I-405, Renton to Bellevue Widening & and Express Toll Lanes Project

DOCUMENT REVIEW

☒ APPROVED, NO EXCEPTION TAKEN
☐ APPROVED AS NOTED
☐ RESUBMIT, REVISE AS NOTED

REVIEWED BY: B. Exley DATE: 12/10/21
E. Ferluga 12/10/21

Review is for general conformance with contract or design documents. Sole responsibility for correctness of dimensions, details, quantities, materials, and safety during fabrication and erection shall remain with the contractor.

MSE Structure Calculations

Prepared for

I-405; Renton to Bellevue Widening and Express Toll Lanes Project – Wall 12.18

King County, Washington
Owner Reference No.: C9242

Client: Flatiron-Lane JV
REVISION 2

TIC Project No.:	O38650
Date:	December 8, 2021
Designed by:	Vanessa Amaya, EIT
Reviewed by:	Robert Johnson, PE (GA+)
Engineer of Record: (MSE Structure Only)	JONG LEE STATE OF WASHINGTON 53995 REGISTERED PROFESSIONAL ENGINEER Jong Lee PE No. 53995

The calculations herein are furnished for use on this specific project only and are based upon specific properties of those specific Tensar products incorporated therein which are proprietary to Tensar. Any substitution of the specified products will invalidate this design. Any party accepting this document does so in confidence and agrees that it shall not be duplicated whole or in part, nor disclosed to others, without the consent of Tensar International Corporation.

Project Summary

Tensar International Corporation (TIC) has performed the design calculations for the I-405; Renton to Bellevue Widening and Express Toll Lanes Project – Wall 12.18 Project. These calculations and related shop drawings have been prepared for Flatiron-Lane JV (Client) under contract. Design Criteria and Construction Requirements on Sheet 2 of the shop drawings presents the design parameters, the scope of work carried out by TIC, and references used to develop the design calculations. The shop drawings are issued under their own cover; the design calculations shall accompany the shop drawings at all times and shall not be made separate without the consent of TIC.

Limitations of Design

The design presented herein is based on information provided by the Client to TIC. It is subject to the conditions and assumptions in the Design Criteria and Construction Requirements on Sheet 2 of the shop drawings which accompany these calculations. As such, TIC accepts no liability for the appropriateness or verification of this information. The Client is responsible to have a qualified engineer review and verify the design parameters, notifying TIC of changes prior to construction.

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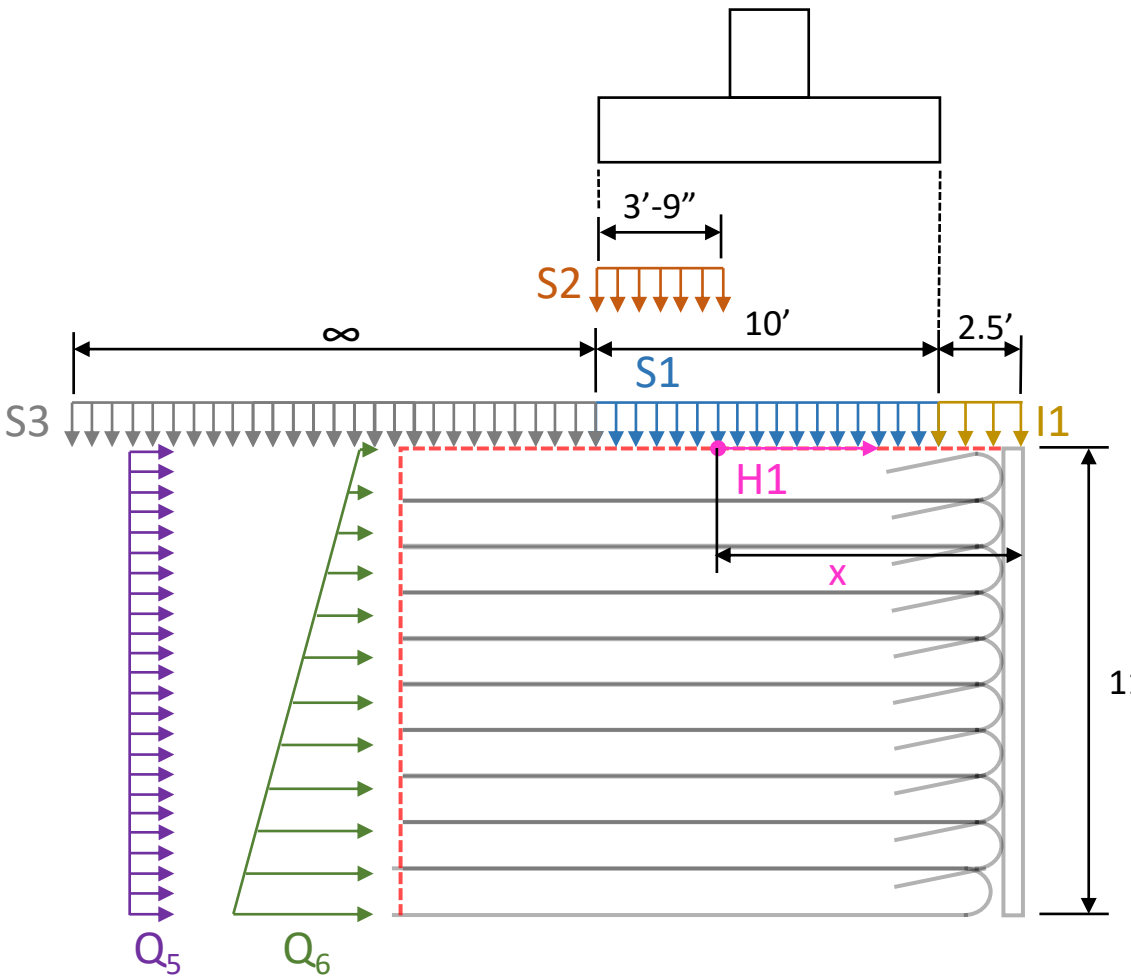
Design Case 1 - Abutment Loading Diagram (Zone C)



S1 = DC + DW + LL = 5.05 ksf

S2 = EV = 1.25 ksf

S3 = EV[1] + LL = 2.815 ksf

I1 = EV[2] = 0.473 ksf

Q_5 = LL = xx ksf (applied by MSEW from S3)

Q_6 = EH = xx ksf (applied by MSEW from S3)*

H1 = 5.31 kips/ft (Static) – given on abutment lateral loading spreadsheet

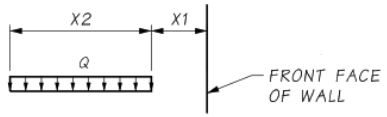
H1 = 16.12 kips/ft (Seismic) – given on abutment lateral loading spreadsheet

x = 2.5' + 7.36' (b.eff) = 9.86'

Loading Table from Contract Plans

LOADING TABLE

ZONE	LOAD TYPE	X1	X2	Q
A	N/A	-	-	-
B	DC	4'-3"	8'-3"	0.70 KSF
	EV	9'-0"	3'-6"	2.35 KSF
C	DC	2'-6"	10'-0"	3.25 KSF
	DW	2'-6"	10'-0"	1.55 KSF
	EV	8'-9"	3'-9"	1.25 KSF
	LL	2'-6"	10'-0"	0.25 KSF



LOADING DIAGRAM

Note: Load Factor of 1.5 is conservatively being used for all dead loads (ie DC, DW, EL)

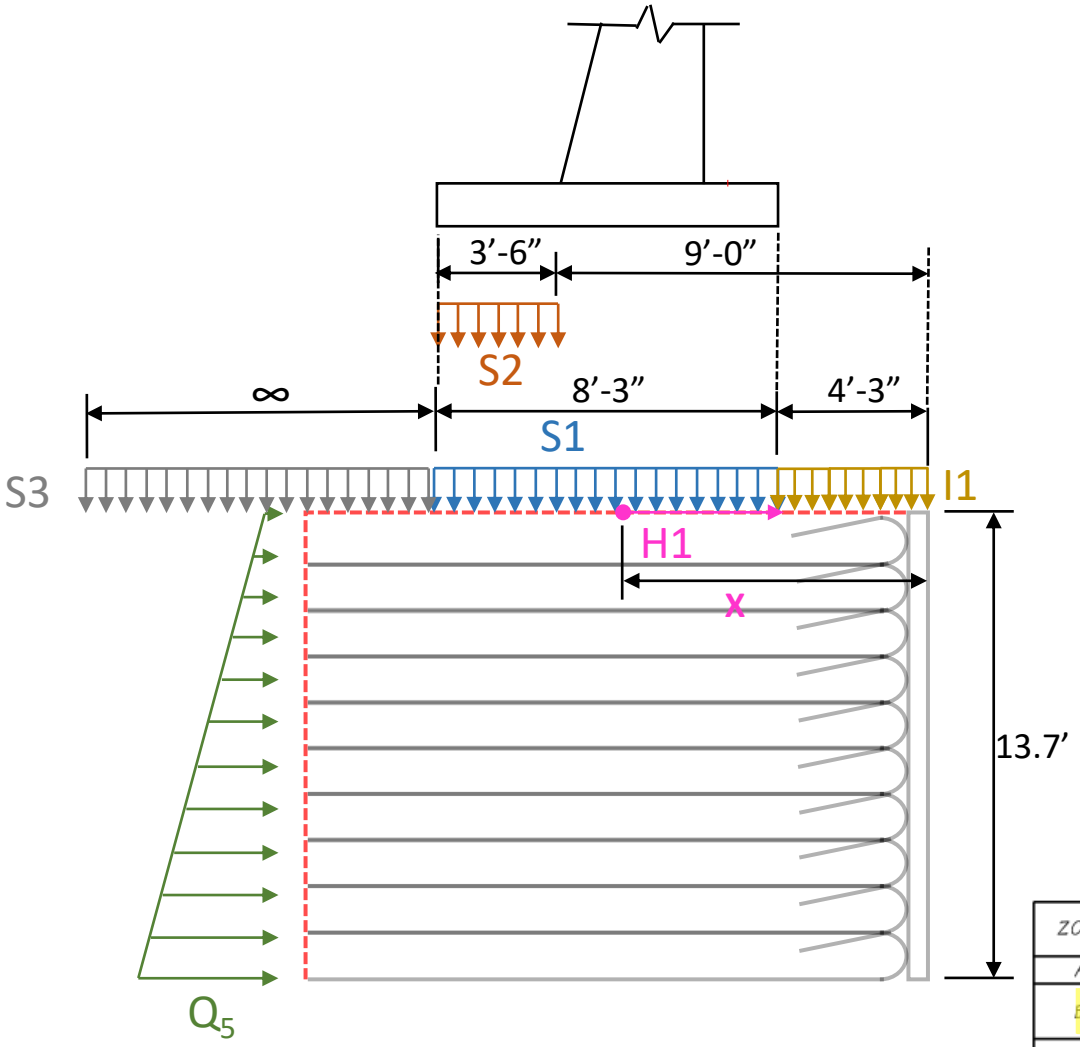
EV[1] = Grade Separation * unit weight of backfill = 19' * 135 pcf = 2565 psf

EV[2] = Grade Separation * unit weight of backfill = 3.5' * 135 pcf = 473 psf

* Horizontal Earth Pressure below GRSS Wall.

-------- GRSS Wall Pressure Surface

Design Case 2 – Wing Wall Loading Diagram (Zone B)



S1 = DC = 0.7 ksf

S2 = EV = 2.35 ksf

S3 = EV^1 = 2.365 ksf

I1 = EV^2 = 0.340 ksf

Q_5 = EH = xx ksf (applied by MSEW)*

H1 = 4.75 kips/ft (Static) – ERC Wingwall Loading by David Evans and Associates

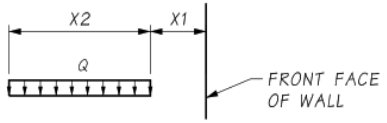
H1 = 8.06 kips/ft (Seismic) – ERC Wingwall Loading by David Evans and Associates

x = 4.25' + 9.47' (b.eff) = 13.72'

Loading Table from Contract Plans

LOADING TABLE

ZONE	LOAD TYPE	X1	X2	Q
A	N/A	-	-	-
B	DC	4'-3"	8'-3"	0.70 KSF
	EV	9'-0"	3'-6"	2.35 KSF
C	DC	2'-6"	10'-0"	3.25 KSF
	DW	2'-6"	10'-0"	1.55 KSF
	EV	8'-9"	3'-9"	1.25 KSF
	LL	2'-6"	10'-0"	0.25 KSF



LOADING DIAGRAM

Note: Load Factor of 1.5 is conservatively being used for all dead loads (ie DC, DW, EL)

EV^1 = Grade Separation * unit weight of backfill = 17.5' * 135 pcf = 2365 psf

EV^2 = Grade Separation * unit weight of backfill = 2.5' * 135 pcf = 340 psf

* Horizontal Earth Pressure below GRSS Wall.

-------- GRSS Wall Pressure Surface

AASHTO 2017-2020
I-405 D/B - Bridge 40P

MSEW+: Update # 2021.12

PROJECT IDENTIFICATION

Title: I-405 D/B - Bridge 40P
Project Number: O38650
Client: Flatiron Lane JV
Designer: VA
Station Number: DH = 11.4'

Description:

Design Case 1 (Static); Design Height = 11.4 ft.; Loading Conditions: DC = 3.25 ksf; DW = 1.55 ksf; EV = 1.25 ksf; LL = 0.25 ksf; H1 = 5.31 kips/ft

Company's information:

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File path and name: K:_ o\O38650\Final\Working Files\Design\Rev2\MSEW\Bridg..... ..... 40P - H=11.4ft.BENp

Original date and time of creating this file: Oct 2021

PROGRAM MODE: ANALYSIS of a SIMPLE STRUCTURE using GEOGRID as reinforcing material.

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SOIL DATA

REINFORCED SOIL

Unit weight, γ	135.0 lb/ft ^{3}
Design value of internal angle of friction, ϕ	38.0 °

RETAINED SOIL

Unit weight, γ	135.0 lb/ft ^{3}
Design value of internal angle of friction, ϕ	38.0 °

FOUNDATION SOIL (Considered as an equivalent uniform soil)

Equivalent unit weight, $\gamma_{equiv.}$	140.0 lb/ft ^{3}
Equivalent internal angle of friction, $\phi_{equiv.}$	43.0 °
Equivalent cohesion, $c_{equiv.}$	0.0 lb/ft ^{2}

Factored bearing capacity resistance of foundation is given: q-ult-static = 120000.0 lb/ft².

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)
Inclination of internal slip plane, ψ = 64.00° (see Fig. 28 in DEMO 82).
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 = N/A N γ= N/A

SEISMICITY

Not Applicable

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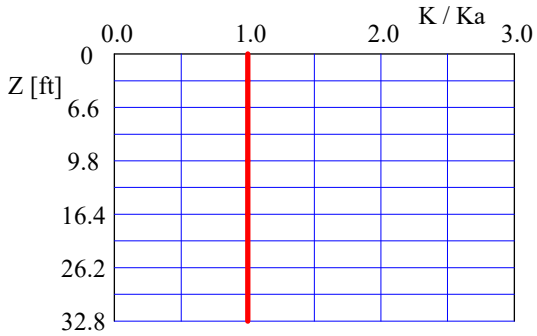
INPUT DATA: Geogrids (Analysis)

D A T A	Geogrid type #1	Geogrid type #2	Geogrid type #3	Geogrid type #4	Geogrid type #5
Tult [lb/ft]	7550.0	9000.0	14500.0		
Durability reduction factor, RFd	1.30	1.30	1.30		
Installation-damage reduction factor, RFid	1.11	1.11	1.11		
Creep reduction factor, RFc	1.51	1.51	1.51	N/A	N/A
CDR for strength	N/A	N/A	N/A		
Coverage ratio, Rc	1.000	1.000	1.000		
Friction angle along geogrid-soil interface, ρ	27.63	27.63	27.63		
Pullout resistance factor, F*	$0.67 \cdot \tan\phi$	$0.67 \cdot \tan\phi$	$0.67 \cdot \tan\phi$	N/A	N/A
Scale-effect correction factor, α	0.8	0.8	0.8		

Variation of Lateral Earth Pressure Coefficient With Depth

Z	K / Ka
0 ft	1.00
3.3 ft	1.00
6.6 ft	1.00
9.8 ft	1.00
13.1 ft	1.00
16.4 ft	1.00
19.7 ft	1.00



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INPUT DATA: Geometry and Surcharge loads (of a SIMPLE STRUCTURE)

Design height, Hd 11.40 [ft] { Embedded depth is E = 0.00 ft, and height above top of finished bottom grade is H = 11.40 ft }

Soil in front of wall is Horizontal.

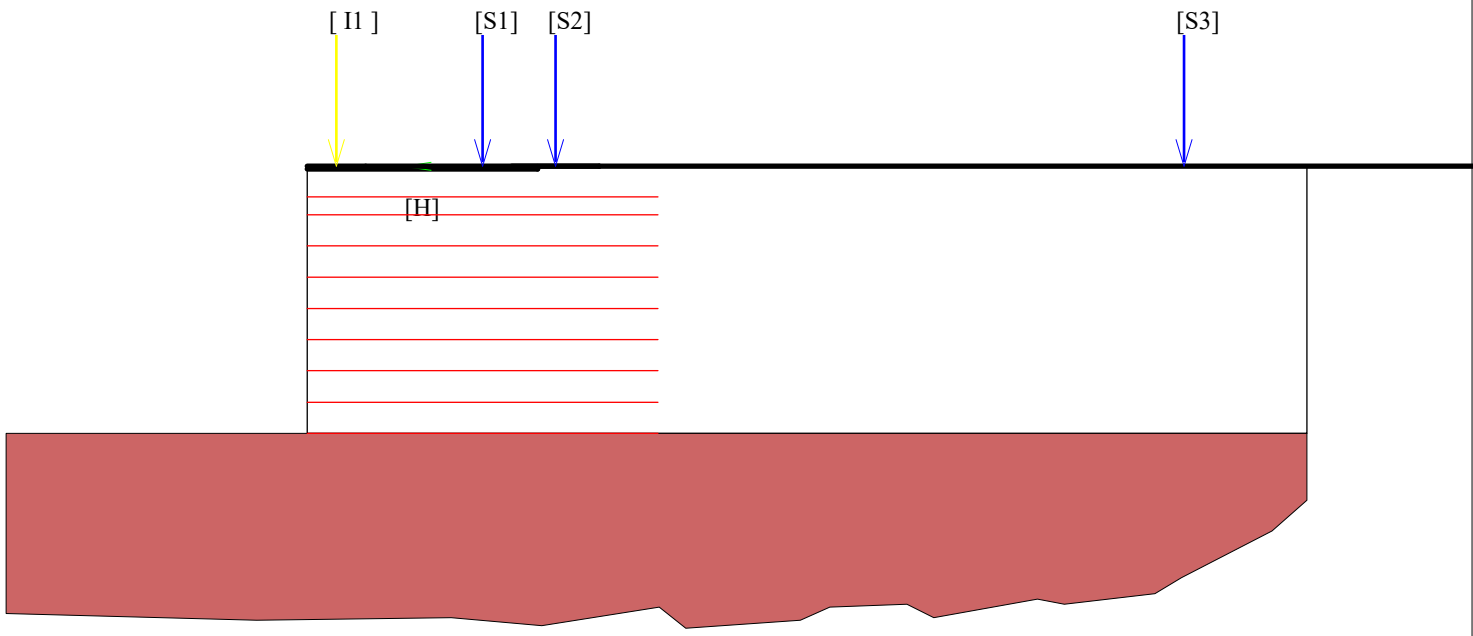
Batter, ω 0.0 [deg]
Backslope, β 0.0 [deg]
Backslope rise 0.0 [ft] Broken back equivalent angle, I = 0.00° (see Fig. 25 in DEMO 82)

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]

OTHER EXTERNAL LOAD(S)
[S1] Strip Load, Qv-d = 4800.0 and Qv-l = 250.0 [lb/ft ²].
Footing width, b=10.0 [ft]. Distance of center of footing from wall face, d = 7.5 [ft] @ depth of 0.0 [ft] below soil surface.
[S2] Strip Load, Qv-d = 1250.0 and Qv-l = 0.0 [lb/ft ²].
Footing width, b=3.8 [ft]. Distance of center of footing from wall face, d = 10.6 [ft] @ depth of 0.0 [ft] below soil surface.
[S3] Strip Load, Qv-d = 2565.0 and Qv-l = 250.0 [lb/ft ²].
Footing width, b=50.0 [ft]. Distance of center of footing from wall face, d = 37.5 [ft] @ depth of 0.0 [ft] below soil surface.
[I1] Isolated Load, Pv-d' = 50000.0 and Pv-l' = 0.0 [lb]. Length of footing, L = 42.0 [ft],
and width, b = 2.5 [ft]. Distance of center of footing from wall face, d = 1.3 [ft] @ depth of 0.0 [ft] below soil surface.
[H1] Horizontal Load, Ph = 5310.0 [lb/ft], acting at a depth of Zh = 0.0 [ft] and at a distance of Lb = 9.9 [ft].

Load Factor of 1.5 is being applied

ANALYZED REINFORCEMENT LAYOUT:



SCALE:

0 2 4 6 8 10 [ft]

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AASHTO 2017-2020 – Load and Resisting Factors

INTERNAL STABILITY

Load factor for vertical earth pressure, EV:	$\gamma_{p\text{-}EV}$	1.35
Load factor for earthquake loads, EQ:	$\gamma_{p\text{-}EQ}$	1.00
Load factor for live load surcharge, LS: (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	ϕ	Static	Combined static/seismic	
Geogrid:		0.90		1.20
Resistance factor for reinforcement tension in connectors	ϕ	Static	Combined static/seismic	
Geogrid:		0.90		1.20
Resistance factor for geosynthetic pullout	ϕ	0.90		1.20

EXTERNAL STABILITY

Load factor for vertical earth pressure, EV			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	$\gamma_{p\text{-}EH}$	1.50
Load factor of active lateral earth pressure during earthquake (does not multiply P_{AE} and P_{IR}):	$(\gamma_{p\text{-}EH})_{EQ}$	1.10
Load factor for earthquake loads, EQ (multiplies P_{AE} and P_{IR}):	$\gamma_{p\text{-}EQ}$	1.00

Resistance factor for shear resistance along common interfaces			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			Static	Combined Static/Seismic	
		ϕ_b	0.65		0.90

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ANALYSIS: CALCULATED FACTORS (Static conditions)

Bearing capacity, CDR = 8.36, factored bearing load = 9333 lb/ft².
Foundation Interface: Direct sliding, CDR = 2.943, Eccentricity, e/L = 0.1006, CDR-overturning = 3.89

GEOGRID #	Elevation [ft]	Length [ft]	Type #	CONNECTION CDR [connection break]		Geogrid strength CDR	Pullout resistance CDR	Direct sliding CDR	Eccentricity e/L	Product name
1	0.00	15.00	3	N/A	N/A	4.776	50.638	1.972	0.1006	SF180
2	1.33	15.00	3	N/A	N/A	2.344	23.443	2.089	0.0795	SF180
3	2.67	15.00	3	N/A	N/A	2.295	21.595	2.224	0.0592	SF180
4	4.00	15.00	3	N/A	N/A	2.251	19.856	2.377	0.0398	SF180
5	5.33	15.00	3	N/A	N/A	2.186	18.111	2.555	0.0212	SF180
6	6.67	15.00	3	N/A	N/A	2.105	16.211	2.766	0.0034	SF180
7	8.00	15.00	3	N/A	N/A	1.996	14.190	3.017	-0.0134	SF180
8	9.33	15.00	3	N/A	N/A	2.376	15.393	3.323	-0.0293	SF180
9	10.10	15.00	3	N/A	N/A	1.355	8.370	3.533	-0.0381	SF180

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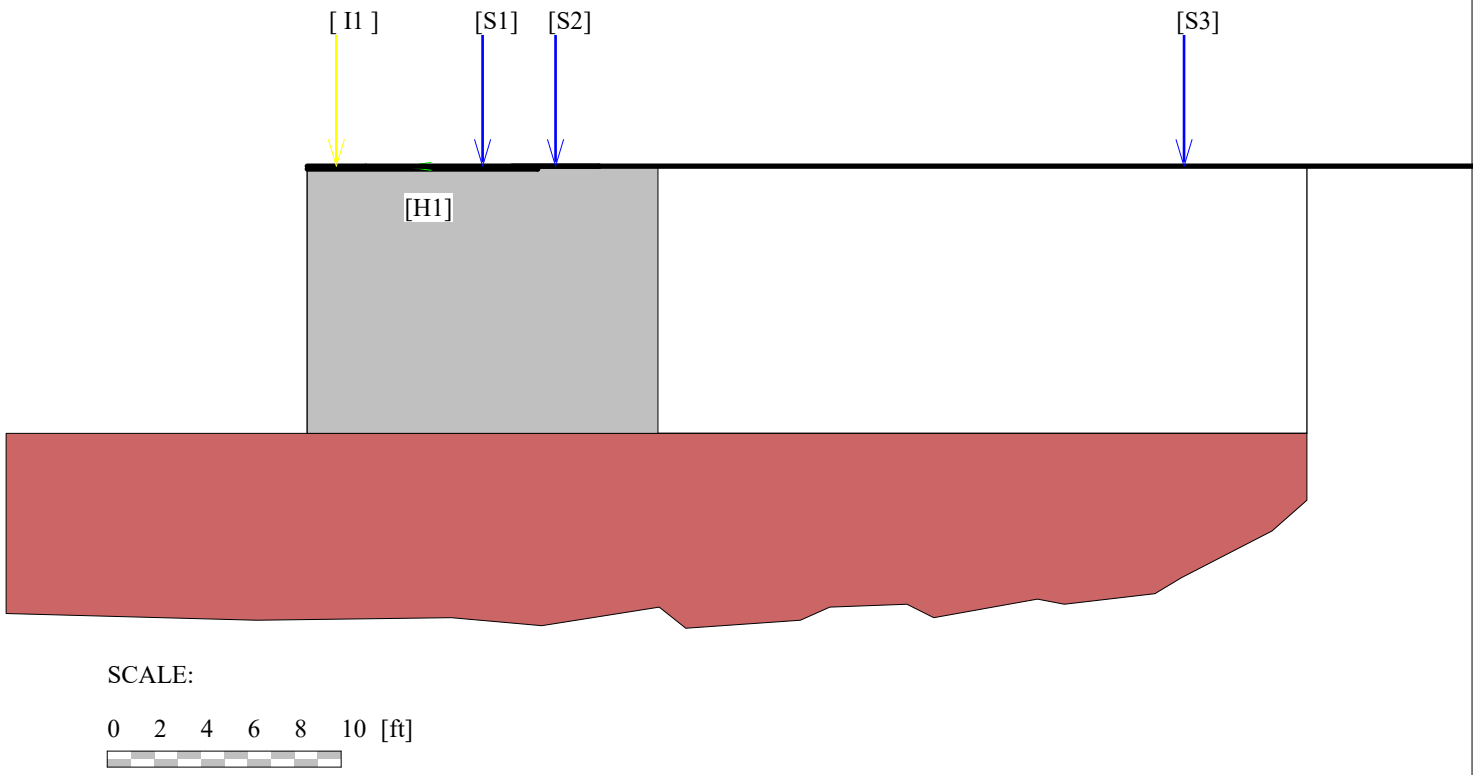
BEARING CAPACITY for GIVEN LAYOUT – Using AASHTO 2017-2020 method

	STATIC	SEISMIC	UNITS
(Given factored bearing resistance, q-n)			
Factored bearing resistance. q-n	78000	N/A	[lb/ft ²]
Factored bearing load, σ_V	9332.8	N/A	[lb/ft ²]
Eccentricity, e	0.72	N/A	[ft]
Eccentricity, e/L	0.048	N/A	
CDR calculated	8.36	N/A	
Base length	15.00	N/A	[ft]

Unfactored applied bearing pressure = (Unfactored R) / [L - 2 * (Unfactored e)] =
Unfactored R = 86500.46 [lb/ft], L = 15.00, Unfactored e = 0.73 [ft], and Sigma = 6392.49 [lb/ft ²]



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DIRECT SLIDING for GIVEN LAYOUT (for GEOGRID reinforcements)

Along reinforced and foundation soils interface: CDR-static = 2.943

#	Geogrid Elevation [ft]	Geogrid Length [ft]	CDR Static	CDR Seismic	Geogrid Type #	Product name
1	0.00	15.00	1.972	N/A	3	SF180
2	1.33	15.00	2.089	N/A	3	SF180
3	2.67	15.00	2.224	N/A	3	SF180
4	4.00	15.00	2.377	N/A	3	SF180
5	5.33	15.00	2.555	N/A	3	SF180
6	6.67	15.00	2.766	N/A	3	SF180
7	8.00	15.00	3.017	N/A	3	SF180
8	9.33	15.00	3.323	N/A	3	SF180
9	10.10	15.00	3.533	N/A	3	SF180

ECCENTRICITY for GIVEN LAYOUT

At interface with foundation: e/L static = 0.1006; Overturning: CDR-static = 3.89

#	Geogrid Elevation [ft]	Geogrid Length [ft]	e / L Static	e / L Seismic	Geogrid Type #	Product name
1	0.00	15.00	0.1006	N/A	3	SF180
2	1.33	15.00	0.0795	N/A	3	SF180
3	2.67	15.00	0.0592	N/A	3	SF180
4	4.00	15.00	0.0398	N/A	3	SF180
5	5.33	15.00	0.0212	N/A	3	SF180
6	6.67	15.00	0.0034	N/A	3	SF180
7	8.00	15.00	-0.0134	N/A	3	SF180
8	9.33	15.00	-0.0293	N/A	3	SF180
9	10.10	15.00	-0.0381	N/A	3	SF180

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RESULTS for STRENGTH

Live Load included in calculating Tmax

#	Geogrid Elevation [ft]	Factored LTDS [lb/ft]	Factored Tmax [lb/ft]	Tmd [lb/ft]	Specified minimum CDR Static	Actual calculated CDR Static	Specified minimum CDR seismic	Actual calculated CDR seismic	Product name
1	0.00	5989.2	1254.1	N/A	N/A	4.776	N/A	N/A	SF180
2	1.33	5989.2	2555.5	N/A	N/A	2.344	N/A	N/A	SF180
3	2.67	5989.2	2610.1	N/A	N/A	2.295	N/A	N/A	SF180
4	4.00	5989.2	2661.0	N/A	N/A	2.251	N/A	N/A	SF180
5	5.33	5989.2	2739.4	N/A	N/A	2.186	N/A	N/A	SF180
6	6.67	5989.2	2844.9	N/A	N/A	2.105	N/A	N/A	SF180
7	8.00	5989.2	3000.7	N/A	N/A	1.996	N/A	N/A	SF180
8	9.33	5989.2	2520.9	N/A	N/A	2.376	N/A	N/A	SF180
9	10.10	5989.2	4420.3	N/A	N/A	1.355	N/A	N/A	SF180

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.

#	Geogrid Elevation [ft]	Coverage Ratio	Factored: Stat./Seis. Tmax [lb/ft]	Tmd [lb/ft]	Le (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	1254.1	N/A	15.00	0.00	63505.6	N/A	50.638	N/A	N/A	N/A
2	1.33	1.000	2555.5	N/A	14.35	0.65	59908.4	N/A	23.443	N/A	N/A	N/A
3	2.67	1.000	2610.1	N/A	13.70	1.30	56365.1	N/A	21.595	N/A	N/A	N/A
4	4.00	1.000	2661.0	N/A	13.05	1.95	52837.6	N/A	19.856	N/A	N/A	N/A
5	5.33	1.000	2739.4	N/A	12.40	2.60	49613.5	N/A	18.111	N/A	N/A	N/A
6	6.67	1.000	2844.9	N/A	11.75	3.25	46117.9	N/A	16.211	N/A	N/A	N/A
7	8.00	1.000	3000.7	N/A	11.10	3.90	42578.9	N/A	14.190	N/A	N/A	N/A
8	9.33	1.000	2520.9	N/A	10.45	4.55	38805.1	N/A	15.393	N/A	N/A	N/A
9	10.10	1.000	4420.3	N/A	10.07	4.93	36997.4	N/A	8.370	N/A	N/A	N/A

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AASHTO 2017-2020
I-405 D/B - Bridge 40P

MSEW+: Update # 2021.12

PROJECT IDENTIFICATION

Title: I-405 D/B - Bridge 40P
Project Number: O38650
Client: Flatiron Lane JV
Designer: VA
Station Number: DH = 11.4'

Description:

Design Case 1 (Seismic); Design Height = 11.4 ft.; Loading Conditions: DC = 3.25 ksf; DW = 1.55 ksf; EV = 1.25 ksf; LL = 0.25 ksf; H1 = 16.12 kips/ft

Company's information:

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Suite 500
Alpharetta, GA 30009
Telephone #: (770) 344-2090
Fax #: (770) 344-2084
E-Mail: vamaya@tensarcorp.com

File path and name: K:_ o\O38650\Final\Working Files\Design\Rev2\MSEW\Bridg..... .....1.4ft - Seismic.BENp

Original date and time of creating this file: Oct 2021

PROGRAM MODE: ANALYSIS
of a SIMPLE STRUCTURE
using GEOGRID as reinforcing material.

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SOIL DATA

REINFORCED SOIL

Unit weight, γ	135.0 lb/ft ^{3}
Design value of internal angle of friction, ϕ	38.0 °

RETAINED SOIL

Unit weight, γ	135.0 lb/ft ^{3}
Design value of internal angle of friction, ϕ	38.0 °

FOUNDATION SOIL (Considered as an equivalent uniform soil)

Equivalent unit weight, $\gamma_{equiv.}$	140.0 lb/ft ^{3}
Equivalent internal angle of friction, $\phi_{equiv.}$	43.0 °
Equivalent cohesion, $c_{equiv.}$	0.0 lb/ft ^{2}

Factored bearing capacity resistance of foundation is given: q-ult-static = 120000.0 lb/ft^2., q-ult-sesmic = 120000.0 lb/ft^2.

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)
Inclination of internal slip plane, ψ = 64.00° (see Fig. 28 in DEMO 82).
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 = N/A N γ= N/A

SEISMICITY (using AASHTO 2017-2020)

Peak ground acceleration coeff., A = PGA = 0.417 and Site Factor, Fpga = 1.183. Maximum ground acceleration coeff., As = 0.493
Design acceleration coefficient in Internal Stability: Kh = Am = 0.247
Design acceleration coefficient in External Stability: Kh_d = 0.247 => Kh = Am = 0.247

Kae (Kh > 0) = 0.3878 Kae (Kh = 0) = 0.2379
Seismic soil-geogrid friction coefficient, F* is 80.0% of its specified static value.

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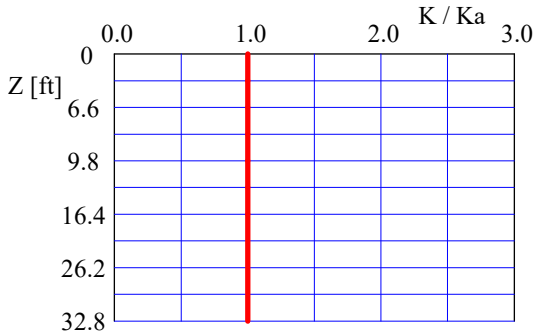
INPUT DATA: Geogrids (Analysis)

D A T A	Geogrid type #1	Geogrid type #2	Geogrid type #3	Geogrid type #4	Geogrid type #5
Tult [lb/ft]	7550.0	9000.0	14500.0		
Durability reduction factor, RFd	1.30	1.30	1.30		
Installation-damage reduction factor, RFid	1.11	1.11	1.11		
Creep reduction factor, RFc	1.51	1.51	1.51	N/A	N/A
CDR for strength	N/A	N/A	N/A		
Coverage ratio, Rc	1.000	1.000	1.000		
Friction angle along geogrid-soil interface, ρ	27.63	27.63	27.63		
Pullout resistance factor, F*	$0.67 \cdot \tan\phi$	$0.67 \cdot \tan\phi$	$0.67 \cdot \tan\phi$	N/A	N/A
Scale-effect correction factor, α	0.8	0.8	0.8		

Variation of Lateral Earth Pressure Coefficient With Depth

Z	K / Ka
0 ft	1.00
3.3 ft	1.00
6.6 ft	1.00
9.8 ft	1.00
13.1 ft	1.00
16.4 ft	1.00
19.7 ft	1.00



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INPUT DATA: Geometry and Surcharge loads (of a SIMPLE STRUCTURE)

Design height, Hd 11.40 [ft] { Embedded depth is E = 0.00 ft, and height above top of finished bottom grade is H = 11.40 ft }

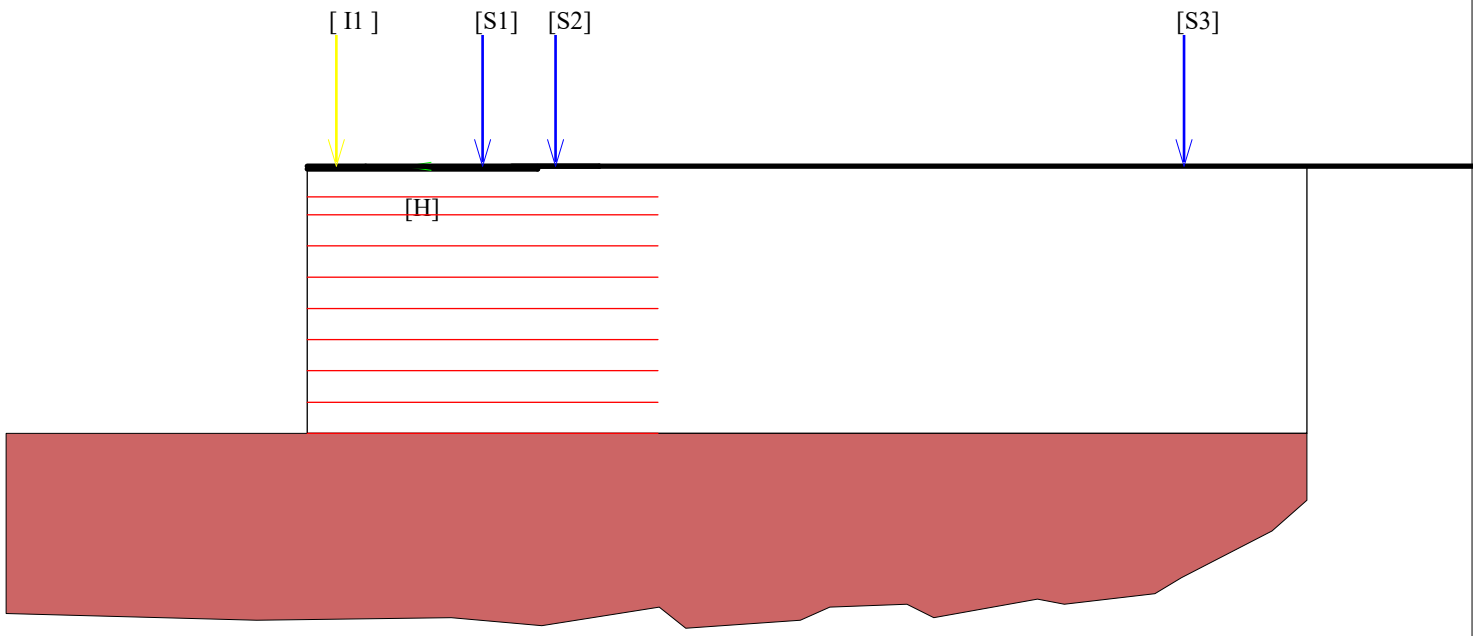
Soil in front of wall is Horizontal.

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]

OTHER EXTERNAL LOAD(S)
[S1] Strip Load, Qv-d = 4800.0 and Qv-l = 250.0 [lb/ft ²].
Footing width, b=10.0 [ft]. Distance of center of footing from wall face, d = 7.5 [ft] @ depth of 0.0 [ft] below soil surface.
[S2] Strip Load, Qv-d = 1250.0 and Qv-l = 0.0 [lb/ft ²].
Footing width, b=3.8 [ft]. Distance of center of footing from wall face, d = 10.6 [ft] @ depth of 0.0 [ft] below soil surface.
[S3] Strip Load, Qv-d = 2565.0 and Qv-l = 250.0 [lb/ft ²].
Footing width, b=50.0 [ft]. Distance of center of footing from wall face, d = 37.5 [ft] @ depth of 0.0 [ft] below soil surface.
[I1] Isolated Load, Pv-d' = 50000.0 and Pv-l' = 0.0 [lb]. Length of footing, L = 42.0 [ft], and width, b = 2.5 [ft]. Distance of center of footing from wall face, d = 1.3 [ft] @ depth of 0.0 [ft] below soil surface.
[H1] Horizontal Load, Ph = 16120.0 [lb/ft], acting at a depth of Zh = 0.0 [ft] and at a distance of Lb = 9.9 [ft].

ANALYZED REINFORCEMENT LAYOUT:



SCALE:

0 2 4 6 8 10 [ft]

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AASHTO 2017-2020 – Load and Resisting Factors

INTERNAL STABILITY

Load factor for vertical earth pressure, EV:	$\gamma_{p\text{-}EV}$	1.35
Load factor for earthquake loads, EQ:	$\gamma_{p\text{-}EQ}$	1.00
Load factor for live load surcharge, LS: (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	ϕ	Static	Combined static/seismic
Geogrid:		0.90	1.20

Resistance factor for reinforcement tension in connectors	ϕ	Static	Combined static/seismic
Geogrid:		0.90	1.20

Resistance factor for geosynthetic pullout	ϕ	0.90	1.20

EXTERNAL STABILITY

Load factor for vertical earth pressure, EV			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	$\gamma_{p\text{-}EH}$	1.50
Load factor of active lateral earth pressure during earthquake (does not multiply P_{AE} and P_{IR}):	$(\gamma_{p\text{-}EH})_{EQ}$	1.10
Load factor for earthquake loads, EQ (multiplies P_{AE} and P_{IR}):	$\gamma_{p\text{-}EQ}$	1.00

Resistance factor for shear resistance along common interfaces		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	Static	Combined Static/Seismic
ϕ_b	0.65	0.90

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ANALYSIS: CALCULATED FACTORS (Static conditions)

Bearing capacity, CDR = 6.55, factored bearing load = 11900 lb/ft².
Foundation Interface: Direct sliding, CDR = 1.699, Eccentricity, e/L = 0.2484, CDR-overturning = 1.88

Refer to previous MSEW calc for static condition.

GEOGRID #	Elevation [ft]	Length [ft]	Type #	CONNECTION CDR [connection break]	Geogrid strength CDR	Pullout resistance CDR	Direct sliding CDR	Eccentricity e/L	Product name
1									F180
2									F180
3									F180
4	4.00	15.00	3	N/A	1.492	13.165	1.202	0.1460	SF180
5	5.33	15.00	3	N/A	1.413	11.707	1.222	0.1116	SF180
6	6.67	15.00	3	N/A	1.335	10.283	1.242	0.0766	SF180
7	8.00	15.00	3	N/A	1.254	8.917	1.262	0.0413	SF180
8	9.33	15.00	3	N/A	1.490	9.651	1.280	0.0054	SF180
9	10.10	15.00	3	N/A	0.854	5.278	1.290	-0.0158	SF180

ANALYSIS: CALCULATED FACTORS (Seismic conditions)

Bearing capacity, CDR = 7.39, factored bearing load = 14615 lb/ft².
Foundation Interface: Direct sliding, CDR = 1.563, Eccentricity, e/L = 0.3457, Fs-overturning = 1.40

GEOGRID #	Elevation [ft]	Length [ft]	Type #	CONNECTION CDR [connection break]	Geogrid strength CDR	Pullout resistance CDR	Direct sliding CDR	Eccentricity e/L	Product name
1	0.00	15.00	3	N/A	6.360	52.302	1.047	0.3457	SF180
2	1.33	15.00	3	N/A	3.152	24.833	1.102	0.2979	SF180
3	2.67	15.00	3	N/A	3.004	22.285	1.164	0.2503	SF180
4	4.00	15.00	3	N/A	2.876	20.012	1.234	0.2037	SF180
5	5.33	15.00	3	N/A	2.734	17.879	1.316	0.1575	SF180
6	6.67	15.00	3	N/A	2.594	15.775	1.412	0.1112	SF180
7	8.00	15.00	3	N/A	2.445	13.741	1.527	0.0654	SF180
8	9.33	15.00	3	N/A	2.896	14.801	1.666	0.0196	SF180
9	10.10	15.00	3	N/A	1.685	8.257	1.723	-0.0070	SF180

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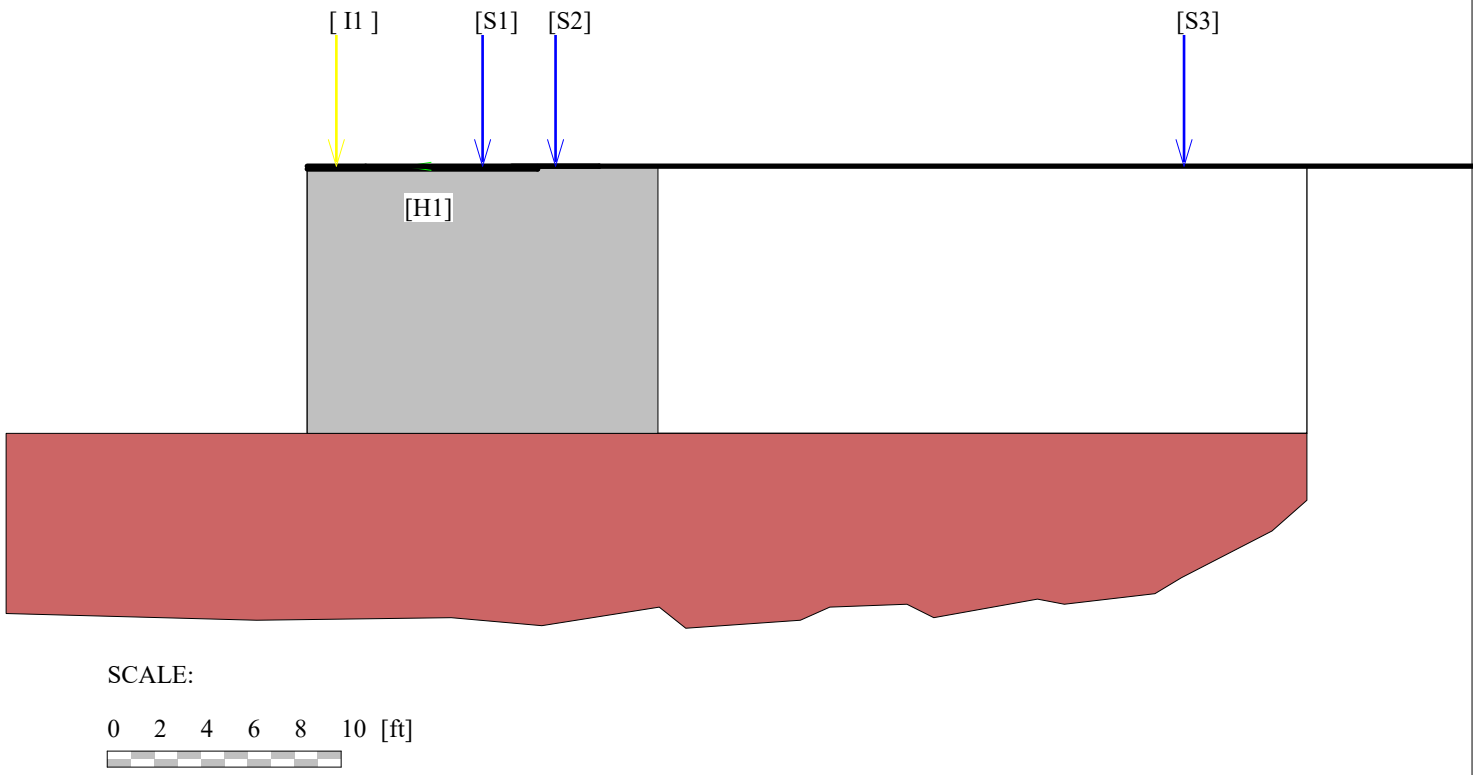
BEARING CAPACITY for GIVEN LAYOUT – Using AASHTO 2017-2020 method

	STATIC	SEISMIC	UNITS
(Given factored bearing resistance, q-n)			
Factored bearing resistance. q-n	78000	108000	[lb/ft ²]
Factored bearing load, σ_V	11899.6	14615	[lb/ft ²]
Eccentricity, e	2.19	3.16	[ft]
Eccentricity, e/L	0.146	0.211	
CDR calculated	6.55	7.39	
Base length	15.00	15.00	[ft]

Unfactored applied bearing pressure = (Unfactored R) / [L - 2 * (Unfactored e)] =
Static: Unfactored R = 86500.46 [lb/ft], L = 15.00, Unfactored e = 2.16 [ft], and Sigma = 8097.59 [lb/ft ²]
Seismic: Unfactored R = 86500.46 [lb/ft], L = 15.00, Unfactored e = 3.33 [ft], and Sigma = 10367.11 [lb/ft ²]



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DIRECT SLIDING for GIVEN LAYOUT (for GEOGRID reinforcements)

Along reinforced and foundation soils interface: CDR-static = 1.699 and CDR-seismic = 1.563

#	Geogrid Elevation [ft]	Geogrid Length [ft]	CDR Static	CDR Seismic	Geogrid Type #	Product name
1	0.00	15.00	1.138	1.047	3	SF180
2	1.33	15.00	1.159	1.102	3	SF180
3	2.67	15.00	1.181	1.164	3	SF180
4	4.00	15.00	1.202	1.234	3	SF180
5	5.33	15.00	1.222	1.316	3	SF180
6	6.67	15.00	1.242	1.412	3	SF180
7	8.00	15.00	1.262	1.527	3	SF180
8	9.33	15.00	1.280	1.666	3	SF180
9	10.10	15.00	1.290	1.723	3	SF180

ECCENTRICITY for GIVEN LAYOUT

At interface with foundation: e/L static = 0.2484, e/L seismic = 0.3457; Overturning: CDR-static = 1.88, CDR-seismic = 1.40

#	Geogrid Elevation [ft]	Geogrid Length [ft]	e / L Static	e / L Seismic	Geogrid Type #	Product name
1	0.00	15.00	0.2484	0.3457	3	SF180
2	1.33	15.00	0.2145	0.2979	3	SF180
3	2.67	15.00	0.1802	0.2503	3	SF180
4	4.00	15.00	0.1460	0.2037	3	SF180
5	5.33	15.00	0.1116	0.1575	3	SF180
6	6.67	15.00	0.0766	0.1112	3	SF180
7	8.00	15.00	0.0413	0.0654	3	SF180
8	9.33	15.00	0.0054	0.0196	3	SF180
9	10.10	15.00	-0.0158	-0.0070	3	SF180

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RESULTS for STRENGTH

Live Load included in calculating Tmax

#	Geogrid Elevation [ft]	LTDS [lb/ft]	Factored: Static/Seismic Tmax [lb/ft]	Tmd [lb/ft]	Specified minimum CDR Static	Actual calculated CDR Static	Specified minimum CDR seismic	Actual calculated CDR seismic	Product name
1	0.00	5989/7986	1737/1178	117.26	N/A	3.448	N/A	6.360	SF180
2	1.33	5989/7986	3631/2456	117.26	N/A	1.650	N/A	3.152	SF180
3	2.67	5989/7986	3827/2581	117.26	N/A	1.565	N/A	3.004	SF180
4	4.00	5989/7986	4013/2699	117.26	N/A	1.492	N/A	2.876	SF180
5	5.33	5989/7986	4238/2843	117.26	N/A	1.413	N/A	2.734	SF180
6	6.67	5989/7986	4485/3001	117.26	N/A	1.335	N/A	2.594	SF180
7	8.00	5989/7986	4775/3188	117.26	N/A	1.254	N/A	2.445	SF180
8	9.33	5989/7986	4021/2679	117.26	N/A	1.490	N/A	2.896	SF180
9	10.10	5989/7986	7010/4662	117.26	N/A	0.854	N/A	1.685	SF180

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.

#	Geogrid Elevation [ft]	Coverage Ratio	Factored: Stat./Seis. Tmax [lb/ft]	Tmd [lb/ft]	Le (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	1737/1178	0/117.3	15.00	0.00	63505.6	N/A	36.563	67739.3	N/A	52.302
2	1.33	1.000	3631/2456	0/117.3	14.35	0.65	59908.4	N/A	16.501	63902.3	N/A	24.833
3	2.67	1.000	3827/2581	0/117.3	13.70	1.30	56365.1	N/A	14.730	60122.8	N/A	22.285
4	4.00	1.000	4013/2699	0/117.3	13.05	1.95	52837.6	N/A	13.165	56360.2	N/A	20.012
5	5.33	1.000	4238/2843	0/117.3	12.40	2.60	49613.5	N/A	11.707	52921.0	N/A	17.879
6	6.67	1.000	4485/3001	0/117.3	11.75	3.25	46117.9	N/A	10.283	49192.4	N/A	15.775
7	8.00	1.000	4775/3188	0/117.3	11.10	3.90	42578.9	N/A	8.917	45417.5	N/A	13.741
8	9.33	1.000	4021/2679	0/117.3	10.45	4.55	38805.1	N/A	9.651	41392.1	N/A	14.801
9	10.10	1.000	7010/4662	0/117.3	10.07	4.93	36997.4	N/A	5.278	39463.9	N/A	8.257

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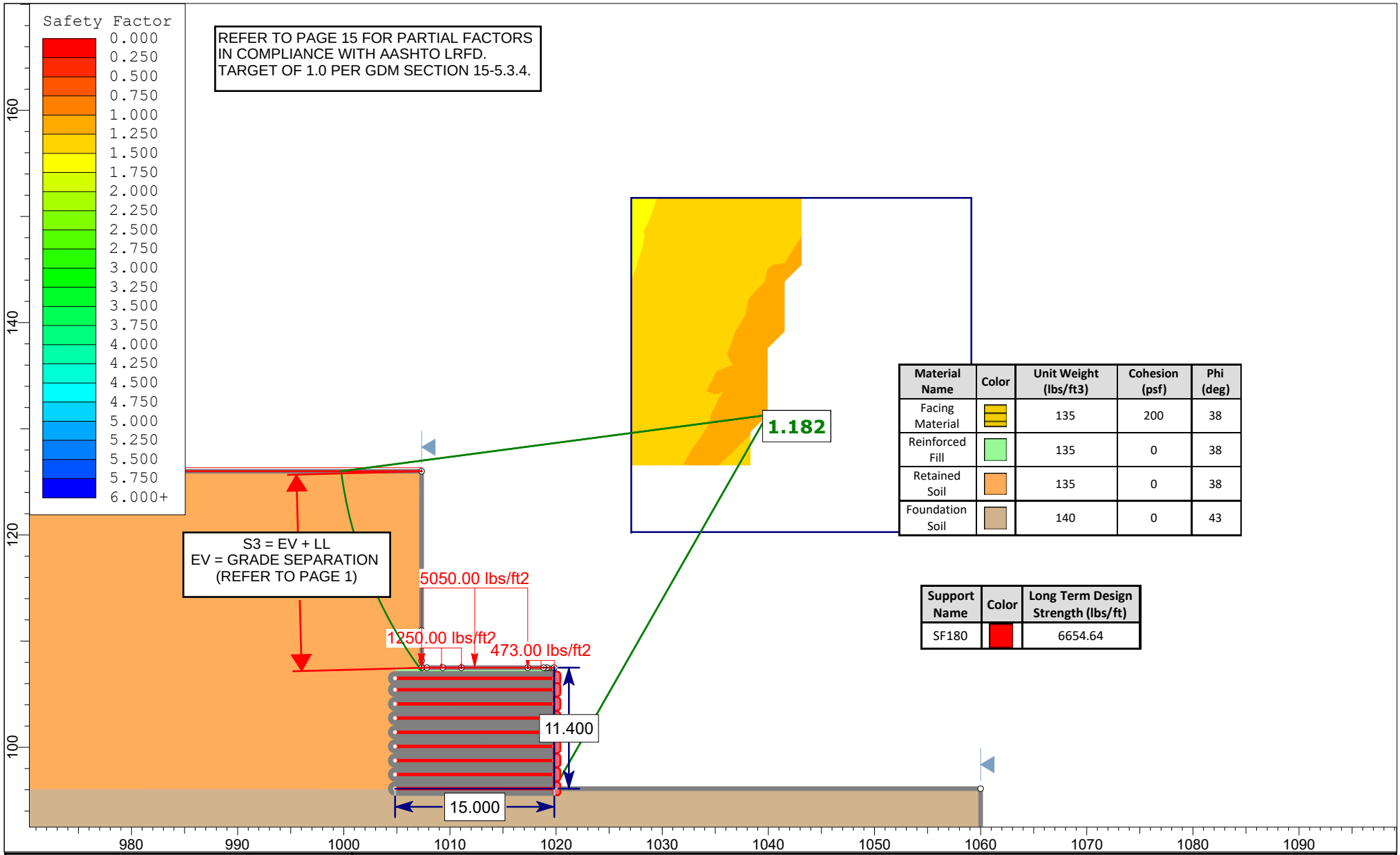


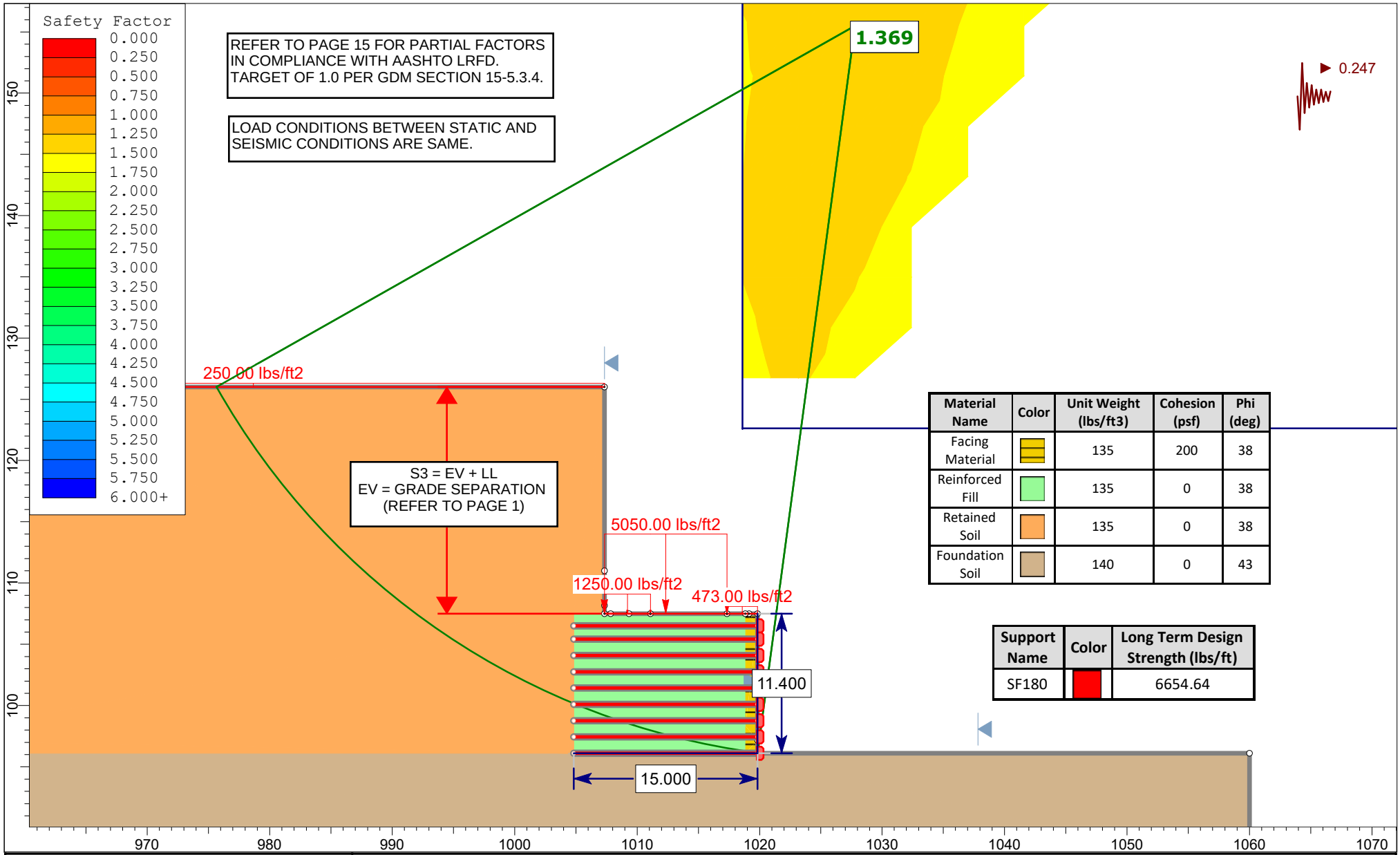
Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
Facing Material		135	200	38
Reinforced Fill		135	0	38
Retained Soil		135	0	38
Foundation Soil		140	0	43

Support Name	Color	Long Term Design Strength (lbs/ft)
SF180		6654.64

Tensar®

SLIDEINTERPRET 9.019

Project	405/40P ERC BRIDGE OVER SB 1-405		
Description	Static	Location	Design Case 1; Design Height = 11.4'
Drawn By	VA	Scale	1:150
Date	12/8/2021	File Name	ROC_DC_1.slmd



Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
Facing Material		135	200	38
Reinforced Fill		135	0	38
Retained Soil		135	0	38
Foundation Soil		140	0	43

Support Name	Color	Long Term Design Strength (lbs/ft)
SF180		6654.64

Tensar®

SLIDEINTERPRET 9.019

Project	405/40P ERC BRIDGE OVER SB 1-405		
Description	Seismic	Location	Design Case 1; Design Height = 11.4'
Drawn By	VA	Scale	1:130
Date	12/8/2021	File Name	ROC_DC_1.slmd

Slide Analysis Information

ROC_DC_1

Project Summary

File Name:	ROC_DC_1.slmd
Slide Modeler Version:	9.019
Project Title:	405/40P ERC BRIDGE OVER SB 1-405
Author:	VA
Comments	
	Design Case 1; Design Height = 11.4'

Currently Open Scenarios

Group Name	Scenario Name	Global Minimum	Compute Time
Group 1	Master Scenario	Bishop Simplified: 1.202830 Spencer: 1.216280	00h:00m:02.378s
	Static	Bishop Simplified: 1.181660 Spencer: 1.200270	00h:00m:01.763s
	Seismic	Bishop Simplified: 1.369280 Spencer: 1.368690	00h:00m:01.793s

General Settings

Units of Measurement:	Imperial Units
Time Units:	days
Permeability Units:	feet/second
Data Output:	Standard
Failure Direction:	Left to Right

Design Standard

Group 1 - Seismic

Selected Type:	BS 8006:2010 Section 7 - Reinforced Slopes (User Defined)
Name:	AASHTO 2020 (Seismic)

Type	Partial Factor
Soil Unit Mass: Unfavourable	1
Soil Unit Mass: Favourable	1
External Dead Loads: Unfavourable	1
External Dead Loads: Favourable	1
External Live Loads: Unfavourable	1
External Live Loads: Favourable	1
Effective cohesion c'	1.1
Effective friction tan(phi)	1.1
Undrained strength	1.1
Shear strength (other models)	1.1
Tensile and plate strength	0.83
Shear strength	0.83
Compressive strength	0.83
Bond strength	0.83
Seismic Coefficient	1

Slide uses the inverse of the resistance factor as the partial factor. For example, resistance factor of 0.9 is partial factor of 1.1 in Slide.

All other Scenarios

Selected Type:	BS 8006:2010 Section 7 - Reinforced Slopes (User Defined)
Name:	AASHTO 2020 (Strength I)

Type	Partial Factor
Soil Unit Mass: Unfavourable	1.35
Soil Unit Mass: Favourable	1
External Dead Loads: Unfavourable	1.5
External Dead Loads: Favourable	0.75
External Live Loads: Unfavourable	1.75
External Live Loads: Favourable	1
Effective cohesion c'	1.33
Effective friction tan(phi)	1.33
Undrained strength	1.33
Shear strength (other models)	1.33
Tensile and plate strength	1.11
Shear strength	1.11
Compressive strength	1.11
Bond strength	1.11
Seismic Coefficient	1

Slide uses the inverse of the resistance factor as the partial factor. For example, resistance factor of 0.75 is partial factor of 1.33 in Slide.

Analysis Options

All Open Scenarios

Slices Type:	Vertical
Analysis Methods Used	
	Bishop simplified
	Spencer
Number of slices:	50
Tolerance:	0.005
Maximum number of iterations:	75
Check malpha < 0.2:	Yes
Create Interslice boundaries at intersections with water tables and piezos:	Yes
Initial trial value of FS:	1
Steffensen Iteration:	Yes

Surface Options

All Open Scenarios

Surface Type:	Circular
Search Method:	Grid Search
Radius Increment:	40
Composite Surfaces:	Disabled
Reverse Curvature:	Invalid Surfaces
Minimum Elevation:	Not Defined
Minimum Depth:	Not Defined
Minimum Area:	Not Defined
Minimum Weight:	Not Defined

Seismic Loading

Group 1 - Seismic

Advanced seismic analysis:	No
Staged pseudostatic analysis:	No
Seismic Load Coefficient (Horizontal):	0.247

All other Scenarios

Advanced seismic analysis:	No
Staged pseudostatic analysis:	No

Loading

All Open Scenarios

Distribution:	Constant
Magnitude [psf]:	250
Orientation:	Vertical
Load Action:	Live

Distribution:	Constant
Magnitude [psf]:	1250
Orientation:	Normal to boundary
Load Action:	Dead

Distribution:	Constant
Magnitude [psf]:	5050
Orientation:	Normal to boundary
Load Action:	Live

Distribution:	Constant
Magnitude [psf]:	473
Orientation:	Normal to boundary
Load Action:	Dead

Materials

Facing Material	
Color	
Strength Type	Mohr-Coulomb
Unit Weight [lbs/ft3]	135
Cohesion [psf]	200
Friction Angle [deg]	38
Water Surface	Assigned per scenario
Ru Value	0
Reinforced Fill	
Color	
Strength Type	Mohr-Coulomb
Unit Weight [lbs/ft3]	135
Cohesion [psf]	0
Friction Angle [deg]	38
Water Surface	Assigned per scenario
Ru Value	0
Retained Soil	
Color	
Strength Type	Mohr-Coulomb
Unit Weight [lbs/ft3]	135
Cohesion [psf]	0
Friction Angle [deg]	38
Water Surface	Assigned per scenario
Ru Value	0
Foundation Soil	
Color	
Strength Type	Mohr-Coulomb
Unit Weight [lbs/ft3]	140
Cohesion [psf]	0
Friction Angle [deg]	43
Water Surface	Assigned per scenario
Ru Value	0

Materials In Use

Material	Group 1	Static	Seismic
Facing Material	✓	✓	✓
Reinforced Fill	✓	✓	✓
Retained Soil	✓	✓	✓
Foundation Soil	✓	✓	✓

Support

SF180	
Color	
Type	Geosynthetic
Force Application	Passive (Method B)
Force Orientation	Parallel to Reinforcement
Strip Coverage (%)	100
Long Term Design Strength	6654.64 lbs/ft
Anchorage	Slope Face
Connection Strength Input	Constant
Connection Strength	6654.64 lbs/ft
Shear Strength Model	Linear
Adhesion	0 psf
Friction Angle	22.1 deg
Material Dependent	No
Use External Loads in Strength Computation	Yes

Global Minimums

Group 1 - Master Scenario

Method: bishop simplified

FS	1.202830
Center:	1040.919, 137.686
Radius:	45.432
Left Slip Surface Endpoint:	997.015, 126.000
Right Slip Surface Endpoint:	1019.830, 97.445
Left Slope Intercept:	997.015 126.000
Right Slope Intercept:	1019.830 107.500
Resisting Moment:	4.92467e+06 lb-ft
Driving Moment:	4.09425e+06 lb-ft
Passive Support Moment:	1.46757e+06 lb-ft
Maximum Single Support Force:	5995.17 lb
Total Support Force:	41966.2 lb
Total Slice Area:	188.763 ft2
Surface Horizontal Width:	22.8147 ft
Surface Average Height:	8.27374 ft

Method: spencer

FS	1.216280
Center:	1042.521, 145.553
Radius:	51.998
Left Slip Surface Endpoint:	994.340, 126.000
Right Slip Surface Endpoint:	1019.830, 98.768
Left Slope Intercept:	994.340 126.000
Right Slope Intercept:	1019.830 107.500
Resisting Moment:	5.48537e+06 lb-ft
Driving Moment:	4.50996e+06 lb-ft
Resisting Horizontal Force:	95753.9 lb
Driving Horizontal Force:	78726.9 lb
Passive Support Moment:	1.51719e+06 lb-ft
Passive Horizontal Support Force:	35971 lb
Maximum Single Support Force:	5995.17 lb
Total Support Force:	35971 lb
Total Slice Area:	202.415 ft2
Surface Horizontal Width:	25.4903 ft
Surface Average Height:	7.94087 ft

Group 1 - Static

Method: bishop simplified

FS	1.181660
Center:	1039.896, 131.296
Radius:	40.505
Left Slip Surface Endpoint:	999.739, 126.000
Right Slip Surface Endpoint:	1019.830, 96.111
Left Slope Intercept:	999.739 126.000
Right Slope Intercept:	1019.830 107.500
Resisting Moment:	4.43605e+06 lb-ft
Driving Moment:	3.7541e+06 lb-ft
Passive Support Moment:	1.40243e+06 lb-ft
Maximum Single Support Force:	5995.17 lb
Total Support Force:	47961.4 lb
Total Slice Area:	171.408 ft2
Surface Horizontal Width:	20.091 ft
Surface Average Height:	8.53158 ft

Method: spencer

FS	1.200270
Center:	1041.498, 139.163
Radius:	46.869
Left Slip Surface Endpoint:	996.515, 126.000
Right Slip Surface Endpoint:	1019.830, 97.603
Left Slope Intercept:	996.515 126.000
Right Slope Intercept:	1019.830 107.500
Resisting Moment:	5.05811e+06 lb-ft
Driving Moment:	4.21413e+06 lb-ft
Resisting Horizontal Force:	98870.4 lb
Driving Horizontal Force:	82373.1 lb
Passive Support Moment:	1.52955e+06 lb-ft
Passive Horizontal Support Force:	41966.2 lb
Maximum Single Support Force:	5995.17 lb
Total Support Force:	41966.2 lb
Total Slice Area:	192.368 ft2
Surface Horizontal Width:	23.3151 ft
Surface Average Height:	8.25077 ft

Group 1 - Seismic

Method: bishop simplified

FS	1.369280
Center:	1027.791, 155.489
Radius:	59.913
Left Slip Surface Endpoint:	975.637, 126.000
Right Slip Surface Endpoint:	1019.830, 96.107
Left Slope Intercept:	975.637 126.000
Right Slope Intercept:	1019.830 107.500
Resisting Moment:	6.32997e+06 lb-ft
Driving Moment:	4.62283e+06 lb-ft
Passive Support Moment:	950458 lb-ft
Maximum Single Support Force:	8017.64 lb
Total Support Force:	16579.1 lb
Total Slice Area:	654.506 ft2
Surface Horizontal Width:	44.1926 ft
Surface Average Height:	14.8103 ft

Method: spencer

FS	1.368690
Center:	1027.791, 155.489
Radius:	59.913
Left Slip Surface Endpoint:	975.637, 126.000
Right Slip Surface Endpoint:	1019.830, 96.107
Left Slope Intercept:	975.637 126.000
Right Slope Intercept:	1019.830 107.500
Resisting Moment:	6.32724e+06 lb-ft
Driving Moment:	4.62283e+06 lb-ft
Resisting Horizontal Force:	98525.3 lb
Driving Horizontal Force:	71985.1 lb
Passive Support Moment:	950458 lb-ft
Passive Horizontal Support Force:	16579.1 lb
Maximum Single Support Force:	8017.64 lb
Total Support Force:	16579.1 lb
Total Slice Area:	654.506 ft2
Surface Horizontal Width:	44.1926 ft
Surface Average Height:	14.8103 ft

Slice Data

Group 1 - Master Scenario

Global Minimum Query (bishop simplified) - Safety Factor: 1.20283

Slice Number	Width [ft]	Weight [lbs]	Angle of Slice Base [deg]	Base Material	Base Cohesion [psf]	Base Friction Angle [deg]	Shear Stress [psf]	Shear Strength [psf]	Base Normal Stress [psf]	Pore Pressure [psf]	Effective Normal Stress [psf]	Base Vertical Stress [psf]	Effective Vertical Stress [psf]
1	0.452239	65.2386	-74.0568	Retained Soil	0	30.4314	104.94	126.225	214.876	0	214.876	582.218	582.218
2	0.452239	188.148	-72.0912	Retained Soil	0	30.4314	166.117	199.811	340.143	0	340.143	854.182	854.182
3	0.452239	297.918	-70.3171	Retained Soil	0	30.4314	226.519	272.464	463.821	0	463.821	1097.06	1097.06
4	0.452239	397.785	-68.6858	Retained Soil	0	30.4314	285.865	343.847	585.339	0	585.339	1318.01	1318.01
5	0.452239	489.814	-67.1664	Retained Soil	0	30.4314	344.053	413.837	704.484	0	704.484	1521.61	1521.61
6	0.452239	575.425	-65.7375	Retained Soil	0	30.4314	401.058	482.405	821.209	0	821.209	1711.01	1711.01
7	0.452239	655.644	-64.384	Retained Soil	0	30.4314	456.895	549.567	935.541	0	935.541	1888.47	1888.47
8	0.452239	731.24	-63.0942	Retained Soil	0	30.4314	511.595	615.362	1047.54	0	1047.54	2055.7	2055.7
9	0.452239	802.811	-61.8594	Retained Soil	0	30.4314	565.198	679.837	1157.3	0	1157.3	2214.02	2214.02
10	0.452239	870.828	-60.6725	Retained Soil	0	30.4314	617.746	743.044	1264.9	0	1264.9	2364.48	2364.48
11	0.452239	935.676	-59.528	Retained Soil	0	30.4314	669.283	805.034	1370.43	0	1370.43	2507.92	2507.92
12	0.452239	997.67	-58.4211	Retained Soil	0	30.4314	719.852	865.859	1473.97	0	1473.97	2645.04	2645.04
13	0.452239	1057.07	-57.348	Retained Soil	0	30.4314	769.49	925.566	1575.61	0	1575.61	2776.43	2776.43
14	0.452239	1114.11	-56.3054	Retained Soil	0	30.4314	818.239	984.202	1675.43	0	1675.43	2902.57	2902.57
15	0.452239	1168.96	-55.2906	Retained Soil	0	30.4314	866.132	1041.81	1773.49	0	1773.49	3023.91	3023.91
16	0.452239	1221.81	-54.3011	Retained Soil	0	30.4314	913.205	1098.43	1869.87	0	1869.87	3140.78	3140.78

17	0.452239	1272.78	-53.3348	Retained Soil	0	30.4314	959.479	1154.09	1964.64	0	1964.64	3253.51	3253.51
18	0.452239	1322	-52.39	Retained Soil	0	30.4314	1005	1208.84	2057.84	0	2057.84	3362.38	3362.38
19	0.452239	1369.6	-51.465	Retained Soil	0	30.4314	1049.78	1262.71	2149.54	0	2149.54	3467.64	3467.64
20	0.452239	1415.65	-50.5583	Retained Soil	0	30.4314	1093.85	1315.72	2239.78	0	2239.78	3569.49	3569.49
21	0.452239	1460.26	-49.6689	Retained Soil	0	30.4314	1137.24	1367.91	2328.62	0	2328.62	3668.13	3668.13
22	0.452239	1503.5	-48.7953	Retained Soil	0	30.4314	1179.97	1419.3	2416.1	0	2416.1	3763.75	3763.75
23	0.456362	1253.03	-47.933	Reinforced Fill	0	30.4314	1658.46	1994.85	3395.88	0	3395.88	5233.46	5233.46
24	0.456362	62.4652	-47.0809	Reinforced Fill	0	30.4314	3475.51	4180.45	7116.48	0	7116.48	10854.1	10854.1
25	0.456362	102.694	-46.2422	Reinforced Fill	0	30.4314	3538.95	4256.75	7246.36	0	7246.36	10942.2	10942.2
26	0.456362	141.77	-45.4162	Reinforced Fill	0	30.4314	3601.21	4331.64	7373.84	0	7373.84	11027.7	11027.7
27	0.456362	179.742	-44.6021	Reinforced Fill	0	30.4314	3662.36	4405.2	7499.06	0	7499.06	11110.9	11110.9
28	0.456362	216.657	-43.7992	Reinforced Fill	0	30.4314	3722.46	4477.49	7622.13	0	7622.13	11191.7	11191.7
29	0.456362	252.558	-43.007	Reinforced Fill	0	30.4314	3781.56	4548.57	7743.13	0	7743.13	11270.4	11270.4
30	0.456362	287.483	-42.2249	Reinforced Fill	0	30.4314	3839.69	4618.5	7862.17	0	7862.17	11346.8	11346.8
31	0.456362	321.469	-41.4523	Reinforced Fill	0	30.4314	3896.91	4687.32	7979.32	0	7979.32	11421.2	11421.2
32	0.456362	354.549	-40.6889	Reinforced Fill	0	30.4314	3319.62	3992.94	6797.26	0	6797.26	9651.46	9651.46
33	0.456362	386.754	-39.9341	Reinforced Fill	0	30.4314	3358.53	4039.74	6876.95	0	6876.95	9688.51	9688.51
34	0.456362	418.113	-39.1875	Reinforced Fill	0	30.4314	3408.24	4099.53	6978.72	0	6978.72	9757.18	9757.18
35	0.456362	448.652	-38.4488	Reinforced Fill	0	30.4314	3457.25	4158.48	7079.09	0	7079.09	9824.06	9824.06
36	0.456362	478.398	-37.7176	Reinforced Fill	0	30.4314	3505.58	4216.62	7178.06	0	7178.06	9889.2	9889.2
37	0.456362	507.373	-36.9935	Reinforced Fill	0	30.4314	3553.27	4273.98	7275.69	0	7275.69	9952.64	9952.64
38	0.456362	535.6	-36.2763	Reinforced Fill	0	30.4314	3600.33	4330.58	7372.04	0	7372.04	10014.4	10014.4
39	0.456362	563.098	-35.5655	Reinforced Fill	0	30.4314	3646.77	4386.45	7467.16	0	7467.16	10074.7	10074.7
40	0.456362	589.888	-34.8611	Reinforced Fill	0	30.4314	3692.62	4441.6	7561.04	0	7561.04	10133.3	10133.3
41	0.456362	615.988	-34.1626	Reinforced Fill	0	30.4314	3737.91	4496.07	7653.75	0	7653.75	10190.5	10190.5
42	0.456362	641.415	-33.4699	Reinforced Fill	0	30.4314	3782.63	4549.86	7745.33	0	7745.33	10246.1	10246.1
43	0.456362	666.184	-32.7826	Reinforced Fill	0	30.4314	3826.82	4603.01	7835.8	0	7835.8	10300.4	10300.4

44	0.456362	690.312	-32.1006	Reinforced Fill	0	30.4314	3870.47	4655.52	7925.19	0	7925.19	10353.2	10353.2
45	0.456362	713.812	-31.4237	Reinforced Fill	0	30.4314	3036.33	3652.19	6217.21	0	6217.21	8072.32	8072.32
46	0.456362	736.699	-30.7516	Reinforced Fill	0	30.4314	879.609	1058.02	1801.1	0	1801.1	2324.45	2324.45
47	0.456362	758.985	-30.0842	Reinforced Fill	0	30.4314	903.444	1086.69	1849.9	0	1849.9	2373.28	2373.28
48	0.456362	780.682	-29.4213	Reinforced Fill	0	30.4314	926.964	1114.98	1898.05	0	1898.05	2420.82	2420.82
49	0.5	879.548	-28.7314	Facing Material	150.376	30.4314	1049.9	1262.85	1893.77	0	1893.77	2469.32	2469.32
50	0.5	904.157	-28.0147	Facing Material	150.376	30.4314	1075.54	1293.7	1946.3	0	1946.3	2518.53	2518.53

Global Minimum Query (spencer) - Safety Factor: 1.21628

Slice Number	Width [ft]	Weight [lbs]	Angle of Slice Base [deg]	Base Material	Base Cohesion [psf]	Base Friction Angle [deg]	Shear Stress [psf]	Shear Strength [psf]	Base Normal Stress [psf]	Pore Pressure [psf]	Effective Normal Stress [psf]	Base Vertical Stress [psf]	Effective Vertical Stress [psf]
1	0.509804	56.3052	-67.1872	Retained Soil	0	30.4314	55.6411	67.6751	115.205	0	115.205	247.487	247.487
2	0.509804	165.254	-65.7781	Retained Soil	0	30.4314	87.211	106.073	180.57	0	180.57	374.425	374.425
3	0.509804	267.423	-64.4424	Retained Soil	0	30.4314	120.979	147.144	250.486	0	250.486	503.468	503.468
4	0.509804	363.771	-63.1691	Retained Soil	0	30.4314	156.207	189.991	323.426	0	323.426	632.248	632.248
5	0.509804	455.04	-61.9495	Retained Soil	0	30.4314	192.433	234.052	398.432	0	398.432	759.577	759.577
6	0.509804	541.824	-60.7768	Retained Soil	0	30.4314	229.358	278.964	474.886	0	474.886	884.885	884.885
7	0.509804	624.601	-59.6457	Retained Soil	0	30.4314	266.79	324.491	552.388	0	552.388	1007.95	1007.95
8	0.509804	703.768	-58.5515	Retained Soil	0	30.4314	304.6	370.479	630.675	0	630.675	1128.74	1128.74
9	0.509804	779.656	-57.4905	Retained Soil	0	30.4314	342.707	416.828	709.575	0	709.575	1247.32	1247.32
10	0.509804	852.545	-56.4596	Retained Soil	0	30.4314	381.055	463.469	788.974	0	788.974	1363.8	1363.8
11	0.509804	922.674	-55.4559	Retained Soil	0	30.4314	419.608	510.361	868.8	0	868.8	1478.33	1478.33
12	0.509804	990.252	-54.4771	Retained Soil	0	30.4314	458.345	557.476	949.004	0	949.004	1591.04	1591.04
13	0.509804	1055.46	-53.5213	Retained Soil	0	30.4314	497.251	604.797	1029.56	0	1029.56	1702.08	1702.08
14	0.509804	1118.45	-52.5865	Retained Soil	0	30.4314	536.32	652.315	1110.45	0	1110.45	1811.59	1811.59
15	0.509804	1179.37	-51.6713	Retained Soil	0	30.4314	575.547	700.026	1191.67	0	1191.67	1919.69	1919.69
16	0.509804	1238.34	-50.7743	Retained Soil	0	30.4314	614.932	747.929	1273.22	0	1273.22	2026.51	2026.51
17	0.509804	1295.47	-49.8941	Retained Soil	0	30.4314	654.476	796.026	1355.09	0	1355.09	2132.14	2132.14
18	0.509804	1350.86	-49.0297	Retained Soil	0	30.4314	694.182	844.32	1437.3	0	1437.3	2236.7	2236.7
19	0.509804	1404.6	-48.1801	Retained Soil	0	30.4314	734.054	892.815	1519.86	0	1519.86	2340.28	2340.28
20	0.509804	1456.78	-47.3443	Retained Soil	0	30.4314	774.096	941.518	1602.76	0	1602.76	2442.94	2442.94
21	0.509804	1507.46	-46.5216	Retained Soil	0	30.4314	814.314	990.434	1686.04	0	1686.04	2544.8	2544.8
22	0.509804	1556.72	-45.7111	Retained Soil	0	30.4314	854.713	1039.57	1769.67	0	1769.67	2645.87	2645.87
23	0.509804	1604.61	-44.9123	Retained Soil	0	30.4314	895.295	1088.93	1853.71	0	1853.71	2746.27	2746.27
24	0.509804	1651.19	-44.1244	Retained Soil	0	30.4314	936.067	1138.52	1938.13	0	1938.13	2846.01	2846.01

25	0.509804	1696.51	-43.3469	Retained Soil	0	30.4314	977.045	1188.36	2022.97	0	2022.97	2945.2	2945.2
26	0.510662	848.641	-42.5785	Reinforced Fill	0	30.4314	1966.83	2392.21	4072.32	0	4072.32	5879.55	5879.55
27	0.510662	64.9308	-41.8189	Reinforced Fill	0	30.4314	2918.21	3549.36	6042.14	0	6042.14	8653.06	8653.06
28	0.510662	106.898	-41.0682	Reinforced Fill	0	30.4314	5349.62	6506.64	11076.4	0	11076.4	15738	15738
29	0.510662	147.776	-40.326	Reinforced Fill	0	30.4314	3068.96	3732.72	6354.29	0	6354.29	8959.36	8959.36
30	0.510662	187.6	-39.5919	Reinforced Fill	0	30.4314	5582.66	6790.08	11558.9	0	11558.9	16176	16176
31	0.510662	226.404	-38.8654	Reinforced Fill	0	30.4314	3220.88	3917.49	6668.84	0	6668.84	9264.55	9264.55
32	0.510662	264.219	-38.1463	Reinforced Fill	0	30.4314	3297.36	4010.51	6827.18	0	6827.18	9416.94	9416.94
33	0.510662	301.073	-37.4343	Reinforced Fill	0	30.4314	5837.63	7100.19	12086.8	0	12086.8	16555.6	16555.6
34	0.510662	336.995	-36.7289	Reinforced Fill	0	30.4314	2882.44	3505.86	5968.11	0	5968.11	8118.88	8118.88
35	0.510662	372.011	-36.03	Reinforced Fill	0	30.4314	2950.85	3589.06	6109.74	0	6109.74	8256.01	8256.01
36	0.510662	406.143	-35.3372	Reinforced Fill	0	30.4314	3019.67	3672.77	6252.24	0	6252.24	8393.23	8393.23
37	0.510662	439.415	-34.6503	Reinforced Fill	0	30.4314	5820.5	7079.36	12051.3	0	12051.3	16074.2	16074.2
38	0.510662	471.849	-33.969	Reinforced Fill	0	30.4314	3158.71	3841.88	6540.11	0	6540.11	8668.2	8668.2
39	0.510662	503.464	-33.2932	Reinforced Fill	0	30.4314	3228.97	3927.33	6685.58	0	6685.58	8806.07	8806.07
40	0.510662	534.28	-32.6225	Reinforced Fill	0	30.4314	3299.75	4013.42	6832.14	0	6832.14	8944.25	8944.25
41	0.510662	564.314	-31.9569	Reinforced Fill	0	30.4314	6277.44	7635.12	12997.4	0	12997.4	16913.4	16913.4
42	0.510662	593.584	-31.296	Reinforced Fill	0	30.4314	3443.01	4187.66	7128.74	0	7128.74	9221.8	9221.8
43	0.510662	622.106	-30.6398	Reinforced Fill	0	30.4314	3515.53	4275.87	7278.92	0	7278.92	9361.29	9361.29
44	0.510662	649.895	-29.9879	Reinforced Fill	0	30.4314	3588.7	4364.86	7430.4	0	7430.4	9501.33	9501.33
45	0.510662	676.965	-29.3403	Reinforced Fill	0	30.4314	6750.56	8210.57	13977	0	13977	17771.5	17771.5
46	0.510662	703.331	-28.6969	Reinforced Fill	0	30.4314	949.707	1155.11	1966.36	0	1966.36	2486.24	2486.24
47	0.510662	729.005	-28.0573	Reinforced Fill	0	30.4314	793.682	965.339	1643.32	0	1643.32	2066.34	2066.34
48	0.510662	753.999	-27.4215	Reinforced Fill	0	30.4314	824.119	1002.36	1706.34	0	1706.34	2133.92	2133.92
49	0.5	761.834	-26.7959	Facing Material	150.376	30.4314	996.116	1211.56	1806.48	0	1806.48	2309.57	2309.57
50	0.5	784.54	-26.1804	Facing Material	150.376	30.4314	999.725	1215.95	1813.93	0	1813.93	2305.43	2305.43

Group 1 - Static

Global Minimum Query (bishop simplified) - Safety Factor: 1.18166

Slice Number	Width [ft]	Weight [lbs]	Angle of Slice Base [deg]	Base Material	Base Cohesion [psf]	Base Friction Angle [deg]	Shear Stress [psf]	Shear Strength [psf]	Base Normal Stress [psf]	Pore Pressure [psf]	Effective Normal Stress [psf]	Base Vertical Stress [psf]	Effective Vertical Stress [psf]
1	0.388373	84.6179	-80.7739	Retained Soil	0	30.4314	80.3045	94.8926	161.538	0	161.538	655.923	655.923
2	0.388373	232.616	-77.7642	Retained Soil	0	30.4314	156.618	185.069	315.047	0	315.047	1037.25	1037.25
3	0.388373	348.686	-75.3797	Retained Soil	0	30.4314	228.617	270.148	459.879	0	459.879	1336.28	1336.28
4	0.388373	447.288	-73.3336	Retained Soil	0	30.4314	297.148	351.128	597.732	0	597.732	1590.29	1590.29
5	0.388373	534.301	-71.5096	Retained Soil	0	30.4314	362.748	428.645	729.692	0	729.692	1814.44	1814.44
6	0.388373	612.853	-69.8462	Retained Soil	0	30.4314	425.816	503.17	856.558	0	856.558	2016.78	2016.78
7	0.388373	684.852	-68.3058	Retained Soil	0	30.4314	486.661	575.068	978.952	0	978.952	2202.24	2202.24
8	0.388373	751.569	-66.8636	Retained Soil	0	30.4314	545.526	644.626	1097.36	0	1097.36	2374.08	2374.08
9	0.388373	813.899	-65.502	Retained Soil	0	30.4314	602.61	712.08	1212.19	0	1212.19	2534.62	2534.62
10	0.388373	872.505	-64.2083	Retained Soil	0	30.4314	658.077	777.623	1323.77	0	1323.77	2685.56	2685.56
11	0.388373	927.891	-62.9724	Retained Soil	0	30.4314	712.065	841.419	1432.36	0	1432.36	2828.21	2828.21
12	0.388373	980.454	-61.7869	Retained Soil	0	30.4314	764.691	903.605	1538.23	0	1538.23	2963.59	2963.59
13	0.388373	1030.51	-60.6455	Retained Soil	0	30.4314	816.055	964.3	1641.55	0	1641.55	3092.51	3092.51
14	0.388373	1078.33	-59.5432	Retained Soil	0	30.4314	866.247	1023.61	1742.51	0	1742.51	3215.65	3215.65
15	0.388373	1124.11	-58.476	Retained Soil	0	30.4314	915.339	1081.62	1841.26	0	1841.26	3333.55	3333.55
16	0.388373	1168.04	-57.4402	Retained Soil	0	30.4314	963.399	1138.41	1937.94	0	1937.94	3446.7	3446.7
17	0.388373	1210.28	-56.433	Retained Soil	0	30.4314	1010.49	1194.05	2032.66	0	2032.66	3555.46	3555.46
18	0.388373	1250.96	-55.4518	Retained Soil	0	30.4314	1056.66	1248.61	2125.53	0	2125.53	3660.21	3660.21
19	0.388373	1290.18	-54.4945	Retained Soil	0	30.4314	1101.96	1302.14	2216.66	0	2216.66	3761.23	3761.23
20	0.403859	734.629	-53.5408	Reinforced Fill	0	30.4314	2122.74	2508.36	4270.04	0	4270.04	7143.04	7143.04
21	0.403859	59.664	-52.59	Reinforced Fill	0	30.4314	3273.52	3868.19	6584.91	0	6584.91	10864.9	10864.9
22	0.403859	97.8886	-51.6593	Reinforced Fill	0	30.4314	3345.47	3953.21	6729.63	0	6729.63	10959.6	10959.6
23	0.403859	134.87	-50.7474	Reinforced Fill	0	30.4314	3415.68	4036.17	6870.86	0	6870.86	11051.1	11051.1
24	0.403859	170.68	-49.853	Reinforced Fill	0	30.4314	3484.28	4117.23	7008.86	0	7008.86	11139.7	11139.7
25	0.403859	205.383	-48.9748	Reinforced Fill	0	30.4314	3551.37	4196.51	7143.81	0	7143.81	11225.6	11225.6
26	0.403859	239.037	-48.1118	Reinforced Fill	0	30.4314	3617.04	4274.11	7275.91	0	7275.91	11308.8	11308.8
27	0.403859	271.694	-47.2631	Reinforced Fill	0	30.4314	3681.37	4350.13	7405.32	0	7405.32	11389.6	11389.6
28	0.403859	303.403	-46.4278	Reinforced Fill	0	30.4314	3744.45	4424.67	7532.22	0	7532.22	11468.1	11468.1

29	0.403859	334.205	-45.6051	Reinforced Fill	0	30.4314	3688.93	4359.06	7420.53	0	7420.53	11188.2	11188.2
30	0.403859	364.141	-44.7942	Reinforced Fill	0	30.4314	3242.8	3831.89	6523.1	0	6523.1	9742.7	9742.7
31	0.403859	393.248	-43.9947	Reinforced Fill	0	30.4314	3296.77	3895.66	6631.67	0	6631.67	9814.74	9814.74
32	0.403859	421.558	-43.2058	Reinforced Fill	0	30.4314	3349.85	3958.38	6738.45	0	6738.45	9884.79	9884.79
33	0.403859	449.102	-42.4269	Reinforced Fill	0	30.4314	3402.08	4020.1	6843.5	0	6843.5	9952.96	9952.96
34	0.403859	475.909	-41.6576	Reinforced Fill	0	30.4314	3453.49	4080.85	6946.92	0	6946.92	10019.3	10019.3
35	0.403859	502.004	-40.8974	Reinforced Fill	0	30.4314	3504.12	4140.68	7048.78	0	7048.78	10083.9	10083.9
36	0.403859	527.414	-40.1458	Reinforced Fill	0	30.4314	3554.01	4199.63	7149.12	0	7149.12	10146.7	10146.7
37	0.403859	552.159	-39.4025	Reinforced Fill	0	30.4314	3603.18	4257.73	7248.02	0	7248.02	10208	10208
38	0.403859	576.262	-38.667	Reinforced Fill	0	30.4314	3651.65	4315.01	7345.54	0	7345.54	10267.6	10267.6
39	0.403859	599.741	-37.939	Reinforced Fill	0	30.4314	3699.47	4371.51	7441.7	0	7441.7	10325.7	10325.7
40	0.403859	622.617	-37.2181	Reinforced Fill	0	30.4314	3746.63	4427.24	7536.6	0	7536.6	10382.3	10382.3
41	0.403859	644.905	-36.5041	Reinforced Fill	0	30.4314	3793.18	4482.25	7630.22	0	7630.22	10437.4	10437.4
42	0.403859	666.622	-35.7965	Reinforced Fill	0	30.4314	3839.13	4536.55	7722.67	0	7722.67	10491.2	10491.2
43	0.403859	687.784	-35.0953	Reinforced Fill	0	30.4314	3884.51	4590.17	7813.93	0	7813.93	10543.5	10543.5
44	0.403859	708.405	-34.4	Reinforced Fill	0	30.4314	3929.32	4643.12	7904.1	0	7904.1	10594.6	10594.6
45	0.403859	728.497	-33.7104	Reinforced Fill	0	30.4314	1806.04	2134.13	3632.98	0	3632.98	4837.94	4837.94
46	0.403859	748.075	-33.0263	Reinforced Fill	0	30.4314	962.756	1137.65	1936.65	0	1936.65	2562.51	2562.51
47	0.403859	767.15	-32.3475	Reinforced Fill	0	30.4314	986.705	1165.95	1984.82	0	1984.82	2609.74	2609.74
48	0.403859	785.733	-31.6738	Reinforced Fill	0	30.4314	1010.35	1193.89	2032.38	0	2032.38	2655.75	2655.75
49	0.5	997.782	-30.9259	Facing Material	150.376	30.4314	1134.5	1340.6	2026.13	0	2026.13	2705.81	2705.81
50	0.5	1024.64	-30.1049	Facing Material	150.376	30.4314	1163.68	1375.08	2084.83	0	2084.83	2759.52	2759.52

Global Minimum Query (spencer) - Safety Factor: 1.20027

Slice Number	Width [ft]	Weight [lbs]	Angle of Slice Base [deg]	Base Material	Base Cohesion [psf]	Base Friction Angle [deg]	Shear Stress [psf]	Shear Strength [psf]	Base Normal Stress [psf]	Pore Pressure [psf]	Effective Normal Stress [psf]	Base Vertical Stress [psf]	Effective Vertical Stress [psf]
1	0.473902	65.7654	-72.7147	Retained Soil	0	30.4314	16.2778	19.5378	33.2597	0	33.2597	85.5691	85.5691
2	0.473902	190.486	-70.8565	Retained Soil	0	30.4314	60.9707	73.1813	124.578	0	124.578	300.22	300.22

3	0.473902	303.199	-69.1589	Retained Soil	0	30.4314	105.44	126.556	215.439	0	215.439	492.413	492.413
4	0.473902	406.573	-67.5851	Retained Soil	0	30.4314	148.063	177.715	302.529	0	302.529	661.491	661.491
5	0.473902	502.393	-66.1101	Retained Soil	0	30.4314	189.146	227.026	386.472	0	386.472	813.507	813.507
6	0.473902	591.924	-64.7166	Retained Soil	0	30.4314	229.23	275.138	468.374	0	468.374	953.678	953.678
7	0.473902	676.104	-63.3917	Retained Soil	0	30.4314	268.753	322.576	549.129	0	549.129	1085.62	1085.62
8	0.473902	755.65	-62.1254	Retained Soil	0	30.4314	308.012	369.698	629.346	0	629.346	1211.7	1211.7
9	0.473902	831.127	-60.91	Retained Soil	0	30.4314	347.201	416.735	709.418	0	709.418	1333.47	1333.47
10	0.473902	902.988	-59.7394	Retained Soil	0	30.4314	386.438	463.83	789.588	0	789.588	1451.94	1451.94
11	0.473902	971.604	-58.6085	Retained Soil	0	30.4314	425.794	511.068	870.003	0	870.003	1567.8	1567.8
12	0.473902	1037.28	-57.5131	Retained Soil	0	30.4314	465.314	558.503	950.751	0	950.751	1681.52	1681.52
13	0.473902	1100.28	-56.4496	Retained Soil	0	30.4314	505.021	606.162	1031.88	0	1031.88	1793.43	1793.43
14	0.473902	1160.83	-55.4152	Retained Soil	0	30.4314	544.93	654.063	1113.43	0	1113.43	1903.8	1903.8
15	0.473902	1219.1	-54.4072	Retained Soil	0	30.4314	585.048	702.215	1195.4	0	1195.4	2012.8	2012.8
16	0.473902	1275.27	-53.4234	Retained Soil	0	30.4314	625.378	750.622	1277.8	0	1277.8	2120.59	2120.59
17	0.473902	1329.49	-52.4619	Retained Soil	0	30.4314	665.922	799.286	1360.64	0	1360.64	2227.29	2227.29
18	0.473902	1381.87	-51.5209	Retained Soil	0	30.4314	706.682	848.209	1443.92	0	1443.92	2333.01	2333.01
19	0.473902	1432.53	-50.599	Retained Soil	0	30.4314	747.659	897.393	1527.65	0	1527.65	2437.84	2437.84
20	0.473902	1481.57	-49.6949	Retained Soil	0	30.4314	788.855	946.839	1611.83	0	1611.83	2541.85	2541.85
21	0.473902	1529.08	-48.8073	Retained Soil	0	30.4314	830.271	996.549	1696.45	0	1696.45	2645.11	2645.11
22	0.473902	1575.14	-47.9351	Retained Soil	0	30.4314	871.912	1046.53	1781.52	0	1781.52	2747.67	2747.67
23	0.45728	1333.04	-47.0922	Reinforced Fill	0	30.4314	1156.22	1387.78	2362.44	0	2362.44	3606.35	3606.35
24	0.45728	60.9232	-46.2773	Reinforced Fill	0	30.4314	2623.58	3149	5360.62	0	5360.62	8103.86	8103.86
25	0.45728	100.22	-45.4743	Reinforced Fill	0	30.4314	5218.68	6263.82	10663	0	10663	15968.8	15968.8
26	0.45728	138.437	-44.6826	Reinforced Fill	0	30.4314	2774.07	3329.63	5668.11	0	5668.11	8411.61	8411.61
27	0.45728	175.62	-43.9015	Reinforced Fill	0	30.4314	5470.04	6565.53	11176.6	0	11176.6	16440.9	16440.9
28	0.45728	211.808	-43.1306	Reinforced Fill	0	30.4314	2925.33	3511.18	5977.15	0	5977.15	8717.56	8717.56
29	0.45728	247.039	-42.3693	Reinforced Fill	0	30.4314	3001.32	3602.39	6132.44	0	6132.44	8870.07	8870.07
30	0.45728	281.347	-41.6171	Reinforced Fill	0	30.4314	5848.96	7020.33	11950.9	0	11950.9	17147	17147
31	0.45728	314.765	-40.8736	Reinforced Fill	0	30.4314	3154.21	3785.9	6444.82	0	6444.82	9174.54	9174.54
32	0.45728	347.323	-40.1384	Reinforced Fill	0	30.4314	2730.51	3277.35	5579.11	0	5579.11	7881.54	7881.54
33	0.45728	379.048	-39.411	Reinforced Fill	0	30.4314	2771.02	3325.97	5661.87	0	5661.87	7938.9	7938.9

34	0.45728	409.967	-38.6911	Reinforced Fill	0	30.4314	5813.59	6977.88	11878.6	0	11878.6	16534.7	16534.7
35	0.45728	440.104	-37.9785	Reinforced Fill	0	30.4314	2908.08	3490.48	5941.91	0	5941.91	8212.19	8212.19
36	0.45728	469.481	-37.2726	Reinforced Fill	0	30.4314	2977.24	3573.49	6083.23	0	6083.23	8349.03	8349.03
37	0.45728	498.12	-36.5733	Reinforced Fill	0	30.4314	6175.72	7412.53	12618.5	0	12618.5	17200.6	17200.6
38	0.45728	526.041	-35.8803	Reinforced Fill	0	30.4314	3116.95	3741.18	6368.7	0	6368.7	8623.36	8623.36
39	0.45728	553.262	-35.1934	Reinforced Fill	0	30.4314	3187.55	3825.92	6512.95	0	6512.95	8760.97	8760.97
40	0.45728	579.802	-34.5121	Reinforced Fill	0	30.4314	3258.69	3911.31	6658.32	0	6658.32	8898.97	8898.97
41	0.45728	605.678	-33.8364	Reinforced Fill	0	30.4314	6670.36	8006.23	13629.2	0	13629.2	18100.8	18100.8
42	0.45728	630.904	-33.166	Reinforced Fill	0	30.4314	3402.69	4084.15	6952.55	0	6952.55	9176.33	9176.33
43	0.45728	655.497	-32.5007	Reinforced Fill	0	30.4314	3475.62	4171.68	7101.54	0	7101.54	9315.81	9315.81
44	0.45728	679.469	-31.8403	Reinforced Fill	0	30.4314	3549.19	4259.99	7251.86	0	7251.86	9455.91	9455.91
45	0.45728	702.835	-31.1846	Reinforced Fill	0	30.4314	2827.83	3394.16	5777.96	0	5777.96	7489.51	7489.51
46	0.45728	725.607	-30.5334	Reinforced Fill	0	30.4314	4429.39	5316.46	9050.32	0	9050.32	11662.9	11662.9
47	0.45728	747.797	-29.8865	Reinforced Fill	0	30.4314	845.018	1014.25	1726.58	0	1726.58	2212.22	2212.22
48	0.45728	769.417	-29.2438	Reinforced Fill	0	30.4314	875.578	1050.93	1789.02	0	1789.02	2279.25	2279.25
49	0.5	865.37	-28.5754	Facing Material	150.376	30.4314	1051.24	1261.78	1891.97	0	1891.97	2464.54	2464.54
50	0.5	889.83	-27.8817	Facing Material	150.376	30.4314	1061.62	1274.24	1913.16	0	1913.16	2474.83	2474.83

Group 1 - Seismic

Global Minimum Query (bishop simplified) - Safety Factor: 1.36928

Slice Number	Width [ft]	Weight [lbs]	Angle of Slice Base [deg]	Base Material	Base Cohesion [psf]	Base Friction Angle [deg]	Shear Stress [psf]	Shear Strength [psf]	Base Normal Stress [psf]	Pore Pressure [psf]	Effective Normal Stress [psf]	Base Vertical Stress [psf]	Effective Vertical Stress [psf]
1	0.884624	90.3124	-59.6771	Retained Soil	0	35.3847	88.1025	120.637	186.833	0	186.833	337.464	337.464
2	0.884624	265.291	-58.0401	Retained Soil	0	35.3847	141.756	194.104	300.615	0	300.615	527.827	527.827
3	0.884624	429.688	-56.4751	Retained Soil	0	35.3847	194.811	266.751	413.125	0	413.125	707.175	707.175
4	0.884624	584.78	-54.9722	Retained Soil	0	35.3847	247.174	338.45	524.168	0	524.168	876.805	876.805
5	0.884624	731.589	-53.5237	Retained Soil	0	35.3847	298.788	409.124	633.622	0	633.622	1037.76	1037.76
6	0.884624	870.947	-52.1233	Retained Soil	0	35.3847	349.617	478.723	741.416	0	741.416	1190.89	1190.89
7	0.884624	1003.55	-50.7655	Retained Soil	0	35.3847	399.642	547.222	847.497	0	847.497	1336.9	1336.9
8	0.884624	1129.96	-49.4462	Retained Soil	0	35.3847	448.853	614.606	951.86	0	951.86	1476.4	1476.4

9	0.884624	1250.69	-48.1614	Retained Soil	0	35.3847	497.25	680.874	1054.49	0	1054.49	1609.88	1609.88
10	0.884624	1366.15	-46.9081	Retained Soil	0	35.3847	544.832	746.027	1155.4	0	1155.4	1737.78	1737.78
11	0.884624	1476.72	-45.6835	Retained Soil	0	35.3847	591.607	810.075	1254.59	0	1254.59	1860.48	1860.48
12	0.884624	1582.7	-44.4851	Retained Soil	0	35.3847	637.581	873.027	1352.08	0	1352.08	1978.31	1978.31
13	0.884624	1684.38	-43.3109	Retained Soil	0	35.3847	682.765	934.897	1447.9	0	1447.9	2091.55	2091.55
14	0.884624	1782	-42.1589	Retained Soil	0	35.3847	727.17	995.7	1542.07	0	1542.07	2200.48	2200.48
15	0.884624	1875.79	-41.0276	Retained Soil	0	35.3847	770.807	1055.45	1634.6	0	1634.6	2305.3	2305.3
16	0.884624	1965.94	-39.9154	Retained Soil	0	35.3847	813.683	1114.16	1725.53	0	1725.53	2406.25	2406.25
17	0.884624	2052.64	-38.821	Retained Soil	0	35.3847	855.815	1171.85	1814.87	0	1814.87	2503.48	2503.48
18	0.884624	2136.03	-37.7432	Retained Soil	0	35.3847	897.209	1228.53	1902.65	0	1902.65	2597.17	2597.17
19	0.884624	2216.26	-36.6808	Retained Soil	0	35.3847	937.872	1284.21	1988.9	0	1988.9	2687.48	2687.48
20	0.884624	2293.47	-35.6329	Retained Soil	0	35.3847	977.828	1338.92	2073.63	0	2073.63	2774.53	2774.53
21	0.884624	2367.77	-34.5986	Retained Soil	0	35.3847	1017.07	1392.66	2156.86	0	2156.86	2858.46	2858.46
22	0.884624	2439.28	-33.577	Retained Soil	0	35.3847	1055.63	1445.45	2238.62	0	2238.62	2939.37	2939.37
23	0.884624	2508.08	-32.5674	Retained Soil	0	35.3847	1093.5	1497.31	2318.92	0	2318.92	3017.37	3017.37
24	0.884624	2574.28	-31.569	Retained Soil	0	35.3847	1130.69	1548.23	2397.8	0	2397.8	3092.56	3092.56
25	0.884624	2637.95	-30.5812	Retained Soil	0	35.3847	1167.21	1598.24	2475.24	0	2475.24	3165.02	3165.02
26	0.884624	2699.18	-29.6034	Retained Soil	0	35.3847	1203.08	1647.35	2551.3	0	2551.3	3234.84	3234.84
27	0.884624	2758.03	-28.635	Retained Soil	0	35.3847	1238.29	1695.56	2625.97	0	2625.97	3302.08	3302.08
28	0.884624	2814.58	-27.6754	Retained Soil	0	35.3847	1272.85	1742.89	2699.27	0	2699.27	3366.84	3366.84
29	0.884624	2868.88	-26.7242	Retained Soil	0	35.3847	1306.78	1789.35	2771.22	0	2771.22	3429.16	3429.16
30	0.884624	2920.99	-25.7809	Retained Soil	0	35.3847	1340.08	1834.94	2841.83	0	2841.83	3489.1	3489.1
31	0.884624	2970.96	-24.845	Retained Soil	0	35.3847	1372.75	1879.68	2911.11	0	2911.11	3546.72	3546.72
32	0.884624	3018.84	-23.9161	Retained Soil	0	35.3847	1404.8	1923.56	2979.08	0	2979.08	3602.07	3602.07
33	0.884624	3064.68	-22.9939	Retained Soil	0	35.3847	1436.24	1966.61	3045.74	0	3045.74	3655.21	3655.21
34	0.875	3074.48	-22.0829	Reinforced Fill	0	35.3847	1466.9	2008.59	3110.76	0	3110.76	3705.89	3705.89
35	0.875	3115.47	-21.1827	Reinforced Fill	0	35.3847	1496.79	2049.53	3174.16	0	3174.16	3754.21	3754.21
36	0.875	2842.42	-20.2879	Reinforced Fill	0	35.3847	1727	2364.74	3662.34	0	3662.34	4300.76	4300.76
37	0.875	1006.59	-19.3983	Reinforced Fill	0	35.3847	2971.88	4069.34	6302.3	0	6302.3	7348.77	7348.77
38	0.875	1042.1	-18.5135	Reinforced Fill	0	35.3847	3010.82	4122.65	6384.87	0	6384.87	7393.06	7393.06
39	0.875	1075.83	-17.6332	Reinforced Fill	0	35.3847	3049.16	4175.16	6466.2	0	6466.2	7435.4	7435.4
40	0.875	1107.82	-16.7573	Reinforced Fill	0	35.3847	3086.95	4226.9	6546.32	0	6546.32	7475.82	7475.82
41	0.875	1138.09	-15.8853	Reinforced Fill	0	35.3847	2683.77	3674.83	5691.32	0	5691.32	6455.07	6455.07

42	0.875	1166.66	-15.0172	Reinforced Fill	0	35.3847	2643.24	3619.33	5605.36	0	5605.36	6314.47	6314.47
43	0.875	1193.55	-14.1525	Reinforced Fill	0	35.3847	2675.55	3663.58	5673.88	0	5673.88	6348.54	6348.54
44	0.875	1218.79	-13.2911	Reinforced Fill	0	35.3847	2707.32	3707.08	5741.27	0	5741.27	6380.8	6380.8
45	0.875	1242.39	-12.4328	Reinforced Fill	0	35.3847	2738.56	3749.85	5807.5	0	5807.5	6411.25	6411.25
46	0.875	1264.37	-11.5772	Reinforced Fill	0	35.3847	2769.26	3791.89	5872.61	0	5872.61	6439.91	6439.91
47	0.875	1284.75	-10.7243	Reinforced Fill	0	35.3847	2799.43	3833.21	5936.6	0	5936.6	6466.79	6466.79
48	0.875	1303.53	-9.87384	Reinforced Fill	0	35.3847	1414.8	1937.26	3000.3	0	3000.3	3246.55	3246.55
49	0.875	1320.74	-9.02553	Reinforced Fill	0	35.3847	863.826	1182.82	1831.88	0	1831.88	1969.09	1969.09
50	1	1528.42	-8.11889	Facing Material	181.818	35.3847	991.33	1357.41	1846.27	0	1846.27	1987.69	1987.69

Global Minimum Query (spencer) - Safety Factor: 1.36869

Slice Number	Width [ft]	Weight [lbs]	Angle of Slice Base [deg]	Base Material	Base Cohesion [psf]	Base Friction Angle [deg]	Shear Stress [psf]	Shear Strength [psf]	Base Normal Stress [psf]	Pore Pressure [psf]	Effective Normal Stress [psf]	Base Vertical Stress [psf]	Effective Vertical Stress [psf]
1	0.884624	90.3124	-59.6771	Retained Soil	0	35.3847	56.0573	76.7251	118.826	0	118.826	214.669	214.669
2	0.884624	265.291	-58.0401	Retained Soil	0	35.3847	86.6274	118.566	183.627	0	183.627	322.476	322.476
3	0.884624	429.688	-56.4751	Retained Soil	0	35.3847	117.466	160.774	248.996	0	248.996	426.299	426.299
4	0.884624	584.78	-54.9722	Retained Soil	0	35.3847	148.65	203.456	315.098	0	315.098	527.174	527.174
5	0.884624	731.589	-53.5237	Retained Soil	0	35.3847	180.216	246.66	382.01	0	382.01	625.769	625.769
6	0.884624	870.947	-52.1233	Retained Soil	0	35.3847	212.178	290.406	449.761	0	449.761	722.544	722.544
7	0.884624	1003.55	-50.7655	Retained Soil	0	35.3847	244.535	334.693	518.35	0	518.35	817.812	817.812
8	0.884624	1129.96	-49.4462	Retained Soil	0	35.3847	277.28	379.51	587.759	0	587.759	911.795	911.795
9	0.884624	1250.69	-48.1614	Retained Soil	0	35.3847	310.4	424.841	657.964	0	657.964	1004.66	1004.66
10	0.884624	1366.15	-46.9081	Retained Soil	0	35.3847	343.882	470.668	728.938	0	728.938	1096.52	1096.52
11	0.884624	1476.72	-45.6835	Retained Soil	0	35.3847	377.714	516.973	800.653	0	800.653	1187.49	1187.49
12	0.884624	1582.7	-44.4851	Retained Soil	0	35.3847	411.881	563.738	873.081	0	873.081	1277.62	1277.62
13	0.884624	1684.38	-43.3109	Retained Soil	0	35.3847	446.374	610.948	946.198	0	946.198	1367	1367
14	0.884624	1782	-42.1589	Retained Soil	0	35.3847	481.183	658.591	1019.98	0	1019.98	1455.66	1455.66
15	0.884624	1875.79	-41.0276	Retained Soil	0	35.3847	516.301	706.656	1094.42	0	1094.42	1543.67	1543.67
16	0.884624	1965.94	-39.9154	Retained Soil	0	35.3847	551.722	755.136	1169.5	0	1169.5	1631.06	1631.06
17	0.884624	2052.64	-38.821	Retained Soil	0	35.3847	587.441	804.025	1245.22	0	1245.22	1717.89	1717.89
18	0.884624	2136.03	-37.7432	Retained Soil	0	35.3847	623.458	853.321	1321.56	0	1321.56	1804.18	1804.18
19	0.884624	2216.26	-36.6808	Retained Soil	0	35.3847	659.773	903.025	1398.54	0	1398.54	1889.98	1889.98
20	0.884624	2293.47	-35.6329	Retained Soil	0	35.3847	696.389	953.14	1476.15	0	1476.15	1975.32	1975.32
21	0.884624	2367.77	-34.5986	Retained Soil	0	35.3847	733.307	1003.67	1554.41	0	1554.41	2060.26	2060.26

22	0.884624	2439.28	-33.577	Retained Soil	0	35.3847	770.54	1054.63	1633.33	0	1633.33	2144.83	2144.83
23	0.884624	2508.08	-32.5674	Retained Soil	0	35.3847	808.087	1106.02	1712.93	0	1712.93	2229.07	2229.07
24	0.884624	2574.28	-31.569	Retained Soil	0	35.3847	845.97	1157.87	1793.22	0	1793.22	2313.03	2313.03
25	0.884624	2637.95	-30.5812	Retained Soil	0	35.3847	884.189	1210.18	1874.24	0	1874.24	2396.76	2396.76
26	0.884624	2699.18	-29.6034	Retained Soil	0	35.3847	922.758	1262.97	1956	0	1956	2480.27	2480.27
27	0.884624	2758.03	-28.635	Retained Soil	0	35.3847	961.708	1316.28	2038.56	0	2038.56	2563.66	2563.66
28	0.884624	2814.58	-27.6754	Retained Soil	0	35.3847	1001.04	1370.11	2121.93	0	2121.93	2646.94	2646.94
29	0.884624	2868.88	-26.7242	Retained Soil	0	35.3847	1040.78	1424.51	2206.18	0	2206.18	2730.19	2730.19
30	0.884624	2920.99	-25.7809	Retained Soil	0	35.3847	1080.95	1479.49	2291.34	0	2291.34	2813.45	2813.45
31	0.884624	2970.96	-24.845	Retained Soil	0	35.3847	1121.58	1535.1	2377.46	0	2377.46	2896.77	2896.77
32	0.884624	3018.84	-23.9161	Retained Soil	0	35.3847	1162.7	1591.37	2464.61	0	2464.61	2980.24	2980.24
33	0.884624	3064.68	-22.9939	Retained Soil	0	35.3847	1204.32	1648.34	2552.84	0	2552.84	3063.89	3063.89
34	0.875	3074.48	-22.0829	Reinforced Fill	0	35.3847	1396.84	1911.84	2960.93	0	2960.93	3527.64	3527.64
35	0.875	3115.47	-21.1827	Reinforced Fill	0	35.3847	1288.53	1763.6	2731.35	0	2731.35	3230.69	3230.69
36	0.875	2842.42	-20.2879	Reinforced Fill	0	35.3847	1577.85	2159.59	3344.62	0	3344.62	3927.91	3927.91
37	0.875	1006.59	-19.3983	Reinforced Fill	0	35.3847	3137.25	4293.92	6650.11	0	6650.11	7754.81	7754.81
38	0.875	1042.1	-18.5135	Reinforced Fill	0	35.3847	5637.7	7716.26	11950.4	0	11950.4	13838.3	13838.3
39	0.875	1075.83	-17.6332	Reinforced Fill	0	35.3847	3303.81	4521.89	7003.19	0	7003.19	8053.33	8053.33
40	0.875	1107.82	-16.7573	Reinforced Fill	0	35.3847	3389.9	4639.72	7185.67	0	7185.67	8206.38	8206.38
41	0.875	1138.09	-15.8853	Reinforced Fill	0	35.3847	2970.27	4065.38	6296.17	0	6296.17	7141.45	7141.45
42	0.875	1166.66	-15.0172	Reinforced Fill	0	35.3847	2962.73	4055.06	6280.19	0	6280.19	7075	7075
43	0.875	1193.55	-14.1525	Reinforced Fill	0	35.3847	5739.45	7855.53	12166.2	0	12166.2	13613.4	13613.4
44	0.875	1218.79	-13.2911	Reinforced Fill	0	35.3847	3122.75	4274.08	6619.39	0	6619.39	7357.07	7357.07
45	0.875	1242.39	-12.4328	Reinforced Fill	0	35.3847	3205.96	4387.97	6795.78	0	6795.78	7502.58	7502.58
46	0.875	1264.37	-11.5772	Reinforced Fill	0	35.3847	3291.51	4505.06	6977.11	0	6977.11	7651.4	7651.4
47	0.875	1284.75	-10.7243	Reinforced Fill	0	35.3847	3379.56	4625.57	7163.75	0	7163.75	7803.81	7803.81
48	0.875	1303.53	-9.87384	Reinforced Fill	0	35.3847	1652.28	2261.46	3502.39	0	3502.39	3789.98	3789.98
49	0.875	1320.74	-9.02553	Reinforced Fill	0	35.3847	956.659	1309.37	2027.87	0	2027.87	2179.83	2179.83
50	1	1528.42	-8.11889	Facing Material	181.818	35.3847	1160.39	1588.21	2203.72	0	2203.72	2369.26	2369.26

AASHTO 2017-2020
I-405 D/B - Bridge 40P

MSEW+: Update # 2021.12

PROJECT IDENTIFICATION

Title: I-405 D/B - Bridge 40P
Project Number: O38650
Client: Flatiron Lane JV
Designer: VA
Station Number: DH = 13.7'

Description:

Design Case 2 (Static); Design Height = 13.7 ft; Loading Conditions:
DC = 0.70 ksf; EV = 2.35 ksf; H1 = 4.75 kips/ft

Company's information:

Name: Tensar International Corporation
Street: 2500 Northwinds Parkway
Suite 500
Alpharetta, GA 30009
Telephone #: (770) 344-2090
Fax #: (770) 344-2084
E-Mail: vamaya@tensarcorp.com

File path and name: K:_o\O38650\Final\Working Files\Design\Rev2\MSEW\Wingw.....
.....wall - H=13.7ft.BENp

Original date and time of creating this file: Oct 2021

PROGRAM MODE: ANALYSIS
of a SIMPLE STRUCTURE
using GEOGRID as reinforcing material.

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SOIL DATA

REINFORCED SOIL

Unit weight, γ	135.0 lb/ft ^{3}
Design value of internal angle of friction, ϕ	38.0 °

RETAINED SOIL

Unit weight, γ	135.0 lb/ft ^{3}
Design value of internal angle of friction, ϕ	38.0 °

FOUNDATION SOIL (Considered as an equivalent uniform soil)

Equivalent unit weight, $\gamma_{equiv.}$	140.0 lb/ft ^{3}
Equivalent internal angle of friction, $\phi_{equiv.}$	43.0 °
Equivalent cohesion, $c_{equiv.}$	0.0 lb/ft ^{2}

Factored bearing capacity resistance of foundation is given: q-ult-static = 120000.0 lb/ft².

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)
Inclination of internal slip plane, ψ = 64.00° (see Fig. 28 in DEMO 82).
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 = N/A N γ= N/A

SEISMICITY

Not Applicable

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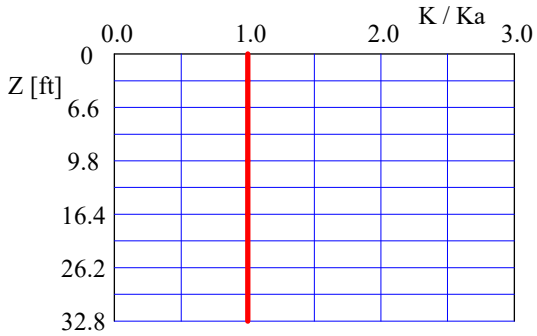
INPUT DATA: Geogrids (Analysis)

D A T A	Geogrid type #1	Geogrid type #2	Geogrid type #3	Geogrid type #4	Geogrid type #5
Tult [lb/ft]	7550.0	9000.0	14500.0		
Durability reduction factor, RFd	1.30	1.30	1.30		
Installation-damage reduction factor, RFid	1.11	1.11	1.11		
Creep reduction factor, RFc	1.51	1.51	1.51	N/A	N/A
CDR for strength	N/A	N/A	N/A		
Coverage ratio, Rc	1.000	1.000	1.000		
Friction angle along geogrid-soil interface, ρ	27.63	27.63	27.63		
Pullout resistance factor, F*	$0.67 \cdot \tan\phi$	$0.67 \cdot \tan\phi$	$0.67 \cdot \tan\phi$	N/A	N/A
Scale-effect correction factor, α	0.8	0.8	0.8		

Variation of Lateral Earth Pressure Coefficient With Depth

Z	K / Ka
0 ft	1.00
3.3 ft	1.00
6.6 ft	1.00
9.8 ft	1.00
13.1 ft	1.00
16.4 ft	1.00
19.7 ft	1.00



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INPUT DATA: Geometry and Surcharge loads (of a SIMPLE STRUCTURE)

Design height, Hd 13.70 [ft] { Embedded depth is E = 0.00 ft, and height above top of finished bottom grade is H = 13.70 ft }

Soil in front of wall is Horizontal.

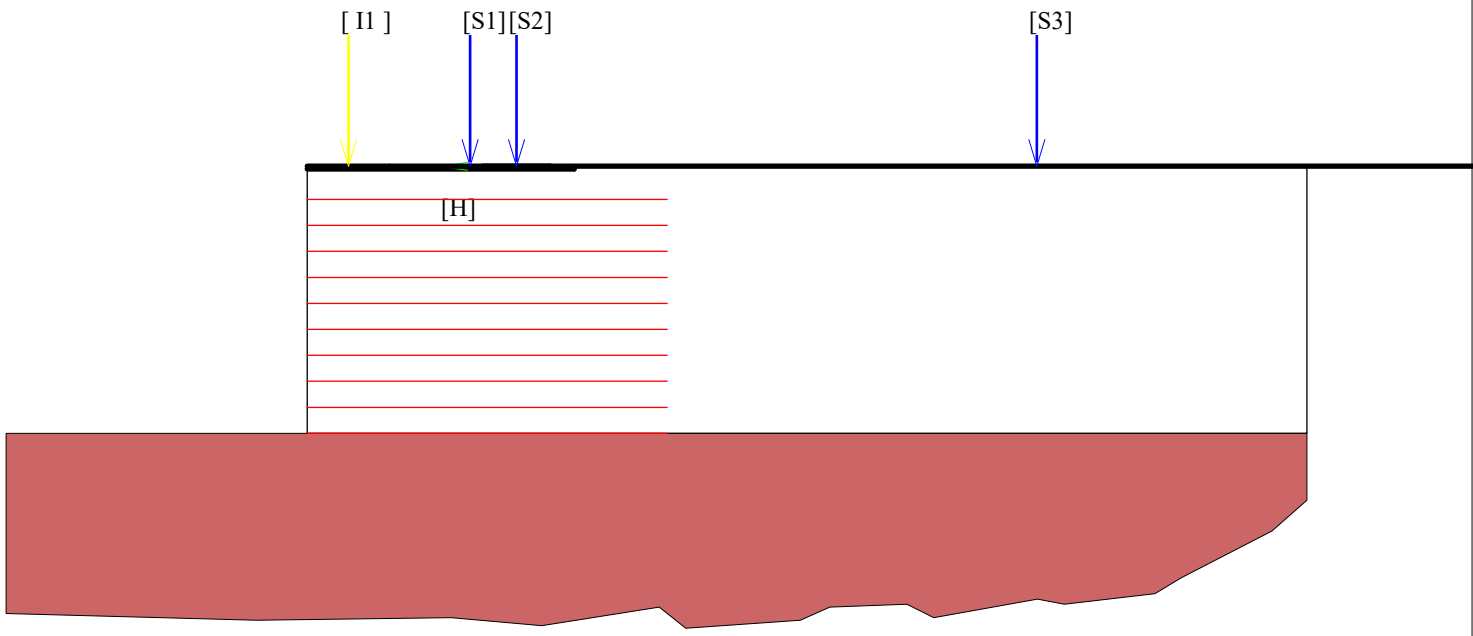
Batter, ω 0.0 [deg]
Backslope, β 0.0 [deg]
Backslope rise 0.0 [ft] Broken back equivalent angle, I = 0.00° (see Fig. 25 in DEMO 82)

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]

OTHER EXTERNAL LOAD(S)
[S1] Strip Load, Qv-d = 700.0 and Qv-l = 0.0 [lb/ft ²].
Footing width, b=8.3 [ft]. Distance of center of footing from wall face, d = 8.4 [ft] @ depth of 0.0 [ft] below soil surface.
[S2] Strip Load, Qv-d = 2350.0 and Qv-l = 0.0 [lb/ft ²].
Footing width, b=3.5 [ft]. Distance of center of footing from wall face, d = 10.8 [ft] @ depth of 0.0 [ft] below soil surface.
[S3] Strip Load, Qv-d = 2365.0 and Qv-l = 0.0 [lb/ft ²].
Footing width, b=50.0 [ft]. Distance of center of footing from wall face, d = 37.5 [ft] @ depth of 0.0 [ft] below soil surface.
[I1] Isolated Load, Pv-d' = 53220.0 and Pv-l' = 0.0 [lb]. Length of footing, L = 36.8 [ft],
and width, b = 4.3 [ft]. Distance of center of footing from wall face, d = 2.1 [ft] @ depth of 0.0 [ft] below soil surface.
[H1] Horizontal Load, Ph = 4750.0 [lb/ft], acting at a depth of Zh = 0.0 [ft] and at a distance of Lb = 13.7 [ft].

Load Factor of 1.5 is being applied.

ANALYZED REINFORCEMENT LAYOUT:



SCALE:

0 2 4 6 8 10 [ft]

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AASHTO 2017-2020 – Load and Resisting Factors

INTERNAL STABILITY

Load factor for vertical earth pressure, EV:	$\gamma_{p\text{-}EV}$	1.35
Load factor for earthquake loads, EQ:	$\gamma_{p\text{-}EQ}$	1.00
Load factor for live load surcharge, LS: (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	ϕ	Static	Combined static/seismic	
Geogrid:		0.90		1.20
Resistance factor for reinforcement tension in connectors	ϕ	Static	Combined static/seismic	
Geogrid:		0.90		1.20
Resistance factor for geosynthetic pullout	ϕ	0.90		1.20

EXTERNAL STABILITY

Load factor for vertical earth pressure, EV			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	$\gamma_{p\text{-}EH}$	1.50
Load factor of active lateral earth pressure during earthquake (does not multiply P_{AE} and P_{IR}):	$(\gamma_{p\text{-}EH})_{EQ}$	1.10
Load factor for earthquake loads, EQ (multiplies P_{AE} and P_{IR}):	$\gamma_{p\text{-}EQ}$	1.00

Resistance factor for shear resistance along common interfaces		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		Static	Combined Static/Seismic	
	ϕ_b	0.65		0.90

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ANALYSIS: CALCULATED FACTORS (Static conditions)

Bearing capacity, CDR = 14.74, factored bearing load = 5293 lb/ft².
Foundation Interface: Direct sliding, CDR = 2.220, Eccentricity, e/L = 0.0981, CDR-overturning = 3.35

GEOGRID #	Elevation [ft]	Length [ft]	Type #	CONNECTION CDR [connection break]		Geogrid strength CDR	Pullout resistance CDR	Direct sliding CDR	Eccentricity e/L	Product name
1	0.00	18.50	2	N/A	N/A	5.661	82.842	1.488	0.0981	SF90
2	1.33	18.50	2	N/A	N/A	2.878	39.277	1.535	0.0767	SF90
3	2.67	18.50	2	N/A	N/A	2.958	37.249	1.586	0.0550	SF90
4	4.00	18.50	2	N/A	N/A	3.051	35.314	1.639	0.0332	SF90
5	5.33	18.50	2	N/A	N/A	3.116	32.960	1.697	0.0110	SF90
6	6.67	18.50	2	N/A	N/A	3.180	30.768	1.759	-0.0119	SF90
7	8.00	18.50	2	N/A	N/A	3.242	28.462	1.825	-0.0355	SF90
8	9.33	18.50	2	N/A	N/A	3.277	25.698	1.896	-0.0602	SF90
9	10.66	18.50	2	N/A	N/A	3.277	23.039	1.974	-0.0865	SF90
10	12.00	18.50	2	N/A	N/A	1.816	11.294	2.058	-0.1152	SF90

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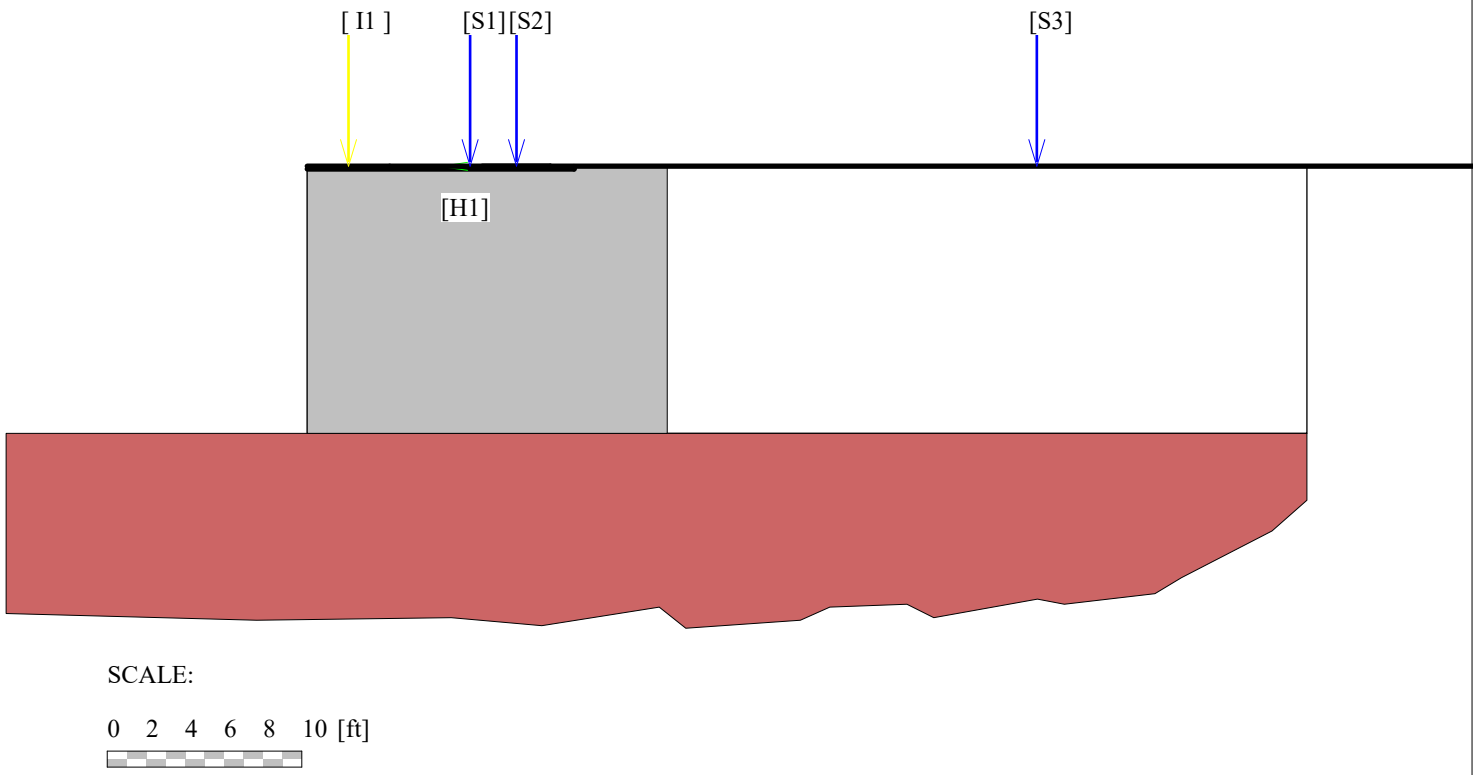
BEARING CAPACITY for GIVEN LAYOUT – Using AASHTO 2017-2020 method

	STATIC	SEISMIC	UNITS
(Given factored bearing resistance, q-n)			
Factored bearing resistance. q-n	78000	N/A	[lb/ft ²]
Factored bearing load, σ_V	5292.9	N/A	[lb/ft ²]
Eccentricity, e	0.76	N/A	[ft]
Eccentricity, e/L	0.041	N/A	
CDR calculated	14.74	N/A	
Base length	18.50	N/A	[ft]

Unfactored applied bearing pressure = (Unfactored R) / [L - 2 * (Unfactored e)] =
Unfactored R = 63850.75 [lb/ft], L = 18.50, Unfactored e = 0.76 [ft], and Sigma = 3761.69 [lb/ft ²]



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DIRECT SLIDING for GIVEN LAYOUT (for GEOGRID reinforcements)

Along reinforced and foundation soils interface: CDR-static = 2.220

#	Geogrid Elevation [ft]	Geogrid Length [ft]	CDR Static	CDR Seismic	Geogrid Type #	Product name
1	0.00	18.50	1.488	N/A	2	SF90
2	1.33	18.50	1.535	N/A	2	SF90
3	2.67	18.50	1.586	N/A	2	SF90
4	4.00	18.50	1.639	N/A	2	SF90
5	5.33	18.50	1.697	N/A	2	SF90
6	6.67	18.50	1.759	N/A	2	SF90
7	8.00	18.50	1.825	N/A	2	SF90
8	9.33	18.50	1.896	N/A	2	SF90
9	10.66	18.50	1.974	N/A	2	SF90
10	12.00	18.50	2.058	N/A	2	SF90

ECCENTRICITY for GIVEN LAYOUT

At interface with foundation: e/L static = 0.0981; Overturning: CDR-static = 3.35

#	Geogrid Elevation [ft]	Geogrid Length [ft]	e / L Static	e / L Seismic	Geogrid Type #	Product name
1	0.00	18.50	0.0981	N/A	2	SF90
2	1.33	18.50	0.0767	N/A	2	SF90
3	2.67	18.50	0.0550	N/A	2	SF90
4	4.00	18.50	0.0332	N/A	2	SF90
5	5.33	18.50	0.0110	N/A	2	SF90
6	6.67	18.50	-0.0119	N/A	2	SF90
7	8.00	18.50	-0.0355	N/A	2	SF90
8	9.33	18.50	-0.0602	N/A	2	SF90
9	10.66	18.50	-0.0865	N/A	2	SF90
10	12.00	18.50	-0.1152	N/A	2	SF90

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RESULTS for STRENGTH

Live Load included in calculating Tmax

#	Geogrid Elevation [ft]	Factored LTDS [lb/ft]	Factored Tmax [lb/ft]	Tmd [lb/ft]	Specified minimum CDR Static	Actual calculated CDR Static	Specified minimum CDR seismic	Actual calculated CDR seismic	Product name
1	0.00	3717.4	656.6	N/A	N/A	5.661	N/A	N/A	SF90
2	1.33	3717.4	1291.5	N/A	N/A	2.878	N/A	N/A	SF90
3	2.67	3717.4	1256.6	N/A	N/A	2.958	N/A	N/A	SF90
4	4.00	3717.4	1218.5	N/A	N/A	3.051	N/A	N/A	SF90
5	5.33	3717.4	1193.1	N/A	N/A	3.116	N/A	N/A	SF90
6	6.67	3717.4	1169.1	N/A	N/A	3.180	N/A	N/A	SF90
7	8.00	3717.4	1146.6	N/A	N/A	3.242	N/A	N/A	SF90
8	9.33	3717.4	1134.3	N/A	N/A	3.277	N/A	N/A	SF90
9	10.66	3717.4	1134.2	N/A	N/A	3.277	N/A	N/A	SF90
10	12.00	3717.4	2046.8	N/A	N/A	1.816	N/A	N/A	SF90

RESULTS for PULLOUT

Live Load included in calculating Tmax

#	Geogrid Elevation [ft]	Coverage Ratio	Factored: Stat./Seis. Tmax [lb/ft]	Tmd [lb/ft]	Le [ft]	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	656.6	N/A	18.50	0.00	54396.6	N/A	82.842	N/A	N/A	N/A
2	1.33	1.000	1291.5	N/A	17.85	0.65	50726.4	N/A	39.277	N/A	N/A	N/A
3	2.67	1.000	1256.6	N/A	17.20	1.30	46808.4	N/A	37.249	N/A	N/A	N/A
4	4.00	1.000	1218.5	N/A	16.55	1.95	43029.0	N/A	35.314	N/A	N/A	N/A
5	5.33	1.000	1193.1	N/A	15.90	2.60	39323.3	N/A	32.960	N/A	N/A	N/A
6	6.67	1.000	1169.1	N/A	15.25	3.25	35972.1	N/A	30.768	N/A	N/A	N/A
7	8.00	1.000	1146.6	N/A	14.60	3.90	32635.5	N/A	28.462	N/A	N/A	N/A
8	9.33	1.000	1134.3	N/A	13.95	4.55	29149.9	N/A	25.698	N/A	N/A	N/A
9	10.66	1.000	1134.2	N/A	13.30	5.20	26131.7	N/A	23.039	N/A	N/A	N/A
10	12.00	1.000	2046.8	N/A	12.65	5.85	23115.7	N/A	11.294	N/A	N/A	N/A

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AASHTO 2017-2020
I-405 D/B - Bridge 40P

MSEW+: Update # 2021.12

PROJECT IDENTIFICATION

Title: I-405 D/B - Bridge 40P
Project Number: O38650
Client: Flatiron Lane JV
Designer: VA
Station Number: DH = 13.7'

Description:

Design Case 2 (Seismic); Design Height = 13.7 ft; Loading Conditions:
DC = 0.70 ksf; EV = 2.35 ksf; H1 = 8.06 kips/ft

Company's information:

Name: Tensar International Corporation
Street: 2500 Northwinds Parkway
Suite 500
Alpharetta, GA 30009
Telephone #: (770) 344-2090
Fax #: (770) 344-2084
E-Mail: vamaya@tensarcorp.com

File path and name: K:_ o\O38650\Final\Working Files\Design\Rev2\MSEW\Wingw.....
.....3.7ft - Seismic.BENp

Original date and time of creating this file: Oct 2021

PROGRAM MODE: ANALYSIS
of a SIMPLE STRUCTURE
using GEOGRID as reinforcing material.

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SOIL DATA

REINFORCED SOIL

Unit weight, γ	135.0 lb/ft ^{3}
Design value of internal angle of friction, ϕ	38.0 °

RETAINED SOIL

Unit weight, γ	135.0 lb/ft ^{3}
Design value of internal angle of friction, ϕ	38.0 °

FOUNDATION SOIL (Considered as an equivalent uniform soil)

Equivalent unit weight, $\gamma_{equiv.}$	140.0 lb/ft ^{3}
Equivalent internal angle of friction, $\phi_{equiv.}$	43.0 °
Equivalent cohesion, $c_{equiv.}$	0.0 lb/ft ^{2}

Factored bearing capacity resistance of foundation is given: q-ult-static = 120000.0 lb/ft^2., q-ult-sesmic = 120000.0 lb/ft^2.

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)
Inclination of internal slip plane, ψ = 64.00° (see Fig. 28 in DEMO 82).
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 = N/A N γ= N/A

SEISMICITY (using AASHTO 2017-2020)

Peak ground acceleration coeff., A = PGA = 0.417 and Site Factor, Fpga = 1.183. Maximum ground acceleration coeff., As = 0.493
Design acceleration coefficient in Internal Stability: Kh = Am = 0.247
Design acceleration coefficient in External Stability: Kh_d = 0.247 => Kh = Am = 0.247

Kae (Kh > 0) = 0.3878 Kae (Kh = 0) = 0.2379
Seismic soil-geogrid friction coefficient, F* is 80.0% of its specified static value.

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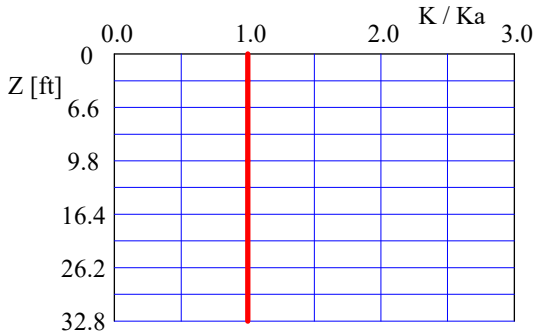
INPUT DATA: Geogrids (Analysis)

D A T A	Geogrid type #1	Geogrid type #2	Geogrid type #3	Geogrid type #4	Geogrid type #5
Tult [lb/ft]	7550.0	9000.0	14500.0		
Durability reduction factor, RFd	1.30	1.30	1.30		
Installation-damage reduction factor, RFid	1.11	1.11	1.11		
Creep reduction factor, RFc	1.51	1.51	1.51	N/A	N/A
CDR for strength	N/A	N/A	N/A		
Coverage ratio, Rc	1.000	1.000	1.000		
Friction angle along geogrid-soil interface, ρ	27.63	27.63	27.63		
Pullout resistance factor, F*	$0.67 \cdot \tan\phi$	$0.67 \cdot \tan\phi$	$0.67 \cdot \tan\phi$	N/A	N/A
Scale-effect correction factor, α	0.8	0.8	0.8		

Variation of Lateral Earth Pressure Coefficient With Depth

Z	K / Ka
0 ft	1.00
3.3 ft	1.00
6.6 ft	1.00
9.8 ft	1.00
13.1 ft	1.00
16.4 ft	1.00
19.7 ft	1.00



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INPUT DATA: Geometry and Surcharge loads (of a SIMPLE STRUCTURE)

Design height, Hd 13.70 [ft] { Embedded depth is E = 0.00 ft, and height above top of finished bottom grade is H = 13.70 ft }

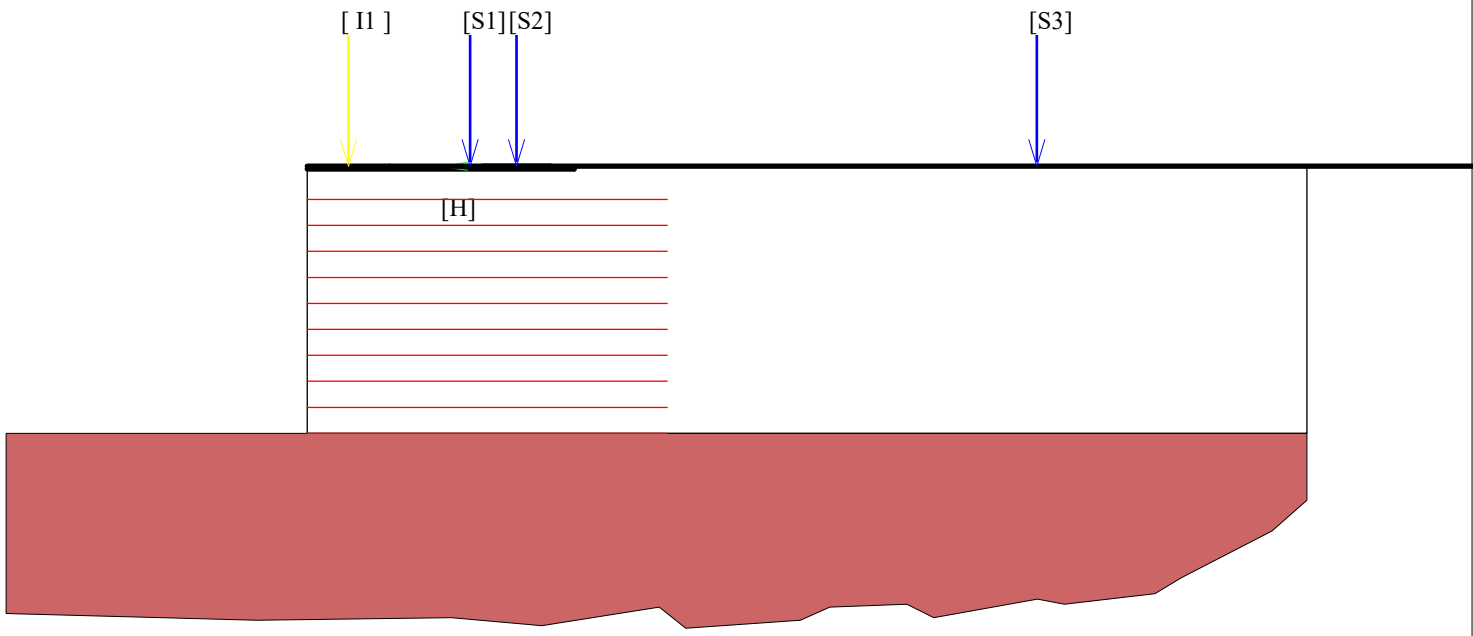
Soil in front of wall is Horizontal.

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]

OTHER EXTERNAL LOAD(S)
[S1] Strip Load, Qv-d = 700.0 and Qv-l = 0.0 [lb/ft ²].
Footing width, b=8.3 [ft]. Distance of center of footing from wall face, d = 8.4 [ft] @ depth of 0.0 [ft] below soil surface.
[S2] Strip Load, Qv-d = 2350.0 and Qv-l = 0.0 [lb/ft ²].
Footing width, b=3.5 [ft]. Distance of center of footing from wall face, d = 10.8 [ft] @ depth of 0.0 [ft] below soil surface.
[S3] Strip Load, Qv-d = 2365.0 and Qv-l = 0.0 [lb/ft ²].
Footing width, b=50.0 [ft]. Distance of center of footing from wall face, d = 37.5 [ft] @ depth of 0.0 [ft] below soil surface.
[I1] Isolated Load, Pv-d' = 53220.0 and Pv-l' = 0.0 [lb]. Length of footing, L = 36.8 [ft],
and width, b = 4.3 [ft]. Distance of center of footing from wall face, d = 2.1 [ft] @ depth of 0.0 [ft] below soil surface.
[H1] Horizontal Load, Ph = 8060.0 [lb/ft], acting at a depth of Zh = 0.0 [ft] and at a distance of Lb = 13.7 [ft].

ANALYZED REINFORCEMENT LAYOUT:



SCALE:

0 2 4 6 8 10 [ft]

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AASHTO 2017-2020 – Load and Resisting Factors

INTERNAL STABILITY

Load factor for vertical earth pressure, EV:	$\gamma_{p\text{-}EV}$	1.35
Load factor for earthquake loads, EQ:	$\gamma_{p\text{-}EQ}$	1.00
Load factor for live load surcharge, LS: (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	ϕ	Static	Combined static/seismic
Geogrid:		0.90	1.20

Resistance factor for reinforcement tension in connectors	ϕ	Static	Combined static/seismic
Geogrid:		0.90	1.20

Resistance factor for geosynthetic pullout	ϕ	0.90	1.20

EXTERNAL STABILITY

Load factor for vertical earth pressure, EV			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	$\gamma_{p\text{-}EH}$	1.50
Load factor of active lateral earth pressure during earthquake (does not multiply P_{AE} and P_{IR}):	$(\gamma_{p\text{-}EH})_{EQ}$	1.10
Load factor for earthquake loads, EQ (multiplies P_{AE} and P_{IR}):	$\gamma_{p\text{-}EQ}$	1.00

Resistance factor for shear resistance along common interfaces		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	Static	Combined Static/Seismic
ϕ_b	0.65	0.90

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ANALYSIS: CALCULATED FACTORS (Static conditions)

Bearing capacity, CDR = 13.42, factored bearing load = 5810 lb/ft².
Foundation Interface: Direct sliding, CDR = 1.818, Eccentricity, e/L = 0.1557, CDR-overturning = 2.51

GEOGRID #	Elevation [ft]	Length [ft]	Type #	CONNECTION CDR [connection break]	Geogrid strength CDR	Pullout resistance CDR	Direct sliding CDR	Eccentricity e/L	Product name
1	0.00								
2	1.33								
3	2.67	18.50	2	N/A	2.409	30.999	1.299	0.1007	SF90
4	4.00	18.50	2	N/A	2.436	28.197	1.272	0.0815	SF90
5	5.33	18.50	2	N/A	2.439	25.801	1.287	0.0555	SF90
6	6.67	18.50	2	N/A	2.442	23.627	1.299	0.0281	SF90
7	8.00	18.50	2	N/A	2.444	21.458	1.309	-0.0006	SF90
8	9.33	18.50	2	N/A	2.428	19.042	1.314	-0.0312	SF90
9	10.66	18.50	2	N/A	2.391	16.810	1.313	-0.0645	SF90
10	12.00	18.50	2	N/A	1.305	8.116	1.306	-0.1017	SF90

Refer to previous MSEW calc for static condition.

ANALYSIS: CALCULATED FACTORS (Seismic conditions)

Bearing capacity, CDR = 15.46, factored bearing load = 6985 lb/ft².
Foundation Interface: Direct sliding, CDR = 1.417, Eccentricity, e/L = 0.2500, Fs-overturning = 1.78

GEOGRID #	Elevation [ft]	Length [ft]	Type #	CONNECTION CDR [connection break]	Geogrid strength CDR	Pullout resistance CDR	Direct sliding CDR	Eccentricity e/L	Product name
1	0.00	18.50	2	N/A	7.633	82.790	0.950	0.2500	SF90
2	1.33	18.50	2	N/A	4.162	43.549	0.987	0.2145	SF90
3	2.67	18.50	2	N/A	4.211	40.645	1.029	0.1788	SF90
4	4.00	18.50	2	N/A	4.274	37.894	1.076	0.1432	SF90
5	5.33	18.50	2	N/A	4.299	34.828	1.130	0.1074	SF90
6	6.67	18.50	2	N/A	4.325	32.040	1.193	0.0706	SF90
7	8.00	18.50	2	N/A	4.351	29.236	1.268	0.0330	SF90
8	9.33	18.50	2	N/A	4.347	26.093	1.360	-0.0061	SF90
9	10.66	18.50	2	N/A	4.309	23.194	1.476	-0.0474	SF90
10	12.00	18.50	2	N/A	2.468	11.969	1.631	-0.0923	SF90

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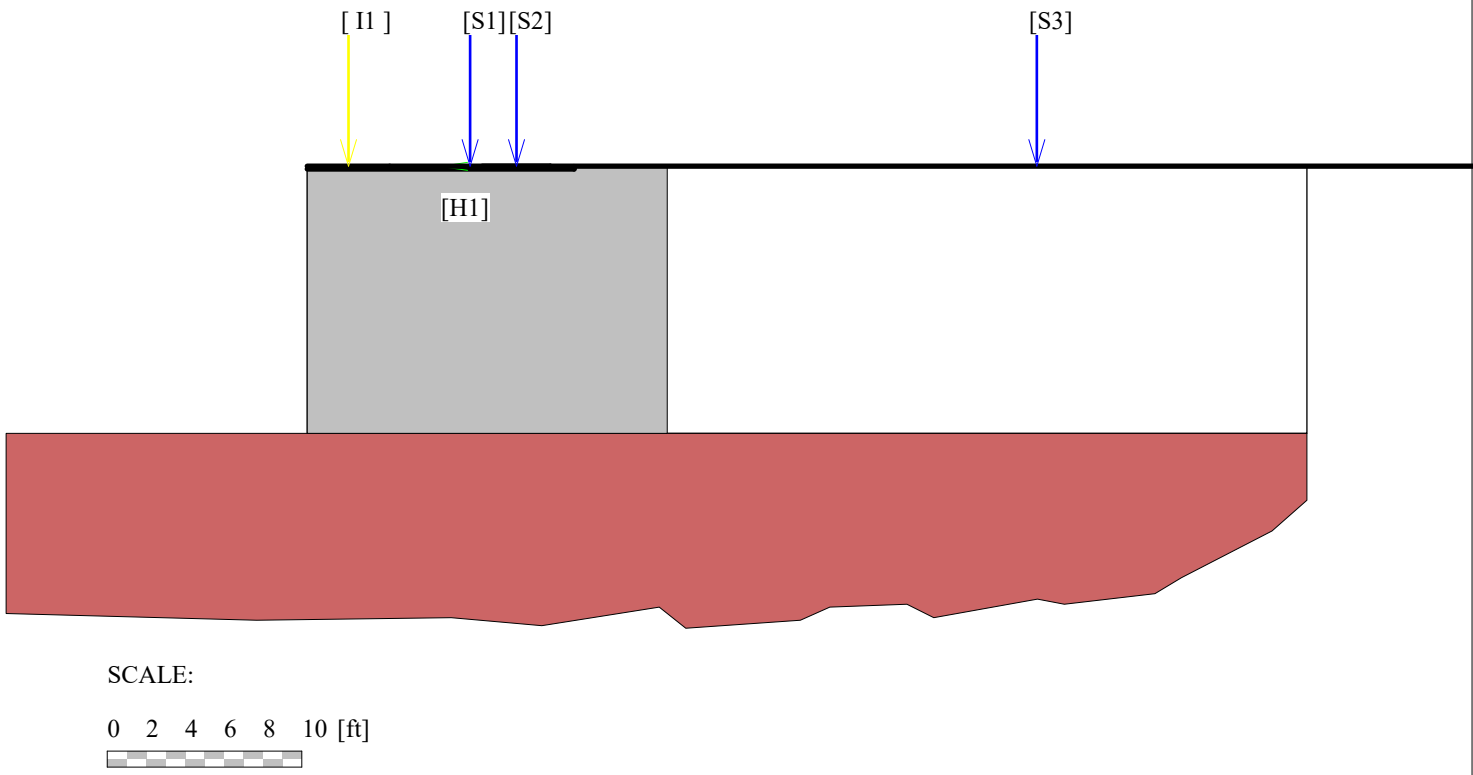
BEARING CAPACITY for GIVEN LAYOUT – Using AASHTO 2017-2020 method

	STATIC	SEISMIC	UNITS
(Given factored bearing resistance, q-n)			
Factored bearing resistance. q-n	78000	108000	[lb/ft ²]
Factored bearing load, σ_V	5810.3	6985	[lb/ft ²]
Eccentricity, e	1.51	2.78	[ft]
Eccentricity, e/L	0.082	0.150	
CDR calculated	13.42	15.46	
Base length	18.50	18.50	[ft]

Unfactored applied bearing pressure = (Unfactored R) / [L - 2 * (Unfactored e)] =
Static: Unfactored R = 63850.75 [lb/ft], L = 18.50, Unfactored e = 1.47 [ft], and Sigma = 4105.22 [lb/ft ²]
Seismic: Unfactored R = 63850.75 [lb/ft], L = 18.50, Unfactored e = 2.90 [ft], and Sigma = 5028.40 [lb/ft ²]



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DIRECT SLIDING for GIVEN LAYOUT (for GEOGRID reinforcements)

Along reinforced and foundation soils interface: CDR-static = 1.818 and CDR-seismic = 1.417

#	Geogrid Elevation [ft]	Geogrid Length [ft]	CDR Static	CDR Seismic	Geogrid Type #	Product name
1	0.00	18.50	1.218	0.950	2	SF90
2	1.33	18.50	1.237	0.987	2	SF90
3	2.67	18.50	1.255	1.029	2	SF90
4	4.00	18.50	1.272	1.076	2	SF90
5	5.33	18.50	1.287	1.130	2	SF90
6	6.67	18.50	1.299	1.193	2	SF90
7	8.00	18.50	1.309	1.268	2	SF90
8	9.33	18.50	1.314	1.360	2	SF90
9	10.66	18.50	1.313	1.476	2	SF90
10	12.00	18.50	1.306	1.631	2	SF90

ECCENTRICITY for GIVEN LAYOUT

At interface with foundation: e/L static = 0.1557, e/L seismic = 0.2500; Overturning: CDR-static = 2.51, CDR-seismic = 1.78

#	Geogrid Elevation [ft]	Geogrid Length [ft]	e / L Static	e / L Seismic	Geogrid Type #	Product name
1	0.00	18.50	0.1557	0.2500	2	SF90
2	1.33	18.50	0.1315	0.2145	2	SF90
3	2.67	18.50	0.1067	0.1788	2	SF90
4	4.00	18.50	0.0815	0.1432	2	SF90
5	5.33	18.50	0.0555	0.1074	2	SF90
6	6.67	18.50	0.0281	0.0706	2	SF90
7	8.00	18.50	-0.0006	0.0330	2	SF90
8	9.33	18.50	-0.0312	-0.0061	2	SF90
9	10.66	18.50	-0.0645	-0.0474	2	SF90
10	12.00	18.50	-0.1017	-0.0923	2	SF90

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RESULTS for STRENGTH

Live Load included in calculating Tmax

#	Geogrid Elevation [ft]	LTDS [lb/ft]	Factored: Static/Seismic Tmax [lb/ft]	Tmd [lb/ft]	Specified minimum CDR Static	Actual calculated CDR Static	Specified minimum CDR seismic	Actual calculated CDR seismic	Product name
1	0.00	3717/4957	780/548	152.41	N/A	4.767	N/A	7.633	SF90
2	1.33	3717/4957	1556/1090	152.41	N/A	2.390	N/A	4.162	SF90
3	2.67	3717/4957	1543/1076	152.41	N/A	2.409	N/A	4.211	SF90
4	4.00	3717/4957	1526/1059	152.41	N/A	2.436	N/A	4.274	SF90
5	5.33	3717/4957	1524/1052	152.41	N/A	2.439	N/A	4.299	SF90
6	6.67	3717/4957	1523/1045	152.41	N/A	2.442	N/A	4.325	SF90
7	8.00	3717/4957	1521/1038	152.41	N/A	2.444	N/A	4.351	SF90
8	9.33	3717/4957	1531/1039	152.41	N/A	2.428	N/A	4.347	SF90
9	10.66	3717/4957	1555/1049	152.41	N/A	2.391	N/A	4.309	SF90
10	12.00	3717/4957	2848/1908	152.41	N/A	1.305	N/A	2.468	SF90

RESULTS for PULLOUT

Live Load included in calculating Tmax

#	Geogrid Elevation [ft]	Coverage Ratio	Factored: Stat./Seis. Tmax [lb/ft]	Tmd [lb/ft]	Le [ft]	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	780/548	0/152.4	18.50	0.00	54396.6	N/A	69.755	58023.0	N/A	82.790
2	1.33	1.000	1556/1090	0/152.4	17.85	0.65	50726.4	N/A	32.610	54108.2	N/A	43.549
3	2.67	1.000	1543/1076	0/152.4	17.20	1.30	46808.4	N/A	30.335	49928.9	N/A	40.645
4	4.00	1.000	1526/1059	0/152.4	16.55	1.95	43029.0	N/A	28.197	45897.6	N/A	37.894
5	5.33	1.000	1524/1052	0/152.4	15.90	2.60	39323.3	N/A	25.801	41944.8	N/A	34.828
6	6.67	1.000	1523/1045	0/152.4	15.25	3.25	35972.1	N/A	23.627	38370.2	N/A	32.040
7	8.00	1.000	1521/1038	0/152.4	14.60	3.90	32635.5	N/A	21.458	34811.2	N/A	29.236
8	9.33	1.000	1531/1039	0/152.4	13.95	4.55	29149.9	N/A	19.042	31093.3	N/A	26.093
9	10.66	1.000	1555/1049	0/152.4	13.30	5.20	26131.7	N/A	16.810	27873.8	N/A	23.194
10	12.00	1.000	2848/1908	0/152.4	12.65	5.85	23115.7	N/A	8.116	24656.7	N/A	11.969

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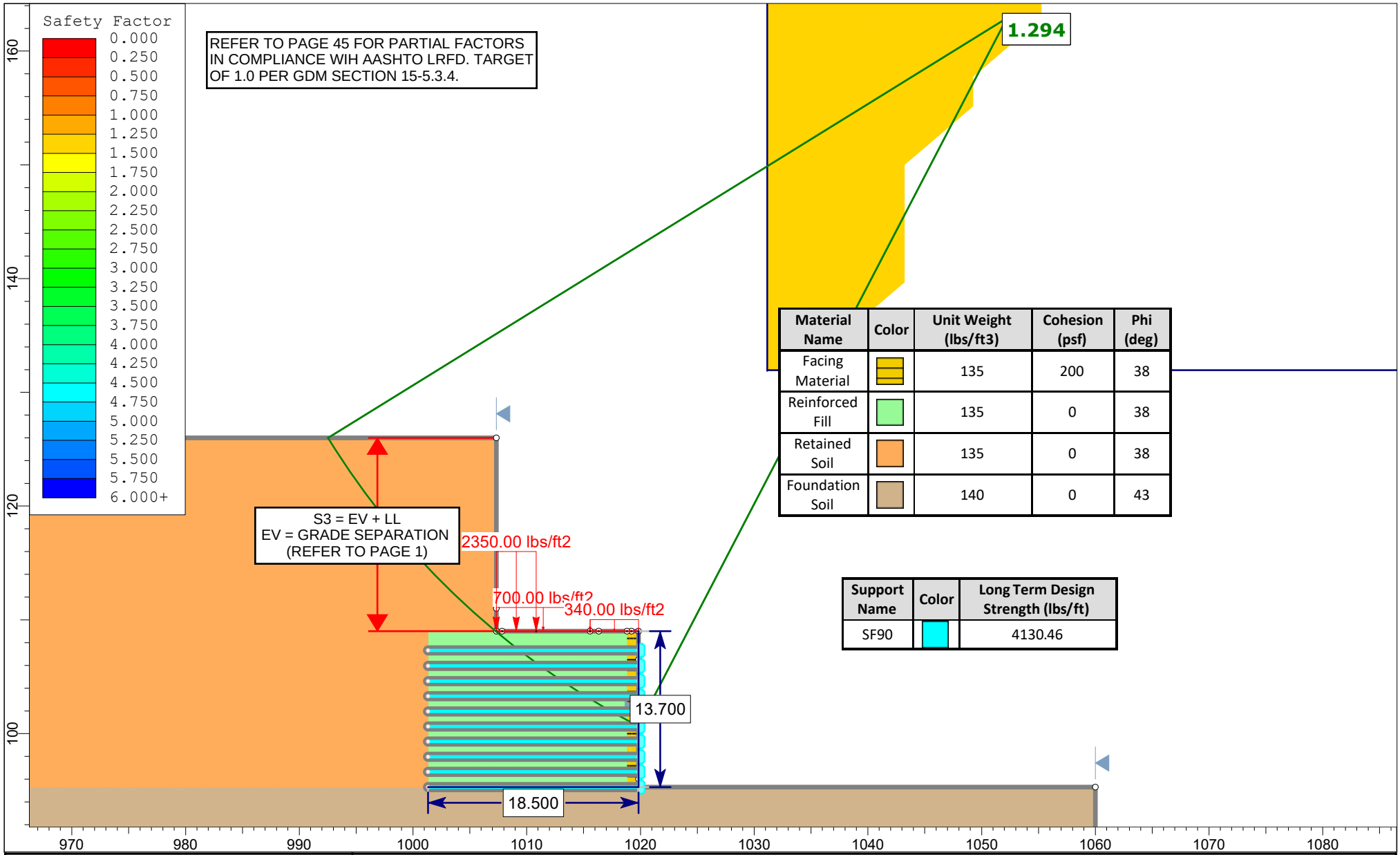


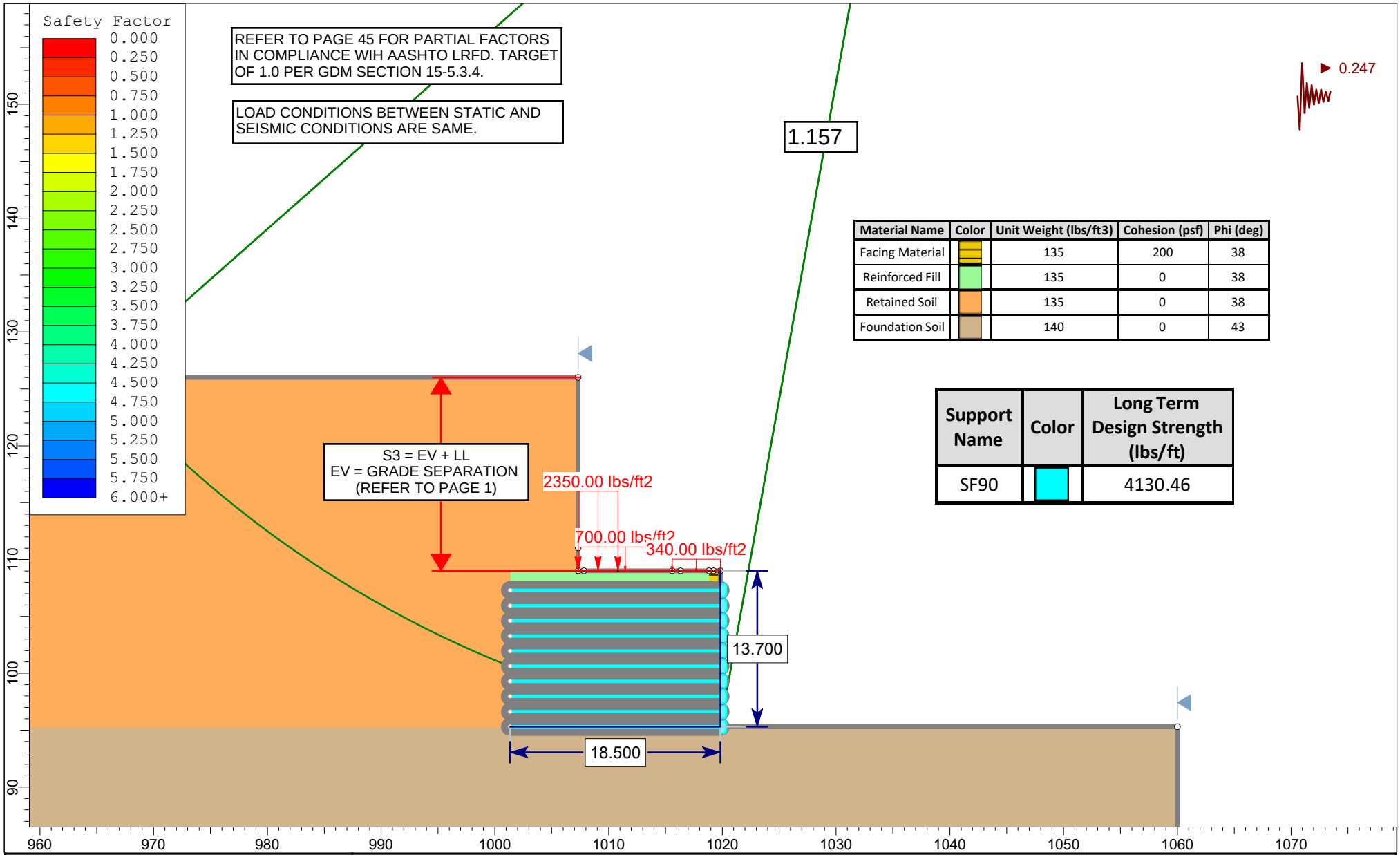
Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
Facing Material		135	200	38
Reinforced Fill		135	0	38
Retained Soil		135	0	38
Foundation Soil		140	0	43

Support Name	Color	Long Term Design Strength (lbs/ft)
SF90		4130.46

Tensar®

SLIDEINTERPRET 9.019

Project	405/40P ERC BRIDGE OVER SB 1-405
Description	Static
Location	Design Case 2; Design Height = 14.2'
Drawn By	VA
Scale	1:140
Date	12/8/2021
File Name	ROC_DC_2.slmd



Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
Facing Material		135	200	38
Reinforced Fill		135	0	38
Retained Soil		135	0	38
Foundation Soil		140	0	43

Support Name	Color	Long Term Design Strength (lbs/ft)
SF90		4130.46

Tensar®

SLIDEINTERPRET 9.019

Project	405/40P ERC BRIDGE OVER SB 1-405
Description	Seismic
Location	Design Case 2; Design Height = 14.2'
Drawn By	VA
Scale	1:140
Date	12/8/2021
File Name	ROC_DC_2.slmd

Slide Analysis Information

ROC_DC_2

Project Summary

File Name:	ROC_DC_2.slmd
Slide Modeler Version:	9.019
Project Title:	405/40P ERC BRIDGE OVER SB 1-405
Author:	VA
Comments	
	Design Case 2; Design Height = 14.2'

Currently Open Scenarios

Group Name	Scenario Name	Global Minimum	Compute Time
Group 1	Static	Bishop Simplified: 1.294090 Spencer: 1.283480	00h:00m:01.751s
	Seismic	Bishop Simplified: 1.157280 Spencer: 1.158110	00h:00m:03.901s

General Settings

Units of Measurement:	Imperial Units
Time Units:	days
Permeability Units:	feet/second
Data Output:	Standard
Failure Direction:	Left to Right

Design Standard

Group 1 - Static

Selected Type:	BS 8006:2010 Section 7 - Reinforced Slopes (User Defined)
Name:	AASHTO 2020 (Strength I)

Type	Partial Factor
Soil Unit Mass: Unfavourable	1.35
Soil Unit Mass: Favourable	1
External Dead Loads: Unfavourable	1.5
External Dead Loads: Favourable	0.75
External Live Loads: Unfavourable	1.75
External Live Loads: Favourable	1
Effective cohesion c'	1.33
Effective friction tan(phi)	1.33
Undrained strength	1.33
Shear strength (other models)	1.33
Tensile and plate strength	1.11
Shear strength	1.11
Compressive strength	1.11
Bond strength	1.11
Seismic Coefficient	1

Slide uses the inverse of the resistance factor as the partial factor. For example, resistance factor of 0.75 is partial factor of 1.33 in Slide.

Group 1 - Seismic

Selected Type:	BS 8006:2010 Section 7 - Reinforced Slopes (User Defined)
Name:	AASHTO 2020 (Seismic)

Type	Partial Factor
Soil Unit Mass: Unfavourable	1
Soil Unit Mass: Favourable	1
External Dead Loads: Unfavourable	1
External Dead Loads: Favourable	1
External Live Loads: Unfavourable	1
External Live Loads: Favourable	1
Effective cohesion c'	1.1
Effective friction tan(phi)	1.1
Undrained strength	1.1
Shear strength (other models)	1.1
Tensile and plate strength	0.83
Shear strength	0.83
Compressive strength	0.83
Bond strength	0.83
Seismic Coefficient	1

Slide uses the inverse of the resistance factor as the partial factor. For example, resistance factor of 0.9 is partial factor of 1.1 in Slide.

Analysis Options

All Open Scenarios

Slices Type:	Vertical
Analysis Methods Used	
	Bishop simplified
	Spencer
Number of slices:	50
Tolerance:	0.005
Maximum number of iterations:	75
Check malpha < 0.2:	Yes
Create Interslice boundaries at intersections with water tables and piezos:	Yes
Initial trial value of FS:	1
Steffensen Iteration:	Yes

Surface Options

All Open Scenarios

Surface Type:	Circular
Search Method:	Grid Search
Radius Increment:	40
Composite Surfaces:	Disabled
Reverse Curvature:	Invalid Surfaces
Minimum Elevation:	Not Defined
Minimum Depth:	Not Defined
Minimum Area:	Not Defined
Minimum Weight:	Not Defined

Seismic Loading

Group 1 - Static

Advanced seismic analysis:	No
Staged pseudostatic analysis:	No

Group 1 - Seismic

Advanced seismic analysis:	No
Staged pseudostatic analysis:	No
Seismic Load Coefficient (Horizontal):	0.247

Loading

All Open Scenarios

Distribution:	Constant
Magnitude [psf]:	700
Orientation:	Normal to boundary
Load Action:	Live

Distribution:	Constant
Magnitude [psf]:	2350
Orientation:	Normal to boundary
Load Action:	Dead

Distribution:	Constant
Magnitude [psf]:	340
Orientation:	Normal to boundary
Load Action:	Dead

Materials

Facing Material	
Color	
Strength Type	Mohr-Coulomb
Unit Weight [lbs/ft3]	135
Cohesion [psf]	200
Friction Angle [deg]	38
Water Surface	Assigned per scenario
Ru Value	0
Reinforced Fill	
Color	
Strength Type	Mohr-Coulomb
Unit Weight [lbs/ft3]	135
Cohesion [psf]	0
Friction Angle [deg]	38
Water Surface	Assigned per scenario
Ru Value	0
Retained Soil	
Color	
Strength Type	Mohr-Coulomb
Unit Weight [lbs/ft3]	135
Cohesion [psf]	0
Friction Angle [deg]	38
Water Surface	Assigned per scenario
Ru Value	0
Foundation Soil	
Color	
Strength Type	Mohr-Coulomb
Unit Weight [lbs/ft3]	140
Cohesion [psf]	0
Friction Angle [deg]	43
Water Surface	Assigned per scenario
Ru Value	0

Materials In Use

Material	Static	Seismic
Facing Material	✓	✓
Reinforced Fill	✓	✓
Retained Soil	✓	✓
Foundation Soil	✓	✓

Support

SF90	
Color	
Type	Geosynthetic
Force Application	Passive (Method B)
Force Orientation	Parallel to Reinforcement
Strip Coverage (%)	100
Long Term Design Strength	4130.46 lbs/ft
Anchorage	Slope Face
Connection Strength Input	Constant
Connection Strength	4130.46 lbs/ft
Shear Strength Model	Linear
Adhesion	0 psf
Friction Angle	22.1 deg
Material Dependent	No
Use External Loads in Strength Computation	Yes

Global Minimums

Group 1 - Static

Method: bishop simplified

FS	1.294090
Center:	1052.234, 162.899
Radius:	70.187
Left Slip Surface Endpoint:	992.529, 126.000
Right Slip Surface Endpoint:	1019.830, 100.640
Left Slope Intercept:	992.529 126.000
Right Slope Intercept:	1019.830 109.000
Resisting Moment:	3.46238e+06 lb-ft
Driving Moment:	2.67554e+06 lb-ft
Passive Support Moment:	1.0844e+06 lb-ft
Maximum Single Support Force:	3721.14 lb
Total Support Force:	18605.7 lb
Total Slice Area:	196.429 ft2
Surface Horizontal Width:	27.301 ft
Surface Average Height:	7.19493 ft

Method: spencer

FS	1.283480
Center:	1052.234, 162.899
Radius:	70.187
Left Slip Surface Endpoint:	992.529, 126.000
Right Slip Surface Endpoint:	1019.830, 100.640
Left Slope Intercept:	992.529 126.000
Right Slope Intercept:	1019.830 109.000
Resisting Moment:	3.43401e+06 lb-ft
Driving Moment:	2.67554e+06 lb-ft
Resisting Horizontal Force:	44830.9 lb
Driving Horizontal Force:	34929.1 lb
Passive Support Moment:	1.0844e+06 lb-ft
Passive Horizontal Support Force:	18605.7 lb
Maximum Single Support Force:	3721.14 lb
Total Support Force:	18605.7 lb
Total Slice Area:	196.429 ft2
Surface Horizontal Width:	27.301 ft
Surface Average Height:	7.19493 ft

Group 1 - Seismic

Method: bishop simplified

FS	1.157280
Center:	1036.679, 189.149
Radius:	95.348
Left Slip Surface Endpoint:	965.240, 126.000
Right Slip Surface Endpoint:	1019.830, 95.301
Left Slope Intercept:	965.240 126.000
Right Slope Intercept:	1019.830 109.000
Resisting Moment:	8.32446e+06 lb-ft
Driving Moment:	7.19315e+06 lb-ft
Passive Support Moment:	1.3614e+06 lb-ft
Maximum Single Support Force:	4976.46 lb
Total Support Force:	14929.4 lb
Total Slice Area:	847.4 ft2
Surface Horizontal Width:	54.5897 ft
Surface Average Height:	15.5231 ft

Method: spencer

FS	1.158110
Center:	1036.679, 189.149
Radius:	95.348
Left Slip Surface Endpoint:	965.240, 126.000
Right Slip Surface Endpoint:	1019.830, 95.301
Left Slope Intercept:	965.240 126.000
Right Slope Intercept:	1019.830 109.000
Resisting Moment:	8.33048e+06 lb-ft
Driving Moment:	7.19315e+06 lb-ft
Resisting Horizontal Force:	82039 lb
Driving Horizontal Force:	70838.5 lb
Passive Support Moment:	1.3614e+06 lb-ft
Passive Horizontal Support Force:	14929.4 lb
Maximum Single Support Force:	4976.46 lb
Total Support Force:	14929.4 lb
Total Slice Area:	847.4 ft2
Surface Horizontal Width:	54.5897 ft
Surface Average Height:	15.5231 ft

Slice Data

Group 1 - Static

Global Minimum Query (bishop simplified) - Safety Factor: 1.29409

Slice Number	Width [ft]	Weight [lbs]	Angle of Slice Base [deg]	Base Material	Base Cohesion [psf]	Base Friction Angle [deg]	Shear Stress [psf]	Shear Strength [psf]	Base Normal Stress [psf]	Pore Pressure [psf]	Effective Normal Stress [psf]	Base Vertical Stress [psf]	Effective Vertical Stress [psf]
1	0.546232	43.2817	-57.8636	Retained Soil	0	30.4314	20.8982	27.0441	46.0378	0	46.0378	79.3054	79.3054
2	0.546232	128.486	-57.0348	Retained Soil	0	30.4314	62.8653	81.3533	138.489	0	138.489	235.422	235.422
3	0.546232	211.06	-56.224	Retained Soil	0	30.4314	104.572	135.325	230.366	0	230.366	386.715	386.715
4	0.546232	291.168	-55.43	Retained Soil	0	30.4314	145.994	188.929	321.618	0	321.618	533.485	533.485
5	0.546232	368.956	-54.6517	Retained Soil	0	30.4314	187.113	242.141	412.202	0	412.202	675.999	675.999
6	0.546232	444.557	-53.8881	Retained Soil	0	30.4314	227.916	294.944	502.09	0	502.09	814.504	814.504
7	0.546232	518.088	-53.1381	Retained Soil	0	30.4314	268.391	347.322	591.255	0	591.255	949.213	949.213
8	0.546232	589.657	-52.401	Retained Soil	0	30.4314	308.529	399.264	679.676	0	679.676	1080.32	1080.32
9	0.546232	659.362	-51.6761	Retained Soil	0	30.4314	348.323	450.761	767.341	0	767.341	1208.02	1208.02
10	0.546232	727.29	-50.9625	Retained Soil	0	30.4314	387.768	501.807	854.236	0	854.236	1332.45	1332.45
11	0.546232	793.523	-50.2598	Retained Soil	0	30.4314	426.861	552.396	940.355	0	940.355	1453.78	1453.78
12	0.546232	858.135	-49.5673	Retained Soil	0	30.4314	465.597	602.524	1025.69	0	1025.69	1572.13	1572.13
13	0.546232	921.195	-48.8845	Retained Soil	0	30.4314	503.977	652.191	1110.24	0	1110.24	1687.64	1687.64
14	0.546232	982.766	-48.2109	Retained Soil	0	30.4314	541.998	701.394	1194	0	1194	1800.42	1800.42
15	0.546232	1042.91	-47.546	Retained Soil	0	30.4314	579.661	750.133	1276.97	0	1276.97	1910.58	1910.58
16	0.546232	1101.67	-46.8895	Retained Soil	0	30.4314	616.965	798.408	1359.14	0	1359.14	2018.2	2018.2

17	0.546232	1159.11	-46.2409	Retained Soil	0	30.4314	653.912	846.221	1440.53	0	1440.53	2123.4	2123.4
18	0.546232	1215.26	-45.5998	Retained Soil	0	30.4314	690.502	893.572	1521.15	0	1521.15	2226.27	2226.27
19	0.546232	1270.18	-44.9661	Retained Soil	0	30.4314	726.738	940.464	1600.97	0	1600.97	2326.85	2326.85
20	0.546232	1323.91	-44.3392	Retained Soil	0	30.4314	762.619	986.898	1680.02	0	1680.02	2425.24	2425.24
21	0.546232	1376.48	-43.719	Retained Soil	0	30.4314	798.152	1032.88	1758.29	0	1758.29	2521.52	2521.52
22	0.546232	1427.92	-43.1052	Retained Soil	0	30.4314	833.327	1078.4	1835.79	0	1835.79	2615.74	2615.74
23	0.546232	1478.28	-42.4974	Retained Soil	0	30.4314	868.162	1123.48	1912.52	0	1912.52	2707.97	2707.97
24	0.546232	1527.59	-41.8955	Retained Soil	0	30.4314	902.642	1168.1	1988.49	0	1988.49	2798.26	2798.26
25	0.546232	1575.86	-41.2992	Retained Soil	0	30.4314	936.79	1212.29	2063.7	0	2063.7	2886.66	2886.66
26	0.546232	1623.14	-40.7083	Retained Soil	0	30.4314	970.589	1256.03	2138.17	0	2138.17	2973.25	2973.25
27	0.546232	1669.45	-40.1226	Retained Soil	0	30.4314	1004.05	1299.33	2211.88	0	2211.88	3058.04	3058.04
28	0.550133	186.351	-39.5399	Reinforced Fill	0	30.4314	1530.63	1980.77	3371.91	0	3371.91	4635.45	4635.45
29	0.550133	67.8336	-38.9599	Reinforced Fill	0	30.4314	1619.08	2095.23	3566.77	0	3566.77	4876	4876
30	0.550133	111.981	-38.3847	Reinforced Fill	0	30.4314	1654.78	2141.43	3645.4	0	3645.4	4956.24	4956.24
31	0.550133	155.231	-37.814	Reinforced Fill	0	30.4314	1690.1	2187.14	3723.22	0	3723.22	5034.86	5034.86
32	0.550133	197.603	-37.2477	Reinforced Fill	0	30.4314	1725.06	2232.38	3800.23	0	3800.23	5111.89	5111.89
33	0.550133	239.119	-36.6856	Reinforced Fill	0	30.4314	1759.65	2277.15	3876.43	0	3876.43	5187.35	5187.35
34	0.550133	279.795	-36.1276	Reinforced Fill	0	30.4314	1142.22	1478.13	2516.25	0	2516.25	3350.01	3350.01
35	0.550133	319.652	-35.5735	Reinforced Fill	0	30.4314	619.204	801.306	1364.08	0	1364.08	1806.95	1806.95
36	0.550133	358.704	-35.0233	Reinforced Fill	0	30.4314	646.732	836.93	1424.72	0	1424.72	1877.96	1877.96
37	0.550133	396.97	-34.4767	Reinforced Fill	0	30.4314	673.973	872.182	1484.73	0	1484.73	1947.54	1947.54
38	0.550133	434.463	-33.9337	Reinforced Fill	0	30.4314	700.926	907.061	1544.11	0	1544.11	2015.71	2015.71
39	0.550133	471.199	-33.3941	Reinforced Fill	0	30.4314	727.592	941.569	1602.86	0	1602.86	2082.51	2082.51
40	0.550133	507.193	-32.8578	Reinforced Fill	0	30.4314	753.972	975.707	1660.97	0	1660.97	2147.95	2147.95
41	0.550133	542.456	-32.3248	Reinforced Fill	0	30.4314	780.062	1009.47	1718.45	0	1718.45	2212.06	2212.06
42	0.550133	577.004	-31.7949	Reinforced Fill	0	30.4314	805.871	1042.87	1775.31	0	1775.31	2274.87	2274.87
43	0.550133	610.847	-31.268	Reinforced Fill	0	30.4314	600.36	776.92	1322.57	0	1322.57	1687.13	1687.13
44	0.550133	643.998	-30.744	Reinforced Fill	0	30.4314	600.966	777.704	1323.9	0	1323.9	1681.36	1681.36

45	0.550133	676.467	-30.2229	Reinforced Fill	0	30.4314	624.802	808.55	1376.41	0	1376.41	1740.39	1740.39
46	0.550133	708.267	-29.7045	Reinforced Fill	0	30.4314	648.364	839.041	1428.32	0	1428.32	1798.21	1798.21
47	0.550133	739.406	-29.1888	Reinforced Fill	0	30.4314	671.651	869.177	1479.62	0	1479.62	1854.82	1854.82
48	0.550133	769.896	-28.6756	Reinforced Fill	0	30.4314	694.665	898.959	1530.32	0	1530.32	1910.25	1910.25
49	0.5	725.654	-28.1882	Facing Material	150.376	30.4314	809.886	1048.07	1528.16	0	1528.16	1962.2	1962.2
50	0.5	749.837	-27.7261	Facing Material	150.376	30.4314	830.683	1074.98	1573.97	0	1573.97	2010.57	2010.57

Global Minimum Query (spencer) - Safety Factor: 1.28348

Slice Number	Width [ft]	Weight [lbs]	Angle of Slice Base [deg]	Base Material	Base Cohesion [psf]	Base Friction Angle [deg]	Shear Stress [psf]	Shear Strength [psf]	Base Normal Stress [psf]	Pore Pressure [psf]	Effective Normal Stress [psf]	Base Vertical Stress [psf]	Effective Vertical Stress [psf]
1	0.546232	43.2817	-57.8636	Retained Soil	0	30.4314	14.1908	18.2136	31.0054	0	31.0054	53.5957	53.5957
2	0.546232	128.486	-57.0348	Retained Soil	0	30.4314	42.9271	55.0961	93.7913	0	93.7913	159.981	159.981
3	0.546232	211.06	-56.224	Retained Soil	0	30.4314	71.8415	92.2071	156.966	0	156.966	264.379	264.379
4	0.546232	291.168	-55.43	Retained Soil	0	30.4314	100.951	129.569	220.568	0	220.568	367.069	367.069
5	0.546232	368.956	-54.6517	Retained Soil	0	30.4314	130.267	167.195	284.62	0	284.62	468.274	468.274
6	0.546232	444.557	-53.8881	Retained Soil	0	30.4314	159.795	205.094	349.137	0	349.137	568.175	568.175
7	0.546232	518.088	-53.1381	Retained Soil	0	30.4314	189.539	243.269	414.123	0	414.123	666.915	666.915
8	0.546232	589.657	-52.401	Retained Soil	0	30.4314	219.497	281.72	479.579	0	479.579	764.612	764.612
9	0.546232	659.362	-51.6761	Retained Soil	0	30.4314	249.668	320.444	545.5	0	545.5	861.363	861.363
10	0.546232	727.29	-50.9625	Retained Soil	0	30.4314	280.05	359.438	611.88	0	611.88	957.25	957.25
11	0.546232	793.523	-50.2598	Retained Soil	0	30.4314	310.636	398.695	678.708	0	678.708	1052.34	1052.34
12	0.546232	858.135	-49.5673	Retained Soil	0	30.4314	341.423	438.21	745.974	0	745.974	1146.68	1146.68
13	0.546232	921.195	-48.8845	Retained Soil	0	30.4314	372.405	477.975	813.668	0	813.668	1240.33	1240.33
14	0.546232	982.766	-48.2109	Retained Soil	0	30.4314	403.578	517.984	881.777	0	881.777	1333.33	1333.33
15	0.546232	1042.91	-47.546	Retained Soil	0	30.4314	434.935	558.23	950.288	0	950.288	1425.7	1425.7
16	0.546232	1101.67	-46.8895	Retained Soil	0	30.4314	466.47	598.705	1019.19	0	1019.19	1517.49	1517.49
17	0.546232	1159.11	-46.2409	Retained Soil	0	30.4314	498.179	639.403	1088.47	0	1088.47	1608.71	1608.71
18	0.546232	1215.26	-45.5998	Retained Soil	0	30.4314	530.057	680.317	1158.12	0	1158.12	1699.39	1699.39
19	0.546232	1270.18	-44.9661	Retained Soil	0	30.4314	562.097	721.44	1228.12	0	1228.12	1789.55	1789.55
20	0.546232	1323.91	-44.3392	Retained Soil	0	30.4314	594.295	762.766	1298.47	0	1298.47	1879.22	1879.22
21	0.546232	1376.48	-43.719	Retained Soil	0	30.4314	626.649	804.291	1369.17	0	1369.17	1968.4	1968.4
22	0.546232	1427.92	-43.1052	Retained Soil	0	30.4314	659.152	846.008	1440.18	0	1440.18	2057.11	2057.11
23	0.546232	1478.28	-42.4974	Retained Soil	0	30.4314	691.8	887.912	1511.52	0	1511.52	2145.38	2145.38
24	0.546232	1527.59	-41.8955	Retained Soil	0	30.4314	724.593	930	1583.16	0	1583.16	2233.2	2233.2
25	0.546232	1575.86	-41.2992	Retained Soil	0	30.4314	757.523	972.266	1655.11	0	1655.11	2320.59	2320.59
26	0.546232	1623.14	-40.7083	Retained Soil	0	30.4314	790.593	1014.71	1727.36	0	1727.36	2407.58	2407.58

27	0.546232	1669.45	-40.1226	Retained Soil	0	30.4314	823.792	1057.32	1799.9	0	1799.9	2494.15	2494.15
28	0.550133	186.351	-39.5399	Reinforced Fill	0	30.4314	1264.95	1623.54	2763.79	0	2763.79	3808.02	3808.02
29	0.550133	67.8336	-38.9599	Reinforced Fill	0	30.4314	1347.76	1729.82	2944.71	0	2944.71	4034.54	4034.54
30	0.550133	111.981	-38.3847	Reinforced Fill	0	30.4314	1387.41	1780.71	3031.35	0	3031.35	4130.39	4130.39
31	0.550133	155.231	-37.814	Reinforced Fill	0	30.4314	2630.51	3376.21	5747.4	0	5747.4	7788.87	7788.87
32	0.550133	197.603	-37.2477	Reinforced Fill	0	30.4314	1467.15	1883.06	3205.57	0	3205.57	4321.13	4321.13
33	0.550133	239.119	-36.6856	Reinforced Fill	0	30.4314	1507.23	1934.5	3293.15	0	3293.15	4416.01	4416.01
34	0.550133	279.795	-36.1276	Reinforced Fill	0	30.4314	985.306	1264.62	2152.79	0	2152.79	2872.02	2872.02
35	0.550133	319.652	-35.5735	Reinforced Fill	0	30.4314	1803.28	2314.47	3939.98	0	3939.98	5229.74	5229.74
36	0.550133	358.704	-35.0233	Reinforced Fill	0	30.4314	565.798	726.191	1236.21	0	1236.21	1632.73	1632.73
37	0.550133	396.97	-34.4767	Reinforced Fill	0	30.4314	593.774	762.097	1297.34	0	1297.34	1705.07	1705.07
38	0.550133	434.463	-33.9337	Reinforced Fill	0	30.4314	1933.94	2482.17	4225.46	0	4225.46	5526.67	5526.67
39	0.550133	471.199	-33.3941	Reinforced Fill	0	30.4314	650.02	834.288	1420.23	0	1420.23	1848.74	1848.74
40	0.550133	507.193	-32.8578	Reinforced Fill	0	30.4314	678.288	870.569	1481.99	0	1481.99	1920.09	1920.09
41	0.550133	542.456	-32.3248	Reinforced Fill	0	30.4314	706.651	906.973	1543.96	0	1543.96	1991.11	1991.11
42	0.550133	577.004	-31.7949	Reinforced Fill	0	30.4314	2110.18	2708.38	4610.55	0	4610.55	5918.66	5918.66
43	0.550133	610.847	-31.268	Reinforced Fill	0	30.4314	551.446	707.77	1204.85	0	1204.85	1539.72	1539.72
44	0.550133	643.998	-30.744	Reinforced Fill	0	30.4314	555.833	713.401	1214.44	0	1214.44	1545.05	1545.05
45	0.550133	676.467	-30.2229	Reinforced Fill	0	30.4314	581.888	746.841	1271.36	0	1271.36	1610.34	1610.34
46	0.550133	708.267	-29.7045	Reinforced Fill	0	30.4314	2047.29	2627.66	4473.12	0	4473.12	5641.08	5641.08
47	0.550133	739.406	-29.1888	Reinforced Fill	0	30.4314	634.223	814.012	1385.71	0	1385.71	1740	1740
48	0.550133	769.896	-28.6756	Reinforced Fill	0	30.4314	660.503	847.743	1443.13	0	1443.13	1804.38	1804.38
49	0.5	725.654	-28.1882	Facing Material	150.376	30.4314	813.962	1044.7	1522.43	0	1522.43	1958.66	1958.66
50	0.5	749.837	-27.7261	Facing Material	150.376	30.4314	847.143	1087.29	1594.93	0	1594.93	2040.18	2040.18

Group 1 - Seismic

Global Minimum Query (bishop simplified) - Safety Factor: 1.15728

Slice Number	Width [ft]	Weight [lbs]	Angle of Slice Base [deg]	Base Material	Base Cohesion [psf]	Base Friction Angle [deg]	Shear Stress [psf]	Shear Strength [psf]	Base Normal Stress [psf]	Pore Pressure [psf]	Effective Normal Stress [psf]	Base Vertical Stress [psf]	Effective Vertical Stress [psf]
1	1.09363	89.7652	-48.033	Retained Soil	0	35.3847	27.2269	31.5092	48.7992	0	48.7992	79.0727	79.0727
2	1.09363	266.284	-47.0592	Retained Soil	0	35.3847	81.8811	94.7594	146.757	0	146.757	234.746	234.746
3	1.09363	436.939	-46.103	Retained Soil	0	35.3847	136.135	157.546	243.996	0	243.996	385.476	385.476
4	1.09363	602.032	-45.1631	Retained Soil	0	35.3847	189.96	219.837	340.468	0	340.468	531.512	531.512
5	1.09363	761.838	-44.2384	Retained Soil	0	35.3847	243.333	281.604	436.128	0	436.128	673.076	673.076
6	1.09363	916.603	-43.328	Retained Soil	0	35.3847	296.233	342.824	530.942	0	530.942	810.371	810.371
7	1.09363	1066.55	-42.4311	Retained Soil	0	35.3847	348.644	403.479	624.879	0	624.879	943.583	943.583
8	1.09363	1211.9	-41.5469	Retained Soil	0	35.3847	400.552	463.551	717.913	0	717.913	1072.88	1072.88
9	1.09363	1352.82	-40.6746	Retained Soil	0	35.3847	451.946	523.028	810.028	0	810.028	1198.41	1198.41
10	1.09363	1489.49	-39.8136	Retained Soil	0	35.3847	502.814	581.897	901.204	0	901.204	1320.34	1320.34
11	1.09363	1622.07	-38.9632	Retained Soil	0	35.3847	553.15	640.15	991.422	0	991.422	1438.77	1438.77
12	1.09363	1750.72	-38.1229	Retained Soil	0	35.3847	602.947	697.778	1080.67	0	1080.67	1553.83	1553.83
13	1.09363	1875.55	-37.2922	Retained Soil	0	35.3847	652.196	754.773	1168.94	0	1168.94	1665.64	1665.64
14	1.09363	1996.71	-36.4706	Retained Soil	0	35.3847	700.895	811.132	1256.22	0	1256.22	1774.3	1774.3
15	1.09363	2114.31	-35.6575	Retained Soil	0	35.3847	749.038	866.847	1342.51	0	1342.51	1879.91	1879.91
16	1.09363	2228.45	-34.8527	Retained Soil	0	35.3847	796.623	921.916	1427.8	0	1427.8	1982.56	1982.56
17	1.09363	2339.24	-34.0557	Retained Soil	0	35.3847	843.646	976.335	1512.08	0	1512.08	2082.32	2082.32
18	1.09363	2446.77	-33.2661	Retained Soil	0	35.3847	890.104	1030.1	1595.35	0	1595.35	2179.28	2179.28
19	1.09363	2551.13	-32.4836	Retained Soil	0	35.3847	935.996	1083.21	1677.6	0	1677.6	2273.52	2273.52
20	1.09363	2652.4	-31.7078	Retained Soil	0	35.3847	981.318	1135.66	1758.84	0	1758.84	2365.1	2365.1
21	1.09363	2750.67	-30.9385	Retained Soil	0	35.3847	1026.08	1187.46	1839.05	0	1839.05	2454.08	2454.08
22	1.09363	2846	-30.1753	Retained Soil	0	35.3847	1070.26	1238.59	1918.24	0	1918.24	2540.53	2540.53
23	1.09363	2938.46	-29.418	Retained Soil	0	35.3847	1113.87	1289.06	1996.4	0	1996.4	2624.5	2624.5
24	1.09363	3028.12	-28.6663	Retained Soil	0	35.3847	1156.91	1338.87	2073.54	0	2073.54	2706.04	2706.04
25	1.09363	3115.04	-27.9199	Retained Soil	0	35.3847	1199.37	1388.01	2149.65	0	2149.65	2785.22	2785.22
26	1.09363	3199.28	-27.1786	Retained Soil	0	35.3847	1241.26	1436.49	2224.73	0	2224.73	2862.07	2862.07
27	1.09363	3280.88	-26.4423	Retained Soil	0	35.3847	1282.58	1484.3	2298.77	0	2298.77	2936.63	2936.63
28	1.09363	3359.9	-25.7106	Retained Soil	0	35.3847	1323.31	1531.44	2371.79	0	2371.79	3008.95	3008.95
29	1.09363	3436.39	-24.9834	Retained Soil	0	35.3847	1363.46	1577.91	2443.76	0	2443.76	3079.07	3079.07
30	1.09363	3510.39	-24.2605	Retained Soil	0	35.3847	1403.05	1623.72	2514.7	0	2514.7	3147.04	3147.04
31	1.09363	3581.95	-23.5417	Retained Soil	0	35.3847	1442.05	1668.86	2584.6	0	2584.6	3212.87	3212.87
32	1.09363	3651.1	-22.8267	Retained Soil	0	35.3847	1480.47	1713.32	2653.47	0	2653.47	3276.61	3276.61
33	1.09363	3717.89	-22.1155	Retained Soil	0	35.3847	1518.31	1757.11	2721.29	0	2721.29	3338.29	3338.29
34	1.09375	3782.77	-21.4079	Reinforced Fill	0	35.3847	1555.58	1800.24	2788.08	0	2788.08	3397.95	3397.95

35	1.09375	3844.95	-20.7036	Reinforced Fill	0	35.3847	1592.26	1842.69	2853.83	0	2853.83	3455.6	3455.6
36	1.09375	3904.86	-20.0025	Reinforced Fill	0	35.3847	1628.35	1884.46	2918.52	0	2918.52	3511.27	3511.27
37	1.09375	3962.54	-19.3046	Reinforced Fill	0	35.3847	1663.87	1925.56	2982.17	0	2982.17	3565	3565
38	1.09375	4018.02	-18.6097	Reinforced Fill	0	35.3847	1698.79	1965.98	3044.77	0	3044.77	3616.79	3616.79
39	1.09375	2780.38	-17.9175	Reinforced Fill	0	35.3847	1913.91	2214.93	3430.33	0	3430.33	4049.16	4049.16
40	1.09375	1612.31	-17.2281	Reinforced Fill	0	35.3847	2120.8	2454.36	3801.15	0	3801.15	4458.78	4458.78
41	1.09375	1661.33	-16.5412	Reinforced Fill	0	35.3847	2156.37	2495.52	3864.88	0	3864.88	4505.31	4505.31
42	1.09375	1708.25	-15.8568	Reinforced Fill	0	35.3847	1840.4	2129.86	3298.57	0	3298.57	3821.32	3821.32
43	1.09375	1753.09	-15.1747	Reinforced Fill	0	35.3847	1101.57	1274.83	1974.38	0	1974.38	2273.14	2273.14
44	1.09375	1795.86	-14.4947	Reinforced Fill	0	35.3847	1127.82	1305.2	2021.41	0	2021.41	2312.97	2312.97
45	1.09375	1836.6	-13.8169	Reinforced Fill	0	35.3847	1153.44	1334.85	2067.32	0	2067.32	2350.99	2350.99
46	1.09375	1875.31	-13.141	Reinforced Fill	0	35.3847	1178.44	1363.78	2112.12	0	2112.12	2387.24	2387.24
47	1.09375	1912.01	-12.467	Reinforced Fill	0	35.3847	1030.98	1193.13	1847.83	0	1847.83	2075.77	2075.77
48	1.09375	1946.73	-11.7947	Reinforced Fill	0	35.3847	1048.47	1213.37	1879.18	0	1879.18	2098.12	2098.12
49	1.09375	1979.47	-11.1241	Reinforced Fill	0	35.3847	1070.36	1238.71	1918.43	0	1918.43	2128.89	2128.89
50	1	1836.81	-10.4836	Facing Material	181.818	35.3847	1219	1410.72	1928.84	0	1928.84	2154.4	2154.4

Global Minimum Query (spencer) - Safety Factor: 1.15811

Slice Number	Width [ft]	Weight [lbs]	Angle of Slice Base [deg]	Base Material	Base Cohesion [psf]	Base Friction Angle [deg]	Shear Stress [psf]	Shear Strength [psf]	Base Normal Stress [psf]	Pore Pressure [psf]	Effective Normal Stress [psf]	Base Vertical Stress [psf]	Effective Vertical Stress [psf]
1	1.09363	89.7652	-48.033	Retained Soil	0	35.3847	17.7414	20.5465	31.821	0	31.821	51.5476	51.5476
2	1.09363	266.284	-47.0592	Retained Soil	0	35.3847	53.7253	62.2198	96.3619	0	96.3619	154.095	154.095
3	1.09363	436.939	-46.103	Retained Soil	0	35.3847	89.9759	104.202	161.381	0	161.381	254.889	254.889
4	1.09363	602.032	-45.1631	Retained Soil	0	35.3847	126.509	146.511	226.905	0	226.905	354.136	354.136
5	1.09363	761.838	-44.2384	Retained Soil	0	35.3847	163.338	189.163	292.962	0	292.962	452.014	452.014
6	1.09363	916.603	-43.328	Retained Soil	0	35.3847	200.475	232.172	359.572	0	359.572	548.675	548.675
7	1.09363	1066.55	-42.4311	Retained Soil	0	35.3847	237.934	275.554	426.758	0	426.758	644.259	644.259
8	1.09363	1211.9	-41.5469	Retained Soil	0	35.3847	275.724	319.319	494.539	0	494.539	738.882	738.882
9	1.09363	1352.82	-40.6746	Retained Soil	0	35.3847	313.856	363.48	562.932	0	562.932	832.649	832.649
10	1.09363	1489.49	-39.8136	Retained Soil	0	35.3847	352.34	408.048	631.956	0	631.956	925.655	925.655

11	1.09363	1622.07	-38.9632	Retained Soil	0	35.3847	391.182	453.032	701.624	0	701.624	1017.98	1017.98
12	1.09363	1750.72	-38.1229	Retained Soil	0	35.3847	430.393	498.443	771.95	0	771.95	1109.7	1109.7
13	1.09363	1875.55	-37.2922	Retained Soil	0	35.3847	469.98	544.289	842.958	0	842.958	1200.89	1200.89
14	1.09363	1996.71	-36.4706	Retained Soil	0	35.3847	509.952	590.58	914.645	0	914.645	1291.58	1291.58
15	1.09363	2114.31	-35.6575	Retained Soil	0	35.3847	550.313	637.323	987.045	0	987.045	1381.87	1381.87
16	1.09363	2228.45	-34.8527	Retained Soil	0	35.3847	591.074	684.529	1060.15	0	1060.15	1471.76	1471.76
17	1.09363	2339.24	-34.0557	Retained Soil	0	35.3847	632.241	732.205	1133.99	0	1133.99	1561.34	1561.34
18	1.09363	2446.77	-33.2661	Retained Soil	0	35.3847	673.82	780.358	1208.56	0	1208.56	1650.61	1650.61
19	1.09363	2551.13	-32.4836	Retained Soil	0	35.3847	715.821	828.999	1283.9	0	1283.9	1739.64	1739.64
20	1.09363	2652.4	-31.7078	Retained Soil	0	35.3847	758.247	878.133	1359.99	0	1359.99	1828.43	1828.43
21	1.09363	2750.67	-30.9385	Retained Soil	0	35.3847	801.108	927.771	1436.86	0	1436.86	1917.05	1917.05
22	1.09363	2846	-30.1753	Retained Soil	0	35.3847	844.41	977.92	1514.54	0	1514.54	2005.51	2005.51
23	1.09363	2938.46	-29.418	Retained Soil	0	35.3847	888.163	1028.59	1593	0	1593	2093.83	2093.83
24	1.09363	3028.12	-28.6663	Retained Soil	0	35.3847	932.373	1079.79	1672.3	0	1672.3	2182.04	2182.04
25	1.09363	3115.04	-27.9199	Retained Soil	0	35.3847	977.04	1131.52	1752.42	0	1752.42	2270.17	2270.17
26	1.09363	3199.28	-27.1786	Retained Soil	0	35.3847	1022.18	1183.8	1833.38	0	1833.38	2358.23	2358.23
27	1.09363	3280.88	-26.4423	Retained Soil	0	35.3847	1067.81	1236.64	1915.22	0	1915.22	2446.26	2446.26
28	1.09363	3359.9	-25.7106	Retained Soil	0	35.3847	1113.92	1290.04	1997.92	0	1997.92	2534.27	2534.27
29	1.09363	3436.39	-24.9834	Retained Soil	0	35.3847	1160.52	1344.01	2081.51	0	2081.51	2622.26	2622.26
30	1.09363	3510.39	-24.2605	Retained Soil	0	35.3847	1207.63	1398.57	2166.01	0	2166.01	2710.27	2710.27
31	1.09363	3581.95	-23.5417	Retained Soil	0	35.3847	1255.26	1453.73	2251.44	0	2251.44	2798.32	2798.32
32	1.09363	3651.1	-22.8267	Retained Soil	0	35.3847	1303.41	1509.49	2337.8	0	2337.8	2886.42	2886.42
33	1.09363	3717.89	-22.1155	Retained Soil	0	35.3847	1352.09	1565.87	2425.12	0	2425.12	2974.57	2974.57
34	1.09375	3782.77	-21.4079	Reinforced Fill	0	35.3847	1401.33	1622.89	2513.41	0	2513.41	3062.81	3062.81
35	1.09375	3844.95	-20.7036	Reinforced Fill	0	35.3847	1451.11	1680.55	2602.71	0	2602.71	3151.14	3151.14
36	1.09375	3904.86	-20.0025	Reinforced Fill	0	35.3847	1501.46	1738.86	2693.02	0	2693.02	3239.59	3239.59
37	1.09375	3962.54	-19.3046	Reinforced Fill	0	35.3847	3224.48	3734.3	5783.41	0	5783.41	6912.9	6912.9
38	1.09375	4018.02	-18.6097	Reinforced Fill	0	35.3847	1603.91	1857.51	2876.78	0	2876.78	3416.86	3416.86
39	1.09375	2780.38	-17.9175	Reinforced Fill	0	35.3847	1997.44	2313.26	3582.61	0	3582.61	4228.44	4228.44
40	1.09375	1612.31	-17.2281	Reinforced Fill	0	35.3847	4138.56	4792.91	7422.92	0	7422.92	8706.24	8706.24
41	1.09375	1661.33	-16.5412	Reinforced Fill	0	35.3847	2449.18	2836.42	4392.85	0	4392.85	5120.25	5120.25
42	1.09375	1708.25	-15.8568	Reinforced Fill	0	35.3847	2084.14	2413.66	3738.11	0	3738.11	4330.09	4330.09

43	1.09375	1753.09	-15.1747	Reinforced Fill	0	35.3847	1185.28	1372.69	2125.93	0	2125.93	2447.4	2447.4
44	1.09375	1795.86	-14.4947	Reinforced Fill	0	35.3847	1227.03	1421.04	2200.8	0	2200.8	2518.01	2518.01
45	1.09375	1836.6	-13.8169	Reinforced Fill	0	35.3847	3166.7	3667.39	5679.79	0	5679.79	6458.6	6458.6
46	1.09375	1875.31	-13.141	Reinforced Fill	0	35.3847	1311.55	1518.92	2352.39	0	2352.39	2658.59	2658.59
47	1.09375	1912.01	-12.467	Reinforced Fill	0	35.3847	1130.54	1309.29	2027.73	0	2027.73	2277.68	2277.68
48	1.09375	1946.73	-11.7947	Reinforced Fill	0	35.3847	1162.74	1346.58	2085.5	0	2085.5	2328.29	2328.29
49	1.09375	1979.47	-11.1241	Reinforced Fill	0	35.3847	1201.79	1391.8	2155.52	0	2155.52	2391.82	2391.82
50	1	1836.81	-10.4836	Facing Material	181.818	35.3847	1383.81	1602.61	2226.01	0	2226.01	2482.08	2482.08

AASHTO 2017-2020
I-405 D/B - Bridge 40P

MSEW+: Update # 2021.12

PROJECT IDENTIFICATION

Title: I-405 D/B - Bridge 40P
Project Number: O38650
Client: Flatiron Lane JV
Designer: VA
Station Number: DH = 16.5'

Description:

Design Case 3; Design Height = 16.5ft;

Company's information:

Name: Tensar International Corporation
Street: 2500 Northwinds Parkway
Suite 500
Alpharetta, GA 30009
Telephone #: (770) 344-2090
Fax #: (770) 344-2084
E-Mail: vamaya@tensarcorp.com

File path and name: K:_o\O38650\Final\Working Files\Design\Rev1\MSEW\Max W.....
.....Wall- H=16.5 ft.BENp

Original date and time of creating this file: Oct 2021

PROGRAM MODE: ANALYSIS
of a SIMPLE STRUCTURE
using GEOGRID as reinforcing material.

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SOIL DATA

REINFORCED SOIL

Unit weight, γ	135.0 lb/ft ^{3}
Design value of internal angle of friction, ϕ	38.0 °

RETAINED SOIL

Unit weight, γ	135.0 lb/ft ^{3}
Design value of internal angle of friction, ϕ	38.0 °

FOUNDATION SOIL (Considered as an equivalent uniform soil)

Equivalent unit weight, $\gamma_{equiv.}$	140.0 lb/ft ^{3}
Equivalent internal angle of friction, $\phi_{equiv.}$	43.0 °
Equivalent cohesion, $c_{equiv.}$	0.0 lb/ft ^{2}

Factored bearing capacity resistance of foundation is given: q-ult-static = 120000.0 lb/ft^2., q-ult-sesmic = 120000.0 lb/ft^2.

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)
Inclination of internal slip plane, ψ = 64.00° (see Fig. 28 in DEMO 82).
Ka (external stability) = 0.2447 (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 = N/A N γ= N/A

SEISMICITY (using AASHTO 2017-2020)

Peak ground acceleration coeff., A = PGA = 0.417 and Site Factor, Fpga = 1.183. Maximum ground acceleration coeff., As = 0.493
Design acceleration coefficient in Internal Stability: Kh = Am = 0.247
Design acceleration coefficient in External Stability: Kh_d = 0.247 => Kh = Am = 0.247

Kae (Kh > 0) = 0.4377 Kae (Kh = 0) = 0.2447
Seismic soil-geogrid friction coefficient, F* is 80.0% of its specified static value.

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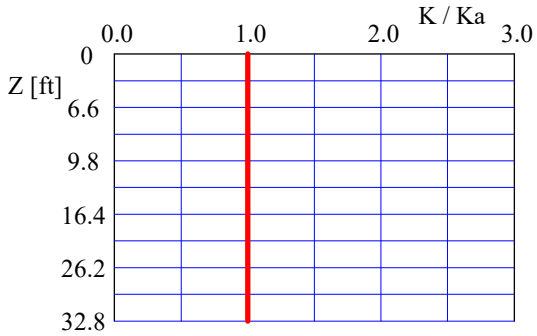
INPUT DATA: Geogrids (Analysis)

D A T A	Geogrid type #1	Geogrid type #2	Geogrid type #3	Geogrid type #4	Geogrid type #5
Tult [lb/ft]	7550.0	9000.0	14500.0		
Durability reduction factor, RFd	1.30	1.30	1.30		
Installation-damage reduction factor, RFid	1.11	1.11	1.11		
Creep reduction factor, RFc	1.51	1.51	1.51	N/A	N/A
CDR for strength	N/A	N/A	N/A		
Coverage ratio, Rc	1.000	1.000	1.000		
Friction angle along geogrid-soil interface, ρ	27.63	27.63	27.63		
Pullout resistance factor, F*	$0.67 \cdot \tan\phi$	$0.67 \cdot \tan\phi$	$0.67 \cdot \tan\phi$	N/A	N/A
Scale-effect correction factor, α	0.8	0.8	0.8		

Variation of Lateral Earth Pressure Coefficient With Depth

Z	K / Ka
0 ft	1.00
3.3 ft	1.00
6.6 ft	1.00
9.8 ft	1.00
13.1 ft	1.00
16.4 ft	1.00
19.7 ft	1.00



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INPUT DATA: Geometry and Surcharge loads (of a SIMPLE STRUCTURE)

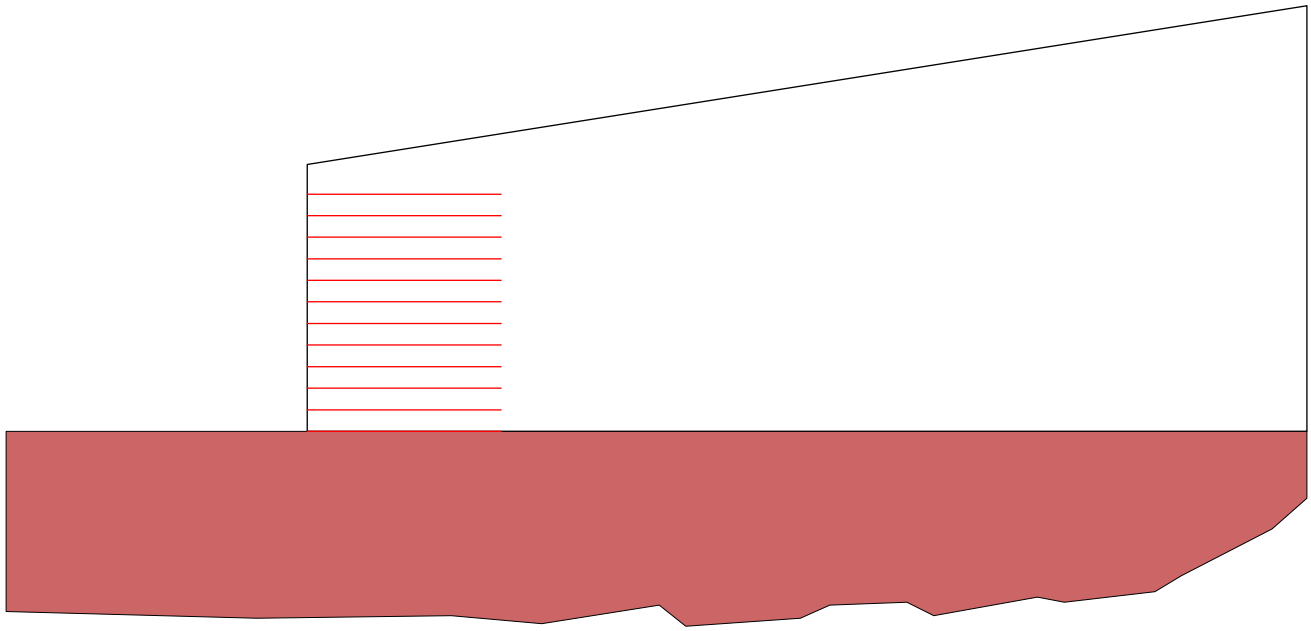
Design height, Hd 16.50 [ft] { Embedded depth is E = 0.00 ft, and height above top of finished bottom grade is H = 16.50 ft }

Soil in front of wall is Horizontal.

Batter, ω 0.0 [deg]
Backslope, β 9.0 [deg]
Backslope rise 10.0 [ft] Broken back equivalent angle, I = 9.00° (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]

ANALYZED REINFORCEMENT LAYOUT:



SCALE:

0 2 4 6 8 10 [ft]

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AASHTO 2017-2020 – Load and Resisting Factors

INTERNAL STABILITY

Load factor for vertical earth pressure, EV:	$\gamma_{p\text{-}EV}$	1.35
Load factor for earthquake loads, EQ:	$\gamma_{p\text{-}EQ}$	1.00
Load factor for live load surcharge, LS: (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	ϕ	Static	Combined static/seismic	
Geogrid:		0.90		1.20
Resistance factor for reinforcement tension in connectors	ϕ	Static	Combined static/seismic	
Geogrid:		0.90		1.20
Resistance factor for geosynthetic pullout	ϕ	0.90		1.20

EXTERNAL STABILITY

Load factor for vertical earth pressure, EV			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	$\gamma_{p\text{-}EH}$	1.50
Load factor of active lateral earth pressure during earthquake (does not multiply P_{AE} and P_{IR}):	$(\gamma_{p\text{-}EH})_{EQ}$	1.10
Load factor for earthquake loads, EQ (multiplies P_{AE} and P_{IR}):	$\gamma_{p\text{-}EQ}$	1.00

Resistance factor for shear resistance along common interfaces			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			Static	Combined Static/Seismic	
		ϕ_b	0.65		0.90

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ANALYSIS: CALCULATED FACTORS (Static conditions)

Bearing capacity, CDR = 19.83, factored bearing load = 3934 lb/ft².
Foundation Interface: Direct sliding, CDR = 2.789, Eccentricity, e/L = 0.1123, CDR-overturning = 3.71

GEOGRID #	Elevation [ft]	Length [ft]	Type #	CONNECTION CDR [connection break]	Geogrid strength CDR	Pullout resistance CDR	Direct sliding CDR	Eccentricity e/L	Product name
1	0.00	12.00	2	N/A	7.548	43.263	1.869	0.1123	SF90
2	1.33	12.00	2	N/A	3.994	20.064	2.000	0.0940	SF90
3	2.67	12.00	2	N/A	4.355	18.976	2.153	0.0767	SF90
4	4.00	12.00	2	N/A	4.806	17.977	2.330	0.0607	SF90
5	5.33	12.00	2	N/A	5.316	16.861	2.541	0.0458	SF90
6	6.67	12.00	2	N/A	5.976	15.791	2.798	0.0319	SF90
7	8.00	12.00	2	N/A	6.848	14.809	3.110	0.0190	SF90
8	9.33	12.00	2	N/A	7.974	13.783	3.503	0.0068	SF90
9	10.66	12.00	2	N/A	9.512	12.744	4.010	-0.0051	SF90
10	12.00	12.00	2	N/A	11.857	11.797	4.693	-0.0175	SF90
11	13.33	12.00	2	N/A	15.783	11.007	5.636	-0.0321	SF90
12	14.66	12.00	2	N/A	15.795	7.034	6.993	-0.0542	SF90

ANALYSIS: CALCULATED FACTORS (Seismic conditions)

Bearing capacity, CDR = 21.19, factored bearing load = 5098 lb/ft².
Foundation Interface: Direct sliding, CDR = 1.722, Eccentricity, e/L = 0.2596, Fs-overturning = 1.90

GEOGRID #	Elevation [ft]	Length [ft]	Type #	CONNECTION CDR [connection break]	Geogrid strength CDR	Pullout resistance CDR	Direct sliding CDR	Eccentricity e/L	Product name
1	0.00	12.00	2	N/A	9.972	40.263	1.154	0.2596	SF90
2	1.33	12.00	2	N/A	6.032	22.405	1.243	0.2220	SF90
3	2.67	12.00	2	N/A	6.484	20.767	1.349	0.1867	SF90
4	4.00	12.00	2	N/A	7.029	19.198	1.474	0.1542	SF90
5	5.33	12.00	2	N/A	7.623	17.525	1.626	0.1241	SF90
6	6.67	12.00	2	N/A	8.359	15.865	1.815	0.0963	SF90
7	8.00	12.00	2	N/A	9.276	14.250	2.053	0.0711	SF90
8	9.33	12.00	2	N/A	10.380	12.576	2.364	0.0480	SF90
9	10.66	12.00	2	N/A	11.754	10.861	2.787	0.0266	SF90
10	12.00	12.00	2	N/A	13.599	9.135	3.398	0.0062	SF90
11	13.33	12.00	2	N/A	16.162	7.392	4.208	-0.0131	SF90
12	14.66	12.00	2	N/A	16.168	4.721	5.452	-0.0398	SF90

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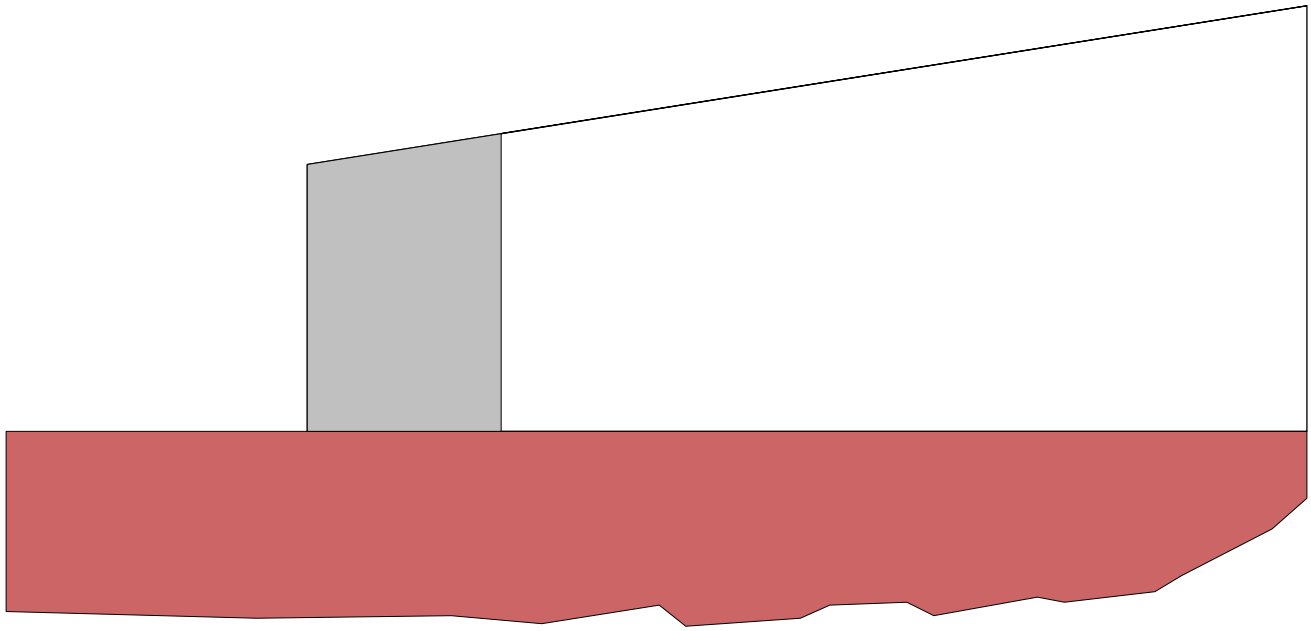
BEARING CAPACITY for GIVEN LAYOUT – Using AASHTO 2017-2020 method

	STATIC	SEISMIC	UNITS
(Given factored bearing resistance, q-n)			
Factored bearing resistance. q-n	78000	108000	[lb/ft ²]
Factored bearing load, σ_V	3933.9	5098	[lb/ft ²]
Eccentricity, e	0.98	2.12	[ft]
Eccentricity, e/L	0.082	0.176	
CDR calculated	19.83	21.19	
Base length	12.00	12.00	[ft]

Unfactored applied bearing pressure = (Unfactored R) / [L - 2 * (Unfactored e)] =
Static: Unfactored R = 29144.35 [lb/ft], L = 12.00, Unfactored e = 0.88 [ft], and Sigma = 2844.31 [lb/ft ²]
Seismic: Unfactored R = 29834.42 [lb/ft], L = 12.00, Unfactored e = 2.35 [ft], and Sigma = 4091.63 [lb/ft ²]



SCALE:

0 2 4 6 8 10 [ft]

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DIRECT SLIDING for GIVEN LAYOUT (for GEOGRID reinforcements)

Along reinforced and foundation soils interface: CDR-static = 2.789 and CDR-seismic = 1.722

#	Geogrid Elevation [ft]	Geogrid Length [ft]	CDR Static	CDR Seismic	Geogrid Type #	Product name
1	0.00	12.00	1.869	1.154	2	SF90
2	1.33	12.00	2.000	1.243	2	SF90
3	2.67	12.00	2.153	1.349	2	SF90
4	4.00	12.00	2.330	1.474	2	SF90
5	5.33	12.00	2.541	1.626	2	SF90
6	6.67	12.00	2.798	1.815	2	SF90
7	8.00	12.00	3.110	2.053	2	SF90
8	9.33	12.00	3.503	2.364	2	SF90
9	10.66	12.00	4.010	2.787	2	SF90
10	12.00	12.00	4.693	3.398	2	SF90
11	13.33	12.00	5.636	4.208	2	SF90
12	14.66	12.00	6.993	5.452	2	SF90

ECCENTRICITY for GIVEN LAYOUT

At interface with foundation: e/L static = 0.1123, e/L seismic = 0.2596; Overturning: CDR-static = 3.71, CDR-seismic = 1.90

#	Geogrid Elevation [ft]	Geogrid Length [ft]	e / L Static	e / L Seismic	Geogrid Type #	Product name
1	0.00	12.00	0.1123	0.2596	2	SF90
2	1.33	12.00	0.0940	0.2220	2	SF90
3	2.67	12.00	0.0767	0.1867	2	SF90
4	4.00	12.00	0.0607	0.1542	2	SF90
5	5.33	12.00	0.0458	0.1241	2	SF90
6	6.67	12.00	0.0319	0.0963	2	SF90
7	8.00	12.00	0.0190	0.0711	2	SF90
8	9.33	12.00	0.0068	0.0480	2	SF90
9	10.66	12.00	-0.0051	0.0266	2	SF90
10	12.00	12.00	-0.0175	0.0062	2	SF90
11	13.33	12.00	-0.0321	-0.0131	2	SF90
12	14.66	12.00	-0.0542	-0.0398	2	SF90

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RESULTS for STRENGTH

Live Load included in calculating Tmax

#	Geogrid Elevation [ft]	LTDS [lb/ft]	Factored: Static/Seismic Tmax [lb/ft]	Tmd [lb/ft]	Specified minimum CDR Static	Actual calculated CDR Static	Specified minimum CDR seismic	Actual calculated CDR seismic	Product name
1	0.00	3717/4957	492/365	199.65	N/A	7.548	N/A	9.972	SF90
2	1.33	3717/4957	931/689	199.65	N/A	3.994	N/A	6.032	SF90
3	2.67	3717/4957	854/632	199.65	N/A	4.355	N/A	6.484	SF90
4	4.00	3717/4957	774/573	199.65	N/A	4.806	N/A	7.029	SF90
5	5.33	3717/4957	699/518	199.65	N/A	5.316	N/A	7.623	SF90
6	6.67	3717/4957	622/461	199.65	N/A	5.976	N/A	8.359	SF90
7	8.00	3717/4957	543/402	199.65	N/A	6.848	N/A	9.276	SF90
8	9.33	3717/4957	466/345	199.65	N/A	7.974	N/A	10.380	SF90
9	10.66	3717/4957	391/289	199.65	N/A	9.512	N/A	11.754	SF90
10	12.00	3717/4957	314/232	199.65	N/A	11.857	N/A	13.599	SF90
11	13.33	3717/4957	236/174	199.65	N/A	15.783	N/A	16.162	SF90
12	14.66	3717/4957	235/174	199.65	N/A	15.795	N/A	16.168	SF90

RESULTS for PULLOUT

Live Load included in calculating Tmax

#	Geogrid Elevation [ft]	Coverage Ratio	Factored: Stat./Seis. Tmax [lb/ft]	Tmd [lb/ft]	Le [ft]	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	492/365	0/199.7	12.00	0.00	21306.5	N/A	43.263	22726.9	N/A	40.263
2	1.33	1.000	931/689	0/199.7	11.35	0.65	18676.0	N/A	20.064	19921.1	N/A	22.405
3	2.67	1.000	854/632	0/199.7	10.70	1.30	16196.4	N/A	18.976	17276.1	N/A	20.767
4	4.00	1.000	774/573	0/199.7	10.05	1.95	13905.4	N/A	17.977	14832.4	N/A	19.198
5	5.33	1.000	699/518	0/199.7	9.40	2.60	11790.4	N/A	16.861	12576.4	N/A	17.525
6	6.67	1.000	622/461	0/199.7	8.75	3.25	9822.5	N/A	15.791	10477.3	N/A	15.865
7	8.00	1.000	543/402	0/199.7	8.10	3.90	8039.4	N/A	14.809	8575.4	N/A	14.250
8	9.33	1.000	466/345	0/199.7	7.45	4.55	6425.3	N/A	13.783	6853.7	N/A	12.576
9	10.66	1.000	391/289	0/199.7	6.80	5.20	4980.4	N/A	12.744	5312.4	N/A	10.861
10	12.00	1.000	314/232	0/199.7	6.15	5.85	3698.7	N/A	11.797	3945.3	N/A	9.135
11	13.33	1.000	236/174	0/199.7	5.50	6.50	2592.5	N/A	11.007	2765.4	N/A	7.392
12	14.66	1.000	235/174	0/199.7	4.85	7.15	1655.4	N/A	7.034	1765.8	N/A	4.721

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AASHTO 2017-2020
I-405 D/B - Bridge 40P

MSEW+: Update # 2021.12

PROJECT IDENTIFICATION

Title: I-405 D/B - Bridge 40P
Project Number: O38650
Client: Flatiron Lane JV
Designer: VA
Station Number: DH = 13.5'

Description:

Design Case 4; Design Height = 13.5ft

Company's information:

Name: Tensar International Corporation
Street: 2500 Northwinds Parkway
Suite 500
Alpharetta, GA 30009
Telephone #: (770) 344-2090
Fax #: (770) 344-2084
E-Mail: vamaya@tensarcorp.com

File path and name: K:_o\O38650\Final\Working Files\Design\Rev1\MSEW\Wall-.....
.....Wall- H=13.5 ft.BENp

Original date and time of creating this file: Oct 2021

PROGRAM MODE: ANALYSIS
of a SIMPLE STRUCTURE
using GEOGRID as reinforcing material.

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SOIL DATA

REINFORCED SOIL

Unit weight, γ	135.0 lb/ft ^{3}
Design value of internal angle of friction, ϕ	38.0 °

RETAINED SOIL

Unit weight, γ	135.0 lb/ft ^{3}
Design value of internal angle of friction, ϕ	38.0 °

FOUNDATION SOIL (Considered as an equivalent uniform soil)

Equivalent unit weight, $\gamma_{equiv.}$	140.0 lb/ft ^{3}
Equivalent internal angle of friction, $\phi_{equiv.}$	43.0 °
Equivalent cohesion, $c_{equiv.}$	0.0 lb/ft ^{2}

Factored bearing capacity resistance of foundation is given: q-ult-static = 120000.0 lb/ft^2., q-ult-sesmic = 120000.0 lb/ft^2.

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)
Inclination of internal slip plane, ψ = 64.00° (see Fig. 28 in DEMO 82).
Ka (external stability) = 0.2612 (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 = N/A N γ= N/A

SEISMICITY (using AASHTO 2017-2020)

Peak ground acceleration coeff., A = PGA = 0.417 and Site Factor, Fpga = 1.183. Maximum ground acceleration coeff., As = 0.493
Design acceleration coefficient in Internal Stability: Kh = Am = 0.247
Design acceleration coefficient in External Stability: Kh_d = 0.247 => Kh = Am = 0.247

Kae (Kh > 0) = 0.5263 Kae (Kh = 0) = 0.2612
Seismic soil-geogrid friction coefficient, F* is 80.0% of its specified static value.

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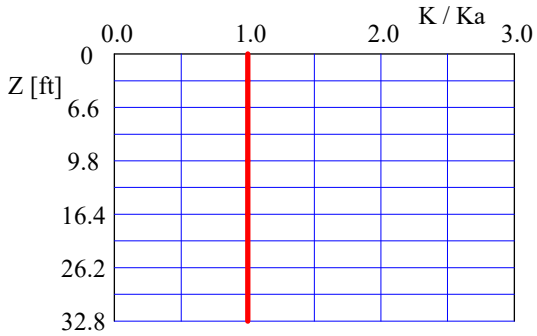
INPUT DATA: Geogrids (Analysis)

D A T A	Geogrid type #1	Geogrid type #2	Geogrid type #3	Geogrid type #4	Geogrid type #5
Tult [lb/ft]	7550.0	9000.0	14500.0		
Durability reduction factor, RFd	1.30	1.30	1.30		
Installation-damage reduction factor, RFid	1.11	1.11	1.11		
Creep reduction factor, RFc	1.51	1.51	1.51	N/A	N/A
CDR for strength	N/A	N/A	N/A		
Coverage ratio, Rc	1.000	1.000	1.000		
Friction angle along geogrid-soil interface, ρ	27.63	27.63	27.63		
Pullout resistance factor, F*	$0.67 \cdot \tan\phi$	$0.67 \cdot \tan\phi$	$0.67 \cdot \tan\phi$	N/A	N/A
Scale-effect correction factor, α	0.8	0.8	0.8		

Variation of Lateral Earth Pressure Coefficient With Depth

Z	K / Ka
0 ft	1.00
3.3 ft	1.00
6.6 ft	1.00
9.8 ft	1.00
13.1 ft	1.00
16.4 ft	1.00
19.7 ft	1.00



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INPUT DATA: Geometry and Surcharge loads (of a SIMPLE STRUCTURE)

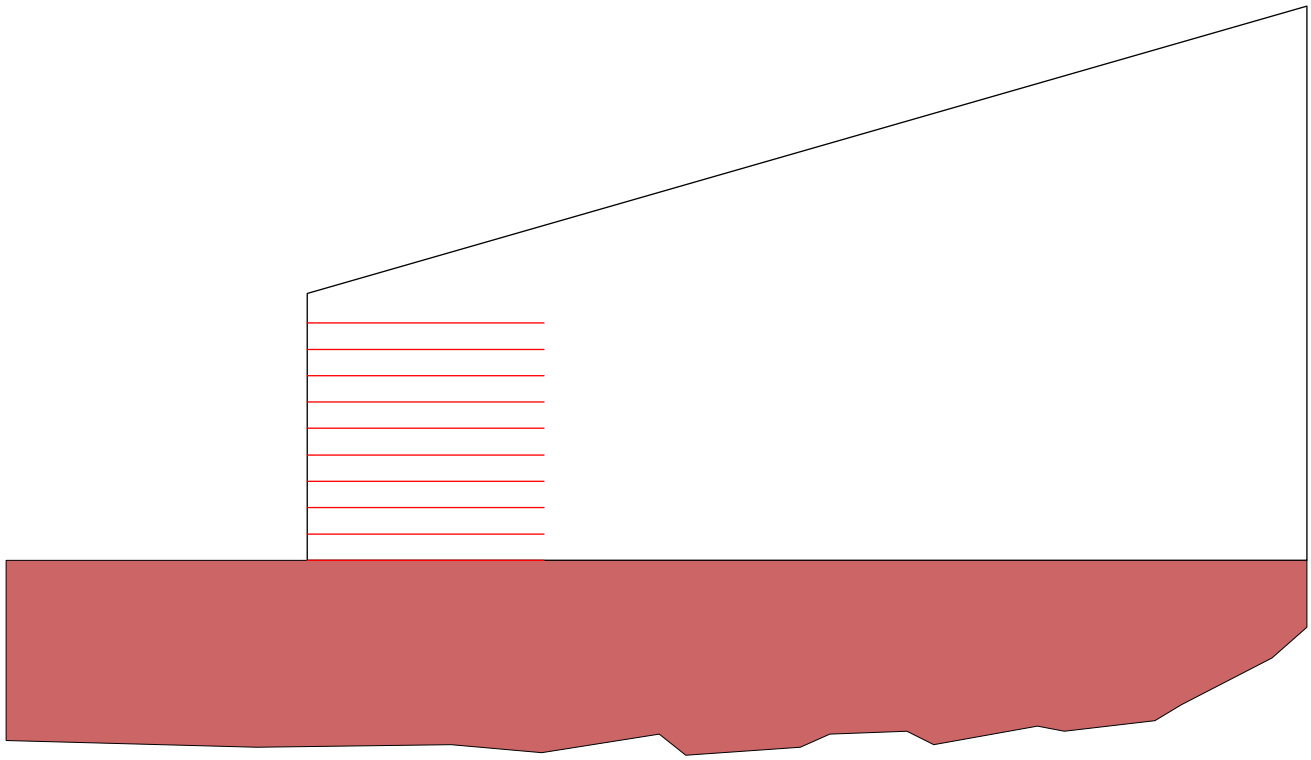
Design height, Hd 13.50 [ft] { Embedded depth is E = 0.00 ft, and height above top of finished bottom grade is H = 13.50 ft }

Soil in front of wall is Horizontal.

Batter, ω	0.0	[deg]	
Backslope, β	16.0	[deg]	
Backslope rise	27.0	[ft]	Broken back equivalent angle, I = 16.00° (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]

ANALYZED REINFORCEMENT LAYOUT:



SCALE:

0 2 4 6 8 10 [ft]

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AASHTO 2017-2020 – Load and Resisting Factors

INTERNAL STABILITY

Load factor for vertical earth pressure, EV:	$\gamma_{p\text{-}EV}$	1.35
Load factor for earthquake loads, EQ:	$\gamma_{p\text{-}EQ}$	1.00
Load factor for live load surcharge, LS: (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	ϕ	Static	Combined static/seismic
Geogrid:		0.90	1.20

Resistance factor for reinforcement tension in connectors	ϕ	Static	Combined static/seismic
Geogrid:		0.90	1.20

Resistance factor for geosynthetic pullout	ϕ	0.90	1.20

EXTERNAL STABILITY

Load factor for vertical earth pressure, EV			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	$\gamma_{p\text{-}EH}$	1.50
Load factor of active lateral earth pressure during earthquake (does not multiply P_{AE} and P_{IR}):	$(\gamma_{p\text{-}EH})_{EQ}$	1.10
Load factor for earthquake loads, EQ (multiplies P_{AE} and P_{IR}):	$\gamma_{p\text{-}EQ}$	1.00

Resistance factor for shear resistance along common interfaces		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	Static	Combined Static/Seismic
ϕ_b	0.65	0.90

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ANALYSIS: CALCULATED FACTORS (Static conditions)

Bearing capacity, CDR = 23.82, factored bearing load = 3274 lb/ft².
Foundation Interface: Direct sliding, CDR = 2.865, Eccentricity, e/L = 0.0719, CDR-overturning = 4.34

GEOGRID #	Elevation [ft]	Length [ft]	Type #	CONNECTION CDR [connection break]	Geogrid strength CDR	Pullout resistance CDR	Direct sliding CDR	Eccentricity e/L	Product name
1	0.00	12.00	2	N/A	8.879	44.384	1.919	0.0719	SF90
2	1.33	12.00	2	N/A	4.750	20.633	2.052	0.0549	SF90
3	2.67	12.00	2	N/A	5.270	19.651	2.206	0.0388	SF90
4	4.00	12.00	2	N/A	5.939	18.789	2.385	0.0235	SF90
5	5.33	12.00	2	N/A	6.745	17.811	2.598	0.0088	SF90
6	6.67	12.00	2	N/A	7.845	16.934	2.854	-0.0057	SF90
7	8.00	12.00	2	N/A	9.405	16.215	3.163	-0.0205	SF90
8	9.33	12.00	2	N/A	11.669	15.561	3.542	-0.0366	SF90
9	10.66	12.00	2	N/A	15.320	15.133	4.007	-0.0565	SF90
10	12.00	12.00	2	N/A	16.195	11.062	4.551	-0.0868	SF90

ANALYSIS: CALCULATED FACTORS (Seismic conditions)

Bearing capacity, CDR = 27.80, factored bearing load = 3885 lb/ft².
Foundation Interface: Direct sliding, CDR = 1.831, Eccentricity, e/L = 0.2032, Fs-overturning = 2.38

GEOGRID #	Elevation [ft]	Length [ft]	Type #	CONNECTION CDR [connection break]	Geogrid strength CDR	Pullout resistance CDR	Direct sliding CDR	Eccentricity e/L	Product name
1	0.00	12.00	2	N/A	11.688	41.107	1.227	0.2032	SF90
2	1.33	12.00	2	N/A	7.145	22.911	1.318	0.1695	SF90
3	2.67	12.00	2	N/A	7.788	21.287	1.427	0.1422	SF90
4	4.00	12.00	2	N/A	8.582	19.733	1.555	0.1157	SF90
5	5.33	12.00	2	N/A	9.492	18.044	1.711	0.0904	SF90
6	6.67	12.00	2	N/A	10.660	16.364	1.903	0.0659	SF90
7	8.00	12.00	2	N/A	12.186	14.707	2.143	0.0421	SF90
8	9.33	12.00	2	N/A	14.165	12.959	2.449	0.0177	SF90
9	10.66	12.00	2	N/A	16.877	11.133	2.842	-0.0094	SF90
10	12.00	12.00	2	N/A	17.454	7.918	3.331	-0.0456	SF90

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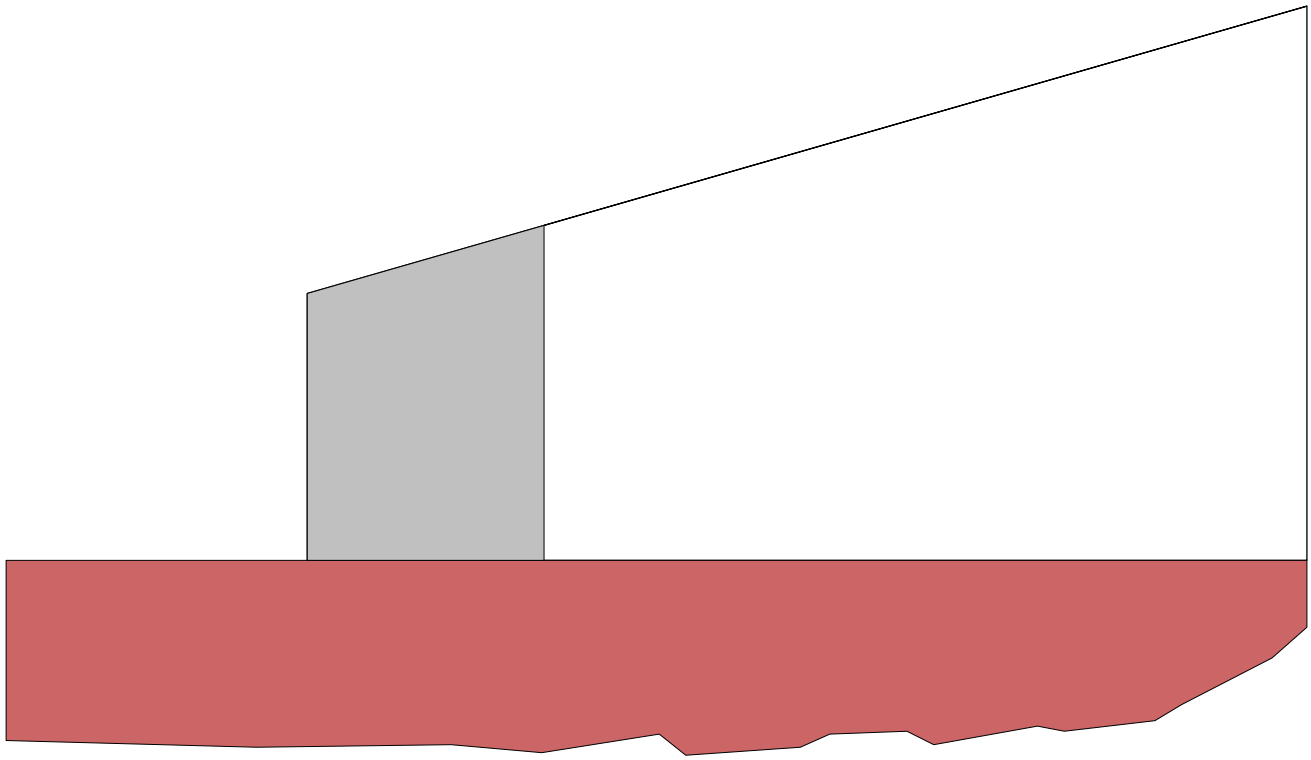
BEARING CAPACITY for GIVEN LAYOUT – Using AASHTO 2017-2020 method

	STATIC	SEISMIC	UNITS
(Given factored bearing resistance, q-n)			
Factored bearing resistance. q-n	78000	108000	[lb/ft ²]
Factored bearing load, σ_V	3274.0	3885	[lb/ft ²]
Eccentricity, e	0.60	1.42	[ft]
Eccentricity, e/L	0.050	0.118	
CDR calculated	23.82	27.80	
Base length	12.00	12.00	[ft]

Unfactored applied bearing pressure = (Unfactored R) / [L - 2 * (Unfactored e)] =
Static: Unfactored R = 26051.75 [lb/ft], L = 12.00, Unfactored e = 0.52 [ft], and Sigma = 2376.58 [lb/ft ²]
Seismic: Unfactored R = 27467.32 [lb/ft], L = 12.00, Unfactored e = 1.71 [ft], and Sigma = 3201.44 [lb/ft ²]



SCALE:

0 2 4 6 8 10 [ft]

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DIRECT SLIDING for GIVEN LAYOUT (for GEOGRID reinforcements)

Along reinforced and foundation soils interface: CDR-static = 2.865 and CDR-seismic = 1.831

#	Geogrid Elevation [ft]	Geogrid Length [ft]	CDR Static	CDR Seismic	Geogrid Type #	Product name
1	0.00	12.00	1.919	1.227	2	SF90
2	1.33	12.00	2.052	1.318	2	SF90
3	2.67	12.00	2.206	1.427	2	SF90
4	4.00	12.00	2.385	1.555	2	SF90
5	5.33	12.00	2.598	1.711	2	SF90
6	6.67	12.00	2.854	1.903	2	SF90
7	8.00	12.00	3.163	2.143	2	SF90
8	9.33	12.00	3.542	2.449	2	SF90
9	10.66	12.00	4.007	2.842	2	SF90
10	12.00	12.00	4.551	3.331	2	SF90

ECCENTRICITY for GIVEN LAYOUT

At interface with foundation: e/L static = 0.0719, e/L seismic = 0.2032; Overturning: CDR-static = 4.34, CDR-seismic = 2.38

#	Geogrid Elevation [ft]	Geogrid Length [ft]	e / L Static	e / L Seismic	Geogrid Type #	Product name
1	0.00	12.00	0.0719	0.2032	2	SF90
2	1.33	12.00	0.0549	0.1695	2	SF90
3	2.67	12.00	0.0388	0.1422	2	SF90
4	4.00	12.00	0.0235	0.1157	2	SF90
5	5.33	12.00	0.0088	0.0904	2	SF90
6	6.67	12.00	-0.0057	0.0659	2	SF90
7	8.00	12.00	-0.0205	0.0421	2	SF90
8	9.33	12.00	-0.0366	0.0177	2	SF90
9	10.66	12.00	-0.0565	-0.0094	2	SF90
10	12.00	12.00	-0.0868	-0.0456	2	SF90

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RESULTS for STRENGTH

Live Load included in calculating Tmax

#	Geogrid Elevation [ft]	LTDS [lb/ft]	Factored: Static/Seismic Tmax [lb/ft]	Tmd [lb/ft]	Specified minimum CDR Static	Actual calculated CDR Static	Specified minimum CDR seismic	Actual calculated CDR seismic	Product name
1	0.00	3717/4957	419/310	172.06	N/A	8.879	N/A	11.688	SF90
2	1.33	3717/4957	783/580	172.06	N/A	4.750	N/A	7.145	SF90
3	2.67	3717/4957	705/523	172.06	N/A	5.270	N/A	7.788	SF90
4	4.00	3717/4957	626/464	172.06	N/A	5.939	N/A	8.582	SF90
5	5.33	3717/4957	551/408	172.06	N/A	6.745	N/A	9.492	SF90
6	6.67	3717/4957	474/351	172.06	N/A	7.845	N/A	10.660	SF90
7	8.00	3717/4957	395/293	172.06	N/A	9.405	N/A	12.186	SF90
8	9.33	3717/4957	319/236	172.06	N/A	11.669	N/A	14.165	SF90
9	10.66	3717/4957	243/180	172.06	N/A	15.320	N/A	16.877	SF90
10	12.00	3717/4957	230/170	172.06	N/A	16.195	N/A	17.454	SF90

RESULTS for PULLOUT

Live Load included in calculating Tmax

#	Geogrid Elevation [ft]	Coverage Ratio	Factored: Stat./Seis. Tmax [lb/ft]	Tmd [lb/ft]	Le [ft]	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	419/310	0/172.1	12.00	0.00	18582.9	N/A	44.384	19821.8	N/A	41.107
2	1.33	1.000	783/580	0/172.1	11.35	0.65	16148.0	N/A	20.633	17224.5	N/A	22.911
3	2.67	1.000	705/523	0/172.1	10.70	1.30	13861.2	N/A	19.651	14785.2	N/A	21.287
4	4.00	1.000	626/464	0/172.1	10.05	1.95	11760.1	N/A	18.789	12544.1	N/A	19.733
5	5.33	1.000	551/408	0/172.1	9.40	2.60	9816.5	N/A	17.811	10470.9	N/A	18.044
6	6.67	1.000	474/351	0/172.1	8.75	3.25	8024.4	N/A	16.934	8559.3	N/A	16.364
7	8.00	1.000	395/293	0/172.1	8.10	3.90	6409.1	N/A	16.215	6836.3	N/A	14.707
8	9.33	1.000	319/236	0/172.1	7.45	4.55	4957.3	N/A	15.561	5287.8	N/A	12.959
9	10.66	1.000	243/180	0/172.1	6.80	5.20	3671.9	N/A	15.133	3916.7	N/A	11.133
10	12.00	1.000	230/170	0/172.1	6.15	5.85	2539.2	N/A	11.062	2708.5	N/A	7.918

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AASHTO 2017-2020
I-405 D/B - Bridge 40P

MSEW+: Update # 2021.12

PROJECT IDENTIFICATION

Title: I-405 D/B - Bridge 40P
Project Number: O38650
Client: Flatiron Lane JV
Designer: VA
Station Number: DH = 10.9'

Description:

Design Case 5; Design Height = 10.9ft

Company's information:

Name: Tensar International Corporation
Street: 2500 Northwinds Parkway
Suite 500
Alpharetta, GA 30009
Telephone #: (770) 344-2090
Fax #: (770) 344-2084
E-Mail: vamaya@tensarcorp.com

File path and name: K:_o\O38650\Final\Working Files\Design\Rev1\MSEW\Wall-.....
.....Wall- H=10.9 ft.BENp

Original date and time of creating this file: Oct 2021

PROGRAM MODE: ANALYSIS
of a SIMPLE STRUCTURE
using GEOGRID as reinforcing material.

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SOIL DATA

REINFORCED SOIL

Unit weight, γ	135.0 lb/ft ^{3}
Design value of internal angle of friction, ϕ	38.0 °

RETAINED SOIL

Unit weight, γ	135.0 lb/ft ^{3}
Design value of internal angle of friction, ϕ	38.0 °

FOUNDATION SOIL (Considered as an equivalent uniform soil)

Equivalent unit weight, $\gamma_{equiv.}$	140.0 lb/ft ^{3}
Equivalent internal angle of friction, $\phi_{equiv.}$	43.0 °
Equivalent cohesion, $c_{equiv.}$	0.0 lb/ft ^{2}

Factored bearing capacity resistance of foundation is given: q-ult-static = 120000.0 lb/ft^2., q-ult-sesmic = 120000.0 lb/ft^2.

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)
Inclination of internal slip plane, ψ = 64.00° (see Fig. 28 in DEMO 82).
Ka (external stability) = 0.2612 (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 = N/A N γ= N/A

SEISMICITY (using AASHTO 2017-2020)

Peak ground acceleration coeff., A = PGA = 0.417 and Site Factor, Fpga = 1.183. Maximum ground acceleration coeff., As = 0.493
Design acceleration coefficient in Internal Stability: Kh = Am = 0.247
Design acceleration coefficient in External Stability: Kh_d = 0.247 => Kh = Am = 0.247

Kae (Kh > 0) = 0.5263 Kae (Kh = 0) = 0.2612
Seismic soil-geogrid friction coefficient, F* is 80.0% of its specified static value.

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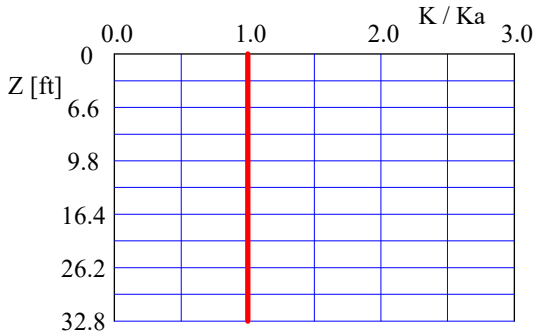
INPUT DATA: Geogrids (Analysis)

D A T A	Geogrid type #1	Geogrid type #2	Geogrid type #3	Geogrid type #4	Geogrid type #5
Tult [lb/ft]	7550.0	9000.0	14500.0		
Durability reduction factor, RFd	1.30	1.30	1.30		
Installation-damage reduction factor, RFid	1.11	1.11	1.11		
Creep reduction factor, RFc	1.51	1.51	1.51	N/A	N/A
CDR for strength	N/A	N/A	N/A		
Coverage ratio, Rc	1.000	1.000	1.000		
Friction angle along geogrid-soil interface, ρ	27.63	27.63	27.63		
Pullout resistance factor, F*	$0.67 \cdot \tan\phi$	$0.67 \cdot \tan\phi$	$0.67 \cdot \tan\phi$	N/A	N/A
Scale-effect correction factor, α	0.8	0.8	0.8		

Variation of Lateral Earth Pressure Coefficient With Depth

Z	K / Ka
0 ft	1.00
3.3 ft	1.00
6.6 ft	1.00
9.8 ft	1.00
13.1 ft	1.00
16.4 ft	1.00
19.7 ft	1.00



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INPUT DATA: Geometry and Surcharge loads (of a SIMPLE STRUCTURE)

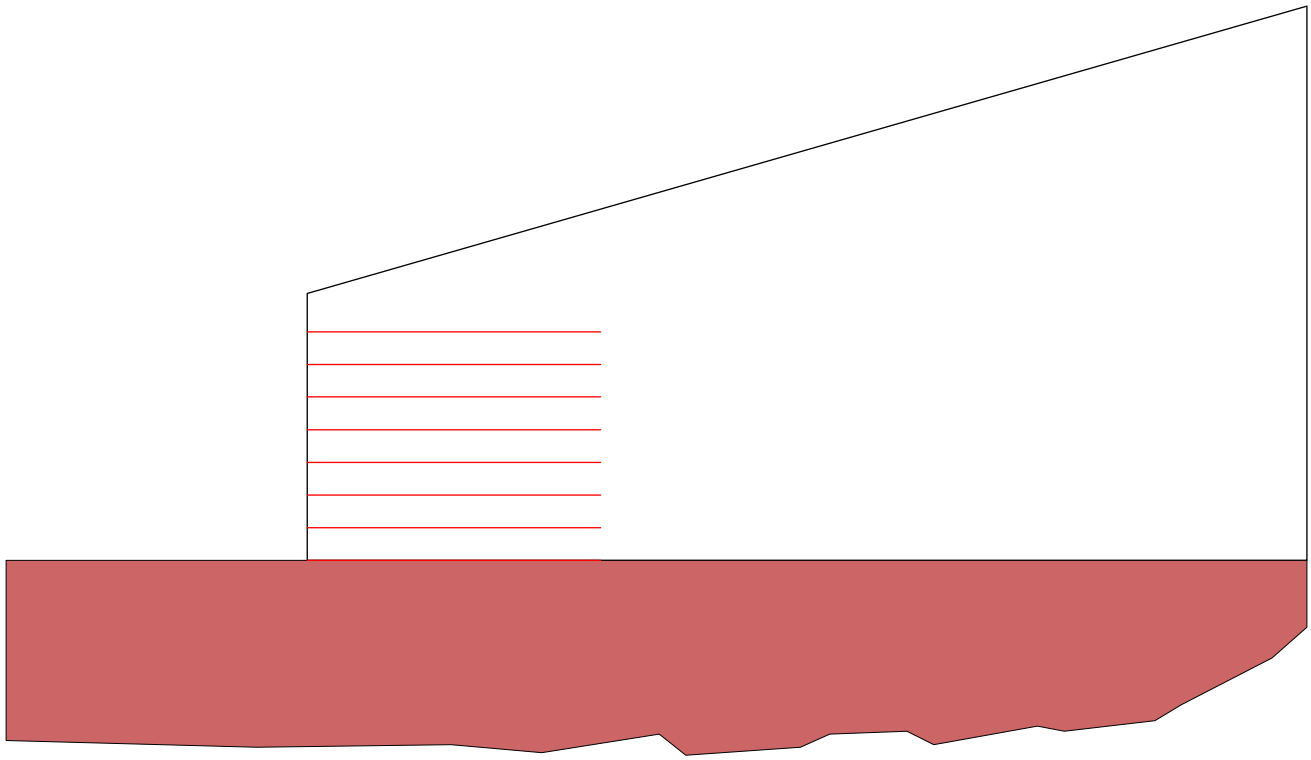
Design height, Hd 10.90 [ft] { Embedded depth is E = 0.00 ft, and height above top of finished bottom grade is H = 10.90 ft }

Soil in front of wall is Horizontal.

Batter, ω	0.0	[deg]	
Backslope, β	16.0	[deg]	
Backslope rise	27.0	[ft]	Broken back equivalent angle, I = 16.00° (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]

ANALYZED REINFORCEMENT LAYOUT:



SCALE:

0 2 4 6 8 10 [ft]

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AASHTO 2017-2020 – Load and Resisting Factors

INTERNAL STABILITY

Load factor for vertical earth pressure, EV:	$\gamma_{p\text{-}EV}$	1.35
Load factor for earthquake loads, EQ:	$\gamma_{p\text{-}EQ}$	1.00
Load factor for live load surcharge, LS: (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	ϕ	Static	Combined static/seismic
Geogrid:		0.90	1.20

Resistance factor for reinforcement tension in connectors	ϕ	Static	Combined static/seismic
Geogrid:		0.90	1.20

Resistance factor for geosynthetic pullout	ϕ	0.90	1.20

EXTERNAL STABILITY

Load factor for vertical earth pressure, EV			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	$\gamma_{p\text{-}EH}$	1.50
Load factor of active lateral earth pressure during earthquake (does not multiply P_{AE} and P_{IR}):	$(\gamma_{p\text{-}EH})_{EQ}$	1.10
Load factor for earthquake loads, EQ (multiplies P_{AE} and P_{IR}):	$\gamma_{p\text{-}EQ}$	1.00

Resistance factor for shear resistance along common interfaces		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	Static	Combined Static/Seismic
ϕ_b	0.65	0.90

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ANALYSIS: CALCULATED FACTORS (Static conditions)

Bearing capacity, CDR = 30.60, factored bearing load = 2549 lb/ft².
Foundation Interface: Direct sliding, CDR = 3.279, Eccentricity, e/L = 0.0396, CDR-overturning = 5.85

GEOGRID #	Elevation [ft]	Length [ft]	Type #	CONNECTION CDR [connection break]	Geogrid strength CDR	Pullout resistance CDR	Direct sliding CDR	Eccentricity e/L	Product name
1	0.00	12.00	2	N/A	11.057	45.825	2.197	0.0396	SF90
2	1.33	12.00	2	N/A	6.024	21.306	2.375	0.0243	SF90
3	2.67	12.00	2	N/A	6.887	20.439	2.587	0.0094	SF90
4	4.00	12.00	2	N/A	8.065	19.744	2.839	-0.0050	SF90
5	5.33	12.00	2	N/A	9.642	19.007	3.145	-0.0197	SF90
6	6.67	12.00	2	N/A	12.058	18.520	3.524	-0.0358	SF90
7	8.00	12.00	2	N/A	16.142	18.531	3.984	-0.0554	SF90
8	9.33	12.00	2	N/A	17.348	13.941	4.522	-0.0847	SF90

ANALYSIS: CALCULATED FACTORS (Seismic conditions)

Bearing capacity, CDR = 38.20, factored bearing load = 2827 lb/ft².
Foundation Interface: Direct sliding, CDR = 2.121, Eccentricity, e/L = 0.1437, Fs-overturning = 3.36

GEOGRID #	Elevation [ft]	Length [ft]	Type #	CONNECTION CDR [connection break]	Geogrid strength CDR	Pullout resistance CDR	Direct sliding CDR	Eccentricity e/L	Product name
1	0.00	12.00	2	N/A	14.497	42.219	1.421	0.1437	SF90
2	1.33	12.00	2	N/A	9.013	23.479	1.548	0.1171	SF90
3	2.67	12.00	2	N/A	10.060	21.791	1.703	0.0916	SF90
4	4.00	12.00	2	N/A	11.413	20.155	1.892	0.0672	SF90
5	5.33	12.00	2	N/A	13.097	18.358	2.129	0.0434	SF90
6	6.67	12.00	2	N/A	15.431	16.523	2.433	0.0189	SF90
7	8.00	12.00	2	N/A	18.815	14.647	2.822	-0.0081	SF90
8	9.33	12.00	2	N/A	19.702	10.659	3.304	-0.0433	SF90

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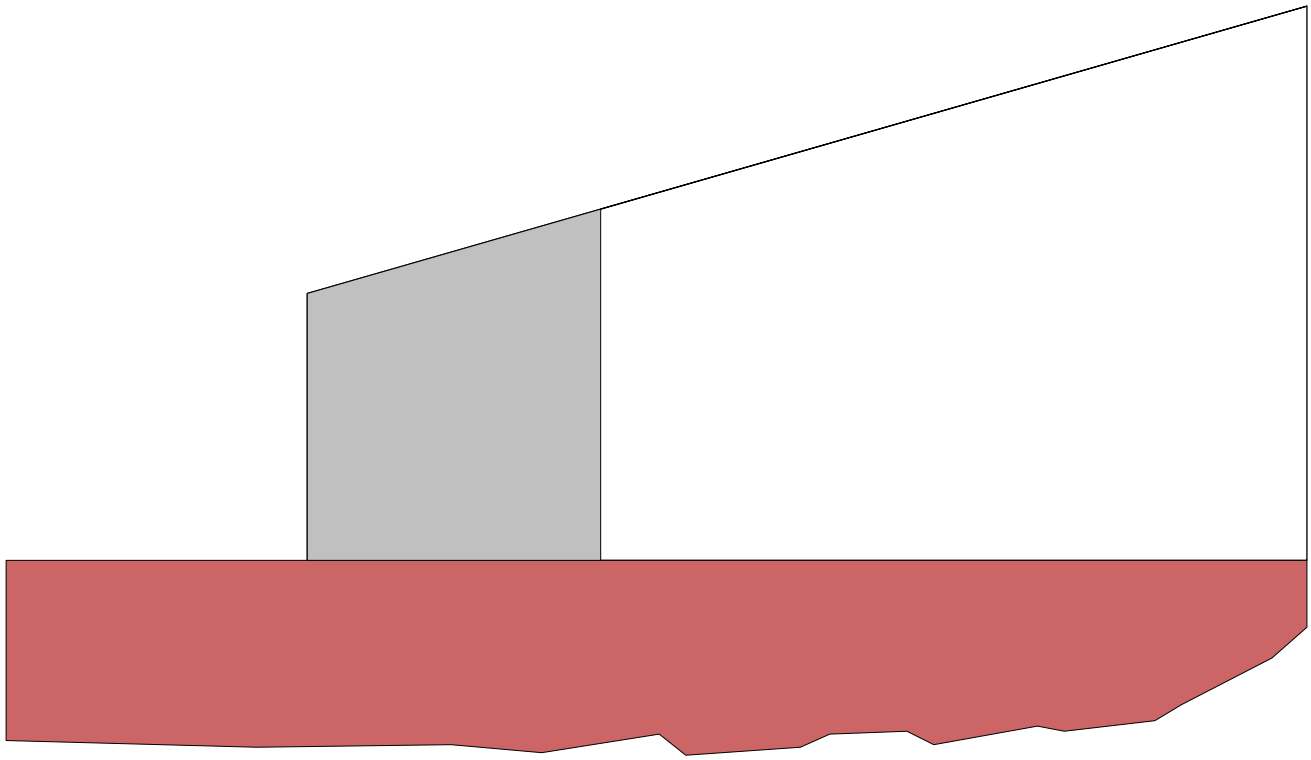
BEARING CAPACITY for GIVEN LAYOUT – Using AASHTO 2017-2020 method

	STATIC	SEISMIC	UNITS
(Given factored bearing resistance, q-n)			
Factored bearing resistance. q-n	78000	108000	[lb/ft ²]
Factored bearing load, σ_V	2548.7	2827	[lb/ft ²]
Eccentricity, e	0.29	0.83	[ft]
Eccentricity, e/L	0.024	0.069	
CDR calculated	30.60	38.20	
Base length	12.00	12.00	[ft]

Unfactored applied bearing pressure = (Unfactored R) / [L - 2 * (Unfactored e)] =
Static: Unfactored R = 21444.53 [lb/ft], L = 12.00, Unfactored e = 0.24 [ft], and Sigma = 1860.65 [lb/ft ²]
Seismic: Unfactored R = 22458.94 [lb/ft], L = 12.00, Unfactored e = 1.04 [ft], and Sigma = 2263.23 [lb/ft ²]



SCALE:

0 2 4 6 8 10 [ft]

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DIRECT SLIDING for GIVEN LAYOUT (for GEOGRID reinforcements)

Along reinforced and foundation soils interface: CDR-static = 3.279 and CDR-seismic = 2.121

#	Geogrid Elevation [ft]	Geogrid Length [ft]	CDR Static	CDR Seismic	Geogrid Type #	Product name
1	0.00	12.00	2.197	1.421	2	SF90
2	1.33	12.00	2.375	1.548	2	SF90
3	2.67	12.00	2.587	1.703	2	SF90
4	4.00	12.00	2.839	1.892	2	SF90
5	5.33	12.00	3.145	2.129	2	SF90
6	6.67	12.00	3.524	2.433	2	SF90
7	8.00	12.00	3.984	2.822	2	SF90
8	9.33	12.00	4.522	3.304	2	SF90

ECCENTRICITY for GIVEN LAYOUT

At interface with foundation: e/L static = 0.0396, e/L seismic = 0.1437; Overturning: CDR-static = 5.85, CDR-seismic = 3.36

#	Geogrid Elevation [ft]	Geogrid Length [ft]	e / L Static	e / L Seismic	Geogrid Type #	Product name
1	0.00	12.00	0.0396	0.1437	2	SF90
2	1.33	12.00	0.0243	0.1171	2	SF90
3	2.67	12.00	0.0094	0.0916	2	SF90
4	4.00	12.00	-0.0050	0.0672	2	SF90
5	5.33	12.00	-0.0197	0.0434	2	SF90
6	6.67	12.00	-0.0358	0.0189	2	SF90
7	8.00	12.00	-0.0554	-0.0081	2	SF90
8	9.33	12.00	-0.0847	-0.0433	2	SF90

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RESULTS for STRENGTH

Live Load included in calculating Tmax

#	Geogrid Elevation [ft]	LTDS [lb/ft]	Factored: Static/Seismic Tmax [lb/ft]	Tmd [lb/ft]	Specified minimum CDR Static	Actual calculated CDR Static	Specified minimum CDR seismic	Actual calculated CDR seismic	Product name
1	0.00	3717/4957	336/249	140.21	N/A	11.057	N/A	14.497	SF90
2	1.33	3717/4957	617/457	140.21	N/A	6.024	N/A	9.013	SF90
3	2.67	3717/4957	540/400	140.21	N/A	6.887	N/A	10.060	SF90
4	4.00	3717/4957	461/341	140.21	N/A	8.065	N/A	11.413	SF90
5	5.33	3717/4957	386/286	140.21	N/A	9.642	N/A	13.097	SF90
6	6.67	3717/4957	308/228	140.21	N/A	12.058	N/A	15.431	SF90
7	8.00	3717/4957	230/171	140.21	N/A	16.142	N/A	18.815	SF90
8	9.33	3717/4957	214/159	140.21	N/A	17.348	N/A	19.702	SF90

RESULTS for PULLOUT

Live Load included in calculating Tmax

#	Geogrid Elevation [ft]	Coverage Ratio	Factored: Stat./Seis. Tmax [lb/ft]	Tmd [lb/ft]	Le [ft]	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	336/249	0/140.2	12.00	0.00	15406.6	N/A	45.825	16433.7	N/A	42.219
2	1.33	1.000	617/457	0/140.2	11.35	0.65	13147.0	N/A	21.306	14023.5	N/A	23.479
3	2.67	1.000	540/400	0/140.2	10.70	1.30	11032.9	N/A	20.439	11768.5	N/A	21.791
4	4.00	1.000	461/341	0/140.2	10.05	1.95	9100.7	N/A	19.744	9707.4	N/A	20.155
5	5.33	1.000	386/286	0/140.2	9.40	2.60	7328.2	N/A	19.007	7816.8	N/A	18.358
6	6.67	1.000	308/228	0/140.2	8.75	3.25	5709.2	N/A	18.520	6089.9	N/A	16.523
7	8.00	1.000	230/171	0/140.2	8.10	3.90	4267.7	N/A	18.531	4552.2	N/A	14.647
8	9.33	1.000	214/159	0/140.2	7.45	4.55	2987.2	N/A	13.941	3186.4	N/A	10.659

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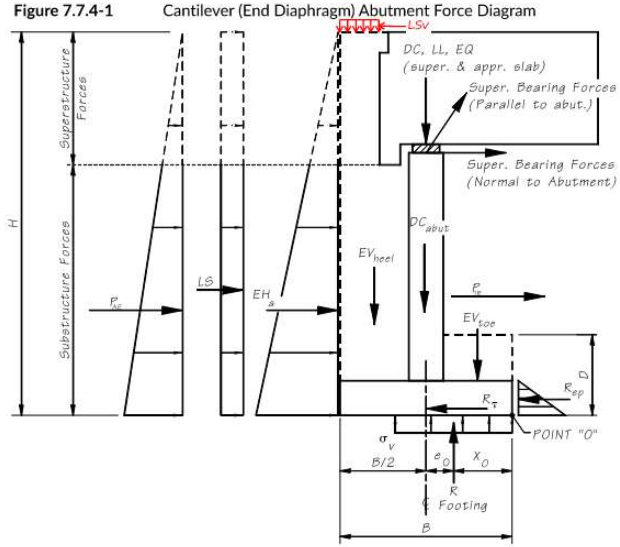
		Unfactored Vertical Forces			Unfactored Lateral Forces			Service				Strength				Extreme (1.0P.AE + 0.5P.IR)				Extreme (0.5P.AE + 1.0P.IR)			
		Force	Dist. from CL ftg	Moment abt. CL ftg	Force	Dist. from bot. ftg.	Moment abt. CL ftg	Load Factor	Vertical Force	Lateral Force	Moment abt. CL ftg	Load Factor	Vertical Force	Lateral Force	Moment abt. CL ftg	Load Factor	Vertical Force	Lateral Force	Moment abt. CL ftg	Load Factor	Vertical Force	Lateral Force	Moment abt. CL ftg
DC	stem wall (DC.abut)	2.13	0.00	0.00				1.00	2.13	0.00	0.00	1.25	2.66	0.00	0.00	1.00	2.13	0.00	0.00	1.00	2.13	0.00	0.00
	footing (DC.abut)	3.10	0.00	0.00				1.00	3.10	0.00	0.00	1.25	3.88	0.00	0.00	1.00	3.10	0.00	0.00	1.00	3.10	0.00	0.00
	from superstructure (DC.super)	25.91	0.00	0.00				1.00	25.91	0.00	0.00	1.25	32.39	0.00	0.00	1.00	25.91	0.00	0.00	1.00	25.91	0.00	0.00
DW	from superstructure (DW.super)	16.09	0.00	0.00				1.00	16.09	0.00	0.00	1.50	24.14	0.00	0.00	1.00	16.09	0.00	0.00	1.00	16.09	0.00	0.00
EV	below diaphragm (EV.heel)	1.67	-2.62	-4.39				1.00	1.67	0.00	-4.39	1.35	2.26	0.00	-5.92	1.00	1.67	0.00	-4.39	1.00	1.67	0.00	-4.39
	behind diaphragm (EV.heel)	0.60	-3.79	-2.27				1.00	0.60	0.00	-2.27	1.35	0.81	0.00	-3.07	1.00	0.60	0.00	-2.27	1.00	0.60	0.00	-2.27
	over toe (EV.toe)	0.00	0.00	0.00				1.00	0.00	0.00	0.00	1.35	0.00	0.00	0.00	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00
LL	from superstructure (LL.super)	2.43	0.00	0.00				1.00	2.43	0.00	0.00	1.75	4.25	0.00	0.00	0.50	1.22	0.00	0.00	0.50	1.22	0.00	0.00
LS	vertical above heel (LS.v)	1.02	-2.63	-2.69				1.00	1.02	0.00	-2.69	1.75	1.79	0.00	-4.70	0.50	0.51	0.00	-1.34	0.50	0.51	0.00	-1.34
	lateral below diaphragm (LS)				0.57	3.50	1.98	1.00	0.00	0.57	1.98	1.75	0.00	0.99	3.47	0.50	0.00	0.28	0.99	0.50	0.00	0.28	0.99
EH	below diaphragm (EH.a)				2.85	3.19	9.07	1.00	0.00	2.85	9.07	1.50	0.00	4.27	13.60		0.00	0.00	0.00		0.00	0.00	0.00
TU	from superstructure (bearing forces)				1.90	8.00	15.20	1.00	0.00	1.90	15.20	1.00	0.00	1.90	15.20		0.00	0.00	0.00		0.00	0.00	0.00
EQ	from superstrucutre (bearing forces)				9.81	8.00	78.46		0.00	0.00	0.00		0.00	0.00	0.00	1.00	0.00	9.81	78.46	0.50	0.00	4.90	39.23
	earth pressure (P.AE)				5.10	3.19	16.26		0.00	0.00	0.00		0.00	0.00	0.00	1.00	0.00	5.10	16.26	0.50	0.00	2.55	8.13
	abutment inertia (P.IR)				1.29	2.88	3.72		0.00	0.00	0.00		0.00	0.00	0.00	0.50	0.00	0.65	1.86	1.00	0.00	1.29	3.72
	soil inertia (P.IR)				0.56	4.85	2.72		0.00	0.00	0.00		0.00	0.00	0.00	0.50	0.00	0.28	1.36	1.00	0.00	0.56	2.72
								R.vertical =	52.96		kips	R.vertical =	72.17		kips	R.vertical =	51.23		kips	R.vertical =	51.23		kips
								R.lateral =	5.31		kips	R.lateral =	7.16		kips	R.lateral =	16.12		kips	R.lateral =	9.59		kips
								e = ΣM/R.vertical =	0.32		ft	e = ΣM/R.vertical =	0.26		ft	e = ΣM/R.vertical =	1.77		ft	e = ΣM/R.vertical =	0.91		ft
								b.eff = 8ft - |2 e| =	7.36		ft	b.eff = 8ft - |2 e| =	7.49		ft	b.eff = 8ft - |2 e| =	4.45		ft	b.eff = 8ft - |2 e| =	6.17		ft

Figure 7.7.4-1 Cantilever (End Diaphragm) Abutment Force Diagram



ERC Wingwall Loading

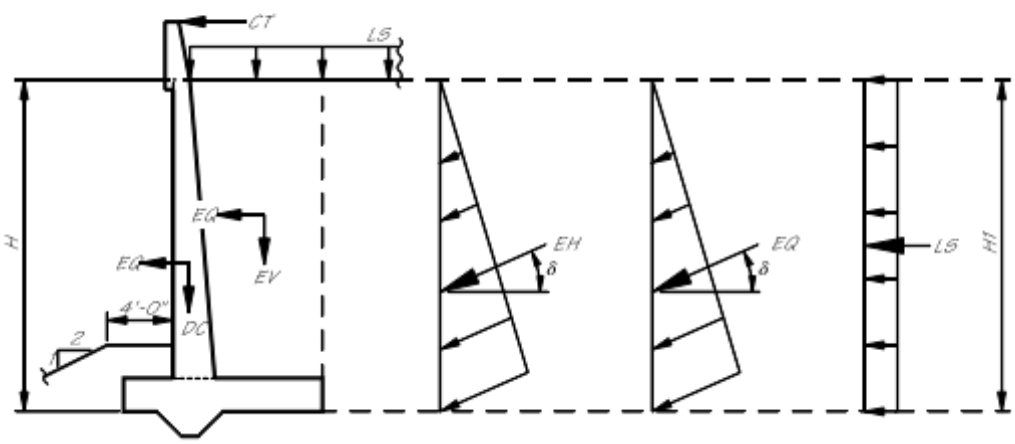
ERC wing walls are standard plan walls with a design height $H := 17\ ft$.
Height of retained soil equal the design height $H_1 := H = 17\ ft$
Toe width $C_v := 3\ ft$, Footing width $B := 9.75\ ft$, Footing Depth, $D := 1.5\ ft$
Top of wall width $A_1 := 10.5\ in$, Bottom of wall width $A := 2.5\ ft$

Assume gravel borrow backfill per Table 1 of the Geotech Memo
Lateral earth pressure coefficients per Table 16A
Acceleration coefficient from Table 5

Concrete unit weight, $\gamma_c := 155\ pcf$
Backfill soil unit weight, $\gamma_s := 135\ pcf$
Active Earth Pressure Coefficient, $K_a := 0.217$
Seismic Earth Pressure Coefficient, $K_{ae} := 0.389$
Horizontal acceleration coefficient, $k_h := 0.5 \cdot 0.493 = 0.247$
Interface friction angle, $\delta := 2 \cdot 38\ deg \div 3 = 25.333\ deg$

Per BDM Figure 8.1.4-1 the loading for a standard plan wall is:

Figure 8.1.4-1 Application of Lateral Loads for walls with a horizontal backfill



Neglect CT load as, the wingwalls do not have traffic barriers associated with them.
DC Loads (per foot width of wall)
Weight of Footing $P_{ftg} := B \cdot D \cdot 1\ ft \cdot \gamma_c = 2.267\ kip$
Distance from toe $X_{ftg} := 0.5 \cdot B = 4.875\ ft$
Distance from bottom $Z_{ftg} := 0.5 \cdot D = 0.750\ ft$

Height of Stem, $H_{stem} := H - D = 15.500\ ft$
Width of wall at top, $B_1 := A_1 = 0.875\ ft$
Width of wall at bottom, $B_2 := A = 2.500\ ft$

Weight of Stem $P_{stem} := 0.5 \cdot (B_1 + B_2) \cdot H_{stem} \cdot 1\ ft \cdot \gamma_c = 4.054\ kip$
Distance from toe $X_{stem} := C_v + (B_1^2 + B_1 \cdot B_2 + B_2^2) \div (3 \cdot (B_1 + B_2)) = 3.909\ ft$
Distance from bottom $Z_{stem} := D + H_{stem} \cdot (2 \cdot B_1 + B_2) \div (3 \cdot (B_1 + B_2)) = 8.006\ ft$

EV Loads (per foot width of wall)

Height of Soil behind wall, $H_{EV} := H_1 - D = 15.500$ ft

Width of soil at top, $B_1 := B - C_v - A_1 = 5.875$ ft

Width of soil at bottom, $B_2 := B - C_v - A = 4.250$ ft

Weight of Soil, $P_{EV} := 0.5 \cdot (B_1 + B_2) \cdot H_{EV} \cdot 1\ ft \cdot \gamma_s = 10.593$ kip

Distance from toe $X_{EV} := B - (B_1^2 + B_1 \cdot B_2 + B_2^2) \div (3 \cdot (B_1 + B_2)) = 7.197$ ft

Distance from bottom $Z_{EV} := D + H_{EV} \cdot (2 \cdot B_1 + B_2) \div (3 \cdot (B_1 + B_2)) = 9.665$ ft

LS Surcharge (per foot width of wall)

live load surcharge (per std. plan), $q_{LS} := 250$ psf

Vertical load acting on wall (bearing check only), $P_{LSv} := q_{LS} \cdot (B - C_v - A_1) \cdot 1\ ft = 1.469$ kip

Distance from toe $X_{LSv} := C_v + A_1 + (B - C_v - A_1) \div 2 = 6.813$ ft

Horizontal load acting on wall, $P_{LSh} := K_a \cdot q_{LS} \cdot H_1 \cdot 1\ ft = 0.922$ kip

Distance from bottom $Z_{LSh} := 0.5 \cdot H_1 = 8.500$ ft

Active Earth Pressure (per foot width of wall)

lateral earth pressure at bottom of wall, $\sigma_{EH} := K_a \cdot \gamma_s \cdot H_1 = 0.498$ ksf

Load acting on wall, $P_{EH} := 0.5 \cdot \sigma_{EH} \cdot H_1 \cdot 1\ ft = 4.233$ kip

Vertical Component, $P_{EHv} := P_{EH} \cdot \sin(\delta) = 1.811$ kip

Distance from toe $X_{EHv} := B = 9.750$ ft

Horizontal Component, $P_{EHh} := P_{EH} \cdot \cos(\delta) = 3.826$ kip

Distance from toe $Z_{EHv} := H_1 \div 3 = 5.667$ ft

Seismic Earth Pressure (per foot width of wall)

lateral earth pressure at bottom of wall, $\sigma_{EQ} := K_{ae} \cdot \gamma_s \cdot H_1 = 0.893$ ksf

Load acting on wall, $P_{EQ} := 0.5 \cdot \sigma_{EQ} \cdot H_1 \cdot 1\ ft = 7.588$ kip

Vertical Component, $P_{EQv} := P_{EQ} \cdot \sin(\delta) = 3.247$ kip

Distance from toe $X_{EQv} := B = 9.750$ ft

Horizontal Component, $P_{EQh} := P_{EQ} \cdot \cos(\delta) = 6.859$ kip

Distance from bottom $Z_{EQv} := H_1 \div 3 = 5.667$ ft

Seismic Inertia Force (per foot width of wall)

Footing Inertia Force, $P_{IR1} := k_h \cdot P_{ftg} = 0.559$ kip

Stem Inertia Force, $P_{IR2} := k_h \cdot P_{stem} = 0.999$ kip

Backfill Inertia Force, $P_{IR3} := k_h \cdot P_{EV} = 2.611$ kip

Total Inertia Force, $P_{IR} := P_{IR1} + P_{IR2} + P_{IR3} = 4.169$ kip

Distance from bottom $Z_{IR} := (P_{IR1} \cdot Z_{ftg} + P_{IR2} \cdot Z_{stem} + P_{IR3} \cdot Z_{EV}) \div P_{IR} = 8.072$ ft

		Unfactored Vertical Forces			Unfactored Lateral Forces			Service			
		Force	Dist. from toe	Moment abt. CL ftg	Force	Dist. from bot. ftg.	Moment abt. CL ftg	Load Factor	Vertical Force	Lateral Force	Moment abt. CL ftg
DC	footing	2.267	4.875	0.000				1.00	2.27	0.00	0.00
	stem wall	4.054	3.909	3.916				1.00	4.05	0.00	3.92
EV	backfill	10.593	7.197	-24.597				1.00	10.59	0.00	-24.60
LS	vertical above heel (bearing only)	1.469	6.813	-2.847				1.00	1.47	0.00	-2.85
	horizontal				0.922	8.500	7.837	1.00	0.00	0.92	7.84
EH	active earth pressure (P.EH)	1.811	9.750	-8.829	3.826	5.667	21.681	1.00	1.81	3.83	12.85
EQ	earth pressure (P.EQ)	3.247	9.750	-15.829	6.859	5.667	38.868		0.00	0.00	0.00
	abutment & soil inertia (P.IR)				4.169	8.072	33.652		0.00	0.00	0.00

R.vertical =	20.19	kips/ft
R.lateral =	4.75	kips/ft
e = ΣM/R.vertical =	-0.14	ft
b.eff = 9.75ft - |2 e| =	9.47	ft
bearing stress = R.vert/b.eff =	2.13	ksf

if e < 0 then b.eff is at heel

if e > 0 then b.eff is at toe

B =	9.75	ft
H =	17.00	ft

		Strength (Maximum Bearing)				Strength (Maximum Overturning and Sliding)			
		Load Factor	Vertical Force	Lateral Force	Moment abt. CL ftg	Load Factor	Vertical Force	Lateral Force	Moment abt. CL ftg
DC	footing	1.25	2.83	0.00	0.00	0.90	2.04	0.00	0.00
	stem wall	1.25	5.07	0.00	4.90	0.90	3.65	0.00	3.52
EV	backfill	1.35	14.30	0.00	-33.21	1.00	10.59	0.00	-24.60
LS	vertical above heel (bearing only)	1.75	2.57	0.00	-4.98		0.00	0.00	0.00
	horizontal	1.75	0.00	1.61	13.71	1.75	0.00	1.61	13.71
EH	active earth pressure (P.EH)	1.50	2.72	5.74	19.28	1.50	2.72	5.74	19.28
EQ	earth pressure (P.EQ)		0.00	0.00	0.00		0.00	0.00	0.00
	abutment & soil inertia (P.IR)		0.00	0.00	0.00		0.00	0.00	0.00

R.vertical =	27.49	kips/ft	R.vertical =	19.00	kips/ft
R.lateral =	7.35	kips/ft	R.lateral =	7.35	kips/ft
e = ΣM/R.vertical =	-0.01	ft	e = ΣM/R.vertical =	0.63	ft
b.eff = 9.75ft - |2 e| =	9.73	ft	b.eff = 9.75ft - |2 e| =	8.50	ft
stress = R.vertical/b.eff =	2.83	ksf	stress = R.vertical/b.eff =	2.24	ksf

if e < 0 then b.eff is at heel
if e > 0 then b.eff is at toe

if e < 0 then b.eff is at heel
if e > 0 then b.eff is at toe

Table 7.7.2-1 Load Factors

Sliding and Overturning, e_o	Bearing Stress (e_c, s_v)
$LL_{min} = 0$	LL_{max}
DC_{min}, DW_{min} for resisting forces, DC_{max}, DW_{max} for causing forces,	DC_{max}, DW_{max} for causing forces DC_{min}, DW_{min} for resisting forces
EV_{min}	EV_{max}
EH_{max}	EH_{max}
LS	LS

Per BDM 8.1.4 the case of 0.5P.AE + 1.0P.IR is used for standard plan wall development

		Extreme (Maximum Bearing)				Extreme (Maximum Overturning and Sliding)			
		Load Factor	Vertical Force	Lateral Force	Moment abt. CL ftg	Load Factor	Vertical Force	Lateral Force	Moment abt. CL ftg
DC	footing	1.00	2.27	0.00	0.00	1.00	2.27	0.00	0.00
	stem wall	1.00	4.05	0.00	3.92	1.00	4.05	0.00	3.92
EV	backfill	1.00	10.59	0.00	-24.60	1.00	10.59	0.00	-24.60
LS	vertical above heel (bearing only)	0.50	0.73	0.00	-1.42		0.00	0.00	0.00
	horizontal	0.50	0.00	0.46	3.92	0.50	0.00	0.46	3.92
EH	active earth pressure (P.EH)		0.00	0.00	0.00		0.00	0.00	0.00
EQ	earth pressure (P.EQ)	0.50	1.62	3.43	11.52	0.50	1.62	3.43	11.52
	abutment & soil inertia (P.IR)	1.00	0.00	4.17	33.65	1.00	0.00	4.17	33.65

R.vertical =	19.27	kips/ft	R.vertical =	18.54	kips/ft
R.lateral =	8.06	kips/ft	R.lateral =	8.06	kips/ft
e = ΣM/R.vertical =	1.40	ft	e = ΣM/R.vertical =	1.53	ft
b.eff = 9.75ft - |2 e| =	6.95	ft	b.eff = 9.75ft - |2 e| =	6.68	ft
stress = R.vertical/b.eff =	2.77	ksf	stress = R.vertical/b.eff =	2.77	ksf

if e < 0 then b.eff is at heel
if e > 0 then b.eff is at toe

if e < 0 then b.eff is at heel
if e > 0 then b.eff is at toe

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Article 3.12.6, differential movements between and within substructure units shall be considered when determining the most critical combinations of force effects.

For segmentally constructed bridges, the following combination shall be investigated at the service limit state:

$$DC + DW + EH + EV + ES + WA + CR + SH + TG + EL + PS \quad (3.4.1\text{-}2)$$

Table 3.4.1-1—Load Combinations and Load Factors

Load Combination Limit State	*DC* *DD* *DW* *EH* *EV* *ES* *EL* *PS* *CR* *SH*	*LL* *IM* *CE* *BR* *PL* *LS*	*WA*	*WS*	*WL*	*FR*	*TU*	*TG*	*SE*	Use One of These at a Time				
										EQ	*BL*	*IC*	*CT*	*CV*
Strength I (unless noted)	γ_p	1.75	1.00	—	—	1.00	0.50/1.20	γ_{TG}	γ_{SE}	—	—	—	—	—
Strength II	γ_p	1.35	1.00	—	—	1.00	0.50/1.20	γ_{TG}	γ_{SE}	—	—	—	—	—
Strength III	γ_p	—	1.00	1.00	—	1.00	0.50/1.20	γ_{TG}	γ_{SE}	—	—	—	—	—
Strength IV	γ_p	—	1.00	—	—	1.00	0.50/1.20	—	—	—	—	—	—	—
Strength V	γ_p	1.35	1.00	1.00	1.00	1.00	0.50/1.20	γ_{TG}	γ_{SE}	—	—	—	—	—
Extreme Event I	1.00	γ_{EQ}	1.00	—	—	1.00	—	—	—	1.00	—	—	—	—
Extreme Event II	1.00	0.50	1.00	—	—	1.00	—	—	—	—	1.00	1.00	1.00	1.00
Service I	1.00	1.00	1.00	1.00	1.00	1.00	1.00/1.20	γ_{TG}	γ_{SE}	—	—	—	—	—
Service II	1.00	1.30	1.00	—	—	1.00	1.00/1.20	—	—	—	—	—	—	—
Service III	1.00	γ_{LL}	1.00	—	—	1.00	1.00/1.20	γ_{TG}	γ_{SE}	—	—	—	—	—
Service IV	1.00	—	1.00	1.00	—	1.00	1.00/1.20	—	1.00	—	—	—	—	—
Fatigue I—*LL*, *IM* & *CE* only	—	1.75	—	—	—	—	—	—	—	—	—	—	—	—
Fatigue II—*LL*, *IM* & *CE* only	—	0.80	—	—	—	—	—	—	—	—	—	—	—	—

Note: For Service I, the load factor for *EV* equals 1.2 for Stiffness Method Soil Failure as shown in Table 3.4.1-2.

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Table 3.4.1-2—Load Factors for Permanent Loads, γ_p

Type of Load, Foundation Type, and Method Used to Calculate Downdrag		Load Factor	
		Maximum	Minimum
DC: Component and Attachments		1.25	0.90
DC: Strength IV only		1.50	0.90
DD: Downdrag	Piles, α Tomlinson Method	1.40	0.25
	Piles, λ Method	1.05	0.30
	Drilled shafts, O'Neill and Reese (2010) Method	1.25	0.35
DW: Wearing Surfaces and Utilities		1.50	0.65
EH: Horizontal Earth Pressure			
• Active		1.50	0.90
• At-Rest		1.35	0.90
• *AEP* for anchored walls		1.35	N/A
EL: Locked-in Construction Stresses		1.00	1.00
EV: Vertical Earth Pressure			
• Overall and Compound Stability		1.00	N/A
• Retaining Walls and Abutments		1.35	1.00
• MSE wall internal stability soil reinforcement loads			
○ Stiffness Method			
▪ Reinforcement and connection rupture		1.35	N/A
▪ Soil failure – geosynthetics (Service I)		1.20	N/A
○ Coherent Gravity Method		1.35	N/A
• Rigid Buried Structure		1.30	0.90
• Rigid Frames		1.35	0.90
• Flexible Buried Structures			
○ Metal Box Culverts, Structural Plate Culverts with Deep Corrugations, and Fiberglass Culverts		1.50	0.90
○ Thermoplastic Culverts		1.30	0.90
○ All others		1.95	0.90
• Internal and Compound Stability for Soil Failure in Soil Nail Walls		1.00	N/A
ES: Earth Surcharge		1.50	0.75

Table 3.4.1-3—Load Factors for Permanent Loads Due to Superimposed Deformations, γ_p

Bridge Component	*PS*	*CR, SH*
Superstructures—Segmental Concrete Substructures supporting Segmental Superstructures (see 3.12.4, 3.12.5)	1.0	See γ_P for *DC*, Table 3.4.1-2
Concrete Superstructures—nonsegmental	1.0	1.0
Substructures supporting non-segmental Superstructures		
• using I_g	0.5	0.5
• using $I_{effectuve}$	1.0	1.0
Steel Substructures	1.0	1.0

Table 3.4.1-4—Load Factors for Live Load for Service III Load Combination, γ_{LL}

Component	γ_{LL}
Prestressed concrete components designed using the refined estimates of time-dependent losses as specified in Article 5.9.5.4 in conjunction with taking advantage of the elastic gain	1.0
All other prestressed concrete components	0.8

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Table 11.5.7-1—Strength Limit State Resistance Factors for Permanent Retaining Walls

Wall-Type and Condition		Resistance Factor
Nongravity Cantilevered and Anchored Walls		
Axial compressive resistance of vertical elements		Article 10.5 applies
Passive resistance of vertical elements		0.75
Pullout resistance of anchors (1)	• Cohesionless (granular) soils • Cohesive soils • Rock	0.65 (1) 0.70 (1) 0.50 (1)
Pullout resistance of anchors (2)	• Where proof tests are conducted	1.0 (2)
Tensile resistance of anchor tendon	• Mild steel (e.g., ASTM A615 bars) • High-strength steel (e.g., ASTM A722 bars)	0.90 (3) 0.80 (3)
Overall stability, soil failure		Article 11.6.3.7 applies
Flexural capacity of vertical elements		0.90
Mechanically Stabilized Earth Walls, Gravity Walls, and Semigravity Walls		
Bearing resistance	• Gravity and semigravity walls • MSE walls	0.55 0.65
Sliding		1.0
Tensile resistance of metallic reinforcement and connectors	Strip reinforcements (4) Grid reinforcements (4) (5)	0.75 0.65
Tensile resistance of geosynthetic reinforcement and connectors	• Geotextile and geogrid reinforcements • Geostrip reinforcements	0.80 0.55
Pullout resistance of metallic reinforcement	• Steel strip reinforcements • Steel grid reinforcements	0.90 0.90
Pullout resistance of geosynthetic reinforcement	• Geotextiles and geogrids • Geostrip reinforcements	0.70 0.70
Service Limit, for soil failure using stiffness method		1.0
Overall and compound stability, soil failure		Article 11.6.3.7 applies
Prefabricated Modular Walls		
Bearing		Article 10.5 applies
Sliding		Article 10.5 applies
Passive resistance		Article 10.5 applies
Overall stability, soil failure		Article 11.6.3.7 applies
Soil Nail Walls (6)		
Lateral sliding		1.00
Overall and Compound stability, soil failure		Article 11.6.3.7 applies
Tensile resistance of nail tendon	Mild steel bars (Grade 75) High resistance bars (Grades 95 and 150)	0.75 0.65
Pullout resistance of nail		0.65
Facing flexure	Initial and final facing	0.90
Facing punching shear	Initial and final facing	0.90
Tensile resistance of headed stud	A307 steel bolt (7) A325 steel bolt	0.70 0.80

(1) Apply to presumptive ultimate unit bond stresses for preliminary design only in Article C11.9.4.2.

(*Continued on next page*)

Refer to Appendix B1 Excerpt

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11.6.3.3—Eccentricity Limits

For foundations on soil, the location of the resultant of the reaction forces shall be within the middle two-thirds of the base width.

For foundations on rock, the location of the resultant of the reaction forces shall be within the middle nine-tenths of the base width.

C11.6.3.3

The specified criteria for the location of the resultant, coupled with investigation of the bearing pressure, replace the investigation of the ratio of stabilizing moment to overturning moment. Location of the resultant within the middle two-thirds of the base width for foundations on soil is based on the use of plastic bearing pressure distribution for the limit state.

11.6.3.4—Subsurface Erosion

For walls constructed along rivers and streams, scour of foundation materials shall be evaluated during design, as specified in Article 2.6.4.4.2. Where potential problem conditions are anticipated, adequate protective measures shall be incorporated in the design.

The provisions of Article 10.6.1.2 shall apply.

The hydraulic gradient shall not exceed:

- For silts and cohesive soils:…….0.20
- For other cohesionless soils:……0.30

Where water seeps beneath a wall, the effects of uplift and seepage forces shall be considered.

C11.6.3.4

The measures most commonly used to ensure that piping does not occur are:

- seepage control,
- reduction of hydraulic gradient, and
- protective filters.

Seepage effects may be investigated by constructing a flow net, or in certain circumstances, by using generally accepted simplified methods.

11.6.3.5—Passive Resistance

Passive resistance shall be neglected in stability computations, unless the base of the wall extends below the depth of maximum scour, freeze–thaw, or other disturbances. In the latter case, only the embedment below the greater of these depths shall be considered effective.

Where passive resistance is utilized to ensure adequate wall stability, the calculated passive resistance of soil in front of abutments and conventional walls shall be sufficient to prevent unacceptable forward movement of the wall.

The passive resistance shall be neglected if the soil providing passive resistance is, or is likely to become soft, loose, or disturbed, or if the contact between the soil and wall is not tight.

C11.6.3.5

Unacceptable deformations may occur before passive resistance is mobilized. Approximate deformations required to mobilize passive resistance are discussed in Article C3.11.1, where H in Table C3.11.1-1 is the effective depth of passive restraint.

11.6.3.6—Sliding

The provisions of Article 10.6.3.4 shall apply.

11.6.3.7—Overall Stability

The overall stability of the retaining wall, retained slope and foundation soil or rock shall be evaluated using limit equilibrium methods of analysis. The overall stability of temporary cut slopes to facilitate construction shall also be evaluated. Special exploration, testing, and

C11.6.3.7

Figure C3.4.1-1 shows a retaining wall overall stability failure. Overall stability for conventional walls (e.g., reinforced concrete gravity and semi-gravity walls) is defined as the stability of a slope soil or rock shear surface that is located outside the back of the wall,

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analyses may be required for bridge abutments or retaining walls constructed over soft deposits.

The evaluation of overall stability of earth slopes with or without a foundation unit should be investigated at the Strength I Load Combination and an appropriate resistance factor. The resistance factor, ϕ, should be taken as:

- Where the geotechnical parameters and subsurface stratigraphy are well defined …….....0.75
- Where the geotechnical parameters and subsurface stratigraphy are highly variable or based on limited information ……..……...0.65

For anchored walls, MSE walls, and soil nail walls, this Article also applies to compound stability evaluation.

including its footing. In the case of MSE, soil nail, and anchored walls, overall stability for walls is defined as the slope soil or rock shear surface that is located behind the ends of the reinforcement elements (see Article 11.10.5.6 and Figure 11.10.5.6-1). For a definition of compound stability, see Article 11.10.5.6.

The Modified Bishop, simplified Janbu, or Spencer methods of analysis may be used.

Soft soil deposits may be subject to consolidation and/or lateral flow which could result in unacceptable long-term settlements or horizontal movements.

Available slope stability programs produce a single factor of safety, *FS*. The specified resistance factors are essentially the inverse of the *FS* that should be targeted in the slope stability program (i.e., ϕ = 0.75 approximately corresponds to *FS* = 1.3, and ϕ = 0.65 approximately corresponds to *FS* = 1.5). These resistance factors address the soil resistance. For anchored walls, MSE walls, and soil nail walls, the resistance factors provided in Article 11.5.7 apply to the resistance of the reinforcement elements.

11.6.4—Safety against Structural Failure

The structural design of individual wall elements and wall foundations shall comply with the provisions of Sections 5, 6, 7, and 8.

The provisions of Article 10.6.1.3 shall be used to determine the distribution of contact pressure for structural design of footings.

11.6.5—Seismic Design for Abutments and Conventional Retaining Walls

11.6.5.1—General

Rigid gravity and semigravity retaining walls and abutments shall be designed to meet overall stability, external stability, and internal stability requirements during seismic loading. The procedures specified in Article 11.6.3.7 for overall stability, Article 11.6.3 for bearing stability, and Article 10.6.3.4 for sliding stability shall be used but including seismically induced earth pressure and inertial forces, using Extreme Event I limit state load and resistance factors as specified in Article 11.5.8.

For seismic eccentricity evaluation of walls with foundations on soil and rock, the location of the resultant of the reaction forces shall be within the middle two-thirds of the base for γ_{EQ} = 0.0 and within the middle eight-tenths of the base for γ_{EQ} = 1.0. For values of γ_{EQ} between 0.0 and 1.0, the resultant location restriction shall be obtained by linear interpolation of the values given in this Article.

For bridge abutments, the abutment seismic design should be conducted in accordance with Articles 5.2 and 6.7 of AASHTO's *Guide Specifications*

C11.6.5.1

The estimation of seismic design forces should account for wall inertia forces in addition to the equivalent static forces. For semigravity walls in which the footing protrudes behind the back of the wall face (i.e., the heel), the weight of the soil located directly above the heel of the footing should be included in the calculated wall inertial force.

Where a wall supports a bridge structure, the seismic design forces should also include seismic forces transferred from the bridge through bearing supports which do not freely slide, e.g., elastomeric bearings in accordance with Article 14.6.3.

The static lateral earth pressure force acting behind the wall is already included in P_{AE} (i.e., P_{AE} is the combination of the static and seismic lateral earth pressure). See

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APPENDIX B11—DETERMINATION OF T_{MAX} FOR MSE WALLS USING THE SIMPLIFIED METHOD

B11.1—GENERAL

This Appendix provides the procedures and requirements to determine the MSE wall reinforcement layer load, T_{max}, using the Simplified Method. Development of the Simplified Method is described in Allen et al. (2001).

B11.2—DETERMINATION OF T_{MAX}

For the Simplified Method, the load in the reinforcements shall be obtained by multiplying the vertical earth pressure at the reinforcement layer level by an empirically adjusted lateral earth pressure coefficient, and applying the resulting lateral pressure to the tributary layer thickness for the reinforcement to estimate the reinforcement load, T_{max}. The vertical earth pressure at each reinforcement layer level shall be the sum of the soil self-weight plus any surcharge present.

The reinforcement load, T_{max}, at each reinforcement level shall be determined as:

$$T_{\max} = S_v k_r \left(\gamma_r Z + \gamma_f S\right) \tag{B11.2-1}$$

where:

S_v = tributary vertical thickness for reinforcement layer as specified in Article 11.10.6.2.1b (ft)
k_r = horizontal pressure coefficient of reinforced fill determined using Figure B11.2-1 (dim.)
Z = depth of reinforcement layer below wall top (ft)
γ_r = unit weight of soil in wall reinforcement zone (lbs/ft^3)
S = average soil surcharge thickness over reinforcement within 0.7H of the wall face (ft)
γ_f = unit weight of soil in wall in surcharge above wall (lbs/ft^3)

Vertical stress for maximum reinforcement load calculations shall be determined as shown in Figures 11.10.6.2.1a-1 and 11.10.6.2.1a-2. Live load is not included in the vertical stress calculation to determine T_{max} for assessing pullout loads when using the Simplified Method.

For design, the load factor applied to T_{max} for the strength limit state, $\gamma_{p\text{-}EV}$, shall be 1.35 as specified in Table 3.4.1-2, and for other loads shall be as specified in Article 3.4.1. Resistance factors for design of steel reinforced MSE walls shall be as specified in Articles 11.5.7 and 11.5.8. For geosynthetic walls, the resistance factor for both pullout and tensile resistance for the strength limit state shall be 0.9. For the Extreme Event I limit state (i.e., seismic), the resistance factor for geosynthetic reinforcement tensile and pullout resistance shall be 1.2.

k_a shall be determined as specified in Articles 11.10.6.2.1c and C11.10.6.2.1c, specifically Eqs. C11.10.6.2.1c-1 and C11.10.6.2.1c-2. The horizontal pressure coefficient, k_r, is determined by applying a multiplier to the active earth pressure coefficient, k_a. The k_a multiplier for the Simplified Method shall be determined as shown in Figure B11.2-1. For assessment of reinforcement pullout, the Simplified Method multiplier for steel strip walls shall be used for all steel reinforced walls. For reinforcement rupture, the multiplier applicable to the specific type of steel reinforcement shall be used. Based on Figure B11.2-1, the k_a multiplier is a function of the reinforcement type and the depth of the reinforcement below the wall top.

Since the lateral stress ratios in this figure have been empirically derived, these values should not be used for wall design cases that are beyond their empirical basis. For design situations that are beyond the empirical basis for this method, see Article C11.10.6.2.1 for additional evaluations that should be considered.

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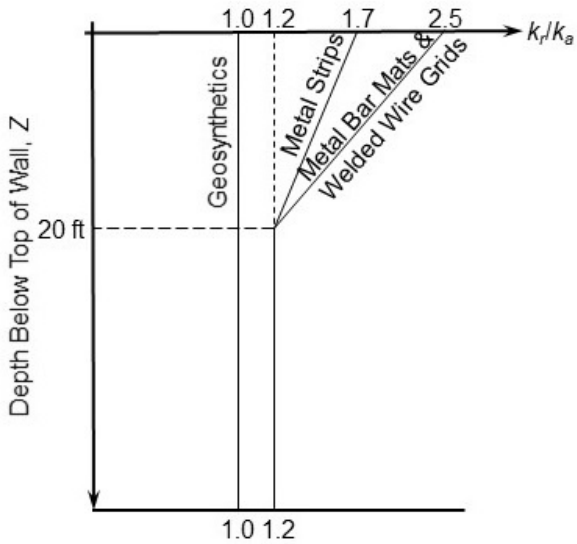

Figure B11.2-1—Variation of the Coefficient of Lateral Stress Ratio, k_r/k_a, with Depth in a Mechanically-Stabilized Earth Wall

The reinforcement shall be designed for pullout, and reinforcement and connection rupture as specified in Articles 11.10.6.3 and 11.10.6.4, respectively. If live load is present, due to the difference in load factors for soil self-weight and live load, $\gamma_{p\text{-}EV}T_{max}$ in Eqs. 11.10.6.3.2-1 and 11.10.6.4.1-1 shall be replaced with T_{totalf} calculated as follows when using the Simplified Method:

$$T_{totalf} = \gamma_{p-EV}T_{\max} + \gamma_{LS}S_v k_r \gamma_f h_{eq} < \phi T_{a\ell}R_c \tag{B11.2-2}$$

where:

T_{totalf} = total factored load for each reinforcement layer (lbs/ft)
T_{max} = applied load to the reinforcement determined using Eq. B11.2-1 (kips/ft)
$\gamma_{p\text{-}EV}$ = load factor for vertical earth pressure specified in Table 3.4.1-2 (dim.)
ϕ = resistance factor for reinforcement tension, specified in Table 11.5.7-1 (dim.)
$T_{a\ell}$ = nominal long-term reinforcement strength (kips/ft)
R_c = reinforcement coverage ratio specified in Article 11.10.6.4.1 (dim.)
γ_{LS} = load factor for live load surcharge, *LS* (dim.)
γ_f = unit weight of soil used to calculate live load surcharge, *LS* (lbs/ft^3)
h_{eq} = equivalent height of soil for live load surcharge, as specified in Article 3.11.6.4 (ft)

Similarly, at the facing connection, $\gamma_{p\text{-}EV}T_o$ shall be replaced with $T_{totalfo}$ calculated as follows when using the Simplified Method:

$$T_{totalfo} = \gamma_{p-EV}T_o + (\gamma_{LS})\gamma_f h_{eq} < \phi T_{ac}R_c \tag{B11.2-3}$$

where:

T_o = applied load at reinforcement/facing connection specified in Article 11.10.6.2.2 (kips/ft)

For more complex loading situations, such as due to the presence of concentrated loads due to foundations located on top of or within the reinforced soil and traffic barrier impact forces, replace T_{max} and T_o with T_{totalf} and $T_{totalfo}$, respectively, as specified in Article 11.10.10, using k_r determined from Figure B11.2-1.

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