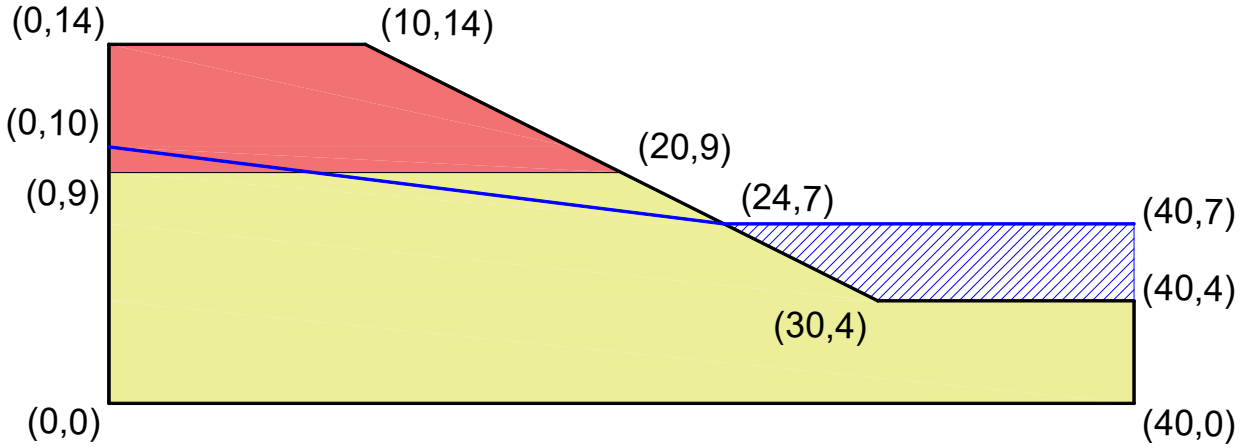
Ponded Water in Slope Stability

Created By: [Roozbeh Geraili Mikola, PhD, PE]
Email: [hyrcan4geo@outlook.com]
Web Page: [www.geowizard.org]



This tutorial will demonstrate how to use ***HYRCAN*** to calculate factor of safety for a layered slope, with ponded water table.

Project Settings

Various important modeling and analysis options are set in the Project Settings dialog, including Failure Direction, Units of Measurement, Analysis Methods and Groundwater property. For this analysis change the failure direction to “Left to Right” then press Apply.

Select: *Analysis* →  *Project Settings*

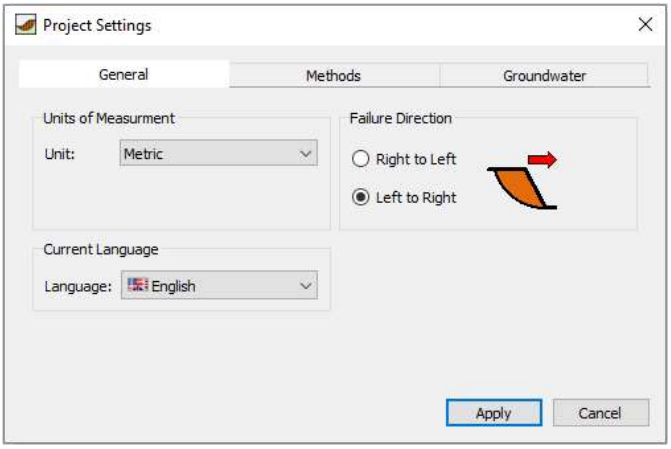


Figure 1- Project Settings dialog.

Create Geometry

- ***External Boundaries***

The first boundary that must be defined for every model, is the External Boundary. To add the External Boundary, select External Boundary from the toolbar or the Boundaries menu.

Select: *Geometry* → 

External Boundary

Enter the following coordinates in the prompt line at the bottom right of the main window.

```
Enter vertex [esc=cancel]: 0 0
Enter vertex [esc=cancel]: 40 0
Enter vertex [esc=cancel]: 40 4
Enter vertex [c=close,esc=cancel]: 30 4
Enter vertex [c=close,esc=cancel]: 10 14
Enter vertex [c=close,esc=cancel]: 0 14
Enter vertex [c=close,esc=cancel]: c
```

Note that entering **c** after the last vertex has been entered, automatically connects the first and last vertices (closes the boundary), and exits the External Boundary option. Your screen should now look as follows:

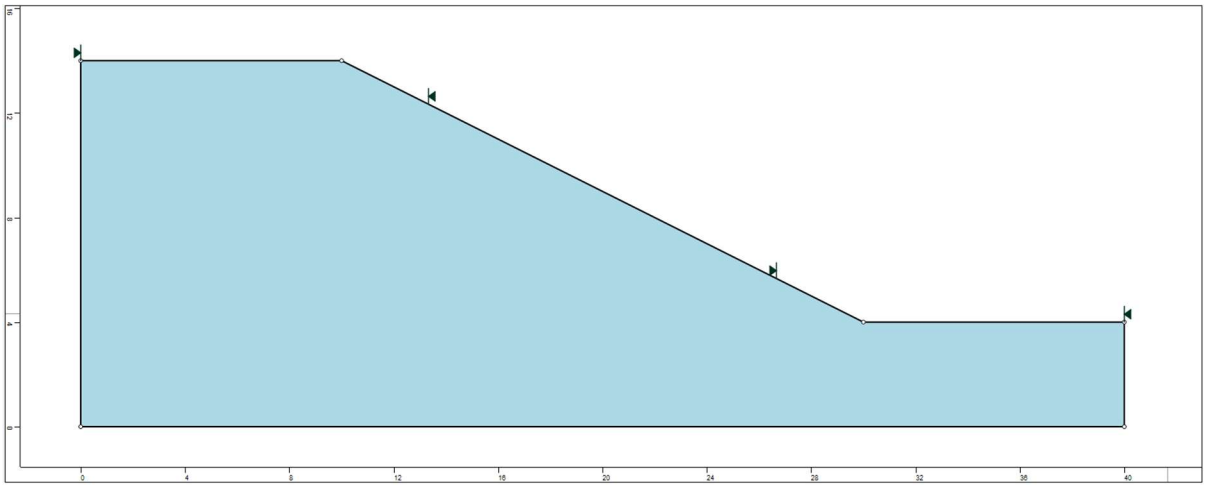
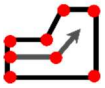


Figure 2- External boundary is created.

- ***Material Boundaries***

Material boundaries are used in ***HYRCAN*** to define the boundaries between different material zones within the External Boundary. Let's add two material boundaries.

Select: *Geometry* → 

Material Boundary

Enter the following coordinates in the prompt line at the bottom right of the main window.

```
Enter vertex [esc=cancel]: 0 9
Enter vertex [d=done,esc=cancel]: 20 9
Enter vertex [d=done,esc=cancel]: d
```

Your screen should now look as follows:

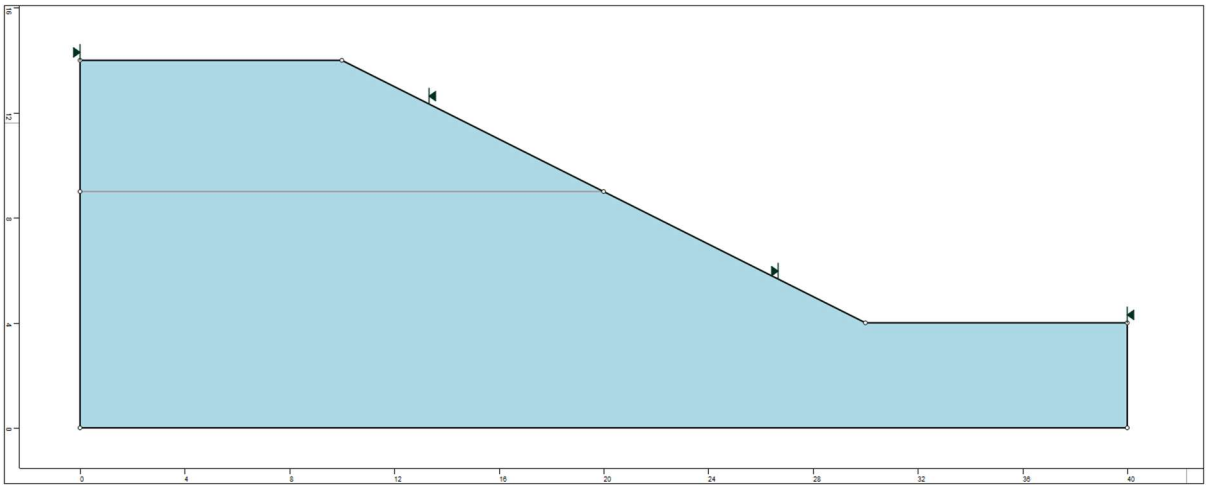


Figure 3- External and material boundaries added.

Properties

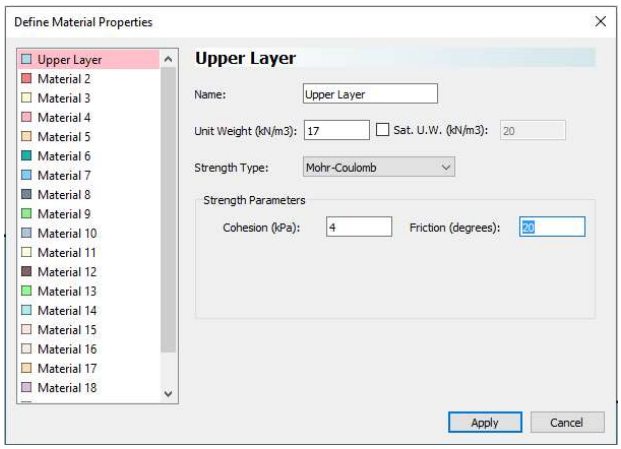
It's time to define our material properties. Select Define Materials from the toolbar or the Properties menu.

Select: *Properties* → 

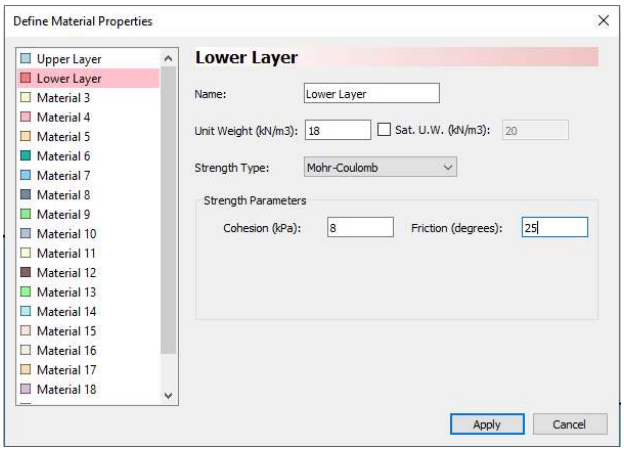
Define Materials

Material	*c* (kN/m^2)	*φ* (degrees)	*γ* (kN/m^3)
Upper Layer	4.0	20.0	17
Lower Layer	8.0	25.0	18

With the first (default) tab selected in the Define Materials dialog, enter the following properties:

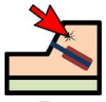


Enter the parameters shown above. When all parameters are entered for the first material, select the second tab, and enter the properties for the second soil layer and press Apply when finished.



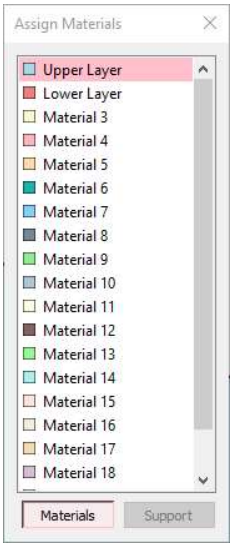
Assigning Properties

Since we have defined two materials, it will be necessary to assign properties to the correct regions of the model, using the Assign Properties option. Select Assign Properties from the toolbar or the Properties menu.

Select: *Properties* → 

Assign Properties

You will see the Assign Materials dialog, shown below.



To assign properties to the soil layers:

1. Use the mouse to select the soil material, in the Assign Materials dialog (notice that the material names are the names you entered in the Define Material Properties dialog).
2. Now place the cursor anywhere in the soil region and click the left mouse button. Repeat the same sequence for other soil materials until all the materials are assigned.

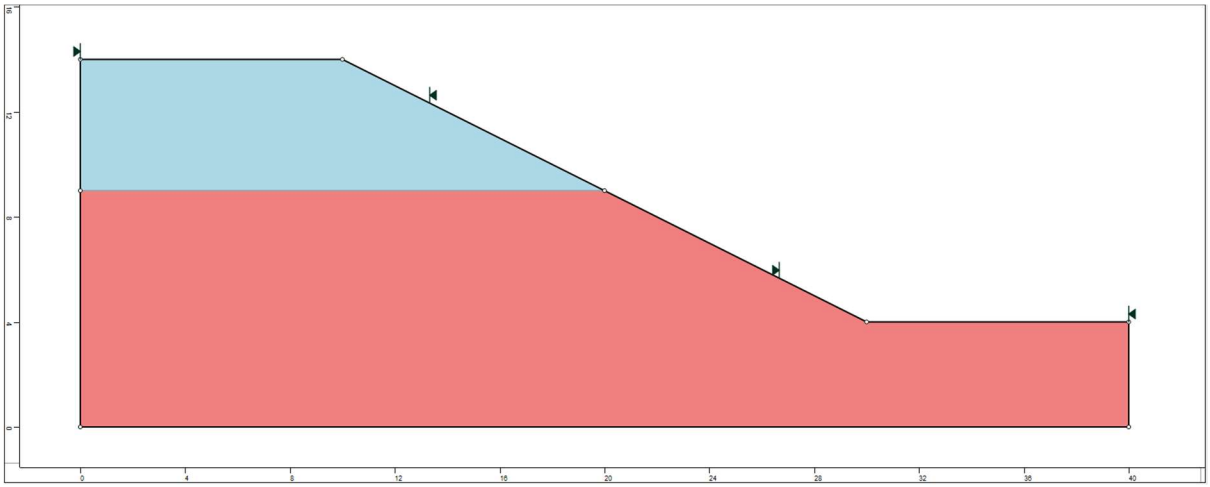
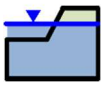


Figure 4- Geometry setup after assigning the properties.

Add Water Table

To add a Water Table to your model:

1. Select Add Water Table from the toolbar or the Geometry menu.

Select: *Geometry* → 

Add Water Table

2. Enter the vertices of the Water Table.

3. When all vertices are entered, right-click and select Done, or type “d” in the prompt line and press Enter.

Enter the following coordinates in the prompt line at the bottom right of the main window.

```
Enter vertex [esc=cancel]: 0 10
Enter vertex [d=done,esc=cancel]: 24 7
Enter vertex [d=done,esc=cancel]: 40 7
Enter vertex [d=done,esc=cancel]: d
```

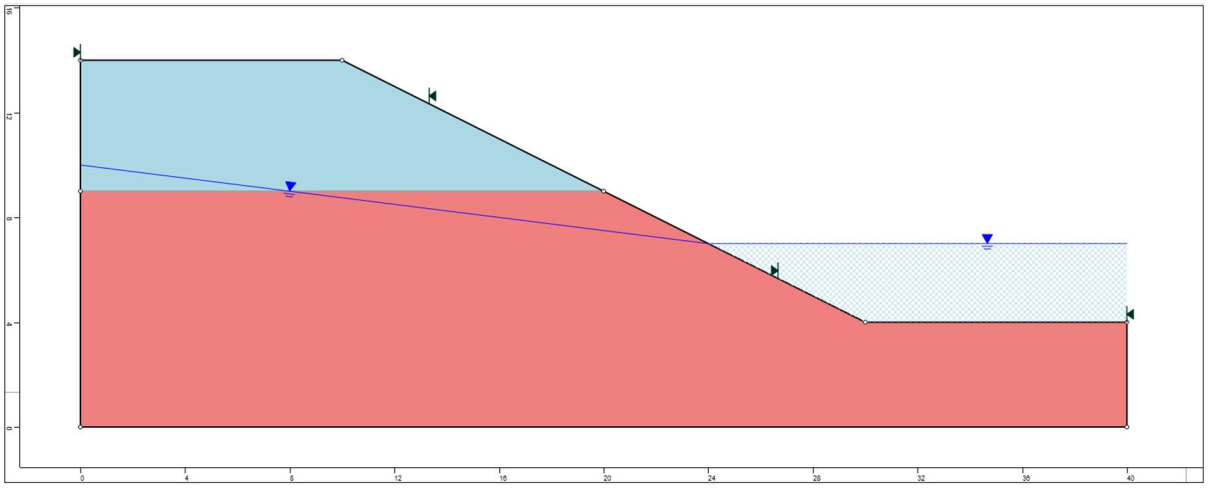


Figure 5- Geometry setup with ponded water.

Notes:

- The Water Table must be defined across all materials for which pore pressure is to be calculated using the Water Table. If it is not, then the analysis will not be able to calculate the pore pressure for slip surfaces.
- ***HYRCAN*** will automatically calculate the pore pressure, based on the inclination (angle) of the Water Surface, above any given point and vertical distance to the water surface to the middle pint of base of the slice.
- If a Water Table is drawn above the External Boundary, ***HYRCAN*** will automatically create a region of ponded water below the Water Table and above the External Boundary.

Compute

The model is now ready to run.

Select: *Analysis* → 

Compute

The engine will proceed in running the analysis. When completed, you are ready to view the results in Result Tab.

Results and Discussions

When calculation completed, you are ready to view the results in Result Tab. By default, when Result Tab opened, the Global Minimum slip surface, for the Bishop Simplified analysis method

will be shown. This resulted in total of approximately 5000 trial slip surfaces. The result of the factor of safety calculation is shown in Figure 6. Table 1 summarize the comparisons of calculated factor of safety for the same model using different commercial programs.

Table 1- Comparison of Minimum Factor of Safety

Method	Slide2	HYRCAN
Bishop Simplified	1.310	1.313

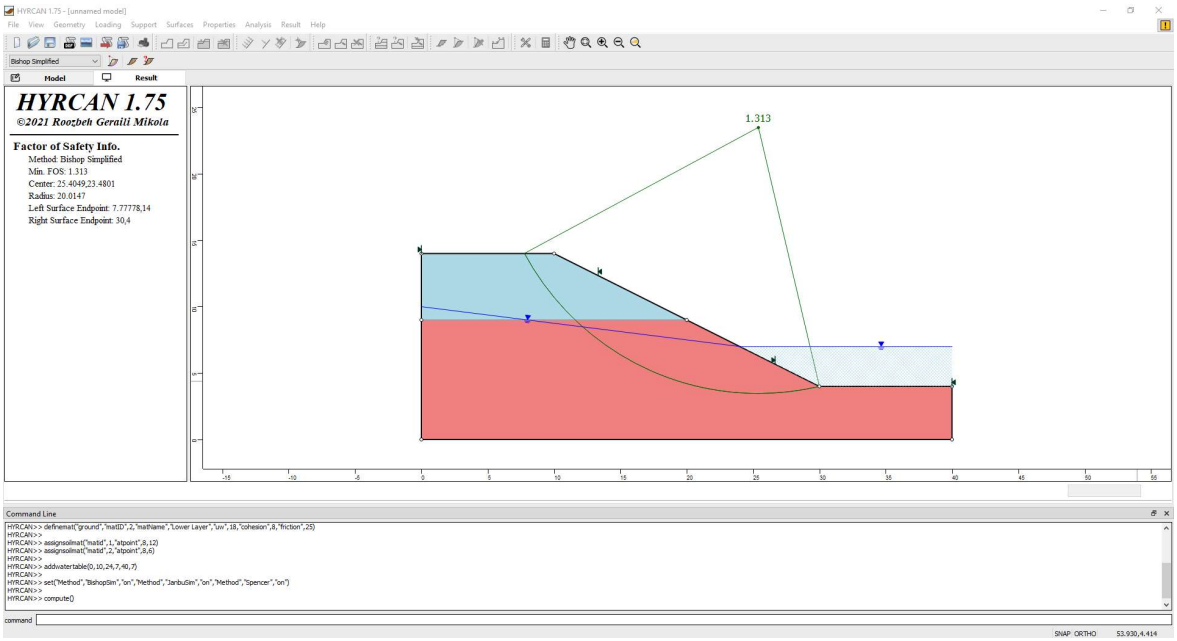


Figure 6- Result of automatic slope search.

To view ALL valid slip surfaces generated by the analysis, select the All Surfaces option from the toolbar or the Result menu.

Select: *Result* → 

All Surfaces

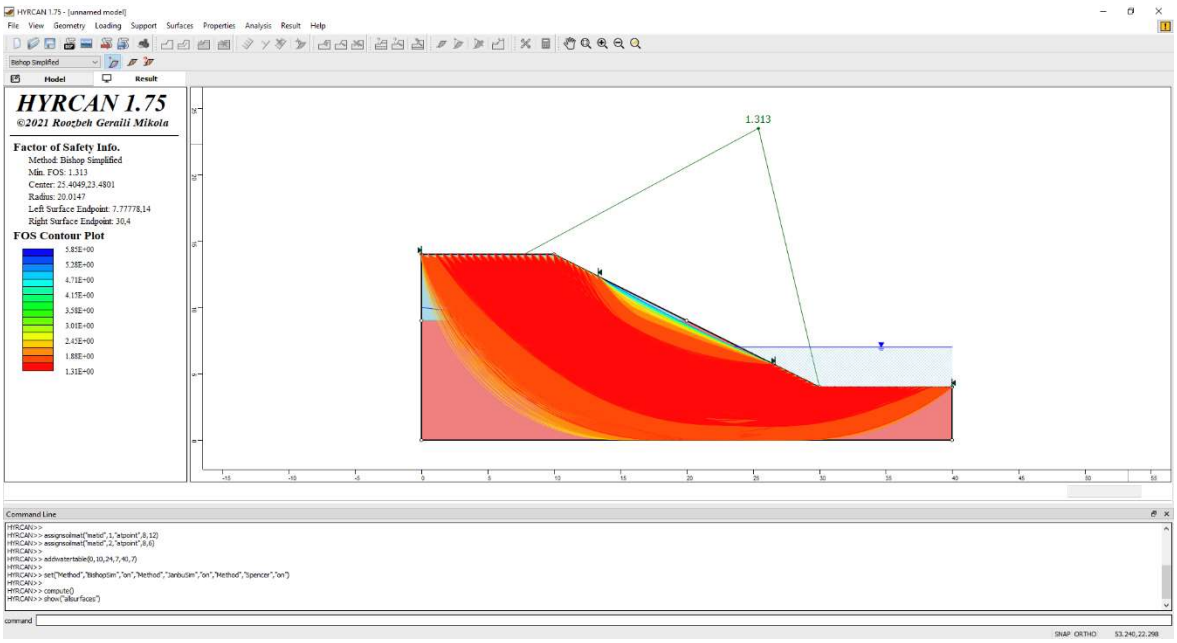


Figure 7- Circular surface search – All surfaces shown.

The Show Slices option can be used to display the actual slices used in the analysis.

Select: *Result* → 

Show Slices

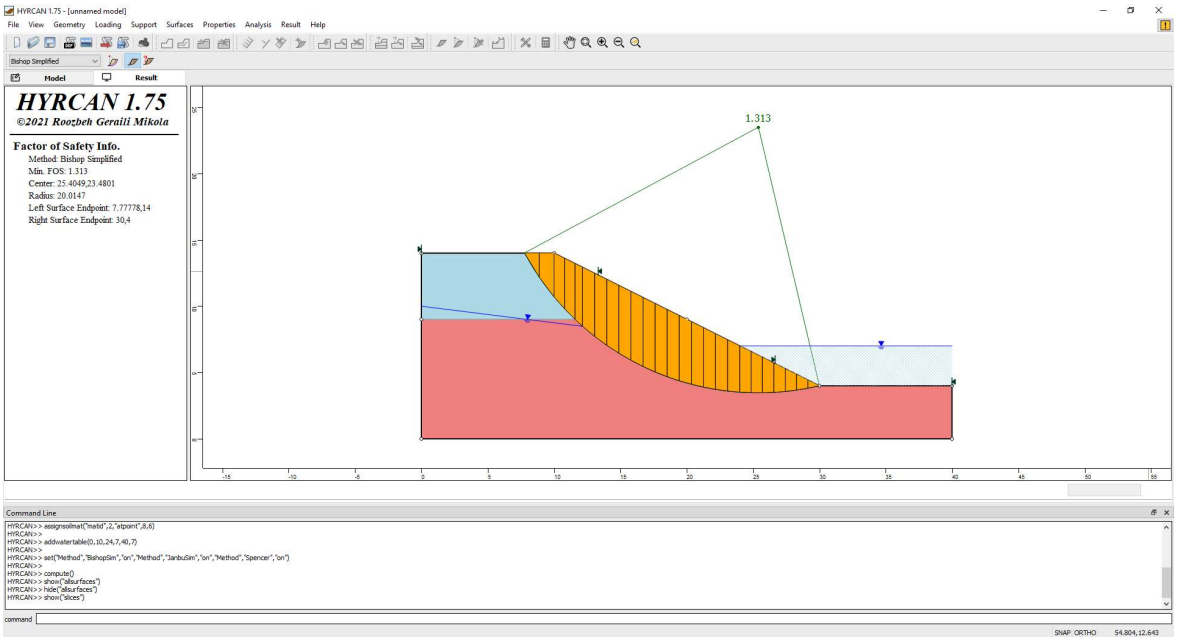


Figure 8- Slice displayed.

The Query Slice Data option allows you to view detailed analysis results for individual slices.

Select: *Result* → 

Query Slice Data

After selecting the Query Slice Data, the Slice Data dialog will show up, which prompts you to "Click on a slice to view slice data". Click on ant slice, and the data for the slice will be displayed in the dialog, as shown below:

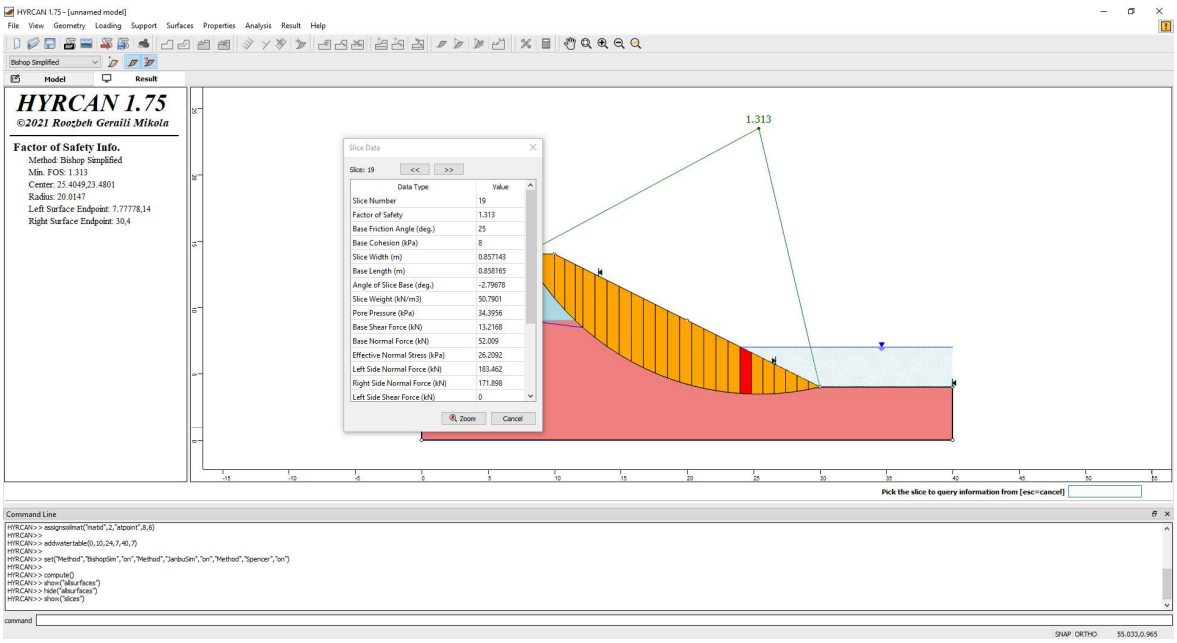


Figure 9- Slice Data dialog.

Script

After finishing the model you will be able to save the generated script by ***HYRCAN*** in the text file.

Select: 

The commands for this tutorial are listed below.

```
newmodel()

set("failureDir","l2r")

extboundary(0,0,40,0,40,4,30,4,10,14,0,14,0,0)

matboundary(0,9,20,9)

definemat("ground","matID",1,"matName","Upper Layer","uw",17,"cohesion",4,"friction",20)
definemat("ground","matID",2,"matName","Lower Layer","uw",18,"cohesion",8,"friction",25)

assignsoilmat("matid",1,"atpoint",8,12)
assignsoilmat("matid",2,"atpoint",8,6)

addwatertable(0,10,24,7,40,7)

compute()
```