2D Consolidation under a Strip Footing

For LUSAS version:	21.0
For software product(s):	LUSAS Bridge plus or LUSAS Civil&Structural plus
With product option(s):	Geotechnical, Nonlinear, Dynamic

Problem Description

The pore water pressure dissipation and settlement in a soil following the application of a distributed load is to be investigated. A load of 3450 kN/m^2 is applied over a 5 m width.

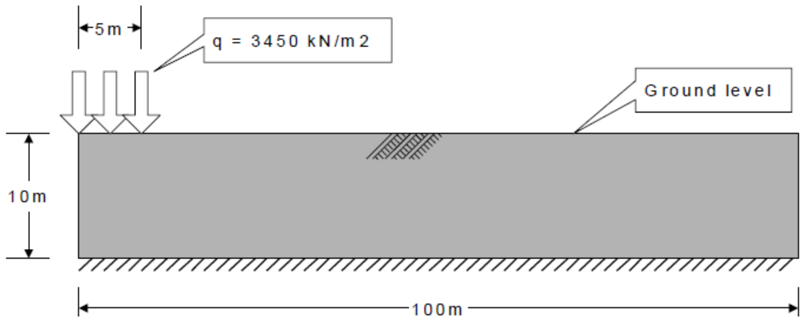


Figure 1: Embankment model

Keywords

Consolidation, Pore Water Pressure, Settlement.

Associated Files

Associated files can be downloaded from the user area of the LUSAS website.

❑ **footing_consolidation.lvb** carries out automated modelling of the example.

- Use **File > New** to create a new model of a suitable name in a chosen location.
- Use **File > Script > Run Script** to open the lvb file named above that was downloaded and placed in a folder of your choosing.

Objectives

The required output from the analysis consists of:

❑ Settlement at the centre of the footing with time.
❑ Pore pressure distribution immediately after application of the load (undrained response).
❑ Pore water pressure dissipation with time at the centre of the footing

Preparing the Model Features

Units of kN, m, t, s, C are used throughout.

Feature Geometry

The model can be created through point and line features which are subsequently converted into surfaces. The user has to ensure proper connection between surfaces and avoid any unintentional overlapping (Figure 2).

Figure 2: Model outlines

Preparing the Model Attributes

Model attributes (mesh, material, geometric properties, etc.) are defined and assigned to the model. Figure 3 shows the attributes of model.

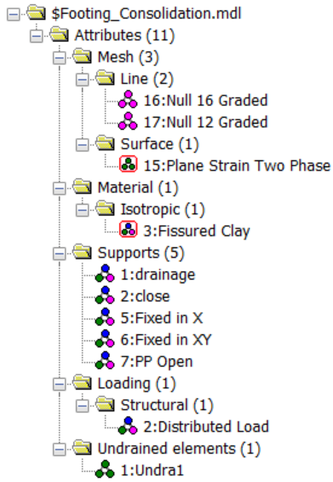


Figure 3: Model Attributes

Defining the Mesh

Since this analysis requires the modelling of pore water pressure, plane-strain two phase elements will be used.

Graded Line meshes are defined and assigned as per figure 4. Plane strain two phase, Quadrilateral, Quadratic elements are defined and assigned to the model. (Figure 5).

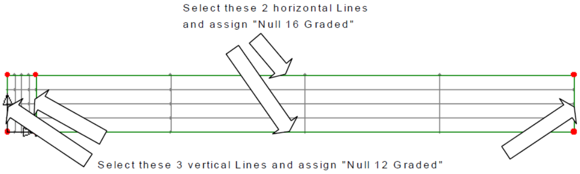


Figure 4: Graded Line Meshing

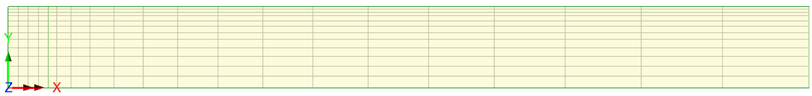


Figure 5: Model Meshing

Defining the Materials

An isotropic elastic material is used for the soil. Material properties are listed in table 1. Figures 6 give the two-phase properties.

Table 1: material properties

Layer	Soil grain density	Young's modulus, E	Poisson's ratio, ν
Clay	1.9 t/m^3	347.0E3 kPa	0.35

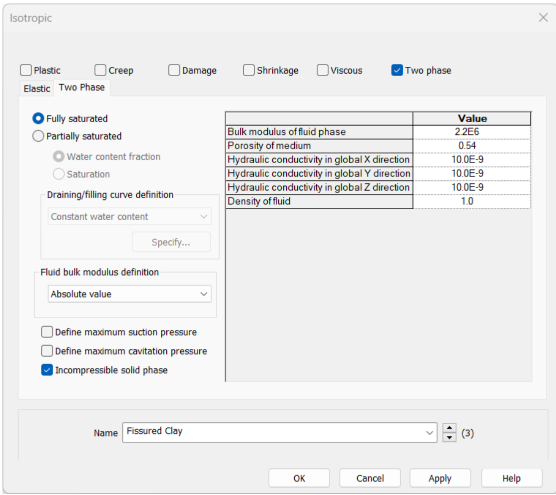


Figure 6: Two-phase properties for clay and peat layers

Defining the Supports

- The model is restrained in X and Y directions along its base and in the X direction for the lateral sides as shown in the figure 7. These conditions are activated during the first stage.

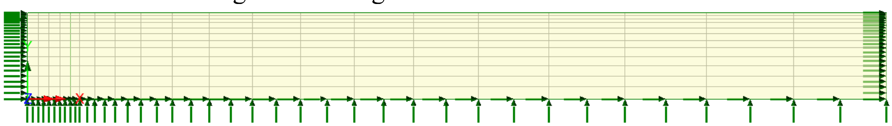


Figure 7: Boundary conditions at initial stage

- To establish the position of the water table, the pore pressure is set to **Open** at point 4 (Figure 8).

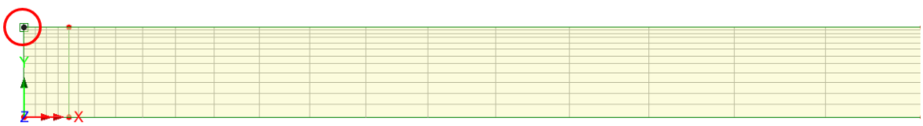


Figure 8: Pore pressure set to Open at point 4

- At the same point 4, the pore pressure set to **Close** for the consolidation phase, to prevent inflow or outflow of water at this location.

- We set the pore pressure to **Drainage** at the ground surface (line 7) as shown in figure 9 for the consolidation phase.

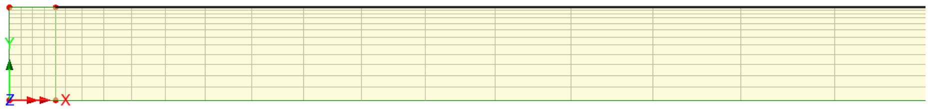


Figure 9: Pore pressure set to Drainage at the ground surface

Defining the Loads

In addition to gravitational force, a uniform load of 3450 kN/m2 is being imposed on a ground surface that has a width of 5 meters.

Defining Other Attributes

Attribute Undrained is defined through the command **Attributes > Pore Water Pressures > Undrained**.

Running the Analysis

The following modelling and loading phases are considered.

Initial Phase

In this phase, the load has not yet been applied (Figure 8). The Pore Pressure Open attribute is included in this phase to establish the hydrostatic pore pressure distribution in the soil.

Nonlinear analysis control properties are defined for this phase, all the parameters are left at their default values.

Undrained Loading

The load is applied to the ground surface, initially leading to an increase in the pore water pressures, that are slow to dissipate due to the low permeability of the soil, but with time the water will drain away and the soil voids will compress.

The soil is defined as an undrained region through the command **Pore Pressure > Undrained**, in such a case, the increase in stress is carried predominately by the pore water with little new stress carried by the soil skeleton.

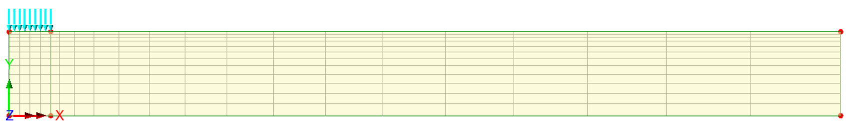


Figure 9: Undrained loading stage

Consolidation

During this phase, the excess pore water pressure dissipates through the soil surface to which the drainage boundary condition was assigned. An automatic time step is set, estimated from the maximum excess pressure which is roughly equivalent to the load of 3450 kN/m^2. If we set a target change in pore water pressure of 20 kN/m^2 per increment we would expect this to dissipate in 170 steps, more or less. A maximum value of excess pore water pressure of 0.01 kPa is set as the termination criterion. A small initial time step is used as this will grow quickly if it is too conservative.

Nonlinear analysis control properties are defined for this phase. The following is selected **Time domain > Two Phase**, the adopted values are given in the figure 10.

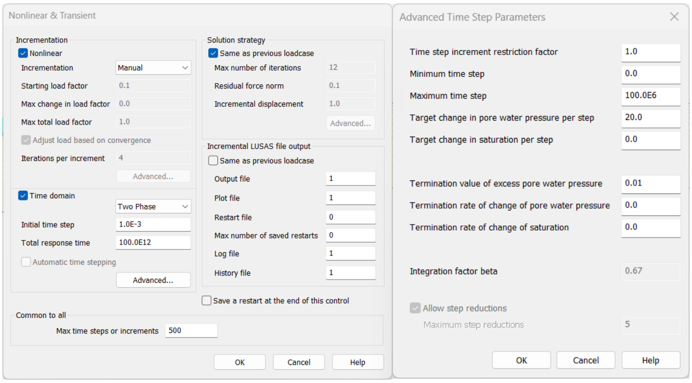


Figure 10: Nonlinear analysis control parameters

Viewing the Analysis

Analysis loadcase results are present in the Treeview.

Settlement

The following figures 11, 12 and 13 show some displacement forms in the model.

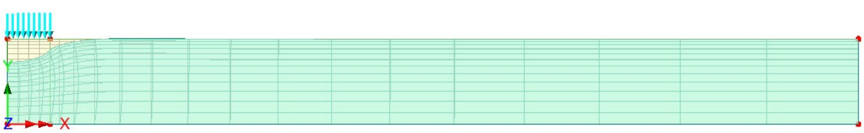


Figure 11: Deformed mesh at the final phase of consolidation

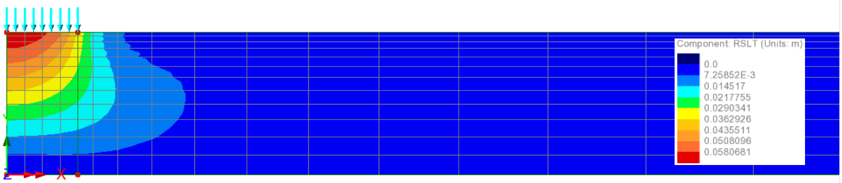


Figure 12: Resultant displacement at the final phase of consolidation (m)

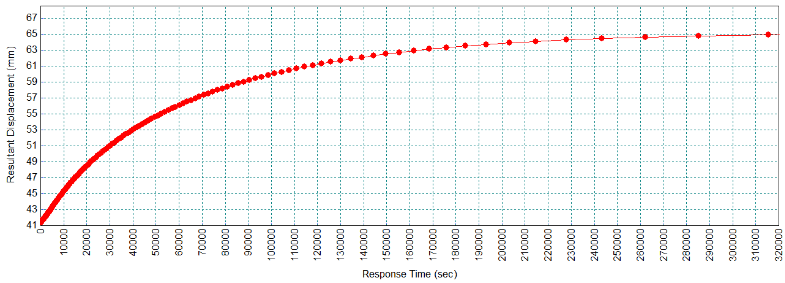
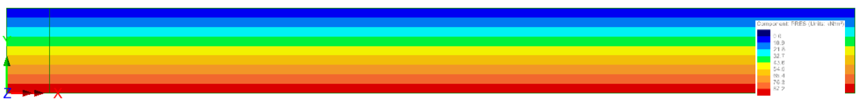


Figure 13: Resultant displacement for the consolidation phase (top left point)

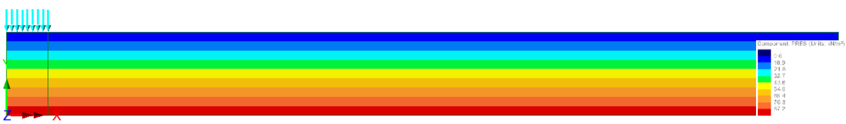
Pore Pressure

The distribution of pore pressure in different stages is shown in figure 14.



Initial Phase

Undrained Phase



End of consolidation

Figure 20: Pore Pressure in different stages