Slope Stability

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Exercise 6

Stability analysis of a dam under different hydraulic boundary conditions.
GEOSTUDIO SEEP/W AND GEOSTUDIO SLOPE/W

The goal of this exercise is the assessment of the stability of the upstream slope of a dam in a gradual drawdown condition by adopting the SEEP/W module of the commercial software GeoStudio for solving the hydraulic problem and the SLOPE/W module of the same software for the mechanical problem.

1.1 Exercise description

The dam considered in this exercise is characterized by the geometry and the material properties reported in Figure 1 and Tables 12. The reservoir depth is 12 m. The reservoir is initially full, and a slow drawdown is planned. Seepage from the upstream slope of the dam toward its downstream toe is expected to occur due to the hydraulic boundary conditions. On the downstream toe, there is a drain, for a distance of L1, with the purpose of reducing the pore water pressures in the downstream slope and preventing erosion. Table 1 also provides, for each geomaterial, the volumetric saturated water content ($\theta_{sat}=V_{w,sat}/V$ with $V_{w,sat}$ volume of water when the soil is saturated and V total volume), the AEV (air entry value of the soil= negative relative pore water pressure starting from which the degree of saturation decreases) and the saturated hydraulic conductivity k_{sat} (=the hydraulic conductivity of the saturated soil).

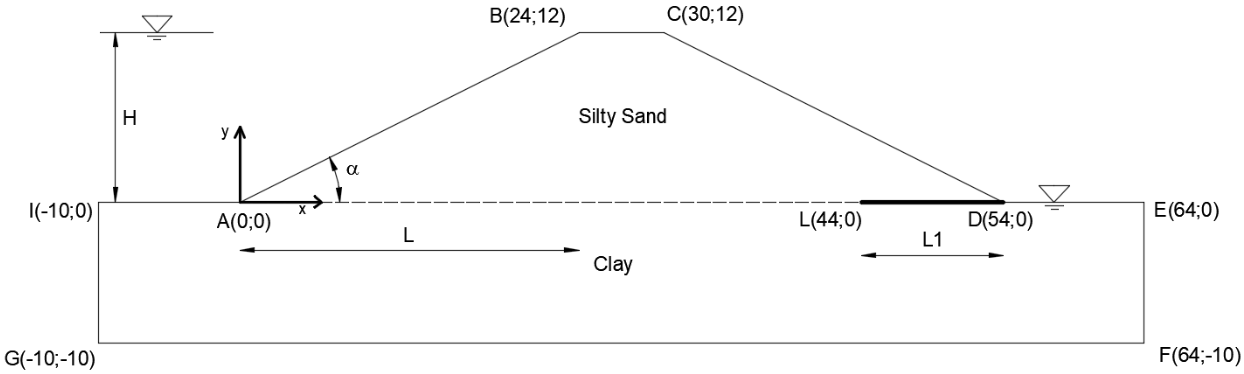

Figure 1: Dam geometry.

Table 1: Soil properties of the dam reported in Figure 1.

Material	γ_{sat} (kN/m^3)	θ_{sat} (-)	*AEV(kPa)*	k_{sat} (m/s)	φ' (°)	c' (kPa)
Silty Sand	20.0	0.35	120	10^{-7}	32.0	10.0
Clay	21.0	0.40	1500	10^{-8}	23.0	10.0

Table 2: Geometry of the dam given in Figure 1.

α (°)	H (m)	L (m)	$L1$ (m)
27.0	12.0	24.0	10.0

Perform a seepage analysis of the dam in the case of a slow drawdown from 12 m to 0 m. Perform a slope stability analysis according to the Morgenstern-Price method for different levels of drawdown. Consider the soil above the piezometric line as saturated by capillarity and verify the correctness of this assumption by analyzing the pore water pressure values in the domain of interest and comparing them with the air entry value (AEV) provided in Table 1.
Finally, plot the evolution of the safety factor obtained for the different water levels and determine the level to which the minimum value of the safety factor corresponds.

Strategy for the resolution of the exercise

The suggested strategy for solving the proposed exercise consists of the following steps:

I. Discretization of the drop in water level in 6 different stages (each of 2 m).
II. Resolution of the hydraulic problem (see the SEEP/W tutorial in the ex.5) for each stage. After drawing the slope and assigning the boundary condition of the hydraulic problem (see Figure 1), the seepage problem is solved, and the distribution of water pressure in the slope of interest is thus obtained;
III. Resolution of the mechanical problem (GeoStudio SLOPE/W) for each stage. Once the distribution of water pressure in the slope of interest is known, the limit equilibrium method is applied for identifying the critical slip surface.
IV. Determination of the level at which the minimum safety factor corresponds.