Numerical modeling and homogenization of soft-particle granular media

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ABSTRACT

Many discrete materials are composed of ultra-soft particles that can undergo large deformations without rupture. Some examples are vesicles, metal powders, microgels and many suspensions. They differ from hard-particle materials whose plastic behavior mainly governed by particle rearrangements and frictional sliding. Soft-particle materials can reach high packing fractions beyond random close packing as a result of particle shape change. Their compaction, volume change behavior under shearing and the properties of the their complex textures have basically remained unexplored due to the lack of proper numerical and experimental tools. We investigate the compaction of ultrasoft particle systems by means of numerical simulations using two different approaches both based on the Contact Dynamics (CD) method for the treatment of frictional contacts between particles [1]. In the first approach, the particles are aggregates of hard frictionless disks interacting by long-range central forces. In the second approach, each particle is discretized by a collection of material points. The information carried by the material points is projected onto a background mesh, where equations of motion are solved. The mesh solution is then used to update the material points. This Material Point Method (MPM) was implemented with implicit time integration, which allows for high numerical stability and efficient coupling with implicit modeling of unilateral contacts and friction between the particles [2]. We show that the compaction process is correctly simulated by both approaches. We evidence a nonlinear behavior of volume change and compressive stress during compaction and quantify the respective roles of rearrangements, particle volume change and particle shape change to compaction.

REFERENCES

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