SEEQUENT

GeoStudio Example File
Pore-Water Pressure Defined using a Piezometric Line

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Introduction

Pore-water pressures impose one of the greatest controls on the stability of slopes. The pore-water pressure can be defined in a SLOPE/W analysis using a variety of approaches including a piezometric line, spatial pressure head function, or a finite element analysis. This example illustrates how to set-up and interpret the results of a SLOPE/W analysis that uses pore-water pressures defined using a piezometric line. Some of subtle nuances of the method are discussed.

Numerical Simulation

Figure 1 presents the problem configuration. The slope and foundation comprise three stratigraphic units. The entry-exit method is used to search for the critical slip surface in all analyses. The GeoStudio Project includes three analyses. The first stability analysis uses a single piezometric line that is applied to all three materials (Figure 2). The second analysis invokes the phreatic surface correction (Figure 3) and the last analysis makes uses of two piezometric lines (Figure 4).

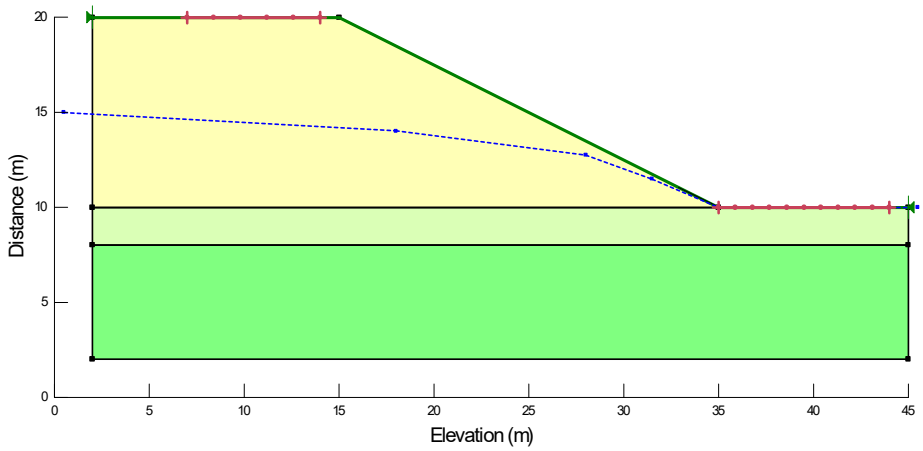

Figure 1. Base case with pore-water pressure from a piezometric line.

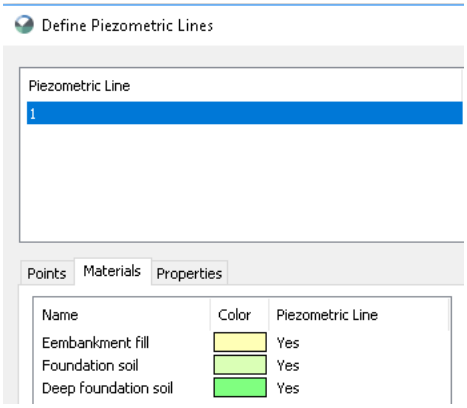

Figure 2. Define Piezometric Lines dialog box showing which materials have the piezometric line applied.

Figure 3. Application of the Phreatic Correction in SLOPE/W.

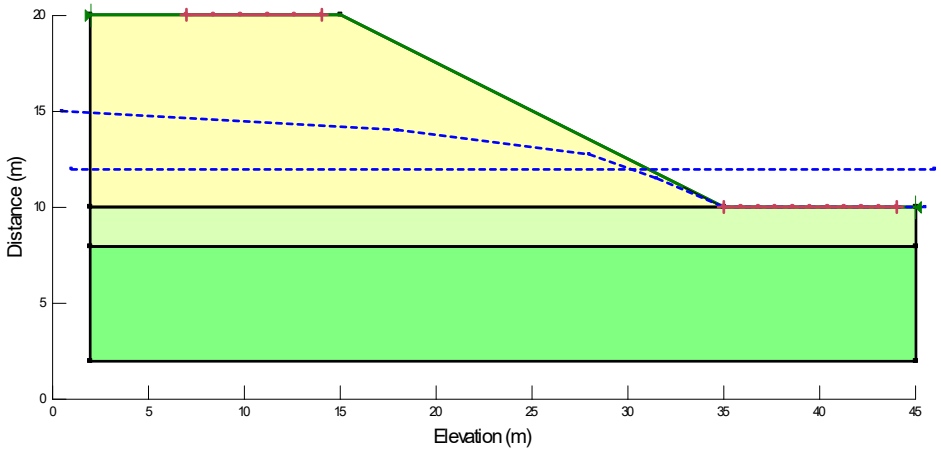

Figure 4. Problem configuration for Case 3 using two piezometric lines.

Results and Discussion

Figure 5 presents the critical slip surface and factor of safety for Case 1. The pore-water pressure (u_w) at the base of each slice is calculate based on the vertical distance from the mid-point of the slice base up to the piezometric line (h; Figure 6):

$$u_w = \gamma_w h$$ Equation 1

where γ_w is the unit weight of water and h is the height. This is not strictly correct for some cases, but is adequate for most field problems.

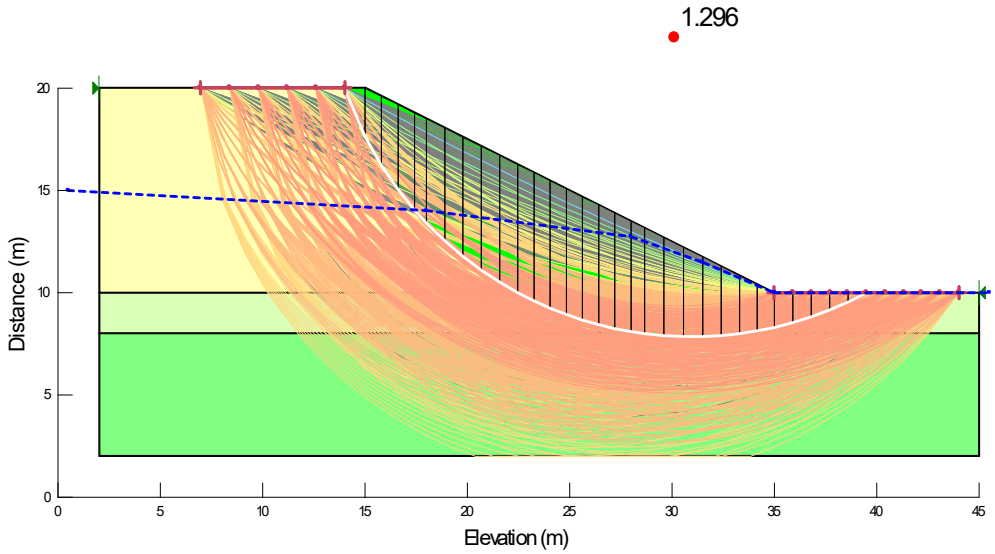

Figure 5. Critical factor of safety for Case 1.

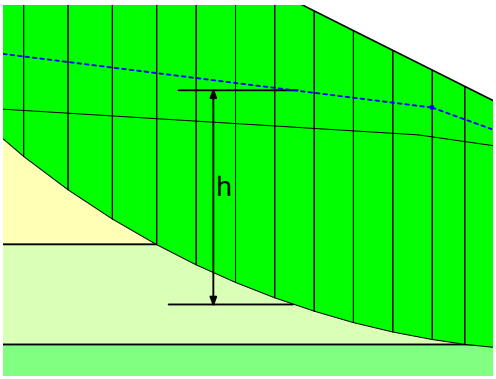

Figure 6. Distance for computing pore-water pressure from a piezometric line.

Figure 7 compares the slice base pore-water pressures for Case 1 and 2. The pore-water pressures are lower for Case 2, which included the phreatic correction. A sloping piezometric line implies downward flow, which also makes the equipotential lines curved in the physical system (Figure 8). The correct distance would is the height to which water would rise in a piezometer installed at that location. This is given by the height from the slice base up to the elevation corresponding to the total head value of the equipotential (vertical distance on the right in Figure 8), not the vertical distance on the left in Figure 8.

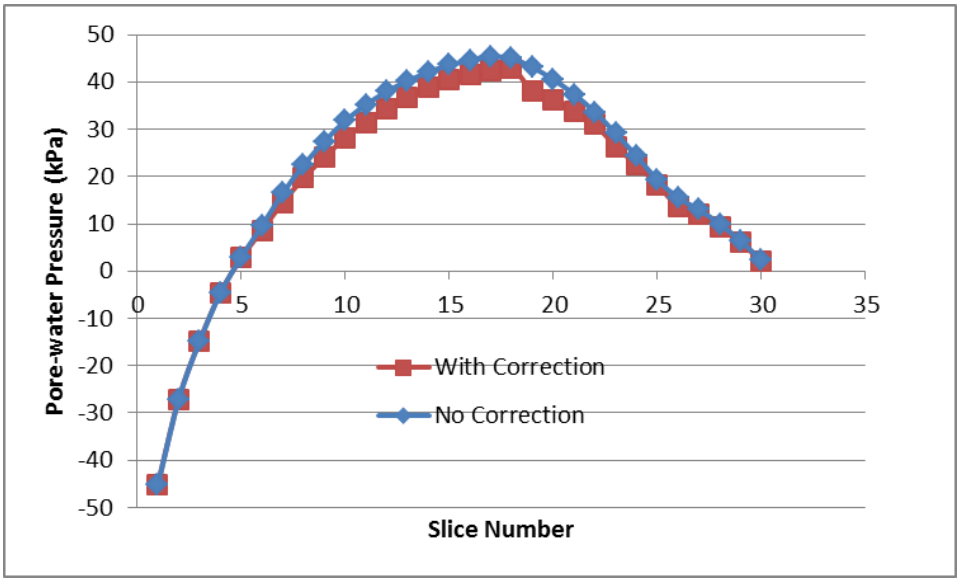

Figure 7. Comparison of pore-water pressures with and without the phreatic correction.

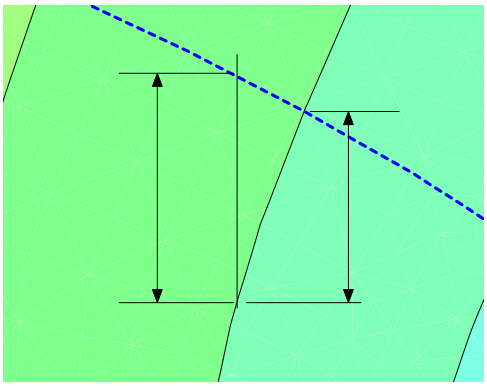

Figure 8. Vertical distances when computing the pore-water pressure from a piezometric line.

Naturally, there are no equipotential lines available when the pore-water pressures are defined via a piezometric line. The correction is based on the inclination of the piezometric surface within each slice and is calculated as:

$$h_c = h_w \cos^2 \omega$$ Equation 2

where h_c is the corrected height used to calculate the pore-water pressure at the base of the slice, h_w is the uncorrected height, and ω is the angle of inclination of the piezometric line. Figure 9 presents the critical slip surface for Case 2, along with the pore-water pressure contours. Notice that the factor of safety is higher with the correction. Also, it should be noted that the phreatic correction can cause sharp changes in the contours as shown near the bottom of the domain between 30 and 35 meters.

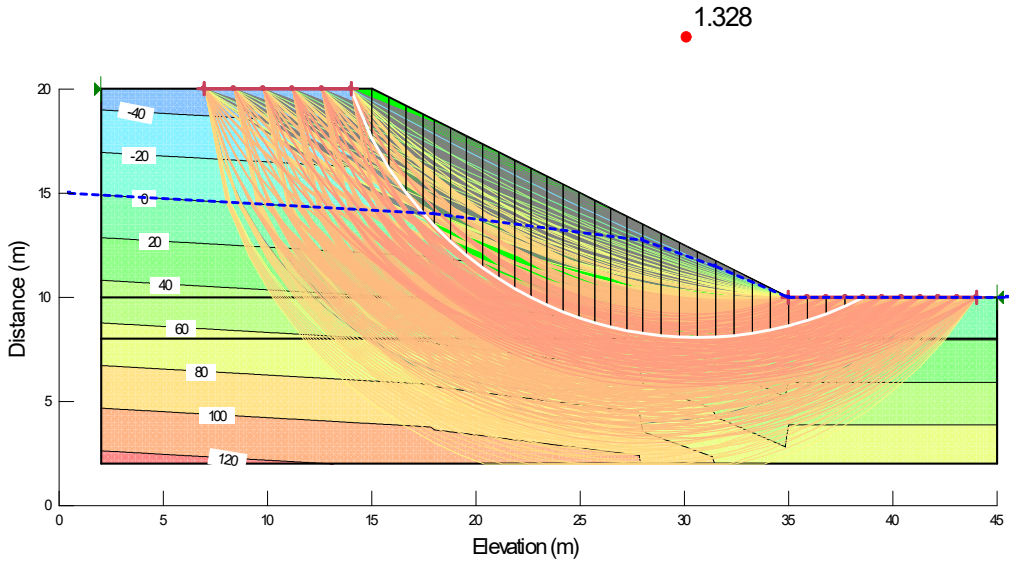

Figure 9. Case with phreatic correction.

Figure 10 presents the results for Case 3, which included two piezometric lines. The first piezometric line was used to define the pore-water pressure in the upper two stratigraphic units, while the lower phreatic line was used for the deepest layer. This would be typical of an artesian aquifer in a field case. It should be noted in the graph or pore-water pressure verses slice base (see GeoStudio file) that the use of multiple piezometric lines can result in sharp changes in pore-water pressure. This can be avoided by using the pore-water pressures from a finite element analysis (e.g. SEEP/W).

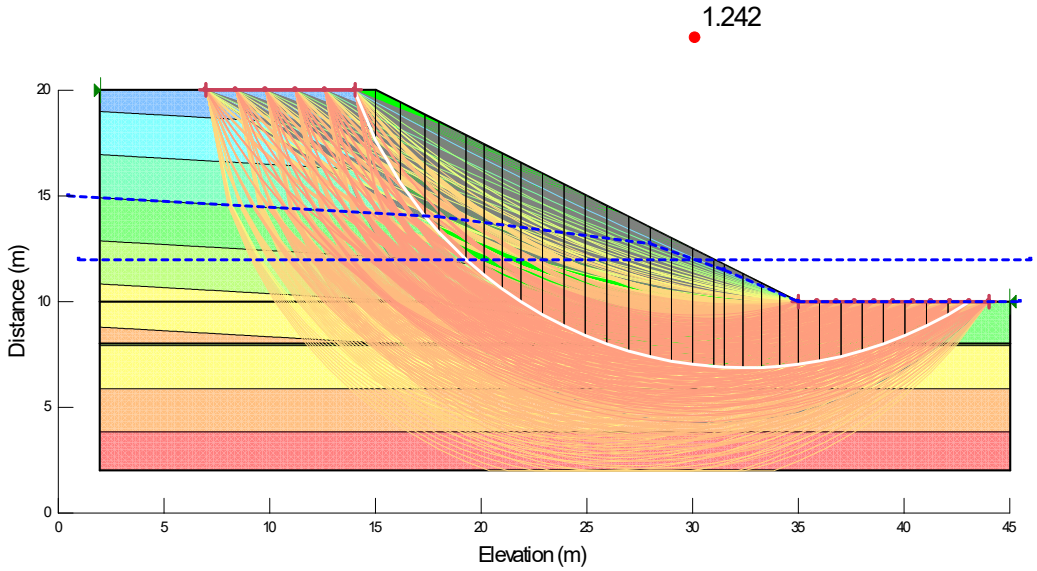

Figure 10. Case 3 with two piezometric lines.

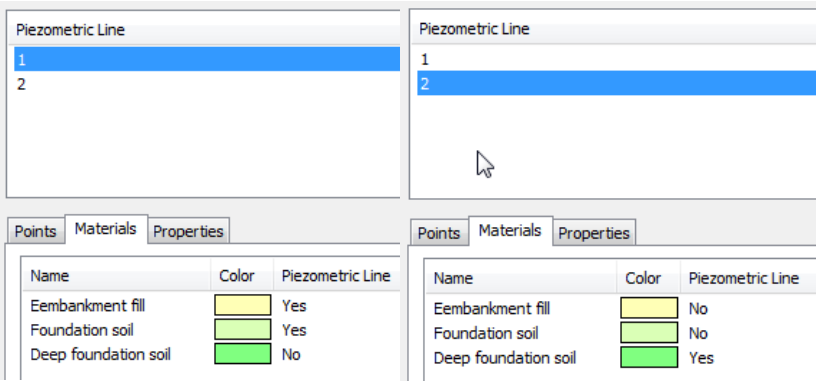

Figure 11. Associating a piezometric line with a soil type.

Summary and Conclusions

This example demonstrates the various approaches of using a piezometric line in a SLOPE/W analysis. Piezometric lines are a simple and quick way to define the pore-water pressures in a domain. Multiple piezometric lines can be defined in a single analysis and applied to different stratigraphic layers. Moreover, a phreatic correction can be used to try and accommodate for non-lateral flow when the piezometric line is not horizontal. This is a crude approximation that is often not warranted given the approximation already made using a piezometric line. A more accurate pore-water pressure distribution can be achieved using a finite element analysis.