

Tier Consult Limited

Cronton Unit 2 Slope Stability Assessment

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Document Control Sheet

**Cronton Colliery
Slope Stability Assessment
Project 2701**

Rev.	Date	Author	Reviewer	Approver	Status
0	November 2023	EF	WF	WF	Initial issue

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1 Introduction

Byland Engineering Limited (BEL) has been appointed by Tier Consult Limited (TCL) to undertake a slope stability assessment for the proposed slopes around a new commercial unit, Unit 2 which forms part of a wider development scheme south of Junction 6 of the M62 on the site of the former Cronton Colliery near Widnes, Merseyside. The centre of the site is located at NGR E347600, N389420 and access is via A5080 which forms the southern boundary to the site or Fox Bank Lane which form the eastern boundary of the site. The wider site will contain Units 1 to the northeast, Unit 2 to the south and Units 3 and 4 to the northwest with a large area to the southeast remaining undeveloped.

A previous slope stability assessment has been undertaken and reported for Unit 1 and is summarised in Byland report 2479-Cronton Colliery Rev.A dated May 2023.

This report considers the slopes around Unit 2 to the north, south and west of the building which comprise a mixture of cut slopes and fill. The area directly to the east of Unit 2 is flat and therefore not requiring assessment. The building comprises a 250m long by 100m wide steel frame building supported on ground bearing foundations, with the long axis aligned northwest to southeast. Loading and parking areas are located to the north and east and a sustrans cycle path is present to the south. An access road circles Unit 2 to the east, north and west.

Due to the relatively weak nature of the ground below the site it is understood that ground improvement comprising rigid inclusions (RI's) will be provided (designed by others).

The slope stability analysis will be undertaken using the Oasys Slope software. This report summarises the results of the analysis.

2 GROUND CONDITIONS

2.1 Slope Locations

4 No. sections have been drawn with the proposed geometry, existing geometry, relevant boreholes and levels which are in Appendix A. The critical identified slopes are as follows:

- A. Located at the south-southwest corner of Unit 2 this slope comprises a upper 1 in 5 slope to the Sustrans path with a lower 1 in 3 slope.
- B. Located to the west-southwest corner of Unit 2 this slope comprises a 1 in 3 slope from Unit 2 to the access road.
- C. Located at the north-northeast corner of the site from the access road down a 1 in 10 slope to the upper yard and a 1 in 3 slope to the lower yard and Unit 2.
- D. Located on the south-southeast corner of Unit 2 comprising a near flat geometry to the Sustrans access path retained by a ~4.6m wall (no details are provided) with a 1 in 3 slope below.

The site was previously occupied by an open cast mine which has now been backfilled. No details of the method of backfilling or material used have been provided. Consideration of mining is outside the scope of this report.

2.2 Geological Mapping

The online British Geological Survey (BGS) Geoindex online mapping at 1:50,000 scale indicates the site to be underlain by the following strata in order of increasing stratigraphic age (and depth):

1. Devensian Till indicted as Diamicton and described as an unsorted to poorly sorted and contains particles ranging in size from clay to boulders. Typically coarse granular material in a fine grained matrix.
2. Bedrock varies either side of a N – S trending fault which bisects the wider site and is mapped as follows:
 - East of the fault is mapped as the Early Triassic Kinnerton Sandstone Formation. It is described as red-brown to yellow, generally pebble-free, fine- to medium-grained Sandstone.
 - West of the fault is mapped as Pennine Middle Coal Measures and described as interbedded grey mudstone, siltstone, pale grey sandstone and commonly coal seams.

2.3 Ground Investigation

Provided relevant ground investigations to Unit 2 include:

1. Tier Environmental Limited (2003)
2. Tier Environmental Limited (2019)
3. Tier Environmental Limited (2020)
4. Tier Environmental Limited (2023)
5. Tier Environmental Limited ARUP(2023)
6. Lankelma Limited CPT (2023)

All relevant exploratory holes to Unit 2 are shown on drawing 2701-BEL-XX-001 in Appendix A based on drawings by TCL and Lankelma.

The following exploratory holes are most relevant to each of the proposed slopes:

Exploratory Hole Type:	Slope A	Slope B	Slope C	Slope D
Rotary Borehole	RB109	-	RB104, RB410-	BH112, ARP-BH01 ARP-BH02
Cable Percussive	CP104, P2/14	P1/13	CP103	CP102-
Windowless Sample	-	WS09	WS112, WS07,	WS116, WS115, WS114
Trial Pit	TP155, TP16	TP155, TP154	TP02	TP107, TP108, TP118, TP157

Table 1 – Summary of relevant exploratory holes

2.4 Ground Conditions

The ground underlying Unit 2 comprises Made Ground overlying Glacial Till and Pennine Coal Measures bedrock.

Geological cross sections are presented on Byland drawings 2701-BEL-XX-002 & 2701-BEL-XX-003 included in Appendix A.

The strata encountered within the various phases of ground investigation are considered in more detail below:

2.4.1 Made Ground

Made Ground was found across the site and due to the mining history of the site is expected to be colliery spoil. The thickness varies from 0.60 to 9.00 and the soil is typically described as loose to medium dense clayey, sandy GRAVEL. Gravel is fine to coarse, angular to sub-angular, of brick concrete, coal and ash.

Standard Penetration Tests (SPT's) undertaken in the Made Ground recorded N values (extrapolated where >50) of 5 to 55 with an average of 21 indicating medium dense soil. SPT N values for all soils are plotted in Figure 1.

A unit weight, γ of 18kN/m^3 will be adopted for the Made Ground.

An angle of friction, ϕ' of 27° is proposed as while the material is predominantly granular there is a significant clay content.

As the Made Ground is predominantly granular the effective cohesion, c' of 0kPa will be taken.

2.4.2 Glacial Till (GT)

The Glacial Till is described as stiff, dark brown, slightly sandy, slightly gravelly CLAY. Gravel is subrounded to angular, fine to coarse of mixed lithologies.

SPT's undertaken within the Glacial Till recorded N values in the range 4 to 33 with an average of 18, confirming the consistency description of stiff.

A unit weight, γ of 19kN/m^3 for the analysed following guidance from Ciria Guide C504 for Engineering in Glacial Till.

3 No. plasticity tests undertaken on samples of the Glacial Till reported plasticity indices of 26, 23 and 22%. Based on Ciria C504 Table 5.1 the highest PI of 26% would indicate a peak angle of friction of 30° . However given the relatively small number of tests a conservative value of 28° will be adopted for the assessment to allow for some variation within the material.

An effective cohesion, c' of 0kPa will be taken.

2.4.3 Weathered Pennine Middle Coal Measures Formation (PMCM)

Unit 2 is located to the south of the site which lies on the western side of the fault and therefore the bedrock is the Pennine Middle Coal Measures, described as extremely weak, brownish grey and dark brown, thickly laminated, slightly sandy to sandy MUDSTONE or extremely weak, light brown, fine to medium SANDSTONE.

The PMCM is dipping to the southwest below the colliery spoil and Till.

9 No. SPT's were undertaken in the Mudstone with N values (extrapolated where > 50) in the range of 61 to 158 with an average of 103.

Adopting the very approximate relationship of Unconfined Compressive Strength (UCS) = $N \times 10$ indicates the UCS is in the range 1.20 to 3.20MPa with an average of 2.10MPa which indicates the rock varies from an extremely weak to a weak Mudstone.

A single SPT was undertaken within the Sandstone with an N value of 120. Using the formula $N \times 10$ indicated the UCS to be 1.5MPa.

For this assessment and in the absence of any validity testing a unit weight of 20kN/m^3 in conjunction with a ϕ' of 32° and a c' of 0 will be adopted.

2.4.5 Groundwater

The borehole groundwater strikes are summarised as follows:

Exploratory hole	Ground level (mOD)	Strike (mBGL)	Time (mins)	Rise (mBGL)	Strike (mOD)	Rise (mOD)
RB102	33.93	10.00	-	-	23.93	-
RB103	33.65	8.40	-	-	25.25	-
RB109	24.47	8.00	-	-	16.47	-

Table 2 – Water strikes during boring of exploratory holes (NP – not proved)

Therefore, a design groundwater level of 25.25mOD will be adopted in this assessment.

2.4.6 Design Parameters

The design parameters for the slope stability analysis are summarised in the following table.

Stratum	Unit weight, γ (kN/m ³)	Peak Angle of friction, ϕ' (°)	Effective cohesion, c' (kPa)
Made Ground/ Fill	18	27	0
Glacial Till	19	28	0
PMCM	20	32	0

Table 3 – Initial geotechnical parameters for slope stability analysis

The site is to undergo a cut and fill exercise at slopes A and B at the southwestern corner of Unit 2. No details have been provided for the intended fill material and therefore it will be assumed that the fill material is no worse than the in-situ Made Ground.

3 Slope Stability Analysis

The results of the ground investigation and earthworks drawings have been used to inform a slope stability analysis. Analyses have been undertaken on the proposed geometries shown in TCL drawings L003-TIE-ZZ-XX-DR-C-6053 Rev P1, L003-TIE-ZZ-XX-DR-C-6050 Rev P2 and Topographic drawings 10208/002/10, 10208/002/11, 10208/002/14 & 10208/002/15.

The analysis has been undertaken using the Oasys Slope software which can check circular and non-circular failures, thereby allowing calculations to be carried out for both soil and rock slopes. The program has been run implementing Bishops method of analysis for circular slips. The location of circular surfaces is defined using a rectangular grid of centres and a number of different radii, a common point through which all circles must pass or a tangential surface which the circle almost touches. For this analysis a number of different radii have been considered.

The slope stability analysis has been undertaken in accordance with BS EN 1997-1 (2013) and BS6031 (2009). 3 No. analyses have been undertaken for each section with the following target factors of safety (FoS)

1. A Serviceability Limit State (SLS) analysis using unfactored parameters and surcharges with a target FoS=1.3 for drained soils.
2. A Combination 1 Ultimate Limit State (ULS) analysis using unfactored soil parameters and factored surcharge loadings with a target FoS =1.0.
3. A Combination 2 ULS analysis using factored soil parameters and factored surcharge loadings with a target FoS =1.0.

Details of the ground profiles and proposed topography are shown on Byland drawing 2701-001 & 002 included in Appendix A.

3.1 Assumptions in the analysis

A number of assumptions have been made to undertake the analysis.

1. The strata have been modelled as drained throughout to represent long term conditions.
2. Limited proposed levels are presented on the drawings and where the geometry is deemed unclear a straight line has been assumed between 2 No. known points.
3. It has been assumed that the strata encountered in the exploratory holes at the toe of the slope continue horizontally.
4. No details of the fill material to be used or the method of placement have been provided. It will therefore be assumed that the fill has material parameters no worse than the in-situ colliery spoil Made Ground.
5. Building loadings of 70kPa under the slab and 150kPa under the pad foundations have been provided on drawing: U2-15-02 Rev. T1 by TCL.

6. Infrastructure such as access roads and service yards are present to the North and West of Unit 2 and will be modelled as a 20kPa surcharge. To the south of Unit 2 a Sustrans Limited asset is present and will be modelled with a 5kPa surcharge.
7. No benefit has been taken within the analysis from the rigid inclusions being installed beneath the footprint of the building as their primary purpose is to improve the stiffness of the ground rather than shear strength.

3.2 Analysis Results

3 No. sections of the proposed slope geometry have been analysed adjacent to Unit 2. The results of the analyses are included in Appendix B and are summarised below with the FOS/ODF:

Analysis	Factor of Safety / Over Design Factor		
	SLS	ULS C1	ULS C2
A	1.40	1.47	1.12
B	1.65	1.65	1.32
C	1.37	1.37	1.10
D	Not Analysed		

Table 4 – Summary of slope stability analyses

The results of the slope stability analysis indicate that factors of safety are adequate when considering drained conditions. The analysis indicates that slopes of 1 in 3 or slacker are stable for the ground conditions indicated to be present below the site

Section D contains a retaining wall to allow the cycle path to rise to a proposed bridge over the access road. No details of the retaining wall have been provided and therefore the slope has not been analysed. It is recommended that a global stability checked is included with the design of the retaining structure.

4 Conclusions & Recommendations

This report presents the results of a slope stability assessment of 3 No. slopes being formed around Unit 2 of a new commercial development at the former Cronton Colliery.

The ground conditions below the site comprise Made Ground which is predominantly colliery spoil overlying Glacial Till and Coal Measures Bedrock.

The existing site topography is higher in the north sloping to the south. To construct Unit 2, related access roads and loading/parking areas the site a cut and fill exercise will be undertaken.

The slopes being analysed are shown on Byland drawings 001,002 & 003 shown in Appendix A and detailed below:

- A. Located at the south-southwest corner of Unit 2 this slope comprises a upper 1 in 5 slope to the Sustrans path with a lower 1 in 3 slope.
- B. Located to the west-southwest corner of Unit 2 this slope comprises a 1 in 3 slope from Unit 2 to the access road.
- C. Located at the north-northeast corner of the site from the access road down a 1 in 10 slope to the upper yard and a 1 in 3 slope to the lower yard and Unit 2.

A slope stability analysis has been undertaken using the Oasys Slope software for the proposed slope geometries. As part of the analysis a number of assumptions have been made which include the following:

- 1. The strata have been modelled as drained throughout to represent long term conditions.
- 2. It has been assumed that the strata encountered in the exploratory holes at the toe of the slope continue horizontally.
- 3. No details of the fill material to be used or the method of placement have been provided. It will therefore be assumed that the fill has material parameters no worse than the in-situ colliery spoil Made Ground.
- 4. Building loadings of 70kPa under the slab and 150kPa under the pad foundations have been provided on drawing: U2-15-02 Rev. T1 by TCL
- 5. Infrastructure such as access roads and service yards are present to the North and West of Unit 2 and will be modelled as a 20kPa surcharge. To the south of Unit 2 a Sustrans Limited asset is present and will be modelled with a 5kPa surcharge.
- 6. No benefit has been taken within the analysis from the rigid inclusions being installed beneath the footprint of the building as their primary purpose is to improve the stiffness of the ground rather than shear strength.

The analysis shows the following:

- 1. All slopes have adequate factors of safety that have been checked with the provided loadings.

2. Generally slopes of 1 in 3 or slacker are stable based on the ground conditions noted in the boreholes.

Recommendations

The following recommendations are made:

1. Slopes should not be steeper than 1 in 3.
2. It is noted that soft and very soft Made Ground deposits were encountered in the area of the proposed new bridge at the south-east corner of the building. It is recommended that this material is removed during the cut/fill exercise and replaced with compacted fill.
3. The proposed fill should be tested to confirm that the parameters detailed within this report can be achieved. In addition the fill should be placed and compacted in with the Specification for Highways Works Series 600.
4. The above analysis does not consider flows of water exiting out of or running over the slopes. Adequate drainage should be provided to intercept any water than might flow towards the slope.

5 References

British Geological Survey Geoindex website <http://www.bgs.ac.uk/geoindex>

BS1377 (1999) British Standard Code of Practice for Tests for Soils for Civil Engineering Purposes, BSI, London

BS5930 (2015) + A1 (2020) British Standard Code of Practice for Site Investigation, BSI, London

BS8002 (2015) British Standard Code of Practice for Earth Retaining Structures, BSI, London

BS6031 (2009) Code of Practice for Earthworks, BSI, London

BS EN 1997-1 (2004) + A1 (2013) – Eurocode 7: Geotechnical design – Part 1 General rules, BSI, London

NA +A1 (2014) to BS EN 1997-1 (2004) + A1 (2013) – UK National Annex to Eurocode 7: Geotechnical design – Part 1: General rules, BSI, London

CIRIA 143 (1995), The standard penetration tests (SPT) : Methods and use, CIRIA, London

CIRIA 504 (1999), Engineering in Glacial Till, CIRIA, London

Oasys Slope 19.1 manual (2015)

Provided information

a) Tier Consult Limited:

- a. TE1163GIR1.3 A Ground Investigation Report dated December 2021
- b. TE1163 Dynamic Probe Results dated August 2022
- c. TE1163 Exploratory Hole Logs dated April 2023
- d. TE1163-TE1163EHLP Exploratory Hole Location Plan dated August 2020 Rev. A
- e. TE1163-TE-00-XX-DR-GE-001-V01 Exploratory Hole Site Wide Plan Rev. P1
- f. 01 P-108417-01 CPT Report & Location Plan
- g. 0208_002 Combined Topographic Drawings Rev. 0
- h. 22604-UMC-XXXX-SI-DR-A-0602 Illustrative Masterplan (Site Wide) Rev. P02
- i. L005-TIE-ZZ-XX-DR-C-6035 Proposed Earthworks Rev. P6
- j. L005-TIE-ZZ-XX-DR-C-6035 Proposed Earthworks Rev. P6

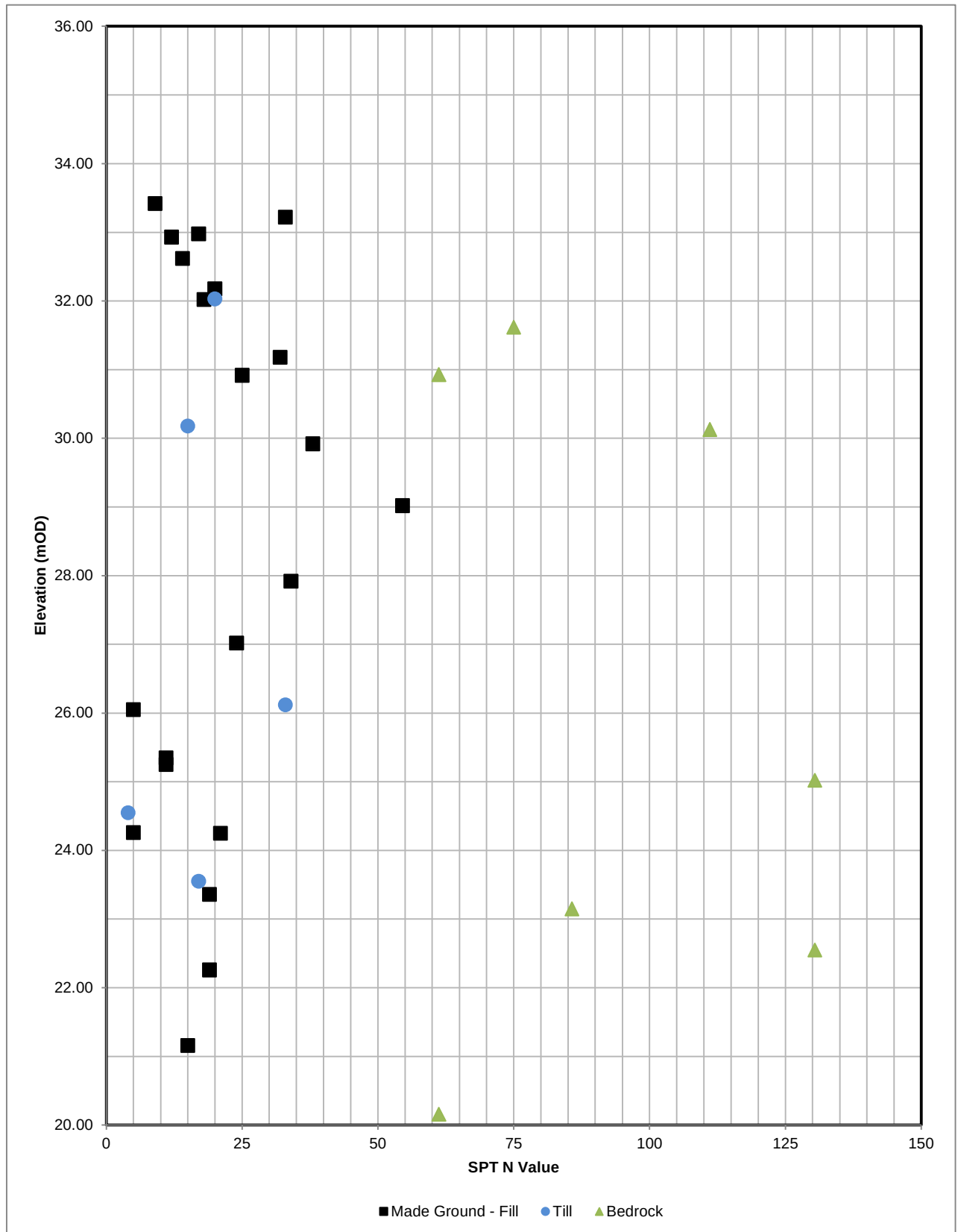
- k. L005-TIE-ZZ-XX-DR-C-6050 Unit 2 Site Sections Rev. P2
- l. L005-TIE-ZZ-XX-DR-C-6051 Unit 2 Earthworks Rev. T1
- m. L005-TIE-ZZ-XX-DR-C-6051 Unit 2 Levels Mine Shaft Lowered Rev. P1
- n. L005-TIE-ZZ-XX-DR-S-U2-1502 CMC Ground Improvement Rev. T1
- o. T-18-2126 Phase 1 Unit 2 Earthworks: Civil/Structural Specification dated 18th September 2023.

Figures



PROJECT Cronton Colliery - Phase 2 (Unit 2)

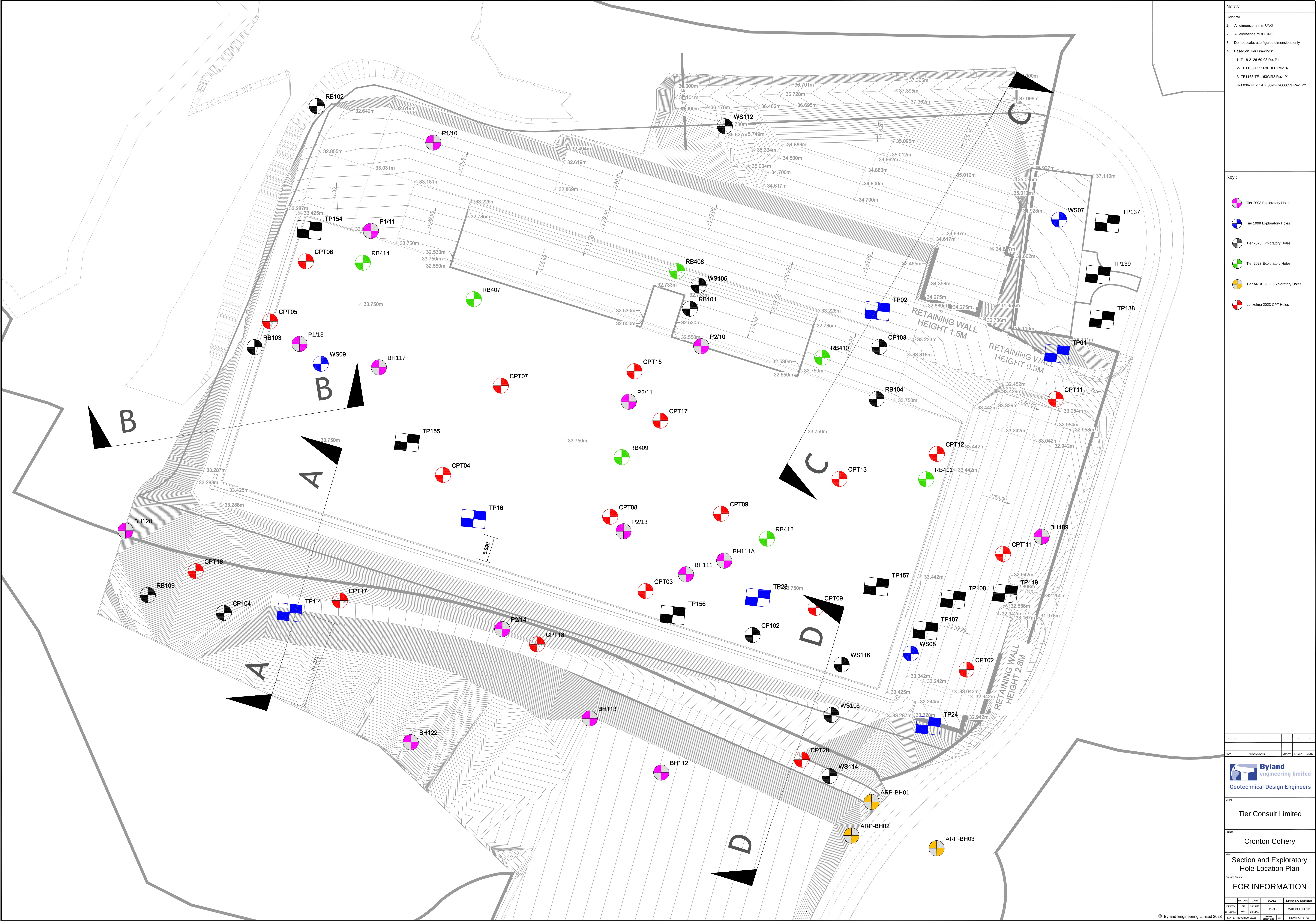
SECTION Profile of SPT N Value versus Elevation



Appendices

Appendix A

Byland drawing 2701-001,002 & 003



Notes:

General

1. All dimensions mm UNO
2. All elevations mOD UNO
3. Do not scale, use figured dimensions only
4. Based on Tier Drawings:
 - 1- T-18-2126-60-03 Re. P1
 - 2- TE1163-TE1163EHP Rev. A
 - 3- TE1163-TE1163GR3 Rev. P1
 - 4- L036-TIE-11-EX-00-D-C-006053 Rev. P2

- Key :
- Tier 2003 Exploratory Holes
 - Tier 1999 Exploratory Holes
 - Tier 2020 Exploratory Holes
 - Tier 2023 Exploratory Holes
 - Tier ARUP 2023 Exploratory Holes
 - Larkelema 2023 CPT Holes

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Geotechnical Design Engineers

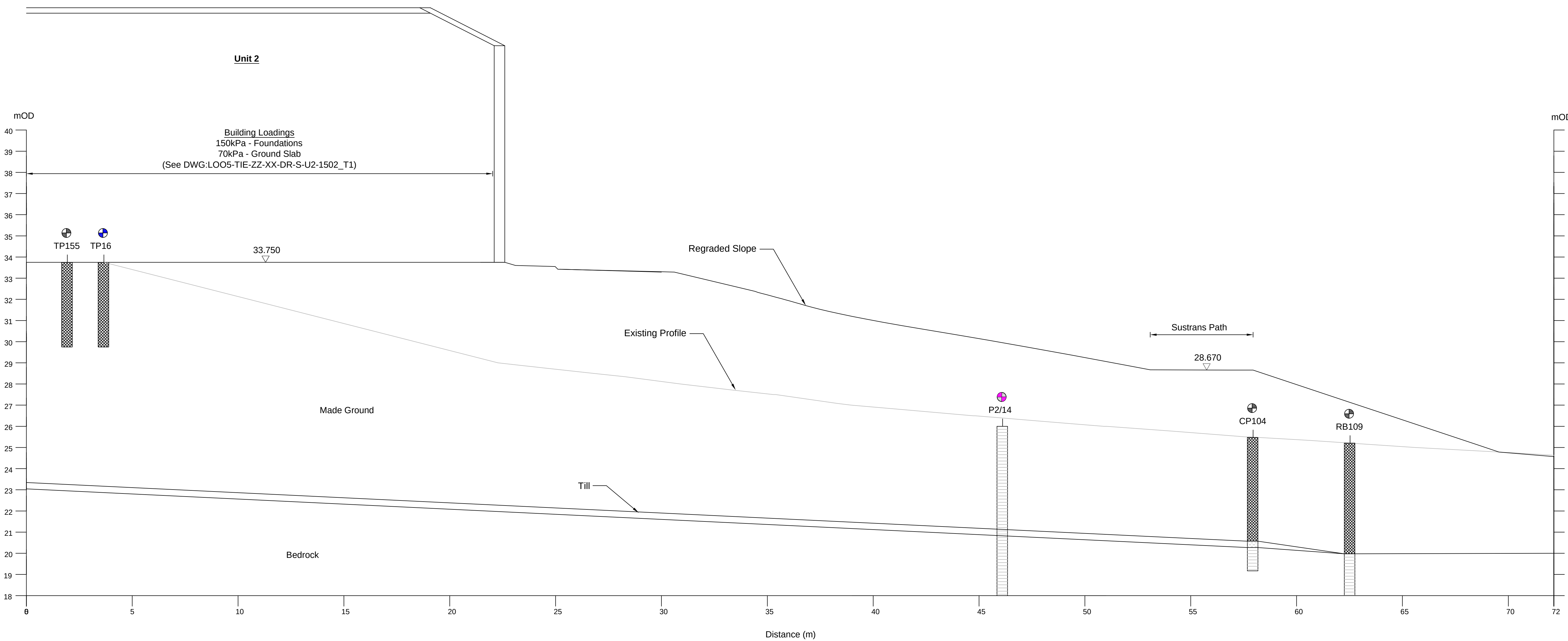
Tier Consult Limited

Cronton Colliery

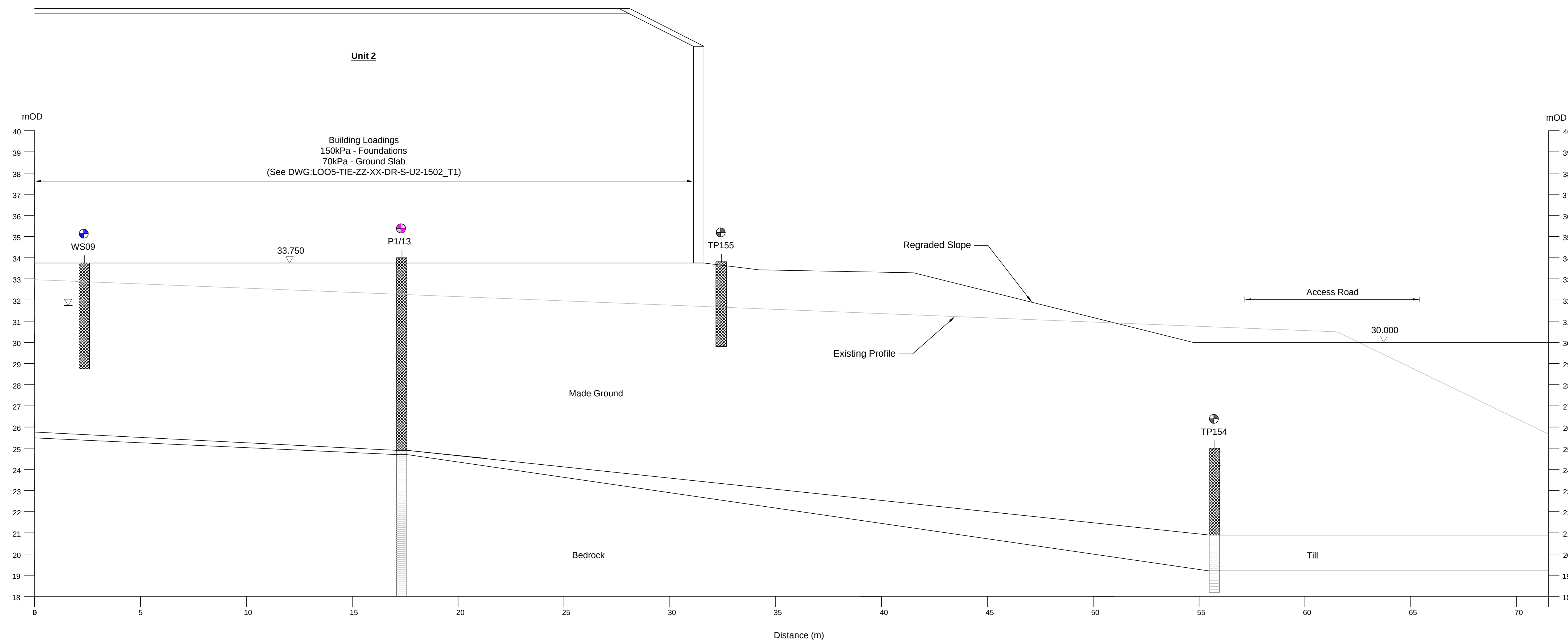
Section and Exploratory Hole Location Plan

FOR INFORMATION

INITIALS	DATE	SCALE	DRAWING NUMBER
DRAWN	20/10/23	2:51	2101-BEL-XX-003
CHECKED	20/10/23		
DATE	NOVEMBER 2023		



Section through Slope AA
Scale 1:100



Section through Slope BB
Scale 1:100

Notes:

General

- All dimensions mm UNO
- All elevations mOD UNO
- Do not scale, use figured dimensions only
- Based on Tier Drawings:
 - T-18-2126-60-03 Rev. P1
 - TE1163-TE1163EHP Rev. A
 - TE1163-TE1163GR3 Rev. P1
 - L036-TIE-11-EX-00-D-C-006053 Rev. P2

Key :

- Made Ground
- Clay
- Silt
- Sandstone
- Mudstone
- Groundwater strike
- Tier 2003 Exploratory Holes
- Tier 1999 Exploratory Holes
- Tier 2020 Exploratory Holes
- Tier 2023 Exploratory Holes
- Tier ARUP 2023 Exploratory Holes
- Lankelma 2023 CPT Holes

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-	-	-	-	-



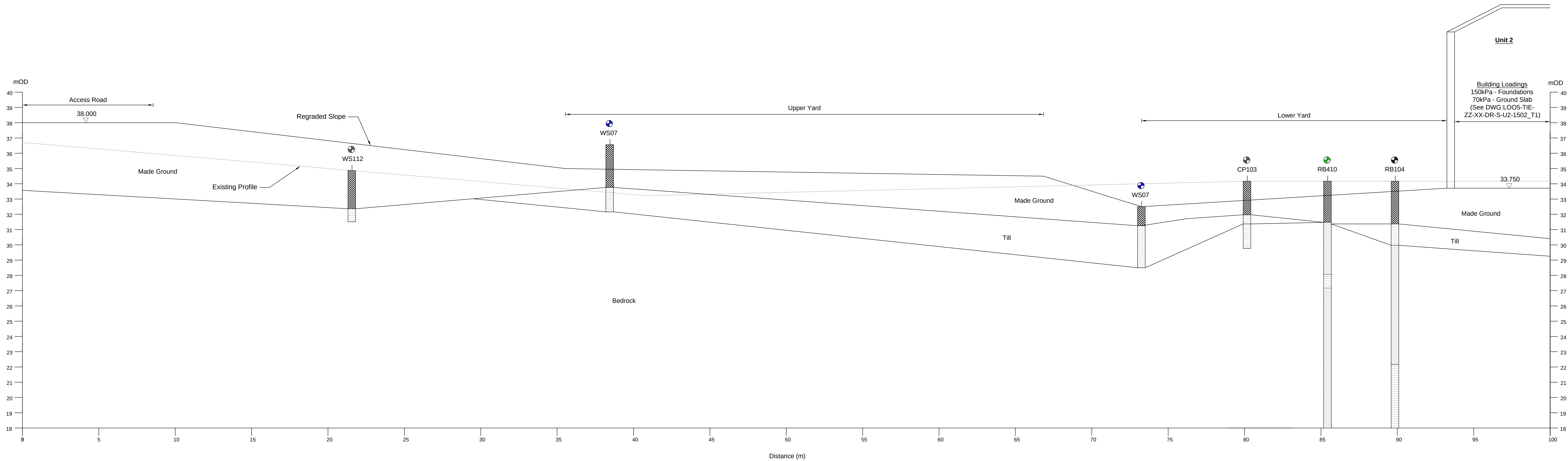
Tier Consult Limited

Project: Cronton Colliery

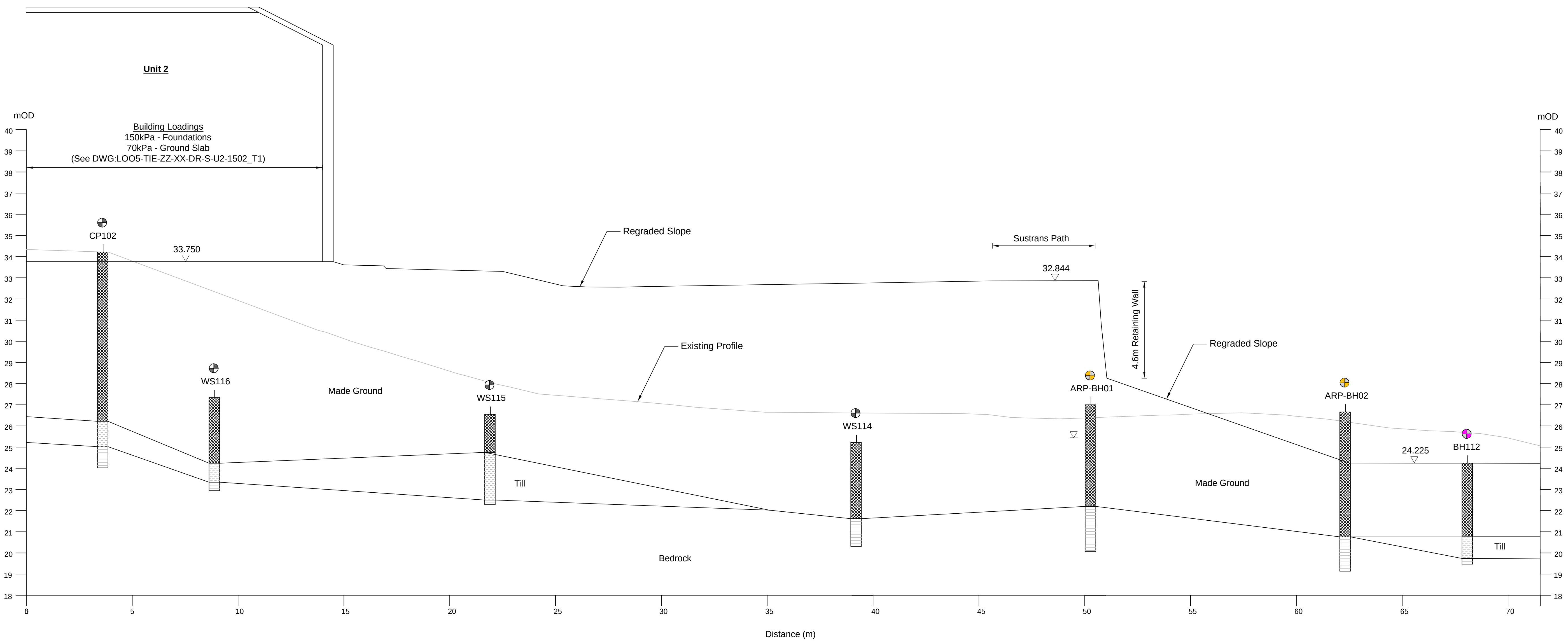
Title: Slope Sections AA & BB

Drawing Status: FOR INFORMATION

INITIALS	DATE	SCALE	DRAWING NUMBER
DRAWN	201103	As Shown	1701-BEL-VV-002
CHECKED	201103		
DATE	NOVEMBER 2023	REVISION	P01



Section through Slope CC
Scale 1:100



Section through Slope DD
Scale 1:100

Notes:

General

- All dimensions mm UNO
- All elevations mOD UNO
- Do not scale, use figured dimensions only
- Based on Tier Drawings:
 - T-18-2126-60-03 Rev. P1
 - TE1163-TE1163EHP Rev. A
 - TE1163-TE1163GR3 Rev. P1
 - L036-TIE-11-EX-00-D-C-006053 Rev. P2

Key :

- Made Ground
- Clay
- Silt
- Sand
- Sandstone
- Groundwater strike
- Tier 2003 Exploratory Holes
- Tier 1999 Exploratory Holes
- Tier 2020 Exploratory Holes
- Tier 2023 Exploratory Holes
- Tier ARUP 2023 Exploratory Holes
- Lanketna 2023 CPT Holes

REV	AMENDMENTS	DRAWN	CHECK	DATE
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Tier Consult Limited

Project: Cronton Colliery

Title: Slope Sections CC & DD

Drawing Status: FOR INFORMATION

INITIALS	DATE	SCALE	DRAWING NUMBER
DRAWN	2011/03	As Shown	1701-BEL-VX-003
CHECKED	2011/03		
DATE	NOVEMBER 2023	REVISION	P01

Appendix B

Oasys Slope input /output

Slope AA



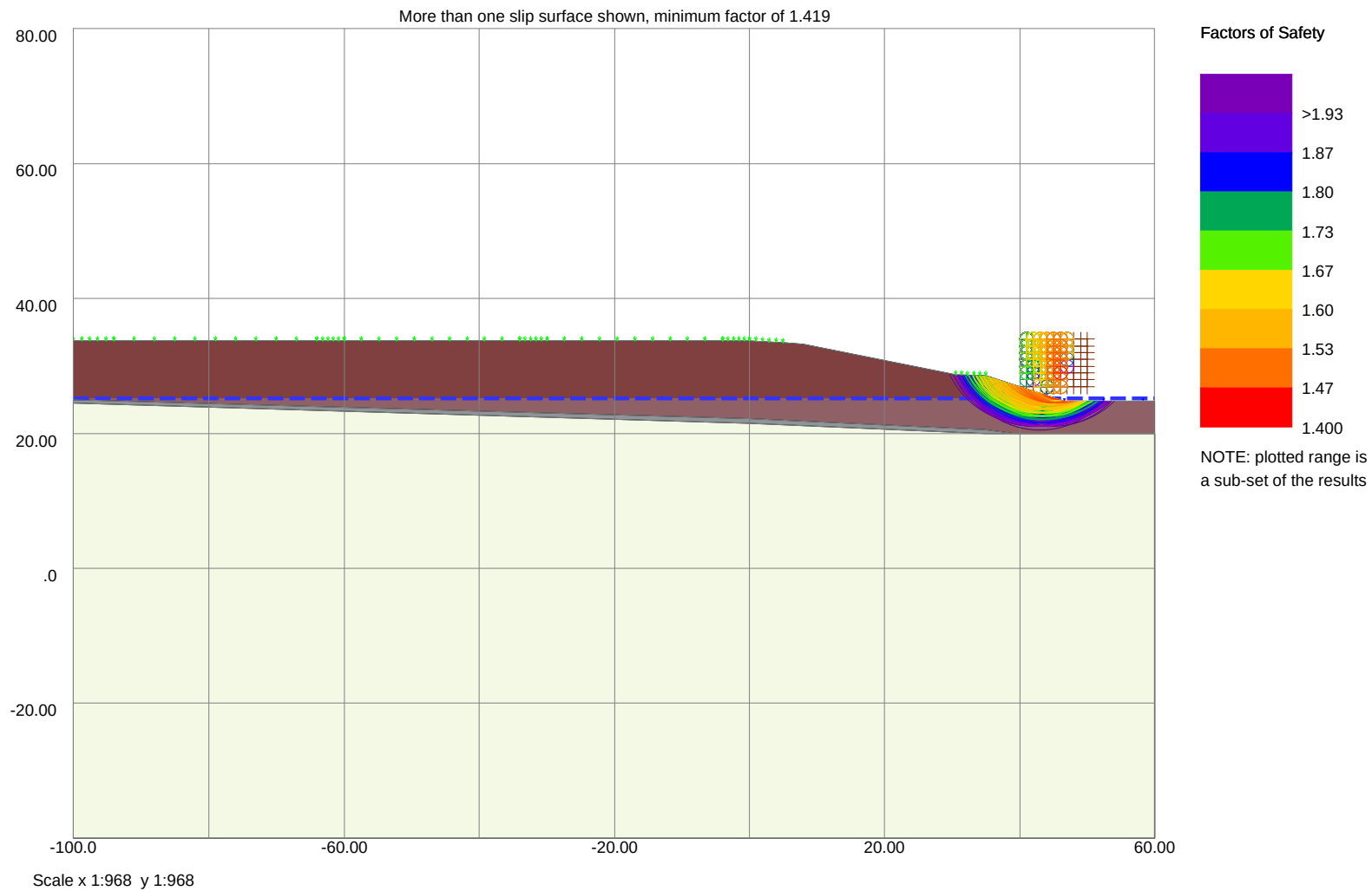
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Cronton Colliery - Slope Stability Assessment

Section A-A

SLS

Job No.	Sheet No.	Rev.
2701		
Drg. Ref.		
Made by	Date	Checked
EF		



Job No.	Sheet No.	Rev.
2701		
Drg. Ref.		
Made by EF	Date	Checked

General Parameters

Direction of slip: DOWNHILL
Minimum slip weight [kN/m] : 0.00000
Type of analysis : STATIC

Analysis Options

Factor of safety on : SHEAR STRENGTH
Minimum number of slices: 25
Method: Bishop (Variably inclined interslice forces)
Maximum number of iterations: 300
Reinforcement: ACTIVE

Material properties

No	Description	Unit Weight Above GWL	Unit Weight Below GWL	Shear Strength Parameters Condition	Phi
or c or c0'					
Phi0					
		[kN/m3]	[kN/m3]		
[°]	[kN/m²]				
1 Fill		18.000	18.000	Drained - linear strength	
27.000	0.0				
2 Till		19.000	19.000	Drained - linear strength	
28.000	0.0				
3 PMCM		20.000	20.000	Drained - linear strength	
32.000	0.0				

Coordinates of top of soil strata

The units of the following coordinates are in m

Stratum	X -->						
	-100.00	0.0	5.5000	8.0000	30.500	35.000	39.300
1	33.750	33.750	33.400	33.280	28.670	28.600	.
2	25.000	22.250	.	.	.	20.570	20.000
3	24.500	21.500	.	.	.	20.000	20.000
GW Profile 1	25.250	.	.	.	.	.	.
Stratum	X -->						
	45.000	46.600	60.000				
1	.	24.780	24.780				
2	.	.	20.000				
3	.	.	20.000				
GW Profile 1	25.250	.	25.250				

Piezometers

Stratum-linked data

No.	Material	Water table	Piezo Set/ Ru value
1	Fill	GW Profile 1	-
2	Till	GW Profile 1	-
3	PMCM	GW Profile 1	-

Surface Loads

No.	Limits of loaded area	Distributed load	Permanent / Variable load	Favourable / UnFavourable load	Use in pull-out calc
	X1	X2	Vert	Horiz	
	[m]	[m]	[kN/m²]	[kN/m²]	
1	-100.00	-94.000	150.00	0.0 Permanent	N/A No
2	-94.000	-64.000	70.000	0.0 Permanent	N/A No
3	-64.000	-60.000	150.00	0.0 Permanent	N/A No
4	-60.000	-34.000	70.000	0.0 Permanent	N/A No
5	-34.000	-30.000	150.00	0.0 Permanent	N/A No
6	-30.000	-4.0000	70.000	0.0 Permanent	N/A No
7	-4.0000	0.0	150.00	0.0 Permanent	N/A No
8	0.0	5.0000	5.0000	0.0 Variable	N/A No
9	30.500	35.000	5.0000	0.0 Variable	N/A No

Slip Surface Specification

Circle centre specification: GRID
Bottom left of grid: x = 41.00000 m y = 30.00000 m
Inclination of grid: 0.00000 deg

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No. Limits of loaded area Distributed load Permanent / Favourable / Use in
(positive anticlockwise direction about bottom left of grid)
Centres on grid: 10 in x direction at 1.00000m spacing
5 in y direction at 1.00000m spacing
Grid extended to find minimum FoS
Initial radius of circle 0.50000 m
Incremented by 0.50000 m until all possible circles considered

WORST CASE

Centre at (46.000m, 28.000m) Radius 3.0000m
Iterations: 5 Horiz acceleration [%g]: 0.0
Net vertical force [kN/m]: 603.09E-6 Slip weight [kN/m] 2.7104
Net horiz force [kN/m]: 0.0018270 Disturbing moment [kN/m]: 1.8775
Restoring moment [kNm/m]: 2.6282
Reinf. Rest. Moment [kNm/m]: 0.0
Factor of Safety: 1.3999

The system of interslice and base forces are in equilibrium when the strengths available at the bases are divided by the computed factor of safety. The interslice forces shown in the following table are in equilibrium with the factored strengths of the soil at the bases of slices.

Slip surface coordinates			Pore Pressure		Interslice forces [kN/m]		
Point	x [m]	y [m]	L	R	T	E	E(u)
			[kN/m ²]	[kN/m ²]			
1	44.275	25.546	-	-2.9574	0.0	0.0	0.0
2	44.325	25.511	-2.6146	-2.6146	-482.40E-6	0.0022016	0.0
3	44.375	25.478	-2.2820	-2.2820	0.0010443	0.0074989	0.0
4	44.426	25.446	-1.9596	-1.9596	0.0040168	0.015271	0.0
5	44.478	25.415	-1.6475	-1.6475	0.0079286	0.024894	0.0
6	44.530	25.385	-1.3460	-1.3460	0.012327	0.035742	0.0
7	44.583	25.356	-1.0551	-1.0551	0.016824	0.047210	0.0
8	44.637	25.327	-0.77490	-0.77490	0.021087	0.058707	0.0
9	44.691	25.301	-0.50560	-0.50560	0.024846	0.069672	0.0
10	44.746	25.275	-0.24727	-0.24727	0.027890	0.079588	0.0
11	44.801	25.250	0.0	0.0	0.030068	0.087985	0.0
12	44.850	25.229	0.20935	0.20935	0.031078	0.095729	0.0021914
13	44.900	25.209	0.40987	0.40987	0.031198	0.10546	0.0083997
14	44.950	25.190	0.60154	0.60154	0.030576	0.11680	0.018092
15	45.000	25.172	0.78426	0.78426	0.029362	0.12943	0.030753
16	45.060	25.151	0.98885	0.98885	0.027364	0.14569	0.048891
17	45.120	25.132	1.1807	1.1807	0.024986	0.16306	0.069708
18	45.181	25.114	1.3599	1.3599	0.022459	0.18129	0.092429
19	45.242	25.097	1.5262	1.5262	0.019819	0.19717	0.11388
20	45.303	25.082	1.6796	1.6796	0.017072	0.20830	0.13183
21	45.365	25.068	1.8200	1.8200	0.014312	0.21416	0.14561
22	45.427	25.055	1.9474	1.9474	0.011633	0.21438	0.15462
23	45.489	25.044	2.0617	2.0617	0.0091235	0.20866	0.15829
24	45.552	25.034	2.1629	2.1629	0.0068620	0.19684	0.15612
25	45.614	25.025	2.2509	2.2509	0.0049134	0.17886	0.14768
26	45.677	25.017	2.3256	2.3256	0.0033242	0.15475	0.13257
27	45.740	25.011	2.3871	2.3871	0.0021173	0.12467	0.11048
28	45.803	25.006	2.4353	2.4353	0.0012902	0.088901	0.081145
29	45.866	25.003	2.4701	2.4701	808.16E-6	0.047796	0.044364
30	45.929	25.001	2.4917	-	603.09E-6	0.0018270	0.0

Slice No.	Strength Parameters		Average Pore Pressure [kN/m ²]	Slice Weight [kN/m]	Forces on base [kN/m]		
	c' [kN/m ²]	Tan phi			Normal	Shear (capacity)	Shear (mobilised)
1	0.0	0.50953	0.0	0.0080134	0.0082442	0.0042006	0.0030008
2	0.0	0.50953	0.0	0.023808	0.021519	0.010964	0.0078324
3	0.0	0.50953	0.0	0.038864	0.034506	0.017582	0.012560
4	0.0	0.50953	0.0	0.053126	0.047120	0.024009	0.017151
5	0.0	0.50953	0.0	0.066510	0.059248	0.030188	0.021565
6	0.0	0.50953	0.0	0.078971	0.070807	0.036078	0.025772
7	0.0	0.50953	0.0	0.090441	0.081697	0.041627	0.029736
8	0.0	0.50953	0.0	0.10086	0.091826	0.046787	0.033423
9	0.0	0.50953	0.0	0.11019	0.10111	0.051518	0.036802
10	0.0	0.50953	0.0	0.11835	0.10945	0.055768	0.039838
11	0.0	0.50953	0.10468	0.11053	0.10381	0.050041	0.035747
12	0.0	0.50953	0.30961	0.11511	0.11025	0.047740	0.034104
13	0.0	0.50953	0.50570	0.11883	0.11558	0.045112	0.032226



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Slice No.	Strength Parameters	Average	Slice Force	Forces on base [kN/m]
14	0.0	0.50953	0.69290	0.11977 0.042146 0.030107
15	0.0	0.50953	0.88655	0.14621 0.14550 0.045561 0.032547
16	0.0	0.50953	1.0848	0.14728 0.14788 0.040381 0.028846
17	0.0	0.50953	1.2703	0.14675 0.14845 0.034690 0.024781
18	0.0	0.50953	1.4430	0.14458 0.15436 0.032141 0.022960
19	0.0	0.50953	1.6029	0.14079 0.16312 0.031445 0.022463
20	0.0	0.50953	1.7498	0.13530 0.17026 0.030352 0.021682
21	0.0	0.50953	1.8837	0.12816 0.17582 0.028864 0.020619
22	0.0	0.50953	2.0046	0.11932 0.17974 0.026969 0.019266
23	0.0	0.50953	2.1123	0.10879 0.18205 0.024671 0.017624
24	0.0	0.50953	2.2069	0.096575 0.18271 0.021965 0.015691
25	0.0	0.50953	2.2882	0.082680 0.18176 0.018855 0.013469
26	0.0	0.50953	2.3563	0.067119 0.17918 0.015345 0.010961
27	0.0	0.50953	2.4112	0.049905 0.17498 0.011439 0.0081716
28	0.0	0.50953	2.4527	0.031063 0.16919 0.0071477 0.0051060
29	0.0	0.50953	2.4809	0.010621 0.16182 0.0024805 0.0017719

Slice No.	Surface Load [kN/m_hor/m]		Point Load [kN/m]		Water Pressure on ground surface [kN/m_hor/m]	
	Vert	Horiz	Vert	Horiz	Vert	Horiz
1	0.0		0.0	0.0	0.0	0.0
2	0.0		0.0	0.0	0.0	0.0
3	0.0		0.0	0.0	0.0	0.0
4	0.0		0.0	0.0	0.0	0.0
5	0.0		0.0	0.0	0.0	0.0
6	0.0		0.0	0.0	0.0	0.0
7	0.0		0.0	0.0	0.0	0.0
8	0.0		0.0	0.0	0.0	0.0
9	0.0		0.0	0.0	0.0	0.0
10	0.0		0.0	0.0	0.0	0.0
11	0.0		0.0	0.0	0.0	0.0
12	0.0		0.0	0.0	0.0	0.0
13	0.0		0.0	0.0	0.0	0.0
14	0.0		0.0	0.0	0.0	0.0
15	0.0		0.0	0.0	0.0	0.0
16	0.0		0.0	0.0	0.0	0.0
17	0.0		0.0	0.0	0.0017538	-577.58E-6
18	0.0		0.0	0.0	0.12696	-0.041809
19	0.0		0.0	0.0	0.32851	-0.10819
20	0.0		0.0	0.0	0.53113	-0.17490
21	0.0		0.0	0.0	0.73471	-0.24193
22	0.0		0.0	0.0	0.93919	-0.30931
23	0.0		0.0	0.0	1.1445	-0.37686
24	0.0		0.0	0.0	1.3504	-0.44471
25	0.0		0.0	0.0	1.5570	-0.51271
26	0.0		0.0	0.0	1.7641	-0.58096
27	0.0		0.0	0.0	1.9716	-0.64926
28	0.0		0.0	0.0	2.1795	-0.71777
29	0.0		0.0	0.0	2.3876	-0.78626



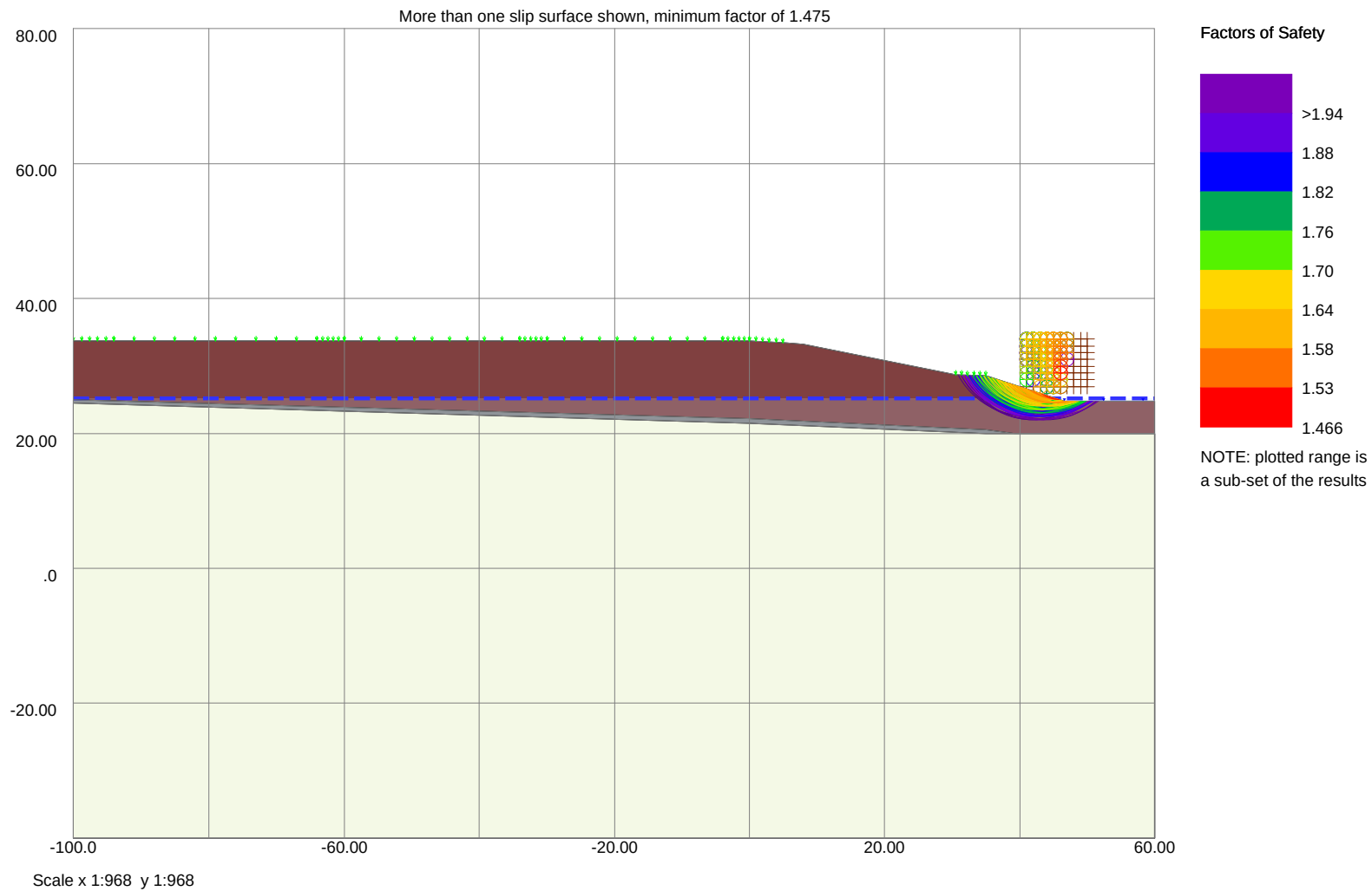
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Cronton Colliery - Slope Stability Assessment

Section A-A

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Made by EF	Date	Checked



Job No.	Sheet No.	Rev.
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General Parameters

Direction of slip: DOWNHILL
Minimum slip weight [kN/m] : 0.00000
Type of analysis : STATIC

Analysis Options

Partial Factor Analysis
Minimum number of slices: 25
Method: Bishop (Variably inclined interslice forces)
Maximum number of iterations: 300
Reinforcement: NOT ACTIVE

Method Partial Factors

Current selection: BS EN 1997-1:2011 DA1-1
Factor on FAVOURABLE PERMANENT LOAD: 1.00000
Factor on UNFAVOURABLE PERMANENT LOAD: 1.35000
Factor on FAVOURABLE VARIABLE LOAD: 0.00000
Factor on UNFAVOURABLE VARIABLE LOAD: 1.50000
Factor on SOIL UNIT WEIGHT: 1.35000
Factor on DRAINED SOIL COHESION: 1.00000
Factor on UNDRAINED SOIL COHESION: 1.00000
Factor on SOIL FRICTION ANGLE: 1.00000
Factor on reinforcement pullout: 1.50000
Economic ramification of failure: 1.00000
Sliding along reinforcement: 1.50000

Material properties

No	Description	Unit Weight Above GWL	Unit Weight Below GWL	Shear Strength Parameters Condition	Phi
	or c or c0'				
	Phi0				
	[°]	[kN/m3]	[kN/m3]		
1	Fill	18.000	18.000	Drained - linear strength	
27.000	0.0				
2	Till	19.000	19.000	Drained - linear strength	
28.000	0.0				
3	PMCM	20.000	20.000	Drained - linear strength	
32.000	0.0				

Coordinates of top of soil strata

The units of the following coordinates are in m

Stratum	X -->						
	-100.00	0.0	5.5000	8.0000	30.500	35.000	39.300
1	33.750	33.750	33.400	33.280	28.670	28.600	.
2	25.000	22.250	.	.	.	20.570	20.000
3	24.500	21.500	.	.	.	20.000	20.000
GW Profile 1	25.250	.	.	.	.	.	.
Stratum	X -->						
	45.000	46.600	60.000				
1	.	24.780	24.780				
2	.	.	20.000				
3	.	.	20.000				
GW Profile 1	25.250	.	25.250				

Piezometers

Stratum-linked data

No.	Material	Water table	Piezo Set/ Ru value
1	Fill	GW Profile 1	-
2	Till	GW Profile 1	-
3	PMCM	GW Profile 1	-

Surface Loads

No.	Limits of loaded area	Distributed load	Permanent / Variable load	Favourable / UnFavourable load	Use in pull-out calc
	X1	X2	Vert	Horiz	
	[m]	[m]	[kN/m²]	[kN/m²]	

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No.	Limits of loaded area			Distributed load	Permanent /	Favourable /	Use in
1	-100.00	-94.000	150.00	0.0	Permanent	Unfavourable	No
2	-94.000	-64.000	70.000	0.0	Permanent	Unfavourable	No
3	-64.000	-60.000	150.00	0.0	Permanent	Unfavourable	No
4	-60.000	-34.000	70.000	0.0	Permanent	Unfavourable	No
5	-34.000	-30.000	150.00	0.0	Permanent	Unfavourable	No
6	-30.000	-4.0000	70.000	0.0	Permanent	Unfavourable	No
7	-4.0000	0.0	150.00	0.0	Permanent	Unfavourable	No
8	0.0	5.0000	5.0000	0.0	Variable	Unfavourable	No
9	30.500	35.000	5.0000	0.0	Variable	Unfavourable	No

Slip Surface Specification

Circle centre specification: GRID
Bottom left of grid: x = 41.00000 m y = 30.00000 m
Inclination of grid: 0.00000 deg
(positive anticlockwise direction about bottom left of grid)
Centres on grid: 10 in x direction at 1.00000m spacing
5 in y direction at 1.00000m spacing
Grid extended to find minimum FoS
Initial radius of circle 0.50000 m
Incremented by 0.50000 m until all possible circles considered

NOTE on EC7 DA1-1 analyses

The approach used here follows Simpson, B (2011) Concise Eurocodes: Geotechnical design. BS EN 1997-1: Eurocode 7, Part 1. BSI.
Commenting on EC7 11.5.1(12), this states:
Paragraph (12) makes it clear that no attempt should be made to partition the sliding mass into favourable and unfavourable ground. Even when the Design Approach or Combination in use requires different factors on favourable or unfavourable permanent actions, the weight of the ground is to be considered as a single source in the terms of 2.4.2(9).

This is at variance with the proposals of Driscoll, R, Scott, P & Powell, J (2008) EC7 - implications for UK practice. CIRIA Report C641.

WORST CASE

Centre at (46.000m, 28.000m) Radius 3.0000m
Iterations: 5 Horiz acceleration [%g]: 0.0
Net vertical force [kN/m]: 0.0010261 Slip weight [kN/m] 3.6590
Net horiz force [kN/m]: 0.0031126 Disturbing moment [kN/m]: 2.7446
Restoring moment [kNm/m]: 4.0235
Reinf. Rest. Moment [kNm/m]: 0.0
Over-Design Factor: 1.4660

The system of interslice and base forces are in equilibrium when the strengths available at the bases are divided by the computed over-design factor. The interslice forces shown in the following table are in equilibrium with the factored strengths of the soil at the bases of slices.

Slip surface coordinates			Pore Pressure		Interslice forces [kN/m]		
Point	x [m]	y [m]	L	R	T	E	E(u)
			[kN/m ²]	[kN/m ²]			
1	44.275	25.546	-	-2.9574	0.0	0.0	0.0
2	44.325	25.511	-2.6146	-2.6146	-901.89E-6	0.0032200	0.0
3	44.375	25.478	-2.2820	-2.2820	0.0010665	0.010859	0.0
4	44.426	25.446	-1.9596	-1.9596	0.0051324	0.022081	0.0
5	44.478	25.415	-1.6475	-1.6475	0.010599	0.036041	0.0
6	44.530	25.385	-1.3460	-1.3460	0.016841	0.051891	0.0
7	44.583	25.356	-1.0551	-1.0551	0.023318	0.068806	0.0
8	44.637	25.327	-0.77490	-0.77490	0.029570	0.085982	0.0
9	44.691	25.301	-0.50560	-0.50560	0.035213	0.10265	0.0
10	44.746	25.275	-0.24727	-0.24727	0.039948	0.11810	0.0
11	44.801	25.250	0.0	0.0	0.043557	0.13167	0.0
12	44.850	25.229	0.20935	0.20935	0.045546	0.14350	0.0021914
13	44.900	25.209	0.40987	0.40987	0.046321	0.15666	0.0083997
14	44.950	25.190	0.60154	0.60154	0.046031	0.17070	0.018092
15	45.000	25.172	0.78426	0.78426	0.044826	0.18522	0.030753
16	45.060	25.151	0.98885	0.98885	0.042448	0.20260	0.048891
17	45.120	25.132	1.1807	1.1807	0.039305	0.21982	0.069708
18	45.181	25.114	1.3599	1.3599	0.035678	0.23662	0.092429
19	45.242	25.097	1.5262	1.5262	0.031704	0.24992	0.11388
20	45.303	25.082	1.6796	1.6796	0.027473	0.25745	0.13183
21	45.365	25.068	1.8200	1.8200	0.023149	0.25880	0.14561
22	45.427	25.055	1.9474	1.9474	0.018897	0.25376	0.15462

Slip surface coordinates		Pore Pressure		Interslice forces [kN/m]			
Point No.	[m]	[m]					
23	45.489	25.044	2.0617	2.0617	0.014873	0.24221	0.15829
24	45.552	25.034	2.1629	2.1629	0.011220	0.22422	0.15612
25	45.614	25.025	2.2509	2.2509	0.0080537	0.19999	0.14768
26	45.677	25.017	2.3256	2.3256	0.0054610	0.16990	0.13257
27	45.740	25.011	2.3871	2.3871	0.0034881	0.13444	0.11048
28	45.803	25.006	2.4353	2.4353	0.0021368	0.094276	0.081145
29	45.866	25.003	2.4701	2.4701	0.0013536	0.050192	0.044364
30	45.929	25.001	2.4917	-	0.0010261	0.0031126	0.0

Slice Strength Parameters			Average Pore Pressure		Slice Weight			Forces on base [kN/m]	
No.	c'	Tan phi	[kN/m ²]	[kN/m ²]	[kN/m]	Normal	Shear (capacity)	Shear (mobilised)	
1	0.0	0.50953	0.0	0.010818	0.011476	0.0058471	0.0039886		
2	0.0	0.50953	0.0	0.032141	0.029395	0.014977	0.010217		
3	0.0	0.50953	0.0	0.052466	0.046927	0.023910	0.016310		
4	0.0	0.50953	0.0	0.071720	0.063952	0.032585	0.022228		
5	0.0	0.50953	0.0	0.089789	0.080322	0.040926	0.027917		
6	0.0	0.50953	0.0	0.10661	0.095922	0.048875	0.033339		
7	0.0	0.50953	0.0	0.12210	0.11062	0.056363	0.038448		
8	0.0	0.50953	0.0	0.13616	0.12429	0.063327	0.043198		
9	0.0	0.50953	0.0	0.14875	0.13681	0.069710	0.047552		
10	0.0	0.50953	0.0	0.15977	0.14806	0.075442	0.051463		
11	0.0	0.50953	0.10468	0.14921	0.14010	0.068535	0.046750		
12	0.0	0.50953	0.30961	0.15540	0.14828	0.067117	0.045784		
13	0.0	0.50953	0.50570	0.16042	0.15507	0.065231	0.044497		
14	0.0	0.50953	0.69290	0.16420	0.16041	0.062856	0.042877		
15	0.0	0.50953	0.88655	0.19738	0.19465	0.070602	0.048161		
16	0.0	0.50953	1.0848	0.19883	0.19768	0.065758	0.044857		
17	0.0	0.50953	1.2703	0.19811	0.19836	0.060120	0.041011		
18	0.0	0.50953	1.4430	0.19518	0.20379	0.057328	0.039106		
19	0.0	0.50953	1.6029	0.19006	0.21149	0.056093	0.038263		
20	0.0	0.50953	1.7498	0.18266	0.21696	0.054147	0.036936		
21	0.0	0.50953	1.8837	0.17302	0.22024	0.051496	0.035128		
22	0.0	0.50953	2.0046	0.16108	0.22125	0.048119	0.032824		
23	0.0	0.50953	2.1123	0.14687	0.22002	0.044020	0.030028		
24	0.0	0.50953	2.2069	0.13038	0.21653	0.039193	0.026735		
25	0.0	0.50953	2.2882	0.11162	0.21078	0.033644	0.022950		
26	0.0	0.50953	2.3563	0.090611	0.20280	0.027380	0.018677		
27	0.0	0.50953	2.4112	0.067372	0.19259	0.020409	0.013922		
28	0.0	0.50953	2.4527	0.041936	0.18018	0.012749	0.0086964		
29	0.0	0.50953	2.4809	0.014338	0.16562	0.0044166	0.0030128		

Slice No.	Surface Load [kN/m_hor/m]		Point Load [kN/m]		Water Pressure on ground surface [kN/m_hor/m]	
	Vert	Horiz	Vert	Horiz	Vert	Horiz
1	0.0	0.0	0.0	0.0	0.0	0.0
2	0.0	0.0	0.0	0.0	0.0	0.0
3	0.0	0.0	0.0	0.0	0.0	0.0
4	0.0	0.0	0.0	0.0	0.0	0.0
5	0.0	0.0	0.0	0.0	0.0	0.0
6	0.0	0.0	0.0	0.0	0.0	0.0
7	0.0	0.0	0.0	0.0	0.0	0.0
8	0.0	0.0	0.0	0.0	0.0	0.0
9	0.0	0.0	0.0	0.0	0.0	0.0
10	0.0	0.0	0.0	0.0	0.0	0.0
11	0.0	0.0	0.0	0.0	0.0	0.0
12	0.0	0.0	0.0	0.0	0.0	0.0
13	0.0	0.0	0.0	0.0	0.0	0.0
14	0.0	0.0	0.0	0.0	0.0	0.0
15	0.0	0.0	0.0	0.0	0.0	0.0
16	0.0	0.0	0.0	0.0	0.0	0.0
17	0.0	0.0	0.0	0.0	0.0017538	-577.58E-6
18	0.0	0.0	0.0	0.0	0.12696	-0.041809
19	0.0	0.0	0.0	0.0	0.32851	-0.10819
20	0.0	0.0	0.0	0.0	0.53113	-0.17490
21	0.0	0.0	0.0	0.0	0.73471	-0.24193
22	0.0	0.0	0.0	0.0	0.93919	-0.30931
23	0.0	0.0	0.0	0.0	1.1445	-0.37686
24	0.0	0.0	0.0	0.0	1.3504	-0.44471



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Slice No	Surface Load [kN/m _{hor} /m]	Point Load [kN/m]	Water Pressure on ground surface [kN/m _{hor} /m]			
25	0.0	0.0	0.0	0.0	1.5570	-0.51271
26	0.0	0.0	0.0	0.0	1.7641	-0.58096
27	0.0	0.0	0.0	0.0	1.9716	-0.64926
28	0.0	0.0	0.0	0.0	2.1795	-0.71777
29	0.0	0.0	0.0	0.0	2.3876	-0.78626



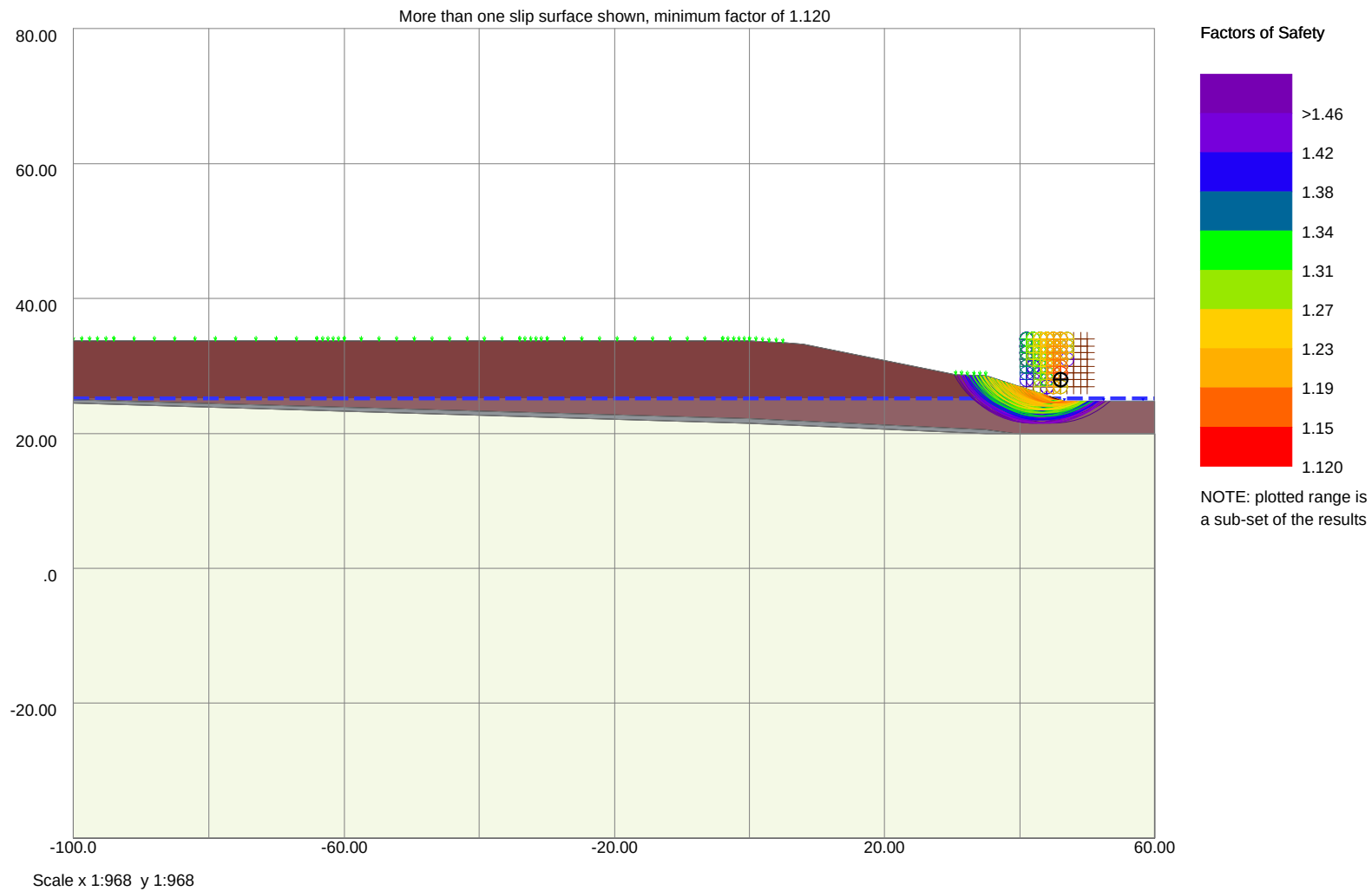
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ULS2

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General Parameters

Direction of slip: DOWNHILL
Minimum slip weight [kN/m] : 0.00000
Type of analysis : STATIC

Analysis Options

Partial Factor Analysis
Minimum number of slices: 25
Method: Bishop (Variably inclined interslice forces)
Maximum number of iterations: 300
Reinforcement: NOT ACTIVE

Method Partial Factors

Current selection: BS EN 1997-1:2011 DA1-2
Factor on FAVOURABLE PERMANENT LOAD: 1.00000
Factor on UNFAVOURABLE PERMANENT LOAD: 1.00000
Factor on FAVOURABLE VARIABLE LOAD: 0.00000
Factor on UNFAVOURABLE VARIABLE LOAD: 1.30000
Factor on SOIL UNIT WEIGHT: 1.00000
Factor on DRAINED SOIL COHESION: 1.25000
Factor on UNDRAINED SOIL COHESION: 1.40000
Factor on SOIL FRICTION ANGLE: 1.25000
Factor on reinforcement pullout: 1.50000
Economic ramification of failure: 1.00000
Sliding along reinforcement: 1.50000

Material properties

No	Description	Unit Weight Above GWL	Unit Weight Below GWL	Shear Strength Parameters Condition	Phi
	or c or c0'				
	Phi0				
	[°]	[kN/m3]	[kN/m3]		
	[kN/m²]				
1	Fill	18.000	18.000	Drained - linear strength	
27.000	0.0				
2	Till	19.000	19.000	Drained - linear strength	
28.000	0.0				
3	PMCM	20.000	20.000	Drained - linear strength	
32.000	0.0				

Coordinates of top of soil strata

The units of the following coordinates are in m

Stratum	X -->						
	-100.00	0.0	5.5000	8.0000	30.500	35.000	39.300
1	33.750	33.750	33.400	33.280	28.670	28.600	.
2	25.000	22.250	.	.	.	20.570	20.000
3	24.500	21.500	.	.	.	20.000	20.000
GW Profile 1	25.250	.	.	.	.	.	.
Stratum	X -->						
	45.000	46.600	60.000				
1	.	24.780	24.780				
2	.	.	20.000				
3	.	.	20.000				
GW Profile 1	25.250	.	25.250				

Piezometers

Stratum-linked data

No.	Material	Water table	Piezo Set/ Ru value
1	Fill	GW Profile 1	-
2	Till	GW Profile 1	-
3	PMCM	GW Profile 1	-

Surface Loads

No.	Limits of loaded area	Distributed load	Permanent / Variable load	Favourable / UnFavourable load	Use in pull-out calc
	X1	X2	Vert	Horiz	
	[m]	[m]	[kN/m²]	[kN/m²]	

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No.	Limits of loaded area			Distributed load	Permanent /	Favourable /	Use in
1	-100.00	-94.000	150.00	0.0	Permanent	Unfavourable	No
2	-94.000	-64.000	70.000	0.0	Permanent	Unfavourable	No
3	-64.000	-60.000	150.00	0.0	Permanent	Unfavourable	No
4	-60.000	-34.000	70.000	0.0	Permanent	Unfavourable	No
5	-34.000	-30.000	150.00	0.0	Permanent	Unfavourable	No
6	-30.000	-4.0000	70.000	0.0	Permanent	Unfavourable	No
7	-4.0000	0.0	150.00	0.0	Permanent	Unfavourable	No
8	0.0	5.0000	5.0000	0.0	Variable	Unfavourable	No
9	30.500	35.000	5.0000	0.0	Variable	Unfavourable	No

Slip Surface Specification

Circle centre specification: GRID
Bottom left of grid: x = 41.00000 m y = 30.00000 m
Inclination of grid: 0.00000 deg
(positive anticlockwise direction about bottom left of grid)
Centres on grid: 10 in x direction at 1.00000m spacing
5 in y direction at 1.00000m spacing
Grid extended to find minimum FoS
Initial radius of circle 0.50000 m
Incremented by 0.50000 m until all possible circles considered

WORST CASE

Centre at (46.000m,28.000m) Radius 3.0000m
Iterations: 5 Horiz acceleration [%g]: 0.0
Net vertical force [kN/m]: 603.09E-6 Slip weight [kN/m] 2.7104
Net horiz force [kN/m]: 0.0018270 Disturbing moment [kNm/m]: 1.8775
Restoring moment [kNm/m]: 2.1026
Reinf.Rest.Moment [kNm/m]: 0.0
Over-Design Factor: 1.1199

The system of interslice and base forces are in equilibrium when the strengths available at the bases are divided by the computed over-design factor. The interslice forces shown in the following table are in equilibrium with the factored strengths of the soil at the bases of slices.

Slip surface coordinates			Pore Pressure		Interslice forces [kN/m]		
Point	x [m]	y [m]	L	R	T	E	E(u)
			[kN/m ²]	[kN/m ²]			
1	44.275	25.546	-	-2.9574	0.0	0.0	0.0
2	44.325	25.511	-2.6146	-2.6146	-482.40E-6	0.0022016	0.0
3	44.375	25.478	-2.2820	-2.2820	0.0010443	0.0074989	0.0
4	44.426	25.446	-1.9596	-1.9596	0.0040168	0.015271	0.0
5	44.478	25.415	-1.6475	-1.6475	0.0079286	0.024894	0.0
6	44.530	25.385	-1.3460	-1.3460	0.012327	0.035742	0.0
7	44.583	25.356	-1.0551	-1.0551	0.016824	0.047210	0.0
8	44.637	25.327	-0.77490	-0.77490	0.021087	0.058707	0.0
9	44.691	25.301	-0.50560	-0.50560	0.024846	0.069672	0.0
10	44.746	25.275	-0.24727	-0.24727	0.027890	0.079588	0.0
11	44.801	25.250	0.0	0.0	0.030068	0.087985	0.0
12	44.850	25.229	0.20935	0.20935	0.031078	0.095729	0.0021914
13	44.900	25.209	0.40987	0.40987	0.031198	0.10546	0.0083997
14	44.950	25.190	0.60154	0.60154	0.030576	0.11680	0.018092
15	45.000	25.172	0.78426	0.78426	0.029362	0.12943	0.030753
16	45.060	25.151	0.98885	0.98885	0.027364	0.14569	0.048891
17	45.120	25.132	1.1807	1.1807	0.024986	0.16306	0.069708
18	45.181	25.114	1.3599	1.3599	0.022459	0.18129	0.092429
19	45.242	25.097	1.5262	1.5262	0.019819	0.19717	0.11388
20	45.303	25.082	1.6796	1.6796	0.017072	0.20830	0.13183
21	45.365	25.068	1.8200	1.8200	0.014312	0.21416	0.14561
22	45.427	25.055	1.9474	1.9474	0.011633	0.21438	0.15462
23	45.489	25.044	2.0617	2.0617	0.0091235	0.20866	0.15829
24	45.552	25.034	2.1629	2.1629	0.0068620	0.19684	0.15612
25	45.614	25.025	2.2509	2.2509	0.0049134	0.17886	0.14768
26	45.677	25.017	2.3256	2.3256	0.0033242	0.15475	0.13257
27	45.740	25.011	2.3871	2.3871	0.0021173	0.12467	0.11048
28	45.803	25.006	2.4353	2.4353	0.0012902	0.088901	0.081145
29	45.866	25.003	2.4701	2.4701	808.16E-6	0.047796	0.044364
30	45.929	25.001	2.4917	-	603.09E-6	0.0018270	0.0

Slice Strength Parameters		Average	Slice	Forces on base [kN/m]		
No.		Pore	Weight			
		Pressure				
	c'	Tan phi	[kN/m ²]	[kN/m]	Normal	Shear
	[kN/m ²]				(capacity)	(mobilised)



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Slice No.	Strength Parameters	Average Base	Slice Weight	Forces on base [kN/m]			
1	0.0	0.40762	0.0	0.0080134	0.0082442	0.0033605	0.0030008
2	0.0	0.40762	0.0	0.023808	0.021519	0.0087714	0.0078324
3	0.0	0.40762	0.0	0.038864	0.034506	0.014065	0.012560
4	0.0	0.40762	0.0	0.053126	0.047120	0.019207	0.017151
5	0.0	0.40762	0.0	0.066510	0.059248	0.024151	0.021565
6	0.0	0.40762	0.0	0.078971	0.070807	0.028862	0.025772
7	0.0	0.40762	0.0	0.090441	0.081697	0.033301	0.029736
8	0.0	0.40762	0.0	0.10086	0.091826	0.037430	0.033423
9	0.0	0.40762	0.0	0.11019	0.10111	0.041215	0.036802
10	0.0	0.40762	0.0	0.11835	0.10945	0.044614	0.039838
11	0.0	0.40762	0.10468	0.11053	0.10381	0.040033	0.035747
12	0.0	0.40762	0.30961	0.11511	0.11025	0.038192	0.034104
13	0.0	0.40762	0.50570	0.11883	0.11558	0.036090	0.032226
14	0.0	0.40762	0.69290	0.12163	0.11977	0.033717	0.030107
15	0.0	0.40762	0.88655	0.14621	0.14550	0.036449	0.032547
16	0.0	0.40762	1.0848	0.14728	0.14788	0.032305	0.028846
17	0.0	0.40762	1.2703	0.14675	0.14845	0.027752	0.024781
18	0.0	0.40762	1.4430	0.14458	0.15436	0.025713	0.022960
19	0.0	0.40762	1.6029	0.14079	0.16312	0.025156	0.022463
20	0.0	0.40762	1.7498	0.13530	0.17026	0.024282	0.021682
21	0.0	0.40762	1.8837	0.12816	0.17582	0.023091	0.020619
22	0.0	0.40762	2.0046	0.11932	0.17974	0.021575	0.019266
23	0.0	0.40762	2.1123	0.10879	0.18205	0.019736	0.017624
24	0.0	0.40762	2.2069	0.096575	0.18271	0.017572	0.015691
25	0.0	0.40762	2.2882	0.082680	0.18176	0.015084	0.013469
26	0.0	0.40762	2.3563	0.067119	0.17918	0.012276	0.010961
27	0.0	0.40762	2.4112	0.049905	0.17498	0.0091513	0.0081716
28	0.0	0.40762	2.4527	0.031063	0.16919	0.0057182	0.0051060
29	0.0	0.40762	2.4809	0.010621	0.16182	0.0019844	0.0017719

Slice No.	Surface Load [kN/m_hor/m]		Point Load [kN/m]		Water Pressure on ground surface [kN/m_hor/m]		
	Vert	Horiz	Vert	Horiz	Vert	Horiz	
1	0.0		0.0	0.0	0.0	0.0	0.0
2	0.0		0.0	0.0	0.0	0.0	0.0
3	0.0		0.0	0.0	0.0	0.0	0.0
4	0.0		0.0	0.0	0.0	0.0	0.0
5	0.0		0.0	0.0	0.0	0.0	0.0
6	0.0		0.0	0.0	0.0	0.0	0.0
7	0.0		0.0	0.0	0.0	0.0	0.0
8	0.0		0.0	0.0	0.0	0.0	0.0
9	0.0		0.0	0.0	0.0	0.0	0.0
10	0.0		0.0	0.0	0.0	0.0	0.0
11	0.0		0.0	0.0	0.0	0.0	0.0
12	0.0		0.0	0.0	0.0	0.0	0.0
13	0.0		0.0	0.0	0.0	0.0	0.0
14	0.0		0.0	0.0	0.0	0.0	0.0
15	0.0		0.0	0.0	0.0	0.0	0.0
16	0.0		0.0	0.0	0.0	0.0	0.0
17	0.0		0.0	0.0	0.0	0.0017538	-577.58E-6
18	0.0		0.0	0.0	0.0	0.12696	-0.041809
19	0.0		0.0	0.0	0.0	0.32851	-0.10819
20	0.0		0.0	0.0	0.0	0.53113	-0.17490
21	0.0		0.0	0.0	0.0	0.73471	-0.24193
22	0.0		0.0	0.0	0.0	0.93919	-0.30931
23	0.0		0.0	0.0	0.0	1.1445	-0.37686
24	0.0		0.0	0.0	0.0	1.3504	-0.44471
25	0.0		0.0	0.0	0.0	1.5570	-0.51271
26	0.0		0.0	0.0	0.0	1.7641	-0.58096
27	0.0		0.0	0.0	0.0	1.9716	-0.64926
28	0.0		0.0	0.0	0.0	2.1795	-0.71777
29	0.0		0.0	0.0	0.0	2.3876	-0.78626

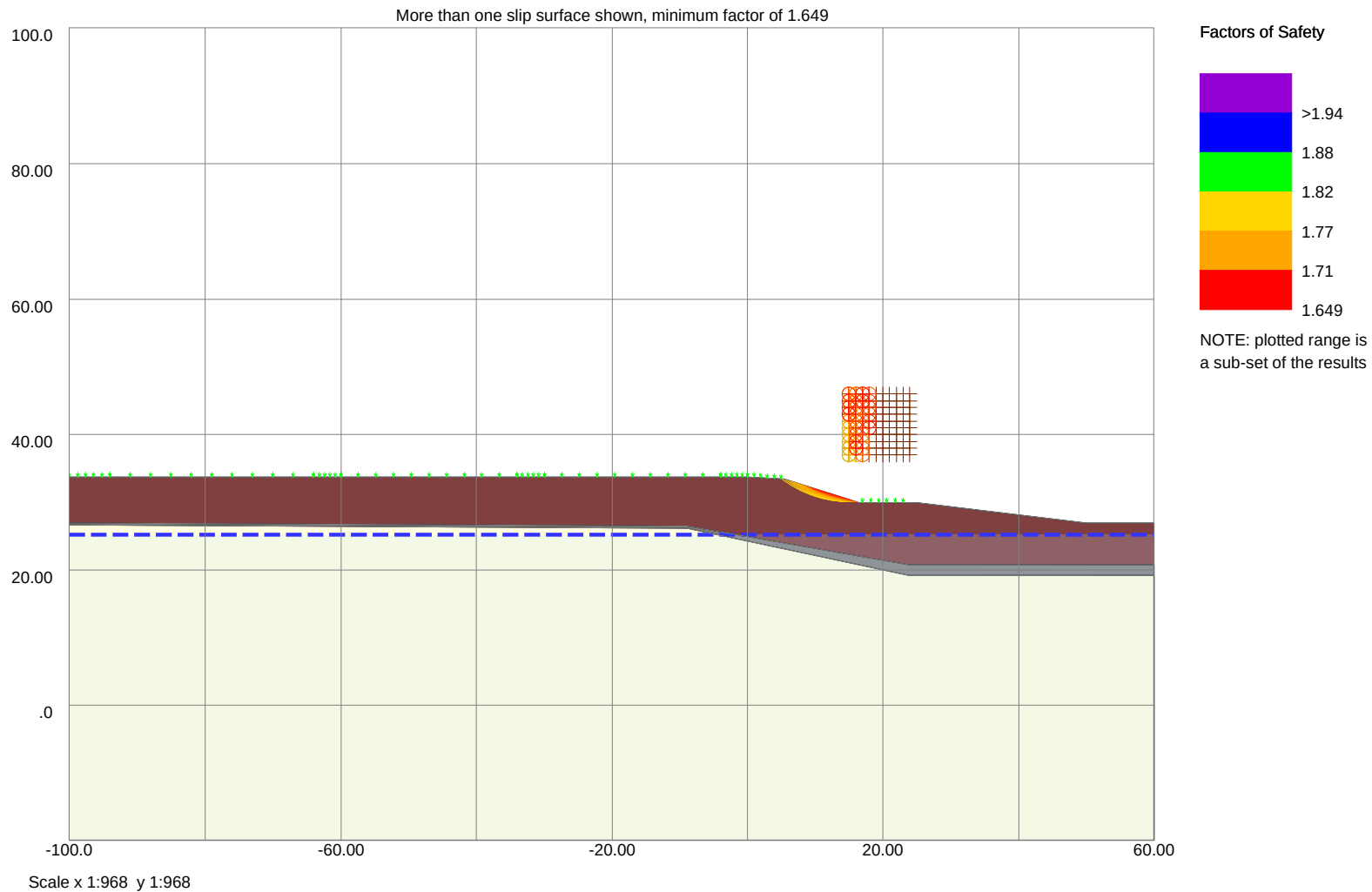
Slope BB



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General Parameters

Direction of slip: DOWNHILL
Minimum slip weight [kN/m] : 0.00000
Type of analysis : STATIC

Analysis Options

Factor of safety on : SHEAR STRENGTH
Minimum number of slices: 25
Method: Bishop (Variably inclined interslice forces)
Maximum number of iterations: 300
Reinforcement: ACTIVE

Material properties

No	Description	Unit Weight Above GWL	Unit Weight Below GWL	Shear Strength Parameters Condition	Phi
or c or c0'					
Phi0					
		[kN/m3]	[kN/m3]		
[°]	[kN/m²]				
1 Fill		18.000	18.000	Drained - linear strength	
27.000	0.0				
2 Till		19.000	19.000	Drained - linear strength	
28.000	0.0				
3 PMCM		20.000	20.000	Drained - linear strength	
32.000	0.0				

Coordinates of top of soil strata

The units of the following coordinates are in m

Stratum	X -->						
	-100.00	-9.0000	0.0	5.5000	16.500	23.800	25.000
1	33.750	.	33.750	33.400	30.000	.	30.000
2	27.000	26.500	.	.	.	20.800	.
3	26.700	26.200	.	.	.	19.200	.
GW Profile 1	25.250	.	.	.	.	.	.
Stratum	X -->						
	50.000						
1	27.000						
2	20.800						
3	19.200						
GW Profile 1	25.250						

Piezometers

Stratum-linked data

No.	Material	Water table	Piezo Set/ Ru value
1 Fill		GW Profile 1	-
2 Till		GW Profile 1	-
3 PMCM		GW Profile 1	-

Surface Loads

No.	Limits of loaded area		Distributed load	Permanent / Variable load	Favourable / UnFavourable load	Use in pull-out calc
	X1	X2	Vert [kN/m²]	Horiz [kN/m²]		
	[m]	[m]				
1	-100.00	-94.000	150.00	0.0 Permanent	N/A	No
2	-94.000	-64.000	70.000	0.0 Permanent	N/A	No
3	-64.000	-60.000	150.00	0.0 Permanent	N/A	No
4	-60.000	-34.000	70.000	0.0 Permanent	N/A	No
5	-34.000	-30.000	150.00	0.0 Permanent	N/A	No
6	-30.000	-4.0000	70.000	0.0 Permanent	N/A	No
7	-4.0000	0.0	150.00	0.0 Permanent	N/A	No
8	0.0	5.0000	5.0000	0.0 Variable	N/A	No
9	17.000	23.000	20.000	0.0 Variable	N/A	No

Slip Surface Specification

Circle centre specification: GRID
Bottom left of grid: x = 15.00000 m y = 37.00000 m
Inclination of grid: 0.00000 deg

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No. Limits of loaded area Distributed load Permanent / Favourable / Use in
(positive anticlockwise direction about bottom left of grid)
Centres on grid: 10 in x direction at 1.00000m spacing
10 in y direction at 1.00000m spacing
Grid extended to find minimum FoS
Initial radius of circle 0.50000 m
Incremented by 0.50000 m until all possible circles considered

WORST CASE

Centre at (20.000m, 42.000m) Radius 12.500m
Iterations: 5 Horiz acceleration [%g]: 0.0
Net vertical force [kN/m]: 0.0 Slip weight [kN/m] 0.0076436
Net horiz force [kN/m]: 0.0 Disturbing moment [kNm/m]: 0.028213
Restoring moment [kNm/m]: 0.046513
Reinf.Rest.Moment [kNm/m]: 0.0
Factor of Safety: 1.6486

The system of interslice and base forces are in equilibrium when the strengths available at the bases are divided by the computed factor of safety. The interslice forces shown in the following table are in equilibrium with the factored strengths of the soil at the bases of slices.

Slip surface coordinates			Pore Pressure		Interslice forces [kN/m]		
Point	x [m]	y [m]	L	R	T	E	E(u)
			[kN/m ²]	[kN/m ²]			
1	16.118	30.118	-	-48.680	0.0	0.0	0.0
2	16.132	30.113	-48.634	-48.634	0.0	0.0	0.0
3	16.146	30.109	-48.588	-48.588	0.0	1.7210E-6	0.0
4	16.161	30.104	-48.543	-48.543	1.1055E-6	3.5629E-6	0.0
5	16.175	30.100	-48.497	-48.497	1.8200E-6	5.8314E-6	0.0
6	16.189	30.095	-48.452	-48.452	2.6099E-6	8.3443E-6	0.0
7	16.203	30.091	-48.407	-48.407	3.4128E-6	10.910E-6	0.0
8	16.217	30.086	-48.362	-48.362	4.2120E-6	13.473E-6	0.0
9	16.231	30.082	-48.318	-48.318	4.9665E-6	15.904E-6	0.0
10	16.245	30.077	-48.273	-48.273	5.6400E-6	18.089E-6	0.0
11	16.259	30.073	-48.229	-48.229	6.1864E-6	19.880E-6	0.0
12	16.273	30.068	-48.184	-48.184	6.6366E-6	21.369E-6	0.0
13	16.287	30.064	-48.140	-48.140	6.9249E-6	22.345E-6	0.0
14	16.302	30.060	-48.097	-48.097	7.0684E-6	22.859E-6	0.0
15	16.316	30.055	-48.053	-48.053	7.0569E-6	22.873E-6	0.0
16	16.330	30.051	-48.009	-48.009	6.8913E-6	22.386E-6	0.0
17	16.344	30.047	-47.966	-47.966	6.5729E-6	21.399E-6	0.0
18	16.358	30.042	-47.923	-47.923	6.1284E-6	19.994E-6	0.0
19	16.372	30.038	-47.880	-47.880	5.5583E-6	18.169E-6	0.0
20	16.387	30.034	-47.837	-47.837	4.8882E-6	16.007E-6	0.0
21	16.401	30.029	-47.794	-47.794	4.1402E-6	13.576E-6	0.0
22	16.415	30.025	-47.752	-47.752	3.3568E-6	11.017E-6	0.0
23	16.429	30.021	-47.709	-47.709	2.5575E-6	8.3923E-6	0.0
24	16.443	30.017	-47.667	-47.667	1.7936E-6	5.8759E-6	0.0
25	16.457	30.013	-47.625	-47.625	1.1033E-6	3.5967E-6	0.0
26	16.472	30.008	-47.583	-47.583	0.0	1.7307E-6	0.0
27	16.486	30.004	-47.542	-47.542	0.0	0.0	0.0
28	16.500	30.000	-47.500	-	0.0	0.0	0.0

Slice Strength Parameters			Average	Slice	Forces on base [kN/m]		
No.			Pore Pressure	Weight			
	c'	Tan phi	[kN/m ²]	[kN/m]	Normal	Shear (capacity)	Shear (mobilised)
	[kN/m ²]						
1	0.0	0.50953	0.0	30.425E-6	28.942E-6	14.747E-6	8.9447E-6
2	0.0	0.50953	0.0	88.680E-6	84.362E-6	42.984E-6	26.073E-6
3	0.0	0.50953	0.0	141.86E-6	134.99E-6	68.782E-6	41.720E-6
4	0.0	0.50953	0.0	190.75E-6	181.58E-6	92.519E-6	56.118E-6
5	0.0	0.50953	0.0	235.33E-6	224.10E-6	114.18E-6	69.259E-6
6	0.0	0.50953	0.0	274.63E-6	261.63E-6	133.31E-6	80.857E-6
7	0.0	0.50953	0.0	309.31E-6	294.77E-6	150.19E-6	91.100E-6
8	0.0	0.50953	0.0	339.99E-6	324.12E-6	165.15E-6	100.17E-6
9	0.0	0.50953	0.0	365.76E-6	348.81E-6	177.73E-6	107.80E-6
10	0.0	0.50953	0.0	386.50E-6	368.75E-6	187.89E-6	113.97E-6
11	0.0	0.50953	0.0	402.85E-6	384.46E-6	195.89E-6	118.82E-6
12	0.0	0.50953	0.0	414.89E-6	396.12E-6	201.83E-6	122.42E-6
13	0.0	0.50953	0.0	422.15E-6	403.19E-6	205.44E-6	124.61E-6
14	0.0	0.50953	0.0	424.69E-6	405.77E-6	206.75E-6	125.41E-6
15	0.0	0.50953	0.0	422.38E-6	403.71E-6	205.70E-6	124.77E-6



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Cronton Colliery - Slope Stability Assessment

Section B-B

SLS

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Slice No.	Strength Parameters	Average Base	Slice Weight	Forces on base [kN/m]			
16	0.0	0.50953	0.0	415.51E-6	397.29E-6	202.43E-6	122.78E-6
17	0.0	0.50953	0.0	404.02E-6	386.43E-6	196.90E-6	119.43E-6
18	0.0	0.50953	0.0	387.90E-6	371.15E-6	189.11E-6	114.71E-6
19	0.0	0.50953	0.0	367.09E-6	351.37E-6	179.03E-6	108.59E-6
20	0.0	0.50953	0.0	341.46E-6	326.96E-6	166.59E-6	101.05E-6
21	0.0	0.50953	0.0	311.19E-6	298.07E-6	151.87E-6	92.121E-6
22	0.0	0.50953	0.0	276.19E-6	264.65E-6	134.85E-6	81.792E-6
23	0.0	0.50953	0.0	236.41E-6	226.61E-6	115.46E-6	70.035E-6
24	0.0	0.50953	0.0	191.93E-6	184.04E-6	93.776E-6	56.880E-6
25	0.0	0.50953	0.0	142.77E-6	136.95E-6	69.782E-6	42.327E-6
26	0.0	0.50953	0.0	88.706E-6	85.129E-6	43.375E-6	26.310E-6
27	0.0	0.50953	0.0	30.231E-6	29.030E-6	14.792E-6	8.9721E-6

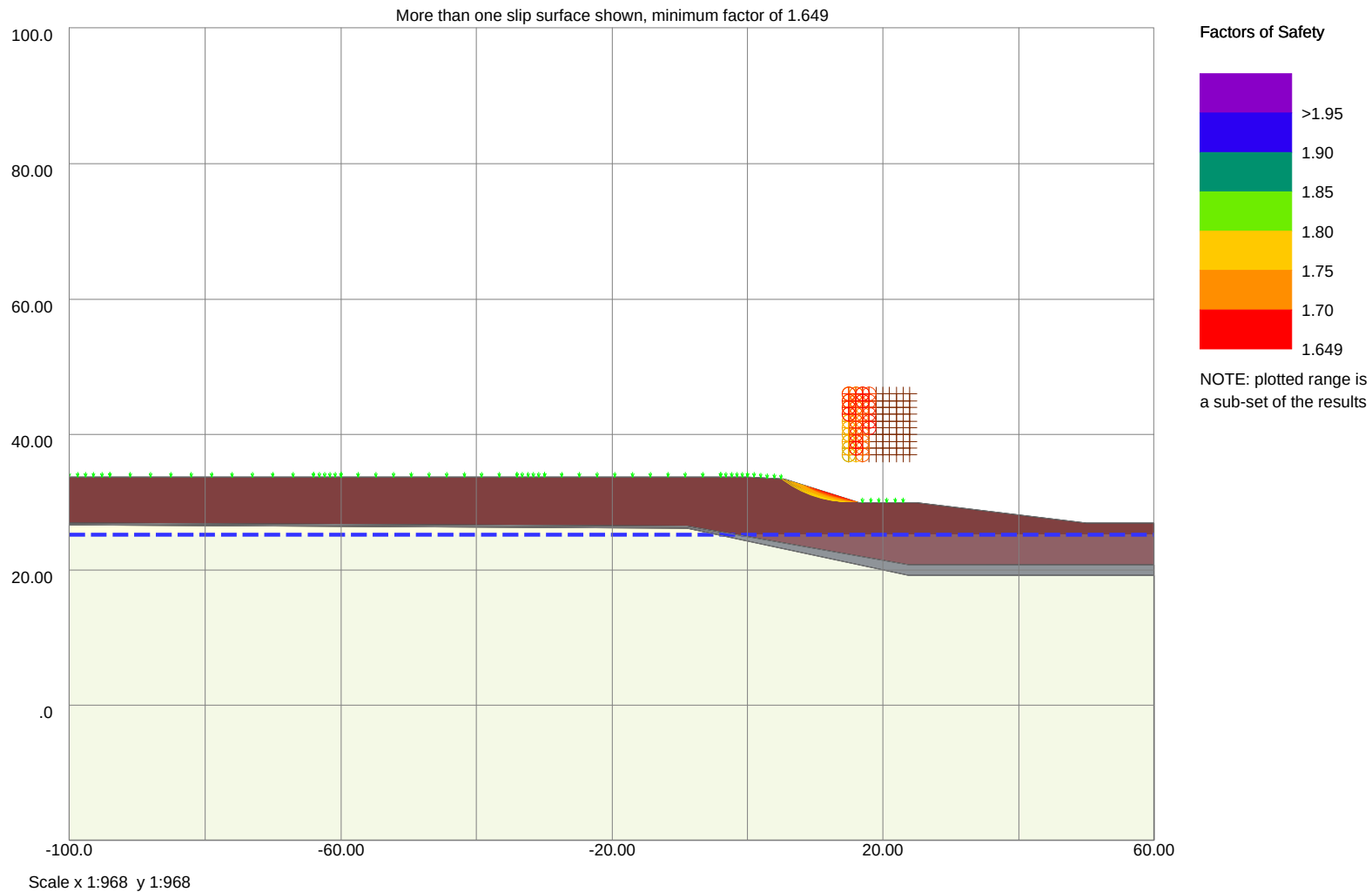
Slice No.	Slice Surface Load [kN/m_hor/m]		Point Load [kN/m]		Water Pressure on ground surface [kN/m_hor/m]	
	Vert	Horiz	Vert	Horiz	Vert	Horiz
1	0.0		0.0	0.0	0.0	0.0
2	0.0		0.0	0.0	0.0	0.0
3	0.0		0.0	0.0	0.0	0.0
4	0.0		0.0	0.0	0.0	0.0
5	0.0		0.0	0.0	0.0	0.0
6	0.0		0.0	0.0	0.0	0.0
7	0.0		0.0	0.0	0.0	0.0
8	0.0		0.0	0.0	0.0	0.0
9	0.0		0.0	0.0	0.0	0.0
10	0.0		0.0	0.0	0.0	0.0
11	0.0		0.0	0.0	0.0	0.0
12	0.0		0.0	0.0	0.0	0.0
13	0.0		0.0	0.0	0.0	0.0
14	0.0		0.0	0.0	0.0	0.0
15	0.0		0.0	0.0	0.0	0.0
16	0.0		0.0	0.0	0.0	0.0
17	0.0		0.0	0.0	0.0	0.0
18	0.0		0.0	0.0	0.0	0.0
19	0.0		0.0	0.0	0.0	0.0
20	0.0		0.0	0.0	0.0	0.0
21	0.0		0.0	0.0	0.0	0.0
22	0.0		0.0	0.0	0.0	0.0
23	0.0		0.0	0.0	0.0	0.0
24	0.0		0.0	0.0	0.0	0.0
25	0.0		0.0	0.0	0.0	0.0
26	0.0		0.0	0.0	0.0	0.0
27	0.0		0.0	0.0	0.0	0.0



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Cronton Colliery - Slope Stability Assessment
Section B-B
ULS1

Job No.	Sheet No.	Rev.
2701		
Drg. Ref.		
Made by EF	Date	Checked



Job No.	Sheet No.	Rev.
2701		
Drg. Ref.		
Made by EF	Date	Checked

General Parameters

Direction of slip: DOWNHILL
Minimum slip weight [kN/m] : 0.00000
Type of analysis : STATIC

Analysis Options

Partial Factor Analysis
Minimum number of slices: 25
Method: Bishop (Variably inclined interslice forces)
Maximum number of iterations: 300
Reinforcement: NOT ACTIVE

Method Partial Factors

Current selection: BS EN 1997-1:2011 DA1-1
Factor on FAVOURABLE PERMANENT LOAD: 1.00000
Factor on UNFAVOURABLE PERMANENT LOAD: 1.35000
Factor on FAVOURABLE VARIABLE LOAD: 0.00000
Factor on UNFAVOURABLE VARIABLE LOAD: 1.50000
Factor on SOIL UNIT WEIGHT: 1.35000
Factor on DRAINED SOIL COHESION: 1.00000
Factor on UNDRAINED SOIL COHESION: 1.00000
Factor on SOIL FRICTION ANGLE: 1.00000
Factor on reinforcement pullout: 1.50000
Economic ramification of failure: 1.00000
Sliding along reinforcement: 1.50000

Material properties

No	Description	Unit Weight		Shear Strength Parameters		Phi
		Above GWL	Below GWL	Condition		
or	c or c0'					
Phi0						
		[kN/m3]	[kN/m3]			
[°]	[kN/m²]					
1 Fill		18.000	18.000	Drained - linear strength		
27.000	0.0					
2 Till		19.000	19.000	Drained - linear strength		
28.000	0.0					
3 PMCM		20.000	20.000	Drained - linear strength		
32.000	0.0					

Coordinates of top of soil strata

The units of the following coordinates are in m

Stratum	X -->						
	-100.00	-9.0000	0.0	5.5000	16.500	23.800	25.000
1	33.750	.	33.750	33.400	30.000	.	30.000
2	27.000	26.500	.	.	.	20.800	.
3	26.700	26.200	.	.	.	19.200	.
GW Profile 1	25.250	.	.	.	.	.	.
Stratum	X -->						
	50.000						
1	27.000						
2	20.800						
3	19.200						
GW Profile 1	25.250						

Piezometers

Stratum-linked data

No.	Material	Water table	Piezo Set/ Ru value
1	Fill	GW Profile 1	-
2	Till	GW Profile 1	-
3	PMCM	GW Profile 1	-

Surface Loads

No.	Limits of loaded area	Distributed load	Permanent / Variable load	Favourable / UnFavourable load	Use in pull-out calc
	X1	X2	Vert	Horiz	
	[m]	[m]	[kN/m²]	[kN/m²]	

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No.	Limits of loaded area Distributed load			Permanent /	Favourable /	Use in
1	-100.00	-94.000	150.00	0.0 Permanent	UnFavourable	No
2	-94.000	-64.000	70.000	0.0 Permanent	UnFavourable	No
3	-64.000	-60.000	150.00	0.0 Permanent	UnFavourable	No
4	-60.000	-34.000	70.000	0.0 Permanent	UnFavourable	No
5	-34.000	-30.000	150.00	0.0 Permanent	UnFavourable	No
6	-30.000	-4.0000	70.000	0.0 Permanent	UnFavourable	No
7	-4.0000	0.0	150.00	0.0 Permanent	UnFavourable	No
8	0.0	5.0000	5.0000	0.0 Variable	UnFavourable	No
9	17.000	23.000	20.000	0.0 Variable	UnFavourable	No

Slip Surface Specification

Circle centre specification: GRID
Bottom left of grid: x = 15.00000 m y = 37.00000 m
Inclination of grid: 0.00000 deg
(positive anticlockwise direction about bottom left of grid)
Centres on grid: 10 in x direction at 1.00000m spacing
10 in y direction at 1.00000m spacing
Grid extended to find minimum FoS
Initial radius of circle 0.50000 m
Incremented by 0.50000 m until all possible circles considered

NOTE on EC7 DA1-1 analyses

The approach used here follows Simpson, B (2011) Concise Eurocodes: Geotechnical design. BS EN 1997-1: Eurocode 7, Part 1. BSI.
Commenting on EC7 11.5.1(12), this states:
Paragraph (12) makes it clear that no attempt should be made to partition the sliding mass into favourable and unfavourable ground. Even when the Design Approach or Combination in use requires different factors on favourable or unfavourable permanent actions, the weight of the ground is to be considered as a single source in the terms of 2.4.2(9).

This is at variance with the proposals of Driscoll, R, Scott, P & Powell, J (2008) EC7 - implications for UK practice. CIRIA Report C641.

WORST CASE

Centre at (20.000m,42.000m) Radius 12.500m
Iterations: 5 Horiz acceleration [%g]: 0.0
Net vertical force [kN/m]: 0.0 Slip weight [kN/m] 0.010319
Net horiz force [kN/m]: 0.0 Disturbing moment [kN/m]: 0.038088
Restoring moment [kNm/m]: 0.062793
Reinf.Rest.Moment [kNm/m]: 0.0
Over-Design Factor: 1.6486

The system of interslice and base forces are in equilibrium when the strengths available at the bases are divided by the computed over-design factor. The interslice forces shown in the following table are in equilibrium with the factored strengths of the soil at the bases of slices.

Slip surface coordinates			Pore Pressure		Interslice forces [kN/m]		
Point	x [m]	y [m]	L	R	T	E	E(u)
			[kN/m ²]	[kN/m ²]			
1	16.118	30.118	-	-48.680	0.0	0.0	0.0
2	16.132	30.113	-48.634	-48.634	0.0	0.0	0.0
3	16.146	30.109	-48.588	-48.588	0.0	2.3234E-6	0.0
4	16.161	30.104	-48.543	-48.543	1.4925E-6	4.8099E-6	0.0
5	16.175	30.100	-48.497	-48.497	2.4570E-6	7.8724E-6	0.0
6	16.189	30.095	-48.452	-48.452	3.5233E-6	11.265E-6	0.0
7	16.203	30.091	-48.407	-48.407	4.6072E-6	14.728E-6	0.0
8	16.217	30.086	-48.362	-48.362	5.6862E-6	18.188E-6	0.0
9	16.231	30.082	-48.318	-48.318	6.7048E-6	21.471E-6	0.0
10	16.245	30.077	-48.273	-48.273	7.6140E-6	24.420E-6	0.0
11	16.259	30.073	-48.229	-48.229	8.3516E-6	26.837E-6	0.0
12	16.273	30.068	-48.184	-48.184	8.9594E-6	28.848E-6	0.0
13	16.287	30.064	-48.140	-48.140	9.3486E-6	30.166E-6	0.0
14	16.302	30.060	-48.097	-48.097	9.5424E-6	30.859E-6	0.0
15	16.316	30.055	-48.053	-48.053	9.5267E-6	30.878E-6	0.0
16	16.330	30.051	-48.009	-48.009	9.3032E-6	30.221E-6	0.0
17	16.344	30.047	-47.966	-47.966	8.8734E-6	28.888E-6	0.0
18	16.358	30.042	-47.923	-47.923	8.2732E-6	26.991E-6	0.0
19	16.372	30.038	-47.880	-47.880	7.5036E-6	24.528E-6	0.0
20	16.387	30.034	-47.837	-47.837	6.5989E-6	21.609E-6	0.0
21	16.401	30.029	-47.794	-47.794	5.5892E-6	18.327E-6	0.0
22	16.415	30.025	-47.752	-47.752	4.5316E-6	14.872E-6	0.0

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Slip surface coordinates			Pore Pressure		Interslice forces [kN/m]		
Point No.	X [m]	Y [m]	1	2	3	4	5
23	16.429	30.021	-47.709	-47.709	3.4525E-6	11.329E-6	0.0
24	16.443	30.017	-47.667	-47.667	2.4212E-6	7.9322E-6	0.0
25	16.457	30.013	-47.625	-47.625	1.4894E-6	4.8553E-6	0.0
26	16.472	30.008	-47.583	-47.583	0.0	2.3362E-6	0.0
27	16.486	30.004	-47.542	-47.542	0.0	0.0	0.0
28	16.500	30.000	-47.500	-	0.0	0.0	0.0

Slice No.	Strength Parameters		Average Pore Pressure	Slice Weight	Forces on base [kN/m]		
	c' [kN/m ²]	Tan phi	[kN/m ²]	[kN/m]	Normal	Shear (capacity)	Shear (mobilised)
1	0.0	0.50953	0.0	41.074E-6	39.072E-6	19.908E-6	12.075E-6
2	0.0	0.50953	0.0	119.72E-6	113.89E-6	58.029E-6	35.198E-6
3	0.0	0.50953	0.0	191.51E-6	182.24E-6	92.855E-6	56.322E-6
4	0.0	0.50953	0.0	257.52E-6	245.13E-6	124.90E-6	75.759E-6
5	0.0	0.50953	0.0	317.70E-6	302.53E-6	154.15E-6	93.500E-6
6	0.0	0.50953	0.0	370.75E-6	353.20E-6	179.96E-6	109.16E-6
7	0.0	0.50953	0.0	417.57E-6	397.93E-6	202.76E-6	122.98E-6
8	0.0	0.50953	0.0	458.99E-6	437.56E-6	222.95E-6	135.23E-6
9	0.0	0.50953	0.0	493.77E-6	470.90E-6	239.93E-6	145.53E-6
10	0.0	0.50953	0.0	521.78E-6	497.82E-6	253.65E-6	153.85E-6
11	0.0	0.50953	0.0	543.85E-6	519.02E-6	264.45E-6	160.41E-6
12	0.0	0.50953	0.0	560.11E-6	534.76E-6	272.47E-6	165.27E-6
13	0.0	0.50953	0.0	569.91E-6	544.31E-6	277.34E-6	168.22E-6
14	0.0	0.50953	0.0	573.34E-6	547.79E-6	279.11E-6	169.30E-6
15	0.0	0.50953	0.0	570.21E-6	545.00E-6	277.69E-6	168.44E-6
16	0.0	0.50953	0.0	560.94E-6	536.34E-6	273.28E-6	165.76E-6
17	0.0	0.50953	0.0	545.42E-6	521.68E-6	265.81E-6	161.23E-6
18	0.0	0.50953	0.0	523.66E-6	501.05E-6	255.30E-6	154.85E-6
19	0.0	0.50953	0.0	495.58E-6	474.35E-6	241.69E-6	146.60E-6
20	0.0	0.50953	0.0	460.97E-6	441.39E-6	224.90E-6	136.42E-6
21	0.0	0.50953	0.0	420.10E-6	402.39E-6	205.03E-6	124.36E-6
22	0.0	0.50953	0.0	372.85E-6	357.28E-6	182.04E-6	110.42E-6
23	0.0	0.50953	0.0	319.15E-6	305.92E-6	155.88E-6	94.548E-6
24	0.0	0.50953	0.0	259.11E-6	248.46E-6	126.60E-6	76.789E-6
25	0.0	0.50953	0.0	192.74E-6	184.89E-6	94.205E-6	57.141E-6
26	0.0	0.50953	0.0	119.75E-6	114.92E-6	58.557E-6	35.518E-6
27	0.0	0.50953	0.0	40.811E-6	39.191E-6	19.969E-6	12.112E-6

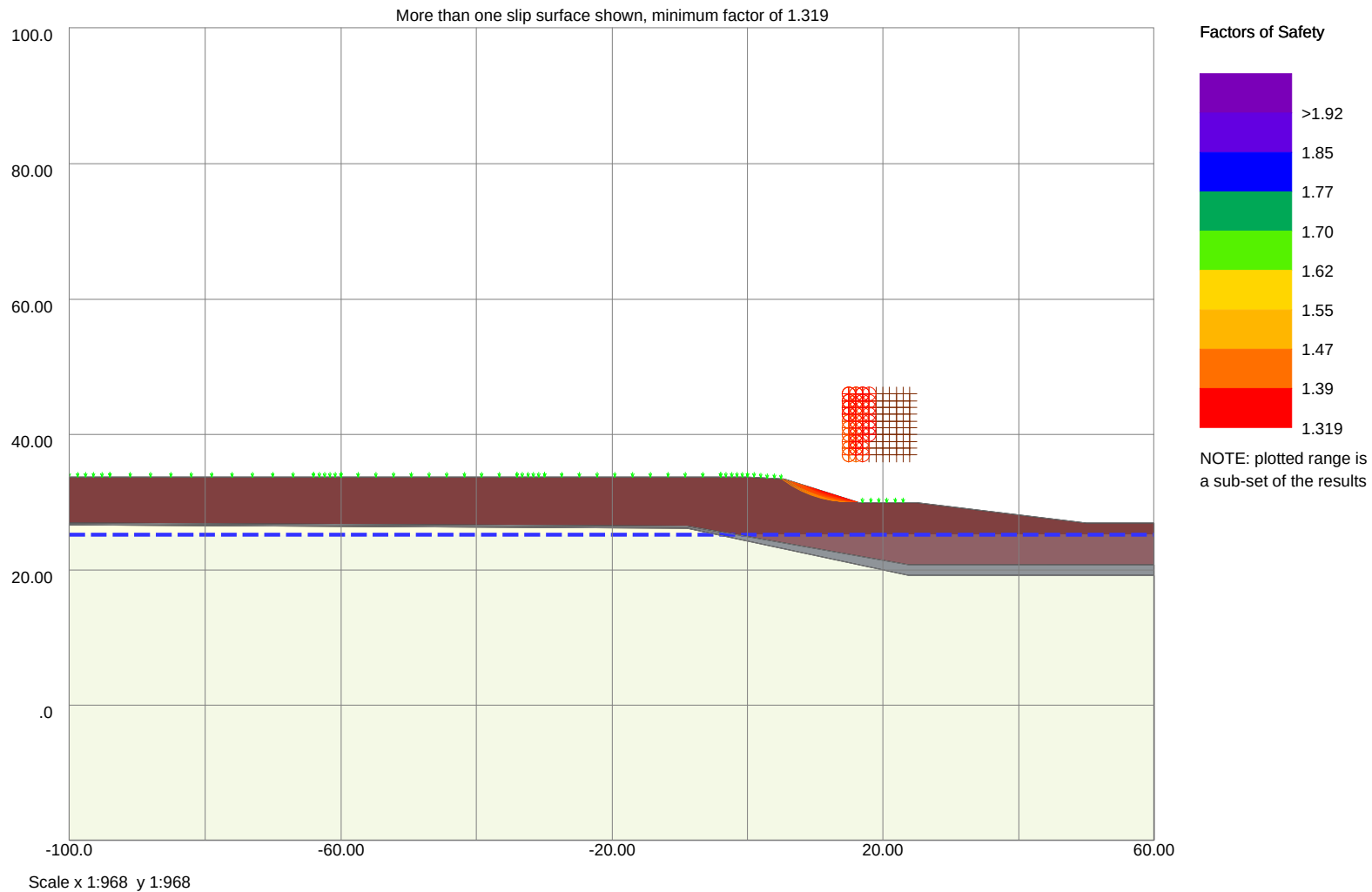
Slice No.	Surface Load [kN/m_hor/m]		Point Load [kN/m]		Water Pressure on ground surface [kN/m_hor/m]	
	Vert	Horiz	Vert	Horiz	Vert	Horiz
1	0.0		0.0	0.0	0.0	0.0
2	0.0		0.0	0.0	0.0	0.0
3	0.0		0.0	0.0	0.0	0.0
4	0.0		0.0	0.0	0.0	0.0
5	0.0		0.0	0.0	0.0	0.0
6	0.0		0.0	0.0	0.0	0.0
7	0.0		0.0	0.0	0.0	0.0
8	0.0		0.0	0.0	0.0	0.0
9	0.0		0.0	0.0	0.0	0.0
10	0.0		0.0	0.0	0.0	0.0
11	0.0		0.0	0.0	0.0	0.0
12	0.0		0.0	0.0	0.0	0.0
13	0.0		0.0	0.0	0.0	0.0
14	0.0		0.0	0.0	0.0	0.0
15	0.0		0.0	0.0	0.0	0.0
16	0.0		0.0	0.0	0.0	0.0
17	0.0		0.0	0.0	0.0	0.0
18	0.0		0.0	0.0	0.0	0.0
19	0.0		0.0	0.0	0.0	0.0
20	0.0		0.0	0.0	0.0	0.0
21	0.0		0.0	0.0	0.0	0.0
22	0.0		0.0	0.0	0.0	0.0
23	0.0		0.0	0.0	0.0	0.0
24	0.0		0.0	0.0	0.0	0.0
25	0.0		0.0	0.0	0.0	0.0
26	0.0		0.0	0.0	0.0	0.0
27	0.0		0.0	0.0	0.0	0.0



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Cronton Colliery - Slope Stability Assessment
Section B-B
ULS2

Job No.	Sheet No.	Rev.
2701		
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Made by EF	Date	Checked



Job No.	Sheet No.	Rev.
2701		
Drg. Ref.		
Made by EF	Date	Checked

General Parameters

Direction of slip: DOWNHILL
Minimum slip weight [kN/m] : 0.00000
Type of analysis : STATIC

Analysis Options

Partial Factor Analysis
Minimum number of slices: 25
Method: Bishop (Variably inclined interslice forces)
Maximum number of iterations: 300
Reinforcement: NOT ACTIVE

Method Partial Factors

Current selection: BS EN 1997-1:2011 DA1-2
Factor on FAVOURABLE PERMANENT LOAD: 1.00000
Factor on UNFAVOURABLE PERMANENT LOAD: 1.00000
Factor on FAVOURABLE VARIABLE LOAD: 0.00000
Factor on UNFAVOURABLE VARIABLE LOAD: 1.30000
Factor on SOIL UNIT WEIGHT: 1.00000
Factor on DRAINED SOIL COHESION: 1.25000
Factor on UNDRAINED SOIL COHESION: 1.40000
Factor on SOIL FRICTION ANGLE: 1.25000
Factor on reinforcement pullout: 1.50000
Economic ramification of failure: 1.00000
Sliding along reinforcement: 1.50000

Material properties

No	Description	Unit Weight		Shear Strength Parameters		Phi
		Above GWL	Below GWL	Condition		
or	c or c0'					
Phi0						
		[kN/m3]	[kN/m3]			
[°]	[kN/m²]					
1 Fill		18.000	18.000	Drained - linear strength		
27.000	0.0					
2 Till		19.000	19.000	Drained - linear strength		
28.000	0.0					
3 PMCM		20.000	20.000	Drained - linear strength		
32.000	0.0					

Coordinates of top of soil strata

The units of the following coordinates are in m

Stratum	X -->						
1	-100.00	-9.0000	0.0	5.5000	16.500	23.800	25.000
2	33.750	.	33.750	33.400	30.000	.	30.000
3	27.000	26.500	.	.	.	20.800	.
3	26.700	26.200	.	.	.	19.200	.
GW Profile 1	25.250	.	.	.	.	.	.
Stratum	X -->						
1	50.000						
2	27.000						
3	20.800						
3	19.200						
GW Profile 1	25.250						

Piezometers

Stratum-linked data

No.	Material	Water table	Piezo Set/ Ru value
1	Fill	GW Profile 1	-
2	Till	GW Profile 1	-
3	PMCM	GW Profile 1	-

Surface Loads

No.	Limits of loaded area	Distributed load	Permanent / Variable load	Favourable / UnFavourable load	Use in pull-out calc
	X1 [m]	X2 [m]	Vert [kN/m²]	Horiz [kN/m²]	

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No.	Limits of loaded area			Distributed load	Permanent /	Favourable /	Use in
1	-100.00	-94.000	150.00	0.0	Permanent	UnFavourable	No
2	-94.000	-64.000	70.000	0.0	Permanent	UnFavourable	No
3	-64.000	-60.000	150.00	0.0	Permanent	UnFavourable	No
4	-60.000	-34.000	70.000	0.0	Permanent	UnFavourable	No
5	-34.000	-30.000	150.00	0.0	Permanent	UnFavourable	No
6	-30.000	-4.0000	70.000	0.0	Permanent	UnFavourable	No
7	-4.0000	0.0	150.00	0.0	Permanent	UnFavourable	No
8	0.0	5.0000	5.0000	0.0	Variable	UnFavourable	No
9	17.000	23.000	20.000	0.0	Variable	UnFavourable	No

Slip Surface Specification

Circle centre specification: GRID
Bottom left of grid: x = 15.00000 m y = 37.00000 m
Inclination of grid: 0.00000 deg
(positive anticlockwise direction about bottom left of grid)
Centres on grid: 10 in x direction at 1.00000m spacing
10 in y direction at 1.00000m spacing
Grid extended to find minimum FoS
Initial radius of circle 0.50000 m
Incremented by 0.50000 m until all possible circles considered

WORST CASE

Centre at (20.000m,42.000m) Radius 12.500m
Iterations: 5 Horiz acceleration [%g]: 0.0
Net vertical force [kN/m]: 0.0 Slip weight [kN/m] 0.0076436
Net horiz force [kN/m]: 0.0 Disturbing moment [kN/m]: 0.028213
Restoring moment [kNm/m]: 0.037211
Reinf.Rest.Moment [kNm/m]: 0.0
Over-Design Factor: 1.3189

The system of interslice and base forces are in equilibrium when the strengths available at the bases are divided by the computed over-design factor. The interslice forces shown in the following table are in equilibrium with the factored strengths of the soil at the bases of slices.

Slip surface coordinates			Pore Pressure		Interslice forces [kN/m]		
Point	x [m]	y [m]	L	R	T	E	E(u)
			[kN/m ²]	[kN/m ²]			
1	16.118	30.118	-	-48.680	0.0	0.0	0.0
2	16.132	30.113	-48.634	-48.634	0.0	0.0	0.0
3	16.146	30.109	-48.588	-48.588	0.0	1.7210E-6	0.0
4	16.161	30.104	-48.543	-48.543	1.1055E-6	3.5629E-6	0.0
5	16.175	30.100	-48.497	-48.497	1.8200E-6	5.8314E-6	0.0
6	16.189	30.095	-48.452	-48.452	2.6099E-6	8.3443E-6	0.0
7	16.203	30.091	-48.407	-48.407	3.4128E-6	10.910E-6	0.0
8	16.217	30.086	-48.362	-48.362	4.2120E-6	13.473E-6	0.0
9	16.231	30.082	-48.318	-48.318	4.9665E-6	15.904E-6	0.0
10	16.245	30.077	-48.273	-48.273	5.6400E-6	18.089E-6	0.0
11	16.259	30.073	-48.229	-48.229	6.1864E-6	19.880E-6	0.0
12	16.273	30.068	-48.184	-48.184	6.6366E-6	21.369E-6	0.0
13	16.287	30.064	-48.140	-48.140	6.9249E-6	22.345E-6	0.0
14	16.302	30.060	-48.097	-48.097	7.0684E-6	22.859E-6	0.0
15	16.316	30.055	-48.053	-48.053	7.0569E-6	22.873E-6	0.0
16	16.330	30.051	-48.009	-48.009	6.8913E-6	22.386E-6	0.0
17	16.344	30.047	-47.966	-47.966	6.5729E-6	21.399E-6	0.0
18	16.358	30.042	-47.923	-47.923	6.1283E-6	19.994E-6	0.0
19	16.372	30.038	-47.880	-47.880	5.5583E-6	18.169E-6	0.0
20	16.387	30.034	-47.837	-47.837	4.8881E-6	16.007E-6	0.0
21	16.401	30.029	-47.794	-47.794	4.1402E-6	13.576E-6	0.0
22	16.415	30.025	-47.752	-47.752	3.3568E-6	11.017E-6	0.0
23	16.429	30.021	-47.709	-47.709	2.5575E-6	8.3923E-6	0.0
24	16.443	30.017	-47.667	-47.667	1.7935E-6	5.8758E-6	0.0
25	16.457	30.013	-47.625	-47.625	1.1033E-6	3.5966E-6	0.0
26	16.472	30.008	-47.583	-47.583	0.0	1.7307E-6	0.0
27	16.486	30.004	-47.542	-47.542	0.0	0.0	0.0
28	16.500	30.000	-47.500	-	0.0	0.0	0.0

Slice Strength Parameters			Average	Slice	Forces on base [kN/m]		
No.			Pore Pressure	Weight			
	c'	Tan phi	[kN/m ²]	[kN/m]	Normal	Shear (capacity)	Shear (mobilised)
	[kN/m ²]						
1	0.0	0.40762	0.0	30.425E-6	28.942E-6	11.797E-6	8.9447E-6
2	0.0	0.40762	0.0	88.680E-6	84.362E-6	34.388E-6	26.073E-6



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Slice No.	Strength Parameters	Average Base	Slice Weight	Forces on base [kN/m]			
3	0.0	0.40762	0.0	141.86E-6	134.99E-6	55.025E-6	41.720E-6
4	0.0	0.40762	0.0	190.75E-6	181.58E-6	74.015E-6	56.118E-6
5	0.0	0.40762	0.0	235.33E-6	224.10E-6	91.347E-6	69.259E-6
6	0.0	0.40762	0.0	274.63E-6	261.63E-6	106.64E-6	80.857E-6
7	0.0	0.40762	0.0	309.31E-6	294.77E-6	120.15E-6	91.100E-6
8	0.0	0.40762	0.0	339.99E-6	324.12E-6	132.12E-6	100.17E-6
9	0.0	0.40762	0.0	365.76E-6	348.81E-6	142.18E-6	107.80E-6
10	0.0	0.40762	0.0	386.50E-6	368.75E-6	150.31E-6	113.97E-6
11	0.0	0.40762	0.0	402.85E-6	384.46E-6	156.71E-6	118.82E-6
12	0.0	0.40762	0.0	414.89E-6	396.12E-6	161.47E-6	122.42E-6
13	0.0	0.40762	0.0	422.15E-6	403.19E-6	164.35E-6	124.61E-6
14	0.0	0.40762	0.0	424.69E-6	405.77E-6	165.40E-6	125.41E-6
15	0.0	0.40762	0.0	422.38E-6	403.71E-6	164.56E-6	124.77E-6
16	0.0	0.40762	0.0	415.51E-6	397.29E-6	161.94E-6	122.78E-6
17	0.0	0.40762	0.0	404.02E-6	386.43E-6	157.52E-6	119.43E-6
18	0.0	0.40762	0.0	387.90E-6	371.15E-6	151.29E-6	114.71E-6
19	0.0	0.40762	0.0	367.09E-6	351.37E-6	143.23E-6	108.59E-6
20	0.0	0.40762	0.0	341.46E-6	326.96E-6	133.28E-6	101.05E-6
21	0.0	0.40762	0.0	311.19E-6	298.07E-6	121.50E-6	92.121E-6
22	0.0	0.40762	0.0	276.19E-6	264.65E-6	107.88E-6	81.792E-6
23	0.0	0.40762	0.0	236.41E-6	226.61E-6	92.371E-6	70.035E-6
24	0.0	0.40762	0.0	191.93E-6	184.04E-6	75.020E-6	56.880E-6
25	0.0	0.40762	0.0	142.77E-6	136.95E-6	55.825E-6	42.327E-6
26	0.0	0.40762	0.0	88.706E-6	85.129E-6	34.700E-6	26.310E-6
27	0.0	0.40762	0.0	30.231E-6	29.030E-6	11.833E-6	8.9721E-6

Slice No.	Surface Load [kN/m_hor/m]		Point Load [kN/m]		Water Pressure on ground surface [kN/m_hor/m]		
	Vert	Horiz	Vert	Horiz	Vert	Horiz	
1	0.0		0.0	0.0	0.0	0.0	0.0
2	0.0		0.0	0.0	0.0	0.0	0.0
3	0.0		0.0	0.0	0.0	0.0	0.0
4	0.0		0.0	0.0	0.0	0.0	0.0
5	0.0		0.0	0.0	0.0	0.0	0.0
6	0.0		0.0	0.0	0.0	0.0	0.0
7	0.0		0.0	0.0	0.0	0.0	0.0
8	0.0		0.0	0.0	0.0	0.0	0.0
9	0.0		0.0	0.0	0.0	0.0	0.0
10	0.0		0.0	0.0	0.0	0.0	0.0
11	0.0		0.0	0.0	0.0	0.0	0.0
12	0.0		0.0	0.0	0.0	0.0	0.0
13	0.0		0.0	0.0	0.0	0.0	0.0
14	0.0		0.0	0.0	0.0	0.0	0.0
15	0.0		0.0	0.0	0.0	0.0	0.0
16	0.0		0.0	0.0	0.0	0.0	0.0
17	0.0		0.0	0.0	0.0	0.0	0.0
18	0.0		0.0	0.0	0.0	0.0	0.0
19	0.0		0.0	0.0	0.0	0.0	0.0
20	0.0		0.0	0.0	0.0	0.0	0.0
21	0.0		0.0	0.0	0.0	0.0	0.0
22	0.0		0.0	0.0	0.0	0.0	0.0
23	0.0		0.0	0.0	0.0	0.0	0.0
24	0.0		0.0	0.0	0.0	0.0	0.0
25	0.0		0.0	0.0	0.0	0.0	0.0
26	0.0		0.0	0.0	0.0	0.0	0.0
27	0.0		0.0	0.0	0.0	0.0	0.0

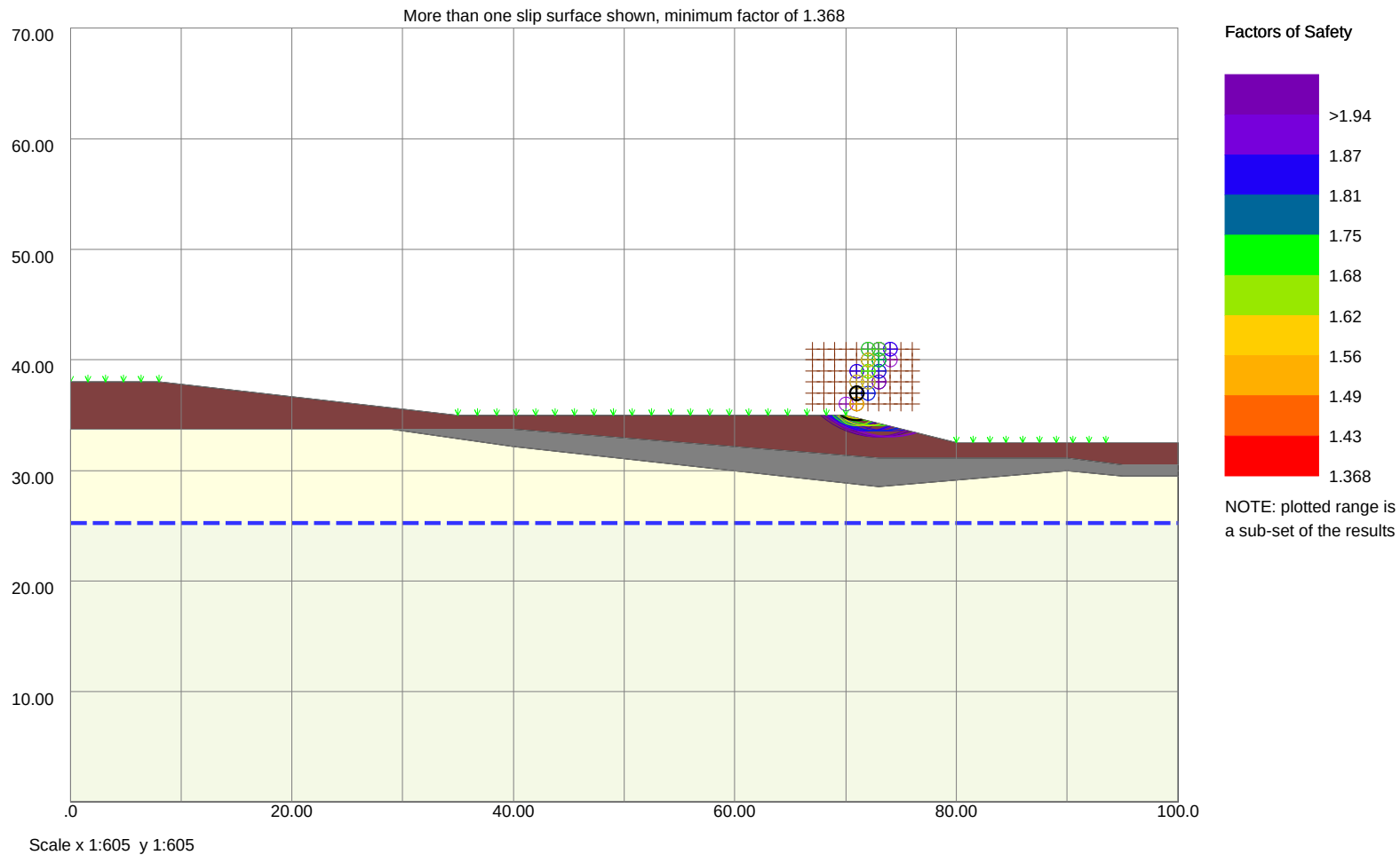
Slope CC



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Cronton Colliery - Slope Stability Assessment
Section C-C
SLS

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General Parameters

Direction of slip: DOWNHILL
Minimum slip weight [kN/m] : 0.00000
Type of analysis : STATIC

Analysis Options

Factor of safety on : SHEAR STRENGTH
Minimum number of slices: 25
Method: Bishop (Variably inclined interslice forces)
Maximum number of iterations: 300
Reinforcement: ACTIVE

Material properties

No	Description	Unit Weight Above GWL	Unit Weight Below GWL	Shear Strength Parameters Condition	Phi
or c or c0'					
Phi0		[kN/m3]	[kN/m3]		
[°]	[kN/m²]				
1	Fill	18.000	18.000	Drained - linear strength	
27.000	0.0				
2	Till	19.000	19.000	Drained - linear strength	
28.000	0.0				
3	PMCM	20.000	20.000	Drained - linear strength	
32.000	0.0				

Coordinates of top of soil strata

The units of the following coordinates are in m

Stratum	X -->						
	0.0	8.0000	29.000	35.000	40.000	70.000	73.000
1	38.000	38.000	.	35.000	.	35.000	.
2	33.750	.	33.750	.	33.750	.	31.150
3	33.750	.	33.750	.	32.150	.	28.500
GW Profile 1	25.250	.	.	.	.	.	.
Stratum	X -->						
	80.000	90.000	95.000				
1	32.500	.	32.500				
2	.	31.150	30.500				
3	.	30.000	29.500				
GW Profile 1	.	.	25.250				

Piezometers

Stratum-linked data

No.	Material	Water table	Piezo Set/ Ru value
1	Fill	GW Profile 1	-
2	Till	GW Profile 1	-
3	PMCM	GW Profile 1	-

Surface Loads

No.	Limits of loaded area		Distributed load		Permanent / Variable load	Favourable / UnFavourable load	Use in pull-out calc
	X1	X2	Vert	Horiz			
	[m]	[m]	[kN/m²]	[kN/m²]			
1	0.0	8.0000	20.000	0.0	Permanent	N/A	No
2	35.000	70.000	20.000	0.0	Permanent	N/A	No
3	80.000	95.000	20.000	0.0	Permanent	N/A	No

Slip Surface Specification

Circle centre specification: GRID
Bottom left of grid: x = 67.00000 m y = 36.00000 m
Inclination of grid: 0.00000 deg
(positive anticlockwise direction about bottom left of grid)
Centres on grid: 10 in x direction at 1.00000m spacing
6 in y direction at 1.00000m spacing
Grid extended to find minimum FoS
Initial radius of circle 0.50000 m
Incremented by 0.50000 m until all possible circles considered

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No. Limits of loaded area Distributed load Permanent / Favourable / Use in

WORST CASE

Centre at (71.000m, 37.000m) Radius 2.5000m
Iterations: 20 Horiz acceleration [%g]: 0.0
Net vertical force [kN/m]: 0.0049139 Slip weight [kN/m] 8.5787
Net horiz force [kN/m]: 0.023948 Disturbing moment [kN/m]: 16.621
Restoring moment [kNm/m]: 22.742
Reinf. Rest. Moment [kNm/m]: 0.0
Factor of Safety: 1.3683

The system of interslice and base forces are in equilibrium when the strengths available at the bases are divided by the computed factor of safety. The interslice forces shown in the following table are in equilibrium with the factored strengths of the soil at the bases of slices.

Slip surface coordinates		Pore Pressure		Interslice forces [kN/m]		
Point	x [m] y [m]	L	R	T	E	E(u)
		[kN/m ²]	[kN/m ²]			
1	69.500	35.000	-	-97.500	0.0	0.0
2	69.567	34.951	-97.014	-97.014	0.16648	0.33398
3	69.636	34.905	-96.550	-96.550	0.30823	0.65329
4	69.706	34.861	-96.110	-96.110	0.42313	0.95067
5	69.778	34.819	-95.693	-95.693	0.50975	1.2186
6	69.850	34.780	-95.300	-95.300	0.56736	1.4494
7	69.925	34.743	-94.931	-94.931	0.59620	1.6359
8	70.000	34.709	-94.587	-94.587	0.59708	1.7706
9	70.078	34.676	-94.262	-94.262	0.54643	1.7884
10	70.157	34.646	-93.964	-93.964	0.49311	1.7906
11	70.237	34.619	-93.693	-93.693	0.43809	1.7755
12	70.318	34.595	-93.449	-93.449	0.38260	1.7421
13	70.399	34.573	-93.232	-93.232	0.32808	1.6902
14	70.482	34.554	-93.043	-93.043	0.27606	1.6198
15	70.565	34.538	-92.882	-92.882	0.22818	1.5318
16	70.648	34.525	-92.749	-92.749	0.18600	1.4276
17	70.732	34.514	-92.644	-92.644	0.15099	1.3096
18	70.816	34.507	-92.568	-92.568	0.12443	1.1803
19	70.900	34.502	-92.520	-92.520	0.10732	1.0431
20	70.985	34.500	-92.500	-92.500	0.10030	0.90203
21	71.069	34.501	-92.510	-92.510	0.099806	0.75985
22	71.154	34.505	-92.547	-92.547	0.097780	0.61775
23	71.238	34.511	-92.613	-92.613	0.093926	0.48004
24	71.322	34.521	-92.708	-92.708	0.087516	0.35139
25	71.405	34.533	-92.831	-92.831	0.077342	0.23654
26	71.488	34.548	-92.982	-92.982	0.061723	0.14047
27	71.571	34.566	-93.161	-93.161	0.038468	0.068013
28	71.653	34.587	-93.368	-	0.0049139	0.023948

Slice No.	Strength Parameters		Average Pore Pressure [kN/m ²]	Slice Weight [kN/m]	Forces on base [kN/m]		
	c' [kN/m ²]	Tan phi			Normal	Shear (capacity)	Shear (mobilised)
1	0.0	0.50953	0.0	0.029348	1.1714	0.59687	0.43622
2	0.0	0.50953	0.0	0.088716	1.2728	0.64852	0.47397
3	0.0	0.50953	0.0	0.14775	1.3743	0.70025	0.51179
4	0.0	0.50953	0.0	0.20599	1.4750	0.75155	0.54928
5	0.0	0.50953	0.0	0.26303	1.5742	0.80210	0.58622
6	0.0	0.50953	0.0	0.31844	1.6709	0.85138	0.62224
7	0.0	0.50953	0.0	0.37185	1.7647	0.89917	0.65717
8	0.0	0.50953	0.0	0.41793	0.43936	0.22386	0.16361
9	0.0	0.50953	0.0	0.43996	0.46220	0.23550	0.17212
10	0.0	0.50953	0.0	0.45770	0.48063	0.24489	0.17898
11	0.0	0.50953	0.0	0.47097	0.49430	0.25186	0.18407
12	0.0	0.50953	0.0	0.47948	0.50275	0.25616	0.18722
13	0.0	0.50953	0.0	0.48320	0.50584	0.25774	0.18837
14	0.0	0.50953	0.0	0.48199	0.50333	0.25646	0.18744
15	0.0	0.50953	0.0	0.47573	0.49503	0.25223	0.18435
16	0.0	0.50953	0.0	0.46444	0.48093	0.24504	0.17909
17	0.0	0.50953	0.0	0.44801	0.46093	0.23485	0.17164
18	0.0	0.50953	0.0	0.42666	0.43528	0.22178	0.16209
19	0.0	0.50953	0.0	0.40025	0.40392	0.20581	0.15042
20	0.0	0.50953	0.0	0.36900	0.37104	0.18905	0.13817
21	0.0	0.50953	0.0	0.33306	0.34116	0.17383	0.12705



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Slice No.	Strength Parameters	Average Base	Slice Weight	Forces on base [kN/m]			
22	0.0	0.50953	0.0	0.29256	0.30642	0.15613	0.11411
23	0.0	0.50953	0.0	0.24771	0.26712	0.13610	0.099472
24	0.0	0.50953	0.0	0.19880	0.22371	0.11399	0.083307
25	0.0	0.50953	0.0	0.14603	0.17652	0.089939	0.065733
26	0.0	0.50953	0.0	0.089777	0.12617	0.064288	0.046985
27	0.0	0.50953	0.0	0.030329	0.073128	0.037261	0.027232

Slice No.	Slice Surface Load [kN/m_hor/m]		Point Load [kN/m]		Water Pressure on ground surface [kN/m_hor/m]		
	Vert	Horiz	Vert	Horiz	Vert	Horiz	
1	20.000		0.0	0.0	0.0	0.0	0.0
2	20.000		0.0	0.0	0.0	0.0	0.0
3	20.000		0.0	0.0	0.0	0.0	0.0
4	20.000		0.0	0.0	0.0	0.0	0.0
5	20.000		0.0	0.0	0.0	0.0	0.0
6	20.000		0.0	0.0	0.0	0.0	0.0
7	20.000		0.0	0.0	0.0	0.0	0.0
8	0.0		0.0	0.0	0.0	0.0	0.0
9	0.0		0.0	0.0	0.0	0.0	0.0
10	0.0		0.0	0.0	0.0	0.0	0.0
11	0.0		0.0	0.0	0.0	0.0	0.0
12	0.0		0.0	0.0	0.0	0.0	0.0
13	0.0		0.0	0.0	0.0	0.0	0.0
14	0.0		0.0	0.0	0.0	0.0	0.0
15	0.0		0.0	0.0	0.0	0.0	0.0
16	0.0		0.0	0.0	0.0	0.0	0.0
17	0.0		0.0	0.0	0.0	0.0	0.0
18	0.0		0.0	0.0	0.0	0.0	0.0
19	0.0		0.0	0.0	0.0	0.0	0.0
20	0.0		0.0	0.0	0.0	0.0	0.0
21	0.0		0.0	0.0	0.0	0.0	0.0
22	0.0		0.0	0.0	0.0	0.0	0.0
23	0.0		0.0	0.0	0.0	0.0	0.0
24	0.0		0.0	0.0	0.0	0.0	0.0
25	0.0		0.0	0.0	0.0	0.0	0.0
26	0.0		0.0	0.0	0.0	0.0	0.0
27	0.0		0.0	0.0	0.0	0.0	0.0



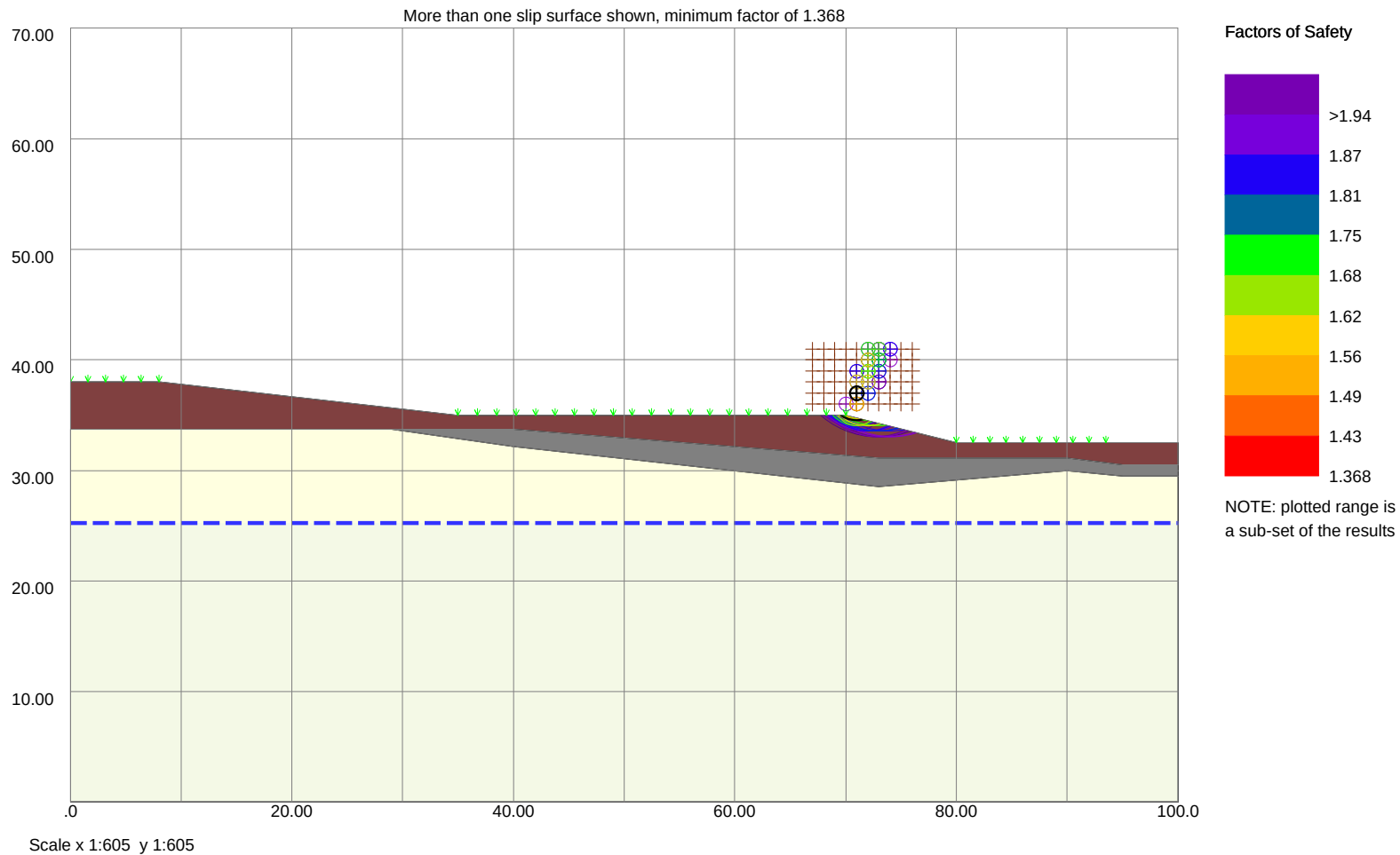
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Cronton Colliery - Slope Stability Assessment

Section C-C

ULS1

Job No.	Sheet No.	Rev.
2701		
Drg. Ref.		
Made by EF	Date	Checked



Job No.	Sheet No.	Rev.
2701		
Drg. Ref.		
Made by EF	Date	Checked

General Parameters

Direction of slip: DOWNHILL
Minimum slip weight [kN/m] : 0.00000
Type of analysis : STATIC

Analysis Options

Partial Factor Analysis
Minimum number of slices: 25
Method: Bishop (Variably inclined interslice forces)
Maximum number of iterations: 300
Reinforcement: NOT ACTIVE

Method Partial Factors

Current selection: BS EN 1997-1:2011 DA1-1
Factor on FAVOURABLE PERMANENT LOAD: 1.00000
Factor on UNFAVOURABLE PERMANENT LOAD: 1.35000
Factor on FAVOURABLE VARIABLE LOAD: 0.00000
Factor on UNFAVOURABLE VARIABLE LOAD: 1.50000
Factor on SOIL UNIT WEIGHT: 1.35000
Factor on DRAINED SOIL COHESION: 1.00000
Factor on UNDRAINED SOIL COHESION: 1.00000
Factor on SOIL FRICTION ANGLE: 1.00000
Factor on reinforcement pullout: 1.50000
Economic ramification of failure: 1.00000
Sliding along reinforcement: 1.50000

Material properties

No	Description	Unit Weight Above GWL	Unit Weight Below GWL	Shear Strength Parameters Condition	Phi
	or c or c0'				
Phi0		[kN/m3]	[kN/m3]		
[°]	[kN/m²]				
1 Fill		18.000	18.000	Drained - linear strength	
27.000	0.0				
2 Till		19.000	19.000	Drained - linear strength	
28.000	0.0				
3 PMCM		20.000	20.000	Drained - linear strength	
32.000	0.0				

Coordinates of top of soil strata

The units of the following coordinates are in m

Stratum	X -->						
	0.0	8.0000	29.000	35.000	40.000	70.000	73.000
1	38.000	38.000	.	35.000	.	35.000	.
2	33.750	.	33.750	.	33.750	.	31.150
3	33.750	.	33.750	.	32.150	.	28.500
GW Profile 1	25.250	.	.	.	.	.	.
Stratum	X -->						
	80.000	90.000	95.000				
1	32.500	.	32.500				
2	.	31.150	30.500				
3	.	30.000	29.500				
GW Profile 1	.	.	25.250				

Piezometers

Stratum-linked data

No.	Material	Water table	Piezo Set/ Ru value
1	Fill	GW Profile 1	-
2	Till	GW Profile 1	-
3	PMCM	GW Profile 1	-

Surface Loads

No.	Limits of loaded area	Distributed load	Permanent / Variable load	Favourable / UnFavourable load	Use in pull-out calc
	X1	X2	Vert	Horiz	
	[m]	[m]	[kN/m²]	[kN/m²]	

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No.	Limits of loaded area	Distributed load	Permanent /	Favourable /	Use in
1	0.0	8.0000	20.000	0.0 Permanent	Unfavourable No
2	35.000	70.000	20.000	0.0 Permanent	Unfavourable No
3	80.000	95.000	20.000	0.0 Permanent	Unfavourable No

Slip Surface Specification

Circle centre specification: GRID
Bottom left of grid: x = 67.00000 m y = 36.00000 m
Inclination of grid: 0.00000 deg
(positive anticlockwise direction about bottom left of grid)
Centres on grid: 10 in x direction at 1.00000m spacing
6 in y direction at 1.00000m spacing
Grid extended to find minimum FoS
Initial radius of circle 0.50000 m
Incremented by 0.50000 m until all possible circles considered

NOTE on EC7 DA1-1 analyses

The approach used here follows Simpson, B (2011) Concise Eurocodes: Geotechnical design. BS EN 1997-1: Eurocode 7, Part 1. BSI.
Commenting on EC7 11.5.1(12), this states:
Paragraph (12) makes it clear that no attempt should be made to partition the sliding mass into favourable and unfavourable ground. Even when the Design Approach or Combination in use requires different factors on favourable or unfavourable permanent actions, the weight of the ground is to be considered as a single source in the terms of 2.4.2(9).

This is at variance with the proposals of Driscoll, R, Scott, P & Powell, J (2008) EC7 - implications for UK practice. CIRIA Report C641.

WORST CASE

Centre at (71.000m, 37.000m) Radius 2.5000m
Iterations: 20 Horiz acceleration [%g]: 0.0
Net vertical force [kN/m]: 0.0066343 Slip weight [kN/m] 11.581
Net horiz force [kN/m]: 0.032331 Disturbing moment [kN/m]: 22.438
Restoring moment [kNm/m]: 30.701
Reinf. Rest. Moment [kNm/m]: 0.0
Over-Design Factor: 1.3683

The system of interslice and base forces are in equilibrium when the strengths available at the bases are divided by the computed over-design factor. The interslice forces shown in the following table are in equilibrium with the factored strengths of the soil at the bases of slices.

Slip surface coordinates			Pore Pressure		Interslice forces [kN/m]		
Point	x [m]	y [m]	L [kN/m ²]	R [kN/m ²]	T	E	E(u)
1	69.500	35.000	-	-97.500	0.0	0.0	0.0
2	69.567	34.951	-97.014	-97.014	0.22475	0.45088	0.0
3	69.636	34.905	-96.550	-96.550	0.41611	0.88195	0.0
4	69.706	34.861	-96.110	-96.110	0.57123	1.2834	0.0
5	69.778	34.819	-95.693	-95.693	0.68816	1.6451	0.0
6	69.850	34.780	-95.300	-95.300	0.76593	1.9567	0.0
7	69.925	34.743	-94.931	-94.931	0.80487	2.2085	0.0
8	70.000	34.709	-94.587	-94.587	0.80605	2.3903	0.0
9	70.078	34.676	-94.262	-94.262	0.73768	2.4144	0.0
10	70.157	34.646	-93.964	-93.964	0.66570	2.4173	0.0
11	70.237	34.619	-93.693	-93.693	0.59143	2.3969	0.0
12	70.318	34.595	-93.449	-93.449	0.51652	2.3519	0.0
13	70.399	34.573	-93.232	-93.232	0.44290	2.2817	0.0
14	70.482	34.554	-93.043	-93.043	0.37269	2.1867	0.0
15	70.565	34.538	-92.882	-92.882	0.30804	2.0679	0.0
16	70.648	34.525	-92.749	-92.749	0.25110	1.9273	0.0
17	70.732	34.514	-92.644	-92.644	0.20384	1.7679	0.0
18	70.816	34.507	-92.568	-92.568	0.16798	1.5934	0.0
19	70.900	34.502	-92.520	-92.520	0.14488	1.4082	0.0
20	70.985	34.500	-92.500	-92.500	0.13541	1.2177	0.0
21	71.069	34.501	-92.510	-92.510	0.13474	1.0258	0.0
22	71.154	34.505	-92.547	-92.547	0.13200	0.83397	0.0
23	71.238	34.511	-92.613	-92.613	0.12680	0.64805	0.0
24	71.322	34.521	-92.708	-92.708	0.11815	0.47437	0.0
25	71.405	34.533	-92.831	-92.831	0.10441	0.31933	0.0
26	71.488	34.548	-92.982	-92.982	0.083326	0.18964	0.0
27	71.571	34.566	-93.161	-93.161	0.051932	0.091819	0.0
28	71.653	34.587	-93.368	-	0.0066343	0.032331	0.0

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Slice No.	Strength Parameters		Average Pore Pressure	Slice Weight	Forces on base [kN/m]		
	c' [kN/m ²]	Tan phi	[kN/m ²]	[kN/m]	Normal	Shear (capacity)	Shear (mobilised)
1	0.0	0.50953	0.0	0.039620	1.5814	0.80577	0.58890
2	0.0	0.50953	0.0	0.11977	1.7183	0.87550	0.63986
3	0.0	0.50953	0.0	0.19947	1.8553	0.94534	0.69091
4	0.0	0.50953	0.0	0.27809	1.9912	1.0146	0.74152
5	0.0	0.50953	0.0	0.35509	2.1252	1.0828	0.79140
6	0.0	0.50953	0.0	0.42989	2.2558	1.1494	0.84002
7	0.0	0.50953	0.0	0.50200	2.3824	1.2139	0.88717
8	0.0	0.50953	0.0	0.56421	0.59314	0.30222	0.22088
9	0.0	0.50953	0.0	0.59395	0.62397	0.31793	0.23236
10	0.0	0.50953	0.0	0.61789	0.64884	0.33060	0.24162
11	0.0	0.50953	0.0	0.63581	0.66730	0.34001	0.24850
12	0.0	0.50953	0.0	0.64729	0.67871	0.34582	0.25274
13	0.0	0.50953	0.0	0.65232	0.68289	0.34795	0.25430
14	0.0	0.50953	0.0	0.65069	0.67950	0.34622	0.25304
15	0.0	0.50953	0.0	0.64224	0.66829	0.34051	0.24887
16	0.0	0.50953	0.0	0.62699	0.64925	0.33081	0.24178
17	0.0	0.50953	0.0	0.60482	0.62225	0.31705	0.23172
18	0.0	0.50953	0.0	0.57600	0.58762	0.29941	0.21883
19	0.0	0.50953	0.0	0.54034	0.54529	0.27784	0.20306
20	0.0	0.50953	0.0	0.49816	0.50090	0.25522	0.18653
21	0.0	0.50953	0.0	0.44963	0.46057	0.23467	0.17151
22	0.0	0.50953	0.0	0.39495	0.41367	0.21078	0.15405
23	0.0	0.50953	0.0	0.33441	0.36061	0.18374	0.13429
24	0.0	0.50953	0.0	0.26838	0.30201	0.15388	0.11246
25	0.0	0.50953	0.0	0.19714	0.23830	0.12142	0.088739
26	0.0	0.50953	0.0	0.12120	0.17033	0.086789	0.063430
27	0.0	0.50953	0.0	0.040944	0.098723	0.050302	0.036764

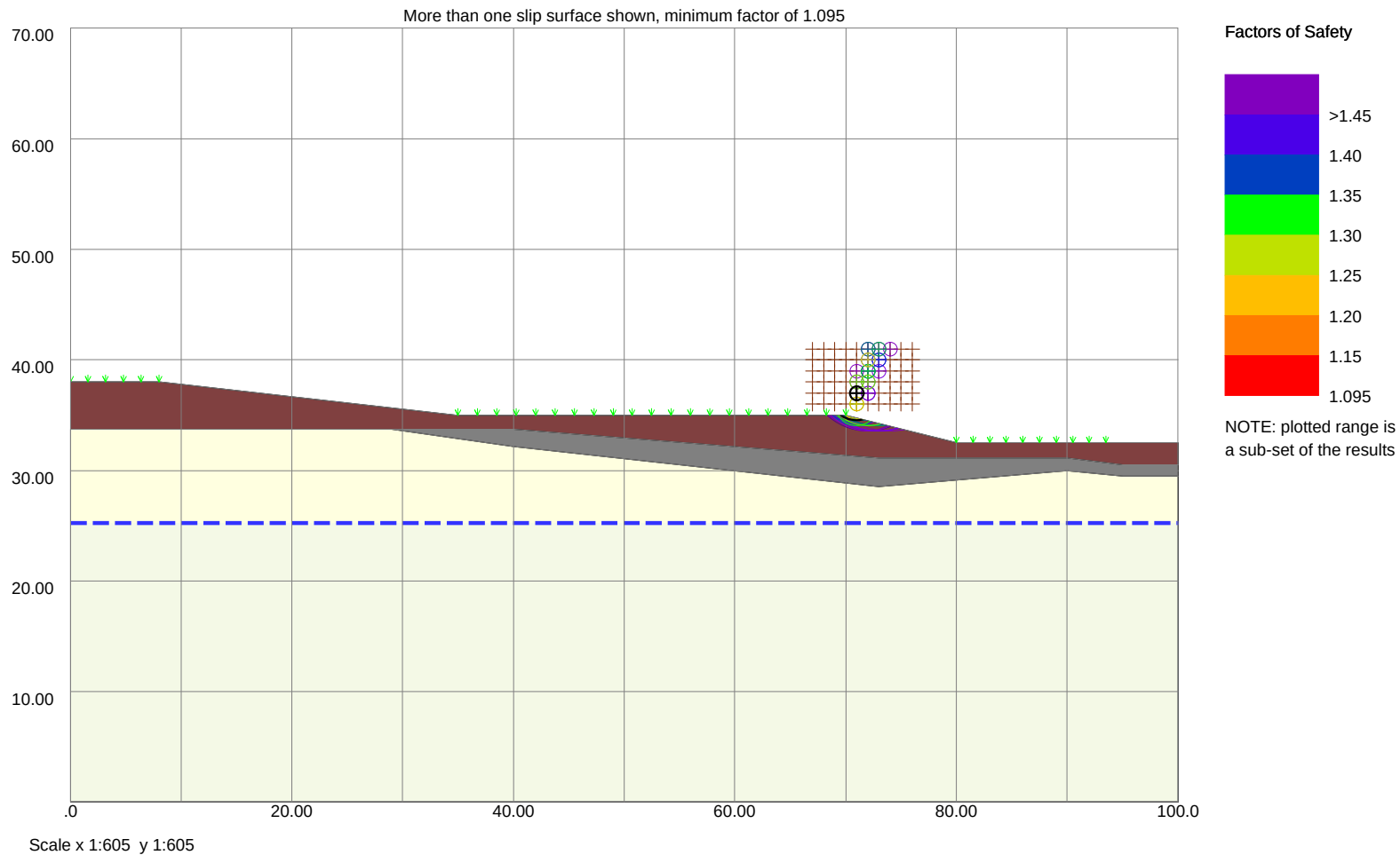
Slice No.	Surface Load [kN/m_hor/m]		Point Load [kN/m]		Water Pressure on ground surface [kN/m_hor/m]	
	Vert	Horiz	Vert	Horiz	Vert	Horiz
1	27.000		0.0	0.0	0.0	0.0
2	27.000		0.0	0.0	0.0	0.0
3	27.000		0.0	0.0	0.0	0.0
4	27.000		0.0	0.0	0.0	0.0
5	27.000		0.0	0.0	0.0	0.0
6	27.000		0.0	0.0	0.0	0.0
7	27.000		0.0	0.0	0.0	0.0
8	0.0		0.0	0.0	0.0	0.0
9	0.0		0.0	0.0	0.0	0.0
10	0.0		0.0	0.0	0.0	0.0
11	0.0		0.0	0.0	0.0	0.0
12	0.0		0.0	0.0	0.0	0.0
13	0.0		0.0	0.0	0.0	0.0
14	0.0		0.0	0.0	0.0	0.0
15	0.0		0.0	0.0	0.0	0.0
16	0.0		0.0	0.0	0.0	0.0
17	0.0		0.0	0.0	0.0	0.0
18	0.0		0.0	0.0	0.0	0.0
19	0.0		0.0	0.0	0.0	0.0
20	0.0		0.0	0.0	0.0	0.0
21	0.0		0.0	0.0	0.0	0.0
22	0.0		0.0	0.0	0.0	0.0
23	0.0		0.0	0.0	0.0	0.0
24	0.0		0.0	0.0	0.0	0.0
25	0.0		0.0	0.0	0.0	0.0
26	0.0		0.0	0.0	0.0	0.0
27	0.0		0.0	0.0	0.0	0.0



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Cronton Colliery - Slope Stability Assessment
Section C-C
ULS2

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2701		
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Made by EF	Date	Checked



Job No.	Sheet No.	Rev.
2701		
Drg. Ref.		
Made by EF	Date	Checked

General Parameters

Direction of slip: DOWNHILL
Minimum slip weight [kN/m] : 0.00000
Type of analysis : STATIC

Analysis Options

Partial Factor Analysis
Minimum number of slices: 25
Method: Bishop (Variably inclined interslice forces)
Maximum number of iterations: 300
Reinforcement: NOT ACTIVE

Method Partial Factors

Current selection: BS EN 1997-1:2011 DA1-2
Factor on FAVOURABLE PERMANENT LOAD: 1.00000
Factor on UNFAVOURABLE PERMANENT LOAD: 1.00000
Factor on FAVOURABLE VARIABLE LOAD: 0.00000
Factor on UNFAVOURABLE VARIABLE LOAD: 1.30000
Factor on SOIL UNIT WEIGHT: 1.00000
Factor on DRAINED SOIL COHESION: 1.25000
Factor on UNDRAINED SOIL COHESION: 1.40000
Factor on SOIL FRICTION ANGLE: 1.25000
Factor on reinforcement pullout: 1.50000
Economic ramification of failure: 1.00000
Sliding along reinforcement: 1.50000

Material properties

No	Description	Unit Weight Above GWL	Unit Weight Below GWL	Shear Strength Parameters Condition	Phi
	or c or c0'				
	Phi0				
	[°]	[kN/m3]	[kN/m3]		
	[kN/m²]				
1	Fill	18.000	18.000	Drained - linear strength	
27.000	0.0				
2	Till	19.000	19.000	Drained - linear strength	
28.000	0.0				
3	PMCM	20.000	20.000	Drained - linear strength	
32.000	0.0				

Coordinates of top of soil strata

The units of the following coordinates are in m

Stratum	X -->						
	0.0	8.0000	29.000	35.000	40.000	70.000	73.000
1	38.000	38.000	.	35.000	.	35.000	.
2	33.750	.	33.750	.	33.750	.	31.150
3	33.750	.	33.750	.	32.150	.	28.500
GW Profile 1	25.250	.	.	.	.	.	.
Stratum	X -->						
	80.000	90.000	95.000				
1	32.500	.	32.500				
2	.	31.150	30.500				
3	.	30.000	29.500				
GW Profile 1	.	.	25.250				

Piezometers

Stratum-linked data

No.	Material	Water table	Piezo Set/ Ru value
1	Fill	GW Profile 1	-
2	Till	GW Profile 1	-
3	PMCM	GW Profile 1	-

Surface Loads

No.	Limits of loaded area	Distributed load	Permanent / Variable load	Favourable / UnFavourable load	Use in pull-out calc
	X1	X2	Vert	Horiz	
	[m]	[m]	[kN/m²]	[kN/m²]	

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No.	Limits of loaded area	Distributed load	Permanent /	Favourable /	Use in
1	0.0	8.0000	20.000	0.0 Permanent	UnFavourable No
2	35.000	70.000	20.000	0.0 Permanent	UnFavourable No
3	80.000	95.000	20.000	0.0 Permanent	UnFavourable No

Slip Surface Specification

Circle centre specification: GRID
Bottom left of grid: x = 67.00000 m y = 36.00000 m
Inclination of grid: 0.00000 deg
(positive anticlockwise direction about bottom left of grid)
Centres on grid: 10 in x direction at 1.00000m spacing
6 in y direction at 1.00000m spacing
Grid extended to find minimum FoS
Initial radius of circle 0.50000 m
Incremented by 0.50000 m until all possible circles considered

WORST CASE

Centre at (71.000m, 37.000m) Radius 2.5000m
Iterations: 22 Horiz acceleration [%g]: 0.0
Net vertical force [kN/m]: 0.0045543 Slip weight [kN/m] 8.5787
Net horiz force [kN/m]: 0.022196 Disturbing moment [kN/m]: 16.621
Restoring moment [kNm/m]: 18.194
Reinf. Rest. Moment [kNm/m]: 0.0
Over-Design Factor: 1.0947

The system of interslice and base forces are in equilibrium when the strengths available at the bases are divided by the computed over-design factor. The interslice forces shown in the following table are in equilibrium with the factored strengths of the soil at the bases of slices.

Slip surface coordinates			Pore Pressure		Interslice forces [kN/m]		
Point	x [m]	y [m]	L	R	T	E	E(u)
			[kN/m ²]	[kN/m ²]			
1	69.500	35.000	-	-97.500	0.0	0.0	0.0
2	69.567	34.951	-97.014	-97.014	0.16679	0.33392	0.0
3	69.636	34.905	-96.550	-96.550	0.30882	0.65318	0.0
4	69.706	34.861	-96.110	-96.110	0.42400	0.95052	0.0
5	69.778	34.819	-95.693	-95.693	0.51086	1.2184	0.0
6	69.850	34.780	-95.300	-95.300	0.56870	1.4493	0.0
7	69.925	34.743	-94.931	-94.931	0.59776	1.6357	0.0
8	70.000	34.709	-94.587	-94.587	0.59883	1.7704	0.0
9	70.078	34.676	-94.262	-94.262	0.54835	1.7883	0.0
10	70.157	34.646	-93.964	-93.964	0.49518	1.7904	0.0
11	70.237	34.619	-93.693	-93.693	0.44030	1.7754	0.0
12	70.318	34.595	-93.449	-93.449	0.38493	1.7420	0.0
13	70.399	34.573	-93.232	-93.232	0.33050	1.6901	0.0
14	70.482	34.554	-93.043	-93.043	0.27857	1.6197	0.0
15	70.565	34.538	-92.882	-92.882	0.23076	1.5317	0.0
16	70.648	34.525	-92.749	-92.749	0.18864	1.4276	0.0
17	70.732	34.514	-92.644	-92.644	0.15367	1.3096	0.0
18	70.816	34.507	-92.568	-92.568	0.12714	1.1803	0.0
19	70.900	34.502	-92.520	-92.520	0.11005	1.0432	0.0
20	70.985	34.500	-92.500	-92.500	0.10304	0.90206	0.0
21	71.069	34.501	-92.510	-92.510	0.10251	0.75987	0.0
22	71.154	34.505	-92.547	-92.547	0.10034	0.61772	0.0
23	71.238	34.511	-92.613	-92.613	0.096227	0.47989	0.0
24	71.322	34.521	-92.708	-92.708	0.089460	0.35107	0.0
25	71.405	34.533	-92.831	-92.831	0.078835	0.23597	0.0
26	71.488	34.548	-92.982	-92.982	0.062676	0.13959	0.0
27	71.571	34.566	-93.161	-93.161	0.038801	0.066737	0.0
28	71.653	34.587	-93.368	-	0.0045543	0.022196	0.0

Slice No.	Strength Parameters		Average Pore Pressure [kN/m ²]	Slice Weight [kN/m]	Forces on base [kN/m]		
	c' [kN/m ²]	Tan phi			Normal	Shear (capacity)	Shear (mobilised)
1	0.0	0.40762	0.0	0.029348	1.1711	0.47738	0.43610
2	0.0	0.40762	0.0	0.088716	1.2725	0.51871	0.47386
3	0.0	0.40762	0.0	0.14775	1.3741	0.56011	0.51167
4	0.0	0.40762	0.0	0.20599	1.4748	0.60115	0.54917
5	0.0	0.40762	0.0	0.26303	1.5740	0.64160	0.58612
6	0.0	0.40762	0.0	0.31844	1.6707	0.68103	0.62214
7	0.0	0.40762	0.0	0.37185	1.7646	0.71927	0.65707



BYLAND
ENGINEERING LIMITED

Cronton Colliery - Slope Stability Assessment
Section C-C
ULS2

Job No.	Sheet No.	Rev.
2701		
Drg. Ref.		
Made by EF	Date	Checked

Slice No.	Strength Parameters	Average	Slice Weight	Forces on base [kN/m]			
8	0.0	0.40762	0.0	0.41793	0.43921	0.17903	0.16355
9	0.0	0.40762	0.0	0.43996	0.46207	0.18835	0.17206
10	0.0	0.40762	0.0	0.45770	0.48051	0.19586	0.17893
11	0.0	0.40762	0.0	0.47097	0.49419	0.20144	0.18402
12	0.0	0.40762	0.0	0.47948	0.50266	0.20489	0.18718
13	0.0	0.40762	0.0	0.48320	0.50577	0.20616	0.18833
14	0.0	0.40762	0.0	0.48199	0.50327	0.20514	0.18740
15	0.0	0.40762	0.0	0.47573	0.49498	0.20176	0.18432
16	0.0	0.40762	0.0	0.46444	0.48089	0.19602	0.17907
17	0.0	0.40762	0.0	0.44801	0.46090	0.18787	0.17163
18	0.0	0.40762	0.0	0.42666	0.43526	0.17742	0.16208
19	0.0	0.40762	0.0	0.40025	0.40391	0.16464	0.15041
20	0.0	0.40762	0.0	0.36900	0.37107	0.15126	0.13818
21	0.0	0.40762	0.0	0.33306	0.34131	0.13912	0.12709
22	0.0	0.40762	0.0	0.29256	0.30668	0.12501	0.11420
23	0.0	0.40762	0.0	0.24771	0.26748	0.10903	0.099601
24	0.0	0.40762	0.0	0.19880	0.22417	0.091378	0.083476
25	0.0	0.40762	0.0	0.14603	0.17708	0.072182	0.065940
26	0.0	0.40762	0.0	0.089777	0.12684	0.051701	0.047231
27	0.0	0.40762	0.0	0.030329	0.073887	0.030118	0.027514

Slice No.	Surface Load [kN/m_hor/m]		Point Load [kN/m]		Water Pressure on ground surface [kN/m_hor/m]		
	Vert	Horiz	Vert	Horiz	Vert	Horiz	
1	20.000		0.0	0.0	0.0	0.0	0.0
2	20.000		0.0	0.0	0.0	0.0	0.0
3	20.000		0.0	0.0	0.0	0.0	0.0
4	20.000		0.0	0.0	0.0	0.0	0.0
5	20.000		0.0	0.0	0.0	0.0	0.0
6	20.000		0.0	0.0	0.0	0.0	0.0
7	20.000		0.0	0.0	0.0	0.0	0.0
8	0.0		0.0	0.0	0.0	0.0	0.0
9	0.0		0.0	0.0	0.0	0.0	0.0
10	0.0		0.0	0.0	0.0	0.0	0.0
11	0.0		0.0	0.0	0.0	0.0	0.0
12	0.0		0.0	0.0	0.0	0.0	0.0
13	0.0		0.0	0.0	0.0	0.0	0.0
14	0.0		0.0	0.0	0.0	0.0	0.0
15	0.0		0.0	0.0	0.0	0.0	0.0
16	0.0		0.0	0.0	0.0	0.0	0.0
17	0.0		0.0	0.0	0.0	0.0	0.0
18	0.0		0.0	0.0	0.0	0.0	0.0
19	0.0		0.0	0.0	0.0	0.0	0.0
20	0.0		0.0	0.0	0.0	0.0	0.0
21	0.0		0.0	0.0	0.0	0.0	0.0
22	0.0		0.0	0.0	0.0	0.0	0.0
23	0.0		0.0	0.0	0.0	0.0	0.0
24	0.0		0.0	0.0	0.0	0.0	0.0
25	0.0		0.0	0.0	0.0	0.0	0.0
26	0.0		0.0	0.0	0.0	0.0	0.0
27	0.0		0.0	0.0	0.0	0.0	0.0