SUBMITTAL

KelleyTrucking inc.
Earthmoving Contractors
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Submittal number	013.0	Date	01/13/2021
Project	TRAILS AT CROWFOOT F9	6454 N. Crowfoot Valley Road Parker, CO	
Project number	202103		
Spec section			
Subsection		Status	Open
Current action	Submitted	Ball in court	
Topic	Retaining Wall Shop Drawings		

Submitter	MICHAEL TOMAS SNYDER
Reviewer	
Cc	

Date submitted	01/13/2021	Submission due date	01/13/2021
Released for review	01/13/2021	Review due date	01/20/2021
Date returned		Required on site date	
Date closed			

Notes
Please see attached retaining wall design report, calculations, and shop drawings.

GEOWALL DESIGNS

FINAL DESIGN REPORT AND
CALCULATIONS PREPARED FOR:

TRAILS AT CROWFOOT
PARKER, CO

December 9, 2020

COLORADO LICENSED
KYLE A HUERD
55768
PROFESSIONAL ENGINEER

Index

1.0 Site Review

This project includes four Allan Block site retaining walls. Walls 1, 2, and 3 are in a tiered layout at the north east edge of Bayou Gulch Rd. with wall 1 being the lowest tier and 3 being the upper tier. Wall 1 has a maximum height of 5.67-feet with a horizontal face length of 164.25-feet. Wall 2 has a maximum height of 5.67-feet with a horizontal face length of 123.75-feet. Wall 3 has a maximum height of 5.67' with a horizontal face length of 93.00-feet. Wall 4 is located near Alpine Phlox St. and Sky Pilot Lane with a maximum height of 5.67-feet and horizontal face length of 117.75-feet.

2.0 Design Methodology

The proposed walls have been designed in accordance with the NCMA (National Concrete Masonry Association) design methodology. The walls have been designed using soil reinforcement with portions designed as gravity (without reinforcement). Refer to the NCMA Design Manual for Segmental Retaining Walls, 3rd edition for additional design and construction requirements.

3.0 Wall System

3.1 Modular Block Wall Units

The walls have been designed using Allan Block Classic 8" units using the standard 6-degree wall batter. Refer to the manufacturers information for additional details on the proposed retaining wall system and its material properties.

3.2 Soil Reinforcement

The proposed walls utilize Mirafi 3XT geogrid soil reinforcement. Refer to the product technical data for the corresponding tensile properties and strength reduction factors.

4.0 Soil Properties

Site soils information was obtained from the geotechnical report prepared by CTL Thompson dated June 14, 2018. The soil strengths shown were assumed and shall be verified by the project geotechnical engineer. GeoWall Designs, LLC should be contacted if the noted soil strengths are not met as a redesign may be required.

Zone	*Description*	*ϕ*	*c'*	*γ*
Reinforced Soil 1	1-1/2" Gravel - GP	38˚	0 psf	115 pcf
Retained Soil 1	Sandy Lean Clay – CL/SC	26˚	0 psf	125 pcf
Retained Soil 2	Gravel - GP	38˚	0 psf	115 pcf
Foundation Soil	Sandy Lean Clay – CL/SC	26˚	50 psf	125 pcf

Refer to the referenced soils report for additional information regarding the site soil conditions and geotechnical engineers' recommendations.

5.0 Maximum Surcharge Loadings & Slope Conditions

Below are the maximum surcharge and site slope conditions as evaluated within this design. The noted extremes may not be present for the entire length of any given wall. Refer to the contract civil plans for locations of all anticipated surcharge locations and grade geometry.

Wall No.	*Live Load (psf)*	*Dead Load (psf)*	*Toe Slope*	*Back Slope*
1	100	N/A	Flat	Flat
2	100	N/A	Flat	Flat
3	100	N/A	Flat	3H:1V
4	100	N/A	3H:1V	3H:1V

6.0 Hydraulic Conditions

The proposed walls are not located within a water application therefore, no hydraulic loadings are anticipated or included in this design. The contractor shall ensure positive drainage is maintained both during and after construction. All downspouts and drains from the existing structure shall be diverted from the wall locations.

7.0 Seismic Conditions

The USGS provided 1-second peak ground acceleration is less than 0.08g and is therefore neglected.

8.0 Wind Conditions

No additional surcharge due to wind is anticipated or included within this design. Refer to ASCE 7-16 for additional information on surcharge applications.

9.0 External Stability and Settlement

Global Stability has been evaluated by GeoWall Designs, LLC as necessary for the proposed site retaining walls and shall be verified by the project geotechnical engineer. Local Bearing Capacities and Settlement are not covered under the scope of this design and shall be evaluated under the scope of the project geotechnical engineer. The foundation soils at each wall location shall be capable of supporting the applied bearing capacities shown within the shop drawings without failure or excessive settlement.

10.0 Limitations of Report

The design presented within this report is based on the information provided. GeoWall Designs, LLC accepts no liability for verifying site geometry, soil parameters, or ensuring all information provided is up to date. The contractor and/or owner's representative shall notify GeoWall Designs, LLC of any changes or conflicts with the actual site geometry prior to construction. Verification of site soil conditions, bearing capacities, anticipated settlement, and global stability shall be completed as directed within the construction plans and project specifications.

Appendix Item A: Design References

CVL Consultants plan set for: Trails at Crowfoot, filing 9 Construction Drawings, Last Dated 10/19/2019, Project No. 8130283701

CTL Thompson, Inc. Geotechnical Investigation, Recreation Center, Trails at Crowfoot, NE of Pradera Parkway and North Crowfoot Valley Road, Parker, Colorado, Last Dated: 06/14/2018, Project No. DN48,372-125-R1

NCMA Design Manual for Segmental Retaining Walls, 3rd Edition

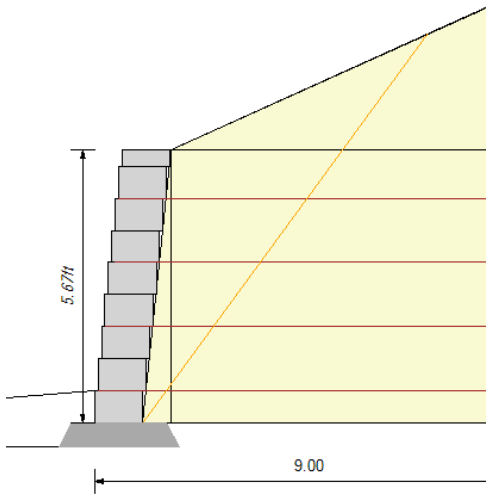
NCMA SRW Best Practices, 2nd Printing, 2017

ASCE 7-16 Minimum Design Loads and Associated Criteria

Appendix Item B: Final Calculations

Calculations attached after this sheet

REA Analysis



Project:	20SBC011 TRAILS AT CROWFOOT
Location:	PARKER, CO
Designer:	BTD
Date:	12/9/2020
Section:	Wall 1, Section 1
Design Method:	NCMA_09_3rd_Ed, Ignore Vert. Force
Design Unit:	AB_Classic 8

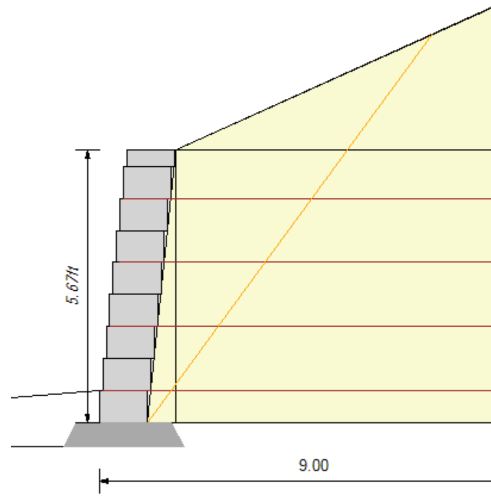
SOIL PARAMETERS	φ	coh	γ
Reinforced Soil:	38 deg	0psf	115pcf
Retained Soil:	26 deg	0psf	125pcf
Foundation Soil:	26 deg	50psf	125pcf
Leveling Pad: Crushed Stone			

GEOMETRY

Design Height:	5.67ft (5.00ft Exp.)	Live Load:	0psf
Wall Batter/Tilt:	6.00/ 0.00 deg	Live Load Offset:	0.00ft
Embedment:	0.67ft	LL2 Width:	0ft
Leveling Pad Depth:	0.50ft	Dead Load:	0psf
Slope Angle:	24.3 deg	Dead Load Offset:	0.0ft
Slope Length:	35.0ft	Dead Load Width:	0ft
Slope Toe Offset:	0.0ft		
Vertical δ on Single Depth		Toe Slope Angle:	4.60
		Toe Slope Length:	4.00
		Toe Slope Bench:	0.00

FACTORS OF SAFETY

Sliding:	1.50	Pullout:	1.50
Overturning:	2.00	Uncertainties:	1.50
Bearing:	2.00	Connection:	1.50
Shear:	1.50	Bending:	1.50



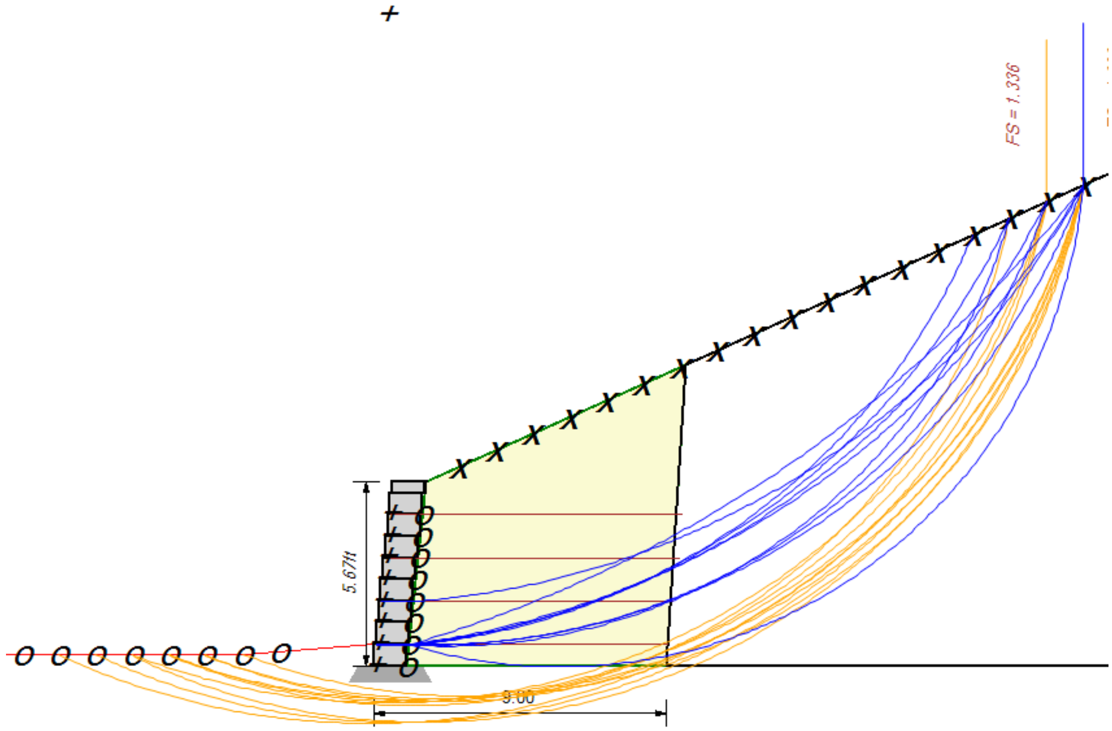
RESULTS

FoS Sliding:	2.67	FoS Overturning:	7.92
Bearing	837	FoS Bearing:	10.94
Pullout	47.42		
Total Pullout	22,128	FoS Total Pullout	50.22
Top FoSot:	20.63	FoS Connection:	1,000.00

ID	Height	Length	Geogrid.	Tallow	% Cvrg	EP(Pa)	LL (Pql)	DL (Pqd)	TMax	FS Str	Tal Cn	FS Pk Cn	FS PO/[Tmax]	FS Sldg [fndn]	Grid Embed
4	4.67	9	3XT	522	100	37	0	0	37	21.29	962	39.19	80.91/[37]	14.90	5.07
3	3.33	9	3XT	522	100	82	0	0	82	9.53	982	17.91	55.03/[82]	10.08	5.91
2	2	9	3XT	522	100	129	0	0	129	6.07	1002	11.64	48.56/[129]	7.52	6.74
1	0.67	9	3XT	522	100	176	0	0	176	4.45	1022	8.71	47.42/[176]	5.95 [2.67]	7.58

Column Descriptions:

Ta: allowable geogrid strength
Rc %: percent coverage for geosynthetics
EP (Pa) internal active earth pressure
LL (Pql) earth pressure due to live load surcharge
DL (Pqd) earth pressure due to dead load surcharge
Tmax maximum earth pressure on geosynthetic layer
FSstr factor of safety on geogrid strength (Ta/Tmax)
Ta cn allowable tension on the connection
FS Pkcn, factor of safety on the connection (Ta cn/Tmax)
FS PO, factor of safety on pullout (Ta pullout/(Tmax - LL)
Grid Embedment, depth of embedment beyond the theorectical failure plane.


FS = 1.336
5.67ft
9.00

COMPOUND RESULTS

Compound stability is a global analysis (Bishop) with the failure planes originating at the top of the slope / wall and exiting out through the face of the wall. For MSE walls, the resistance of the geogrid reinforcement is included in the analysis and the shear resistance of the face units is included.

ID	Enter Point X	Enter Point Y	Exit Point X	Exit Point Y	Center X	Center Y	Radius	FoS
4	21.87	14.83	1.07	0.67	-2.53	28.32	27.89	1.696
4	20.74	14.31	1.07	0.67	-1.85	25.88	25.38	1.744
4	19.61	13.80	1.07	0.67	-1.23	23.56	23.00	1.782
5	21.87	14.83	1.07	0.67	1.46	22.45	21.79	1.805
5	20.74	14.31	1.07	0.67	1.84	20.56	19.91	1.825
4	18.47	13.29	1.07	0.67	-0.66	21.35	20.76	1.855
3	21.87	14.83	1.07	0.67	-10.24	39.64	40.58	1.856
5	19.61	13.80	1.07	0.67	2.17	18.76	18.13	1.885
4	21.87	14.83	1.21	2.00	-0.66	28.08	26.15	1.890
7	21.87	14.83	1.07	0.67	5.74	16.17	16.19	1.893

GLOBAL RESULTS

Global stability is a global analysis (Bishop) with the failure planes originating at the top of the slope / wall and exiting out below the wall in the area infront of the structure. For MSE walls, the resistance of the geogrid reinforcement is included in the resisting forces. The curve may go through the base of the wall and the wall shear would be included. In most cases the failure plane will pass below the structure.

ID	Enter Point X	Enter Point Y	Exit Point X	Exit Point Y	Center X	Center Y	Radius	FoS
3	20.74	14.31	-7.47	0.35	0.34	20.05	21.19	1.336
3	21.87	14.83	-5.20	0.35	2.05	19.34	20.33	1.342
3	21.87	14.83	-6.33	0.35	1.17	20.44	21.45	1.342
3	19.61	13.80	-6.33	0.35	1.23	17.50	18.75	1.360
3	21.87	14.83	-4.06	0.35	2.93	18.29	19.26	1.361
3	20.74	14.31	-6.33	0.35	1.21	18.95	20.07	1.363
3	20.74	14.31	-5.20	0.35	2.08	17.89	19.00	1.364
4	21.87	14.83	-9.73	0.35	-0.13	21.12	22.88	1.366
4	21.87	14.83	-8.60	0.35	0.72	20.04	21.78	1.381
4	21.87	14.83	-7.47	0.35	1.57	19.00	20.73	1.381

GEOGRID REINFORCING

STRUCTURAL PROPERTIES: Mirafi

GEOGRID PROPERTIES

Name	Tult	RFcr	RFd	RFid	Ci	Cd	Alpha	Ltds
3XT	3500	1.45	2.20	1.40	0.90	0.90	0.80	784

CONNECTION STRENGTHS

Geogrid	Slope 1	Intercept 1	Peak Break	Slope 2	Intercept 2	Max Normal	Rup Conn	Conn Creep	Tlot (%)	Tlot
2XT	58.00	125	937	5.00	1542	1372	False	1.45	110	2200
3XT	10.70	1420	-1	0.00	0	2422	False	1.45	110	3850
5XT	18.00	1192	917	16.00	1227	2341	False	1.45	110	5170
7XT	26.00	1065	-1	0.00	0	3081	False	1.45	110	6490
8XT	40.00	1063	-1	0.00	0	2156	False	1.45	110	8140
10XT	52.00	513	1065	24.00	1402	2869	False	1.45	110	10450

SHEAR STRENGTHS

Slope 38 deg

Intercept 2671psf

CALCULATION RESULTS

OVERVIEW

REA Wall calculates stability assuming the wall is a rigid body. Forces and moments are calculated about the base and the front toe of the wall. The base block width or bottom reinforcement length is used in the calculations. The concrete units, granular fill over the blocks or reinforced zone soils are used as resisting forces.

EARTH PRESSURES

The method of analysis uses the Coulomb Earth Pressure equation (below) to calculate active earth pressures. Wall friction is assumed to act at the back of the wall face. The component of earth pressure is assumed to act perpendicular to the boundary surface. The effective delta angle is delta minus the wall batter at the back face (assumed to be vertical). If the slope breaks within the failure zone, a trial wedge method of analysis is used.

INTERNAL EARTH PRESSURES

Effective internal Delta angle (2/3 phi)	delta =25.3 deg
Coefficient of active earth pressure	ka =0.243
Internal failure plane	ρ = 53.7 deg

EXTERNAL EARTH PRESSURES

Effective external Delta angle	delta =26.00 deg
Coefficient of active earth pressure	ka =0.299
External failure plane	ρ = 34.8 deg

$$Ka := \frac{\cos(\phi_i + i)^2}{\cos(i)^2 \cdot \cos(\delta_i - i)\left(1 + \sqrt{\frac{\sin(\phi_i + \delta_i)\cdot\sin(\phi_i - \beta)}{\cos(\delta_i - i)\cdot\cos(i + \beta)}}\right)^2}$$

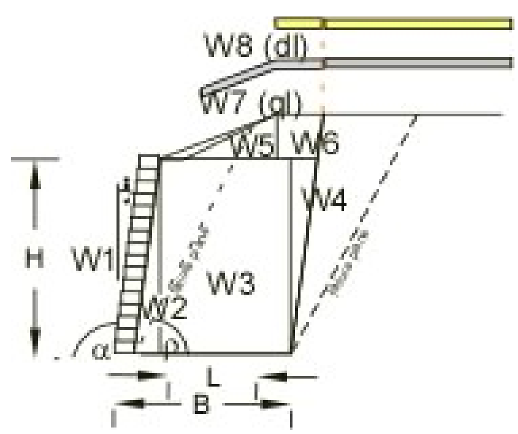
FORCES AND MOMENTS

REA Wall resolves all the geometry into simple geometric shapes to make checking easier. All x and y coordinates are referenced to a zero point at the front toe. The wall image can be exported to CAD for a more detailed output.

Name	Factor γ	Force (V)	Force (H)	X-len	Y-len	Mo	Mr
Face Blocks(W1)	1.00	680	--	0.76	--	--	519
Soil(W2)	1.00	172	--	1.40	--	--	241
Soil(W3)	1.00	4828	--	5.30	--	--	25578
Soil(W4)	1.00	194	--	9.20	--	--	1787
Slope(W5)	1.00	1662	--	6.73	--	--	11180
Pa_h	1.00	--	1574	--	3.15	4963	--
Sum (V, H)	1.00	7536	1574		Sum Mom	4963	39305

W0: leveling pad
W1: facing units
W2: soil wedge behind the face
W3: rectangular area in MSE area
W4: the wedge at the back of the mass
W5: slope area over the mass
W6: Rectangle zone in broken back
W7: Live load over the mass
W8: Dead load over the mass
W9: Force Pa
W10: Surcharge load Paq
W11: Dead Load Surcharge Paqd
X-Len: is measured from the center of the base (+) Driving, (-) Resisting.

Pa_h: horizontal earth pressure
Pq_h: horizontal surcharge pressure
Pa_v: vertical earth pressure
Pq_v: vertical surcharge pressure



BASE SLIDING

Sliding at the base is checked at the soil-to-soil interface between the reinforced mass and the foundation soil.

Forces resisting sliding = (SumVr- W0 - W1 - W7)	
7,536 - 0 - 680 - 0	SumVr = 6,856ppf
Resisting force = SumVr x tan(26) + c x L + Base Shear	Rf1 =4,200
where L is the base width	
where Base Shear = N tan(40.0) * 0.8	456.47
Driving force is the horizontal component of Pah + Pqh+ Pdh	Df = 1,574
Factor of Safety = Rf/Df	FSsl =2.67

OVERTURNING ABOUT THE TOE

Overturning at the base is checked by assuming rotation about the front toe by the block mass, soil retained on the blocks or within the reinforced zone. Allowable overturning can be defined by eccentricity (e/L) or by the ratio of resisting moments divided by overturning moment (FSot).

Moments resisting overturning = Sum(M1 to M6) + MPav + MPqv	Mr =39,305ft-lbs
Moments causing overturning = MPah + MPqh	Mo =4,963ft-lbs
Factor of safety = Mr/Mo	FSot =7.92 OK

ECCENTRICITY AND BEARING

Eccentricity is the calculation of the distance of the resultant away from the centroid of mass. In wall ReinDesign the eccentricity is used to calculate an effective footing width, or in rigid structure, it is used to calculate the pressure distribution below the base.

Calculation of Eccentricity

e = (SumMr + M7 + SumMo)/SumV

Mr = -8,468.69

Mo = 8,037.99

e = (-8,468.698,037.99) /7,535.81) e =-2.190

Because 'e' is negative (leaning into the embankment), it is ignored to get the maximum bearing at the face of the wall.

Calculation of Bearing Pressures

Qult = c*Nc + q*Nq + 0.5*gamma*(B')*Ng

where:

Nc =22.25

Nq =11.85

Ng =12.54

c =50.00psf

q =83.75psf

B' =13.38ft

Calculate Ultimate Bearing, Qult Qult =1,321.83psf

Applied Bearing Pressures = (SumVert / B' + (2B + LP depth)/2 * LP depth *gamma)

sigma =837.31psf

Calculated Factors of Safety for Bearing Qult/sigma =10.94

TENSION CALCULATIONS

Tmax is the maximum tension in the reinforcing based on the earth pressure and surcharge loads applied. In the NCMA design method, earth pressures are calculated using the Coulomb Earth pressure equation. Infinite surcharge loads are applied as q x ka. In designs were there is a broken back slope, or the surcharge is not uniform over the area, a tie-back wedge analysis method is used.

FS = (Tal * FS_tn) / Tmax

TABLE OF RESULTS

Elevation[ft]	ka	z	sv	Name[ft]	Tult[ppf]	Ta[ppf]	Rc %	Tmax[ppf]	FS
4.67	0.243	0.84	1.67	3XT	3,500	522	100	37	21.29
3.33	0.243	2.34	1.33	3XT	3,500	522	100	82	9.53
2.00	0.243	3.67	1.33	3XT	3,500	522	100	129	6.07
0.67	0.243	5.00	1.33	3XT	3,500	522	100	176	4.45

PULLOUT CALCULATIONS

Pullout is the amount of resistance of the reinforcing has to a pullout failure based on the Tmax applied and the depth of embedment (resistance). In an NCMA design the failure place is defined as the Coulomb failure plane which varies with face batter, backslope angle, and surcharge loads applied. All failure planes begin at the tail. of the facing units.

For AASHTO calculations, the live load surcharge is not included in the Tmax value for pullout.

Failure Plane Angle (ρ) = 53.7 Deg

NOTE: The pullout capacity is limited by the LTDS of the reinforcing layer, not the ultimate pullout capacity calculated.

F* = 0.67 x tan(φ) = 0.67 x 0.78 = 0.52
Le = embedment length = Li - block depth - hi * Tan(90 - ρ)
La = Li - Le
sv = geogrid spacing
Rc = % coverage
α = scale effect correction
Pullout = 2 x Le x F* x sv x α x Rc

TABLE OF RESULTS

Elevation[ft]	Normal[lbf]	Ci	% Coverage	Tmax[ppf]	Le[ft]	La[ft]	Pullout_[Pr][ppf]	FS PO
4.67	2117.84	0.90	100	37	5.07	3.93	2978	80.91
3.33	3217.98	0.90	100	82	5.91	3.09	4525	55.03
2.00	4460.60	0.90	100	129	6.74	2.26	6273	48.56
0.67	5938.11	0.90	100	176	7.58	1.42	8351	47.42

CONNECTION CALCULATIONS

Connection is the amount of resistance of the reinforcing has to a pullout failure from the facing units based on the Tmax applied and the normal load on the units. In an AASHTO LRFD design, creep on the connection may be applied for frictional and mechanical connections. In NCMA or AASHTO 2002, a frictional failure is based on the peak connection capacity divided by a factor of safety. For a rupture connection the capacity is the peak load divided by a creep reduction factor and a factor of safety.

Frictional Connection

Peak Connection = N(ppf) tan(slope) + intercept

Rupture Connection

Connection Capacity = [N(ppf) tan(slope) + intercept] / RFcr

RFcr can be a value obtained from long-term testing or by default could be the creep reduction factor of the geogrid reinforcing.

Tal_cn = Allowable connection capacity = Tult_cn / FScn

Rc = % coverage

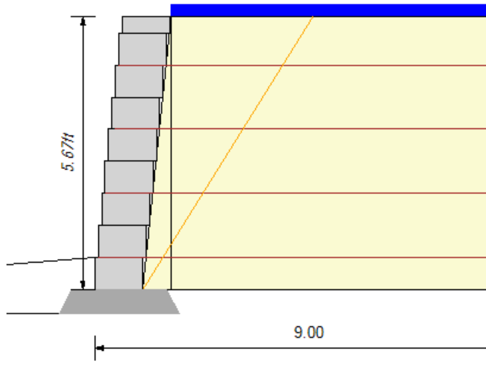
FS = Tal_cn * FScn/Tmax

TABLE OF RESULTS

Elev[ft]	Name	Tmax[ppf]	Rc %	N[ppf]	Tult_cn	Tac[ppf]	FS
4.67	3XT	37	100	120	3174	962	39.19
3.33	3XT	82	100	280	3240	982	17.91
2.00	3XT	129	100	440	3307	1002	11.64
0.67	3XT	176	100	600	3373	1022	8.71

REA Analysis

Project: 20SBC011 TRAILS AT CROWFOOT
Location: PARKER, CO
Designer: BTD
Date: 12/9/2020
Section: Wall 1, Section 2
Design Method: NCMA_09_3rd_Ed, Ignore Vert. Force
Design Unit: AB_Classic 8



SOIL PARAMETERS	φ	coh	γ
Reinforced Soil:	38 deg	0psf	115pcf
Retained Soil:	26 deg	0psf	125pcf
Foundation Soil:	26 deg	50psf	125pcf

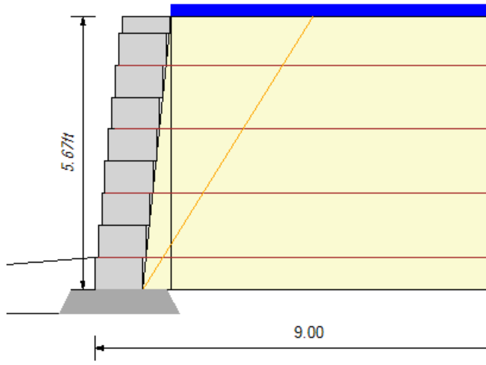
Leveling Pad: Crushed Stone

GEOMETRY

Design Height:	5.67ft (5.00ft Exp.)	Live Load:	100psf
Wall Batter/Tilt:	6.00/ 0.00 deg	Live Load Offset:	0.00ft
Embedment:	0.67ft	LL2 Width:	7ft
Leveling Pad Depth:	0.50ft	Dead Load:	1,000psf
Slope Angle:	0.0 deg	Dead Load Offset:	7.0ft
Slope Length:	0.0ft	Dead Load Width:	100ft
Slope Toe Offset:	0.0ft		
Vertical δ on Single Depth		Toe Slope Angle:	4.60
		Toe Slope Length:	4.00
		Toe Slope Bench:	0.00

FACTORS OF SAFETY

Sliding:	1.50	Pullout:	1.50
Overturning:	2.00	Uncertainties:	1.50
Bearing:	2.00	Connection:	1.50
Shear:	1.50	Bending:	1.50



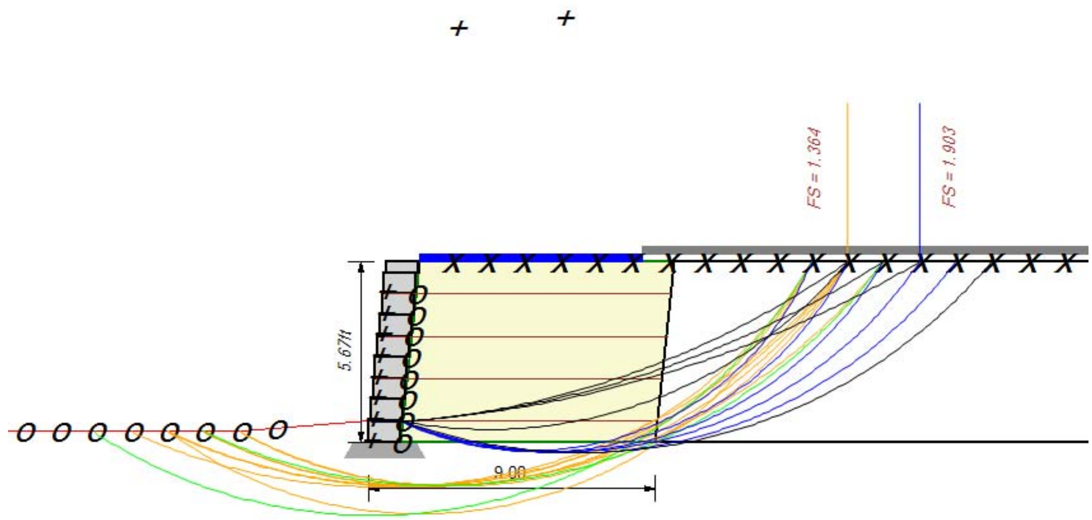
RESULTS

FoS Sliding:	1.51	FoS Overturning:	4.90
Bearing	730	FoS Bearing:	12.54
Pullout	52.91		
Total Pullout	17,545	FoS Total Pullout	41.92
Top FoSot:	12.49	FoS Connection:	1,000.00

ID	Height	Length	Geogrid.	Tallow	% Cvrg	EP(Pa)	LL (Pql)	DL (Pqd)	TMax	FS Str	Tal Cn	FS Pk Cn	FS PO/[Tmax]	FS Sldg [fndn]	Grid Embed
4	4.67	9	3XT	522	100	24	8	0	32	24.25	962	44.64	89.61/[24]	15.24	5.57
3	3.33	9	3XT	522	100	60	22	0	82	9.50	982	17.86	58.70/[60]	7.19	6.27
2	2	9	3XT	522	100	94	22	0	117	6.71	1002	12.87	52.91/[94]	4.54	6.96
1	0.67	9	3XT	522	100	129	22	0	151	5.19	1022	10.15	53.30/[129]	3.69 [1.51]	7.65

Column Descriptions:

- Ta: allowable geogrid strength
- Rc %: percent coverage for geosynthetics
- EP (Pa) internal active earth pressure
- LL (Pql) earth pressure due to live load surcharge
- DL (Pqd) earth pressure due to dead load surcharge
- Tmax maximum earth pressure on geosynthetic layer
- FSstr factor of safety on geogrid strength (Ta/Tmax)
- Ta cn allowable tension on the connection
- FS Pkcn, factor of safety on the connection (Ta cn/Tmax)
- FS PO, factor of safety on pullout (Ta pullout/(Tmax - LL)
- Grid Embedment, depth of embedment beyond the theorectical failure plane.



FS = 1.364
FS = 1.903
5.67ft
9.00

COMPOUND RESULTS

Compound stability is a global analysis (Bishop) with the failure planes originating at the top of the slope / wall and exiting out through the face of the wall. For MSE walls, the resistance of the geogrid reinforcement is included in the analysis and the shear resistance of the face units is included.

ID	Enter Point X	Enter Point Y	Exit Point X	Exit Point Y	Center X	Center Y	Radius	FoS
4	17.34	5.67	1.07	0.67	6.10	13.27	13.57	1.903
4	15.07	5.67	1.07	0.67	5.48	10.43	10.71	1.911
4	16.20	5.67	1.07	0.67	5.78	11.80	12.09	1.931
4	18.47	5.67	1.07	0.67	6.41	14.86	15.16	1.979
4	13.94	5.67	1.07	0.67	5.17	9.17	9.44	1.997
2	16.20	5.67	1.07	0.67	-1.17	32.85	32.26	2.036
2	17.34	5.67	1.07	0.67	-1.29	37.30	36.71	2.045
2	15.07	5.67	1.07	0.67	-1.06	28.71	28.13	2.051
4	19.61	5.67	1.07	0.67	6.73	16.55	16.86	2.058
3	15.07	5.67	1.07	0.67	3.76	15.24	14.81	2.059

GLOBAL RESULTS

Global stability is a global analysis (Bishop) with the failure planes originating at the top of the slope / wall and exiting out below the wall in the area infront of the structure. For MSE walls, the resistance of the geogrid reinforcement is included in the resisting forces. The curve may go through the base of the wall and the wall shear would be included. In most cases the failure plane will pass below the structure.

ID	Enter Point X	Enter Point Y	Exit Point X	Exit Point Y	Center X	Center Y	Radius	FoS
3	15.07	5.67	-4.06	0.35	2.74	12.96	14.33	1.364
3	13.94	5.67	-4.06	0.35	2.38	11.65	13.01	1.368
3	15.07	5.67	-6.33	0.35	1.18	15.82	17.20	1.369
3	16.20	5.67	-6.33	0.35	1.54	17.37	18.76	1.384
3	13.94	5.67	-5.20	0.35	1.60	12.96	14.33	1.390
3	15.07	5.67	-5.20	0.35	1.96	14.35	15.72	1.394
3	15.07	5.67	-7.47	0.35	0.41	17.37	18.76	1.396
4	13.94	5.67	-6.33	0.35	1.65	11.21	13.48	1.399
4	13.94	5.67	-8.60	0.35	0.16	13.62	15.90	1.402
3	16.20	5.67	-5.20	0.35	2.32	15.82	17.20	1.405

GEOGRID REINFORCING

STRUCTURAL PROPERTIES: Mirafi

GEOGRID PROPERTIES

Name	Tult	RFcr	RFd	RFid	Ci	Cd	Alpha	Ltds
3XT	3500	1.45	2.20	1.40	0.90	0.90	0.80	784

CONNECTION STRENGTHS

Geogrid	Slope 1	Intercept 1	Peak Break	Slope 2	Intercept 2	Max Normal	Rup Conn	Conn Creep	Tlot (%)	Tlot
2XT	58.00	125	937	5.00	1542	1372	False	1.45	110	2200
3XT	10.70	1420	-1	0.00	0	2422	False	1.45	110	3850
5XT	18.00	1192	917	16.00	1227	2341	False	1.45	110	5170
7XT	26.00	1065	-1	0.00	0	3081	False	1.45	110	6490
8XT	40.00	1063	-1	0.00	0	2156	False	1.45	110	8140
10XT	52.00	513	1065	24.00	1402	2869	False	1.45	110	10450

SHEAR STRENGTHS

Slope 38 deg

Intercept 2671psf

CALCULATION RESULTS

OVERVIEW

REA Wall calculates stability assuming the wall is a rigid body. Forces and moments are calculated about the base and the front toe of the wall. The base block width or bottom reinforcement length is used in the calculations. The concrete units, granular fill over the blocks or reinforced zone soils are used as resisting forces.

EARTH PRESSURES

The method of analysis uses the Coulomb Earth Pressure equation (below) to calculate active earth pressures. Wall friction is assumed to act at the back of the wall face. The component of earth pressure is assumed to act perpendicular to the boundary surface. The effective delta angle is delta minus the wall batter at the back face (assumed to be vertical). If the slope breaks within the failure zone, a trial wedge method of analysis is used.

INTERNAL EARTH PRESSURES

Effective internal Delta angle (2/3 phi)	delta =25.3 deg
Coefficient of active earth pressure	ka =0.178
Internal failure plane	ρ = 58.0 deg

EXTERNAL EARTH PRESSURES

Effective external Delta angle	delta =26.00 deg
Coefficient of active earth pressure	ka =0.344
External failure plane	ρ = 51.0 deg

$$Ka := \frac{\cos(\phi_i + i)^2}{\cos(i)^2 \cdot \cos(\delta_i - i)\left(1 + \sqrt{\frac{\sin(\phi_i + \delta_i)\cdot \sin(\phi_i - \beta)}{\cos(\delta_i - i)\cdot \cos(i + \beta)}}\right)^2}$$

FORCES AND MOMENTS

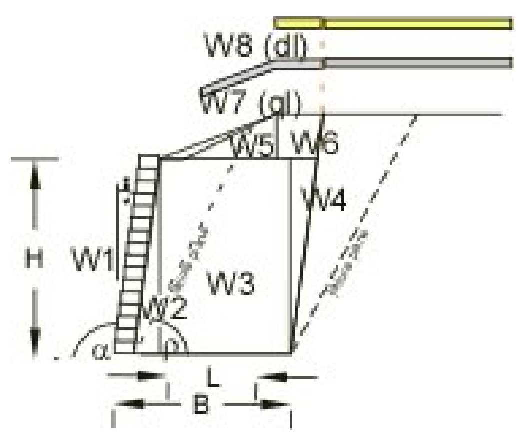
REA Wall resolves all the geometry into simple geometric shapes to make checking easier. All x and y coordinates are referenced to a zero point at the front toe. The wall image can be exported to CAD for a more detailed output.

Name	Factor γ	Force (V)	Force (H)	X-len	Y-len	Mo	Mr
Face Blocks(W1)	1.00	680	--	0.76	--	--	519
Soil(W2)	1.00	172	--	1.40	--	--	241
Soil(W3)	1.00	4828	--	5.30	--	--	25578
Soil(W4)	1.00	194	--	9.20	--	--	1787
LL(W7)	1.00	700	--	5.10	--	--	3567
Pa_h	1.00	--	649	--	1.89	1226	--
Pqd_h	1.00	--	1594	--	2.84	4519	--
Sum (V, H)	1.00	6574	2243		Sum Mom	5745	28125

W0: leveling pad
W1: facing units
W2: soil wedge behind the face
W3: rectangular area in MSE area
W4: the wedge at the back of the mass
W5: slope area over the mass
W6: Rectangle zone in broken back
W7: Live load over the mass
W8: Dead load over the mass
W9: Force Pa
W10: Surcharge load Paq
W11: Dead Load Surcharge Paqd

X-Len: is measured from the center of the base (+) Driving, (-) Resisting.

Pa_h: horizontal earth pressure
Pq_h: horizontal surcharge pressure
Pa_v: vertical earth pressure
Pq_v: vertical surcharge pressure



BASE SLIDING

Sliding at the base is checked at the soil-to-soil interface between the reinforced mass and the foundation soil.

Forces resisting sliding = (SumVr- W0 - W1 - W7)	
6,574 - 0 - 680 - 700	SumVr = 5,194ppf
Resisting force = SumVr x tan(26) + c x L + Base Shear	Rf1 =3,390
where L is the base width	
where Base Shear = N tan(40.0) * 0.8	456.47
Driving force is the horizontal component of Pah + Pqh+ Pdh	Df = 2,243
Factor of Safety = Rf/Df	FSsl =1.51

OVERTURNING ABOUT THE TOE

Overturning at the base is checked by assuming rotation about the front toe by the block mass, soil retained on the blocks or within the reinforced zone. Allowable overturning can be defined by eccentricity (e/L) or by the ratio of resisting moments divided by overturning moment (FSot).

Moments resisting overturning = Sum(M1 to M6) + MPav + MPqv	Mr =28,125ft-lbs
Moments causing overturning = MPah + MPqh	Mo =5,745ft-lbs
Factor of safety = Mr/Mo	FSot =4.90 OK

ECCENTRICITY AND BEARING

Eccentricity is the calculation of the distance of the resultant away from the centroid of mass. In wall ReinDesign the eccentricity is used to calculate an effective footing width, or in rigid structure, it is used to calculate the pressure distribution below the base.

Calculation of Eccentricity

e = (SumMr + M7 + SumMo)/SumV

Mr = -5,182.52

Mo = 8,820.04

e = (-5,182.528,820.04) /6,574.23) e =-1.587

Because 'e' is negative (leaning into the embankment), it is ignored to get the maximum bearing at the face of the wall.

Calculation of Bearing Pressures

Qult = c*Nc + q*Nq + 0.5*gamma*(B')*Ng

where:

Nc =22.25

Nq =11.85

Ng =12.54

c =50.00psf

q =83.75psf

B' =12.17ft

Calculate Ultimate Bearing, Qult Qult =1,321.83psf

Applied Bearing Pressures = (SumVert / B' + (2B + LP depth)/2 * LP depth *gamma)

sigma =730.47psf

Calculated Factors of Safety for Bearing Qult/sigma =12.54

TENSION CALCULATIONS

Tmax is the maximum tension in the reinforcing based on the earth pressure and surcharge loads applied. In the NCMA design method, earth pressures are calculated using the Coulomb Earth pressure equation. Infinite surcharge loads are applied as q x ka. In designs were there is a broken back slope, or the surcharge is not uniform over the area, a tie-back wedge analysis method is used.

FS = (Tal * FS_tn) / Tmax

TABLE OF RESULTS

Elevation[ft]	ka	z	sv	Name[ft]	Tult[ppf]	Ta[ppf]	Rc %	Tmax[ppf]	FS
4.67	0.159	0.84	1.67	3XT	3,500	522	100	32	24.25
3.33	0.178	2.34	1.33	3XT	3,500	522	100	82	9.50
2.00	0.178	3.67	1.33	3XT	3,500	522	100	117	6.71
0.67	0.178	5.00	1.33	3XT	3,500	522	100	151	5.19

PULLOUT CALCULATIONS

Pullout is the amount of resistance of the reinforcing has to a pullout failure based on the Tmax applied and the depth of embedment (resistance). In an NCMA design the failure place is defined as the Coulomb failure plane which varies with face batter, backslope angle, and surcharge loads applied. All failure planes begin at the tail. of the facing units.

For AASHTO calculations, the live load surcharge is not included in the Tmax value for pullout.

Failure Plane Angle (ρ) = 58.0 Deg

NOTE: The pullout capacity is limited by the LTDS of the reinforcing layer, not the ultimate pullout capacity calculated.

F* = 0.67 x tan(φ) = 0.67 x 0.78 = 0.52
Le = embedment length = Li - block depth - hi * Tan(90 - ρ)
La = Li - Le
sv = geogrid spacing
Rc = % coverage
α = scale effect correction
Pullout = 2 x Le x F* x sv x α x Rc

TABLE OF RESULTS

Elevation[ft]	Normal[lbf]	Ci	% Coverage	Tmax[ppf]	Le[ft]	La[ft]	Pullout_[Pr][ppf]	FS PO
4.67	1537.74	0.90	100	32	5.57	3.43	2163	66.91
3.33	2508.64	0.90	100	82	6.27	2.73	3528	42.78
2.00	3551.93	0.90	100	117	6.96	2.04	4995	42.78
0.67	4877.82	0.90	100	151	7.65	1.35	6860	45.41

CONNECTION CALCULATIONS

Connection is the amount of resistance of the reinforcing has to a pullout failure from the facing units based on the Tmax applied and the normal load on the units. In an AASHTO LRFD design, creep on the connection may be applied for frictional and mechanical connections. In NCMA or AASHTO 2002, a frictional failure is based on the peak connection capacity divided by a factor of safety. For a rupture connection the capacity is the peak load divided by a creep reduction factor and a factor of safety.

Frictional Connection

Peak Connection = N(ppf) tan(slope) + intercept

Rupture Connection

Connection Capacity = [N(ppf) tan(slope) + intercept] / RFcr

RFcr can be a value obtained from long-term testing or by default could be the creep reduction factor of the geogrid reinforcing.

Tal_cn = Allowable connection capacity = Tult_cn / FScn

Rc = % coverage

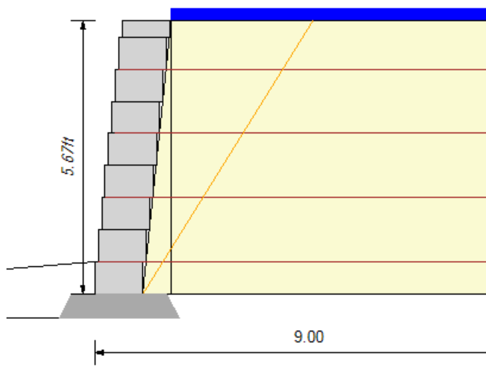
FS = Tal_cn * FScn/Tmax

TABLE OF RESULTS

Elev[ft]	Name	Tmax[ppf]	Rc %	N[ppf]	Tult_cn	Tac[ppf]	FS
4.67	3XT	32	100	120	3174	962	44.64
3.33	3XT	82	100	280	3240	982	17.86
2.00	3XT	117	100	440	3307	1002	12.87
0.67	3XT	151	100	600	3373	1022	10.15

REA Analysis

Project:	20SBC011 TRAILS AT CROWFOOT
Location:	PARKER, CO
Designer:	BTD
Date:	12/9/2020
Section:	Wall 2, Section 1
Design Method:	NCMA_09_3rd_Ed, Ignore Vert. Force
Design Unit:	AB_Classic 8



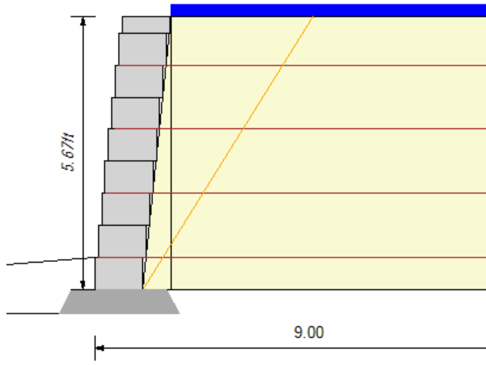
SOIL PARAMETERS	φ	coh	γ
Reinforced Soil:	38 deg	0psf	115pcf
Retained Soil:	26 deg	0psf	125pcf
Foundation Soil:	26 deg	50psf	125pcf
Leveling Pad: Crushed Stone			

GEOMETRY

Design Height:	5.67ft (5.00ft Exp.)	Live Load:	100psf
Wall Batter/Tilt:	6.00/ 0.00 deg	Live Load Offset:	0.00ft
Embedment:	0.67ft	LL2 Width:	7ft
Leveling Pad Depth:	0.50ft	Dead Load:	1,000psf
Slope Angle:	0.0 deg	Dead Load Offset:	7.0ft
Slope Length:	0.0ft	Dead Load Width:	100ft
Slope Toe Offset:	0.0ft		
Vertical δ on Single Depth		Toe Slope Angle:	4.60
		Toe Slope Length:	4.00
		Toe Slope Bench:	0.00

FACTORS OF SAFETY

Sliding:	1.50	Pullout:	1.50
Overturning:	2.00	Uncertainties:	1.50
Bearing:	2.00	Connection:	1.50
Shear:	1.50	Bending:	1.50



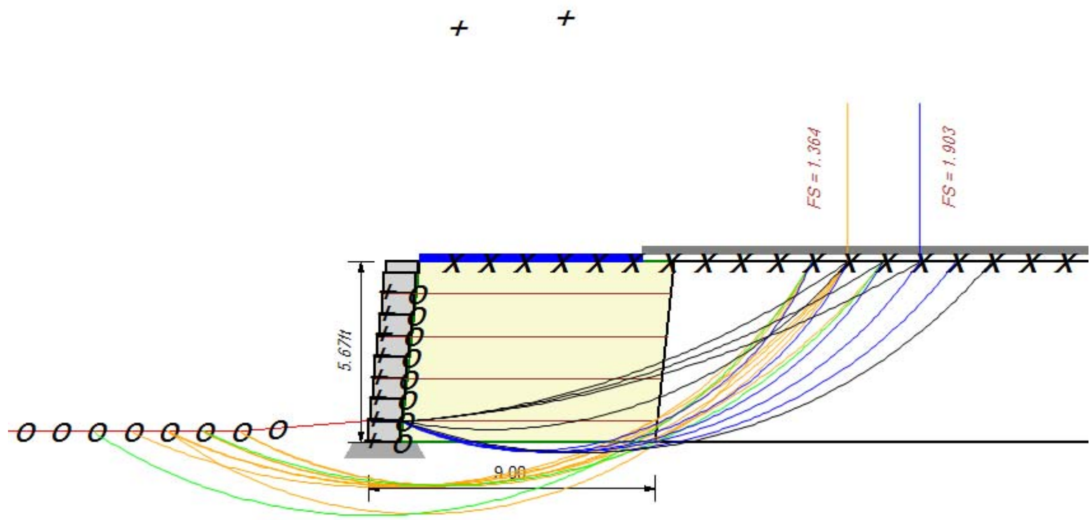
RESULTS

FoS Sliding:	1.51	FoS Overturning:	4.90
Bearing	730	FoS Bearing:	12.54
Pullout	52.91		
Total Pullout	17,545	FoS Total Pullout	41.92
Top FoSot:	12.49	FoS Connection:	1,000.00

ID	Height	Length	Geogrid.	Tallow	% Cvrg	EP(Pa)	LL (Pql)	DL (Pqd)	TMax	FS Str	Tal Cn	FS Pk Cn	FS PO/[Tmax]	FS Sldg [fndn]	Grid Embed
4	4.67	9	3XT	522	100	24	8	0	32	24.25	962	44.64	89.61/[24]	15.24	5.57
3	3.33	9	3XT	522	100	60	22	0	82	9.50	982	17.86	58.70/[60]	7.19	6.27
2	2	9	3XT	522	100	94	22	0	117	6.71	1002	12.87	52.91/[94]	4.54	6.96
1	0.67	9	3XT	522	100	129	22	0	151	5.19	1022	10.15	53.30/[129]	3.69 [1.51]	7.65

Column Descriptions:

- Ta: allowable geogrid strength
- Rc %: percent coverage for geosynthetics
- EP (Pa) internal active earth pressure
- LL (Pql) earth pressure due to live load surcharge
- DL (Pqd) earth pressure due to dead load surcharge
- Tmax maximum earth pressure on geosynthetic layer
- FSstr factor of safety on geogrid strength (Ta/Tmax)
- Ta cn allowable tension on the connection
- FS Pkcn, factor of safety on the connection (Ta cn/Tmax)
- FS PO, factor of safety on pullout (Ta pullout/(Tmax - LL)
- Grid Embedment, depth of embedment beyond the theorectical failure plane.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STRUCTURAL PROPERTIES: Mirafi

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Slope 38 deg

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FORCES AND MOMENTS

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LL(W7)	1.00	700	--	5.10	--	--	3567
Pa_h	1.00	--	649	--	1.89	1226	--
Pqd_h	1.00	--	1594	--	2.84	4519	--
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W8: Dead load over the mass
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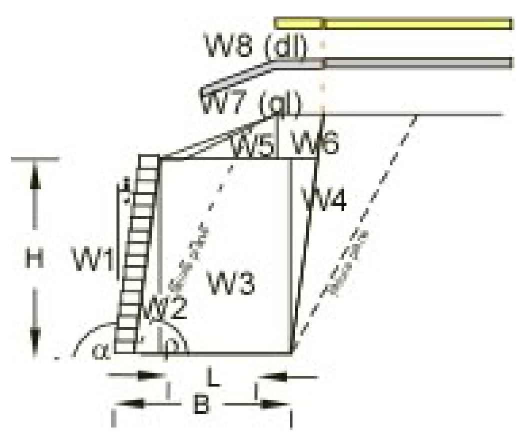
W10: Surcharge load Paq
W11: Dead Load Surcharge Paqd
X-Len: is measured from the center of the base (+) Driving, (-) Resisting.

Pa_h: horizontal earth pressure
Pq_h: horizontal surcharge pressure
Pa_v: vertical earth pressure
Pq_v: vertical surcharge pressure



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where L is the base width	
where Base Shear = N tan(40.0) * 0.8	456.47
Driving force is the horizontal component of Pah + Pqh+ Pdh	Df = 2,243
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Moments causing overturning = MPah + MPqh	Mo =5,745ft-lbs
Factor of safety = Mr/Mo	FSot =4.90 OK

ECCENTRICITY AND BEARING

Eccentricity is the calculation of the distance of the resultant away from the centroid of mass. In wall ReinDesign the eccentricity is used to calculate an effective footing width, or in rigid structure, it is used to calculate the pressure distribution below the base.

Calculation of Eccentricity

e = (SumMr + M7 + SumMo)/SumV

Mr = -5,182.52

Mo = 8,820.04

e = (-5,182.528,820.04) /6,574.23) e =-1.587

Because 'e' is negative (leaning into the embankment), it is ignored to get the maximum bearing at the face of the wall.

Calculation of Bearing Pressures

Qult = c*Nc + q*Nq + 0.5*gamma*(B')*Ng

where:

Nc =22.25

Nq =11.85

Ng =12.54

c =50.00psf

q =83.75psf

B' =12.17ft

Calculate Ultimate Bearing, Qult Qult =1,321.83psf

Applied Bearing Pressures = (SumVert / B' + (2B + LP depth)/2 * LP depth *gamma)

sigma =730.47psf

Calculated Factors of Safety for Bearing Qult/sigma =12.54

TENSION CALCULATIONS

Tmax is the maximum tension in the reinforcing based on the earth pressure and surcharge loads applied. In the NCMA design method, earth pressures are calculated using the Coulomb Earth pressure equation. Infinite surcharge loads are applied as q x ka. In designs were there is a broken back slope, or the surcharge is not uniform over the area, a tie-back wedge analysis method is used.

FS = (Tal * FS_tn) / Tmax

TABLE OF RESULTS

Elevation[ft]	ka	z	sv	Name[ft]	Tult[ppf]	Ta[ppf]	Rc %	Tmax[ppf]	FS
4.67	0.159	0.84	1.67	3XT	3,500	522	100	32	24.25
3.33	0.178	2.34	1.33	3XT	3,500	522	100	82	9.50
2.00	0.178	3.67	1.33	3XT	3,500	522	100	117	6.71
0.67	0.178	5.00	1.33	3XT	3,500	522	100	151	5.19

PULLOUT CALCULATIONS

Pullout is the amount of resistance of the reinforcing has to a pullout failure based on the Tmax applied and the depth of embedment (resistance). In an NCMA design the failure place is defined as the Coulomb failure plane which varies with face batter, backslope angle, and surcharge loads applied. All failure planes begin at the tail. of the facing units.

For AASHTO calculations, the live load surcharge is not included in the Tmax value for pullout.

Failure Plane Angle (ρ) = 58.0 Deg

NOTE: The pullout capacity is limited by the LTDS of the reinforcing layer, not the ultimate pullout capacity calculated.

$F^* = 0.67 \times \tan(\varphi) = 0.67 \times 0.78 = 0.52$
Le = embedment length = Li - block depth - hi * Tan(90 - ρ)
La = Li - Le
sv = geogrid spacing
Rc = % coverage
α = scale effect correction
Pullout = 2 x Le x F* x sv x α x Rc

TABLE OF RESULTS

Elevation[ft]	Normal[lbf]	Ci	% Coverage	Tmax[ppf]	Le[ft]	La[ft]	Pullout_[Pr][ppf]	FS PO
4.67	1537.74	0.90	100	32	5.57	3.43	2163	66.91
3.33	2508.64	0.90	100	82	6.27	2.73	3528	42.78
2.00	3551.93	0.90	100	117	6.96	2.04	4995	42.78
0.67	4877.82	0.90	100	151	7.65	1.35	6860	45.41

CONNECTION CALCULATIONS

Connection is the amount of resistance of the reinforcing has to a pullout failure from the facing units based on the Tmax applied and the normal load on the units. In an AASHTO LRFD design, creep on the connection may be applied for frictional and mechanical connections. In NCMA or AASHTO 2002, a frictional failure is based on the peak connection capacity divided by a factor of safety. For a rupture connection the capacity is the peak load divided by a creep reduction factor and a factor of safety.

Frictional Connection

Peak Connection = N(ppf) tan(slope) + intercept

Rupture Connection

Connection Capacity = [N(ppf) tan(slope) + intercept] / RFcr

RFcr can be a value obtained from long-term testing or by default could be the creep reduction factor of the geogrid reinforcing.

Tal_cn = Allowable connection capacity = Tult_cn / FScn

Rc = % coverage

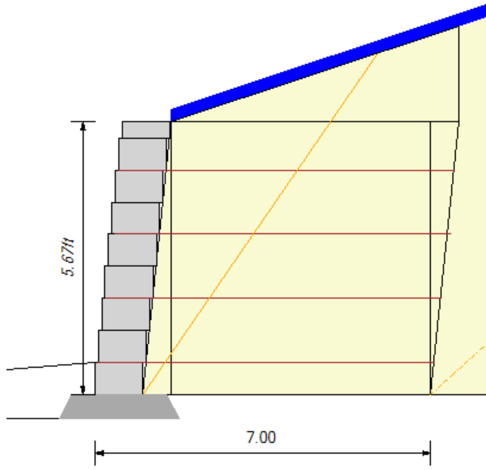
FS = Tal_cn * FScn/Tmax

TABLE OF RESULTS

Elev[ft]	Name	Tmax[ppf]	Rc %	N[ppf]	Tult_cn	Tac[ppf]	FS
4.67	3XT	32	100	120	3174	962	44.64
3.33	3XT	82	100	280	3240	982	17.86
2.00	3XT	117	100	440	3307	1002	12.87
0.67	3XT	151	100	600	3373	1022	10.15

REA Analysis

Project:	20SBC011 TRAILS AT CROWFOOT
Location:	PARKER, CO
Designer:	BTD
Date:	12/9/2020
Section:	Wall 3, Section 1
Design Method:	NCMA_09_3rd_Ed, Ignore Vert. Force
Design Unit:	AB_Classic 8



SOIL PARAMETERS	φ	coh	γ
Reinforced Soil:	38 deg	0psf	115pcf
Retained Soil:	26 deg	0psf	125pcf
Foundation Soil:	26 deg	50psf	125pcf

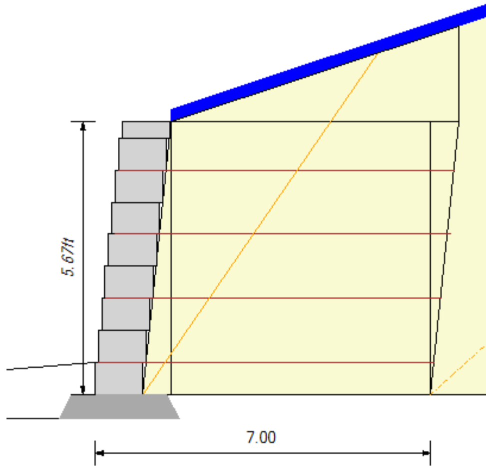
Leveling Pad: Crushed Stone

GEOMETRY

Design Height:	5.67ft (5.00ft Exp.)	Live Load:	100psf
Wall Batter/Tilt:	6.00/ 0.00 deg	Live Load Offset:	0.00ft
Embedment:	0.67ft	LL2 Width:	100ft
Leveling Pad Depth:	0.50ft	Dead Load:	0psf
Slope Angle:	18.4 deg	Dead Load Offset:	0.0ft
Slope Length:	20.0ft	Dead Load Width:	0ft
Slope Toe Offset:	0.0ft		
Vertical δ on Single Depth		Toe Slope Angle:	4.60
		Toe Slope Length:	4.00
		Toe Slope Bench:	0.00

FACTORS OF SAFETY

Sliding:	1.50	Pullout:	1.50
Overturning:	2.00	Uncertainties:	1.50
Bearing:	2.00	Connection:	1.50
Shear:	1.50	Bending:	1.50



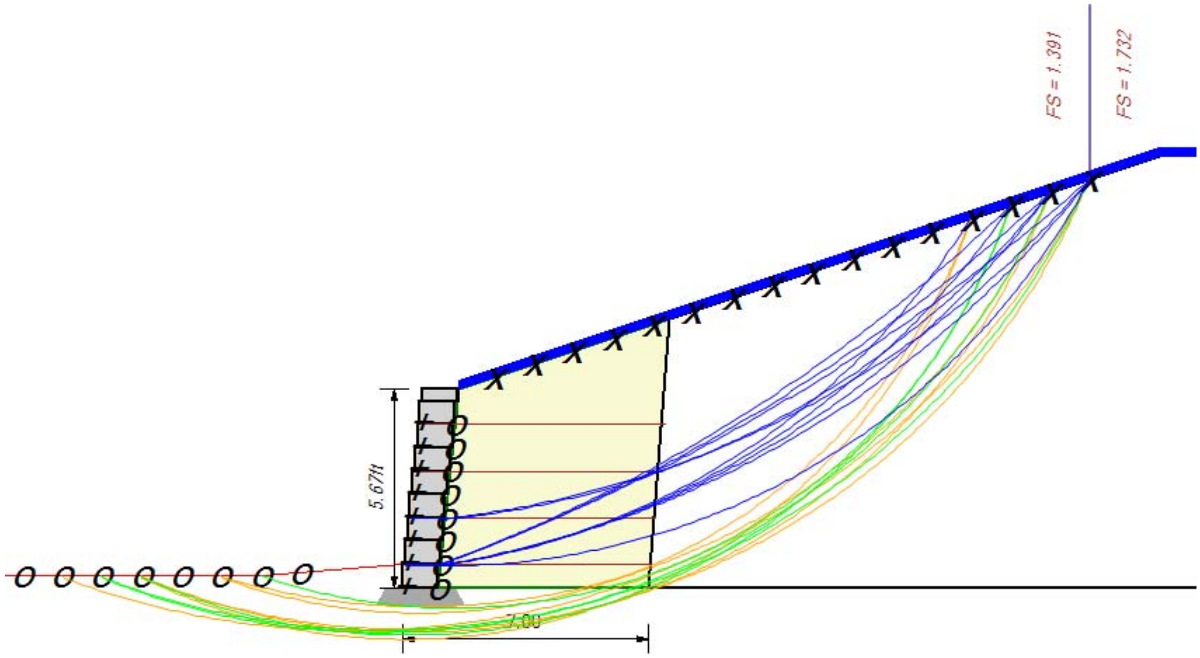
RESULTS

FoS Sliding:	1.67	FoS Overturning:	4.21
Bearing	837	FoS Bearing:	9.07
Pullout	32.40		
Total Pullout	12,967	FoS Total Pullout	24.73
Top FoSot:	6.36	FoS Connection:	11.82

ID	Height	Length	Geogrid.	Tallow	% Cvrg	EP(Pa)	LL (Pql)	DL (Pqd)	TMax	FS Str	Tal Cn	FS Pk Cn	FS PO/[Tmax]	FS Sldg [fndn]	Grid Embed
4	4.67	7	3XT	522	100	33	110	0	143	5.49	962	10.10	40.55/[33]	20.06	3.27
3	3.33	7	3XT	522	100	74	51	0	125	6.29	982	11.82	32.90/[74]	11.82	4.05
2	2	7	3XT	522	100	116	43	0	159	4.93	1002	9.46	32.40/[116]	8.13	4.83
1	0.67	7	3XT	522	100	159	39	0	197	3.97	1022	7.77	34.13/[159]	6.11 [1.67]	5.61

Column Descriptions:

- Ta: allowable geogrid strength
- Rc %: percent coverage for geosynthetics
- EP (Pa) internal active earth pressure
- LL (Pql) earth pressure due to live load surcharge
- DL (Pqd) earth pressure due to dead load surcharge
- Tmax maximum earth pressure on geosynthetic layer
- FSstr factor of safety on geogrid strength (Ta/Tmax)
- Ta cn allowable tension on the connection
- FS Pkcn, factor of safety on the connection (Ta cn/Tmax)
- FS PO, factor of safety on pullout (Ta pullout/(Tmax - LL)
- Grid Embedment, depth of embedment beyond the theorectical failure plane.


FS = 1.391
FS = 1.732
5.67ft
7.00

COMPOUND RESULTS

Compound stability is a global analysis (Bishop) with the failure planes originating at the top of the slope / wall and exiting out through the face of the wall. For MSE walls, the resistance of the geogrid reinforcement is included in the analysis and the shear resistance of the face units is included.

ID	Enter Point X	Enter Point Y	Exit Point X	Exit Point Y	Center X	Center Y	Radius	FoS
3	19.61	11.66	1.07	0.67	-3.96	30.27	30.03	1.732
4	19.61	11.66	1.07	0.67	1.23	21.52	20.85	1.739
2	19.61	11.66	1.07	0.67	-19.02	55.67	58.56	1.782
3	18.47	11.28	1.07	0.67	-3.24	27.29	26.97	1.807
3	17.34	10.91	1.07	0.67	-2.57	24.48	24.09	1.828
2	18.47	11.28	1.07	0.67	-17.02	49.89	52.44	1.861
2	17.34	10.91	1.07	0.67	-15.13	44.45	46.69	1.882
3	18.47	11.28	1.21	2.00	-1.06	26.91	25.01	1.883
3	19.61	11.66	1.21	2.00	-1.67	29.83	27.98	1.899
3	16.20	10.53	1.07	0.67	-1.95	21.85	21.39	1.916

GLOBAL RESULTS

Global stability is a global analysis (Bishop) with the failure planes originating at the top of the slope / wall and exiting out below the wall in the area infront of the structure. For MSE walls, the resistance of the geogrid reinforcement is included in the resisting forces. The curve may go through the base of the wall and the wall shear would be included. In most cases the failure plane will pass below the structure.

ID	Enter Point X	Enter Point Y	Exit Point X	Exit Point Y	Center X	Center Y	Radius	FoS
3	19.61	11.66	-9.73	0.35	-1.40	22.43	23.60	1.391
3	18.47	11.28	-7.47	0.35	0.26	18.26	19.51	1.396
2	16.20	10.53	-5.20	0.35	0.54	15.86	16.54	1.396
3	19.61	11.66	-7.47	0.35	0.31	19.78	20.93	1.396
2	18.47	11.28	-5.20	0.35	0.56	18.98	19.50	1.398
3	16.20	10.53	-7.47	0.35	0.09	15.39	16.83	1.399
3	17.34	10.91	-7.47	0.35	0.18	16.80	18.14	1.400
3	18.47	11.28	-8.60	0.35	-0.59	19.50	20.76	1.400
3	19.61	11.66	-8.60	0.35	-0.54	21.08	22.24	1.402
2	17.34	10.91	-4.06	0.35	1.44	16.15	16.74	1.405

GEOGRID REINFORCING

STRUCTURAL PROPERTIES: Mirafi

GEOGRID PROPERTIES

Name	Tult	RFcr	RFd	RFid	Ci	Cd	Alpha	Ltds
3XT	3500	1.45	2.20	1.40	0.90	0.90	0.80	784

CONNECTION STRENGTHS

Geogrid	Slope 1	Intercept 1	Peak Break	Slope 2	Intercept 2	Max Normal	Rup Conn	Conn Creep	Tlot (%)	Tlot
2XT	58.00	125	937	5.00	1542	1372	False	1.45	110	2200
3XT	10.70	1420	-1	0.00	0	2422	False	1.45	110	3850
5XT	18.00	1192	917	16.00	1227	2341	False	1.45	110	5170
7XT	26.00	1065	-1	0.00	0	3081	False	1.45	110	6490
8XT	40.00	1063	-1	0.00	0	2156	False	1.45	110	8140
10XT	52.00	513	1065	24.00	1402	2869	False	1.45	110	10450

SHEAR STRENGTHS

Slope 38 deg

Intercept 2671psf

CALCULATION RESULTS

OVERVIEW

REA Wall calculates stability assuming the wall is a rigid body. Forces and moments are calculated about the base and the front toe of the wall. The base block width or bottom reinforcement length is used in the calculations. The concrete units, granular fill over the blocks or reinforced zone soils are used as resisting forces.

EARTH PRESSURES

The method of analysis uses the Coulomb Earth Pressure equation (below) to calculate active earth pressures. Wall friction is assumed to act at the back of the wall face. The component of earth pressure is assumed to act perpendicular to the boundary surface. The effective delta angle is delta minus the wall batter at the back face (assumed to be vertical). If the slope breaks within the failure zone, a trial wedge method of analysis is used.

INTERNAL EARTH PRESSURES

Effective internal Delta angle (2/3 phi)	delta =25.3 deg
Coefficient of active earth pressure	ka =0.219
Internal failure plane	ρ = 55.4 deg

EXTERNAL EARTH PRESSURES

Effective external Delta angle	delta =26.00 deg
Coefficient of active earth pressure	ka =0.425
External failure plane	ρ = 42.0 deg

$$Ka := \frac{\cos(\phi_i + i)^2}{\cos(i)^2 \cdot \cos(\delta_i - i)\left(1 + \sqrt{\frac{\sin(\phi_i + \delta_i)\cdot \sin(\phi_i - \beta)}{\cos(\delta_i - i)\cdot \cos(i + \beta)}}\right)^2}$$

FORCES AND MOMENTS

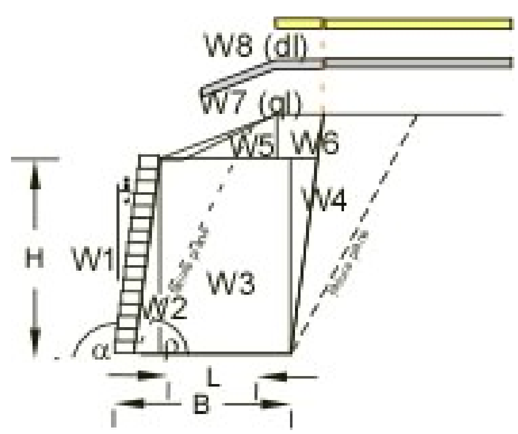
REA Wall resolves all the geometry into simple geometric shapes to make checking easier. All x and y coordinates are referenced to a zero point at the front toe. The wall image can be exported to CAD for a more detailed output.

Name	Factor γ	Force (V)	Force (H)	X-len	Y-len	Mo	Mr
Face Blocks(W1)	1.00	680	--	0.76	--	--	519
Soil(W2)	1.00	172	--	1.40	--	--	241
Soil(W3)	1.00	3524	--	4.30	--	--	15145
Soil(W4)	1.00	194	--	7.20	--	--	1399
Slope(W5)	1.00	689	--	5.34	--	--	3674
LL(W7)	1.00	600	--	4.60	--	--	2758
Pa_h	1.00	--	1495	--	2.58	3857	--
Pq_h	1.00	--	290	--	3.87	1122	--
Sum (V, H)	1.00	5859	1785		Sum Mom	4980	20977

W0: leveling pad
W1: facing units
W2: soil wedge behind the face
W3: rectangular area in MSE area
W4: the wedge at the back of the mass
W5: slope area over the mass
W6: Rectangle zone in broken back
W7: Live load over the mass
W8: Dead load over the mass
W9: Force Pa
W10: Surcharge load Paq
W11: Dead Load Surcharge Paqd

X-Len: is measured from the center of the base (+) Driving, (-) Resisting.

Pa_h: horizontal earth pressure
Pq_h: horizontal surcharge pressure
Pa_v: vertical earth pressure
Pq_v: vertical surcharge pressure



BASE SLIDING

Sliding at the base is checked at the soil-to-soil interface between the reinforced mass and the foundation soil.

Forces resisting sliding = (SumVr- W0 - W1 - W7)	
5,859 - 0 - 680 - 600	SumVr = 4,579ppf
Resisting force = SumVr x tan(26) + c x L + Base Shear	Rf1 =2,990
where L is the base width	
where Base Shear = N tan(40.0) * 0.8	456.47
Driving force is the horizontal component of Pah + Pqh+ Pdh	Df = 1,785
Factor of Safety = Rf/Df	FSsl =1.67

OVERTURNING ABOUT THE TOE

Overturning at the base is checked by assuming rotation about the front toe by the block mass, soil retained on the blocks or within the reinforced zone. Allowable overturning can be defined by eccentricity (e/L) or by the ratio of resisting moments divided by overturning moment (FSot).

Moments resisting overturning = Sum(M1 to M6) + MPav + MPqv	Mr =20,977ft-lbs
Moments causing overturning = MPah + MPqh	Mo =4,980ft-lbs
Factor of safety = Mr/Mo	FSot =4.21 OK

ECCENTRICITY AND BEARING

Eccentricity is the calculation of the distance of the resultant away from the centroid of mass. In wall ReinDesign the eccentricity is used to calculate an effective footing width, or in rigid structure, it is used to calculate the pressure distribution below the base.

Calculation of Eccentricity

e = (SumMr + M7 + SumMo)/SumV

Mr = -5,451.63

Mo = 7,202.16

e = (-5,451.637,202.16) /5,858.72) e =-1.689

Because 'e' is negative (leaning into the embankment), it is ignored to get the maximum bearing at the face of the wall.

Calculation of Bearing Pressures

Qult = c*Nc + q*Nq + 0.5*gamma*(B')*Ng

where:

Nc =22.25

Nq =11.85

Ng =12.54

c =50.00psf

q =83.75psf

B' =10.38ft

Calculate Ultimate Bearing, Qult Qult =1,321.83psf

Applied Bearing Pressures = (SumVert / B' + (2B + LP depth)/2 * LP depth *gamma)

sigma =836.96psf

Calculated Factors of Safety for Bearing Qult/sigma =9.07

TENSION CALCULATIONS

Tmax is the maximum tension in the reinforcing based on the earth pressure and surcharge loads applied. In the NCMA design method, earth pressures are calculated using the Coulomb Earth pressure equation. Infinite surcharge loads are applied as q x ka. In designs were there is a broken back slope, or the surcharge is not uniform over the area, a tie-back wedge analysis method is used.

FS = (Tal * FS_tn) / Tmax

TABLE OF RESULTS

Elevation[ft]	ka	z	sv	Name[ft]	Tult[ppf]	Ta[ppf]	Rc %	Tmax[ppf]	FS
4.67	0.219	0.84	1.67	3XT	3,500	522	100	143	5.49
3.33	0.219	2.34	1.33	3XT	3,500	522	100	125	6.29
2.00	0.219	3.67	1.33	3XT	3,500	522	100	159	4.93
0.67	0.219	5.00	1.33	3XT	3,500	522	100	197	3.97

PULLOUT CALCULATIONS

Pullout is the amount of resistance of the reinforcing has to a pullout failure based on the Tmax applied and the depth of embedment (resistance). In an NCMA design the failure place is defined as the Coulomb failure plane which varies with face batter, backslope angle, and surcharge loads applied. All failure planes begin at the tail. of the facing units.

For AASHTO calculations, the live load surcharge is not included in the Tmax value for pullout.

Failure Plane Angle (ρ) = 55.4 Deg

NOTE: The pullout capacity is limited by the LTDS of the reinforcing layer, not the ultimate pullout capacity calculated.

F* = 0.67 x tan(φ) = 0.67 x 0.78 = 0.52
Le = embedment length = Li - block depth - hi * Tan(90 - ρ)
La = Li - Le
sv = geogrid spacing
Rc = % coverage
α = scale effect correction
Pullout = 2 x Le x F* x sv x α x Rc

TABLE OF RESULTS

Elevation[ft]	Normal[lbf]	Ci	% Coverage	Tmax[ppf]	Le[ft]	La[ft]	Pullout_[Pr][ppf]	FS PO
4.67	956.23	0.90	100	143	3.27	3.73	1345	9.41
3.33	1732.96	0.90	100	125	4.05	2.95	2437	19.55
2.00	2680.83	0.90	100	159	4.83	2.17	3770	23.72
0.67	3850.45	0.90	100	197	5.61	1.39	5415	27.42

CONNECTION CALCULATIONS

Connection is the amount of resistance of the reinforcing has to a pullout failure from the facing units based on the Tmax applied and the normal load on the units. In an AASHTO LRFD design, creep on the connection may be applied for frictional and mechanical connections. In NCMA or AASHTO 2002, a frictional failure is based on the peak connection capacity divided by a factor of safety. For a rupture connection the capacity is the peak load divided by a creep reduction factor and a factor of safety.

Frictional Connection
Peak Connection = N(ppf) tan(slope) + intercept
Rupture Connection
Connection Capacity = [N(ppf) tan(slope) + intercept] / RFcr
RFcr can be a value obtained from long-term testing or by default could be the creep reduction factor of the geogrid reinforcing.

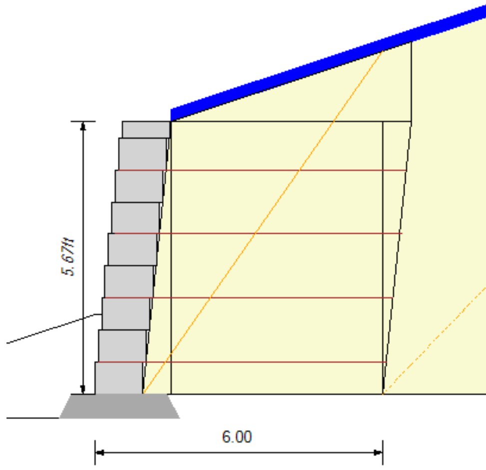
Tal_cn = Allowable connection capacity = Tult_cn / FScn
Rc = % coverage
FS = Tal_cn * FScn/Tmax

TABLE OF RESULTS

Elev[ft]	Name	Tmax[ppf]	Rc %	N[ppf]	Tult_cn	Tac[ppf]	FS
4.67	3XT	143	100	120	3174	962	10.10
3.33	3XT	125	100	280	3240	982	11.82
2.00	3XT	159	100	440	3307	1002	9.46
0.67	3XT	197	100	600	3373	1022	7.77

REA Analysis

Project: 20SBC011 TRAILS AT CROWFOOT
Location: PARKER, CO
Designer: BTD
Date: 12/9/2020
Section: Wall 4, Section 1
Design Method: NCMA_09_3rd_Ed, Ignore Vert. Force
Design Unit: AB_Classic 8



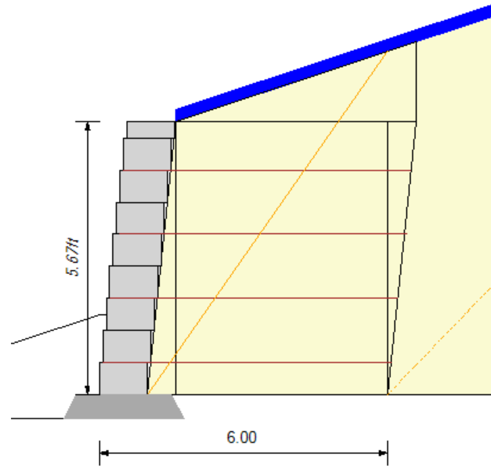
SOIL PARAMETERS	φ	coh	γ
Reinforced Soil:	38 deg	0psf	115pcf
Retained Soil:	26 deg	0psf	125pcf
Foundation Soil:	26 deg	50psf	125pcf
Leveling Pad: Crushed Stone			

GEOMETRY

Design Height:	5.67ft (4.00ft Exp.)	Live Load:	100psf	Live Load 2:	150psf
Wall Batter/Tilt:	6.00/ 0.00 deg	Live Load Offset:	0.00ft	LL2 Offset:	15ft
Embedment:	1.67ft	Live Load Width:	15ft	LL2 Width:	24ft
Leveling Pad Depth:	0.50ft	Dead Load:	0psf		
Slope Angle:	18.4 deg	Dead Load Offset:	0.0ft		
Slope Length:	11.0ft	Dead Load Width:	0ft		
Slope Toe Offset:	0.0ft				
Vertical δ on Single Depth		Toe Slope Angle:	18.40		
		Toe Slope Length:	4.00		
		Toe Slope Bench:	0.00		

FACTORS OF SAFETY

Sliding:	1.50	Pullout:	1.50
Overturning:	2.00	Uncertainties:	1.50
Bearing:	2.00	Connection:	1.50
Shear:	1.50	Bending:	1.50



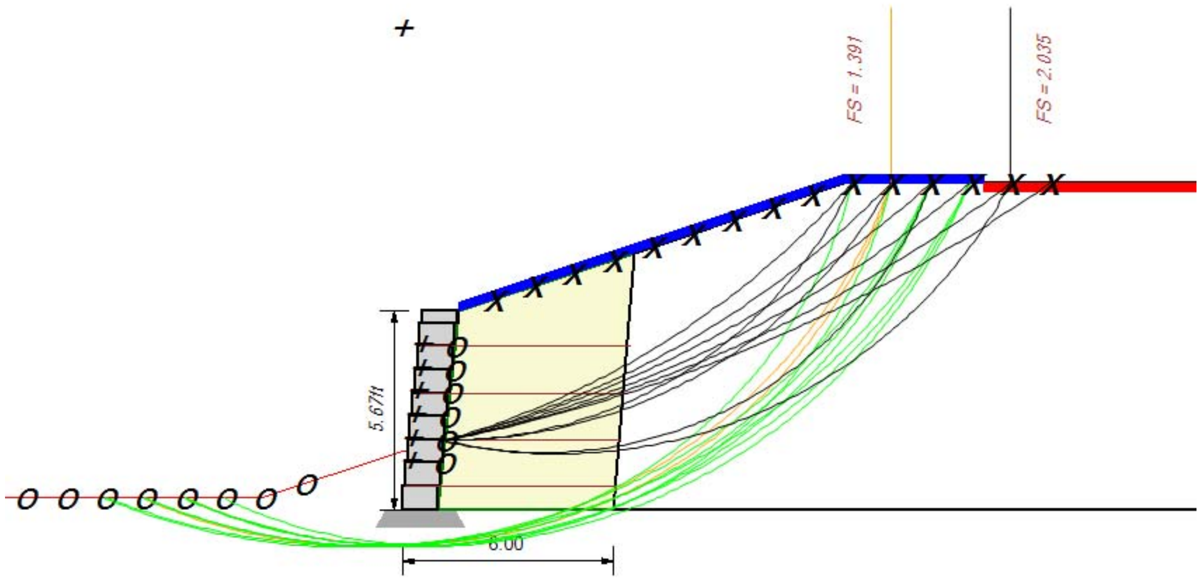
RESULTS

FoS Sliding:	1.60	FoS Overturning:	3.60
Bearing	816	FoS Bearing:	10.16
Pullout	23.39		
Total Pullout	9,759	FoS Total Pullout	19.30
Top FoSot:	7.03	FoS Connection:	1,000.00

ID	Height	Length	Geogrid.	Tallow	% Cvrg	EP(Pa)	LL (Pql)	LL2 (Pql2)	DL (Pqd)	TMax	FS Str	Tal Cn	FS Pk Cn	FS PO/[Tmax]	FS Sldg [fndn]	Grid Embed
4	4.67	6	3XT	522	100	28	28	0	0	56	14.01	962	25.79	30.61/[28]	16.94	2.22
3	3.33	6	3XT	522	100	74	28	0	0	102	7.71	982	14.49	23.39/[74]	9.16	3.02
2	2	6	3XT	522	100	116	28	0	0	144	5.45	1002	10.45	24.63/[116]	6.06	3.81
1	0.67	6	3XT	522	100	159	28	0	0	186	4.21	1022	8.24	27.17/[159]	4.51 [1.60]	4.60

Column Descriptions:

Ta: allowable geogrid strength
Rc %: percent coverage for geosynthetics
EP (Pa) internal active earth pressure
LL (Pql) earth pressure due to live load surcharge
DL (Pqd) earth pressure due to dead load surcharge
Tmax maximum earth pressure on geosynthetic layer
FSstr factor of safety on geogrid strength (Ta/Tmax)
Ta cn allowable tension on the connection
FS Pkcn, factor of safety on the connection (Ta cn/Tmax)
FS PO, factor of safety on pullout (Ta pullout/(Tmax - LL)
Grid Embedment, depth of embedment beyond the theorectical failure plane.


FS = 1.391
FS = 2.035
5.67ft
6.00

COMPOUND RESULTS

Compound stability is a global analysis (Bishop) with the failure planes originating at the top of the slope / wall and exiting out through the face of the wall. For MSE walls, the resistance of the geogrid reinforcement is included in the analysis and the shear resistance of the face units is included.

ID	Enter Point X	Enter Point Y	Exit Point X	Exit Point Y	Center X	Center Y	Radius	FoS
2	17.34	9.33	1.21	2.00	-6.75	40.92	39.73	2.035
2	18.47	9.33	1.21	2.00	-7.14	45.67	44.46	2.035
2	16.20	9.33	1.21	2.00	-6.36	36.49	35.32	2.068
3	13.94	9.33	1.21	2.00	1.35	16.48	14.48	2.071
2	15.07	9.33	1.21	2.00	-5.99	32.38	31.23	2.073
3	12.80	9.33	1.21	2.00	1.26	14.76	12.76	2.103
2	13.94	9.33	1.21	2.00	-5.63	28.59	27.46	2.156
2	12.80	9.33	1.21	2.00	-5.29	25.11	24.01	2.282
4	17.34	9.33	1.21	2.00	4.48	16.20	14.58	2.351
4	15.07	9.33	1.21	2.00	4.05	13.39	11.74	2.354

GLOBAL RESULTS

Global stability is a global analysis (Bishop) with the failure planes originating at the top of the slope / wall and exiting out below the wall in the area infront of the structure. For MSE walls, the resistance of the geogrid reinforcement is included in the resisting forces. The curve may go through the base of the wall and the wall shear would be included. In most cases the failure plane will pass below the structure.

ID	Enter Point X	Enter Point Y	Exit Point X	Exit Point Y	Center X	Center Y	Radius	FoS
3	13.94	9.33	-6.23	0.34	-0.09	13.68	14.68	1.391
3	13.94	9.33	-7.36	0.34	-0.94	14.84	15.86	1.397
3	12.80	9.33	-6.23	0.34	-0.37	12.59	13.57	1.405
3	16.20	9.33	-7.36	0.34	-0.36	17.36	18.40	1.405
3	15.07	9.33	-6.23	0.34	0.20	14.84	15.86	1.407
2	15.07	9.33	-8.49	0.34	-1.49	17.36	18.40	1.408
3	15.07	9.33	-7.36	0.34	-0.65	16.06	17.10	1.413
3	13.94	9.33	-5.09	0.34	0.76	12.59	13.57	1.414
3	16.20	9.33	-6.23	0.34	0.49	16.06	17.10	1.429
3	16.20	9.33	-8.49	0.34	-1.20	18.71	19.77	1.437

GEOGRID REINFORCING

STRUCTURAL PROPERTIES: Mirafi

GEOGRID PROPERTIES

Name	Tult	RFcr	RFd	RFid	Ci	Cd	Alpha	Ltds
3XT	3500	1.45	2.20	1.40	0.90	0.90	0.80	784

CONNECTION STRENGTHS

Geogrid	Slope 1	Intercept 1	Peak Break	Slope 2	Intercept 2	Max Normal	Rup Conn	Conn Creep	Tlot (%)	Tlot
2XT	58.00	125	937	5.00	1542	1372	False	1.45	110	2200
3XT	10.70	1420	-1	0.00	0	2422	False	1.45	110	3850
5XT	18.00	1192	917	16.00	1227	2341	False	1.45	110	5170
7XT	26.00	1065	-1	0.00	0	3081	False	1.45	110	6490
8XT	40.00	1063	-1	0.00	0	2156	False	1.45	110	8140
10XT	52.00	513	1065	24.00	1402	2869	False	1.45	110	10450

SHEAR STRENGTHS

Slope 38 deg

Intercept 2671psf

CALCULATION RESULTS

OVERVIEW

REA Wall calculates stability assuming the wall is a rigid body. Forces and moments are calculated about the base and the front toe of the wall. The base block width or bottom reinforcement length is used in the calculations. The concrete units, granular fill over the blocks or reinforced zone soils are used as resisting forces.

EARTH PRESSURES

The method of analysis uses the Coulomb Earth Pressure equation (below) to calculate active earth pressures. Wall friction is assumed to act at the back of the wall face. The component of earth pressure is assumed to act perpendicular to the boundary surface. The effective delta angle is delta minus the wall batter at the back face (assumed to be vertical). If the slope breaks within the failure zone, a trial wedge method of analysis is used.

INTERNAL EARTH PRESSURES

Effective internal Delta angle (2/3 phi)	delta =25.3 deg
Coefficient of active earth pressure	ka =0.219
Internal failure plane	ρ = 55.0 deg

EXTERNAL EARTH PRESSURES

Effective external Delta angle	delta =26.00 deg
Coefficient of active earth pressure	ka =0.409
External failure plane	ρ = 46.0 deg

$$Ka := \frac{\cos(\phi_i + i)^2}{\cos(i)^2 \cdot \cos(\delta_i - i)\left(1 + \sqrt{\frac{\sin(\phi_i + \delta_i)\cdot\sin(\phi_i - \beta)}{\cos(\delta_i - i)\cdot\cos(i + \beta)}}\right)^2}$$

FORCES AND MOMENTS

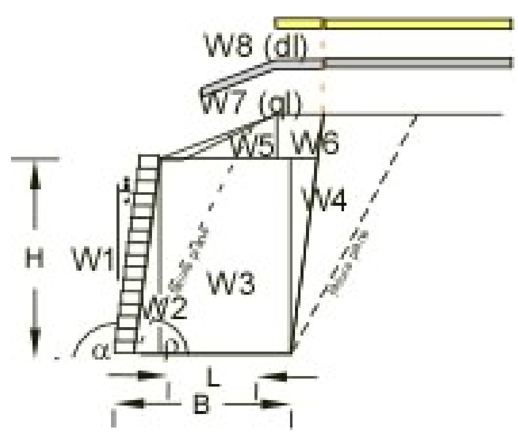
REA Wall resolves all the geometry into simple geometric shapes to make checking easier. All x and y coordinates are referenced to a zero point at the front toe. The wall image can be exported to CAD for a more detailed output.

Name	Factor γ	Force (V)	Force (H)	X-len	Y-len	Mo	Mr
Face Blocks(W1)	1.00	680	--	0.76	--	--	519
Soil(W2)	1.00	172	--	1.40	--	--	241
Soil(W3)	1.00	2872	--	3.80	--	--	10907
Soil(W4)	1.00	194	--	6.20	--	--	1204
Slope(W5)	1.00	478	--	4.66	--	--	2227
LL(W7)	1.00	500	--	4.10	--	--	2048
Pa_h	1.00	--	1312	--	2.46	3232	--
Pq_h	1.00	--	259	--	3.70	959	--
Sum (V, H)	1.00	4896	1571		Sum Mom	4191	15097

W0: leveling pad
W1: facing units
W2: soil wedge behind the face
W3: rectangular area in MSE area
W4: the wedge at the back of the mass
W5: slope area over the mass
W6: Rectangle zone in broken back
W7: Live load over the mass
W8: Dead load over the mass
W9: Force Pa
W10: Surcharge load Paq
W11: Dead Load Surcharge Paqd

X-Len: is measured from the center of the base (+) Driving, (-) Resisting.

Pa_h: horizontal earth pressure
Pq_h: horizontal surcharge pressure
Pa_v: vertical earth pressure
Pq_v: vertical surcharge pressure



BASE SLIDING

Sliding at the base is checked at the soil-to-soil interface between the reinforced mass and the foundation soil.

Forces resisting sliding = (SumVr- W0 - W1 - W7)
4,896 - 0 - 680 - 500 SumVr = 3,716ppf

Resisting force = SumVr x tan(26) + c x L + Base Shear Rf1 =2,519
where L is the base width
where Base Shear = N tan(40.0) * 0.8 456.47

Driving force is the horizontal component of Pah + Pqh+ Pdh Df = 1,571
Factor of Safety = Rf/Df FSsl =1.60

OVERTURNING ABOUT THE TOE

Overturning at the base is checked by assuming rotation about the front toe by the block mass, soil retained on the blocks or within the reinforced zone. Allowable overturning can be defined by eccentricity (e/L) or by the ratio of resisting moments divided by overturning moment (FSot).

Moments resisting overturning = Sum(M1 to M6) + MPav + MPqv	Mr =15,097ft-lbs
Moments causing overturning = MPah + MPqh	Mo =4,191ft-lbs
Factor of safety = Mr/Mo	FSot =3.60 OK

ECCENTRICITY AND BEARING

Eccentricity is the calculation of the distance of the resultant away from the centroid of mass. In wall ReinDesign the eccentricity is used to calculate an effective footing width, or in rigid structure, it is used to calculate the pressure distribution below the base.

Calculation of Eccentricity

e = (SumMr + M7 + SumMo)/SumV
Mr = -4,252.99
Mo = 5,987.71
e = (-4,252.995,987.71) /4,896.27) e =-1.673

Because 'e' is negative (leaning into the embankment), it is ignored to get the maximum bearing at the face of the wall.

Calculation of Bearing Pressures

Qult = c*Nc + q*Nq + 0.5*gamma*(B')*Ng
where:
Nc =22.25
Nq =11.85
Ng =12.54
c =50.00psf
q =208.75psf
B' =9.35ft

Calculate Ultimate Bearing, Qult Qult =2,803.61psf
Applied Bearing Pressures = (SumVert / B' + (2B + LP depth)/2 * LP depth *gamma)
sigma =816.04psf
Calculated Factors of Safety for Bearing Qult/sigma =10.16

TENSION CALCULATIONS

Tmax is the maximum tension in the reinforcing based on the earth pressure and surcharge loads applied. In the NCMA design method, earth pressures are calculated using the Coulomb Earth pressure equation. Infinite surcharge loads are applied as q x ka. In designs were there is a broken back slope, or the surcharge is not uniform over the area, a tie-back wedge analysis method is used.

FS = (Tal * FS_tn) / Tmax

TABLE OF RESULTS

Elevation[ft]	ka	z	sv	Name[ft]	Tult[ppf]	Ta[ppf]	Rc %	Tmax[ppf]	FS
4.67	0.184	0.84	1.67	3XT	3,500	522	100	56	14.01
3.33	0.219	2.34	1.33	3XT	3,500	522	100	102	7.71
2.00	0.219	3.67	1.33	3XT	3,500	522	100	144	5.45
0.67	0.219	5.00	1.33	3XT	3,500	522	100	186	4.21

PULLOUT CALCULATIONS

Pullout is the amount of resistance of the reinforcing has to a pullout failure based on the Tmax applied and the depth of embedment (resistance). In an NCMA design the failure place is defined as the Coulomb failure plane which varies with face batter, backslope angle, and surcharge loads applied. All failure planes begin at the tail. of the facing units.

For AASHTO calculations, the live load surcharge is not included in the Tmax value for pullout.

Failure Plane Angle (ρ) = 55.0 Deg

NOTE: The pullout capacity is limited by the LTDS of the reinforcing layer, not the ultimate pullout capacity calculated.

F* = 0.67 x tan(φ) = 0.67 x 0.78 = 0.52
Le = embedment length = Li - block depth - hi * Tan(90 - ρ)
La = Li - Le
sv = geogrid spacing
Rc = % coverage
α = scale effect correction
Pullout = 2 x Le x F* x sv x α x Rc

TABLE OF RESULTS

Elevation[ft]	Normal[lbf]	Ci	% Coverage	Tmax[ppf]	Le[ft]	La[ft]	Pullout_[Pr][ppf]	FS PO
4.67	606.16	0.90	100	56	2.22	3.78	852	15.24
3.33	1231.65	0.90	100	102	3.02	2.98	1732	17.04
2.00	2037.14	0.90	100	144	3.81	2.19	2865	19.91
0.67	3064.49	0.90	100	186	4.60	1.40	4310	23.15

CONNECTION CALCULATIONS

Connection is the amount of resistance of the reinforcing has to a pullout failure from the facing units based on the Tmax applied and the normal load on the units. In an AASHTO LRFD design, creep on the connection may be applied for frictional and mechanical connections. In NCMA or AASHTO 2002, a frictional failure is based on the peak connection capacity divided by a factor of safety. For a rupture connection the capacity is the peak load divided by a creep reduction factor and a factor of safety.

Frictional Connection

Peak Connection = N(ppf) tan(slope) + intercept

Rupture Connection

Connection Capacity = [N(ppf) tan(slope) + intercept] / RFcr

RFcr can be a value obtained from long-term testing or by default could be the creep reduction factor of the geogrid reinforcing.

Tal_cn = Allowable connection capacity = Tult_cn / FScn

Rc = % coverage

FS = Tal_cn * FScn/Tmax

TABLE OF RESULTS

Elev[ft]	Name	Tmax[ppf]	Rc %	N[ppf]	Tult_cn	Tac[ppf]	FS
4.67	3XT	56	100	120	3174	962	25.79
3.33	3XT	102	100	280	3240	982	14.49
2.00	3XT	144	100	440	3307	1002	10.45
0.67	3XT	186	100	600	3373	1022	8.24

GEOWALL DESIGNS

TRAILS AT CROWFOOT
PARKER, CO

RETAINING WALL (RW) CONSTRUCTION ADDRESSED BY THESE DRAWINGS ARE PART OF A SIGNIFICANTLY LARGER PROJECT BEING BUILT BY THE GENERAL CONTRACTOR, WHO HAS SEPARATELY RETAINED AN EARTHWORK GRADING CONTRACTOR TO ASSIST IN DEVELOPING THE SITE FOR THE OWNER. THE OWNER HAS RETAINED A PROJECT GEOTECHNICAL ENGINEER TO ADVISE IT ON MATTERS RELATIVE TO CONSTRUCTION AND WHO WILL BE PROVIDING QUALITY ASSURANCE TESTING AND OBSERVATION OF THE RW CONSTRUCTION WORK FOR THE OWNER. OUTLINED BELOW IS A BRIEF SUMMARY OF THE RESPONSIBILITIES OF EACH OF THE PARTIES REQUIRED BY THE RW CONSTRUCTION, AS OUTLINED IN THESE DRAWINGS, TO ENSURE A QUALITY CONSTRUCTION PROJECT:

A. GENERAL/EARTHWORK CONTRACTOR SHALL BE RESPONSIBLE FOR OVERALL SITE GRADING AND STORM WATER CONTROL, BEFORE, DURING, AND AFTER RW CONSTRUCTION, UNTIL THE PERMANENT PAVING AND STORM WATER DRAINAGE CONTROLS ARE ALL IN PLACE AND OPERATIONAL. DAMAGE TO EXISTING RW CONSTRUCTION BY POORLY CONTROLLED STORM WATER DRAINAGE SHALL NOT BE THE RESPONSIBILITIES THE RW CONTRACTOR OR RW DESIGNER.
B. GENERAL/EARTHWORK CONTRACTOR SHALL BE RESPONSIBLE FOR EROSION AND SEDIMENTATION CONTROL, BEFORE, DURING, AND AFTER RW CONSTRUCTION.
C. OWNER AND/OR GENERAL CONTRACTOR SHALL PROVIDE SURVEYING SERVICES SUFFICIENT TO LOCATE THE WALL, HORIZONTALLY AND VERTICALLY ON THE SITE FOR CONSTRUCTION PURPOSES.
D. GENERAL/EARTHWORK CONTRACTOR SHALL BE RESPONSIBLE FOR PROVIDING A BEARING SURFACE AT THE BOTTOM RETAINING WALL ELEVATION THAT MEETS THE BEARING REQUIREMENTS SHOWN ON THESE DRAWINGS. THE BEARING SURFACE AND ALL AREAS INTO WHICH THE RW CONTRACTOR WILL PLACE AND COMPACT FILL MUST BE CLEARED, GRUBBED AND ALL DELETERIOUS SOILS AND/OR ORGANIC MATTER REMOVED TO PROJECT GEOTECHNICAL ENGINEER'S SATISFACTION, AS PROVIDED IN THEIR DAILY PROJECT REPORTING.
E. THE OWNER'S PROJECT GEOTECHNICAL ENGINEER SHALL OBSERVE AND PROVIDE WRITTEN APPROVAL THAT THE "ALLOWABLE" BEARING CAPACITY AT THE BOTTOM RETAINING WALL ELEVATION AND WITHIN THE ENTIRE REINFORCED (GEOGRID) ZONE IN EACH LOCATION MEETS OR EXCEEDS THE MINIMUM REQUIREMENTS SHOWN ON THESE DRAWINGS. THE RW CONTRACTOR WILL NOT BEGIN CONSTRUCTION WITHOUT THE APPROVAL.
F. THE OWNER AND/OR GENERAL CONTRACTOR SHALL PROVIDE THE FILL SOILS TO THE RW CONTRACTOR TO UTILIZE FOR RW CONSTRUCTION. THOSE FILL SOILS SHOULD BE TESTED PRIOR TO STARTING RW CONSTRUCTION, AND PERIODICALLY THROUGHOUT THE PROJECT, TO ENSURE THEY MEET THE SPECIFICATION OUTLINED HEREIN. RW CONTRACTOR WILL NOTIFY THE OWNER'S GEOTECHNICAL ENGINEER AND/OR THE GENERAL/EARTHWORK CONTRACTOR WHEN A CHANGE IN FILL SOIL APPEARANCE, CONSISTENCY, OR GRADATION LOOKS TO BE DETRIMENTAL, OR HAS REASON TO BELIEVE THE SOIL BEING PROVIDED DOES NOT MEET THE PROJECT SPECIFICATIONS. HOWEVER, THE OWNER'S GEOTECHNICAL ENGINEER SHALL BE RESPONSIBLE FOR DETERMINING WHETHER THE FILL MATERIALS MEET AND ARE PLACED ACCORDING TO THE SPECIFICATIONS IN THESE DRAWINGS.
G. THE OWNER AND/OR PROJECT GEOTECHNICAL ENGINEER SHALL BE RESPONSIBLE FOR OBTAINING SUFFICIENT DATA THROUGHOUT THE RW CONSTRUCTION TO SATISFY THE REQUIREMENTS OF THE LOCAL GOVERNING AUTHORITY TO SECURE APPROVAL OF THE RETAINING WALL CONSTRUCTION AND ULTIMATELY THE "CERTIFICATE OF OCCUPANCY" FOR THE BUILDING ITSELF.

SHEET INDEX

No.	Date	Revision	Drawn	Design	Check
1	9 DEC 2020	REVISED REINFORCED BACKFILL TYPE AND GRID SPACING	BD	BD	BD
0	3 DEC 2020	RELEASED FOR CONSTRUCTION	BD	BD	KH

SLATON BROS, INC
3033 SOUTH PARKER RD STE 1150, AURORA, CO 80014
(303) 806-8160 • WWW.SLATONBROS.COM

GEOWALL DESIGNS
4770 FOREST ST. UNIT B, DENVER, CO 80216
720.826.6440
WWW.GEOWALLDESIGNS.COM

Title: TITLE SHEET

Project: TRAILS AT CROWFOOT
PARKER, CO

SEGMENTAL RETAINING WALL PLANS

Project No:	Date:	Scale:	Sheet No:
20SBC011	3 DEC 2020	N.T.S.	RW-1.0

COLORADO LICENSED PROFESSIONAL ENGINEER KYLE A HUERD 55768

1.0 MATERIALS

1.1 BACKFILL SOILS

1.1.1 REINFORCED FILL 1 MATERIALS SHALL BE APPROVED IN WRITING BY GEOWALL DESIGNS AND THE OWNER'S REPRESENTATIVE AND SHALL MEET THE STRENGTH REQUIREMENTS AS DEFINED IN SECTION 6.0. THE REINFORCED BACKFILL MATERIAL SHALL MEET THE FOLLOWING GRADATION:

SIEVE SIZE	PERCENT PASSING
2"	100%
1"	40-60%
1/2"	0-10%
No. 4	0-5%

LOSS BY WASHING 2.0% MAX

1.1.2 REINFORCED BACKFILL AND RETAINED SOIL/FILL MATERIALS SHALL BE FREE OF EXCESS MOISTURE, ROOTS, MUCK, SOD, SNOW, FROZEN LUMPS, ORGANIC MATTER OR OTHER DELETERIOUS MATERIALS. ALL ROCK PARTICLES AND HARD EARTH CLODS SHALL BE LESS THAN FOUR INCHES IN THE LONGEST DIMENSION. REINFORCED BACKFILL MATERIALS WHICH DO NOT MEET THIS CRITERIA SHALL BE CONSIDERED UNSUITABLE AND REMOVED.

1.1.3 DRAINAGE FILL SHALL CONSIST OF CLEAN CRUSHED STONE OR CRUSHED GRAVEL MEETING THE FOLLOWING GRADATION TESTED IN ACCORDANCE WITH ASTM C-136:

SIEVE SIZE	PERCENT PASSING
1.5"	100%
1.0"	95-100%
1/2"	25-60%
No. 4	0-10%
No. 8	0-5%

LOSS BY WASHING 2.0% MAX

1.1.4 LEVELING PAD SHALL CONSIST OF DENSE-GRADED OR WELL-GRADED CRUSHED STONE OR CRUSHED GRAVEL MEETING THE FOLLOWING GRADATION TESTED IN ACCORDANCE WITH ASTM C-136:

SIEVE SIZE	PERCENT PASSING
1.5"	100%
3/4"	60-90%
No. 10	25-45%
No. 60	5-30%
No. 200	4-11%

1.2 GEOGRID REINFORCING TYPE SHALL BE AS SHOWN OR APPROVED EQUAL. THE GEOGRID MANUFACTURER SHALL PROVIDE A MATERIAL CERTIFICATION THAT THE PRODUCT SHIPPED TO THE PROJECT MEETS OR EXCEEDS THE STRENGTHS USED IN THE DESIGN.

1.3 BLOCK FACING SHALL BE ALLAN BLOCK CLASSIC, 8"x18" UNITS. UNITS SHALL MEET ASTM C1372, EXCEPT MANUFACTURED CONCRETE VERTICAL DIMENSIONAL TOLERANCE SHALL BE +/- 1/16". THE MINIMUM COMPRESSIVE STRENGTH SHALL BE 4,500 PSI AND MAXIMUM ABSORPTION SHALL BE 5% WHEN TESTED IN ACCORDANCE WITH ASTM C140.

1.4 FILTER FABRIC SHALL BE 4 oz/sy (MIN.) NON-WOVEN, NEEDLE PUNCHED, POLYPROPYLENE GEOTEXTILE - WINFAB 400N OR EQUAL.

1.5 DRAIN PIPE SHALL BE 4" DIAMETER FLEX-DRAIN WITHOUT FILTER SOCK. FLEX-DRAIN AND PIPE FITTINGS SHALL MEET ASTM F405-05, EXCEPT ELONGATION REQUIREMENT SHALL BE WAIVED DUE TO FLEX-DRAIN EXPANDABLE DESIGN. FLEX-DRAIN AND PIPE FITTINGS SHALL MEET CPPA 100-97.

2.0 TECHNICAL REQUIREMENTS

2.1 THE OWNER'S REPRESENTATIVE OR GRADING CONTRACTOR SHALL SUBMIT TO GEOWALL DESIGNS THE GRADATION AND STRENGTH PARAMETERS OF THE REINFORCED BACKFILL MATERIAL, RETAINED SOIL/FILL AND FOUNDATION SOIL, FOR APPROVAL, PRIOR TO PROCEEDING WITH CONSTRUCTION. WORK SHALL NOT PROCEED UNTIL THIS SUBMITTAL IS APPROVED BY GEOWALL DESIGNS.

2.2 PRIOR TO CONSTRUCTION OF THE WALLS, THE GRADING CONTRACTOR SHALL CLEAR AND GRUB THE REINFORCED BACKFILL ZONE AREA, REMOVING TOP SOILS, BRUSH, SOD OR OTHER ORGANIC OR DELETERIOUS MATERIALS. ANY UNSUITABLE SOILS SHALL BE OVER-EXCAVATED, REPLACED AND COMPACTED WITH REINFORCED BACKFILL MATERIAL TO PROJECT SPECIFICATIONS OR OTHERWISE DIRECTED BY THE OWNER'S GEOTECHNICAL ENGINEER.

2.3 THE GEOTECHNICAL ENGINEER SHALL CONFIRM THAT THE SITE HAS BEEN PROPERLY PREPARED AND THE DESIGN PARAMETERS IN SECTION 6.0 ARE APPROPRIATE PRIOR TO FILL PLACEMENT. A WRITTEN CONFIRMATION SHALL BE PROVIDED TO GEOWALL DESIGNS PRIOR TO FILL PLACEMENT.

2.4 FILL SHALL BE PLACED IN HORIZONTAL LAYERS NOT EXCEEDING 8" (INCHES) IN UNCOMPACTED THICKNESS FOR HEAVY COMPACTION EQUIPMENT. FOR ZONES WHERE COMPACTION IS ACCOMPLISHED WITH HAND OPERATED EQUIPMENT, FILL SHALL BE PLACED IN HORIZONTAL LAYERS NOT EXCEEDING 6" (INCHES) IN UNCOMPACTED THICKNESS. ONLY HAND-OPERATED EQUIPMENT SHALL BE ALLOWED WITHIN THREE FEET OF THE BACK FACE OF WALL FACING.

2.5 FILL MATERIALS SHALL BE PLACED FROM THE BACK OF THE FACING UNITS TOWARDS THE ENDS OF THE GEOGRID TO ENSURE FURTHER TENSIONING.

2.6 TESTING METHODS AND VERIFICATION OF MATERIAL SPECIFICATIONS AND COMPACTION TESTING IS THE RESPONSIBILITY OF THE OWNER'S REPRESENTATIVE. COMPACTION OF CRUSHED STONE BACKFILL SHALL BE FIELD VERIFIED BY THE PROJECT GEOTECHNICAL ENGINEER USING MATERIAL APPROPRIATE METHODS OF VERIFICATION.

2.6.1 WHERE COMPACTION OF STONE BACKFILL CANNOT BE VERIFIED USING IN-SITU FIELD DENSITY TEST METHODS, THE FILL SHALL BE COMPACTED USING APPROPRIATE VIBRATORY EQUIPMENT AS APPROVED BY THE SITE GEOTECHNICAL ENGINEER. THE CONTRACTOR SHALL MAKE A SUFFICIENT NUMBER OF PASSES WITH APPROVED ROLLING EQUIPMENT UNTIL THE SURFACE SHOWS NO VISIBLE SIGN OF FUTHER CONSOLIDATION. THE SITE GEOTECHNICAL ENGINEER SHALL APPROVE MEANS AND METHODS AND VERIFY COMPACTION.

2.7 WHERE REQUIRED, CAP UNITS SHALL BE PERMANENTLY SECURED TO THE BLOCK UNITS USING AN OUTDOOR CONSTRUCTION ADHESIVE FOR CONCRETE MASONRY OR HARDSCAPES SUCH AS LIQUID NAILS (OR EQUIVALENT).

2.8 AN APPROVED SET OF CONSTRUCTION DRAWINGS AND CONTRACT SPECIFICATIONS SHALL BE ON-SITE AT ALL TIMES, DURING CONSTRUCTION OF THE RETAINING WALLS.

3.0 GEOGRID PLACEMENT

3.1 GEOGRID SHALL BE PLACED AT THE LOCATIONS AND ELEVATIONS SHOWN ON THE CONSTRUCTION DRAWINGS.

3.2 GEOGRID LENGTH SHALL BE AS SHOWN ON THE CONSTRUCTION DRAWINGS. GEOGRID LENGTH IS MEASURED FROM THE FRONT FACE OF WALL UNITS TO THE TAIL OF GEOGRID.

3.2.1 GEOGRID REINFORCEMENT SHALL BE CONTINUOUS THROUGHOUT THEIR EMBEDMENT LENGTH(S).

3.3 PRIOR TO PLACING FILL, THE GEOGRID MATERIALS SHALL BE PLACED IN BETWEEN BLOCK COURSES. REMOVE GEOGRID SLACK AND ANCHOR GEOGRID PRIOR TO FILL PLACEMENT AND COMPACTION.

3.4 CONSTRUCTION EQUIPMENT SHALL NOT BE OPERATED DIRECTLY ON THE GEOGRID. A MINIMUM FILL THICKNESS OF SIX INCHES IS REQUIRED FOR OPERATION OF TRACKED VEHICLES OVER THE GEOGRID. TURNING OF VEHICLES SHOULD BE KEPT TO A MINIMUM TO PREVENT DISPLACING THE FILL AND/OR THE GEOGRID.

3.5 GEOGRID SHALL BE ROLLED OUT WITH THE LONG AXIS OF THE APERTURES (MACHINE DIRECTION) PERPENDICULAR TO THE WALL FACE.

3.6 A MINIMUM OF 3 INCHES OF FILL MATERIAL SHALL BE REQUIRED BETWEEN OVERLAPPING LAYERS OF GEOGRID AND FILTER FABRIC, UNLESS OTHERWISE SHOWN.

4.0 CHANGES

4.1 NO CHANGES TO THE GEOGRID LAYOUT, INCLUDING, BUT NOT LIMITED TO, LENGTH, GEOGRID TYPE, OR ELEVATION, SHALL BE MADE WITHOUT THE EXPRESSED PRIOR WRITTEN CONSENT OF GEOWALL DESIGNS.

4.2 NO CHANGES TO THE WALL FACING TYPE SHALL BE MADE WITHOUT THE EXPRESSED PRIOR WRITTEN CONSENT OF GEOWALL DESIGNS.

5.0 DRAINAGE

5.1 AT THE END OF EACH WORK DAY, BACKFILL SURFACE SHALL BE COMPACTED WITH A SMOOTH PLATE COMPACTOR TO MINIMIZE PONDING OF WATER AND SATURATION OF THE BACKFILL.

5.2 PERMANENT AND TEMPORARY SURFACE WATER DIVERSION SHALL BE AS REQUIRED AND PROVIDED BY THE OWNER OR OWNER'S REPRESENTATIVE. SURFACE WATER SHALL BE DIVERTED AWAY FROM THE REINFORCED FILL ZONE AND WALL FACE DURING WALL CONSTRUCTION OR AT THE END OF EACH WORK DAY.

No.	Date	Revision	Drawn	Design	Check
1	9 DEC 2020	REVISED REINFORCED BACKFILL TYPE AND GRID SPACING	BD	BD	BD
0	3 DEC 2020	RELEASED FOR CONSTRUCTION	BD	BD	KH

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Title: CONSTRUCTION NOTES

Project: TRAILS AT CROWFOOT
PARKER, CO

SEGMENTAL RETAINING WALL PLANS

Project No:	Date:	Scale:	Sheet No:
20SBC011	3 DEC 2020	N.T.S.	RW-2.0

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55768
PROFESSIONAL ENGINEER

6.0 DESIGN PARAMETERS

6.1 DESIGN OF THE REINFORCED SOIL STRUCTURE IS BASED ON THE FOLLOWING EFFECTIVE PARAMETERS:

	FRICTION ANGLE (ϕ)	COHESION (C')	MOIST UNIT WT (γ)
REINFORCED FILL 1 (1-1/2" GRAVEL - GP)	38°	0 psf	115 pcf
RETAINED SOILS (SANDY LEAN CLAY - CL/SC)	26°	0 psf	125 pcf
FOUNDATION SOILS (SANDY LEAN CLAY - CL/SC)	26°	75 psf	125 pcf

6.1.1 DESIGN METHODOLOGY: NCMA GUIDELINES, THIRD EDITION

6.2 FACTORS OF SAFETY

6.2.1 INTERNAL STABILITY:

STATIC
MIN. FACTOR OF SAFETY FOR GEOGRID PULLOUT = 1.5
MIN. FACTOR OF SAFETY FOR BLOCK CONNECTION = 1.5
MIN. FACTOR OF SAFETY FOR FACING STABILITY = 1.5
MIN. FACTOR OF SAFETY FOR SLIDING AT LOWEST GEOGRID = 1.5

SOIL-GEOGRID INTERACTION COEFFICIENT = 0.8
PERCENT COVERAGE OF GEOGRID = 100%

6.2.2 EXTERNAL STABILITY:

STATIC
MIN. FACTOR OF SAFETY FOR OVERTURNING = 2.0
MIN. FACTOR OF SAFETY FOR SLIDING = 1.5

6.2.3 OVERALL / GLOBAL STABILITY:

STATIC
MIN. FACTOR OF SAFETY FOR GLOBAL STABILITY = 1.3

6.3 SURCHARGE LOADING

LIVE LOAD (LANDSCAPE AREAS) = 100 PSF
LIVE LOAD (ROAD/PARKING AREAS) = 150 PSF

6.4 MAXIMUM APPLIED BEARING PRESSURE = (SEE ELEVATION VIEWS)

6.5 FENCE LOADING

WALLS ARE NOT DESIGNED FOR ANY CONCENTRATED FENCE LOADS. SLEEVE-ITS SHALL BE USED WHERE POSTS CANNOT BE PLACED A MINIMUM OF 3.00' FROM WALL FACE.

6.6 PHREATIC WATER SURFACE OR HYDROSTATIC WATER PRESSURE

THE DESIGN DOES NOT CONSIDER PHREATIC WATER SURFACE OR HYDROSTATIC WATER PRESSURE AND ASSUME WATER IS SUFFICIENTLY BELOW BOTTOM OF STRUCTURE SO AS NOT TO INFLUENCE STRUCTURE STABILITY.

6.7 WIND LOADING (ASD)

WIND LOAD HAS NOT BEEN EVALUATED IN THE DESIGN OF THE PROPOSED REINFORCED SOIL (MECHANICALLY STABILIZED EARTH) STRUCTURE.

7.0 SPECIAL PROVISIONS

7.1 THE DESIGN PRESENTED HEREIN IS BASED ON SOIL PARAMETERS, FOUNDATION CONDITIONS, GROUNDWATER CONDITIONS, AND LOADINGS STATED IN SECTION 6.0., AND INTERPOLATED FROM INFORMATION PROVIDED BY OTHERS. GEOTECHNICAL DATA IS INTERPOLATED FROM REPORT PREPARED BY CTL THOMPSON, REPORT #: DN48,372-125-R1, DATED 06/14/2018.

7.2 WALL ELEVATION VIEWS AND LOCATIONS AND GEOMETRY OF EXISTING STRUCTURES AND GRADE ABOVE AND BELOW THE WALLS MUST BE VERIFIED BY THE CONTRACTOR, TO MATCH ELEVATIONS SHOWN IN THE CONTRACT DOCUMENTS, PRIOR TO CONSTRUCTION.

7.3 GEOWALL DESIGNS ASSUMES NO LIABILITY FOR INFORMATION SUPPLIED BY OTHERS SUCH AS GEOTECHNICAL REPORT, SITE PLAN, AND WATER ELEVATIONS.

7.4 THE ON SITE GEOTECHNICAL ENGINEER MUST VERIFY IN WRITING THAT THE FOUNDATION CONDITIONS WITHIN THE WALL AND REINFORCED FILL ZONE OF INFLUENCE ARE SUITABLE FOR THE APPLIED BEARING PRESSURE LISTED IN SECTION 6.0.

7.5 THE SOIL DESIGN PARAMETERS STATED IN SECTION 6.0 SHALL BE VERIFIED BY THE PROJECT GEOTECHNICAL ENGINEER. WRITTEN VERIFICATION OF DESIGN PARAMETERS SHALL BE SUBMITTED TO GEOWALL DESIGNS AND THE OWNER'S REPRESENTATIVE PRIOR TO COMMENCING WITH CONSTRUCTION.

7.6 IF ANY ROCK FORMATIONS AND/OR GROUNDWATER ARE ENCOUNTERED DURING THE CONSTRUCTION OF THIS WALL, IMMEDIATELY CONTACT GEOWALL DESIGNS AT 952-303-4190 AND THE OWNER'S REPRESENTATIVE.

7.7 ANY REVISIONS TO DESIGN PARAMETERS STATED IN SECTION 6.0 OR STRUCTURE GEOMETRY SHALL REQUIRE DESIGN MODIFICATIONS PRIOR TO PROCEEDING WITH CONSTRUCTION.

7.8 ALL PIPES AND UTILITIES WITHIN 100 FEET OF THE RETAINING WALL MUST BE CONSTRUCTED WITH WATER TIGHT JOINTS.

7.9 THE SITE GEOTECHNICAL ENGINEER OR OWNER'S REPRESENTATIVE SHALL BE RESPONSIBLE FOR EVALUATING TOTAL AND DIFFERENTIAL SETTLEMENTS.

7.10 THE OWNER OR OWNER'S REPRESENTATIVE SHALL BE RESPONSIBLE FOR THE SELECTION OF PERMANENT EROSION PROTECTION AND PERMANENT VEGETATION FOR SLOPES LOCATED ABOVE OR BELOW THE PROPOSED RETAINING WALL(S).

8.0 QUALITY ASSURANCE

8.1 DUTIES OF THE SPECIAL INSPECTOR:

8.1.1 THE SPECIAL INSPECTOR SHALL OBSERVE THE WORK REQUIRING SPECIAL INSPECTION FOR CONFORMANCE WITH THE APPROVED DESIGN DRAWINGS AND SPECIFICATIONS.

8.1.2 THE SPECIAL INSPECTOR SHALL FURNISH REPORTS TO BE KEPT AT THE SITE FOR USE BY THE BUILDING OFFICIAL, THE CONTRACTOR, AND THE ENGINEER OF RECORD. IF SPECIAL INSPECTION IS PROVIDED BY ANYONE OTHER THAN THE ENGINEER OF RECORD, REPORTS SHALL BE SUBMITTED TO THE OFFICE OF THE ENGINEER OF RECORD ON A WEEKLY BASIS. ALL DISCREPANCIES SHALL BE BROUGHT TO THE ATTENTION OF THE CONTRACTOR FOR CORRECTION, THEN IF UNCORRECTED, TO THE DESIGN AUTHORITY AND THE BUILDING OFFICIAL.

8.1.3 UPON COMPLETION OF THE ASSIGNED WORK, THE SPECIAL INSPECTOR SHALL COMPLETE AND SIGN A FINAL REPORT CERTIFYING THAT TO THE BEST OF HIS/HER KNOWLEDGE, THE WORK IS IN CONFORMANCE WITH THE APPROVED PLANS AND SPECIFICATIONS, AND THE APPLICABLE WORKMANSHIP PROVISIONS OF THE CODE.

8.2 SEE THE "SPECIAL INSPECTION SCHEDULE" FOR THE TYPES, EXTENTS, AND FREQUENCY OF SPECIFIC ITEMS REQUIRING SPECIAL INSPECTIONS AS PART OF THIS PROJECT.

SPECIAL INSPECTION SCHEDULE

REQUIRED SPECIAL INSPECTION AREAS:	FREQUENCY OF TESTING		COMMENTS:
	CONTINUOUS	PERIODIC	
RETAINING WALLS			
GEOGRID		X	INSPECTION SHALL BE MADE OF THE TYPE, LOCATION, ORIENTATION, AND EXTENT OF GEOGRID PLACEMENT IN EACH WALL
DRAIN TILE INSTALLATION		X	INSPECTION SHALL BE MADE OF THE PLACEMENT, LOCATION, AND VENTING TO DAYLIGHT
SOILS			
EXCAVATIONS		X	VERIFY EXCAVATION ARE EXTENDED TO PROPER DEPTHS AND HAVE REACHED REQUIRED MATERIAL
FIELD DENSITY		X	IN ACCORDANCE WITH ASTM D-6938 OR ASTM D-1556
MOISTURE-DENSITY RELATIONSHIPS		X	IN ACCORDANCE WITH AASHTO OR ASTM CRITERIA AS SPECIFIED FOR SUBGRADE, LEVELING PAD, AND REINFORCED BACKFILL
GRADATION ANALYSIS		X	IN ACCORDANCE WITH ASTM D-422
WALL BACKFILL		X	VERIFY USE OF PROPER MATERIALS, DENSITIES, LIFT THICKNESS DURING PLACEMENT AND COMPACTION OF REINFORCED BACKFILL

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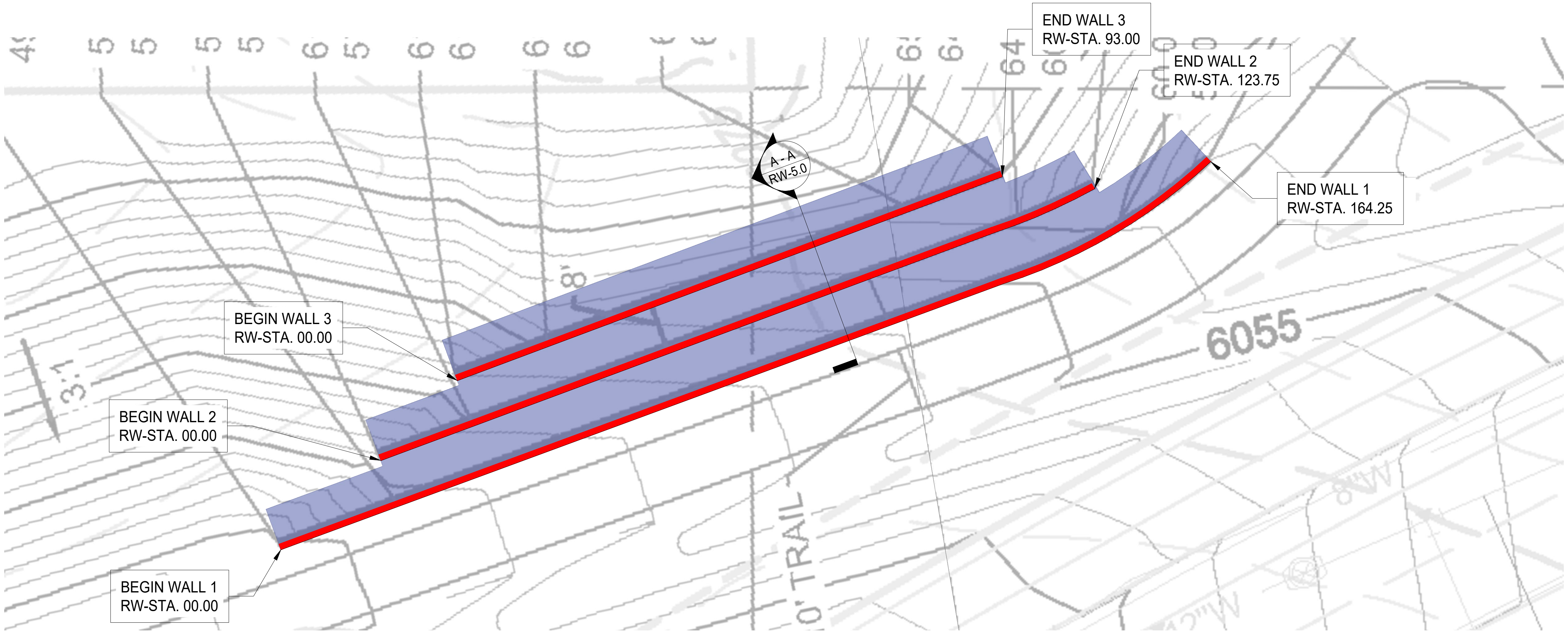
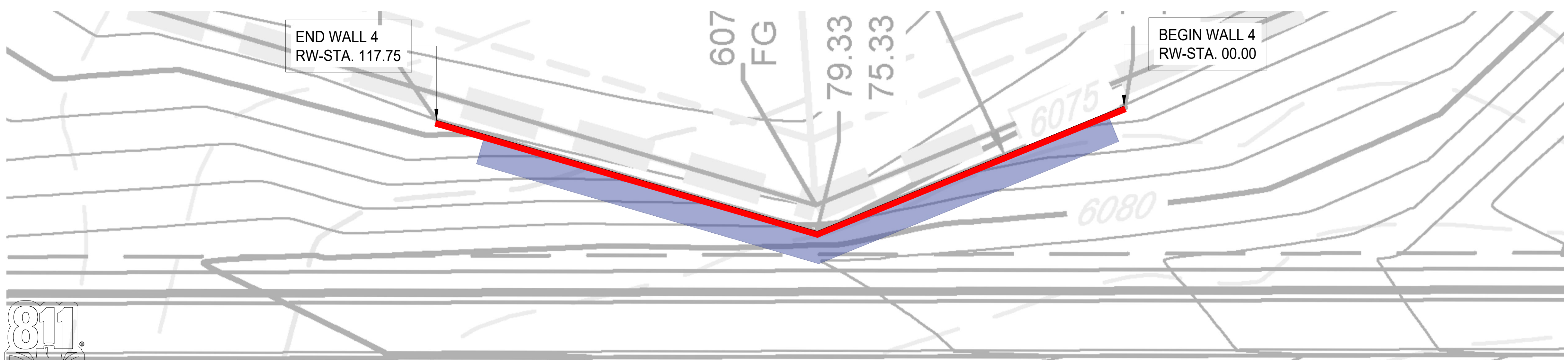
Title: CONSTRUCTION NOTES

Project: TRAILS AT CROWFOOT
PARKER, CO
SEGMENTAL RETAINING WALL PLANS

Project No:	Date:	Scale:	Sheet No:
20SBC011	3 DEC 2020	N.T.S.	RW-2.1

COLORADO LICENSED KYLE A HUERD 55768 PROFESSIONAL ENGINEER





NOTE:

1. SITE PLAN IS FOR ILLUSTRATIVE PURPOSES ONLY AND IS TAKEN FROM THE CONTRACT PLANS PREPARED BY CVL CONSULTANTS LAST DATED 11-19-2019.
2. NORTH ARROW DIRECTION IS APPROXIMATE, REFER TO CONTRACT PLANS FOR ACTUAL HEADING.
3. REFER TO CONTRACT PLANS FOR ALL HORIZONTAL ALIGNMENT AND ACTUAL SITE GEOMETRY.

LEGEND:

TOP OF WALL

APPROXIMATE GEOGRID COVERAGE

SCALE UNIT

20 10 0 20 40

NORTH

Know what's BELOW. CALL before you dig.

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Title: WALL LOCATION PLAN VIEW

Project: TRAILS AT CROWFOOT
PARKER, CO
SEGMENTAL RETAINING WALL PLANS

Project No:	Date:	Scale:	Sheet No:
20SBC011	3 DEC 2020	1" = 20'	RW-3.0

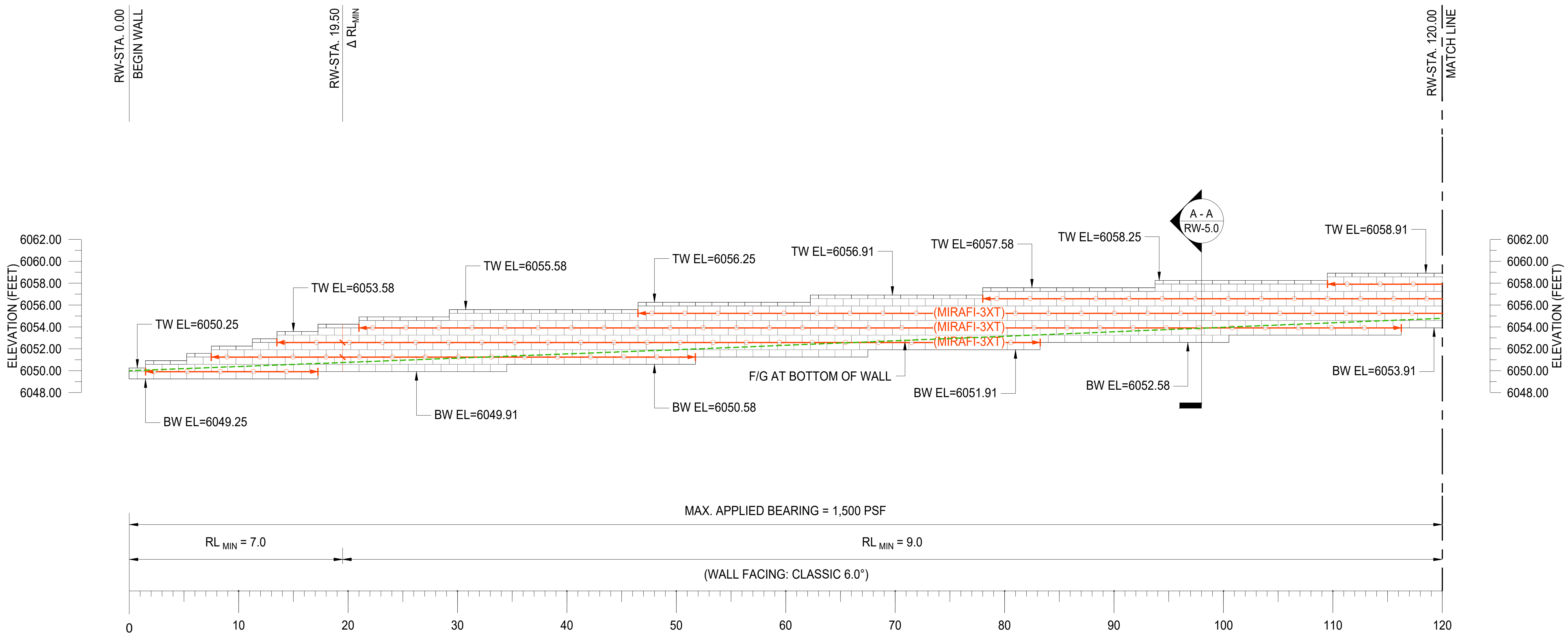
COLORADO LICENSED PROFESSIONAL ENGINEER KYLE A HUERD 55768

GENERAL NOTES:

1. ALL ELEVATIONS AND DISTANCES ARE SHOWN IN FEET ALONG FACE OF WALL.
2. THE WALLS SHALL BE CONSTRUCTED USING ALLAN BLOCK: CLASSIC 8" UNITS AND MIRAFI 3XT GEOGRID SOIL REINFORCEMENT. SEE SHEET RW-2.0 FOR MATERIAL SPECIFICATIONS.
3. SEE MANUFACTURER'S INFORMATION FOR ADDITIONAL DETAILS ON THE BLOCK SYSTEM SHOWN.

LEGEND:

TOP OF WALL ELEVATION (TOP OF CAP)	TW EL= XX.XX
BOTTOM OF WALL ELEVATION (BOTTOM OF BLOCK)	BW EL= XX.XX
FINISHED GRADE LINE	- - - - - - -
MIRAFI 3XT GEOGRID	(MIRAFI 3XT)



WALL 1 ELEVATION

DISTANCE SHOWN IN FEET ALONG FRONT FACE

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Title: WALL 1 ELEVATION

Project: TRAILS AT CROWFOOT
PARKER, CO

SEGMENTAL RETAINING WALL PLANS

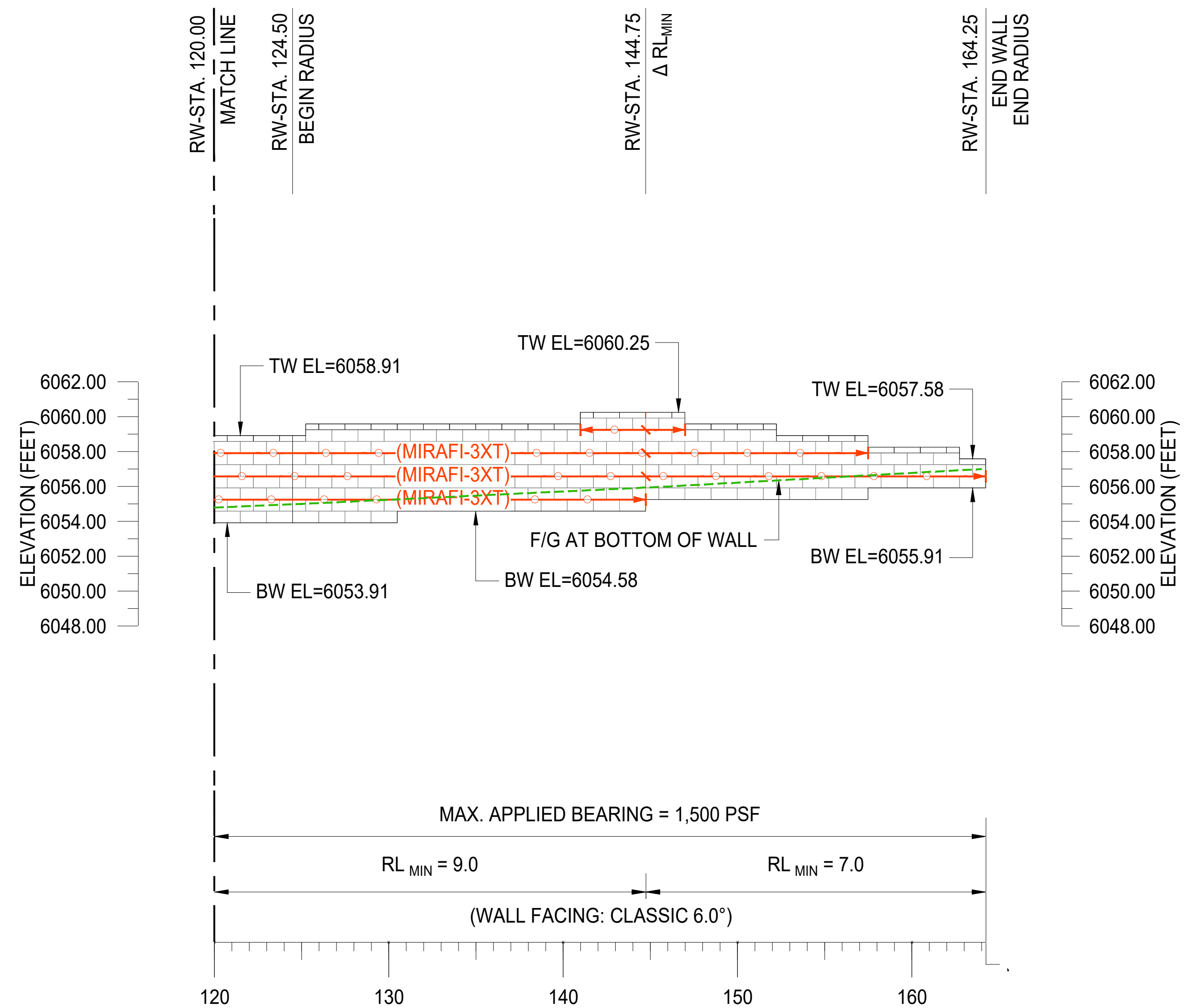
Project No:	Date:	Scale:	Sheet No:
20SBC011	3 DEC 2020	1" = 10'	RW-4.0

GENERAL NOTES:

1. ALL ELEVATIONS AND DISTANCES ARE SHOWN IN FEET ALONG FACE OF WALL.
2. THE WALLS SHALL BE CONSTRUCTED USING ALLAN BLOCK: CLASSIC 8" UNITS AND MIRAFI 3XT GEOGRID SOIL REINFORCEMENT. SEE SHEET RW-2.0 FOR MATERIAL SPECIFICATIONS.
3. SEE MANUFACTURER'S INFORMATION FOR ADDITIONAL DETAILS ON THE BLOCK SYSTEM SHOWN.

LEGEND:

TOP OF WALL ELEVATION (TOP OF CAP)	TW EL= XX.XX
BOTTOM OF WALL ELEVATION (BOTTOM OF BLOCK)	BW EL= XX.XX
FINISHED GRADE LINE	- - - - - -
MIRAFI 3XT GEOGRID	(MIRAFI 3XT)



WALL 1 ELEVATION

DISTANCE SHOWN IN FEET ALONG FRONT FACE

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20SBC011	3 DEC 2020	1" = 10'	RW-4.1

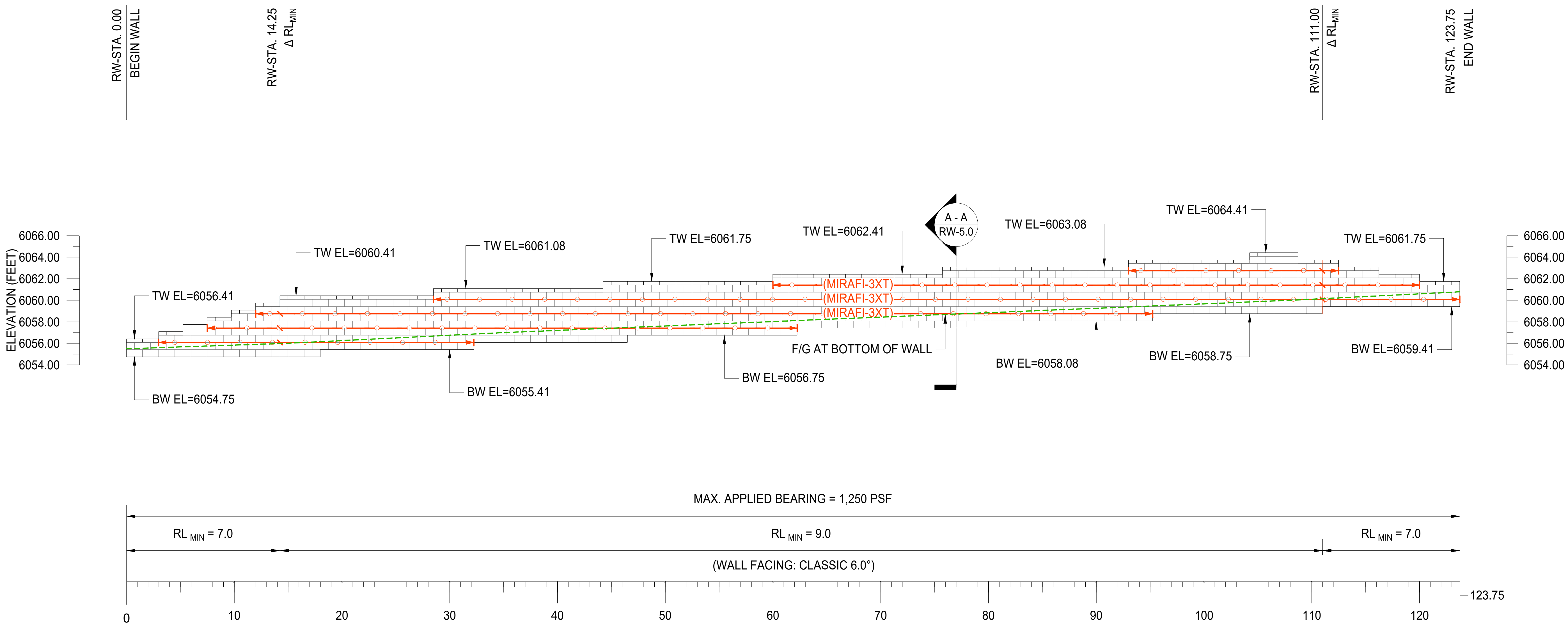
COLORADO LICENSED PROFESSIONAL ENGINEER KYLE A HUERD 55768

GENERAL NOTES:

1. ALL ELEVATIONS AND DISTANCES ARE SHOWN IN FEET ALONG FACE OF WALL.
2. THE WALLS SHALL BE CONSTRUCTED USING ALLAN BLOCK: CLASSIC 8" UNITS AND MIRAFI 3XT GEOGRID SOIL REINFORCEMENT. SEE SHEET RW-2.0 FOR MATERIAL SPECIFICATIONS.
3. SEE MANUFACTURER'S INFORMATION FOR ADDITIONAL DETAILS ON THE BLOCK SYSTEM SHOWN.

LEGEND:

TOP OF WALL ELEVATION (TOP OF CAP)	TW EL= XX.XX
BOTTOM OF WALL ELEVATION (BOTTOM OF BLOCK)	BW EL= XX.XX
FINISHED GRADE LINE	
MIRAFI 3XT GEOGRID	(MIRAFI 3XT)



WALL 2 ELEVATION

DISTANCE SHOWN IN FEET ALONG FRONT FACE

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1	9 DEC 2020	REVISED REINFORCED BACKFILL TYPE AND GRID SPACING	BD	BD	BD
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Title: WALL 2 ELEVATION

Project: TRAILS AT CROWFOOT
PARKER, CO
SEGMENTAL RETAINING WALL PLANS

Project No:	Date:	Scale:	Sheet No:
20SBC011	3 DEC 2020	1" = 10'	RW-4.2

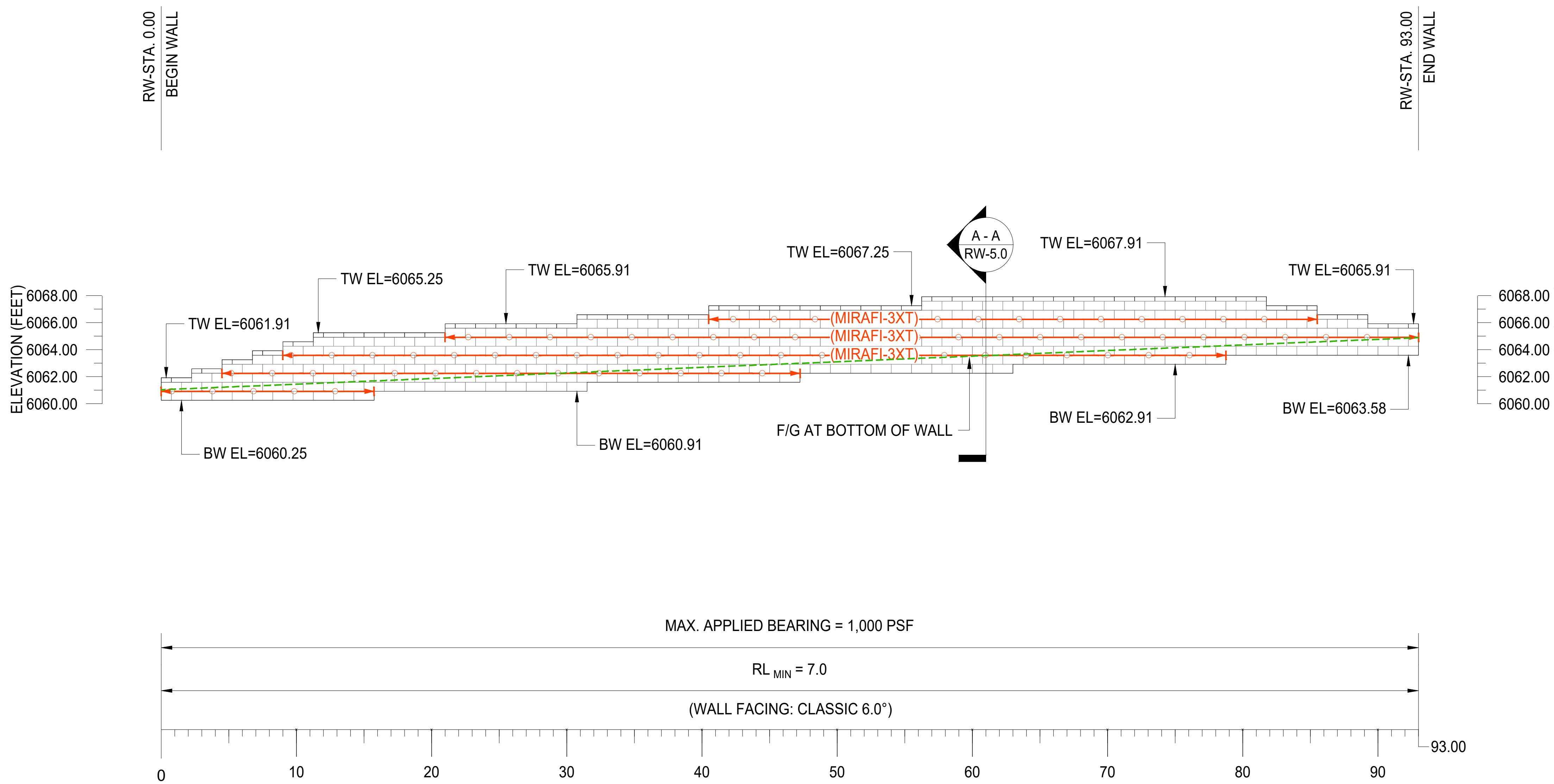
COLORADO LICENSED PROFESSIONAL ENGINEER
KYLE A HUERD
55768

GENERAL NOTES:

1. ALL ELEVATIONS AND DISTANCES ARE SHOWN IN FEET ALONG FACE OF WALL.
2. THE WALLS SHALL BE CONSTRUCTED USING ALLAN BLOCK: CLASSIC 8" UNITS AND MIRAFI 3XT GEOGRID SOIL REINFORCEMENT. SEE SHEET RW-2.0 FOR MATERIAL SPECIFICATIONS.
3. SEE MANUFACTURER'S INFORMATION FOR ADDITIONAL DETAILS ON THE BLOCK SYSTEM SHOWN.

LEGEND:

TOP OF WALL ELEVATION (TOP OF CAP)	TW EL= XX.XX
BOTTOM OF WALL ELEVATION (BOTTOM OF BLOCK)	BW EL= XX.XX
FINISHED GRADE LINE	- - - - - - - -
MIRAFI 3XT GEOGRID	(MIRAFI 3XT)



WALL 3 ELEVATION

DISTANCE SHOWN IN FEET ALONG FRONT FACE

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No.	Date	Revision	Drawn	Design	Check
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Title: WALL 3 ELEVATION

Project: TRAILS AT CROWFOOT
PARKER, CO

SEGMENTAL RETAINING WALL PLANS

Project No:	Date:	Scale:	Sheet No:
20SBC011	3 DEC 2020	1" = 10'	RW-4.3

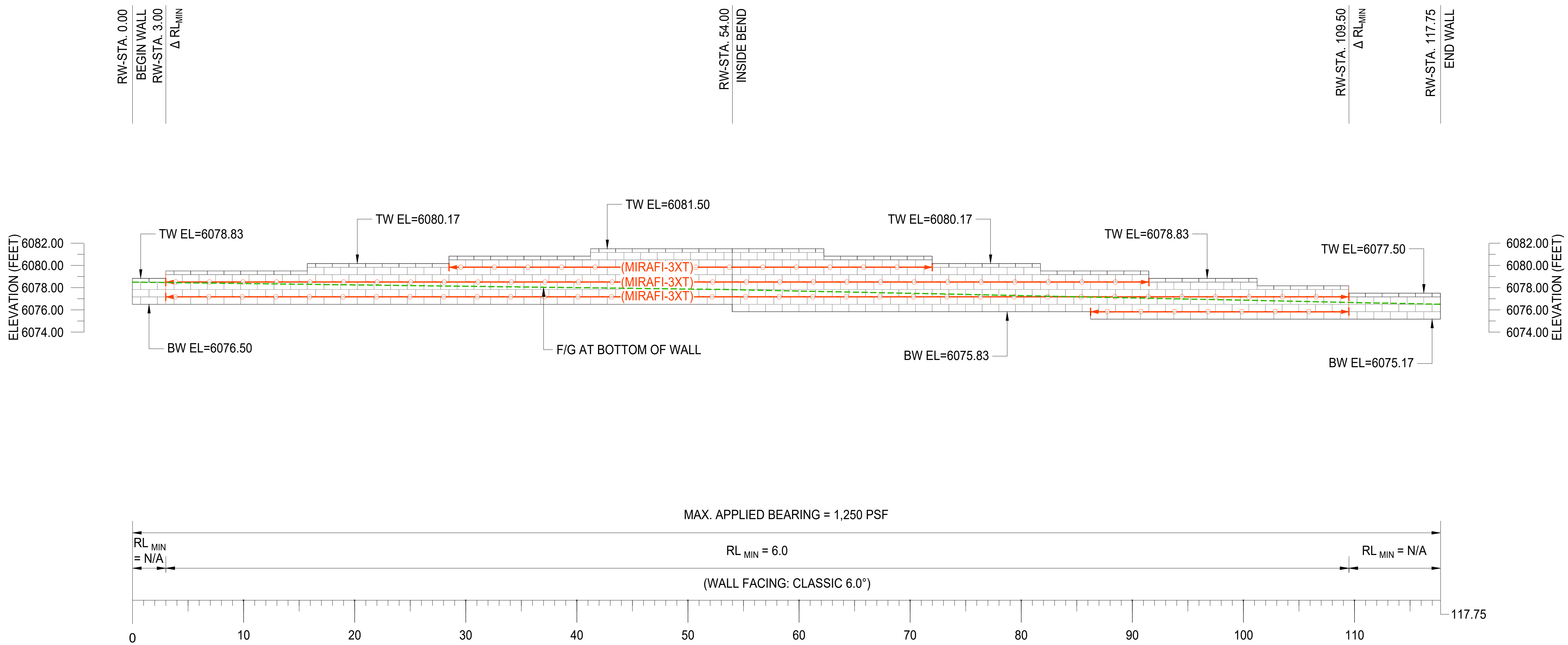
COLORADO LICENSED PROFESSIONAL ENGINEER KYLE A HUERD 55768

GENERAL NOTES:

1. ALL ELEVATIONS AND DISTANCES ARE SHOWN IN FEET ALONG FACE OF WALL.
2. THE WALLS SHALL BE CONSTRUCTED USING ALLAN BLOCK: CLASSIC 8" UNITS AND MIRAFI 3XT GEOGRID SOIL REINFORCEMENT. SEE SHEET RW-2.0 FOR MATERIAL SPECIFICATIONS.
3. SEE MANUFACTURER'S INFORMATION FOR ADDITIONAL DETAILS ON THE BLOCK SYSTEM SHOWN.

LEGEND:

TOP OF WALL ELEVATION (TOP OF CAP)	TW EL= XX.XX
BOTTOM OF WALL ELEVATION (BOTTOM OF BLOCK)	BW EL= XX.XX
FINISHED GRADE LINE	- - - - - -
MIRAFI 3XT GEOGRID	(MIRAFI 3XT)



WALL 4 ELEVATION

DISTANCE SHOWN IN FEET ALONG FRONT FACE

No.	Date	Revision	Drawn	Design	Check
1	9 DEC 2020	REVISED REINFORCED BACKFILL TYPE AND GRID SPACING	BD	BD	BD
0	3 DEC 2020	RELEASED FOR CONSTRUCTION	BD	BD	KH

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Title: WALL 4 ELEVATION

Project: TRAILS AT CROWFOOT
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Project No:	Date:	Scale:	Sheet No:
20SBC011	3 DEC 2020	1" = 10'	RW-4.4

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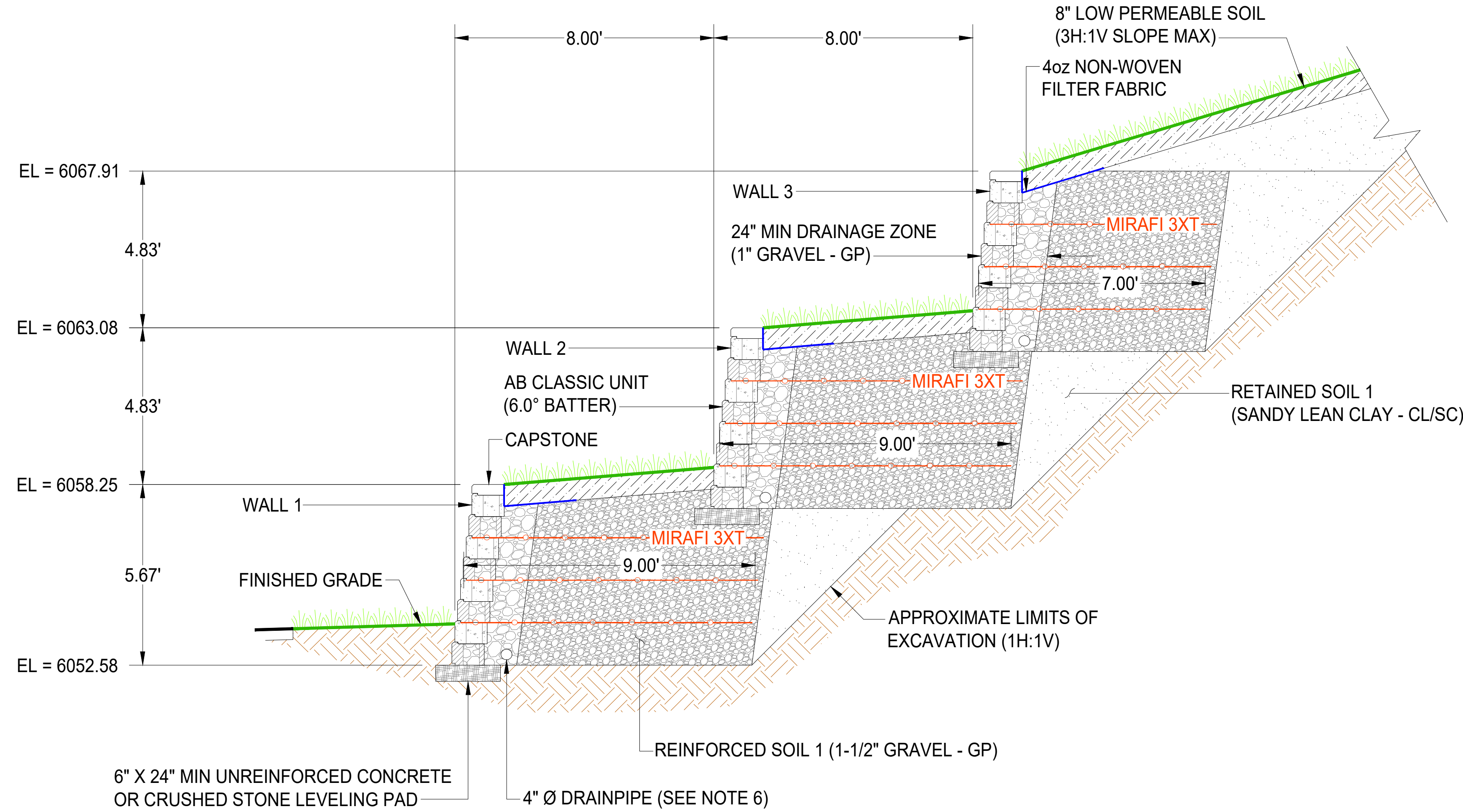
GENERAL NOTES:

1. THE SECTION SHOWN IS A REPRESENTATIVE WALL SECTION. THE WALL HEIGHTS, ELEVATIONS, TOE SLOPES, AND BACK SLOPES VARY ACCORDING TO THE ELEVATION PLAN AND SITE PLAN RESPECTIVELY.
2. UPON EXCAVATION, WHERE UNSUITABLE SOILS ARE FOUND, SUBCUT AS REQUIRED BY THE ONSITE GEOTECHNICAL ENGINEER AND REPLACE WITH SUITABLE COMPACTED STRUCTURAL FILL TO ACHIEVE THE REQUIRED BEARING CAPACITY. THE STRUCTURAL FILL SHALL BE COMPACTED TO A MINIMUM 95% STANDARD PROCTOR DENSITY.
3. APPROXIMATE LIMITS OF EXCAVATION VARIES WHERE SUBCUT IS REQUIRED. ACTUAL LIMITS AND SIDE SLOPES SHALL BE DETERMINED BY OSHA REGULATIONS AND MATCH FIELD CONDITIONS AS DETERMINED BY THE CONTRACTOR.
4. THE WALL IS DESIGNED AS A REINFORCED WALL REQUIRING MIRAFI 3XT REINFORCEMENT AT THE ELEVATIONS SHOWN AND SHALL BE CONSTRUCTED WITH ALLAN BLOCK: CLASSIC 8" UNITS USING THE 6.0° BATTER.
5. 4" CORRUGATED PERFORATED DRAINPIPE INSTALLED AS LOW AS POSSIBLE WITH POSITIVE DRAINAGE. OUTLET INTO ONSITE DRAINAGE OR THROUGH WALL FACE AT 50.0' O.C. AND LOW ENDS OF WALL. SEE DETAIL 2/RW-6.0.
6. INSPECT EXCAVATION SLOPES FOR ACTIVE SEEPAGE AND PLACE ADDITIONAL DRAINS WHERE SEEPAGE OCCURS.
7. 1/4" EXPANSION MATERIAL SHALL BE PLACED BETWEEN THE MODULAR BLOCK RETAINING WALL UNITS AND ANY CONCRETE PLACED AFTER CONSTRUCTION OF THE MODULAR BLOCK RETAINING WALL.
8. DO NOT BRING HEAVY COMPACTION OR PAVING EQUIPMENT WITHIN 3' OF THE BACK OF THE ALLAN BLOCK RETAINING WALL.
9. SEE MANUFACTURER'S INFORMATION FOR ADDITIONAL DETAILS ON THE ALLAN BLOCK RETAINING WALL SYSTEM.



WALL SECTION A - A

(SECTION CUT: SEE PROFILES FOR SECTION LOCATIONS)

LEGEND

- LOW PERMEABLE SOIL
- WALL ROCK (1" GRAVEL - GP)
- REINFORCED SOIL 1 (1-1/2" GRAVEL - GP)
- RETAINED SOIL 1 (SANDY LEAN CLAY-CL/SC)
- LEVELING PAD (GRAVEL - GW)
- IN-SITU/STRUCTURAL FILL
- MIRAFI 3XT GEOGRID
- 4 oz NON-WOVEN FILTER FABRIC

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Title: WALL SECTION A-A

Project: TRAILS AT CROWFOOT
PARKER, CO
SEGMENTAL RETAINING WALL PLANS

Project No:	Date:	Scale:	Sheet No:
20SBC011	3 DEC 2020	1" = 5'	RW-5.0

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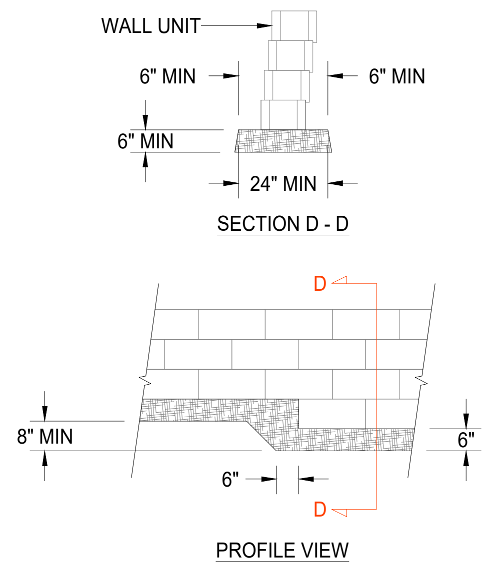
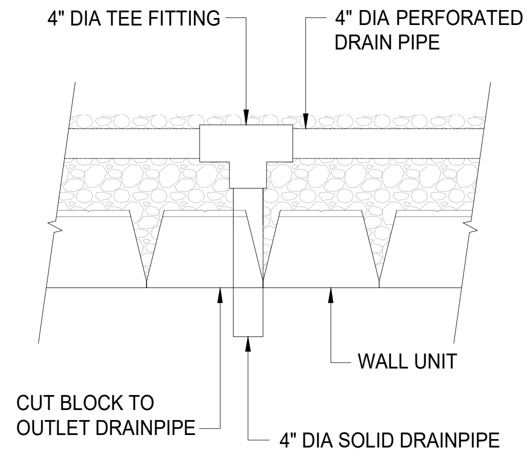
KYLE A HUERD
55768

NOTES:
1. FOUNDATION SOILS SHALL BE APPROVED BY THE GEOTECHNICAL ENGINEER PRIOR TO PLACEMENT OF THE LEVELING PAD.
2. LEVELING PAD SHALL BE CONSTRUCTED TO THE DIMENSIONS SHOWN USING CRUSHED STONE OR 2,000 PSI UNREINFORCED CONCRETE.



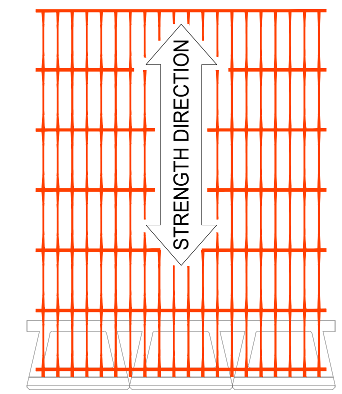
1 LEVELING PAD DETAIL - N.T.S

NOTES:
1. THE DRAINAGE SYSTEM SHALL CONSIST OF A 4" MINIMUM DIAMETER CORRUGATED PERFORATED PLASTIC DRAINPIPE.



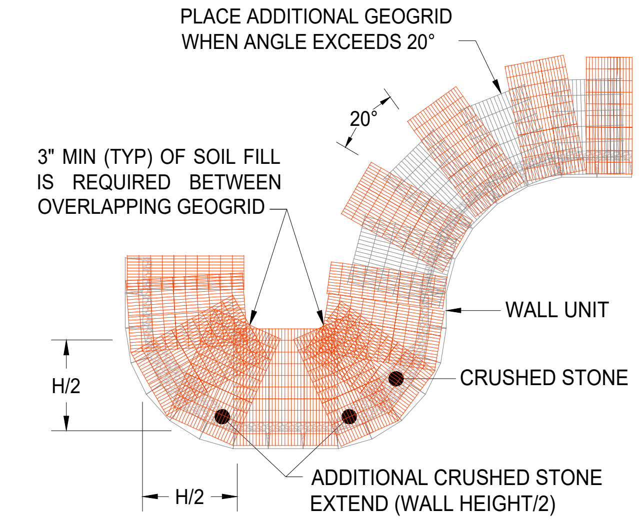
2 DRAIN PIPE OUTLET DETAIL - N.T.S

NOTES:
1. COMPACTED BACKFILL SHALL BE LEVEL WITH THE TOP OF THE WALL PRIOR TO GEOGRID PLACEMENT.
2. TYPICALLY GEOGRID IS PLACED WITHIN 1" OF THE FRONT FACE OF WALL UNIT. (GEOGRID CONNECTION DEVICES SHALL BE INSTALLED AS DIRECTED BY THE BLOCK MANUFACTURER.)
3. GEOGRID SHALL LAY FLAT ON THE WALL UNIT AND COMPACTED BACKFILL SOILS BEHIND WALL UNIT.
4. PLACE THE NEXT COURSE OF WALL UNITS. PULL GEOGRID TAUT TO REMOVE SLACK AND WRINKLES.
5. STAKE AS REQUIRED TO KEEP GEOGRID TAUT DURING BACKFILL PLACEMENT.



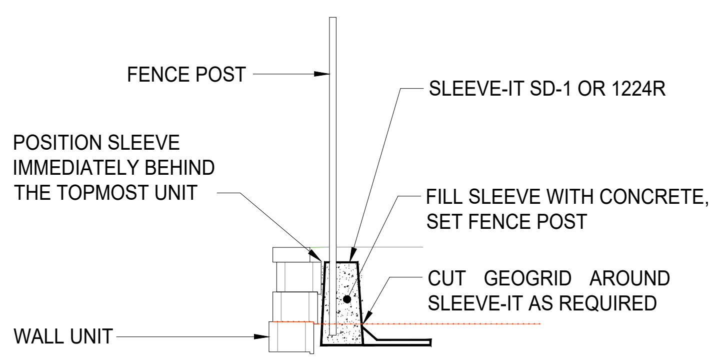
3 GEOGRID ORIENTATION DETAIL - N.T.S

NOTES:
1. INSTALL GEOGRID IN ACCORDANCE WITH MANUFACTURER'S RECOMMENDATION AND CONSTRUCTION DRAWINGS.
2. "H" IS EQUAL TO TOTAL WALL HEIGHT.

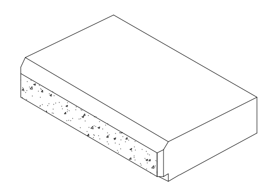


4 GEOGRID INSTALLATION ON CURVES DETAIL - N.T.S

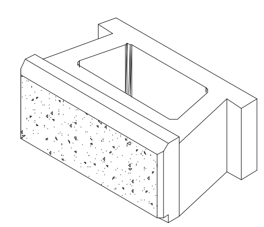
NOTES:
1. SLEEVE-IT FENCE POST FOOTING SHALL BE USED WHERE POST MUST BE PLACED WITHIN 3-FEET OF THE FACE OF WALL. WHERE POSTS ARE LOCATED 3-FEET OR GREATER FROM FACE OF WALL SONO-TUBES SHALL BE USED FOR POST INSTALLATION.
2. FENCING SYSTEMS APPROVED FOR USE WITH THE SLEEVE-IT SD-1 OR 1224R ARE LIMITED TO THE FOLLOWING HEIGHTS: CHAIN LINK UP TO 8 FT, PRIVACY UP TO 6 FT (WOODEN, PVC, METAL). MAXIMUM POST SIZE 4" X 4".



5 TYPICAL POST DETAIL - N.T.S



CAPSTONE
HEIGHT: 4" ±
DEPTH: 12" ±
WIDTH: 18" ±
WEIGHT: 55 LBS ±



CLASSIC UNIT
HEIGHT: 8" ±
DEPTH: 12" ±
WIDTH: 18" ±
WEIGHT: 75 LBS ±

6 TYPICAL UNIT DETAIL - N.T.S

No.	Date	Revision	Drawn	Design	Check
1	9 DEC 2020	REVISED REINFORCED BACKFILL TYPE AND GRID SPACING	BD	BD	BD
0	3 DEC 2020	RELEASED FOR CONSTRUCTION	BD	BD	KH

SLATON BROS, INC
3033 SOUTH PARKER RD STE 1150, AURORA, CO 80014
(303) 806-8160 • WWW.SLATONBROS.COM

GEOWALL DESIGNS
4770 FOREST ST. UNIT B, DENVER, CO 80216
720.826.6440
WWW.GEOWALLDESIGNS.COM

Title: CONSTRUCTION DETAILS

Project: TRAILS AT CROWFOOT
PARKER, CO
SEGMENTAL RETAINING WALL PLANS

Project No:	Date:	Scale:	Sheet No:
20SBC011	3 DEC 2020	AS NOTED	RW-6.0