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Numerical investigation of landslide scenarios in laboratory and real scale

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The increasing number of landslides which are initiated by rainfall events causes huge harm for people as well as for the economy. Therefore, the development of advanced numerical tools for reliable predictions of slope movements is required in order to prematurely warn against the threat of a slope failure. This goal can only be achieved by a close cooperation of research partners working on different research areas such as hydrological, geological, experimental and mechanical fields. For instance, it is virtually impossible to exactly determine the substructure of an entire natural slope. However, the composition of the slope has a strong influence on the pore-water motion and the solid deformation. Unfortunatly, most of the substructure investigation is based on the analysis of only a few drill core samples and rough knowledge of the geological structure for the region. Therefore, it is essential to develop an idealised model of the slope including experts of the different research areas. Because of the incomplete data, numerical simulations can help to figure out some relevant failure scenarios of the slope by studying various assumptions concerning the substructure and different load cases by simply changing the initial and boundary conditions of the initial-boundary-value problem (IBVP). These findings can be used to formulate hazard potential criteria for specific constellations of load cases. But first, the numerical tool, the coupled model accounting for elasto-plastic solid deformation and pore-fluid flow as well as its numerical implementation have to be calibrated, validated and tested on well-defined laboratory experiments. Only then, it can be applied to simulate real landslides in order to give qualitative statements of conceivable failure processes triggered by heavy rainfall events.

In this contribution, unsaturated soil is described as a triphasic multi-physical material consisting of a soil skeleton, such as fine sand, a pore liquid, such as water, and a pore gas, such as air. The presented triphasic model is embedded in the well-founded Theory of Porous Media (TPM), while numerical solutions are realised by use of the finite-element solver PANDAS tailored for solution of coupled porous media problems. Proceeding from a cohesionless fine sand as the basic soil under study, the material parameters governing the soil behaviour are taken from triaxial experiments on dry sand specimens carried out under homogeneous loading conditions. The parameters governing the hydraulic behaviour are determined from experiments on saturated soil specimens under undeformed conditions. The stress-strain relation of the soil is described by an elasto-plasticity model for soil materials consisting of a geometrically linear approach based on the hyperelasticity law and an advanced hardening plasticity scheme. Using the verified model of an unsaturated soil, simulations of diverse failure scenarios of well-defined slope failure experiments are presented, which reveal the strong coupling of the soil deformation and the hydraulic behaviour during slope failure processes. Finally, qualitative simulations of the flow and deformation behaviour of the natural Heumoes slope in Ebnit situated near Dornbirn in the eastern part of the Voralberg Alps (Austria) will be shown. Unfortunately, this slope is still in motion.

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