MacWall Vertica Retaining Wall

Location Address:	Penistone Lane, Feaney Bridge
Geoman Design Reference Number:	24-5915-F1
Maccaferri CRM Project Number:	25-44342

Issued to	Issue purpose	Revision	Designed	Checked	Date
Maccaferri Ltd. for K Haran Civils	For Approval	0	DMCG	GM	25.03.25

Contents

1.0 Introduction

1.1 Brief

Maccaferri Ltd. requested that Geoman Ltd. carry out a design for a MacWall Vertica retaining wall as an element of the permanent works at the proposed development at Penistone Lane, Feaney Bridge. This report covers the design of proposed wall noted on Geoman Ltd. Drawing No. SK24-5915-F1-01 Plan.

1.2 Scope

The wall is shown on Geoman Drawing No. SK24-5915-F1-01 and to be constructed with geogrid-reinforced granular backfill. The limits of the MacWall element design are from the base MacWall block to the rear of the base layer of geogrid, up to ground level to the rear of the top layer of geogrid. ***Concrete backfill will be required behind the Vertica MacWall blocks where the manhole is 0.5m behind the top Vertica block. Refer to Geoman Ltd. Drawing No. SK24-5915-F1-03 for further details.***

Four cross-sections have been considered as follows:

Section	Retained height	Crest slope details	Toe slope details	Drawing Ref:
1-1	1.80m	None	None	SK24-5915-F1-03
2-2	1.73m	None	Maximum 1V:2H offset 1.0m	SK24-5915-F1-03
3-3	3.00m	Maximum 1V:4H	Maximum 1V:3H offset 1.0m	SK24-5915-F1-04
4-4	3.10m	Maximum 1V:4H	Maximum 1V:4H offset 1.0m	SK24-5915-F1-04

THE PRINCIPAL CONTRACTOR SHOULD CHECK THE REQUIRED WALL GEOMETRY ON SITE TO ENSURE IT IS NOT MORE ONEROUS THAN THAT CONSIDERED ABOVE IN THE DESIGN SECTIONS. FOR INTERMEDIATE WALL HEIGHTS GEOGRID EXTENTS FROM THE HIGHER SECTIONS SHOULD BE USED. GEOGRID BACKFILL EXTENTS AND SPACINGS SHOULD BE AS PER THE WALL ELEVATIONS ON SK24-5915-F1-02.

Additional design scope notes:

- A maximum variable unfavourable surcharge load of 10kN/m^2 was assumed to act on the retained side of the wall. Please advise if a higher surcharge should be considered.
- We have assumed that a maximum 1.2m high fence (designed by others) is to be installed behind the MacWall Vertica retaining wall, to be confirmed by Client's Consulting Engineer/ Principal Contractor. The fence posts must be fully concreted into minimum 0.8m long, 0.3m Ø sleeves pre-installed into the wall backfill. The geogrid tails can be locally cut to suit where required. Please advise us if a higher fence or any wind load/impact loads should be considered, and we will revise the design. Any VRS requirements above the wall are outside the scope of this design.
- A minimum 150mm diameter PVC perforated drainage pipe is to be placed at the rear of the wall, with a fall to a suitable outlet, as per Geoman Ltd. Drawing No. SK24-5915-F1-03 & -04. The drainage pipe is to be fully roddable/ jettable and regularly maintained. Site drainage must be installed to ensure the wall is not inundated with water and that it is maintained in a fully drained condition for the design life of the structure. During the construction phase, the Principal Contractor must install suitable temporary drainage measures to direct surface water/ run-off away from the line of wall and also to prevent "ponding" at the toe/foundation which could cause this to deteriorate and soften over time. Permanent and maintained site drainage must also be installed to ensure run-off is directed away from the wall in the

long term. Site drainage is outside the scope of this design. The Client must accept responsibility to ensure the wall remain in a fully drained condition for the full life span of the structure. Regular drainage maintenance should be included in the maintenance regime for the site.

- The attenuation tank should be installed alongside the Vertica MacWall and any excavations between the two structures should be replaced with compacted granular fill to avoid the creation of a weak zone in the retained material and reduce the risk of differential settlement. The installer must ensure the tank is fully watertight so that water is not discharging into the walls backfill. *Ensuring minimal hydrostatic pressure behind the wall for the full design life of the structure is critical to the wall's stability.*
- Settlement can occur after construction, depending on the variability of the subgrade and compaction of the backfill to the walls. To reduce the risk of settlement, the backfill should be monitored post-construction and the installation of surface finishes, fences etc. delayed until it has ceased.
- There is an allowance for unforeseen future excavation in front of the walls of 10% of the height (limited to a maximum of 0.5m), as per Eurocode 7, Cl. 9.3.2.2.
- The Principal Contractor and Client's Consulting Engineer must ensure that any excavation required for the proposed MacWall retaining wall does not affect the stability of any surrounding existing or proposed roads, services or structures. Unless the Client's Consulting Engineer accepts this, it is recommended that construction does not proceed.
- Temporary excavations have the potential to collapse rapidly and without warning. This retaining wall solution is for the permanent works only and is on the basis that a safe system of works is provided for construction. The Principal Contractor should provide a method statement for the works to satisfy the Client's Consulting Engineer. Geoman Ltd. is not responsible for temporary stability or design of any temporary works.
- All building/structure foundations located close to the MacWall must be designed NOT to rely on the flexible MacWall and the reinforced backfill for any support (including lateral support).

All wall geometry, setting out and required offsets are to be confirmed by the Principal Contractor and Project Consulting Engineer prior to construction. The Principal Contractor and Project Consulting Engineer must also confirm the locations of all services prior to construction and ensure that none will be affected by the MacWall Vertica's and their installation.

Any solution outside this scope is not covered by this design and Geoman Ltd. should be informed of any required revisions so that a new design can be advised as necessary. Site drainage is outside the scope of this design.

Please advise us before proceeding with construction if there are any errors in the scope.

1.3 Responsible Parties

- Maccaferri Ltd. is the material supplier, solution installer and our Client.
- Honey is the Project Client and the Client's Consulting Engineer.
- Honey Homes is the Principal Contractor.
- The Principal Designer is to be confirmed.

The above parties should all read and check this design document before proceeding.

1.4 Information

This design package is based on the information provided to Geoman Ltd. as follows:

- Haigh Huddleston & Associates Drawing No. E23/8060/004D Road & Sewer Plan
- Haigh Huddleston & Associates Drawing No. E23/8060/021_01B External Works Plan
- Honey Drawing No. C005-102-J Planning Layout
- Ground Information:
    - Haigh Huddleston & Associates Geo-Environmental GI Report No. E23/8060/R001A (Sep 24)
- Maccaferri Design Brief
- Geoman Ltd keep a record of all email correspondence.

2.0 Design

2.1 Ground Conditions/Design Parameters

The Project Consulting Engineer and Principal Contractor must ensure that all parameters used comply with those found on site. Any variance in these must be reported to Geoman Ltd. immediately so that the implications can be assessed.

2.1.1 Relevant Geotechnical Information

We have been provided with Haigh Huddleston & Associates Geo-Environmental GI Report No. E23/8060/R001A (Sep 24) which includes the logs of trial pits/ exploratory holes sunk on site as well as results of in-situ and laboratory geotechnical testing.

Logs TP101, TP107, TP109, TPE01, TPE05, TPE06, TPE07 BH09 & BH10 are located closest to the proposed wall.

2.1.2 In-sit Ground Conditions Local to Wall

The logs indicate some topsoil/ soft CLAY present at shallow depths overlying weak to moderately weak SANDSTONE/ MUDSTONE BEDROCK. Due to proposed vs existing topography at the site, the wall will be in a significant cut. Most of the retained material will also be well below existing ground level with the exception of towards the end of the wall and will therefore will also be directly retaining the bedrock. Where the road is present on the retained side we have assumed a compacted granular fill road build up is directly overlying the BEDROCK and towards the end of the wall we have assumed a soft stratum is present in the top 1.0m below existing ground level.

The original, weak to moderately weak SANDSTONE/ MUDSTONE BEDROCK is considered to be a suitable founding stratum based on the information noted above.

2.1.3 Selected Design Parameters

The soil parameters assumed in the design, are therefore as follows:

Material	Description	Unit Weight (kN/m^3)	Effective Angle of Internal Friction	Effective Cohesion (kN/m^2)
Foundation	Original, weak to moderately weak SANDSTONE/ MUDSTONE BEDROCK	21.0	32°	5
Retained	Original, weak to moderately weak SANDSTONE/ MUDSTONE BEDROCK	21.0	32°	5
	Granular fill (Road Build Up where relevant)	18.0	38°	0
	Soft CLAY/ MADE GROUND or Class 1/ 2 engineered upfill	18.0	28°	0

To achieve a suitable foundation for the wall, excavation must take place down to the levels indicated on the drawings and allow for the placement of a minimum 300mm deep C20/25 concrete levelling pad. It must be ensured that original, undisturbed weak to moderately weak SANDSTONE/ MUDSTONE BEDROCK is present at and below formation level. This should be confirmed prior to construction by the Contractor. Any soft/ loose overburden present at and below formation level must be excavated out down to original BEDROCK and replaced with compacted Class 6F2/ 6F5 granular fill.

2.1.4 Reinforced Backfill

The reinforced backfill for the walls shall comprise a selected compacted granular fill material which complies with Class 6I of the Manual of Contract Documents for Highway Works, SFHW, Series 600. The Principal Contractor is responsible for the selection of this material to ensure compliance with the geotechnical characteristics as shown on the relevant drawings and in the design documents/ calculations.

The soil parameters assumed for the imported fill in the design calculations are as follows:

Class of Fill (MCHW vol. 1, Series 600)	*Description*	*Use*	*Unit Weight (kN/m^3)*	*Effective Angle of Internal Friction*	*Cohesion (kN/m^2)*
Class 6I	Selected well graded granular material	Reinforced backfill	19.0	38°	0

2.2 Surcharge Loads

A maximum variable unfavourable surcharge load of $10kN/m^2$ was assumed to act on the retained side of the wall. If the surcharge on the retained side of the MacWall is to exceed this, the Principal Contractor must inform Geoman Ltd. prior to construction to allow this design to be reviewed.

2.3 Crest/ Toe Slopes

Refer to Geoman Ltd. Drawing No's. SK24-5915-F1-03 & -04 and Table in Section 1.2.

If the site geometry is more onerous than considered then Geoman should be informed to check and revised the design if necessary.

2.4 Ground Water

It has been assumed that the wall and retained material will be maintained in a fully drained condition. Site drainage is outside the scope of this design.

Any excavations should be checked for any flows or seepage that require drainage measures. Any flows, seepage or standing water should be directed to a suitable outfall as soon as they are encountered.

No porewater pressure Coefficients (r_u) or piezometric surfaces were considered for analysis purposes.

The attenuation tank should be installed alongside the Vertica MacWall and any excavations between the two structures should be replaced with compacted granular fill to avoid the creation of a weak zone in the retained material and reduce the risk of differential settlement. The installer must ensure the tank is fully watertight so that water is not discharging into the walls backfill. *Ensuring minimal hydrostatic pressure behind the wall for the full design life of the structure is critical to the wall's stability.*

2.5 Drainage

A 150mm diameter PVC perforated drainage pipe must be provided behind the rear of the wall, as indicated on SK24-5915-F1-03 & -04, discharging to an approved outlet point. The pipe must be fully roddable/jettable and regularly maintained.

During the construction phase, the Principal Contractor must install suitable temporary drainage measures to direct surface water/ run-off away from the line of wall and also to prevent “ponding” at the toe/foundation which could cause this to deteriorate and soften over time. Permanent and maintained site drainage must also be installed to ensure run-off is directed away from the wall in the long term. Site drainage is outside the scope of this design. The Client must accept responsibility to ensure the wall remain in a fully drained condition for the full life span of the structure. Regular drainage maintenance should be included in the maintenance regime for the site.

3.0 Analysis

- Methods of Analysis: BS8006:2010 and BSEN1997-1:2004
- Factors of Safety: According to BS8006:2010 and BSEN1997-1:2004, DA1
- Retaining System: MacWall Vertica with geogrid reinforcement

Fine GEO5 software packages MSE Wall and Stability were used for analysis purposes for the proposed MacWall. Analysis outputs GE24-5915-F1-01 & -02 are included in the attached Appendix.

As shown by all degrees of utilisation for the worst Load Combinations being less than 100%, the requirements of BS8006:2010 and BSEN1997-1:2004 were satisfied for all analyses.

4.0 Summary

This design proposal and associated drawing have been produced using the methodology detailed above. However, it should be noted that the design proposal has been generated from information provided to Geoman Ltd, which has not been independently verified and may contain assumptions and inaccuracies regarding geotechnical, hydraulic and other parameters.

If any discrepancy is noted between the site conditions and the design assumptions (regarding water levels, soil conditions, proposed loadings etc.), the Principal Contractor and/ or Project Consulting Engineer must contact Geoman Ltd. immediately to facilitate a review of the design.

Geoman Ltd did not undertake to supervise the construction of the structure, and therefore cannot comment on the standard of workmanship. The main issues to consider are adequate compaction of the foundation soils and imported fill, and adequate drainage.

The material supplier can provide typical health & safety hazards to consider when approaching this work. Designer's hazards include falling from height and the stability of excavated cuttings.

5.0 Construction Supervision Requirements

The following construction supervision requirements should be adhered to by the project team (Principal Designer, Project Consulting Engineer & Principal Contractor). If any issues arise on site which differ from what has been assumed in this design, Geoman Ltd. should be contacted immediately so the possible consequences can be assessed.

- The Principal Contractor and/ or a geotechnical engineer must confirm the localised suitability of the material at formation level over the full extent of the wall.

- The reinforced backfill is to be compacted Class 6I granular fill, compacted in accordance with SFHW Series 600.
- The MacWall to be constructed should be checked for the required geometry and retained height to ensure that they are within the scope of this design (See Section 1.2)
- Any excavations should be checked for any flows or seepage that require drainage measures. Any flows, seepage or standing water should be directed to a suitable outfall as soon as they are encountered.
- It should be ensured that the face batter is not compromised by the use of heavy compaction plant machinery too close to the front face of the wall.

- The wall construction should be carried out in accordance with the manufacturer's installation guidelines by an installer experienced with segmental wall systems.
- Setting out to be provided by scheme designer and is outside the scope of Geoman/ Maccaferri's work. Wall line shown on plan is as per drawings provided. Fenceline is offset from toe of wall as shown on sections - any required correction to toe line to accommodate to be confirmed prior to construction.
- Within 2m of the back of the facing blocks, the maximum compaction plant shall be:
  - Vibratory roller: 1,300kg/m and a total mass of 1,000kg
  - Vibrating plate compactor not greater than 1,000kg
  - Vibro-tamper not exceeding 75kg.

PARAGRID PLACEMENT RULES:

1) 1st layer no higher than top of the 1st block course

2) Subsequent layers at no greater than 600mm vertical c/c (3 MacWall block courses)

3) Top layer to be min 200 mm (1 block) or max 400mm (2 blocks) below finished ground level. *Refer to Geoman Ltd. drawings for more details. Top geogrid layer may be increased to 600mm below finished retained height to avoid clash with the road where applicable.*

4) Where a geogrid layer steps up/down one course, there should be a minimum overlap of 440mm (one block length)

5) Grid lengths from the higher sections should be used for intermediate wall heights.

6) Geogrid must be installed by rolling it out perpendicular to the wall and cutting to the required length, the grid must not be rolled out longitudinally along the wall.

7) When filling over the geogrid, a minimum of 100mm of fill must be placed over the geogrid before driving plant over it.

6.0 Maintenance Requirements

- The MacWall drainage must be routinely inspected and maintained (rodded/jetted) annually and after particularly heavy rainfall events. Rodding facilities must be provided to ensure the full length of drainage can be maintained.
- The MacWall segmental wall capping blocks should be checked annually to ensure they are suitably fixed to the upper course of retaining wall blocks. If any capping blocks are missing, they should be replaced and if any are loose, they should be fixed using epoxy mortar.
- The walls should be routinely inspected for signs of any faults, vandalism or movement. The batter of the walls should be checked to ensure it remains within the allowed tolerances (+/-2^{o}).
- The ground above and below the walls should also be inspected for signs of any movement.

These requirements should be included in the maintenance regime for the site.

7.0 CDM Regulations

Geoman is not the Principal Designer but has considered the risks associated with this element of the works that affect or are affected by the design. "**Designers"** are responsible for fulfilling their obligations as defined in the Construction (Design & Management) Regulations 2015.

Geoman Ltd., as designers, understand that under the Regulations its duties are generally to;

- Ensure that the client for the project is aware of the duties and responsibilities that they have.
- So far as is reasonably practicable, taking due account of other relevant design considerations, avoid foreseeable risks to the health and safety of any persons carrying out, liable to be affected by such or maintaining the permanent fixtures and fittings of construction work.

In discharging this duty, the designer shall:

- Eliminate hazards that may give rise to risks
- Reduce risks from any remaining hazards and in doing so give collective measures priority over individual measures.

The designer shall also:

- Take all reasonable steps to provide with the design sufficient information about aspects of the design of the structure or its construction or maintenance as will adequately assist clients, other designers and contractors to comply with their duties under the Regulations.

In respect of this particular project, Geoman hereby draws to the attention of the Principal Designer and Principal Contractor that they have specific duties under CDM 2015.

The 'Principal Contractor' must be responsible for and fulfil all the contractor's obligations.

However, since the **Principal Designer** has designated the chosen location and dimensions of the structures on this site, the **Principal Designer** has, in this respect, acted as a 'designer' under CDM 2015. The **Principal Designer** is therefore responsible for fulfilling all the obligations that this entails.

The scope of Geoman, as element 'designer', to minimise design risks is therefore limited by those elements of the design pre-determined by the **Principal Designer**. The significant design risks shown in Section 7.1 remain and must therefore be addressed by the **Principal Designer, Project Consulting Engineer** and **Principal Contractor.**

7.1 SIGNIFICANT DESIGN RISKS REMAINING:

RISK		SUGGESTED REMEDIATION	ACTION BY
01	Wall stability compromised and/ or excessive settlement due to in situ soils not complying with design assumptions.	The Principal Contractor and/or a Geotechnical Engineer must confirm the localised suitability of the formation material under the full extent of the footings. **Refer to Section 2.1 for details of the requirements of the foundation soils.**	Principal Contractor/ Client's Consulting Engineer.
02	Wall stability compromised due to backfill soils not complying with design assumptions.	Backfill for MacWall to be compacted Class 6I granular fill, to be confirmed to meet minimum requirements outline in Section 2.1.4. Quality control testing to follow principles set out in HA 44/91 and under the responsibility of the Principal Contractor. ***Refer to Geoman Ltd. Drawing No. SK24-5915-F1-03 for details at pinchpoint where concrete backfill will be required between the Vertica MacWall blocks and the manhole.***	Principal Contractor
03	Instability of the temporary cut slope.	**Temporary excavations have the potential to collapse rapidly and without warning.** This retaining wall solution is for the permanent works only and is on the basis that a safe system of works is provided for construction. The Principal Contractor should provide a method statement for the works to satisfy the Client's Consulting Engineer. Geoman Ltd. is not responsible for temporary stability or design of any temporary works.	Principal Contractor
04	Serviceability movement of MacWall affecting roads, services or structures at the crest of the wall.	Some settlement of the wall and retained material will occur following construction. This should be monitored and the installation of surface finishes, fences etc. delayed until it has ceased.	Principal Contractor
05	Groundwater or surface run-off affecting wall stability.	Any excavated slopes should be checked for any flows or seepage that requires drainage measures. Any flows, seepage or standing water should be directed to a suitable outfall as soon as they are encountered. **Geoman should be informed if there is a shallow groundwater level on the site as the design will need to be revised.**	Principal Contractor/ Scheme drainage designer
06	Wall constructed outside design tolerances.	We recommend that the batter of the wall is checked with every 1m of construction to ensure it is within the allowed tolerances. Heavy construction plant should not traffic behind the wall during construction as this can cause bulging of the face. We recommend that an experienced installer is appointed to construct the wall.	Principal Contractor/ Wall Installer
07	Wind/impact loads on fences affecting the wall stability.	We have assumed that a maximum 1.2m high fence (designed by others) is to be installed behind the MacWall Vertica retaining wall, to be confirmed by Client's Consulting Engineer/ Principal Contractor. The fence posts must be fully concreted into minimum 0.8m long, 0.3m Ø sleeves pre-installed into the wall backfill. The geogrid tails can be locally cut to suit where required. Please advise us if a higher fence or any wind load/impact loads should be considered, and we will revise the design. Any VRS requirements above the wall are outside the scope of this design.	Principal Contractor/ Client's Consulting Engineer
08	Inexperienced installer appointed to construct the wall.	An experienced installer should be appointed to install the wall. The installer should have experience on work of a similar nature in terms of constructing high reinforced earth walls and placing and compacting reinforced granular backfill.	Principal Contractor
09	Heavy construction plant close to the wall.	If construction plant is to traffic the crest area of the wall, a suitable haul road design must be undertaken and be set back and adequate distance from the rear of the wall (designed by others). If construction plant operates on the unprotected retained material, distortion/ bulging of the wall may occur.	Principal Contractor/ Client's Consulting Engineer

RISK		SUGGESTED REMEDIATION	ACTION BY
10	Building foundations close to the wall.	All building/structure foundations located close to the MacWalls must be designed NOT to rely on the flexible MacWalls and the reinforced backfill for any support (including lateral support). The building and wall foundations must act independently.	Principal Contractor/ Client's Consulting Engineer
11	Inadequate drainage measures.	Drainage must be installed to ensure the wall is maintained in a fully drained condition at all times. Refer to Section 2.5 and the design sections for details of the required wall drainage. **Regular maintenance of the wall and site drainage is required to ensure it remains fully functioning at all times. This maintenance should be included in the maintenance regime for the site.** During the construction phase, the Principal Contractor must install suitable temporary drainage measures to direct surface water/ run-off away from the line of wall and also to prevent "ponding" at the toe/foundation which could cause this to deteriorate and soften over time. Permanent and maintained site drainage must also be installed to ensure run-off is directed away from the wall in the long term. Site drainage is outside the scope of this design. The Client must accept responsibility to ensure the wall remain in a fully drained condition for the full life span of the structure. Regular drainage maintenance should be included in the maintenance regime for the site.	Principal Contractor/ Client's Consulting Engineer
12	Attenuation tank on the retained side of the wall.	The tank should be installed alongside the Vertica MacWall and any excavations between the two structures should be replaced with compacted granular fill to avoid the creation of a weak zone in the retained material and reduce the risk of differential settlement. The installer must ensure the tank is fully watertight so that water is not discharging into the walls backfill. *Ensuring minimal hydrostatic pressure behind the wall for the full design life of the structure is critical to the wall's stability.*	Principal Contractor/ Client's Consulting Engineer

8.0 Manufacturer´s Risk Assessment

CONSTRUCTION OF MacWall

This is a Designers Risk Assessment which lists general risk items compiled without visiting site, please refer to the sub-contractor/ solution installers risk assessment for more site specific risks.

No.	Hazards	Risk	Initial Potential for Harm			Action Req'd	Control Measures	Residual Potential for Harm		
			H	M	L	(Y/N)		H	M	L
1.	Ground Collapse	Crushing of personnel	X			Y	Ground to be excavated and battered back and **monitored** on a daily basis. Weekly inspection sheet to be completed.			X
2.	Plant 360° Excavators	Collision with other plant or personnel. Reversing.		X		Y	All plant operators are to hold current CPCS. All Weekly inspection reports to be completed. All plant to be inspected daily prior to use. All plant to have all round vision, to include mirrors, and banksman where required. All statutory inspection to be completed. All personnel to wear full PPE. Exclusion to be set up around works			X
3.	Damage to Services	Injury to personnel and property	X			Y	All Services to be clearly marked and briefed to all site personnel at the site induction. All site personnel to carefully follow the site induction when working around the services.			X
4.	Handling, cutting mesh, lacing, etc.	Personal Injury		X		Y	Use of suitable PPE (safety goggles, gloves, etc.)			X
5.	Manual Handling	Injury to personnel		X		Y	Tool box Talk on correct lifting techniques, avoidance of manual lifting, use plant when required and risk assessment in place. Maccaferri supervisor to ensure job rotation takes place every 15 minutes to reduce the risk of repetitive injuries happening.			X

6.	Work at Height	Falls from height		X		Y	After completion of the first row of GTM the rear face will be back filled and compacted in layers up to the top level of the unit and an edge protection system will be installed to the front face. As the wall progresses the backfilling/edge protection system will be re-installed to the higher level.			X
7.	Re-fuelling of plant on site	Contamination to watercourses, injury to personnel		X		Y	All operatives to wear gloves during re-fuelling process. All re-fuelling to be carried out in whilst using a drip tray and having a spill kit to hand, and 30m away from any watercourses or drainage.			X
8.	Environmental issues	Pollution to watercourse.	X			Y	All pumped water will be filtered and screened prior to release.			X
9.	Site plant, other vehicles, Live roads.	Collisions with Plant, machinery and other vehicles resulting in serious injury or fatality.	X			Y	All Maccaferri Personnel MUST adhere to the site-specific Traffic Management			X
10.	Excavation into existing material to foundation level	Striking existing services/ Striking live cables/ Personal injury/Electrocution		X		Y	Principal Designer to provide details of all existing services in the vicinity of the wall to Contractor. Use of Cable Avoidance Tools (CAT scanners). Principal Designer to provide details of all existing electrical services in the vicinity of the wall to Contractor. Electrical services to be relocated where risk is unacceptable. Use of Cable Avoidance Tools (CAT scanners).			X
11.	General Installation of MacWall	Personal Injury		X		Y	Adhere to Supplier Installation Guidelines.			X

9.0 Appendices

- Geoman Ltd. Drawings:
  - SK24-5915-F1-01 Plan
  - SK24-5915-F1-02 Elevation
  - SK24-5915-F1-03 Sections
  - SK24-5915-F1-04 Sections
- GE05 analysis outputs:
  - GE24-5915-F1-01
  - GE24-5915-F1-02

INDICATIVE LOCATION OF VERTICA MACWALL
1:250
All wall geometry, setting out and required offsets to be confirmed by the Principal Contractor/Clients Consulting Engineer prior to construction. The Principal Contractor/Clients Consulting Engineer must also confirm the locations of all services prior to construction and ensure that none will be affected by the Vertica MacWall and its installation.

A1

MANHOLE TO BE MOVED BACK A MINIMUM OF 0.50m BEHIND THE BACK OF THE TOP VERTICA BLOCK (TBC). C20/25 CONCRETE TO BE PLACED BETWEEN THE BACK OF THE WALL AND THE MANHOLE WITH GEOGRIDS TO BE SPLAYED AROUND THE MANHOLE. REFER TO MANHOLE PLAN DETAIL.

ATTENUATION TANK

SERVICE CORRIDOR

SERVICE MARGIN

ROWLEY LANE

ROMNI FEY LANE

PENISTONE ROAD

EASEMENT

ROUGH GRASS

STONE WALL H10.0M

CH0.000m
CH10.000m
CH20.000m
CH30.000m
CH40.000m
CH50.000m
CH60.000m
CH70.000m
CH80.000m
CH90.000m
CH100.000m
CH110.000m
CH120.000m
CH130.000m
CH140.000m
CH150.000m
CH160.000m
CH170.000m
CH180.000m
CH190.000m
CH200.000m
CH210.000m
CH215.500m

								Drawing Title: VERTICA MACWALL PLAN	Designed: DMCG	Date: 21.03.25	Project Title: K HARAN CIVILS
								Scale @ A1: AS SHOWN	Unit: MM	Project Number: 24-5915-F1	Drawn: DMCG
								Drawing Number: SK24-5915-F1-01	Revision: 0	Checked: GM	Date: 21.03.25
0			DMcG		21.03.25			Drawing Status: CONCEPT/PRELIMINARY ONLY ☐ **FOR APPROVAL** ☒ FOR CONSTRUCTION ☐ AS BUILT ☐			
Status/Rev:	Description:		Drawn:	App.:	Date:						

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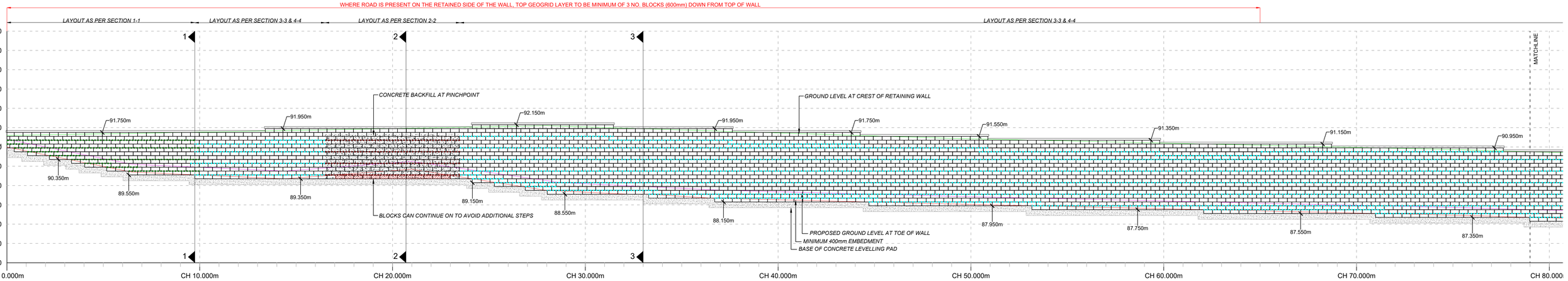
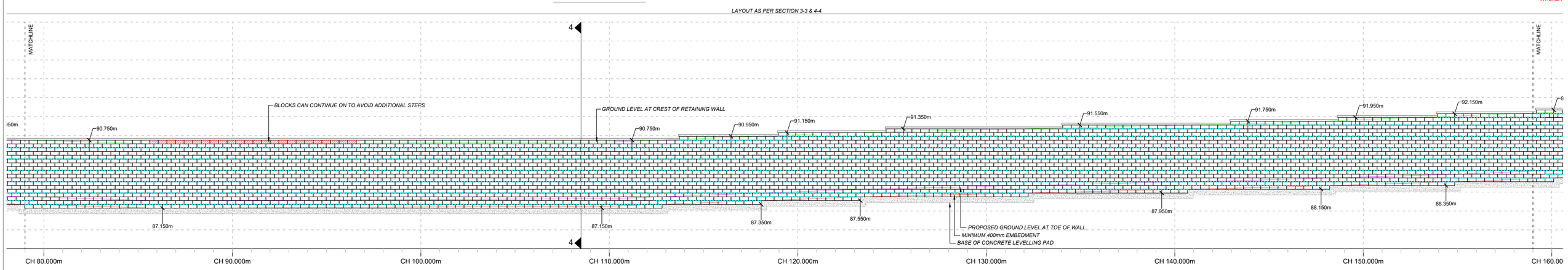
A1

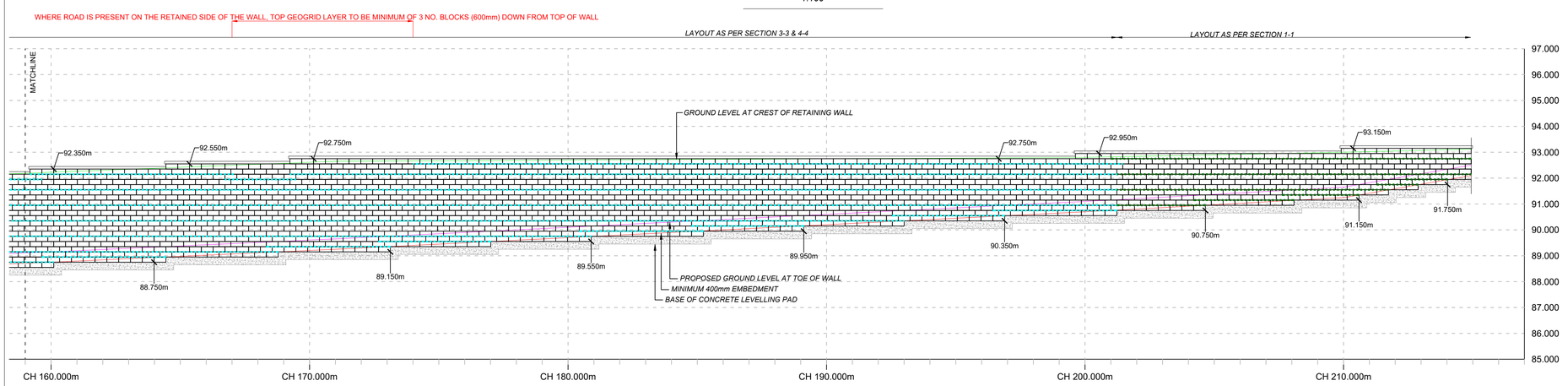
WALL ELEVATION (1/3)
1:100



WALL ELEVATION (2/3)
1:100



WALL ELEVATION (3/3)
1:100



					Drawing Title: VERTICA MACWALL ELEVATION		Designed: DMCG	Date: 21.03.25	Project Title: K HARAN CIVILS
					Scale @ A1: AS SHOWN	Unit: MM / Project Number: 24-5915-F1	Drawn: DMCG	Date: 21.03.25	Client: PENINSTONE LANE, FEANEY BRIDGE
					Drawing Number: SK24-5915-F1-02	Revision: 0	Checked: GM	Date: 21.03.25	Drawing Status: CONCEPT/PRELIMINARY ONLY ☐ **FOR APPROVAL** ☒ FOR CONSTRUCTION ☐ AS BUILT ☐
0		DMcG		21.03.25					
Status/Rev:	Description:	Drawn:	App.:	Date:					

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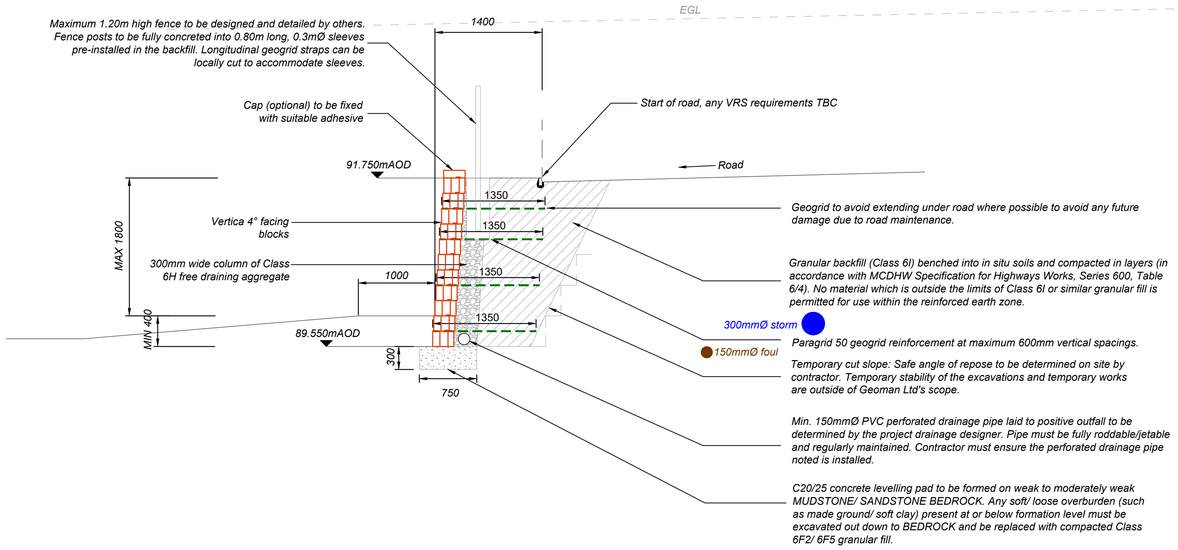
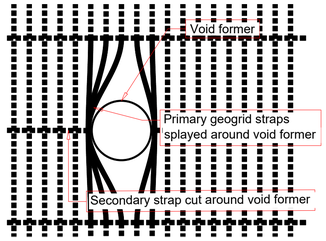
A1

SECTION 1-1
1:40

> ⚠ *Some settlement of the reinforced backfill and retained material will occur following construction. This should be monitored and the installation of surface finishes, barriers/ fences, etc delayed until it has ceased.*



FENCE POST SLEEVE DETAIL
NTS



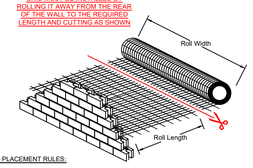
The retaining structure is designed to support a 1.20m fence in the permanent condition, however in the temporary condition issues can arise as the fence may not be fully supported. This can lead to damage to the fence and the retaining structure. Therefore we would make the following recommendations to avoid any movement of the fence in the temporary condition.

- We strongly recommend all fence boarding to be left off where possible until all other surrounding works are complete (e.g. fence returns, upfilling, surrounding structures)
- Where boarding must be installed prior to installation of fence returns (ie fences between gardens) , temporary braces should be installed.
- Backfill **must** be brought up to design height prior to boarding being installed
- In locations where any of the above is not possible boarding **must not** be installed until all other works are complete

Where any movement occurs in the temporary case and these recommendations have not been followed, Maccaferri shall not be held liable for the cost of any repairs to the fencing and / or the retaining structure.

PARAGRID CONSTRUCTION DETAIL
NTS

GRID MUST BE INSTALLED BY ROLLING IT AWAY FROM THE REAR OF THE WALL TO THE REQUIRED LENGTH AND CUTTING AS SHOWN



GEOGRID PLACEMENT RULES:

1) 1st layer no higher than top of the 1st block course

2) Subsequent layers at no greater than 600mm vertical c/c (3 Vertica block courses)

3) Top layer to be min 200 mm (1 blocks) or max 400mm (2 blocks) below finished ground level. *If geogrid is present in road build up it may need lowered to suit to avoid damage due to road maintenance. Refer to sections for more details.*

4) Where a geogrid layer steps up/down one course, there should be a minimum overlap of 457mm (one block length)

5) Grid lengths from the higher sections should be used for intermediate wall heights.

6) The geogrid is always placed with the roll direction (direction of strength) perpendicular to the wall face, i.e. cut in the required lengths.

7) When filling over the geogrid, a minimum of 100mm of fill must be placed over the geogrid before driving plant over it.

NOTES:

1) All dimensions in mm's unless otherwise specified.

2) BLOCKS:
Block type: MacWall Vertica 4 degree blocks

3) INSTALLATION:
Please refer to standard Manufacturer's installation guidelines.

4) GEOGRID REINFORCEMENT:
Paragrid 50/15 geogrid. Grids to be installed at maximum 3 block vertical centres with the bottom geogrid layer to be placed on top of the base Vertica block. Grid lengths to be as shown in sections. Intermediate wall heights to be constructed with grid lengths from the higher section.

5) BACKFILL:
GEOGRID SECTIONS
The reinforced backfill for the wall shall comprise a selected compacted granular fill material to comply with SFHW Class 6I or similar approved. This material is assumed to have the following characteristics: Phi' = 38 degrees, Gamma = 18 kN/m³ and c' = 0 kPa, compacted in accordance with SFHW Series 600, Table 6/4.

The Contractor is responsible for the selection of this material to ensure compliance with the geotechnical characteristics as shown on the relevant drawings and in the design documents/ calculations.

No material which is outside the limits of Class 6I or similar granular fill is permitted for use within the reinforced earth zone.

BLOCKS IN FRONT OF MANHOLES
C20/25 concrete backfill with minimum density of 24kN/m³. The concrete backfill is to be placed in maximum 600mm high lifts per day. Concrete backfill to be tamped into the voids in and behind the Vertica blocks at the wall as per Section 2-2 to create a monolithic structure.

6) DRAINAGE:
Standard Vertica MacWall drainage detail is to be formed behind the facing blocks. This is to comprise a 300mm width of free draining aggregate (CLASS 6H) behind the blocks (with block voids filled with same material), A 150mmØ rigid perforated drainage pipe should be placed along the full length of the wall at the base of the drainage column. The pipe should be roddable and connected to an appropriate site drainage outlet with consent to discharge. To be confirmed by drainage designer. ***Any run-off from the road must not enter the walls backfill, permanent and temporary drainage are outside the scope of this design.***

The excavated slopes should be checked for any flows or seepage that require drainage measures. Any flows, seepage or standing water must be directed to a suitable outfall as soon as they are encountered. It should be ensured that adequate drainage is present beyond the crest of the Vertica MacWall to avoid excess surface water run-off from entering the backfill of the wall.

7) FOUNDATION FOR WALL:
To achieve a suitable foundation for the block wall, excavation must take place down to the levels indicated on the drawing and allow for the placement of a 300mm deep C20/25 concrete foundation. It must be ensured that original, undisturbed weak to moderately weak SANDSTONE/ MUDSTONE BEDROCK at and below formation level. **This should be confirmed prior to construction by the Contractor.** Any soft/ loose overburden present at or below formation level must be excavated out down to original BEDROCK and replaced with compacted Class 6F2/6F5 granular fill.

8) SITE / IN-SITU SOILS:

FOUNDATION:

Original, weak to moderately weak SANDSTONE/ MUDSTONE, this material is assumed to have the following minimum properties:

Φ' = 32°, γ = 21kN/m³, c' = 5kPa

RETAINED:

Original, weak to moderately weak SANDSTONE/ MUDSTONE, this material is assumed to have the following minimum properties:

Φ' = 32°, γ = 21kN/m³, c' = 5kPa

Granular fill (Road Build Up assumed for the top 500mm below finished road level where road is present), this material is assumed to have the following minimum properties:

Φ' = 38°, γ = 18kN/m³, c' = 0kPa

Soft CLAY/ MADE GROUND or Class 1/ 2 engineered upfill (*towards the end of the wall where the finished levels sit above existing level*s), this material is assumed to have the following minimum properties:

Φ' = 28°, γ = 18kN/m³, c' = 0kPa

As the wall is in a significant cut it is likely most of the soft stratum noted in Haigh Huddleston & Associates Geo-Environmental Report No. E23/8060/R001A will be removed for large parts of the retaining wall prior to reaching finished retained levels at the site.

9) TYPICAL FRONT FACE STEP:
Face angle = 4°

10) TEMPORARY EXCAVATION:
This solution is for the permanent works only, and is issued on the basis that a safe system of works is provided for construction. Temporary stability and design of any temporary works is entirely outside our scope and should be confirmed by a Temporary Works Designer appointed by the Principal Contractor.

11) HEAVY CONSTRUCTION TRAFFIC OPERATING CLOSE TO THE WALL:
It should be ensured that the face batter is not compromised by the use of heavy compaction plant machinery too close to the front face of the MacWall. If construction plant is to traffic the crest area of the wall, a suitable haul road design must be undertaken and be set back an adequate distance from the rear of the wall (designed by others). If construction plant operates on the unprotected retained material, bulging of the wall may occur.

12) SURCHARGE AT THE CREST OF THE WALL:
A maximum live load of 10kN/m² was assumed to act on the slope on the retained side of the wall in the permanent condition. Please advise us if the surcharge on the retained side of the wall in the permanent condition is to exceed the assumed loads. The Principal Designer/ Client's Consulting Engineer must inform Geoman Ltd. prior to construction to allow this design to be reviewed.

13) PEDESTRIAN/ VEHICLE PROTECTION:
It is assumed a maximum 1.2m high fence (designed by others) will be installed behind the MacWall. The geogrids may be cut locally in the secondary reinforcement direction to accommodate the fence post sleeves. ***Refer to notes regarding the fence in the temporary condition for more details.***

Any VRS requirements are outside the scope of this design and should be confirmed prior to construction.

14) STATUTORY APPROVALS:
Any statutory approvals should be confirmed by others. We strongly recommend construction does not proceed until approvals have been granted (if required).

15) SETTLEMENT OF THE REINFORCED BACKFILL:
Some settlement of the reinforced backfill and retained material will occur following construction. This should be monitored and the installation of surface finishes, barriers/fences, etc. delayed until it has ceased.

16) MAINTENANCE REQUIREMENTS:
The client should be made aware of the maintenance requirements for the wall noted in Section 6.0 of the document.

17) SETTING OUT:
Setting out to be provided by scheme designer. Wall line shown on plan is as per drawing provided (Haigh Huddleston & Associates Drawing No. E23/8060/021_01B External Works Plan). Fenceline is offset from toe of walls as shown on sections - any required correction to toe line to accommodate to be confirmed prior to construction.

18) PROPOSED BUILDING FOUNDATIONS:
The proposed building foundations must be taken to such a level so as to ensure that no loads will be transferred to the retaining wall. The building foundations must not rely on the flexible wall for support (including lateral support), and are outside the scope of this design.

This design considers a general uniformly distributed load of 10kN/m² on the retained side of the wall. The flexible wall retaining system is sensitive to additional surcharge loading. Please advise if a more onerous surcharge should be considered.

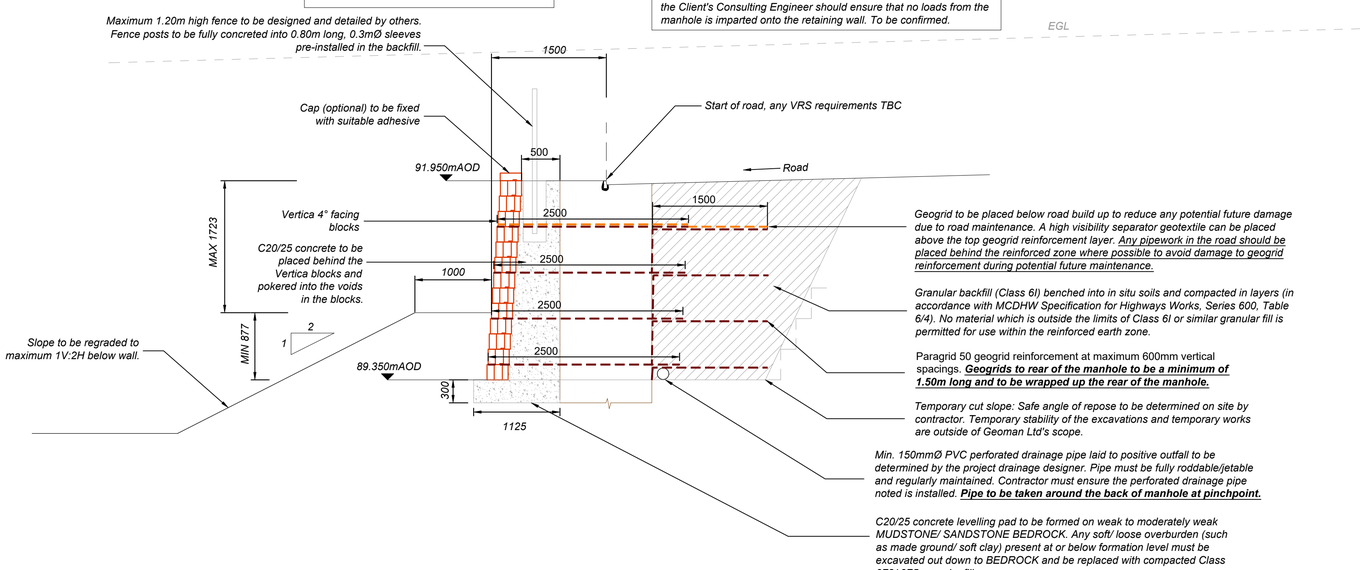
19) ATTENUATION TANK:
The tank should be installed alongside the Vertica MacWall and any excavations between the two structures should be replaced with compacted granular fill to avoid the creation of a weak zone in the retained material and reduce the risk of differential settlement. The installer must ensure the tank is fully watertight so that water is not discharging into the walls backfill.

20) NOTES ON CALCULATIONS/DRAWINGS:
These plans and the accompanying design documentation should be thoroughly checked by the Client's Consulting Engineer/ Principal Designer. Any apparent errors, omissions or variations should be reported immediately to Geoman Ltd. Construction of the wall shall not commence unless and until the Client's Consulting Engineer/ Principal Designer has considered the Geoman Design Submission Document (QP06 Ref: 24-5915-F1) to ensure that there are no errors, omissions or conflict with the scheme design.

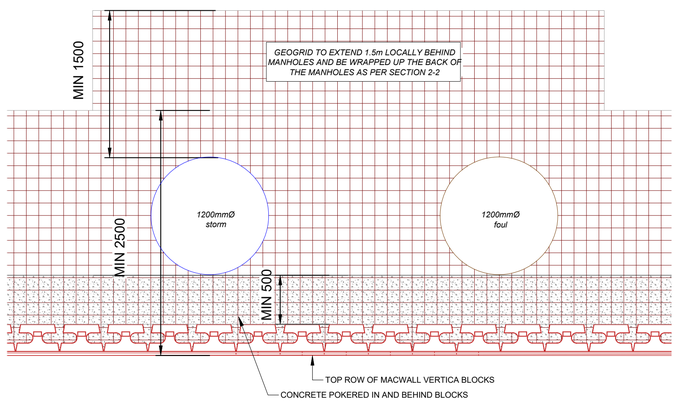
SECTION 2-2
1:40

> ⚠ *Some settlement of the reinforced backfill and retained material will occur following construction. This should be monitored and the installation of surface finishes, barriers/ fences, etc delayed until it has ceased.*

> ⚠ *There is a manhole close to the rear of the Vertica MacWall. C20/25 concrete is to be poured between the Vertica blocks and the manhole. The manhole is to be a minimum of 500mm from the back of the top Vertica block. Geogrids should be splayed around the manhole and the Client's Consulting Engineer should ensure that no loads from the manhole is imparted onto the retaining wall. To be confirmed.*



MANHOLE DETAIL
NTS



							Drawing Title: VERTICA MACWALL SECTIONS	Designed: DMCG	Date: 21.03.25	Project Title: K HARAN CIVILS
							Scale @ A1: AS SHOWN	Unit: MM	Project Number: 24-5915-F1	Drawn: DMCG	Date: 21.03.25	Client: PENINSTONE LANE, FEANEY BRIDGE
							Drawing Number: SK24-5915-F1-03	Revision: 0	Checked: GM	Date: 21.03.25	Drawing Status: CONCEPT/PRELIMINARY ONLY ☐ **FOR APPROVAL** ☒ FOR CONSTRUCTION ☐ AS BUILT ☐
0			DMcG		21.03.25						
Status/Rev:	Description:		Drawn:	App.:	Date:						

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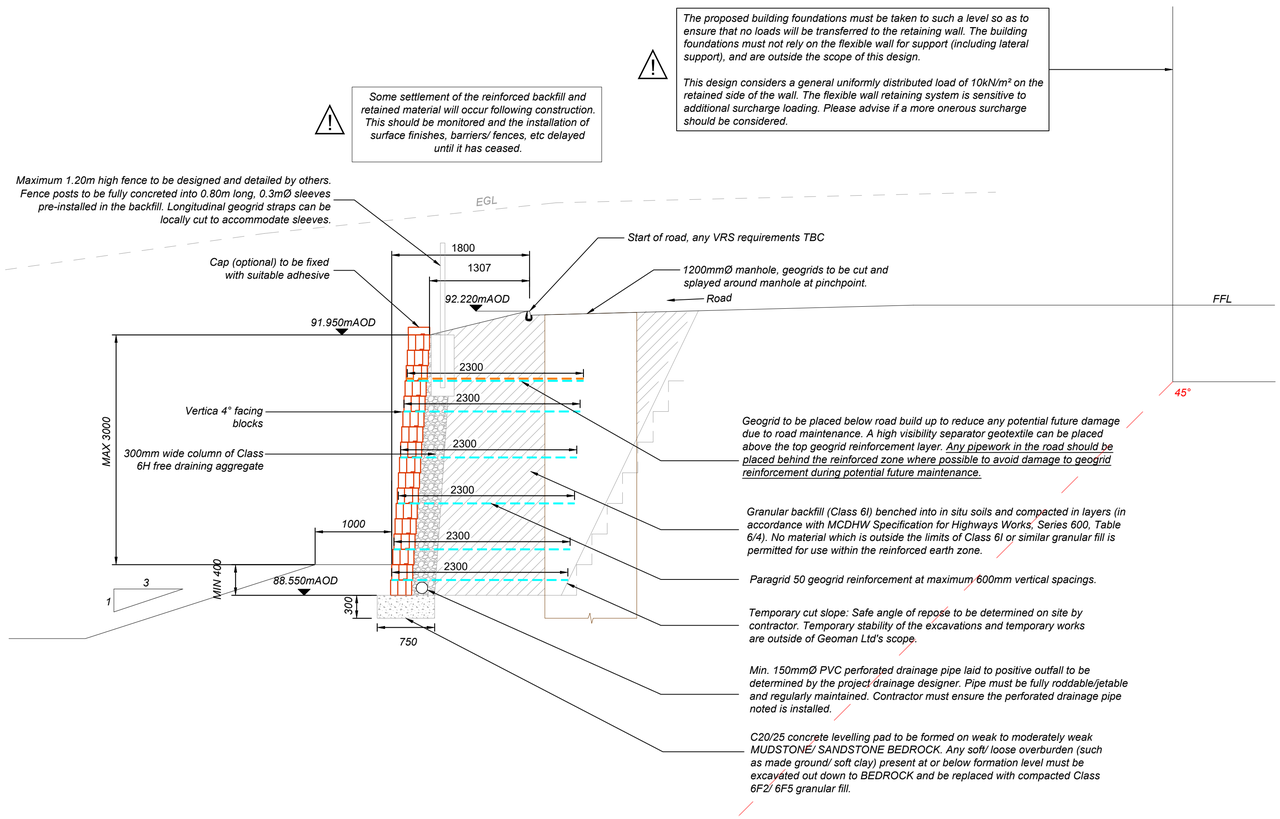
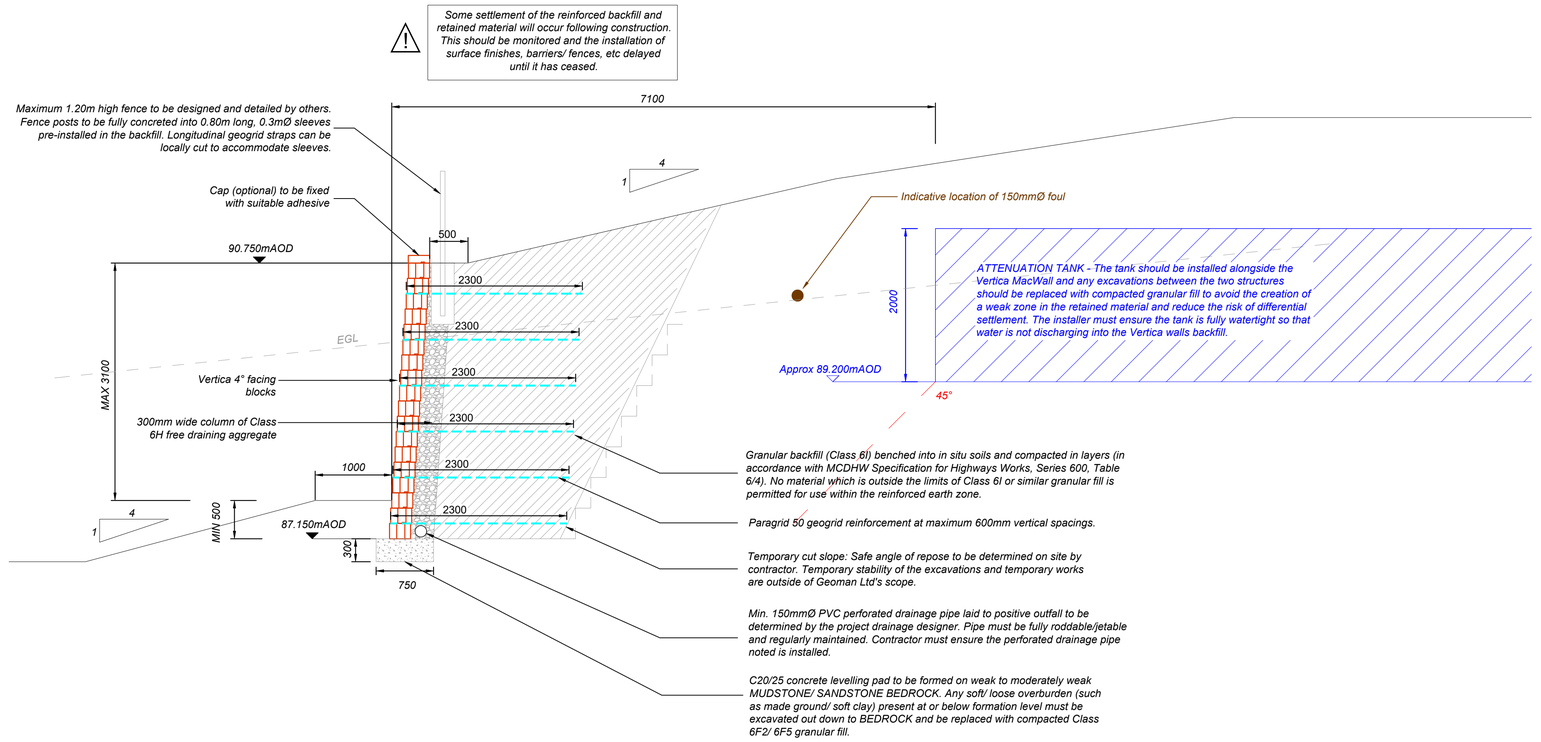
A1

SECTION 3-3
1:40



SECTION 4-4
1:40



NOTES:

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Block type: MacWall Vertica 4 degree blocks

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						Drawing Title: VERTICA MACWALL SECTIONS		Designed: DMCG	Date: 21.03.25
						Scale @ A1: AS SHOWN	Unit: MM	Project Number: 24-5915-F1	Drawn: DMCG / Date: 21.03.25
						Drawing Number: SK24-5915-F1-04	Revision: 0	Checked: GM	Date: 21.03.25
0		DMcG		21.03.25					
Status/Rev:	Description:	Drawn:	App.:	Date:					

Project Title: K HARAN CIVILS
Client: PENINSTONE LANE, FEANEY BRIDGE
Drawing Status: CONCEPT/PRELIMINARY ONLY ☐ **FOR APPROVAL**☒ FOR CONSTRUCTION ☐ AS BUILT ☐

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Analysis of reinforced slopes

Input data

Project

Task : Penistone Lane Feaney Bridge
Part : Section 1-1
Description : Vertica MacWall
Author : DMcG
Date : 23/03/2025
Project number : 24-5915

Settings

BS 8006 - MSE Wall

Materials and standards

Concrete structures : EN 1992-1-1 (EC2)
Coefficients EN 1992-1-1 : standard

Wall analysis

Active earth pressure calculation : Coulomb
Passive earth pressure calculation : Caquot-Kerisel
Earthquake analysis : Mononobe-Okabe
Shape of earth wedge : Calculate as skew
Allowable eccentricity : 0.333
Internal stability : Standard - straight slip surface
Verification methodology : according to BS 8006

Partial factors of soil properties			
Partial factor on internal friction :	f_{ms} =	1.00	[–]
Partial factor on effective cohesion :	f_{ms} =	1.60	[–]
Partial factor on undrained shear strength :	f_{ms} =	1.00	[–]

Resistance factors			
Resistance factor on sliding :	f_s =	1.20	[–]
Resistance factor on bearing capacity :	f_{ms} =	1.35	[–]
Resistance factor for pullout of reinforcement :	f_p =	1.30	[–]
Partial factors of slip on reinforcement :	f_s =	1.30	[–]

Partial factors - wall					
		Combination A		Combination B	
Dead load of structural components :	f_{fs} =	1.50	[–]	1.00	[–]
Earth pressure - active :	f_{fs} =	1.50	[–]	1.50	[–]
Permanent load - on the block :	f_f =	1.50	[–]	1.00	[–]
Permanent load - behind the block :	f_f =	1.50	[–]	1.50	[–]
Variable load - on the block :	f_q =	1.50	[–]	0.00	[–]
Variable load - behind the block :	f_q =	1.50	[–]	1.50	[–]

Partial factors - slope			
Dead load of structural components :	f_{fs} =	1.50	[–]
Earth surcharge load (permanent) :	f_f =	1.20	[–]
Live load surcharge :	f_q =	1.30	[–]

Stability analysis

Verification methodology : according to EN 1997
Design approach : 1 - reduction of actions and soil parameters

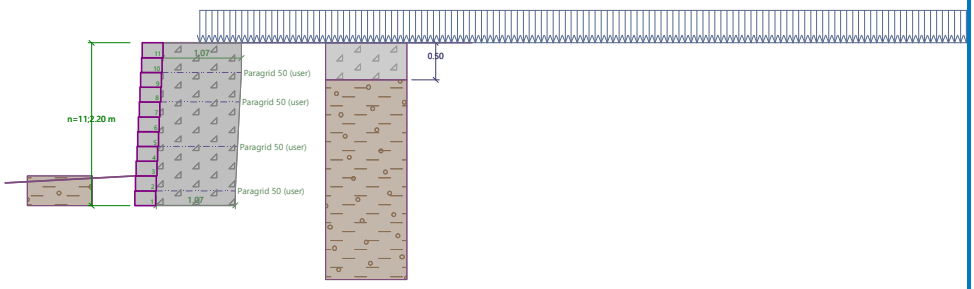
Partial factors on actions (A)								
Permanent design situation								
		Combination 1				Combination 2		
		Unfavourable		Favourable		Unfavourable		Favourable	
Permanent actions :	γ_G =	1.35	[–]	1.00	[–]	1.00	[–]	1.00	[–]
Variable actions :	γ_Q =	1.50	[–]	0.00	[–]	1.30	[–]	0.00	[–]
Water load :	γ_w =	1.00	[–]			1.00	[–]		

Partial factors for soil parameters (M)					
Permanent design situation					
		Combination 1		Combination 2	
Partial factor on internal friction :	γ_ϕ =	1.00	[–]	1.25	[–]
Partial factor on effective cohesion :	γ_c =	1.00	[–]	1.25	[–]
Partial factor on undrained shear strength :	γ_{cu} =	1.00	[–]	1.40	[–]

Geometry of structure

Number of blocks n = 11
Block height h = 0.20 m
Block width b = 0.28 m
Block offset o_1 = 0.01 m

Name : Geometry	Stage - analysis : 1 - 0



Material

Block material

Unit weight γ = 20.50 kN/m^3
Cohesion c = 0.00 kPa
Friction f = 0.533
Shear bearing capacity of joint R_s = 0.00 kN/m

Reinforced soil - Class 6I/6N

Types of reinforcements

No.	Name	Type of reinforcement	Line type	Reinforcement strength		Coefficient	
				T_{ult}[kN/m]	R_t[kN/m]	C_{ds}[–]	C_i[–]
1	Paragrid 50 (user)	user-defined	— · — · — · -	50.00	33.98	0.80	0.90

Reinforcement details

1. Paragrid 50 (user)

Short-term char. strength T_{ult} = 50.00 kN/m
Long-term design strength R_t = 33.98 kN/m
Overall coeff. of model uncertainty FS_{UNC} = 1.00

Input reduction factors
Creep red. factor RF_{CR} = 1.31
Durability red. factor RF_D = 1.08
Installation damage red. factor RF_{ID} = 1.04

Reinforcement

Total number of input reinforcements : 4.

Reinforcement details

Block No.	Type of reinforcement	Origin l_1[m]	End l_2[m]	Height from bottom y[m]	Length l[m]
2	Paragrid 50 (user)	-0.09	0.98	0.20	1.07
5	Paragrid 50 (user)	-0.06	1.01	0.80	1.07
8	Paragrid 50 (user)	-0.03	1.04	1.40	1.07
10	Paragrid 50 (user)	-0.01	1.06	1.80	1.07

Soil parameters

Class 6I/6N

Unit weight : γ = 18.00 kN/m^3
Angle of internal friction : φ_{ef} = 38.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Angle of friction struc.-soil : δ = 25.33 °
Saturated unit weight : γ_{sat} = 18.00 kN/m^3

Weak to moderately weak BEDROCK

Unit weight : γ = 21.00 kN/m^3
Angle of internal friction : φ_{ef} = 32.00 °
Cohesion of soil : c_{ef} = 5.00 kPa
Angle of friction struc.-soil : δ = 21.33 °
Saturated unit weight : γ_{sat} = 21.00 kN/m^3

Geological profile and assigned soils

No.	Thickness of layer t [m]	Depth z [m]	Assigned soil	Pattern
1	0.50	0.00 .. 0.50	Class 6I/6N	
2	9.50	0.50 .. 10.00	Weak to moderately weak BEDROCK	
3	-	10.00 .. ∞	Weak to moderately weak BEDROCK	

Terrain profile

Terrain behind the structure is flat.

Water influence

Ground water table is located below the structure.

Input surface surcharges

No.	Surcharge new	Surcharge change	Action	Mag.1 [kN/m^2]	Mag.2 [kN/m^2]	Ord.x x [m]	Length l [m]	Depth z [m]
1	Yes		variable	10.00		0.50	20.00	on terrain

No.	Name
1	10kPa

Resistance on front face of the structure

Resistance on front face of the structure: not considered
Soil on front face of the structure - Weak to moderately weak BEDROCK
Soil thickness in front of structure h = 0.40 m
Soil slope in front of structure β = -3.00 °

Settings of the stage of construction

Coeff. for structure types : wall

Verification No. 1

Forces acting on construction - combination A

Name	F_{hor} [kN/m]	App.Pt. z [m]	F_{vert} [kN/m]	App.Pt. x [m]	Coeff. overtur.	Coeff. sliding	Coeff. stress
Weight - reinforced soil	0.00	-1.10	42.50	0.87	1.500	1.500	1.500
Active pressure	6.41	-0.62	3.65	1.38	1.500	1.500	1.500
10kPa	4.89	-1.03	2.91	1.40	1.500	1.500	1.500
Weight - wall	0.00	-1.10	12.63	0.19	1.500	1.500	1.500
10kPa	0.00	-2.20	5.60	1.16	1.500	1.500	1.500

Verification of complete wall

Check for overturning stability
Resisting moment M_{res} = 82.26 kNm/m
Overturning moment M_{ovr} = 13.44 kNm/m

Wall for overturning is SATISFACTORY

Check for slip
Resisting horizontal force H_{res} = 56.07 kN/m
Active horizontal force H_{act} = 16.95 kN/m

Wall for slip is SATISFACTORY

Overall check - WALL is SATISFACTORY

Forces acting on construction - combination B

Name	F_{hor} [kN/m]	App.Pt. z [m]	F_{vert} [kN/m]	App.Pt. x [m]	Coeff. overtur.	Coeff. sliding	Coeff. stress
Weight - reinforced soil	0.00	-1.10	42.50	0.87	1.000	1.000	1.000
Active pressure	6.41	-0.62	3.65	1.38	1.500	1.500	1.500
10kPa	4.89	-1.03	2.91	1.40	1.500	1.500	1.500
Weight - wall	0.00	-1.10	12.63	0.19	1.000	1.000	1.000
10kPa	0.00	-2.20	5.60	1.16	0.000	0.000	1.500

Verification of complete wall

Check for overturning stability

Resisting moment M_{res} = 52.91 kNm/m
Overturning moment M_{ovr} = 13.44 kNm/m

Wall for overturning is SATISFACTORY

Check for slip
Resisting horizontal force H_{res} = 36.99 kN/m
Active horizontal force H_{act} = 16.95 kN/m

Wall for slip is SATISFACTORY

Overall check - WALL is SATISFACTORY

Dimensioning No. 1

Forces acting on construction - combination A

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	-0.40	4.59	0.16	1.500	1.500	1.500
Active pressure	1.13	-0.27	0.53	0.29	1.500	1.500	1.500
10kPa	0.81	-0.20	0.38	0.29	1.500	1.500	1.500
Reinforcement	-1.52	-0.40	0.00	1.22	1.000	1.000	1.000

Check of construction joint above the most utilized block No.: 7

Check for overturning stability
Resisting moment M_{res} = 2.07 kNm/m
Overturning moment M_{ovr} = 0.70 kNm/m

Joint for overturning stability is SATISFACTORY

Check for slip
Resisting horizontal force H_{res} = 4.94 kN/m
Active horizontal force H_{act} = 2.91 kN/m

Joint for slip is SATISFACTORY

Forces acting on construction - combination B

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	-0.40	4.59	0.16	1.000	1.000	1.000
Active pressure	1.13	-0.27	0.53	0.29	1.500	1.500	1.500
10kPa	0.81	-0.20	0.38	0.29	1.500	1.500	1.500
Reinforcement	-1.52	-0.40	0.00	1.22	1.000	1.000	1.000

Check of construction joint above the most utilized block No.: 7

Check for overturning stability
Resisting moment M_{res} = 1.72 kNm/m
Overturning moment M_{ovr} = 0.70 kNm/m

Joint for overturning stability is SATISFACTORY

Check for slip
Resisting horizontal force H_{res} = 3.92 kN/m
Active horizontal force H_{act} = 2.91 kN/m

Joint for slip is SATISFACTORY

Dimensioning No. 2

Forces acting on construction - combination A

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	-0.40	4.59	0.16	1.500	1.500	1.500
Active pressure	1.13	-0.27	0.53	0.29	1.500	1.500	1.500
10kPa	0.81	-0.20	0.38	0.29	1.500	1.500	1.500
Reinforcement	-1.52	-0.40	0.00	1.22	1.000	1.000	1.000

Check of construction joint above the most utilized block No.: 7

Check for overturning stability
Resisting moment M_{res} = 2.07 kNm/m
Overturning moment M_{ovr} = 0.70 kNm/m

Joint for overturning stability is SATISFACTORY

Check for slip
Resisting horizontal force H_{res} = 4.94 kN/m
Active horizontal force H_{act} = 2.91 kN/m

Joint for slip is SATISFACTORY

Forces acting on construction - combination B

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	-0.40	4.59	0.16	1.000	1.000	1.000
Active pressure	1.13	-0.27	0.53	0.29	1.500	1.500	1.500
10kPa	0.81	-0.20	0.38	0.29	1.500	1.500	1.500
Reinforcement	-1.52	-0.40	0.00	1.22	1.000	1.000	1.000

Check of construction joint above the most utilized block No.: 7

Check for overturning stability
Resisting moment M_{res} = 1.72 kNm/m
Overturning moment M_{ovr} = 0.70 kNm/m

Joint for overturning stability is SATISFACTORY

Check for slip
Resisting horizontal force H_{res} = 3.92 kN/m
Active horizontal force H_{act} = 2.91 kN/m

Joint for slip 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	-0.70	100.93	16.95	0.000	74.76
2	4.38	64.96	16.95	0.050	53.46
3	0.31	73.36	16.95	0.003	54.68

Service load acting at the center of footing bottom

No.	Moment [kNm/m]	Norm. force [kN/m]	Shear Force [kN/m]
1	-1.76	66.09	8.78

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

Bearing capacity of foundation soil $R = 200.00$ kPa
Partial factor on bearing capacity $\gamma_{Rv} = 1.35$
Max. stress at footing bottom $\sigma = 74.76$ kPa
Bearing capacity of foundation soil $R_d = 148.15$ kPa

Bearing capacity of foundation soil is SATISFACTORY

Overall verification - bearing capacity of found. soil is SATISFACTORY

Verification of slip on georeinforcement No. 1

Forces acting on construction (verification of most utilized reinforcement)

Name	F_{hor} [kN/m]	App.Pt. z [m]	F_{vert} [kN/m]	App.Pt. x [m]	Design coefficient
Weight - wall	0.00	-1.00	11.48	-0.09	1.000
Active pressure	4.95	-0.56	2.80	1.10	1.500
10kPa	4.45	-0.93	2.60	1.12	1.500
Weight - reinforced soil	0.00	-1.00	38.77	0.58	1.000
10kPa	0.00	-2.00	5.85	0.89	0.000

Check for slip along geo-reinforcement with the maximal utilization (Reinforc. No.: 1)

Inclination of slip surface = 87.00 °
Overall normal force acting on reinforcement = 46.87 kN/m
Coefficient of reduction of slip along geo-textile = 0.80
Resistance along geo-reinforcement = 29.29 kN/m
Wall resistance = 6.12 kN/m
Overall bearing capacity of reinforcements = 0.00 kN/m

Check for slip:

Resisting horizontal force $H_{res} = 27.24$ kN/m
Active horiz. force $H_{act} = 14.10$ kN/m

Slip along geotextile is SATISFACTORY

Calculation of internal stability No. 1

Calculated forces and strength of reinforcements

No.	Name	F_x [kN/m]	Depth z[m]	R_t [kN/m]	Utiliz. [%]	T_p [kN/m]	Utiliz. [%]
1	Paragrid 50 (user)	-6.32	2.00	33.98	18.60	38.02	16.62
2	Paragrid 50 (user)	-5.96	1.40	33.98	17.53	18.94	31.46
3	Paragrid 50 (user)	-3.61	0.80	33.98	10.62	6.44	56.07
4	Paragrid 50 (user)	-1.53	0.40	33.98	4.50	1.76	86.98

Check for tensile strength (reinforcement No.1)

Tension strength $R_t = 33.98$ kN/m
Force in reinforcement $F_x = 6.32$ kN/m

Reinforcement for tensile strength is SATISFACTORY

Check for pull out resistance (reinforcement No.4)
Pull out resistance T_p = 1.76 kN/m
Force in reinforcement F_x = 1.53 kN/m

Reinforcement for pull out resistance is SATISFACTORY

Overall verification - reinforcement is SATISFACTORY

Slope stability analysis

Input data

Project

Settings

BS 8006 - MSE Wall

Wall analysis

Partial factors of soil properties			
Partial factor on internal friction :	f_{ms} =	1.00	[–]
Partial factor on effective cohesion :	f_{ms} =	1.60	[–]
Partial factor on undrained shear strength :	f_{ms} =	1.00	[–]

Resistance factors			
Resistance factor on sliding :	f_s =	1.20	[–]
Resistance factor on bearing capacity :	f_{ms} =	1.35	[–]
Resistance factor for pullout of reinforcement :	f_p =	1.30	[–]
Partial factors of slip on reinforcement :	f_s =	1.30	[–]

Partial factors - wall					
		Combination A		Combination B	
Dead load of structural components :	f_{fs} =	1.50	[–]	1.00	[–]
Earth pressure - active :	f_{fs} =	1.50	[–]	1.50	[–]
Permanent load - on the block :	f_f =	1.50	[–]	1.00	[–]
Permanent load - behind the block :	f_f =	1.50	[–]	1.50	[–]
Variable load - on the block :	f_q =	1.50	[–]	0.00	[–]
Variable load - behind the block :	f_q =	1.50	[–]	1.50	[–]

Partial factors - slope			
Dead load of structural components :	f_{fs} =	1.50	[–]
Earth surcharge load (permanent) :	f_f =	1.20	[–]
Live load surcharge :	f_q =	1.30	[–]

Stability analysis

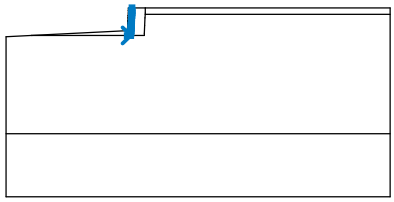
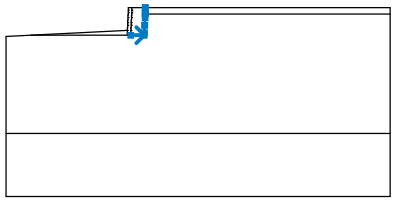
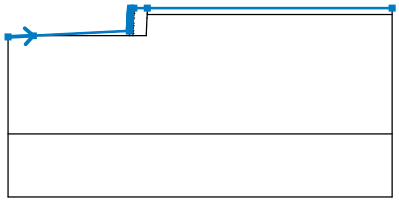
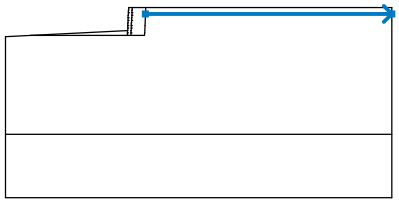
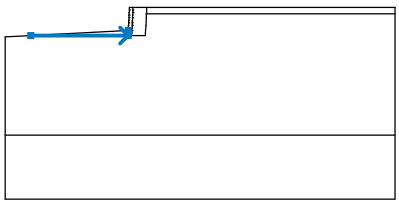
Earthquake analysis : Standard
Verification methodology : according to EN 1997
Design approach : 1 - reduction of actions and soil parameters

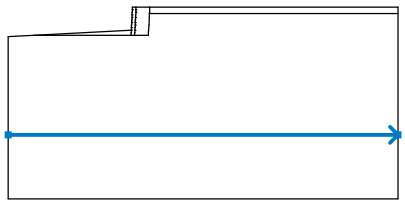
Partial factors on actions (A)					
Permanent design situation					
		Combination 1		Combination 2	
		Unfavourable	Favourable	Unfavourable	Favourable
Permanent actions :	γ_G =	1.35 [–]	1.00 [–]	1.00 [–]	1.00 [–]

Partial factors on actions (A)								
Permanent design situation								
Variable actions :	γ_Q =	1.50	[–]	0.00	[–]	1.30	[–]	0.00 [–]
Water load :	γ_w =	1.00	[–]			1.00	[–]	

Partial factors for soil parameters (M)					
Permanent design situation					
		Combination 1		Combination 2	
Partial factor on internal friction :	γ_ϕ =	1.00	[–]	1.25	[–]
Partial factor on effective cohesion :	γ_c =	1.00	[–]	1.25	[–]
Partial factor on undrained shear strength :	γ_{cu} =	1.00	[–]	1.40	[–]

Interface

No.	Interface location	Coordinates of interface points [m]					
		x	z	x	z	x	z
1		-0.38	-2.20	-0.10	-2.20	-0.10	-2.00
		-0.09	-2.00	-0.09	-1.80	-0.08	-1.80
		-0.08	-1.60	-0.07	-1.60	-0.07	-1.40
		-0.06	-1.40	-0.06	-1.20	-0.05	-1.20
		-0.05	-1.00	-0.04	-1.00	-0.04	-0.80
		-0.03	-0.80	-0.03	-0.60	-0.02	-0.60
		-0.02	-0.40	-0.01	-0.40	-0.01	-0.20
		0.00	-0.20	0.00	0.00		
2		-0.10	-2.20	0.97	-2.20	0.98	-2.00
		1.01	-1.40	1.04	-0.80	1.05	-0.50
		1.06	-0.40	1.06	0.00		
3		-10.00	-2.30	-8.00	-2.20	-0.37	-1.80
		-0.36	-1.80	-0.36	-1.60	-0.35	-1.60
		-0.35	-1.40	-0.34	-1.40	-0.34	-1.20
		-0.33	-1.20	-0.33	-1.00	-0.32	-1.00
		-0.32	-0.80	-0.31	-0.80	-0.31	-0.60
		-0.30	-0.60	-0.30	-0.40	-0.29	-0.40
		-0.29	-0.20	-0.28	-0.20	-0.28	0.00
		0.00	0.00	1.06	0.00	20.50	0.00
4		1.05	-0.50	20.50	-0.50		
5		-8.00	-2.20	-0.38	-2.20	-0.38	-2.00
		-0.37	-2.00	-0.37	-1.80		

No.	Interface location	Coordinates of interface points [m]					
		x	z	x	z	x	z
6		-10.00	-10.00	20.50	-10.00		

Soil parameters - effective stress state

No.	Name	Pattern	φ_{ef} [°]	c_{ef} [kPa]	γ [kN/m^3]
1	Class 6I/6N		38.00	0.00	18.00
2	Weak to moderately weak BEDROCK		32.00	5.00	21.00

Soil parameters - uplift

No.	Name	Pattern	γ_{sat} [kN/m^3]	γ_s [kN/m^3]	n [–]
1	Class 6I/6N		18.00		
2	Weak to moderately weak BEDROCK		21.00		

Soil parameters

Class 6I/6N

Unit weight : γ = 18.00 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 38.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 18.00 kN/m^3

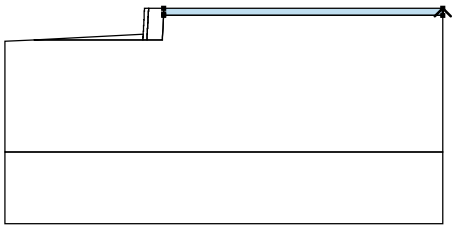
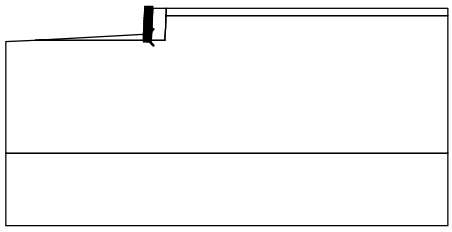
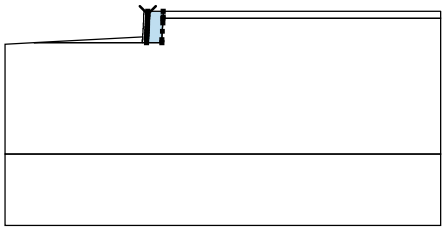
Weak to moderately weak BEDROCK

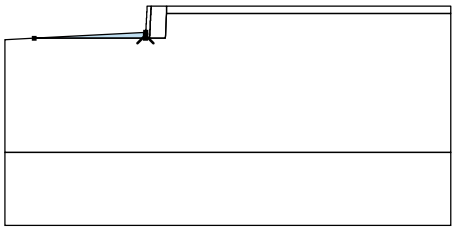
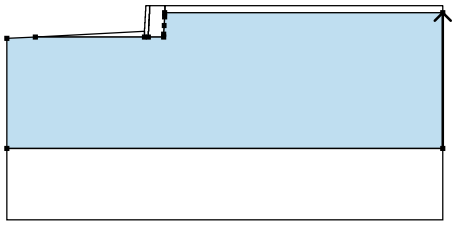
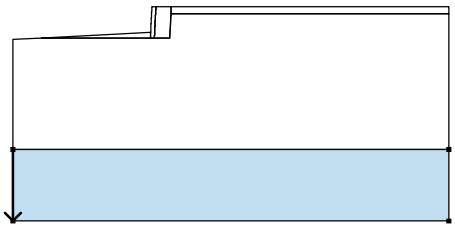
Unit weight : γ = 21.00 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 32.00 °
Cohesion of soil : c_{ef} = 5.00 kPa
Saturated unit weight : γ_{sat} = 21.00 kN/m^3

Rigid Bodies

No.	Name	Sample	γ [kN/m³]
1	Material of structure		20.50

Assigning and surfaces

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
1		20.50	-0.50	20.50	0.00	Class 6I/6N
		1.06	0.00	1.06	-0.40	
		1.05	-0.50			
2		-0.37	-2.00	-0.38	-2.00	Material of structure
		-0.38	-2.20	-0.10	-2.20	
		-0.10	-2.00	-0.09	-2.00	
		-0.09	-1.80	-0.08	-1.80	
		-0.08	-1.60	-0.07	-1.60	
		-0.07	-1.40	-0.06	-1.40	
		-0.06	-1.20	-0.05	-1.20	
		-0.05	-1.00	-0.04	-1.00	
		-0.04	-0.80	-0.03	-0.80	
		-0.03	-0.60	-0.02	-0.60	
		-0.02	-0.40	-0.01	-0.40	
		-0.01	-0.20	0.00	-0.20	
		0.00	0.00	-0.28	0.00	
		-0.28	-0.20	-0.29	-0.20	
		-0.29	-0.40	-0.30	-0.40	
		-0.30	-0.60	-0.31	-0.60	
		-0.31	-0.80	-0.32	-0.80	
		-0.32	-1.00	-0.33	-1.00	
		-0.33	-1.20	-0.34	-1.20	
		-0.34	-1.40	-0.35	-1.40	
		-0.35	-1.60	-0.36	-1.60	
		-0.36	-1.80	-0.37	-1.80	
3		0.00	0.00	0.00	-0.20	Class 6I/6N
		-0.01	-0.20	-0.01	-0.40	
		-0.02	-0.40	-0.02	-0.60	
		-0.03	-0.60	-0.03	-0.80	
		-0.04	-0.80	-0.04	-1.00	
		-0.05	-1.00	-0.05	-1.20	
		-0.06	-1.20	-0.06	-1.40	
		-0.07	-1.40	-0.07	-1.60	
		-0.08	-1.60	-0.08	-1.80	
		-0.09	-1.80	-0.09	-2.00	
		-0.10	-2.00	-0.10	-2.20	
		0.97	-2.20	0.98	-2.00	
		1.01	-1.40	1.04	-0.80	

No.	Surface position	Coordinates of surface points [m] x	z	x	z	Assigned soil
		1.05	-0.50	1.06	-0.40	
		1.06	0.00			
4		-0.38	-2.20	-0.38	-2.00	Weak to moderately weak BEDROCK
		-0.37	-2.00	-0.37	-1.80	
		-8.00	-2.20			
5		20.50	-10.00	20.50	-0.50	Weak to moderately weak BEDROCK
		1.05	-0.50	1.04	-0.80	
		1.01	-1.40	0.98	-2.00	
		0.97	-2.20	-0.10	-2.20	
		-0.38	-2.20	-8.00	-2.20	
		-10.00	-2.30	-10.00	-10.00	
6		-10.00	-10.00	-10.00	-15.00	Weak to moderately weak BEDROCK
		20.50	-15.00	20.50	-10.00	

Reinforcements

No.	Point to the left x [m]	z [m]	Point to the right x [m]	z [m]	Length L [m]	Strength R_t [kN/m]	Pull out resist.	End of reinf.
1	-0.01	-0.40	1.06	-0.40	1.07	33.98	T_p = 10.13 kN/m^2	Fixed
2	-0.03	-0.80	1.04	-0.80	1.07	33.98	T_p = 16.20 kN/m^2	Fixed
3	-0.06	-1.40	1.01	-1.40	1.07	33.98	T_p = 28.34 kN/m^2	Fixed
4	-0.09	-2.00	0.98	-2.00	1.07	33.98	T_p = 40.49 kN/m^2	Fixed

Surcharge

No.	Type	Type of action	Location z [m]	Origin x [m]	Length l [m]	Width b [m]	Slope α [°]	Magnitude q, q_1, f, F, x	q_2, z	unit
1	strip	variable	on terrain	x = 0.50	l = 20.00		0.00	10.00		kN/m^2

Surcharges

No.	Name
1	10kPa

Results (Stage of construction 1)

Analysis 1

Circular slip surface

Slip surface parameters							
Center :	x =	-0.51	[m]	Angles :	α_1 =	-31.66	[°]
	z =	0.82	[m]		α_2 =	75.10	[°]
Radius :	R =	3.19	[m]				
The slip surface after optimization.							

Reinforcement bearing capacity

Combination 1

Reinforcement	Bearing capacity [kN/m]
1	0.00
2	0.00
3	0.00
4	0.00

Combination 2

Reinforcement	Bearing capacity [kN/m]
1	0.00
2	0.00
3	0.00
4	0.16

Slope stability verification (Bishop)

Combination 1

Sum of active forces : F_a = 65.38 kN/m
Sum of passive forces : F_p = 123.61 kN/m

Sliding moment : M_a = 200.72 kNm/m
Resisting moment : M_p = 379.49 kNm/m
Utilization : 52.9 %

Slope stability ACCEPTABLE

Combination 2

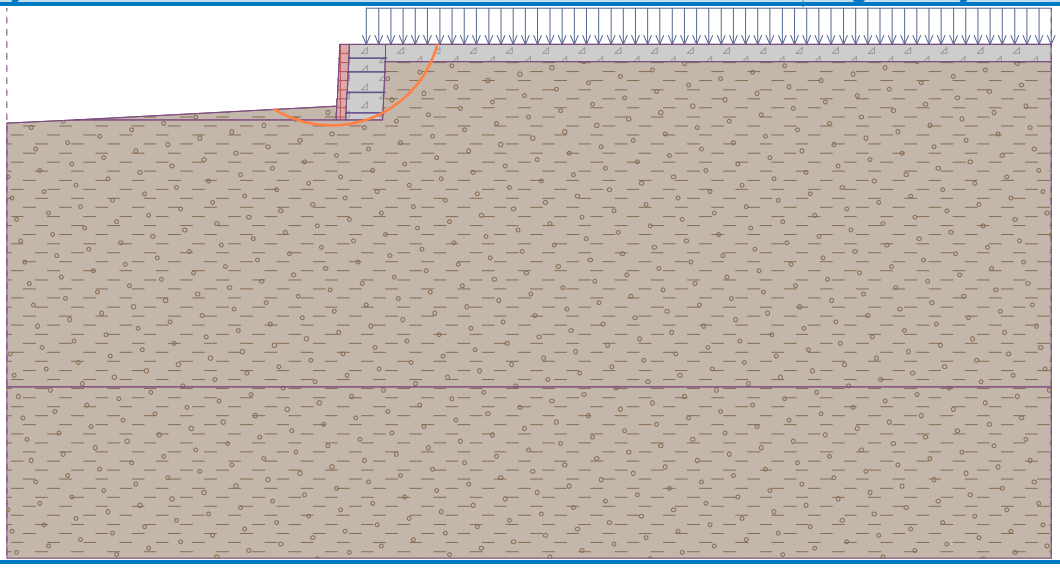
Sum of active forces : F_a = 54.92 kN/m
Sum of passive forces : F_p = 91.93 kN/m

Sliding moment : M_a = 175.20 kNm/m
Resisting moment : M_p = 293.25 kNm/m
Utilization : 59.7 %

Slope stability ACCEPTABLE

Optimized slip surface for : Combination 2

Name : Analysis | **Stage - analysis : 1 - 1**



Analysis of reinforced slopes

Input data

Project

Task : Penistone Lane Feaney Bridge
Part : Section 4-4
Description : Vertica MacWall
Author : DMcG
Date : 23/03/2025
Project number : 24-5915

Settings

BS 8006 - MSE Wall

Materials and standards

Concrete structures : EN 1992-1-1 (EC2)
Coefficients EN 1992-1-1 : standard

Wall analysis

Active earth pressure calculation : Coulomb
Passive earth pressure calculation : Caquot-Kerisel
Earthquake analysis : Mononobe-Okabe
Shape of earth wedge : Calculate as skew
Allowable eccentricity : 0.333
Internal stability : Standard - straight slip surface
Verification methodology : according to BS 8006

Partial factors of soil properties			
Partial factor on internal friction :	f_{ms} =	1.00	[–]
Partial factor on effective cohesion :	f_{ms} =	1.60	[–]
Partial factor on undrained shear strength :	f_{ms} =	1.00	[–]

Resistance factors			
Resistance factor on sliding :	f_s =	1.20	[–]
Resistance factor on bearing capacity :	f_{ms} =	1.35	[–]
Resistance factor for pullout of reinforcement :	f_p =	1.30	[–]
Partial factors of slip on reinforcement :	f_s =	1.30	[–]

Partial factors - wall					
		Combination A		Combination B	
Dead load of structural components :	f_{fs} =	1.50	[–]	1.00	[–]
Earth pressure - active :	f_{fs} =	1.50	[–]	1.50	[–]
Permanent load - on the block :	f_f =	1.50	[–]	1.00	[–]
Permanent load - behind the block :	f_f =	1.50	[–]	1.50	[–]
Variable load - on the block :	f_q =	1.50	[–]	0.00	[–]
Variable load - behind the block :	f_q =	1.50	[–]	1.50	[–]

Partial factors - slope			
Dead load of structural components :	f_{fs} =	1.50	[–]
Earth surcharge load (permanent) :	f_f =	1.20	[–]
Live load surcharge :	f_q =	1.30	[–]

Stability analysis

Verification methodology : according to EN 1997
Design approach : 1 - reduction of actions and soil parameters

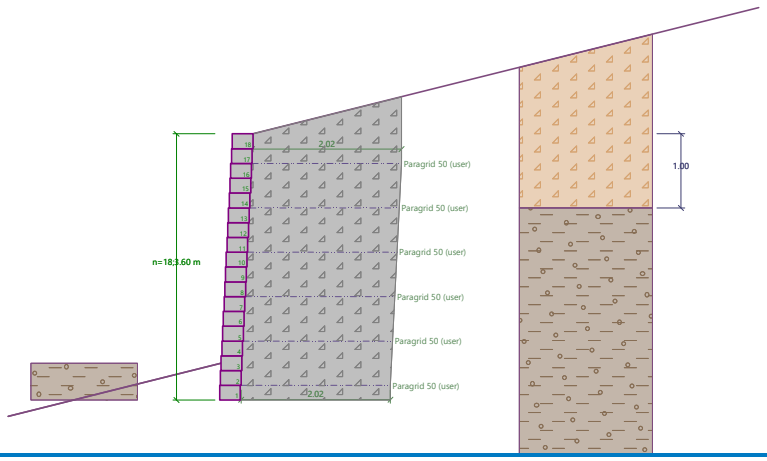
Partial factors on actions (A)									
Permanent design situation									
		Combination 1				Combination 2			
		Unfavourable		Favourable		Unfavourable		Favourable	
Permanent actions :	γ_G =	1.35	[–]	1.00	[–]	1.00	[–]	1.00	[–]
Variable actions :	γ_Q =	1.50	[–]	0.00	[–]	1.30	[–]	0.00	[–]
Water load :	γ_w =	1.00	[–]			1.00	[–]		

Partial factors for soil parameters (M)					
Permanent design situation					
		Combination 1		Combination 2	
Partial factor on internal friction :	γ_ϕ =	1.00	[–]	1.25	[–]
Partial factor on effective cohesion :	γ_c =	1.00	[–]	1.25	[–]
Partial factor on undrained shear strength :	γ_{cu} =	1.00	[–]	1.40	[–]

Geometry of structure

Number of blocks n = 18
Block height h = 0.20 m
Block width b = 0.28 m
Block offset o_1 = 0.01 m

Name : Geometry	Stage - analysis : 1 - 0



Material

Block material

Unit weight γ = 20.50 kN/m^3
Cohesion c = 0.00 kPa
Friction f = 0.533
Shear bearing capacity of joint R_s = 0.00 kN/m

Reinforced soil - Class 6I/6N

Types of reinforcements

No.	Name	Type of reinforcement	Line type	Reinforcement strength		Coefficient	
				T_{ult}[kN/m]	R_t[kN/m]	C_{ds}[–]	C_i[–]
1	Paragrid 50 (user)	user-defined	— · — · — · -	50.00	33.98	0.80	0.90

Reinforcement details

1. Paragrid 50 (user)

Short-term char. strength T_{ult} = 50.00 kN/m
Long-term design strength R_t = 33.98 kN/m
Overall coeff. of model uncertainty FS_{UNC} = 1.00

Input reduction factors
Creep red. factor RF_{CR} = 1.31
Durability red. factor RF_D = 1.08
Installation damage red. factor RF_{ID} = 1.04

Reinforcement

Total number of input reinforcements : 6.

Reinforcement details

Block No.	Type of reinforcement	Origin l_1[m]	End l_2[m]	Height from bottom y[m]	Length l[m]
2	Paragrid 50 (user)	-0.16	1.86	0.20	2.02
5	Paragrid 50 (user)	-0.13	1.89	0.80	2.02
8	Paragrid 50 (user)	-0.10	1.92	1.40	2.02
11	Paragrid 50 (user)	-0.07	1.95	2.00	2.02
14	Paragrid 50 (user)	-0.04	1.98	2.60	2.02
17	Paragrid 50 (user)	-0.01	2.01	3.20	2.02

Soil parameters

Class 6I/6N

Unit weight : γ = 18.00 kN/m^3
Angle of internal friction : φ_{ef} = 38.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Angle of friction struc.-soil : δ = 25.33 °
Saturated unit weight : γ_{sat} = 18.00 kN/m^3

Weak to moderately weak BEDROCK

Unit weight : γ = 21.00 kN/m^3
Angle of internal friction : φ_{ef} = 32.00 °
Cohesion of soil : c_{ef} = 5.00 kPa
Angle of friction struc.-soil : δ = 21.33 °
Saturated unit weight : γ_{sat} = 21.00 kN/m^3

Soft CLAY/ MADE GROUND

Unit weight : γ = 18.00 kN/m^3
Angle of internal friction : φ_{ef} = 28.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Angle of friction struc.-soil : δ = 18.60 °
Saturated unit weight : γ_{sat} = 18.00 kN/m^3

Geological profile and assigned soils

No.	Thickness of layer t [m]	Depth z [m]	Assigned soil	Pattern
1	1.00	0.00 .. 1.00	Soft CLAY/ MADE GROUND	
2	9.00	1.00 .. 10.00	Weak to moderately weak BEDROCK	
3	-	10.00 .. ∞	Weak to moderately weak BEDROCK	

Terrain profile

Terrain behind construction has the slope 1: 4.01 (slope angle is 14.00 °).

Water influence

Ground water table is located below the structure.

Input surface surcharges

No.	Surcharge new	Surcharge change	Action	Mag.1 [kN/m²]	Mag.2 [kN/m²]	Ord.x x [m]	Length l [m]	Depth z [m]
1	Yes		variable	10.00		0.50	20.00	on terrain

No.	Name
1	10kPa

Resistance on front face of the structure

Resistance on front face of the structure: not considered
Soil on front face of the structure - Weak to moderately weak BEDROCK
Soil thickness in front of structure h = 0.50 m
Soil slope in front of structure β = -14.00 °

Settings of the stage of construction

Coeff. for structure types : wall

Verification No. 1

Forces acting on construction - combination A

Name	F_{hor} [kN/m]	App.Pt. z [m]	F_{vert} [kN/m]	App.Pt. x [m]	Coeff. overtur.	Coeff. sliding	Coeff. stress
Weight - reinforced soil	0.00	-1.93	140.21	1.40	1.500	1.500	1.500
Active pressure	37.44	-1.42	20.42	2.37	1.500	1.500	1.500
10kPa	12.94	-2.12	6.95	2.40	1.500	1.500	1.500
Weight - wall	0.00	-1.80	20.66	0.22	1.500	1.500	1.500
10kPa	0.00	-3.91	15.10	1.71	1.500	1.500	1.500

Verification of complete wall

Check for overturning stability
Resisting moment M_{res} = 438.32 kNm/m
Overturning moment M_{ovr} = 120.88 kNm/m

Wall for overturning is SATISFACTORY

Check for slip
Resisting horizontal force H_{res} = 164.25 kN/m
Active horizontal force H_{act} = 75.56 kN/m

Wall for slip is SATISFACTORY

Overall check - WALL is SATISFACTORY

Forces acting on construction - combination B

Name	F_{hor} [kN/m]	App.Pt. z [m]	F_{vert} [kN/m]	App.Pt. x [m]	Coeff. overtur.	Coeff. sliding	Coeff. stress
Weight - reinforced soil	0.00	-1.93	140.21	1.40	1.000	1.000	1.000
Active pressure	37.44	-1.42	20.42	2.37	1.500	1.500	1.500
10kPa	12.94	-2.12	6.95	2.40	1.500	1.500	1.500
Weight - wall	0.00	-1.80	20.66	0.22	1.000	1.000	1.000
10kPa	0.00	-3.91	15.10	1.71	0.000	0.000	1.500

Verification of complete wall

Check for overturning stability
Resisting moment M_{res} = 298.98 kNm/m
Overturning moment M_{ovr} = 120.88 kNm/m

Wall for overturning is SATISFACTORY

Check for slip
Resisting horizontal force H_{res} = 109.74 kN/m
Active horizontal force H_{act} = 75.56 kN/m

Wall for slip is SATISFACTORY

Overall check - WALL is SATISFACTORY

Dimensioning No. 1

Forces acting on construction - combination A

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	-0.20	2.30	0.15	1.500	1.500	1.500
Active pressure	0.33	-0.13	0.16	0.28	1.500	1.500	1.500
10kPa	0.31	-0.07	0.15	0.28	1.500	1.500	1.500

Check of construction joint above the most utilized block No.: 16

Check for overturning stability
Resisting moment M_{res} = 0.63 kNm/m
Overturning moment M_{ovr} = 0.10 kNm/m

Joint for overturning stability is SATISFACTORY

Check for slip
Resisting horizontal force H_{res} = 1.73 kN/m
Active horizontal force H_{act} = 0.96 kN/m

Joint for slip is SATISFACTORY

Forces acting on construction - combination B

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	-0.20	2.30	0.15	1.000	1.000	1.000
Active pressure	0.33	-0.13	0.16	0.28	1.500	1.500	1.500
10kPa	0.31	-0.07	0.15	0.28	0.000	1.500	1.500

Check of construction joint above the most utilized block No.: 16

Check for overturning stability
Resisting moment M_{res} = 0.40 kNm/m
Overturning moment M_{ovr} = 0.07 kNm/m

Joint for overturning stability is SATISFACTORY

Check for slip
Resisting horizontal force H_{res} = 1.22 kN/m
Active horizontal force H_{act} = 0.96 kN/m

Joint for slip is SATISFACTORY

Dimensioning No. 2

Forces acting on construction - combination A

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	-0.20	2.30	0.15	1.500	1.500	1.500
Active pressure	0.33	-0.13	0.16	0.28	1.500	1.500	1.500
10kPa	0.31	-0.07	0.15	0.28	1.500	1.500	1.500

Check of construction joint above the most utilized block No.: 16

Check for overturning stability
Resisting moment M_{res} = 0.63 kNm/m
Overturning moment M_{ovr} = 0.10 kNm/m

Joint for overturning stability is SATISFACTORY

Check for slip
Resisting horizontal force H_{res} = 1.73 kN/m
Active horizontal force H_{act} = 0.96 kN/m

Joint for slip is SATISFACTORY

Forces acting on construction - combination B

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	-0.20	2.30	0.15	1.000	1.000	1.000
Active pressure	0.33	-0.13	0.16	0.28	1.500	1.500	1.500
10kPa	0.31	-0.07	0.15	0.28	0.000	1.500	1.500

Check of construction joint above the most utilized block No.: 16

Check for overturning stability
Resisting moment M_{res} = 0.40 kNm/m
Overturning moment M_{ovr} = 0.07 kNm/m

Joint for overturning stability is SATISFACTORY

Check for slip
Resisting horizontal force H_{res} = 1.22 kN/m
Active horizontal force H_{act} = 0.96 kN/m

Joint for slip 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	33.32	305.01	75.56	0.047	146.53
2	54.11	201.92	75.56	0.117	114.47
3	41.54	224.57	75.56	0.080	116.36

Service load acting at the center of footing bottom

No.	Moment [kNm/m]	Norm. force [kN/m]	Shear Force [kN/m]
1	19.74	201.12	46.39

Verification of foundation soil

Stress in the footing bottom : rectangle

Eccentricity verification

Max. eccentricity of normal force $e = 0.047$
Maximum allowable eccentricity $e_{alw} = 0.333$

Eccentricity of the normal force is SATISFACTORY

Verification of bearing capacity

Bearing capacity of foundation soil $R = 200.00$ kPa
Partial factor on bearing capacity $\gamma_{Rv} = 1.35$
Max. stress at footing bottom $\sigma = 146.53$ kPa
Bearing capacity of foundation soil $R_d = 148.15$ kPa

Bearing capacity of foundation soil is SATISFACTORY

Overall verification - bearing capacity of found. soil is SATISFACTORY

Verification of slip on georeinforcement No. 1

Forces acting on construction (verification of most utilized reinforcement)

Name	F_{hor} [kN/m]	App.Pt. z [m]	F_{vert} [kN/m]	App.Pt. x [m]	Design coefficient
Weight - wall	0.00	-1.70	19.52	-0.05	1.000
Active pressure	33.34	-1.26	18.87	2.10	1.500
10kPa	12.24	-2.03	6.58	2.13	1.500
Weight - reinforced soil	0.00	-1.83	133.59	1.13	1.000
10kPa	0.00	-3.72	15.65	1.45	0.000

Check for slip along geo-reinforcement with the maximal utilization (Reinforc. No.: 1)

Inclination of slip surface = 87.00 °
Overall normal force acting on reinforcement = 171.77 kN/m
Coefficient of reduction of slip along geo-textile = 0.80
Resistance along geo-reinforcement = 107.36 kN/m
Wall resistance = 10.40 kN/m
Overall bearing capacity of reinforcements = 0.00 kN/m

Check for slip:

Resisting horizontal force $H_{res} = 90.58$ kN/m
Active horiz. force $H_{act} = 68.38$ kN/m

Slip along geotextile is SATISFACTORY

Calculation of internal stability No. 1

Calculated forces and strength of reinforcements

No.	Name	F_x [kN/m]	Depth z[m]	R_t [kN/m]	Utiliz. [%]	T_p [kN/m]	Utiliz. [%]
1	Paragrid 50 (user)	-10.65	3.40	33.98	31.35	135.91	7.84
2	Paragrid 50 (user)	-11.16	2.80	33.98	32.84	98.20	11.36
3	Paragrid 50 (user)	-9.39	2.20	33.98	27.62	66.60	14.09
4	Paragrid 50 (user)	-7.61	1.60	33.98	22.40	41.11	18.52

No.	Name	F_x [kN/m]	Depth z[m]	R_t [kN/m]	Utiliz. [%]	T_p [kN/m]	Utiliz. [%]
5	Paragrid 50 (user)	-5.84	1.00	33.98	17.18	21.73	26.88
6	Paragrid 50 (user)	-3.39	0.40	33.98	9.99	8.45	40.15

Check for tensile strength (reinforcement No.2)
Tension strength R_t = 33.98 kN/m
Force in reinforcement F_x = 11.16 kN/m

Reinforcement for tensile strength is SATISFACTORY

Check for pull out resistance (reinforcement No.6)
Pull out resistance T_p = 8.45 kN/m
Force in reinforcement F_x = 3.39 kN/m

Reinforcement for pull out resistance is SATISFACTORY

Overall verification - reinforcement is SATISFACTORY

Slope stability analysis

Input data

Project

Settings

BS 8006 - MSE Wall

Wall analysis

Partial factors of soil properties			
Partial factor on internal friction :	f_{ms} =	1.00	[–]
Partial factor on effective cohesion :	f_{ms} =	1.60	[–]
Partial factor on undrained shear strength :	f_{ms} =	1.00	[–]

Resistance factors			
Resistance factor on sliding :	f_s =	1.20	[–]
Resistance factor on bearing capacity :	f_{ms} =	1.35	[–]
Resistance factor for pullout of reinforcement :	f_p =	1.30	[–]
Partial factors of slip on reinforcement :	f_s =	1.30	[–]

Partial factors - wall		Combination A		Combination B	
Dead load of structural components :	f_{fs} =	1.50	[–]	1.00	[–]
Earth pressure - active :	f_{fs} =	1.50	[–]	1.50	[–]
Permanent load - on the block :	f_f =	1.50	[–]	1.00	[–]
Permanent load - behind the block :	f_f =	1.50	[–]	1.50	[–]
Variable load - on the block :	f_q =	1.50	[–]	0.00	[–]
Variable load - behind the block :	f_q =	1.50	[–]	1.50	[–]

Partial factors - slope			
Dead load of structural components :	f_{fs} =	1.50	[–]
Earth surcharge load (permanent) :	f_f =	1.20	[–]
Live load surcharge :	f_q =	1.30	[–]

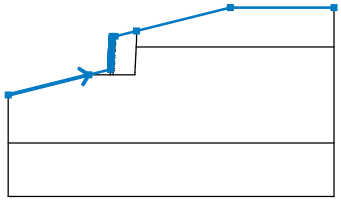
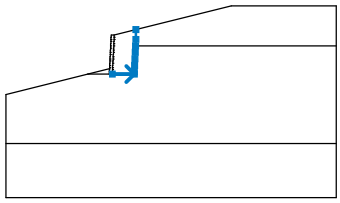
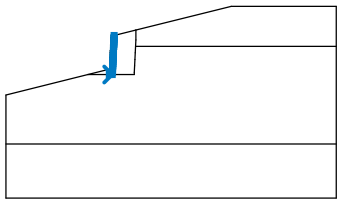
Stability analysis

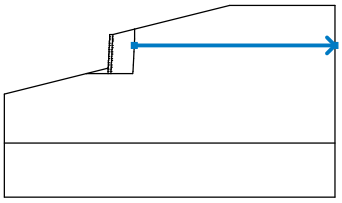
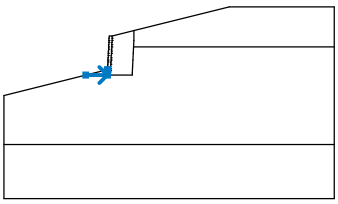
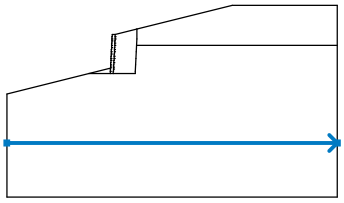
Earthquake analysis : Standard
Verification methodology : according to EN 1997
Design approach : 1 - reduction of actions and soil parameters

Partial factors on actions (A)									
Permanent design situation									
		Combination 1				Combination 2			
		Unfavourable		Favourable		Unfavourable		Favourable	
Permanent actions :	γ_G =	1.35	[–]	1.00	[–]	1.00	[–]	1.00	[–]
Variable actions :	γ_Q =	1.50	[–]	0.00	[–]	1.30	[–]	0.00	[–]
Water load :	γ_w =	1.00	[–]			1.00	[–]		

Partial factors for soil parameters (M)					
Permanent design situation					
		Combination 1		Combination 2	
Partial factor on internal friction :	γ_ϕ =	1.00	[–]	1.25	[–]
Partial factor on effective cohesion :	γ_c =	1.00	[–]	1.25	[–]
Partial factor on undrained shear strength :	γ_{cu} =	1.00	[–]	1.40	[–]

Interface

No.	Interface location	Coordinates of interface points [m]					
		x	z	x	z	x	z
1		-10.00	-5.49	-2.44	-3.60	-0.43	-3.10
		-0.43	-3.00	-0.42	-3.00	-0.42	-2.80
		-0.41	-2.80	-0.41	-2.60	-0.40	-2.60
		-0.40	-2.40	-0.39	-2.40	-0.39	-2.20
		-0.38	-2.20	-0.38	-2.00	-0.37	-2.00
		-0.37	-1.80	-0.36	-1.80	-0.36	-1.60
		-0.35	-1.60	-0.35	-1.40	-0.34	-1.40
		-0.34	-1.20	-0.33	-1.20	-0.33	-1.00
		-0.32	-1.00	-0.32	-0.80	-0.31	-0.80
		-0.31	-0.60	-0.30	-0.60	-0.30	-0.40
		-0.29	-0.40	-0.29	-0.20	-0.28	-0.20
		-0.28	0.00	0.00	0.00	2.01	0.50
		10.80	2.69	20.50	2.69		
2		-0.17	-3.60	1.85	-3.60	1.86	-3.40
		1.89	-2.80	1.92	-2.20	1.95	-1.60
		1.98	-1.00	2.01	-0.40	2.01	0.50
3		-0.45	-3.60	-0.17	-3.60	-0.17	-3.40
		-0.16	-3.40	-0.16	-3.20	-0.15	-3.20
		-0.15	-3.00	-0.14	-3.00	-0.14	-2.80
		-0.13	-2.80	-0.13	-2.60	-0.12	-2.60
		-0.12	-2.40	-0.11	-2.40	-0.11	-2.20
		-0.10	-2.20	-0.10	-2.00	-0.09	-2.00
		-0.09	-1.80	-0.08	-1.80	-0.08	-1.60
		-0.07	-1.60	-0.07	-1.40	-0.06	-1.40
		-0.06	-1.20	-0.05	-1.20	-0.05	-1.00
		-0.04	-1.00	-0.04	-0.80	-0.03	-0.80

No.	Interface location	Coordinates of interface points [m]					
		x	z	x	z	x	z
		-0.03	-0.60	-0.02	-0.60	-0.02	-0.40
		-0.01	-0.40	-0.01	-0.20	0.00	-0.20
		0.00	0.00				
4		1.98	-1.00	20.50	-1.00		
5		-2.44	-3.60	-0.45	-3.60	-0.45	-3.40
		-0.44	-3.40	-0.44	-3.20	-0.43	-3.20
		-0.43	-3.10				
6		-10.00	-10.00	20.50	-10.00		

Soil parameters - effective stress state

No.	Name	Pattern	φ_{ef} [°]	c_{ef} [kPa]	γ [kN/m^3]
1	Class 6I/6N		38.00	0.00	18.00
2	Weak to moderately weak BEDROCK		32.00	5.00	21.00
3	Soft CLAY/ MADE GROUND		28.00	0.00	18.00

Soil parameters - uplift

No.	Name	Pattern	γ_{sat} [kN/m^3]	γ_s [kN/m^3]	n [–]
1	Class 6I/6N		18.00		
2	Weak to moderately weak BEDROCK		21.00		

No.	Name	Pattern	γ_{sat} [kN/m^3]	γ_s [kN/m^3]	n [–]
3	Soft CLAY/ MADE GROUND		18.00		

Soil parameters

Class 6I/6N

Unit weight :	γ =	18.00 kN/m^3
Stress-state :		effective
Angle of internal friction :	φ_{ef} =	38.00 °
Cohesion of soil :	c_{ef} =	0.00 kPa
Saturated unit weight :	γ_{sat} =	18.00 kN/m^3

Weak to moderately weak BEDROCK

Unit weight :	γ =	21.00 kN/m^3
Stress-state :		effective
Angle of internal friction :	φ_{ef} =	32.00 °
Cohesion of soil :	c_{ef} =	5.00 kPa
Saturated unit weight :	γ_{sat} =	21.00 kN/m^3

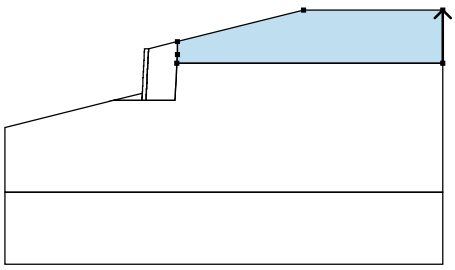
Soft CLAY/ MADE GROUND

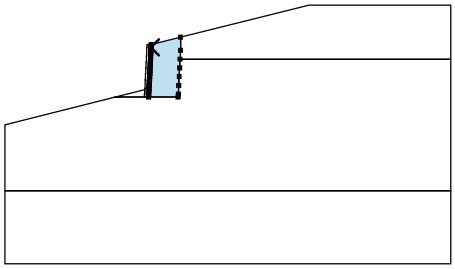
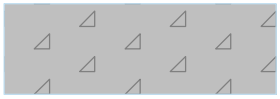
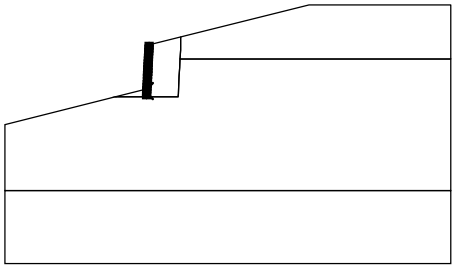
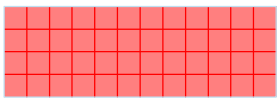
Unit weight :	γ =	18.00 kN/m^3
Stress-state :		effective
Angle of internal friction :	φ_{ef} =	28.00 °
Cohesion of soil :	c_{ef} =	0.00 kPa
Saturated unit weight :	γ_{sat} =	18.00 kN/m^3

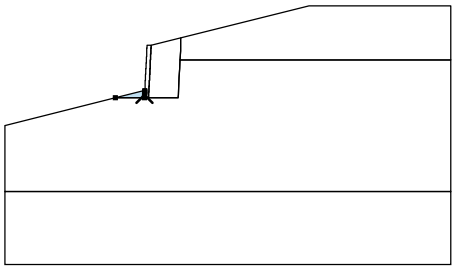
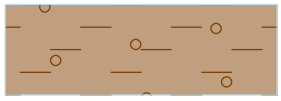
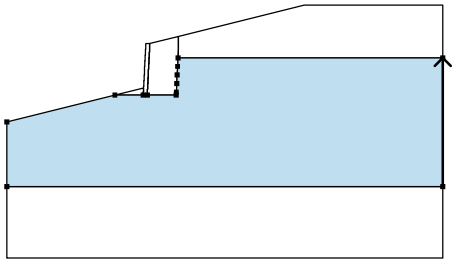
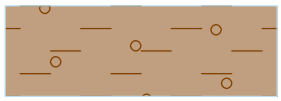
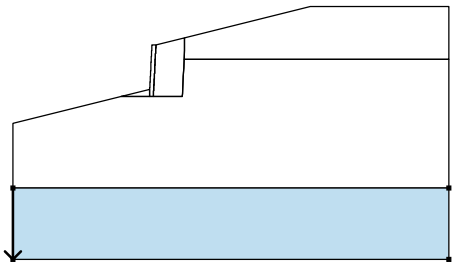
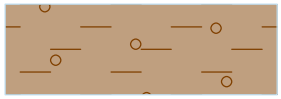
Rigid Bodies

No.	Name	Sample	γ [kN/m^3]
1	Material of structure		20.50

Assigning and surfaces

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
1		20.50	-1.00	20.50	2.69	Soft CLAY/ MADE GROUND
		10.80	2.69	2.01	0.50	
		2.01	-0.40	1.98	-1.00	

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
2		0.00	-0.20	-0.01	-0.20	Class 6I/6N 
		-0.01	-0.40	-0.02	-0.40	
		-0.02	-0.60	-0.03	-0.60	
		-0.03	-0.80	-0.04	-0.80	
		-0.04	-1.00	-0.05	-1.00	
		-0.05	-1.20	-0.06	-1.20	
		-0.06	-1.40	-0.07	-1.40	
		-0.07	-1.60	-0.08	-1.60	
		-0.08	-1.80	-0.09	-1.80	
		-0.09	-2.00	-0.10	-2.00	
		-0.10	-2.20	-0.11	-2.20	
		-0.11	-2.40	-0.12	-2.40	
		-0.12	-2.60	-0.13	-2.60	
		-0.13	-2.80	-0.14	-2.80	
		-0.14	-3.00	-0.15	-3.00	
		-0.15	-3.20	-0.16	-3.20	
		-0.16	-3.40	-0.17	-3.40	
		-0.17	-3.60	1.85	-3.60	
		1.86	-3.40	1.89	-2.80	
		1.92	-2.20	1.95	-1.60	
		1.98	-1.00	2.01	-0.40	
		2.01	0.50	0.00	0.00	
3		-0.43	-3.20	-0.44	-3.20	Material of structure 
		-0.44	-3.40	-0.45	-3.40	
		-0.45	-3.60	-0.17	-3.60	
		-0.17	-3.40	-0.16	-3.40	
		-0.16	-3.20	-0.15	-3.20	
		-0.15	-3.00	-0.14	-3.00	
		-0.14	-2.80	-0.13	-2.80	
		-0.13	-2.60	-0.12	-2.60	
		-0.12	-2.40	-0.11	-2.40	
		-0.11	-2.20	-0.10	-2.20	
		-0.10	-2.00	-0.09	-2.00	
		-0.09	-1.80	-0.08	-1.80	
		-0.08	-1.60	-0.07	-1.60	
		-0.07	-1.40	-0.06	-1.40	
		-0.06	-1.20	-0.05	-1.20	
		-0.05	-1.00	-0.04	-1.00	
		-0.04	-0.80	-0.03	-0.80	
		-0.03	-0.60	-0.02	-0.60	
		-0.02	-0.40	-0.01	-0.40	
		-0.01	-0.20	0.00	-0.20	
		0.00	0.00	-0.28	0.00	
		-0.28	-0.20	-0.29	-0.20	
		-0.29	-0.40	-0.30	-0.40	
		-0.30	-0.60	-0.31	-0.60	
		-0.31	-0.80	-0.32	-0.80	
		-0.32	-1.00	-0.33	-1.00	
		-0.33	-1.20	-0.34	-1.20	
		-0.34	-1.40	-0.35	-1.40	
		-0.35	-1.60	-0.36	-1.60	

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
		-0.36	-1.80	-0.37	-1.80	
		-0.37	-2.00	-0.38	-2.00	
		-0.38	-2.20	-0.39	-2.20	
		-0.39	-2.40	-0.40	-2.40	
		-0.40	-2.60	-0.41	-2.60	
		-0.41	-2.80	-0.42	-2.80	
		-0.42	-3.00	-0.43	-3.00	
		-0.43	-3.10			
4		-0.45	-3.60	-0.45	-3.40	Weak to moderately weak BEDROCK
		-0.44	-3.40	-0.44	-3.20	
		-0.43	-3.20	-0.43	-3.10	
		-2.44	-3.60			
5		20.50	-10.00	20.50	-1.00	Weak to moderately weak BEDROCK
		1.98	-1.00	1.95	-1.60	
		1.92	-2.20	1.89	-2.80	
		1.86	-3.40	1.85	-3.60	
		-0.17	-3.60	-0.45	-3.60	
		-2.44	-3.60	-10.00	-5.49	
		-10.00	-10.00			
6		-10.00	-10.00	-10.00	-15.00	Weak to moderately weak BEDROCK
		20.50	-15.00	20.50	-10.00	

Reinforcements

No.	Point to the left		Point to the right		Length	Strength	Pull out resist.	End of reinf.
	x [m]	z [m]	x [m]	z [m]	L [m]	R_t [kN/m]		
1	-0.01	-0.40	2.01	-0.40	2.02	33.98	T_p = 6.89 kN/m^2	Fixed
2	-0.04	-1.00	1.98	-1.00	2.02	33.98	T_p = 17.23 kN/m^2	Fixed
3	-0.07	-1.60	1.95	-1.60	2.02	33.98	T_p = 32.39 kN/m^2	Fixed
4	-0.10	-2.20	1.92	-2.20	2.02	33.98	T_p = 44.54 kN/m^2	Fixed
5	-0.13	-2.80	1.89	-2.80	2.02	33.98	T_p = 56.69 kN/m^2	Fixed
6	-0.16	-3.40	1.86	-3.40	2.02	33.98	T_p = 68.84 kN/m^2	Fixed

Surcharge

No.	Type	Type of action	Location z [m]	Origin x [m]	Length l [m]	Width b [m]	Slope α [°]	Magnitude q, q_1, f, F, x	Magnitude q_2, z	Magnitude unit
1	strip	variable	on terrain	x = 0.50	l = 20.00		0.00	10.00		kN/m^2

Surcharges

No.	Name
1	10kPa

Results (Stage of construction 1)

Analysis 1

Circular slip surface

Slip surface parameters						
Center :	x =	-2.56	[m]	Angles :	α_1 =	-15.39 [°]
	z =	4.54	[m]		α_2 =	70.47 [°]
Radius :	R =	9.10	[m]			
The slip surface after optimization.						

Reinforcement bearing capacity

Combination 1

Reinforcement	Bearing capacity [kN/m]
1	0.00
2	0.00
3	0.00
4	0.00
5	0.00
6	0.00

Combination 2

Reinforcement	Bearing capacity [kN/m]
1	0.00
2	0.00
3	0.00
4	0.00
5	0.00
6	0.00

Slope stability verification (Bishop)

Combination 1

Sum of active forces : F_a = 292.56 kN/m
Sum of passive forces : F_p = 400.54 kN/m

Sliding moment : M_a = 2682.75 kNm/m
Resisting moment : M_p = 3672.99 kNm/m
Utilization : 73.0 %

Slope stability ACCEPTABLE

Combination 2

Sum of active forces : F_a = 242.07 kN/m
Sum of passive forces : F_p = 288.41 kN/m

Sliding moment : M_a = 2202.86 kNm/m
Resisting moment : M_p = 2624.52 kNm/m
Utilization : 83.9 %

Slope stability ACCEPTABLE

Optimized slip surface for : Combination 2

Name : Analysis	Stage - analysis : 1 - 1