VICI 10828: Bridging the gap between particulate systems and continuum theory

Progress report of Nishant Kumar, June 2014

Project description and Background

Granular materials behave differently from usual solids or fluids and show peculiar mechanical properties like dilatancy, history dependence, ratcheting and anisotropy. The bulk behavior of powder systems depends on the contact properties of their constituents. The focus of this project is the determination of macroscopic models and constitutive laws to be obtained from the microscopic DEM simulations called as the *micro-macro transition*. The role of microstructure, stress state and volume fraction on the evolution of the elastic moduli is analysed, with the goal to characterize them in terms of a unique, limited set of variables of the stiffness tensor.

Publications in 2014:

1. **N. Kumar**, S. Luding, and V. Magnanimo, *Macroscopic model with anisotropy based on micro-macro informations,* Acta Mechanica, in press, (2014)
2. **N. Kumar**, O. I. Imole, V. Magnanimo, and S. Luding, *Effects of polydispersity on the micro-macro behavior of granular assemblies under different deformation paths*, Particuology 12, 64-79, (2014)
3. **N. Kumar**, *Micro-Macro and jamming transition in granular materials*, PhD Thesis, ISBN 978-90-365-3634-9 (2014)
4. **N. Kumar** and S. Luding, *Memory of jamming and shear-jamming (in soft and granular matter), In progress*, (2014)

Presentations in 2014:

1. March, 2014,
   Micro-Macro and jamming transition in granular materials
   PhD Defense, University of Twente

Ongoing Efforts:

A) Micro-Macro transition with focus on polydisperse granular assembly

The focus of this research is to understand and analyse the relation of the elastic moduli with stress, microstructure and volume fraction for samples with different polydispersity (uniform). Following the research in [1,2], in order to calculate the stiffness tensor, we apply small-strain probes to various equilibrium states along a volume conserving (undrained) shear deformation path and inherently exclude the effect of polydispersity, using only the knowledge of evolution the jamming volume fraction with polydispersity.

B) Optimizing the stiffness of granular mixtures

This project focuses on optimizing the stiffness of a base granular assembly by simply adding a small amount of stiffer particles. We use DEM simulations to address the problem of high relevance for industrial applications. Goal is to find the optimal percentage of stiff particles to be added to a base granular material, in order to optimize the bulk modulus of the new mixture. The ongoing focus is to perform experiments at the Ruhr-Bochum University under the supervision of Prof. Steeb and make a qualitative/quantitative comparison.

C) Stress and microscructural incremental behaviour of granular soils under undrained axisymmetric compression

The influence of the micromechanics on non-coaxiality of stress, strain and fabric is an essential part of a constitutive model for granular matter because it contains the information of how the different deformation paths affect the mechanical state of the system. Here we study a granular aggregate, first isotropically compressed and then subjected to axisymmetric strain at constant volume. Goal is to characterize the stress and microstructure responses along the loading path. By using Discrete Element (DEM) simulation on a three dimensional polydisperse system, we determine the stress and fabric that result from the application of a series of strain probes with identical magnitude but different directions. Results are resumed in response envelopes.