Pore Scale Model of Wet Granular Material

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ABSTRACT

Landslides are one of the main natural threats for both people and infrastructure in mountainous regions. In most cases, landslides are triggered by the loss of cohesion in a soil due to the increasing liquid saturation level after long or intense rainfalls. Only little is known on the triggering of failures at the microscopic scale due to the limited experimental accessibility and the lack of micromechanical models that combine the granular mechanics and the fluid transport in the pore space for the relevant saturation levels simultaneously.

We study this problem by a discrete model approach based on contact dynamics [1], where forces excreted from a liquid phase add to the motion of spherical particles. The model can deal with arbitrary saturation levels, ranging from the capillary bridge regime to the fully saturated state. To account for liquid in the pore space we develop a geometrical pore-scale model similar to the models proposed recently by Gladkikh [2] and Motealleh [3]. In our model, we allow the formation of isolated arbitrary-sized liquid clusters which can have different Laplace pressures and exchange liquid through liquid films on the grain surface. These clusters can grow in size, shrink, merge and split, depending on local conditions and changes of accessible liquid and the pore space. In the first step the model is applied to an immobile dense packing of spheres. We demonstrate the validity of the proposed model on benchmark examples, including evolution of a small single cluster (trimer), an equilibrated packing at different saturation levels and cluster growth by liquid injection [4, 5]. Next, we calculate the failure envelope for the dilatant material under multi-axial loading, considering possible rearrangements of particles and fluid interfaces at changing saturation states.

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