ARCADIS

Mr. David Young
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Date: 7 June 2023
Our Ref: 30127480 – Geotech
Subject: **Geotechnical Review – Global Stability Analysis**
Proposed Retaining wall, Merivale Warehouse
1881 Merivale Road, Ottawa

Dear Mr. Young,

As per our proposal dated 8 May 2023, Arcadis Canada Inc,. (Arcadis) has prepared the following memorandum to provide a geotechnical review of the global stability analysis of the proposed retaining wall structure.

Background Information

As requested, Arcadis Canada Inc,. (Arcadis) completed a Redi-Rock retaining wall design to be located on the eastern side of the truck unloading bay 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 National Building Code of Canada 2020 (NBCC). Details of the retaining wall are presented below and are depicted in Drawing C-01 attached.

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

- Project No. CCO-23-1150, Drawing C101, Grading, Drainage and Erosion & Sediment Control Plan, Revision 1 dated 13 February 2023.

Based on our review, the exposed portions of the subject Redi Rock retaining wall vary in height between 0.3m to 1.9m.

Retaining Wall Fencing

The proposed fencing is recommended to be extended through the top two blocks of the Redi Rock wall and designed by others. 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

Global and Internal Stability Analysis

The global stability analysis was modeled using Redi-Rock+ software (part of the Fine suite by Geo 5), 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 software further allows for the internal review of the design as per various codes including the CHBDC 2019. 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. Based on the configuration of the Site plans reviewed and the conservative nature of the software/parameters used, a factor of safety of 1.3 was considered acceptable. An analysis considering seismic loading was also completed. A horizontal acceleration of 0.1515 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. Based on the conservative nature of the software/parameters used, including the fact that the model does not account for the wall being affixed to the adjacent structure, a factor of safety within rounding error is considered acceptable.

The highest retaining wall cross-section was studied as the worst-case scenario. The following parameters were used for the slope stability analysis under static and seismic conditions:

Table 1 - Effective Soil Parameters for Stability Analysis

Soil Layer	Unit Weight (kN/m^3)	Friction Angle (degrees)	Cohesion (kPa)
SAND, some silt	18	35	0
Granular B Type II	21	40	0

The total strength parameters for seismic analysis were chosen based on the geotechnical testing results from the subject site, and are the same as those used above.

Analysis Results

The factor of safety for the retaining wall section was greater than 1.3 for static conditions. Similarly, the results under seismic loading yielded a factor of safety for this section greater than 1.1.

The internal and structural design reviewed the bearing capacity, overturning resistance, and sliding resistance of the retaining wall units. All analysis were found to be acceptable, the worst case scenarios are presented in attached calculation sheets.

Based on these results, the retaining wall design is considered suitable from a geotechnical perspective.

Geotechnical Recommendations

Backfill Material

The retaining wall should be backfilled with free-draining granular backfill materials and incorporate longitudinal drains and weep holes to provide positive drainage of the backfill. For the purpose of this report, it is recommended that the wall be backfilled with either OPSS Granular B Type II or Granular A materials. The backfill should be placed within a wedge-shaped zone defined by a line drawn up and back from the back edge of the base block of the wall at an inclination of 1H:1V or a minimum of 1 m behind the back of the blocks. All material should be compacted to a minimum of 98% of the material's SPMDD.

Drainage

A 100 mm diameter perforated drainage pipe wrapped in geotextile and surrounded on all sides by 150 mm of clear crushed stone, should be installed at the heel of the bottom block. The drainage should have positive drainage to a nearby outlet such as a catch basin or an existing ditch. It is recommended that the outlets be spaced evenly along the retaining wall with a minimum spacing of 30m center to center passing through the wall or connected to a nearby catch basin.

General Recommendations

It is recommended that the following be completed once the retaining wall design and course of action are determined

- Observation of all bearing surfaces prior to backfill;
- Observation of all subgrades prior to placing backfilling materials;
- Observation of the drainage system prior to backfilling;
- Field density tests to ensure the specified level of compaction was achieved;
- Periodic observation of the retaining wall installation, especially at the first course.

A report confirming that these works have been conducted in general accordance with Arcadis's recommendations could be issued upon request, following the completion of a satisfactory material testing and observation program by the geotechnical consultant.

We trust the current memorandum satisfies your immediate requirements.

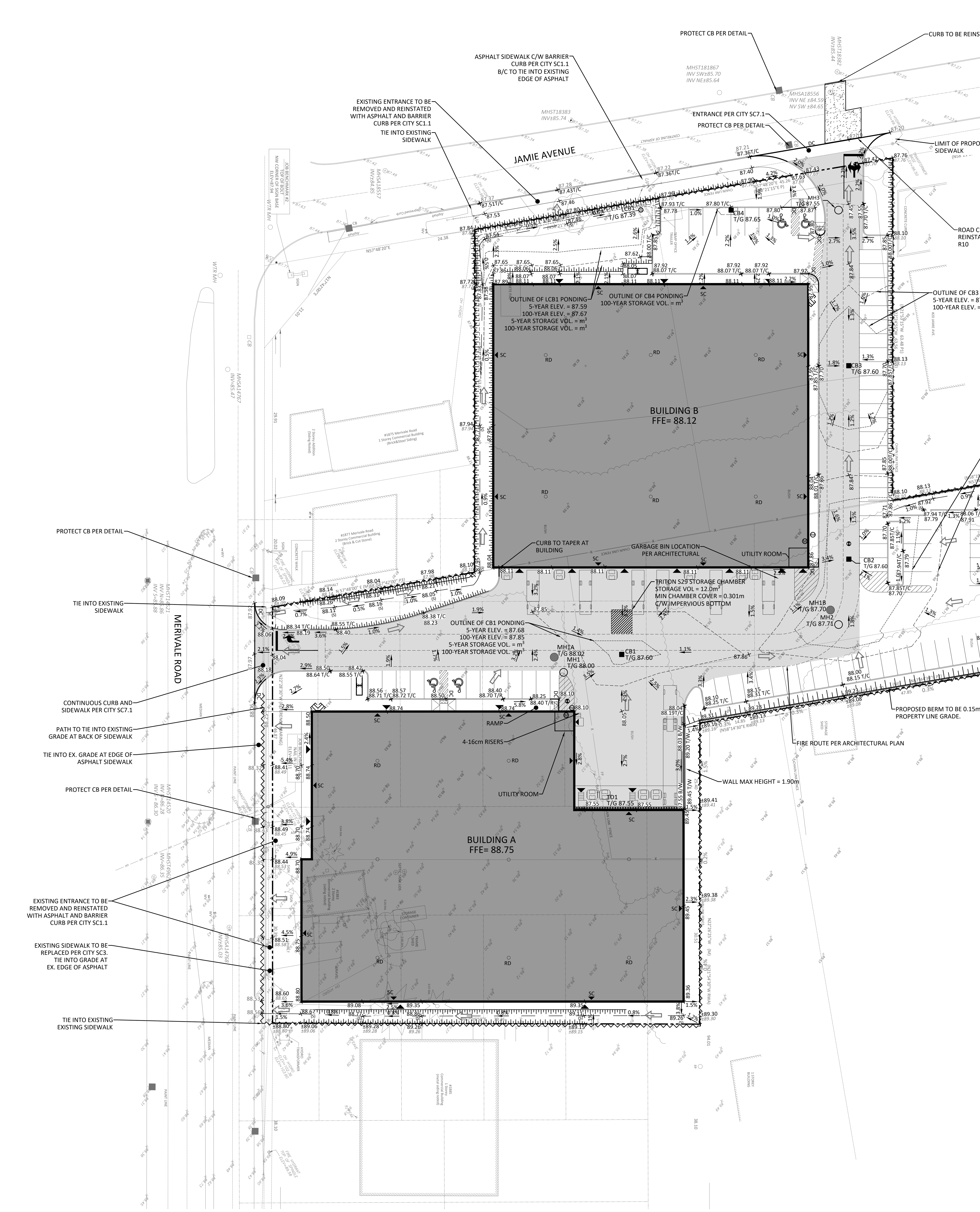
Sincerely,
Arcadis Canada Inc.

Troy Austrins P.Eng., PMP
Resource Manager

Ryan Janzen, P.Eng
Geotechnical Engineer

Enclosures:

- Attachment 1: Drawing C101: Grading, Drainage and Erosion & Sediment and Erosion Control Plan
- Attachment 2: Drawing C-01: Retaining Wall -1; Retaining Wall Design
- Attachment 3: Global Stability Section Plots

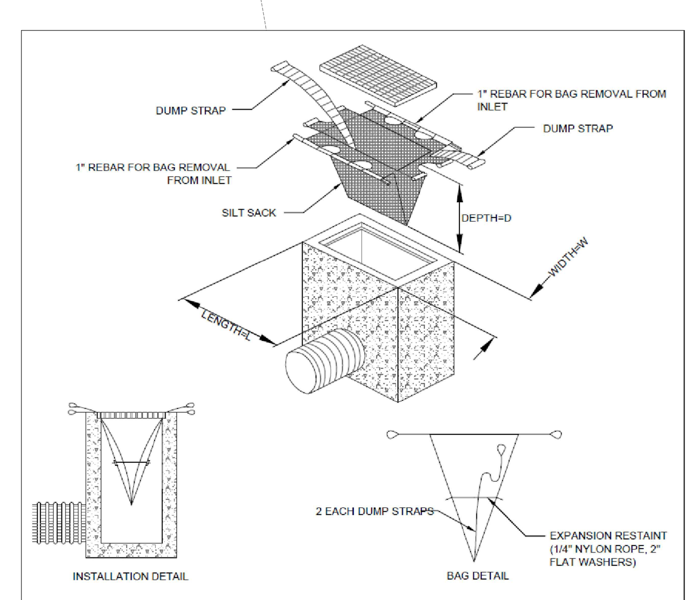


GENERAL NOTES

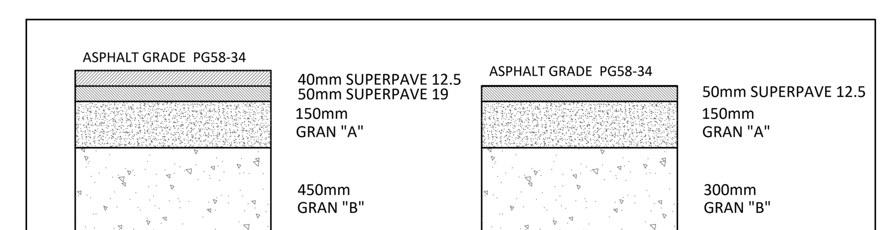
1. THE ORIGINAL TOPOGRAPHY, GROUND ELEVATION AND SURVEY DATA SHOWN ARE SUPPLIED FOR INFORMATION PURPOSES ONLY, AND IMPLY NO GUARANTEE OF ACCURACY. IT SHALL BE THE RESPONSIBILITY OF THE CONTRACTOR TO VERIFY ALL INFORMATION SHOWN.
2. THIS PLAN IS NOT A CADASTRAL SURVEY SHOWING LEGAL PROPERTY BOUNDARIES AND EASEMENTS. THE PROPERTY BOUNDARIES SHOWN HEREON HAVE BEEN DERIVED INFORMATION SUPPLIED BY FAIRHALL MOFFATT & WOODLAND LTD. (JOB NO. AC21300) AND CANNOT BE RELIED UPON TO BE ACCURATE OR COMPLETE. THE PRECISE LOCATION OF THE CURRENT PROPERTY BOUNDARIES AND EASEMENTS CAN ONLY BE DETERMINED BY AN UP-TO-DATE LAND TITLES SEARCH AND A SUBSEQUENT CADASTRAL SURVEY PERFORMED AND CERTIFIED BY AN ONTARIO LAND SURVEYOR.
3. THE CONTRACTOR IS TO OBTAIN AND PAY FOR ALL NECESSARY PERMITS AND APPROVALS FROM THE CITY BEFORE COMMENCING CONSTRUCTION.
4. THE CONTRACTOR IS RESPONSIBLE FOR ALL LAYOUT.
5. THE CONTRACTOR IS TO DETERMINE THE EXACT LOCATION, SIZE, MATERIAL AND ELEVATION OF ALL EXISTING UTILITIES PRIOR TO COMMENCING CONSTRUCTION. PROTECT AND ASSUME ALL RESPONSIBILITY FOR EXISTING UTILITIES WHETHER OR NOT SHOWN ON THESE DRAWINGS. IF THERE IS ANY DISCREPANCY THE CONTRACTOR IS TO NOTIFY THE ENGINEER PROMPTLY.
6. RESTORE ALL TRENCHES AND SURFACES OF PUBLIC ROAD ALLOWANCES TO CONDITION EQUAL OR BETTER THAN ORIGINAL CONDITION AND TO THE SATISFACTION OF THE CITY AUTHORITIES.
7. EXCAVATE AND DISPOSE OF ALL EXCESS EXCAVATED MATERIAL, SUCH AS ASPHALT, CURBING AND DEBRIS, OFF SITE AS DIRECTED BY THE ENGINEER AND THE CITY.
8. ALL DISTURBED AREAS TO BE RESTORED TO ORIGINAL CONDITION OR BETTER UNLESS OTHERWISE SPECIFIED.
9. THE CONTRACTOR SHALL BE RESPONSIBLE FOR ALL TRAFFIC CONTROL AND SAFETY MEASURES DURING THE CONSTRUCTION PERIOD, INCLUDING THE SUPPLY, INSTALLATION, AND REMOVAL OF ALL NECESSARY SIGNAGE, DELINEATORS, MARKERS AND BARRIERS.
10. DO NOT ALTER GRADING OF THE SITE WITHOUT PRIOR APPROVAL OF THE ENGINEER/CITY.
11. ALL ROADWAY, PARKING LOT, AND GRADING WORKS TO BE UNDERTAKEN IN ACCORDANCE WITH CITY STANDARDS AND SPECIFICATIONS. THE CONTRACTOR IS TO PROVIDE POSITIVE DRAINAGE AWAY FROM THE BUILDING.
12. CONTACT THE CITY FOR INSPECTION OF ROUGH GRADING OF PARKING LOTS, ROADWAYS AND LANDSCAPED AREAS PRIOR TO PLACEMENT OF ASPHALT AND TOPSOIL. ALL DEFICIENCIES NOTED SHALL BE RECTIFIED TO THE CITY'S SATISFACTION PRIOR TO PLACEMENT OF ANY ASPHALT, TOPSOIL, SEED & MULCH AND/OR SOD.
13. ALL DIMENSIONS AND INVERTS MUST BE VERIFIED PRIOR TO CONSTRUCTION, IF THERE IS ANY DISCREPANCY THE CONTRACTOR IS TO NOTIFY THE ENGINEER PROMPTLY.
14. ELECTRICAL, GAS, TELEPHONE AND TELEVISION SERVICE LOCATIONS ARE SUBJECT TO THE INDIVIDUAL AGENCY:
    - ELECTRICAL SERVICE - HYDRO OTTAWA,
    - GAS SERVICE - ENBRIDGE,
    - TELEPHONE SERVICE - BELL CANADA,
    - TELEVISION SERVICE - ROGERS.
16. INSTALLATION TO BE IN ACCORDANCE WITH CURRENT CODES AND STANDARDS OF APPROVAL AGENCIES HYDRO OTTAWA, BELL AND THE CITY.
17. CONTRACTOR TO ENSURE ALL APPLICABLE OPS SPECIFICATIONS ARE FOLLOWED DURING CONSTRUCTION
18. ALL PROPOSED CURB TO BE CONCRETE BARRIER CURB UNLESS OTHERWISE SPECIFIED.
19. THIS PLAN MUST BE READ IN CONJUNCTION WITH THE GEOTECHNICAL INVESTIGATION COMPLETED BY ARCADIS, DATED JANUARY 29, 2023

EROSION AND SEDIMENT CONTROL

1. THE CONTRACTOR SHALL IMPLEMENT BEST MANAGEMENT PRACTICES, TO PROVIDE FOR PROTECTION OF THE AREA DRAINAGE SYSTEM AND THE RECEIVING WATERCOURSE, DURING CONSTRUCTION ACTIVITIES. THIS INCLUDES LIMITING THE AMOUNT OF EXPOSED SOIL, TEMPORARY SEDIMENT CONTROL (GEOSOCK INSERTS WITH AN OVERFLOW UNDER GRATE OR COVER) TO BE IMPLEMENTED DURING CONSTRUCTION ON ALL PROPOSED ROAD CATCHBASINS, REARYARD CATCHBASINS AND CATCHBASIN MANHOLES AND OTHER SEDIMENT TRAPS. NO RECYCLED GEOSOCK MATERIAL SHALL BE PERMITTED FOR USE ON SITE.
2. AT THE DISCRETION OF THE PROJECT MANAGER OR MUNICIPAL STAFF, ADDITIONAL SILT CONTROL DEVICES SHALL BE INSTALLED AT DESIGNATED LOCATIONS.
3. FOR SILT FENCE BARRIER, USE OPSD 219.110. GEOTEXTILE FOR SILT FENCE AS PER OPSS 1860, TABLE 3.
4. EXCEPT AS PROVIDED IN PARAGRAPHS 4.1., and 4.2. BELOW, STABILIZATION MEASURES SHALL BE INITIATED AS SOON AS FEASIBLE IN PORTIONS OF THE SITE WHERE CONSTRUCTION ACTIVITIES HAVE TEMPORARILY OR PERMANENTLY CEASED, BUT IN NO CASE MORE THAN 14 DAYS AFTER THE CONSTRUCTION ACTIVITY HAS TEMPORARILY OR PERMANENTLY CEASED.
   - 4.1. WHERE THE INITIATION OF STABILIZATION MEASURES BY THE 14TH DAY AFTER CONSTRUCTION ACTIVITY TEMPORARILY OR PERMANENTLY CEASE IS PRECLUDED BY SNOW COVER, STABILIZATION MEASURES SHALL BE INITIATED AS SOON AS FEASIBLE.
   - 4.2. WHERE CONSTRUCTION ACTIVITY WILL RESUME ON A PORTION OF THE SITE WITHIN 21 DAYS FROM WHEN ACTIVITIES CEASED, (E.G. THE TOTAL TIME PERIOD THAT CONSTRUCTION ACTIVITY IS TEMPORARILY CEASED IS LESS THAN 21 DAYS) THEN STABILIZATION MEASURES DO NOT HAVE TO BE INITIATED ON THAT PORTION OF SITE BY THE 14TH DAY AFTER CONSTRUCTION ACTIVITY TEMPORARILY CEASED.
5. SEDIMENT THAT IS ACCUMULATED BY THE TEMPORARY EROSION AND SEDIMENT CONTROL MEASURES SHALL BE REMOVED IN A MANNER THAT AVOIDS ESCAPE OF THE SEDIMENT TO THE DOWNSTREAM SIDE OF THE CONTROL MEASURE AND AVOIDS DAMAGE TO THE CONTROL MEASURE. SEDIMENT SHALL BE REMOVED TO THE LEVEL OF THE GRADE EXISTING AT THE TIME THE CONTROL MEASURE WAS CONSTRUCTED AND BE ACCORDING TO THE FOLLOWING:
   - 5.1. FOR LIGHT-DUTY SEDIMENT BARRIERS, ACCUMULATED SEDIMENT SHALL BE REMOVED ONCE IT REACHES THE LESSER OF THE FOLLOWING:
     - 5.1.1. A DEPTH OF ONE-HALF THE EFFECTIVE HEIGHT OF THE CONTROL MEASURE.
     - 5.1.2. A DEPTH OF 300 MM IMMEDIATELY UPSTREAM OF THE CONTROL MEASURE.
   - 5.2. FOR ALL CONTROL MEASURES, ACCUMULATED SEDIMENT SHALL BE REMOVED AS NECESSARY TO PERFORM MAINTENANCE REPAIRS.
   - 5.3. ACCUMULATED SEDIMENT SHALL BE REMOVED PRIOR TO THE REMOVAL OF THE CONTROL MEASURE.
   - 5.4. ACCUMULATED SEDIMENT IS TO BE REMOVED AND DISPOSED OF AS PER OPSS 180.
6. ALL TEMPORARY EROSION AND SEDIMENT CONTROL MEASURES SHALL BE MONITORED TO ENSURE THEY ARE IN EFFECTIVE WORKING ORDER. THE CONDITION OF THE CONTROL MEASURES SHALL BE MONITORED PRIOR TO ANY FORECAST STORM EVENT AND FOLLOWING A STORM EVENT.
7. DUST CONTROL MEASURES SHOULD BE CONSIDERED PRIOR TO CLEARING AND GRADING. THE USE OF WATER, CALCIUM CHLORIDE FLAKES/SOLUTION OR MAGNESIUM CHLORIDE FLAKES/SOLUTION SHALL BE USED AS DUST SUPPRESSANTS AS PER OPSS 506. THIS IS TO LIMIT WIND EROSION OF SOILS WHICH MAY TRANSPORT SEDIMENTS OFFSITE, WHERE THEY MAY BE WASHED INTO THE RECEIVING WATER BY THE NEXT RAINSTORM.
8. ALL 'GREEN AREAS' TO BE TREATED WITH 150mm TOPSOIL AND HYDROSEEDING AS SOON AS FEASIBLE, AS PER OPSS 570.
9. TOPSOIL TO BE STRIPPED. CLEAN FILL TO BE PLACED IN FILL AREAS AND COMPACTED TO 95% STANDARD PROCTOR DENSITY.
10. ALL DISTURBED AREAS TO BE RESTORED TO ORIGINAL CONDITION OR BETTER UNLESS OTHERWISE SPECIFIED.
11. STOCKPILED MATERIAL IS TO BE STORED AWAY FROM POTENTIAL RECEIVERS (E.G. STORM CATCHBASINS, MANHOLES), AND BE SURROUNDED BY EROSION CONTROL MEASURES WHERE MATERIAL IS LEFT IN PLACE IN EXCESS OF 14 DAYS.
12. IF REQUIRED, DEWATERING/SETTLING BASINS SHALL BE CONSTRUCTED AS PER OPSD 219.240 AND LOCATED ON FLAT GRADE UPSTREAM OF OTHER EXISTING MITIGATION MEASURES. WATERCOURSES SHALL NOT BE DIVERTED, OR BLOCKED, AND TEMPORARY WATERCOURSES CROSSINGS SHALL NOT BE CONSTRUCTED OR UTILIZED, UNLESS OTHERWISE SPECIFIED IN THE CONTRACT. IF CLOSURE OF ANY PERMANENT WATER PASSAGE IS NECESSARY, THE CONTRACTOR SHALL RELEASE ANY STRANDED FISH TO THE OPEN PORTION OF THE WATERCOURSE WITHOUT HARM.
13. ALL EROSION AND SEDIMENT CONTROL MEASURES SHALL CONFORM TO OPSS 577
14. WHERE DEWATERING IS REQUIRED, THE DISCHARGED WATER SHALL BE CONTROLLED IN ACCORDANCE WITH OPSS 518.
15. ALL SETTLING/FILTRATION BASINS SHALL BE EQUIPPED WITH TERRAFIX 270R GEOTEXTILE (OR APPROVED EQUIVALENT) AND SHALL BE CLEANED AND REPLACED AS REQUIRED



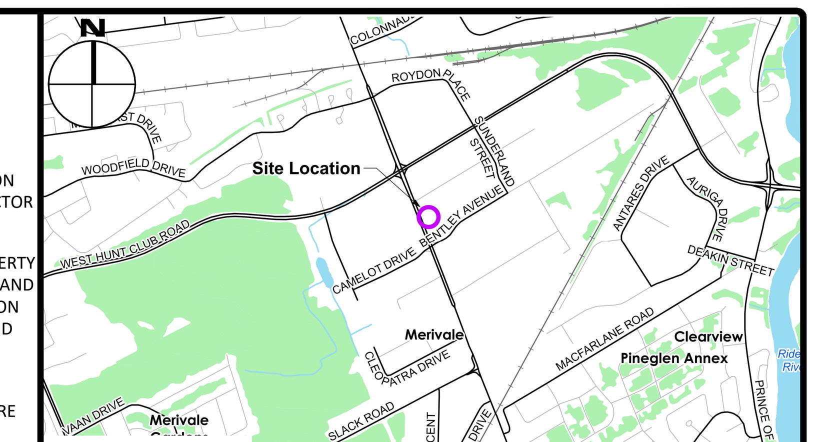
INLET SEDIMENT CONTROL DEVICE
N.T.S.



HEAVY DUTY PAVEMENT CROSS-SECTION
NOT TO SCALE

PARKING AREA PAVEMENT CROSS-SECTION
NOT TO SCALE

ASPHALT CROSS-SECTIONS TO CONFORM TO GEOTECHNICAL REPORT COMPLETED BY ARCADIS, DATED JANUARY 29, 2023



LOCATION PLAN

LEGEND

- PROPERTY LINE
- BARRIER CURB & CURB DEPRESSION
- PROPOSED HEAVY DUTY ASPHALT
- PROPOSED CONCRETE WALKWAY
- STORM MANHOLE
- CATCHBASIN, CURB INLET OR DITCH INLET
- SANITARY MANHOLE
- PERFORATED PIPE
- WATER VALVE/CHAMBER
- FIRE HYDRANT
- PROPOSED WALL
- SEDIMENT CONTROL DEVICE PER DETAIL
- ROADCUT AND REINSTATEMENT PER CITY R10
- SERVICE/WATERMAIN BEND
- SERVICE/SEWER CROSSING LOCATION
- CENTRELINE OF SWALE
- CENTRELINE OF DITCH
- SLOPING AT 3:1 UNLESS SPECIFIED
- 95.94 / 93.20 PROPOSED ELEVATION / EXISTING ELEVATION
- 95.94 SWALE ELEVATION
- T/W=100.50 B/W=90.50 TOP/BOTTOM WALL FACE ELEVATIONS
- EMERGENCY OVERLAND FLOW ROUTE
- SILT FENCE BARRIER PER OPSD 219.110
- BUILDING ENTRANCE OVERHEAD DOOR
- REDUCER
- LOCATION OF TWSI PER ARCHITECTURAL
- LOCATION OF SIAMESE CONNECTION
- LOCATION OF ROOF DRAIN
- LOCATION OF SCUPPER
- LOCATION OF PROPOSED ASPHALT SIDEWALK C/W BARRIER CURB PER SC1.1

FOR REVIEW ONLY
NOT FOR CONSTRUCTION

No.	Revisions	Date
1	ISSUED FOR SITE PLAN CONTROL	FEB 13, 2023

Check and verify all dimensions before proceeding with the work — Do not scale drawings

SCALE 1 : 400
0 10 20 30 40 Metres

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Stamp:

Client:
Z.V. HOLDINGS CORP.
1801 WOODWARD DRIVE
OTTAWA, ON K2C 0R3

Project:
WAREHOUSE DEVELOPMENT
1881 MERIVALE ROAD
OTTAWA ON

Drawing Title:
GRADING, DRAINAGE AND EROSION & SEDIMENT CONTROL PLAN

Scale: 1:400	Project Number: CCO-23-1150
Drawn By: R.R.R.	
Checked By: R.D.F.	Drawing Number: C101
Designed By: R.R.R.	

D07-12-XX-XXXX

#XXXXX

FILENAME: U:\Infrastructure\2023\CCO-23-1150 Amon Dev 1881 Merivale Road\12 - Drawings\CCO-23-1150_PRESENTATION.dwg
LAST SAVED: Thursday, February 16, 2023 LAST SAVED BY: rrobineau
LAST PLOTTED: Thursday, May 18, 2023 CTB FILE USED: ----

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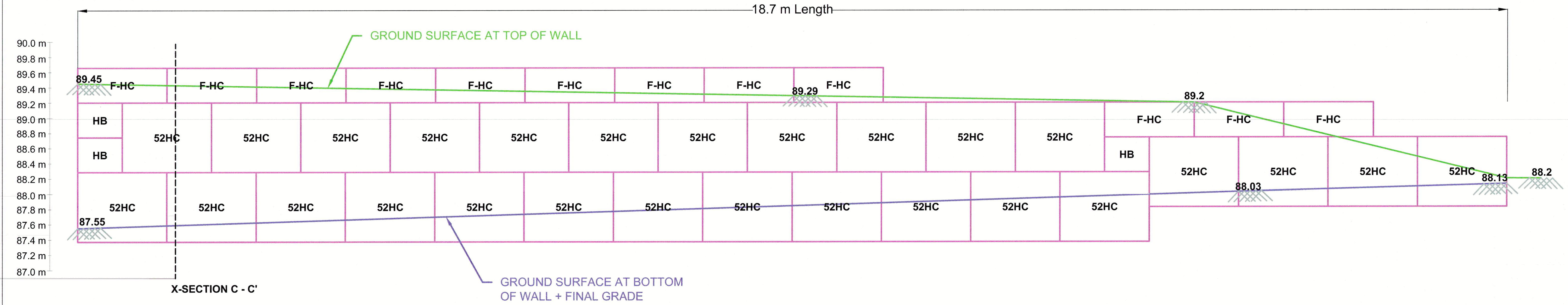
PROFILE VIEW
SCALE 1 : 30



KEY PLAN
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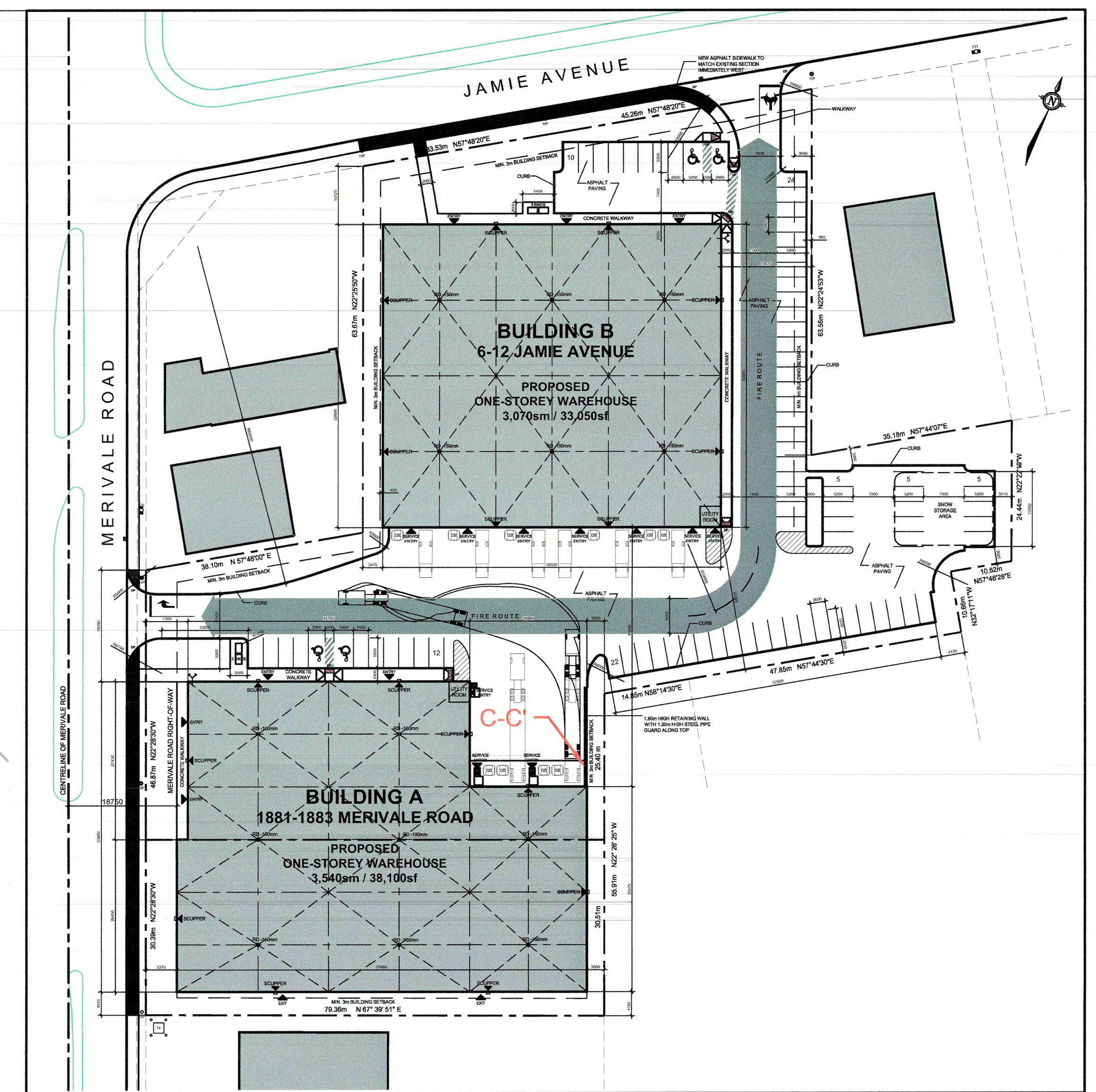
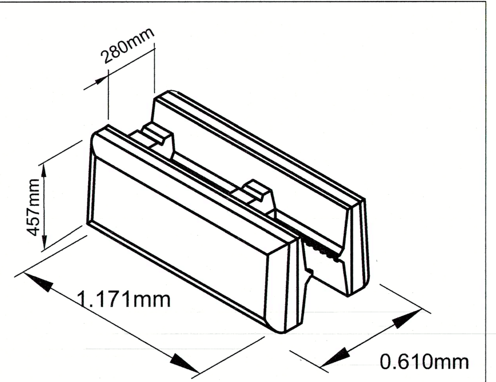
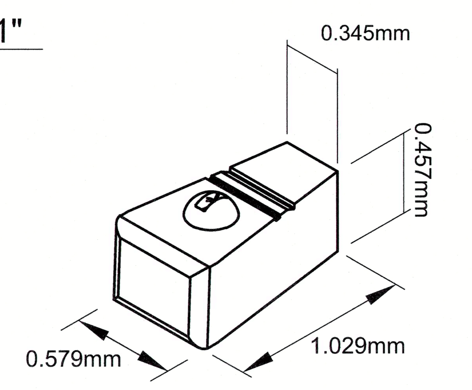


Free-Standing Hollow Core (F-HC)



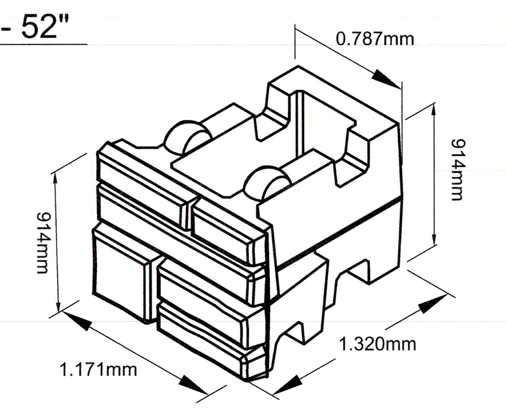
12 UNITS

Half Bottom - 41" (HB)



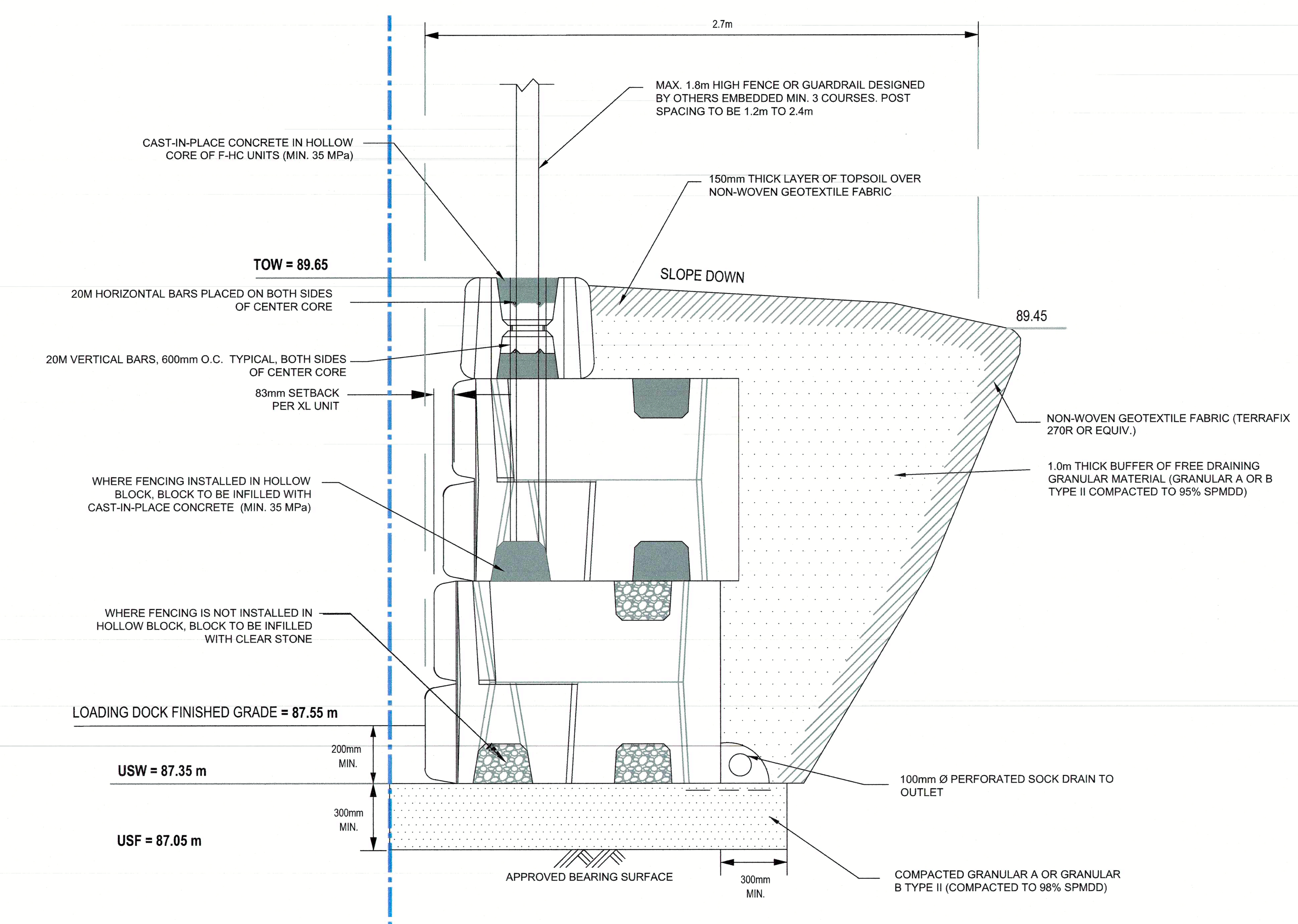
3 UNITS

XL Hollow Core - 52" (52 HC)



27 UNITS

CROSS SECTION C-C:
SCALE 1:35



NOTES:

1. THE CONTRACTOR IS SOLELY RESPONSIBLE FOR UTILITY CLEARANCES AND CONSTRUCTION SITE SAFETY. ARCADIS 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	21 kN/m^3	18 kN/m^3
COHESION - C	0 kPa	0 kPa
SOIL TYPE	OPSS GRANULAR B TYPE II	POORLY GRADED SAND, FINE GRAINED, LIGHT GREY, MEDIUM DENSITY, SOME SILT {SPT=10}

MATERIAL PROPERTIES ARE BASED ON SITE EVALUATION BY ARCADIS AND DISCUSSIONS WITH CONTRACTOR. SEISMIC LOADIN GWAS EVALUATED ACCORDING TO THE CURRENT NBCC WITH A PEAK GROUND ACCELERATION VALUE OF 0.303.

3. DESIGN ELEVATIONS WERE BASED ON GRADING PLAN PROVIDED BY MCROBIE ARCHITECTS, DATED 9 MAY 2023. WALL BASE DESIGN ASSUMES A BEARING RESISTANCE AT SLS OF 100 KPA ON MEDIUM DENSITY SAND. ARCADIS 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 1.3 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 HEREIN. 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 ARCADIS 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 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 10.0m ON CENTRES. 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.
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 ARCADIS ONCE THE WALL CONSTRUCTION IS COMPLETED AND REVIEWED BY ARCADIS DURING CONSTRUCTION, A CERTIFICATE LETTER WILL BE ISSUED BY ARCADIS.
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 ARCADIS RECOMMENDATIONS.
18. THE CONTRACTOR SHOULD REFER TO THE INSTALLATION MANUAL PROVIDED FOR THE RETAINING WALL BLOCK TYPE PROVIDED HEREIN FOR ADDITIONAL DETAILS ON ACCEPTABLE INSTALLATION PRACTICES.

SCALE(S) AS INDICATED

THIS BAR REPRESENTS ONE INCH ON THE ORIGINAL DRAWING: USE TO VERIFY FIGURE REPRODUCTION SCALE

No.	Date	Revisions	By	Ckd

Professional Engineer's Name: Ryan V. Janzen
Professional Engineer's No.: 100209056
Province: ON | Date Signed: 7 June 2023 | Project Mgr.: RVJ
Designed by: RVJ | Drawn by: BYR | Checked by: TA

LICENSED PROFESSIONAL ENGINEER 2023.06.07 R. V. JANZEN 100209056 PROVINCE OF ONTARIO

ARCADIS
ARCADIS CANADA, INC.

HP URBAN/ ZV HOLDINGS CORPORATION. • 1881/1883 MERIVALE ROAD, OTTAWA
RETAINING WALL DESIGN

RETAINING WALL - 1

ARCADIS Project No. 30127480
Date 31 MAY 2023

Arcadis Canada Inc.
Suite 500, 333 Preston Street
Ottawa ON K1S 5N4 Canada
TEL. 613-703-3035

C-01

Analysis of Redi Rock wall

Input data (Stage of construction 1)

Task : Global Stability
Part : 1881 Merivale Development_Geotech
Description : Truck Bay Retaining Wall
Customer : ZV Holdings Corp.
Author : Ryan Janzen, P.Eng.
Date : 2023-05-17
Project ID : Merivale Geotech Consult
Project number : 30127480

Settings

USA - LRFD

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

No.	Description	Height h [mm]	Width w [mm]	Unit weight γ [kN/m³]
7	Top block 28	457.2	711.2	18.85
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 R-5236 HC	2	82.6
2	Top block 24 straight	1	-

Base

Geometry

Upper setback a_1 = 0.15 m
Lower setback a_2 = 0.30 m
Height h = 0.30 m
Width b = 1.90 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	SAND, some silt, trace clay		35.00	0.00	18.00	9.00	25.00
2	Granular		40.00	0.00	21.00	12.00	30.00

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

Soil parameters

SAND, some silt, trace clay

Unit weight :	γ = 18.00 kN/m³
Stress-state :	effective
Angle of internal friction :	φ_{ef} = 35.00 °
Cohesion of soil :	c_{ef} = 0.00 kPa
Angle of friction struc.-soil :	δ = 25.00 °
Saturated unit weight :	γ_{sat} = 19.00 kN/m³

Granular

Unit weight :	γ = 21.00 kN/m³
Stress-state :	effective
Angle of internal friction :	φ_{ef} = 40.00 °
Cohesion of soil :	c_{ef} = 0.00 kPa
Angle of friction struc.-soil :	δ = 30.00 °
Saturated unit weight :	γ_{sat} = 22.00 kN/m³

Backfill

Assigned soil : Granular
Slope = 45.00 °

Geological profile and assigned soils

No.	Thickness of layer t [m]	Depth z [m]	Assigned soil	Pattern
1	2.29	0.00 .. 2.29	SAND, some silt, trace clay	
2	-	2.29 .. ∞	SAND, some silt, trace 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	5.00		1.00	0.30	on terrain

No.	Name
1	Pedestrians

Resistance on front face of the structure

Resistance on front face of the structure: not considered
Soil on front face of the structure - Granular

Soil thickness in front of structure h = 0.50 m

Terrain in front of structure is flat.

Applied forces acting on the structure

No.	Force new	Force edit	Name	Action	F_x [kN/m]	F_z [kN/m]	M [kNm/m]	x [m]	z [m]
1	Yes		Fence Load	permanent	0.00	3.00	0.00	-0.30	0.00

Settings of the stage of construction

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

Verification No. 1 (Stage of construction 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	-1.07	57.40	0.98	1.000	1.000	1.000
Weight - earth wedge	0.00	-0.48	1.60	1.72	1.000	1.000	1.000
Weight - earth wedge	0.00	-2.35	5.14	1.33	1.000	1.000	1.000
Active pressure	13.69	-0.80	15.86	1.76	1.000	1.000	1.000
Pedestrians	0.47	-1.64	0.25	1.68	1.000	1.000	1.000
Fence Load	0.00	-2.59	3.00	0.77	1.000	1.000	1.000

Verification of complete wall

Check for overturning stability
Resisting moment M_{res} = 96.30 kNm/m
Overturning moment M_{ovr} = 11.75 kNm/m

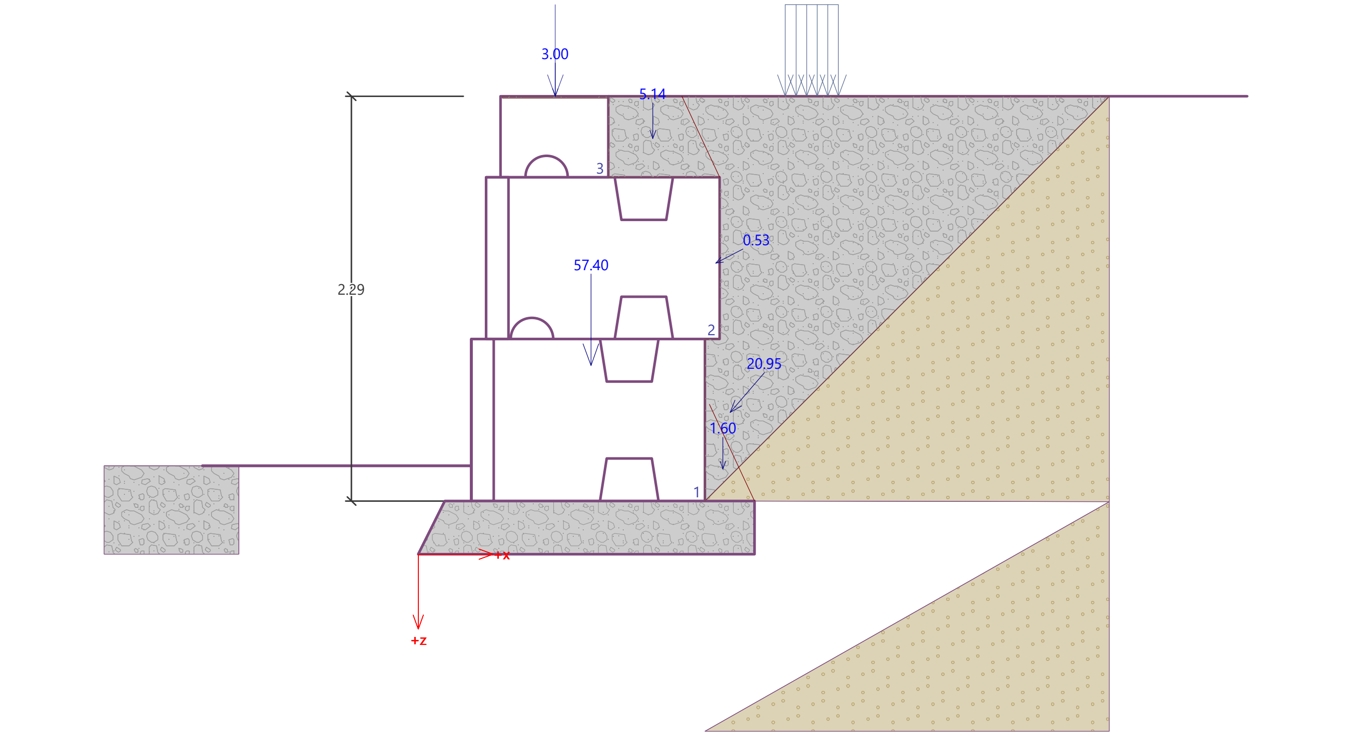
Capacity demand ratio CDR = 8.19
Wall for overturning is SATISFACTORY

Check for slip
Resisting horizontal force H_{res} = 58.29 kN/m
Active horizontal force H_{act} = 14.17 kN/m

Capacity demand ratio CDR = 4.11
Wall for slip is SATISFACTORY

Overall check - WALL is SATISFACTORY

Name : Verification	Stage - analysis : 1 - 1
Description : Initial	



Dimensioning No. 1 (Stage of construction 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	-1.01	45.43	0.68	1.000	1.000	1.000
Weight - earth wedge	0.00	-2.05	5.14	1.03	1.000	1.000	1.000
Active pressure	9.07	-0.78	5.48	1.35	1.000	1.000	1.000
Pedestrians	0.47	-1.34	0.25	1.38	1.000	1.000	1.000
Fence Load	0.00	-2.29	3.00	0.47	1.000	1.000	1.000

Verification of block No. 1

Check for overturning stability

Resisting moment M_{res} = 45.45 kNm/m
Overturning moment M_{ovr} = 7.69 kNm/m

Capacity demand ratio CDR = 5.91
Joint for overturning stability is SATISFACTORY

Check for slip

Resisting horizontal force H_{res} = 49.75 kN/m
Active horizontal force H_{act} = 9.54 kN/m

Capacity demand ratio CDR = 5.21
Joint for verification is SATISFACTORY

Bearing capacity of foundation soil (Stage of construction 1)

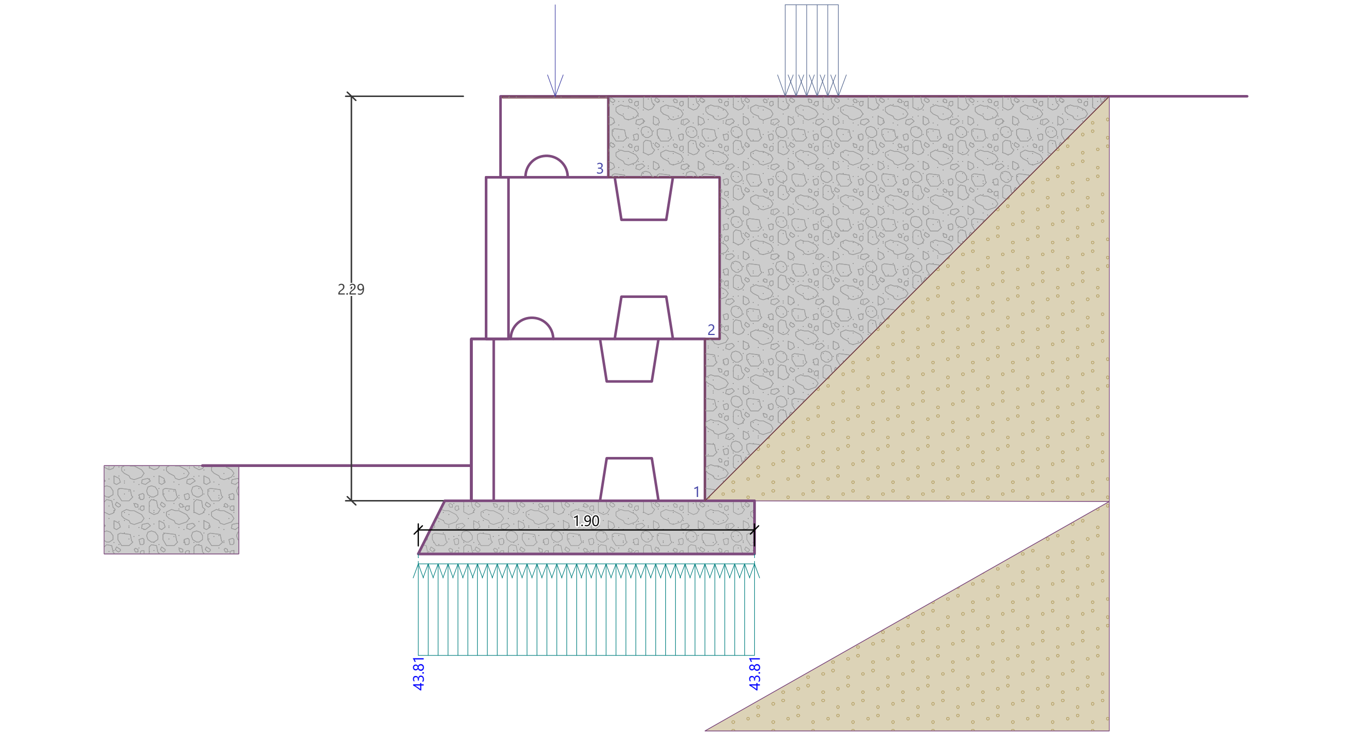
Design load acting at the center of footing bottom

No.	Moment [kNm/m]	Norm. force [kN/m]	Shear Force [kN/m]	Eccentricity [–]	Stress [kPa]
1	-5.46	83.25	14.17	0.000	43.81

Service load acting at the center of footing bottom

No.	Moment [kNm/m]	Norm. force [kN/m]	Shear Force [kN/m]
1	-5.46	83.25	14.17

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



Slope stability analysis

Input data (Construction stage 1)

Settings

USA - LRFD

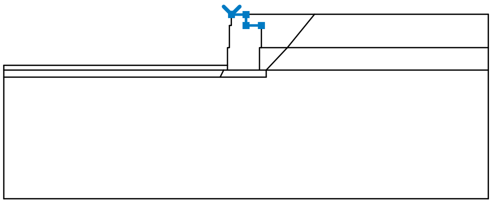
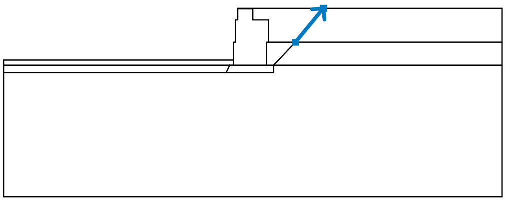
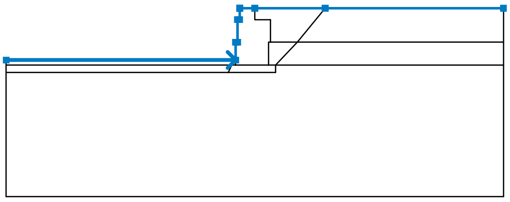
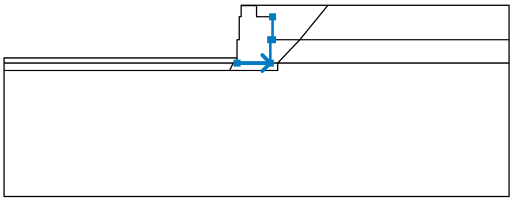
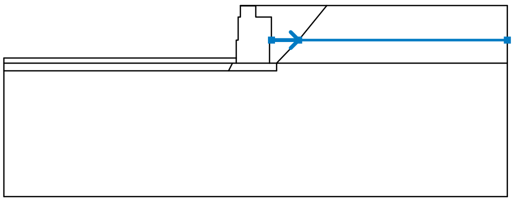
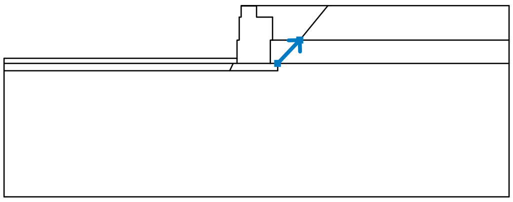
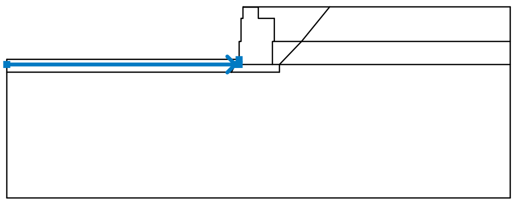
Stability analysis

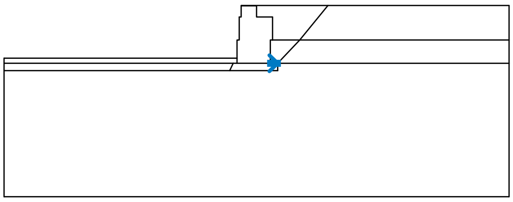
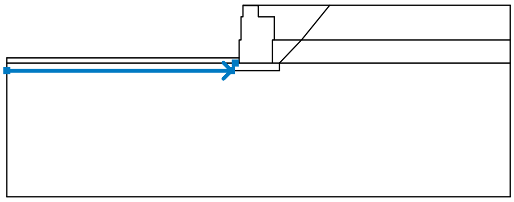
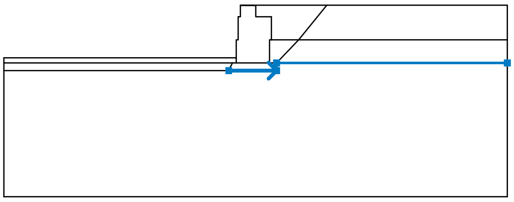
Verification methodology : according to LRFD
Earthquake analysis : Standard

Load factors			
Design situation - Service I			
		Minimum	Maximum
Earth surcharge load (permanent) :	ES =	1.00 [–]	1.00 [–]
Live load surcharge :	LL =	0.00 [–]	1.00 [–]

Resistance factors		
Design situation - Service I		
Resistance factor on stability :	ϕ_{SS} =	0.65 [–]

Interface

No.	Interface location	Coordinates of interface points [m]					
		x	z	x	z	x	z
1		-0.60	0.00	-0.60	-0.01	0.00	-0.01
		0.00	-0.46	0.63	-0.46		
2		1.71	-1.37	2.83	0.00		
3		-10.00	-2.09	-0.77	-2.09	-0.77	-1.37
		-0.69	-1.37	-0.69	-0.46	-0.61	-0.46
		-0.61	0.00	-0.60	0.00	0.00	0.00
		2.83	0.00	10.00	0.00		
4		-0.77	-2.29	0.55	-2.29	0.55	-1.37
		0.63	-1.37	0.63	-0.46		
5		0.63	-1.37	1.71	-1.37	10.00	-1.37
6		0.83	-2.29	1.71	-1.37		
7		-10.00	-2.29	-0.92	-2.29	-0.77	-2.29
		-0.77	-2.09				

No.	Interface location	Coordinates of interface points [m]					
		x	z	x	z	x	z
8		0.55	-2.29	0.83	-2.29		
9		-10.00	-2.59	-1.07	-2.59	-0.92	-2.29
10		-1.07	-2.59	0.83	-2.59	0.83	-2.29
		10.00	-2.29				

Soil parameters - effective stress state

No.	Name	Pattern	φ_{ef} [°]	c_{ef} [kPa]	γ [kN/m^3]
1	SAND, some silt, trace clay		35.00	0.00	18.00
2	Granular		40.00	0.00	21.00

Soil parameters - uplift

No.	Name	Pattern	γ_{sat} [kN/m^3]	γ_s [kN/m^3]	n [–]
1	SAND, some silt, trace clay		19.00		
2	Granular		22.00		

Soil parameters

SAND, some silt, trace clay

Unit weight : γ = 18.00 kN/m^3
Stress-state : effective
Shear strength : Mohr-Coulomb
Angle of internal friction : φ_{ef} = 35.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 19.00 kN/m^3

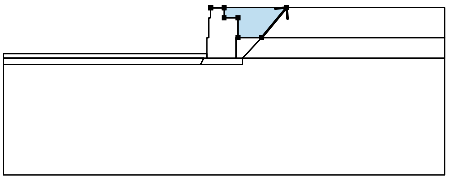
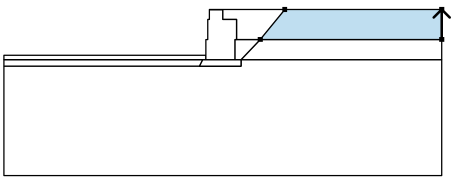
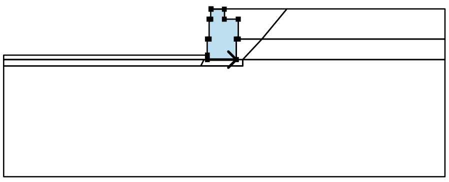
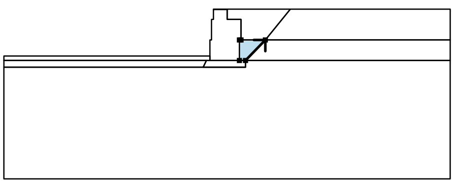
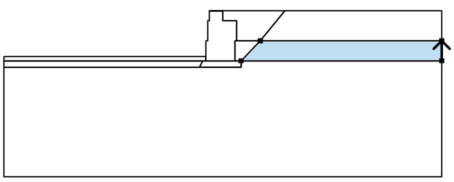
Granular

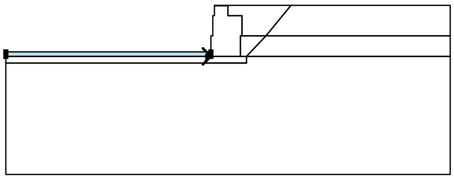
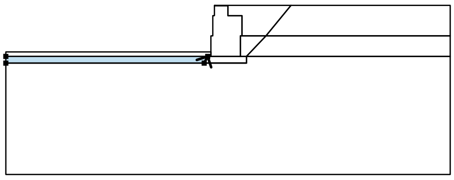
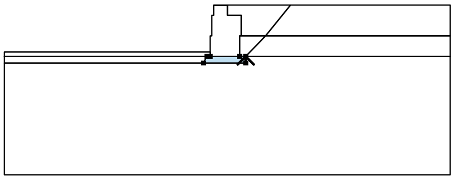
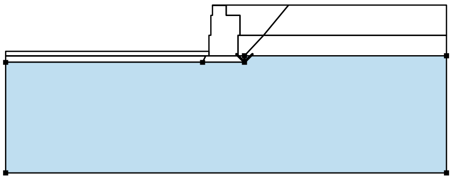
Unit weight :	γ = 21.00 kN/m^3
Stress-state :	effective
Shear strength :	Mohr-Coulomb
Angle of internal friction :	φ_{ef} = 40.00 °
Cohesion of soil :	c_{ef} = 0.00 kPa
Saturated unit weight :	γ_{sat} = 22.00 kN/m^3

Rigid Bodies

No.	Name	Sample	γ [kN/m^3]
1	Material of structure		18.85

Assigning and surfaces

No.	Surface position	Coordinates of surface points [m] x	z	x	z	Assigned soil
1		1.71	-1.37	2.83	0.00	Granular
		0.00	0.00	-0.60	0.00	
		-0.60	-0.01	0.00	-0.01	
		0.00	-0.46	0.63	-0.46	
		0.63	-1.37			
2		10.00	-1.37	10.00	0.00	SAND, some silt, trace clay
		2.83	0.00	1.71	-1.37	
3		-0.77	-2.29	0.55	-2.29	Material of structure
		0.55	-1.37	0.63	-1.37	
		0.63	-0.46	0.00	-0.46	
		0.00	-0.01	-0.60	-0.01	
		-0.60	0.00	-0.61	0.00	
		-0.61	-0.46	-0.69	-0.46	
		-0.69	-1.37	-0.77	-1.37	
		-0.77	-2.09			
4		0.83	-2.29	1.71	-1.37	Granular
		0.63	-1.37	0.55	-1.37	
		0.55	-2.29			
5		10.00	-2.29	10.00	-1.37	SAND, some silt, trace clay
		1.71	-1.37	0.83	-2.29	

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
6		-0.92 -0.77 -10.00	-2.29 -2.09 -2.29	-0.77 -10.00	-2.29 -2.09	Granular
7		-1.07 -10.00	-2.59 -2.29	-0.92 -10.00	-2.29 -2.59	Granular
8		0.83 0.55 -0.92	-2.59 -2.29 -2.29	0.83 -0.77 -1.07	-2.29 -2.29 -2.59	Granular
9		0.83 -1.07 -10.00 10.00	-2.29 -2.59 -7.59 -2.29	0.83 -10.00 10.00	-2.59 -2.59 -7.59	SAND, some silt, trace clay

Surcharge

No.	Type	Type of action	Location	Origin	Length	Width	Slope	Magnitude		
			z [m]	x [m]	l [m]	b [m]	α [°]	q, q_1, f, F, x	q_2, z	unit
1	strip	variable	on terrain	x = 1.00	l = 0.30		0.00	5.00		kN/m^2

Surcharges

No.	Name
1	Pedestrians

Earthquake

Earthquake not included.

Settings of the stage of construction

Design situation : Service **I**

Results (Construction stage 1)

Analysis 1

Circular slip surface

Slip surface parameters								
Center :	x =	-1.03	[m]	Angles :	α_1 =	-35.12	[°]
	z =	0.83	[m]		α_2 =	76.56	[°]
Radius :	R =	3.57	[m]				
The slip surface after optimization.							

Total weight of soil above the slip surface: 145.52 kN/m

Slope stability verification (Bishop)

Sum of active forces : F_a = 52.63 kN/m

Sum of passive forces : F_p = 113.14 kN/m

Sliding moment : M_a = 187.91 kNm/m

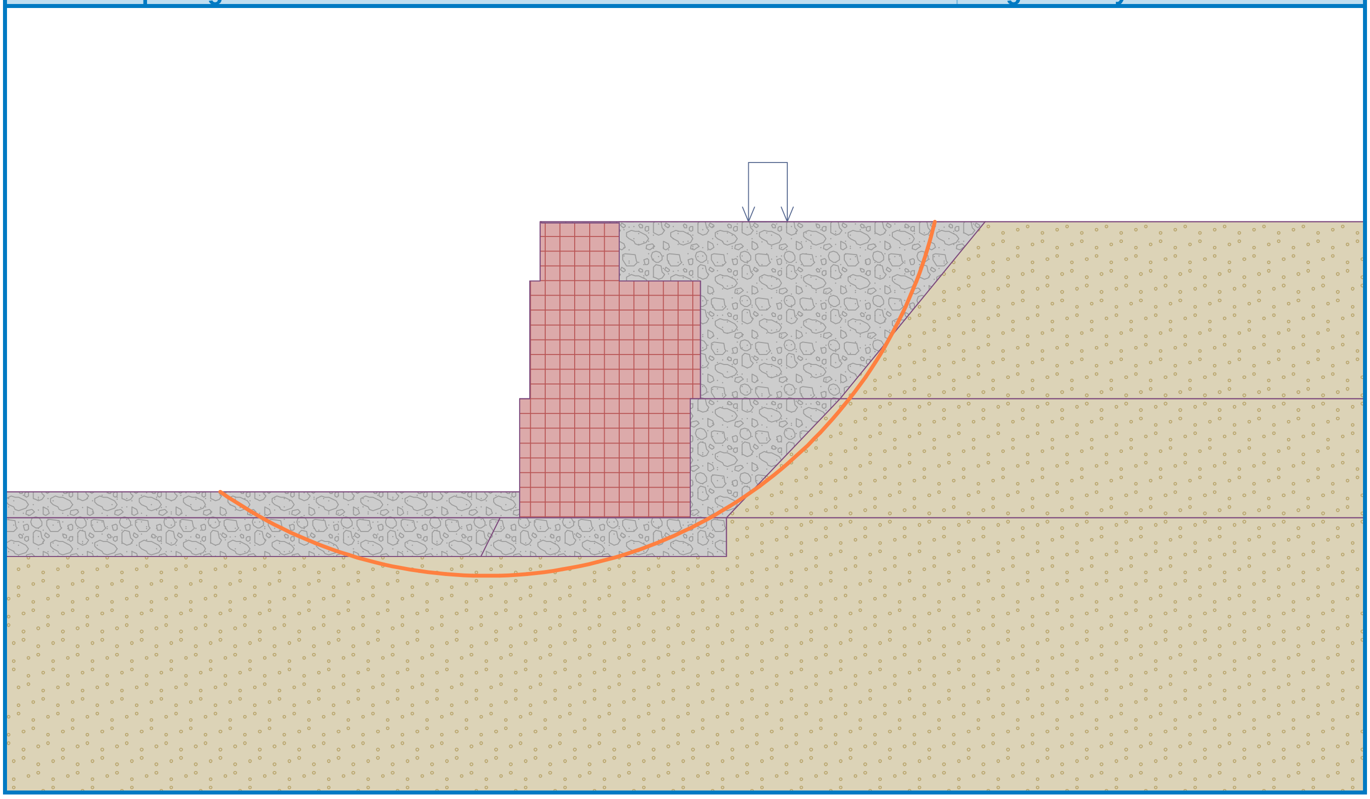
Resisting moment : M_p = 262.53 kNm/m

Utilization : 71.6 %

Capacity demand ratio CDR: 1.397

Slope stability ACCEPTABLE

Name : Slip Stage 1 **Stage - analysis : 1 - 1**



Input data (Stage of construction 2)

Geological profile and assigned soils

No.	Thickness of layer t [m]	Depth z [m]	Assigned soil	Pattern
1	2.29	0.00 .. 2.29	SAND, some silt, trace clay	
2	-	2.29 .. ∞	SAND, some silt, trace clay	

Terrain profile

Terrain behind the structure is flat.

Water influence

Ground water table is located below the structure.

Resistance on front face of the structure

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

Terrain in front of structure is flat.

Applied forces acting on the structure

No.	Force new	Force edit	Name	Action	F_x [kN/m]	F_z [kN/m]	M [kNm/m]	x [m]	z [m]
1	No	No	Fence Load	permanent	0.00	3.00	0.00	-0.30	0.00

Earthquake

Factor of horizontal acceleration K_h = 0.1515
Factor of vertical acceleration K_v = 0.0000

Water below the GWT is restricted.
Combination 1 - Seismic load reduction factor $p_{1,ir}$ = 0.50
Combination 1 - Earth pressure reduction factor $p_{1,ae}$ = 1.00
Combination 2 - Seismic load reduction factor $p_{2,ir}$ = 1.00
Combination 2 - Earth pressure reduction factor $p_{2,ae}$ = 0.50

Settings of the stage of construction

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

Verification No. 1 (Stage of construction 2)

Forces acting on construction - combination 1

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	-1.07	57.40	0.98	1.000	1.000	1.000
Earthq.- constr.	8.84	-1.12	0.00	0.97	0.500	0.500	0.500
FF resistance	-0.94	-0.17	0.01	-0.15	1.000	1.000	1.000
Weight - earth wedge	0.00	-0.48	1.60	1.72	1.000	1.000	1.000
Earthquake - soil wedge	0.24	-0.48	0.00	1.72	0.500	0.500	0.500
Weight - earth wedge	0.00	-2.35	5.14	1.33	1.000	1.000	1.000
Earthquake - soil wedge	0.78	-2.35	0.00	1.33	0.500	0.500	0.500
Active pressure	13.69	-0.80	15.86	1.76	1.000	1.000	1.000
Earthq.- act.pressure	5.82	-1.75	7.37	1.64	1.000	1.000	1.000
Fence Load	0.00	-2.59	3.00	0.77	1.000	1.000	1.000

Verification of complete wall

Check for overturning stability
Resisting moment M_{res} = 107.96 kNm/m
Overturning moment M_{ovr} = 26.94 kNm/m

Capacity demand ratio CDR = 4.01
Wall for overturning is SATISFACTORY

Check for slip
Resisting horizontal force H_{res} = 63.28 kN/m
Active horizontal force H_{act} = 23.50 kN/m

Capacity demand ratio CDR = 2.69
Wall for slip is SATISFACTORY

Overall check - WALL is SATISFACTORY

Forces acting on construction - combination 2

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	-1.07	57.40	0.98	1.000	1.000	1.000
Earthq.- constr.	8.84	-1.12	0.00	0.97	1.000	1.000	1.000
FF resistance	-0.94	-0.17	0.01	-0.15	1.000	1.000	1.000
Weight - earth wedge	0.00	-0.48	1.60	1.72	1.000	1.000	1.000
Earthquake - soil wedge	0.24	-0.48	0.00	1.72	1.000	1.000	1.000
Weight - earth wedge	0.00	-2.35	5.14	1.33	1.000	1.000	1.000
Earthquake - soil wedge	0.78	-2.35	0.00	1.33	1.000	1.000	1.000
Active pressure	13.69	-0.80	15.86	1.76	0.500	0.500	0.500
Earthq.- act.pressure	5.82	-1.75	7.37	1.64	0.500	0.500	0.500
Fence Load	0.00	-2.59	3.00	0.77	1.000	1.000	1.000

Verification of complete wall

Check for overturning stability

Resisting moment M_{res} = 87.94 kNm/m

Overturning moment M_{ovr} = 22.27 kNm/m

Capacity demand ratio CDR = 3.95

Wall for overturning is SATISFACTORY

Check for slip

Resisting horizontal force H_{res} = 55.15 kN/m

Active horizontal force H_{act} = 18.68 kN/m

Capacity demand ratio CDR = 2.95

Wall for slip is SATISFACTORY

Overall check - WALL is SATISFACTORY

Dimensioning No. 1 (Stage of construction 2)

Forces acting on construction - combination 1

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	-1.01	45.43	0.68	1.000	1.000	1.000
Earthq.- constr.	7.29	-1.03	0.00	0.68	0.500	0.500	0.500
FF resistance	-0.15	-0.07	0.00	0.00	1.000	1.000	1.000
Weight - earth wedge	0.00	-2.05	5.14	1.03	1.000	1.000	1.000
Earthquake - soil wedge	0.78	-2.05	0.00	1.03	0.500	0.500	0.500
Active pressure	9.07	-0.78	5.48	1.35	1.000	1.000	1.000
Earthq.- act.pressure	4.64	-1.56	5.44	1.31	1.000	1.000	1.000
Fence Load	0.00	-2.29	3.00	0.47	1.000	1.000	1.000

Verification of block No. 1

Check for overturning stability

Resisting moment M_{res} = 52.26 kNm/m

Overturning moment M_{ovr} = 18.82 kNm/m

Capacity demand ratio CDR = 2.78

Joint for overturning stability is SATISFACTORY

Check for slip

Resisting horizontal force H_{res} = 54.12 kN/m
Active horizontal force H_{act} = 17.59 kN/m

Capacity demand ratio CDR = 3.08
Joint for verification is SATISFACTORY

Forces acting on construction - combination 2

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	-1.01	45.43	0.68	1.000	1.000	1.000
Earthq.- constr.	7.29	-1.03	0.00	0.68	1.000	1.000	1.000
FF resistance	-0.15	-0.07	0.00	0.00	1.000	1.000	1.000
Weight - earth wedge	0.00	-2.05	5.14	1.03	1.000	1.000	1.000
Earthquake - soil wedge	0.78	-2.05	0.00	1.03	1.000	1.000	1.000
Active pressure	9.07	-0.78	5.48	1.35	0.500	0.500	0.500
Earthq.- act.pressure	4.64	-1.56	5.44	1.31	0.500	0.500	0.500
Fence Load	0.00	-2.29	3.00	0.47	1.000	1.000	1.000

Verification of block No. 1

Check for overturning stability
Resisting moment M_{res} = 44.99 kNm/m
Overturning moment M_{ovr} = 16.21 kNm/m

Capacity demand ratio CDR = 2.78
Joint for overturning stability is SATISFACTORY

Check for slip
Resisting horizontal force H_{res} = 49.53 kN/m
Active horizontal force H_{act} = 14.77 kN/m

Capacity demand ratio CDR = 3.35
Joint for verification is SATISFACTORY

Bearing capacity of foundation soil (Stage of construction 2)

Design load acting at the center of footing bottom

No.	Moment [kNm/m]	Norm. force [kN/m]	Shear Force [kN/m]	Eccentricity [–]	Stress [kPa]
1	4.83	90.37	23.50	0.028	50.40
2	9.15	78.76	18.68	0.061	47.23
3	9.15	78.76	18.68	0.061	47.23

Service load acting at the center of footing bottom

No.	Moment [kNm/m]	Norm. force [kN/m]	Shear Force [kN/m]
1	10.75	90.37	28.43

Slope stability analysis

Input data (Construction stage 1)

Settings

USA - LRFD

Stability analysis

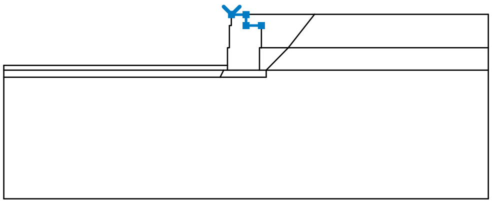
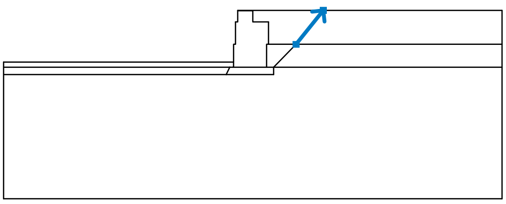
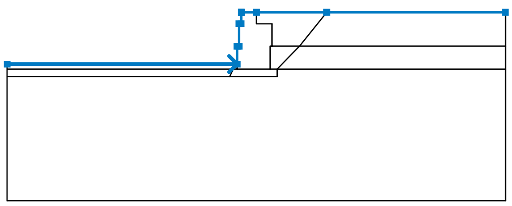
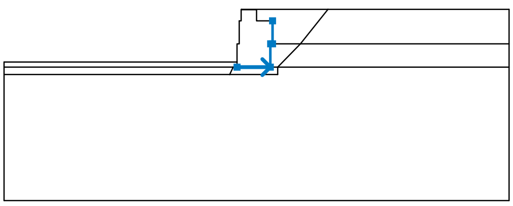
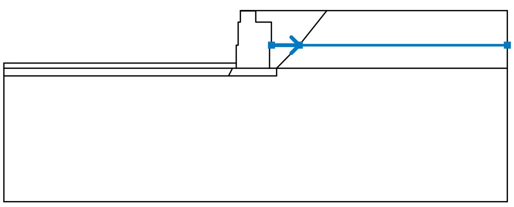
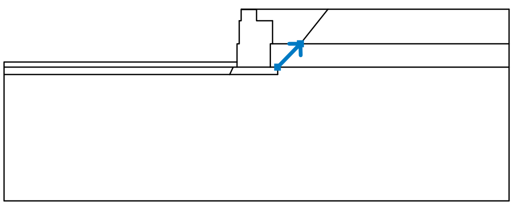
Verification methodology : according to LRFD

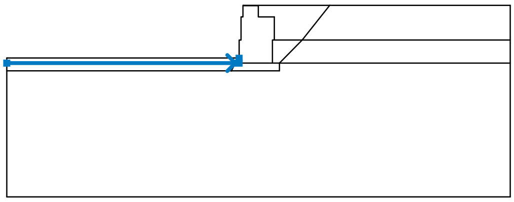
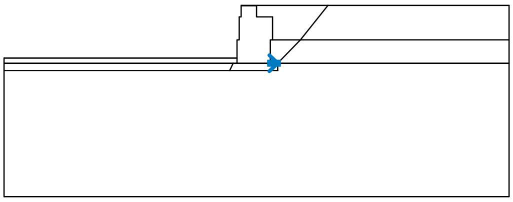
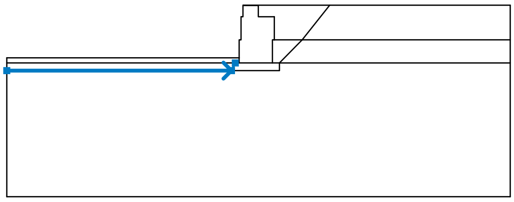
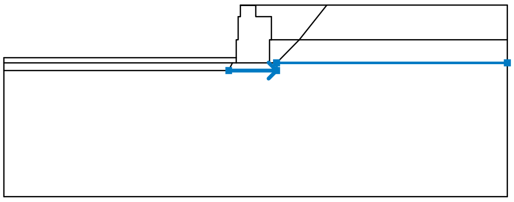
Earthquake analysis : Standard

Load factors						
Design situation - Service I						
		Minimum		Maximum		
Earth surcharge load (permanent) :	ES =	1.00	[–]	1.00	[–]
Live load surcharge :	LL =	0.00	[–]	1.00	[–]

Resistance factors			
Design situation - Service I			
Resistance factor on stability :	ϕ_{SS} =	0.65	[–]

Interface

No.	Interface location	Coordinates of interface points [m]					
		x	z	x	z	x	z
1		-0.60	0.00	-0.60	-0.01	0.00	-0.01
		0.00	-0.46	0.63	-0.46		
2		1.74	-1.37	2.83	0.00		
3		-10.00	-2.09	-0.77	-2.09	-0.77	-1.37
		-0.69	-1.37	-0.69	-0.46	-0.61	-0.46
		-0.61	0.00	-0.60	0.00	0.00	0.00
		2.83	0.00	10.00	0.00		
4		-0.77	-2.29	0.55	-2.29	0.55	-1.37
		0.63	-1.37	0.63	-0.46		
5		0.63	-1.37	1.74	-1.37	10.00	-1.37
6		0.83	-2.29	1.74	-1.37		

No.	Interface location	Coordinates of interface points [m]					
		x	z	x	z	x	z
7		-10.00	-2.29	-0.92	-2.29	-0.77	-2.29
		-0.77	-2.09				
8		0.55	-2.29	0.83	-2.29		
9		-10.00	-2.59	-1.07	-2.59	-0.92	-2.29
10		-1.07	-2.59	0.83	-2.59	0.83	-2.29
		10.00	-2.29				

Soil parameters - effective stress state

No.	Name	Pattern	φ_{ef} [°]	c_{ef} [kPa]	γ [kN/m^3]
1	SAND, some silt, trace clay		35.00	0.00	18.00
2	Granular		40.00	0.00	21.00

Soil parameters - uplift

No.	Name	Pattern	γ_{sat} [kN/m^3]	γ_s [kN/m^3]	n [–]
1	SAND, some silt, trace clay		19.00		
2	Granular		22.00		

Soil parameters

SAND, some silt, trace clay

Unit weight :	γ = 18.00 kN/m^3
Stress-state :	effective
Shear strength :	Mohr-Coulomb
Angle of internal friction :	φ_{ef} = 35.00 °
Cohesion of soil :	c_{ef} = 0.00 kPa
Saturated unit weight :	γ_{sat} = 19.00 kN/m^3

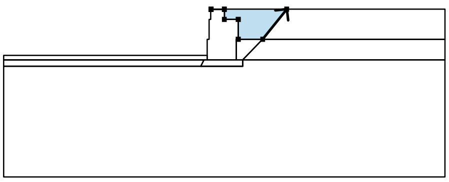
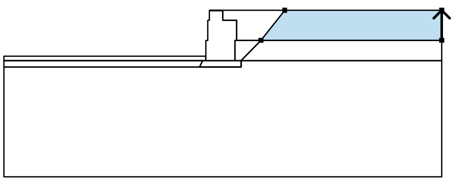
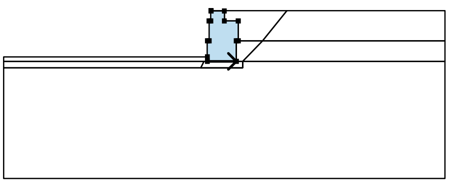
Granular

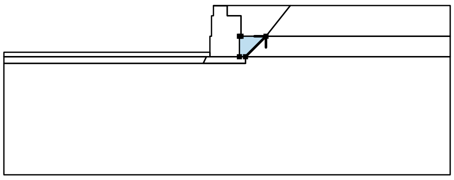
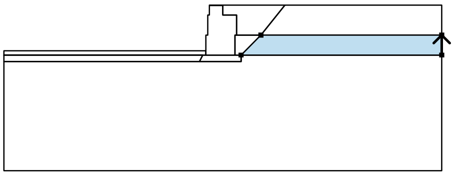
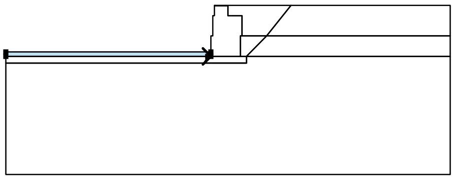
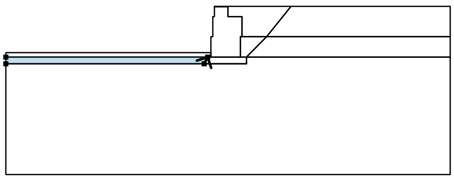
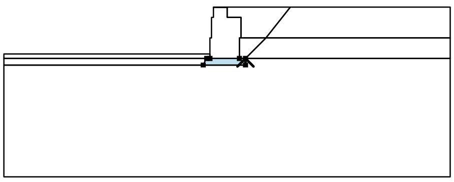
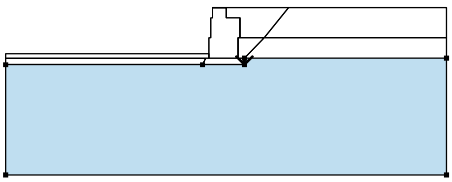
Unit weight :	γ = 21.00 kN/m^3
Stress-state :	effective
Shear strength :	Mohr-Coulomb
Angle of internal friction :	φ_{ef} = 40.00 °
Cohesion of soil :	c_{ef} = 0.00 kPa
Saturated unit weight :	γ_{sat} = 22.00 kN/m^3

Rigid Bodies

No.	Name	Sample	γ [kN/m^3]
1	Material of structure		18.85

Assigning and surfaces

No.	Surface position	Coordinates of surface points [m] x	z	x	z	Assigned soil
1		1.74	-1.37	2.83	0.00	Granular
		0.00	0.00	-0.60	0.00	
		-0.60	-0.01	0.00	-0.01	
		0.00	-0.46	0.63	-0.46	
		0.63	-1.37			
2		10.00	-1.37	10.00	0.00	SAND, some silt, trace clay
		2.83	0.00	1.74	-1.37	
3		-0.77	-2.29	0.55	-2.29	Material of structure
		0.55	-1.37	0.63	-1.37	
		0.63	-0.46	0.00	-0.46	
		0.00	-0.01	-0.60	-0.01	
		-0.60	0.00	-0.61	0.00	
		-0.61	-0.46	-0.69	-0.46	
		-0.69	-1.37	-0.77	-1.37	
		-0.77	-2.09			

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
4		0.83	-2.29	1.74	-1.37	Granular
		0.63	-1.37	0.55	-1.37	
		0.55	-2.29			
5		10.00	-2.29	10.00	-1.37	SAND, some silt, trace clay
		1.74	-1.37	0.83	-2.29	
6		-0.92	-2.29	-0.77	-2.29	Granular
		-0.77	-2.09	-10.00	-2.09	
		-10.00	-2.29			
7		-1.07	-2.59	-0.92	-2.29	Granular
		-10.00	-2.29	-10.00	-2.59	
8		0.83	-2.59	0.83	-2.29	Granular
		0.55	-2.29	-0.77	-2.29	
		-0.92	-2.29	-1.07	-2.59	
9		0.83	-2.29	0.83	-2.59	SAND, some silt, trace clay
		-1.07	-2.59	-10.00	-2.59	
		-10.00	-7.59	10.00	-7.59	
		10.00	-2.29			

Earthquake

Horizontal seismic coefficient : K_h = 0.1515
Vertical seismic coefficient : K_v = 0.0000

Settings of the stage of construction

Design situation : Service I

Results (Construction stage 1)

Analysis 1

Circular slip surface

Slip surface parameters							
Center :	x =	-1.24	[m]	Angles :	α_1 =	-32.07	[°]
	z =	1.52	[m]		α_2 =	69.10	[°]
Radius :	R =	4.26	[m]				
The slip surface after optimization.							

Total weight of soil above the slip surface: 154.93 kN/m

Slope stability verification (Bishop)

Sum of active forces : F_a = 69.39 kN/m

Sum of passive forces : F_p = 113.67 kN/m

Sliding moment : M_a = 295.59 kNm/m

Resisting moment : M_p = 314.75 kNm/m

Utilization : 93.9 %

Capacity demand ratio CDR: 1.065

Slope stability ACCEPTABLE

Name : Slip Stage 2	Stage - analysis : 1 - 1