Weak Layer

1. Introduction

The Weak Layer option in Slide2 allows you to define a weak layer using only a **polyline**. A weak layer polyline has assigned strength properties. Since a weak layer polyline has no physical thickness, it is intended to be used for modelling interfaces, joints or very thin weak layers with negligible thickness, along which sliding might occur.

Before we proceed we should clarify what we mean by a "weak layer".

MODELING WEAK LAYERS IN SLIDE2

In typical slope stability modelling, a weak layer is defined as a thin material layer, bounded by two material boundaries. The layer has a finite thickness and is assigned material properties, as shown in the example below.

Weak layer modelled as a thin material layer

This method of modelling weak layers is commonly used and works very well in most circumstances. The advanced search algorithms in Slide2 can locate critical slip surfaces even in thin irregular weak layers, with excellent results in most cases.

However, there are some limitations to this method.

- For very thin weak layers (thickness approaching zero), or irregular non-linear weak layers, even the best search algorithms may have trouble locating slip surfaces within such layers. In some cases, the user may be forced to define a search polyline inside a finite weak layer, to focus the search within the weak layer.
- If a weak layer represents an interface with zero thickness, then the user is forced to create a thin material layer to model the interface, using two material boundaries, since

you cannot create a zero-thickness material. For example, when modelling a geomembrane interface in landfill.

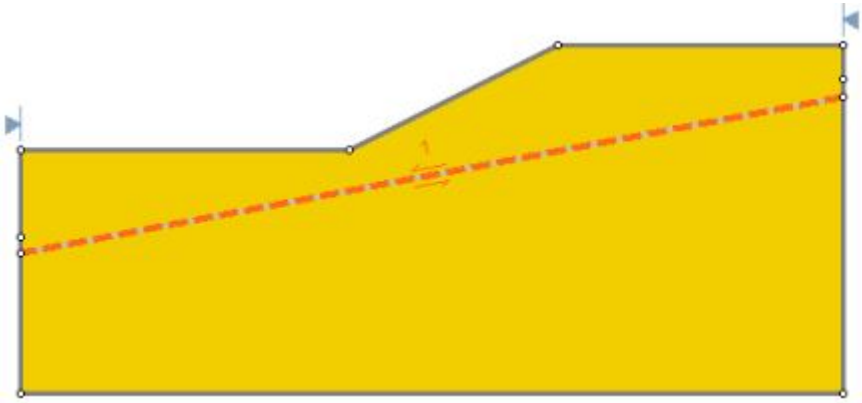
Due to these limitations, Slide2 now offers an alternative method for modelling weak layers: using the **Weak Layer polyline** option.

Weak Layer Polyline

The Weak Layer polyline option has the following attributes:

- A weak layer is defined by a polyline.
- The polyline is assigned material (strength) properties.
- The search algorithms in Slide2 will attempt to "follow" the weak layer polyline, to generate slip surfaces along the polyline (in this sense, a weak layer polyline behaves as a search focus object).
- A weak layer polyline is an independent modelling entity and does NOT get intersected with any other model boundaries.
- A weak layer polyline can NOT be used as a material boundary. If you require a material boundary at the same location as a weak layer boundary, then you will have to add a material boundary AND a weak layer polyline at the same location.

A typical use of a Weak Layer polyline would be to model a very thin interface of zero or negligible thickness, such as a geomembrane interface in a landfill.



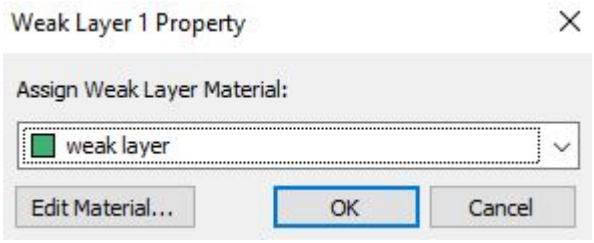
Weak layer modelled as a polyline

2. Weak Layer Example 1

We will start by importing the Tutorial 2 model.

1. Select **File > Recent > Tutorials** and open the file *Tutorial 2 Materials and Loading.slmd.*
2. Right-click on the **Group 1** group in the Document Viewer and select Duplicate Group.
3. Right-click and rename the Groups "**Material**" and "**Polyline**," respectively.
4. Click on the Polyline group.
5. Select **Boundaries > Add Weak Layer** in the menu.

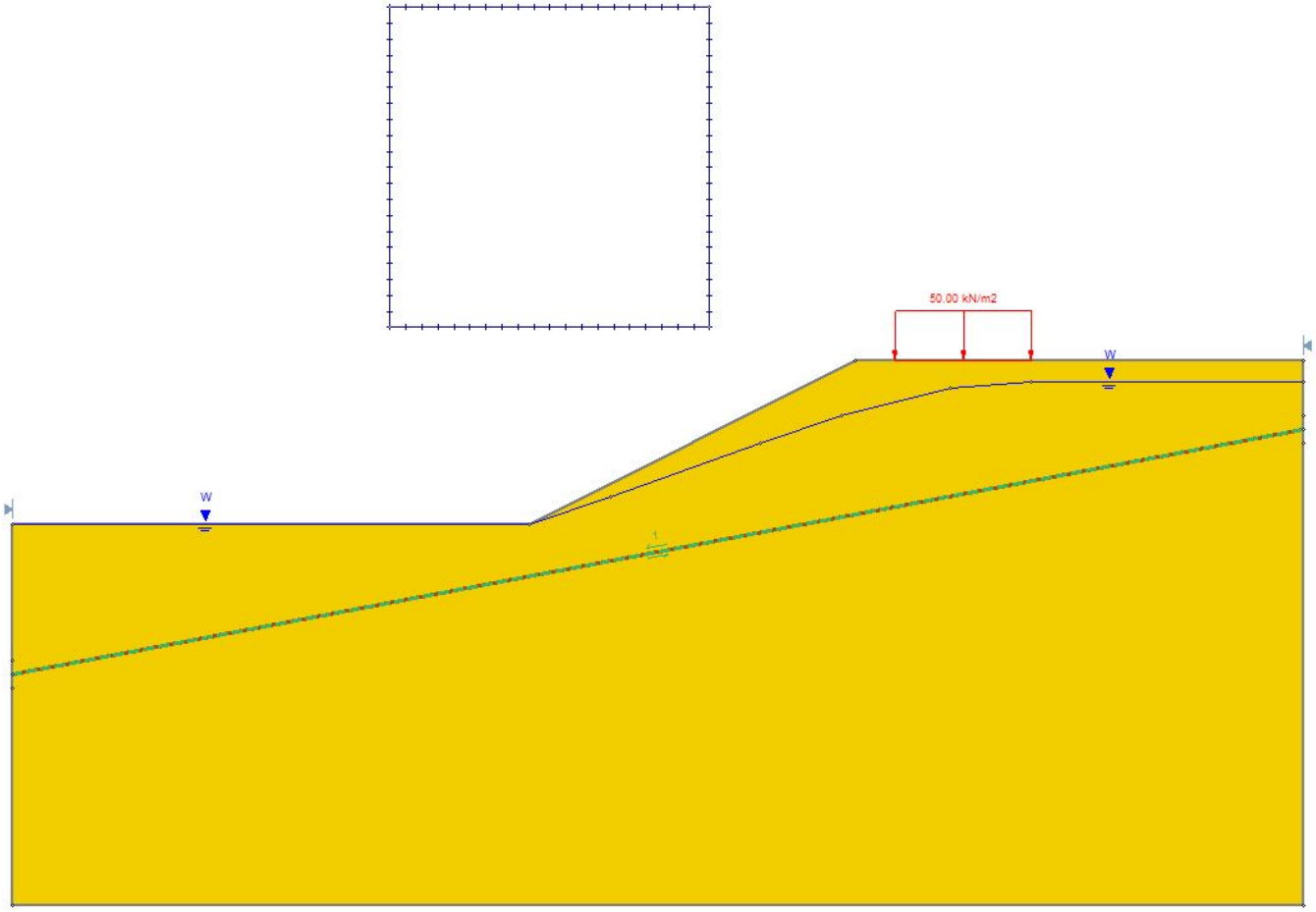
6. You will be prompted to enter the vertices of the boundary in the command line or graphically. In the command line enter 5, 17 and press **Enter**. Then enter 100, 35 and press **Enter** again. Right-click and select **Done** to finish entering coordinates.
7. A Weak Layer dialog will appear. Change the material to weak layer, indicating that the polyline will have the properties of this material. Click **OK**.



The weak layer has been defined. We can now remove the material layer.

8. Right-click on the gray boundaries of the green layer and select "**Delete Boundary**." You will have to do this twice.

Your model should look as shown.



3. Compute

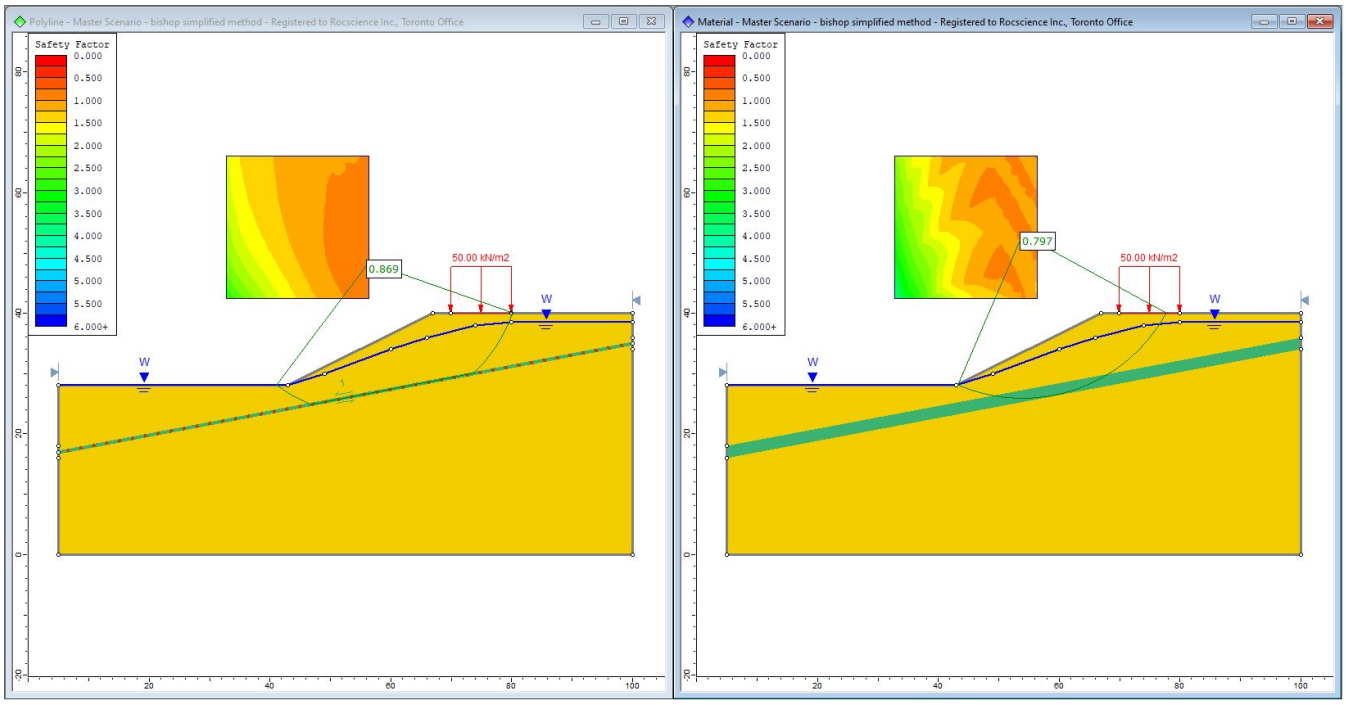
We are now ready to view the results.

1. Select **Compute**  to run the analysis

4. Interpret

1. Select **Interpret**
2. Then select **Window > Tile Vertically** to see both results.

You will see the following:



Firstly, notice that using the weak layer polyline, the surface conforms to the polyline. Using circular surfaces with weak layer material, the surface is still circular.

> **Note**
>
> The results are slightly different. This is because in the weak layer material case, the material is relatively thick (2 m) so it is not identical to the weak layer polyline case. The difference is also due to the shape of the surface as already noted.

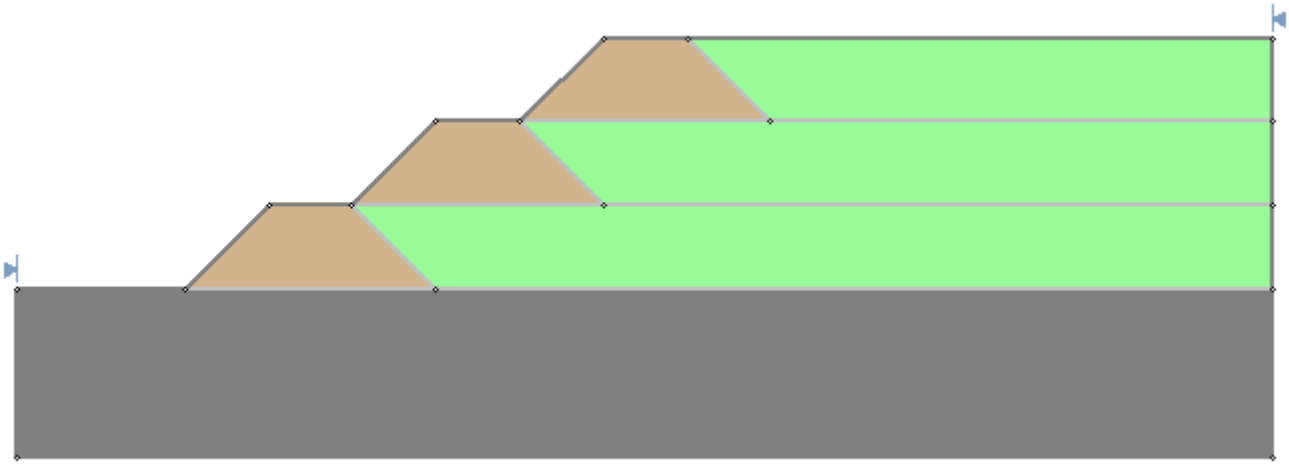
5. Weak Layer Example 2

In some cases, there may be multiple weak layers that overlap in the model. Sometimes, the material beneath a weak layer can be weaker than the weak layer itself. When the Weak Layer Handling feature is enabled, *Slide2* can determine which configuration of weak layers produces the most critical slip surfaces.

Now let's look at a more complex model.

1. Select **File > Recent > Tutorials** and open the file *Tutorial 35 Weak Layer 2 – starting file.slmd.*

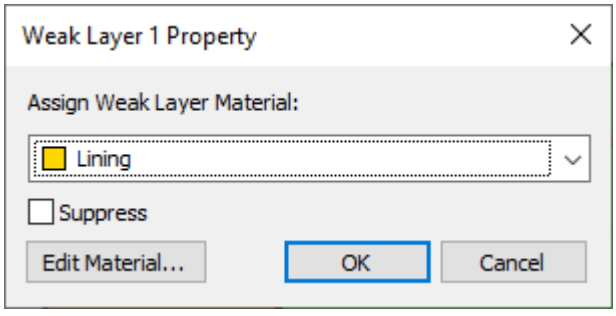
You will see the landfill model shown below. By hovering over the different materials you can see that the green material is the waste, the brown material is the berm material, and the grey material is the native soil underneath the landfill.



In this example, we want to apply three layers of liner to the model with the weak layer option.

2. Select **Boundaries > Add Weak Layer**.
3. Click through the vertices along the bottom of the bottom layer of waste material: **(20,5), (25,0), (75,0)** and press **Enter**.
4. In the **Assign Weak Layer** dialog, select the **Lining** as **shown** and click OK.
5. Repeat the above steps for the upper two layers of waste material.

- Middle layer coordinates: (30,10), (35,5), and (75,5).
- Top layer coordinates: (40,15), (45,10), and (75,10).



Note

The “Suppress” checkbox can be toggled to exclude the weak layer from the analysis without needing to delete the entity. They can be unsuppressed by right-clicking the weak layer and unchecking the “Suppress” option.

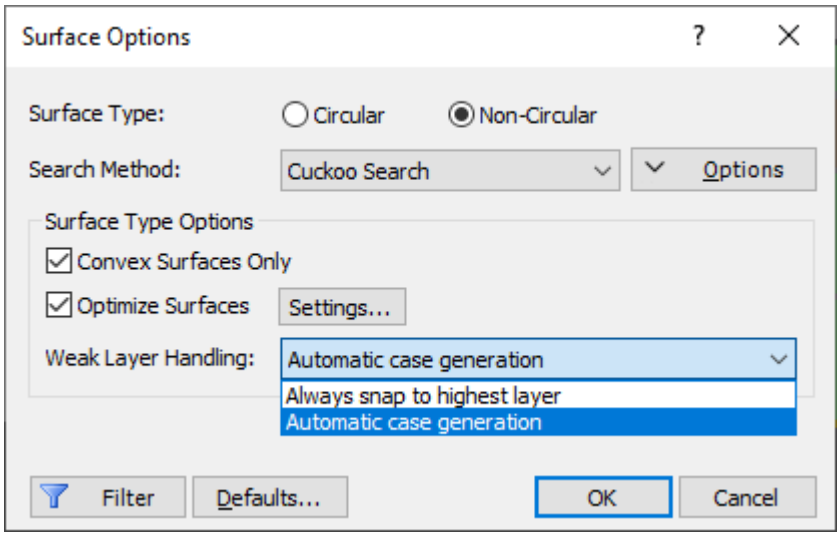
6. Enable Weak Layer Handling

1. Go to **Surfaces > Surface Options**.

2. Ensure that Weak Layer Handling: **Automatic case generation** has been selected.

This option will be enabled by default for new models created in *Slide2.* A description of the options is given below.

- **Automatic case generation**: Evaluates the factor of safety for all possible configurations of including or excluding each of the weak layers intersected by a slip surface.
- **Always snap to highest layer**: Snaps every point on the slip surface vertically upwards to the highest weak layer found at that location and does not consider multiple cases. This will save computational time if you know that only the top weak layer needs to be analyzed.

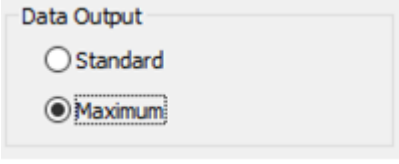


3. Click **OK**.

7. Data Output Settings

1. Finally, open the **Project Settings** and change the **Data Output** to **Maximum**.

As demonstrated in the following steps, this will allow Slide2 to show all the valid slip surfaces generated in the analysis using the weak layers. Note that to conserve file size, the default setting is Standard, which only outputs the critical cases generated by the weak layers.



8. Compute

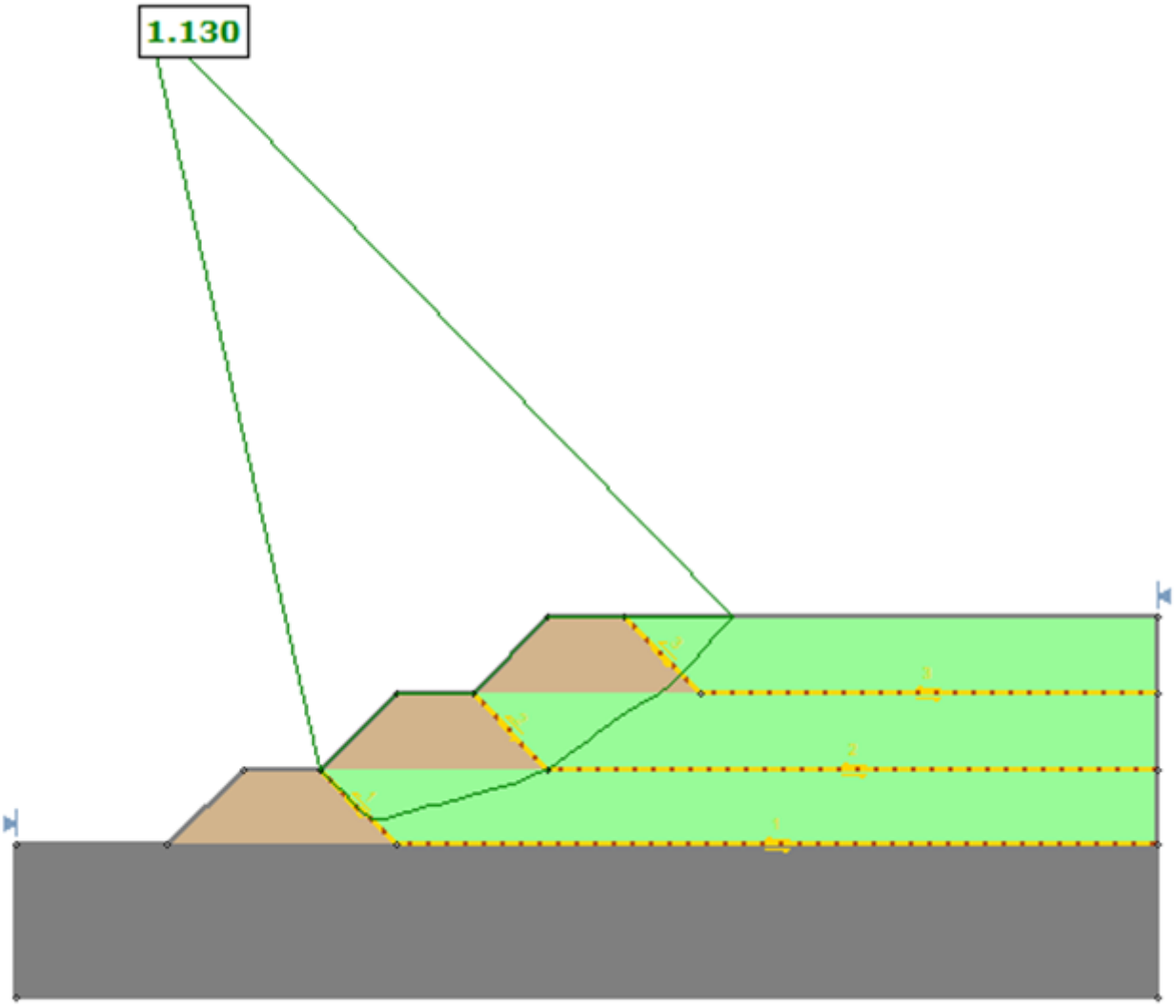
We are now ready to view the results.

1. Click **Compute** to run the analysis.

9. Interpret

1. Click **Interpret**

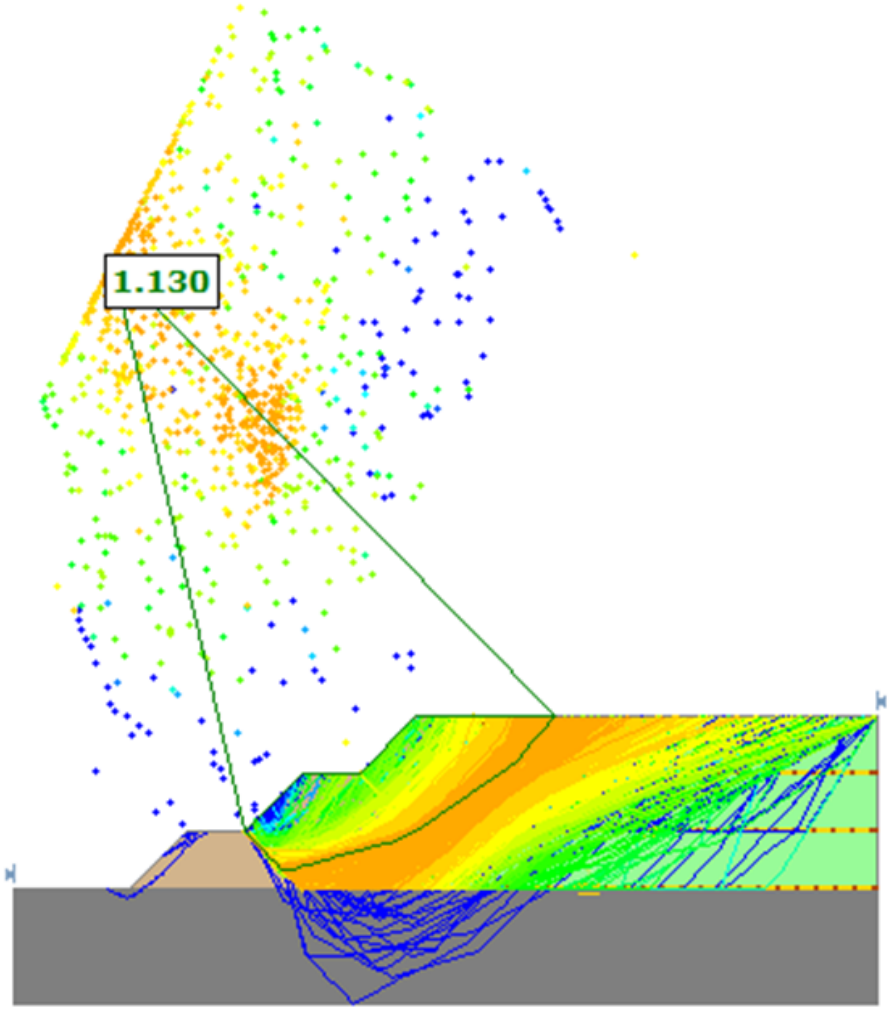
You will see the following:



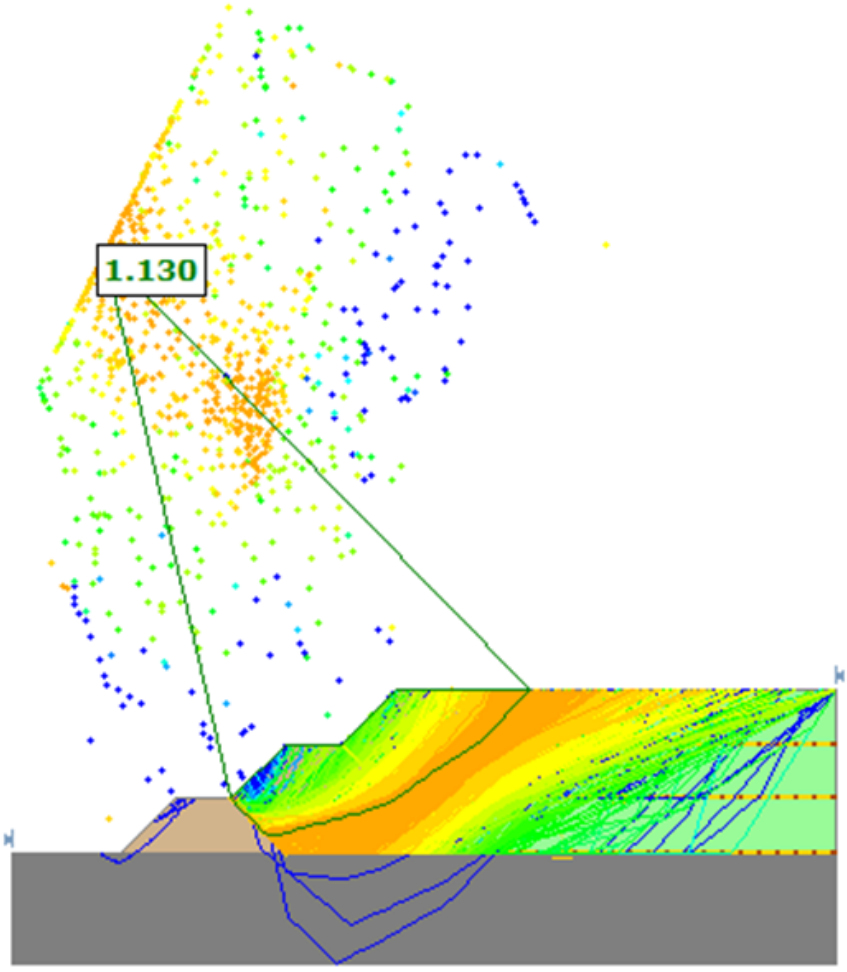
Notice that the governing slip surface ignores the top two lining layers and curves through the bottom liner.

2. Click on **All Surfaces** to reveal a map of all the surfaces generated during the search.

Notice that slip surfaces are generated beneath every weak layer in the model.

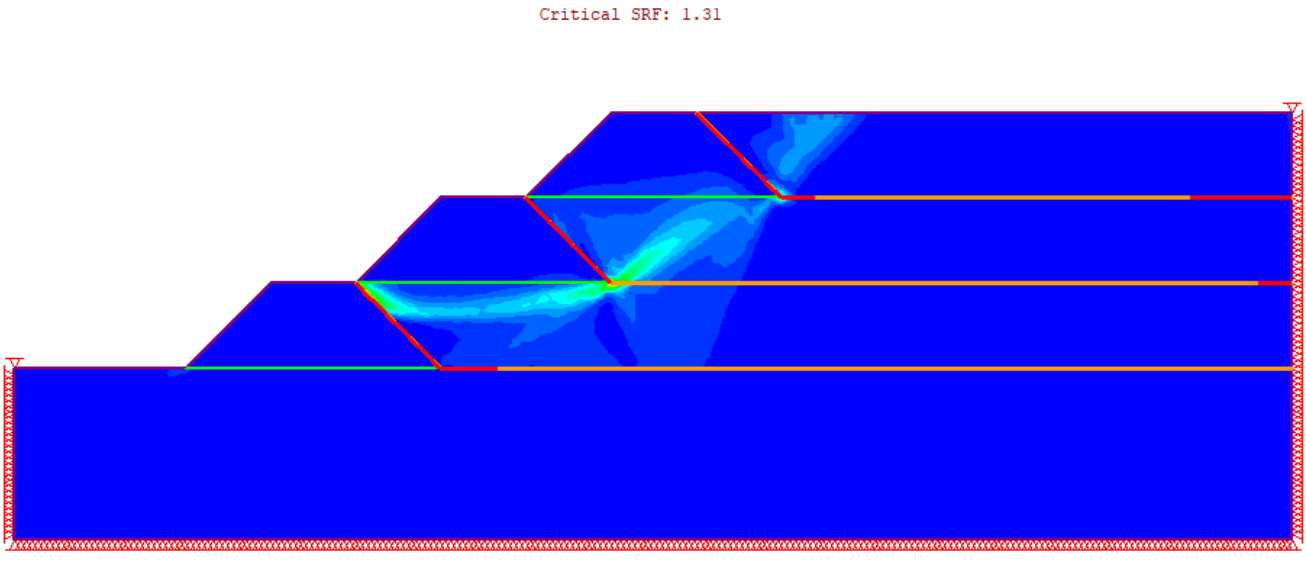


The above output was generated using the Maximum data output settings. For comparison, switching to **Standard data output** will show the following surfaces:



Note

The global minimum result can be validated in RS2, with the shear strain results shown below (blue = no strain, and lighter colours representing increasing strain). The areas of maximum strain in the model match the critical slip surface obtained in Slide2. A similar strength reduction factor (1.31) is also reported.



10. Limitations

Please see Weak Layer Overview for a detailed discussion of the limitations for the weak layers feature in Slide2. These limitations concern models that have discontinuous and/or vertical weak layers.

This concludes the Weak Layer tutorial.