as elastic plates with real wall/footing thicknesses. The bending and normal stiffness of the structural elements depend on the modulus of elasticity of the material, E and G, the moment of inertia of the structural elements, I, and the cross-sectional area of the structural elements, A, which are derived from the element thickness. The shear and Young's modulus of the walls/footings were selected based on concrete with 4,000 pounds per square inch (psi) compressive strength. The effect of reinforcement inside walls/footings was not considered, for a conservative approach.

Table E-2 presents the PLAXIS 3D plate elements input parameters for the walls/footings. The thickness, geometry, size, and location of the walls/footing for the existing pier were obtained by reviewing the historical as-built plans. The thickness, geometry, size, and location of the walls/footing for the new pier were provided by COWI.

Table E-2. PLAXIS 3D Plate Structural Properties

Structural Element	Thickness (ft)	Unit Weight (pcf)	Young's Modulus (ksf)	Shear Modulus (ksf)
Existing Pier Wall	2.5	150	5.52E05	2.30E05
Existing Pier Footing	3.5	150	5.52E05	2.30E05
Existing Wing Wall	0.5	150	1.66E05	6.92E04
New Pier Wall	4.0	150	5.52E05	2.30E05
New Pier Footing	3.5	150	5.52E05	2.30E05

Notes:
pcf – pounds per cubic foot
ksf – kips per square foot

3.4.1.2 Welded-Wire Mat Element Input Parameters

We understand both the existing and new Hilfiker walls use welded-wire mesh as reinforcements. The welded wire meshes are modeled as elastoplastic geogrid elements in PLAXIS 3D with constant normal stiffness (EA) and shear stiffness (GA). The normal stiffness (EA) was computed by the steel young's modulus times the effect steel cross section area considering corrosion. The geogrid element was modeled as an isotropic material, and the shear stiffness GA is taken as half of EA as suggested in the PLAXIS 3D manual. The strength of the geogrid element (Np) at different depths was selected based on welded-wire mesh specification and was reduced with consideration of steel corrosion over time. The interaction between the welded wire mesh and surrounding soil is modeled using interface elements, modeled by choosing a suitable value for the strength factor of the interface (R_{inter}). This factor relates the interface shear strength (wall friction and adhesion) to the soil shear strength (friction angle and cohesion). The value of R_{inter} was selected as 1.0, which was suggested by the Hilfiker Wall manufacturer Cesaretti Engineered Solutions. The structural properties of the geogrid elements in PLAXIS 3D are summarized in Table E-3.

Table E-3. PLAXIS 3D Geogrid Structural Properties

Layer No.	Elevation (feet)	EA (lbf/ft)	GA (lbf/ft)	Np (lbf/ft)
1	95.5	1.94E06	9.71E05	4,352
2	93.5	1.94E06	9.71E05	4,352
3	91.5	1.94E06	9.71E05	4,352
4	89.5	1.94E06	9.71E05	4,352
5	87.5	1.94E06	9.71E05	4,352
6	85.5	1.94E06	9.71E05	4,352
7	83.5	1.94E06	9.71E05	4,352
8	81.5	1.94E06	9.71E05	4,352
9	79.5	1.94E06	9.71E05	4,352
10	77.5	1.94E06	9.71E05	4,352
11	75.5	3.21E06	1.61E06	7,204
12	73.5	3.21E06	1.61E06	7,204
13	72	3.21E06	1.61E06	7,204
14	70	3.21E06	1.61E06	7,204
15	68	3.21E06	1.61E06	7,204
16	66	3.21E06	1.61E06	7,204
17	64	3.21E06	1.61E06	7,204
18	62	3.21E06	1.61E06	7,204
19	60	3.21E06	1.61E06	7,204
20	58	4.12E06	2.06E06	9,327
21	56	4.12E06	2.06E06	7,204

Layer No.	Elevation (feet)	EA (lbf/ft)	GA (lbf/ft)	Np (lbf/ft)
22	54	4.12E06	2.06E06	7,204
23	52	4.12E06	2.06E06	7,204
24	50	4.12E06	2.06E06	7,204
25	48	4.12E06	2.06E06	7,204

3.1.5 Construction Sequence Simulation

The construction of the proposed Bridge 17.7 new West abutment in PLAXIS 3D is modeled in stages. The modeling sequence used in our numerical simulation considered the following steps:

1. Set up model geometry and calculate initial stress conditions. The initial geostatic conditions were built up with the soil units, ramp road, pier wall geometry and existing structural elements.
2. Excavate soil zones of ramp road and embankment behind existing pier wall to elevation 67 feet. The bottom width of the excavation is about 22 feet and the cut into the existing ramp road and embankment follows a 1.5H:1V slope.
3. Construct the new pier wall/footing and built new Hilfiker wall behind the new pier wall by lifts. The welded-wire mats were modeled in both the ramp road zone and slope embankment zone.
4. Load top 4 feet of the new pier wall with displacement loadings of 0.12, 0.24, 0.6, 1.2, 2.4 and 3.6 inches. During these loading stages, connections were set between bridge panel load zone (top 4 feet of the new pier wall) and new pier wall to make sure only shear were transferred. The interface stress behind the new pier wall and the displacements of the wall nodes were tracked during loading and are used to develop lateral soil springs.

4.0 Results of Finite Element Analysis

Using the approach described above, we finished numerical modeling of the Bridge 17.7 West abutment new pier wall construction and loading with proposed Case 1 and Case 2 soil profiles. Figures E-14 through E-20 present the soil springs evaluated at various depths for Case 1. Figures E-21 through E-27 present the soil springs evaluated at various depths for Case 2. The soil springs were calculated as the ratio of the average interface stress behind the new pier wall and the average new pier wall plate node displacements. We provided soil springs in a 4-foot depth interval: 0 to 4 feet, 4 to 8 feet, 8 to 12 feet, 12 to 16 feet, 16 to 20 feet, 20 to 24 feet and over 24 feet. For each depth interval, we also provided soil springs at different locations along the wall width to demonstrate the 3D effect of the soil spring due the complex 3D geometry of the model and nonlinear soil-structure interaction.

At small strain level (with 0.12 inches displacement load at the top of wall), the soil springs from PLAXIS 3D modeling agree well with the preliminary soil spring curves obtained from the commercially available computer program PYWall. However, with increasing soil deformation, the soil springs from PLAXIS 3D modeling are softer compared to the soil springs from PYWall analyses. There are two major factors for this reduction. The first one is attributed to the soil modulus degradation, which is considered in the plastic hardening model, but ignored in a PYWall analysis. The nonlinear soil behavior decreases the soil stiffness with large soil strain. The second factor is attributed to the 3D effect of the model. The soils behind the new piers are dipping down in both ramp road direction to the west and the slope embankment direction to the south. These two dipping directions reduce the magnitude of the soil springs behind the wall. When the top of the wall is loaded with uniform displacement boundary condition, we observed the bottom part of the new pier moves away from the underlying soil, which leads to comparable softer springs for depth over 16 feet. The soil springs were tabulated and transmitted to COWI for use in their structural model.

The model was also used to estimate the static deformation due to construction at the bottom of the existing Wall 03.63L where a few existing utilities are known to be located. Settlement estimates are expected to be less than 1 inch.

5.0 References

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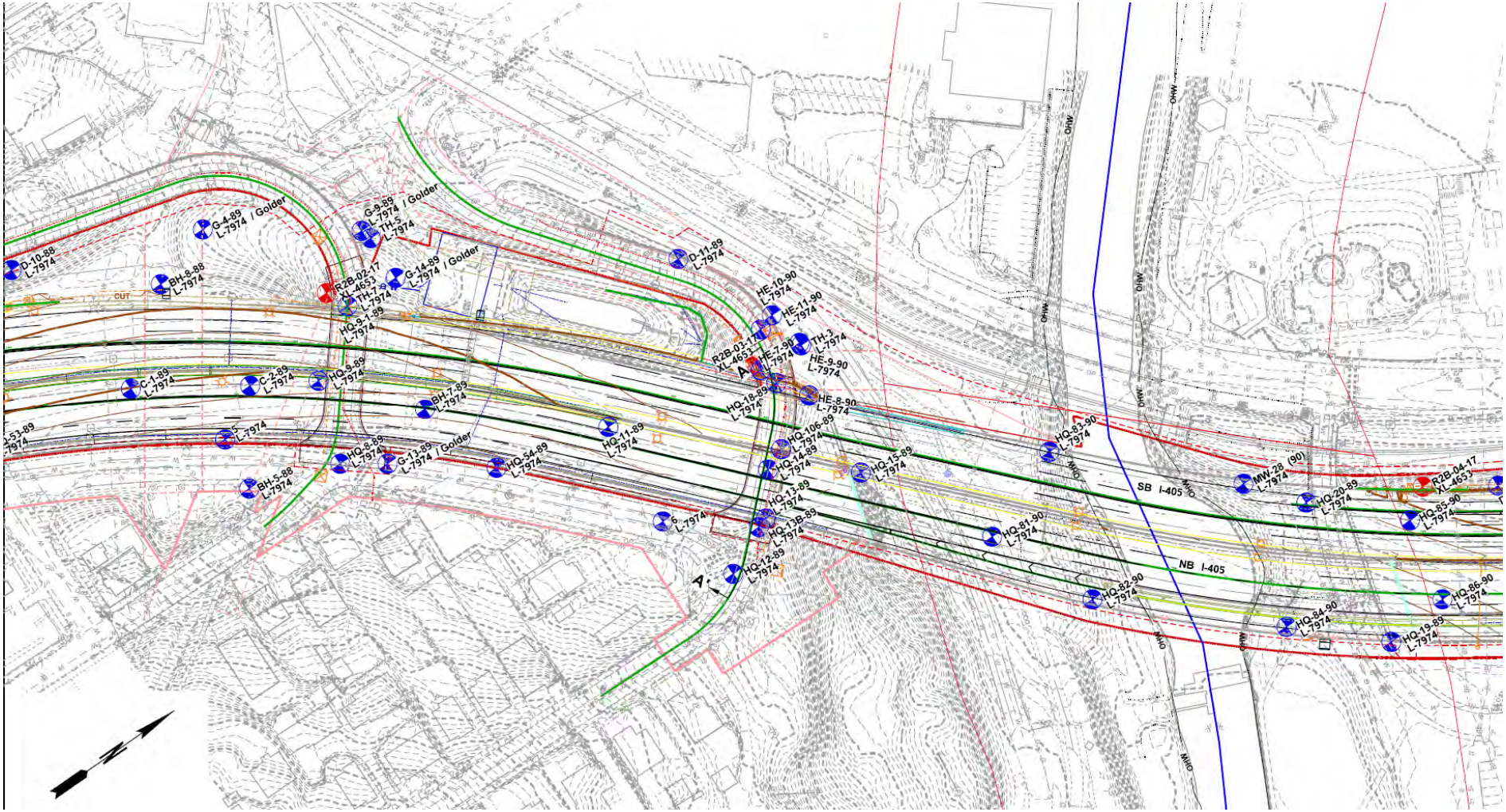
Figures

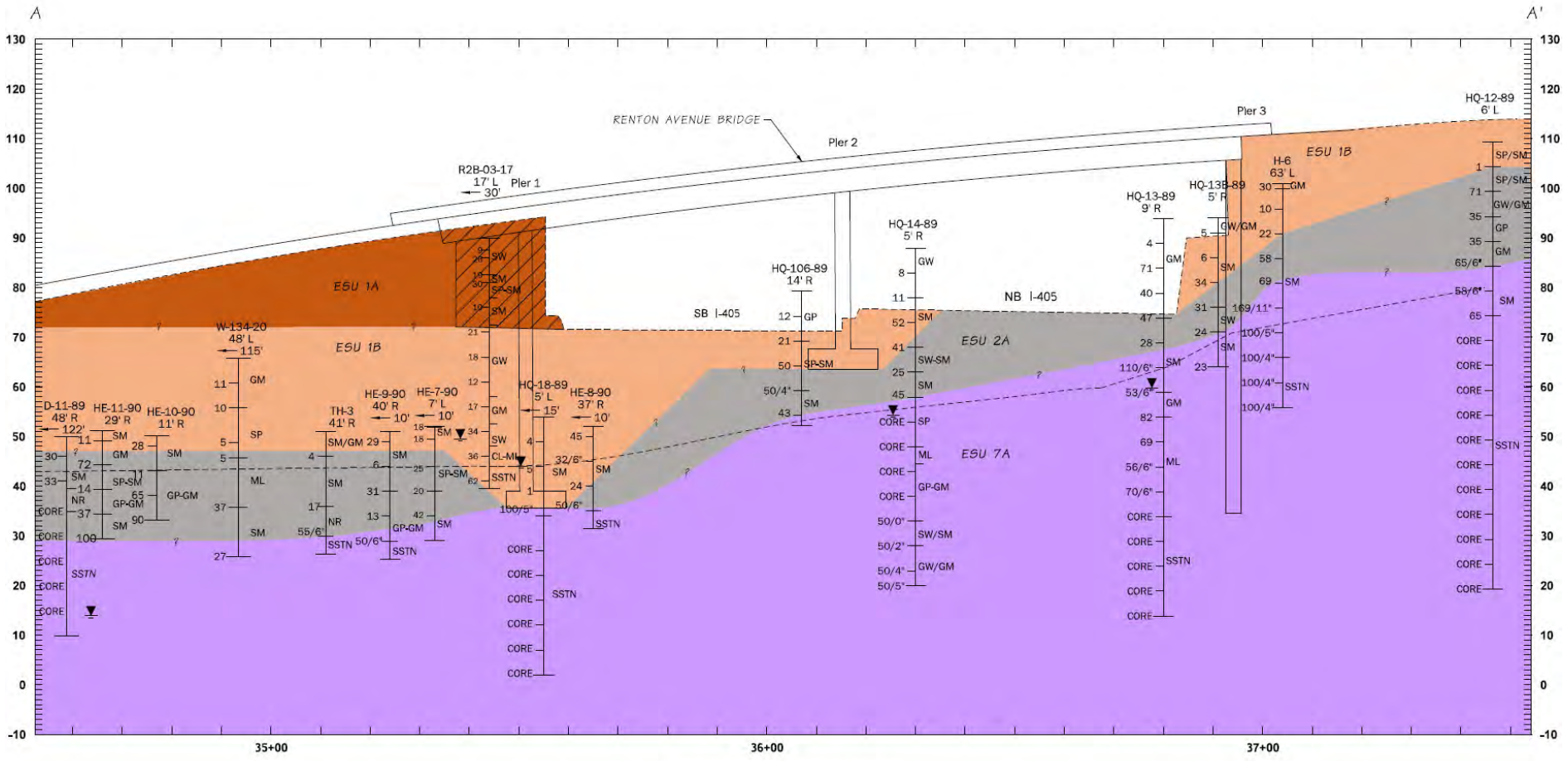


Site Plan

I-405 Renton to Bellevue Bridge 17.7
Renton, Washington

GeoEngineers

Figure E-1



BRIDGE 17.7 STATIONING

Cross Section A-A'

I-405 Renton to Bellevue Bridge 17.7
Renton, Washington

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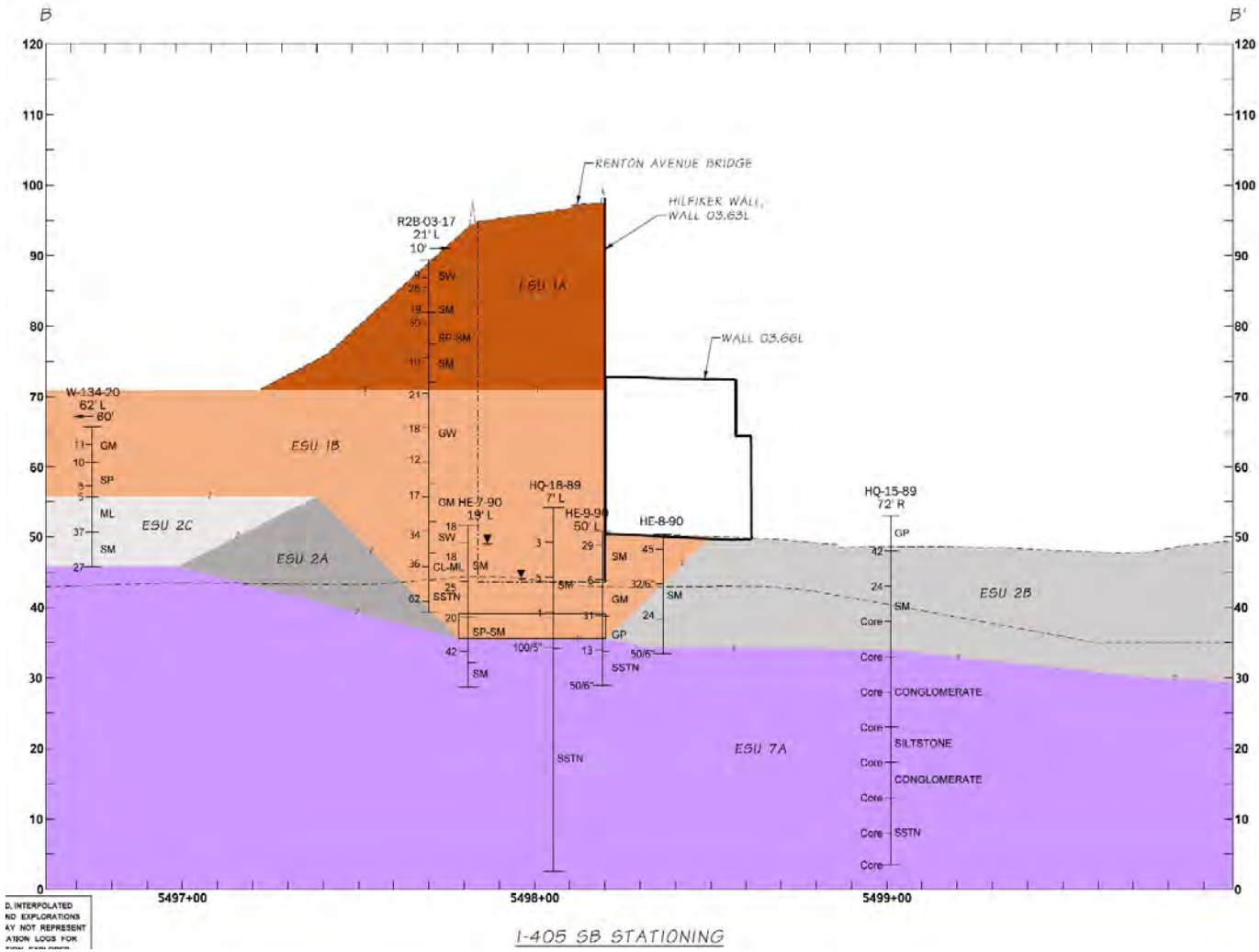
Figure E-2



Cross Section B-B'

I-405 Renton to Bellevue Bridge 17.7
Renton, Washington

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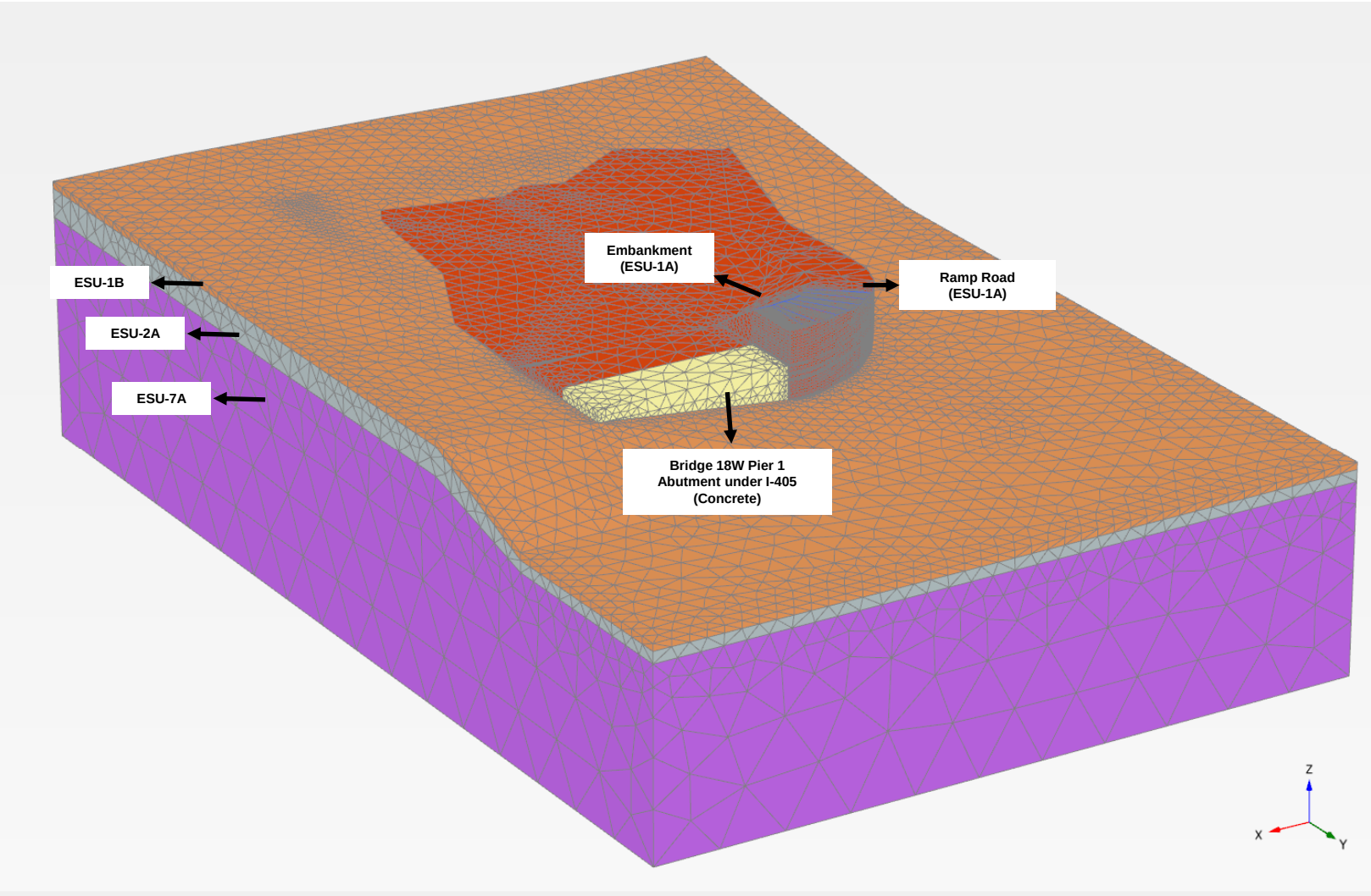
Figure E-3

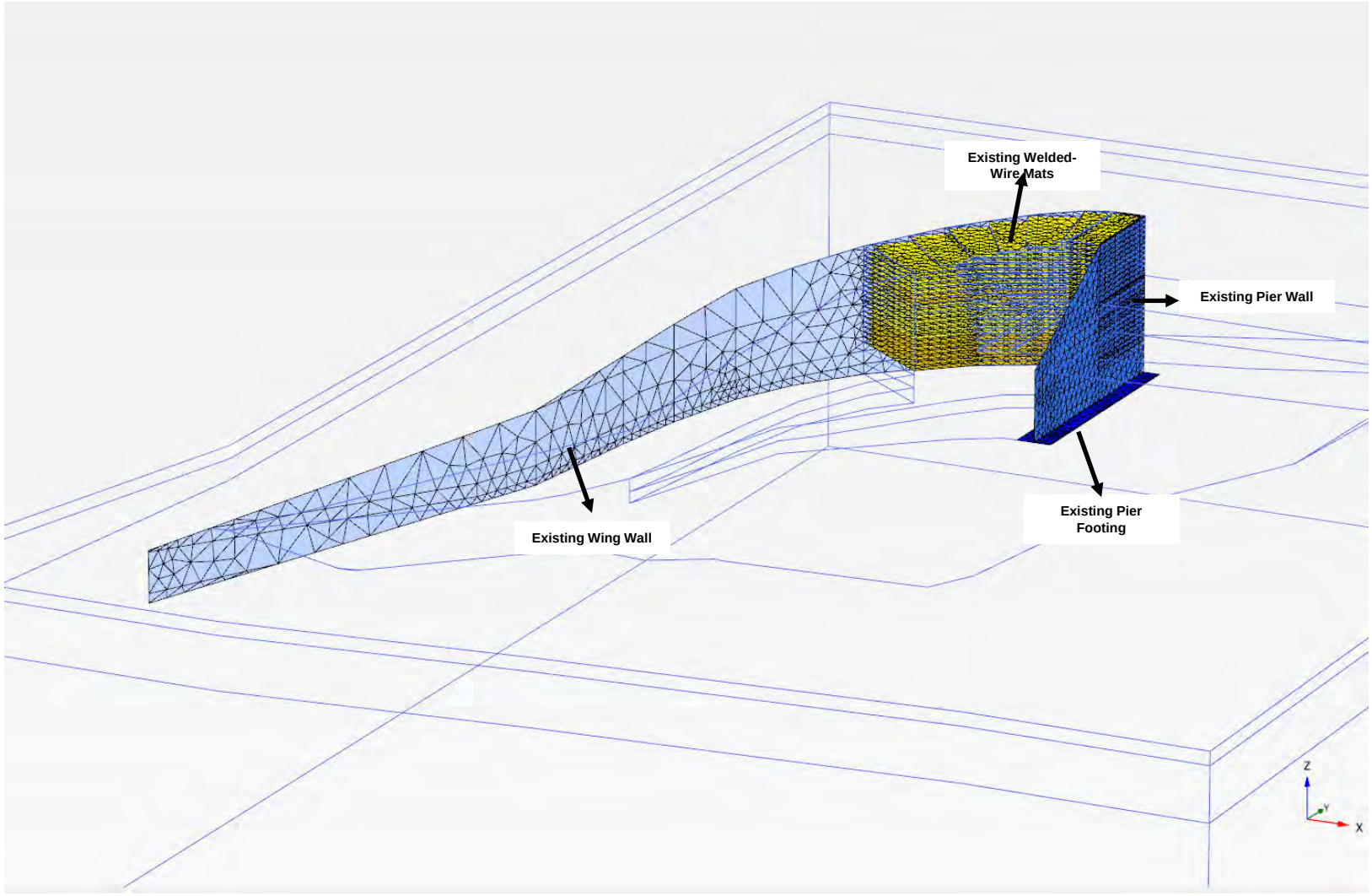


Plaxis 3D Soil Model
Existing Condition, General View

I-405 Renton to Bellevue Bridge 17.7
Renton, Washington

GeoEngineers

Figure E-4

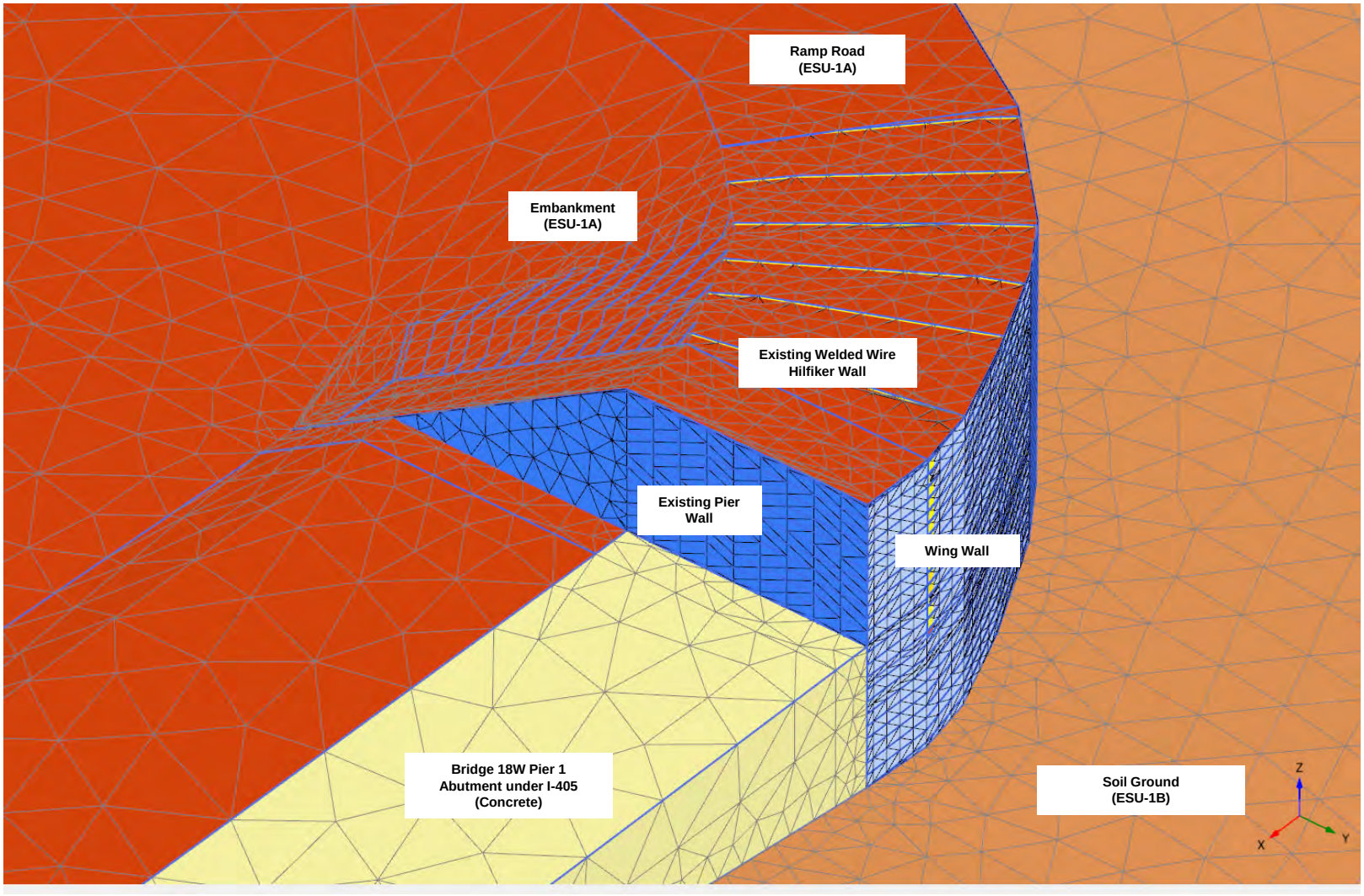


Plaxis 3D Model for Structural Elements
Existing Condition, General View

I-405 Renton to Bellevue Bridge 17.7
Renton, Washington

GeoEngineers

Figure E-5

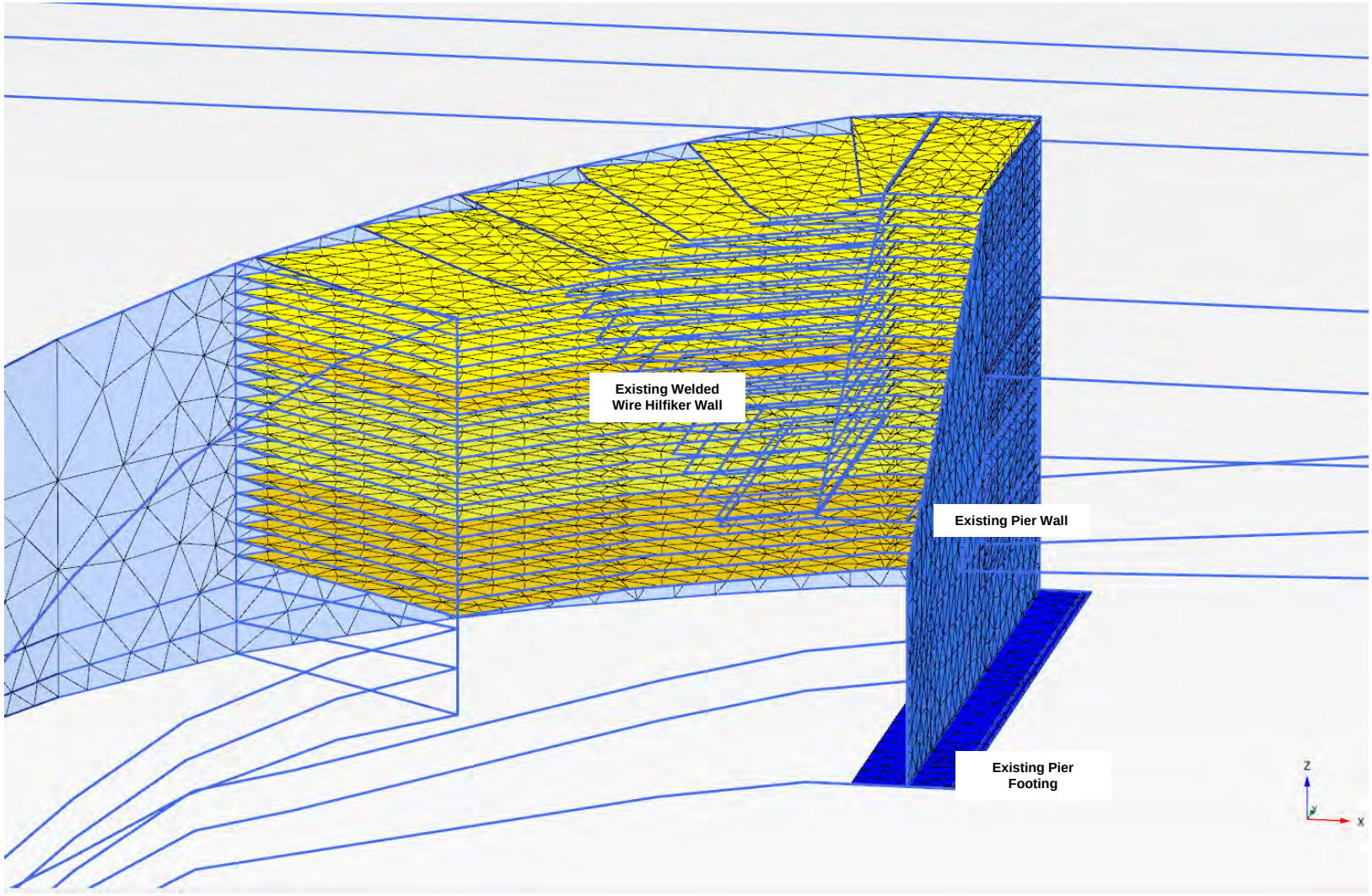


Plaxis 3D Soil Model
Existing Condition

I-405 Renton to Bellevue Bridge 17.7
Renton, Washington

GeoEngineers

Figure E-6



Plaxis 3D Model for Structural Elements
Existing Condition

I-405 Renton to Bellevue Bridge 17.7
Renton, Washington

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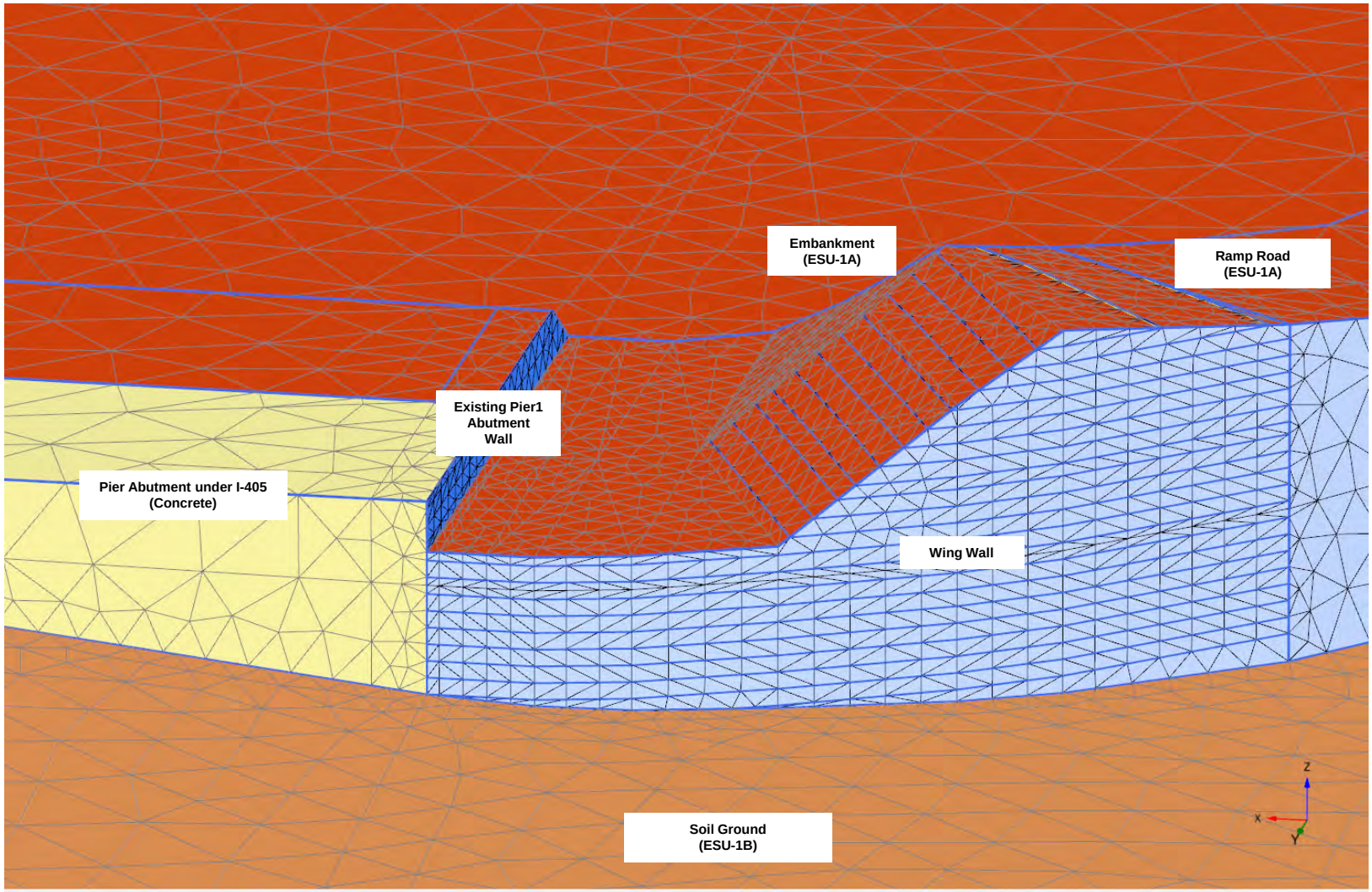
Figure E- 7

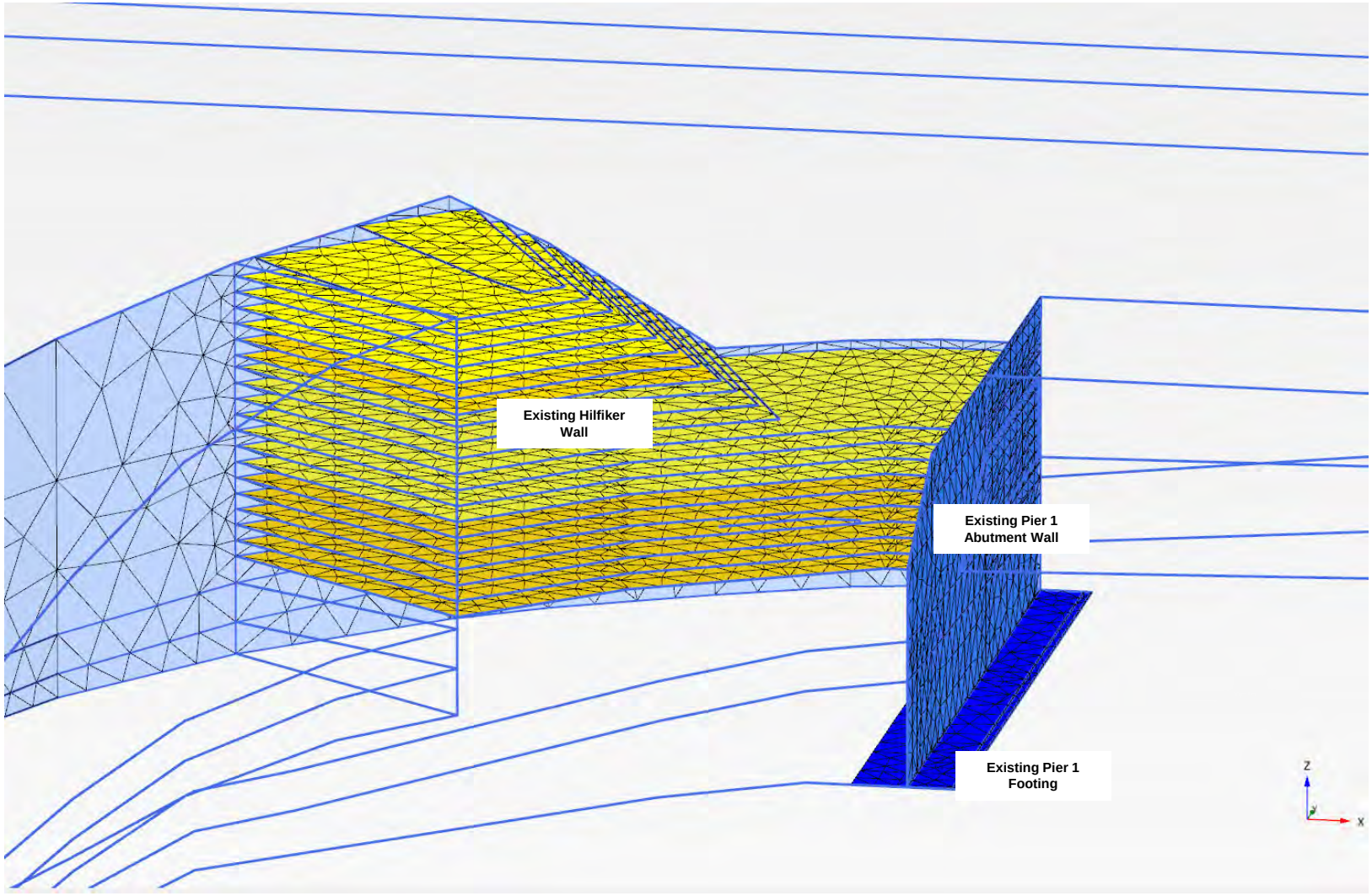


Plaxis 3D Soil and Structural Model
Excavation

I-405 Renton to Bellevue Bridge 17.7
Renton, Washington

GeoEngineers

Figure E-8

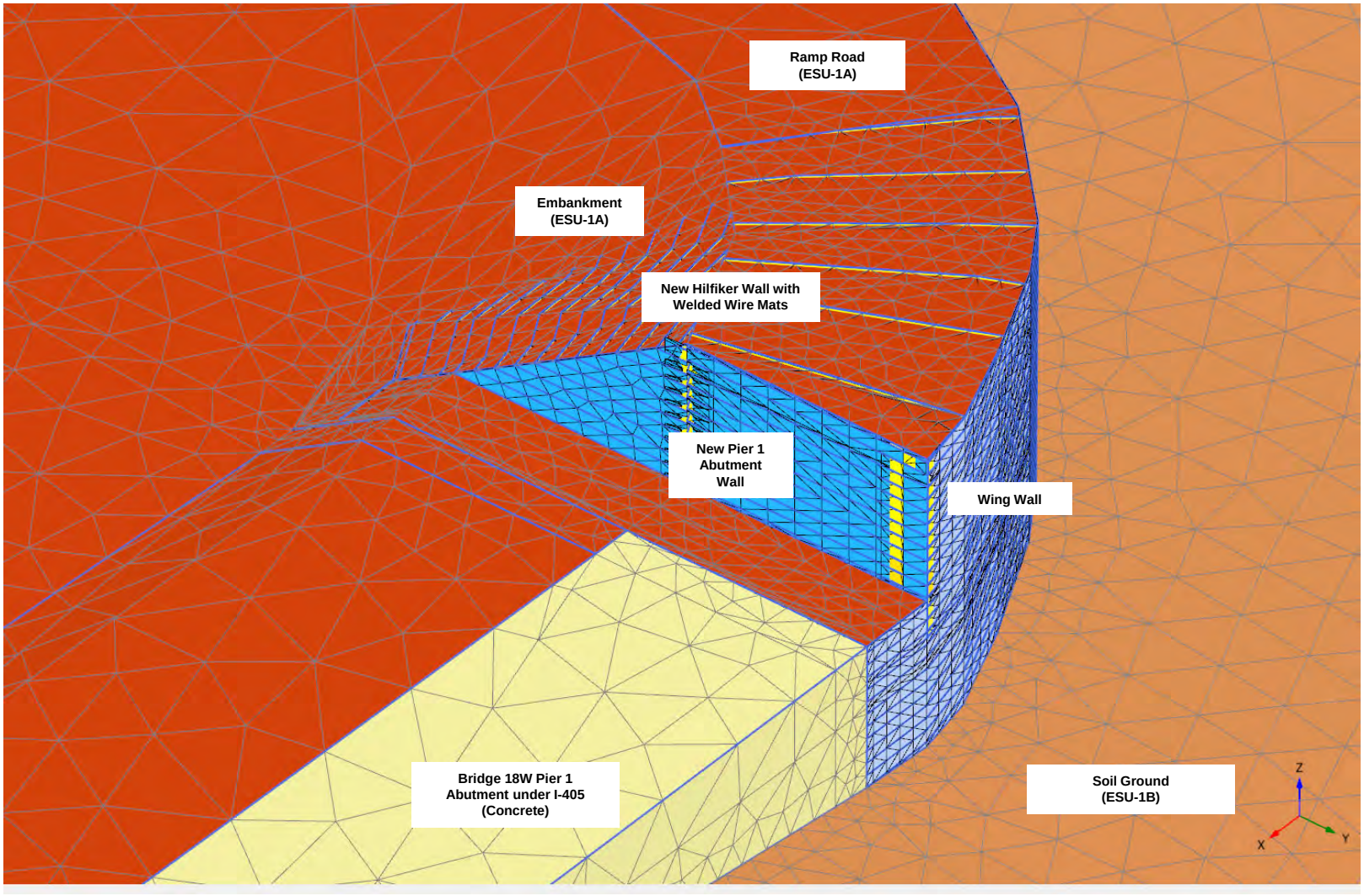


Plaxis 3D Model for Structural Elements Excavation

I-405 Renton to Bellevue Bridge 17.7
Renton, Washington

GeoEngineers

Figure E-9

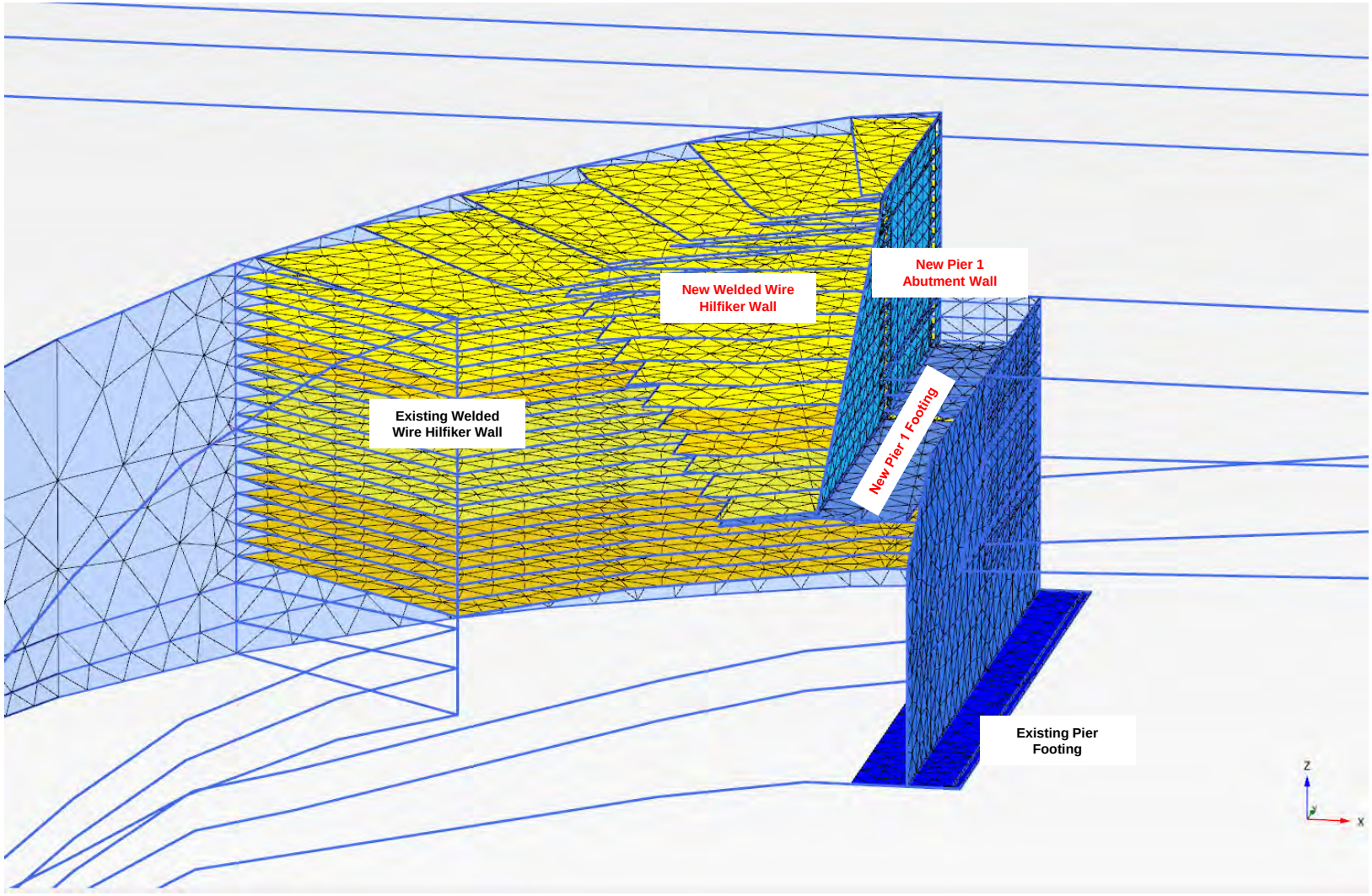


Plaxis 3D Soil and Structural Model
New Pier/Hilfiker Wall Construction

I-405 Renton to Bellevue Bridge 17.7
Renton, Washington

GeoEngineers

Figure E-10

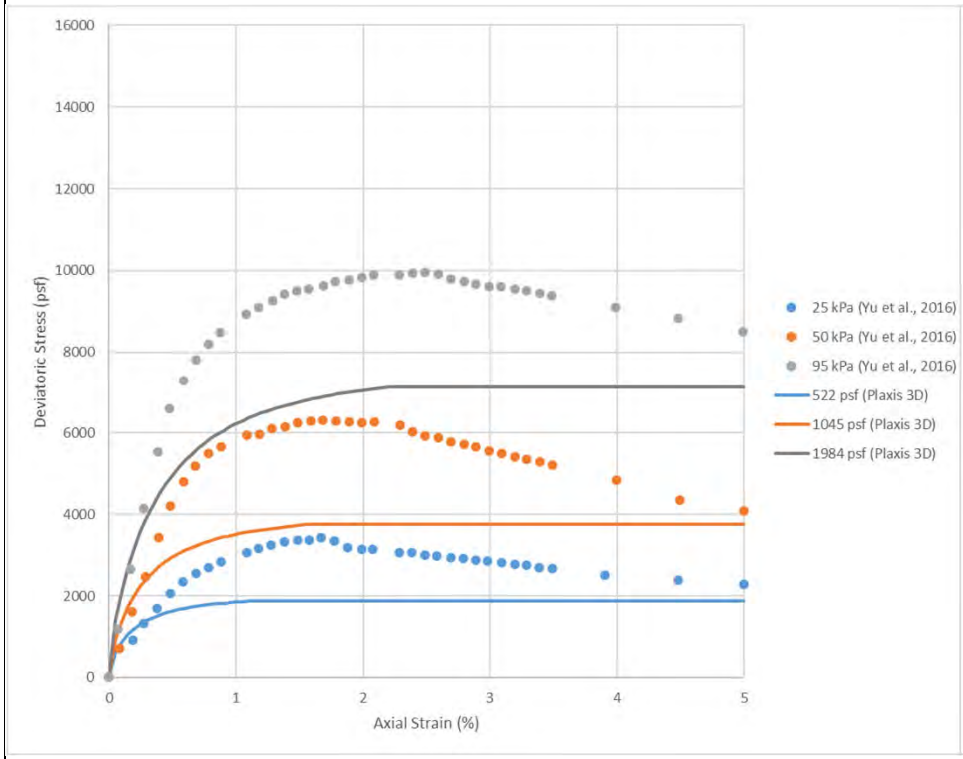


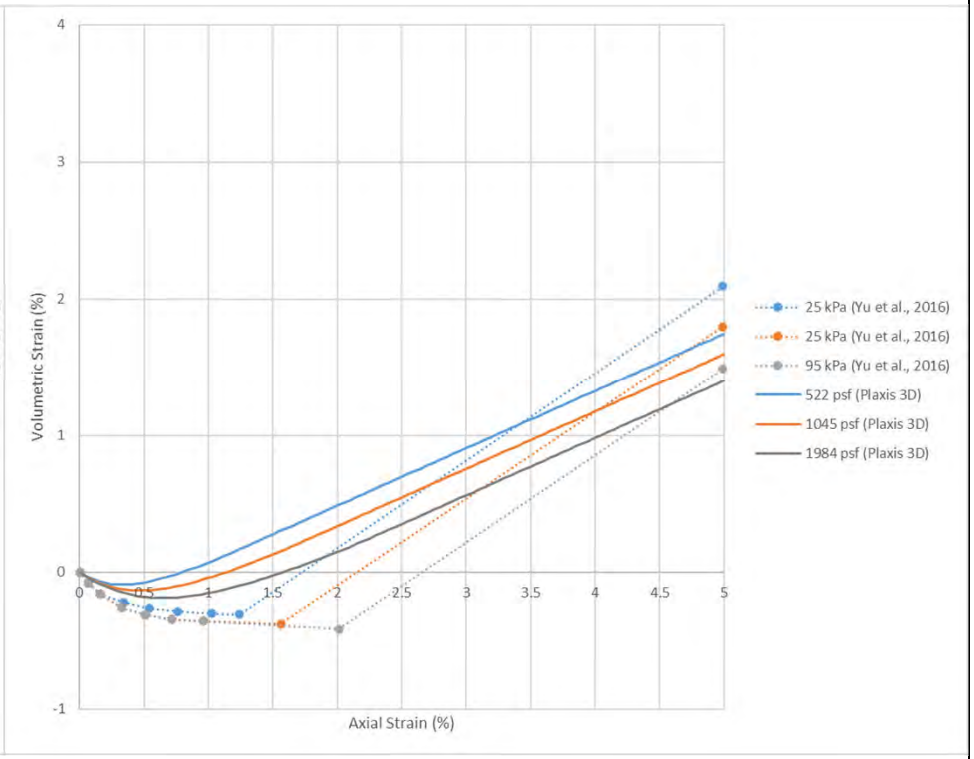
Plaxis 3D Model for Structural Elements
New Pier/Hilfiker Wall Construction

I-405 Renton to Bellevue Bridge 17.7
Renton, Washington

GeoEngineers

Figure E-11



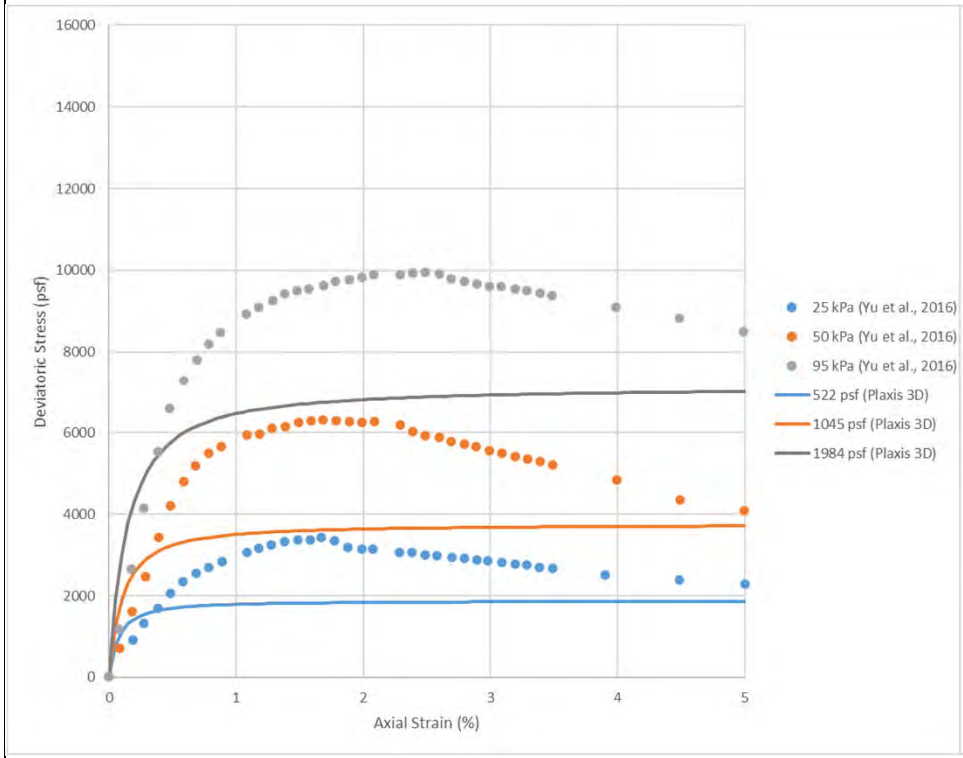


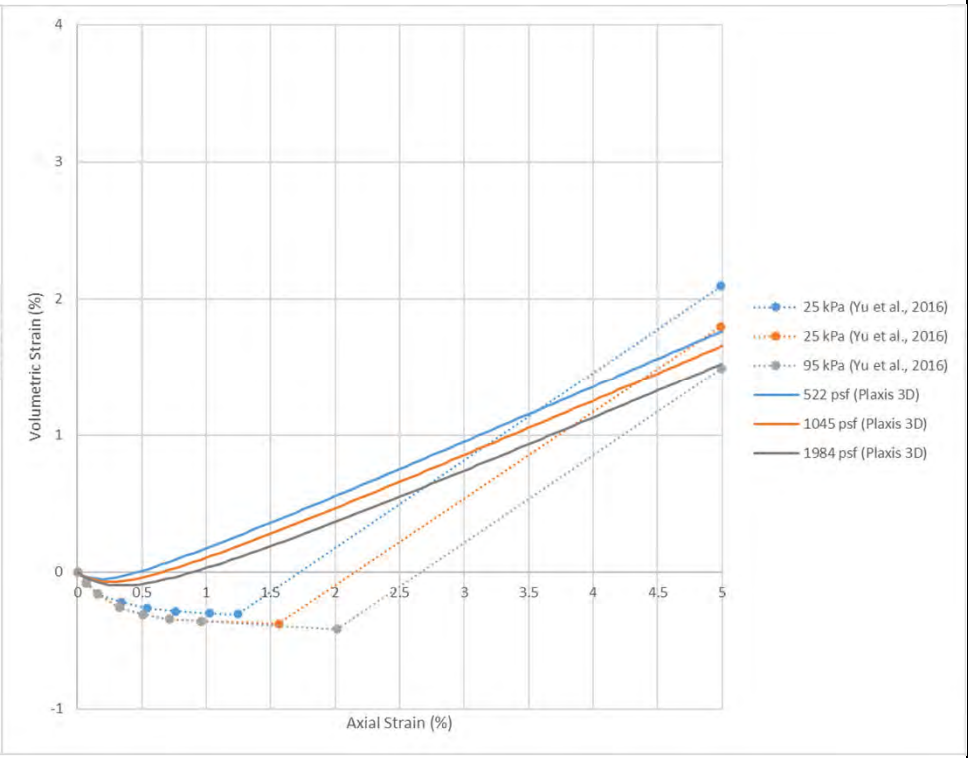
Plastic Hardening Soil Model Triaxial Compression Tests
ESU-1A, Case 1, Vs = 662 ft/s

I-405 Renton to Bellevue Bridge 17.7
Renton, Washington

GeoEngineers

Figure E-12



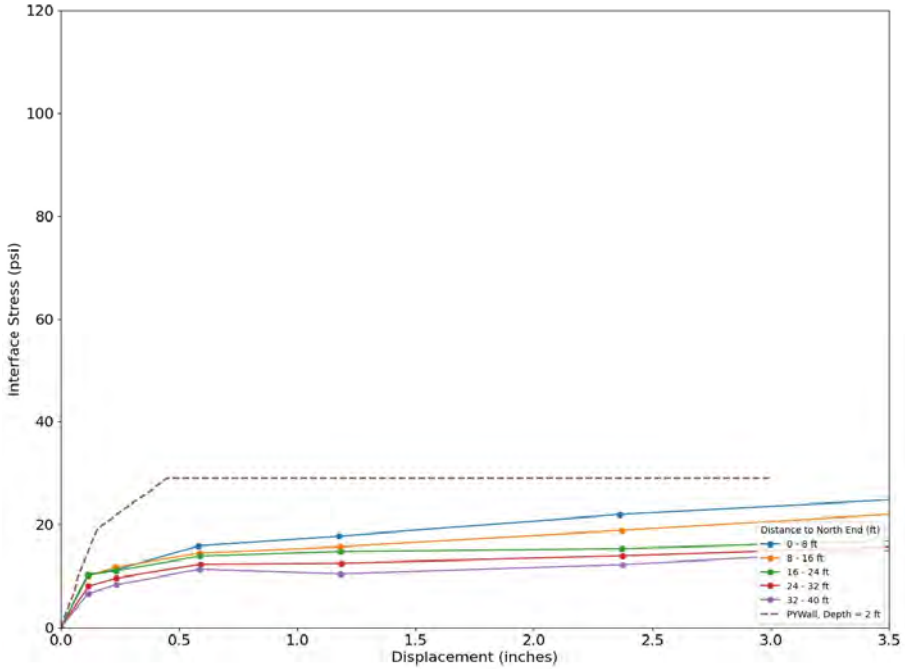


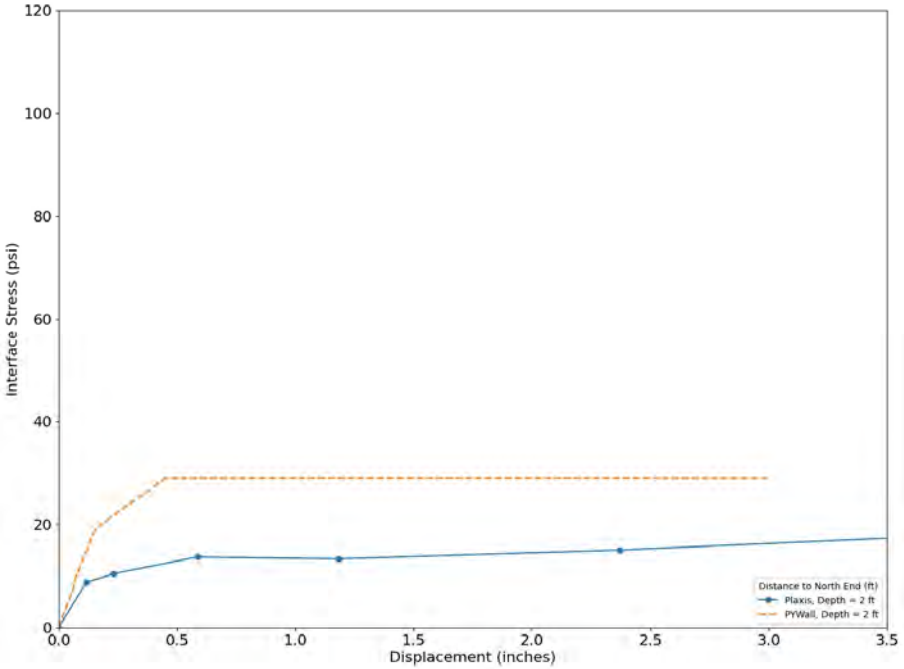
Plastic Hardening Soil Model Triaxial Compression Tests
ESU-1A, Case 2, Vs = 937 ft/s

I-405 Renton to Bellevue Bridge 17.7
Renton, Washington

GeoEngineers

Figure E-13



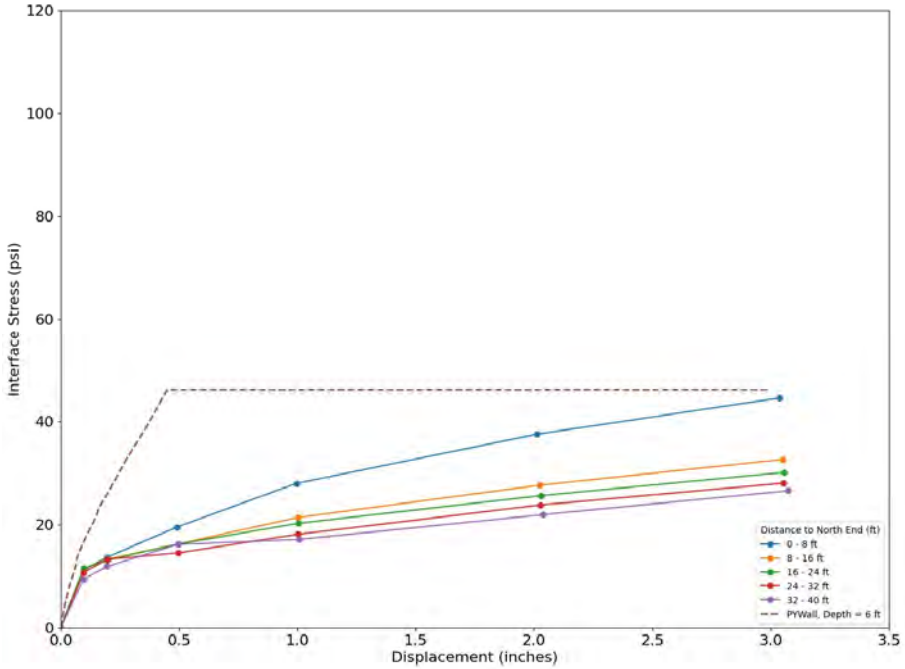


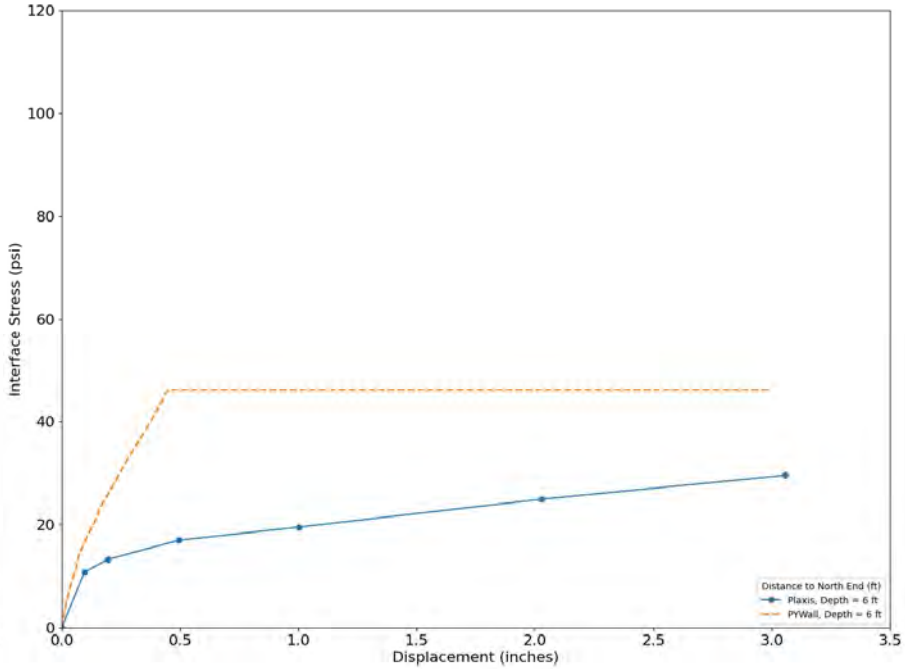
Soil Spring behind New Pier Wall, Case 1
Depth 0 to 4 ft

I-405 Renton to Bellevue Bridge 17.7
Renton, Washington

GeoEngineers

Figure E-14



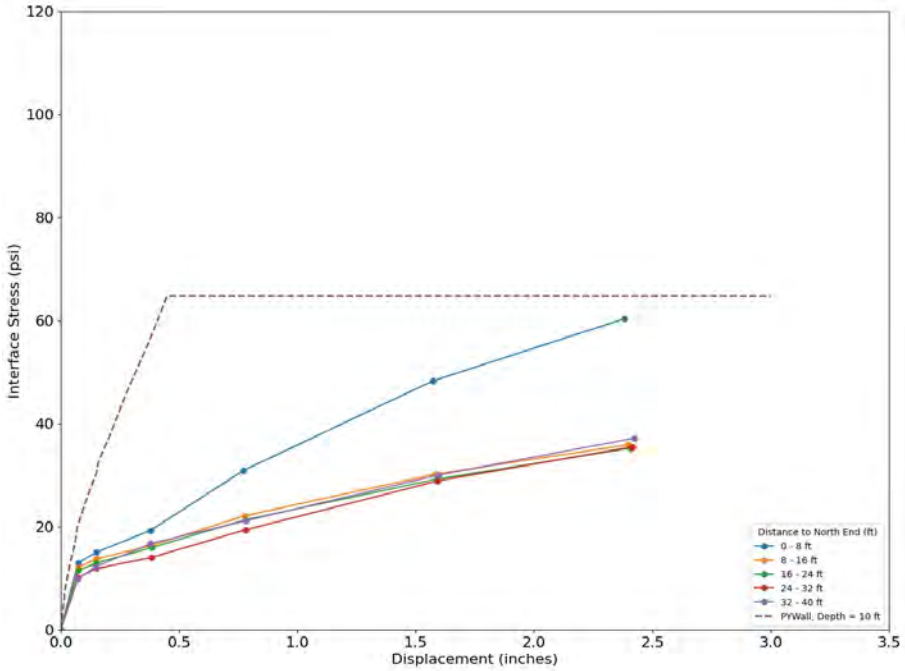


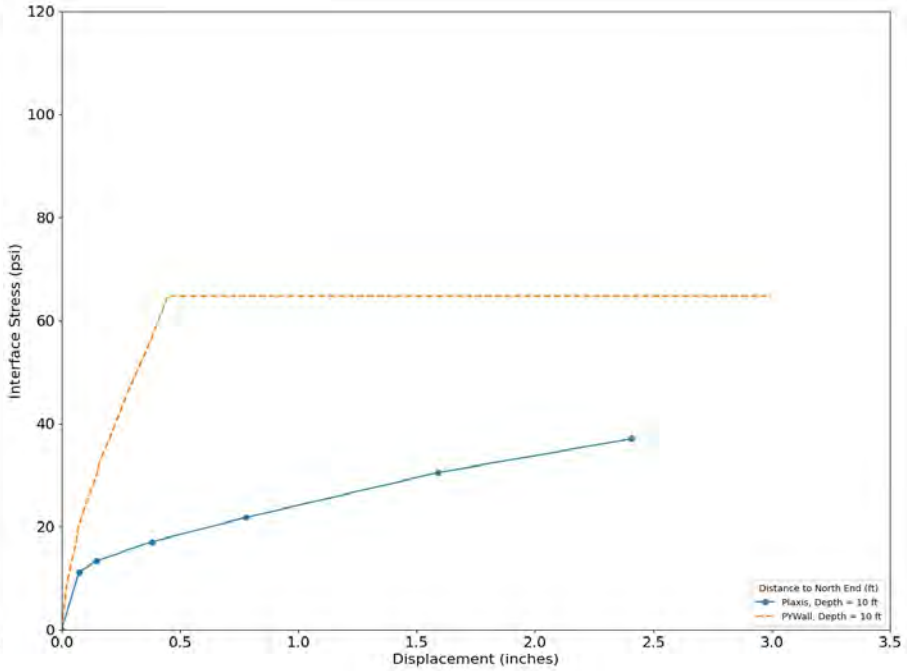
Soil Spring behind New Pier Wall, Case 1
Depth 4 to 8 ft

I-405 Renton to Bellevue Bridge 17.7
Renton, Washington

GeoEngineers

Figure E-15



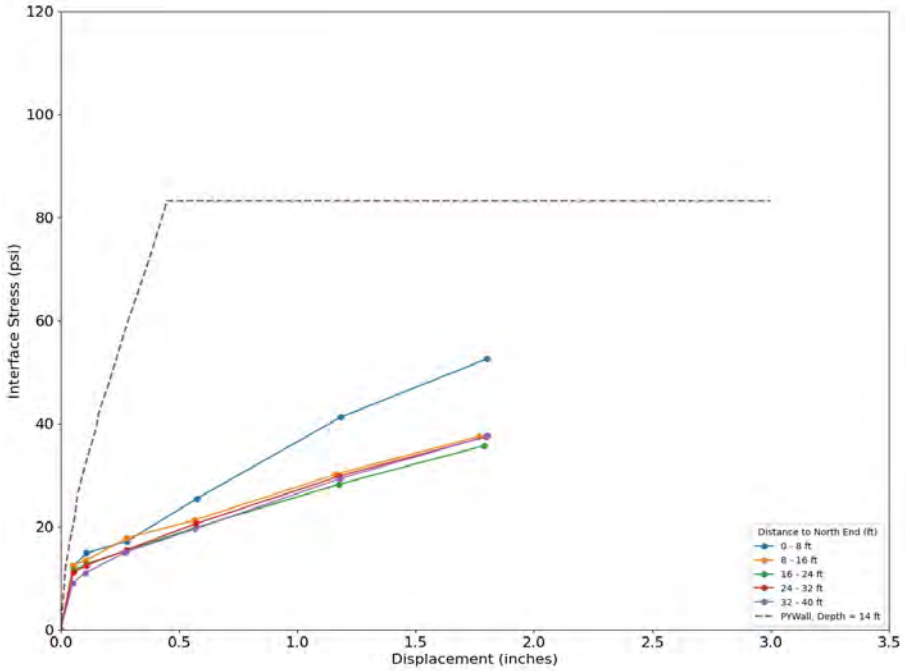


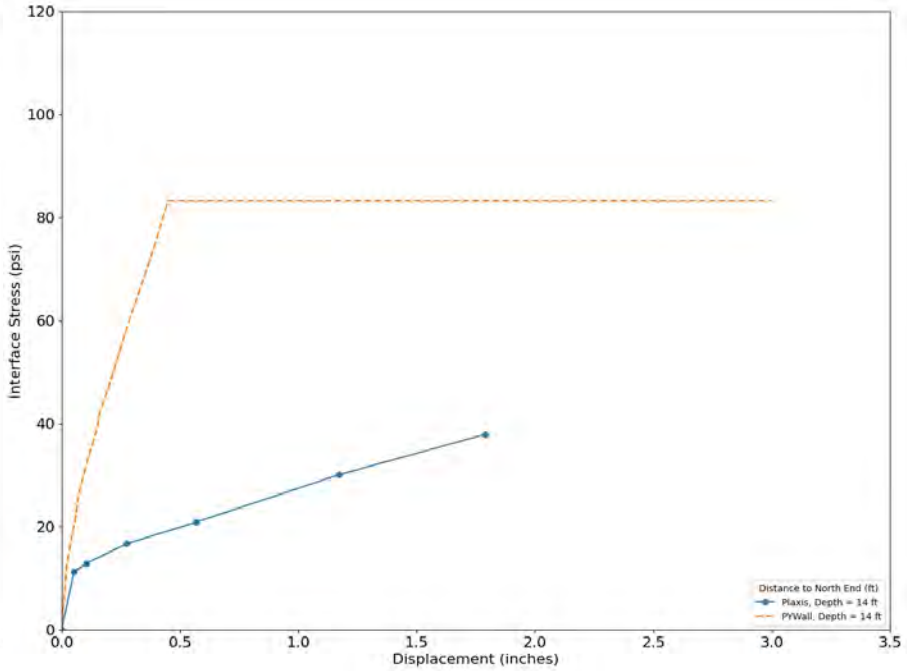
Soil Spring behind New Pier Wall, Case 1
Depth 8 to 12 ft

I-405 Renton to Bellevue Bridge 17.7
Renton, Washington

GeoEngineers

Figure E-16



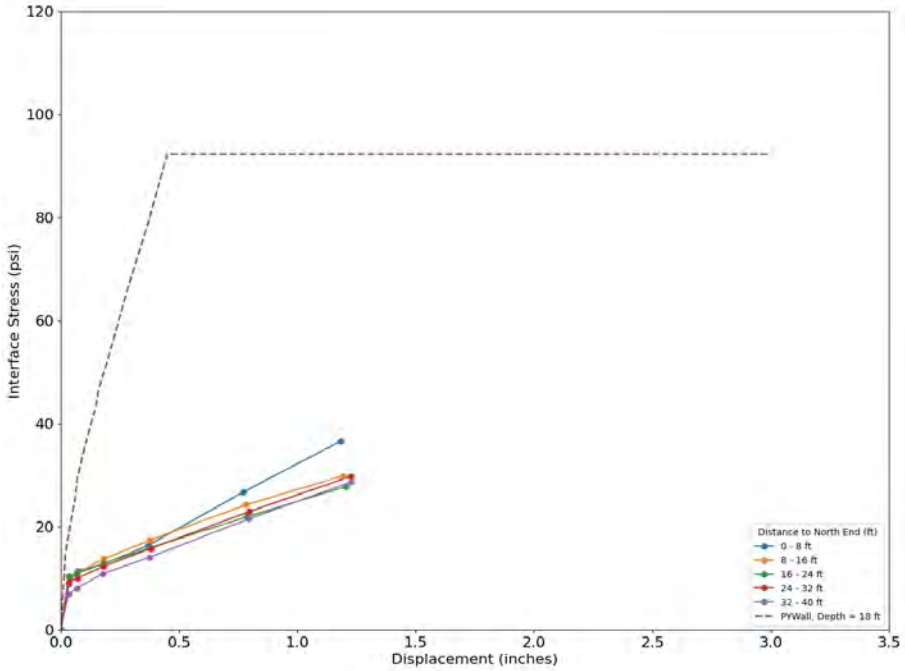


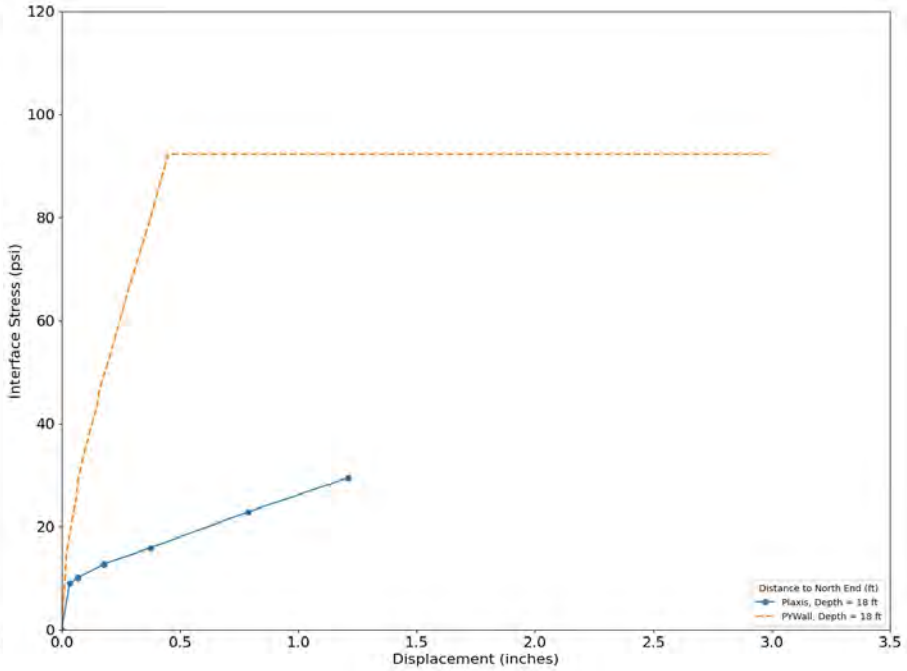
Soil Spring behind New Pier Wall, Case 1
Depth 12 to 16 ft

I-405 Renton to Bellevue Bridge 17.7
Renton, Washington

GeoEngineers

Figure E-17



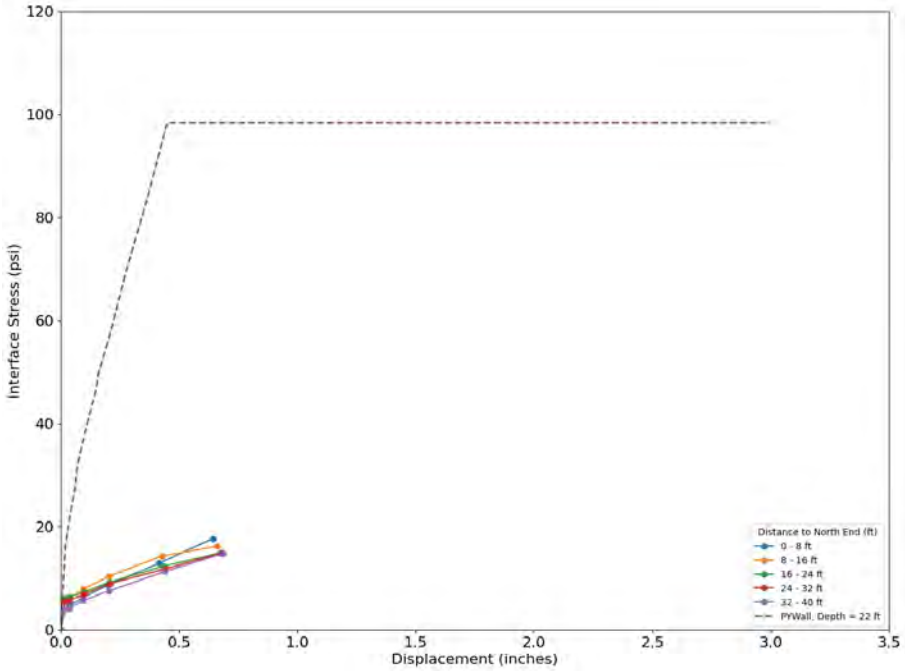


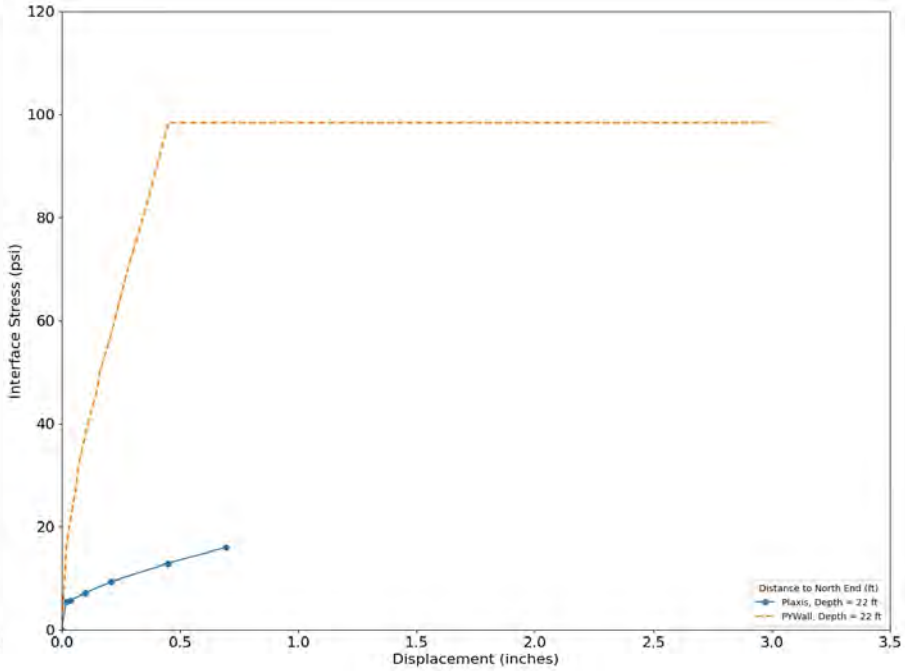
Soil Spring behind New Pier Wall, Case 1
Depth 16 to 20 ft

I-405 Renton to Bellevue Bridge 17.7
Renton, Washington

GeoEngineers

Figure E-18



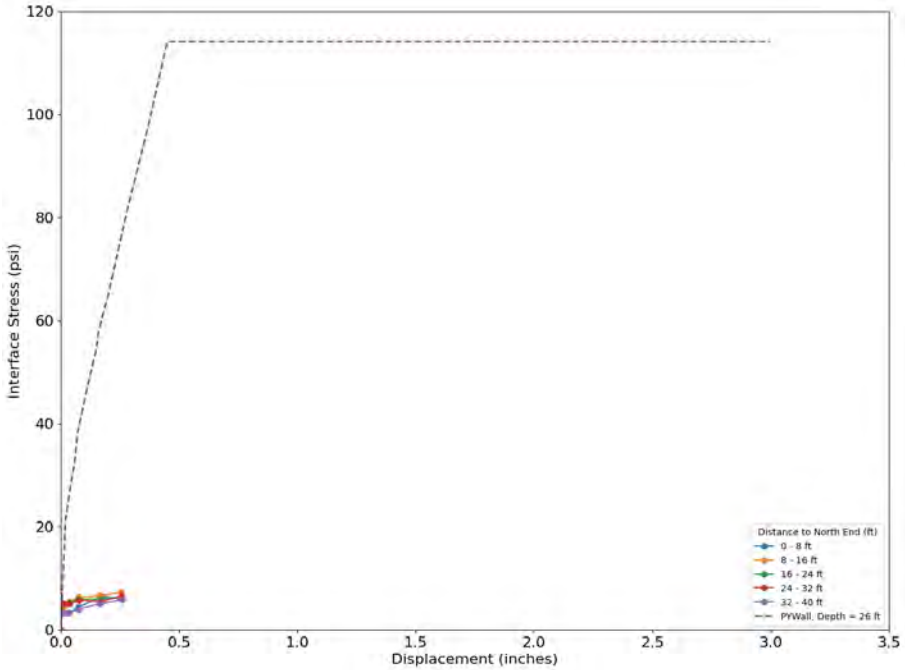


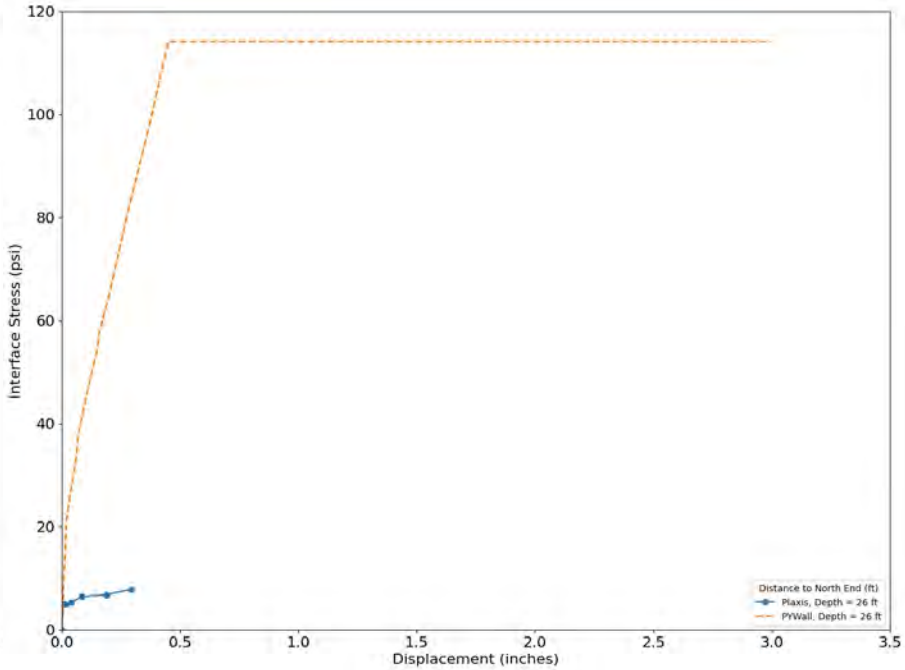
Soil Spring behind New Pier Wall, Case 1
Depth 20 to 24 ft

I-405 Renton to Bellevue Bridge 17.7
Renton, Washington

GeoEngineers

Figure E-19



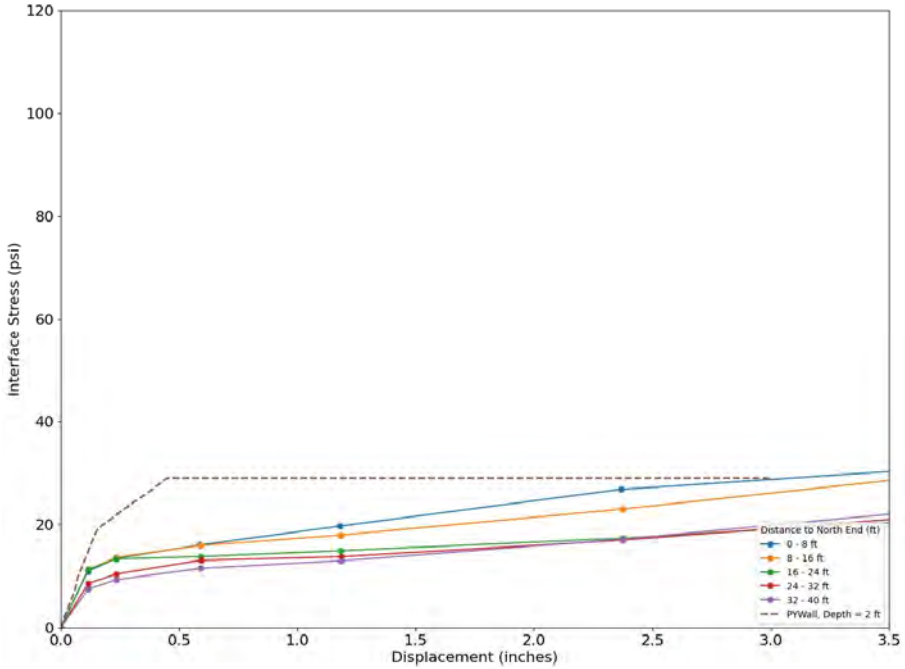


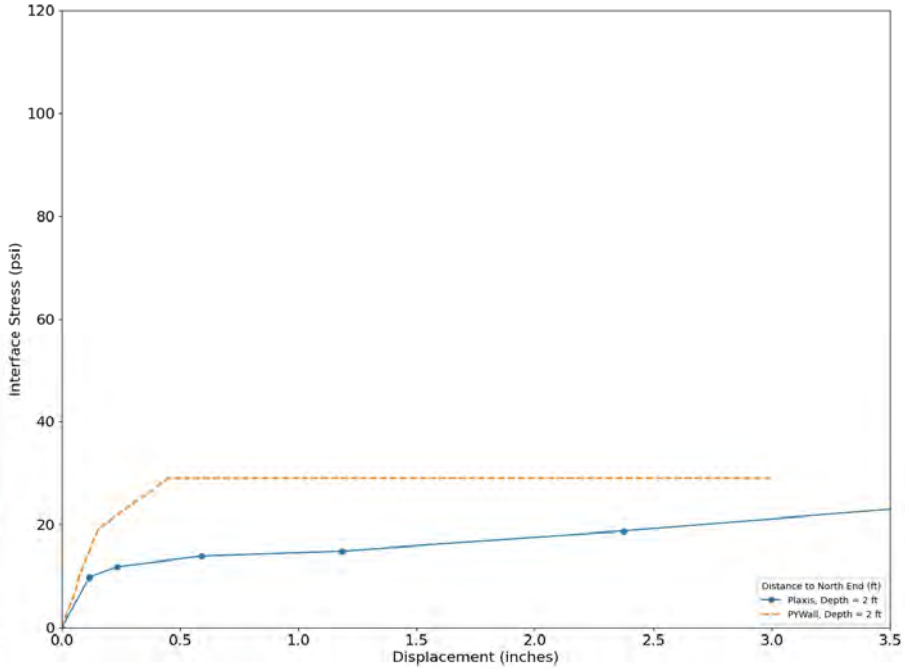
Soil Spring behind New Pier Wall, Case 1
Depth over 24 ft

I-405 Renton to Bellevue Bridge 17.7
Renton, Washington

GeoEngineers

Figure E-20



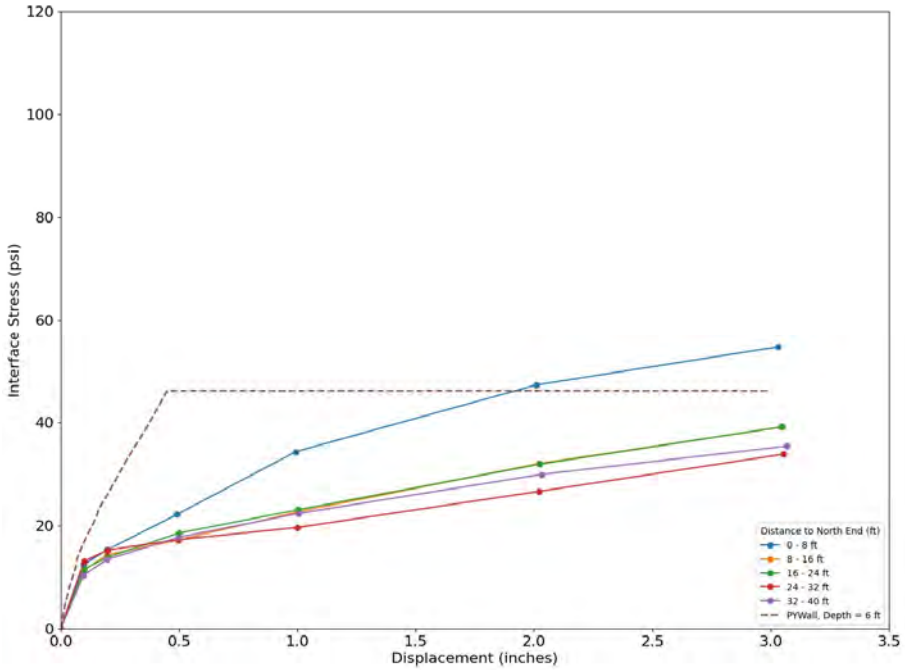


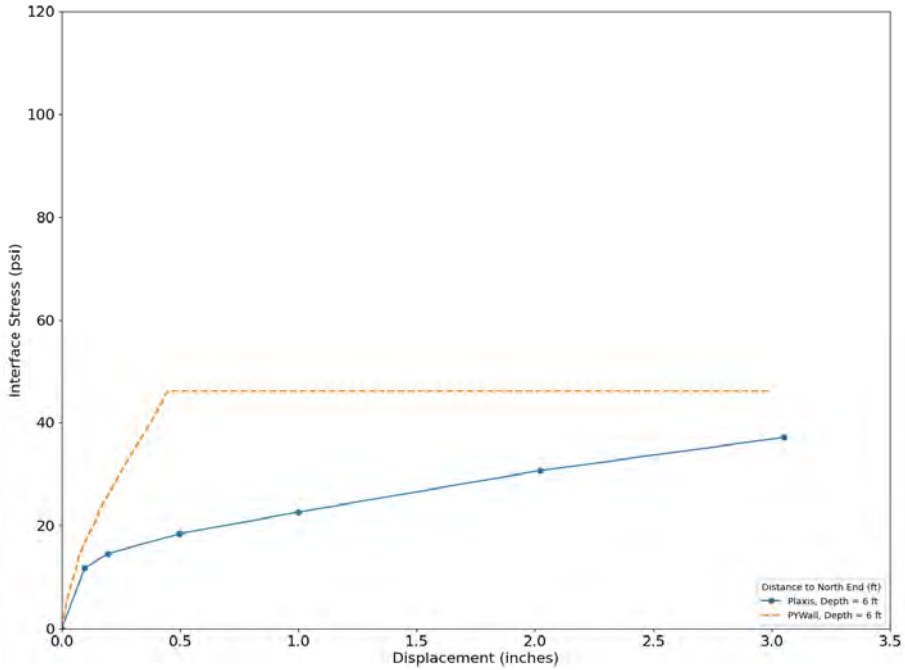
Soil Spring behind New Pier Wall, Case 2
Depth 0 to 4 ft

I-405 Renton to Bellevue Bridge 17.7
Renton, Washington

GeoEngineers

Figure E-21



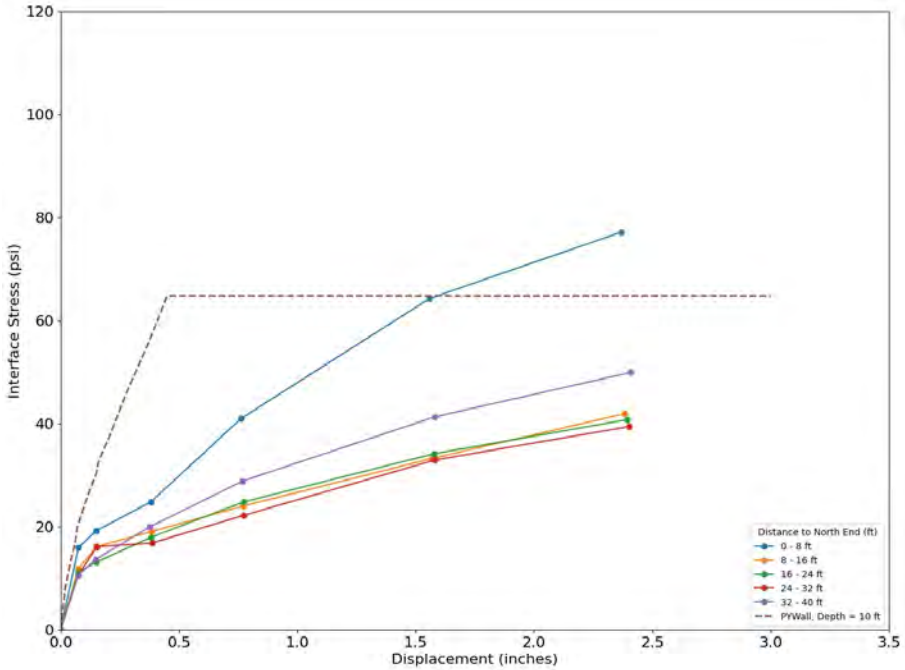


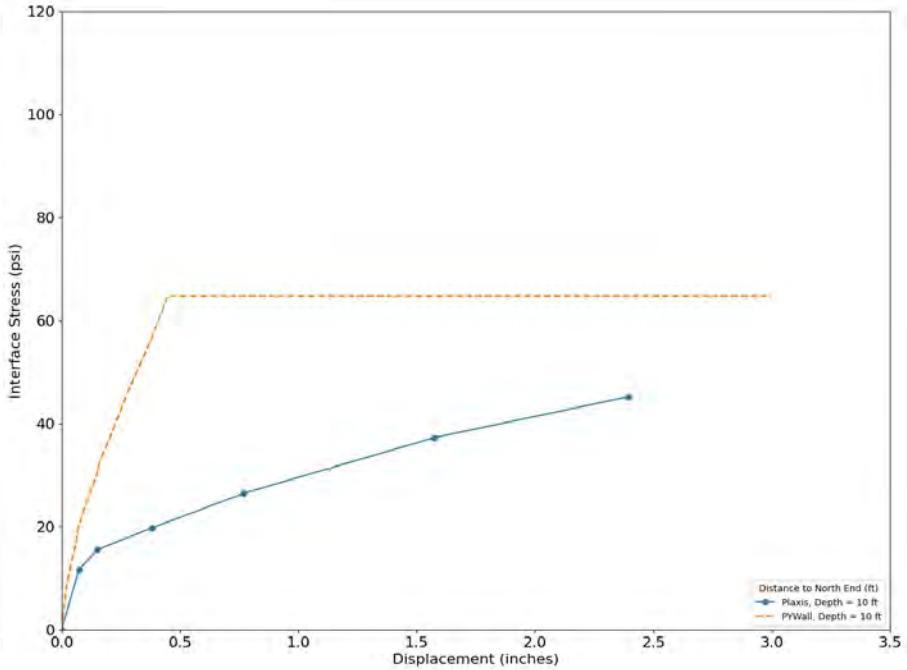
Soil Spring behind New Pier Wall, Case 2
Depth 4 to 8 ft

I-405 Renton to Bellevue Bridge 17.7
Renton, Washington

GeoEngineers

Figure E-22



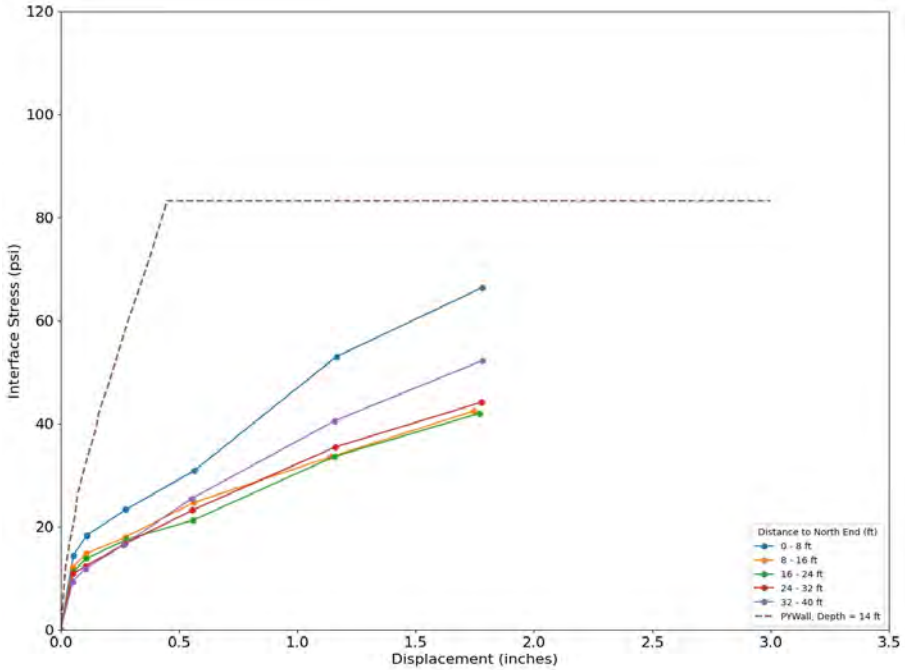


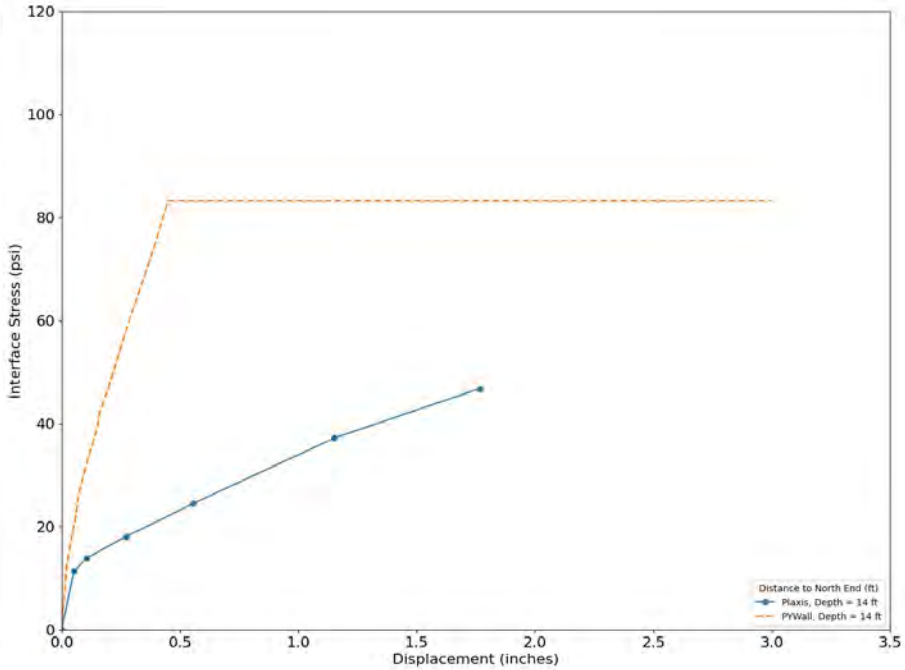
Soil Spring behind New Pier Wall, Case 2
Depth 8 to 12 ft

I-405 Renton to Bellevue Bridge 17.7
Renton, Washington

GeoEngineers

Figure E-23



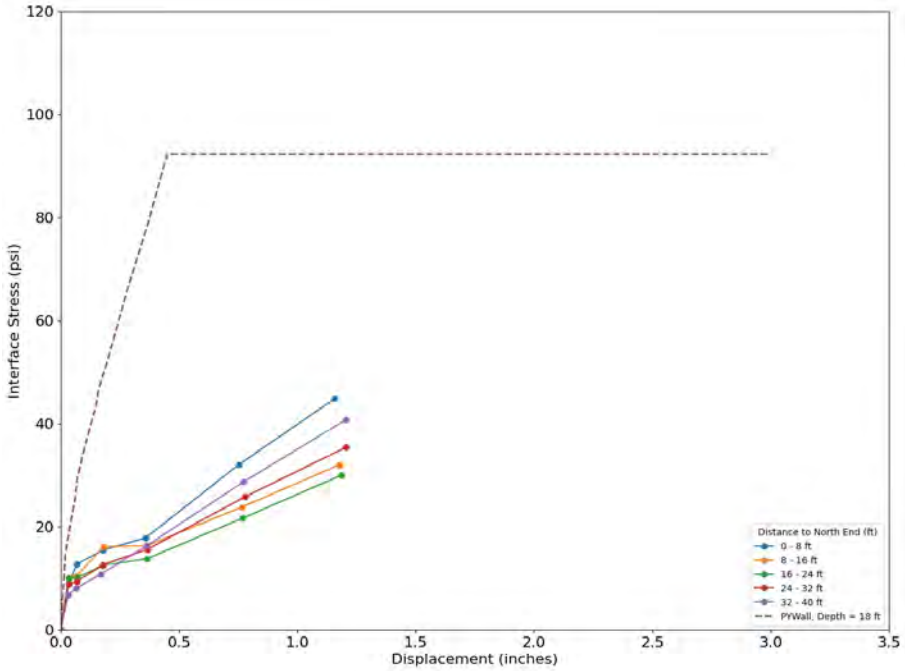


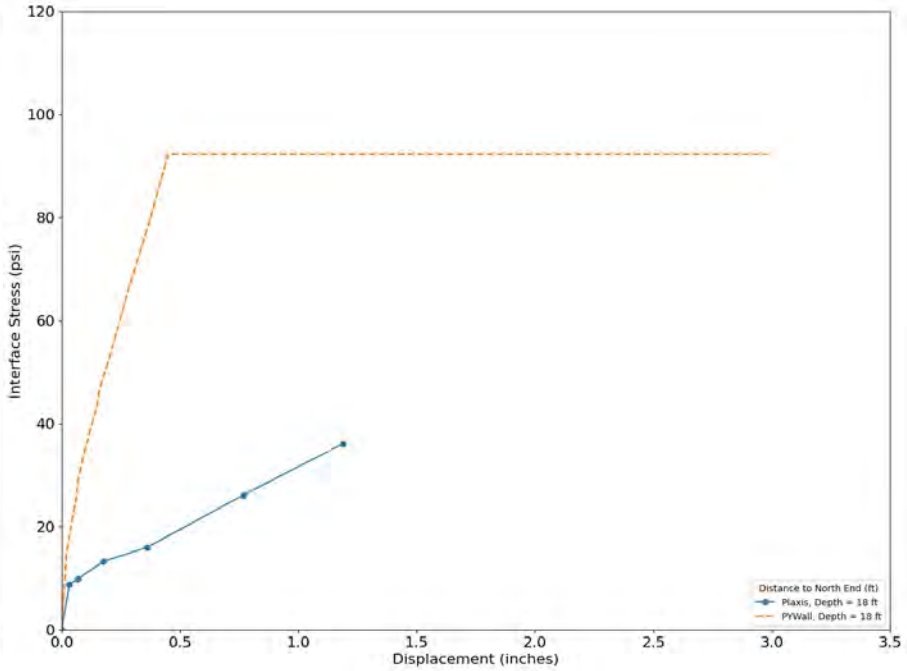
Soil Spring behind New Pier Wall, Case 2
Depth 12 to 16 ft

I-405 Renton to Bellevue Bridge 17.7
Renton, Washington

GeoEngineers

Figure E-24



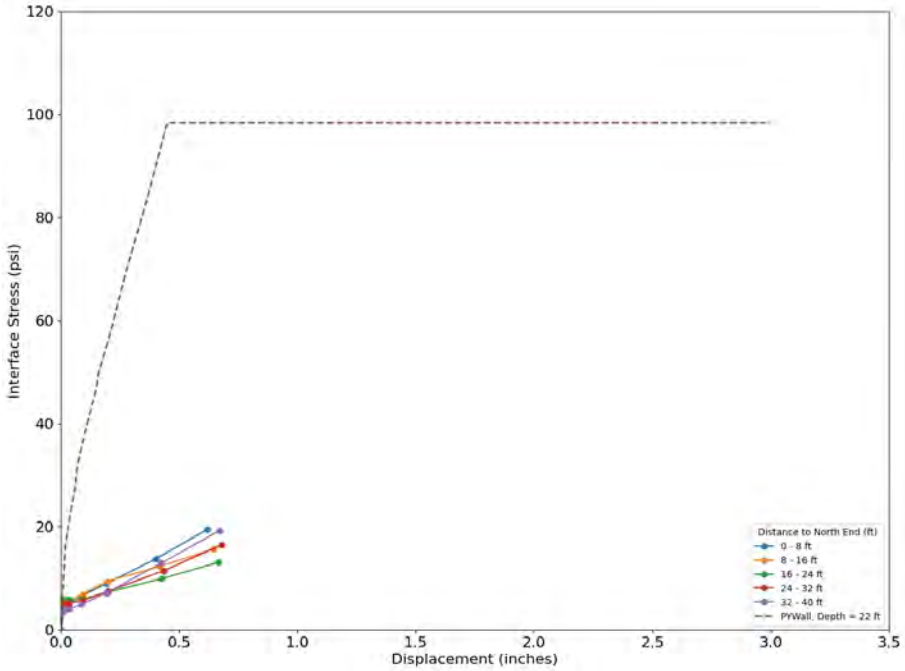


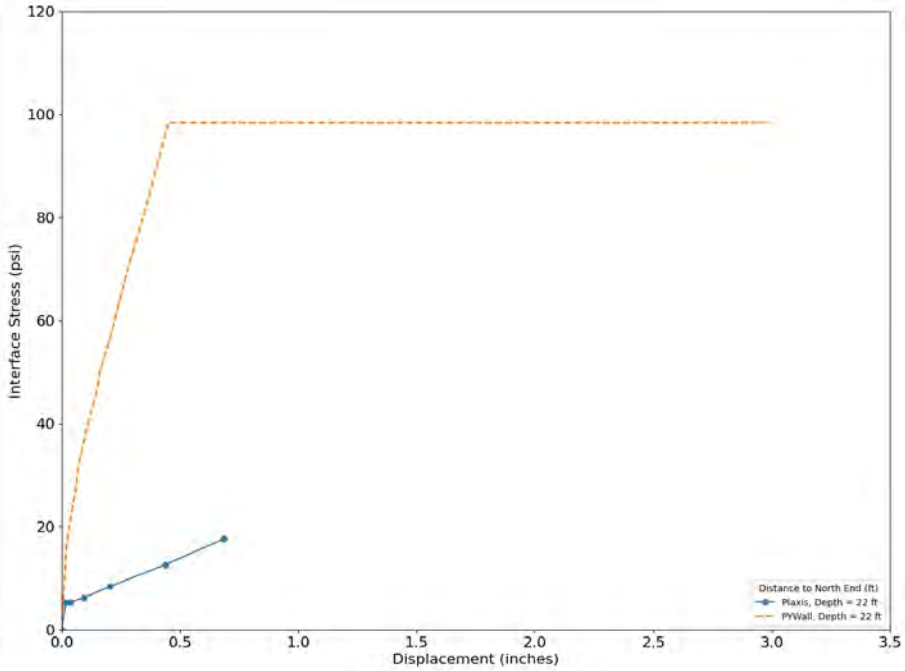
Soil Spring behind New Pier Wall, Case 2
Depth 16 to 20 ft

I-405 Renton to Bellevue Bridge 17.7
Renton, Washington

GeoEngineers

Figure E-25



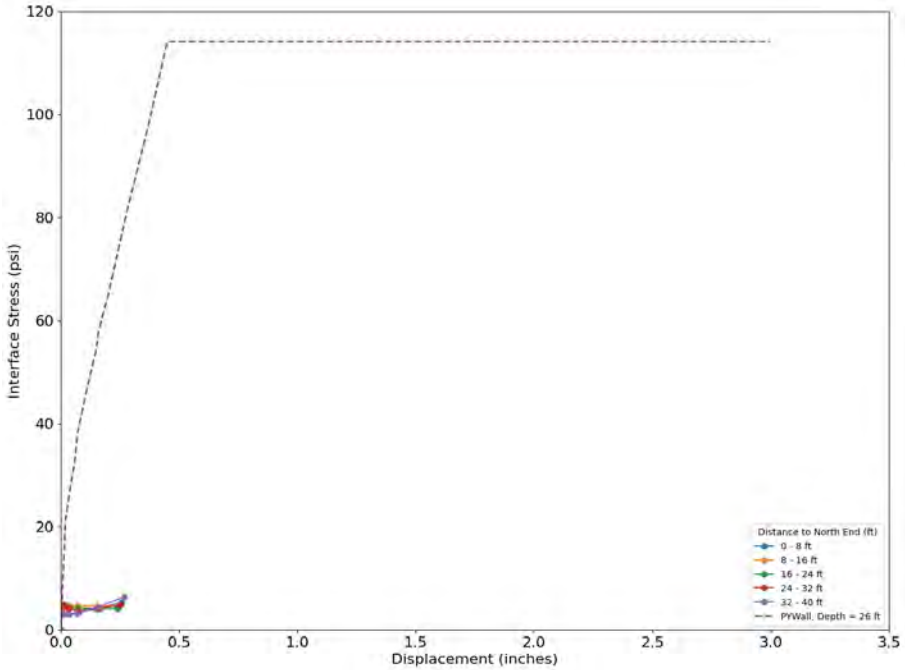


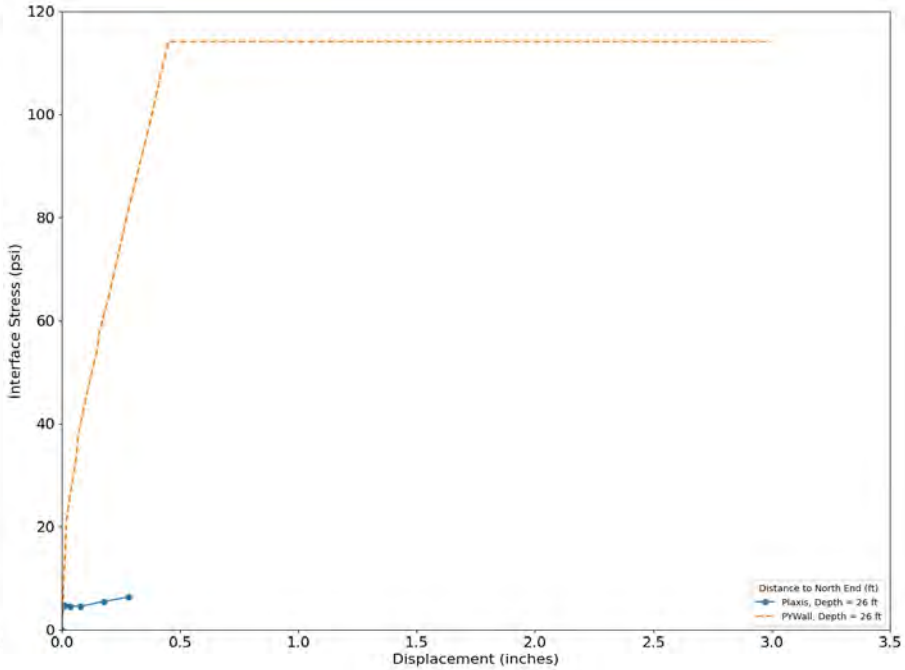
Soil Spring behind New Pier Wall, Case 2
Depth 20 to 24 ft

I-405 Renton to Bellevue Bridge 17.7
Renton, Washington

GeoEngineers

Figure E-26





Soil Spring behind New Pier Wall, Case 2
Depth over 24 ft

I-405 Renton to Bellevue Bridge 17.7
Renton, Washington

GeoEngineers

Figure E-27

Appendix F
Wall 03.65L Calculations

APPENDIX F – Wall 03.65L Calculation Package

This appendix presents the geotechnical calculation details for Wall 03.65L including:

- Engineering Stratigraphic Unit (ESU) Soil Properties
- Site Class Designation
- Liquefaction Evaluation
- Global Stability
- Compound Stability
- Bearing Resistance
- Settlement
- Lateral Earth Pressure and Sliding
- Slope Stability

Wall 03.65L plan, profile, and the location of the design cross section (Sta. 1+59) can be found on Figure F-1. The cross section is shown in the slope stability models in Appendices F.3 and F.4.

1.0 ESU Properties

The selected Wall 03.65L (in conjunction with Bridge 17.7) ESU properties and selection process details are presented and described in Appendix C.

2.0 Seismic Design Parameters

The design functional evaluation earthquake (FEE) and safety evaluation earthquake (SEE) response spectra for Seismic Site Class C and D at Bridge 17.7 use the probabilistic seismic hazard analysis (PSHA) results available at Bridge 18W. The design FEE and SEE response spectra for Seismic Site Class C and D at Bridge 18W were developed and provided by Hart Crowser and are included in the following report:

- "I-405 R2B Segment 1a Site Specific Hazard Analysis" dated March 25, 2021 (Submittal 1197) by Hart Crowser.

These analyses were completed by Hart Crowser in accordance with the Project Geotechnical Design Manual (Project GDM). The ground motion parameters for design are based on the projected ground motion at the project site that has either a 30 percent (FEE) or 7 percent (SEE) probability of exceedance in a 75-year period (approximate 210- and 975-year return periods). Details regarding the determination of the seismic parameters are included in the above referenced report.

We used the recommended the SEE response spectra peak ground acceleration (PGA) and Mean Magnitude (Mw) in our analyses.

2.1 Wave Scattering Evaluations

Per the National Cooperative Highway Research Program (NCHRP) Report 611 the PGA can be adjusted to account for variations in the average ground acceleration behind retaining walls and/or slopes greater than 20 feet in height by applying a scaling factor (or alpha value) to the PGA. The normalized SEE spectral shape developed by Hart Crowser falls in the mid-spectral shape range because the PSHA results typically peak at about 0.3 second (NCHRP Figure 5-4). Using the mid-spectral shape curve, the PGA was scaled for qualifying wall and slope heights.

Per American Association of State Highway and Transportation Officials (AASHTO) Load and Resistance Factor Design (LRFD) Section 11.6.5.2.2, the wall height was taken as the distance from the bottom of the back of the wall to the ground surface directly above the back of the wall for seismic lateral earth pressure analyses. For global and compound pseudo-static analyses, wave scatter was based on the height of the failure surface mobilized in the design seismic event. Wave scatter reductions were not applied for heights less than 20 feet.

Calculations of the corrected PGAs are presented in Appendix F.2 and the results are presented in Table F-1.

Table F-1: Wave Scattering Scaling Factors and Corrected PGAs

Wall Station	Seismic Analysis	Design Height (ft.)	Scaling Factor	Corrected PGA (SEE)	Kh (g)
1+49	Lateral Earth Pressures	21.5	0.850	0.434	0.217
	Global Stability	24.1	0.835	0.426	0.213
	Compound Stability	20.8	0.854	0.436	0.218

Abbreviations:
SEE = safety evaluation earthquake

2.2 Liquefaction Analysis

As discussed in the report, there are no soil layers present that are considered susceptible to liquefaction. Details of that discussion are provided in the Section 6.4 of the report.

3.0 Global Stability Analysis

We performed global stability analyses for the following critical cross section:

- Wall 03.65L Sta. 1+49 (Cross-section D-D' on Figure 3) where the wall is at its maximum height.

We estimated the global stability factor of safety (FS) for static conditions using SLOPE/W (Geo-Slope International 2021 version 11.01) and the Spencer and Morgenstern-Price Method. We used static strength soil parameters. We modeled the structural earth (SE) Wall as a "High Strength" material having a unit weight of 130 pounds per cubic foot (pcf) consistent with Gravel Borrow backfill. Design backfill properties are within the suggested range presented in the Project GDM Table 5-2.

We used a horizontal seismic acceleration coefficient (kh) to estimate seismic lateral earth pressures and to evaluate pseudo-static global stability. For our analyses, kh is 50 percent of A_s (kh = 0.5 * A_s) for flexible wall displacements of 1- to 2-inches. Kh is also reduced considering the wall height-dependent seismic coefficient (wave scatter coefficient), a (kh = a * A_s). This horizontal acceleration was corrected by the wave scattering reduction factors presented in Table F-1, above.

A summary of global stability results is presented in Table F-2. See Appendix F.3 for the global stability results figures (Figures F.3-1 through F.3-4) and the detailed input/output reports from Slope/W. To meet global stability analysis minimum static and pseudo static FS requirements, Wall 03.65L is required to have a minimum embedment of 2 feet and a minimum strap length of 0.7* Height of the wall plus embedment (H) or 8 feet at a minimum.

Table F-2: Slope Stability Results – Wall 03.65L

Wall	Wall Station Analyzed	Loading Type	Minimum Required Factor of Safety	Calculated FS (Spencer/ Morgenstern & Price)	Minimum Required Strap Length/ Minimum Wall Embedment[1]
Wall 03.65L	Wall 03.65L	Static	1.3	2.5 / 2.5	The greater of 0.7H or 8 feet / 2 feet Embedment
		Pseudo-Static	1.1	1.7 / 1.7	The greater of 0.7H or 8 feet / 2 feet Embedment

Notes:
1. H represents the wall face height plus 2 feet of embedment.

4.0 Compound Stability Analysis

We evaluated compound stability of the single design section at Wall 03.65L using the computer design software Slope/W (Geo Slope International, Ltd. 2020). We performed limit equilibrium analyses following the procedures outlined in Project GDM Section 15-5.3.4. Factors of safety were developed using both Spencer's method and the Morgenstern-Price method with entry and exit search limits for a circular failure surface.

We modeled the soil reinforcements as inextensible welded wire mats (Hilfiker type) connected to cast-in-place (CIP) concrete facing panels. The welded wire reinforcing rows all consist of W7.0xW3.5 welded wire mats with 6-inch longitudinal bar spacing and 12-inch transverse bar spacing. All reinforcing mats have galvanized corrosion protection. The pre-corrosion gross steel reinforcement wire diameter of the longitudinal wires in the W7.0xW3.5 mats were 0.299 inches. We calculated the corrosion losses in the steel wires over the full 75-year design life using the prescribed steel corrosion rates presented in AASHTO LRFD Section 11.10.6.4.2a and Federal Highway Association (FHWA) Geotechnical Engineering Circular No. 11 Tables 3-7 and 3-8.

We applied resistance factors presented in AASHTO LRFD Section 11.5 and FHWA Geotechnical Engineering Circular No. 11 Table 4-7 to calculate the pullout resistance and tensile capacity of the steel grid reinforcements at Wall 03.63L. We modeled the reinforced fill as Gravel Backfill for SE Walls. Using the thickness of the transverse bar and the transverse bar spacing we calculated the pullout resistance factor F* in accordance with AASHTO LRFD Section 11.10.6.3.2 and FHWA Geotechnical Engineering Circular No. 11 Section 3.4.2 equations 3-6 and 3-7. We used the pullout resistance to calculate an interface shear friction angle at each reinforcing grid, considering the grid wire size and spacing. The calculated tensile capacity and interface shear friction angles were input into Slope/W to model the reinforced zone.

Slope/W does not have a specific welded-wire grid reinforcement input option. Therefore, the tensile strength of the grids were modeled as continuous reinforcement. The calculated allowable tensile grid capacity was converted to a continuous reinforcement tensile capacity by distributing the capacity over the tributary width. The longitudinal wires are spaced every 6 inches, therefore two bars exist within each 1-foot representative width of grid.

For pseudo-static analyses, we used an apparent cohesion in the native soils above the groundwater table based on the fines content ranges presented in Table 11-2 of the FHWA Geotechnical Engineering Circular No. 3. We used the horizontal seismic coefficients, kh, for compound stability presented in Table F-1 for the pseudo-static analyses. We applied the apparent cohesion values to applicable ESUs in the pseudo-static analyses for ESU layers above the groundwater. The amount of apparent cohesion was dependent on the ESU's fines content per FHWA-NHI-11-032, Table 11-2.

Groundwater levels were modeled using a piezometric surface. The piezometric surface was based on measured or observed groundwater levels at Bridge 17.7 as discussed in Appendix C.

We used the results of the global stability analyses to model and evaluate compound stability of Wall 03.65L at the design section presented in Table F-3. Per Project GDM Sections 15-4.12 and 6-4.3.2, a static resistance factor of 0.75 (FS = 1.3) and seismic resistance factor of 0.9 (FS = 1.1) shall be used for compound stability. The required minimum static and pseudo-static FSs were met for Wall 03.65L at Station 1+49.

Structural loads were not included in our analyses. Any structural foundation loads applied to the wall shall include the appropriate load factors in AASHTO LRFD Table 3.4.1-1 consistent with Strength Limit State and Extreme Event Limit State design.

The results of our compound stability analyses for Wall 03.65L are summarized in Table F-3. Compound stability models showing FS for critical failures at the design sections are provided in Appendix F.4, specifically in Figures F.4-1 through F.4-4. Compound stability Slope/W reports are also provided in Appendix F.4 after the figures.

Table F-3. Wall 03.65L Compound Stability Results

Design Section	Loading Type	Minimum Required Factor of Safety	Calculated Factor of Safety (Spencer/ Morgenstern-Price)	Number of Reinforcement Rows
Station 1+49	Static	1.3	2.2 / 2.2	10
	Pseudo-Static	1.1	1.5 / 1.5	

5.0 Shallow Foundation Bearing Resistance and Elastic Settlement

Per Project GDM Section 15-4.5, the minimum embedment of Wall 03.65L was verified by calculating the bearing capacity. We evaluated the shallow foundation bearing resistance based on AASHTO LRFD Section 10.6.3.1.2 and using the Shallow Foundation Resistance and Elastic Settlement spread sheet developed by GeoEngineers.

Bearing capacity was evaluated by considering the maximum height of Wall 03.65L over ESU 1B. The minimum strap lengths for the respective wall heights (as determined from global stability) were used as the wall widths, and gravel borrow as the required fill in the reinforced zone of the SE Wall. These parameters were used to calculate the weight of the wall as the minimum bearing resistance needed. Bearing resistance results and calculations for the foundations are presented in Appendix F.5 (Figures F.5-1 through F.5-3). A summary of the bearing capacity results is presented in Table F-4.

Table F-4. Bearing Resistance Summary

Scenario	Wall Load Pressure	Wall Width	Footing Length	Unfactored Bearing Resistance	Factored Extreme Event Resistance[1]	Factored Strength Bearing Resistance[2]	Factored Service Limit State[3]	
							1" Deflection	2" Deflection
	(ksf)	(feet)	(feet)	(ksf)[5]	(ksf)	(ksf)	(ksf)	(ksf)
Wall 03.65L **Sta. 1+49 H=21.5ft** (ESU 1A)	2.8	15	48	79.2	71.3	51.5	6.6	13.2

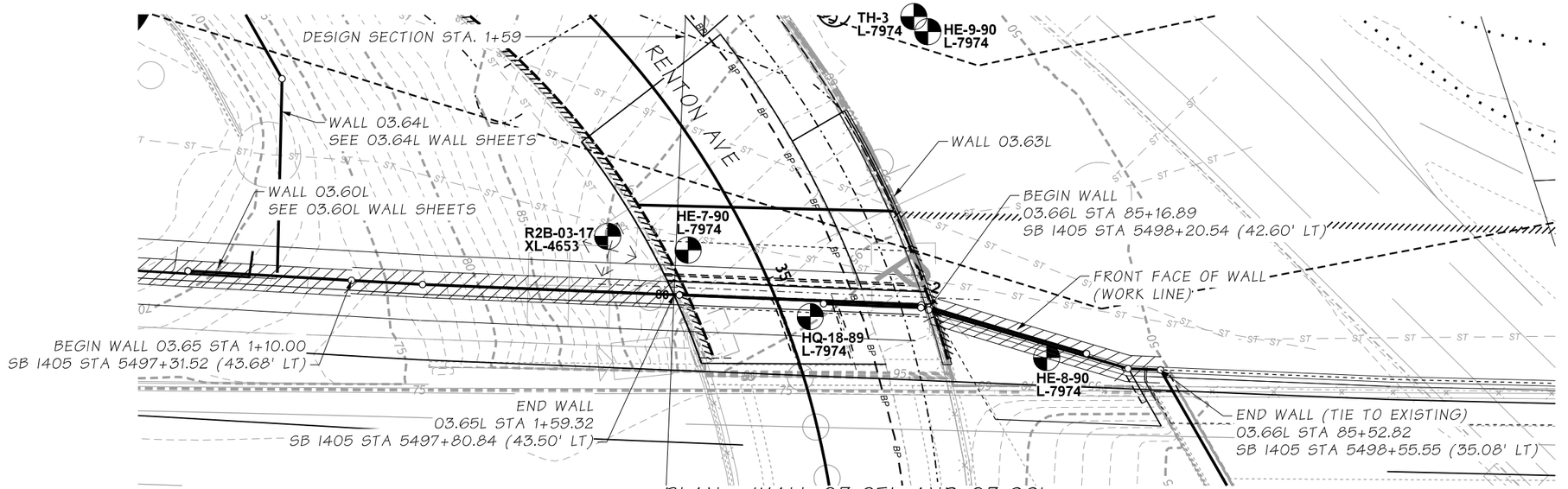
Notes:
1. Resistance factor of 0.9 included in the factored bearing resistance values presented for Extreme Limit State load cases (AASHTO 11.5.8) for MSE Walls.
2. Strength Limit State factor (0.65) MSE Walls from AASHTO 11.5.7.1.
3. Resistance factor of 1.0 included in the factored bearing resistance values presented for Service Limit State load cases.
4. Maximum Height of wall
5. ksf = kips per square foot

6.0 Lateral Earth Pressure

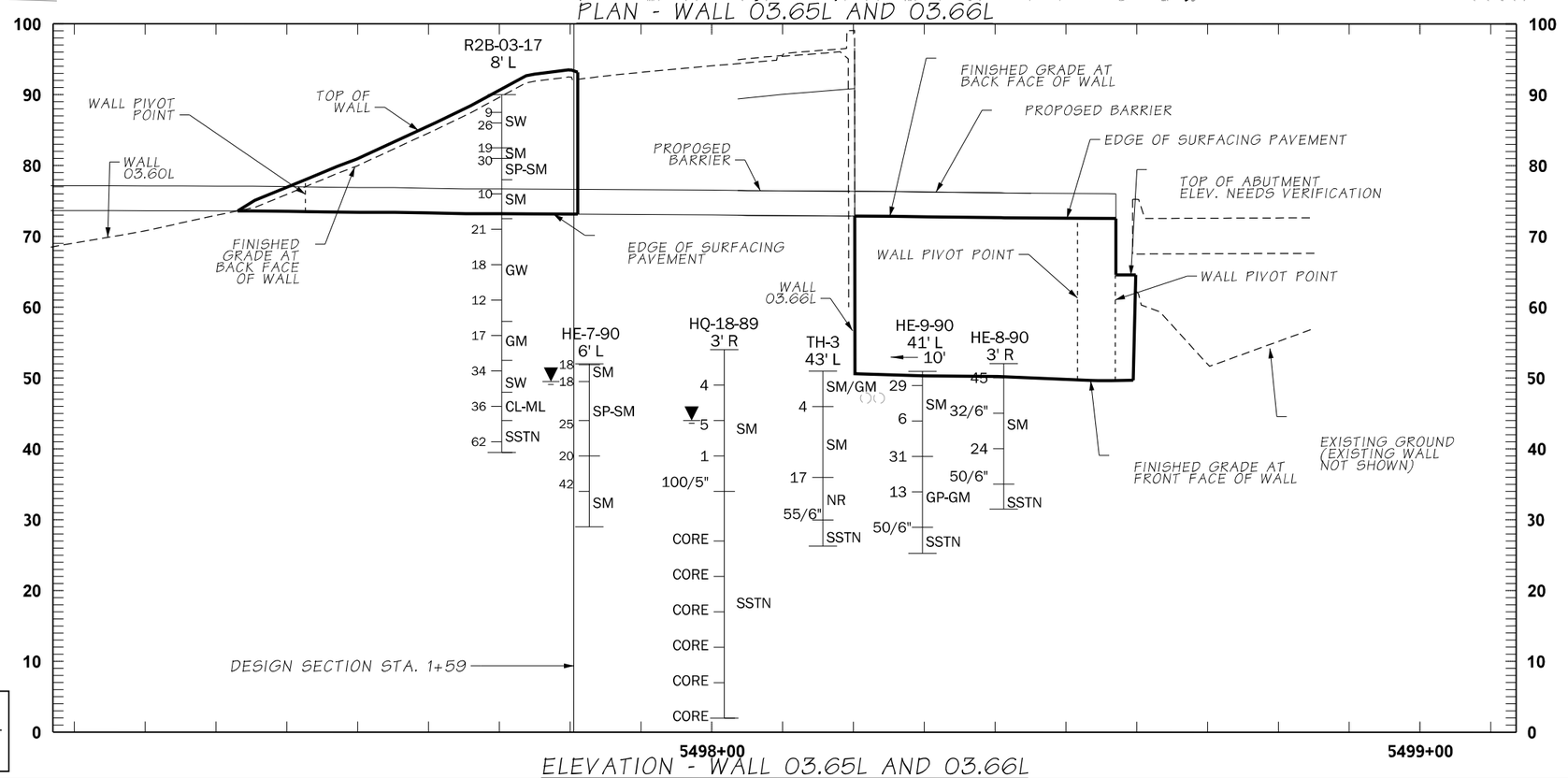
Lateral earth pressures were calculated using a spreadsheet developed by GeoEngineers based on Rankine and Coulomb earth pressure theory per AASHTO Section 3.11.5. Seismic active lateral earth pressure coefficients were developed using the Mononobe-Okabe Method per AASHTO Section A11.3.1. Lateral earth pressure calculations are presented in Appendix F.6 (Figures F.6-1 through F.6-2). Active static lateral earth pressure coefficients, ka, and active static + seismic earth pressure coefficients, kae, and the corresponding lateral earth pressures on the back of Wall 03.65L are presented in Appendix F.6. We recommend lateral earth pressures be applied using a triangular distribution.

Coefficients of friction against sliding were calculated for Wall 03.65L using AASHTO Equation 10.6.3.4-2 for concrete structures (such as fascia wall footings) and for soil-to-soil resistance to sliding at the base of the SE Wall. Friction coefficients are provided for native soils and each of the approved import materials. A coefficient of 1.0 was used for concrete cast against soil and 0.8 for precast concrete. For SE Wall sliding coefficients with discontinuous reinforcements (e.g., strips) the angle of sliding friction was taken as the lesser of the friction angle of the reinforced fill and the friction angle of the foundation soil (AASHTO 11.10.5.3). For sliding coefficients for the SE Wall with continuous reinforcements (e.g., grids and sheets) the angle of sliding friction was taken as the minimum of the reinforced fill friction angle, foundation soil friction angle, and the soil-reinforcement interface angle (taken as $^2/_3$ of the lesser of the foundation or reinforced soil friction angle in absence of specific information) per AASHTO Section 11.10.5.3. Calculations for these coefficients are presented in Appendix F.6. Sliding friction coefficients are presented on Figure F.6-3.

Appendix F.1
Wall 03.65L Cross Section



PLAN - WALL 03.65L AND 03.66L



ELEVATION - WALL 03.65L AND 03.66L

THE ESU STRATIFICATION HAVE BEEN INTERPRETED, INTERPOLATED BETWEEN EXPLORATIONS, AND EXTRAPOLATED BEYOND EXPLORATIONS FOR ENGINEERING DESIGN PURPOSES, THE STRATA MAY NOT REPRESENT ACTUAL SUBSURFACE CONDITIONS, SEE THE EXPLORATION LOGS FOR DETAILED SUBSURFACE CONDITIONS AT THE LOCATION EXPLORED.

DATUM
(NAVD) 88

FILE NAME	c:\users\hmara\documents\projectwise\workingdir\wsdot\dms17795\XL5467_WA-03.65L-03.66L_PP-1.dgn				REGION NO.	STATE	FED.AID PROJ.NO.
TIME	4:46:33 PM				10	WASH	
DATE	9/27/2021				JOB NUMBER		
PLOTTED BY	hmara						
DESIGNED BY					CONTRACT NO.		LOCATION NO.
ENTERED BY							
CHECKED BY							
PROJ. ENGR.							
REGIONAL ADM.		REVISION	DATE	BY			

P.E. STAMP BOX — DATE

P.E. STAMP BOX — DATE

Washington State Department of Transportation

FLATIRON LANE

wood.

I-405; RENTON TO BELLEVUE WIDENING AND EXPRESS TOLL LANES PROJECT

RETAINING WALL PLAN AND PROFILE
WALL 03.65L AND 03.66L

PLAN REF NO

SHEET 1 OF 1 SHEETS

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Appendix F.2
Wave Scatter Calculations

Calculating Corrected PGA for Wave Scattering Effects

(Wall 03.65L)

Per the National Cooperative Highway Research Program (NCHRP) Report 611 the Peak Ground Acceleration (PGA) can be adjusted to account for variations in the average ground acceleration due to wave scattering behind tall retaining walls or slopes by applying a scaling factor (or alpha value) to the PGA.

For Wall 03.65L, we will be applying the Mid Spectral shape curve to calculate our alpha scaling factor. This was determined by using Figure 5-4 in Report 611 (see below) and comparing it to the spectral shape developed by the PSHA provided by Hart Crowser ("I-405 R2B Segment 1a Site Specific Hazard Analysis RFU" (released for use) dated March 25, 2021 [Submittal 1197]). At Wall 03.65L, the design seismic site class of C was selected.

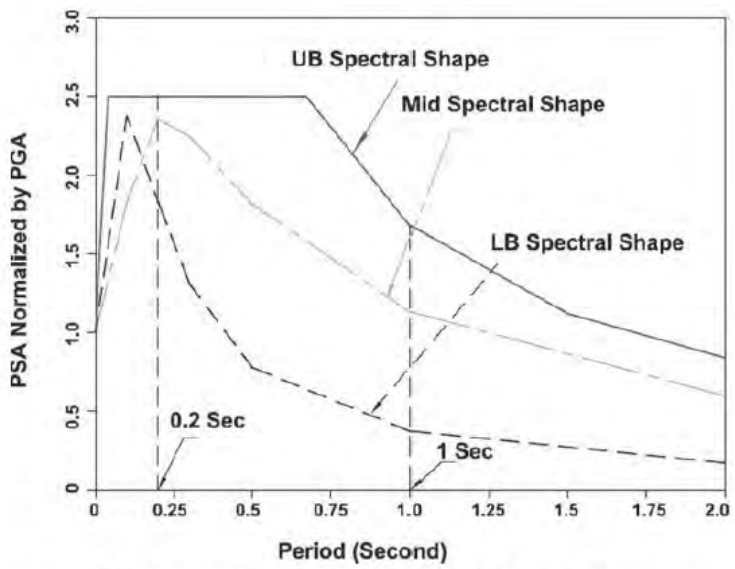

Figure 5-4. Spectral curve shapes adopted for further ground motion studies.

The alpha factor for global stability calculataions is selected using the applicable design height. For global and compound analyses, the deisgn height consists of the veritcal height of the critical pseudo-static failure surface. For lateral earth pressure calculations, the design height consists of the vertical distance from the back of the bottom reinforcement layer to the ground surface.

Wall design heights are presented below:

$H\_Wall_{LEP} := 21.5\ ft$ — Height of Wall 03.65L from the back of the bottom reinforcement layer to the ground surface

$H\_Wall_{global} := 24.1\ ft$ — Height of failure surface for Wall 03.65L global stability pseudo-static analysis

$H\_Wall_{compound} := 20.8\ ft$ — Height of failure surface for Wall 03.65L compound stability pseudo-static analysis

Using the slope and/or wall heights, the alpha scaling factor was selected from Figure 6-13

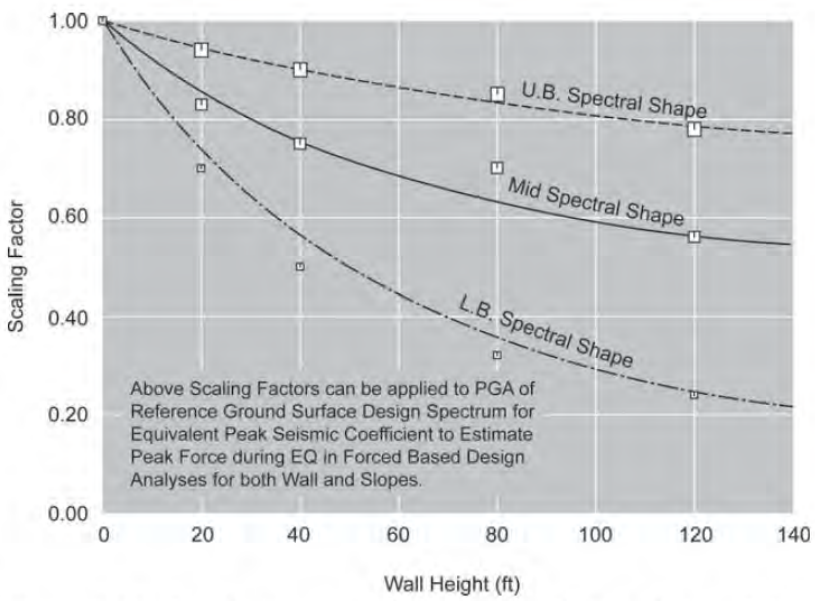

Figure 6-13. Resultant wave scattering α coefficients for retaining wall design.

$PGA := 0.51$

$H\_Wall_{LEP} = 21.5\ ft$ $\alpha_1 := 0.850$ Reduced PGA to be used for Wall 03.65L lateral earth pressure analyses

$PGAr := PGA \cdot \alpha_1 = 0.434$

$H\_Wall_{global} = 24.1\ ft$ $\alpha_1 := 0.835$ Reduced PGA to be used for Wall 03.65L global stability analyses

$PGAr := PGA \cdot \alpha_1 = 0.426$

$H\_Wall_{compound} = 20.8\ ft$ $\alpha_1 := 0.854$ Reduced PGA to be used for Wall 03.65L compound stability analyses

$PGAr := PGA \cdot \alpha_1 = 0.436$

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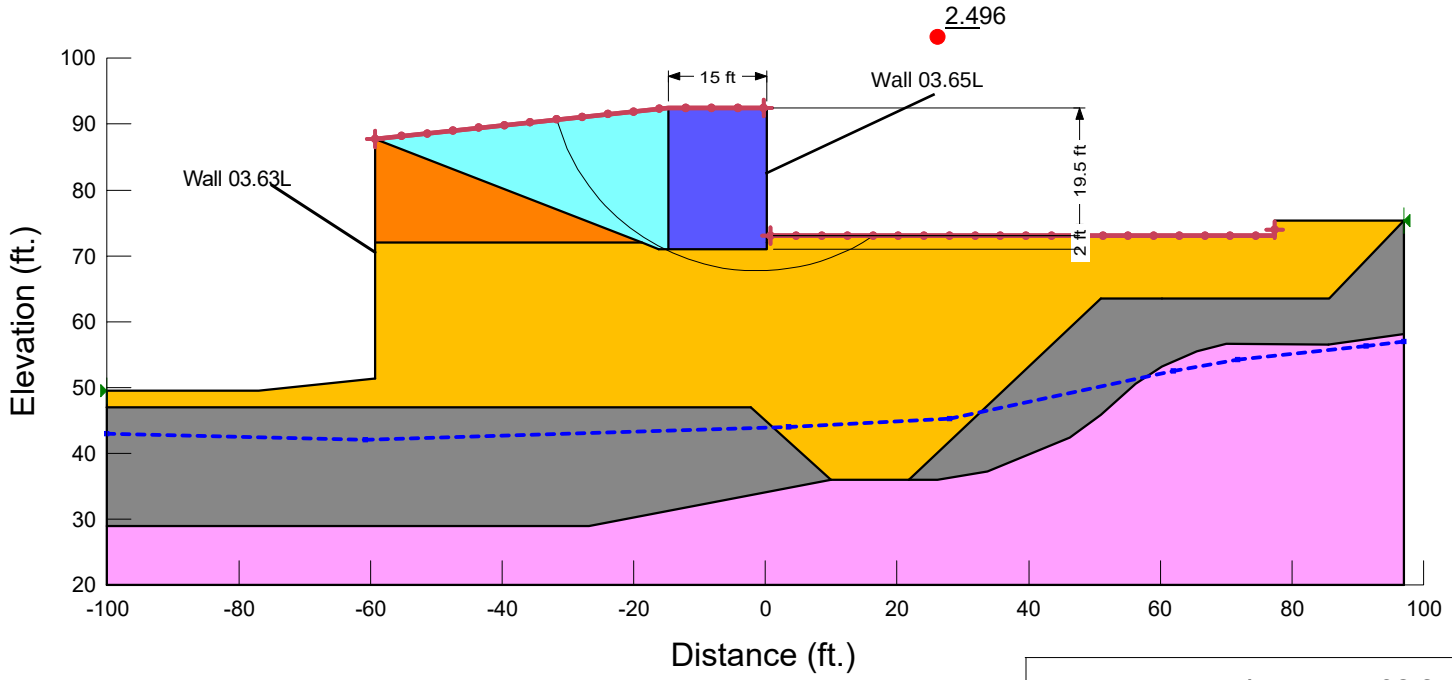
Appendix F.3
Global Stability Analyses

Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Common Borrow	Mohr-Coulomb	120	0	32
	ESU 1A - Existing Granular Fill	Mohr-Coulomb	120	0	40
	ESU 1B - Existing Gravelly Granular Fill	Mohr-Coulomb	125	0	38
	ESU 2A - Native Sand and Gravel	Mohr-Coulomb	120	0	39
	ESU 7A - Weathered Sandstone	Mohr-Coulomb	135	0	43
	SE Wall	High Strength	130		



Notes:

1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document.
3. GeoEngineers, Inc. cannot guarantee the accuracy and context of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Bridge 17.7 - Wall 03.65L - Sta. 1+49
Static Global Stability (M-P)

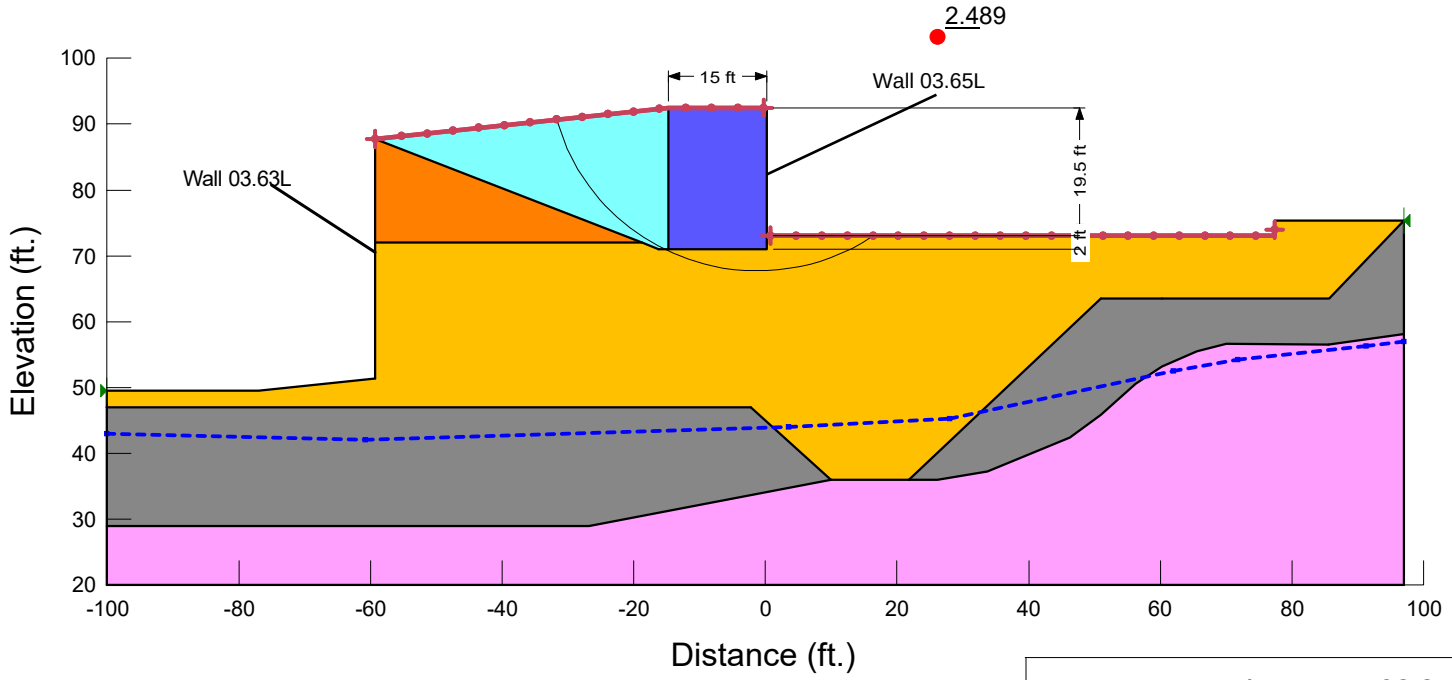
WSDOT I-405 Renton to Bellevue
King County, Washington

GeoEngineers

Figure F.3 - 1

00180-366-01 Date Exported: 10/05/21

Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Common Borrow	Mohr-Coulomb	120	0	32
	ESU 1A - Existing Granular Fill	Mohr-Coulomb	120	0	40
	ESU 1B - Existing Gravelly Granular Fill	Mohr-Coulomb	125	0	38
	ESU 2A - Native Sand and Gravel	Mohr-Coulomb	120	0	39
	ESU 7A - Weathered Sandstone	Mohr-Coulomb	135	0	43
	SE Wall	High Strength	130		



Notes:

1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document.
3. GeoEngineers, Inc. cannot guarantee the accuracy and context of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Bridge 17.7 - Wall 03.65L - Sta. 1+49
Static Global Stability (Spencer)

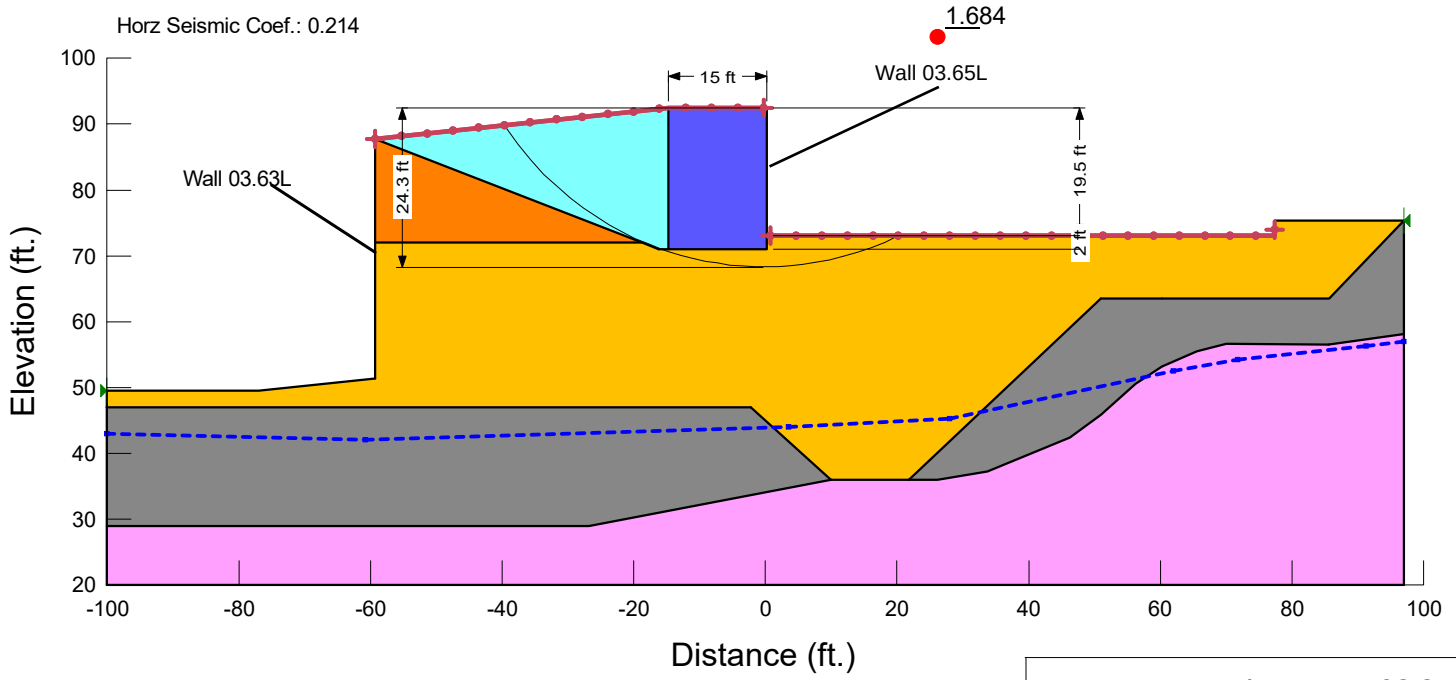
WSDOT I-405 Renton to Bellevue
King County, Washington

GeoEngineers

Figure F.3 - 2

00180-366-01 Date Exported: 10/05/21

Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Common Borrow	Mohr-Coulomb	120	0	32
	ESU 1A - Existing Granular Fill (Pseudo-Static)	Mohr-Coulomb	120	50	40
	ESU 1B - Existing Gravelly Granular Fill	Mohr-Coulomb	125	0	38
	ESU 2A - Native Sand and Gravel	Mohr-Coulomb	120	0	39
	ESU 7A - Weathered Sandstone	Mohr-Coulomb	135	0	43
	SE Wall	High Strength	130		



Notes:

1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document.
3. GeoEngineers, Inc. cannot guarantee the accuracy and context of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Bridge 17.7 - Wall 03.65L - Sta. 1+49
Pseudo-Static Global Stability (M-P)

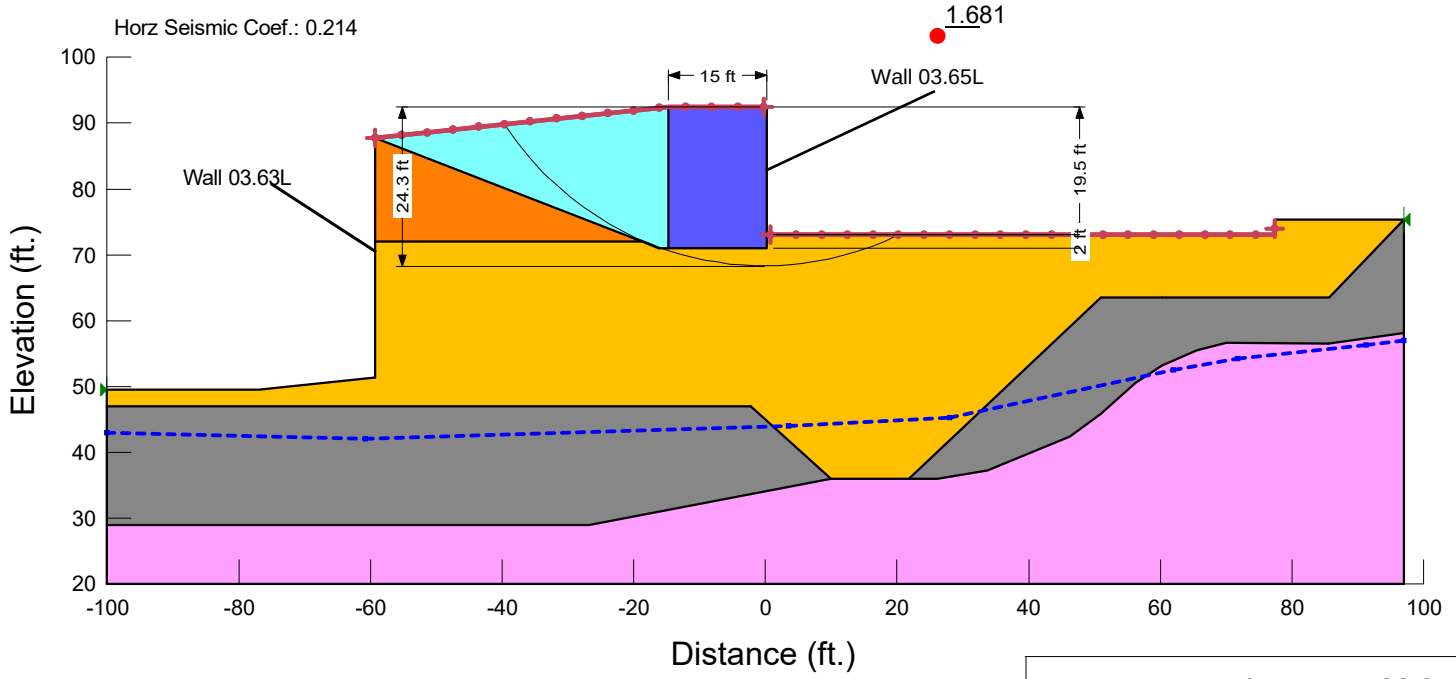
WSDOT I-405 Renton to Bellevue
King County, Washington

GeoEngineers

Figure F.3 - 3

00180-366-01 Date Exported: 10/05/21

Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Common Borrow	Mohr-Coulomb	120	0	32
	ESU 1A - Existing Granular Fill (Pseudo-Static)	Mohr-Coulomb	120	50	40
	ESU 1B - Existing Gravelly Granular Fill	Mohr-Coulomb	125	0	38
	ESU 2A - Native Sand and Gravel	Mohr-Coulomb	120	0	39
	ESU 7A - Weathered Sandstone	Mohr-Coulomb	135	0	43
	SE Wall	High Strength	130		



Notes:

1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document.
3. GeoEngineers, Inc. cannot guarantee the accuracy and context of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Bridge 17.7 - Wall 03.65L - Sta. 1+49
Pseudo-Static Global Stability (Spencer)

WSDOT I-405 Renton to Bellevue
King County, Washington

GeoEngineers

Figure F.3 - 4

00180-366-01 Date Exported: 10/05/21

1.1 Static (M-P) Wall 03.65L - Global Stability

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File Informa on

File Version: 11.01
Created By: Mikayla S. Hatch
Last Edited By: Kirsten R. Hooper
Revision Number: 283
Date: 10/06/2021
Time: 05:48:20 PM
Tool Version: 11.1
File Name: Wall 03.65L - Bridge 17.7.gsz
Directory: P:\0\0180366\01\Analysis\Bridge 17.7\SlopeW\
Last Solved Date: 10/06/2021
Last Solved Time: 05:48:30 PM

Project Se ngs

Unit System: U.S. Customary Units

Analysis Se ngs

1.1 Sta c (M-P)

Kind: SLOPE/W
Parent: 1. Global Stability
Analysis Type: Morgenstern-Price
Se ngs
Side Func on
Interslice force func on op on: Half-Sine
PWP Condi ons from: Piezometric Line
Apply Phrea c Correc on: No
Use Staged Rapid Drawdown: No
Unit Weight of Water: 62.430189 pcf
Slip Surface
Direc on of movement: Le. to Right
Use Passive Mode: No
Slip Surface Op on: Entry and Exit
Cri cal slip surfaces saved: 1
Op mize Cri cal Slip Surface Loca on: No
Tension Crack Op on: (none)
Distribu on
F of S Calcula on Op on: Constant
Advanced
Geometry Se ngs
Minimum Slip Surface Depth: 0.1 ft
Number of Slices: 30
Factor of Safety Convergence Se ngs
Maximum Number of Itera ons: 100
Tolerable difference in F of S: 0.001

Solu□on Se□ ngs
Search Method: Root Finder
Tolerable difference between star□ng and converged F of S: 3
Maximum itera□ons to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

SE Wall

Slope Stability Material Model: High Strength
Unit Weight: 130 pcf
Pore Water Pressure
Piezometric Line: 1

ESU 2A - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 39 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 7A - Weathered Sandstone

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 43 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1A - Exis ng Granular Fill

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 40 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1B - Exis ng Gravelly Granular Fill

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Common Borrow

Slope Stability Material Model: Mohr-Coulomb

Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (-59.25, 87.75) ft
Left-Zone Right Coordinate: (-0.26557, 92.5) ft
Left-Zone Increment: 15
Right Type: Range
Right-Zone Left Coordinate: (0.82396, 73) ft
Right-Zone Right Coordinate: (77.4, 74) ft
Right-Zone Increment: 20
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (-100, 49.5) ft
Right Coordinate: (97, 75.35) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	-100 ft	42.975 ft
Coordinate 2	-60.75 ft	42 ft
Coordinate 3	3.5 ft	44 ft
Coordinate 4	28 ft	45.225 ft
Coordinate 5	62 ft	52.475 ft
Coordinate 6	71.75 ft	54.225 ft
Coordinate 7	91.25 ft	56.25 ft
Coordinate 8	97 ft	57 ft

Geometry

Name: Wall 03.65L

Se ngs

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	-100 ft	49.5 ft

Point 2	-77 ft	49.5 ft
Point 3	-59.25 ft	51.375 ft
Point 4	-59.25 ft	87.75 ft
Point 5	0.25 ft	92.5 ft
Point 6	0.25 ft	73 ft
Point 7	60.25 ft	73 ft
Point 8	60.25 ft	20 ft
Point 9	-100 ft	20 ft
Point 10	-59.25 ft	72 ft
Point 11	-100 ft	47 ft
Point 12	-2.25 ft	47 ft
Point 13	10 ft	36 ft
Point 14	21.8 ft	36 ft
Point 15	50.9 ft	63.5 ft
Point 16	60.2 ft	63.5 ft
Point 17	97 ft	75.35 ft
Point 18	77.4 ft	75.35 ft
Point 19	77.4 ft	73 ft
Point 20	85.6 ft	63.5 ft
Point 21	97 ft	20 ft
Point 22	-100 ft	29 ft
Point 23	-26.8 ft	29 ft
Point 24	26.1 ft	36 ft
Point 25	33.7 ft	37.2 ft
Point 26	46.3 ft	42.35 ft
Point 27	50.9 ft	45.8 ft
Point 28	56.2 ft	50.5 ft
Point 29	65.5 ft	55.5 ft
Point 30	60.21187 ft	53.139391 ft
Point 31	70 ft	56.6 ft
Point 32	85.55 ft	56.575 ft
Point 33	97 ft	58.075 ft
Point 34	0.25 ft	72 ft
Point 35	-14.75 ft	92.5 ft
Point 36	-14.75 ft	71 ft
Point 37	-14.75 ft	91.086957 ft
Point 38	-14.75 ft	72 ft
Point 39	0.25 ft	71 ft
Point 40	-16.25 ft	71 ft
Point 41	-18.75 ft	72 ft

Regions

	Material	Points	Area
Region 1	ESU 1B - Exis□ng Gravelly Granular Fill	6,34,39,36,40,41,10,3,2,1,11,12,13,14,15,16,20,17,18,19,7	3,438.8 ft²
Region 2	ESU 7A - Weathered Sandstone	28,27,26,25,24,14,13,23,22,9,8,21,33,32,31,29,30	3,479.3 ft²
Region 3	ESU 2A - Na□ve Sand and Gravel	12,11,22,23,13	1,783.8 ft²

Region 4	ESU 2A - Na□ve Sand and Gravel	15,14,24,25,26,27,28,30,29,31,32,33,17,20,16	766.88 ft²
Region 5	SE Wall	6,5,35,37,38,36,39,34	322.5 ft²
Region 6	ESU 1A - Exis□ng Granular Fill	10,41,4	318.94 ft²
Region 7	Common Borrow	37,35,4,41,40,36,38	490.37 ft²

Slip Results

Slip Surfaces Analysed: 512 of 1680 converged

Current Slip Surface

Slip Surface: 759
Factor of Safety: 2.496
Volume: 647.38356 ft³
Weight: 81,364.857 lbf
Resis□ng Moment: 1,955,959.7 lbf·ft
Ac□va□ng Moment: 783,739.58 lbf·ft
Resis□ng Force: 56,044.675 lbf
Ac□va□ng Force: 22,453.581 lbf
Slip Rank: 1 of 1,680 slip surfaces
Exit: (16.339168, 73) ft
Entry: (-31.762114, 90.6841) ft
Radius: 31.807287 ft
Center: (-1.2091926, 99.528448) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Fric□onal Strength	Cohesive Strength	Suc□on Strength	Base Material
Slice 1	-30.93773 ft	88.468251 ft	-2,843.086 psf	154.472 psf	96.524816 psf	0 psf	0 psf	Common Borrow
Slice 2	-29.288963 ft	84.692142 ft	-2,604.1386 psf	449.55184 psf	280.91117 psf	0 psf	0 psf	Common Borrow
Slice 3	-27.640196 ft	81.896123 ft	-2,426.3785 psf	680.311 psf	425.10549 psf	0 psf	0 psf	Common Borrow
Slice 4	-25.991428 ft	79.633469 ft	-2,281.9164 psf	876.64548 psf	547.7889 psf	0 psf	0 psf	Common Borrow
Slice 5	-24.342661 ft	77.731635 ft	-2,159.9804 psf	1,053.6876 psf	658.4171 psf	0 psf	0 psf	Common Borrow
Slice 6	-22.693893 ft	76.100687 ft	-2,054.9559 psf	1,220.6538 psf	762.74918 psf	0 psf	0 psf	Common Borrow
Slice 7	-21.045126 ft	74.68642 ft	-1,963.4588 psf	1,383.7474 psf	864.66134 psf	0 psf	0 psf	Common Borrow
Slice 8	-19.396358 ft	73.453167 ft	-1,883.2624 psf	1,547.3909 psf	966.91714 psf	0 psf	0 psf	Common Borrow
Slice 9	-17.747591 ft	72.376042 ft	-1,812.8132 psf	1,714.8056 psf	1,071.5295 psf	0 psf	0 psf	Common Borrow
Slice	-16.098823	71.436957	-1,750.9818	1,888.2811	1,179.929	0 psf	0 psf	Common

10	ft	ft	psf	psf	psf			Borrow
Slice 11	-15.01222 ft	70.873688 ft	-1,713.7052 psf	1,999.7471 psf	1,562.3737 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 12	-13.916667 ft	70.384029 ft	-1,681.0066 psf	2,302.7878 psf	1,799.135 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 13	-12.25 ft	69.712103 ft	-1,635.8192 psf	2,499.2808 psf	1,952.6522 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 14	-10.583333 ft	69.146406 ft	-1,597.2638 psf	2,702.6147 psf	2,111.514 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 15	-8.9166667 ft	68.681073 ft	-1,564.974 psf	2,910.2933 psf	2,273.7703 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 16	-7.25 ft	68.311598 ft	-1,538.6687 psf	3,118.3275 psf	2,436.3045 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 17	-5.5833333 ft	68.034598 ft	-1,518.1366 psf	3,321.0858 psf	2,594.7166 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 18	-3.9166667 ft	67.84764 ft	-1,503.2259 psf	3,511.2467 psf	2,743.2866 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 19	-2.25 ft	67.74913 ft	-1,493.8369 psf	3,679.9264 psf	2,875.0736 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 20	-0.58333333 ft	67.738243 ft	-1,489.9184 psf	3,817.0627 psf	2,982.2162 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 21	1.0625 ft	67.812846 ft	-1,491.3774 psf	876.84198 psf	685.06403 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill

Slice 22	2.6875 ft	67.971371 ft	-1,498.1162 psf	880.81956 psf	688.17166 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 23	4.302448 ft	68.212933 ft	-1,509.1131 psf	860.66941 psf	672.42864 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 24	5.907344 ft	68.538441 ft	-1,524.4249 psf	815.11331 psf	636.83631 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 25	7.51224 ft	68.951597 ft	-1,545.2087 psf	743.82793 psf	581.14207 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 26	9.117136 ft	69.456025 ft	-1,571.6905 psf	647.92448 psf	506.21408 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 27	10.722032 ft	70.056428 ft	-1,604.1641 psf	529.89733 psf	414.00117 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 28	12.326928 ft	70.758838 ft	-1,643.0059 psf	393.33827 psf	307.30954 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 29	13.931824 ft	71.570974 ft	-1,688.6981 psf	242.45877 psf	189.42955 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 30	15.53672 ft	72.502779 ft	-1,741.8611 psf	81.507852 psf	63.680913 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill

1.1 Static (Spencer) Wall 03.65L - Global Stability

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File Informa on

File Version: 11.01
Created By: Mikayla S. Hatch
Last Edited By: Kirsten R. Hooper
Revision Number: 283
Date: 10/06/2021
Time: 05:48:20 PM
Tool Version: 11.1
File Name: Wall 03.65L - Bridge 17.7.gsz
Directory: P:\0\0180366\01\Analysis\Bridge 17.7\SlopeW\
Last Solved Date: 10/06/2021
Last Solved Time: 05:48:30 PM

Project Se ngs

Unit System: U.S. Customary Units

Analysis Se ngs

1.1 Sta c (Spencer)

Kind: SLOPE/W
Parent: 1. Global Stability
Analysis Type: Spencer
Se ngs
PWP Condi ons from: Piezometric Line
Apply Phrea c Correc on: No
Use Staged Rapid Drawdown: No
Unit Weight of Water: 62.430189 pcf
Slip Surface
Direc on of movement: Le. to Right
Use Passive Mode: No
Slip Surface Op on: Entry and Exit
Cri cal slip surfaces saved: 1
Op mize Cri cal Slip Surface Loca on: No
Tension Crack Op on: (none)
Distribu on
F of S Calcula on Op on: Constant
Advanced
Geometry Se ngs
Minimum Slip Surface Depth: 0.1 ft
Number of Slices: 30
Factor of Safety Convergence Se ngs
Maximum Number of Itera ons: 100
Tolerable difference in F of S: 0.001
Solu on Se ngs
Search Method: Root Finder

Tolerable difference between star□ng and converged F of S: 3
Maximum itera□ons to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

SE Wall

Slope Stability Material Model: High Strength
Unit Weight: 130 pcf
Pore Water Pressure
Piezometric Line: 1

ESU 2A - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 39 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 7A - Weathered Sandstone

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 43 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1A - Exis ng Granular Fill

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 40 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1B - Exis ng Gravelly Granular Fill

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Common Borrow

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf

Effec□ve Fric□on Angle: 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (-59.25, 87.75) ft
Left-Zone Right Coordinate: (-0.26557, 92.5) ft
Left-Zone Increment: 15
Right Type: Range
Right-Zone Left Coordinate: (0.82396, 73) ft
Right-Zone Right Coordinate: (77.4, 74) ft
Right-Zone Increment: 20
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (-100, 49.5) ft
Right Coordinate: (97, 75.35) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	-100 ft	42.975 ft
Coordinate 2	-60.75 ft	42 ft
Coordinate 3	3.5 ft	44 ft
Coordinate 4	28 ft	45.225 ft
Coordinate 5	62 ft	52.475 ft
Coordinate 6	71.75 ft	54.225 ft
Coordinate 7	91.25 ft	56.25 ft
Coordinate 8	97 ft	57 ft

Geometry

Name: Wall 03.65L

Se ngs

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	-100 ft	49.5 ft
Point 2	-77 ft	49.5 ft

Point 3	-59.25 ft	51.375 ft
Point 4	-59.25 ft	87.75 ft
Point 5	0.25 ft	92.5 ft
Point 6	0.25 ft	73 ft
Point 7	60.25 ft	73 ft
Point 8	60.25 ft	20 ft
Point 9	-100 ft	20 ft
Point 10	-59.25 ft	72 ft
Point 11	-100 ft	47 ft
Point 12	-2.25 ft	47 ft
Point 13	10 ft	36 ft
Point 14	21.8 ft	36 ft
Point 15	50.9 ft	63.5 ft
Point 16	60.2 ft	63.5 ft
Point 17	97 ft	75.35 ft
Point 18	77.4 ft	75.35 ft
Point 19	77.4 ft	73 ft
Point 20	85.6 ft	63.5 ft
Point 21	97 ft	20 ft
Point 22	-100 ft	29 ft
Point 23	-26.8 ft	29 ft
Point 24	26.1 ft	36 ft
Point 25	33.7 ft	37.2 ft
Point 26	46.3 ft	42.35 ft
Point 27	50.9 ft	45.8 ft
Point 28	56.2 ft	50.5 ft
Point 29	65.5 ft	55.5 ft
Point 30	60.21187 ft	53.139391 ft
Point 31	70 ft	56.6 ft
Point 32	85.55 ft	56.575 ft
Point 33	97 ft	58.075 ft
Point 34	0.25 ft	72 ft
Point 35	-14.75 ft	92.5 ft
Point 36	-14.75 ft	71 ft
Point 37	-14.75 ft	91.086957 ft
Point 38	-14.75 ft	72 ft
Point 39	0.25 ft	71 ft
Point 40	-16.25 ft	71 ft
Point 41	-18.75 ft	72 ft

Regions

	Material	Points	Area
Region 1	ESU 1B - Exis□ng Gravelly Granular Fill	6,34,39,36,40,41,10,3,2,1,11,12,13,14,15,16,20,17,18,19,7	3,438.8 ft²
Region 2	ESU 7A - Weathered Sandstone	28,27,26,25,24,14,13,23,22,9,8,21,33,32,31,29,30	3,479.3 ft²
Region 3	ESU 2A - Na□ve Sand and Gravel	12,11,22,23,13	1,783.8 ft²
Region	ESU 2A - Na□ve Sand and	15,14,24,25,26,27,28,30,29,31,32,33,17,20,16	766.88

4	Gravel		ft²
Region 5	SE Wall	6,5,35,37,38,36,39,34	322.5 ft²
Region 6	ESU 1A - Exis□ng Granular Fill	10,41,4	318.94 ft²
Region 7	Common Borrow	37,35,4,41,40,36,38	490.37 ft²

Slip Results

Slip Surfaces Analysed: 506 of 1680 converged

Current Slip Surface

Slip Surface: 759
Factor of Safety: 2.489
Volume: 647.38356 ft³
Weight: 81,364.857 lbf
Resis□ng Moment: 1,950,666.1 lbf·ft
Ac□va□ng Moment: 783,739.58 lbf·ft
Resis□ng Force: 55,930.903 lbf
Ac□va□ng Force: 22,469.461 lbf
Slip Rank: 1 of 1,680 slip surfaces
Exit: (16.339168, 73) ft
Entry: (-31.762114, 90.6841) ft
Radius: 31.807287 ft
Center: (-1.2091926, 99.528448) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Fric□onal Strength	Cohesive Strength	Suc□on Strength	Base Material
Slice 1	-30.93773 ft	88.468251 ft	-2,843.086 psf	110.22696 psf	68.87745 psf	0 psf	0 psf	Common Borrow
Slice 2	-29.288963 ft	84.692142 ft	-2,604.1386 psf	368.1126 psf	230.02228 psf	0 psf	0 psf	Common Borrow
Slice 3	-27.640196 ft	81.896123 ft	-2,426.3785 psf	613.32098 psf	383.24549 psf	0 psf	0 psf	Common Borrow
Slice 4	-25.991428 ft	79.633469 ft	-2,281.9164 psf	846.00457 psf	528.64233 psf	0 psf	0 psf	Common Borrow
Slice 5	-24.342661 ft	77.731635 ft	-2,159.9804 psf	1,067.4094 psf	666.99144 psf	0 psf	0 psf	Common Borrow
Slice 6	-22.693893 ft	76.100687 ft	-2,054.9559 psf	1,278.7701 psf	799.06426 psf	0 psf	0 psf	Common Borrow
Slice 7	-21.045126 ft	74.68642 ft	-1,963.4588 psf	1,481.1417 psf	925.52006 psf	0 psf	0 psf	Common Borrow
Slice 8	-19.396358 ft	73.453167 ft	-1,883.2624 psf	1,675.4039 psf	1,046.9086 psf	0 psf	0 psf	Common Borrow
Slice 9	-17.747591 ft	72.376042 ft	-1,812.8132 psf	1,862.2941 psf	1,163.6905 psf	0 psf	0 psf	Common Borrow
Slice 10	-16.098823 ft	71.436957 ft	-1,750.9818 psf	2,042.4397 psf	1,276.258 psf	0 psf	0 psf	Common Borrow

Slice 11	-15.01222 ft	70.873688 ft	-1,713.7052 psf	2,144.3452 psf	1,675.3461 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 12	-13.916667 ft	70.384029 ft	-1,681.0066 psf	2,436.1519 psf	1,903.3305 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 13	-12.25 ft	69.712103 ft	-1,635.8192 psf	2,602.8609 psf	2,033.5778 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 14	-10.583333 ft	69.146406 ft	-1,597.2638 psf	2,764.0004 psf	2,159.4738 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 15	-8.9166667 ft	68.681073 ft	-1,564.974 psf	2,920.0702 psf	2,281.4088 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 16	-7.25 ft	68.311598 ft	-1,538.6687 psf	3,071.5687 psf	2,399.7724 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 17	-5.5833333 ft	68.034598 ft	-1,518.1366 psf	3,219.0158 psf	2,514.9707 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 18	-3.9166667 ft	67.84764 ft	-1,503.2259 psf	3,362.979 psf	2,627.4471 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 19	-2.25 ft	67.74913 ft	-1,493.8369 psf	3,504.1057 psf	2,737.7074 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 20	-0.58333333 ft	67.738243 ft	-1,489.9184 psf	3,643.1662 psf	2,846.3534 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 21	1.0625 ft	67.812846 ft	-1,491.3774 psf	767.3918 psf	599.55219 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice	2.6875 ft	67.971371	-1,498.1162	775.23999	605.68386	0 psf	0 psf	ESU 1B -

22		ft	psf	psf	psf			Exis□ng Gravelly Granular Fill
Slice 23	4.302448 ft	68.212933 ft	-1,509.1131 psf	770.85068 psf	602.25456 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 24	5.907344 ft	68.538441 ft	-1,524.4249 psf	752.64834 psf	588.03333 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 25	7.51224 ft	68.951597 ft	-1,545.2087 psf	718.40886 psf	561.28252 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 26	9.117136 ft	69.456025 ft	-1,571.6905 psf	665.01355 psf	519.56552 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 27	10.722032 ft	70.056428 ft	-1,604.1641 psf	588.03593 psf	459.42402 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 28	12.326928 ft	70.758838 ft	-1,643.0059 psf	480.91692 psf	375.73348 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 29	13.931824 ft	71.570974 ft	-1,688.6981 psf	333.39832 psf	260.47931 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 30	15.53672 ft	72.502779 ft	-1,741.8611 psf	128.28919 psf	100.2305 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill

2.1 Pseudo-Static (M-P) Wall 03.65L - Global Stability

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File Informa on

File Version: 11.02
Created By: Mikayla S. Hatch
Last Edited By: Addison J. Wilson
Revision Number: 285
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Tool Version: 11.2.2.23310
File Name: Wall 03.65L - Bridge 17.7.gsz
Directory: P:\0\0180366\01\Analysis\Bridge 17.7\SlopeW\
Last Solved Date: 10/14/2021
Last Solved Time: 01:26:42 PM

Project Se ngs

Unit System: U.S. Customary Units

Analysis Se ngs

2.1 Pseudo-Sta c (M-P)

Kind: SLOPE/W
Parent: 1. Global Stability
Analysis Type: Morgenstern-Price
Se ngs
Side Func on
Interslice force func on op on: Half-Sine
PWP Condi ons from: Piezometric Line
Apply Phrea c Correc on: No
Use Staged Rapid Drawdown: No
Unit Weight of Water: 62.430189 pcf
Slip Surface
Direc on of movement: Le. to Right
Use Passive Mode: No
Slip Surface Op on: Entry and Exit
Cri cal slip surfaces saved: 1
Op mize Cri cal Slip Surface Loca on: No
Tension Crack Op on: (none)
Distribu on
F of S Calcula on Op on: Constant
Advanced
Geometry Se ngs
Minimum Slip Surface Depth: 0.1 ft
Number of Slices: 30
Factor of Safety Convergence Se ngs
Maximum Number of Itera ons: 100
Tolerable difference in F of S: 0.001

Solu□on Se□ ngs
Search Method: Root Finder
Tolerable difference between star□ng and converged F of S: 3
Maximum itera□ons to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

SE Wall

Slope Stability Material Model: High Strength
Unit Weight: 130 pcf
Pore Water Pressure
Piezometric Line: 1

ESU 1A - Exis ng Granular Fill (Pseudo-Sta c)

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 50 psf
Effec□ve Fric□on Angle: 40 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2A - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 39 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 7A - Weathered Sandstone

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 43 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1B - Exis ng Gravelly Granular Fill

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Common Borrow

Slope Stability Material Model: Mohr-Coulomb

Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (-59.25, 87.75) ft
Left-Zone Right Coordinate: (-0.26557, 92.5) ft
Left-Zone Increment: 15
Right Type: Range
Right-Zone Left Coordinate: (0.82396, 73) ft
Right-Zone Right Coordinate: (77.4, 74) ft
Right-Zone Increment: 20
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (-100, 49.5) ft
Right Coordinate: (97, 75.35) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	-100 ft	42.975 ft
Coordinate 2	-60.75 ft	42 ft
Coordinate 3	3.5 ft	44 ft
Coordinate 4	28 ft	45.225 ft
Coordinate 5	62 ft	52.475 ft
Coordinate 6	71.75 ft	54.225 ft
Coordinate 7	91.25 ft	56.25 ft
Coordinate 8	97 ft	57 ft

Seismic Coefficients

Horz Seismic Coef.: 0.214

Geometry

Name: Wall 03.65L

Se ngs

View: 2D

Element Thickness: 1 ft

Points

	X	Y
Point 1	-100 ft	49.5 ft
Point 2	-77 ft	49.5 ft
Point 3	-59.25 ft	51.375 ft
Point 4	-59.25 ft	87.75 ft
Point 5	0.25 ft	92.5 ft
Point 6	0.25 ft	73 ft
Point 7	60.25 ft	73 ft
Point 8	60.25 ft	20 ft
Point 9	-100 ft	20 ft
Point 10	-59.25 ft	72 ft
Point 11	-100 ft	47 ft
Point 12	-2.25 ft	47 ft
Point 13	10 ft	36 ft
Point 14	21.8 ft	36 ft
Point 15	50.9 ft	63.5 ft
Point 16	60.2 ft	63.5 ft
Point 17	97 ft	75.35 ft
Point 18	77.4 ft	75.35 ft
Point 19	77.4 ft	73 ft
Point 20	85.6 ft	63.5 ft
Point 21	97 ft	20 ft
Point 22	-100 ft	29 ft
Point 23	-26.8 ft	29 ft
Point 24	26.1 ft	36 ft
Point 25	33.7 ft	37.2 ft
Point 26	46.3 ft	42.35 ft
Point 27	50.9 ft	45.8 ft
Point 28	56.2 ft	50.5 ft
Point 29	65.5 ft	55.5 ft
Point 30	60.21187 ft	53.139391 ft
Point 31	70 ft	56.6 ft
Point 32	85.55 ft	56.575 ft
Point 33	97 ft	58.075 ft
Point 34	0.25 ft	72 ft
Point 35	-14.75 ft	92.5 ft
Point 36	-14.75 ft	71 ft
Point 37	-14.75 ft	91.086957 ft
Point 38	-14.75 ft	72 ft
Point 39	0.25 ft	71 ft
Point 40	-16.25 ft	71 ft
Point 41	-18.75 ft	72 ft

Regions

	Material	Points	Area
Region	ESU 1B - Exis□ng Gravelly	6,34,39,36,40,41,10,3,2,1,11,12,13,14,15,16,20,17,18,19,7	3,438.8

1	Granular Fill		ft²
Region 2	ESU 7A - Weathered Sandstone	28,27,26,25,24,14,13,23,22,9,8,21,33,32,31,29,30	3,479.3 ft²
Region 3	ESU 2A - Na□ve Sand and Gravel	12,11,22,23,13	1,783.8 ft²
Region 4	ESU 2A - Na□ve Sand and Gravel	15,14,24,25,26,27,28,30,29,31,32,33,17,20,16	766.88 ft²
Region 5	SE Wall	6,5,35,37,38,36,39,34	322.5 ft²
Region 6	ESU 1A - Exis□ng Granular Fill (Pseudo-Sta□c)	10,41,4	318.94 ft²
Region 7	Common Borrow	37,35,4,41,40,36,38	490.37 ft²

Slip Results

Slip Surfaces Analysed: 514 of 1680 converged

Current Slip Surface

Slip Surface: 553
Factor of Safety: 1.684
Volume: 741.17065 ft³
Weight: 92,619.088 lbf
Resis□ng Moment: 3,140,120.4 lbf·ft
Ac□va□ng Moment: 1,865,461.3 lbf·ft
Resis□ng Force: 63,539.433 lbf
Ac□va□ng Force: 37,737.294 lbf
Slip Rank: 1 of 1,680 slip surfaces
Exit: (20.21797, 73) ft
Entry: (-39.615796, 89.845786) ft
Radius: 46.923129 ft
Center: (-0.17188769, 115.26149) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Fric□onal Strength	Cohesive Strength	Suc□on Strength	Base Material
Slice 1	-38.621418 ft	88.421304 ft	-2,855.0871 psf	110.80374 psf	69.237861 psf	0 psf	0 psf	Common Borrow
Slice 2	-36.632663 ft	85.76756 ft	-2,685.5485 psf	306.33233 psf	191.41768 psf	0 psf	0 psf	Common Borrow
Slice 3	-34.643907 ft	83.460403 ft	-2,537.6475 psf	463.63203 psf	289.70945 psf	0 psf	0 psf	Common Borrow
Slice 4	-32.655152 ft	81.42782 ft	-2,406.8881 psf	596.65405 psf	372.83083 psf	0 psf	0 psf	Common Borrow
Slice 5	-30.666396 ft	79.622297 ft	-2,290.304 psf	715.04353 psf	446.80879 psf	0 psf	0 psf	Common Borrow
Slice 6	-28.677641 ft	78.010529 ft	-2,185.8162 psf	826.1093 psf	516.21038 psf	0 psf	0 psf	Common Borrow
Slice 7	-26.688885 ft	76.568138 ft	-2,091.9026 psf	935.84644 psf	584.78176 psf	0 psf	0 psf	Common Borrow

Slice 8	-24.70013 ft	75.276689 ft	-2,007.4124 psf	1,049.5115 psf	655.80756 psf	0 psf	0 psf	Common Borrow
Slice 9	-22.711374 ft	74.121901 ft	-1,931.4539 psf	1,171.955 psf	732.31873 psf	0 psf	0 psf	Common Borrow
Slice 10	-20.722619 ft	73.092501 ft	-1,863.3234 psf	1,307.7976 psf	817.20267 psf	0 psf	0 psf	Common Borrow
Slice 11	-18.733863 ft	72.179469 ft	-1,802.4578 psf	1,461.4804 psf	913.23433 psf	0 psf	0 psf	Common Borrow
Slice 12	-16.745108 ft	71.37552 ft	-1,748.4022 psf	1,637.1847 psf	1,023.0266 psf	0 psf	0 psf	Common Borrow
Slice 13	-15.250365 ft	70.830193 ft	-1,711.4526 psf	1,863.2186 psf	1,455.7059 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 14	-13.8125 ft	70.375485 ft	-1,680.2708 psf	2,210.1723 psf	1,726.7758 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 15	-11.9375 ft	69.8477 ft	-1,643.6773 psf	2,462.3002 psf	1,923.7598 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 16	-10.0625 ft	69.402622 ft	-1,612.2472 psf	2,741.508 psf	2,141.9008 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 17	-8.1875 ft	69.037855 ft	-1,585.8309 psf	3,043.4402 psf	2,377.7961 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 18	-6.3125 ft	68.751508 ft	-1,564.3104 psf	3,359.464 psf	2,624.7009 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 19	-4.4375 ft	68.542135 ft	-1,547.5955 psf	3,675.7404 psf	2,871.8031 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 20	-2.5625 ft	68.408704 ft	-1,535.6215 psf	3,972.8902 psf	3,103.962 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 21	-0.6875 ft	68.350564 ft	-1,528.3481 psf	4,226.7986 psf	3,302.337 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill

Slice 22	1.0625 ft	68.361645 ft	-1,525.639 psf	1,046.8157 psf	817.86209 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 23	2.6875 ft	68.432641 ft	-1,526.9134 psf	1,082.8643 psf	846.0263 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 24	4.5448731 ft	68.587846 ft	-1,531.7623 psf	1,085.2402 psf	847.8826 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 25	6.6346194 ft	68.846664 ft	-1,541.3972 psf	1,037.9323 psf	810.92156 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 26	8.7243656 ft	69.201703 ft	-1,557.0391 psf	938.1213 psf	732.94069 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 27	10.814112 ft	69.655213 ft	-1,578.8287 psf	795.39364 psf	621.42962 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 28	12.903858 ft	70.210175 ft	-1,606.952 psf	624.39552 psf	487.83124 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 29	14.993604 ft	70.870404 ft	-1,641.647 psf	440.73855 psf	344.34269 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 30	17.083351 ft	71.640692 ft	-1,683.2131 psf	257.25975 psf	200.99334 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 31	19.173097 ft	72.527008 ft	-1,732.0228 psf	82.265979 psf	64.273227 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill

2.1 Pseudo-Static (Spencer) Wall 03.65L - Global Stability

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File Informa on

File Version: 11.02
Created By: Mikayla S. Hatch
Last Edited By: Addison J. Wilson
Revision Number: 285
Date: 10/14/2021
Time: 01:26:16 PM
Tool Version: 11.2.2.23310
File Name: Wall 03.65L - Bridge 17.7.gsz
Directory: P:\0\0180366\01\Analysis\Bridge 17.7\SlopeW\
Last Solved Date: 10/14/2021
Last Solved Time: 01:26:42 PM

Project Se ngs

Unit System: U.S. Customary Units

Analysis Se ngs

2.1 Pseudo-Sta c (Spencer)

Kind: SLOPE/W
Parent: 1. Global Stability
Analysis Type: Spencer
Se ngs
PWP Condi ons from: Piezometric Line
Apply Phrea c Correc on: No
Use Staged Rapid Drawdown: No
Unit Weight of Water: 62.430189 pcf
Slip Surface
Direc on of movement: Le. to Right
Use Passive Mode: No
Slip Surface Op□on: Entry and Exit
Cri□cal slip surfaces saved: 1
Op□mize Cri□cal Slip Surface Loca□on: No
Tension Crack Op□on: (none)
Distribu□on
F of S Calcula□on Op□on: Constant
Advanced
Geometry Se□ ngs
Minimum Slip Surface Depth: 0.1 ft
Number of Slices: 30
Factor of Safety Convergence Se□ ngs
Maximum Number of Itera□ons: 100
Tolerable difference in F of S: 0.001
Solu□on Se□ ngs
Search Method: Root Finder

Tolerable difference between star□ng and converged F of S: 3
Maximum itera□ons to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

SE Wall

Slope Stability Material Model: High Strength
Unit Weight: 130 pcf
Pore Water Pressure
Piezometric Line: 1

ESU 1A - Exis ng Granular Fill (Pseudo-Sta c)

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 50 psf
Effec□ve Fric□on Angle: 40 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2A - Na ve Sand and Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 39 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 7A - Weathered Sandstone

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 43 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1B - Exis ng Gravelly Granular Fill

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effec□ve Cohesion: 0 psf
Effec□ve Fric□on Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Common Borrow

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effec□ve Cohesion: 0 psf

Effec□ve Fric□on Angle: 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (-59.25, 87.75) ft
Left-Zone Right Coordinate: (-0.26557, 92.5) ft
Left-Zone Increment: 15
Right Type: Range
Right-Zone Left Coordinate: (0.82396, 73) ft
Right-Zone Right Coordinate: (77.4, 74) ft
Right-Zone Increment: 20
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (-100, 49.5) ft
Right Coordinate: (97, 75.35) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	-100 ft	42.975 ft
Coordinate 2	-60.75 ft	42 ft
Coordinate 3	3.5 ft	44 ft
Coordinate 4	28 ft	45.225 ft
Coordinate 5	62 ft	52.475 ft
Coordinate 6	71.75 ft	54.225 ft
Coordinate 7	91.25 ft	56.25 ft
Coordinate 8	97 ft	57 ft

Seismic Coefficients

Horz Seismic Coef.: 0.214

Geometry

Name: Wall 03.65L

Se ngs

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	-100 ft	49.5 ft
Point 2	-77 ft	49.5 ft
Point 3	-59.25 ft	51.375 ft
Point 4	-59.25 ft	87.75 ft
Point 5	0.25 ft	92.5 ft
Point 6	0.25 ft	73 ft
Point 7	60.25 ft	73 ft
Point 8	60.25 ft	20 ft
Point 9	-100 ft	20 ft
Point 10	-59.25 ft	72 ft
Point 11	-100 ft	47 ft
Point 12	-2.25 ft	47 ft
Point 13	10 ft	36 ft
Point 14	21.8 ft	36 ft
Point 15	50.9 ft	63.5 ft
Point 16	60.2 ft	63.5 ft
Point 17	97 ft	75.35 ft
Point 18	77.4 ft	75.35 ft
Point 19	77.4 ft	73 ft
Point 20	85.6 ft	63.5 ft
Point 21	97 ft	20 ft
Point 22	-100 ft	29 ft
Point 23	-26.8 ft	29 ft
Point 24	26.1 ft	36 ft
Point 25	33.7 ft	37.2 ft
Point 26	46.3 ft	42.35 ft
Point 27	50.9 ft	45.8 ft
Point 28	56.2 ft	50.5 ft
Point 29	65.5 ft	55.5 ft
Point 30	60.21187 ft	53.139391 ft
Point 31	70 ft	56.6 ft
Point 32	85.55 ft	56.575 ft
Point 33	97 ft	58.075 ft
Point 34	0.25 ft	72 ft
Point 35	-14.75 ft	92.5 ft
Point 36	-14.75 ft	71 ft
Point 37	-14.75 ft	91.086957 ft
Point 38	-14.75 ft	72 ft
Point 39	0.25 ft	71 ft
Point 40	-16.25 ft	71 ft
Point 41	-18.75 ft	72 ft

Regions

	Material	Points	Area
Region 1	ESU 1B - Exis□ng Gravelly Granular Fill	6,34,39,36,40,41,10,3,2,1,11,12,13,14,15,16,20,17,18,19,7	3,438.8 ft²
Region	ESU 7A - Weathered Sandstone	28,27,26,25,24,14,13,23,22,9,8,21,33,32,31,29,30	3,479.3

2			ft²
Region 3	ESU 2A - Na□ve Sand and Gravel	12,11,22,23,13	1,783.8 ft²
Region 4	ESU 2A - Na□ve Sand and Gravel	15,14,24,25,26,27,28,30,29,31,32,33,17,20,16	766.88 ft²
Region 5	SE Wall	6,5,35,37,38,36,39,34	322.5 ft²
Region 6	ESU 1A - Exis□ng Granular Fill (Pseudo-Sta□c)	10,41,4	318.94 ft²
Region 7	Common Borrow	37,35,4,41,40,36,38	490.37 ft²

Slip Results

Slip Surfaces Analysed: 461 of 1680 converged

Current Slip Surface

Slip Surface: 553
Factor of Safety: 1.681
Volume: 741.17065 ft³
Weight: 92,619.088 lbf
Resis□ng Moment: 3,135,645.9 lbf·ft
Ac□va□ng Moment: 1,865,461.3 lbf·ft
Resis□ng Force: 63,318.569 lbf
Ac□va□ng Force: 37,653.431 lbf
Slip Rank: 1 of 1,680 slip surfaces
Exit: (20.21797, 73) ft
Entry: (-39.615796, 89.845786) ft
Radius: 46.923129 ft
Center: (-0.17188769, 115.26149) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Fric□onal Strength	Cohesive Strength	Suc□on Strength	Base Material
Slice 1	-38.621418 ft	88.421304 ft	-2,855.0871 psf	70.215376 psf	43.875437 psf	0 psf	0 psf	Common Borrow
Slice 2	-36.632663 ft	85.76756 ft	-2,685.5485 psf	221.83559 psf	138.61826 psf	0 psf	0 psf	Common Borrow
Slice 3	-34.643907 ft	83.460403 ft	-2,537.6475 psf	378.3432 psf	236.41507 psf	0 psf	0 psf	Common Borrow
Slice 4	-32.655152 ft	81.42782 ft	-2,406.8881 psf	538.05679 psf	336.2152 psf	0 psf	0 psf	Common Borrow
Slice 5	-30.666396 ft	79.622297 ft	-2,290.304 psf	700.03708 psf	437.43172 psf	0 psf	0 psf	Common Borrow
Slice 6	-28.677641 ft	78.010529 ft	-2,185.8162 psf	863.76747 psf	539.74182 psf	0 psf	0 psf	Common Borrow
Slice 7	-26.688885 ft	76.568138 ft	-2,091.9026 psf	1,028.9918 psf	642.98543 psf	0 psf	0 psf	Common Borrow
Slice 8	-24.70013 ft	75.276689 ft	-2,007.4124 psf	1,195.6296 psf	747.11227 psf	0 psf	0 psf	Common Borrow

Slice 9	-22.711374 ft	74.121901 ft	-1,931.4539 psf	1,363.7312 psf	852.15385 psf	0 psf	0 psf	Common Borrow
Slice 10	-20.722619 ft	73.092501 ft	-1,863.3234 psf	1,533.4554 psf	958.20926 psf	0 psf	0 psf	Common Borrow
Slice 11	-18.733863 ft	72.179469 ft	-1,802.4578 psf	1,705.0597 psf	1,065.4395 psf	0 psf	0 psf	Common Borrow
Slice 12	-16.745108 ft	71.37552 ft	-1,748.4022 psf	1,878.9013 psf	1,174.0678 psf	0 psf	0 psf	Common Borrow
Slice 13	-15.250365 ft	70.830193 ft	-1,711.4526 psf	2,070.5835 psf	1,617.7171 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 14	-13.8125 ft	70.375485 ft	-1,680.2708 psf	2,381.8578 psf	1,860.9113 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 15	-11.9375 ft	69.8477 ft	-1,643.6773 psf	2,562.5934 psf	2,002.1174 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 16	-10.0625 ft	69.402622 ft	-1,612.2472 psf	2,748.8067 psf	2,147.6032 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 17	-8.1875 ft	69.037855 ft	-1,585.8309 psf	2,941.7553 psf	2,298.3511 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 18	-6.3125 ft	68.751508 ft	-1,564.3104 psf	3,143.0191 psf	2,455.5956 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 19	-4.4375 ft	68.542135 ft	-1,547.5955 psf	3,354.606 psf	2,620.9055 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 20	-2.5625 ft	68.408704 ft	-1,535.6215 psf	3,579.1023 psf	2,796.3012 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 21	-0.6875 ft	68.350564 ft	-1,528.3481 psf	3,819.8911 psf	2,984.426 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 22	1.0625 ft	68.361645 ft	-1,525.639 psf	753.99539 psf	589.08576 psf	0 psf	0 psf	ESU 1B - Exis□ng

								Gravelly Granular Fill
Slice 23	2.6875 ft	68.432641 ft	-1,526.9134 psf	789.73221 psf	617.00642 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 24	4.5448731 ft	68.587846 ft	-1,531.7623 psf	823.25714 psf	643.19897 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 25	6.6346194 ft	68.846664 ft	-1,541.3972 psf	851.75604 psf	665.46475 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 26	8.7243656 ft	69.201703 ft	-1,557.0391 psf	866.42303 psf	676.92386 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 27	10.814112 ft	69.655213 ft	-1,578.8287 psf	862.04756 psf	673.50537 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 28	12.903858 ft	70.210175 ft	-1,606.952 psf	829.50424 psf	648.07974 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 29	14.993604 ft	70.870404 ft	-1,641.647 psf	751.41412 psf	587.06905 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 30	17.083351 ft	71.640692 ft	-1,683.2131 psf	591.63261 psf	462.23405 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill
Slice 31	19.173097 ft	72.527008 ft	-1,732.0228 psf	267.86683 psf	209.28051 psf	0 psf	0 psf	ESU 1B - Exis□ng Gravelly Granular Fill

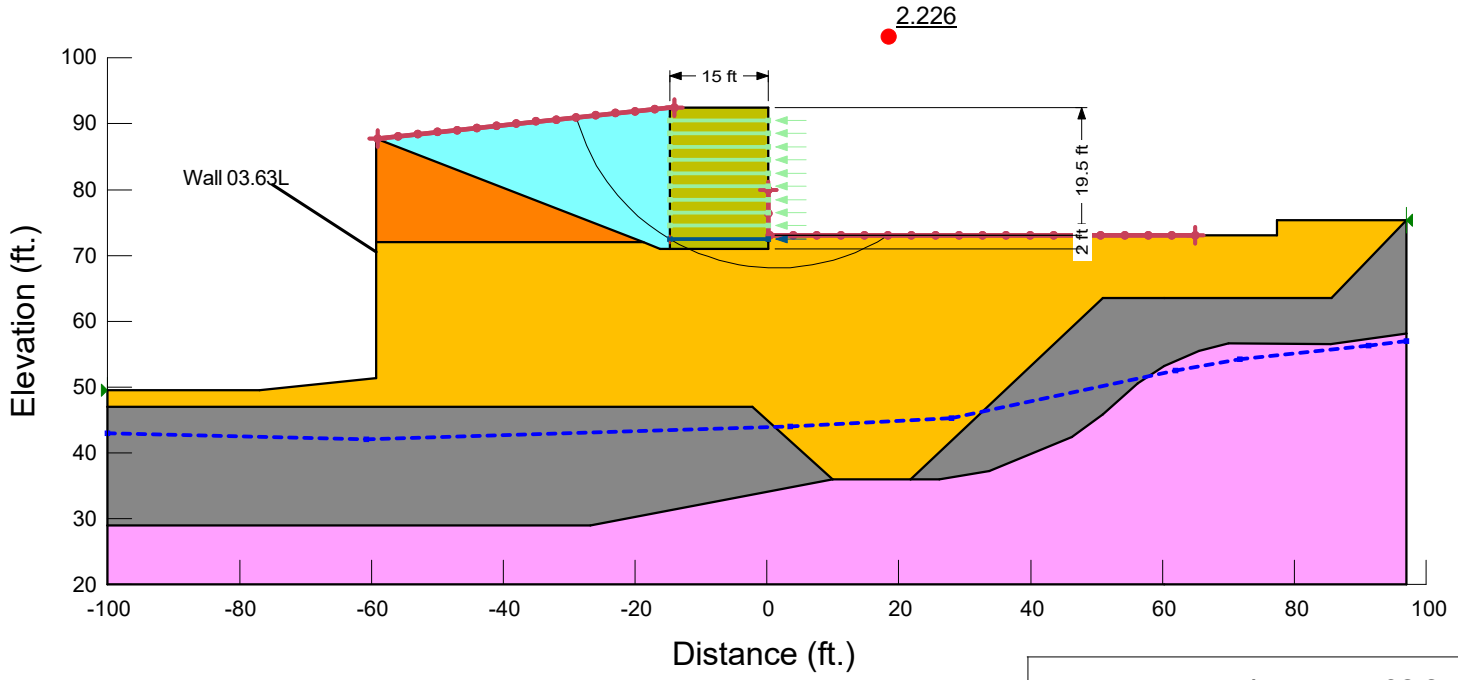
FLATIRON | LANE | wood.

In Association with

Appendix F.4
Compound Stability

Color	Name	Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Common Borrow	Mohr-Coulomb	120	0	32
	ESU 1A - Existing Granular Fill	Mohr-Coulomb	120	0	40
	ESU 1B - Existing Gravelly Granular Fill	Mohr-Coulomb	125	0	38
	ESU 2A - Native Sand and Gravel	Mohr-Coulomb	120	0	39
	ESU 7A - Weathered Sandstone	Mohr-Coulomb	135	0	43
	Gravel Borrow	Mohr-Coulomb	130	0	38

Color	Name	Type	Interface Adhesion (psf)	Interface Shear Angle (°)	Factored Tensile Capacity
	W7.0x3.5 (depth<20ft)	Geosynthetic	0	20.1	3,940 lbf/ft
	W7.0x3.5 (depth>=20ft)	Geosynthetic	0	10.4	3,940 lbf/ft



Notes:

1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document.
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Bridge 17.7 - Wall 03.65L - Sta. 1+49
Static Compound Stability (M-P)

WSDOT I-405 Renton to Bellevue
King County, Washington

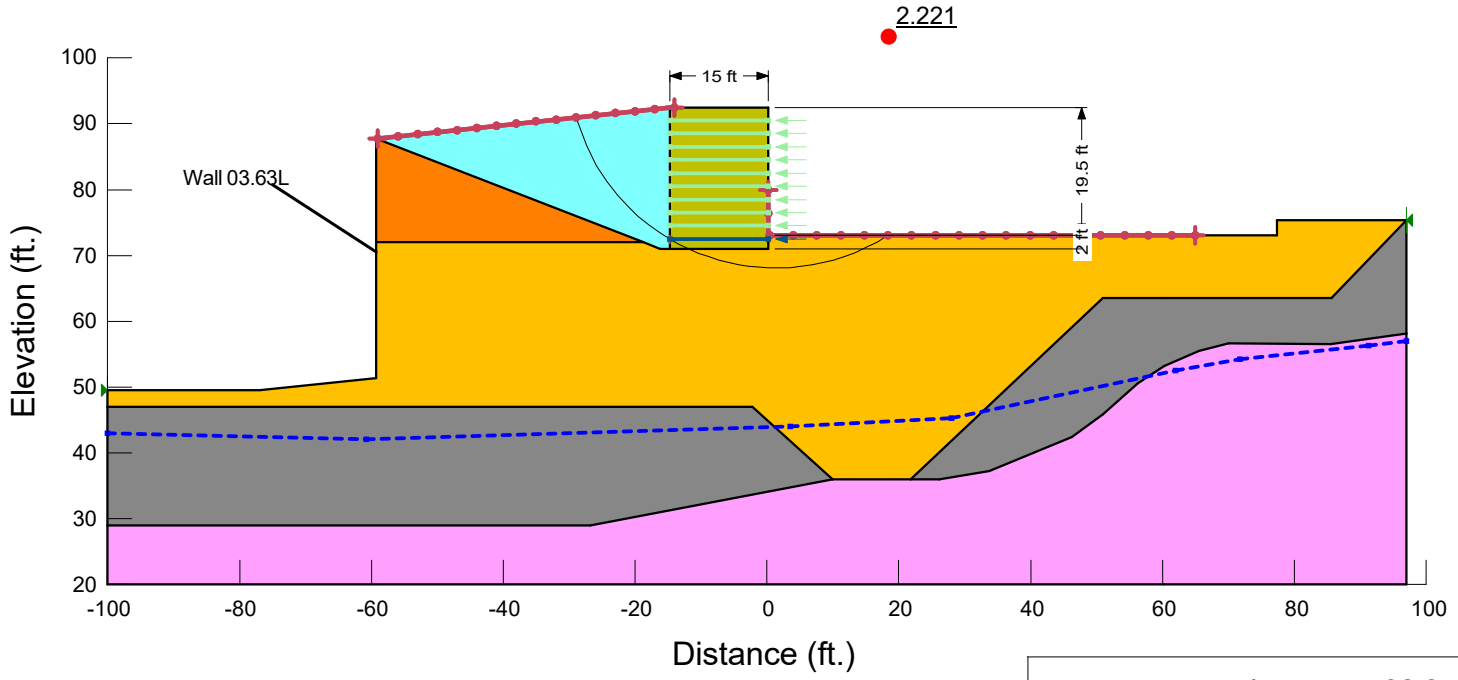
GeoEngineers

Figure #

00180-366-01 Date Exported: 12/07/21

Color	Name	Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Common Borrow	Mohr-Coulomb	120	0	32
	ESU 1A - Existing Granular Fill	Mohr-Coulomb	120	0	40
	ESU 1B - Existing Gravelly Granular Fill	Mohr-Coulomb	125	0	38
	ESU 2A - Native Sand and Gravel	Mohr-Coulomb	120	0	39
	ESU 7A - Weathered Sandstone	Mohr-Coulomb	135	0	43
	Gravel Borrow	Mohr-Coulomb	130	0	38

Color	Name	Type	Interface Adhesion (psf)	Interface Shear Angle (°)	Factored Tensile Capacity
	W7.0x3.5 (depth<20ft)	Geosynthetic	0	20.1	3,940 lbf/ft
	W7.0x3.5 (depth>=20ft)	Geosynthetic	0	10.4	3,940 lbf/ft



Notes:

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Bridge 17.7 - Wall 03.65L - Sta. 1+49
Static Compound Stability (Spencer)

WSDOT I-405 Renton to Bellevue
King County, Washington

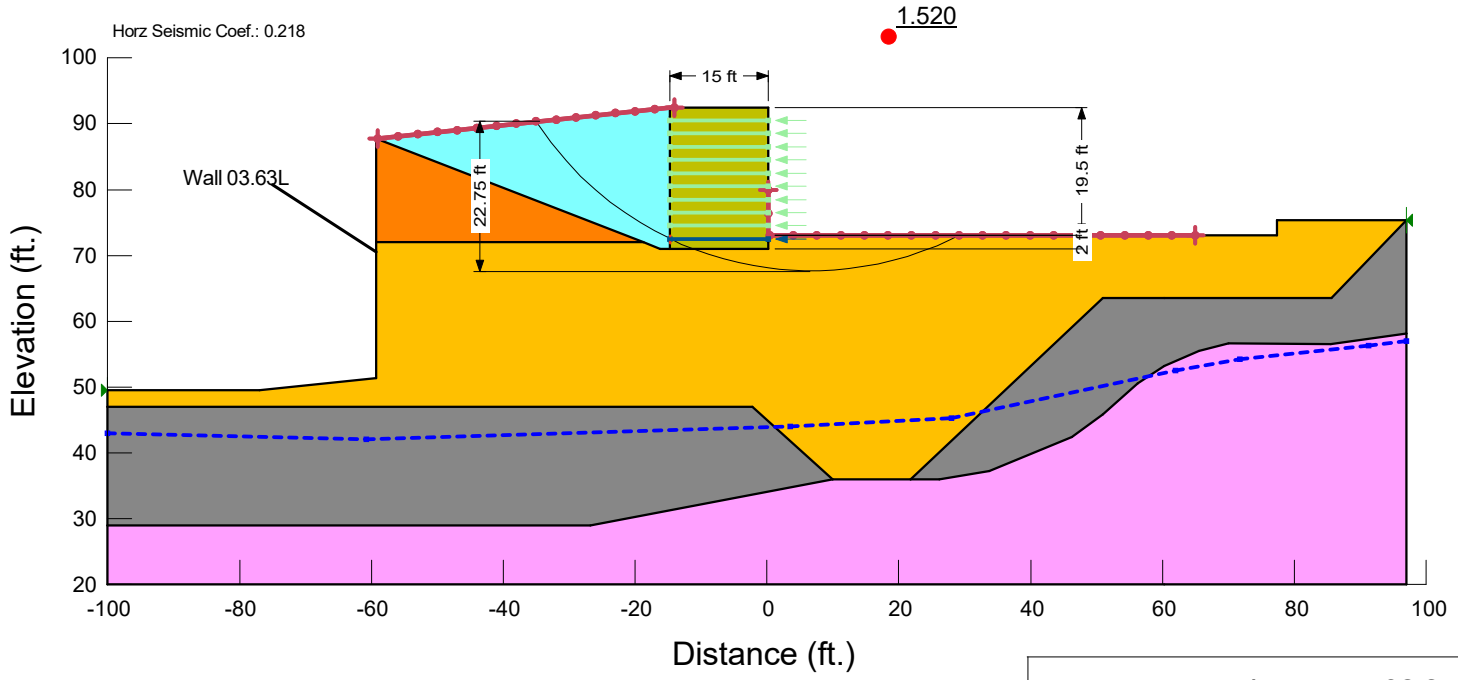
GeoEngineers

Figure #

00180-366-01 Date Exported: 12/07/21

Color	Name	Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Common Borrow	Mohr-Coulomb	120	0	32
	ESU 1A - Existing Granular Fill (Pseudo-Static)	Mohr-Coulomb	120	50	40
	ESU 1B - Existing Gravelly Granular Fill	Mohr-Coulomb	125	0	38
	ESU 2A - Native Sand and Gravel	Mohr-Coulomb	120	0	39
	ESU 7A - Weathered Sandstone	Mohr-Coulomb	135	0	43
	Gravel Borrow	Mohr-Coulomb	130	0	38

Color	Name	Type	Interface Adhesion (psf)	Interface Shear Angle (°)	Factored Tensile Capacity
	W7.0x3.5 (depth<20ft)(EQ)	Geosynthetic	0	26	5,150 lbf/ft
	W7.0x3.5 (depth>=20ft)(EQ)	Geosynthetic	0	13.7	5,150 lbf/ft



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Bridge 17.7 - Wall 03.65L - Sta. 1+49
Pseudo-Static Compound Stability (M-P)

WSDOT I-405 Renton to Bellevue
King County, Washington

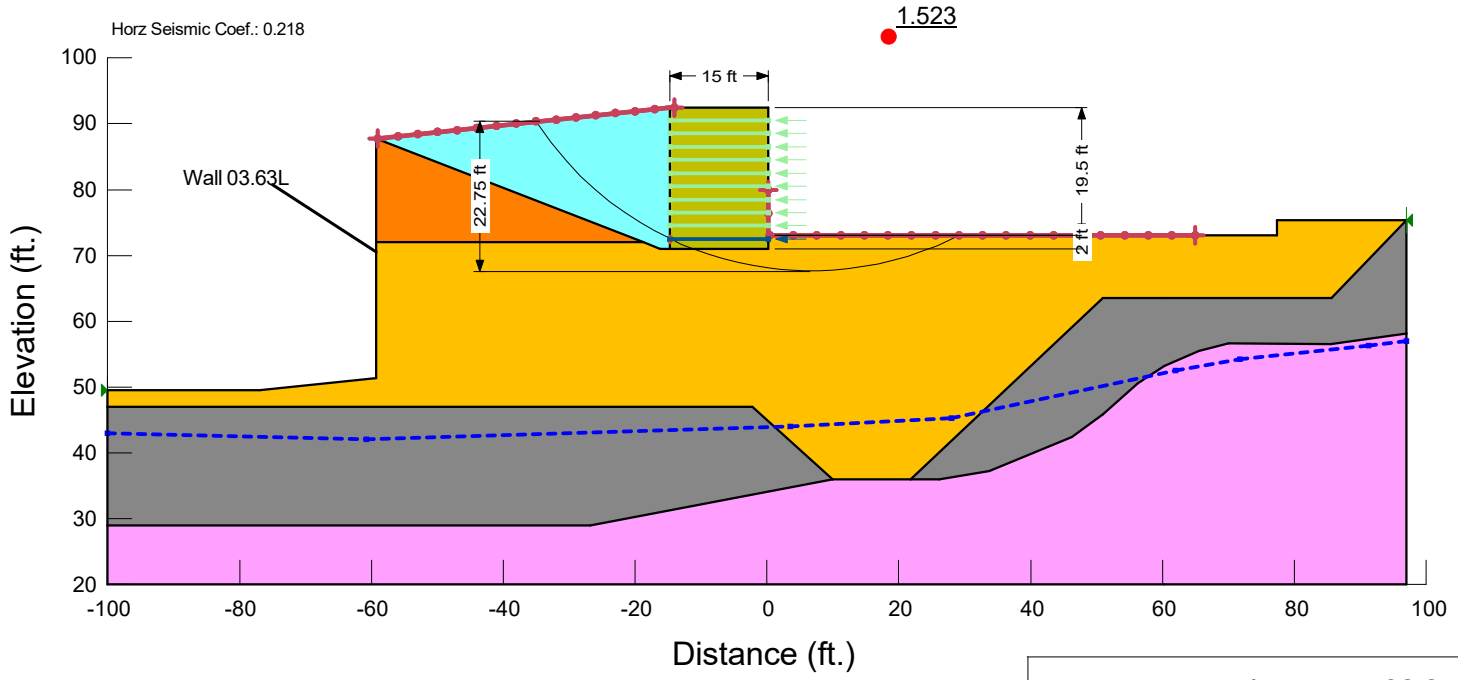
GeoEngineers

Figure #

00180-366-01 Date Exported: 12/07/21

Color	Name	Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Common Borrow	Mohr-Coulomb	120	0	32
	ESU 1A - Existing Granular Fill (Pseudo-Static)	Mohr-Coulomb	120	50	40
	ESU 1B - Existing Gravelly Granular Fill	Mohr-Coulomb	125	0	38
	ESU 2A - Native Sand and Gravel	Mohr-Coulomb	120	0	39
	ESU 7A - Weathered Sandstone	Mohr-Coulomb	135	0	43
	Gravel Borrow	Mohr-Coulomb	130	0	38

Color	Name	Type	Interface Adhesion (psf)	Interface Shear Angle (°)	Factored Tensile Capacity
	W7.0x3.5 (depth<20ft)(EQ)	Geosynthetic	0	26	5,150 lbf/ft
	W7.0x3.5 (depth>=20ft)(EQ)	Geosynthetic	0	13.7	5,150 lbf/ft



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Bridge 17.7 - Wall 03.65L - Sta. 1+49
Pseudo-Static Compound Stability (Spencer)

WSDOT I-405 Renton to Bellevue
King County, Washington

GeoEngineers

Figure #

00180-366-01 Date Exported: 12/07/21

Calculating MSE Strip Properties for Slope/W (Wall 03.65L)

For global stability analyses, the MSE wall is modeled as a high strength material and the failure is forced outside of the reinforced zone. To check for compound stability, the high strength material is replaced with gravel borrow and welded wire grids. The properties of the metal grids are calculated based on FHWA NHI-10-024 and NHI-10-025. The reinforcement properties are converted to per unit width basis, and implemented as a continuous layer in Slope/W.

Input Soil Properties:

Backfill meeting WSDOT standard specifications 9-03.14(4), Gravel Borrow for Structural Earth Wall.

$\phi_{gravel} := 38\ deg$

Input Grid Properties:

$d_{W7.0xW3.5} := 0.299\ in$	Gross Diameter (no corrosion)
$f_y := 65.0\ ksi$	Yield stress
$s_t := 12\ in$	Spacing of Transverse Bars
$s_l := 6\ in$	Spacing of Longitudinal Bars
$w := 1\ ft$	Gross Grid Width
$TWE := 92.5\ ft$	Top of Wall Elevation

Calculate Corrosion Reduction:

Calculate new cross-sectional area of steel grid after 75 years of corrosion exposure.

Table 3-7. Minimum Galvanization Thickness by Steel Thickness
(after AASHTO M 111 and ASTM A123).

Category	Steel Thickness	Minimum Galvanization Thickness
Strip	< ¼ in. (6.4 mm)	3.4 mils (85 µm)
	> ¼ in. (6.4 mm)	3.9 mils (100 µm)
Wire*	All diameters	3.4 mils (85 µm)

* For bar mats fabricated from uncoated steel wire.

The corrosion rates presented in Table 3-8 are suitable for conservative design. **These rates assume a moderately corrosive backfill material having the controlled electrochemical property limits** that are discussed under electrochemical properties in this chapter.

Table 3-8 Steel Corrosion Rates for Moderately Corrosive Reinforced Fill.

For zinc/side:	0.58 mils/yr (15 µm/year) (first 2 years)
	0.16 mils/yr (4 µm/year) (thereafter)
For residual carbon steel/side:	0.47 mils/yr (12 µm/year) (thereafter)

Calculate time (in years) to corrode through galvinization.

$$0.58 \cdot 2 + 0.16 \cdot \left(t_g - 2\right) = 3.4$$

$$t_g := \frac{3.4 - 0.58 \cdot 2}{0.16}\ yr + 2\ yr = 16\ yr$$

Calculate the new diameter after 75 years of corrosion exposure:

$$years := 75\ yr$$

$$dc_{W7.0xW3.5} := d_{W7.0xW3.5} - \left(2 \cdot 0.00047\ \frac{in}{yr} \cdot \left(years - t_g\right)\right) = 0.244\ in$$

Calculate cross-sectional area after 75 years of corrosion exposure:

$$A_{sW7.0xW3.5} := \pi \cdot \left(\frac{dc_{W7.0xW3.5}}{2}\right)^2 = 0.047\ in^2$$

LRFD Resistance Factors for Tensile and Pullout Resistance for MSE Walls with Grid Reinforcements:

Table 4-7. Resistance Factors, ϕ, for Tensile and Pullout Resistance for MSE Walls
(after Table 11.5.6-1, AASHTO {2007}).

Reinforcement Type and Loading Condition			Resistance Factor
Metallic reinforcement and connectors	Strip reinforcements [A]		
		Static loading	0.75
		Combined static/earthquake loading	1.00
		Combined static/traffic barrier impact [B]	1.00
	Grid reinforcements [A, C]		
		Static loading	0.65
		Combined static/earthquake loading	0.85
		Combined static/traffic barrier impact [B]	0.85
Geosynthetic reinforcement and connectors		Static loading	0.90
		Combined static/earthquake loading	1.20
		Combined static/traffic barrier impact [B]	1.20
Pullout resistance of tensile reinforcement (metallic and geosynthetic)		Static loading	0.90
		Combined static/earthquake loading	1.20
		Combined static/traffic barrier impact [B]	1.00

Notes:
A. Apply to gross cross-section less sacrificial area. For sections with holes, reduce gross area in accordance with AASHTO (2007) Article 6.8.3 and apply to net section less sacrificial area.
B. Combined static/traffic barrier impact resistance factors are not presented in AASHTO.
C. Applies to grid reinforcements connected to rigid facing element, e.g., a concrete panel or block. For grid reinforcements connected to a flexible facing mat or which are continuous with the facing mat, use the resistance factor for strip reinforcements.

Resistance Factors:

$\Phi_{static} := 0.65$ $\Phi_{pullout\_static} := 0.9$

$\Phi_{seismic} := 0.85$ $\Phi_{pullout\_seismic} := 1.2$

Calculate Slope/W Reinforcement Inputs:

$H_{wall} := 21.5\ ft$

The vertical (s_v) spacing of the steel grids within each SE wall panel was determined based on typical values. For calculation efficiency, the calculations are performed using matrices.

$$s_v := \begin{bmatrix} 1.5 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \\ 2 \end{bmatrix} ft \qquad t := \begin{bmatrix} dc_{W7.0xW3.5} \\ dc_{W7.0xW3.5} \\ dc_{W7.0xW3.5} \\ dc_{W7.0xW3.5} \\ dc_{W7.0xW3.5} \\ dc_{W7.0xW3.5} \\ dc_{W7.0xW3.5} \\ dc_{W7.0xW3.5} \\ dc_{W7.0xW3.5} \\ dc_{W7.0xW3.5} \end{bmatrix}$$

The matrix represents the same order of the SE Wall reinforcement. Top row of the matrix represents the bottom row (Row 1) of the SE Wall reinforcement and the bottom row of the matrix represents the row of reinforcement closest to the ground surface (Row 10).

t represents the calculated thickness of each row of reinforcement for the existing Hilfiker wall after 75 years of corrosion exposure. This thickness is applied below in the grid capacity calculations.

$i := 0 .. \text{length}(s_v) - 1$ Calculate number of elements

Calculate each grid's vertical elevation and depth from the top of the wall, with the base of the wall as elevation 0 ft. Top row of the matrix represents the bottom reinforcement row.

$$elevation_i := \sum_{j=0}^{i} s_{v_j} = \begin{bmatrix} 1.5 \\ 3.5 \\ 5.5 \\ 7.5 \\ 9.5 \\ 11.5 \\ 13.5 \\ 15.5 \\ 17.5 \\ 19.5 \end{bmatrix} ft \quad depth_i := H_{wall} - elevation_i = \begin{bmatrix} 20 \\ 18 \\ 16 \\ 14 \\ 12 \\ 10 \\ 8 \\ 6 \\ 4 \\ 2 \end{bmatrix} ft \qquad TWE - depth = \begin{bmatrix} 72.5 \\ 74.5 \\ 76.5 \\ 78.5 \\ 80.5 \\ 82.5 \\ 84.5 \\ 86.5 \\ 88.5 \\ 90.5 \end{bmatrix} ft$$

Calculate Pullout Resistance Slope/W Input:

For design and comparison purposes, a normalized definition of pullout resistance will be used throughout the manual. The pullout resistance, P_r, at each of the reinforcement levels per unit width of reinforcement is given by:

$$P_r = F^* \alpha \sigma'_v L_e C \qquad (3\text{-}2)$$

where:

- $L_e C$ = the total surface area per unit width of the reinforcement in the resistive zone behind the failure surface
- L_e = the embedment or adherence length in the resisting zone behind the failure surface
- C = the reinforcement effective unit perimeter; e.g., C = 2 for and sheets, and because the edges are neglected C = 2 for strips and grids
- F^* = the pullout resistance (or friction-bearing-interaction) factor
- α = a scale effect correction factor to account for a non linear stress reduction over the embedded length of highly extensible reinforcements, based on laboratory data (generally 1.0 for metallic reinforcements and 0.6 to 1.0 for geosynthetic reinforcements, see Table 3-6).
- σ'_v = the effective vertical stress at the soil-reinforcement interfaces.

The factored pullout resistance is then given by:

$$P_r = \Phi_{pullout} \left(F \cdot \alpha \cdot \sigma_v' \cdot L_e \cdot C\right)$$

In Slope/W, pullout resistance per unit width of wall is given by:

$$P_r = \left(c + \sigma_v' \cdot tan\left(\phi_{interface}\right)\right) \cdot \alpha \cdot L_e \cdot C$$

Where α and C can be defined within the reinforcement properties, and are set to be the same as defined above. Overburden pressure, σ_v' and effective length, Le, are determined from the limit equilibrium analysis performed in Slope/W. Interface adhesion, c, is assumed to be negligible for metal grids in granular backfill.

To select a representative interface friction angle, $\phi_{interface}$, that will produce the same factored resistance per unit width of wall, the two expressions are set to be equal:

$$\Phi_{pullout} \left(F \cdot \alpha \cdot \sigma_v' \cdot L_e \cdot C\right) = \sigma_v' \cdot tan\left(\phi_{interface}\right) \cdot \alpha \cdot L_e \cdot C$$

Removing common constants and rearranging produces:

$$\phi_{interface} = atan\left(\Phi_{pullout} \cdot F\right)$$

Calculate Pullout Resistance Factor F*:

For steel grid reinforcements with transverse spacing of $S_t \geq 6$ inches (150 mm) (see Figure 3-4), F* is a function of a bearing or embedment factor, F_q, applied over the contributing bearing α_β, as follows:

$F^* = F_q\,\alpha_\beta = 40\,\alpha_\beta = 40\,(t/2S_t) = 20\,(t/S_t)$ at the top of the structure (3-6)

$F^* = F_q\,\alpha_\beta = 20\,\alpha_\beta = 20\,(t/2S_t) = 10\,(t/S_t)$ at a depth of 20 ft (6 m) and below (3-7)

Where, t is the thickness of the transverse bar. S_t must be uniform throughout the length of the reinforcement rather than having transverse grid members concentrated only in the resistant zone. The maximum S_t distance is 24 in. (610 mm). For sloping backfills see Figure 4-15.

$$F_i := \text{if } depth_i < 20\ ft \left\| \begin{array}{l} 20 \cdot \left(\frac{t_i}{s_t}\right) \\ \text{else} \\ 10 \cdot \left(\frac{t_i}{s_t}\right) \end{array} \right.$$

$$F = \begin{bmatrix} 0.2 \\ 0.41 \\ 0.41 \\ 0.41 \\ 0.41 \\ 0.41 \\ 0.41 \\ 0.41 \\ 0.41 \\ 0.41 \end{bmatrix}$$

Calculated F* for each row of reinforcement. Top row of matrix represents the bottom row of reinforcement.

Calculate Interface Shear Angle (degrees):

$$\phi_{interface\_static} := \operatorname{atan}\left(\Phi_{pullout\_static} \cdot F\right) = \begin{bmatrix} 10.4 \\ 20.1 \\ 20.1 \\ 20.1 \\ 20.1 \\ 20.1 \\ 20.1 \\ 20.1 \\ 20.1 \\ 20.1 \end{bmatrix} \ deg$$

Static interface shear angle for each row of reinforcement. Top row of matrix represents the bottom reinforcement row.

$$\phi_{interface\_seismic} := \operatorname{atan}\left(\Phi_{pullout\_seismic} \cdot F\right) = \begin{bmatrix} 13.7 \\ 26 \\ 26 \\ 26 \\ 26 \\ 26 \\ 26 \\ 26 \\ 26 \\ 26 \end{bmatrix} \ deg$$

Seismic interface shear angle for each row of reinforcement. Top row of matrix represents the bottom reinforcement row.

Calculate Allowable Tensile Capacity of Steel Straps:

$$T_{capacity} = \Phi_{static} \cdot f_y \, A_s$$

Slope/W does not have grid reinforcement inputs. Therefore, the tensile strength of the grids were modeled as continuous reinforcement. The calculated allowable tensile grid capacity was converted to a continuous reinforcement tensile capacity by distributing the capacity over the tributary width. The longitudinal wires are spaced every 6 inches, therefore there are two bars within each 1 foot width of grid.

$$T_{al\_static} := \frac{\Phi_{static} \cdot f_y \, A_{sW7.0xW3.5} \cdot \frac{1 \ ft}{s_l}}{w} = 3.94 \ \frac{kip}{ft}$$

$$T_{al\_seismic} := \frac{\Phi_{seismic} \cdot f_y \, A_{sW7.0xW3.5} \cdot \frac{1 \ ft}{s_l}}{w} = 5.15 \ \frac{kip}{ft}$$

2.1 Static (M-P)

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File Information

File Version: 11.01
Created By: Mikayla S. Hatch
Last Edited By: Yi Tyan Tsai
Revision Number: 292
Date: 12/07/2021
Time: 04:06:32 PM
Tool Version: 11.1.1.22085
File Name: Wall 03.65L - Bridge 17.7 - Hilfiker.gsz
Directory: P:\0\0180366\01\Analysis\Bridge 17.7\SlopeW\
Last Solved Date: 12/07/2021
Last Solved Time: 04:06:47 PM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

2.1 Static (M-P)

Kind: SLOPE/W
Parent: 2. Compound Stability
Analysis Type: Morgenstern-Price
Settings
    Side Function
        Interslice force function option: Half-Sine
    PWP Conditions from: Piezometric Line
    Apply Phreatic Correction: No
    Use Staged Rapid Drawdown: No
    Critical Slip Surface Source from: (none)
    Unit Weight of Water: 62.430189 pcf
Slip Surface
    Direction of movement: Left to Right
    Use Passive Mode: No
    Slip Surface Option: Entry and Exit
    Critical slip surfaces saved: 1
    Optimize Critical Slip Surface Location: No
    Tension Crack Option: (none)
Distribution
    F of S Calculation Option: Constant
Advanced

Geometry Settings
Minimum Slip Surface Depth: 0.1 ft
Number of Slices: 30
Factor of Safety Convergence Settings
Maximum Number of Iterations: 100
Tolerable difference in F of S: 0.001
Solution Settings
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Gravel Borrow

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2A - Native Sand and Gravel

Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 39 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 7A - Weathered Sandstone

Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 43 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1A - Existing Granular Fill

Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 40 °
Phi-B: 0 °

Pore Water Pressure
Piezometric Line: 1

ESU 1B - Existing Gravelly Granular Fill

Material Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Common Borrow

Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Reinforcements

W7.0x3.5 (depth<20ft)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 20.1 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 3,940 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,940 lbf/ft

W7.0x3.5 (depth>=20ft)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 10.4 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 3,940 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes

Factored Tensile Capacity: 3,940 lbf/ft

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (-59, 87.776685) ft
Left-Zone Right Coordinate: (-14, 92.5) ft
Left-Zone Increment: 15
Right Type: Range
Right-Zone Left Coordinate: (0.25, 80) ft
Right-Zone Right Coordinate: (65, 73) ft
Right-Zone Increment: 20
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (-100, 49.5) ft
Right Coordinate: (97, 75.35) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	-100 ft	42.975 ft
Coordinate 2	-60.75 ft	42 ft
Coordinate 3	3.5 ft	44 ft
Coordinate 4	28 ft	45.225 ft
Coordinate 5	62 ft	52.475 ft
Coordinate 6	71.75 ft	54.225 ft
Coordinate 7	91.25 ft	56.25 ft
Coordinate 8	97 ft	57 ft

Reinforcement Lines

Reinforcement Line 1

Reinforcement: W7.0x3.5 (depth>=20ft)
Lock to Ground Surface: No
Outside Point: (0.25, 72.5) ft
Inside Point: (-14.75, 72.5) ft
Length: 15 ft
Orientation: 180 °
Slip Surface Intersection: (-14.713551, 72.5) ft
Max. Pullout Force: 3,940 lbf

Available Length: 0.036449237 ft
Required Length: 0.036449237 ft
Pullout Force: 35.453414 lbf
Pullout Force per Length: 972.67919 lbf/ft
Governing Component: Pullout Resistance

Reinforcement Line 2

Reinforcement: W7.0x3.5 (depth<20ft)
Lock to Ground Surface: Yes
Outside Point: (0.25, 74.5) ft
Inside Point: (-14.75, 74.5) ft
Length: 15 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 3

Reinforcement: W7.0x3.5 (depth<20ft)
Lock to Ground Surface: Yes
Outside Point: (0.25, 76.5) ft
Inside Point: (-14.75, 76.5) ft
Length: 15 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 4

Reinforcement: W7.0x3.5 (depth<20ft)
Lock to Ground Surface: Yes
Outside Point: (0.25, 78.5) ft
Inside Point: (-14.75, 78.5) ft
Length: 15 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 5

Reinforcement: W7.0x3.5 (depth<20ft)
Lock to Ground Surface: Yes
Outside Point: (0.25, 80.5) ft
Inside Point: (-14.75, 80.5) ft
Length: 15 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 6

Reinforcement: W7.0x3.5 (depth<20ft)
Lock to Ground Surface: Yes
Outside Point: (0.25, 82.5) ft
Inside Point: (-14.75, 82.5) ft
Length: 15 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 7

Reinforcement: W7.0x3.5 (depth<20ft)
Lock to Ground Surface: Yes
Outside Point: (0.25, 84.5) ft
Inside Point: (-14.75, 84.5) ft
Length: 15 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 8

Reinforcement: W7.0x3.5 (depth<20ft)
Lock to Ground Surface: Yes
Outside Point: (0.25, 86.5) ft
Inside Point: (-14.75, 86.5) ft
Length: 15 ft

Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 9

Reinforcement: W7.0x3.5 (depth<20ft)
Lock to Ground Surface: Yes
Outside Point: (0.25, 88.5) ft
Inside Point: (-14.75, 88.5) ft
Length: 15 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 10

Reinforcement: W7.0x3.5 (depth<20ft)
Lock to Ground Surface: Yes
Outside Point: (0.25, 90.5) ft
Inside Point: (-14.75, 90.5) ft
Length: 15 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Geometry

Name: Wall 03.65L

Settings

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	-100 ft	49.5 ft
Point 2	-77 ft	49.5 ft

Point 3	-59.25 ft	51.375 ft
Point 4	-59.25 ft	87.75 ft
Point 5	0.25 ft	92.5 ft
Point 6	0.25 ft	73 ft
Point 7	60.25 ft	73 ft
Point 8	60.25 ft	20 ft
Point 9	-100 ft	20 ft
Point 10	-59.25 ft	72 ft
Point 11	-100 ft	47 ft
Point 12	-2.25 ft	47 ft
Point 13	10 ft	36 ft
Point 14	21.8 ft	36 ft
Point 15	50.9 ft	63.5 ft
Point 16	60.2 ft	63.5 ft
Point 17	97 ft	75.35 ft
Point 18	77.4 ft	75.35 ft
Point 19	77.4 ft	73 ft
Point 20	85.6 ft	63.5 ft
Point 21	97 ft	20 ft
Point 22	-100 ft	29 ft
Point 23	-26.8 ft	29 ft
Point 24	26.1 ft	36 ft
Point 25	33.7 ft	37.2 ft
Point 26	46.3 ft	42.35 ft
Point 27	50.9 ft	45.8 ft
Point 28	56.2 ft	50.5 ft
Point 29	65.5 ft	55.5 ft
Point 30	60.21187 ft	53.139391 ft
Point 31	70 ft	56.6 ft
Point 32	85.55 ft	56.575 ft
Point 33	97 ft	58.075 ft
Point 34	0.25 ft	72 ft
Point 35	-14.75 ft	92.5 ft
Point 36	-14.75 ft	71 ft
Point 37	-14.75 ft	91.086957 ft
Point 38	-14.75 ft	72 ft
Point 39	0.25 ft	71 ft
Point 40	-16.25 ft	71 ft
Point 41	-18.75 ft	72 ft

Regions

	Material	Points	Area
Region 1	ESU 1B - Existing Gravelly Granular Fill	6,34,39,36,40,41,10,3,2,1,11,12,13,14,15,16,20,17,18,19,7	3,438.8 ft²
Region 2	ESU 7A - Weathered Sandstone	28,27,26,25,24,14,13,23,22,9,8,21,33,32,31,29,30	3,479.3 ft²
Region 3	ESU 2A - Native Sand and Gravel	12,11,22,23,13	1,783.8 ft²
Region			766.88

4	ESU 2A - Native Sand and Gravel	15,14,24,25,26,27,28,30,29,31,32,33,17,20,16	ft²
Region 5	Gravel Borrow	6,5,35,37,38,36,39,34	322.5 ft²
Region 6	ESU 1A - Existing Granular Fill	10,41,4	318.94 ft²
Region 7	Common Borrow	37,35,4,41,40,36,38	490.37 ft²

Slip Results

Slip Surfaces Analysed: 1339 of 1680 converged

Current Slip Surface

Slip Surface: 1,089
Factor of Safety: 2.226
Volume: 581.70135 ft³
Weight: 73,431.275 lbf
Resisting Moment: 1,748,441.9 lbf·ft
Activating Moment: 785,668.13 lbf·ft
Resisting Force: 49,831.971 lbf
Activating Force: 22,388.634 lbf
Slip Rank: 1 of 1,680 slip surfaces
Exit: (18.3625, 73) ft
Entry: (-29.002824, 90.978631) ft
Radius: 31.653534 ft
Center: (1.4155364, 99.734746) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength	Suction Strength	Base Material
Slice 1	-28.211001 ft	88.827801 ft	-2,860.2337 psf	142.56877 psf	89.086855 psf	0 psf	0 psf	Common Borrow
Slice 2	-26.627354 ft	85.154063 ft	-2,627.804 psf	419.33435 psf	262.02919 psf	0 psf	0 psf	Common Borrow
Slice 3	-25.043706 ft	82.42107 ft	-2,454.1051 psf	639.36173 psf	399.51755 psf	0 psf	0 psf	Common Borrow
Slice 4	-23.460059 ft	80.202541 ft	-2,312.5244 psf	828.26261 psf	517.55592 psf	0 psf	0 psf	Common Borrow
Slice 5	-21.876412 ft	78.332368 ft	-2,192.6915 psf	999.54441 psf	624.58467 psf	0 psf	0 psf	Common Borrow
Slice 6	-20.292765 ft	76.723643 ft	-2,089.1809 psf	1,161.6279 psf	725.86565 psf	0 psf	0 psf	Common Borrow
Slice 7	-18.709118 ft	75.323859 ft	-1,998.7146 psf	1,320.2811 psf	825.00321 psf	0 psf	0 psf	Common Borrow
Slice 8	-17.125471 ft	74.098398 ft	-1,919.1312 psf	1,479.6856 psf	924.61018 psf	0 psf	0 psf	Common Borrow
Slice	-15.541824	73.023054	-1,848.9197	1,642.9476	1,026.6276	0 psf	0 psf	Common

9	ft	ft	psf	psf	psf			Borrow
Slice 10	-14.027695 ft	72.116492 ft	-1,789.3804 psf	1,942.1275 psf	1,517.3563 psf	0 psf	0 psf	Gravel Borrow
Slice 11	-12.583085 ft	71.356301 ft	-1,739.1141 psf	2,109.2971 psf	1,647.9635 psf	0 psf	0 psf	Gravel Borrow
Slice 12	-11.103857 ft	70.673918 ft	-1,693.6381 psf	2,285.9803 psf	1,786.0035 psf	0 psf	0 psf	ESU 1B - Existing Gravelly Granular Fill
Slice 13	-9.5900091 ft	70.067046 ft	-1,652.8091 psf	2,472.7262 psf	1,931.9054 psf	0 psf	0 psf	ESU 1B - Existing Gravelly Granular Fill
Slice 14	-8.0761616 ft	69.548254 ft	-1,617.4789 psf	2,665.6763 psf	2,082.6545 psf	0 psf	0 psf	ESU 1B - Existing Gravelly Granular Fill
Slice 15	-6.562314 ft	69.113049 ft	-1,587.367 psf	2,862.6507 psf	2,236.5479 psf	0 psf	0 psf	ESU 1B - Existing Gravelly Granular Fill
Slice 16	-5.0484664 ft	68.7579 ft	-1,562.253 psf	3,060.2954 psf	2,390.9648 psf	0 psf	0 psf	ESU 1B - Existing Gravelly Granular Fill
Slice 17	-3.5346189 ft	68.480068 ft	-1,541.966 psf	3,253.9624 psf	2,542.2741 psf	0 psf	0 psf	ESU 1B - Existing Gravelly Granular Fill
Slice 18	-2.0207713 ft	68.277501 ft	-1,526.3778 psf	3,437.6602 psf	2,685.7945 psf	0 psf	0 psf	ESU 1B - Existing Gravelly Granular Fill
Slice 19	-0.50692378 ft	68.148747 ft	-1,515.3977 psf	3,604.124 psf	2,815.8503 psf	0 psf	0 psf	ESU 1B - Existing Gravelly Granular Fill
Slice 20	1.0625 ft	68.093612 ft	-1,508.9057 psf	800.49172 psf	625.41268 psf	0 psf	0 psf	ESU 1B - Existing Gravelly Granular Fill
Slice 21	2.6875 ft	68.117233 ft	-1,507.2224 psf	838.58047 psf	655.17087 psf	0 psf	0 psf	ESU 1B - Existing Gravelly Granular Fill
Slice 22	4.3256944 ft	68.226182 ft	-1,509.8677 psf	855.24175 psf	668.18809 psf	0 psf	0 psf	ESU 1B - Existing Gravelly Granular Fill
Slice 23	5.9770833 ft	68.422731 ft	-1,516.9835 psf	846.68787 psf	661.50506 psf	0 psf	0 psf	ESU 1B - Existing Gravelly Granular Fill
Slice 24	7.6284722 ft	68.708361 ft	-1,529.6606 psf	810.26736 psf	633.05024 psf	0 psf	0 psf	ESU 1B - Existing Gravelly Granular Fill
Slice 25	9.2798611 ft	69.085571 ft	-1,548.055 psf	745.19734 psf	582.21197 psf	0 psf	0 psf	ESU 1B - Existing Gravelly Granular Fill
Slice 26	10.93125 ft	69.557804 ft	-1,572.3818 psf	652.55041 psf	509.82825 psf	0 psf	0 psf	ESU 1B - Existing Gravelly Granular Fill
Slice 27	12.582639 ft	70.129624 ft	-1,602.9258 psf	535.23022 psf	418.16767 psf	0 psf	0 psf	ESU 1B - Existing Gravelly Granular Fill

Slice 28	14.234028 ft	70.806959 ft	-1,640.0571 psf	397.60293 psf	310.64146 psf	0 psf	0 psf	ESU 1B - Existing Gravelly Granular Fill
Slice 29	15.885417 ft	71.597463 ft	-1,684.2536 psf	244.84322 psf	191.29249 psf	0 psf	0 psf	ESU 1B - Existing Gravelly Granular Fill
Slice 30	17.536806 ft	72.511042 ft	-1,736.1337 psf	82.136394 psf	64.171984 psf	0 psf	0 psf	ESU 1B - Existing Gravelly Granular Fill

2.1 Static (Spencer)

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File Information

File Version: 11.01
Created By: Mikayla S. Hatch
Last Edited By: Yi Tyan Tsai
Revision Number: 292
Date: 12/07/2021
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Tool Version: 11.1.1.22085
File Name: Wall 03.65L - Bridge 17.7 - Hilfiker.gsz
Directory: P:\0\0180366\01\Analysis\Bridge 17.7\SlopeW\
Last Solved Date: 12/07/2021
Last Solved Time: 04:06:45 PM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

2.1 Static (Spencer)

Kind: SLOPE/W
Parent: 2. Compound Stability
Analysis Type: Spencer
Settings
- PWP Conditions from: Piezometric Line
- Apply Phreatic Correction: No
- Use Staged Rapid Drawdown: No
- Critical Slip Surface Source from: (none)
- Unit Weight of Water: 62.430189 pcf

Slip Surface
- Direction of movement: Left to Right
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 1
- Optimize Critical Slip Surface Location: No
- Tension Crack Option: (none)

Distribution
- F of S Calculation Option: Constant

Advanced
- Geometry Settings
  - Minimum Slip Surface Depth: 0.1 ft

Number of Slices: 30
Factor of Safety Convergence Settings
Maximum Number of Iterations: 100
Tolerable difference in F of S: 0.001
Solution Settings
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Gravel Borrow

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2A - Native Sand and Gravel

Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 39 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 7A - Weathered Sandstone

Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 43 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1A - Existing Granular Fill

Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 40 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1B - Existing Gravelly Granular Fill

Material Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Common Borrow

Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Reinforcements

W7.0x3.5 (depth<20ft)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 20.1 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 3,940 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,940 lbf/ft

W7.0x3.5 (depth>=20ft)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 10.4 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 3,940 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,940 lbf/ft

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (-59, 87.776685) ft
Left-Zone Right Coordinate: (-14, 92.5) ft
Left-Zone Increment: 15
Right Type: Range
Right-Zone Left Coordinate: (0.25, 80) ft
Right-Zone Right Coordinate: (65, 73) ft
Right-Zone Increment: 20
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (-100, 49.5) ft
Right Coordinate: (97, 75.35) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	-100 ft	42.975 ft
Coordinate 2	-60.75 ft	42 ft
Coordinate 3	3.5 ft	44 ft
Coordinate 4	28 ft	45.225 ft
Coordinate 5	62 ft	52.475 ft
Coordinate 6	71.75 ft	54.225 ft
Coordinate 7	91.25 ft	56.25 ft
Coordinate 8	97 ft	57 ft

Reinforcement Lines

Reinforcement Line 1

Reinforcement: W7.0x3.5 (depth>=20ft)
Lock to Ground Surface: No
Outside Point: (0.25, 72.5) ft
Inside Point: (-14.75, 72.5) ft
Length: 15 ft
Orientation: 180 °
Slip Surface Intersection: (-14.713551, 72.5) ft
Max. Pullout Force: 3,940 lbf
Available Length: 0.036449237 ft
Required Length: 0.036449237 ft
Pullout Force: 35.453414 lbf

Pullout Force per Length: 972.67919 lbf/ft
Governing Component: Pullout Resistance

Reinforcement Line 2

Reinforcement: W7.0x3.5 (depth<20ft)
Lock to Ground Surface: Yes
Outside Point: (0.25, 74.5) ft
Inside Point: (-14.75, 74.5) ft
Length: 15 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 3

Reinforcement: W7.0x3.5 (depth<20ft)
Lock to Ground Surface: Yes
Outside Point: (0.25, 76.5) ft
Inside Point: (-14.75, 76.5) ft
Length: 15 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 4

Reinforcement: W7.0x3.5 (depth<20ft)
Lock to Ground Surface: Yes
Outside Point: (0.25, 78.5) ft
Inside Point: (-14.75, 78.5) ft
Length: 15 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 5

Reinforcement: W7.0x3.5 (depth<20ft)
Lock to Ground Surface: Yes

Outside Point: (0.25, 80.5) ft
Inside Point: (-14.75, 80.5) ft
Length: 15 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 6

Reinforcement: W7.0x3.5 (depth<20ft)
Lock to Ground Surface: Yes
Outside Point: (0.25, 82.5) ft
Inside Point: (-14.75, 82.5) ft
Length: 15 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 7

Reinforcement: W7.0x3.5 (depth<20ft)
Lock to Ground Surface: Yes
Outside Point: (0.25, 84.5) ft
Inside Point: (-14.75, 84.5) ft
Length: 15 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 8

Reinforcement: W7.0x3.5 (depth<20ft)
Lock to Ground Surface: Yes
Outside Point: (0.25, 86.5) ft
Inside Point: (-14.75, 86.5) ft
Length: 15 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft

Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 9

Reinforcement: W7.0x3.5 (depth<20ft)
Lock to Ground Surface: Yes
Outside Point: (0.25, 88.5) ft
Inside Point: (-14.75, 88.5) ft
Length: 15 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 10

Reinforcement: W7.0x3.5 (depth<20ft)
Lock to Ground Surface: Yes
Outside Point: (0.25, 90.5) ft
Inside Point: (-14.75, 90.5) ft
Length: 15 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Geometry

Name: Wall 03.65L

Settings

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	-100 ft	49.5 ft
Point 2	-77 ft	49.5 ft
Point 3	-59.25 ft	51.375 ft
Point 4	-59.25 ft	87.75 ft
Point 5	0.25 ft	92.5 ft

Point 6	0.25 ft	73 ft
Point 7	60.25 ft	73 ft
Point 8	60.25 ft	20 ft
Point 9	-100 ft	20 ft
Point 10	-59.25 ft	72 ft
Point 11	-100 ft	47 ft
Point 12	-2.25 ft	47 ft
Point 13	10 ft	36 ft
Point 14	21.8 ft	36 ft
Point 15	50.9 ft	63.5 ft
Point 16	60.2 ft	63.5 ft
Point 17	97 ft	75.35 ft
Point 18	77.4 ft	75.35 ft
Point 19	77.4 ft	73 ft
Point 20	85.6 ft	63.5 ft
Point 21	97 ft	20 ft
Point 22	-100 ft	29 ft
Point 23	-26.8 ft	29 ft
Point 24	26.1 ft	36 ft
Point 25	33.7 ft	37.2 ft
Point 26	46.3 ft	42.35 ft
Point 27	50.9 ft	45.8 ft
Point 28	56.2 ft	50.5 ft
Point 29	65.5 ft	55.5 ft
Point 30	60.21187 ft	53.139391 ft
Point 31	70 ft	56.6 ft
Point 32	85.55 ft	56.575 ft
Point 33	97 ft	58.075 ft
Point 34	0.25 ft	72 ft
Point 35	-14.75 ft	92.5 ft
Point 36	-14.75 ft	71 ft
Point 37	-14.75 ft	91.086957 ft
Point 38	-14.75 ft	72 ft
Point 39	0.25 ft	71 ft
Point 40	-16.25 ft	71 ft
Point 41	-18.75 ft	72 ft

Regions

	Material	Points	Area
Region 1	ESU 1B - Existing Gravelly Granular Fill	6,34,39,36,40,41,10,3,2,1,11,12,13,14,15,16,20,17,18,19,7	3,438.8 ft²
Region 2	ESU 7A - Weathered Sandstone	28,27,26,25,24,14,13,23,22,9,8,21,33,32,31,29,30	3,479.3 ft²
Region 3	ESU 2A - Native Sand and Gravel	12,11,22,23,13	1,783.8 ft²
Region 4	ESU 2A - Native Sand and Gravel	15,14,24,25,26,27,28,30,29,31,32,33,17,20,16	766.88 ft²
Region 5	Gravel Borrow	6,5,35,37,38,36,39,34	322.5 ft²

Region 6	ESU 1A - Existing Granular Fill	10,41,4	318.94 ft²
Region 7	Common Borrow	37,35,4,41,40,36,38	490.37 ft²

Slip Results

Slip Surfaces Analysed: 1309 of 1680 converged

Current Slip Surface

Slip Surface: 1,089
Factor of Safety: 2.221
Volume: 581.70135 ft³
Weight: 73,431.275 lbf
Resisting Moment: 1,745,109.7 lbf·ft
Activating Moment: 785,668.13 lbf·ft
Resisting Force: 49,757.84 lbf
Activating Force: 22,398.611 lbf
Slip Rank: 1 of 1,680 slip surfaces
Exit: (18.3625, 73) ft
Entry: (-29.002824, 90.978631) ft
Radius: 31.653534 ft
Center: (1.4155364, 99.734746) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength	Suction Strength	Base Material
Slice 1	-28.211001 ft	88.827801 ft	-2,860.2337 psf	101.73547 psf	63.571375 psf	0 psf	0 psf	Common Borrow
Slice 2	-26.627354 ft	85.154063 ft	-2,627.804 psf	343.27467 psf	214.50182 psf	0 psf	0 psf	Common Borrow
Slice 3	-25.043706 ft	82.42107 ft	-2,454.1051 psf	575.45256 psf	359.58267 psf	0 psf	0 psf	Common Borrow
Slice 4	-23.460059 ft	80.202541 ft	-2,312.5244 psf	797.51975 psf	498.34565 psf	0 psf	0 psf	Common Borrow
Slice 5	-21.876412 ft	78.332368 ft	-2,192.6915 psf	1,010.2364 psf	631.26579 psf	0 psf	0 psf	Common Borrow
Slice 6	-20.292765 ft	76.723643 ft	-2,089.1809 psf	1,214.5174 psf	758.91468 psf	0 psf	0 psf	Common Borrow
Slice 7	-18.709118 ft	75.323859 ft	-1,998.7146 psf	1,411.1996 psf	881.81537 psf	0 psf	0 psf	Common Borrow
Slice 8	-17.125471 ft	74.098398 ft	-1,919.1312 psf	1,601.0102 psf	1,000.4222 psf	0 psf	0 psf	Common Borrow
Slice 9	-15.541824 ft	73.023054 ft	-1,848.9197 psf	1,784.5779 psf	1,115.128 psf	0 psf	0 psf	Common Borrow
Slice 10	-14.027695 ft	72.116492 ft	-1,789.3804 psf	2,086.7915 psf	1,630.3802 psf	0 psf	0 psf	Gravel Borrow
Slice	-12.583085	71.356301	-1,739.1141	2,246.9406	1,755.5024			

11	ft	ft	psf	psf	psf	0 psf	0 psf	Gravel Borrow
Slice 12	-11.103857 ft	70.673918 ft	-1,693.6381 psf	2,404.8359 psf	1,878.8637 psf	0 psf	0 psf	ESU 1B - Existing Gravelly Granular Fill
Slice 13	-9.5900091 ft	70.067046 ft	-1,652.8091 psf	2,560.9468 psf	2,000.8309 psf	0 psf	0 psf	ESU 1B - Existing Gravelly Granular Fill
Slice 14	-8.0761616 ft	69.548254 ft	-1,617.4789 psf	2,713.2559 psf	2,119.8279 psf	0 psf	0 psf	ESU 1B - Existing Gravelly Granular Fill
Slice 15	-6.562314 ft	69.113049 ft	-1,587.367 psf	2,862.179 psf	2,236.1793 psf	0 psf	0 psf	ESU 1B - Existing Gravelly Granular Fill
Slice 16	-5.0484664 ft	68.7579 ft	-1,562.253 psf	3,008.147 psf	2,350.222 psf	0 psf	0 psf	ESU 1B - Existing Gravelly Granular Fill
Slice 17	-3.5346189 ft	68.480068 ft	-1,541.966 psf	3,151.6231 psf	2,462.3178 psf	0 psf	0 psf	ESU 1B - Existing Gravelly Granular Fill
Slice 18	-2.0207713 ft	68.277501 ft	-1,526.3778 psf	3,293.1225 psf	2,572.8693 psf	0 psf	0 psf	ESU 1B - Existing Gravelly Granular Fill
Slice 19	-0.50692378 ft	68.148747 ft	-1,515.3977 psf	3,433.2378 psf	2,682.3394 psf	0 psf	0 psf	ESU 1B - Existing Gravelly Granular Fill
Slice 20	1.0625 ft	68.093612 ft	-1,508.9057 psf	694.53668 psf	542.63152 psf	0 psf	0 psf	ESU 1B - Existing Gravelly Granular Fill
Slice 21	2.6875 ft	68.117233 ft	-1,507.2224 psf	720.83149 psf	563.17528 psf	0 psf	0 psf	ESU 1B - Existing Gravelly Granular Fill
Slice 22	4.3256944 ft	68.226182 ft	-1,509.8677 psf	736.7993 psf	575.6507 psf	0 psf	0 psf	ESU 1B - Existing Gravelly Granular Fill
Slice 23	5.9770833 ft	68.422731 ft	-1,516.9835 psf	740.92892 psf	578.87711 psf	0 psf	0 psf	ESU 1B - Existing Gravelly Granular Fill
Slice 24	7.6284722 ft	68.708361 ft	-1,529.6606 psf	731.19998 psf	571.27604 psf	0 psf	0 psf	ESU 1B - Existing Gravelly Granular Fill
Slice 25	9.2798611 ft	69.085571 ft	-1,548.055 psf	705.1979 psf	550.96098 psf	0 psf	0 psf	ESU 1B - Existing Gravelly Granular Fill
Slice 26	10.93125 ft	69.557804 ft	-1,572.3818 psf	659.57393 psf	515.31563 psf	0 psf	0 psf	ESU 1B - Existing Gravelly Granular Fill
Slice 27	12.582639 ft	70.129624 ft	-1,602.9258 psf	589.5033 psf	460.57045 psf	0 psf	0 psf	ESU 1B - Existing Gravelly Granular Fill
Slice 28	14.234028 ft	70.806959 ft	-1,640.0571 psf	487.7004 psf	381.03331 psf	0 psf	0 psf	ESU 1B - Existing Gravelly Granular Fill
Slice	15.885417	71.597463	-1,684.2536	342.4969	267.5879			ESU 1B -

29	ft	ft	psf	psf	psf	0 psf	0 psf	Existing Gravelly Granular Fill
Slice 30	17.536806 ft	72.511042 ft	-1,736.1337 psf	133.74516 psf	104.49317 psf	0 psf	0 psf	ESU 1B - Existing Gravelly Granular Fill

2.2 Pseudo-Static (M-P)

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File Information

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Last Solved Date: 12/07/2021
Last Solved Time: 04:06:55 PM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

2.2 Pseudo-Static (M-P)

Kind: SLOPE/W
Parent: 2. Compound Stability
Analysis Type: Morgenstern-Price
Settings
    Side Function
        Interslice force function option: Half-Sine
    PWP Conditions from: Piezometric Line
    Apply Phreatic Correction: No
    Use Staged Rapid Drawdown: No
    Critical Slip Surface Source from: (none)
    Unit Weight of Water: 62.430189 pcf
Slip Surface
    Direction of movement: Left to Right
    Use Passive Mode: No
    Slip Surface Option: Entry and Exit
    Critical slip surfaces saved: 1
    Optimize Critical Slip Surface Location: No
    Tension Crack Option: (none)
Distribution
    F of S Calculation Option: Constant
Advanced

Geometry Settings
Minimum Slip Surface Depth: 0.1 ft
Number of Slices: 30
Factor of Safety Convergence Settings
Maximum Number of Iterations: 100
Tolerable difference in F of S: 0.001
Solution Settings
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Gravel Borrow

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1A - Existing Granular Fill (Pseudo-Static)

Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effective Cohesion: 50 psf
Effective Friction Angle: 40 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2A - Native Sand and Gravel

Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 39 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 7A - Weathered Sandstone

Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 43 °
Phi-B: 0 °

Pore Water Pressure
Piezometric Line: 1

ESU 1B - Existing Gravelly Granular Fill

Material Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Common Borrow

Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Reinforcements

W7.0x3.5 (depth<20ft)(EQ)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 26 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 5,150 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,150 lbf/ft

W7.0x3.5 (depth>=20ft)(EQ)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 13.7 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 5,150 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes

Factored Tensile Capacity: 5,150 lbf/ft

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (-59, 87.776685) ft
Left-Zone Right Coordinate: (-14, 92.5) ft
Left-Zone Increment: 15
Right Type: Range
Right-Zone Left Coordinate: (0.25, 80) ft
Right-Zone Right Coordinate: (65, 73) ft
Right-Zone Increment: 20
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (-100, 49.5) ft
Right Coordinate: (97, 75.35) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	-100 ft	42.975 ft
Coordinate 2	-60.75 ft	42 ft
Coordinate 3	3.5 ft	44 ft
Coordinate 4	28 ft	45.225 ft
Coordinate 5	62 ft	52.475 ft
Coordinate 6	71.75 ft	54.225 ft
Coordinate 7	91.25 ft	56.25 ft
Coordinate 8	97 ft	57 ft

Seismic Coefficients

Horz Seismic Coef.: 0.218

Reinforcement Lines

Reinforcement Line 1

Reinforcement: W7.0x3.5 (depth>=20ft)(EQ)
Lock to Ground Surface: No
Outside Point: (0.25, 72.5) ft
Inside Point: (-14.75, 72.5) ft

Length: 15 ft
Orientation: 180 °
Slip Surface Intersection: (-14.646678, 72.5) ft
Max. Pullout Force: 5,150 lbf
Available Length: 0.10332195 ft
Required Length: 0.10332195 ft
Pullout Force: 133.3352 lbf
Pullout Force per Length: 1,290.4828 lbf/ft
Governing Component: Pullout Resistance

Reinforcement Line 2

Reinforcement: W7.0x3.5 (depth<20ft)(EQ)
Lock to Ground Surface: Yes
Outside Point: (0.25, 74.5) ft
Inside Point: (-14.75, 74.5) ft
Length: 15 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 3

Reinforcement: W7.0x3.5 (depth<20ft)(EQ)
Lock to Ground Surface: Yes
Outside Point: (0.25, 76.5) ft
Inside Point: (-14.75, 76.5) ft
Length: 15 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 4

Reinforcement: W7.0x3.5 (depth<20ft)(EQ)
Lock to Ground Surface: Yes
Outside Point: (0.25, 78.5) ft
Inside Point: (-14.75, 78.5) ft
Length: 15 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft

Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 5

Reinforcement: W7.0x3.5 (depth<20ft)(EQ)
Lock to Ground Surface: Yes
Outside Point: (0.25, 80.5) ft
Inside Point: (-14.75, 80.5) ft
Length: 15 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 6

Reinforcement: W7.0x3.5 (depth<20ft)(EQ)
Lock to Ground Surface: Yes
Outside Point: (0.25, 82.5) ft
Inside Point: (-14.75, 82.5) ft
Length: 15 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 7

Reinforcement: W7.0x3.5 (depth<20ft)(EQ)
Lock to Ground Surface: Yes
Outside Point: (0.25, 84.5) ft
Inside Point: (-14.75, 84.5) ft
Length: 15 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 8

Reinforcement: W7.0x3.5 (depth<20ft)(EQ)

Lock to Ground Surface: Yes
Outside Point: (0.25, 86.5) ft
Inside Point: (-14.75, 86.5) ft
Length: 15 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 9

Reinforcement: W7.0x3.5 (depth<20ft)(EQ)
Lock to Ground Surface: Yes
Outside Point: (0.25, 88.5) ft
Inside Point: (-14.75, 88.5) ft
Length: 15 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 10

Reinforcement: W7.0x3.5 (depth<20ft)(EQ)
Lock to Ground Surface: Yes
Outside Point: (0.25, 90.5) ft
Inside Point: (-14.75, 90.5) ft
Length: 15 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Geometry

Name: Wall 03.65L

Settings

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	-100 ft	49.5 ft
Point 2	-77 ft	49.5 ft
Point 3	-59.25 ft	51.375 ft
Point 4	-59.25 ft	87.75 ft
Point 5	0.25 ft	92.5 ft
Point 6	0.25 ft	73 ft
Point 7	60.25 ft	73 ft
Point 8	60.25 ft	20 ft
Point 9	-100 ft	20 ft
Point 10	-59.25 ft	72 ft
Point 11	-100 ft	47 ft
Point 12	-2.25 ft	47 ft
Point 13	10 ft	36 ft
Point 14	21.8 ft	36 ft
Point 15	50.9 ft	63.5 ft
Point 16	60.2 ft	63.5 ft
Point 17	97 ft	75.35 ft
Point 18	77.4 ft	75.35 ft
Point 19	77.4 ft	73 ft
Point 20	85.6 ft	63.5 ft
Point 21	97 ft	20 ft
Point 22	-100 ft	29 ft
Point 23	-26.8 ft	29 ft
Point 24	26.1 ft	36 ft
Point 25	33.7 ft	37.2 ft
Point 26	46.3 ft	42.35 ft
Point 27	50.9 ft	45.8 ft
Point 28	56.2 ft	50.5 ft
Point 29	65.5 ft	55.5 ft
Point 30	60.21187 ft	53.139391 ft
Point 31	70 ft	56.6 ft
Point 32	85.55 ft	56.575 ft
Point 33	97 ft	58.075 ft
Point 34	0.25 ft	72 ft
Point 35	-14.75 ft	92.5 ft
Point 36	-14.75 ft	71 ft
Point 37	-14.75 ft	91.086957 ft
Point 38	-14.75 ft	72 ft
Point 39	0.25 ft	71 ft
Point 40	-16.25 ft	71 ft
Point 41	-18.75 ft	72 ft

Regions

	Material	Points	Area
Region 1	ESU 1B - Existing Gravelly Granular Fill	6,34,39,36,40,41,10,3,2,1,11,12,13,14,15,16,20,17,18,19,7	3,438.8 ft²

Region 2	ESU 7A - Weathered Sandstone	28,27,26,25,24,14,13,23,22,9,8,21,33,32,31,29,30	3,479.3 ft²
Region 3	ESU 2A - Native Sand and Gravel	12,11,22,23,13	1,783.8 ft²
Region 4	ESU 2A - Native Sand and Gravel	15,14,24,25,26,27,28,30,29,31,32,33,17,20,16	766.88 ft²
Region 5	Gravel Borrow	6,5,35,37,38,36,39,34	322.5 ft²
Region 6	ESU 1A - Existing Granular Fill (Pseudo-Static)	10,41,4	318.94 ft²
Region 7	Common Borrow	37,35,4,41,40,36,38	490.37 ft²

Slip Results

Slip Surfaces Analysed: 1392 of 1680 converged

Current Slip Surface

Slip Surface: 893
Factor of Safety: 1.520
Volume: 687.98718 ft³
Weight: 86,421.556 lbf
Resisting Moment: 3,093,238 lbf·ft
Activating Moment: 2,034,136.8 lbf·ft
Resisting Force: 58,092.557 lbf
Activating Force: 38,214.206 lbf
Slip Rank: 1 of 1,680 slip surfaces
Exit: (29.125, 73) ft
Entry: (-35.002259, 90.338242) ft
Radius: 49.744697 ft
Center: (6.7265301, 117.4167) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength	Suction Strength	Base Material
Slice 1	-33.877134 ft	88.744892 ft	-2,866.069 psf	121.71327 psf	76.054893 psf	0 psf	0 psf	Common Borrow
Slice 2	-31.626883 ft	85.787233 ft	-2,677.0487 psf	342.91191 psf	214.27514 psf	0 psf	0 psf	Common Borrow
Slice 3	-29.376632 ft	83.234565 ft	-2,513.3122 psf	527.55849 psf	329.65513 psf	0 psf	0 psf	Common Borrow
Slice 4	-27.126381 ft	81.000285 ft	-2,369.4526 psf	688.69616 psf	430.34512 psf	0 psf	0 psf	Common Borrow
Slice 5	-24.87613 ft	79.028124 ft	-2,241.9572 psf	835.91917 psf	522.34027 psf	0 psf	0 psf	Common Borrow
Slice 6	-22.625879 ft	77.279088 ft	-2,128.3915 psf	976.83614 psf	610.39497 psf	0 psf	0 psf	Common Borrow
Slice	-20.375628	75.724891	-2,026.9897	1,117.8723	698.52414			Common

7	ft	ft	psf	psf	psf	0 psf	0 psf	Borrow
Slice 8	-18.125377 ft	74.344318 ft	-1,936.4272 psf	1,264.7244 psf	790.2875 psf	0 psf	0 psf	Common Borrow
Slice 9	-15.875126 ft	73.121053 ft	-1,855.6855 psf	1,422.5997 psf	888.93893 psf	0 psf	0 psf	Common Borrow
Slice 10	-13.853176 ft	72.139333 ft	-1,790.4672 psf	1,745.6108 psf	1,363.8206 psf	0 psf	0 psf	Gravel Borrow
Slice 11	-12.059527 ft	71.365852 ft	-1,738.6929 psf	1,909.6584 psf	1,491.9886 psf	0 psf	0 psf	Gravel Borrow
Slice 12	-10.021432 ft	70.591799 ft	-1,686.408 psf	2,111.8043 psf	1,649.9223 psf	0 psf	0 psf	ESU 1B - Existing Gravelly Granular Fill
Slice 13	-7.7388919 ft	69.836627 ft	-1,634.8266 psf	2,364.6543 psf	1,847.4704 psf	0 psf	0 psf	ESU 1B - Existing Gravelly Granular Fill
Slice 14	-5.4563513 ft	69.201283 ft	-1,590.7262 psf	2,645.111 psf	2,066.5872 psf	0 psf	0 psf	ESU 1B - Existing Gravelly Granular Fill
Slice 15	-3.1738108 ft	68.68107 ft	-1,553.8134 psf	2,949.7654 psf	2,304.6093 psf	0 psf	0 psf	ESU 1B - Existing Gravelly Granular Fill
Slice 16	-0.89127027 ft	68.272321 ft	-1,523.8594 psf	3,270.4467 psf	2,555.153 psf	0 psf	0 psf	ESU 1B - Existing Gravelly Granular Fill
Slice 17	1.0625 ft	68.002283 ft	-1,503.204 psf	782.56946 psf	611.41027 psf	0 psf	0 psf	ESU 1B - Existing Gravelly Granular Fill
Slice 18	2.6875 ft	67.842953 ft	-1,490.099 psf	882.74671 psf	689.67732 psf	0 psf	0 psf	ESU 1B - Existing Gravelly Granular Fill
Slice 19	4.6136364 ft	67.729399 ft	-1,477.9546 psf	990.63133 psf	773.96602 psf	0 psf	0 psf	ESU 1B - Existing Gravelly Granular Fill
Slice 20	6.8409091 ft	67.684604 ft	-1,468.2056 psf	1,095.206 psf	855.66873 psf	0 psf	0 psf	ESU 1B - Existing Gravelly Granular Fill
Slice 21	9.0681818 ft	67.739659 ft	-1,464.6903 psf	1,165.6223 psf	910.68394 psf	0 psf	0 psf	ESU 1B - Existing Gravelly Granular Fill
Slice 22	11.295455 ft	67.894898 ft	-1,467.4294 psf	1,191.3273 psf	930.76692 psf	0 psf	0 psf	ESU 1B - Existing Gravelly Granular Fill
Slice 23	13.522727 ft	68.15127 ft	-1,476.4823 psf	1,165.1408 psf	910.30778 psf	0 psf	0 psf	ESU 1B - Existing Gravelly Granular Fill
Slice 24	15.75 ft	68.510368 ft	-1,491.9484 psf	1,085.364 psf	847.97929 psf	0 psf	0 psf	ESU 1B - Existing Gravelly Granular Fill
Slice 25	17.977273 ft	68.974483 ft	-1,513.9707 psf	956.76995 psf	747.51061 psf	0 psf	0 psf	ESU 1B - Existing Gravelly Granular Fill
Slice	20.204545	69.546675	-1,542.7403	789.87337	617.11671	0 psf	0 psf	ESU 1B - Existing Gravelly

26	ft	ft	psf	psf	psf			Granular Fill
Slice 27	22.431818 ft	70.230886 ft	-1,578.5033 psf	598.4998 psf	467.59929 psf	0 psf	0 psf	ESU 1B - Existing Gravelly Granular Fill
Slice 28	24.659091 ft	71.032086 ft	-1,621.5699 psf	396.4656 psf	309.75287 psf	0 psf	0 psf	ESU 1B - Existing Gravelly Granular Fill
Slice 29	26.886364 ft	71.956479 ft	-1,672.3275 psf	194.72035 psf	152.13221 psf	0 psf	0 psf	ESU 1B - Existing Gravelly Granular Fill
Slice 30	28.5625 ft	72.725166 ft	-1,709.3524 psf	47.989728 psf	37.493684 psf	0 psf	0 psf	ESU 1B - Existing Gravelly Granular Fill

2.2 Pseudo-Static (Spencer)

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File Information

File Version: 11.01
Created By: Mikayla S. Hatch
Last Edited By: Yi Tyan Tsai
Revision Number: 292
Date: 12/07/2021
Time: 04:06:32 PM
Tool Version: 11.1.1.22085
File Name: Wall 03.65L - Bridge 17.7 - Hilfiker.gsz
Directory: P:\0\0180366\01\Analysis\Bridge 17.7\SlopeW\
Last Solved Date: 12/07/2021
Last Solved Time: 04:06:52 PM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

2.2 Pseudo-Static (Spencer)

Kind: SLOPE/W
Parent: 2. Compound Stability
Analysis Type: Spencer
Settings
- PWP Conditions from: Piezometric Line
- Apply Phreatic Correction: No
- Use Staged Rapid Drawdown: No
- Critical Slip Surface Source from: (none)
- Unit Weight of Water: 62.430189 pcf

Slip Surface
- Direction of movement: Left to Right
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 1
- Optimize Critical Slip Surface Location: No
- Tension Crack Option: (none)

Distribution
- F of S Calculation Option: Constant

Advanced
- Geometry Settings
  - Minimum Slip Surface Depth: 0.1 ft

Number of Slices: 30
Factor of Safety Convergence Settings
Maximum Number of Iterations: 100
Tolerable difference in F of S: 0.001
Solution Settings
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Gravel Borrow

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1A - Existing Granular Fill (Pseudo-Static)

Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effective Cohesion: 50 psf
Effective Friction Angle: 40 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2A - Native Sand and Gravel

Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 39 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 7A - Weathered Sandstone

Material Model: Mohr-Coulomb
Unit Weight: 135 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 43 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1B - Existing Gravelly Granular Fill

Material Model: Mohr-Coulomb
Unit Weight: 125 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Common Borrow

Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Reinforcements

W7.0x3.5 (depth<20ft)(EQ)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 26 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 5,150 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,150 lbf/ft

W7.0x3.5 (depth>=20ft)(EQ)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 13.7 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 5,150 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,150 lbf/ft

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (-59, 87.776685) ft
Left-Zone Right Coordinate: (-14, 92.5) ft
Left-Zone Increment: 15
Right Type: Range
Right-Zone Left Coordinate: (0.25, 80) ft
Right-Zone Right Coordinate: (65, 73) ft
Right-Zone Increment: 20
Radius Increments: 4

Slip Surface Limits

Left Coordinate: (-100, 49.5) ft
Right Coordinate: (97, 75.35) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	-100 ft	42.975 ft
Coordinate 2	-60.75 ft	42 ft
Coordinate 3	3.5 ft	44 ft
Coordinate 4	28 ft	45.225 ft
Coordinate 5	62 ft	52.475 ft
Coordinate 6	71.75 ft	54.225 ft
Coordinate 7	91.25 ft	56.25 ft
Coordinate 8	97 ft	57 ft

Seismic Coefficients

Horz Seismic Coef.: 0.218

Reinforcement Lines

Reinforcement Line 1

Reinforcement: W7.0x3.5 (depth>=20ft)(EQ)
Lock to Ground Surface: No
Outside Point: (0.25, 72.5) ft
Inside Point: (-14.75, 72.5) ft
Length: 15 ft
Orientation: 180 °

Slip Surface Intersection: (-14.646678, 72.5) ft
Max. Pullout Force: 5,150 lbf
Available Length: 0.10332195 ft
Required Length: 0.10332195 ft
Pullout Force: 133.3352 lbf
Pullout Force per Length: 1,290.4828 lbf/ft
Governing Component: Pullout Resistance

Reinforcement Line 2

Reinforcement: W7.0x3.5 (depth<20ft)(EQ)
Lock to Ground Surface: Yes
Outside Point: (0.25, 74.5) ft
Inside Point: (-14.75, 74.5) ft
Length: 15 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 3

Reinforcement: W7.0x3.5 (depth<20ft)(EQ)
Lock to Ground Surface: Yes
Outside Point: (0.25, 76.5) ft
Inside Point: (-14.75, 76.5) ft
Length: 15 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 4

Reinforcement: W7.0x3.5 (depth<20ft)(EQ)
Lock to Ground Surface: Yes
Outside Point: (0.25, 78.5) ft
Inside Point: (-14.75, 78.5) ft
Length: 15 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft

Governing Component: (none)

Reinforcement Line 5

Reinforcement: W7.0x3.5 (depth<20ft)(EQ)
Lock to Ground Surface: Yes
Outside Point: (0.25, 80.5) ft
Inside Point: (-14.75, 80.5) ft
Length: 15 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 6

Reinforcement: W7.0x3.5 (depth<20ft)(EQ)
Lock to Ground Surface: Yes
Outside Point: (0.25, 82.5) ft
Inside Point: (-14.75, 82.5) ft
Length: 15 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 7

Reinforcement: W7.0x3.5 (depth<20ft)(EQ)
Lock to Ground Surface: Yes
Outside Point: (0.25, 84.5) ft
Inside Point: (-14.75, 84.5) ft
Length: 15 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 8

Reinforcement: W7.0x3.5 (depth<20ft)(EQ)
Lock to Ground Surface: Yes
Outside Point: (0.25, 86.5) ft

Inside Point: (-14.75, 86.5) ft
Length: 15 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 9

Reinforcement: W7.0x3.5 (depth<20ft)(EQ)
Lock to Ground Surface: Yes
Outside Point: (0.25, 88.5) ft
Inside Point: (-14.75, 88.5) ft
Length: 15 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 10

Reinforcement: W7.0x3.5 (depth<20ft)(EQ)
Lock to Ground Surface: Yes
Outside Point: (0.25, 90.5) ft
Inside Point: (-14.75, 90.5) ft
Length: 15 ft
Orientation: 180 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Geometry

Name: Wall 03.65L

Settings

View: 2D
Element Thickness: 1 ft

Points

	X	Y

Point 1	-100 ft	49.5 ft
Point 2	-77 ft	49.5 ft
Point 3	-59.25 ft	51.375 ft
Point 4	-59.25 ft	87.75 ft
Point 5	0.25 ft	92.5 ft
Point 6	0.25 ft	73 ft
Point 7	60.25 ft	73 ft
Point 8	60.25 ft	20 ft
Point 9	-100 ft	20 ft
Point 10	-59.25 ft	72 ft
Point 11	-100 ft	47 ft
Point 12	-2.25 ft	47 ft
Point 13	10 ft	36 ft
Point 14	21.8 ft	36 ft
Point 15	50.9 ft	63.5 ft
Point 16	60.2 ft	63.5 ft
Point 17	97 ft	75.35 ft
Point 18	77.4 ft	75.35 ft
Point 19	77.4 ft	73 ft
Point 20	85.6 ft	63.5 ft
Point 21	97 ft	20 ft
Point 22	-100 ft	29 ft
Point 23	-26.8 ft	29 ft
Point 24	26.1 ft	36 ft
Point 25	33.7 ft	37.2 ft
Point 26	46.3 ft	42.35 ft
Point 27	50.9 ft	45.8 ft
Point 28	56.2 ft	50.5 ft
Point 29	65.5 ft	55.5 ft
Point 30	60.21187 ft	53.139391 ft
Point 31	70 ft	56.6 ft
Point 32	85.55 ft	56.575 ft
Point 33	97 ft	58.075 ft
Point 34	0.25 ft	72 ft
Point 35	-14.75 ft	92.5 ft
Point 36	-14.75 ft	71 ft
Point 37	-14.75 ft	91.086957 ft
Point 38	-14.75 ft	72 ft
Point 39	0.25 ft	71 ft
Point 40	-16.25 ft	71 ft
Point 41	-18.75 ft	72 ft

Regions

	Material	Points	Area
Region 1	ESU 1B - Existing Gravelly Granular Fill	6,34,39,36,40,41,10,3,2,1,11,12,13,14,15,16,20,17,18,19,7	3,438.8 ft²
Region 2	ESU 7A - Weathered Sandstone	28,27,26,25,24,14,13,23,22,9,8,21,33,32,31,29,30	3,479.3 ft²
Region			1,783.8

3	ESU 2A - Native Sand and Gravel	12,11,22,23,13	ft²
Region 4	ESU 2A - Native Sand and Gravel	15,14,24,25,26,27,28,30,29,31,32,33,17,20,16	766.88 ft²
Region 5	Gravel Borrow	6,5,35,37,38,36,39,34	322.5 ft²
Region 6	ESU 1A - Existing Granular Fill (Pseudo-Static)	10,41,4	318.94 ft²
Region 7	Common Borrow	37,35,4,41,40,36,38	490.37 ft²

Slip Results

Slip Surfaces Analysed: 1225 of 1680 converged

Current Slip Surface

Slip Surface: 893
Factor of Safety: 1.523
Volume: 687.98718 ft³
Weight: 86,421.556 lbf
Resisting Moment: 3,097,756.6 lbf·ft
Activating Moment: 2,034,136.8 lbf·ft
Resisting Force: 58,056.264 lbf
Activating Force: 38,106.917 lbf
Slip Rank: 1 of 1,680 slip surfaces
Exit: (29.125, 73) ft
Entry: (-35.002259, 90.338242) ft
Radius: 49.744697 ft
Center: (6.7265301, 117.4167) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength	Suction Strength	Base Material
Slice 1	-33.877134 ft	88.744892 ft	-2,866.069 psf	84.766615 psf	52.96806 psf	0 psf	0 psf	Common Borrow
Slice 2	-31.626883 ft	85.787233 ft	-2,677.0487 psf	267.49409 psf	167.14886 psf	0 psf	0 psf	Common Borrow
Slice 3	-29.376632 ft	83.234565 ft	-2,513.3122 psf	454.85183 psf	284.22297 psf	0 psf	0 psf	Common Borrow
Slice 4	-27.126381 ft	81.000285 ft	-2,369.4526 psf	644.77625 psf	402.90092 psf	0 psf	0 psf	Common Borrow
Slice 5	-24.87613 ft	79.028124 ft	-2,241.9572 psf	836.16583 psf	522.4944 psf	0 psf	0 psf	Common Borrow
Slice 6	-22.625879 ft	77.279088 ft	-2,128.3915 psf	1,028.4326 psf	642.63603 psf	0 psf	0 psf	Common Borrow
Slice 7	-20.375628 ft	75.724891 ft	-2,026.9897 psf	1,221.2947 psf	763.14966 psf	0 psf	0 psf	Common Borrow
Slice	-18.125377	74.344318	-1,936.4272	1,414.6719	883.98512	0 psf	0 psf	Common

8	ft	ft	psf	psf	psf			Borrow
Slice 9	-15.875126 ft	73.121053 ft	-1,855.6855 psf	1,608.6312 psf	1,005.1843 psf	0 psf	0 psf	Common Borrow
Slice 10	-13.853176 ft	72.139333 ft	-1,790.4672 psf	1,944.4068 psf	1,519.1371 psf	0 psf	0 psf	Gravel Borrow
Slice 11	-12.059527 ft	71.365852 ft	-1,738.6929 psf	2,104.8994 psf	1,644.5276 psf	0 psf	0 psf	Gravel Borrow
Slice 12	-10.021432 ft	70.591799 ft	-1,686.408 psf	2,285.2444 psf	1,785.4286 psf	0 psf	0 psf	ESU 1B - Existing Gravelly Granular Fill
Slice 13	-7.7388919 ft	69.836627 ft	-1,634.8266 psf	2,490.2879 psf	1,945.6261 psf	0 psf	0 psf	ESU 1B - Existing Gravelly Granular Fill
Slice 14	-5.4563513 ft	69.201283 ft	-1,590.7262 psf	2,699.0007 psf	2,108.6904 psf	0 psf	0 psf	ESU 1B - Existing Gravelly Granular Fill
Slice 15	-3.1738108 ft	68.68107 ft	-1,553.8134 psf	2,912.5608 psf	2,275.5419 psf	0 psf	0 psf	ESU 1B - Existing Gravelly Granular Fill
Slice 16	-0.89127027 ft	68.272321 ft	-1,523.8594 psf	3,132.4716 psf	2,447.3551 psf	0 psf	0 psf	ESU 1B - Existing Gravelly Granular Fill
Slice 17	1.0625 ft	68.002283 ft	-1,503.204 psf	654.85889 psf	511.63184 psf	0 psf	0 psf	ESU 1B - Existing Gravelly Granular Fill
Slice 18	2.6875 ft	67.842953 ft	-1,490.099 psf	705.36135 psf	551.08869 psf	0 psf	0 psf	ESU 1B - Existing Gravelly Granular Fill
Slice 19	4.6136364 ft	67.729399 ft	-1,477.9546 psf	760.05318 psf	593.81862 psf	0 psf	0 psf	ESU 1B - Existing Gravelly Granular Fill
Slice 20	6.8409091 ft	67.684604 ft	-1,468.2056 psf	817.63214 psf	638.80424 psf	0 psf	0 psf	ESU 1B - Existing Gravelly Granular Fill
Slice 21	9.0681818 ft	67.739659 ft	-1,464.6903 psf	867.01276 psf	677.3846 psf	0 psf	0 psf	ESU 1B - Existing Gravelly Granular Fill
Slice 22	11.295455 ft	67.894898 ft	-1,467.4294 psf	906.66694 psf	708.36584 psf	0 psf	0 psf	ESU 1B - Existing Gravelly Granular Fill
Slice 23	13.522727 ft	68.15127 ft	-1,476.4823 psf	934.49546 psf	730.10787 psf	0 psf	0 psf	ESU 1B - Existing Gravelly Granular Fill
Slice 24	15.75 ft	68.510368 ft	-1,491.9484 psf	947.48114 psf	740.2534 psf	0 psf	0 psf	ESU 1B - Existing Gravelly Granular Fill
Slice 25	17.977273 ft	68.974483 ft	-1,513.9707 psf	941.05606 psf	735.23357 psf	0 psf	0 psf	ESU 1B - Existing Gravelly Granular Fill
Slice 26	20.204545 ft	69.546675 ft	-1,542.7403 psf	907.8783 psf	709.31227 psf	0 psf	0 psf	ESU 1B - Existing Gravelly Granular Fill
Slice	22.431818	70.230886	-1,578.5033	835.31649	652.62077			ESU 1B -

27	ft	ft	psf	psf	psf	0 psf	0 psf	Existing Gravelly Granular Fill
Slice 28	24.659091 ft	71.032086 ft	-1,621.5699 psf	699.91618 psf	546.83445 psf	0 psf	0 psf	ESU 1B - Existing Gravelly Granular Fill
Slice 29	26.886364 ft	71.956479 ft	-1,672.3275 psf	454.29145 psf	354.93138 psf	0 psf	0 psf	ESU 1B - Existing Gravelly Granular Fill
Slice 30	28.5625 ft	72.725166 ft	-1,709.3524 psf	143.9559 psf	112.47068 psf	0 psf	0 psf	ESU 1B - Existing Gravelly Granular Fill

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Appendix F.5
Bearing Capacity

LRFD Foundation Design

Spreadsheet Reference Section 10.6.3.1.2 of The 2014 AASHTO LRFD Bridge Design Specifications

Date/Time:	11/29/21 1:58 PM
Project Name:	**Wall 03.65L Maximum Height (21.5-ft) - ESU 1B**
Project No.:	**00180-366-01**

Foundation Soil Conditions	
Unit Weight, γ (pcf)	**125**
Friction angle, Φ (degrees)	**38**
Friction angle, Φ (rad)	0.663
Cohesion, C (psf)	**0**
Embedment, D_f (ft)	**2**
Depth to Groundwater, D_w (ft)	**27.6**
Footing Length, L (ft)	**48**
Footing Width, B (ft)	**15**
Poissons Ration, ν	**0.25**
Young's Modulus, E_s (ksf)	**1720**

Bearing Capacity Factors	
N_γ	78
N_c	61
N_q	49

Footing Width, B	**Water Depth Factors**		**Shape Factors**			**Unfactored Bearing Resistance**	**Extreme Event Resistance** Resistance Factor (0.9) Bearing Resistance for Seismic Loading (AASHTO 11.5.8 for MSE Wall)	**Working Bearing Resistance** Resistance Factor (0.65) Bearing Resistance for MSE Wall (AASHTO Table 11.5.7.1)	Deflection from Elastic Settlement Spreadsheet	Deflection from Elastic Settlement Spreadsheet
	C_{wq}	$C_{w\gamma}$	Sc	S_γ	Sq				**1" Deflection**	**2" Deflection**
(ft)						(ksf)	(ksf)	(ksf)	(ksf)	(ksf)
2.0	1.0	1.0	1.03	0.98	1.03	22.2	20.0	14.4	22.0	22.2
4.0	1.0	1.0	1.07	0.97	1.07	31.9	28.7	20.7	15.6	31.1
6.0	1.0	1.0	1.10	0.95	1.10	41.2	37.1	26.8	12.1	24.2
8.0	1.0	1.0	1.13	0.93	1.13	50.2	45.2	32.6	9.9	19.9
10.0	1.0	1.0	1.17	0.92	1.16	58.9	53.0	38.3	8.6	17.2
12.0	1.0	1.0	1.20	0.90	1.20	67.3	60.5	43.7	7.6	15.2
14.0	1.0	1.0	1.23	0.88	1.23	75.3	67.8	48.9	6.9	13.8
15.0	1.0	1.0	1.25	0.88	1.24	79.2	71.3	51.5	6.6	13.2
16.0	1.0	1.0	1.27	0.87	1.26	83.0	74.7	54.0	6.3	12.7
18.0	1.0	0.5	1.30	0.85	1.29	53.1	47.8	34.5	5.9	11.8
20.0	1.0	0.5	1.33	0.83	1.33	56.8	51.1	36.9	5.5	11.1

Note: Depth and inclination modifier were taken as 1 because the load is applied axially and during construction the soils above the wall are to be excavated.

Wall 03.65L

Bearing Capacity Summary

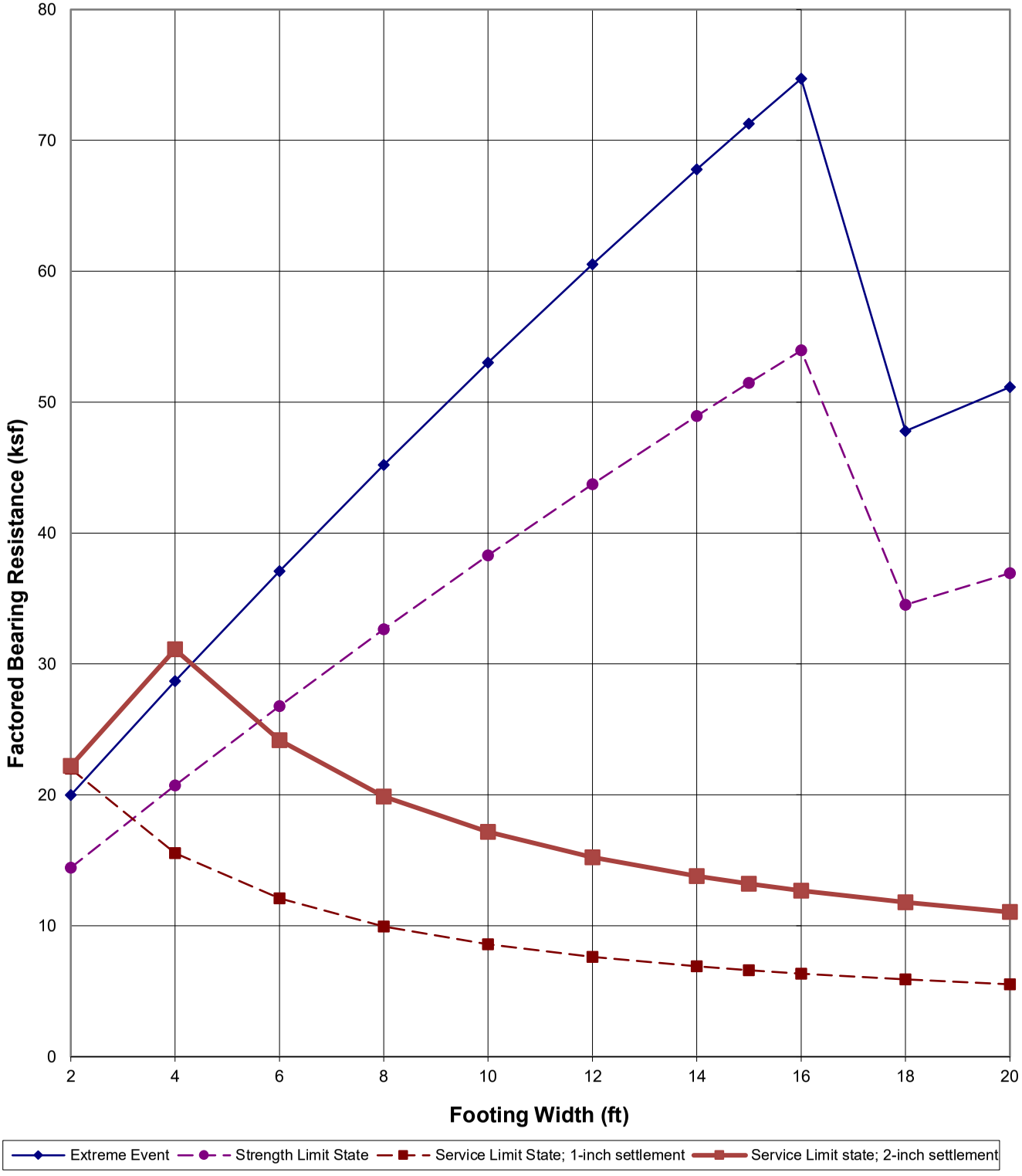
Footing Width	Footing Length	Unfactored Bearing Resistance	Factored Bearing Resistance		Service Limit State	
			Extreme Event[a]	Strength[b]	1" Deflection	2" Deflection
(ft)	(ft)	(ksf)	(ksf)	(ksf)	(ksf)	(ksf)
2.0	48.0	22.2	20.0	14.4	22.0	22.2
4.0	48.0	31.9	28.7	20.7	15.6	31.1
6.0	48.0	41.2	37.1	26.8	12.1	24.2
8.0	48.0	50.2	45.2	32.6	9.9	19.9
10.0	48.0	58.9	53.0	38.3	8.6	17.2
12.0	48.0	67.3	60.5	43.7	7.6	15.2
14.0	48.0	75.3	67.8	48.9	6.9	13.8
15.0	48.0	79.2	71.3	51.5	6.6	13.2
16.0	48.0	83.0	74.7	54.0	6.3	12.7
18.0	48.0	53.1	47.8	34.5	5.9	11.8
20.0	48.0	56.8	51.1	36.9	5.5	11.1

Notes:

a. Resistance Factor (0.9) bearing resistance for seismic loading (Section 8.10; 2015 WSDOT *Geotechnical Design Manual* M 46-03.11)

b. Resistance Factor (0.45) Theoretical method in sand (0.50) Theoretical method in clay (2017 AASHTO Table 10.5.5.2.2-1)

Shallow Foundation Factored Bearing Resistance
Wall 03.65L



*Assumes Footing Length of 48 feet

GeoEngineers
Earth Science + Technology

Shallow Strip Foundation Design

Figure 1

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Appendix F.6
Elastic Settlement Analyses

Lateral Earth Pressures for Cohesionless Soils

Project Information

Project:	I-405/Renton to Bellevue Corridor Widening
Owner:	WSDOT
Job Number:	00180-366-01
Analysis by:	MSH
Date/Time:	10/4/2021 4:00 PM
Checked by:	IAH

Input Parameters

Material	ϕ Friction Angle (deg)	β_2 (-) Foreslope (deg)	i (+) Backslope (deg)	δ Wall Friction - Active (deg)	δ Wall Friction - Passive (deg)	β Wall Batter (deg)	γ_m (pcf)	γ_b (pcf)	Passive Factor of Safety	k_h (g)	k_v (g)
Common Borrow	32	0	-6	21.3	0	0	120	57.6	1	0.217	0

Figure F.6-1

Lateral Earth Pressures

Output

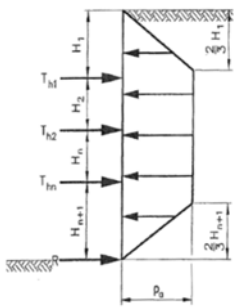
Material	Active			Passive					At Rest			Apparent EP Trapezoid		Seismic				Seismic Pressure - Rectangular
	K_a	γ_a (pcf)	γ'_a (pcf)	K_p	$\gamma_{p(all)}$ (pcf)	$\gamma'_{p(all)}$ (pcf)	$\gamma_{pe(all)}$ (pcf)	$\gamma'_{pe(all)}$ (pcf)	K_o	γ_o (pcf)	γ'_o (pcf)	Single Tieback (psf * H)	Mult. Tiebacks[1], X	K_{ae}	γ_{ae} (pcf)	γ'_{ae} (pcf)	K_{pe}	(psf * H)
Common Borrow	0.26	30.95	14.86	3.25	390.55	187.46	584.28	280.45	0.47	56.41	27.08	30.95	30.95	0.14	48.03	23.06	4.87	8.54

Notes:

[1] "X" to be used in the following equation:

$$\frac{X \cdot H^2}{1.5H - 0.5H_1 - 0.5H_{n+1}}$$

where H_1 and H_{n+1} are represented by this diagram:



Recommended Lateral Earth Pressures

Figure F.6-2

Sliding Friction Coefficients					
Soil Type	φ'	Soil-to-Soil Sliding Friction Coefficient		Concrete Structure Sliding Friction Coefficient	
		Discontinuous Reinforcements	Continuous Reinforcements	Cast-In-Place Concrete	Precast Concrete
Wall 03.65L and/or Bridge 17.7 Pier 1 Footing					
ESU 1B	38	0.78	0.47	0.78	0.63
Common Borrow	32	0.62	0.39	0.62	0.50
Select Borrow	36	0.73	0.45	0.73	0.58
Gravel Borrow	38	0.78	0.47	0.78	0.63

Notes:
Sliding coefficients calculated according to AASHTO Equation 10.6.3.4-2
Structural Earth Walls (SEW) are termed Mechanically Stabilized Earth (MSE) walls in AASHTO.

Coefficient of Friction for Discontinuous Reinforcements, e.g., Strips:
Coefficient of friction = 1.0*tan(Phi')
Phi' = lesser of friction angle of foundation soil and friction angle of reinforced fill per AASHTO 11.10.5.3

Coefficient of Friction for Continuous Reinforcements, e.g., Grids and Sheets:
Coefficient of friction = 1.0*tan(Phi')
Phi' = lesser of friction angle of foundation soil, friction angle of reinforced fill, and soil-reinforcement interface friction angle per AASHTO 11.10.5.3
In the absence of specific data, a maximum friction angle of 2/3 of friction angle of foundation soil or 2/3 of friction angle of reinforced fill should be used.

Cast-In-Place Concrete Coefficient of Friction:
Coefficient of friction = 1.0*tan(Phi')

Precast Concrete Coefficient of Friction:
Coefficient of friction = 0.8*tan(Phi')

AASHTO 10.6.3.4:

$$R_\tau = CV \tan \phi_f \qquad (10.6.3.4\text{-}2)$$

for which:

C = 1.0 for concrete cast against soil
= 0.8 for precast concrete footing
= 1.0 for MSE Wall per AASHTO Table 11.5.7-1

where:

ϕ_f = internal friction angle of drained soil (degrees)
V = total vertical force (kips)

Figure F.6-3

Appendix G
Wall 03.66L Calculations

APPENDIX G –Wall 03.66L Calculation Package

This appendix presents the geotechnical calculations for Wall 03.66L including:

- Engineering Stratigraphic Unit (ESU) Soil Properties
- Bearing Resistance and Settlement
- Seismic Springs

Retaining wall 03.66L was constructed as part of Bridge 18W. The existing wall is cast-in-place on a spread footing. Relevant pages of the design drawings are attached in Appendix G.1. The proposed wall 03.66L will be connected to existing Bridge 17.7 Pier 1 wingwall and proposed Bridge 18W Pier 1. Cross-sections depicting subsurface conditions for Wall 03.66L can be found in Appendix C.

To accommodate widening southbound I-405 under the existing Bridge 17.7, the existing retaining wall between Bridge 18W Pier 1 and Bridge 17.7 Pier 1 wingwall will be extended. The proposed Wall 03.66L will span between the two piers. At existing Bridge 18W Pier 1 the proposed wall will be connected with drilled and epoxied dowels and connected to the new Bridge 18W Pier 1 widening with reinforcement. The proposed Wall 03.66L will also be connected to existing Bridge 17.7 Pier 1 wingwall with drilled and epoxied dowels. Geotechnical calculations for Wall 03.66L were completed based on the existing Bridge 18W Pier 1 and Bridge 17.7 Pier 1 configurations.

The design recommendations of Bridge 18W Pier 1 are presented in our Released For Use (RFU) geotechnical report dated April 22, 2021 and the subsequent RFU geotechnical report addendum dated September 21, 2021.

This appendix presents the geotechnical calculations for existing Bridge 17.7, including

- ESU Soil Properties
- Bearing Resistance
- Seismic Springs

1.0 ESU Properties

ESU properties and selection process are presented in Appendix C.

2.0 Seismic Design Parameters

The design functional evaluation earthquake (FEE) and safety evaluation earthquake (SEE) response spectra for Seismic Site Class C and D at Wall 03.66L use the probabilistic seismic hazard analysis (PSHA) results available at Bridge 18W. The design FEE and SEE response spectra for Seismic Site Class C and D at Bridge 18W were developed and provided by Hart Crowser and is included in the report “I-405 R2B Segment 1a Site Specific Hazard Analysis” dated March 25, 2021 (Submittal 1197).

These analyses were completed in accordance with the Project Geotechnical Design Manual (Project GDM). The ground motion parameters for design are based on the projected ground motion at the project site that has either a 30 percent (FEE) or 7 percent (SEE) probability of exceedance in a 75-year period (approximate 210- and 975-year return periods). Further details about the determination of the seismic parameters are included in the above referenced report.

We used the recommended the SEE response spectra peak ground acceleration (PGA) and Mean Magnitude (Mw) in our analyses.

3.0 Wall 03.66L Design Analyses

To accommodate widening southbound Interstate 405 (I-405) under the existing Bridge 17.7, a new retaining wall (Wall 03.66L) will be constructed a few feet to the west of the existing retaining wall that spans between the existing Bridge 18W Pier 1 and the existing Bridge 17.7 Pier 1. The backfill zone between the new and existing retaining walls will be filled with mass concrete. The load of the proposed Wall 03.66L and its concrete backfill will be structurally supported at its two ends, one end bearing on Bridge 18W Pier 1 and the other end bearing on Bridge 17.7 Pier 1.

Figure 3 shows the location of Wall 3.66L.

The design analyses of Bridge 18W Pier 1 are presented in our RFU geotechnical report dated April 22, 2021 and the subsequent RFU geotechnical report addendum dated September 21, 2021.

3.1 Wall 03.66L Wave Scattering Evaluations

Per the National Cooperative Highway Research Program (NCHRP) Report 611 the PGA can be adjusted to account for variations in the average ground acceleration behind retaining walls and/or slopes greater than 20 feet in height by applying a scaling factor (or alpha value) to the PGA. The existing retaining wall has approximately 20 feet of exposed height and the proposed Wall 03.66L will be approximately 23.5 feet tall. Accordingly, we did not apply wave scattering effects.

3.2 Wall 03.66L Shallow Foundation Bearing Resistance and Settlement

We evaluated the bearing resistance of the existing Bridge 17.7 Pier 1 foundation because the new Wall 03.66L will bear on the existing bridge foundation.

Shallow foundation bearing resistance was evaluated based on American Association of State Highway and Transportation Officials (AASHTO) Load and Resistance Factor Design (LRFD) Section 10.6.3.1.2 and by using the Shallow Foundation Resistance and Elastic Settlement spreadsheet developed by GeoEngineers. We evaluated the estimated Service Limit State loads that will cause ¼-inch and ½-inch of additional settlement for the existing footing dimensions. This is exclusive of any existing loads that the footings are currently experiencing and any settlement that the footings have already experienced. This is a calculation of the settlement that is expected to occur from the new additional loads on the existing footings only. All settlement is anticipated to occur immediately as the load is applied.

Bearing resistance results and calculations are presented in Appendix G.2 (Figures G.2-1 through G.2-3). A summary of the bearing resistance results is presented in Table G-1.

Table G-1. Bearing Resistance Summary

Scenario	Maximum Bearing Resistance Limited by Bearing Resistance Calculation				
	Unfactored Bearing Resistance	Factored Extreme Event Resistance1	Factored Strength Bearing Resistance2	Factored Service Limit State3	
				1/4-inches Deflection	1/2-inches Deflection
	(ksf) 4	(ksf) 4	(ksf) 4	(ksf) 4	(ksf) 4
Pier 1 Existing Footing **B=12ft** **L=41.7ft** (ESU 7A)	578.3	520.5	260.3	1.3	2.7

Notes:

1. Resistance factor of 0.9 included in the factored bearing resistance values presented for Extreme Limit State load cases (AASHTO 11.5.8) for MSE Walls.
2. Strength Limit State factor (0.65) MSE Walls from AASHTO 11.5.7.1.
3. Resistance factor of 1.0 included in the factored bearing resistance values presented for Service Limit State load cases.
4. ksf = kips per square foot

3.3 Pier 1 Seismic Spread Footing Springs

We calculated seismic structural footing spring values for the existing and proposed Bridge 17.7 Pier 1 footings. Per Federal Emergency Management Agency (FEMA) 356 (ASCE 2000) as referenced in Project GDM Section 6-5.1.1 the initial shear modulus (G_o) was correlated the corrected standard penetration test (SPT) blow count, $(N_1)_{60}$. Correlated G_o values are presented in Table G-2 below. Calculations are presented in Appendix G.3.

Table G-2: Foundation Spring Inputs and Shear Modulus Summary

Property		Existing Pier 1 (ESU 7A)
SEE	Footing Width (ft.)	12
	Footing Length (ft.)	41.7
	Embedment (ft.)	8.5 [5]
	Footing Thickness (ft.)	3.5
	σ_o' (psf)	680
	$S_{XS}/2.5$ [1]	0.51
	G/G_o [2]	0.71
	G_o [3] (ksf)	2018
	G [4] (ksf)	1430

Notes:

5. Effective peak acceleration
6. Effective shear modulus ratio from FEMA Table 4-7
7. The initial shear modulus calculated using Go = 20,000 * $(N_1)_{60}$1/3 * Sqrt(σ_o') (Equation 4-5, FEMA)
8. Effective shear modulus
9. Embedment with historic ground surface

Using the shear modulus values presented in Table G-2, The Effective Shear Modulus, (G/G_o) was calculated using Table 4-7 (FEMA 356) by using the effective peak acceleration ($S_{XS}/2.5$). Spring constants were developed for the SEE hazard level. A summary of the calculated spring constants is presented in Table G-3 below. Calculations for these values are presented in Appendix G.3.

Table G-3: Summary of the 6-Degree-of-Freedom Structural Seismic Spring Constants for Pier 1

Results Summary[1]						
Pier	$K_{x,emb}$	$K_{y,emb}$	$K_{z,emb}$	$K_{xx,emb}$	$K_{yy,emb}$	$K_{zz,emb}$
	kips/in	kips/in	kips/in	kip-in	kip-in	kip-in
Pier 1 – Existing (ESU 7A) (SEE)	1380	15,350	13,510	138,100,000	647,500,000	730,300,000

Notes:

1. Spring values calculated using equations presented in Figure 4-4 (FEMA)

Appendix G.1
Existing Wall 03.66L Plans

CS 1743, Project No. L7974-D, District No. 1, South Renton to Sunset Blvd. HOV Lanes, SR 405, Cedar River O'Xing No. 405/18

BRIDGE DESIGN ENGR.	[signature]	3-89
DESIGN SUPERVISOR	R. T. Shaefer	9/91
DESIGNED BY	A. A. Buckway	9/91
CHECKED BY	PMN	9-91
DETAILED BY	VSN	2-89
BRIDGE PROJECTS ENGR.	[signature]	3-89
PRELIMINARY PLAN BY	M. H. Bauer	2-89
ARCHITECT/SPECIALIST	R. Mays	8-89

DATE	REVISION	BY
10/91	Δ Curtain Wall Dimensions	RTS

REGION NO.	STATE	FED. AID PROJ. NO.
10	WASH	I-IR-405-3(783)
JOB NUMBER 9IW097		
CONTRACT NO. 4052		

BRIDGE AND STRUCTURES OFFICE

DATE 10.13.91

19-SEP-1991 1 Z64I105.10 CEDARVR2.DGN;1

Washington State Department of Transportation

SR 405
SOUTH RENTON TO SUNSET BLVD. HOV
CEDAR RIVER & BNRR O'XING
BR. 405/18 E&W REPLACEMENT

LAYOUT

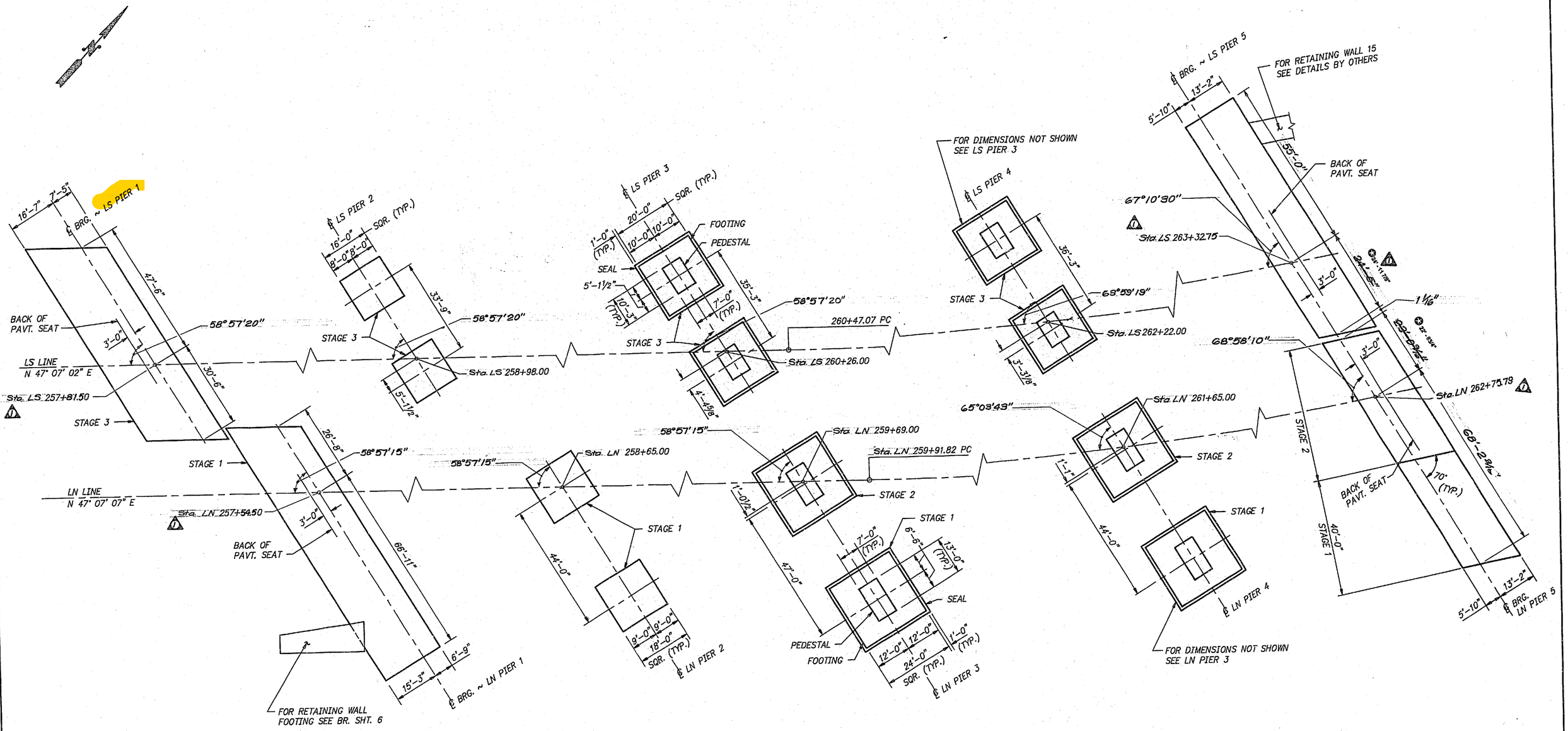
BR. SHEET 2 OF 2 — SHEET 228 OF 634 SHEETS

SR 405 JOB FILE NO. 1562

DOT FORM 221-013B Revised 3/91

SR 405/135

285/285



LN & LS LINES FOOTING LAYOUT

FOR LN AND LS LINES CURVE DATA SEE BR. SHT. 3
BEARINGS OF ALL PIERS = S 73° 55' 38" E

AS BUILT CHANGES 10/8/97

Bridge Design Engr.	Mingkwen 9/91				
Supervisor	R.T. Shaefer 9/91				
Designed By	A.A. Bushnag 8/91				
Checked By	V.A. Mhatre 8/91				
Detailed By	KRONES DRAFTING SERVICE				
Bridge Planning Engr.					
Preliminary Plan By		10/91	Footing Dimensions, Rev'd Stationing	RTS	
Architect/Specialist		DATE	REVISION	BY	APP'D

REGION NO.	STATE	FED. AID PROJ. NO.	SHEET NO.	TOTAL SHEETS
10	WASH.	I-IR-405-3(783)		
JOB NUMBER 91W097				
CONTRACT NO 4052				

BRIDGES AND STRUCTURES

10/13/91
APPROVED

Washington State Department of Transportation

SR 405
SOUTH RENTON TO SUNSET BLVD. HOV
CEDAR RIVER & BNRR O'XING
BR. 405/18 E&W REPLACEMENT

FOOTING LAYOUT

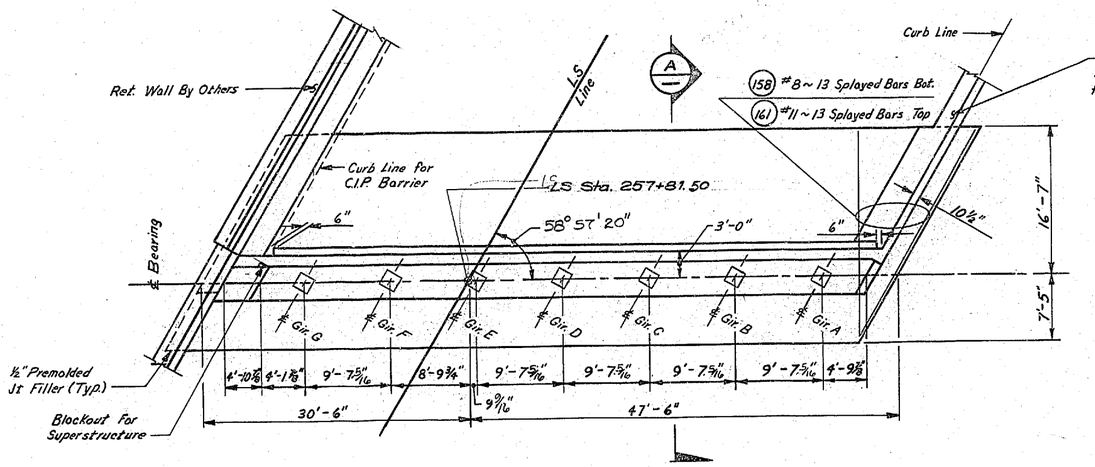
BRIDGE SHEET NO. 4

SHEET 230 OF 634 SHEETS

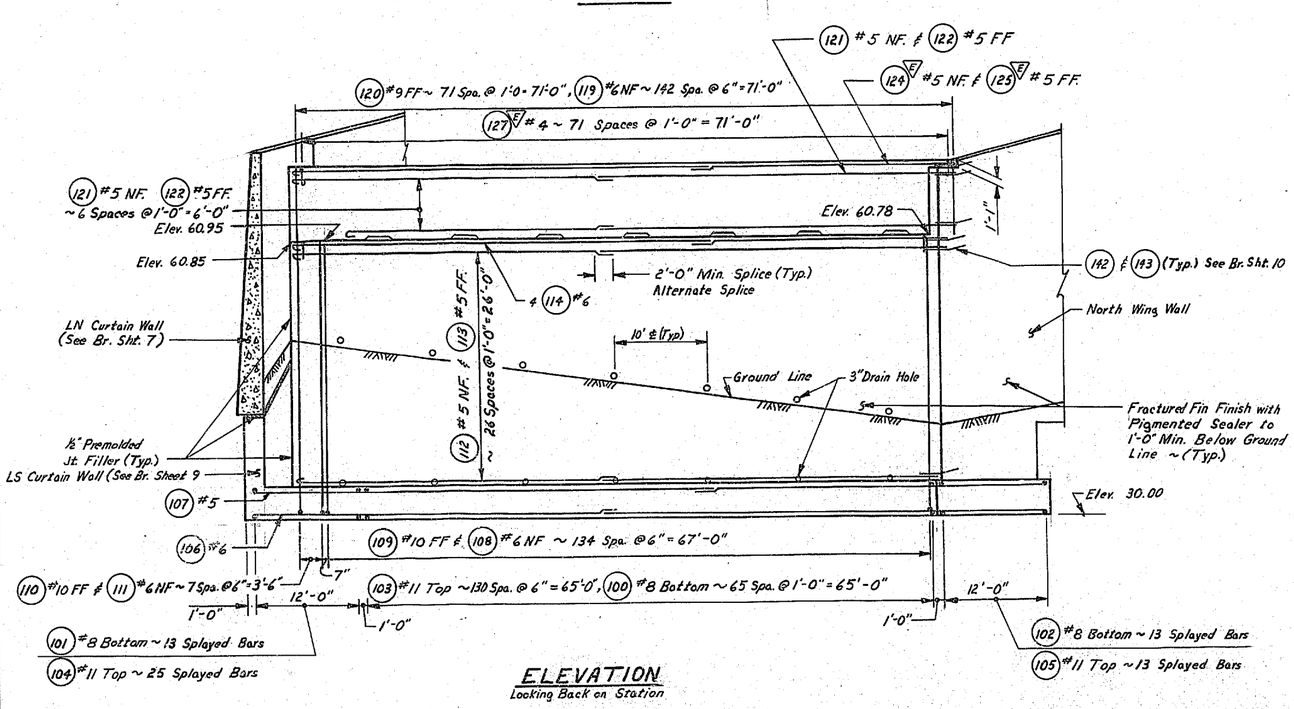
205/203

SR 405 JOB NO. 1562 SHEET

SR 405/135

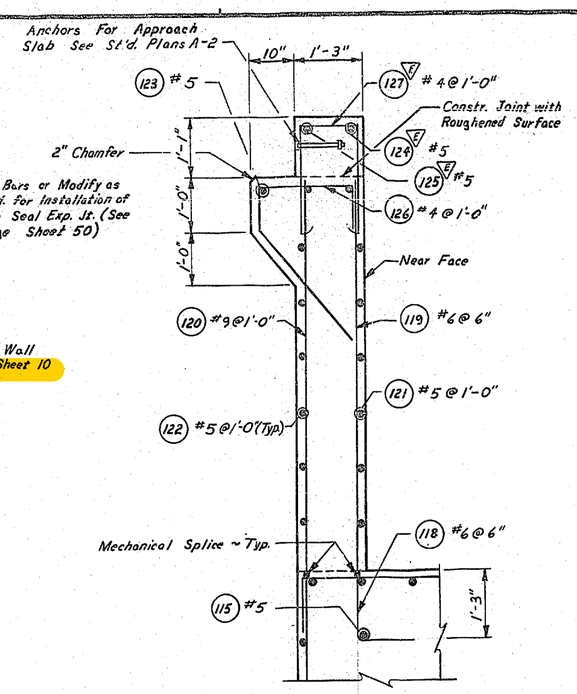


PLAN

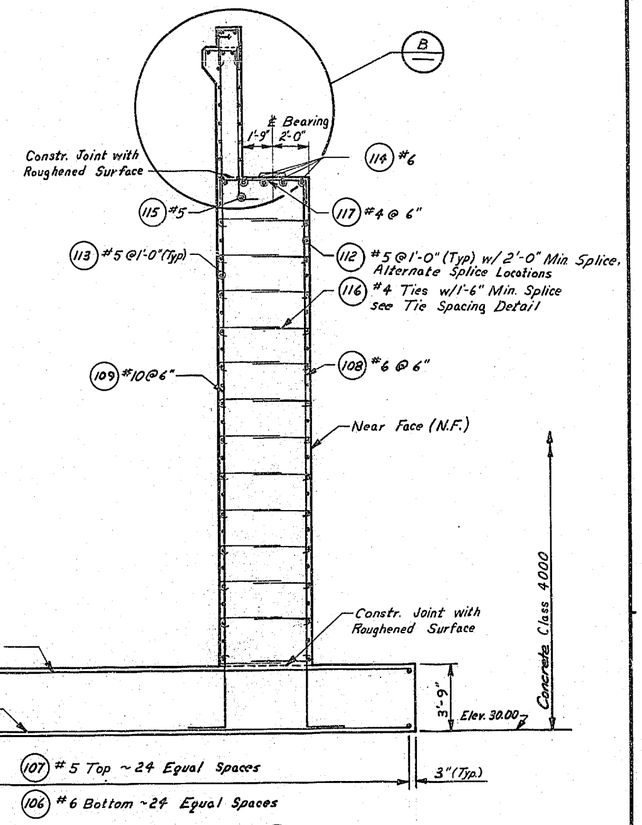


ELEVATION

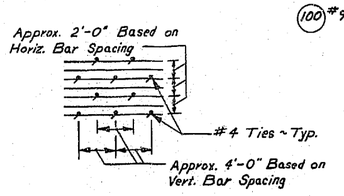
Looking Back on Station



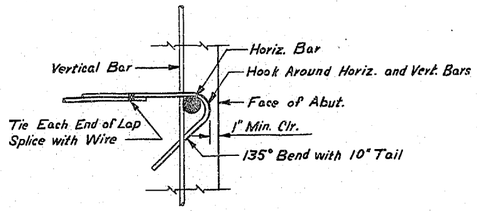
DETAIL B



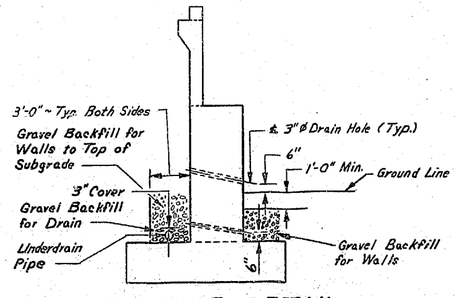
SECTION A



TIE SPACING DETAIL



TIE BAR DETAIL



DRAINAGE DETAIL

Pier	A	B	C	D	E	F	G
1	60.94	60.92	60.92	60.93	60.95	60.99	61.05

TOP OF GROUT PAD ELEVATIONS AT ℄ BEARING (1)

Bridge Design Engineer	Mjwilson 1-91				REGION NO.	STATE	FED. AID PROJ. NO.	CNTRY NO.	TOTAL SHEETS
Supervisor	R.T. Skarfan 1/91				10	WASH			
Reviewed By					JOB NUMBER		I-IR-405-3(783)		
Designed By	D.M. Dones 1/91				91W097				
Checked By	Z.Y. Fidow 1-91				CONTRACT NO.				
Detailed By	R. D. Ames 5/90				4052				
Architect		10/91	(1) Revid. Elevs., Added Stationing	RS					
Preliminary Plan By		DATE	REVISION	BY	APP'D				

BRIDGES AND STRUCTURES

10-13-91
APPROVED

Washington State Department of Transportation

SR 405
SOUTH RENTON TO SUNSET BLVD. HOV
CEDAR RIVER & BNRR O'XING
BR. 405/18 E&W REPLACEMENT

PIER 1 LS

BRIDGE SHEET NO. 8

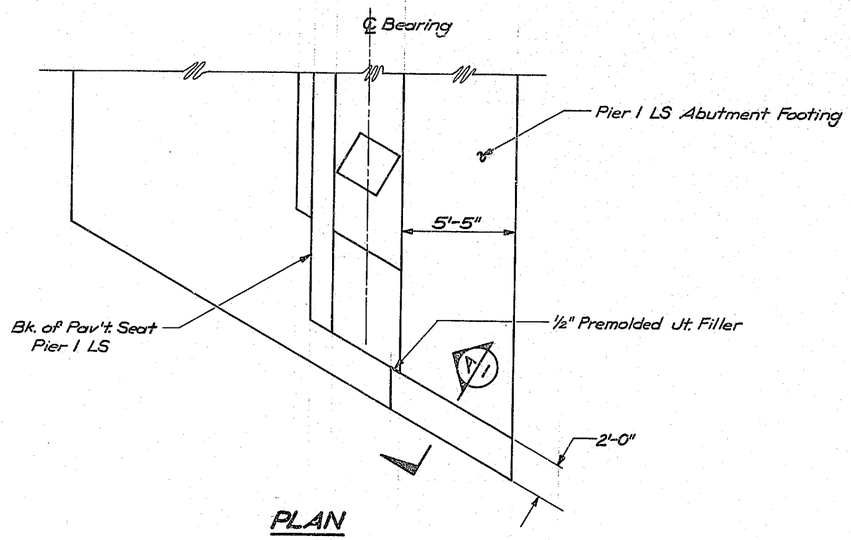
SHEET 234 OF 634 SHEETS

JOB NO. SHEET SR

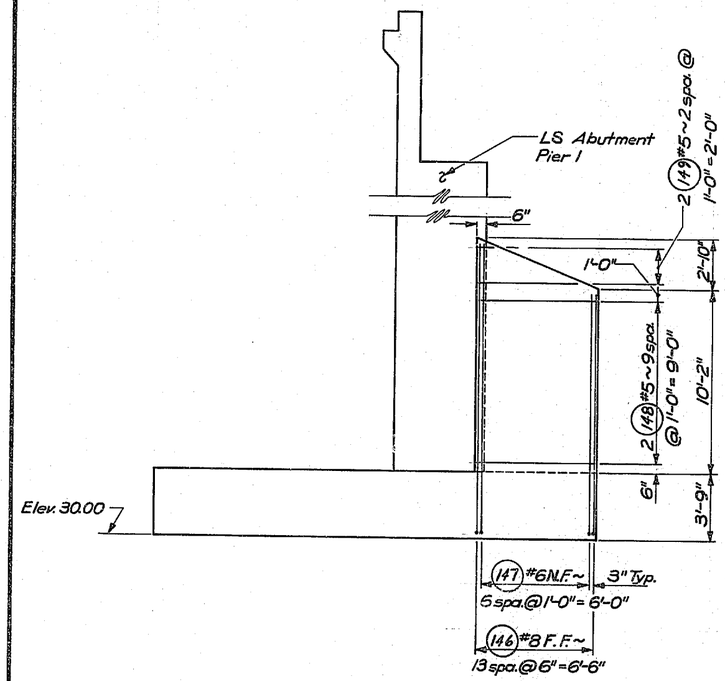
K-E 111165 DOT FORM 221-013 Revised 9/82

SR 405/13.5

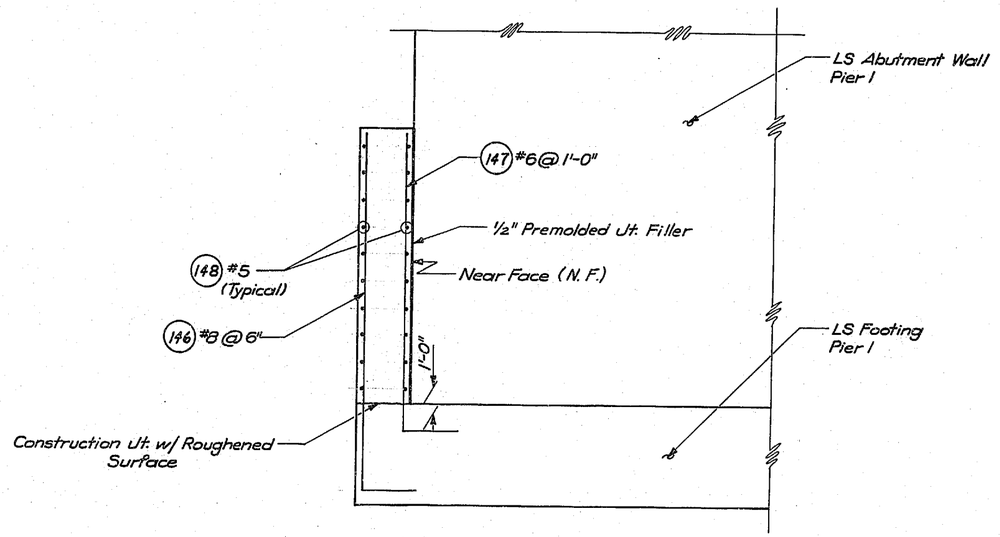
205/199



PLAN



ELEVATION



SECTION (A)

Bridge Design Engineer	Mgmtfsin 1-91									
Supervisor	R.T. Sheaffer 1/91									
Reviewed By										
Designed By	D.M. Jones 11/91									
Checked By	Z.Y. Fabian 1-91									
Detailed By	B.H. Crews 9/90									
Architect										
Preliminary Plan By										
	DATE	REVISION		BY	APP'D					

JOB NO. — SHEET — OF — SHEETS

H∑ 111103 DOT FORM 221-013 Revised 9/92

REGION NO.	STATE	FED. AID PROJ. NO.	SHEET NO.	TOTAL SHEETS
10	WASH	I-IR-405-3(783)		
JOB NUMBER 91W097				
CONTRACT NO. 4052				

BRIDGES AND STRUCTURES

10/13/91
APPROVED

ALLAN A. WALTER — STATE OF WASHINGTON — 10247 — REGISTERED PROFESSIONAL ENGINEER

Washington State Department of Transportation

SR 405
SOUTH RENTON TO SUNSET BLVD. HOV
CEDAR RIVER & BNRR O'XING
BR. 405/18 E&W REPLACEMENT

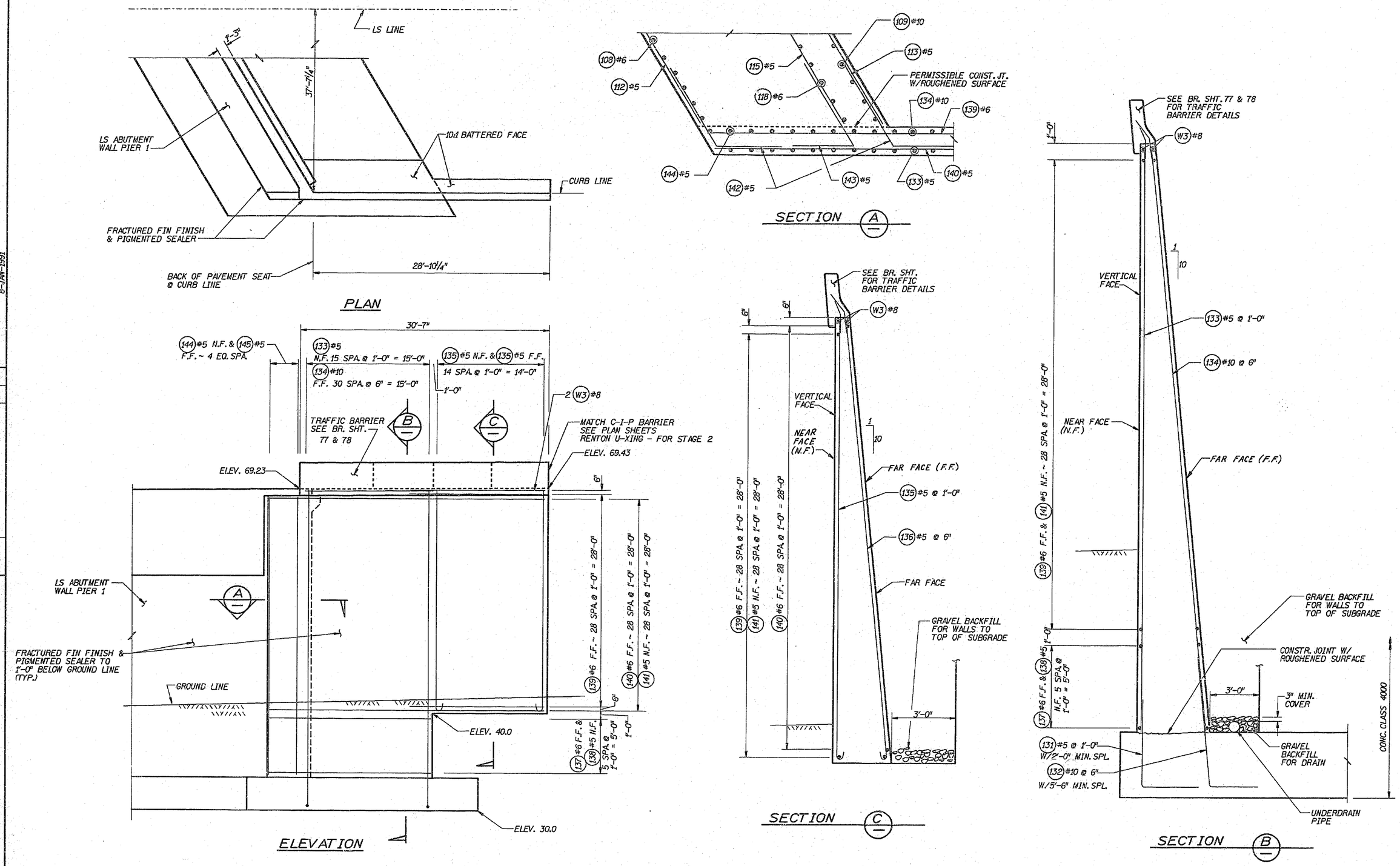
PIER 1 LS ~ CURTAIN WALL

BRIDGE SHEET NO. 9

SHEET 235 OF 634 SHEETS

SR 405/135

205/198



Bridge Design Engr. Myinthwin 1-91					REGION NO.	STATE	FED.AID PROJ.NO.	SHEET NO.	TOTAL SHEETS	BRIDGE AND STRUCTURES OFFICE
Supervisor R.T. Shaefer 1/91					10	WASH.	I-IR-405-3(783)			
Designed By D.M. JONES 9-90					JOB NUMBER 91W097					
Checked By Z.Y. Fahoun 1-91					CONTRACT NO 4052					
Detailed By V.S. NGUYEN 9-90										
Bridge Projects Engr.										
Preliminary Plan By										
Architect/Specialist	DATE	REVISION	BY	APP'D						

DATE 10.13.91

1 ZGA5:[105.6]WA405Z18.DGN;1

Washington State Department of Transportation

SR 405
SOUTH RENTON TO SUNSET BLVD. HOV
CEDAR RIVER & BNRR O'XING
BR. 405/18 E&W REPLACEMENT

PIER 1 LS ~ NORTH CURTAIN WALL

BRIDGE SHEET NO. 10

SHEET 236 OF 634 SHEETS

DOT FORM 221-013 Revised 11/83

SR 405 JOB NO. 1562 SHEET 10 OF

SR 405/135

205/197

8-JAN-1991

FLATIRON | LANE | wood.

In Association with

Appendix G.2
Existing Bridge 17.7 Pier 1 Bearing Capacity Calculations

LRFD Foundation Design — **Spreadsheet Reference Section 10.6.3.1.2 of The 2014 AASHTO LRFD Bridge Design Specifications**

Date/Time:	12/6/2021
Project Name:	**Bridge 17.7W - Existing Pier 1 - Strip Footing - ESU 7A**
Project No.:	**00180-366-01**

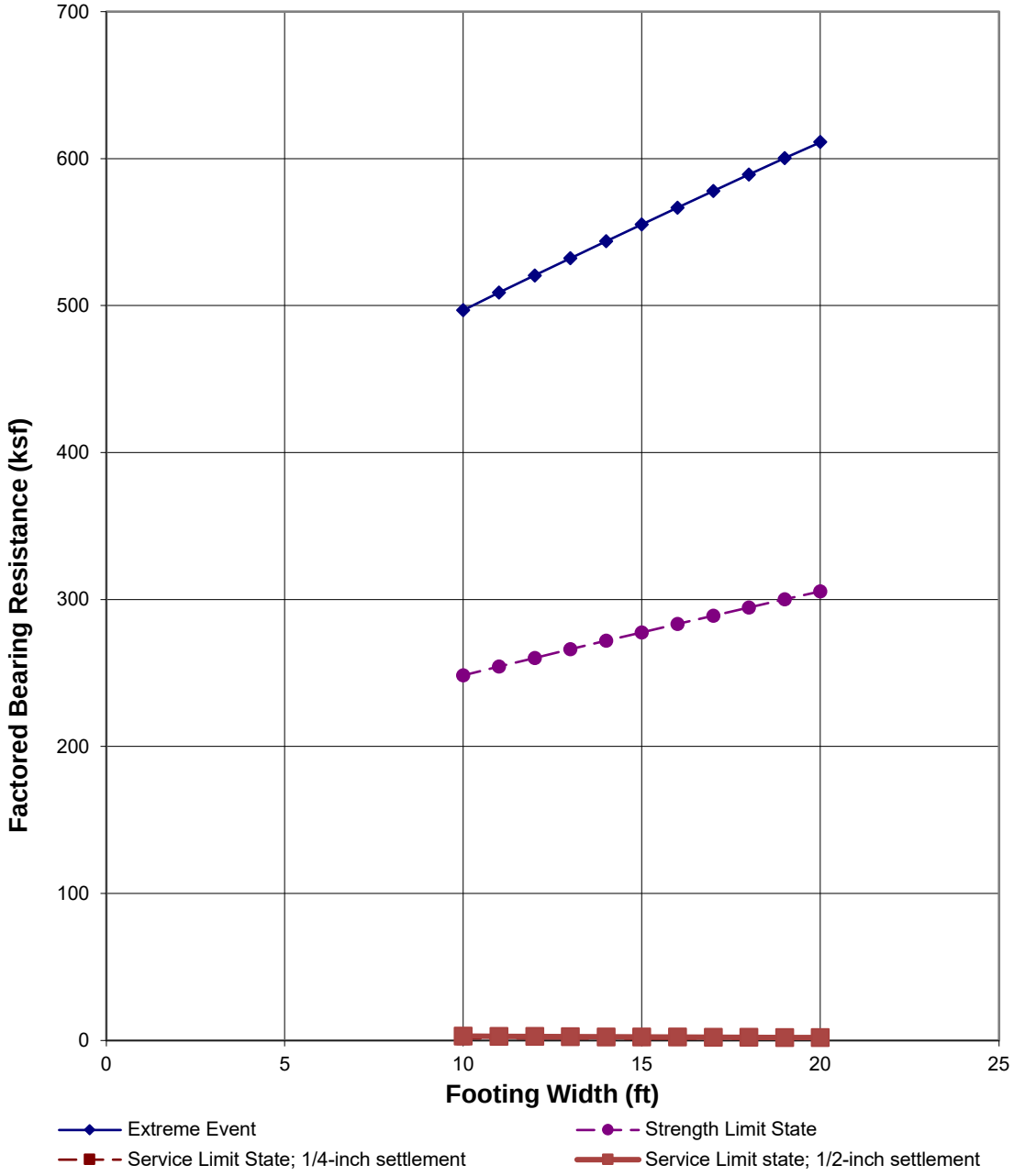
Foundation Soil Conditions	
Unit Weight, γ (pcf)	**135**
Friction angle, Φ (degrees)	**42**
Friction angle, Φ (rad)	0.733
Cohesion, C (psf)	**0**
Embedment, D_f (ft)	**36**
Depth to Groundwater, D_w (ft)	**29**
Footing Length, L (ft)	**41.7**
Footing Width, B (ft)	**12**
Poissons Ration, ν	**0.32**
Young's Modulus, E_s (ksf)	**1107**

Bearing Capacity Factors	
N_γ	156
N_c	94
N_q	85

Footing Width, B	**Water Depth Factors**		**Shape Factors**			**Unfactored Bearing Resistance**	**Extreme Event Resistance** Resistance Factor (0.9) bearing resistance for seismic loading (Section 8.10; 2014 WSDOT GDM)	**Working Bearing Resistance** Resistance Factor (0.45) Theoretical method in sand (0.50) Theoretical method in clay (Table 10.5.5.2.2-1)	Deflection from Elastic Settlement Spreadsheet **1/4" Deflection**	Deflection from Elastic Settlement Spreadsheet **1/2" Deflection**
	C_{wq}	$C_{w\gamma}$	Sc	S_γ	Sq					
(ft)						(ksf)	(ksf)	(ksf)	(ksf)	(ksf)
10.0	1.0	0.5	1.22	0.90	1.22	552.1	496.9	248.5	1.5	3.0
11.0	1.0	0.5	1.24	0.89	1.24	565.3	508.8	254.4	1.4	2.8
12.0	1.0	0.5	1.26	0.88	1.26	578.3	520.5	260.3	1.3	2.7
13.0	1.0	0.5	1.28	0.88	1.28	591.3	532.2	266.1	1.3	2.6
14.0	1.0	0.5	1.31	0.87	1.30	604.2	543.7	271.9	1.2	2.4
15.0	1.0	0.5	1.33	0.86	1.32	616.9	555.2	277.6	1.2	2.3
16.0	1.0	0.5	1.35	0.85	1.35	629.6	566.6	283.3	1.1	2.2
17.0	1.0	0.5	1.37	0.84	1.37	642.1	577.9	288.9	1.1	2.2
18.0	1.0	0.5	1.39	0.83	1.39	654.6	589.1	294.5	1.0	2.1
19.0	1.0	0.5	1.42	0.82	1.41	666.9	600.2	300.1	1.0	2.0
20.0	1.0	0.5	1.44	0.81	1.43	679.2	611.2	305.6	1.0	2.0

Note: Depth and inclination modifier were taken as 1 because the load is applied axially and during construction the soils above the footing were excavated.

Figure D.8-8



*Assumes Footing Length of 41.7 feet

GeoEngineers
Earth Science + Technology

Shallow Strip Foundation Design

Figure D.8-9

Bridge 17.7 - Existing Pier 1 (ESU 7A)
Bearing Capacity Summary

Footing Width	Footing Length	Unfactored Bearing Resistance	Extreme Event Resistance[a]	Strength Bearing Resistance[b]	Service Limit State	
					1/4" Deflection	1/2" Deflection
(ft)	(ft)	(ksf)	(ksf)	(ksf)	(ksf)	(ksf)
10.0	41.7	552.1	496.9	248.5	1.5	3.0
11.0	41.7	565.3	508.8	254.4	1.4	2.8
12.0	41.7	578.3	520.5	260.3	1.3	2.7
13.0	41.7	591.3	532.2	266.1	1.3	2.6
14.0	41.7	604.2	543.7	271.9	1.2	2.4
15.0	41.7	616.9	555.2	277.6	1.2	2.3
16.0	41.7	629.6	566.6	283.3	1.1	2.2
17.0	41.7	642.1	577.9	288.9	1.1	2.2
18.0	41.7	654.6	589.1	294.5	1.0	2.1
19.0	41.7	666.9	600.2	300.1	1.0	2.0
20.0	41.7	679.2	611.2	305.6	1.0	2.0

Notes:
a. Resistance Factor (0.9) bearing resistance for seismic loading (Section 8.10; 2014 WSDOT GDM)
b. Resistance Factor (0.45) Theoretical method in sand (0.50) Theoretical method in clay (Table 10.5.5.2.2-1)

Figure D.8-10

FLATIRON | LANE | wood.

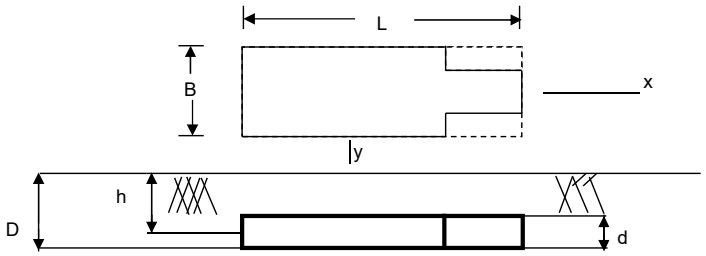
In Association with

Appendix G.3
Existing Bridge 17.7 Pier 1 Shallow Foundation Seismic Spring Calculations

Foundation Spring Constants

Project:	**WSDOT I-405 Renton to Bellevue Widening**
Owner:	**WSDOT**
Job Number:	**00180-366-01**
Analysis by:	**IAH**
Date/Time:	**10/18/2021**
Foundation soil:	**ESU 7A**
Foundation:	**Pier 1 Existing Spread Footing**
EQ Return Interval	**SEE**
FEMA 356	

B	12	ft
L	41.7	ft
D	8.5	ft
d	3.5	ft
h	6.75	ft



ESU	7A	
υ	0.36	
G_0	2018.1	ksf
$(N_1)_{60}$	58	
γ_{total}	135	pcf
D_w	1	ft
σ'_o	679.5	psf
Site Class	C	
$S_{XS}/2.5$	0.51	
G/G_0	0.71	*From Table 4-7 (FEMA 356)
G	1430.3	ksf

h	Distance of the effective sidewall centroid from ground surf
Vso	Shear wave velocity
υ	Poissons ratio
G_o	Initial Shear Modulus
$S_{XS}/2.5$	Effective Peak Acceleration
S_{XS}	Spectral response acceleration at short periods for the sele hazard level and damping adjusted for site class

Foundation on surface of homogeneous halfspace

Lateral x		
$K_{x,sur}$	9.248E+04	kips/ft
	7.706E+03	kips/in
Lateral y		
$K_{y,sur}$	1.028E+05	kips/ft
	8.569E+03	kips/in
Vertical		
$K_{z,sur}$	1.272E+05	kips/ft
	1.060E+04	kips/in
Rocking rx		
$K_{xx,sur}$	5.750E+06	kip-ft
	6.900E+07	kip-in
Rocking ry		
$K_{yy,sur}$	3.613E+07	kip-ft
	4.336E+08	kip-in
Torsional		
$K_{zz,sur}$	2.891E+07	kip-ft
	3.470E+08	kip-in

Foundation embedded in homogeneous halfspace

Lateral x		
Beta	1.79	
$K_{x,emb}$	1.656E+05	kips/ft
$K_{x,emb}$	1.380E+04	kips/in
Lateral y		
Beta	1.79	
$K_{y,emb}$	1.842E+05	kips/ft
$K_{y,emb}$	1.535E+04	kips/in
Vertical		
Beta	1.27	
$K_{z,emb}$	1.621E+05	kips/ft
$K_{z,emb}$	1.351E+04	kips/in
Rocking rx		
Beta	2.00	
$K_{xx,emb}$	1.151E+07	kip-ft
$K_{xx,emb}$	1.381E+08	kip-in
Rocking ry		
Beta	1.49	
$K_{yy,emb}$	5.395E+07	kip-ft
$K_{yy,emb}$	6.475E+08	kip-in
Torsional		
Beta	2.10	
$K_{zz,emb}$	6.086E+07	kip-ft
$K_{zz,emb}$	7.303E+08	kip-in

Figure D.10-2