Bridging the gap between particulate systems and continuum theory

Abhinendra Singh May 2014

Project description

This report gives a brief review of the current activities related to the project and provides a few aspects of the ongoing research. The project is mainly concerned with the micro-macro transition required to obtain the macroscopic quantities to describe flow of the granular materials and the effect of particle properties on the bulk behaviour. In particular, we focus on the shear banding, and the rheology of the granular flows in three dimensional split-bottom ring shear cell.

Publications:

1. A. Singh, K. Saitoh, V. Magnanimo and S. Luding
   Effect of cohesion on shear banding in quasi-static granular material,
   Physics Review E (under review).
2. A. Singh, V. Magnanimo and S. Luding.
   Mescoscale contact models for sticky particles,
   Powder Technology (under review).
3. A. Singh
   Micro-macro and rheology in sheared granular matter,
   PhD thesis.

Presentations:

1. January, 2014,
   How does a granular matter fail on moon?
   Physics@FOM, Veldhoven, The Netherlands

Ongoing Efforts:

A) Effect of gravity and softness on macroscopic flow behaviour under slow shear

Currently, we are focussing on the effect of gravity (external compression) and particle softness on the macroscopic flow behaviour in

quasi-static granular materials. A series of Discrete Element simulations are performed on a frictional granular assembly in a split-bottom geometry varying over a wide range of particle softness and gravity. We show that these two properties affect the flow behaviour in a very similar fashion. In the steady state, the macroscopic friction decreases systematically with an increase in either particle softness or gravity and the ratio between forces due to gravity and contact stiffness is a suitable non-dimensional parameter to describe the bulk behaviour of the material. This trend is traced back to the anisotropy in the contact network, leading to a linear relation between macroscopic friction and deviatoric fabric in the steady state.

B) Three dimensional of local rheology of sheared granular matter

This work is in progress, here we probe the local rheology of granular matter in critical state under shear. The dilatancy and friction laws when plotted against the inertial number (ratio of microscopic and macroscopic time scales) are in good agreement with previous studies. In the steady state, the system is found to be heterogeneous, and local rheology presents a transition from quasistatic at low shear rate (high volume fraction) to an inertial regime, where stress increases proportionally to shear rate.

C) Effect of cohesion on the bulk behaviour

Several contact models to describe the interaction between two adhesive particles are presented in [2,3]. [1] discusses the effect of cohesion on the bulk behaviour of dry, frictional cohesive material using an elasto-plastic contact model. Here we discussed cohesive interaction due to plastic dissipation at contacts. However, there can be different origins of cohesive interaction between the particles. Direct cohesion between two particles associated to van der Waals forces can be well characterised by irreversible elastic-plastic cohesive model as presented in chapter three. Capillary forces due to the presence of humidity can also lead to cohesion at contact. In this work, we address an important question, if the results on shear banding and force distributions are independent of the details of the interaction between the particles.