Tunnel Stability in Cohesive Soil

Keywords

2D, Plane Strain, Phi-c reduction, Settlement

Problem Description

A stability analysis of circular excavation in cohesive soil is considered in this example. The excavation has 5m as diameter, located at a depth of 5m. The stability of the circular is affected by some parameters such as the ground surcharge, internal pressure, diameter, and excavation depth.

Discretisation

The model shown in Figure 1 is a half-symmetry. It uses quadratic triangular elements, TPN6. Fixed supports restrain the model at the left, right and bottom sides of the model.

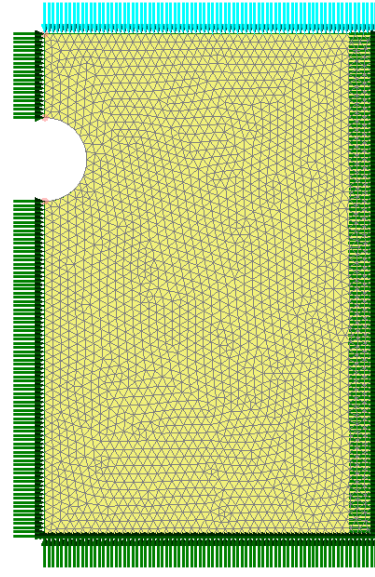

Figure 1: Finite element mesh showing supports.

Material Properties

Modified Mohr-Coulomb is used and the following properties are assigned to the model. Table 1 gives the material properties for this example.

Table 1: material properties

Mass Density	Young's modulus, E	Poisson's ratio, ν	Angle of friction, φ	Cohesion, c
2.7 t/m^3	20E3 kPa	0.3	0°	10 kPa

Loading Conditions

A distribution load of 20 kPa is applied on the ground surface.

Theory

The calculation of the maximum settlement in a homogeneous body is given by the equation 1 [1]. The safety factor has been calculated using Phi-c reduction approach as stability indicator of the tunnel.

$$S_{max} = (1 - v^2)\frac{p}{E}\frac{4\,r^2 Z}{Z^2 - r^2} \qquad (1)$$

Comparison

The maximum settlement is calculated using equation 1 is equal to 27.7 mm (Figure 2) at the ground surface, which is the same the value obtained from LUSAS, 27.7 mm (Figure 3). Phi-c reduction analysis is used to assess soil stability and safety factor for soil, which is found to be 1.22. RS2 [2] also calculate a factor of safety of 1.22. Figure 5 shows the plot of maximum shear strain at failure.

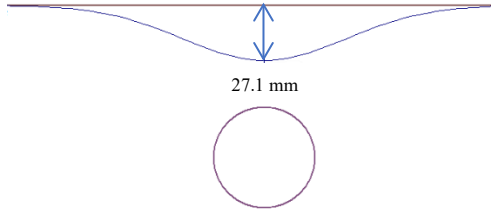

Figure 2: Maximum Settlement using analytical approach

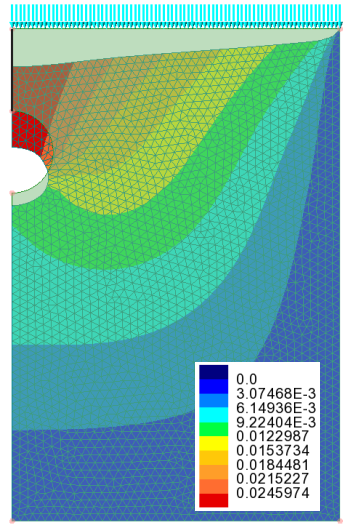

Figure 3: Displacement contours (m)

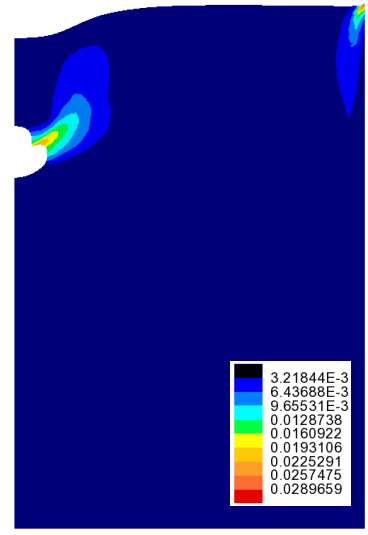

Figure 4: Maximum Shear Strain

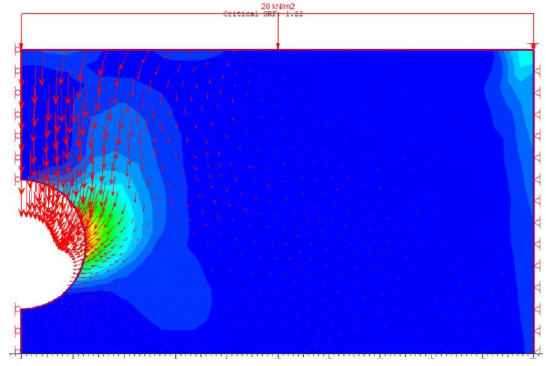

Figure 5: Maximum Shear Strain in RS2 [2]

References

[1] Geo5 manual, Fine, 2022.

[2] RS2, Stress Analysis Verification Manual, Rocscience, 2022

Input Data

Tunnel_Stability.lvb