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Structural Design Calculations

Tualatin Garden Corner Curves
Tualatin, OR

Client Information
David Brokaw
Wallis Engineering
215 W 4th St., Suite 200
Vancouver, WA 98660

Project Site
Tualatin Garden Corner Curves
SW 105th Ave., Blake St., SW 108th Ave.
Tualatin, OR 97062
45.3644, -122.7863

Prepared By:
Peterson Structural Engineers
March 27, 2020
Job No. 1801-0336

Endorsement

Scope To provide structural calculations for the Tualatin Garden Curves roadway improvement project at the location given on the cover page. Elements under review include Mechanically Stabilized Earth (MSE) walls supporting the roadway and Cantilever Cast-in-Place (CIP) walls retaining soil. Any other elements not specifically referenced in these calculations are outside the purview of these calculations and are designed by others.

References

1. American Association of State Highway and Transportation Officials LRFD Bridge Design Specifications, 8th Edition (AASHTO)
2. 2018 Oregon Department of Transportation Standard Specifications for Construction (ODOT)
3. 2018 Oregon Department of Transportation Geotechnical Design Manual (ODOT GDM)
4. 2014 Building Code Requirements for Structural Concrete, ACI 318-14, and Commentary (ACI)
5. 2010 Manual of Steel Construction, 14th Edition, American Institute of Steel Construction (AISC)
6. National Concrete Masonry Association Design Manual for Segmental Retaining Walls, 3rd Edition, 5th Printing (NCMA)
7. Geotechnical Report prepared by GRI dated February 20, 2019
8. 90% Civil Drawings provide by client dated July 10, 2019, issued September 16, 2019

Table of Contents

Project Information

- Project Site: SW 105th Ave., Blake St., SW 108th Ave in Tualatin, OR 97062
- Below is a graphic of the structural elements included in PSE's scope:

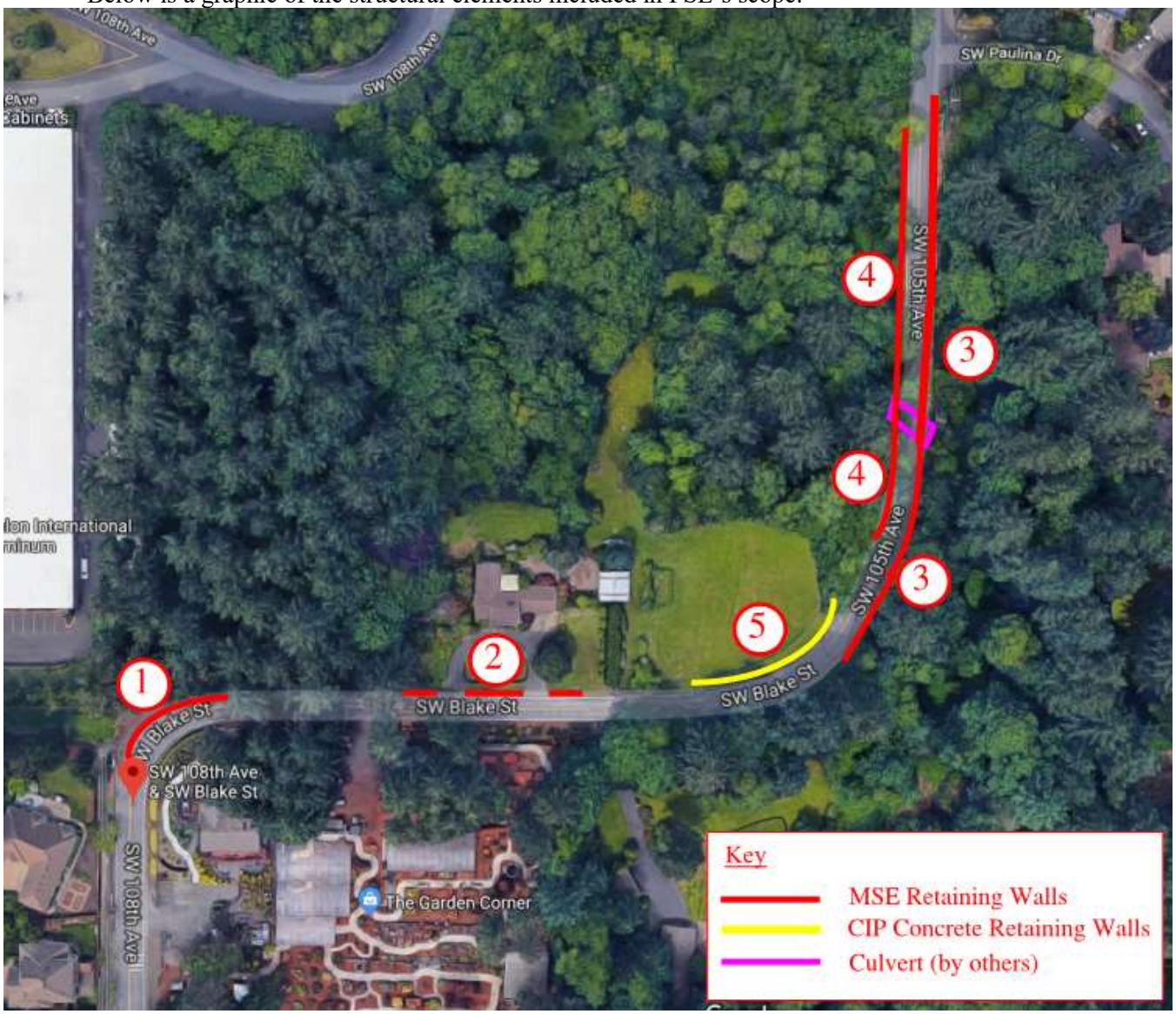


Figure 1: Roadway Plan

Retaining Wall Information:

- MSE Walls:
  - Wall 1
    - Max Height = 6.0’
    - Supports Roadway
  - Wall 2
    - Max Height = 4.0’
    - Supports Roadway
  - Wall 3:
    - Max Height = 10.5’
    - Supports Bicycle lane/roadway
    - Culvert interrupts, MSE wall portion above culvert
    - Located near stream
  - Wall 4:
    - Max Height = 7’-0”
    - Supports bicycle lane
    - Culvert interrupts, MSE wall portion above culvert
- CIP Cantilever Walls
  - Wall 5:
    - Max Height = 6’-0”
    - Retains soil on roadway side

Design Loads: Per AASHTO, ODOT, and Geotech Report

Lateral Loads

Soil Lateral Loads (per Geotech)

- Active Earth Pressure:
  - CIP Cantilever Wall = 35pcf (yielding wall)
  - MSE Wall: Coulomb theory used with the following parameters:
    - Soil density of 130pcf
    - Soil internal friction angle = 34-36°
    - Soil-Structure friction angle = 34°
- Passive Earth Pressure: conservatively ignore

Seismic Loads

- Concrete Retaining Walls: 0H @ top of wall, 8H @ bottom (yielding wall) – Triangular load distribution per Geotech
- MSE Walls: Per ODOT Geotechnical Design Manual, calculate pseudo-static acceleration coefficients:
  - Horizontal Pseudo Seismic Load, $k_h = 0.5A_s$ [ODOT GDM, Section 6.5.3.1]
    - $A_s = F_{pga}$*PGA [AASHTO 3.10.4.2-2]
    - 1000yr PGA = 0.27 [Per ODOT Seismic Maps]
    - $F_{pga} = 1.2$ [Per ASHTO 3.10.3.2]
    - $k_h = 0.162g$ ← Used as pseudo-static horizontal seismic acceleration in analysis software for analyzing MSE walls
  - Vertical Pseudo Seismic Load, $k_h = 0.00g$ [ODOT GDM, Section 6.5.3.1]

Gravity Loads

Surcharge Loads (per Geotech)

- Concrete Retaining Walls: No surcharge loads
- MSE Walls:
  - Uniform Vertical Surcharge = 200psf (accounts for traffic and construction loads)

MSE Wall Design

By inspection, Walls 3 controls for the design of Wall 1, 2, 3, and 4 as it retains the greatest soil height under equivalent load parameters and conditions. Design for Wall heights ranging from 0'-0" to 10'-6" at increments of 1'-6" (equivalent to block height).

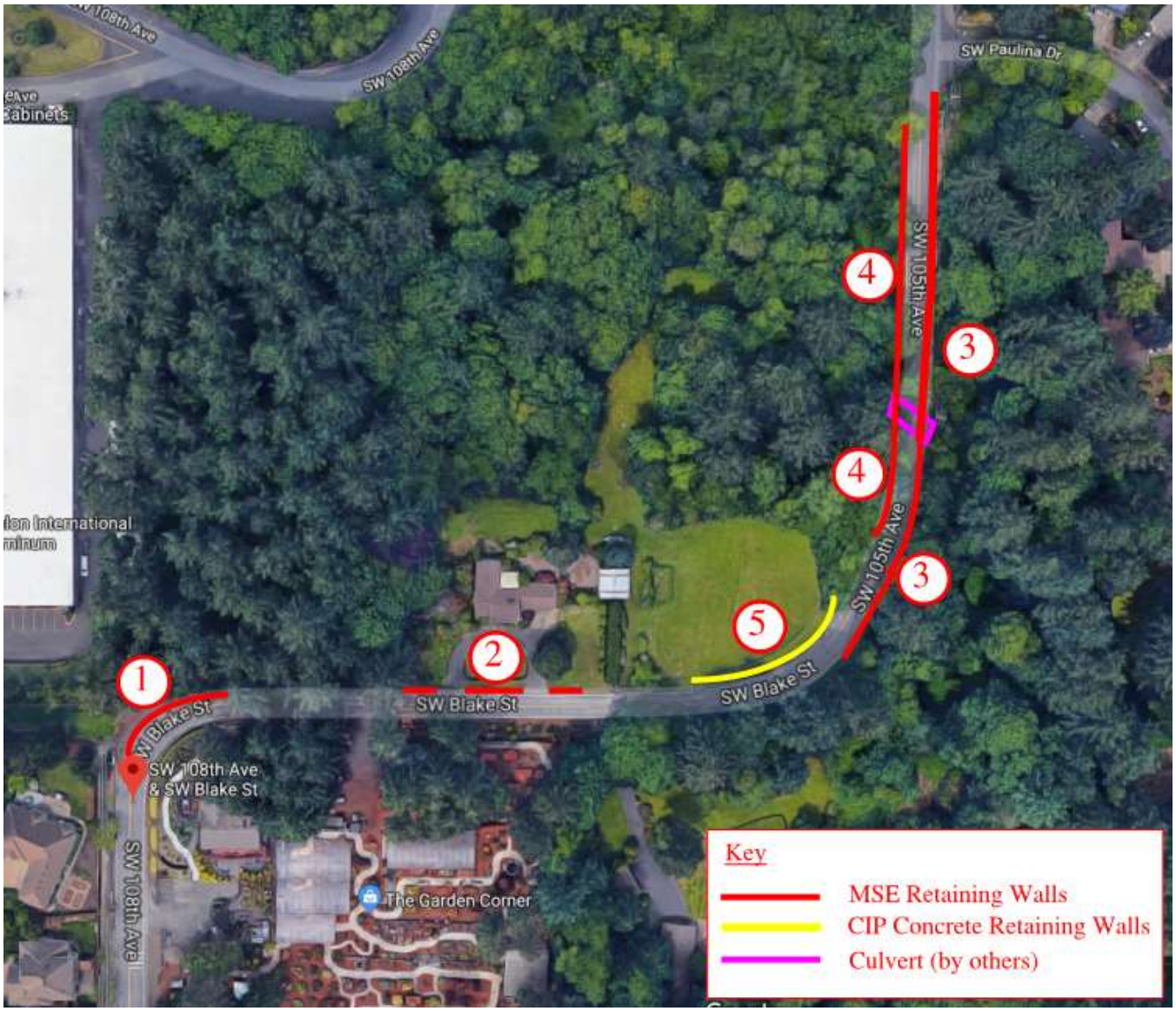


Figure 2: Roadway Plan

MSE Wall Design – Walls 1-4

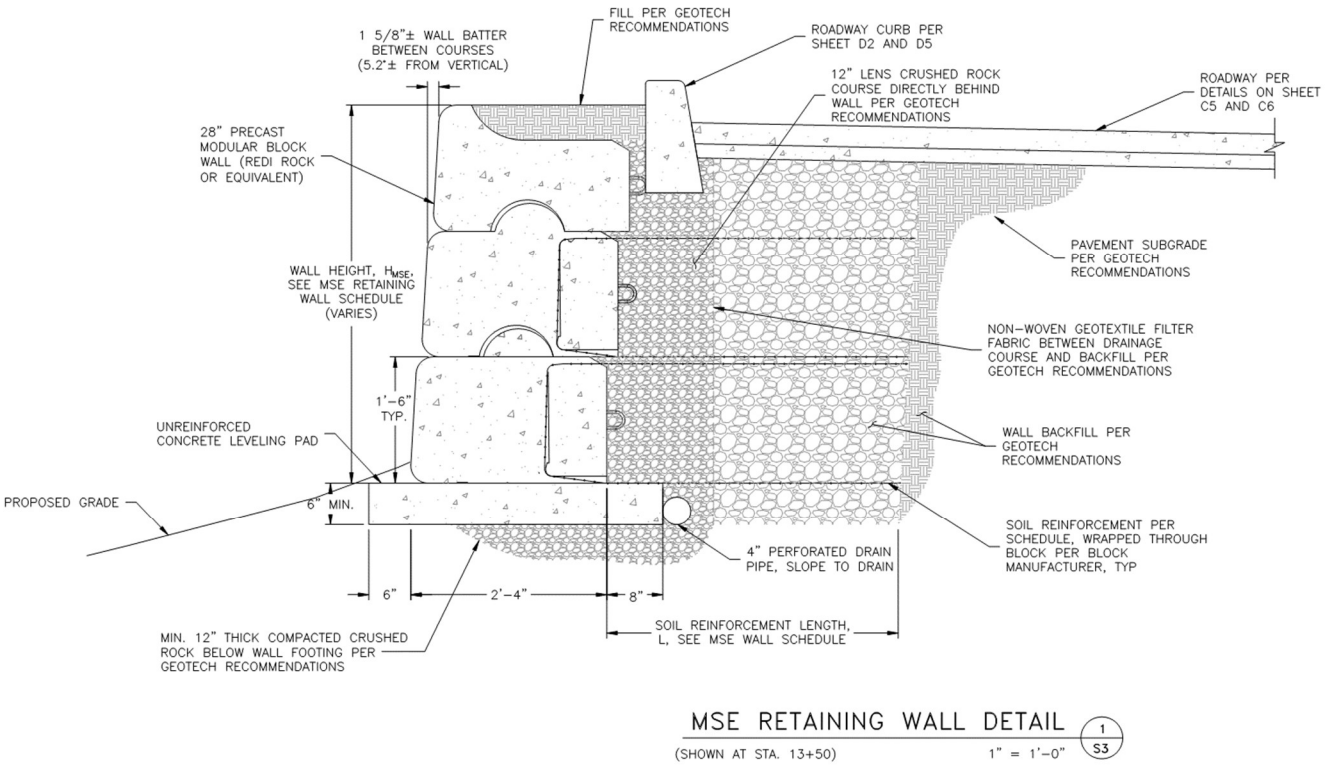


Figure 3: MSE Retaining Wall Detail

Wall Information:

- Max Height = 10.5'
- Max Number of Courses = 7
- Curved wall sections around the road curves. Varies in height along length.
- Supports roadway in some regions (Wall 1, 2, and 4) and bike path in others (Wall 3). All MSE wall segments designed to resist roadway surcharge loading.
- Design for Wall heights ranging from 0'-0" to 10'-6" at increments of 1'-6" (equivalent to unit block height).

Design Criteria:

- Evaluated per AASHTO Chapter 11.10, Requirements per Geotechnical Engineer, and NCMA Design Manual for Segmental Retaining Walls
- Active Earth Pressure Calculation Method: Coulomb
- Passive Earth Pressure conservatively ignored
- Seismic Analysis Method: Mononobe-Okabe (Per AASHTO)
- Min. Required Reinforcement Length = 0.7*Height of Wall (Per AASHTO 11.10.2.1)
- Block and geogrid internal stability and strength evaluated using Safety Factors
- Verification Methodology: Safety Factors (Per NCMA Table 5-2)

Case	Transient/Variable	Seismic
Overturning FS	1.50	1.10
Sliding FS	1.50	1.10
Soil Bearing FS*	1.33 (1500psf)	1.00 (2000psf)
Sliding Along Geo-Reinforcement FS	1.50	1.10
Geo-Reinforcement Strength FS	1.50	1.10
Geo-Reinforcement Pull Out FS	1.50	1.10
Geo-Reinforcement Connection FS	1.50	1.10

*Allowable soil bearing pressures were prescribed by the Geotechnical engineer (1500 psf for static and 2000psf for seismic). As such, an additional factor of safety was not applied in the structural calculations for soil bearing pressure, as PSE understands that it was already accounted for in the recommended allowable pressure prescribed by the Geotechnical engineer.

Design Loads:

- Active Earth Pressure = 35pcf (yielding wall)
- Uniform Vertical Surcharge atop wall = 200psf
- Horizontal Seismic Loads: $k_h = 0.162g$
- Vertical Seismic Loads: $k_v = 0.00g$

Per MSE wall analysis software (See Appendix A), the following design outcomes are acceptable for varying heights of MSE walls:

MSE RETAINING WALL SCHEDULE

WALL HEIGHT* "H_{MSE}"	NUMBER OF BLOCKS, VERTICAL	NUMBER OF BLOCKS W/SOIL REINFORCEMENT (FROM BOTTOM)	SOIL REINFORCEMENT TYPE	SOIL REINFORCEMENT LENGTH, "L"
0'–0" TO 3'–0"	2	1	12" MIRAFI 5XT GEOGRID (OR EQUIVALENT)	2'–6"**
3'–0" TO 4'–6"	3	2	12" MIRAFI 5XT GEOGRID (OR EQUIVALENT)	3'–6"
4'–6" TO 6'–0"	4	3	12" MIRAFI 5XT GEOGRID (OR EQUIVALENT)	4'–6"
6'–0" TO 7'–6"	5	4	12" MIRAFI 5XT GEOGRID (OR EQUIVALENT)	5'–6"
7'–6" TO 9'–0"	6	5	12" MIRAFI 5XT GEOGRID (OR EQUIVALENT)	6'–6"
9'–0" TO 10'–6"	7	6	12" MIRAFI 5XT GEOGRID (OR EQUIVALENT)	7'–6"

* WALL HEIGHT MEASURED FROM SOIL GRADE AT THE BASE OF THE WALL TO TOP OF RETAINING WALL. SUBGRADE PORTIONS OF THE WALL ARE NOT INCLUDED IN THE TABULATED WALL HEIGHT RANGES.
** MSE WALL SEGMENTS LESS THAN 3'–0" TALL THAT SUPPORT THE BIKE PATH DO NOT REQUIRE SOIL REINFORCEMENT. WHERE MSE WALL SEGMENTS SUPPORT THE ROADWAY, THE SOIL REINFORCEMENT SHALL BE AS TABULATED ABOVE.

Cast- in-Place Cantilever Wall Design

Figure 4: Roadway Plan

Design the CIP Concrete Retaining Walls per AASHTO Chapter 11.6.

CIP Cantilever Wall Design – Wall 5

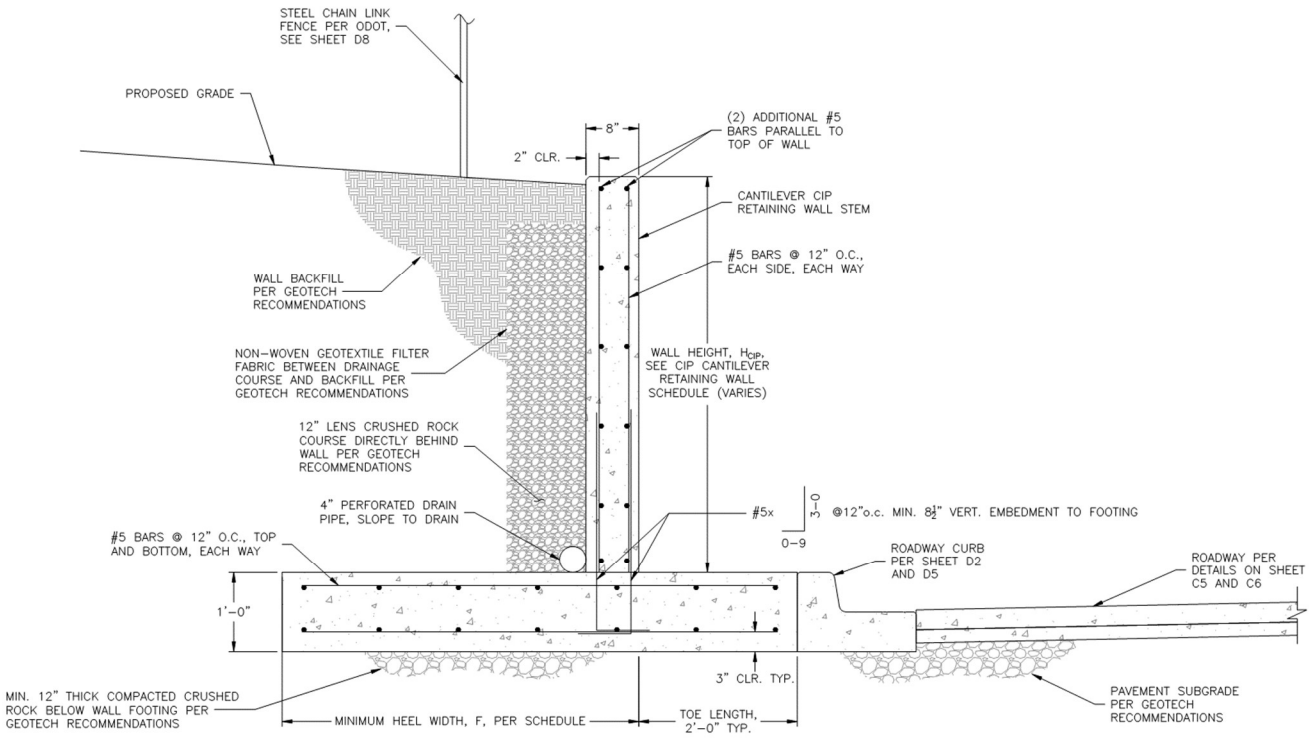


Figure 5: CIP Cantilever Retaining Wall

Wall Information:

- Max Height = 6.0'
- Retains soil from roadway
- Concrete Strength, f'_c = 4,000psi
- Wall Stem = 8" thick. Reinforced with #5 bars @ 12" o.c., each way, both faces
  - The stem has been conservatively evaluated in RetainPro as a singly reinforced section with #5 bars @ 12" o.c. at the tension face.
- Wall Footing:
  - Depth = 1'-0"
  - Toe Width = 2'-0"
  - Heel Width = 4'-6" max, 2'-6" min (varies with wall height)
  - Reinforced with #5 bars @ 12" o.c., each way, both faces
- Wall Key: No wall key present

Design Criteria

- Evaluated per AASHTO and Requirements per Geotechnical Engineer
  - Load Factors input for Strength Level I state:
    - Dead Load, DC = 1.25
    - Surcharge Load (live), ES = 1.50 (Note: surcharge = 0psf)
    - Earth Active Pressure, EH = 1.50
    - Seismic, EQ = N/A
  - Load Factors input for Extreme Event I state: By inspection, Controls
    - Dead Load, DC = 1.25
    - Surcharge Load (live), ES = γEQ = 0.75 (Note: surcharge = 0psf)
    - Earth Active Pressure, EH = 1.50
    - Seismic, EQ = 1.00
- External Stability:
  - Overturning FS = 1.5
  - Sliding FS = 1.5
- Allowable Bearing Pressure = 2000psf (allowed 1/3 increase for short term loads per Geotech report)
- Stem wall and Footing Design: Per AASHTO & ACI LRFD Criteria

Design Loads:

- Active Earth Pressure = 35pcf (yielding wall)
- Passive Earth Pressure conservatively ignored
- Uniform Vertical Surcharge = 0psf (doesn't support roadway)
- Seismic Loads: 0H @ top of wall, 8H at bottom of wall

Per RetainPro (see Appendix), the following table is acceptable for varying heights of CIP walls:

CIP CANTILEVER WALL SCHEDULE

WALL HEIGHT, "H_{CIP}"	STEM THICKNESS	STEM REINFORCEMENT	FOOTING HEEL WIDTH, "F"	FOOTING TOE WIDTH	FOOTING DEPTH	FOOTING REINFORCEMENT
0'–0" TO 3'–0"	0'–8"	#5 BARS @ 12" O.C., BOTH FACES, EACH WAY	2'–6"	2'–0"	1'–0"	#5 BARS @ 12" O.C., TOP AND BOTTOM, EACH WAY
3'–0" TO 4'–6"	0'–8"	#5 BARS @ 12"O.C., BOTH FACES, EACH WAY	3'–6"	2'–0"	1'–0"	#5 BARS @ 12" O.C., TOP AND BOTTOM, EACH WAY
4'–6" TO 6'–0"	0'–8"	#5 BARS @ 12"O.C., BOTH FACES, EACH WAY	4'–6"	2'–0"	1'–0"	#5 BARS @ 12" O.C., TOP AND BOTTOM, EACH WAY

CIP CANTILEVER RETAINING WALL NOTES

1. ALL CIP CANTILEVER WALLS OF VARYING HEIGHT SHALL CONFORM TO THE REQUIREMENTS OUTLINED IN THE CIP CANTILEVER WALL SCHEDULE.
2. POST INSTALLED FENCES ATOP WALLS SHALL BE INSTALLED PER ODOT ANCHORAGE REQUIREMENTS. E.O.R. SHALL BE NOTIFIED PRIOR TO ANCHORING TO WALLS.
3. TABULATED FOOTING WIDTHS MAY BE INCREASED AT CONTRACTOR'S OPTION.
4. WALL FOOTINGS SHALL NOT BE MULTIPURPOSED FOR ROADWAY/CURB FOOTINGS.
5. E.O.R. SHALL BE NOTIFIED IF TREE ROOTS CONFLICT WITH RETAINING WALLS/WALL FOOTINGS.

Note: By inspection, the MSE Retaining walls are designed for greater loading than the CIP Cantilever wall since the MSE walls are responsible for supporting the roadway and surcharge loads. As such, the MSE wall designs control. At contractor/owner's option, MSE walls may be constructed in lieu of CIP cantilever walls. Finish grade elevations behind and in front of the walls shall not change. MSE walls must be constructed in conformance with MSE wall construction details and schedule.

Appendix A – MSE Wall Design

10'-6" Tall Wall – Seismic Case

Analysis of Redi Rock wall

Input data

Project

Date : 11/25/2019

Settings

(input for current task)

Materials and standards

AASHTO - reduce parameters of friction soil/soil by 2/3 φ

Wall analysis

Active earth pressure calculation :	Coulomb
Passive earth pressure calculation :	Mazindrani (Rankine)
Earthquake analysis :	Mononobe-Okabe
Shape of earth wedge :	Calculate as skew
Allowable eccentricity :	0.333
Internal stability :	Standard - straight slip surface
Reduction coeff. of contact first block - base :	1.00
Verification methodology :	Safety factors (ASD)

Safety factors			
Seismic design situation			
Safety factor for overturning :	SF_o =	1.10	[–]
Safety factor for sliding resistance :	SF_s =	1.10	[–]
Safety factor for bearing capacity :	SF_b =	1.00	[–]
Safety factor for sliding along geo-reinforcement :	SF_{sr} =	1.10	[–]
Safety factor for geo-reinforcement strength :	SF_{st} =	1.10	[–]
Safety factor for pull out resistance of geo-reinf. :	SF_{po} =	1.10	[–]
Safety factor for connection strength :	SF_{con} =	1.10	[–]

Geometry

No. group	Description	Count	Setbacks [in]
1	Block 28 PC	6	1.62
2	Top block 28	1	-

Base

Geometry

Upper setback a_1 = 0.50 ft
Lower setback a_2 = 0.50 ft
Height h = 0.50 ft
Width b = 3.50 ft

Material

Unreinforced Footing
Concrete self-weight γ = 150.00 pcf
Shear cub (key) capacity = 0.00 lbf/ft
Friction angle concrete-concrete = 30.00 °

Types of reinforcements

No.	Name	Type of reinforcement	Line type	Tensile strength T_{ult} [lbf/ft]	R_t [lbf/ft]	R_{con} [lbf/ft]
1	Miragrid 5XT	Miragrid 5XT	- - - - - - -	4700.00	2069.35	2174.26
2	Miragrid 8XT	Miragrid 8XT	- - - - - - - - -	7400.00	3393.87	3423.30
3	Miragrid 10XT	Miragrid 10XT	- - - - - - -	9500.00	4357.00	4287.39
4	Miragrid 20XT	Miragrid 20XT	~~~~~~~~~~~~	13705.00	6558.83	6030.20
5	Miragrid 24XT	Miragrid 24XT	~~~~~~~~~~~~	27415.00	13716.42	10560.73

Reinforcement details

1. Miragrid 5XT

Short-term char. strength	T_{ult}	=	4700.00	lbf/ft
Creep red. factor	RF_{CR}	=	1.58	
Durability red. factor	RF_D	=	1.15	
Installation damage red. factor	RF_{ID}	=	1.25	
Long-term design strength	R_t	=	2069.35	lbf/ft
Coefficient of direct slip along reinforcement	C_{ds}	=	0.67	
Coefficient of interaction of soil and geo-reinforcement	C_i	=	0.67	
Scale correction factor	α	=	0.8	
Long-term strength reduction factor	CR_{cr}	=	0.532	
Analysis of long-term strength	R_{con}	=	2174.26	lbf/ft

2. Miragrid 8XT

Short-term char. strength	T_{ult}	=	7400.00	lbf/ft
Creep red. factor	RF_{CR}	=	1.58	
Durability red. factor	RF_D	=	1.15	
Installation damage red. factor	RF_{ID}	=	1.20	
Long-term design strength	R_t	=	3393.87	lbf/ft
Coefficient of direct slip along reinforcement	C_{ds}	=	0.67	
Coefficient of interaction of soil and geo-reinforcement	C_i	=	0.67	
Scale correction factor	α	=	0.8	
Long-term strength reduction factor	CR_{cr}	=	0.532	
Analysis of long-term strength	R_{con}	=	3423.30	lbf/ft

3. Miragrid 10XT

Short-term char. strength	T_{ult}	=	9500.00	lbf/ft
Creep red. factor	RF_{CR}	=	1.58	
Durability red. factor	RF_D	=	1.15	
Installation damage red. factor	RF_{ID}	=	1.20	
Long-term design strength	R_t	=	4357.00	lbf/ft
Coefficient of direct slip along reinforcement	C_{ds}	=	0.67	
Coefficient of interaction of soil and geo-reinforcement	C_i	=	0.67	
Scale correction factor	α	=	0.8	
Long-term strength reduction factor	CR_{cr}	=	0.519	
Analysis of long-term strength	R_{con}	=	4287.39	lbf/ft

4. Miragrid 20XT

Short-term char. strength	T_{ult}	=	13705.00	lbf/ft

Creep red. factor	RF_{CR}	=	1.58	
Durability red. factor	RF_D	=	1.15	
Installation damage red. factor	RF_{ID}	=	1.15	
Long-term design strength	R_t	=	6558.83	lbf/ft
Coefficient of direct slip along reinforcement	C_{ds}	=	0.67	
Coefficient of interaction of soil and geo-reinforcement	C_i	=	0.67	
Scale correction factor	α	=	0.8	
Long-term strength reduction factor	CR_{cr}	=	0.506	
Analysis of long-term strength	R_{con}	=	6030.20	lbf/ft

5. Miragrid 24XT

Short-term char. strength	T_{ult}	=	27415.00	lbf/ft
Creep red. factor	RF_{CR}	=	1.58	
Durability red. factor	RF_D	=	1.15	
Installation damage red. factor	RF_{ID}	=	1.10	
Long-term design strength	R_t	=	13716.42	lbf/ft
Coefficient of direct slip along reinforcement	C_{ds}	=	0.67	
Coefficient of interaction of soil and geo-reinforcement	C_i	=	0.67	
Scale correction factor	α	=	0.8	
Long-term strength reduction factor	CR_{cr}	=	0.443	
Analysis of long-term strength	R_{con}	=	10560.73	lbf/ft

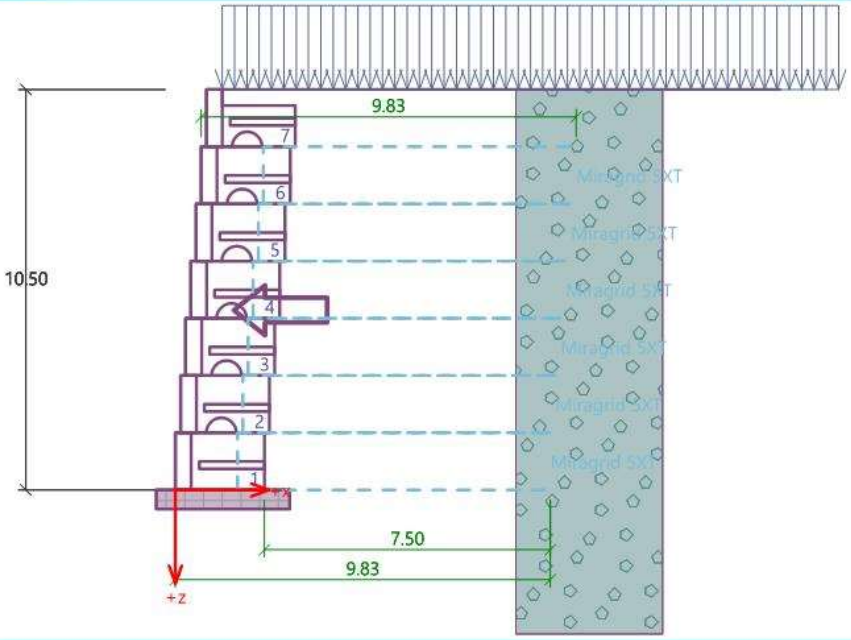
Reinforcements

Input mode : 1 reinforcement type
Reinf. installation : in every row of blocks (50%)
Type of reinforcement : Miragrid 5XT
Top reinforcement : straight (25%)
Reinforcement geometry : identical length of reinforcements
Length of reinforcement l = 7.50 ft

Reinforcements

No.	Consider	Name	Length of reinforcement l [ft]	End pt. coordinate l_k [ft]
1	Yes	Miragrid 5XT	7.50	
2	Yes	Miragrid 5XT	7.50	
3	Yes	Miragrid 5XT	7.50	
4	Yes	Miragrid 5XT	7.50	
5	Yes	Miragrid 5XT	7.50	
6	Yes	Miragrid 5XT	7.50	
7	No			

Name : Reinforcements | **Stage - analysis : 1 - 0**



Soil parameters

Gravel Backfill

Unit weight :	γ =	130.0 pcf
Stress-state :		effective
Angle of internal friction :	φ_{ef} =	35.50 °
Cohesion of soil :	c_{ef} =	0.0 psf
Angle of friction struc.-soil :	δ =	34.00 °
Saturated unit weight :	γ_{sat} =	130.0 pcf

Input surface surcharges

No.	Surcharge new	Surcharge change	Action	Mag.1 [lbf/ft²]	Mag.2 [lbf/ft²]	Ord.x x [ft]	Length l [ft]	Depth z [ft]
1	Yes		variable	200.0				on terrain

No.	Name
1	Roadway Surcharge

Resistance on front face of the structure

Resistance on front face of the structure is not considered.

Earthquake

Factor of horizontal acceleration K_h = 0.1620
Factor of vertical acceleration K_v = 0.0000

Water below the GWT is free.
Specific gravity of soil particles G_s = 2.08.

Settings of the stage of construction

Design situation : seismic

Verification No. 1

Forces acting on construction

Name	F_{hor} [lbf/ft]	App.Pt. z [ft]	F_{vert} [lbf/ft]	App.Pt. x [ft]	Design coefficient
Weight - reinforced soil	0.0	-5.28	10380.9	6.46	1.000
Earthquake - soil wedge	1681.7	-5.28	0.0	6.46	1.000
Active pressure	1572.7	-3.50	689.3	10.51	1.000
Earthq.- act.pressure	700.5	-7.00	307.0	10.51	1.000
Roadway Surcharge	460.9	-5.25	202.0	10.51	1.000
Weight - wall	0.0	-5.08	2844.2	1.55	1.000
Earthq.- constr.	460.8	-5.08	0.0	1.55	1.000

Verification of complete wall

Place of verification : bottom of blocks

Check for overturning stability

Resisting moment M_{res} = 84064.0 lbfft/ft
Overturning moment M_{ovr} = 24049.4 lbfft/ft

Safety factor = 3.50 > 1.10
Wall for overturning is SATISFACTORY

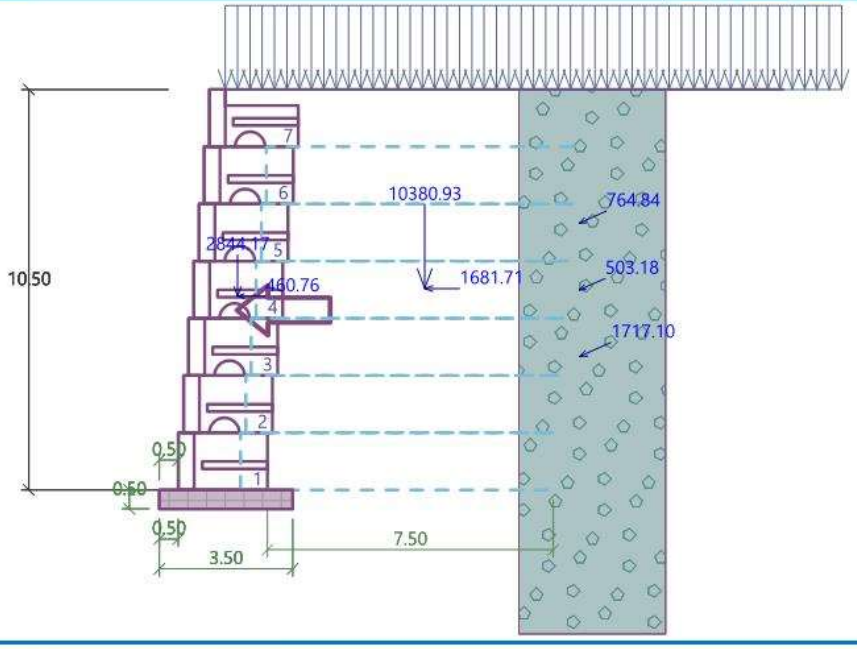
Check for slip

Resisting horizontal force H_{res} = 9439.32 lbf/ft
Active horizontal force H_{act} = 4876.53 lbf/ft

Safety factor = 1.94 > 1.10
Wall for slip is SATISFACTORY

Overall check - WALL is SATISFACTORY

Name : Verification | Stage - analysis : 1 - 1



Bearing capacity of foundation soil

Design load acting at the center of footing bottom

No.	Moment [lbfft/ft]	Norm. force [lbf/ft]	Shear Force [lbf/ft]	Eccentricity [–]	Stress [psf]
1	-17234.3	5745.70	-2468.01	0.000	1641.6

Service load acting at the center of footing bottom

No.	Moment [lbfft/ft]	Norm. force [lbf/ft]	Shear Force [lbf/ft]
1	-17234.3	5745.70	-2468.01

Verification of foundation soil

Place of verification : bottom of leveling pad
Stress in the footing bottom : trapezoid

Eccentricity verification
Max. eccentricity of normal force e = 0.000
Maximum allowable eccentricity e_{alw} = 0.333

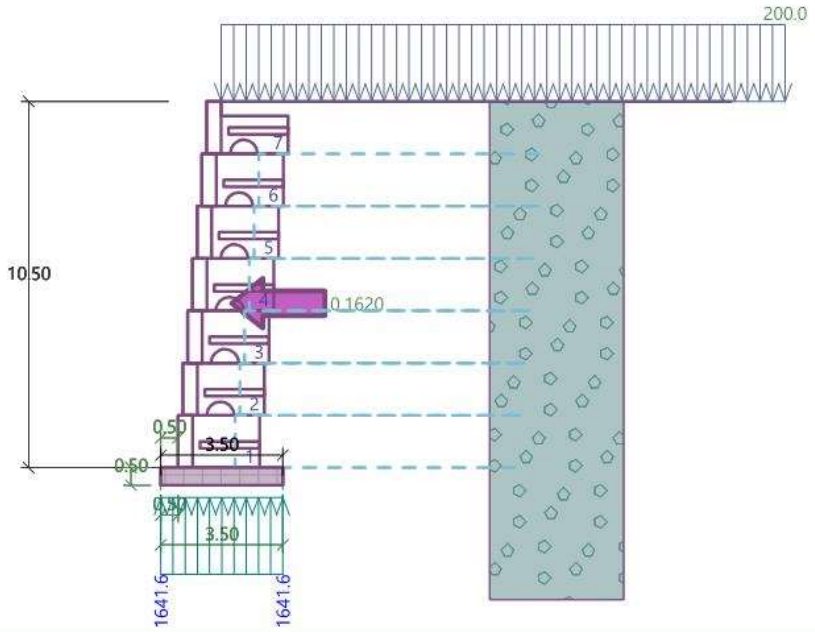
Eccentricity of the normal force is SATISFACTORY

Verification of bearing capacity
Max. stress at footing bottom σ = 1641.6 psf
Bearing capacity of foundation soil R_d = 2000.0 psf

Safety factor = 1.22 > 1.00
Bearing capacity of foundation soil is SATISFACTORY

Overall verification - bearing capacity of found. soil is SATISFACTORY

Name : Bearing cap. | **Stage - analysis : 1 - -1**



Verification of slip on georeinforcement No. 1

Forces acting on construction (verification of reinforcement No.: 1)

Name	F_{hor} [lbf/ft]	App.Pt. z [ft]	F_{vert} [lbf/ft]	App.Pt. x [ft]	Design coefficient
Weight - wall	0.0	-5.08	2891.6	-3.78	1.000
Earthq.- constr.	468.4	-5.08	0.0	-3.78	1.000
Active pressure	1572.7	-3.50	689.3	7.50	1.000
Earthq.- act.pressure	700.5	-7.00	307.0	7.50	1.000
Roadway Surcharge	460.9	-5.25	202.0	7.50	1.000
Weight - reinforced soil	0.0	-5.14	9760.4	3.95	1.000
Earthquake - soil wedge	1568.6	-5.14	0.0	3.95	1.000
Roadway Surcharge	0.0	-10.50	1720.8	0.20	1.000

Verification against slip along geotextile No.: 1

Inclination of slip surface	=	90.00	°
Overall normal force acting on reinforcement	=	12679.49	lbf/ft
Coefficient of reduction of slip along geo-textile	=	0.92	
Resistance along geo-reinforcement	=	8298.05	lbf/ft
Wall resistance	=	0.00	lbf/ft
Overall bearing capacity of reinforcements	=	0.00	lbf/ft

Check for slip:

Resisting horizontal force H_{res} = 8298.05 lbf/ft
Active horiz. force H_{act} = 2734.06 lbf/ft

Factor of safety = 3.04 > 1.10

Slip along geotextile is SATISFACTORY

Calculation of internal stability No. 1

Calculated forces and strength of reinforcements

No.	Name	F_x [lbf/ft]	Depth z[ft]	R_t [lbf/ft]	Utiliz. [%]	T_p [lbf/ft]	Utiliz. [%]	R_{con} [lbf/ft]	Utiliz. [%]
1	Miragrid 5XT	-233.67	10.50	517.34	49.68	1957.03	13.13	543.57	47.29
2	Miragrid 5XT	-423.11	9.00	1034.67	44.98	3030.75	15.36	1087.13	42.81
3	Miragrid 5XT	-375.37	7.50	1034.67	39.91	2255.49	18.31	1087.13	37.98
4	Miragrid 5XT	-350.42	6.00	1034.67	37.25	1588.29	24.27	1087.13	35.46
5	Miragrid 5XT	-325.48	4.50	1034.67	34.60	1029.14	34.79	1087.13	32.93
6	Miragrid 5XT	-300.53	3.00	1034.67	31.95	578.04	57.19	1087.13	30.41

Check for tensile strength (reinforcement No.1)
Tension strength R_t = 517.34 lbf/ft
Force in reinforcement F_x = 233.67 lbf/ft

Safety factor = 2.21 > 1.10
Reinforcement for tensile strength is SATISFACTORY

Check for pull out resistance (reinforcement No.6)
Pull out resistance T_p = 578.04 lbf/ft
Force in reinforcement F_x = 300.53 lbf/ft

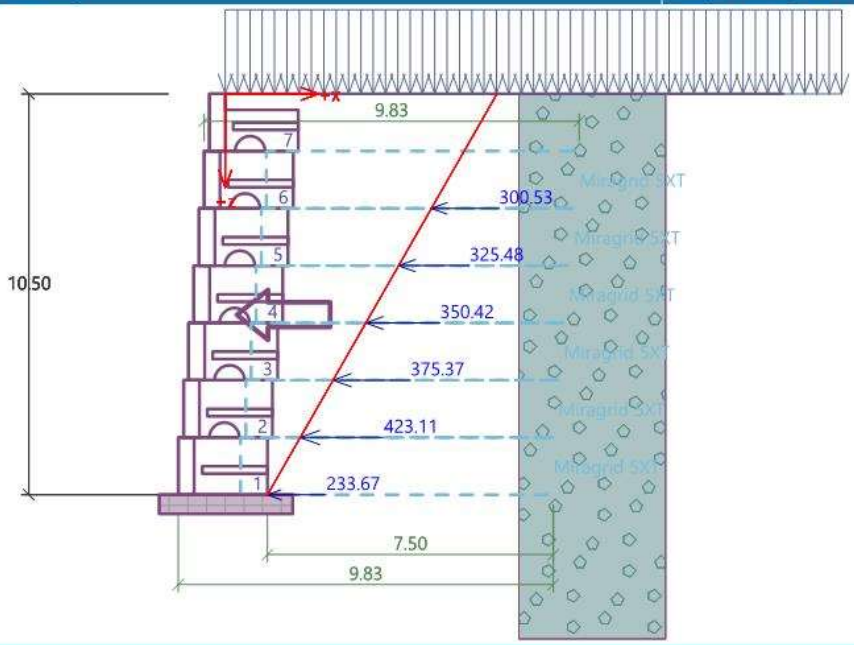
Safety factor = 1.92 > 1.10
Reinforcement for pull out resistance is SATISFACTORY

Verification of connection strength (reinforcement No.1)
Connection strength R_{con} = 543.57 lbf/ft
Force in reinforcement F_x = 233.67 lbf/ft

Safety factor = 2.33 > 1.10
Connection strength is SATISFACTORY

Overall verification - reinforcement is SATISFACTORY

Name : Internal stability | **Stage - analysis : 1 - 1**



10'-6" Tall Wall – Transient Case

Analysis of Redi Rock wall

Input data

Project

Date : 11/25/2019

Settings

(input for current task)

Materials and standards

AASHTO - reduce parameters of friction soil/soil by 2/3 φ

Wall analysis

Active earth pressure calculation :	Coulomb
Passive earth pressure calculation :	Mazindrani (Rankine)
Earthquake analysis :	Mononobe-Okabe
Shape of earth wedge :	Calculate as skew
Allowable eccentricity :	0.333
Internal stability :	Standard - straight slip surface
Reduction coeff. of contact first block - base :	1.00
Verification methodology :	Safety factors (ASD)

Safety factors			
Transient design situation			
Safety factor for overturning :	SF_o =	1.50	[–]
Safety factor for sliding resistance :	SF_s =	1.50	[–]
Safety factor for bearing capacity :	SF_b =	1.33	[–]
Safety factor for sliding along geo-reinforcement :	SF_{sr} =	1.50	[–]
Safety factor for geo-reinforcement strength :	SF_{st} =	1.50	[–]
Safety factor for pull out resistance of geo-reinf. :	SF_{po} =	1.50	[–]
Safety factor for connection strength :	SF_{con} =	1.50	[–]

Geometry

No. group	Description	Count	Setbacks [in]
1	Block 28 PC	6	1.62
2	Top block 28	1	-

Base

Geometry

Upper setback a_1 = 0.50 ft
Lower setback a_2 = 0.50 ft
Height h = 0.50 ft
Width b = 3.50 ft

Material

Unreinforced Footing
Concrete self-weight γ = 150.00 pcf
Shear cub (key) capacity = 0.00 lbf/ft
Friction angle concrete-concrete = 30.00 °

Types of reinforcements

No.	Name	Type of reinforcement	Line type	Tensile strength		
				T_{ult} [lbf/ft]	R_t [lbf/ft]	R_{con} [lbf/ft]
1	Miragrid 5XT	Miragrid 5XT	- - - - - - -	4700.00	2069.35	2174.26
2	Miragrid 8XT	Miragrid 8XT	- - - - - - - - -	7400.00	3393.87	3423.30
3	Miragrid 10XT	Miragrid 10XT	- - - - - - -	9500.00	4357.00	4287.39
4	Miragrid 20XT	Miragrid 20XT	~~~~~~~~~~~	13705.00	6558.83	6030.20
5	Miragrid 24XT	Miragrid 24XT	~~~~~~~~~~~	27415.00	13716.42	10560.73

Reinforcement details

1. Miragrid 5XT

Short-term char. strength	T_{ult}	=	4700.00	lbf/ft
Creep red. factor	RF_{CR}	=	1.58	
Durability red. factor	RF_D	=	1.15	
Installation damage red. factor	RF_{ID}	=	1.25	
Long-term design strength	R_t	=	2069.35	lbf/ft
Coefficient of direct slip along reinforcement	C_{ds}	=	0.67	
Coefficient of interaction of soil and geo-reinforcement	C_i	=	0.67	
Scale correction factor	α	=	0.8	
Long-term strength reduction factor	CR_{cr}	=	0.532	
Analysis of long-term strength	R_{con}	=	2174.26	lbf/ft

2. Miragrid 8XT

Short-term char. strength	T_{ult}	=	7400.00	lbf/ft
Creep red. factor	RF_{CR}	=	1.58	
Durability red. factor	RF_D	=	1.15	
Installation damage red. factor	RF_{ID}	=	1.20	
Long-term design strength	R_t	=	3393.87	lbf/ft
Coefficient of direct slip along reinforcement	C_{ds}	=	0.67	
Coefficient of interaction of soil and geo-reinforcement	C_i	=	0.67	
Scale correction factor	α	=	0.8	
Long-term strength reduction factor	CR_{cr}	=	0.532	
Analysis of long-term strength	R_{con}	=	3423.30	lbf/ft

3. Miragrid 10XT

Short-term char. strength	T_{ult}	=	9500.00	lbf/ft
Creep red. factor	RF_{CR}	=	1.58	
Durability red. factor	RF_D	=	1.15	
Installation damage red. factor	RF_{ID}	=	1.20	
Long-term design strength	R_t	=	4357.00	lbf/ft
Coefficient of direct slip along reinforcement	C_{ds}	=	0.67	
Coefficient of interaction of soil and geo-reinforcement	C_i	=	0.67	
Scale correction factor	α	=	0.8	
Long-term strength reduction factor	CR_{cr}	=	0.519	
Analysis of long-term strength	R_{con}	=	4287.39	lbf/ft

4. Miragrid 20XT

Short-term char. strength	T_{ult}	=	13705.00	lbf/ft
Creep red. factor	RF_{CR}	=	1.58	
Durability red. factor	RF_D	=	1.15	
Installation damage red. factor	RF_{ID}	=	1.15	
Long-term design strength	R_t	=	6558.83	lbf/ft
Coefficient of direct slip along reinforcement	C_{ds}	=	0.67	
Coefficient of interaction of soil and geo-reinforcement	C_i	=	0.67	
Scale correction factor	α	=	0.8	
Long-term strength reduction factor	CR_{cr}	=	0.506	
Analysis of long-term strength	R_{con}	=	6030.20	lbf/ft

5. Miragrid 24XT

Short-term char. strength	T_{ult}	=	27415.00	lbf/ft
Creep red. factor	RF_{CR}	=	1.58	
Durability red. factor	RF_D	=	1.15	
Installation damage red. factor	RF_{ID}	=	1.10	
Long-term design strength	R_t	=	13716.42	lbf/ft
Coefficient of direct slip along reinforcement	C_{ds}	=	0.67	
Coefficient of interaction of soil and geo-reinforcement	C_i	=	0.67	
Scale correction factor	α	=	0.8	
Long-term strength reduction factor	CR_{cr}	=	0.443	
Analysis of long-term strength	R_{con}	=	10560.73	lbf/ft

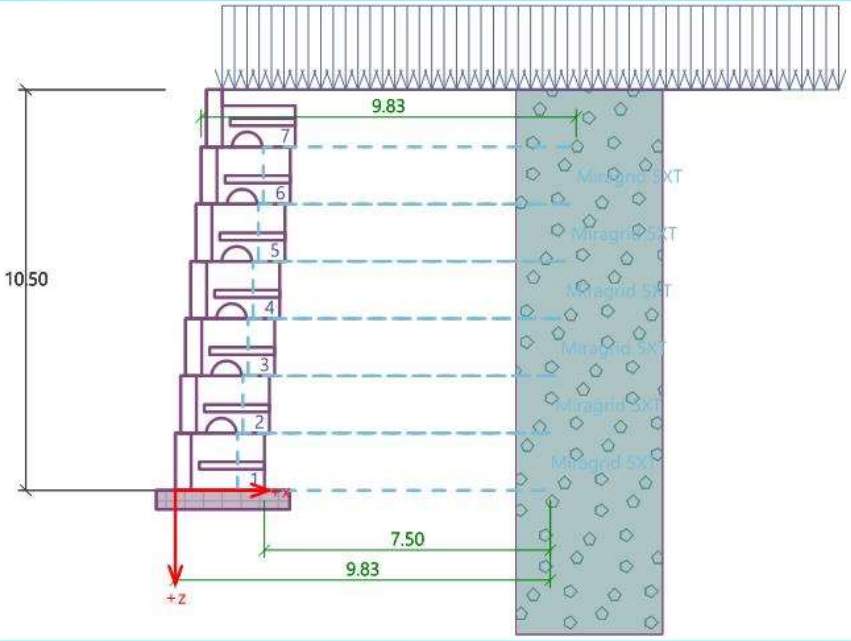
Reinforcements

Input mode : 1 reinforcement type
Reinf. installation : in every row of blocks (50%)
Type of reinforcement : Miragrid 5XT
Top reinforcement : straight (25%)
Reinforcement geometry : identical length of reinforcements
Length of reinforcement l = 7.50 ft

Reinforcements

No.	Consider	Name	Length of reinforcement l [ft]	End pt. coordinate l_k [ft]
1	Yes	Miragrid 5XT	7.50	
2	Yes	Miragrid 5XT	7.50	
3	Yes	Miragrid 5XT	7.50	
4	Yes	Miragrid 5XT	7.50	
5	Yes	Miragrid 5XT	7.50	
6	Yes	Miragrid 5XT	7.50	
7	No			

Name : Reinforcements | **Stage - analysis : 1 - 0**



Soil parameters

Gravel Backfill

Unit weight :	γ =	130.0 pcf
Stress-state :		effective
Angle of internal friction :	φ_{ef} =	35.50 °
Cohesion of soil :	c_{ef} =	0.0 psf
Angle of friction struc.-soil :	δ =	34.00 °
Saturated unit weight :	γ_{sat} =	130.0 pcf

Input surface surcharges

No.	Surcharge new	Surcharge change	Action	Mag.1 [lbf/ft²]	Mag.2 [lbf/ft²]	Ord.x x [ft]	Length l [ft]	Depth z [ft]
1	Yes		variable	200.0				on terrain

No.	Name
1	Roadway Surcharge

Resistance on front face of the structure

Resistance on front face of the structure is not considered.

Settings of the stage of construction

Design situation : transient

Verification No. 1

Forces acting on construction

Name	F_{hor} [lbf/ft]	App.Pt. z [ft]	F_{vert} [lbf/ft]	App.Pt. x [ft]	Design coefficient
Weight - reinforced soil	0.0	-5.28	10380.9	6.46	1.000
Active pressure	1572.7	-3.50	689.3	10.51	1.000
Roadway Surcharge	460.9	-5.25	202.0	10.51	1.000
Weight - wall	0.0	-5.08	2844.2	1.55	1.000

Verification of complete wall

Place of verification : bottom of blocks

Check for overturning stability
Resisting moment M_{res} = 80837.1 lbfft/ft
Overturning moment M_{ovr} = 7923.9 lbfft/ft

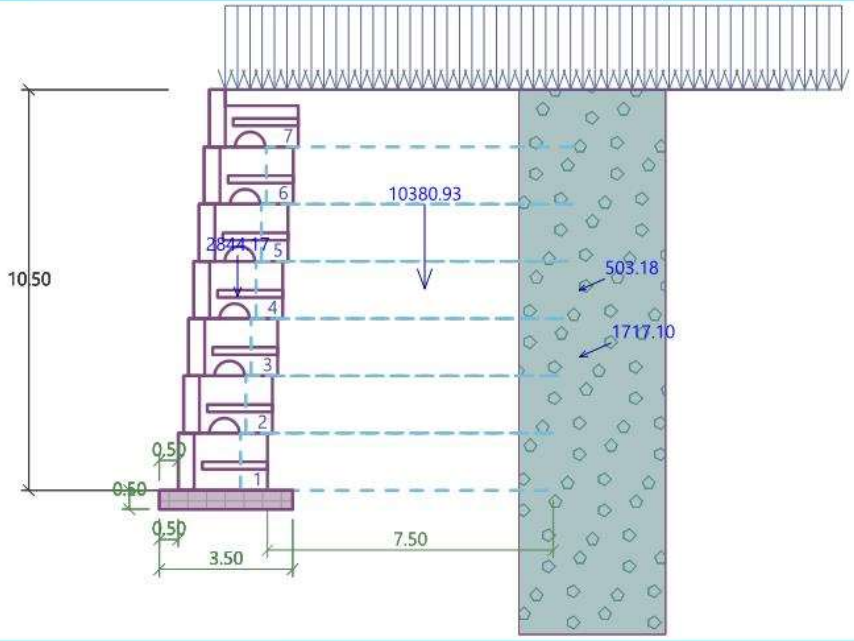
Safety factor = 10.20 > 1.50
Wall for overturning is SATISFACTORY

Check for slip
Resisting horizontal force H_{res} = 9238.39 lbf/ft
Active horizontal force H_{act} = 2033.55 lbf/ft

Safety factor = 4.54 > 1.50
Wall for slip is SATISFACTORY

Overall check - WALL is SATISFACTORY

Name : Verification | Stage - analysis : 1 - 1



Bearing capacity of foundation soil

Design load acting at the center of footing bottom

No.	Moment [lbfft/ft]	Norm. force [lbf/ft]	Shear Force [lbf/ft]	Eccentricity [–]	Stress [psf]
1	-24844.3	5170.87	-3778.51	0.000	1477.4

Service load acting at the center of footing bottom

No.	Moment [lbfft/ft]	Norm. force [lbf/ft]	Shear Force [lbf/ft]
1	-24844.3	5170.87	-3778.51

Verification of foundation soil

Place of verification : bottom of leveling pad
Stress in the footing bottom : trapezoid

Eccentricity verification
Max. eccentricity of normal force e = 0.000
Maximum allowable eccentricity e_{alw} = 0.333

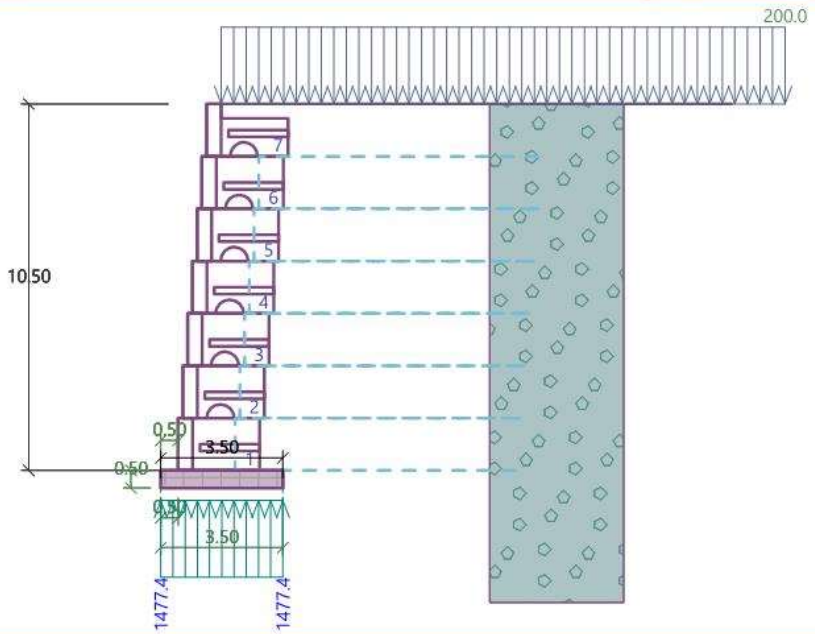
Eccentricity of the normal force is SATISFACTORY

Verification of bearing capacity
Max. stress at footing bottom σ = 1477.4 psf
Bearing capacity of foundation soil R_d = 2000.0 psf

Safety factor = 1.35 > 1.33
Bearing capacity of foundation soil is SATISFACTORY

Overall verification - bearing capacity of found. soil is SATISFACTORY

Name : Bearing cap.	Stage - analysis : 1 - -1



Verification of slip on georeinforcement No. 1

Forces acting on construction (verification of reinforcement No.: 1)

Name	F_{hor} [lbf/ft]	App.Pt. z [ft]	F_{vert} [lbf/ft]	App.Pt. x [ft]	Design coefficient
Weight - wall	0.0	-5.08	2891.6	-3.78	1.000
Active pressure	1572.7	-3.50	689.3	7.50	1.000
Roadway Surcharge	460.9	-5.25	202.0	7.50	1.000
Weight - reinforced soil	0.0	-5.14	9760.4	3.95	1.000
Roadway Surcharge	0.0	-10.50	1720.8	0.20	1.000

Verification against slip along geotextile No.: 1

Inclination of slip surface	=	90.00	°
Overall normal force acting on reinforcement	=	12372.47	lbf/ft
Coefficient of reduction of slip along geo-textile	=	0.92	
Resistance along geo-reinforcement	=	8097.12	lbf/ft
Wall resistance	=	1669.45	lbf/ft
Overall bearing capacity of reinforcements	=	0.00	lbf/ft

Check for slip:

Resisting horizontal force H_{res} = 9766.57 lbf/ft
Active horiz. force H_{act} = 2033.55 lbf/ft

Factor of safety = 4.80 > 1.50

Slip along geotextile is SATISFACTORY

Calculation of internal stability No. 1

Calculated forces and strength of reinforcements

No.	Name	F_x [lbf/ft]	Depth z[ft]	R_t [lbf/ft]	Utiliz. [%]	T_p [lbf/ft]	Utiliz. [%]	R_{con} [lbf/ft]	Utiliz. [%]
1	Miragrid 5XT	-230.06	10.50	517.34	66.71	1957.03	17.63	543.57	63.49
2	Miragrid 5XT	-394.78	9.00	1034.67	57.23	3030.75	19.54	1087.13	54.47
3	Miragrid 5XT	-319.28	7.50	1034.67	46.29	2255.49	21.23	1087.13	44.05
4	Miragrid 5XT	-266.29	6.00	1034.67	38.61	1588.29	25.15	1087.13	36.74
5	Miragrid 5XT	-213.31	4.50	1034.67	30.92	1029.14	31.09	1087.13	29.43
6	Miragrid 5XT	-160.32	3.00	1034.67	23.24	578.04	41.60	1087.13	22.12

Check for tensile strength (reinforcement No.1)

Tension strength R_t = 517.34 lbf/ft

Force in reinforcement F_x = 230.06 lbf/ft

Safety factor = 2.25 > 1.50

Reinforcement for tensile strength is SATISFACTORY

Check for pull out resistance (reinforcement No.6)

Pull out resistance T_p = 578.04 lbf/ft

Force in reinforcement F_x = 160.32 lbf/ft

Safety factor = 3.61 > 1.50

Reinforcement for pull out resistance is SATISFACTORY

Verification of connection strength (reinforcement No.1)

Connection strength R_{con} = 543.57 lbf/ft

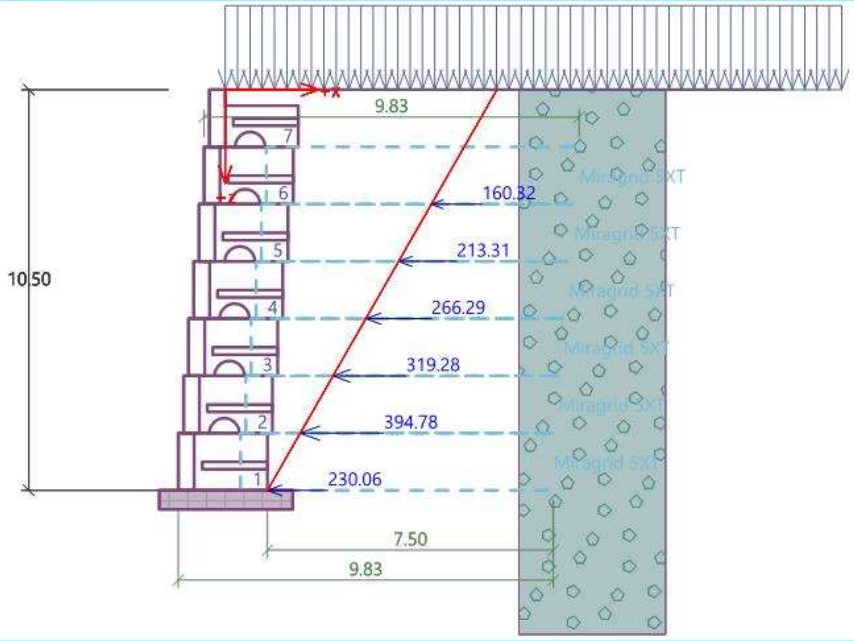
Force in reinforcement F_x = 230.06 lbf/ft

Safety factor = 2.36 > 1.50

Connection strength is SATISFACTORY

Overall verification - reinforcement is SATISFACTORY

Name : Internal stability | **Stage - analysis : 1 - 1**



9'-0" Tall Wall – Seismic Case

Analysis of Redi Rock wall

Input data

Project

Task : MSE Wall Design
Part : 9.0' MSE Wall - Seismic Case
Author : NRW
Date : 11/25/2019
Project number : 1801-0336

Settings

(input for current task)

Materials and standards

AASHTO - reduce parameters of friction soil/soil by 2/3 φ

Wall analysis

Active earth pressure calculation : Coulomb
Passive earth pressure calculation : Mazindrani (Rankine)
Earthquake analysis : Mononobe-Okabe
Shape of earth wedge : Calculate as skew
Allowable eccentricity : 0.333
Internal stability : Standard - straight slip surface
Reduction coeff. of contact first block - base : 1.00
Verification methodology : Safety factors (ASD)

Safety factors			
Seismic design situation			
Safety factor for overturning :	SF_o =	1.10	[–]
Safety factor for sliding resistance :	SF_s =	1.10	[–]
Safety factor for bearing capacity :	SF_b =	1.00	[–]
Safety factor for sliding along geo-reinforcement :	SF_{sr} =	1.10	[–]
Safety factor for geo-reinforcement strength :	SF_{st} =	1.10	[–]
Safety factor for pull out resistance of geo-reinf. :	SF_{po} =	1.10	[–]
Safety factor for connection strength :	SF_{con} =	1.10	[–]

Geometry

No. group	Description	Count	Setback s [in]
1	Block 28 PC	5	1.62
2	Top block 28	1	-

Base

Geometry
Upper setback a_1 = 0.50 ft
Lower setback a_2 = 0.50 ft
Height h = 0.50 ft
Width b = 3.50 ft

Material
Unreinforced Footing
Concrete self-weight γ = 150.00 pcf
Shear cub (key) capacity = 0.00 lbf/ft
Friction angle concrete-concrete = 30.00 °

Types of reinforcements

No.	Name	Type of reinforcement	Line type	Tensile strength		
				T_{ult} [lbf/ft]	R_t [lbf/ft]	R_{con} [lbf/ft]
1	Miragrid 5XT	Miragrid 5XT		4700.00	2069.35	2174.26
2	Miragrid 8XT	Miragrid 8XT		7400.00	3393.87	3423.30
3	Miragrid 10XT	Miragrid 10XT		9500.00	4357.00	4287.39
4	Miragrid 20XT	Miragrid 20XT		13705.00	6558.83	6030.20
5	Miragrid 24XT	Miragrid 24XT		27415.00	13716.42	10560.73

Reinforcement details

1. Miragrid 5XT

Short-term char. strength	T_{ult}	=	4700.00	lbf/ft
Creep red. factor	RF_{CR}	=	1.58	
Durability red. factor	RF_D	=	1.15	
Installation damage red. factor	RF_{ID}	=	1.25	
Long-term design strength	R_t	=	2069.35	lbf/ft
Coefficient of direct slip along reinforcement	C_{ds}	=	0.67	
Coefficient of interaction of soil and geo-reinforcement	C_i	=	0.67	
Scale correction factor	α	=	0.8	
Long-term strength reduction factor	CR_{cr}	=	0.532	
Analysis of long-term strength	R_{con}	=	2174.26	lbf/ft

2. Miragrid 8XT

Short-term char. strength	T_{ult}	=	7400.00	lbf/ft
Creep red. factor	RF_{CR}	=	1.58	
Durability red. factor	RF_D	=	1.15	
Installation damage red. factor	RF_{ID}	=	1.20	
Long-term design strength	R_t	=	3393.87	lbf/ft
Coefficient of direct slip along reinforcement	C_{ds}	=	0.67	
Coefficient of interaction of soil and geo-reinforcement	C_i	=	0.67	
Scale correction factor	α	=	0.8	
Long-term strength reduction factor	CR_{cr}	=	0.532	
Analysis of long-term strength	R_{con}	=	3423.30	lbf/ft

3. Miragrid 10XT

Short-term char. strength	T_{ult}	=	9500.00	lbf/ft
Creep red. factor	RF_{CR}	=	1.58	
Durability red. factor	RF_D	=	1.15	
Installation damage red. factor	RF_{ID}	=	1.20	
Long-term design strength	R_t	=	4357.00	lbf/ft
Coefficient of direct slip along reinforcement	C_{ds}	=	0.67	
Coefficient of interaction of soil and geo-reinforcement	C_i	=	0.67	
Scale correction factor	α	=	0.8	
Long-term strength reduction factor	CR_{cr}	=	0.519	
Analysis of long-term strength	R_{con}	=	4287.39	lbf/ft

4. Miragrid 20XT

Short-term char. strength	T_{ult}	=	13705.00	lbf/ft
Creep red. factor	RF_{CR}	=	1.58	
Durability red. factor	RF_D	=	1.15	
Installation damage red. factor	RF_{ID}	=	1.15	
Long-term design strength	R_t	=	6558.83	lbf/ft
Coefficient of direct slip along reinforcement	C_{ds}	=	0.67	
Coefficient of interaction of soil and geo-reinforcement	C_i	=	0.67	
Scale correction factor	α	=	0.8	
Long-term strength reduction factor	CR_{cr}	=	0.506	
Analysis of long-term strength	R_{con}	=	6030.20	lbf/ft

5. Miragrid 24XT

Short-term char. strength	T_{ult}	=	27415.00	lbf/ft
Creep red. factor	RF_{CR}	=	1.58	
Durability red. factor	RF_D	=	1.15	
Installation damage red. factor	RF_{ID}	=	1.10	
Long-term design strength	R_t	=	13716.42	lbf/ft
Coefficient of direct slip along reinforcement	C_{ds}	=	0.67	
Coefficient of interaction of soil and geo-reinforcement	C_i	=	0.67	
Scale correction factor	α	=	0.8	
Long-term strength reduction factor	CR_{cr}	=	0.443	
Analysis of long-term strength	R_{con}	=	10560.73	lbf/ft

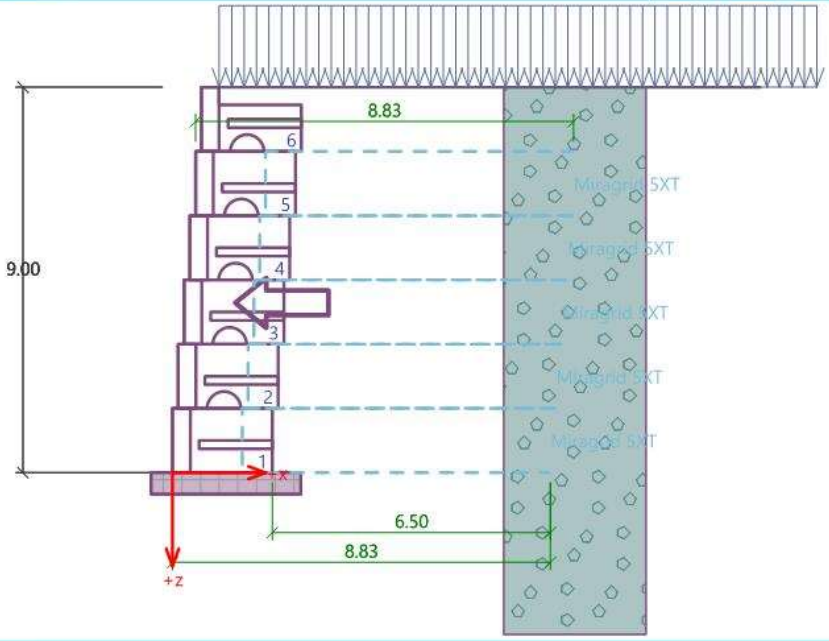
Reinforcements

Input mode : 1 reinforcement type
Reinf. installation : in every row of blocks (50%)
Type of reinforcement : Miragrid 5XT
Top reinforcement : straight (25%)
Reinforcement geometry : identical length of reinforcements
Length of reinforcement l = 6.50 ft

Reinforcements

No.	Consider	Name	Length of reinforcement l [ft]	End pt. coordinate l_k [ft]
1	Yes	Miragrid 5XT	6.50	
2	Yes	Miragrid 5XT	6.50	
3	Yes	Miragrid 5XT	6.50	
4	Yes	Miragrid 5XT	6.50	
5	Yes	Miragrid 5XT	6.50	
6	No			

Name : Reinforcements | **Stage - analysis : 1 - 0**



Basic soil parameters

No.	Name	Pattern	φ_{ef} [°]	c_{ef} [psf]	γ [pcf]	γ_{su} [pcf]	δ [°]
1	Gravel Backfill		35.50	0.0	130.00	67.50	34.00

All soils are considered as cohesionless for at rest pressure analysis.

Soil parameters

Gravel Backfill

Unit weight : γ = 130.0 pcf
Stress-state : effective
Angle of internal friction : φ_{ef} = 35.50 °
Cohesion of soil : c_{ef} = 0.0 psf
Angle of friction struc.-soil : δ = 34.00 °
Saturated unit weight : γ_{sat} = 130.0 pcf

Input surface surcharges

No.	Surcharge new	Surcharge change	Action	Mag.1 [lbf/ft²]	Mag.2 [lbf/ft²]	Ord.x x [ft]	Length l [ft]	Depth z [ft]
1	Yes		variable	200.0				on terrain

No.	Name
1	Roadway Surcharge

Resistance on front face of the structure

Resistance on front face of the structure is not considered.

Earthquake

Factor of horizontal acceleration K_h = 0.1620
Factor of vertical acceleration K_v = 0.0000

Water below the GWT is free.
Specific gravity of soil particles G_s = 2.08.

Settings of the stage of construction

Design situation : seismic

Verification No. 1

Forces acting on construction

Name	F_{hor} [lbf/ft]	App.Pt. z [ft]	F_{vert} [lbf/ft]	App.Pt. x [ft]	Design coefficient
Weight - reinforced soil	0.0	-4.54	7735.2	5.88	1.000
Earthquake - soil wedge	1253.1	-4.54	0.0	5.88	1.000
Active pressure	1155.4	-3.00	506.4	9.38	1.000
Earthq.- act.pressure	514.7	-6.00	225.6	9.38	1.000
Roadway Surcharge	395.0	-4.50	173.1	9.38	1.000
Weight - wall	0.0	-4.33	2424.2	1.48	1.000
Earthq.- constr.	392.7	-4.33	0.0	1.48	1.000

Verification of complete wall

Place of verification : bottom of blocks

Check for overturning stability
Resisting moment M_{res} = 57560.9 lbfft/ft
Overturning moment M_{ovr} = 15716.9 lbfft/ft

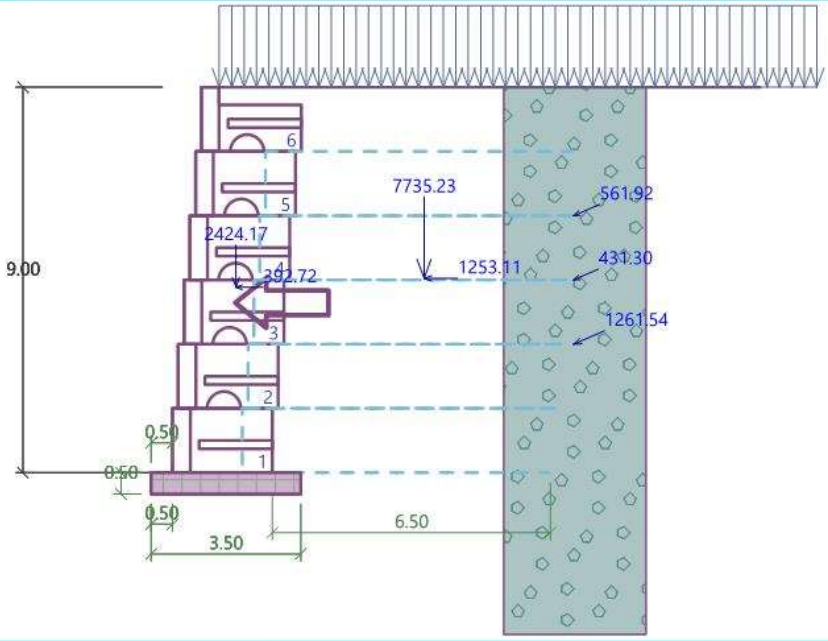
Safety factor = 3.66 > 1.10
Wall for overturning is SATISFACTORY

Check for slip
Resisting horizontal force H_{res} = 7241.11 lbf/ft
Active horizontal force H_{act} = 3710.95 lbf/ft

Safety factor = 1.95 > 1.10
Wall for slip is SATISFACTORY

Overall check - WALL is SATISFACTORY

Name : Verification | Stage - analysis : 1 - 1



Bearing capacity of foundation soil

Design load acting at the center of footing bottom

No.	Moment [lbfft/ft]	Norm. force [lbf/ft]	Shear Force [lbf/ft]	Eccentricity [–]	Stress [psf]
1	-11905.0	4805.98	-2079.23	0.000	1373.1

Service load acting at the center of footing bottom

No.	Moment [lbfft/ft]	Norm. force [lbf/ft]	Shear Force [lbf/ft]
1	-11905.0	4805.98	-2079.23

Verification of foundation soil

Place of verification : bottom of leveling pad
Stress in the footing bottom : trapezoid

Eccentricity verification
Max. eccentricity of normal force e = 0.000
Maximum allowable eccentricity e_{alw} = 0.333

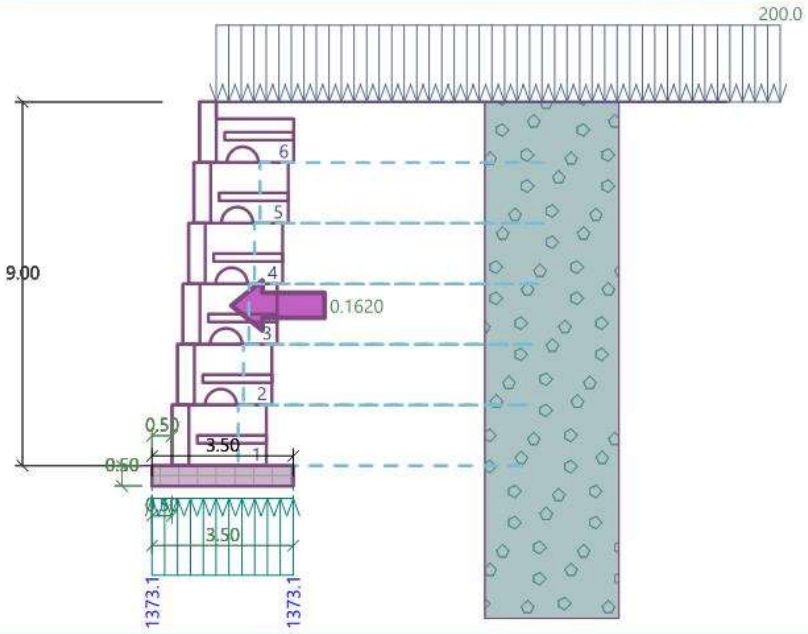
Eccentricity of the normal force is SATISFACTORY

Verification of bearing capacity
Max. stress at footing bottom σ = 1373.1 psf
Bearing capacity of foundation soil R_d = 2000.0 psf

Safety factor = 1.46 > 1.00
Bearing capacity of foundation soil is SATISFACTORY

Overall verification - bearing capacity of found. soil is SATISFACTORY

Name : Bearing cap. | **Stage - analysis : 1 - -1**



Verification of slip on georeinforcement No. 1

Forces acting on construction (verification of reinforcement No.: 1)

Name	F_{hor} [lbf/ft]	App.Pt. z [ft]	F_{vert} [lbf/ft]	App.Pt. x [ft]	Design coefficient
Weight - wall	0.0	-4.33	2470.8	-3.85	1.000
Earthq.- constr.	400.3	-4.33	0.0	-3.85	1.000
Active pressure	1155.4	-3.00	506.4	6.50	1.000
Earthq.- act.pressure	514.7	-6.00	225.6	6.50	1.000
Roadway Surcharge	395.0	-4.50	173.1	6.50	1.000
Weight - reinforced soil	0.0	-4.40	7286.3	3.41	1.000
Earthquake - soil wedge	1167.8	-4.40	0.0	3.41	1.000
Roadway Surcharge	0.0	-9.00	1547.9	-0.37	1.000

Verification against slip along geotextile No.: 1

Inclination of slip surface	=	90.00	°
Overall normal force acting on reinforcement	=	9739.33	lbf/ft
Coefficient of reduction of slip along geo-textile	=	0.92	
Resistance along geo-reinforcement	=	6373.87	lbf/ft
Wall resistance	=	0.00	lbf/ft
Overall bearing capacity of reinforcements	=	0.00	lbf/ft

Check for slip:
Resisting horizontal force H_{res} = 6373.87 lbf/ft

Active horiz. force H_{act} = 2065.13 lbf/ft

Factor of safety = 3.09 > 1.10
Slip along geotextile is SATISFACTORY

Calculation of internal stability No. 1

Calculated forces and strength of reinforcements

No.	Name	F_x [lbf/ft]	Depth z[ft]	R_t [lbf/ft]	Utiliz. [%]	T_p [lbf/ft]	Utiliz. [%]	R_{con} [lbf/ft]	Utiliz. [%]
1	Miragrid 5XT	-204.08	9.00	517.34	43.39	1453.79	15.44	543.57	41.30
2	Miragrid 5XT	-367.03	7.50	1034.67	39.02	2152.86	18.75	1087.13	37.14
3	Miragrid 5XT	-322.38	6.00	1034.67	34.27	1506.18	23.54	1087.13	32.62
4	Miragrid 5XT	-297.44	4.50	1034.67	31.62	967.56	33.81	1087.13	30.10
5	Miragrid 5XT	-272.49	3.00	1034.67	28.97	536.99	55.82	1087.13	27.57

Check for tensile strength (reinforcement No.1)
Tension strength R_t = 517.34 lbf/ft
Force in reinforcement F_x = 204.08 lbf/ft

Safety factor = 2.54 > 1.10
Reinforcement for tensile strength is SATISFACTORY

Check for pull out resistance (reinforcement No.5)
Pull out resistance T_p = 536.99 lbf/ft
Force in reinforcement F_x = 272.49 lbf/ft

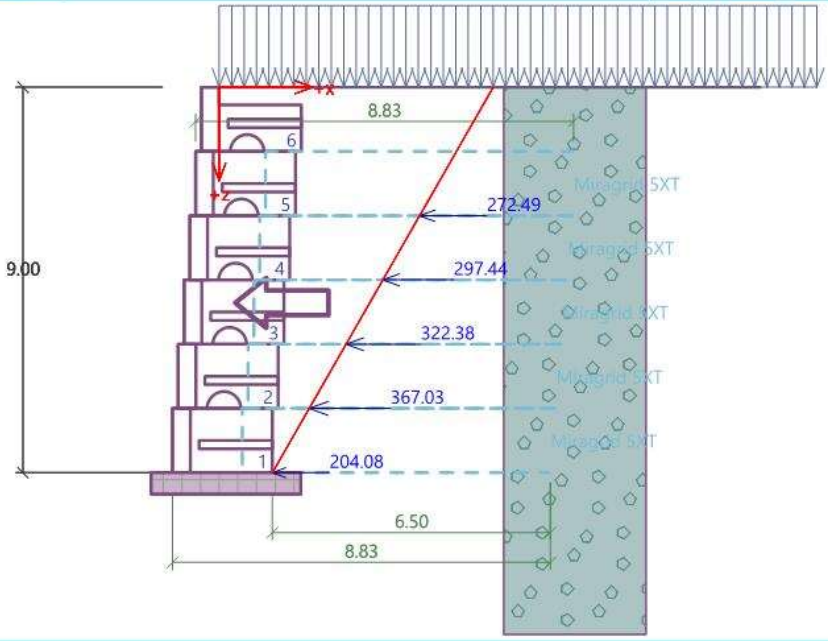
Safety factor = 1.97 > 1.10
Reinforcement for pull out resistance is SATISFACTORY

Verification of connection strength (reinforcement No.1)
Connection strength R_{con} = 543.57 lbf/ft
Force in reinforcement F_x = 204.08 lbf/ft

Safety factor = 2.66 > 1.10
Connection strength is SATISFACTORY

Overall verification - reinforcement is SATISFACTORY

Name : Internal stability | **Stage - analysis : 1 - 1**



9'-0" Tall Wall – Transient Case

Analysis of Redi Rock wall

Input data

Project

Part : 9.0' MSE Wall - Transient Case
Author : NRW
Date : 11/25/2019
Project number : 1801-0336

Settings

(input for current task)

Materials and standards

AASHTO - reduce parameters of friction soil/soil by 2/3 φ

Wall analysis

Active earth pressure calculation : Coulomb
Passive earth pressure calculation : Mazindrani (Rankine)
Earthquake analysis : Mononobe-Okabe
Shape of earth wedge : Calculate as skew
Allowable eccentricity : 0.333
Internal stability : Standard - straight slip surface
Reduction coeff. of contact first block - base : 1.00
Verification methodology : Safety factors (ASD)

Safety factors			
Transient design situation			
Safety factor for overturning :	SF_o =	1.50	[–]
Safety factor for sliding resistance :	SF_s =	1.50	[–]
Safety factor for bearing capacity :	SF_b =	1.33	[–]
Safety factor for sliding along geo-reinforcement :	SF_{sr} =	1.50	[–]
Safety factor for geo-reinforcement strength :	SF_{st} =	1.50	[–]
Safety factor for pull out resistance of geo-reinf. :	SF_{po} =	1.50	[–]
Safety factor for connection strength :	SF_{con} =	1.50	[–]

Blocks

No.	Description	Height h [in]	Width w [in]	Unit weight γ [pcf]
1	Top block 24 straight	18.00	24.00	108.00
2	Block 28 PC	18.00	28.00	120.00
3	Block 41 PC	18.00	40.50	120.00
4	Top block 28	18.00	28.00	120.00
5	Top block 41	18.00	40.50	120.00
6	Top block 24 straight garden	18.00	24.00	80.00

No.	Description	Min. shear strength F_{min} [lbf/ft]	Max. shear strength F_{max} [lbf/ft]	Friction f [°]
1	Top block 24 straight	6061.00	11276.00	44.00
2	Block 28 PC	6061.00	11276.00	44.00
3	Block 41 PC	6061.00	11276.00	44.00
4	Top block 28	6061.00	11276.00	44.00

No.	Description	Min. shear strength F_{min} [lbf/ft]	Max. shear strength F_{max} [lbf/ft]	Friction f [°]
5	Top block 41	6061.00	11276.00	44.00
6	Top block 24 straight garden	6061.00	11276.00	44.00

Setbacks

No.	Setback s [in]
1	0.010
2	0.375
3	1.625
6	3.250

Geometry

No. group	Description	Count	Setback s [in]
1	Block 28 PC	5	1.62
2	Top block 28	1	-

Base

Geometry

Upper setback a_1 = 0.50 ft
Lower setback a_2 = 0.50 ft
Height h = 0.50 ft
Width b = 3.50 ft

Material

Unreinforced Footing
Concrete self-weight γ = 150.00 pcf
Shear cub (key) capacity = 0.00 lbf/ft
Friction angle concrete-concrete = 30.00 °

Types of reinforcements

No.	Name	Type of reinforcement	Line type	Tensile strength T_{ult} [lbf/ft]	R_t [lbf/ft]	R_{con} [lbf/ft]
1	Miragrid 5XT	Miragrid 5XT		4700.00	2069.35	2174.26
2	Miragrid 8XT	Miragrid 8XT		7400.00	3393.87	3423.30
3	Miragrid 10XT	Miragrid 10XT		9500.00	4357.00	4287.39
4	Miragrid 20XT	Miragrid 20XT		13705.00	6558.83	6030.20
5	Miragrid 24XT	Miragrid 24XT		27415.00	13716.42	10560.73

Reinforcement details

1. Miragrid 5XT

Short-term char. strength T_{ult} = 4700.00 lbf/ft
Creep red. factor RF_{CR} = 1.58

Durability red. factor	RF_D	=	1.15	
Installation damage red. factor	RF_{ID}	=	1.25	
Long-term design strength	R_t	=	2069.35	lbf/ft
Coefficient of direct slip along reinforcement	C_{ds}	=	0.67	
Coefficient of interaction of soil and geo-reinforcement	C_i	=	0.67	
Scale correction factor	α	=	0.8	
Long-term strength reduction factor	CR_{cr}	=	0.532	
Analysis of long-term strength	R_{con}	=	2174.26	lbf/ft

2. Miragrid 8XT

Short-term char. strength	T_{ult}	=	7400.00	lbf/ft
Creep red. factor	RF_{CR}	=	1.58	
Durability red. factor	RF_D	=	1.15	
Installation damage red. factor	RF_{ID}	=	1.20	
Long-term design strength	R_t	=	3393.87	lbf/ft
Coefficient of direct slip along reinforcement	C_{ds}	=	0.67	
Coefficient of interaction of soil and geo-reinforcement	C_i	=	0.67	
Scale correction factor	α	=	0.8	
Long-term strength reduction factor	CR_{cr}	=	0.532	
Analysis of long-term strength	R_{con}	=	3423.30	lbf/ft

3. Miragrid 10XT

Short-term char. strength	T_{ult}	=	9500.00	lbf/ft
Creep red. factor	RF_{CR}	=	1.58	
Durability red. factor	RF_D	=	1.15	
Installation damage red. factor	RF_{ID}	=	1.20	
Long-term design strength	R_t	=	4357.00	lbf/ft
Coefficient of direct slip along reinforcement	C_{ds}	=	0.67	
Coefficient of interaction of soil and geo-reinforcement	C_i	=	0.67	
Scale correction factor	α	=	0.8	
Long-term strength reduction factor	CR_{cr}	=	0.519	
Analysis of long-term strength	R_{con}	=	4287.39	lbf/ft

4. Miragrid 20XT

Short-term char. strength	T_{ult}	=	13705.00	lbf/ft
Creep red. factor	RF_{CR}	=	1.58	
Durability red. factor	RF_D	=	1.15	
Installation damage red. factor	RF_{ID}	=	1.15	
Long-term design strength	R_t	=	6558.83	lbf/ft
Coefficient of direct slip along reinforcement	C_{ds}	=	0.67	
Coefficient of interaction of soil and geo-reinforcement	C_i	=	0.67	
Scale correction factor	α	=	0.8	
Long-term strength reduction factor	CR_{cr}	=	0.506	
Analysis of long-term strength	R_{con}	=	6030.20	lbf/ft

5. Miragrid 24XT

Short-term char. strength	T_{ult}	=	27415.00	lbf/ft
Creep red. factor	RF_{CR}	=	1.58	
Durability red. factor	RF_D	=	1.15	
Installation damage red. factor	RF_{ID}	=	1.10	
Long-term design strength	R_t	=	13716.42	lbf/ft
Coefficient of direct slip along reinforcement	C_{ds}	=	0.67	

Coefficient of interaction of soil and geo-reinforcement	C_i	=	0.67
Scale correction factor	α	=	0.8
Long-term strength reduction factor	CR_{cr}	=	0.443
Analysis of long-term strength	R_{con}	=	10560.73 lbf/ft

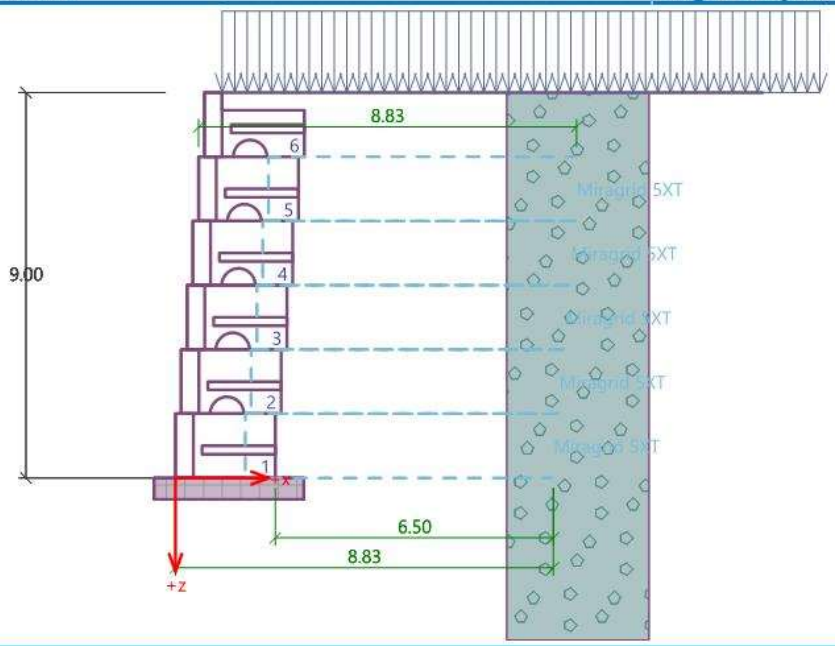
Reinforcements

Input mode : 1 reinforcement type
Reinf. installation : in every row of blocks (50%)
Type of reinforcement : Miragrid 5XT
Top reinforcement : straight (25%)
Reinforcement geometry : identical length of reinforcements
Length of reinforcement l = 6.50 ft

Reinforcements

No.	Consider	Name	Length of reinforcement l [ft]	End pt. coordinate l_k [ft]
1	Yes	Miragrid 5XT	6.50	
2	Yes	Miragrid 5XT	6.50	
3	Yes	Miragrid 5XT	6.50	
4	Yes	Miragrid 5XT	6.50	
5	Yes	Miragrid 5XT	6.50	
6	No			

Name : Reinforcements | Stage - analysis : 1 - 0



Basic soil parameters

No.	Name	Pattern	φ_{ef} [°]	c_{ef} [psf]	γ [pcf]	γ_{su} [pcf]	δ [°]
1	Gravel Backfill		35.50	0.0	130.00	67.50	34.00

All soils are considered as cohesionless for at rest pressure analysis.

Soil parameters

Gravel Backfill

Unit weight : γ = 130.0 pcf
Stress-state : effective
Angle of internal friction : φ_{ef} = 35.50 °
Cohesion of soil : c_{ef} = 0.0 psf
Angle of friction struc.-soil : δ = 34.00 °
Saturated unit weight : γ_{sat} = 130.0 pcf

Geological profile and assigned soils

No.	Thickness of layer t [ft]	Depth z [ft]	Assigned soil	Pattern
1	-	0.00 .. ∞	Gravel Backfill	

Terrain profile

Terrain behind the structure is flat.

Water influence

Ground water table is located below the structure.

Input surface surcharges

No.	Surcharge new	Surcharge change	Action	Mag.1 [lbf/ft²]	Mag.2 [lbf/ft²]	Ord.x x [ft]	Length l [ft]	Depth z [ft]
1	Yes		variable	200.0				on terrain

No.	Name
1	Roadway Surcharge

Resistance on front face of the structure

Resistance on front face of the structure is not considered.

Settings of the stage of construction

Design situation : transient

Verification No. 1

Forces acting on construction

Name	F_{hor} [lbf/ft]	App.Pt. z [ft]	F_{vert} [lbf/ft]	App.Pt. x [ft]	Design coefficient
Weight - reinforced soil	0.0	-4.54	7735.2	5.88	1.000
Active pressure	1155.4	-3.00	506.4	9.38	1.000

Name	F_{hor} [lbf/ft]	App.Pt. z [ft]	F_{vert} [lbf/ft]	App.Pt. x [ft]	Design coefficient
Roadway Surcharge	395.0	-4.50	173.1	9.38	1.000
Weight - wall	0.0	-4.33	2424.2	1.48	1.000

Verification of complete wall

Place of verification : bottom of blocks

Check for overturning stability

Resisting moment M_{res} = 55446.3 lbfft/ft
Overturning moment M_{ovr} = 5243.9 lbfft/ft

Safety factor = 10.57 > 1.50
Wall for overturning is SATISFACTORY

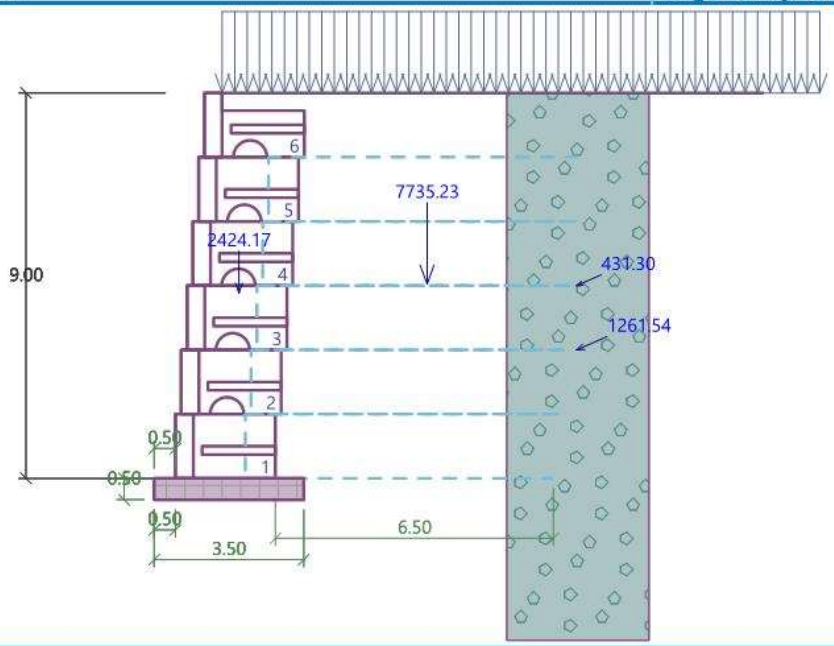
Check for slip

Resisting horizontal force H_{res} = 7093.49 lbf/ft
Active horizontal force H_{act} = 1550.47 lbf/ft

Safety factor = 4.58 > 1.50
Wall for slip is SATISFACTORY

Overall check - WALL is SATISFACTORY

Name : Verification | Stage - analysis : 1 - 1



Bearing capacity of foundation soil

Design load acting at the center of footing bottom

No.	Moment [lbfft/ft]	Norm. force [lbf/ft]	Shear Force [lbf/ft]	Eccentricity [–]	Stress [psf]
1	-17038.2	4369.40	-3123.97	0.000	1248.4

Service load acting at the center of footing bottom

No.	Moment [lbfft/ft]	Norm. force [lbf/ft]	Shear Force [lbf/ft]
1	-17038.2	4369.40	-3123.97

Verification of foundation soil

Place of verification : bottom of leveling pad
Stress in the footing bottom : trapezoid

Eccentricity verification
Max. eccentricity of normal force $e = 0.000$
Maximum allowable eccentricity $e_{alw} = 0.333$

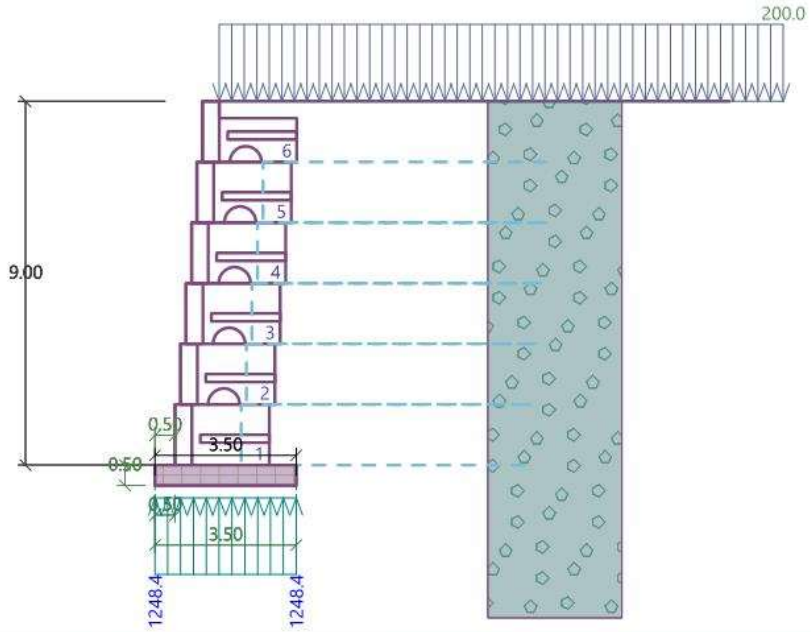
Eccentricity of the normal force is SATISFACTORY

Verification of bearing capacity
Max. stress at footing bottom $\sigma = 1248.4$ psf
Bearing capacity of foundation soil $R_d = 2000.0$ psf

Safety factor = 1.60 > 1.33
Bearing capacity of foundation soil is SATISFACTORY

Overall verification - bearing capacity of found. soil is SATISFACTORY

Name : Bearing cap. | Stage - analysis : 1 - -1



Verification of slip on georeinforcement No. 1

Forces acting on construction (verification of reinforcement No.: 1)

Name	F_{hor} [lbf/ft]	App.Pt. z [ft]	F_{vert} [lbf/ft]	App.Pt. x [ft]	Design coefficient
Weight - wall	0.0	-4.33	2470.8	-3.85	1.000
Active pressure	1155.4	-3.00	506.4	6.50	1.000
Roadway Surcharge	395.0	-4.50	173.1	6.50	1.000
Weight - reinforced soil	0.0	-4.40	7286.3	3.41	1.000
Roadway Surcharge	0.0	-9.00	1547.9	-0.37	1.000

Verification against slip along geotextile No.: 1

Inclination of slip surface = 90.00 °
Overall normal force acting on reinforcement = 9513.77 lbf/ft
Coefficient of reduction of slip along geo-textile = 0.92
Resistance along geo-reinforcement = 6226.25 lbf/ft
Wall resistance = 1426.51 lbf/ft
Overall bearing capacity of reinforcements = 0.00 lbf/ft

Check for slip:
Resisting horizontal force H_{res} = 7652.76 lbf/ft
Active horiz. force H_{act} = 1550.47 lbf/ft

Factor of safety = 4.94 > 1.50
Slip along geotextile is SATISFACTORY

Calculation of internal stability No. 1

Calculated forces and strength of reinforcements

No.	Name	F_x [lbf/ft]	Depth z[ft]	R_t [lbf/ft]	Utiliz. [%]	T_p [lbf/ft]	Utiliz. [%]	R_{con} [lbf/ft]	Utiliz. [%]
1	Miragrid 5XT	-200.48	9.00	517.34	58.13	1453.79	20.68	543.57	55.32
2	Miragrid 5XT	-338.70	7.50	1034.67	49.10	2152.86	23.60	1087.13	46.73
3	Miragrid 5XT	-266.29	6.00	1034.67	38.61	1506.18	26.52	1087.13	36.74
4	Miragrid 5XT	-213.31	4.50	1034.67	30.92	967.56	33.07	1087.13	29.43
5	Miragrid 5XT	-160.32	3.00	1034.67	23.24	536.99	44.78	1087.13	22.12

Check for tensile strength (reinforcement No.1)

Tension strength R_t = 517.34 lbf/ft
Force in reinforcement F_x = 200.48 lbf/ft

Safety factor = 2.58 > 1.50
Reinforcement for tensile strength is SATISFACTORY

Check for pull out resistance (reinforcement No.5)

Pull out resistance T_p = 536.99 lbf/ft
Force in reinforcement F_x = 160.32 lbf/ft

Safety factor = 3.35 > 1.50
Reinforcement for pull out resistance is SATISFACTORY

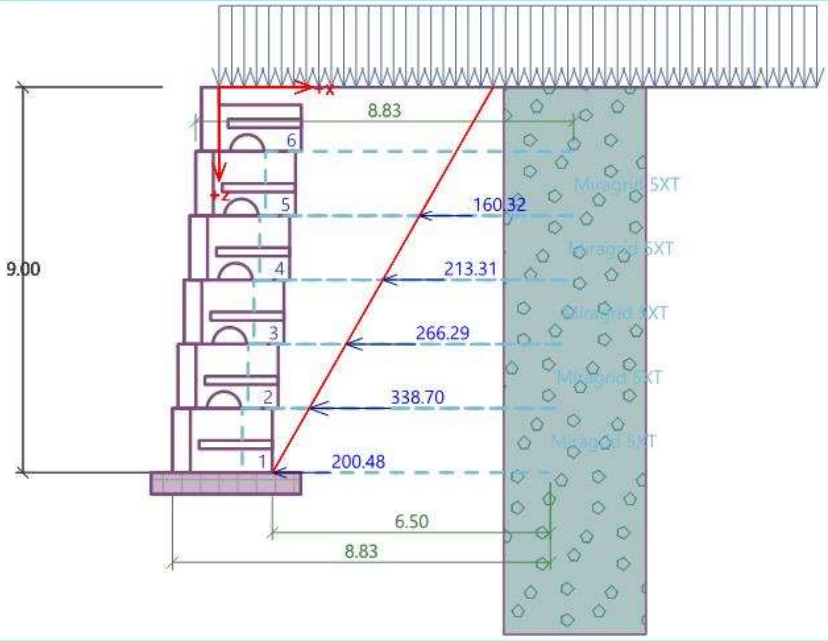
Verification of connection strength (reinforcement No.1)

Connection strength R_{con} = 543.57 lbf/ft
Force in reinforcement F_x = 200.48 lbf/ft

Safety factor = 2.71 > 1.50
Connection strength is SATISFACTORY

Overall verification - reinforcement is SATISFACTORY

Name : Internal stability | **Stage - analysis : 1 - 1**



7'-6" Tall Wall – Seismic Case

Analysis of Redi Rock wall

Input data

Project

Task : MSE Wall Design
Part : 7.5' MSE Wall - Seismic Case
Author : NRW
Date : 11/25/2019
Project number : 1801-0336

Settings

(input for current task)

Materials and standards

AASHTO - reduce parameters of friction soil/soil by 2/3 φ

Wall analysis

Active earth pressure calculation : Coulomb
Passive earth pressure calculation : Mazindrani (Rankine)
Earthquake analysis : Mononobe-Okabe
Shape of earth wedge : Calculate as skew
Allowable eccentricity : 0.333
Internal stability : Standard - straight slip surface
Reduction coeff. of contact first block - base : 1.00
Verification methodology : Safety factors (ASD)

Safety factors			
Seismic design situation			
Safety factor for overturning :	SF_o =	1.10	[–]
Safety factor for sliding resistance :	SF_s =	1.10	[–]
Safety factor for bearing capacity :	SF_b =	1.00	[–]
Safety factor for sliding along geo-reinforcement :	SF_{sr} =	1.10	[–]
Safety factor for geo-reinforcement strength :	SF_{st} =	1.10	[–]
Safety factor for pull out resistance of geo-reinf. :	SF_{po} =	1.10	[–]
Safety factor for connection strength :	SF_{con} =	1.10	[–]

Geometry

No. group	Description	Count	Setback s [in]
1	Block 28 PC	4	1.62
2	Top block 28	1	-

Base

Geometry
Upper setback a_1 = 0.50 ft
Lower setback a_2 = 0.50 ft
Height h = 0.50 ft
Width b = 3.50 ft

Material
Unreinforced Footing
Concrete self-weight γ = 150.00 pcf
Shear cub (key) capacity = 0.00 lbf/ft
Friction angle concrete-concrete = 30.00 °

Types of reinforcements

No.	Name	Type of reinforcement	Line type	Tensile strength		
				T_{ult} [lbf/ft]	R_t [lbf/ft]	R_{con} [lbf/ft]
1	Miragrid 5XT	Miragrid 5XT		4700.00	2069.35	2174.26
2	Miragrid 8XT	Miragrid 8XT		7400.00	3393.87	3423.30
3	Miragrid 10XT	Miragrid 10XT		9500.00	4357.00	4287.39
4	Miragrid 20XT	Miragrid 20XT		13705.00	6558.83	6030.20
5	Miragrid 24XT	Miragrid 24XT		27415.00	13716.42	10560.73

Reinforcement details

1. Miragrid 5XT

Short-term char. strength	T_{ult}	=	4700.00	lbf/ft
Creep red. factor	RF_{CR}	=	1.58	
Durability red. factor	RF_D	=	1.15	
Installation damage red. factor	RF_{ID}	=	1.25	
Long-term design strength	R_t	=	2069.35	lbf/ft
Coefficient of direct slip along reinforcement	C_{ds}	=	0.67	
Coefficient of interaction of soil and geo-reinforcement	C_i	=	0.67	
Scale correction factor	α	=	0.8	
Long-term strength reduction factor	CR_{cr}	=	0.532	
Analysis of long-term strength	R_{con}	=	2174.26	lbf/ft

2. Miragrid 8XT

Short-term char. strength	T_{ult}	=	7400.00	lbf/ft
Creep red. factor	RF_{CR}	=	1.58	
Durability red. factor	RF_D	=	1.15	
Installation damage red. factor	RF_{ID}	=	1.20	
Long-term design strength	R_t	=	3393.87	lbf/ft
Coefficient of direct slip along reinforcement	C_{ds}	=	0.67	
Coefficient of interaction of soil and geo-reinforcement	C_i	=	0.67	
Scale correction factor	α	=	0.8	
Long-term strength reduction factor	CR_{cr}	=	0.532	
Analysis of long-term strength	R_{con}	=	3423.30	lbf/ft

3. Miragrid 10XT

Short-term char. strength	T_{ult}	=	9500.00	lbf/ft
Creep red. factor	RF_{CR}	=	1.58	
Durability red. factor	RF_D	=	1.15	
Installation damage red. factor	RF_{ID}	=	1.20	
Long-term design strength	R_t	=	4357.00	lbf/ft
Coefficient of direct slip along reinforcement	C_{ds}	=	0.67	
Coefficient of interaction of soil and geo-reinforcement	C_i	=	0.67	
Scale correction factor	α	=	0.8	
Long-term strength reduction factor	CR_{cr}	=	0.519	
Analysis of long-term strength	R_{con}	=	4287.39	lbf/ft

4. Miragrid 20XT

Short-term char. strength	T_{ult}	=	13705.00	lbf/ft
Creep red. factor	RF_{CR}	=	1.58	
Durability red. factor	RF_D	=	1.15	
Installation damage red. factor	RF_{ID}	=	1.15	
Long-term design strength	R_t	=	6558.83	lbf/ft
Coefficient of direct slip along reinforcement	C_{ds}	=	0.67	
Coefficient of interaction of soil and geo-reinforcement	C_i	=	0.67	
Scale correction factor	α	=	0.8	
Long-term strength reduction factor	CR_{cr}	=	0.506	
Analysis of long-term strength	R_{con}	=	6030.20	lbf/ft

5. Miragrid 24XT

Short-term char. strength	T_{ult}	=	27415.00	lbf/ft
Creep red. factor	RF_{CR}	=	1.58	
Durability red. factor	RF_D	=	1.15	
Installation damage red. factor	RF_{ID}	=	1.10	
Long-term design strength	R_t	=	13716.42	lbf/ft
Coefficient of direct slip along reinforcement	C_{ds}	=	0.67	
Coefficient of interaction of soil and geo-reinforcement	C_i	=	0.67	
Scale correction factor	α	=	0.8	
Long-term strength reduction factor	CR_{cr}	=	0.443	
Analysis of long-term strength	R_{con}	=	10560.73	lbf/ft

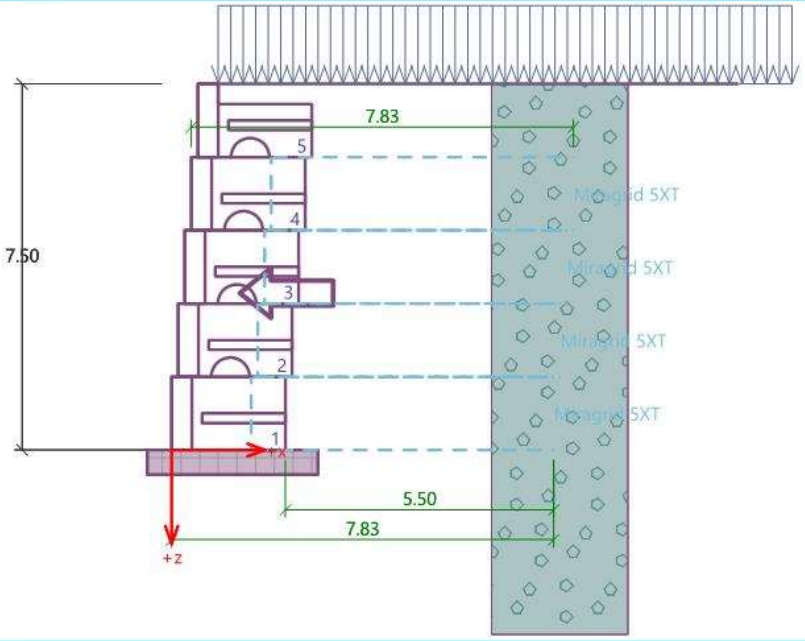
Reinforcements

Input mode : 1 reinforcement type
Reinf. installation : in every row of blocks (50%)
Type of reinforcement : Miragrid 5XT
Top reinforcement : straight (25%)
Reinforcement geometry : identical length of reinforcements
Length of reinforcement l = 5.50 ft

Reinforcements

No.	Consider	Name	Length of reinforcement l [ft]	End pt. coordinate l_k [ft]
1	Yes	Miragrid 5XT	5.50	
2	Yes	Miragrid 5XT	5.50	
3	Yes	Miragrid 5XT	5.50	
4	Yes	Miragrid 5XT	5.50	
5	No			

Name : Reinforcements | **Stage - analysis : 1 - 0**



Basic soil parameters

No.	Name	Pattern	φ_{ef} [°]	c_{ef} [psf]	γ [pcf]	γ_{su} [pcf]	δ [°]
1	Gravel Backfill		35.50	0.0	130.00	67.50	34.00

All soils are considered as cohesionless for at rest pressure analysis.

Soil parameters

Gravel Backfill

Unit weight :	γ =	130.0 pcf
Stress-state :		effective
Angle of internal friction :	φ_{ef} =	35.50 °
Cohesion of soil :	c_{ef} =	0.0 psf
Angle of friction struc.-soil :	δ =	34.00 °
Saturated unit weight :	γ_{sat} =	130.0 pcf

Input surface surcharges

No.	Surcharge new	Surcharge change	Action	Mag.1 [lbf/ft²]	Mag.2 [lbf/ft²]	Ord.x x [ft]	Length l [ft]	Depth z [ft]
1	Yes		variable	200.0				on terrain

No.	Name
1	Roadway Surcharge

Resistance on front face of the structure

Resistance on front face of the structure is not considered.

Earthquake

Factor of horizontal acceleration K_h = 0.1620
Factor of vertical acceleration K_v = 0.0000

Water below the GWT is free.
Specific gravity of soil particles G_s = 2.08.

Settings of the stage of construction

Design situation : seismic

Verification No. 1

Forces acting on construction

Name	F_{hor} [lbf/ft]	App.Pt. z [ft]	F_{vert} [lbf/ft]	App.Pt. x [ft]	Design coefficient
Weight - reinforced soil	0.0	-3.79	5479.5	5.29	1.000
Earthquake - soil wedge	887.7	-3.79	0.0	5.29	1.000
Active pressure	802.4	-2.50	351.7	8.24	1.000
Earthq.- act.pressure	357.4	-5.00	156.6	8.24	1.000
Roadway Surcharge	329.2	-3.75	144.3	8.24	1.000
Weight - wall	0.0	-3.58	2004.2	1.41	1.000
Earthq.- constr.	324.7	-3.58	0.0	1.41	1.000

Verification of complete wall

Place of verification : bottom of blocks

Check for overturning stability
Resisting moment M_{res} = 37220.9 lbfft/ft
Overturning moment M_{ovr} = 9557.5 lbfft/ft

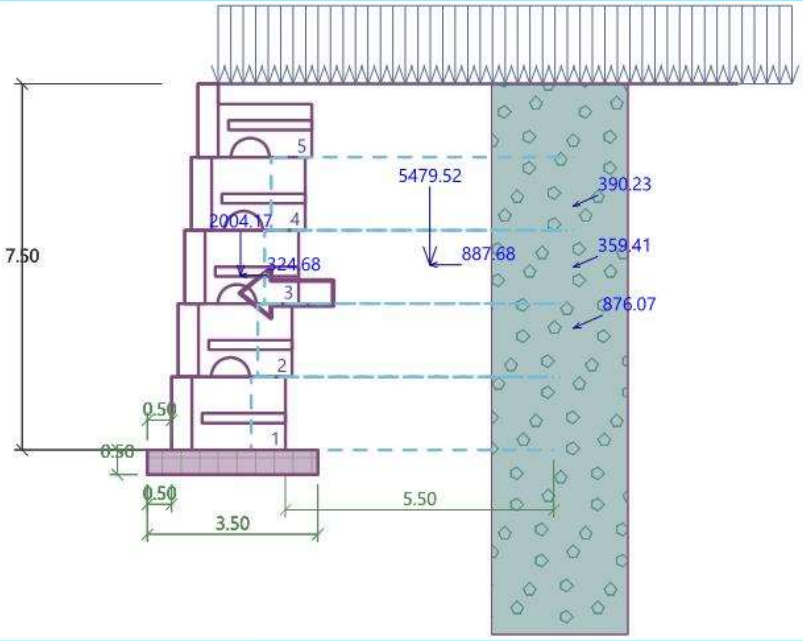
Safety factor = 3.89 > 1.10
Wall for overturning is SATISFACTORY

Check for slip
Resisting horizontal force H_{res} = 5324.76 lbf/ft
Active horizontal force H_{act} = 2701.34 lbf/ft

Safety factor = 1.97 > 1.10
Wall for slip is SATISFACTORY

Overall check - WALL is SATISFACTORY

Name : Verification | Stage - analysis : 1 - 1



Bearing capacity of foundation soil

Design load acting at the center of footing bottom

No.	Moment [lbfft/ft]	Norm. force [lbf/ft]	Shear Force [lbf/ft]	Eccentricity [–]	Stress [psf]
1	-7344.7	3925.51	-1599.26	0.000	1121.6

Service load acting at the center of footing bottom

No.	Moment [lbfft/ft]	Norm. force [lbf/ft]	Shear Force [lbf/ft]
1	-7344.7	3925.51	-1599.26

Verification of foundation soil

Place of verification : bottom of leveling pad
Stress in the footing bottom : trapezoid

Eccentricity verification
Max. eccentricity of normal force e = 0.000
Maximum allowable eccentricity e_{alw} = 0.333

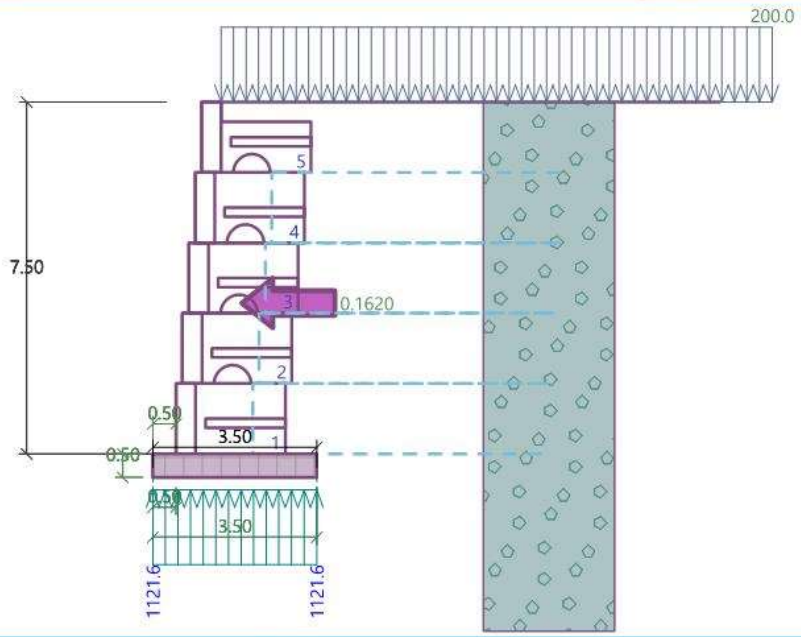
Eccentricity of the normal force is SATISFACTORY

Verification of bearing capacity
Max. stress at footing bottom σ = 1121.6 psf
Bearing capacity of foundation soil R_d = 2000.0 psf

Safety factor = 1.78 > 1.00
Bearing capacity of foundation soil is SATISFACTORY

Overall verification - bearing capacity of found. soil is SATISFACTORY

Name : Bearing cap. | **Stage - analysis : 1 - -1**



Verification of slip on georeinforcement No. 1

Forces acting on construction (verification of reinforcement No.: 1)

Name	F_{hor} [lbf/ft]	App.Pt. z [ft]	F_{vert} [lbf/ft]	App.Pt. x [ft]	Design coefficient
Weight - wall	0.0	-3.58	2049.7	-3.92	1.000
Earthq.- constr.	332.1	-3.58	0.0	-3.92	1.000
Active pressure	802.4	-2.50	351.7	5.50	1.000
Earthq.- act.pressure	357.4	-5.00	156.6	5.50	1.000
Roadway Surcharge	329.2	-3.75	144.3	5.50	1.000
Weight - reinforced soil	0.0	-3.67	5175.9	2.88	1.000
Earthquake - soil wedge	825.9	-3.67	0.0	2.88	1.000
Roadway Surcharge	0.0	-7.50	1375.0	-0.94	1.000

Verification against slip along geotextile No.: 1

Inclination of slip surface	=	90.00	°
Overall normal force acting on reinforcement	=	7203.44	lbf/ft
Coefficient of reduction of slip along geo-textile	=	0.92	
Resistance along geo-reinforcement	=	4714.26	lbf/ft
Wall resistance	=	0.00	lbf/ft
Overall bearing capacity of reinforcements	=	0.00	lbf/ft

Check for slip:
Resisting horizontal force H_{res} = 4714.26 lbf/ft

Active horiz. force H_{act} = 1488.98 lbf/ft

Factor of safety = 3.17 > 1.10
Slip along geotextile is SATISFACTORY

Calculation of internal stability No. 1

Calculated forces and strength of reinforcements

No.	Name	F_x [lbf/ft]	Depth z[ft]	R_t [lbf/ft]	Utiliz. [%]	T_p [lbf/ft]	Utiliz. [%]	R_{con} [lbf/ft]	Utiliz. [%]
1	Miragrid 5XT	-174.49	7.50	517.34	37.10	1025.11	18.72	543.57	35.31
2	Miragrid 5XT	-310.95	6.00	1034.67	33.06	1424.07	24.02	1087.13	31.46
3	Miragrid 5XT	-269.39	4.50	1034.67	28.64	905.98	32.71	1087.13	27.26
4	Miragrid 5XT	-244.45	3.00	1034.67	25.99	495.93	54.22	1087.13	24.73

Check for tensile strength (reinforcement No.1)
Tension strength R_t = 517.34 lbf/ft
Force in reinforcement F_x = 174.49 lbf/ft

Safety factor = 2.96 > 1.10
Reinforcement for tensile strength is SATISFACTORY

Check for pull out resistance (reinforcement No.4)
Pull out resistance T_p = 495.93 lbf/ft
Force in reinforcement F_x = 244.45 lbf/ft

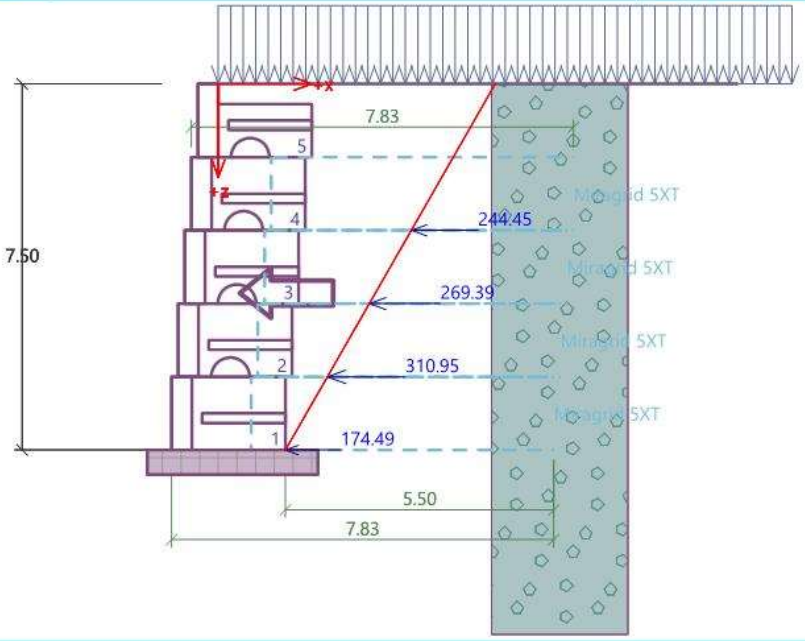
Safety factor = 2.03 > 1.10
Reinforcement for pull out resistance is SATISFACTORY

Verification of connection strength (reinforcement No.1)
Connection strength R_{con} = 543.57 lbf/ft
Force in reinforcement F_x = 174.49 lbf/ft

Safety factor = 3.12 > 1.10
Connection strength is SATISFACTORY

Overall verification - reinforcement is SATISFACTORY

Name : Internal stability | **Stage - analysis : 1 - 1**



7’-6” Tall Wall – Transient Case

Analysis of Redi Rock wall

Input data

Project

Part : 7.5' MSE Wall - Transient Case
Author : NRW
Date : 12/6/2019
Project number : 1801-0336

Settings

(input for current task)

Materials and standards

AASHTO - reduce parameters of friction soil/soil by 2/3 φ

Wall analysis

Active earth pressure calculation : Coulomb
Passive earth pressure calculation : Mazindrani (Rankine)
Earthquake analysis : Mononobe-Okabe
Shape of earth wedge : Calculate as skew
Allowable eccentricity : 0.333
Internal stability : Standard - straight slip surface
Reduction coeff. of contact first block - base : 1.00
Verification methodology : Safety factors (ASD)

Safety factors			
Transient design situation			
Safety factor for overturning :	SF_o =	1.50	[–]
Safety factor for sliding resistance :	SF_s =	1.50	[–]
Safety factor for bearing capacity :	SF_b =	1.33	[–]
Safety factor for sliding along geo-reinforcement :	SF_{sr} =	1.50	[–]
Safety factor for geo-reinforcement strength :	SF_{st} =	1.50	[–]
Safety factor for pull out resistance of geo-reinf. :	SF_{po} =	1.50	[–]
Safety factor for connection strength :	SF_{con} =	1.50	[–]

Geometry

No. group	Description	Count	Setback s [in]
1	Block 28 PC	4	1.62
2	Top block 28	1	-

Base

Geometry
Upper setback a_1 = 0.50 ft
Lower setback a_2 = 0.50 ft
Height h = 0.50 ft
Width b = 3.50 ft

Material
Unreinforced Footing
Concrete self-weight γ = 150.00 pcf
Shear cub (key) capacity = 0.00 lbf/ft
Friction angle concrete-concrete = 30.00 °

Types of reinforcements

No.	Name	Type of reinforcement	Line type	Tensile strength T_{ult} [lbf/ft]	R_t [lbf/ft]	R_{con} [lbf/ft]
1	Miragrid 5XT	Miragrid 5XT	- - - - - - -	4700.00	2069.35	2174.26
2	Miragrid 8XT	Miragrid 8XT	- - - - - - - - -	7400.00	3393.87	3423.30
3	Miragrid 10XT	Miragrid 10XT	- - - - - - -	9500.00	4357.00	4287.39
4	Miragrid 20XT	Miragrid 20XT	~~~~~~~~~~~	13705.00	6558.83	6030.20
5	Miragrid 24XT	Miragrid 24XT	~~~~~~~~~~~	27415.00	13716.42	10560.73

Reinforcement details

1. Miragrid 5XT

Short-term char. strength	T_{ult}	= 4700.00	lbf/ft
Creep red. factor	RF_{CR}	= 1.58	
Durability red. factor	RF_D	= 1.15	
Installation damage red. factor	RF_{ID}	= 1.25	
Long-term design strength	R_t	= 2069.35	lbf/ft
Coefficient of direct slip along reinforcement	C_{ds}	= 0.67	
Coefficient of interaction of soil and geo-reinforcement	C_i	= 0.67	
Scale correction factor	α	= 0.8	
Long-term strength reduction factor	CR_{cr}	= 0.532	
Analysis of long-term strength	R_{con}	= 2174.26	lbf/ft

2. Miragrid 8XT

Short-term char. strength	T_{ult}	= 7400.00	lbf/ft
Creep red. factor	RF_{CR}	= 1.58	
Durability red. factor	RF_D	= 1.15	
Installation damage red. factor	RF_{ID}	= 1.20	
Long-term design strength	R_t	= 3393.87	lbf/ft
Coefficient of direct slip along reinforcement	C_{ds}	= 0.67	
Coefficient of interaction of soil and geo-reinforcement	C_i	= 0.67	
Scale correction factor	α	= 0.8	
Long-term strength reduction factor	CR_{cr}	= 0.532	
Analysis of long-term strength	R_{con}	= 3423.30	lbf/ft

3. Miragrid 10XT

Short-term char. strength	T_{ult}	= 9500.00	lbf/ft
Creep red. factor	RF_{CR}	= 1.58	
Durability red. factor	RF_D	= 1.15	
Installation damage red. factor	RF_{ID}	= 1.20	
Long-term design strength	R_t	= 4357.00	lbf/ft
Coefficient of direct slip along reinforcement	C_{ds}	= 0.67	
Coefficient of interaction of soil and geo-reinforcement	C_i	= 0.67	
Scale correction factor	α	= 0.8	
Long-term strength reduction factor	CR_{cr}	= 0.519	
Analysis of long-term strength	R_{con}	= 4287.39	lbf/ft

4. Miragrid 20XT

Short-term char. strength	T_{ult}	=	13705.00	lbf/ft
Creep red. factor	RF_{CR}	=	1.58	
Durability red. factor	RF_D	=	1.15	
Installation damage red. factor	RF_{ID}	=	1.15	
Long-term design strength	R_t	=	6558.83	lbf/ft
Coefficient of direct slip along reinforcement	C_{ds}	=	0.67	
Coefficient of interaction of soil and geo-reinforcement	C_i	=	0.67	
Scale correction factor	α	=	0.8	
Long-term strength reduction factor	CR_{cr}	=	0.506	
Analysis of long-term strength	R_{con}	=	6030.20	lbf/ft

5. Miragrid 24XT

Short-term char. strength	T_{ult}	=	27415.00	lbf/ft
Creep red. factor	RF_{CR}	=	1.58	
Durability red. factor	RF_D	=	1.15	
Installation damage red. factor	RF_{ID}	=	1.10	
Long-term design strength	R_t	=	13716.42	lbf/ft
Coefficient of direct slip along reinforcement	C_{ds}	=	0.67	
Coefficient of interaction of soil and geo-reinforcement	C_i	=	0.67	
Scale correction factor	α	=	0.8	
Long-term strength reduction factor	CR_{cr}	=	0.443	
Analysis of long-term strength	R_{con}	=	10560.73	lbf/ft

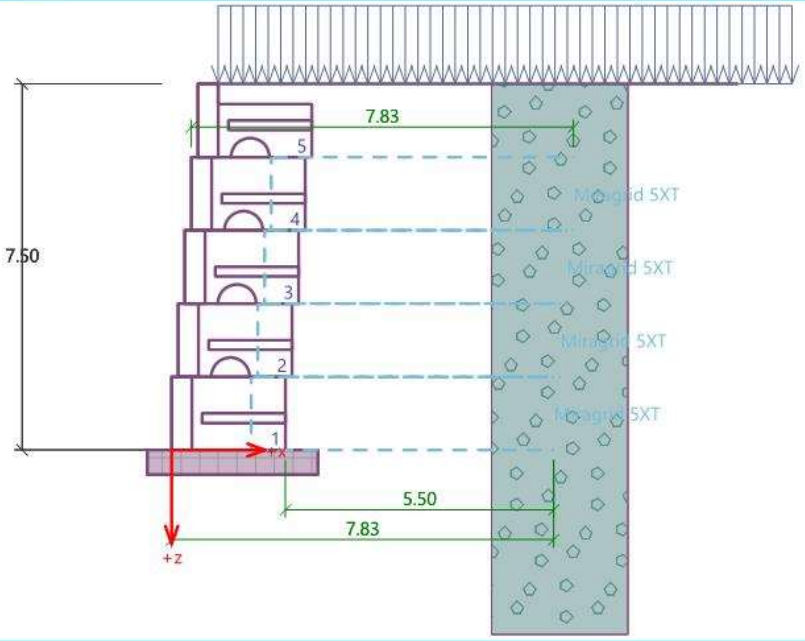
Reinforcements

Input mode : 1 reinforcement type
Reinf. installation : in every row of blocks (50%)
Type of reinforcement : Miragrid 5XT
Top reinforcement : straight (25%)
Reinforcement geometry : identical length of reinforcements
Length of reinforcement l = 5.50 ft

Reinforcements

No.	Consider	Name	Length of reinforcement l [ft]	End pt. coordinate l_k [ft]
1	Yes	Miragrid 5XT	5.50	
2	Yes	Miragrid 5XT	5.50	
3	Yes	Miragrid 5XT	5.50	
4	Yes	Miragrid 5XT	5.50	
5	No			

Name : Reinforcements | **Stage - analysis : 1 - 0**



Soil parameters

Gravel Backfill

Unit weight :	γ =	130.0 pcf
Stress-state :		effective
Angle of internal friction :	φ_{ef} =	35.50 °
Cohesion of soil :	c_{ef} =	0.0 psf
Angle of friction struc.-soil :	δ =	34.00 °
Saturated unit weight :	γ_{sat} =	130.0 pcf

Input surface surcharges

No.	Surcharge new	Surcharge change	Action	Mag.1 [lbf/ft²]	Mag.2 [lbf/ft²]	Ord.x x [ft]	Length l [ft]	Depth z [ft]
1	Yes		variable	200.0				on terrain

No.	Name
1	Roadway Surcharge

Resistance on front face of the structure

Resistance on front face of the structure is not considered.

Settings of the stage of construction

Design situation : transient

Verification No. 1

Forces acting on construction

Name	F_{hor} [lbf/ft]	App.Pt. z [ft]	F_{vert} [lbf/ft]	App.Pt. x [ft]	Design coefficient
Weight - reinforced soil	0.0	-3.79	5479.5	5.29	1.000
Active pressure	802.4	-2.50	351.7	8.24	1.000
Roadway Surcharge	329.2	-3.75	144.3	8.24	1.000
Weight - wall	0.0	-3.58	2004.2	1.41	1.000

Verification of complete wall

Place of verification : bottom of blocks

Check for overturning stability
Resisting moment M_{res} = 35930.2 lbfft/ft
Overturning moment M_{ovr} = 3240.4 lbfft/ft

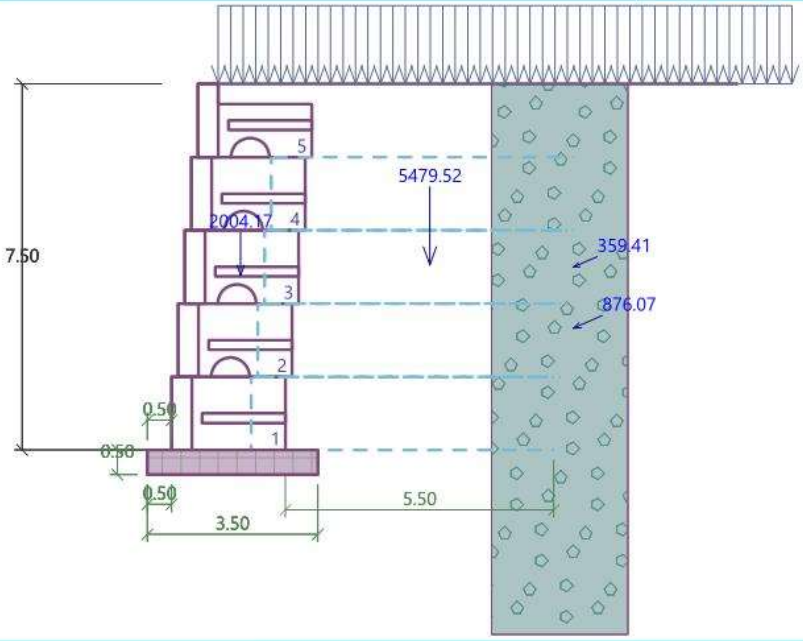
Safety factor = 11.09 > 1.50
Wall for overturning is SATISFACTORY

Check for slip
Resisting horizontal force H_{res} = 5222.24 lbf/ft
Active horizontal force H_{act} = 1131.58 lbf/ft

Safety factor = 4.62 > 1.50
Wall for slip is SATISFACTORY

Overall check - WALL is SATISFACTORY

Name : Verification | Stage - analysis : 1 - 1



Bearing capacity of foundation soil

Design load acting at the center of footing bottom

No.	Moment [lbfft/ft]	Norm. force [lbf/ft]	Shear Force [lbf/ft]	Eccentricity [–]	Stress [psf]
1	-10599.5	3607.75	-2407.02	0.000	1030.8

Service load acting at the center of footing bottom

No.	Moment [lbfft/ft]	Norm. force [lbf/ft]	Shear Force [lbf/ft]
1	-10599.5	3607.75	-2407.02

Verification of foundation soil

Place of verification : bottom of leveling pad
Stress in the footing bottom : trapezoid

Eccentricity verification
Max. eccentricity of normal force e = 0.000
Maximum allowable eccentricity e_{alw} = 0.333

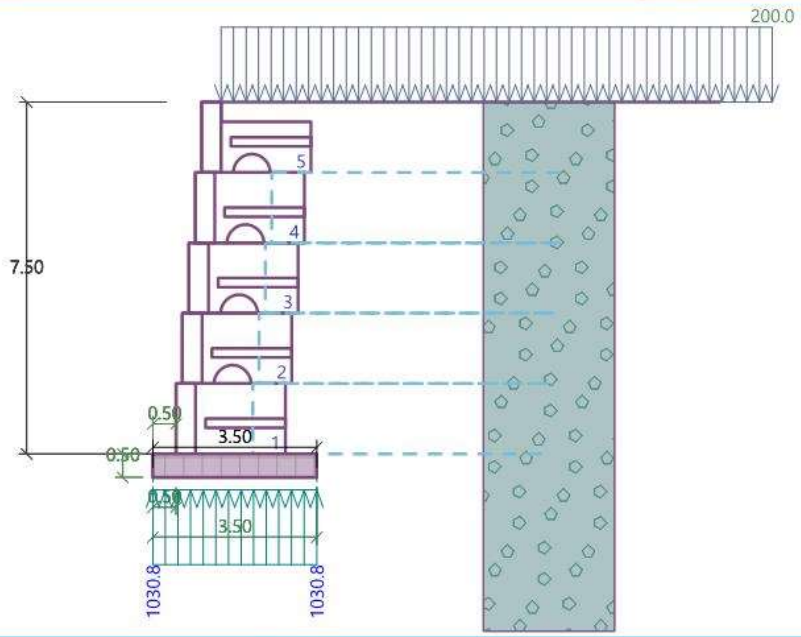
Eccentricity of the normal force is SATISFACTORY

Verification of bearing capacity
Max. stress at footing bottom σ = 1030.8 psf
Bearing capacity of foundation soil R_d = 2000.0 psf

Safety factor = 1.94 > 1.33
Bearing capacity of foundation soil is SATISFACTORY

Overall verification - bearing capacity of found. soil is SATISFACTORY

Name : Bearing cap. | **Stage - analysis : 1 - -1**



Verification of slip on georeinforcement No. 1

Forces acting on construction (verification of reinforcement No.: 1)

Name	F_{hor} [lbf/ft]	App.Pt. z [ft]	F_{vert} [lbf/ft]	App.Pt. x [ft]	Design coefficient
Weight - wall	0.0	-3.58	2049.7	-3.92	1.000
Active pressure	802.4	-2.50	351.7	5.50	1.000
Roadway Surcharge	329.2	-3.75	144.3	5.50	1.000
Weight - reinforced soil	0.0	-3.67	5175.9	2.88	1.000
Roadway Surcharge	0.0	-7.50	1375.0	-0.94	1.000

Verification against slip along geotextile No.: 1

Inclination of slip surface	=	90.00	°
Overall normal force acting on reinforcement	=	7046.79	lbf/ft
Coefficient of reduction of slip along geo-textile	=	0.92	
Resistance along geo-reinforcement	=	4611.75	lbf/ft
Wall resistance	=	1183.40	lbf/ft
Overall bearing capacity of reinforcements	=	0.00	lbf/ft

Check for slip:

Resisting horizontal force H_{res} = 5795.15 lbf/ft
Active horiz. force H_{act} = 1131.58 lbf/ft

Factor of safety = 5.12 > 1.50

Slip along geotextile is SATISFACTORY

Calculation of internal stability No. 1

Calculated forces and strength of reinforcements

No.	Name	F_x [lbf/ft]	Depth z[ft]	R_t [lbf/ft]	Utiliz. [%]	T_p [lbf/ft]	Utiliz. [%]	R_{con} [lbf/ft]	Utiliz. [%]
1	Miragrid 5XT	-170.89	7.50	517.34	49.55	1025.11	25.01	543.57	47.16
2	Miragrid 5XT	-282.62	6.00	1034.67	40.97	1424.07	29.77	1087.13	38.99
3	Miragrid 5XT	-213.31	4.50	1034.67	30.92	905.98	35.32	1087.13	29.43
4	Miragrid 5XT	-160.32	3.00	1034.67	23.24	495.93	48.49	1087.13	22.12

Check for tensile strength (reinforcement No.1)

Tension strength R_t = 517.34 lbf/ft

Force in reinforcement F_x = 170.89 lbf/ft

Safety factor = 3.03 > 1.50

Reinforcement for tensile strength is SATISFACTORY

Check for pull out resistance (reinforcement No.4)

Pull out resistance T_p = 495.93 lbf/ft

Force in reinforcement F_x = 160.32 lbf/ft

Safety factor = 3.09 > 1.50

Reinforcement for pull out resistance is SATISFACTORY

Verification of connection strength (reinforcement No.1)

Connection strength R_{con} = 543.57 lbf/ft

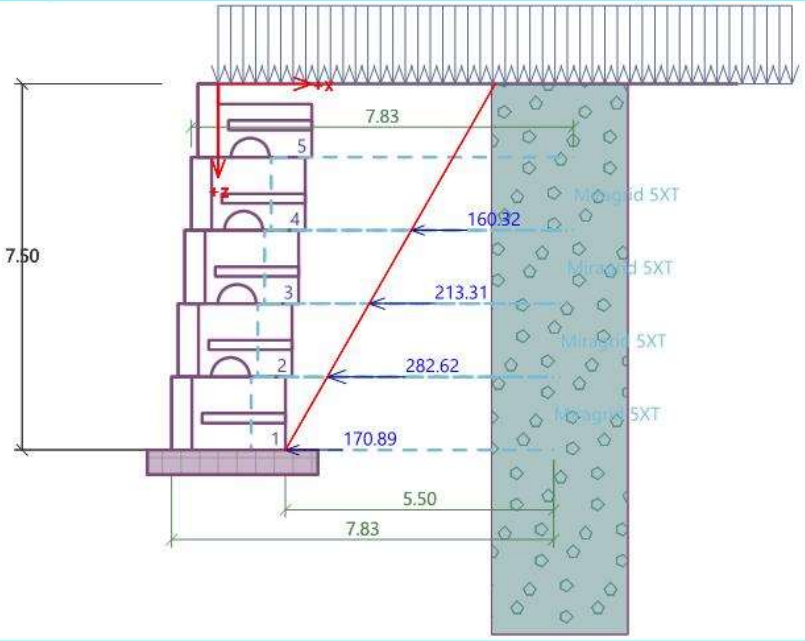
Force in reinforcement F_x = 170.89 lbf/ft

Safety factor = 3.18 > 1.50

Connection strength is SATISFACTORY

Overall verification - reinforcement is SATISFACTORY

Name : Internal stability | **Stage - analysis : 1 - 1**



6'-0" Tall Wall – Seismic Case

Analysis of Redi Rock wall

Input data

Project

Task : MSE Wall Design
Part : 6.0' MSE Wall - Seismic Case
Author : NRW
Date : 11/25/2019
Project number : 1801-0336

Settings

(input for current task)

Materials and standards

AASHTO - reduce parameters of friction soil/soil by 2/3 φ

Wall analysis

Active earth pressure calculation : Coulomb
Passive earth pressure calculation : Mazindrani (Rankine)
Earthquake analysis : Mononobe-Okabe
Shape of earth wedge : Calculate as skew
Allowable eccentricity : 0.333
Internal stability : Standard - straight slip surface
Reduction coeff. of contact first block - base : 1.00
Verification methodology : Safety factors (ASD)

Safety factors			
Seismic design situation			
Safety factor for overturning :	SF_o =	1.10	[–]
Safety factor for sliding resistance :	SF_s =	1.10	[–]
Safety factor for bearing capacity :	SF_b =	1.00	[–]
Safety factor for sliding along geo-reinforcement :	SF_{sr} =	1.10	[–]
Safety factor for geo-reinforcement strength :	SF_{st} =	1.10	[–]
Safety factor for pull out resistance of geo-reinf. :	SF_{po} =	1.10	[–]
Safety factor for connection strength :	SF_{con} =	1.10	[–]

Geometry

No. group	Description	Count	Setbacks [in]
1	Block 28 PC	3	1.62
2	Top block 28	1	-

Base

Geometry
Upper setback a_1 = 0.50 ft
Lower setback a_2 = 0.50 ft
Height h = 0.50 ft
Width b = 3.50 ft

Material
Unreinforced Footing
Concrete self-weight γ = 150.00 pcf
Shear cub (key) capacity = 0.00 lbf/ft
Friction angle concrete-concrete = 30.00 °

Types of reinforcements

No.	Name	Type of reinforcement	Line type	Tensile strength		
				T_{ult} [lbf/ft]	R_t [lbf/ft]	R_{con} [lbf/ft]
1	Miragrid 5XT	Miragrid 5XT		4700.00	2069.35	2174.26
2	Miragrid 8XT	Miragrid 8XT		7400.00	3393.87	3423.30
3	Miragrid 10XT	Miragrid 10XT		9500.00	4357.00	4287.39
4	Miragrid 20XT	Miragrid 20XT		13705.00	6558.83	6030.20
5	Miragrid 24XT	Miragrid 24XT		27415.00	13716.42	10560.73

Reinforcement details

1. Miragrid 5XT

Short-term char. strength	T_{ult}	=	4700.00	lbf/ft
Creep red. factor	RF_{CR}	=	1.58	
Durability red. factor	RF_D	=	1.15	
Installation damage red. factor	RF_{ID}	=	1.25	
Long-term design strength	R_t	=	2069.35	lbf/ft
Coefficient of direct slip along reinforcement	C_{ds}	=	0.67	
Coefficient of interaction of soil and geo-reinforcement	C_i	=	0.67	
Scale correction factor	α	=	0.8	
Long-term strength reduction factor	CR_{cr}	=	0.532	
Analysis of long-term strength	R_{con}	=	2174.26	lbf/ft

2. Miragrid 8XT

Short-term char. strength	T_{ult}	=	7400.00	lbf/ft
Creep red. factor	RF_{CR}	=	1.58	
Durability red. factor	RF_D	=	1.15	
Installation damage red. factor	RF_{ID}	=	1.20	
Long-term design strength	R_t	=	3393.87	lbf/ft
Coefficient of direct slip along reinforcement	C_{ds}	=	0.67	
Coefficient of interaction of soil and geo-reinforcement	C_i	=	0.67	
Scale correction factor	α	=	0.8	
Long-term strength reduction factor	CR_{cr}	=	0.532	
Analysis of long-term strength	R_{con}	=	3423.30	lbf/ft

3. Miragrid 10XT

Short-term char. strength	T_{ult}	=	9500.00	lbf/ft
Creep red. factor	RF_{CR}	=	1.58	
Durability red. factor	RF_D	=	1.15	
Installation damage red. factor	RF_{ID}	=	1.20	
Long-term design strength	R_t	=	4357.00	lbf/ft
Coefficient of direct slip along reinforcement	C_{ds}	=	0.67	
Coefficient of interaction of soil and geo-reinforcement	C_i	=	0.67	
Scale correction factor	α	=	0.8	
Long-term strength reduction factor	CR_{cr}	=	0.519	
Analysis of long-term strength	R_{con}	=	4287.39	lbf/ft

4. Miragrid 20XT

Short-term char. strength	T_{ult}	=	13705.00	lbf/ft
Creep red. factor	RF_{CR}	=	1.58	
Durability red. factor	RF_D	=	1.15	
Installation damage red. factor	RF_{ID}	=	1.15	
Long-term design strength	R_t	=	6558.83	lbf/ft
Coefficient of direct slip along reinforcement	C_{ds}	=	0.67	
Coefficient of interaction of soil and geo-reinforcement	C_i	=	0.67	
Scale correction factor	α	=	0.8	
Long-term strength reduction factor	CR_{cr}	=	0.506	
Analysis of long-term strength	R_{con}	=	6030.20	lbf/ft

5. Miragrid 24XT

Short-term char. strength	T_{ult}	=	27415.00	lbf/ft
Creep red. factor	RF_{CR}	=	1.58	
Durability red. factor	RF_D	=	1.15	
Installation damage red. factor	RF_{ID}	=	1.10	
Long-term design strength	R_t	=	13716.42	lbf/ft
Coefficient of direct slip along reinforcement	C_{ds}	=	0.67	
Coefficient of interaction of soil and geo-reinforcement	C_i	=	0.67	
Scale correction factor	α	=	0.8	
Long-term strength reduction factor	CR_{cr}	=	0.443	
Analysis of long-term strength	R_{con}	=	10560.73	lbf/ft

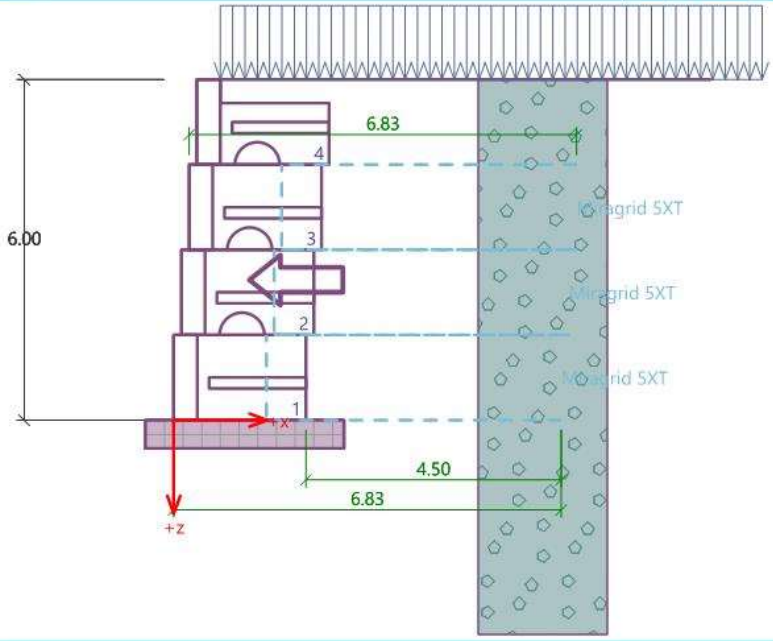
Reinforcements

Input mode : 1 reinforcement type
Reinf. installation : in every row of blocks (50%)
Type of reinforcement : Miragrid 5XT
Top reinforcement : straight (25%)
Reinforcement geometry : identical length of reinforcements
Length of reinforcement l = 4.50 ft

Reinforcements

No.	Consider	Name	Length of reinforcement l [ft]	End pt. coordinate l_k [ft]
1	Yes	Miragrid 5XT	4.50	
2	Yes	Miragrid 5XT	4.50	
3	Yes	Miragrid 5XT	4.50	
4	No			

Name : Reinforcements | **Stage - analysis : 1 - 0**



Basic soil parameters

No.	Name	Pattern	φ_{ef} [°]	c_{ef} [psf]	γ [pcf]	γ_{su} [pcf]	δ [°]
1	Gravel Backfill		35.50	0.0	130.00	67.50	34.00

All soils are considered as cohesionless for at rest pressure analysis.

Soil parameters

Gravel Backfill

Unit weight :	γ =	130.0 pcf
Stress-state :		effective
Angle of internal friction :	φ_{ef} =	35.50 °
Cohesion of soil :	c_{ef} =	0.0 psf
Angle of friction struc.-soil :	δ =	34.00 °
Saturated unit weight :	γ_{sat} =	130.0 pcf

Input surface surcharges

No.	Surcharge new	Surcharge change	Action	Mag.1 [lbf/ft²]	Mag.2 [lbf/ft²]	Ord.x x [ft]	Length l [ft]	Depth z [ft]
1	Yes		variable	200.0				on terrain

No.	Name
1	Roadway Surcharge

Resistance on front face of the structure

Resistance on front face of the structure is not considered.

Earthquake

Factor of horizontal acceleration K_h = 0.1620
Factor of vertical acceleration K_v = 0.0000

Water below the GWT is free.
Specific gravity of soil particles G_s = 2.08.

Settings of the stage of construction

Design situation : seismic

Verification No. 1

Forces acting on construction

Name	F_{hor} [lbf/ft]	App.Pt. z [ft]	F_{vert} [lbf/ft]	App.Pt. x [ft]	Design coefficient
Weight - reinforced soil	0.0	-3.05	3613.8	4.70	1.000
Earthquake - soil wedge	585.4	-3.05	0.0	4.70	1.000
Active pressure	513.5	-2.00	225.1	7.10	1.000
Earthq.- act.pressure	228.7	-4.00	100.3	7.10	1.000
Roadway Surcharge	263.3	-3.00	115.4	7.10	1.000
Weight - wall	0.0	-2.83	1584.2	1.34	1.000
Earthq.- constr.	256.6	-2.83	0.0	1.34	1.000

Verification of complete wall

Place of verification : bottom of blocks

Check for overturning stability
Resisting moment M_{res} = 22241.1 lbfft/ft
Overturning moment M_{ovr} = 5246.9 lbfft/ft

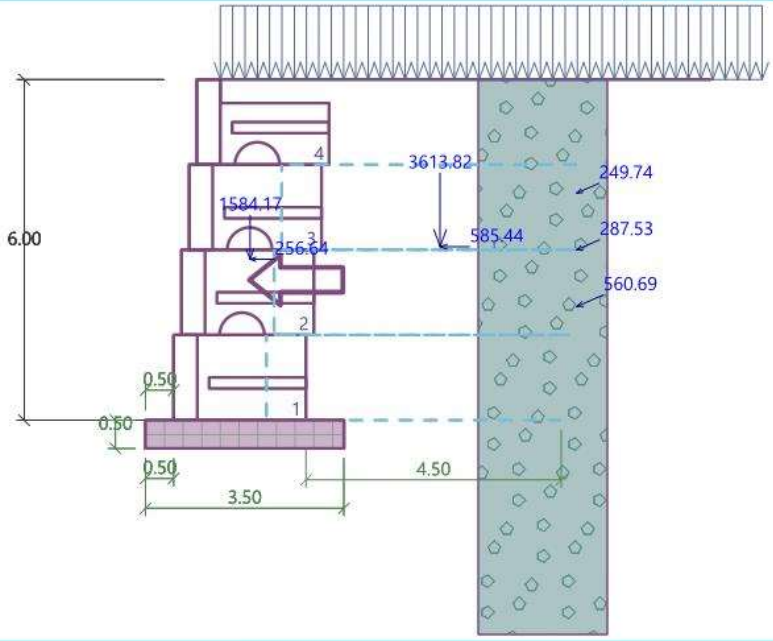
Safety factor = 4.24 > 1.10
Wall for overturning is SATISFACTORY

Check for slip
Resisting horizontal force H_{res} = 3690.24 lbf/ft
Active horizontal force H_{act} = 1847.69 lbf/ft

Safety factor = 2.00 > 1.10
Wall for slip is SATISFACTORY

Overall check - WALL is SATISFACTORY

Name : Verification | Stage - analysis : 1 - 1



Bearing capacity of foundation soil

Design load acting at the center of footing bottom

No.	Moment [lbfft/ft]	Norm. force [lbf/ft]	Shear Force [lbf/ft]	Eccentricity [–]	Stress [psf]
1	-3725.5	3104.24	-1026.26	0.000	886.9

Service load acting at the center of footing bottom

No.	Moment [lbfft/ft]	Norm. force [lbf/ft]	Shear Force [lbf/ft]
1	-3725.5	3104.24	-1026.26

Verification of foundation soil

Place of verification : bottom of leveling pad
Stress in the footing bottom : trapezoid

Eccentricity verification
Max. eccentricity of normal force e = 0.000
Maximum allowable eccentricity e_{alw} = 0.333

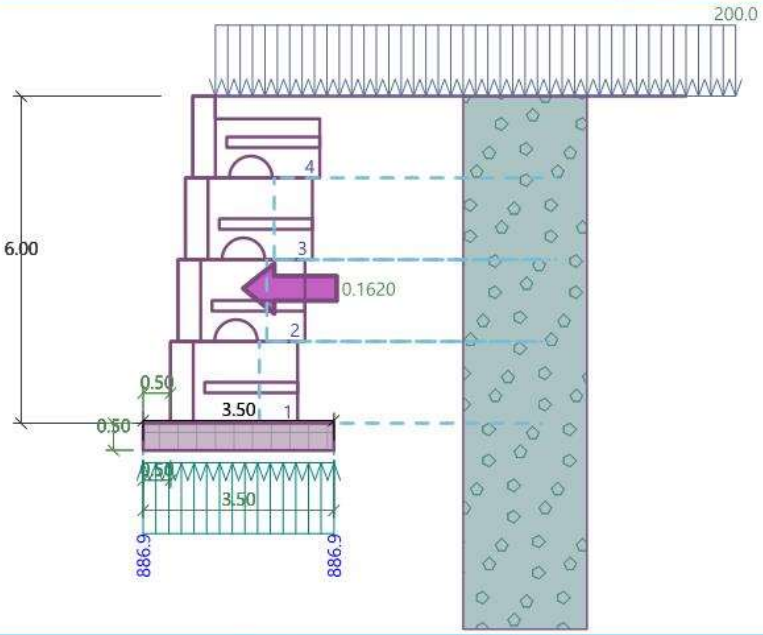
Eccentricity of the normal force is SATISFACTORY

Verification of bearing capacity
Max. stress at footing bottom σ = 886.9 psf
Bearing capacity of foundation soil R_d = 2000.0 psf

Safety factor = 2.25 > 1.00
Bearing capacity of foundation soil is SATISFACTORY

Overall verification - bearing capacity of found. soil is SATISFACTORY

Name : Bearing cap. | **Stage - analysis : 1 - -1**



Verification of slip on georeinforcement No. 1

Forces acting on construction (verification of reinforcement No.: 1)

Name	F_{hor} [lbf/ft]	App.Pt. z [ft]	F_{vert} [lbf/ft]	App.Pt. x [ft]	Design coefficient
Weight - wall	0.0	-2.83	1628.2	-3.99	1.000
Earthq.- constr.	263.8	-2.83	0.0	-3.99	1.000
Active pressure	513.5	-2.00	225.1	4.50	1.000
Earthq.- act.pressure	228.7	-4.00	100.3	4.50	1.000
Roadway Surcharge	263.3	-3.00	115.4	4.50	1.000
Weight - reinforced soil	0.0	-2.94	3429.0	2.35	1.000
Earthquake - soil wedge	543.0	-2.94	0.0	2.35	1.000
Roadway Surcharge	0.0	-6.00	1202.1	-1.51	1.000

Verification against slip along geotextile No.: 1

Inclination of slip surface	=	90.00	°
Overall normal force acting on reinforcement	=	5071.80	lbf/ft
Coefficient of reduction of slip along geo-textile	=	0.92	
Resistance along geo-reinforcement	=	3319.22	lbf/ft
Wall resistance	=	0.00	lbf/ft
Overall bearing capacity of reinforcements	=	0.00	lbf/ft

Check for slip:
Resisting horizontal force H_{res} = 3319.22 lbf/ft

Active horiz. force H_{act} = 1005.62 lbf/ft

Factor of safety = 3.30 > 1.10
Slip along geotextile is SATISFACTORY

Calculation of internal stability No. 1

Calculated forces and strength of reinforcements

No.	Name	F_x [lbf/ft]	Depth z[ft]	R_t [lbf/ft]	Utiliz. [%]	T_p [lbf/ft]	Utiliz. [%]	R_{con} [lbf/ft]	Utiliz. [%]
1	Miragrid 5XT	-144.90	6.00	517.34	30.81	670.98	23.76	543.57	29.32
2	Miragrid 5XT	-254.87	4.50	1034.67	27.10	844.39	33.20	1087.13	25.79
3	Miragrid 5XT	-216.41	3.00	1034.67	23.01	454.88	52.33	1087.13	21.90

Check for tensile strength (reinforcement No.1)
Tension strength R_t = 517.34 lbf/ft
Force in reinforcement F_x = 144.90 lbf/ft

Safety factor = 3.57 > 1.10
Reinforcement for tensile strength is SATISFACTORY

Check for pull out resistance (reinforcement No.3)
Pull out resistance T_p = 454.88 lbf/ft
Force in reinforcement F_x = 216.41 lbf/ft

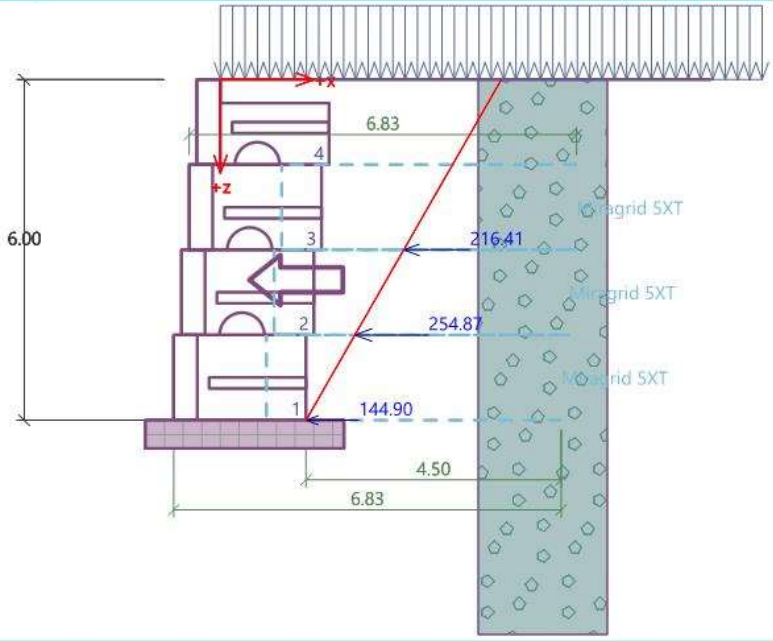
Safety factor = 2.10 > 1.10
Reinforcement for pull out resistance is SATISFACTORY

Verification of connection strength (reinforcement No.1)
Connection strength R_{con} = 543.57 lbf/ft
Force in reinforcement F_x = 144.90 lbf/ft

Safety factor = 3.75 > 1.10
Connection strength is SATISFACTORY

Overall verification - reinforcement is SATISFACTORY

Name : Internal stability | **Stage - analysis : 1 - 1**



6'-0" Tall Wall – Transient Case

Analysis of Redi Rock wall

Input data

Project

Part : 6.0' MSE Wall - Transient Case
Author : NRW
Date : 12/6/2019
Project number : 1801-0336

Settings

(input for current task)

Materials and standards

AASHTO - reduce parameters of friction soil/soil by 2/3 φ

Wall analysis

Active earth pressure calculation : Coulomb
Passive earth pressure calculation : Mazindrani (Rankine)
Earthquake analysis : Mononobe-Okabe
Shape of earth wedge : Calculate as skew
Allowable eccentricity : 0.333
Internal stability : Standard - straight slip surface
Reduction coeff. of contact first block - base : 1.00
Verification methodology : Safety factors (ASD)

Safety factors			
Transient design situation			
Safety factor for overturning :	SF_o =	1.50	[–]
Safety factor for sliding resistance :	SF_s =	1.50	[–]
Safety factor for bearing capacity :	SF_b =	1.33	[–]
Safety factor for sliding along geo-reinforcement :	SF_{sr} =	1.50	[–]
Safety factor for geo-reinforcement strength :	SF_{st} =	1.50	[–]
Safety factor for pull out resistance of geo-reinf. :	SF_{po} =	1.50	[–]
Safety factor for connection strength :	SF_{con} =	1.50	[–]

Geometry

No. group	Description	Count	Setback s [in]
1	Block 28 PC	3	1.62
2	Top block 28	1	-

Base

Geometry
Upper setback a_1 = 0.50 ft
Lower setback a_2 = 0.50 ft
Height h = 0.50 ft
Width b = 3.50 ft

Material
Unreinforced Footing
Concrete self-weight γ = 150.00 pcf
Shear cub (key) capacity = 0.00 lbf/ft
Friction angle concrete-concrete = 30.00 °

Types of reinforcements

No.	Name	Type of reinforcement	Line type	Tensile strength T_{ult} [lbf/ft]	R_t [lbf/ft]	R_{con} [lbf/ft]
1	Miragrid 5XT	Miragrid 5XT	- - - - - - -	4700.00	2069.35	2174.26
2	Miragrid 8XT	Miragrid 8XT	- - - - - - - - -	7400.00	3393.87	3423.30
3	Miragrid 10XT	Miragrid 10XT	- - - - - - -	9500.00	4357.00	4287.39
4	Miragrid 20XT	Miragrid 20XT	~~~~~~~~~~~	13705.00	6558.83	6030.20
5	Miragrid 24XT	Miragrid 24XT	~~~~~~~~~~~	27415.00	13716.42	10560.73

Reinforcement details

1. Miragrid 5XT

Short-term char. strength	T_{ult}	=	4700.00	lbf/ft
Creep red. factor	RF_{CR}	=	1.58	
Durability red. factor	RF_D	=	1.15	
Installation damage red. factor	RF_{ID}	=	1.25	
Long-term design strength	R_t	=	2069.35	lbf/ft
Coefficient of direct slip along reinforcement	C_{ds}	=	0.67	
Coefficient of interaction of soil and geo-reinforcement	C_i	=	0.67	
Scale correction factor	α	=	0.8	
Long-term strength reduction factor	CR_{cr}	=	0.532	
Analysis of long-term strength	R_{con}	=	2174.26	lbf/ft

2. Miragrid 8XT

Short-term char. strength	T_{ult}	=	7400.00	lbf/ft
Creep red. factor	RF_{CR}	=	1.58	
Durability red. factor	RF_D	=	1.15	
Installation damage red. factor	RF_{ID}	=	1.20	
Long-term design strength	R_t	=	3393.87	lbf/ft
Coefficient of direct slip along reinforcement	C_{ds}	=	0.67	
Coefficient of interaction of soil and geo-reinforcement	C_i	=	0.67	
Scale correction factor	α	=	0.8	
Long-term strength reduction factor	CR_{cr}	=	0.532	
Analysis of long-term strength	R_{con}	=	3423.30	lbf/ft

3. Miragrid 10XT

Short-term char. strength	T_{ult}	=	9500.00	lbf/ft
Creep red. factor	RF_{CR}	=	1.58	
Durability red. factor	RF_D	=	1.15	
Installation damage red. factor	RF_{ID}	=	1.20	
Long-term design strength	R_t	=	4357.00	lbf/ft
Coefficient of direct slip along reinforcement	C_{ds}	=	0.67	
Coefficient of interaction of soil and geo-reinforcement	C_i	=	0.67	
Scale correction factor	α	=	0.8	
Long-term strength reduction factor	CR_{cr}	=	0.519	
Analysis of long-term strength	R_{con}	=	4287.39	lbf/ft

4. Miragrid 20XT

Short-term char. strength	T_{ult}	=	13705.00	lbf/ft
Creep red. factor	RF_{CR}	=	1.58	
Durability red. factor	RF_D	=	1.15	
Installation damage red. factor	RF_{ID}	=	1.15	
Long-term design strength	R_t	=	6558.83	lbf/ft
Coefficient of direct slip along reinforcement	C_{ds}	=	0.67	
Coefficient of interaction of soil and geo-reinforcement	C_i	=	0.67	
Scale correction factor	α	=	0.8	
Long-term strength reduction factor	CR_{cr}	=	0.506	
Analysis of long-term strength	R_{con}	=	6030.20	lbf/ft

5. Miragrid 24XT

Short-term char. strength	T_{ult}	=	27415.00	lbf/ft
Creep red. factor	RF_{CR}	=	1.58	
Durability red. factor	RF_D	=	1.15	
Installation damage red. factor	RF_{ID}	=	1.10	
Long-term design strength	R_t	=	13716.42	lbf/ft
Coefficient of direct slip along reinforcement	C_{ds}	=	0.67	
Coefficient of interaction of soil and geo-reinforcement	C_i	=	0.67	
Scale correction factor	α	=	0.8	
Long-term strength reduction factor	CR_{cr}	=	0.443	
Analysis of long-term strength	R_{con}	=	10560.73	lbf/ft

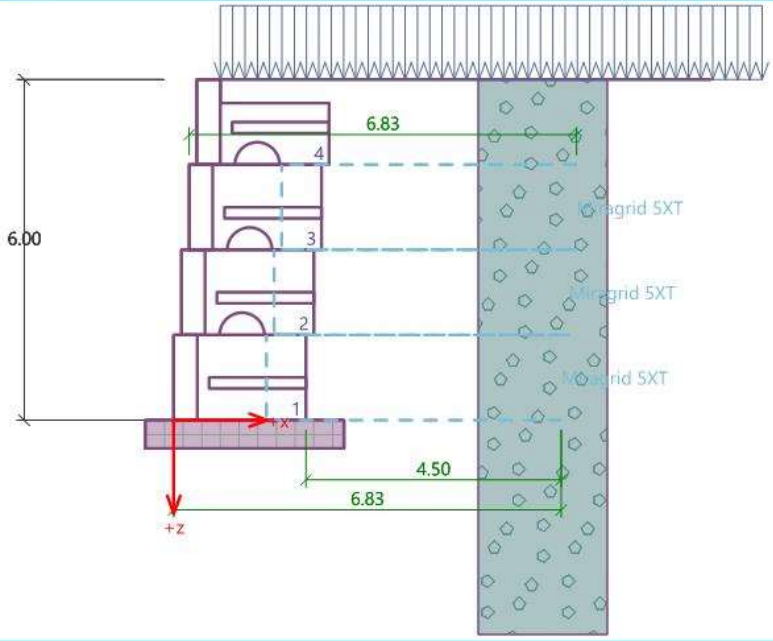
Reinforcements

Input mode : 1 reinforcement type
Reinf. installation : in every row of blocks (50%)
Type of reinforcement : Miragrid 5XT
Top reinforcement : straight (25%)
Reinforcement geometry : identical length of reinforcements
Length of reinforcement l = 4.50 ft

Reinforcements

No.	Consider	Name	Length of reinforcement l [ft]	End pt. coordinate l_k [ft]
1	Yes	Miragrid 5XT	4.50	
2	Yes	Miragrid 5XT	4.50	
3	Yes	Miragrid 5XT	4.50	
4	No			

Name : Reinforcements | **Stage - analysis : 1 - 0**



Soil parameters

Gravel Backfill

Unit weight :	γ =	130.0 pcf
Stress-state :		effective
Angle of internal friction :	φ_{ef} =	35.50 °
Cohesion of soil :	c_{ef} =	0.0 psf
Angle of friction struc.-soil :	δ =	34.00 °
Saturated unit weight :	γ_{sat} =	130.0 pcf

Input surface surcharges

No.	Surcharge new	Surcharge change	Action	Mag.1 [lbf/ft²]	Mag.2 [lbf/ft²]	Ord.x x [ft]	Length l [ft]	Depth z [ft]
1	Yes		variable	200.0				on terrain

No.	Name
1	Roadway Surcharge

Resistance on front face of the structure

Resistance on front face of the structure is not considered.

Settings of the stage of construction

Design situation : transient

Verification No. 1

Forces acting on construction

Name	F_{hor} [lbf/ft]	App.Pt. z [ft]	F_{vert} [lbf/ft]	App.Pt. x [ft]	Design coefficient
Weight - reinforced soil	0.0	-3.05	3613.8	4.70	1.000
Active pressure	513.5	-2.00	225.1	7.10	1.000
Roadway Surcharge	263.3	-3.00	115.4	7.10	1.000
Weight - wall	0.0	-2.83	1584.2	1.34	1.000

Verification of complete wall

Place of verification : bottom of blocks

Check for overturning stability
Resisting moment M_{res} = 21528.9 lbfft/ft
Overturning moment M_{ovr} = 1817.1 lbfft/ft

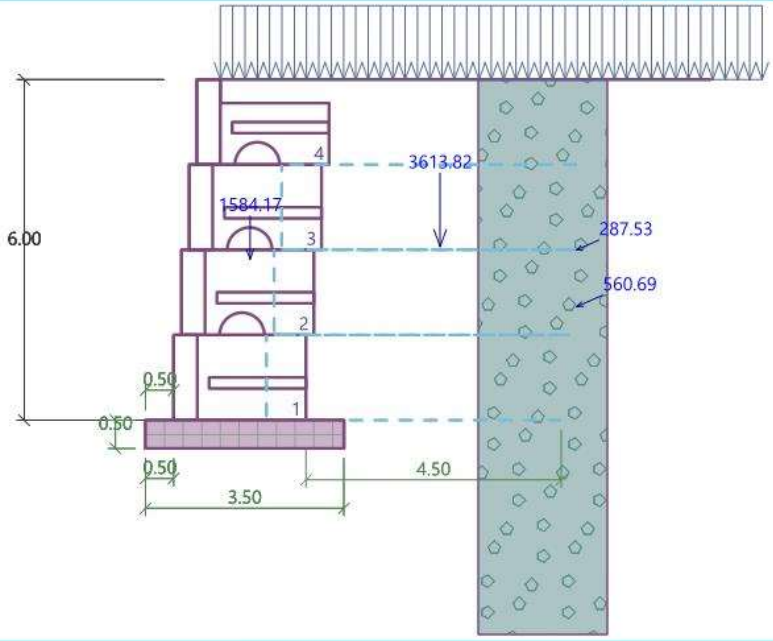
Safety factor = 11.85 > 1.50
Wall for overturning is SATISFACTORY

Check for slip
Resisting horizontal force H_{res} = 3624.63 lbf/ft
Active horizontal force H_{act} = 776.88 lbf/ft

Safety factor = 4.67 > 1.50
Wall for slip is SATISFACTORY

Overall check - WALL is SATISFACTORY

Name : Verification | Stage - analysis : 1 - 1



Bearing capacity of foundation soil

Design load acting at the center of footing bottom

No.	Moment [lbfft/ft]	Norm. force [lbf/ft]	Shear Force [lbf/ft]	Eccentricity [–]	Stress [psf]
1	-5618.8	2885.87	-1625.84	0.000	824.5

Service load acting at the center of footing bottom

No.	Moment [lbfft/ft]	Norm. force [lbf/ft]	Shear Force [lbf/ft]
1	-5618.8	2885.87	-1625.84

Verification of foundation soil

Place of verification : bottom of leveling pad
Stress in the footing bottom : trapezoid

Eccentricity verification
Max. eccentricity of normal force e = 0.000
Maximum allowable eccentricity e_{alw} = 0.333

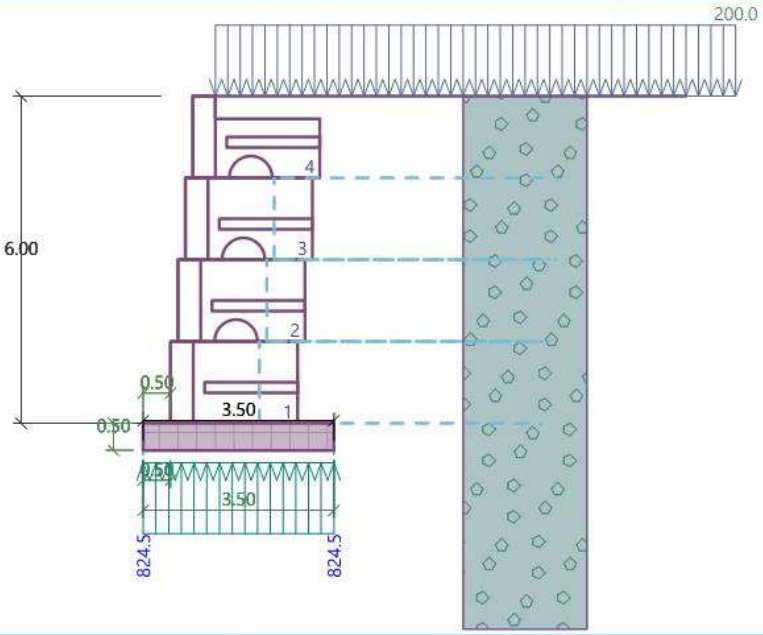
Eccentricity of the normal force is SATISFACTORY

Verification of bearing capacity
Max. stress at footing bottom σ = 824.5 psf
Bearing capacity of foundation soil R_d = 2000.0 psf

Safety factor = 2.43 > 1.33
Bearing capacity of foundation soil is SATISFACTORY

Overall verification - bearing capacity of found. soil is SATISFACTORY

Name : Bearing cap. | **Stage - analysis : 1 - -1**



Verification of slip on georeinforcement No. 1

Forces acting on construction (verification of reinforcement No.: 1)

Name	F_{hor} [lbf/ft]	App.Pt. z [ft]	F_{vert} [lbf/ft]	App.Pt. x [ft]	Design coefficient
Weight - wall	0.0	-2.83	1628.2	-3.99	1.000
Active pressure	513.5	-2.00	225.1	4.50	1.000
Roadway Surcharge	263.3	-3.00	115.4	4.50	1.000
Weight - reinforced soil	0.0	-2.94	3429.0	2.35	1.000
Roadway Surcharge	0.0	-6.00	1202.1	-1.51	1.000

Verification against slip along geotextile No.: 1

Inclination of slip surface	=	90.00	°
Overall normal force acting on reinforcement	=	4971.55	lbf/ft
Coefficient of reduction of slip along geo-textile	=	0.92	
Resistance along geo-reinforcement	=	3253.61	lbf/ft
Wall resistance	=	940.03	lbf/ft
Overall bearing capacity of reinforcements	=	0.00	lbf/ft

Check for slip:

Resisting horizontal force H_{res} = 4193.64 lbf/ft
Active horiz. force H_{act} = 776.88 lbf/ft

Factor of safety = 5.40 > 1.50

Slip along geotextile is SATISFACTORY

Calculation of internal stability No. 1

Calculated forces and strength of reinforcements

No.	Name	F_x [lbf/ft]	Depth z[ft]	R_t [lbf/ft]	Utiliz. [%]	T_p [lbf/ft]	Utiliz. [%]	R_{con} [lbf/ft]	Utiliz. [%]
1	Miragrid 5XT	-141.30	6.00	517.34	40.97	670.98	31.59	543.57	38.99
2	Miragrid 5XT	-226.54	4.50	1034.67	32.84	844.39	40.24	1087.13	31.26
3	Miragrid 5XT	-160.32	3.00	1034.67	23.24	454.88	52.87	1087.13	22.12

Check for tensile strength (reinforcement No.1)

Tension strength R_t = 517.34 lbf/ft
Force in reinforcement F_x = 141.30 lbf/ft

Safety factor = 3.66 > 1.50
Reinforcement for tensile strength is SATISFACTORY

Check for pull out resistance (reinforcement No.3)

Pull out resistance T_p = 454.88 lbf/ft
Force in reinforcement F_x = 160.32 lbf/ft

Safety factor = 2.84 > 1.50
Reinforcement for pull out resistance is SATISFACTORY

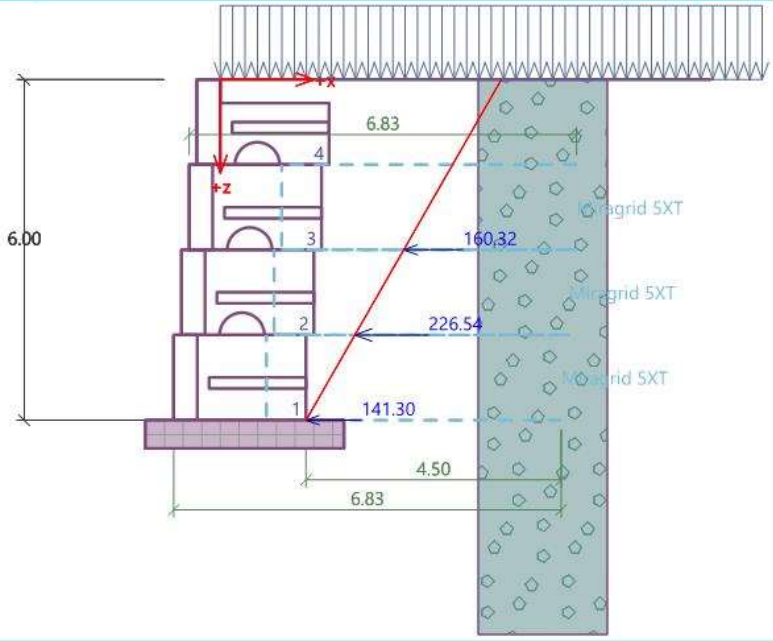
Verification of connection strength (reinforcement No.1)

Connection strength R_{con} = 543.57 lbf/ft
Force in reinforcement F_x = 141.30 lbf/ft

Safety factor = 3.85 > 1.50
Connection strength is SATISFACTORY

Overall verification - reinforcement is SATISFACTORY

Name : Internal stability | Stage - analysis : 1 - 1



4’-6” Tall Wall – Seismic Case

Analysis of Redi Rock wall

Input data

Project

Task : MSE Wall Design
Part : 4.5' MSE Wall - Seismic Case
Author : NRW
Date : 11/25/2019
Project number : 1801-0336

Settings

(input for current task)

Materials and standards

AASHTO - reduce parameters of friction soil/soil by 2/3 φ

Wall analysis

Active earth pressure calculation : Coulomb
Passive earth pressure calculation : Mazindrani (Rankine)
Earthquake analysis : Mononobe-Okabe
Shape of earth wedge : Calculate as skew
Allowable eccentricity : 0.333
Internal stability : Standard - straight slip surface
Reduction coeff. of contact first block - base : 1.00
Verification methodology : Safety factors (ASD)

Safety factors			
Seismic design situation			
Safety factor for overturning :	SF_o =	1.10	[–]
Safety factor for sliding resistance :	SF_s =	1.10	[–]
Safety factor for bearing capacity :	SF_b =	1.00	[–]
Safety factor for sliding along geo-reinforcement :	SF_{sr} =	1.10	[–]
Safety factor for geo-reinforcement strength :	SF_{st} =	1.10	[–]
Safety factor for pull out resistance of geo-reinf. :	SF_{po} =	1.10	[–]
Safety factor for connection strength :	SF_{con} =	1.10	[–]

Geometry

No. group	Description	Count	Setbacks [in]
1	Block 28 PC	2	1.62
2	Top block 28	1	-

Base

Geometry

Upper setback a_1 = 0.50 ft
Lower setback a_2 = 0.50 ft
Height h = 0.50 ft
Width b = 3.50 ft

Material

Unreinforced Footing
Concrete self-weight γ = 150.00 pcf
Shear cub (key) capacity = 0.00 lbf/ft
Friction angle concrete-concrete = 30.00 °

Types of reinforcements

No.	Name	Type of reinforcement	Line type	Tensile strength		
				T_{ult} [lbf/ft]	R_t [lbf/ft]	R_{con} [lbf/ft]
1	Miragrid 5XT	Miragrid 5XT		4700.00	2069.35	2174.26
2	Miragrid 8XT	Miragrid 8XT		7400.00	3393.87	3423.30
3	Miragrid 10XT	Miragrid 10XT		9500.00	4357.00	4287.39
4	Miragrid 20XT	Miragrid 20XT		13705.00	6558.83	6030.20
5	Miragrid 24XT	Miragrid 24XT		27415.00	13716.42	10560.73

Reinforcement details

1. Miragrid 5XT

Short-term char. strength	T_{ult}	=	4700.00	lbf/ft
Creep red. factor	RF_{CR}	=	1.58	
Durability red. factor	RF_D	=	1.15	
Installation damage red. factor	RF_{ID}	=	1.25	
Long-term design strength	R_t	=	2069.35	lbf/ft
Coefficient of direct slip along reinforcement	C_{ds}	=	0.67	
Coefficient of interaction of soil and geo-reinforcement	C_i	=	0.67	
Scale correction factor	α	=	0.8	
Long-term strength reduction factor	CR_{cr}	=	0.532	
Analysis of long-term strength	R_{con}	=	2174.26	lbf/ft

2. Miragrid 8XT

Short-term char. strength	T_{ult}	=	7400.00	lbf/ft
Creep red. factor	RF_{CR}	=	1.58	
Durability red. factor	RF_D	=	1.15	
Installation damage red. factor	RF_{ID}	=	1.20	
Long-term design strength	R_t	=	3393.87	lbf/ft
Coefficient of direct slip along reinforcement	C_{ds}	=	0.67	
Coefficient of interaction of soil and geo-reinforcement	C_i	=	0.67	
Scale correction factor	α	=	0.8	
Long-term strength reduction factor	CR_{cr}	=	0.532	
Analysis of long-term strength	R_{con}	=	3423.30	lbf/ft

3. Miragrid 10XT

Short-term char. strength	T_{ult}	=	9500.00	lbf/ft
Creep red. factor	RF_{CR}	=	1.58	
Durability red. factor	RF_D	=	1.15	
Installation damage red. factor	RF_{ID}	=	1.20	
Long-term design strength	R_t	=	4357.00	lbf/ft
Coefficient of direct slip along reinforcement	C_{ds}	=	0.67	
Coefficient of interaction of soil and geo-reinforcement	C_i	=	0.67	
Scale correction factor	α	=	0.8	
Long-term strength reduction factor	CR_{cr}	=	0.519	
Analysis of long-term strength	R_{con}	=	4287.39	lbf/ft

4. Miragrid 20XT

Short-term char. strength	T_{ult}	=	13705.00	lbf/ft
Creep red. factor	RF_{CR}	=	1.58	
Durability red. factor	RF_D	=	1.15	
Installation damage red. factor	RF_{ID}	=	1.15	
Long-term design strength	R_t	=	6558.83	lbf/ft
Coefficient of direct slip along reinforcement	C_{ds}	=	0.67	
Coefficient of interaction of soil and geo-reinforcement	C_i	=	0.67	
Scale correction factor	α	=	0.8	
Long-term strength reduction factor	CR_{cr}	=	0.506	
Analysis of long-term strength	R_{con}	=	6030.20	lbf/ft

5. Miragrid 24XT

Short-term char. strength	T_{ult}	=	27415.00	lbf/ft
Creep red. factor	RF_{CR}	=	1.58	
Durability red. factor	RF_D	=	1.15	
Installation damage red. factor	RF_{ID}	=	1.10	
Long-term design strength	R_t	=	13716.42	lbf/ft
Coefficient of direct slip along reinforcement	C_{ds}	=	0.67	
Coefficient of interaction of soil and geo-reinforcement	C_i	=	0.67	
Scale correction factor	α	=	0.8	
Long-term strength reduction factor	CR_{cr}	=	0.443	
Analysis of long-term strength	R_{con}	=	10560.73	lbf/ft

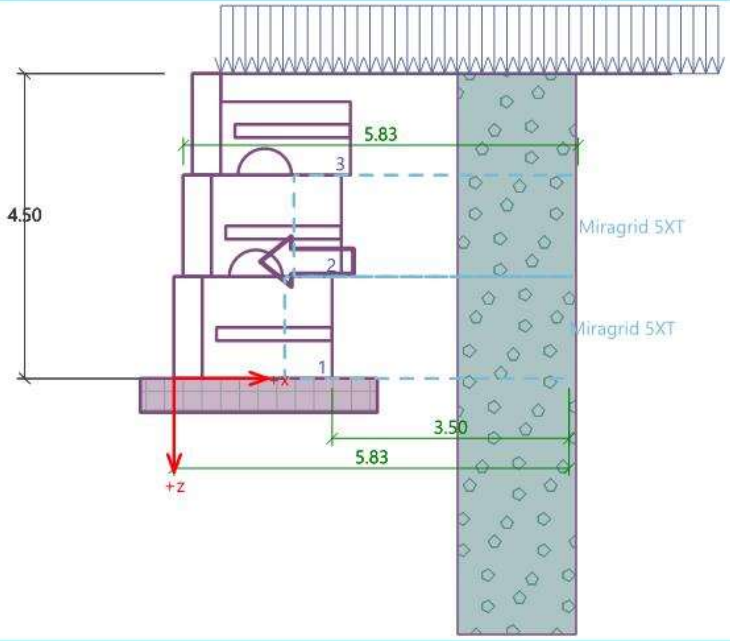
Reinforcements

Input mode : 1 reinforcement type
Reinf. installation : in every row of blocks (50%)
Type of reinforcement : Miragrid 5XT
Top reinforcement : straight (25%)
Reinforcement geometry : identical length of reinforcements
Length of reinforcement l = 3.50 ft

Reinforcements

No.	Consider	Name	Length of reinforcement l [ft]	End pt. coordinate l_k [ft]
1	Yes	Miragrid 5XT	3.50	
2	Yes	Miragrid 5XT	3.50	
3	No			

Name : Reinforcements | **Stage - analysis : 1 - 0**



Basic soil parameters

No.	Name	Pattern	φ_{ef} [°]	c_{ef} [psf]	γ [pcf]	γ_{su} [pcf]	δ [°]
1	Gravel Backfill		35.50	0.0	130.00	67.50	34.00

All soils are considered as cohesionless for at rest pressure analysis.

Soil parameters

Gravel Backfill

Unit weight :	γ = 130.0 pcf
Stress-state :	effective
Angle of internal friction :	φ_{ef} = 35.50 °
Cohesion of soil :	c_{ef} = 0.0 psf
Angle of friction struc.-soil :	δ = 34.00 °
Saturated unit weight :	γ_{sat} = 130.0 pcf

Input surface surcharges

No.	Surcharge new	Surcharge change	Action	Mag.1 [lbf/ft²]	Mag.2 [lbf/ft²]	Ord.x x [ft]	Length l [ft]	Depth z [ft]
1	Yes		variable	200.0				on terrain

No.	Name
1	Roadway Surcharge

Resistance on front face of the structure

Resistance on front face of the structure is not considered.

Earthquake

Factor of horizontal acceleration K_h = 0.1620
Factor of vertical acceleration K_v = 0.0000

Water below the GWT is free.
Specific gravity of soil particles G_s = 2.08.

Settings of the stage of construction

Design situation : seismic

Verification No. 1

Forces acting on construction

Name	F_{hor} [lbf/ft]	App.Pt. z [ft]	F_{vert} [lbf/ft]	App.Pt. x [ft]	Design coefficient
Weight - reinforced soil	0.0	-2.32	2138.1	4.08	1.000
Earthquake - soil wedge	346.4	-2.32	0.0	4.08	1.000
Active pressure	288.9	-1.50	126.6	5.97	1.000
Earthq.- act.pressure	128.7	-3.00	56.4	5.97	1.000
Roadway Surcharge	197.5	-2.25	86.6	5.97	1.000
Weight - wall	0.0	-2.08	1164.2	1.27	1.000
Earthq.- constr.	188.6	-2.08	0.0	1.27	1.000

Verification of complete wall

Place of verification : bottom of blocks

Check for overturning stability
Resisting moment M_{res} = 11818.8 lbfft/ft
Overturning moment M_{ovr} = 2460.9 lbfft/ft

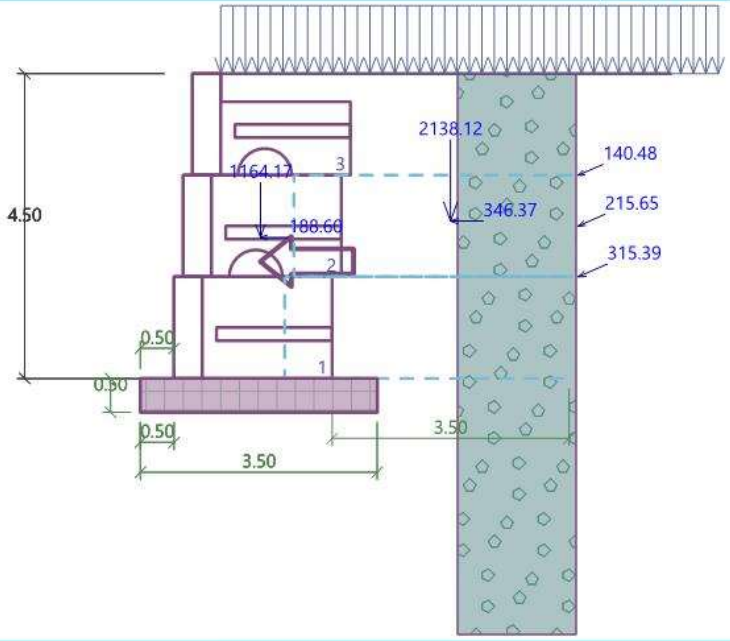
Safety factor = 4.80 > 1.10
Wall for overturning is SATISFACTORY

Check for slip
Resisting horizontal force H_{res} = 2337.58 lbf/ft
Active horizontal force H_{act} = 1150.01 lbf/ft

Safety factor = 2.03 > 1.10
Wall for slip is SATISFACTORY

Overall check - WALL is SATISFACTORY

Name : Verification | Stage - analysis : 1 - 1



Bearing capacity of foundation soil

Design load acting at the center of footing bottom

No.	Moment [lbfft/ft]	Norm. force [lbf/ft]	Shear Force [lbf/ft]	Eccentricity [–]	Stress [psf]
1	-1224.4	2342.04	-355.86	0.000	669.2

Service load acting at the center of footing bottom

No.	Moment [lbfft/ft]	Norm. force [lbf/ft]	Shear Force [lbf/ft]
1	-1224.4	2342.04	-355.86

Verification of foundation soil

Place of verification : bottom of leveling pad
Stress in the footing bottom : trapezoid

Eccentricity verification
Max. eccentricity of normal force e = 0.000
Maximum allowable eccentricity e_{alw} = 0.333

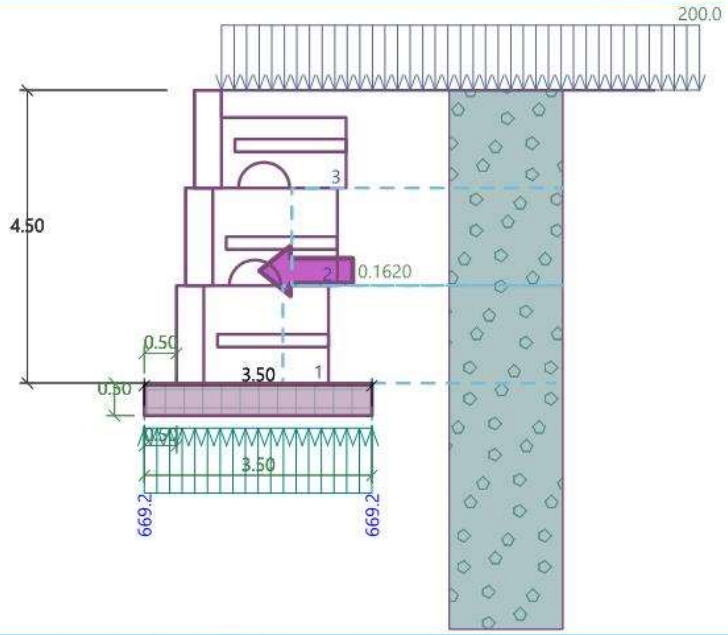
Eccentricity of the normal force is SATISFACTORY

Verification of bearing capacity
Max. stress at footing bottom σ = 669.2 psf
Bearing capacity of foundation soil R_d = 2000.0 psf

Safety factor = 2.99 > 1.00
Bearing capacity of foundation soil is SATISFACTORY

Overall verification - bearing capacity of found. soil is SATISFACTORY

Name : Bearing cap. | **Stage - analysis : 1 - -1**



Verification of slip on georeinforcement No. 1

Forces acting on construction (verification of reinforcement No.: 1)

Name	F_{hor} [lbf/ft]	App.Pt. z [ft]	F_{vert} [lbf/ft]	App.Pt. x [ft]	Design coefficient
Weight - wall	0.0	-2.08	1205.7	-4.06	1.000
Earthq.- constr.	195.3	-2.08	0.0	-4.06	1.000
Active pressure	288.9	-1.50	126.6	3.50	1.000
Earthq.- act.pressure	128.7	-3.00	56.4	3.50	1.000
Roadway Surcharge	197.5	-2.25	86.6	3.50	1.000
Weight - reinforced soil	0.0	-2.21	2045.7	1.82	1.000
Earthquake - soil wedge	318.9	-2.21	0.0	1.82	1.000
Roadway Surcharge	0.0	-4.50	1029.2	-2.07	1.000

Verification against slip along geotextile No.: 1

Inclination of slip surface	=	90.00	°
Overall normal force acting on reinforcement	=	3344.42	lbf/ft
Coefficient of reduction of slip along geo-textile	=	0.92	
Resistance along geo-reinforcement	=	2188.74	lbf/ft
Wall resistance	=	0.00	lbf/ft
Overall bearing capacity of reinforcements	=	0.00	lbf/ft

Check for slip:
Resisting horizontal force H_{res} = 2188.74 lbf/ft

Active horiz. force H_{act} = 615.04 lbf/ft

Factor of safety = 3.56 > 1.10
Slip along geotextile is SATISFACTORY

Calculation of internal stability No. 1

Calculated forces and strength of reinforcements

No.	Name	F_x [lbf/ft]	Depth z[ft]	R_t [lbf/ft]	Utiliz. [%]	T_p [lbf/ft]	Utiliz. [%]	R_{con} [lbf/ft]	Utiliz. [%]
1	Miragrid 5XT	-115.31	4.50	517.34	24.52	391.41	32.41	543.57	23.34
2	Miragrid 5XT	-198.79	3.00	1034.67	21.13	413.82	52.84	1087.13	20.11

Check for tensile strength (reinforcement No.1)
Tension strength R_t = 517.34 lbf/ft
Force in reinforcement F_x = 115.31 lbf/ft

Safety factor = 4.49 > 1.10
Reinforcement for tensile strength is SATISFACTORY

Check for pull out resistance (reinforcement No.2)
Pull out resistance T_p = 413.82 lbf/ft
Force in reinforcement F_x = 198.79 lbf/ft

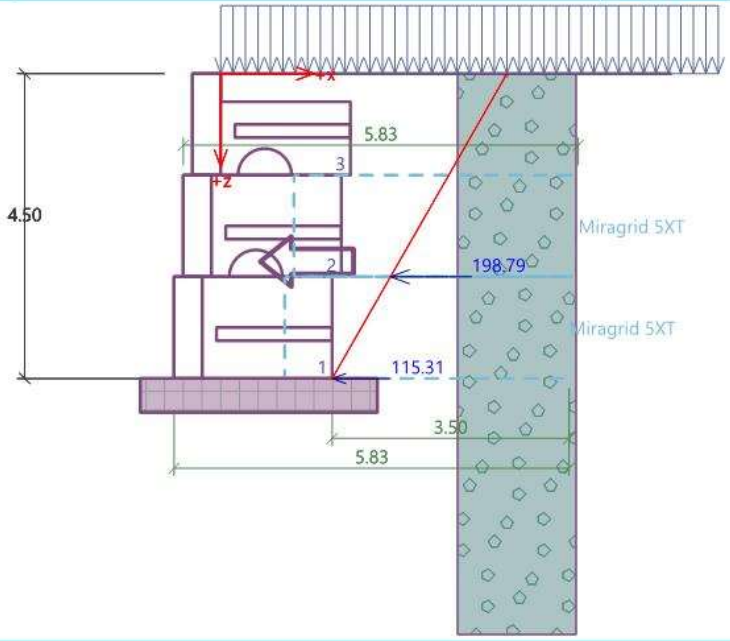
Safety factor = 2.08 > 1.10
Reinforcement for pull out resistance is SATISFACTORY

Verification of connection strength (reinforcement No.1)
Connection strength R_{con} = 543.57 lbf/ft
Force in reinforcement F_x = 115.31 lbf/ft

Safety factor = 4.71 > 1.10
Connection strength is SATISFACTORY

Overall verification - reinforcement is SATISFACTORY

Name : Internal stability | **Stage - analysis : 1 - 1**



4'-6" Tall Wall – Transient Case

Analysis of Redi Rock wall

Input data

Project

Part : 4.5' MSE Wall - Transient Case
Author : NRW
Date : 12/6/2019
Project number : 1801-0336

Settings

(input for current task)

Materials and standards

AASHTO - reduce parameters of friction soil/soil by 2/3 φ

Wall analysis

Active earth pressure calculation : Coulomb
Passive earth pressure calculation : Mazindrani (Rankine)
Earthquake analysis : Mononobe-Okabe
Shape of earth wedge : Calculate as skew
Allowable eccentricity : 0.333
Internal stability : Standard - straight slip surface
Reduction coeff. of contact first block - base : 1.00
Verification methodology : Safety factors (ASD)

Safety factors			
Transient design situation			
Safety factor for overturning :	SF_o =	1.50	[–]
Safety factor for sliding resistance :	SF_s =	1.50	[–]
Safety factor for bearing capacity :	SF_b =	1.33	[–]
Safety factor for sliding along geo-reinforcement :	SF_{sr} =	1.50	[–]
Safety factor for geo-reinforcement strength :	SF_{st} =	1.50	[–]
Safety factor for pull out resistance of geo-reinf. :	SF_{po} =	1.50	[–]
Safety factor for connection strength :	SF_{con} =	1.50	[–]

Geometry

No. group	Description	Count	Setback s [in]
1	Block 28 PC	2	1.62
2	Top block 28	1	-

Base

Geometry
Upper setback a_1 = 0.50 ft
Lower setback a_2 = 0.50 ft
Height h = 0.50 ft
Width b = 3.50 ft

Material
Unreinforced Footing
Concrete self-weight γ = 150.00 pcf
Shear cub (key) capacity = 0.00 lbf/ft
Friction angle concrete-concrete = 30.00 °

Types of reinforcements

No.	Name	Type of reinforcement	Line type	Tensile strength T_{ult} [lbf/ft]	R_t [lbf/ft]	R_{con} [lbf/ft]
1	Miragrid 5XT	Miragrid 5XT	- - - - - - -	4700.00	2069.35	2174.26
2	Miragrid 8XT	Miragrid 8XT	- - - - - - - - -	7400.00	3393.87	3423.30
3	Miragrid 10XT	Miragrid 10XT	- - - - - - -	9500.00	4357.00	4287.39
4	Miragrid 20XT	Miragrid 20XT	~~~~~~~~~~~	13705.00	6558.83	6030.20
5	Miragrid 24XT	Miragrid 24XT	~~~~~~~~~~~	27415.00	13716.42	10560.73

Reinforcement details

1. Miragrid 5XT

Short-term char. strength	T_{ult}	=	4700.00	lbf/ft
Creep red. factor	RF_{CR}	=	1.58	
Durability red. factor	RF_D	=	1.15	
Installation damage red. factor	RF_{ID}	=	1.25	
Long-term design strength	R_t	=	2069.35	lbf/ft
Coefficient of direct slip along reinforcement	C_{ds}	=	0.67	
Coefficient of interaction of soil and geo-reinforcement	C_i	=	0.67	
Scale correction factor	α	=	0.8	
Long-term strength reduction factor	CR_{cr}	=	0.532	
Analysis of long-term strength	R_{con}	=	2174.26	lbf/ft

2. Miragrid 8XT

Short-term char. strength	T_{ult}	=	7400.00	lbf/ft
Creep red. factor	RF_{CR}	=	1.58	
Durability red. factor	RF_D	=	1.15	
Installation damage red. factor	RF_{ID}	=	1.20	
Long-term design strength	R_t	=	3393.87	lbf/ft
Coefficient of direct slip along reinforcement	C_{ds}	=	0.67	
Coefficient of interaction of soil and geo-reinforcement	C_i	=	0.67	
Scale correction factor	α	=	0.8	
Long-term strength reduction factor	CR_{cr}	=	0.532	
Analysis of long-term strength	R_{con}	=	3423.30	lbf/ft

3. Miragrid 10XT

Short-term char. strength	T_{ult}	=	9500.00	lbf/ft
Creep red. factor	RF_{CR}	=	1.58	
Durability red. factor	RF_D	=	1.15	
Installation damage red. factor	RF_{ID}	=	1.20	
Long-term design strength	R_t	=	4357.00	lbf/ft
Coefficient of direct slip along reinforcement	C_{ds}	=	0.67	
Coefficient of interaction of soil and geo-reinforcement	C_i	=	0.67	
Scale correction factor	α	=	0.8	
Long-term strength reduction factor	CR_{cr}	=	0.519	
Analysis of long-term strength	R_{con}	=	4287.39	lbf/ft

4. Miragrid 20XT

Short-term char. strength	T_{ult}	=	13705.00	lbf/ft
Creep red. factor	RF_{CR}	=	1.58	
Durability red. factor	RF_D	=	1.15	
Installation damage red. factor	RF_{ID}	=	1.15	
Long-term design strength	R_t	=	6558.83	lbf/ft
Coefficient of direct slip along reinforcement	C_{ds}	=	0.67	
Coefficient of interaction of soil and geo-reinforcement	C_i	=	0.67	
Scale correction factor	α	=	0.8	
Long-term strength reduction factor	CR_{cr}	=	0.506	
Analysis of long-term strength	R_{con}	=	6030.20	lbf/ft

5. Miragrid 24XT

Short-term char. strength	T_{ult}	=	27415.00	lbf/ft
Creep red. factor	RF_{CR}	=	1.58	
Durability red. factor	RF_D	=	1.15	
Installation damage red. factor	RF_{ID}	=	1.10	
Long-term design strength	R_t	=	13716.42	lbf/ft
Coefficient of direct slip along reinforcement	C_{ds}	=	0.67	
Coefficient of interaction of soil and geo-reinforcement	C_i	=	0.67	
Scale correction factor	α	=	0.8	
Long-term strength reduction factor	CR_{cr}	=	0.443	
Analysis of long-term strength	R_{con}	=	10560.73	lbf/ft

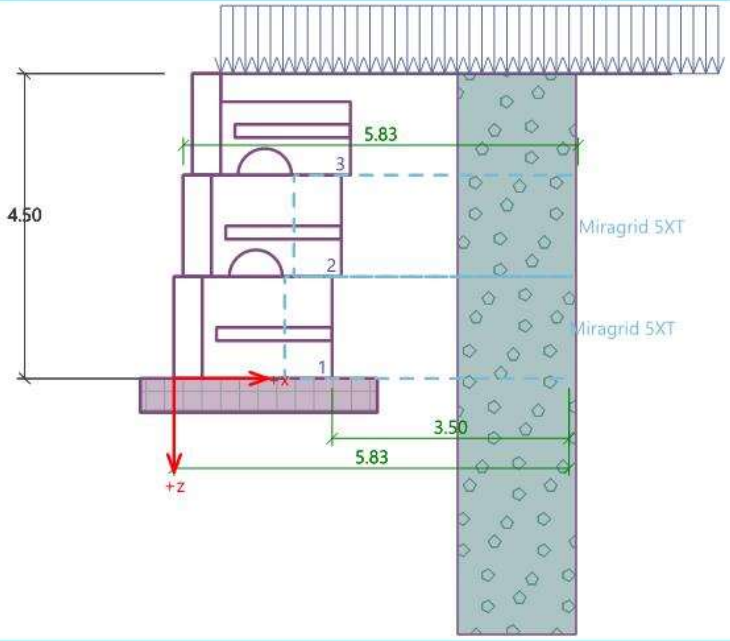
Reinforcements

Input mode : 1 reinforcement type
Reinf. installation : in every row of blocks (50%)
Type of reinforcement : Miragrid 5XT
Top reinforcement : straight (25%)
Reinforcement geometry : identical length of reinforcements
Length of reinforcement l = 3.50 ft

Reinforcements

No.	Consider	Name	Length of reinforcement l [ft]	End pt. coordinate l_k [ft]
1	Yes	Miragrid 5XT	3.50	
2	Yes	Miragrid 5XT	3.50	
3	No			

Name : Reinforcements | **Stage - analysis : 1 - 0**



Soil parameters

Gravel Backfill

Unit weight :	γ =	130.0 pcf
Stress-state :		effective
Angle of internal friction :	φ_{ef} =	35.50 °
Cohesion of soil :	c_{ef} =	0.0 psf
Angle of friction struc.-soil :	δ =	34.00 °
Saturated unit weight :	γ_{sat} =	130.0 pcf

Input surface surcharges

No.	Surcharge new	Surcharge change	Action	Mag.1 [lbf/ft²]	Mag.2 [lbf/ft²]	Ord.x x [ft]	Length l [ft]	Depth z [ft]
1	Yes		variable	200.0				on terrain

No.	Name
1	Roadway Surcharge

Resistance on front face of the structure

Resistance on front face of the structure is not considered.

Settings of the stage of construction

Design situation : transient

Verification No. 1

Forces acting on construction

Name	F_{hor} [lbf/ft]	App.Pt. z [ft]	F_{vert} [lbf/ft]	App.Pt. x [ft]	Design coefficient
Weight - reinforced soil	0.0	-2.32	2138.1	4.08	1.000
Active pressure	288.9	-1.50	126.6	5.97	1.000
Roadway Surcharge	197.5	-2.25	86.6	5.97	1.000
Weight - wall	0.0	-2.08	1164.2	1.27	1.000

Verification of complete wall

Place of verification : bottom of blocks

Check for overturning stability
Resisting moment M_{res} = 11482.2 lbfft/ft
Overturning moment M_{ovr} = 877.7 lbfft/ft

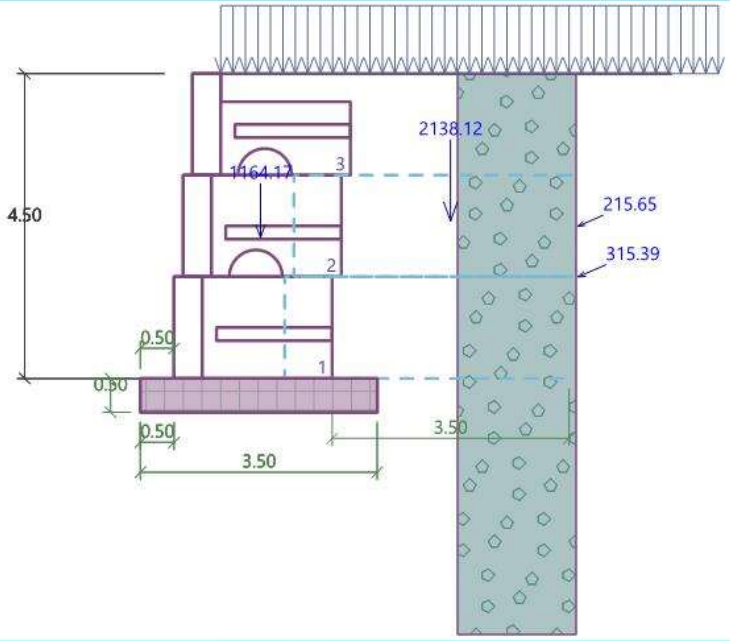
Safety factor = 13.08 > 1.50
Wall for overturning is SATISFACTORY

Check for slip
Resisting horizontal force H_{res} = 2300.67 lbf/ft
Active horizontal force H_{act} = 486.37 lbf/ft

Safety factor = 4.73 > 1.50
Wall for slip is SATISFACTORY

Overall check - WALL is SATISFACTORY

Name : Verification | Stage - analysis : 1 - 1



Bearing capacity of foundation soil

Design load acting at the center of footing bottom

No.	Moment [lbfft/ft]	Norm. force [lbf/ft]	Shear Force [lbf/ft]	Eccentricity [–]	Stress [psf]
1	-2192.2	2203.63	-776.02	0.000	629.6

Service load acting at the center of footing bottom

No.	Moment [lbfft/ft]	Norm. force [lbf/ft]	Shear Force [lbf/ft]
1	-2192.2	2203.63	-776.02

Verification of foundation soil

Place of verification : bottom of leveling pad
Stress in the footing bottom : trapezoid

Eccentricity verification
Max. eccentricity of normal force e = 0.000
Maximum allowable eccentricity e_{alw} = 0.333

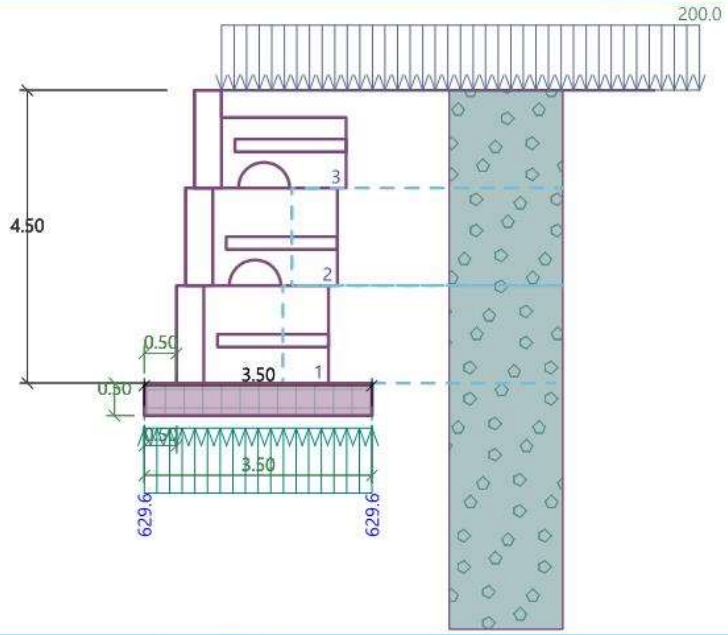
Eccentricity of the normal force is SATISFACTORY

Verification of bearing capacity
Max. stress at footing bottom σ = 629.6 psf
Bearing capacity of foundation soil R_d = 2000.0 psf

Safety factor = 3.18 > 1.33
Bearing capacity of foundation soil is SATISFACTORY

Overall verification - bearing capacity of found. soil is SATISFACTORY

Name : Bearing cap. | **Stage - analysis : 1 - -1**



Verification of slip on georeinforcement No. 1

Forces acting on construction (verification of reinforcement No.: 1)

Name	F_{hor} [lbf/ft]	App.Pt. z [ft]	F_{vert} [lbf/ft]	App.Pt. x [ft]	Design coefficient
Weight - wall	0.0	-2.08	1205.7	-4.06	1.000
Active pressure	288.9	-1.50	126.6	3.50	1.000
Roadway Surcharge	197.5	-2.25	86.6	3.50	1.000
Weight - reinforced soil	0.0	-2.21	2045.7	1.82	1.000
Roadway Surcharge	0.0	-4.50	1029.2	-2.07	1.000

Verification against slip along geotextile No.: 1

Inclination of slip surface	=	90.00	°
Overall normal force acting on reinforcement	=	3288.03	lbf/ft
Coefficient of reduction of slip along geo-textile	=	0.92	
Resistance along geo-reinforcement	=	2151.84	lbf/ft
Wall resistance	=	696.14	lbf/ft
Overall bearing capacity of reinforcements	=	0.00	lbf/ft

Check for slip:

Resisting horizontal force H_{res} = 2847.97 lbf/ft
Active horiz. force H_{act} = 486.37 lbf/ft

Factor of safety = 5.86 > 1.50

Slip along geotextile is SATISFACTORY

Calculation of internal stability No. 1

Calculated forces and strength of reinforcements

No.	Name	F_x [lbf/ft]	Depth z[ft]	R_t [lbf/ft]	Utiliz. [%]	T_p [lbf/ft]	Utiliz. [%]	R_{con} [lbf/ft]	Utiliz. [%]
1	Miragrid 5XT	-111.71	4.50	517.34	32.39	391.41	42.81	543.57	30.83
2	Miragrid 5XT	-170.46	3.00	1034.67	24.71	413.82	61.79	1087.13	23.52

Check for tensile strength (reinforcement No.1)
Tension strength R_t = 517.34 lbf/ft
Force in reinforcement F_x = 111.71 lbf/ft

Safety factor = 4.63 > 1.50
Reinforcement for tensile strength is SATISFACTORY

Check for pull out resistance (reinforcement No.2)
Pull out resistance T_p = 413.82 lbf/ft
Force in reinforcement F_x = 170.46 lbf/ft

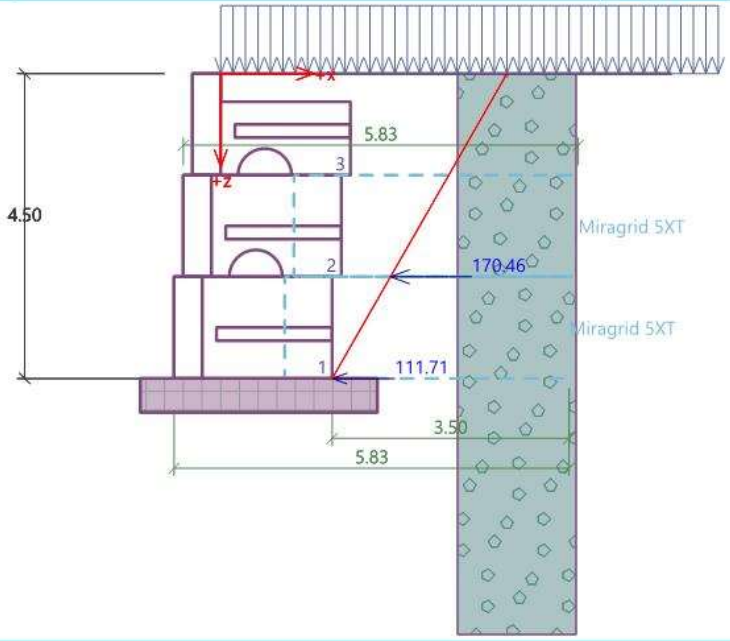
Safety factor = 2.43 > 1.50
Reinforcement for pull out resistance is SATISFACTORY

Verification of connection strength (reinforcement No.1)
Connection strength R_{con} = 543.57 lbf/ft
Force in reinforcement F_x = 111.71 lbf/ft

Safety factor = 4.87 > 1.50
Connection strength is SATISFACTORY

Overall verification - reinforcement is SATISFACTORY

Name : Internal stability | **Stage - analysis : 1 - 1**



3'-0" Tall Wall – Seismic Case

Analysis of Redi Rock wall

Input data

Project

Task : MSE Wall Design
Part : 3.0' MSE Wall - Seismic Case - Unreinforced Soil
Author : NRW
Date : 11/25/2019
Project number : 1801-0336

Settings

(input for current task)

Materials and standards

AASHTO - reduce parameters of friction soil/soil by 2/3 φ

Wall analysis

Active earth pressure calculation :	Coulomb
Passive earth pressure calculation :	Mazindrani (Rankine)
Earthquake analysis :	Mononobe-Okabe
Shape of earth wedge :	Calculate as skew
Allowable eccentricity :	0.333
Internal stability :	Standard - straight slip surface
Reduction coeff. of contact first block - base :	1.00
Verification methodology :	Safety factors (ASD)

Safety factors			
Seismic design situation			
Safety factor for overturning :	SF_o =	1.10	[–]
Safety factor for sliding resistance :	SF_s =	1.10	[–]
Safety factor for bearing capacity :	SF_b =	1.00	[–]
Safety factor for sliding along geo-reinforcement :	SF_{sr} =	1.10	[–]
Safety factor for geo-reinforcement strength :	SF_{st} =	1.10	[–]
Safety factor for pull out resistance of geo-reinf. :	SF_{po} =	1.10	[–]
Safety factor for connection strength :	SF_{con} =	1.10	[–]

Geometry

No. group	Description	Count	Setbacks [in]
1	Block 28	1	1.62
2	Top block 28	1	-

Base

Geometry

Upper setback a_1 = 0.50 ft
Lower setback a_2 = 0.50 ft
Height h = 0.50 ft
Width b = 3.50 ft

Material

Unreinforced Footing
Concrete self-weight γ = 150.00 pcf
Shear cub (key) capacity = 0.00 lbf/ft
Friction angle concrete-concrete = 30.00 °

Basic soil parameters

No.	Name	Pattern	φ_{ef} [°]	c_{ef} [psf]	γ [pcf]	γ_{su} [pcf]	δ [°]
1	Gravel Backfill		35.50	0.0	130.00	67.50	34.00

All soils are considered as cohesionless for at rest pressure analysis.

Soil parameters

Gravel Backfill

Unit weight : γ = 130.0 pcf
Stress-state : effective
Angle of internal friction : φ_{ef} = 35.50 °
Cohesion of soil : c_{ef} = 0.0 psf
Angle of friction struc.-soil : δ = 34.00 °
Saturated unit weight : γ_{sat} = 130.0 pcf

Backfill

Backfill is not considered.

Input surface surcharges

No.	Surcharge new	Surcharge change	Action	Mag.1 [lbf/ft^2]	Mag.2 [lbf/ft^2]	Ord.x x [ft]	Length l [ft]	Depth z [ft]
1	Yes		variable	200.0				on terrain

No.	Name
1	Roadway Surcharge

Resistance on front face of the structure

Resistance on front face of the structure is not considered.

Earthquake

Factor of horizontal acceleration K_h = 0.1620
Factor of vertical acceleration K_v = 0.0000

Water below the GWT is free.
Specific gravity of soil particles G_s = 2.08.

Settings of the stage of construction

Design situation : seismic

Verification No. 1

Forces acting on construction

Name	F_{hor} [lbf/ft]	App.Pt. z [ft]	F_{vert} [lbf/ft]	App.Pt. x [ft]	Design coefficient
Weight - wall	0.0	-1.48	1010.6	1.73	1.000
Earthq.- constr.	164.4	-1.49	0.0	1.72	1.000
Weight - earth wedge	0.0	-0.87	47.7	3.09	1.000
Earthquake - soil wedge	7.7	-0.87	0.0	3.09	1.000

Name	F_{hor} [lbf/ft]	App.Pt. z [ft]	F_{vert} [lbf/ft]	App.Pt. x [ft]	Design coefficient
Weight - earth wedge	0.0	-3.29	98.0	1.96	1.000
Earthquake - soil wedge	15.9	-3.29	0.0	1.96	1.000
Active pressure	204.8	-1.14	202.3	3.23	1.000
Earthq.- act.pressure	81.5	-2.33	73.7	2.99	1.000
Roadway Surcharge	178.1	-1.73	173.8	3.12	1.000

Verification of complete wall

Check for overturning stability

Resisting moment M_{res} = 3505.9 lbfft/ft
Overturning moment M_{ovr} = 1035.5 lbfft/ft

Safety factor = 3.39 > 1.10
Wall for overturning is SATISFACTORY

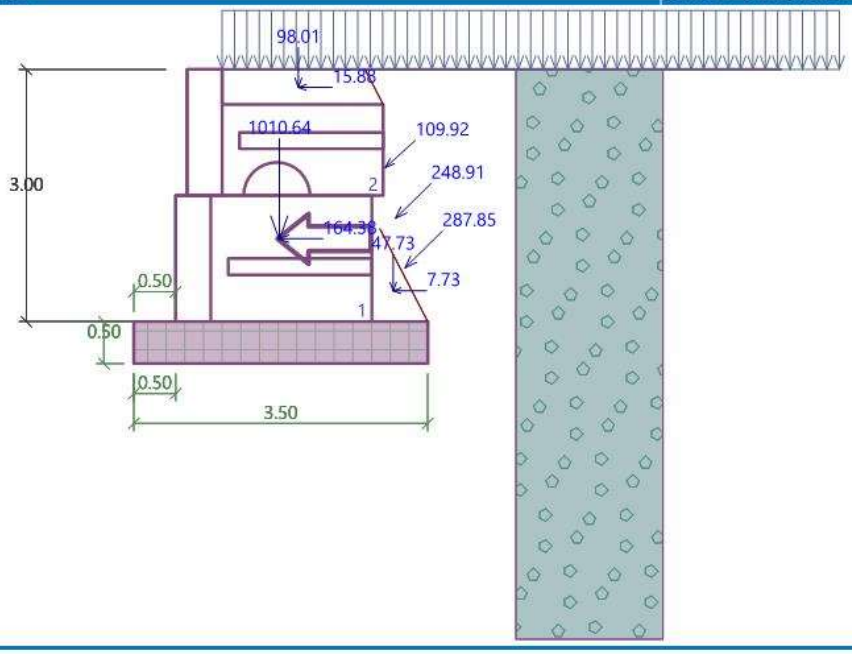
Check for slip

Resisting horizontal force H_{res} = 1145.72 lbf/ft
Active horizontal force H_{act} = 652.43 lbf/ft

Safety factor = 1.76 > 1.10
Wall for slip is SATISFACTORY

Overall check - WALL is SATISFACTORY

Name : Verification | Stage - analysis : 1 - 1



Dimensioning No. 1

Forces acting on construction

Name	F_{hor} [lbf/ft]	App.Pt. z [ft]	F_{vert} [lbf/ft]	App.Pt. x [ft]	Design coefficient
Weight - wall	0.0	-1.41	748.1	1.23	1.000
Earthq.- constr.	128.7	-1.33	0.0	1.22	1.000
Weight - earth wedge	0.0	-2.79	98.0	1.46	1.000
Earthquake - soil wedge	15.9	-2.79	0.0	1.46	1.000
Active pressure	110.5	-1.05	66.7	2.41	1.000
Earthq.- act.pressure	58.8	-2.03	47.0	2.41	1.000
Roadway Surcharge	125.5	-1.65	93.2	2.41	1.000

Verification of block No. 1

Check for overturning stability
Resisting moment M_{res} = 1559.2 lbfft/ft
Overturning moment M_{ovr} = 656.9 lbfft/ft

Safety factor = 2.37 > 1.10
Joint for overturning stability is SATISFACTORY

Check for slip
Resisting horizontal force H_{res} = 608.01 lbf/ft
Active horizontal force H_{act} = 439.32 lbf/ft

Safety factor = 1.38 > 1.10
Joint for verification is SATISFACTORY

Bearing capacity of foundation soil

Design load acting at the center of footing bottom

No.	Moment [lbfft/ft]	Norm. force [lbf/ft]	Shear Force [lbf/ft]	Eccentricity [–]	Stress [psf]
1	340.5	1606.24	652.43	0.061	522.2

Service load acting at the center of footing bottom

No.	Moment [lbfft/ft]	Norm. force [lbf/ft]	Shear Force [lbf/ft]
1	340.5	1606.24	652.43

Verification of foundation soil

Stress in the footing bottom : trapezoid

Eccentricity verification
Max. eccentricity of normal force e = 0.061
Maximum allowable eccentricity e_{alw} = 0.333

Eccentricity of the normal force is SATISFACTORY

Verification of bearing capacity
Max. stress at footing bottom σ = 625.7 psf

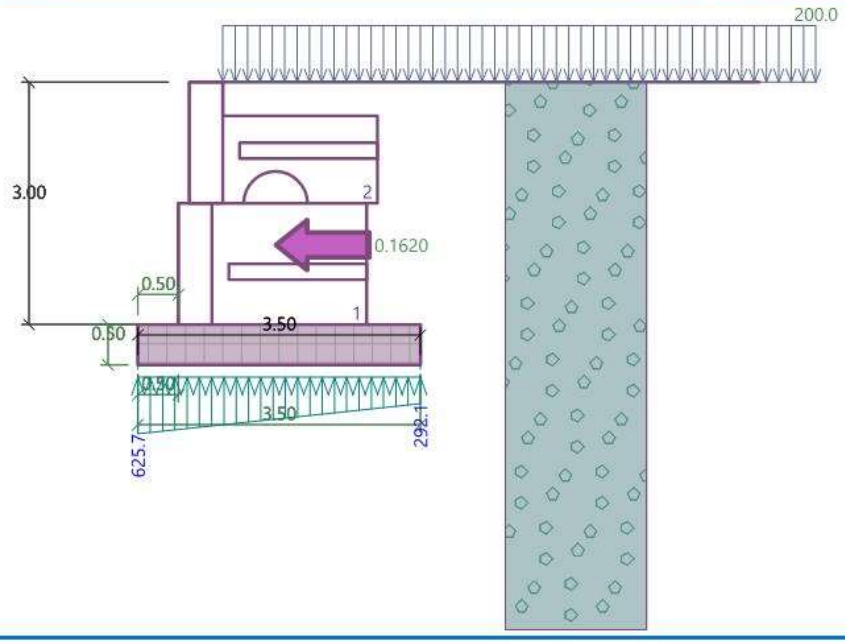
Bearing capacity of foundation soil R_d = 2000.0 psf

Safety factor = 3.20 > 1.00

Bearing capacity of foundation soil is SATISFACTORY

Overall verification - bearing capacity of found. soil is SATISFACTORY

Name : Bearing cap.	Stage - analysis : 1 - -1



3'-0" Tall Wall – Transient Case

Analysis of Redi Rock wall

Input data

Project

Task : MSE Wall Design
Part : 3.0' MSE Wall - Transient Case - Unreinforced Soil
Author : NRW
Date : 11/25/2019
Project number : 1801-0336

Settings

(input for current task)

Materials and standards

AASHTO - reduce parameters of friction soil/soil by 2/3 φ

Wall analysis

Active earth pressure calculation : Coulomb
Passive earth pressure calculation : Mazindrani (Rankine)
Earthquake analysis : Mononobe-Okabe
Shape of earth wedge : Calculate as skew
Allowable eccentricity : 0.333
Internal stability : Standard - straight slip surface
Reduction coeff. of contact first block - base : 1.00
Verification methodology : Safety factors (ASD)

Safety factors			
Transient design situation			
Safety factor for overturning :	SF_o =	1.50	[–]
Safety factor for sliding resistance :	SF_s =	1.50	[–]
Safety factor for bearing capacity :	SF_b =	1.33	[–]
Safety factor for sliding along geo-reinforcement :	SF_{sr} =	1.50	[–]
Safety factor for geo-reinforcement strength :	SF_{st} =	1.50	[–]
Safety factor for pull out resistance of geo-reinf. :	SF_{po} =	1.50	[–]
Safety factor for connection strength :	SF_{con} =	1.50	[–]

Geometry

No. group	Description	Count	Setback s [in]
1	Block 28	1	1.62
2	Top block 28	1	-

Base

Geometry

Upper setback a_1 = 0.50 ft
Lower setback a_2 = 0.50 ft
Height h = 0.50 ft
Width b = 3.50 ft

Material

Unreinforced Footing
Concrete self-weight γ = 150.00 pcf
Shear cub (key) capacity = 0.00 lbf/ft
Friction angle concrete-concrete = 30.00 °

Basic soil parameters

No.	Name	Pattern	φ_{ef} [°]	c_{ef} [psf]	γ [pcf]	γ_{su} [pcf]	δ [°]
1	Gravel Backfill		35.50	0.0	130.00	67.50	34.00

All soils are considered as cohesionless for at rest pressure analysis.

Soil parameters

Gravel Backfill

Unit weight : γ = 130.0 pcf
Stress-state : effective
Angle of internal friction : φ_{ef} = 35.50 °
Cohesion of soil : c_{ef} = 0.0 psf
Angle of friction struc.-soil : δ = 34.00 °
Saturated unit weight : γ_{sat} = 130.0 pcf

Backfill

Backfill is not considered.

Input surface surcharges

No.	Surcharge new	Surcharge change	Action	Mag.1 [lbf/ft^2]	Mag.2 [lbf/ft^2]	Ord.x x [ft]	Length l [ft]	Depth z [ft]
1	Yes		variable	200.0				on terrain

No.	Name
1	Roadway Surcharge

Resistance on front face of the structure

Resistance on front face of the structure is not considered.

Settings of the stage of construction

Design situation : transient

Verification No. 1

Forces acting on construction

Name	F_{hor} [lbf/ft]	App.Pt. z [ft]	F_{vert} [lbf/ft]	App.Pt. x [ft]	Design coefficient
Weight - wall	0.0	-1.48	1010.6	1.73	1.000
Weight - earth wedge	0.0	-0.87	47.7	3.09	1.000
Weight - earth wedge	0.0	-3.29	98.0	1.96	1.000
Active pressure	204.8	-1.14	202.3	3.23	1.000
Roadway Surcharge	178.1	-1.73	173.8	3.12	1.000

Verification of complete wall

Check for overturning stability

Resisting moment M_{res} = 3285.1 lbfft/ft
Overturning moment M_{ovr} = 542.2 lbfft/ft

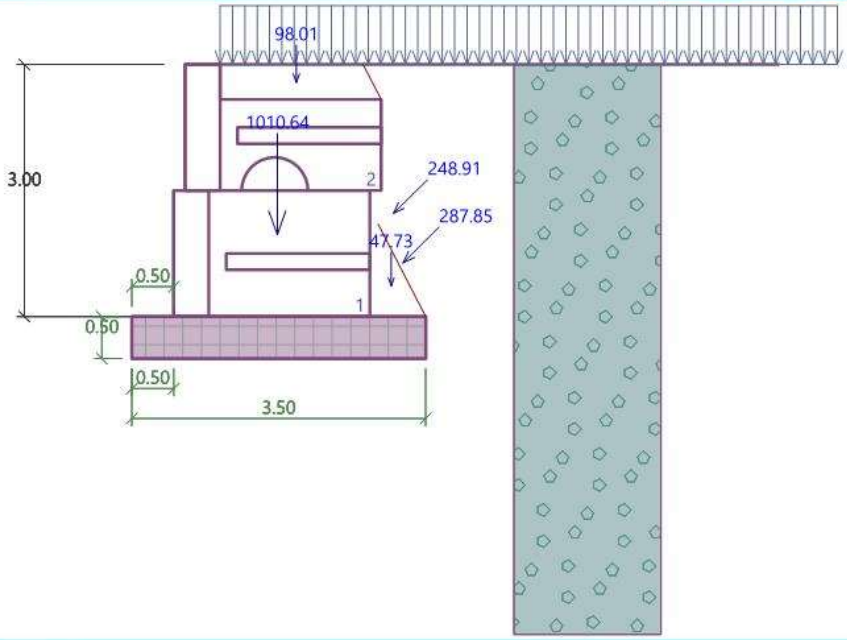
Safety factor = 6.06 > 1.50
Wall for overturning is SATISFACTORY

Check for slip
Resisting horizontal force H_{res} = 1093.12 lbf/ft
Active horizontal force H_{act} = 382.93 lbf/ft

Safety factor = 2.85 > 1.50
Wall for slip is SATISFACTORY

Overall check - WALL is SATISFACTORY

Name : Verification | **Stage - analysis : 1 - 1**



Dimensioning No. 1

Forces acting on construction

Name	F_{hor} [lbf/ft]	App.Pt. z [ft]	F_{vert} [lbf/ft]	App.Pt. x [ft]	Design coefficient
Weight - wall	0.0	-1.41	748.1	1.23	1.000
Weight - earth wedge	0.0	-2.79	98.0	1.46	1.000
Active pressure	110.5	-1.05	66.7	2.41	1.000
Roadway Surcharge	125.5	-1.65	93.2	2.41	1.000

Verification of block No. 1

Check for overturning stability
Resisting moment M_{res} = 1445.7 lbfft/ft

Overturning moment M_{ovr} = 322.6 lbfft/ft

Safety factor = 4.48 > 1.50
Joint for overturning stability is SATISFACTORY

Check for slip
Resisting horizontal force H_{res} = 580.85 lbf/ft
Active horizontal force H_{act} = 236.02 lbf/ft

Safety factor = 2.46 > 1.50
Joint for verification is SATISFACTORY

Bearing capacity of foundation soil

Design load acting at the center of footing bottom

No.	Moment [lbfft/ft]	Norm. force [lbf/ft]	Shear Force [lbf/ft]	Eccentricity [–]	Stress [psf]
1	-61.0	1532.50	382.93	0.000	437.9

Service load acting at the center of footing bottom

No.	Moment [lbfft/ft]	Norm. force [lbf/ft]	Shear Force [lbf/ft]
1	-61.0	1532.50	382.93

Verification of foundation soil

Stress in the footing bottom : trapezoid

Eccentricity verification
Max. eccentricity of normal force e = 0.000
Maximum allowable eccentricity e_{alw} = 0.333

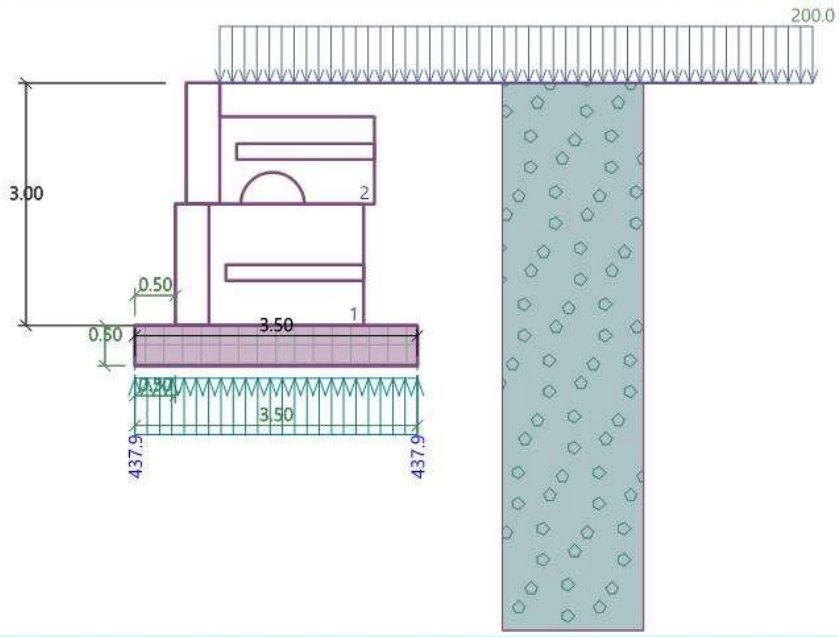
Eccentricity of the normal force is SATISFACTORY

Verification of bearing capacity
Max. stress at footing bottom σ = 437.9 psf
Bearing capacity of foundation soil R_d = 2000.0 psf

Safety factor = 4.57 > 1.33
Bearing capacity of foundation soil is SATISFACTORY

Overall verification - bearing capacity of found. soil is SATISFACTORY

Name : Bearing cap. | **Stage - analysis : 1 - -1**



Appendix B – CIP Cantilever Wall Design

6'-0" Tall Wall

Peterson Structural Engineers, Inc.
708 Broadway, Suite 110
Tacoma, Washington 98402
Phone: 253-830-2140
www.psengineers.com

Project Name/Number : 1801-0336-02
Title **Garden Curves**
Dsgnr: **NRW**
Description....
Wall 5 - CIP Cantilever Wall (6'-0" Segment)

Date: 12 JUL 2019

This Wall in File: X:\2018\01-PDX\1801-0326 to 1801-0350\1801-0336\Working Files by Program\Enercalc

Cantilevered Retaining Wall

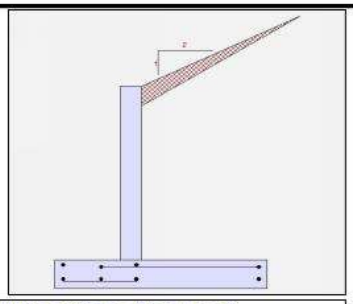
Code: IBC 2015,ACI 318-14,ACI 530-13

Criteria

Retained Height	=	6.00 ft
Wall height above soil	=	0.00 ft
Slope Behind Wall	=	2.00
Height of Soil over Toe	=	0.00 in
Water height over heel	=	0.0 ft

Soil Data

Allow Soil Bearing	=	2,000.0 psf
Equivalent Fluid Pressure Method		
Active Heel Pressure	=	35.0 psf/ft
	=	
Passive Pressure	=	0.0 psf/ft
Soil Density, Heel	=	130.00 pcf
Soil Density, Toe	=	110.00 pcf
Footing||Soil Friction	=	0.400
Soil height to ignore for passive pressure	=	0.00 in



Surcharge Loads

Surcharge Over Heel	=	0.0 psf
Used To Resist Sliding & Overturning		
Surcharge Over Toe	=	0.0
Used for Sliding & Overturning		

Lateral Load Applied to Stem

Lateral Load	=	0.0 #/ft
...Height to Top	=	8.00 ft
...Height to Bottom	=	0.00 ft
Load Type	=	Earth (H) (Service Level)
Wind on Exposed Stem (Strength Level)	=	0.0 psf

Adjacent Footing Load

Adjacent Footing Load	=	0.0 lbs
Footing Width	=	0.00 ft
Eccentricity	=	0.00 in
Wall to Ftg CL Dist	=	0.00 ft
Footing Type		Line Load
Base Above/Below Soil at Back of Wall	=	0.0 ft
Poisson's Ratio	=	0.300

Axial Load Applied to Stem

Axial Dead Load	=	0.0 lbs
Axial Live Load	=	0.0 lbs
Axial Load Eccentricity	=	0.0 in

Earth Pressure Seismic Load

Method : Triangular
Load at bottom of Triangular Distribution . . . . . = 48.000 psf (Strength)

Total Strength-Level Seismic Load. . . . . = 168.000 lbs
Total Service-Level Seismic Load. . . . . = 117.600 lbs

Design Summary

Wall Stability Ratios

Overturning	=	4.71	OK
Sliding	=	1.56	OK
Total Bearing Load	=	5,893 lbs	
...resultant ecc.	=	0.00 in	
Soil Pressure @ Toe	=	907 psf	OK
Soil Pressure @ Heel	=	907 psf	OK
Allowable	=	2,000 psf	
Soil Pressure Less Than Allowable			
ACI Factored @ Toe	=	1,086 psf	
ACI Factored @ Heel	=	1,086 psf	
Footing Shear @ Toe	=	9.8 psi	OK
Footing Shear @ Heel	=	5.7 psi	OK
Allowable	=	94.9 psi	

Sliding Calcs

Lateral Sliding Force	=	1,509.0 lbs	
less 100% Passive Force	= -	0.0 lbs	
less 100% Friction Force	= -	2,357.3 lbs	
Added Force Req'd	=	0.0 lbs	OK
....for 1.5 Stability	=	0.0 lbs	OK

Vertical component of active lateral soil pressure IS considered in the calculation of soil bearing pressures.

Load Factors

Building Code	IBC 2015,ACI
Dead Load	1.200
Live Load	1.600
Earth, H	1.600
Wind, W	1.000
Seismic, E	1.000

Stem Construction

Bottom

			Stem OK
Design Height Above Ftg	ft =		0.00
Wall Material Above "Ht"	=		Concrete
Design Method	=		LRFD
Thickness	=		8.00
Rebar Size	=		# 5
Rebar Spacing	=		12.00
Rebar Placed at	=		6 in
Design Data			
fb/FB + fa/Fa	=		**0.280**
Total Force @ Section			
Service Level	lbs =		
Strength Level	lbs =		1,131.4
Moment....Actual			
Service Level	ft-# =		
Strength Level	ft-# =		2,262.9
Moment.....Allowable	=		8,051.1
Shear.....Actual			
Service Level	psi =		
Strength Level	psi =		15.7
Shear.....Allowable	psi =		94.9
Anet (Masonry)	in2 =		
Rebar Depth 'd'	in =		6.00
Masonry Data			
f'm	psi =		
Fs	psi =		
Solid Grouting	=		
Modular Ratio 'n'	=		
Wall Weight	psf =		100.0
Short Term Factor	=		
Equiv. Solid Thick.	=		
Masonry Block Type	=		Medium Weight
Masonry Design Method	=		ASD
Concrete Data			
f'c	psi =		4,000.0
Fy	psi =		60,000.0

Concrete Stem Rebar Area Details

Bottom Stem	Vertical Reinforcing	Horizontal Reinforcing
As (based on applied moment) :	0.0885 in2/ft	
(4/3) * As :	0.118 in2/ft	Min Stem T&S Reinf Area 1.152 in2
200bd/fy : 200(12)(6)/60000 :	0.24 in2/ft	Min Stem T&S Reinf Area per ft of stem Height : 0.192 in2/ft
0.0018bh : 0.0018(12)(8) :	0.1728 in2/ft	Horizontal Reinforcing Options :
	==========	One layer of : Two layers of :
Required Area :	0.1728 in2/ft	#4@ 12.50 in #4@ 25.00 in
Provided Area :	0.31 in2/ft	#5@ 19.38 in #5@ 38.75 in
Maximum Area :	1.3005 in2/ft	#6@ 27.50 in #6@ 55.00 in

Footing Data

Toe Width	=	2.00 ft
Heel Width	=	4.50
Total Footing Width	=	6.50
Footing Thickness	=	12.00 in
Key Width	=	12.00 in
Key Depth	=	0.00 in
Key Distance from Toe	=	2.00 ft

f'c = 4,000 psi Fy = 60,000 psi
Footing Concrete Density = 150.00 pcf
Min. As % = 0.0018
Cover @ Top 3.00 @ Btm.= 3.00 in

Footing Design Results

		Toe	Heel	
Factored Pressure	=	1,086	1,086	psf
Mu' : Upward	=	2,172	7,980	ft-#
Mu' : Downward	=	360	9,664	ft-#
Mu: Design	=	1,812	1,684	ft-#
Actual 1-Way Shear	=	9.75	5.73	psi
Allow 1-Way Shear	=	50.60	50.60	psi

Toe Reinforcing = # 5 @ 12.00 in
Heel Reinforcing = # 5 @ 12.00 in
Key Reinforcing = # 5 @ 12.00 in
Footing Torsion, Tu = 0.00 ft-lbs
Footing Allow. Torsion, phi Tu = 0.00 ft-lbs

If torsion exceeds allowable, provide supplemental design for footing torsion.

Other Acceptable Sizes & Spacings

Toe: #4@ 9.25 in, #5@ 14.34 in, #6@ 20.36 in, #7@ 27.77 in, #8@ 36.56 in, #9@ 46
Heel: Not req'd: Mu < phi*5*lambda*sqrt(f'c)*Sm
Key: Not req'd: Mu < phi*5*lambda*sqrt(f'c)*Sm

Min footing T&S reinf Area 1.68 in2
Min footing T&S reinf Area per foot 0.26 in2 /ft

If one layer of horizontal bars:	If two layers of horizontal bars:
#4@ 9.26 in	#4@ 18.52 in
#5@ 14.35 in	#5@ 28.70 in
#6@ 20.37 in	#6@ 40.74 in

Summary of Overturning & Resisting Forces & Moments

Item		.....OVERTURNING..... Force lbs	Distance ft	Moment ft-#		.....RESISTING..... Force lbs	Distance ft	Moment ft-#
HL Act Pres (ab water tbl)		423.0	1.33	4,135.5	Soil Over HL (ab. water tbl)	715.0	3.58	13,704.2
HL Act Pres (be water tbl)					Soil Over HL (bel. water tbl)		3.58	13,704.2
Hydrostatic Force					Watre Table			
Buoyant Force	=				Sloped Soil Over Hee =	477.6	5.22	2,494.0
Surcharge over Heel	=				Surcharge Over Heel =			
Surcharge Over Toe	=				Adjacent Footing Load =			
Adjacent Footing Load	=				Axial Dead Load on Stem =			
Added Lateral Load	=				* Axial Live Load on Stem =			
Load @ Stem Above Soil	=				Soil Over Toe =			
Seismic Earth Load	=	117.6	2.33	274.4	Surcharge Over Toe =			
	=				Stem Weight(s) =	600.0	2.33	1,400.0
					Earth @ Stem Transitions =			
					Footing Weigh! =	975.0	3.25	3,168.8
					Key Weight =		2.50	
					Vert. Component =			
Total	=	1,509.0	**O.T.M.** =	4,409.9	**Total =**	5,042.6 lbs	**R.M.=**	20,766.9

Resisting/Overturning Ratio = **4.71**
Vertical Loads used for Soil Pressure = 5,893.2 lbs

* Axial live load NOT included in total displayed, or used for overturning resistance, but is included for soil pressure calculation.

If seismic is included, the OTM and sliding ratios be 1.1 per section 1807.2.3 of IBC 2009 or IBC 201

Vertical component of active lateral soil pressure IS considered in the calculation of Sliding Resistance.

Vertical component of active lateral soil pressure IS NOT considered in the calculation of Overturning Resistance.

Tilt

Horizontal Deflection at Top of Wall due to settlement of soil

(Deflection due to wall bending not considered)

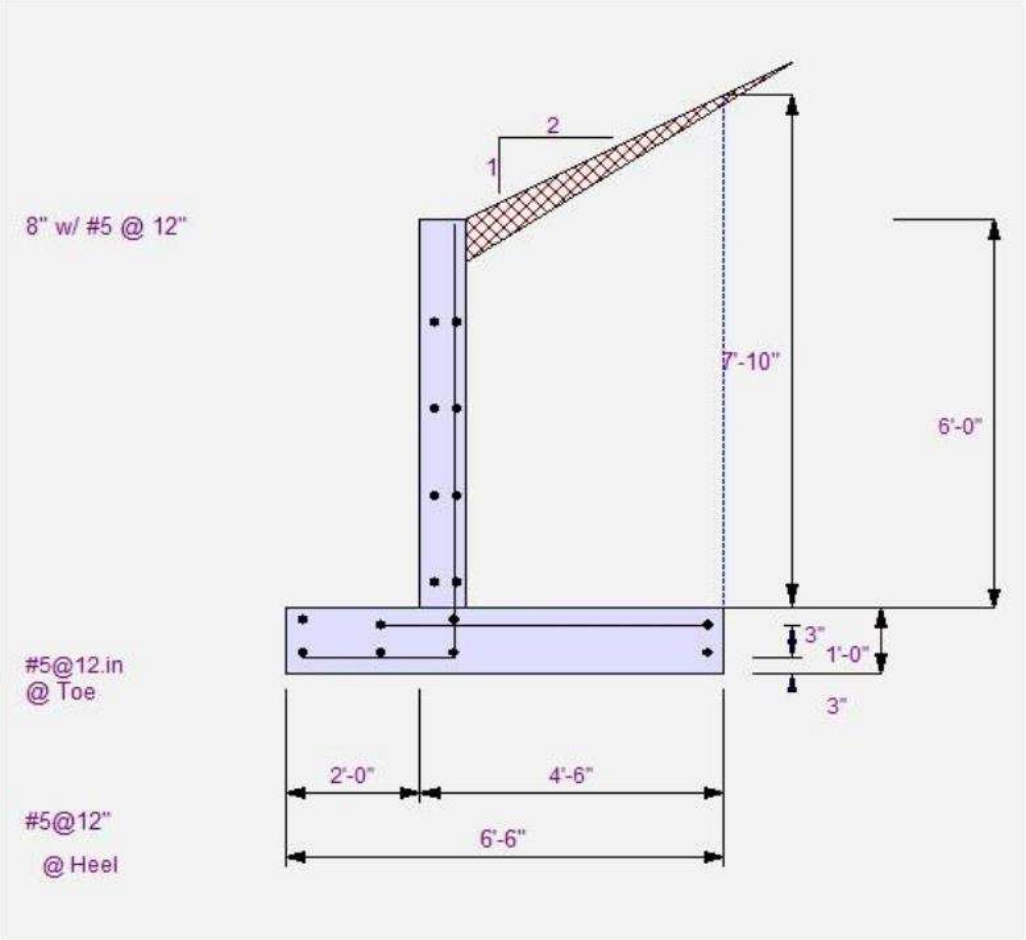
Soil Spring Reaction Modulus	250.0	pci
Horizontal Defl @ Top of Wall (approximate only)	0.000	in

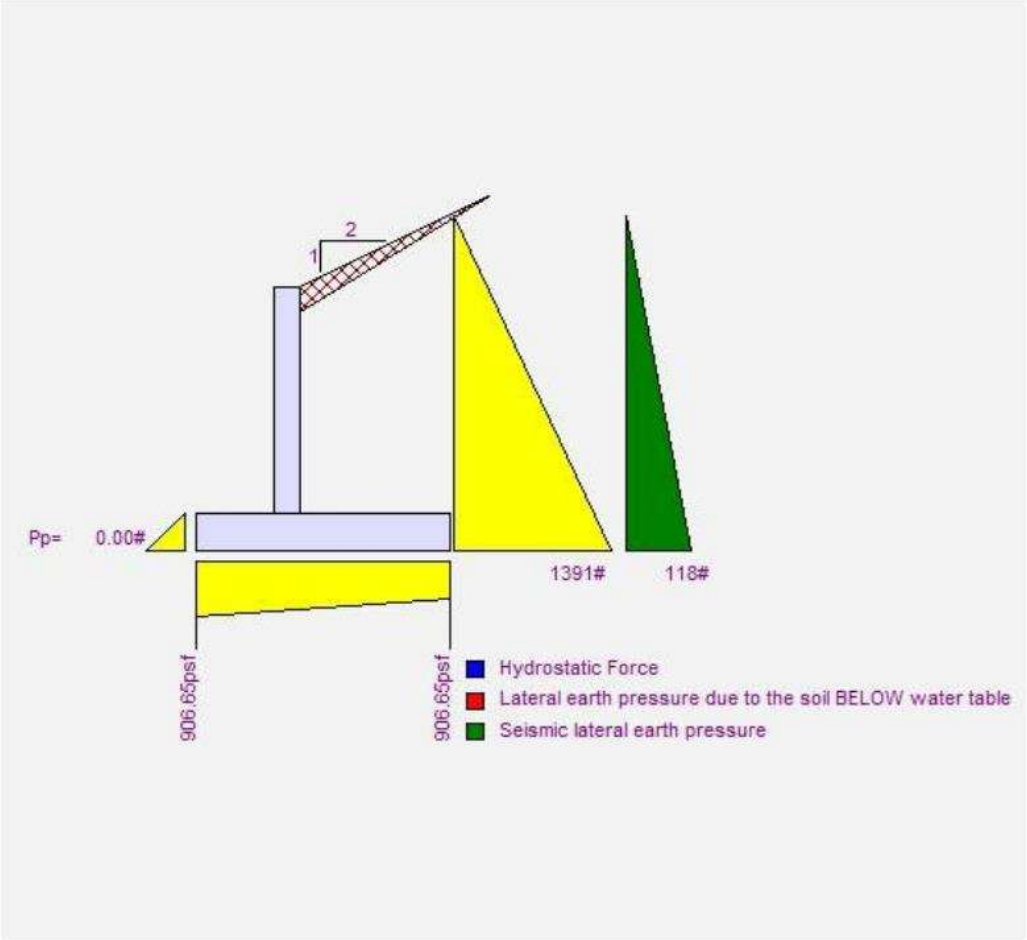
The above calculation is not valid if the heel soil bearing pressure exceeds that of the toe, because the wall would then tend to rotate into the retained soil.

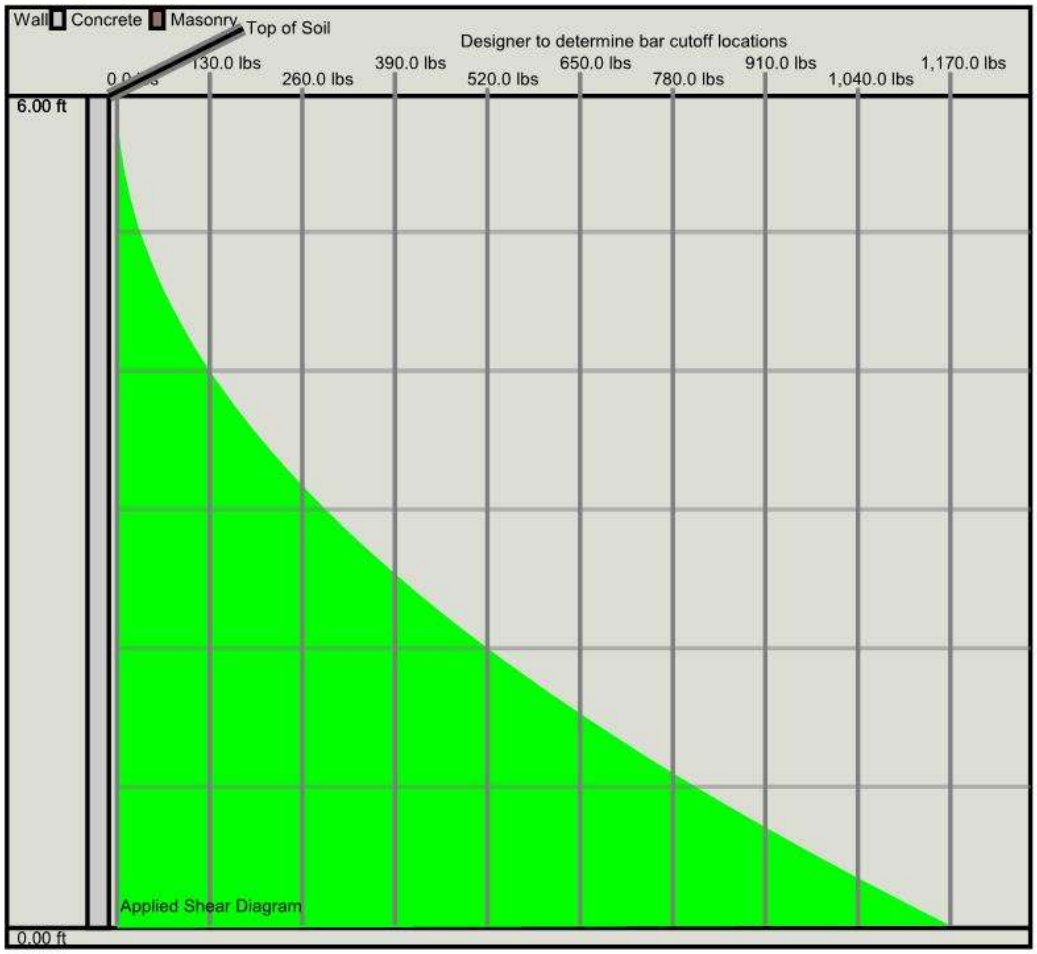
Rebar Lap & Embedment Lengths Information

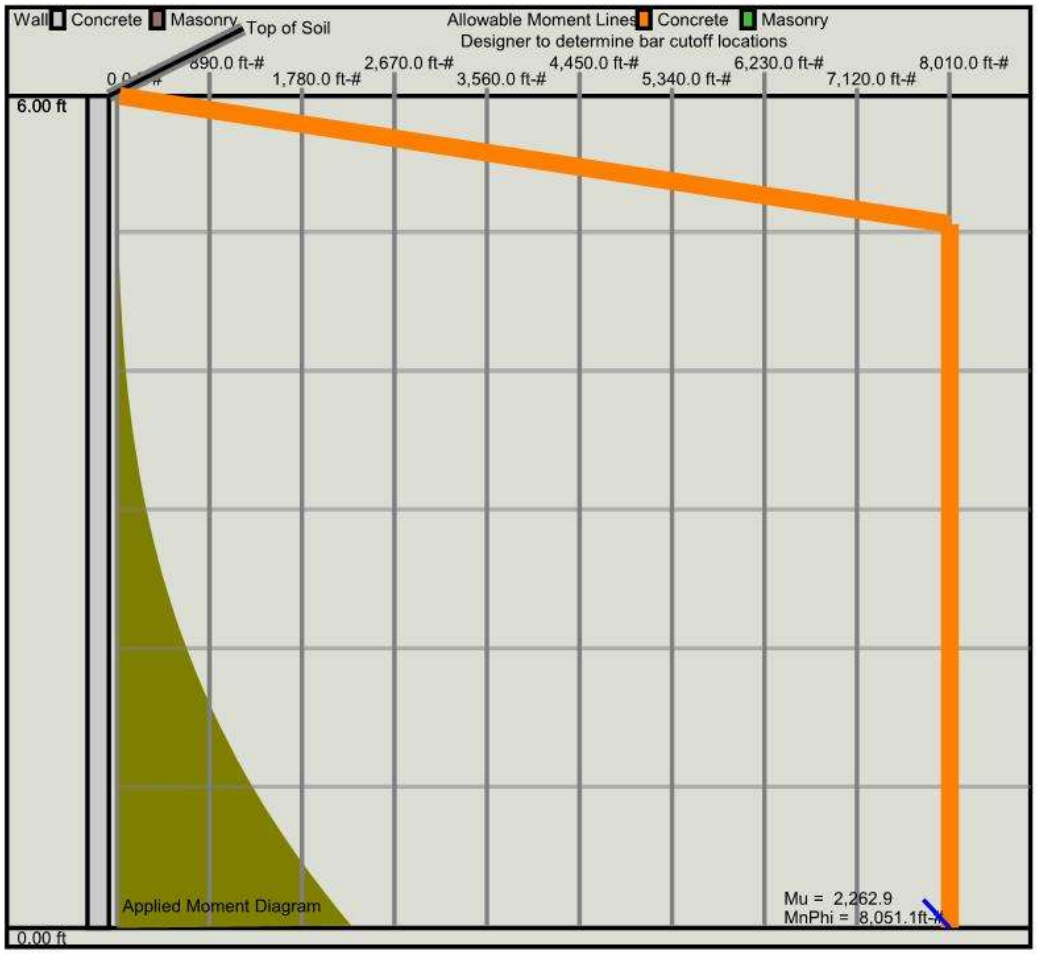
Stem Design Segment: Bottom
Stem Design Height: 0.00 ft above top of footing

Lap Splice length for #5 bar specified in this stem design segment =	18.50 in
Development length for #5 bar specified in this stem design segment =	14.23 in
Hooked embedment length into footing for #5 bar specified in this stem design segment =	6.00 in
As Provided =	0.3100 in2/ft
As Required =	0.1728 in2/ft


2
1
8" w/ #5 @ 12"
7'-10"
6'-0"
3"
1'-0"
3"
#5@12.in
@ Toe
2'-0"
4'-6"
#5@12"
@ Heel
6'-6"


2
1
Pp=
0.00#
1391#
118#
906.65psf
906.65psf
Hydrostatic Force
Lateral earth pressure due to the soil BELOW water table
Seismic lateral earth pressure


Wall
Concrete
Masonry
Top of Soil
Designer to determine bar cutoff locations
130.0 lbs
260.0 lbs
390.0 lbs
520.0 lbs
650.0 lbs
780.0 lbs
910.0 lbs
1,040.0 lbs
1,170.0 lbs
6.00 ft
Applied Shear Diagram
0.00 ft


Wall Concrete Masonry
Top of Soil
Allowable Moment Lines Concrete Masonry
Designer to determine bar cutoff locations
890.0 ft-#
1,780.0 ft-#
2,670.0 ft-#
3,560.0 ft-#
4,450.0 ft-#
5,340.0 ft-#
6,230.0 ft-#
7,120.0 ft-#
8,010.0 ft-#
6.00 ft
Applied Moment Diagram
Mu = 2,262.9
MnPhi = 8,051.1ft-#
0.00 ft

4’-6” Tall Wall

Peterson Structural Engineers, Inc.
708 Broadway, Suite 110
Tacoma, Washington 98402
Phone: 253-830-2140
www.psengineers.com

Project Name/Number : 1801-0336-02
Title **Garden Curves**
Dsgnr: **NRW**
Description....
Wall 5 - CIP Cantilever Wall (4'-6" segment)

This Wall in File: X:\2018\01-PDX\1801-0326 to 1801-0350\1801-0336\Working Files by Program\Enercalc

Cantilevered Retaining Wall

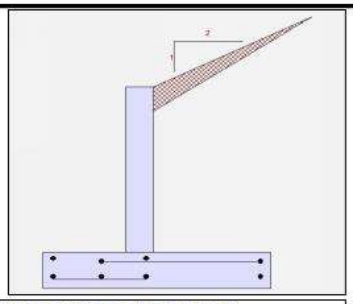
Code: IBC 2015,ACI 318-14,ACI 530-13

Criteria

Retained Height	=	4.50 ft
Wall height above soil	=	0.00 ft
Slope Behind Wall	=	2.00
Height of Soil over Toe	=	0.00 in
Water height over heel	=	0.0 ft

Soil Data

Allow Soil Bearing	=	2,000.0 psf
Equivalent Fluid Pressure Method		
Active Heel Pressure	=	35.0 psf/ft
	=	
Passive Pressure	=	0.0 psf/ft
Soil Density, Heel	=	130.00 pcf
Soil Density, Toe	=	110.00 pcf
Footing||Soil Friction	=	0.400
Soil height to ignore for passive pressure	=	0.00 in



Surcharge Loads

Surcharge Over Heel	=	0.0 psf
Used To Resist Sliding & Overturning		
Surcharge Over Toe	=	0.0
Used for Sliding & Overturning		

Lateral Load Applied to Stem

Lateral Load	=	0.0 #/ft
...Height to Top	=	8.00 ft
...Height to Bottom	=	0.00 ft
Load Type	=	Earth (H) (Service Level)
Wind on Exposed Stem (Strength Level)	=	0.0 psf

Adjacent Footing Load

Adjacent Footing Load	=	0.0 lbs
Footing Width	=	0.00 ft
Eccentricity	=	0.00 in
Wall to Ftg CL Dist	=	0.00 ft
Footing Type		Line Load
Base Above/Below Soil at Back of Wall	=	0.0 ft
Poisson's Ratio	=	0.300

Axial Load Applied to Stem

Axial Dead Load	=	0.0 lbs
Axial Live Load	=	0.0 lbs
Axial Load Eccentricity	=	0.0 in

Earth Pressure Seismic Load

Method : Triangular
Load at bottom of Triangular Distribution . . . . . = 48.000 psf (Strength)

Total Strength-Level Seismic Load. . . . . = 132.000 lbs
Total Service-Level Seismic Load. . . . = 92.400 lbs

Design Summary

Wall Stability Ratios

Overturning	=	5.37	OK
Sliding	=	1.59	OK
Total Bearing Load	=	3,705 lbs	
...resultant ecc.	=	0.00 in	
Soil Pressure @ Toe	=	674 psf	OK
Soil Pressure @ Heel	=	674 psf	OK
Allowable	=	2,000 psf	
Soil Pressure Less Than Allowable			
ACI Factored @ Toe	=	813 psf	
ACI Factored @ Heel	=	813 psf	
Footing Shear @ Toe	=	6.8 psi	OK
Footing Shear @ Heel	=	4.2 psi	OK
Allowable	=	75.0 psi	

Sliding Calcs

Lateral Sliding Force	=	929.6 lbs	
less 100% Passive Force	= -	0.0 lbs	
less 100% Friction Force	= -	1,482.1 lbs	
Added Force Req'd	=	0.0 lbs	OK
....for 1.5 Stability	=	0.0 lbs	OK

Vertical component of active lateral soil pressure IS considered in the calculation of soil bearing pressures.

Load Factors

Building Code	IBC 2015,ACI
Dead Load	1.200
Live Load	1.600
Earth, H	1.600
Wind, W	1.000
Seismic, E	1.000

Stem Construction

		Bottom
		Stem OK
Design Height Above Ftg	ft =	0.00
Wall Material Above "Ht"	=	Concrete
Design Method	=	LRFD
Thickness	=	8.00
Rebar Size	=	# 5
Rebar Spacing	=	12.00
Rebar Placed at	=	6 in
Design Data		
fb/FB + fa/Fa	=	**0.124**
Total Force @ Section		
Service Level	lbs =	
Strength Level	lbs =	655.4
Moment....Actual		
Service Level	ft-# =	
Strength Level	ft-# =	983.0
Moment.....Allowable	=	7,859.7
Shear.....Actual		
Service Level	psi =	
Strength Level	psi =	9.1
Shear.....Allowable	psi =	75.0
Anet (Masonry)	in2 =	
Rebar Depth 'd'	in =	6.00
Masonry Data		
f'm	psi =	
Fs	psi =	
Solid Grouting	=	
Modular Ratio 'n'	=	
Wall Weight	psf =	100.0
Short Term Factor	=	
Equiv. Solid Thick.	=	
Masonry Block Type	=	Medium Weight
Masonry Design Method	=	ASD
Concrete Data		
f'c	psi =	2,500.0
Fy	psi =	60,000.0

Concrete Stem Rebar Area Details

Bottom Stem	Vertical Reinforcing	Horizontal Reinforcing	
As (based on applied moment) :	0.0385 in2/ft		
(4/3) * As :	0.0513 in2/ft	Min Stem T&S Reinf Area 0.864 in2	
200bd/fy : 200(12)(6)/60000 :	0.24 in2/ft	Min Stem T&S Reinf Area per ft of stem Height : 0.192 in2/ft	
0.0018bh : 0.0018(12)(8) :	0.1728 in2/ft	Horizontal Reinforcing Options :	
	==========	One layer of :	Two layers of :
Required Area :	0.1728 in2/ft	#4@ 12.50 in	#4@ 25.00 in
Provided Area :	0.31 in2/ft	#5@ 19.38 in	#5@ 38.75 in
Maximum Area :	0.8128 in2/ft	#6@ 27.50 in	#6@ 55.00 in

Footing Data

Toe Width	=	2.00 ft
Heel Width	=	3.50
Total Footing Width	=	5.50
Footing Thickness	=	12.00 in
Key Width	=	12.00 in
Key Depth	=	0.00 in
Key Distance from Toe	=	2.00 ft

f'c = 2,500 psi Fy = 60,000 psi
Footing Concrete Density = 150.00 pcf
Min. As % = 0.0018
Cover @ Top 3.00 @ Btm.= 3.00 in

Footing Design Results

		Toe	Heel	
Factored Pressure	=	813	813	psf
Mu' : Upward	=	1,626	3,263	ft-#
Mu' : Downward	=	360	4,132	ft-#
Mu: Design	=	1,266	869	ft-#
Actual 1-Way Shear	=	6.81	4.24	psi
Allow 1-Way Shear	=	40.00	40.00	psi

Toe Reinforcing = # 5 @ 12.00 in
Heel Reinforcing = # 5 @ 12.00 in
Key Reinforcing = # 5 @ 12.00 in
Footing Torsion, Tu = 0.00 ft-lbs
Footing Allow. Torsion, phi Tu = 0.00 ft-lbs

If torsion exceeds allowable, provide supplemental design for footing torsion.

Other Acceptable Sizes & Spacings

Toe: #4@ 9.25 in, #5@ 14.34 in, #6@ 20.36 in, #7@ 27.77 in, #8@ 36.56 in, #9@ 46
Heel: Not req'd: Mu < phi*5*lambda*sqrt(f'c)*Sm
Key: Not req'd: Mu < phi*5*lambda*sqrt(f'c)*Sm

Min footing T&S reinf Area 1.43 in2
Min footing T&S reinf Area per foot 0.26 in2 /ft

If one layer of horizontal bars:	If two layers of horizontal bars:
#4@ 9.26 in	#4@ 18.52 in
#5@ 14.35 in	#5@ 28.70 in
#6@ 20.37 in	#6@ 40.74 in

Cantilevered Retaining Wall

Code: IBC 2015,ACI 318-14,ACI 530-13

Summary of Overturning & Resisting Forces & Moments

Item		.....OVERTURNING..... Force lbs	Distance ft	Moment ft-#		.....RESISTING..... Force lbs	Distance ft	Moment ft-#
HL Act Pres (ab water tbl)		423.0	1.33	1,930.2	Soil Over HL (ab. water tbl)	715.0	3.58	6,768.1
HL Act Pres (be water tbl)					Soil Over HL (bel. water tbl)		3.58	6,768.1
Hydrostatic Force					Watre Table			
Buoyant Force	=				Sloped Soil Over Hee =	260.9	4.56	1,188.6
Surcharge over Heel	=				Surcharge Over Heel =			
Surcharge Over Toe	=				Adjacent Footing Load =			
Adjacent Footing Load	=				Axial Dead Load on Stem =			
Added Lateral Load	=				* Axial Live Load on Stem =			
Load @ Stem Above Soil	=				Soil Over Toe =			
Seismic Earth Load	=	92.4	1.83	169.4	Surcharge Over Toe =			
	=				Stem Weight(s) =	450.0	2.33	1,050.0
					Earth @ Stem Transitions =			
Total	=	929.6	**O.T.M.** =	2,099.6	Footing Weigh! =	825.0	2.75	2,268.8
					Key Weight =		2.50	
					Vert. Component =			
					Total =	3,193.4 lbs	**R.M.=**	11,275.4

Resisting/Overturning Ratio = **5.37**
Vertical Loads used for Soil Pressure = 3,705.3 lbs

* Axial live load NOT included in total displayed, or used for overturning resistance, but is included for soil pressure calculation.

If seismic is included, the OTM and sliding ratios be 1.1 per section 1807.2.3 of IBC 2009 or IBC 201

Vertical component of active lateral soil pressure IS considered in the calculation of Sliding Resistance.

Vertical component of active lateral soil pressure IS NOT considered in the calculation of Overturning Resistance.

Tilt

Horizontal Deflection at Top of Wall due to settlement of soil

(Deflection due to wall bending not considered)

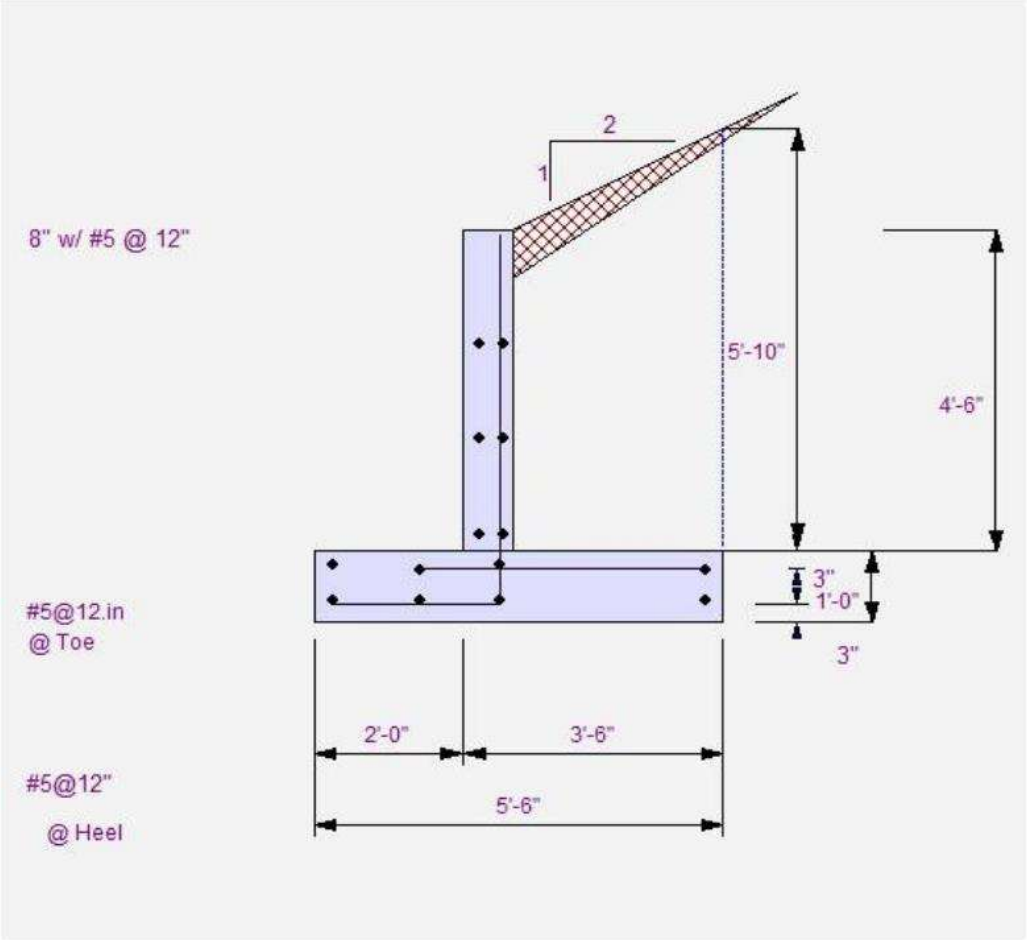
Soil Spring Reaction Modulus	250.0	pci
Horizontal Defl @ Top of Wall (approximate only)	0.000	in

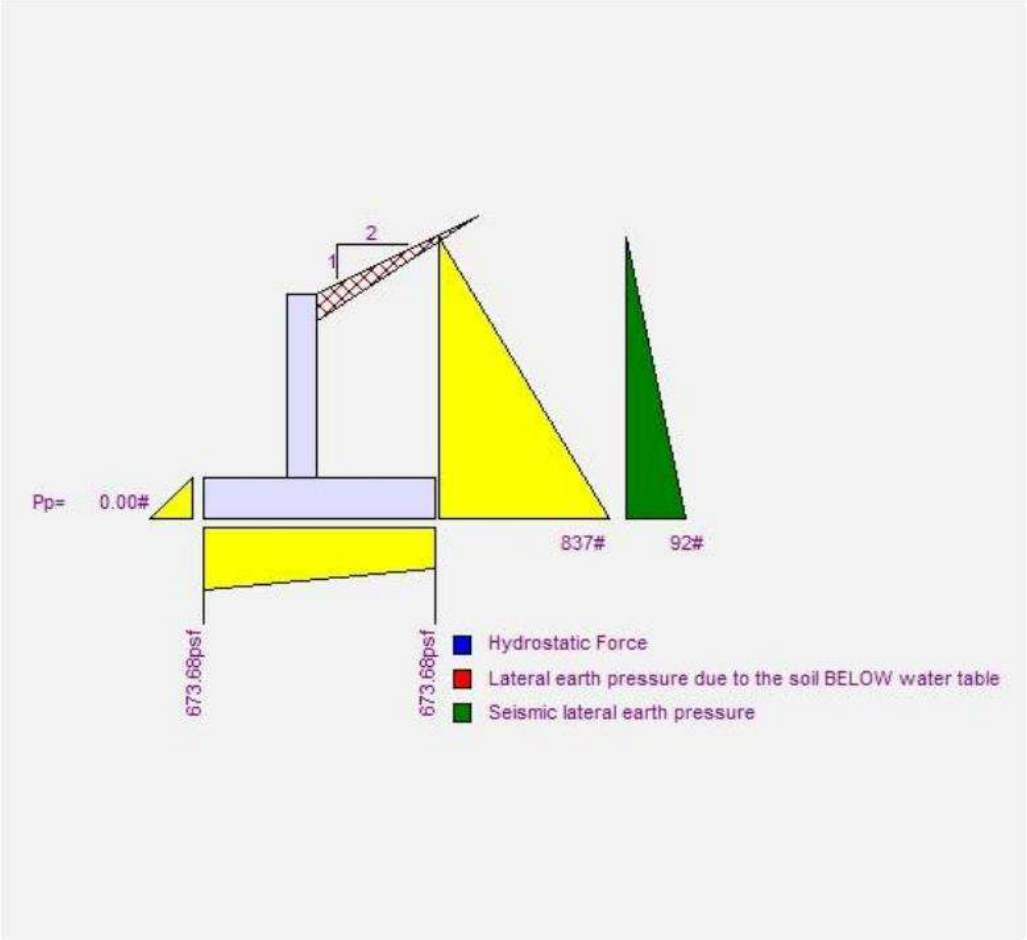
The above calculation is not valid if the heel soil bearing pressure exceeds that of the toe, because the wall would then tend to rotate into the retained soil.

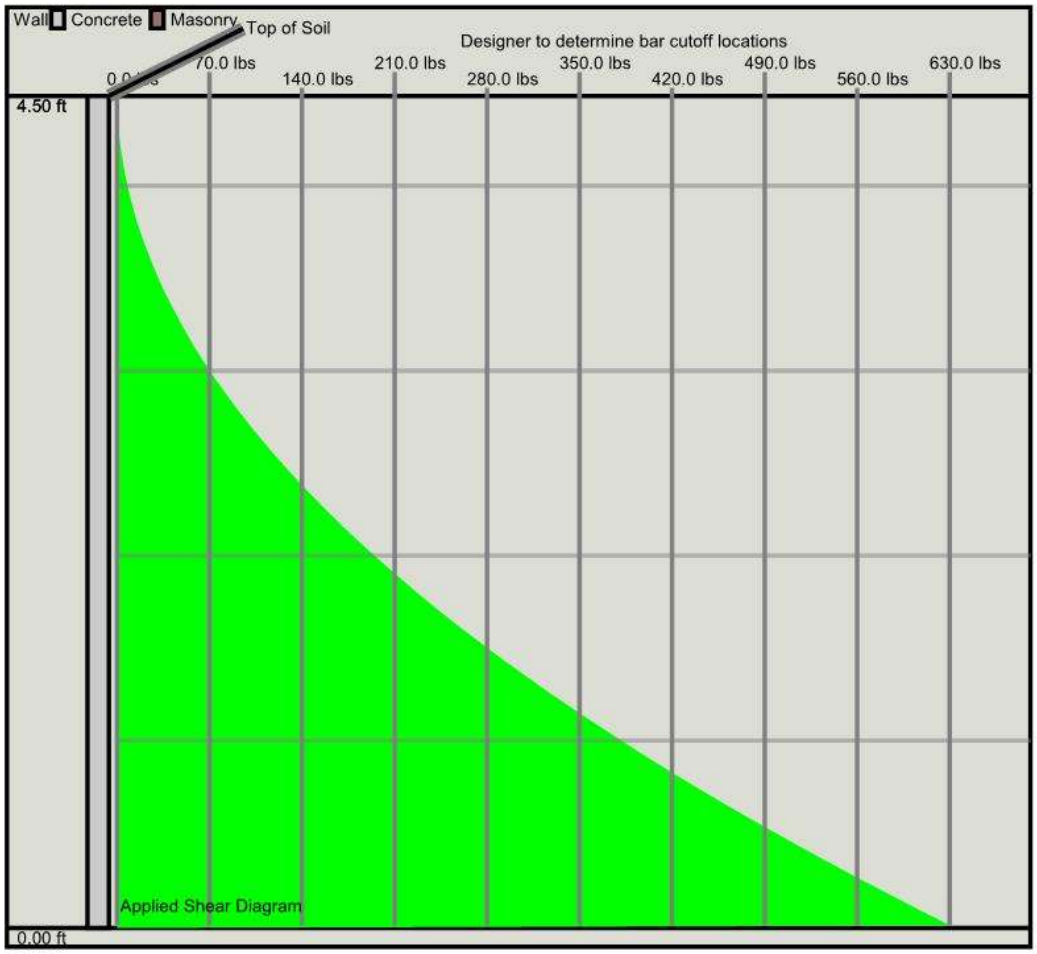
Rebar Lap & Embedment Lengths Information

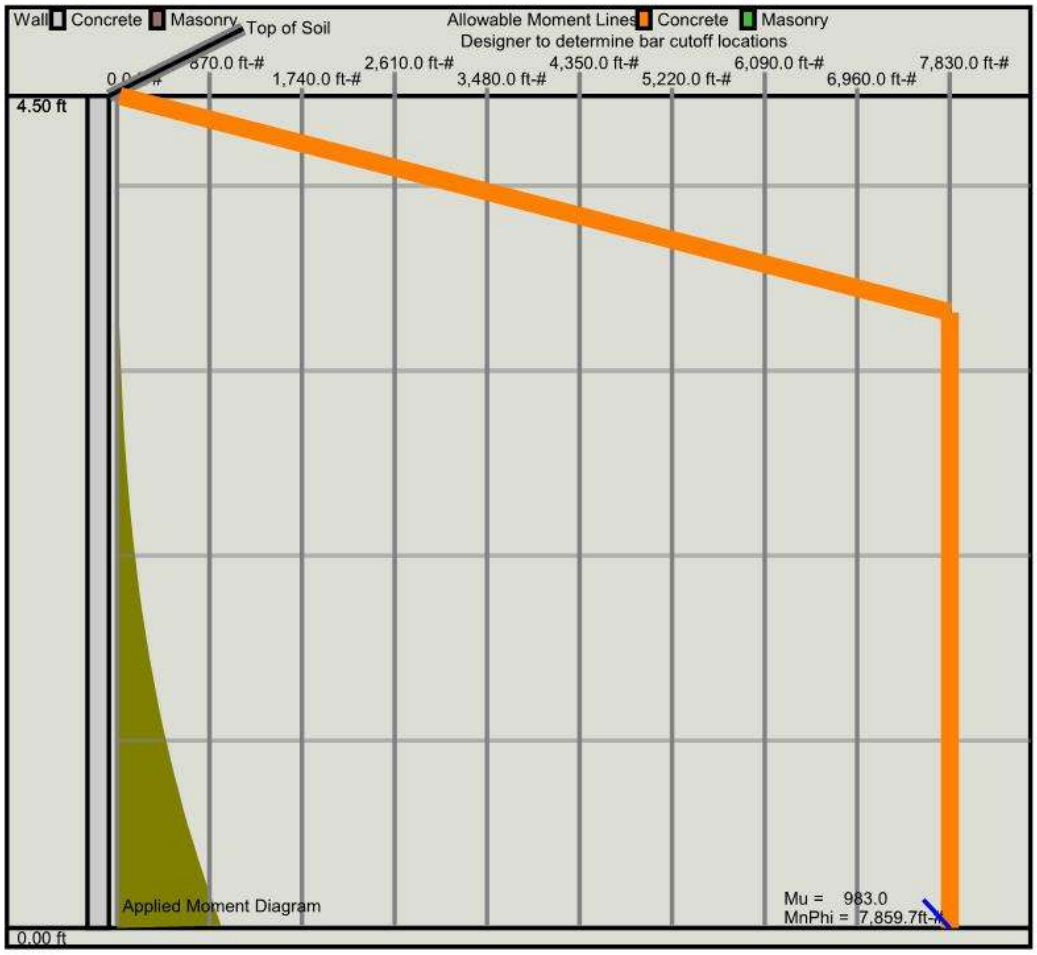
Stem Design Segment: Bottom
Stem Design Height: 0.00 ft above top of footing

Lap Splice length for #5 bar specified in this stem design segment =	23.40 in
Development length for #5 bar specified in this stem design segment =	18.00 in
Hooked embedment length into footing for #5 bar specified in this stem design segment =	6.00 in
As Provided =	0.3100 in2/ft
As Required =	0.1728 in2/ft


2
1
8" w/ #5 @ 12"
5'-10"
4'-6"
3"
1'-0"
3"
#5@12.in
@ Toe
2'-0"
3'-6"
#5@12"
@ Heel
5'-6"


2
1
Pp=
0.00#
837#
92#
673.68psf
673.68psf
Hydrostatic Force
Lateral earth pressure due to the soil BELOW water table
Seismic lateral earth pressure


Wall Concrete Masonry
Top of Soil
Designer to determine bar cutoff locations
70.0 lbs
140.0 lbs
210.0 lbs
280.0 lbs
350.0 lbs
420.0 lbs
490.0 lbs
560.0 lbs
630.0 lbs
4.50 ft
Applied Shear Diagram
0.00 ft


Wall Concrete Masonry
Top of Soil
Allowable Moment Lines Concrete Masonry
Designer to determine bar cutoff locations
870.0 ft-#
1,740.0 ft-#
2,610.0 ft-#
3,480.0 ft-#
4,350.0 ft-#
5,220.0 ft-#
6,090.0 ft-#
6,960.0 ft-#
7,830.0 ft-#
4.50 ft
Applied Moment Diagram
Mu = 983.0
MnPhi = 7,859.7ft-#
0.00 ft

3'-0" Tall Wall

Peterson Structural Engineers, Inc.
708 Broadway, Suite 110
Tacoma, Washington 98402
Phone: 253-830-2140
www.psengineers.com

Project Name/Number : 1801-0336-02
Title **Garden Curves**
Dsgnr: **NRW**
Description....
Wall 5 - CIP Cantilever Wall (3'-0" Tall Segment)

Date: 12 JUL 2019

This Wall in File: X:\2018\01-PDX\1801-0326 to 1801-0350\1801-0336\Working Files by Program\Enercalc

Cantilevered Retaining Wall

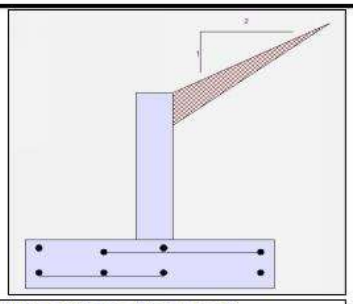
Code: IBC 2015,ACI 318-14,ACI 530-13

Criteria

Retained Height	=	3.00 ft
Wall height above soil	=	0.00 ft
Slope Behind Wall	=	2.00
Height of Soil over Toe	=	0.00 in
Water height over heel	=	0.0 ft

Soil Data

Allow Soil Bearing	=	2,000.0 psf
Equivalent Fluid Pressure Method		
Active Heel Pressure	=	35.0 psf/ft
	=	
Passive Pressure	=	0.0 psf/ft
Soil Density, Heel	=	130.00 pcf
Soil Density, Toe	=	110.00 pcf
Footing||Soil Friction	=	0.400
Soil height to ignore for passive pressure	=	0.00 in



Surcharge Loads

Surcharge Over Heel	=	0.0 psf
Used To Resist Sliding & Overturning		
Surcharge Over Toe	=	0.0
Used for Sliding & Overturning		

Lateral Load Applied to Stem

Lateral Load	=	0.0 #/ft
...Height to Top	=	8.00 ft
...Height to Bottom	=	0.00 ft
Load Type	=	Earth (H) (Service Level)
Wind on Exposed Stem (Strength Level)	=	0.0 psf

Adjacent Footing Load

Adjacent Footing Load	=	0.0 lbs
Footing Width	=	0.00 ft
Eccentricity	=	0.00 in
Wall to Ftg CL Dist	=	0.00 ft
Footing Type		Line Load
Base Above/Below Soil at Back of Wall	=	0.0 ft
Poisson's Ratio	=	0.300

Axial Load Applied to Stem

Axial Dead Load	=	0.0 lbs
Axial Live Load	=	0.0 lbs
Axial Load Eccentricity	=	0.0 in

Earth Pressure Seismic Load

Method : Triangular
Load at bottom of Triangular Distribution . . . . . = 48.000 psf (Strength)

Total Strength-Level Seismic Load. . . . . = 96.000 lbs
Total Service-Level Seismic Load. . . . . = 67.200 lbs

Design Summary

Wall Stability Ratios

Overturning	=	7.96	OK
Sliding	=	1.68	OK
Total Bearing Load	=	2,058 lbs	
...resultant ecc.	=	11.12 in	
Soil Pressure @ Toe	=	907 psf	OK
Soil Pressure @ Heel	=	0 psf	OK
Allowable	=	2,000 psf	
Soil Pressure Less Than Allowable			
ACI Factored @ Toe	=	1,269 psf	
ACI Factored @ Heel	=	0 psf	
Footing Shear @ Toe	=	9.5 psi	OK
Footing Shear @ Heel	=	8.7 psi	OK
Allowable	=	75.0 psi	

Sliding Calcs

Lateral Sliding Force	=	490.2 lbs	
less 100% Passive Force	= -	0.0 lbs	
less 100% Friction Force	= -	823.1 lbs	
Added Force Req'd	=	0.0 lbs	OK
....for 1.5 Stability	=	0.0 lbs	OK

Vertical component of active lateral soil pressure IS considered in the calculation of soil bearing pressures.

Load Factors

Building Code	IBC 2015,ACI
Dead Load	1.200
Live Load	1.600
Earth, H	1.600
Wind, W	1.000
Seismic, E	1.000

Stem Construction

Bottom

			Stem OK
Design Height Above Ftg	ft =		0.00
Wall Material Above "Ht"	=		Concrete
Design Method	=		LRFD
Thickness	=		8.00
Rebar Size	=		# 5
Rebar Spacing	=		12.00
Rebar Placed at	=		6 in
Design Data			
fb/FB + fa/Fa	=		**0.038**
Total Force @ Section			
Service Level	lbs =		
Strength Level	lbs =		306.0
Moment....Actual			
Service Level	ft-# =		
Strength Level	ft-# =		306.0
Moment.....Allowable	=		7,859.7
Shear.....Actual			
Service Level	psi =		
Strength Level	psi =		4.3
Shear.....Allowable	psi =		75.0
Anet (Masonry)	in2 =		
Rebar Depth 'd'	in =		6.00
Masonry Data			
f'm	psi =		
Fs	psi =		
Solid Grouting	=		
Modular Ratio 'n'	=		
Wall Weight	psf =		100.0
Short Term Factor	=		
Equiv. Solid Thick.	=		
Masonry Block Type	=		Medium Weight
Masonry Design Method	=		ASD
Concrete Data			
f'c	psi =		2,500.0
Fy	psi =		60,000.0

Concrete Stem Rebar Area Details

Bottom Stem	Vertical Reinforcing	Horizontal Reinforcing	
As (based on applied moment) :	0.012 in2/ft		
(4/3) * As :	0.016 in2/ft	Min Stem T&S Reinf Area 0.576 in2	
200bd/fy : 200(12)(6)/60000 :	0.24 in2/ft	Min Stem T&S Reinf Area per ft of stem Height : 0.192 in2/ft	
0.0018bh : 0.0018(12)(8) :	0.1728 in2/ft	Horizontal Reinforcing Options :	
	==========	One layer of :	Two layers of :
Required Area :	0.1728 in2/ft	#4@ 12.50 in	#4@ 25.00 in
Provided Area :	0.31 in2/ft	#5@ 19.38 in	#5@ 38.75 in
Maximum Area :	0.8128 in2/ft	#6@ 27.50 in	#6@ 55.00 in

Footing Data

Toe Width	=	2.00 ft
Heel Width	=	2.50
Total Footing Width	=	4.50
Footing Thickness	=	12.00 in
Key Width	=	12.00 in
Key Depth	=	0.00 in
Key Distance from Toe	=	2.00 ft

f'c = 2,500 psi Fy = 60,000 psi
Footing Concrete Density = 150.00 pcf
Min. As % = 0.0018
Cover @ Top 3.00 @ Btm.= 3.00 in

Footing Design Results

		Toe	Heel	
Factored Pressure	=	1,269	0	psf
Mu' : Upward	=	25,344	1,414	ft-#
Mu' : Downward	=	4,320	14,991	ft-#
Mu: Design	=	760	309	ft-#
Actual 1-Way Shear	=	9.50	8.73	psi
Allow 1-Way Shear	=	40.00	40.00	psi

Toe Reinforcing = # 5 @ 12.00 in
Heel Reinforcing = # 5 @ 12.00 in
Key Reinforcing = # 5 @ 12.00 in
Footing Torsion, Tu = 0.00 ft-lbs
Footing Allow. Torsion, phi Tu = 0.00 ft-lbs

If torsion exceeds allowable, provide supplemental design for footing torsion.

Other Acceptable Sizes & Spacings

Toe: Not req'd: Mu < phi*5*lambda*sqrt(f'c)*Sm
Heel: Not req'd: Mu < phi*5*lambda*sqrt(f'c)*Sm
Key: No key defined

Min footing T&S reinf Area 1.17 in2
Min footing T&S reinf Area per foot 0.26 in2 /ft

If one layer of horizontal bars:	If two layers of horizontal bars:
#4@ 9.26 in	#4@ 18.52 in
#5@ 14.35 in	#5@ 28.70 in
#6@ 20.37 in	#6@ 40.74 in

Summary of Overturning & Resisting Forces & Moments

Item		.....OVERTURNING..... Force lbs	Distance ft	Moment ft-#		.....RESISTING..... Force lbs	Distance ft	Moment ft-#
HL Act Pres (ab water tbl)		423.0	1.33	693.3	Soil Over HL (ab. water tbl)	715.0	3.58	2,562.1
HL Act Pres (be water tbl)					Soil Over HL (bel. water tbl)		3.58	2,562.1
Hydrostatic Force					Watre Table			
Buoyant Force	=				Sloped Soil Over Hee =	109.2	3.89	424.8
Surcharge over Heel	=				Surcharge Over Heel =			
Surcharge Over Toe	=				Adjacent Footing Load =			
Adjacent Footing Load	=				Axial Dead Load on Stem =			
Added Lateral Load	=				* Axial Live Load on Stem =			
Load @ Stem Above Soil	=				Soil Over Toe =			
Seismic Earth Load	=	67.2	1.33	89.6	Surcharge Over Toe =			
	=				Stem Weight(s) =	300.0	2.33	700.0
					Earth @ Stem Transitions =			
					Footing Weigh! =	675.0	2.25	1,518.8
					Key Weight =		2.50	
					Vert. Component =			
Total	=	490.2	**O.T.M.** =	653.7	**Total =**	1,799.2 lbs	**R.M.=**	5,205.6

Resisting/Overturning Ratio = **7.96**
Vertical Loads used for Soil Pressure = 2,057.9 lbs

* Axial live load NOT included in total displayed, or used for overturning resistance, but is included for soil pressure calculation.

If seismic is included, the OTM and sliding ratios be 1.1 per section 1807.2.3 of IBC 2009 or IBC 201

Vertical component of active lateral soil pressure IS considered in the calculation of Sliding Resistance.

Vertical component of active lateral soil pressure IS NOT considered in the calculation of Overturning Resistance.

Tilt

Horizontal Deflection at Top of Wall due to settlement of soil

(Deflection due to wall bending not considered)

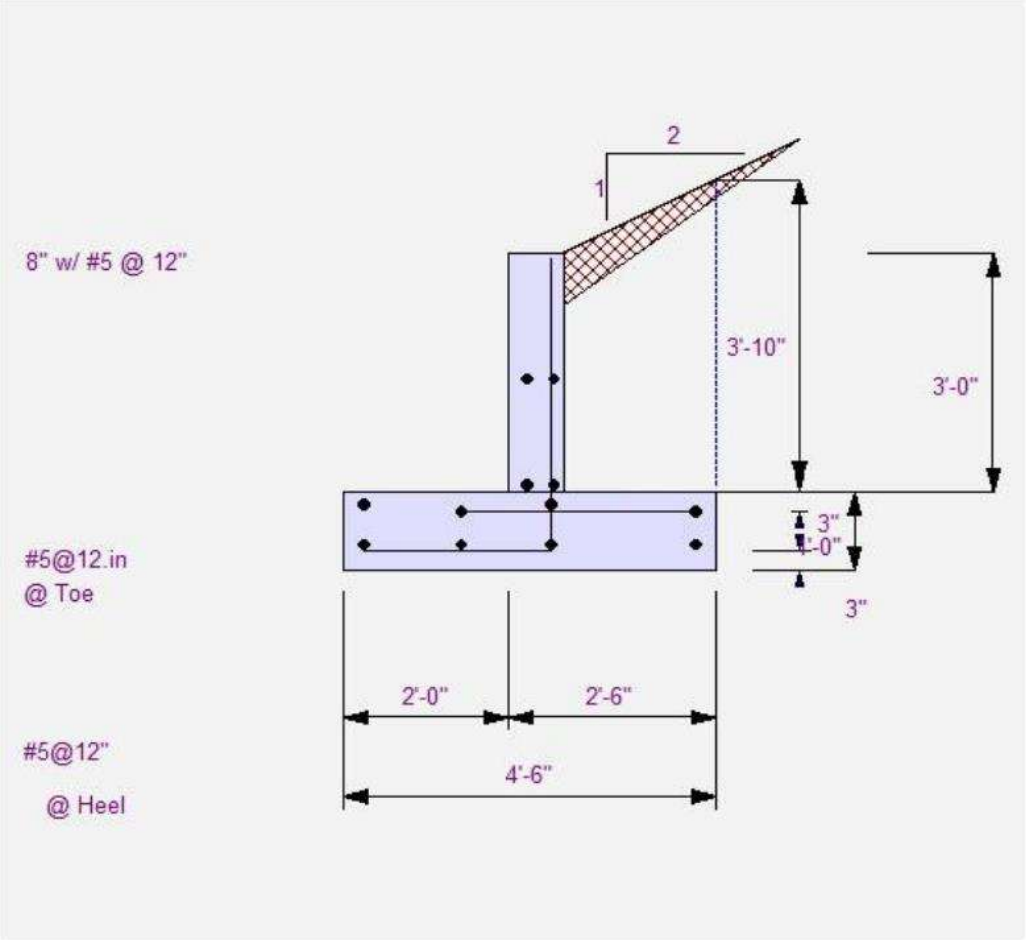
Soil Spring Reaction Modulus	250.0	pci
Horizontal Defl @ Top of Wall (approximate only)	0.000	in

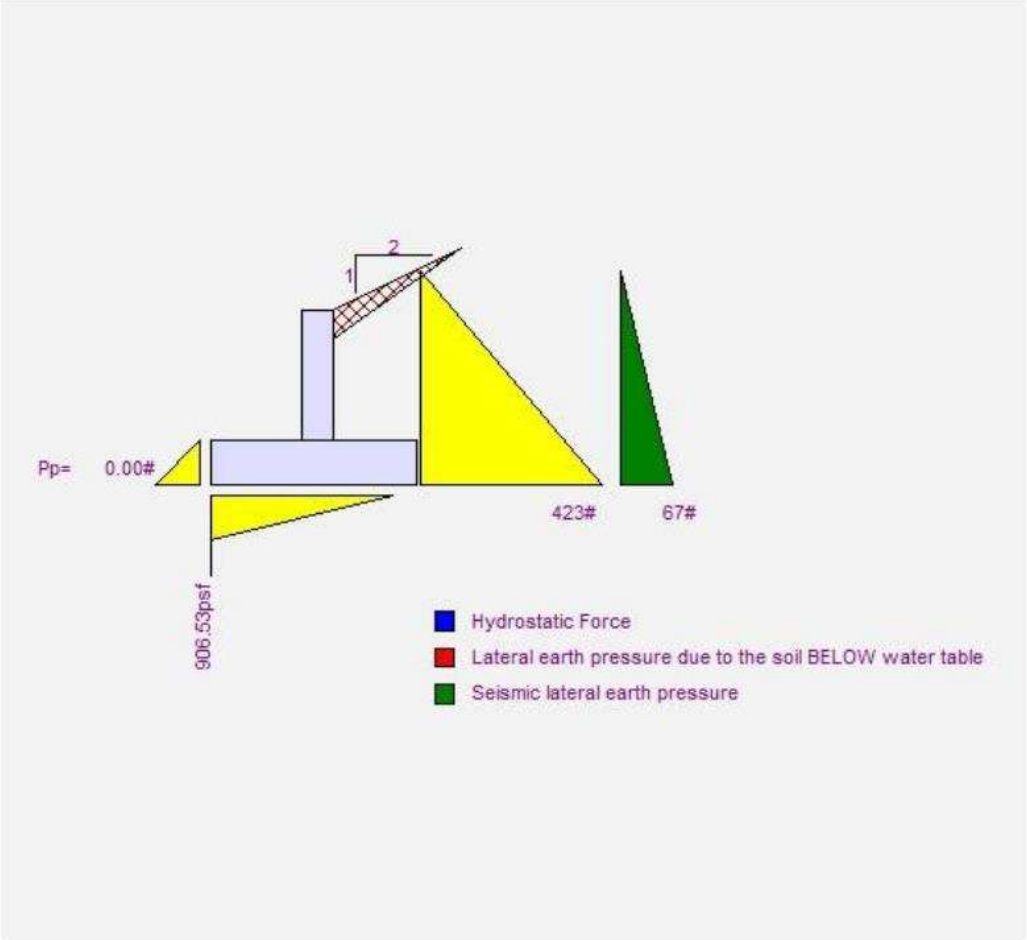
The above calculation is not valid if the heel soil bearing pressure exceeds that of the toe, because the wall would then tend to rotate into the retained soil.

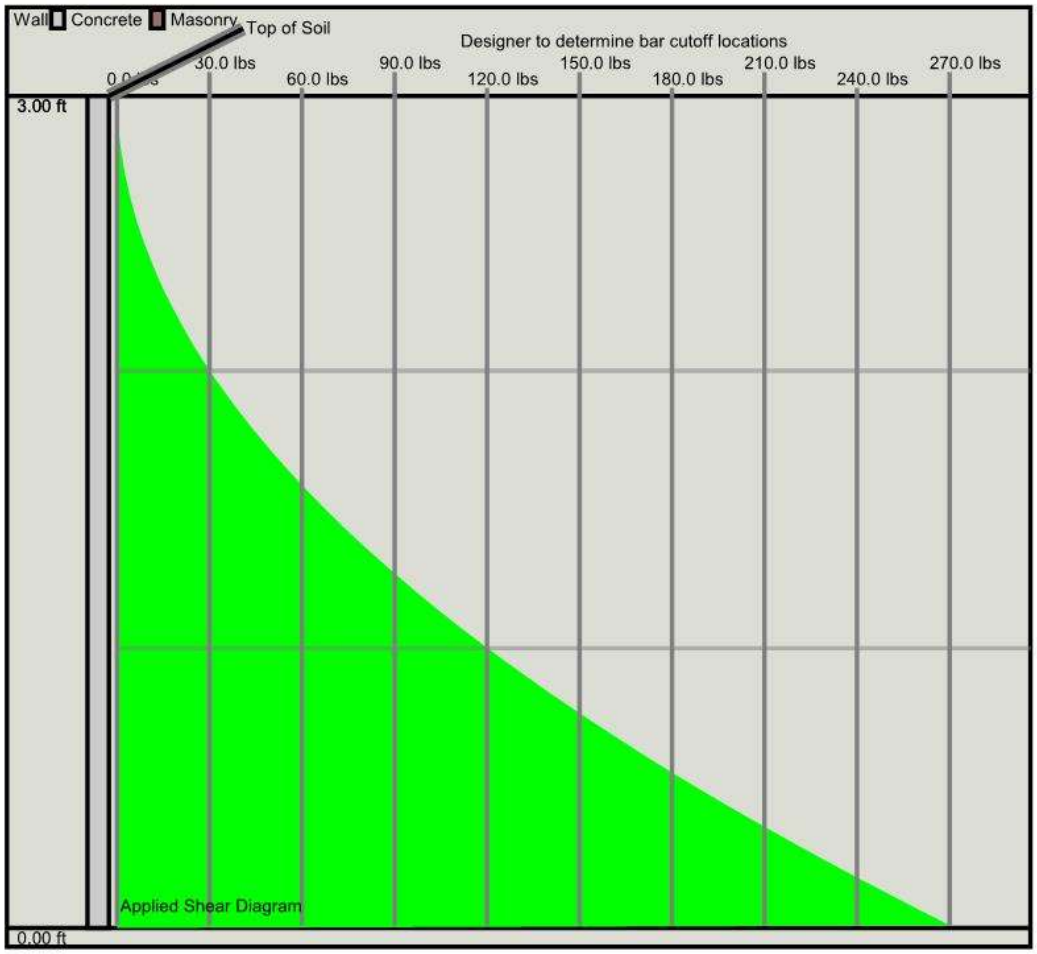
Rebar Lap & Embedment Lengths Information

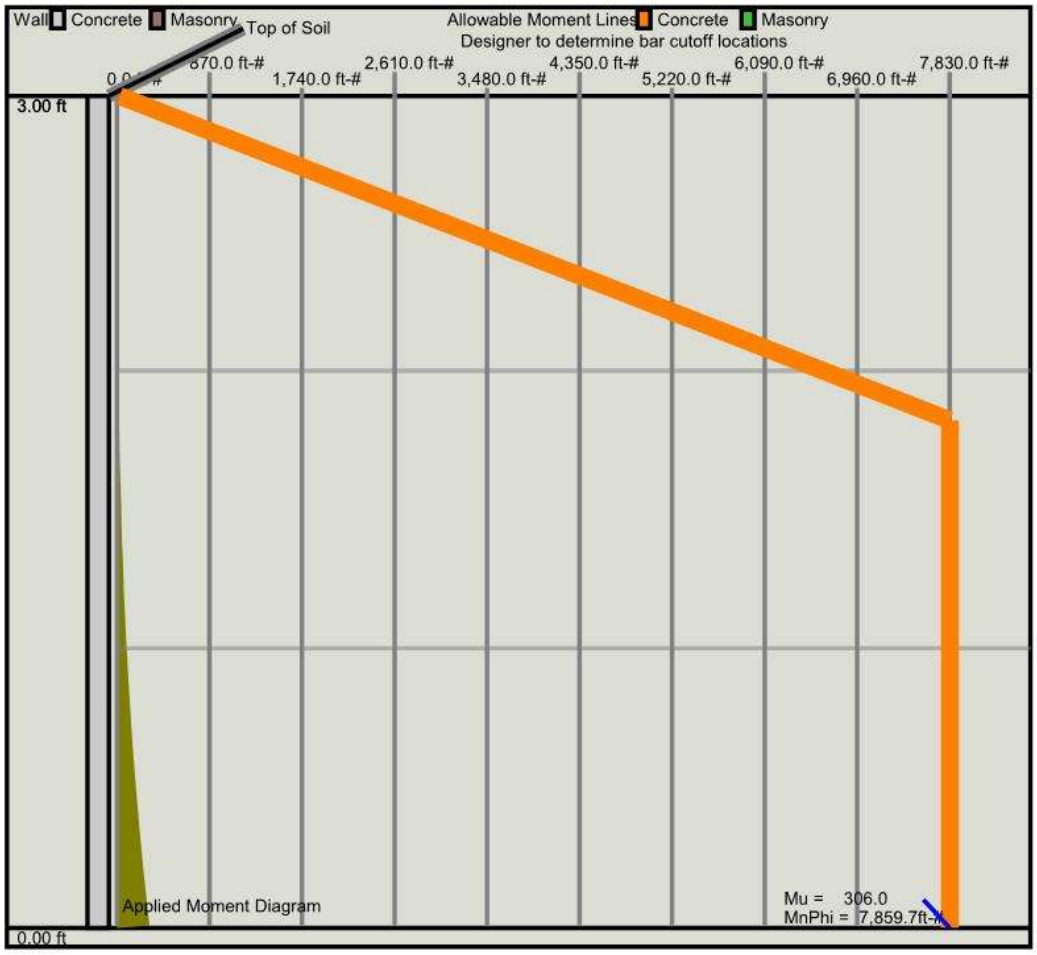
Stem Design Segment: Bottom
Stem Design Height: 0.00 ft above top of footing

Lap Splice length for #5 bar specified in this stem design segment =	23.40 in
Development length for #5 bar specified in this stem design segment =	18.00 in
Hooked embedment length into footing for #5 bar specified in this stem design segment =	6.00 in
As Provided =	0.3100 in2/ft
As Required =	0.1728 in2/ft


2
1
8" w/ #5 @ 12"
3'-10"
3'-0"
#5@12.in
@ Toe
3"
1'-0"
3"
2'-0"
2'-6"
#5@12"
@ Heel
4'-6"


2
1
Pp=
0.00#
423#
67#
906.53psf
Hydrostatic Force
Lateral earth pressure due to the soil BELOW water table
Seismic lateral earth pressure


Wall
Concrete
Masonry
Top of Soil
Designer to determine bar cutoff locations
0.0 lbs
30.0 lbs
60.0 lbs
90.0 lbs
120.0 lbs
150.0 lbs
180.0 lbs
210.0 lbs
240.0 lbs
270.0 lbs
3.00 ft
Applied Shear Diagram
0.00 ft


Wall Concrete Masonry
Top of Soil
Allowable Moment Lines Concrete Masonry
Designer to determine bar cutoff locations
870.0 ft-#
1,740.0 ft-#
2,610.0 ft-#
3,480.0 ft-#
4,350.0 ft-#
5,220.0 ft-#
6,090.0 ft-#
6,960.0 ft-#
7,830.0 ft-#
3.00 ft
Applied Moment Diagram
Mu = 306.0
MnPhi = 7,859.7ft-#
0.00 ft