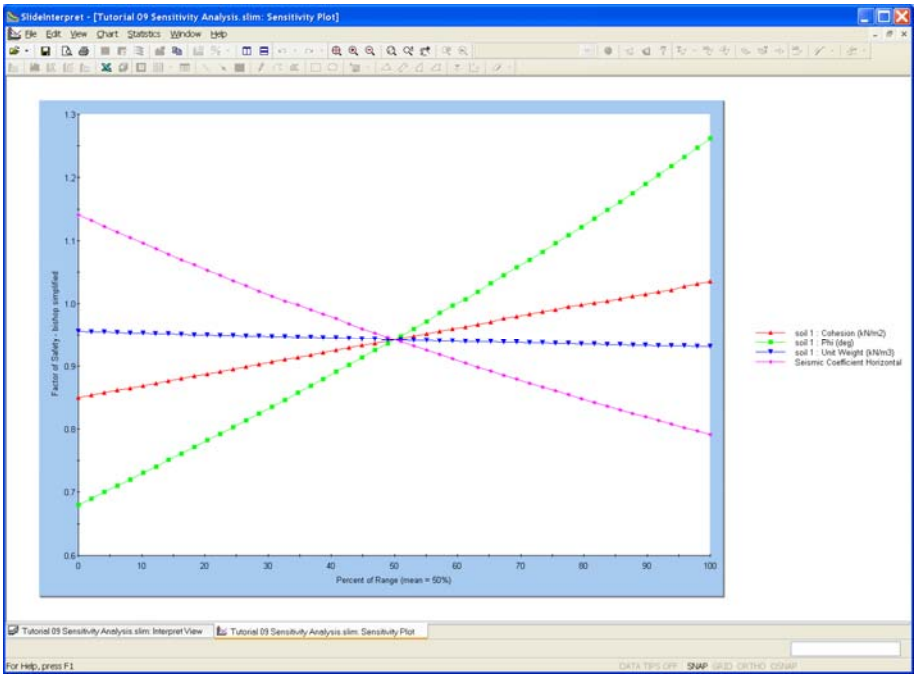
Sensitivity Analysis



Sensitivity analysis is extremely easy to perform with *Slide*. Any input parameter which can be defined as a random variable (for a Probabilistic Analysis) can also be defined as a variable for a Sensitivity Analysis.

A Sensitivity Analysis simply means the following:

1. For one or more selected input parameters, the user specifies a Minimum and a Maximum value.

2. Each parameter is then varied in uniform increments, between the Minimum and Maximum values, and the safety factor of the Global Minimum slip surface is calculated at each value. NOTE: while a parameter is being varied, ALL OTHER input parameters are held constant, at their MEAN values.

3. This results in a plot of safety factor versus the input parameter(s), and allows you to determine the "sensitivity" of the safety factor, to changes in the input parameter(s).

4. A steeply changing curve on a Sensitivity Plot, indicates that the safety factor is sensitive to the value of the parameter.

5. A relatively "flat" curve indicates that the safety factor is not sensitive to the value of the parameter.

A sensitivity analysis indicates which input parameters may be critical to the assessment of slope stability, and which input parameters are less important.

A Sensitivity Plot can be used to determine the value of a parameter which corresponds to a specified Factor of Safety (e.g. Factor of Safety = 1).

The finished product of this tutorial can be found in the **Tutorial 09 Sensitivity Analysis.slim** data file. All tutorial files installed with *Slide* 6.0 can be accessed by selecting File > Recent Folders > Tutorials Folder from the *Slide* main menu.

Model

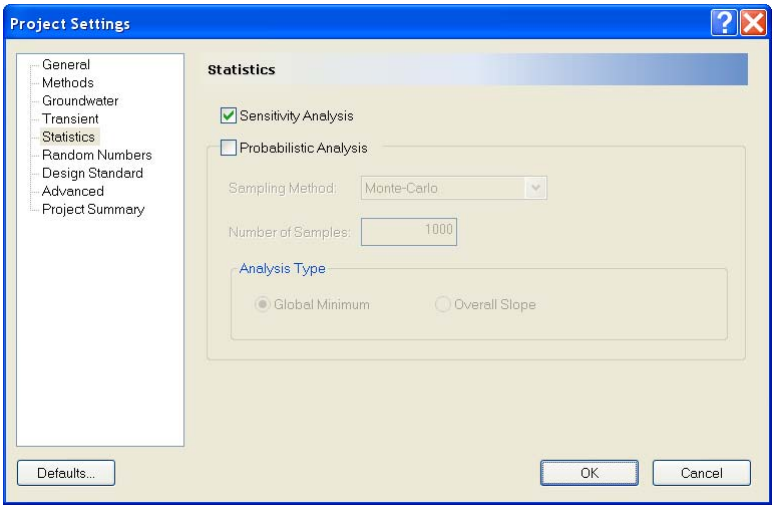
We will start with the same example discussed in the previous tutorial.

Select File > Recent Folders > Tutorials Folder from the *Slide* main menu, and open the **Tutorial 08 Probabilistic Analysis.slim** file.

Project Settings

To enable a Sensitivity Analysis with *Slide*, you must first select the Sensitivity Analysis checkbox in Project Settings.

Select: Analysis → Project Settings



In the Project Settings dialog, select the Statistics page, and select the Sensitivity Analysis checkbox. Clear the Probabilistic Analysis checkbox. Select OK.

NOTE:

- You can perform BOTH a Sensitivity Analysis and a Probabilistic Analysis, at the same time, using the same variables. This is discussed at the end of this tutorial.

However, for this example, we will just run the Sensitivity Analysis only.

Defining Sensitivity Variables

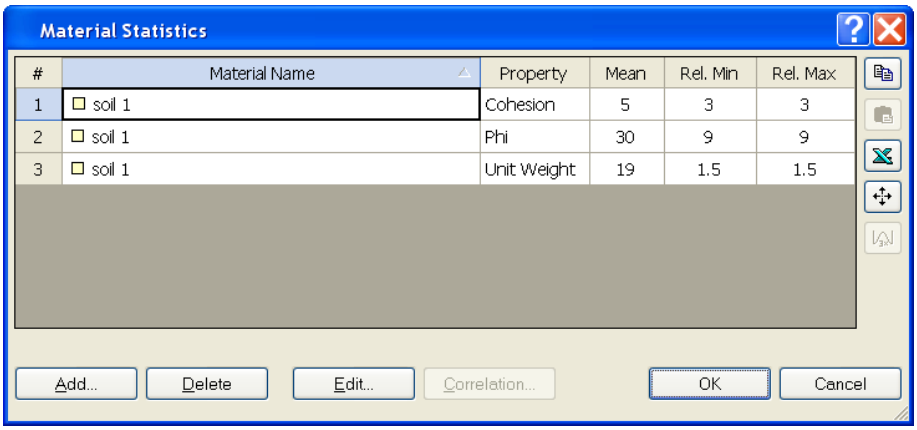
The procedure for selecting and defining variables for a Sensitivity Analysis, is exactly the same as the procedure described in the previous tutorial, for a Probabilistic Analysis. However, note that:

- For a Sensitivity Analysis, ONLY a Minimum and Maximum value is required for each variable.

- A Statistical Distribution and Standard Deviation are NOT applicable for Sensitivity Analysis.

Let's examine the Material Statistics dialog.

Select: Statistics → Materials



Notice that the 3 variables which we defined previously for the Probabilistic Analysis (**Tutorial 08**), are still displayed in the Material Statistics dialog.

Because we are only considering a Sensitivity Analysis, the statistical distribution and standard deviation are no longer displayed in the dialog. Only the mean, minimum and maximum values are necessary for the Sensitivity Analysis.

We will not make any changes to this data, so select OK or Cancel in the dialog.

Compute

Before we run the analysis, first save the file with a new file name: **sens1.sli**.

Select: File → Save As

Use the Save As dialog to save the file. Now select Compute.

Select: Analysis → Compute

NOTE:

- When you run a Sensitivity Analysis with *Slide*, the regular (deterministic) analysis is always computed first. This is necessary in order to determine the Global Minimum slip surface. Remember that the Sensitivity Analysis is performed on the Global Minimum slip surface.

- The Sensitivity Analysis automatically follows. The progress of the analysis is indicated in the Compute dialog. A Sensitivity Analysis usually only takes a very small amount of time, so you may not even notice the calculation in the Compute dialog.

Interpret

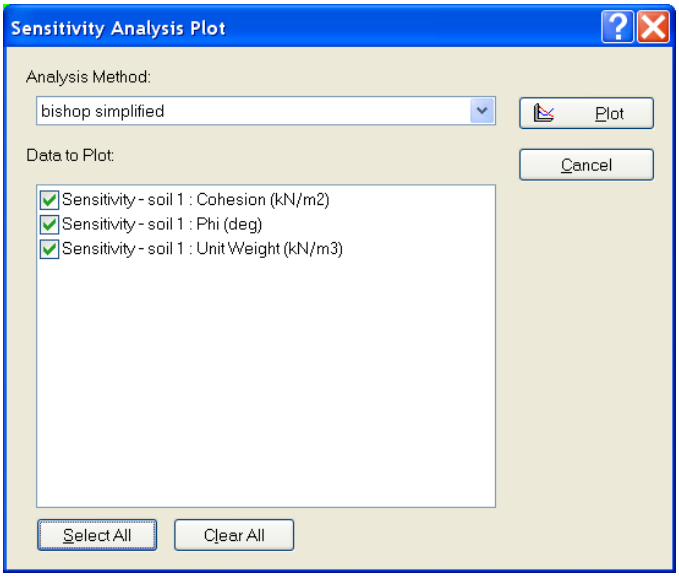
To view the results of the analysis:

Select: Analysis → Interpret

The results of the Sensitivity Analysis are viewed by selecting the Sensitivity Plot option, from the toolbar or the Statistics menu.

Select: Statistics → Sensitivity Plot

You will see the following dialog.



Select the checkboxes for all 3 variables. TIP: you can use the Select All button to automatically select all checkboxes. Select the Plot button.

You should see the following sensitivity plot.

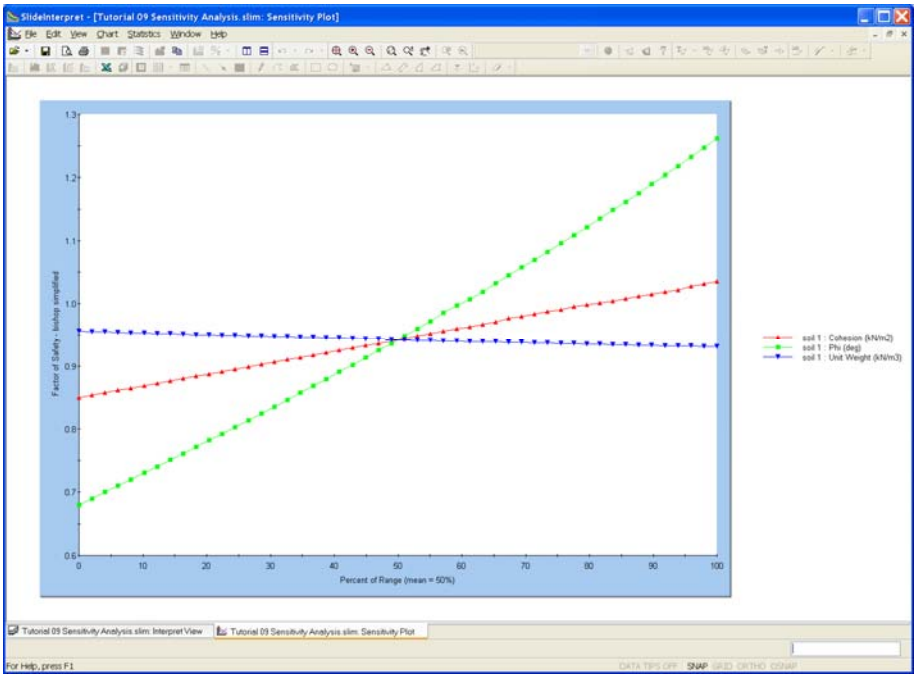


Figure 9-1: Sensitivity Plot of 3 variables.

As you can see from the plot, the safety factor is most sensitive to the Friction Angle (steepest curve), and least sensitive to the Unit Weight (curve is almost flat).

Note the following about the Sensitivity Plot:

1. When multiple variables are plotted, the horizontal axis of the plot is in terms of Percent of Range.

2. Percent of Range = 0 represents the Minimum value of each variable, and Percent of Range = 100 represents the Maximum value of each variable.

3. Notice that all 3 curves intersect at Percent of Range = 50%. Percent of Range = 50% ALWAYS represents the MEAN value of each variable.

If you wish to see the actual value of a variable on the horizontal axis, then you must only plot ONE Sensitivity variable at a time (only select ONE checkbox in the Sensitivity Plot dialog). Let's do that now.

1. Right-click on the plot and select Change Plot Data from the popup menu.

2. Clear the checkboxes for Cohesion and Unit Weight, so that only Phi is selected. Select Done.

The Sensitivity Plot now only displays the curve for Friction Angle. Notice that the Horizontal Axis is now in terms of the actual unit of the variable (degrees).

Sampler

The Sampler option allows you to easily obtain the coordinates of any point on a Sensitivity Plot curve.

1. Right-click on the plot and select the Sampler option.

2. Notice that a horizontal dotted line is now displayed on the plot. This is the Sampler line, and allows you to graphically obtain the coordinates along the curve.

3. Click and HOLD the LEFT mouse button on the plot, and drag the mouse. As you move the mouse, the Sampler will continuously display the coordinates of the current location on the curve.

4. You can also sample exact locations on the curve. Right-click on the plot and select Sample Exact Value.

5. In the dialog, enter a Safety Factor = 1 for the Vertical Axis. Select OK.

6. The Sampler now shows the Friction Angle for Safety Factor = 1. The Friction Angle = 26.22 degrees. This is the critical Friction Angle, if all other variables are assumed to be equal to their mean values.

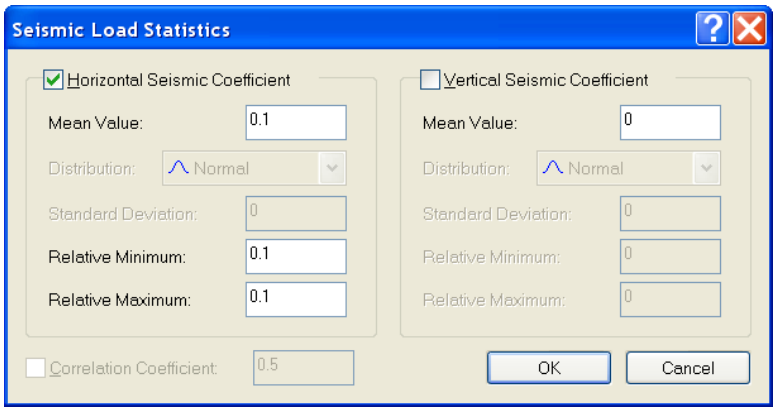
Seismic Coefficient Sensitivity

Let's add one more Sensitivity Analysis variable, and re-run the analysis. Return to the *Slide* Model program, and select the Seismic Load option from the Statistics menu.

Select: Statistics → Seismic Load

1. In the dialog, select the checkbox for Horizontal Seismic Coefficient.

2. Enter a Mean Value = 0.1. Also enter Relative Minimum = 0.1 and Relative Maximum = 0.1. Select OK.



3. When the Sensitivity Analysis is run, the Horizontal Seismic Coefficient will be varied between 0 and 0.2. Select Compute to run the analysis, and then view the results in Interpret.

4. Create a Sensitivity Plot (only select the checkbox for Horizontal Seismic Coefficient).

5. To determine the critical seismic coefficient, right-click on the plot and select Sample Exact Value. In the dialog, enter safety factor = 1 for the vertical axis. Select OK. The critical seismic coefficient which gives a safety factor = 1 is approximately 0.068.

6. The plot should appear as shown in Figure 9-2.

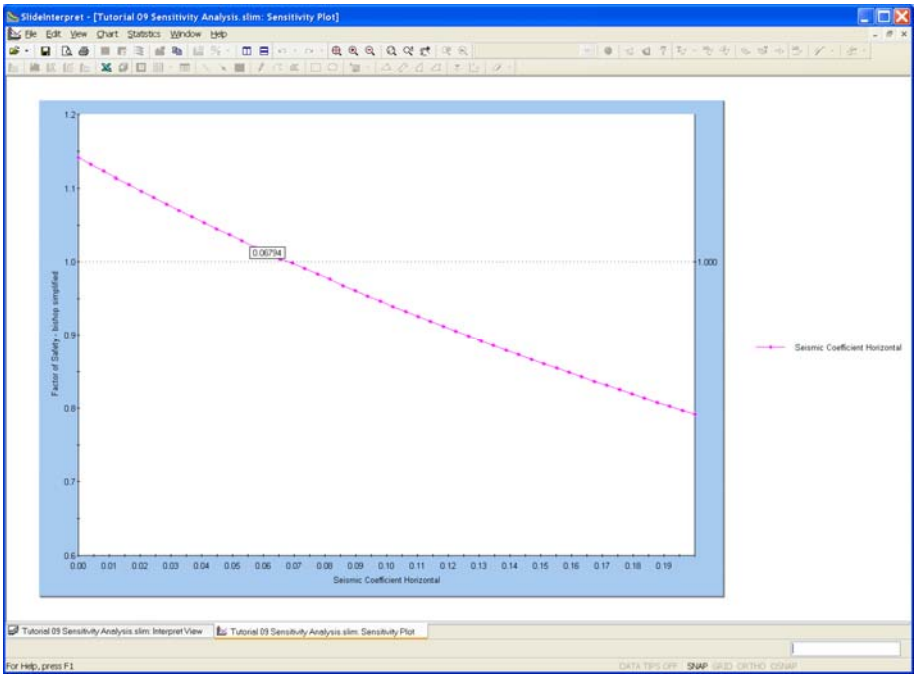


Figure 9-2: Sensitivity Plot of Horizontal Seismic Coefficient.

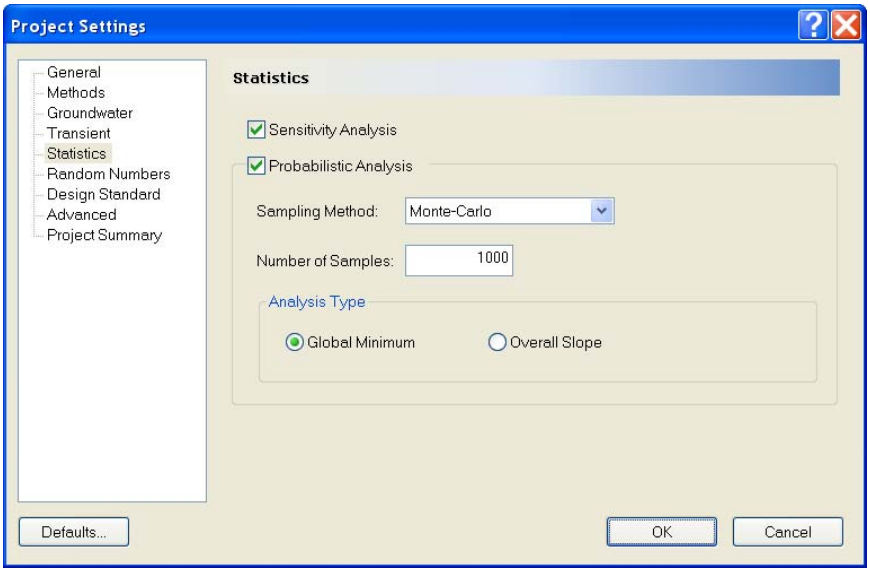
Sensitivity and Probabilistic Analysis

A Sensitivity Analysis should not be confused with a Probabilistic Analysis. Remember:

- A Sensitivity Analysis simply involves the variation of individual variables between minimum and maximum values. A Sensitivity Analysis is performed on ONLY ONE VARIABLE AT A TIME.

- A Probabilistic Analysis involves the statistical sampling of distributions that you have defined for your random variables. A Probabilistic Analysis uses sampled values of ALL random variables, for each iteration of the Probabilistic Analysis.

However, you can perform BOTH a Sensitivity Analysis, AND a Probabilistic Analysis, at the same time, by selecting both checkboxes in Project Settings.



If you do this, note the following:

- The Sensitivity analysis will use the same variables that you have selected for the Probabilistic Analysis.

- The Sensitivity Analysis will only use the Minimum and Maximum values that you have defined for each variable. It will ignore the statistical distributions and standard deviations that you have entered to define the random variables for the Probabilistic Analysis.

This is convenient, because if you have already performed a Probabilistic Analysis on a model, then you can also perform a Sensitivity Analysis, using all of the same variables, simply by selecting the Sensitivity Analysis checkbox in Project Settings.