Micro origin of granular plasticity: on the stabilizing role played by free particles.

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Abstract

Even for the most simple geometrical shapes and simple contact laws, the micro-origin of non reversible deformations in granular materials is still an open issue as they involve contact deformation and particle rearrangements. Thanks to a DEM (Discrete Element Method) approach, the micro origin of granular plasticity is investigated in 3D assemblies of spherical particles interacting through non cohesive elasto-frictional contact laws (Cundall and Strack, 1979). Several stress states are considered along an undrained axisymmetric triaxial path, and the incremental responses of granular samples are explored using a stress controlled directional analysis within Rendulic's plane Gudehus (1979). For stress states close to the onset of the softening regime for dense assemblies (or close to the critical state for loose assemblies), large plastic strain are observed in some loading directions. Based on specific micromechanical tools Wautier et al. (2017), it is shown that the plastic strain is triggered of by the sliding of contacts and that its intensity is closely related to the ability of free particles to get jammed in force chains.

Within the framework of the second order work theory (Nicot and Darve, 2007), the existence of some mechanical instabilities is then related to the intensity of the plastic strain. Removing free particles increases plastic strains which results in an increase in the number of loading directions associated with a vanishing second order work. On the contrary, adding free particles inside the pores of an unstable granular assembly is shown to have a stabilizing effect.

References

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