BEARING CAPACITY OF STRIP FOOTING

This document describes an example that has been used to verify the bearing capacity of a strip foundation in PLAXIS, considering both rough and smooth footings under undrained soil conditions.

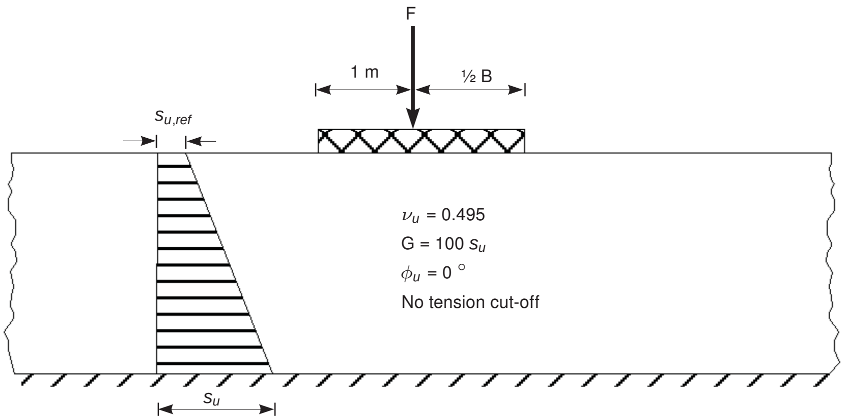

Figure 1 Problem geometry

Used version:

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

Geometry: Calculations are carried out for a rough and a rigid footing. The geometry of the PLAXIS 2D model is shown in Figure 2. Due to symmetry, only half of the geometry is modelled using 15-node elements. A line prescribed displacement is used to simulate the footing. Its downward component in y-direction equals 0.05 m. For the rigid footing, the x-direction of the prescribed displacement is set to *Free* whereas for the rough footing the x-direction of the prescribed displacement is set to *Fixed*.

The geometry of the PLAXIS 3D model is shown in Figure 3. The strip footing is defined as a surface prescribed displacement equal to 0.05 m in z-direction, pointing downwards. Horizontal prescribed displacement directions (x,y) are set free for the smooth case and to fixed for the rough case. A vertical surface is placed at the edge of the strip footing to enable local control of the mesh. The surface is extended 0.4 m downwards. At this surface, a positive interface is used, to create an extra row of nodes at the right-hand edge of the footing, for reasons of accuracy. Relevant dimensions are displayed in Figure 3. The phreatic level is set at the bottom of the model.

Materials: The material properties are presented in Figure 1. The Mohr-Coulomb model is used to model the behavior of the soil in order to be consistent with the conventional foundation design (Potts & Zdravković (2001)). The soil unit weight γ is selected equal to zero. The undrained shear strength at the soil surface $s_{u,ref}$ is taken 1 kN/m^2. In the *Advanced* settings, the *Undrained C* method is used with the undrained shear strength gradient, $s_{u,inc}$, equal to 2 kN/m^2/m, using the top of the layer as a reference level (PLAXIS 2D y_{ref} = 0 m, PLAXIS 3D z_{ref} = 0 m). The stiffness at the top is given by E_u =

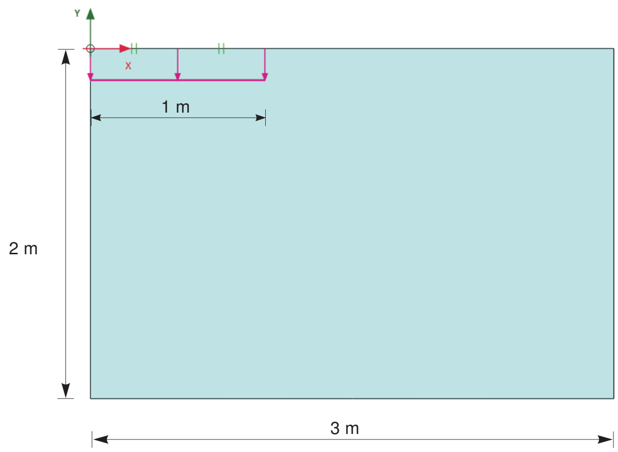

Figure 2 Model geometry (PLAXIS 2D)

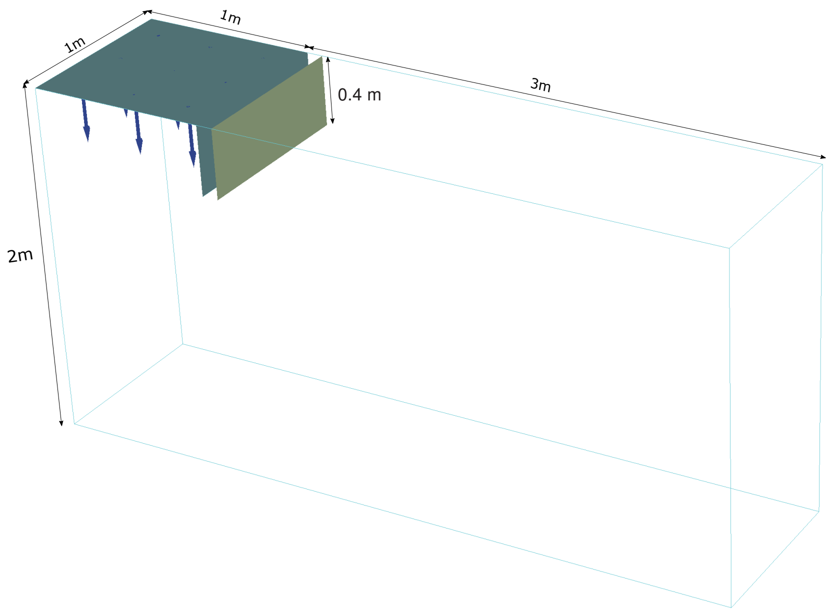

Figure 3 Model geometry (PLAXIS 3D)

299 kN/m^2 and the increase of stiffness with depth is defined by $E_{u,inc}$ = 598 kN/m^2/m. Tension cut-off is not used. The interface strength is set to Rigid (Rinter = 1.0).

Meshing: In PLAXIS 2D the *Medium* option is selected for the *Global coarseness*. The point at the right end of the prescribed displacement is refined with a *Coarseness factor* of 0.05 and the prescribed displacement has a *Coarseness factor* of 0.25 by default. The resulting finite element mesh is shown in Figure 4.

In PLAXIS 3D the *Medium* option is selected for the *Global coarseness*. The surface prescribed displacement representing the footing is refined with a *Coarseness factor* of 0.5. The surface at the right of the footing is refined with a *Coarseness factor* of 0.1. The

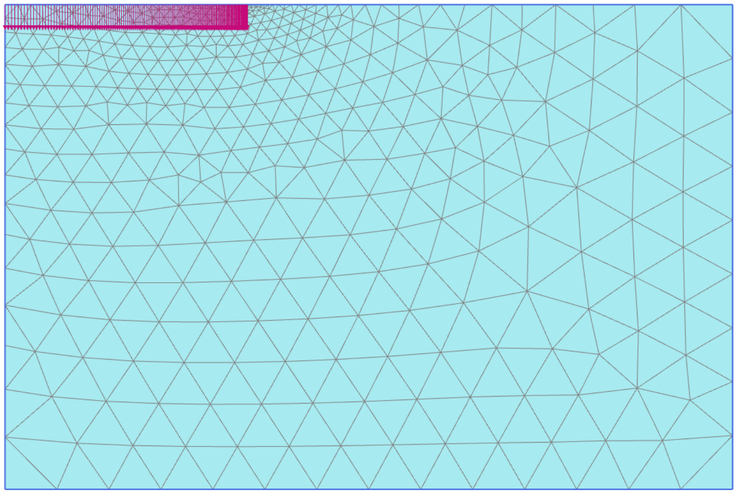

Figure 4 The finite element mesh (PLAXIS 2D)

resulting finite element mesh is depicted in Figure 5.

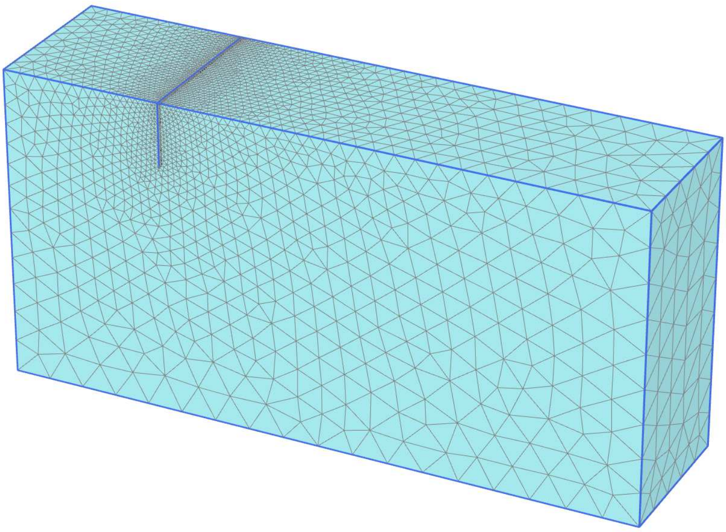

Figure 5 The finite element mesh (PLAXIS 3D)

Calculations: In the Initial phase zero initial stresses are generated by using the K0 procedure (γ = 0). The prescribed displacement is activated in a separate phase. In case of a smooth footing the horizontal prescribed displacement is set to *Free*. In case of a rigid footing the horizontal prescribed displacement is *Fixed*. The calculation type is set to *Plastic analysis* and a *Tolerated error* of 0.001 is defined. The *Reset displacements to zero* option is selected and the *Max steps* parameter is set to 500. In PLAXIS 3D, the Pardiso (multicore direct) solver is being used for faster convergence.

Output: To obtain PLAXIS results a soil node is used at the soil surface (left boundary) of the models. In PLAXIS 2D, the calculated maximum average vertical stress under the smooth footing is 7.831 kN/m^2 and under the rough footing is 9.168 kN/m^2. In PLAXIS 3D, the calculated maximum average vertical stress under the smooth footing is 7.921 kN/m^2 and under the rough footing is 9.564 kN/m^2. The computed load-displacement curves are shown in Figure 6 for both PLAXIS 2D and PLAXIS 3D.

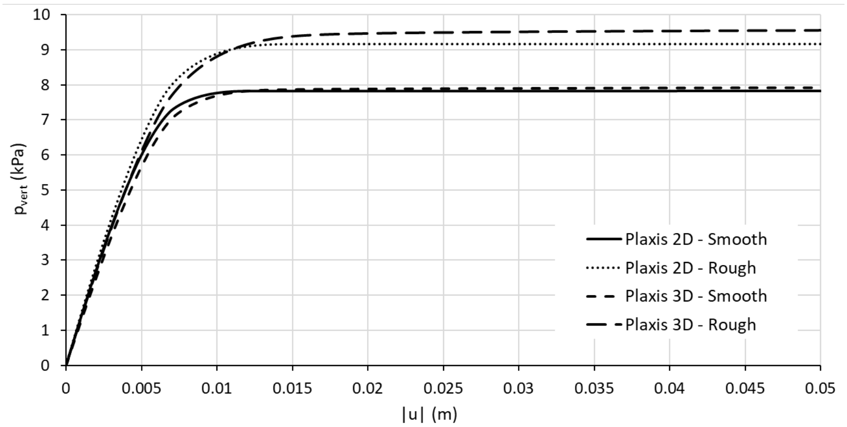

Figure 6 Comparison of results for smooth and rough footing (PLAXIS 2D and PLAXIS 3D)

Verification: The analytical solution derived by Davis & Booker (1973) for the mean ultimate vertical stress beneath the footing, p_{max}, is given by Eq. (1).

$$p_{\max} = \frac{F}{B} = \beta\left[(2+\pi)s_{u,ref} + \frac{B \times s_{u,inc}}{4}\right] \qquad (1)$$

where B is the total width of the footing (2 m in this example) and β is a factor which depends on the footing roughness and the rate of increase of soil strength with depth. The selected values of β in this case are 1.27 for the smooth footing and 1.48 for the rough footing. The analytical solution therefore gives average vertical stresses at collapse of 7.8 kN/m^2 for the smooth footing and 9.1 kN/m^2 for the rough footing. The error in PLAXIS 2D results is 0.4% and 0.7% respectively. The error in PLAXIS 3D results is 1.6% and 5.1% respectively.

REFERENCES

[1] Davis, E.H., Booker, J.R. (1973). The effect of increasing strength with depth on the bearing capacity of clays. Géotechnique, 23(4), 551–563.

[2] Potts, D.M., Zdravković, L. (2001). Finite element analysis in geotechnical engineering application. Thomas Telford, London.