Simple Slope with Water table

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

Problem Description

This example examines the stability of an embankment with a water table. The definition of the water table is covered in detail.

Keywords

2D, Plane Strain, Modified Mohr-Coulomb, phi-c, phreatic surface.

Associated Files

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

- **Simple_slope_with_water_table.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.

Discretisation

The model is meshed using two phase quadratic triangular plane strain elements (TPN6P). The bottom surface is fully restrained whilst the sides are allowed to displace vertically. A phreatic surface is prescribed within the domain with water pressure increasing linearly above and below it. Figure 1 shows the problem geometry and Figure 2 the mesh and boundary conditions.

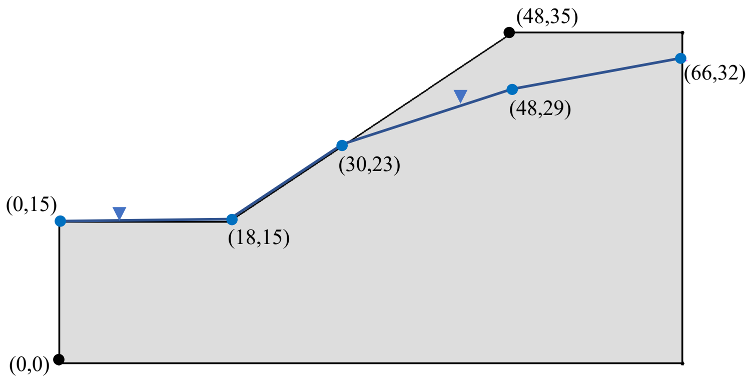

Figure 1: Problem geometry

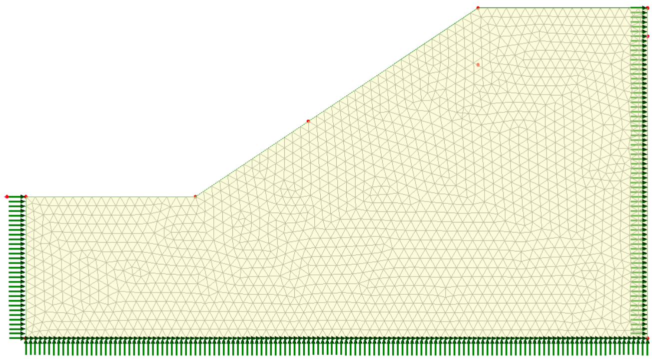

Figure 2: Mesh and boundary conditions

Material Properties

The soil properties are listed in table 1.

Table 1: Material properties

Mass density	Young's modulus, E	Poisson's ratio, ν	Friction angle, φ^o	Dilation angle, ψ^o	Cohesion, c	Rankine stress, σ_1
1.918 t/m^3	50E3 kPa	0.4	15.0	0	41.65 kPa	150 kPa

Table 2: hydraulic properties

Bulk modulus of water	Porosity	Hydraulic conductivity	Density of water	Saturation at residual water content	Saturation at full water content
2.2E6 kPa	0.3	0.1 m/day	1.0 T/m^3	0.0	1.0

Loading Conditions

Gravity loading is applied.

Modelling Hints

The pore water pressure distribution is generated from a 'Profile Variation'. A single profile relating water pressure to depth is assigned to each of the five points defining the linear segments shown in figure 1. The profile is extrapolated to cover the top and bottom of the problem domain. The definition of the pore water pressure distribution is detailed in the following.

From **Attributes > Loading…** click the radio button **Distributed loads** and then **Water Pressure Distribution** followed by **Next>** (figure 3).

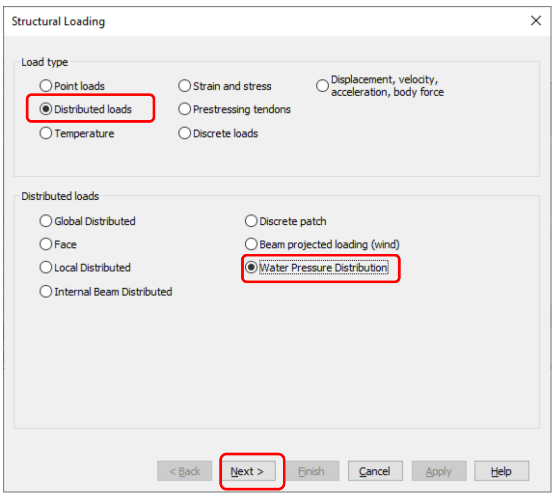

Figure 3: Structural loading dialog

Click the radio button **Fully defined by profiles, assigned to continuum** (figure 4). Then click the arrow in the **Profile variation** dropbox and click on **New…**

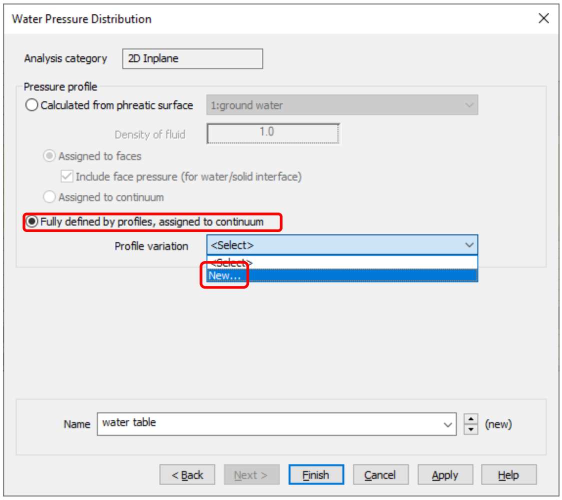

Figure 4: Water pressure dialog

On following dialog select **Profile variation** and click **Next>** (figure 5).

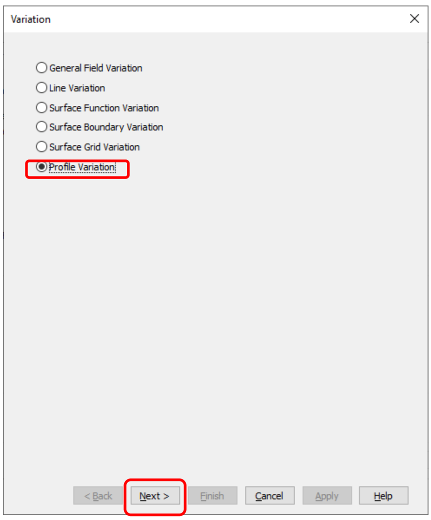

Figure 5: Variation dialog

On the **Profile Variation** dialog click on **New…** to define a new variation (figure 6).

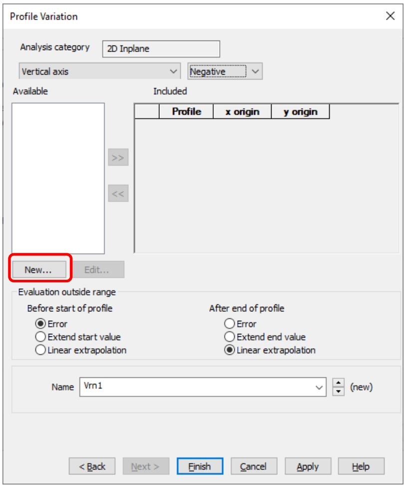

Figure 6: Profile variation dialog

In the line variation dialog enter (0,0) and (1,9.81) (ie the pressure at 1m's depth). In the **Name** field enter 'hydrostatic pressure' and then click **OK** (figure 7).

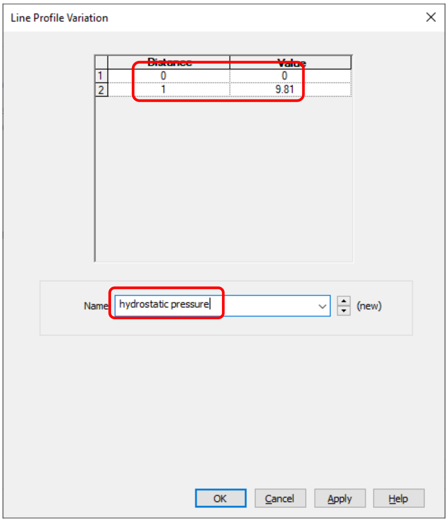

Figure 7: Line variation dialog

Now click 'hydrostatic pressure' followed by the double chevrons >> (figure 8).

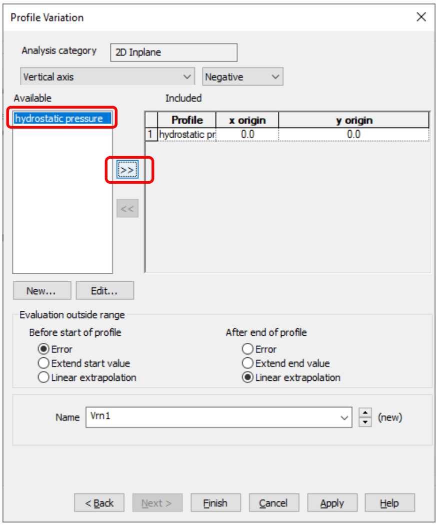

Figure 8: Select profile

In the profile origin fields enter (0,15) to mark the starting point of the profile. Click on the radio button **Linear extrapolation** in the **Before start of profile** section and confirm that **Linear extrapolation** is set in the **After end of profile** section (figure 9).

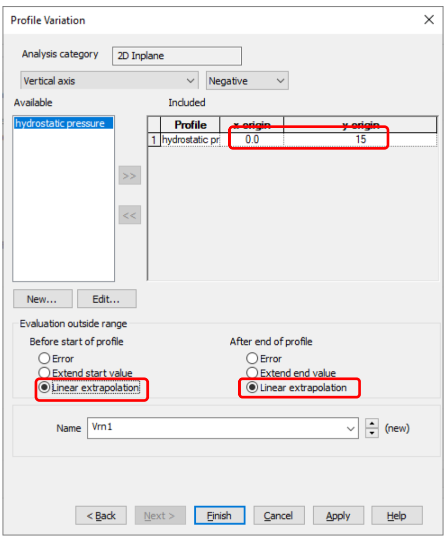

Figure 9: Enter profile details

Repeat for each of the points (18,15), (30,23), (48,29) and (66,32). Finally, enter 'water table' in the **Name** field and click on **Finish** (figure 10).

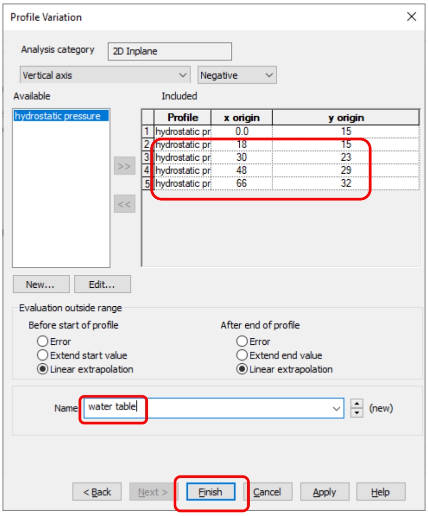

Figure 10: Finish water pressure distribution definition

Enter 'water table' in the **Name** field and click on **Finish** (figure 11).

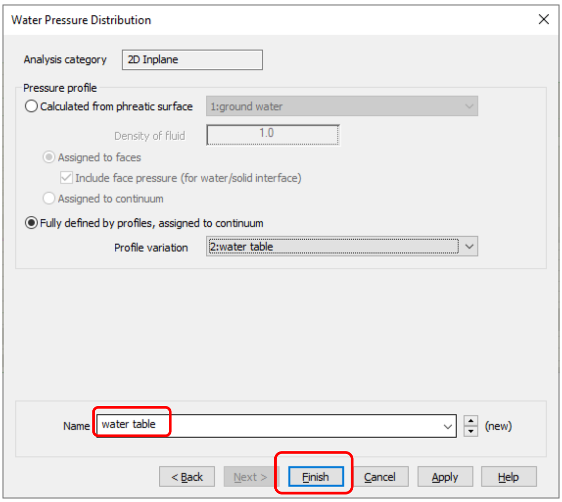

Figure 11: Name water pressure distribution

The water table load appears in treeview (figure 12). It is assigned to all the model surfaces.

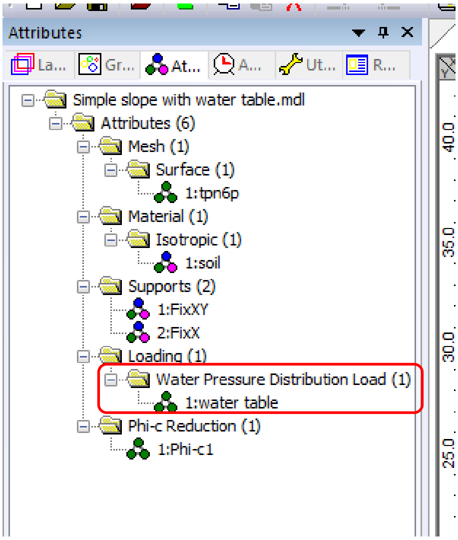

Figure 12: Water pressure load in treeview

The phi-c convergence tolerance is increased from 0.01 to 0.001 to compare with the other solutions which are quoted to three decimal places.

Comparison

The porewater pressure distribution is shown in figure 13.

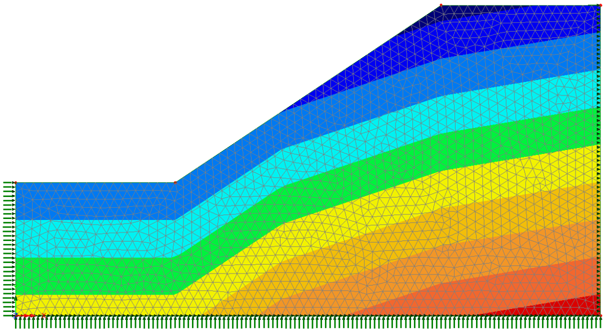

Figure 13: Pore water pressure distribution

Figure 14 shows contour plots of effective strain. At the start of the phi-c analysis the slope is already showing signs of failure. At the safety factor SF=1.1 the failure surface is well established but failure is contained by the fixed boundary on the left-hand side. At SF=1.145 the upper failure surface starts to form which is fully complete at SF=1.148.

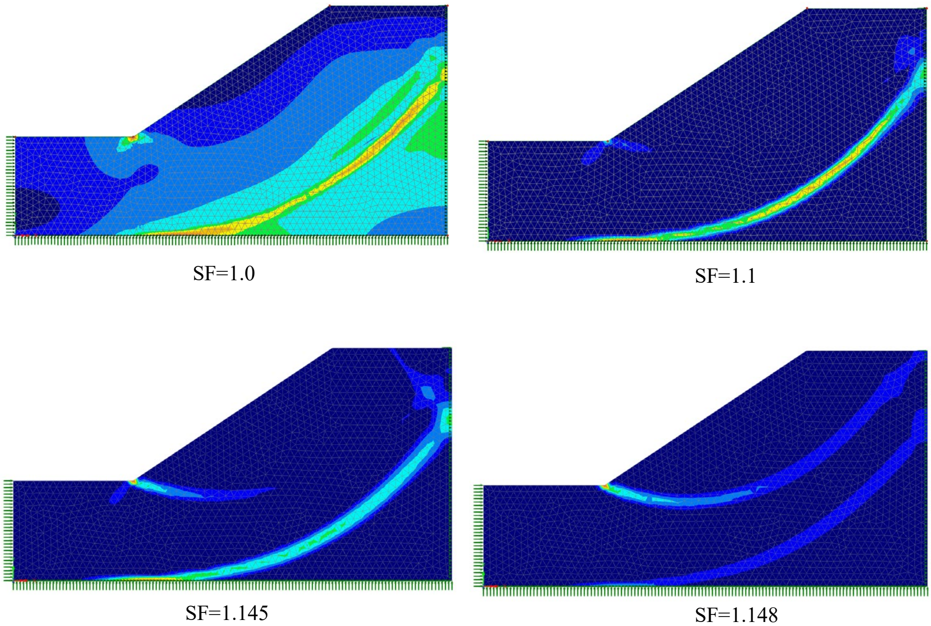

Figure 14: Plots of effective strain at different safety factors

The factor of safety is compared to other results [1] in table 3 with LUSAS giving a slightly higher result than the other methods.

Table 3: Factor of safety for different solution methods

<table>
<tr><th rowspan="2">Method</th><th colspan="2">Factor of safety</th></tr>
<tr><th>Circular surface</th><th>Non-circular surface</th></tr>
<tr><td>Bishop</td><td>1.117</td><td></td></tr>
<tr><td>Janbu simplified</td><td>1.046</td><td></td></tr>
<tr><td>Janbu corrected</td><td>1.131</td><td></td></tr>
<tr><td>Spencer</td><td>1.118</td><td></td></tr>
<tr><td>RS2</td><td colspan="2">1.09</td></tr>
<tr><td>LUSAS MMC</td><td colspan="2">1.148</td></tr>
</table>

References

[1] RS2