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High pore fluid pressure effects on granular material behaviour and granular slope instability triggering

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At the particle scale, granular materials obey a well-defined organization. Intergrains contacts can be classified into two categories depending on the intensity of the force they transmit. Contacts transmitting a force larger than the average force form the strong contacts network (40% of the contacts). These force chains are responsible for the mechanical strength of the whole granular structure. By contrast, weak forces result in a mean pressure and contribute to a smaller extend to the stress state.

By carrying part of the stress, a pore fluid pressure reduces the frictional resistance within sloping submarine granular sediments and can trigger gravitational gliding. In this contribution, we study the effect of such pore fluid pressure on the force transmission at the particle scale in a granular slope close to the stability limit. Our analysis is performed by means of two dimensional numerical simulations. In our two phase numerical approach, the assembly of solid particles is modelled by a Distinct Element Method, whereas pore fluid is assumed to be a continuous medium. A semi-empirical relation is used for evaluating the fluid-particle interaction force. The models consist in granular inclined beds built by 10000 particles in an hexagonal arrangement. The grains diameters vary in a ratio of 1.3 to induce geometrical disorder. A fluid pressure is applied at the base and is progressively increased to a limit value for which a slide is triggered. To distinguish between weak and strong contacts, the effects of gravity and pore fluid are filtered. All contact forces are thus normalized.

For simulations involving steep slope, the effect of pore fluid on the granular texture amounts to a rotation of the fabric tensor of the strong contacts network in correlation with the change of the principal stress direction. By contrast, anisotropy of the weak contacts network remains unchanged. The pore fluid effect is thus similar to an increase of slope dip.

For simulations involving very gentle slopes, avalanches are triggered by higher pore fluid pressures (close to fluidization). In these models, the fluid pressure seems to change the granular texture. In particular, the distinction between the twice networks disappears if considering the probability distribution of normal forces. This change of stress transmission depends on the heterogeneity of permeability at a scale of several grains. Thus, if local permeability greatly depends on the local porosity, pore fluid effect results in heterogeneous seepage forces at the grain scale. As a first order parameter, the deformation becomes poorly localized and the granular medium progressively evolves towards a fluid like behaviour.