PERFORMANCE OF SPRINGS

This document describes an example used to verify that the performance of springs, connected to floors and walls, is correctly implemented in PLAXIS.

Used version:

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

Geometry: 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. The assignment of a soil material to the clusters is required before generating the mesh.

In PLAXIS 2D, two plane strain models are used to study the problem. 'Model A' consists of an horizontal plate which is loaded by a distributed load equal to 100 kN/m/m, acting vertically downwards. The plate is supported by two vertical springs at its corners. The springs are simulated as *Fixed-end anchors* hinged to the structure and fully fixed to the outer soil. In 'model B', the horizontal plate is connected at its edges with two vertical plates, which in turn are supported by vertical springs at their bottom edge.

Fixed-end anchors transport forces parallel to their direction and have no perpendicular stiffness. Thus, a *Point displacement* fixed at the horizontal x-direction is assigned at the left corner of the horizontal plate in both 'model A' and 'model B'. Figure 1 illustrates the model geometries in PLAXIS 2D.

In order to model the analogous conditions in PLAXIS 3D, two models with horizontal plates of 2×2 m are used. Each horizontal plate is loaded by a distributed load equal to 100 kN/m^2, acting vertically downwards. The plates should not be in contact with the model boundaries. The horizontal plate in 'Model A' is directly supported by four vertical springs at the corners. The horizontal plate in 'Model B' is supported by two vertical plates, which in turn are supported by vertical springs at their four corners. Figure 2 illustrates the model geometries in PLAXIS 3D.

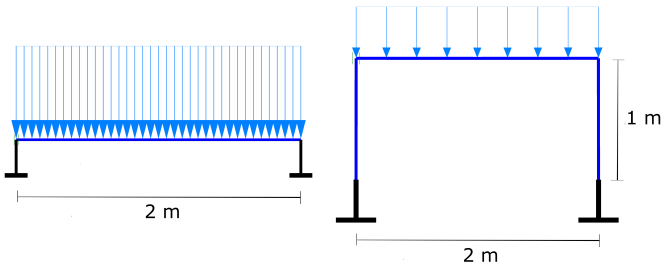

Figure 1 Model geometries in PLAXIS 2D: model A (left) and model B (right)

Materials: *Fixed-end anchors* have axial stiffness EA/L equal to 10^3 kN/m and their equivalent length is set equal to 1 m. *Plates* have Young's modulus E' equal to 210×10^7 kN/m^2, Poisson's ratio ν' equal to 0.0 and thickness d equal to 0.1 m. Arbitrary values are assigned to the soil material properties as it will be deactivated during the calculation.

Meshing: In both PLAXIS 2D and PLAXIS 3D, the *Coarse* option is selected for the

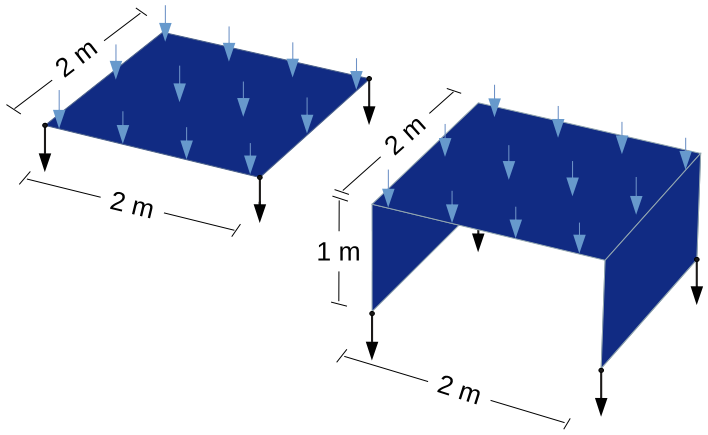

Figure 2 Model geometries in PLAXIS 3D: model A (left) and model B (right)

Element distribution. The mesh is locally refined by a *Coarseness factor* of 0.2 at the points where the anchors are located.

Calculations: The soil is deactivated at the *Stage construction* mode. A *Plastic analysis* is performed and all the features mentioned above are activated.

Verification: In both PLAXIS 2D and PLAXIS 3D the axial force in all springs equals 100 kN. The vertical displacement of the plates equals 0.1 m. It is concluded that the performance of springs is correctly implemented in PLAXIS.