# BENDING OF PLATES

This document describes an example that has been used to verify the behaviour of plates in PLAXIS. The problem involves involves a concentrated load and a uniformly distributed load on a plate.

Used version:

- PLAXIS 2D - Version 2011
- PLAXIS 3D - Version 2012

**Input:** In PLAXIS the structures cannot be used individually. A soil cluster is used to create the geometry. Note that the properties of the material assigned to the soil do not affect the results as the clusters will be deactivated in the calculation phase (Phase 1). However assignment of a soil material to the clusters is required before generating the mesh.

In PLAXIS 2D two plates of unit dimensions are used (1 x 1 m). In a plane strain model a 1m width is in the out of plane direction. Unit point and distributed loads are assigned to the plates. The 2D model is shown in Figure 1. Point fixities are used at the end points of the plates.

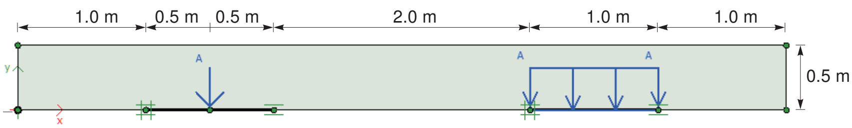


Figure 1 Loading scheme for testing plates (2D)

In PLAXIS 3D two plates of unit dimensions are used (1 x 1 m). Unit line and distributed loads re assigned to the plates. Line prescribed displacements are assigned to model the fixities (Figure 2).

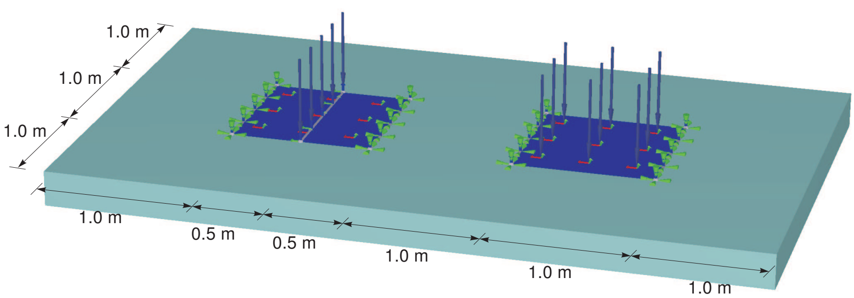


Figure 2 Loading scheme for testing plates (3D)

**Materials:** The properties and the load of the plate in PLAXIS 2D model are:

| | | |
|---|---|---|
| Elastic | EA = 100000 kN | EI = 83.33 kNm$^2$ |
| $\nu$ = 0.0 | F = 100 kN | q = 200 kN/m |

The properties and the load of the plate in PLAXIS 3D model are:

| | | |
|---|---|---|
| d = 0.10 m | $E_1$ = 1·10$^6$ kNm$^2$ | $\nu$ = 0.0 |
| $G_{12}$ = 5·10$^5$ kNm$^2$ | F = 100 kN | q = 200 kN/m |

**Meshing:** The *Very coarse* option is selected for the *Element distribution* of the *Global coarseness*. In the 2D model the geometry lines representing the plates are refined with a *Local element size factor* of 0.5. In the 3D model the plates are refined with a *Fineness factor* of 0.2.

**Calculations:** In the Initial phase zero initial stresses are generated by using the K0 procedure with Σ *-Mweight* equal to zero. A new calculation phase is introduced (Phase 1) and the *Calculation type* is set to *Plastic analysis*. The *Reset displacements to zero* is selected and the *Tolerated error* for *Iterative procedure* is set to 0.001. In this phase the soil clusters are deactivated and the plates are activated.

**Output:** The results of the calculations in PLAXIS 2D are plotted in Figures 3 to 5.

| | | |
|---|---|---|
| Point load: | $M_{max}$ = 25.0 kNm | $u_{max}$ = 25.60 mm |
| Distributed load: | $M_{max}$ = 25.0 kNm | $u_{max}$ = 31.85 mm |

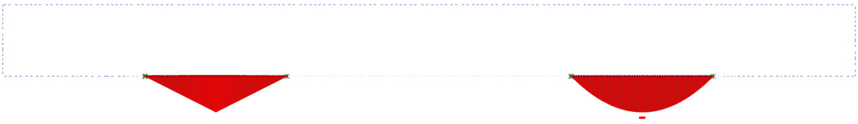

Figure 3 Computed distribution of moments

Figure 4 Computed shear forces

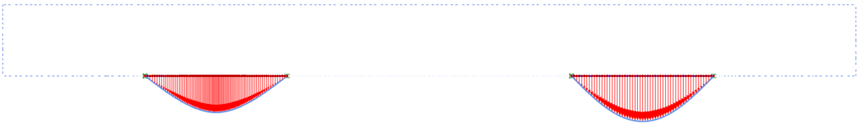

Figure 5 Computed displacements

The results of the calculations in PLAXIS 3D are plotted in Figures 6 to 8.

Line load: $M_{max}$ = 25.0 kNm $u_{max}$ = 25.60 mm

Distributed load: $M_{max}$ = 25.0 kNm $u_{max}$ = 31.58 mm

Figure 6 Computed distribution of moments

Figure 7 Computed shear forces

Figure 8 Computed displacements

**Verification:** As a first verification, it is observed that PLAXIS yields the correct distribution of moments. For further verification we consider the well-known formulas as listed below. These formulas give approximately the values as obtained from the PLAXIS analysis.

Point load: $M_{max} = \frac{1}{4} Fl = 25 \text{ kNm}$ $u_{max} = \frac{1}{48} \frac{Fl^3}{EI} + \frac{Q}{GA} = 25.00 \text{ mm}$

Distributed load: $M_{max} = \frac{1}{8} ql^2 = 25 \text{ kNm}$ $u_{max} = \frac{5}{384} \frac{ql^4}{EI} = 31.25 \text{ mm}$

The well-known formulas consider only vertical displacement due to bending, whereas the Mindlin element in PLAXIS 2D and PLAXIS 3D also involve shear deformation, which leads to more vertical displacement.