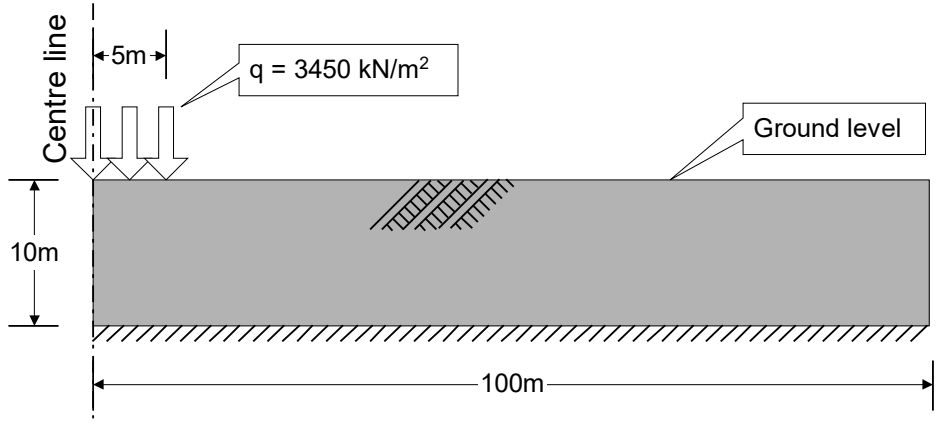
2D Consolidation under a Strip Footing

For LUSAS version:	24.0
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 half-model is used with a load of 3450kN/m^2 applied over a 5m width to one side of the centreline.



Model geometry

Keywords

Consolidation, Pore Water Pressure, Settlement.

Associated Files

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

- **2D_consolidation_under_a_strip_footing.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

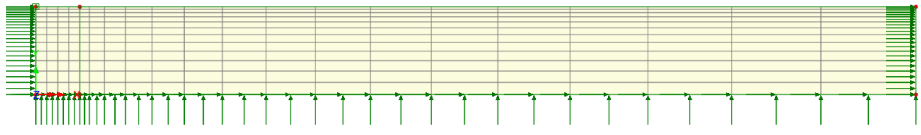
The required output from the analysis consists of:

- Settlement at the centre of the footing with time.
- Pore pressure distribution immediately after application of the load (undrained response).
- Pore water pressure dissipation for a node at the centre of the footing at selected stages/times.

Modelling overview

The model is created using an analysis category of **2D Inplane**, with model units of **kN,m,t,s,C**.

After running the supplied script, this view of the model is obtained.



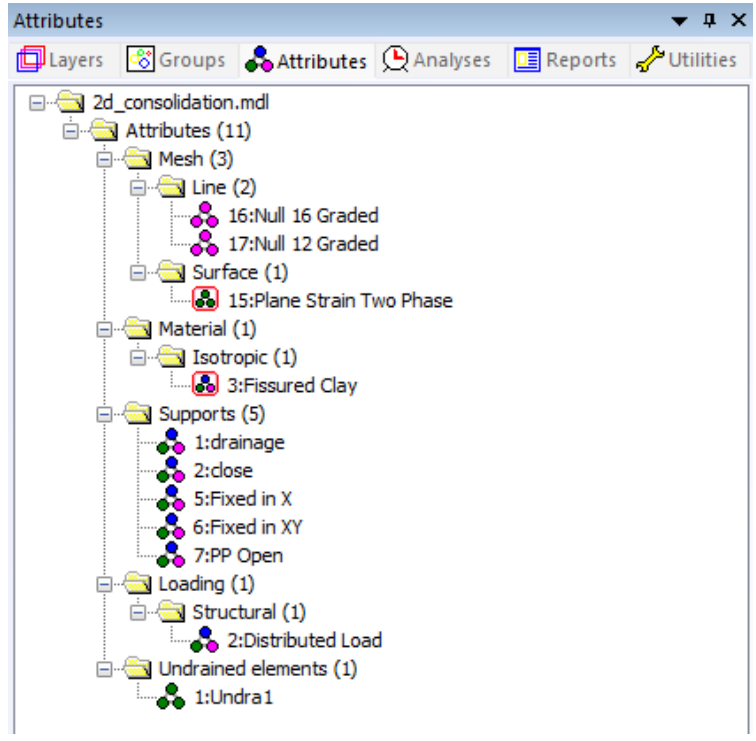
Feature Geometry

The model is created from surfaces that include point and line features.

Surfaces defined

Model Attributes

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

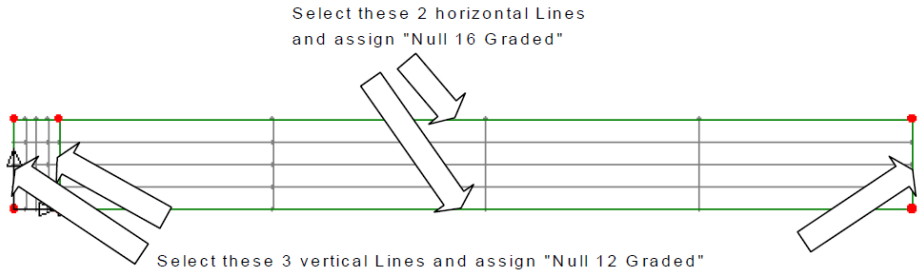


Attributes treeview

Mesh

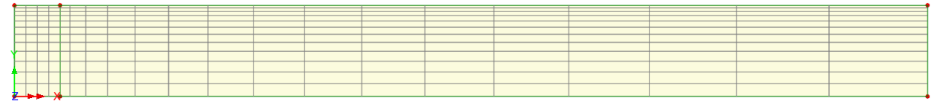
Since this analysis requires the modelling of pore water pressure, plane-strain two phase elements are used.

Graded line meshes are defined and assigned as shown below.



Graded Line Meshing

Plane strain two phase, Quadrilateral, Quadratic elements are defined and assigned to the model



Model as meshed

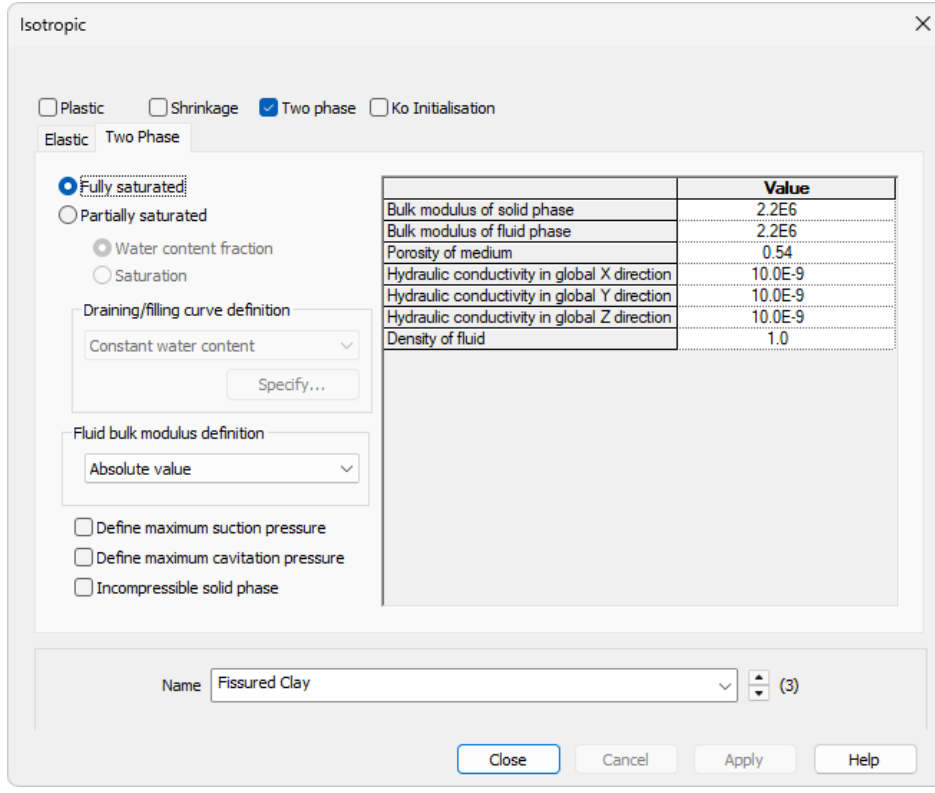
Materials

An isotropic elastic material is used for the soil. Material properties are listed in Table 1.

Table 1: Material properties

Layer	Young's modulus, E	Poisson's ratio, ν	Fully saturated soil density
Fissured Clay	347.0E3 kPa	0.35	1.9 t/m^3

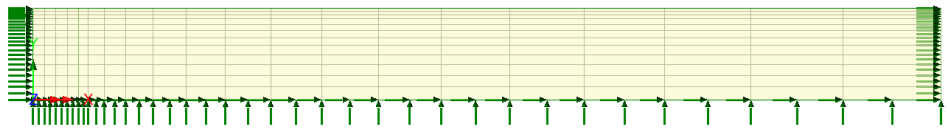
Two-phase properties are shown in the following image.



Two-phase properties for clay layer

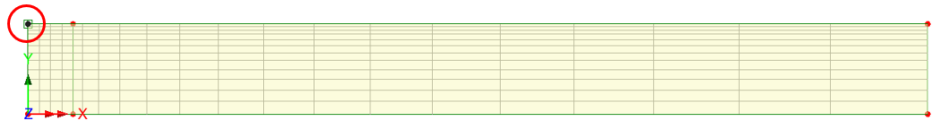
Supports

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



Boundary conditions at initial stage

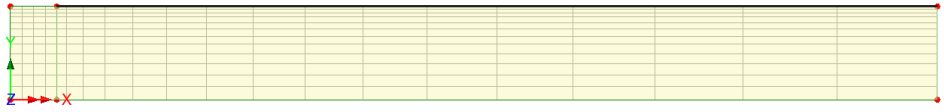
To establish the position of the water table, the pore pressure is set to **Open** at point 4 as shown below.



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 below for the consolidation phase.



Pore pressure set to Drainage at the ground surface

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 5m.

Other Attributes

The attribute 'Undrained' is defined through the command **Attributes > Pore Water Pressures > Undrained**.

Analyses considered

The following modelling and loading phases are considered.

Initial Phase

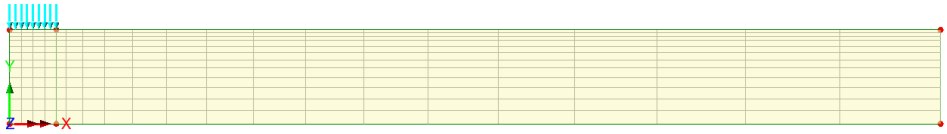
In this phase, the load has not yet been applied. The Pore Pressure Open attribute is included in this phase to establish the hydrostatic pore pressure distribution in the soil.

Nonlinear analysis control properties are defined for this phase with all parameters left as 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 using the menu item **Attributes > 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.



Undrained loading stage

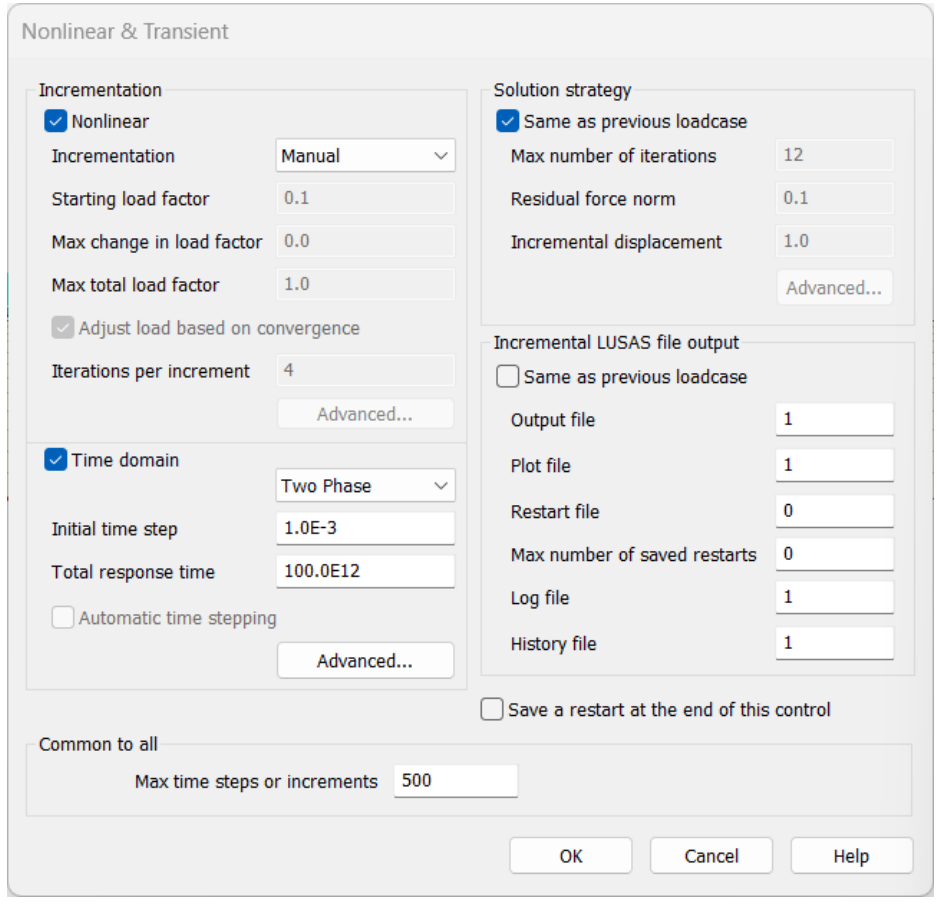
Consolidation

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.

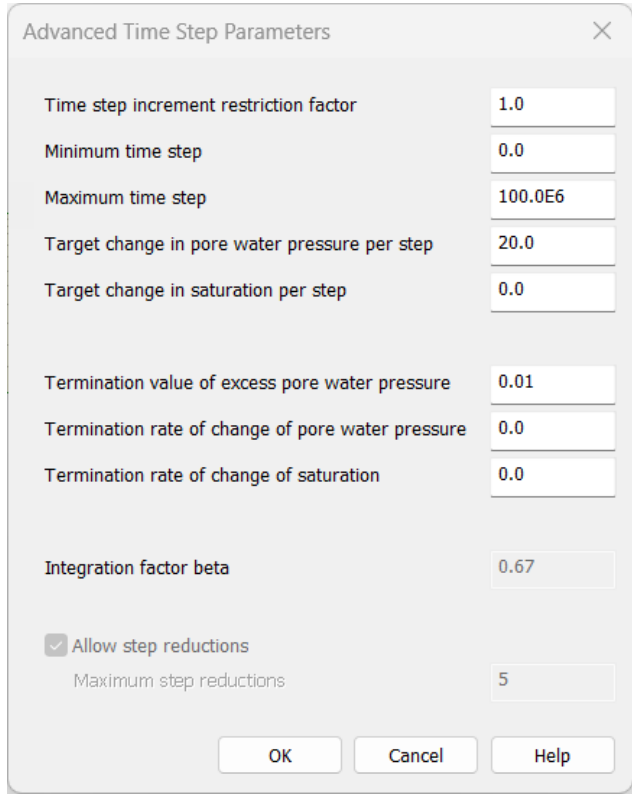
A maximum value of excess pore water pressure of 0.01 kPa is set as the termination criterion. A small initial time step is used as this will grow quickly if it is too conservative.

The nonlinear analysis control properties are defined for this phase as shown on the following image.



Nonlinear analysis control parameters

By selecting the **Time domain** and **Two Phase** options, the required values are specified in the following dialog.



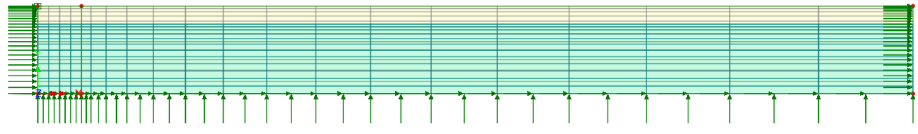
Advanced nonlinear analysis control parameters

Running the Analysis

 Press **OK** to run the analysis.

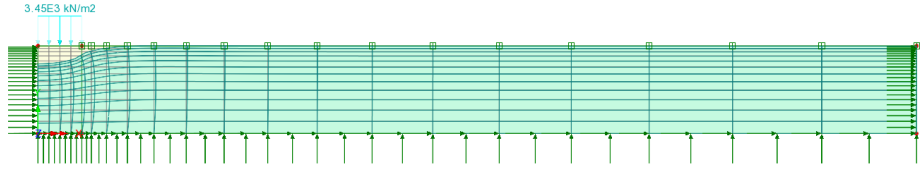
Viewing the Results

Analysis loadcase results are present in the Analyses treeview. The model view will initially show this.



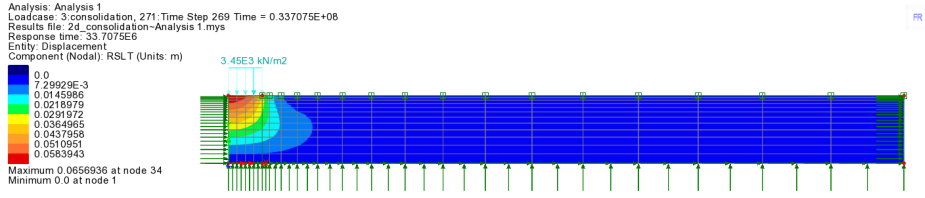
Settlement

- Set active the consolidation loadcase to show the deformed mesh at the last load increment.



Deformed mesh at the final phase of consolidation

- Turn off the display of the Deformed mesh layer.
- Add the contours layer to plot contours of entity **Displacement** and component **RSLT**.

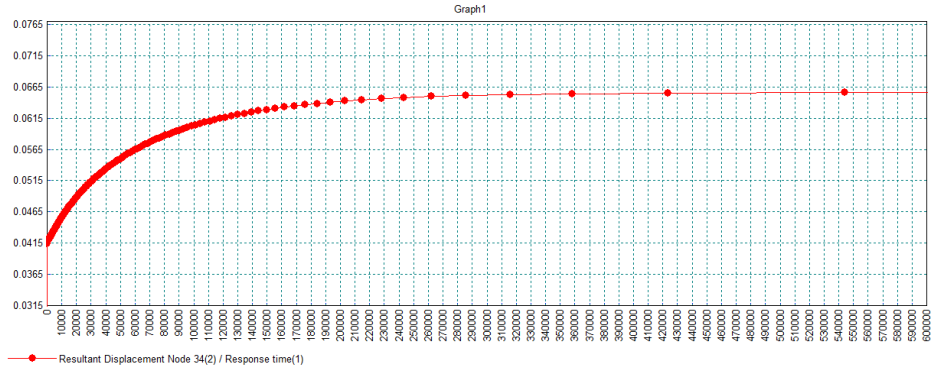


Resultant displacement at the final phase of consolidation

Graphing of settlement

To plot a graph of displacement for the top-left node in the model

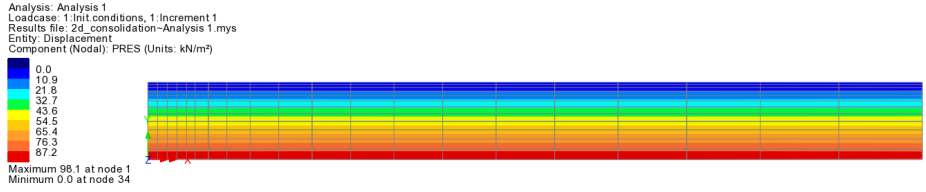
- Select the node
- Select the menu item **Utilities > Graph Wizard** to plot a graph of response time against resultant displacement, setting a manual maximum value for the x axis of 1e6
- Zoom in on the graph created to show the region of interest in more detail as shown below.



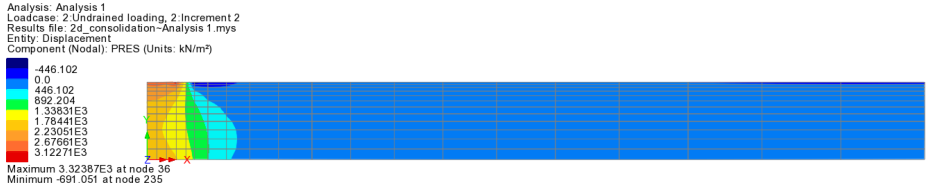
Resultant displacement for the consolidation phase (top left node)

Pore Pressure

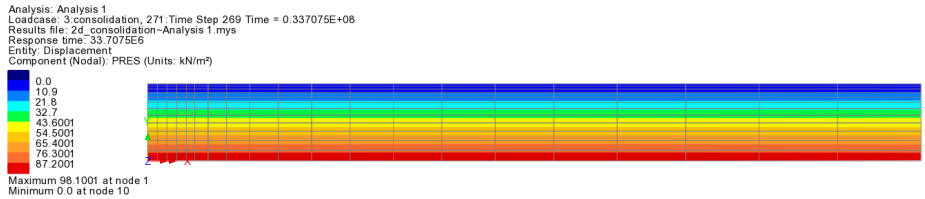
- Turn off the display of the geometry layer and supports
- Change the contour layer to plot contours of component **Displacement** and entity **PRES**
- Set active the loadcases for initial conditions, undrained loading and consolidation phases in turn to view the change of pore pressure that takes place.



Initial phase



Undrained loading phase



End of consolidation