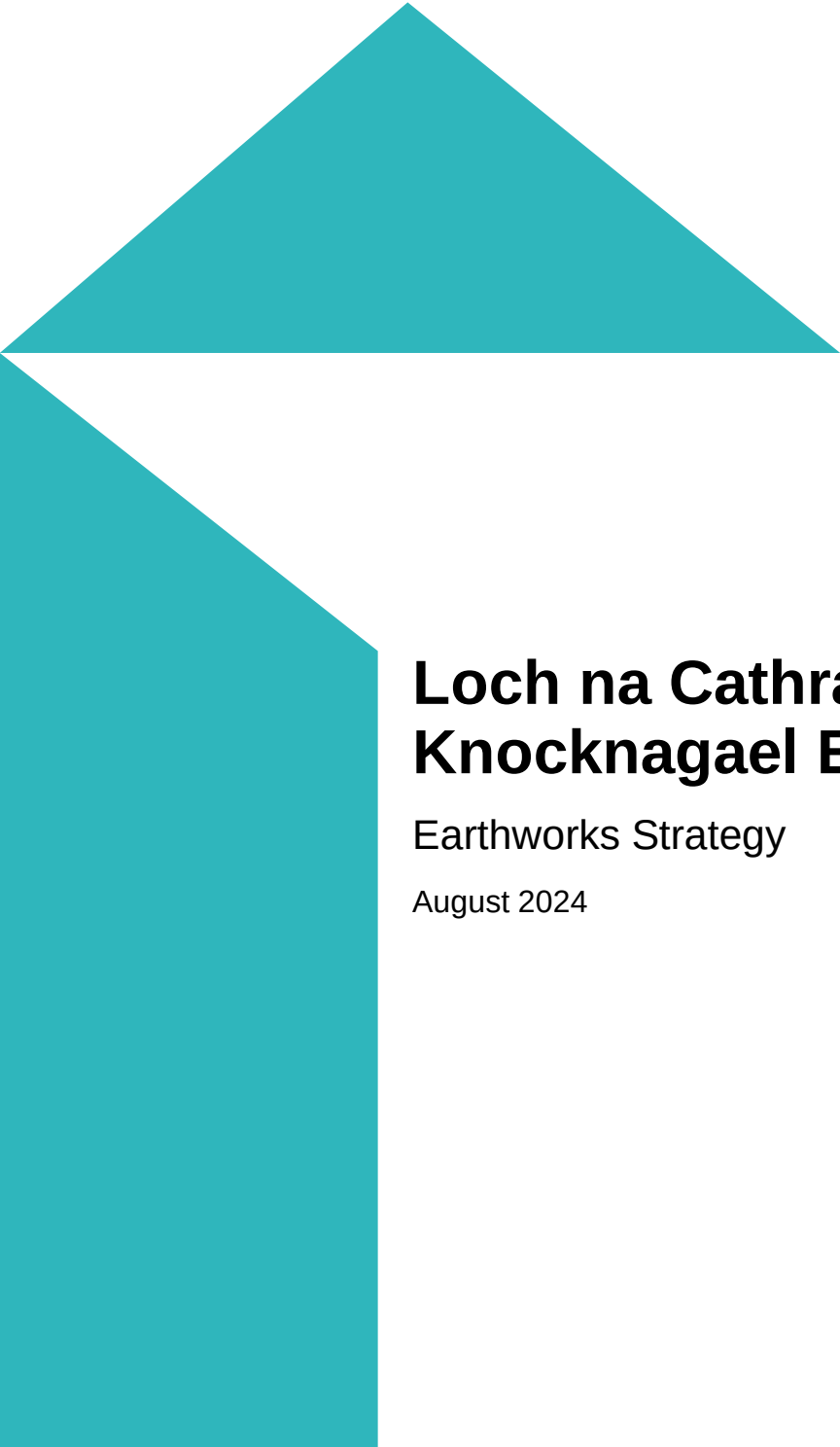




Loch na Cathrach Knocknagael Extension Works

Earthworks Strategy

August 2024

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1 Introduction

1.1 Project Overview

In order to accommodate the connection for the 450MW Red John pumped storage hydro project at 275kV, the Knocknagael 275/132kV substation requires an extension. The extension is required to create an additional bay due to current full utilisation of the existing 275kV bays within the Knocknagael substation site.

Mott MacDonald has been appointed by Scottish & Southern Energy Networks (SSEN) to produce an Earthworks Strategy document for the proposed earthworks associated with the extension of the Knocknagael substation platform, temporary haul road for construction access as well as a new permanent basin.

1.2 Scope of Work

Mott MacDonald have completed a geotechnical desk study which has been used in coordination with earthwork modelling to develop a strategy for the site earthworks. The scope of work to be reviewed in this document includes the following areas:

- The proposed **finished platform extension**, suitable for permanent substation use at 175.5m AOD (Above Ordnance Datum), comprises 7075m² (including the permeable platform and internal roads area but excluding embankments).
- **Access road**, there is a temporary internal access road being constructed connected to the external road. The proposed internal road is around the perimeter to the platform bay extension.
- **New attenuation pond**, there is an attenuation pond to be created for the platform bay extension. A basin has an independent network of filter drains. Basin storage volume is 350m³. Network of filter drains: 170m³.

1.3 Objectives

The aim of this document is to develop the earthworks strategy to a sufficient level of detail for planning purposes. It can be summarised that the scope of this document encompasses the following:

- Summarise the information which has been utilised in the earthwork's strategy.
- Define the assumptions and methodology which have been adopted for the earthworks design.
- Provide estimated earthwork quantities.
- Outline testing requirements for the proposed earthworks fill materials.

1.4 Earthworks Design Approach

1.4.1 Purpose

The purpose of this Earthworks Strategy for the Knocknagael 275/132kV substation is to assess the earthworks with respect to the platform requirements, verify that there is sufficient material for the construction of the proposed extension and associated development while where able minimising the impact on the surrounding environment, and allowing safe use of the substation throughout its design life.

Consideration has been given to potential planning requirements, topography, a practical and economic design, minimisation of traffic movements on public roads, design and technical specification requirements, and site environment within the strategy.

1.4.2 Design Specification

The earthworks design for the proposed development has been undertaken in reference to:

1. SP-NET-CIV-501 Earthworks, Specification, SSEN, 2023.
2. SP-NET-CIV-502 Drainage Specification, SSEN, July 2020.

1.5 Limitations

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2 Background Information

2.1 Substation Extension Works Layout

shows the proposed site development layout, with the extension shown in bold with the existing infrastructure in a lighter grey. The existing substation finished platform surface level is approximately 175.5m AOD (Above Ordnance Datum).

Site Location plan 109116-MMD-KNOC-DR-CE-0010 include the red line boundary and ownership boundary.

- The extension works consist of the following areas:
- **Substation Areas:** There is an extension to the substation, south-east of the site. This has been referred to as Bay 2 in the Geotechnical and Geo-environmental desk study (document reference: MMD-106510-DOC-10003, Revision A). The elevation will match that of the existing substation (FFL= 175.5m AOD), for which earthworks will be required.
- **Cable Route:** In order to connect the proposed extension of the Knocknagael substation with the Red John (the existing 275kV Switching Station) a cable route is to be design by another consultancy. The cable route external to the site is not considered in this report.
- **Access Track:** for accessing the substation extension works during the construction phase only.

Excavation and re-use of material is intended where possible, however, this will be reviewed in detail in future design stages.

2.2 Topography Data

LiDAR Survey data provided by CainTech identifies the finished platform level at 175.5m AOD (Drawing Reference: CTCH-5118-01). Within the extension works footprints, the existing ground level is 188.5m AOD.

2.3 Geology

According to the British Geological Survey (BGS) geological mapping and aerial images, geological setting of the area is described as Glacial deposits (superficial) and Inishes Flagstone formation (bedrock). No publicly available historical boreholes or ground investigation reports are available within 2km of the proposed site works.

A historical ground investigation reported in an Earthworks Methodology Review, issued by Grontmij in April 2010 to support the existing substation earthworks design, included 17 trial pits across the existing platform. The investigations, which are summarised in the report, indicate that superficial deposits comprising sandy gravelly clays and clayey sands and gravels were encountered across the majority of the site to a depth of up to 3.9m below ground level. Underlying the superficial deposits, strata comprising closely fracture sandstone were described which in the report was assumed to be the top of bedrock. The logs for the trial pits are not included within the appendices of the Grontmij report.

It is understood that an older investigation was completed for the original project whose report reference is 3661 and dated from 3rd March 2009 but the information from this was not able to be sourced.

Recent site-specific ground investigation includes four boreholes with depths ranging from 16m bgl to 17.25m below ground level. Preliminary borehole descriptions are available indicating superficial deposits down to the bottom of the boreholes. Top of bedrock has not been proven which discounts the relatively shallow top of bedrock assumption from Grontmij's report.

The following sections describe the anticipated geology. It is noted that laboratory testing from the recent investigation is on-going at the time of this strategy report, and that conclusions and recommendations made within this report will require review taking into consideration the completed factual report once received.

2.3.1 Made Ground

The BGS GeoIndex does not record any Made Ground within the site area; however, due to existing infrastructure, it can be concluded that Made Ground is present for the existing platform area associated with earthworks, underlying cables, and existing drainage. The composition of this made ground is unknown but anticipated to comprise engineered fill derived from the associated earthworks.

North of the existing platform there is a drainage basin comprising a 2m wide soil bund. The composition of the bund is unknown, but likely to be formed from site won materials.

2.3.2 Topsoil

Aerial images show vegetation is present where the extensions are proposed, indicating the presence of topsoil. An average thickness of 400mm has been assumed for the purposes of this document.

2.3.3 Superficial Deposits

BGS geological mapping indicates that the site falls on the boundary of two superficial deposits (@scale 1:50,000). The extent of the site is shown to be underlain by Devensian Till, consisting of diamicton in the east extents of the site and Hummocky (moundy) Glacial Deposits comprising diamicton, sand and gravels in the west.

Cohesive till is described in the preliminary logs of the recent ground investigation as soft to very stiff blueish grey to brown, variably sandy silty gravelly clay with some cobbles and boulders. Granular till is described as greyish brown to reddish brown gravelly clayey becoming very clayey fine to coarse sand with low to medium cobble content and low boulder content. Gravels, cobbles and boulders are sandstone, siltstone and granite. Cobbles and gravels are subangular to subrounded while boulders are subangular.

2.3.4 Bedrock

BGS GeoIndex indicates that the bedrock underlying the site is Inshes Flagstone Formation (sandstone). It is described in the BGS as red, green and grey flaggy sandstone with rare grey calcareous mudstones and limestones.

2.3.5 Lithological Descriptions

Table 2.1 contains the lithological descriptions as provided by BGS Lexicon for the superficial and bedrock formations discussed above.

Table 2.1: Lithological Descriptions

	Lithology	Age Range	BGS Lithological Description
Superficial	Devensian Till	Devensian Stage (QD)	Diamicton.
	Hummocky Glacial Deposits	Pleistocene Epoch (QP)	Diamicton, sands and gravels.

	Lithology	Age Range	BGS Lithological Description
Bedrock	Inshes Flagstone Formation	Mid Devonian Epoch (DM)	Red, green and grey flaggy sandstone with rare grey calcareous mudstones and limestones.

3 Earthworks Model

3.1 Earthworks 3D Design

Earthworks modelling has been undertaken using Civil 3D software combining topographical data, layout drawings and existing ground investigation data.

The following drawing are produced to show the earthworks preliminary design:

- Earthworks plan cut and fill 109116-MMD-KNOC-DR-CE-0002.
- Earthworks plan operational phase 109116-MMD-KNOC-DR-CE-0004.
- Earthworks sections 109116-MMD-KNOC-DR-CE-0012.

3.2 Development Components

The proposed development, subject to consent under the Town and Country Planning (Scotland) (TCPA) 1997 Act comprises:

- The creation of an earthwork's platform and associated drainage which includes an attenuation pond;
- Formation of temporary construction access track; and
- Storage areas for temporary and permanent earth bunds.

3.3 Earthwork Slopes

The extended platform will be formed by cut which will require excavation within superficial deposits comprising granular and cohesive till.

Potential wetland has been noted to the northwest of the existing substation in the Geotechnical and Geo-environmental desk study (MMD-106510-DOC-10003, Revision A, 2022) which should not be affected by the extended platform.

The following assumptions have been made within the model regarding suitable embankment cutting angles. Final slopes will be refined, including the requirement for any remediation, post ground investigation or during further design depending on conditions encountered.

Table 3.1: Earthwork Slopes

Purpose	Location	Slope Details
Platform extension	Southeast of the existing substation	Cutting Slope: 1V:2H with soil nails Cutting Slope 1V:3H
Drainage	Northeast Pond	Embankment Slope: 1V:3H
Access Track	Southeast	Longitudinal Gradient: maximum 7% Slope Gradient: 1V:3H
Earth bund	Southwest	Embankment slope: max 1V:3H

3.4 Platform Material

The platform fill material sequence follows the recommendations of the SSEN's Earthworks Specification (SP-NET-CIV-501). This comprises 3 layers of compacted specific aggregate material. Thicknesses and material details are shown in Table 3.2.

Table 3.2: Platform Construction Fill Sequence

Platform Layers	Material Class	Thickness
Layer 1	20mm Aggregate (single size)	0.075m
Layer 2	Aggregate: Type 3	0.200m
Layer 3	Aggregate: Class 6F2 (free draining)	0.725m
Capping layer	General Platform fill	Not expected

Notes:

- Modified well-graded Class 6F2 with low fines to enable free draining. Minimum 0.725m layer to have a minimum CBR of 15%.

The position of the formation layer (underside of platform layers) and any sub-formation layer will be dictated by the design taking into consideration the results of the site-specific ground investigation, site topography, soil strata and anticipated structural design.

The upper three platform layers shall have sufficient drainage such that the platform is not subject to ponding at the platform surface.

3.5 Temporary Access Road Material

The compacted materials to be used to construct the temporary access road are in accordance with SSEN's Transmission Earthworks Specification (SP-NET-CIV-501). Summary of the provisionally assumed layering is shown in Table 3.3

Table 3.3: Temporary Access Road Construction Fill Sequence

Road Layers	Material Class	Thickness
Layer 1	Aggregate: Type 1 (granular)	0.200m
Layer 2	Aggregate: Class 6F2 (free draining)	0.800m

Notes:

- Modified well-graded Class 6F2 with low fines to enable free draining. Minimum 0.725m layer to have a minimum CBR of 15%.

The position of the formation layer (underside of platform layers) and any sub-formation layer will be dictated by the design taking into consideration the results of the site-specific ground investigation, site topography, soil strata and anticipated structural design.

General fill is expected to be created primarily from selected well graded granular engineered fill to provide the structural capacity and performance to withstand the loads from the vehicles. The upper two road layers shall have sufficient drainage properties such that the road is not subject to ponding at the road surface.

3.6 Earthworks Construction Surface Water Run-off

There are two burns within the local area surrounding the site, Big Burn (SEPA (Scottish Environmental Protection Agency) ID: 20260), approximately 350m east of the proposed extension location, and Essich Burn, approximately 500m west of the current substation. In addition, there is a pond to the north, which acts as a drain for surface water. It is recommended that an appropriate level of management of suspended particulates and run-off volume (based on material conditions, earthwork extent and proximity) is employed to minimise the risk of adverse impacts to the receptors.

3.7 Access

Access to the proposed development can be gained by a winding single-track road via Essich Road, which connects to the A8082 to the north and the B862 to the south. Alternative access can be granted, using a winding single-track road from Bunachton, reachable from the B581.

The scope of works includes the provision of a temporary access road to be constructed to the east of the platform, diverting from the existing single-track road as shown in Figure 2.2.

3.8 Temporary Site Compound

A temporary compound including welfare facilities will need to be constructed for the proposed extension works.. The details of this are not considered within this document.

3.9 Stockpiles

Temporary stockpiles of material will be required, some of which will be within the platform extension footprint, however, where possible excavated materials should be placed in or close to its permanent location. Additionally, as per BS3882, sub-soil shall not be mixed with topsoil and defined turf storage areas shall be used to avoid mixing of materials and double handling where feasible.

One permanent stockpile is necessary as the majority of the excavated material will not be reused as the filling areas are very limited. Design of the permanent bund comprises cohesive and granular till topped with topsoil material as far as reasonable practicable. Slope gradient for the bund is 1V:3H.

The temporary and permanent bunds are shown in drawing 109116-MMD-KNOC-XX-DR-CE-0002. Red denotes an area of cut and green denotes area of fill.

3.10 Earthworks Classification

Classification of the materials anticipated for re-use on site as fill material is still uncertain. The quality of the soil with regards to its potential reuse as fill material in the temporary road will be evaluated upon receipt of the laboratory testing results of the recent ground investigation. The required amount of fill material to be reused is very limited and therefore the rest of the cutting material is envisaged to be used in the landscape bund. Assumptions have been made in order to assess the slope stability of the bund. These assumptions are to be verified at a later stage when the data collected during the GI is available.

4 Earthworks Volumes and Material Use

4.1 Introduction

Earthwork software 3D modelling exercises have been undertaken to assess the cut and fill volumes required. The cut and fill volumes are based on the findings from the ground investigation undertaken on April 2024. These figures and details are to be developed following completion of the specific ground investigation and further design.

Current excavation is based on:

- Topsoil strip thickness is 400mm.
- Interbedded cohesive and granular till.

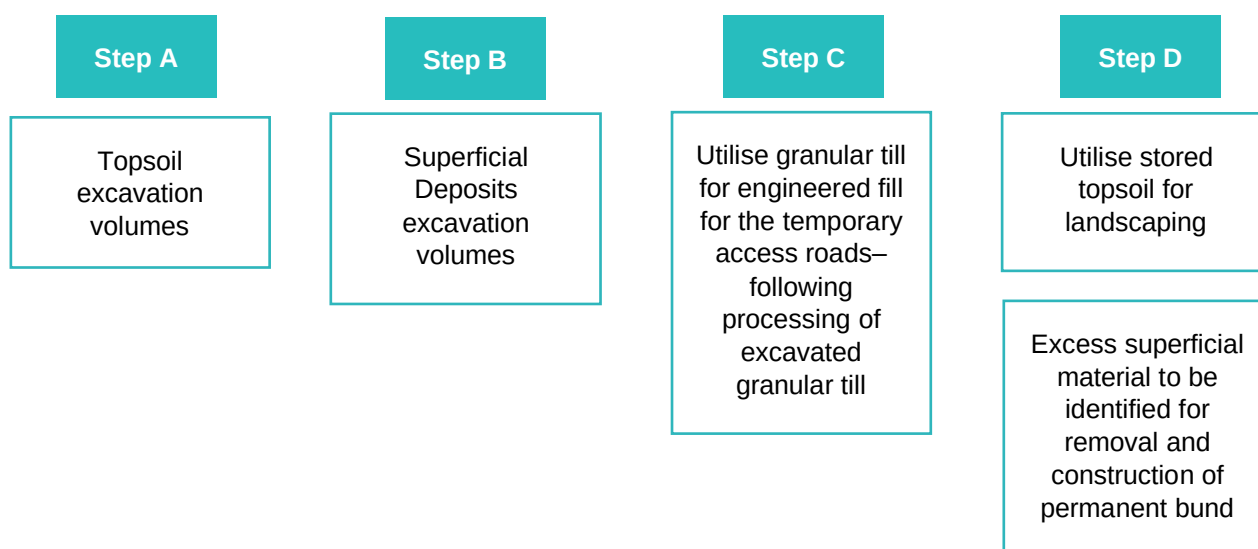
4.2 Earthworks Quantities

The earthworks quantification can be considered as being four principal calculation steps as summarised below:

- **Step A** – Strip of topsoil and any unsuitable material
- **Step B** – Excavation of material (superficial) to formation level for building platform
- **Step C** - Engineered fill (from processing of granular till on site) to achieve finished levels for the temporary access road.
- **Step D** – Non-engineered fill to building platforms, roads and embankment slopes for reinstatement and landscaping.

The process of estimating volumes is shown below in Figure 4.1:

Figure 4.1: Estimating Cut/Fill Volumes Process



4.3 Bulking Factors

Bulking factors which account for the difference in volume following cutting, filling and compaction have been estimated as the following values shown in Table 4.1. based on the BGS User Guide for “BGS Civils”- a suite of engineering properties datasets and engineering judgement. This will be reviewed in the construction phase.

Table 4.1: Bulking and Compaction Factors

Material	Bulking Factor	Compaction Factor	Residual Bulk & Compaction Factor
Topsoil	1.35	1.35	1
Superficial Deposits (Stoney Cohesive)	-	-	1
Superficial Deposits (Sands and Gravels)	1.15	1.15	1

4.4 Excavation / Fill Volumes

Table 4.2 contains the estimated volumes of material excavation (cut) and the fill required for the construction of various works and locations and indicates the extracted volumes characterised into topsoil and superficial soil based upon the assumed thicknesses and depths, including the application of the respective bulking and recompaction volume. This table also includes the percentage reuse potential of the extracted material and subsequently the volume of material required to be stored on site in a permanent bund. It is assumed that granular till will be suitable to reuse as fill material in the temporary access road.

The cut and fill volumes figure from next table are calculated based on the raw figures from the drawings 109116-MMD-KNOC-DR-CE-0002 and Earthworks plan operational phase 109116-MMD-KNOC-DR-CE-0004 and the bulking and compression factors from Table 4.1 of this report.

Notes:

- Total volume to be storage is the sum of the stored excess including residual bulk factor and compaction factor = 1.
- No topsoil strip out is assumed to be undertaken in the earth bund area.
- Topsoil and subsoil from laydown area is excluded from this design.

The removed materials will be stored in a permanent bund. Also, there is a temporary bund on site. The location and capacity of these bunds are shown in the drawing 109116-MMD-KNOC-DR-CE-0002 and in Table 4.3.

Table 4.2: Cut and Fill Volumes

Topsoil						
Location of Earthworks	Cut volume (m ³)	Fill volume (m ³)	Imported fill volume (m ³)	Excess usable cut volume (m ³)	Total volume to be exported/stored in bunds (m ³)	
Platform Extension	5,497	-	-	-	5,497	Stored in permanent bund
Attenuation Basin	794	-	-	-	794	Stored in permanent bund
Temporary Haul Road	2,615	-	-	-	2,615	Stored in temporary bund
Subsoil						
Platform Extension	79,681	0	0	0	79,681	Stored in permanent bund
Attenuation Basin	3,953	0	0	0	3,953	Stored in permanent bund
Temporary Haul Road	5,420	363	0	363	5,057	Stored in temporary bund until it's reinstated
TOTAL	97,960	363	0	363	97,597	

NOTE – Volumes include bulking and compaction factors

- From the total volume excavated from the site (permanent pond and substation extension), 6291m³ of topsoil and 83634m³ of subsoil is to be stored in permanent bund. The topsoil is to be used for landscaping of the permanent bund and dressing the slopes of the platform extension. The total volume required to store the topsoil and subsoil of the permanent elements is 89925m³.
- From the total volume excavated from the temporary access track, 5057m³ of subsoil is to be stored in a temporary bund.
- During the excavation of the topsoil, a temporary bund for only topsoil with a volume of $(5,497 + 794 + 2,615) = 8906 \text{ m}^3$ is required up to the finalization of the permanent bund works. Then, the total volume of topsoil will be used for landscaping of the permanent bund and dressing the slopes of the platform extension. Also, subsoil from the temporary access road should be located on temporary bund onsite, as this area is to be reinstated as per planning requirements following construction completion.

4.5 Cut Storage Locations

The extracted materials will be stored in bunds. There are temporary and permanent bunds on site, and the location and maximum capacity of the bunds available on site are shown below:

Table 4.3: Bund Capacity available on site

Onsite bunds	Capacity m ³
Permanent bund (maximum elevation +195mAOD)	89462
Temporary bund (maximum elevation +180mAOD)	6310

An excess of cut is required to extract offsite (89925m³ required - 89462 m³) = 463 m³ of subsoil material.

The maximum temporary bund available on the site is 6310 m³. This bund does not have enough capacity to store the required 8906m³ volume of topsoil. Therefore, an extra area with a capacity of 2596 m³ is required during the construction phase only to store the topsoil.

A temporary bund of 5057m³ of subsoil material is required to store the subsoil of the temporary track road up to completion of the construction phase.

4.6 Import Materials Volume

Next table shows the volumes of construction materials required to be imported to site to build the site up to finished platform level and to construct the roads. The contractor will develop the design in the detailed design stage.

Imported Materials				
Location	Materials	Depth (m)	Area (m ²)	Volume (m ³)
Substation Platform	Chippings	0.0725	7,720	560
	MOT Type 3 permeable gravel	0.2	7,720	1,544
	Capping layer	0.725	7,720	5,597
Internal Substation Road	Asphalt Layers	0.18	1,880	339
	Type 1	0.2	1,880	376
	Capping layer	0.15	1,880	282
Temporary Access Road	Type 1	0.2	3,362	673
	Capping layer	0.8	3,362	2,690
Compound	Type 1	0.2	2,000	400
	Capping layer	0.8	2,000	1600
Total granular layers:				13,712
Total with 1.1 Compression factor:				13,872

The capping road for the internal road is shown indicative and will be assessed at the detailed design stage.

4.7 Anticipated Description of Material Usage

The amount of material to be extracted is an approximation based on the anticipated geology. The possible material uses are outlined below.

4.7.1 Topsoil Strip

Extracted topsoil would be used for landscaping in the permanent earth bund. Topsoil dressing the platform cutting slopes has not been considered.

It will be necessary to prescribe precise methods and timing involved in excavating, handling and storing topsoil for use in reinstatement. A best practice method statement to govern the process will be produced and will be based on the following principles:

- Suitable temporary storage areas within the Development Boundary should be sited in areas with lower ecological value, low stability risk and a suitable distance from water courses.
- Reinstatement should, in all instances, be undertaken at the earliest opportunity to minimise storage of topsoil material.
- Careful handling is essential to retain any existing structure and integrity of excavated materials and thereby maximise the potential for excavated material to be used.
- To minimise handling and transportation, topsoil should be placed as close as is reasonably practicable to the location which will be reused.
- Timing the construction work as much as possible to avoid periods when topsoil material is likely to be wetter.

4.7.2 Superficial Deposits

The re-use potential of the superficial deposits is uncertain and will require a review once geotechnical laboratory testing results are received. Characteristic geotechnical parameters will be derived from the samples collected during the recent ground investigation to verify the slope stability of the bund and platform slopes. It is assumed that the granular soil excavated will be suitable for reuse as general fill for the temporary access road after processing on site. This needs to be verified upon receiving the geotechnical laboratory testing results. The rest of the material extracted from site will be used in the landscape bund.

4.7.3 Bedrock

Based on the information gathered during the site specific recent ground investigation, no bedrock material is expected to be excavated during the works. Bedrock has not been found in any of the boreholes locations. The maximum investigation depth achieved was 17.25mbgl.

5 Slope Stability Assessment

5.1 Methodology

The assessment of the slope stability for the proposed permanent earth bund and platform cutting have been carried out in accordance with Eurocode 7 Geotechnical Design- BS EN 1997-1:2004+A1:2013 using a GEO limit state, Design Approach 1 with partial factors combination 1 and 2 being applied as follows:

- Combination 1: A1+M1+R1
- Combination 2: A2+M2+R1

Slope/W software (2023 version 23.1.2.11) developed by Geostudio was used to assess the stability of the critical slope for an earth bund. The minimum factor of safety for slip surfaces based on the Morgenstern-Price method of analysis was adopted. A minimum design factor of safety of 1.0 is required.

The stability of the slopes was assessed based on assumed conservative soil parameters due to the lack of site-specific GI data at the time of the assessment. The values used in the analyses are provided in Table 5.1.

Topsoil was modelled as a Uniform Distributed Load of 8kPa.

5.2 Ground Model

The ground model comprises topsoil (maximum 0.5m thick) overlying superficial deposits which consists of cohesive and granular till. Only cohesive till has been considered for the analyses as this provides critical conditions and therefore a conservative assumption at this stage. Bedrock was not found during the recent GI which maximum achieved depth was 17.25mbgl. For the purpose of the analyses, bedrock has been considered to be found at 40mbgl.

An assessment of the SPT N values taken during the recent GI with respect to depth of the strata has been undertaken and plotted as shown in Figure 5.1. SPT N values for the cohesive till vary from 11 to 50. SPT N values of 50 might be indicative of refusal due to boulders encountered and thus they have been discarded. Based on the SPT N value, the undrained shear strength (C_u) can be derived using the Stroud and Butler correlation (1974): $C_u = f_1 \times N$ for cohesive materials. A factor, f_1 , was defined as the ratio of C_u/N . For a clay with a Plasticity Index of about 50% a typical value of f_1 of 4.5 was identified. Therefore, based on the SPT N values obtained during the recent GI and the typical f_1 factor, undrained shear strength values have been derived as shown in Figure 5.2. An increase in undrained shear strength with depth of 40+ 3.5z capped at 100kPa has been obtained as a result.

Figure 5.1: SPT N value with Depth

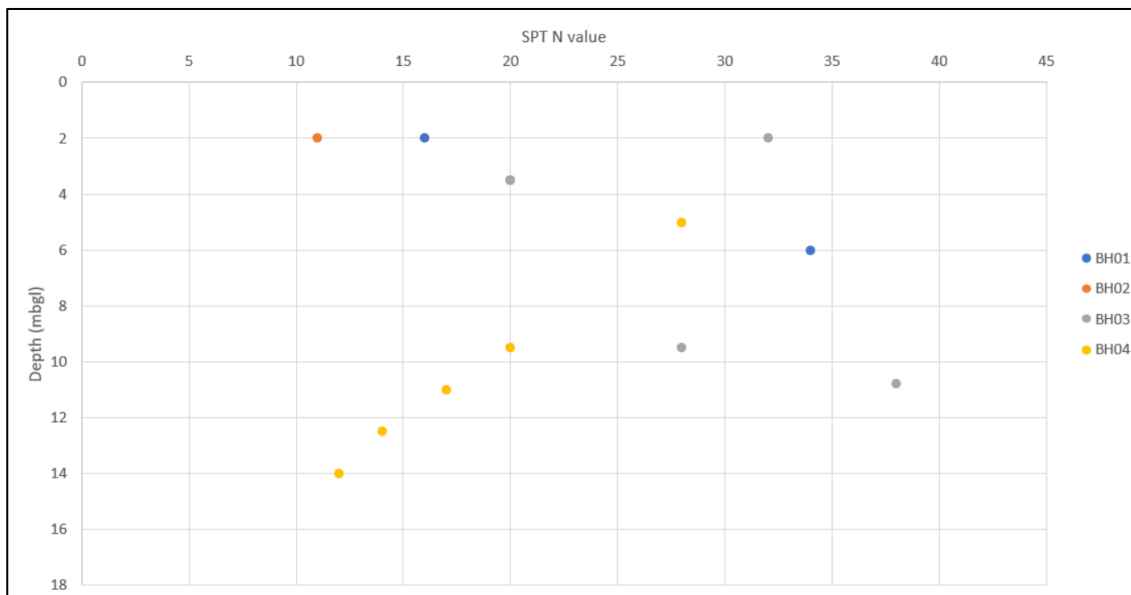
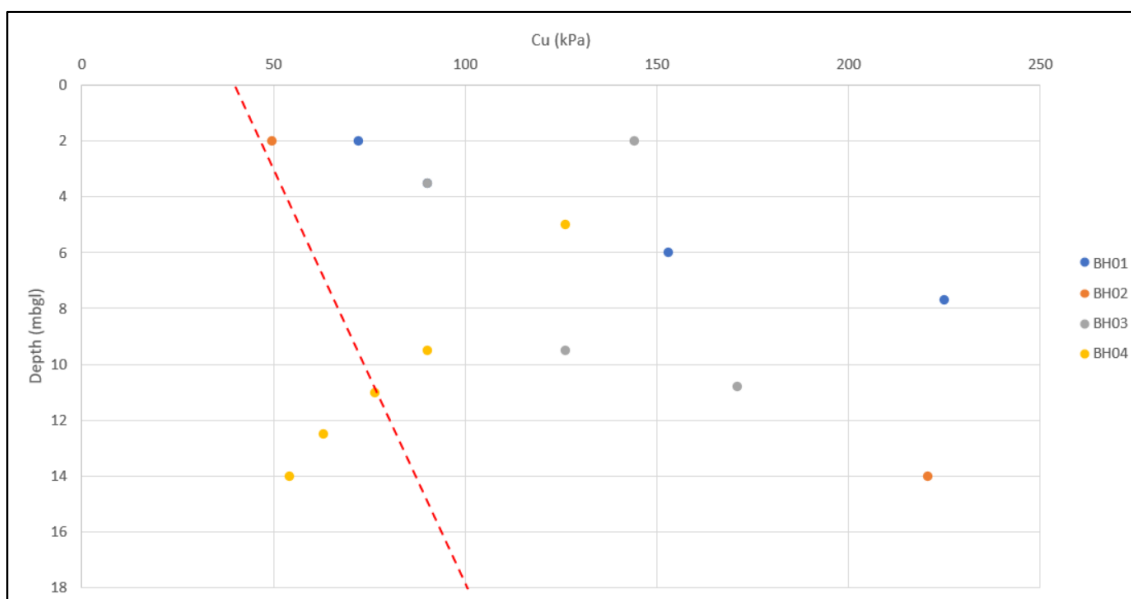


Figure 5.2: Undrained Shear Strength with Depth



The remaining geotechnical parameters shown in Table 5.1 have been estimated based on the preliminary logs' descriptions received from the recent GI and engineering judgement. Glacial till deposits are considered to have low sensitivity. The glacial till is to be compacted to 95% of maximum dry density when excavated and placed in the permanent bund area. Therefore, the in-situ parameters have been also used for the earth bund analyses.

Groundwater monitoring data is not currently available and therefore conservative assumptions have been made based on water strikes found during the ground investigation between 174.4mAOD and 183.8mAOD (between 1.1 and 5.5mbgl). For the groundwater level a piezometric line was modelled as shown in Figure 5.3 to Figure 5.5.

Table 5.1 summarises the assumed conservative geotechnical parameters used in the analysis.

Table 5.1: Summary of assumed geotechnical parameters.

Material	c' (kPa)	ϕ' (°)	γ (kN/m ³)	C_u (kPa)
Cohesive Till	0	27	21	40+3.5z capped at 100

These assumptions are to be verified at the next stage when all GI information is available.

Ground conditions comprise cohesive till material and thus for each section analysed two different assessments have been undertaken: short-term using undrained parameters and long-term using drained parameters.

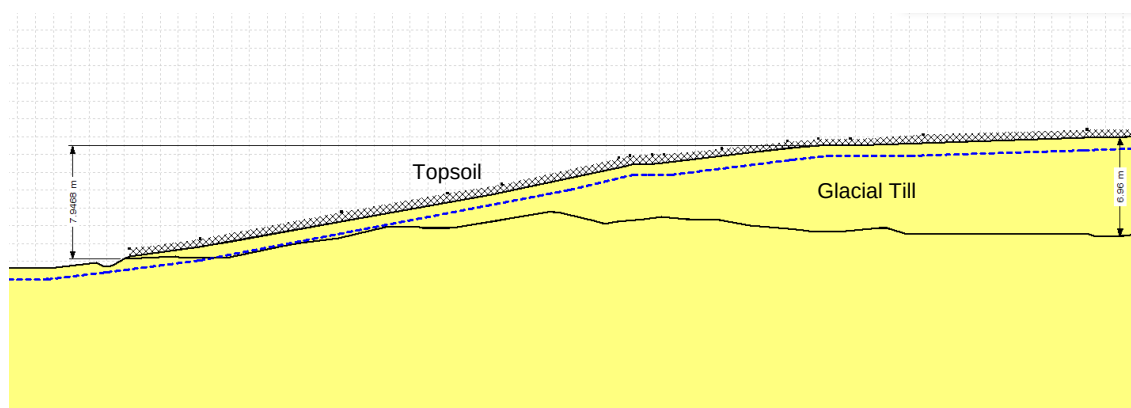
5.3 Design

5.3.1 Permanent Earth Bund

For the purpose of the analyses, the proposed bund comprises cohesive till/ The slope is variable, with a maximum slope gradient of 1V in 3H. Figure 5.3 shows a sketch of the proposed bund design.

The maximum elevation of the bund is 195.25m AOD with a maximum height of the bund of 7m at the lowest topography area, approximately in the centre of the bund (Figure 5.3). Topsoil is modelled as a surcharge over the bund with a maximum thickness of 0.5m.

Figure 5.3: Landscape Bund design



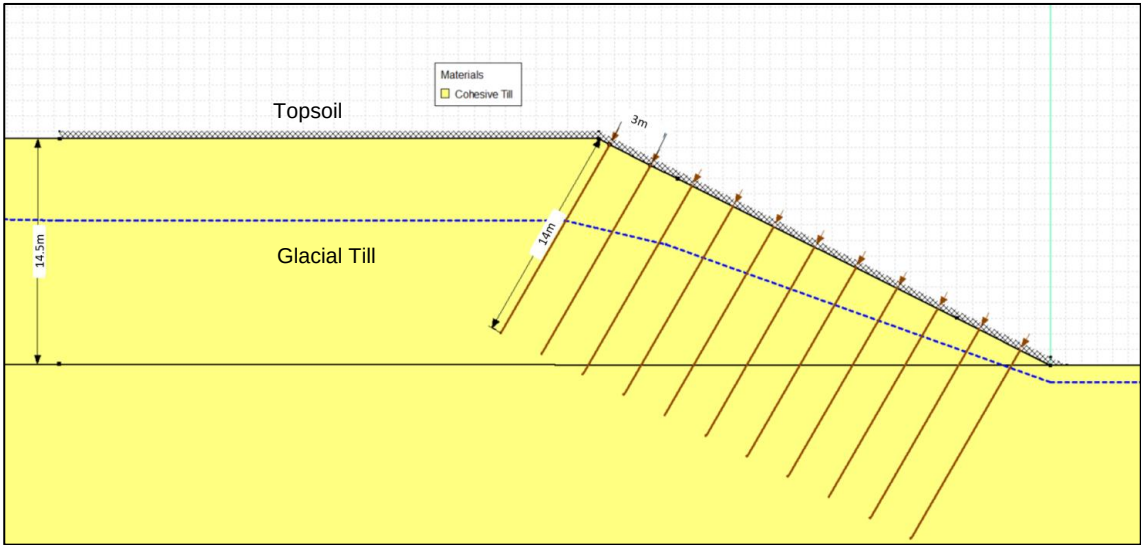
5.3.2 Platform Cutting

There are two variations for the platform cutting:

- Slope 1V:3H gradient
- Slope 1V:2H with soil reinforcement due to space constraints at the south of the platform where the sealing end compound is present.

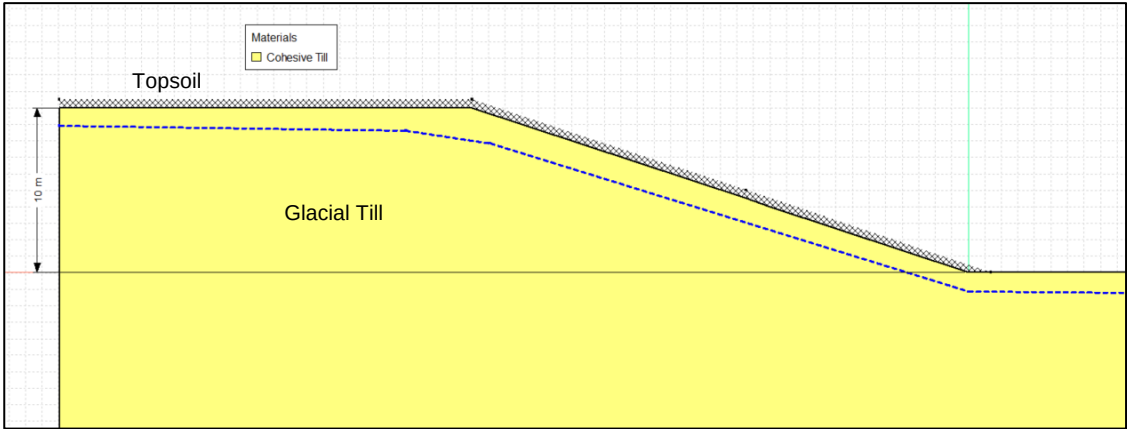
For each variation the deepest cutting section has been analysed. Details of the dimensions and geometry considered in the design is shown in Figure 5.5 and Figure 5.5.

Figure 5.4: 1V:2H Slope Platform Cutting design with soil reinforcement.



Soil nails are analysed as the soil reinforcement option for the 1V:2H slope. They are assumed to have a spacing of 3m (centre to centre) in the direction along the slope, 14m long and 1.5m (centre to centre) in the direction across the slope for 35mm diameter soil nails. Soils nails are modelled to have a pull-out resistance of 85kPa and a tensile capacity of 770kN. This will be verified at detailed design.

Figure 5.5: 1V:3H Slope Platform Cutting design



5.4 Results

5.4.1 Permanent Earth Bund

After undertaking a slope stability analysis of the proposed earth bund, the results obtained are summarised in Table 5.2. Appendix A show the output and analyses of the various cases assessed.

Table 5.2: Earth Bund Slope Stability Analysis results

Factor of Safety obtained	Long term	Serviceability Limit State	1.68
		Ultimate Limit State- Comb. 1	1.61
		Ultimate Limit State- Comb. 2	1.35
		Serviceability Limit State	2.38

Short term	Ultimate Limit State- Comb. 1	1.58
	Ultimate Limit State- Comb. 2	1.70

5.4.2 Platform Cutting

5.4.2.1 1V:3H Slope Gradient

The slope stability analysis of the proposed 1V:3H slope gradient at the deepest cutting section shows the results summarised in Table 5.3. Appendix B illustrate the output and present the analyses of the different cases assessed.

Table 5.3: Platform 1V:3H Cutting Slope Stability Analysis results

Factor of Safety obtained	Long term	Serviceability Limit State	1.27
		Ultimate Limit State- Comb. 1	1.31
		Ultimate Limit State- Comb. 2	1.02
	Short term	Serviceability Limit State	2.19
		Ultimate Limit State- Comb. 1	1.49
		Ultimate Limit State- Comb. 2	1.56

5.4.2.2 1V:2H Slope Gradient with soil reinforcement

The slope stability assessment results of the proposed 1V:2H slope gradient with soil nails at the deepest cutting section are summarised in Table 5.4. Appendix C show the output and the analyses of the various cases assessed.

Table 5.4: Platform 1V:2H Cutting Slope with soil nails Stability Analysis results

Factor of Safety obtained	Long term	Serviceability Limit State	1.34
		Ultimate Limit State- Comb. 1	1.26
		Ultimate Limit State- Comb. 2	1.06
	Short term	Serviceability Limit State	1.60
		Ultimate Limit State- Comb. 1	1.03
		Ultimate Limit State- Comb. 2	1.14

6 Material Excavation Methodology

6.1 Introduction

Based on the assumed ground conditions and development construction proposals, it is envisaged that considerable volumes of superficial deposits excavation will be required. Further review will be required upon receipt of site-specific ground investigation results, confirming the suitability of the material (granular till) as fill material in the temporary access road.

6.2 Assumed Methodology

It is assumed that mechanical excavation such as mechanical plant and dump trucks will be used for the excavation of the superficial deposits and topsoil. The topsoil will be excavated and temporary stored south of the platform extension and next to the permanent earth bund as shown in . The excavated superficial deposits will be placed directly and compacted at the earth bund location shown in and covered with the topsoil stored next to the bund. Part of the excavated granular till will potentially be used as fill in the temporary access road.

6.3 Materials and Performance Testing

6.3.1 Testing

Earthworks testing is to be undertaken to verify that the cut and filling operations meet the requirements of the earthworks specification which will be developed as a Testing and Inspection Plan prior to construction works.

6.3.2 Materials Testing

Materials testing may comprise laboratory and field testing, including verification of strength/stiffness parameters. Type and frequency of testing is to be confirmed following detailed design.

6.3.3 Performance Testing

Performance testing shall comprise onsite field testing of cut surfaces and/or placed materials to verify the compaction, strength and stiffness characteristics of formation horizons and filling operations to confirm compliance with the design and associated earthworks specifications. Type and frequency of testing is to be confirmed following detailed design.

6.4 Seasonal Changes

This earthworks strategy is preferably to be implemented in the drier months. The acceptability of the fill depends on moisture content, which could be affected by weather. Working in winter increases the risk of the excavated material being over the allowable moisture content level. If the earthworks must take place in the winter months, there are a number of ways in which this could be mitigated:

- If the excavated material is too wet, then an amount of lime and/or cement can be added. However, if this does not improve the material, the earthworks duration could affect the programme.
- If the exposed formation layer is found to be unsuitably soft/wet during the winter months, in order to fill during this time of the year a starter layer can be constructed. This layer could be imported granular fill e.g. capping, or it could be stabilised ground using lime and/ or cement.

7 Risks

The following risk register identifies potential risks, mitigation measures and residual risks associated with this earthwork's strategy.

Table 7.1 - Earthworks Risk Register

ITEM	RISK	MITIGATION	RESIDUAL RISK
Cut and fill swell/compaction	The volume of excavated material or after the material is compacted may differ from the estimated in the calculations.	Bulking/Compaction factors have been applied, following engineering judgement, references and anticipated ground conditions described in geotechnical desk study. Volumes provided should be considered as guidance only	Additional material may be required, or storage and disposal of excess material may be greater than expected.
Ground conditions	Uncertainty of ground conditions leading to geotechnical works being more onerous than the estimated in design. Uncertainty of ground conditions leading to overconservative design	Geotechnical information has been gathered from the Desk study and ground investigation information available as far as reasonably practicable. Design to be revised once site specific GI is available	Insufficient information leading to works being more onerous than anticipated. Overconservative design. Risk of contamination or other ground hazards not identified in the desk study.
Ground conditions	Presence of low bearing capacity in Glacial Till material	Recent ground investigation undertaken to characterise ground to determine strength and consolidation properties	Instability of temporary excavations
Made Ground presence associated with the construction of the existing substation	Risk of slope instability during cable installation or construction of shallow foundations. Unsuitability as founding stratum for the proposed development. Risk of total/differential settlement in response to loading.	Recent ground investigation undertaken to characterise ground conditions on site. Results to be used to inform the detailed design of the proposed works.	
Unknown rockhead profile	Unsuitable methodology of extracting material if bedrock found shallower than expected. Potential changes in design and construction methodologies which would delay the programme and increase in cost. It could also mean risk of total/differential settlement	Site-specific Ground Investigation designed to characterise the ground conditions on site to an adequate depth. Results to be used to inform the detailed design of the proposed works.	Sufficient information - Review of existing geotechnical information and requirement for further investigation to inform detail design
Buried artificial obstructions (e.g. structures, groundworks associated with the existing substation)	Damage to plant and equipment if unexpected obstructions are encountered. Potential delay to programme, changes in design and construction methodologies and cost increase as consequence.	Ground Investigation designed to assess the depth and extent of surface obstructions across the site. Results to be used to inform the detailed design of the proposed works. Client to provide as-built drawings. Suitable design construction methodologies to be adopted including avoiding or removing known obstructions.	

ITEM	RISK	MITIGATION	RESIDUAL RISK
Natural obstructions such as cobbles and boulders due to the glacial till nature	Damage to plant and equipment if unexpected obstructions are encountered. Potential delay to programme, changes in design and construction methodologies and cost increase as consequence.	Ground Investigation designed to assess the depth and extent of surface obstructions across the site. Results to be used to inform the detailed design of the proposed works. Suitable design construction methodologies to be adopted including avoiding or removing known obstructions.	Sufficient information - Review of existing geotechnical information and requirement for further investigation to inform detail design
Sloping Ground required to construct the proposed working platform	Risk of instability of the cutting slopes. Potential delay in programme and increase in cost as consequence of design rework.	Site-specific Ground Investigation designed to characterise the ground conditions on site. Results to be used to inform the detailed design of the proposed works Topographic Survey designed to provide detailed information on site levels.	
Services and utilities expected beneath the whole site area	Possible injury or death if the utility is hit during intrusive works. Temporary loss of the utility. Potential damage to cables with tools and machinery. Delay to programme and cost increase due to repair needs.	Client to provide all known utilities information prior to intrusive works. Access road crosses the buried HV cable. Access road design to address protection of cable.	Damage to cable. Hazard Risk to construction personnel.
UXO	Risk of injury or death is UXO is encountered, and therefore explodes during works. Damage to equipment and existing services/infrastructure if UXO is encountered.	Competent Contractor to have awareness training of UXO risks. The PDSA obtained from Zetica indicates that the site is at low risk of encountering UXO	Residual risk, albeit low, to encounter UXO.
Groundwater- Groundwater levels beneath the site are unknown. There is a potential for localised perched groundwater due to the presence of low permeability clay beneath the site.	Slope instability during constructions works if shallow groundwater is present. Potential injury to construction workers if the excavation collapses/fails. Potential programme delays and cost increase if mitigation measures required. Requirement for pumping from excavations. Presence of contamination may require treatment on site before disposal.	GI designed to assess groundwater regime beneath the site. Results used to inform detailed design of the proposed works.	Sufficient information - Review of existing geotechnical information and requirement for further investigation to inform detail design
Excavation within Glacial Till deposits	Glacial Till deposits always carries the possibility of discreet pockets of perched water within cut slopes, cut platform or fill foundations.	The earthworks design/ drawings should allow space for a perimeter filter drain as well as potential for filter drains and herringbone arrays to control any seepages. Protect the excavation against further wetting during construction which would further reduce the amount of re-usable soil.	

ITEM	RISK	MITIGATION	RESIDUAL RISK
Nearby structure affected by the platform excavation	Risk of instability of the cutting slopes and failure of the existing sealing end and structure foundations. Potential temporary loss of service.	Client to provide available information about the existing platform, structure and its foundation to be assessed at a detail design stage.	
Invasive or protected species	Injury to personnel or members of the public. Prosecution for harming protected species. Prosecution for distributing invasive species. Programme delays and cost.	Ecology survey and assessment to be undertaken.	Manage any environmental constraints identified in the ecology survey assessment.
Contaminated land	Potential injury or damage as a result of spreading contamination due to inadequate procedures in place on site if contamination encountered. Risk to construction workers, members of the public and controlled waters during construction/operation. Delays to construction and associated costs of treatment and/or removal and/or disposal off-site. Potential delays and costs associated.	A Preliminary Risk Assessment was undertaken as part of the Desk Study. Potential sources of contamination have been identified. Site-specific GI undertaken to analyse representative soil and groundwater samples for contamination.	
Soil or groundwater chemically aggressive to concrete	Sulphate attack on buried concrete that may cause structural failure of the proposed shallow foundations.	Appropriate testing to be undertaken during the site-specific GI in accordance with BRE Special Digest No.1 to characterise the ground and groundwater and provide appropriate Concrete Class.	Review results to be taken into account at detailed design.
Variable depth to competent founding material for proposed structure foundations	Change of preferred design option or outline foundation solution.	Ground investigation and associated laboratory testing undertaken to enable appropriate design solution.	Review results to be taken into account at detailed design.
Radon	Inhalation of radon poses a risk to human health.	Consider basic protection measures into any occupied structural designs to prevent ingress and build-up of radon in enclosed spaces. According to UKHSA Radon Map, the site area is said to be in the lowest band of radon potential.	
Soil nails performance/ installation	Granular layers and cobbles and boulder can obstruct drilling or cause deflection resulting in deflected nails. Wash-out of grout can occur into the granular material. These issues may result in reduced bond length and potential bore instability.	Ground investigation and associated laboratory testing undertaken for the cutting to assess the ground and groundwater conditions and characterise the ground.	Sufficient information - Review of existing geotechnical information and requirement for further investigation to inform detail design
Seasonal Springs encountered next the earth bund	Proposed permanent bund works could be	Design review at detail stage. A new swale/ditch along the edge of the permanent bund	

ITEM	RISK	MITIGATION	RESIDUAL RISK
	affected by the seasonal springs.	have been proposed to divert any water from the seasonal springs, discharging the water to the new culvert underneath the temporary haul road.	
Seasonal Springs in the cutting slope of the platform	Slope stability could be affected by the seasonal springs.	Design review at detail stage. Competent contractor to be used. Temporary works to be designed to protect the stability of the proposed cutting slope.	

8 References

- Grontmij, Knocknagael Substation Earthworks - Earthworks Methodology Review, April 2010.
- Mott MacDonald, Geotechnical and Geo-environmental desk study, Document reference: MMD-106510-DOC-10003, Revision A, 2022.
- Preliminary Ground Investigation data, April 2024.
- Entwisle, D, Lee, K A, and Lawley, R S. 2015. User guide for 'BGS Civils' - a suite of engineering properties datasets. British Geological Survey Internal Report, OR/15/065.
- SSEN, Earthworks Specification, SP-NET-CIV-501, July 2020.
SSEN, Drainage Specification, SP-NET-CIV-502, July 2020. Material Property Requirements
- Earthworks plan operational phase 109116-MMD-KNOC-DR-CE-0004.

A. Permanent Earth Bund Analyses

File Information

File Version: 11.05
Created By: Laura Castro
Last Edited By: Laura Castro
Revision Number: 82
Date: 02/08/2024
Time: 23:59:55
Tool Version: 23.1.2.11
File Name: Till 1 in 3- 7m with piezometric line.gsz
Directory: C:\Users\CAS111646\OneDrive - Mott MacDonald\Desktop\Knocknagael\Slope stability analysis\Earth bund\
Last Solved Date: 03/08/2024
Last Solved Time: 00:00:38

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

SLS

Kind: SLOPE/W
Analysis Type: Morgenstern-Price
Settings
 Side Function
 Intercolumn force function option: Half-Sine
 PWP Conditions from: Piezometric Surfaces
 Apply Phreatic Correction: No
 Use Staged Rapid Drawdown: No
 Unit Weight of Water: 9.807 kN/m³
Slip Surface
 Direction of movement: Right to Left
 Use Passive Mode: No
 Slip Surface Option: Grid and Radius
 Critical slip surfaces saved: 1
 Optimize Critical Slip Surface Location: No
 Tension Crack Option: (none)
Distribution
 F of S Calculation Option: Constant
Convergence
 Geometry Settings
 Minimum Slip Surface Depth: 0.5 m
 Minimum Slip Surface Volume: 1 m³
 Number of Columns: 30
 Factor of Safety Convergence Settings
 Maximum Number of Iterations: 100
 Tolerable difference in F of S: 0.001
 Under-Relaxation Criteria
 Initial Rate: 1
 Minimum Rate: 0.1
 Rate Reduction Factor: 0.65
 Reduction Frequency (iterations): 50
 Solution Settings
 Search Method: Root Finder
 Tolerable difference between starting and converged F of S: 3
 Maximum iterations to calculate converged lambda: 20
 Max Absolute Lambda: 2

Materials

Cohesive Till

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 21 kN/m³
Effective Cohesion: 0 kPa
Effective Friction Angle: 27 °
Phi-B: 0 °
Pore Water Pressure
 Piezometric Surface: 1

Slip Surface Grid

Upper Left: (50.51875, 214.72425) m
Lower Left: (31.877499, 189.6475) m
Lower Right: (140.063, 197.4145) m
Grid Horizontal Increment: 25
Grid Vertical Increment: 30

Slip Surface Radius

Upper Left Coordinate: (66.537998, 174.163) m
Upper Right Coordinate: (148.2165, 189.18875) m
Lower Left Coordinate: (66.537998, 156.31175) m
Lower Right Coordinate: (148.2165, 156.31175) m
Number of Increments: 25
Use Left Projection: No
Left Projection Angle: 135 °
Use Right Projection: No
Right Projection Angle: 45 °

Slip Surface Limits

Left Coordinate: (23.511751, 174.37725) m
Right Coordinate: (231.72725, 186.975) m

Piezometric Surfaces

Piezometric Surface 1

Coordinates

	X	Y
Coordinate 1	23.511751 m	173.37775 m
Coordinate 2	72.087267 m	173.7085 m
Coordinate 3	76.230751 m	174.18775 m
Coordinate 4	82.7825 m	175.01725 m
Coordinate 5	108.68775 m	179.97875 m
Coordinate 6	113.128 m	181.03675 m
Coordinate 7	114.299 m	181.03675 m
Coordinate 8	115.7725 m	181.03675 m
Coordinate 9	124.25925 m	182.085 m
Coordinate 10	126.767 m	182.37025 m
Coordinate 11	132.54275 m	182.37025 m
Coordinate 12	144.738 m	182.76675 m
Coordinate 13	154.1835 m	183.1275 m
Coordinate 14	168.21275 m	184.08625 m
Coordinate 15	173.9545 m	184.96775 m
Coordinate 16	180.105 m	185.828 m
Coordinate 17	183.877 m	186.11425 m
Coordinate 18	231.70882 m	185.55675 m

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 10 kN/m³
Direction: Vertical

Coordinates

	X	Y
	77.857249 m	175.84225 m
	82.804251 m	176.5385 m
	92.695999 m	178.4335 m
	100.133 m	179.7475 m
	103.9505 m	180.3685 m
	112.14275 m	182.22325 m
	112.937 m	182.3775 m
	114.472 m	182.47825 m
	115.30225 m	182.47825 m
	119.37625 m	182.886 m
	123.99725 m	183.411 m
	126.1645 m	183.578 m
	128.375 m	183.578 m
	133.479 m	183.86825 m
	144.9805 m	184.2175 m
	148.8755 m	184.2175 m
	150.437 m	184.3255 m
	153.85275 m	184.5305 m
	163.08175 m	185.31775 m
	169.33725 m	185.74925 m
	176.91825 m	187.14925 m
	182.50825 m	187.68625 m
	231.75475 m	187.50375 m

Geometry

Name: 2D Geometry

Settings

View: 2D
Element Thickness: 0.3048 m

Points

	X	Y
Point 1	65.099751 m	174.48775 m
Point 2	72.17675 m	174.48775 m
Point 3	76.083249 m	174.592 m
Point 4	76.404749 m	174.592 m
Point 5	76.790501 m	174.768 m
Point 6	77.482501 m	175.14275 m
Point 7	79.88025 m	175.277 m
Point 8	81.063249 m	175.32875 m
Point 9	81.57125 m	175.20875 m
Point 10	84.621999 m	175.20875 m
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Point 12	89.82225 m	176.29425 m
Point 13	92.478999 m	176.60275 m
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Point 17	100.451 m	177.2995 m
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Point 19	107.5495 m	178.44625 m
Point 20	108.09675 m	178.376 m
Point 21	109.4745 m	178.0295 m
Point 22	110.40375 m	177.7965 m
Point 23	111.20575 m	177.6315 m
Point 24	111.4265 m	177.6715 m
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Point 26	113.88975 m	177.96275 m
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Point 28	116.855 m	177.9615 m
Point 29	117.5775 m	177.911 m
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Point 31	121.35075 m	177.50325 m
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Point 33	124.5835 m	177.20375 m
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Point 35	125.8675 m	177.05925 m
Point 36	126.1485 m	177.02475 m
Point 37	126.3855 m	177.02475 m
Point 38	127.1585 m	177.02475 m
Point 39	127.455 m	177.05125 m
Point 40	128.67575 m	177.15475 m
Point 41	130.3785 m	177.297 m
Point 42	130.93025 m	177.297 m
Point 43	132.34725 m	176.877 m
Point 44	139.22375 m	176.877 m
Point 45	145.087 m	176.877 m
Point 46	145.5985 m	176.72525 m
Point 47	146.67375 m	176.72525 m
Point 48	148.568 m	176.87425 m
Point 49	149.663 m	176.95525 m
Point 50	152.291 m	177.08325 m
Point 51	154.14725 m	177.16575 m
Point 52	158.67325 m	178.04375 m
Point 53	163.142 m	179.09075 m
Point 54	164.49 m	179.52875 m
Point 55	166.673 m	179.66575 m
Point 56	170.615 m	179.81175 m
Point 57	174.5425 m	180.07225 m
Point 58	176.931 m	180.2235 m
Point 59	178.71025 m	180.33725 m
Point 60	180.38625 m	180.436 m
Point 61	181.59025 m	180.436 m
Point 62	188.54025 m	180.436 m
Point 63	194.36275 m	180.66825 m
Point 64	200.26475 m	181.1245 m
Point 65	203.531 m	181.4065 m
Point 66	204.0745 m	181.44725 m
Point 67	205.32825 m	181.44725 m
Point 68	211.22875 m	181.44725 m
Point 69	219.44675 m	180.634 m
Point 70	220.73025 m	180.52925 m
Point 71	223.526 m	180.52925 m
Point 72	226.0465 m	180.83925 m
Point 73	226.66925 m	180.93725 m

Point 74	229.69425 m	181.07125 m
Point 75	230.50475 m	181.1075 m
Point 76	231.651 m	181.1075 m
Point 77	231.651 m	153.8075 m
Point 78	23.511751 m	153.8075 m
Point 79	23.511751 m	174.37725 m
Point 80	77.850501 m	175.34125 m
Point 81	82.693749 m	176.02025 m
Point 82	103.20025 m	179.6745 m
Point 83	112.611 m	181.675 m
Point 84	112.99375 m	181.77025 m
Point 85	113.6425 m	181.77025 m
Point 86	114.08375 m	181.77025 m
Point 87	115.192 m	181.88875 m
Point 88	117.47675 m	182.1555 m
Point 89	119.3455 m	182.367 m
Point 90	124.097 m	182.918 m
Point 91	126.166 m	183.0895 m
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Point 93	133.396 m	183.2805 m
Point 94	136.57275 m	183.38975 m
Point 95	144.7355 m	183.68525 m
Point 96	146.721 m	183.68525 m
Point 97	148.88525 m	183.77025 m
Point 98	150.31575 m	183.864 m
Point 99	153.5605 m	184.05425 m
Point 100	162.3055 m	184.6565 m
Point 101	169.026 m	185.1205 m
Point 102	171.5865 m	185.498 m
Point 103	176.931 m	186.45625 m
Point 104	182.45875 m	186.975 m
Point 105	231.72725 m	186.975 m
Point 106	75.489999 m	174.8707 m

Regions

	Material	Poin
Region 1	Cohesive Till	1,79,78,77,76,75,74,73,72,71,70,69,68,67,66,65,64,63,62,61,60,59,58,57,56,55,54,53,52,51,50,49,48,47,46,45,44,43,42,41,40,39,38,37,36,35,34,33,32,
Region 2	Cohesive Till	6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50,51,52,53,54,55,5

Slip Results

Slip Surfaces Analysed: 15975 of 20956 converged

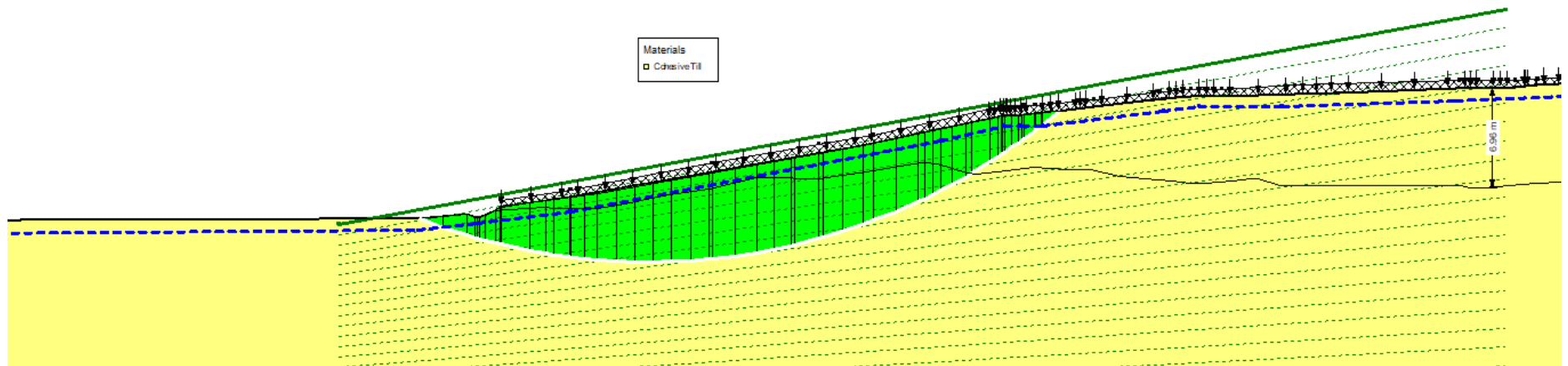
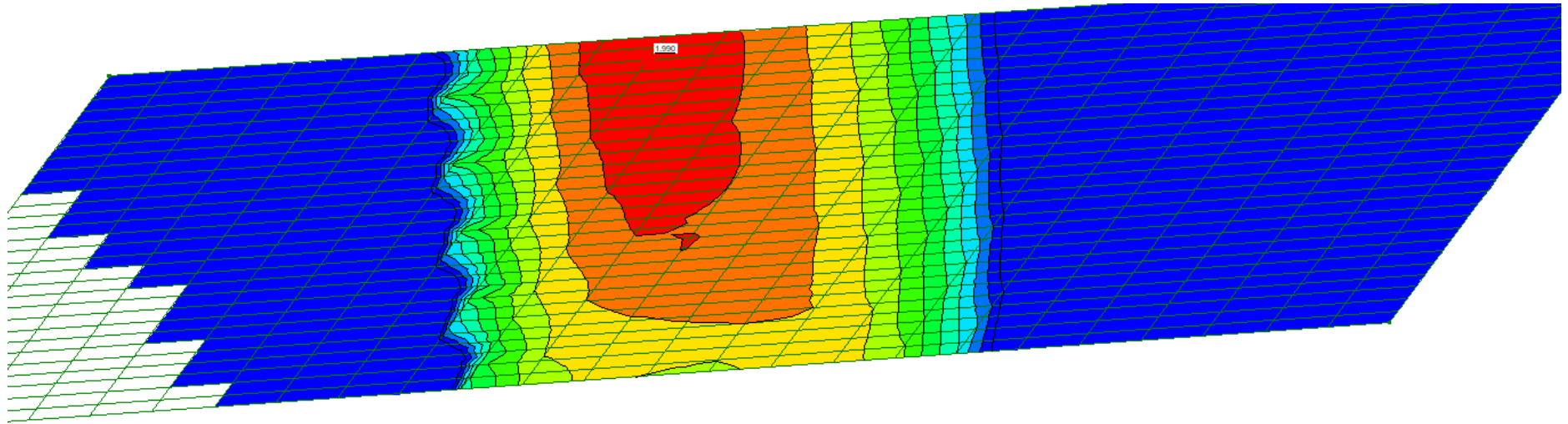
Current Slip Surface

Slip Surface: 19,171
Factor of Safety: 1.990
Volume: 57.302009 m³
Weight: 1,203.3422 kN
Resisting Moment: 18,660.255 kN-m
Activating Moment: 9,375.1274 kN-m
Resisting Force: 403.2284 kN
Activating Force: 202.63127 kN
Slip Rank: 1 of 20,956 slip surfaces
Exit: (116.97801, 182.09727) m
Entry: (72.229135, 174.4938) m
Radius: 44.339766 m
Center: (88.22278, 215.84859) m

Slip Columns

	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength	Suction Strength	Base Material
Column 1	381.80859 m	595.80636 m	-4.8110951 kPa	11.92762 kPa	6.0774261 kPa	0 kPa	0 kPa	Cohesive Till
Column 2	379.68682 m	594.06665 m	-0.34095928 kPa	19.876723 kPa	10.127696 kPa	0 kPa	0 kPa	Cohesive Till
Column 3	378.91541 m	593.46336 m	1.4623905 kPa	22.845053 kPa	10.895011 kPa	0 kPa	0 kPa	Cohesive Till
Column 4	378.10737 m	592.83510 m	3.3403864 kPa	26.031558 kPa	11.561729 kPa	0 kPa	0 kPa	Cohesive Till
Column 5	376.74541 m	591.80988 m	6.4049346 kPa	31.476378 kPa	12.774538 kPa	0 kPa	0 kPa	Cohesive Till
Column 6	375.28051 m	590.71630 m	9.6738452 kPa	37.232731 kPa	14.041954 kPa	0 kPa	0 kPa	Cohesive Till
Column 7	374.64362 m	590.25375 m	11.056468 kPa	39.567052 kPa	14.526868 kPa	0 kPa	0 kPa	Cohesive Till
Column 8	373.56669 m	589.48555 m	13.352771 kPa	43.609383 kPa	15.416514 kPa	0 kPa	0 kPa	Cohesive Till
Column 9	371.99885 m	588.39076 m	16.625287 kPa	49.549005 kPa	16.775472 kPa	0 kPa	0 kPa	Cohesive Till
Column 10	370.93463 m	587.66011 m	18.652471 kPa	53.485011 kPa	17.748065 kPa	0 kPa	0 kPa	Cohesive Till
Column 11	370.62131 m	587.44858 m	19.061602 kPa	54.691331 kPa	18.154254 kPa	0 kPa	0 kPa	Cohesive Till
Column 12	369.99344 m	587.03038 m	19.864485 kPa	56.281671 kPa	18.555483 kPa	0 kPa	0 kPa	Cohesive Till
Column 13	368.69054 m	586.17579 m	21.491011 kPa	59.47638 kPa	19.354512 kPa	0 kPa	0 kPa	Cohesive Till
Column 14	365.77663 m	584.35389 m	24.861571 kPa	66.167311 kPa	21.046326 kPa	0 kPa	0 kPa	Cohesive Till
Column 15	362.92394 m	582.61724 m	28.020902 kPa	72.436476 kPa	22.630865 kPa	0 kPa	0 kPa	Cohesive Till
Column 16	360.69267 m	581.34710 m	30.228363 kPa	76.876062 kPa	23.76819 kPa	0 kPa	0 kPa	Cohesive Till
Column 17	357.87771 m	579.80264 m	32.840069 kPa	82.2097 kPa	25.155083 kPa	0 kPa	0 kPa	Cohesive Till

Column 18	355.61762 m	578.61937 m	34.902822 kPa	86.237217 kPa	26.156181 kPa	0 kPa	0 kPa	Cohesive Till
Column 19	353.75041 m	577.68172 m	36.636625 kPa	89.38981 kPa	26.87909 kPa	0 kPa	0 kPa	Cohesive Till
Column 20	352.11409 m	576.88671 m	38.076262 kPa	92.030884 kPa	27.491253 kPa	0 kPa	0 kPa	Cohesive Till
Column 21	348.79285 m	575.37981 m	40.67923 kPa	96.879528 kPa	28.635482 kPa	0 kPa	0 kPa	Cohesive Till
Column 22	343.62759 m	573.18877 m	44.271512 kPa	103.80197 kPa	30.332285 kPa	0 kPa	0 kPa	Cohesive Till
Column 23	339.81423 m	571.69778 m	46.545193 kPa	108.60984 kPa	31.623516 kPa	0 kPa	0 kPa	Cohesive Till
Column 24	336.32854 m	570.47570 m	48.202646 kPa	112.97797 kPa	33.004676 kPa	0 kPa	0 kPa	Cohesive Till
Column 25	331.81861 m	569.02116 m	49.968569 kPa	118.33083 kPa	34.83231 kPa	0 kPa	0 kPa	Cohesive Till
Column 26	329.04199 m	568.18688 m	50.872753 kPa	121.39047 kPa	35.930571 kPa	0 kPa	0 kPa	Cohesive Till
Column 27	325.76977 m	567.32987 m	51.561155 kPa	124.2598 kPa	37.04181 kPa	0 kPa	0 kPa	Cohesive Till
Column 28	322.51887 m	566.50362 m	52.169838 kPa	127.03507 kPa	38.14574 kPa	0 kPa	0 kPa	Cohesive Till
Column 29	320.05126 m	565.96338 m	52.371992 kPa	128.68389 kPa	38.882856 kPa	0 kPa	0 kPa	Cohesive Till
Column 30	316.11671 m	565.17301 m	52.482025 kPa	130.96196 kPa	39.987527 kPa	0 kPa	0 kPa	Cohesive Till
Column 31	311.64226 m	564.41889 m	52.174573 kPa	132.74646 kPa	41.053427 kPa	0 kPa	0 kPa	Cohesive Till
Column 32	306.62791 m	563.73345 m	51.352759 kPa	133.78366 kPa	42.000641 kPa	0 kPa	0 kPa	Cohesive Till
Column 33	303.76476 m	563.39996 m	50.710472 kPa	133.98231 kPa	42.429123 kPa	0 kPa	0 kPa	Cohesive Till
Column 34	301.22970 m	563.18761 m	49.893886 kPa	133.48928 kPa	42.59398 kPa	0 kPa	0 kPa	Cohesive Till
Column 35	296.87151 m	562.89907 m	48.261317 kPa	132.05018 kPa	42.692557 kPa	0 kPa	0 kPa	Cohesive Till
Column 36	292.61565 m	562.74238 m	46.293201 kPa	129.65783 kPa	42.476402 kPa	0 kPa	0 kPa	Cohesive Till
Column 37	288.38761 m	562.71274 m	43.961259 kPa	126.23179 kPa	41.918928 kPa	0 kPa	0 kPa	Cohesive Till
Column 38	284.08506 m	562.80770 m	41.214191 kPa	121.64857 kPa	40.983364 kPa	0 kPa	0 kPa	Cohesive Till
Column 39	279.78251 m	563.03024 m	38.085752 kPa	115.91141 kPa	39.654156 kPa	0 kPa	0 kPa	Cohesive Till
Column 40	276.25389 m	563.29888 m	35.262612 kPa	110.39411 kPa	38.28141 kPa	0 kPa	0 kPa	Cohesive Till
Column 41	273.27202 m	563.60380 m	32.644022 kPa	105.03117 kPa	36.883093 kPa	0 kPa	0 kPa	Cohesive Till
Column 42	271.63181 m	563.78771 m	31.155267 kPa	101.91684 kPa	36.054822 kPa	0 kPa	0 kPa	Cohesive Till
Column 43	271.45054 m	563.81026 m	31.012334 kPa	101.58272 kPa	35.957407 kPa	0 kPa	0 kPa	Cohesive Till
Column 44	269.46358 m	564.08377 m	29.442794 kPa	97.91632 kPa	34.889004 kPa	0 kPa	0 kPa	Cohesive Till
Column 45	266.78888 m	564.47053 m	27.274476 kPa	92.837234 kPa	33.405894 kPa	0 kPa	0 kPa	Cohesive Till
Column 46	264.01493 m	564.94649 m	24.801922 kPa	86.943172 kPa	31.662548 kPa	0 kPa	0 kPa	Cohesive Till
Column 47	258.75574 m	566.00749 m	19.640078 kPa	74.425806 kPa	27.914723 kPa	0 kPa	0 kPa	Cohesive Till
Column 48	255.42610 m	566.72657 m	16.230515 kPa	60.429111 kPa	22.52031 kPa	0 kPa	0 kPa	Cohesive Till
Column 49	254.81135 m	566.87721 m	15.547574 kPa	57.045211 kPa	21.144102 kPa	0 kPa	0 kPa	Cohesive Till
Column 50	253.07251 m	567.31833 m	13.570906 kPa	47.26301 kPa	17.166985 kPa	0 kPa	0 kPa	Cohesive Till
Column 51	251.30454 m	567.78340 m	11.511635 kPa	37.575094 kPa	13.279996 kPa	0 kPa	0 kPa	Cohesive Till
Column 52	250.38632 m	568.03488 m	10.412405 kPa	33.765699 kPa	11.899097 kPa	0 kPa	0 kPa	Cohesive Till
Column 53	249.85892 m	568.18287 m	9.778377 kPa	32.734952 kPa	11.696959 kPa	0 kPa	0 kPa	Cohesive Till
Column 54	248.64378 m	568.53567 m	8.303677 kPa	33.52726 kPa	12.852058 kPa	0 kPa	0 kPa	Cohesive Till
Column 55	244.94650 m	569.69545 m	3.5585854 kPa	26.463752 kPa	11.670765 kPa	0 kPa	0 kPa	Cohesive Till
Column 56	239.59732 m	571.52855 m	-3.7702736 kPa	9.0617717 kPa	4.6172033 kPa	0 kPa	0 kPa	Cohesive Till



ULS C1

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File Information

File Version: 11.05
Created By: Laura Castro
Last Edited By: Laura Castro
Revision Number: 82
Date: 02/08/2024
Time: 23:59:55
Tool Version: 23.1.2.11
File Name: Till 1 in 3- 7m with piezometric line.gsz
Directory: C:\Users\CAS111646\OneDrive - Mott MacDonald\Desktop\Knocknagael\Slope stability analysis\Earth bund\
Last Solved Date: 03/08/2024
Last Solved Time: 00:02:10

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

ULS C1

Kind: SLOPE/W
Analysis Type: Morgenstern-Price
Settings
 Side Function
 Intercolumn force function option: Half-Sine
 PWP Conditions from: Piezometric Surfaces
 Apply Phreatic Correction: No
 Use Staged Rapid Drawdown: No
 Limit State Design Approach: Eurocode 7 - DA1, C1
 Unit Weight of Water: 9.807 kN/m³
Slip Surface
 Direction of movement: Right to Left
 Use Passive Mode: No
 Slip Surface Option: Grid and Radius
 Critical slip surfaces saved: 1
 Optimize Critical Slip Surface Location: No
 Tension Crack Option: (none)
Distribution
 ODF Calculation Option: Constant
Convergence
 Geometry Settings
 Minimum Slip Surface Depth: 0.5 m
 Minimum Slip Surface Volume: 1 m³
 Number of Columns: 30
 Overdesign Factor Convergence Settings
 Maximum Number of Iterations: 100
 Tolerable difference in ODF: 0.001
 Under-Relaxation Criteria
 Initial Rate: 1
 Minimum Rate: 0.1
 Rate Reduction Factor: 0.65
 Reduction Frequency (iterations): 50
 Solution Settings
 Search Method: Root Finder
 Tolerable difference between starting and converged ODF: 3
 Maximum iterations to calculate converged lambda: 20
 Max Absolute Lambda: 2

Materials

Cohesive Till

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 21 kN/m³
Effective Cohesion: 0 kPa
Effective Friction Angle: 27 °
Phi-B: 0 °
Pore Water Pressure
 Piezometric Surface: 1

Slip Surface Grid

Upper Left: (50.51875, 214.72425) m
Lower Left: (31.877499, 189.6475) m
Lower Right: (140.063, 197.4145) m
Grid Horizontal Increment: 25
Grid Vertical Increment: 30

Slip Surface Radius

Upper Left Coordinate: (66.537998, 174.163) m
Upper Right Coordinate: (148.2165, 189.18875) m
Lower Left Coordinate: (66.537998, 156.31175) m
Lower Right Coordinate: (148.2165, 156.31175) m
Number of Increments: 25
Use Left Projection: No
Left Projection Angle: 135 °
Use Right Projection: No
Right Projection Angle: 45 °

Slip Surface Limits

Left Coordinate: (23.511751, 174.37725) m
Right Coordinate: (231.72725, 186.975) m

Piezometric Surfaces

Piezometric Surface 1

Coordinates

	X	Y
Coordinate 1	23.511751 m	173.37775 m
Coordinate 2	72.02225 m	173.67775 m
Coordinate 3	76.328501 m	174.10275 m
Coordinate 4	82.7825 m	175.01725 m
Coordinate 5	108.68775 m	179.97875 m
Coordinate 6	113.128 m	181.03675 m
Coordinate 7	114.299 m	181.03675 m
Coordinate 8	115.7725 m	181.03675 m
Coordinate 9	124.25925 m	182.085 m
Coordinate 10	126.767 m	182.37025 m
Coordinate 11	132.54275 m	182.37025 m
Coordinate 12	144.738 m	182.76675 m
Coordinate 13	154.1835 m	183.1275 m
Coordinate 14	168.21275 m	184.08625 m
Coordinate 15	173.9545 m	184.96775 m
Coordinate 16	180.105 m	185.828 m
Coordinate 17	183.877 m	186.11425 m
Coordinate 18	231.70882 m	185.55675 m

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 10 kN/m³
Direction: Vertical
Mode: Permanent

Coordinates

	X	Y
	77.857249 m	175.84225 m
	82.804251 m	176.5385 m
	92.695999 m	178.4335 m
	100.133 m	179.7475 m
	103.9505 m	180.3685 m
	112.14275 m	182.22325 m
	112.937 m	182.3775 m
	114.472 m	182.47825 m
	115.30225 m	182.47825 m
	119.37625 m	182.886 m
	123.99725 m	183.411 m
	126.1645 m	183.578 m
	128.375 m	183.578 m
	133.479 m	183.86825 m
	144.9805 m	184.2175 m
	148.8755 m	184.2175 m
	150.437 m	184.3255 m
	153.85275 m	184.5305 m
	163.08175 m	185.31775 m
	169.33725 m	185.74925 m
	176.91825 m	187.14925 m
	182.50825 m	187.68625 m
	231.75475 m	187.50375 m

Design Factor Set: Eurocode 7 - DA1, C1

Permanent Point Loads & Surcharge Loads: Favorable = 1, Unfavorable = 1.35

Variable Point Loads & Surcharge Loads: Favorable = 0, Unfavorable = 1.5
Soil Unit Weight: Favorable = 1, Unfavorable = 1.35
Effective Cohesion: 1
Effective Coefficient of Friction: 1
Undrained Strength: 1
Shear Strength (Other Models): 1
Pullout Resistance: 1.1
Shear Force: 1.1
Tensile Strength: 1.1
Compressive Strength: 1.1
Seismic Coefficients: 1
Earth Resistance: 1

Geometry

Name: 2D Geometry

Settings

View: 2D
Element Thickness: 0.3048 m

Points

	X	Y
Point 1	65.099751 m	174.48775 m
Point 2	72.17675 m	174.48775 m
Point 3	76.083249 m	174.592 m
Point 4	76.404749 m	174.592 m
Point 5	76.790501 m	174.768 m
Point 6	77.482501 m	175.14275 m
Point 7	79.88025 m	175.277 m
Point 8	81.063249 m	175.32875 m
Point 9	81.57125 m	175.20875 m
Point 10	84.621999 m	175.20875 m
Point 11	88.556251 m	176.02625 m
Point 12	89.82225 m	176.29425 m
Point 13	92.478999 m	176.60275 m
Point 14	95.752749 m	177.413 m
Point 15	98.151251 m	177.413 m
Point 16	98.456249 m	177.2995 m
Point 17	100.451 m	177.2995 m
Point 18	107.09925 m	178.44625 m
Point 19	107.5495 m	178.44625 m
Point 20	108.09675 m	178.376 m
Point 21	109.4745 m	178.0295 m
Point 22	110.40375 m	177.7965 m
Point 23	111.20575 m	177.6315 m
Point 24	111.4265 m	177.6715 m
Point 25	112.0235 m	177.74725 m
Point 26	113.88975 m	177.96275 m
Point 27	115.137 m	178.10475 m
Point 28	116.855 m	177.9615 m
Point 29	117.5775 m	177.911 m
Point 30	119.14125 m	177.911 m
Point 31	121.35075 m	177.50325 m
Point 32	123.9915 m	177.25575 m
Point 33	124.5835 m	177.20375 m
Point 34	125.0825 m	177.1485 m
Point 35	125.8675 m	177.05925 m
Point 36	126.1485 m	177.02475 m
Point 37	126.3855 m	177.02475 m
Point 38	127.1585 m	177.02475 m
Point 39	127.455 m	177.05125 m
Point 40	128.67575 m	177.15475 m
Point 41	130.3785 m	177.297 m
Point 42	130.93025 m	177.297 m
Point 43	132.34725 m	176.877 m
Point 44	139.22375 m	176.877 m
Point 45	145.087 m	176.877 m
Point 46	145.5985 m	176.72525 m
Point 47	146.67375 m	176.72525 m
Point 48	148.568 m	176.87425 m
Point 49	149.663 m	176.95525 m
Point 50	152.291 m	177.08325 m
Point 51	154.14725 m	177.16575 m
Point 52	158.67325 m	178.04375 m
Point 53	163.142 m	179.09075 m
Point 54	164.49 m	179.52875 m
Point 55	166.673 m	179.66575 m
Point 56	170.615 m	179.81175 m
Point 57	174.5425 m	180.07225 m

Point 58	176.931 m	180.2235 m
Point 59	178.71025 m	180.33725 m
Point 60	180.38625 m	180.436 m
Point 61	181.59025 m	180.436 m
Point 62	188.54025 m	180.436 m
Point 63	194.36275 m	180.66825 m
Point 64	200.26475 m	181.1245 m
Point 65	203.531 m	181.4065 m
Point 66	204.0745 m	181.44725 m
Point 67	205.32825 m	181.44725 m
Point 68	211.22875 m	181.44725 m
Point 69	219.44675 m	180.634 m
Point 70	220.73025 m	180.52925 m
Point 71	223.526 m	180.52925 m
Point 72	226.0465 m	180.83925 m
Point 73	226.66925 m	180.93725 m
Point 74	229.69425 m	181.07125 m
Point 75	230.50475 m	181.1075 m
Point 76	231.651 m	181.1075 m
Point 77	231.651 m	153.8075 m
Point 78	23.511751 m	153.8075 m
Point 79	23.511751 m	174.37725 m
Point 80	77.850501 m	175.34125 m
Point 81	82.693749 m	176.02025 m
Point 82	103.20025 m	179.6745 m
Point 83	112.611 m	181.675 m
Point 84	112.99375 m	181.77025 m
Point 85	113.6425 m	181.77025 m
Point 86	114.08375 m	181.77025 m
Point 87	115.192 m	181.88875 m
Point 88	117.47675 m	182.1555 m
Point 89	119.3455 m	182.367 m
Point 90	124.097 m	182.918 m
Point 91	126.166 m	183.0895 m
Point 92	128.33 m	183.0895 m
Point 93	133.396 m	183.2805 m
Point 94	136.57275 m	183.38975 m
Point 95	144.7355 m	183.68525 m
Point 96	146.721 m	183.68525 m
Point 97	148.88525 m	183.77025 m
Point 98	150.31575 m	183.864 m
Point 99	153.5605 m	184.05425 m
Point 100	162.3055 m	184.6565 m
Point 101	169.026 m	185.1205 m
Point 102	171.5865 m	185.498 m
Point 103	176.931 m	186.45625 m
Point 104	182.45875 m	186.975 m
Point 105	231.72725 m	186.975 m
Point 106	75.489999 m	174.8707 m

Regions

	Material	Poin
Region 1	Cohesive Till	1,79,78,77,76,75,74,73,72,71,70,69,68,67,66,65,64,63,62,61,60,59,58,57,56,55,54,53,52,51,50,49,48,47,46,45,44,43,42,41,40,39,38,37,36,35,34,33,32,
Region 2	Cohesive Till	6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50,51,52,53,54,55,5

Slip Results

Slip Surfaces Analysed: 17077 of 20956 converged

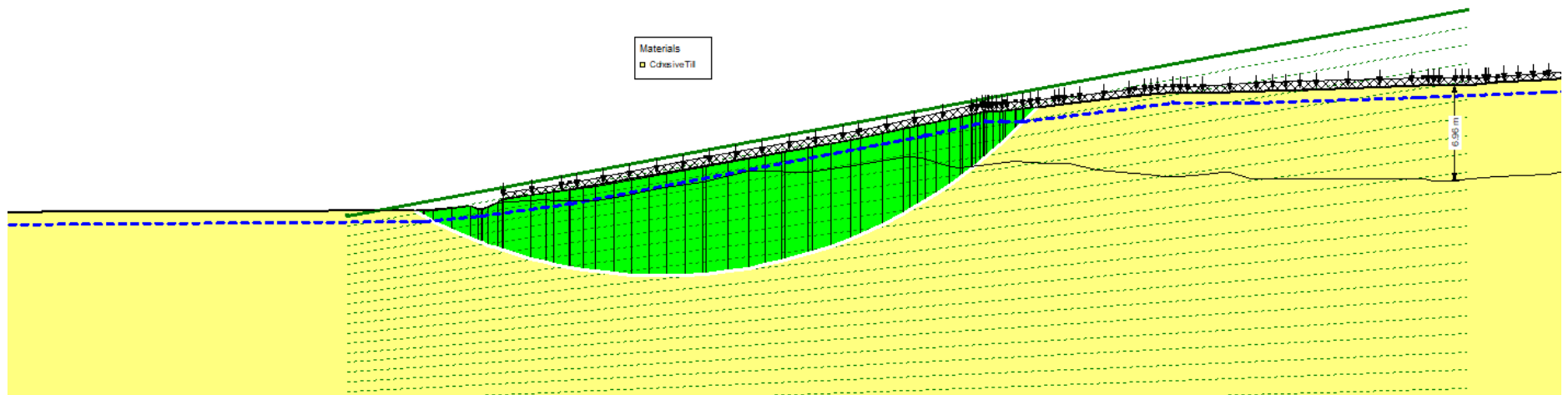
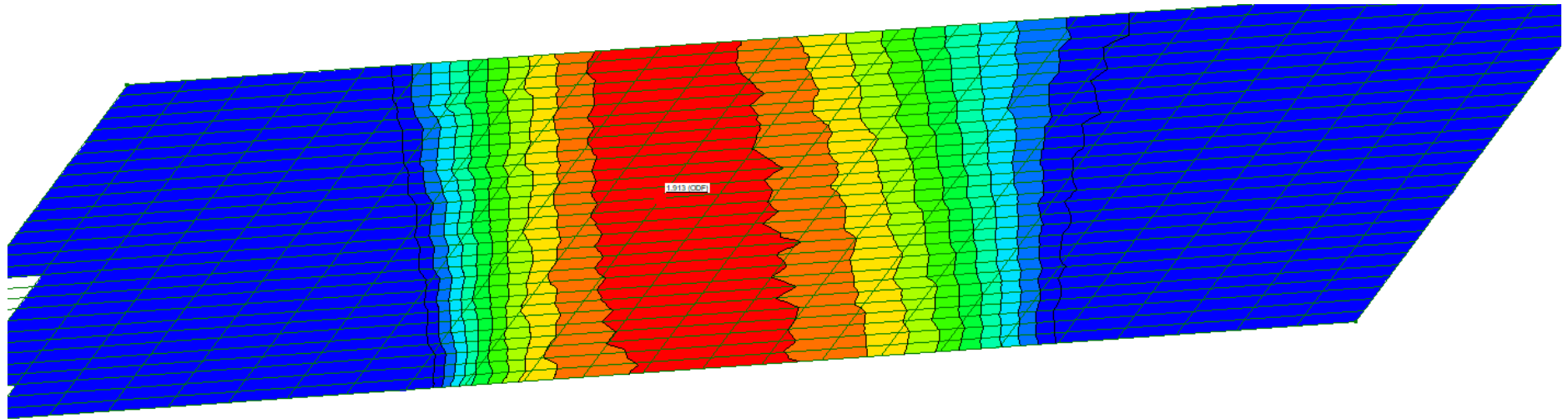
Current Slip Surface

Slip Surface: 11,113
Overdesign Factor: 1.913
Degree of Utilization: 0.523
Volume: 75.685352 m³
Weight: 1,962.2438 kN
Resisting Moment: 26,956.274 kN·m
Activating Moment: 14,089.624 kN·m
Resisting Force: 691.15811 kN
Activating Force: 361.43737 kN
Slip Rank: 1 of 20,956 slip surfaces
Exit: (116.82883, 182.07985) m
Entry: (71.430443, 174.48775) m
Radius: 36.668279 m
Center: (89.42112, 206.43925) m

Slip Columns

	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength	Suction Strength	Base Material
--	---	---	-----	--------------------	---------------------	-------------------	------------------	---------------

Column 1	381.73591 m	595.68497 m	-4.475084 kPa	15.868954 kPa	8.0856361 kPa	0 kPa	0 kPa	Cohesive Till
Column 2	380.00309 m	593.81655 m	0.47016051 kPa	27.234236 kPa	13.636977 kPa	0 kPa	0 kPa	Cohesive Till
Column 3	379.05963 m	592.85524 m	3.2801809 kPa	33.574762 kPa	15.43586 kPa	0 kPa	0 kPa	Cohesive Till
Column 4	378.10737 m	591.89302 m	6.1564059 kPa	39.983155 kPa	17.235589 kPa	0 kPa	0 kPa	Cohesive Till
Column 5	376.74541 m	590.57807 m	10.087029 kPa	49.049756 kPa	19.852501 kPa	0 kPa	0 kPa	Cohesive Till
Column 6	375.28051 m	589.17877 m	14.269789 kPa	58.649533 kPa	22.612609 kPa	0 kPa	0 kPa	Cohesive Till
Column 7	374.64362 m	588.59148 m	16.025293 kPa	62.549311 kPa	23.705171 kPa	0 kPa	0 kPa	Cohesive Till
Column 8	373.56669 m	587.62069 m	18.927153 kPa	69.208665 kPa	25.61971 kPa	0 kPa	0 kPa	Cohesive Till
Column 9	371.99885 m	586.24460 m	23.040522 kPa	78.889065 kPa	28.456254 kPa	0 kPa	0 kPa	Cohesive Till
Column 10	370.93463 m	585.33007 m	25.617362 kPa	85.298523 kPa	30.40907 kPa	0 kPa	0 kPa	Cohesive Till
Column 11	370.62131 m	585.06637 m	26.182443 kPa	87.234469 kPa	31.107561 kPa	0 kPa	0 kPa	Cohesive Till
Column 12	369.99344 m	584.54663 m	27.288837 kPa	90.030261 kPa	31.968352 kPa	0 kPa	0 kPa	Cohesive Till
Column 13	368.93675 m	583.68358 m	29.116008 kPa	94.602248 kPa	33.366906 kPa	0 kPa	0 kPa	Cohesive Till
Column 14	368.16863 m	583.06688 m	30.412356 kPa	97.946245 kPa	34.410235 kPa	0 kPa	0 kPa	Cohesive Till
Column 15	367.72679 m	582.71766 m	31.141532 kPa	99.810993 kPa	34.988838 kPa	0 kPa	0 kPa	Cohesive Till
Column 16	366.55184 m	581.81333 m	33.007887 kPa	104.5305 kPa	36.44259 kPa	0 kPa	0 kPa	Cohesive Till
Column 17	365.21038 m	580.79322 m	35.101726 kPa	109.85647 kPa	38.089443 kPa	0 kPa	0 kPa	Cohesive Till
Column 18	363.53265 m	579.57909 m	37.53601 kPa	116.10113 kPa	40.03093 kPa	0 kPa	0 kPa	Cohesive Till
Column 19	360.69267 m	577.60517 m	41.413623 kPa	126.1965 kPa	43.199036 kPa	0 kPa	0 kPa	Cohesive Till
Column 20	357.87771 m	575.75598 m	44.936226 kPa	135.57934 kPa	46.184975 kPa	0 kPa	0 kPa	Cohesive Till
Column 21	355.61762 m	574.34998 m	47.664774 kPa	142.6786 kPa	48.411964 kPa	0 kPa	0 kPa	Cohesive Till
Column 22	353.75041 m	573.24292 m	49.904967 kPa	148.24879 kPa	50.108679 kPa	0 kPa	0 kPa	Cohesive Till
Column 23	352.11409 m	572.30880 m	51.760429 kPa	152.93393 kPa	51.550475 kPa	0 kPa	0 kPa	Cohesive Till
Column 24	348.79285 m	570.55472 m	55.102257 kPa	161.60739 kPa	54.267074 kPa	0 kPa	0 kPa	Cohesive Till
Column 25	343.62759 m	568.02616 m	59.703464 kPa	174.18136 kPa	58.329399 kPa	0 kPa	0 kPa	Cohesive Till
Column 26	339.81423 m	566.32341 m	62.610121 kPa	182.97707 kPa	61.330022 kPa	0 kPa	0 kPa	Cohesive Till
Column 27	336.32854 m	564.94628 m	64.731027 kPa	190.83717 kPa	64.254289 kPa	0 kPa	0 kPa	Cohesive Till
Column 28	331.81861 m	563.32358 m	66.999629 kPa	200.55542 kPa	68.050075 kPa	0 kPa	0 kPa	Cohesive Till
Column 29	329.04199 m	562.40105 m	68.167624 kPa	206.2089 kPa	70.335544 kPa	0 kPa	0 kPa	Cohesive Till
Column 30	325.76977 m	561.46984 m	69.077809 kPa	211.75247 kPa	72.696369 kPa	0 kPa	0 kPa	Cohesive Till
Column 31	322.51887 m	560.57565 m	69.889569 kPa	217.19673 kPa	75.056745 kPa	0 kPa	0 kPa	Cohesive Till
Column 32	320.05126 m	560.00332 m	70.18766 kPa	220.6126 kPa	76.645337 kPa	0 kPa	0 kPa	Cohesive Till
Column 33	316.11671 m	559.17716 m	70.404648 kPa	225.53422 kPa	79.042467 kPa	0 kPa	0 kPa	Cohesive Till
Column 34	311.64226 m	558.41319 m	70.126664 kPa	229.86674 kPa	81.391636 kPa	0 kPa	0 kPa	Cohesive Till
Column 35	306.62791 m	557.75004 m	69.238201 kPa	233.1813 kPa	83.533179 kPa	0 kPa	0 kPa	Cohesive Till
Column 36	303.76476 m	557.44127 m	68.522032 kPa	234.43669 kPa	84.537738 kPa	0 kPa	0 kPa	Cohesive Till
Column 37	301.22970 m	557.26783 m	67.589125 kPa	234.46087 kPa	85.0254 kPa	0 kPa	0 kPa	Cohesive Till
Column 38	296.87151 m	557.06191 m	65.709603 kPa	233.48681 kPa	85.486759 kPa	0 kPa	0 kPa	Cohesive Till
Column 39	292.61565 m	557.01170 m	63.423209 kPa	171.00303 kPa	54.814657 kPa	0 kPa	0 kPa	Cohesive Till
Column 40	288.38761 m	557.11414 m	60.696451 kPa	167.85669 kPa	54.600866 kPa	0 kPa	0 kPa	Cohesive Till
Column 41	284.08506 m	557.37011 m	57.468083 kPa	163.21187 kPa	53.879151 kPa	0 kPa	0 kPa	Cohesive Till
Column 42	279.78251 m	557.78148 m	53.775217 kPa	157.01518 kPa	52.603388 kPa	0 kPa	0 kPa	Cohesive Till
Column 43	276.25389 m	558.22424 m	50.431592 kPa	150.81531 kPa	51.148058 kPa	0 kPa	0 kPa	Cohesive Till
Column 44	273.27202 m	558.69429 m	47.319393 kPa	144.60801 kPa	49.571027 kPa	0 kPa	0 kPa	Cohesive Till
Column 45	271.63181 m	558.97284 m	45.547749 kPa	140.95338 kPa	48.611598 kPa	0 kPa	0 kPa	Cohesive Till
Column 46	271.45054 m	559.00639 m	45.365389 kPa	140.55378 kPa	48.500908 kPa	0 kPa	0 kPa	Cohesive Till
Column 47	269.46358 m	559.40688 m	43.326649 kPa	136.09456 kPa	47.267613 kPa	0 kPa	0 kPa	Cohesive Till
Column 48	266.78888 m	559.96924 m	40.512789 kPa	129.84139 kPa	45.515194 kPa	0 kPa	0 kPa	Cohesive Till
Column 49	264.01493 m	560.64656 m	37.313253 kPa	122.47427 kPa	43.391703 kPa	0 kPa	0 kPa	Cohesive Till
Column 50	258.75574 m	562.13269 m	30.64343 kPa	106.57174 kPa	38.687405 kPa	0 kPa	0 kPa	Cohesive Till
Column 51	255.42610 m	563.13402 m	26.240001 kPa	89.888525 kPa	32.430542 kPa	0 kPa	0 kPa	Cohesive Till
Column 52	254.81135 m	563.34200 m	25.357928 kPa	85.922222 kPa	30.859049 kPa	0 kPa	0 kPa	Cohesive Till
Column 53	253.07251 m	563.94996 m	22.804152 kPa	74.434517 kPa	26.306985 kPa	0 kPa	0 kPa	Cohesive Till
Column 54	251.30454 m	564.58983 m	20.142639 kPa	62.968178 kPa	21.820702 kPa	0 kPa	0 kPa	Cohesive Till
Column 55	250.54667 m	564.87370 m	18.9731 kPa	58.724181 kPa	20.254188 kPa	0 kPa	0 kPa	Cohesive Till
Column 56	250.01927 m	565.07679 m	18.19435 kPa	57.234934 kPa	19.892171 kPa	0 kPa	0 kPa	Cohesive Till
Column 57	248.64378 m	565.62206 m	16.158657 kPa	56.660306 kPa	20.636621 kPa	0 kPa	0 kPa	Cohesive Till
Column 58	245.46405 m	566.97017 m	11.190876 kPa	48.277193 kPa	18.896422 kPa	0 kPa	0 kPa	Cohesive Till
Column 59	241.05096 m	568.99455 m	3.8377301 kPa	29.699697 kPa	13.17733 kPa	0 kPa	0 kPa	Cohesive Till
Column 60	237.82238 m	570.59277 m	-1.8920976 kPa	15.134449 kPa	7.7113869 kPa	0 kPa	0 kPa	Cohesive Till
Column 61	236.54692 m	571.26072 m	-4.265002 kPa	9.1303636 kPa	4.6521526 kPa	0 kPa	0 kPa	Cohesive Till
Column 62	235.32266 m	571.93146 m	-6.362685 kPa	4.0466161 kPa	2.0618539 kPa	0 kPa	0 kPa	Cohesive Till



ULS C2

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File Information

File Version: 11.05
Created By: Laura Castro
Last Edited By: Laura Castro
Revision Number: 82
Date: 02/08/2024
Time: 23:59:55
Tool Version: 23.1.2.11
File Name: Till 1 in 3- 7m with piezometric line.gsz
Directory: C:\Users\CAS111646\OneDrive - Mott MacDonald\Desktop\Knocknagael\Slope stability analysis\Earth bund\
Last Solved Date: 03/08/2024
Last Solved Time: 00:01:22

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

ULS C2

Kind: SLOPE/W
Analysis Type: Morgenstern-Price
Settings
 Side Function
 Intercolumn force function option: Half-Sine
 PWP Conditions from: Piezometric Surfaces
 Apply Phreatic Correction: No
 Use Staged Rapid Drawdown: No
 Limit State Design Approach: Eurocode 7 - DA1, C2
 Unit Weight of Water: 9.807 kN/m³
Slip Surface
 Direction of movement: Right to Left
 Use Passive Mode: No
 Slip Surface Option: Grid and Radius
 Critical slip surfaces saved: 1
 Optimize Critical Slip Surface Location: No
 Tension Crack Option: (none)
Distribution
 ODF Calculation Option: Constant
Convergence
 Geometry Settings
 Minimum Slip Surface Depth: 0.5 m
 Minimum Slip Surface Volume: 1 m³
 Number of Columns: 30
 Overdesign Factor Convergence Settings
 Maximum Number of Iterations: 100
 Tolerable difference in ODF: 0.001
 Under-Relaxation Criteria
 Initial Rate: 1
 Minimum Rate: 0.1
 Rate Reduction Factor: 0.65
 Reduction Frequency (iterations): 50
 Solution Settings
 Search Method: Root Finder
 Tolerable difference between starting and converged ODF: 3
 Maximum iterations to calculate converged lambda: 20
 Max Absolute Lambda: 2

Materials

Cohesive Till

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 21 kN/m³
Effective Cohesion: 0 kPa
Effective Friction Angle: 27 °
Phi-B: 0 °
Pore Water Pressure
 Piezometric Surface: 1

Slip Surface Grid

Upper Left: (50.51875, 214.72425) m
Lower Left: (31.877499, 189.6475) m
Lower Right: (140.063, 197.4145) m
Grid Horizontal Increment: 25
Grid Vertical Increment: 30

Slip Surface Radius

Upper Left Coordinate: (66.537998, 174.163) m
Upper Right Coordinate: (148.2165, 189.18875) m
Lower Left Coordinate: (66.537998, 156.31175) m
Lower Right Coordinate: (148.2165, 156.31175) m
Number of Increments: 25
Use Left Projection: No
Left Projection Angle: 135 °
Use Right Projection: No
Right Projection Angle: 45 °

Slip Surface Limits

Left Coordinate: (23.511751, 174.37725) m
Right Coordinate: (231.72725, 186.975) m

Piezometric Surfaces

Piezometric Surface 1

Coordinates

	X	Y
Coordinate 1	23.511751 m	173.37775 m
Coordinate 2	72.02225 m	173.57675 m
Coordinate 3	76.328501 m	173.97875 m
Coordinate 4	82.7825 m	175.01725 m
Coordinate 5	108.68775 m	179.97875 m
Coordinate 6	113.128 m	181.03675 m
Coordinate 7	114.299 m	181.03675 m
Coordinate 8	115.7725 m	181.03675 m
Coordinate 9	124.25925 m	182.085 m
Coordinate 10	126.767 m	182.37025 m
Coordinate 11	132.54275 m	182.37025 m
Coordinate 12	144.738 m	182.76675 m
Coordinate 13	154.1835 m	183.1275 m
Coordinate 14	168.21275 m	184.08625 m
Coordinate 15	173.9545 m	184.96775 m
Coordinate 16	180.105 m	185.828 m
Coordinate 17	183.877 m	186.11425 m
Coordinate 18	231.70882 m	185.55675 m

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 10 kN/m³
Direction: Vertical
Mode: Permanent

Coordinates

	X	Y
	77.857249 m	175.84225 m
	82.804251 m	176.5385 m
	92.695999 m	178.4335 m
	100.133 m	179.7475 m
	103.9505 m	180.3685 m
	112.14275 m	182.22325 m
	112.937 m	182.3775 m
	114.472 m	182.47825 m
	115.30225 m	182.47825 m
	119.37625 m	182.886 m
	123.99725 m	183.411 m
	126.1645 m	183.578 m
	128.375 m	183.578 m
	133.479 m	183.86825 m
	144.9805 m	184.2175 m
	148.8755 m	184.2175 m
	150.437 m	184.3255 m
	153.85275 m	184.5305 m
	163.08175 m	185.31775 m
	169.33725 m	185.74925 m
	176.91825 m	187.14925 m
	182.50825 m	187.68625 m
	231.75475 m	187.50375 m

Design Factor Set: Eurocode 7 - DA1, C2

Permanent Point Loads & Surcharge Loads: Favorable = 1, Unfavorable = 1

Variable Point Loads & Surcharge Loads: Favorable = 0, Unfavorable = 1.3
Soil Unit Weight: Favorable = 1, Unfavorable = 1
Effective Cohesion: 1.4
Effective Coefficient of Friction: 1.25
Undrained Strength: 1.4
Shear Strength (Other Models): 1.25
Pullout Resistance: 1.1
Shear Force: 1.1
Tensile Strength: 1.1
Compressive Strength: 1.1
Seismic Coefficients: 1
Earth Resistance: 1

Geometry

Name: 2D Geometry

Settings

View: 2D
Element Thickness: 0.3048 m

Points

	X	Y
Point 1	65.099751 m	174.48775 m
Point 2	72.17675 m	174.48775 m
Point 3	76.083249 m	174.592 m
Point 4	76.404749 m	174.592 m
Point 5	76.790501 m	174.768 m
Point 6	77.482501 m	175.14275 m
Point 7	79.88025 m	175.277 m
Point 8	81.063249 m	175.32875 m
Point 9	81.57125 m	175.20875 m
Point 10	84.621999 m	175.20875 m
Point 11	88.556251 m	176.02625 m
Point 12	89.82225 m	176.29425 m
Point 13	92.478999 m	176.60275 m
Point 14	95.752749 m	177.413 m
Point 15	98.151251 m	177.413 m
Point 16	98.456249 m	177.2995 m
Point 17	100.451 m	177.2995 m
Point 18	107.09925 m	178.44625 m
Point 19	107.5495 m	178.44625 m
Point 20	108.09675 m	178.376 m
Point 21	109.4745 m	178.0295 m
Point 22	110.40375 m	177.7965 m
Point 23	111.20575 m	177.6315 m
Point 24	111.4265 m	177.6715 m
Point 25	112.0235 m	177.74725 m
Point 26	113.88975 m	177.96275 m
Point 27	115.137 m	178.10475 m
Point 28	116.855 m	177.9615 m
Point 29	117.5775 m	177.911 m
Point 30	119.14125 m	177.911 m
Point 31	121.35075 m	177.50325 m
Point 32	123.9915 m	177.25575 m
Point 33	124.5835 m	177.20375 m
Point 34	125.0825 m	177.1485 m
Point 35	125.8675 m	177.05925 m
Point 36	126.1485 m	177.02475 m
Point 37	126.3855 m	177.02475 m
Point 38	127.1585 m	177.02475 m
Point 39	127.455 m	177.05125 m
Point 40	128.67575 m	177.15475 m
Point 41	130.3785 m	177.297 m
Point 42	130.93025 m	177.297 m
Point 43	132.34725 m	176.877 m
Point 44	139.22375 m	176.877 m
Point 45	145.087 m	176.877 m
Point 46	145.5985 m	176.72525 m
Point 47	146.67375 m	176.72525 m
Point 48	148.568 m	176.87425 m
Point 49	149.663 m	176.95525 m
Point 50	152.291 m	177.08325 m
Point 51	154.14725 m	177.16575 m
Point 52	158.67325 m	178.04375 m
Point 53	163.142 m	179.09075 m
Point 54	164.49 m	179.52875 m
Point 55	166.673 m	179.66575 m
Point 56	170.615 m	179.81175 m
Point 57	174.5425 m	180.07225 m

Point 58	176.931 m	180.2235 m
Point 59	178.71025 m	180.33725 m
Point 60	180.38625 m	180.436 m
Point 61	181.59025 m	180.436 m
Point 62	188.54025 m	180.436 m
Point 63	194.36275 m	180.66825 m
Point 64	200.26475 m	181.1245 m
Point 65	203.531 m	181.4065 m
Point 66	204.0745 m	181.44725 m
Point 67	205.32825 m	181.44725 m
Point 68	211.22875 m	181.44725 m
Point 69	219.44675 m	180.634 m
Point 70	220.73025 m	180.52925 m
Point 71	223.526 m	180.52925 m
Point 72	226.0465 m	180.83925 m
Point 73	226.66925 m	180.93725 m
Point 74	229.69425 m	181.07125 m
Point 75	230.50475 m	181.1075 m
Point 76	231.651 m	181.1075 m
Point 77	231.651 m	153.8075 m
Point 78	23.511751 m	153.8075 m
Point 79	23.511751 m	174.37725 m
Point 80	77.850501 m	175.34125 m
Point 81	82.693749 m	176.02025 m
Point 82	103.20025 m	179.6745 m
Point 83	112.611 m	181.675 m
Point 84	112.99375 m	181.77025 m
Point 85	113.6425 m	181.77025 m
Point 86	114.08375 m	181.77025 m
Point 87	115.192 m	181.88875 m
Point 88	117.47675 m	182.1555 m
Point 89	119.3455 m	182.367 m
Point 90	124.097 m	182.918 m
Point 91	126.166 m	183.0895 m
Point 92	128.33 m	183.0895 m
Point 93	133.396 m	183.2805 m
Point 94	136.57275 m	183.38975 m
Point 95	144.7355 m	183.68525 m
Point 96	146.721 m	183.68525 m
Point 97	148.88525 m	183.77025 m
Point 98	150.31575 m	183.864 m
Point 99	153.5605 m	184.05425 m
Point 100	162.3055 m	184.6565 m
Point 101	169.026 m	185.1205 m
Point 102	171.5865 m	185.498 m
Point 103	176.931 m	186.45625 m
Point 104	182.45875 m	186.975 m
Point 105	231.72725 m	186.975 m
Point 106	75.489999 m	174.8707 m

Regions

	Material	Poin
Region 1	Cohesive Till	1,79,78,77,76,75,74,73,72,71,70,69,68,67,66,65,64,63,62,61,60,59,58,57,56,55,54,53,52,51,50,49,48,47,46,45,44,43,42,41,40,39,38,37,36,35,34,33,32,
Region 2	Cohesive Till	6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50,51,52,53,54,55,5

Slip Results

Slip Surfaces Analysed: 16162 of 20956 converged

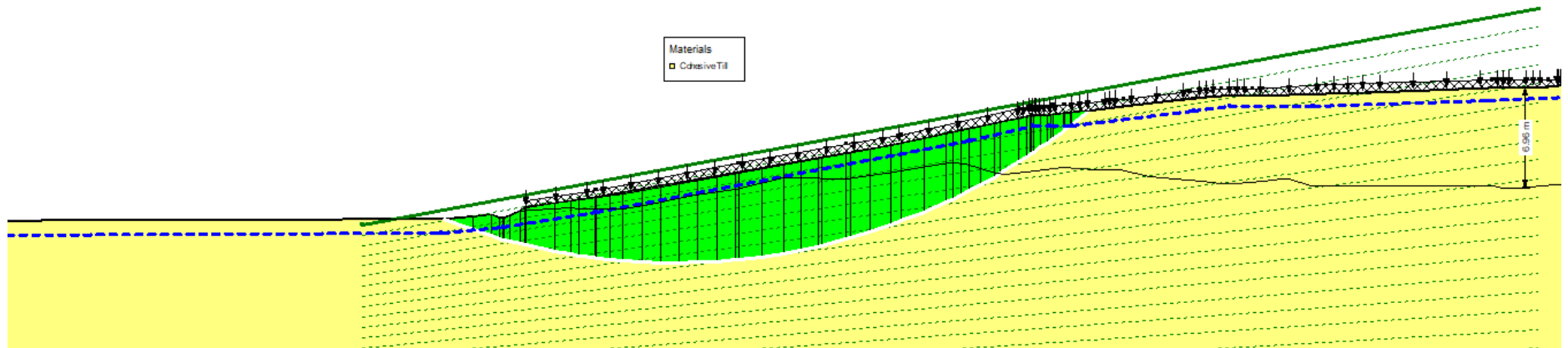
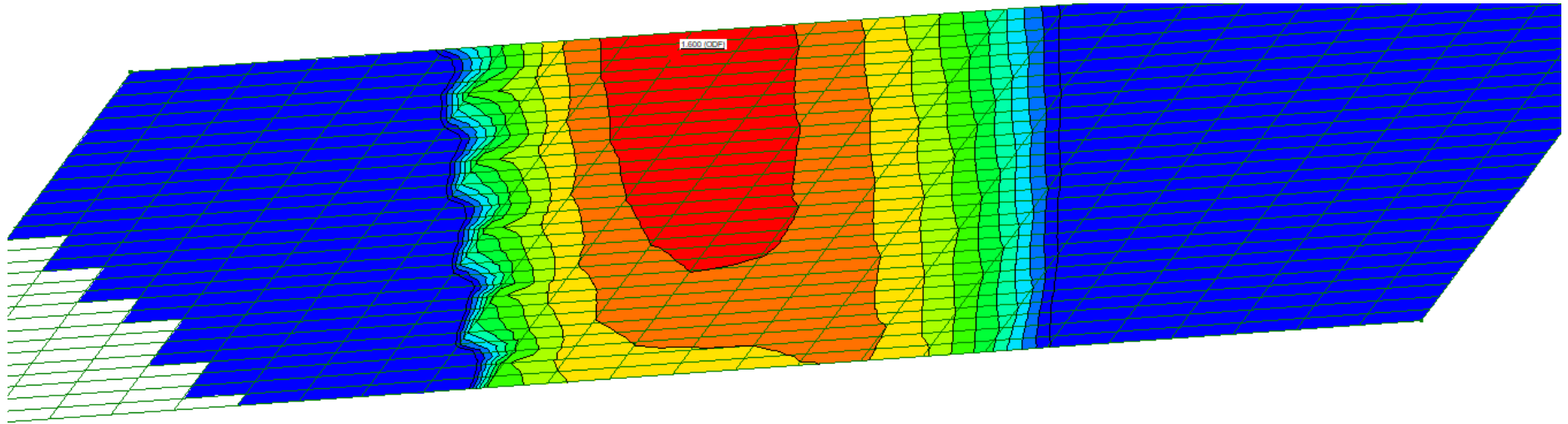
Current Slip Surface

Slip Surface: 19,171
Overdesign Factor: 1.600
Degree of Utilization: 0.625
Volume: 57.301142 m³
Weight: 1,203.324 kN
Resisting Moment: 14,999.928 kN·m
Activating Moment: 9,375.095 kN·m
Resisting Force: 324.13752 kN
Activating Force: 202.63304 kN
Slip Rank: 1 of 20,956 slip surfaces
Exit: (116.97801, 182.09727) m
Entry: (72.229135, 174.4938) m
Radius: 44.339766 m
Center: (88.22278, 215.84859) m

Slip Columns

	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength	Suction Strength	Base Material
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Column 1	381.80859 m	595.80636 m	-4.8110951 kPa	11.937677 kPa	4.8660402 kPa	0 kPa	0 kPa	Cohesive Till
Column 2	379.68682 m	594.06665 m	-0.34095928 kPa	19.893083 kPa	8.1088257 kPa	0 kPa	0 kPa	Cohesive Till
Column 3	378.91541 m	593.46336 m	1.4623905 kPa	22.862604 kPa	8.7231629 kPa	0 kPa	0 kPa	Cohesive Till
Column 4	378.10737 m	592.83510 m	3.3403864 kPa	26.050167 kPa	9.2569691 kPa	0 kPa	0 kPa	Cohesive Till
Column 5	376.74541 m	591.80988 m	6.4049346 kPa	31.496974 kPa	10.228026 kPa	0 kPa	0 kPa	Cohesive Till
Column 6	375.28051 m	590.71630 m	9.6738452 kPa	37.255418 kPa	11.24281 kPa	0 kPa	0 kPa	Cohesive Till
Column 7	374.64362 m	590.25375 m	11.056468 kPa	39.590563 kPa	11.631078 kPa	0 kPa	0 kPa	Cohesive Till
Column 8	373.56669 m	589.48555 m	13.352771 kPa	43.634402 kPa	12.343409 kPa	0 kPa	0 kPa	Cohesive Till
Column 9	371.99885 m	588.39076 m	16.625287 kPa	49.576311 kPa	13.431508 kPa	0 kPa	0 kPa	Cohesive Till
Column 10	370.93463 m	587.66011 m	18.652471 kPa	53.513905 kPa	14.21023 kPa	0 kPa	0 kPa	Cohesive Till
Column 11	370.62131 m	587.44858 m	19.061602 kPa	54.720836 kPa	14.53543 kPa	0 kPa	0 kPa	Cohesive Till
Column 12	369.99344 m	587.03038 m	19.864485 kPa	56.311807 kPa	14.85667 kPa	0 kPa	0 kPa	Cohesive Till
Column 13	368.69054 m	586.17579 m	21.491011 kPa	59.507747 kPa	15.496396 kPa	0 kPa	0 kPa	Cohesive Till
Column 14	365.77663 m	584.35389 m	24.861571 kPa	66.201108 kPa	16.850837 kPa	0 kPa	0 kPa	Cohesive Till
Column 15	362.92394 m	582.61724 m	28.020902 kPa	72.472282 kPa	18.119287 kPa	0 kPa	0 kPa	Cohesive Till
Column 16	360.69267 m	581.34710 m	30.228363 kPa	76.913062 kPa	19.029634 kPa	0 kPa	0 kPa	Cohesive Till
Column 17	357.87771 m	579.80264 m	32.840069 kPa	82.247837 kPa	20.139612 kPa	0 kPa	0 kPa	Cohesive Till
Column 18	355.61762 m	578.61937 m	34.902822 kPa	86.275894 kPa	20.94071 kPa	0 kPa	0 kPa	Cohesive Till
Column 19	353.75041 m	577.68172 m	36.636625 kPa	89.428667 kPa	21.519111 kPa	0 kPa	0 kPa	Cohesive Till
Column 20	352.11409 m	576.88671 m	38.076262 kPa	92.069738 kPa	22.00884 kPa	0 kPa	0 kPa	Cohesive Till
Column 21	348.79285 m	575.37981 m	40.67923 kPa	96.917832 kPa	22.923999 kPa	0 kPa	0 kPa	Cohesive Till
Column 22	343.62759 m	573.18877 m	44.271512 kPa	103.83828 kPa	24.280626 kPa	0 kPa	0 kPa	Cohesive Till
Column 23	339.81423 m	571.69778 m	46.545193 kPa	108.64381 kPa	25.312661 kPa	0 kPa	0 kPa	Cohesive Till
Column 24	336.32854 m	570.47570 m	48.202646 kPa	113.00918 kPa	26.416462 kPa	0 kPa	0 kPa	Cohesive Till
Column 25	331.81861 m	569.02116 m	49.968569 kPa	118.3575 kPa	27.876722 kPa	0 kPa	0 kPa	Cohesive Till
Column 26	329.04199 m	568.18688 m	50.872753 kPa	121.41384 kPa	28.753982 kPa	0 kPa	0 kPa	Cohesive Till
Column 27	325.76977 m	567.32987 m	51.561155 kPa	124.27872 kPa	29.64116 kPa	0 kPa	0 kPa	Cohesive Till
Column 28	322.51887 m	566.50362 m	52.169838 kPa	127.0492 kPa	30.522354 kPa	0 kPa	0 kPa	Cohesive Till
Column 29	320.05126 m	565.96338 m	52.371992 kPa	128.69416 kPa	31.110468 kPa	0 kPa	0 kPa	Cohesive Till
Column 30	316.11671 m	565.17301 m	52.482025 kPa	130.96579 kPa	31.991581 kPa	0 kPa	0 kPa	Cohesive Till
Column 31	311.64226 m	564.41889 m	52.174573 kPa	132.74282 kPa	32.841259 kPa	0 kPa	0 kPa	Cohesive Till
Column 32	306.62791 m	563.73345 m	51.352759 kPa	133.77187 kPa	33.595706 kPa	0 kPa	0 kPa	Cohesive Till
Column 33	303.76476 m	563.39996 m	50.710472 kPa	133.9661 kPa	33.936688 kPa	0 kPa	0 kPa	Cohesive Till
Column 34	301.22970 m	563.18761 m	49.893886 kPa	133.46956 kPa	34.067146 kPa	0 kPa	0 kPa	Cohesive Till
Column 35	296.87151 m	562.89907 m	48.261317 kPa	132.02519 kPa	34.143859 kPa	0 kPa	0 kPa	Cohesive Till
Column 36	292.61565 m	562.74238 m	46.293201 kPa	129.62898 kPa	33.969358 kPa	0 kPa	0 kPa	Cohesive Till
Column 37	288.38761 m	562.71274 m	43.961259 kPa	126.20062 kPa	33.522439 kPa	0 kPa	0 kPa	Cohesive Till
Column 38	284.08506 m	562.80770 m	41.214191 kPa	121.61682 kPa	32.773749 kPa	0 kPa	0 kPa	Cohesive Till
Column 39	279.78251 m	563.03024 m	38.085752 kPa	115.881 kPa	31.710926 kPa	0 kPa	0 kPa	Cohesive Till
Column 40	276.25389 m	563.29888 m	35.262612 kPa	110.36621 kPa	30.613755 kPa	0 kPa	0 kPa	Cohesive Till
Column 41	273.27202 m	563.60380 m	32.644022 kPa	105.00645 kPa	29.496399 kPa	0 kPa	0 kPa	Cohesive Till
Column 42	271.63181 m	563.78771 m	31.155267 kPa	101.89421 kPa	28.834632 kPa	0 kPa	0 kPa	Cohesive Till
Column 43	271.45054 m	563.81026 m	30.997407 kPa	101.5614 kPa	28.763318 kPa	0 kPa	0 kPa	Cohesive Till
Column 44	269.46358 m	564.08377 m	29.224141 kPa	97.912472 kPa	27.998762 kPa	0 kPa	0 kPa	Cohesive Till
Column 45	266.78888 m	564.47053 m	26.781583 kPa	92.858476 kPa	26.934287 kPa	0 kPa	0 kPa	Cohesive Till
Column 46	264.01493 m	564.94649 m	24.024613 kPa	86.991543 kPa	25.666602 kPa	0 kPa	0 kPa	Cohesive Till
Column 47	258.75574 m	566.00749 m	18.32354 kPa	74.528427 kPa	22.910256 kPa	0 kPa	0 kPa	Cohesive Till
Column 48	255.42610 m	566.72657 m	14.572586 kPa	60.57195 kPa	18.750277 kPa	0 kPa	0 kPa	Cohesive Till
Column 49	254.81135 m	566.87721 m	13.826615 kPa	57.195735 kPa	17.678136 kPa	0 kPa	0 kPa	Cohesive Till
Column 50	253.07251 m	567.31833 m	11.671661 kPa	47.435346 kPa	14.578006 kPa	0 kPa	0 kPa	Cohesive Till
Column 51	251.30454 m	567.78340 m	9.4311191 kPa	37.769534 kPa	11.551315 kPa	0 kPa	0 kPa	Cohesive Till
Column 52	250.54667 m	567.99004 m	8.4489296 kPa	34.281286 kPa	10.529794 kPa	0 kPa	0 kPa	Cohesive Till
Column 53	250.01927 m	568.13802 m	7.8341535 kPa	33.249201 kPa	10.359691 kPa	0 kPa	0 kPa	Cohesive Till
Column 54	248.64378 m	568.53567 m	6.2616884 kPa	33.719009 kPa	11.192163 kPa	0 kPa	0 kPa	Cohesive Till
Column 55	245.57208 m	569.48392 m	2.5700428 kPa	28.614571 kPa	10.61628 kPa	0 kPa	0 kPa	Cohesive Till
Column 56	240.22290 m	571.31702 m	-4.4020679 kPa	11.116382 kPa	4.5312636 kPa	0 kPa	0 kPa	Cohesive Till



SLS Undrained

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File Information

File Version: 11.05
Created By: Laura Castro
Last Edited By: Laura Castro
Revision Number: 82
Date: 02/08/2024
Time: 23:59:55
Tool Version: 23.1.2.11
File Name: Till 1 in 3- 7m with piezometric line.gsz
Directory: C:\Users\CAS111646\OneDrive - Mott MacDonald\Desktop\Knocknagael\Slope stability analysis\Earth bund\
Last Solved Date: 03/08/2024
Last Solved Time: 00:02:50

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

SLS Undrained

Kind: SLOPE/W
Analysis Type: Morgenstern-Price
Settings
 Side Function
 Intercolumn force function option: Half-Sine
 PWP Conditions from: Piezometric Surfaces
 Apply Phreatic Correction: No
 Use Staged Rapid Drawdown: No
 Unit Weight of Water: 9.807 kN/m³
Slip Surface
 Direction of movement: Right to Left
 Use Passive Mode: No
 Slip Surface Option: Grid and Radius
 Critical slip surfaces saved: 1
 Optimize Critical Slip Surface Location: No
 Tension Crack Option: (none)
Distribution
 F of S Calculation Option: Constant
Convergence
 Geometry Settings
 Minimum Slip Surface Depth: 0.5 m
 Minimum Slip Surface Volume: 1 m³
 Number of Columns: 30
 Factor of Safety Convergence Settings
 Maximum Number of Iterations: 100
 Tolerable difference in F of S: 0.001
 Under-Relaxation Criteria
 Initial Rate: 1
 Minimum Rate: 0.1
 Rate Reduction Factor: 0.65
 Reduction Frequency (iterations): 50
 Solution Settings
 Search Method: Root Finder
 Tolerable difference between starting and converged F of S: 3
 Maximum iterations to calculate converged lambda: 20
 Max Absolute Lambda: 2

Materials

Cohesive Till Undrained

Slope Stability Material Model: S=f(depth)
Unit Weight: 21 kN/m³
C-Top of Layer: 40 kPa
C-Rate of Change: 3.5 (kN/m²)/m
C-Maximum: 110 kPa
Pore Water Pressure
 Piezometric Surface: 1

Slip Surface Grid

Upper Left: (50.51875, 214.72425) m
Lower Left: (31.877499, 189.6475) m
Lower Right: (140.063, 197.4145) m
Grid Horizontal Increment: 25
Grid Vertical Increment: 30

Slip Surface Radius

Upper Left Coordinate: (66.537998, 174.163) m
Upper Right Coordinate: (148.2165, 189.18875) m
Lower Left Coordinate: (66.537998, 156.31175) m
Lower Right Coordinate: (148.2165, 156.31175) m
Number of Increments: 25
Use Left Projection: No
Left Projection Angle: 135 °
Use Right Projection: No
Right Projection Angle: 45 °

Slip Surface Limits

Left Coordinate: (23.511751, 174.37725) m
Right Coordinate: (231.72725, 186.975) m

Piezometric Surfaces

Piezometric Surface 1

Coordinates

	X	Y
Coordinate 1	23.511751 m	173.37775 m
Coordinate 2	72.087267 m	173.7085 m
Coordinate 3	76.230751 m	174.18775 m
Coordinate 4	82.7825 m	175.01725 m
Coordinate 5	108.68775 m	179.97875 m
Coordinate 6	113.128 m	181.03675 m
Coordinate 7	114.299 m	181.03675 m
Coordinate 8	115.7725 m	181.03675 m
Coordinate 9	124.25925 m	182.085 m
Coordinate 10	126.767 m	182.37025 m
Coordinate 11	132.54275 m	182.37025 m
Coordinate 12	144.738 m	182.76675 m
Coordinate 13	154.1835 m	183.1275 m
Coordinate 14	168.21275 m	184.08625 m
Coordinate 15	173.9545 m	184.96775 m
Coordinate 16	180.105 m	185.828 m
Coordinate 17	183.877 m	186.11425 m
Coordinate 18	231.70882 m	185.55675 m

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 10 kN/m³
Direction: Vertical

Coordinates

	X	Y
	77.857249 m	175.84225 m
	82.804251 m	176.5385 m
	92.695999 m	178.4335 m
	100.133 m	179.7475 m
	103.9505 m	180.3685 m
	112.14275 m	182.22325 m
	112.937 m	182.3775 m
	114.472 m	182.47825 m
	115.30225 m	182.47825 m
	119.37625 m	182.886 m
	123.99725 m	183.411 m
	126.1645 m	183.578 m
	128.375 m	183.578 m
	133.479 m	183.86825 m
	144.9805 m	184.2175 m
	148.8755 m	184.2175 m
	150.437 m	184.3255 m
	153.85275 m	184.5305 m
	163.08175 m	185.31775 m
	169.33725 m	185.74925 m
	176.91825 m	187.14925 m
	182.50825 m	187.68625 m
	231.75475 m	187.50375 m

Geometry

Name: 2D Geometry

Settings

View: 2D
Element Thickness: 0.3048 m

Points

	X	Y
Point 1	65.099751 m	174.48775 m
Point 2	72.17675 m	174.48775 m
Point 3	76.083249 m	174.592 m
Point 4	76.404749 m	174.592 m
Point 5	76.790501 m	174.768 m
Point 6	77.482501 m	175.14275 m
Point 7	79.88025 m	175.277 m
Point 8	81.063249 m	175.32875 m
Point 9	81.57125 m	175.20875 m
Point 10	84.621999 m	175.20875 m
Point 11	88.556251 m	176.02625 m
Point 12	89.82225 m	176.29425 m
Point 13	92.478999 m	176.60275 m
Point 14	95.752749 m	177.413 m
Point 15	98.151251 m	177.413 m
Point 16	98.456249 m	177.2995 m
Point 17	100.451 m	177.2995 m
Point 18	107.09925 m	178.44625 m
Point 19	107.5495 m	178.44625 m
Point 20	108.09675 m	178.376 m
Point 21	109.4745 m	178.0295 m
Point 22	110.40375 m	177.7965 m
Point 23	111.20575 m	177.6315 m
Point 24	111.4265 m	177.6715 m
Point 25	112.0235 m	177.74725 m
Point 26	113.88975 m	177.96275 m
Point 27	115.137 m	178.10475 m
Point 28	116.855 m	177.9615 m
Point 29	117.5775 m	177.911 m
Point 30	119.14125 m	177.911 m
Point 31	121.35075 m	177.50325 m
Point 32	123.9915 m	177.25575 m
Point 33	124.5835 m	177.20375 m
Point 34	125.0825 m	177.1485 m
Point 35	125.8675 m	177.05925 m
Point 36	126.1485 m	177.02475 m
Point 37	126.3855 m	177.02475 m
Point 38	127.1585 m	177.02475 m
Point 39	127.455 m	177.05125 m
Point 40	128.67575 m	177.15475 m
Point 41	130.3785 m	177.297 m
Point 42	130.93025 m	177.297 m
Point 43	132.34725 m	176.877 m
Point 44	139.22375 m	176.877 m
Point 45	145.087 m	176.877 m
Point 46	145.5985 m	176.72525 m
Point 47	146.67375 m	176.72525 m
Point 48	148.568 m	176.87425 m
Point 49	149.663 m	176.95525 m
Point 50	152.291 m	177.08325 m
Point 51	154.14725 m	177.16575 m
Point 52	158.67325 m	178.04375 m
Point 53	163.142 m	179.09075 m
Point 54	164.49 m	179.52875 m
Point 55	166.673 m	179.66575 m
Point 56	170.615 m	179.81175 m
Point 57	174.5425 m	180.07225 m
Point 58	176.931 m	180.2235 m
Point 59	178.71025 m	180.33725 m
Point 60	180.38625 m	180.436 m
Point 61	181.59025 m	180.436 m
Point 62	188.54025 m	180.436 m
Point 63	194.36275 m	180.66825 m
Point 64	200.26475 m	181.1245 m
Point 65	203.531 m	181.4065 m
Point 66	204.0745 m	181.44725 m
Point 67	205.32825 m	181.44725 m
Point 68	211.22875 m	181.44725 m
Point 69	219.44675 m	180.634 m
Point 70	220.73025 m	180.52925 m
Point 71	223.526 m	180.52925 m
Point 72	226.0465 m	180.83925 m
Point 73	226.66925 m	180.93725 m

Point 74	229.69425 m	181.07125 m
Point 75	230.50475 m	181.1075 m
Point 76	231.651 m	181.1075 m
Point 77	231.651 m	153.8075 m
Point 78	23.511751 m	153.8075 m
Point 79	23.511751 m	174.37725 m
Point 80	77.850501 m	175.34125 m
Point 81	82.693749 m	176.02025 m
Point 82	103.20025 m	179.6745 m
Point 83	112.611 m	181.675 m
Point 84	112.99375 m	181.77025 m
Point 85	113.6425 m	181.77025 m
Point 86	114.08375 m	181.77025 m
Point 87	115.192 m	181.88875 m
Point 88	117.47675 m	182.1555 m
Point 89	119.3455 m	182.367 m
Point 90	124.097 m	182.918 m
Point 91	126.166 m	183.0895 m
Point 92	128.33 m	183.0895 m
Point 93	133.396 m	183.2805 m
Point 94	136.57275 m	183.38975 m
Point 95	144.7355 m	183.68525 m
Point 96	146.721 m	183.68525 m
Point 97	148.88525 m	183.77025 m
Point 98	150.31575 m	183.864 m
Point 99	153.5605 m	184.05425 m
Point 100	162.3055 m	184.6565 m
Point 101	169.026 m	185.1205 m
Point 102	171.5865 m	185.498 m
Point 103	176.931 m	186.45625 m
Point 104	182.45875 m	186.975 m
Point 105	231.72725 m	186.975 m
Point 106	75.489999 m	174.8707 m

Regions

	Material	Po
Region 1	Cohesiva Till Undrained	1,79,78,77,76,75,74,73,72,71,70,69,68,67,66,65,64,63,62,61,60,59,58,57,56,55,54,53,52,51,50,49,48,47,46,45,44,43,42,41,40,39,38,37,36,35,34,33,32,31,30,29,28,27,26,25,24,23,22,21,20,19,18,17,16,15,14,13,12,11,10,9,8,7,6,5,4,3,2,1
Region 2	Cohesiva Till Undrained	6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50,51,52,53,54,55

Slip Results

Slip Surfaces Analysed: 15611 of 20956 converged

Current Slip Surface

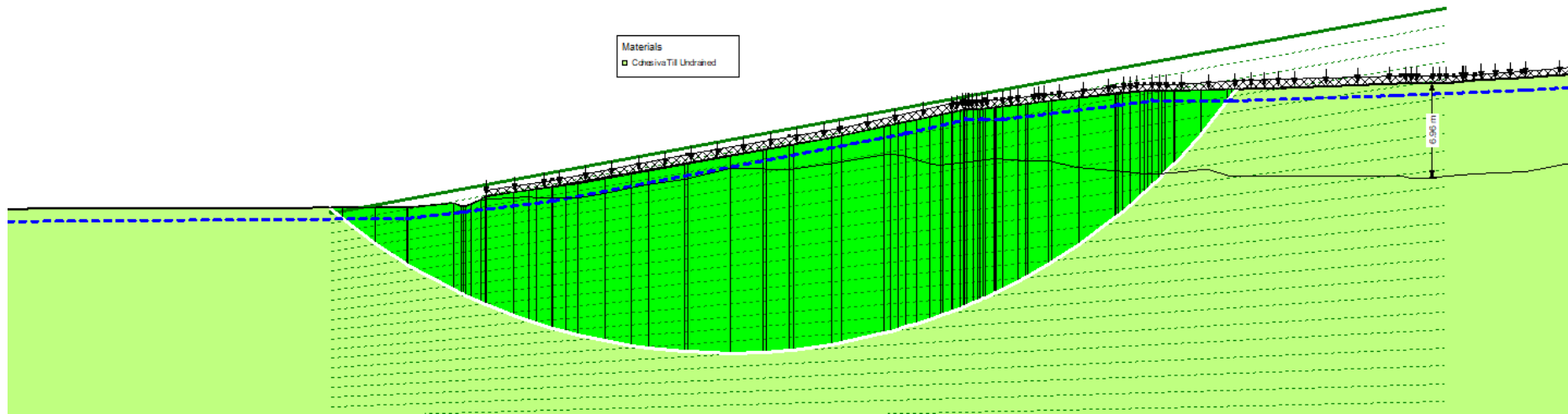
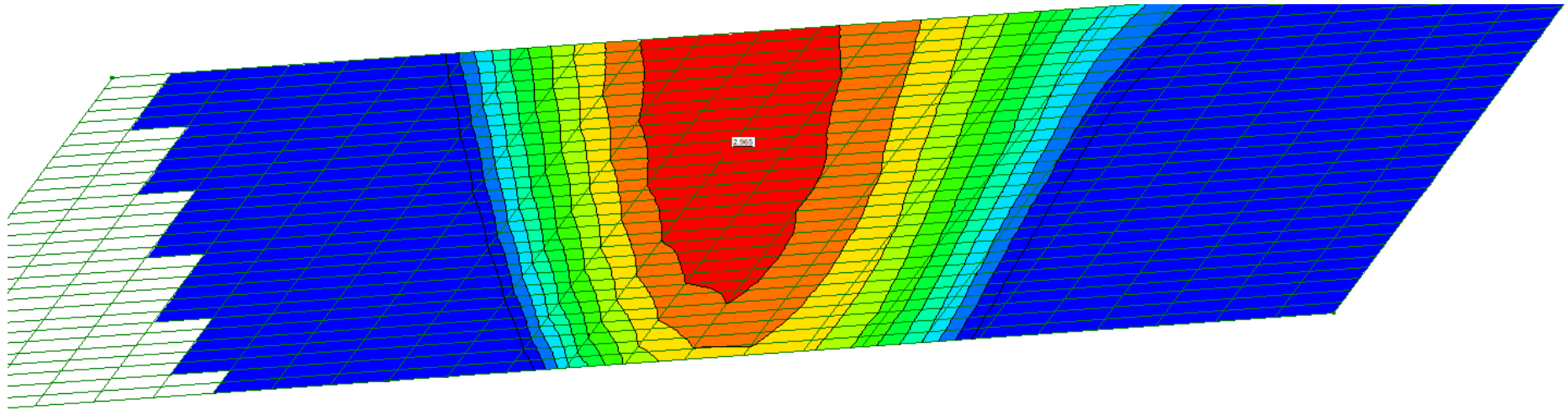
Slip Surface: 13,174
Factor of Safety: 2.965
Volume: 211.5478 m³
Weight: 4,442.5038 kN
Resisting Moment: 78,231.793 kN·m
Activating Moment: 26,378.369 kN·m
Resisting Force: 1,551.5866 kN
Activating Force: 523.30292 kN
Slip Rank: 1 of 20,956 slip surfaces
Exit: (132.88566, 183.26126) m
Entry: (66.352741, 174.48775) m
Radius: 45.443216 m
Center: (95.612665, 209.2576) m

Slip Columns

	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength	Suction Strength	Base Material
Column 1	435.41406 m	600.45546 m	-6.3059001 kPa	-8.7543263 kPa	0 kPa	40.825902 kPa	0 kPa	Cohesiva Till Undrained
Column 2	434.36821 m	598.99383 m	-1.991498 kPa	0.12347655 kPa	0 kPa	42.343106 kPa	0 kPa	Cohesiva Till Undrained
Column 3	430.70812 m	594.29759 m	12.046373 kPa	28.253396 kPa	0 kPa	47.205841 kPa	0 kPa	Cohesiva Till Undrained
Column 4	424.35459 m	586.74484 m	34.622865 kPa	72.796967 kPa	0 kPa	55.007574 kPa	0 kPa	Cohesiva Till Undrained
Column 5	421.10400 m	583.14539 m	45.382221 kPa	93.786013 kPa	0 kPa	58.716718 kPa	0 kPa	Cohesiva Till Undrained
Column 6	419.98490 m	582.00583 m	48.788588 kPa	100.66242 kPa	0 kPa	59.92944 kPa	0 kPa	Cohesiva Till Undrained
Column 7	418.54954 m	580.55700 m	53.119388 kPa	109.41503 kPa	0 kPa	61.47505 kPa	0 kPa	Cohesiva Till Undrained
Column 8	417.67307 m	579.69768 m	55.688034 kPa	114.59847 kPa	0 kPa	62.391769 kPa	0 kPa	Cohesiva Till Undrained

Column 9	416.54446 m	578.61228 m	58.932482 kPa	121.14078 kPa	0 kPa	63.549673 kPa	0 kPa	Cohesiva Till Undrained
Column 10	415.27641 m	577.41765 m	62.290658 kPa	128.33757 kPa	0 kPa	64.824106 kPa	0 kPa	Cohesiva Till Undrained
Column 11	414.29052 m	576.50585 m	64.680964 kPa	133.82901 kPa	0 kPa	65.796811 kPa	0 kPa	Cohesiva Till Undrained
Column 12	413.92798 m	576.17442 m	65.548421 kPa	135.84056 kPa	0 kPa	66.15017 kPa	0 kPa	Cohesiva Till Undrained
Column 13	413.89927 m	576.14835 m	65.616566 kPa	135.98453 kPa	0 kPa	66.175435 kPa	0 kPa	Cohesiva Till Undrained
Column 14	413.41208 m	575.70978 m	66.761896 kPa	138.39563 kPa	0 kPa	66.600227 kPa	0 kPa	Cohesiva Till Undrained
Column 15	411.66339 m	574.17226 m	70.763236 kPa	146.83006 kPa	0 kPa	68.085819 kPa	0 kPa	Cohesiva Till Undrained
Column 16	409.55709 m	572.36220 m	75.457651 kPa	156.74955 kPa	0 kPa	69.830534 kPa	0 kPa	Cohesiva Till Undrained
Column 17	408.20661 m	571.23888 m	78.356264 kPa	162.89279 kPa	0 kPa	70.909468 kPa	0 kPa	Cohesiva Till Undrained
Column 18	407.40855 m	570.58774 m	80.023523 kPa	166.45048 kPa	0 kPa	71.533536 kPa	0 kPa	Cohesiva Till Undrained
Column 19	406.97875 m	570.24136 m	80.900224 kPa	168.34168 kPa	0 kPa	71.859274 kPa	0 kPa	Cohesiva Till Undrained
Column 20	402.47375 m	566.88873 m	89.258529 kPa	185.65274 kPa	0 kPa	74.878551 kPa	0 kPa	Cohesiva Till Undrained
Column 21	394.89337 m	561.56283 m	102.37981 kPa	213.23221 kPa	0 kPa	79.622455 kPa	0 kPa	Cohesiva Till Undrained
Column 22	391.60392 m	559.42738 m	107.54851 kPa	224.31338 kPa	0 kPa	81.493608 kPa	0 kPa	Cohesiva Till Undrained
Column 23	391.21843 m	559.19249 m	108.10833 kPa	225.54434 kPa	0 kPa	81.697501 kPa	0 kPa	Cohesiva Till Undrained
Column 24	388.31816 m	557.50491 m	112.08198 kPa	234.39983 kPa	0 kPa	83.147637 kPa	0 kPa	Cohesiva Till Undrained
Column 25	385.58768 m	555.93033 m	115.78054 kPa	242.73037 kPa	0 kPa	84.497722 kPa	0 kPa	Cohesiva Till Undrained
Column 26	384.40248 m	555.28986 m	117.25744 kPa	246.10969 kPa	0 kPa	85.033992 kPa	0 kPa	Cohesiva Till Undrained
Column 27	381.60679 m	553.83158 m	120.58429 kPa	253.82303 kPa	0 kPa	86.241481 kPa	0 kPa	Cohesiva Till Undrained
Column 28	379.05963 m	552.54646 m	123.77011 kPa	260.6672 kPa	0 kPa	87.295195 kPa	0 kPa	Cohesiva Till Undrained
Column 29	378.10737 m	552.08348 m	125.15405 kPa	263.19482 kPa	0 kPa	87.6705 kPa	0 kPa	Cohesiva Till Undrained
Column 30	377.83628 m	551.95383 m	125.54159 kPa	263.96478 kPa	0 kPa	87.775992 kPa	0 kPa	Cohesiva Till Undrained
Column 31	376.65518 m	551.40255 m	127.18946 kPa	267.2997 kPa	0 kPa	88.229371 kPa	0 kPa	Cohesiva Till Undrained
Column 32	375.28051 m	550.76554 m	129.0936 kPa	271.11783 kPa	0 kPa	88.752128 kPa	0 kPa	Cohesiva Till Undrained
Column 33	374.64362 m	550.47862 m	129.95124 kPa	272.74818 kPa	0 kPa	88.985562 kPa	0 kPa	Cohesiva Till Undrained
Column 34	373.97228 m	550.17975 m	130.84462 kPa	274.51841 kPa	0 kPa	89.26412 kPa	0 kPa	Cohesiva Till Undrained
Column 35	373.24845 m	549.86232 m	131.79347 kPa	276.57077 kPa	0 kPa	89.602753 kPa	0 kPa	Cohesiva Till Undrained
Column 36	371.99885 m	549.32692 m	133.39386 kPa	280.05445 kPa	0 kPa	90.173914 kPa	0 kPa	Cohesiva Till Undrained
Column 37	370.93463 m	548.87669 m	134.58283 kPa	283.00161 kPa	0 kPa	90.654224 kPa	0 kPa	Cohesiva Till Undrained
Column 38	370.62131 m	548.74665 m	134.74838 kPa	283.96556 kPa	0 kPa	90.768236 kPa	0 kPa	Cohesiva Till Undrained
Column 39	369.99344 m	548.49008 m	135.06812 kPa	284.97557 kPa	0 kPa	90.875258 kPa	0 kPa	Cohesiva Till Undrained
Column 40	368.69054 m	547.96710 m	135.70341 kPa	286.98661 kPa	0 kPa	91.117009 kPa	0 kPa	Cohesiva Till Undrained
Column 41	367.72679 m	547.58615 m	136.15571 kPa	288.51089 kPa	0 kPa	91.304848 kPa	0 kPa	Cohesiva Till Undrained
Column 42	366.55184 m	547.13871 m	136.65633 kPa	290.19121 kPa	0 kPa	91.515727 kPa	0 kPa	Cohesiva Till Undrained
Column 43	365.21038 m	546.63399 m	137.20958 kPa	292.08789 kPa	0 kPa	91.749952 kPa	0 kPa	Cohesiva Till Undrained
Column 44	363.53265 m	546.03394 m	137.80827 kPa	294.29955 kPa	0 kPa	92.009612 kPa	0 kPa	Cohesiva Till Undrained
Column 45	360.69267 m	545.06082 m	138.69434 kPa	297.84448 kPa	0 kPa	92.403701 kPa	0 kPa	Cohesiva Till Undrained
Column 46	357.87771 m	544.15387 m	139.40042 kPa	301.07954 kPa	0 kPa	92.732867 kPa	0 kPa	Cohesiva Till Undrained
Column 47	355.61762 m	543.46924 m	139.97266 kPa	303.46039 kPa	0 kPa	92.9507 kPa	0 kPa	Cohesiva Till Undrained
Column 48	353.75041 m	542.93470 m	140.50152 kPa	305.26853 kPa	0 kPa	93.097512 kPa	0 kPa	Cohesiva Till Undrained
Column 49	352.11409 m	542.48726 m	140.9022 kPa	306.74563 kPa	0 kPa	93.203763 kPa	0 kPa	Cohesiva Till Undrained
Column 50	346.21022 m	541.13502 m	141.5643 kPa	310.62238 kPa	0 kPa	93.307474 kPa	0 kPa	Cohesiva Till Undrained

Column 51	339.81423 m	539.76074 m	142.01054 kPa	314.66527 kPa	0 kPa	93.323092 kPa	0 kPa	Cohesiva Till Undrained
Column 52	334.07358 m	538.91896 m	141.24025 kPa	317.34357 kPa	0 kPa	93.084654 kPa	0 kPa	Cohesiva Till Undrained
Column 53	329.04199 m	538.24222 m	140.38255 kPa	319.49608 kPa	0 kPa	92.850077 kPa	0 kPa	Cohesiva Till Undrained
Column 54	325.76977 m	537.96459 m	139.3391 kPa	319.74933 kPa	0 kPa	92.524199 kPa	0 kPa	Cohesiva Till Undrained
Column 55	322.51887 m	537.71127 m	138.23516 kPa	319.82037 kPa	0 kPa	92.176428 kPa	0 kPa	Cohesiva Till Undrained
Column 56	318.08399 m	537.56554 m	136.13181 kPa	318.57558 kPa	0 kPa	91.488812 kPa	0 kPa	Cohesiva Till Undrained
Column 57	309.13509 m	537.60283 m	130.89708 kPa	313.61014 kPa	0 kPa	89.74781 kPa	0 kPa	Cohesiva Till Undrained
Column 58	303.76476 m	537.77993 m	127.29319 kPa	309.35338 kPa	0 kPa	88.537967 kPa	0 kPa	Cohesiva Till Undrained
Column 59	299.05061 m	538.23387 m	123.23742 kPa	303.18503 kPa	0 kPa	87.157524 kPa	0 kPa	Cohesiva Till Undrained
Column 60	292.61565 m	538.96062 m	117.38101 kPa	293.6995 kPa	0 kPa	85.158919 kPa	0 kPa	Cohesiva Till Undrained
Column 61	287.31197 m	539.83740 m	111.72382 kPa	283.62521 kPa	0 kPa	83.215331 kPa	0 kPa	Cohesiva Till Undrained
Column 62	280.85814 m	541.14628 m	104.11651 kPa	269.24563 kPa	0 kPa	80.592117 kPa	0 kPa	Cohesiva Till Undrained
Column 63	276.25389 m	542.23226 m	98.234394 kPa	257.62123 kPa	0 kPa	78.55831 kPa	0 kPa	Cohesiva Till Undrained
Column 64	273.27202 m	543.04149 m	94.108328 kPa	249.21394 kPa	0 kPa	77.128155 kPa	0 kPa	Cohesiva Till Undrained
Column 65	271.63181 m	543.50392 m	91.787055 kPa	244.42939 kPa	0 kPa	76.323037 kPa	0 kPa	Cohesiva Till Undrained
Column 66	271.45054 m	543.55742 m	91.551607 kPa	243.91049 kPa	0 kPa	76.231503 kPa	0 kPa	Cohesiva Till Undrained
Column 67	269.46358 m	544.17244 m	88.96122 kPa	238.21392 kPa	0 kPa	75.272321 kPa	0 kPa	Cohesiva Till Undrained
Column 68	266.78888 m	545.02063 m	85.413584 kPa	230.40238 kPa	0 kPa	73.967442 kPa	0 kPa	Cohesiva Till Undrained
Column 69	264.01493 m	545.98264 m	81.488158 kPa	221.64355 kPa	0 kPa	72.526296 kPa	0 kPa	Cohesiva Till Undrained
Column 70	258.75574 m	547.98421 m	73.514784 kPa	203.58856 kPa	0 kPa	69.604461 kPa	0 kPa	Cohesiva Till Undrained
Column 71	255.42610 m	549.30464 m	68.307686 kPa	186.46428 kPa	0 kPa	67.697847 kPa	0 kPa	Cohesiva Till Undrained
Column 72	254.81135 m	549.56883 m	67.285311 kPa	182.4857 kPa	0 kPa	67.066972 kPa	0 kPa	Cohesiva Till Undrained
Column 73	253.07251 m	550.33352 m	64.341456 kPa	170.99785 kPa	0 kPa	65.248016 kPa	0 kPa	Cohesiva Till Undrained
Column 74	251.30454 m	551.13025 m	61.290801 kPa	159.52071 kPa	0 kPa	63.434253 kPa	0 kPa	Cohesiva Till Undrained
Column 75	250.38632 m	551.55564 m	59.671721 kPa	154.69525 kPa	0 kPa	62.672441 kPa	0 kPa	Cohesiva Till Undrained
Column 76	249.85892 m	551.80413 m	58.737272 kPa	153.01513 kPa	0 kPa	62.407355 kPa	0 kPa	Cohesiva Till Undrained
Column 77	248.64378 m	552.39063 m	56.563997 kPa	152.13375 kPa	0 kPa	62.269396 kPa	0 kPa	Cohesiva Till Undrained
Column 78	242.23548 m	555.83375 m	44.056318 kPa	127.56083 kPa	0 kPa	58.413835 kPa	0 kPa	Cohesiva Till Undrained
Column 79	236.65357 m	558.89359 m	32.980048 kPa	102.38621 kPa	0 kPa	54.479439 kPa	0 kPa	Cohesiva Till Undrained
Column 80	232.61728 m	561.50410 m	25.046874 kPa	84.664571 kPa	0 kPa	51.69455 kPa	0 kPa	Cohesiva Till Undrained
Column 81	224.83827 m	566.91493 m	8.7146293 kPa	48.19005 kPa	0 kPa	45.922275 kPa	0 kPa	Cohesiva Till Undrained
Column 82	219.32074 m	571.13511 m	-4.0125096 kPa	20.114328 kPa	0 kPa	41.420191 kPa	0 kPa	Cohesiva Till Undrained



ULS C1 Undrained

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File Information

File Version: 11.05
Created By: Laura Castro
Last Edited By: Laura Castro
Revision Number: 82
Date: 02/08/2024
Time: 23:59:55
Tool Version: 23.1.2.11
File Name: Till 1 in 3- 7m with piezometric line.gsz
Directory: C:\Users\CAS111646\OneDrive - Mott MacDonald\Desktop\Knocknagael\Slope stability analysis\Earth bund\
Last Solved Date: 03/08/2024
Last Solved Time: 00:02:48

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

ULS C1 Undrained

Kind: SLOPE/W
Analysis Type: Morgenstern-Price
Settings
 Side Function
 Intercolumn force function option: Half-Sine
 PWP Conditions from: Piezometric Surfaces
 Apply Phreatic Correction: No
 Use Staged Rapid Drawdown: No
 Limit State Design Approach: Eurocode 7 - DA1, C1
 Unit Weight of Water: 9.807 kN/m³
Slip Surface
 Direction of movement: Right to Left
 Use Passive Mode: No
 Slip Surface Option: Grid and Radius
 Critical slip surfaces saved: 1
 Optimize Critical Slip Surface Location: No
 Tension Crack Option: (none)
Distribution
 ODF Calculation Option: Constant
Convergence
 Geometry Settings
 Minimum Slip Surface Depth: 0.5 m
 Minimum Slip Surface Volume: 1 m³
 Number of Columns: 30
 Overdesign Factor Convergence Settings
 Maximum Number of Iterations: 100
 Tolerable difference in ODF: 0.001
 Under-Relaxation Criteria
 Initial Rate: 1
 Minimum Rate: 0.1
 Rate Reduction Factor: 0.65
 Reduction Frequency (iterations): 50
 Solution Settings
 Search Method: Root Finder
 Tolerable difference between starting and converged ODF: 3
 Maximum iterations to calculate converged lambda: 20
 Max Absolute Lambda: 2

Materials

Cohesive Till Undrained

Slope Stability Material Model: S=f(depth)
Unit Weight: 21 kN/m³
C-Top of Layer: 40 kPa
C-Rate of Change: 3.5 (kN/m²)/m
C-Maximum: 110 kPa
Pore Water Pressure
 Piezometric Surface: 1

Slip Surface Grid

Upper Left: (50.51875, 214.72425) m
Lower Left: (31.877499, 189.6475) m
Lower Right: (140.063, 197.4145) m
Grid Horizontal Increment: 25
Grid Vertical Increment: 30

Slip Surface Radius

Upper Left Coordinate: (66.537998, 174.163) m
Upper Right Coordinate: (148.2165, 189.18875) m
Lower Left Coordinate: (66.537998, 156.31175) m
Lower Right Coordinate: (148.2165, 156.31175) m
Number of Increments: 25
Use Left Projection: No
Left Projection Angle: 135 °
Use Right Projection: No
Right Projection Angle: 45 °

Slip Surface Limits

Left Coordinate: (23.511751, 174.37725) m
Right Coordinate: (231.72725, 186.975) m

Piezometric Surfaces

Piezometric Surface 1

Coordinates

	X	Y
Coordinate 1	23.511751 m	173.37775 m
Coordinate 2	72.02225 m	173.67775 m
Coordinate 3	76.328501 m	174.10275 m
Coordinate 4	82.7825 m	175.01725 m
Coordinate 5	108.68775 m	179.97875 m
Coordinate 6	113.128 m	181.03675 m
Coordinate 7	114.299 m	181.03675 m
Coordinate 8	115.7725 m	181.03675 m
Coordinate 9	124.25925 m	182.085 m
Coordinate 10	126.767 m	182.37025 m
Coordinate 11	132.54275 m	182.37025 m
Coordinate 12	144.738 m	182.76675 m
Coordinate 13	154.1835 m	183.1275 m
Coordinate 14	168.21275 m	184.08625 m
Coordinate 15	173.9545 m	184.96775 m
Coordinate 16	180.105 m	185.828 m
Coordinate 17	183.877 m	186.11425 m
Coordinate 18	231.70882 m	185.55675 m

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 10 kN/m³
Direction: Vertical
Mode: Permanent

Coordinates

	X	Y
	77.857249 m	175.84225 m
	82.804251 m	176.5385 m
	92.695999 m	178.4335 m
	100.133 m	179.7475 m
	103.9505 m	180.3685 m
	112.14275 m	182.22325 m
	112.937 m	182.3775 m
	114.472 m	182.47825 m
	115.30225 m	182.47825 m
	119.37625 m	182.886 m
	123.99725 m	183.411 m
	126.1645 m	183.578 m
	128.375 m	183.578 m
	133.479 m	183.86825 m
	144.9805 m	184.2175 m
	148.8755 m	184.2175 m
	150.437 m	184.3255 m
	153.85275 m	184.5305 m
	163.08175 m	185.31775 m
	169.33725 m	185.74925 m
	176.91825 m	187.14925 m
	182.50825 m	187.68625 m
	231.75475 m	187.50375 m

Design Factor Set: Eurocode 7 - DA1, C1

Permanent Point Loads & Surcharge Loads: Favorable = 1, Unfavorable = 1.35

Variable Point Loads & Surcharge Loads: Favorable = 0, Unfavorable = 1.5
Soil Unit Weight: Favorable = 1, Unfavorable = 1.35
Effective Cohesion: 1
Effective Coefficient of Friction: 1
Undrained Strength: 1
Shear Strength (Other Models): 1
Pullout Resistance: 1.1
Shear Force: 1.1
Tensile Strength: 1.1
Compressive Strength: 1.1
Seismic Coefficients: 1
Earth Resistance: 1

Geometry

Name: 2D Geometry

Settings

View: 2D
Element Thickness: 0.3048 m

Points

	X	Y
Point 1	65.099751 m	174.48775 m
Point 2	72.17675 m	174.48775 m
Point 3	76.083249 m	174.592 m
Point 4	76.404749 m	174.592 m
Point 5	76.790501 m	174.768 m
Point 6	77.482501 m	175.14275 m
Point 7	79.88025 m	175.277 m
Point 8	81.063249 m	175.32875 m
Point 9	81.57125 m	175.20875 m
Point 10	84.621999 m	175.20875 m
Point 11	88.556251 m	176.02625 m
Point 12	89.82225 m	176.29425 m
Point 13	92.478999 m	176.60275 m
Point 14	95.752749 m	177.413 m
Point 15	98.151251 m	177.413 m
Point 16	98.456249 m	177.2995 m
Point 17	100.451 m	177.2995 m
Point 18	107.09925 m	178.44625 m
Point 19	107.5495 m	178.44625 m
Point 20	108.09675 m	178.376 m
Point 21	109.4745 m	178.0295 m
Point 22	110.40375 m	177.7965 m
Point 23	111.20575 m	177.6315 m
Point 24	111.4265 m	177.6715 m
Point 25	112.0235 m	177.74725 m
Point 26	113.88975 m	177.96275 m
Point 27	115.137 m	178.10475 m
Point 28	116.855 m	177.9615 m
Point 29	117.5775 m	177.911 m
Point 30	119.14125 m	177.911 m
Point 31	121.35075 m	177.50325 m
Point 32	123.9915 m	177.25575 m
Point 33	124.5835 m	177.20375 m
Point 34	125.0825 m	177.1485 m
Point 35	125.8675 m	177.05925 m
Point 36	126.1485 m	177.02475 m
Point 37	126.3855 m	177.02475 m
Point 38	127.1585 m	177.02475 m
Point 39	127.455 m	177.05125 m
Point 40	128.67575 m	177.15475 m
Point 41	130.3785 m	177.297 m
Point 42	130.93025 m	177.297 m
Point 43	132.34725 m	176.877 m
Point 44	139.22375 m	176.877 m
Point 45	145.087 m	176.877 m
Point 46	145.5985 m	176.72525 m
Point 47	146.67375 m	176.72525 m
Point 48	148.568 m	176.87425 m
Point 49	149.663 m	176.95525 m
Point 50	152.291 m	177.08325 m
Point 51	154.14725 m	177.16575 m
Point 52	158.67325 m	178.04375 m
Point 53	163.142 m	179.09075 m
Point 54	164.49 m	179.52875 m
Point 55	166.673 m	179.66575 m
Point 56	170.615 m	179.81175 m
Point 57	174.5425 m	180.07225 m

Point 58	176.931 m	180.2235 m
Point 59	178.71025 m	180.33725 m
Point 60	180.38625 m	180.436 m
Point 61	181.59025 m	180.436 m
Point 62	188.54025 m	180.436 m
Point 63	194.36275 m	180.66825 m
Point 64	200.26475 m	181.1245 m
Point 65	203.531 m	181.4065 m
Point 66	204.0745 m	181.44725 m
Point 67	205.32825 m	181.44725 m
Point 68	211.22875 m	181.44725 m
Point 69	219.44675 m	180.634 m
Point 70	220.73025 m	180.52925 m
Point 71	223.526 m	180.52925 m
Point 72	226.0465 m	180.83925 m
Point 73	226.66925 m	180.93725 m
Point 74	229.69425 m	181.07125 m
Point 75	230.50475 m	181.1075 m
Point 76	231.651 m	181.1075 m
Point 77	231.651 m	153.8075 m
Point 78	23.511751 m	153.8075 m
Point 79	23.511751 m	174.37725 m
Point 80	77.850501 m	175.34125 m
Point 81	82.693749 m	176.02025 m
Point 82	103.20025 m	179.6745 m
Point 83	112.611 m	181.675 m
Point 84	112.99375 m	181.77025 m
Point 85	113.6425 m	181.77025 m
Point 86	114.08375 m	181.77025 m
Point 87	115.192 m	181.88875 m
Point 88	117.47675 m	182.1555 m
Point 89	119.3455 m	182.367 m
Point 90	124.097 m	182.918 m
Point 91	126.166 m	183.0895 m
Point 92	128.33 m	183.0895 m
Point 93	133.396 m	183.2805 m
Point 94	136.57275 m	183.38975 m
Point 95	144.7355 m	183.68525 m
Point 96	146.721 m	183.68525 m
Point 97	148.88525 m	183.77025 m
Point 98	150.31575 m	183.864 m
Point 99	153.5605 m	184.05425 m
Point 100	162.3055 m	184.6565 m
Point 101	169.026 m	185.1205 m
Point 102	171.5865 m	185.498 m
Point 103	176.931 m	186.45625 m
Point 104	182.45875 m	186.975 m
Point 105	231.72725 m	186.975 m
Point 106	75.489999 m	174.8707 m

Regions

	Material	Po
Region 1	Cohesiva Till Undrained	1,79,78,77,76,75,74,73,72,71,70,69,68,67,66,65,64,63,62,61,60,59,58,57,56,55,54,53,52,51,50,49,48,47,46,45,44,43,42,41,40,39,38,37,36,35,34,33,3:
Region 2	Cohesiva Till Undrained	6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50,51,52,53,54,55

Slip Results

Slip Surfaces Analysed: 17148 of 20956 converged

Current Slip Surface

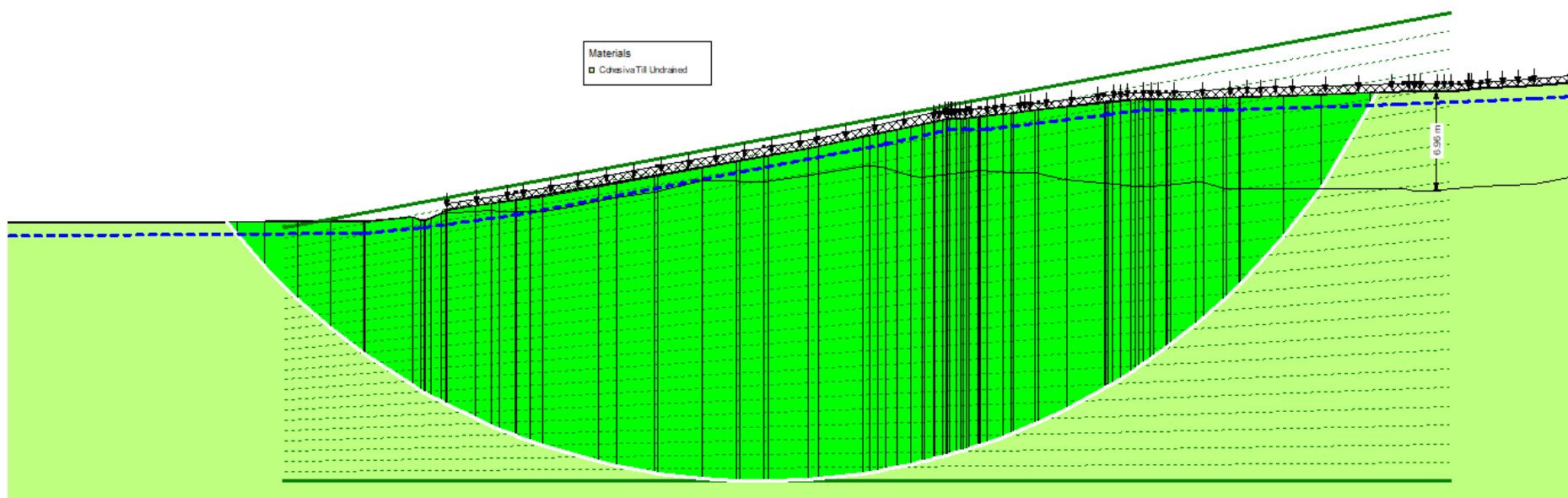
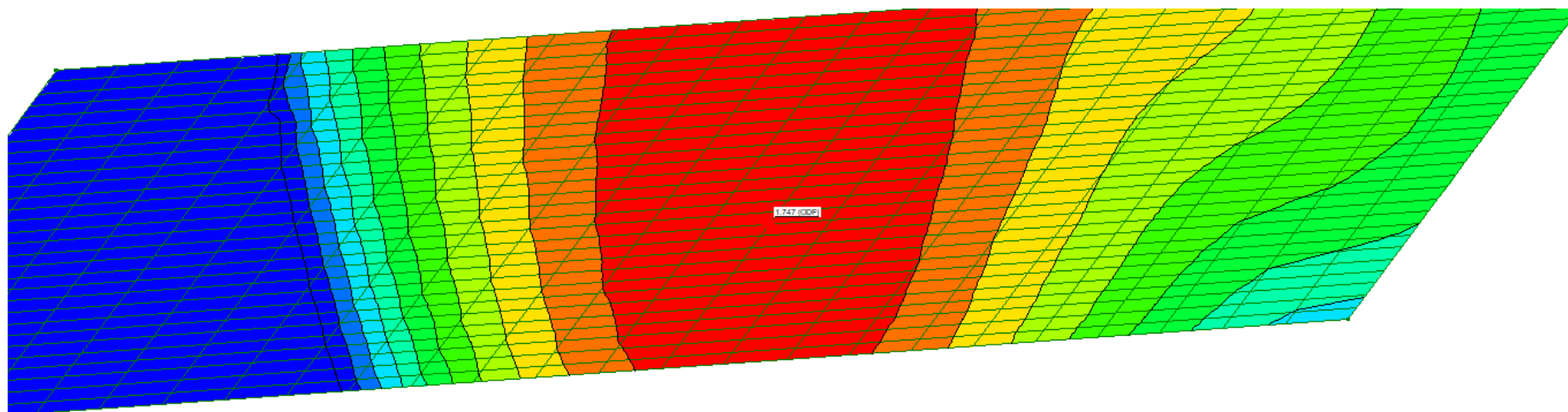
Slip Surface: 8,502
Overdesign Factor: 1.747
Degree of Utilization: 0.572
Volume: 400.73508 m³
Weight: 10,152.939 kN
Resisting Moment: 126,661.6 kN·m
Activating Moment: 72,497.102 kN·m
Resisting Force: 2,296.6166 kN
Activating Force: 1,314.7636 kN
Slip Rank: 1 of 20,956 slip surfaces
Exit: (143.05155, 183.62429) m
Entry: (62.450722, 174.48071) m
Radius: 47.71597 m
Center: (99.91788, 204.02772) m

Slip Columns

	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength	Suction Strength	Base Material
Column 1	468.58969 m	600.92118 m	-4.473819 kPa	-28.660634 kPa	0 kPa	41.593742 kPa	0 kPa	Cohesiva Till Undrained
Column 2	462.19981 m	589.85279 m	27.990511 kPa	61.57934 kPa	0 kPa	53.154726 kPa	0 kPa	Cohesiva Till Undrained
Column 3	452.31140 m	574.73071 m	72.232028 kPa	184.06388 kPa	0 kPa	68.90508 kPa	0 kPa	Cohesiva Till Undrained
Column 4	442.99828 m	563.62870 m	104.51275 kPa	273.15001 kPa	0 kPa	80.398839 kPa	0 kPa	Cohesiva Till Undrained
Column 5	437.78708 m	557.96671 m	120.93096 kPa	318.6883 kPa	0 kPa	86.247861 kPa	0 kPa	Cohesiva Till Undrained
Column 6	436.25123 m	556.48790 m	125.20213 kPa	330.40489 kPa	0 kPa	87.764167 kPa	0 kPa	Cohesiva Till Undrained
Column 7	434.53084 m	554.84468 m	129.97798 kPa	343.44837 kPa	0 kPa	89.447962 kPa	0 kPa	Cohesiva Till Undrained
Column 8	431.88567 m	552.47659 m	137.05659 kPa	362.26459 kPa	0 kPa	91.86784 kPa	0 kPa	Cohesiva Till Undrained
Column 9	428.65609 m	549.64504 m	145.52058 kPa	384.8644 kPa	0 kPa	94.758642 kPa	0 kPa	Cohesiva Till Undrained
Column 10	424.95776 m	546.67153 m	154.40892 kPa	408.71045 kPa	0 kPa	97.782032 kPa	0 kPa	Cohesiva Till Undrained
Column 11	421.67118 m	544.09072 m	162.12342 kPa	429.55265 kPa	0 kPa	100.40305 kPa	0 kPa	Cohesiva Till Undrained
Column 12	421.10400 m	543.66637 m	163.39189 kPa	433.01043 kPa	0 kPa	100.83294 kPa	0 kPa	Cohesiva Till Undrained
Column 13	419.59481 m	542.57272 m	166.66098 kPa	442.45089 kPa	0 kPa	101.99668 kPa	0 kPa	Cohesiva Till Undrained
Column 14	417.67307 m	541.19291 m	170.78548 kPa	454.43588 kPa	0 kPa	103.46866 kPa	0 kPa	Cohesiva Till Undrained
Column 15	416.54446 m	540.41012 m	173.12536 kPa	461.27726 kPa	0 kPa	104.30373 kPa	0 kPa	Cohesiva Till Undrained
Column 16	415.27641 m	539.54671 m	175.49346 kPa	468.8567 kPa	0 kPa	105.22482 kPa	0 kPa	Cohesiva Till Undrained
Column 17	414.29052 m	538.88653 m	177.13165 kPa	474.67669 kPa	0 kPa	105.9291 kPa	0 kPa	Cohesiva Till Undrained
Column 18	413.92798 m	538.64630 m	177.72648 kPa	476.82104 kPa	0 kPa	106.18517 kPa	0 kPa	Cohesiva Till Undrained
Column 19	413.89927 m	538.62740 m	177.77322 kPa	476.97078 kPa	0 kPa	106.20279 kPa	0 kPa	Cohesiva Till Undrained
Column 20	413.41208 m	538.30909 m	178.55904 kPa	479.48108 kPa	0 kPa	106.49928 kPa	0 kPa	Cohesiva Till Undrained
Column 21	411.66339 m	537.19126 m	181.30587 kPa	488.32116 kPa	0 kPa	107.53715 kPa	0 kPa	Cohesiva Till Undrained
Column 22	409.55709 m	535.87327 m	184.5294 kPa	498.79756 kPa	0 kPa	108.75692 kPa	0 kPa	Cohesiva Till Undrained
Column 23	408.20661 m	535.05375 m	186.51989 kPa	505.34326 kPa	0 kPa	109.51176 kPa	0 kPa	Cohesiva Till Undrained
Column 24	407.40855 m	534.57827 m	187.66206 kPa	509.15311 kPa	0 kPa	109.94843 kPa	0 kPa	Cohesiva Till Undrained
Column 25	406.97875 m	534.32521 m	188.25983 kPa	511.23409 kPa	0 kPa	110 kPa	0 kPa	Cohesiva Till Undrained
Column 26	402.47375 m	531.87221 m	193.92898 kPa	530.3898 kPa	0 kPa	110 kPa	0 kPa	Cohesiva Till Undrained
Column 27	394.89337 m	527.97860 m	202.76888 kPa	561.03878 kPa	0 kPa	110 kPa	0 kPa	Cohesiva Till Undrained
Column 28	391.60392 m	526.41958 m	206.21456 kPa	573.42794 kPa	0 kPa	110 kPa	0 kPa	Cohesiva Till Undrained
Column 29	391.21843 m	526.24866 m	206.58316 kPa	574.81289 kPa	0 kPa	110 kPa	0 kPa	Cohesiva Till Undrained
Column 30	388.31816 m	525.02510 m	209.16978 kPa	584.7898 kPa	0 kPa	110 kPa	0 kPa	Cohesiva Till Undrained
Column 31	385.58768 m	523.88433 m	211.57161 kPa	594.15933 kPa	0 kPa	110 kPa	0 kPa	Cohesiva Till Undrained
Column 32	384.40248 m	523.42328 m	212.51217 kPa	597.95752 kPa	0 kPa	110 kPa	0 kPa	Cohesiva Till Undrained
Column 33	381.60679 m	522.37807 m	214.6043 kPa	606.60935 kPa	0 kPa	110 kPa	0 kPa	Cohesiva Till Undrained
Column 34	379.05963 m	521.46104 m	216.68984 kPa	614.2641 kPa	0 kPa	110 kPa	0 kPa	Cohesiva Till Undrained
Column 35	378.10737 m	521.13244 m	217.67207 kPa	617.09723 kPa	0 kPa	110 kPa	0 kPa	Cohesiva Till Undrained
Column 36	377.83628 m	521.04066 m	217.94641 kPa	617.97465 kPa	0 kPa	110 kPa	0 kPa	Cohesiva Till Undrained
Column 37	376.65518 m	520.65201 m	219.10816 kPa	621.78402 kPa	0 kPa	110 kPa	0 kPa	Cohesiva Till Undrained
Column 38	375.28051 m	520.20348 m	220.44888 kPa	626.12642 kPa	0 kPa	110 kPa	0 kPa	Cohesiva Till Undrained
Column 39	374.64362 m	520.00249 m	221.04967 kPa	627.95472 kPa	0 kPa	110 kPa	0 kPa	Cohesiva Till Undrained
Column 40	373.97228 m	519.79360 m	221.67408 kPa	629.95973 kPa	0 kPa	110 kPa	0 kPa	Cohesiva Till Undrained
Column 41	373.24845 m	519.57240 m	222.3353 kPa	632.327 kPa	0 kPa	110 kPa	0 kPa	Cohesiva Till Undrained

Column 42	371.99885 m	519.20108 m	223.44523 kPa	636.33792 kPa	0 kPa	110 kPa	0 kPa	Cohesiva Till Undrained
Column 43	370.93463 m	518.88967 m	224.21923 kPa	639.7245 kPa	0 kPa	110 kPa	0 kPa	Cohesiva Till Undrained
Column 44	370.62131 m	518.80011 m	224.2638 kPa	640.85111 kPa	0 kPa	110 kPa	0 kPa	Cohesiva Till Undrained
Column 45	369.99344 m	518.62402 m	224.34294 kPa	641.8329 kPa	0 kPa	110 kPa	0 kPa	Cohesiva Till Undrained
Column 46	368.69054 m	518.26663 m	224.48327 kPa	643.76069 kPa	0 kPa	110 kPa	0 kPa	Cohesiva Till Undrained
Column 47	367.72679 m	518.00728 m	224.57209 kPa	645.23876 kPa	0 kPa	110 kPa	0 kPa	Cohesiva Till Undrained
Column 48	366.55184 m	517.70559 m	224.63705 kPa	646.80595 kPa	0 kPa	110 kPa	0 kPa	Cohesiva Till Undrained
Column 49	365.21038 m	517.36639 m	224.69553 kPa	648.56162 kPa	0 kPa	110 kPa	0 kPa	Cohesiva Till Undrained
Column 50	363.53265 m	516.96899 m	224.68845 kPa	650.55094 kPa	0 kPa	110 kPa	0 kPa	Cohesiva Till Undrained
Column 51	360.69267 m	516.33321 m	224.56615 kPa	653.64581 kPa	0 kPa	110 kPa	0 kPa	Cohesiva Till Undrained
Column 52	357.87771 m	515.75320 m	224.29498 kPa	656.33393 kPa	0 kPa	110 kPa	0 kPa	Cohesiva Till Undrained
Column 53	355.61762 m	515.32568 m	224.09865 kPa	658.19728 kPa	0 kPa	110 kPa	0 kPa	Cohesiva Till Undrained
Column 54	353.75041 m	514.99990 m	224.00349 kPa	659.52072 kPa	0 kPa	110 kPa	0 kPa	Cohesiva Till Undrained
Column 55	352.11409 m	514.73303 m	223.86441 kPa	660.53261 kPa	0 kPa	110 kPa	0 kPa	Cohesiva Till Undrained
Column 56	346.21022 m	514.00544 m	222.65933 kPa	662.23925 kPa	0 kPa	110 kPa	0 kPa	Cohesiva Till Undrained
Column 57	339.81423 m	513.29928 m	221.10843 kPa	663.7463 kPa	0 kPa	110 kPa	0 kPa	Cohesiva Till Undrained
Column 58	334.07358 m	513.02413 m	218.64438 kPa	663.84963 kPa	0 kPa	110 kPa	0 kPa	Cohesiva Till Undrained
Column 59	329.04199 m	512.83951 m	216.31566 kPa	663.60399 kPa	0 kPa	110 kPa	0 kPa	Cohesiva Till Undrained
Column 60	325.76977 m	512.87136 m	214.34711 kPa	492.96007 kPa	0 kPa	110 kPa	0 kPa	Cohesiva Till Undrained
Column 61	322.51887 m	512.92423 m	212.32793 kPa	492.07781 kPa	0 kPa	110 kPa	0 kPa	Cohesiva Till Undrained
Column 62	318.08399 m	513.18627 m	209.00566 kPa	489.52942 kPa	0 kPa	110 kPa	0 kPa	Cohesiva Till Undrained
Column 63	309.13509 m	514.03433 m	201.34743 kPa	481.90301 kPa	0 kPa	110 kPa	0 kPa	Cohesiva Till Undrained
Column 64	303.76476 m	514.69261 m	196.30519 kPa	476.04986 kPa	0 kPa	110 kPa	0 kPa	Cohesiva Till Undrained
Column 65	299.05061 m	515.56293 m	191.00481 kPa	468.51172 kPa	0 kPa	110 kPa	0 kPa	Cohesiva Till Undrained
Column 66	292.61565 m	516.85716 m	183.45208 kPa	456.964 kPa	0 kPa	108.73889 kPa	0 kPa	Cohesiva Till Undrained
Column 67	284.08506 m	519.21583 m	171.51785 kPa	436.00772 kPa	0 kPa	104.60097 kPa	0 kPa	Cohesiva Till Undrained
Column 68	276.25389 m	521.57570 m	159.98044 kPa	414.5507 kPa	0 kPa	100.59473 kPa	0 kPa	Cohesiva Till Undrained
Column 69	273.27202 m	522.65261 m	155.05425 kPa	404.88652 kPa	0 kPa	98.879022 kPa	0 kPa	Cohesiva Till Undrained
Column 70	271.63181 m	523.26276 m	152.29138 kPa	399.39756 kPa	0 kPa	97.9163 kPa	0 kPa	Cohesiva Till Undrained
Column 71	271.45054 m	523.33267 m	152.00032 kPa	398.79971 kPa	0 kPa	97.807264 kPa	0 kPa	Cohesiva Till Undrained
Column 72	269.46358 m	524.12856 m	148.77967 kPa	392.23323 kPa	0 kPa	96.655128 kPa	0 kPa	Cohesiva Till Undrained
Column 73	266.78888 m	525.22104 m	144.3812 kPa	383.23001 kPa	0 kPa	95.089647 kPa	0 kPa	Cohesiva Till Undrained
Column 74	264.01493 m	526.43996 m	139.56272 kPa	373.18176 kPa	0 kPa	93.374429 kPa	0 kPa	Cohesiva Till Undrained
Column 75	258.75574 m	528.93791 m	129.86837 kPa	352.53206 kPa	0 kPa	89.923048 kPa	0 kPa	Cohesiva Till Undrained
Column 76	255.42610 m	530.57548 m	123.56312 kPa	333.67597 kPa	0 kPa	87.678108 kPa	0 kPa	Cohesiva Till Undrained
Column 77	254.81135 m	530.89949 m	122.33422 kPa	329.31375 kPa	0 kPa	86.983422 kPa	0 kPa	Cohesiva Till Undrained
Column 78	253.07251 m	531.83457 m	118.80263 kPa	316.71134 kPa	0 kPa	84.982697 kPa	0 kPa	Cohesiva Till Undrained
Column 79	251.30454 m	532.80590 m	115.15032 kPa	304.07555 kPa	0 kPa	82.982669 kPa	0 kPa	Cohesiva Till Undrained
Column 80	250.54667 m	533.23138 m	113.5575 kPa	299.27059 kPa	0 kPa	82.22077 kPa	0 kPa	Cohesiva Till Undrained
Column 81	250.01927 m	533.53275 m	112.48498 kPa	297.28882 kPa	0 kPa	81.899264 kPa	0 kPa	Cohesiva Till Undrained
Column 82	248.64378 m	534.33365 m	109.68514 kPa	295.19653 kPa	0 kPa	81.532578 kPa	0 kPa	Cohesiva Till Undrained
Column 83	242.23548 m	538.45682 m	95.469745 kPa	266.42235 kPa	0 kPa	76.951544 kPa	0 kPa	Cohesiva Till Undrained

Column 84	236.54692 m	542.19134 m	82.628428 kPa	236.6796 kPa	0 kPa	72.297405 kPa	0 kPa	Cohesiva Till Undrained
Column 85	232.50820 m	545.28016 m	73.250651 kPa	215.57653 kPa	0 kPa	69.002246 kPa	0 kPa	Cohesiva Till Undrained
Column 86	224.93767 m	551.49029 m	54.547557 kPa	172.90576 kPa	0 kPa	62.377283 kPa	0 kPa	Cohesiva Till Undrained
Column 87	217.36713 m	558.56613 m	33.256702 kPa	124.20564 kPa	0 kPa	54.828779 kPa	0 kPa	Cohesiva Till Undrained
Column 88	210.37274 m	565.98377 m	10.954776 kPa	73.245604 kPa	0 kPa	46.906538 kPa	0 kPa	Cohesiva Till Undrained
Column 89	206.02722 m	571.03601 m	-4.2275714 kPa	38.63622 kPa	0 kPa	41.504493 kPa	0 kPa	Cohesiva Till Undrained



ULS C2 Undrained

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File Information

File Version: 11.05
Created By: Laura Castro
Last Edited By: Laura Castro
Revision Number: 82
Date: 02/08/2024
Time: 23:59:55
Tool Version: 23.1.2.11
File Name: Till 1 in 3- 7m with piezometric line.gsz
Directory: C:\Users\CAS111646\OneDrive - Mott MacDonald\Desktop\Knocknagael\Slope stability analysis\Earth bund\
Last Solved Date: 03/08/2024
Last Solved Time: 00:03:26

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

ULS C2 Undrained

Kind: SLOPE/W
Analysis Type: Morgenstern-Price
Settings
 Side Function
 Intercolumn force function option: Half-Sine
 PWP Conditions from: Piezometric Surfaces
 Apply Phreatic Correction: No
 Use Staged Rapid Drawdown: No
 Limit State Design Approach: Eurocode 7 - DA1, C2
 Unit Weight of Water: 9.807 kN/m³
Slip Surface
 Direction of movement: Right to Left
 Use Passive Mode: No
 Slip Surface Option: Grid and Radius
 Critical slip surfaces saved: 1
 Optimize Critical Slip Surface Location: No
 Tension Crack Option: (none)
Distribution
 ODF Calculation Option: Constant
Convergence
 Geometry Settings
 Minimum Slip Surface Depth: 0.5 m
 Minimum Slip Surface Volume: 1 m³
 Number of Columns: 30
 Overdesign Factor Convergence Settings
 Maximum Number of Iterations: 100
 Tolerable difference in ODF: 0.001
 Under-Relaxation Criteria
 Initial Rate: 1
 Minimum Rate: 0.1
 Rate Reduction Factor: 0.65
 Reduction Frequency (iterations): 50
 Solution Settings
 Search Method: Root Finder
 Tolerable difference between starting and converged ODF: 3
 Maximum iterations to calculate converged lambda: 20
 Max Absolute Lambda: 2

Materials

Cohesive Till Undrained

Slope Stability Material Model: S=f(depth)
Unit Weight: 21 kN/m³
C-Top of Layer: 40 kPa
C-Rate of Change: 3.5 (kN/m²)/m
C-Maximum: 110 kPa
Pore Water Pressure
 Piezometric Surface: 1

Slip Surface Grid

Upper Left: (50.51875, 214.72425) m
Lower Left: (31.877499, 189.6475) m
Lower Right: (140.063, 197.4145) m
Grid Horizontal Increment: 25
Grid Vertical Increment: 30

Slip Surface Radius

Upper Left Coordinate: (66.537998, 174.163) m
Upper Right Coordinate: (148.2165, 189.18875) m
Lower Left Coordinate: (66.537998, 156.31175) m
Lower Right Coordinate: (148.2165, 156.31175) m
Number of Increments: 25
Use Left Projection: No
Left Projection Angle: 135 °
Use Right Projection: No
Right Projection Angle: 45 °

Slip Surface Limits

Left Coordinate: (23.511751, 174.37725) m
Right Coordinate: (231.72725, 186.975) m

Piezometric Surfaces

Piezometric Surface 1

Coordinates

	X	Y
Coordinate 1	23.511751 m	173.37775 m
Coordinate 2	72.02225 m	173.57675 m
Coordinate 3	76.328501 m	173.97875 m
Coordinate 4	82.7825 m	175.01725 m
Coordinate 5	108.68775 m	179.97875 m
Coordinate 6	113.128 m	181.03675 m
Coordinate 7	114.299 m	181.03675 m
Coordinate 8	115.7725 m	181.03675 m
Coordinate 9	124.25925 m	182.085 m
Coordinate 10	126.767 m	182.37025 m
Coordinate 11	132.54275 m	182.37025 m
Coordinate 12	144.738 m	182.76675 m
Coordinate 13	154.1835 m	183.1275 m
Coordinate 14	168.21275 m	184.08625 m
Coordinate 15	173.9545 m	184.96775 m
Coordinate 16	180.105 m	185.828 m
Coordinate 17	183.877 m	186.11425 m
Coordinate 18	231.70882 m	185.55675 m

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 10 kN/m³
Direction: Vertical
Mode: Permanent

Coordinates

	X	Y
	77.857249 m	175.84225 m
	82.804251 m	176.5385 m
	92.695999 m	178.4335 m
	100.133 m	179.7475 m
	103.9505 m	180.3685 m
	112.14275 m	182.22325 m
	112.937 m	182.3775 m
	114.472 m	182.47825 m
	115.30225 m	182.47825 m
	119.37625 m	182.886 m
	123.99725 m	183.411 m
	126.1645 m	183.578 m
	128.375 m	183.578 m
	133.479 m	183.86825 m
	144.9805 m	184.2175 m
	148.8755 m	184.2175 m
	150.437 m	184.3255 m
	153.85275 m	184.5305 m
	163.08175 m	185.31775 m
	169.33725 m	185.74925 m
	176.91825 m	187.14925 m
	182.50825 m	187.68625 m
	231.75475 m	187.50375 m

Design Factor Set: Eurocode 7 - DA1, C2

Permanent Point Loads & Surcharge Loads: Favorable = 1, Unfavorable = 1

Variable Point Loads & Surcharge Loads: Favorable = 0, Unfavorable = 1.3
Soil Unit Weight: Favorable = 1, Unfavorable = 1
Effective Cohesion: 1.4
Effective Coefficient of Friction: 1.25
Undrained Strength: 1.4
Shear Strength (Other Models): 1.25
Pullout Resistance: 1.1
Shear Force: 1.1
Tensile Strength: 1.1
Compressive Strength: 1.1
Seismic Coefficients: 1
Earth Resistance: 1

Geometry

Name: 2D Geometry

Settings

View: 2D
Element Thickness: 0.3048 m

Points

	X	Y
Point 1	65.099751 m	174.48775 m
Point 2	72.17675 m	174.48775 m
Point 3	76.083249 m	174.592 m
Point 4	76.404749 m	174.592 m
Point 5	76.790501 m	174.768 m
Point 6	77.482501 m	175.14275 m
Point 7	79.88025 m	175.277 m
Point 8	81.063249 m	175.32875 m
Point 9	81.57125 m	175.20875 m
Point 10	84.621999 m	175.20875 m
Point 11	88.556251 m	176.02625 m
Point 12	89.82225 m	176.29425 m
Point 13	92.478999 m	176.60275 m
Point 14	95.752749 m	177.413 m
Point 15	98.151251 m	177.413 m
Point 16	98.456249 m	177.2995 m
Point 17	100.451 m	177.2995 m
Point 18	107.09925 m	178.44625 m
Point 19	107.5495 m	178.44625 m
Point 20	108.09675 m	178.376 m
Point 21	109.4745 m	178.0295 m
Point 22	110.40375 m	177.7965 m
Point 23	111.20575 m	177.6315 m
Point 24	111.4265 m	177.6715 m
Point 25	112.0235 m	177.74725 m
Point 26	113.88975 m	177.96275 m
Point 27	115.137 m	178.10475 m
Point 28	116.855 m	177.9615 m
Point 29	117.5775 m	177.911 m
Point 30	119.14125 m	177.911 m
Point 31	121.35075 m	177.50325 m
Point 32	123.9915 m	177.25575 m
Point 33	124.5835 m	177.20375 m
Point 34	125.0825 m	177.1485 m
Point 35	125.8675 m	177.05925 m
Point 36	126.1485 m	177.02475 m
Point 37	126.3855 m	177.02475 m
Point 38	127.1585 m	177.02475 m
Point 39	127.455 m	177.05125 m
Point 40	128.67575 m	177.15475 m
Point 41	130.3785 m	177.297 m
Point 42	130.93025 m	177.297 m
Point 43	132.34725 m	176.877 m
Point 44	139.22375 m	176.877 m
Point 45	145.087 m	176.877 m
Point 46	145.5985 m	176.72525 m
Point 47	146.67375 m	176.72525 m
Point 48	148.568 m	176.87425 m
Point 49	149.663 m	176.95525 m
Point 50	152.291 m	177.08325 m
Point 51	154.14725 m	177.16575 m
Point 52	158.67325 m	178.04375 m
Point 53	163.142 m	179.09075 m
Point 54	164.49 m	179.52875 m
Point 55	166.673 m	179.66575 m
Point 56	170.615 m	179.81175 m
Point 57	174.5425 m	180.07225 m

Point 58	176.931 m	180.2235 m
Point 59	178.71025 m	180.33725 m
Point 60	180.38625 m	180.436 m
Point 61	181.59025 m	180.436 m
Point 62	188.54025 m	180.436 m
Point 63	194.36275 m	180.66825 m
Point 64	200.26475 m	181.1245 m
Point 65	203.531 m	181.4065 m
Point 66	204.0745 m	181.44725 m
Point 67	205.32825 m	181.44725 m
Point 68	211.22875 m	181.44725 m
Point 69	219.44675 m	180.634 m
Point 70	220.73025 m	180.52925 m
Point 71	223.526 m	180.52925 m
Point 72	226.0465 m	180.83925 m
Point 73	226.66925 m	180.93725 m
Point 74	229.69425 m	181.07125 m
Point 75	230.50475 m	181.1075 m
Point 76	231.651 m	181.1075 m
Point 77	231.651 m	153.8075 m
Point 78	23.511751 m	153.8075 m
Point 79	23.511751 m	174.37725 m
Point 80	77.850501 m	175.34125 m
Point 81	82.693749 m	176.02025 m
Point 82	103.20025 m	179.6745 m
Point 83	112.611 m	181.675 m
Point 84	112.99375 m	181.77025 m
Point 85	113.6425 m	181.77025 m
Point 86	114.08375 m	181.77025 m
Point 87	115.192 m	181.88875 m
Point 88	117.47675 m	182.1555 m
Point 89	119.3455 m	182.367 m
Point 90	124.097 m	182.918 m
Point 91	126.166 m	183.0895 m
Point 92	128.33 m	183.0895 m
Point 93	133.396 m	183.2805 m
Point 94	136.57275 m	183.38975 m
Point 95	144.7355 m	183.68525 m
Point 96	146.721 m	183.68525 m
Point 97	148.88525 m	183.77025 m
Point 98	150.31575 m	183.864 m
Point 99	153.5605 m	184.05425 m
Point 100	162.3055 m	184.6565 m
Point 101	169.026 m	185.1205 m
Point 102	171.5865 m	185.498 m
Point 103	176.931 m	186.45625 m
Point 104	182.45875 m	186.975 m
Point 105	231.72725 m	186.975 m
Point 106	75.489999 m	174.8707 m

Regions

	Material	Po
Region 1	Cohesiva Till Undrained	1,79,78,77,76,75,74,73,72,71,70,69,68,67,66,65,64,63,62,61,60,59,58,57,56,55,54,53,52,51,50,49,48,47,46,45,44,43,42,41,40,39,38,37,36,35,34,33,3:
Region 2	Cohesiva Till Undrained	6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50,51,52,53,54,55

Slip Results

Slip Surfaces Analysed: 15745 of 20956 converged

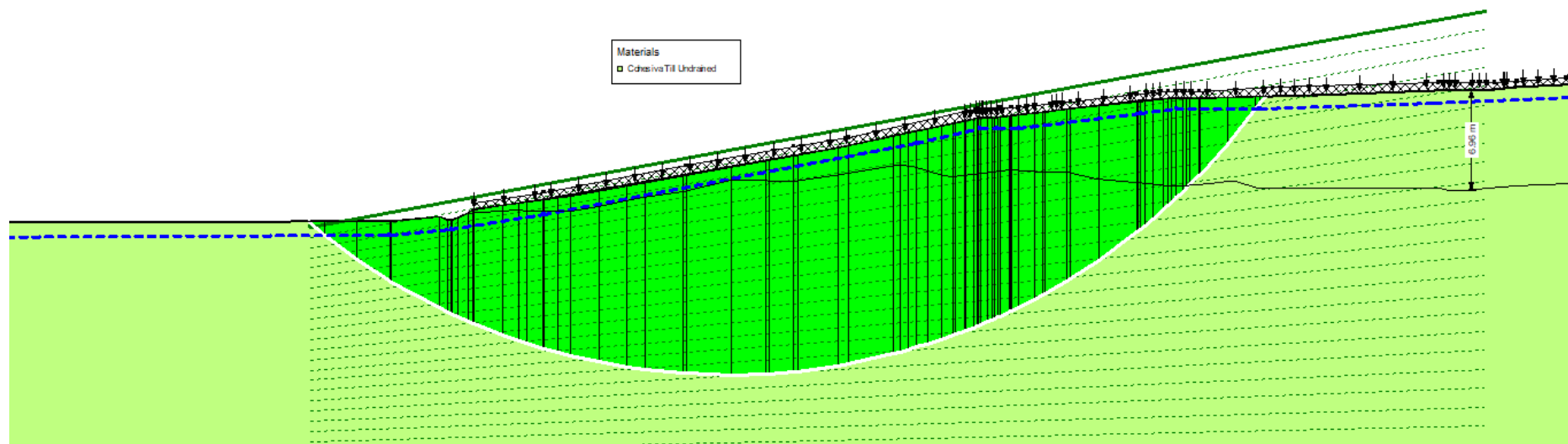
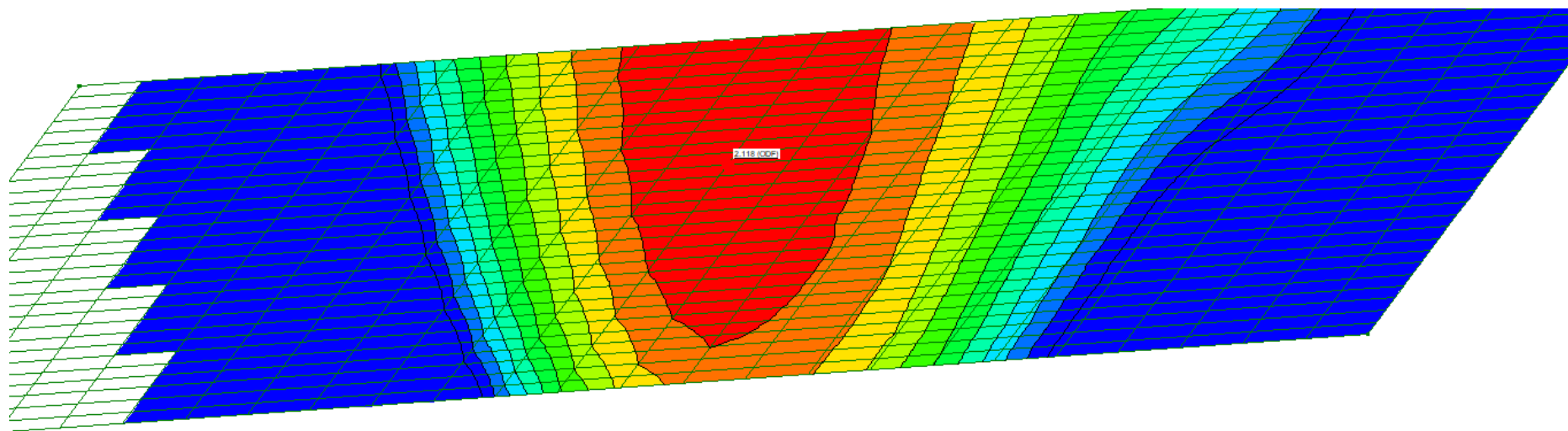
Current Slip Surface

Slip Surface: 13,174
 Overdesign Factor: 2.118
 Degree of Utilization: 0.472
 Volume: 211.55076 m³
 Weight: 4,442.5659 kN
 Resisting Moment: 55,880.334 kN·m
 Activating Moment: 26,377.846 kN·m
 Resisting Force: 1,108.2836 kN
 Activating Force: 523.29174 kN
 Slip Rank: 1 of 20,956 slip surfaces
 Exit: (132.88566, 183.26126) m
 Entry: (66.352741, 174.48775) m
 Radius: 45.443216 m
 Center: (95.612665, 209.2576) m

Slip Columns

	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength	Suction Strength	Base Material
Column 1	435.41406 m	600.45546 m	-6.3059001 kPa	-8.7537613 kPa	0 kPa	29.161359 kPa	0 kPa	Cohesiva Till Undrained
Column 2	434.36821 m	598.99383 m	-1.991498 kPa	0.12405684 kPa	0 kPa	30.245076 kPa	0 kPa	Cohesiva Till Undrained
Column 3	430.70812 m	594.29759 m	12.046373 kPa	28.253893 kPa	0 kPa	33.718458 kPa	0 kPa	Cohesiva Till Undrained
Column 4	424.35459 m	586.74484 m	34.622865 kPa	72.797065 kPa	0 kPa	39.291125 kPa	0 kPa	Cohesiva Till Undrained
Column 5	421.10400 m	583.14539 m	45.382221 kPa	93.785826 kPa	0 kPa	41.940513 kPa	0 kPa	Cohesiva Till Undrained
Column 6	419.98490 m	582.00583 m	48.788588 kPa	100.66212 kPa	0 kPa	42.806743 kPa	0 kPa	Cohesiva Till Undrained
Column 7	418.54954 m	580.55700 m	53.119388 kPa	109.41458 kPa	0 kPa	43.91075 kPa	0 kPa	Cohesiva Till Undrained
Column 8	417.67307 m	579.69768 m	55.688034 kPa	114.59794 kPa	0 kPa	44.565549 kPa	0 kPa	Cohesiva Till Undrained
Column 9	416.54446 m	578.61228 m	58.932482 kPa	121.14013 kPa	0 kPa	45.392624 kPa	0 kPa	Cohesiva Till Undrained
Column 10	415.27641 m	577.41765 m	62.290658 kPa	128.33678 kPa	0 kPa	46.302933 kPa	0 kPa	Cohesiva Till Undrained
Column 11	414.29052 m	576.50585 m	64.680964 kPa	133.82811 kPa	0 kPa	46.997722 kPa	0 kPa	Cohesiva Till Undrained
Column 12	413.92798 m	576.17442 m	65.548421 kPa	135.83962 kPa	0 kPa	47.250122 kPa	0 kPa	Cohesiva Till Undrained
Column 13	413.89927 m	576.14835 m	65.616566 kPa	135.9836 kPa	0 kPa	47.268168 kPa	0 kPa	Cohesiva Till Undrained
Column 14	413.41208 m	575.70978 m	66.761896 kPa	138.39464 kPa	0 kPa	47.571591 kPa	0 kPa	Cohesiva Till Undrained
Column 15	411.66339 m	574.17226 m	70.763236 kPa	146.82889 kPa	0 kPa	48.632728 kPa	0 kPa	Cohesiva Till Undrained
Column 16	409.55709 m	572.36220 m	75.457651 kPa	156.74817 kPa	0 kPa	49.878953 kPa	0 kPa	Cohesiva Till Undrained
Column 17	408.20661 m	571.23888 m	78.356264 kPa	162.89127 kPa	0 kPa	50.64962 kPa	0 kPa	Cohesiva Till Undrained
Column 18	407.40855 m	570.58774 m	80.023523 kPa	166.44887 kPa	0 kPa	51.095383 kPa	0 kPa	Cohesiva Till Undrained
Column 19	406.97875 m	570.24136 m	80.900224 kPa	168.34004 kPa	0 kPa	51.328053 kPa	0 kPa	Cohesiva Till Undrained
Column 20	402.47375 m	566.88873 m	89.258529 kPa	185.65068 kPa	0 kPa	53.484679 kPa	0 kPa	Cohesiva Till Undrained
Column 21	394.89337 m	561.56283 m	102.37981 kPa	213.22957 kPa	0 kPa	56.873182 kPa	0 kPa	Cohesiva Till Undrained
Column 22	391.60392 m	559.42738 m	107.54851 kPa	224.31052 kPa	0 kPa	58.20972 kPa	0 kPa	Cohesiva Till Undrained
Column 23	391.21843 m	559.19249 m	108.10833 kPa	225.54146 kPa	0 kPa	58.355358 kPa	0 kPa	Cohesiva Till Undrained
Column 24	388.31816 m	557.50491 m	112.08198 kPa	234.39681 kPa	0 kPa	59.391169 kPa	0 kPa	Cohesiva Till Undrained
Column 25	385.58768 m	555.93033 m	115.78054 kPa	242.72723 kPa	0 kPa	60.355515 kPa	0 kPa	Cohesiva Till Undrained
Column 26	384.40248 m	555.28986 m	117.25744 kPa	246.10651 kPa	0 kPa	60.738566 kPa	0 kPa	Cohesiva Till Undrained
Column 27	381.60679 m	553.83158 m	120.58429 kPa	253.81977 kPa	0 kPa	61.601058 kPa	0 kPa	Cohesiva Till Undrained
Column 28	379.05963 m	552.54646 m	123.77011 kPa	260.66389 kPa	0 kPa	62.353711 kPa	0 kPa	Cohesiva Till Undrained
Column 29	378.10737 m	552.08348 m	125.15405 kPa	263.1915 kPa	0 kPa	62.621785 kPa	0 kPa	Cohesiva Till Undrained
Column 30	377.83628 m	551.95383 m	125.54159 kPa	263.96145 kPa	0 kPa	62.697137 kPa	0 kPa	Cohesiva Till Undrained
Column 31	376.65518 m	551.40255 m	127.18946 kPa	267.29637 kPa	0 kPa	63.020979 kPa	0 kPa	Cohesiva Till Undrained
Column 32	375.28051 m	550.76554 m	129.0936 kPa	271.11448 kPa	0 kPa	63.394377 kPa	0 kPa	Cohesiva Till Undrained
Column 33	374.64362 m	550.47862 m	129.95124 kPa	272.74483 kPa	0 kPa	63.561116 kPa	0 kPa	Cohesiva Till Undrained
Column 34	373.97228 m	550.17975 m	130.84462 kPa	274.51506 kPa	0 kPa	63.760086 kPa	0 kPa	Cohesiva Till Undrained
Column 35	373.24845 m	549.86232 m	131.79347 kPa	276.56743 kPa	0 kPa	64.001966 kPa	0 kPa	Cohesiva Till Undrained
Column 36	371.99885 m	549.32692 m	133.39386 kPa	280.05111 kPa	0 kPa	64.409939 kPa	0 kPa	Cohesiva Till Undrained
Column 37	370.93463 m	548.87669 m	134.58283 kPa	282.99828 kPa	0 kPa	64.753017 kPa	0 kPa	Cohesiva Till Undrained
Column 38	370.62131 m	548.74665 m	134.74838 kPa	283.96223 kPa	0 kPa	64.834455 kPa	0 kPa	Cohesiva Till Undrained
Column 39	369.99344 m	548.49008 m	135.06812 kPa	284.97225 kPa	0 kPa	64.910898 kPa	0 kPa	Cohesiva Till Undrained
Column 40	368.69054 m	547.96710 m	135.70341 kPa	286.98332 kPa	0 kPa	65.083578 kPa	0 kPa	Cohesiva Till Undrained
Column 41	367.72679 m	547.58615 m	136.15571 kPa	288.50763 kPa	0 kPa	65.217749 kPa	0 kPa	Cohesiva Till Undrained

Column 42	366.55184 m	547.13871 m	136.65633 kPa	290.18799 kPa	0 kPa	65.368376 kPa	0 kPa	Cohesiva Till Undrained
Column 43	365.21038 m	546.63399 m	137.20958 kPa	292.08472 kPa	0 kPa	65.53568 kPa	0 kPa	Cohesiva Till Undrained
Column 44	363.53265 m	546.03394 m	137.80827 kPa	294.29645 kPa	0 kPa	65.721151 kPa	0 kPa	Cohesiva Till Undrained
Column 45	360.69267 m	545.06082 m	138.69434 kPa	297.84151 kPa	0 kPa	66.002643 kPa	0 kPa	Cohesiva Till Undrained
Column 46	357.87771 m	544.15387 m	139.40042 kPa	301.07674 kPa	0 kPa	66.237762 kPa	0 kPa	Cohesiva Till Undrained
Column 47	355.61762 m	543.46924 m	139.97266 kPa	303.45773 kPa	0 kPa	66.393357 kPa	0 kPa	Cohesiva Till Undrained
Column 48	353.75041 m	542.93470 m	140.50152 kPa	305.266 kPa	0 kPa	66.498223 kPa	0 kPa	Cohesiva Till Undrained
Column 49	352.11409 m	542.48726 m	140.9022 kPa	306.74322 kPa	0 kPa	66.574117 kPa	0 kPa	Cohesiva Till Undrained
Column 50	346.21022 m	541.13502 m	141.5643 kPa	310.62047 kPa	0 kPa	66.648196 kPa	0 kPa	Cohesiva Till Undrained
Column 51	339.81423 m	539.76074 m	142.01054 kPa	314.66396 kPa	0 kPa	66.659351 kPa	0 kPa	Cohesiva Till Undrained
Column 52	334.07358 m	538.91896 m	141.24025 kPa	317.34286 kPa	0 kPa	66.489039 kPa	0 kPa	Cohesiva Till Undrained
Column 53	329.04199 m	538.24222 m	140.38255 kPa	319.4959 kPa	0 kPa	66.321484 kPa	0 kPa	Cohesiva Till Undrained
Column 54	325.76977 m	537.96459 m	139.3391 kPa	319.74951 kPa	0 kPa	66.088713 kPa	0 kPa	Cohesiva Till Undrained
Column 55	322.51887 m	537.71127 m	138.23516 kPa	319.82091 kPa	0 kPa	65.840306 kPa	0 kPa	Cohesiva Till Undrained
Column 56	318.08399 m	537.56554 m	136.13181 kPa	318.57661 kPa	0 kPa	65.349152 kPa	0 kPa	Cohesiva Till Undrained
Column 57	309.13509 m	537.60283 m	130.89708 kPa	313.61207 kPa	0 kPa	64.105579 kPa	0 kPa	Cohesiva Till Undrained
Column 58	303.76476 m	537.77993 m	127.29319 kPa	309.3558 kPa	0 kPa	63.241405 kPa	0 kPa	Cohesiva Till Undrained
Column 59	299.05061 m	538.23387 m	123.23742 kPa	303.18782 kPa	0 kPa	62.255374 kPa	0 kPa	Cohesiva Till Undrained
Column 60	292.61565 m	538.96062 m	117.38101 kPa	293.70269 kPa	0 kPa	60.827799 kPa	0 kPa	Cohesiva Till Undrained
Column 61	287.31197 m	539.83740 m	111.72382 kPa	283.62863 kPa	0 kPa	59.439522 kPa	0 kPa	Cohesiva Till Undrained
Column 62	280.85814 m	541.14628 m	104.11651 kPa	269.24919 kPa	0 kPa	57.565798 kPa	0 kPa	Cohesiva Till Undrained
Column 63	276.25389 m	542.23226 m	98.234394 kPa	257.62478 kPa	0 kPa	56.113079 kPa	0 kPa	Cohesiva Till Undrained
Column 64	273.27202 m	543.04149 m	94.108328 kPa	249.21744 kPa	0 kPa	55.09154 kPa	0 kPa	Cohesiva Till Undrained
Column 65	271.63181 m	543.50392 m	91.787055 kPa	244.43286 kPa	0 kPa	54.516455 kPa	0 kPa	Cohesiva Till Undrained
Column 66	271.45054 m	543.55742 m	91.536679 kPa	243.91395 kPa	0 kPa	54.451073 kPa	0 kPa	Cohesiva Till Undrained
Column 67	269.46358 m	544.17244 m	88.742568 kPa	238.21732 kPa	0 kPa	53.765943 kPa	0 kPa	Cohesiva Till Undrained
Column 68	266.78888 m	545.02063 m	84.920692 kPa	230.40568 kPa	0 kPa	52.833887 kPa	0 kPa	Cohesiva Till Undrained
Column 69	264.01493 m	545.98264 m	80.71085 kPa	221.64671 kPa	0 kPa	51.804497 kPa	0 kPa	Cohesiva Till Undrained
Column 70	258.75574 m	547.98421 m	72.198246 kPa	203.59139 kPa	0 kPa	49.717472 kPa	0 kPa	Cohesiva Till Undrained
Column 71	255.42610 m	549.30464 m	66.649757 kPa	186.46682 kPa	0 kPa	48.355605 kPa	0 kPa	Cohesiva Till Undrained
Column 72	254.81135 m	549.56883 m	65.564352 kPa	182.48818 kPa	0 kPa	47.90498 kPa	0 kPa	Cohesiva Till Undrained
Column 73	253.07251 m	550.33352 m	62.442212 kPa	171.00016 kPa	0 kPa	46.605725 kPa	0 kPa	Cohesiva Till Undrained
Column 74	251.30454 m	551.13025 m	59.210286 kPa	159.52284 kPa	0 kPa	45.310181 kPa	0 kPa	Cohesiva Till Undrained
Column 75	250.54667 m	551.48026 m	57.799509 kPa	155.20664 kPa	0 kPa	44.823469 kPa	0 kPa	Cohesiva Till Undrained
Column 76	250.01927 m	551.72875 m	56.884312 kPa	153.52701 kPa	0 kPa	44.634122 kPa	0 kPa	Cohesiva Till Undrained
Column 77	248.64378 m	552.39063 m	54.522008 kPa	152.13568 kPa	0 kPa	44.47814 kPa	0 kPa	Cohesiva Till Undrained
Column 78	242.23548 m	555.83375 m	42.441712 kPa	127.5622 kPa	0 kPa	41.724168 kPa	0 kPa	Cohesiva Till Undrained
Column 79	236.54692 m	558.95825 m	31.51468 kPa	101.94657 kPa	0 kPa	38.864617 kPa	0 kPa	Cohesiva Till Undrained
Column 80	232.57968 m	561.52092 m	23.738145 kPa	84.547808 kPa	0 kPa	36.911861 kPa	0 kPa	Cohesiva Till Undrained
Column 81	225.15211 m	566.67347 m	8.2452061 kPa	49.80172 kPa	0 kPa	32.985619 kPa	0 kPa	Cohesiva Till Undrained
Column 82	219.56552 m	570.94148 m	-4.5811244 kPa	21.394201 kPa	0 kPa	29.733394 kPa	0 kPa	Cohesiva Till Undrained



B. Platform Cutting- 1:3 Slope analyses

SLS

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File Information

File Version: 11.05
Created By: Laura Castro
Last Edited By: Laura Castro
Revision Number: 93
Date: 12/06/2024
Time: 17:57:23
Tool Version: 23.1.2.11
File Name: Till 1 in 3- 10m with grid and radius.gsz
Directory: C:\Users\CAS111646\OneDrive - Mott MacDonald\Desktop\Knocknagael\Slope stability analysis\Platform cutting\
Last Solved Date: 12/06/2024
Last Solved Time: 17:57:34

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

SLS

Kind: [SLOPE/W](#)
Analysis Type: [Morgenstern-Price](#)
Settings
 Side Function
 Intercolumn force function option: [Half-Sine](#)
 PWP Conditions from: [Piezometric Surfaces](#)
 Apply Phreatic Correction: [No](#)
 Use Staged Rapid Drawdown: [No](#)
 Unit Weight of Water: [9.807 kN/m³](#)
Slip Surface
 Direction of movement: [Left to Right](#)
 Use Passive Mode: [No](#)
 Slip Surface Option: [Grid and Radius](#)
 Critical slip surfaces saved: [1](#)
 Optimize Critical Slip Surface Location: [No](#)
 Tension Crack Option: [\(none\)](#)
Distribution
 F of S Calculation Option: [Constant](#)
Convergence
 Geometry Settings
 Minimum Slip Surface Depth: [0.5 m](#)
 Minimum Slip Surface Volume: [1 m³](#)
 Number of Columns: [30](#)
 Factor of Safety Convergence Settings
 Maximum Number of Iterations: [100](#)
 Tolerable difference in F of S: [0.001](#)
 Under-Relaxation Criteria
 Initial Rate: [1](#)
 Minimum Rate: [0.1](#)

Rate Reduction Factor: 0.65
Reduction Frequency (iterations): 50
Solution Settings
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Cohesive Till

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 21 kN/m³
Effective Cohesion: 0 kPa
Effective Friction Angle: 27 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Surface: 1

Slip Surface Grid

Upper Left: (-36.854999, 39.92) m
Lower Left: (-55.309999, 15.21) m
Lower Right: (10.87, 14.175) m
Grid Horizontal Increment: 30
Grid Vertical Increment: 20

Slip Surface Radius

Upper Left Coordinate: (-30.005, 10.5) m
Upper Right Coordinate: (0.64000075, 0.045000062) m
Lower Left Coordinate: (-30.000001, -9.7549999) m
Lower Right Coordinate: (0.64000075, -9.7549999) m
Number of Increments: 25
Use Left Projection: No
Left Projection Angle: 135 °
Use Right Projection: No
Right Projection Angle: 45 °

Slip Surface Limits

Left Coordinate: (-54.949999, 10) m
Right Coordinate: (62.319999, 0) m

Piezometric Surfaces

Piezometric Surface 1

Coordinates

	X	Y
Coordinate 1	-54.949999 m	8.895 m
Coordinate 2	-34.005 m	8.5900001 m
Coordinate 3	-28.885 m	7.845 m

Coordinate 4	0 m	-1.1599999 m
Coordinate 5	9.9999942 m	-1.205 m
Coordinate 6	62.319999 m	-1.0849999 m

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 8 kN/m³
Direction: Vertical

Coordinates

	X	Y
	-54.955001 m	10.5 m
	-30.005 m	10.5 m
	-13.440001 m	5.0050001 m
	1.3749985 m	0 m

Geometry

Name: 2D Geometry

Settings

View: 2D
Element Thickness: 0.3048 m

Points

	X	Y
Point 1	0 m	0 m
Point 2	10 m	0 m
Point 3	-27.000001 m	-10 m
Point 4	-12 m	4.0000001 m
Point 5	-13.42 m	4.5000001 m
Point 6	-27.020008 m	-2.8001793 m
Point 7	-30.005 m	10 m
Point 8	-54.949999 m	10 m
Point 9	-54.949999 m	-10.19 m
Point 10	-54.949999 m	-22.79 m
Point 11	10.11 m	-22.79 m
Point 12	62.319999 m	0 m
Point 13	62.319999 m	-22.79 m

Regions

	Material	Points	Area
Region 1	Cohesive Till	1,4,5,7,8,9,10,11,13,12,2	3,072.3 m²

Slip Results

Slip Surfaces Analysed: 11255 of 16926 converged

Current Slip Surface

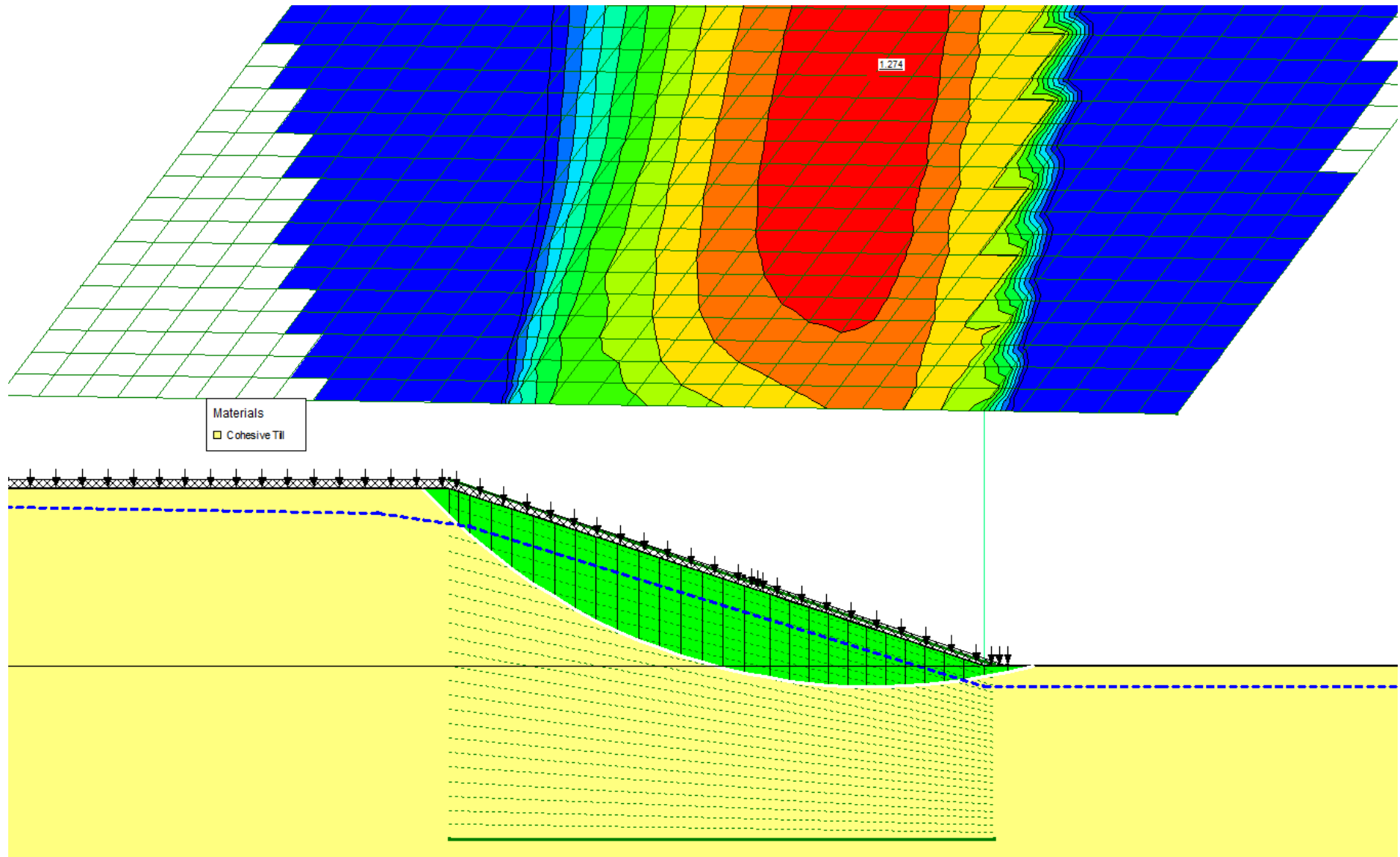
Slip Surface: 12,516

Factor of Safety: 1.274
 Volume: 35.134505 m³
 Weight: 737.82461 kN
 Resisting Moment: 9,698.0381 kN·m
 Activating Moment: 7,613.4152 kN·m
 Resisting Force: 263.1072 kN
 Activating Force: 206.6052 kN
 Slip Rank: 1 of 16,926 slip surfaces
 Exit: (2.7767069, 0) m
 Entry: (-31.547989, 10) m
 Radius: 34.375894 m
 Center: (-6.1727494, 33.1905) m

Slip Columns

	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength	Suction Strength	Base Material
Column 1	-100.97275 m	30.211627 m	-10.67273 kPa	14.316758 kPa	7.2947528 kPa	0 kPa	0 kPa	Cohesive Till
Column 2	-97.59963 m	26.821347 m	-2.0057242 kPa	28.566829 kPa	14.555526 kPa	0 kPa	0 kPa	Cohesive Till
Column 3	-95.76236 m	25.130584 m	2.2491402 kPa	34.058653 kPa	16.207757 kPa	0 kPa	0 kPa	Cohesive Till
Column 4	-92.81812 m	22.594505 m	7.5808225 kPa	42.408725 kPa	17.745703 kPa	0 kPa	0 kPa	Cohesive Till
Column 5	-88.92023 m	19.459249 m	13.320262 kPa	52.134674 kPa	19.776931 kPa	0 kPa	0 kPa	Cohesive Till
Column 6	-85.02233 m	16.595131 m	18.24922 kPa	60.551735 kPa	21.554208 kPa	0 kPa	0 kPa	Cohesive Till
Column 7	-81.12445 m	13.977514 m	22.441348 kPa	67.909535 kPa	23.167199 kPa	0 kPa	0 kPa	Cohesive Till
Column 8	-77.22655 m	11.586437 m	25.956304 kPa	74.398207 kPa	24.682382 kPa	0 kPa	0 kPa	Cohesive Till
Column 9	-73.32867 m	9.405520 m	28.843056 kPa	80.158174 kPa	26.146359 kPa	0 kPa	0 kPa	Cohesive Till
Column 10	-69.43077 m	7.421178 m	31.142213 kPa	85.28647 kPa	27.587877 kPa	0 kPa	0 kPa	Cohesive Till
Column 11	-65.53288 m	5.622053 m	32.887724 kPa	89.840752 kPa	29.019017 kPa	0 kPa	0 kPa	Cohesive Till
Column 12	-61.63500 m	3.998594 m	34.108136 kPa	93.841875 kPa	30.43586 kPa	0 kPa	0 kPa	Cohesive Till
Column 13	-57.73710 m	2.542743 m	34.827543 kPa	97.27571 kPa	31.81893 kPa	0 kPa	0 kPa	Cohesive Till
Column 14	-53.83922 m	1.247686 m	35.066306 kPa	100.09489 kPa	33.133719 kPa	0 kPa	0 kPa	Cohesive Till
Column 15	-49.94132 m	0.107672 m	34.841621 kPa	102.22112 kPa	34.331571 kPa	0 kPa	0 kPa	Cohesive Till
Column 16	-46.04344 m	-0.882138 m	34.167947 kPa	103.54869 kPa	35.351254 kPa	0 kPa	0 kPa	Cohesive Till
Column 17	-44.06168 m	-1.347130 m	33.711119 kPa	103.99374 kPa	35.810783 kPa	0 kPa	0 kPa	Cohesive Till
Column 18	-41.69947 m	-1.805534 m	32.880065 kPa	103.68722 kPa	36.078047 kPa	0 kPa	0 kPa	Cohesive Till
Column 19	-37.58488 m	-2.534549 m	31.224885 kPa	102.58665 kPa	36.360637 kPa	0 kPa	0 kPa	Cohesive Till
Column 20	-34.01448 m	-3.031761 m	29.383934 kPa	100.62037 kPa	36.296779 kPa	0 kPa	0 kPa	Cohesive Till

Column 21	-30.44407 m	-3.413292 m	27.197189 kPa	97.507339 kPa	35.824811 kPa	0 kPa	0 kPa	Cohesive Till
Column 22	-26.87367 m	-3.680317 m	24.66817 kPa	93.159483 kPa	34.898067 kPa	0 kPa	0 kPa	Cohesive Till
Column 23	-23.30327 m	-3.833653 m	21.799311 kPa	87.513946 kPa	33.483279 kPa	0 kPa	0 kPa	Cohesive Till
Column 24	-19.73287 m	-3.873762 m	18.592 kPa	80.540954 kPa	31.564569 kPa	0 kPa	0 kPa	Cohesive Till
Column 25	-16.16247 m	-3.800767 m	15.0466 kPa	72.249641 kPa	29.146405 kPa	0 kPa	0 kPa	Cohesive Till
Column 26	-12.59206 m	-3.614447 m	11.16245 kPa	62.690823 kPa	26.255018 kPa	0 kPa	0 kPa	Cohesive Till
Column 27	-9.02166 m	-3.314236 m	6.9378627 kPa	51.956072 kPa	22.937923 kPa	0 kPa	0 kPa	Cohesive Till
Column 28	-5.45126 m	-2.899216 m	2.3700917 kPa	40.172821 kPa	19.261453 kPa	0 kPa	0 kPa	Cohesive Till
Column 29	-1.83303 m	-2.359393 m	-2.6153112 kPa	27.019304 kPa	13.767023 kPa	0 kPa	0 kPa	Cohesive Till
Column 30	2.25557 m	-1.596443 m	-6.6344152 kPa	14.066834 kPa	7.1674098 kPa	0 kPa	0 kPa	Cohesive Till
Column 31	6.81054 m	-0.568484 m	-9.7684339 kPa	4.1686824 kPa	2.1240498 kPa	0 kPa	0 kPa	Cohesive Till



ULS C1

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File Information

File Version: 11.05
Created By: Laura Castro
Last Edited By: Laura Castro
Revision Number: 93
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Time: 17:57:23
Tool Version: 23.1.2.11
File Name: Till 1 in 3- 10m with grid and radius.gsz
Directory: C:\Users\CAS111646\OneDrive - Mott MacDonald\Desktop\Knocknagael\Slope stability analysis\Platform cutting\
Last Solved Date: 12/06/2024
Last Solved Time: 17:57:36

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

ULS C1

Kind: SLOPE/W
Analysis Type: Morgenstern-Price
Settings
Side Function
Intercolumn force function option: Half-Sine
PWP Conditions from: Piezometric Surfaces
Apply Phreatic Correction: No
Use Staged Rapid Drawdown: No
Limit State Design Approach: Eurocode 7 - DA1, C1
Unit Weight of Water: 9.807 kN/m³

Slip Surface
Direction of movement: Left to Right
Use Passive Mode: No
Slip Surface Option: Grid and Radius
Critical slip surfaces saved: 1
Optimize Critical Slip Surface Location: No
Tension Crack Option: (none)

Distribution
ODF Calculation Option: Constant

Convergence
Geometry Settings
Minimum Slip Surface Depth: 0.5 m
Minimum Slip Surface Volume: 1 m³
Number of Columns: 30
Overdesign Factor Convergence Settings
Maximum Number of Iterations: 100
Tolerable difference in ODF: 0.001
Under-Relaxation Criteria
Initial Rate: 1

Minimum Rate: 0.1
Rate Reduction Factor: 0.65
Reduction Frequency (iterations): 50

Solution Settings

Search Method: Root Finder
Tolerable difference between starting and converged ODF: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Cohesive Till

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 21 kN/m³
Effective Cohesion: 0 kPa
Effective Friction Angle: 27 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Surface: 1

Slip Surface Grid

Upper Left: (-36.854999, 39.92) m
Lower Left: (-55.309999, 15.21) m
Lower Right: (10.87, 14.175) m
Grid Horizontal Increment: 30
Grid Vertical Increment: 20

Slip Surface Radius

Upper Left Coordinate: (-30.005, 10.5) m
Upper Right Coordinate: (1.3749985, 0) m
Lower Left Coordinate: (-30.000001, -9.8150001) m
Lower Right Coordinate: (1.1599987, -9.8150001) m
Number of Increments: 25
Use Left Projection: No
Left Projection Angle: 135 °
Use Right Projection: No
Right Projection Angle: 45 °

Slip Surface Limits

Left Coordinate: (-54.949999, 10) m
Right Coordinate: (62.319999, 0) m

Piezometric Surfaces

Piezometric Surface 1

Coordinates

	X	Y
Coordinate 1	-54.949999 m	8.895 m
Coordinate 2	-34.005 m	8.5900001 m

Coordinate 3	-28.885 m	7.845 m
Coordinate 4	0 m	-1.1599999 m
Coordinate 5	9.9899998 m	-1.205 m
Coordinate 6	62.319999 m	-1.1950001 m

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 8 kN/m³

Direction: Vertical

Mode: Permanent

Coordinates

	X	Y
	-54.955001 m	10.5 m
	-30.005 m	10.5 m
	-13.440001 m	5.0050001 m
	1.3749985 m	0 m

Design Factor Set: Eurocode 7 - DA1, C1

Permanent Point Loads & Surcharge Loads: Favorable = 1, Unfavorable = 1.35

Variable Point Loads & Surcharge Loads: Favorable = 0, Unfavorable = 1.5

Soil Unit Weight: Favorable = 1, Unfavorable = 1.35

Effective Cohesion: 1

Effective Coefficient of Friction: 1

Undrained Strength: 1

Shear Strength (Other Models): 1

Pullout Resistance: 1.1

Shear Force: 1.1

Tensile Strength: 1.1

Compressive Strength: 1.1

Seismic Coefficients: 1

Earth Resistance: 1

Geometry

Name: 2D Geometry

Settings

View: 2D

Element Thickness: 0.3048 m

Points

	X	Y
Point 1	0 m	0 m
Point 2	10 m	0 m
Point 3	-27.000001 m	-10 m
Point 4	-12 m	4.0000001 m
Point 5	-13.42 m	4.5000001 m
Point 6	-27.020008 m	-2.8001793 m
Point 7	-30.005 m	10 m
Point 8	-54.949999 m	10 m

Point 9	-54.949999 m	-10.19 m
Point 10	-54.949999 m	-22.79 m
Point 11	10.11 m	-22.79 m
Point 12	62.319999 m	0 m
Point 13	62.319999 m	-22.79 m

Regions

	Material	Points	Area
Region 1	Cohesive Till	1,4,5,7,8,9,10,11,13,12,2	3,072.3 m ²

Slip Results

Slip Surfaces Analysed: 12628 of 16926 converged

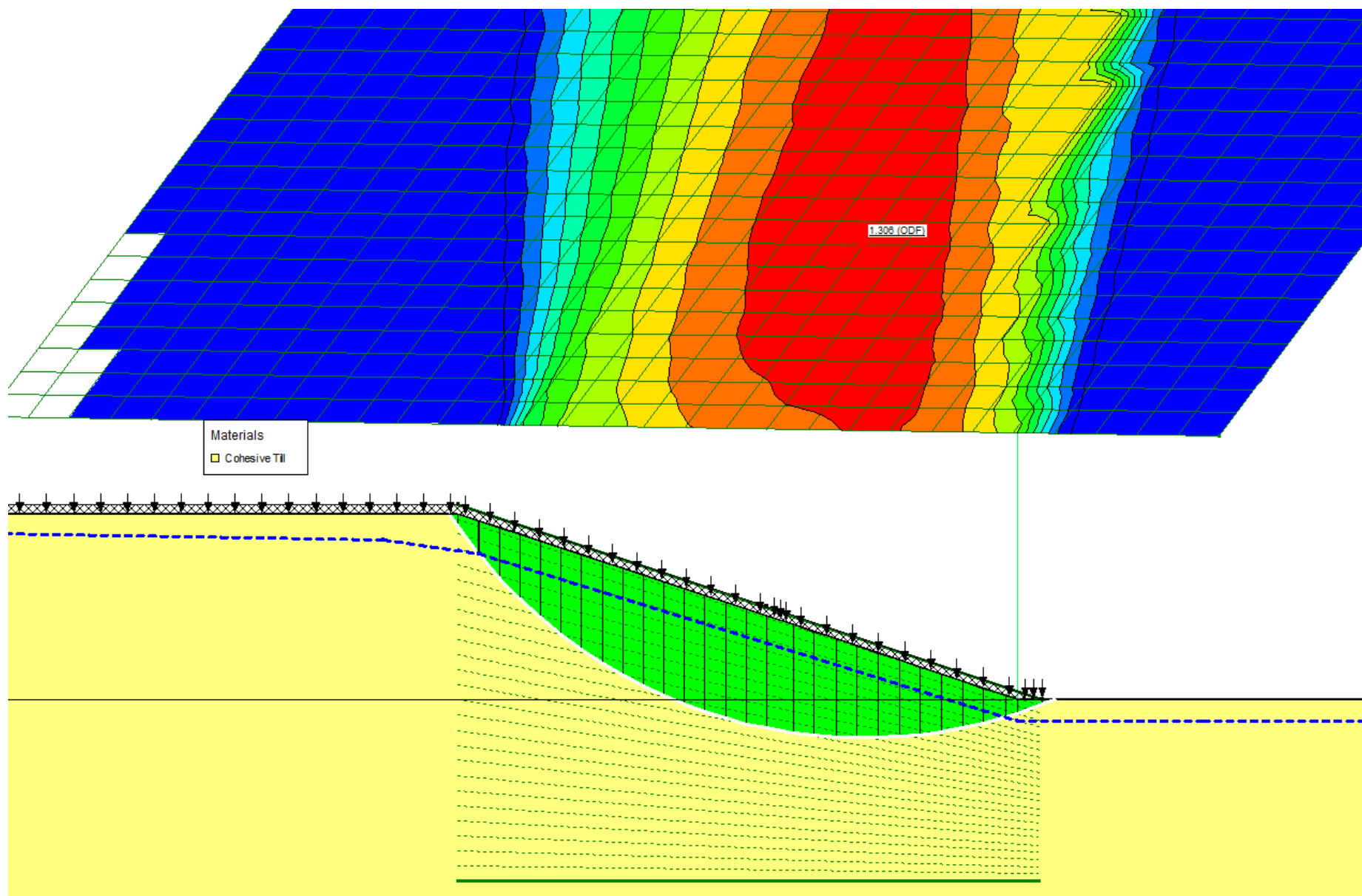
Current Slip Surface

Slip Surface: 6,928
Overdesign Factor: 1.306
Degree of Utilization: 0.766
Volume: 41.339733 m³
Weight: 1,110.8264 kN
Resisting Moment: 11,807.133 kN·m
Activating Moment: 9,040.8676 kN·m
Resisting Force: 407.79868 kN
Activating Force: 312.42774 kN
Slip Rank: 1 of 16,926 slip surfaces
Exit: (2.0515193, 0) m
Entry: (-30.467788, 10) m
Radius: 26.541135 m
Center: (-8.2199994, 24.473) m

Slip Columns

	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength	Suction Strength	Base Material
Column 1	-99.20077 m	31.680349 m	-15.833715 kPa	9.4836036 kPa	4.8321374 kPa	0 kPa	0 kPa	Cohesive Till
Column 2	-96.64472 m	28.151122 m	-6.3959876 kPa	25.825331 kPa	13.158663 kPa	0 kPa	0 kPa	Cohesive Till
Column 3	-94.80745 m	25.699748 m	0.13247674 kPa	36.339935 kPa	18.448621 kPa	0 kPa	0 kPa	Cohesive Till
Column 4	-92.95733 m	23.545080 m	4.8691186 kPa	46.498307 kPa	21.211131 kPa	0 kPa	0 kPa	Cohesive Till
Column 5	-89.33786 m	19.581427 m	13.344236 kPa	64.76876 kPa	26.202104 kPa	0 kPa	0 kPa	Cohesive Till
Column 6	-85.71839 m	16.066794 m	20.477154 kPa	80.255819 kPa	30.458751 kPa	0 kPa	0 kPa	Cohesive Till
Column 7	-82.09892 m	12.930214 m	26.480004 kPa	93.658441 kPa	34.229123 kPa	0 kPa	0 kPa	Cohesive Till
Column 8	-78.47945 m	10.120608 m	31.505474 kPa	105.47916 kPa	37.691475 kPa	0 kPa	0 kPa	Cohesive Till
Column 9	-74.85998 m	7.599830 m	35.667586 kPa	116.08212 kPa	40.973252 kPa	0 kPa	0 kPa	Cohesive Till
Column 10	-71.24051 m	5.338592 m	39.053891 kPa	125.72683 kPa	44.16207 kPa	0 kPa	0 kPa	Cohesive Till

Column 11	-67.62104 m	3.313922 m	41.733048 kPa	134.58803 kPa	47.311977 kPa	0 kPa	0 kPa	Cohesive Till
Column 12	-64.00157 m	1.507516 m	43.75978 kPa	142.76714 kPa	50.446771 kPa	0 kPa	0 kPa	Cohesive Till
Column 13	-60.38210 m	-0.095389 m	45.17821 kPa	150.29857 kPa	53.561499 kPa	0 kPa	0 kPa	Cohesive Till
Column 14	-56.76263 m	-1.506790 m	46.024203 kPa	157.15291 kPa	56.622903 kPa	0 kPa	0 kPa	Cohesive Till
Column 15	-53.14316 m	-2.736480 m	46.327028 kPa	163.23882 kPa	59.569531 kPa	0 kPa	0 kPa	Cohesive Till
Column 16	-49.52369 m	-3.792448 m	46.110572 kPa	168.40501 kPa	62.312129 kPa	0 kPa	0 kPa	Cohesive Till
Column 17	-45.90422 m	-4.681187 m	45.394237 kPa	172.44396 kPa	64.735066 kPa	0 kPa	0 kPa	Cohesive Till
Column 18	-44.06168 m	-5.091043 m	44.902327 kPa	174.16945 kPa	65.864887 kPa	0 kPa	0 kPa	Cohesive Till
Column 19	-41.69947 m	-5.497593 m	43.916271 kPa	174.98967 kPa	66.785234 kPa	0 kPa	0 kPa	Cohesive Till
Column 20	-37.50596 m	-6.124881 m	41.883469 kPa	175.29287 kPa	67.975487 kPa	0 kPa	0 kPa	Cohesive Till
Column 21	-33.77773 m	-6.498438 m	39.525808 kPa	173.34554 kPa	68.184559 kPa	0 kPa	0 kPa	Cohesive Till
Column 22	-30.04949 m	-6.710702 m	36.686014 kPa	168.84272 kPa	67.337205 kPa	0 kPa	0 kPa	Cohesive Till
Column 23	-26.32125 m	-6.762856 m	33.367621 kPa	120.3769 kPa	44.33344 kPa	0 kPa	0 kPa	Cohesive Till
Column 24	-22.59302 m	-6.655187 m	29.571493 kPa	113.17452 kPa	42.597869 kPa	0 kPa	0 kPa	Cohesive Till
Column 25	-18.86478 m	-6.387100 m	25.295844 kPa	103.70186 kPa	39.949858 kPa	0 kPa	0 kPa	Cohesive Till
Column 26	-15.13654 m	-5.957095 m	20.536197 kPa	91.981932 kPa	36.40342 kPa	0 kPa	0 kPa	Cohesive Till
Column 27	-11.40831 m	-5.362730 m	15.285247 kPa	78.148393 kPa	32.030373 kPa	0 kPa	0 kPa	Cohesive Till
Column 28	-7.68007 m	-4.600545 m	9.5326541 kPa	62.440592 kPa	26.957941 kPa	0 kPa	0 kPa	Cohesive Till
Column 29	-3.95184 m	-3.665959 m	3.2647284 kPa	45.184432 kPa	21.359156 kPa	0 kPa	0 kPa	Cohesive Till
Column 30	-1.04386 m	-2.829352 m	-1.9459372 kPa	30.622489 kPa	15.602937 kPa	0 kPa	0 kPa	Cohesive Till
Column 31	2.25557 m	-1.699837 m	-6.3253826 kPa	15.85589 kPa	8.0789793 kPa	0 kPa	0 kPa	Cohesive Till
Column 32	5.62093 m	-0.447945 m	-10.112819 kPa	3.4807057 kPa	1.7735081 kPa	0 kPa	0 kPa	Cohesive Till



ULS C2

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File Information

File Version: 11.05
Created By: Laura Castro
Last Edited By: Laura Castro
Revision Number: 93
Date: 12/06/2024
Time: 17:57:23
Tool Version: 23.1.2.11
File Name: Till 1 in 3- 10m with grid and radius.gsz
Directory: C:\Users\CAS111646\OneDrive - Mott MacDonald\Desktop\Knocknagael\Slope stability analysis\Platform cutting\
Last Solved Date: 12/06/2024
Last Solved Time: 17:57:34

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

ULS C2

Kind: [SLOPE/W](#)
Analysis Type: [Morgenstern-Price](#)
Settings
 Side Function
 Intercolumn force function option: [Half-Sine](#)
 PWP Conditions from: [Piezometric Surfaces](#)
 Apply Phreatic Correction: [No](#)
 Use Staged Rapid Drawdown: [No](#)
 Limit State Design Approach: [Eurocode 7 - DA1, C2](#)
 Unit Weight of Water: [9.807 kN/m³](#)
Slip Surface
 Direction of movement: [Left to Right](#)
 Use Passive Mode: [No](#)
 Slip Surface Option: [Grid and Radius](#)
 Critical slip surfaces saved: [1](#)
 Optimize Critical Slip Surface Location: [No](#)
 Tension Crack Option: [\(none\)](#)
Distribution
 ODF Calculation Option: [Constant](#)
Convergence
 Geometry Settings
 Minimum Slip Surface Depth: [0.5 m](#)
 Minimum Slip Surface Volume: [1 m³](#)
 Number of Columns: [30](#)
 Overdesign Factor Convergence Settings
 Maximum Number of Iterations: [100](#)
 Tolerable difference in ODF: [0.001](#)
 Under-Relaxation Criteria
 Initial Rate: [1](#)

Minimum Rate: 0.1
Rate Reduction Factor: 0.65
Reduction Frequency (iterations): 50

Solution Settings

Search Method: Root Finder
Tolerable difference between starting and converged ODF: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Cohesive Till

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 21 kN/m³
Effective Cohesion: 0 kPa
Effective Friction Angle: 27 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Surface: 1

Slip Surface Grid

Upper Left: (-36.854999, 39.92) m
Lower Left: (-55.309999, 15.21) m
Lower Right: (10.87, 14.175) m
Grid Horizontal Increment: 30
Grid Vertical Increment: 20

Slip Surface Radius

Upper Left Coordinate: (-30.005, 10.5) m
Upper Right Coordinate: (1.3749985, 0) m
Lower Left Coordinate: (-30.060001, -9.6950001) m
Lower Right Coordinate: (0.8599993, -9.6950001) m
Number of Increments: 25
Use Left Projection: No
Left Projection Angle: 135 °
Use Right Projection: No
Right Projection Angle: 45 °

Slip Surface Limits

Left Coordinate: (-54.949999, 10) m
Right Coordinate: (62.319999, 0) m

Piezometric Surfaces

Piezometric Surface 1

Coordinates

	X	Y
Coordinate 1	-54.949999 m	8.895 m
Coordinate 2	-34.005 m	8.5900001 m

Coordinate 3	-28.885 m	7.845 m
Coordinate 4	0 m	-1.1599999 m
Coordinate 5	9.9949986 m	-1.205 m
Coordinate 6	62.319999 m	-1.1950001 m

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 8 kN/m³

Direction: Vertical

Mode: Permanent

Coordinates

	X	Y
	-54.955001 m	10.5 m
	-30.005 m	10.5 m
	-13.440001 m	5.0050001 m
	1.3749985 m	0 m

Design Factor Set: Eurocode 7 - DA1, C2

Permanent Point Loads & Surcharge Loads: Favorable = 1, Unfavorable = 1

Variable Point Loads & Surcharge Loads: Favorable = 0, Unfavorable = 1.3

Soil Unit Weight: Favorable = 1, Unfavorable = 1

Effective Cohesion: 1.4

Effective Coefficient of Friction: 1.25

Undrained Strength: 1.4

Shear Strength (Other Models): 1.25

Pullout Resistance: 1.1

Shear Force: 1.1

Tensile Strength: 1.1

Compressive Strength: 1.1

Seismic Coefficients: 1

Earth Resistance: 1

Geometry

Name: 2D Geometry

Settings

View: 2D

Element Thickness: 0.3048 m

Points

	X	Y
Point 1	0 m	0 m
Point 2	10 m	0 m
Point 3	-27.000001 m	-10 m
Point 4	-12 m	4.0000001 m
Point 5	-13.42 m	4.5000001 m
Point 6	-27.020008 m	-2.8001793 m
Point 7	-30.005 m	10 m
Point 8	-54.949999 m	10 m

Point 9	-54.949999 m	-10.19 m
Point 10	-54.949999 m	-22.79 m
Point 11	10.11 m	-22.79 m
Point 12	62.319999 m	0 m
Point 13	62.319999 m	-22.79 m

Regions

	Material	Points	Area
Region 1	Cohesive Till	1,4,5,7,8,9,10,11,13,12,2	3,072.3 m ²

Slip Results

Slip Surfaces Analysed: 11231 of 16926 converged

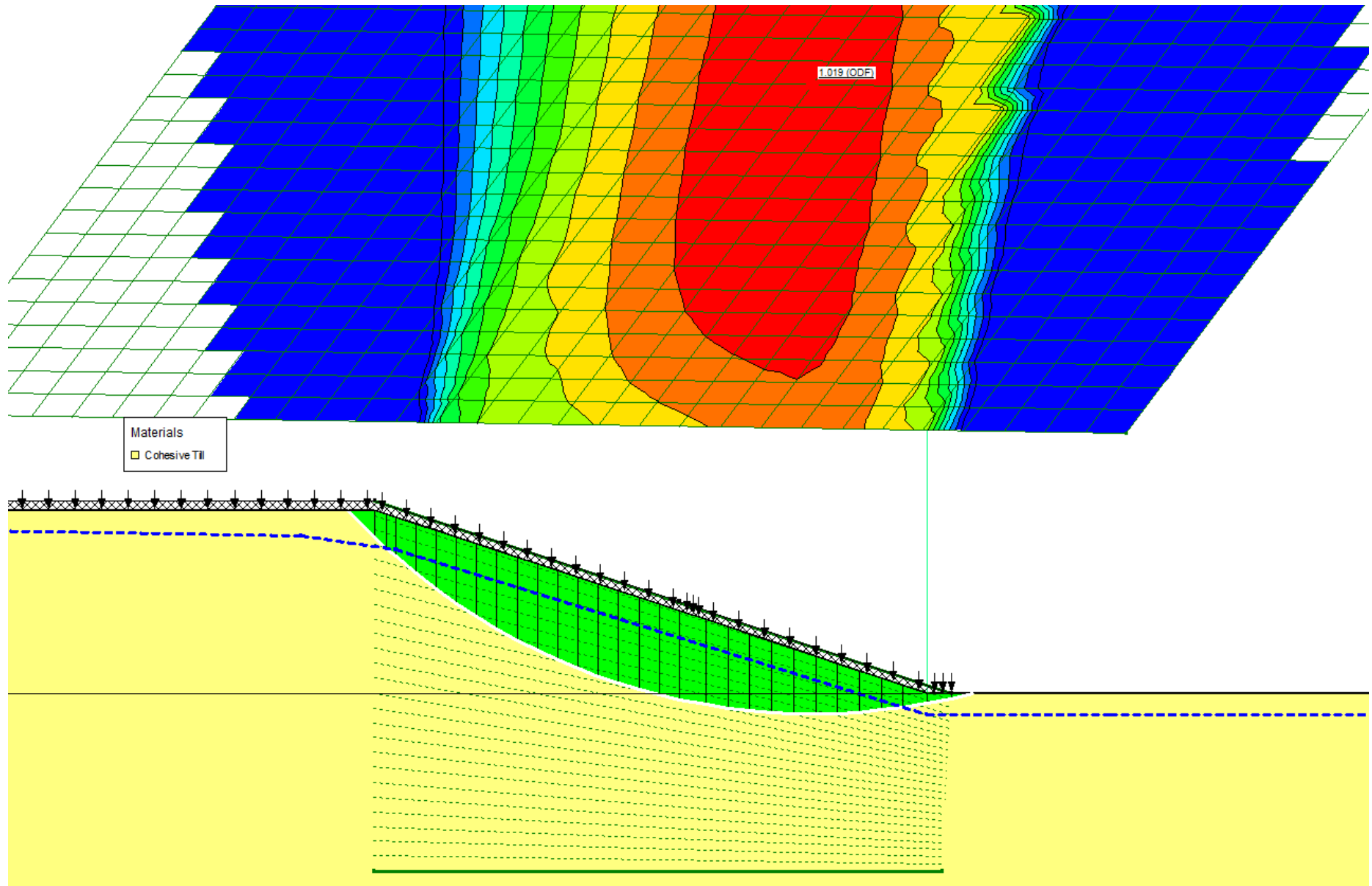
Current Slip Surface

Slip Surface: 12,516
Overdesign Factor: 1.019
Degree of Utilization: 0.982
Volume: 34.381985 m³
Weight: 722.02169 kN
Resisting Moment: 7,606.04 kN·m
Activating Moment: 7,465.5387 kN·m
Resisting Force: 206.74142 kN
Activating Force: 202.9864 kN
Slip Rank: 1 of 16,926 slip surfaces
Exit: (2.5186423, 0) m
Entry: (-31.458126, 10) m
Radius: 34.309614 m
Center: (-6.1727494, 33.1905) m

Slip Columns

	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength	Suction Strength	Base Material
Column 1	-100.82534 m	30.362633 m	-11.188229 kPa	13.659804 kPa	5.5680141 kPa	0 kPa	0 kPa	Cohesive Till
Column 2	-97.40897 m	26.944610 m	-2.4571064 kPa	27.740909 kPa	11.307759 kPa	0 kPa	0 kPa	Cohesive Till
Column 3	-95.57170 m	25.247795 m	1.8158507 kPa	33.158374 kPa	12.775851 kPa	0 kPa	0 kPa	Cohesive Till
Column 4	-92.95733 m	22.991505 m	6.5238514 kPa	40.59214 kPa	13.886928 kPa	0 kPa	0 kPa	Cohesive Till
Column 5	-89.33786 m	20.052444 m	11.936285 kPa	49.766111 kPa	15.420207 kPa	0 kPa	0 kPa	Cohesive Till
Column 6	-85.71839 m	17.350875 m	16.638812 kPa	57.770132 kPa	16.765964 kPa	0 kPa	0 kPa	Cohesive Till
Column 7	-82.09892 m	14.866258 m	20.692832 kPa	64.816291 kPa	17.98562 kPa	0 kPa	0 kPa	Cohesive Till
Column 8	-78.47945 m	12.581753 m	24.148683 kPa	71.069754 kPa	19.125984 kPa	0 kPa	0 kPa	Cohesive Till
Column 9	-74.85998 m	10.483387 m	27.048133 kPa	76.656366 kPa	20.221326 kPa	0 kPa	0 kPa	Cohesive Till
Column 10	-71.24051 m	8.559455 m	29.426171 kPa	81.667718 kPa	21.294718 kPa	0 kPa	0 kPa	Cohesive Till

Column 11	-67.62104 m	6.800074 m	31.312336 kPa	86.164484 kPa	22.358852 kPa	0 kPa	0 kPa	Cohesive Till
Column 12	-64.00157 m	5.196852 m	32.731713 kPa	90.178585 kPa	23.416515 kPa	0 kPa	0 kPa	Cohesive Till
Column 13	-60.38210 m	3.742636 m	33.705689 kPa	93.714657 kPa	24.460877 kPa	0 kPa	0 kPa	Cohesive Till
Column 14	-56.76263 m	2.431308 m	34.252545 kPa	96.751248 kPa	25.475744 kPa	0 kPa	0 kPa	Cohesive Till
Column 15	-53.14316 m	1.257638 m	34.387916 kPa	99.242123 kPa	26.435895 kPa	0 kPa	0 kPa	Cohesive Till
Column 16	-49.52369 m	0.217162 m	34.125151 kPa	101.11811 kPa	27.307695 kPa	0 kPa	0 kPa	Cohesive Till
Column 17	-45.90422 m	-0.693922 m	33.475607 kPa	102.28989 kPa	28.050101 kPa	0 kPa	0 kPa	Cohesive Till
Column 18	-44.06168 m	-1.124651 m	33.046092 kPa	102.68345 kPa	28.385604 kPa	0 kPa	0 kPa	Cohesive Till
Column 19	-41.69947 m	-1.583975 m	32.217787 kPa	102.3669 kPa	28.594208 kPa	0 kPa	0 kPa	Cohesive Till
Column 20	-37.41316 m	-2.338123 m	30.477713 kPa	101.14899 kPa	28.807053 kPa	0 kPa	0 kPa	Cohesive Till
Column 21	-33.49932 m	-2.872003 m	28.426323 kPa	98.839113 kPa	28.701687 kPa	0 kPa	0 kPa	Cohesive Till
Column 22	-29.58548 m	-3.266808 m	25.959215 kPa	95.123134 kPa	28.192621 kPa	0 kPa	0 kPa	Cohesive Till
Column 23	-25.67164 m	-3.524006 m	23.080775 kPa	89.892572 kPa	27.233848 kPa	0 kPa	0 kPa	Cohesive Till
Column 24	-21.75781 m	-3.644541 m	19.793827 kPa	83.08021 kPa	25.796818 kPa	0 kPa	0 kPa	Cohesive Till
Column 25	-17.84397 m	-3.628853 m	16.099684 kPa	74.671708 kPa	23.875149 kPa	0 kPa	0 kPa	Cohesive Till
Column 26	-13.93013 m	-3.476885 m	11.998176 kPa	64.712658 kPa	21.487496 kPa	0 kPa	0 kPa	Cohesive Till
Column 27	-10.01629 m	-3.188082 m	7.4876444 kPa	53.309456 kPa	18.677903 kPa	0 kPa	0 kPa	Cohesive Till
Column 28	-6.10245 m	-2.761381 m	2.5649108 kPa	40.623137 kPa	15.513308 kPa	0 kPa	0 kPa	Cohesive Till
Column 29	-2.07277 m	-2.174127 m	-2.9456959 kPa	26.101362 kPa	10.639446 kPa	0 kPa	0 kPa	Cohesive Till
Column 30	2.25557 m	-1.374464 m	-7.2979647 kPa	12.327468 kPa	5.0249269 kPa	0 kPa	0 kPa	Cohesive Till
Column 31	6.38721 m	-0.457031 m	-10.095932 kPa	3.3268273 kPa	1.3560825 kPa	0 kPa	0 kPa	Cohesive Till



Undrained SLS

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File Information

File Version: 11.05
Created By: Laura Castro
Last Edited By: Laura Castro
Revision Number: 96
Date: 03/08/2024
Time: 19:21:28
Tool Version: 23.1.2.11
File Name: Till 1 in 3- 10m with grid and radius.gsz
Directory: C:\Users\CAS111646\OneDrive - Mott MacDonald\Desktop\Knocknagael\Slope stability analysis\Platform cutting\
Last Solved Date: 03/08/2024
Last Solved Time: 19:22:06

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

Undrained SLS

Kind: SLOPE/W
Analysis Type: Morgenstern-Price
Settings
Side Function
Intercolumn force function option: Half-Sine
PWP Conditions from: Piezometric Surfaces
Apply Phreatic Correction: No
Use Staged Rapid Drawdown: No
Unit Weight of Water: 9.807 kN/m³

Slip Surface
Direction of movement: Left to Right
Use Passive Mode: No
Slip Surface Option: Grid and Radius
Critical slip surfaces saved: 1
Optimize Critical Slip Surface Location: No
Tension Crack Option: (none)

Distribution
F of S Calculation Option: Constant

Convergence
Geometry Settings
Minimum Slip Surface Depth: 0.5 m
Minimum Slip Surface Volume: 1 m³
Number of Columns: 30
Factor of Safety Convergence Settings
Maximum Number of Iterations: 100
Tolerable difference in F of S: 0.001
Under-Relaxation Criteria
Initial Rate: 1
Minimum Rate: 0.1
Rate Reduction Factor: 0.65

Reduction Frequency (iterations): 50
Solution Settings
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Cohesive Till Undrained

Slope Stability Material Model: $S=f(\text{depth})$
Unit Weight: 21 kN/m³
C-Top of Layer: 40 kPa
C-Rate of Change: 3.5 (kN/m²)/m
C-Maximum: 110 kPa
Pore Water Pressure
Piezometric Surface: 1

Slip Surface Grid

Upper Left: (-36.854999, 39.92) m
Lower Left: (-55.309999, 15.21) m
Lower Right: (10.87, 14.175) m
Grid Horizontal Increment: 30
Grid Vertical Increment: 20

Slip Surface Radius

Upper Left Coordinate: (-29.899999, 10.005) m
Upper Right Coordinate: (0.34000135, -0.015000122) m
Lower Left Coordinate: (-29.899999, -9.875) m
Lower Right Coordinate: (0.34000135, -9.875) m
Number of Increments: 25
Use Left Projection: No
Left Projection Angle: 135 °
Use Right Projection: No
Right Projection Angle: 45 °

Slip Surface Limits

Left Coordinate: (-54.949999, 10) m
Right Coordinate: (62.319999, 0) m

Piezometric Surfaces

Piezometric Surface 1

Coordinates

	X	Y
Coordinate 1	-54.949999 m	8.895 m
Coordinate 2	-34.005 m	8.5900001 m
Coordinate 3	-28.885 m	7.845 m
Coordinate 4	0 m	-1.1599999 m
Coordinate 5	9.9899998 m	-1.205 m

Coordinate 6	62.319999 m	-1.15 m
--------------	-------------	---------

Geometry

Name: 2D Geometry

Settings

View: 2D
Element Thickness: 0.3048 m

Points

	X	Y
Point 1	0 m	0 m
Point 2	10 m	0 m
Point 3	-27.0000001 m	-10 m
Point 4	-12 m	4.0000001 m
Point 5	-13.42 m	4.5000001 m
Point 6	-27.0200008 m	-2.8001793 m
Point 7	-30.005 m	10 m
Point 8	-54.949999 m	10 m
Point 9	-54.949999 m	-10.19 m
Point 10	-54.949999 m	-22.79 m
Point 11	10.11 m	-22.79 m
Point 12	62.319999 m	0 m
Point 13	62.319999 m	-22.79 m

Regions

	Material	Points	Area
Region 1	Cohesive Till Undrained	1,4,5,7,8,9,10,11,13,12,2	3,072.3 m ²

Slip Results

Slip Surfaces Analysed: 11024 of 16926 converged

Current Slip Surface

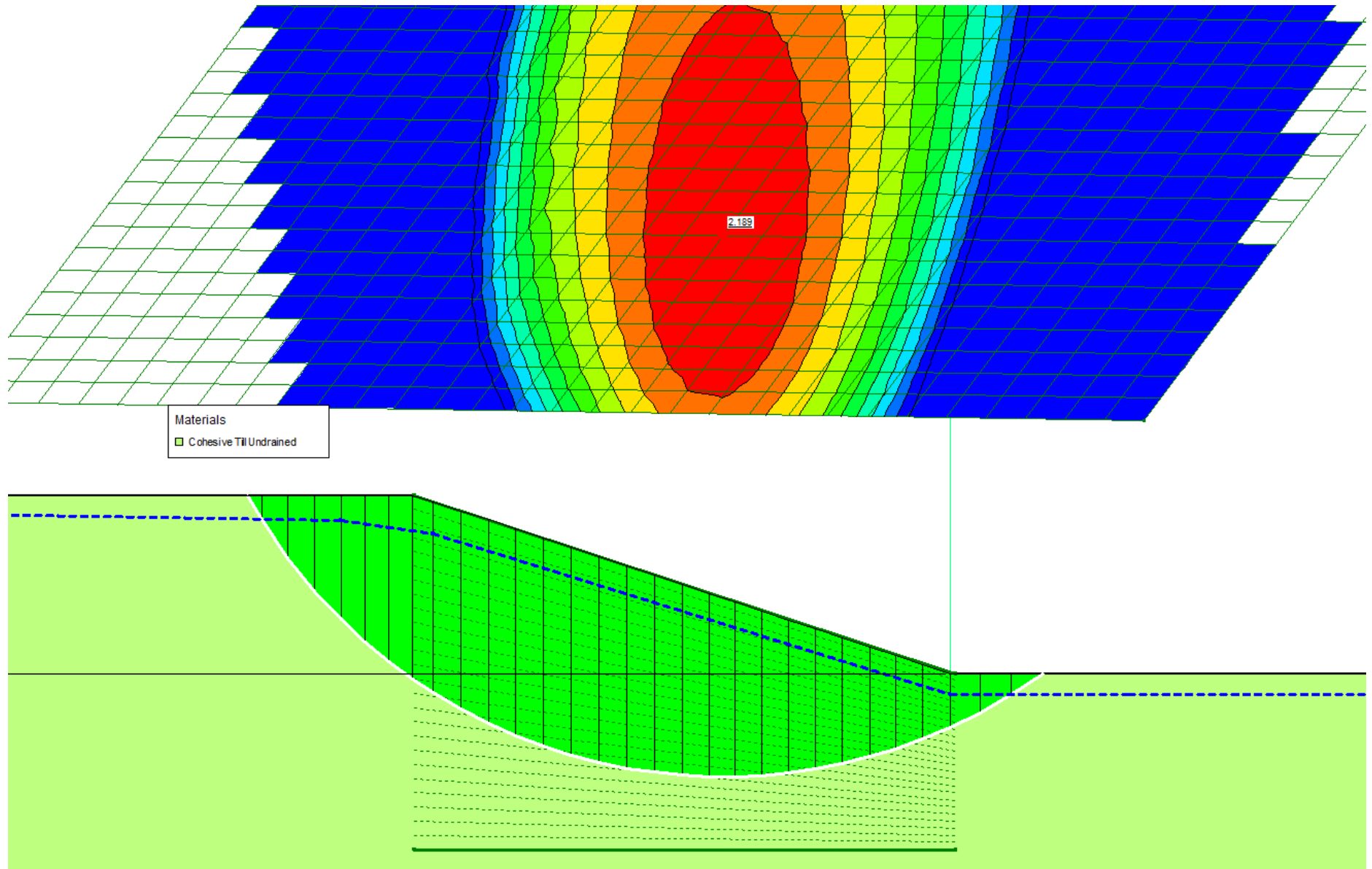
Slip Surface: 6,883
Factor of Safety: 2.189
Volume: 105.11675 m³
Weight: 2,207.4518 kN
Resisting Moment: 31,398.342 kN·m
Activating Moment: 14,339.533 kN·m
Resisting Force: 909.43353 kN
Activating Force: 415.42096 kN
Slip Rank: 1 of 16,926 slip surfaces
Exit: (5.1764813, 0) m
Entry: (-39.23993, 10) m
Radius: 30.322463 m
Center: (-12.631999, 24.542) m

Slip Columns

	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength	Suction Strength	Base Material
Column 1	-127.45940 m	30.601811 m	-6.540137 kPa	-18.702746 kPa	0 kPa	42.353989 kPa	0 kPa	Cohesive Till

								Undrained
Column 2	-123.74323 m	24.797749 m	10.647453 kPa	18.869072 kPa	0 kPa	48.545762 kPa	0 kPa	Cohesive Till Undrained
Column 3	-118.87192 m	18.175264 m	30.231171 kPa	60.214134 kPa	0 kPa	55.610629 kPa	0 kPa	Cohesive Till Undrained
Column 4	-114.00061 m	12.550157 m	46.833553 kPa	94.468879 kPa	0 kPa	61.611493 kPa	0 kPa	Cohesive Till Undrained
Column 5	-109.37773 m	7.903813 m	59.664931 kPa	122.55613 kPa	0 kPa	66.568212 kPa	0 kPa	Cohesive Till Undrained
Column 6	-105.00328 m	4.039807 m	69.312455 kPa	146.06582 kPa	0 kPa	70.690334 kPa	0 kPa	Cohesive Till Undrained
Column 7	-100.62883 m	0.602207 m	77.685377 kPa	167.3693 kPa	0 kPa	74.357565 kPa	0 kPa	Cohesive Till Undrained
Column 8	-96.60433 m	-2.242194 m	84.437339 kPa	182.02608 kPa	0 kPa	76.741988 kPa	0 kPa	Cohesive Till Undrained
Column 9	-92.23015 m	-4.973803 m	89.439367 kPa	191.81659 kPa	0 kPa	78.108582 kPa	0 kPa	Cohesive Till Undrained
Column 10	-87.15633 m	-7.794022 m	93.141274 kPa	201.7105 kPa	0 kPa	79.322189 kPa	0 kPa	Cohesive Till Undrained
Column 11	-82.08251 m	-10.243107 m	95.733795 kPa	210.02974 kPa	0 kPa	80.139869 kPa	0 kPa	Cohesive Till Undrained
Column 12	-77.00869 m	-12.350558 m	97.305115 kPa	216.8755 kPa	0 kPa	80.593095 kPa	0 kPa	Cohesive Till Undrained
Column 13	-71.93487 m	-14.139288 m	97.923722 kPa	222.27635 kPa	0 kPa	80.706309 kPa	0 kPa	Cohesive Till Undrained
Column 14	-66.86106 m	-15.627151 m	97.642987 kPa	226.20259 kPa	0 kPa	80.498559 kPa	0 kPa	Cohesive Till Undrained
Column 15	-61.78724 m	-16.827990 m	96.504285 kPa	228.57738 kPa	0 kPa	79.984611 kPa	0 kPa	Cohesive Till Undrained
Column 16	-56.71342 m	-17.752358 m	94.539164 kPa	229.28636 kPa	0 kPa	79.175724 kPa	0 kPa	Cohesive Till Undrained
Column 17	-51.63960 m	-18.408029 m	91.770859 kPa	228.18682 kPa	0 kPa	78.08019 kPa	0 kPa	Cohesive Till Undrained
Column 18	-46.56578 m	-18.800337 m	88.21532 kPa	225.1172 kPa	0 kPa	76.703702 kPa	0 kPa	Cohesive Till Undrained
Column 19	-41.69947 m	-18.937168 m	84.089494 kPa	219.8911 kPa	0 kPa	75.077171 kPa	0 kPa	Cohesive Till Undrained
Column 20	-36.90945 m	-18.830863 m	79.307976 kPa	212.58391 kPa	0 kPa	73.213765 kPa	0 kPa	Cohesive Till Undrained
Column 21	-31.98819 m	-18.483557 m	73.683768 kPa	203.11635 kPa	0 kPa	71.093259 kPa	0 kPa	Cohesive Till

								Undrained
Column 22	-27.06693 m	-17.889069 m	67.320689 kPa	191.22464 kPa	0 kPa	68.709059 kPa	0 kPa	Cohesive Till Undrained
Column 23	-22.14567 m	-17.042868 m	60.205199 kPa	176.81917 kPa	0 kPa	66.056332 kPa	0 kPa	Cohesive Till Undrained
Column 24	-17.22441 m	-15.938313 m	52.317441 kPa	159.84902 kPa	0 kPa	63.127993 kPa	0 kPa	Cohesive Till Undrained
Column 25	-12.30315 m	-14.566373 m	43.630425 kPa	140.30747 kPa	0 kPa	59.914407 kPa	0 kPa	Cohesive Till Undrained
Column 26	-7.38189 m	-12.915235 m	34.108834 kPa	118.23436 kPa	0 kPa	56.402972 kPa	0 kPa	Cohesive Till Undrained
Column 27	-2.46063 m	-10.969729 m	23.707331 kPa	93.714211 kPa	0 kPa	52.577507 kPa	0 kPa	Cohesive Till Undrained
Column 28	2.81526 m	-8.521889 m	14.059379 kPa	71.15792 kPa	0 kPa	49.091151 kPa	0 kPa	Cohesive Till Undrained
Column 29	8.44579 m	-5.489509 m	4.919256 kPa	50.229525 kPa	0 kPa	45.856208 kPa	0 kPa	Cohesive Till Undrained
Column 30	14.12213 m	-1.928250 m	-5.802397 kPa	26.090658 kPa	0 kPa	42.057057 kPa	0 kPa	Cohesive Till Undrained



Undrained ULS C1

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File Information

File Version: 11.05
Created By: Laura Castro
Last Edited By: Laura Castro
Revision Number: 96
Date: 03/08/2024
Time: 19:21:28
Tool Version: 23.1.2.11
File Name: Till 1 in 3- 10m with grid and radius.gsz
Directory: C:\Users\CAS111646\OneDrive - Mott MacDonald\Desktop\Knocknagael\Slope stability analysis\Platform cutting\
Last Solved Date: 03/08/2024
Last Solved Time: 19:22:12

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

Undrained ULS C1

Kind: SLOPE/W
Analysis Type: Morgenstern-Price
Settings
Side Function
Intercolumn force function option: Half-Sine
PWP Conditions from: Piezometric Surfaces
Apply Phreatic Correction: No
Use Staged Rapid Drawdown: No
Limit State Design Approach: Eurocode 7 - DA1, C1
Unit Weight of Water: 9.807 kN/m³
Slip Surface
Direction of movement: Left to Right
Use Passive Mode: No
Slip Surface Option: Grid and Radius
Critical slip surfaces saved: 1
Optimize Critical Slip Surface Location: No
Tension Crack Option: (none)
Distribution
ODF Calculation Option: Constant
Convergence
Geometry Settings
Minimum Slip Surface Depth: 0.5 m
Minimum Slip Surface Volume: 1 m³
Number of Columns: 30
Overdesign Factor Convergence Settings
Maximum Number of Iterations: 100
Tolerable difference in ODF: 0.001
Under-Relaxation Criteria
Initial Rate: 1
Minimum Rate: 0.1
Rate Reduction Factor: 0.65

Reduction Frequency (iterations): 50
Solution Settings
Search Method: Root Finder
Tolerable difference between starting and converged ODF: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Cohesive Till Undrained

Slope Stability Material Model: $S=f(\text{depth})$
Unit Weight: 21 kN/m³
C-Top of Layer: 40 kPa
C-Rate of Change: 3.5 (kN/m²)/m
C-Maximum: 110 kPa
Pore Water Pressure
Piezometric Surface: 1

Slip Surface Grid

Upper Left: (-36.854999, 39.92) m
Lower Left: (-55.309999, 15.21) m
Lower Right: (10.87, 14.175) m
Grid Horizontal Increment: 30
Grid Vertical Increment: 20

Slip Surface Radius

Upper Left Coordinate: (-30.060001, 10.005) m
Upper Right Coordinate: (0.34000135, 0.084999881) m
Lower Left Coordinate: (-30.060001, -9.875) m
Lower Right Coordinate: (0.34000135, -9.8150001) m
Number of Increments: 25
Use Left Projection: No
Left Projection Angle: 135 °
Use Right Projection: No
Right Projection Angle: 45 °

Slip Surface Limits

Left Coordinate: (-54.949999, 10) m
Right Coordinate: (62.319999, 0) m

Piezometric Surfaces

Piezometric Surface 1

Coordinates

	X	Y
Coordinate 1	-54.949999 m	8.895 m
Coordinate 2	-34.005 m	8.5900001 m
Coordinate 3	-28.885 m	7.845 m
Coordinate 4	0 m	-1.1599999 m
Coordinate 5	9.9799993 m	-1.205 m

Coordinate 6	62.319999 m	-1.1950001 m
--------------	-------------	--------------

Design Factor Set: Eurocode 7 - DA1, C1

Permanent Point Loads & Surcharge Loads: Favorable = 1, Unfavorable = 1.35
 Variable Point Loads & Surcharge Loads: Favorable = 0, Unfavorable = 1.5
 Soil Unit Weight: Favorable = 1, Unfavorable = 1.35
 Effective Cohesion: 1
 Effective Coefficient of Friction: 1
 Undrained Strength: 1
 Shear Strength (Other Models): 1
 Pullout Resistance: 1.1
 Shear Force: 1.1
 Tensile Strength: 1.1
 Compressive Strength: 1.1
 Seismic Coefficients: 1
 Earth Resistance: 1

Geometry

Name: 2D Geometry

Settings

View: 2D
 Element Thickness: 0.3048 m

Points

	X	Y
Point 1	0 m	0 m
Point 2	10 m	0 m
Point 3	-27.000001 m	-10 m
Point 4	-12 m	4.0000001 m
Point 5	-13.42 m	4.5000001 m
Point 6	-27.020008 m	-2.8001793 m
Point 7	-30.005 m	10 m
Point 8	-54.949999 m	10 m
Point 9	-54.949999 m	-10.19 m
Point 10	-54.949999 m	-22.79 m
Point 11	10.11 m	-22.79 m
Point 12	62.319999 m	0 m
Point 13	62.319999 m	-22.79 m

Regions

	Material	Points	Area
Region 1	Cohesive Till Undrained	1,4,5,7,8,9,10,11,13,12,2	3,072.3 m²

Slip Results

Slip Surfaces Analysed: 12836 of 16926 converged

Current Slip Surface

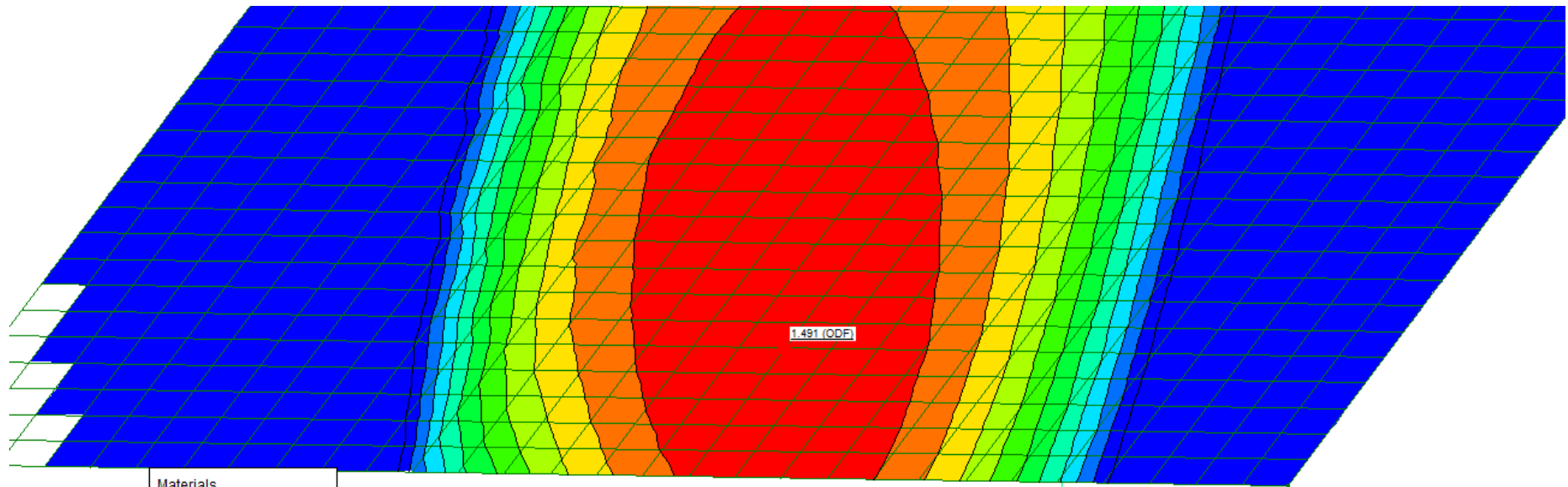
Slip Surface: 4,496
 Overdesign Factor: 1.491
 Degree of Utilization: 0.671
 Volume: 145.76512 m³

Weight: 3,781.0039 kN
 Resisting Moment: 38,046.77 kN·m
 Activating Moment: 25,521.979 kN·m
 Resisting Force: 1,099.4942 kN
 Activating Force: 737.77318 kN
 Slip Rank: 1 of 16,926 slip surfaces
 Exit: (7.7049329, 0) m
 Entry: (-40.631374, 10) m
 Radius: 29.486563 m
 Center: (-13.194249, 20.801) m

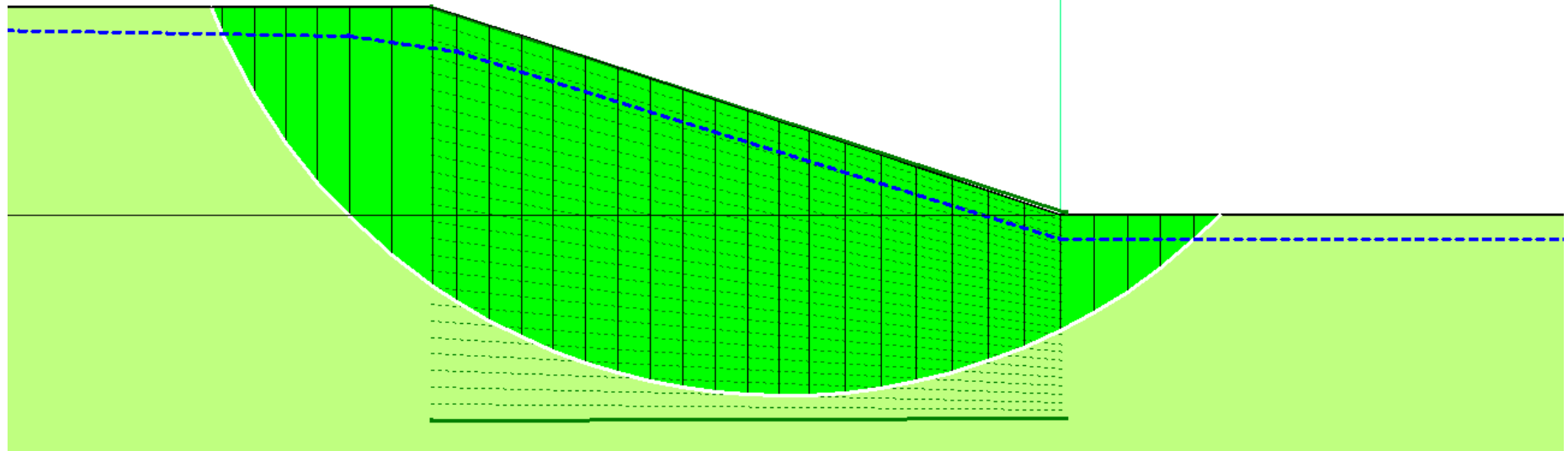
Slip Columns

	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength	Suction Strength	Base Material
Column 1	-132.39004 m	30.640372 m	-6.4407817 kPa	-47.757849 kPa	0 kPa	42.312851 kPa	0 kPa	Cohesive Till Undrained
Column 2	-128.98629 m	23.685827 m	14.1994 kPa	15.498287 kPa	0 kPa	49.73196 kPa	0 kPa	Cohesive Till Undrained
Column 3	-124.00877 m	15.117903 m	39.59375 kPa	90.304646 kPa	0 kPa	58.872221 kPa	0 kPa	Cohesive Till Undrained
Column 4	-119.03124 m	8.197212 m	60.064235 kPa	149.06346 kPa	0 kPa	66.255214 kPa	0 kPa	Cohesive Till Undrained
Column 5	-114.05372 m	2.383831 m	77.224779 kPa	197.98059 kPa	0 kPa	72.45693 kPa	0 kPa	Cohesive Till Undrained
Column 6	-108.28412 m	-3.271963 m	92.5956 kPa	245.92992 kPa	0 kPa	78.49053 kPa	0 kPa	Cohesive Till Undrained
Column 7	-101.72244 m	-8.743813 m	106.09792 kPa	293.57587 kPa	0 kPa	84.327899 kPa	0 kPa	Cohesive Till Undrained
Column 8	-96.60433 m	-12.447907 m	114.94399 kPa	322.43738 kPa	0 kPa	87.629442 kPa	0 kPa	Cohesive Till Undrained
Column 9	-92.23015 m	-15.150673 m	119.8598 kPa	336.88507 kPa	0 kPa	88.965267 kPa	0 kPa	Cohesive Till Undrained
Column 10	-87.15633 m	-17.930924 m	123.44223 kPa	351.50258 kPa	0 kPa	90.136235 kPa	0 kPa	Cohesive Till Undrained
Column 11	-82.08251 m	-20.333431 m	125.89553 kPa	363.8107 kPa	0 kPa	90.904227 kPa	0 kPa	Cohesive Till Undrained
Column 12	-77.00869 m	-22.388381 m	127.30991 kPa	373.95583 kPa	0 kPa	91.301445 kPa	0 kPa	Cohesive Till Undrained
Column 13	-71.93487 m	-24.119073 m	127.75503 kPa	381.99161 kPa	0 kPa	91.352744 kPa	0 kPa	Cohesive Till Undrained
Column 14	-66.86106 m	-25.543525 m	127.28475 kPa	387.89808 kPa	0 kPa	91.077347 kPa	0 kPa	Cohesive Till Undrained
Column 15	-61.78724 m	-26.675573 m	125.94042 kPa	391.59597 kPa	0 kPa	90.490012 kPa	0 kPa	Cohesive Till Undrained

Column 16	-56.71342 m	-27.525618 m	123.75313 kPa	392.95838 kPa	0 kPa	89.601837 kPa	0 kPa	Cohesive Till Undrained
Column 17	-51.63960 m	-28.101147 m	120.74527 kPa	391.82113 kPa	0 kPa	88.420808 kPa	0 kPa	Cohesive Till Undrained
Column 18	-46.56578 m	-28.407078 m	116.93154 kPa	387.9927 kPa	0 kPa	86.952173 kPa	0 kPa	Cohesive Till Undrained
Column 19	-41.69947 m	-28.454836 m	112.53946 kPa	286.0226 kPa	0 kPa	85.23062 kPa	0 kPa	Cohesive Till Undrained
Column 20	-36.55793 m	-28.220364 m	107.04725 kPa	279.38553 kPa	0 kPa	83.105484 kPa	0 kPa	Cohesive Till Undrained
Column 21	-30.93363 m	-27.661905 m	100.13672 kPa	269.51184 kPa	0 kPa	80.50972 kPa	0 kPa	Cohesive Till Undrained
Column 22	-25.30934 m	-26.767513 m	92.222024 kPa	256.27537 kPa	0 kPa	77.555583 kPa	0 kPa	Cohesive Till Undrained
Column 23	-19.68504 m	-25.527540 m	83.274329 kPa	239.49595 kPa	0 kPa	74.23278 kPa	0 kPa	Cohesive Till Undrained
Column 24	-14.06074 m	-23.927984 m	73.251779 kPa	219.03107 kPa	0 kPa	70.526374 kPa	0 kPa	Cohesive Till Undrained
Column 25	-8.43645 m	-21.949632 m	62.096941 kPa	194.78229 kPa	0 kPa	66.415867 kPa	0 kPa	Cohesive Till Undrained
Column 26	-2.81215 m	-19.566758 m	49.732917 kPa	166.69601 kPa	0 kPa	61.873817 kPa	0 kPa	Cohesive Till Undrained
Column 27	2.64515 m	-16.842567 m	38.933587 kPa	142.01911 kPa	0 kPa	57.967651 kPa	0 kPa	Cohesive Till Undrained
Column 28	7.93544 m	-13.762393 m	29.655106 kPa	120.99324 kPa	0 kPa	54.681721 kPa	0 kPa	Cohesive Till Undrained
Column 29	13.22574 m	-10.204638 m	18.949056 kPa	96.433183 kPa	0 kPa	50.886308 kPa	0 kPa	Cohesive Till Undrained
Column 30	18.51603 m	-6.100149 m	6.6087208 kPa	68.193955 kPa	0 kPa	46.507639 kPa	0 kPa	Cohesive Till Undrained
Column 31	23.21992 m	-1.950595 m	-5.8584157 kPa	40.031401 kPa	0 kPa	42.080895 kPa	0 kPa	Cohesive Till Undrained



Materials
■ Cohesive TII Undrained



Undrained ULS C2

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File Information

File Version: 11.05
Created By: Laura Castro
Last Edited By: Laura Castro
Revision Number: 96
Date: 03/08/2024
Time: 19:21:28
Tool Version: 23.1.2.11
File Name: Till 1 in 3- 10m with grid and radius.gsz
Directory: C:\Users\CAS111646\OneDrive - Mott MacDonald\Desktop\Knocknagael\Slope stability analysis\Platform cutting\
Last Solved Date: 03/08/2024
Last Solved Time: 19:22:21

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

Undrained ULS C2

Kind: SLOPE/W
Analysis Type: Morgenstern-Price
Settings
Side Function
Intercolumn force function option: Half-Sine
PWP Conditions from: Piezometric Surfaces
Apply Phreatic Correction: No
Use Staged Rapid Drawdown: No
Limit State Design Approach: Eurocode 7 - DA1, C2
Unit Weight of Water: 9.807 kN/m³
Slip Surface
Direction of movement: Left to Right
Use Passive Mode: No
Slip Surface Option: Grid and Radius
Critical slip surfaces saved: 1
Optimize Critical Slip Surface Location: No
Tension Crack Option: (none)
Distribution
ODF Calculation Option: Constant
Convergence
Geometry Settings
Minimum Slip Surface Depth: 0.5 m
Minimum Slip Surface Volume: 1 m³
Number of Columns: 30
Overdesign Factor Convergence Settings
Maximum Number of Iterations: 100
Tolerable difference in ODF: 0.001
Under-Relaxation Criteria
Initial Rate: 1
Minimum Rate: 0.1
Rate Reduction Factor: 0.65

Reduction Frequency (iterations): 50
Solution Settings
Search Method: Root Finder
Tolerable difference between starting and converged ODF: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Cohesive Till Undrained

Slope Stability Material Model: $S=f(\text{depth})$
Unit Weight: 21 kN/m³
C-Top of Layer: 40 kPa
C-Rate of Change: 3.5 (kN/m²)/m
C-Maximum: 110 kPa
Pore Water Pressure
Piezometric Surface: 1

Slip Surface Grid

Upper Left: (-36.854999, 39.92) m
Lower Left: (-55.309999, 15.21) m
Lower Right: (10.87, 14.175) m
Grid Horizontal Increment: 30
Grid Vertical Increment: 20

Slip Surface Radius

Upper Left Coordinate: (-30.120001, 10.005) m
Upper Right Coordinate: (0.11999976, 0.045000062) m
Lower Left Coordinate: (-30.120001, -9.875) m
Lower Right Coordinate: (0.11999976, -9.875) m
Number of Increments: 25
Use Left Projection: No
Left Projection Angle: 135 °
Use Right Projection: No
Right Projection Angle: 45 °

Slip Surface Limits

Left Coordinate: (-54.949999, 10) m
Right Coordinate: (62.319999, 0) m

Piezometric Surfaces

Piezometric Surface 1

Coordinates

	X	Y
Coordinate 1	-54.949999 m	8.895 m
Coordinate 2	-34.005 m	8.5900001 m
Coordinate 3	-28.885 m	7.845 m
Coordinate 4	0 m	-1.1599999 m
Coordinate 5	9.9799993 m	-1.205 m

Coordinate 6	62.319999 m	-1.15 m
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Design Factor Set: Eurocode 7 - DA1, C2

Permanent Point Loads & Surcharge Loads: Favorable = 1, Unfavorable = 1
 Variable Point Loads & Surcharge Loads: Favorable = 0, Unfavorable = 1.3
 Soil Unit Weight: Favorable = 1, Unfavorable = 1
 Effective Cohesion: 1.4
 Effective Coefficient of Friction: 1.25
 Undrained Strength: 1.4
 Shear Strength (Other Models): 1.25
 Pullout Resistance: 1.1
 Shear Force: 1.1
 Tensile Strength: 1.1
 Compressive Strength: 1.1
 Seismic Coefficients: 1
 Earth Resistance: 1

Geometry

Name: 2D Geometry

Settings

View: 2D
 Element Thickness: 0.3048 m

Points

	X	Y
Point 1	0 m	0 m
Point 2	10 m	0 m
Point 3	-27.000001 m	-10 m
Point 4	-12 m	4.0000001 m
Point 5	-13.42 m	4.5000001 m
Point 6	-27.020008 m	-2.8001793 m
Point 7	-30.005 m	10 m
Point 8	-54.949999 m	10 m
Point 9	-54.949999 m	-10.19 m
Point 10	-54.949999 m	-22.79 m
Point 11	10.11 m	-22.79 m
Point 12	62.319999 m	0 m
Point 13	62.319999 m	-22.79 m

Regions

	Material	Points	Area
Region 1	Cohesive Till Undrained	1,4,5,7,8,9,10,11,13,12,2	3,072.3 m²

Slip Results

Slip Surfaces Analysed: 11266 of 16926 converged

Current Slip Surface

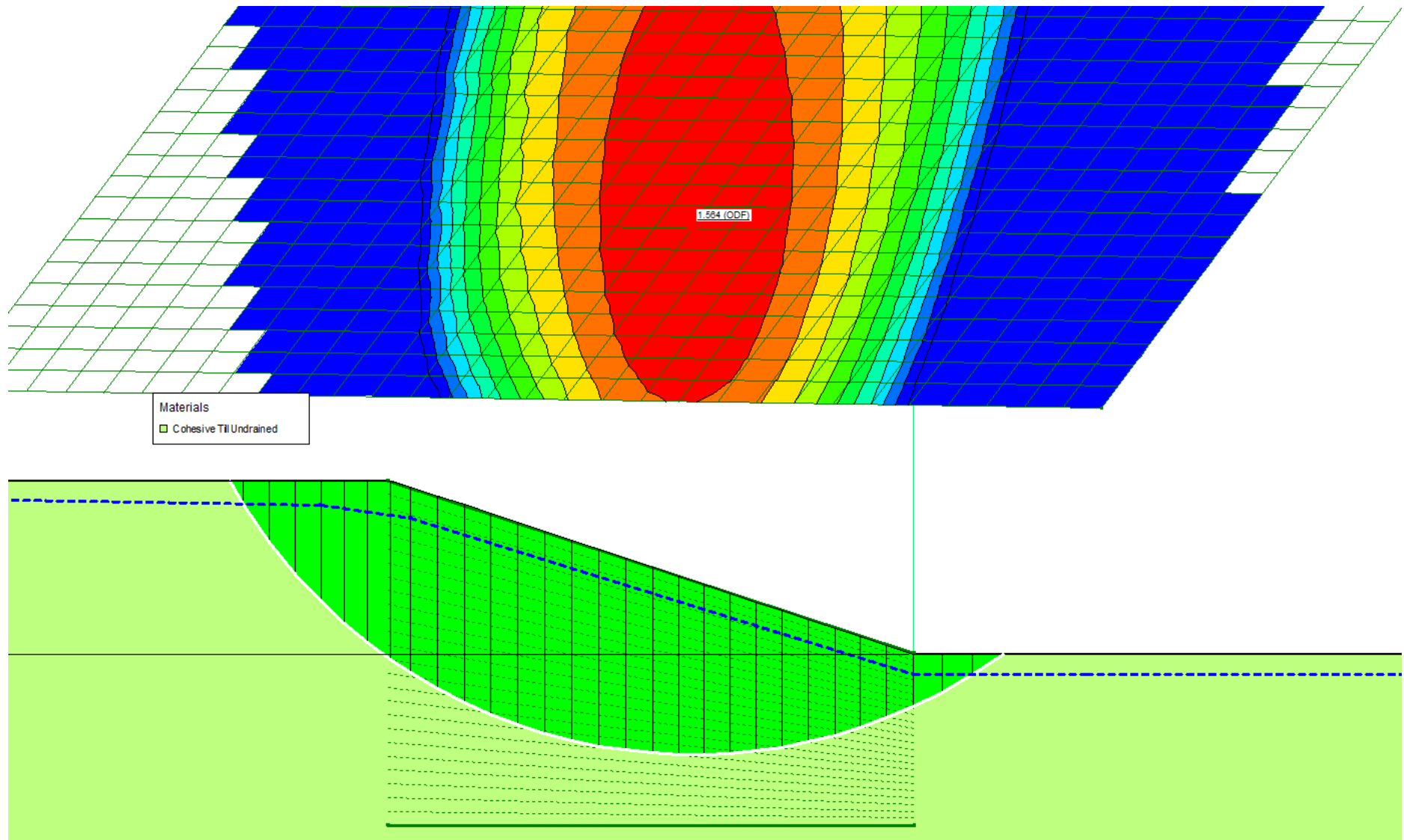
Slip Surface: 6,883
 Overdesign Factor: 1.564
 Degree of Utilization: 0.639
 Volume: 105.30777 m³

Weight: 2,211.4631 kN
 Resisting Moment: 22,464.356 kN·m
 Activating Moment: 14,363.127 kN·m
 Resisting Force: 650.3747 kN
 Activating Force: 415.92613 kN
 Slip Rank: 1 of 16,926 slip surfaces
 Exit: (5.1972387, 0) m
 Entry: (-39.253827, 10) m
 Radius: 30.334658 m
 Center: (-12.631999, 24.542) m

Slip Columns

	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength	Suction Strength	Base Material
Column 1	-127.50590 m	30.602156 m	-6.5391447 kPa	-18.721841 kPa	0 kPa	30.252586 kPa	0 kPa	Cohesive Till Undrained
Column 2	-123.78272 m	24.785813 m	10.684851 kPa	18.927641 kPa	0 kPa	34.684639 kPa	0 kPa	Cohesive Till Undrained
Column 3	-118.89562 m	18.141600 m	30.332829 kPa	60.401962 kPa	0 kPa	39.747529 kPa	0 kPa	Cohesive Till Undrained
Column 4	-114.00851 m	12.500577 m	46.9821 kPa	94.746183 kPa	0 kPa	44.045989 kPa	0 kPa	Cohesive Till Undrained
Column 5	-109.37773 m	7.848963 m	59.828888 kPa	122.86033 kPa	0 kPa	47.590519 kPa	0 kPa	Cohesive Till Undrained
Column 6	-105.00328 m	3.987738 m	69.468098 kPa	146.35066 kPa	0 kPa	50.532772 kPa	0 kPa	Cohesive Till Undrained
Column 7	-100.62883 m	0.552384 m	77.834307 kPa	167.63959 kPa	0 kPa	53.150512 kPa	0 kPa	Cohesive Till Undrained
Column 8	-96.60433 m	-2.290296 m	84.581126 kPa	182.28625 kPa	0 kPa	54.85236 kPa	0 kPa	Cohesive Till Undrained
Column 9	-92.23015 m	-5.020374 m	89.578575 kPa	192.06893 kPa	0 kPa	55.827331 kPa	0 kPa	Cohesive Till Undrained
Column 10	-87.15633 m	-7.839102 m	93.276027 kPa	201.95634 kPa	0 kPa	56.693057 kPa	0 kPa	Cohesive Till Undrained
Column 11	-82.08251 m	-10.286968 m	95.864905 kPa	210.27157 kPa	0 kPa	57.276186 kPa	0 kPa	Cohesive Till Undrained
Column 12	-77.00869 m	-12.393422 m	97.433245 kPa	217.11546 kPa	0 kPa	57.599159 kPa	0 kPa	Cohesive Till Undrained
Column 13	-71.93487 m	-14.181341 m	98.049427 kPa	222.51631 kPa	0 kPa	57.679409 kPa	0 kPa	Cohesive Till Undrained
Column 14	-66.86106 m	-15.668553 m	97.766745 kPa	226.44425 kPa	0 kPa	57.530519 kPa	0 kPa	Cohesive Till Undrained
Column 15	-61.78724 m	-16.868881 m	96.626514 kPa	228.82231 kPa	0 kPa	57.163024 kPa	0 kPa	Cohesive Till Undrained

Column 16	-56.71342 m	-17.792864 m	94.660243 kPa	229.53597 kPa	0 kPa	56.584954 kPa	0 kPa	Cohesive Till Undrained
Column 17	-51.63960 m	-18.448266 m	91.891134 kPa	228.4424 kPa	0 kPa	55.802225 kPa	0 kPa	Cohesive Till Undrained
Column 18	-46.56578 m	-18.840415 m	88.33512 kPa	225.37987 kPa	0 kPa	54.818898 kPa	0 kPa	Cohesive Till Undrained
Column 19	-41.69947 m	-18.977191 m	84.209128 kPa	220.16143 kPa	0 kPa	53.657048 kPa	0 kPa	Cohesive Till Undrained
Column 20	-36.90945 m	-18.870929 m	79.427739 kPa	212.86244 kPa	0 kPa	52.326077 kPa	0 kPa	Cohesive Till Undrained
Column 21	-31.98819 m	-18.523763 m	73.803951 kPa	203.40371 kPa	0 kPa	50.811537 kPa	0 kPa	Cohesive Till Undrained
Column 22	-27.06693 m	-17.929518 m	67.441599 kPa	191.52095 kPa	0 kPa	49.108722 kPa	0 kPa	Cohesive Till Undrained
Column 23	-22.14567 m	-17.083669 m	60.327158 kPa	177.12423 kPa	0 kPa	47.214185 kPa	0 kPa	Cohesive Till Undrained
Column 24	-17.22441 m	-15.979581 m	52.440798 kPa	160.16225 kPa	0 kPa	45.12287 kPa	0 kPa	Cohesive Till Undrained
Column 25	-12.30315 m	-14.608238 m	43.755564 kPa	140.62795 kPa	0 kPa	42.827906 kPa	0 kPa	Cohesive Till Undrained
Column 26	-7.38189 m	-12.957840 m	34.236188 kPa	118.56085 kPa	0 kPa	40.320302 kPa	0 kPa	Cohesive Till Undrained
Column 27	-2.46063 m	-11.013242 m	23.837397 kPa	94.045199 kPa	0 kPa	37.588519 kPa	0 kPa	Cohesive Till Undrained
Column 28	2.83398 m	-8.556549 m	14.162694 kPa	71.423419 kPa	0 kPa	35.091519 kPa	0 kPa	Cohesive Till Undrained
Column 29	8.50194 m	-5.502358 m	4.9567934 kPa	50.338616 kPa	0 kPa	32.764226 kPa	0 kPa	Cohesive Till Undrained
Column 30	14.19361 m	-1.928444 m	-5.8029705 kPa	26.108831 kPa	0 kPa	30.040903 kPa	0 kPa	Cohesive Till Undrained



C. Platform Cutting 1:2 Slope with Soil Nails Analyses

SLS

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File Information

File Version: 11.05
Created By: Laura Castro
Last Edited By: Laura Castro
Revision Number: 278
Date: 12/06/2024
Time: 17:42:02
Tool Version: 23.1.2.11
File Name: 1 in 2 slope with soil nails_v2.gsz
Directory: C:\Users\CAS111646\OneDrive - Mott MacDonald\Desktop\Knocknagael\Slope stability analysis\Platform cutting\
Last Solved Date: 12/06/2024
Last Solved Time: 17:42:14

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

SLS

Kind: SLOPE/W

Analysis Type: Morgenstern-Price

Settings

Side Function

Intercolumn force function option: Half-Sine

PWP Conditions from: Piezometric Surfaces

Apply Phreatic Correction: No

Use Staged Rapid Drawdown: No

Unit Weight of Water: 9.807 kN/m³

Slip Surface

Direction of movement: Left to Right

Use Passive Mode: No

Slip Surface Option: Grid and Radius

Critical slip surfaces saved: 1

Optimize Critical Slip Surface Location: No

Tension Crack Option: (none)

Distribution

F of S Calculation Option: Constant

Convergence

Geometry Settings

Minimum Slip Surface Depth: 0.5 m

Minimum Slip Surface Volume: 1 m³

Number of Columns: 30

Factor of Safety Convergence Settings

Maximum Number of Iterations: 100

Tolerable difference in F of S: 0.001

Under-Relaxation Criteria

Initial Rate: 1

Minimum Rate: 0.1

Rate Reduction Factor: 0.65
Reduction Frequency (iterations): 50

Solution Settings

Search Method: Linear Search
Must Obtain at Lambda Factor of Safety: 0.2
Lambda

Lambda 1: -1
Lambda 2: -0.8
Lambda 3: -0.6
Lambda 4: -0.4
Lambda 5: -0.2
Lambda 6: 0
Lambda 7: 0.2
Lambda 8: 0.4
Lambda 9: 0.6
Lambda 10: 0.8
Lambda 11: 1

Materials

Cohesive Till

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 21 kN/m³
Effective Cohesion: 0 kPa
Effective Friction Angle: 27 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Surface: 1

Bedrock

Slope Stability Material Model: Bedrock (Impenetrable)
Pore Water Pressure
Piezometric Surface: 1

Reinforcements

Soil nail

Type: Nail
Pullout Resistance: 85 kPa
Pullout Resistance Reduction Factor: 1.5
Tensile Capacity: 770 kN
Tensile Capacity Reduction Factor: 1.5
Shear Force: 0 kN
Shear Force Reduction Factor: 1
Apply Shear: Parallel to Slip
F of S Dependent: No
Force Distribution: Distributed
Bond Diameter: 0.105 m
Out-of-Plane Spacing: 1.5 m
Face Anchorage: Yes
Factored Pullout Resistance: 12.462 kN/m/m
Factored Tensile Capacity: 342.22 kN/m

Slip Surface Grid

Upper Left: (-69.137299, 47.1568) m
Lower Left: (-86.193301, 20.8563) m
Lower Right: (19.295599, 12.901599) m
Grid Horizontal Increment: 25
Grid Vertical Increment: 20

Slip Surface Radius

Upper Left Coordinate: (-29.373701, 14.3643) m
Upper Right Coordinate: (2.2273992, -0.42290086) m
Lower Left Coordinate: (-29.445701, -34.098199) m
Lower Right Coordinate: (2.2273992, -34.098199) m
Number of Increments: 25
Use Left Projection: No
Left Projection Angle: 135 °
Use Right Projection: No
Right Projection Angle: 45 °

Slip Surface Limits

Left Coordinate: (-100.2138, 14.5) m
Right Coordinate: (105.0929, -0.063236856) m

Piezometric Surfaces

Piezometric Surface 1

Coordinates

	X	Y
Coordinate 1	-100.2138 m	9.6522997 m
Coordinate 2	-78.492099 m	9.5901998 m
Coordinate 3	-63.636412 m	9.2500003 m
Coordinate 4	-31.174999 m	9.2500003 m
Coordinate 5	-24.674999 m	7.7250006 m
Coordinate 6	0 m	-1.1279002 m
Coordinate 7	105.0929 m	-1.1104992 m

Reinforcement Sets

Reinforcement Sets

Reinforcement: Soil nail
Lock to Ground Surface: Yes
Range Start: (-1.9682045, 0.94160926) m
X: -1.9682045 m
Y: 0.94160926 m
Range End: (-28.313271, 14.154946) m
X: -28.313271 m
Y: 14.154946 m
Orientation Type: Absolute Angle
Orientation: -120 °
Length: 14 m

Spacing Type: Evenly
Distribution Type: Specify number of reinforcements
Number of Reinforcements: 11

Reinforcement Lines

Reinforcement Line 1

Reinforcement: Soil nail
Reinforcement Set: Soil nails
Lock to Ground Surface: No
Outside Point: (-1.9682033, 0.9416095) m
Inside Point: (-8.9682036, -11.182746) m
Length: 14 m
Orientation: -120 °
Slip Surface Intersection: (-5.7317407, -5.5770283) m
Max. Pullout Force: 53.176357 kN
Available Length: 6.4729256 m
Required Length: 6.4729256 m
Pullout Force: 24.586186 kN
Pullout Force per Length: 3.7983112 kN/m
Governing Component: Pullout Resistance

Reinforcement Line 2

Reinforcement: Soil nail
Reinforcement Set: Soil nails
Lock to Ground Surface: No
Outside Point: (-4.5921503, 2.281236) m
Inside Point: (-11.592151, -9.8431198) m
Length: 14 m
Orientation: -120 °
Slip Surface Intersection: (-9.0309821, -5.4070461) m
Max. Pullout Force: 53.176357 kN
Available Length: 5.1223367 m
Required Length: 5.1223367 m
Pullout Force: 19.456229 kN
Pullout Force per Length: 3.7983112 kN/m
Governing Component: Pullout Resistance

Reinforcement Line 3

Reinforcement: Soil nail
Reinforcement Set: Soil nails
Lock to Ground Surface: No
Outside Point: (-7.2222177, 3.6102554) m
Inside Point: (-14.222218, -8.5141003) m
Length: 14 m
Orientation: -120 °
Slip Surface Intersection: (-12.120835, -4.8743983) m
Max. Pullout Force: 53.176357 kN
Available Length: 4.2027659 m
Required Length: 4.2027659 m
Pullout Force: 15.963413 kN
Pullout Force per Length: 3.7983112 kN/m
Governing Component: Pullout Resistance

Reinforcement Line 4

Reinforcement: Soil nail

Reinforcement Set: Soil nails
Lock to Ground Surface: No
Outside Point: (-9.8593778, 4.9269975) m
Inside Point: (-16.859378, -7.1973582) m
Length: 14 m
Orientation: -120 °
Slip Surface Intersection: (-15.030028, -4.0288314) m
Max. Pullout Force: 53.176357 kN
Available Length: 3.6586997 m
Required Length: 3.6586997 m
Pullout Force: 13.89688 kN
Pullout Force per Length: 3.7983112 kN/m
Governing Component: Pullout Resistance

Reinforcement Line 5

Reinforcement: Soil nail
Reinforcement Set: Soil nails
Lock to Ground Surface: No
Outside Point: (-12.496535, 6.2437366) m
Inside Point: (-19.496535, -5.8806192) m
Length: 14 m
Orientation: -120 °
Slip Surface Intersection: (-17.771283, -2.8923952) m
Max. Pullout Force: 53.176357 kN
Available Length: 3.4505039 m
Required Length: 3.4505039 m
Pullout Force: 13.106087 kN
Pullout Force per Length: 3.7983112 kN/m
Governing Component: Pullout Resistance

Reinforcement Line 6

Reinforcement: Soil nail
Reinforcement Set: Soil nails
Lock to Ground Surface: No
Outside Point: (-15.133695, 7.5604787) m
Inside Point: (-22.133692, -4.5638771) m
Length: 13.999999 m
Orientation: -120 °
Slip Surface Intersection: (-20.351701, -1.4773767) m
Max. Pullout Force: 53.176351 kN
Available Length: 3.5639832 m
Required Length: 3.5639832 m
Pullout Force: 13.537117 kN
Pullout Force per Length: 3.7983112 kN/m
Governing Component: Pullout Resistance

Reinforcement Line 7

Reinforcement: Soil nail
Reinforcement Set: Soil nails
Lock to Ground Surface: No
Outside Point: (-17.770852, 8.8772177) m
Inside Point: (-24.770852, -3.247138) m
Length: 14 m
Orientation: -120 °
Slip Surface Intersection: (-22.774354, 0.21089828) m
Max. Pullout Force: 53.176357 kN
Available Length: 3.9929964 m
Required Length: 3.9929964 m

Pullout Force: 15.166643 kN
Pullout Force per Length: 3.7983112 kN/m
Governing Component: Pullout Resistance

Reinforcement Line 8

Reinforcement: Soil nail
Reinforcement Set: Soil nails
Lock to Ground Surface: No
Outside Point: (-20.408012, 10.19396) m
Inside Point: (-27.408009, -1.9303959) m
Length: 13.999999 m
Orientation: -120 °
Slip Surface Intersection: (-25.032993, 2.183254) m
Max. Pullout Force: 53.176351 kN
Available Length: 4.7500333 m
Required Length: 4.7500333 m
Pullout Force: 18.042105 kN
Pullout Force per Length: 3.7983112 kN/m
Governing Component: Pullout Resistance

Reinforcement Line 9

Reinforcement: Soil nail
Reinforcement Set: Soil nails
Lock to Ground Surface: No
Outside Point: (-23.045169, 11.510699) m
Inside Point: (-30.045169, -0.61365689) m
Length: 14 m
Orientation: -120 °
Slip Surface Intersection: (-27.116723, 4.4585607) m
Max. Pullout Force: 53.176357 kN
Available Length: 5.8568924 m
Required Length: 5.8568924 m
Pullout Force: 22.2463 kN
Pullout Force per Length: 3.7983112 kN/m
Governing Component: Pullout Resistance

Reinforcement Line 10

Reinforcement: Soil nail
Reinforcement Set: Soil nails
Lock to Ground Surface: No
Outside Point: (-25.693829, 12.807519) m
Inside Point: (-32.693829, 0.68316348) m
Length: 14 m
Orientation: -120 °
Slip Surface Intersection: (-29.007645, 7.0678224) m
Max. Pullout Force: 53.176357 kN
Available Length: 7.3723691 m
Required Length: 7.3723691 m
Pullout Force: 28.002552 kN
Pullout Force per Length: 3.7983112 kN/m
Governing Component: Pullout Resistance

Reinforcement Line 11

Reinforcement: Soil nail
Reinforcement Set: Soil nails
Lock to Ground Surface: No
Outside Point: (-28.313271, 14.154946) m
Inside Point: (-35.313272, 2.0305898) m

Length: 14 m
Orientation: -120 °
Slip Surface Intersection: (-30.649121, 10.109136) m
Max. Pullout Force: 53.176357 kN
Available Length: 9.3283014 m
Required Length: 9.3283014 m
Pullout Force: 35.431792 kN
Pullout Force per Length: 3.7983112 kN/m
Governing Component: Pullout Resistance

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 8 kN/m³
Direction: Vertical

Coordinates

	X	Y
	-63.625001 m	15 m
	-29.000001 m	15 m
	0.024999696 m	0.50000002 m
	1.0499994 m	0 m

Geometry

Name: 2D Geometry

Settings

View: 2D
Element Thickness: 0.3048 m

Points

	X	Y
Point 1	-6.0000002 m	3.0000001 m
Point 2	0 m	-0.063236856 m
Point 3	10 m	-0.063236856 m
Point 4	-29.000001 m	14.5 m
Point 5	-63.625001 m	14.5 m
Point 6	37.399999 m	-0.063236856 m
Point 7	-63.724999 m	-70.361166 m
Point 8	-23.924999 m	11.950001 m
Point 9	-28.31321 m	14.154915 m
Point 10	-78.492099 m	14.5 m
Point 11	-78.492099 m	-0.063462408 m
Point 12	-63.656416 m	0.04572 m
Point 13	-25.694 m	12.807602 m
Point 14	-100.2138 m	14.5 m
Point 15	-100.2138 m	-0.15406726 m
Point 16	-99.984501 m	-70.427673 m
Point 17	105.0929 m	-0.063236856 m
Point 18	105.0929 m	-70.171693 m
Point 19	-46.704266 m	-70.361166 m
Point 20	-70.251261 m	-70.390561 m

Point 21	-100.13362 m	-25.469301 m
Point 22	-63.733601 m	-25.510599 m
Point 23	105.0929 m	-25.473599 m

Regions

	Material	Points	Area
Region 1	Cohesive Till	17,6,3,2,12,11,15,21,22,23	5,222.9 m ²
Region 2	Cohesive Till	12,2,1,8,13,9,4,5,10,14,15,11	1,245.5 m ²
Region 3	Bedrock	16,20,7,19,18,23,22,21	9,192.2 m ²

Slip Results

Slip Surfaces Analysed: 8493 of 14196 converged

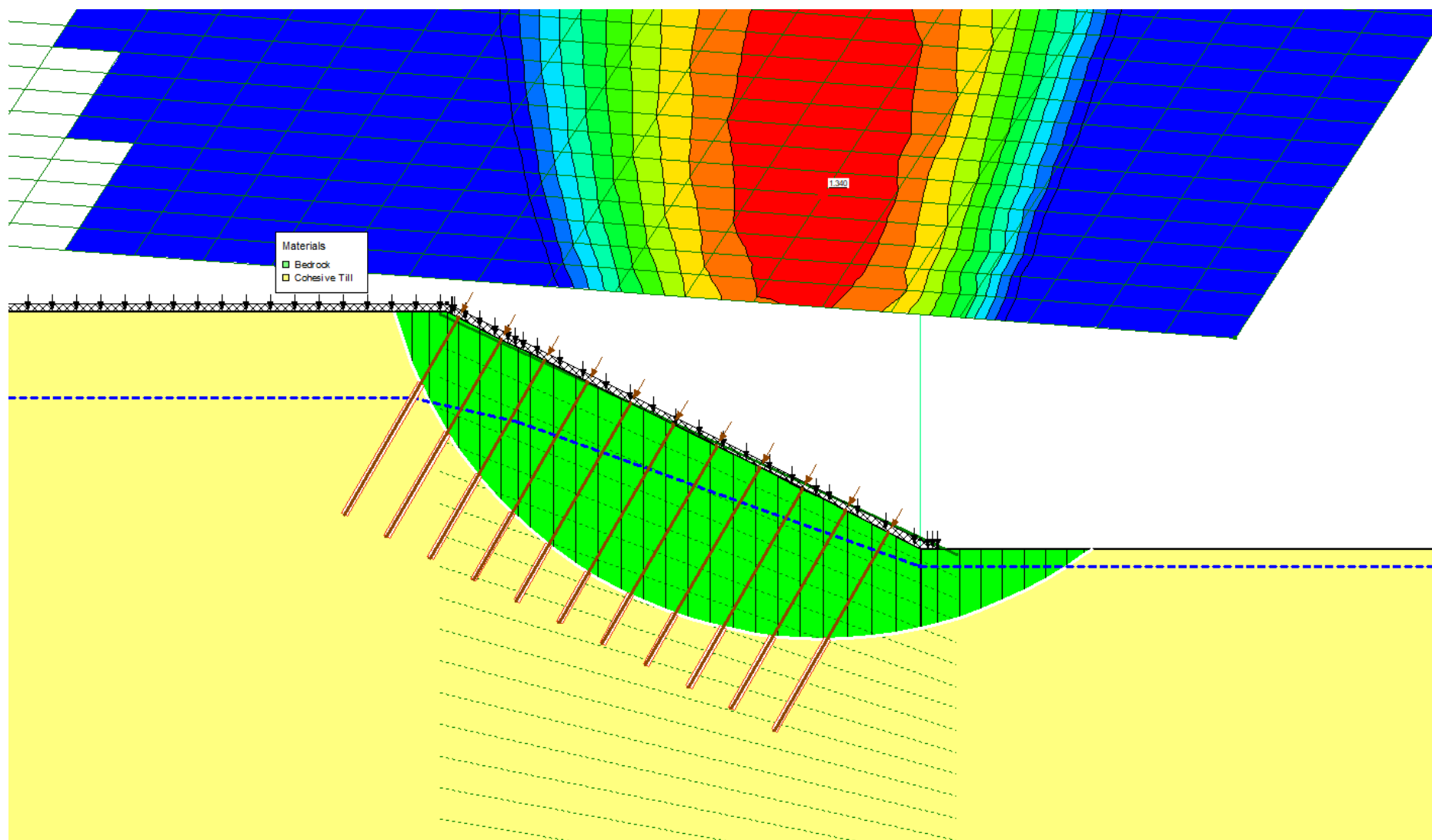
Current Slip Surface

Slip Surface: 3,856
Factor of Safety: 1.340
Volume: 100.08246 m³
Weight: 2,101.7316 kN
Resisting Moment: 24,628.019 kN·m
Activating Moment: 18,380.329 kN·m
Resisting Force: 772.86179 kN
Activating Force: 578.12609 kN
Slip Rank: 1 of 14,196 slip surfaces
Exit: (10.479796, -0.063236856) m
Entry: (-32.297474, 14.5) m
Radius: 27.288278 m
Center: (-5.9772928, 21.70404) m

Slip Columns

	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength	Suction Strength	Base Material
Column 1	-104.12151 m	42.20642 m	-35.447576 kPa	17.579735 kPa	8.9573224 kPa	0 kPa	0 kPa	Cohesive Till
Column 2	-100.56698 m	33.19228 m	-9.7042 kPa	75.789248 kPa	38.61655 kPa	0 kPa	0 kPa	Cohesive Till
Column 3	-96.99907 m	26.34451 m	8.2627687 kPa	116.55936 kPa	55.179871 kPa	0 kPa	0 kPa	Cohesive Till
Column 4	-94.01774 m	21.46004 m	20.772461 kPa	120.3169 kPa	50.720423 kPa	0 kPa	0 kPa	Cohesive Till
Column 5	-90.74281 m	16.95808 m	31.932886 kPa	136.01237 kPa	53.031145 kPa	0 kPa	0 kPa	Cohesive Till
Column 6	-86.44620 m	11.72724 m	44.555532 kPa	154.47328 kPa	56.005892 kPa	0 kPa	0 kPa	Cohesive Till
Column 7	-82.62631 m	7.65578 m	54.046915 kPa	168.8666 kPa	58.503552 kPa	0 kPa	0 kPa	Cohesive Till
Column 8	-79.72440 m	4.88318 m	59.842957 kPa	185.82443 kPa	64.190764 kPa	0 kPa	0 kPa	Cohesive Till
Column 9	-76.13215 m	1.84343 m	65.076752 kPa	178.3835 kPa	57.732671 kPa	0 kPa	0 kPa	Cohesive Till
Column 10	-71.51667 m	-1.68592 m	70.676679 kPa	189.87135 kPa	60.732716 kPa	0 kPa	0 kPa	Cohesive Till
Column 11	-67.00957 m	-4.69786 m	74.846226 kPa	197.24402 kPa	62.364791 kPa	0 kPa	0 kPa	Cohesive Till

Column 12	-62.50247 m	-7.33573 m	77.897628 kPa	205.71165 kPa	65.124497 kPa	0 kPa	0 kPa	Cohesive Till
Column 13	-57.99538 m	-9.63637 m	79.94097 kPa	212.41015 kPa	67.49642 kPa	0 kPa	0 kPa	Cohesive Till
Column 14	-53.48828 m	-11.62801 m	81.060655 kPa	219.40431 kPa	70.489613 kPa	0 kPa	0 kPa	Cohesive Till
Column 15	-48.98118 m	-13.33258 m	81.322241 kPa	225.8562 kPa	73.643731 kPa	0 kPa	0 kPa	Cohesive Till
Column 16	-44.47408 m	-14.76721 m	80.776958 kPa	231.2452 kPa	76.667399 kPa	0 kPa	0 kPa	Cohesive Till
Column 17	-39.96698 m	-15.94530 m	79.464787 kPa	237.25817 kPa	80.399744 kPa	0 kPa	0 kPa	Cohesive Till
Column 18	-35.45988 m	-16.87715 m	77.416595 kPa	240.25066 kPa	82.968102 kPa	0 kPa	0 kPa	Cohesive Till
Column 19	-30.95279 m	-17.57055 m	74.655624 kPa	249.26789 kPa	88.969392 kPa	0 kPa	0 kPa	Cohesive Till
Column 20	-26.44569 m	-18.03107 m	71.198535 kPa	248.57513 kPa	90.377888 kPa	0 kPa	0 kPa	Cohesive Till
Column 21	-21.93859 m	-18.26232 m	67.056107 kPa	234.22283 kPa	85.175697 kPa	0 kPa	0 kPa	Cohesive Till
Column 22	-17.20938 m	-18.25451 m	61.960899 kPa	240.259 kPa	90.84742 kPa	0 kPa	0 kPa	Cohesive Till
Column 23	-12.25807 m	-17.98399 m	55.842177 kPa	228.48922 kPa	87.968061 kPa	0 kPa	0 kPa	Cohesive Till
Column 24	-7.33681 m	-17.44130 m	48.942169 kPa	178.82471 kPa	66.178461 kPa	0 kPa	0 kPa	Cohesive Till
Column 25	-2.44560 m	-16.62476 m	41.255778 kPa	157.7797 kPa	59.371902 kPa	0 kPa	0 kPa	Cohesive Till
Column 26	0.04101 m	-16.13759 m	37.176769 kPa	144.95963 kPa	54.918108 kPa	0 kPa	0 kPa	Cohesive Till
Column 27	1.76345 m	-15.71491 m	35.91414 kPa	139.65972 kPa	52.861014 kPa	0 kPa	0 kPa	Cohesive Till
Column 28	5.61022 m	-14.66549 m	32.779152 kPa	128.8954 kPa	48.973677 kPa	0 kPa	0 kPa	Cohesive Till
Column 29	9.94091 m	-13.27208 m	28.616155 kPa	117.62327 kPa	45.351392 kPa	0 kPa	0 kPa	Cohesive Till
Column 30	14.27160 m	-11.62895 m	23.7067 kPa	103.23962 kPa	40.524049 kPa	0 kPa	0 kPa	Cohesive Till
Column 31	18.60229 m	-9.72084 m	18.00516 kPa	85.942775 kPa	34.615944 kPa	0 kPa	0 kPa	Cohesive Till
Column 32	22.93298 m	-7.52840 m	11.453721 kPa	66.035887 kPa	27.811003 kPa	0 kPa	0 kPa	Cohesive Till
Column 33	27.26367 m	-5.02699 m	3.9787224 kPa	43.89636 kPa	20.339052 kPa	0 kPa	0 kPa	Cohesive Till
Column 34	31.11870 m	-2.53318 m	-3.4738125 kPa	21.4618 kPa	10.935333 kPa	0 kPa	0 kPa	Cohesive Till
Column 35	33.59547 m	-0.78912 m	-8.6858806 kPa	5.2799988 kPa	2.6902938 kPa	0 kPa	0 kPa	Cohesive Till



ULS C1

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File Information

File Version: 11.05
Created By: Laura Castro
Last Edited By: Laura Castro
Revision Number: 278
Date: 12/06/2024
Time: 17:42:02
Tool Version: 23.1.2.11
File Name: 1 in 2 slope with soil nails_v2.gsz
Directory: C:\Users\CAS111646\OneDrive - Mott MacDonald\Desktop\Knocknagael\Slope stability analysis\Platform cutting\
Last Solved Date: 12/06/2024
Last Solved Time: 17:42:20

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

ULS C1

Kind: SLOPE/W
Analysis Type: Morgenstern-Price
Settings
Side Function
Intercolumn force function option: Half-Sine
PWP Conditions from: Piezometric Surfaces
Apply Phreatic Correction: No
Use Staged Rapid Drawdown: No
Limit State Design Approach: Eurocode 7 - DA1, C1
Unit Weight of Water: 9.807 kN/m³

Slip Surface
Direction of movement: Left to Right
Use Passive Mode: No
Slip Surface Option: Grid and Radius
Critical slip surfaces saved: 1
Optimize Critical Slip Surface Location: No
Tension Crack Option: (none)

Distribution
ODF Calculation Option: Constant

Convergence
Geometry Settings
Minimum Slip Surface Depth: 0.5 m
Minimum Slip Surface Volume: 1 m³
Number of Columns: 30
Overdesign Factor Convergence Settings
Maximum Number of Iterations: 100
Tolerable difference in ODF: 0.001
Under-Relaxation Criteria
Initial Rate: 1

Minimum Rate: 0.1
Rate Reduction Factor: 0.65
Reduction Frequency (iterations): 50

Solution Settings

Search Method: Linear Search
Must Obtain at Lambda Overdesign Factor: 0.2
Lambda

Lambda 1: -1
Lambda 2: -0.8
Lambda 3: -0.6
Lambda 4: -0.4
Lambda 5: -0.2
Lambda 6: 0
Lambda 7: 0.2
Lambda 8: 0.4
Lambda 9: 0.6
Lambda 10: 0.8
Lambda 11: 1

Materials

Cohesive Till

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 21 kN/m³
Effective Cohesion: 0 kPa
Effective Friction Angle: 27 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Surface: 1

Bedrock

Slope Stability Material Model: Bedrock (Impenetrable)
Pore Water Pressure
Piezometric Surface: 1

Reinforcements

Soil nail

Type: Nail
Pullout Resistance: 85 kPa
Pullout Resistance Reduction Factor: 1.5
Tensile Capacity: 770 kN
Tensile Capacity Reduction Factor: 1.5
Shear Force: 0 kN
Shear Force Reduction Factor: 1
Apply Shear: Parallel to Slip
F of S Dependent: No
Force Distribution: Distributed
Bond Diameter: 0.105 m
Out-of-Plane Spacing: 1.5 m
Face Anchorage: Yes
Factored Pullout Resistance: 12.462 kN/m/m
Factored Tensile Capacity: 342.22 kN/m

Slip Surface Grid

Upper Left: (-69.137299, 47.1568) m
Lower Left: (-86.193301, 20.8563) m
Lower Right: (19.295599, 12.901599) m
Grid Horizontal Increment: 25
Grid Vertical Increment: 20

Slip Surface Radius

Upper Left Coordinate: (-28.313271, 14.154946) m
Upper Right Coordinate: (1.0499994, 0) m
Lower Left Coordinate: (-28.586299, -33.019901) m
Lower Right Coordinate: (0.56850077, -33.019901) m
Number of Increments: 25
Use Left Projection: No
Left Projection Angle: 135 °
Use Right Projection: No
Right Projection Angle: 45 °

Slip Surface Limits

Left Coordinate: (-100.2138, 14.5) m
Right Coordinate: (105.0929, -0.063236856) m

Piezometric Surfaces

Piezometric Surface 1

Coordinates

	X	Y
Coordinate 1	-100.2138 m	9.6522997 m
Coordinate 2	-78.492099 m	9.5901998 m
Coordinate 3	-63.636412 m	9.2500003 m
Coordinate 4	-31.174999 m	9.2500003 m
Coordinate 5	-24.674999 m	7.7250006 m
Coordinate 6	0 m	-1.1279002 m
Coordinate 7	105.0929 m	-1.1104992 m

Reinforcement Sets

Reinforcement Sets

Reinforcement: Soil nail
Lock to Ground Surface: Yes
Range Start: (-1.9682045, 0.94160926) m
X: -1.9682045 m
Y: 0.94160926 m
Range End: (-28.313271, 14.154946) m
X: -28.313271 m
Y: 14.154946 m
Orientation Type: Absolute Angle
Orientation: -120 °
Length: 14 m

Spacing Type: Evenly
Distribution Type: Specify number of reinforcements
Number of Reinforcements: 11

Reinforcement Lines

Reinforcement Line 1

Reinforcement: Soil nail
Reinforcement Set: Soil nails
Lock to Ground Surface: No
Outside Point: (-1.9682033, 0.9416095) m
Inside Point: (-8.9682036, -11.182746) m
Length: 14 m
Orientation: -120 °
Slip Surface Intersection: (-5.4021519, -5.0061638) m
Max. Pullout Force: 53.176357 kN
Available Length: 7.1321031 m
Required Length: 7.1321031 m
Pullout Force: 24.627224 kN
Pullout Force per Length: 3.4530102 kN/m
Governing Component: Pullout Resistance

Reinforcement Line 2

Reinforcement: Soil nail
Reinforcement Set: Soil nails
Lock to Ground Surface: No
Outside Point: (-4.5921503, 2.281236) m
Inside Point: (-11.592151, -9.8431198) m
Length: 14 m
Orientation: -120 °
Slip Surface Intersection: (-8.7839294, -4.9791381) m
Max. Pullout Force: 53.176357 kN
Available Length: 5.6164422 m
Required Length: 5.6164422 m
Pullout Force: 19.393632 kN
Pullout Force per Length: 3.4530102 kN/m
Governing Component: Pullout Resistance

Reinforcement Line 3

Reinforcement: Soil nail
Reinforcement Set: Soil nails
Lock to Ground Surface: No
Outside Point: (-7.2222177, 3.6102554) m
Inside Point: (-14.222218, -8.5141003) m
Length: 14 m
Orientation: -120 °
Slip Surface Intersection: (-11.923642, -4.53285) m
Max. Pullout Force: 53.176357 kN
Available Length: 4.5971519 m
Required Length: 4.5971519 m
Pullout Force: 15.874012 kN
Pullout Force per Length: 3.4530102 kN/m
Governing Component: Pullout Resistance

Reinforcement Line 4

Reinforcement: Soil nail

Reinforcement Set: Soil nails
Lock to Ground Surface: No
Outside Point: (-9.8593778, 4.9269975) m
Inside Point: (-16.859378, -7.1973582) m
Length: 14 m
Orientation: -120 °
Slip Surface Intersection: (-14.866348, -3.7453286) m
Max. Pullout Force: 53.176357 kN
Available Length: 3.9860605 m
Required Length: 3.9860605 m
Pullout Force: 13.763907 kN
Pullout Force per Length: 3.4530102 kN/m
Governing Component: Pullout Resistance

Reinforcement Line 5

Reinforcement: Soil nail
Reinforcement Set: Soil nails
Lock to Ground Surface: No
Outside Point: (-12.496535, 6.2437366) m
Inside Point: (-19.496535, -5.8806192) m
Length: 14 m
Orientation: -120 °
Slip Surface Intersection: (-17.62734, -2.6430778) m
Max. Pullout Force: 53.176357 kN
Available Length: 3.7383907 m
Required Length: 3.7383907 m
Pullout Force: 12.908701 kN
Pullout Force per Length: 3.4530102 kN/m
Governing Component: Pullout Resistance

Reinforcement Line 6

Reinforcement: Soil nail
Reinforcement Set: Soil nails
Lock to Ground Surface: No
Outside Point: (-15.133695, 7.5604787) m
Inside Point: (-22.133692, -4.5638771) m
Length: 13.999999 m
Orientation: -120 °
Slip Surface Intersection: (-20.214492, -1.2397243) m
Max. Pullout Force: 53.176351 kN
Available Length: 3.8384006 m
Required Length: 3.8384006 m
Pullout Force: 13.254036 kN
Pullout Force per Length: 3.4530102 kN/m
Governing Component: Pullout Resistance

Reinforcement Line 7

Reinforcement: Soil nail
Reinforcement Set: Soil nails
Lock to Ground Surface: No
Outside Point: (-17.770852, 8.8772177) m
Inside Point: (-24.770852, -3.247138) m
Length: 14 m
Orientation: -120 °
Slip Surface Intersection: (-22.624224, 0.47093078) m
Max. Pullout Force: 53.176357 kN
Available Length: 4.2932561 m
Required Length: 4.2932561 m

Pullout Force: 14.824657 kN
Pullout Force per Length: 3.4530102 kN/m
Governing Component: Pullout Resistance

Reinforcement Line 8

Reinforcement: Soil nail
Reinforcement Set: Soil nails
Lock to Ground Surface: No
Outside Point: (-20.408012, 10.19396) m
Inside Point: (-27.408009, -1.9303959) m
Length: 13.999999 m
Orientation: -120 °
Slip Surface Intersection: (-24.8748, 2.4572525) m
Max. Pullout Force: 53.176351 kN
Available Length: 5.0664195 m
Required Length: 5.0664195 m
Pullout Force: 17.494398 kN
Pullout Force per Length: 3.4530102 kN/m
Governing Component: Pullout Resistance

Reinforcement Line 9

Reinforcement: Soil nail
Reinforcement Set: Soil nails
Lock to Ground Surface: No
Outside Point: (-23.045169, 11.510699) m
Inside Point: (-30.045169, -0.61365689) m
Length: 14 m
Orientation: -120 °
Slip Surface Intersection: (-26.926648, 4.7877798) m
Max. Pullout Force: 53.176357 kN
Available Length: 6.2370419 m
Required Length: 6.2370419 m
Pullout Force: 21.536569 kN
Pullout Force per Length: 3.4530102 kN/m
Governing Component: Pullout Resistance

Reinforcement Line 10

Reinforcement: Soil nail
Reinforcement Set: Soil nails
Lock to Ground Surface: No
Outside Point: (-25.693829, 12.807519) m
Inside Point: (-32.693829, 0.68316348) m
Length: 14 m
Orientation: -120 °
Slip Surface Intersection: (-28.759582, 7.4974797) m
Max. Pullout Force: 53.176357 kN
Available Length: 7.8684946 m
Required Length: 7.8684946 m
Pullout Force: 27.169992 kN
Pullout Force per Length: 3.4530102 kN/m
Governing Component: Pullout Resistance

Reinforcement Line 11

Reinforcement: Soil nail
Reinforcement Set: Soil nails
Lock to Ground Surface: No
Outside Point: (-28.313271, 14.154946) m
Inside Point: (-35.313272, 2.0305898) m

Length: 14 m
Orientation: -120 °
Slip Surface Intersection: (-30.276947, 10.753759) m
Max. Pullout Force: 53.176357 kN
Available Length: 10.072648 m
Required Length: 10.072648 m
Pullout Force: 34.780956 kN
Pullout Force per Length: 3.4530102 kN/m
Governing Component: Pullout Resistance

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 8 kN/m³
Direction: Vertical
Mode: Permanent

Coordinates

	X	Y
	-63.625001 m	15 m
	-29.000001 m	15 m
	0.024999696 m	0.50000002 m
	1.0499994 m	0 m

Design Factor Set: Eurocode 7 - DA1, C1

Permanent Point Loads & Surcharge Loads: Favorable = 1, Unfavorable = 1.35
Variable Point Loads & Surcharge Loads: Favorable = 0, Unfavorable = 1.5
Soil Unit Weight: Favorable = 1, Unfavorable = 1.35
Effective Cohesion: 1
Effective Coefficient of Friction: 1
Undrained Strength: 1
Shear Strength (Other Models): 1
Pullout Resistance: 1.1
Shear Force: 1.1
Tensile Strength: 1.1
Compressive Strength: 1.1
Seismic Coefficients: 1
Earth Resistance: 1

Geometry

Name: 2D Geometry

Settings

View: 2D
Element Thickness: 0.3048 m

Points

	X	Y
Point 1	-6.0000002 m	3.0000001 m
Point 2	0 m	-0.063236856 m
Point 3	10 m	-0.063236856 m
Point 4	-29.000001 m	14.5 m

Point 5	-63.625001 m	14.5 m
Point 6	37.399999 m	-0.063236856 m
Point 7	-63.724999 m	-70.361166 m
Point 8	-23.924999 m	11.950001 m
Point 9	-28.31321 m	14.154915 m
Point 10	-78.492099 m	14.5 m
Point 11	-78.492099 m	-0.063462408 m
Point 12	-63.656416 m	0.04572 m
Point 13	-25.694 m	12.807602 m
Point 14	-100.2138 m	14.5 m
Point 15	-100.2138 m	-0.15406726 m
Point 16	-99.984501 m	-70.427673 m
Point 17	105.0929 m	-0.063236856 m
Point 18	105.0929 m	-70.171693 m
Point 19	-46.704266 m	-70.361166 m
Point 20	-70.251261 m	-70.390561 m
Point 21	-100.13362 m	-25.469301 m
Point 22	-63.733601 m	-25.510599 m
Point 23	105.0929 m	-25.473599 m

Regions

	Material	Points	Area
Region 1	Cohesive Till	17,6,3,2,12,11,15,21,22,23	5,222.9 m ²
Region 2	Cohesive Till	12,2,1,8,13,9,4,5,10,14,15,11	1,245.5 m ²
Region 3	Bedrock	16,20,7,19,18,23,22,21	9,192.2 m ²

Slip Results

Slip Surfaces Analysed: 10621 of 14196 converged

Current Slip Surface

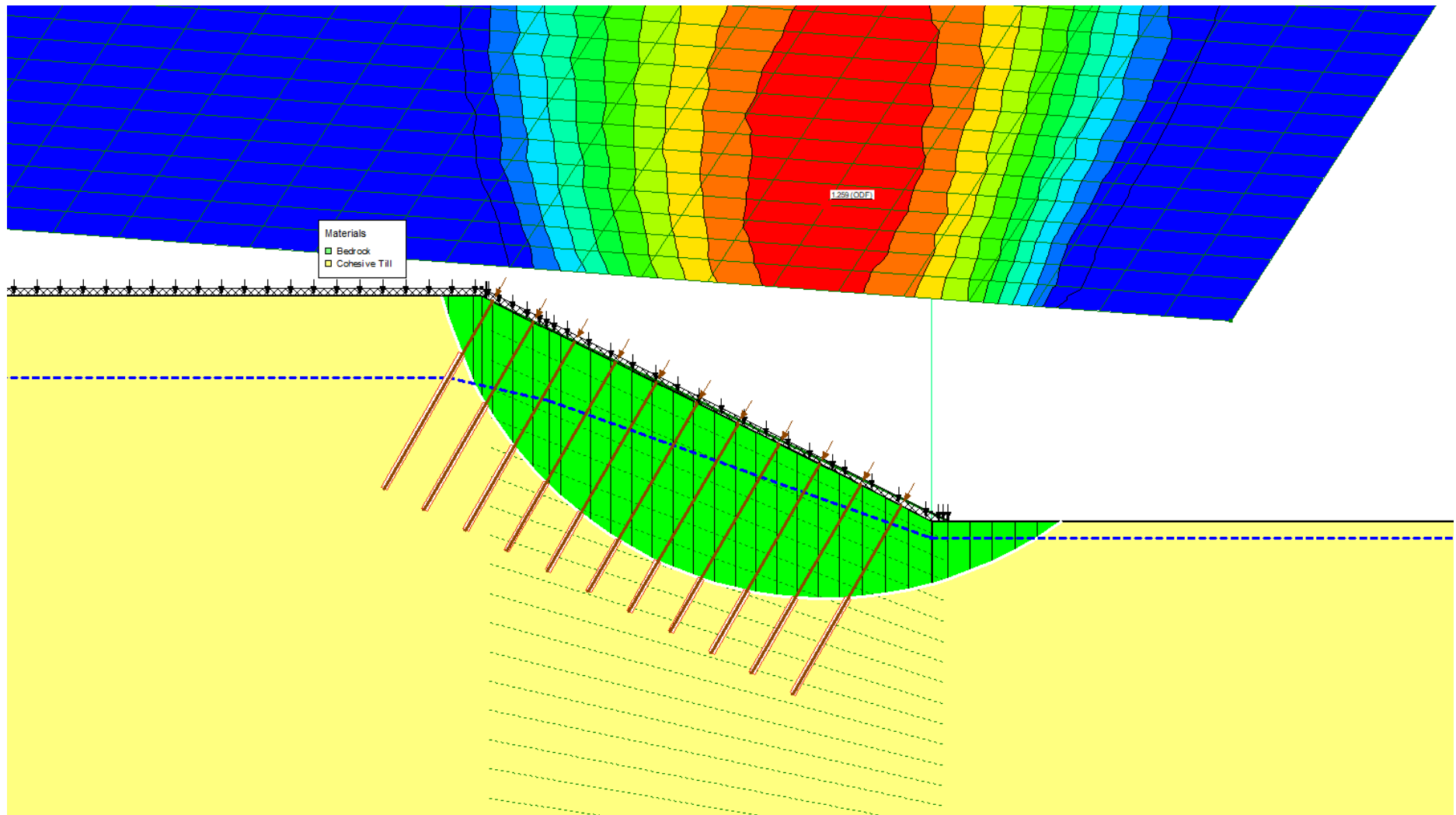
Slip Surface: 3,180
Overdesign Factor: 1.259
Degree of Utilization: 0.794
Volume: 91.336145 m³
Weight: 2,437.9453 kN
Resisting Moment: 28,020.75 kN·m
Activating Moment: 22,255.953 kN·m
Resisting Force: 939.54297 kN
Activating Force: 746.4016 kN
Slip Rank: 1 of 14,196 slip surfaces
Exit: (8.3094734, -0.063236856) m
Entry: (-31.585306, 14.5) m
Radius: 25.446042 m
Center: (-6.8300929, 20.389015) m

Slip Columns

	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength	Suction Strength	Base Material
Column 1	-102.95326 m	45.08615 m	-44.055567 kPa	10.590658 kPa	5.39621 kPa	0 kPa	0 kPa	Cohesive Till

Column 2	-99.55669 m	35.83497 m	-18.312191 kPa	64.074995 kPa	32.647841 kPa	0 kPa	0 kPa	Cohesive Till
Column 3	-95.98878 m	27.49287 m	4.1216042 kPa	147.10741 kPa	72.854906 kPa	0 kPa	0 kPa	Cohesive Till
Column 4	-94.01774 m	24.03356 m	13.079782 kPa	134.79891 kPa	62.018995 kPa	0 kPa	0 kPa	Cohesive Till
Column 5	-90.74281 m	19.08080 m	25.587699 kPa	148.22095 kPa	62.484763 kPa	0 kPa	0 kPa	Cohesive Till
Column 6	-86.44620 m	13.43685 m	39.445221 kPa	184.71981 kPa	74.021101 kPa	0 kPa	0 kPa	Cohesive Till
Column 7	-82.62631 m	9.12094 m	49.667305 kPa	202.38252 kPa	77.812289 kPa	0 kPa	0 kPa	Cohesive Till
Column 8	-79.72440 m	6.21641 m	55.857682 kPa	224.25959 kPa	85.805057 kPa	0 kPa	0 kPa	Cohesive Till
Column 9	-75.36982 m	2.48522 m	62.34078 kPa	216.09567 kPa	78.342031 kPa	0 kPa	0 kPa	Cohesive Till
Column 10	-70.05553 m	-1.60714 m	68.874189 kPa	238.54533 kPa	86.451767 kPa	0 kPa	0 kPa	Cohesive Till
Column 11	-65.67549 m	-4.45847 m	72.699928 kPa	250.10943 kPa	90.394656 kPa	0 kPa	0 kPa	Cohesive Till
Column 12	-61.29545 m	-6.93995 m	75.420071 kPa	262.82328 kPa	95.486703 kPa	0 kPa	0 kPa	Cohesive Till
Column 13	-56.91540 m	-9.08801 m	77.143595 kPa	273.85367 kPa	100.22879 kPa	0 kPa	0 kPa	Cohesive Till
Column 14	-52.53536 m	-10.93041 m	77.953445 kPa	285.1707 kPa	105.58246 kPa	0 kPa	0 kPa	Cohesive Till
Column 15	-48.15532 m	-12.48852 m	77.91352 kPa	295.93782 kPa	111.08893 kPa	0 kPa	0 kPa	Cohesive Till
Column 16	-43.77527 m	-13.77889 m	77.073251 kPa	305.25081 kPa	116.26227 kPa	0 kPa	0 kPa	Cohesive Till
Column 17	-39.39523 m	-14.81424 m	75.470692 kPa	314.87629 kPa	121.98324 kPa	0 kPa	0 kPa	Cohesive Till
Column 18	-35.01519 m	-15.60421 m	73.134637 kPa	320.42431 kPa	126.00038 kPa	0 kPa	0 kPa	Cohesive Till
Column 19	-30.63515 m	-16.15582 m	70.08608 kPa	331.5965 kPa	133.24621 kPa	0 kPa	0 kPa	Cohesive Till
Column 20	-26.25510 m	-16.47381 m	66.339206 kPa	330.63384 kPa	134.66484 kPa	0 kPa	0 kPa	Cohesive Till
Column 21	-21.87506 m	-16.56086 m	61.902019 kPa	238.25453 kPa	89.856094 kPa	0 kPa	0 kPa	Cohesive Till
Column 22	-17.20938 m	-16.39232 m	56.39449 kPa	244.18621 kPa	95.684662 kPa	0 kPa	0 kPa	Cohesive Till
Column 23	-12.25807 m	-15.93439 m	49.715587 kPa	230.00129 kPa	91.860152 kPa	0 kPa	0 kPa	Cohesive Till
Column 24	-7.33681 m	-15.18191 m	42.188458 kPa	173.84396 kPa	67.081827 kPa	0 kPa	0 kPa	Cohesive Till
Column 25	-2.44560 m	-14.13026 m	33.799296 kPa	147.99268 kPa	58.184433 kPa	0 kPa	0 kPa	Cohesive Till
Column 26	0.04101 m	-13.51626 m	29.341145 kPa	132.32232 kPa	52.471531 kPa	0 kPa	0 kPa	Cohesive Till
Column 27	1.76345 m	-12.99606 m	27.78704 kPa	125.13422 kPa	49.600863 kPa	0 kPa	0 kPa	Cohesive Till
Column 28	5.78478 m	-11.64737 m	23.757567 kPa	109.43773 kPa	43.656223 kPa	0 kPa	0 kPa	Cohesive Till
Column 29	10.46459 m	-9.80454 m	18.251323 kPa	91.675646 kPa	37.411561 kPa	0 kPa	0 kPa	Cohesive Till

Column 30	15.14440 m	-7.62242 m	11.730925 kPa	70.328188 kPa	29.856797 kPa	0 kPa	0 kPa	Cohesive Till
Column 31	19.82420 m	-5.07000 m	4.1035988 kPa	46.140047 kPa	21.41864 kPa	0 kPa	0 kPa	Cohesive Till
Column 32	24.71308 m	-1.95213 m	-5.2138302 kPa	16.688036 kPa	8.502979 kPa	0 kPa	0 kPa	Cohesive Till



ULS C2

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File Information

File Version: 11.05
Created By: Laura Castro
Last Edited By: Laura Castro
Revision Number: 278
Date: 12/06/2024
Time: 17:42:02
Tool Version: 23.1.2.11
File Name: 1 in 2 slope with soil nails_v2.gsz
Directory: C:\Users\CAS111646\OneDrive - Mott MacDonald\Desktop\Knocknagael\Slope stability analysis\Platform cutting\
Last Solved Date: 12/06/2024
Last Solved Time: 17:42:44

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

ULS C2

Kind: SLOPE/W
Analysis Type: Morgenstern-Price
Settings
Side Function
Intercolumn force function option: Half-Sine
PWP Conditions from: Piezometric Surfaces
Apply Phreatic Correction: No
Use Staged Rapid Drawdown: No
Limit State Design Approach: Eurocode 7 - DA1, C2
Unit Weight of Water: 9.807 kN/m³

Slip Surface
Direction of movement: Left to Right
Use Passive Mode: No
Slip Surface Option: Grid and Radius
Critical slip surfaces saved: 1
Optimize Critical Slip Surface Location: No
Tension Crack Option: (none)

Distribution
ODF Calculation Option: Constant

Convergence
Geometry Settings
Minimum Slip Surface Depth: 0.5 m
Minimum Slip Surface Volume: 1 m³
Number of Columns: 30
Overdesign Factor Convergence Settings
Maximum Number of Iterations: 100
Tolerable difference in ODF: 0.001
Under-Relaxation Criteria
Initial Rate: 1

Minimum Rate: 0.1
Rate Reduction Factor: 0.65
Reduction Frequency (iterations): 50

Solution Settings

Search Method: Linear Search
Must Obtain at Lambda Overdesign Factor: 0.2
Lambda

Lambda 1: -1
Lambda 2: -0.8
Lambda 3: -0.6
Lambda 4: -0.4
Lambda 5: -0.2
Lambda 6: 0
Lambda 7: 0.2
Lambda 8: 0.4
Lambda 9: 0.6
Lambda 10: 0.8
Lambda 11: 1

Materials

Cohesive Till

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 21 kN/m³
Effective Cohesion: 0 kPa
Effective Friction Angle: 27 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Surface: 1

Bedrock

Slope Stability Material Model: Bedrock (Impenetrable)
Pore Water Pressure
Piezometric Surface: 1

Reinforcements

Soil nail

Type: Nail
Pullout Resistance: 85 kPa
Pullout Resistance Reduction Factor: 1.5
Tensile Capacity: 770 kN
Tensile Capacity Reduction Factor: 1.5
Shear Force: 0 kN
Shear Force Reduction Factor: 1
Apply Shear: Parallel to Slip
F of S Dependent: No
Force Distribution: Distributed
Bond Diameter: 0.105 m
Out-of-Plane Spacing: 1.5 m
Face Anchorage: Yes
Factored Pullout Resistance: 12.462 kN/m/m
Factored Tensile Capacity: 342.22 kN/m

Slip Surface Grid

Upper Left: (-69.137299, 47.1568) m
Lower Left: (-86.193301, 20.8563) m
Lower Right: (19.295599, 12.901599) m
Grid Horizontal Increment: 25
Grid Vertical Increment: 20

Slip Surface Radius

Upper Left Coordinate: (-28.313271, 14.154946) m
Upper Right Coordinate: (0.024999696, 0.50000002) m
Lower Left Coordinate: (-28.0886, -34.9691) m
Lower Right Coordinate: (-0.63420041, -34.9691) m
Number of Increments: 25
Use Left Projection: No
Left Projection Angle: 135 °
Use Right Projection: No
Right Projection Angle: 45 °

Slip Surface Limits

Left Coordinate: (-100.2138, 14.5) m
Right Coordinate: (105.0929, -0.063236856) m

Piezometric Surfaces

Piezometric Surface 1

Coordinates

	X	Y
Coordinate 1	-100.2138 m	9.6522997 m
Coordinate 2	-78.492099 m	9.5901998 m
Coordinate 3	-63.636412 m	9.2500003 m
Coordinate 4	-31.174999 m	9.2500003 m
Coordinate 5	-24.674999 m	7.7250006 m
Coordinate 6	0 m	-1.1279002 m
Coordinate 7	105.0929 m	-1.1104992 m

Reinforcement Sets

Reinforcement Sets

Reinforcement: Soil nail
Lock to Ground Surface: Yes
Range Start: (-1.9682045, 0.94160926) m
X: -1.9682045 m
Y: 0.94160926 m
Range End: (-28.313271, 14.154946) m
X: -28.313271 m
Y: 14.154946 m
Orientation Type: Absolute Angle
Orientation: -120 °
Length: 14 m

Spacing Type: Evenly
Distribution Type: Specify number of reinforcements
Number of Reinforcements: 11

Reinforcement Lines

Reinforcement Line 1

Reinforcement: Soil nail
Reinforcement Set: Soil nails
Lock to Ground Surface: No
Outside Point: (-1.9682033, 0.9416095) m
Inside Point: (-8.9682036, -11.182746) m
Length: 14 m
Orientation: -120 °
Slip Surface Intersection: (-5.0271127, -4.3565769) m
Max. Pullout Force: 53.176357 kN
Available Length: 7.8821815 m
Required Length: 7.8821815 m
Pullout Force: 27.217253 kN
Pullout Force per Length: 3.4530102 kN/m
Governing Component: Pullout Resistance

Reinforcement Line 2

Reinforcement: Soil nail
Reinforcement Set: Soil nails
Lock to Ground Surface: No
Outside Point: (-4.5921503, 2.281236) m
Inside Point: (-11.592151, -9.8431198) m
Length: 14 m
Orientation: -120 °
Slip Surface Intersection: (-8.3176193, -4.1714653) m
Max. Pullout Force: 53.176357 kN
Available Length: 6.5490625 m
Required Length: 6.5490625 m
Pullout Force: 22.613979 kN
Pullout Force per Length: 3.4530102 kN/m
Governing Component: Pullout Resistance

Reinforcement Line 3

Reinforcement: Soil nail
Reinforcement Set: Soil nails
Lock to Ground Surface: No
Outside Point: (-7.2222177, 3.6102554) m
Inside Point: (-14.222218, -8.5141003) m
Length: 14 m
Orientation: -120 °
Slip Surface Intersection: (-11.403949, -3.6327148) m
Max. Pullout Force: 53.176357 kN
Available Length: 5.6365385 m
Required Length: 5.6365385 m
Pullout Force: 19.463025 kN
Pullout Force per Length: 3.4530102 kN/m
Governing Component: Pullout Resistance

Reinforcement Line 4

Reinforcement: Soil nail

Reinforcement Set: Soil nails
Lock to Ground Surface: No
Outside Point: (-9.8593778, 4.9269975) m
Inside Point: (-16.859378, -7.1973582) m
Length: 14 m
Orientation: -120 °
Slip Surface Intersection: (-14.30855, -2.7791951) m
Max. Pullout Force: 53.176357 kN
Available Length: 5.1016554 m
Required Length: 5.1016554 m
Pullout Force: 17.616068 kN
Pullout Force per Length: 3.4530102 kN/m
Governing Component: Pullout Resistance

Reinforcement Line 5

Reinforcement: Soil nail
Reinforcement Set: Soil nails
Lock to Ground Surface: No
Outside Point: (-12.496535, 6.2437366) m
Inside Point: (-19.496535, -5.8806192) m
Length: 14 m
Orientation: -120 °
Slip Surface Intersection: (-17.044327, -1.6332697) m
Max. Pullout Force: 53.176357 kN
Available Length: 4.9044168 m
Required Length: 4.9044168 m
Pullout Force: 16.935001 kN
Pullout Force per Length: 3.4530102 kN/m
Governing Component: Pullout Resistance

Reinforcement Line 6

Reinforcement: Soil nail
Reinforcement Set: Soil nails
Lock to Ground Surface: No
Outside Point: (-15.133695, 7.5604787) m
Inside Point: (-22.133692, -4.5638771) m
Length: 13.999999 m
Orientation: -120 °
Slip Surface Intersection: (-19.618219, -0.20694764) m
Max. Pullout Force: 53.176351 kN
Available Length: 5.0309483 m
Required Length: 5.0309483 m
Pullout Force: 17.371915 kN
Pullout Force per Length: 3.4530102 kN/m
Governing Component: Pullout Resistance

Reinforcement Line 7

Reinforcement: Soil nail
Reinforcement Set: Soil nails
Lock to Ground Surface: No
Outside Point: (-17.770852, 8.8772177) m
Inside Point: (-24.770852, -3.247138) m
Length: 14 m
Orientation: -120 °
Slip Surface Intersection: (-22.033706, 1.4937375) m
Max. Pullout Force: 53.176357 kN
Available Length: 5.4742915 m
Required Length: 5.4742915 m

Pullout Force: 18.902784 kN
Pullout Force per Length: 3.4530102 kN/m
Governing Component: Pullout Resistance

Reinforcement Line 8

Reinforcement: Soil nail
Reinforcement Set: Soil nails
Lock to Ground Surface: No
Outside Point: (-20.408012, 10.19396) m
Inside Point: (-27.408009, -1.9303959) m
Length: 13.999999 m
Orientation: -120 °
Slip Surface Intersection: (-24.29193, 3.4668145) m
Max. Pullout Force: 53.176351 kN
Available Length: 6.2321612 m
Required Length: 6.2321612 m
Pullout Force: 21.519716 kN
Pullout Force per Length: 3.4530102 kN/m
Governing Component: Pullout Resistance

Reinforcement Line 9

Reinforcement: Soil nail
Reinforcement Set: Soil nails
Lock to Ground Surface: No
Outside Point: (-23.045169, 11.510699) m
Inside Point: (-30.045169, -0.61365689) m
Length: 14 m
Orientation: -120 °
Slip Surface Intersection: (-26.363701, 5.7628326) m
Max. Pullout Force: 53.176357 kN
Available Length: 7.3629359 m
Required Length: 7.3629359 m
Pullout Force: 25.424293 kN
Pullout Force per Length: 3.4530102 kN/m
Governing Component: Pullout Resistance

Reinforcement Line 10

Reinforcement: Soil nail
Reinforcement Set: Soil nails
Lock to Ground Surface: No
Outside Point: (-25.693829, 12.807519) m
Inside Point: (-32.693829, 0.68316348) m
Length: 14 m
Orientation: -120 °
Slip Surface Intersection: (-28.256686, 8.3685205) m
Max. Pullout Force: 53.176357 kN
Available Length: 8.8742859 m
Required Length: 8.8742859 m
Pullout Force: 30.642999 kN
Pullout Force per Length: 3.4530102 kN/m
Governing Component: Pullout Resistance

Reinforcement Line 11

Reinforcement: Soil nail
Reinforcement Set: Soil nails
Lock to Ground Surface: No
Outside Point: (-28.313271, 14.154946) m
Inside Point: (-35.313272, 2.0305898) m

Length: 14 m
Orientation: -120 °
Slip Surface Intersection: (-29.90589, 11.39645) m
Max. Pullout Force: 53.176357 kN
Available Length: 10.814763 m
Required Length: 10.814763 m
Pullout Force: 37.343488 kN
Pullout Force per Length: 3.4530102 kN/m
Governing Component: Pullout Resistance

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 8 kN/m³
Direction: Vertical
Mode: Permanent

Coordinates

	X	Y
	-63.625001 m	15 m
	-29.000001 m	15 m
	0.024999696 m	0.50000002 m
	1.0499994 m	0 m

Design Factor Set: Eurocode 7 - DA1, C2

Permanent Point Loads & Surcharge Loads: Favorable = 1, Unfavorable = 1
Variable Point Loads & Surcharge Loads: Favorable = 0, Unfavorable = 1.3
Soil Unit Weight: Favorable = 1, Unfavorable = 1
Effective Cohesion: 1.4
Effective Coefficient of Friction: 1.25
Undrained Strength: 1.4
Shear Strength (Other Models): 1.25
Pullout Resistance: 1.1
Shear Force: 1.1
Tensile Strength: 1.1
Compressive Strength: 1.1
Seismic Coefficients: 1
Earth Resistance: 1

Geometry

Name: 2D Geometry

Settings

View: 2D
Element Thickness: 0.3048 m

Points

	X	Y
Point 1	-6.0000002 m	3.0000001 m
Point 2	0 m	-0.063236856 m
Point 3	10 m	-0.063236856 m
Point 4	-29.000001 m	14.5 m

Point 5	-63.625001 m	14.5 m
Point 6	37.399999 m	-0.063236856 m
Point 7	-63.724999 m	-70.361166 m
Point 8	-23.924999 m	11.950001 m
Point 9	-28.31321 m	14.154915 m
Point 10	-78.492099 m	14.5 m
Point 11	-78.492099 m	-0.063462408 m
Point 12	-63.656416 m	0.04572 m
Point 13	-25.694 m	12.807602 m
Point 14	-100.2138 m	14.5 m
Point 15	-100.2138 m	-0.15406726 m
Point 16	-99.984501 m	-70.427673 m
Point 17	105.0929 m	-0.063236856 m
Point 18	105.0929 m	-70.171693 m
Point 19	-46.704266 m	-70.361166 m
Point 20	-70.251261 m	-70.390561 m
Point 21	-100.13362 m	-25.469301 m
Point 22	-63.733601 m	-25.510599 m
Point 23	105.0929 m	-25.473599 m

Regions

	Material	Points	Area
Region 1	Cohesive Till	17,6,3,2,12,11,15,21,22,23	5,222.9 m ²
Region 2	Cohesive Till	12,2,1,8,13,9,4,5,10,14,15,11	1,245.5 m ²
Region 3	Bedrock	16,20,7,19,18,23,22,21	9,192.2 m ²

Slip Results

Slip Surfaces Analysed: 8522 of 14196 converged

Current Slip Surface

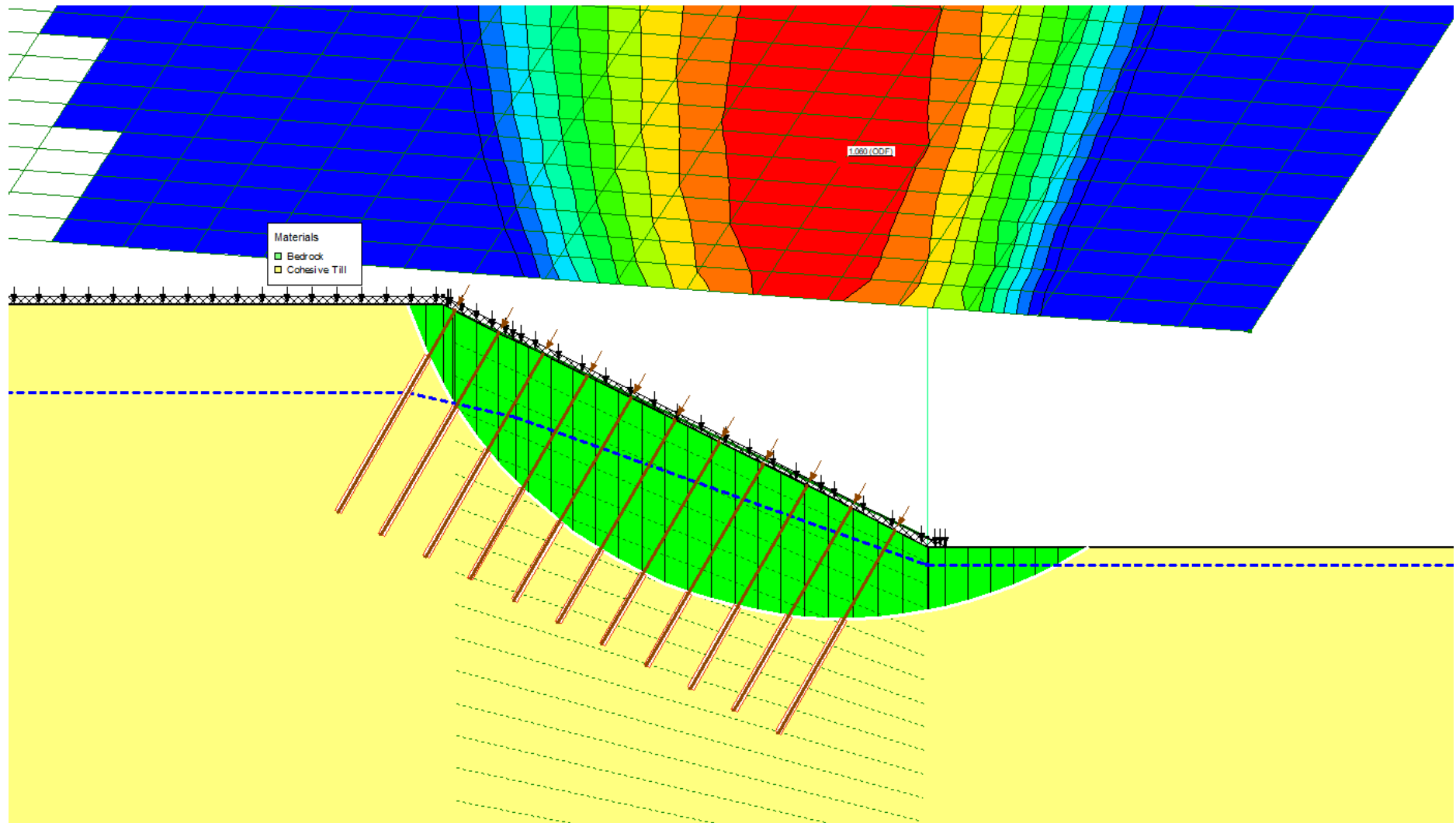
Slip Surface: 4,531
Overdesign Factor: 1.060
Degree of Utilization: 0.944
Volume: 81.087015 m³
Weight: 1,702.8273 kN
Resisting Moment: 17,065.231 kN·m
Activating Moment: 16,104.89 kN·m
Resisting Force: 533.98952 kN
Activating Force: 504.58799 kN
Slip Rank: 1 of 14,196 slip surfaces
Exit: (9.6120041, -0.063236856) m
Entry: (-31.151066, 14.5) m
Radius: 27.385343 m
Center: (-5.1244927, 23.019065) m

Slip Columns

	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength	Suction Strength	Base Material
Column 1	-100.43734 m	43.03115 m	-39.205234 kPa	16.087704 kPa	6.5576759 kPa	0 kPa	0 kPa	Cohesive Till

Column 2	-96.90869 m	35.00252 m	-17.680925 kPa	72.46171 kPa	29.536868 kPa	0 kPa	0 kPa	Cohesive Till
Column 3	-94.17115 m	29.86593 m	-4.2465994 kPa	116.74806 kPa	47.588885 kPa	0 kPa	0 kPa	Cohesive Till
Column 4	-93.04452 m	27.97099 m	0.6275878 kPa	69.123179 kPa	27.920198 kPa	0 kPa	0 kPa	Cohesive Till
Column 5	-90.74281 m	24.60571 m	9.0727813 kPa	102.40746 kPa	38.045115 kPa	0 kPa	0 kPa	Cohesive Till
Column 6	-86.44620 m	18.84687 m	23.27371 kPa	136.18295 kPa	46.024105 kPa	0 kPa	0 kPa	Cohesive Till
Column 7	-82.62631 m	14.40725 m	33.8656 kPa	132.28292 kPa	40.116902 kPa	0 kPa	0 kPa	Cohesive Till
Column 8	-79.72440 m	11.40004 m	40.362931 kPa	168.66815 kPa	52.299821 kPa	0 kPa	0 kPa	Cohesive Till
Column 9	-76.30098 m	8.25348 m	46.097065 kPa	145.37835 kPa	40.469075 kPa	0 kPa	0 kPa	Cohesive Till
Column 10	-71.91477 m	4.60987 m	52.284431 kPa	167.09079 kPa	46.797408 kPa	0 kPa	0 kPa	Cohesive Till
Column 11	-67.52855 m	1.40504 m	57.160201 kPa	163.98898 kPa	43.545584 kPa	0 kPa	0 kPa	Cohesive Till
Column 12	-63.05293 m	-1.46655 m	60.943967 kPa	182.6529 kPa	49.61104 kPa	0 kPa	0 kPa	Cohesive Till
Column 13	-58.48789 m	-4.03317 m	63.720235 kPa	178.73729 kPa	46.883295 kPa	0 kPa	0 kPa	Cohesive Till
Column 14	-53.92284 m	-6.26456 m	65.494443 kPa	197.07779 kPa	53.636049 kPa	0 kPa	0 kPa	Cohesive Till
Column 15	-49.35780 m	-8.18766 m	66.347106 kPa	191.38236 kPa	50.966917 kPa	0 kPa	0 kPa	Cohesive Till
Column 16	-44.79276 m	-9.82339 m	66.340779 kPa	209.57497 kPa	58.385173 kPa	0 kPa	0 kPa	Cohesive Till
Column 17	-40.22772 m	-11.18808 m	65.524255 kPa	201.07224 kPa	55.25212 kPa	0 kPa	0 kPa	Cohesive Till
Column 18	-35.66268 m	-12.29440 m	63.935432 kPa	219.41157 kPa	63.375237 kPa	0 kPa	0 kPa	Cohesive Till
Column 19	-31.09764 m	-13.15205 m	61.603305 kPa	206.15945 kPa	58.924027 kPa	0 kPa	0 kPa	Cohesive Till
Column 20	-26.53260 m	-13.76823 m	58.549354 kPa	234.33255 kPa	71.652809 kPa	0 kPa	0 kPa	Cohesive Till
Column 21	-21.96756 m	-14.14791 m	54.788502 kPa	213.80038 kPa	64.816478 kPa	0 kPa	0 kPa	Cohesive Till
Column 22	-17.20938 m	-14.29007 m	50.110484 kPa	209.93806 kPa	65.148972 kPa	0 kPa	0 kPa	Cohesive Till
Column 23	-12.25807 m	-14.17530 m	44.457344 kPa	198.06475 kPa	62.613507 kPa	0 kPa	0 kPa	Cohesive Till
Column 24	-7.33681 m	-13.79012 m	38.028135 kPa	145.56208 kPa	43.833026 kPa	0 kPa	0 kPa	Cohesive Till
Column 25	-2.44560 m	-13.13432 m	30.822257 kPa	125.00971 kPa	38.392725 kPa	0 kPa	0 kPa	Cohesive Till
Column 26	0.04101 m	-12.73017 m	26.991402 kPa	112.59149 kPa	34.892339 kPa	0 kPa	0 kPa	Cohesive Till
Column 27	1.76345 m	-12.36696 m	25.906536 kPa	107.58333 kPa	33.293122 kPa	0 kPa	0 kPa	Cohesive Till
Column 28	5.65819 m	-11.43965 m	23.136592 kPa	97.494725 kPa	30.309889 kPa	0 kPa	0 kPa	Cohesive Till
Column 29	10.08481 m	-10.17303 m	19.352637 kPa	87.087034 kPa	27.60992 kPa	0 kPa	0 kPa	Cohesive Till

Column 30	14.51143 m	-8.65471 m	14.81629 kPa	73.893653 kPa	24.081136 kPa	0 kPa	0 kPa	Cohesive Till
Column 31	18.93804 m	-6.87071 m	9.4858151 kPa	58.174273 kPa	19.846407 kPa	0 kPa	0 kPa	Cohesive Till
Column 32	23.36466 m	-4.80329 m	3.3080999 kPa	40.282517 kPa	15.071525 kPa	0 kPa	0 kPa	Cohesive Till
Column 33	28.55671 m	-1.95185 m	-5.2127727 kPa	15.385198 kPa	6.2713201 kPa	0 kPa	0 kPa	Cohesive Till



Undrained SLS

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File Information

File Version: 11.05
Created By: Laura Castro
Last Edited By: Laura Castro
Revision Number: 282
Date: 03/08/2024
Time: 19:35:54
Tool Version: 23.1.2.11
File Name: 1 in 2 slope with soil nails.gsz
Directory: C:\Users\CAS111646\OneDrive - Mott MacDonald\Desktop\Knocknagael\Slope stability analysis\Platform cutting\
Last Solved Date: 03/08/2024
Last Solved Time: 19:37:06

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

Undrained SLS

Kind: SLOPE/W
Analysis Type: Morgenstern-Price
Settings
 Side Function
 Intercolumn force function option: Half-Sine
 PWP Conditions from: Piezometric Surfaces
 Apply Phreatic Correction: No
 Use Staged Rapid Drawdown: No
 Unit Weight of Water: 9.807 kN/m³
Slip Surface
 Direction of movement: Left to Right
 Use Passive Mode: No
 Slip Surface Option: Grid and Radius
 Critical slip surfaces saved: 1
 Optimize Critical Slip Surface Location: No
 Tension Crack Option: (none)
Distribution
 F of S Calculation Option: Constant
Convergence
 Geometry Settings
 Minimum Slip Surface Depth: 0.5 m
 Minimum Slip Surface Volume: 1 m³
 Number of Columns: 30
 Factor of Safety Convergence Settings
 Maximum Number of Iterations: 100
 Tolerable difference in F of S: 0.001
 Under-Relaxation Criteria
 Initial Rate: 1
 Minimum Rate: 0.1
 Rate Reduction Factor: 0.65

Reduction Frequency (iterations): 50
Solution Settings
Search Method: Linear Search
Must Obtain at Lambda Factor of Safety: 0.2
Lambda
Lambda 1: -1
Lambda 2: -0.8
Lambda 3: -0.6
Lambda 4: -0.4
Lambda 5: -0.2
Lambda 6: 0
Lambda 7: 0.2
Lambda 8: 0.4
Lambda 9: 0.6
Lambda 10: 0.8
Lambda 11: 1

Materials

Cohesive Till Undrained

Slope Stability Material Model: $S=f(\text{depth})$
Unit Weight: 21 kN/m³
C-Top of Layer: 40 kPa
C-Rate of Change: 3.5 (kN/m²)/m
C-Maximum: 110 kPa
Pore Water Pressure
Piezometric Surface: 1

Bedrock

Slope Stability Material Model: Bedrock (Impenetrable)
Pore Water Pressure
Piezometric Surface: 1

Reinforcements

Soil nail

Type: Nail
Pullout Resistance: 85 kPa
Pullout Resistance Reduction Factor: 1.5
Tensile Capacity: 770 kN
Tensile Capacity Reduction Factor: 1.5
Shear Force: 0 kN
Shear Force Reduction Factor: 1
Apply Shear: Parallel to Slip
F of S Dependent: No
Force Distribution: Distributed
Bond Diameter: 0.105 m
Out-of-Plane Spacing: 1.5 m
Face Anchorage: Yes
Factored Pullout Resistance: 12.462 kN/m/m
Factored Tensile Capacity: 342.22 kN/m

Slip Surface Grid

Upper Left: (-69.137299, 47.1568) m
Lower Left: (-86.193301, 20.8563) m

Lower Right: (19.295599, 12.901599) m
Grid Horizontal Increment: 25
Grid Vertical Increment: 20

Slip Surface Radius

Upper Left Coordinate: (-28.313271, 14.154946) m
Upper Right Coordinate: (1.024701, -0.091199208) m
Lower Left Coordinate: (-28.7107, -35.798602) m
Lower Right Coordinate: (1.024701, -35.798602) m
Number of Increments: 25
Use Left Projection: No
Left Projection Angle: 135 °
Use Right Projection: No
Right Projection Angle: 45 °

Slip Surface Limits

Left Coordinate: (-100.2138, 14.5) m
Right Coordinate: (105.0929, -0.063236856) m

Piezometric Surfaces

Piezometric Surface 1

Coordinates

	X	Y
Coordinate 1	-100.2138 m	9.6522997 m
Coordinate 2	-78.492099 m	9.5901998 m
Coordinate 3	-63.636412 m	9.2500003 m
Coordinate 4	-31.174999 m	9.2500003 m
Coordinate 5	-24.674999 m	7.7250006 m
Coordinate 6	0 m	-1.1279002 m
Coordinate 7	105.0929 m	-1.1104992 m

Reinforcement Sets

Reinforcement Sets

Reinforcement: Soil nail
Lock to Ground Surface: Yes
Range Start: (-1.9682045, 0.94160926) m
X: -1.9682045 m
Y: 0.94160926 m
Range End: (-28.313271, 14.154946) m
X: -28.313271 m
Y: 14.154946 m
Orientation Type: Absolute Angle
Orientation: -120 °
Length: 14 m
Spacing Type: Evenly
Distribution Type: Specify number of reinforcements
Number of Reinforcements: 11

Reinforcement Lines

Reinforcement Line 1

Reinforcement: Soil nail
Reinforcement Set: Soil nails
Lock to Ground Surface: No
Outside Point: (-1.9682033, 0.9416095) m
Inside Point: (-8.9682036, -11.182746) m
Length: 14 m
Orientation: -120 °
Slip Surface Intersection: (-6.1858315, -6.3635366) m
Max. Pullout Force: 53.176357 kN
Available Length: 5.5647441 m
Required Length: 5.5647441 m
Pullout Force: 21.13663 kN
Pullout Force per Length: 3.7983112 kN/m
Governing Component: Pullout Resistance

Reinforcement Line 2

Reinforcement: Soil nail
Reinforcement Set: Soil nails
Lock to Ground Surface: No
Outside Point: (-4.5921503, 2.281236) m
Inside Point: (-11.592151, -9.8431198) m
Length: 14 m
Orientation: -120 °
Slip Surface Intersection: (-9.6765344, -6.5251754) m
Max. Pullout Force: 53.176357 kN
Available Length: 3.8312322 m
Required Length: 3.8312322 m
Pullout Force: 14.552212 kN
Pullout Force per Length: 3.7983112 kN/m
Governing Component: Pullout Resistance

Reinforcement Line 3

Reinforcement: Soil nail
Reinforcement Set: Soil nails
Lock to Ground Surface: No
Outside Point: (-7.2222177, 3.6102554) m
Inside Point: (-14.222218, -8.5141003) m
Length: 14 m
Orientation: -120 °
Slip Surface Intersection: (-12.948731, -6.3083558) m
Max. Pullout Force: 53.176357 kN
Available Length: 2.5469743 m
Required Length: 2.5469743 m
Pullout Force: 9.6742011 kN
Pullout Force per Length: 3.7983112 kN/m
Governing Component: Pullout Resistance

Reinforcement Line 4

Reinforcement: Soil nail
Reinforcement Set: Soil nails
Lock to Ground Surface: No
Outside Point: (-9.8593778, 4.9269975) m
Inside Point: (-16.859378, -7.1973582) m
Length: 14 m
Orientation: -120 °

Slip Surface Intersection: (-16.035297, -5.7700076) m
Max. Pullout Force: 53.176357 kN
Available Length: 1.6481625 m
Required Length: 1.6481625 m
Pullout Force: 6.2602341 kN
Pullout Force per Length: 3.7983112 kN/m
Governing Component: Pullout Resistance

Reinforcement Line 5

Reinforcement: Soil nail
Reinforcement Set: Soil nails
Lock to Ground Surface: No
Outside Point: (-12.496535, 6.2437366) m
Inside Point: (-19.496535, -5.8806192) m
Length: 14 m
Orientation: -120 °
Slip Surface Intersection: (-18.956037, -4.9444485) m
Max. Pullout Force: 53.176357 kN
Available Length: 1.0809968 m
Required Length: 1.0809968 m
Pullout Force: 4.105962 kN
Pullout Force per Length: 3.7983112 kN/m
Governing Component: Pullout Resistance

Reinforcement Line 6

Reinforcement: Soil nail
Reinforcement Set: Soil nails
Lock to Ground Surface: No
Outside Point: (-15.133695, 7.5604787) m
Inside Point: (-22.133692, -4.5638771) m
Length: 13.999999 m
Orientation: -120 °
Slip Surface Intersection: (-21.715678, -3.8398546) m
Max. Pullout Force: 53.176351 kN
Available Length: 0.83602906 m
Required Length: 0.83602906 m
Pullout Force: 3.1754985 kN
Pullout Force per Length: 3.7983112 kN/m
Governing Component: Pullout Resistance

Reinforcement Line 7

Reinforcement: Soil nail
Reinforcement Set: Soil nails
Lock to Ground Surface: No
Outside Point: (-17.770852, 8.8772177) m
Inside Point: (-24.770852, -3.247138) m
Length: 14 m
Orientation: -120 °
Slip Surface Intersection: (-24.337556, -2.4966473) m
Max. Pullout Force: 53.176357 kN
Available Length: 0.86659208 m
Required Length: 0.86659208 m
Pullout Force: 3.2915864 kN
Pullout Force per Length: 3.7983112 kN/m
Governing Component: Pullout Resistance

Reinforcement Line 8

Reinforcement: Soil nail
Reinforcement Set: Soil nails

Lock to Ground Surface: No
Outside Point: (-20.408012, 10.19396) m
Inside Point: (-27.408009, -1.9303959) m
Length: 13.999999 m
Orientation: -120 °
Slip Surface Intersection: (-26.795419, -0.86935875) m
Max. Pullout Force: 53.176351 kN
Available Length: 1.2251801 m
Required Length: 1.2251801 m
Pullout Force: 4.6536152 kN
Pullout Force per Length: 3.7983112 kN/m
Governing Component: Pullout Resistance

Reinforcement Line 9

Reinforcement: Soil nail
Reinforcement Set: Soil nails
Lock to Ground Surface: No
Outside Point: (-23.045169, 11.510699) m
Inside Point: (-30.045169, -0.61365689) m
Length: 14 m
Orientation: -120 °
Slip Surface Intersection: (-29.131278, 0.96924836) m
Max. Pullout Force: 53.176357 kN
Available Length: 1.8277815 m
Required Length: 1.8277815 m
Pullout Force: 6.9424831 kN
Pullout Force per Length: 3.7983112 kN/m
Governing Component: Pullout Resistance

Reinforcement Line 10

Reinforcement: Soil nail
Reinforcement Set: Soil nails
Lock to Ground Surface: No
Outside Point: (-25.693829, 12.807519) m
Inside Point: (-32.693829, 0.68316348) m
Length: 14 m
Orientation: -120 °
Slip Surface Intersection: (-31.30223, 3.0934842) m
Max. Pullout Force: 53.176357 kN
Available Length: 2.7831986 m
Required Length: 2.7831986 m
Pullout Force: 10.571454 kN
Pullout Force per Length: 3.7983112 kN/m
Governing Component: Pullout Resistance

Reinforcement Line 11

Reinforcement: Soil nail
Reinforcement Set: Soil nails
Lock to Ground Surface: No
Outside Point: (-28.313271, 14.154946) m
Inside Point: (-35.313272, 2.0305898) m
Length: 14 m
Orientation: -120 °
Slip Surface Intersection: (-33.294421, 5.5273422) m
Max. Pullout Force: 53.176357 kN
Available Length: 4.0377019 m
Required Length: 4.0377019 m
Pullout Force: 15.336448 kN
Pullout Force per Length: 3.7983112 kN/m

Geometry

Name: 2D Geometry

Settings

View: 2D

Element Thickness: 0.3048 m

Points

	X	Y
Point 1	-6.0000002 m	3.0000001 m
Point 2	0 m	-0.063236856 m
Point 3	10 m	-0.063236856 m
Point 4	-29.000001 m	14.5 m
Point 5	37.399999 m	-0.063236856 m
Point 6	-63.724999 m	-70.361166 m
Point 7	-23.924999 m	11.950001 m
Point 8	-28.31321 m	14.154915 m
Point 9	-78.492099 m	14.5 m
Point 10	-78.492099 m	-0.063462408 m
Point 11	-25.694 m	12.807602 m
Point 12	-100.2138 m	14.5 m
Point 13	-100.2138 m	-0.15406726 m
Point 14	-99.984501 m	-70.427673 m
Point 15	105.0929 m	-0.063236856 m
Point 16	105.0929 m	-70.171693 m
Point 17	-46.704266 m	-70.361166 m
Point 18	-70.251261 m	-70.390561 m
Point 19	-100.13362 m	-25.469301 m
Point 20	105.0929 m	-25.473599 m

Regions

	Material	Points	Area
Region 1	Cohesiva Till Undrained	15,5,3,2,10,13,19,20	5,214.5 m ²
Region 2	Cohesiva Till Undrained	2,1,7,11,8,4,9,12,13,10	1,249.8 m ²
Region 3	Bedrock	14,18,6,17,16,20,19	9,196.4 m ²

Slip Results

Slip Surfaces Analysed: 7871 of 14196 converged

Current Slip Surface

Slip Surface: 4,507

Factor of Safety: 1.602

Volume: 136.29396 m³

Weight: 2,862.1732 kN

Resisting Moment: 37,768.363 kN·m

Activating Moment: 23,573.772 kN·m

Resisting Force: 1,051.326 kN

Activating Force: 656.30973 kN

Slip Rank: 1 of 14,196 slip surfaces

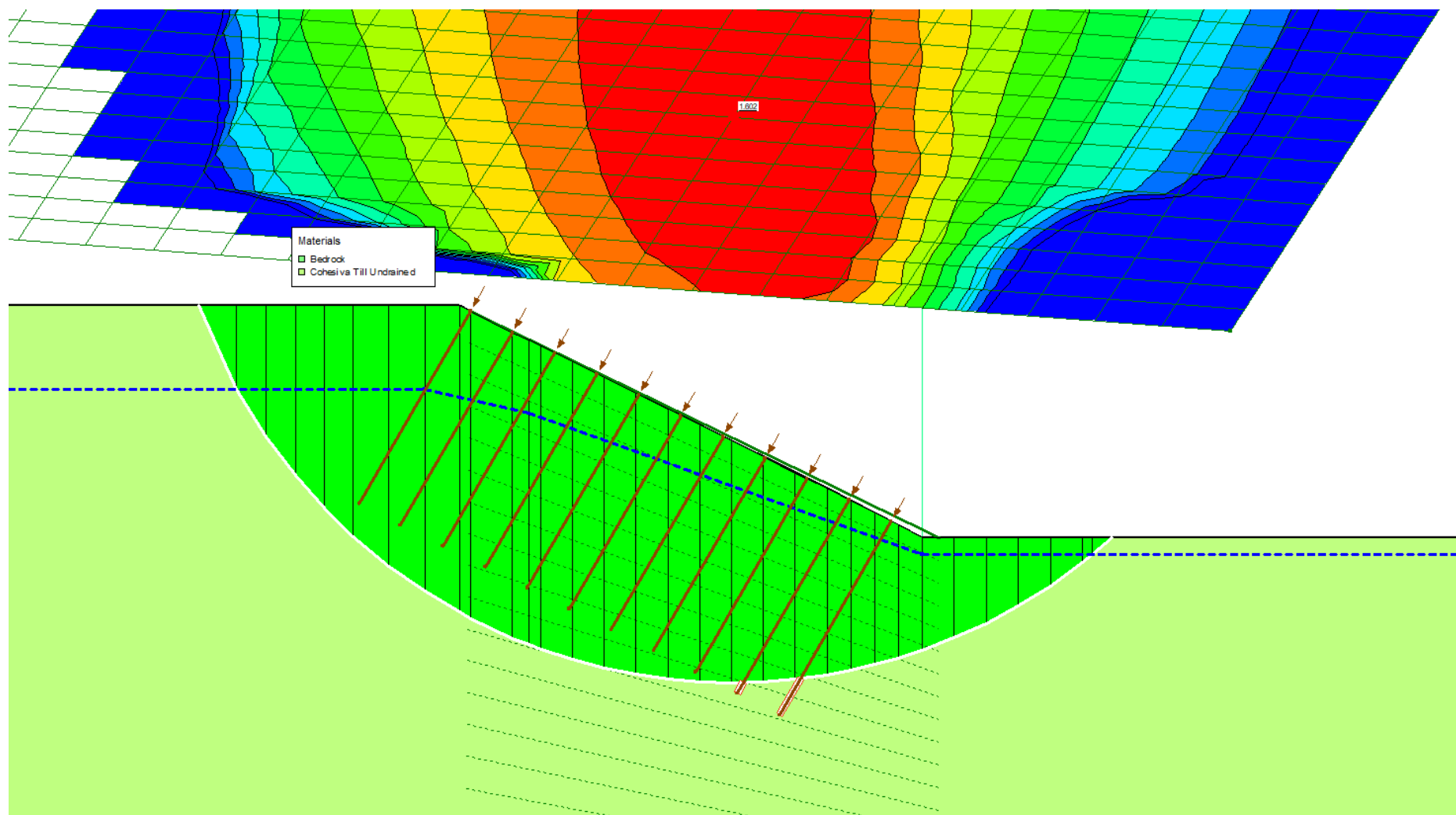
Exit: (9.2247029, -0.063236856) m

Entry: (-37.879718, 14.5) m
Radius: 29.872755 m
Center: (-9.3440487, 23.337253) m

Slip Columns

	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength	Suction Strength	Base Material
Column 1	-120.67968 m	38.95998 m	-25.743376 kPa	-16.381654 kPa	0 kPa	49.1875 kPa	0 kPa	Cohesiva Till Undrained
Column 2	-114.61509 m	26.23269 m	12.300687 kPa	69.546118 kPa	0 kPa	62.764967 kPa	0 kPa	Cohesiva Till Undrained
Column 3	-109.68112 m	18.74589 m	34.680039 kPa	126.1604 kPa	0 kPa	70.751888 kPa	0 kPa	Cohesiva Till Undrained
Column 4	-104.74716 m	12.52025 m	53.289561 kPa	168.67095 kPa	0 kPa	77.393402 kPa	0 kPa	Cohesiva Till Undrained
Column 5	-98.71227 m	6.21481 m	69.635398 kPa	205.63675 kPa	0 kPa	84.120038 kPa	0 kPa	Cohesiva Till Undrained
Column 6	-94.01774 m	1.80842 m	79.514583 kPa	233.49079 kPa	0 kPa	88.216884 kPa	0 kPa	Cohesiva Till Undrained
Column 7	-92.23410 m	0.32290 m	82.704176 kPa	247.87842 kPa	0 kPa	88.837195 kPa	0 kPa	Cohesiva Till Undrained
Column 8	-87.93750 m	-2.83346 m	89.125839 kPa	240.13255 kPa	0 kPa	89.846598 kPa	0 kPa	Cohesiva Till Undrained
Column 9	-82.62631 m	-6.50495 m	96.375788 kPa	251.96583 kPa	0 kPa	90.901572 kPa	0 kPa	Cohesiva Till Undrained
Column 10	-79.72440 m	-8.26238 m	99.137296 kPa	262.59754 kPa	0 kPa	91.275597 kPa	0 kPa	Cohesiva Till Undrained
Column 11	-75.82095 m	-10.36289 m	101.22983 kPa	260.49247 kPa	0 kPa	91.456276 kPa	0 kPa	Cohesiva Till Undrained
Column 12	-70.47467 m	-12.94093 m	103.20238 kPa	268.53733 kPa	0 kPa	91.358799 kPa	0 kPa	Cohesiva Till Undrained
Column 13	-65.12840 m	-15.13500 m	104.02718 kPa	271.722 kPa	0 kPa	90.851703 kPa	0 kPa	Cohesiva Till Undrained
Column 14	-59.78212 m	-16.97224 m	103.78537 kPa	275.12427 kPa	0 kPa	89.963947 kPa	0 kPa	Cohesiva Till Undrained
Column 15	-54.43584 m	-18.47344 m	102.53907 kPa	279.14925 kPa	0 kPa	88.717698 kPa	0 kPa	Cohesiva Till Undrained
Column 16	-49.08957 m	-19.65438 m	100.33546 kPa	276.7788 kPa	0 kPa	87.129798 kPa	0 kPa	Cohesiva Till Undrained
Column 17	-43.74329 m	-20.52679 m	97.209599 kPa	278.2058 kPa	0 kPa	85.212759 kPa	0 kPa	Cohesiva Till Undrained

Column 18	-38.39701 m	-21.09897 m	93.18628 kPa	270.69319 kPa	0 kPa	82.975427 kPa	0 kPa	Cohesiva Till Undrained
Column 19	-33.05073 m	-21.37619 m	88.281283 kPa	268.7503 kPa	0 kPa	80.423436 kPa	0 kPa	Cohesiva Till Undrained
Column 20	-27.70446 m	-21.36096 m	82.502117 kPa	257.61085 kPa	0 kPa	77.559463 kPa	0 kPa	Cohesiva Till Undrained
Column 21	-22.35818 m	-21.05315 m	75.848371 kPa	252.31141 kPa	0 kPa	74.383364 kPa	0 kPa	Cohesiva Till Undrained
Column 22	-17.19770 m	-20.48097 m	68.603629 kPa	226.82982 kPa	0 kPa	70.994381 kPa	0 kPa	Cohesiva Till Undrained
Column 23	-12.22301 m	-19.65953 m	60.813077 kPa	207.15956 kPa	0 kPa	67.408641 kPa	0 kPa	Cohesiva Till Undrained
Column 24	-7.30175 m	-18.58565 m	52.325221 kPa	170.13809 kPa	0 kPa	63.582691 kPa	0 kPa	Cohesiva Till Undrained
Column 25	-2.43392 m	-17.25611 m	43.130467 kPa	145.38193 kPa	0 kPa	59.513108 kPa	0 kPa	Cohesiva Till Undrained
Column 26	2.55889 m	-15.60180 m	35.576446 kPa	126.23359 kPa	0 kPa	56.422674 kPa	0 kPa	Cohesiva Till Undrained
Column 27	7.67666 m	-13.59165 m	29.570286 kPa	112.67108 kPa	0 kPa	54.278244 kPa	0 kPa	Cohesiva Till Undrained
Column 28	12.79444 m	-11.23736 m	22.535439 kPa	96.261451 kPa	0 kPa	51.766688 kPa	0 kPa	Cohesiva Till Undrained
Column 29	17.91222 m	-8.51023 m	14.386095 kPa	77.042349 kPa	0 kPa	48.857381 kPa	0 kPa	Cohesiva Till Undrained
Column 30	23.02999 m	-5.37281 m	5.0103459 kPa	55.0693 kPa	0 kPa	45.510386 kPa	0 kPa	Cohesiva Till Undrained
Column 31	27.92683 m	-1.95185 m	-5.2130871 kPa	31.579011 kPa	0 kPa	41.860901 kPa	0 kPa	Cohesiva Till Undrained



Undrained ULS C1

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File Information

File Version: 11.05
Created By: Laura Castro
Last Edited By: Laura Castro
Revision Number: 282
Date: 03/08/2024
Time: 19:35:54
Tool Version: 23.1.2.11
File Name: 1 in 2 slope with soil nails.gsz
Directory: C:\Users\CAS111646\OneDrive - Mott MacDonald\Desktop\Knocknagael\Slope stability analysis\Platform cutting\
Last Solved Date: 03/08/2024
Last Solved Time: 19:37:14

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

Undrained ULS C1

Kind: SLOPE/W
Analysis Type: Morgenstern-Price
Settings
Side Function
Intercolumn force function option: Half-Sine
PWP Conditions from: Piezometric Surfaces
Apply Phreatic Correction: No
Use Staged Rapid Drawdown: No
Limit State Design Approach: Eurocode 7 - DA1, C1
Unit Weight of Water: 9.807 kN/m³

Slip Surface
Direction of movement: Left to Right
Use Passive Mode: No
Slip Surface Option: Grid and Radius
Critical slip surfaces saved: 1
Optimize Critical Slip Surface Location: No
Tension Crack Option: (none)

Distribution
ODF Calculation Option: Constant

Convergence
Geometry Settings
Minimum Slip Surface Depth: 0.5 m
Minimum Slip Surface Volume: 1 m³
Number of Columns: 30
Overdesign Factor Convergence Settings
Maximum Number of Iterations: 100
Tolerable difference in ODF: 0.001
Under-Relaxation Criteria
Initial Rate: 1
Minimum Rate: 0.1

Rate Reduction Factor: 0.65
Reduction Frequency (iterations): 50
Solution Settings
Search Method: Root Finder
Tolerable difference between starting and converged ODF: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Cohesive Till Undrained

Slope Stability Material Model: $S=f(\text{depth})$
Unit Weight: 21 kN/m³
C-Top of Layer: 40 kPa
C-Rate of Change: 3.5 (kN/m²)/m
C-Maximum: 110 kPa
Pore Water Pressure
Piezometric Surface: 1

Bedrock

Slope Stability Material Model: Bedrock (Impenetrable)
Pore Water Pressure
Piezometric Surface: 1

Slip Surface Grid

Upper Left: (-53.205699, 46.298699) m
Lower Left: (-73.365701, 19.860299) m
Lower Right: (24.3527, 18.765899) m
Grid Horizontal Increment: 30
Grid Vertical Increment: 25

Slip Surface Radius

Upper Left Coordinate: (-28.313271, 14.154946) m
Upper Right Coordinate: (4.2595008, -0.091199208) m
Lower Left Coordinate: (-27.964199, -36.005899) m
Lower Right Coordinate: (4.2595008, -36.005899) m
Number of Increments: 20
Use Left Projection: No
Left Projection Angle: 135 °
Use Right Projection: No
Right Projection Angle: 45 °

Slip Surface Limits

Left Coordinate: (-100.2138, 14.5) m
Right Coordinate: (105.0929, -0.063236856) m

Piezometric Surfaces

Piezometric Surface 1

Coordinates

	X	Y
Coordinate 1	-100.2138 m	9.6522997 m
Coordinate 2	-78.492099 m	9.5901998 m
Coordinate 3	-63.636412 m	9.2500003 m
Coordinate 4	-31.174999 m	9.2500003 m
Coordinate 5	-24.674999 m	7.7250006 m
Coordinate 6	0 m	-1.1279002 m
Coordinate 7	105.0929 m	-1.1104992 m

Design Factor Set: Eurocode 7 - DA1, C1

- Permanent Point Loads & Surcharge Loads: Favorable = 1, Unfavorable = 1.35
- Variable Point Loads & Surcharge Loads: Favorable = 0, Unfavorable = 1.5
- Soil Unit Weight: Favorable = 1, Unfavorable = 1.35
- Effective Cohesion: 1
- Effective Coefficient of Friction: 1
- Undrained Strength: 1
- Shear Strength (Other Models): 1
- Pullout Resistance: 1.1
- Shear Force: 1.1
- Tensile Strength: 1.1
- Compressive Strength: 1.1
- Seismic Coefficients: 1
- Earth Resistance: 1

Geometry

Name: 2D Geometry

Settings

- View: 2D
- Element Thickness: 0.3048 m

Points

	X	Y
Point 1	-6.0000002 m	3.0000001 m
Point 2	0 m	-0.063236856 m
Point 3	10 m	-0.063236856 m
Point 4	-29.000001 m	14.5 m
Point 5	37.399999 m	-0.063236856 m
Point 6	-63.724999 m	-70.361166 m
Point 7	-23.924999 m	11.950001 m
Point 8	-28.31321 m	14.154915 m
Point 9	-78.492099 m	14.5 m
Point 10	-78.492099 m	-0.063462408 m
Point 11	-25.694 m	12.807602 m
Point 12	-100.2138 m	14.5 m
Point 13	-100.2138 m	-0.15406726 m
Point 14	-99.984501 m	-70.427673 m

Point 15	105.0929 m	-0.063236856 m
Point 16	105.0929 m	-70.171693 m
Point 17	-46.704266 m	-70.361166 m
Point 18	-70.251261 m	-70.390561 m
Point 19	-100.13362 m	-25.469301 m
Point 20	105.0929 m	-25.473599 m

Regions

	Material	Points	Area
Region 1	Cohesiva Till Undrained	15,5,3,2,10,13,19,20	5,214.5 m ²
Region 2	Cohesiva Till Undrained	2,1,7,11,8,4,9,12,13,10	1,249.8 m ²
Region 3	Bedrock	14,18,6,17,16,20,19	9,196.4 m ²

Slip Results

Slip Surfaces Analysed: 13798 of 16926 converged

Current Slip Surface

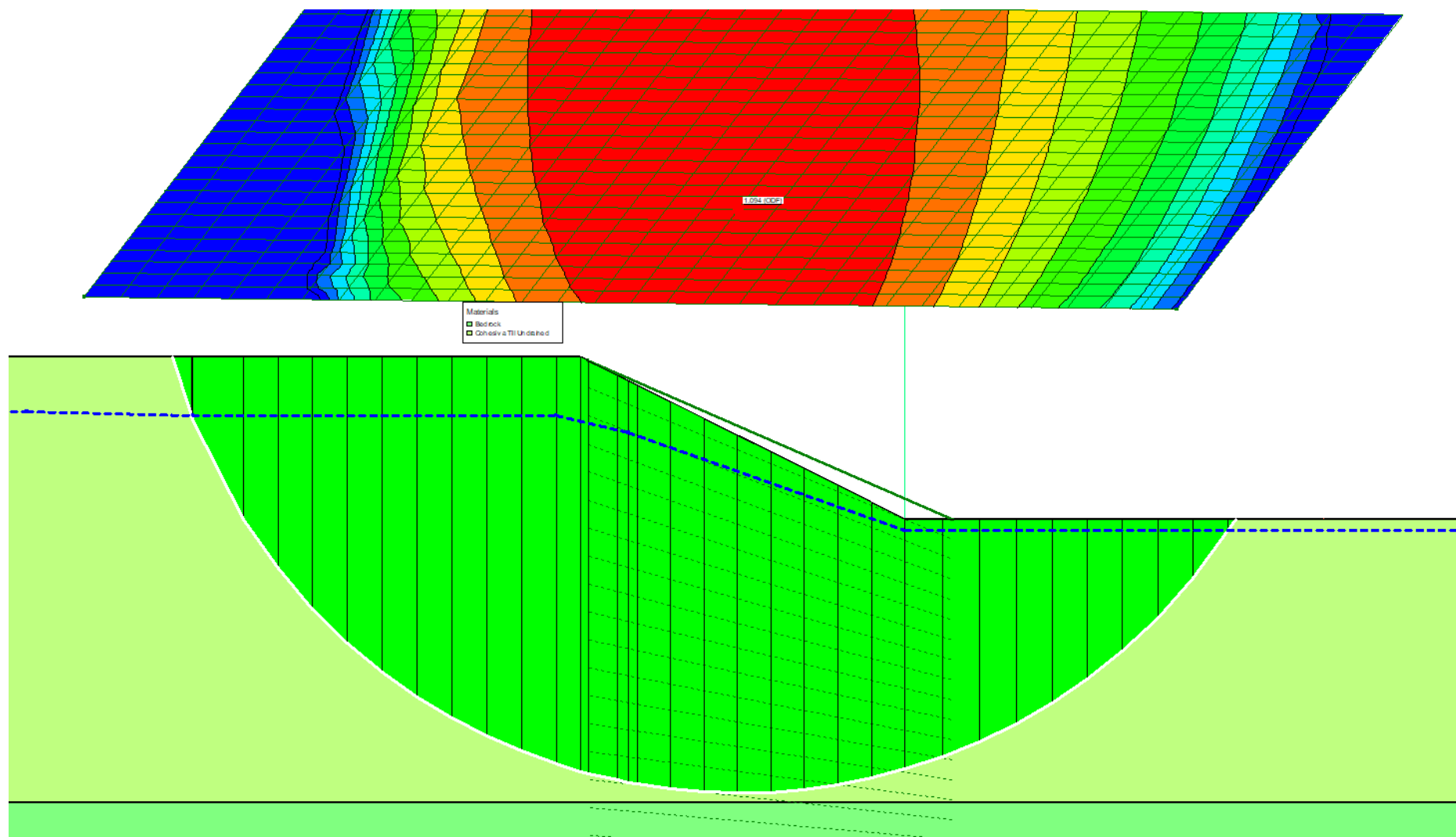
Slip Surface: 5,560
Overdesign Factor: 1.094
Degree of Utilization: 0.914
Volume: 681.44224 m³
Weight: 17,463.951 kN
Resisting Moment: 185,943.97 kN·m
Activating Moment: 170,041.79 kN·m
Resisting Force: 2,896.8855 kN
Activating Force: 2,648.2539 kN
Slip Rank: 1 of 16,926 slip surfaces
Exit: (29.556253, -0.063236856) m
Entry: (-65.443195, 14.5) m
Radius: 52.346437 m
Center: (-14.79802, 27.736907) m

Slip Columns

	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength	Suction Strength	Base Material
Column 1	-211.96799 m	38.96509 m	-25.540489 kPa	-65.783109 kPa	0 kPa	49.182047 kPa	0 kPa	Cohesiva Till Undrained
Column 2	-209.00411 m	29.77299 m	1.733387 kPa	13.613083 kPa	0 kPa	58.988172 kPa	0 kPa	Cohesiva Till Undrained
Column 3	-201.42487 m	14.48998 m	47.401679 kPa	145.77091 kPa	0 kPa	75.292088 kPa	0 kPa	Cohesiva Till Undrained
Column 4	-188.96948 m	-7.47910 m	113.07108 kPa	336.18235 kPa	0 kPa	98.728707 kPa	0 kPa	Cohesiva Till Undrained
Column 5	-178.77074 m	-20.69530 m	152.57658 kPa	454.7423 kPa	0 kPa	110 kPa	0 kPa	Cohesiva Till Undrained
Column 6	-168.57200 m	-31.63127 m	185.26612 kPa	561.31669 kPa	0 kPa	110 kPa	0 kPa	Cohesiva Till Undrained

Column 7	-158.37326 m	-40.86899 m	212.87925 kPa	650.4714 kPa	0 kPa	110 kPa	0 kPa	Cohesiva Till Undrained
Column 8	-148.17452 m	-48.75103 m	236.44004 kPa	726.98717 kPa	0 kPa	110 kPa	0 kPa	Cohesiva Till Undrained
Column 9	-137.97577 m	-55.49897 m	256.6108 kPa	793.76193 kPa	0 kPa	110 kPa	0 kPa	Cohesiva Till Undrained
Column 10	-127.77703 m	-61.26503 m	273.84657 kPa	852.65885 kPa	0 kPa	110 kPa	0 kPa	Cohesiva Till Undrained
Column 11	-117.57829 m	-66.15813 m	288.4729 kPa	904.90738 kPa	0 kPa	110 kPa	0 kPa	Cohesiva Till Undrained
Column 12	-107.37955 m	-70.25825 m	300.72885 kPa	951.31551 kPa	0 kPa	110 kPa	0 kPa	Cohesiva Till Undrained
Column 13	-98.71227 m	-73.20850 m	307.04546 kPa	986.91521 kPa	0 kPa	110 kPa	0 kPa	Cohesiva Till Undrained
Column 14	-94.01774 m	-74.60773 m	307.93572 kPa	999.96828 kPa	0 kPa	110 kPa	0 kPa	Cohesiva Till Undrained
Column 15	-88.59450 m	-75.94764 m	308.1376 kPa	994.88939 kPa	0 kPa	110 kPa	0 kPa	Cohesiva Till Undrained
Column 16	-82.62631 m	-77.31666 m	308.04429 kPa	988.77355 kPa	0 kPa	110 kPa	0 kPa	Cohesiva Till Undrained
Column 17	-79.72440 m	-77.88218 m	307.24299 kPa	985.50274 kPa	0 kPa	110 kPa	0 kPa	Cohesiva Till Undrained
Column 18	-73.59334 m	-78.83195 m	303.50672 kPa	975.91913 kPa	0 kPa	110 kPa	0 kPa	Cohesiva Till Undrained
Column 19	-63.79183 m	-79.99146 m	296.46099 kPa	957.19724 kPa	0 kPa	110 kPa	0 kPa	Cohesiva Till Undrained
Column 20	-53.99032 m	-80.58369 m	287.71959 kPa	933.30897 kPa	0 kPa	110 kPa	0 kPa	Cohesiva Till Undrained
Column 21	-44.18881 m	-80.61454 m	277.30011 kPa	673.54423 kPa	0 kPa	110 kPa	0 kPa	Cohesiva Till Undrained
Column 22	-34.38730 m	-80.08431 m	265.20347 kPa	649.94313 kPa	0 kPa	110 kPa	0 kPa	Cohesiva Till Undrained
Column 23	-24.58579 m	-78.98773 m	251.41392 kPa	621.97446 kPa	0 kPa	110 kPa	0 kPa	Cohesiva Till Undrained
Column 24	-14.71035 m	-77.29658 m	235.7678 kPa	588.81815 kPa	0 kPa	110 kPa	0 kPa	Cohesiva Till Undrained
Column 25	-4.86783 m	-75.01550 m	218.39356 kPa	550.68194 kPa	0 kPa	110 kPa	0 kPa	Cohesiva Till Undrained
Column 26	5.46807 m	-71.92169 m	203.92782 kPa	523.39271 kPa	0 kPa	110 kPa	0 kPa	Cohesiva Till

								Undrained
Column 27	16.40420 m	-67.87314 m	191.8314 kPa	505.81719 kPa	0 kPa	110 kPa	0 kPa	Cohesiva Till Undrained
Column 28	27.34033 m	-62.94193 m	177.09656 kPa	480.20546 kPa	0 kPa	106.92512 kPa	0 kPa	Cohesiva Till Undrained
Column 29	37.96862 m	-57.23448 m	160.04126 kPa	446.61828 kPa	0 kPa	100.83641 kPa	0 kPa	Cohesiva Till Undrained
Column 30	48.28907 m	-50.69603 m	140.50183 kPa	405.74334 kPa	0 kPa	93.861201 kPa	0 kPa	Cohesiva Till Undrained
Column 31	58.60952 m	-43.04416 m	117.63414 kPa	355.85013 kPa	0 kPa	85.698176 kPa	0 kPa	Cohesiva Till Undrained
Column 32	68.92997 m	-34.07193 m	90.819713 kPa	295.54906 kPa	0 kPa	76.126606 kPa	0 kPa	Cohesiva Till Undrained
Column 33	79.25041 m	-23.46350 m	59.11437 kPa	222.63916 kPa	0 kPa	64.809529 kPa	0 kPa	Cohesiva Till Undrained
Column 34	89.57086 m	-10.69341 m	20.947466 kPa	133.21264 kPa	0 kPa	51.186398 kPa	0 kPa	Cohesiva Till Undrained
Column 35	95.85021 m	-1.94612 m	-5.1965797 kPa	70.85532 kPa	0 kPa	41.854794 kPa	0 kPa	Cohesiva Till Undrained



Undrained ULS C2

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File Information

File Version: 11.05
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Time: 19:35:54
Tool Version: 23.1.2.11
File Name: 1 in 2 slope with soil nails.gsz
Directory: C:\Users\CAS111646\OneDrive - Mott MacDonald\Desktop\Knocknagael\Slope stability analysis\Platform cutting\
Last Solved Date: 03/08/2024
Last Solved Time: 19:37:38

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

Undrained ULS C2

Kind: SLOPE/W
Analysis Type: Morgenstern-Price
Settings
Side Function
Intercolumn force function option: Half-Sine
PWP Conditions from: Piezometric Surfaces
Apply Phreatic Correction: No
Use Staged Rapid Drawdown: No
Limit State Design Approach: Eurocode 7 - DA1, C2
Unit Weight of Water: 9.807 kN/m³

Slip Surface
Direction of movement: Left to Right
Use Passive Mode: No
Slip Surface Option: Grid and Radius
Critical slip surfaces saved: 1
Optimize Critical Slip Surface Location: No
Tension Crack Option: (none)

Distribution
ODF Calculation Option: Constant

Convergence
Geometry Settings
Minimum Slip Surface Depth: 0.5 m
Minimum Slip Surface Volume: 1 m³
Number of Columns: 30
Overdesign Factor Convergence Settings
Maximum Number of Iterations: 100
Tolerable difference in ODF: 0.001
Under-Relaxation Criteria
Initial Rate: 1
Minimum Rate: 0.1

Rate Reduction Factor: 0.65
Reduction Frequency (iterations): 50
Solution Settings
Search Method: Linear Search
Must Obtain at Lambda Overdesign Factor: 0.2
Lambda
Lambda 1: -1
Lambda 2: -0.8
Lambda 3: -0.6
Lambda 4: -0.4
Lambda 5: -0.2
Lambda 6: 0
Lambda 7: 0.2
Lambda 8: 0.4
Lambda 9: 0.6
Lambda 10: 0.8
Lambda 11: 1

Materials

Cohesive Till Undrained

Slope Stability Material Model: $S=f(\text{depth})$
Unit Weight: 21 kN/m³
C-Top of Layer: 40 kPa
C-Rate of Change: 3.5 (kN/m²)/m
C-Maximum: 110 kPa
Pore Water Pressure
Piezometric Surface: 1

Bedrock

Slope Stability Material Model: Bedrock (Impenetrable)
Pore Water Pressure
Piezometric Surface: 1

Reinforcements

Soil nail

Type: Nail
Pullout Resistance: 85 kPa
Pullout Resistance Reduction Factor: 1.5
Tensile Capacity: 770 kN
Tensile Capacity Reduction Factor: 1.5
Shear Force: 0 kN
Shear Force Reduction Factor: 1
Apply Shear: Parallel to Slip
F of S Dependent: No
Force Distribution: Distributed
Bond Diameter: 0.105 m
Out-of-Plane Spacing: 1.5 m
Face Anchorage: Yes
Factored Pullout Resistance: 12.462 kN/m/m
Factored Tensile Capacity: 342.22 kN/m

Slip Surface Grid

Upper Left: (-69.137299, 47.1568) m

Lower Left: (-86.193301, 20.8563) m
Lower Right: (19.295599, 12.901599) m
Grid Horizontal Increment: 25
Grid Vertical Increment: 20

Slip Surface Radius

Upper Left Coordinate: (-28.313271, 14.154946) m
Upper Right Coordinate: (2.2273992, 0.0332994) m
Lower Left Coordinate: (-27.756899, -35.798602) m
Lower Right Coordinate: (2.2273992, -35.798602) m
Number of Increments: 25
Use Left Projection: No
Left Projection Angle: 135 °
Use Right Projection: No
Right Projection Angle: 45 °

Slip Surface Limits

Left Coordinate: (-100.2138, 14.5) m
Right Coordinate: (105.0929, -0.063236856) m

Piezometric Surfaces

Piezometric Surface 1

Coordinates

	X	Y
Coordinate 1	-100.2138 m	9.6522997 m
Coordinate 2	-78.492099 m	9.5901998 m
Coordinate 3	-63.636412 m	9.2500003 m
Coordinate 4	-31.174999 m	9.2500003 m
Coordinate 5	-24.674999 m	7.7250006 m
Coordinate 6	0 m	-1.1279002 m
Coordinate 7	105.0929 m	-1.1104992 m

Reinforcement Sets

Reinforcement Sets

Reinforcement: Soil nail
Lock to Ground Surface: Yes
Range Start: (-1.9682045, 0.94160926) m
X: -1.9682045 m
Y: 0.94160926 m
Range End: (-28.313271, 14.154946) m
X: -28.313271 m
Y: 14.154946 m
Orientation Type: Absolute Angle
Orientation: -120 °
Length: 14 m
Spacing Type: Evenly
Distribution Type: Specify number of reinforcements
Number of Reinforcements: 11

Reinforcement Lines

Reinforcement Line 1

Reinforcement: Soil nail
Reinforcement Set: Soil nails
Lock to Ground Surface: No
Outside Point: (-1.9682033, 0.9416095) m
Inside Point: (-8.9682036, -11.182746) m
Length: 14 m
Orientation: -120 °
Slip Surface Intersection: (-6.0573695, -6.1410338) m
Max. Pullout Force: 53.176357 kN
Available Length: 5.8216681 m
Required Length: 5.8216681 m
Pullout Force: 20.102279 kN
Pullout Force per Length: 3.4530102 kN/m
Governing Component: Pullout Resistance

Reinforcement Line 2

Reinforcement: Soil nail
Reinforcement Set: Soil nails
Lock to Ground Surface: No
Outside Point: (-4.5921503, 2.281236) m
Inside Point: (-11.592151, -9.8431198) m
Length: 14 m
Orientation: -120 °
Slip Surface Intersection: (-9.5554621, -6.3154719) m
Max. Pullout Force: 53.176357 kN
Available Length: 4.0733769 m
Required Length: 4.0733769 m
Pullout Force: 14.065412 kN
Pullout Force per Length: 3.4530102 kN/m
Governing Component: Pullout Resistance

Reinforcement Line 3

Reinforcement: Soil nail
Reinforcement Set: Soil nails
Lock to Ground Surface: No
Outside Point: (-7.2222177, 3.6102554) m
Inside Point: (-14.222218, -8.5141003) m
Length: 14 m
Orientation: -120 °
Slip Surface Intersection: (-12.83403, -6.1096877) m
Max. Pullout Force: 53.176357 kN
Available Length: 2.7763766 m
Required Length: 2.7763766 m
Pullout Force: 9.5868565 kN
Pullout Force per Length: 3.4530102 kN/m
Governing Component: Pullout Resistance

Reinforcement Line 4

Reinforcement: Soil nail
Reinforcement Set: Soil nails
Lock to Ground Surface: No
Outside Point: (-9.8593778, 4.9269975) m
Inside Point: (-16.859378, -7.1973582) m
Length: 14 m
Orientation: -120 °

Slip Surface Intersection: (-15.923777, -5.576849) m
Max. Pullout Force: 53.176357 kN
Available Length: 1.8712028 m
Required Length: 1.8712028 m
Pullout Force: 6.4612824 kN
Pullout Force per Length: 3.4530102 kN/m
Governing Component: Pullout Resistance

Reinforcement Line 5

Reinforcement: Soil nail
Reinforcement Set: Soil nails
Lock to Ground Surface: No
Outside Point: (-12.496535, 6.2437366) m
Inside Point: (-19.496535, -5.8806192) m
Length: 14 m
Orientation: -120 °
Slip Surface Intersection: (-18.844812, -4.7518025) m
Max. Pullout Force: 53.176357 kN
Available Length: 1.3034453 m
Required Length: 1.3034453 m
Pullout Force: 4.5008098 kN
Pullout Force per Length: 3.4530102 kN/m
Governing Component: Pullout Resistance

Reinforcement Line 6

Reinforcement: Soil nail
Reinforcement Set: Soil nails
Lock to Ground Surface: No
Outside Point: (-15.133695, 7.5604787) m
Inside Point: (-22.133692, -4.5638771) m
Length: 13.999999 m
Orientation: -120 °
Slip Surface Intersection: (-21.610452, -3.6575979) m
Max. Pullout Force: 53.176351 kN
Available Length: 1.0464809 m
Required Length: 1.0464809 m
Pullout Force: 3.6135093 kN
Pullout Force per Length: 3.4530102 kN/m
Governing Component: Pullout Resistance

Reinforcement Line 7

Reinforcement: Soil nail
Reinforcement Set: Soil nails
Lock to Ground Surface: No
Outside Point: (-17.770852, 8.8772177) m
Inside Point: (-24.770852, -3.247138) m
Length: 14 m
Orientation: -120 °
Slip Surface Intersection: (-24.232368, -2.3144564) m
Max. Pullout Force: 53.176357 kN
Available Length: 1.0769679 m
Required Length: 1.0769679 m
Pullout Force: 3.7187813 kN
Pullout Force per Length: 3.4530102 kN/m
Governing Component: Pullout Resistance

Reinforcement Line 8

Reinforcement: Soil nail
Reinforcement Set: Soil nails

Lock to Ground Surface: No
Outside Point: (-20.408012, 10.19396) m
Inside Point: (-27.408009, -1.9303959) m
Length: 13.999999 m
Orientation: -120 °
Slip Surface Intersection: (-26.694138, -0.69393356) m
Max. Pullout Force: 53.176351 kN
Available Length: 1.4277436 m
Required Length: 1.4277436 m
Pullout Force: 4.9300132 kN
Pullout Force per Length: 3.4530102 kN/m
Governing Component: Pullout Resistance

Reinforcement Line 9

Reinforcement: Soil nail
Reinforcement Set: Soil nails
Lock to Ground Surface: No
Outside Point: (-23.045169, 11.510699) m
Inside Point: (-30.045169, -0.61365689) m
Length: 14 m
Orientation: -120 °
Slip Surface Intersection: (-29.02735, 1.1492582) m
Max. Pullout Force: 53.176357 kN
Available Length: 2.035639 m
Required Length: 2.035639 m
Pullout Force: 7.0290823 kN
Pullout Force per Length: 3.4530102 kN/m
Governing Component: Pullout Resistance

Reinforcement Line 10

Reinforcement: Soil nail
Reinforcement Set: Soil nails
Lock to Ground Surface: No
Outside Point: (-25.693829, 12.807519) m
Inside Point: (-32.693829, 0.68316348) m
Length: 14 m
Orientation: -120 °
Slip Surface Intersection: (-31.194991, 3.2792269) m
Max. Pullout Force: 53.176357 kN
Available Length: 2.9976759 m
Required Length: 2.9976759 m
Pullout Force: 10.351005 kN
Pullout Force per Length: 3.4530102 kN/m
Governing Component: Pullout Resistance

Reinforcement Line 11

Reinforcement: Soil nail
Reinforcement Set: Soil nails
Lock to Ground Surface: No
Outside Point: (-28.313271, 14.154946) m
Inside Point: (-35.313272, 2.0305898) m
Length: 14 m
Orientation: -120 °
Slip Surface Intersection: (-33.181037, 5.7237281) m
Max. Pullout Force: 53.176357 kN
Available Length: 4.2644688 m
Required Length: 4.2644688 m
Pullout Force: 14.725254 kN
Pullout Force per Length: 3.4530102 kN/m

Governing Component: Pullout Resistance

Design Factor Set: Eurocode 7 - DA1, C2

- Permanent Point Loads & Surcharge Loads: Favorable = 1, Unfavorable = 1
- Variable Point Loads & Surcharge Loads: Favorable = 0, Unfavorable = 1.3
- Soil Unit Weight: Favorable = 1, Unfavorable = 1
- Effective Cohesion: 1.4
- Effective Coefficient of Friction: 1.25
- Undrained Strength: 1.4
- Shear Strength (Other Models): 1.25
- Pullout Resistance: 1.1
- Shear Force: 1.1
- Tensile Strength: 1.1
- Compressive Strength: 1.1
- Seismic Coefficients: 1
- Earth Resistance: 1

Geometry

Name: 2D Geometry

Settings

- View: 2D
- Element Thickness: 0.3048 m

Points

	X	Y
Point 1	-6.0000002 m	3.0000001 m
Point 2	0 m	-0.063236856 m
Point 3	10 m	-0.063236856 m
Point 4	-29.000001 m	14.5 m
Point 5	37.399999 m	-0.063236856 m
Point 6	-63.724999 m	-70.361166 m
Point 7	-23.924999 m	11.950001 m
Point 8	-28.31321 m	14.154915 m
Point 9	-78.492099 m	14.5 m
Point 10	-78.492099 m	-0.063462408 m
Point 11	-25.694 m	12.807602 m
Point 12	-100.2138 m	14.5 m
Point 13	-100.2138 m	-0.15406726 m
Point 14	-99.984501 m	-70.427673 m
Point 15	105.0929 m	-0.063236856 m
Point 16	105.0929 m	-70.171693 m
Point 17	-46.704266 m	-70.361166 m
Point 18	-70.251261 m	-70.390561 m
Point 19	-100.13362 m	-25.469301 m
Point 20	105.0929 m	-25.473599 m

Regions

	Material	Points	Area
Region 1	Cohesiva Till Undrained	15,5,3,2,10,13,19,20	5,214.5 m²
Region 2	Cohesiva Till Undrained	2,1,7,11,8,4,9,12,13,10	1,249.8 m²
Region 3	Bedrock	14,18,6,17,16,20,19	9,196.4 m²

Slip Results

Slip Surfaces Analysed: 8208 of 14196 converged

Current Slip Surface

Slip Surface: 4,507
Overdesign Factor: 1.142
Degree of Utilization: 0.876
Volume: 132.61846 m³
Weight: 2,784.9877 kN
Resisting Moment: 26,280.386 kN·m
Activating Moment: 23,008.963 kN·m
Resisting Force: 736.87485 kN
Activating Force: 645.23796 kN
Slip Rank: 1 of 14,196 slip surfaces
Exit: (8.8842746, -0.063236856) m
Entry: (-37.659374, 14.5) m
Radius: 29.662345 m
Center: (-9.3440487, 23.337253) m

Slip Columns

	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength	Suction Strength	Base Material
Column 1	-119.92641 m	38.95998 m	-25.743376 kPa	-15.906131 kPa	0 kPa	35.133929 kPa	0 kPa	Cohesiva Till Undrained
Column 2	-113.96206 m	26.46308 m	11.612019 kPa	68.513388 kPa	0 kPa	44.656564 kPa	0 kPa	Cohesiva Till Undrained
Column 3	-109.28931 m	19.36652 m	32.824857 kPa	122.83057 kPa	0 kPa	50.06414 kPa	0 kPa	Cohesiva Till Undrained
Column 4	-104.61656 m	13.41823 m	50.605346 kPa	163.7686 kPa	0 kPa	54.596742 kPa	0 kPa	Cohesiva Till Undrained
Column 5	-98.71227 m	7.18216 m	66.743838 kPa	199.70169 kPa	0 kPa	59.348625 kPa	0 kPa	Cohesiva Till Undrained
Column 6	-94.01774 m	2.71591 m	76.801939 kPa	228.04021 kPa	0 kPa	62.320553 kPa	0 kPa	Cohesiva Till Undrained
Column 7	-91.67566 m	0.77078 m	80.973745 kPa	233.54288 kPa	0 kPa	62.894961 kPa	0 kPa	Cohesiva Till Undrained
Column 8	-87.37905 m	-2.42041 m	87.499534 kPa	237.51234 kPa	0 kPa	63.642507 kPa	0 kPa	Cohesiva Till Undrained
Column 9	-82.62631 m	-5.68923 m	93.937473 kPa	247.27955 kPa	0 kPa	64.308119 kPa	0 kPa	Cohesiva Till Undrained
Column 10	-79.72440 m	-7.46379 m	96.750198 kPa	257.75649 kPa	0 kPa	64.588336 kPa	0 kPa	Cohesiva Till Undrained
Column 11	-76.04371 m	-9.47482 m	98.814131 kPa	255.73982 kPa	0 kPa	64.733955 kPa	0 kPa	Cohesiva Till Undrained

Column 12	-71.14296 m	-11.88899 m	100.77464 kPa	263.80267 kPa	0 kPa	64.708963 kPa	0 kPa	Cohesiva Till Undrained
Column 13	-66.24220 m	-13.97365 m	101.75022 kPa	266.68369 kPa	0 kPa	64.432895 kPa	0 kPa	Cohesiva Till Undrained
Column 14	-61.34145 m	-15.75123 m	101.80787 kPa	272.18354 kPa	0 kPa	63.922827 kPa	0 kPa	Cohesiva Till Undrained
Column 15	-56.44070 m	-17.23925 m	100.99997 kPa	272.39765 kPa	0 kPa	63.192113 kPa	0 kPa	Cohesiva Till Undrained
Column 16	-51.53994 m	-18.45135 m	99.367311 kPa	273.84307 kPa	0 kPa	62.251152 kPa	0 kPa	Cohesiva Till Undrained
Column 17	-46.63919 m	-19.39803 m	96.941244 kPa	272.03593 kPa	0 kPa	61.107935 kPa	0 kPa	Cohesiva Till Undrained
Column 18	-41.73843 m	-20.08710 m	93.745149 kPa	270.87675 kPa	0 kPa	59.768423 kPa	0 kPa	Cohesiva Till Undrained
Column 19	-36.83768 m	-20.52406 m	89.795465 kPa	264.95214 kPa	0 kPa	58.236806 kPa	0 kPa	Cohesiva Till Undrained
Column 20	-31.93693 m	-20.71233 m	85.102374 kPa	263.13947 kPa	0 kPa	56.515679 kPa	0 kPa	Cohesiva Till Undrained
Column 21	-27.03617 m	-20.65334 m	79.670206 kPa	252.38422 kPa	0 kPa	54.606147 kPa	0 kPa	Cohesiva Till Undrained
Column 22	-22.13542 m	-20.34665 m	73.497608 kPa	248.04946 kPa	0 kPa	52.507865 kPa	0 kPa	Cohesiva Till Undrained
Column 23	-17.19770 m	-19.78375 m	66.519533 kPa	221.3027 kPa	0 kPa	50.178995 kPa	0 kPa	Cohesiva Till Undrained
Column 24	-12.22301 m	-18.95631 m	58.711034 kPa	201.47677 kPa	0 kPa	47.613176 kPa	0 kPa	Cohesiva Till Undrained
Column 25	-7.30175 m	-17.87443 m	50.199245 kPa	165.02257 kPa	0 kPa	44.874254 kPa	0 kPa	Cohesiva Till Undrained
Column 26	-2.43392 m	-16.53472 m	40.974085 kPa	140.09697 kPa	0 kPa	41.959658 kPa	0 kPa	Cohesiva Till Undrained
Column 27	2.43769 m	-14.91504 m	33.523547 kPa	121.09242 kPa	0 kPa	39.7786 kPa	0 kPa	Cohesiva Till Undrained
Column 28	7.31306 m	-12.99978 m	27.800913 kPa	108.13308 kPa	0 kPa	38.319172 kPa	0 kPa	Cohesiva Till Undrained
Column 29	12.18844 m	-10.77052 m	21.139659 kPa	92.597762 kPa	0 kPa	36.62047 kPa	0 kPa	Cohesiva Till Undrained
Column 30	17.06382 m	-8.20236 m	13.465407 kPa	74.524366 kPa	0 kPa	34.663535 kPa	0 kPa	Cohesiva Till Undrained
Column 31	21.93919 m	-5.26325 m	4.6822943 kPa	53.96625 kPa	0 kPa	32.423929 kPa	0 kPa	Cohesiva Till

								Undrained
Column 32	26.76238 m	-1.95195 m	-5.2133635 kPa	31.248803 kPa	0 kPa	29.90072 kPa	0 kPa	Cohesive Till Undrained

