BI-AXIAL COMPRESSION TEST WITH LINEAR ELASTIC MODEL

This document describes an example that has been used to verify the elastic deformation capabilities of PLAXIS, according to Hooke's law of isotropic elasticity. 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). Unit *line loads* are assigned to the right and top model boundaries. In PLAXIS 3D, a cubic specimen is used ($1 \times 1 \times 1$ m^3). Unit *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. The axial stress σ_1 is represented by a distributed load on the top of the model. In total, three load combinations are studied:

Test 1:	Lateral loading	σ_1: deactivated	σ_2 = -1 kN/m^2
Test 2:	Axial loading	σ_1 = -1 kN/m^2	σ_2: deactivated
Test 3:	Bi-axial loading	σ_1 = -1 kN/m^2	σ_2 = -1 kN/m^2

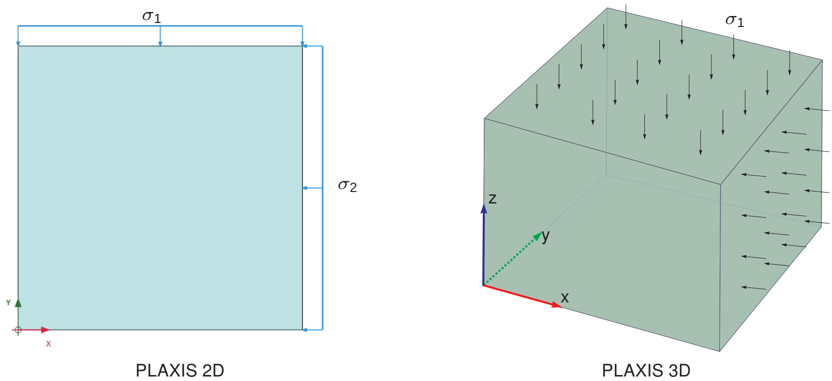

Figure 1 Bi-axial test models and loading conditions

Material: The unit weight γ is set to zero. The remaining material properties are:

Linear elastic E' = 1000 kN/m^2 ν' = 0.25

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. 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). The calculation type is *Plastic analysis*. *Tolerated error* of 0.001 is used. As mentioned above, three loading tests are performed in three separate phases, starting from the initial phase. 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: The resulting displacements are presented below. Since a specimen of unit length is considered, the values of these displacement components are equal to the strains in the corresponding directions.

PLAXIS 2D:

Phase 1: u_x = -0.9375 mm u_y = 0.3125 mm

Phase 2: u_x = 0.3125 mm u_y = -0.9375 mm

Phase 3: u_x = -0.6250 mm u_y = -0.6250 mm

PLAXIS 3D:

Phase 1: u_x = -0.9375 mm u_y = 0 mm u_z = 0.3125 mm

Phase 2: u_x = 0.3125 mm u_y = 0 mm u_z = -0.9375 mm

Phase 3: u_x = -0.6250 mm u_y = 0 mm u_z = -0.6250 mm

Verification: The theoretical solution of principal strains reads:

$$\epsilon_1 = \frac{\sigma_1 - \nu'(\sigma_2 + \sigma_3)}{E'}$$

$$\epsilon_2 = \frac{\sigma_2 - \nu'(\sigma_1 + \sigma_3)}{E'}$$

$$\epsilon_3 = \frac{\sigma_3 - \nu'(\sigma_1 + \sigma_2)}{E'} = 0 \Rightarrow \sigma_3 = \nu'(\sigma_1 + \sigma_2)$$

A summary of the results obtained from the theoretical solutions is shown in Table 1.

Table 1 Results of analytical solutions

Test 1:	σ_1 = 0 kN/m^2 ϵ_1 = 0.3125·10^{-3}	σ_2 = -1 kN/m^2 ϵ_2 = -0.9375·10^{-3}	σ_3 = -0.25 kN/m^2 ϵ_3 = 0
Test 2:	σ_1 = -1 kN/m^2 ϵ_1 = -0.9375·10^{-3}	σ_2 = 0 kN/m^2 ϵ_2= 0.3125·10^{-3}	σ_3 = -0.25 kN/m^2 ϵ_3 = 0
Test 3:	σ_1 = -1 kN/m^2 ϵ_1 = -0.6250·10^{-3}	σ_2 = -1 kN/m^2 ϵ_2 = -0.6250·10^{-3}	σ_3 = -0.50 kN/m^2 ϵ_3 = 0

The correspondence between axes 1, 2 and 3 of the theoretical solution and axes x, y and z of PLAXIS is (refer to Figure 1):

PLAXIS 2D: 1 $\rightarrow$ y, 2 $\rightarrow$ x, 3 $\rightarrow$ z

PLAXIS 3D: 1 $\rightarrow$ z, 2 $\rightarrow$ x, 3 $\rightarrow$ y

Theoretical and PLAXIS results are in perfect agreement.