



Developer's Tip:

How to import strength data from Phase2 into Slide

Introduction

The S_u/p_o ratio of undrained shear strength (S_u) to effective overburden pressure (p_o) has been used since the late 1940's to describe the shear strength behavior of cohesive soils with depth. A number of correlations exist to describe this ratio in terms of either a soil's plasticity index, liquid limit, or liquidity index (Bowles 1996). Regardless which correlation is used, in most cases, this ratio is taken as a constant $K = S_u/p_o$. Using values of K determined from lab tests, and computed values of effective overburden pressure, p_o , the strength at any point within the soil can be computed:

$$S_u = K p_o \quad (1)$$

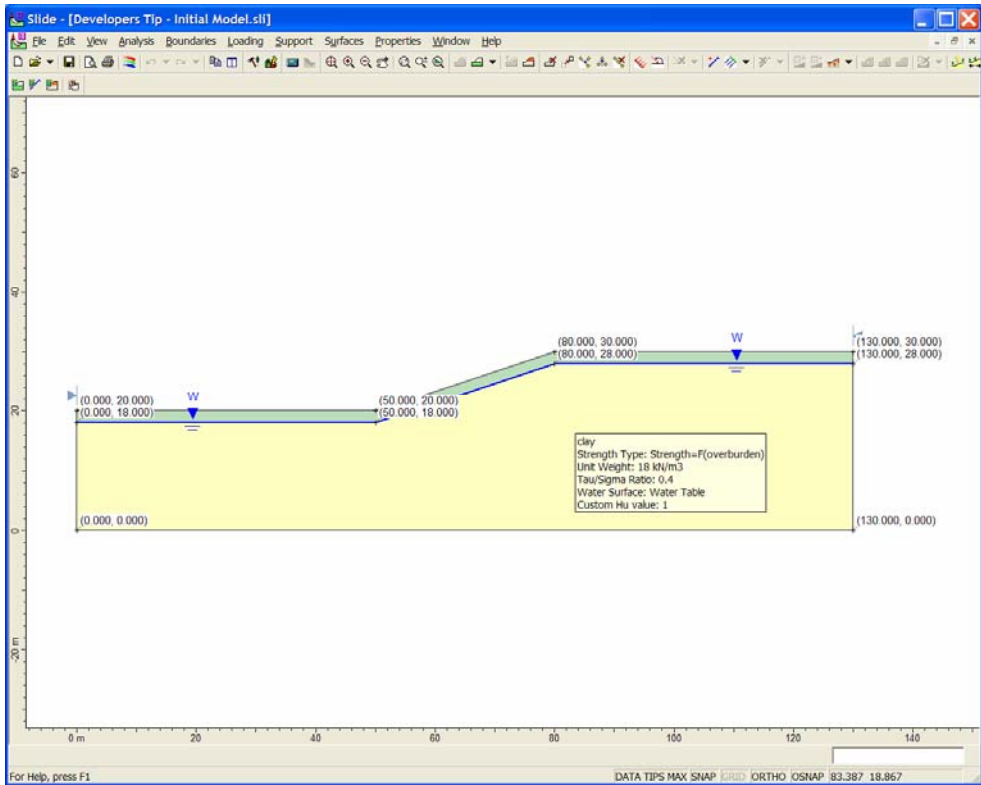
In the cases of complicated staging, where material is sequentially added or removed, and water levels within the soil change from stage to stage, a logical and accurate approach is to compute the effective overburden pressure using a finite-element analysis. Once the distribution of effective overburden pressure is known, equation 1 can be used to compute the strength of the soil at any point. This strength distribution can then be imported into a limit-equilibrium analysis to determine slope stability.

Rocscience offers a software solution to easily do this type of analysis using the [Phase2](#) finite-element program combined with the [Slide](#) limit-equilibrium slope stability program.

This Developer's Tip shows how to export the strength data for a simple slope from *Phase2* into *Slide*.

Model

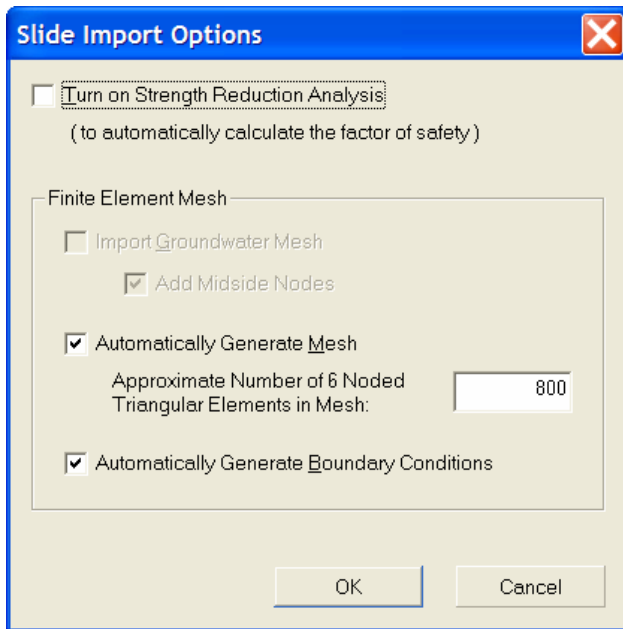
Download the [zip file](#) containing both the *Phase2* and *Slide* data files. The file **Developer's Tip – Initial Model.sli** contains the initial *Slide* data file. The slope is comprised of a soft clay layer overlain by a sandy soil. The clay has a K value equal to 0.4 and the undrained shear strength is modeled using equation 1. The water table sits at the top of the clay layer. The following figure illustrates the geometry.



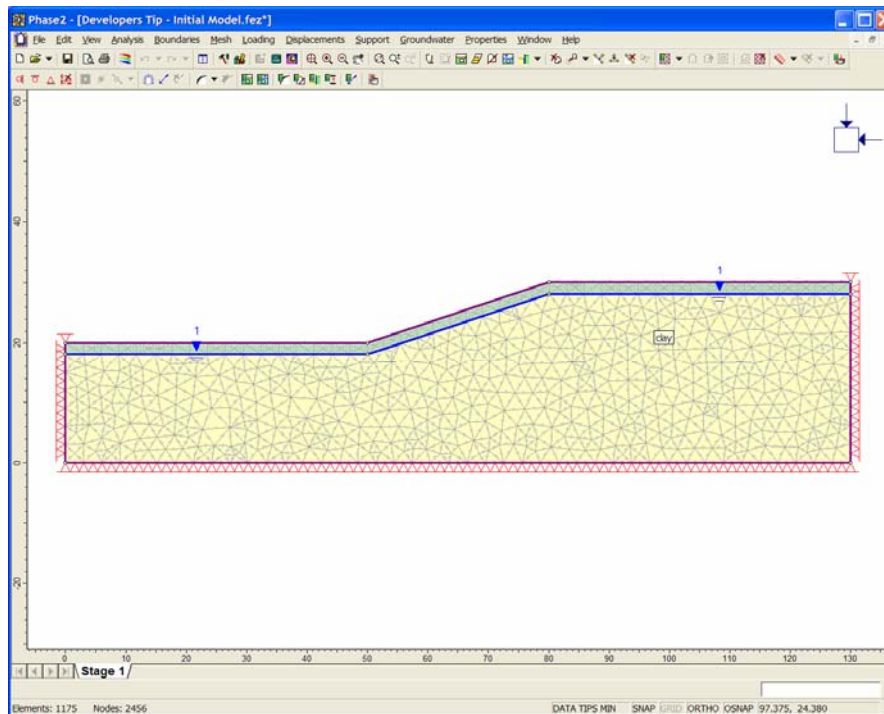
Analysis

To determine the undrained shear strength of the clay, a finite-element analysis using *Phase2* is performed on the above slope. The following is a step by step process for doing the analysis:

1. Unzip the file containing the model in the above figure.
2. Start *Phase2*. Select the **File...Import...Import Slide** option. Read the **Developers Tip - Initial Model.sli** file.
3. In the *Slide* Import Options dialog, uncheck the **Turn on Strength Reduction Analysis** option. Press the OK button.



4. *Phase2* will automatically mesh and define the initial stresses and boundary conditions for you.



Select the **Properties...Define Materials** menu option. In the material properties dialog, change the material type from plastic to elastic for both the clay and the sand. Changing to elastic materials means that the effective overburden pressure will be computed using an elastic stress analysis. Press OK to exit the dialog.

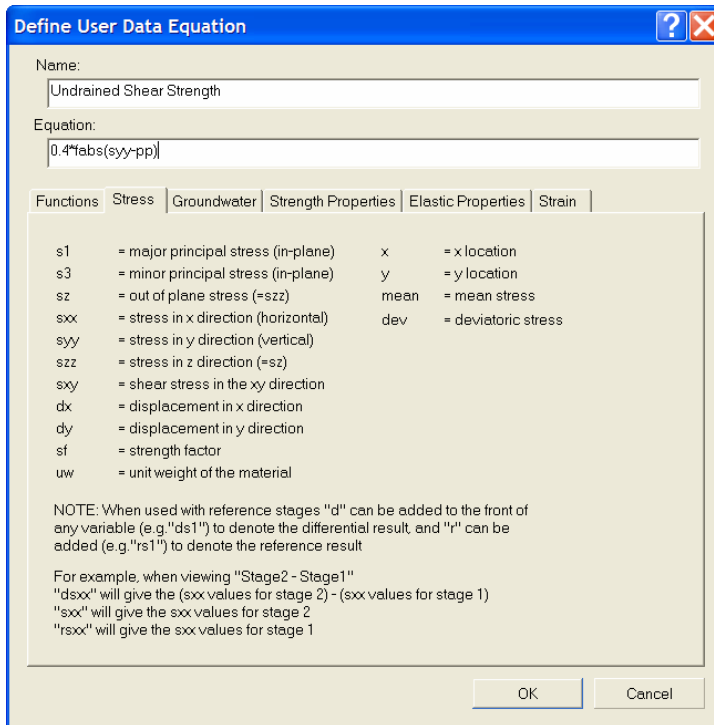
5. Since *Phase2* automatically sets up the mesh, stresses, and boundary conditions for you, that's all you have to do. Now run the stress analysis by selecting the **Analysis...Compute** menu option or by pressing the Compute toolbar button.
6. When the Compute dialog finishes, select the **Analysis...Interpret** option.
7. In order to compute the undrained shear strength, we must first define a user data function in *Phase2*. A user data function is a function that you define which incorporates stresses, displacements, pore pressures, etc. It allows the customer the ability to plot their own function of stress, strain, displacement. In the Interpreter, choose the **Data...Define User Data...** menu option. In the User Data dialog that comes up, press the New button.
8. Define a user data function with the name:

Undrained Shear Strength

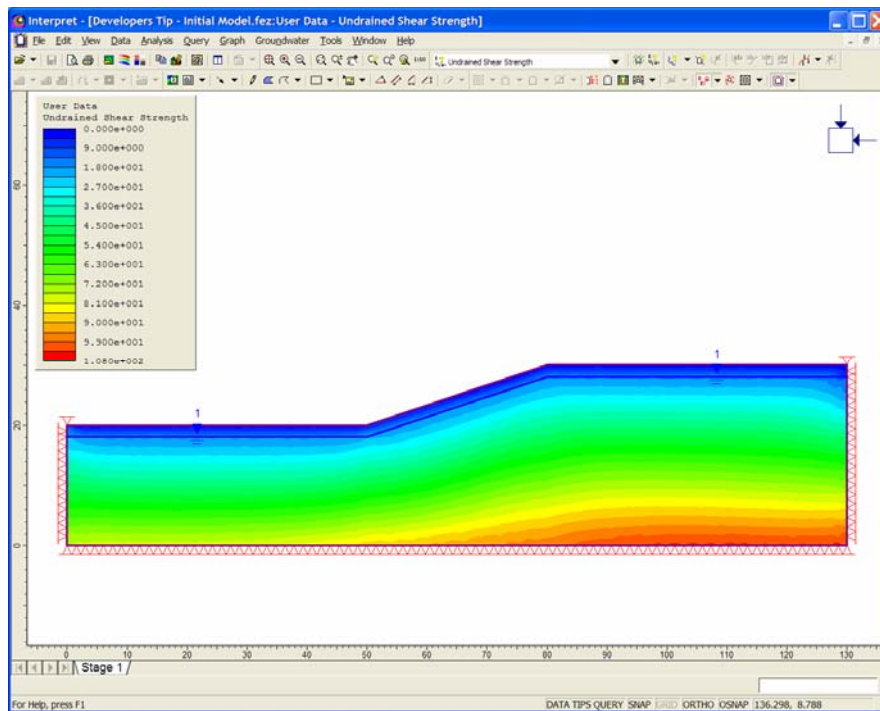
for the equation type in:

$$0.4*\text{fabs}(\text{syy}-\text{pp})$$

syy is the total vertical stress, pp is the pore pressure, and 0.4 is the K value as defined in equation 1. Therefore **syy-pp** is the effective overburden pressure. The fabs function ensures that all values of shear strength are positive. In a finite-element analysis, very small values of tension can occur near the ground surface due to numerical error. The fabs simply filters these out. Note: *Slide* does not allow the import of negative undrained shear strengths. Press OK to close the Define User Data Equation dialog. Press the Display button to close the User Data dialog and display the Undrained Shear Strength dataset.

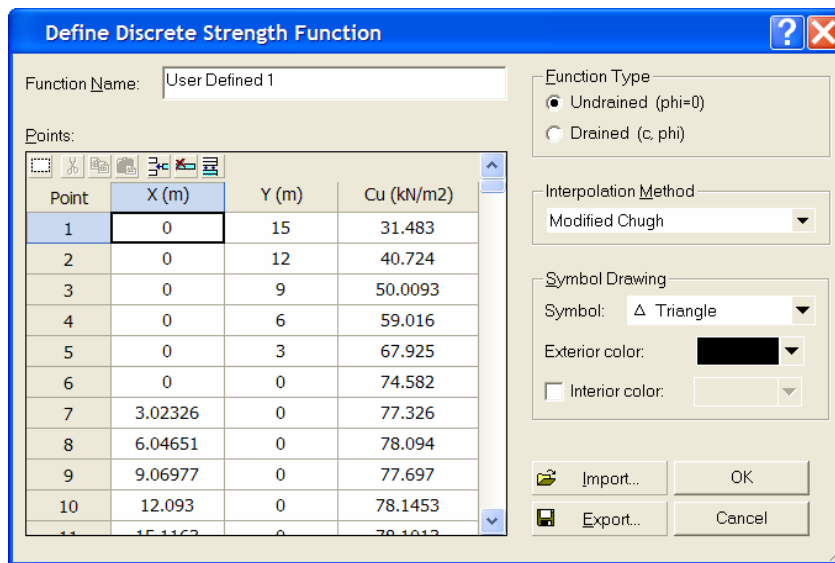


9. The distribution of Undrained shear strength is now plotted on the slope.



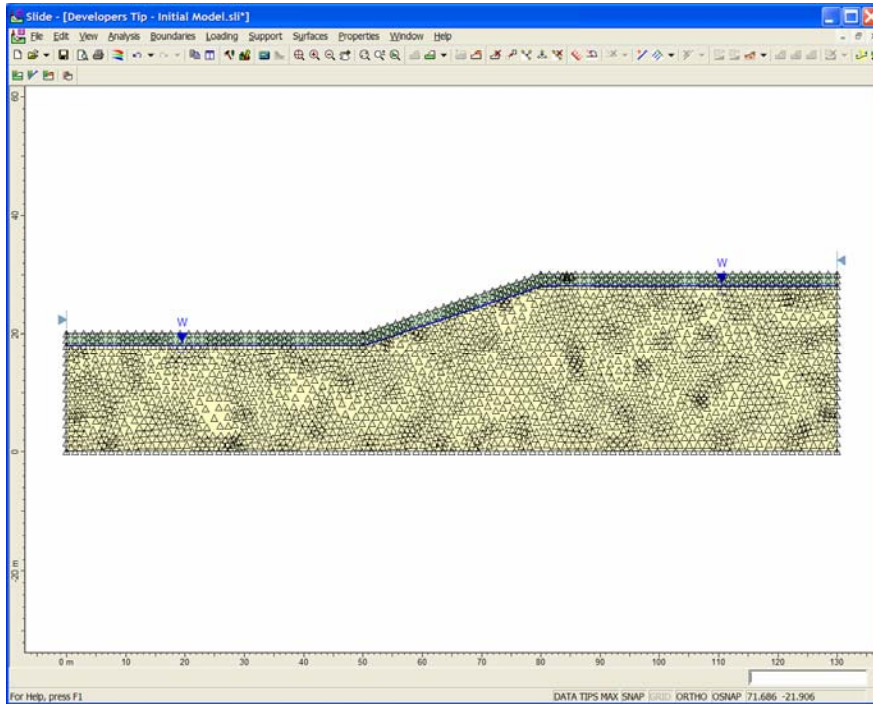
The next step is to export this data to use in a *Slide* analysis. Select the **File...Export...Value at all nodes...** menu option. Use the file name **Developers Tip - Initial Model.csv**. Press the Save button. This file contains a comma separated value (csv) list of the undrained shear strength values at each node in the finite-element mesh. It can also be viewed by any program that supports csv files (e.g. Excel).

10. Close the *Phase2* Interpreter and start *Slide*. Read in the **Developers Tip - Initial Model.sli** data file. This file contains the *Slide* model that you read into *Phase2*. The analysis methods, geometry, search method, and the material properties for the sand have already been defined. All you have to do is define the undrained shear strength distribution for the clay.
11. Open the Material Properties dialog using the **Properties...Define Materials** menu option or the corresponding toolbar icon. Select the clay material tab. Change the strength type to Discrete Function. Press the New button.
12. In the Define Discrete Strength Function dialog, select the Import button. In the Open dialog, change the **Files as type** combobox to **Comma, Tab, or Space Delimited Text Files**. Select the **Developers Tip - Initial Model.csv** file saved in step 9. Press the Open button to read the data. The Define Strength Function dialog should now look like:



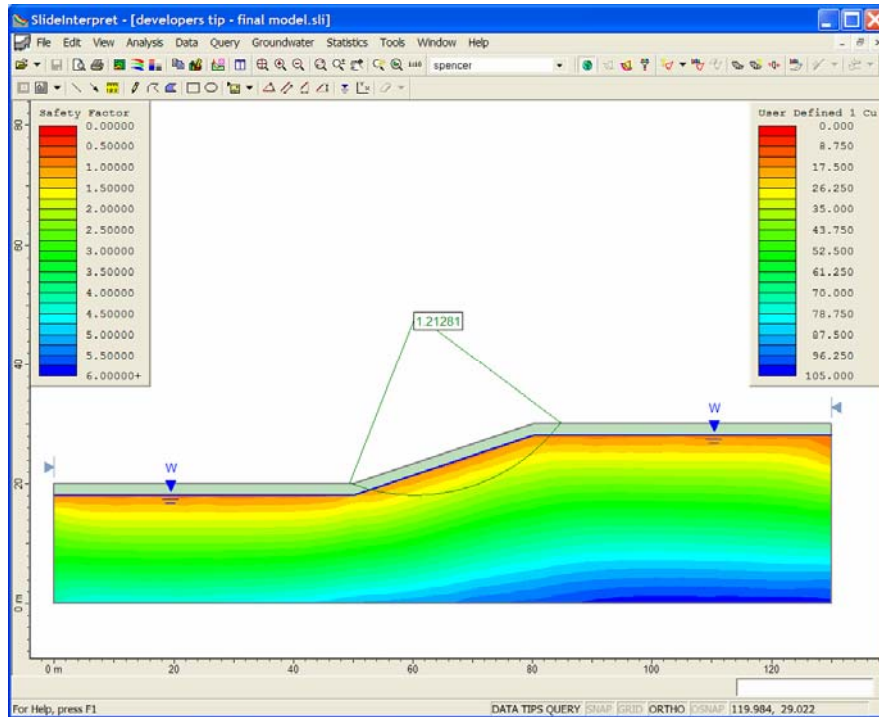
Press the OK button. Press the OK button again to close the Define Materials dialog.

13. The *Slide* model should now look like:



Each one of the black triangles in the above figure represents a discrete value of undrained shear strength taken from the nodal values in the finite-element analysis. These values are used by *Slide* to interpolate values of undrained shear strength at any point within the clay. Now save the model to a file named **Developers Tip - Final Model.sli**.

14. Run Compute by selecting the **Analysis...Compute** menu option. When Compute is finished, select the **Analysis...Interpret** menu option or the Interpret toolbar button.
15. The first thing you will notice is that the Spencer Factor of Safety is 1.21.
16. First turn off the triangular symbols representing the locations of the discrete undrained shear strength values. Select the **View...Display Options** menu option. Select the General Tab. Uncheck the Strength Functions Symbols checkbox. Press the Done button to close the Display Options dialog.
17. A useful option in Interpret is the contouring of the Discrete Strength Function. Select the **Data...Supplemental Contours...Setup** menu option. Check the **Show Supplemental Contours** checkbox. Make sure the Data combo reads **User Defined 1 Cu**. Uncheck the **Detailed and more accurate contour generation** checkbox. Press OK to close the Supplemental Contours Setup dialog.
18. The Interpreter view should look like:



Notice the contours showing the distribution of undrained shear strength lie only within the clay material (i.e. the material in which the discrete strength function was defined.)

Closing Remarks

As seen above, the process for determining undrained shear strength using a *Phase2* finite-element analysis is both quick and easy. Importing the strength data into *Slide* for use in a slope stability analysis is also very straight forward.

The model used for this Developer's Tip is very simple and could have easily been done without using *Phase2*. The **Vertical Stress Ratio** material strength type in *Slide*, could have been used for the clay material instead of the *Phase2* results. In this case, the effective overburden pressure is calculated based on the slice weight and pore pressure. All the user defines is the K value from equation 1 for the vertical stress ratio. You can easily check this by reading in the **Developers Tip - Initial Model.sli** file into *Slide*. Open the Material Properties dialog, and change the Strength Type to **Vertical Stress Ratio**. Define a value of 0.4 for the ratio. Save and re-run the analysis. You'll see that the Factor of Safety is 1.20 which compares very well with the 1.21 calculated above.

For more complicated slopes with staging of geometry and groundwater levels, the Vertical Stress Ratio method might not be applicable. In these cases, the method demonstrated in this Developer's Tip using *Phase2*, can be used to determine the undrained shear strength.

References

Bowles, J.E., "Foundation Analysis and Design", 5th edition, McGraw Hill, 1996.