From elasto-plasticity to visco-elasto-plasticity for saturated granular materials

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ABSTRACT

In this talk, we report a recent extension of the DEM for dense mixtures of non-colloidal particles and viscous fluids [1] in the non-inertial regime. As an application, we examine how viscous dissipation generates rate dependency for both the bulk shear stress and the dilatancy in sheared granular materials.

The numerical model includes sphere-sphere contacts using a soft contact approach [2], short range hydrodynamic interactions defined by frame-invariant expressions of forces and torques in the lubrication approximation, and drag forces resulting from the poromechanical coupling computed with the DEM-PFV technique [3]. Series of simulations in which some of the coupling terms are neglected highlight the role of the poromechanical coupling in the transient regimes. They also reveal that the shear component of the lubrication forces, though frequently neglected in the literature, has a dominant effect in the volume changes. On the other hand, the effects of lubrication torques are much less significant.

The bulk shear stress is decomposed into contact stress and hydrodynamic stress terms whose dependency on a dimensionless shear rate - the so called viscous number Iv - are examined. Both contributions are increasing functions of Iv, contacts contribution dominates at low viscous number (Iv<0.15) whereas lubrication contributions are dominant for Iv>0.15, consistently with a phenomenological law infered by other authors [4].

Statistics of microstructural variables highlight a complex interplay between solid contacts and hydrodynamic interactions. In contrast with a popular idea, the results suggest that lubrication may not necessarily reduce the contribution of contact forces to the bulk shear stress. The proposed model is general and applies directly to sheared immersed granular media in which pore pressure feedback plays a key role (triggering and run-out of debris flow, liquefaction,...).

REFERENCES

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