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Rheology of granular materials with a Discrete Element Method

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ABSTRACT

To study the rheology of granular materials various strategies coexist: either continuous, or discrete. The most common in the continuous models is the Soil mechanics model which stipulates a relation between the stresses and the deformations [3]. But it proves that they are not able to provide a simple explanation to the complex behaviors of this kind of material. Other continuous theories like the model of Janssen [2] or model OSL [7] introduce relations between the components of the stress tensors without considering deformations. The first is a shell model which works on a mean stress while the relation between stresses proposed by OSL is local.

The Discrete Element Method (DEM) developed in this paper consider the granular material as a set of rigid particules which are subjected to their own weight and with the contact forces exerted by the particules in the neighbourhood [1]. The knowledge of these local forces makes it possible to identify a stress homogenized for a sample test [5]. To deduce from it the behavior of the whole studied material, one meshes space in basic cells which behave each one like the studied sample. The DEM are limited by the CPU time. The extrapolation of results for macro assemblies remains delicate. One proposes here, starting from a DEM approach, to establish the link between the discrete approach and the continuous one by simulating a set of particle and by validating the various phenomenologic models. Initially, the DEM will enable us to identify the importance of some local parameters and in the second time, to propose a new approach for the continuous model to the rheology of granular materials.

For example, L. Vanel [6] have shown that the construction history effects the pressure distribution at the bottom of a sand pile on a rigid base. They observed the existence of a pressure dip at the center of a sand pile if the filling procedure corresponded to a localized source. Numerical simulations and experiments have shown that the structure and the nature of these chains plays a critical role in the dynamics and statics of dense granular systems even if there is no strong disorder in the granular packings.

Necessarily, the presence of these chains must be reflected in the continuum constitutive relations which are needed to close the governing equations and thereby solve even the simplest boundary value

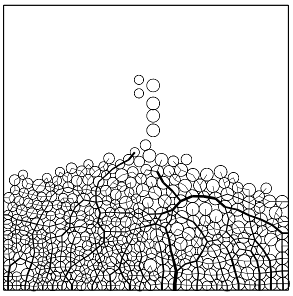

Figure 1: Example of chains of stress in a granular material

problems in granular statics. The most common in the continuous models is the Soil mechanics model which stipulates a relation between the stresses and the deformations [3]. But it proves that they are not able to provide a simple explanation to the complex behaviors of this kind of material.

A sand pile is formed by layerwise deposition of particles that have rolled down its free surface. Thus the grains of sand may and up arranged in a packing that locally distinguishes the directions toward and away from the control axis. The continuity equations should be closed by means of a constitutive relation beetween different components of the stress tensor.

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