From discrete element simulations to a continuum model

Abstract:
One of the essential questions in material sciences and especially in the area of granular matter is, how to obtain macroscopic quantities like velocity-field, stress or strain from "microscopic" quantities like contact-forces and deformations as well as particle-displacements and rotations in a granular assembly. We examine a two-dimensional (2D) shear-cell by means of discrete element simulations and compute kinematic quantities like the velocity field, the elastic deformation gradient and the deformation rate. Furthermore, we examine the density, the coordination number, the fabric and the stress. From some combinations of those quantities, one gets, e.g., the bulk-stiffness of the granulate and its shear modulus. The bulk modulus is a linear function of the trace of the fabric tensor which itself is proportional to the density and the coordination number. Finally, we note that the fabric, the stress and the strain tensors are not co-linear so that a more refined analysis than classical isotropic elasticity theory is required here. Another result is that the displacement rate (velocity) in the shear zone decays exponentially with the distance from the moving wall which applies the shear. Connected to the shear deformation is a rotation of the innermost layers in opposite direction, i.e., these layers roll over each other.

Stichworte:
Micro–macro description; Couette shear cell; Fabric tensor; Stress- and strain-averaging; Shear bands; DEM
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