GEOMAN
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Ecocrib Retaining Walls

Location Address:	Horwich Golf Club, Bolton
Geoman Design Reference Number:	23-5006-F20

Issued to	Issue purpose	Revision	Designed	Checked	Date
PC Construction	For Approval	0	ST	[redacted]	27.11.23
PC Construction	For Approval	A	ST		25.01.24
PC Construction	For Approval	B	ST		08.02.24
PC Construction	For Approval	C	ST		08.02.24

This design is in accordance with the principles set out in current British Standards, Codes of Practice and industry specification. Reference to a particular standard, code of practice or specification does not imply total compliance with the whole of the document only that they are complied with where considered appropriate, in the experience of the designer.

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1.0 Introduction

1.1 Brief

Geoman Ltd. was requested by PC Construction Ltd. to prepare a design for three Ecocrib retaining walls as an element of the permanent works at the entrance of the development at Horwich Golf Club in Bolton.

1.2 Scope

This design covers the three proposed Ecocrib walls around the entrance road to the proposed development as shown indicatively on Geoman drawing number SK23-5006-F20-01A. The limits of the Ecocrib element design are the crib base width, back to ground level at the back of the top course of header units.

The most onerous cross-sections were considered as follows:

Section	Retained height	Crest slope details	Toe slope details	Drawing Ref:
1-1	2.423m (Lower tier) 1.775m (Upper tier)	Maximum 1V:5H (12°)	None	SK23-5006-F20-02C
2-2	2.459m	Maximum 1V:3H (18°)	None	SK23-5006-F20-01A

For the above sections:

A maximum surcharge of 5kN/m^2 was assumed to act on the retained side of the Ecocrib wall. If the surcharge on the retained side of the wall is to exceed 5kN/m², the Principal Contractor must inform Geoman Ltd. prior to construction to allow this design to be reviewed.

Some settlement will occur after construction, depending on the compaction and condition of the backfill placed. The settlement should be monitored and placement of any surface finishes delayed until it has ceased.

Allowance has been made for unforeseen excavation in front of the wall of 10% of its height, in accordance with BSEN1997-1:2004 - Eurocode 7, Cl. 9.3.2.2.

This solution is for the permanent works only and is issued on the basis that a safe system of works is provided for construction. The Principal Contractor/ Ecocrib installer must produce a method statement and risk assessment for the works to be approved by the Principal Designer. Geoman Ltd. is not responsible for temporary stability or design of any temporary works.

A minimum 150mm diameter perforated drainage pipe is to be placed at the rear of the walls, with a fall to a suitable outlet, as per Geoman Ltd. drawing numbers SK23-5006-F20-01A and -02C. The drainage pipe is to be jettable and regularly maintained. Site drainage is outside the scope of this design.

Pedestrian and vehicle barrier requirements at the crest and toes of the walls are to be determined by the Client's Consulting Engineer. It has been assumed that a maximum 1.8m high pedestrian fence will be installed within the Ecocrib walls and that no additional horizontal loading will be transferred to the Ecocrib walls.

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

The Principal Contractor must contact the Client's Consulting Engineer to ensure that any earthworks required for the proposed retaining wall do 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.

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

P.C. Construction is material supplier and our client.
The Scheme Client is Northstone Homes
The Clients Consulting Engineer is to be confirmed
The Principal Contractor and Principal Design in accordance with CDM 2015 should be confirmed.

The above parties should all read and check this design document before proceeding. Please advise us before proceeding with construction if there are any errors in the scope.

1.3 Information

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

Cad file '105 EXTERNAL WORKS 17.10.23'
E3p Phase 1 and 2 Geoenvironmental Site Assessment Report No. 15-259-R1-2 (April 2023)
General email correspondence (copies retained by Geoman Ltd.)

2.0 Design

2.1 Ground Conditions/Design Parameters

The Client's 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.

We have been provided with E3p Phase 1 and 2 Geoenvironmental Site Assessment Report No. 15-259-R1-2 (April 2023) which includes logs of exploratory holes sunk on the site and results of in-situ testing in the logs.

The most relevant logs to this design are HP201, WS201, WS150, TP235 and WS151. The logs generally encountered a superficial depth of Made Ground overlying firm slightly silty CLAY or clayey GRAVEL (Weathered Mudstone Bedrock). It is assumed that formation of the walls will be within the dense very clayey GRAVEL (Weathered MUDSTONE). A minimum effective angle of internal friction of 30 degrees has been assumed for the formation material based on a minimum SPT' N' value of 10 in WS150 (BS8002:1994). It is assumed that the retained material will also consist of dense clayey GRAVEL.

The Client's 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.

Based on the geotechnical information above, the soil parameters assumed in the design are as follows:

Material	Description	Unit Weight (kN/m^3)	Assumed Effective Angle of Internal Friction	Cohesion (kN/m^2)
Foundation	Dense very clayey GRAVEL (Weathered MUDSTONE)	19.0	30°	0
Retained	Dense clayey GRAVEL	19.0	30°	0

The Principal Contractor and/or a Geotechnical Engineer must confirm the localised suitability of the formation material under the full extent of the footings. It must be ensured dense very clayey GRAVEL (Weathered MUDSTONE) with a minimum safe bearing resistance in excess of 100kPa is present at formation level. Any soft, loose or unsuitable material (such as made ground, topsoil, peat or alluvium) present at or below formation level must be excavated down to weathered MUDSTONE and replaced with compacted granular fill.

Several plate bearing tests should be undertaken to confirm a minimum safe bearing resistance of 100kPa for the material present at and below formation level. Plate bearing tests should be carried out to comply with BS1377-9. Incremental load tests to CI4.1.6.4.2. A minimum 600mm diameter plate should be used and loaded to at least 250kPa in 50kPa increments. If cohesive material is found at formation level, hand shear vane tests should be carried out to confirm a minimum undrained shear strength (cu) of 50kPa. If any material with an undrained shear strength of <50kPa is left in place at or below formation level, excessive settlement and/or global instability may occur. Geoman are not responsible or verifying the competency of the formation.

2.2 Ecocrib Backfill

Free draining compacted Class 6N or Type 1 granular backfill is to be used behind the proposed retaining wall. 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 600/800)	Description	Use	Unit Weight (kN/m^3)	Effective Angle of Internal Friction	Cohesion (kN/m^2)
Class 6N/ Type 1	Selected well graded granular material	Ecocrib backfill	18.0	35^o	0

2.3 Surcharge Loads

A maximum surcharge of $5kN/m^2$ was assumed to act on the retained side of the Ecocrib wall.

2.4 Crest/ Toe Slopes

Refer to section 1.2 and Geoman Ltd. drawing number SK23-5006-F20-01A and -02C. The topography at the crest of the walls needs to be checked prior to construction and Geoman Ltd. must be informed if it is more onerous than assumed, as the design will need to be reviewed.

2.5 Ground Water

No groundwater was recorded in the relevant logs but for analysis purposes, a water table at formation level of the walls was considered.

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

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.

2.6 Drainage

A 150mm diameter jettable robust drainage pipe must be provided as indicated on SK23-5006-F20-01A and -02C, discharging to an approved outlet point. The pipe must be fully roddable/ jettable and regularly maintained.

3.0 Analysis

3.1 Method of Analysis

Methods of Analysis: BSEN1997-1:2004 - Eurocode 7
Retaining System: Ecocrib mass gravity retaining wall.

Fine GEO5 software packages Prefab Wall and Stability were used for analysis purposes for the proposed Ecocrib retaining walls. Analysis files GE23-5006-F20-01A to -04 are included in the attached Appendix.

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

4.0 Summary

Ecocrib elements supplied by P.C. Construction are to be used for construction of the wall. Headers are to be installed at 750mm centres.

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.

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. Please refer to the manufacturer's installation guidelines.

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

Geoman Ltd accordingly does not accept responsibility for the accuracy or completeness of information or assumptions from which the design proposal has been produced. The design proposal remains the copyright and property of Geoman Ltd and is not to be copied or disclosed to any person other than the person to whom it is originally intended.

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

5.0 Construction Supervision Requirements

The following construction supervision requirements should be adhered to by the project team (Principal Designer, Client's 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.

1. The Principal Contractor and/or a Geotechnical Engineer must confirm the localised suitability of the formation material under the full extent of the footings. See Section 2.1.
2. The backfill is to be compacted Class 6N or Type 1 granular fill, compacted in accordance with SFHW Series 600, Table 6/4.
3. The wall to be constructed should be checked for the required geometry and retained height to ensure that they are within the scope of this design.
4. 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.
5. 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.
6. 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.
7. Some settlement of the subgrade and backfill will occur after construction, depending on the compaction of the foundation soils. The settlement should be monitored, and all finishes should be delayed until settlement is complete.

6.0 Maintenance Requirements

The wall 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 walls should be routinely inspected for signs of any faults, vandalism or movement. Initially a six month inspection and annually after that. 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 6.1 remain and must therefore be addressed by the Principal Designer, Client's Consulting Engineer and Principal Contractor.

7.1 SIGNIFICANT DESIGN RISKS REMAINING:

RISK		SUGGESTED REMEDIATION
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 suitability of the founding material, and that it has a minimum safe bearing resistance of 100kPa, prior to construction commencing. Section 2.1 for details.
02	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. Principal Contractor and/ or Groundworks Contractor to provide 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.
03	Serviceability movement of wall affecting roads, services or structures at the crest of the walls.	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.
04	Wind loads on fence affecting wall stability	Pedestrian and vehicle barrier requirements at the crest and toe of the walls are to be determined by the Client's Consulting Engineer. It has been assumed that a maximum 1.8m high pedestrian fence will be installed within the Ecocrib walls (designed and detailed by others) and that no additional horizontal loading will be transferred to the Ecocrib walls.
05	Topography	We have received limited information on proposed levels beyond the site boundary behind Wall 03, The topography should be checked and confirmed on site prior to construction.

8.0 Designer Risk Assessment

CONSTRUCTION OF AN ECOCRIB WALL

NOTICE OF HAZARD IDENTIFICATION (GENERIC DESIGNER RISK ASSESSMENT)

CATEGORY C/D/M	ACTIVITY/ELEMENT	POSSIBLE HAZARD	RISK ASSESSMENT Low/Medium/High	ACTION PROPOSED	ACTION BY
C	Working at heights >2m	Falling	H	Wear Harness OR provide access scaffold	Contractor
C/M	Working at heights	Falling	M	Wear Harness OR provide access scaffold	Contractor
C	Cutting crib elements, placing concrete, etc.	Personal Injury	M	Use of suitable PPE (safety goggles, gloves, etc.)	Contractor
C	Placing backfill	Personal Injury	M	Use mini excavator to place stone fill where practicable	Contractor
C	Excavation of embankment/ existing wall prior to installation of wall	Embankment Slip - Personal Injury	H	Excavation of embankment to a safe angle of repose for the short term. Consider using temporary propping such as sheet piles and excavating in short lengths	Contractor/ Principal Designer
M	Steep retaining structures > 2m in height	Falling/Personal Injury	H	Provision of permanent fence/ barrier at crest of retaining structure	Client

Category: C = Construction, M = Maintenance/Use, D = Demolition

NOTICE OF HAZARD IDENTIFICATION (SPECIFIC DESIGNER RISK ASSESSMENT)

CATEGORY C/D/M	ACTIVITY/ELEMENT	POSSIBLE HAZARD	RISK ASSESSMENT Low/Medium/High	ACTION PROPOSED	ACTION BY
C	Excavation into existing material to foundation level	Bank slip / Personal injury	H	Excavation of ground to a safe angle of repose for the short term and/ or foundation excavation & construction of lower courses carried out in short lengths. Temporary propping of cut embankment such as sheet piles to be considered. Use of granular backfill.	Principal Contractor / Wall Installer
C	Excavation into existing material to foundation level	Striking existing services/ Personal injury	M	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 / Principal Contractor / Wall Installer
C	Excavation into existing material to foundation level	Striking live cables/ electrocution	M	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).	Principal Designer / Principal Contractor / Wall Installer
C	General Installation of Ecocrib	Personal Injury	M	Adhere to Supplier Installation Guidelines.	Contractor

Category: C = Construction, M = Maintenance/Use, D = Demolition

9.0 Appendices

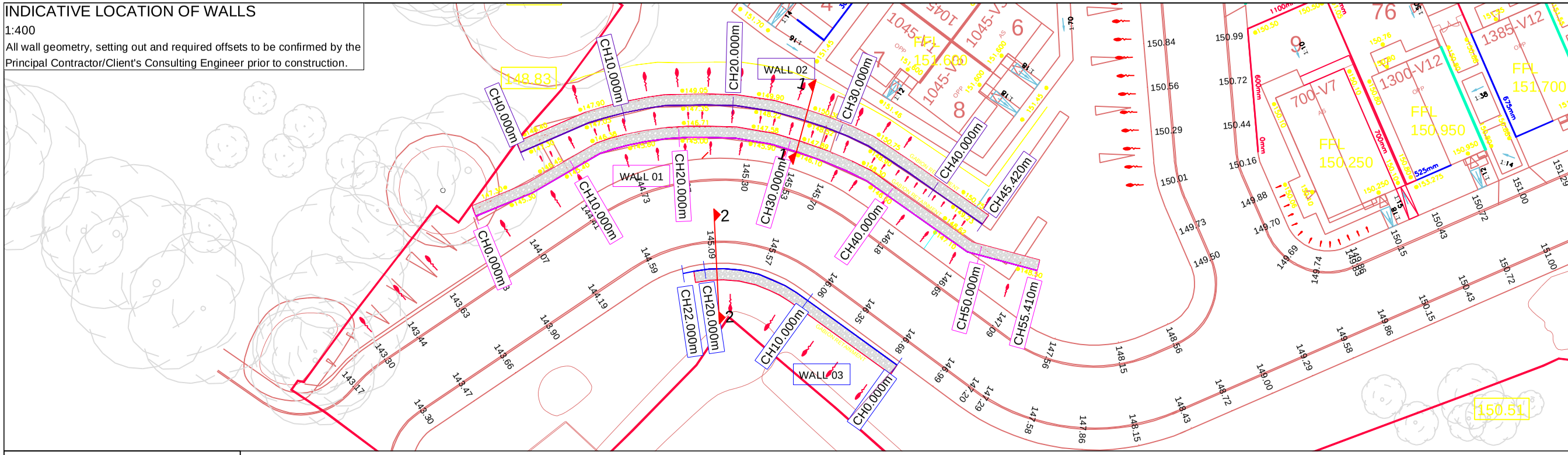
Geoman Ltd. drawing SK23-5006-F20-01A and -02C

GEO5 analysis files GE523-5006-F20-01A to -04

INDICATIVE LOCATION OF WALLS

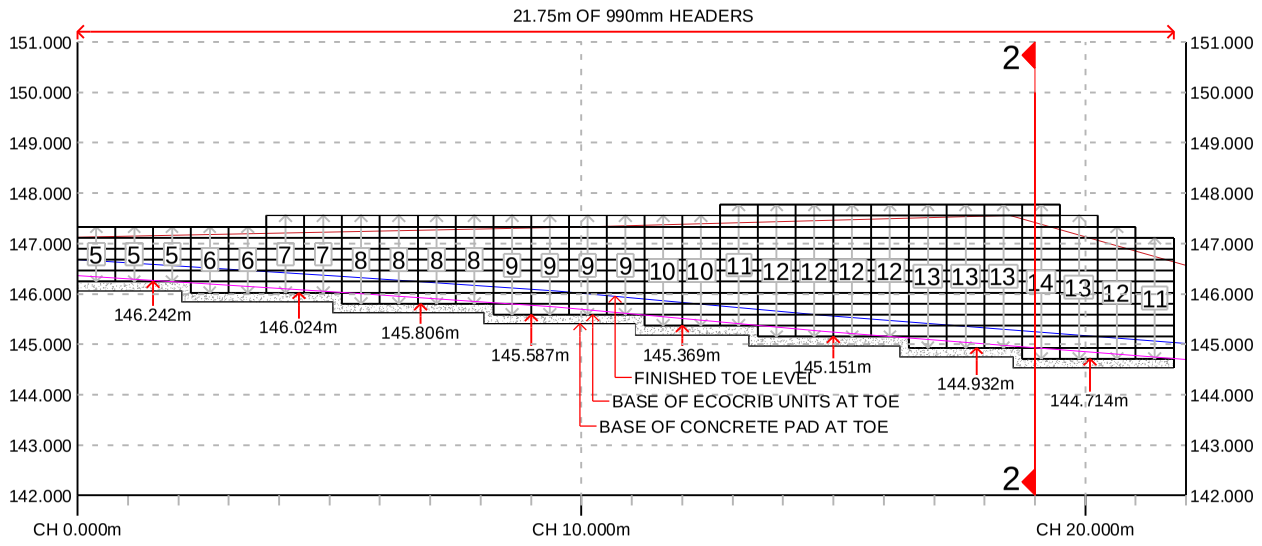
1:400

All wall geometry, setting out and required offsets to be confirmed by the Principal Contractor/Client's Consulting Engineer prior to construction.



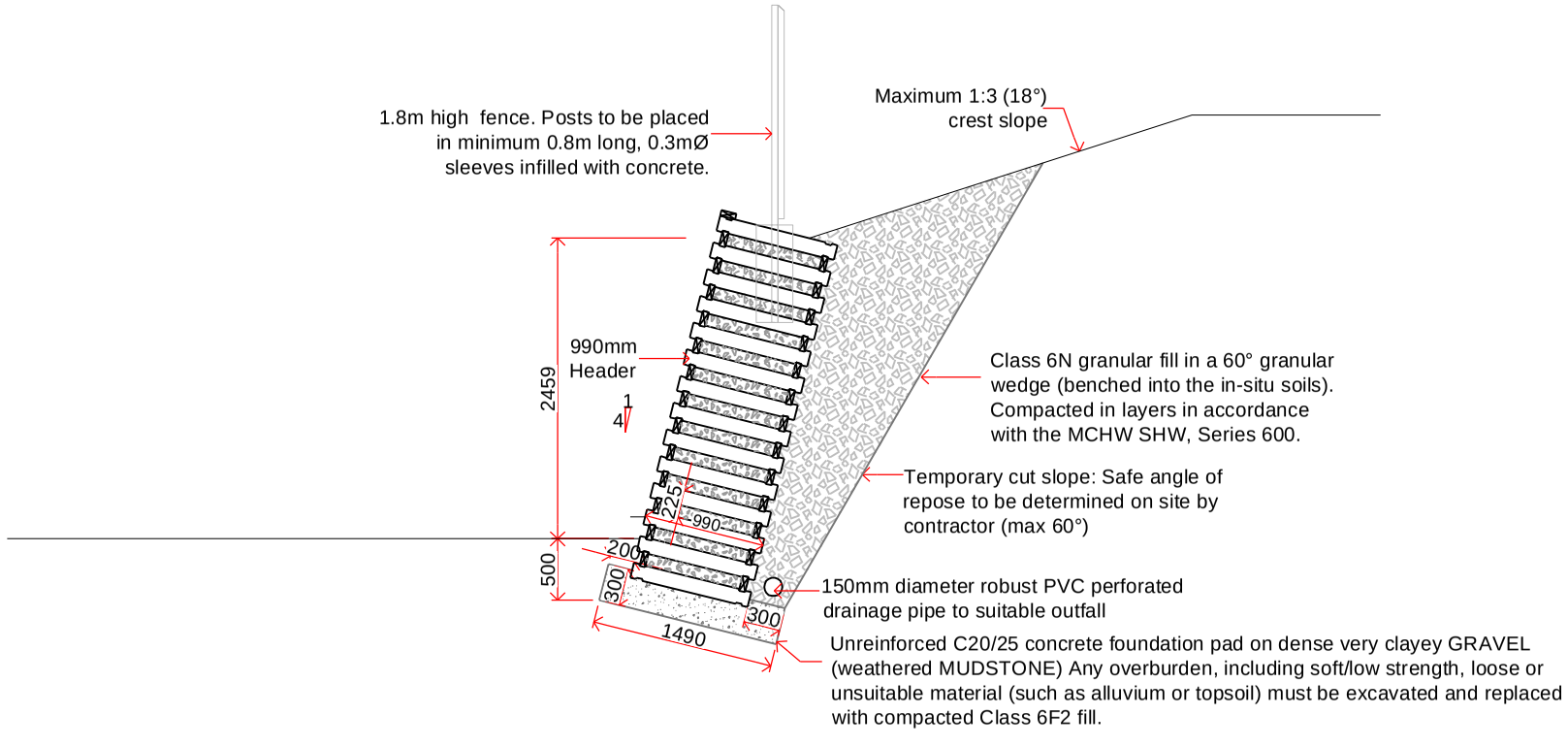
WALL 03 ELEVATION

1:150



SECTION 2-2

1:50



Notes:

1) DIMENSIONS Dimensions in mms unless specified.

2) ECOCRIB/ GEOGRID SPECIFICATION:
Wall to be constructed using ECO44 Ecocrib components in accordance with Technical Data Sheet Ref: *DS10-5187-01 (31.03.11)*.

3) INSTALLATION: Refer to manufacturer's guidelines.

4) INFILL FOR ECOCRIB: 40-75mm stone.

5) BACKFILL TO ECOCRIB
The backfill shall comprise selected compacted granular fill material, to the standards of Class 6N/6P/6Q fill in SFHW Series 600. This material is assumed to have the following characteristics: Effective angle of internal friction = 35 degrees, density = 18 kN/m³ and c' = 0kPa, compacted to a minimum of 95% maximum dry density in accordance with SFHW Series 600. 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.

6) FOUNDATION FOR ECOCRIB WALLS
It is assumed that formation level of the Ecocrib will be on dense very clayey GRAVEL (weathered MUDSTONE), with a minimum safe bearing resistance of 100kPa. Any soft/ low strength, loose or unsuitable material present at or below formation level must be excavated down to a firm-stiff/ medium-dense stratum and replaced with compacted Class 6F2 granular fill.
The soils present at and below formation level must possess a minimum allowable bearing capacity of 100kPa.

Minimum embedment to the top of the concrete pad to be maintained at 0.2m below finished ground level and 0.5m to the base of the concrete foundation. The Principal Contractor/Client's Consulting Engineer must confirm the locations of all services prior to construction and ensure that none will be affected by the wall and its installation.

7) SITE / IN-SITU SOILS :
Retained: Assumed to be dense very clayey GRAVEL or compacted Class 1/2 general fill (site-won weathered rock or Glacial Till); this material is assumed to have the following minimum properties:
f ' = 30°, γ = 20kN/m³ and c' = 0kPa.

Foundation: Assumed to be dense very clayey GRAVEL (weathered MUDSTONE); this material is assumed to have the following minimum properties:
f ' = 30°, γ = 20kN/m³ and c' = 0kPa.

8) PEDESTRIAN FENCE/ VEHICLE BARRIER:
A maximum 1.8m high close boarded fence (designed by others) is to be installed at the top of the wall. The fence posts should be placed in minimum 0.8m long, 0.3mØ sleeves. The sleeves are to be infilled around the posts with concrete.

10) TECHNICAL APPROVAL
It is assumed that Technical Approval (to CG300) of the Ecocrib wall is NOT required. Please advise if Technical Approval is required, as this design may need revised.

11) CHECKING OF CALCULATIONS/ DRAWINGS
All information is referenced within the QP06 design document that accompanies this drawing. These plans and the accompanying design documentation should be thoroughly checked by the Client's Consulting Engineer. Any apparent errors, omissions or variations should be reported immediately to Geoman Ltd. Construction of the walls shall not commence unless and until the Client/ Client's Consulting Engineer has considered the Geoman Design Submission Document (QP06 Ref: 23-5006) to ensure that there are no errors, omissions or conflict with the scheme design.

DRAFT FOR COMMENT
NOT FOR CONSTRUCTION

Issue / Revision:	Drawn:	Date:
Rev. A - Changed to EcoCrib	ST	05.02.24
Rev. 0	ST	27.11.23

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02890 664941 geoman@geoman.co.uk

Project Title: HORWICH GOLF CLUB

Client: PC CONSTRUCTION LTD.

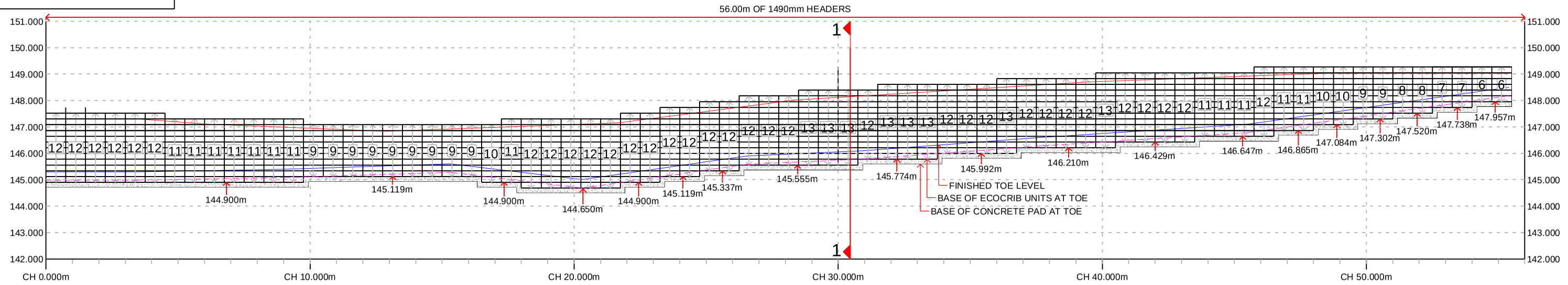
Drawing Title: ECOCRIB ENTRANCE WALL

Designed:			Date:	Project No:	23-5006
Drawn:	ST		Date: 27.11.23	Scale:	AS INDICATED AT A3
Checked:			Date:		

Drawing No: SK23-5006-F20-01 Revision: A

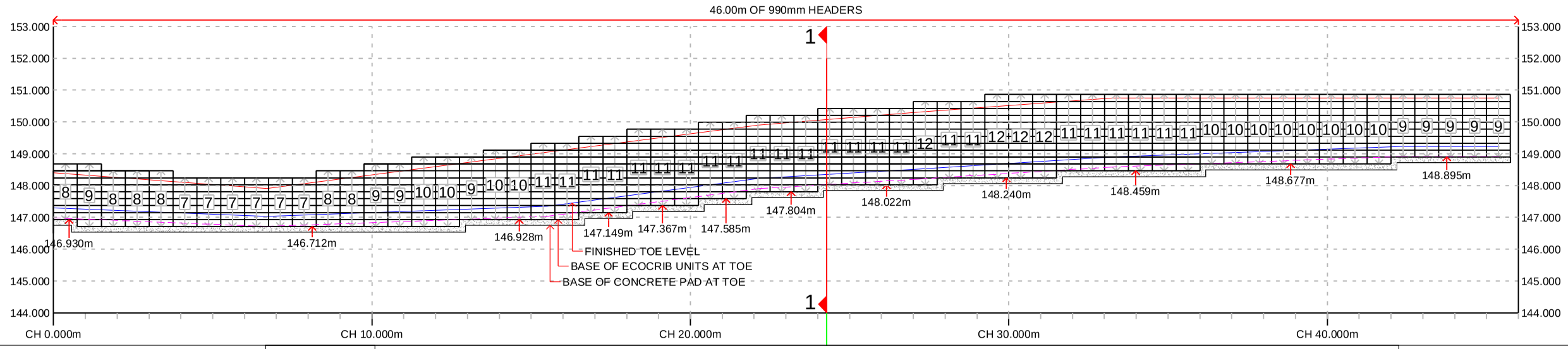
WALL 01 ELEVATION

1:150



WALL 02 ELEVATION

1:150



Notes:

1) DIMENSIONS Dimensions in mms unless specified.

2) ECOCRIB/ GEOGRID SPECIFICATION:
Wall to be constructed using ECO44 Ecocrib components in accordance with Technical Data Sheet Ref: *DS10-5187-01 (31.03.11)*.

3) INSTALLATION: Refer to manufacturer's guidelines.

4) INFILL FOR ECOCRIB: 40-75mm stone.

5) BACKFILL TO ECOCRIB
The backfill shall comprise selected compacted granular fill material, to the standards of Class 6N/6P/6Q fill in SFHW Series 600. This material is assumed to have the following characteristics: Effective angle of internal friction = 35 degrees, density = 18 kN/m³ and c' = 0kPa, compacted to a minimum of 95% maximum dry density in accordance with SFHW Series 600. 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.

6) FOUNDATION FOR ECOCRIB WALLS
It is assumed that formation level of the Ecocrib will be on dense very clayey GRAVEL (weathered MUDSTONE), with a minimum safe bearing resistance of 100kPa. Any soft/ low strength, loose or unsuitable material present at or below formation level must be excavated down to a firm-stiff/ medium-dense stratum and replaced with compacted Class 6F2 granular fill.
The soils present at and below formation level must possess a minimum allowable bearing capacity of 100kPa.

Minimum embedment to the top of the concrete pad to be maintained at 0.2m below finished ground level and 0.5m to the base of the concrete foundation. The Principal Contractor/Client's Consulting Engineer must confirm the locations of all services prior to construction and ensure that none will be affected by the wall and its installation.

7) SITE / IN-SITU SOILS :
Retained: Assumed to be dense very clayey GRAVEL or compacted Class 1/2 general fill (site-won weathered rock or Glacial Till); this material is assumed to have the following minimum properties:
f ' = 30°, γ = 20kN/m³ and c' = 0kPa.

Foundation: Assumed to be dense very clayey GRAVEL (weathered MUDSTONE); this material is assumed to have the following minimum properties:
f ' = 30°, γ = 20kN/m³ and c' = 0kPa.

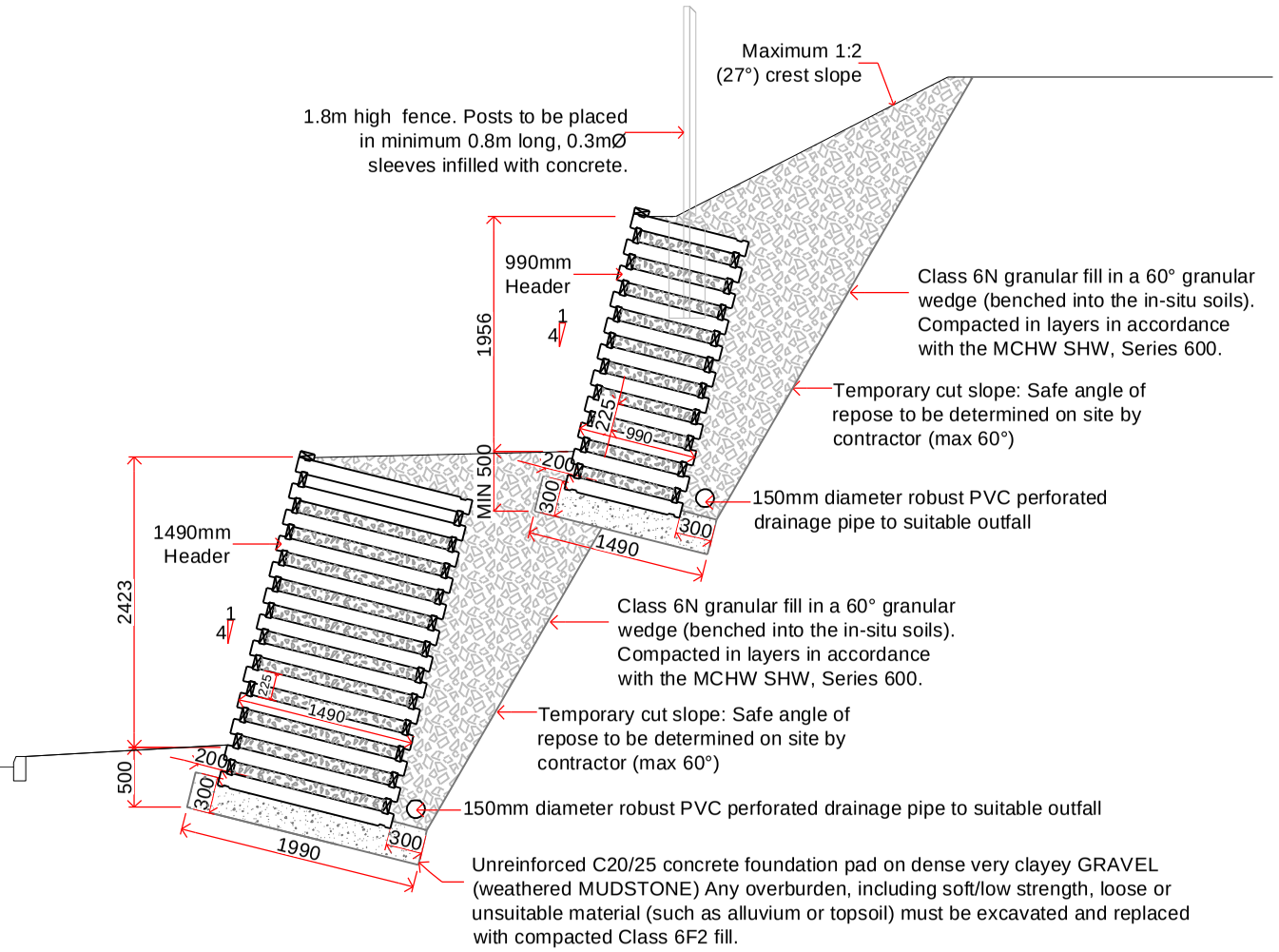
8) PEDESTRIAN FENCE/ VEHICLE BARRIER:
A maximum 1.8m high close boarded fence (designed by others) is to be installed at the top of the wall. The fence posts should be placed in minimum 0.8m long, 0.3mØ sleeves. The sleeves are to be infilled around the posts with concrete.

10) TECHNICAL APPROVAL
It is assumed that Technical Approval (to CG300) of the Ecocrib wall is NOT required. Please advise if Technical Approval is required, as this design may need revised.

11) CHECKING OF CALCULATIONS/ DRAWINGS
All information is referenced within the QP06 design document that accompanies this drawing. These plans and the accompanying design documentation should be thoroughly checked by the Client's Consulting Engineer. Any apparent errors, omissions or variations should be reported immediately to Geoman Ltd. Construction of the walls shall not commence unless and until the Client/ Client's Consulting Engineer has considered the Geoman Design Submission Document (QP06 Ref: 23-5006) to ensure that there are no errors, omissions or conflict with the scheme design.

SECTION 1-1

1:50



DRAFT FOR COMMENT
NOT FOR CONSTRUCTION

Rev. C	ST	19.02.24
Rev. B	ST	05.02.24
Rev. A	ST	25.01.24
Rev. 0	ST	28.11.23
Issue / Revision:	Drawn:	Date:

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Project Title:
HORWICH GOLF CLUB

Client:
PC CONSTRUCTION LTD.

Drawing Title:
ECOCRIB ENTRANCE WALL

Designed:			Date:	Project No: 23-5006
Drawn:	ST		Date: 27.11.23	Scale: AS INDICATED AT A3
Checked:			Date:	
Drawing No:	SK23-5006-F20-02			Revision: C

Prefab wall analysis

Input data

Project

Task : HORWICH GOLF CLUB
Part : SECTION 1-1
Description : ECOCRIB
Author : WM
Date : 22/08/23
Project number : 23-5006

Settings

Standard - EN 1997 - DA1

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
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 =	1.35	[–]			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	[–]
Partial factor on Poisson's ratio :	γ_v =	1.00	[–]	1.00	[–]

Partial factors for variable actions

Permanent design situation

Factor for combination value :	ψ_0 =	0.70	[–]
Factor for frequent value :	ψ_1 =	0.50	[–]
Factor for quasi-permanent value :	ψ_2 =	0.30	[–]

Geometry of structure

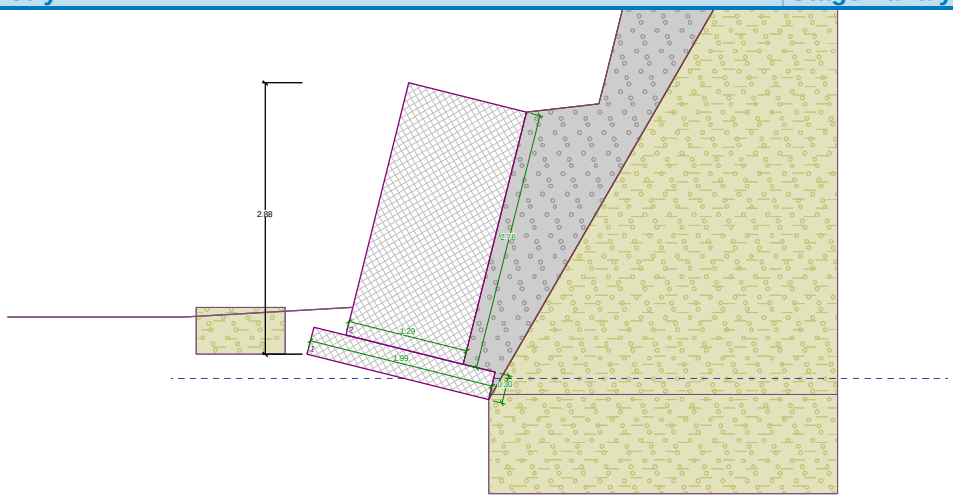
Slope of wall = 14.04 °

No.	Width b [m]	Height h [m]	Offset k [m]	Offs.(L) o_1 [m]	Offs.(R) o_2 [m]	Merge	Self w. [kN/m^3]	Friction [–]	Cohesion [kPa]	Shear bear.cap. R_s [kN/m]
2	1.29	2.76	0.35	0.00	0.00	No	18.00	0.533	0.00	0.00

No.	Width b [m]	Height h [m]	Offset k [m]	Offs.(L) o_1 [m]	Offs.(R) o_2 [m]	Merge	Self w. [kN/m3]	Friction [–]	Cohesion [kPa]	Shear bear.cap. R_s [kN/m]
1	1.99	0.30	0.00	0.00	0.00	-	24.00	-	-	-

Note: Blocks are ordered from bottom to the top

Name : Geometry | **Stage - analysis : 1 - 0**



Basic soil parameters

No.	Name	Pattern	φ_{ef} [°]	c_{ef} [kPa]	γ [kN/m3]	γ_{su} [kN/m3]	δ [°]
1	Dense GRAVEL		30.00	0.00	20.00	11.00	20.00
2	CLASS 6N		35.00	0.00	18.00	9.00	23.33

Soil parameters to compute pressure at rest

No.	Name	Pattern	Type calculation	φ_{ef} [°]	v [–]	OCR [–]	K_r [–]
1	Dense GRAVEL		cohesive	-	0.30	-	-
2	CLASS 6N		cohesionless	35.00	-	-	-

Soil parameters

Dense GRAVEL

Unit weight : γ = 20.00 kN/m3
Stress-state : effective
Angle of internal friction : φ_{ef} = 30.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Angle of friction struc.-soil : δ = 20.00 °
Soil : cohesive
Poisson's ratio : v = 0.30
Saturated unit weight : γ_{sat} = 21.00 kN/m3

CLASS 6N

Unit weight : γ = 18.00 kN/m3
Stress-state : effective

Angle of internal friction : φ_{ef} = 35.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Angle of friction struc.-soil : δ = 23.33 °
Soil : cohesionless
Saturated unit weight : γ_{sat} = 19.00 kN/m^3

Backfill

Assigned soil : CLASS 6N
Slope = 60.00 °

Geological profile and assigned soils

No.	Thickness of layer t [m]	Depth z [m]	Assigned soil	Pattern
1	3.00	0.00 .. 3.00	Dense GRAVEL	
2	-	3.00 ..	Dense GRAVEL	

Foundation

Type of foundation : soil from geological profile

Terrain profile

No.	Coordinates x [m]	Depth z [m]
1	0.00	0.00
2	0.77	-0.09
3	0.85	-0.41
4	1.40	-2.61
5	1.52	-2.58
6	1.75	-2.58
7	4.03	-3.75
8	5.03	-3.75

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

Water influence

GWT behind the structure lies at a depth of 2.83 m
GWT in front of the structure lies at a depth of 2.83 m
Subgrade at the heel is not permeable.
Uplift in foot. bottom due to different pressures is not considered.

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	5.00		0.30	30.00	on terrain

No.	Name
1	5kPa

Resistance on front face of the structure

Resistance on front face of the structure: not considered
Soil on front face of the structure - Dense GRAVEL
Soil thickness in front of structure h = 0.50 m

Terrain shape in front of structure

No.	Coordinate x[m]	Depth z[m]
1	0.00	0.00
2	0.00	-0.50
3	-0.01	-0.50
4	-1.79	-0.40
5	-2.79	-0.40

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

Global settings

Settings of the stage of construction

Design situation : permanent
The wall is free to move. Active earth pressure is therefore assumed.

Verification No. 1

Forces acting on construction - combination 1

Name	F_{hor} [kN/m]	App.Pt. z [m]	F_{vert} [kN/m]	App.Pt. x [m]	Coeff. overtur.	Coeff. sliding	Coeff. stress
Weight - wall	0.00	-1.14	77.35	1.30	1.000	1.000	1.350
Weight - earth wedge	0.00	-0.32	4.41	1.89	1.000	1.000	1.350
Active pressure	37.30	-0.74	18.46	2.01	1.350	1.350	1.350
Water pressure	0.00	-2.57	0.00	2.33	1.000	1.000	1.350
5kPa	3.47	-0.98	1.44	2.03	1.500	1.500	1.500

Verification of complete wall

Check for overturning stability
Resisting moment M_{res} = 163.47 kNm/m
Overturning moment M_{ovr} = 42.24 kNm/m

Wall for overturning is SATISFACTORY

Check for slip
Resisting horizontal force H_{res} = 68.75 kN/m
Active horizontal force H_{act} = 27.49 kN/m

Wall for slip is SATISFACTORY

Overall check - WALL is SATISFACTORY

Maximum stress in footing bottom : 73.79 kPa

Forces acting on construction - combination 2

Name	F_{hor} [kN/m]	App.Pt. z [m]	F_{vert} [kN/m]	App.Pt. x [m]	Coeff. overtur.	Coeff. sliding	Coeff. stress
Weight - wall	0.00	-1.14	77.35	1.30	1.000	1.000	1.000
Weight - earth wedge	0.00	-0.32	4.41	1.89	1.000	1.000	1.000
Active pressure	49.94	-0.74	18.82	2.01	1.000	1.000	1.000
Water pressure	0.00	-2.57	0.00	2.33	1.000	1.000	1.000
5kPa	4.80	-1.02	1.47	2.02	1.300	1.300	1.300

Verification of complete wall

Check for overturning stability
Resisting moment M_{res} = 150.64 kNm/m
Overturning moment M_{ovr} = 43.06 kNm/m

Wall for overturning is SATISFACTORY

Check for slip
Resisting horizontal force H_{res} = 52.22 kN/m
Active horizontal force H_{act} = 29.64 kN/m

Wall for slip is SATISFACTORY

Overall check - WALL is SATISFACTORY

Maximum stress in footing bottom : 59.41 kPa

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	-13.25	146.84	18.28	0.000	73.79
2	-2.75	119.08	25.01	0.000	59.84
3	4.92	113.07	27.07	0.023	59.41
4	4.92	113.07	27.07	0.023	59.41

Service load acting at the center of footing bottom

No.	Moment [kNm/m]	Norm. force [kN/m]	Shear Force [kN/m]
1	-10.11	108.52	13.23

Verification of foundation soil

Stress in the footing bottom : rectangle

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

Eccentricity of the normal force is SATISFACTORY

Verification of bearing capacity
Max. stress at footing bottom σ = 73.79 kPa
Bearing capacity of foundation soil R_d = 100.00 kPa

Bearing capacity of foundation soil is SATISFACTORY

Overall verification - bearing capacity of found. soil is SATISFACTORY

Dimensioning No. 1

Forces acting on construction - combination 1

Name	F_{hor} [kN/m]	App.Pt. z [m]	F_{vert} [kN/m]	App.Pt. x [m]	Coeff. overtur.	Coeff. sliding	Coeff. stress
Weight - wall	0.00	-1.18	64.09	0.96	1.000	1.000	1.350
Active pressure	26.94	-0.79	4.40	1.53	1.350	1.350	1.350
Water pressure	0.00	-2.36	0.00	1.92	1.000	1.000	1.350
5kPa	3.21	-0.94	0.53	1.56	1.500	1.500	1.500

Verification of the most stressed construction joint - above the block No. 1

Check for overturning stability
Resisting moment M_{res} = 71.86 kNm/m
Overturning moment M_{ovr} = 33.08 kNm/m

Joint for overturning stability is SATISFACTORY

Check for slip
Resisting horizontal force H_{res} = 41.95 kN/m
Active horizontal force H_{act} = 22.78 kN/m

Joint for slip is SATISFACTORY

Forces acting on construction - combination 2

Name	F_{hor} [kN/m]	App.Pt. z [m]	F_{vert} [kN/m]	App.Pt. x [m]	Coeff. overtur.	Coeff. sliding	Coeff. stress
Weight - wall	0.00	-1.18	64.09	0.96	1.000	1.000	1.000
Active pressure	36.80	-0.79	3.52	1.53	1.000	1.000	1.000
Water pressure	0.00	-2.36	0.00	1.92	1.000	1.000	1.000
5kPa	4.50	-0.96	0.43	1.57	1.300	1.300	1.300

Verification of the most stressed construction joint - above the block No. 1

Check for overturning stability
Resisting moment M_{res} = 67.80 kNm/m
Overturning moment M_{ovr} = 34.69 kNm/m

Joint for overturning stability is SATISFACTORY

Check for slip
Resisting horizontal force H_{res} = 40.76 kN/m
Active horizontal force H_{act} = 24.84 kN/m

Joint for slip is SATISFACTORY

Slope stability analysis

Input data

Project

Task : HORWICH GOLF CLUB
Part : SECTION 1-1
Description : ECOCRIB
Author : WM
Date : 22/08/23
Project number : 23-5006

Settings

Standard - EN 1997 - DA1

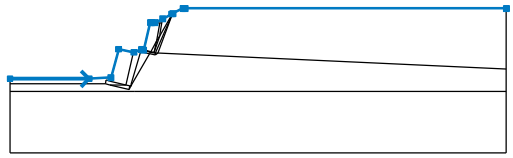
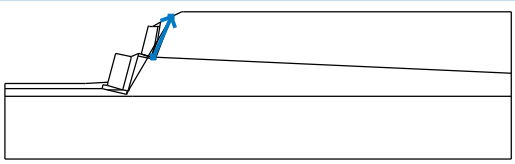
Stability analysis

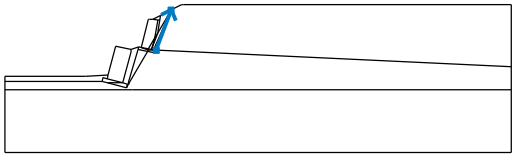
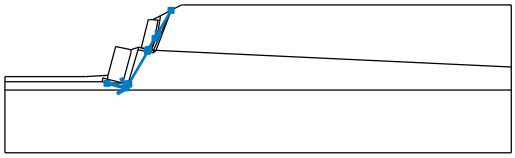
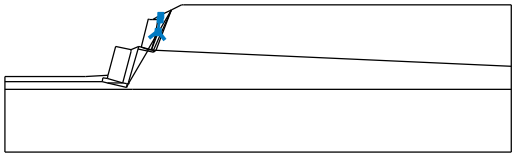
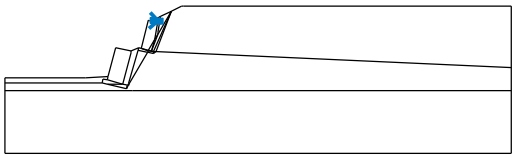
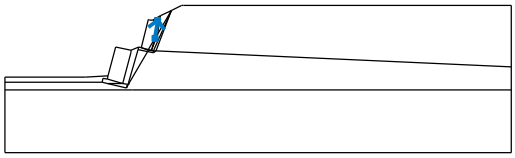
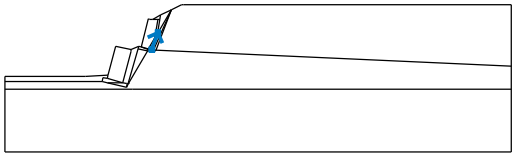
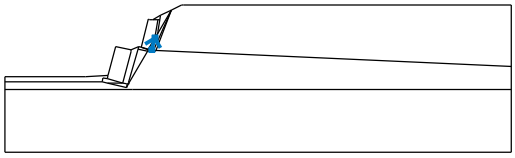
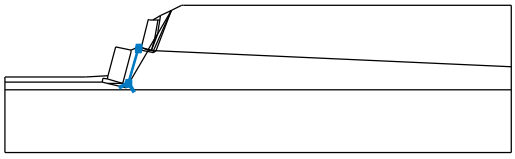
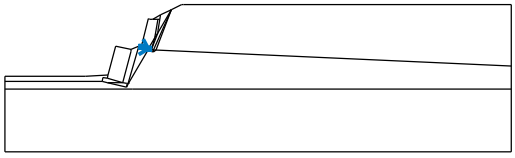
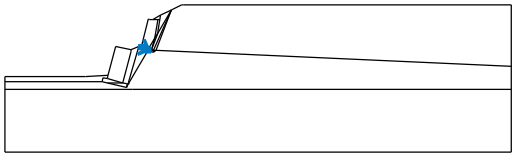
Earthquake analysis : Standard
Verification methodology : according to EN 1997
Design approach : 1 - reduction of actions and soil parameters

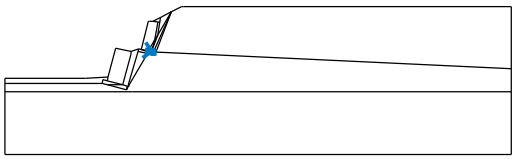
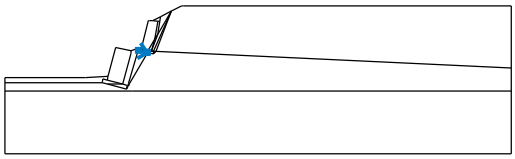
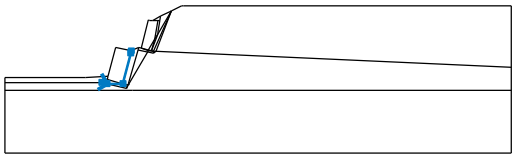
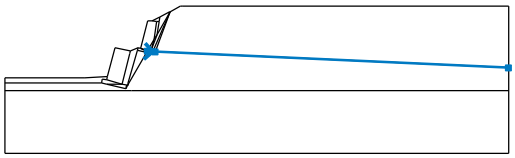
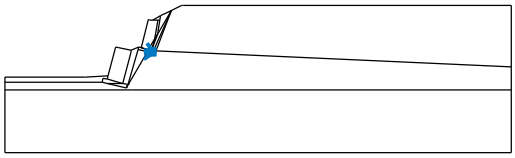
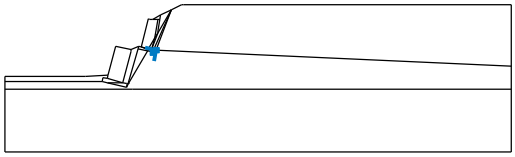
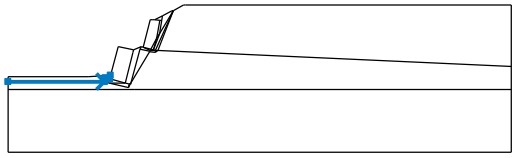
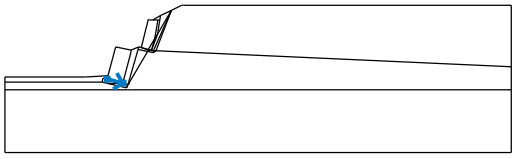
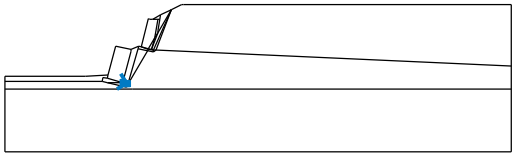
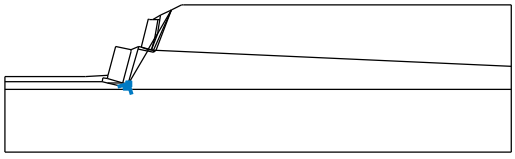
Partial factors on actions (A)								
Permanent design situation								
		Combination 1				Combination 2			
		Unfavourable		Favourable		Unfavourable		Favourable	
Permanent actions :	γ_G =	1.35	[–]	1.00	[–]	1.00	[–]	1.00	[–]
Variable actions :	γ_Q =	1.50	[–]	0.00	[–]	1.30	[–]	0.00	[–]
Water load :	γ_w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

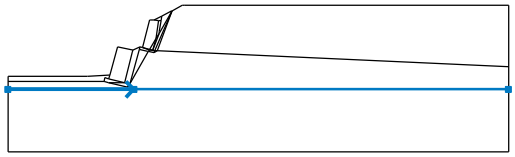
Partial factors for soil parameters (M)					
Permanent design situation					
		Combination 1		Combination 2	
Partial factor on internal friction :	γ_ϕ =	1.00	[–]	1.25	[–]
Partial factor on effective cohesion :	γ_c =	1.00	[–]	1.25	[–]
Partial factor on undrained shear strength :	γ_{cu} =	1.00	[–]	1.40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

Interface

No.	Interface location	Coordinates of interface points [m]					
		x	z	x	z	x	z
1		-10.00	-1.96	-3.59	-1.96	-1.80	-1.86
		-1.18	0.43	0.04	0.17	0.65	0.42
		0.84	0.37	1.40	2.61	1.52	2.58
		1.75	2.58	2.38	2.90	3.13	3.29
		3.21	3.33	4.03	3.75	4.21	3.75
		30.30	3.75				
2		1.80	0.13	3.21	3.33		

No.	Interface location	Coordinates of interface points [m]					
		x	z	x	z	x	z
3		2.02	0.12	3.21	3.33		
4		-1.88	-2.46	-0.35	-2.84	-0.28	-2.55
		-0.20	-2.55	-0.18	-2.55	1.32	0.05
		1.38	0.15	1.42	0.22	1.92	1.10
		2.16	1.50	3.21	3.33		
5		2.16	1.50	2.18	1.64	2.32	2.54
		2.38	2.90				
6		1.75	2.58	2.15	2.55	2.32	2.54
7		1.92	1.10	2.15	2.55		
8		1.67	0.17	2.16	1.50		
9		1.67	0.17	1.92	1.10		
10		-0.20	-2.55	-0.16	-2.42	0.59	0.21
		0.65	0.42				
11		0.84	0.37	1.42	0.22		
12		0.84	0.37	1.38	0.15		

No.	Interface location	Coordinates of interface points [m]					
		x	z	x	z	x	z
13		1.42	0.22	1.67	0.17	1.80	0.13
14		0.59	0.21	1.27	0.06	1.32	0.05
15		-2.28	-2.36	-1.88	-2.46	-0.62	-2.46
		0.00	0.00	0.04	0.17		
16		1.38	0.15	1.80	0.13	2.02	0.12
		30.30	-1.17				
17		1.32	0.05	1.78	-0.04	1.80	0.13
18		1.78	-0.04	2.02	0.12		
19		-10.00	-2.36	-2.28	-2.36	-2.21	-2.07
		-1.87	-2.15	-1.80	-1.86		
20		-1.87	-2.15	-0.62	-2.46		
21		-0.62	-2.46	-0.33	-2.54	-0.28	-2.55
22		-0.35	-2.84	-0.18	-2.55		

No.	Interface location	Coordinates of interface points [m]					
		x	z	x	z	x	z
23		-10.00	-3.00	0.14	-3.00	30.30	-3.00

Soil parameters - effective stress state

No.	Name	Pattern	φ_{ef} [°]	c_{ef} [kPa]	γ [kN/m^3]
1	Dense GRAVEL		30.00	0.00	20.00
2	CLASS 6N		35.00	0.00	18.00

Soil parameters - uplift

No.	Name	Pattern	γ_{sat} [kN/m^3]	γ_s [kN/m^3]	n [–]
1	Dense GRAVEL		21.00		
2	CLASS 6N		19.00		

Soil parameters

Dense GRAVEL

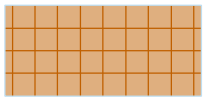
Unit weight : γ = 20.00 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 30.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 21.00 kN/m^3

CLASS 6N

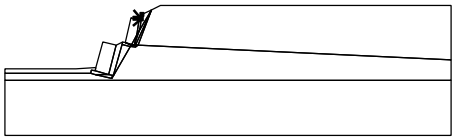
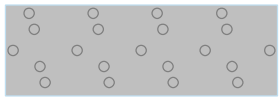
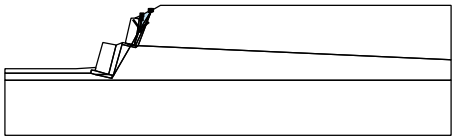
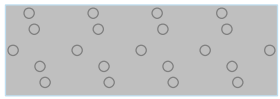
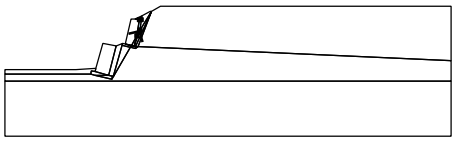
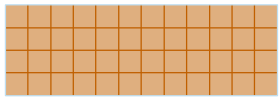
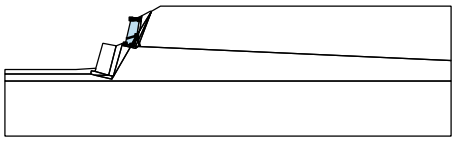
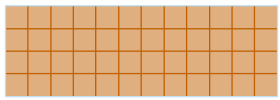
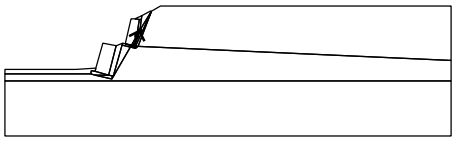
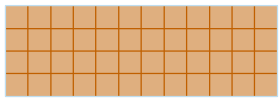
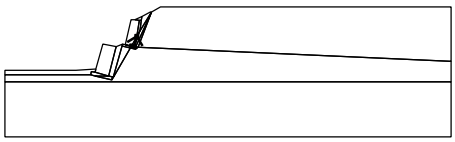
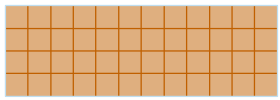
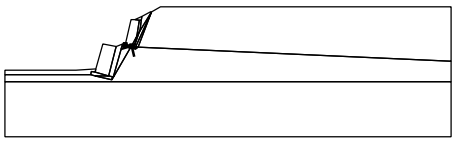
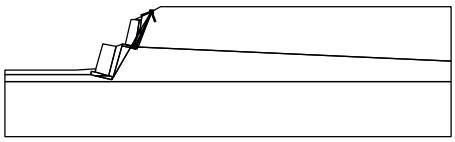
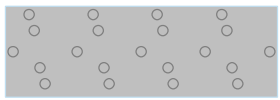
Unit weight : γ = 18.00 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 35.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 19.00 kN/m^3

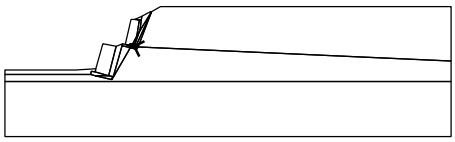
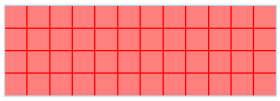
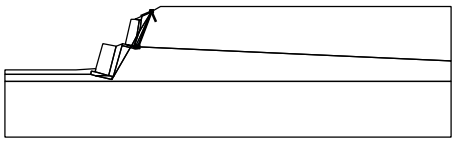
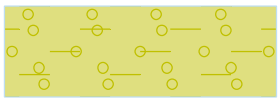
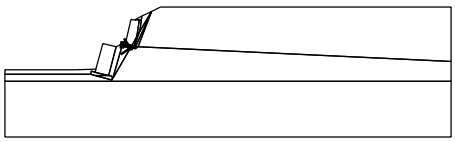
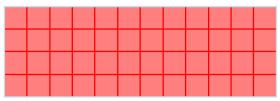
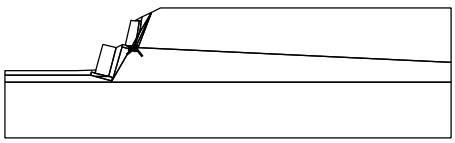
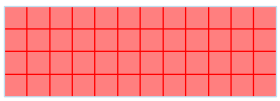
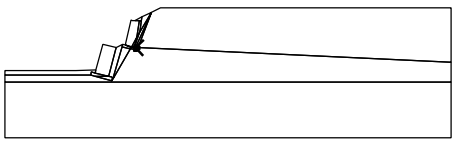
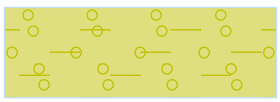
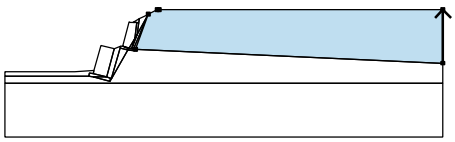
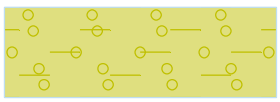
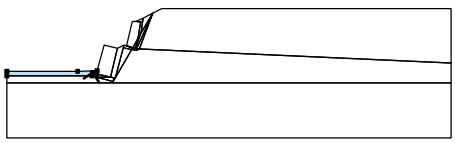
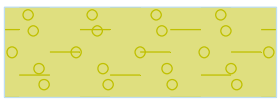
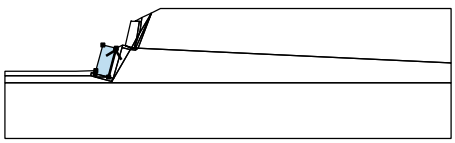
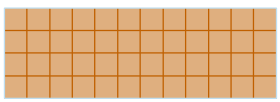
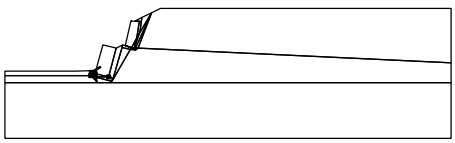
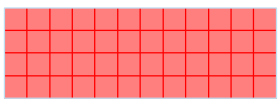
Rigid Bodies

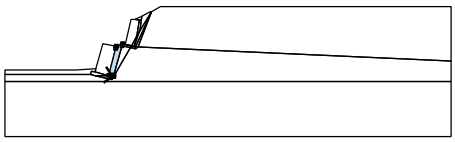
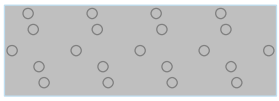
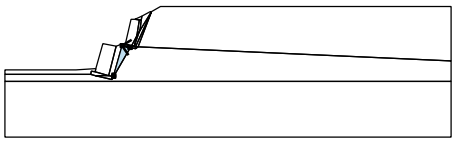
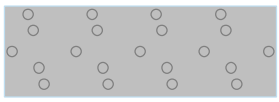
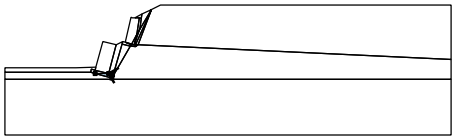
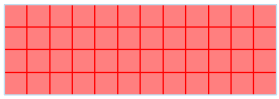
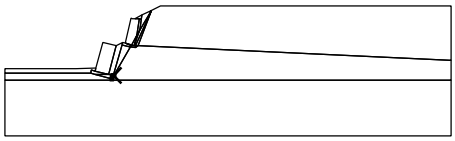
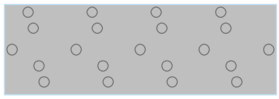
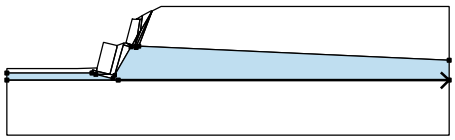
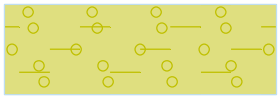
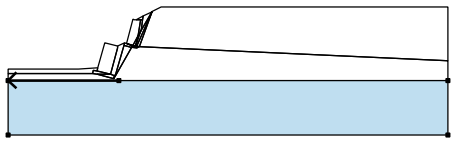
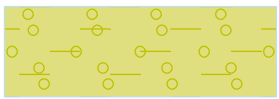
No.	Name	Sample	γ [kN/m^3]
1	Material of structure		24.00

No.	Name	Sample	γ [kN/m³]
2	Ecocrib		18.00

Assigning and surfaces

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
1		2.15	2.55	2.32	2.54	CLASS 6N
		2.38	2.90	1.75	2.58	
2		2.32	2.54	2.18	1.64	CLASS 6N
		2.16	1.50	3.21	3.33	
		3.13	3.29	2.38	2.90	
3		1.92	1.10	2.16	1.50	Ecocrib
		2.18	1.64	2.32	2.54	
		2.15	2.55			
4		1.42	0.22	1.92	1.10	Ecocrib
		2.15	2.55	1.75	2.58	
		1.52	2.58	1.40	2.61	
		0.84	0.37			
5		1.67	0.17	2.16	1.50	Ecocrib
		1.92	1.10			
						
6		1.67	0.17	1.92	1.10	Ecocrib
		1.42	0.22			
						
7		1.38	0.15	1.42	0.22	Material of structure
		0.84	0.37			
						
8		1.80	0.13	3.21	3.33	CLASS 6N
		2.16	1.50	1.67	0.17	
						

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
9		1.80	0.13	1.67	0.17	Material of structure
		1.42	0.22	1.38	0.15	
10		2.02	0.12	3.21	3.33	Dense GRAVEL
		1.80	0.13			
11		1.27	0.06	1.32	0.05	Material of structure
		1.38	0.15	0.84	0.37	
		0.65	0.42	0.59	0.21	
12		1.78	-0.04	1.80	0.13	Material of structure
		1.38	0.15	1.32	0.05	
13		2.02	0.12	1.80	0.13	Dense GRAVEL
		1.78	-0.04			
14		30.30	-1.17	30.30	3.75	Dense GRAVEL
		4.21	3.75	4.03	3.75	
		3.21	3.33	2.02	0.12	
15		-2.28	-2.36	-2.21	-2.07	Dense GRAVEL
		-1.87	-2.15	-1.80	-1.86	
		-3.59	-1.96	-10.00	-1.96	
		-10.00	-2.36			
16		-0.62	-2.46	0.00	0.00	Ecocrib
		0.04	0.17	-1.18	0.43	
		-1.80	-1.86	-1.87	-2.15	
17		-1.87	-2.15	-2.21	-2.07	Material of structure
		-2.28	-2.36	-1.88	-2.46	
		-0.62	-2.46			

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
18		-0.33	-2.54	-0.28	-2.55	CLASS 6N
		-0.20	-2.55	-0.16	-2.42	
		0.59	0.21	0.65	0.42	
		0.04	0.17	0.00	0.00	
		-0.62	-2.46			
19		1.27	0.06	0.59	0.21	CLASS 6N
		-0.16	-2.42	-0.20	-2.55	
		-0.18	-2.55	1.32	0.05	
20		-0.33	-2.54	-0.62	-2.46	Material of structure
		-1.88	-2.46	-0.35	-2.84	
		-0.28	-2.55			
21		-0.18	-2.55	-0.20	-2.55	CLASS 6N
		-0.28	-2.55	-0.35	-2.84	
22		0.14	-3.00	30.30	-3.00	Dense GRAVEL
		30.30	-1.17	2.02	0.12	
		1.78	-0.04	1.32	0.05	
		-0.18	-2.55	-0.35	-2.84	
		-1.88	-2.46	-2.28	-2.36	
		-10.00	-2.36	-10.00	-3.00	
23		0.14	-3.00	-10.00	-3.00	Dense GRAVEL
		-10.00	-8.00	30.30	-8.00	
		30.30	-3.00			

Surcharge

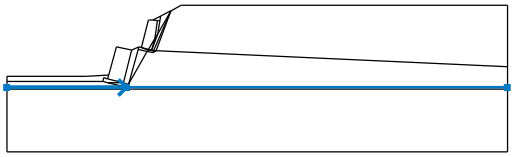
No.	Type	Type of action	Location z [m]	Origin x [m]	Length l [m]	Width b [m]	Slope α [°]	Magnitude q, q_1, f, F, x	Magnitude q_2, z	Magnitude unit
1	strip	variable	on terrain	x = 0.30	l = 30.00		0.00	5.00		kN/m^2

Surcharges

No.	Name
1	5kPa

Water

Water type : GWT

No.	GWT location	Coordinates of GWT points [m]					
		x	z	x	z	x	z
1		-10.00	-2.83	-0.35	-2.83	30.30	-2.83

Tensile crack

Tensile crack not input.

Earthquake

Earthquake not included.

Settings of the stage of construction

Design situation : permanent

Results (Stage of construction 1)

Analysis 1

Circular slip surface

Slip surface parameters							
Center :	x =	-2.05	[m]	Angles :	α_1 =	-30.54	[°]
	z =	4.62	[m]		α_2 =	83.46	[°]
Radius :	R =	7.64	[m]				
The slip surface after optimization.							

Slope stability verification (Bishop)
Combination 1
Sum of active forces : F_a = 317.83 kN/m
Sum of passive forces : F_p = 364.06 kN/m

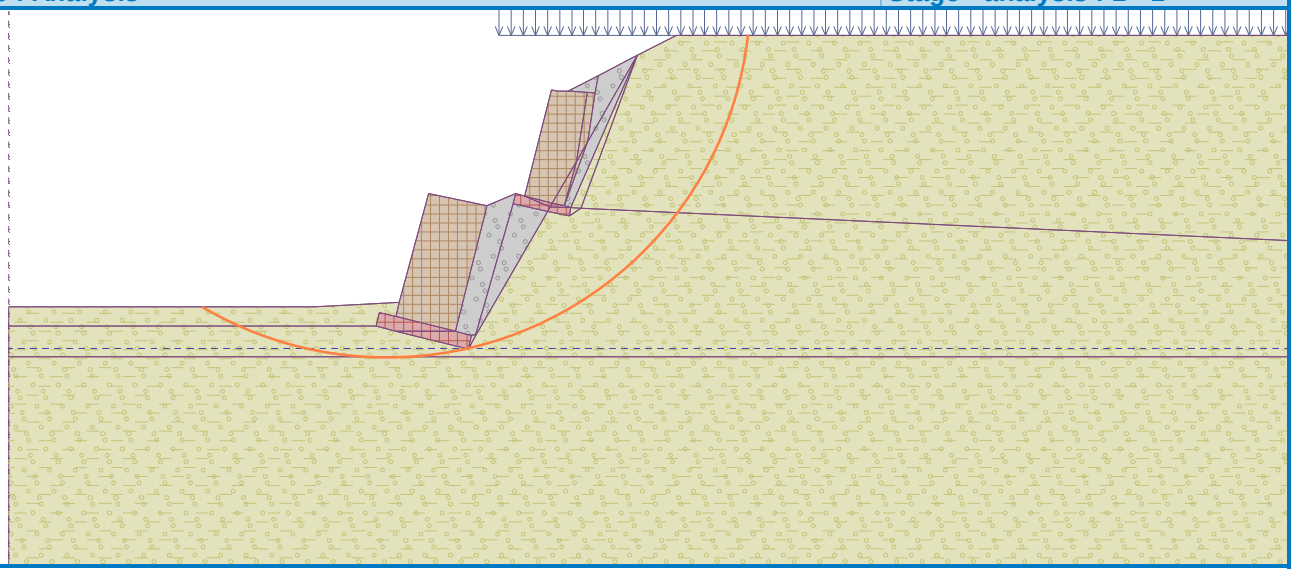
Sliding moment : M_a = 2405.97 kNm/m
Resisting moment : M_p = 2755.92 kNm/m
Utilization : 87.3 %

Slope stability ACCEPTABLE
Combination 2
Sum of active forces : F_a = 257.14 kN/m
Sum of passive forces : F_p = 261.31 kN/m

Sliding moment : M_a = 1964.58 kNm/m
Resisting moment : M_p = 1996.38 kNm/m
Utilization : 98.4 %

Slope stability ACCEPTABLE
Optimized slip surface for : Combination 2

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



Prefab wall analysis

Input data

Project

Task : HORWICH GOLF CLUB
Part : SECTION 2-2
Description : ECOCRIB
Author : WM
Date : 22/08/23
Project number : 23-5006

Settings

Standard - EN 1997 - DA1

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
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 =	1.35	[–]			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	[–]
Partial factor on Poisson's ratio :	γ_v =	1.00	[–]	1.00	[–]

Partial factors for variable actions

Permanent design situation

Factor for combination value :	ψ_0 =	0.70	[–]
Factor for frequent value :	ψ_1 =	0.50	[–]
Factor for quasi-permanent value :	ψ_2 =	0.30	[–]

Geometry of structure

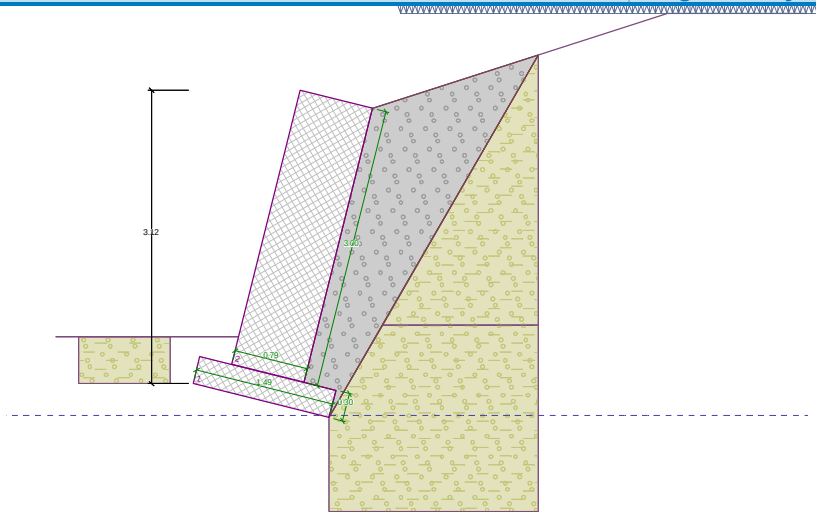
Slope of wall = 14.04 °

No.	Width b [m]	Height h [m]	Offset k [m]	Offs.(L) o_1 [m]	Offs.(R) o_2 [m]	Merge	Self w. [kN/m^3]	Friction [–]	Cohesion [kPa]	Shear bear.cap. R_s [kN/m]
2	0.79	3.00	0.35	0.00	0.00	No	18.00	0.533	0.00	0.00

No.	Width b [m]	Height h [m]	Offset k [m]	Offs.(L) o_1 [m]	Offs.(R) o_2 [m]	Merge	Self w. [kN/m3]	Friction [–]	Cohesion [kPa]	Shear bear.cap. R_s [kN/m]
1	1.49	0.30	0.00	0.00	0.00	-	24.00	-	-	-

Note: Blocks are ordered from bottom to the top

Name : Geometry | **Stage - analysis : 1 - 0**



Basic soil parameters

No.	Name	Pattern	φ_{ef} [°]	c_{ef} [kPa]	γ [kN/m3]	γ_{su} [kN/m3]	δ [°]
1	Dense GRAVEL		30.00	0.00	20.00	11.00	20.00
2	CLASS 6N		35.00	0.00	18.00	9.00	23.33

Soil parameters to compute pressure at rest

No.	Name	Pattern	Type calculation	φ_{ef} [°]	v [–]	OCR [–]	K_r [–]
1	Dense GRAVEL		cohesive	-	0.30	-	-
2	CLASS 6N		cohesionless	35.00	-	-	-

Soil parameters

Dense GRAVEL

Unit weight : γ = 20.00 kN/m3
Stress-state : effective
Angle of internal friction : φ_{ef} = 30.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Angle of friction struc.-soil : δ = 20.00 °
Soil : cohesive
Poisson's ratio : v = 0.30
Saturated unit weight : γ_{sat} = 21.00 kN/m3

CLASS 6N

Unit weight : γ = 18.00 kN/m3
Stress-state : effective

Angle of internal friction : φ_{ef} = 35.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Angle of friction struc.-soil : δ = 23.33 °
Soil : cohesionless
Saturated unit weight : γ_{sat} = 19.00 kN/m3

Backfill

Assigned soil : CLASS 6N
Slope = 60.00 °

Geological profile and assigned soils

No.	Thickness of layer t [m]	Depth z [m]	Assigned soil	Pattern
1	2.30	0.00 .. 2.30	Dense GRAVEL	
2	-	2.30 ..	Dense GRAVEL	

Foundation

Type of foundation : soil from geological profile

Terrain profile

No.	Coordinates x [m]	Depth z [m]
1	0.00	0.00
2	0.01	0.00
3	3.14	-1.01
4	4.14	-1.01

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

Water influence

GWT behind the structure lies at a depth of 3.26 m
GWT in front of the structure lies at a depth of 3.26 m
Subgrade at the heel is not permeable.
Uplift in foot. bottom due to different pressures is not considered.

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	5.00		0.30	30.00	on terrain

No.	Name
1	5kPa

Resistance on front face of the structure

Resistance on front face of the structure: not considered
Soil on front face of the structure - Dense GRAVEL
Soil thickness in front of structure h = 0.50 m

Terrain in front of structure is flat.

Global settings

Settings of the stage of construction

Design situation : permanent
The wall is free to move. Active earth pressure is therefore assumed.

Verification No. 1

Forces acting on construction - combination 1

Name	F_{hor} [kN/m]	App.Pt. z [m]	F_{vert} [kN/m]	App.Pt. x [m]	Coeff. overtur.	Coeff. sliding	Coeff. stress
Weight - wall	0.00	-1.24	53.37	1.08	1.000	1.000	1.350
Weight - earth wedge	0.00	-0.15	1.61	1.33	1.000	1.000	1.350
Active pressure	23.39	-0.62	16.98	1.42	1.350	1.350	1.350
Water pressure	0.00	-2.92	0.00	1.91	1.000	1.000	1.350
5kPa	3.51	-1.30	1.10	1.49	1.500	1.500	1.500

Verification of complete wall

Check for overturning stability

Resisting moment M_{res} = 94.85 kNm/m
Overturning moment M_{ovr} = 26.58 kNm/m

Wall for overturning is SATISFACTORY

Check for slip

Resisting horizontal force H_{res} = 49.73 kN/m
Active horizontal force H_{act} = 16.44 kN/m

Wall for slip is SATISFACTORY

Overall check - WALL is SATISFACTORY

Maximum stress in footing bottom : 70.34 kPa

Forces acting on construction - combination 2

Name	F_{hor} [kN/m]	App.Pt. z [m]	F_{vert} [kN/m]	App.Pt. x [m]	Coeff. overtur.	Coeff. sliding	Coeff. stress
Weight - wall	0.00	-1.24	53.37	1.08	1.000	1.000	1.000
Weight - earth wedge	0.00	-0.15	1.61	1.33	1.000	1.000	1.000
Active pressure	32.14	-0.65	16.99	1.42	1.000	1.000	1.000
Water pressure	0.00	-2.92	0.00	1.91	1.000	1.000	1.000
5kPa	4.90	-1.33	1.09	1.48	1.300	1.300	1.300

Verification of complete wall

Check for overturning stability

Resisting moment M_{res} = 86.01 kNm/m
Overturning moment M_{ovr} = 29.42 kNm/m

Wall for overturning is SATISFACTORY

Check for slip

Resisting horizontal force H_{res} = 37.20 kN/m
Active horizontal force H_{act} = 19.56 kN/m

Wall for slip is SATISFACTORY

Overall check - WALL is SATISFACTORY

Maximum stress in footing bottom : 57.33 kPa

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	-11.10	104.80	10.31	0.000	70.34
2	-4.11	86.13	14.84	0.000	57.81
3	3.43	80.55	17.82	0.029	57.33
4	3.43	80.55	17.82	0.029	57.33

Service load acting at the center of footing bottom

No.	Moment [kNm/m]	Norm. force [kN/m]	Shear Force [kN/m]
1	-8.71	77.42	7.31

Verification of foundation soil

Stress in the footing bottom : rectangle

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

Eccentricity of the normal force is SATISFACTORY

Verification of bearing capacity
Max. stress at footing bottom $\sigma = 70.34$ kPa
Bearing capacity of foundation soil $R_d = 100.00$ kPa

Bearing capacity of foundation soil is SATISFACTORY

Overall verification - bearing capacity of found. soil is SATISFACTORY

Dimensioning No. 1

Forces acting on construction - combination 1

Name	F_{hor} [kN/m]	App.Pt. z [m]	F_{vert} [kN/m]	App.Pt. x [m]	Coeff. overtur.	Coeff. sliding	Coeff. stress
Weight - wall	0.00	-1.36	42.66	0.75	1.000	1.000	1.350
Active pressure	14.52	-0.78	2.37	1.01	1.350	1.350	1.350
Water pressure	0.00	-2.72	0.00	1.49	1.000	1.000	1.350
5kPa	3.34	-1.21	0.55	1.12	1.500	1.500	1.500

Verification of the most stressed construction joint - above the block No. 1

Check for overturning stability
Resisting moment $M_{res} = 36.02$ kNm/m
Overturning moment $M_{ovr} = 21.27$ kNm/m

Joint for overturning stability is SATISFACTORY

Check for slip
Resisting horizontal force $H_{res} = 27.32$ kN/m
Active horizontal force $H_{act} = 12.55$ kN/m

Joint for slip is SATISFACTORY

Forces acting on construction - combination 2

Name	F_{hor} [kN/m]	App.Pt. z [m]	F_{vert} [kN/m]	App.Pt. x [m]	Coeff. overtur.	Coeff. sliding	Coeff. stress
Weight - wall	0.00	-1.36	42.66	0.75	1.000	1.000	1.000
Active pressure	21.27	-0.78	2.03	1.01	1.000	1.000	1.000
Water pressure	0.00	-2.72	0.00	1.49	1.000	1.000	1.000

Name	F_{hor} [kN/m]	App.Pt. z [m]	F_{vert} [kN/m]	App.Pt. x [m]	Coeff. overtur.	Coeff. sliding	Coeff. stress
5kPa	4.66	-1.23	0.45	1.12	1.300	1.300	1.300

Verification of the most stressed construction joint - above the block No. 1

Check for overturning stability

Resisting moment M_{res} = 34.57 kNm/m

Overturning moment M_{ovr} = 23.99 kNm/m

Joint for overturning stability is SATISFACTORY

Check for slip

Resisting horizontal force H_{res} = 26.94 kN/m

Active horizontal force H_{act} = 15.53 kN/m

Joint for slip is SATISFACTORY

Slope stability analysis

Input data

Project

Settings

Standard - EN 1997 - DA1

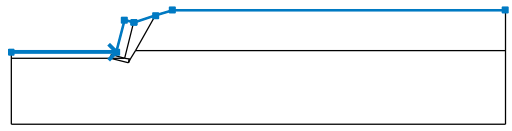
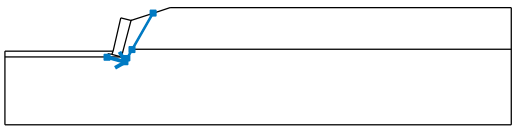
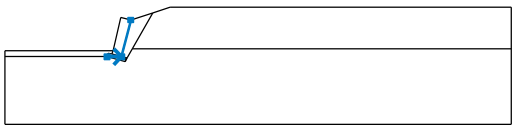
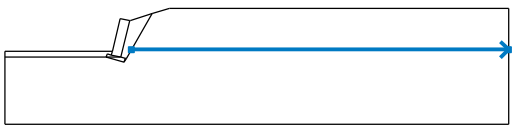
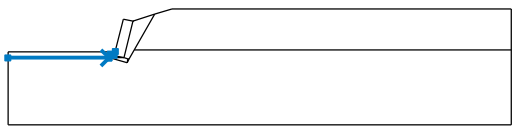
Stability analysis

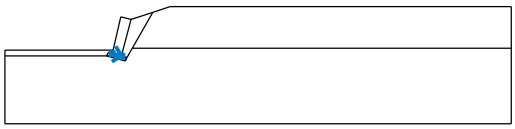
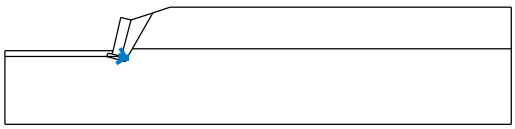
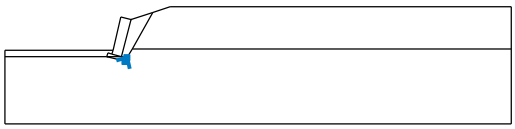
Earthquake analysis : Standard
Verification methodology : according to EN 1997
Design approach : 1 - reduction of actions and soil parameters

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 =	1.35	[–]			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	-2.42	-1.42	-2.42	-0.77	0.19
		0.00	0.00	0.01	0.00	1.76	0.57
		3.14	1.01	30.30	1.01		
2		-1.91	-2.92	-0.46	-3.29	-0.39	-3.00
		-0.29	-3.00	0.11	-2.30	1.76	0.57
3		-1.91	-2.91	-0.73	-2.91	0.00	0.00
4		0.11	-2.30	30.30	-2.30		
5		-10.00	-2.92	-1.91	-2.92	-1.91	-2.91
		-1.83	-2.63	-1.49	-2.72	-1.42	-2.42

No.	Interface location	Coordinates of interface points [m]					
		x	z	x	z	x	z
6		-1.49	-2.72	-0.73	-2.91		
7		-0.73	-2.91	-0.39	-3.00		
8		-0.46	-3.29	-0.29	-3.00		

Soil parameters - effective stress state

No.	Name	Pattern	φ_{ef} [°]	c_{ef} [kPa]	γ [kN/m^3]
1	Dense GRAVEL		30.00	0.00	20.00
2	CLASS 6N		35.00	0.00	18.00

Soil parameters - uplift

No.	Name	Pattern	γ_{sat} [kN/m^3]	γ_s [kN/m^3]	n [–]
1	Dense GRAVEL		21.00		
2	CLASS 6N		19.00		

Soil parameters

Dense GRAVEL

Unit weight : γ = 20.00 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 30.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 21.00 kN/m^3

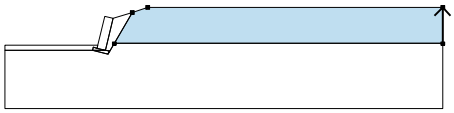
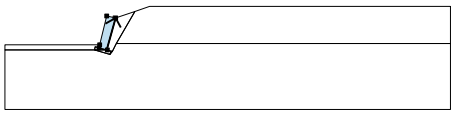
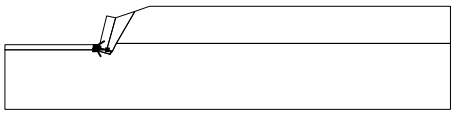
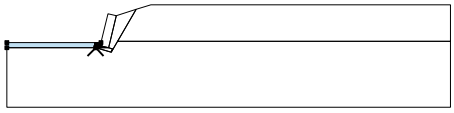
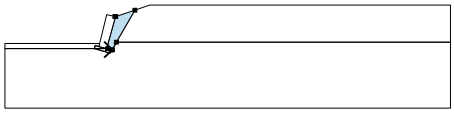
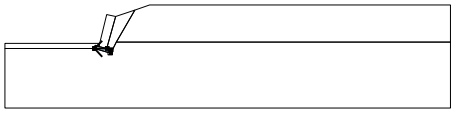
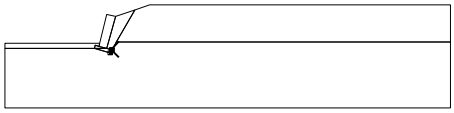
CLASS 6N

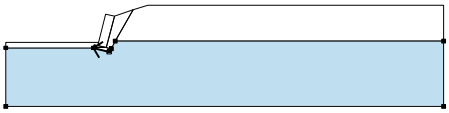
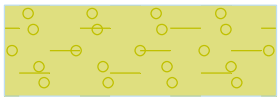
Unit weight : γ = 18.00 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 35.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 19.00 kN/m^3

Rigid Bodies

No.	Name	Sample	γ [kN/m³]
1	Material of structure		24.00
2	Ecocrib		18.00

Assigning and surfaces

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
1		30.30	-2.30	30.30	1.01	Dense GRAVEL
		3.14	1.01	1.76	0.57	
		0.11	-2.30			
2		-0.73	-2.91	0.00	0.00	Ecocrib
		-0.77	0.19	-1.42	-2.42	
		-1.49	-2.72			
3		-1.49	-2.72	-1.83	-2.63	Material of structure
		-1.91	-2.91	-0.73	-2.91	
4		-1.91	-2.92	-1.91	-2.91	Dense GRAVEL
		-1.83	-2.63	-1.49	-2.72	
		-1.42	-2.42	-10.00	-2.42	
		-10.00	-2.92			
5		-0.39	-3.00	-0.29	-3.00	CLASS 6N
		0.11	-2.30	1.76	0.57	
		0.01	0.00	0.00	0.00	
		-0.73	-2.91			
6		-0.73	-2.91	-1.91	-2.91	Material of structure
		-1.91	-2.92	-0.46	-3.29	
		-0.39	-3.00			
7		-0.29	-3.00	-0.39	-3.00	CLASS 6N
		-0.46	-3.29			

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
8		-0.46	-3.29	-1.91	-2.92	Dense GRAVEL
		-10.00	-2.92	-10.00	-8.29	
		30.30	-8.29	30.30	-2.30	
		0.11	-2.30	-0.29	-3.00	

Surcharge

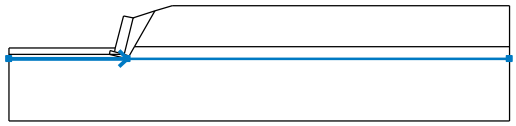
No.	Type	Type of action	Location z [m]	Origin x [m]	Length l [m]	Width b [m]	Slope α [°]	Magnitude q, q_1, f, F, x	Magnitude q_2, z	Magnitude unit
1	strip	variable	on terrain	x = 0.30	l = 30.00		0.00	5.00		kN/m^2

Surcharges

No.	Name
1	5kPa

Water

Water type : GWT

No.	GWT location	Coordinates of GWT points [m]					
		x	z	x	z	x	z
1		-10.00	-3.26	-0.45	-3.26	30.30	-3.26

Tensile crack

Tensile crack not input.

Earthquake

Earthquake not included.

Settings of the stage of construction

Design situation : permanent

Results (Stage of construction 1)

Analysis 1

Circular slip surface

Slip surface parameters							
Center :	x =	-1.69	[m]	Angles :	α_1 =	-34.33	[°]
	z =	2.32	[m]		α_2 =	76.81	[°]
Radius :	R =	5.74	[m]				
The slip surface after optimization.							

Slope stability verification (Bishop)
Combination 1
Sum of active forces : F_a = 147.00 kN/m

Sum of passive forces : F_p = 202.12 kN/m

Sliding moment : M_a = 787.90 kNm/m
Resisting moment : M_p = 1083.34 kNm/m
Utilization : 72.7 %

Slope stability ACCEPTABLE

Combination 2

Sum of active forces : F_a = 126.64 kN/m
Sum of passive forces : F_p = 155.31 kN/m

Sliding moment : M_a = 726.92 kNm/m
Resisting moment : M_p = 891.47 kNm/m
Utilization : 81.5 %

Slope stability ACCEPTABLE

Optimized slip surface for : Combination 2

Name : Analysis	Stage - analysis : 1 - 1