Slope Stability

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Exercise 5 - Solution

SEEPAGE AND STABILITY ANALYSES GEOSTUDIO SEEP/W AND GEOSTUDIO SLOPE/W

The goal of this exercise is: a) to perform a seepage analysis of a slope, under given hydraulic boundary conditions, by adopting the SEEP/W module of the commercial software GeoStudio (*student license version*); b) to assess the stability of the slope by using the SLOPE/W module of the same software. A tutorial is presented in order to guide the student through the basic steps of the application.

1.1 Exercise description

The slope considered in this exercise is characterized by the same geometry and material properties considered in exercise 4a (see Figure 1 and Table 1). However, differently from the previous exercise where the slope was considered to be submerged, the one analyzed in this exercise is characterized by the water table level depicted in Figure 1. Seepage is hence expected to occur.

Table 1 provides also 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 saturatad hydraulic conductivity k_{sat} (=the hydraulic conductivity of the saturated soil).

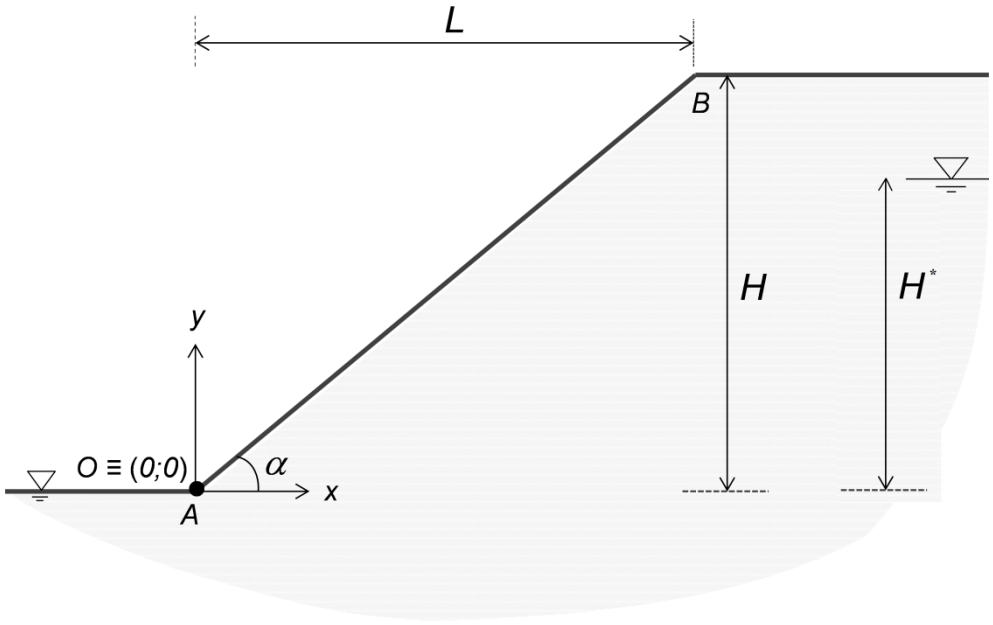

Figure 1: slope geometry.

Table 1: geometry and soil properties of the slope reported in Figure 1.

γ_{sat} (kN/m^3)	θ_{sat} (-)	*AEV (kPa)*	k_{sat} (m/s)	α (°)	H (m)	H^* (m)	L (m)	φ' (°)	c' (kPa)
21.0	0.35	100	10^{-7}	30.0	8.0	5	13.9	22.0	5.0

Perform a seepage analysis of the considered slope in steady state conditions and focus on the quantitative evaluation of *(i)* pore water pressure and *(ii)* total head within the considered domain. Consider the material above the water table 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, perform a slope stability analysis according to the simplified Bishop method and compare the obtained results with those in the context of exercise 4a (slope in dry and submerged conditions).

1. Results

1.1 Seepage analysis

The analysis of the seepage problem performed with GeoStudio SEEP/W module allows obtaining the following results in terms of: water total head (Figure 2), water pressure head (Figure 3), water pressure (Figure 4) and water conductivity (Figure 5).

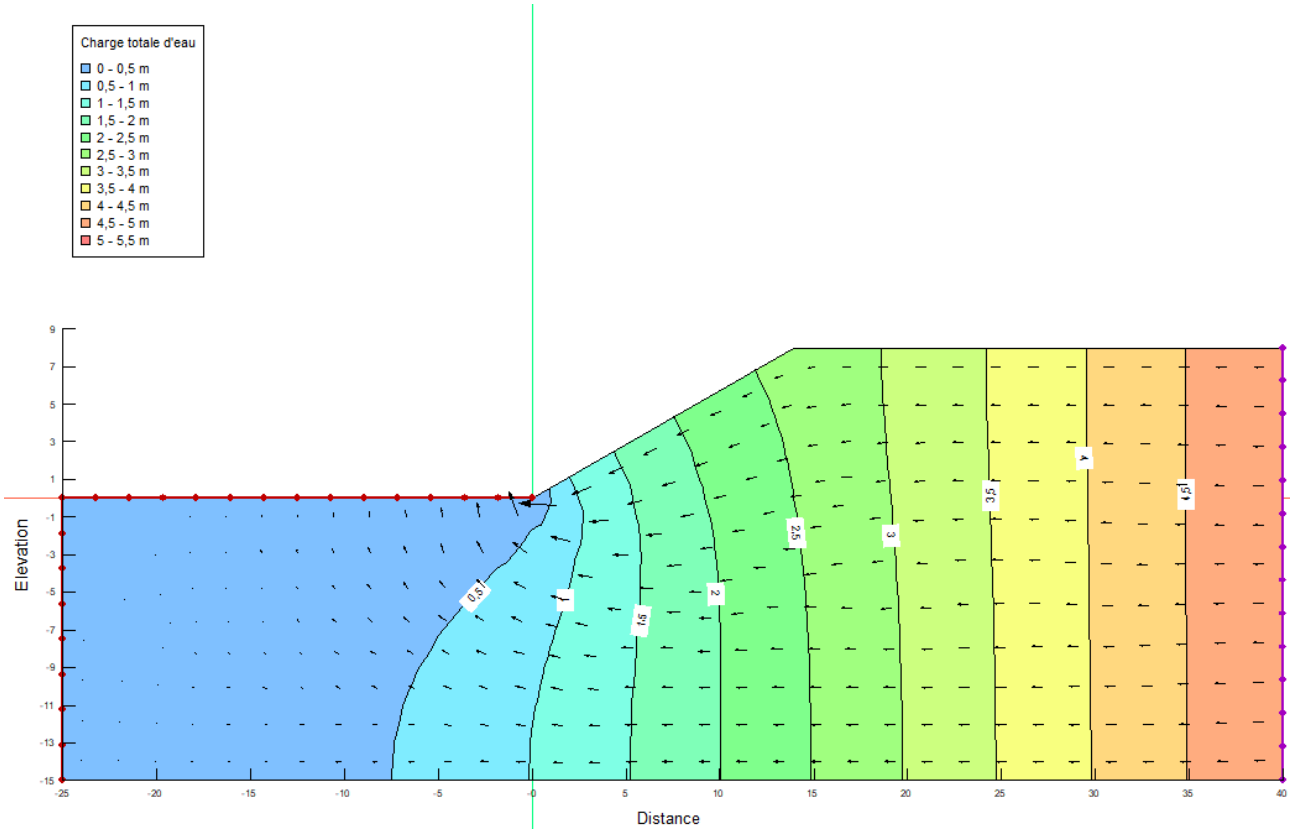

Figure 2: Water total head.

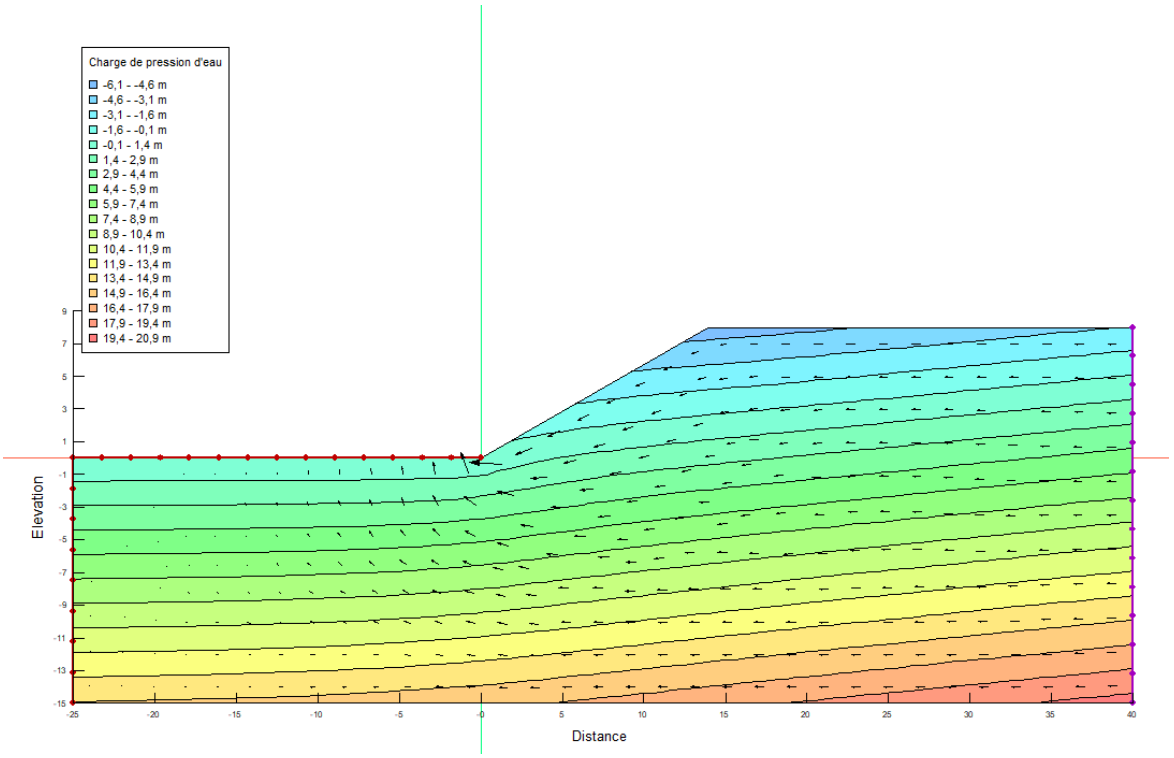

Figure 3: Water pressure head.

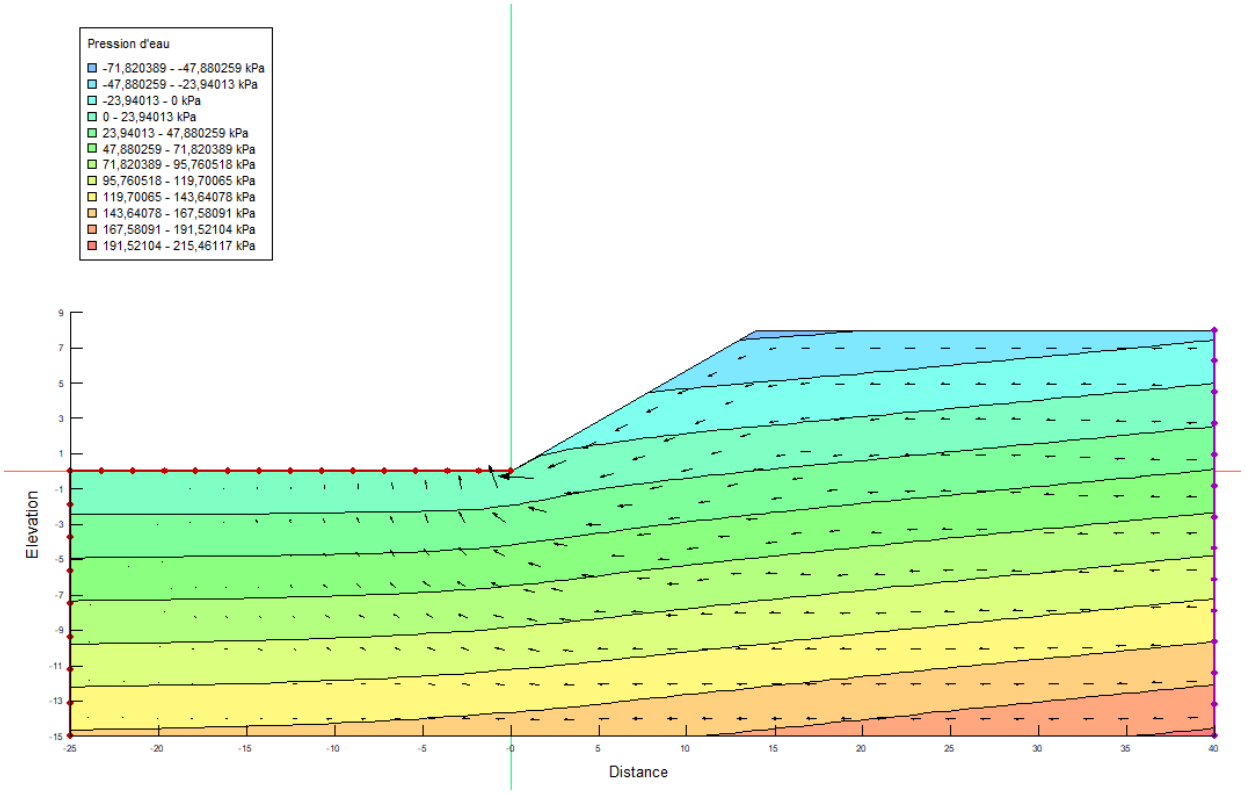

Figure 4: Water pressure.

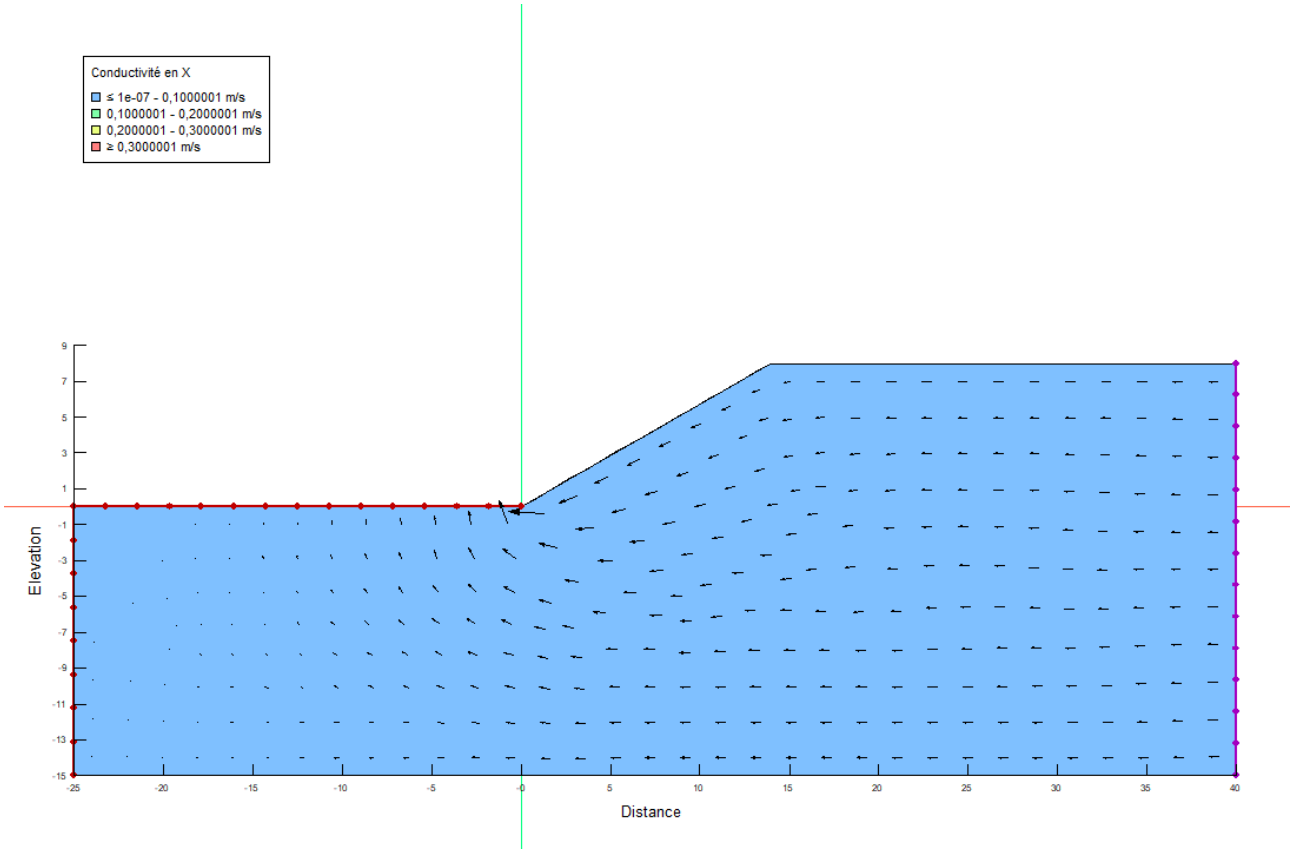

Figure 5: Water conductivity (the values of the x and y components are the same for the given isotropic material).

2.2 Slope stability analysis

The slope stability results in terms of safety factor and critical slip surface's characteristics are given in the following table and figure.

Table 2: Results.

Slope with a seepage flow	*BISHOP simplified*
Resolution	F = 1.042 (x_C ; y_C) = (1.99 m; 14.20 m) r = 14.35 m

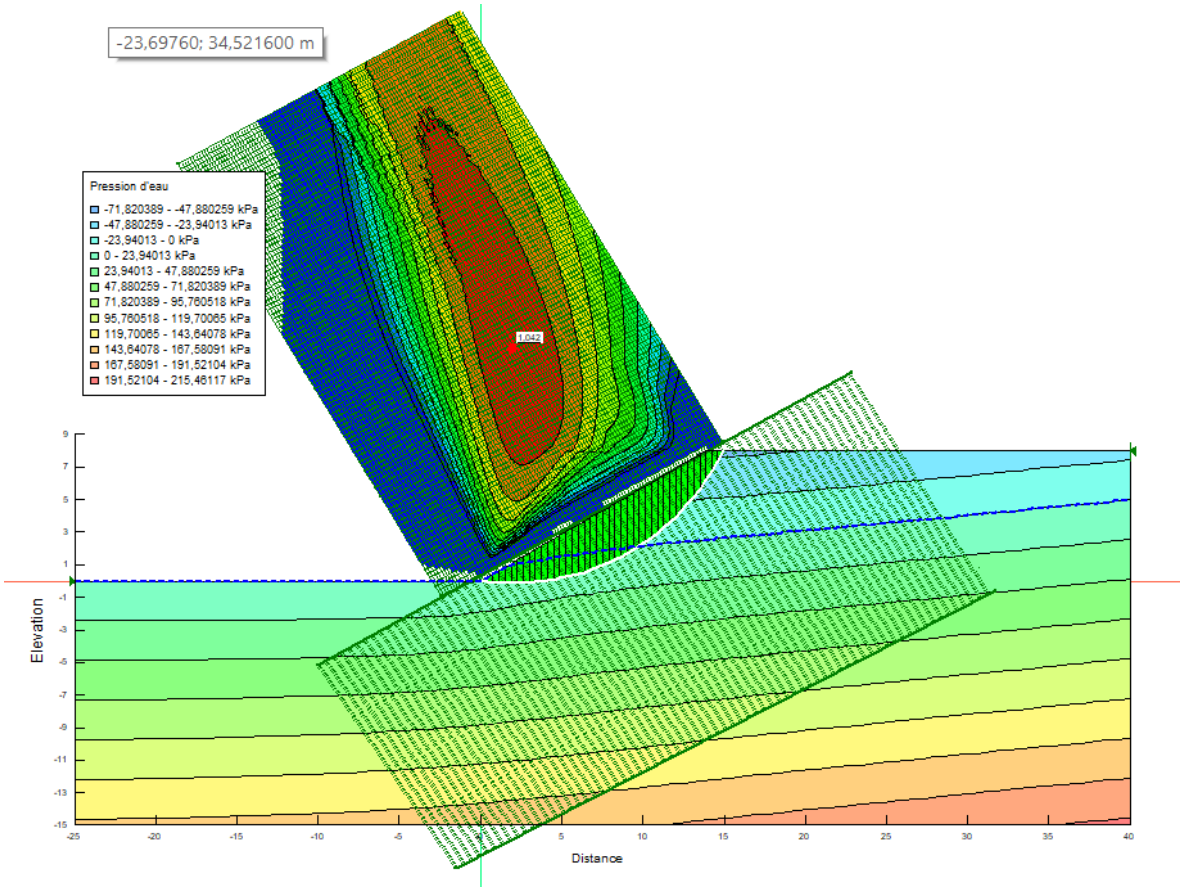

Figure 6: Critical slip surface.

2. Comparison between the results obtained for the same slope in exercise 4 and 5

Table 4: Summary of results obtained in exercise 4 and 5

	BISHOP simplified
dry slope	F = 1.195 (x_C ; y_C) = (0.37 m; 18.59 m) r = 18.59 m

submerged slope	F = 1.403 (x_C ; y_C) = (1.52 m; 16.72 m) r = 16.78
slope with a seepage flow (solution for the given water retention properties and hydraulic boundary conditions)	F = 1.042 (x_C ; y_C) = (1.99 m; 14.20 m) r = 14.35 m