A MICROMECHANICAL INVESTIGATION OF THE EFFECT OF FABRIC AND PARTICLE SHAPE ON THE RESPONSE OF GRANULAR SOILS

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ABSTRACT

The response of granular soils to static or dynamic loads is a function of the void ratio, confining stresses, and also of the packing (or fabric) of the assemblage of the soil particles. A soil may have different fabrics under the same void ratio that can lead to drastic variations in small and large strain soil behavior. Such variations account for the dramatic contrast of behavior exhibited by the same soil when deposited by hydraulic fill, as compared to dry pluviation.

In this study, the impact of fabric on the dynamic behavior of granular soils was assessed using the discrete element method (DEM). These soils were idealized as collection of spherical and non-spherical particles that interact according to the Hertz's law. Different fabrics of the same soil were obtained by extracting particles from the weak or strong inter-particle force network. The associated stiffness properties were evaluated for various levels of confining stress under triaxial stress conditions. The conducted analysis showed that a soil with a given void ratio may have various fabrics associated with noticeably different elastic shear moduli. For isotropic conditions, the mechanical coordination number (average number of contacts per particle), and the particle shape, were found to be main factors that dictate soil stiffness properties. For a specific level of confining stress, the shear stiffness of a particulate soil is linked by a unique relation to the mechanical coordination number and the particle shape. For anisotropic conditions, the elastic stiffness properties were found to be a function of the particle orientation and the stress acting in the direction of loading.

Cyclic test simulations were also conducted under drained and undrained conditions. Soil fabric was found to have little impact on the shear modulus reduction as a function of strain amplitude (G/Gmax), and on damping ratio relations as well. In contrast, soil fabric was shown to be a major factor that dictates the rate of pore water pressure buildup and soil liquefaction. The conducted simulations confirmed that the low-strain stiffness properties (and not the void ratio or porosity) are good macro-scale parameters to characterize and predict the undrained response of granular soils.