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November 19, 2024

Bradley Heights SS, LLC
1816C – 11th Avenue
Seattle, Washington 98122

PRRWF20250217

Attn: Mr. Jorden Mellergaard
(509) 899-0326
jorden@timberlanepartners.com

City of Puyallup
Building
REVIEWED
FOR
COMPLIANCE
SKinnear
02/21/2025
9:21:56 AM

Calculations required to be provided by the Permittee on site for all Inspections

Retaining Wall Design Letter
Proposed Redi-Rock Walls
Bradley Heights
202 – 27th Avenue East
Puyallup, Washington
PN: 0419036006
Doc: Timberlane.BradleyHeights.RW

INTRODUCTION

We are pleased to present this *Retaining Wall Design Letter* for the proposed Redi-Rock retaining walls to be constructed as part of the Bradley Heights development in Puyallup, Washington. The new retaining walls will provide grade separation between the site and the adjacent parcels to the south. We understand the proposed walls will be Redi-Rock walls constructed in a gravity configuration.

Grading, wall elevations, and wall location information was given in the retaining wall plan sheets G-12 to G-144 prepared by Azure Green Consultants. Soil and design parameters used for the retaining wall designs were based on our previously prepared *Geotechnical Engineering Report* dated February 10, 2022 for the site.

PURPOSE & SCOPE

The purpose of our services was to prepare a retaining wall design for the proposed project. Specifically, our scope of services for this project included the following:

1. Reviewing available geologic data for the site vicinity;
2. Performing two retaining wall designs using the Redi-Rock proprietary software; and,
3. Providing this written *Retaining Wall Design Letter* summarizing our retaining wall calculation, our geotechnical recommendations and design criteria, along with the supporting data.

CONCLUSIONS AND RECOMMENDATIONS

Based on our understanding of the project, it is our opinion that the use of a Redi-Rock gravity retaining wall is feasible from a geotechnical standpoint. A total of three different Redi-Rock gravity retaining walls are proposed in the project. The walls are shown and labeled on Figure 1. The design calculations contained in this letter provide verification of the maximum considered configurations of total wall height and surcharges. Proposed Redi-rock walls with lower maximum heights should follow the same block schedule and meet the proposed design height by removing blocks from the bottom course. Pertinent conclusions and recommendations are provided below.

Retaining Wall Design Inputs

The Redi-Rock concrete block walls should be constructed per the manufacturer's specifications, recommendations contained in our *Geotechnical Engineering Report*, and the recommendations contained herein. The Redi-Rock wall system can be designed both as a gravity wall (without geosynthetic reinforcement) or as a reinforced earth fill wall. For this project, we understand the walls will be designed as gravity walls be placed in front of cuts. We designed the wall sections using the proprietary Redi-Rock Wall Professional program (which uses GEO5 2024 software) and American Association of State and Highway Transportation Officials (AASHTO) Allowable Strength Design (ASD) methods. Global stability analyses were not performed as part of our scope of work.

Block Information

Redi-Rock gravity blocks are cast with knobs on the top of each block that establish the setback for the row of blocks above. The standard Redi-Rock setback is 1.625 inches per block, or approximately a 5 degree batter. The standard Redi-Rock setback blocks were used in our design. The Redi-Rock blocks measure 18 inches tall by approximately 46 inches wide and vary in depth.

Wall Design Assumptions

We assumed the walls would be placed in front of a temporary cut slope in the native soils and be backfilled with the excavated soils compacted to at least 95 percent of the maximum dry density (MDD) as determined by ASTM D1557. Our wall designs assume drained conditions with level foreslopes, and level to 3H:1V backslopes. A 3-foot bench from the face of wall to the start of the back slope was assumed for Wall 3. Our retaining wall calculations include a horizontal seismic acceleration coefficient of 0.3g based on half of the mapped PGA_M stated in our February 2022 report. Passive pressures were not accounted for in our retaining wall design, but we recommend a minimum embedment depth of at least 6 inches for erosion protection.

We used the soil properties in Table 1, below, based on our experience with the soils at the site and typical values per the 2021 WSDOT *Geotechnical Design Manual*, Chapter 5. If the proposed conditions are modified or are not correct, we should be notified and allowed to review our calculations prior to construction of the proposed wall.

TABLE 1:
SOIL PROPERTIES FOR WALL DESIGN

Soil Type	Soil Description	Unit Weight (pcf)	Cohesion (psf)	Phi (degrees)
SM	Retained Soil (Recessional Outwash)	130	0	34
GW-GM	Crushed Surfacing Top Course (CSTC, Leveling Pad)	130	0	40
GP	Structural Fill	130	0	36

Wall Bearing Surfaces

We assumed that the walls will be founded on a leveling pad of crushed rock supported on suitable native soils. The compacted leveling pad of crushed rock should have a minimum thickness of 6 inches, that extends a minimum of 6-inches in all directions from the base blocks.

Gravity Retaining Wall Design

Table 2, below, describes block dimensions and configuration for the gravity wall sections. A typical detail is included as Figure 2. Calculations for the wall sections described are provided in Appendix A. Standard details from the manufacturer are included in Appendix B.

TABLE 2:
REDI ROCK GRAVITY WALL CONFIGURATION

Section	# Rows of Blocks	Row No. (Bottom up)	Block Size (Inches)	Setback (Inches)	Total Wall Height (feet)	Surcharges
Walls 1 & 2	6	1-2 3-4 5 6	60 41 28 28T[1]	1.625 1.625 1.625 1.625	9.0	Seismic
Wall 3	6	1-2 3-4 5 6	60 41 28 28T[1]	1.625 1.625 1.625 1.625	9.0	Seismic, 3H:1V backslope

[1] 28 inch wide top block

Wall Drainage

Drainage behind all walls should be constructed in accordance with the "**Wall Drainage**" section of our previously prepared *Geotechnical Engineering Report* dated February 10, 2022.

Structural Fill

All fill associated with the proposed walls should be placed as structural fill in accordance with the "**Structural Fill**" section of our previously prepared *Geotechnical Engineering Report* dated February 10, 2022.

Temporary Excavations

Temporary excavations should be constructed in accordance with the "**Temporary Excavations**" section of our previously prepared *Geotechnical Engineering Report* dated February 10, 2022. The temporary excavations will likely extend across the property line for the proposed walls.

Additional Services and Construction Observation

We recommend GeoResources be retained to observe the geotechnical aspects of construction, particularly the wall subgrade, fill placement and compaction, and drainage activities, including the wall drainage course. This observation would allow us to verify the subsurface conditions as they are exposed during construction and to determine that work is accomplished in accordance with recommendations.

LIMITATIONS

We have prepared this *Retaining Wall Design Letter* for Bradley Heights SS, LLC, Timberlane Partners and other members of the design team for use in evaluating a portion of this project.

Subsurface conditions described herein were based on our previous subsurface explorations at the site.

The analyses, conclusions, and recommendations contained in this report are based on site conditions as they presently exist. We did not perform additional subsurface explorations for this project. If actual conditions differ from those observed previously for the site are observed or appear to be present during construction, we should be advised at once so that we can review these conditions and reconsider our recommendations, where necessary. If there is a substantial lapse of time between submission of our report and the start of work at the site, or if conditions have changed because of natural forces or construction operations at or near the site, it is recommended that this report be reviewed to determine the applicability of the conclusions and recommendations.

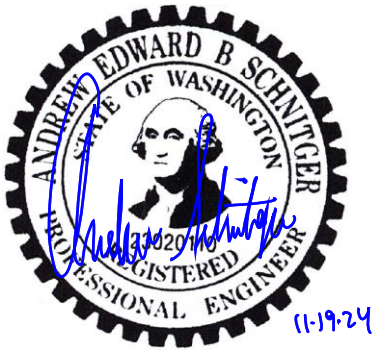
This report may be made available to regulatory agencies or others, but this report and conclusions should not be construed as a warranty of subsurface conditions. Subsurface conditions can vary over short distances and can change with time. The scope of our services did not include geotechnical investigation, environmental assessment or evaluation regarding the presence or absence of wetlands or hazardous or toxic materials in the soil, surface water, groundwater, or air at the subject site other than those activities described in this report.

Within the limitations of scope, schedule and budget, our services have been executed in accordance with generally accepted practices in this area at the time.

◆ ◆ ◆

We have appreciated the opportunity to be of service to you on this project. If you have any questions or comments, please do not hesitate to call at your earliest convenience.

Respectfully submitted,
GeoResources, LLC



Andrew Schnitger, PE
Project Engineer

Eric Heller, PE, LG
Senior Geotechnical Engineer

AES:EWH/aes
DocID: Timberlane.BradleyHeights.RW
Attachments: Figure 1: Site Plan
Figure 2: Typical Redi-Rock Wall Detail
Appendix A: Redi-Rock Retaining Wall Calculations
Appendix B: Block Manufacturer Standard Details

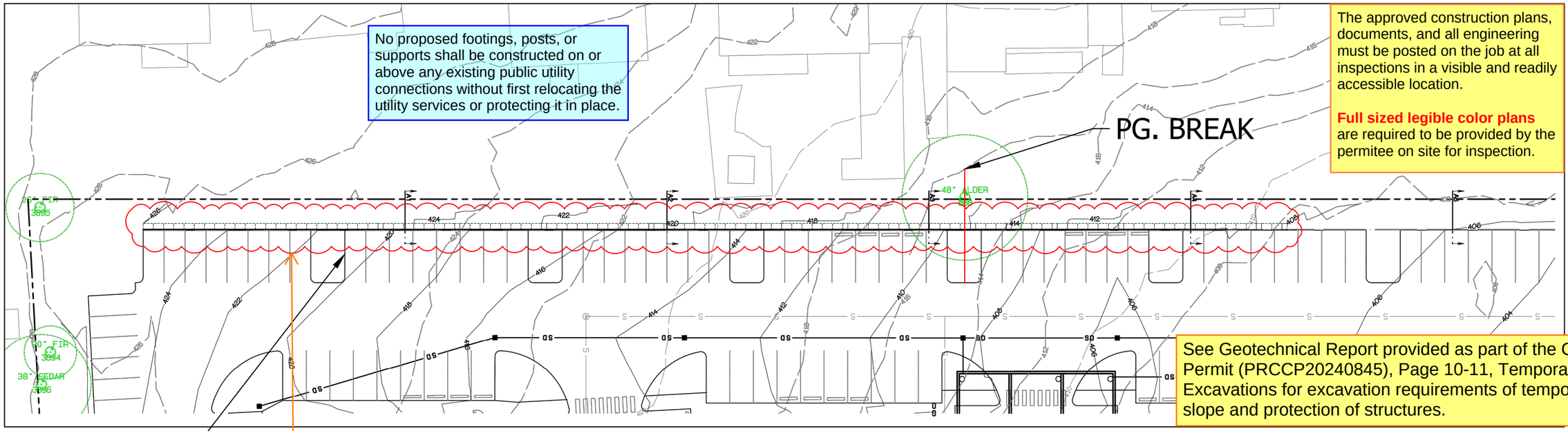
PRRWF20250217

No proposed footings, posts, or supports shall be constructed on or above any existing public utility connections without first relocating the utility services or protecting it in place.

The approved construction plans, documents, and all engineering must be posted on the job at all inspections in a visible and readily accessible location.

Full sized legible color plans are required to be provided by the permitee on site for inspection.

PG. BREAK



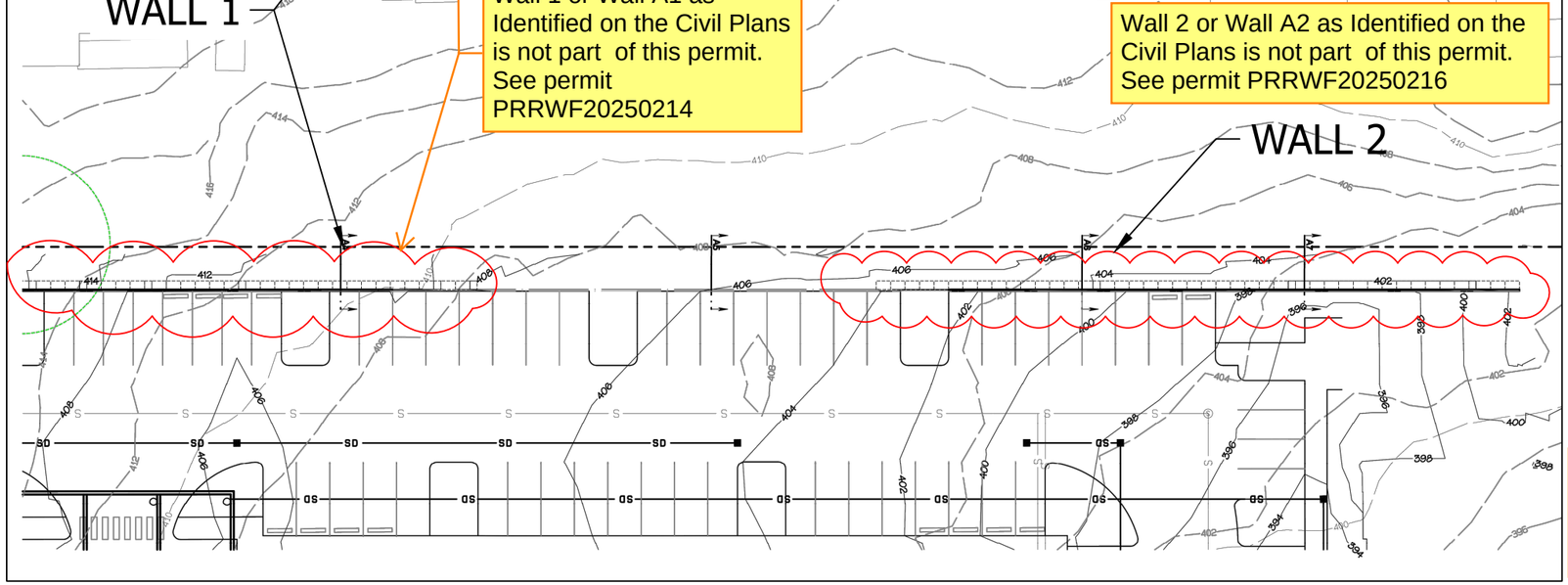
See Geotechnical Report provided as part of the Civil Permit (PRCCP20240845), Page 10-11, Temporary Excavations for excavation requirements of temporary cut slope and protection of structures.

WALL 1

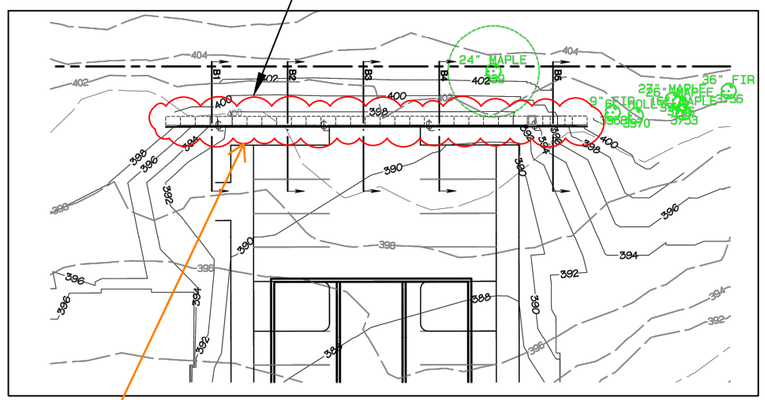
Wall 1 or Wall A1 as Identified on the Civil Plans is not part of this permit. See permit PRRWF20250214

Wall 2 or Wall A2 as Identified on the Civil Plans is not part of this permit. See permit PRRWF20250216

WALL 2



WALL 3



Permit is for Wall B as identified on the Civil Plans (PRCCP20240845), Sheet G-8.

0 40 80

Scale: 1" = 40"

Notes

Excerpts from Sheets G12 to G14 of the project plans by Azure Green Consultants

Approval of submitted plans is not an approval of omissions or oversights by this office or non compliance with any applicable regulations of local government. The contractor is responsible for making sure that the building complies with all applicable codes and regulations of the local government.

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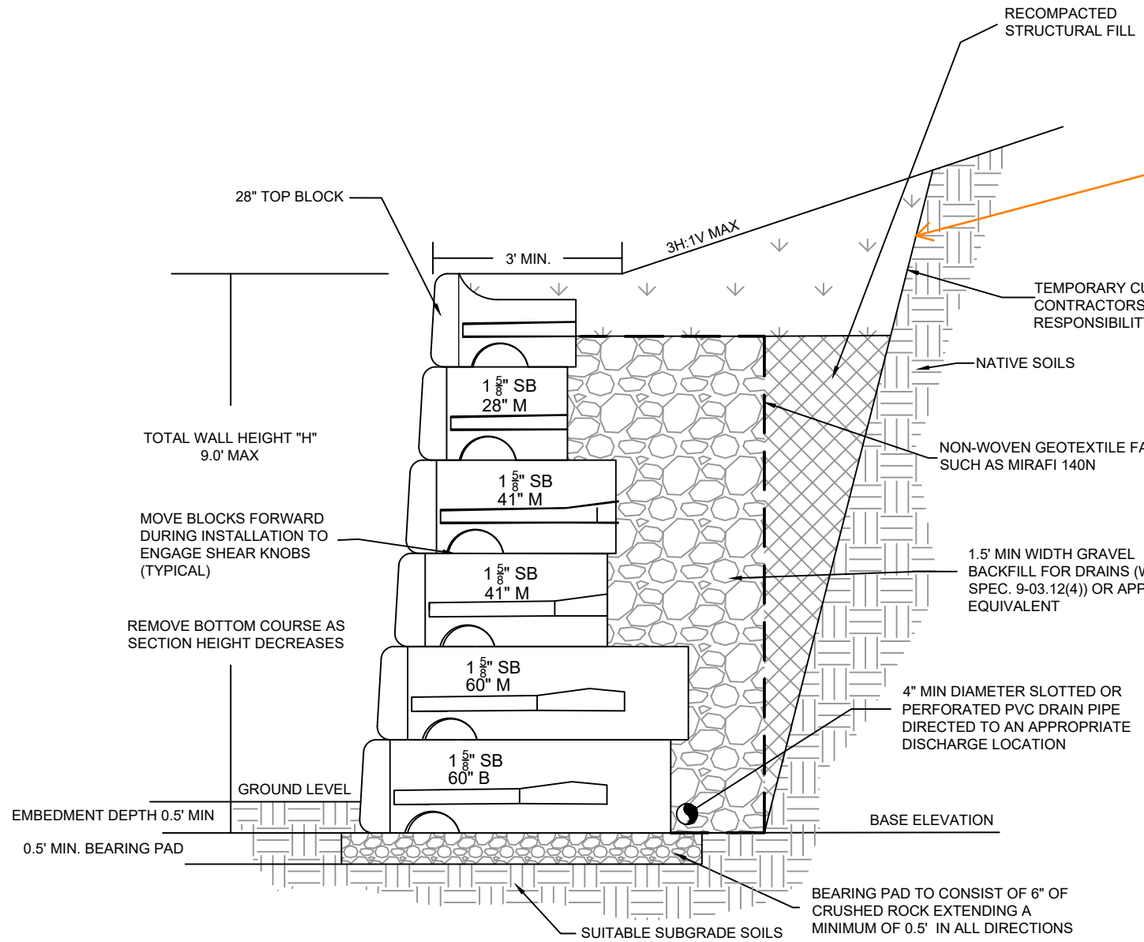
Site Plan

Proposed Redi-Rock Walls
Bradley Heights
202 - 27th Avenue East
Puyallup, Washington
PN: 0419036006

DocID: Timberlane.BradleyHeights.F	November 2024	Figure 1

PRRWF20250217



See Geotechnical Report provided as part of the Civil Permit (PRCCP20240845), Page 10-11, Temporary Excavations for excavation requirements of temporary cut slope and protection of structures.

9.0 FT REDI-ROCK GRAVITY WALL (MAX HEIGHT)

(No Scale)

Notes

Maximum height retaining wall = 9.0 feet

Maximum backslope = 3H:1V

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Typical Redi-Rock Wall Detail

Proposed Redi-Rock Walls

Bradley Heights

202 - 27th Avenue East

Puyallup, Washington

PN: 0419036006

DocID: Timberlane.BradleyHeights.F	November 2024	Figure 2

Appendix A

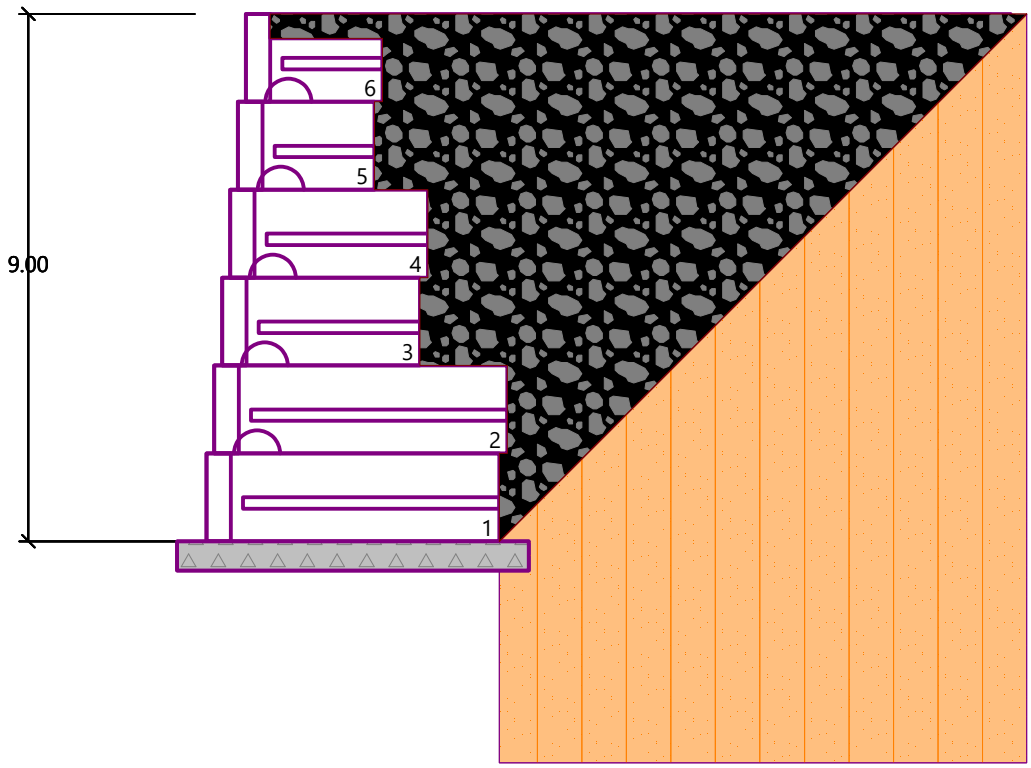
Redi-Rock Retaining Wall Calculations

Analysis of Redi Rock wall

Input data (Stage of construction 1)

Project : 9 FOOT WALL LEVEL BACKSLOPE
Customer : BRADLEY HEIGHTS SS,LLC
Author : AES
Date : 11/12/2024
Project ID : TIMBERLANE.BRADLEY HEIGHTS

Name : 9 foot with slopes	Stage - analysis : 1 - 0



Settings

(input for current task)

Wall analysis

Verification methodology :	Safety factors (ASD)
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

Safety factors			
Permanent design situation			
Safety factor for overturning :	SF_o =	1.50	[–]
Safety factor for sliding resistance :	SF_s =	1.50	[–]

Safety factors			
Permanent design situation			
Safety factor for bearing capacity :	SF_b =	2.00	[–]
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	[–]

Safety factors			
Seismic design situation			
Safety factor for overturning :	SF_o =	1.12	[–]
Safety factor for sliding resistance :	SF_s =	1.12	[–]
Safety factor for bearing capacity :	SF_b =	1.50	[–]
Safety factor for sliding along geo-reinforcement :	SF_{sr} =	1.12	[–]
Safety factor for geo-reinforcement strength :	SF_{st} =	1.12	[–]
Safety factor for pull out resistance of geo-reinf. :	SF_{po} =	1.12	[–]
Safety factor for connection strength :	SF_{con} =	1.12	[–]

Blocks

No.	Description	Block height h [in]	Block width w [in]	Unit weight γ [pcf]
1	Block 28	18.00	28.00	120.00
2	Block 41	18.00	40.50	120.00
3	Block 60	18.00	60.00	130.00
4	Top block 28	18.00	28.00	120.00

No.	Description	Shear bearing capacity of joint F_{min} [lbf/ft]	Max. shear strength F_{max} [lbf/ft]	Block friction f [°]
1	Block 28	6061.00	11276.00	44.00
2	Block 41	6061.00	11276.00	44.00
3	Block 60	6061.00	11276.00	44.00
4	Top block 28	6061.00	11276.00	44.00

Setbacks

No.	Setback s [in]
1	0.000
2	0.033
3	0.135
4	0.781
5	1.385

Geometry

No. group	Description	Count	Setback s [in]
1	Block 60	2	0.13
2	Block 41	2	0.13
3	Block 28	1	0.13
4	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 = 6.00 ft

Material

Soil creating foundation - CSTC

Basic soil parameters

No.	Name	Pattern	φ_{ef} [°]	c_{ef} [psf]	γ [pcf]	γ_{su} [pcf]	δ [°]
1	Retained Soils		34.00	0.0	130.00	67.50	22.78
2	CSTC		40.00	0.0	130.00	67.50	26.80
3	Structural Fill		36.00	0.0	130.00	67.50	24.12

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

Soil parameters

Retained Soils

Unit weight : γ = 130.0 pcf
Stress-state : effective
Angle of internal friction : φ_{ef} = 34.00 °
Cohesion of soil : c_{ef} = 0.0 psf
Angle of friction struc.-soil : δ = 22.78 °
Saturated unit weight : γ_{sat} = 130.0 pcf

CSTC

Unit weight : γ = 130.0 pcf
Stress-state : effective
Angle of internal friction : φ_{ef} = 40.00 °
Cohesion of soil : c_{ef} = 0.0 psf
Angle of friction struc.-soil : δ = 26.80 °
Saturated unit weight : γ_{sat} = 130.0 pcf

Structural Fill

Unit weight : γ = 130.0 pcf
Stress-state : effective
Angle of internal friction : φ_{ef} = 36.00 °
Cohesion of soil : c_{ef} = 0.0 psf

Angle of friction struc.-soil : $\delta = 24.12$ °
Saturated unit weight : $\gamma_{sat} = 130.0$ pcf

Backfill

Assigned soil : Structural Fill
Slope = 45.00 °

Geological profile and assigned soils

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

Terrain profile

Terrain behind the structure is flat.

Water influence

Ground water table is located below the structure.

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 : permanent
Reduction of soil/soil friction angle : do not reduce

Verification No. 1 (Stage of construction 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	-3.72	4303.1	2.77	1.000
Weight - earth wedge	0.0	-0.80	29.3	5.68	1.000
Weight - earth wedge	0.0	-4.40	260.5	4.68	1.000
Weight - earth wedge	0.0	-7.00	89.3	3.72	1.000
Weight - earth wedge	0.0	-9.29	98.1	2.50	1.000
Active pressure	1384.0	-3.22	1806.3	5.16	1.000

Verification of complete wall

Check for overturning stability
Resisting moment $M_{res} = 23187.5$ lbfft/ft
Overturning moment $M_{ovr} = 4456.9$ lbfft/ft

Safety factor = 5.20 > 1.50
Wall for overturning is SATISFACTORY

Check for slip
Resisting horizontal force $H_{res} = 4442.69$ lbf/ft
Active horizontal force $H_{act} = 1384.03$ lbf/ft

Safety factor = 3.21 > 1.50
Wall for slip is SATISFACTORY

Overall check - WALL is SATISFACTORY

Dimensioning No. 1 (Stage of construction 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	-3.56	3913.1	2.24	1.000
Weight - earth wedge	0.0	-3.90	260.5	4.18	1.000
Weight - earth wedge	0.0	-6.50	89.3	3.22	1.000
Weight - earth wedge	0.0	-8.79	98.1	2.00	1.000
Active pressure	1185.6	-3.18	1316.5	4.40	1.000

Verification of most stressed block No. 1

Check for overturning stability

Resisting moment M_{res} = 16150.0 lbfft/ft
Overturning moment M_{ovr} = 3775.0 lbfft/ft

Safety factor = 4.28 > 1.50
Joint for overturning stability is SATISFACTORY

Check for slip

Resisting horizontal force H_{res} = 4763.90 lbf/ft
Active horizontal force H_{act} = 1185.59 lbf/ft

Safety factor = 4.02 > 1.50
Joint for verification is SATISFACTORY

Bearing capacity of foundation soil (Stage of construction 1)

Design load acting at the center of footing bottom

No.	Moment [lbfft/ft]	Norm. force [lbf/ft]	Shear Force [lbf/ft]	Eccentricity [–]	Stress [psf]
1	1029.1	6586.56	1384.03	0.026	1158.1

Service load acting at the center of footing bottom

No.	Moment [lbfft/ft]	Norm. force [lbf/ft]	Shear Force [lbf/ft]
1	1029.1	6586.56	1384.03

Verification of foundation soil

Stress in the footing bottom : rectangle

Eccentricity verification

Max. eccentricity of normal force e = 0.026
Maximum allowable eccentricity e_{alw} = 0.333

Eccentricity of the normal force is SATISFACTORY

Verification of bearing capacity

Max. stress at footing bottom σ = 1158.1 psf
Allowable bearing capacity of foundation soil R_d = 6000.0 psf

Safety factor = 5.18 > 2.00

Bearing capacity of foundation soil is SATISFACTORY

Overall verification - bearing capacity of found. soil is SATISFACTORY

Input data (Stage of construction 2)

Geological profile and assigned soils

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

Terrain profile

Terrain behind the structure is flat.

Water influence

Ground water table is located below the structure.

Resistance on front face of the structure

Resistance on front face of the structure is not considered.

Earthquake

Factor of horizontal acceleration K_h = 0.3000
Factor of vertical acceleration K_v = 0.0000

Water below the GWT is restricted.

Settings of the stage of construction

Design situation : seismic
Reduction of soil/soil friction angle : do not reduce

Verification No. 1 (Stage of construction 2)

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	-3.72	4303.1	2.77	1.000
Earthq.- constr.	1292.3	-3.79	0.0	2.75	1.000
Weight - earth wedge	0.0	-0.80	29.3	5.68	1.000
Earthquake - soil wedge	8.8	-0.80	0.0	5.68	1.000
Weight - earth wedge	0.0	-4.40	260.5	4.68	1.000
Earthquake - soil wedge	78.1	-4.40	0.0	4.68	1.000
Weight - earth wedge	0.0	-7.00	89.3	3.72	1.000
Earthquake - soil wedge	26.8	-7.00	0.0	3.72	1.000
Weight - earth wedge	0.0	-9.29	98.1	2.50	1.000
Earthquake - soil wedge	29.4	-9.29	0.0	2.50	1.000
Active pressure	1384.0	-3.22	1806.3	5.16	1.000
Earthq.- act.pressure	1604.8	-6.33	2448.9	4.32	1.000

Verification of complete wall

Check for overturning stability
Resisting moment M_{res} = 33759.8 lbfft/ft
Overturning moment M_{ovr} = 20336.4 lbfft/ft

Safety factor = 1.66 > 1.12

Wall for overturning is SATISFACTORY

Check for slip
Resisting horizontal force H_{res} = 6094.52 lbf/ft
Active horizontal force H_{act} = 4424.28 lbf/ft

Safety factor = 1.38 > 1.12
Wall for slip is SATISFACTORY

Overall check - WALL is SATISFACTORY

Dimensioning No. 1 (Stage of construction 2)

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	-2.61	1963.1	1.66	1.000
Earthq.- constr.	616.6	-2.58	0.0	1.65	1.000
Weight - earth wedge	0.0	-3.50	89.3	2.95	1.000
Earthquake - soil wedge	26.8	-3.50	0.0	2.95	1.000
Weight - earth wedge	0.0	-5.79	98.1	1.73	1.000
Earthquake - soil wedge	29.4	-5.79	0.0	1.73	1.000
Active pressure	500.7	-2.10	383.7	3.24	1.000
Earthq.- act.pressure	599.2	-4.07	752.8	2.97	1.000

Verification of most stressed block No. 3

Check for overturning stability
Resisting moment M_{res} = 7164.0 lbfft/ft
Overturning moment M_{ovr} = 5346.7 lbfft/ft

Safety factor = 1.34 > 1.12
Joint for overturning stability is SATISFACTORY

Check for slip
Resisting horizontal force H_{res} = 9235.23 lbf/ft
Active horizontal force H_{act} = 1772.82 lbf/ft

Safety factor = 5.21 > 1.12
Joint for verification is SATISFACTORY

Bearing capacity of foundation soil (Stage of construction 2)

Design load acting at the center of footing bottom

No.	Moment [lbfft/ft]	Norm. force [lbf/ft]	Shear Force [lbf/ft]	Eccentricity [–]	Stress [psf]
1	13683.2	9035.49	4424.28	0.252	3041.0

Service load acting at the center of footing bottom

No.	Moment [lbfft/ft]	Norm. force [lbf/ft]	Shear Force [lbf/ft]
1	13683.2	9035.49	4424.28

Verification of foundation soil

Stress in the footing bottom : rectangle

Eccentricity verification

Max. eccentricity of normal force $e = 0.252$
Maximum allowable eccentricity $e_{alw} = 0.333$

Eccentricity of the normal force is SATISFACTORY

Verification of bearing capacity

Max. stress at footing bottom $\sigma = 3041.0$ psf
Allowable bearing capacity of foundation soil $R_d = 9000.0$ psf

Safety factor = 2.96 > 1.50
Bearing capacity of foundation soil is SATISFACTORY

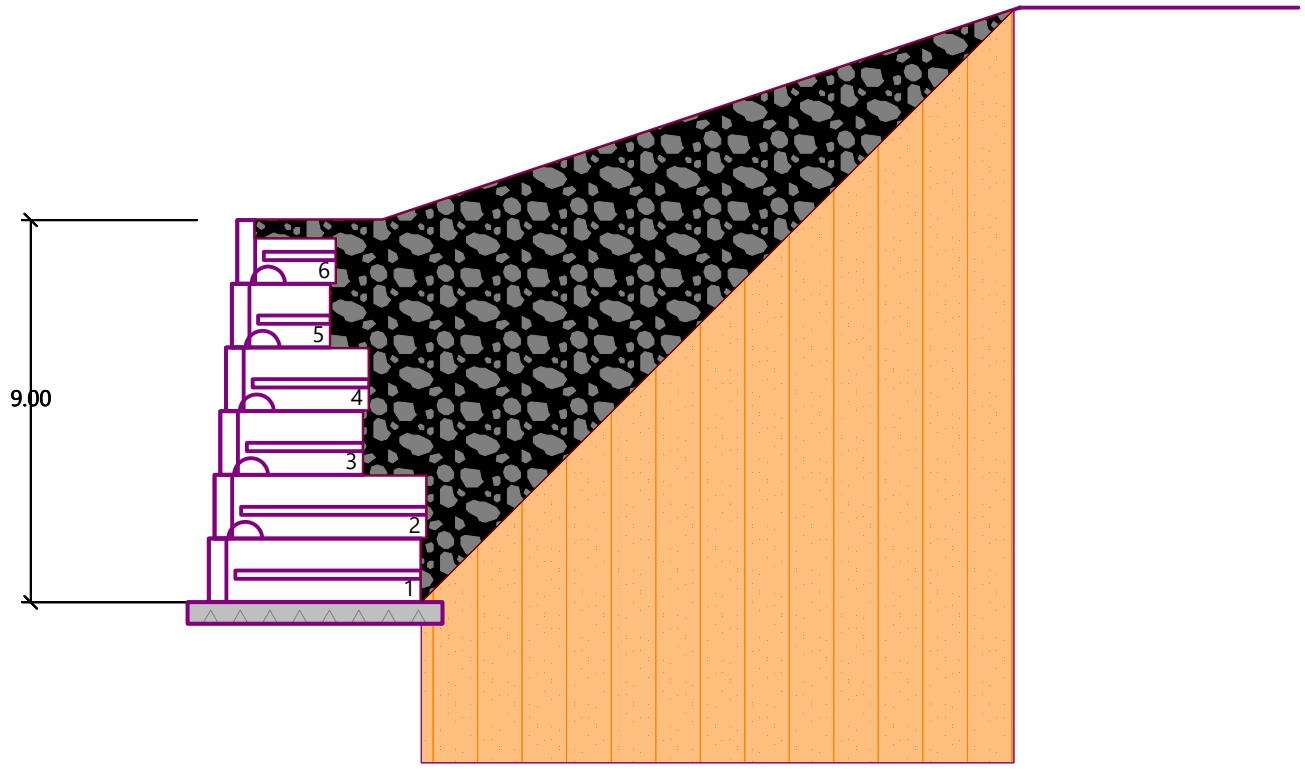
Overall verification - bearing capacity of found. soil is SATISFACTORY

Analysis of Redi Rock wall

Input data (Stage of construction 1)

Project : 9 FOOT WALL WITH SLOPES
Customer : BRADLEY HEIGHTS SS,LLC
Author : AES
Date : 11/12/2024
Project ID : TIMBERLANE.BRADLEY HEIGHTS

Name : 9 foot with slopes	Stage - analysis : 1 - 0



Settings

(input for current task)

Wall analysis

Verification methodology :	Safety factors (ASD)
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

Safety factors			
Permanent design situation			
Safety factor for overturning :	SF_o =	1.50	[–]
Safety factor for sliding resistance :	SF_s =	1.50	[–]

Safety factors			
Permanent design situation			
Safety factor for bearing capacity :	SF_b =	2.00	[–]
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	[–]

Safety factors			
Seismic design situation			
Safety factor for overturning :	SF_o =	1.12	[–]
Safety factor for sliding resistance :	SF_s =	1.12	[–]
Safety factor for bearing capacity :	SF_b =	1.50	[–]
Safety factor for sliding along geo-reinforcement :	SF_{sr} =	1.12	[–]
Safety factor for geo-reinforcement strength :	SF_{st} =	1.12	[–]
Safety factor for pull out resistance of geo-reinf. :	SF_{po} =	1.12	[–]
Safety factor for connection strength :	SF_{con} =	1.12	[–]

Blocks

No.	Description	Block height h [in]	Block width w [in]	Unit weight γ [pcf]
1	Block 28	18.00	28.00	120.00
2	Block 41	18.00	40.50	120.00
3	Block 60	18.00	60.00	130.00
4	Top block 28	18.00	28.00	120.00

No.	Description	Shear bearing capacity of joint F_{min} [lbf/ft]	Max. shear strength F_{max} [lbf/ft]	Block friction f [°]
1	Block 28	6061.00	11276.00	44.00
2	Block 41	6061.00	11276.00	44.00
3	Block 60	6061.00	11276.00	44.00
4	Top block 28	6061.00	11276.00	44.00

Setbacks

No.	Setback s [in]
1	0.000
2	0.033
3	0.135
4	0.781
5	1.385

Geometry

No. group	Description	Count	Setback s [in]
1	Block 60	2	0.13
2	Block 41	2	0.13
3	Block 28	1	0.13
4	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 = 6.00 ft

Material

Soil creating foundation - CSTC

Basic soil parameters

No.	Name	Pattern	φ_{ef} [°]	c_{ef} [psf]	γ [pcf]	γ_{su} [pcf]	δ [°]
1	Retained Soils		34.00	0.0	130.00	67.50	22.78
2	CSTC		40.00	0.0	130.00	67.50	26.80
3	Structural Fill		36.00	0.0	130.00	67.50	24.12

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

Soil parameters

Retained Soils

Unit weight : γ = 130.0 pcf
Stress-state : effective
Angle of internal friction : φ_{ef} = 34.00 °
Cohesion of soil : c_{ef} = 0.0 psf
Angle of friction struc.-soil : δ = 22.78 °
Saturated unit weight : γ_{sat} = 130.0 pcf

CSTC

Unit weight : γ = 130.0 pcf
Stress-state : effective
Angle of internal friction : φ_{ef} = 40.00 °
Cohesion of soil : c_{ef} = 0.0 psf
Angle of friction struc.-soil : δ = 26.80 °
Saturated unit weight : γ_{sat} = 130.0 pcf

Structural Fill

Unit weight : γ = 130.0 pcf
Stress-state : effective
Angle of internal friction : φ_{ef} = 36.00 °
Cohesion of soil : c_{ef} = 0.0 psf

Angle of friction struc.-soil : δ = 24.12 °
Saturated unit weight : γ_{sat} = 130.0 pcf

Backfill

Assigned soil : Structural Fill
Slope = 45.00 °

Geological profile and assigned soils

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

Terrain profile

No.	Coordinates x [ft]	Depth z [ft]
1	0.00	0.00
2	3.00	0.00
3	18.00	-5.00
4	19.00	-5.00

Origin [0,0] is located in upper right edge of construction.
Positive coordinate +z has downward direction.

Water influence

Ground water table is located below the structure.

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 : permanent
Reduction of soil/soil friction angle : do not reduce

Verification No. 1 (Stage of construction 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	-3.72	4303.1	2.77	1.000
Weight - earth wedge	0.0	-0.87	36.3	5.68	1.000
Weight - earth wedge	0.0	-5.36	447.2	4.41	1.000
Weight - earth wedge	0.0	-9.29	98.1	2.50	1.000
Active pressure	1747.2	-3.16	2116.7	5.25	1.000

Verification of complete wall

Check for overturning stability
Resisting moment M_{res} = 25440.1 lbfft/ft
Overturning moment M_{ovr} = 5527.2 lbfft/ft

Safety factor = 4.60 > 1.50
Wall for overturning is SATISFACTORY

Check for slip
Resisting horizontal force H_{res} = 4722.50 lbf/ft
Active horizontal force H_{act} = 1747.21 lbf/ft

Safety factor = 2.70 > 1.50
Wall for slip is SATISFACTORY

Overall check - WALL is SATISFACTORY

Dimensioning No. 1 (Stage of construction 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	-3.56	3913.1	2.24	1.000
Weight - earth wedge	0.0	-4.86	447.2	3.91	1.000
Weight - earth wedge	0.0	-8.79	98.1	2.00	1.000
Active pressure	1448.6	-3.20	1487.1	4.49	1.000

Verification of most stressed block No. 1

Check for overturning stability
Resisting moment M_{res} = 17405.8 lbfft/ft
Overturning moment M_{ovr} = 4629.2 lbfft/ft

Safety factor = 3.76 > 1.50
Joint for overturning stability is SATISFACTORY

Check for slip
Resisting horizontal force H_{res} = 4988.86 lbf/ft
Active horizontal force H_{act} = 1448.65 lbf/ft

Safety factor = 3.44 > 1.50
Joint for verification is SATISFACTORY

Bearing capacity of foundation soil (Stage of construction 1)

Design load acting at the center of footing bottom

No.	Moment [lbfft/ft]	Norm. force [lbf/ft]	Shear Force [lbf/ft]	Eccentricity [–]	Stress [psf]
1	1091.2	7001.39	1747.21	0.026	1230.8

Service load acting at the center of footing bottom

No.	Moment [lbfft/ft]	Norm. force [lbf/ft]	Shear Force [lbf/ft]
1	1091.2	7001.39	1747.21

Verification of foundation soil

Stress in the footing bottom : rectangle

Eccentricity verification
Max. eccentricity of normal force e = 0.026
Maximum allowable eccentricity e_{alw} = 0.333

Eccentricity of the normal force is SATISFACTORY

Verification of bearing capacity
Max. stress at footing bottom σ = 1230.8 psf
Allowable bearing capacity of foundation soil R_d = 6000.0 psf

Safety factor = 4.87 > 2.00
Bearing capacity of foundation soil is SATISFACTORY

Overall verification - bearing capacity of found. soil is SATISFACTORY

Input data (Stage of construction 2)

Geological profile and assigned soils

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

Terrain profile

No.	Coordinates x [ft]	Depth z [ft]
1	0.00	0.00
2	3.00	0.00
3	18.00	-5.00
4	19.00	-5.00

Origin [0,0] is located in upper right edge of construction.
Positive coordinate +z has downward direction.

Water influence

Ground water table is located below the structure.

Resistance on front face of the structure

Resistance on front face of the structure is not considered.

Earthquake

Factor of horizontal acceleration K_h = 0.3000
Factor of vertical acceleration K_v = 0.0000

Water below the GWT is restricted.

Settings of the stage of construction

Design situation : seismic
Reduction of soil/soil friction angle : do not reduce

Verification No. 1 (Stage of construction 2)

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	-3.72	4303.1	2.77	1.000
Earthq.- constr.	1292.3	-3.79	0.0	2.75	1.000
Weight - earth wedge	0.0	-0.87	36.3	5.68	1.000
Earthquake - soil wedge	10.9	-0.87	0.0	5.68	1.000
Weight - earth wedge	0.0	-5.36	447.2	4.41	1.000
Earthquake - soil wedge	134.2	-5.36	0.0	4.41	1.000

Name	F_{hor} [lbf/ft]	App.Pt. z [ft]	F_{vert} [lbf/ft]	App.Pt. x [ft]	Design coefficient
Weight - earth wedge	0.0	-9.29	98.1	2.50	1.000
Earthquake - soil wedge	29.4	-9.29	0.0	2.50	1.000
Active pressure	1747.2	-3.16	2116.7	5.25	1.000
Earthq.- act.pressure	3931.0	-6.48	5998.3	4.32	1.000

Verification of complete wall

Check for overturning stability
Resisting moment M_{res} = 51342.4 lbfft/ft
Overturning moment M_{ovr} = 36907.9 lbfft/ft

Safety factor = 1.39 > 1.12
Wall for overturning is SATISFACTORY

Check for slip
Resisting horizontal force H_{res} = 8768.40 lbf/ft
Active horizontal force H_{act} = 7144.94 lbf/ft

Safety factor = 1.23 > 1.12
Wall for slip is SATISFACTORY

Overall check - WALL is SATISFACTORY

Dimensioning No. 1 (Stage of construction 2)

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	-3.56	3913.1	2.24	1.000
Earthq.- constr.	1179.7	-3.63	0.0	2.23	1.000
Weight - earth wedge	0.0	-4.86	447.2	3.91	1.000
Earthquake - soil wedge	134.2	-4.86	0.0	3.91	1.000
Weight - earth wedge	0.0	-8.79	98.1	2.00	1.000
Earthquake - soil wedge	29.4	-8.79	0.0	2.00	1.000
Active pressure	1448.6	-3.20	1487.1	4.49	1.000
Earthq.- act.pressure	3446.6	-6.17	5251.5	3.76	1.000

Verification of most stressed block No. 1

Check for overturning stability
Resisting moment M_{res} = 37152.7 lbfft/ft
Overturning moment M_{ovr} = 31074.2 lbfft/ft

Safety factor = 1.20 > 1.12
Joint for overturning stability is SATISFACTORY

Check for slip
Resisting horizontal force H_{res} = 9395.36 lbf/ft
Active horizontal force H_{act} = 6238.56 lbf/ft

Safety factor = 1.51 > 1.12
Joint for verification is SATISFACTORY

Bearing capacity of foundation soil (Stage of construction 2)

Design load acting at the center of footing bottom

No.	Moment [lbfft/ft]	Norm. force [lbf/ft]	Shear Force [lbf/ft]	Eccentricity [–]	Stress [psf]
1	24564.6	12999.69	7144.94	0.315	5853.8

Service load acting at the center of footing bottom

No.	Moment [lbfft/ft]	Norm. force [lbf/ft]	Shear Force [lbf/ft]
1	24564.6	12999.69	7144.94

Verification of foundation soil

Stress in the footing bottom : rectangle

Eccentricity verification
Max. eccentricity of normal force $e = 0.315$
Maximum allowable eccentricity $e_{alw} = 0.333$

Eccentricity of the normal force is SATISFACTORY

Verification of bearing capacity
Max. stress at footing bottom $\sigma = 5853.8$ psf
Allowable bearing capacity of foundation soil $R_d = 9000.0$ psf

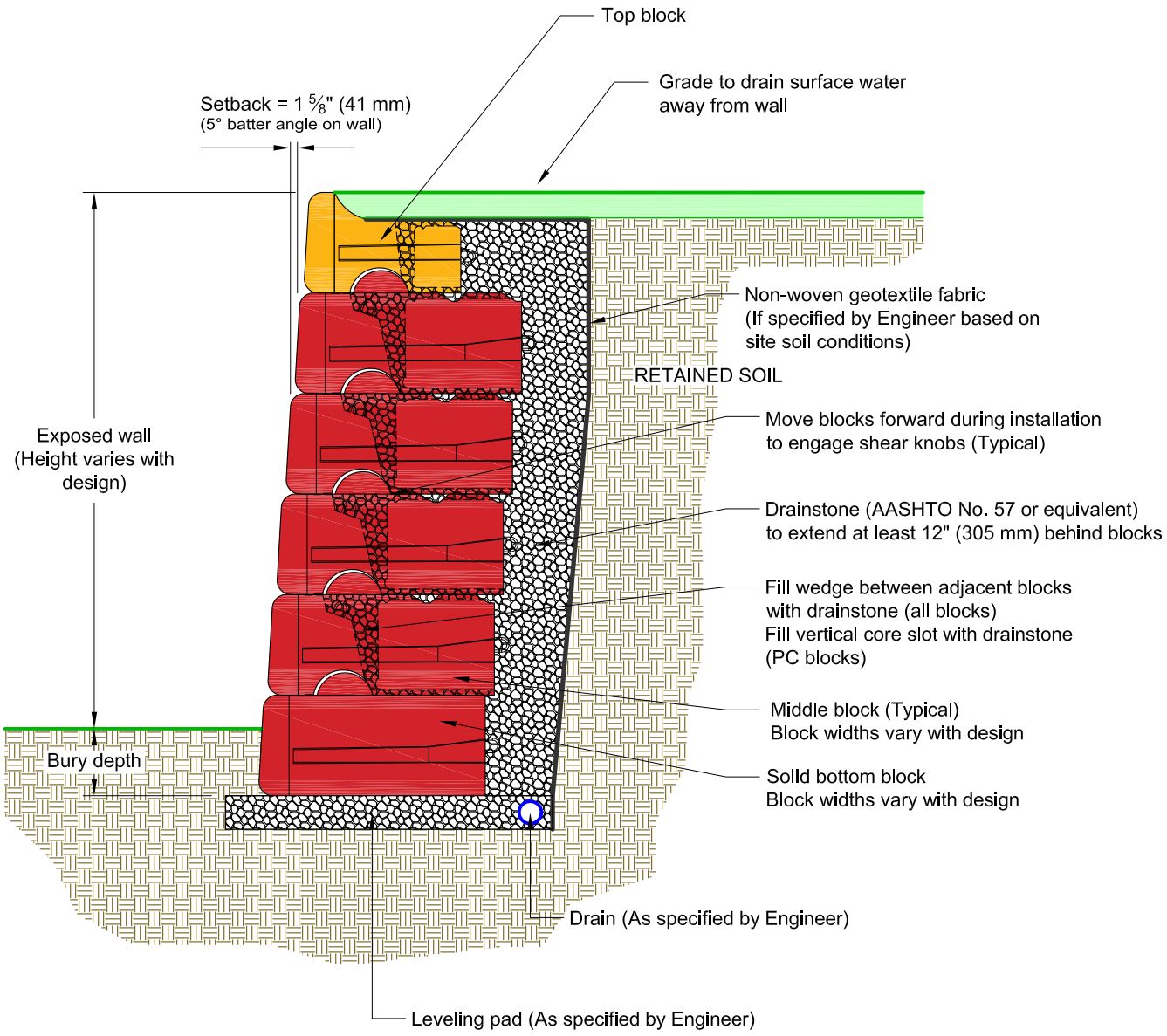
Safety factor = 1.54 > 1.50
Bearing capacity of foundation soil is SATISFACTORY

Overall verification - bearing capacity of found. soil is SATISFACTORY

Appendix B

Block Manufacturer Standard Details

Typical Gravity Wall Section



DRAWN BY:	JRJ	TITLE:	Typical Gravity Wall Detail
APPROVED BY:	JRJ		
DATE:	17MAR2016		
SHEET:	1 of 1	FILE:	1 Typical Gravity Wall Detail 031716.dwg

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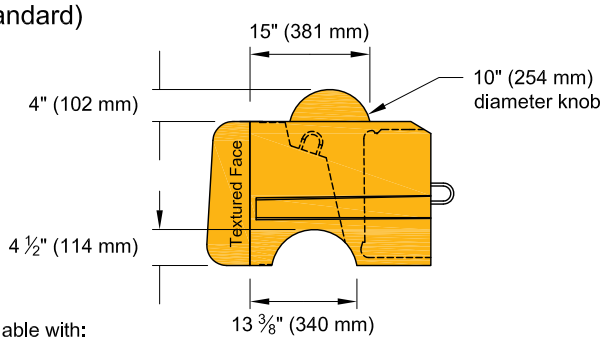
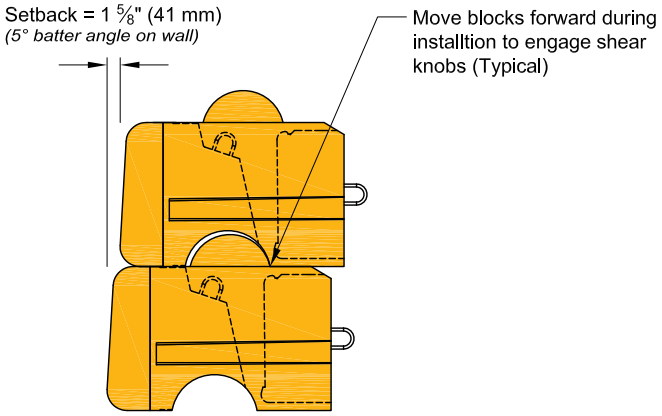
BLOCK-TO-BLOCK SETBACK OPTIONS

NO SCALE

Five degree (5°) setback

(Standard)



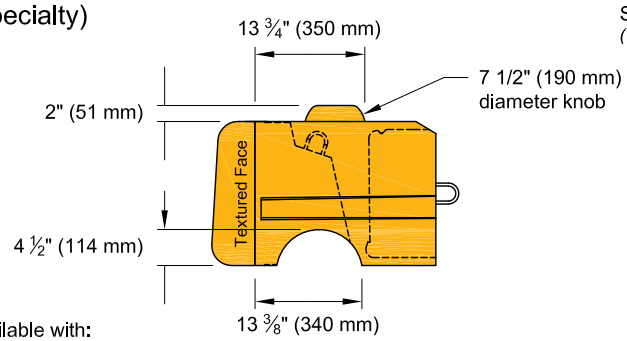


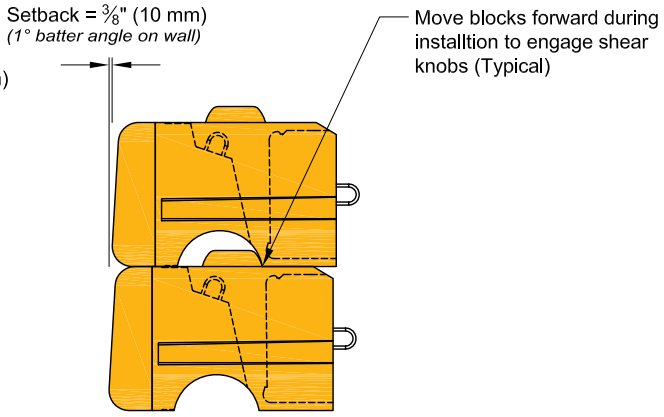
Available with:

- 28" (710 mm) blocks, 41" (1030 mm) blocks, and 60" (1520 mm) blocks
- 28" (710 mm) PC blocks (shown here) and 41" (1030 mm) PC blocks

One degree (1°) setback

(Specialty)



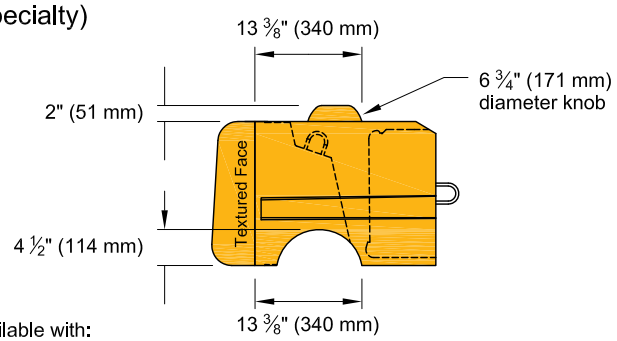


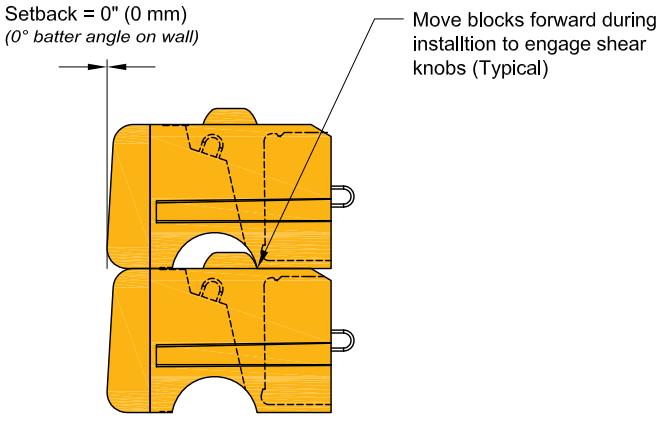
Available with:

- 28" (710 mm) blocks, 41" (1030 mm) blocks, and 60" (1520 mm) blocks
- 28" (710 mm) PC blocks (shown here) and 41" (1030 mm) PC blocks

Zero (0°) setback

(Specialty)





Available with:

- 28" (710 mm) blocks, 41" (1030 mm) blocks, and 60" (1520 mm) blocks
- 28" (710 mm) PC blocks (shown here) and 41" (1030 mm) PC blocks

The block-to-block setback available with Redi-Rock is controlled by the size and location of the shear knobs (domes) cast into the blocks. While the 10" (254 mm) diameter knob and the 1 5/8" (41 mm) setback position is the most common configuration, Redi-Rock has three different knob sizes and three different locations available.

DRAWN BY:	JRJ	TITLE:	Block Setback Options Normal Batter
APPROVED BY:	JRJ		
DATE:	06-22-2015		
SHEET:	1 of 1	FILE:	4 Block Setback Options Normal Batter 062215.dwg

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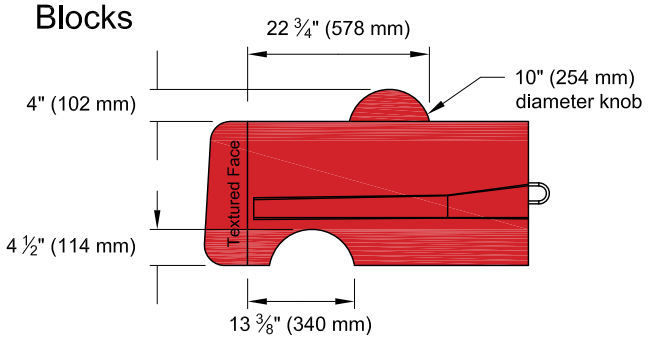
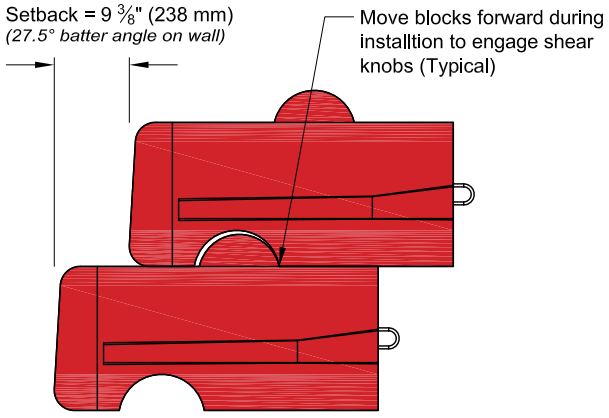
BLOCK-TO-BLOCK SETBACK OPTIONS

NO SCALE

9" (230 mm) Setback Blocks

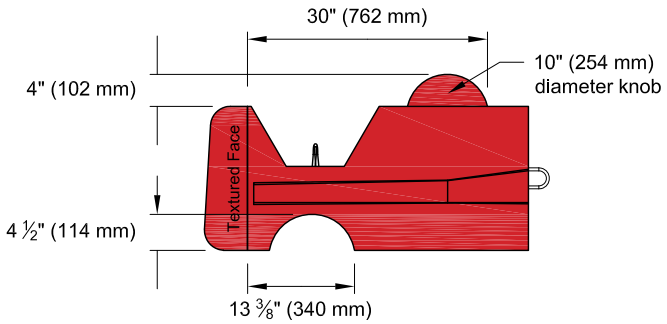


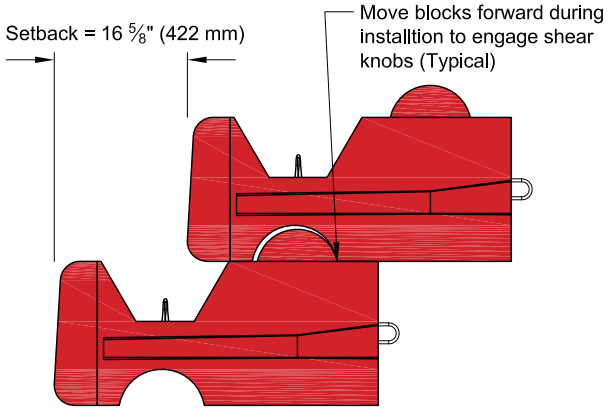


Available with:

- 41" (1030 mm) blocks (shown here) and 60" (1520 mm) blocks
- Not available in PC blocks

Planter Blocks





Available with:

- 41" (1030 mm) blocks (shown here) and 60" (1520 mm) blocks
- Not available in PC blocks

Redi-Rock has two options for large batter retaining walls. Both options are created by relocating the knob so that it is further back in the Redi-Rock blocks compared to our smaller batter walls (5° and less). There are two knob locations further back in the block which create the 9" (230 mm) setback block and the planter block. Blocks made with knobs in either of these locations almost exclusively use 10" (254 mm) diameter knobs.

DRAWN BY:	JRJ	TITLE:	Block Setback Options Large Batter
APPROVED BY:	JRJ		
DATE:	06-22-2015		
SHEET:	1 of 1	FILE:	5 Block Setback Options Normal Batter 062215.dwg

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