STRIP LOAD ON ELASTIC GIBSON SOIL

This document describes an example that is used to verify that the deformations on an elastic Gibson soil under a strip load are correctly calculated in PLAXIS.

Used version:

- PLAXIS 2D - Version 2018.0
- PLAXIS 3D - Version 2018.0

Geometry: 'Gibson soil' is an elastic non-homogeneous half-space of an incompressible medium, in which the shear modulus increases linearly with depth. Using *y* to denote depth, the shear modulus *G* is assumed equal to zero at the soil surface (y = 0) and varies linearly with depth:

$G_{(y)} = \alpha \cdot y$

where α is selected equal to 100. To simulate an incompressible medium a Poisson's ratio of 0.499 is used. Thus, the Young's modulus varies as:

$E_{(y)} = 299.8 \cdot y$

Due to the symmetry of the problem, it is sufficient to consider half model to save calculation time, without compromising on accuracy. In PLAXIS 2D a *Plane strain* model is used with 15-noded triangular elements. Figure 1 depicts the model geometry. Depth equals 30m and the right model boundary is placed 30m away from the plane of symmetry (left boundary). A vertical load with length equal to 1m is applied to the soil surface. Geometry lines are used for local mesh refinement in an area 2m $\times$ 2m, in the vicinity of the load. As depicted in Figure 1, a point (*A*) is selected as a reference point for the results.

Figure 2 illustrates the model geometry in PLAXIS 3D. The model is extended by 1m in the y-direction. In order to minimize the number of mesh elements, two mesh refinement zones are created by using geometry surfaces. The point *A* is selected to be at y = 0.5m.

Materials: *Linear elastic* soil material model is used with *Undrained C* option as drainage type to model an incompressible medium. Zero unit weight γ is selected. The variation of the shear modulus *G* with depth is achieved in PLAXIS by varying the Young's modulus in the *Material properties* window. A very small value is selected as reference value at the soil surface, i.e. 0.001kN/m^2. The increment of Young's modulus E_{inc} per unit depth is set equal to 299.8 kN/m^2/m. The reference depth (y_{ref} in PLAXIS 2D and z_{ref} in PLAXIS 3D) is set at the soil surface (model's top boundary). The adopted soil material properties are listed below.

Soil: Linear elastic (Undrained C) E_u=0.001 kN/m^2 E_{inc}=299.8 kN/m^2/m ν_u=0.499

Meshing: In PLAXIS 2D the *Very fine* option is used for the *Element distribution*. An area 2m $\times$ 2m around the load is refined with a *Coarseness factor* of 0.03125.

In PLAXIS 3D the *Element distribution* is set to *Medium*. To avoid generation of excess number of mesh elements, three mesh zones are used. The *Coarseness factor* for a volume 2 m $\times$ 2 m $\times$ 1 m around the load (first refinement zone in Figure 2) is set equal to 0.05. A second refinement zone 15 m $\times$ 15m $\times$ 1m is defined, in which the *Coarseness factor* equals 1.0. For the rest of the model a *Coarseness factor* of 8.0 is used.

Calculations: In the Initial phase zero initial stresses are generated by using the *K0*

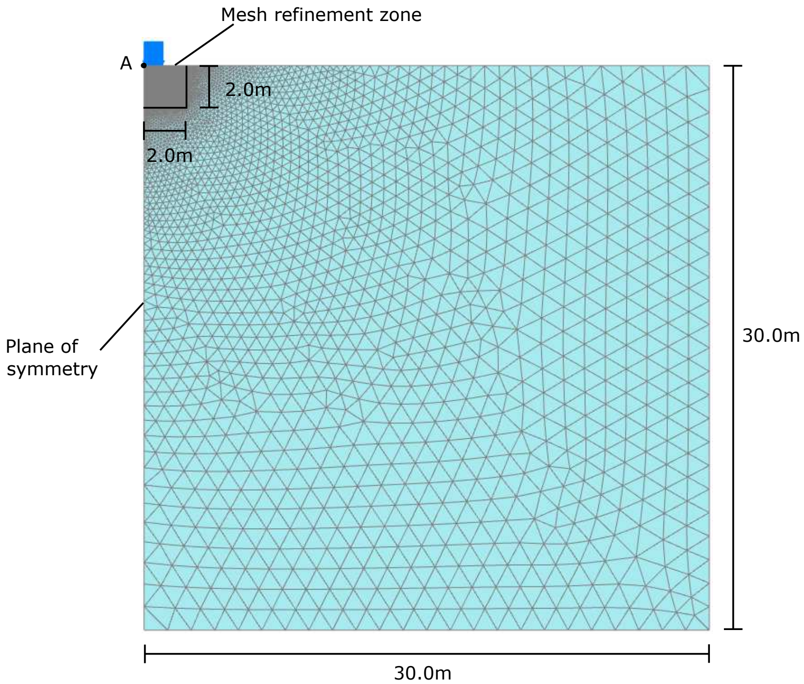

Figure 1 Model geometry (PLAXIS 2D)

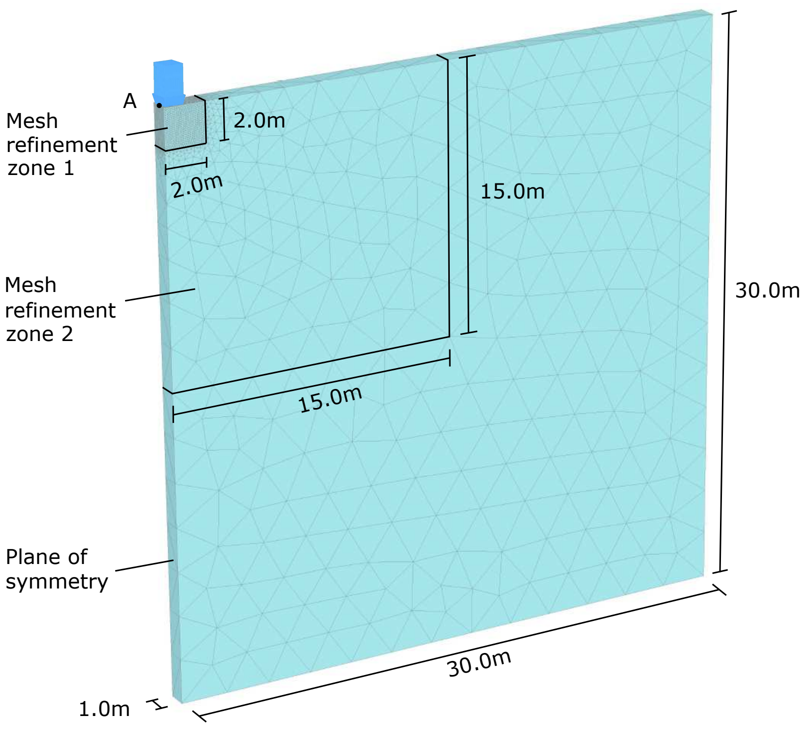

Figure 2 Model geometry (PLAXIS 3D)

procedure (unit weight γ equals zero). The load is activated in Phase 1, in which a *Plastic analysis* is performed.

Output: PLAXIS results indicate an almost uniform settlement of the soil surface underneath the strip load as can be seen from the vertical displacements distribution plots in Figures 3 and 4. The computed settlement at point A is 0.04965m and 0.04950m in PLAXIS 2D and PLAXIS 3D respectively.

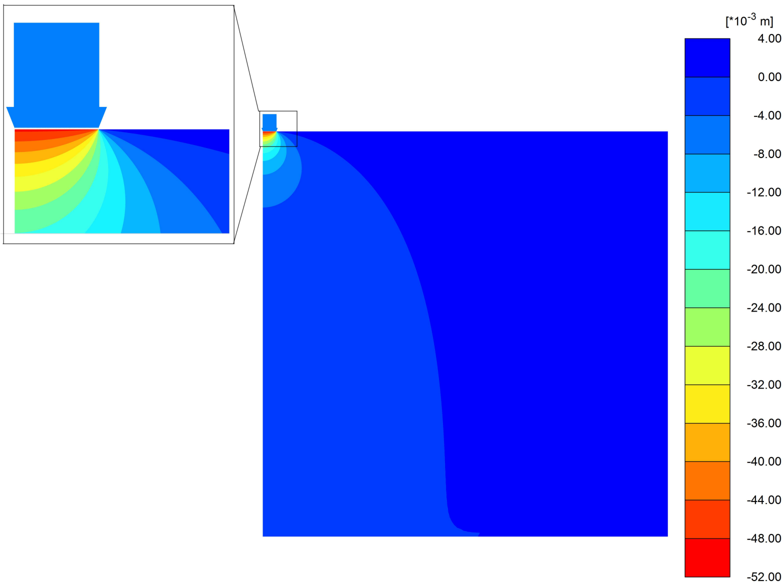

Figure 3 Vertical displacements distribution (PLAXIS 2D)

Verification: An exact solution for this problem is only available for the case of a Poisson's ratio equal to 0.5. In PLAXIS calculation a value of 0.499 is used for the Poisson's ratio in order to approximate the incompressible condition. In addition, the analytic solution is exact only for an infinite half-space, whereas the PLAXIS solution is obtained for a medium of finite depth (30 m). However, the effect of a shear modulus that increases linearly with depth is to localize the deformations near the surface. Thus, it is expected that the finite soil thickness will have small effect on the results.

The exact solution for this particular problem is given by Gibson (1967) and results in a uniform settlement δ beneath the load with magnitude equal to:

$$\delta = \frac{q}{2\alpha}$$

In this case the exact solution gives a settlement of 0.05 m. The error is 0.7% and 1.0% in PLAXIS 2D and PLAXIS 3D respectively. It is concluded that PLAXIS results are in good agreement with the analytical solution.

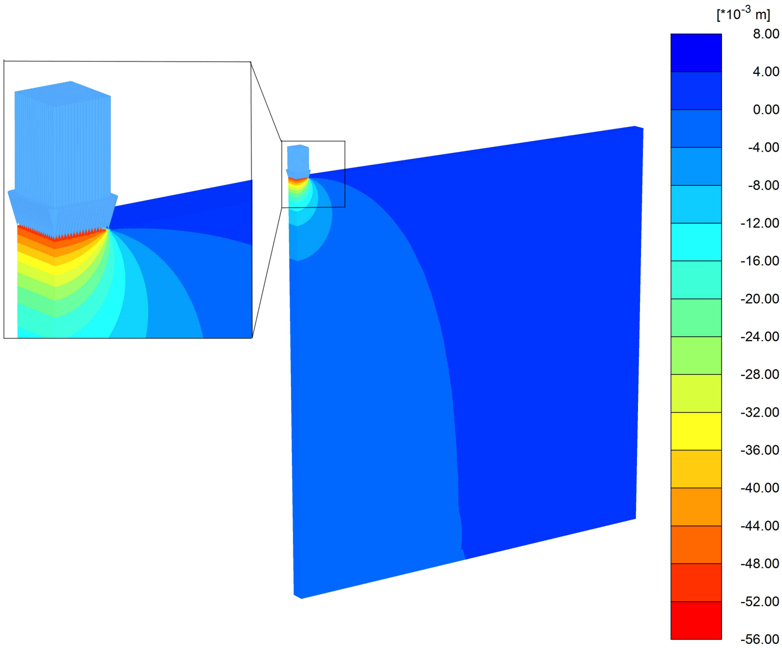

Figure 4 Vertical displacements distribution (PLAXIS 3D)

REFERENCES

[1] Gibson, R.E. (1967). Some results concerning displacements and stresses in a non-homogeneous elastic half-space. Géotechnique, 17, 58–64.