Rheological analysis of wet cohesive granular packings under simple shear deformation using DEM: effect of particle size and scaling parameters

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ABSTRACT

The Discrete Element Method (DEM) of modelling individual particles has been increasingly used to study granular systems. When it comes to modelling cohesive powders, the inherent high number of very small particles often makes DEM impractical due to very high computational times and costs. One emerging method to tackle this problem is by developing a meso-particle or coarse graining approach whereby larger sized particles are used in a DEM model that is capable of reproducing the key mechanical responses observed in the original fine powder systems. Thakur et al. (2016) has shown how the contact model parameters should be scaled to provide particle scale independent predictions for cohesion-less and dry cohesive bulk solids under quasi-static conditions. Janda and Ooi (2016) have further extended the scaling relationships from quasi-static to inertial states. In this paper, the effect of particle size and scaling laws are investigated with the aim of achieving a coarse-grained approach for wet cohesive granular systems undergoing a wide range of shearing regimes.

Main goal is to understand and describe the relation between particle size and rheology of wet granular packings under volume conserving simple shear deformations, representing unsaturated porous media in the pendular state limit. Three dimensionless groups: Bond number, Inertial number and Ohnesorge number, are investigated to describe the rheology for granular packings under simple shear, with different solid fractions and moisture contents. Long range contacts (liquid bridges) and short range repulsive contacts are considered separately to evaluate the contributions they give to coordination number and stress tensor at different shear rates, solid fractions, liquid contents and attractive force strength.

Two distinct results are found: (i) the introduction of cohesive forces in dry systems with solid fractions below jamming affects significantly the viscosity of the system; however, much smaller effects are found for systems above jamming due to their dominating solid-like response; (ii) the apparent viscosity and coordination number are shown to be equivalent for distinct systems with different particle sizes and scaled parameters, when all the proposed dimensionless groups are kept constant. The resulting coarse grained model makes it feasible to model much larger scale particle systems with the smaller number of meso-particles, at least for the simple shear flow regimes considered so far.

REFERENCES

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