BI-AXIAL COMPRESSION TEST WITH MOHR-COULOMB MODEL

This document describes an example that has been used to verify the elasto-plastic deformation capabilities of PLAXIS, according to the linear-elastic perfectly-plastic Mohr-Coulomb model. The problem involves axial compressive loading under bi-axial test conditions.

Used version:

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

Geometry: A bi-axial test is conducted on the geometry displayed in Figure 1 for PLAXIS 2D and PLAXIS 3D. In PLAXIS 2D, a square specimen is used (1×1 m^2). *Line loads* are assigned to the right and top model boundaries. In PLAXIS 3D, a cubic specimen is used ($1\times1\times1$ m^3). *Surface loads* are assigned to the right and top model faces. As illustrated in Figure 1, the lateral stress σ_2 is represented by a distributed load on the right side of the model. The axial stress σ_1 is represented by a distributed load on the top of the model.

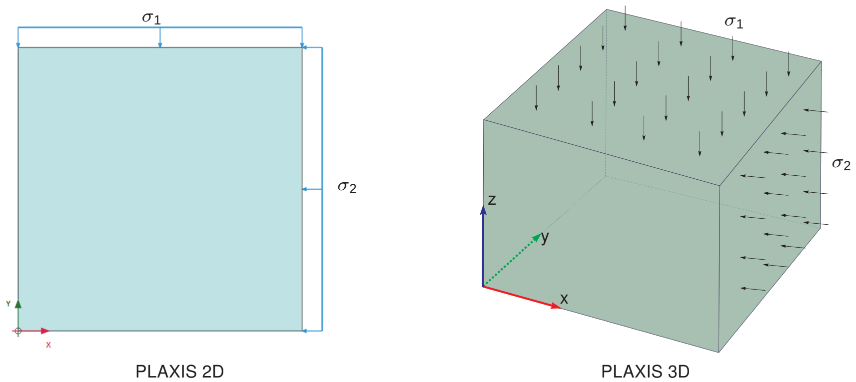

Figure 1 Bi-axial compression test - loading conditions

Material: The material behaviour is modelled by means of the Mohr-Coulomb model. The unit weight γ is set to zero. The model parameters are:

Mohr-Coulomb E' = 1000 kN/m^2 ν' = 0.25 c'_{ref} = 1 kN/m^2 φ' = 30°

Meshing: In order to create an very coarse mesh, the *Expert mesh* settings (without any local refinements) are used for the model in PLAXIS 2D and PLAXIS 3D and the *Relative element size* is selected equal to 20.00 and a *Coarseness factor* equal to 1.0 is used for the whole geometry.

Calculations: In the Initial phase zero initial stresses are generated by using the K0 procedure (γ = 0). In Phase 1, both σ_1 and σ_2 are activated and set equal to -1 kN/m/m in PLAXIS 2D and -1 kN/m^2 in PLAXIS 3D. A consecutive phase 2 follows in which σ_2 remains constant and σ_1 is set equal to -10 kN/m/m in PLAXIS 2D and -10 kN/m^2 in PLAXIS 3D. The calculation type in Phases 1 and 2 is *Plastic analysis*. *Tolerated error* of 0.001 and *Max load fraction per step* of 0.05 are used.

With respect to the boundary conditions in Phases 1 and 2, in PLAXIS 2D, the right

(x_{max}) boundary is set to *Free* and the bottom (y_{min}) boundary is set to *Normally fixed*. The default boundary conditions for the other two boundaries are appropriate. In PLAXIS 3D, the right (x_{max}) boundary is set to *Free*, while the bottom boundary (z_{min}) is set to *Normally fixed*. The default boundary conditions for the rest four boundaries are appropriate.

Output: Soil fails at an effective axial stress σ_1' equal to -6.4641 kN/m^2 in both PLAXIS 2D and PLAXIS 3D. The plot of the principal effective stress σ_1' versus the principal strain ϵ_1 is shown in Figure 2.

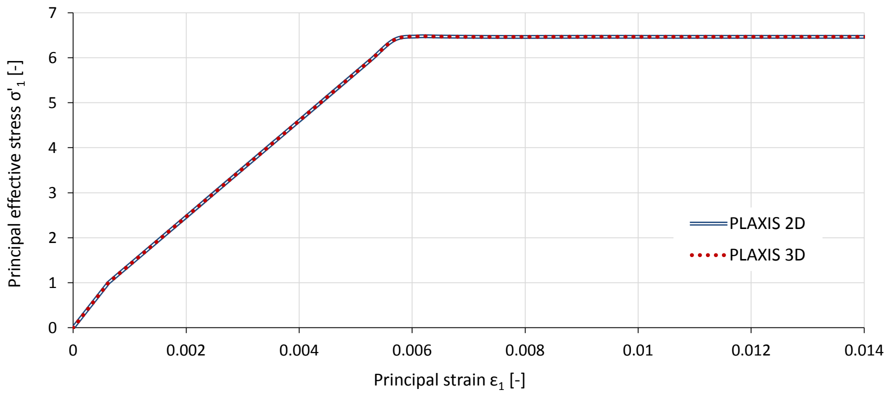

Figure 2 Principal effective stress σ_1' versus principal strain ϵ_1

Verification: The theoretical solution for the failure of the specimen is given by the Mohr-Coulomb criterion:

$$f = \frac{|\sigma_1' - \sigma_2'|}{2} + \frac{\sigma_1' + \sigma_2'}{2} \cdot \sin\varphi' - c' \cdot \cos\varphi' = 0$$

Failure occurs in compression at:

$$\sigma_1' = \sigma_2' \cdot \frac{1 + \sin\varphi'}{1 - \sin\varphi'} - 2c' \cdot \frac{\cos\varphi'}{1 - \sin\varphi'} = -6.4641 \text{ kN/m}^2$$

Theoretical and PLAXIS results are in perfect agreement.