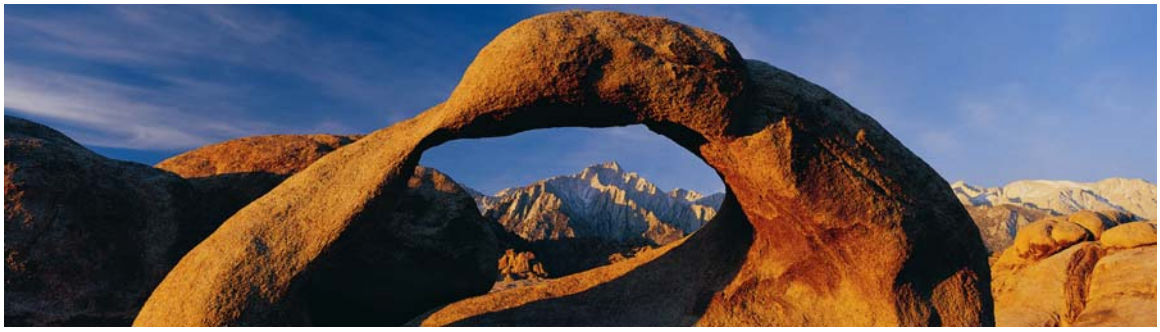

Developer's Tip:

Slope Stability using *Phase*^{2} and *Slide*

Exporting Slide Data Files from *Phase*^{2} 7.0

Introduction

Phase^2 utilizes the finite-element method and the shear strength reduction technique to determine the factor of safety of a slope. *Slide* uses standard limit-equilibrium techniques (Bishop, Janbu, Spencer, GLE etc.) to determine the factor of safety of a slope. Utilizing both these approaches has become standard engineering practice for determining the stability of slopes. So being able to quickly and efficiently use both approaches is extremely important to the design engineer. As a result, Rocscience has put a great deal of effort into the interoperability of the *Phase*^{2} and *Slide*.

In *Phase*^{2} 6.0, you could import *Slide* 5.0 data files in order to do a Shear Strength Reduction (SSR) analysis. However, you could not build a slope stability model in *Phase*^{2} and export a *Slide* data file. In *Phase*^{2} 7.0, you can now export a *Slide* data file at any stage of the *Phase*^{2} model. Simply select the desired stage and use the Export *Slide* option. The export engine supports finite-element groundwater analysis, ponded water, all *Phase*^{2} bolt models, Mohr-Coulomb and Hoek-Brown material types and other modeling features.

Example

One the next page, Figure 1 illustrates a simple two stage model with ponded water. In the first stage, the ponded water elevation is 40m while in the second stage there is a drawdown to an elevation of 35m. The slope is 20m high with a slope angle of 34°. The strength model of the material is Mohr-Coulomb with a cohesion=5 kPa and a friction angle of 33°. The material is perfectly plastic with residual strength equal to the peak. The modulus of the material is 50000 kPa. The permeability of the material is 1e-7 m/s. Pore pressure dissipation between stage 1 and 2 is assumed to be instantaneous. The pore pressure distributions are assumed to be steady state.

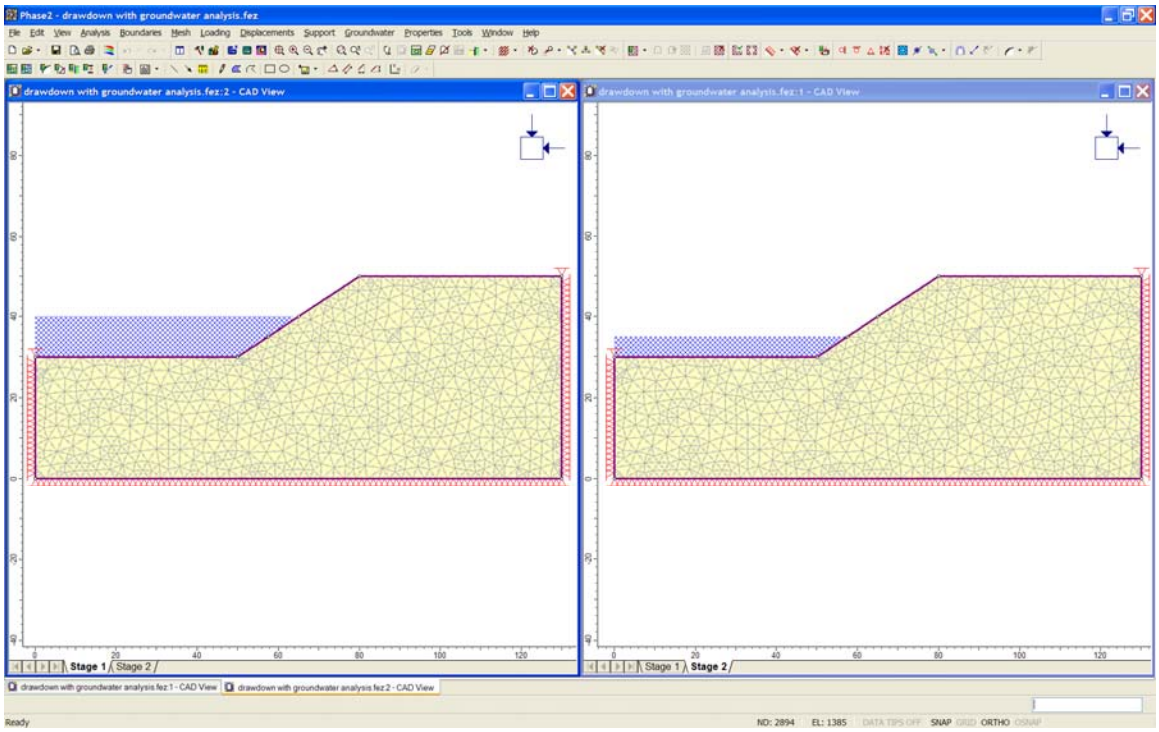

Figure 1 – Two stage drawdown

There are two ways you can define the pore pressure distribution within the slope. The first method is to perform a staged finite-element groundwater analysis. The second method is to use staged piezometric surfaces. The specifics of how to set up a model with these two different methods can be found in the Slope stability with drawdown tutorial which comes with *Phase*^{2} 7.0 and which is also included with the data files associated with this developer's tip. This developer's tip will only deal with using finite element groundwater analysis to define the pore pressures. Data files using piezometric lines are included for comparison purposes.

SSR – Pore pressure defined using groundwater analysis

One the next page, Figure 2 shows the results of a Shear Strength Reduction analysis of the model shown in Figure 1, with the pore pressures defined using a finite-element groundwater analysis.

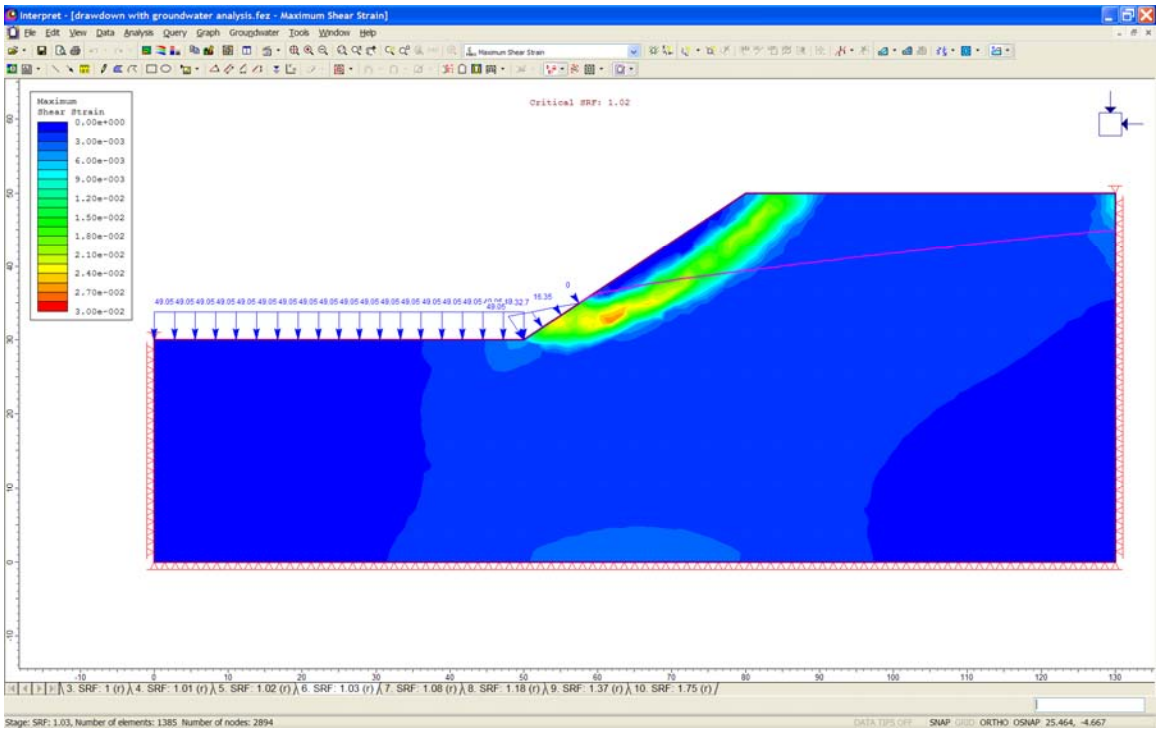

Figure 2 – SSR with groundwater analysis

The results indicate a factor of safety for the slope of 1.02. This factor of safety is for the drawdown stage (stage 2). In *Phase*^{2}, the SSR analysis is always performed on the last stage of a model.

To determine the factor of safety of the slope from a limit-equilibrium analysis, simply export a *Slide* data file. From the File menu of the *Phase*^{2} modeler, go to the Export menu and choose the Export Slide option (see Figure 3). Please note that you have to first select the stage that you want to export by selecting the desired stage tab at the bottom of the window. In this case, select the stage 2 tab before exporting the *Slide* data file.

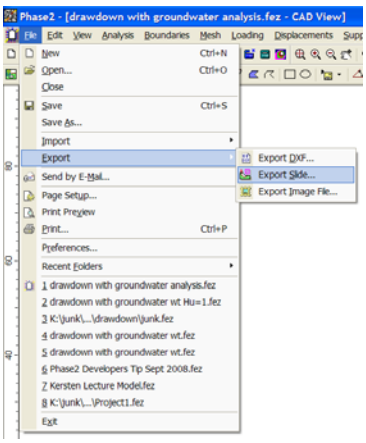

Figure 3 – Choosing the Export Slide option

Now read the exported file into *Slide* using the standard File…Open option. After reading the file, click the Compute button. Figure 4 shows the results of the *Slide* analysis using circular failure surfaces. The *Slide* data file exported by *Phase*^{2} performs a circular analysis by default. If you want, you can easily change the analysis to noncircular failure surfaces within *Slide*. You may also want to use the results of the SSR analysis to define Search objects to improve the search for the global minimum failure surface within *Slide*.

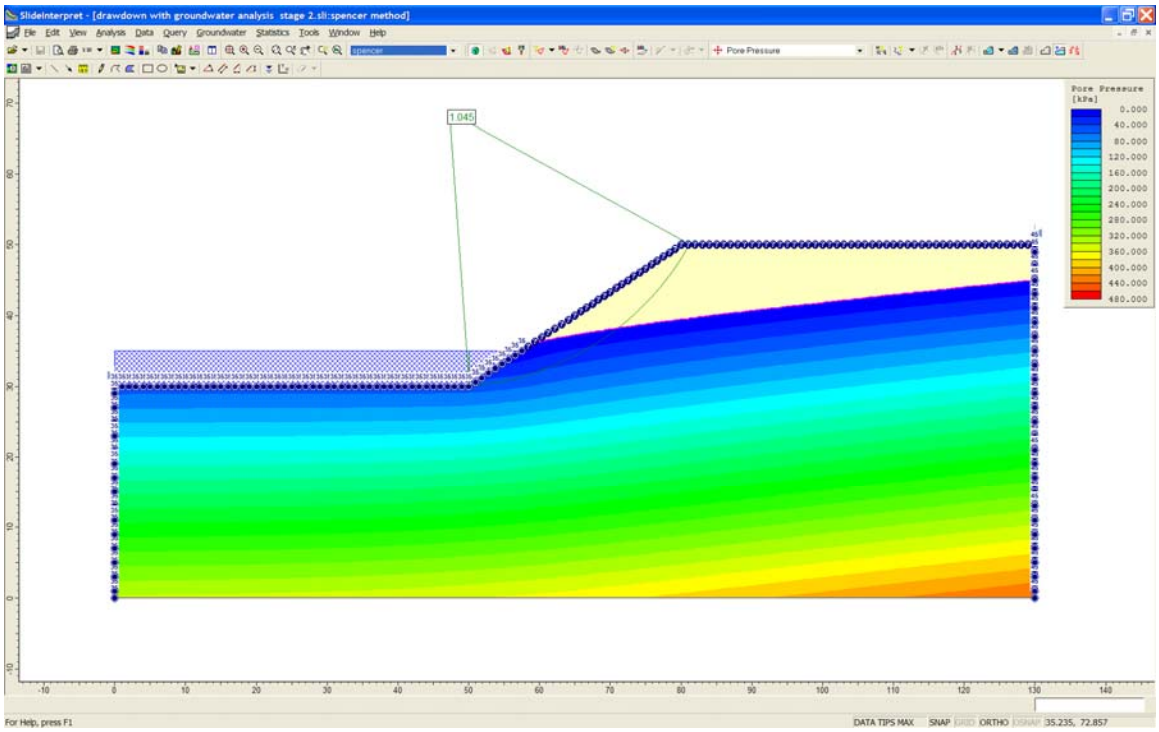

Figure 4 – Slide analysis with groundwater

The limit-equilibrium factor of safety using Spencer's method is 1.045. This factor of safety and the location of the global minimum compares quite nicely to the results of the SSR analysis. If you change the analysis to noncircular and turn on optimization to automatically hunt for the global minimum, the Spencer global minimum surface has a factor of safety of 1.03 (see Figure 5). The contours in Figures 4 and 5 represent the pore pressure from the groundwater analysis.

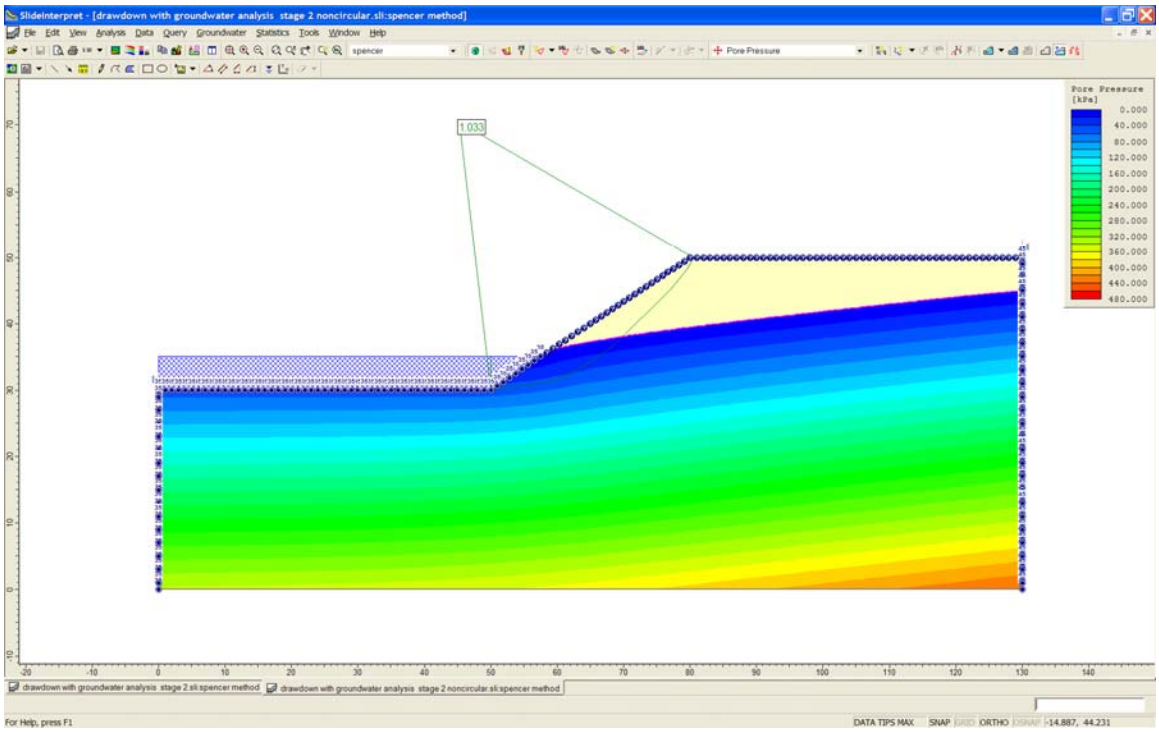

Figure 5 – Noncircular analysis

Exporting Stage 1

Any stage of a *Phase*^{2} analysis can be exported to *Slide*. For example, say you wanted to see the factor of safety of the above slope prior to drawdown. This is represented by stage 1 of the *Phase*^{2} analysis. Simply select stage 1 by clicking on the stage 1 tab at the bottom of the window. Then select the Export Slide option as shown in Figure 3. Read this data file into *Slide* and click the Compute button. Figure 6 shows the results of the *Slide* limit-equilibrium analysis using Spencer's method. The factor of safety is 1.061, a little larger than the 1.045 computed for the drawdown stage.

One the next page, the pink line in Figure 6 represents the phreatic surface (water table). This is computed by the groundwater analysis based on the hydraulic boundary conditions defined for the slope.

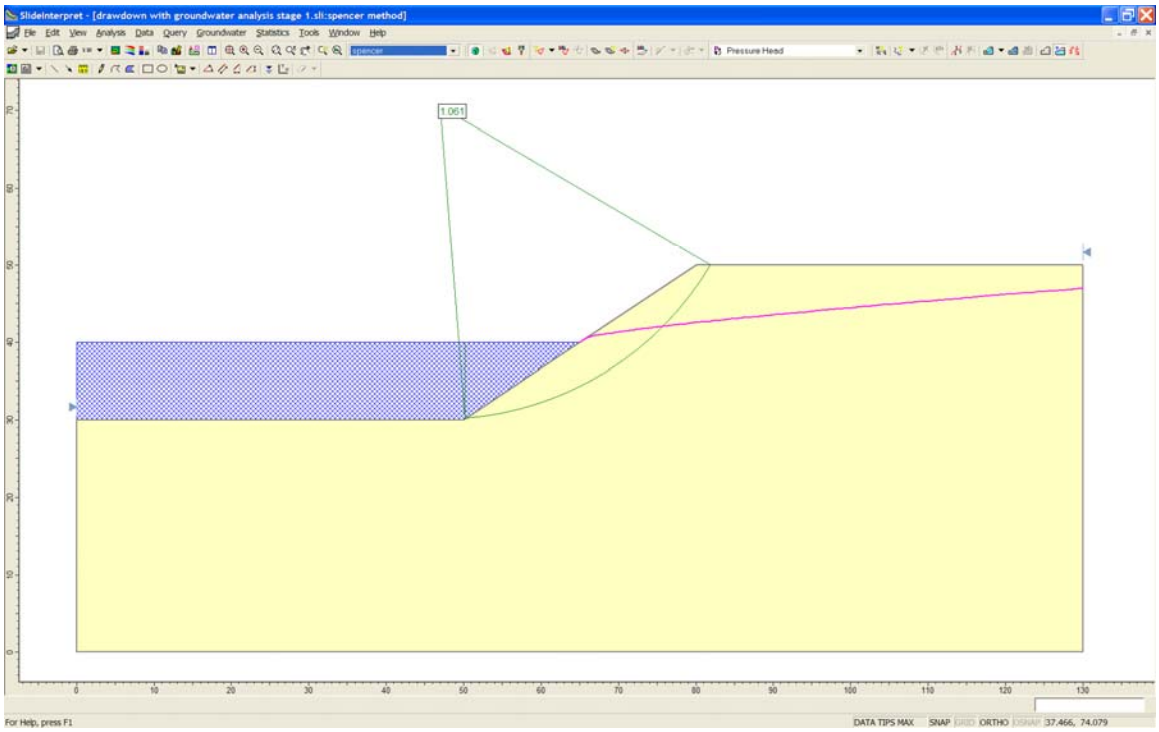

Figure 6 – Slide analysis of stage 1

Closing Remarks

As seen above, the process for exporting slope stability models from *Phase*^{2} to *Slide* is both quick and easy, and will greatly enhance your ability to properly model the stability of slopes.