Seepage Through Dam

For LUSAS version:	24.0
For software product(s):	LUSAS Bridge plus or LUSAS Civil&Structural plus
With product option(s):	Geotechnical, Nonlinear

Problem Description

In this problem, we are examining the transient seepage that occurs when the water level in a reservoir on one side of an earth fill dam is raised. The base of the earth fill dam is 52m wide. The initial steady-state reservoir level is 4m. The flow is unconfined, with the dam built on an impermeable foundation.

Keywords

Seepage, Pore Pressure, Two Phase Material.

Associated Files

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

- **seepage_through_dam.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

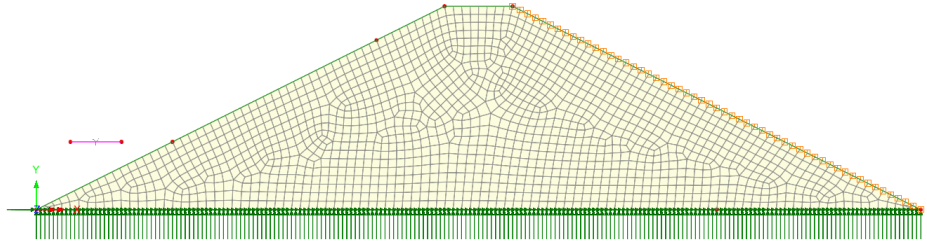
The required output from the analysis consists of:

- Plotting pore pressure contours.

- Plotting displacement on the downstream face of the dam during filling.

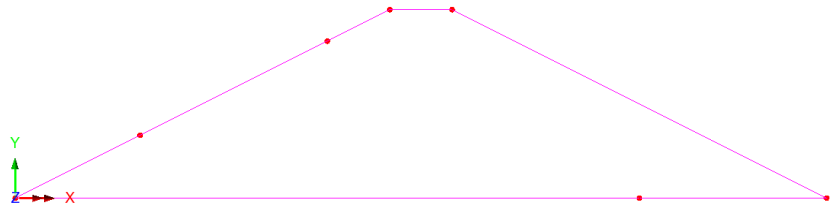
Modelling overview

The model is created using an analysis category of **2D Inplane** and model units of kN,m,t,s,C. Timescale is set to **Days**



The model created from running the supplied script.

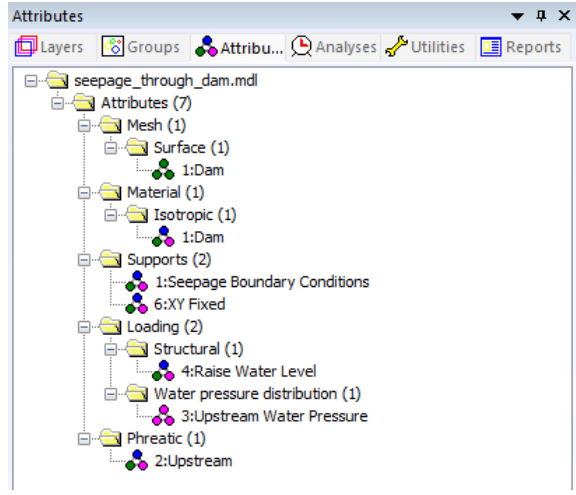
The dam model is created by entering point coordinates that define the dam's shape, as shown below, and then drawing lines between these points to form the surface.



Model geometry

Model Attributes

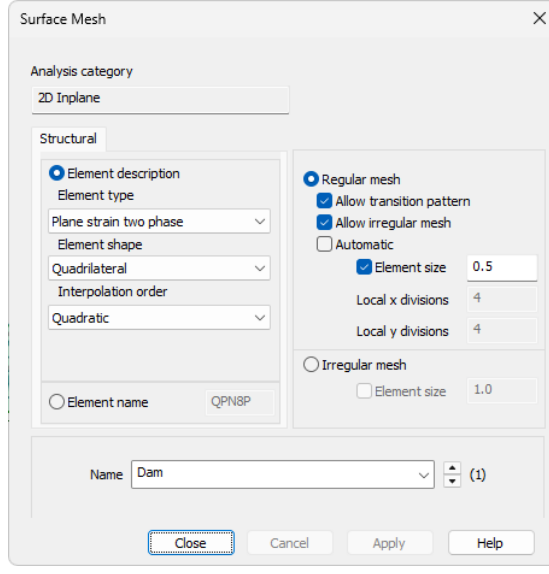
Model attributes (mesh, material, geometric properties, etc.) are defined and assigned to the model.



Model Attributes

Mesh

The surface feature is meshed using plane strain, two phase, quadrilateral, quadratic elements (QPN8P) with a regular mesh with an element size of 0.5m.



Surface mesh

Materials

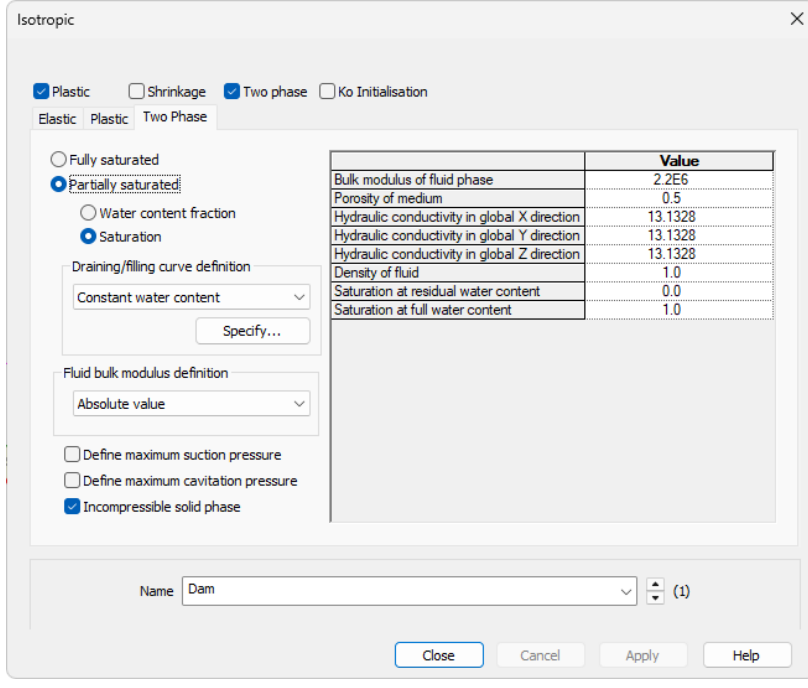
An isotropic nonlinear material utilising the Modified Mohr-Coulomb failure surface will be used for the sandy soil.

Table 1 gives the material properties for this example.

Table 1: material properties

Layer	Mass Density	Young's modulus, E	Poisson's ratio, ν	Angle of friction, φ	Dilation	Cohesion, c
Sand	2.0 t/m^3	50.0E3 kPa	0.4	35°	35°	5 kPa

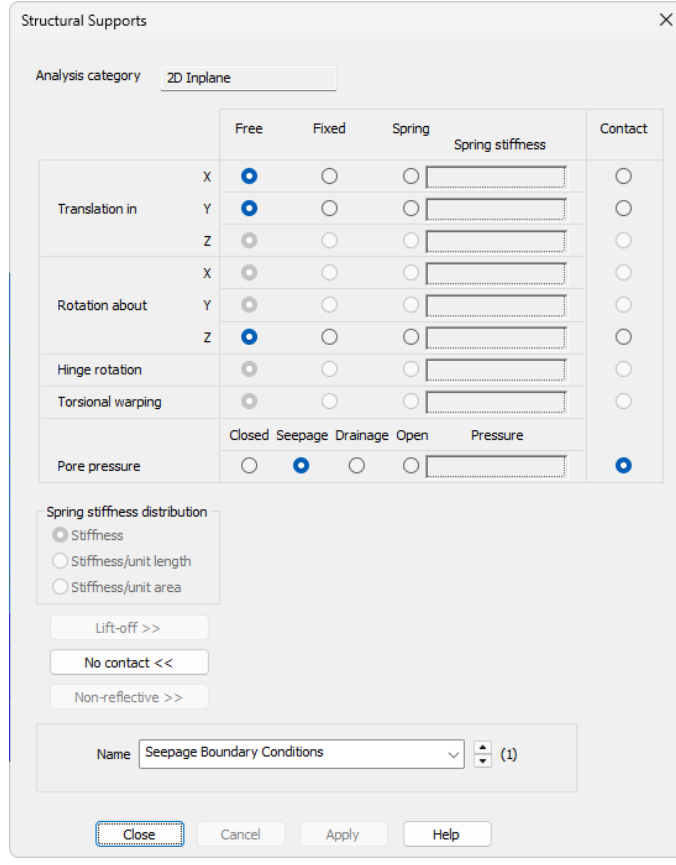
Two-phase material properties are required as well. The adopted properties and selected options are shown below. It is to be noted that hydraulic conductivity is entered in units of m/day.



Two-Phase properties

Supports

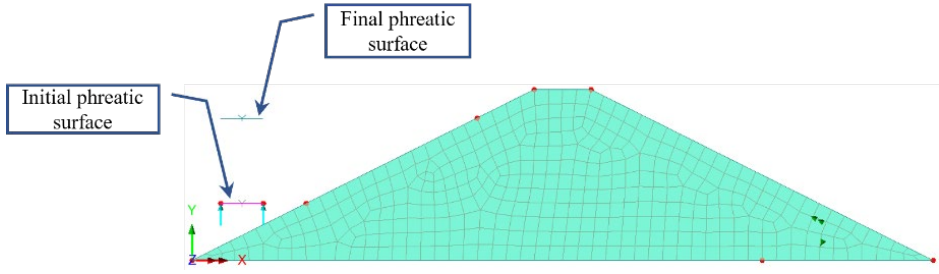
Fully fixed supports are assigned for the base of the dam. Seepage boundary conditions are required on the downstream slope of the dam and are defined by selecting the **Seepage** radio button on the **Structural Supports** dialog.



Seepage boundary conditions

Defining Loads and Phreatic Surface

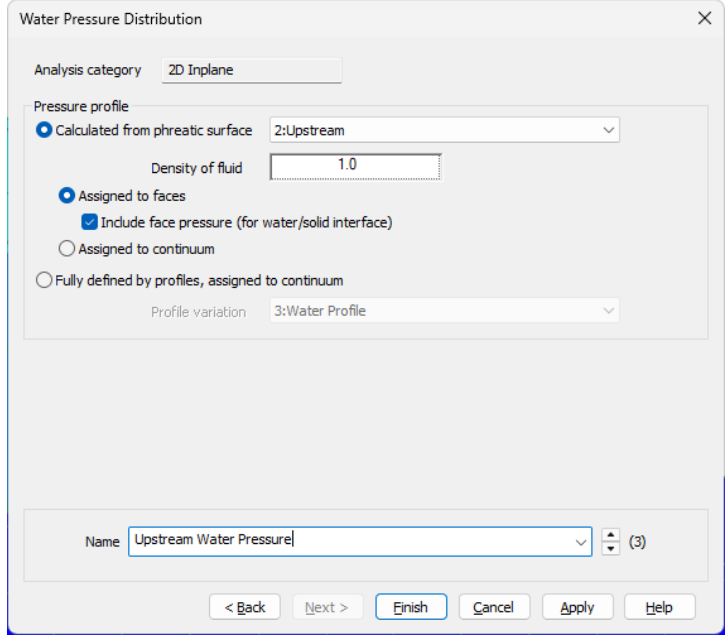
To simulate changes in the water level in the reservoir, we establish the phreatic surface using the command: **Attributes > Pore Water Pressure > Phreatic Surface**. The resulting attribute is then applied to a line feature as shown.



Assigning the phreatic surface

As the water level rises, this line will need to be moved upward. To achieve this, we define a displacement of 6m in the Y direction for the line using the command **Attributes > Loading** choosing **Displacement, velocity, acceleration** for a **Prescribed displacement** and then assign this to the line.

Finally, to calculate and obtain the water pressure distribution from the established phreatic surface, we create a water pressure distribution attribute using the command **Attributes > Loading** choosing **Distributed loading** and then **Water Pressure Distribution** and link it to the previously established Phreatic Surface attribute.



Water pressure distribution

Self-weight is considered by right-clicking on the loadcase in the Analyses Treeview and selecting **Gravity**.

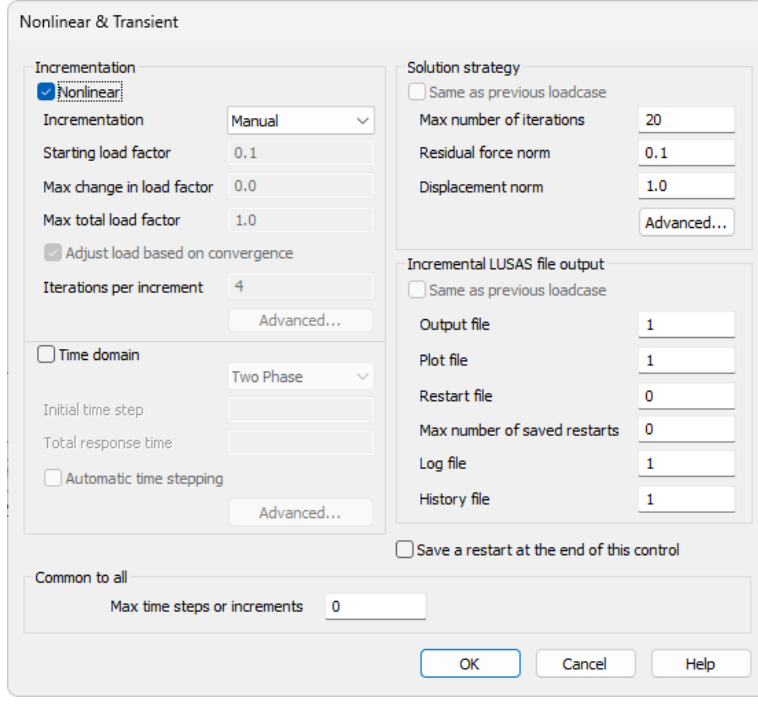
Construction stages

Two construction stages are considered.

1. Initial Phase

This stage simulates the initial conditions where we have the initial level of water level of 4m. Nonlinear analysis control properties are defined for this phase, with the number of iterations increased to 20 as the initial stage takes longer to convergence than the default number provided on the dialog.

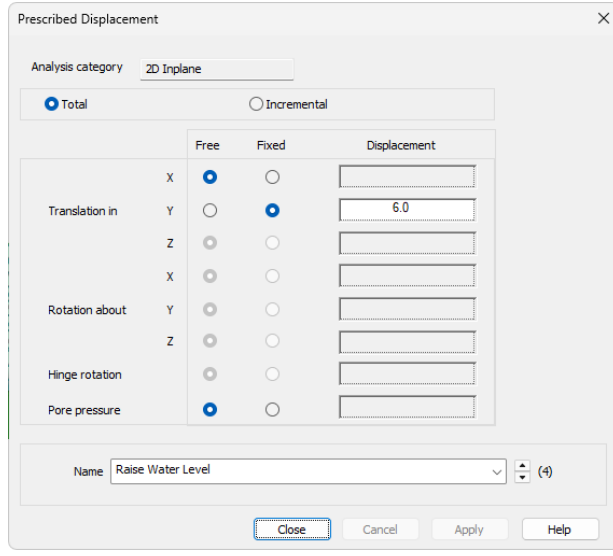
Line searches are also searched are switched off via the Advanced button of the Solution strategy panel.



Increase maximum number of iterations

2. Rising Water Level

Using a **Prescribed Displacement** load of 6m assigned to the line representing the water level, it is raised up to sit at a height of 10m.



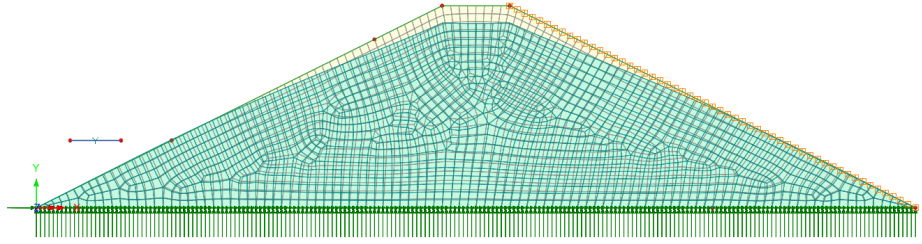
A prescribed displacement of 6m.

Running the Analysis

Press **OK** to run the analysis.

Viewing the results

Analysis loadcase results are present in the Treeview. The view will show this.

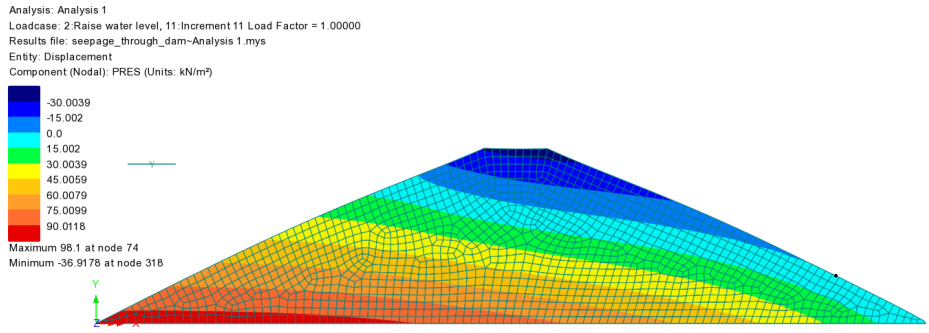


Pore Pressure

To see pore pressure contours for the final phase:

- Set active the **Raise water level** loadcase.

- Turn off the display of the geometry and mesh layers, and the supports and loading.
- Add the **Contours** layer and select entity **Displacement** and component **PRES.**

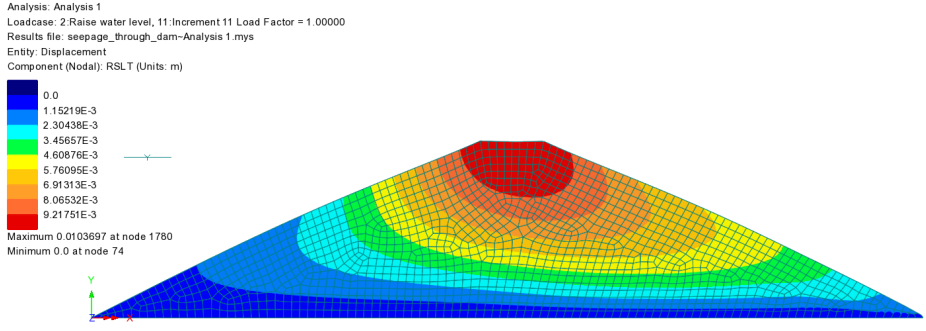


Pore pressure contours (water level at 10m)

Downstream Displacement

To see the resultant displacement when the reservoir is full:

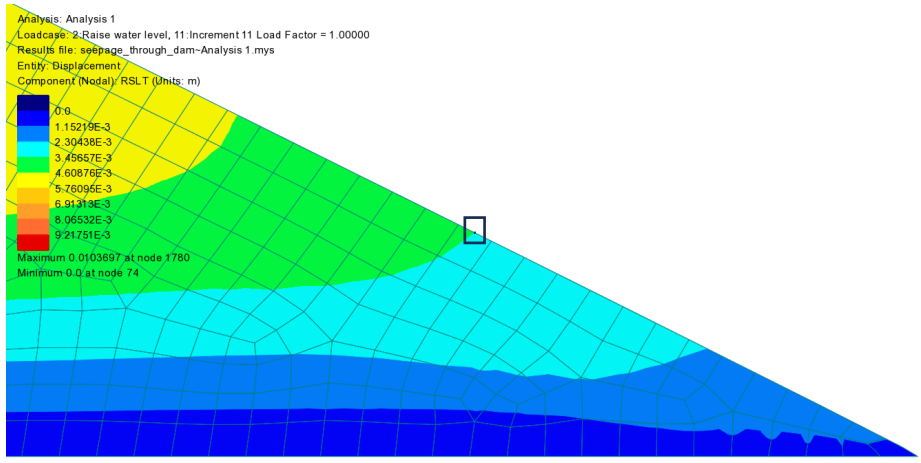
- Change the contours layer to show contours of entity **Displacement** and component **RLST**.



Resultant displacement (water level at 10m)

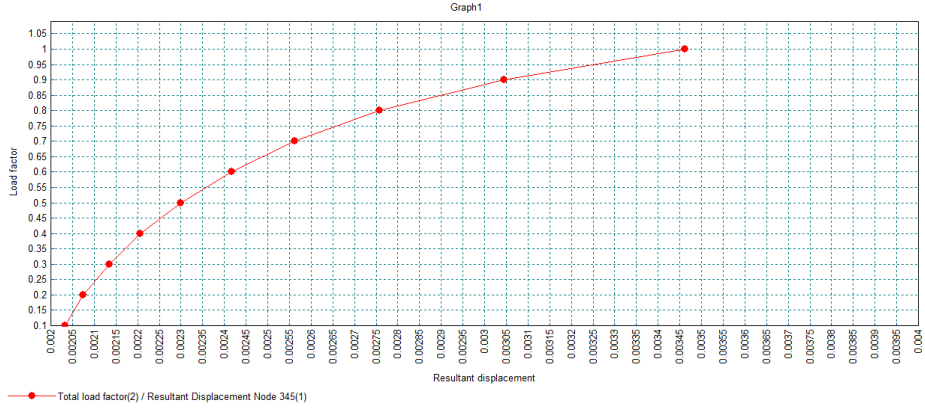
A graph of resultant displacement of a chosen node in relation to water level can be produced as follows:

- Select a node on the downstream face. The one at the contour boundary shown has been selected in this example.



Selection of node for graphing purposes (water level at 10m)

- Use **Utilities > Graph wizard** to create a graph of time history of nodal resultant displacement for only the load increments related to the raising of the water against the total load factor.



Graph of resultant displacement of a chosen node in relation to water level