On The Use Of COMSOL Multiphysics® For The Simulation Of Stability Of Soil Slopes During Rainfall Infiltration

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Abstract

The soil stability is of a prime important hydro-mechanical problem in the aspect of natural risk management. Slope instabilities and landslides are commonly associated with events of intense rainfall. Changes in soil saturation cause changes in suction forces in the deformable porous medium. This problem is often investigated using the equilibrium state via the local factor of safety method. Based on the equilibrium state, this method allows for evaluating a local safety factor that can represent the risk of landslide. The local safety factor is usually calculated numerically. The intense rainfall increases the soil saturation and in consequence the load. The unsaturated flow and the change in soil saturation are often modeled with the Richard's equation. This equation is coupled to the mechanical momentum balance equation representing the static equilibrium and the linear elasticity model as constitutive relation. The existing models neglect the effect of saturation on the soil properties. However, it is clear that, the risk of landslide can be significantly affected by the processes of capillary surface tension. Thus, it is important to include these processes in modeling studies. In this work, we suggest a new mathematical model, at Darcy's scale, for the investigation the stability of soil slopes during rainfall infiltration. The new model can effectively consider the capillary surface tension surface forces which are derived by an up-scaling procedure. The new mathematical model is solved using the finite element method via COMSOL Multiphysics®. Several benchmarks are simulated to validate the developed numerical model. The validated model is then used to investigate a hypothetical case of soil slopes. Comparison between the standard model (neglecting the surface tension effects) and the new developed model (taking into account the surface tension forces) is performed. It is found that considering the surface tension forces leads to an increase in the magnitude of stress tensors over the domain, and consequently, we would have a higher risk of landslide. A detailed parameter sensitivity analysis of the new developed model is performed to understand effect of pertinent parameters on the local safety factor.