DEM SIMULATIONS OF THE STRESS-STRAIN BEHAVIOR OF UNSATURATED SOILS

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Intense rainfall-induced landslides often occur on marginally stable slopes that consist of various types of soils, such as colluvial and residual ones. These soils are frequently found in regions where the groundwater table is relatively deep below the surface and the pore water pressures in the soil beneath the surface and above the water table are negative relative to atmospheric conditions. This negative pore water pressure, referred to as matric suction when referenced to the pore air pressure, contributes to the stability of unsaturated soil slopes as it increases the available shear strength on a potential slip surface [1]. During prolonged wet periods when there is sufficient rainfall infiltration into the slope, the matric suction of the soil decreases and consequently the shear strength can decrease triggering a shallow landslide [2].

Rainfall-induced landslides in unsaturated residual soils can occur slowly under drained (nearly constant suction) conditions or rapidly under undrained (constant water content) conditions. The stress paths followed by a soil element in a slope that fails under any of these conditions can be simulated in a triaxial testing environment by conducting, respectively, consolidated drained and constant water content tests [3]. In this study, micro-mechanical three-dimensional DEM computational simulations are performed to investigate the stress-strain response of unsaturated soils. The soil grains are modeled as an assemblage of rigid spherical particles whereas the interstitial fluid is assumed to be at a pendular state and is modeled as a liquid bridge between particles. The resulting capillary force of a toroidal liquid bridge is calculated based on the gorge of the bridge method [4]. A liquid bridge is formed whenever the separation distance between two particles is less than a critical distance that can be found empirically [5]. An iterative algorithm is applied to calculate the half-filling angle as a function of the liquid bridge volume and the separation distance between particles. The surface roughness of the particles is accounted for by specifying a minimum separation distance between particles in contact. Computational triaxial test simulations were conducted under both consolidated drained and constant water content conditions. A number of state variables were monitored during the course of these simulations such as the wet coordination number, porosity, and the average stress and strain tensors. The outcome of the conducted simulations is consistent with experimental observations (see reference [3]), and provided valuable information on the behavior of unsaturated soils during shearing at the micro-scale and the macro-scale levels.

References

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