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Coupled Hydro-Mechanical Constitutive Model for Vegetated Soils: Validation and Applications

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It is well known, that presence of vegetation influences stability of the slope. However, the quantitative assessment of this contribution remains challenging. It is essential to develop a numerical model, which combines mechanical root reinforcement and root water uptake, and allows modelling rainfall induced landslides of vegetated slopes.
Therefore a novel constitutive formulation is proposed, which is based on the modified Cam-clay model for unsaturated soils. Mechanical root reinforcement is modelled introducing a new constitutive parameter, which governs the evolution of the Cam-clay failure surface with the degree of root reinforcement. Evapotranspiration is modelled in terms of the root water uptake, defined as a sink term in the water flow continuity equation. The original concept is extended for different shapes of the root architecture in three dimensions, and combined with the mechanical model. The model is implemented in the research finite element code Comes-Geo, and in the commercial software Abaqus. The formulation is tested, performing a series of numerical examples, which allow validation of the concept. The direct shear test and the triaxial test are modelled in order to test the performance of the mechanical part of the model. In order to validate the hydrological part of the constitutive formulation, evapotranspiration from the vegetated box is simulated and compared with the experimental results.
Obtained numerical results exhibit a good agreement with the experimental data. The implemented model is capable of reproducing results of basic geotechnical laboratory tests. Moreover, the constitutive formulation can be used to model rainfall induced landslides of vegetated slopes, taking into account the most important factors influencing the slope stability (root reinforcement and evapotranspiration).