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Drainage efficiency of large dowels as a stabilising measure, case study of Slano Blato landslide (Slovenia)

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The Slano Blato landslide, with a volume of more than 1 million m^3, is one of the largest landslides in Slovenia. The sliding mass consists mainly of clay and clayey gravel of highly weathered and deteriorated flysch type clastic soft rocks, while a minor part represents grains of limestones. Large movements were firstly scientifically reported in 1789 by B. Hacquet followed by the catastrophic events in 1888 and 1902. The landslide was stabilised through extensive remediation measures approximately 100 years ago. The landslide was reactivated again in November 2000, after an intense rainfall event. The upper part of the landslide was stabilized by a curved row of large hollow dowels (6 to 8 m in diameter and $\sim$20 m deep), which were designed to fulfil both retaining and the drainage requirements. Draining the sliding material will have two effects, i) decreasing the unsaturated hydraulic conductivity of the slope and ii) increasing the effective stress and shear strength of the sliding material.

The drainage efficiency of the installed dowels is examined analytically and numerically. The analytical calculation is performed under simplified assumptions according to the classical theory of Dupuit and Thiem. Comparison between these results and limited insitu measurements implies that the amount of water discharge into the dowels and the groundwater drawdown can be fairly well determined using a simplified 3D analytical model.

The numerical calculations were conducted using the finite element program PLAXIS under different steady state and transient scenarios. Results are compared with a case of 'no drainage' to capture the extent of drainage upslope and downslope. These simulations show that the installation of the dowels leads to successful drainage of the slope at least to a radius of 40 m.

The pattern of potential lines of the flow net in the slope, derived from the 3D analytical models, shows that the row of dowels can be replaced by a 2D plane flow trench drain with equivalent hydraulic properties. This observation is valid due to the small spacing between the dowels and is supported by the agreement between the results of 2D plane flow analyses and the insitu measurements of the discharge into the dowels and water table drawdown.

However, it should be noted that analytical and numerical results include significant simplifications in the soil models and boundary conditions. For example, assuming uniform hydraulic properties for the materials might have important effects, especially in the case of the Slano Blato landslide, as flysch bedrock exhibits significant heterogeneous hydro-mechanical features. Accordingly, models need to be calibrated further based on a denser network of insitu measurements.