Internal states, stress-strain behavior and elasticity in oedometrically compressed model granular materials

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ABSTRACT

The behavior of a model granular material (an assembly of slightly polydisperse spherical beads, with Hertz-Mindlin elastic and frictional contacts) subjected to one dimensional (oedometric) compressions is studied by DEM simulations. We systematically investigate the influence of the (idealized) packing process on the microstructure and stresses in the initial, weakly confined equilibrium state. Such characteristics as density (ranging from maximally dense to moderately loose), coordination number (which might vary independently of solid fraction, especially in dense systems), fabric and stress anisotropies are monitored in oedometric loading cycles in which the major principal stress varies by up to 5 orders of magnitude.

The evolution of the solid fraction (or the void ratio) versus the imposed vertical (principal) stress as observed in the loading and unloading paths, like in the case of isotropic compression **[1]** and unlike laboratory tests on sands, the behavior shows only very limited plastic strain and is very nearly reversible in dense samples (which tend nevertheless to lose contacts in a loading cycle if the initial coordination number was large). The irreversibility observed in sands should thus be attributed to plasticity or damage within inter granular contacts.

The anisotropy of the microstructure is described by the angular distributions of contacts and forces. It is explicitly linked to the stresses in the loading history, by semi-quantitative relations. One of the important characteristics measured during the compression is the ratio of lateral to controlled ('vertical') stress, $K_{0.}$ We discuss conditions in which K_0 might be regarded as constant.

We calculate, via a static (matrix) method **[2]**, the complete tensor of elastic moduli, expressing response to very small stress increments about the transversely isotropic equilibrium states along the loading path. Moduli are compared with slopes of stress-strain curves and related to internal structure and anisotropy.

In a second stage, we study the stability of the contact structure under a constant load. Its sensitivity to various kinds of perturbations is probed (removing a contact, setting its friction to zero, changing one bead diameter, applying small forces). The occurrence and the amplitude of ensuing rearrangements are studied and such results are regarded as usefully characterizing the propensity to creep.

REFERENCES

[1] Agnolin, I., & Roux, J.-N. (2007). *Internal states of model isotropic granular packings. II. Compression and pressure cycles*. Physical Review E, 76(6), 061303.

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