Gravity Retaining Wall

1 Introduction

The difficulty with retaining walls is that they are often concrete or a similar material which, compared to soil, are extremely strong (Figure 1). It is not advisable to include the actual strength of the retaining wall in the analysis, due to potential convergence difficulties. Consider also that failure of retaining walls is usually a result of undercutting of the retaining wall, not shearing of the concrete itself. For this mode of failure, the strength of the retaining wall itself becomes inconsequential, but the weight of the wall acting as a stabilizing force is critical.

The purpose of this example is to outline and describe an appropriate procedure for analyzing the stability of the gravity retaining wall. Features of this simulation include:

- Use of a no-strength soil model to represent non-water materials
- Fully specified slip surface
- A specified axis of rotation
- Automatic search for tension crack
- Optimization of the most critical slip surface

Figure 1 Profile used for gravity retaining wall simulation

2 Configuration and setup

In this example, a series of fully specified slip surfaces that pass underneath the gravity retaining wall are specified, and an axis of rotation is defined as shown in Figure 2. When using an axis of rotation, it is important to ensure that a rigorous analysis method that satisfies both force and moment equilibrium is used (i.e., Spencer, Morgenstern-Price, GLE) as the solution is insensitive to the location of the axis.

Note that all seven of the fully specified slip surfaces start and end outside the geometry of the profile. The slip surfaces have different projection angles behind the retaining wall, but coalesce to a single failure plane under the wall itself.

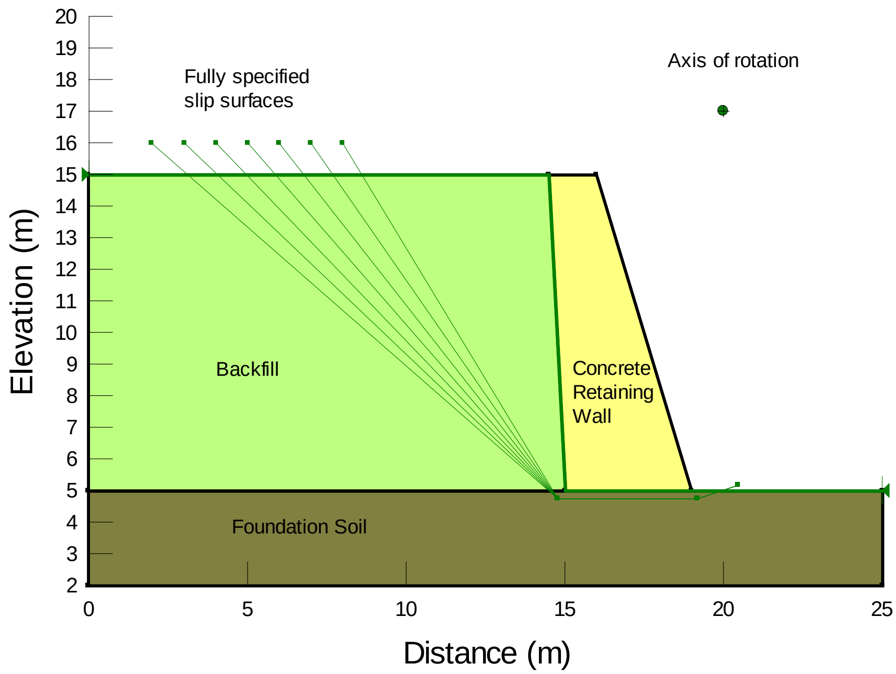

Figure 2 Location of the fully specified slip surfaces and the axis of rotation

By defining a series of fully specified slip surfaces that pass beneath the gravity retaining wall, an undercutting failure mechanism can be analyzed and the actual strength of the wall (i.e., c' and ϕ') does not need to be quantified. The gravity retaining wall can be modeled as a no-strength soil model with an appropriate unit weight that ensures that the weight of the wall is included in the analysis. The strength parameters of the concrete will not come into the factor of safety calculation, and therefore do not need to be quantified.

The material properties used in this analysis are shown in Table 1.

Table 1 Material properties used for the fully specified slip surface example

Material	**Unit Weight**	**c'**	**ϕ'**
Retaining Wall	22	-	-
Backfill	18	10	35
Foundation Soil	18	10	25

3 Critical factor of safety

The critical slip surface and factor of safety are shown in Figure 3Figure 3 Factor of safety and location of the critical slip surface. Note that the slip surface is forced to slide just below the gravity wall. Figure 4 is a graph showing the frictional angle used along the slip surface. You can see that the correct frictional angles for the backfill material (35^{o}) and the foundation soil (25^{o}) are used correctly.

Figure 3 Factor of safety and location of the critical slip surface

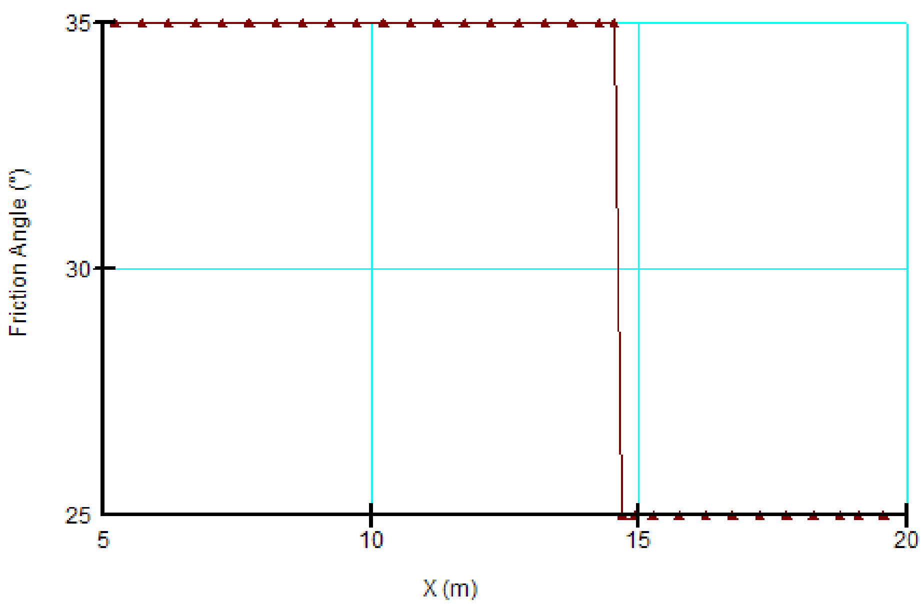

Figure 4 Frictional angle used along the slip surface

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 5. For this particular situation, the optimized slip surface analysis becomes an enhancement to the original critical slip surface analysis.

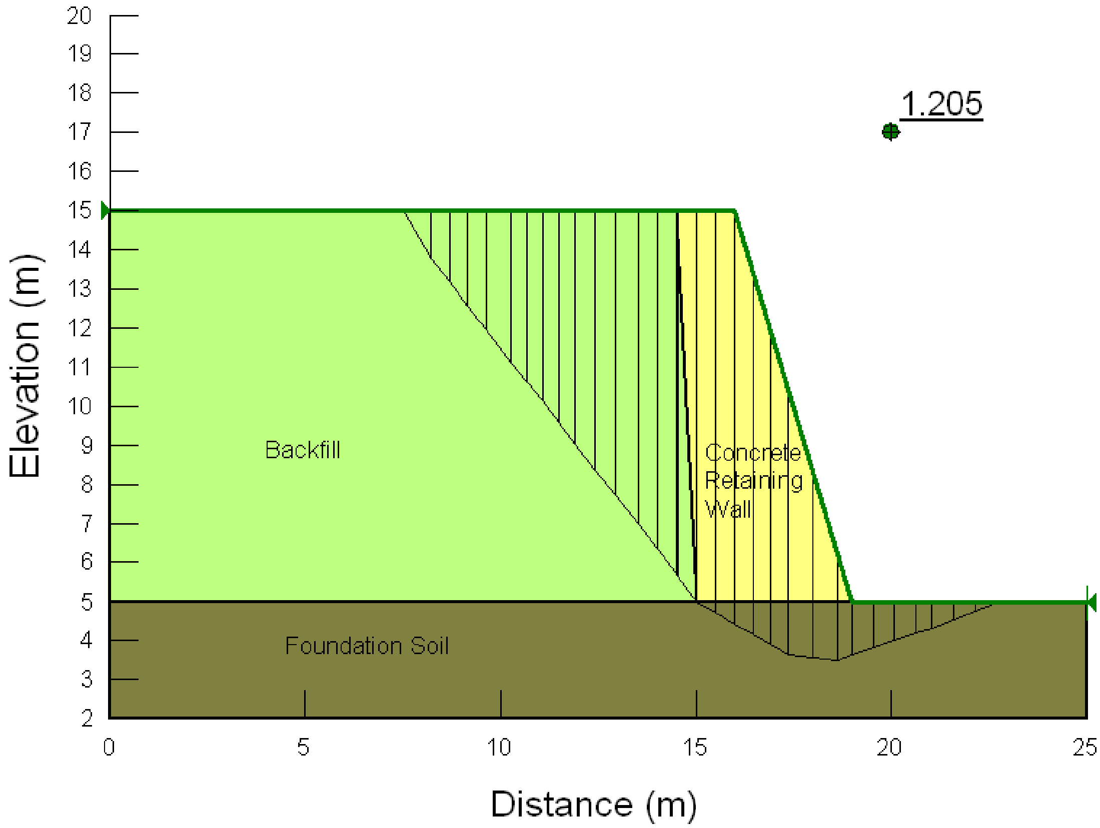

Figure 5 Shape and factor of safety of the optimized slip surface

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, since the gravity retaining wall is modeled with a no strength model, it is possible that during the optimization procedure, a trial slip surface may cut through the gravity retaining wall resulting in a lower factor of safety. Since the purpose of this analysis was specifically to study a mode of failure that undercut the wall, this would have to be interpreted and dismissed as an invalid solution.

Perhaps a better option is to model the gravity retaining wall as a material with a high cohesion and frictional angle. This will ensure that any trial slip surface cutting into the gravity retaining wall during the optimization process will result in a higher factor of safety. In other words, our primary objectives can be guaranteed even when the critical slip surface is optimized. In this analysis, the retaining wall is modeled with a Mohr-Coulomb soil model with cohesion = 100 kPa and a frictional angles of 45 degrees.

Note that the optimized critical slip surface has a lower factor of safety and a steeper slope. The steeper slope also resulted in a tension crack, which was determined by the automatic tension crack search routine in SLOPE/W.