Week #13 -Slope stability
Strength reduction

In this exercise we will analyze in Optum G2 the stability of a slope under different construction stages using a strength reduction / limit analysis approach. Decide case by case if a short or long term analysis is necessary.

1 Initial configuration

Consider a slope located next to a river as shown in figure 1. This slope consists of two layers of soil, namely medium and dense sand (the materials to choose are defined in the next paragraph). Create the mesh of the problem (consider 1000 elements and a 3-step adaptive mesh upon shear dissipation with 1000 starting elements), assign the materials and proper boundary conditions, and perform a strength reduction analysis with both, lower and upper elements. What are the lower and upper safety factors? Observe the location of the rupture surface and comment.

1.1 Materials

For the upper material (light brown in figures 1 trough 5) use the default material Medium Sand-MC where you adapt the Young's modulus to $E = 30[MPa]$, the strength parameters to $c = 2.5[kPa]$ and $\phi = 25°$ and switch from a nonassociated to an associated flow rule. The base layer (dark brown in figures 1 trough 5) consists of a dense sand. Choose the Dense Sand-MC and change the youngs modulus to $E = 30[MPa]$ the strength parameters to $c = 5[kPa]$ and $\phi = 30°$ and again an associated flow rule.

2 Excavation - works along the riverside

Further up the river a dam is constructed, this creates the necessity of excavating the slope (see figure 2) as to be able to transport people and machinery to the construction site. Assess the stability of the slope under this new condition by performing a strength reduction analysis with both lower and upper elements on the new configuration. What are the new safety factors and where does the rupture surface pass? Will the load of the machinery passing on the temporary road affect this safety factor?

In addition, as the construction takes place in a rainy region, the risk of collapse due to an increase of the water table associated with a heavy rainfall cannot be neglected. Hence, re-assess the stability of the slope by performing the same previous analysis but now considering the water table at the top of the slope on the left (see figure 3). Is the slope still safe?

3 Retaining wall solution

One possible way of mitigation against the risk of collapse due to an increase of the water level, is to build a retaining wall as shown in figure 5. In order to build this wall, first we need to do an additional excavation to provide enough space to allow both transit to the dam and works on the retaining wall (see figure 4).

Compute the lower and upper safety factors for both situations: one, just after the new excavation (figure 4); and two, after finishing the construction of the retaining wall which implies to fill the excavation behind the retaining wall with the original material/soil until the initial slope is reached again (see figure 5). In the

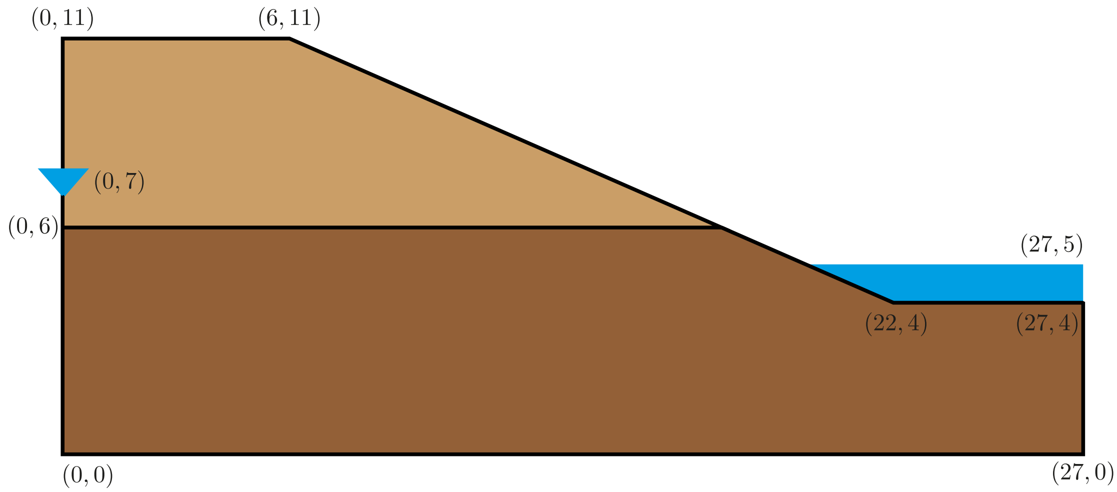

Figure 1: Initial configuration

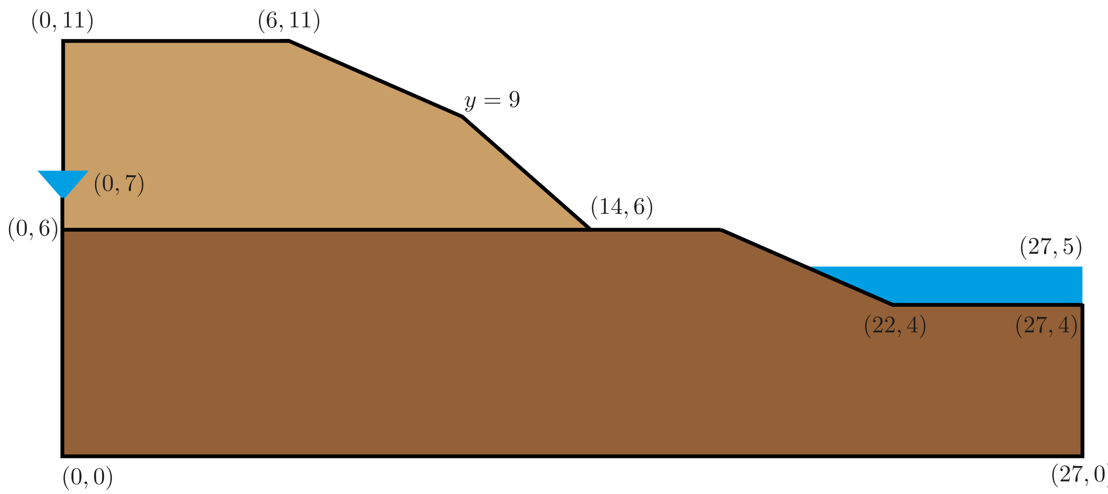

Figure 2: Slope after excavation

latter case, consider the worst case scenario with the water table right at the top of the surface on the left. Is the slope + retaining wall system now stable? Explore the failure mode of the system.

4 Short vs. long term

Explore now the changes if you switch from long to short term or vice versa. What differences occurs and how can you explain them? Discuss.

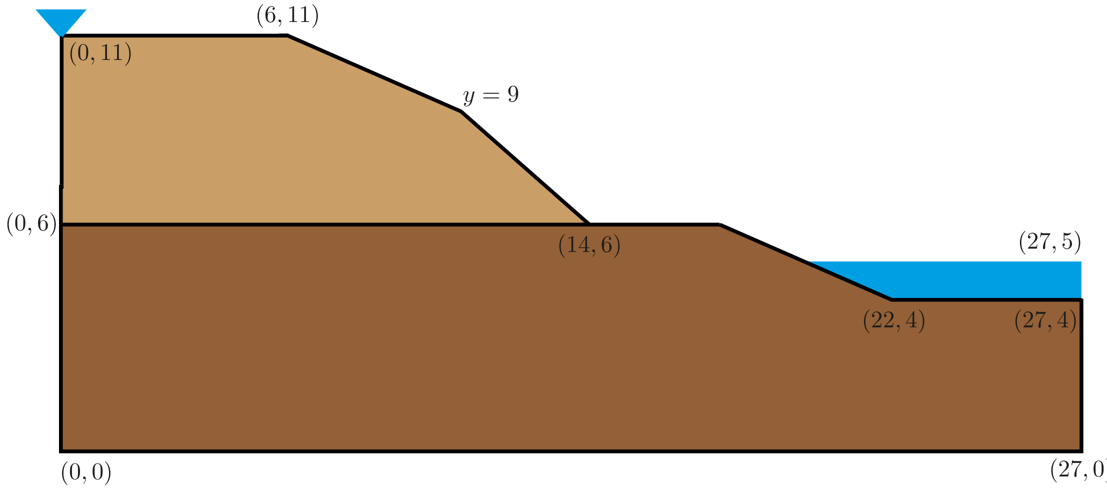

Figure 3: Slope after water table level increase

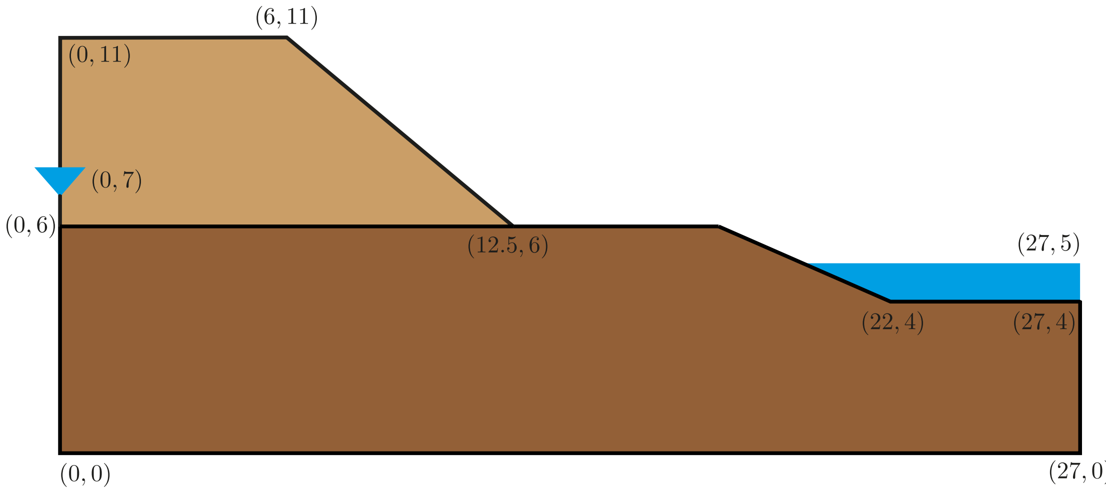

Figure 4: Additional excavation to build retaining wall

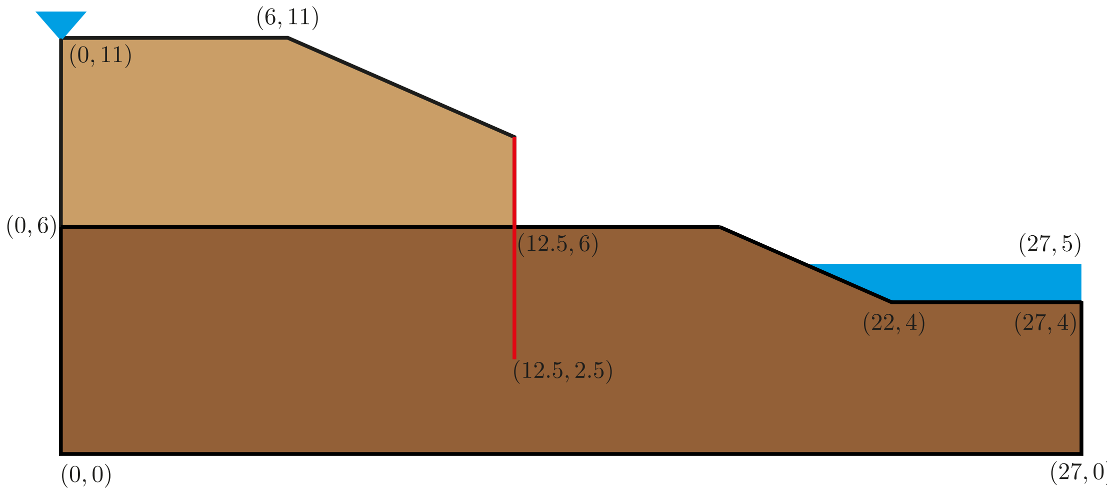

Figure 5: Slope + retaining wall system