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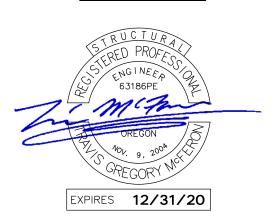
708 Broadway Suite 110 Tacoma, WA 98402 Phone: 253.830.2140

Structural Design Calculations

Tualatin Garden Corner Curves Tualatin, OR

<u>Client Information</u> 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

<u>Prepared By:</u> 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)
- 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

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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:

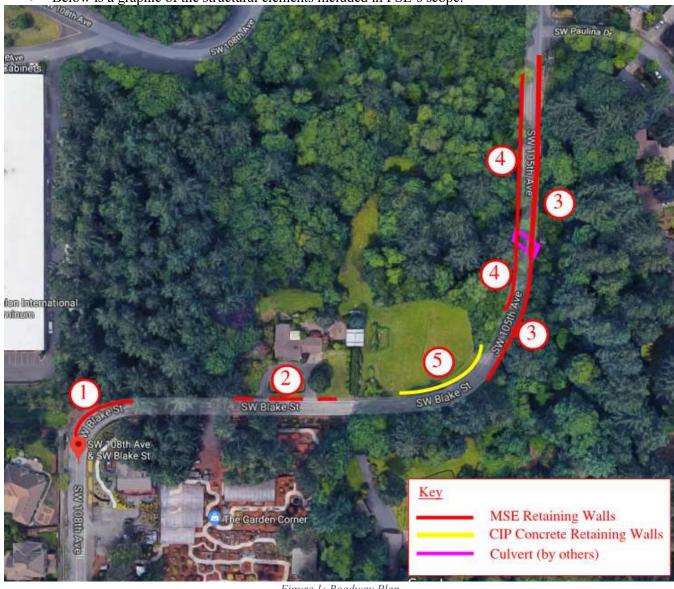


Figure 1: Roadway Plan



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Retaining Wall Information:

- MSE Walls:
 - o Wall 1
 - Max Height = 6.0'
 - Supports Roadway
 - \circ 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



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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 = $34-36^{\circ}$
 - 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:
 - \circ 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]
 - $\underline{k_h} = 0.162g \leftarrow$ Used as pseudo-static horizontal seismic acceleration in analysis software for analyzing MSE walls
 - \circ 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)



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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).

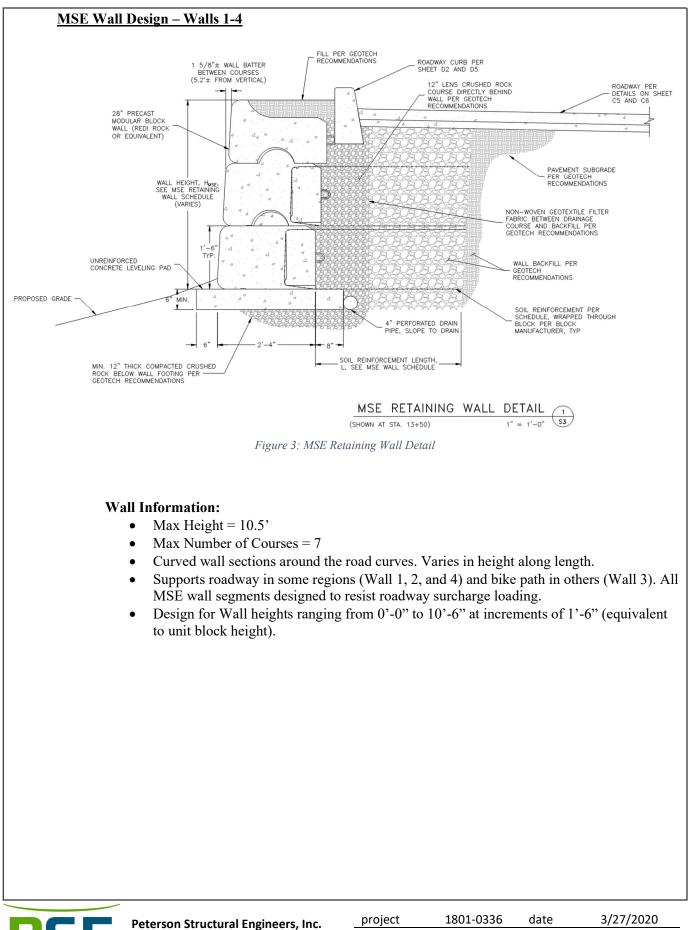


Figure 2: Roadway Plan



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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

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

	MSE RETAINING WALL SCHEDULE							
WALL HEIGHT* "H _{MSE} "	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'-O" 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.



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Cast- in-Place Cantilever Wall Design

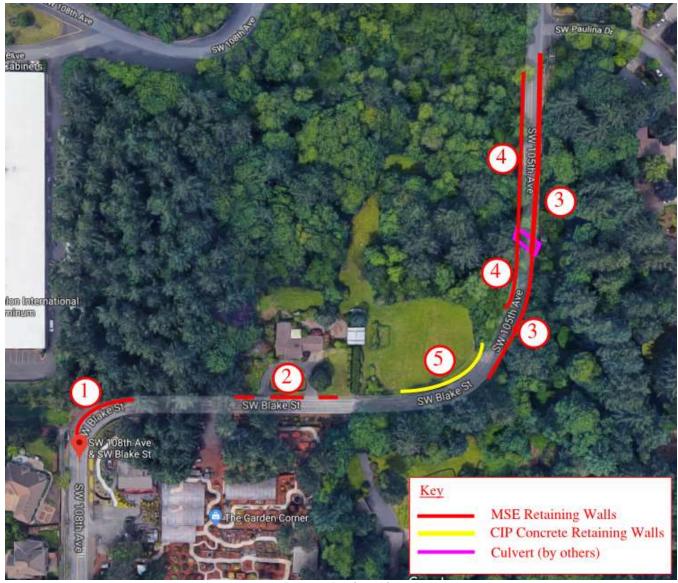


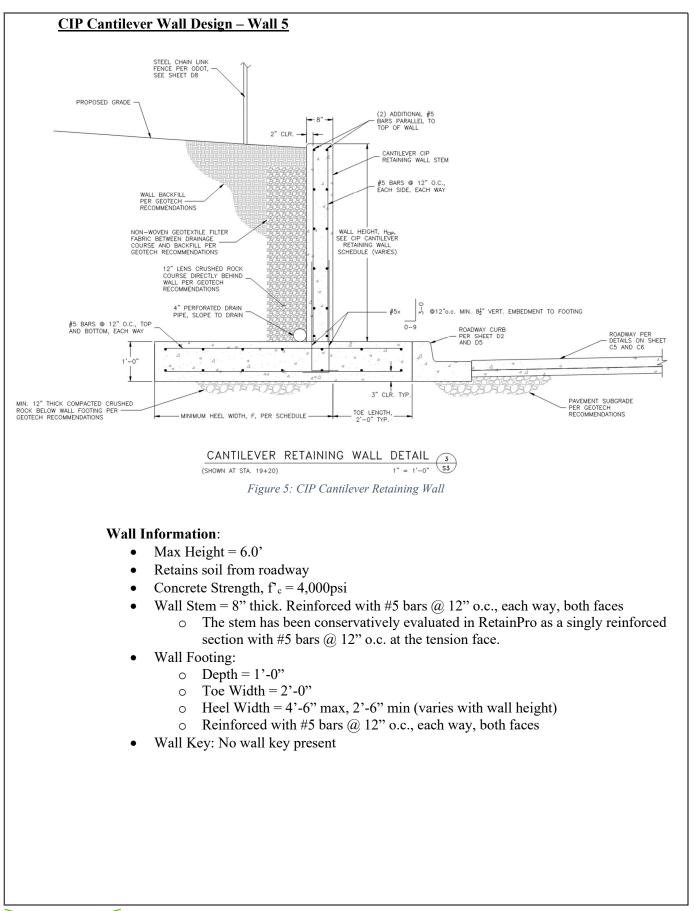
Figure 4: Roadway Plan

Design the CIP Concrete Retaining Walls per AASHTO Chapter 11.6.



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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
 - o Load Factors input for Extreme Event I state: By inspection, Controls
 - Dead Load, DC = 1.25
 - Surcharge Load (live), $ES = \gamma EQ = 0.75$ (Note: surcharge = 0psf)
 - Earth Active Pressure, EH = 1.50
 - Seismic, EQ = 1.00
- External Stability:
 - \circ Overturning FS = 1.5
 - \circ 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.



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Appendix A – MSE Wall Design



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<u> 10'-6" Tall Wall – Seismic Case</u>



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NRW

Tualatin Garden Corner Curves 10.5ft MSE 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 fa	ctors		
Seismic desig	n 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	6	1.62
2	Top block 28	1	5

Base

a ₁	=	0.50	ft
a ₂	=	0.50	ft
h	=	0.50	ft
b	=	3.50	ft
	a ₂ h	a ₂ = h =	$a_1 = 0.50$ $a_2 = 0.50$ h = 0.50 b = 3.50

Material

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

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Tualatin Garden Corner Curves 10.5ft MSE Wall - Seismic Case

Types of reinforcements

Reinforcement details

				Tensile strength			
No.	Name	Type of reinforcement	Line type	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	www.	27415.00	13716.42	10560.73	

1. Miragrid 5XT				
Short-term char. strength	Tult		4700.00	lbf/ft
Creep red. factor	RF_{CR}	=	1.58	
Durability red. factor	RF_D	=	1.15	
Installation damage red. factor	RF ID			
Long-term design strength	Rt	=	2069.35	lbf/ft
Coefficient of direct slip along reinforcement	Cds	=	0.67	
Coefficient of interaction of soil and geo-reinforcement	Ci	=	0.67	
Scale correction factor	α	=	0.0	
Long-term strength reduction factor	CRcr	=	0.532	
Analysis of long-term strength	R _{con}	=	2174.26	lbf/ft
2. Miragrid 8XT				
Short-term char. strength	Tult	=	7400.00	lbf/ft
Creep red. factor	RFCR	=	1.58	
Durability red. factor	RFD	=	1.15	
Installation damage red. factor	RFID	=	1.20	
Long-term design strength	Rt	=	3393.87	lbf/ft
Coefficient of direct slip along reinforcement	Cds	=	0.67	
Coefficient of interaction of soil and geo-reinforcement	Ci	=	0.67	
Scale correction factor	α	=	0.8	
Long-term strength reduction factor	CRcr	=	0.532	
Analysis of long-term strength	R _{con}	=	3423.30	lbf/ft
3. Miragrid 10XT				
Short-term char. strength	Tult		9500.00	lbf/ft
Creep red. factor	RFCR	=	1.58	
Durability red. factor	RFD	=	1.15	
Installation damage red. factor	RFID	=	1.20	
Long-term design strength	Rt	=	4357.00	lbf/ft
Coefficient of direct slip along reinforcement	Cds	=	0.67	
Coefficient of interaction of soil and geo-reinforcement	Ci	=	0.67	
Scale correction factor	α	=	0.8	
Long-term strength reduction factor	CRcr	=	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

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Tualatin Garden Corner Curves 10.5ft MSE Wall - Seismic Case

Creep red. factor	RF _{CR}	=	1.58	
Durability red. factor	RFD	=	1.15	
Installation damage red. factor	RFID	=	1.15	
Long-term design strength	Rt	=	6558.83	lbf/ft
Coefficient of direct slip along reinforcement	Cds	=	0.67	
Coefficient of interaction of soil and geo-reinforcement		=	0.67	
Scale correction factor	α	=	0.8	
Long-term strength reduction factor	CRcr	=	0.506	
Analysis of long-term strength	R _{con}	=	6030.20	lbf/ft
5. Miragrid 24XT				
Short-term char. strength	Tult	=	27415.00	lbf/ft
Creep red. factor	RFCR	=	1.58	
Durability red. factor	RFD	=	1.15	
Installation damage red. factor	RFID	=	1.10	
Long-term design strength	Rt	=	13716.42	lbf/ft
Coefficient of direct slip along reinforcement	Cds	=	0.67	
Coefficient of interaction of soil and geo-reinforcement		=	0.67	
Scale correction factor	α	=	0.8	
Long-term strength reduction factor	CRcr	=	0.443	
Analysis of long-term strength	R _{con}	=	10560.73	lbf/ft
- Contract Induction and the second second				

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 I = 7.50 ft **Reinforcements**

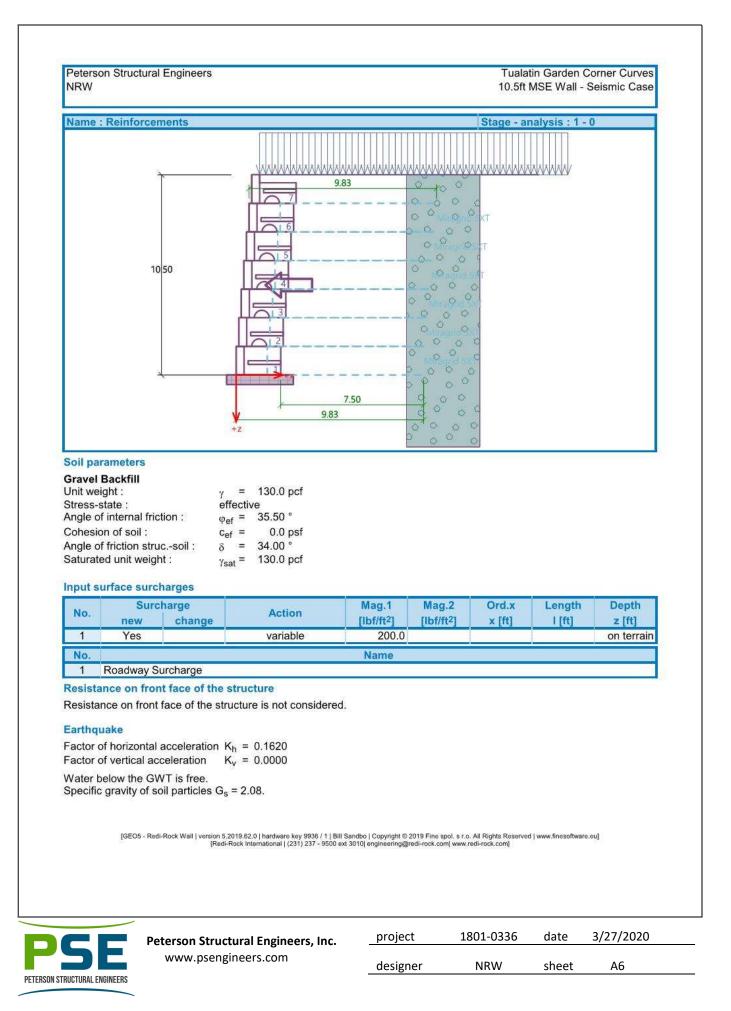
No.	Consider	Name	Length of reinforcement I [ft]	End pt. coordinate I _k [ft]
1	Yes	Miragrid 5XT	7.50	
2	Yes	Miragrid 5XT	7.50	
3	Yes	Miragrid 5XT	7.50	
4	Yes	Miragrid 5XT	7.50	
5	Yes	Miragrid 5XT	7.50	
6	Yes	Miragrid 5XT	7.50	
7	No			

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Tualatin Garden Corner Curves 10.5ft MSE Wall - Seismic Case

Settings of the stage of construction

Design situation : seismic

Verification No. 1

Forces acting on construction

Name	Fhor	App.Pt.	Fvert	App.Pt.	Design
	[lbf/ft]	z [ft]	[lbf/ft]	x [ft]	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

Safety factor = 1.94 > 1.10 Wall for slip is SATISFACTORY

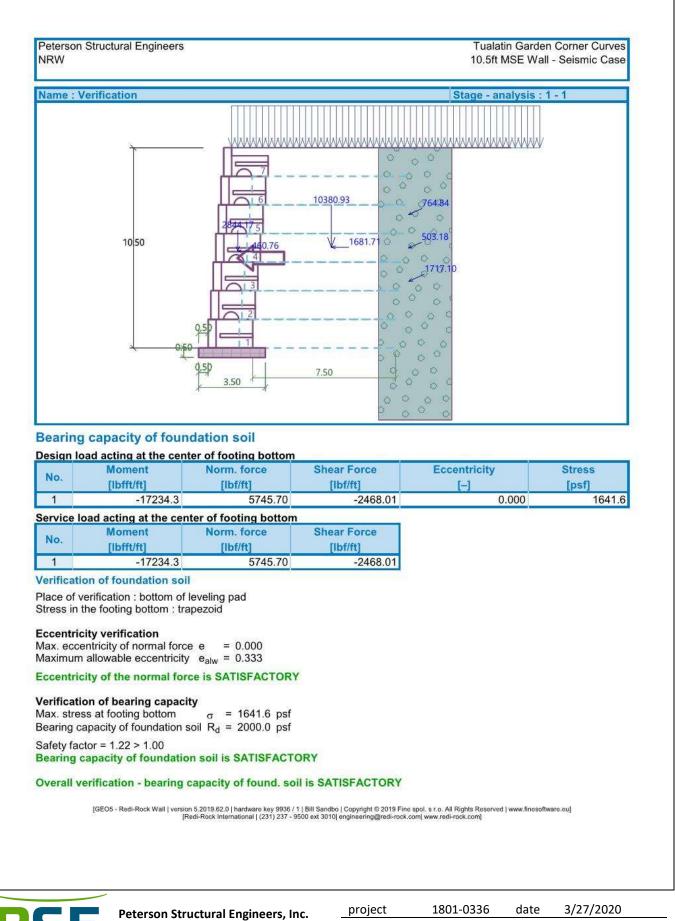
Overall check - WALL is SATISFACTORY

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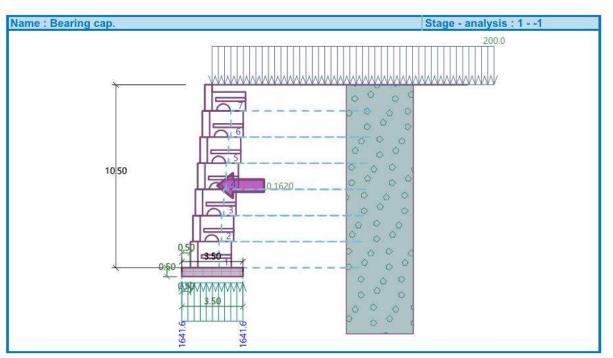
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Tualatin Garden Corner Curves 10.5ft MSE Wall - Seismic Case



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	٥
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:

Factor of safety = 3.04 > 1.10

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project	1801-0336	date	3/27/2020	
designer	NRW	sheet	A9	

Tualatin Garden Corner Curves 10.5ft MSE Wall - Seismic Case

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 $R_t = 517.34 \text{ lbf/ft}$

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

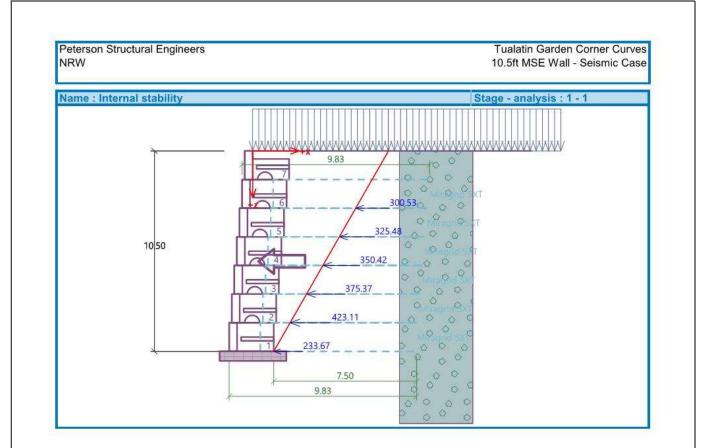
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designer	NRW	sheet	A10	



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project 1801-0336 c		
designer NRW s	sheet	A11

<u>10'-6" Tall Wall – Transient Case</u>



project	1801-0336	date	3/27/2020	
designer	NRW	sheet	A12	

PSE NRW

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 :	
Verification methodology :	Safety factors (ASD)

Safety fa	ctors						
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	6	1.62
2	Top block 28	1	5 .

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 °

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designer	NRW	sheet	A13	

Tualatin Garden Corner Curves
10.5ft MSE Wall - Transient Case

Types of reinforcements

Reinforcement details

PSE NRW

No.	and the second second		a server server	Tensile strength			
	Name	Type of reinforcement	Line type	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	www.	27415.00	13716.42	10560.73	

1. Miragrid 5XT				
Short-term char. strength	Tult	=	4700.00	lbf/ft
Creep red. factor	RFCR	=	1.58	
Durability red. factor	RFD	=	1.15	
Installation damage red. factor	RFID	=	1.25	
Long-term design strength	Rt	=	2069.35	lbf/ft
Coefficient of direct slip along reinforcement	Cds	=	0.67	
Coefficient of interaction of soil and geo-reinforcement	Ci	=	0.67	
Scale correction factor	α	=	0.8	
Long-term strength reduction factor	CRcr	Ξ	0.001	
Analysis of long-term strength	R_{con}	=	2174.26	lbf/ft
2. Miragrid 8XT	_		-	
Short-term char. strength	Tult		7400.00	
Creep red. factor	RFCR			
Durability red. factor	RFD			
Installation damage red. factor	RFID	=	10000000000000000000000000000000000000	
Long-term design strength	Rt	=	3393.87	lbf/ft
Coefficient of direct slip along reinforcement	C_{ds}	=		
Coefficient of interaction of soil and geo-reinforcement	Ci	=		
Scale correction factor	α	=	0.0	
Long-term strength reduction factor	CR_{cr}	=		
Analysis of long-term strength	R _{con}	Ξ	3423.30	lbf/ft
3. Miragrid 10XT	T		0500.00	11-5/64
Short-term char. strength	Tult		9500.00	
Creep red. factor	RFCR			
Durability red. factor	RFD	=		
Installation damage red. factor	RFID	=		
Long-term design strength	Rt		4357.00	IDT/T
Coefficient of direct slip along reinforcement	Cds	=	0.01	
Coefficient of interaction of soil and geo-reinforcement	Ci	=	0.07	
Scale correction factor	α	=	0.0	
Long-term strength reduction factor	CRcr	=	0.0.0	
Analysis of long-term strength	R_{con}	Ξ	4287.39	lbf/ft
4. Miragrid 20XT				

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designer	NRW	sheet	A14	

PSE NRW Tualatin Garden Corner Curves 10.5ft MSE Wall - Transient Case

Short-term char. strength	Tult	=	13705.00	lbf/ft
Creep red. factor	RFCR	=	1.58	
Durability red. factor	RFD	=	1.15	
Installation damage red. factor	RFID	=	1.15	
Long-term design strength	Rt	=	6558.83	lbf/ft
Coefficient of direct slip along reinforcement	Cds	=	0.67	
Coefficient of interaction of soil and geo-reinforcement		=	0.67	
Scale correction factor	α	=	0.8	
Long-term strength reduction factor	CRcr	=	0.506	
Analysis of long-term strength	R _{con}	=	6030.20	lbf/ft
5. Miragrid 24XT				
Short-term char. strength	Tult	=	27415.00	lbf/ft
Creep red. factor	RFCR	=	1.58	
Durability red. factor	RFD	=	1.15	
Installation damage red. factor	RFID	=	1.10	
Long-term design strength	Rt	=	13716.42	lbf/ft
Coefficient of direct slip along reinforcement	Cds	=	0.67	
Coefficient of interaction of soil and geo-reinforcement		=	0.67	
Scale correction factor	α	=	0.8	
Long-term strength reduction factor	CRcr	Ξ	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 I = 7.50 ft **Reinforcements**

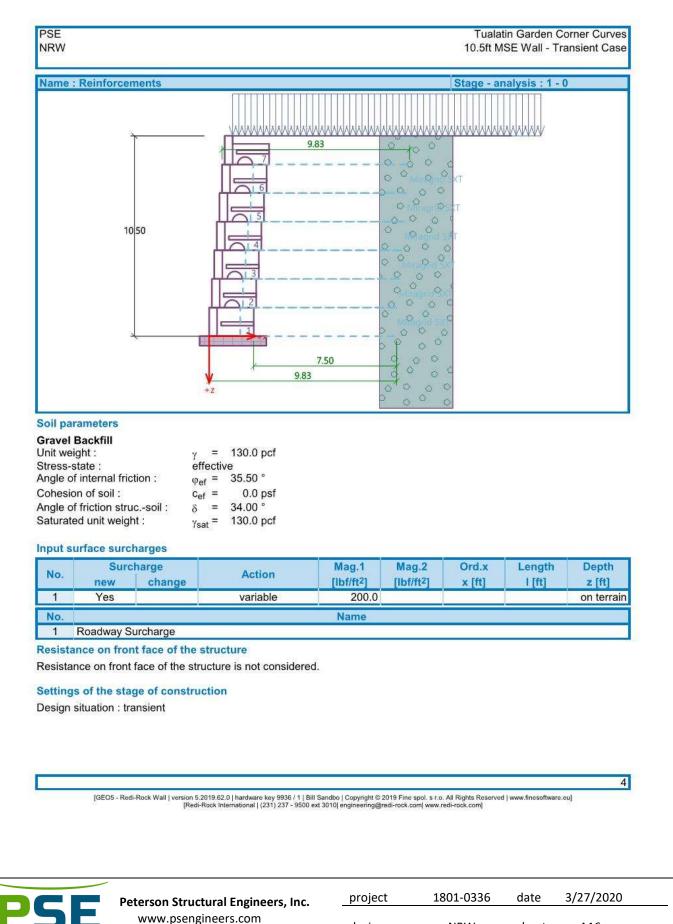
No.	Consider	Name	Length of reinforcement I [ft]	End pt. coordinate I _k [ft]
1	Yes	Miragrid 5XT	7.50	
2	Yes	Miragrid 5XT	7.50	
3	Yes	Miragrid 5XT	7.50	
4	Yes	Miragrid 5XT	7.50	
5	Yes	Miragrid 5XT	7.50	
6	Yes	Miragrid 5XT	7.50	
7	No			

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designer	NRW	sheet	A15	



designer

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er NRW sheet A16

PSE NRW

Tualatin Garden Corner Curves 10.5ft MSE Wall - Transient Case

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 Movr = 7923.9 lbfft/ft

Safety factor = 10.20 > 1.50 Wall for overturning is SATISFACTORY

Check for slip

Resisting horizontal force Hres = 9238.39 lbf/ft Active horizontal force Hact = 2033.55 lbf/ft

Safety factor = 4.54 > 1.50 Wall for slip is SATISFACTORY

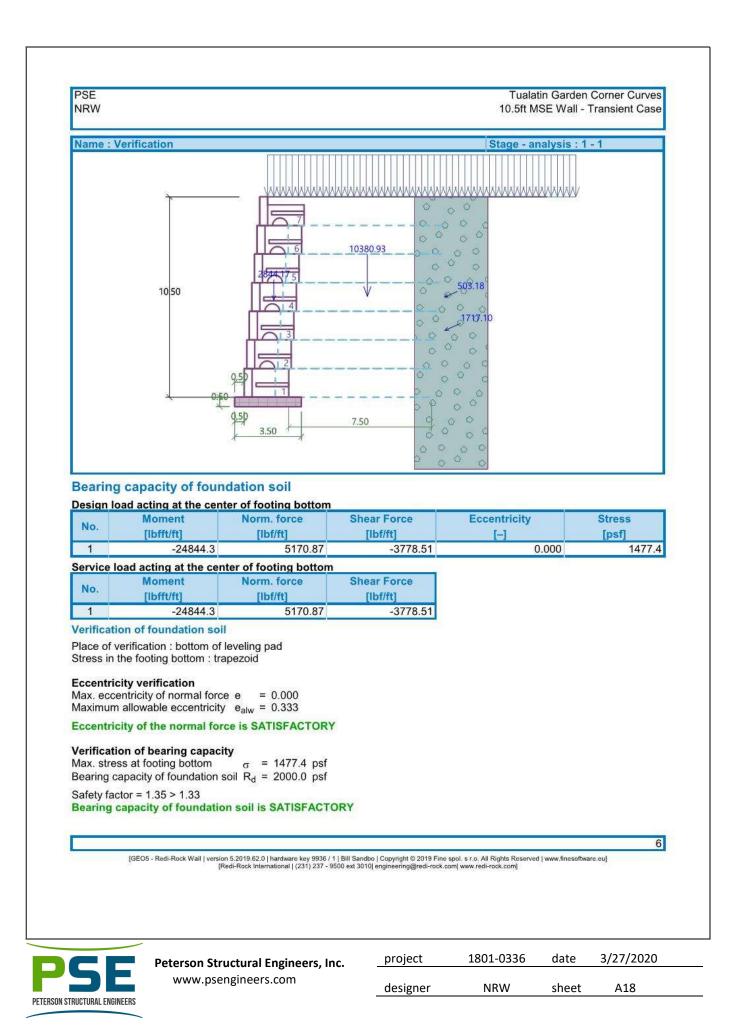
Overall check - WALL is SATISFACTORY

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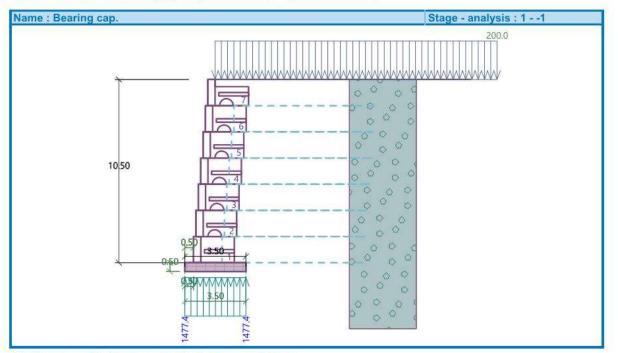
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PSE NRW Tualatin Garden Corner Curves 10.5ft MSE Wall - Transient Case

Overall verification - bearing capacity of found. soil is SATISFACTORY



Verification of slip on georeinforcement No. 1

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

Roadway Surcharge Weight - reinforced soil Roadway Surcharge	0.0 1572.7 460.9 0.0 0.0	-5.08 -3.50 -5.25 -5.14	2891.6 689.3 202.0	-3.78 7.50 7.50	1.000 1.000
Active pressure Roadway Surcharge Weight - reinforced soil Roadway Surcharge Verification against slip along geotextil	460.9 0.0	-5.25			
Weight - reinforced soil Roadway Surcharge	0.0		202.0	7 50	
Roadway Surcharge		-5.14		1.50	1.000
	0.0	-0.14	9760.4	3.95	1.000
Verification against slip along geotextil	0.0	-10.50	1720.8	0.20	1.000
9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9	e No.: 1				
Overall normal force acting on reinforcemed Coefficient of reduction of slip along geo-te Resistance along geo-reinforcement Wall resistance Overall bearing capacity of reinforcements Check for slip: Resisting horizontal force H _{res} = 9766.57 Active horiz, force H _{act} = 2033.55	extile = = 8 = 1 = Ibf/ft	2372.47 lbf/ft 0.92 3097.12 lbf/ft 1669.45 lbf/ft 0.00 lbf/ft			
Factor of safety = 4.80 > 1.50 Slip along geotextile is SATISFACTORY					
					7



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project	1801-0336	date	3/27/2020	
designer	NRW	sheet	A19	

Tualatin Garden Corner Curves
10.5ft MSE Wall - Transient Case

Calculation of internal stability No. 1

PSE NRW

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

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

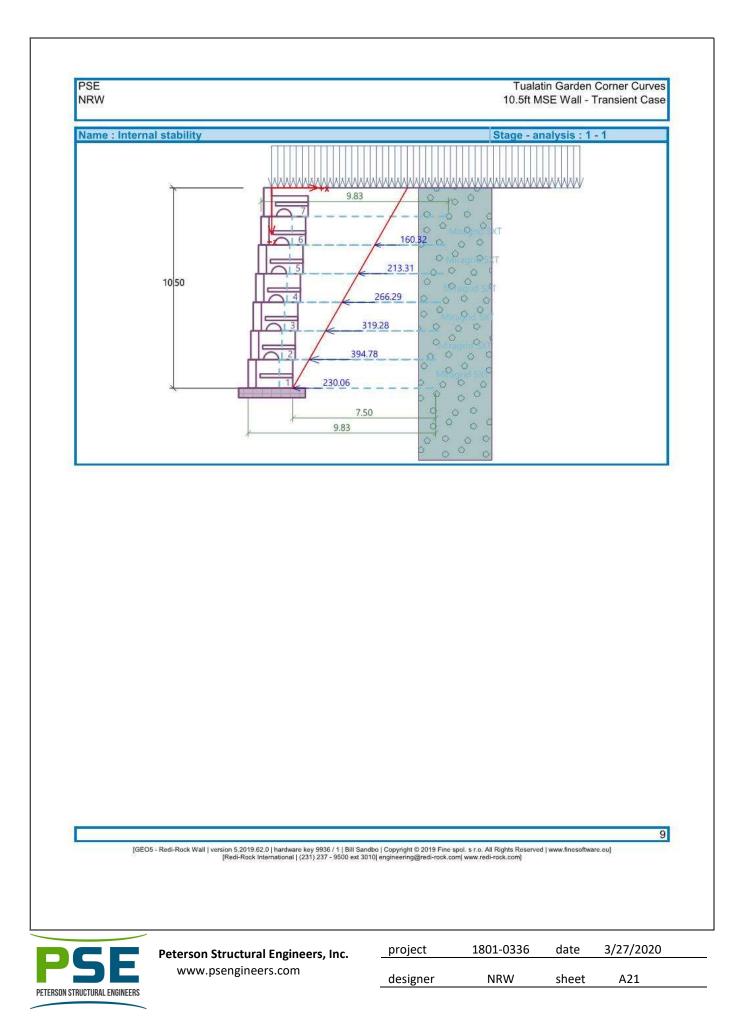
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designer	NRW	sheet	A20	



9'-0" Tall Wall – Seismic Case



project	1801-0336	date	3/27/2020	
designer	NRW	sheet	A22	

MSE Wall Design 9.0' MSE Wall - Seismic Case

Analysis of Redi Rock wall

Input data

Project

NRW

Task: MSE Wall DesignPart: 9.0' MSE Wall - Seismic CaseAuthor: NRWDate: 11/25/2019Project 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 :
 Could

 Passive earth pressure calculation :
 Mazin

 Earthquake analysis :
 Monor

 Shape of earth wedge :
 Calculation

 Allowable eccentricity :
 0.333

 Internal stability :
 Stand

 Reduction coeff. of contact first block - base :
 1.000

 Verification methodology :
 Safet

Coulomb Mazindrani (Rankine) Mononobe-Okabe Calculate as skew 0.333 Standard - straight slip surface 1.00 Safety factors (ASD)

Safety fac	ctors					
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

Material

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

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designer	NRW	sheet	A23	

Types of reinforcements

NRW

NI.	Manag	The state of the st		Tensile strength			
No.	Name	Type of reinforcement	Line type	Tult [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	mmmm	27415.00	13716.42	10560.73	

Reinforcement details

1. Miragrid 5XT	22.5		1000.00	
Short-term char. strength	Tult		4700.00	
Creep red. factor	RFCR		1.58	
Durability red. factor	RFD	=	1.15	
Installation damage red. factor	RFID	=	1.25	
Long-term design strength	Rt	=	2069.35	lbf/ft
Coefficient of direct slip along reinforcement	Cds	=	0.67	
Coefficient of interaction of soil and geo-reinforcement	Ci	=	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	Tult	=	7400.00	lbf/ft
Creep red. factor	RFCR	=	1.58	
Durability red. factor	RFD	=	1.15	
Installation damage red. factor	RFID	=	1.20	
Long-term design strength	Rt	=	3393.87	lbf/ft
Coefficient of direct slip along reinforcement	Cds	=	0.67	
Coefficient of interaction of soil and geo-reinforcement		=	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	Tult	=	9500.00	lbf/ft
Creep red. factor	RF_{CR}	=	1.58	
Durability red. factor	RFD	=	1.15	
Installation damage red. factor	RFID	=	1.20	
Long-term design strength	Rt	=	4357.00	lbf/ft
Coefficient of direct slip along reinforcement	Cds	=	0.67	
Coefficient of interaction of soil and geo-reinforcement	Ci	=	0.67	
Scale correction factor	α	=	0.8	
Long-term strength reduction factor	CR _{cr}	=	0.519	
Analysis of long-term strength	R _{con}	Ξ	4287.39	lbf/ft

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designer NRW	sheet	A24	

NRW

MSE Wall Design 9.0' MSE Wall - Seismic Case

4. Miragrid 20XT				
Short-term char. strength	Tult	=	13705.00	lbf/ft
Creep red. factor	RFCR	=	1.58	
Durability red. factor	RFD	=	1.15	
Installation damage red. factor	RFID	=	1.15	
Long-term design strength	Rt	=	6558.83	lbf/ft
Coefficient of direct slip along reinforcement	Cds	=	0.67	
Coefficient of interaction of soil and geo-reinforcement		=	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	Tult	=	27415.00	lbf/ft
Creep red. factor	RFCR	=	1.58	
Durability red. factor	RFD	=	1.15	
Installation damage red. factor	RFID	=	1.10	
Long-term design strength	Rt	=	13716.42	lbf/ft
Coefficient of direct slip along reinforcement	Cds	=	0.67	
Coefficient of interaction of soil and geo-reinforcement		=	0.67	
Scale correction factor	α	=	0.8	
Long-term strength reduction factor	CRcr	=	0.443	
Analysis of long-term strength	R _{con}	=	10560.73	lbf/ft
Painforcoments				

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 I = 6.50 ft **Reinforcements**

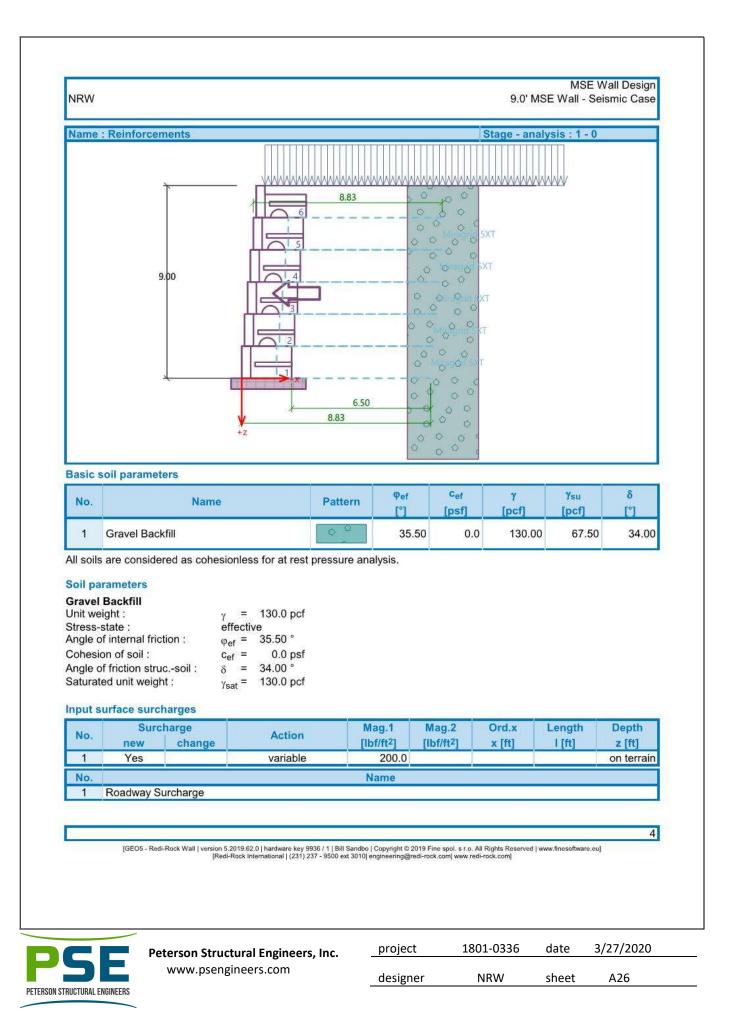
No.	Consider	Name	Length of reinforcement I [ft]	End pt. coordinate I _k [ft]
1	Yes	Miragrid 5XT	6.50	
2	Yes	Miragrid 5XT	6.50	
3	Yes	Miragrid 5XT	6.50	
4	Yes	Miragrid 5XT	6.50	
5	Yes	Miragrid 5XT	6.50	
6	No	0.539		

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NRW

Resistance on front face of the structure

Resistance on front face of the structure is not considered.

Earthquake

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	Fhor	App.Pt.	Fvert	App.Pt.	Design
	[lbf/ft]	z [ft]	[lbf/ft]	x [ft]	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

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

5

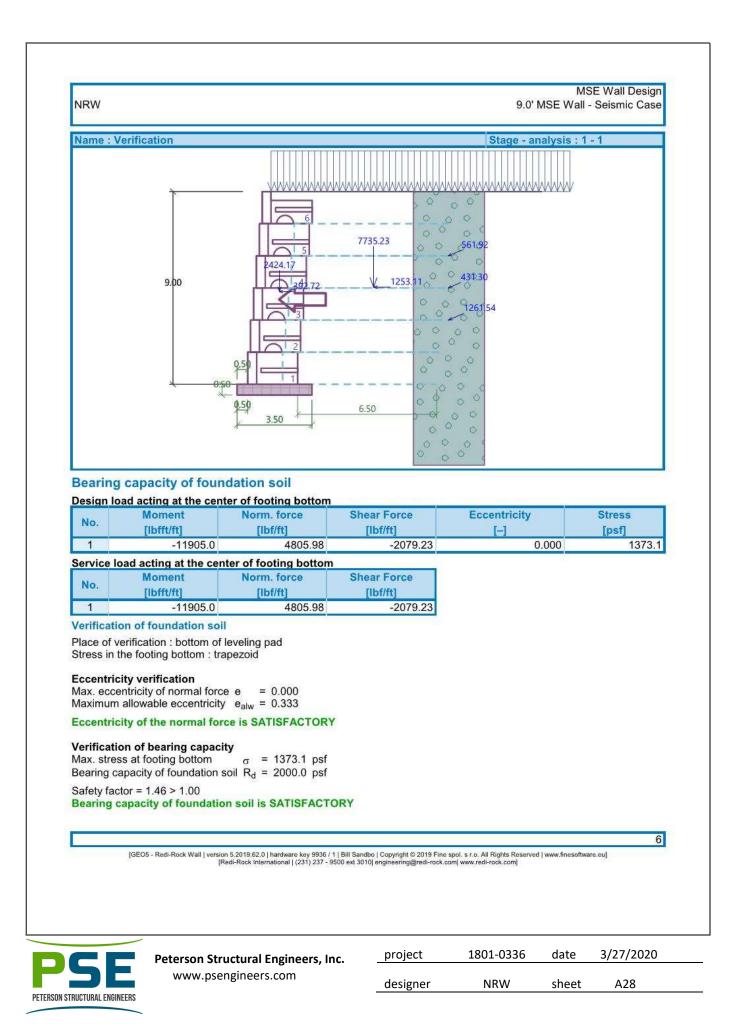
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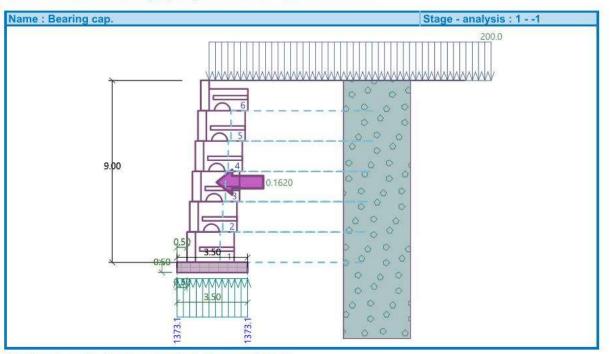
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Overall verification - bearing capacity of found. soil is SATISFACTORY



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	0
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:

NRW

Resisting horizontal force Hres = 6373.87 lbf/ft

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NRW

Active horiz, force $H_{act} = 2065.13 \text{ lbf/ft}$ 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

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

Overall verification - reinforcement is SATISFACTORY

Force in reinforcement $F_x = 204.08$ lbf/ft Safety factor = 2.66 > 1.10 **Connection strength is SATISFACTORY**

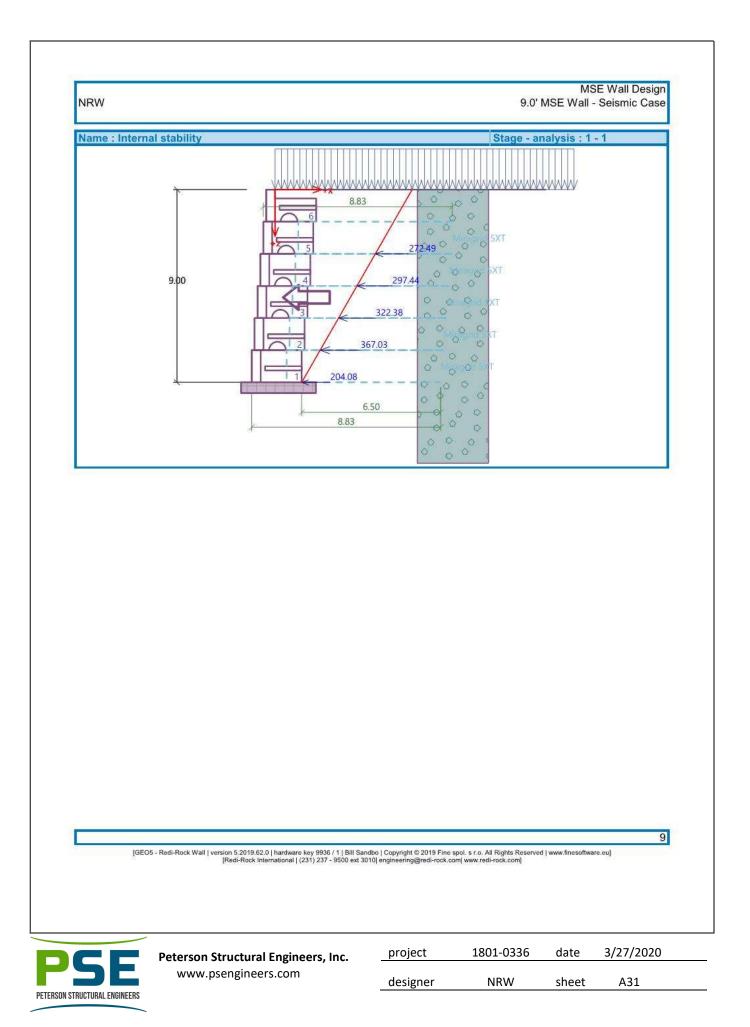
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<u>9'-0" Tall Wall – Transient Case</u>



project	1801-0336	date	3/27/2020	
designer	NRW	sheet	A32	

PSE NRW

1801-0336 9.0' MSE 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
Reduction coeff. of contact first block - base :	1.00
Verification methodology :	Safety factors (ASD)

	Standard - straight slip surface
:	1.00
	Safety factors (ASD)

Safety fac	ctors		
Transient desig	n 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

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project	1801-0336	date	3/27/2020	
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	Top block 41 Top block 24 straight garden	Fmir			ngth	
6 etback No. 1 2	Top block 24 straight garden		n [lbf/ft]		[lbf/ft]	f [°]
etback No. 1 2			6061.00		11276.00	44.0
No. 1 2	(S		6061.00		11276.00	44.0
1 2						
2	Setback s [in]					
	0.010					
	0.375					
6	3.250					
eome						
No.	Description			Count		Setback s [in]
Statement of the local division in the local	Block 28 PC				5	1.6
2	Top block 28				1	-
lpper s ower s leight /idth lateria Inreinfo concret hear c	etback $a_1 = 0.50$ ft etback $a_2 = 0.50$ ft h = 0.50 ft b = 3.50 ft					
ower s leight /idth lateria Inreinfo concret hear c riction	etback $a_1 = 0.50$ ft etback $a_2 = 0.50$ ft h = 0.50 ft b = 3.50 ft l preced Footing te self-weight $\gamma = 150.00$ pcf ub (key) capacity = 0.00 lbf/ft					
Ipper s ower s leight /idth Inreinfo concret hear cl riction	etback $a_1 = 0.50$ ft etback $a_2 = 0.50$ ft h = 0.50 ft b = 3.50 ft l prede Footing te self-weight $\gamma = 150.00$ pcf ub (key) capacity = 0.00 lbf/ft angle concrete-concrete = 30.00 °	t Line type	• Tutt	Te [lbf/ft]	ensile streng R _t [lbf/ft]	The second second second
Ipper s ower s leight Vidth Iateria Inreinfo concret hear co riction ypes c No.	etback $a_1 = 0.50$ ft etback $a_2 = 0.50$ ft h = 0.50 ft b = 3.50 ft l prede Footing te self-weight $\gamma = 150.00$ pcf ub (key) capacity = 0.00 lbf/ft angle concrete-concrete = 30.00 ° of reinforcements	Line type	• Tut			R _{con} [lbf/ft]
lpper s ower s leight /idth lateria inreinfo concret hear ci riction ypes c No.	etback $a_1 = 0.50$ ft etback $a_2 = 0.50$ ft h = 0.50 ft b = 3.50 ft l proced Footing te self-weight $\gamma = 150.00$ pcf ub (key) capacity = 0.00 lbf/ft angle concrete-concrete = 30.00 ° of reinforcements Name Type of reinforcement	Line type	•	[lbf/ft]	R _t [lbf/ft]	R _{con} [lbf/ft]
lpper s ower s leight /idth lateria inreinfo concret hear ci riction ypes c No. 1 2	etback $a_1 = 0.50$ ft etback $a_2 = 0.50$ ft h = 0.50 ft b = 3.50 ft l proced Footing te self-weight $\gamma = 150.00$ pcf ub (key) capacity = 0.00 lbf/ft angle concrete-concrete = 30.00 ° of reinforcements Name Type of reinforcement Miragrid 5XT Miragrid 5XT	Line type	• Tull	[lbf/ft] 4700.00	R _t [lbf/ft] 2069.35	R _{con} [lbf/ft] 2174.20 3423.30
lpper s ower s leight /idth lateria lorreinfo concret hear co riction ypes c No. 1 2 3	etback $a_1 = 0.50$ ft etback $a_2 = 0.50$ ft $h = 0.50$ ft $b = 3.50$ ftIb = 3.50 ftIpreced Footing te self-weight $\gamma = 150.00$ pcf ub (key) capacity = 0.00 lbf/ft angle concrete-concrete = 30.00 °of reinforcementsType of reinforcementMiragrid 5XTMiragrid 5XTMiragrid 8XTMiragrid 8XT	t Line type		[lbf/ft] 4700.00 7400.00	R _t [lbf/ft] 2069.35 3393.87	R _{con} [lbf/ft] 2174.20 3423.30 4287.30



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project	1801-0336	date	3/27/2020	
designer	NRW	sheet	A34	

PSE NRW 1801-0336 9.0' MSE Wall - Transient Case

Durability red. factor	RFD	=	1.15				
	RFID	=					
	Rt	=	2069.35	lbf/ft			
	Cds	=	0.67				
Coefficient of interaction of soil and geo-reinforcement		=	0.67				
Scale correction factor	α	=	0.8				
		=	0.532				
		=	2174.26	lbf/ft			
2. Miragrid 8XT							
· 전철 사망 사망 수 있는 것 같은 것 같	Tult	=	7400.00	lbf/ft			
Creep red. factor	RFCR	=	1.58				
		=					
	RFID	=	1.20				
	Rt		3393.87	lbf/ft			
	Cds	=	0.67				
Coefficient of interaction of soil and geo-reinforcement	100000000	=	0.67				
	α	=					
	2010-01	=	12 N (232)(23)				
	R _{con}	=	3423.30	lbf/ft			
3. Miragrid 10XT							
2 2 2 4 1 2 2 2 5 5 5 2 2 2 2 2 2 2 2 2 2 2 2 2	T _{ult}	=	9500.00	lbf/ft			
Creep red. factor	RFCR	=	1.58				
Durability red. factor	RFD	=	1.15				
Installation damage red. factor	RF ID	=	1.20				
Long-term design strength	Rt	=	4357.00	lbf/ft			
Coefficient of direct slip along reinforcement	Cds	=	0.67				
Coefficient of interaction of soil and geo-reinforcement		=	0.67				
Scale correction factor	α	=	0.8				
Long-term strength reduction factor	CR _{cr}	=	0.519				
	R _{con}	=	4287.39	lbf/ft			
4. Miragrid 20XT							
	Tult	=	13705.00	lbf/ft	ť		
	RFCR	=	1.58	1			
		=		i			
	RFID	=	1.15				
	Rt	=		lbf/ft	it		
	Cds	=	0.67	•			
Coefficient of interaction of soil and geo-reinforcement		=					
<u> </u>	α	=					
		=					
전문 전화 중 전화 방법 전문 전문 전화 전문 전문 전문 전화 영화 전문					it		
5. Miragrid 24XT	07500						
	Tult	=	27415.00	lbf/ft	ft		
	RFCR						
	RFD						
	RFID						
	Rt		13716.42		ft		
Long-term design strength			10.12	- month			

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1801-0336 9.0' MSE Wall - Transient Case

Coefficient of interaction of soil and geo-reinforcement	Ci	=	0.67
Scale correction factor	α	Ξ	0.8
Long-term strength reduction factor	CRcr	=	0.443
Analysis of long-term strength	R _{con}	=	10560.73 lbf/ft

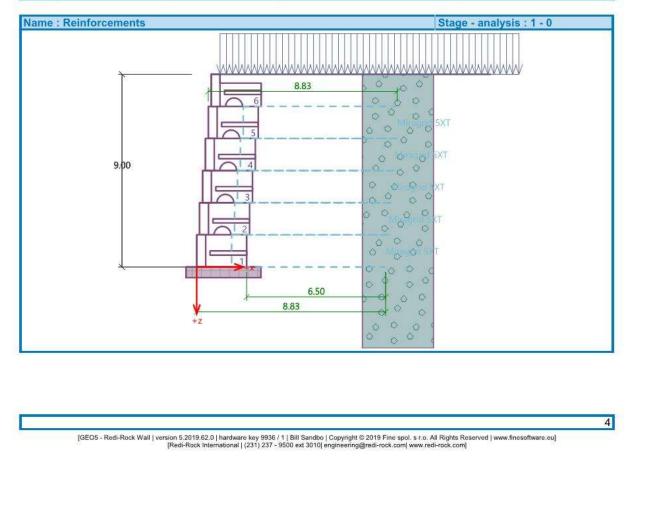
Reinforcements

PSE

NRW

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 I = 6.50 ft **Reinforcements**

No.	Consider	Name	Length of reinforcement I [ft]	End pt. coordinate I _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			





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project	1801-0336	date	3/27/2020	
designer	NRW	sheet	A36	

PSE NRW					9.0' MSE	1 Wall - Trans	801-0336 ient Case
Basic No.	soil parameters Name	Pattern	Φef [°]	c _{ef} [psf]	γ [pcf]	Ύsu [pcf]	δ [°]
1	Gravel Backfill		35.50	0.0	130.00	67.50	34.00

Soil parameters

Gravel Backfill		
Unit weight :	γ =	130.0 pcf
Stress-state :	effectiv	ve
Angle of internal friction :	$\varphi_{ef} =$	35.50 °
Cohesion of soil :	c _{ef} =	0.0 psf
Angle of friction strucsoil :	δ =	34.00 °
Saturated unit weight :	_{γsat} =	130.0 pcf

Geological profile and assigned soils

No.	Thickness of layer t [ft]	Depth z [ft]	Assigned soil	Pattern
1	-	∞ 00.0	Gravel Backfill	©

Terrain profile

Terrain behind the structure is flat.

Water influence

Ground water table is located below the structure.

Input surface surcharges

No.	Sur	charge change	Action	Mag.1 [lbf/ft ²]	Mag.2 [lbf/ft ²]	Ord.x x [ft]	Length I [ft]	Depth z [ft]
1	Yes		variable	200.0				on terrain
No.				Name				
1	Roadway S	urcharge						- Di

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

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designer NRW sh	neet A37

PSE NRW				9.0' MSE Wa	1801-0336 Il - Transient Case
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

0.0

-4.33

2424.2

1.48

1.000

Verification of complete wall

Place of verification : bottom of blocks

Check for overturning stability

Safety factor = 10.57 > 1.50 Wall for overturning is SATISFACTORY

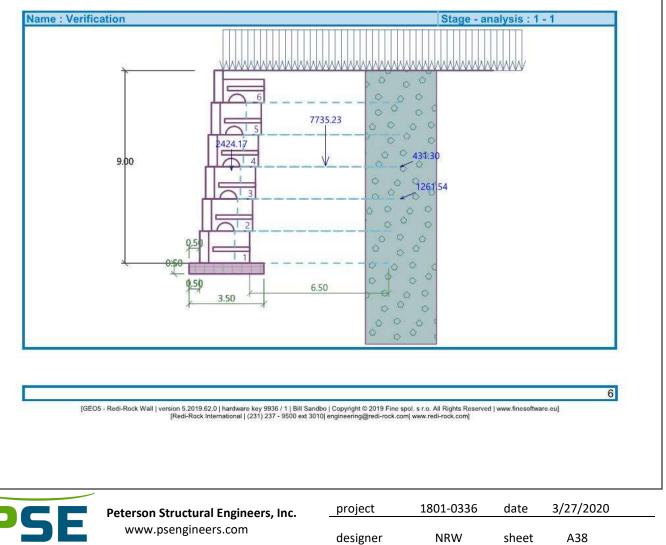
Check for slip

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Weight - wall

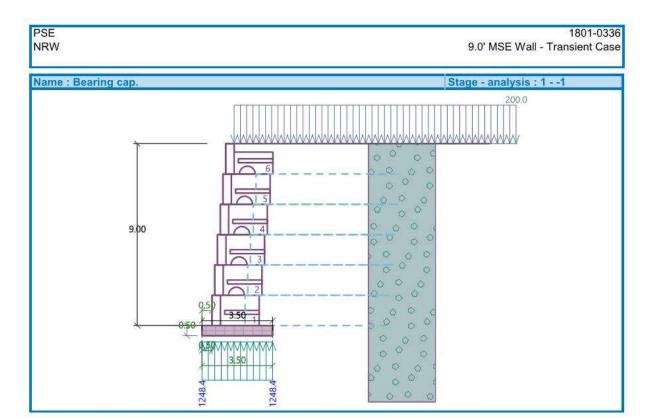
Safety factor = 4.58 > 1.50 Wall for slip is SATISFACTORY

Overall check - WALL is SATISFACTORY



				9.0' MSE	Wall - Tran	1801-0336 sient Case
Bearing	capacity of four	ndation soil				
	ad acting at the cer Moment	nter of footing bottom	Shear Force	Eccentricity	Str	ress
No.	[lbfft/ft]	[lbf/ft]	[lbf/ft]	[-]		osf]
1	-17038.2	4369.40	-3123.97	0.00	0	1248.4
Service lo		nter of footing bottom	Shear Force			
No.	Moment [lbfft/ft]	Norm. force [lbf/ft]	[lbf/ft]			
1	-17038.2	4369.40	-3123.97			
Verificati	on of foundation so	il				
	verification : bottom of the footing bottom : tr					
Max. ecce	ity verification entricity of normal fore allowable eccentricit					
		rce is SATISFACTOR	1			
Verification Max. stress	on of bearing capac ss at footing bottom					
	ctor = 1.60 > 1.33	on soil is SATISFACT				
						7
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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	0
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 $H_{act} = 1550.47 \text{ lbf/ft}$

Factor of safety = 4.94 > 1.50

Slip along geotextile is SATISFACTORY

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project	1801-0336	date	3/27/2020	
designer	NRW	sheet	A40	

1801-0336 9.0' MSE Wall - Transient Case

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

PSE

NRW

Reinforcement for tensile strength is SATISFACTORY

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

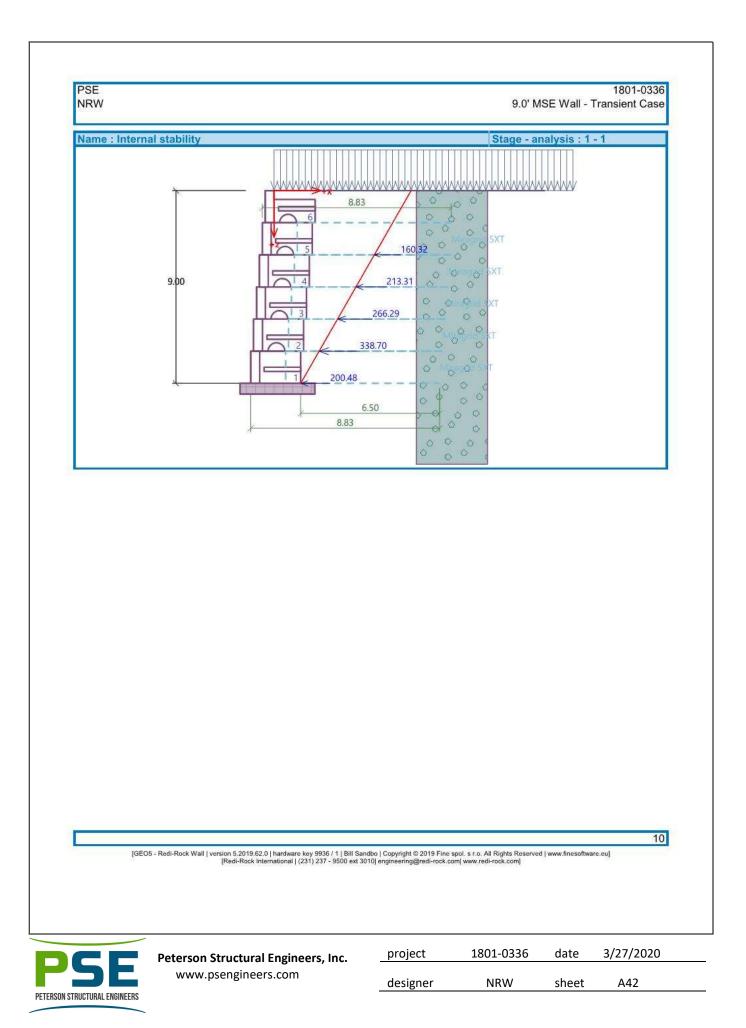
Overall verification - reinforcement is SATISFACTORY

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designer	NRW	sheet	A41	



7'-6" Tall Wall – Seismic Case



project	1801-0336	date	3/27/2020	
designer	NRW	sheet	A43	

Analysis of Redi Rock wall

Input data

Project

NRW

Task: MSE Wall DesignPart: 7.5' MSE Wall - Seismic CaseAuthor: NRWDate: 11/25/2019Project 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 :
 Could

 Passive earth pressure calculation :
 Mazin

 Earthquake analysis :
 Monor

 Shape of earth wedge :
 Calculation

 Allowable eccentricity :
 0.333

 Internal stability :
 Stand

 Reduction coeff. of contact first block - base :
 1.000

 Verification methodology :
 Safet

Coulomb Mazindrani (Rankine) Mononobe-Okabe Calculate as skew 0.333 Standard - straight slip surface 1.00 Safety factors (ASD)

Safety fac	tors	
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

Material

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

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designer	NRW	sheet	A44	

Types of reinforcements

No. Namo	Name Time of reinforcement		Tensile strength			
No.	Name	Type of reinforcement	Line type	Tult [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	6030.2 <mark>0</mark>
5	Miragrid 24XT	Miragrid 24XT	mmmmm	27415.00	13716.42	10560.73

Reinforcement details

1. Miragrid 5XT	252		10350/255	10121210
Short-term char. strength	Tult		4700.00	lbf/ft
Creep red. factor	RFCR		1.58	
Durability red. factor	RFD	=	1.15	
Installation damage red. factor	RF ID	=	1.25	
Long-term design strength	Rt	=	2069.35	lbf/ft
Coefficient of direct slip along reinforcement	Cds	=	0.67	
Coefficient of interaction of soil and geo-reinforcement	Ci	Ξ	0.67	
Scale correction factor	α	=	0.8	
Long-term strength reduction factor	CRcr	=	0.532	
Analysis of long-term strength	R_{con}	=	2174.26	lbf/ft
2. Miragrid 8XT				
Short-term char. strength	Tult	=	7400.00	lbf/ft
Creep red. factor	RFCR	=	1.58	
Durability red. factor	RFD	=	1.15	
Installation damage red. factor	RFID	=	1.20	
Long-term design strength	Rt	=	3393.87	lbf/ft
Coefficient of direct slip along reinforcement	Cds	=	0.67	
Coefficient of interaction of soil and geo-reinforcement		=	0.67	
Scale correction factor	α	=	0.8	
Long-term strength reduction factor	CRcr	=	0.532	
Analysis of long-term strength	R _{con}	=	3423.30	lbf/ft
3. Miragrid 10XT				
Short-term char. strength	Tult	=	9500.00	lbf/ft
Creep red. factor	RFCR	=	1.58	
Durability red. factor	RFD	=	1.15	
Installation damage red. factor	RFID	=	1.20	
Long-term design strength	Rt	=	4357.00	lbf/ft
Coefficient of direct slip along reinforcement	Cds	=	0.67	
Coefficient of interaction of soil and geo-reinforcement	Ci	=	0.67	
Scale correction factor	α	=	0.8	
Long-term strength reduction factor	CRcr	=	0.519	
Analysis of long-term strength	R _{con}	Ξ	4287.39	lbf/ft

2

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designer	NRW	sheet	A45	

NRW

NRW

4. Miragrid 20XT				
Short-term char. strength	Tult	=	13705.00	lbf/ft
Creep red. factor	RFCR	=	1.58	
Durability red. factor	RFD	=	1.15	
Installation damage red. factor	RFID	=	1.15	
Long-term design strength	Rt	=	6558.83	lbf/ft
Coefficient of direct slip along reinforcement	Cds	=	0.67	
Coefficient of interaction of soil and geo-reinforcement		=	0.67	
Scale correction factor	α	=	0.8	
Long-term strength reduction factor	CRcr	=	0.506	
Analysis of long-term strength	R _{con}	=	6030.20	lbf/ft
5. Miragrid 24XT				
Short-term char. strength	Tult	=	27415.00	lbf/ft
Creep red. factor	RFCR	=	1.58	
Durability red. factor	RFD	=	1.15	
Installation damage red. factor	RFID	=	1.10	
Long-term design strength	Rt	=	13716.42	lbf/ft
Coefficient of direct slip along reinforcement	Cds	=	0.67	
Coefficient of interaction of soil and geo-reinforcement		=	0.67	
Scale correction factor	α	=	0.8	
Long-term strength reduction factor	CRcr	=	0.443	
Analysis of long-term strength	R _{con}	=	10560.73	lbf/ft
Painforcomonte				

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 I = 5.50 ft **Reinforcements**

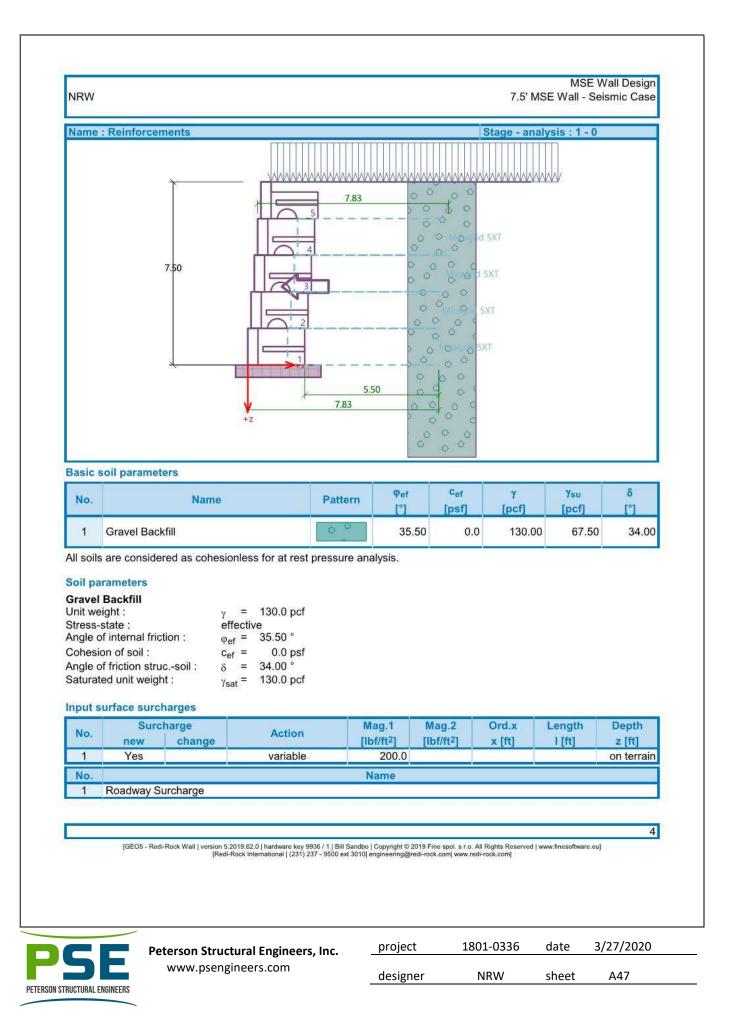
No.	Consider	Name	Length of reinforcement I [ft]	End pt. coordinate I _k [ft]
1	Yes	Miragrid 5XT	5.50	
2	Yes	Miragrid 5XT	5.50	
3	Yes	Miragrid 5XT	5.50	
4	Yes	Miragrid 5XT	5.50	
5	No			

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designer	NRW	sheet	A46



NRW

Resistance on front face of the structure

Resistance on front face of the structure is not considered.

Earthquake

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	Fhor	App.Pt.	Fvert	App.Pt.	Design
	[lbf/ft]	z [ft]	[lbf/ft]	x [ft]	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

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

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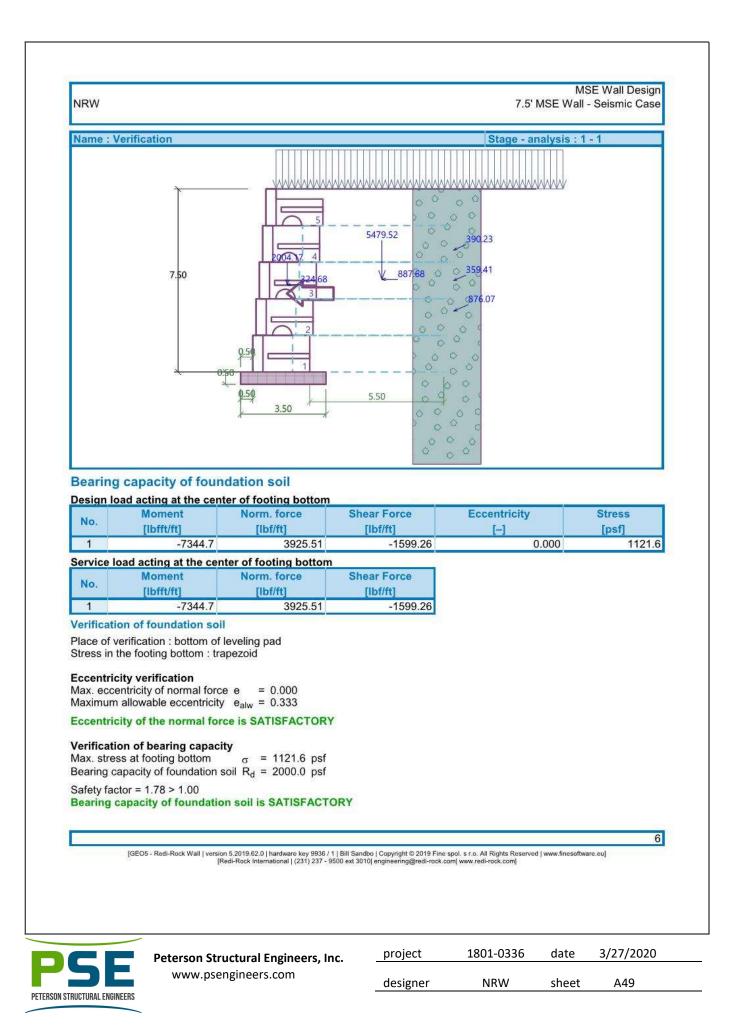
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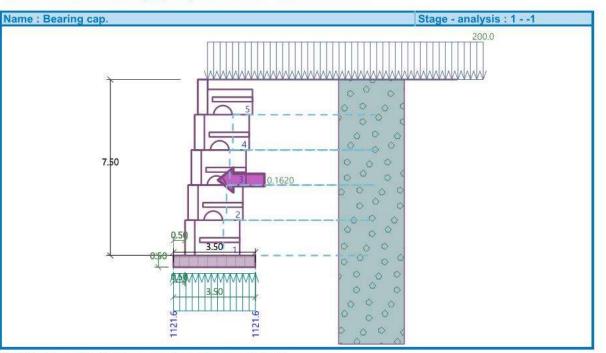
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designer	NRW	sheet	A48



Overall verification - bearing capacity of found. soil is SATISFACTORY



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	0
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:

NRW

Resisting horizontal force Hres = 4714.26 lbf/ft

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Active horiz. forceHact= 1488.98 lbf/ftFactor of safety = 3.17 > 1.10Slip 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

NRW

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

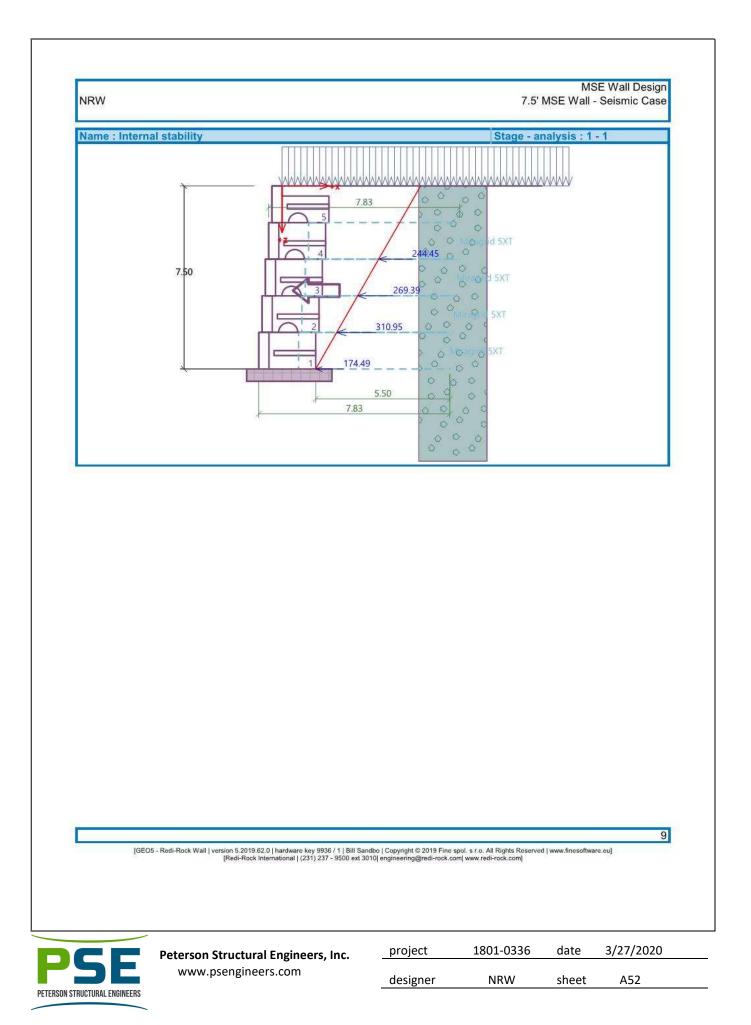
Overall verification - reinforcement is SATISFACTORY

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designer	NRW	sheet	A51	



7'-6" Tall Wall – Transient Case



project	1801-0336	date	3/27/2020	
designer	NRW	sheet	A53	

PSE NRW 1801-0336 7.5' MSE 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 :	
Verification methodology :	Safety factors (ASD)

Safety fac	ctors	
Transient desig	n 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	25

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 °

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designer	NRW	sheet	A54	

1801-0336 7.5' MSE Wall - Transient Case

Types of reinforcements

Reinforcement details

PSE

NRW

No.	A DECEMBER OF	The second second	1.000	Te	nsile strengt	strength	
NO.	Name	Type of reinforcement	Line type	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	mmmm	27415.00	13716.42	10560.73	

1. Miragrid 5XT	_			
Short-term char. strength	Tult		4700.00	lbf/ft
Creep red. factor	RFCR		1.58	
Durability red. factor	RFD	=	1.15	
Installation damage red. factor	RFID	-	1.25	
Long-term design strength	Rt	=	1000	lbf/ft
Coefficient of direct slip along reinforcement	Cds	=	0.67	
Coefficient of interaction of soil and geo-reinforcement	Ci	=	0.0.	
Scale correction factor	α	=	0.0	
Long-term strength reduction factor	CR_{cr}	=	0.00-	
Analysis of long-term strength	R_{con}	=	2174.26	lbf/ft
2. Miragrid 8XT				
Short-term char. strength	Tult		7400.00	lbf/ft
Creep red. factor	RF_{CR}		1.58	
Durability red. factor	RF_D	=		
Installation damage red. factor	RF ID	=		
Long-term design strength	Rt	=	3393.87	lbf/ft
Coefficient of direct slip along reinforcement	Cds	=	0.67	
Coefficient of interaction of soil and geo-reinforcement	Ci	=	0.67	
Scale correction factor	α	=	0.0	
Long-term strength reduction factor	CR_{cr}	=		
Analysis of long-term strength	R _{con}	=	3423.30	lbf/ft
3. Miragrid 10XT				
Short-term char. strength	Tult		9500.00	lbf/ft
Creep red. factor	RFCR	=	1.58	
Durability red. factor	RFD	=	1.15	
Installation damage red. factor	RFID	=	1.20	
Long-term design strength	Rt	=	4357.00	lbf/ft
Coefficient of direct slip along reinforcement	Cds	=	0.67	
Coefficient of interaction of soil and geo-reinforcement	Ci	=	0.67	
Scale correction factor	α	=	0.8	
Long-term strength reduction factor	CRcr	=	0.519	
Analysis of long-term strength	R _{con}	=	4287.39	lbf/ft
4. Miragrid 20XT				

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designer	NRW	sheet	A55	

PSE NRW 1801-0336 7.5' MSE Wall - Transient Case

Short-term char. strength	Tult	=	13705.00	lbf/ft
Creep red. factor	RFCR	=	1.58	
Durability red. factor	RFD	=	1.15	
Installation damage red. factor	RFID	=	1.15	
Long-term design strength	Rt	=	6558.83	lbf/ft
Coefficient of direct slip along reinforcement	Cds	=	0.67	
Coefficient of interaction of soil and geo-reinforcement		=	0.67	
Scale correction factor	α	=	0.8	
Long-term strength reduction factor	CRcr	=	0.506	
Analysis of long-term strength	R _{con}	=	6030.20	lbf/ft
5. Miragrid 24XT				
Short-term char. strength	Tult	=	27415.00	lbf/ft
Creep red. factor	RFCR	=	1.58	
Durability red. factor	RFD	=	1.15	
Installation damage red. factor	RFID	=	1.10	
Long-term design strength	Rt	=	13716.42	lbf/ft
Coefficient of direct slip along reinforcement	Cds	=	0.67	
Coefficient of interaction of soil and geo-reinforcement		=	0.67	
Scale correction factor	α	=	0.8	
Long-term strength reduction factor	CRcr	Ξ	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 I = 5.50 ft **Reinforcements**

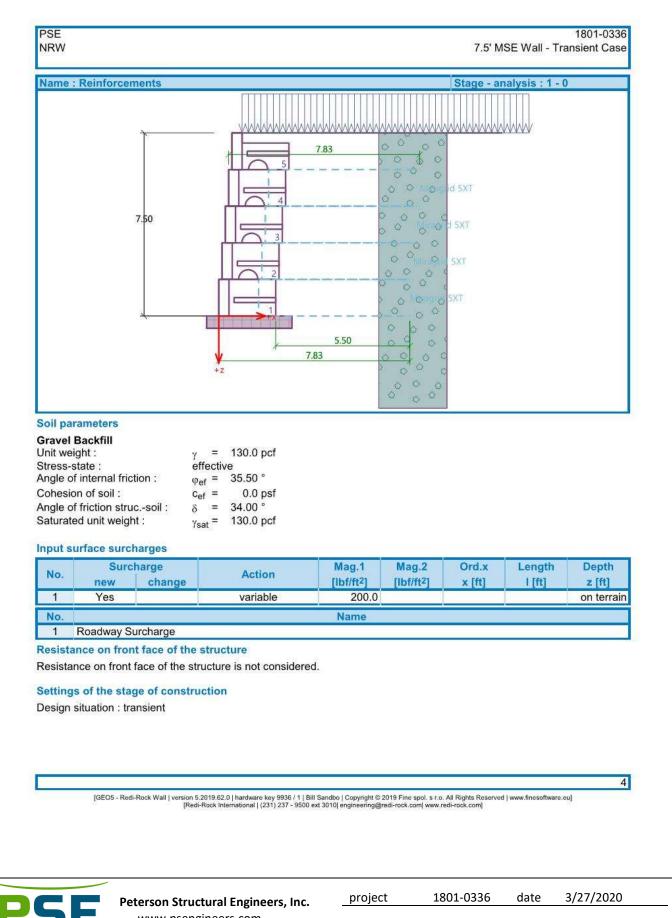
No.	Consider	Name	Length of reinforcement I [ft]	End pt. coordinate I _k [ft]
1	Yes	Miragrid 5XT	5.50	
2	Yes	Miragrid 5XT	5.50	
3	Yes	Miragrid 5XT	5.50	
4	Yes	Miragrid 5XT	5.50	
5	No			

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designer	NRW	sheet	A56	



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designer	NRW	sheet	A57	

PSE NRW

1801-0336 7.5' MSE Wall - Transient Case

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 Movr = 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

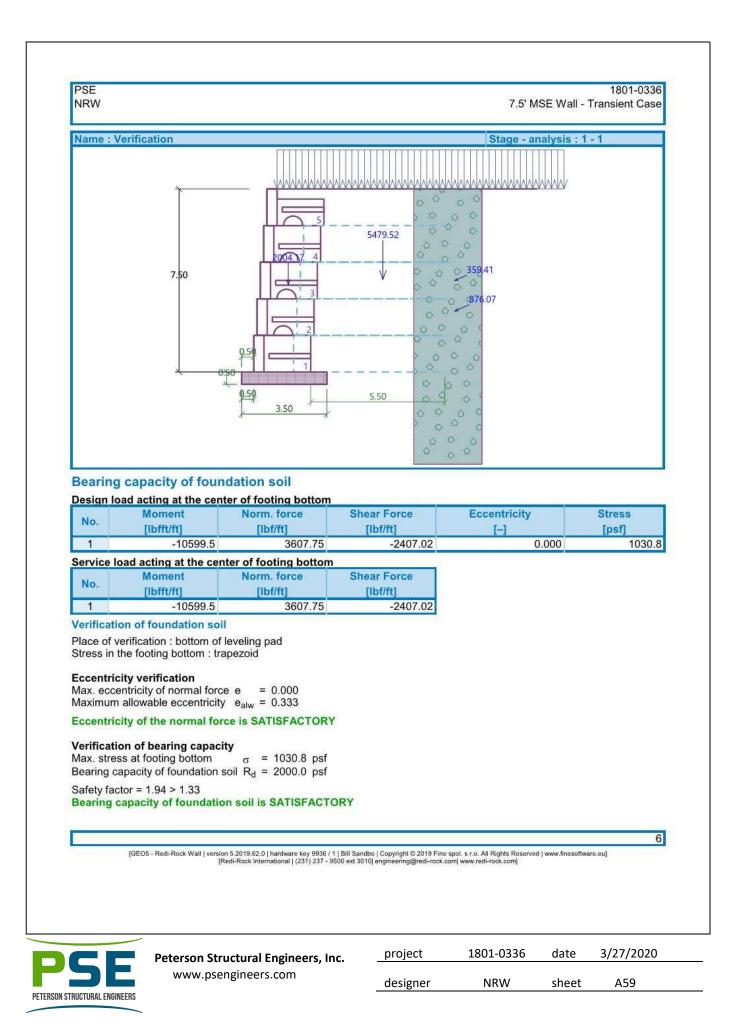
Overall check - WALL is SATISFACTORY

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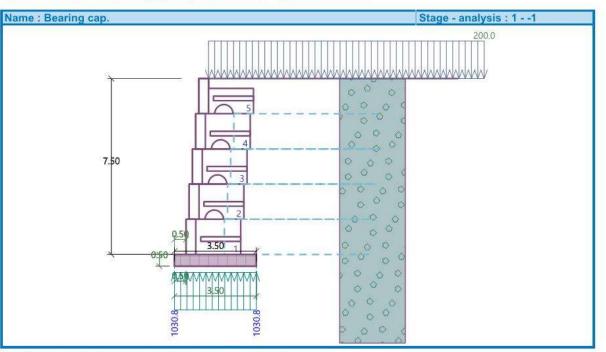
project	1801-0336	date	3/27/2020	
designer	NRW	sheet	A58	



1801-0336

7.5' MSE Wall - Transient Case

Overall verification - bearing capacity of found. soil is SATISFACTORY



Verification of slip on georeinforcement No. 1

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

Weight - wall Active pressure Roadway Surcharge Weight - reinforced soil Roadway Surcharge /erification against slip along ge	0.0 802.4 329.2 0.0 0.0	-3.58 -2.50 -3.75 -3.67	[lbf/ft] 2049.7 351.7 144.3	-3.92 5.50 5.50	1.000 1.000 1.000
Roadway Surcharge Weight - reinforced soil Roadway Surcharge /erification against slip along geo	329.2 0.0	-3.75	144.3	A second s	a second a second s
Weight - reinforced soil Roadway Surcharge /erification against slip along geo	0.0			5.50	1 000
Roadway Surcharge /erification against slip along get		-3.67	E 1 3 5 0		1.000
erification against slip along ge	0.0		5175.9	2.88	1.000
• • • • • • • • •	(T. 1 T.	-7.50	1375.0	-0.94	1.000
actor of safety = 5.12 > 1.50 Silp along geotextile is SATISFAC	= 70 geo-textile = 46 tt = 46 = 11 ements = 795.15 lbf/ft 131.58 lbf/ft CTORY				7 Sftware.cu]



PSE

NRW

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designer	NRW	sheet	A60	

1801-0336 7.5' MSE Wall - Transient Case

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 $R_t = 517.34 \text{ lbf/ft}$

Force in reinforcement $F_x = 170.89$ lbf/ft

Safety factor = 3.03 > 1.50

PSE

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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

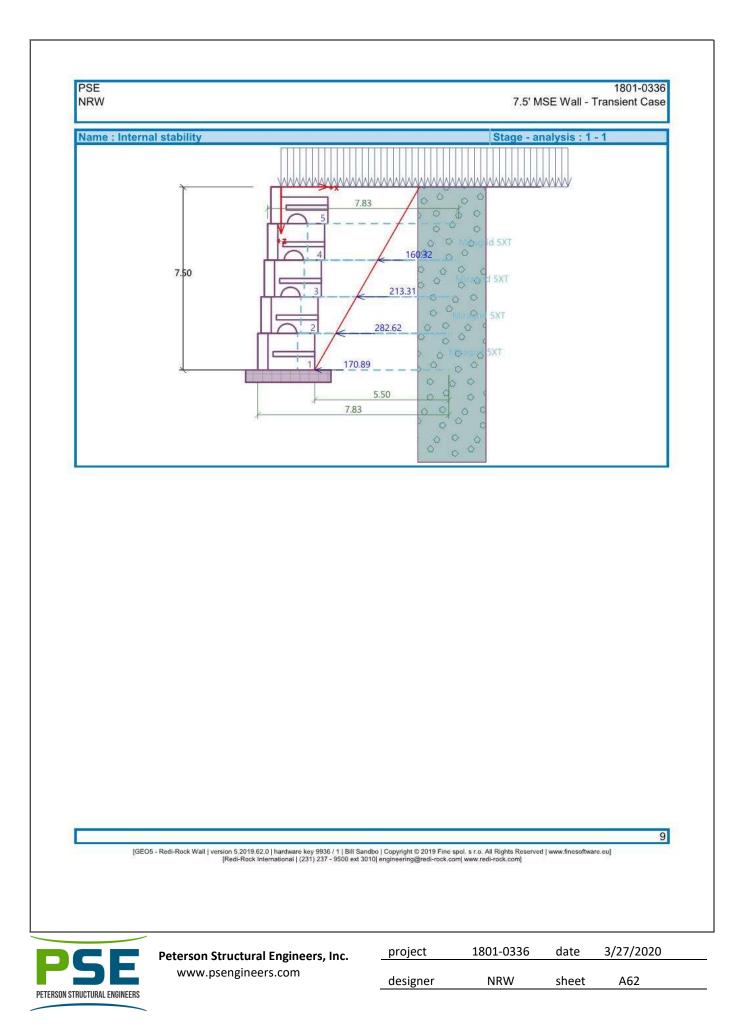
Overall verification - reinforcement is SATISFACTORY

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designer	NRW	sheet	A61	



<u>6'-0" Tall Wall – Seismic Case</u>



project	1801-0336	date	3/27/2020	
designer	NRW	sheet	A63	

Analysis of Redi Rock wall

Input data

Project

NRW

Task: MSE Wall DesignPart: 6.0' MSE Wall - Seismic CaseAuthor: NRWDate: 11/25/2019Project 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 :
 Could

 Passive earth pressure calculation :
 Mazin

 Earthquake analysis :
 Monor

 Shape of earth wedge :
 Calculation

 Allowable eccentricity :
 0.333

 Internal stability :
 Stand

 Reduction coeff. of contact first block - base :
 1.000

 Verification methodology :
 Safet

Coulomb Mazindrani (Rankine) Mononobe-Okabe Calculate as skew 0.333 Standard - straight slip surface 1.00 Safety factors (ASD)

Safety fac	tors	
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	3	1.62
2	Top block 28	1	-

Base

Material

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

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Types of reinforcements

No.		Torres of a later and a		Tensile strength			
NO.	No. Name	Type of reinforcement	Line type	Tult [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	·www.	27415.00	13716.42	10560.73	

Reinforcement details

1. Miragrid 5XT	200		1000.00	
Short-term char. strength	Tult		4700.00	
Creep red. factor	RFCR		1.58	
Durability red. factor	RFD	=	1.15	
Installation damage red. factor	RFID	=	1.25	
Long-term design strength	Rt	=	2069.35	lbf/ft
Coefficient of direct slip along reinforcement	Cds	=	0.67	
Coefficient of interaction of soil and geo-reinforcement	Ci	=	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	Tult	=	7400.00	lbf/ft
Creep red. factor	RFCR	=	1.58	
Durability red. factor	RFD	=	1.15	
Installation damage red. factor	RFID	=	1.20	
Long-term design strength	Rt	=	3393.87	lbf/ft
Coefficient of direct slip along reinforcement	Cds	=	0.67	
Coefficient of interaction of soil and geo-reinforcement		=	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	Tult	=	9500.00	lbf/ft
Creep red. factor	RFCR	=	1.58	
Durability red. factor	RFD	=	1.15	
Installation damage red. factor	RFID	=	1.20	
Long-term design strength	Rt	=	4357.00	lbf/ft
Coefficient of direct slip along reinforcement	Cds	=	0.67	
Coefficient of interaction of soil and geo-reinforcement	Ci	=	0.67	
Scale correction factor	α	=	0.8	
Long-term strength reduction factor	CRcr	=	0.519	
Analysis of long-term strength	R _{con}	Ξ	4287.39	lbf/ft

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NRW

MSE Wall Design 6.0' MSE Wall - Seismic Case

4. Miragrid 20XT				
Short-term char. strength	Tult	=	13705.00	lbf/ft
Creep red. factor	RFCR	=	1.58	
Durability red. factor	RFD	=	1.15	
Installation damage red. factor	RFID	=	1.15	
Long-term design strength	Rt	=	6558.83	lbf/ft
Coefficient of direct slip along reinforcement	Cds	=	0.67	
Coefficient of interaction of soil and geo-reinforcement		=	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	Tult	=	27415.00	lbf/ft
Creep red. factor	RFCR	=	1.58	
Durability red. factor	RFD	=	1.15	
Installation damage red. factor	RFID	=	1.10	
Long-term design strength	Rt	=	13716.42	lbf/ft
Coefficient of direct slip along reinforcement	Cds	=	0.67	
Coefficient of interaction of soil and geo-reinforcement		=	0.67	
Scale correction factor	α	=	0.8	
Long-term strength reduction factor	CRcr	=	0.443	
Analysis of long-term strength	R _{con}	=	10560.73	lbf/ft
Reinforcements				

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 I = 4.50 ft **Reinforcements**

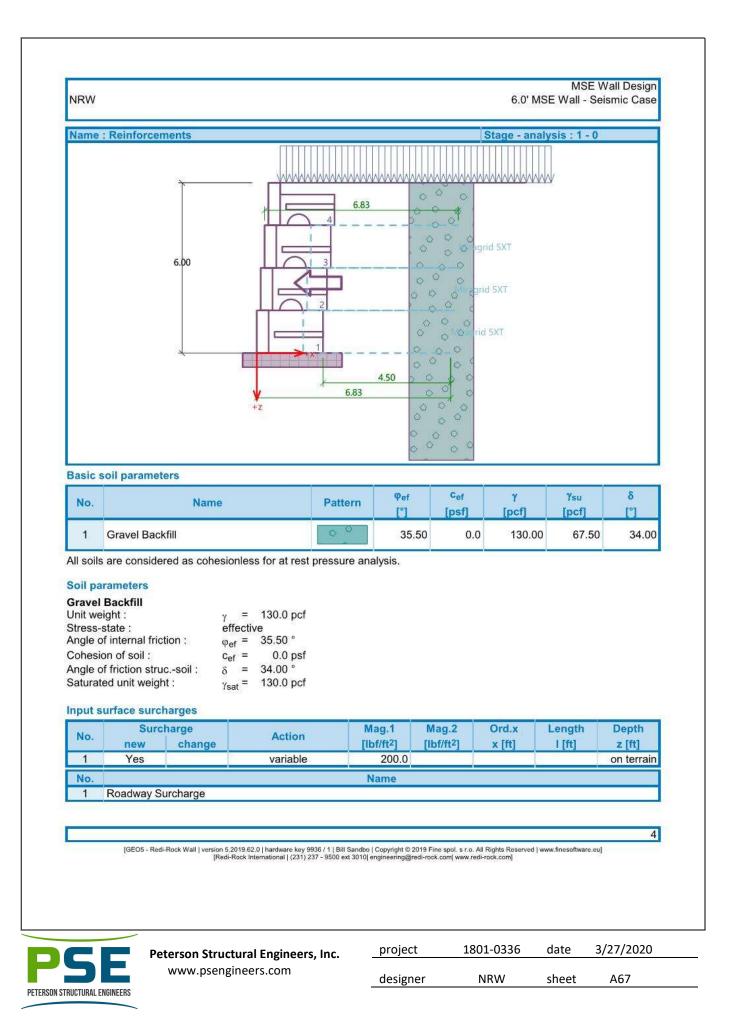
No.	Consider	Name	Length of reinforcement I [ft]	End pt. coordinate I _k [ft]
1	Yes	Miragrid 5XT	4.50	
2	Yes	Miragrid 5XT	4.50	
3	Yes	Miragrid 5XT	4.50	
4	No			

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designer	NRW	sheet	A66	



NRW

Resistance on front face of the structure

Resistance on front face of the structure is not considered.

Earthquake

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	Fhor	App.Pt.	Fvert	App.Pt.	Design
	[lbf/ft]	z [ft]	[lbf/ft]	x [ft]	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

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

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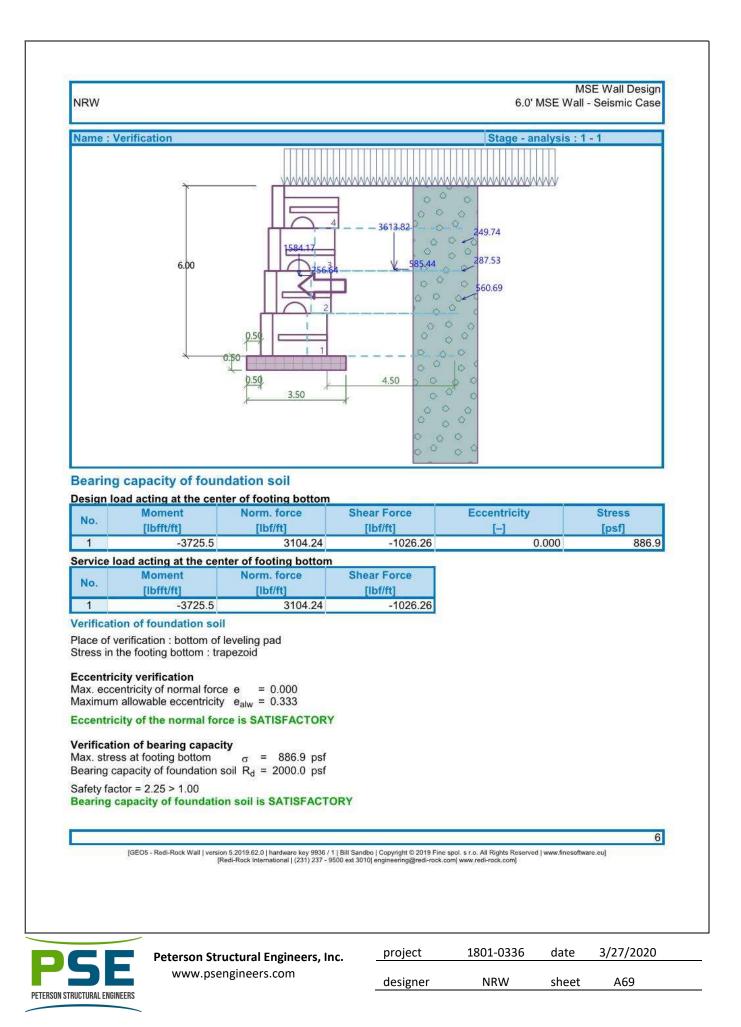
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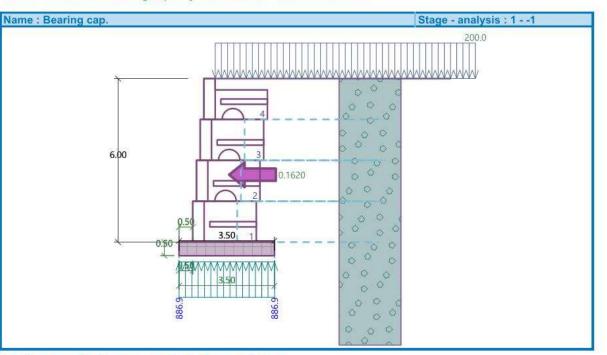
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Overall verification - bearing capacity of found. soil is SATISFACTORY



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	0
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:

NRW

Resisting horizontal force Hres = 3319.22 lbf/ft

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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

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

Check for pull out resistance (reinforcement No.3)

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

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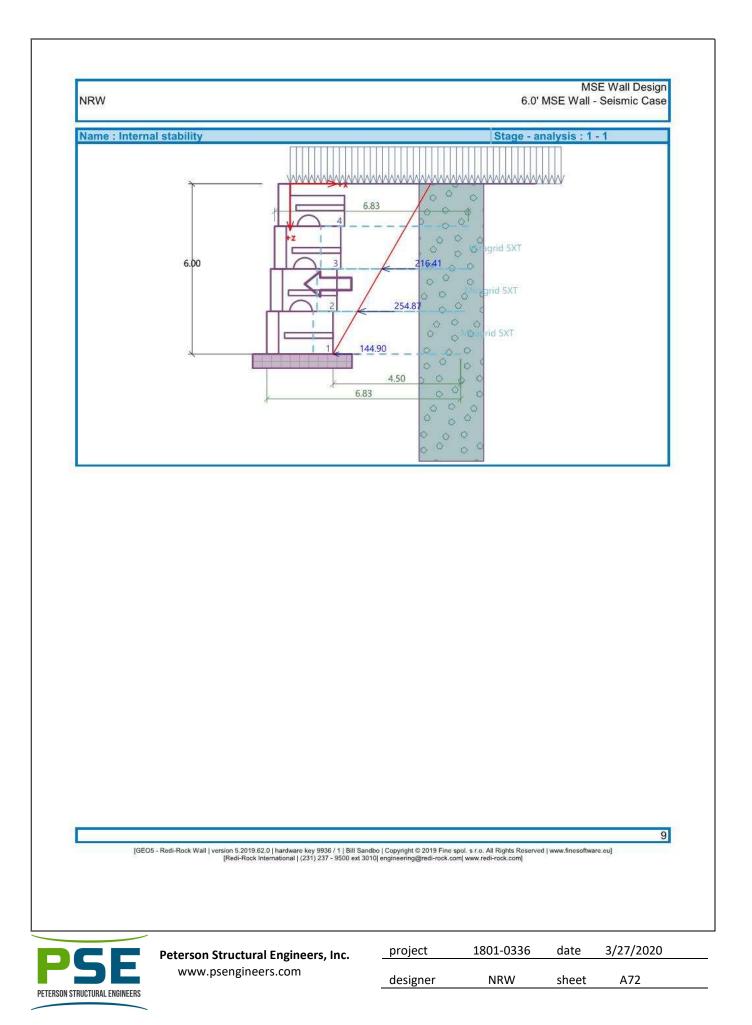
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NRW



<u>6'-0" Tall Wall – Transient Case</u>



project	1801-0336	date	3/27/2020	
designer	NRW	sheet	A73	

1801-0336 6.0' MSE 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 fac	tors				
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 °

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1801-0336 6.0' MSE Wall - Transient Case

Types of reinforcements

Reinforcement details

PSE

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No.	No. Name	Name Type of reinforcement	1.000	Tensile strength				
NO.	wame	Type of reinforcement	Line type	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		

1. Miragrid 5XT Short-term char. strength Creep red. factor Durability red. factor	Tult	=	4700.00	
Creep red. factor Durability red. factor		=	4700 00	11 6164
Durability red. factor			4100.00	IDT/Tt
	RFCR	=	1.	
	RFD	=	1.15	
Installation damage red. factor	RFID	=	1.25	
Long-term design strength	Rt	=	2069.35	lbf/ft
Coefficient of direct slip along reinforcement	Cds	=	0.67	
Coefficient of interaction of soil and geo-reinforcement		=	0.67	
Scale correction factor	α	=	0.8	
Long-term strength reduction factor	CRcr	=	0.532	
Analysis of long-term strength	R_{con}	=	2174.26	lbf/ft
2. Miragrid 8XT				
Short-term char. strength	Tult		7400.00	
Creep red. factor	RFCR		1.58	
Durability red. factor	RF_D	=	1.15	
Installation damage red. factor	RFID	=	1.20	
Long-term design strength	Rt	=	3393.87	lbf/ft
Coefficient of direct slip along reinforcement	Cds	=	0.67	
Coefficient of interaction of soil and geo-reinforcement	Ci	=	0.67	
Scale correction factor	α	=	0.8	
Long-term strength reduction factor	CR _{cr}	=	0.532	
Analysis of long-term strength	R _{con}	Ξ	3423.30	lbf/ft
3. Miragrid 10XT				
Short-term char. strength	Tult		9500.00	
Creep red. factor	RFCR	=	1.58	
Durability red. factor	RF_D	=	1.15	
Installation damage red. factor	RFID	=	1.20	
Long-term design strength	Rt	=	4357.00	lbf/ft
Coefficient of direct slip along reinforcement	Cds	=	0.67	
Coefficient of interaction of soil and geo-reinforcement	Ci	=	0.67	
Scale correction factor	α	=	0.8	
Long-term strength reduction factor	CRcr	=	0.519	
Analysis of long-term strength	R _{con}	=	4287.39	lbf/ft
4. Miragrid 20XT				

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designer	NRW	sheet	A75	

1801-0336 6.0' MSE Wall - Transient Case

Short-term char. strength	Tult	=	13705.00	lbf/ft
Creep red. factor	RFCR	=	1.58	
Durability red. factor	RFD	=	1.15	
Installation damage red. factor	RFID	=	1.15	
Long-term design strength	Rt	=	6558.83	lbf/ft
Coefficient of direct slip along reinforcement	Cds	=	0.67	
Coefficient of interaction of soil and geo-reinforcement		=	0.67	
Scale correction factor	α	=	0.8	
Long-term strength reduction factor	CRcr	=	0.506	
Analysis of long-term strength	R_{con}	=	6030.20	lbf/ft
5. Miragrid 24XT				
Short-term char. strength	Tult	=	27415.00	lbf/ft
Creep red. factor	RFCR	=	1.58	
Durability red. factor	RFD	=	1.15	
Installation damage red. factor	RFID	=	1.10	
Long-term design strength	Rt	=	13716.42	lbf/ft
Coefficient of direct slip along reinforcement	C_{ds}	=	0.67	
Coefficient of interaction of soil and geo-reinforcement		=	0.67	
Scale correction factor	α	=	0.8	
Long-term strength reduction factor	CRcr	=	0.443	
Analysis of long-term strength	R_{con}	=	10560.73	lbf/ft
Reinforcements				
Input mode : 1 reinforcement type				

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 I = 4.50 ft **Reinforcements**

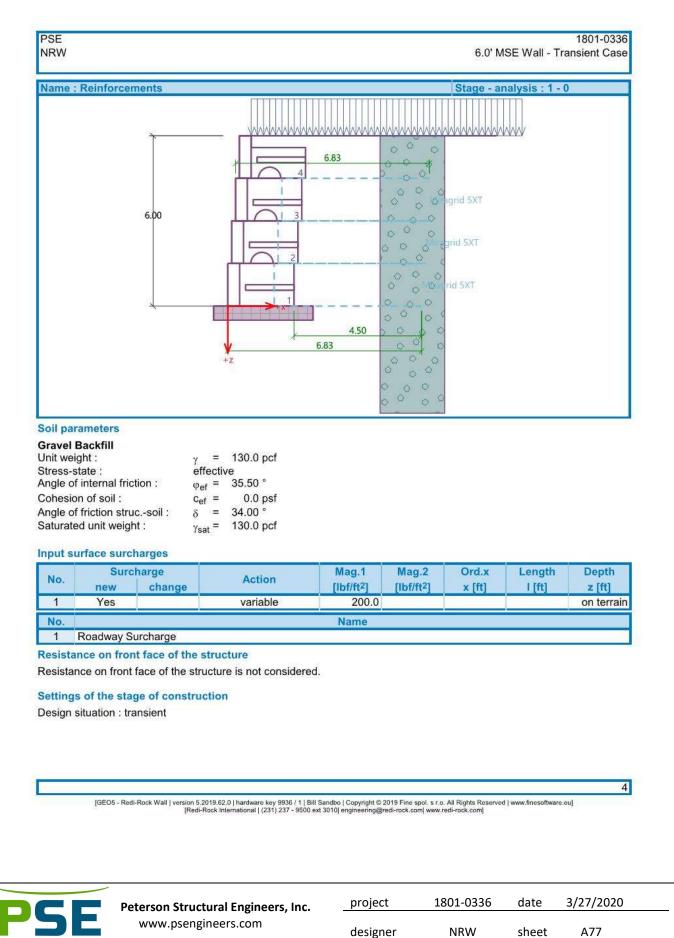
No.	Consider	Name	Length of reinforcement I [ft]	End pt. coordinate I _k [ft]
1	Yes	Miragrid 5XT	4.50	
2	Yes	Miragrid 5XT	4.50	
3	Yes	Miragrid 5XT	4.50	
4	No	0.999		

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designer	NRW	sheet	A76	



NRW

designer

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1801-0336 6.0' MSE Wall - Transient Case

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

 $\begin{array}{rcl} \mbox{Resisting horizontal force} & \mbox{H}_{res} &=& 3624.63 & \mbox{lbf/ft} \\ \mbox{Active horizontal force} & \mbox{H}_{act} &=& 776.88 & \mbox{lbf/ft} \end{array}$

Safety factor = 4.67 > 1.50 Wall for slip is SATISFACTORY

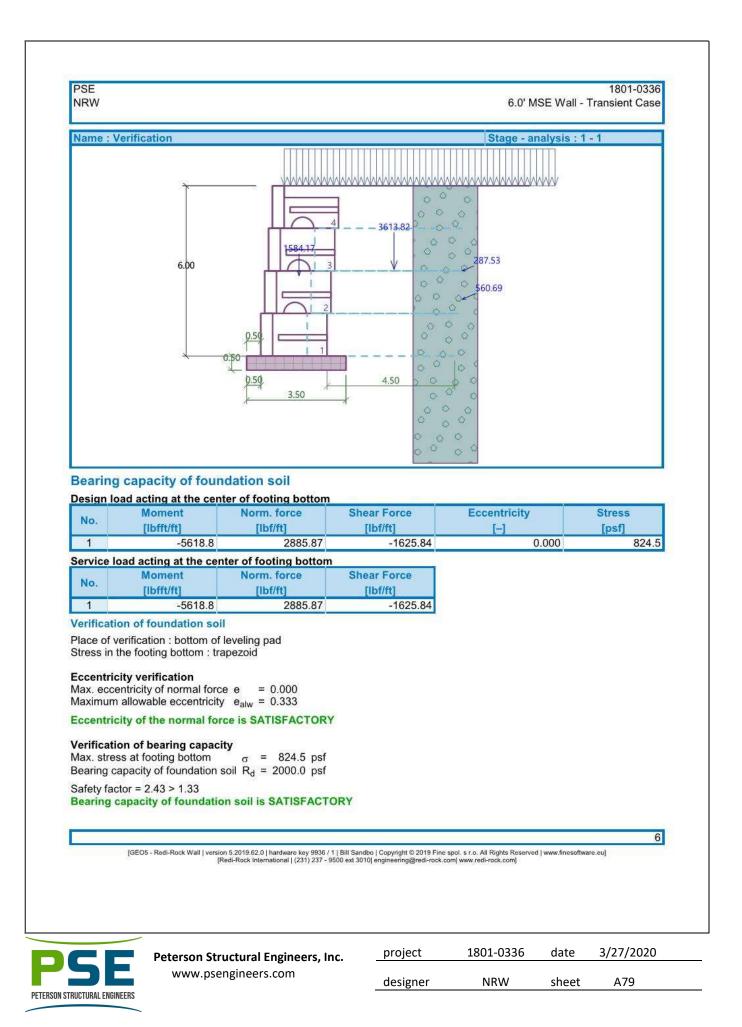
Overall check - WALL is SATISFACTORY

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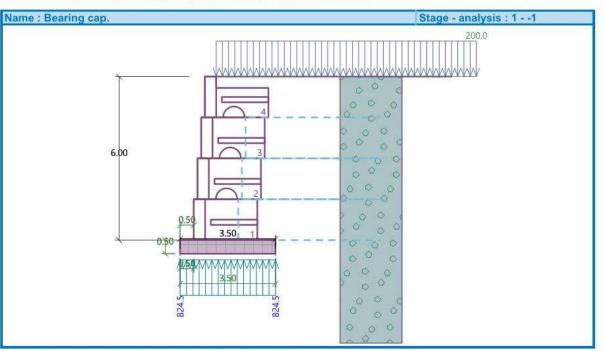
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1801-0336

6.0' MSE Wall - Transient Case

Overall verification - bearing capacity of found. soil is SATISFACTORY



Verification of slip on georeinforcement No. 1

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

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	Fhor	App.Pt.	Fvert	App.Pt.	Design
	[lbf/ft]	z [ft]	[lbf/ft]	x [ft]	coefficient
Veight - 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
Veight - reinforced soil	0.0	-2.94	3429.0	2.35	1.000
Roadway Surcharge	0.0	-6.00	1202.1	-1.51	1.000
derification against slip along generification of slip surfaceoverall normal force acting on reinfocefficient of reduction of slip alongcoefficient of safety = $5.40 > 1.50$ clip alongcoefficient of safety = $5.40 > 1.50$	orcement = 4 geo-textile = 3 nt = 3 ements = 193.64 lbf/ft 776.88 lbf/ft	90.00 ° 1971.55 lbf/ft 0.92 3253.61 lbf/ft 940.03 lbf/ft 0.00 lbf/ft	© 2019 Fine snol s r.o. All	Right-Deserved Lyon feed	7

designer

NRW

sheet

A80



PSE

NRW

1801-0336 6.0' MSE Wall - Transient Case

Calculation of internal stability No. 1

Calculated forces and strength of reinforcements

No.	Name	Fx	Depth	Rt	Utiliz.	Tp	Utiliz.	R _{con}	Utiliz.
140.		[lbf/ft]	z[ft]	[lbf/ft]	[%]	[lbf/ft]	[%]	[lbf/ft]	[%]
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

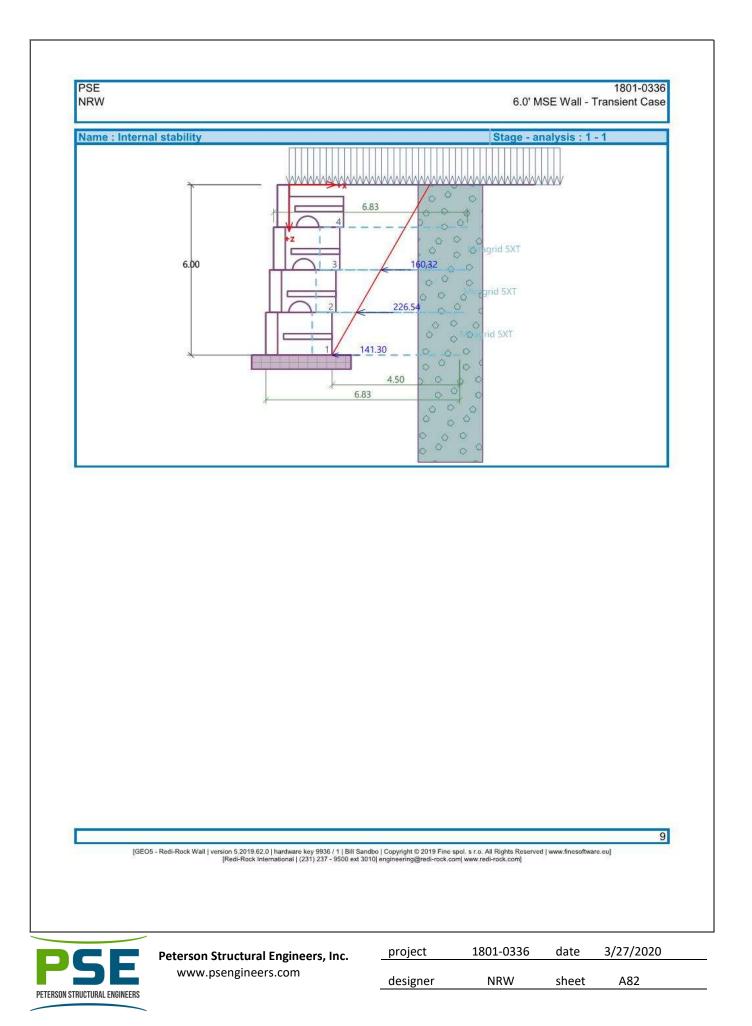
Overall verification - reinforcement is SATISFACTORY

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designer	NRW	sheet	A81	



4'-6" Tall Wall – Seismic Case



project	1801-0336	date	3/27/2020	
designer	NRW	sheet	A83	

Analysis of Redi Rock wall

Input data

Project

NRW

Task: MSE Wall DesignPart: 4.5' MSE Wall - Seismic CaseAuthor: NRWDate: 11/25/2019Project 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 :
 Could

 Passive earth pressure calculation :
 Mazin

 Earthquake analysis :
 Monor

 Shape of earth wedge :
 Calculation

 Allowable eccentricity :
 0.333

 Internal stability :
 Stand

 Reduction coeff. of contact first block - base :
 1.000

 Verification methodology :
 Safet

Coulomb Mazindrani (Rankine) Mononobe-Okabe Calculate as skew 0.333 Standard - straight slip surface 1.00 Safety factors (ASD)

Safety fac	ctors						
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	2	1.62
2	Top block 28	1	

Base

Material

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

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Types of reinforcements

No	The state of the st		Tensile strength			
No.	Name Type of reinforcement	Line type	Tult [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	mmmmm	27415.00	13716.42	10560.73

Reinforcement details

1. Miragrid 5XT	222			
Short-term char. strength	Tult		4700.00	
Creep red. factor	RFCR		1.58	
Durability red. factor	RFD	=	1.15	
Installation damage red. factor	RF ID	=	1	
Long-term design strength	Rt	=	2069.35	lbf/ft
Coefficient of direct slip along reinforcement	Cds	=	0.67	
Coefficient of interaction of soil and geo-reinforcement	Ci	=	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	Tult	=	7400.00	lbf/ft
Creep red. factor	RFCR	=	1.58	
Durability red. factor	RFD	=	1.15	
Installation damage red. factor	RFID	=	1.20	
Long-term design strength	Rt	=	3393.87	lbf/ft
Coefficient of direct slip along reinforcement	Cds	=	0.67	
Coefficient of interaction of soil and geo-reinforcement	Ci	=	0.67	
Scale correction factor	α	=	0.8	
Long-term strength reduction factor	CRcr	=	0.532	
Analysis of long-term strength	R _{con}	=	3423.30	lbf/ft
3. Miragrid 10XT				
Short-term char. strength	Tult		9500.00	lbf/ft
Creep red. factor	RFCR	=	1.58	
Durability red. factor	RFD	=	1.15	
Installation damage red. factor	RFID	=	1.20	
Long-term design strength	Rt	=	4357.00	lbf/ft
Coefficient of direct slip along reinforcement	Cds	=	0.67	
Coefficient of interaction of soil and geo-reinforcement	Ci	=	0.67	
Scale correction factor	α	=	0.8	
Long-term strength reduction factor	CRcr	=	0.519	
Analysis of long-term strength	R _{con}	=	4287.39	lbf/ft

2

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NRW

MSE Wall Design 4.5' MSE Wall - Seismic Case

4. Miragrid 20XT				
Short-term char. strength	Tult	=	13705.00	lbf/ft
Creep red. factor	RFCR	=	1.58	
Durability red. factor	RFD	=	1.15	
Installation damage red. factor	RFID	=	1.15	
Long-term design strength	Rt	=	6558.83	lbf/ft
Coefficient of direct slip along reinforcement	Cds	=	0.67	
Coefficient of interaction of soil and geo-reinforcement		=	0.67	
Scale correction factor	α	=	0.8	
Long-term strength reduction factor	CRcr	=	0.506	
Analysis of long-term strength	R _{con}	=	6030.20	lbf/ft
5. Miragrid 24XT				
Short-term char. strength	Tult	=	27415.00	lbf/ft
Creep red. factor	RFCR	=	1.58	
Durability red. factor	RFD	=	1.15	
Installation damage red. factor	RFID	=	1.10	
Long-term design strength	Rt	=	13716.42	lbf/ft
Coefficient of direct slip along reinforcement	Cds	=	0.67	
Coefficient of interaction of soil and geo-reinforcement		=	0.67	
Scale correction factor	α	=	0.8	
Long-term strength reduction factor	CRcr	=	0.443	
Analysis of long-term strength	R _{con}	-	10560.73	lbf/ft
Reinforcements				

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 I = 3.50 ft **Reinforcements**

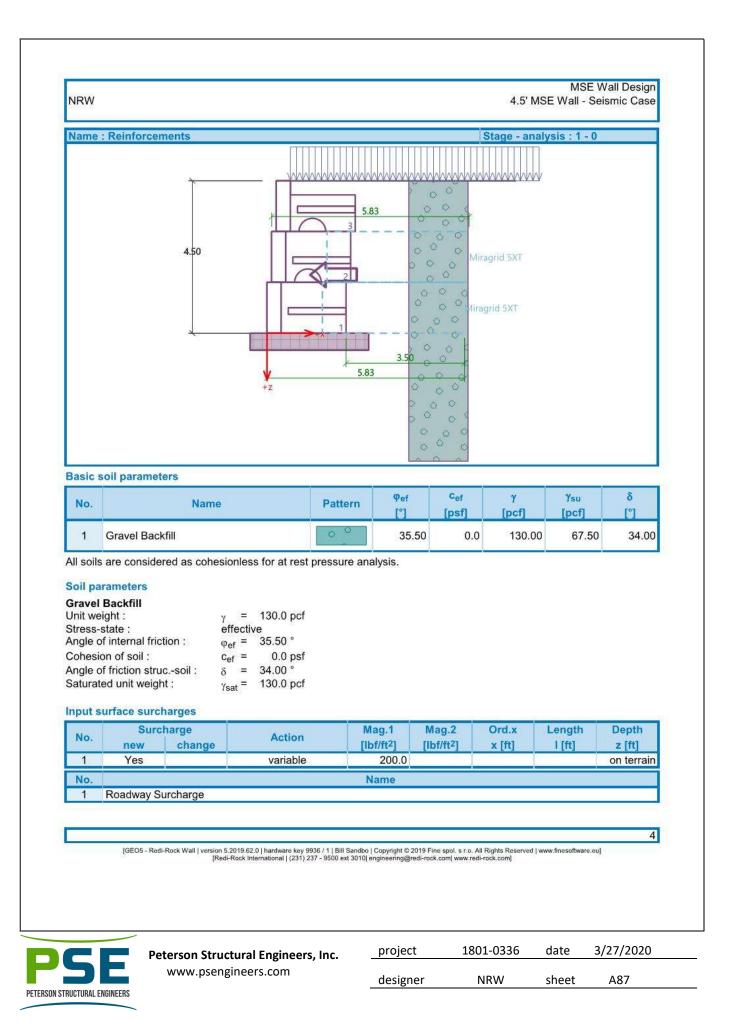
No.	Consider	Name	Length of reinforcement I [ft]	End pt. coordinate I _k [ft]
1	Yes	Miragrid 5XT	3.50	
2	Yes	Miragrid 5XT	3.50	
3	No			

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designer	NRW	sheet	A86



NRW

Resistance on front face of the structure

Resistance on front face of the structure is not considered.

Earthquake

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	Fhor	App.Pt.	Fvert	App.Pt.	Design
Walks on which the set of the set of	[lbf/ft]	z [ft]	[lbf/ft]	x [ft]	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

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

1

5

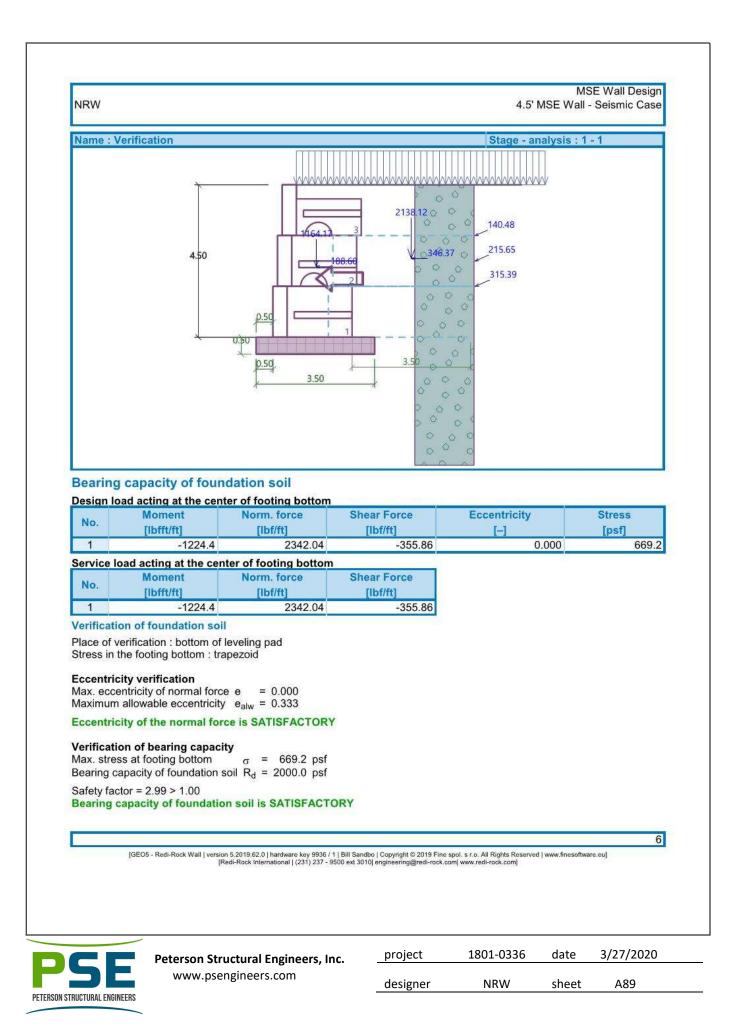
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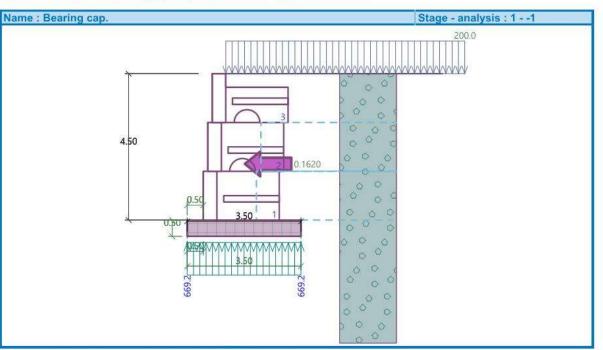
project	1801-0336	-0336 date 3/27/2		
designer	NRW	sheet	A88	



MSE Wall Design

4.5' MSE Wall - Seismic Case

Overall verification - bearing capacity of found. soil is SATISFACTORY



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	0
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:

NRW

Resisting horizontal force Hres = 2188.74 lbf/ft

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Active horiz. forceHact=615.04 lbf/ftFactor of safety = 3.56 > 1.10Slip 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

NRW

Reinforcement for tensile strength is SATISFACTORY

Check for pull out resistance (reinforcement No.2)

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

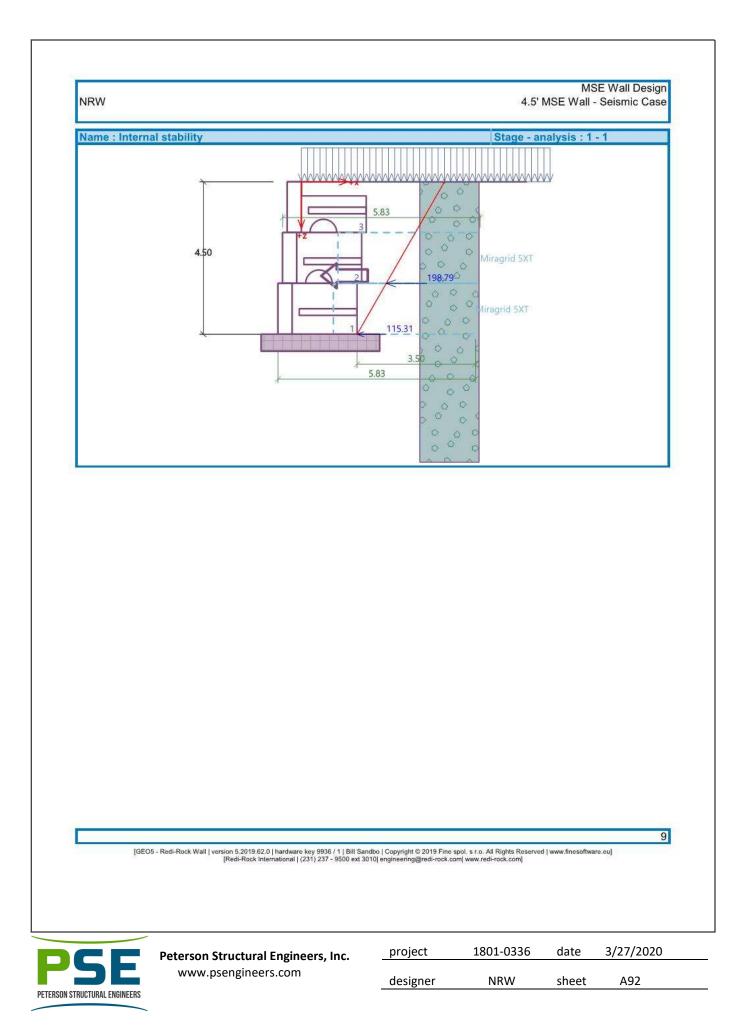
Overall verification - reinforcement is SATISFACTORY

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<u>4'-6" Tall Wall – Transient Case</u>



project	1801-0336	date	3/27/2020	
designer	NRW	sheet	A93	

1801-0336 4.5' MSE 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 :	
Verification methodology :	Safety factors (ASD)

Safety fac	tors					
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 °

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designer	NRW	sheet	A94	

1801-0336 4.5' MSE Wall - Transient Case

Types of reinforcements

Reinforcement details

PSE

NRW

No.	No. News	The second second		Tensile strength			
NO.	Name	Type of reinforcement	Line type	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	mmmm	27415.00	13716.42	10560.73	

1 Missorid EVT				
1. Miragrid 5XT Short-term char. strength	Tult	=	4700.00	lbf/ft
Creep red. factor	RFCR		1.58	
Durability red. factor	RFD	=	1.15	
Installation damage red. factor	RFID	=	1.25	
Long-term design strength	Rt	=	2069.35	lbf/ft
Coefficient of direct slip along reinforcement	Cds	=	0.67	
Coefficient of interaction of soil and geo-reinforcement	Ci	=	0.67	
Scale correction factor	α	=	0.8	
Long-term strength reduction factor	CRcr	=	0.532	
Analysis of long-term strength	R_{con}	=	2174.26	lbf/ft
2. Miragrid 8XT				
Short-term char. strength	Tult		7400.00	lbf/ft
Creep red. factor	RF_{CR}	=	1.58	
Durability red. factor	RFD	=	1.15	
Installation damage red. factor	RFID	=	10000000000000000000000000000000000000	
Long-term design strength	Rt	=	3393.87	lbf/ft
Coefficient of direct slip along reinforcement	C_{ds}	=	0.67	
Coefficient of interaction of soil and geo-reinforcement	Ci	=	0.67	
Scale correction factor	α	=	0.8	
Long-term strength reduction factor	CR_{cr}	=		
Analysis of long-term strength	R _{con}	Ξ	3423.30	lbf/ft
3. Miragrid 10XT				
Short-term char. strength	Tult		9500.00	
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	Rt	=	4357.00	lbf/ft
Coefficient of direct slip along reinforcement	Cds	=	0.67	
Coefficient of interaction of soil and geo-reinforcement	Ci	=	0.01	
Scale correction factor	α	=	0.8	
Long-term strength reduction factor	CR _{cr}	=	0.0.0	
Analysis of long-term strength	R _{con}	=	4287.39	lbf/ft
Analysis of long-term strength	CON			

2

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project	1801-0336	date	3/27/2020	
designer	NRW	sheet	A95	

1801-0336 4.5' MSE Wall - Transient Case

T_{ult} = 13705.00 lbf/ft Short-term char. strength Creep red. factor $RF_{CR} =$ 1.58 Durability red. factor $RF_D =$ 1.15 Installation damage red. factor $RF_{ID} =$ 1.15 Rt Long-term design strength = 6558.83 lbf/ft Coefficient of direct slip along reinforcement C_{ds} = 0.67 Coefficient of interaction of soil and geo-reinforcement Ci = 0.67 Scale correction factor = 0.8 α Long-term strength reduction factor $CR_{cr} =$ 0.506 $R_{con} = 6030.20 \text{ lbf/ft}$ Analysis of long-term strength 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 $RF_{ID} =$ Installation damage red. factor 1.10 = 13716.42 lbf/ft Long-term design strength Rt C_{ds} = Coefficient of direct slip along reinforcement 0.67 Coefficient of interaction of soil and geo-reinforcement Ci 0.67 2 Scale correction factor 0.8 = Long-term strength reduction factor $CR_{cr} =$ 0.443 R_{con} = 10560.73 lbf/ft Analysis of long-term strength 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 I = 3.50 ft

Reinforcements

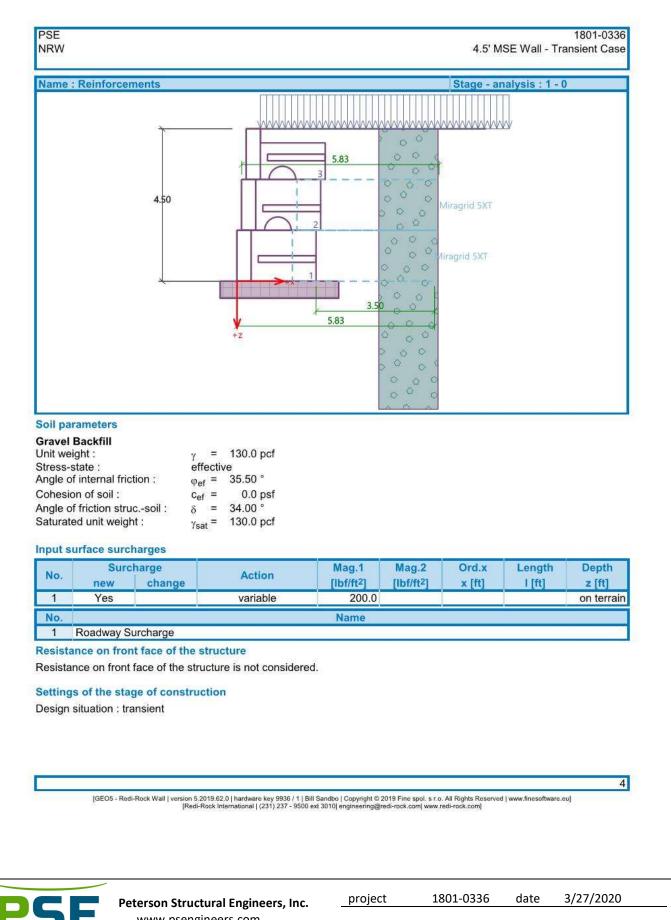
No.	Consider	Name	Length of reinforcement I [ft]	End pt. coordinate I _k [ft]
1	Yes	Miragrid 5XT	3.50	
2	Yes	Miragrid 5XT	3.50	
3	No			

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project	1801-0336	date	3/27/2020	
designer	NRW	sheet	A96	
ucsigner		Sheet	730	_



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designer	NRW	sheet	A97

PSE NRW 1801-0336 4.5' MSE Wall - Transient Case

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

Safety factor = 13.08 > 1.50 Wall for overturning is SATISFACTORY

Check for slip

Safety factor = 4.73 > 1.50 Wall for slip is SATISFACTORY

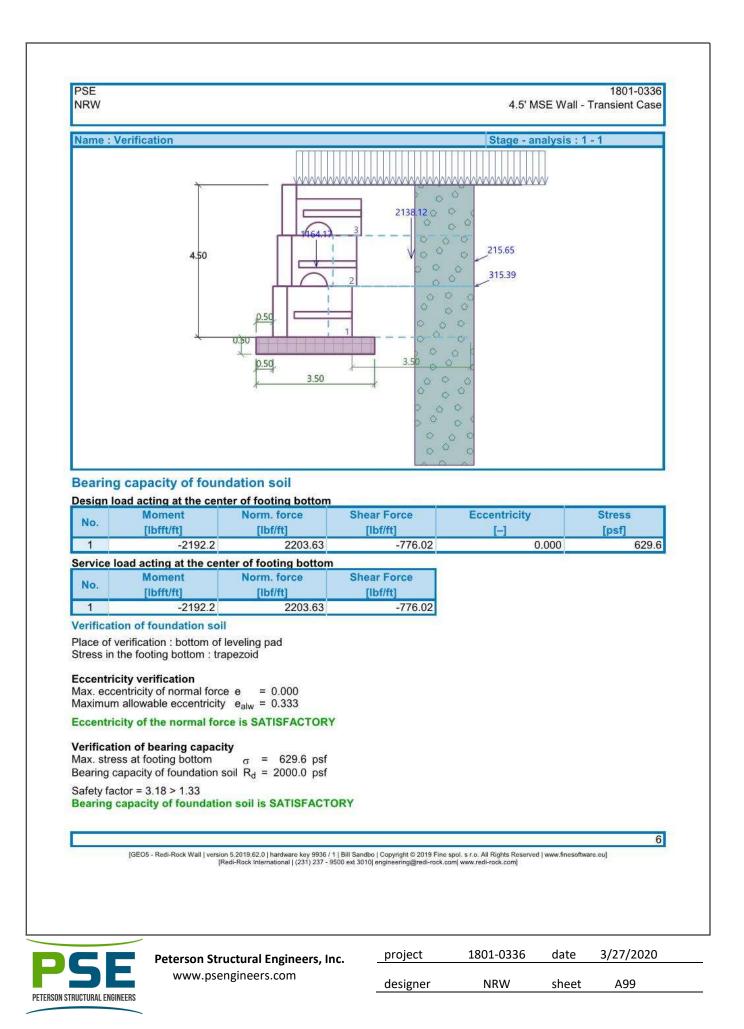
Overall check - WALL is SATISFACTORY

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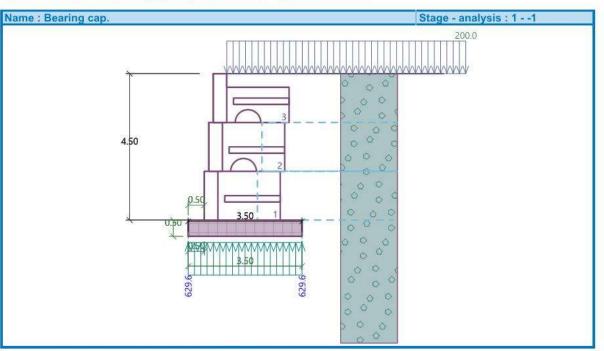
project	1801-0336	date	3/27/2020	
designer	NRW	sheet	A98	



1801-0336

4.5' MSE Wall - Transient Case

Overall verification - bearing capacity of found. soil is SATISFACTORY



Verification of slip on georeinforcement No. 1

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

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Name	Fhor	App.Pt.	Fvert	App.Pt.	Design
Africht world	[lbf/ft]	z [ft]	[lbf/ft]	x [ft]	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
Factor of safety = 5.86 > 1.50 Slip along geotextile is SATIS	long geo-textile = ment = 2 forcements = = 2847.97 lbf/ft = 486.37 lbf/ft	90.00 ° 3288.03 lbf/ft 0.92 151.84 lbf/ft 696.14 lbf/ft 0.00 lbf/ft /1 Bill Sandbo Copyright 0 9500 ext 3010 engineering(9 2019 Fine spol. s r.o. All gredi-rock.com www.redi-	Rights Reserved www.fine rock.com]	7 software.eu]
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designer

NRW

sheet

A100



PSE

NRW

PSE NRW 1801-0336 4.5' MSE Wall - Transient Case

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

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

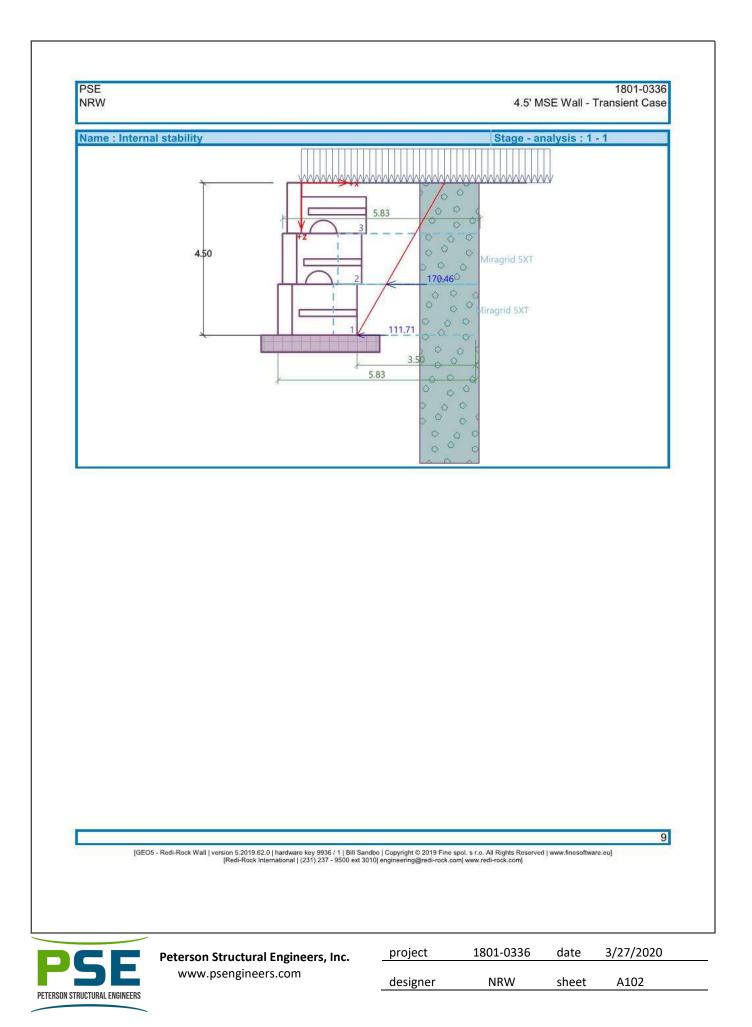
Overall verification - reinforcement is SATISFACTORY

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project	1801-0336	date	3/27/2020	
designer	NRW	sheet	A101	



<u>3'-0" Tall Wall – Seismic Case</u>



project	1801-0336	date	3/27/2020	
designer	NRW	sheet	A103	

MSE Wall Design 3.0' MSE Wall - Seismic Case - Unreinforced Soil

Analysis of Redi Rock wall

Input data

Project

NRW

Task: MSE Wall DesignPart: 3.0' MSE Wall - Seismic Case - Unreinforced SoilAuthor: NRWDate: 11/25/2019Project 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 :
Passive earth pressure calculation :
Earthquake analysis :
Shape of earth wedge :
Allowable eccentricity :
Internal stability :
Reduction coeff. of contact first block - base :
Verification methodology :

Mazindrani (Rankine) Mononobe-Okabe Calculate as skew 0.333 Standard - straight slip surface 1.00 Safety factors (ASD)

Coulomb

Safety fac	tors			
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	1	1.62
2	Top block 28	1	· · · · · · · · · · · · · · · · · · ·

Base

Material

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

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project	1801-0336	date	3/27/2020	
designer	NRW	sheet	A104	

MSE Wall Design

3.0' MSE Wall - Seismic Case - Unreinforced Soil

Basic soil parameters

NRW

No.	Name	Pattern	Фef [°]	C _{ef} [psf]	γ [pcf]	γ _{su} [pcf]	δ [°]
1	Gravel Backfill	0 0	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 :	effecti	ve
Angle of internal friction :	$\varphi_{ef} =$	35.50 °
Cohesion of soil :	c _{ef} =	0.0 psf
Angle of friction strucsoil :	δ =	34.00 °
Saturated unit weight :	γ _{sat} =	130.0 pcf

Backfill

Backfill is not considered.

Input surface surcharges

No.	Surd	charge change	Action	Mag.1 [lbf/ft ²]	Mag.2 [lbf/ft ²]	Ord.x x [ft]	Length I [ft]	Depth z [ft]
1	Yes		variable	200.0				on terrain
No.				Name				
1	Roadway S	Surcharge		Contraction of the				

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

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project	1801-0336	date	3/27/2020	
designer	NRW	sheet	A105	

NRW

MSE Wall Design

3.0' MSE Wall - Seismic Case - Unreinforced Soil

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

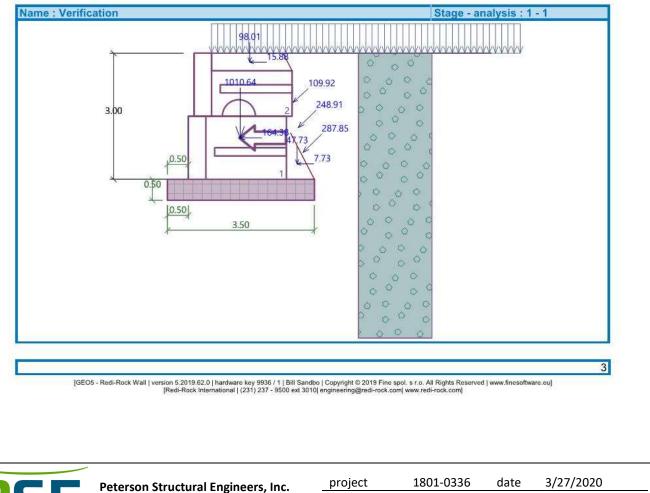
Safety factor = 3.39 > 1.10

Wall for overturning is SATISFACTORY

Check for slip

Safety factor = 1.76 > 1.10 Wall for slip is SATISFACTORY

Overall check - WALL is SATISFACTORY



designer

NRW

sheet

A106



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MSE Wall Design

3.0' MSE Wall - Seismic Case - Unreinforced Soil

Dimensioning No. 1

NRW

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 stabilityResisting momentMres = 1559.2Overturning momentMovr = 656.9Ibfft/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 $H_{act} = 439.32 \text{ lbf/ft}$

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

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1 340.5 1606.24 652.43 0.061 522.2 Service load acting at the center of footing bottom No. Moment Norm. force Shear Force [Ibf/ft] 1 340.5 1606.24 652.43 Verification of foundation soil Ibf/ft] Ibf/ft] 652.43 Verification of foundation soil Stress in the footing bottom : trapezoid 652.43 Eccentricity verification Max. eccentricity of normal force e = 0.061 Maximum allowable eccentricity e _{alw} = 0.333 652.43 Lecentricity of the normal force is SATISFACTORY Verification of bearing capacity	No.	Moment	Norm. force	Shear Force	Eccentricity	Stress
Service load acting at the center of footing bottomNo.Moment [lbfft/ft]Norm. force [lbf/ft]Shear Force [lbf/ft]1340.51606.24652.43Verification of foundation soilStress in the footing bottom : trapezoidEccentricity verification Max. eccentricity of normal force $e = 0.061$ Maximum allowable eccentricity $e_{alw} = 0.333$ Eccentricity of the normal force is SATISFACTORYVerification of bearing capacity Max. stress at footing bottom $\sigma = 625.7 \text{ psf}$		[lbfft/ft]	[lbf/ft]	[lbf/ft]	(-)	[psf]
No.Moment [lbfft/ft]Norm. force [lbf/ft]Shear Force [lbf/ft]1340.51606.24652.43Verification of foundation soilStress in the footing bottom : trapezoidEccentricity verification Max. eccentricity of normal force $e = 0.061$ Maximum allowable eccentricity $e_{alw} = 0.333$ Eccentricity of the normal force is SATISFACTORYVerification of bearing capacity Max. stress at footing bottom $\sigma = 625.7 psf$	1	340.5	1606.24	652.43	0.061	522.2
No. [lbfft/ft] [lbf/ft] [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	Service le	oad acting at the cen	CANADA COMPANY AND A CANADA CANA			
Verification of foundation soilStress in the footing bottom : trapezoidEccentricity 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 $\sigma = 625.7 \text{ psf}$	No.					
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 $\sigma = 625.7$ psf	1	340.5	1606.24	652.43		
4						
	Maximum Eccentric Verificati	a allowable eccentricity city of the normal for on of bearing capaci ss at footing bottom	$r e_{alw} = 0.333$ ce is SATISFACTORY ity $\sigma = 625.7 \text{ psf}$		spol. s r.o. All Rights Reserved www.fin om www.redi-rock.com]	

designer

NRW

A107

sheet



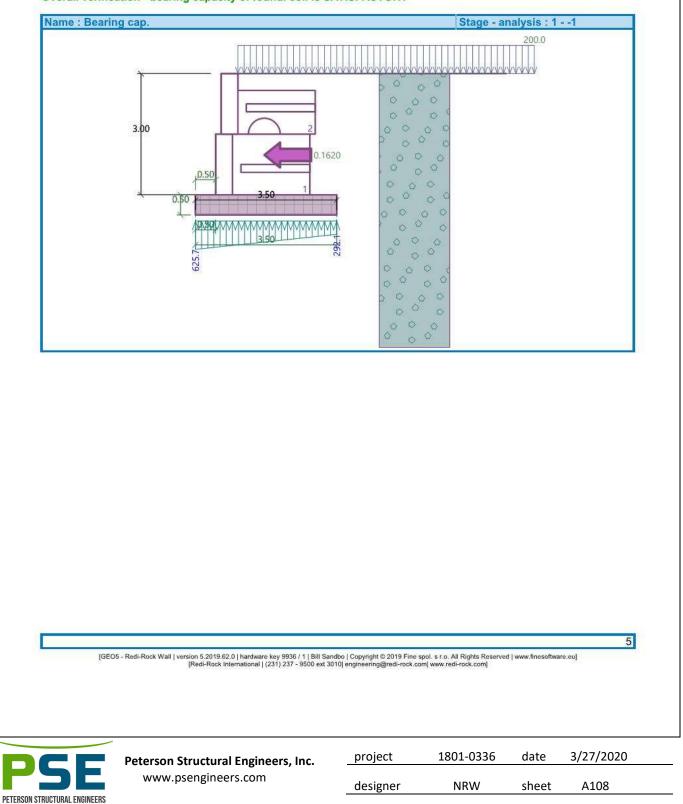
NRW

MSE Wall Design 3.0' MSE Wall - Seismic Case - Unreinforced Soil

Bearing capacity of foundation soil $R_d = 2000.0 \text{ psf}$

Safety factor = 3.20 > 1.00 Bearing capacity of foundation soil is SATISFACTORY

Overall verification - bearing capacity of found. soil is SATISFACTORY



<u>3'-0" Tall Wall – Transient Case</u>



project	1801-0336	date	3/27/2020	
designer	NRW	sheet	A109	

Analysis of Redi Rock wall

Input data

Project

NRW

Task: MSE Wall DesignPart: 3.0' MSE Wall - Transient Case - Unreinforced SoilAuthor: NRWDate: 11/25/2019Project 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 :
Passive earth pressure calculation :
Earthquake analysis :
Shape of earth wedge :
Allowable eccentricity :
Internal stability :
Reduction coeff. of contact first block - base
Verification methodology :

Coulomb Mazindrani (Rankine) Mononobe-Okabe Calculate as skew 0.333 Standard - straight slip surface e : 1.00 Safety factors (ASD)

Safety fac	tors		
Transient desig	n 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

Material

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

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project	1801-0336	date	3/27/2020	
designer	NRW	sheet	A110	

MSE Wall Design

3.0' MSE Wall - Transient Case - Unreinforced Soil

Basic soil parameters

NRW

No.	Name	Pattern	Фef [°]	c _{ef} [psf]	γ [pcf]	γ _{su} [pcf]	δ [°]
1	Gravel Backfill	0	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 :	effecti	ve
Angle of internal friction :	$\varphi_{ef} =$	35.50 °
Cohesion of soil :	c _{ef} =	0.0 psf
Angle of friction strucsoil :	δ =	34.00 °
Saturated unit weight :	γ _{sat} =	130.0 pcf

Backfill

Backfill is not considered.

Input surface surcharges

No.	Surd	harge	Action	Mag.1	Mag.2	Ord.x	Length	Depth
NO.	new		[lbf/ft ²]	[lbf/ft ²]	x [ft]	I [ft]	z [ft]	
1	Yes		variable	200.0				on terrain
No.				Name				
1	Roadway S	urcharge						

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 $M_{ovr} = 542.2$ lbft/ft

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designer	NRW	sheet	A111	

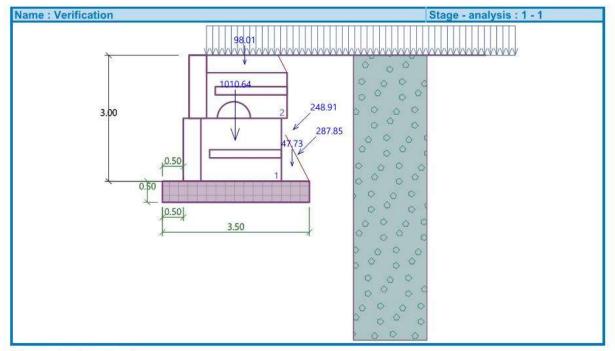
NRW

Safety factor = 6.06 > 1.50 Wall for overturning is SATISFACTORY

Check for slip

Safety factor = 2.85 > 1.50 Wall for slip is SATISFACTORY

Overall check - WALL is SATISFACTORY



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

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project	1801-0336	date	3/27/2020	
designer	NRW	sheet	A112	

NRW

PETERSON STRUCTURAL ENGINEERS

MSE Wall Design 3.0' MSE Wall - Transient Case - Unreinforced Soil

Overturning moment Movr = 322.6 lbfft/ft

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

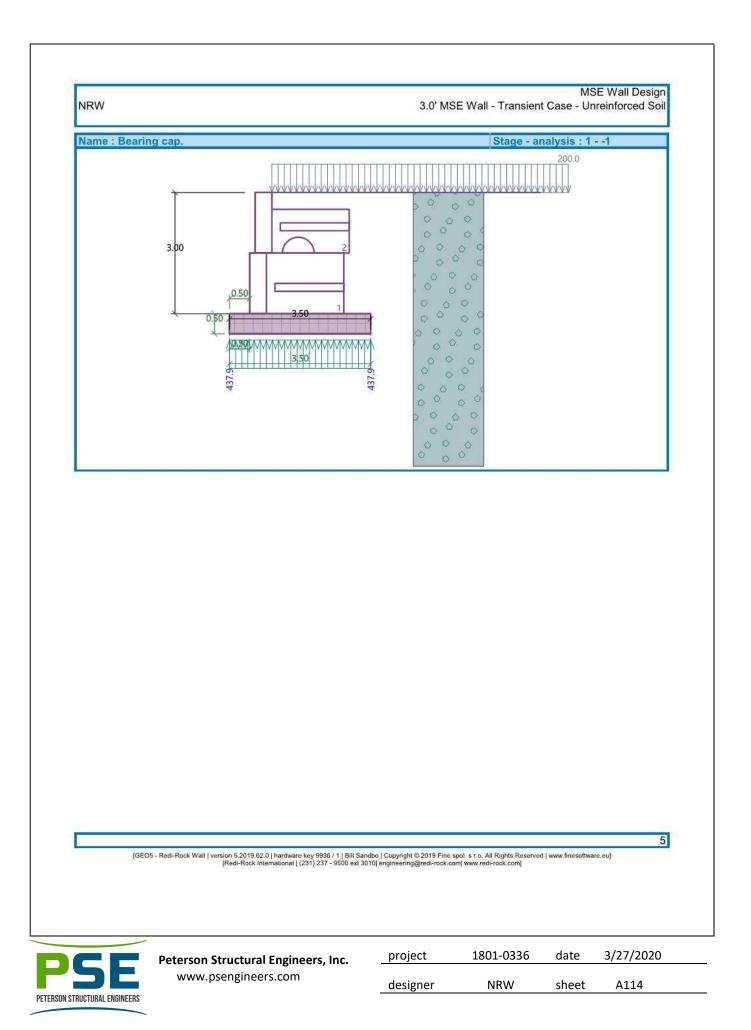
Check for slip Resisting horizontal force H_{res} = 580.85 lbf/ft Active horizontal force Hact = 236.02 lbf/ft

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

Jesign id	Moment	Norm, force	Shear Force	Eccentricity	Stress
No.	[lbfft/ft]	[lbf/ft]	[lbf/ft]	(-)	[psf]
1	-61.0	1532.50	382.93	0.000) 437.9
Service le	oad acting at the ce	nter of footing botton	n		
No.	Moment	Norm. force	Shear Force		
NO.	[lbfft/ft]	[lbf/ft]	[lbf/ft]		
1	-61.0	1532.50	382.93		
Eccentric Max. ecce Maximum Eccentric Verification Max. stres Bearing ci Safety fac	on of bearing capac ss at footing bottom	the e = 0.000 y e_{alw} = 0.333 rce is SATISFACTOR' ity σ = 437.9 psf soil R _d = 2000.0 psf			
Overall v	erification - bearing	capacity of found. so	1 Bill Sandbo Copyright © 2019 Fine 9500 ext 3010 engineering@redi-rock.c	spol. s r.o. All Rights Reserved www om[www.redi-rock.com]	
Overall v	[GEO5 - Redi-Rock Wall versi	capacity of found. so	1 Bill Sandbo Copyright © 2019 Fine 9500 ext 3010 engineering@redi-rock.c	om(www.redi-rock.com)	4 .finesoftware.eu] ate 3/27/2020



<u>Appendix B – CIP Cantilever Wall Design</u>



project	1801-0336	date	3/27/2020	
designer	NRW	sheet	B1	

<u>6'-0" Tall Wall</u>



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project	1801-0336	date	3/27/2020	
designer	NRW	sheet	B2	

Used To Resist Silding & Overturning Surcharge Overturning	Peterson Shudural Engineers, Inc.	acoma, V hone: 25 /ww.pser	lway, Suite 110 Washington 9840 53-830-2140 ngineers.com				all (6'-0" Segment)	Dat	e: 12 JUL 2019
Circleria Soli Data Retained Height = 0.00 it Stope Bohm Wall = 0.00 it Attail Load (and (and (and (and (and (and (and (a	etainPro (c) 1987-2019,	Build 11.1	9.07.17	A			NAME OF ADDRESS OF	15,ACI 3	18-14,ACI 530
Strapping across soil = 0.00 ft Stope Betind Wall = 200 Eduvalent Fluid Pressure = 3.5 p strit. Stope Betind Wall = 200 Passive Pressure = 0.0 p strit. Wall height of Soil Over Toe = 0.00 in Water height over toe = 0.00 in Soil Density, rele = 1100.00 pcf Footing[Soil Friction = 0.00 in Soil Density, rele = 100.00 pcf Toesing[Soil Pressure = 0.00 in Avail Loe Load = 0.00 in Soil Density Toe = 0.00 in Card and a 20 overturing Unchange Over Heal = 0.00 in Soil Density Toe = 0.00 in Avail Loe Load = 0.00 in Avail Loe Load = 0.00 in Soil Pressure Soismic Load = 0.00 in Soil Pressure Soismic Load Image Density Toe = 0.00 in Card Type = Earth (ft) (Service Level) Valia Loe Load = 0.00 in Soil Pressure Soismic Load Image Density Toe = 0.00 in Card Trangular Image Density Toe = 0.00 in Card Type = Earth (ft) (Service Level) Image Density Toe = 0.00 in Card Strength-Level Seismic Load = 0.00 in Soil Pressure (Trangular Load Strength-Level Seismic Load = 0.00 in Soil Pressure (Trangular Distribution = 2.000 pf Contary (Trangular Distribution = 2.000 pf Soil Pressure (Trangular Distribution = 2.000 pf Contary (Trangular Distribution = 2.000 pf Contary (Trangular Distribution = 2.000 pf Soil Pressure (Trangular Distribution = 2.000 pf Soil Pressure (Trangular Distribution = 2.000 pf Contary (Trangular Distribution = 2.000 pf Contary (Trangu							2		
Surcharge Loads Solvertuning 0.00 in Surcharge Core Heal 0.00 pdf 0.00 in Varial Load Applied to Stem 0.00 pdf Axial Load Eccentricity 0.01 bdf Base Above Bleaves 0.00 pdf Certary Base Above Bleaves 0.00 pdf Base Above Bleaves 0.00 pdf Certary Base Above Bleaves 0.00 pdf Contransport 0.00 pdf Certary Base Above Bleaves 0.00 pdf Certary Base Above Bleaves 0.00 pdf Certary Base Above Bleaves 0.00 pdf Stem Construction Estem Construction Estem Pesign Base Above Bleaves 0.00 pdf Stem Construction Estem Stem Construction Design Data Concrete Base Above Bleaves Stem Construction Estem Stem Construction Stem Construction Estem Construction	Wall height above so Slope Behind Wall Height of Soil over T	il = = pe =	0.00 ft 2.00 0.00 in	Equivalent Fluid Press Active Heel Pressure Passive Pressure	ure Method = 35.0 = 0.0) psf/ft) psf/ft			
Surcharge Over Heal = 0.0 pinf Surcharge Over Toe = 0.0 Used for Siding & Overtraining Axial Load Applied to Stem Lateral Load = 0.0 pinf Height to Tor Surcharge Over Toe = 0.0 Used for Siding & Overtraining Axial Load Applied to Stem Adjacet Fooding Load = 0.0 pinf Height to Tor Surcharge Over Toe = 0.00 th Surcharge Over Toe = 0.0 bis Axial Load act = 0.0 bis Axial Load Eccentricity = 0.0 in Earth Pressure Seismic Load Lateral Load = 0.0 pinf Height to Tor (Strength) Adjacet Fooding Load = 0.0 bis Height to Tor (Strength) Adjacet Fooding Load = 0.0 bis Height to Tor (Strength) Adjacet Fooding Load = 0.0 bis Height to Tor Height Above Fit Height Above				Footing Soil Friction Soil height to ignore	= 0.400)			
Used for Resist Siding & OverturningContend to TomeAxial Load Applied to Stem	Surcharge Loa	ds		Lateral Load Ap	plied to Stem	۱ ا ۱	Adjacent Footi	ng Load	a la
Avial Dead LoadColl bis Avial Load Careful to Coll bis Avial Load Careful to 2 0.0 bis Method 1: Triangular Load at battom of Triangular DistributionColl to 2 0.0 bis (Strength Level)Biss Above File Poisson's RatioImage: Coll bis 0.0 psfDesign SummaryStem ConstructionBottom Stem Correcte Design MethodBottom 1 0.0 bis Material Above Fit 1 17 600 bis Stem Correcte Design MethodSold 1 0.0 bis 1 0.0 bis Stem Correcte 1 0.0 bis Material Above Fit 1 12 0.0 bis Rebar SizeSold 2 0.0 bis 1 0.0 bis Material Above Fit 1 12 0.0 bis Rebar SizeSold 1 0.0 bis 1 0.0 bis 	Used To Resist Sli Surcharge Over Toe Used for Sliding &	ding & Ov = Overturnin	verturning 0.0 ng	Height to Tor Height to Bottom	= 8.00 ft = 0.00 ft		Footing Width Eccentricity Wall to Ftg CL Dist	= =	0.00 in 0.00 ft
Earth Pressure Seismic Load Total Strength-Level Seismic Load = 168.000 kt Method : Triangular Distribution = 48.000 pst Total Service-Level Seismic Load = 117.600 kt Strength Sterngth = 48.000 pst Total Service-Level Seismic Load = 117.600 kt Verturning = 47.1 0K Sterngth-Level Seismic Load = 117.600 kt = 117.600 kt Ving Stability Ratios = 1.56 0K Stern Construction = 0.00 in Stern Construction = 0.00 in Total Bearing Load = 5.893 bts = 0.00 in Rebar Spacing = 12.00 Rebar Spacing = 12.00 Soil Pressure (B Toe = 907 psf 0K Multiter fairs = 0.280 Total Force (B Section = 0.00 in Soil Pressure (B Toe = 1.086 psf MorentAllowable = 0.051.1 Strength Level Ibs = 1.131.4 ACI Factored (B Toe = 1.996 psf Strength Level psi = 15.7 Strength Level psi = 15.7 Still Gales Strength Level psi = 15.7 Strength Level psi = 15.7 Strength Level psi = 15.7 Storing Cace = 0.0 lbs OK Anet (Massonry) in 2 = Rebar Oepth 'd' in = 6.00 Masonry Block Ty	Axial Dead Load Axial Live Load	=	0.0 lbs 0.0 lbs		1977 A.	28	Base Above/Below at Back of Wall	121	0.0 ft
Wall Stability Ratios Overturning End of the system of	Load at bottom of T		Distribution	= 48.000 psf					168.000 lbs 117.600 lbs
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Peterson Structural Engineers, Inc. project 1801-0336 date 3/27/	Wind, W		1.000	f'c	AC 23				
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PETERSON STRUCTURAL ENGINEERS



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

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

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Concrete Stem Reb	ar Ar	ea Details					
Bottom Stem		Vertical	Reinforcing H	lorizor	ntal Reinfor	cing	
As (based on applied mor	ment):	0.0885	n2/ft			2	
(4/3) * As :		0.118 ir	2/ft N	Ain Ste	em T&S Re	inf Area 1.1	52 in2
200bd/fy : 200(12)(6)/600	00:	0.24 in2	/ft N	Ain Ste	m T&S Re	inf Area per	ft of stem Height : 0.192 in2/ft
0.0018bh : 0.0018(12)(8)	1	0.1728	n2/ft H	Iorizo	ntal Reinfor	cing Options	1
		=====	====== (One la	ver of :	Two layers	of :
Required Area :		0.1728	n2/ft #	4@ 1	2.50 in	#4@ 25.0	0 in
Provided Area :		0.31 in2	/ft #	15@1	9.38 in	#5@ 38.7	5 in
Maximum Area :		1.3005	n2/ft #	6@ 2	7.50 in	#6@ 55.0	0 in
Footing Data		10	Footing Desig	n Re	sults		
Toe Width Heel Width	=	2.00 ft 4.50	Factored Pressure	-	<u>Toe</u> 1.086	Heel 1,086 ps	
Total Footing Width	- C	6.50	Mu' : Upward	=	2,172	7,980 ft-i	
Footing Thickness	2	12.00 in	Mu' : Downward	=	360	9,664 ft-i	
			Mu: Design	=	1,812	1,684 ft-#	ŧ
Key Width Key Depth		12.00 in 0.00 in	Actual 1-Way Shear		9.75	5.73 ps	
Key Distance from Toe	=	2.00 ft	Allow 1-Way Shear	=	50.60	50.60 ps	i
AND CONTRACTOR AND	-		Toe Reinforcing Heel Reinforcing		5 @ 12.00 5 @ 12.00		
fc = 4,000 psi Footing Concrete Densit	Fy =	60,000 psi 150.00 pcf	Key Reinforcing		5 @ 12.00		
Min. As %	=	0.0018	Footing Torsion, Tu		=	0.00 ft	-lbs
Cover @ Top 3.00	@	Btm.= 3.00 in	Footing Allow. Torsio	n, phi	Tu =	0.00 ft	-lbs
			If torsion exceed supplemental de				
			Other Acceptable S	izes	& Spacing	S	
			Toe: #4@ 9.25 in Heel: Not req'd: M Key: Not req'd: M	u < ph	i*5*lambda	*sqrt(f'c)*Sm	
			Min footing T&S re Min footing T&S re If one layer of horiz	inf Are	a per foot	0.26	in2 in2 .ft rs of horizontal bars:
			#4@ 9.26 in			#4@ 18	
			#5@ 14.35 in			#5@ 28	
			#6@ 20.37 in			#6@ 40	.74 IN



project	1801-0336	date	3/27/2020	
designer	NRW	sheet	B4	



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)

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

Date:

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Summary of Overturning & Resisting Forces & Moments

		OV	ERTURNING			F	RESISTING	0.002 0
Item		Force Ibs	Distance ft	Moment ft-#		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 Hydrostatic Force					Soil Over HL (bel. water tbl) Watre Table		3.58	13,704.2
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
	<u>.</u>			1	Earth @ Stem Transitions =			
Total	=	1,509.0	O.T.M. =	4,409.9	Footing Weight =	975.0	3.25	3,168.8
					Key Weight =		2.50	
Resisting/Overturning			=	4.71	Vert. Component =			
Vertical Loads used for	or Soi	I Pressure	= 5,893.	2 lbs	Total =	5.042.6	lbs R.M.=	20,766.9

* 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	рсі
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.



project	1801-0336	date	3/27/2020	
designer	NRW	sheet	B5	

-				1
1	-)			5
1	2 B	- 1	-	
		and Engr		

As Provided = As Required =

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

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0.3100 in2/ft

0.1728 in2/ft

RetainPro (c) 1987-2019, Build 11.19.07.17 License : KW-06056912 Cantilevered Retaining Wall Code: IBC 2015,ACI 318-14,ACI 530-13 **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



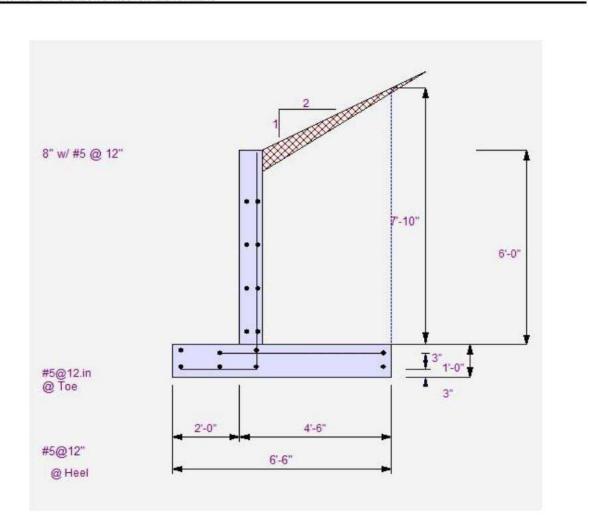
project	1801-0336	date	3/27/2020	
designer	NRW	sheet	B6	



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

Page : 5 12 JUL 2019 Date:

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project	1801-0336	date	3/27/2020	
designer	NRW	sheet	B7	



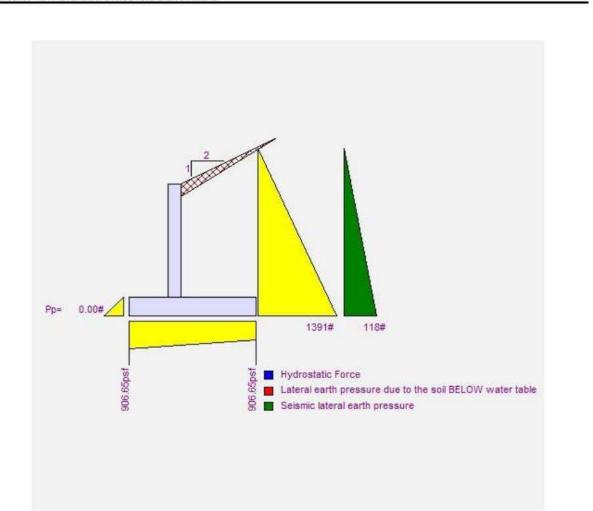
Project Name/Number : 1801-0336-02 Title Garden Curves Dsgnr: NRW Description.... Wall 5 - CIP Cantilever Wall (6'-0" Segment)

Page: 6 12 JUL 2019 Date:

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

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project	1801-0336	date	3/27/2020	
designer	NRW	sheet	B8	



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

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Wall Concrete Masonry Top of Soil Designer to determine bar cutoff locations 650.0 lbs 910.0 lbs 1,040.0 lbs 1,170.0 lbs 0.0 lbs 390.0 lbs 260.0 lbs 520.0 lbs 0 6.00 ft Applied Shear Diagram 0.00 f



project	1801-0336	date	3/27/2020	
designer	NRW	sheet	B9	



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

Page: 8 12 JUL 2019 Date:

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

Wall Concrete Masonry Top of Soil Allowable Moment Lines Designer to determine bar cutoff locations 90.0 ft-# 2,670.0 ft-# 2,670.0 ft-# 3,560.0 ft-# 5,340.0 ft-# 7,120.0 ft-# 7,120.0 ft-# 0.0 6.00 ft Mu = 2,262.9 MnPhi = 8,051.1ft-Applied Moment Diagram 0.00 f



project	1801-0336	date	3/27/2020	
designer	NRW	sheet	B10	

4'-6" Tall Wall



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project	1801-0336	date	3/27/2020	
designer	NRW	sheet	B11	



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

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O 14 1	STRUC	CTURAL ENG			1997.) 1	Ŀ		1000
Criteria			S	oil Data			_ 2	
Retained Height	=	4.50 ft	AI	low Soil Bearing = 2	2,000.0) psf		
Wall height above soil	=	0.00 ft		quivalent Fluid Pressure Metho				
Slope Behind Wall	-	2.00	Ac	ctive Heel Pressure =	35.0) psf/ft		
				=				
Height of Soil over Toe	8 2 8 8858	0.00 in	Pa	assive Pressure =	0.0) psf/ft		
Water height over heel	=	0.0 ft			130.00			
					110.00			
				ooting Soil Friction =	0.400	5 (2 * 5 C) (2 · - 7		
				bil height to ignore	0.100			
				for passive pressure =	0.00	in		
Surcharge Loads				ateral Load Applied to	Stem	ו [Adjacent Footing Load	
Surcharge Over Heel Used To Resist Sliding	= & Ove	0.0 psf		ateral Load =	0.0 #		Adjacent Footing Load = 0.0 lbs Footing Width = 0.00 ft	
Surcharge Over Toe	=	0.0			8.00 ft		Eccentricity = 0.00 in	
Used for Sliding & Ove				5	0.00 ft		Wall to Ftg CL Dist = 0.00 ft	
Axial Load Applied	C 1000		Lo	pad Type = Earl			Footing Type Line Load	
	103			(Sei	vice L	evel)	Base Above/Below Soil	
Axial Dead Load	=	0.0 lbs		Vind on Exposed Stem $=$	0.0 p	sf	at Back of Wall = 0.0 ft	
Axial Live Load	=	0.0 lbs	((Strength Level)			Poisson's Ratio = 0.300	
Axial Load Eccentricity		0.0 in	1.000				17777771222222222222222222222222222222	
Earth Pressure Se	eismie	c Load						
Method : Triangular		2011 - 10 - 10 - 10 - 10 - 10 - 10 - 10		Total S	trengt	h-Level Se	ismic Load = 132.000 lb:	S
Load at bottom of Triang	oular D	istribution					smic Load = 92.400 lb	S
(Strength)	guiar D	istribution		- Holoco par Total c			31110 L000	3
Design Summary			Ę	Stem Construction]	Bottom		
			9) E	Design Height Above Ftg	ft =	Stem OK 0.00		
Wall Stability Ratios				Wall Material Above "Ht"		Concrete		
Overturning	=	5.37 OK		Design Method	=	LRFD		
Sliding	Æ	1.59 OK		Thickness	=	8.00		
				Rebar Size	=	# 5		
Total Bearing Load	=	3,705 lbs		Rebar Spacing	1	12.00		
resultant ecc.	=	0.00 in		Rebar Placed at	=	6 in		
Soil Pressure @ Toe	=	674 psf	OK	besign Data fb/FB + fa/Fa	-	0.124		
Soil Pressure @ Heel	=	674 psf			- 2	0.124	50	
Soli i lessure @ lieei		2,000 psf		Total Force @ Section Service Level	lbs =			
Allowable	=			Service Level	ius =	CEE A		
Allowable Soil Pressure Les	s Than	Allowable		Strongth Lough	lbe -			
Allowable Soil Pressure Les ACI Factored @ Toe	s Than =	Allowable 813 psf		Strength Level	lbs =	655.4		
Allowable Soil Pressure Les ACI Factored @ Toe ACI Factored @ Heel	s Than = =	Allowable 813 psf 813 psf	1202	MomentActual		000.4		
Allowable Soil Pressure Les ACI Factored @ Toe ACI Factored @ Heel Footing Shear @ Toe	s Than = = =	Allowable 813 psf 813 psf 6.8 psi		MomentActual Service Level	ft-# =			
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Allowable Soil Pressure Les ACI Factored @ Toe ACI Factored @ Heel Footing Shear @ Toe Footing Shear @ Heel Allowable Sliding Calcs Lateral Sliding Force	is Than = = = = =	Allowable 813 psf 813 psf 6.8 psi 4.2 psi 75.0 psi 929.6 lbs		MomentActual Service Level Strength Level MomentAllowable ShearActual Service Level	ft-# = ft-# = = psi =	983.0 7,859.7		
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Allowable Soil Pressure Les ACI Factored @ Toe ACI Factored @ Heel Footing Shear @ Toe Footing Shear @ Heel Allowable Silding Calcs Lateral Sliding Force less 100% Passive For less 100% Friction Force Added Force Req'd	s Than = = = = = = ce = - = =	Allowable 813 psf 813 psf 6.8 psi 4.2 psi 75.0 psi 929.6 lbs 0.0 lbs 1,482.1 lbs 0.0 lbs	ок	MomentActual Service Level Strength Level MomentAllowable ShearActual Service Level Strength Level ShearAllowable Anet (Masonry)	ft-# = ft-# = psi = psi = psi = in2 =	983.0 7,859.7 9.1 75.0		
Allowable Soil Pressure Les ACI Factored @ Toe ACI Factored @ Heel Footing Shear @ Toe Footing Shear @ Heel Allowable Silding Calcs Lateral Sliding Force less 100% Passive Forc less 100% Friction Force	s Than = = = = = ce = -	Allowable 813 psf 813 psf 6.8 psi 4.2 psi 75.0 psi 929.6 lbs 0.0 lbs 1,482.1 lbs	ок	MomentActual Service Level Strength Level MomentAllowable ShearActual Service Level Strength Level ShearAllowable Anet (Masonry) Rebar Depth 'd'	ft-# = ft-# = psi = psi = psi =	983.0 7,859.7 9.1		
Allowable Soil Pressure Les ACI Factored @ Toe ACI Factored @ Heel Footing Shear @ Toe Footing Shear @ Heel Allowable Silding Calcs Lateral Sliding Force less 100% Passive For less 100% Friction Force Added Force Req'd	s Than = = = = = = ce = - = =	Allowable 813 psf 813 psf 6.8 psi 4.2 psi 75.0 psi 929.6 lbs 0.0 lbs 1,482.1 lbs 0.0 lbs	ок	MomentActual Service Level Strength Level MomentAllowable ShearActual Service Level Strength Level ShearAllowable Anet (Masonry) Rebar Depth 'd' Masonry Data	ft-# = ft-# = psi = psi = in2 = in =	983.0 7,859.7 9.1 75.0		
Allowable Soil Pressure Les ACI Factored @ Toe ACI Factored @ Heel Footing Shear @ Toe Footing Shear @ Heel Allowable Silding Calcs Lateral Sliding Force less 100% Passive For less 100% Friction Force Added Force Req'd	s Than = = = = = = ce = - = =	Allowable 813 psf 813 psf 6.8 psi 4.2 psi 75.0 psi 929.6 lbs 0.0 lbs 1,482.1 lbs 0.0 lbs	ок	MomentActual Service Level Strength Level MomentAllowable ShearActual Service Level Strength Level ShearAllowable Anet (Masonry) Rebar Depth 'd' Masonry Data fm	ft-# = ft-# = psi = psi = in2 = in = psi =	983.0 7,859.7 9.1 75.0		
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Allowable Soil Pressure Les ACI Factored @ Toe ACI Factored @ Heel Footing Shear @ Heel Allowable Silding Calcs Lateral Sliding Force less 100% Passive For less 100% Priction Forc Added Force Req'd for 1.5 Stability	s Than = = = = ce = - = = = =	Allowable 813 psf 813 psf 6.8 psi 4.2 psi 75.0 psi 929.6 lbs 0.0 lbs 1,482.1 lbs 0.0 lbs 0.0 lbs 0.0 lbs	OK OK OK	MomentActual Service Level Strength Level MomentAllowable ShearActual Service Level Strength Level ShearAllowable Anet (Masonry) Rebar Depth 'd' Masonry Data fm Fs Solid Grouting	ft-# = ft-# = psi = psi = in2 = in = psi =	983.0 7,859.7 9.1 75.0		
Allowable Soil Pressure Les ACI Factored @ Toe ACI Factored @ Heel Footing Shear @ Heel Allowable Silding Calcs Lateral Sliding Force less 100% Passive For less 100% Priction Forc Added Force Req'd for 1.5 Stability	s Than = = = = ce = - = = = =	Allowable 813 psf 813 psf 6.8 psi 4.2 psi 75.0 psi 929.6 lbs 0.0 lbs 1,482.1 lbs 0.0 lbs 0.0 lbs 0.0 lbs	OK OK OK	MomentActual Service Level Strength Level MomentAllowable ShearActual Service Level Strength Level ShearAllowable Anet (Masonry) Rebar Depth 'd' Masonry Data fm Fs Solid Grouting s. Modular Ratio 'n'	ft-# = ft-# = psi = psi = in2 = in2 = in = psi = psi = =	983.0 7,859.7 9.1 75.0 6.00		
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Allowable Soil Pressure Les ACI Factored @ Toe ACI Factored @ Heel Footing Shear @ Toe Footing Shear @ Heel Allowable Sliding Calcs Lateral Sliding Force less 100% Passive Force less 100% Priction Force Added Force Req'd for 1.5 Stability	ss Than = = = = = = = = = = = = = =	Allowable 813 psf 813 psf 6.8 psi 4.2 psi 75.0 psi 929.6 lbs 0.0 lbs 1,482.1 lbs 0.0 lbs 0.0 lbs 0.0 lbs	OK OK OK	MomentActual Service Level Strength Level MomentAllowable ShearAllowable Strength Level Strength Level ShearAllowable Anet (Masonry) Rebar Depth 'd' Masonry Data fm Fs Solid Grouting Solid Grouting Modular Ratio 'n' Wall Weight Short Term Factor	ft-# = ft-# = psi = psi = in 2 = in = psi = psi = = psf = =	983.0 7,859.7 9.1 75.0 6.00		
Allowable Soil Pressure Les ACI Factored @ Toe ACI Factored @ Heel Footing Shear @ Toe Footing Shear @ Toe Footing Shear @ Heel Allowable Silding Calcs Lateral Sliding Force less 100% Passive Forc less 100% Passive Forc less 100% Passive Forc less 100% Passive Forc less 100% Passive Force less	ss Than = = = = = = = = = = = = = =	Allowable 813 psf 813 psf 6.8 psi 4.2 psi 75.0 psi 929.6 lbs 0.0 lbs 1,482.1 lbs 0.0 lbs 0.0 lbs 0.0 lbs 0.0 lbs 0.0 lbs 0.0 lbs	OK OK OK	MomentActual Service Level Strength Level MomentAllowable ShearActual Service Level Strength Level ShearAllowable Anet (Masonry) Rebar Depth 'd' Masonry Data fm Fs Solid Grouting Modular Ratio 'n' Wall Weight Short Term Factor Equiv. Solid Thick.	ft-# = ft-# = psi = psi = in2 = in = psi = psi = psi = = psf = = =	983.0 7,859.7 9.1 75.0 6.00		
Allowable Soil Pressure Les ACI Factored @ Toe ACI Factored @ Heel Footing Shear @ Toe Footing Shear @ Heel Allowable Silding Calcs Lateral Sliding Force less 100% Passive For less 100% Passive For less 100% Friction Forc Added Force Req'd for 1.5 Stability entical component of activ nsidered in the calculatio coad Factors Building Code	ss Than = = = = = = = = = = = = = =	Allowable 813 psf 813 psf 6.8 psi 4.2 psi 75.0 psi 929.6 lbs 0.0 lbs 1,482.1 lbs 0.0 lbs 0.0 lbs 0.0 lbs 0.0 lbs C 2015,ACI	OK OK OK	MomentActual Service Level Strength Level MomentAllowable ShearActual Service Level Strength Level ShearAllowable Anet (Masonry) Rebar Depth 'd' Masonry Data fm Fs Solid Grouting Solid Grouting Modular Ratio 'n' Wall Weight Short Term Factor Equiv. Solid Thick. Masonry Block Type	ft-# = ft-# = psi = psi = in2 = in2 = psi = psi = = psi = = psf = = =	983.0 7,859.7 9.1 75.0 6.00 100.0		
Allowable Soil Pressure Les ACI Factored @ Toe ACI Factored @ Heel Footing Shear @ Toe Footing Shear @ Hee Allowable Sliding Calcs Lateral Sliding Force less 100% Passive Ford less 100% Friction Forc Added Force Req'd for 1.5 Stability ertical component of activ nsidered in the calculatio coad Factors Building Code Dead Load	ss Than = = = = = = = = = = = = = =	Allowable 813 psf 813 psf 6.8 psi 4.2 psi 75.0 psi 929.6 lbs 0.0 lbs 1.482.1 lbs 0.0 lbs 0.0 lbs 0.0 lbs 0.0 lbs C 2015,ACI 1.200	OK OK OK	MomentActual Service Level Strength Level MomentAllowable ShearActual Service Level Strength Level ShearAllowable Anet (Masonry) Rebar Depth 'd' Masonry Data fm Fs Solid Grouting Modular Ratio 'n' Wall Weight Short Term Factor Equiv. Solid Thick.	ft-# = ft-# = psi = psi = in2 = in2 = psi = psi = = psi = = psf = = =	983.0 7,859.7 9.1 75.0 6.00		
Allowable Soil Pressure Les ACI Factored @ Toe ACI Factored @ Heel Footing Shear @ Hee Allowable Sliding Calcs Lateral Sliding Force less 100% Passive Forn less 100% Friction Forc Added Force Req'd for 1.5 Stability ertical component of actin nsidered in the calculation coad Factors Building Code Dead Load Live Load	ss Than = = = = = = = = = = = = = =	Allowable 813 psf 813 psf 6.8 psi 4.2 psi 75.0 psi 929.6 lbs 0.0 lbs 1,482.1 lbs 0.0 lbs 0.0 lbs 0.0 lbs 0.0 lbs C 2015,ACI 1.200 1.600	OK OK OK	MomentActual Service Level Strength Level MomentAllowable ShearAllowable Strength Level Strength Level ShearAllowable Anet (Masonry) Rebar Depth 'd' Masonry Data fm Fs Solid Grouting Solid Grouting Modular Ratio 'n' Wall Weight Short Term Factor Equiv. Solid Thick. Masonry Block Type Masonry Design Method	ft-# = ft-# = psi = psi = in2 = in2 = psi = psi = = psi = = = psf = =	983.0 7,859.7 9.1 75.0 6.00 100.0))) Veight	
Allowable Soil Pressure Les ACI Factored @ Toe ACI Factored @ Heel Footing Shear @ Toe Footing Shear @ Toe Footing Shear @ Heel Allowable Sliding Calcs Lateral Sliding Force less 100% Passive Forre less 100% Passive Forre less 100% Friction Force Added Force Req'd for 1.5 Stability ertical component of acti- nsidered in the calculation coad Factors Building Code Dead Load Live Load Earth, H	ss Than = = = = = = = = = = = = = =	Allowable 813 psf 813 psf 6.8 psi 4.2 psi 4.2 psi 75.0 psi 929.6 lbs 0.0 lbs 1,482.1 lbs 0.0 lbs 0.0 lbs 0.0 lbs C 2015,ACI 1.200 1.600 1.600	OK OK OK	MomentActual Service Level Strength Level MomentAllowable ShearAllowable ShearAllowable Anet (Masonry) Rebar Depth 'd' Masonry Data fm Fs Solid Grouting s. Modular Ratio 'n' Wall Weight Short Term Factor Equiv. Solid Thick. Masonry Block Type Masonry Design Method Concrete Data	ft-# = ft+# = = psi = psi = in 2 = in 2 = psi = = = psi = = = = = = = = = = = = = = = =	983.0 7,859.7 9.1 75.0 6.00 100.0 Medium V ASD 2,500.0))) Veight	



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project	1801-0336	date	3/27/2020	
designer	NRW	sheet	B12	



Project Name/Number : 1801-0336-02 Title Garden Curves Dsgnr: NRW Description....

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Wall 5 - CIP Cantilever Wall (4'-6" segment)

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RetainPro (c) 1987-2019, Build 11.19.07.17 License : KW-06056912 **Cantilevered Retaining Wall**

Concrete Stem Rebar A	rea Details				
Bottom Stem	Vertica	Reinforcing	Horizoi	ntal Reinfor	rcing
As (based on applied moment) : 0.0385		in2/ft			8
(4/3) * As :	0.0513	in2/ft	Min Ste	em T&S Re	einf Area 0.864 in2
200bd/fy : 200(12)(6)/60000 :	0.24 in:	2/ft /	Min Ste	em T&S Re	einf Area per ft of stem Height : 0.192 in2/ft
0.0018bh : 0.0018(12)(8) :	0.1728	in2/ft I	Horizo	ntal Reinfor	rcing Options :
	=====		One la	ver of :	Two layers of :
Required Area :	0.1728	in2/ft #	#4@ 1	2.50 in	#4@ 25.00 in
Provided Area :	0.31 in:		-	9.38 in	#5@ 38.75 in
Maximum Area :	0.8128		\sim	7.50 in	#6@ 55.00 in
Footing Data		Footing Desig	-	200 Sec. 200 200	
The second second	and the second	Tooting Desig	JII IX		
Toe Width =	2.00 ft	17 1720 - 171 - 1725		Toe	Heel
Heel Width = Total Footing Width =	3.50	Factored Pressure	=	813	813 psf
		Mu' : Upward Mu' : Downward	=	1,626	3,263 ft-#
Footing Thickness =	12.00 in	Mu: Design	= =	360 1,266	4,132 ft-# 869 ft-#
Key Width =	12.00 in	Actual 1-Way Shear		6.81	4.24 psi
Key Depth =	0.00 in	Allow 1-Way Shear	-	40.00	40.00 psi
Key Distance from Toe =	2.00 ft	Toe Reinforcing	= #	5 @ 12.00	
f'c = 2,500 psi Fy =	60,000 psi	Heel Reinforcing		5 @ 12.00	
Footing Concrete Density =	150.00 pcf	Key Reinforcing	= #	5 @ 12.00) in
Min. As % =	0.0018	Footing Torsion, Tu		=	0.00 ft-lbs
Cover @ Top 3.00 @	Btm.= 3.00 in	Footing Allow. Torsic	on, phi	Tu =	0.00 ft-lbs
		If torsion exceed	ds allo	wable, pro	ovide
		supplemental de	esign	for footing	torsion.
		Other Acceptable S	Sizes	& Spacing	as
		Toe: #4@ 9.25 in	, #5@	14.34 in, #	#6@ 20.36 in, #7@ 27.77 in, #8@ 36.56 in, #9@
		Heel: Not req'd: M			
		Key: Not req'd: M	lu < ph	ni*5*lambda	a*sqrt(f'c)*Sm
		Min footing T&S re	einf Are	ea	1.43 in2
		Min footing T&S re			0.26 in2 .ft
		If one layer of horiz	zontal	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



project	1801-0336	date	3/27/2020	
designer	NRW	sheet	B13	



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)

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

Summary of Overturning & Resisting Forces & Moments

		OV	ERTURNIN	G		F	RESISTING	 (3433) (3)
Item	_	Force Ibs	Distance ft	Moment ft-#	<i></i>	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 Hydrostatic Force				Sale Constraint Sale	Soil Over HL (bel. water tbl) Watre Table		3.58	6,768.1
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 Soi	=				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
			-	1	Earth @ Stem Transitions =			
Total	=	929.6	O.T.M. =	2,099.6	Footing Weight =	825.0	2.75	2,268.8
					Key Weight =		2.50	
Resisting/Overturning			=	5.37	Vert. Component =			
Vertical Loads used for	or Soi	I Pressure	= 3,705	i.3 lbs	Total =	3,193.4	lbs R.M.=	11,275.4

* 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.



project	1801-0336	date	3/27/2020	
designer	NRW	sheet	B14	

Peteram Straturi Engineera, Inc. Phone: 253-830-2140 www.psengineers.com This Wall in File: X:\2018\01-PDX\1801-0326 to 1801 RetainPro (c) 1987-2019, Build 11.19.07.17	-0350\1
Peterson Structural Enginee 708 Broadway, Suite 110 Tacoma, Washington 98402	rs, Inc.

Project Name/Number : 1801-0336-02 Title Garden Curves Dsgnr: NRW Description.... Wall 5 - CIP Cantilever Wall (4'-6" segment) 50\1801-0336\Working Files by Program\Enercalc

Page: 4 Date: 12 JUL 2019

RetainPro (c) 1987-2019, Build 11.19.07.17 License : KW-06056912 License To : PETERSON STRUCTURAL EN	Cantilevered Retaining Wall	Code: IBC 2015,ACI 318-14,ACI 530-13
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 th	is stem design segment =	18.00 in
Hooked embedment length into footing for #5	6.00 in	
As Provided =		0.3100 in2/ft
As Required =		0.1728 in2/ft



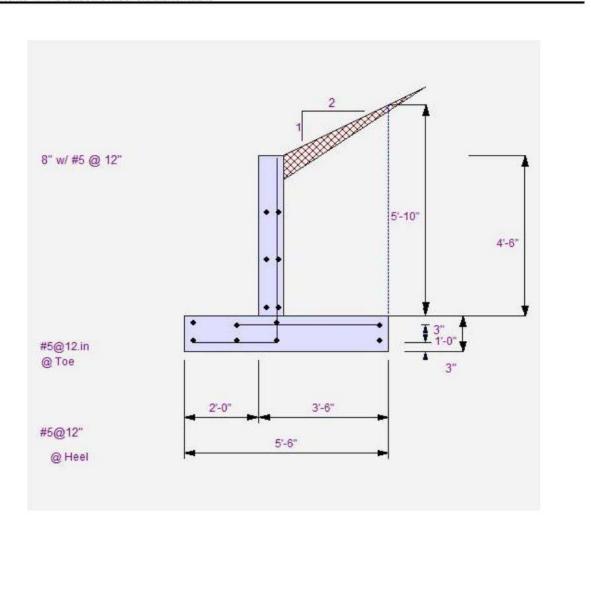
project	1801-0336	date	3/27/2020	
designer	NRW	sheet	B15	



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

Page : 5 12 JUL 2019 Date:

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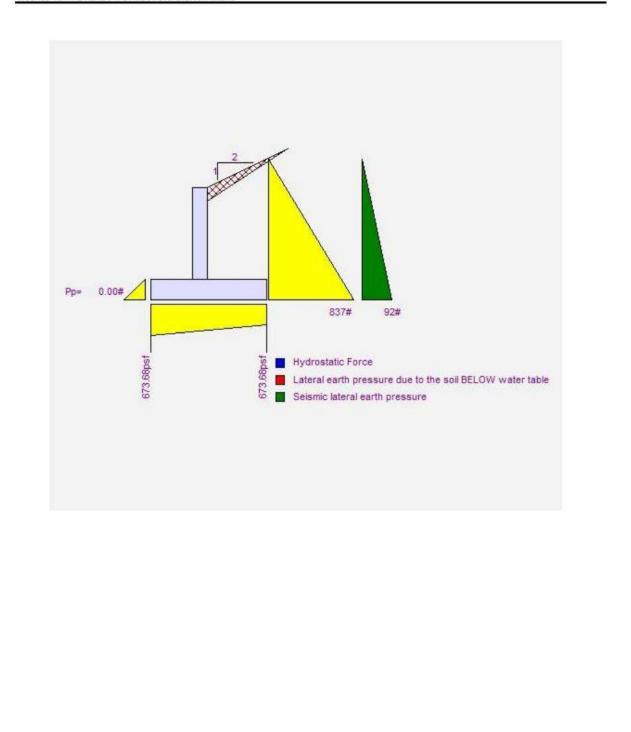
project	1801-0336	date	3/27/2020	
designer	NRW	sheet	B16	



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

Page: 6 12 JUL 2019 Date:

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project	1801-0336	date	3/27/2020	
designer	NRW	sheet	B17	

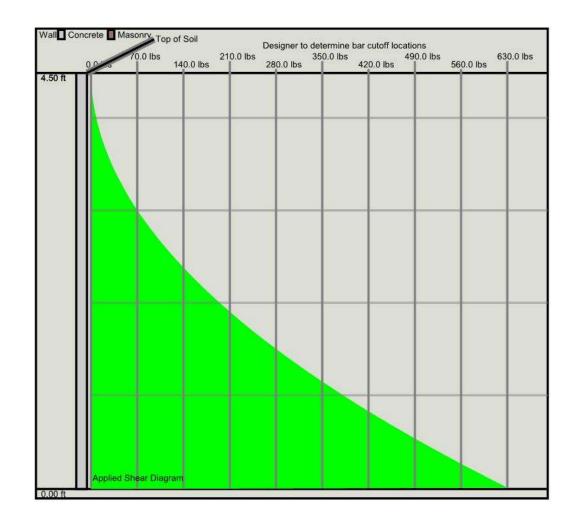


Project Name/Number : 1801-0336-02 Title Garden Curves Dsgnr: NRW Description.... Wall 5 - CIP Cantilever Wall (4'-6" segment)

Page : 7 12 JUL 2019 Date:

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project	1801-0336	date	3/27/2020	
designer	NRW	sheet	B18	



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

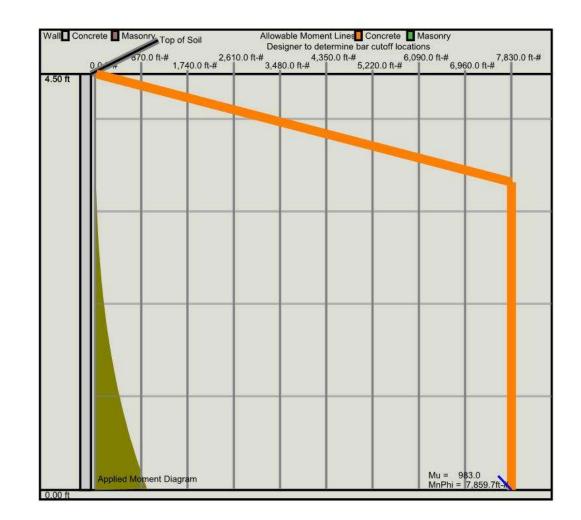
Page: 8 12 JUL 2019 Date:

RetainPro (c) 1987-2019, Build 11.19.07.17

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

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project	1801-0336	date	3/27/2020	
designer	NRW	sheet	B19	

3'-0" Tall Wall



Peterson Structural Engineers, Inc. www.psengineers.com

project 1	801-0336	date	3/27/2020
designer	NRW	sheet	B20



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

Page : 1 12 JUL 2019 Date:

ainPro (c) 1987-2019, Build ense : KW-06056912 ense To : PETERSON S			Cantilevered	l Retaini	ng V	Vall	Code	: IBC 2015	,ACI 3	18-14,ACI 530-
Criteria	moor		Soil Data				1		-	2
Retained Height	= 3	.00 ft	Allow Soil Bearing	= 2	,000.0) psf			1	
		.00 ft	Equivalent Fluid Pres						1	
알려 알려진 것 같은 것은 것은 것은 것은 것은 것은 ³⁴ 가지가 있는 것은 것을 했다.	15 R	.00	Active Heel Pressure	=	35.0) psf/ft				
Height of Soil over Toe				=						
성상 귀엽이 걸려 다 걸렸다. 것이 같아요. 것이 같아요. 나는 것이 않아요. 나는 않아요. 나는 것이 않아요. 나는 않아요. 나는 것이 않아요. 나는 않아요. 나는 않아요. 나는 것이 않아요. 나는 것이 않아요. 나는 것이 않아요. 나 않아요. 나는 것이 않아요. 나는 않아요. 나는 않아요.			Passive Pressure	=	0.0) psf/ft				
Vater height over heel	=	0.0 ft	Soil Density, Heel	= 3	130.00) pcf				
			Soil Density, Toe		110.00) pcf				
			Footing Soil Friction	1	0.400)				
			Soil height to ignore			230.	•	• •		
		1	for passive pressur		0.00			• •		•
Surcharge Loads			Lateral Load Ap	oplied to			12 - 202 - 10 - 10 - 10 - 10 - 10 - 10 -	nt Footing		
Surcharge Over Heel Used To Resist Sliding a		0.0 psf Imina	Lateral Load Height to Tor	=	0.0 #. 8.00 ft		Adjacent i Footing W	Footing Load	=	0.0 lbs 0.00 ft
Surcharge Over Toe		0.0	Height to Bottom		0.00 ft		Eccentrici		=	0.00 in
Used for Sliding & Overt	turning		Load Type	= Eart			Wall to Ft	g CL Dist	=	0.00 ft
Axial Load Applied	to Ste	m	Load Type		vice L	evel)	Footing Ty	/pe		Line Load
		0.0 lbs	Mind Fundadia	3		23 1		ve/Below Soi	il _	0.0 ft
		0.0 lbs	Wind on Exposed St (Strength Level)	iem =	0.0 p			of Wall Patie		
Axial Load Eccentricity		0.0 in	(estergal motor)				Poisson's	Ratio	=	0.300
Earth Pressure Sei	ismic I	Load								
Method : Triangular				Total S	trength	h-Level Sei	smic Loac		=	96.000 lbs
Load at bottom of Triang	ular Dist	ribution	= 48.000 ps	f Total S	ervice	-Level Seis	mic Load.		=	67.200 lbs
(Strength)			8 <u> </u>							
Design Summary			Stem Construc	ction	_	Bottom Stem OK				
Wall Stability Ratios			Design Height	이지 말했다. 영화 영화가 말했구.		0.00				
Overturning	÷	7.96 OK	Wall Material Design Metho		=	Concrete LRFD				
Sliding	=	1.68 OK	Thickness		=	8.00				
			Rebar Size		=	# 5				
Total Bearing Load	=	2,058 lbs	Rebar Spacin	na						
				17.11	=	12.00				
	=	11.12 in	Rebar Placed	17.11	=	12.00 6 in				
			Rebar Placed Design Data	at	=	6 in	8			
resultant ecc. Soil Pressure @ Toe Soil Pressure @ Heel	-	11.12 in 907 psf C 0 psf C	Rebar Placed Design Data bK fb/FB + fa/Fa	at			8			
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resultant ecc. Soil Pressure @ Toe Soil Pressure @ Heel Allowable Soil Pressure Less ACI Factored @ Toe	= = = s Than A =	11.12 in 907 psf C 0 psf C 2,000 psf Illowable 1,269 psf	Rebar Placed Design Data fb/FB + fa/Fa Total Force (Service Le Strength L MomentAc Strength I	@ Section vel evel ctual evel	= = lbs = lbs =	6 in 0.038 306.0 306.0				
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resultant ecc. Soil Pressure @ Toe Soil Pressure @ Heel Allowable Soil Pressure Less ACI Factored @ Toe ACI Factored @ Heel Footing Shear @ Toe Footing Shear @ Toe Footing Shear @ Heel Allowable Solid Factors Added Force Req'd for 1.5 Stability rtical component of active rsidered in the calculation Solid Factors Building Code	= = = = = = = = = = = = = = = = = = =	11.12 in 907 psf (0 psf (2,000 psf 1,269 psf 9.5 psi (8.7 psi (75.0 psi 490.2 lbs 0.0 lbs (0.0	Rebar Placed Design Data fb/FB + fa/Fa Service Le Strength L MomentAd Service Le Strength L MomentAd ShearAttr Shear	g g g g b 'n' ctual evel evel evel wable y) 'd' g b 'n' ctor rhick. ck Type	= lbs = lbs = ft-# = ft-# = psi = psi = psi = psi = psi = psi = psi = = = =	6 in 0.038 306.0 7,859.7 4.3 75.0 6.00 100.0 Medium W				
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resultant ecc. Soil Pressure @ Toe Soil Pressure @ Heel Allowable Soil Pressure Less ACI Factored @ Toe ACI Factored @ Heel Footing Shear @ Toe Footing Shear @ Heel Allowable Siding Calcs Lateral Siding Force less 100% Friction Force Added Force Req'd for 1.5 Stability rtical component of active rsidered in the calculation coad Factors Building Code Dead Load Live Load	= = = = = = = = = = = = = = = = = = =	11.12 in 907 psf (0 psf (2,000 psf 1,269 psf 0 psf 9.5 psi (8.7 psi (75.0 psi 490.2 lbs 0.0 lbs (0.0 lbs	Rebar Placed Design Data fb/FB + fa/Fa Service Le Strength L MomentAd Service Le Strength L MomentAd ShearAttr Shear	g g g cttor rvel evel evel lowable ual evel evel evel wable y) 'd' g o 'n' actor Fhick. ck Type ign Method	= lbs = lbs = ft-# = ft-# = psi = psi = psi = psi = psi = psi = psi = = = =	6 in 0.038 306.0 7,859.7 4.3 75.0 6.00 100.0 Medium W				



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designer	NRW	sheet	B21	



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Wall 5 - CIP Cantilever Wall (3'-0" Tall Segment)

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RetainPro (c) 1987-2019, Build 11.19.07.17 License : KW-06056912 Cantilevered Retaining Wall License To : PETERSON STRUCTURAL ENGINEERS Code: IBC 2015,ACI 318-14,ACI 530-13 Concrete Stem Rebar Area Details Bottom Stem Vertical Reinforcing Horizontal Reinforcing

the Mitchiel and the set of the Providence of the set o	0.040 - 0	101			
s (based on applied momer	그 바람 그 아이는		Min Ci		
4/3) * As :	0.016 in2				einf Area 0.576 in2
00bd/fy : 200(12)(6)/60000					einf Area per ft of stem Height : 0.192 in2/ft
.0018bh : 0.0018(12)(8) :	0.1728 in				rcing Options :
1.51.918				ayer of :	Two layers of :
Required Area :	0.1728 in			12.50 in	#4@ 25.00 in
rovided Area :	0.31 in2/f			19.38 in	#5@ 38.75 in
faximum Area :	0.8128 in	2/ft	#6@ 2	27.50 in	#6@ 55.00 in
Footing Data		Footing Desi	gn R	esults	
PIE = (0.0000000)	= 2.00 ft	2. 12.4 Mit 1485		Toe	Heel
	=	Factored Pressure		1,269	0 psf
	= 4.50	Mu' : Upward Mu' : Downward	-	25,344 4,320	1,414 ft-# 14,991 ft-#
Footing Thickness =	= 12.00 in	Mu: Design	=	4,320	309 ft-#
	= 12.00 in	Actual 1-Way Shear		9.50	8.73 psi
	= 0.00 in	Allow 1-Way Shear		40.00	40.00 psi
Key Distance from Toe	= 2.00 ft	Toe Reinforcing		\$ 5 @ 12.00	
f'c = 2,500 psi Fy	= 60,000 psi	Heel Reinforcing		¥ 5 @ 12.00	
	= 150.00 pcf	Key Reinforcing	= #	\$ 5 @ 12.00	
	= 0.0018	Footing Torsion, Tu			0.00 ft-lbs
Cover @ Top 3.00	@ Btm.= 3.00 in	Footing Allow. Torsi	on, ph	iTu =	0.00 ft-lbs
		If torsion excee			
		supplemental d	lesign	for footing	y torsion.
		Other Acceptable	Sizes	& Spacing	gs
		Toe: Not req'd: N Heel: Not req'd: N Key: No key defi	/u < pl		
		Min footing T&S r			1.17 in2
		Min footing T&S r			
		If one layer of hor	izontal	bars:	If two layers of horizontal bars:
		#4@ 9.26 in			#4@ 18.52 in
		#5@ 14.35 in			#5@ 28.70 in



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Description.

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Wall 5 - CIP Cantilever Wall (3'-0" Tall Segment)

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Summary of Overturning & Resisting Forces & Moments

		OV	ERTURNING			F	RESISTING	S833 - S
Item	. <u>.</u>	Force Ibs	Distance ft	Moment ft-#	8	Force lbs	Distance ft	Moment ft-#
HL Act Pres (ab water tb	0	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 Hydrostatic Force					Soil Over HL (bel. water tbl) Watre Table		3.58	2,562.1
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 Soi	1 =				Soil Over Toe =			
Seismic Earth Load	=	67.2	1.33	89.6	Surcharge Over Toe =			
	=				Stem Weight(s) =	300.0	2.33	700.0
	(0) 100				Earth @ Stem Transitions =			
Total	=	490.2	O.T.M. =	653.7	Footing Weight =	675.0	2.25	1,518.8
					Key Weight =		2.50	
Resisting/Overturning	•		=	7.96	Vert. Component =			
Vertical Loads used for	or So	il Pressure	= 2,057.	9 lbs	Total =	1,799.2	lbs R.M.=	5,205.6

* 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	рсі
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.



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designer	NRW	sheet	B23	

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

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0.1728 in2/ft

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Rebar Lap & Embedment Length	s Information	
Stem Design Segment: Bottom		
Stem Design Height: 0.00 ft above top	of footing	
Lap Splice length for #5 bar specified in th	is 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 =



project	1801-0336	date	3/27/2020	
designer	NRW	sheet	B24	

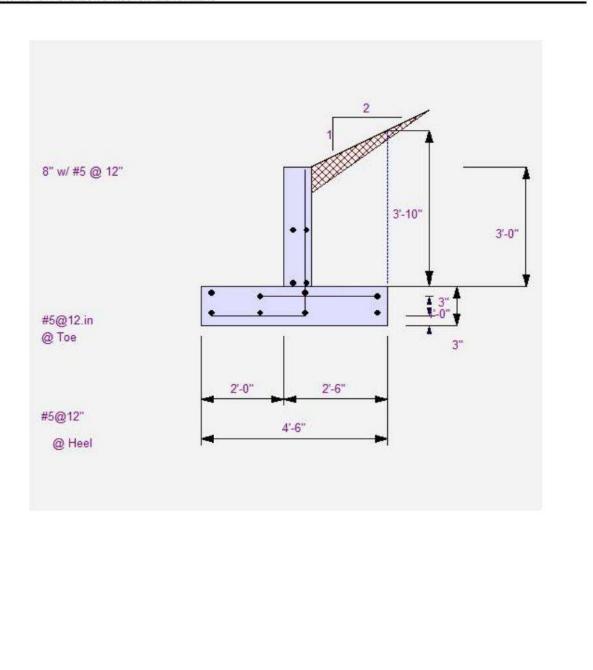


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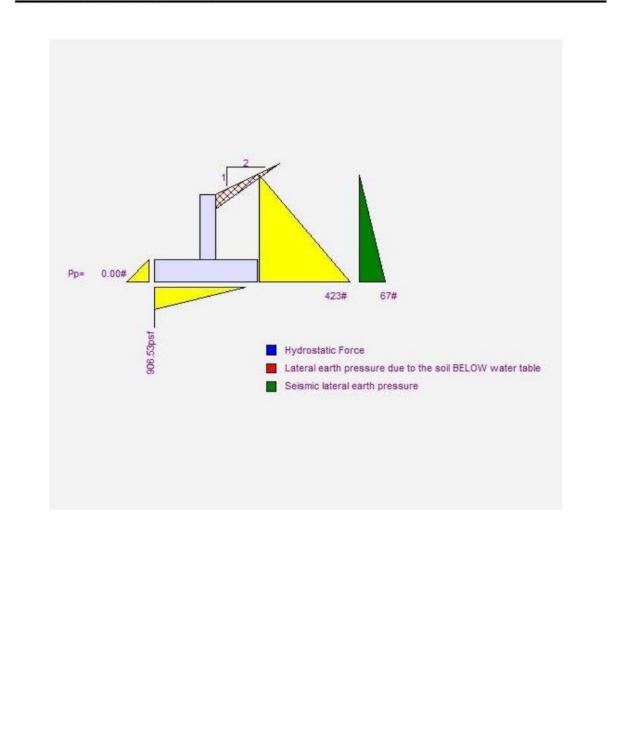
project	1801-0336	date	3/27/2020	
designer	NRW	sheet	B25	_



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Wall Concrete Masonry Top of Soil Designer to determine bar cutoff locations 210.0 lbs 150.0 lbs 0.0 lbs 90.0 lbs 270.0 lbs 180.0 lbs 60.0 lbs 120.0 lbs 240.0 lbs 0 3.00 ft Applied Shear Diagram 0.00 f



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

Wall Concrete Masonry Top of Soil Allowable Moment Lines Designer to determine bar cutoff locations 0.0 ft-# 2,610.0 ft-# 4,350.0 ft-# 6,990.0 ft-# 7,830.0 ft-# 7,830.0 ft-# 01 3.00 ft Mu = 306.0 MnPhi = 7,859.7ftpplied Moment Diagram 0.00 f



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designer	NRW	sheet	B28	