**Geotechnical Planning Review Report (GPRR) for Small technical room in Tai O Pier within the RGC project No. C5032-22EF - Hong Kong Coastal HF-Radar Network**

## 1. Introduction

This document contains the geotechnical planning review for placing a small technical room atop the coastal defence wall adjacent to the Old Pier in Tai O. This installation will serve as server room to control and collect data from the new Radar network that will be deployed across Hong Kong waters to enhance the region's coastal resilience to flooding.

This report has been prepared to seek approval from the Town Planning Board under section 16 of the Town Planning Ordinance (cap. 131).

This report contains the following as listed.

(a) an outline of the topography and geology of the site;
(b) a general description of the proposed works and discussion of how the existing geotechnical features (such as slopes and retaining walls) and adjacent foundations will affect or be affected by such works.

## 2. Outline of the topography and geology of the site

The Tai O Pier is a significant feature of the Tai O fishing village on Lantau Island. The Tai O Pier has been a crucial part of the local community for many years, serving as a hub for transportation and trade. It has facilitated the movement of people and goods, connecting Tai O to other parts of Hong Kong and the mainland. The area of coastline behind Tai O Old Pier is not open to the public, with no designated entry points or infrastructure for public use.
The site is characterized by a gently sloping beach that reaches the base of the containment wall. This 2-meter-high vertical structure is built of squared rock; its schematic representation, along with the proposed installation, is shown in *Figure 1*.

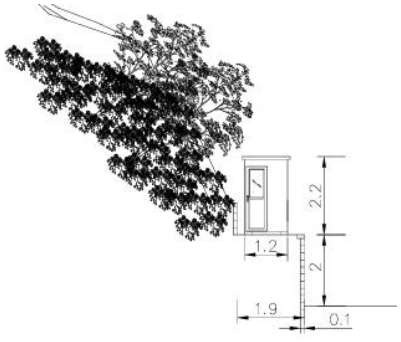


Figure 1 Schematic representation of the containment wall

The location site is shown in *Figure 2*.


Figure 2 Site layout

The ground investigation information belongs to previous works (LGL, 2001) and the results are summarized in *Table 1*.

Table 1 Nearby borehole information

| Borehole ID | Depth range | Soil type |
|---|---|---|
| DH/14/1 | 16.85 to 15.85 meters | Fill |
| | 15.85 to 12.95 meters | Colluvium |
| | 12.95 to 12.75 meters | Colluvium |
| | 12.75 to 10.55 meters | CDT |
| | 10.55 to 5.95 meters | CDT/HDT |
| | 5.95 to 5.83 meters | HDT/MDT |
| | 5.83 to 4.25 meters | CDT/HDT |
| | 4.25 to 4.10 meters | MDT |
| | 4.10 to -3.15 meters | CDT/HDT |
| | -3.15 to -3.58 meters | MDT |
| TP/14/1 | 10.14 to 9.44 meters | Colluvium |
| | 9.44 to 6.54 meters | CDT |

The soil parameters employed for analysis and design are based on Halcrow, 2004. The unit weight $\gamma$, the effective cohesion c' and the effective angle of friction $\varphi'$ for each type of soil in the area are listed in *Table 2*.

Table 2 Soil strength parameters

| Soil Type | $\gamma$ (kN/m$^3$) | $c'$ (kPa) | $\varphi'$ (degrees) |
|---|---|---|---|
| Fill | 17 | 0 | 28 |

| | | | |
|---|---|---|---|
| Colluvium | 18 | 6 | 28 |
| CDT | 19 | 6 | 35 |

The design groundwater table is assumed at the toe of the slope according to previous monitoring records (the highest monitored groundwater level: +2.23 mPD).

The slope ground profile was established using the 2020 LiDAR data and field observations (https://sdportal.cedd.gov.hk/#/en/lidar).

## 3. Proposed works

Within the framework of the RGC Project, the primary objective is to deploy a network of low-impact pole-mounted antennas at strategic locations throughout Hong Kong

The data gathered by this network is critical for ongoing hydrological studies and, crucially, for enhancing emergency response protocols during flood events. The system is intended to provide vital real-time information that can support early warning systems, thereby improving public safety and resilience.

The small technical cabin, which is the subject of this geotechnical assessment, is an essential component of this network. Its fundamental purpose is to house on-site server equipment dedicated to the continuous collection, processing, and storage of the radar data transmitted by the antennas.

Based on a comprehensive site evaluation, the optimal location for this cabin has been identified atop the existing beach containment wall, without any foundation works given the temporary nature of the project. Consequently, a detailed assessment of the wall's structural integrity and overall stability is a prerequisite for the safe and feasible installation of this critical infrastructure.

The components are as follows:

- Portable cabin
- Server rack
- AC unit

The embedment depth of the masonry wall is assumed as 0.5 m and its thickness is about 0.1 m. The surcharge load is around 4 kPa with a footprint of the portable cabin of 1.2 m by 1.2 m.

The slope stability is evaluated based on the Category 1 (High) ‘Consequence-to-Life’ requirement.

The geological model was constructed based on the nearby boreholes and information from Section A-A of the feature No. 9SW-C/C 15 (Halcrow, 2004).

In *Table 3* a summary of the stability analysis is provided.

Table 3 Summary of stability analysis with and without surcharge load

| Case | Critical FOS (Morgenstern-Price Method) | | Acceptable |
|---|---|---|---|
| | Calculated | Required | |
| Without surcharge load | 1.51 | 1.40 | Yes |
| With surcharge load | 1.46 | 1.40 | Yes |

*Figure 3* and *Figure 4* present the results of the stability analysis for both the unloaded condition and the condition with the cabin surcharge load applied.

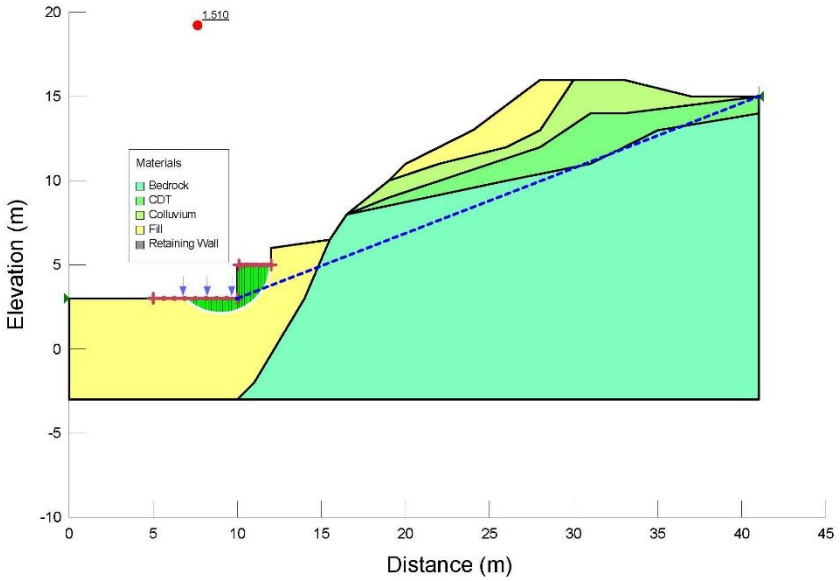


Figure 3 Slope stability analysis without surcharge load

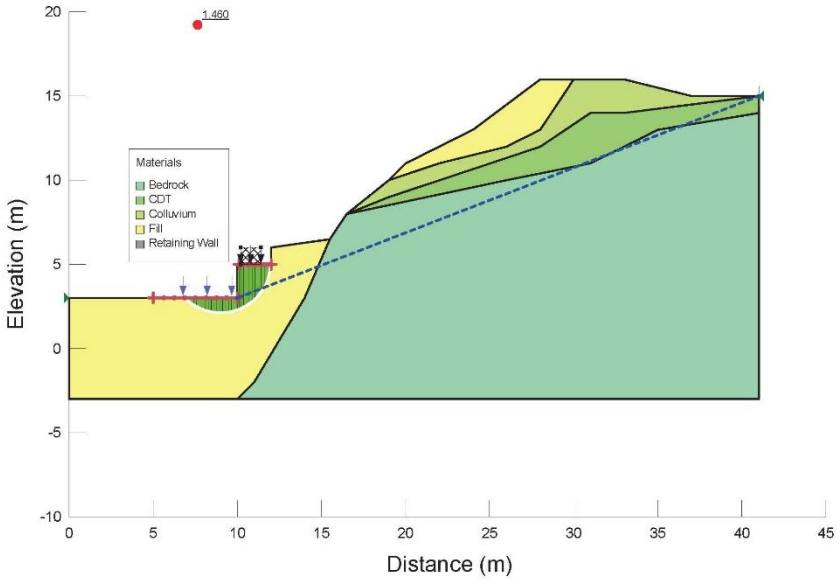


Figure 4 Slope stability analysis with surcharge load

## 4. Impact on adjacent premises/ geotechnical features

As the existing registered retaining walls and slope might be affected by the positioning of the

portable cabin, consideration shall be taken in the design of the proposed works.

Given the temporary nature of the proposed installation and the intrinsic characteristics of the structure, a lightweight, prefabricated outdoor cabin requiring no foundational excavation, its impact on adjacent structures is considered negligible. This assessment is based on the structure minimal weight and surface-mounted placement. The cabin will be positioned atop the existing wall as a fixed surface load.

Consequently, groundwater control measures are deemed unnecessary for this project, as no excavation or ground penetration works will be conducted.

## 5. Conclusion

Based on the available geotechnical information, the following conclusions and recommendations are drawn:

(a) The proposed installation as presented is considered as a geotechnical feasible scheme.
(b) No groundwater control scheme shall be considered in design.
(c) Stability of all slopes (man-made and natural terrains) and retaining walls within or in vicinity to the lot resulted not to be affected by the presence of the portable cabin.

Based on the current assessment, the proposed development is considered geotechnically feasible.

## References

De la Varga, M., Schaaf, A., & Wellmann, F. (2019). GemPy 1.0: open-source stochastic geological modelling and inversion. *Geoscientific Model Development*, 12(1), 1-32.

LGL (2001). Ground investigation fieldwork report. *Works Order No. GE 2001/08/GI/14 Feature No. 9SW-C/C15. Contract No. GE/2001/08*.

Halcrow China Ltd (2004). Feature No. 9SW-C/C 15 Tai O police station, Tai O, Lantau. *CED Contract No. GE/2002/17*.

**Retaining Wall Stability Analysis**

**Assumptions**

(1) The retaining wall is simplified as a rectangular gravity wall with 1.7 m width and 2.3 m height, with the embedment depth of 0.5 m and concrete unit weight of 24 kN/m$^3$. The wall width is estimated by based on site observations and estimates. The retaining wall geometry is shown in Table 1;

(2) The retained Fill is horizontal behind the wall based on the 2020 LiDAR data and field observations;

(3) The static groundwater table of +2.2 mPD for wall stability analysis is adopted based on the highest monitored groundwater level of +2.23 mPD (Halcrow, 2004);

(4) The Fill parameters are selected based on the nearby slope feature No. 9SW-C/C 15 ground investigation works (Halcrow, 2004), as shown in Table 1;

(5) The uniform surcharge load is around 4 kPa;

(6) The earth pressure is estimated using Rankine's theory, as shown in Fig. 1.

Table 1. Soil strength parameters

| Soil Type | $\gamma$ (kN/m$^3$) | $c'$ (kPa) | $\phi'$ (degrees) |
|---|---|---|---|
| Fill | 17 | 0 | 28 |

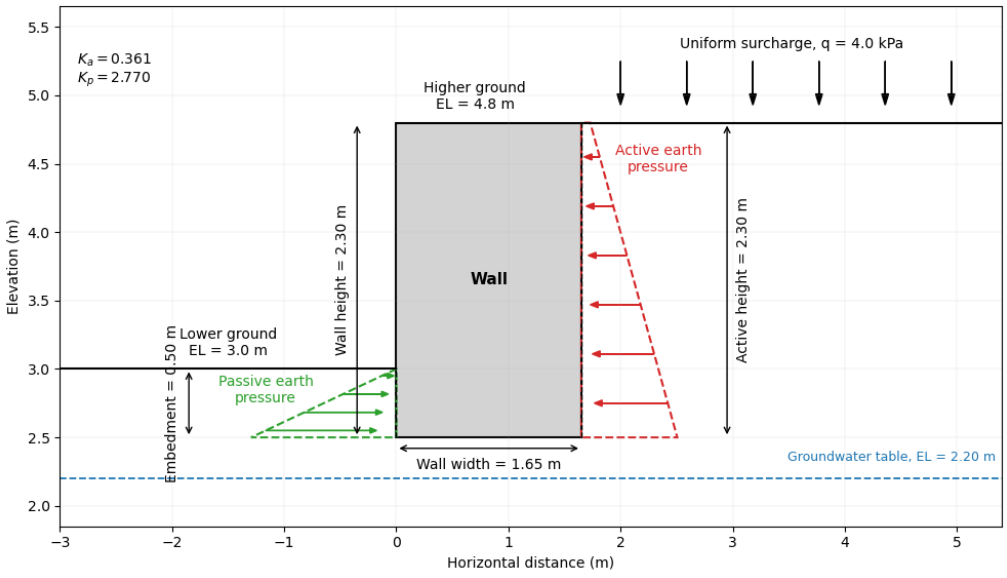


Figure 1. Retaining wall geometry and earth pressure.

**Ultimate Limit State (ULS) Approach**

The Hong Kong Geoguide 1 (GEO, 2020) adopts partial factors of material parameters and actions for ultimate limit state retaining wall design. The factors used below are shown in Table 2.

Table 2. Minimum partial load and material factors for use in design against ULSs

| | Type | Partial factor |
|---|---|---|
| Load | Dead load due to weight of the retaining wall | 1.0 |
| | Dead load due to weight of soil, rock and water | 1.0 |
| | Surcharge | 1.5 |
| Material | Unit weight | 1.0 |
| | Base friction angle | 1.2 |
| | Drained shear strength | 1.2 |

(1) Factored strength and surcharge:

The factored friction angle is obtained by factoring $\tan\phi'$:

$$\tan\phi'_f = \frac{\tan\phi'}{\gamma_m} = \frac{\tan 28°}{1.2} = 0.443$$

$$\phi'_f = 23.9°$$

The factored surcharge is: $q_f = \gamma_f q = 1.5 \times 4 = 6.0$ kPa

The ULS active and passive earth pressure coefficients are:

$$K_{a,f} = \tan^2\left(45° - \frac{\phi'_f}{2}\right) = 0.423$$

$$K_{p,f} = \tan^2\left(45° + \frac{\phi'_f}{2}\right) = 2.362$$

(2) ULS active and passive thrusts:

Wall height: $H_{wall} = 2.3$ m

Active height on the retained side: $H_a = 2.3$ m

Passive embedment height on the lower ground side: $H_p = 0.5$ m

ULS active thrust due to soil self-weight: $P_{a,soil,f} = \frac{1}{2}K_{a.f}\gamma_{soil}H_a^2 = 19.037$ kN/m

ULS active thrust due to surcharge: $P_{a,q,f} = K_{a,f}qH_a = 5.843$ kN/m

Total ULS active thrust: $P_{a,f} = P_{a,soil,f} + P_{a,q,f} = 24.880$ kN/m

The ULS passive thrust: $P_{p,soil,f} = \frac{1}{2}K_{p,f}\gamma_{soil}H_p^2 = 5.019$ kN/m

(3) ULS sliding check:

The angle of base shearing resistance is assumed as the lower bound of "rough concrete" case recommend in Geoguide 1 (GEO, 2020), which is $0.9\phi'$

The factored base friction angle is obtained by factoring $\tan(0.9\phi')$:

$$\tan\delta'_f = \frac{\tan(0.9\phi')}{\gamma_m} = \frac{\tan(0.9 \times 28°)}{1.2} = 0.392$$

$$\delta'_f = 21.4°$$

Wall self-weight: $W_{wall} = \gamma_c B H_{wall} = 93.84$ kN/m

The design sliding action is: $D_f = P_{a,f} = 24.880 \ \ \text{kN/m}$

The ULS sliding resistance is: $R_f = \tan(\delta_f') \times W_{wall} + P_{p,soil,f} = 40.735 \ \ \text{kN/m}$

The ULS sliding utilization is: $U_{sliding} = \frac{D_f}{R_f} = 0.61 < 1.0$

The ULS sliding check is satisfied.

(4) ULS overturning check:

The ULS overturning moment is:

$$M_{O,f} = P_{a,soil,f} \times H_a/3 + P_{a,q,f} \times H_a/2 = 21.314 \ \ \text{kN.m/m}$$

The resisting moment from wall self-weight: $M_{R1,f} = W_{wall} \times 0.5B = 75.141 \ \ \text{kN.m/m}$

The resisting moment from passive thrust: $M_{R2,f} = P_{p,soil,f} \times H_p/3 = 0.837 \ \ \text{kN.m/m}$

The total stabilizing moment is: $M_{R,f} = M_{R1,f} + M_{R2,f} = 75.978 \ \ \text{kN.m/m}$

The ULS overturning utilization is: $U_{overturning} = \frac{M_{O,f}}{M_{R,f}} = 0.28 < 1.0$

The ULS overturning moment check is satisfied.

The ULS eccentricity is: $e_f = 0.5B - (M_{R,f} - M_{O,f})/W_{wall} \approx 0.218 \ \ \text{m}$

Eccentricity check: $|e_f| \leq B/6 = 0.283 \ \ \text{m}$; Tension will not develop in the soil.

The base remains in compression under the ULS loading.

(5) ULS bearing capacity check:

The effective width is: $B_f' = B - 2e_f \approx 1.264 \ \ \text{m}$

The ULS applied bearing pressure is: $q_{applied,f} = W_{wall}/B_f' \approx 74.266 \ \ \text{kPa}$

The ultimate bearing capacity with $c' = 0$ is: $q_{ult} = q_0 N_q i_q + 0.5\gamma B' N_\gamma i_\gamma$

Using the factored friction angle $\phi_f' = 23.9°$, the bearing capacity factors are:

$$N_{q,f} = e^{\pi \tan \phi_f'} \tan^2\left(45° + \frac{\phi_f'}{2}\right) = 9.502$$

$$N_{\gamma,f} = 2(N_{q,f} + 1)\tan \phi_f' = 9.307$$

The net horizontal design load for bearing inclination factors is:

$$H_{net,f} = P_{a,f} - P_{p,soil,f} = 19.861 \ \ \text{kN/m}$$

The net vertical design load for bearing inclination factors is:

$$V_{net,f} = W_{wall} = 93.84 \ \ \text{kN/m}$$

For s strip footing with $c' = 0$, the inclination factors are taken as:

$$i_{q,f} = \left(1 - \frac{H_{net,f}}{V_{net,f}}\right)^2 = 0.611$$

$$i_{\gamma,f} = \left(1 - \frac{H_{net,f}}{V_{net,f}}\right)^3 = 0.478$$

The embedment depth: $D_f = 0.5 \ \ \text{m}$

The groundwater table is withing one range of wall width, therefore:

$$\gamma' = \frac{(EL_{wall\_base} - EL_{GWT}) \times \gamma + \left[B - (EL_{wall\_base} - EL_{GWT})\right] \times (\gamma - \gamma_w)}{B}$$

The overburden pressure at the base level is: $q_0 = \gamma D_f = 8.5$ kPa

The ULS bearing capacity is: $q_{ult,f} = q_0 N_{q,f} i_{q,f} + 0.5\gamma' B'_f N_{\gamma,f} i_{\gamma,f} = 75.897$ kPa

The ULS bearing utilization is: $U_{bearing} = \frac{q_{applied,f}}{q_{ult,f}} = 0.98 < 1.0$

The ULS bearing capacity check is satisfied.

**Summary**

ULS approach check:

| Check | Value | Requirement | Result |
|---|---|---|---|
| Sliding utilization | 0.61 | ≤ 1.0 | OK |
| Overturning utilization | 0.28 | ≤ 1.0 | OK |
| Eccentricity | 0.218 m | ≤ *B*/6 = 0.283 m | OK |
| Bearing utilization | 0.98 | ≤ 1.0 | OK |

Following the Geoguide 1 design philosophy, the relevant actions and material parameters are factored directly, and the design action is compared with the corresponding design resistance. Under this approach, the retaining wall satisfies the sliding and overturning stability checks. The ULS bearing utilization is approximately 1.0. The eccentricity also remains within the middle third of the base, and the minimum bearing pressure remains positive. Therefore, the wall satisfies the ULS bearing capacity requirement.

**References**

GEO (2020). *Guide to Retaining Wall Design (Geoguide 1) (Second Edition)*. Geotechnical Engineering Office, Civil Engineering and Development Department, HKSAR Government.

Halcrow China Ltd (2004). Feature No. 9SW-C/C 15 Tai O police station, Tai O, Lantau. *CED Contract No. GE/2002/17*.

# Slope Stability (2)



## File Information

File Version: 11.05
Product Version: 23.1.2.11
Revision Number: 42
Date: 04/01/2026
Time: 04:50:27 PM
File Name: With_loading111.gsz
Directory: C:\Users\Administrator\Desktop\20260401\
Last Solved Date: 2026/04/01
Last Solved Time: 16:50:26

## Project Settings

Unit System: International System of Units (SI)

## Analysis Settings

### Slope Stability (2)

Kind: SLOPE/W
Analysis Type: Morgenstern-Price
Settings
- Side Function
  - Intercolumn force function option: Half-Sine
- PWP Conditions from: Piezometric Surfaces
- Apply Phreatic Correction: Yes
- 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: Entry and Exit
- 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: 0.1 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

## Fill

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 17 kN/m³
Effective Cohesion: 0 kPa
Effective Friction Angle: 28 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Surface: 1

## Colluvium

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 18 kN/m³
Effective Cohesion: 6 kPa
Effective Friction Angle: 28 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Surface: 1

## CDT

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 19 kN/m³
Effective Cohesion: 6 kPa
Effective Friction Angle: 35 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Surface: 1

## Bedrock

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 19 kN/m³
Effective Cohesion: 40 kPa
Effective Friction Angle: 10 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Surface: 1

## Retaining Wall

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 24 kN/m³
Effective Cohesion: 500 kPa
Effective Friction Angle: 89 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Surface: 1

# Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (5, 3) m

Left-Zone Right Coordinate: (10, 3) m
Left-Zone Increment: 8
Right Type: Range
Right-Zone Left Coordinate: (10.1, 5) m
Right-Zone Right Coordinate: (12, 5) m
Right-Zone Increment: 8
Radius Increments: 4

# Slip Surface Limits

Left Coordinate: (0, 3) m
Right Coordinate: (41, 15) m

# Piezometric Surfaces

## Piezometric Surface 1

### Coordinates

| | X | Y |
|---|---|---|
| Coordinate 1 | 10 m | 3 m |
| Coordinate 2 | 41 m | 15 m |

# Surcharge Loads

## Surcharge Load 1

Surcharge (Unit Weight): 4 kN/m³
Direction: Vertical

### Coordinates

| | X | Y |
|---|---|---|
| | 10.2 m | 5 m |
| | 10.2 m | 6 m |
| | 11.4 m | 6 m |

# Geometry

Name: 2D Geometry

## Settings

View: 2D
Element Thickness: 1.2 m

## Points

| | X | Y |
|---|---|---|
| Point 1 | 10.000401 m | 5 m |
| Point 2 | 16 m | 5 m |
| Point 3 | 10.000401 m | 3 m |
| Point 4 | 16.5 m | 8 m |
| Point 5 | 16 m | 2 m |
| Point 6 | 17 m | -2 m |
| Point 7 | 18 m | -8 m |

| | | |
|---|---|---|
| Point 8 | 19 m | 10 m |
| Point 9 | 22 m | 11 m |
| Point 10 | 26 m | 12 m |
| Point 11 | 28 m | 13 m |
| Point 12 | 30 m | 16 m |
| Point 13 | 33 m | 16 m |
| Point 14 | 37 m | 15 m |
| Point 15 | 41 m | 15 m |
| Point 16 | 33 m | 14 m |
| Point 17 | 31 m | 14 m |
| Point 18 | 28 m | 12 m |
| Point 19 | 19 m | 9 m |
| Point 20 | 20 m | -8 m |
| Point 21 | 22 m | -8 m |
| Point 22 | 26 m | 10 m |
| Point 23 | 31 m | 11 m |
| Point 24 | 35 m | 13 m |
| Point 25 | 41 m | 14 m |
| Point 26 | 41 m | -8 m |
| Point 27 | 20 m | 11 m |
| Point 28 | 24 m | 13 m |
| Point 29 | 28 m | 16 m |
| Point 30 | 10.100401 m | 5 m |
| Point 31 | 10.100401 m | 3 m |
| Point 32 | 10.100401 m | 2.5 m |
| Point 33 | 10.000267 m | 2.5 m |
| Point 34 | 0 m | -8 m |
| Point 35 | 0 m | 3 m |
| Point 36 | 12 m | 5 m |
| Point 37 | 12 m | 6 m |
| Point 38 | 15.5 m | 6.5 m |

### Regions

| | Material | Points | Area |
|---|---|---|---|
| Region 1 | Bedrock | 21,26,25,24,23,22,4,2,5,6,7,20 | 459.25 m² |
| Region 2 | Fill | 8,27,28,29,12,11,10,9 | 17 m² |
| Region 3 | Retaining Wall | 30,1,3,33,32,31 | 0.25003 m² |
| Region 4 | Fill | 34,35,3,33,32,31,30,36,37,38,4,2,5,6,7 | 204.62 m² |
| Region 5 | Colluvium | 8,9,10,11,12,13,14,15,16,17,18,19,4 | 25.25 m² |
| Region 6 | CDT | 23,24,25,15,16,17,18,19,4,22 | 31.75 m² |

## Slip Results

Slip Surfaces Analysed: 20 of 405 converged

## Current Slip Surface

Slip Surface: 180
Factor of Safety: 1.460
Volume: 5.9083281 m³
Weight: 102.19181 kN
Resisting Moment: 172.47679 kN·m
Activating Moment: 118.15698 kN·m

Resisting Force: 47.829736 kN
Activating Force: 32.76554 kN
Slip Rank: 1 of 405 slip surfaces
Exit: (12, 5) m
Entry: (6.875, 3) m
Radius: 3.0117139 m
Center: (8.9916578, 5.1424707) m

## Slip Columns

| | X | Y | PWP | Base Normal Stress | Frictional Strength | Cohesive Strength | Suction Strength | Column Base Material |
|---|---|---|---|---|---|---|---|---|
| Column 1 | 11.896712 m | 4.518847 m | -6.6921468 kPa | 2.8277952 kPa | 1.5035654 kPa | 0 kPa | 0 kPa | Fill |
| Column 2 | 11.690135 m | 3.825978 m | -1.4647051 kPa | 10.223339 kPa | 5.4358457 kPa | 0 kPa | 0 kPa | Fill |
| Column 3 | 11.493423 m | 3.474167 m | 0.88643549 kPa | 14.82439 kPa | 7.4109421 kPa | 0 kPa | 0 kPa | Fill |
| Column 4 | 11.314286 m | 3.229976 m | 2.3777117 kPa | 20.941087 kPa | 9.8703217 kPa | 0 kPa | 0 kPa | Fill |
| Column 5 | 11.142857 m | 3.038252 m | 3.4469409 kPa | 23.96851 kPa | 10.911512 kPa | 0 kPa | 0 kPa | Fill |
| Column 6 | 10.971429 m | 2.875760 m | 4.2668526 kPa | 26.756028 kPa | 11.957707 kPa | 0 kPa | 0 kPa | Fill |
| Column 7 | 10.800000 m | 2.736474 m | 4.8888463 kPa | 29.440206 kPa | 13.05419 kPa | 0 kPa | 0 kPa | Fill |
| Column 8 | 10.628571 m | 2.616505 m | 5.3460771 kPa | 32.110633 kPa | 14.230967 kPa | 0 kPa | 0 kPa | Fill |
| Column 9 | 10.457143 m | 2.513185 m | 5.6613166 kPa | 34.828122 kPa | 15.508266 kPa | 0 kPa | 0 kPa | Fill |
| Column 10 | 10.285714 m | 2.424599 m | 5.850883 kPa | 37.632823 kPa | 16.898757 kPa | 0 kPa | 0 kPa | Fill |
| Column 11 | 10.150201 m | 2.363030 m | 5.9285974 kPa | 36.519948 kPa | 16.26571 kPa | 0 kPa | 0 kPa | Fill |
| Column 12 | 10.050401 m | 2.323494 m | 5.936312 kPa | 53.514434 kPa | 25.297736 kPa | 0 kPa | 0 kPa | Fill |
| Column 13 | 10.000334 m | 2.304691 m | 6.8201627 kPa | 10.396203 kPa | 1.9014144 kPa | 0 kPa | 0 kPa | Fill |
| Column 14 | 10.000134 m | 2.304620 m | 6.8201004 kPa | 8.8438363 kPa | 1.0760394 kPa | 0 kPa | 0 kPa | Fill |
| Column 15 | 9.913194 m | 2.276659 m | 0 kPa | 9.6919587 kPa | 5.1533059 kPa | 0 kPa | 0 kPa | Fill |
| Column 16 | 9.739583 m | 2.226481 m | 0 kPa | 11.488014 kPa | 6.1082855 kPa | 0 kPa | 0 kPa | Fill |
| Column 17 | 9.565972 m | 2.187346 m | 0 kPa | 13.251989 kPa | 7.0462073 kPa | 0 kPa | 0 kPa | Fill |
| Column 18 | 9.392361 m | 2.158817 m | 0 kPa | 14.956042 kPa | 7.9522686 kPa | 0 kPa | 0 kPa | Fill |
| Column 19 | 9.218750 m | 2.140593 m | 0 kPa | 16.560309 kPa | 8.8052726 kPa | 0 kPa | 0 kPa | Fill |
| Column 20 | 9.045139 m | 2.132483 m | 0 kPa | 18.012649 kPa | 9.5774953 kPa | 0 kPa | 0 kPa | Fill |
| Column 21 | 8.871528 m | 2.134408 m | 0 kPa | 19.249434 kPa | 10.235106 kPa | 0 kPa | 0 kPa | Fill |
| Column 22 | 8.697917 m | 2.146385 m | 0 kPa | 20.197816 kPa | 10.739369 kPa | 0 kPa | 0 kPa | Fill |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Column 23 | 8.524306 m | 2.168537 m | 0 kPa | 20.779791 kPa | 11.048811 kPa | 0 kPa | 0 kPa | Fill |
| Column 24 | 8.350694 m | 2.201094 m | 0 kPa | 20.91815 kPa | 11.122378 kPa | 0 kPa | 0 kPa | Fill |
| Column 25 | 8.177083 m | 2.244409 m | 0 kPa | 20.543915 kPa | 10.923393 kPa | 0 kPa | 0 kPa | Fill |
| Column 26 | 8.003472 m | 2.298975 m | 0 kPa | 19.604349 kPa | 10.423817 kPa | 0 kPa | 0 kPa | Fill |
| Column 27 | 7.829861 m | 2.365459 m | 0 kPa | 18.070017 kPa | 9.6079987 kPa | 0 kPa | 0 kPa | Fill |
| Column 28 | 7.656250 m | 2.444745 m | 0 kPa | 15.939066 kPa | 8.4749519 kPa | 0 kPa | 0 kPa | Fill |
| Column 29 | 7.482639 m | 2.538010 m | 0 kPa | 13.236877 kPa | 7.0381722 kPa | 0 kPa | 0 kPa | Fill |
| Column 30 | 7.309028 m | 2.646831 m | 0 kPa | 10.009679 kPa | 5.3222407 kPa | 0 kPa | 0 kPa | Fill |
| Column 31 | 7.135417 m | 2.773372 m | 0 kPa | 6.3111603 kPa | 3.3557034 kPa | 0 kPa | 0 kPa | Fill |
| Column 32 | 6.961806 m | 2.920693 m | 0 kPa | 2.1806878 kPa | 1.1594923 kPa | 0 kPa | 0 kPa | Fill |

# Slope Stability



## File Information

File Version: 11.05
Product Version: 23.1.2.11
Revision Number: 42
Date: 04/01/2026
Time: 04:50:27 PM
File Name: With_loading111.gsz
Directory: C:\Users\Administrator\Desktop\20260401\
Last Solved Date: 2026/04/01
Last Solved Time: 16:50:26

## Project Settings

Unit System: International System of Units (SI)

## Analysis Settings

### Slope Stability

Kind: SLOPE/W
Analysis Type: Morgenstern-Price
Settings
- Side Function
  - Intercolumn force function option: Half-Sine
- PWP Conditions from: Piezometric Surfaces
- Apply Phreatic Correction: Yes
- 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: Entry and Exit
- 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: 0.1 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

## Fill

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 17 kN/m³
Effective Cohesion: 0 kPa
Effective Friction Angle: 28 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Surface: 1

## Colluvium

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 18 kN/m³
Effective Cohesion: 6 kPa
Effective Friction Angle: 28 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Surface: 1

## CDT

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 19 kN/m³
Effective Cohesion: 6 kPa
Effective Friction Angle: 35 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Surface: 1

## Bedrock

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 19 kN/m³
Effective Cohesion: 40 kPa
Effective Friction Angle: 10 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Surface: 1

## Retaining Wall

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 24 kN/m³
Effective Cohesion: 500 kPa
Effective Friction Angle: 89 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Surface: 1

# Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (5, 3) m

Left-Zone Right Coordinate: (10, 3) m
Left-Zone Increment: 8
Right Type: Range
Right-Zone Left Coordinate: (10.1, 5) m
Right-Zone Right Coordinate: (12, 5) m
Right-Zone Increment: 8
Radius Increments: 4

# Slip Surface Limits

Left Coordinate: (0, 3) m
Right Coordinate: (41, 15) m

# Piezometric Surfaces

## Piezometric Surface 1

### Coordinates

| | X | Y |
|---|---|---|
| Coordinate 1 | 10 m | 3 m |
| Coordinate 2 | 41 m | 15 m |

# Geometry

Name: 2D Geometry

## Settings

View: 2D
Element Thickness: 1.2 m

## Points

| | X | Y |
|---|---|---|
| Point 1 | 10.000401 m | 5 m |
| Point 2 | 16 m | 5 m |
| Point 3 | 10.000401 m | 3 m |
| Point 4 | 16.5 m | 8 m |
| Point 5 | 16 m | 2 m |
| Point 6 | 17 m | -2 m |
| Point 7 | 18 m | -8 m |
| Point 8 | 19 m | 10 m |
| Point 9 | 22 m | 11 m |
| Point 10 | 26 m | 12 m |
| Point 11 | 28 m | 13 m |
| Point 12 | 30 m | 16 m |
| Point 13 | 33 m | 16 m |
| Point 14 | 37 m | 15 m |
| Point 15 | 41 m | 15 m |
| Point 16 | 33 m | 14 m |
| Point 17 | 31 m | 14 m |
| Point 18 | 28 m | 12 m |
| Point 19 | 19 m | 9 m |
| Point 20 | 20 m | -8 m |

| | | |
|---|---|---|
| Point 21 | 22 m | -8 m |
| Point 22 | 26 m | 10 m |
| Point 23 | 31 m | 11 m |
| Point 24 | 35 m | 13 m |
| Point 25 | 41 m | 14 m |
| Point 26 | 41 m | -8 m |
| Point 27 | 20 m | 11 m |
| Point 28 | 24 m | 13 m |
| Point 29 | 28 m | 16 m |
| Point 30 | 10.100401 m | 5 m |
| Point 31 | 10.100401 m | 3 m |
| Point 32 | 10.100401 m | 2.5 m |
| Point 33 | 10.000267 m | 2.5 m |
| Point 34 | 0 m | -8 m |
| Point 35 | 0 m | 3 m |
| Point 36 | 12 m | 5 m |
| Point 37 | 12 m | 6 m |
| Point 38 | 15.5 m | 6.5 m |

### Regions

| | Material | Points | Area |
|---|---|---|---|
| Region 1 | Bedrock | 21,26,25,24,23,22,4,2,5,6,7,20 | 459.25 m² |
| Region 2 | Fill | 8,27,28,29,12,11,10,9 | 17 m² |
| Region 3 | Retaining Wall | 30,1,3,33,32,31 | 0.25003 m² |
| Region 4 | Fill | 34,35,3,33,32,31,30,36,37,38,4,2,5,6,7 | 204.62 m² |
| Region 5 | Colluvium | 8,9,10,11,12,13,14,15,16,17,18,19,4 | 25.25 m² |
| Region 6 | CDT | 23,24,25,15,16,17,18,19,4,22 | 31.75 m² |

## Slip Results

Slip Surfaces Analysed: 18 of 405 converged

## Current Slip Surface

Slip Surface: 180
Factor of Safety: 1.510
Volume: 5.9086539 m³
Weight: 102.19735 kN
Resisting Moment: 165.27553 kN·m
Activating Moment: 109.48579 kN·m
Resisting Force: 45.900215 kN
Activating Force: 30.405609 kN
Slip Rank: 1 of 405 slip surfaces
Exit: (12, 5) m
Entry: (6.875, 3) m
Radius: 3.0117139 m
Center: (8.9916578, 5.1424707) m

### Slip Columns

| | X | Y | PWP | Base Normal Stress | Frictional Strength | Cohesive Strength | Suction Strength | Column Base Material |
|---|---|---|---|---|---|---|---|---|
| Column 1 | 11.896712 m | 4.518847 m | -6.6921468 kPa | 2.880926 kPa | 1.5318155 kPa | 0 kPa | 0 kPa | Fill |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Column 2 | 11.690135 m | 3.825978 m | -1.4647051 kPa | 10.333085 kPa | 5.4941986 kPa | 0 kPa | 0 kPa | Fill |
| Column 3 | 11.504266 m | 3.488790 m | 0.79751296 kPa | 14.714483 kPa | 7.3997844 kPa | 0 kPa | 0 kPa | Fill |
| Column 4 | 11.339105 m | 3.260322 m | 2.2008307 kPa | 18.03951 kPa | 8.4215752 kPa | 0 kPa | 0 kPa | Fill |
| Column 5 | 11.173945 m | 3.070355 m | 3.2757671 kPa | 20.902151 kPa | 9.3721144 kPa | 0 kPa | 0 kPa | Fill |
| Column 6 | 11.008784 m | 2.908810 m | 4.1083039 kPa | 23.513098 kPa | 10.317712 kPa | 0 kPa | 0 kPa | Fill |
| Column 7 | 10.843624 m | 2.769778 m | 4.7488166 kPa | 25.999819 kPa | 11.299359 kPa | 0 kPa | 0 kPa | Fill |
| Column 8 | 10.678463 m | 2.649447 m | 5.2298359 kPa | 28.446695 kPa | 12.344623 kPa | 0 kPa | 0 kPa | Fill |
| Column 9 | 10.513302 m | 2.545192 m | 5.5737425 kPa | 30.911978 kPa | 13.472579 kPa | 0 kPa | 0 kPa | Fill |
| Column 10 | 10.348142 m | 2.455127 m | 5.796616 kPa | 33.435619 kPa | 14.695919 kPa | 0 kPa | 0 kPa | Fill |
| Column 11 | 10.182981 m | 2.377858 m | 5.9103596 kPa | 36.04279 kPa | 16.021698 kPa | 0 kPa | 0 kPa | Fill |
| Column 12 | 10.050401 m | 2.323494 m | 5.936312 kPa | 53.563939 kPa | 25.324058 kPa | 0 kPa | 0 kPa | Fill |
| Column 13 | 10.000334 m | 2.304691 m | 6.8201627 kPa | 10.423502 kPa | 1.9159292 kPa | 0 kPa | 0 kPa | Fill |
| Column 14 | 10.000134 m | 2.304620 m | 6.8201004 kPa | 8.8708491 kPa | 1.0904024 kPa | 0 kPa | 0 kPa | Fill |
| Column 15 | 9.913194 m | 2.276659 m | 0 kPa | 9.7201124 kPa | 5.1682754 kPa | 0 kPa | 0 kPa | Fill |
| Column 16 | 9.739583 m | 2.226481 m | 0 kPa | 11.498356 kPa | 6.1137846 kPa | 0 kPa | 0 kPa | Fill |
| Column 17 | 9.565972 m | 2.187346 m | 0 kPa | 13.242358 kPa | 7.0410869 kPa | 0 kPa | 0 kPa | Fill |
| Column 18 | 9.392361 m | 2.158817 m | 0 kPa | 14.924701 kPa | 7.9356043 kPa | 0 kPa | 0 kPa | Fill |
| Column 19 | 9.218750 m | 2.140593 m | 0 kPa | 16.506023 kPa | 8.776408 kPa | 0 kPa | 0 kPa | Fill |
| Column 20 | 9.045139 m | 2.132483 m | 0 kPa | 17.934791 kPa | 9.5360976 kPa | 0 kPa | 0 kPa | Fill |
| Column 21 | 8.871528 m | 2.134408 m | 0 kPa | 19.148108 kPa | 10.18123 kPa | 0 kPa | 0 kPa | Fill |
| Column 22 | 8.697917 m | 2.146385 m | 0 kPa | 20.073977 kPa | 10.673523 kPa | 0 kPa | 0 kPa | Fill |
| Column 23 | 8.524306 m | 2.168537 m | 0 kPa | 20.635366 kPa | 10.972019 kPa | 0 kPa | 0 kPa | Fill |
| Column 24 | 8.350694 m | 2.201094 m | 0 kPa | 20.756137 kPa | 11.036234 kPa | 0 kPa | 0 kPa | Fill |
| Column 25 | 8.177083 m | 2.244409 m | 0 kPa | 20.368462 kPa | 10.830104 kPa | 0 kPa | 0 kPa | Fill |
| Column 26 | 8.003472 m | 2.298975 m | 0 kPa | 19.42081 kPa | 10.326228 kPa | 0 kPa | 0 kPa | Fill |
| Column 27 | 7.829861 m | 2.365459 m | 0 kPa | 17.884989 kPa | 9.5096174 kPa | 0 kPa | 0 kPa | Fill |
| Column 28 | 7.656250 m | 2.444745 m | 0 kPa | 15.760442 kPa | 8.3799754 kPa | 0 kPa | 0 kPa | Fill |
| Column 29 | 7.482639 m | 2.538010 m | 0 kPa | 13.073966 kPa | 6.9515508 kPa | 0 kPa | 0 kPa | Fill |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Column 30 | 7.309028 m | 2.646831 m | 0 kPa | 9.8735216 kPa | 5.2498445 kPa | 0 kPa | 0 kPa | Fill |
| Column 31 | 7.135417 m | 2.773372 m | 0 kPa | 6.2152777 kPa | 3.3047218 kPa | 0 kPa | 0 kPa | Fill |
| Column 32 | 6.961806 m | 2.920693 m | 0 kPa | 2.1428189 kPa | 1.139357 kPa | 0 kPa | 0 kPa | Fill |