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Effect of unstable layer depth on the pore pressure distribution, case study of the Slano Blato landslide (Slovenia)

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The Slano Blato landslide is one of the largest landslides in Slovenia with a volume of more than 1 mio m^3 of moving debris. The landslide is located at the border of Triassic limestone and Eocene flysch formations. Flysch is composed of layers of marls and sandstones. The sliding mass consists mainly of clay and clayey gravel of highly weathered and deteriorated flysch, while a minor part represents grains and blocks of limestones. (Petkovšek et al., 2009). The first documentation of an instability event dates back to 1789 and the landslide was reactivated during a heavy rain period in November 2000. Since then, the ground surface level above the unstable material on the upper zones of the landslide is significantly decreasing so that the current slope surface is now more than 10 m below the terrain surveyed in 1998. The new landslide topography results in different pore pressure distributions in the slope, which were anticipated to have a detrimental effect on the stability and movement regime of the slope.

The main goal of this work is to investigate the effect of the overlying debris depth on the pore water pressure distribution during a predefined precipitation scenario. The behaviour of the unsaturated soil and the effects of fissures in the bedrock are also considered in the analysis. Hydro-mechanical simulations were performed using 2D finite element software (PLAXIS) and numerical results are compared with results from analytical models, which use a 1D steady state formulation for the hydraulic part and a 2D limit equilibrium approach to calculate the safety factors.

The numerical studies show significant change in the pore water pressure distribution in the landslide body with variation of the debris depth. An increase in the debris depth leads to higher suction due to the deeper location of the water table. Higher suction increases landslide stability due to: i) increase of the effective stress and hence the shear strength of the material and ii) decrease of the unsaturated hydraulic conductivity. Accordingly, a longer rainfall event with a similar intensity is required to destabilize the slope.

The calculated suction profile for the current slope surface was compared to the in situ measurements, and the results show partial agreement. The slight discrepancy might be attributed to several factors such as: i) possible difference in the height of the water table in the model and reality, ii) differences in location between observation points in numerical model and in-situ observations, as there are no tensiometers in the upper part of the slope, iii) modelling the underlying flysch layer as a homogenous and isotropic material in PLAXIS, which is not the case in reality.

Reference:

Petkovsek, A., Macek, M., Kocevar, M., Benko, I., Majes, B., 2009. Soil matric suction as an indicator of the mud flow occurrence. 17th International Conference of Soil Mechanics and Geotechnical Engineering, Alexandria, Egypt, 1855 - 1860.