PO Box 68697
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Letter of Transmittal

To: James Harper, P.E.
WSDOT
MS NB82-52
P O Box 330310
Seattle, WA 98133-9710
Ph: (206)768-5601

Transmittal #: 55
Date: 12/21/2021
Contract #: 9698 Ravensdale Creek Fish Passage

SBI Job #: 1.0009698.00

Subject: Submittal for retaining wall engineering

WE ARE SENDING YOU

- ☑ Attached
- ☐ Under separate cover via None the following items:
- ☐ Shop drawings
- ☐ Prints
- ☐ Plans
- ☐ Samples
- ☐ Copy of letter
- ☐ Change order
- ☐ Specifications
- ☑ Submittal

Document Type	Copies	Date	No.	Description
Attachment	1	12/20/21		Submittal of 12-21-21 (Retaining Wall Drawings & Calcs).pdf

THESE ARE TRANSMITTED as checked below:

- ☑ For approval
- ☐ Approved as submitted
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- ☐ Approved as noted
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- ☐ Returned for corrections
- ☐ Return ___ corrected prints
- ☐ For review and comment
- ☐ Other
- ☐ FOR BIDS DUE
- ☐ PRINTS RETURNED AFTER LOAN TO US

Remarks:

Copy To:

From: Slater, Kevin (Scarsella Bros, Inc.)

Signature: Kevin Slater

If enclosures are not as noted, kindly notify us at once.

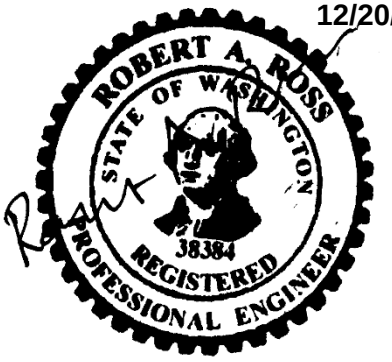
SEW CALCULATIONS
BRIDGE 169 NW & SW APPROACH WALLS

SR 169 Ravensdale Creek Fish Passage
King County, Washington
ZGA Project Number 2496.01
December 20, 2021

Prepared For:

Basalite Concrete Products

12/20/21



ZipperGeo
Geoprofessional Consultants

19019 36th Ave. W. Suite E
Lynnwood, WA 98036
P. 425-582-9928 | F. 425-582-9930

Table of Contents

General Calculation Notes:

1. **The calculations presented herein consider only local internal stability and local external stability. These calculations do not include assessment of overall global stability, compound stability, lateral deformations, and vertical deformations, and such assessments should be completed as deemed necessary by others.**

1 Project Requirements and Design Criteria

- Design Standards and References: Analyses presented in this package are in general accordance with the design standards listed below. Analyses are based on information referenced from the additional documents listed below.
  - 2021 WSDOT Geotechnical Design Manual M46-03.14 (GDM, 2021)
  - 2020 AASHTO LRFD Bridge Design Specifications, 9th Edition (AASHTO, 2020)
  - Section 6-13 and related project specific special provision supplements of the 2021 WSDOT Standard Specifications for Road, Bridge and Municipal Construction, M41-10 (6-13, 2021)
  - Project Special Provisions Addendum 1 (SP-AD1)
  - Contract Provisions, Appendix G, Summary of Geotechnical Conditions (CP-AG)
  - WSDOT Geotechnical Report Erratum #1, June 9, 2021 (GRE, 2021)
  - Phase 1 Girder Erection Plan, Ravensdale Creek Fish Passage, WSDOT Contract No. 9698, prepared by SB Structures dated August 26, 2021 (SB, 2021)
  - Contract Plans, Ravensdale Creek Fish Passage, dated April 28, 2021 (Plans, 2021)
  - NCHRP Report 663, Design of Roadside Barrier Systems Placed on MSE Retaining Walls (NCHRP 663)
  - SB Structures, Personal Communication, December 3, 2021 (SB, 2021)
- **Geometry**:
  - Wall Batter: 1H:64V (0.9°) (GDM, 2021)
  - Backslope: Level (Plans, 2021)
  - Toe Slopes: Assumed flat. Ground surfaces below walls are actually sloping, however toe slope only affects bearing capacity and bearing capacities are prescribed per GRE, 2021.
  - Min. Embedment Criteria: 2 ft min. (Plans, 2021)
  - Geosynthetic Lengths (Plans, 2021):
    - 0.7H or 8 ft min.
  - Geosynthetic Vertical Spacing (SP-AD1):
    - 16 in. max.

- **Permanent Loading Conditions:**
  - **Traffic Surcharge (AASHTO, 2020):**
    - 250 psf general traffic
  - **CIP Traffic Barrier Impact Loading (GDM, 2021) (NCHRP 663)**
    - Assume TL-4 loading
    - Reinforcement pullout
      - 500 lb/ft concentrated horizontal load at top row of reinforcement
      - 500 lb/ft concentrated horizontal load at second row of reinforcement.
    - Reinforcement Rupture
      - 2,000 lb/ft concentrated horizontal load at top row of reinforcement
      - 500 lb/ft concentrated horizontal load at second row of reinforcement

- **CIP Traffic Barrier Dead Load:**
  - Maximum distance between top of wall and finished grade is about 2 feet. Assume unit weight of 145 PCF. $Q_d = 145*2 = 290$ PSF
- **Temporary Construction Load Case:**
  - Maximum unfactored crane surcharge load of 1,875 PSF (30 kips over 16 ft^2 (4'x4')) area with edge no closer than 5 feet from back face of either wall (SB, 2021)
- **Seismic Design (6-13, 2021):**
  - $k_h = 0.22g$
  - For MSEW input purposes, assume $As = 2*k_h = 0.44g$

- **Design Methodology:** Simplified Stiffness Method (AASHTO, 2020)
- **Performance Criteria**
  - CDR ≥ 1.0
  - Maximum Eccentricity (e/L) = 0.33 (Static) 0.40 (Seismic)
  - Maximum Reinforcement Strain at each level = 2%

2 Geotechnical Design Parameters

- Soil Properties (6-13, 2021) (SP-AD1) (GRE, 2021)
  - Reinforced Soil: γ = 130 pcf, φ = 38°, c = 0 psf
  - Retained Soil: γ = 115 pcf, φ = 30°, c = 0 psf
  - Foundation Soil (for evaluation of sliding resistance only):
    - NW Wall A Line Sta. 70+53.82 to 71+81
      - γ = 130 pcf, φ = 38°, c = 0 psf
    - NW Wall A Line Sta. 71+81 to 71+95
      - γ = 130 pcf, φ = 30°, c = 0 psf
    - SW Wall A Line Sta. 68+69 to 68+94 (SW Wall Sta. 0+35.5 to End)
      - γ = 130 pcf, φ = 30°, c = 0 psf
    - SW Wall A Line Sta. 68+94 to 69+29 (SW Wall Sta. 0+00 to 0+35.5)
      - γ = 130 pcf, φ = 38°, c = 0 psf

- Bearing Capacity:

EXHIBIT 6-1: NOMINAL SE WALL BEARING RESISTANCE [UPDATED 6/4/2021]

Bearing Material	Reinforcement Length (feet)	Unfactored Strength and Extreme Event Limit State Bearing Resistances (ksf)	Unfactored Service Limit State Bearing Resistance (ksf)
ESU 2 or Stabilization Material Over ESU 2	8	25.4	~~37.3~~ 29.7
	10	29.1	~~32.7~~ 24.0
	12	32.5	~~29.4~~ 20.2
	14	35.4	~~27.0~~ 17.5
ESU 1	8	~~22.2~~ 9.0	~~15.2~~ 9.8
	10	~~26.3~~ 10.1	~~14.0~~ 8.8
	12	~~30.3~~ 10.9	~~13.2~~ 8.1
	14	~~34.2~~ 11.6	~~12.6~~ 7.6

NOTES:
ksf = kips per square foot

- Groundwater Conditions:
  - Reinforced zone assumed fully drained.
  - Bearing capacities are prescribed and therefore GW not used in MSEW for bearing capacity evaluation purposes.

- Soil / Geogrid Interface Friction Angel used for direct sliding analyses
  - Within reinforced fill mass:
    - Tan ρ=C_{ds} Tan φ_r , Per manufacturer's data, C_{ds} = 0.8 (See appendix for manufacturer's data)
    - ρ= 32^o
    - Note: There is no input parameter in MSEW for C_{ds}, only ρ. The input value for ρ is shown on the "INPUT DATA: Geogrids" pages of the MSEW output.

- Friction Angle Between reinforced and retained fill, δ
  - Per Section 3.11.5.8.1 (AASHTO, 202), δ=2/3$\emptyset_{ret}$ = 2/3*30 = 20^o
    - δ=20^o

3 ***Reinforcement and Facing Design Parameters***

- Facing: Geowall Max II block units by Basalite
  - Facing Stiffness Factor, Φ_{fs}: Conservatively assumed to be 1.0
- Geosynthetic Reinforcement: Miragrid 7XT Geogrid. Refer to appendix for WSDOT QPL geosynthetic strengths, long-term reduction factors, and low strain creep stiffnesses, $J_{2\%}$
- Geogrid/Soil Interaction Parameters:

- α (Scale Effect Correction Factor). Default values per AASHTO, 2020
  - ☐ Inextensible (metallic) Grids or Strips, α = 1.0
  - ☒ Extensible (polymer) Grids: α = 0.80
  - ☐ Extensible (polymer) Sheets: α = 0.60
- ☒ C_i (Coefficient of Shear Stress Interaction for Geosynthetics). Default value per AASHTO, 2020
  - C_i = 0.67

- Coverage Ratios: 100% There are no known geogrid penetrations from guard rails, pedestrian barriers, or utilities.

4 Load and Resistance Factors (AASHTO, 2020)

Stiffness Method 2020 – Load and Resisting Factors

INTERNAL STABILITY

Load factor for vertical earth pressure, EV:	$\gamma_{p\text{-}EV}$	1.35		
Load factor for prediction of Tmax for the soil failure limit state:	$\gamma_{p\text{-}EVfs}$	1.20		
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:		0.80		1.00
Resistance factor accounting for uncertainty in measurement of geosynthetic stiffness J at 2% strain	Φ_{sf}	1.000		
Facing stiffness factor (recommended by AASHTO for flexible facing as 1.0)	Φ_{fs}	1.000		
Resistance factor for reinforcement tension in connectors	ϕ	Static	Combined static/seismic	
Geogrid:		0.90		1.00
Resistance factor for geosynthetic pullout	ϕ	0.70		1.00

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}):	$(\gamma_{p\text{-}EH})_{EQ}$	1.00
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

- For Extreme Event II (traffic barrier impact loading) the following load factors are used.

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}	—	—	—	—	—

- For Extreme Event II, all resistance factors, with the exception of bearing capacity, are set to 1.0 per Section 11.5.8 (AASHTO, 2020). For evaluation of geogrid connection and tensile strength, Creep is ignored (i.e. RF_C is set to 1.0). The static component is checked via strength limit state.

- For temporary loading associated with crane surcharge loads, the surcharge load is modeled as a live load with a 1.5 load factor. All resistance factors are set equivalent to the Strength I limit state. For evaluation of geogrid connection and tensile strength, Creep is ignored (i.e. RF_C is set to 1.0)

NW WALL
ANALYSIS RESULTS

Stiffness Method 2020
Ravensdale Creek Fish Passage

MSEW+: Update # 2021.20

PROJECT IDENTIFICATION

Title:	Ravensdale Creek Fish Passage
Project Number:	2496.01
Client:	Basalite
Designer:	RAR
Station Number:	NW Wall Sta. 0+00

Description:

Strength I and Extreme I Limit States

Company's information:

Name: Zipper Geo Associates, LLC
Street: 19019 36th Ave. W. Ste. E

Lynnwood, WA 98036
Telephone #: 425-582-9928
Fax #:
E-Mail: rross@zippergeo.com

File path and name: Z:\Projects\2451 - 2500\2496 Ravensdale Creek GRS-IBS S..... ..... Wall Sta. 0+00.BENp

Original date and time of creating this file: Mon Mar 29 16:56:42 2021

PROGRAM MODE:

ANALYSIS
of a SIMPLE STRUCTURE
using GEOGRID as reinforcing material.

SOIL DATA

REINFORCED SOIL

Unit weight, γ	130.0 lb/ft ³
Design value of internal angle of friction, ϕ	38.0 °

RETAINED SOIL

Unit weight, γ	115.0 lb/ft ³
Design value of internal angle of friction, ϕ	30.0 °

FOUNDATION SOIL (Considered as an equivalent uniform soil)

Equivalent unit weight, $\gamma_{equiv.}$	130.0 lb/ft ³
Equivalent internal angle of friction, $\phi_{equiv.}$	38.0 °
Equivalent cohesion, $c_{equiv.}$	0.0 lb/ft ²

Factored bearing capacity resistance of foundation is given: q-ult-static = 29100.0 lb/ft²., q-ult-sesmic = 29100.0 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) = 0.2973 (eq. 17 is utilized to calculate Ka for all batters)
(For external stability user specified δ = 20.00°)

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 = 0.440 and Site Factor, Fpga = 1.000. Maximum ground acceleration coeff., As = 0.440
Design acceleration coefficient in Internal Stability: Kh = Am = 0.220
Design acceleration coefficient in External Stability: Kh_d = 0.220 => Kh = Am = 0.220
Kh(ext.) (Displ. >1" AASHTO 11.6.5.2.2)

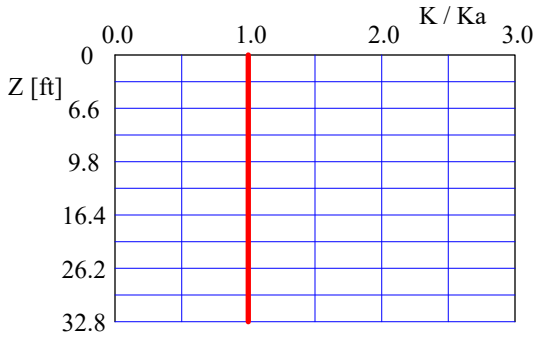
Ka = 0.2973   Kae = 0.4747   In Coulomb equation for Ka, Omega was taken as ZERO and backslope inclined at angle I.
In M-O equation for Kae, Omega is always set to ZERO.
Seismic soil-geogrid friction coefficient, F* is 80.0% of its specified static value.

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]	4700.0	5900.0	7400.0	4700.0	
Durability reduction factor, RFd	1.30	1.30	1.30	1.30	
Installation-damage reduction factor, RFid	1.12	1.12	1.12	1.12	
Creep reduction factor, RFc	1.45	1.45	1.45	1.45	N/A
CDR for strength	N/A	N/A	N/A	N/A	
Coverage ratio, Rc	1.000	1.000	1.000	0.850	
Friction angle along geogrid-soil interface, ρ	32.00	32.00	32.00	32.00	
Pullout resistance factor, F*	$0.67 \cdot \tan\phi$	$0.67 \cdot \tan\phi$	$0.67 \cdot \tan\phi$	$0.67 \cdot \tan\phi$	N/A
Scale-effect correction factor, α	0.8	0.8	0.8	0.8	

Variation of Lateral Earth Pressure Coefficient With Depth

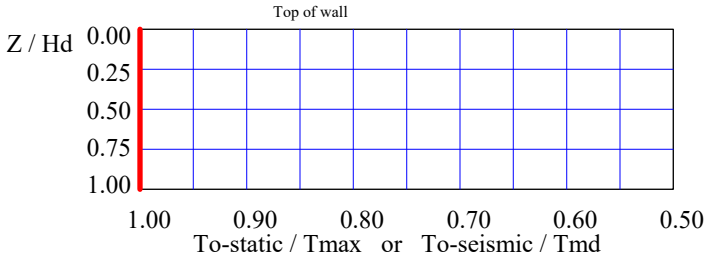
Z	K / Ka
0 ft	1.00
3.3 ft	1.00
6.6 ft	1.00
9.8 ft	1.00
13.1 ft	1.00
16.4 ft	1.00
19.7 ft	1.00



INPUT DATA: Facia and Connection (according to revised Demo 82) (Analysis)

FACIA type: Facing enabling frictional connection of reinforcement (e.g., modular concrete blocks, gabions)
Depth/height of block is 1.50/0.67 ft. Horizontal distance to Center of Gravity of block is: 0.75 ft.
Average unit weight of block is: γ_f = 125.00 lb/ft ³

Z / Hd	To-static / Tmax or To-seismic / Tmd
0.00	1.00
0.25	1.00
0.50	1.00
0.75	1.00
1.00	1.00



Connection strength, T-lot, is related to T-ult

Geogrid Type #1		Geogrid Type #2		Geogrid Type #3		Geogrid Type #4		Geogrid Type #5	
N-1	Tult-conn	N-2	Tult-conn	N-3	Tult-conn	N-4	Tult-conn	N-5	Tult-conn
0.0	1600.00	0.0	2074.20	0.0	1600.00	0.0	1600.00		
787.0	2037.00	1500.0	2686.65	1695.1	2038.00	787.0	2037.00	N/A	
1535.0	2657.00	2500.0	3094.95	1551.0	2900.00	1535.0	2657.00		
2293.0	3038.00	3500.0	3503.25	2326.4	3157.00	2293.0	3038.00		
4601.0	3105.00	4500.0	3911.55	4615.0	3808.00	4601.0	3105.00		

Geogrid Type #1		Geogrid Type #2		Geogrid Type #3		Geogrid Type #4		Geogrid Type #5	
σ	CRu	σ	CRu	σ	CRu	σ	CRu	σ	CRu
0.0	0.34	0.0	0.35	0.0	0.22	0.0	0.34		
524.7	0.43	1000.0	0.46	516.7	0.28	524.7	0.43	N/A	
1023.3	0.57	1666.7	0.52	1034.0	0.39	1023.3	0.57		
1528.7	0.65	2333.3	0.59	1550.9	0.43	1528.7	0.65		
3067.3	0.66	3000.0	0.66	3076.7	0.51	3067.3	0.66		

(1) σ = Confining stress in between stacked blocks [lb/ft ²]
(2) CRult = Tc-ult / Tult
(3) CRcr = Tcre / Tult

In seismic analysis, long term strength is reduced to 80% of its static value.

D A T A (for connection only)	Type #1	Type #2	Type #3	Type #4	Type #5
Product Name	5XT	7XT	8XT	5XT-RC	N/A
Connection strength reduction factor, RFd	1.30	1.30	1.30	1.30	N/A
Creep reduction factor, RFc	N/A	N/A	N/A	N/A	N/A

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

Design height, Hd 13.33 [ft] { Embedded depth is E = 2.00 ft, and height above top of finished bottom grade is H = 11.33 ft }

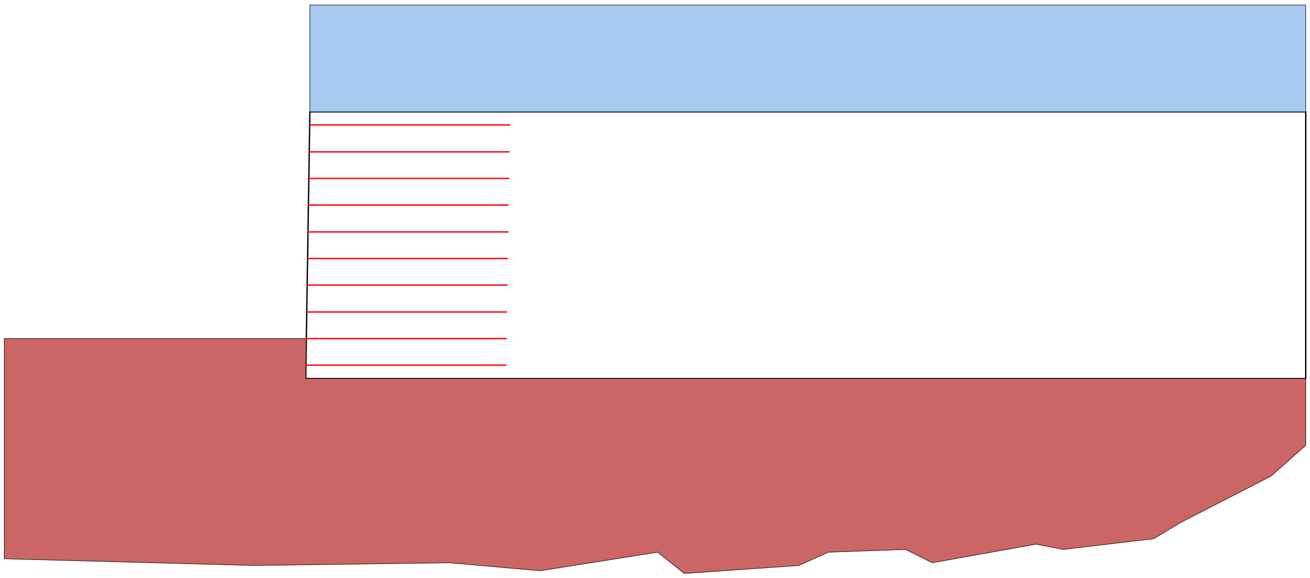
Soil in front of wall is Horizontal.

Batter, ω	0.9	[deg]	
Backslope, β	0.0	[deg]	
Backslope rise	0.0	[ft]	Broken back equivalent angle, I = 0.00° (see Fig. 25 in DEMO 82)

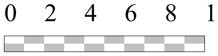
UNIFORM SURCHARGE

Uniformly distributed dead load is 290.0 [lb/ft ²], and live load is 250.0 [lb/ft ²]

ANALYZED REINFORCEMENT LAYOUT:



SCALE:



Stiffness Method 2020 – Load and Resisting Factors

INTERNAL STABILITY

Load factor for vertical earth pressure, EV:	$\gamma_{p\text{-}EV}$	1.35
Load factor for prediction of Tmax for the soil failure limit state:	$\gamma_{p\text{-}EVfs}$	1.20
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:		0.80	1.00
Resistance factor accounting for uncertainty in measurement of geosynthetic stiffness J at 2% strain	Φ_{sf}	1.000	
Facing stiffness factor (recommended by AASHTO for flexible facing as 1.0)	Φ_{fs}	1.000	

Resistance factor for reinforcement tension in connectors	ϕ	Static	Combined static/seismic
Geogrid:		0.80	1.00
Resistance factor for geosynthetic pullout	ϕ	0.70	1.00

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}):	$(\gamma_{p\text{-}EH})_{EQ}$	1.50
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

ANALYSIS: CALCULATED FACTORS (Static conditions)

Bearing capacity, CDR = 4.70, factored bearing load = 4025 lb/ft².

Foundation Interface: Direct sliding, CDR = 2.358, Eccentricity, e/L = 0.1135, CDR-overturning = 3.16

GEOGRID #	Elevation [ft]	Length [ft]	Type #	CONNECTION CDR [connection strength]	Geogrid strength CDR	Pullout resistance CDR	Direct sliding CDR	Eccentricity e/L	Product name
1	0.67	10.00	2	2.58	4.459	21.915	1.948	0.1020	7XT
2	2.00	10.00	2	2.50	4.472	18.715	2.089	0.0806	7XT
3	3.33	10.00	2	2.40	4.459	15.669	2.258	0.0609	7XT
4	4.67	10.00	2	2.32	4.459	12.904	2.467	0.0430	7XT
5	6.00	10.00	2	2.26	4.522	10.560	2.730	0.0272	7XT
6	7.33	10.00	2	2.28	4.740	8.698	3.080	0.0136	7XT
7	8.67	10.00	2	2.38	5.147	7.142	3.585	0.0024	7XT
8	10.00	10.00	2	2.50	5.648	5.651	4.399	-0.0059	7XT
9	11.33	10.00	2	2.63	6.213	4.166	6.099	-0.0101	7XT
10	12.67	10.00	2	2.81	6.955	2.752	13.917	-0.0072	7XT

ANALYSIS: CALCULATED FACTORS (Seismic conditions)

Bearing capacity, CDR = 4.90, factored bearing load = 5340 lb/ft².

Foundation Interface: Direct sliding, CDR = 1.770, Eccentricity, e/L = 0.2887, Fs-overturning = 1.75

GEOGRID #	Elevation [ft]	Length [ft]	Type #	CONNECTION CDR [connection strength]	Geogrid strength CDR	Pullout resistance CDR	Direct sliding CDR	Eccentricity e/L	Product name
1	0.67	10.00	2	2.63	5.680	22.985	1.471	0.2688	7XT
2	2.00	10.00	2	2.54	5.693	19.611	1.597	0.2307	7XT
3	3.33	10.00	2	2.45	5.680	16.434	1.750	0.1946	7XT
4	4.67	10.00	2	2.36	5.680	13.534	1.943	0.1602	7XT
5	6.00	10.00	2	2.30	5.740	11.026	2.192	0.1282	7XT
6	7.33	10.00	2	2.29	5.945	8.942	2.530	0.0984	7XT
7	8.67	10.00	2	2.33	6.317	7.138	3.027	0.0708	7XT
8	10.00	10.00	2	2.39	6.753	5.461	3.843	0.0459	7XT
9	11.33	10.00	2	2.44	7.218	3.881	5.563	0.0239	7XT
10	12.67	10.00	2	2.51	7.790	2.448	13.436	0.0061	7XT

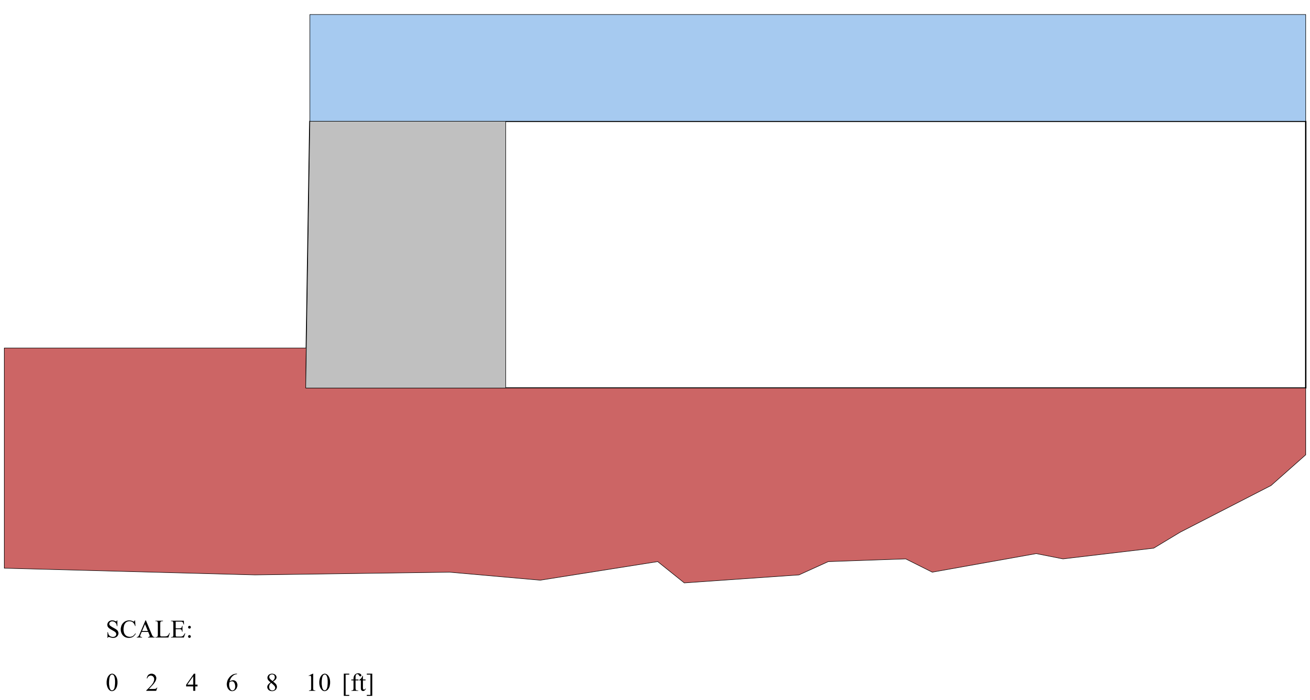
BEARING CAPACITY for GIVEN LAYOUT – Using AASHTO 2017-2020 method

	STATIC	SEISMIC	UNITS
(Given factored bearing resistance, q-n)			
Factored bearing resistance. q-n	18915	26190	[lb/ft ²]
Factored bearing load, σ_V	4024.8	5340	[lb/ft ²]
Eccentricity, e	0.72	1.54	[ft]
Eccentricity, e/L	0.072	0.154	
CDR calculated	4.70	4.90	
Base length	10.00	10.00	[ft]

Unfactored applied bearing pressure = (Unfactored R) / [L - 2 * (Unfactored e)] =

Static: Unfactored R = 24205.39 [lb/ft], L = 10.00, Unfactored e = 0.65 [ft], and Sigma = 2783.58 [lb/ft ²]

Seismic: Unfactored R = 24937.35 [lb/ft], L = 10.00, Unfactored e = 1.51 [ft], and Sigma = 3572.10 [lb/ft ²]



SCALE:

0 2 4 6 8 10 [ft]

RESULTS for STRENGTH

Live Load included in calculating Tmax

#	Geogrid Elevation [ft]	Factored: Static/Seismic	Limit State Tmax [lb/ft]	Service Limit Tmax [lb/ft]	Reinf. Strain Stat./Seism [%]	Tmd [lb/ft]	Specified minimum CDR Static	Actual calculated CDR Static	Specified minimum CDR seismic	Actual calculated CDR seismic	Product name
1	0.67	2236/2795	501/371	370.83	1.145/1.684	174.92	N/A	4.459	N/A	5.680	7XT
2	2.00	2236/2795	500/370	369.82	1.141/1.681	174.92	N/A	4.472	N/A	5.693	7XT
3	3.33	2236/2795	501/371	370.83	1.145/1.684	174.92	N/A	4.459	N/A	5.680	7XT
4	4.67	2236/2795	501/371	370.83	1.145/1.684	174.92	N/A	4.459	N/A	5.680	7XT
5	6.00	2236/2795	494/366	364.95	1.126/1.666	174.92	N/A	4.522	N/A	5.740	7XT
6	7.33	2236/2795	472/349	344.48	1.063/1.603	174.92	N/A	4.740	N/A	5.945	7XT
7	8.67	2236/2795	434/322	311.30	0.961/1.501	174.92	N/A	5.147	N/A	6.317	7XT
8	10.00	2236/2795	396/293	277.34	0.856/1.396	174.92	N/A	5.648	N/A	6.753	7XT
9	11.33	2236/2795	360/267	245.06	0.756/1.296	174.92	N/A	6.213	N/A	7.218	7XT
10	12.67	2236/2795	321/238	211.22	0.652/1.192	174.92	N/A	6.955	N/A	7.790	7XT

Stiffness Method 2020
Ravensdale Creek Fish Passage

MSEW+: Update # 2021.20

PROJECT IDENTIFICATION

Title:	Ravensdale Creek Fish Passage
Project Number:	2496.01
Client:	Basalite
Designer:	RAR
Station Number:	NW Wall Sta. 0+00

Description:

Extreme II Limit State - Traffic Barrier Impact

Company's information:

Name: Zipper Geo Associates, LLC
Street: 19019 36th Ave. W. Ste. E

Lynnwood, WA 98036
Telephone #: 425-582-9928
Fax #:
E-Mail: rross@zippergeo.com

File path and name: Z:\Projects\2451 - 2500\2496 Ravensdale Creek GRS-IBS S..... .....00 (Extreme II).BENp

Original date and time of creating this file: Mon Mar 29 16:56:42 2021

PROGRAM MODE:

ANALYSIS
of a SIMPLE STRUCTURE
using GEOGRID as reinforcing material.

SOIL DATA

REINFORCED SOIL

Unit weight, γ	130.0 lb/ft ³
Design value of internal angle of friction, ϕ	38.0 °

RETAINED SOIL

Unit weight, γ	115.0 lb/ft ³
Design value of internal angle of friction, ϕ	30.0 °

FOUNDATION SOIL (Considered as an equivalent uniform soil)

Equivalent unit weight, $\gamma_{equiv.}$	130.0 lb/ft ³
Equivalent internal angle of friction, $\phi_{equiv.}$	38.0 °
Equivalent cohesion, $c_{equiv.}$	0.0 lb/ft ²

Factored bearing capacity resistance of foundation is given: q-ult-static = 29100.0 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) = 0.2973 (eq. 17 is utilized to calculate Ka for all batters)
(For external stability user specified δ = 20.00°)

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

FOR EXTERNAL STABILITY

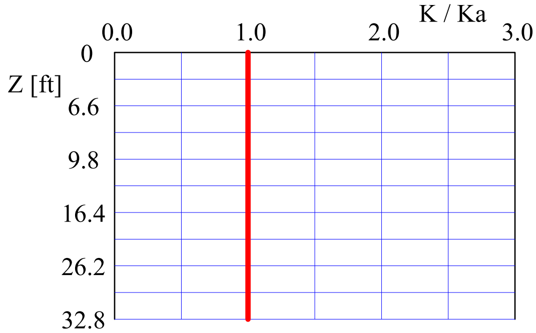
Ka = 0.2973 In Coulomb equation for Ka, Omega was taken as ZERO and backslope inclined at angle I.

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]	4700.0	5900.0	7400.0	4700.0	
Durability reduction factor, RFd	1.30	1.30	1.30	1.30	
Installation-damage reduction factor, RFid	1.12	1.12	1.12	1.12	
Creep reduction factor, RFc	1.45	1.00	1.45	1.45	N/A
CDR for strength	N/A	N/A	N/A	N/A	
Coverage ratio, Rc	1.000	1.000	1.000	0.850	
Friction angle along geogrid-soil interface, ρ	32.00	32.00	32.00	32.00	
Pullout resistance factor, F*	$0.67 \cdot \tan\phi$	$0.67 \cdot \tan\phi$	$0.67 \cdot \tan\phi$	$0.67 \cdot \tan\phi$	N/A
Scale-effect correction factor, α	0.8	0.8	0.8	0.8	

Variation of Lateral Earth Pressure Coefficient With Depth

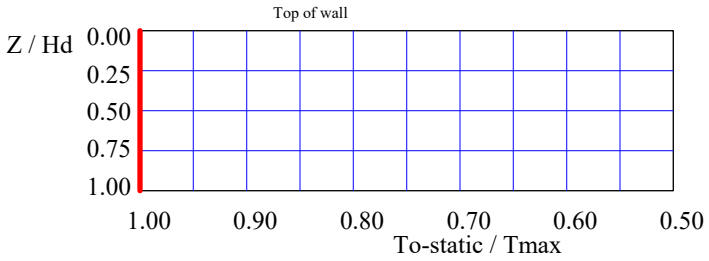
Z	K / Ka
0 ft	1.00
3.3 ft	1.00
6.6 ft	1.00
9.8 ft	1.00
13.1 ft	1.00
16.4 ft	1.00
19.7 ft	1.00



INPUT DATA: Facia and Connection (according to revised Demo 82) (Analysis)

FACIA type: Facing enabling frictional connection of reinforcement (e.g., modular concrete blocks, gabions)
Depth/height of block is 1.50/0.67 ft. Horizontal distance to Center of Gravity of block is: 0.75 ft.
Average unit weight of block is: γ_f = 125.00 lb/ft ³

Z / Hd	To-static / Tmax
0.00	1.00
0.25	1.00
0.50	1.00
0.75	1.00
1.00	1.00



Connection strength, T-lot, is related to T-ult

Geogrid Type #1		Geogrid Type #2		Geogrid Type #3		Geogrid Type #4		Geogrid Type #5	
N-1	Tult-conn	N-2	Tult-conn	N-3	Tult-conn	N-4	Tult-conn	N-5	Tult-conn
0.0	1600.00	0.0	2074.20	0.0	1600.00	0.0	1600.00		
787.0	2037.00	1500.0	2686.65	1695.1	2038.00	787.0	2037.00	N/A	
1535.0	2657.00	2500.0	3094.95	1551.0	2900.00	1535.0	2657.00		
2293.0	3038.00	3500.0	3503.25	2326.4	3157.00	2293.0	3038.00		
4601.0	3105.00	4500.0	3911.55	4615.0	3808.00	4601.0	3105.00		

Geogrid Type #1		Geogrid Type #2		Geogrid Type #3		Geogrid Type #4		Geogrid Type #5	
σ	CRu	σ	CRu	σ	CRu	σ	CRu	σ	CRu
0.0	0.34	0.0	0.35	0.0	0.22	0.0	0.34		
524.7	0.43	1000.0	0.46	516.7	0.28	524.7	0.43	N/A	
1023.3	0.57	1666.7	0.52	1034.0	0.39	1023.3	0.57		
1528.7	0.65	2333.3	0.59	1550.9	0.43	1528.7	0.65		
3067.3	0.66	3000.0	0.66	3076.7	0.51	3067.3	0.66		

(1) σ = Confining stress in between stacked blocks [lb/ft ²]
(2) CRult = Tc-ult / Tult
(3) CRcr = Tcre / Tult

D A T A (for connection only)	Type #1	Type #2	Type #3	Type #4	Type #5
Product Name	5XT	7XT	8XT	5XT-RC	N/A
Connection strength reduction factor, RFd	1.30	1.30	1.30	1.30	N/A
Creep reduction factor, RFc	N/A	N/A	N/A	N/A	N/A

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

Design height, Hd 13.33 [ft] { Embedded depth is E = 2.00 ft, and height above top of finished bottom grade is H = 11.33 ft }

Soil in front of wall is Horizontal.

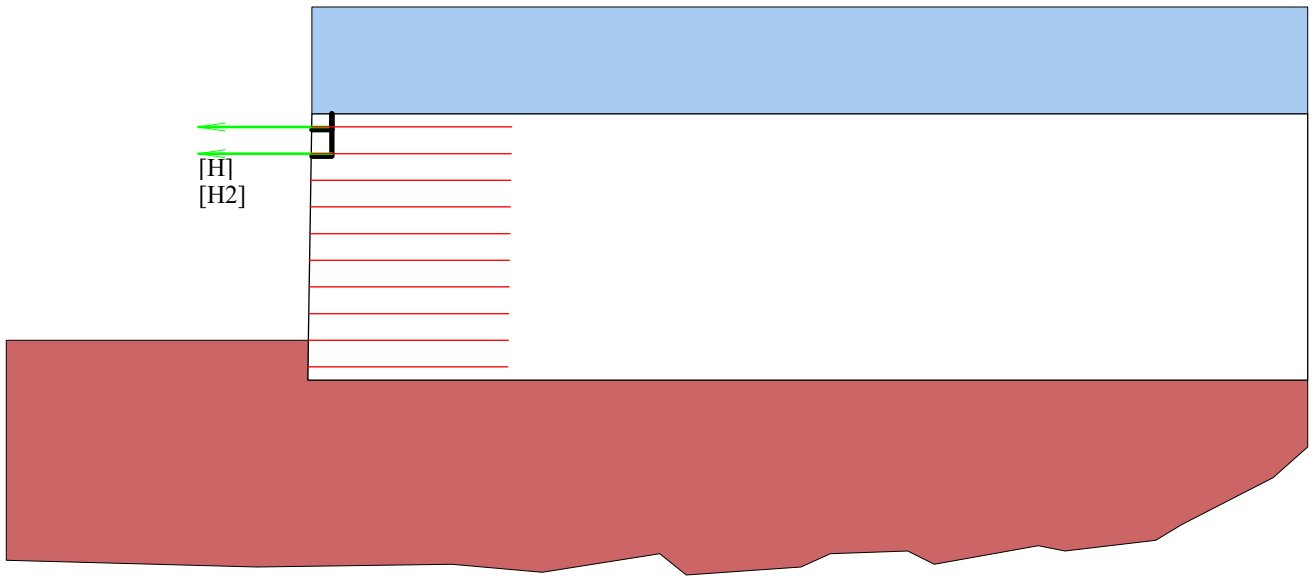
Batter, ω 0.9 [deg]
Backslope, β 0.0 [deg]
Backslope rise 0.0 [ft] Broken back equivalent angle, I = 0.00° (see Fig. 25 in DEMO 82)

U N I F O R M S U R C H A R G E

Uniformly distributed dead load is 290.0 [lb/ft ²], and live load is 250.0 [lb/ft ²]

OTHER EXTERNAL LOAD(S)
[H1] Horizontal Load, Ph = 2000.0 [lb/ft], acting at a depth of Zh = 0.7 [ft] and at a distance of Lb = 1.0 [ft].
[H2] Horizontal Load, Ph = 500.0 [lb/ft], acting at a depth of Zh = 2.0 [ft] and at a distance of Lb = 1.0 [ft].

ANALYZED REINFORCEMENT LAYOUT:



SCALE:

0 2 4 6 8 10 [ft]

Stiffness Method 2020 – Load and Resisting Factors

INTERNAL STABILITY

Load factor for vertical earth pressure, EV:	$\gamma_{p\text{-}EV}$	1.00
Load factor for prediction of Tmax for the soil failure limit state:	$\gamma_{p\text{-}EVfs}$	1.00
Load factor for earthquake loads, EQ:	$\gamma_{p\text{-}EQ}$	1.00
Load factor for live load surcharge, LS: (Same as in External Stability).	$\gamma_{p\text{-}LS}$	0.50
Load factor for dead load surcharge, ES: (Same as in External Stability).	$\gamma_{p\text{-}ES}$	1.00

Resistance factor for reinforcement tension		Static	Combined static/seismic
Geogrid:	ϕ	1.00	1.00
Resistance factor accounting for uncertainty in measurement of geosynthetic stiffness J at 2% strain	Φ_{sf}	1.000	
Facing stiffness factor (recommended by AASHTO for flexible facing as 1.0)	Φ_{fs}	1.000	

Resistance factor for reinforcement tension in connectors		Static	Combined static/seismic
Geogrid:	ϕ	1.00	1.00
Resistance factor for geosynthetic pullout	ϕ	1.00	1.00

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}):	$(\gamma_{p\text{-}EH})_{EQ}$	1.50
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

ANALYSIS: CALCULATED FACTORS (Static conditions)

Bearing capacity, CDR = 4.33, factored bearing load = 4364 lb/ft².

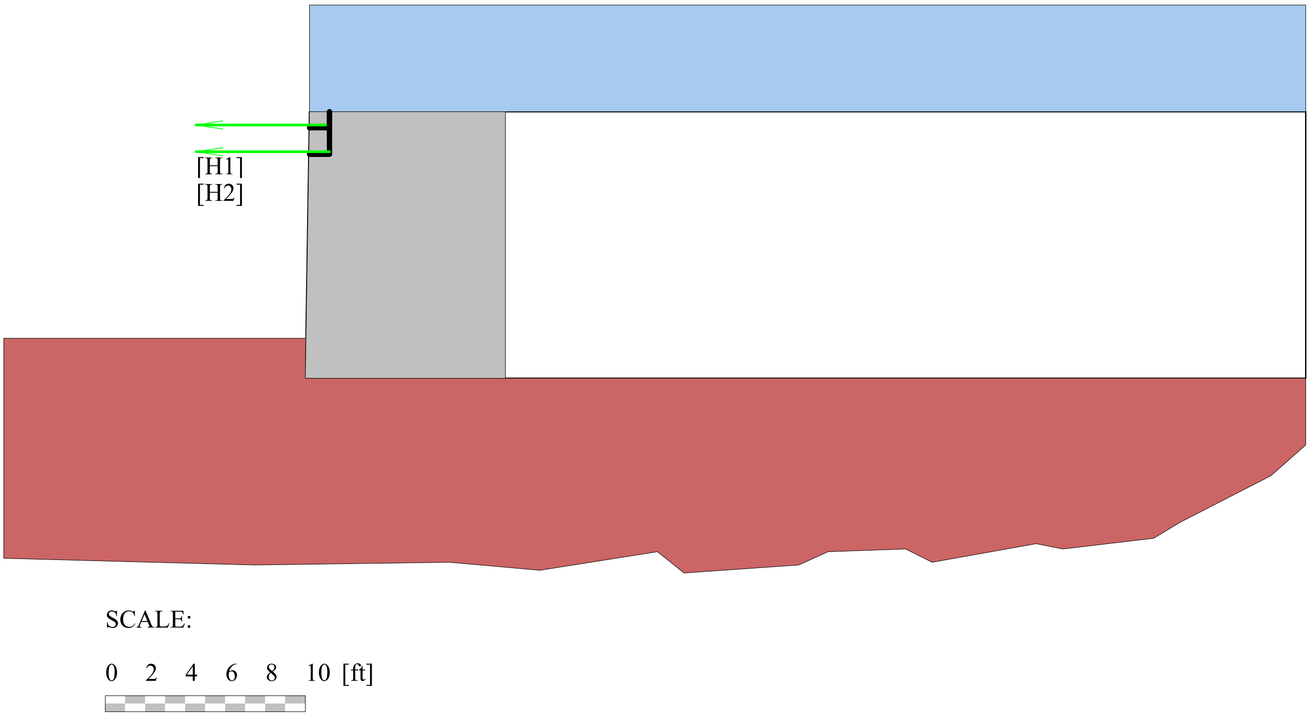
Foundation Interface: Direct sliding, CDR = 2.074, Eccentricity, e/L = 0.2194, CDR-overturning = 2.03

GEOGRID #	Elevation [ft]	Length [ft]	Type #	CONNECTION CDR [connection strength]	Geogrid strength CDR	Pullout resistance CDR	Direct sliding CDR	Eccentricity e/L	Product name
1	0.67	10.00	2	7.86	13.602	52.686	1.682	0.2093	7XT
2	2.00	10.00	2	7.62	13.639	44.984	1.723	0.1900	7XT
3	3.33	10.00	2	7.33	13.602	37.669	1.756	0.1716	7XT
4	4.67	10.00	2	7.07	13.602	31.022	1.772	0.1539	7XT
5	6.00	10.00	2	6.92	13.828	25.451	1.765	0.1366	7XT
6	7.33	10.00	2	7.06	14.684	21.239	1.723	0.1189	7XT
7	8.67	10.00	2	7.53	16.320	17.848	1.631	0.0992	7XT
8	10.00	10.00	2	6.96	15.742	12.414	1.474	0.0753	7XT
9	11.33	10.00	2	3.06	7.229	3.820	1.239	0.0409	7XT
10	12.67	10.00	2	1.33	3.288	1.026	27.188	-0.0221	7XT

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

	STATIC	SEISMIC	UNITS
(Given factored bearing resistance, q-n)			
Factored bearing resistance. q-n	18915	N/A	[lb/ft ²]
Factored bearing load, σ_V	4363.6	N/A	[lb/ft ²]
Eccentricity, e	1.64	N/A	[ft]
Eccentricity, e/L	0.164	N/A	
CDR calculated	4.33	N/A	
Base length	10.00	N/A	[ft]

Unfactored applied bearing pressure = (Unfactored R) / [L - 2 * (Unfactored e)] =
Unfactored R = 24205.39 [lb/ft], L = 10.00, Unfactored e = 1.93 [ft], and Sigma = 3945.07 [lb/ft ²]



Stiffness Method 2020
Ravensdale Creek Fish Passage

MSEW+: Update # 2021.20

PROJECT IDENTIFICATION

Title: Ravensdale Creek Fish Passage
Project Number: 2496.01
Client: Basalite
Designer: RAR
Station Number: NW Wall Sta. 0+00

Description:

Temporary crane surcharge loading.

Company's information:

Name: Zipper Geo Associates, LLC
Street: 19019 36th Ave. W. Ste. E

Lynnwood, WA 98036
Telephone #: 425-582-9928
Fax #:
E-Mail: rross@zippergeo.com

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.....00 (TEMP CRANE).BENp

Original date and time of creating this file: Mon Mar 29 16:56:42 2021

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

SOIL DATA

REINFORCED SOIL

Unit weight, γ	130.0 lb/ft ³
Design value of internal angle of friction, ϕ	38.0 °

RETAINED SOIL

Unit weight, γ	115.0 lb/ft ³
Design value of internal angle of friction, ϕ	30.0 °

FOUNDATION SOIL (Considered as an equivalent uniform soil)

Equivalent unit weight, $\gamma_{\text{equiv.}}$	130.0 lb/ft ³
Equivalent internal angle of friction, $\phi_{\text{equiv.}}$	38.0 °
Equivalent cohesion, $c_{\text{equiv.}}$	0.0 lb/ft ²

Factored bearing capacity resistance of foundation is given: q-ult-static = 29100.0 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) = 0.2973 (eq. 17 is utilized to calculate Ka for all batters)
(For external stability user specified δ = 20.00°)

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

FOR EXTERNAL STABILITY

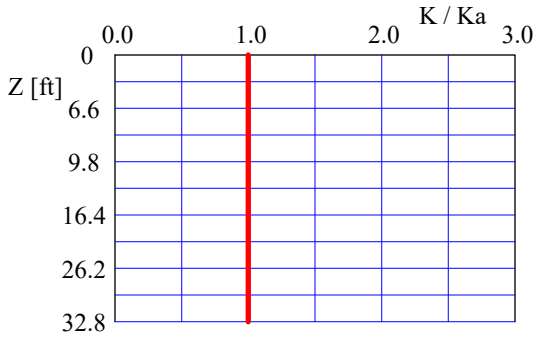
Ka = 0.2973 In Coulomb equation for Ka, Omega was taken as ZERO and backslope inclined at angle I.

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]	4700.0	5900.0	7400.0	4700.0	
Durability reduction factor, RFd	1.30	1.30	1.30	1.30	
Installation-damage reduction factor, RFid	1.12	1.12	1.12	1.12	
Creep reduction factor, RFc	1.45	1.00	1.45	1.45	N/A
CDR for strength	N/A	N/A	N/A	N/A	
Coverage ratio, Rc	1.000	1.000	1.000	0.850	
Friction angle along geogrid-soil interface, ρ	32.00	32.00	32.00	32.00	
Pullout resistance factor, F*	$0.67 \cdot \tan\phi$	$0.67 \cdot \tan\phi$	$0.67 \cdot \tan\phi$	$0.67 \cdot \tan\phi$	N/A
Scale-effect correction factor, α	0.8	0.8	0.8	0.8	

Variation of Lateral Earth Pressure Coefficient With Depth

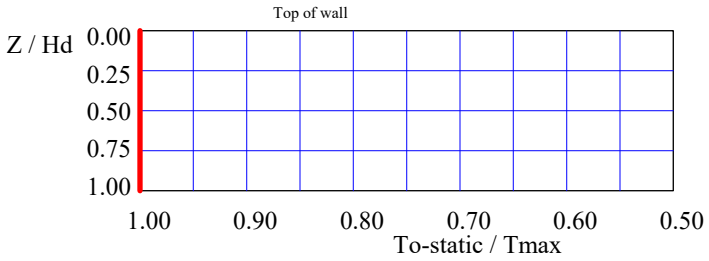
Z	K / Ka
0 ft	1.00
3.3 ft	1.00
6.6 ft	1.00
9.8 ft	1.00
13.1 ft	1.00
16.4 ft	1.00
19.7 ft	1.00



INPUT DATA: Facia and Connection (according to revised Demo 82) (Analysis)

FACIA type: Facing enabling frictional connection of reinforcement (e.g., modular concrete blocks, gabions)
Depth/height of block is 1.50/0.67 ft. Horizontal distance to Center of Gravity of block is: 0.75 ft.
Average unit weight of block is: γ_f = 125.00 lb/ft ³

Z / Hd	To-static / Tmax
0.00	1.00
0.25	1.00
0.50	1.00
0.75	1.00
1.00	1.00



Connection strength, T-lot, is related to T-ult

Geogrid Type #1		Geogrid Type #2		Geogrid Type #3		Geogrid Type #4		Geogrid Type #5	
N-1	Tult-conn	N-2	Tult-conn	N-3	Tult-conn	N-4	Tult-conn	N-5	Tult-conn
0.0	1600.00	0.0	2074.20	0.0	1600.00	0.0	1600.00		
787.0	2037.00	1500.0	2686.65	1695.1	2038.00	787.0	2037.00	N/A	
1535.0	2657.00	2500.0	3094.95	1551.0	2900.00	1535.0	2657.00		
2293.0	3038.00	3500.0	3503.25	2326.4	3157.00	2293.0	3038.00		
4601.0	3105.00	4500.0	3911.55	4615.0	3808.00	4601.0	3105.00		

Geogrid Type #1		Geogrid Type #2		Geogrid Type #3		Geogrid Type #4		Geogrid Type #5	
σ	CRu	σ	CRu	σ	CRu	σ	CRu	σ	CRu
0.0	0.34	0.0	0.35	0.0	0.22	0.0	0.34		
524.7	0.43	1000.0	0.46	516.7	0.28	524.7	0.43	N/A	
1023.3	0.57	1666.7	0.52	1034.0	0.39	1023.3	0.57		
1528.7	0.65	2333.3	0.59	1550.9	0.43	1528.7	0.65		
3067.3	0.66	3000.0	0.66	3076.7	0.51	3067.3	0.66		

(1) σ = Confining stress in between stacked blocks [lb/ft ²]
(2) CRult = Tc-ult / Tult
(3) CRcr = Tcre / Tult

D A T A (for connection only)	Type #1	Type #2	Type #3	Type #4	Type #5
Product Name	5XT	7XT	8XT	5XT-RC	N/A
Connection strength reduction factor, RFd	1.30	1.30	1.30	1.30	N/A
Creep reduction factor, RFc	N/A	N/A	N/A	N/A	N/A

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

Design height, Hd 13.33 [ft] { Embedded depth is E = 2.00 ft, and height above top of finished bottom grade is H = 11.33 ft }

Soil in front of wall is Horizontal.

Batter, ω	0.9	[deg]	
Backslope, β	0.0	[deg]	
Backslope rise	0.0	[ft]	Broken back equivalent angle, I = 0.00° (see Fig. 25 in DEMO 82)

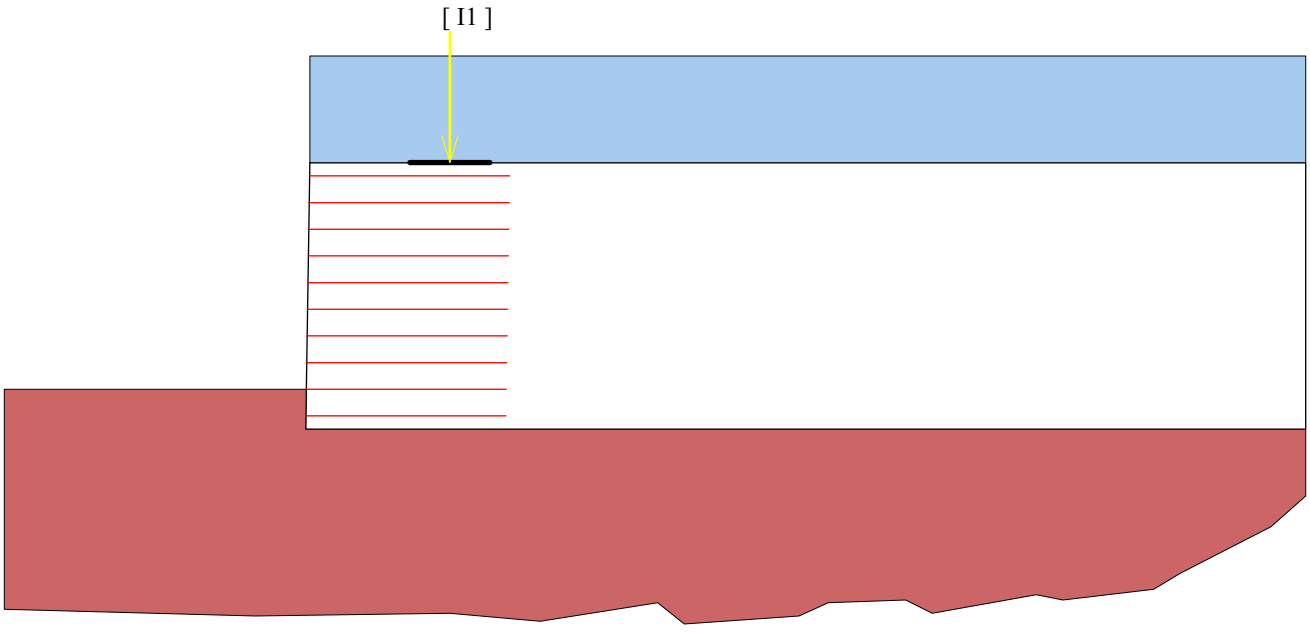
U N I F O R M S U R C H A R G E

Uniformly distributed dead load is 290.0 [lb/ft ²]

OTHER EXTERNAL LOAD(S)

[I1] Isolated Load, Pv-d' = 0.0 and Pv-l' = 30000.0 [lb]. Length of footing, L = 4.0 [ft], and width, b = 4.0 [ft]. Distance of center of footing from wall face, d = 7.0 [ft] @ depth of 0.0 [ft] below soil surface.

ANALYZED REINFORCEMENT LAYOUT:



SCALE:

0 2 4 6 8 10 [ft]

Stiffness Method 2020 – Load and Resisting Factors

INTERNAL STABILITY

Load factor for vertical earth pressure, EV:	$\gamma_{p\text{-}EV}$	1.35	
Load factor for prediction of Tmax for the soil failure limit state:	$\gamma_{p\text{-}EVfs}$	1.20	
Load factor for earthquake loads, EQ:	$\gamma_{p\text{-}EQ}$	1.00	
Load factor for live load surcharge, LS: (Same as in External Stability).	$\gamma_{p\text{-}LS}$	1.50	
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:		0.80	1.00
Resistance factor accounting for uncertainty in measurement of geosynthetic stiffness J at 2% strain	Φ_{sf}	1.000	
Facing stiffness factor (recommended by AASHTO for flexible facing as 1.0)	Φ_{fs}	1.000	
Resistance factor for reinforcement tension in connectors	ϕ	Static	Combined static/seismic
Geogrid:		0.80	1.00
Resistance factor for geosynthetic pullout	ϕ	0.70	1.00

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}):	$(\gamma_{p\text{-}EH})_{EQ}$	1.50
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

ANALYSIS: CALCULATED FACTORS (Static conditions)

Bearing capacity, CDR = 5.08, factored bearing load = 3723 lb/ft².

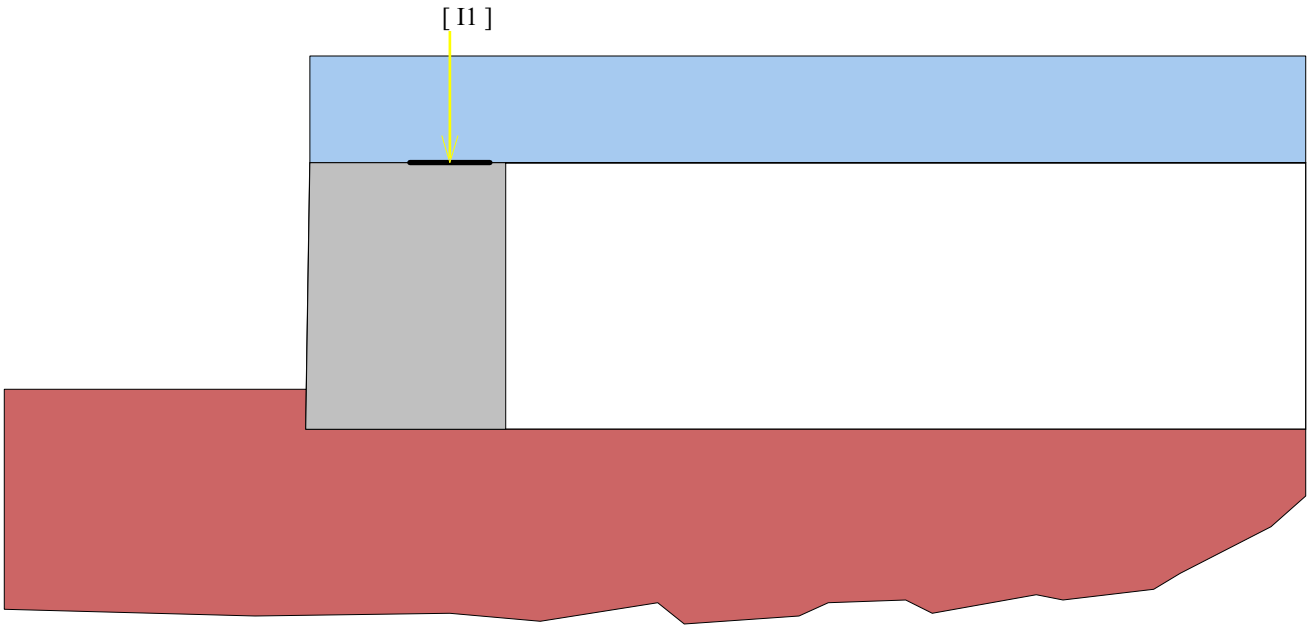
Foundation Interface: Direct sliding, CDR = 2.930, Eccentricity, e/L = 0.0808, CDR-overturning = 4.11

GEOGRID #	Elevation [ft]	Length [ft]	Type #	CONNECTION CDR [connection strength]	Geogrid strength CDR	Pullout resistance CDR	Direct sliding CDR	Eccentricity e/L	Product name
1	0.67	10.00	2	4.53	7.847	30.317	2.442	0.0716	7XT
2	2.00	10.00	2	4.32	7.745	25.882	2.666	0.0548	7XT
3	3.33	10.00	2	4.09	7.579	21.676	2.943	0.0397	7XT
4	4.67	10.00	2	3.82	7.361	17.851	3.296	0.0265	7XT
5	6.00	10.00	2	3.59	7.178	14.666	3.756	0.0153	7XT
6	7.33	10.00	2	3.44	7.146	12.329	4.390	0.0062	7XT
7	8.67	10.00	2	3.31	7.163	10.501	5.340	-0.0007	7XT
8	10.00	10.00	2	3.06	6.911	8.689	6.926	-0.0052	7XT
9	11.33	10.00	2	2.62	6.191	6.786	10.328	-0.0067	7XT
10	12.67	10.00	2	2.02	5.005	4.833	26.092	-0.0041	7XT

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

	STATIC	SEISMIC	UNITS
(Given factored bearing resistance, q-n)			
Factored bearing resistance. q-n	18915	N/A	[lb/ft ²]
Factored bearing load, σ_V	3722.9	N/A	[lb/ft ²]
Eccentricity, e	0.02	N/A	[ft]
Eccentricity, e/L	0.002	N/A	
CDR calculated	5.08	N/A	
Base length	10.00	N/A	[ft]

Unfactored applied bearing pressure = (Unfactored R) / [L - 2 * (Unfactored e)] =
Unfactored R = 28918.86 [lb/ft], L = 10.00, Unfactored e = -0.17 [ft], and Sigma = 2996.35 [lb/ft ²]



SCALE:

0 2 4 6 8 10 [ft]

RESULTS for STRENGTH

Live Load included in calculating Tmax

#	Geogrid Elevation [ft]		Limit State Tmax [lb/ft]	Service Limit Tmax [lb/ft]	Reinf. Strain Static [%]	Tmd [lb/ft]	Specified minimum CDR Static	Actual calculated CDR Static	Specified minimum CDR seismic	Actual calculated CDR seismic	Product name
1	0.67	3241.8	413.1	325.25	1.004	N/A	N/A	7.847	N/A	N/A	7XT
2	2.00	3241.8	418.6	328.80	1.015	N/A	N/A	7.745	N/A	N/A	7XT
3	3.33	3241.8	427.7	335.00	1.034	N/A	N/A	7.579	N/A	N/A	7XT
4	4.67	3241.8	440.4	343.42	1.060	N/A	N/A	7.361	N/A	N/A	7XT
5	6.00	3241.8	451.6	349.59	1.079	N/A	N/A	7.178	N/A	N/A	7XT
6	7.33	3241.8	453.7	345.69	1.067	N/A	N/A	7.146	N/A	N/A	7XT
7	8.67	3241.8	452.5	336.65	1.039	N/A	N/A	7.163	N/A	N/A	7XT
8	10.00	3241.8	469.1	339.34	1.047	N/A	N/A	6.911	N/A	N/A	7XT
9	11.33	3241.8	523.6	367.46	1.134	N/A	N/A	6.191	N/A	N/A	7XT
10	12.67	3241.8	647.7	441.89	1.364	N/A	N/A	5.005	N/A	N/A	7XT

Stiffness Method 2020
Ravensdale Creek Fish Passage

MSEW+: Update # 2021.20

PROJECT IDENTIFICATION

Title: Ravensdale Creek Fish Passage
Project Number: 2496.01
Client: Basalite
Designer: RAR
Station Number: NW Wall Sta. 1+22

Description:

Strenght and Extreme I limit states

Company's information:

Name: Zipper Geo Associates, LLC
Street: 19019 36th Ave. W. Ste. E

Lynnwood, WA 98036
Telephone #: 425-582-9928
Fax #:
E-Mail: rross@zippergeo.com

File path and name: Z:\Projects\2451 - 2500\2496 Ravensdale Creek GRS-IBS S..... ..... Wall Sta. 1+22.BENp

Original date and time of creating this file: Mon Mar 29 16:56:42 2021

PROGRAM MODE:

ANALYSIS
of a SIMPLE STRUCTURE
using GEOGRID as reinforcing material.

SOIL DATA

REINFORCED SOIL

Unit weight, γ	130.0 lb/ft ³
Design value of internal angle of friction, ϕ	38.0 °

RETAINED SOIL

Unit weight, γ	115.0 lb/ft ³
Design value of internal angle of friction, ϕ	30.0 °

FOUNDATION SOIL (Considered as an equivalent uniform soil)

Equivalent unit weight, $\gamma_{equiv.}$	130.0 lb/ft ³
Equivalent internal angle of friction, $\phi_{equiv.}$	30.0 °
Equivalent cohesion, $c_{equiv.}$	0.0 lb/ft ²

Factored bearing capacity resistance of foundation is given: q-ult-static = 9000.0 lb/ft²., q-ult-sesmic = 9000.0 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) = 0.2973 (eq. 17 is utilized to calculate Ka for all batters)
(For external stability user specified δ = 20.00°)

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 = 0.440 and Site Factor, Fpga = 1.000. Maximum ground acceleration coeff., As = 0.440
Design acceleration coefficient in Internal Stability: Kh = Am = 0.220
Design acceleration coefficient in External Stability: Kh_d = 0.220 => Kh = Am = 0.220
Kh(ext.) (Displ. >1" AASHTO 11.6.5.2.2)

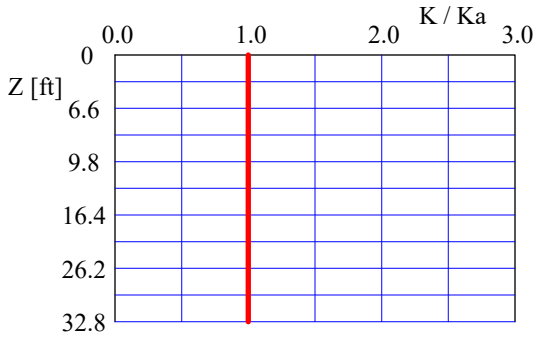
Ka = 0.2973 Kae = 0.4747 In Coulomb equation for Ka, Omega was taken as ZERO and backslope inclined at angle I.
In M-O equation for Kae, Omega is always set to ZERO.
Seismic soil-geogrid friction coefficient, F* is 80.0% of its specified static value.

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]	4700.0	5900.0	7400.0	4700.0	
Durability reduction factor, RFd	1.30	1.30	1.30	1.30	
Installation-damage reduction factor, RFid	1.12	1.12	1.12	1.12	
Creep reduction factor, RFc	1.45	1.45	1.45	1.45	N/A
CDR for strength	N/A	N/A	N/A	N/A	
Coverage ratio, Rc	1.000	1.000	1.000	0.850	
Friction angle along geogrid-soil interface, ρ	32.00	32.00	32.00	32.00	
Pullout resistance factor, F*	$0.67 \cdot \tan\phi$	$0.67 \cdot \tan\phi$	$0.67 \cdot \tan\phi$	$0.67 \cdot \tan\phi$	N/A
Scale-effect correction factor, α	0.8	0.8	0.8	0.8	

Variation of Lateral Earth Pressure Coefficient With Depth

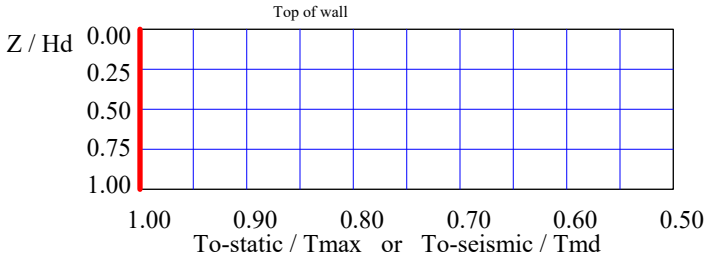
Z	K / Ka
0 ft	1.00
3.3 ft	1.00
6.6 ft	1.00
9.8 ft	1.00
13.1 ft	1.00
16.4 ft	1.00
19.7 ft	1.00



INPUT DATA: Facia and Connection (according to revised Demo 82) (Analysis)

FACIA type: Facing enabling frictional connection of reinforcement (e.g., modular concrete blocks, gabions)
Depth/height of block is 1.50/0.67 ft. Horizontal distance to Center of Gravity of block is: 0.75 ft.
Average unit weight of block is: γ_f = 125.00 lb/ft ³

Z / Hd	To-static / Tmax or To-seismic / Tmd
0.00	1.00
0.25	1.00
0.50	1.00
0.75	1.00
1.00	1.00



Connection strength, T-lot, is related to T-ult

Geogrid Type #1		Geogrid Type #2		Geogrid Type #3		Geogrid Type #4		Geogrid Type #5	
N-1	Tult-conn	N-2	Tult-conn	N-3	Tult-conn	N-4	Tult-conn	N-5	Tult-conn
0.0	1600.00	0.0	2074.20	0.0	1600.00	0.0	1600.00		
787.0	2037.00	1500.0	2686.65	1695.1	2038.00	787.0	2037.00	N/A	
1535.0	2657.00	2500.0	3094.95	1551.0	2900.00	1535.0	2657.00		
2293.0	3038.00	3500.0	3503.25	2326.4	3157.00	2293.0	3038.00		
4601.0	3105.00	4500.0	3911.55	4615.0	3808.00	4601.0	3105.00		

Geogrid Type #1		Geogrid Type #2		Geogrid Type #3		Geogrid Type #4		Geogrid Type #5	
σ	CRu	σ	CRu	σ	CRu	σ	CRu	σ	CRu
0.0	0.34	0.0	0.35	0.0	0.22	0.0	0.34		
524.7	0.43	1000.0	0.46	516.7	0.28	524.7	0.43	N/A	
1023.3	0.57	1666.7	0.52	1034.0	0.39	1023.3	0.57		
1528.7	0.65	2333.3	0.59	1550.9	0.43	1528.7	0.65		
3067.3	0.66	3000.0	0.66	3076.7	0.51	3067.3	0.66		

(1) σ = Confining stress in between stacked blocks [lb/ft ²]
(2) CRult = Tc-ult / Tult
(3) CRcr = Tcre / Tult

In seismic analysis, long term strength is reduced to 80% of its static value.

D A T A (for connection only)	Type #1	Type #2	Type #3	Type #4	Type #5
Product Name	5XT	7XT	8XT	5XT-RC	N/A
Connection strength reduction factor, RFd	1.30	1.30	1.30	1.30	N/A
Creep reduction factor, RFc	N/A	N/A	N/A	N/A	N/A

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

Design height, Hd 7.33 [ft] { Embedded depth is E = 2.00 ft, and height above top of finished bottom grade is H = 5.33 ft }

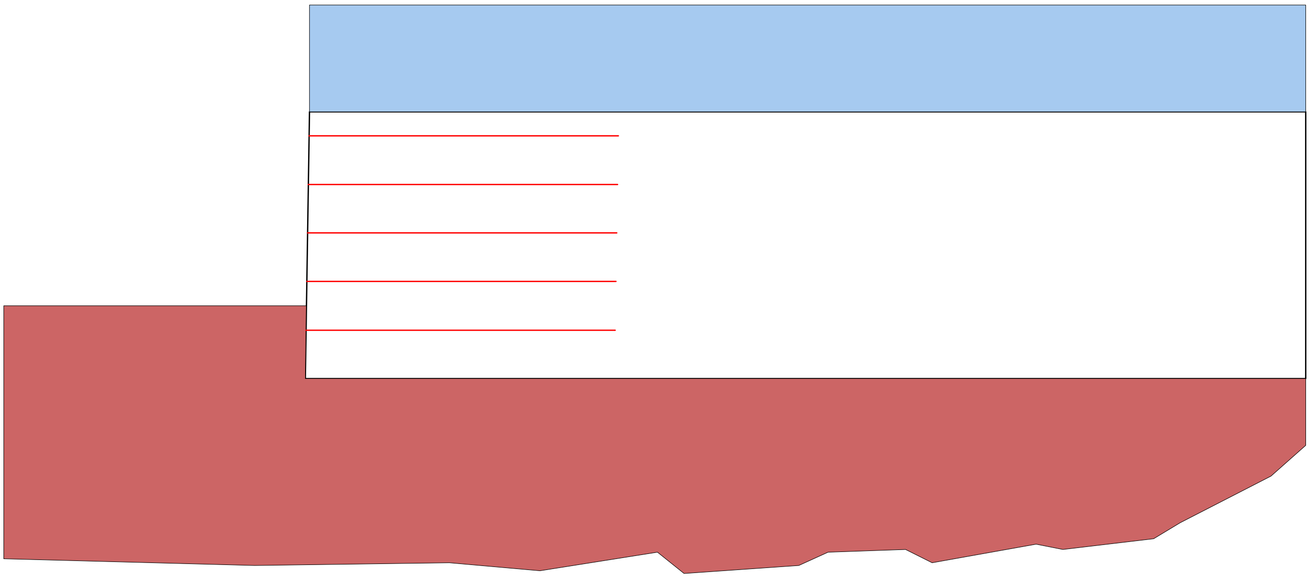
Soil in front of wall is Horizontal.

Batter, ω	0.9	[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 290.0 [lb/ft ²], and live load is 250.0 [lb/ft ²]

ANALYZED REINFORCEMENT LAYOUT:



SCALE:

0 2 4 6 [ft]

Stiffness Method 2020 – Load and Resisting Factors

INTERNAL STABILITY

Load factor for vertical earth pressure, EV:	$\gamma_{p\text{-}EV}$	1.35
Load factor for prediction of Tmax for the soil failure limit state:	$\gamma_{p\text{-}EVfs}$	1.20
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:		0.80		1.00
Resistance factor accounting for uncertainty in measurement of geosynthetic stiffness J at 2% strain	Φ_{sf}	1.000		
Facing stiffness factor (recommended by AASHTO for flexible facing as 1.0)	Φ_{fs}	1.000		
Resistance factor for reinforcement tension in connectors	ϕ	Static	Combined static/seismic	
Geogrid:		0.80		1.00
Resistance factor for geosynthetic pullout	ϕ	0.70		1.00

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}):	$(\gamma_{p\text{-}EH})_{EQ}$	1.50
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

ANALYSIS: CALCULATED FACTORS (Static conditions)

Bearing capacity, CDR = 2.44, factored bearing load = 2393 lb/ft².

Foundation Interface: Direct sliding, CDR = 2.173, Eccentricity, e/L = 0.0464, CDR-overturning = 5.60

GEOGRID				CONNECTION					
#	Elevation [ft]	Length [ft]	Type #	CDR [connection strength]	Geogrid strength CDR	Pullout resistance CDR	Direct sliding CDR	Eccentricity e/L	Product name
1	1.33	8.50	2	1.89	3.940	8.700	2.649	0.0268	7XT
2	2.67	8.50	2	2.57	5.567	9.466	3.079	0.0102	7XT
3	4.00	8.50	2	2.55	5.763	7.222	3.771	-0.0024	7XT
4	5.33	8.50	2	2.66	6.287	5.426	5.216	-0.0098	7XT
5	6.67	8.50	2	2.89	7.164	3.778	11.862	-0.0081	7XT

ANALYSIS: CALCULATED FACTORS (Seismic conditions)

Bearing capacity, CDR = 2.94, factored bearing load = 2760 lb/ft².

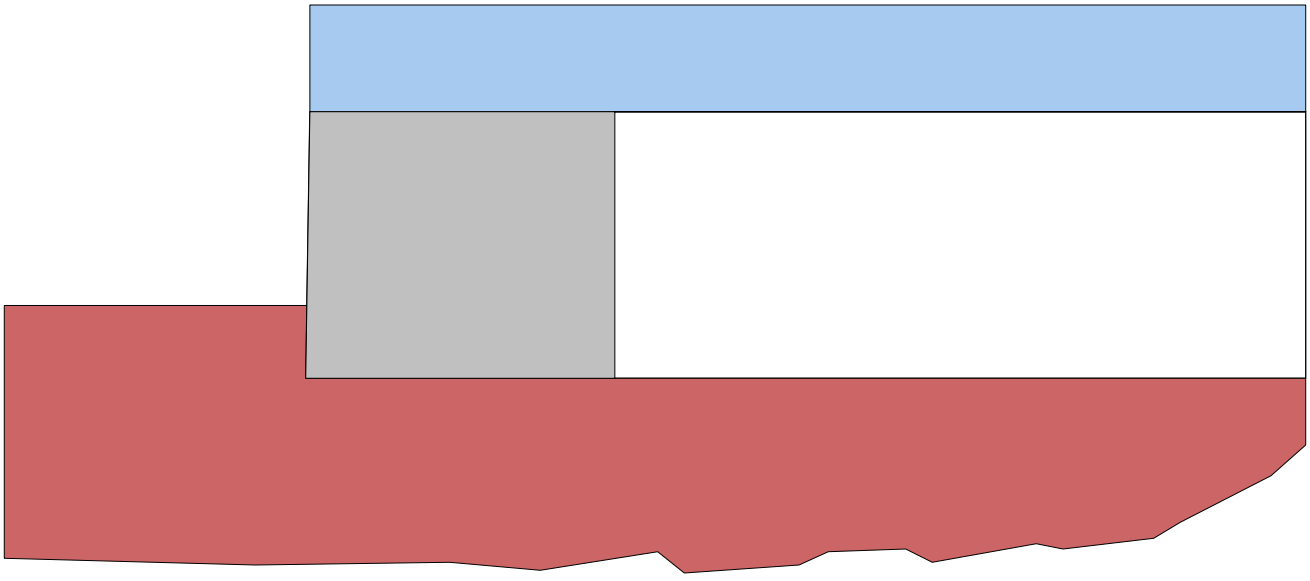
Foundation Interface: Direct sliding, CDR = 1.745, Eccentricity, e/L = 0.1663, Fs-overturning = 3.16

GEOGRID				CONNECTION					
#	Elevation [ft]	Length [ft]	Type #	CDR [connection strength]	Geogrid strength CDR	Pullout resistance CDR	Direct sliding CDR	Eccentricity e/L	Product name
1	1.33	8.50	2	2.10	5.457	10.197	2.176	0.1274	7XT
2	2.67	8.50	2	2.65	7.180	10.092	2.600	0.0914	7XT
3	4.00	8.50	2	2.61	7.372	7.617	3.294	0.0589	7XT
4	5.33	8.50	2	2.66	7.869	5.562	4.758	0.0305	7XT
5	6.67	8.50	2	2.79	8.655	3.700	11.452	0.0075	7XT

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

	STATIC	SEISMIC	UNITS
(Given factored bearing resistance, q-n)			
Factored bearing resistance. q-n	5850	8100	[lb/ft ²]
Factored bearing load, σ_V	2393.2	2760	[lb/ft ²]
Eccentricity, e	0.22	0.53	[ft]
Eccentricity, e/L	0.026	0.063	
CDR calculated	2.44	2.94	
Base length	8.50	8.50	[ft]

Unfactored applied bearing pressure = (Unfactored R) / [L - 2 * (Unfactored e)] =
Static: Unfactored R = 13289.25 [lb/ft], L = 8.50, Unfactored e = 0.20 [ft], and Sigma = 1639.63 [lb/ft ²]
Seismic: Unfactored R = 13691.75 [lb/ft], L = 8.50, Unfactored e = 0.47 [ft], and Sigma = 1808.89 [lb/ft ²]



SCALE:

0 2 4 6 [ft]

RESULTS for STRENGTH

Live Load included in calculating Tmax

#	Geogrid Elevation [ft]	Factored: Static/Seismic	Limit State Tmax [lb/ft]	Service Limit Tmax [lb/ft]	Reinf. Strain Stat./Seism [%]	Tmd [lb/ft]	Specified minimum CDR Static	Actual calculated CDR Static	Specified minimum CDR seismic	Actual calculated CDR seismic	Product name
1	1.33	2236/2795	568/420	392.38	1.211/1.622	133.01	N/A	3.940	N/A	5.457	7XT
2	2.67	2236/2795	402/297	282.17	0.871/1.281	133.01	N/A	5.567	N/A	7.180	7XT
3	4.00	2236/2795	388/287	270.33	0.834/1.245	133.01	N/A	5.763	N/A	7.372	7XT
4	5.33	2236/2795	356/263	241.27	0.745/1.155	133.01	N/A	6.287	N/A	7.869	7XT
5	6.67	2236/2795	312/231	202.88	0.626/1.037	133.01	N/A	7.164	N/A	8.655	7XT

Stiffness Method 2020
Ravensdale Creek Fish Passage

MSEW+: Update # 2021.20

PROJECT IDENTIFICATION

Title:	Ravensdale Creek Fish Passage
Project Number:	2496.01
Client:	Basalite
Designer:	RAR
Station Number:	NW Wall Sta. 1+22

Description:

Extreme II Limit State - Traffic Barrier Impact

Company's information:

Name: Zipper Geo Associates, LLC
Street: 19019 36th Ave. W. Ste. E

Lynnwood, WA 98036
Telephone #: 425-582-9928
Fax #:
E-Mail: rross@zippergeo.com

File path and name: Z:\Projects\2451 - 2500\2496 Ravensdale Creek GRS-IBS S..... .....22 (Extreme II).BENp

Original date and time of creating this file: Mon Mar 29 16:56:42 2021

PROGRAM MODE:

ANALYSIS
of a SIMPLE STRUCTURE
using GEOGRID as reinforcing material.

SOIL DATA

REINFORCED SOIL

Unit weight,	γ	130.0 lb/ft ^{3}
Design value of internal angle of friction,	ϕ	38.0 °

RETAINED SOIL

Unit weight,	γ	115.0 lb/ft ^{3}
Design value of internal angle of friction,	ϕ	30.0 °

FOUNDATION SOIL (Considered as an equivalent uniform soil)

Equivalent unit weight,	$\gamma_{equiv.}$	130.0 lb/ft ^{3}
Equivalent internal angle of friction,	$\phi_{equiv.}$	30.0 °
Equivalent cohesion,	$c_{equiv.}$	0.0 lb/ft ^{2}

Factored bearing capacity resistance of foundation is given: q-ult-static = 9000.0 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) = 0.2973 (eq. 17 is utilized to calculate Ka for all batters)
(For external stability user specified δ = 20.00°)

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

FOR EXTERNAL STABILITY

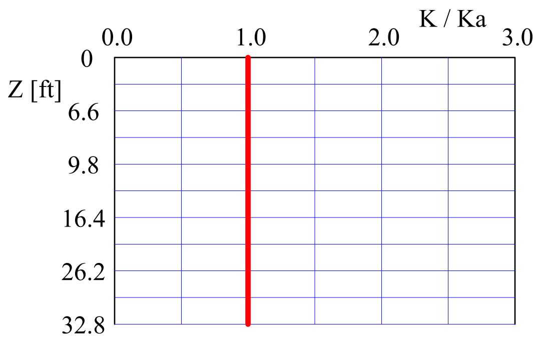
Ka = 0.2973 In Coulomb equation for Ka, Omega was taken as ZERO and backslope inclined at angle I.

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]	4700.0	5900.0	7400.0	4700.0	
Durability reduction factor, RFd	1.30	1.30	1.30	1.30	
Installation-damage reduction factor, RFid	1.12	1.12	1.12	1.12	
Creep reduction factor, RFc	1.45	1.00	1.45	1.45	N/A
CDR for strength	N/A	N/A	N/A	N/A	
Coverage ratio, Rc	1.000	1.000	1.000	0.850	
Friction angle along geogrid-soil interface, ρ	32.00	32.00	32.00	32.00	
Pullout resistance factor, F*	$0.67 \cdot \tan\phi$	$0.67 \cdot \tan\phi$	$0.67 \cdot \tan\phi$	$0.67 \cdot \tan\phi$	N/A
Scale-effect correction factor, α	0.8	0.8	0.8	0.8	

Variation of Lateral Earth Pressure Coefficient With Depth

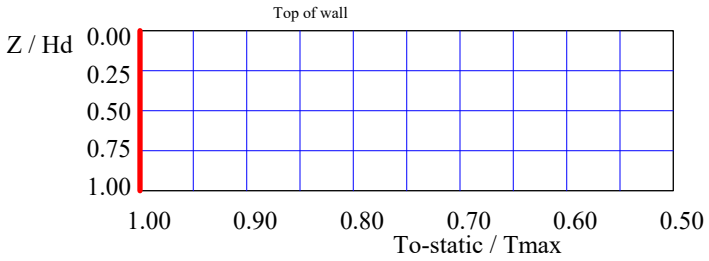
Z	K / Ka
0 ft	1.00
3.3 ft	1.00
6.6 ft	1.00
9.8 ft	1.00
13.1 ft	1.00
16.4 ft	1.00
19.7 ft	1.00



INPUT DATA: Facia and Connection (according to revised Demo 82) (Analysis)

FACIA type: Facing enabling frictional connection of reinforcement (e.g., modular concrete blocks, gabions)
Depth/height of block is 1.50/0.67 ft. Horizontal distance to Center of Gravity of block is: 0.75 ft.
Average unit weight of block is: γ_f = 125.00 lb/ft ³

Z / Hd	To-static / Tmax
0.00	1.00
0.25	1.00
0.50	1.00
0.75	1.00
1.00	1.00



Connection strength, T-lot, is related to T-ult

Geogrid Type #1		Geogrid Type #2		Geogrid Type #3		Geogrid Type #4		Geogrid Type #5	
N-1	Tult-conn	N-2	Tult-conn	N-3	Tult-conn	N-4	Tult-conn	N-5	Tult-conn
0.0	1600.00	0.0	2074.20	0.0	1600.00	0.0	1600.00		
787.0	2037.00	1500.0	2686.65	1695.1	2038.00	787.0	2037.00	N/A	
1535.0	2657.00	2500.0	3094.95	1551.0	2900.00	1535.0	2657.00		
2293.0	3038.00	3500.0	3503.25	2326.4	3157.00	2293.0	3038.00		
4601.0	3105.00	4500.0	3911.55	4615.0	3808.00	4601.0	3105.00		

Geogrid Type #1		Geogrid Type #2		Geogrid Type #3		Geogrid Type #4		Geogrid Type #5	
σ	CRu	σ	CRu	σ	CRu	σ	CRu	σ	CRu
0.0	0.34	0.0	0.35	0.0	0.22	0.0	0.34		
524.7	0.43	1000.0	0.46	516.7	0.28	524.7	0.43	N/A	
1023.3	0.57	1666.7	0.52	1034.0	0.39	1023.3	0.57		
1528.7	0.65	2333.3	0.59	1550.9	0.43	1528.7	0.65		
3067.3	0.66	3000.0	0.66	3076.7	0.51	3067.3	0.66		

(1) σ = Confining stress in between stacked blocks [lb/ft ²]
(2) CRult = Tc-ult / Tult
(3) CRcr = Tcre / Tult

D A T A (for connection only)	Type #1	Type #2	Type #3	Type #4	Type #5
Product Name	5XT	7XT	8XT	5XT-RC	N/A
Connection strength reduction factor, RFd	1.30	1.30	1.30	1.30	N/A
Creep reduction factor, RFc	N/A	N/A	N/A	N/A	N/A

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

Design height, Hd 7.33 [ft] { Embedded depth is E = 2.00 ft, and height above top of finished bottom grade is H = 5.33 ft }

Soil in front of wall is Horizontal.

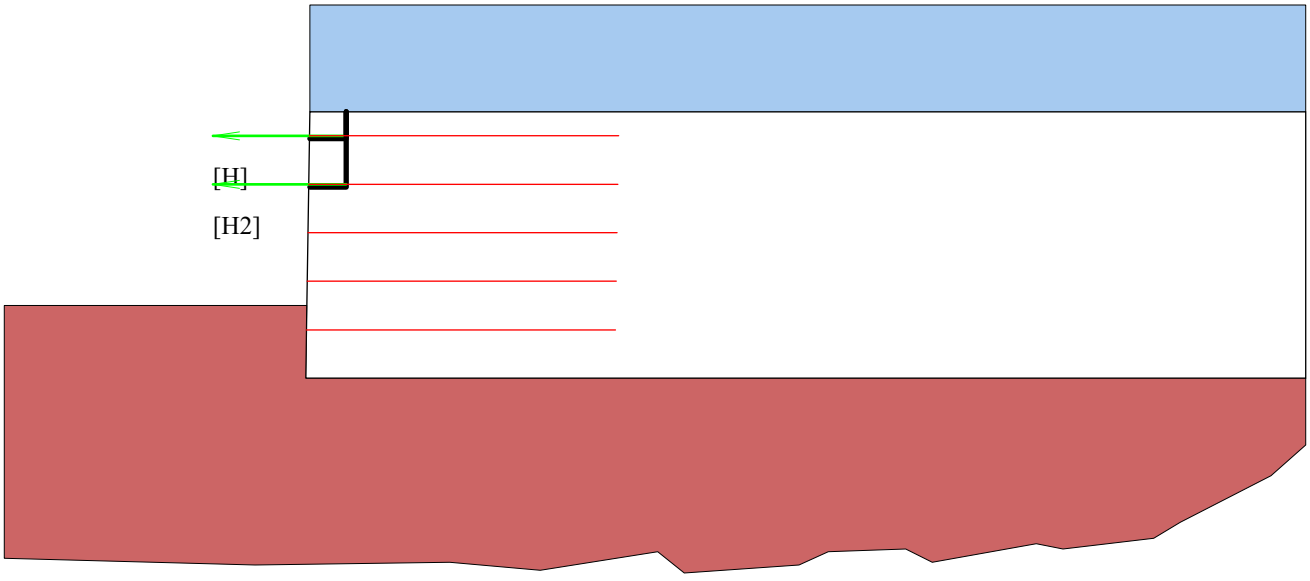
Batter, ω 0.9 [deg]
Backslope, β 0.0 [deg]
Backslope rise 0.0 [ft] Broken back equivalent angle, I = 0.00° (see Fig. 25 in DEMO 82)

U N I F O R M S U R C H A R G E

Uniformly distributed dead load is 290.0 [lb/ft ²], and live load is 250.0 [lb/ft ²]

OTHER EXTERNAL LOAD(S)
[H1] Horizontal Load, Ph = 2000.0 [lb/ft], acting at a depth of Zh = 0.7 [ft] and at a distance of Lb = 1.0 [ft].
[H2] Horizontal Load, Ph = 500.0 [lb/ft], acting at a depth of Zh = 2.0 [ft] and at a distance of Lb = 1.0 [ft].

ANALYZED REINFORCEMENT LAYOUT:



SCALE:

0 2 4 6 [ft]

Stiffness Method 2020 – Load and Resisting Factors

INTERNAL STABILITY

Load factor for vertical earth pressure, EV:	$\gamma_{p\text{-}EV}$	1.00	
Load factor for prediction of Tmax for the soil failure limit state:	$\gamma_{p\text{-}EVfs}$	1.00	
Load factor for earthquake loads, EQ:	$\gamma_{p\text{-}EQ}$	1.00	
Load factor for live load surcharge, LS: (Same as in External Stability).	$\gamma_{p\text{-}LS}$	0.50	
Load factor for dead load surcharge, ES: (Same as in External Stability).	$\gamma_{p\text{-}ES}$	1.00	
Resistance factor for reinforcement tension	ϕ	Static	Combined static/seismic
Geogrid:		1.00	1.00
Resistance factor accounting for uncertainty in measurement of geosynthetic stiffness J at 2% strain	Φ_{sf}	1.000	
Facing stiffness factor (recommended by AASHTO for flexible facing as 1.0)	Φ_{fs}	1.000	
Resistance factor for reinforcement tension in connectors	ϕ	Static	Combined static/seismic
Geogrid:		1.00	1.00
Resistance factor for geosynthetic pullout	ϕ	1.00	1.00

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}):	$(\gamma_{p\text{-}EH})_{EQ}$	1.50
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

ANALYSIS: CALCULATED FACTORS (Static conditions)

Bearing capacity, CDR = 2.35, factored bearing load = 2494 lb/ft².

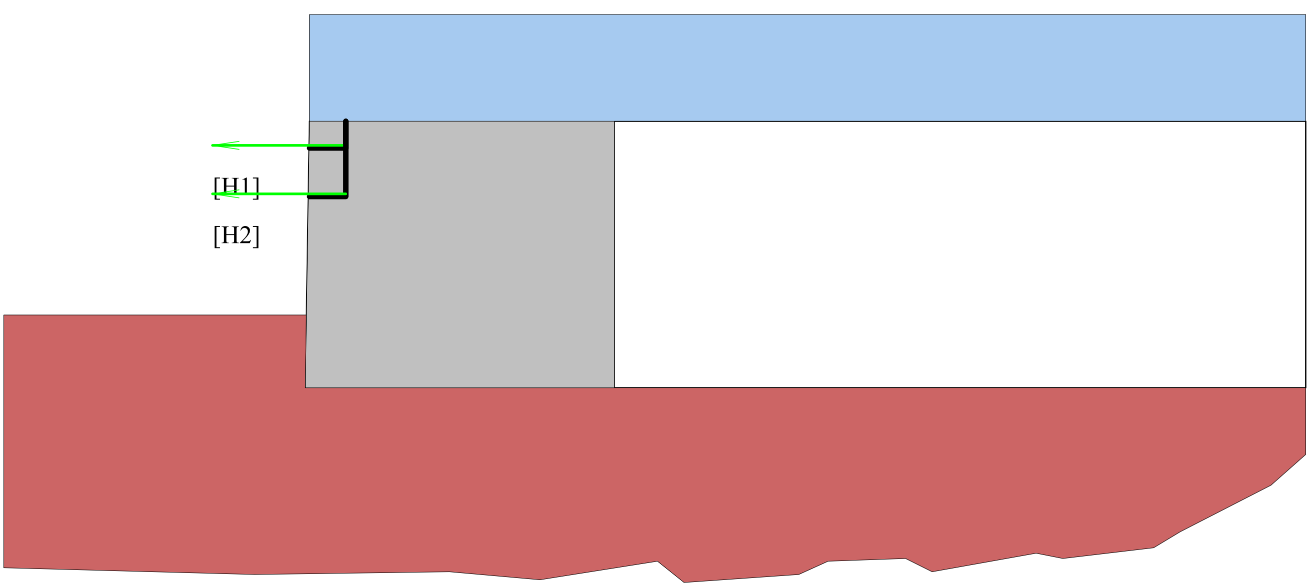
Foundation Interface: Direct sliding, CDR = 1.399, Eccentricity, e/L = 0.1941, CDR-overturning = 2.31

GEOGRID #	Elevation [ft]	Length [ft]	Type #	CONNECTION CDR [connection strength]	Geogrid strength CDR	Pullout resistance CDR	Direct sliding CDR	Eccentricity e/L	Product name
1	1.33	8.50	2	6.28	13.058	22.728	1.476	0.1690	7XT
2	2.67	8.50	2	8.35	18.088	24.242	1.395	0.1412	7XT
3	4.00	8.50	2	7.12	16.107	15.910	1.260	0.1074	7XT
4	5.33	8.50	2	3.07	7.270	4.945	1.056	0.0589	7XT
5	6.67	8.50	2	1.33	3.307	1.374	23.140	-0.0296	7XT

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

	STATIC	SEISMIC	UNITS
(Given factored bearing resistance, q-n)			
Factored bearing resistance. q-n	5850	N/A	[lb/ft ²]
Factored bearing load, σ_V	2494.4	N/A	[lb/ft ²]
Eccentricity, e	1.22	N/A	[ft]
Eccentricity, e/L	0.143	N/A	
CDR calculated	2.35	N/A	
Base length	8.50	N/A	[ft]

Unfactored applied bearing pressure = (Unfactored R) / [L - 2 * (Unfactored e)] =
Unfactored R = 13289.25 [lb/ft], L = 8.50, Unfactored e = 1.40 [ft], and Sigma = 2331.72 [lb/ft ²]



SCALE:

0 2 4 6 [ft]

Stiffness Method 2020
Ravensdale Creek Fish Passage

MSEW+: Update # 2021.20

PROJECT IDENTIFICATION

Title: Ravensdale Creek Fish Passage
Project Number: 2496.01
Client: Basalite
Designer: RAR
Station Number: NW Wall Sta. 1+22

Description:

Temp Crane Surcharge Loading

Company's information:

Name: Zipper Geo Associates, LLC
Street: 19019 36th Ave. W. Ste. E

Lynnwood, WA 98036
Telephone #: 425-582-9928
Fax #:
E-Mail: rross@zippergeo.com

File path and name: Z:\Projects\2451 - 2500\2496 Ravensdale Creek GRS-IBS S.....
.....22 (TEMP CRANE).BENp

Original date and time of creating this file: Mon Mar 29 16:56:42 2021

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

SOIL DATA

REINFORCED SOIL

Unit weight, γ	130.0 lb/ft ^{3}
Design value of internal angle of friction, ϕ	38.0 °

RETAINED SOIL

Unit weight, γ	115.0 lb/ft ^{3}
Design value of internal angle of friction, ϕ	30.0 °

FOUNDATION SOIL (Considered as an equivalent uniform soil)

Equivalent unit weight, $\gamma_{equiv.}$	130.0 lb/ft ^{3}
Equivalent internal angle of friction, $\phi_{equiv.}$	30.0 °
Equivalent cohesion, $c_{equiv.}$	0.0 lb/ft ^{2}

Factored bearing capacity resistance of foundation is given: q-ult-static = 9000.0 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) = 0.2973 (eq. 17 is utilized to calculate Ka for all batters)
(For external stability user specified δ = 20.00°)

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

FOR EXTERNAL STABILITY

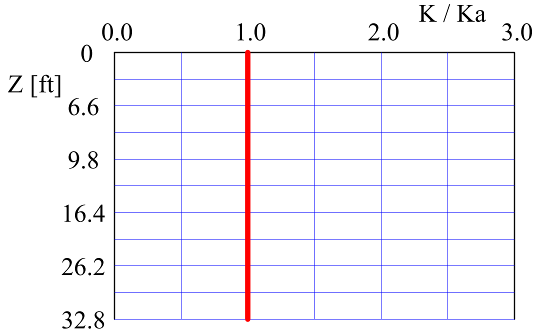
Ka = 0.2973 In Coulomb equation for Ka, Omega was taken as ZERO and backslope inclined at angle I.

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]	4700.0	5900.0	7400.0	4700.0	
Durability reduction factor, RFd	1.30	1.30	1.30	1.30	
Installation-damage reduction factor, RFid	1.12	1.12	1.12	1.12	
Creep reduction factor, RFc	1.45	1.00	1.45	1.45	N/A
CDR for strength	N/A	N/A	N/A	N/A	
Coverage ratio, Rc	1.000	1.000	1.000	0.850	
Friction angle along geogrid-soil interface, ρ	32.00	32.00	32.00	32.00	
Pullout resistance factor, F*	0.67·tan ϕ	0.67·tan ϕ	0.67·tan ϕ	0.67·tan ϕ	N/A
Scale-effect correction factor, α	0.8	0.8	0.8	0.8	

Variation of Lateral Earth Pressure Coefficient With Depth

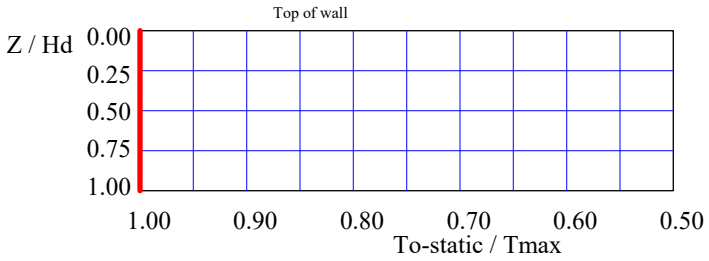
Z	K / Ka
0 ft	1.00
3.3 ft	1.00
6.6 ft	1.00
9.8 ft	1.00
13.1 ft	1.00
16.4 ft	1.00
19.7 ft	1.00



INPUT DATA: Facia and Connection (according to revised Demo 82) (Analysis)

FACIA type: Facing enabling frictional connection of reinforcement (e.g., modular concrete blocks, gabions)
Depth/height of block is 1.50/0.67 ft. Horizontal distance to Center of Gravity of block is: 0.75 ft.
Average unit weight of block is: γ_f = 125.00 lb/ft ³

Z / Hd	To-static / Tmax
0.00	1.00
0.25	1.00
0.50	1.00
0.75	1.00
1.00	1.00



Connection strength, T-lot, is related to T-ult

Geogrid Type #1		Geogrid Type #2		Geogrid Type #3		Geogrid Type #4		Geogrid Type #5	
N-1	Tult-conn	N-2	Tult-conn	N-3	Tult-conn	N-4	Tult-conn	N-5	Tult-conn
0.0	1600.00	0.0	2074.20	0.0	1600.00	0.0	1600.00		
787.0	2037.00	1500.0	2686.65	1695.1	2038.00	787.0	2037.00	N/A	
1535.0	2657.00	2500.0	3094.95	1551.0	2900.00	1535.0	2657.00		
2293.0	3038.00	3500.0	3503.25	2326.4	3157.00	2293.0	3038.00		
4601.0	3105.00	4500.0	3911.55	4615.0	3808.00	4601.0	3105.00		

Geogrid Type #1		Geogrid Type #2		Geogrid Type #3		Geogrid Type #4		Geogrid Type #5	
σ	CRu	σ	CRu	σ	CRu	σ	CRu	σ	CRu
0.0	0.34	0.0	0.35	0.0	0.22	0.0	0.34		
524.7	0.43	1000.0	0.46	516.7	0.28	524.7	0.43	N/A	
1023.3	0.57	1666.7	0.52	1034.0	0.39	1023.3	0.57		
1528.7	0.65	2333.3	0.59	1550.9	0.43	1528.7	0.65		
3067.3	0.66	3000.0	0.66	3076.7	0.51	3067.3	0.66		

(1) σ = Confining stress in between stacked blocks [lb/ft ²]
(2) CRult = Tc-ult / Tult
(3) CRcr = Tcre / Tult

D A T A (for connection only)	Type #1	Type #2	Type #3	Type #4	Type #5
Product Name	5XT	7XT	8XT	5XT-RC	N/A
Connection strength reduction factor, RFd	1.30	1.30	1.30	1.30	N/A
Creep reduction factor, RFc	N/A	N/A	N/A	N/A	N/A

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

Design height, Hd 7.33 [ft] { Embedded depth is E = 2.00 ft, and height above top of finished bottom grade is H = 5.33 ft }

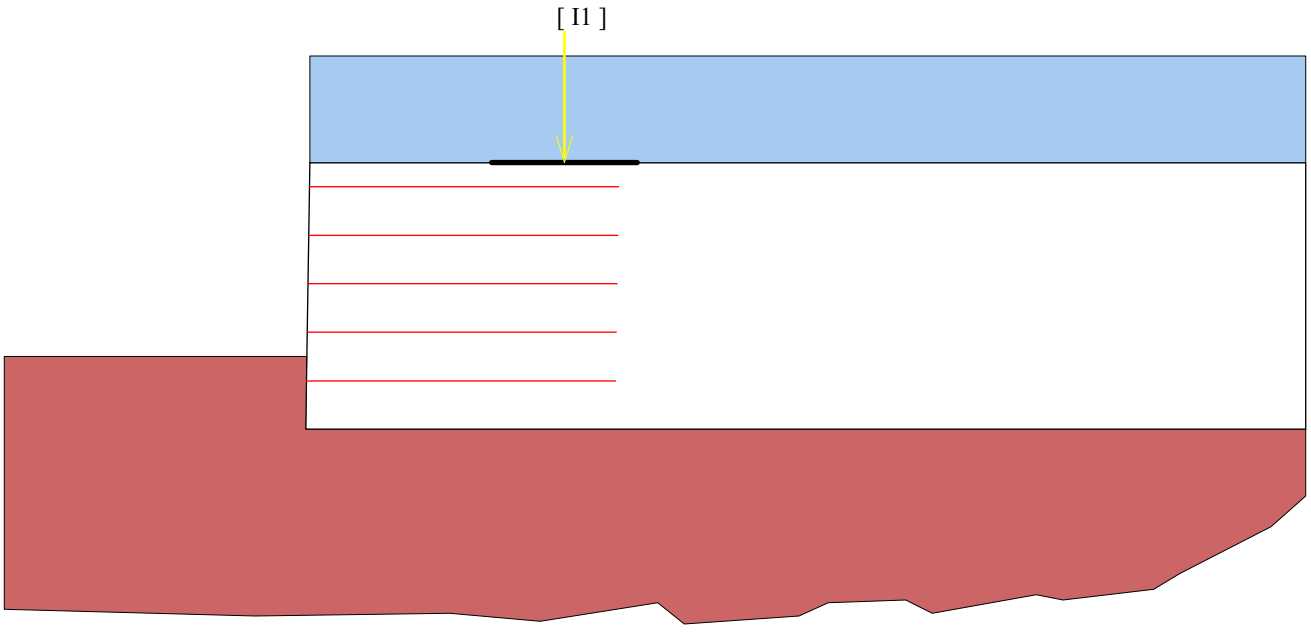
Soil in front of wall is Horizontal.

Batter, ω 0.9 [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 290.0 [lb/ft ²]

OTHER EXTERNAL LOAD(S)
[I1] Isolated Load, Pv-d' = 0.0 and Pv-l' = 30000.0 [lb]. Length of footing, L = 4.0 [ft], and width, b = 4.0 [ft]. Distance of center of footing from wall face, d = 7.0 [ft] @ depth of 0.0 [ft] below soil surface.

ANALYZED REINFORCEMENT LAYOUT:



SCALE:

0 2 4 6 [ft]

Stiffness Method 2020 – Load and Resisting Factors

INTERNAL STABILITY

Load factor for vertical earth pressure, EV:	$\gamma_{p\text{-}EV}$	1.35	
Load factor for prediction of Tmax for the soil failure limit state:	$\gamma_{p\text{-}EVfs}$	1.20	
Load factor for earthquake loads, EQ:	$\gamma_{p\text{-}EQ}$	1.00	
Load factor for live load surcharge, LS: (Same as in External Stability).	$\gamma_{p\text{-}LS}$	1.50	
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:		0.80	1.00
Resistance factor accounting for uncertainty in measurement of geosynthetic stiffness J at 2% strain	Φ_{sf}	1.000	
Facing stiffness factor (recommended by AASHTO for flexible facing as 1.0)	Φ_{fs}	1.000	
Resistance factor for reinforcement tension in connectors	ϕ	Static	Combined static/seismic
Geogrid:		0.80	1.00
Resistance factor for geosynthetic pullout	ϕ	0.70	1.00

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}):	$(\gamma_{p\text{-}EH})_{EQ}$	1.50
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

ANALYSIS: CALCULATED FACTORS (Static conditions)

Bearing capacity, CDR = 2.03, factored bearing load = 2875 lb/ft².

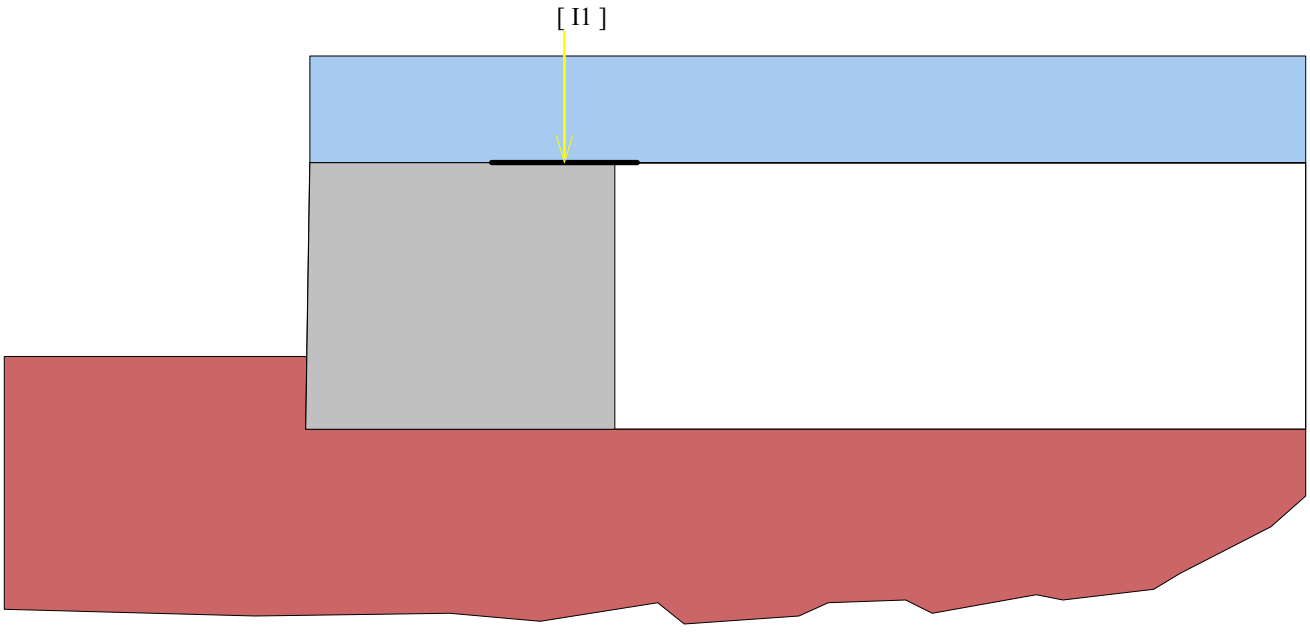
Foundation Interface: Direct sliding, CDR = 1.823, Eccentricity, e/L = 0.0932, CDR-overturning = 3.63

GEOGRID #	Elevation [ft]	Length [ft]	Type #	CONNECTION CDR [connection strength]	Geogrid strength CDR	Pullout resistance CDR	Direct sliding CDR	Eccentricity e/L	Product name
1	1.33	8.50	2	4.34	9.021	13.739	2.099	0.0649	7XT
2	2.67	8.50	2	5.70	12.342	14.473	2.245	0.0378	7XT
3	4.00	8.50	2	5.74	12.991	11.228	2.433	0.0125	7XT
4	5.33	8.50	2	6.33	14.963	8.905	2.771	-0.0101	7XT
5	6.67	8.50	2	7.53	18.667	6.789	4.417	-0.0199	7XT

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

	STATIC	SEISMIC	UNITS
(Given factored bearing resistance, q-n)			
Factored bearing resistance. q-n	5850	N/A	[lb/ft ²]
Factored bearing load, σ_V	2875.4	N/A	[lb/ft ²]
Eccentricity, e	-0.42	N/A	[ft]
Eccentricity, e/L	-0.049	N/A	
CDR calculated	2.03	N/A	
Base length	8.50	N/A	[ft]

Unfactored applied bearing pressure = (Unfactored R) / [L - 2 * (Unfactored e)] =
Unfactored R = 17732.76 [lb/ft], L = 8.50, Unfactored e = -0.57 [ft], and Sigma = 2409.15 [lb/ft ²]



SCALE:

0 2 4 6 [ft]

RESULTS for STRENGTH

Live Load included in calculating Tmax

#	Geogrid Elevation [ft]		Limit State Tmax [lb/ft]	Service Limit Tmax [lb/ft]	Reinf. Strain Static [%]	Tmd [lb/ft]	Specified minimum CDR Static	Actual calculated CDR Static	Specified minimum CDR seismic	Actual calculated CDR seismic	Product name
1	1.33	3241.8	359.4	273.44	0.844	N/A	N/A	9.021	N/A	N/A	7XT
2	2.67	3241.8	262.7	202.77	0.626	N/A	N/A	12.342	N/A	N/A	7XT
3	4.00	3241.8	249.5	191.23	0.590	N/A	N/A	12.991	N/A	N/A	7XT
4	5.33	3241.8	216.6	161.88	0.500	N/A	N/A	14.963	N/A	N/A	7XT
5	6.67	3241.8	173.7	123.78	0.382	N/A	N/A	18.667	N/A	N/A	7XT

SW WALL
ANALYSIS RESULTS

Stiffness Method 2020
Ravensdale Creek Fish Passage

MSEW+: Update # 2021.20

PROJECT IDENTIFICATION

Title: Ravensdale Creek Fish Passage
Project Number: 2496.01
Client: Basalite
Designer: RAR
Station Number: SW Wall Sta. 0+00

Description:

Strength and Extreme I Limit States

Company's information:

Name: Zipper Geo Associates, LLC
Street: 19019 36th Ave. W. Ste. E

Lynnwood, WA 98036
Telephone #: 425-582-9928
Fax #:
E-Mail: rross@zippergeo.com

File path and name: Z:\Projects\2451 - 2500\2496 Ravensdale Creek GRS-IBS S..... ..... Wall Sta. 0+00.BENp

Original date and time of creating this file: Mon Mar 29 16:56:42 2021

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

SOIL DATA

REINFORCED SOIL

Unit weight,	γ	130.0 lb/ft ^{3}
Design value of internal angle of friction,	ϕ	38.0 °

RETAINED SOIL

Unit weight,	γ	115.0 lb/ft ^{3}
Design value of internal angle of friction,	ϕ	30.0 °

FOUNDATION SOIL (Considered as an equivalent uniform soil)

Equivalent unit weight,	$\gamma_{equiv.}$	130.0 lb/ft ^{3}
Equivalent internal angle of friction,	$\phi_{equiv.}$	38.0 °
Equivalent cohesion,	$c_{equiv.}$	0.0 lb/ft ^{2}

Factored bearing capacity resistance of foundation is given: q-ult-static = 29100.0 lb/ft^2., q-ult-sesmic = 29100.0 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) = 0.2973 (eq. 17 is utilized to calculate Ka for all batters)
(For external stability user specified δ = 20.00°)

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 = 0.440 and Site Factor, Fpga = 1.000. Maximum ground acceleration coeff., As = 0.440
Design acceleration coefficient in Internal Stability: Kh = Am = 0.220
Design acceleration coefficient in External Stability: Kh_d = 0.220 => Kh = Am = 0.220
Kh(ext.) (Displ. >1" AASHTO 11.6.5.2.2)

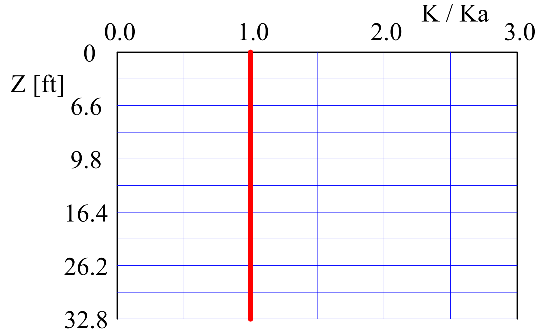
Ka = 0.2973 Kae = 0.4747 In Coulomb equation for Ka, Omega was taken as ZERO and backslope inclined at angle I.
In M-O equation for Kae, Omega is always set to ZERO.
Seismic soil-geogrid friction coefficient, F* is 80.0% of its specified static value.

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]	4700.0	5900.0	7400.0	4700.0	
Durability reduction factor, RFd	1.30	1.30	1.30	1.30	
Installation-damage reduction factor, RFid	1.12	1.12	1.12	1.12	
Creep reduction factor, RFc	1.45	1.45	1.45	1.45	N/A
CDR for strength	N/A	N/A	N/A	N/A	
Coverage ratio, Rc	1.000	1.000	1.000	0.850	
Friction angle along geogrid-soil interface, ρ	32.00	32.00	32.00	32.00	
Pullout resistance factor, F*	0.67·tan ϕ	0.67·tan ϕ	0.67·tan ϕ	0.67·tan ϕ	N/A
Scale-effect correction factor, α	0.8	0.8	0.8	0.8	

Variation of Lateral Earth Pressure Coefficient With Depth

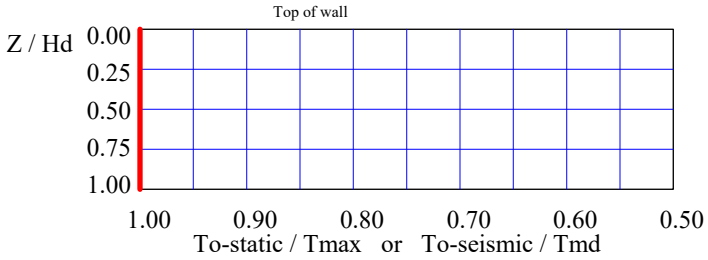
Z	K / Ka
0 ft	1.00
3.3 ft	1.00
6.6 ft	1.00
9.8 ft	1.00
13.1 ft	1.00
16.4 ft	1.00
19.7 ft	1.00



INPUT DATA: Facia and Connection (according to revised Demo 82) (Analysis)

FACIA type: Facing enabling frictional connection of reinforcement (e.g., modular concrete blocks, gabions)
Depth/height of block is 1.50/0.67 ft. Horizontal distance to Center of Gravity of block is: 0.75 ft.
Average unit weight of block is: γ_f = 125.00 lb/ft ³

Z / Hd	To-static / Tmax or To-seismic / Tmd
0.00	1.00
0.25	1.00
0.50	1.00
0.75	1.00
1.00	1.00



Connection strength, T-lot, is related to T-ult

Geogrid Type #1		Geogrid Type #2		Geogrid Type #3		Geogrid Type #4		Geogrid Type #5	
N-1	Tult-conn	N-2	Tult-conn	N-3	Tult-conn	N-4	Tult-conn	N-5	Tult-conn
0.0	1600.00	0.0	2074.20	0.0	1600.00	0.0	1600.00		
787.0	2037.00	1500.0	2686.65	1695.1	2038.00	787.0	2037.00	N/A	
1535.0	2657.00	2500.0	3094.95	1551.0	2900.00	1535.0	2657.00		
2293.0	3038.00	3500.0	3503.25	2326.4	3157.00	2293.0	3038.00		
4601.0	3105.00	4500.0	3911.55	4615.0	3808.00	4601.0	3105.00		

Geogrid Type #1		Geogrid Type #2		Geogrid Type #3		Geogrid Type #4		Geogrid Type #5	
σ	CRu	σ	CRu	σ	CRu	σ	CRu	σ	CRu
0.0	0.34	0.0	0.35	0.0	0.22	0.0	0.34		
524.7	0.43	1000.0	0.46	516.7	0.28	524.7	0.43	N/A	
1023.3	0.57	1666.7	0.52	1034.0	0.39	1023.3	0.57		
1528.7	0.65	2333.3	0.59	1550.9	0.43	1528.7	0.65		
3067.3	0.66	3000.0	0.66	3076.7	0.51	3067.3	0.66		

(1) σ = Confining stress in between stacked blocks [lb/ft ²]
(2) CRult = Tc-ult / Tult
(3) CRcr = Tcre / Tult

In seismic analysis, long term strength is reduced to 80% of its static value.

D A T A (for connection only)	Type #1	Type #2	Type #3	Type #4	Type #5
Product Name	5XT	7XT	8XT	5XT-RC	N/A
Connection strength reduction factor, RFd	1.30	1.30	1.30	1.30	N/A
Creep reduction factor, RFc	N/A	N/A	N/A	N/A	N/A

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

Design height, Hd 13.33 [ft] { Embedded depth is E = 2.00 ft, and height above top of finished bottom grade is H = 11.33 ft }

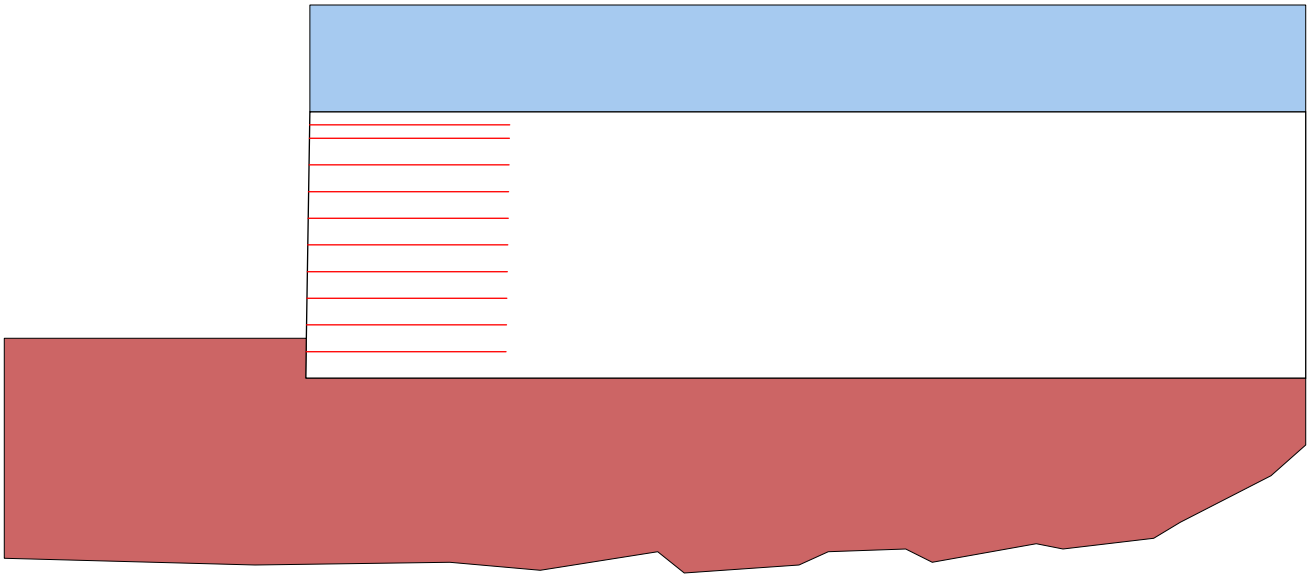
Soil in front of wall is Horizontal.

Batter, ω 0.9 [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 290.0 [lb/ft ²], and live load is 250.0 [lb/ft ²]

ANALYZED REINFORCEMENT LAYOUT:



SCALE:

0 2 4 6 8 10 [ft]

Stiffness Method 2020 – Load and Resisting Factors

INTERNAL STABILITY

Load factor for vertical earth pressure, EV:	$\gamma_{p\text{-}EV}$	1.35	
Load factor for prediction of Tmax for the soil failure limit state:	$\gamma_{p\text{-}EVfs}$	1.20	
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:		0.80	1.00
Resistance factor accounting for uncertainty in measurement of geosynthetic stiffness J at 2% strain	Φ_{sf}	1.000	
Facing stiffness factor (recommended by AASHTO for flexible facing as 1.0)	Φ_{fs}	1.000	
Resistance factor for reinforcement tension in connectors	ϕ	Static	Combined static/seismic
Geogrid:		0.80	1.00
Resistance factor for geosynthetic pullout	ϕ	0.70	1.00

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}):	$(\gamma_{p\text{-}EH})_{EQ}$	1.50
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

ANALYSIS: CALCULATED FACTORS (Static conditions)

Bearing capacity, CDR = 4.70, factored bearing load = 4025 lb/ft².

Foundation Interface: Direct sliding, CDR = 2.358, Eccentricity, e/L = 0.1135, CDR-overturning = 3.16

GEOGRID #	Elevation [ft]	Length [ft]	Type #	CONNECTION CDR [connection strength]	Geogrid strength CDR	Pullout resistance CDR	Direct sliding CDR	Eccentricity e/L	Product name
1	1.33	10.00	2	1.85	3.263	14.832	2.015	0.0911	7XT
2	2.67	10.00	2	2.46	4.492	17.253	2.170	0.0704	7XT
3	4.00	10.00	2	2.38	4.505	14.402	2.357	0.0517	7XT
4	5.33	10.00	2	2.29	4.492	11.722	2.589	0.0349	7XT
5	6.67	10.00	2	2.27	4.628	9.607	2.892	0.0201	7XT
6	8.00	10.00	2	2.35	4.982	7.991	3.307	0.0077	7XT
7	9.33	10.00	2	2.44	5.407	6.425	3.932	-0.0021	7XT
8	10.67	10.00	2	2.57	5.934	4.908	5.064	-0.0086	7XT
9	12.00	10.00	2	3.47	8.403	4.419	8.099	-0.0099	7XT
10	12.67	10.00	2	3.74	9.270	3.668	13.917	-0.0072	7XT

ANALYSIS: CALCULATED FACTORS (Seismic conditions)

Bearing capacity, CDR = 4.90, factored bearing load = 5340 lb/ft².

Foundation Interface: Direct sliding, CDR = 1.770, Eccentricity, e/L = 0.2887, Fs-overturning = 1.75

GEOGRID #	Elevation [ft]	Length [ft]	Type #	CONNECTION CDR [connection strength]	Geogrid strength CDR	Pullout resistance CDR	Direct sliding CDR	Eccentricity e/L	Product name
1	1.33	10.00	2	2.02	4.449	17.017	1.530	0.2497	7XT
2	2.67	10.00	2	2.51	5.712	18.053	1.670	0.2123	7XT
3	4.00	10.00	2	2.42	5.724	15.055	1.841	0.1772	7XT
4	5.33	10.00	2	2.33	5.712	12.265	2.058	0.1441	7XT
5	6.67	10.00	2	2.29	5.841	9.955	2.348	0.1129	7XT
6	8.00	10.00	2	2.33	6.168	8.078	2.752	0.0843	7XT
7	9.33	10.00	2	2.37	6.546	6.309	3.373	0.0581	7XT
8	10.67	10.00	2	2.42	6.991	4.655	4.515	0.0344	7XT
9	12.00	10.00	2	2.91	8.796	3.612	7.584	0.0143	7XT
10	12.67	10.00	2	3.01	9.337	2.860	13.436	0.0061	7XT

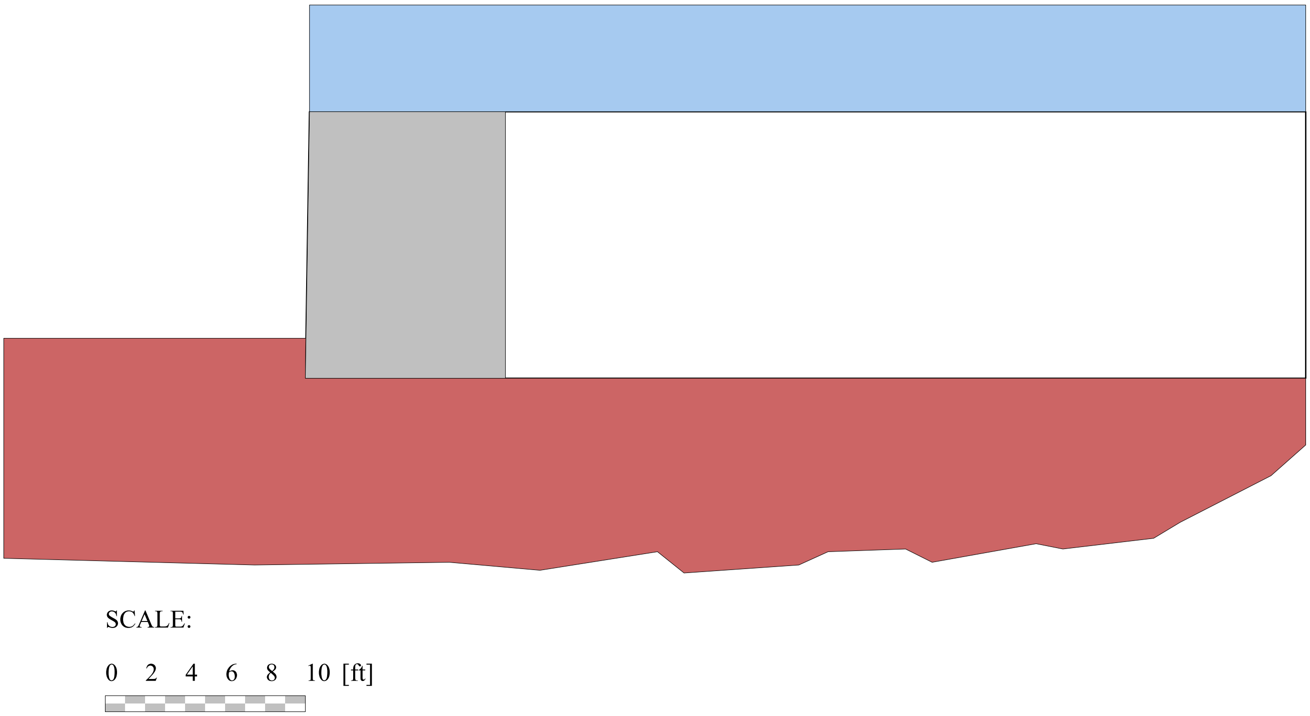
BEARING CAPACITY for GIVEN LAYOUT – Using AASHTO 2017-2020 method

	STATIC	SEISMIC	UNITS
(Given factored bearing resistance, q-n)			
Factored bearing resistance. q-n	18915	26190	[lb/ft ²]
Factored bearing load, σ_V	4024.8	5340	[lb/ft ²]
Eccentricity, e	0.72	1.54	[ft]
Eccentricity, e/L	0.072	0.154	
CDR calculated	4.70	4.90	
Base length	10.00	10.00	[ft]

Unfactored applied bearing pressure = (Unfactored R) / [L - 2 * (Unfactored e)] =

Static: Unfactored R = 24205.39 [lb/ft], L = 10.00, Unfactored e = 0.65 [ft], and Sigma = 2783.58 [lb/ft ²]

Seismic: Unfactored R = 24937.35 [lb/ft], L = 10.00, Unfactored e = 1.51 [ft], and Sigma = 3572.10 [lb/ft ²]



RESULTS for STRENGTH

Live Load included in calculating Tmax

#	Geogrid Elevation [ft]	Factored: Static/Seismic	Limit State Tmax [lb/ft]	Service Limit Tmax [lb/ft]	Reinf. Strain Stat./Seism [%]	Tmd [lb/ft]	Specified minimum CDR Static	Actual calculated CDR Static	Specified minimum CDR seismic	Actual calculated CDR seismic	Product name
1	1.33	2236/2795	685/507	496.90	1.534/2.074	174.92	N/A	3.263	N/A	4.449	7XT
2	2.67	2236/2795	498/369	367.56	1.134/1.674	174.92	N/A	4.492	N/A	5.712	7XT
3	4.00	2236/2795	496/368	366.55	1.131/1.671	174.92	N/A	4.505	N/A	5.724	7XT
4	5.33	2236/2795	498/369	367.56	1.134/1.674	174.92	N/A	4.492	N/A	5.712	7XT
5	6.67	2236/2795	483/358	354.57	1.094/1.634	174.92	N/A	4.628	N/A	5.841	7XT
6	8.00	2236/2795	449/332	324.40	1.001/1.541	174.92	N/A	4.982	N/A	6.168	7XT
7	9.33	2236/2795	414/306	292.75	0.904/1.443	174.92	N/A	5.407	N/A	6.546	7XT
8	10.67	2236/2795	377/279	260.11	0.803/1.343	174.92	N/A	5.934	N/A	6.991	7XT
9	12.00	2236/2795	266/197	180.45	0.557/1.097	174.92	N/A	8.403	N/A	8.796	7XT
10	12.67	2236/2795	241/179	158.63	0.490/1.029	174.92	N/A	9.270	N/A	9.337	7XT

Stiffness Method 2020
Ravensdale Creek Fish Passage

MSEW+: Update # 2021.20

PROJECT IDENTIFICATION

Title:	Ravensdale Creek Fish Passage
Project Number:	2496.01
Client:	Basalite
Designer:	RAR
Station Number:	SW Wall Sta. 0+00

Description:

Extreme II - Barrier Impact

Company's information:

Name: Zipper Geo Associates, LLC
Street: 19019 36th Ave. W. Ste. E

Lynnwood, WA 98036
Telephone #: 425-582-9928
Fax #:
E-Mail: rross@zippergeo.com

File path and name: Z:\Projects\2451 - 2500\2496 Ravensdale Creek GRS-IBS S.....
.....00 (Extreme II).BENp

Original date and time of creating this file: Mon Mar 29 16:56:42 2021

PROGRAM MODE:

ANALYSIS
of a SIMPLE STRUCTURE
using GEOGRID as reinforcing material.

SOIL DATA

REINFORCED SOIL

Unit weight, γ	130.0 lb/ft³
Design value of internal angle of friction, ϕ	38.0 °

RETAINED SOIL

Unit weight, γ	115.0 lb/ft³
Design value of internal angle of friction, ϕ	30.0 °

FOUNDATION SOIL (Considered as an equivalent uniform soil)

Equivalent unit weight, $\gamma_{equiv.}$	130.0 lb/ft³
Equivalent internal angle of friction, $\phi_{equiv.}$	38.0 °
Equivalent cohesion, $c_{equiv.}$	0.0 lb/ft²

Factored bearing capacity resistance of foundation is given: q-ult-static = 29100.0 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) = 0.2973 (eq. 17 is utilized to calculate Ka for all batters)
(For external stability user specified δ = 20.00°)

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

FOR EXTERNAL STABILITY

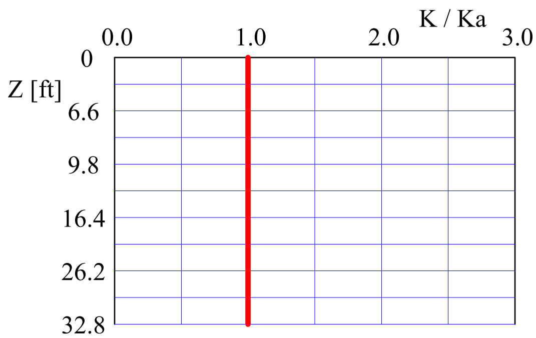
Ka = 0.2973 In Coulomb equation for Ka, Omega was taken as ZERO and backslope inclined at angle I.

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]	4700.0	5900.0	7400.0	4700.0	
Durability reduction factor, RFd	1.30	1.30	1.30	1.30	
Installation-damage reduction factor, RFid	1.12	1.12	1.12	1.12	
Creep reduction factor, RFc	1.45	1.00	1.45	1.45	N/A
CDR for strength	N/A	N/A	N/A	N/A	
Coverage ratio, Rc	1.000	1.000	1.000	0.850	
Friction angle along geogrid-soil interface, ρ	32.00	32.00	32.00	32.00	
Pullout resistance factor, F*	$0.67 \cdot \tan\phi$	$0.67 \cdot \tan\phi$	$0.67 \cdot \tan\phi$	$0.67 \cdot \tan\phi$	N/A
Scale-effect correction factor, α	0.8	0.8	0.8	0.8	

Variation of Lateral Earth Pressure Coefficient With Depth

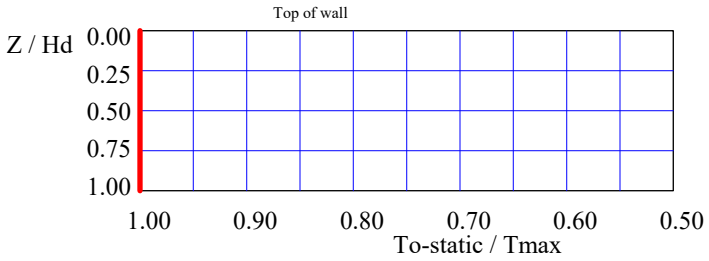
Z	K / Ka
0 ft	1.00
3.3 ft	1.00
6.6 ft	1.00
9.8 ft	1.00
13.1 ft	1.00
16.4 ft	1.00
19.7 ft	1.00



INPUT DATA: Facia and Connection (according to revised Demo 82) (Analysis)

FACIA type: Facing enabling frictional connection of reinforcement (e.g., modular concrete blocks, gabions)
Depth/height of block is 1.50/0.67 ft. Horizontal distance to Center of Gravity of block is: 0.75 ft.
Average unit weight of block is: γ_f = 125.00 lb/ft ³

Z / Hd	To-static / Tmax
0.00	1.00
0.25	1.00
0.50	1.00
0.75	1.00
1.00	1.00



Connection strength, T-lot, is related to T-ult

Geogrid Type #1		Geogrid Type #2		Geogrid Type #3		Geogrid Type #4		Geogrid Type #5	
N-1	Tult-conn	N-2	Tult-conn	N-3	Tult-conn	N-4	Tult-conn	N-5	Tult-conn
0.0	1600.00	0.0	2074.20	0.0	1600.00	0.0	1600.00		
787.0	2037.00	1500.0	2686.65	1695.1	2038.00	787.0	2037.00	N/A	
1535.0	2657.00	2500.0	3094.95	1551.0	2900.00	1535.0	2657.00		
2293.0	3038.00	3500.0	3503.25	2326.4	3157.00	2293.0	3038.00		
4601.0	3105.00	4500.0	3911.55	4615.0	3808.00	4601.0	3105.00		

Geogrid Type #1		Geogrid Type #2		Geogrid Type #3		Geogrid Type #4		Geogrid Type #5	
σ	CRu	σ	CRu	σ	CRu	σ	CRu	σ	CRu
0.0	0.34	0.0	0.35	0.0	0.22	0.0	0.34		
524.7	0.43	1000.0	0.46	516.7	0.28	524.7	0.43	N/A	
1023.3	0.57	1666.7	0.52	1034.0	0.39	1023.3	0.57		
1528.7	0.65	2333.3	0.59	1550.9	0.43	1528.7	0.65		
3067.3	0.66	3000.0	0.66	3076.7	0.51	3067.3	0.66		

(1) σ = Confining stress in between stacked blocks [lb/ft ²]
(2) CRult = Tc-ult / Tult
(3) CRcr = Tcre / Tult

D A T A (for connection only)	Type #1	Type #2	Type #3	Type #4	Type #5
Product Name	5XT	7XT	8XT	5XT-RC	N/A
Connection strength reduction factor, RFd	1.30	1.30	1.30	1.30	N/A
Creep reduction factor, RFc	N/A	N/A	N/A	N/A	N/A

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

Design height, Hd 13.33 [ft] { Embedded depth is E = 2.00 ft, and height above top of finished bottom grade is H = 11.33 ft }

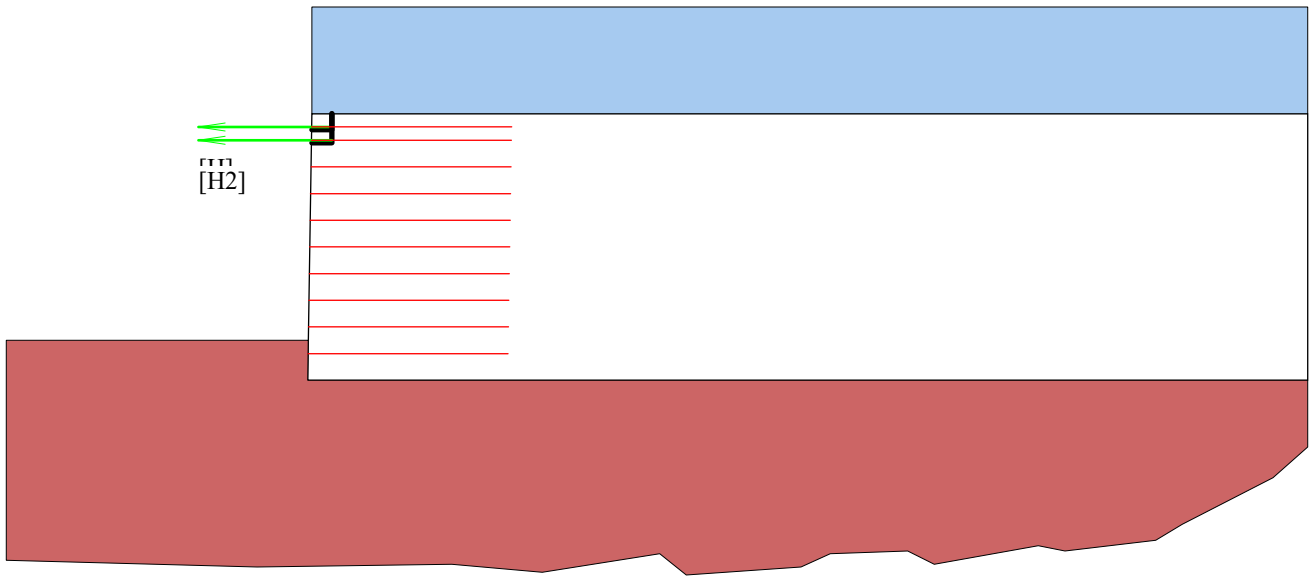
Soil in front of wall is Horizontal.

Batter, ω 0.9 [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 290.0 [lb/ft ²], and live load is 250.0 [lb/ft ²]

OTHER EXTERNAL LOAD(S)
[H1] Horizontal Load, Ph = 2000.0 [lb/ft], acting at a depth of Zh = 0.7 [ft] and at a distance of Lb = 1.0 [ft].
[H2] Horizontal Load, Ph = 500.0 [lb/ft], acting at a depth of Zh = 1.3 [ft] and at a distance of Lb = 1.0 [ft].

ANALYZED REINFORCEMENT LAYOUT:



SCALE:

0 2 4 6 8 10 [ft]

Stiffness Method 2020 – Load and Resisting Factors

INTERNAL STABILITY

Load factor for vertical earth pressure, EV:	$\gamma_{p\text{-}EV}$	1.00
Load factor for prediction of Tmax for the soil failure limit state:	$\gamma_{p\text{-}EVfs}$	1.00
Load factor for earthquake loads, EQ:	$\gamma_{p\text{-}EQ}$	1.00
Load factor for live load surcharge, LS: (Same as in External Stability).	$\gamma_{p\text{-}LS}$	0.50
Load factor for dead load surcharge, ES: (Same as in External Stability).	$\gamma_{p\text{-}ES}$	1.00

Resistance factor for reinforcement tension		Static	Combined static/seismic
Geogrid:	ϕ	1.00	1.00
Resistance factor accounting for uncertainty in measurement of geosynthetic stiffness J at 2% strain	Φ_{sf}	1.000	
Facing stiffness factor (recommended by AASHTO for flexible facing as 1.0)	Φ_{fs}	1.000	

Resistance factor for reinforcement tension in connectors		Static	Combined static/seismic
Geogrid:	ϕ	1.00	1.00
Resistance factor for geosynthetic pullout	ϕ	1.00	1.00

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}):	$(\gamma_{p\text{-}EH})_{EQ}$	1.50
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

ANALYSIS: CALCULATED FACTORS (Static conditions)

Bearing capacity, CDR = 4.32, factored bearing load = 4378 lb/ft².

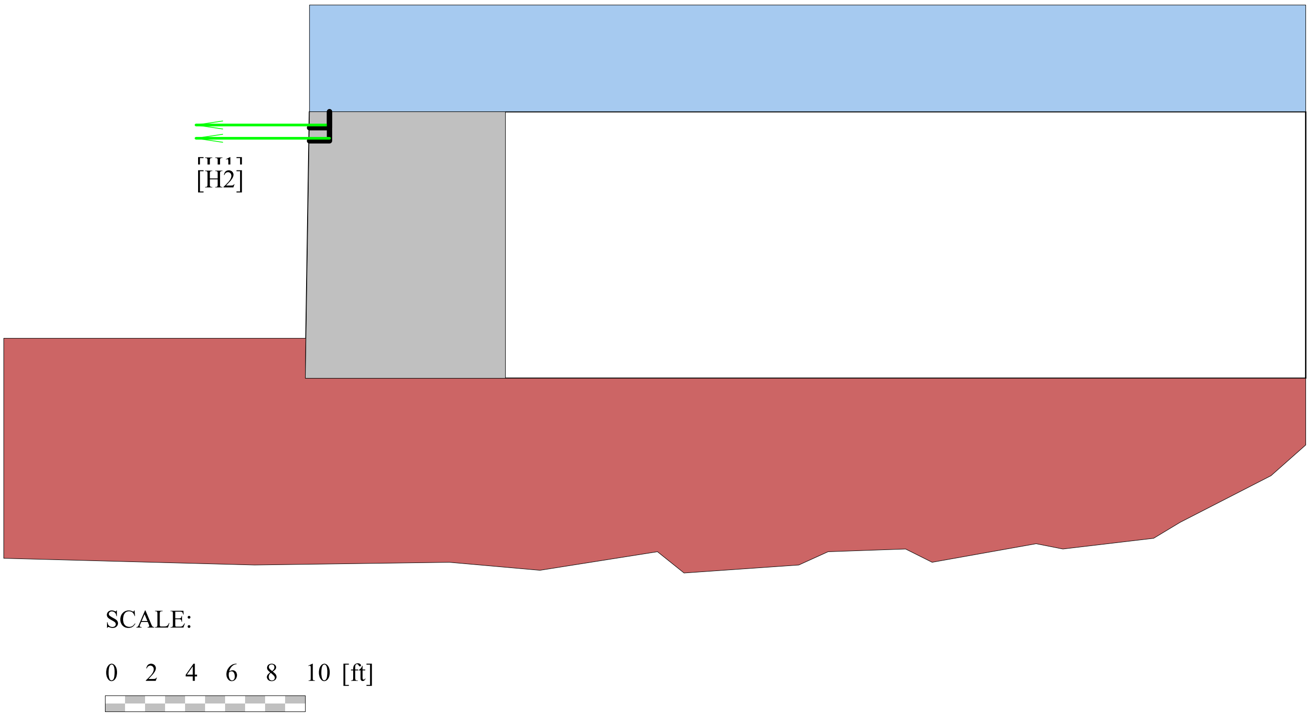
Foundation Interface: Direct sliding, CDR = 2.074, Eccentricity, e/L = 0.2210, CDR-overturning = 2.02

GEOGRID				CONNECTION					
#	Elevation [ft]	Length [ft]	Type #	CDR [connection strength]	Geogrid strength CDR	Pullout resistance CDR	Direct sliding CDR	Eccentricity e/L	Product name
1	1.33	10.00	2	5.79	10.196	36.524	1.703	0.2012	7XT
2	2.67	10.00	2	7.53	13.727	41.554	1.741	0.1825	7XT
3	4.00	10.00	2	7.29	13.765	34.678	1.766	0.1648	7XT
4	5.33	10.00	2	7.00	13.727	28.232	1.772	0.1477	7XT
5	6.67	10.00	2	6.99	14.250	23.313	1.749	0.1305	7XT
6	8.00	10.00	2	7.36	15.630	19.761	1.684	0.1127	7XT
7	9.33	10.00	2	7.86	17.403	16.300	1.562	0.0922	7XT
8	10.67	10.00	2	7.43	17.178	11.200	1.366	0.0651	7XT
9	12.00	10.00	2	1.51	3.664	1.519	1.087	0.0222	7XT
10	12.67	10.00	2	2.34	5.789	1.806	27.188	-0.0133	7XT

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

	STATIC	SEISMIC	UNITS
(Given factored bearing resistance, q-n)			
Factored bearing resistance. q-n	18915	N/A	[lb/ft ²]
Factored bearing load, σ_V	4378.5	N/A	[lb/ft ²]
Eccentricity, e	1.65	N/A	[ft]
Eccentricity, e/L	0.165	N/A	
CDR calculated	4.32	N/A	
Base length	10.00	N/A	[ft]

Unfactored applied bearing pressure = (Unfactored R) / [L - 2 * (Unfactored e)] =
Unfactored R = 24205.39 [lb/ft], L = 10.00, Unfactored e = 1.95 [ft], and Sigma = 3962.94 [lb/ft ²]



Stiffness Method 2020
Ravensdale Creek Fish Passage

MSEW+: Update # 2021.20

PROJECT IDENTIFICATION

Title: Ravensdale Creek Fish Passage
Project Number: 2496.01
Client: Basalite
Designer: RAR
Station Number: SW Wall Sta. 0+00

Description:

Temporary crane loading for girder pics.

Company's information:

Name: Zipper Geo Associates, LLC
Street: 19019 36th Ave. W. Ste. E

Lynnwood, WA 98036
Telephone #: 425-582-9928
Fax #:
E-Mail: rross@zippergeo.com

File path and name: Z:\Projects\2451 - 2500\2496 Ravensdale Creek GRS-IBS S..... .....00 (TEMP CRANE).BENp

Original date and time of creating this file: Mon Mar 29 16:56:42 2021

PROGRAM MODE:

ANALYSIS
of a SIMPLE STRUCTURE
using GEOGRID as reinforcing material.

SOIL DATA

REINFORCED SOIL

Unit weight, γ	130.0 lb/ft ³
Design value of internal angle of friction, ϕ	38.0 °

RETAINED SOIL

Unit weight, γ	115.0 lb/ft ³
Design value of internal angle of friction, ϕ	30.0 °

FOUNDATION SOIL (Considered as an equivalent uniform soil)

Equivalent unit weight, $\gamma_{equiv.}$	130.0 lb/ft ³
Equivalent internal angle of friction, $\phi_{equiv.}$	38.0 °
Equivalent cohesion, $c_{equiv.}$	0.0 lb/ft ²

Factored bearing capacity resistance of foundation is given: q-ult-static = 29100.0 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) = 0.2973 (eq. 17 is utilized to calculate Ka for all batters)
(For external stability user specified δ = 20.00°)

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

FOR EXTERNAL STABILITY

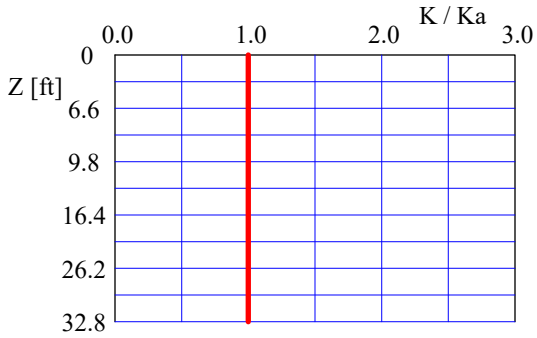
Ka = 0.2973 In Coulomb equation for Ka, Omega was taken as ZERO and backslope inclined at angle I.

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]	4700.0	5900.0	7400.0	4700.0	
Durability reduction factor, RFd	1.30	1.30	1.30	1.30	
Installation-damage reduction factor, RFid	1.12	1.12	1.12	1.12	
Creep reduction factor, RFc	1.45	1.00	1.45	1.45	N/A
CDR for strength	N/A	N/A	N/A	N/A	
Coverage ratio, Rc	1.000	1.000	1.000	0.850	
Friction angle along geogrid-soil interface, ρ	32.00	32.00	32.00	32.00	
Pullout resistance factor, F*	$0.67 \cdot \tan\phi$	$0.67 \cdot \tan\phi$	$0.67 \cdot \tan\phi$	$0.67 \cdot \tan\phi$	N/A
Scale-effect correction factor, α	0.8	0.8	0.8	0.8	

Variation of Lateral Earth Pressure Coefficient With Depth

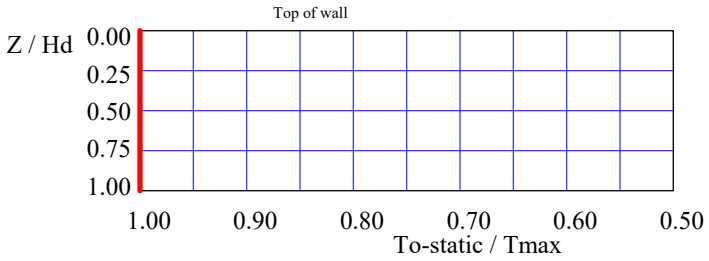
Z	K / Ka
0 ft	1.00
3.3 ft	1.00
6.6 ft	1.00
9.8 ft	1.00
13.1 ft	1.00
16.4 ft	1.00
19.7 ft	1.00



INPUT DATA: Facia and Connection (according to revised Demo 82) (Analysis)

FACIA type: Facing enabling frictional connection of reinforcement (e.g., modular concrete blocks, gabions)
Depth/height of block is 1.50/0.67 ft. Horizontal distance to Center of Gravity of block is: 0.75 ft.
Average unit weight of block is: γ_f = 125.00 lb/ft ³

Z / Hd	To-static / Tmax
0.00	1.00
0.25	1.00
0.50	1.00
0.75	1.00
1.00	1.00



Connection strength, T-lot, is related to T-ult

Geogrid Type #1		Geogrid Type #2		Geogrid Type #3		Geogrid Type #4		Geogrid Type #5	
N-1	Tult-conn	N-2	Tult-conn	N-3	Tult-conn	N-4	Tult-conn	N-5	Tult-conn
0.0	1600.00	0.0	2074.20	0.0	1600.00	0.0	1600.00		
787.0	2037.00	1500.0	2686.65	1695.1	2038.00	787.0	2037.00	N/A	
1535.0	2657.00	2500.0	3094.95	1551.0	2900.00	1535.0	2657.00		
2293.0	3038.00	3500.0	3503.25	2326.4	3157.00	2293.0	3038.00		
4601.0	3105.00	4500.0	3911.55	4615.0	3808.00	4601.0	3105.00		

Geogrid Type #1		Geogrid Type #2		Geogrid Type #3		Geogrid Type #4		Geogrid Type #5	
σ	CRu	σ	CRu	σ	CRu	σ	CRu	σ	CRu
0.0	0.34	0.0	0.35	0.0	0.22	0.0	0.34		
524.7	0.43	1000.0	0.46	516.7	0.28	524.7	0.43	N/A	
1023.3	0.57	1666.7	0.52	1034.0	0.39	1023.3	0.57		
1528.7	0.65	2333.3	0.59	1550.9	0.43	1528.7	0.65		
3067.3	0.66	3000.0	0.66	3076.7	0.51	3067.3	0.66		

(1) σ = Confining stress in between stacked blocks [lb/ft ²]
(2) CRult = Tc-ult / Tult
(3) CRcr = Tcre / Tult

D A T A (for connection only)	Type #1	Type #2	Type #3	Type #4	Type #5
Product Name	5XT	7XT	8XT	5XT-RC	N/A
Connection strength reduction factor, RFd	1.30	1.30	1.30	1.30	N/A
Creep reduction factor, RFc	N/A	N/A	N/A	N/A	N/A

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

Design height, Hd 13.33 [ft] { Embedded depth is E = 2.00 ft, and height above top of finished bottom grade is H = 11.33 ft }

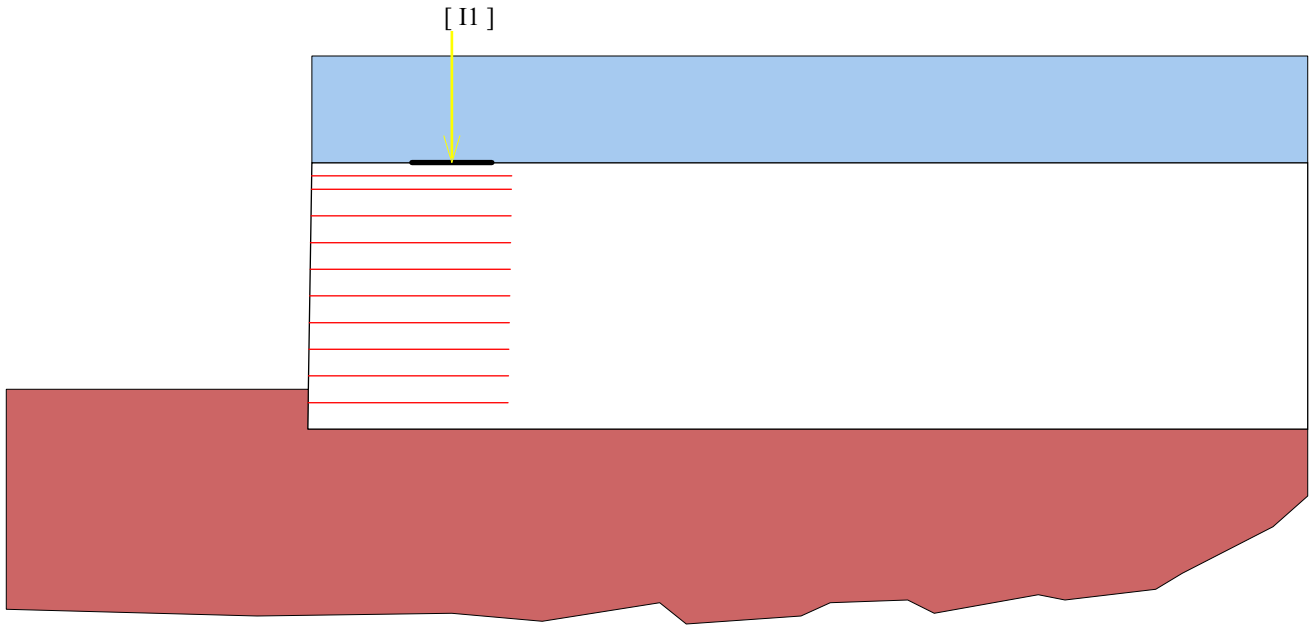
Soil in front of wall is Horizontal.

Batter, ω 0.9 [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 290.0 [lb/ft ²]

OTHER EXTERNAL LOAD(S)
[I1] Isolated Load, Pv-d' = 0.0 and Pv-l' = 30000.0 [lb]. Length of footing, L = 4.0 [ft], and width, b = 4.0 [ft]. Distance of center of footing from wall face, d = 7.0 [ft] @ depth of 0.0 [ft] below soil surface.

ANALYZED REINFORCEMENT LAYOUT:



SCALE:

0 2 4 6 8 10 [ft]

Stiffness Method 2020 – Load and Resisting Factors

INTERNAL STABILITY

Load factor for vertical earth pressure, EV:	$\gamma_{p\text{-}EV}$	1.35
Load factor for prediction of Tmax for the soil failure limit state:	$\gamma_{p\text{-}EVfs}$	1.20
Load factor for earthquake loads, EQ:	$\gamma_{p\text{-}EQ}$	1.00
Load factor for live load surcharge, LS: (Same as in External Stability).	$\gamma_{p\text{-}LS}$	1.50
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:		0.80		1.00
Resistance factor accounting for uncertainty in measurement of geosynthetic stiffness J at 2% strain	Φ_{sf}	1.000		
Facing stiffness factor (recommended by AASHTO for flexible facing as 1.0)	Φ_{fs}	1.000		

Resistance factor for reinforcement tension in connectors	ϕ	Static	Combined static/seismic	
Geogrid:		0.80		1.00
Resistance factor for geosynthetic pullout	ϕ	0.70		1.00

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}):	$(\gamma_{p\text{-}EH})_{EQ}$	1.50
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

ANALYSIS: CALCULATED FACTORS (Static conditions)

Bearing capacity, CDR = 5.08, factored bearing load = 3723 lb/ft².

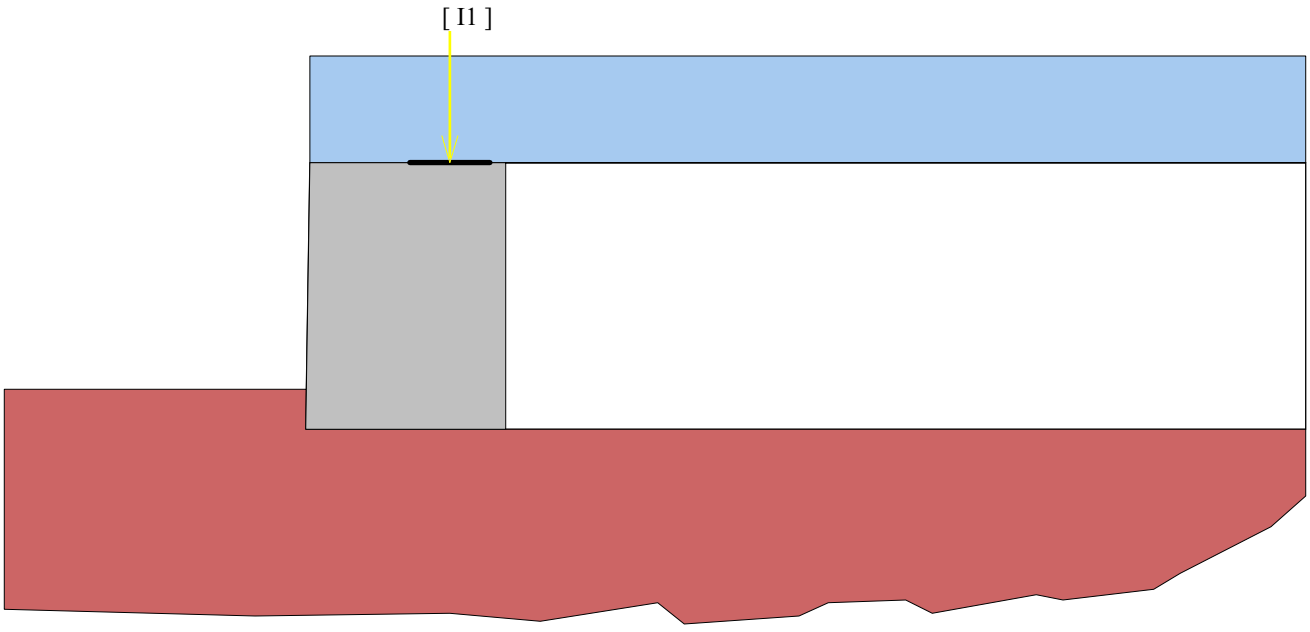
Foundation Interface: Direct sliding, CDR = 2.930, Eccentricity, e/L = 0.0808, CDR-overturning = 4.11

GEOGRID #	Elevation [ft]	Length [ft]	Type #	CONNECTION CDR [connection strength]	Geogrid strength CDR	Pullout resistance CDR	Direct sliding CDR	Eccentricity e/L	Product name
1	1.33	10.00	2	3.33	5.863	21.305	2.548	0.0630	7XT
2	2.67	10.00	2	4.24	7.721	23.936	2.798	0.0470	7XT
3	4.00	10.00	2	4.01	7.568	19.973	3.108	0.0329	7XT
4	5.33	10.00	2	3.72	7.285	16.262	3.507	0.0207	7XT
5	6.67	10.00	2	3.52	7.180	13.485	4.048	0.0105	7XT
6	8.00	10.00	2	3.42	7.250	11.555	4.812	0.0025	7XT
7	9.33	10.00	2	3.21	7.107	9.676	6.009	-0.0032	7XT
8	10.67	10.00	2	2.86	6.623	7.775	8.249	-0.0063	7XT
9	12.00	10.00	2	3.04	7.361	7.259	14.364	-0.0061	7XT
10	12.67	10.00	2	2.46	6.099	6.429	26.092	-0.0041	7XT

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

	STATIC	SEISMIC	UNITS
(Given factored bearing resistance, q-n)			
Factored bearing resistance. q-n	18915	N/A	[lb/ft ²]
Factored bearing load, σ_V	3722.9	N/A	[lb/ft ²]
Eccentricity, e	0.02	N/A	[ft]
Eccentricity, e/L	0.002	N/A	
CDR calculated	5.08	N/A	
Base length	10.00	N/A	[ft]

Unfactored applied bearing pressure = (Unfactored R) / [L - 2 * (Unfactored e)] =
Unfactored R = 28918.86 [lb/ft], L = 10.00, Unfactored e = -0.17 [ft], and Sigma = 2996.35 [lb/ft ²]



SCALE:

0 2 4 6 8 10 [ft]

RESULTS for STRENGTH

Live Load included in calculating Tmax

#	Geogrid Elevation [ft]		Limit State Tmax [lb/ft]	Service Limit Tmax [lb/ft]	Reinf. Strain Static [%]	Tmd [lb/ft]	Specified minimum CDR Static	Actual calculated CDR Static	Specified minimum CDR seismic	Actual calculated CDR seismic	Product name
1	1.33	3241.8	552.9	428.62	1.323	N/A	N/A	5.863	N/A	N/A	7XT
2	2.67	3241.8	419.9	328.93	1.015	N/A	N/A	7.721	N/A	N/A	7XT
3	4.00	3241.8	428.4	334.51	1.032	N/A	N/A	7.568	N/A	N/A	7XT
4	5.33	3241.8	445.0	345.67	1.067	N/A	N/A	7.285	N/A	N/A	7XT
5	6.67	3241.8	451.5	346.75	1.070	N/A	N/A	7.180	N/A	N/A	7XT
6	8.00	3241.8	447.2	336.49	1.039	N/A	N/A	7.250	N/A	N/A	7XT
7	9.33	3241.8	456.1	334.40	1.032	N/A	N/A	7.107	N/A	N/A	7XT
8	10.67	3241.8	489.4	348.45	1.075	N/A	N/A	6.623	N/A	N/A	7XT
9	12.00	3241.8	440.4	306.58	0.946	N/A	N/A	7.361	N/A	N/A	7XT
10	12.67	3241.8	531.5	362.04	1.117	N/A	N/A	6.099	N/A	N/A	7XT

Stiffness Method 2020
Ravensdale Creek Fish Passage

MSEW+: Update # 2021.20

PROJECT IDENTIFICATION

Title: Ravensdale Creek Fish Passage
Project Number: 2496.01
Client: Basalite
Designer: RAR
Station Number: SW Wall Sta. 0+37

Description:

Strengh and Extreme I

Company's information:

Name: Zipper Geo Associates, LLC
Street: 19019 36th Ave. W. Ste. E

Lynnwood, WA 98036
Telephone #: 425-582-9928
Fax #:
E-Mail: rross@zippergeo.com

File path and name: Z:\Projects\2451 - 2500\2496 Ravensdale Creek GRS-IBS S..... ..... Wall Sta. 0+37.BENp

Original date and time of creating this file: Mon Mar 29 16:56:42 2021

PROGRAM MODE:

ANALYSIS
of a SIMPLE STRUCTURE
using GEOGRID as reinforcing material.

SOIL DATA

REINFORCED SOIL

Unit weight, γ	130.0 lb/ft ^{3}
Design value of internal angle of friction, ϕ	38.0 °

RETAINED SOIL

Unit weight, γ	115.0 lb/ft ^{3}
Design value of internal angle of friction, ϕ	30.0 °

FOUNDATION SOIL (Considered as an equivalent uniform soil)

Equivalent unit weight, $\gamma_{equiv.}$	130.0 lb/ft ^{3}
Equivalent internal angle of friction, $\phi_{equiv.}$	30.0 °
Equivalent cohesion, $c_{equiv.}$	0.0 lb/ft ^{2}

Factored bearing capacity resistance of foundation is given: q-ult-static = 9000.0 lb/ft^2., q-ult-sesmic = 9000.0 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) = 0.2973 (eq. 17 is utilized to calculate Ka for all batters)
(For external stability user specified δ = 20.00°)

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 = 0.440 and Site Factor, Fpga = 1.000. Maximum ground acceleration coeff., As = 0.440
Design acceleration coefficient in Internal Stability: Kh = Am = 0.220
Design acceleration coefficient in External Stability: Kh_d = 0.220 => Kh = Am = 0.220
Kh(ext.) (Displ. >1" AASHTO 11.6.5.2.2)

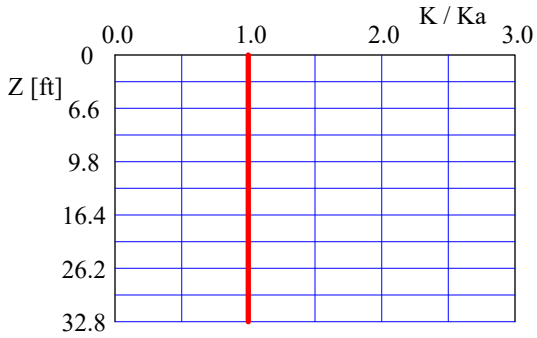
Ka = 0.2973   Kae = 0.4747   In Coulomb equation for Ka, Omega was taken as ZERO and backslope inclined at angle I.
In M-O equation for Kae, Omega is always set to ZERO.
Seismic soil-geogrid friction coefficient, F* is 80.0% of its specified static value.

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]	4700.0	5900.0	7400.0	4700.0	
Durability reduction factor, RFd	1.30	1.30	1.30	1.30	
Installation-damage reduction factor, RFid	1.12	1.12	1.12	1.12	
Creep reduction factor, RFc	1.45	1.45	1.45	1.45	N/A
CDR for strength	N/A	N/A	N/A	N/A	
Coverage ratio, Rc	1.000	1.000	1.000	0.850	
Friction angle along geogrid-soil interface, ρ	32.00	32.00	32.00	32.00	
Pullout resistance factor, F*	$0.67 \cdot \tan\phi$	$0.67 \cdot \tan\phi$	$0.67 \cdot \tan\phi$	$0.67 \cdot \tan\phi$	N/A
Scale-effect correction factor, α	0.8	0.8	0.8	0.8	

Variation of Lateral Earth Pressure Coefficient With Depth

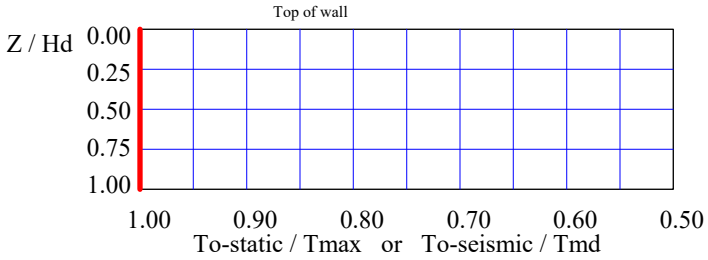
Z	K / Ka
0 ft	1.00
3.3 ft	1.00
6.6 ft	1.00
9.8 ft	1.00
13.1 ft	1.00
16.4 ft	1.00
19.7 ft	1.00



INPUT DATA: Facia and Connection (according to revised Demo 82) (Analysis)

FACIA type: Facing enabling frictional connection of reinforcement (e.g., modular concrete blocks, gabions)
Depth/height of block is 1.50/0.67 ft. Horizontal distance to Center of Gravity of block is: 0.75 ft.
Average unit weight of block is: γ_f = 125.00 lb/ft ³

Z / Hd	To-static / Tmax or To-seismic / Tmd
0.00	1.00
0.25	1.00
0.50	1.00
0.75	1.00
1.00	1.00



Connection strength, T-lot, is related to T-ult

Geogrid Type #1		Geogrid Type #2		Geogrid Type #3		Geogrid Type #4		Geogrid Type #5	
N-1	Tult-conn	N-2	Tult-conn	N-3	Tult-conn	N-4	Tult-conn	N-5	Tult-conn
0.0	1600.00	0.0	2074.20	0.0	1600.00	0.0	1600.00		
787.0	2037.00	1500.0	2686.65	1695.1	2038.00	787.0	2037.00	N/A	
1535.0	2657.00	2500.0	3094.95	1551.0	2900.00	1535.0	2657.00		
2293.0	3038.00	3500.0	3503.25	2326.4	3157.00	2293.0	3038.00		
4601.0	3105.00	4500.0	3911.55	4615.0	3808.00	4601.0	3105.00		

Geogrid Type #1		Geogrid Type #2		Geogrid Type #3		Geogrid Type #4		Geogrid Type #5	
σ	CRu	σ	CRu	σ	CRu	σ	CRu	σ	CRu
0.0	0.34	0.0	0.35	0.0	0.22	0.0	0.34		
524.7	0.43	1000.0	0.46	516.7	0.28	524.7	0.43	N/A	
1023.3	0.57	1666.7	0.52	1034.0	0.39	1023.3	0.57		
1528.7	0.65	2333.3	0.59	1550.9	0.43	1528.7	0.65		
3067.3	0.66	3000.0	0.66	3076.7	0.51	3067.3	0.66		

(1) σ = Confining stress in between stacked blocks [lb/ft ²]
(2) CRult = Tc-ult / Tult
(3) CRcr = Tcre / Tult

In seismic analysis, long term strength is reduced to 80% of its static value.

D A T A (for connection only)	Type #1	Type #2	Type #3	Type #4	Type #5
Product Name	5XT	7XT	8XT	5XT-RC	N/A
Connection strength reduction factor, RFd	1.30	1.30	1.30	1.30	N/A
Creep reduction factor, RFc	N/A	N/A	N/A	N/A	N/A

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

Design height, Hd 8.00 [ft] { Embedded depth is E = 2.00 ft, and height above top of finished bottom grade is H = 6.00 ft }

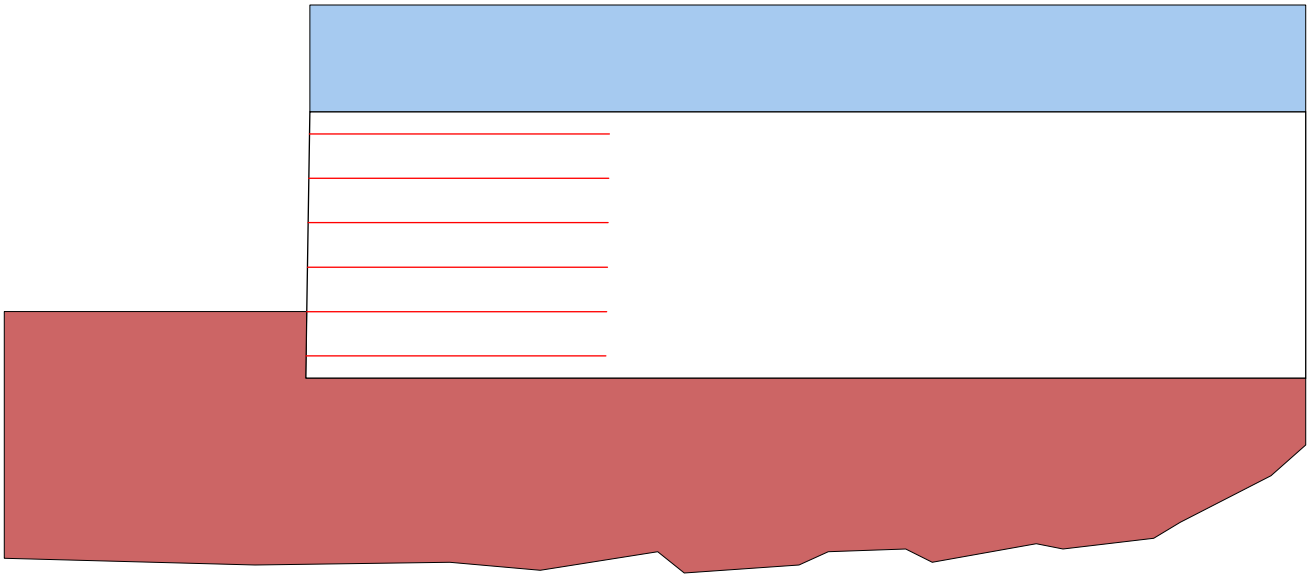
Soil in front of wall is Horizontal.

Batter, ω 0.9 [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 290.0 [lb/ft ²], and live load is 250.0 [lb/ft ²]

ANALYZED REINFORCEMENT LAYOUT:



SCALE:

0 2 4 6 [ft]

Stiffness Method 2020 – Load and Resisting Factors

INTERNAL STABILITY

Load factor for vertical earth pressure, EV:	$\gamma_{p\text{-}EV}$	1.35	
Load factor for prediction of Tmax for the soil failure limit state:	$\gamma_{p\text{-}EVfs}$	1.20	
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:		0.80	1.00
Resistance factor accounting for uncertainty in measurement of geosynthetic stiffness J at 2% strain	Φ_{sf}	1.000	
Facing stiffness factor (recommended by AASHTO for flexible facing as 1.0)	Φ_{fs}	1.000	
Resistance factor for reinforcement tension in connectors	ϕ	Static	Combined static/seismic
Geogrid:		0.80	1.00
Resistance factor for geosynthetic pullout	ϕ	0.70	1.00

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}):	$(\gamma_{p\text{-}EH})_{EQ}$	1.50
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

ANALYSIS: CALCULATED FACTORS (Static conditions)

Bearing capacity, CDR = 2.31, factored bearing load = 2535 lb/ft².

Foundation Interface: Direct sliding, CDR = 2.172, Eccentricity, e/L = 0.0485, CDR-overturning = 5.48

GEOGRID #	Elevation [ft]	Length [ft]	Type #	CONNECTION CDR [connection strength]	Geogrid strength CDR	Pullout resistance CDR	Direct sliding CDR	Eccentricity e/L	Product name
1	0.67	9.00	2	2.72	5.431	15.368	2.478	0.0388	7XT
2	2.00	9.00	2	2.62	5.448	12.313	2.793	0.0216	7XT
3	3.33	9.00	2	2.51	5.431	9.489	3.243	0.0072	7XT
4	4.67	9.00	2	2.51	5.678	7.314	3.980	-0.0038	7XT
5	6.00	9.00	2	2.67	6.316	5.618	5.511	-0.0100	7XT
6	7.33	9.00	2	2.87	7.122	3.902	12.393	-0.0078	7XT

ANALYSIS: CALCULATED FACTORS (Seismic conditions)

Bearing capacity, CDR = 2.76, factored bearing load = 2937 lb/ft².

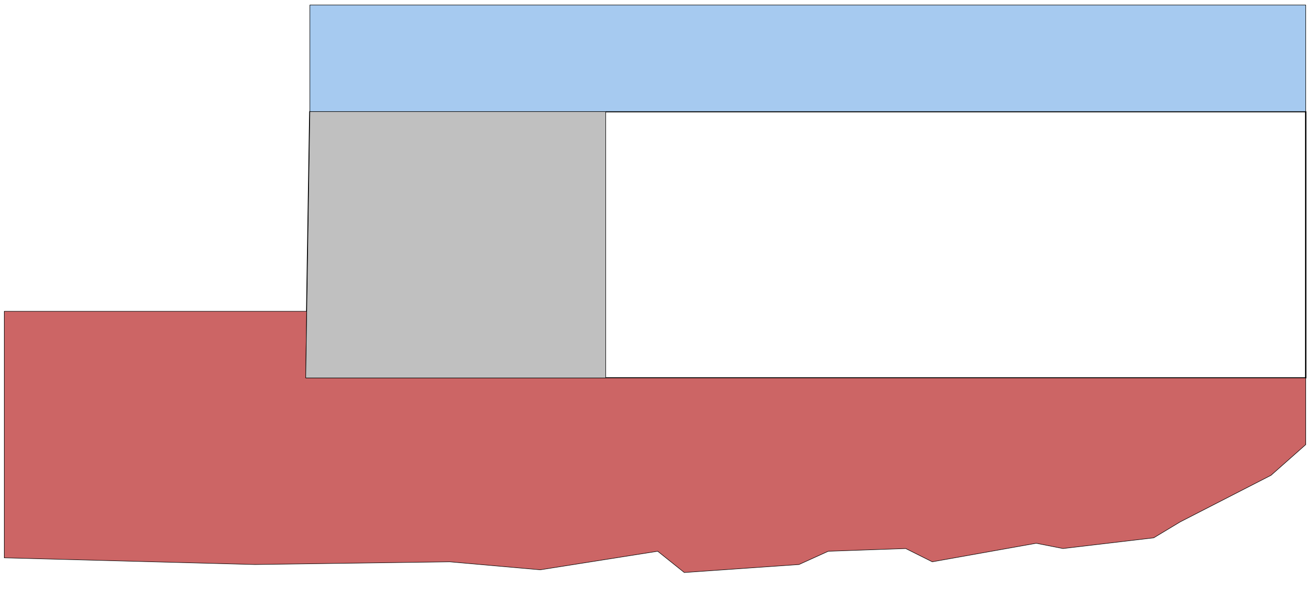
Foundation Interface: Direct sliding, CDR = 1.727, Eccentricity, e/L = 0.1706, Fs-overturning = 3.07

GEOGRID #	Elevation [ft]	Length [ft]	Type #	CONNECTION CDR [connection strength]	Geogrid strength CDR	Pullout resistance CDR	Direct sliding CDR	Eccentricity e/L	Product name
1	0.67	9.00	2	2.85	7.119	16.740	1.990	0.1518	7XT
2	2.00	9.00	2	2.75	7.137	13.399	2.294	0.1164	7XT
3	3.33	9.00	2	2.63	7.119	10.336	2.738	0.0837	7XT
4	4.67	9.00	2	2.61	7.369	7.862	3.477	0.0539	7XT
5	6.00	9.00	2	2.70	7.989	5.840	5.026	0.0280	7XT
6	7.33	9.00	2	2.82	8.730	3.893	11.959	0.0071	7XT

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

	STATIC	SEISMIC	UNITS
(Given factored bearing resistance, q-n)			
Factored bearing resistance. q-n	5850	8100	[lb/ft ²]
Factored bearing load, σ_V	2534.5	2937	[lb/ft ²]
Eccentricity, e	0.25	0.60	[ft]
Eccentricity, e/L	0.027	0.067	
CDR calculated	2.31	2.76	
Base length	9.00	9.00	[ft]

Unfactored applied bearing pressure = (Unfactored R) / [L - 2 * (Unfactored e)] =
Static: Unfactored R = 14900.28 [lb/ft], L = 9.00, Unfactored e = 0.22 [ft], and Sigma = 1741.73 [lb/ft ²]
Seismic: Unfactored R = 15339.56 [lb/ft], L = 9.00, Unfactored e = 0.53 [ft], and Sigma = 1932.32 [lb/ft ²]



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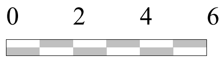


RESULTS for STRENGTH

Live Load included in calculating Tmax

#	Geogrid Elevation [ft]	Factored: Static/Seismic	Limit State Tmax [lb/ft]	Service Limit Tmax [lb/ft]	Reinf. Strain Stat./Seism [%]	Tmd [lb/ft]	Specified minimum CDR Static	Actual calculated CDR Static	Specified minimum CDR seismic	Actual calculated CDR seismic	Product name
1	0.67	2236/2795	412/305	291.13	0.899/1.291	127.00	N/A	5.431	N/A	7.119	7XT
2	2.00	2236/2795	410/304	290.27	0.896/1.288	127.00	N/A	5.448	N/A	7.137	7XT
3	3.33	2236/2795	412/305	291.13	0.899/1.291	127.00	N/A	5.431	N/A	7.119	7XT
4	4.67	2236/2795	394/292	275.17	0.849/1.241	127.00	N/A	5.678	N/A	7.369	7XT
5	6.00	2236/2795	354/262	240.13	0.741/1.133	127.00	N/A	6.316	N/A	7.989	7XT
6	7.33	2236/2795	314/233	204.22	0.630/1.022	127.00	N/A	7.122	N/A	8.730	7XT

Stiffness Method 2020
Ravensdale Creek Fish Passage

MSEW+: Update # 2021.20

PROJECT IDENTIFICATION

Title:	Ravensdale Creek Fish Passage
Project Number:	2496.01
Client:	Basalite
Designer:	RAR
Station Number:	SW Wall Sta. 0+37

Description:

Exteme II Limit State

Company's information:

Name: Zipper Geo Associates, LLC
Street: 19019 36th Ave. W. Ste. E

Lynnwood, WA 98036
Telephone #: 425-582-9928
Fax #:
E-Mail: rross@zippergeo.com

File path and name: Z:\Projects\2451 - 2500\2496 Ravensdale Creek GRS-IBS S.....
.....37 (Extreme II).BENp

Original date and time of creating this file: Mon Mar 29 16:56:42 2021

PROGRAM MODE:

ANALYSIS
of a SIMPLE STRUCTURE
using GEOGRID as reinforcing material.

SOIL DATA

REINFORCED SOIL

Unit weight, γ	130.0 lb/ft ³
Design value of internal angle of friction, ϕ	38.0 °

RETAINED SOIL

Unit weight, γ	115.0 lb/ft ³
Design value of internal angle of friction, ϕ	30.0 °

FOUNDATION SOIL (Considered as an equivalent uniform soil)

Equivalent unit weight, $\gamma_{equiv.}$	130.0 lb/ft ³
Equivalent internal angle of friction, $\phi_{equiv.}$	30.0 °
Equivalent cohesion, $c_{equiv.}$	0.0 lb/ft ²

Factored bearing capacity resistance of foundation is given: q-ult-static = 9000.0 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) = 0.2973 (eq. 17 is utilized to calculate Ka for all batters)
(For external stability user specified δ = 20.00°)

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

FOR EXTERNAL STABILITY

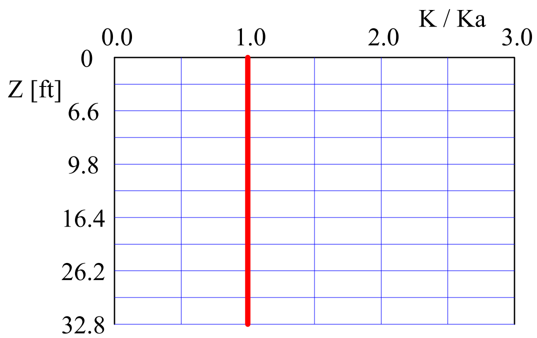
Ka = 0.2973 In Coulomb equation for Ka, Omega was taken as ZERO and backslope inclined at angle I.

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]	4700.0	5900.0	7400.0	4700.0	
Durability reduction factor, RFd	1.30	1.30	1.30	1.30	
Installation-damage reduction factor, RFid	1.12	1.12	1.12	1.12	
Creep reduction factor, RFc	1.45	1.00	1.45	1.45	N/A
CDR for strength	N/A	N/A	N/A	N/A	
Coverage ratio, Rc	1.000	1.000	1.000	0.850	
Friction angle along geogrid-soil interface, ρ	32.00	32.00	32.00	32.00	
Pullout resistance factor, F*	$0.67 \cdot \tan\phi$	$0.67 \cdot \tan\phi$	$0.67 \cdot \tan\phi$	$0.67 \cdot \tan\phi$	N/A
Scale-effect correction factor, α	0.8	0.8	0.8	0.8	

Variation of Lateral Earth Pressure Coefficient With Depth

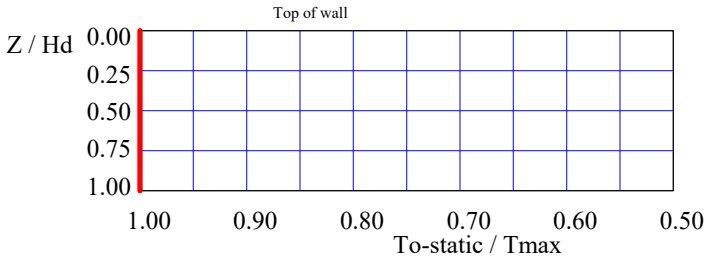
Z	K / Ka
0 ft	1.00
3.3 ft	1.00
6.6 ft	1.00
9.8 ft	1.00
13.1 ft	1.00
16.4 ft	1.00
19.7 ft	1.00



INPUT DATA: Facia and Connection (according to revised Demo 82) (Analysis)

FACIA type: Facing enabling frictional connection of reinforcement (e.g., modular concrete blocks, gabions)
Depth/height of block is 1.50/0.67 ft. Horizontal distance to Center of Gravity of block is: 0.75 ft.
Average unit weight of block is: γ_f = 125.00 lb/ft ³

Z / Hd	To-static / Tmax
0.00	1.00
0.25	1.00
0.50	1.00
0.75	1.00
1.00	1.00



Connection strength, T-lot, is related to T-ult

Geogrid Type #1		Geogrid Type #2		Geogrid Type #3		Geogrid Type #4		Geogrid Type #5	
N-1	Tult-conn	N-2	Tult-conn	N-3	Tult-conn	N-4	Tult-conn	N-5	Tult-conn
0.0	1600.00	0.0	2074.20	0.0	1600.00	0.0	1600.00		
787.0	2037.00	1500.0	2686.65	1695.1	2038.00	787.0	2037.00	N/A	
1535.0	2657.00	2500.0	3094.95	1551.0	2900.00	1535.0	2657.00		
2293.0	3038.00	3500.0	3503.25	2326.4	3157.00	2293.0	3038.00		
4601.0	3105.00	4500.0	3911.55	4615.0	3808.00	4601.0	3105.00		

Geogrid Type #1		Geogrid Type #2		Geogrid Type #3		Geogrid Type #4		Geogrid Type #5	
σ	CRu	σ	CRu	σ	CRu	σ	CRu	σ	CRu
0.0	0.34	0.0	0.35	0.0	0.22	0.0	0.34		
524.7	0.43	1000.0	0.46	516.7	0.28	524.7	0.43	N/A	
1023.3	0.57	1666.7	0.52	1034.0	0.39	1023.3	0.57		
1528.7	0.65	2333.3	0.59	1550.9	0.43	1528.7	0.65		
3067.3	0.66	3000.0	0.66	3076.7	0.51	3067.3	0.66		

(1) σ = Confining stress in between stacked blocks [lb/ft ²]
(2) CRult = Tc-ult / Tult
(3) CRcr = Tcre / Tult

D A T A (for connection only)	Type #1	Type #2	Type #3	Type #4	Type #5
Product Name	5XT	7XT	8XT	5XT-RC	N/A
Connection strength reduction factor, RFd	1.30	1.30	1.30	1.30	N/A
Creep reduction factor, RFc	N/A	N/A	N/A	N/A	N/A

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

Design height, Hd 8.00 [ft] { Embedded depth is E = 2.00 ft, and height above top of finished bottom grade is H = 6.00 ft }

Soil in front of wall is Horizontal.

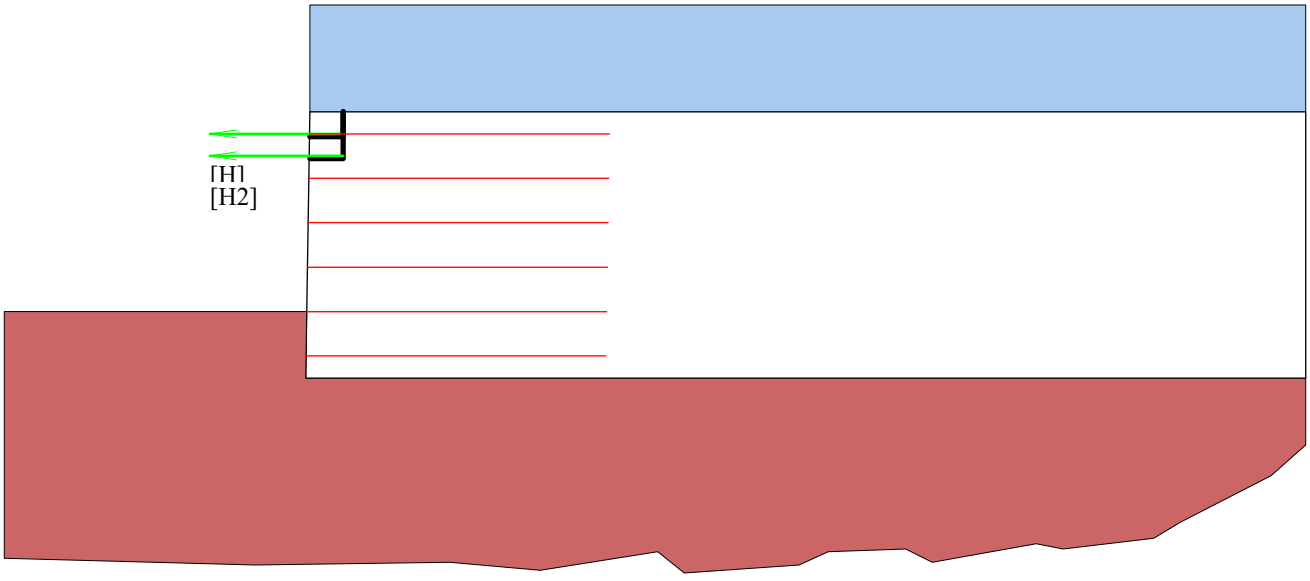
Batter, ω 0.9 [deg]
Backslope, β 0.0 [deg]
Backslope rise 0.0 [ft] Broken back equivalent angle, I = 0.00° (see Fig. 25 in DEMO 82)

U N I F O R M S U R C H A R G E

Uniformly distributed dead load is 290.0 [lb/ft ²], and live load is 250.0 [lb/ft ²]

OTHER EXTERNAL LOAD(S)
[H1] Horizontal Load, Ph = 2000.0 [lb/ft], acting at a depth of Zh = 0.7 [ft] and at a distance of Lb = 1.0 [ft].
[H2] Horizontal Load, Ph = 500.0 [lb/ft], acting at a depth of Zh = 1.3 [ft] and at a distance of Lb = 1.0 [ft].

ANALYZED REINFORCEMENT LAYOUT:



SCALE:

0 2 4 6 [ft]

Stiffness Method 2020 – Load and Resisting Factors

INTERNAL STABILITY

Load factor for vertical earth pressure, EV:	$\gamma_{p\text{-}EV}$	1.00
Load factor for prediction of Tmax for the soil failure limit state:	$\gamma_{p\text{-}EVfs}$	1.00
Load factor for earthquake loads, EQ:	$\gamma_{p\text{-}EQ}$	1.00
Load factor for live load surcharge, LS: (Same as in External Stability).	$\gamma_{p\text{-}LS}$	0.50
Load factor for dead load surcharge, ES: (Same as in External Stability).	$\gamma_{p\text{-}ES}$	1.00

Resistance factor for reinforcement tension		Static	Combined static/seismic
Geogrid:	ϕ	1.00	1.00
Resistance factor accounting for uncertainty in measurement of geosynthetic stiffness J at 2% strain	Φ_{sf}	1.000	
Facing stiffness factor (recommended by AASHTO for flexible facing as 1.0)	Φ_{fs}	1.000	

Resistance factor for reinforcement tension in connectors		Static	Combined static/seismic
Geogrid:	ϕ	1.00	1.00
Resistance factor for geosynthetic pullout	ϕ	1.00	1.00

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}):	$(\gamma_{p\text{-}EH})_{EQ}$	1.50
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

ANALYSIS: CALCULATED FACTORS (Static conditions)

Bearing capacity, CDR = 2.23, factored bearing load = 2623 lb/ft².
Foundation Interface: Direct sliding, CDR = 1.483, Eccentricity, e/L = 0.1855, CDR-overturning = 2.40

GEOGRID #	Elevation [ft]	Length [ft]	Type #	CONNECTION CDR [connection strength]	Geogrid strength CDR	Pullout resistance CDR	Direct sliding CDR	Eccentricity e/L	Product name
1	0.67	9.00	2	8.76	17.504	39.043	1.598	0.1749	7XT
2	2.00	9.00	2	8.44	17.556	31.274	1.559	0.1532	7XT
3	3.33	9.00	2	8.08	17.504	24.107	1.475	0.1295	7XT
4	4.67	9.00	2	8.21	18.571	18.855	1.331	0.1004	7XT
5	6.00	9.00	2	3.28	7.752	5.435	1.117	0.0592	7XT
6	7.33	9.00	2	1.32	3.280	1.416	1.024	-0.0150	7XT

Stiffness Method 2020
Ravensdale Creek Fish Passage

MSEW+: Update # 2021.20

PROJECT IDENTIFICATION

Title:	Ravensdale Creek Fish Passage
Project Number:	2496.01
Client:	Basalite
Designer:	RAR
Station Number:	SW Wall Sta. 0+37

Description:

Temporary crane surcharge for girder pics

Company's information:

Name: Zipper Geo Associates, LLC
Street: 19019 36th Ave. W. Ste. E

Lynnwood, WA 98036
Telephone #: 425-582-9928
Fax #:
E-Mail: rross@zippergeo.com

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PROGRAM MODE:

ANALYSIS
of a SIMPLE STRUCTURE
using GEOGRID as reinforcing material.

SOIL DATA

REINFORCED SOIL

Unit weight, γ 130.0 lb/ft ³

Design value of internal angle of friction, ϕ 38.0 °

RETAINED SOIL

Unit weight, γ 115.0 lb/ft ³

Design value of internal angle of friction, ϕ 30.0 °

FOUNDATION SOIL (Considered as an equivalent uniform soil)

Equivalent unit weight, $\gamma_{equiv.}$ 130.0 lb/ft ³

Equivalent internal angle of friction, $\phi_{equiv.}$ 30.0 °

Equivalent cohesion, $c_{equiv.}$ 0.0 lb/ft ²

Factored bearing capacity resistance of foundation is given: q-ult-static = 9000.0 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) = 0.2973 (eq. 17 is utilized to calculate Ka for all batters)
(For external stability user specified δ = 20.00°)

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

FOR EXTERNAL STABILITY

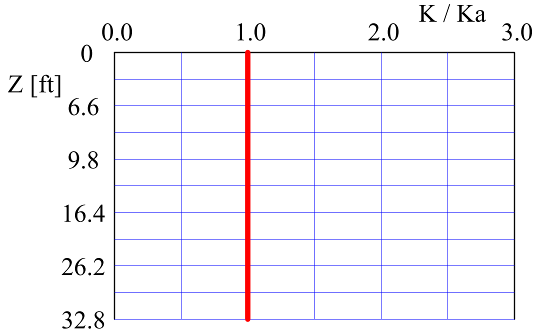
Ka = 0.2973 In Coulomb equation for Ka, Omega was taken as ZERO and backslope inclined at angle I.

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]	4700.0	5900.0	7400.0	4700.0	
Durability reduction factor, RFd	1.30	1.30	1.30	1.30	
Installation-damage reduction factor, RFid	1.12	1.12	1.12	1.12	
Creep reduction factor, RFc	1.45	1.00	1.45	1.45	N/A
CDR for strength	N/A	N/A	N/A	N/A	
Coverage ratio, Rc	1.000	1.000	1.000	0.850	
Friction angle along geogrid-soil interface, ρ	32.00	32.00	32.00	32.00	
Pullout resistance factor, F*	$0.67 \cdot \tan\phi$	$0.67 \cdot \tan\phi$	$0.67 \cdot \tan\phi$	$0.67 \cdot \tan\phi$	N/A
Scale-effect correction factor, α	0.8	0.8	0.8	0.8	

Variation of Lateral Earth Pressure Coefficient With Depth

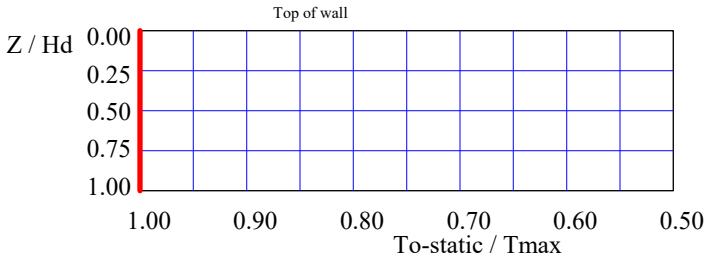
Z	K / Ka
0 ft	1.00
3.3 ft	1.00
6.6 ft	1.00
9.8 ft	1.00
13.1 ft	1.00
16.4 ft	1.00
19.7 ft	1.00



INPUT DATA: Facia and Connection (according to revised Demo 82) (Analysis)

FACIA type: Facing enabling frictional connection of reinforcement (e.g., modular concrete blocks, gabions)
Depth/height of block is 1.50/0.67 ft. Horizontal distance to Center of Gravity of block is: 0.75 ft.
Average unit weight of block is: γ_f = 125.00 lb/ft ³

Z / Hd	To-static / Tmax
0.00	1.00
0.25	1.00
0.50	1.00
0.75	1.00
1.00	1.00



Connection strength, T-lot, is related to T-ult

Geogrid Type #1		Geogrid Type #2		Geogrid Type #3		Geogrid Type #4		Geogrid Type #5	
N-1	Tult-conn	N-2	Tult-conn	N-3	Tult-conn	N-4	Tult-conn	N-5	Tult-conn
0.0	1600.00	0.0	2074.20	0.0	1600.00	0.0	1600.00		
787.0	2037.00	1500.0	2686.65	1695.1	2038.00	787.0	2037.00	N/A	
1535.0	2657.00	2500.0	3094.95	1551.0	2900.00	1535.0	2657.00		
2293.0	3038.00	3500.0	3503.25	2326.4	3157.00	2293.0	3038.00		
4601.0	3105.00	4500.0	3911.55	4615.0	3808.00	4601.0	3105.00		

Geogrid Type #1		Geogrid Type #2		Geogrid Type #3		Geogrid Type #4		Geogrid Type #5	
σ	CRu	σ	CRu	σ	CRu	σ	CRu	σ	CRu
0.0	0.34	0.0	0.35	0.0	0.22	0.0	0.34		
524.7	0.43	1000.0	0.46	516.7	0.28	524.7	0.43	N/A	
1023.3	0.57	1666.7	0.52	1034.0	0.39	1023.3	0.57		
1528.7	0.65	2333.3	0.59	1550.9	0.43	1528.7	0.65		
3067.3	0.66	3000.0	0.66	3076.7	0.51	3067.3	0.66		

(1) σ = Confining stress in between stacked blocks [lb/ft ²]
(2) CRult = Tc-ult / Tult
(3) CRcr = Tcre / Tult

D A T A (for connection only)	Type #1	Type #2	Type #3	Type #4	Type #5
Product Name	5XT	7XT	8XT	5XT-RC	N/A
Connection strength reduction factor, RFd	1.30	1.30	1.30	1.30	N/A
Creep reduction factor, RFc	N/A	N/A	N/A	N/A	N/A

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

Design height, Hd 8.00 [ft] { Embedded depth is E = 2.00 ft, and height above top of finished bottom grade is H = 6.00 ft }

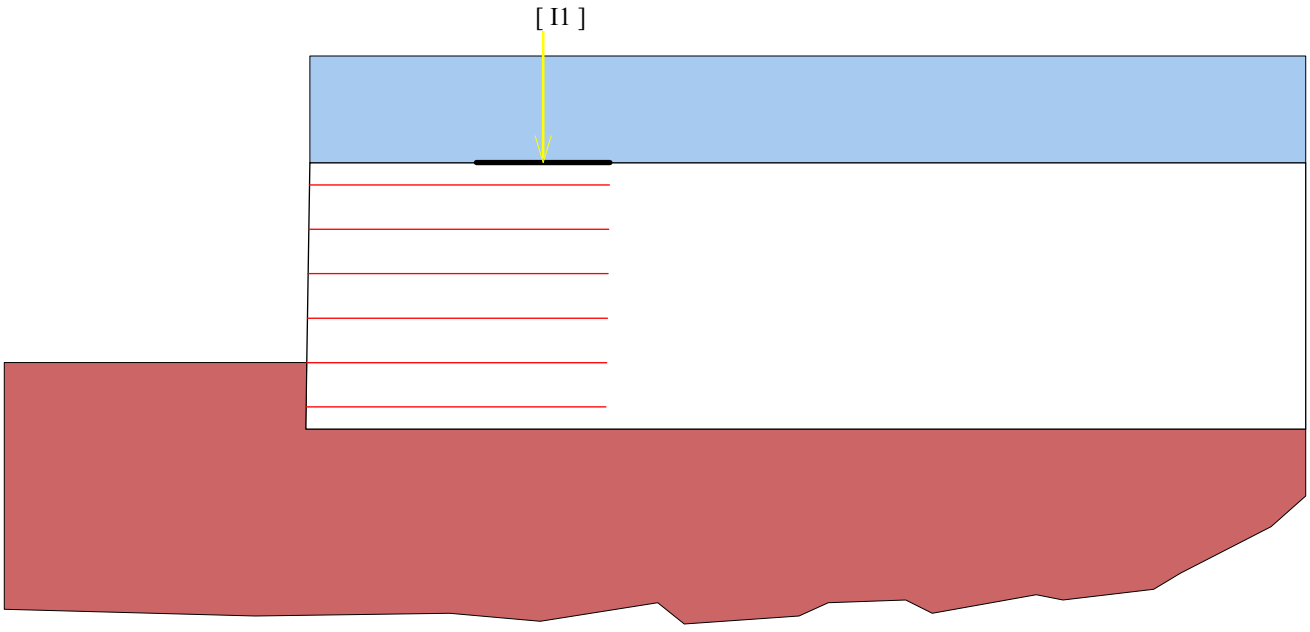
Soil in front of wall is Horizontal.

Batter, ω 0.9 [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 290.0 [lb/ft ²]

OTHER EXTERNAL LOAD(S)
[I1] Isolated Load, Pv-d' = 0.0 and Pv-l' = 30000.0 [lb]. Length of footing, L = 4.0 [ft], and width, b = 4.0 [ft]. Distance of center of footing from wall face, d = 7.0 [ft] @ depth of 0.0 [ft] below soil surface.

ANALYZED REINFORCEMENT LAYOUT:



SCALE:

0 2 4 6 [ft]

Stiffness Method 2020 – Load and Resisting Factors

INTERNAL STABILITY

Load factor for vertical earth pressure, EV:	$\gamma_{p\text{-}EV}$	1.35
Load factor for prediction of Tmax for the soil failure limit state:	$\gamma_{p\text{-}EVfs}$	1.20
Load factor for earthquake loads, EQ:	$\gamma_{p\text{-}EQ}$	1.00
Load factor for live load surcharge, LS: (Same as in External Stability).	$\gamma_{p\text{-}LS}$	1.50
Load factor for dead load surcharge, ES: (Same as in External Stability).	$\gamma_{p\text{-}ES}$	1.50

Resistance factor for reinforcement tension		Static	Combined static/seismic
Geogrid:	ϕ	0.80	1.00
Resistance factor accounting for uncertainty in measurement of geosynthetic stiffness J at 2% strain	Φ_{sf}	1.000	
Facing stiffness factor (recommended by AASHTO for flexible facing as 1.0)	Φ_{fs}	1.000	

Resistance factor for reinforcement tension in connectors		Static	Combined static/seismic
Geogrid:	ϕ	0.80	1.00
Resistance factor for geosynthetic pullout	ϕ	0.70	1.00

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}):	$(\gamma_{p\text{-}EH})_{EQ}$	1.50
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

ANALYSIS: CALCULATED FACTORS (Static conditions)

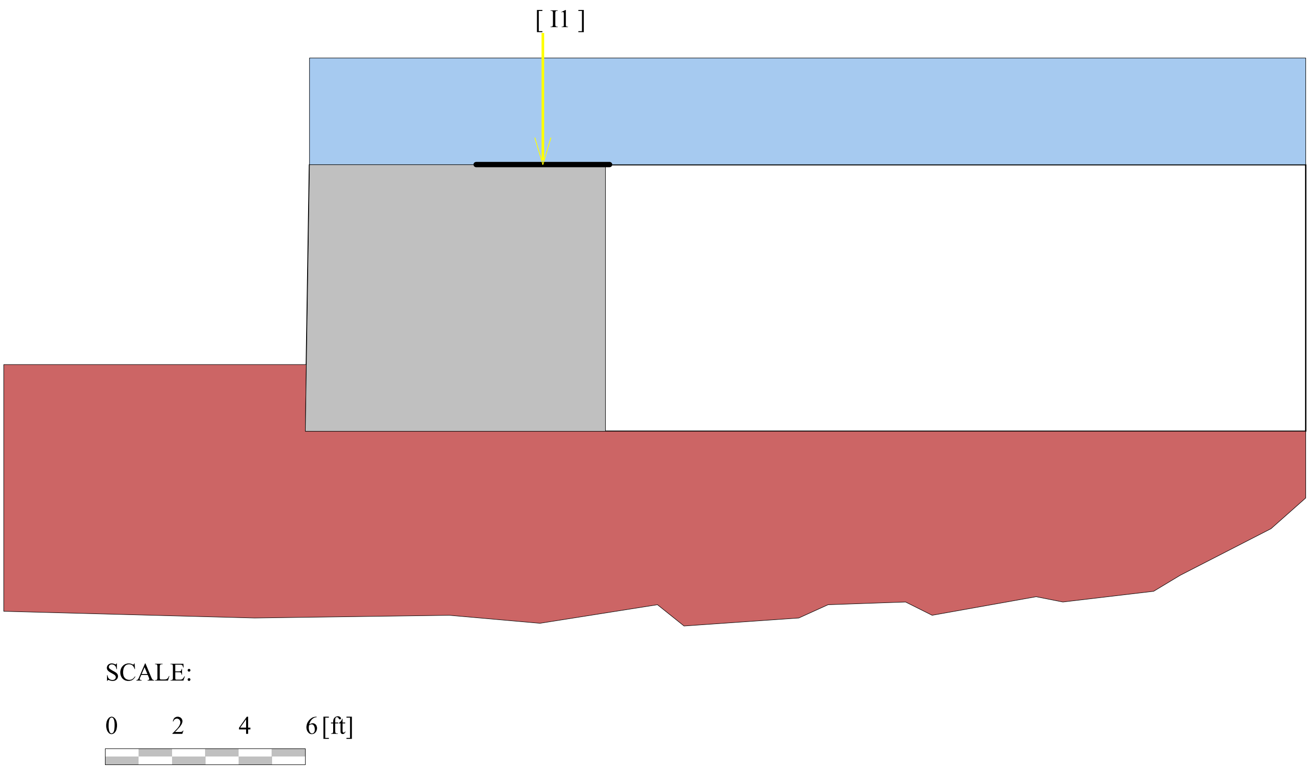
Bearing capacity, CDR = 1.90, factored bearing load = 3085 lb/ft².
Foundation Interface: Direct sliding, CDR = 2.195, Eccentricity, e/L = 0.0738, CDR-overturning = 4.40

GEOGRID				CONNECTION					
#	Elevation [ft]	Length [ft]	Type #	CDR [connection strength]	Geogrid strength CDR	Pullout resistance CDR	Direct sliding CDR	Eccentricity e/L	Product name
1	0.67	9.00	2	5.95	11.886	23.197	2.499	0.0618	7XT
2	2.00	9.00	2	5.73	11.919	18.579	2.803	0.0400	7XT
3	3.33	9.00	2	5.49	11.886	14.323	3.233	0.0208	7XT
4	4.67	9.00	2	5.63	12.723	11.303	3.930	0.0049	7XT
5	6.00	9.00	2	6.36	15.038	9.225	5.364	-0.0060	7XT
6	7.33	9.00	2	7.48	18.528	7.000	11.798	-0.0075	7XT

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

	STATIC	SEISMIC	UNITS
(Given factored bearing resistance, q-n)			
Factored bearing resistance. q-n	5850	N/A	[lb/ft ²]
Factored bearing load, σ_V	3084.5	N/A	[lb/ft ²]
Eccentricity, e	-0.48	N/A	[ft]
Eccentricity, e/L	-0.053	N/A	
CDR calculated	1.90	N/A	
Base length	9.00	N/A	[ft]

Unfactored applied bearing pressure = (Unfactored R) / [L - 2 * (Unfactored e)] =
Unfactored R = 19970.34 [lb/ft], L = 9.00, Unfactored e = -0.65 [ft], and Sigma = 2592.86 [lb/ft ²]



RESULTS for STRENGTH

Live Load included in calculating Tmax

#	Geogrid Elevation [ft]		Limit State Tmax [lb/ft]	Service Limit Tmax [lb/ft]	Reinf. Strain Static [%]	Tmd [lb/ft]	Specified minimum CDR Static	Actual calculated CDR Static	Specified minimum CDR seismic	Actual calculated CDR seismic	Product name
1	0.67	3241.8	272.7	211.74	0.654	N/A	N/A	11.886	N/A	N/A	7XT
2	2.00	3241.8	272.0	211.17	0.652	N/A	N/A	11.919	N/A	N/A	7XT
3	3.33	3241.8	272.7	211.74	0.654	N/A	N/A	11.886	N/A	N/A	7XT
4	4.67	3241.8	254.8	195.78	0.604	N/A	N/A	12.723	N/A	N/A	7XT
5	6.00	3241.8	215.6	161.04	0.497	N/A	N/A	15.038	N/A	N/A	7XT
6	7.33	3241.8	175.0	124.83	0.385	N/A	N/A	18.528	N/A	N/A	7XT

APPENDIX A

REFERENCE DATA

NOTE: This section includes backup information for geogrid strengths, interaction coefficients and other referenced data.

GEOSYNTHETIC RETAINING WALL
Classes 1 and 2 Non-aggressive Environments

Note 1: May be used for Class 1 and 2 walls and slopes in non-aggressive environments. Acceptability of the product for a specific contract bid item requires that the approved long-term geosynthetic strength as listed in Table 1 below meet or exceed the required long-term strength specified in the contract. The ultimate tensile strength listed in Table 1 is to be used for lot specific acceptance once the product arrives at the project site. (See Acceptance Code 7021)

Table 1. Long-term and ultimate strengths of geosynthetic products qualified for use in Classes 1 and 2 walls and reinforced slopes, non-aggressive environments.

Product	Ref. No.	Year last Updated	[1]T_{ult} (lb/ft)	Long-Term Strength Reduction Factors			[2]Long-Term Tensile Strength, T_{al} (lb/ft)	[3]Low Strain Creep Stiffness, $J_{2\%}$ (lbs/ft)
				RF_{ID}	RF_{CR}	RF_D		
Miragrid 2XT, MD - TenCate	1993-921	2012	2000	1.12	1.45	1.3	947	11000
Miragrid 3XT, MD - TenCate	1993-921	2012	3500	1.12	1.45	1.3	1660	19200
Miragrid 5XT, MD - TenCate	1993-921	2012	4700	1.12	1.45	1.3	2230	25800
Miragrid 7XT, MD - TenCate	1993-921	2012	5900	1.12	1.45	1.3	2790	32400
Miragrid 8XT, MD - TenCate	1993-921	2012	7400	1.12	1.45	1.3	3510	40700
Miragrid 10XT, MD - TenCate	1993-921	2012	9500	1.12	1.45	1.3	4500	52200
Miragrid 20XT, MD - TenCate	1993-921	2012	13705	1.12	1.45	1.3	6490	75300
Miragrid 22XT, MD - TenCate	1993-921	2012	20559	1.12	1.45	1.3	9740	113000
Miragrid 24XT, MD - TenCate	1993-921	2012	27415	1.12	1.45	1.3	13000	151000
ParaGrid 30/05, MD – Linear Composites		2010	2055	1.1	1.39	1.3	1040	13400
ParaGrid 40/05, MD – Linear Composites		2010	2740	1.1	1.39	1.3	1380	16900
ParaGrid 50/05, MD – Linear Composites		2010	3425	1.1	1.39	1.3	1730	20200
ParaGrid 60/05, MD – Linear Composites		2010	4110	1.1	1.39	1.3	2070	23600
ParaGrid 65/05, MD – Linear Composites		2010	4452	1.1	1.39	1.3	2240	25300
ParaGrid 70/05, MD – Linear Composites		2010	4795	1.1	1.39	1.3	2420	27000
ParaGrid 80/05, MD – Linear Composites		2010	5479	1.1	1.39	1.3	2760	30400
ParaGrid 90/05, MD – Linear Composites		2010	6164	1.1	1.39	1.3	3110	33700
ParaGrid 100/05, MD – Linear Composites		2010	6849	1.1	1.39	1.3	3450	37100
ParaGrid 110/05, MD – Linear Composites		2010	7534	1.1	1.39	1.3	3800	40500
ParaGrid 125/05, MD – Linear Composites		2010	8562	1.1	1.39	1.3	4310	45600
ParaGrid 150/05, MD – Linear Composites		2010	10274	1.1	1.39	1.3	5170	54000
ParaGrid 175/05, MD – Linear Composites		2010	11986	1.1	1.39	1.3	6040	62500
ParaGrid 180/05, MD – Linear Composites		2010	12329	1.1	1.39	1.3	6210	64200
ParaGrid 200/05, MD – Linear Composites		2010	13699	1.1	1.39	1.3	6900	70900
SF20, MD - Synteen		2016	2025	1.19	1.51	1.3	865	16400
SF35, MD - Synteen		2016	3600	1.19	1.51	1.3	1540	23700
SF55, MD - Synteen		2016	5000	1.19	1.51	1.3	2140	30200
SF65, MD - Synteen		2016	6200	1.19	1.51	1.3	2650	35800
SF80, MD - Synteen		2016	7550	1.11	1.51	1.3	3460	42100
SF90, MD - Synteen		2016	9000	1.11	1.51	1.3	4130	48900
SF110, MD - Synteen		2016	10300	1.11	1.51	1.3	4730	54900
SF180, MD - Synteen		2016	14500	1.11	1.51	1.3	6650	74400
SF190, MD - Synteen		2016	20560	1.11	1.51	1.3	9430	102600

[1]T_{ult} is determined using ASTM D6637 for geogrids and ASTM D4595 for geotextiles. The value provided in the table represents the manufacturer's Minimum Average Roll Value (MARV) or minimum value for the product. WSDOT acceptance test results for the product as delivered to the project must be greater than or equal to this value.

[2]T_{al} is determined at a design life of 75 years and is based on the MARV or minimum value for T_{ult} provided in this table.

[3]$J_{2\%}$ is the creep stiffness determined at a strain level of 2% after 1,000 hours of loading, based on the MARV or minimum value for T_{ult} provided in this table.

RF_{ID} = installation damage reduction factor, RF_{CR} = creep reduction factor, RF_D = durability reduction factor.

MD = Machine Direction (longitudinal direction), XMD = Cross Machine Direction (transverse direction)

REPORT

RESULTS OF

TENCATE MIRAGRID 7XT GEOGRID

WITH BASALITE GW8 DOT MAX II CONCRETE BLOCK UNITS

CONNECTION CAPACITY TESTING

Submitted to

TenCate Geosynthetics & Basalite Concrete Products

CONFIDENTIAL

Distribution:

TenCate Geosynthetics
365 South Holland Drive
Pendergrass GA 30567
United States of America

BASALITE Concrete Products, LLC
3299 International Place
Dupont, WA 98327-7707
www.BASALITE.com

TRI Environmental, Inc.
9063 Bee Caves Road
Austin, Texas 78733

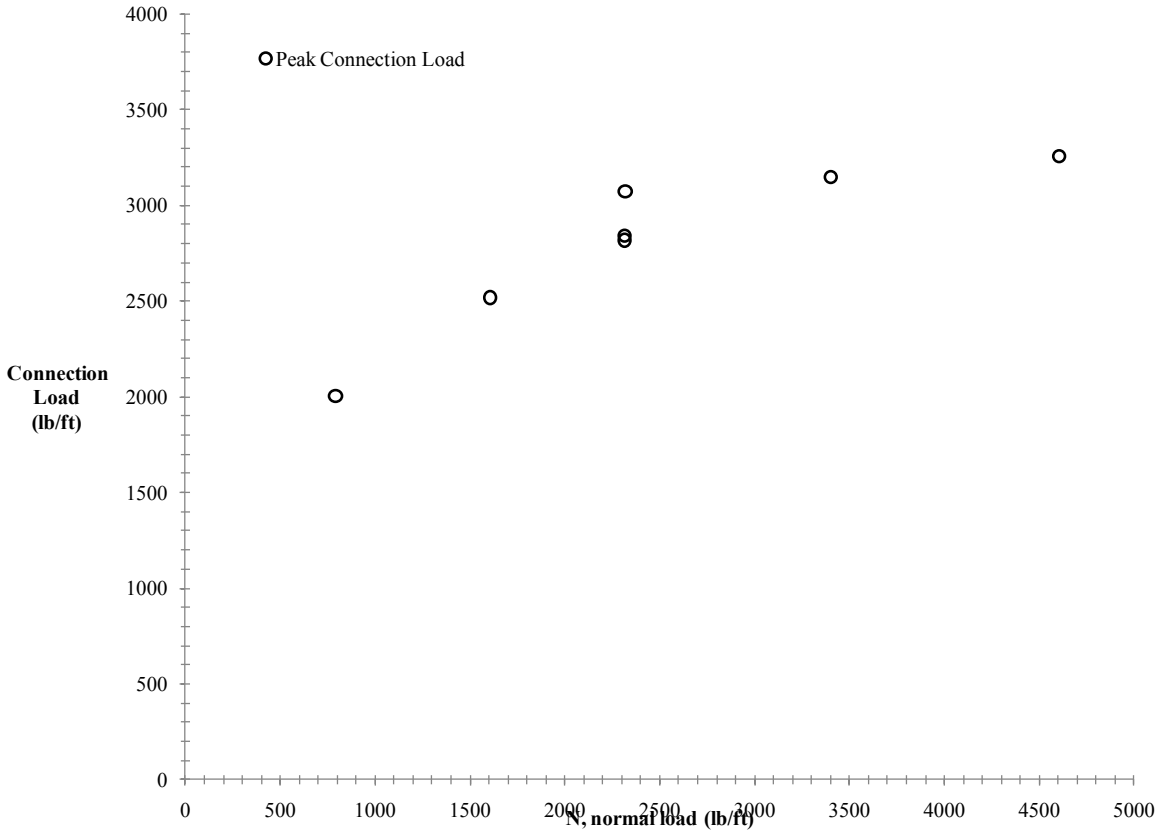


Figure 5: Summary of connection capacities for and TenCate Miragrid 7XT geogrid with BASALITE GW8 DOT MAX II concrete blocks in Standard Units.

Table 1: Data Summary for TenCate Miragrid 7XT geogrid and BASALITE GW8 DOT MAX II concrete blocks in Standard Units.

Test Number	Normal Load Applied (lb/ft)	Approximate Wall Height (ft)	Approximate number of Blocks Tall	Peak Connection Load (lb/ft)	Connection Load at 0.75" Displacement (lb/ft)
1	2313.2	15.1	22.6	2844.1	2481.2
2	790.4	5.2	7.7	2006.1	1522.8
3	4607.0	30.0	45.1	3259.1	2953.5
4	2313.0	15.1	22.6	2817.5	2304.1
5	1604.2	10.5	15.7	2517.7	1770.5
6	3403.0	22.2	33.3	3147.4	2736.5
7	2318.0	15.1	22.7	3075.6	2337.1

SR 169 RAVENSDALE CREEK FISH PASSAGE
BRIDGE 169 STRUCTURAL EARTH RETAINING WALLS
WORKING DRAWINGS

CONTACT INFORMATION:

CLIENT/SUPPLIER:

BASALITE CONCRETE PRODUCTS
3299 INTERNATIONAL PLACE
DUPONT, WASHINGTON
(253) 797-4167
CONTACT: DOUG KINNAMAN

WALL DESIGNER:

ZIPPER GEO ASSOCIATES, LLC
19019 36th AVE. WEST, SUITE E
LYNNWOOD, WA 98036
(425) 582-9928
CONTACT: ROB ROSS, P.E.
rross@zippergeo.com

SHEET INDEX

ZipperGeo
Geoprofessional Consultants
www.zippergeo.com

BASALITE®
CONCRETE PRODUCTS, LLC

SUBMITTAL RECORD

NO.	DATE	BY	DESCRIPTION
⚠			
-	12/20/21	RAR	INITIAL RELEASE

DESIGNED:	RAR
DRAWN:	RAR
CHECKED:	TAJ
SCALE:	AS NOTED
DATE:	12/20/21
JOB NO.	2496.01
PLOT DATE:	12/20/21
LAST EDIT:	Rob

ROBERT A. ROSS — STATE OF WASHINGTON — 38384 — REGISTERED PROFESSIONAL ENGINEER — 12/20/21

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RAVENSDALE CREEK FISH PASSAGE
BRIDGE 169 STRUCTURAL EARTH RETAINING WALLS

COVER SHEET

DRAWING
SEW1.0
SHEET 1 OF 8

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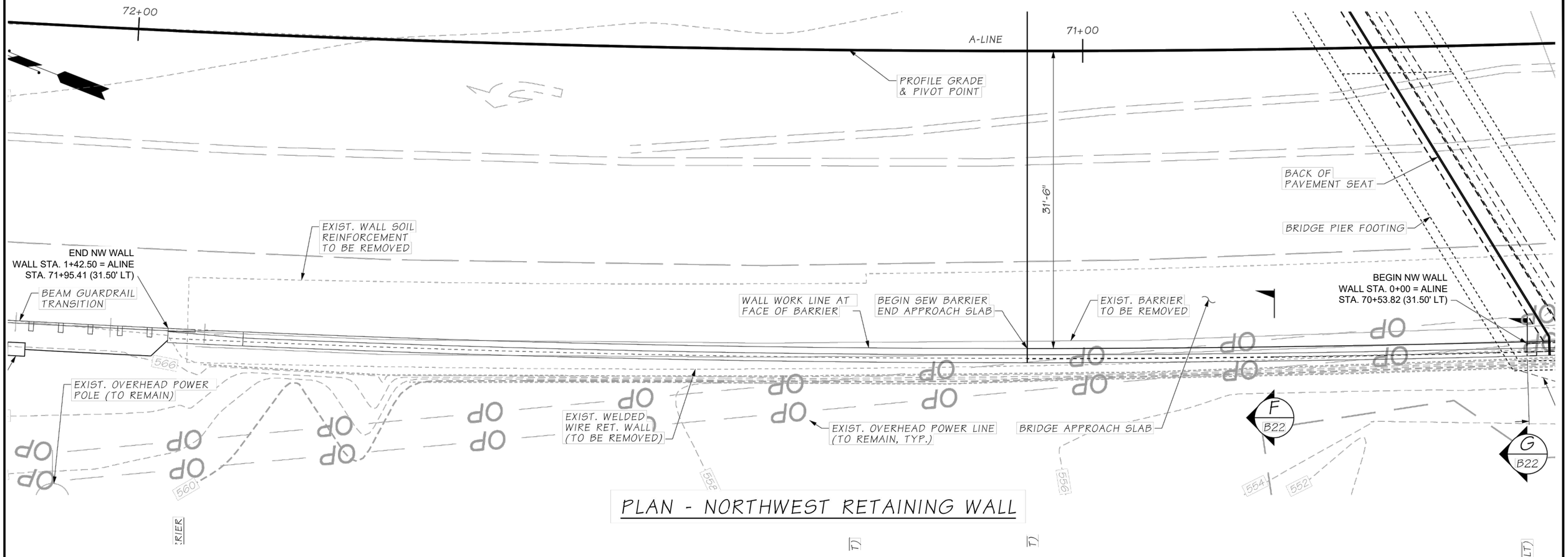
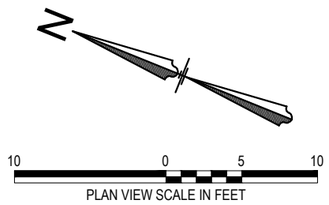


PLAN - NORTHWEST RETAINING WALL

PLAN & ELEV. VIEW GENERAL NOTES:

1. THESE NOTES APPLY TO ALL PLAN AND ELEVATION VIEW SHEETS.
2. NOT ALL INFORMATION SHOWN ON THE CONTRACT DRAWINGS IS SHOWN ON THESE PLANS. SEE CONTRACT DRAWINGS FOR ADDITIONAL INFORMATION.
3. SEE SHEETS SEW3.0 - SEW3.2 FOR DETAILS AND SECTIONS.
4. STRUCTURAL EARTH WALLS SHALL BE CONSTRUCTED IN ACCORDANCE WITH SECTION 6-13 OF THE WSDOT STANDARD SPECIFICATIONS AND AMENDMENTS TO SECTION 6-13 PER THE CONTRACT SPECIAL PROVISIONS.
5. PLAN VIEWS ARE TAKEN DIRECTLY FROM CONTRACT PLANS. FOR NOTES SHOWN ON PLAN VIEW, REFER TO CONTRACT PLANS.



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BRIDGE 169 STRUCTURAL EARTH RETAINING WALLS

BRIDGE 169 - NW WALL PLAN VIEW

DRAWING
SEW2.0
SHEET 2 OF 8

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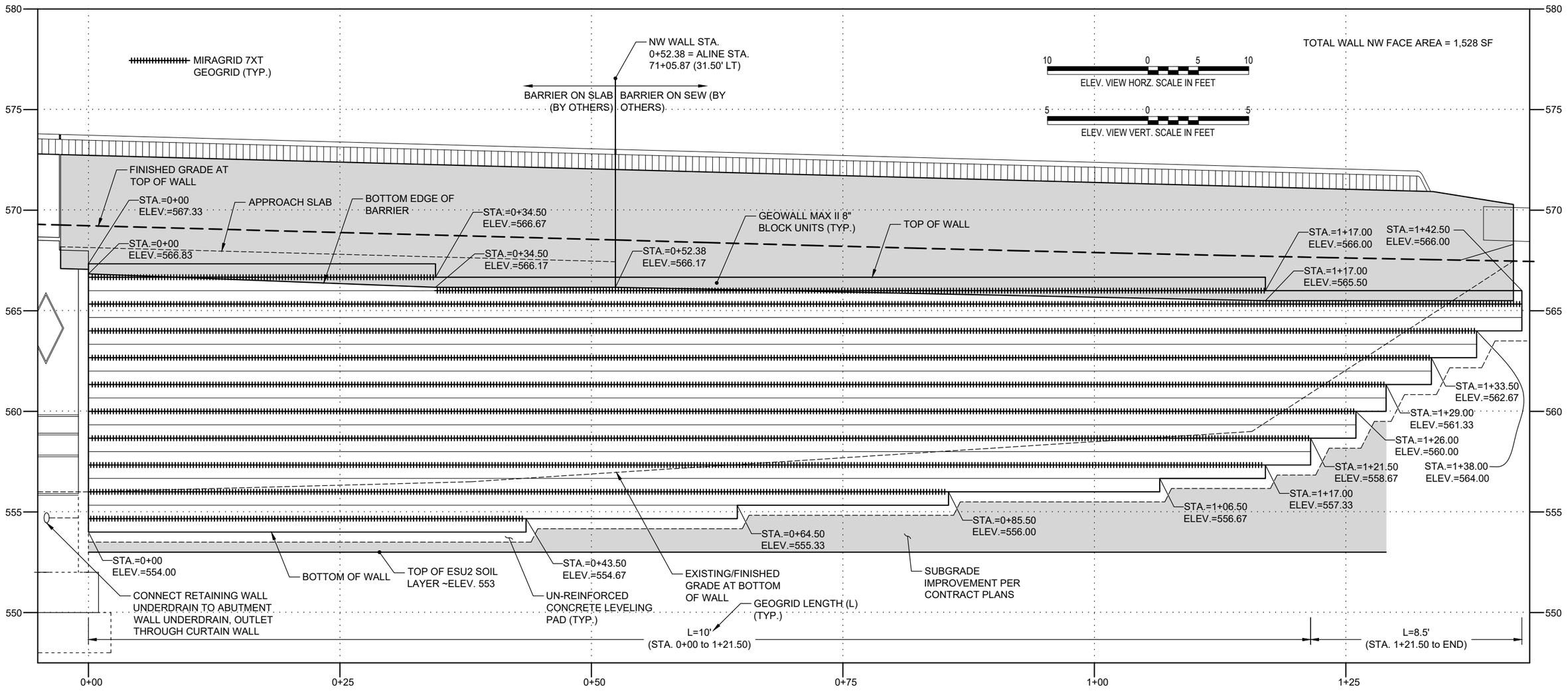

1 / - NW WALL - ELEVATION VIEW

SUBMITTAL RECORD			
NO.	DATE	BY	DESCRIPTION
-	12/20/21	RAR	INITIAL RELEASE

DESIGNED:	RAR
DRAWN:	RAR
CHECKED:	TAJ
SCALE:	AS NOTED
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BRIDGE 169 STRUCTURAL EARTH RETAINING WALLS

BRIDGE 169 – NW WALL ELEV. VIEW

DRAWING
SEW2.1
SHEET 3 OF 8

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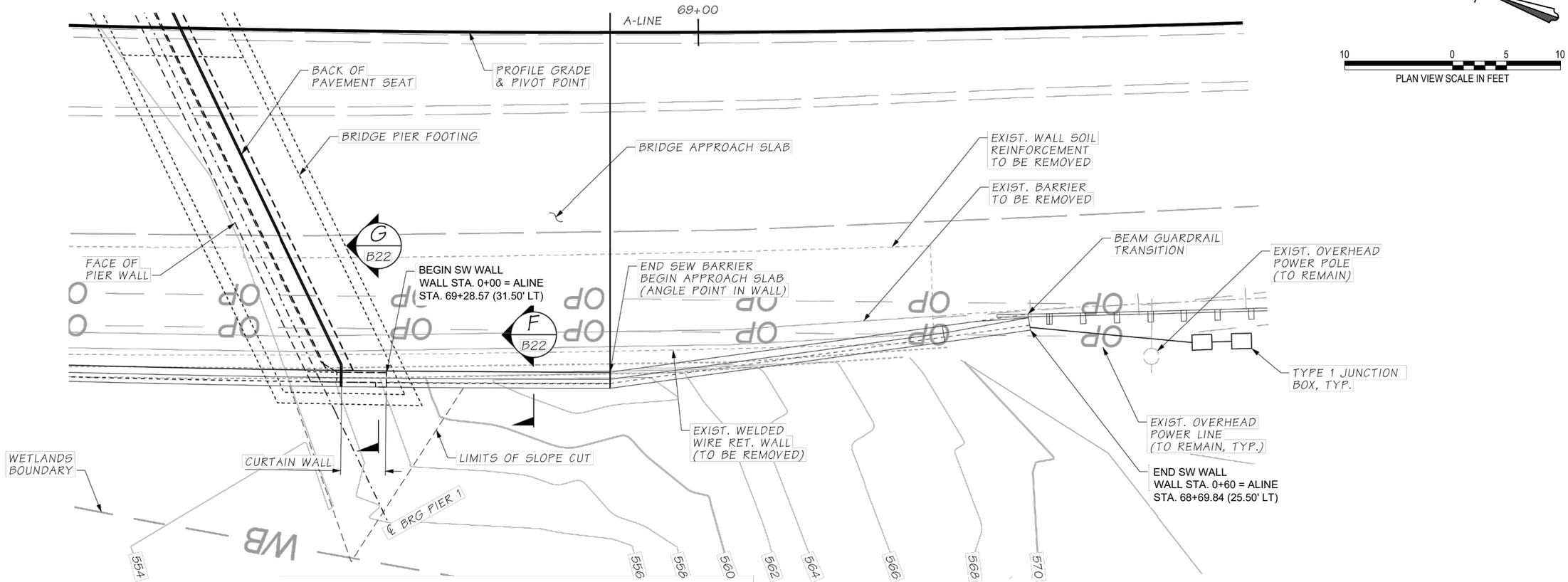

PLAN - SOUTHWEST RETAINING WALL

SUBMITTAL RECORD			
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NO.	DATE	BY	DESCRIPTION

DESIGNED:	RAR
DRAWN:	RAR
CHECKED:	TAJ
SCALE:	AS NOTED
DATE:	12/20/21
JOB NO.	2496.01
PLOT DATE:	12/20/21
LAST EDIT:	Rob

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BRIDGE 169 STRUCTURAL EARTH RETAINING WALLS

BRIDGE 169 - SW WALL PLAN VIEW

DRAWING
SEW2.2
SHEET 4 OF 8

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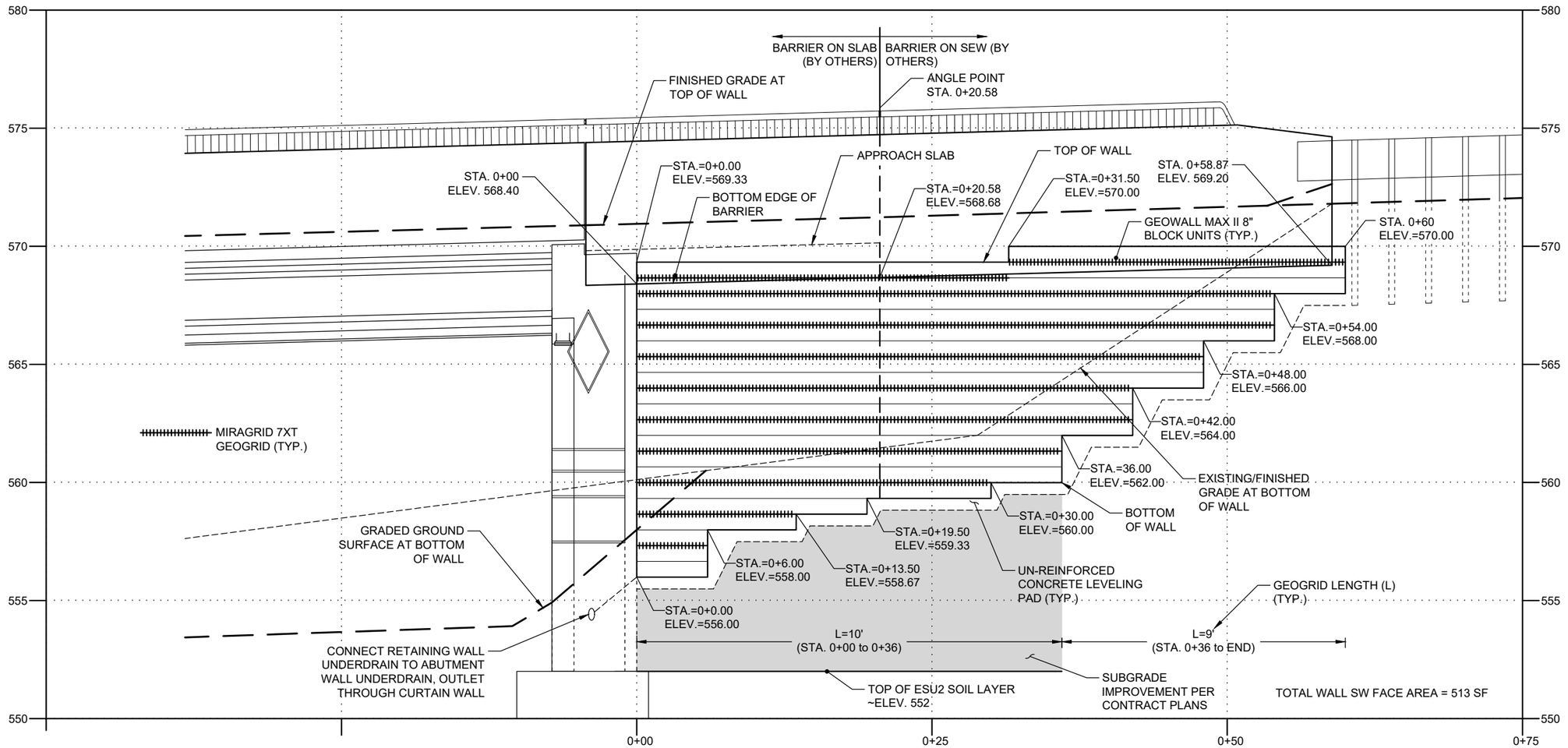

1 / - SW WALL - ELEVATION VIEW

10 0 5 10 ELEV. VIEW HORZ. SCALE IN FEET

5 0 5 ELEV. VIEW VERT. SCALE IN FEET

SUBMITTAL RECORD			
1			
-	12/20/21	RAR	INITIAL RELEASE
NO.	DATE	BY	DESCRIPTION

DESIGNED:	RAR
DRAWN:	RAR
CHECKED:	TAJ
SCALE:	AS NOTED
DATE:	12/20/21
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SR 169
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BRIDGE 169 STRUCTURAL EARTH RETAINING WALLS

BRIDGE 169 - SW WALL ELEV. VIEW

DRAWING
SEW2.0
SHEET 5 OF 8

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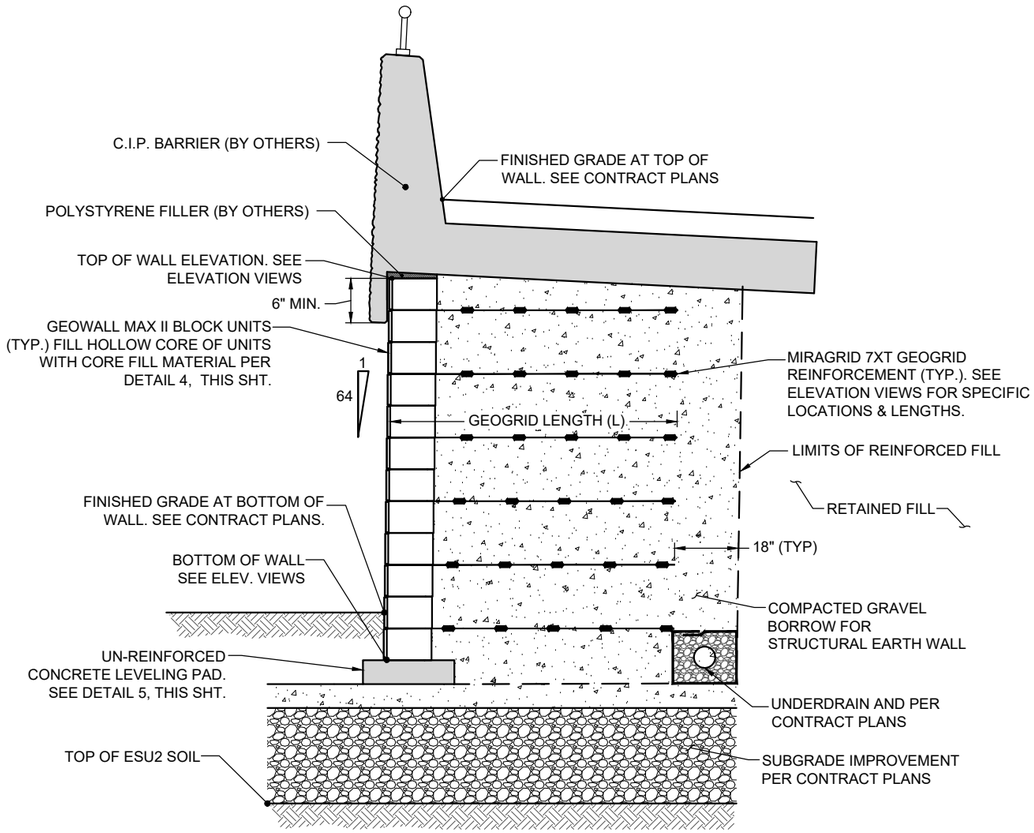

1 / - STRUCTURAL EARTH WALL - TYPICAL SECTION
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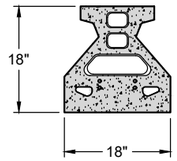
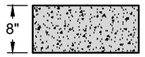


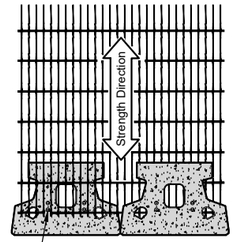
GEOWALL MAX II PLAN



GEOWALL MAX II ELEVATION

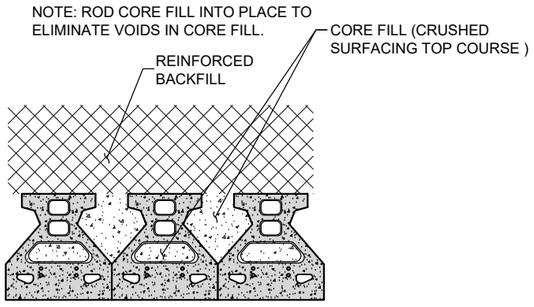
*ALL UNITS SHALL BE STRAIGHT-FACE

2 / - UNIT DETAILS (TYP.)
NOT TO SCALE

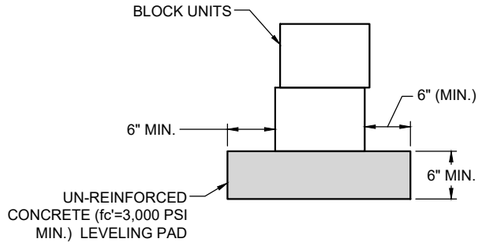


GEOGRID IS TO BE PLACED ON LEVEL BACKFILL AND EXTENDED OVER THE FIBERGLASS PINS. GRID SHALL BE HELD IN PLACE UNDER NOMINAL TENSION TO ELIMINATE SLACK.

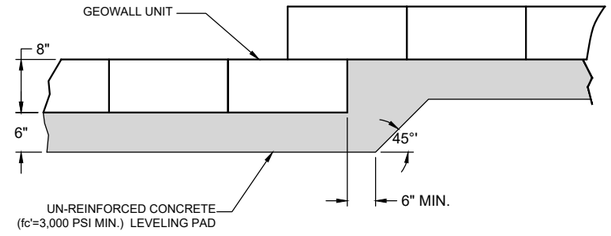
3 / - GEOGRID BLOCK CONNECTION (TYP.)
NOT TO SCALE



4 / - CORE FILL (TYP.)
NOT TO SCALE



5 / - LEVELING PAD (TYP.)
NOT TO SCALE



6 / - LEVELING PAD STEPS (TYP.)
NOT TO SCALE

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⚠1			
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SR 169
RAVENSDALE CREEK FISH PASSAGE
BRIDGE 169 STRUCTURAL EARTH RETAINING WALLS

SECTIONS AND DETAILS

DRAWING
SEW3.0
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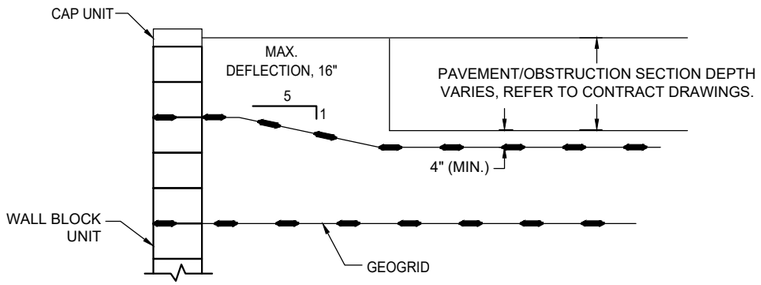


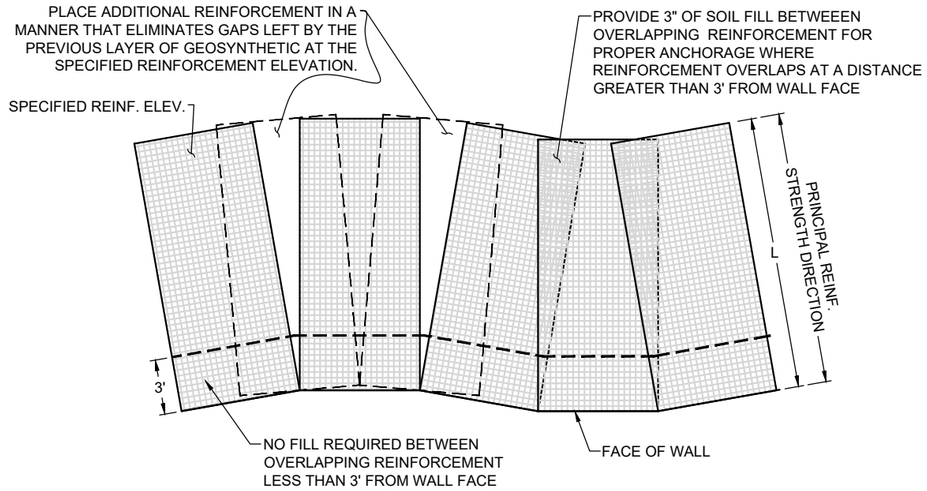
HORIZONTAL PAVEMENT STRUCTURE

NOTE:

CONTRACTOR IS RESPONSIBLE TO COORDINATE THE PLACEMENT OF THE GEOGRID TO AVOID CONFLICT WITH THE CONTRACT PAVEMENT/OBSTRUCTION SECTION. GEOGRID MUST BE SEPARATED FROM THE PAVEMENT/OBSTRUCTION SECTION BY A MINIMUM OF 4".

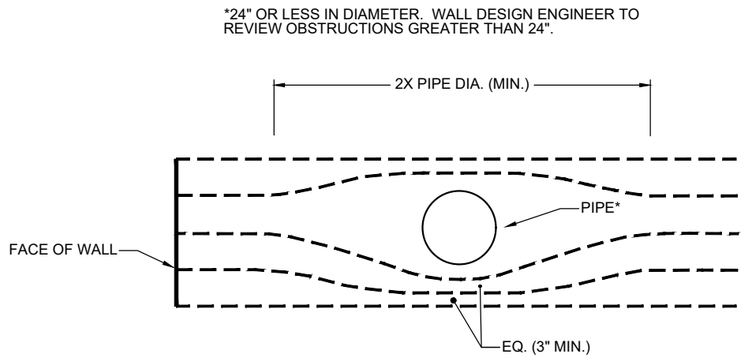
1 / - GEOGRID PLACEMENT AT PAVEMENT/OBSTRUCTION (TYP.)

NOT TO SCALE



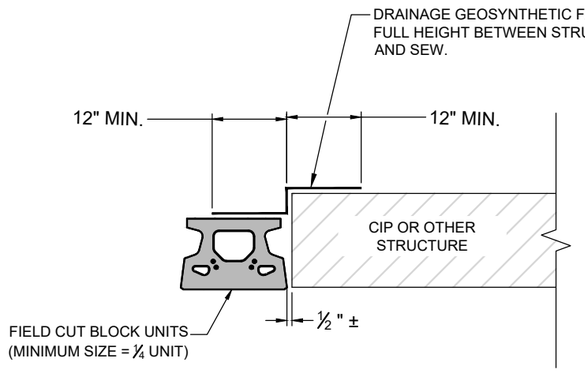
2 / - GEGORID PLACEMENT AT CURVES AND ANGLE POINTS (TYP.)

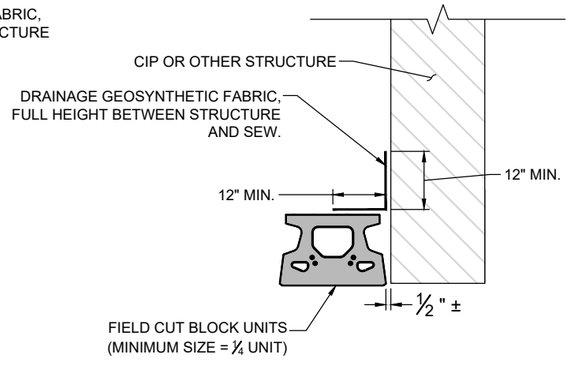
NOT TO SCALE



3 / - GEOGRID PLACEMENT AT HORIZONTAL OBSTRUCTION (TYP.)

NOT TO SCALE





NOTES:

1. GEOGRID AND CONNECTORS NOT SHOWN FOR CLARITY.
2. FIELD CUT BLOCK UNITS (MIN. 1/4 UNIT) FOR RUNNING BOND.
3. REFER TO TYPICAL CROSS-SECTION FOR FILL AND DRAINAGE REQUIREMENT AT BACK OF WALL.
4. SEE SECTION 6-13 OF PROJECT SPECIAL PROVISIONS FOR DRAINAGE GEOSYNTHETIC FABRIC REQUIREMENTS.

4 / - STRUCTURE/WALL TRANSITION DETAIL (TYP.)

NOT TO SCALE

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SHEET 7 OF 8

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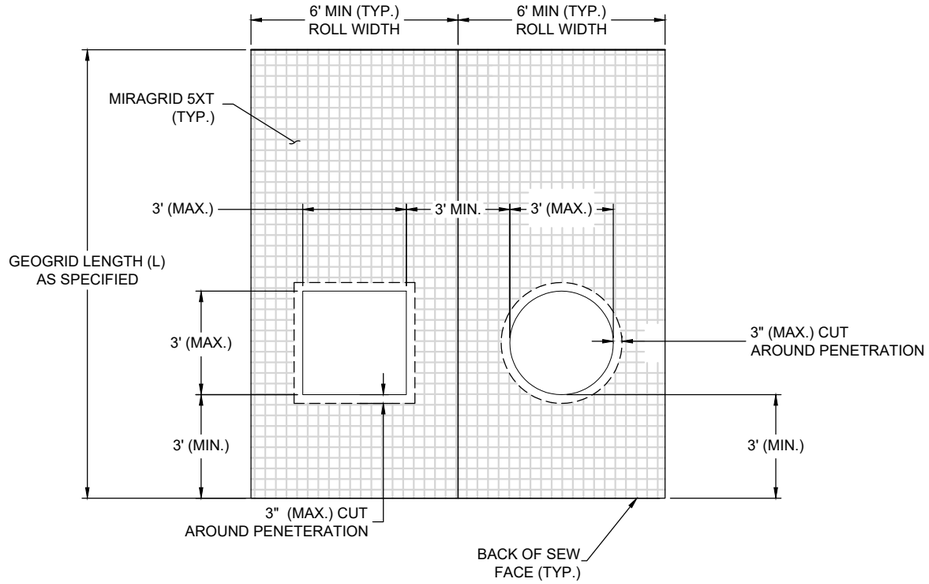
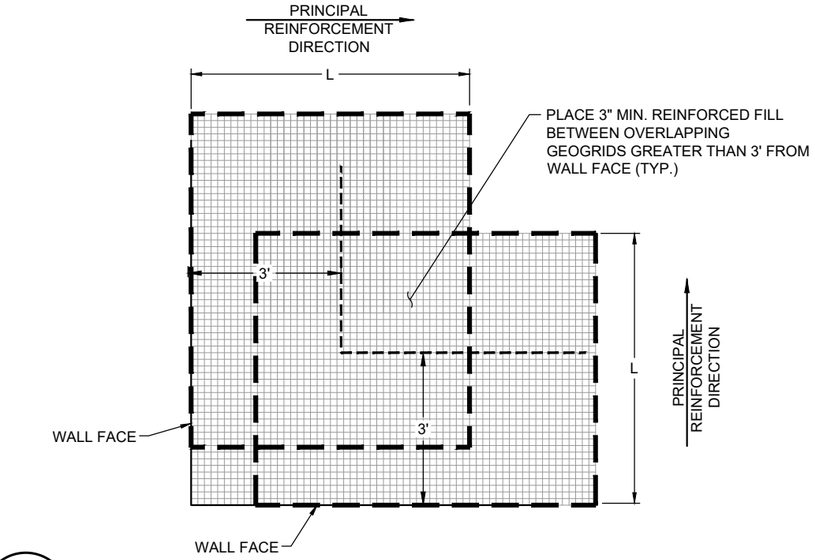
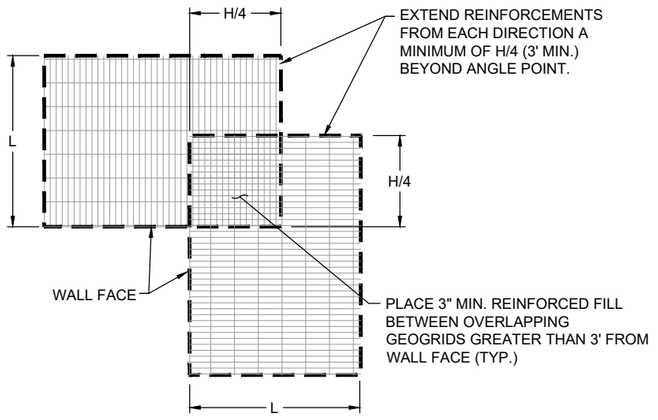


NOTE: WALL DESIGNER SHALL REVIEW VERTICAL OBSTRUCTIONS PRIOR TO USE OF THIS DETAIL.

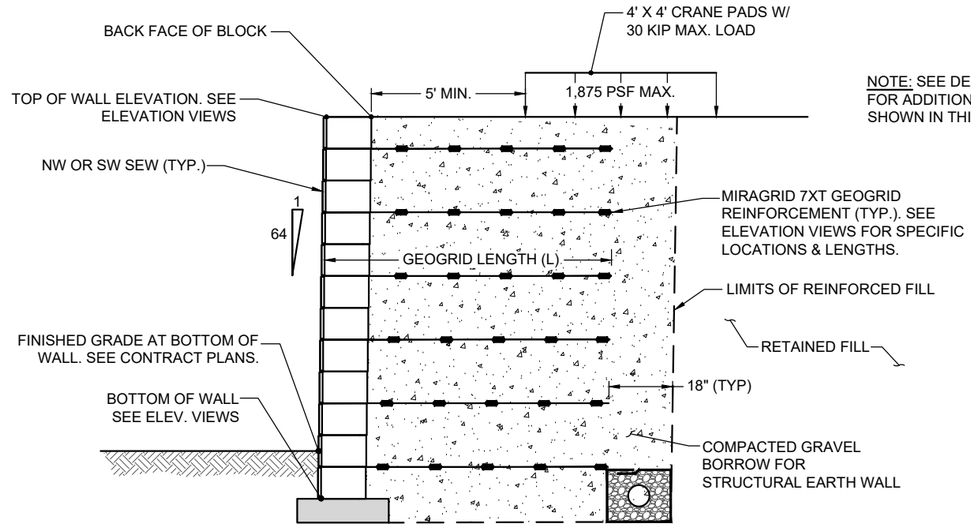
1 / - GEOGRID PLACEMENT AT VERTICAL OBSTRUCTION (TYP.)
NOT TO SCALE



2 / - GEOGRID PLACEMENT AT OUTSIDE 90° ANGLE POINT (TYP.)
NOT TO SCALE



3 / - GEOGRID PLACEMENT AT INSIDE 90° ANGLE POINT (TYP.)
NOT TO SCALE



NOTE: SEE DETAIL 1, SHT. SEW3.0 FOR ADDITIONAL NOTES NOT SHOWN IN THIS DETAIL (TYP.)

4 / - TEMPORARY CRANE SURCHARGE LIMITS (TYP.)
NOT TO SCALE

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SEW3.2
SHEET 8 OF 8

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