What is wrong in Love-Weber stress for unsaturated granular materials?

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ABSTRACT

Discrete element simulations of unsaturated soils at low water content are performed using a pendular regime model inspired by the work of Scholtes [3] and implemented in the open source DEM code Yade. They are interpreted in a thermodynamic framework taking into acount the interfaces that separate the different phases in the medium[2,5,6]. These interfaces and other geometric properties are calculated by solving the Laplace-Young equation which gives the shape of the microscopic pendular water bridge connecting two spherical particles of different size in perfect wetting conditions. For a two-grain configuration, the free energy of the system and the work supplied to it are defined, and the energy changes are analyzed for succion changes and movements of the particles, extending Morrow's thought experiment [4]. The model allows to simulate deformation under static and dynamic loading. The energy balance of the system is checked and the importance of each interface and its energy is discussed.

At the macro scale, energies are determined for regular and random packings of grains and the effect of the changes that occurs at the micro scale on the formulation of energy at macro scale are evaluated. The effective stress derived from the energy balance is compared to the averaged stress calculated from the Love formula [1] in isotropic and anisotropic conditions. It is shown that, for random packings, the average stress is not able to describe the elastic regime of unsaturated materials properly.

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