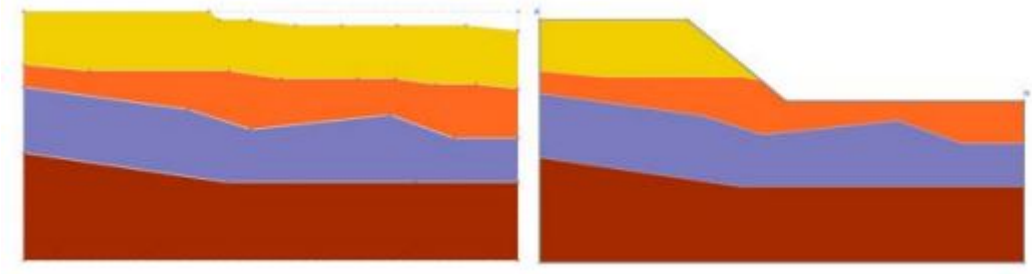
rocscience

Soil Profile Modelling

1. Introduction

The Soil Profile option is an extension of geometry modelling capabilities in Slide2. It allows you to define a master profile of your material boundaries (e.g. geological or soil profile) and ground surface. The profile is then used as a base template, over which you can use the regular boundary options (e.g. Add External, Add Material) to superimpose different slope geometries (e.g. cut back a slope).



Soil profile boundaries (left) and slope external boundary (right) superimposed on profile

The general procedure to use the Soil Profile option is as follows:

1. **Project Settings** - First enable the Soil Profile checkbox in the Project Settings dialog.

2. **Profile Mode** - a Profile workflow tab will appear, and the soil profile modelling options (e.g. Add Soil Profile Boundary, Borehole Editor) will be enabled in the menus and toolbar. NOTE: to define or edit the Soil Profile, the Profile tab must always be selected. The Soil Profile Mode can also be selected from the Analysis menu.

3. **Profile Extents** - in the sidebar at the left of the screen, a Profile Extents input option will appear. This allows you to input the limits (left, right, top, bottom) of the Soil Profile region you wish to define. Input the desired limits, and the corresponding rectangular region will be highlighted by a dotted line.

4. **Profile Boundaries** - you must then define the Soil Profile Boundaries. There are two methods of doing this:

• Boundaries can be explicitly defined using the Add Soil Profile Boundary option.

• Boundaries can be interpolated from borehole data using the Borehole Editor dialog.

Profile boundaries can represent material boundaries, the ground surface or other boundaries.

5. **Assign Material Properties** - material properties can then be assigned to the regions defined by the profile boundaries. Properties can be assigned from the right-click shortcut menu or with the Assign Properties dialog.

6. **Excavation Assignment** - if you need to define excavated regions of the profile (e.g. above the ground surface and below the upper Profile Extent), this can also be assigned using the right-click assign a shortcut.

7. **External Boundary** - when your profile boundaries and material assignments are completed, you can move on to the Geometry workflow tab, to define the External Boundary of the slope you wish to analyze. There are TWO options for adding an External Boundary, when you are using the Soil Profile option:

• The external boundary can be entered as a user-defined polyline, OR

• The external boundary can be initially defined with a rectangular window, which is then used to "clip" the desired region of the profile, and the external boundary will be automatically generated from the clipped region.

In general, the External boundary should be contained within (or overlap) the Profile boundaries/extents, and should not be larger than the Profile Extents.

8. **Material Boundaries** - you can define additional material boundaries, if necessary, while you are in Geometry mode. It is important to note that Soil Profile boundaries (defined in Profile mode) and Material Boundaries (defined in Geometry mode) are independent modelling entities, even though they may both be used to represent material or other types of model boundaries.

In general, you should always be aware of which modelling "mode" you are in (Profile or Geometry), as this will affect the available modelling and editing options.

WHY USE A SOIL PROFILE?

The Soil Profile option may be very useful for some modelling situations, and not useful or applicable for other modelling situations. Here are some guidelines:

• The Soil Profile option should be most useful for models with relatively complex material layering, over which you would like to define several different slope excavation scenarios. For example, an open-pit mine with several material layers, which is to be excavated or cut back in stages. The profile boundaries will remain constant, while you can define different slope boundaries (i.e. external boundary) over the profile.

• The Soil Profile option may not be useful for simple models, where the layering is simple and/or final geometry is fixed. In such cases, it is probably easier to define the entire model in Geometry mode, rather than first defining profile boundaries.

SOIL PROFILE + MULTI-SCENARIO MODELING

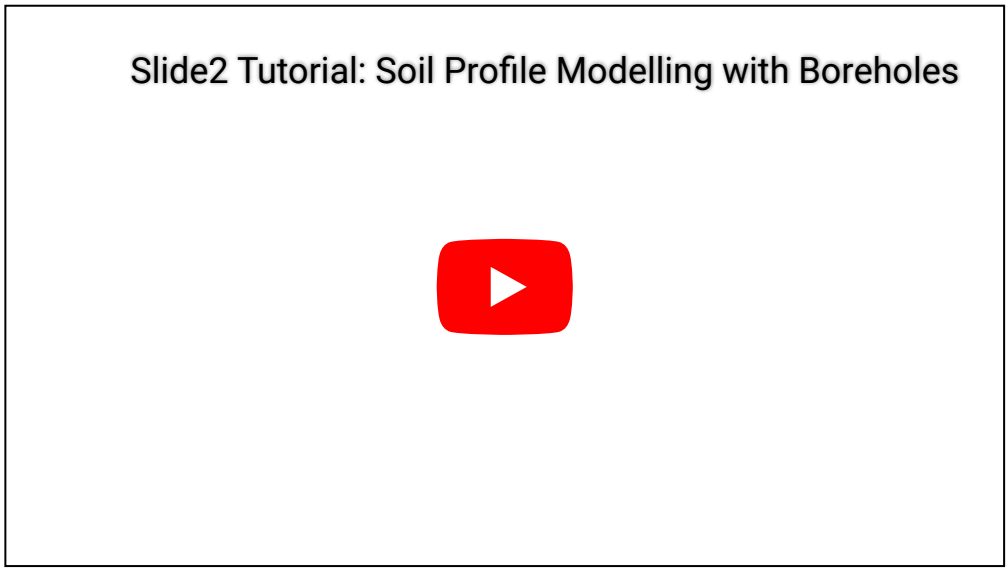
In general, it is helpful to use a Soil Profile in conjunction with Multi Scenario modelling, because the Multi Scenario option allows you to test different slope geometries by defining multiple models and changing the slope geometry for each model.

However, the Soil Profile option does NOT require the use of the Multi Scenario modelling feature of Slide2 and can be used independently.

2. Model

We will now demonstrate the use of the Soil Profile option using a simple example.

Want to watch a video version of this tutorial? Check it out here:

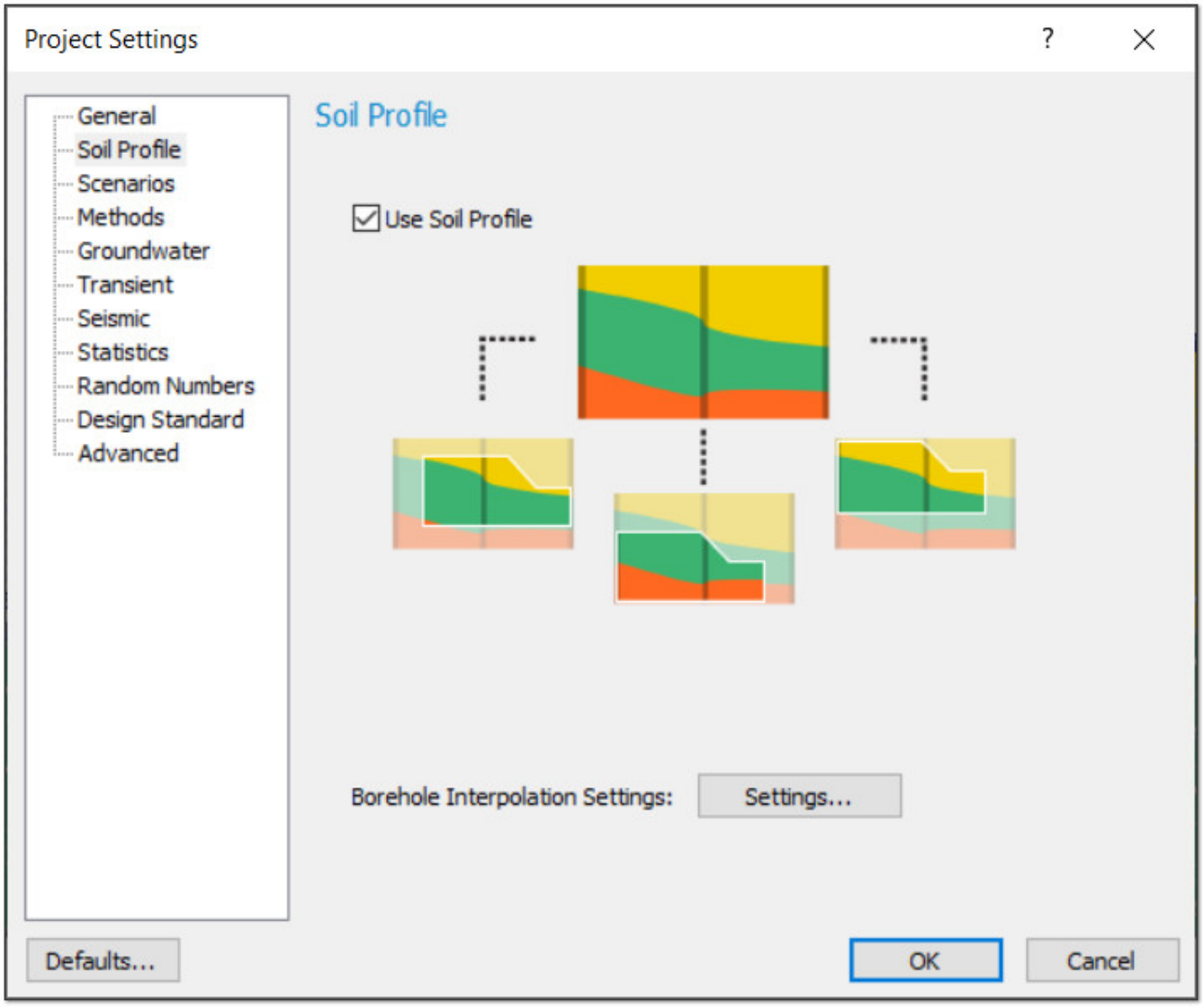


PROJECT SETTINGS

Turn on the Soil Profile option in Project Settings.

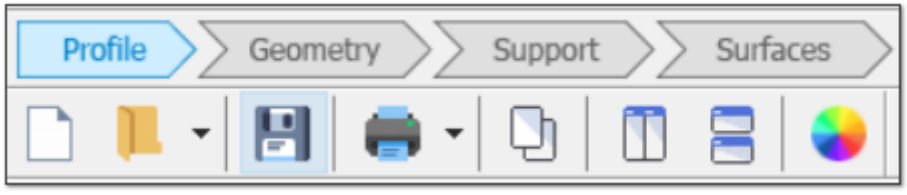
Select **Analysis > Project Settings**

Select the **Soil Profile** page, and select the **Use Soil Profile** checkbox. Select **OK**.



PROFILE MODE

Notice that a Profile workflow tab now appears at the left of the tabs.



In order to define or edit the Profile extents and boundaries, the Profile tab must be selected.

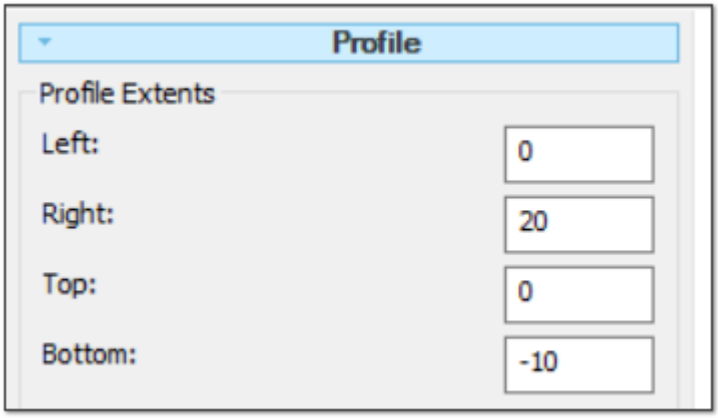
PROFILE EXTENTS

The **Profile Extents** define a rectangular region which defines the limits of the profile boundaries you wish to define. The Profile Extents are entered in the sidebar at the left of the screen, and can only be entered when you are in Profile Mode.

For this example, enter the following Profile Extents:

- Left: 0

- Right: 20
- Top: 0
- Bottom: -10



Notice that the Profile Extents are displayed as a rectangular dotted line in the model view.

PROFILE BOUNDARIES

Now let's define the **Profile Boundaries**. Profile boundaries can represent material boundaries, the ground surface or other boundaries. There are two possible ways of defining the profile boundaries.

• Boundaries can be explicitly defined using the **Add Soil Profile Boundary** option.

• Boundaries can be interpolated from borehole data using the **Borehole Editor** dialog.

We will use the first method:

1. Select **Boundaries > Add Soil Profile Boundary**
2. Enter the coordinates (0, -40) and (100, -30) and press Enter.

   Let's add three more profile boundaries.

3. Repeat **Step 1** three more times and enter the following coordinates.

- - (0,-30) and (100,-20)
  - (0,-20) and (100,-10)
  - (0,-10) and (100,0)

ASSIGN MATERIALS

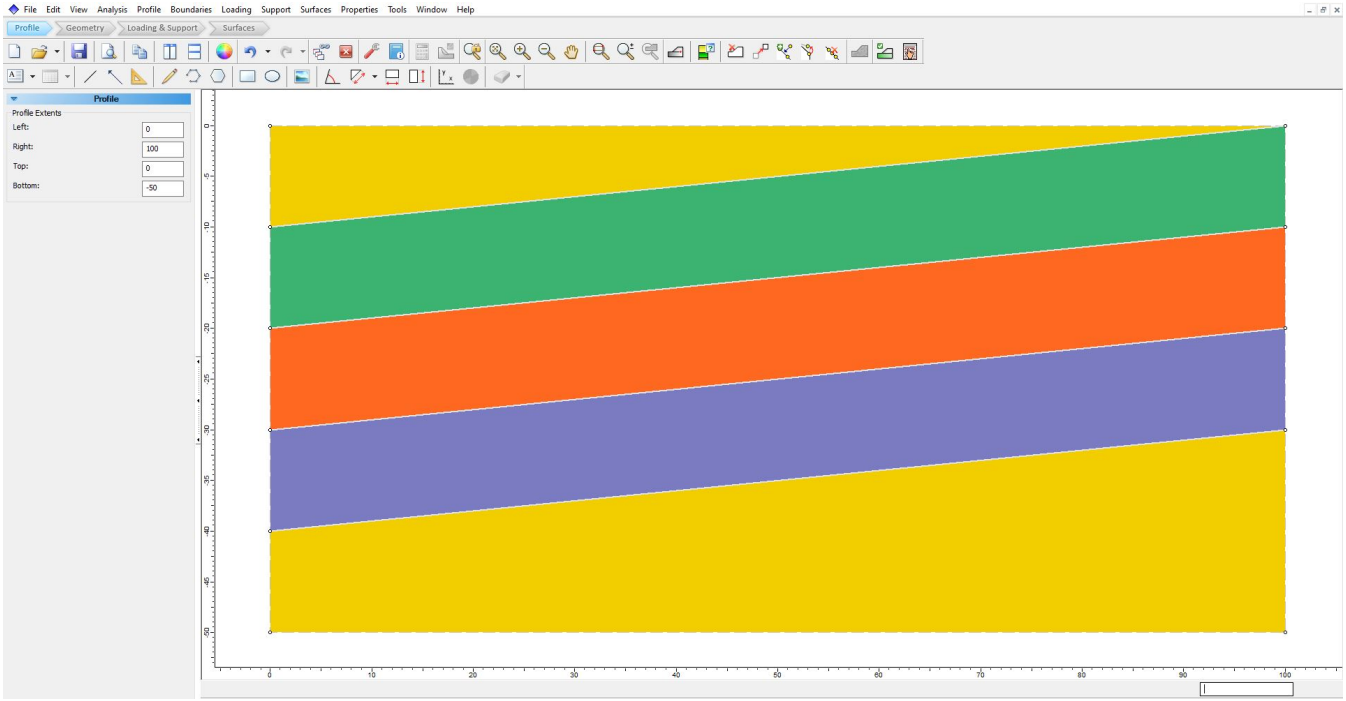
Now let's assign materials to the regions created by the profile boundaries.

• Right-click the mouse between the first and second profile boundaries (from the top) and select **Assign > Material 2** from the popup menu.

• Right-click the mouse between the second and third profile boundaries (from the top) and select **Assign > Material 3** from the popup menu.

• Right-click the mouse between the third and fourth profile boundaries (from the top) and select **Assign > Material 4** from the popup menu.

The model should look as follows.

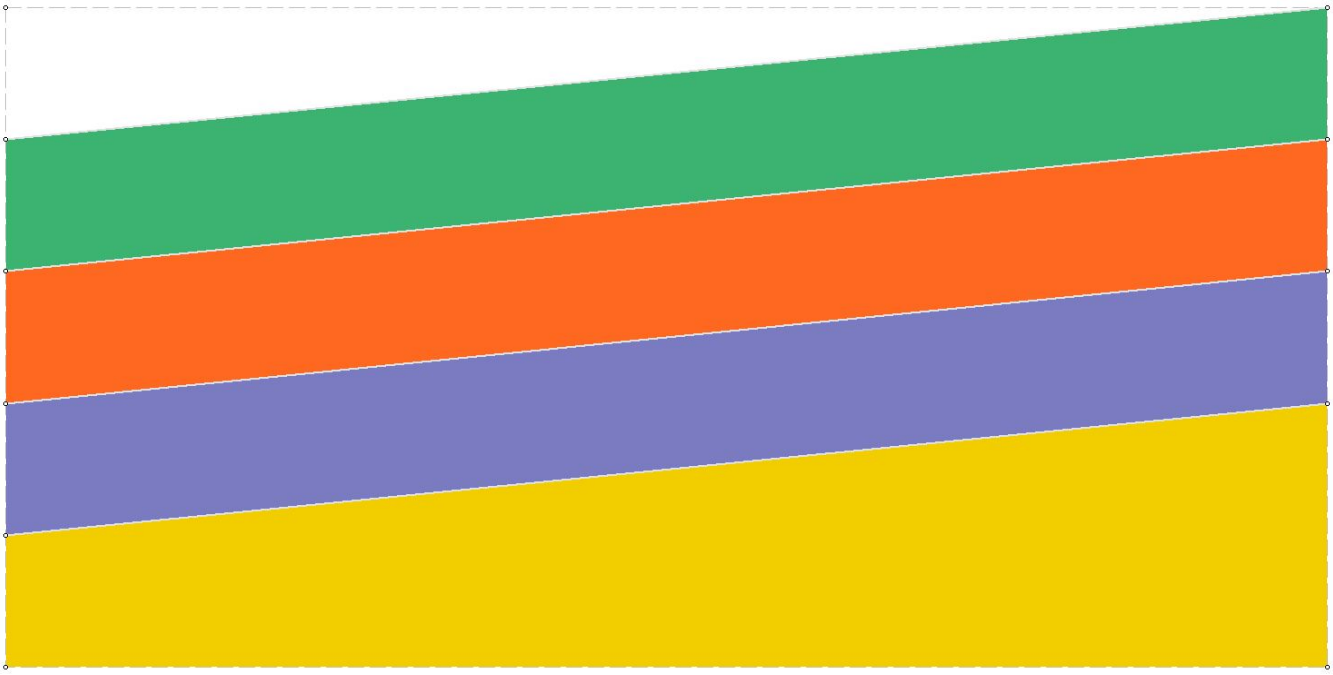


ASSIGN EXCAVATION

You can also excavate regions at the top of the profile, to define a ground surface. Let's do that now.

• Right-click the mouse in the triangular region at the top of the soil profile, and select **Assign Materials > Excavate.**

The soil profile should look as follows



DEFINE MATERIALS

Now let's define the material properties. To keep things simple, we will make the lower layers stronger by defining a high cohesion value, and the upper layers will have lower strength properties.

Select Define Materials from the toolbar or the Properties menu.

Select **Properties > Define Materials**

Enter only the following properties (leave other values at their defaults):

• For Material 1 enter Cohesion = 50 kPa Phi = 35

• For Material 2 enter Cohesion = 10 kPa Phi = 35

• For Material 3 (weak layer) enter Cohesion = 5 and Phi = 25

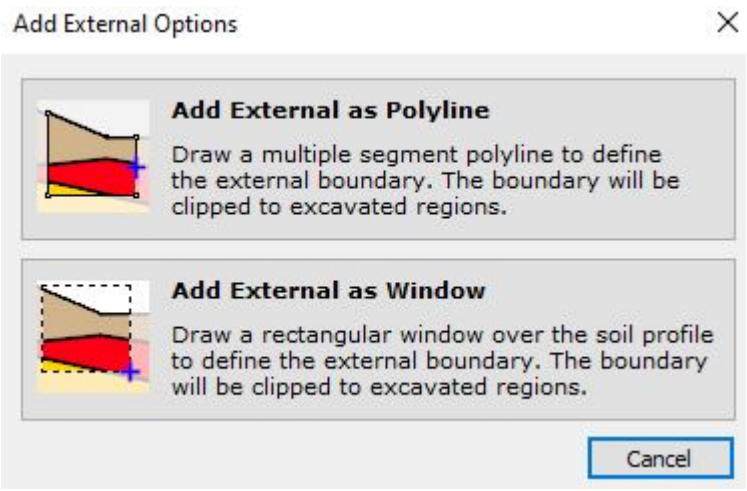
• For Material 4 enter Cohesion = 40 kPa Phi = 35

DEFINE GEOMETRY

Now select the **Geometry** workflow tab, and we will define the **External boundary** for the model. Notice that as soon as you select the Geometry tab, the Profile boundaries and materials are displayed in a semi-transparent shade, since you are no longer in Profile mode.

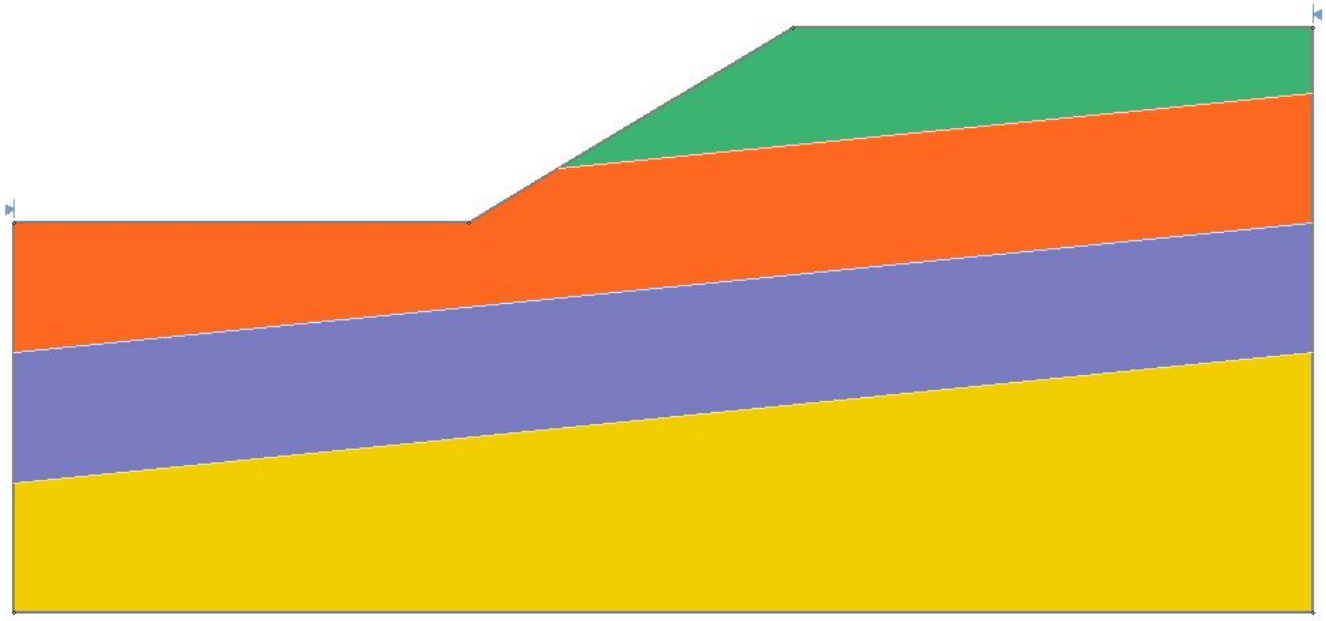
Select **Boundaries > Add External Boundary**

When you are using the **Soil Profile** option, and you select **Add External Boundary**, you will first see a dialog which gives you two methods of Adding the external boundary. We will use the first method. Select the **Add External as Polyline** option.



Enter the following coordinates for the External Boundary: (0, -50), (100, -50), (100, -5), (60, -5), (35, -20), (0, -20)

Press **Enter**. The slope model should look as follows. As you can see, the Soil Profile boundaries are "cropped" by the External Boundary.



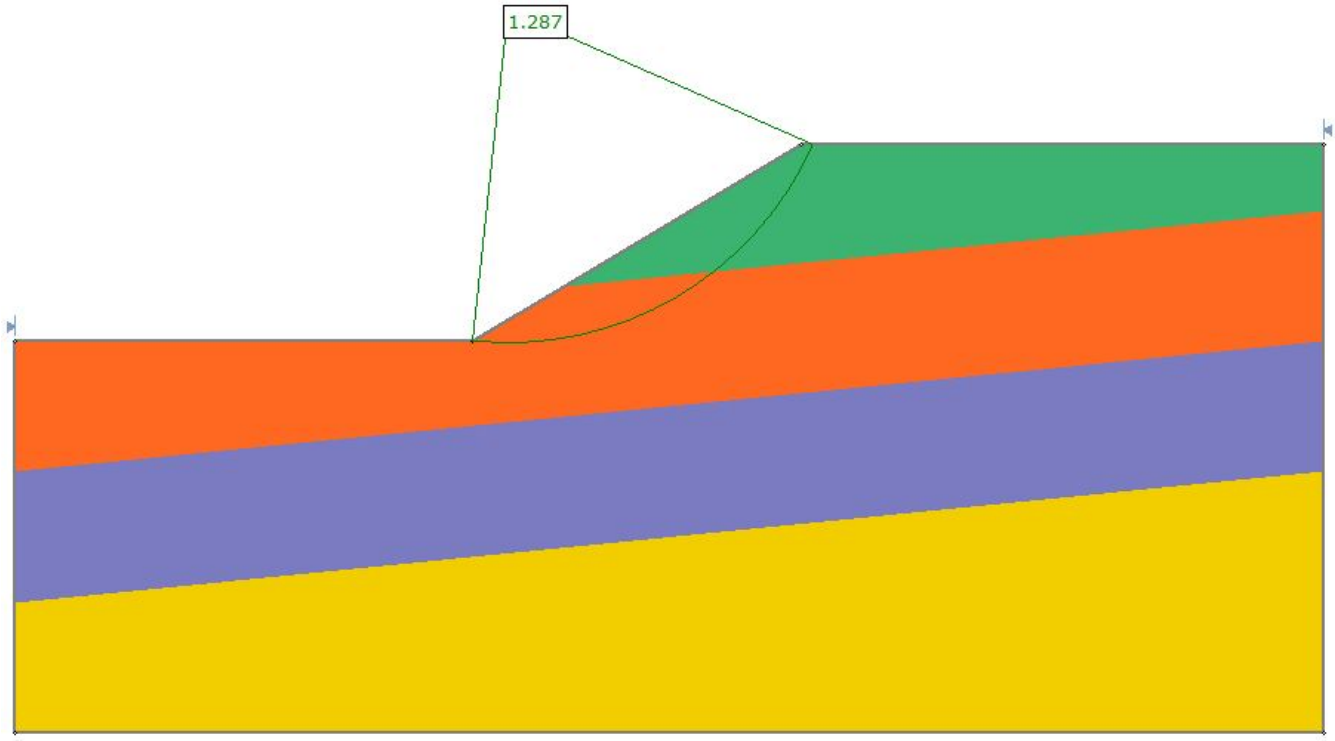
SURFACES

For the slip surface search, we will use the Auto Refine Search Method for Circular Slip surfaces.

1. Select **Surfaces > Surface Options**
2. Choose the **Auto Refine Search** method and select **OK**.
3. Save the file as *Tutorial 25.slmd*.
4. Select Compute to run the analysis.
5. View the results in **Interpret**.

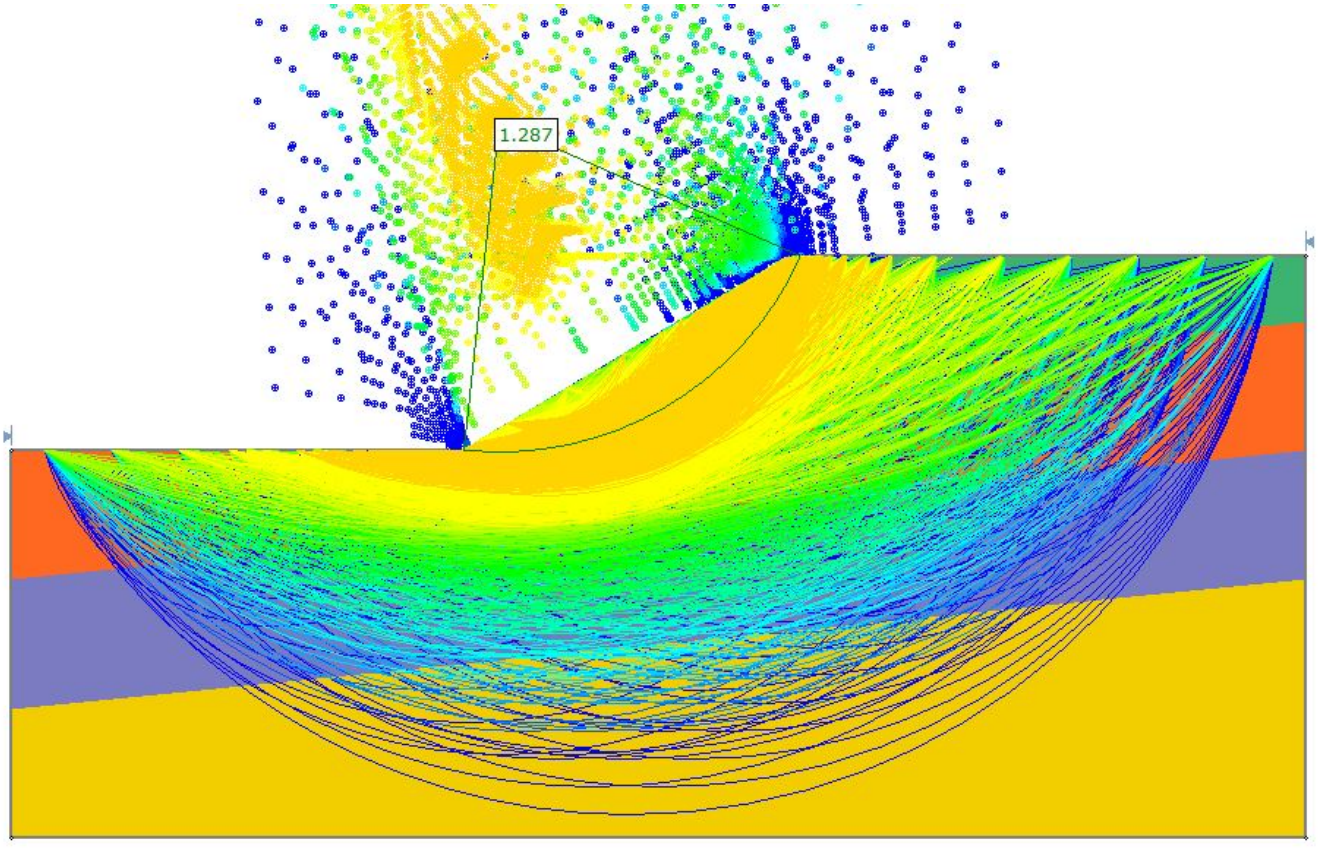
3. Interpret

The Global Minimum (Bishop) safety factor is 1.287. The circular surface goes through the toe of the slope and the weak layer.



Turn on the All Surfaces option to view all slip surfaces generated by the Auto Refine search.

Select **Data > All Surfaces**



Now we will demonstrate how you can use the Soil Profile option, in conjunction with the Multi Scenario modelling option, to analyze different slope geometries while maintaining a

constant soil profile. Return to the Slide2 model program.

4. Model

Change the name of Group 1 to Slope Angle 31 Degrees.

Duplicate the Slope Angle 31 Degrees Group and name the new group Slope Angle 45 Degrees.

CHANGE SLOPE ANGLE

Make sure Slope Angle 45 degrees is the selected view.

Let's change the slope angle.

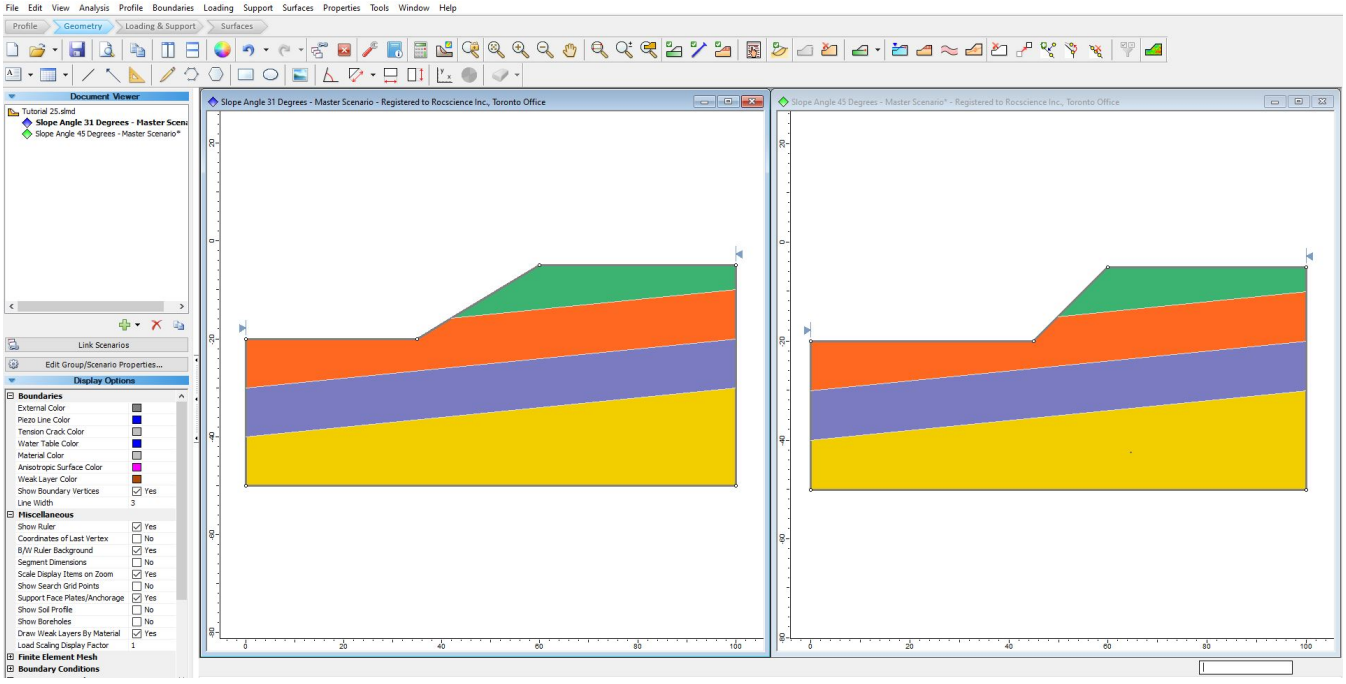
1. Right-click the mouse on the vertex at the toe of the slope.

2. Select Move To from the popup menu.

3. Notice that the Soil Profile becomes visible, and as you move the mouse, the external boundary vertex will interactively follow the mouse position, as shown below.

4. Rather than entering the point graphically, enter the exact coordinates (45, -20) in the prompt line.

5. Tile the views



You have now created two models which are identical, except for the slope angle, using the Soil Profile option in conjunction with the Multi Scenario option

5. Compute

Select Compute.

Select **Analysis > Compute**

In the multi-scenario Compute dialog, make sure both scenario checkboxes are selected. Select OK to run the analysis.

6. Interpret

Both scenario models are automatically opened in Interpret. Select the Slope Angle 45 degrees scenario view.

The Global Minimum circular slip surface has a Factor of Safety = 0.904, so increasing the slope angle has caused the slope to become unstable.

7. Summary

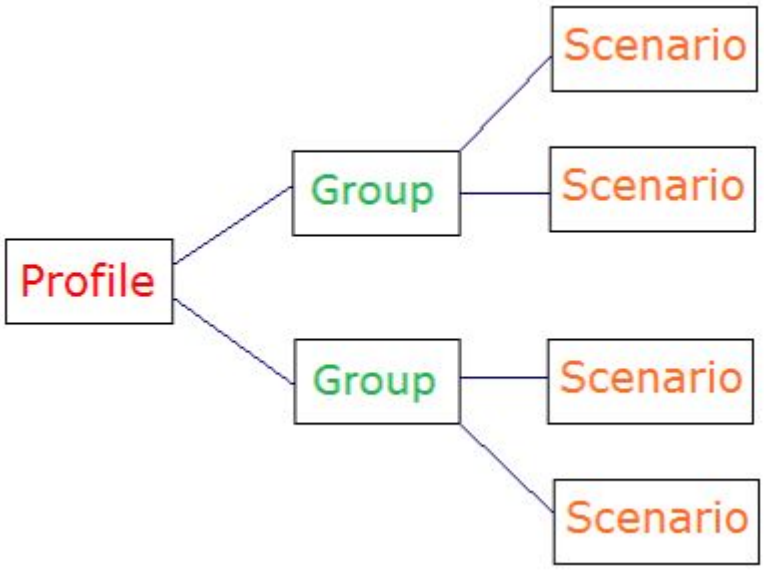
The simple example shown here was for the purpose of demonstrating the modelling procedure when using the Soil Profile option.

It is important to note that you may create much more complicated soil profile boundaries and slope geometry, using all of the modelling and editing capabilities of Slide2. In fact, the Soil Profile option is most useful when working with complicated boundaries, since it can save a great deal of modelling effort.

Furthermore, soil profile boundaries can be easily edited using the same editing options used for other geometry, although you must be in Profile mode to edit Profile boundaries. When you edit the soil profile boundaries, all associated models will be accordingly updated (e.g. if you are using the Multi Scenario option).

SOIL PROFILE + MULTI-SCENARIO

The Soil Profile option is most useful when used in conjunction with Multi Scenario modelling. When you use Soil Profile + Multi Scenario modelling, this creates a three-level modelling hierarchy as follows:



1. The Soil Profile is constant for ALL groups/scenarios. If the Profile is edited, the changes will propagate to all scenarios in all groups.

2. The External boundary is constant for EACH group but can vary between groups. If the external boundary is edited, it will propagate to all scenarios within that group.

3. All other input can be modified individually for EACH scenario.

Also note:

• The material properties database is common to all groups/scenarios.

• Any number of groups and/or scenarios can be defined.

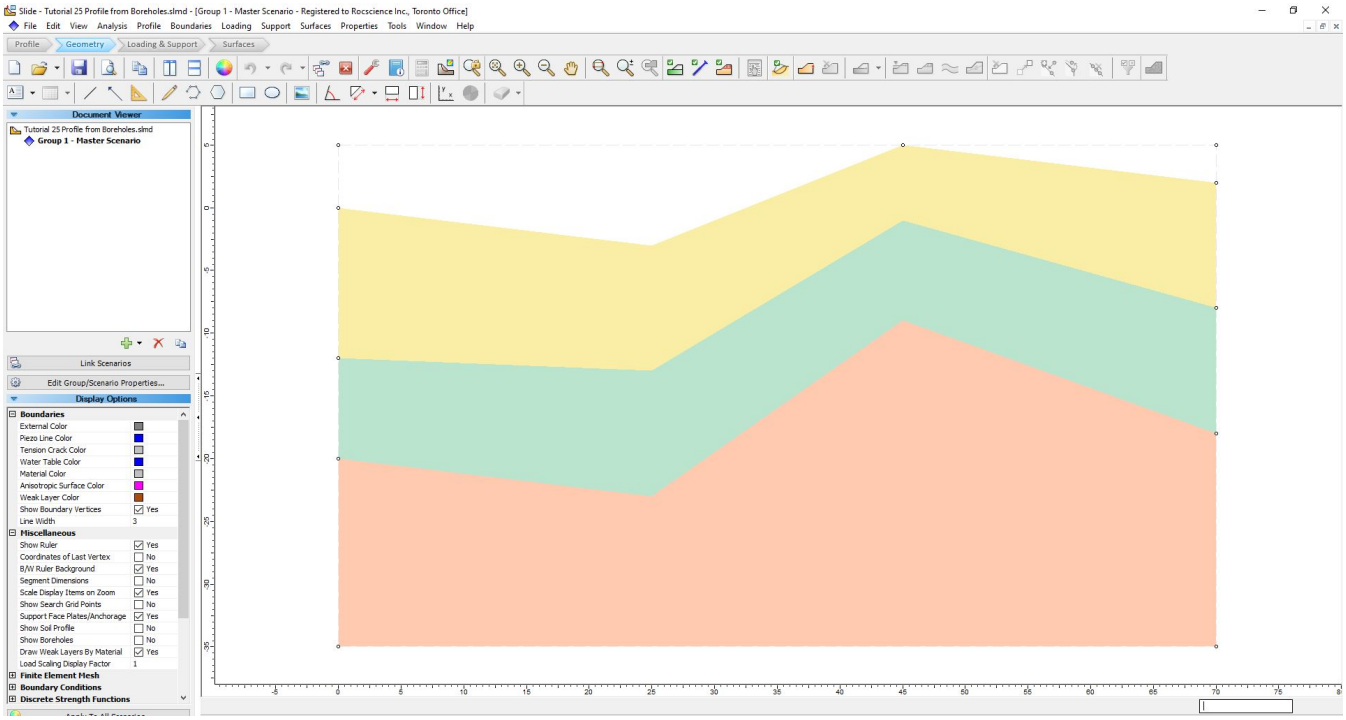
• Each group will always have at least one scenario.

8. Soil Profile from Borehole Data

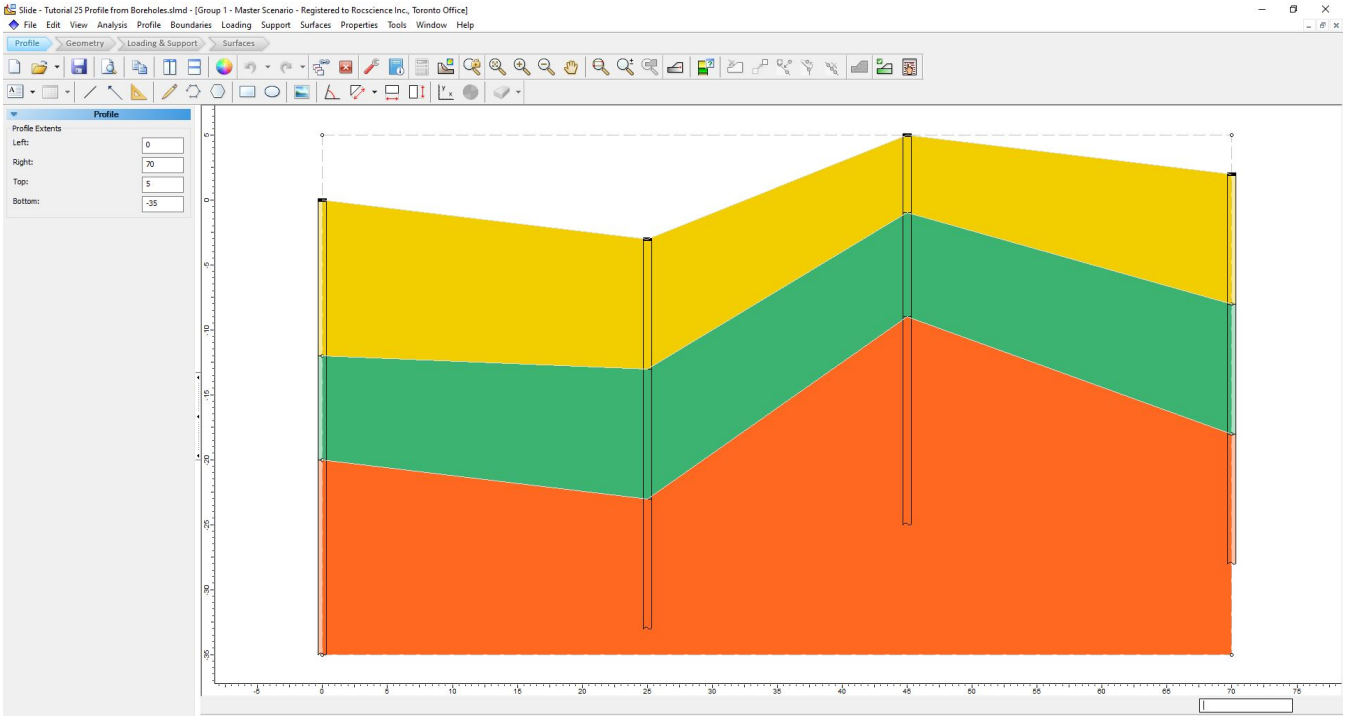
Soil Profile boundaries can also be created from borehole measurements of material layers. We will read in a file to demonstrate this option.

Select **File > Recent Folders > Tutorials** folder, and open the file *Tutorial 25 Profile from Boreholes.slim.*

You should see the following model:

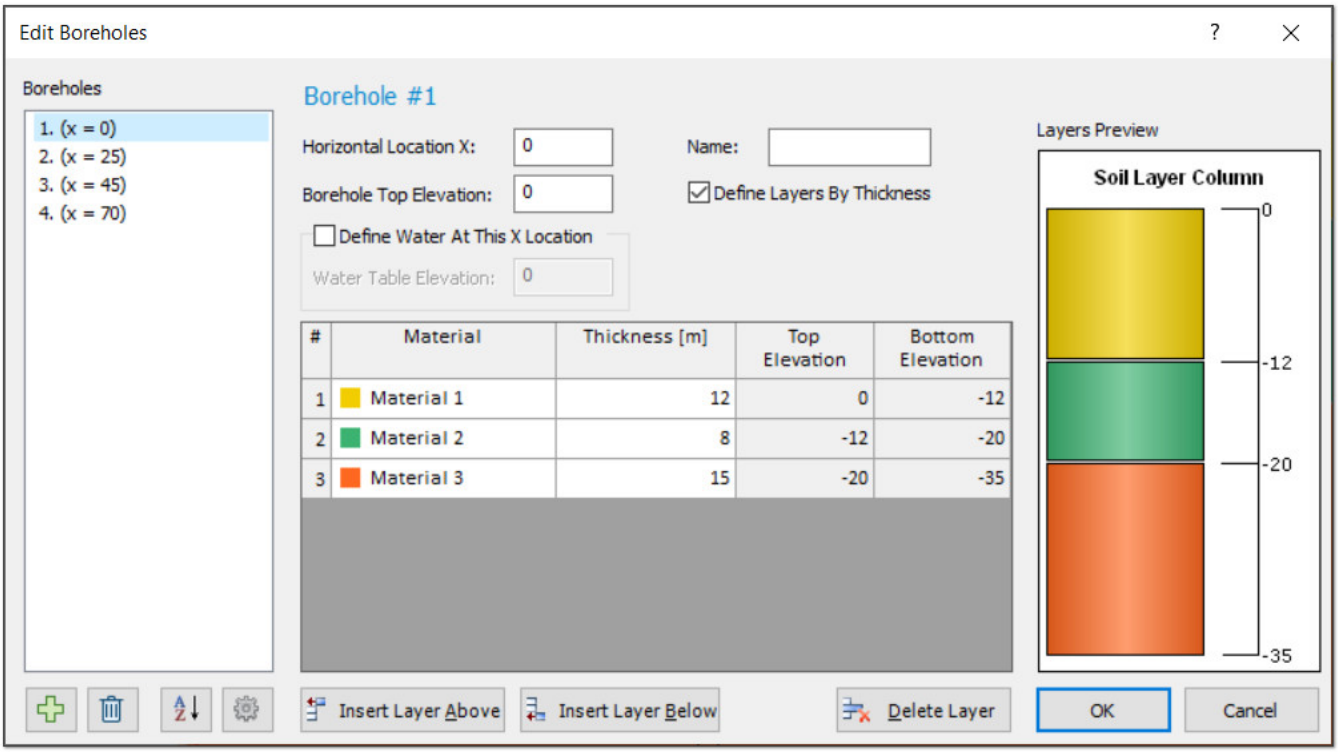


Since you are in Geometry mode, the profile boundaries and material assignments are displayed in a transparent shade. Select the Profile workflow tab to enable editing of the soil profile.



Select the **Borehole Editor** option from the toolbar or the **Profile** menu.

Select: **Profile → Borehole Editor**



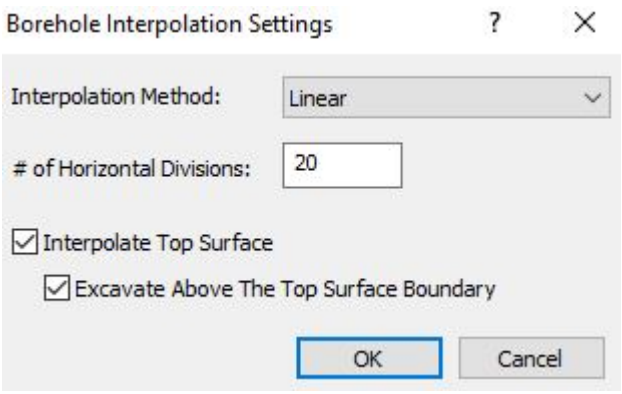
In the Edit Boreholes dialog, note the following:

• In this example, FOUR boreholes have been defined. Click on the list at the left of the dialog, to see the input for each borehole.

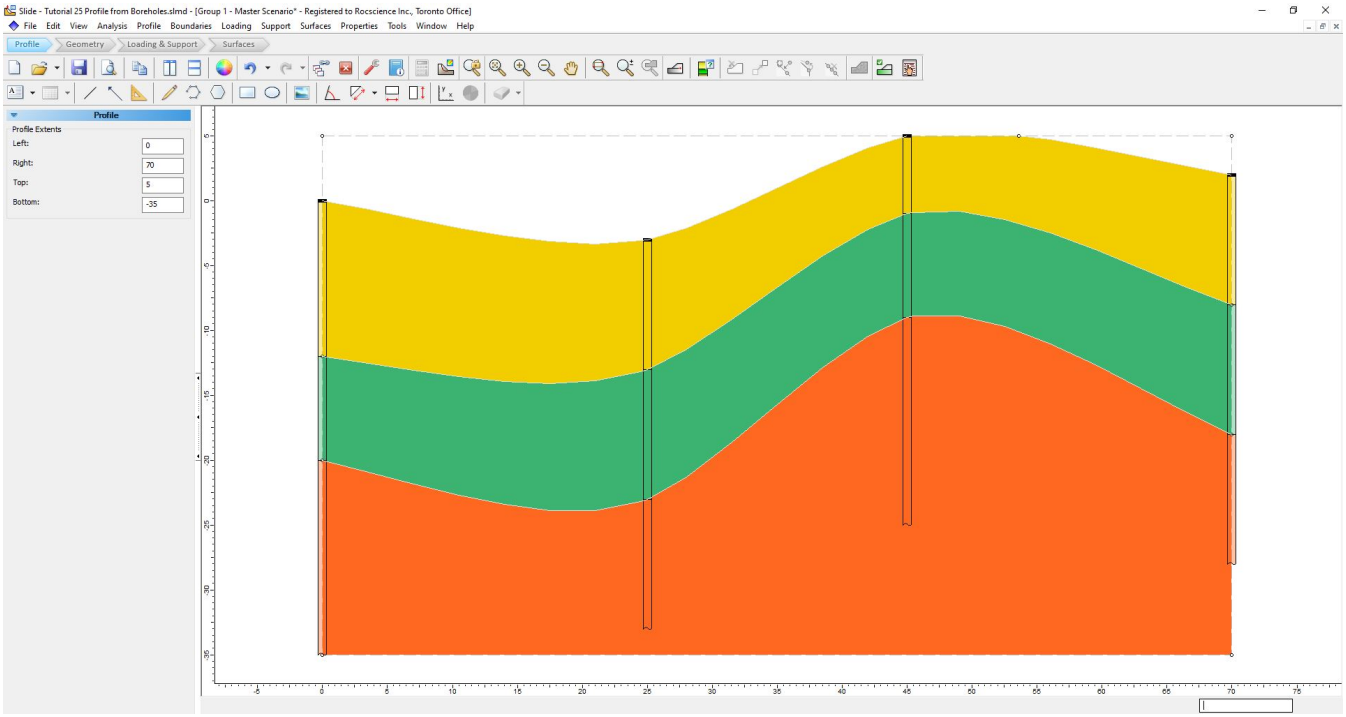
• Boreholes are assumed to be VERTICAL.

• Material layers can be defined by thickness or elevation.

In the dialog, click on the settings button to view the interpolation settings. Notice that the default interpolation method is Linear



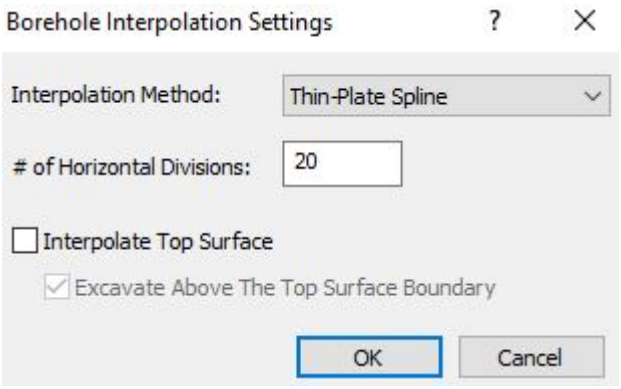
Change the **Interpolation Method** to **Thin Plate Spline**. Select **OK** in both dialogs. The interpolated boundaries are now smooth (instead of linear) due to the spline curve fit of the borehole data.



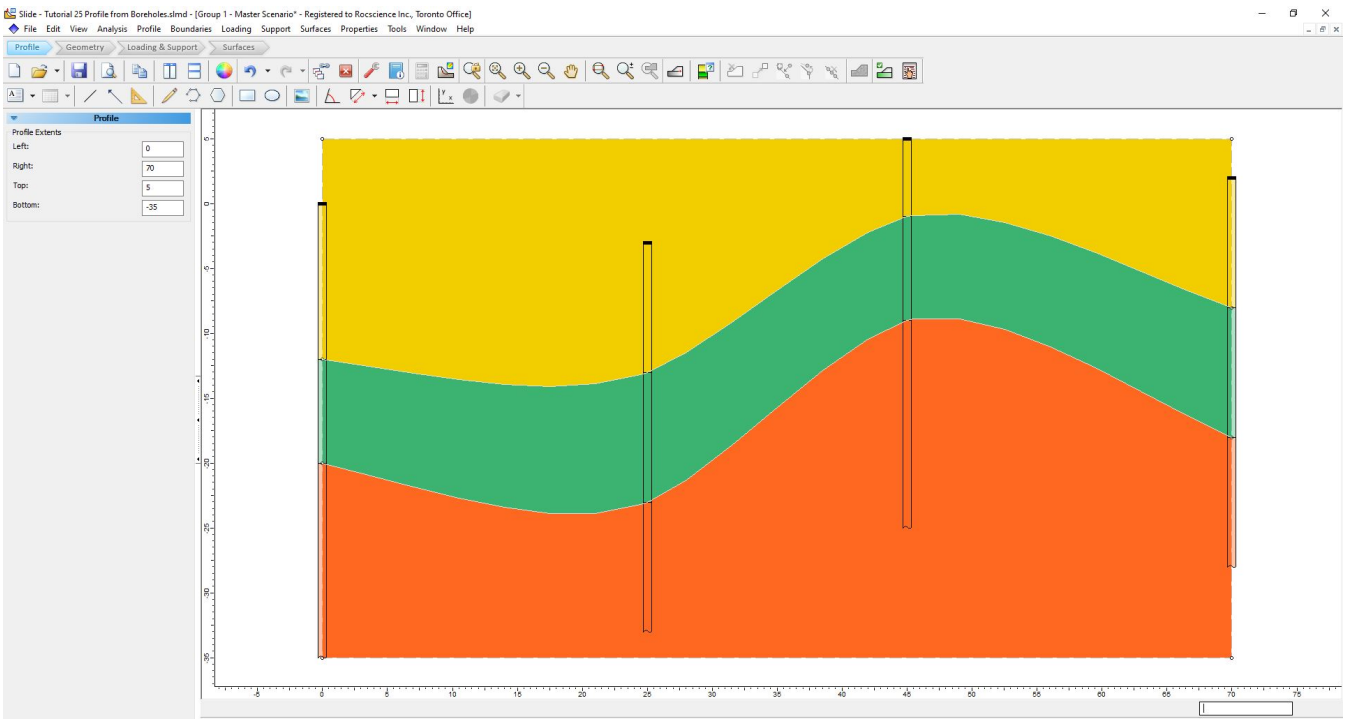
Thin plate spline curve fit of borehole data.

Return to the **Borehole Editor** dialog, and select the **Settings** button again.

Turn OFF the checkbox for **Interpolate Top Surface**. Select **OK** in both dialogs.



The model should look as follows:



Notice that there is no longer a profile boundary through the top of each borehole, and the upper material assignment extends to the upper profile extent.

This allows you to define a ground surface using the **Add Soil Profile Boundary** option, rather than having the ground surface automatically interpolated.

EDITING INTERPOLATED PROFILE BOUNDARIES

It is important to note that you cannot directly edit soil profile boundaries which have been interpolated from borehole data. You can only change the interpolation settings.

However, you can add additional boundaries using the Add Soil Profile Boundary option, if you need to modify or adjust the material regions, after defining the boreholes.

You are encouraged to experiment with the Borehole options to become familiar with the capabilities of this option.

9. Summary

Whether you define profile boundaries explicitly using the Add Soil Profile Boundary option, or by interpolation of borehole data, or some combination of both options, the modelling procedure AFTER defining the Soil Profile is the same in either case. You must define an external boundary in Geometry mode, and proceed as described earlier in this tutorial.