Block Slip Surfaces

1 Introduction

Block searches are especially useful when an embankment rests on a relatively thick stratum of weak material. The purpose of this example is to show how to use the block specified slip surface option. Features of this simulation include:

- Block specified slip surface
- Piezometric line
- Wet tension crack
- A specified axis of rotation
- Optimization of the most critical slip surface

2 Configuration and set-up

Figure 1 shows the soil profile and the specified left and right search blocks. The weight and hydrostatic force contributed by the downstream ponded water layer is automatically computed due to the presence of the piezometric line. Note that a piezometric line was drawn through the profile and extended above the ground surface to represent the surface of the water. The piezometric line is also used to determine the pore-water pressures at the base of each slice. At the top of the slope is a desiccated clay layer, which is assumed to have tension cracks that are fully saturated.

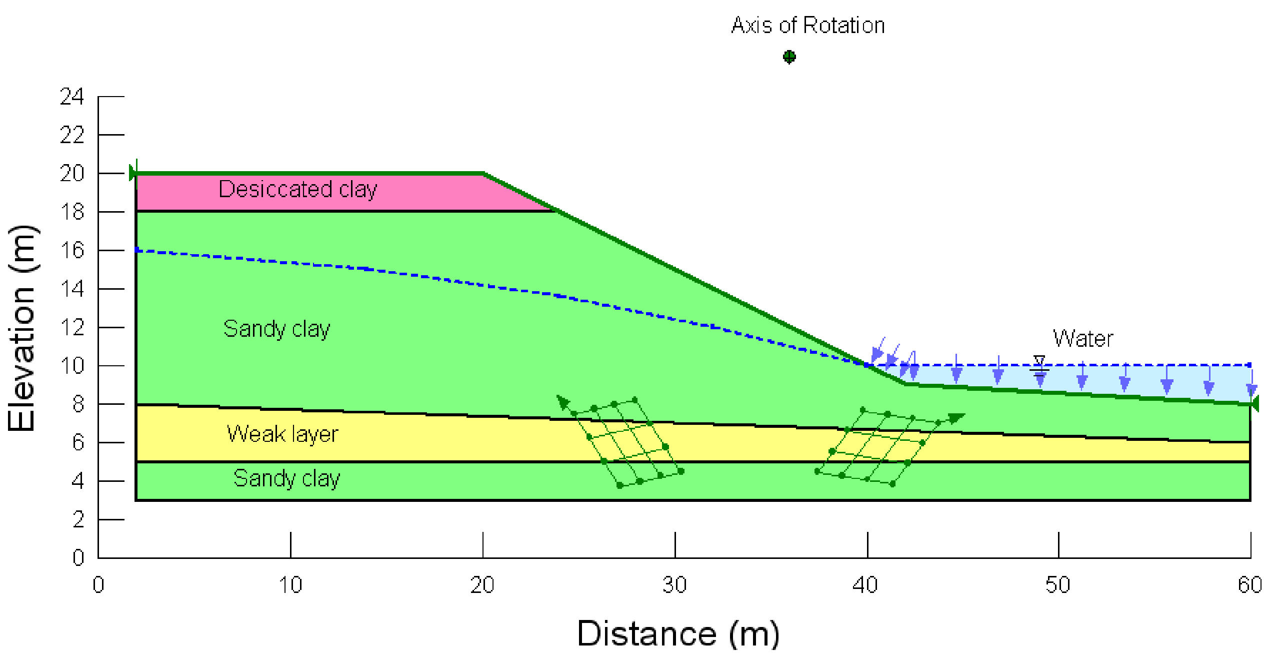

Figure 1 Profile used for the block specified slip search example

The material properties of the materials used in this analysis can be found in Table 1.

Table 1 Material properties for the block specified analysis

Description	Soil Model	Unit Weight	c’	ϕ’
Desiccated clay	Mohr-Coulomb	15	10	25
Sandy clay	Mohr-Coulomb	18	20	30
Weak layer	Mohr-Coulomb	18	0	10

For a block search analysis, a series of slip surfaces are developed that consist of three line segments. One of the segments is a line that extends from a grid point in the left block over to a grid point in the right block. The other two line segments are projections to the ground surface at a range of specified angles from each block. These three line segments define a single slip surface. All the grid points in the right block are connected to all the grid points in the left block, resulting in a large number of potential slip surfaces to be analyzed. Although a range of projection angles can be specified, for this particular example, a single projection angle was defined for each block, as shown by the green arrows in Figure 1.

An axis of rotation is required for a block search analysis. We should specify an axis approximately at the center of the slip surfaces. If this center is not specified, SLOPE/W will generate one based on the positions of the left and right blocks. While an axis of rotation is required for this type of analysis, the solution will not be overly sensitive to the location of the axis, as long as a rigorous solution method is being used (i.e., Morgenstern-Price, Spencer, GLE).

In this example, a tension crack zone is defined by drawing a tension crack line and indicating that the tension crack is completely filled with water. The presence of water in the tension crack results does not affect the pore-water pressure existing at the base of the slice, but it does result in a small hydrostatic pressure being applied to the outermost slice existing at the top of the embankment.

3 Critical Factor of Safety

Figure 2 shows the resulting factor of safety (1.070) and the location of the critical slip surface. Note that while the slip surface is comprised of three lines, the direction of the two projection lines is altered by the presence of the tension crack zone in the dessicated clay layer. The vertical projection of the entry line indicates that no resisting strength is contributed in this material.

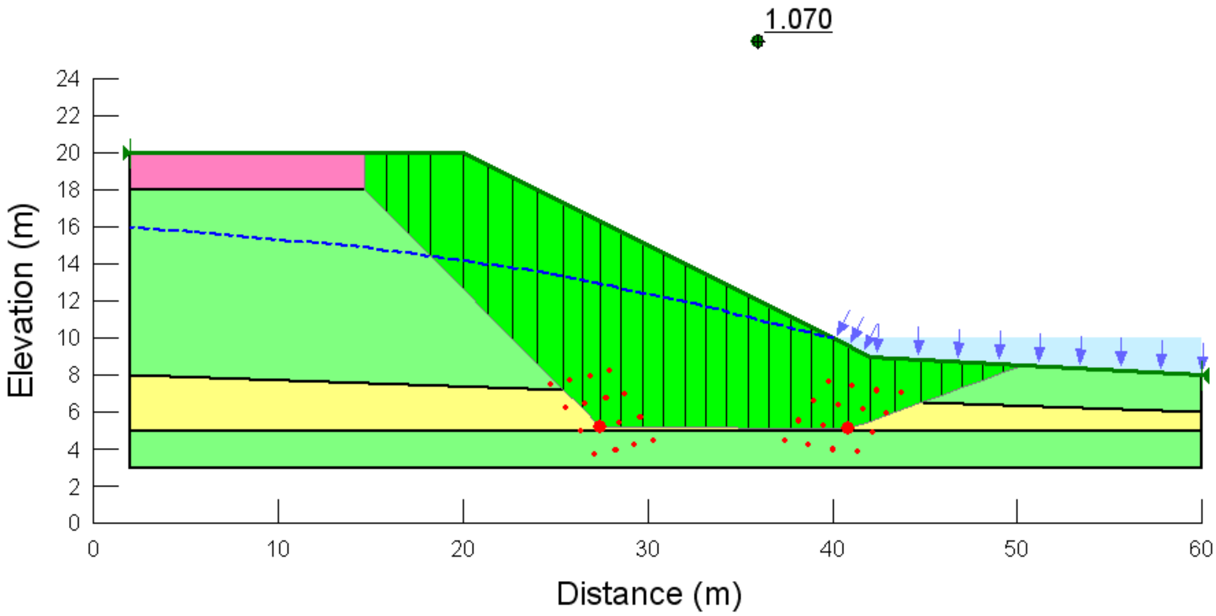

Figure 2 Factor of safety and location of the critical slip surface

The presence of the water in the tension crack can be confirmed by viewing slice force information for the left-most slice in the slip surface. Figure 3 shows the slice forces acting on this slice and the presence of a left side force (water pressure acting over the side area of the slice) equal to 19.614 kN, which is computed as (9.807 * 2 * 2 /2).

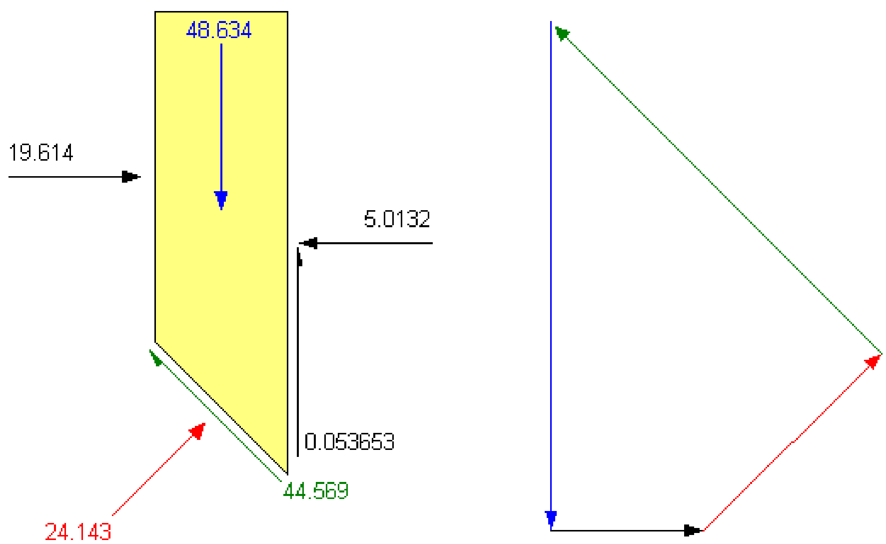

Figure 3 Slice forces for the left-most slice at the top of the embankment

You can also use view slice forces to verify that the ponded water has been appropriately modeled. Figure 4 shows the slice forces that exist for slice 23, which exists under the sloping portion of the embankment where it is submerged.   The slice weight of 82.111 kN only accounts for the weight of the soil and does not include the weight of the water. However, the resultant line load force acting on the top of the slice is comprised of two forces; the vertical weight of the water and the horizontal hydrostatic force which acts on the ground surface at the top of the slice. The pore-water pressure at the base of the slice, as reported in the detailed slice force information, is 46.096 kPa (kN/m^2). Given that the depth of water to the mid-point at the base of the slice is 4.7 m and the unit weight of water is 9.807 kN/m^3, the pore-water pressure is correct as calculated (4.7 * 9.807) = 46.096.

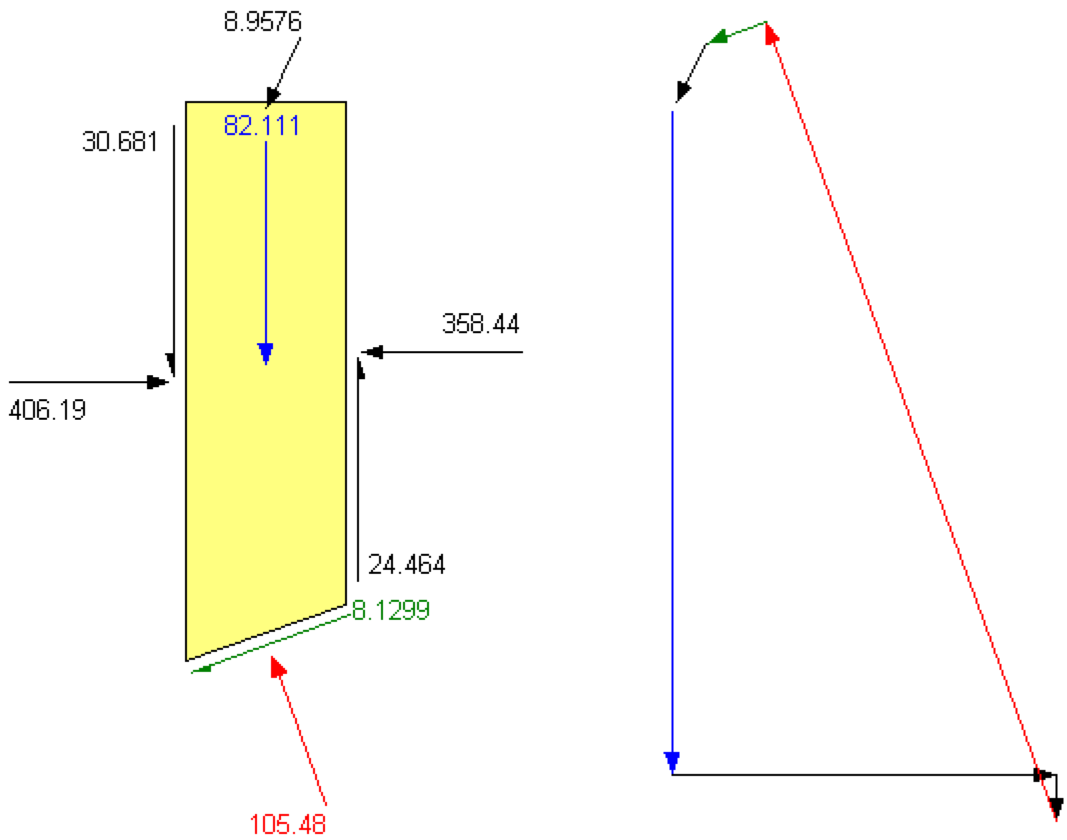

Figure 4 Slice forces for the right-most slice at the bottom of the embankment

Figure 5 shows a plot of the shear strength available and the shear strength mobilized along the slip surface. Note that the two curves are very similar to each other, which is reflected in the factor of safety being very close to unity (i.e., 1.070).

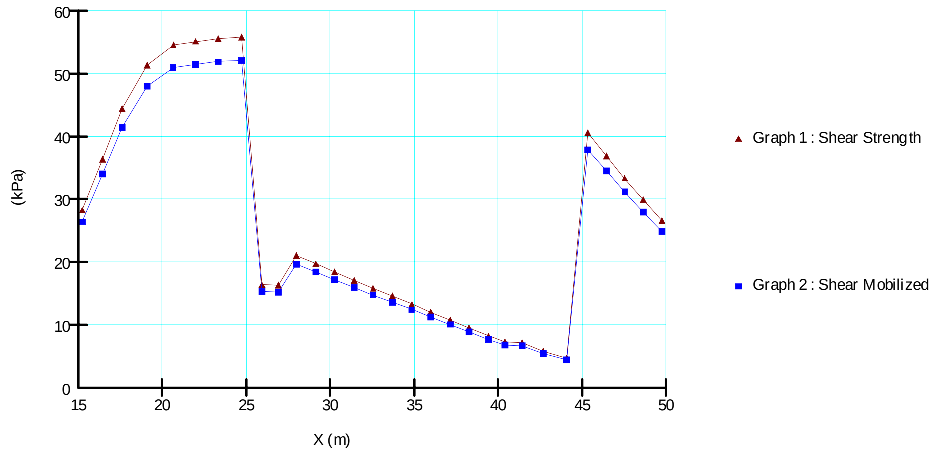

Figure 5 Graph of the shear strength available and the shear strength mobilized along the slip surface

4 Optimized Factor of Safety

Since a slip surface with angular corners is not physically realistic, optimization of the critical slip surface was performed, which resulted in a lower factor of safety and a slip surface as shown in Figure 6. For this particular situation, the optimized slip surface analysis becomes an enhancement to the original critical slip surface analysis.

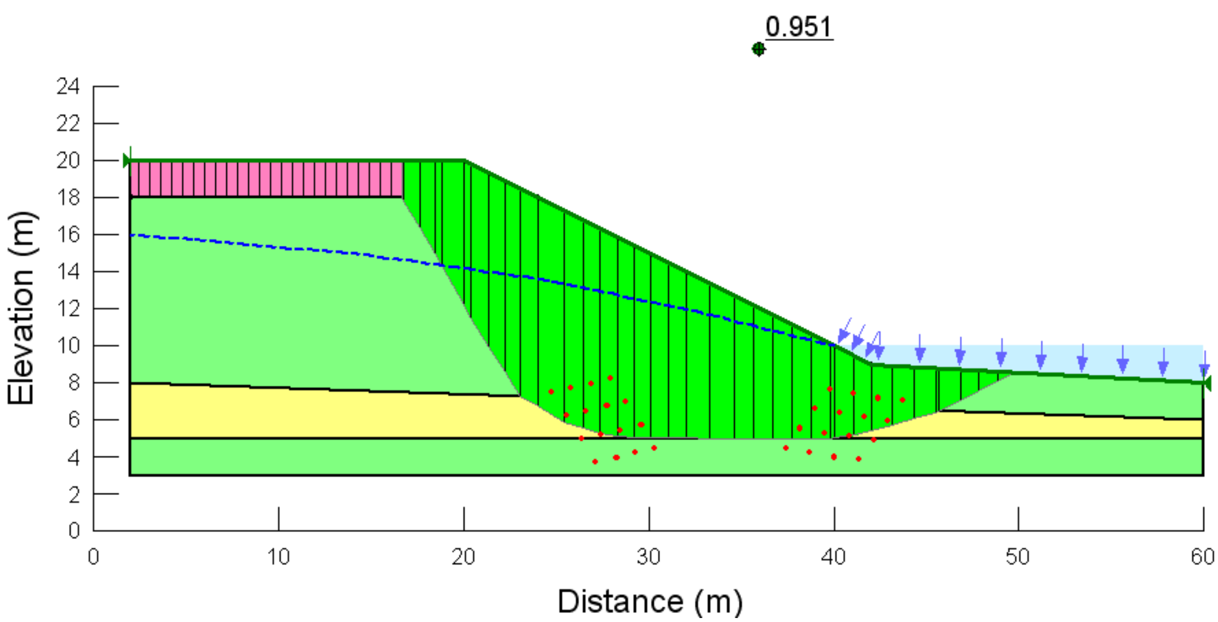

Figure 6 Shape and factor of safety of the optimized slip surface

It is important to note that while the optimized slip surface presented for this particular simulation appears to be reasonable, it is possible that the optimized slip surface might have been significantly different in shape than the original fully specified critical slip surface. For example, depending on the relative strength between the sandy clay material and the weak layer, it may be possible that during the optimization process, a lower factor of safety may be obtained with the slip surface missing the weak layer entirely. Since the purpose of this analysis was specifically to study a mode of failure along the weak soil layer, this would have to be interpreted and dismissed as an invalid solution. Care should be used when using optimization with a block search analysis to ensure that the primary objectives are not compromised.