GeoStudio Example File
Search Techniques: Entry and Exit

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Introduction

Historically the trial slips surfaces in a slope stability analysis have been specified by defining a grid of circle centres together with a range of circle radii. This approach has some undesirable side effects, and consequently, an alternative has been developed and implemented in SLOPE/W. It is called the *Entry-Exit* method. This illustrative example explains how the method functions and highlights the advantages.

Background

The concept of the Entry-Exit method of specifying trial slip surfaces is that the analyst will have some conceptual image of the approximate location of the head scarp and the toe of a potential failure. Specifying the head scarp and toe-areas is then a natural and intuitive way of specifying where to search for the critical slip surface. The red line segments in Figure 1 represent the entry and exit zones.

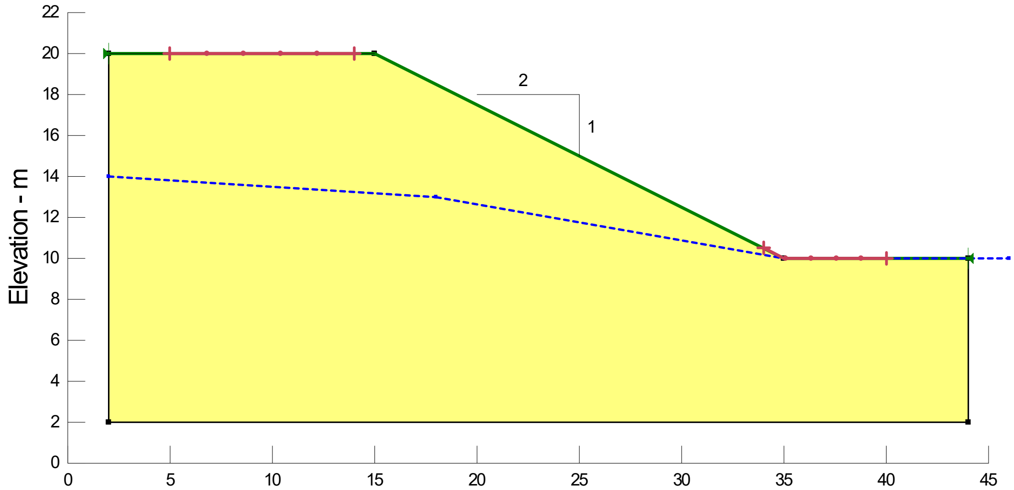

Figure 1. Problem configuration.

The first step is to create a straight line between points on the entry and exit zones. This becomes the chord or diameter of a circle as shown in Figure 2. The next step is to create a line normal to the chord at the mid-point. The Entry of the circle lines on the bisector. This is followed by finding the largest radius possible such that the potential slip surface does not fold back on itself. The distance along the bisector from the circle to the chord is then computed and divided into the user specified number of radius increments. The shallowest slip needs some curvature (cannot be a straight line) and is consequently slightly offset from the chord along the bisector as illustrated in Figure 3.

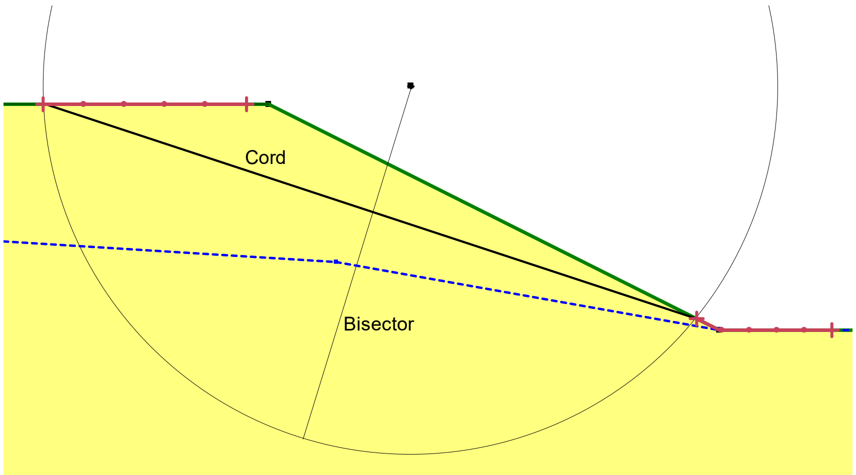

Figure 2. Largest slip circle possible for this configuration.

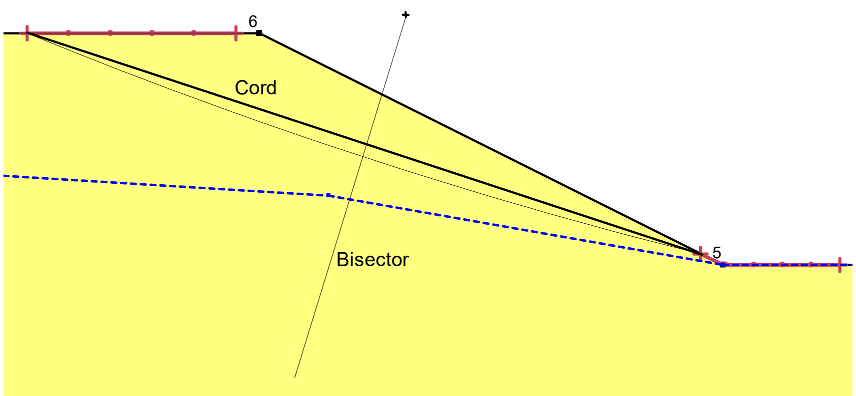

Figure 3. Shallowest slip circle possible for this configuration.

This procedure is repeated for each pair of points on the Entry and Exit lines. For the illustrative example here, there are six points on the Entry line, six points on the Exit line and 11 points (10 increments) along the radius bisector line, making a total of 396 trial-slip surfaces.

It should be noted that the actual center of rotation for the circles is not displayed in results view. This is done because the location is often inconvenient to present. Even though the locations are not displayed, the actual coordinates are used for the moment factor of safety computations. All moments can be summed about a user specified point. This is called an Axis Point. When an Axis Point is specified, it overrides the circle Entry as points about which to sum moments.

Numerical Simulation

The numerical model comprises a 2H to 1V slope with a piezometric line used to represent pore-water pressure conditions. The soil has a friction angle of 26°, cohesion of 10 kPa, and a unit with of 20 kN/m^3. There are a total of three analyses in the GeoStudio Project. Case 1 is a conventional entry-exit configuration, Case 2 collapses the exit zone to a point to analyze a toe failure, and Case 3 makes use of radius tangent lines to impose further controls on the search location. It is possible to use the Radius Tangent Lines control from the Grid-Radius method in conjunction with the Entry-Exit method. This option has to be deliberately selected for both Case 2 and 3(Figure 4).

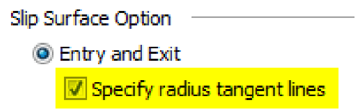

Figure 4. Option to use the Radius Tangent Lines control in Entry-Exit method.

Results and Discussion

Case 1

Figure 5 presents the factor of safety and position of the critical slip surface for Case 1. Note that the critical slip surface starts within the Entry zone and exits within the Exit zone (i.e., not at the end points). The computed factor of safety of 1.523 is the lowest out of 396 trial slips. Note that all slip surfaces are displayed, including invalid slip surfaces, by selecting the appropriate filter in the Slip Surfaces docked window and activating the contours in Draw Slip Surface Results. It is sometimes useful to use additional filtering such a range of factors (Figure 6).

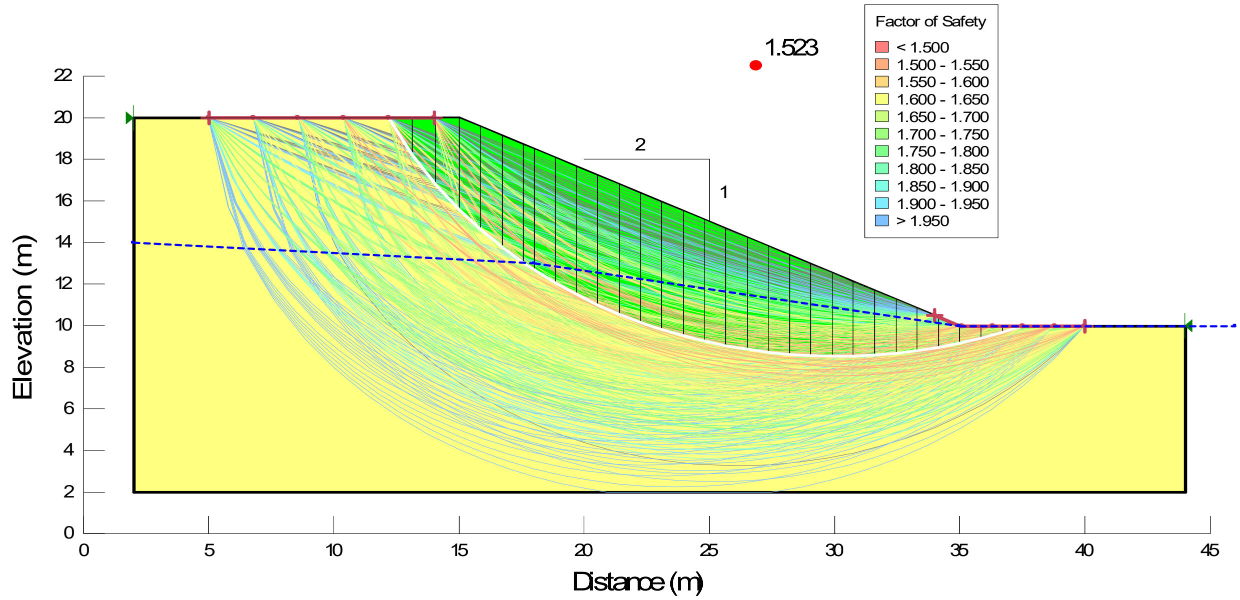

Figure 5. Result with Entry-Exit method.

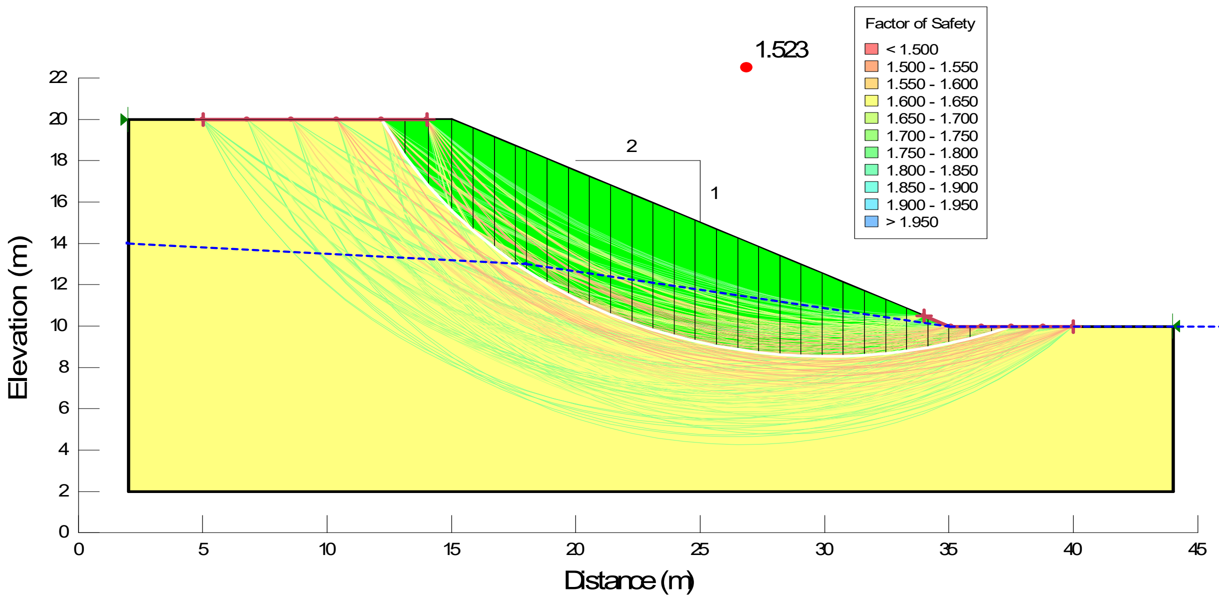

Figure 6. Display of the slips surfaces with a factor of safety ranging between 1.5 and 1.8.

Another useful approach for interpreting results to display only the Safety Map (Figure 7). This makes it possible to show a band within which the factor of safety falls within a selected range. As seen in Figure 7, slips within the band adjacent to the critical slip surface have a factor of safety between 1.523 (minimum) and 1.55.

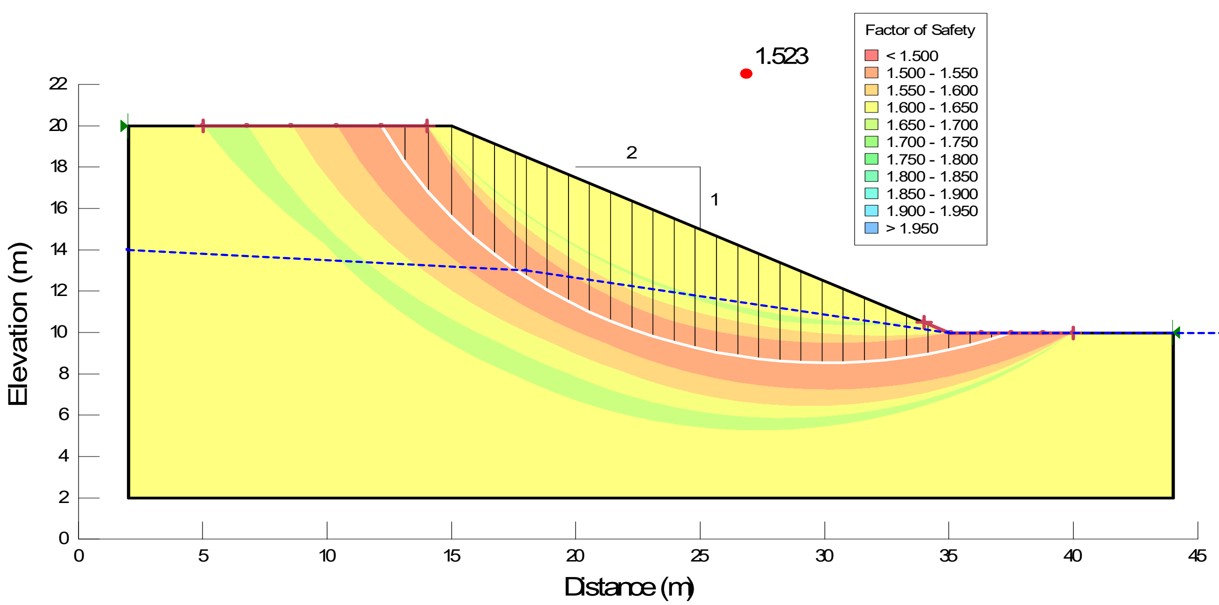

Figure 7. A band with the most critical slips surfaces.

Portraying a band encompassing a range of safety factors gives the message that there is a shear zone as opposed to a single paper-thin slips surface. The existence of a shear zone is likely much more realistic than a single, well-defined slip surface.

Case 2

In Case 2, the Exit range was collapsed to a single point. This makes it possible to analyze a specific mode of failure (Figure 8). In this case, the mode under consideration is failure at the toe of the slope. The introduction of radius tangent lines ensures that all trial slip surface are tangent to one of the lines, which focuses the search zone.

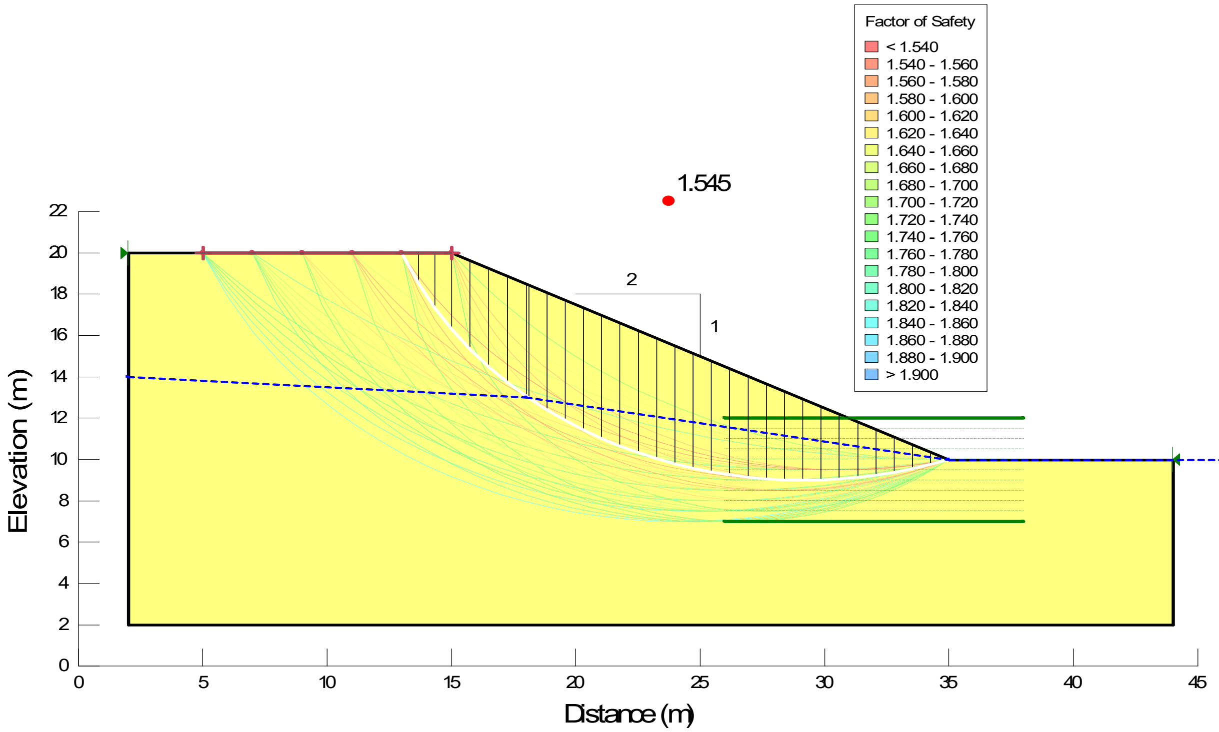

Figure 8. All slips surfaces passing through a point (the toe).

Case 3

Figure 9 present the result for Case 3, in which the radius tangent lines were collapsed to a single line. Using the Tangent Lines (or even a single point) in conjunction with the Entry-Exit method greatly restricts the number of legitimate trial slips. Defining a single tangent line in Case 3 reduces the number of trial slips from 396 to 36. Consequently, this option has limited use, but can be very effective in special cases.

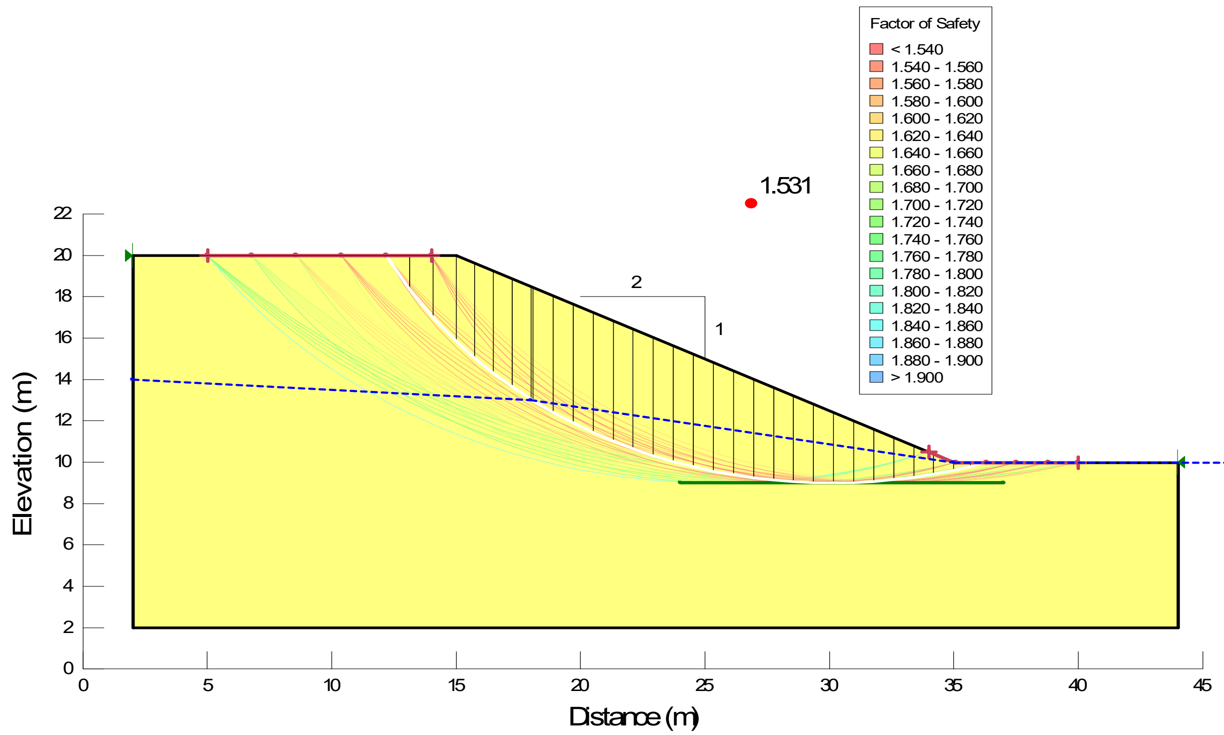

Figure 9. A Tangent Radius line in conjunction with Entry-Exit.

Summary and Conclusions

The Entry-Exit method is the most intuitive method in SLOPE/W to search for the critical slip surface because the analyst can visualize the search zone before solving the analysis. Moreover, the entry-exit method can be used in conjunction with radius tangent lines to further constrain the search zone.