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Geotechnical Engineering
Environmental Engineering
Hydrogeology
Materials Testing
Building Science
Rural Development Design
Retaining Wall Design
Noise and Vibration Studies

patersongroup.ca

November 22, 2022
File: PG4772-LET.01

Nautical Lands Group
2962 Carp Road
Carp, Ontario
K0A 1L0

Attention: Ms. Angela Mariani

Subject: Redi Rock Wall Design
Wellings of Stittsville – Phase 2
20 Cedarow Court, Ottawa, Ontario

Dear Madam,

As requested, Paterson Group Inc. (Paterson) completed a Redi-Rock retaining wall design to be located at the southeastern corner of the proposed development. The Redi-Rock retaining wall system has been designed for the subject site to consider site constraints and grading requirements. The walls have also been designed in accordance with the Canadian Highway and Bridge Design Code (CHBDC) 2019. Details of the retaining walls are presented below and are depicted in Drawing PG4772-2 attached.

The following grading plan prepared by Stantec was reviewed as part of our retaining wall designs:

❑ Project No. 160401511 – Grading Plan, Drawing No. GP-1, Revision 3, dated September 2, 2021

Based on our review, the exposed portions of the subject Redi Rock retaining wall vary in height between 1.02 m to 1.45 m and is designed to support the proposed pathway.

Retaining Wall System Stability

The proposed retaining walls has been checked for global stability and has an adequate factor of safety in excess of the required 1.5 for static conditions and 1.1 for seismic loading conditions. The internal and external failure modes of the retaining wall sections have been designed with similar factors of safety provided. The applicable seismic design incorporates a PGA of 0.32, as per NBCC 2015.

Design details and recommendations for the retaining walls construction are presented in Drawing PG4772-2 – Redi Rock Retaining Wall attached to the present report.

Retaining Wall Fencing

The proposed railing is recommended to be extended through the top two blocks of the Redi Rock and installed using minimum 30 Mpa non shrink grout. Field core in to the second course will be required for the installation of guard rail based on the above methodology. Open guide rail, chain link fences and others of a “flow-through” configuration, will not impart significant wind loads on the wall. It should be noted that the fencing should be installed using galvanized steel to protect the railing/fencing system from long-term corrosion. Refer to City of Ottawa fencing standard - Figure 7.9.

Bearing Resistance Values

Geotechnical field review must be completed at the time of excavation, prior to placing the granular bedding layer, to assess the bearing medium under the proposed wall. A bearing capacity of 75 kPa SLS and 125 KPa ULS should be available below the 300 mm granular base. The compacted granular base will distribute the load over a larger area and provide a slightly higher bearing capacity that would prevent bearing and overturning failures of the retaining wall. The bearing medium at the subgrade level for the retaining wall should consist of an undisturbed, native compact silty clay layer or approved fill material.

An undisturbed soil bearing surface consists of a surface from which all topsoil and deleterious materials, such as loose, frozen or disturbed soil, whether in situ or not, have been removed, in the dry, prior to the placement of concrete for footings.

Global Stability Analysis

The global stability analysis was modeled in Slide, a computer program which permits a two-dimensional slope stability analysis calculating several methods including the Bishop’s method, which is a widely accepted slope analysis method. The program calculates a factor of safety, which represents the ratio of the forces resisting failure to forces favoring failure. Theoretically, a factor of safety of 1.0 represents a condition where the slope is stable. However, due to intrinsic limitations of the calculation methods and the variability of the subsurface soil and groundwater conditions, a factor of safety greater than 1.0 is generally required for the failure risk to be considered acceptable.

A minimum factor of safety of 1.5 is generally recommended for conditions where the slope failure would comprise permanent structures. An analysis considering seismic loading was also completed. A horizontal acceleration of 0.16 g was considered for the sections for the seismic loading condition. A factor of safety of 1.1 is considered to be satisfactory for stability analyses including seismic loading.

The retaining wall section was reviewed using the design loading according to CHBDC 2019.

The highest retaining wall cross-section was studied as the worst-case scenario which can be referred to in the attached documents. The following parameters were used for the slope stability analysis under static and seismic conditions:

Table 1 - Effective Soil Parameters for Global Stability Analysis

Soil Layer	Unit Weight (kN/m3)	Friction Angle (degrees)	Cohesion effective (kPa)	Cohesion Total (kPa)
Granular B Type II	22	36	0	0
Silty Clay	17	33	5	100
Glacial Till	22	33	0	0

The total strength parameters for seismic analysis were chosen based on the in situ, undrained shear strengths recovered within the open boreholes completed at the time of the geotechnical investigation.

Analysis Results

The factor of safety for the retaining wall section was greater than 1.5 for static conditions. Similarly, the results under seismic loading yielded a factor of safety for this section greater than 1.1. Based on these results, the retaining walls are considered to be stable under static and seismic loading, and therefore a stable slope allowance is not required.

Structural Design

The structural design of the retaining walls was completed using Fine Geo5, a computer program which permits a two-dimensional analysis calculating several methods including the method described in the CHBDC 2019, which is a widely accepted for retaining wall designs. The results of the analysis are attached to the end of this memorandum.

Construction Recommendations and Monitoring

It is recommended that the Paterson personnel conduct field reviews of the subgrade for the base of the wall, and testing or visual observations of the compaction methods for the base and backfill during wall construction. The Construction notes provided in the design Drawing PG4772-2 should be followed and inspected by Paterson at the time of construction should a certification letter is required for the proposed walls.

It is further recommended that all bedding and backfill materials be placed under dry conditions and above freezing temperatures and approved by the geotechnical consultant at the time of construction. Precautions should be taken to ensure that the bedding material does not freeze before placement and backfill of the retaining wall base blocks, which could lead to detrimental movement within the retaining wall, once the frost leaves the bedding material.

We trust this information satisfies your requirements.

Best Regards,

Paterson Group Inc.

LICENSED PROFESSIONAL ENGINEER
Nov 22, 2022
J. R. VILLENEUVE
100504344
PROVINCE OF ONTARIO

Balaji Nirmala, M.Eng.

Joey R. Villeneuve, M.A.Sc., P.Eng

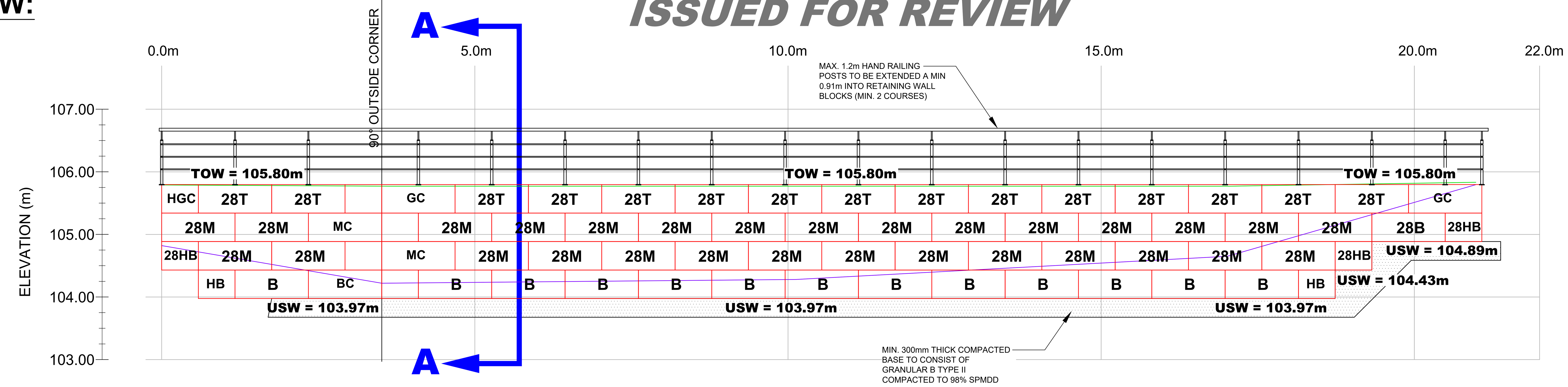
Attachments

- PG4772-2 – Redi Rock Retaining wall Design
- Global Stability Sections
- Structural Analysis

PROFILE VIEW:

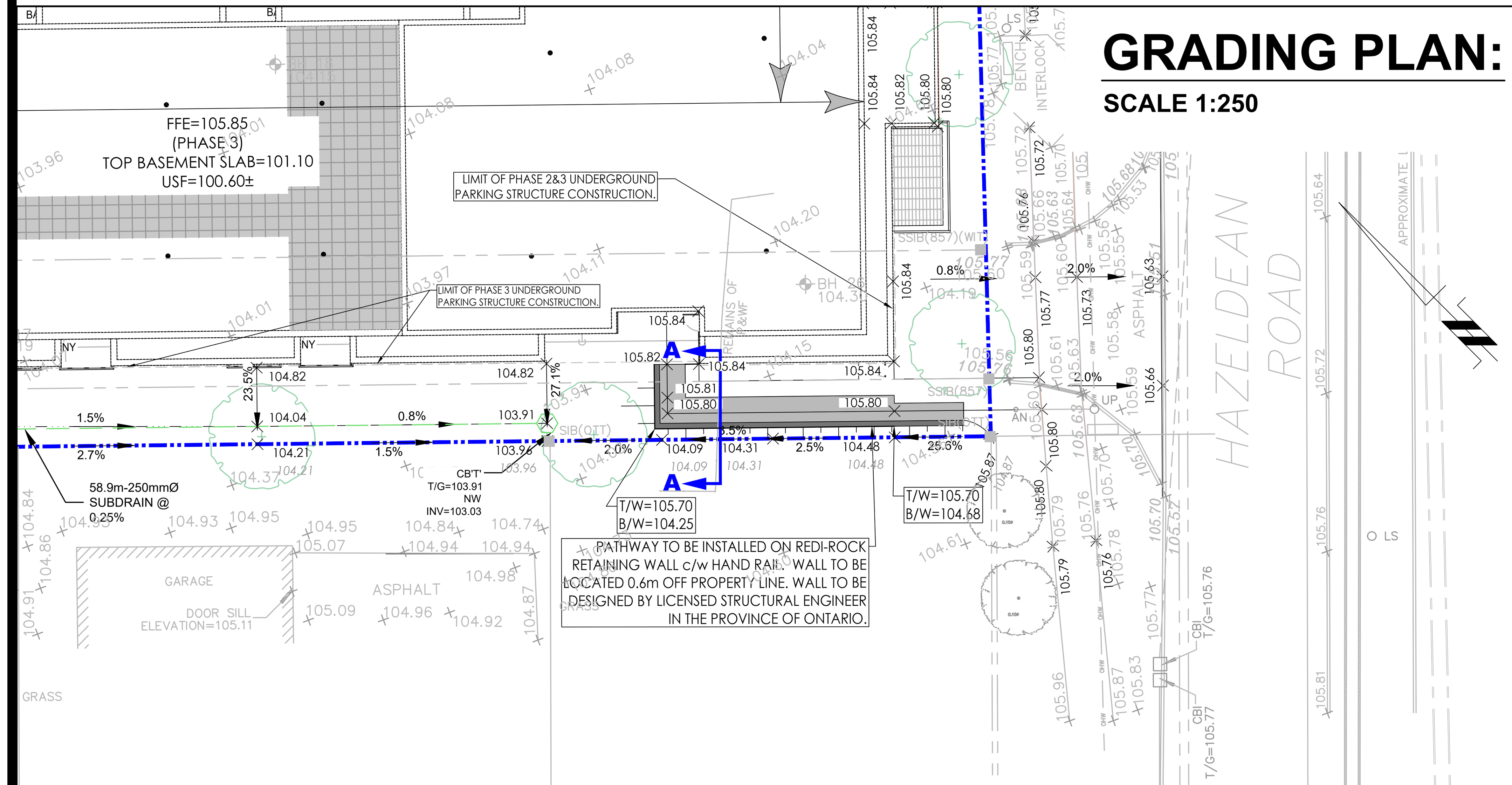
SCALE 1:40

ISSUED FOR REVIEW



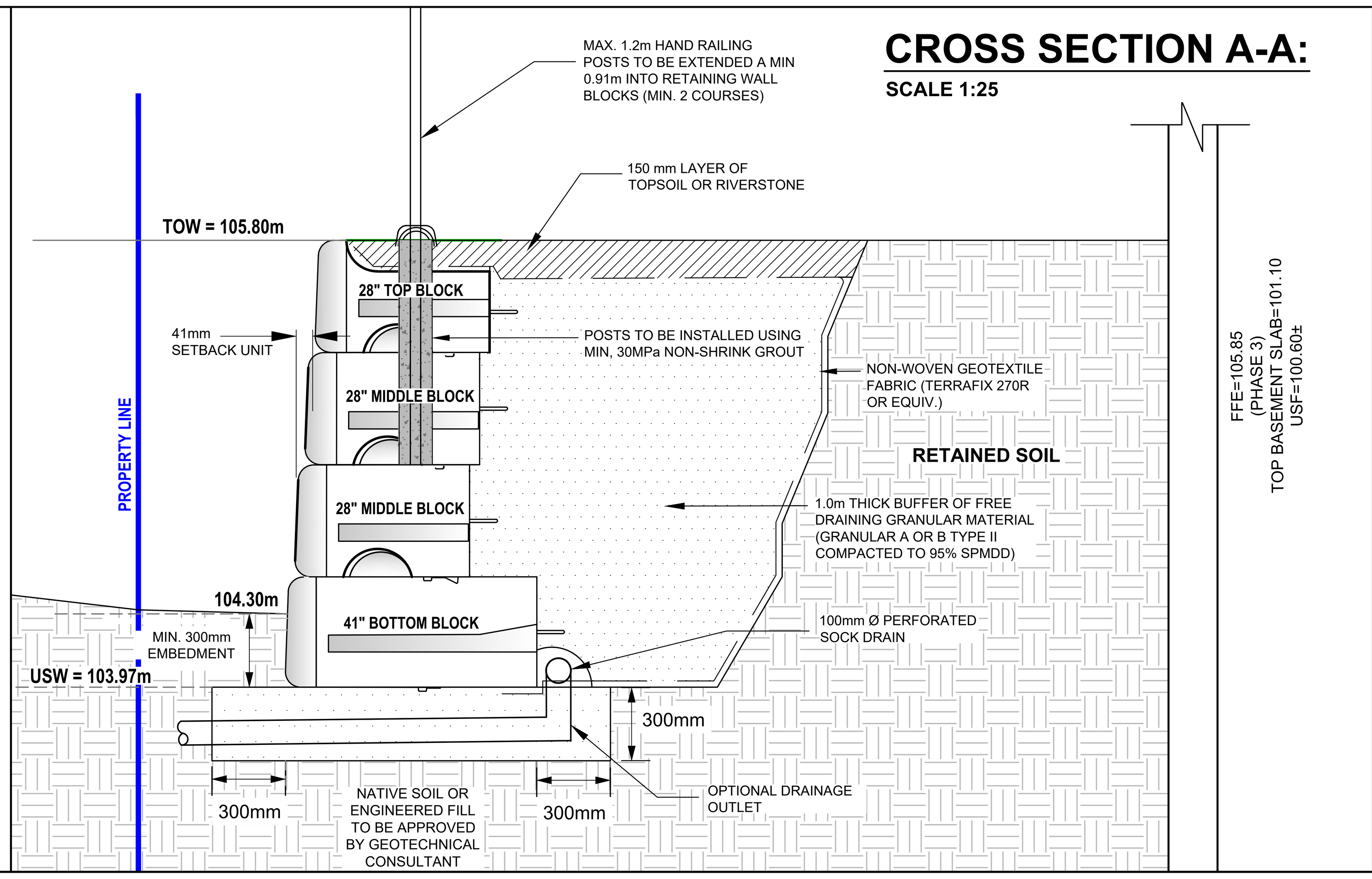
GRADING PLAN:

SCALE 1:250



CROSS SECTION A-A:

SCALE 1:25



NOTES:

1. THE CONTRACTOR IS SOLELY RESPONSIBLE FOR UTILITY CLEARANCES AND CONSTRUCTION SITE SAFETY. PATERSON GROUP SHALL NOT BE RESPONSIBLE FOR MEANS OR METHODS OF CONSTRUCTION OR FOR SAFETY OF WORKERS OR OF THE PUBLIC.

2. THIS DESIGN IS BASED ON THE FOLLOWING SOIL PROPERTIES:

PROPERTY	RETAINED FILL	FOUNDATION MEDIUM (1)
FRICTION ANGLE - ϕ	40°	33°
UNIT WEIGHT - γ	22 kN/m3	18 kN/m3
COHESION - C	0	5 kPa
SOIL TYPE	OPSS GRANULAR B TYPE II	VERY STIFF SILTY CLAY

MATERIAL PROPERTIES ARE BASED ON SITE EVALUATION BY PATERSON GROUP AND DISCUSSIONS WITH CONTRACTOR. SEISMIC LOADING WAS EVALUATED ACCORDING TO THE CURRENT CHBDC S6:2019 WITH A PEAK GROUND ACCELERATION VALUE OF 0.32.

3. THE DESIGN ELEVATIONS USED WERE BASED ON A GRADING PLAN PROVIDED BY STANTEC CONSULTING PR.160401511 - GRADING PLAN - GP1 REVISION 3. THE WALL BASE DESIGN ASSUMES A BEARING RESISTANCE AT SLS OF 150 kPa ON VERY STIFF SILTY CLAY. PATERSON GROUP ENGINEER SHOULD OBSERVE THE BEARING CONDITIONS AND ADJUST THE THICKNESS OF THE GRANULAR BASE TO ACCOMMODATE THE SITE CONDITIONS, IF NECESSARY.

4. THE DESIGN HAS BEEN REVIEWED FOR THE STABILITY OF THE PRECAST MODULAR RETAINING WALL SYSTEM AND GLOBAL STABILITY WITH A FACTOR OF SAFETY OF 1.5 FOR STATIC CONDITIONS AND 1.1 UNDER SEISMIC CONDITIONS. WALL GEOMETRY AND GRADE ELEVATIONS ABOVE AND BELOW THE WALL SHOULD CONFORM WITH THE GRADING PLAN PROVIDED HERE IN. IF ACTUAL SITE GRADES VARY SIGNIFICANTLY FROM THOSE SHOWN OR IF THE BACK SLOPE DOES NOT CONFORM, INSTALLATION SHALL NOT PROCEED UNTIL THE DESIGN IS VERIFIED OR MODIFIED IN THE APPLICABLE AREA.

5. PRECAST UNITS SHALL BE REDI-ROCK RETAINING WALL UNITS MANUFACTURED UNDER LICENSE FROM REDI-ROCK.

6. THE WALL BASE FOR THE WALL SHALL CONSIST OF A MIN. 300mm THICK OPSS GRANULAR A COMPACTED TO MIN. 98% OF THE MATERIALS SPMDD AND TESTED BY PATERSONGROUP GEOTECHNICAL PERSONNEL AT THE TIME OF CONSTRUCTION. SURFACE OF GRANULAR BASE MAY BE DRESSED WITH FINER AGGREGATE TO AID LEVELING. ENSURE GRADATION OF DRESSING MATERIAL IS SUCH AS TO PRECLUDE LOSS OF FINES INTO BASE. THE THICKNESS OF DRESSING LAYER SHOULD NOT EXCEED 3 TIMES THE MAXIMUM PARTICLE SIZE USED.

7. WALL IS DESIGNED WITH A MIN. 200mm TOE EMBEDMENT WITH A MIN. HORIZONTAL LEDGE WITH A GRANULAR BEDDING LAYER EXTENDING A MIN. 300mm BEYOND THE FACE AND HEEL OF THE BASE BLOCK

8. INSTALL 100mm DIAMETER PERFORATED PIPE WRAPPED WITH A GEOSOCK DRAIN BEHIND HEEL OR UNDER THE WALL. PROVIDE CLEAR STONE SURROUND TO PROTECT PIPE FROM CLOGGING AND DAMAGE. PROVIDE OUTLETS THROUGH WALL, NO FURTHER APART THAN 15.0m ON CENTRES AND OR AT THE END OF THE WALL. THE DRAINAGE PIPE SHOULD BE CONNECTED TO A POSITIVE OUTLET ON BOTH ENDS OF THE RETAINING WALL SUCH AS AN EXISTING DITCH OR CATCH BASIN. ANY PIPE OUTLET SHOULD BE PROTECTED BY A RODENT GUARD.

9. THE CONDITIONS WILL BE EVALUATED BY THE GEOTECHNICAL ENGINEER DURING PREPARATION FOR WALL CONSTRUCTION IN EACH AREA. WHERE GRANULAR BEDDING WILL NOT BE SUFFICIENT THE USE OF CONCRETE BEDDING MAY BE REQUIRED.

10. ALIGNMENT OF THE BOTTOM WALL UNIT COURSE SHOULD BE PLANNED TO CONSIDER THAT A NOMINAL 41mm AUTOMATIC SETBACK WILL OCCUR WITH EACH 0.46m INCREMENT OF HEIGHT.

11. BACKFILL MATERIAL SHALL BE APPROVED BY THE SITE GEOTECHNICAL ENGINEER PRIOR TO USE AND SHOULD CONSIST OF OPSS GRANULAR A OR B TYPE II FOLLOWED BY SUITABLE BACKFILL MATERIAL. ALL FILL WITHIN A 1H:1V ZONE UP AND BACK FROM THE HEEL SHOULD ALSO BE COMPACTED. BACKFILL SHALL BE PLACED IN MAXIMUM 300mm LOOSE LIFTS AND COMPACTED TO A MINIMUM OF 95% OF SPMDD. MOISTURE CONTENT SHOULD BE CONTROLLED AND MAINTAINED WITHIN -3 TO +4 PERCENT OF OPTIMUM.

12. MAINTAIN TEMPORARY GRADES TO DIVERT SURFACE WATER AWAY FROM THE RETAINING WALL EXCAVATION. SLOPE FINAL BACKFILL TO PROVIDE POSITIVE DRAINAGE AND TO ELIMINATE PONDING.

13. BACKSLOPE SHOULD BE CUT BACK TO A MINIMUM OF 2H:1V TO 3H:1V TO MAINTAIN A LONG TERM SAFE SLOPE BEHIND THE RETAINING WALL. IT SHOULD BE NOTED THAT WHERE TREES ARE PRESENT WITHIN THE TOP OF SLOPE. A MINIMUM 1.0m SET BACK IS REQUIRED FOR EXCAVATION FROM THE EDGE OF THE TREE LINE WHERE PRESENT.

14. EXCAVATION SIDE SLOPES SHOULD BE PROTECTED TEMPORARILY DURING CONSTRUCTION FROM PRECIPITATION EVENTS BY PLACEMENT OF TARPS.

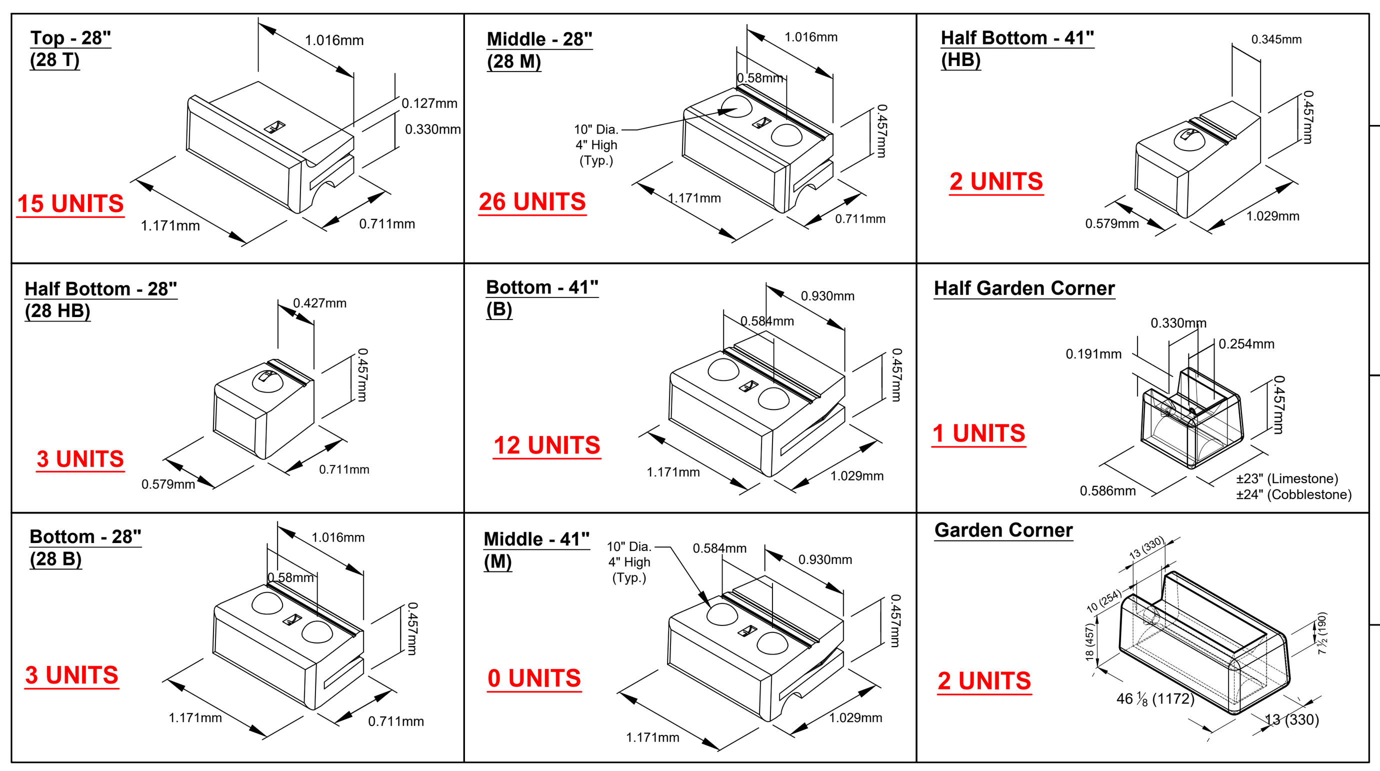
15. ALL RETAINING WALL RELATED INSPECTIONS (BEARING SURFACE, COMPACTION, BLOCK INSTALLATION, ETC.) MUST BE COMPLETED BY PATERSON GROUP. ONCE THE WALL CONSTRUCTION IS COMPLETED AND REVIEWED BY PATERSON DURING CONSTRUCTION, A CERTIFICATE LETTER WILL BE ISSUED BY PATERSON GROUP.

16. ANY CUTTING OF BLOCKS TO SUIT SITE CONDITIONS OR WALL DESIGN WILL BE RESPONSIBILITY OF THE CONTRACTOR.

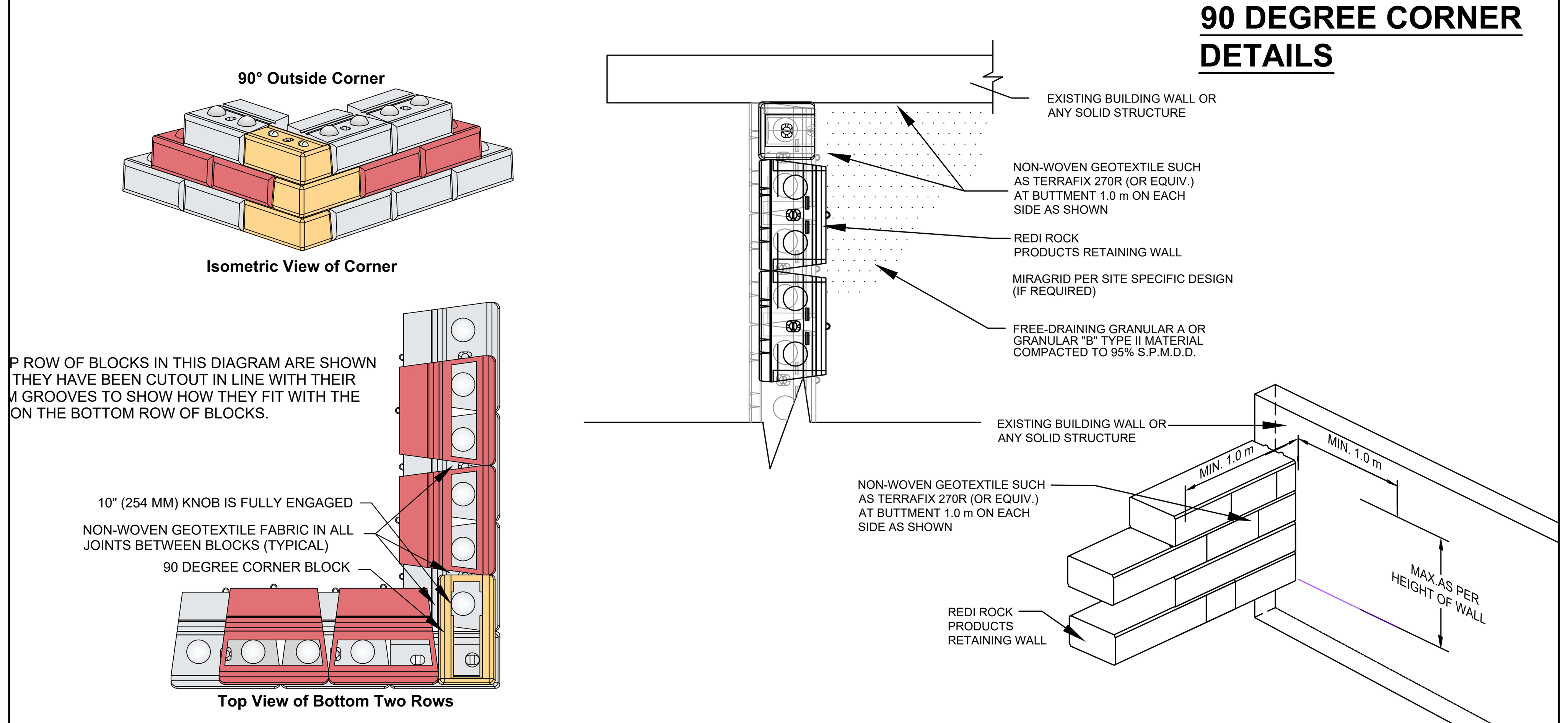
17. IF WINTER CONSTRUCTION IS CONSIDERED, HEAT MUST BE MAINTAINED WHEN THE BASE IS EXPOSED. THE WALL BASE MUST COVERED WITH HIGH GRADE INSULATION TARPS TO MAINTAIN HEAT AND PROTECT THE BASE FROM POTENTIAL FROST HEAVE. ONCE THE BASE IS BACKFILLED, THE TOP OF THE WALL MUST BE COVERED WITH INSULATION TARPS OVERNIGHT UNTIL THE WALL CONSTRUCTION IS COMPLETED. ADDITIONAL INSPECTIONS WILL BE REQUIRED DURING WINTER CONSTRUCTION TO ENSURE THE WALL CONSTRUCTION IS IN GENERAL CONFORMANCE WITH PATERSON'S RECOMMENDATIONS.

BLOCK COUNT:

N.T.S.



90 DEGREE CORNER DETAILS



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NO.	REVISIONS	DATE	INITIAL

NAUTICAL LANDS

PROPOSED RETAINING WALL

PROPOSED MIXED-USE DEVELOPMENT - WELLINGS OF STITTSVILLE PHASE 2 - 20 CEDAROW COURT.

OTTAWA ONTARIO

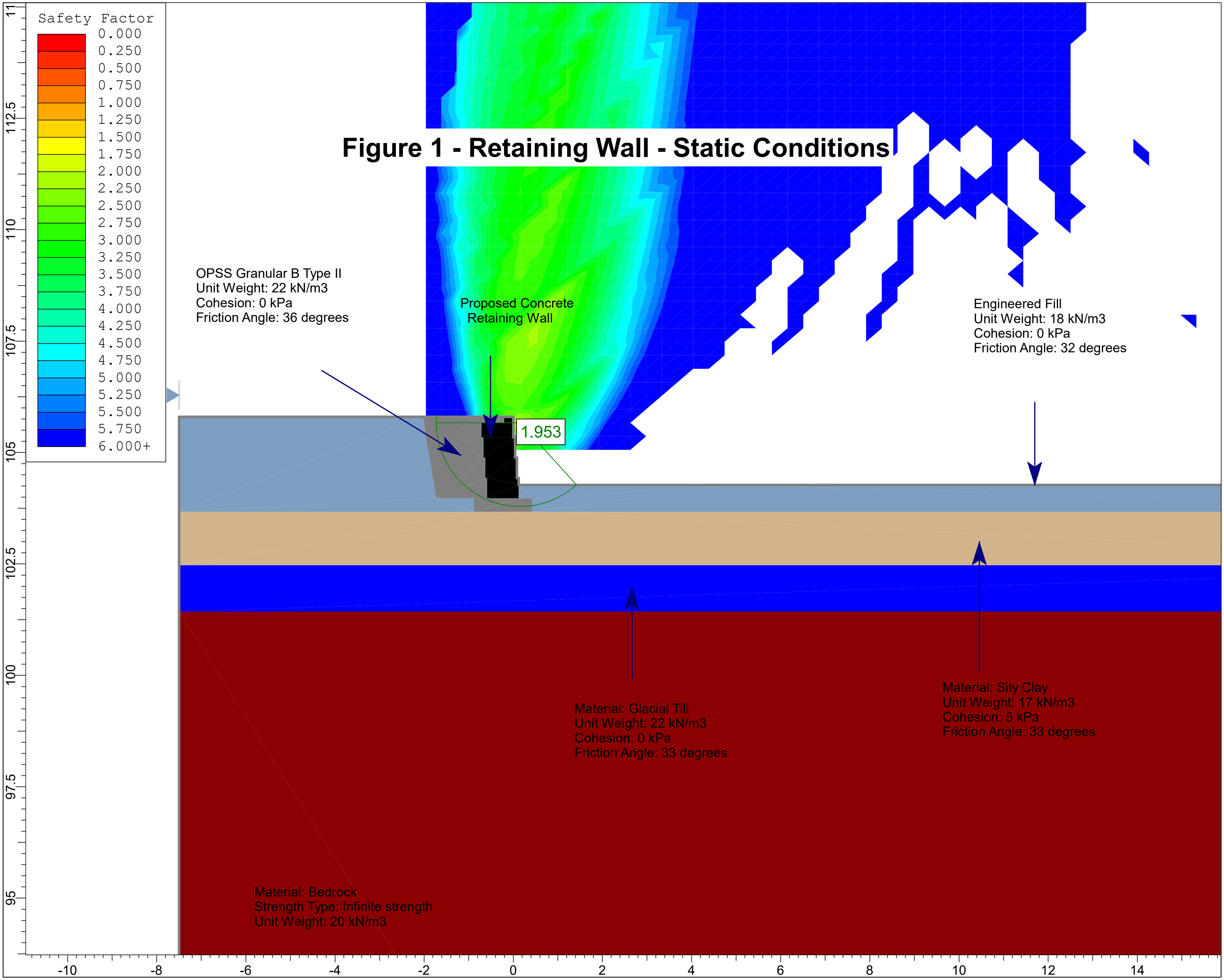
Title:

REDI ROCK RETAINING WALL DESIGN

Stamp: LICENSED PROFESSIONAL ENGINEER 02/11/2022 J. R. VILLENEUVE 100504344 PROVINCE OF ONTARIO

Scale:	AS SHOWN
Drawn by:	RCG
Checked by:	BN
Approved by:	JV
Date:	02/2022
File No.:	PG4772
Drawing No.:	PG4772-2
Revision No.:	

Figure 1 - Retaining Wall - Static Conditions



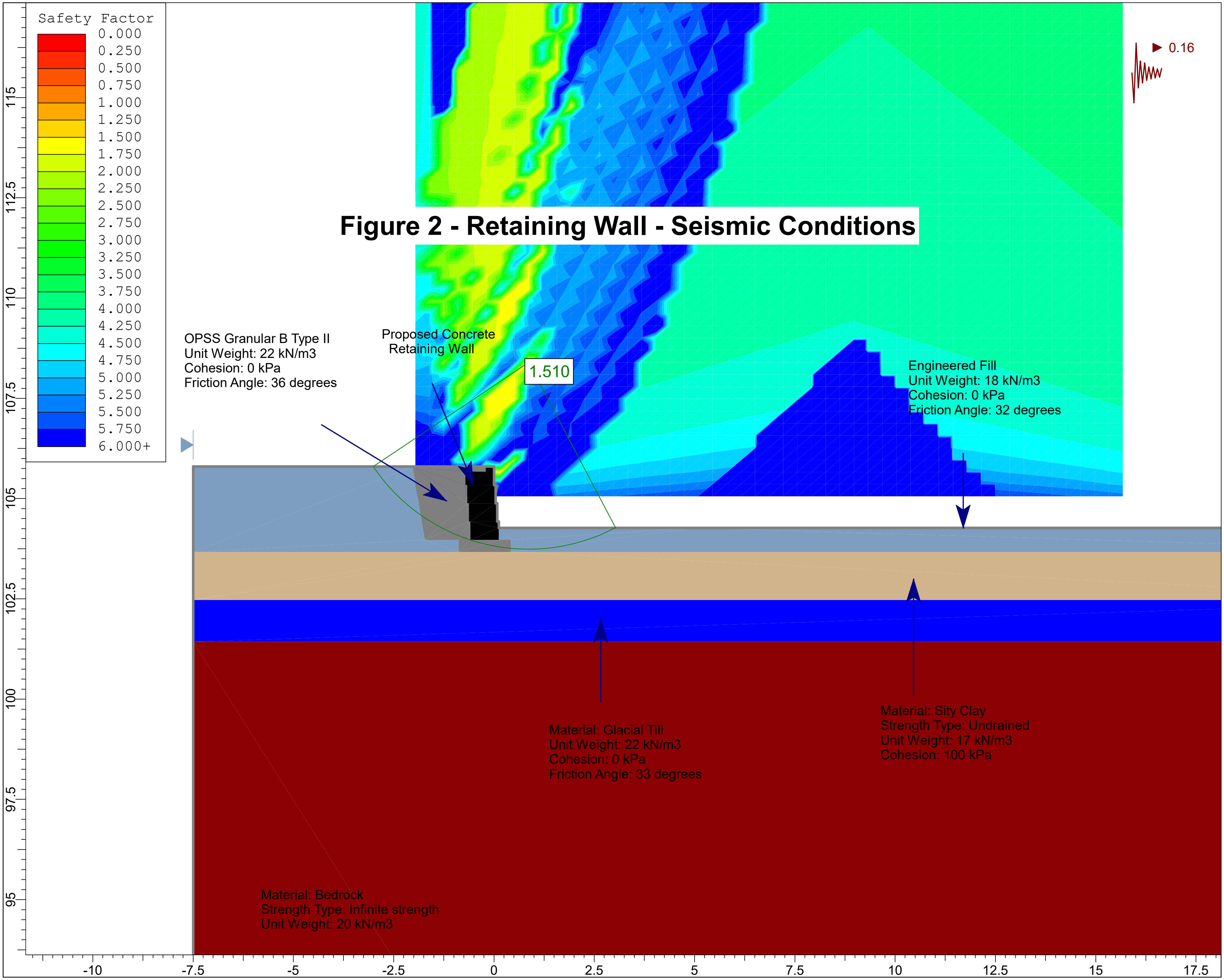


Figure 2 - Retaining Wall - Seismic Conditions
Safety Factor
0.000
0.250
0.500
0.750
1.000
1.250
1.500
1.750
2.000
2.250
2.500
2.750
3.000
3.250
3.500
3.750
4.000
4.250
4.500
4.750
5.000
5.250
5.500
5.750
6.000+
0.16
1.510
OPSS Granular B Type II
Unit Weight: 22 kN/m3
Cohesion: 0 kPa
Friction Angle: 36 degrees
Proposed Concrete
Retaining Wall
Engineered Fill
Unit Weight: 18 kN/m3
Cohesion: 0 kPa
Friction Angle: 32 degrees
Material: Glacial Till
Unit Weight: 22 kN/m3
Cohesion: 0 kPa
Friction Angle: 33 degrees
Material: Sity Clay
Strength Type: Undrained
Unit Weight: 17 kN/m3
Cohesion: 100 kPa
Material: Bedrock
Strength Type: Infinite strength
Unit Weight: 20 kN/m3
115
112.5
110
107.5
105
102.5
100
97.5
95
-10
-7.5
-5
-2.5
0
2.5
5
7.5
10
12.5
15
17.5

Analysis of Redi Rock wall

Input data

Project

Date : 11/21/2022

Settings

Canadian Highway and Bridge Design Code

Wall analysis

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

Load factors					
Design situation - Service I					
		Minimum		Maximum	
Dead load of structural components :	DC =	1.00	[–]	1.00	[–]
Dead load of wearing surfaces :	DW =	1.00	[–]	1.00	[–]
Earth pressure - active :	EH_A =	1.00	[–]	1.00	[–]
Earth pressure - at rest :	EH_R =	1.00	[–]	1.00	[–]
Earth surcharge load (permanent) :	ES =	1.00	[–]	1.00	[–]
Vertical pressure of earth fill :	EV =	1.00	[–]	1.00	[–]
Live load surcharge :	LL =	0.00	[–]	1.00	[–]
Water load :	WA =	1.00	[–]	1.00	[–]

Resistance factors			
Design situation - Service I			
Resistance factor on overturning :	φ_o =	1.00	[–]
Resistance factor on sliding :	φ_t =	1.00	[–]
Resistance factor on bearing capacity :	φ_b =	1.00	[–]
Resistance factor on passive pressure :	φ_{VE} =	1.00	[–]

Blocks

No.	Description	Height h [mm]	Width w [mm]	Unit weight γ [kN/m³]
1	Block 28	457.2	711.2	18.85
2	Block 41	457.2	1028.7	18.85
3	Block 60	457.2	1524.0	20.42
4	Top block 24 straight	457.2	609.6	16.97
5	Planter 41	457.2	1028.7	18.85
6	Planter 60	457.2	1524.0	17.59
7	Top block 28	457.2	711.2	18.85

No.	Description	Height h [mm]	Width w [mm]	Unit weight γ [kN/m^3]
8	Top block 41	457.2	1028.7	18.85
9	Top block 24 straight garden	457.2	609.6	12.57
10	Block R-5236 HC	914.4	1320.8	17.28
11	Block R-7236 HC	914.4	1828.8	17.28
12	Block R-9636 HC	914.4	2438.4	17.28
13	Block R-41 HC	457.2	1028.7	17.28

No.	Description	Min. shear strength F_{min} [kN/m]	Max. shear strength F_{max} [kN/m]	Friction f [°]
1	Block 28	88.45	164.56	44.00
2	Block 41	88.45	164.56	44.00
3	Block 60	88.45	164.56	44.00
4	Top block 24 straight	88.45	164.56	44.00
5	Planter 41	88.45	164.56	44.00
6	Planter 60	88.45	164.56	44.00
7	Top block 28	88.45	164.56	44.00
8	Top block 41	88.45	164.56	44.00
9	Top block 24 straight garden	88.45	164.56	44.00
10	Block R-5236 HC	66.40	175.13	44.00
11	Block R-7236 HC	66.40	175.13	44.00
12	Block R-9636 HC	66.40	175.13	44.00
13	Block R-41 HC	78.19	188.35	37.00

Setbacks

No.	Setback s [mm]
1	0.254
2	9.525
3	41.275
4	238.125
5	422.275

Geometry

No. group	Description	Count	Setback s [mm]
1	Block 41	1	41.3
2	Block 28	2	41.3
3	Top block 28	1	-

Base

Geometry

Upper setback a_1 = 0.30 m
Lower setback a_2 = 0.30 m
Height h = 0.30 m

Width b = 1.60 m

Material

Soil creating foundation - Granular

Basic soil parameters

No.	Name	Pattern	ϕ_{ef} [°]	c_{ef} [kPa]	γ [kN/m³]	γ_{su} [kN/m³]	δ [°]
1	Granular		36.00	0.00	22.00	12.00	28.00
2	Silty Clay		33.00	5.00	18.00	8.00	27.00

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

Soil parameters

Granular

Unit weight : γ = 22.00 kN/m³
Stress-state : effective
Angle of internal friction : ϕ_{ef} = 36.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Angle of friction struc.-soil : δ = 28.00 °
Saturated unit weight : γ_{sat} = 22.00 kN/m³

Silty Clay

Unit weight : γ = 18.00 kN/m³
Stress-state : effective
Angle of internal friction : ϕ_{ef} = 33.00 °
Cohesion of soil : c_{ef} = 5.00 kPa
Angle of friction struc.-soil : δ = 27.00 °
Saturated unit weight : γ_{sat} = 18.00 kN/m³

Backfill - rock behind the wall

Assigned soil : Granular
Length : l_1 = 0.50 m
l_2 = 1.00 m

Coeff. of pressure reduction : k = 0.5
Depth of limited slip surface : z = 1.83 m

Geological profile and assigned soils

No.	Thickness of layer t [m]	Depth z [m]	Assigned soil	Pattern
1	-	0.00 .. ∞	Silty Clay	

Terrain profile

Terrain behind the structure is flat.

Water influence

Ground water table is located below the structure.

Input surface surcharges

No.	Surcharge		Action	Mag.1 [kN/m²]	Mag.2 [kN/m²]	Ord.x x [m]	Length l [m]	Depth z [m]
	new	change						
1	Yes		variable	10.00				on terrain

Resistance on front face of the structure

Resistance on front face of the structure: at rest
Soil on front face of the structure - Silty Clay
Soil thickness in front of structure h = 0.50 m

Terrain in front of structure is flat.

Settings of the stage of construction

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

Verification No. 1

Forces acting on construction

Name	F_{hor} [kN/m]	App.Pt. z [m]	F_{vert} [kN/m]	App.Pt. x [m]	Coeff. overtur.	Coeff. sliding	Coeff. stress
Weight - wall	0.00	-0.83	36.47	0.77	1.000	1.000	1.000
FF resistance	-1.02	-0.17	0.00	-0.15	1.000	1.000	1.000
Weight - earth wedge	0.00	-0.72	3.37	1.29	1.000	1.000	1.000
Weight - earth wedge	0.00	-2.06	1.56	0.83	1.000	1.000	1.000
Active pressure	10.83	-0.76	16.47	1.38	1.000	1.000	1.000
Surch.1 - surface	5.02	-1.03	6.72	1.32	1.000	1.000	1.000
Surch.1 - surface	0.00	-2.13	5.19	0.81	0.000	0.000	1.000

Verification of complete wall

Check for overturning stability

Resisting moment M_{res} = 65.41 kNm/m
Overturning moment M_{ovr} = 13.18 kNm/m

CDR CDR = 4.96

Wall for overturning is SATISFACTORY

Check for slip

Resisting horizontal force H_{res} = 49.95 kN/m
Active horizontal force H_{act} = 14.83 kN/m

CDR CDR = 3.37

Wall for slip is SATISFACTORY

Overall check - WALL is SATISFACTORY

Dimensioning No. 1

Forces acting on construction

Name	F_{hor} [kN/m]	App.Pt. z [m]	F_{vert} [kN/m]	App.Pt. x [m]	Coeff. overtur.	Coeff. sliding	Coeff. stress
Weight - wall	0.00	-0.81	25.91	0.46	1.000	1.000	1.000
Weight - earth wedge	0.00	-0.61	1.40	0.86	1.000	1.000	1.000
Weight - earth wedge	0.00	-1.76	1.56	0.53	1.000	1.000	1.000

Name	F_{hor} [kN/m]	App.Pt. z [m]	F_{vert} [kN/m]	App.Pt. x [m]	Coeff. overtur.	Coeff. sliding	Coeff. stress
Active pressure	8.14	-0.61	8.58	0.93	1.000	1.000	1.000
Surch.1 - surface	4.02	-0.91	4.24	0.89	1.000	1.000	1.000
Surch.1 - surface	0.00	-1.83	5.19	0.51	0.000	0.000	1.000

Verification of most stressed block No. 1

Check for overturning stability

Resisting moment M_{res} = 25.79 kNm/m
Overturning moment M_{ovr} = 8.60 kNm/m

CDR CDR = 3.00

Joint for overturning stability is SATISFACTORY

Check for slip

Resisting horizontal force H_{res} = 30.29 kN/m
Active horizontal force H_{act} = 12.16 kN/m

CDR CDR = 2.49

Joint for verification is SATISFACTORY

Bearing capacity of foundation soil

Design load acting at the center of footing bottom

No.	Moment [kNm/m]	Norm. force [kN/m]	Shear Force [kN/m]	Eccentricity [–]	Stress [kPa]
1	-0.60	69.78	14.83	0.000	43.61
2	-0.55	64.60	14.83	0.000	40.37

Service load acting at the center of footing bottom

No.	Moment [kNm/m]	Norm. force [kN/m]	Shear Force [kN/m]
1	-0.60	69.78	14.83
2	-0.55	64.60	14.83

Verification of foundation soil

Stress in the footing bottom : rectangle

Eccentricity verification

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

Eccentricity of the normal force is SATISFACTORY

Verification of bearing capacity

Max. stress at footing bottom σ = 43.61 kPa
Bearing capacity of foundation soil R_d = 75.00 kPa
CDR CDR = 1.72

Bearing capacity of foundation soil is SATISFACTORY

Overall verification - bearing capacity of found. soil is SATISFACTORY

Analysis of Redi Rock wall

Input data

Project

Date : 11/21/2022

Settings

Canadian Highway and Bridge Design Code

Wall analysis

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

Load factors					
Design situation - Extreme I					
		Minimum		Maximum	
Dead load of structural components :	DC =	0.90	[–]	1.10	[–]
Dead load of wearing surfaces :	DW =	0.65	[–]	1.50	[–]
Earth pressure - active :	EH_A =	0.80	[–]	1.25	[–]
Earth pressure - at rest :	EH_R =	0.80	[–]	1.25	[–]
Earth surcharge load (permanent) :	ES =	0.50	[–]	1.25	[–]
Vertical pressure of earth fill :	EV =	0.80	[–]	1.50	[–]
Live load surcharge :	LL =	0.00	[–]	0.00	[–]
Water load :	WA =	0.90	[–]	1.10	[–]

Resistance factors			
Design situation - Extreme I			
Resistance factor on overturning :	φ_o =	1.00	[–]
Resistance factor on sliding :	φ_t =	1.00	[–]
Resistance factor on bearing capacity :	φ_b =	1.00	[–]
Resistance factor on passive pressure :	φ_{VE} =	1.00	[–]

Blocks

No.	Description	Height h [mm]	Width w [mm]	Unit weight γ [kN/m³]
1	Block 28	457.2	711.2	18.85
2	Block 41	457.2	1028.7	18.85
3	Block 60	457.2	1524.0	20.42
4	Top block 24 straight	457.2	609.6	16.97
5	Planter 41	457.2	1028.7	18.85
6	Planter 60	457.2	1524.0	17.59
7	Top block 28	457.2	711.2	18.85

No.	Description	Height h [mm]	Width w [mm]	Unit weight γ [kN/m^3]
8	Top block 41	457.2	1028.7	18.85
9	Top block 24 straight garden	457.2	609.6	12.57
10	Block R-5236 HC	914.4	1320.8	17.28
11	Block R-7236 HC	914.4	1828.8	17.28
12	Block R-9636 HC	914.4	2438.4	17.28
13	Block R-41 HC	457.2	1028.7	17.28

No.	Description	Min. shear strength F_{min} [kN/m]	Max. shear strength F_{max} [kN/m]	Friction f [°]
1	Block 28	88.45	164.56	44.00
2	Block 41	88.45	164.56	44.00
3	Block 60	88.45	164.56	44.00
4	Top block 24 straight	88.45	164.56	44.00
5	Planter 41	88.45	164.56	44.00
6	Planter 60	88.45	164.56	44.00
7	Top block 28	88.45	164.56	44.00
8	Top block 41	88.45	164.56	44.00
9	Top block 24 straight garden	88.45	164.56	44.00
10	Block R-5236 HC	66.40	175.13	44.00
11	Block R-7236 HC	66.40	175.13	44.00
12	Block R-9636 HC	66.40	175.13	44.00
13	Block R-41 HC	78.19	188.35	37.00

Setbacks

No.	Setback s [mm]
1	0.254
2	9.525
3	41.275
4	238.125
5	422.275

Geometry

No. group	Description	Count	Setback s [mm]
1	Block 41	1	41.3
2	Block 28	2	41.3
3	Top block 28	1	-

Base

Geometry

Upper setback a_1 = 0.30 m
Lower setback a_2 = 0.30 m
Height h = 0.30 m

Width b = 1.60 m

Material

Soil creating foundation - Granular

Basic soil parameters

No.	Name	Pattern	ϕ_{ef} [°]	c_{ef} [kPa]	γ [kN/m³]	γ_{su} [kN/m³]	δ [°]
1	Granular		36.00	0.00	22.00	12.00	28.00
2	Silty Clay		33.00	5.00	18.00	8.00	27.00

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

Soil parameters

Granular

Unit weight : γ = 22.00 kN/m^3
Stress-state : effective
Angle of internal friction : ϕ_{ef} = 36.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Angle of friction struc.-soil : δ = 28.00 °
Saturated unit weight : γ_{sat} = 22.00 kN/m^3

Silty Clay

Unit weight : γ = 18.00 kN/m^3
Stress-state : effective
Angle of internal friction : ϕ_{ef} = 33.00 °
Cohesion of soil : c_{ef} = 5.00 kPa
Angle of friction struc.-soil : δ = 27.00 °
Saturated unit weight : γ_{sat} = 18.00 kN/m^3

Backfill - rock behind the wall

Assigned soil : Granular
Length : l_1 = 0.50 m
l_2 = 1.00 m

Coeff. of pressure reduction : k = 0.5
Depth of limited slip surface : z = 1.83 m

Geological profile and assigned soils

No.	Thickness of layer t [m]	Depth z [m]	Assigned soil	Pattern
1	-	0.00 .. ∞	Silty Clay	

Terrain profile

Terrain behind the structure is flat.

Water influence

Ground water table is located below the structure.

Input surface surcharges

No.	Surcharge		Action	Mag.1	Mag.2	Ord.x	Length	Depth
	new	change		[kN/m²]	[kN/m²]	x [m]	l [m]	z [m]
1	Yes		variable	10.00				on terrain

Resistance on front face of the structure

Resistance on front face of the structure: at rest
Soil on front face of the structure - Silty Clay
Soil thickness in front of structure h = 0.50 m

Terrain in front of structure is flat.

Earthquake

Factor of horizontal acceleration K_h = 0.1600
Factor of vertical acceleration K_v = 0.0000

Water below the GWT is restricted.

Settings of the stage of construction

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

Verification No. 1

Forces acting on construction

Name	F_{hor} [kN/m]	App.Pt. z [m]	F_{vert} [kN/m]	App.Pt. x [m]	Coeff. overtur.	Coeff. sliding	Coeff. stress
Weight - wall	0.00	-0.83	36.47	0.77	0.900	0.900	1.100
Earthq.- constr.	5.88	-0.86	0.00	0.77	1.000	1.000	1.000
FF resistance	-1.02	-0.17	0.00	-0.15	0.800	0.800	1.250
Weight - earth wedge	0.00	-0.72	3.37	1.29	0.800	0.800	1.500
Earthquake - soil wedge	0.54	-0.72	0.00	1.29	1.000	1.000	1.000
Weight - earth wedge	0.00	-2.06	1.56	0.83	0.800	0.800	1.500
Earthquake - soil wedge	0.25	-2.06	0.00	0.83	1.000	1.000	1.000
Active pressure	10.83	-0.76	16.47	1.38	0.800	1.250	1.250
Earthq.- act.pressure	4.80	-1.40	5.78	1.23	1.000	1.000	1.000
Surch.1 - surface	5.02	-1.03	6.72	1.32	0.000	0.000	0.000
Surch.1 - surface	0.00	-2.13	5.19	0.81	0.000	0.000	0.000

Verification of complete wall

Check for overturning stability
Resisting moment M_{res} = 55.16 kNm/m
Overturning moment M_{ovr} = 19.08 kNm/m

CDR CDR = 2.89
Wall for overturning is SATISFACTORY

Check for slip
Resisting horizontal force H_{res} = 47.76 kN/m
Active horizontal force H_{act} = 24.18 kN/m

CDR CDR = 1.97
Wall for slip is SATISFACTORY

Overall check - WALL is SATISFACTORY

Dimensioning No. 1

Forces acting on construction

Name	F_{hor} [kN/m]	App.Pt. z [m]	F_{vert} [kN/m]	App.Pt. x [m]	Coeff. overtur.	Coeff. sliding	Coeff. stress
Weight - wall	0.00	-0.65	17.05	0.39	0.900	0.900	1.100
Earthq.- constr.	2.89	-0.63	0.00	0.40	1.000	1.000	1.000
Weight - earth wedge	0.00	-1.31	1.54	0.49	0.800	0.800	1.500
Earthquake - soil wedge	0.25	-1.31	0.00	0.49	1.000	1.000	1.000
Active pressure	3.90	-0.47	1.76	0.75	1.250	1.250	1.250
Earthq.- act.pressure	2.02	-0.93	1.57	0.77	1.000	1.000	1.000
Surch.1 - surface	2.71	-0.72	1.73	0.76	0.000	0.000	0.000
Surch.1 - surface	0.00	-1.37	5.19	0.47	0.000	0.000	0.000

Verification of most stressed block No. 2

Check for overturning stability

Resisting moment M_{res} = 9.50 kNm/m
Overturning moment M_{ovr} = 6.31 kNm/m

CDR CDR = 1.51

Joint for overturning stability is SATISFACTORY

Check for slip

Resisting horizontal force H_{res} = 108.10 kN/m
Active horizontal force H_{act} = 10.03 kN/m

CDR CDR = 10.78

Joint for verification is SATISFACTORY

Bearing capacity of foundation soil

Design load acting at the center of footing bottom

No.	Moment [kNm/m]	Norm. force [kN/m]	Shear Force [kN/m]	Eccentricity [–]	Stress [kPa]
1	6.82	73.89	23.72	0.058	52.21
2	8.50	55.73	24.18	0.095	43.03

Service load acting at the center of footing bottom

No.	Moment [kNm/m]	Norm. force [kN/m]	Shear Force [kN/m]
1	9.59	75.56	26.29
2	9.64	70.38	26.29

Verification of foundation soil

Stress in the footing bottom : rectangle

Eccentricity verification

Max. eccentricity of normal force e = 0.095
Maximum allowable eccentricity e_{alw} = 0.333

Eccentricity of the normal force is SATISFACTORY

Verification of bearing capacity

Max. stress at footing bottom	σ	=	52.21	kPa
Bearing capacity of foundation soil	R_d	=	75.00	kPa
CDR	CDR	=	1.44	

Bearing capacity of foundation soil is SATISFACTORY

Overall verification - bearing capacity of found. soil is SATISFACTORY