Discrete element simulation of wet granular materials: plastic compression

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ABSTRACT

Bonded granular materials are encountered in several civil engineering and applied geomechanics contexts. In the case of granular soils, the presence of liquid menisci between soil particles plays a key role in the overall behavior. Natural cementation between particles may also allow the existence of metastable microstructures that lead to mechanical instabilities when the soil in subjected to hydro-mechanical loadings (the case of loess soils, Muñoz-Castelblanco *et al.*, 2011).

We use the Discrete Element Method (DEM) simulations in 3D to study the quasistatic response of very loose assemblies of frictional spherical grains to an isotropic compression in the presence of a small amount of an interstitial liquid, which gives rise to capillary menisci and attractive forces. This program is developed base on the program in 2D of (Gilabert *et al.*, 2007 and 2008). A reduced pressure P^* is defined as $P^*=Pa^2/F_O$, comparing the applied pressure P on grains of diameter a to the tensile strength of contacts F_O. Firstly, we study the influence of the initial assembling process and of various micromechanical parameters on the plastic compression curve, which takes the form, in some range of P^*, of a linear relation between $\log(P^*)$ and the void ratio. Secondly, we show in particular how the plastic response along those compression curves is influenced by rolling resistance in contacts. We characterize the evolution of microstructure (fabric) and force transmission along the compression curve.

Although the initial state may influence the irreversible compaction response by its solid fraction Φ_O (see Fig. 1) and connectivity, itself determined by the agitation intensity V_O/V^* (see Fig. 2) in the assembling stage, the material properties of bonded granular soils are found independent of such assembling process parameters for small enough initial solid fraction, and in the limit of weak initial agitation. If present, resistance to rolling and twisting motions in contact may considerably affect the plastic compression curves as shown in Figs. 1-2. The case of solid intergranular bridges (cementation) may be dealt with as the limit of large resistance and we plan to investigate its properties for different rupture criteria.

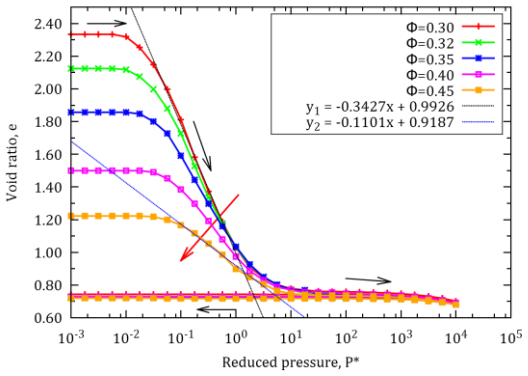

Fig.1. The influence of initial solid fraction Φ_O

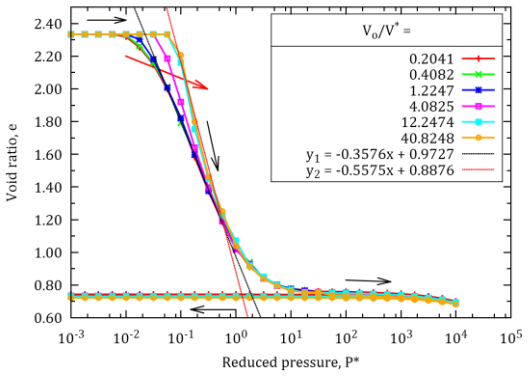

Fig. 2. The influence of agitation intensity V_O/V^*

Keywords: Bonded granular soils; DEM; Quasistatic; Interstitial liquid; Reduced pressure.

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