The effect of the stress path on maximum shear stiffness of granular packing at micro and macroscopic levels

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ABSTRACT

The elastic properties of granular material at macroscopic level are strongly related to the microscale field variables and kinetic processes. Material properties of the particles, interaction laws at the contact level, as well as the distribution of contact- and force-networks, i.e. the microstructure of the sample, can induce modifications to the shear stiffness of the packing, as measured in experiments. The effect of various parameters on elastic shear stiffness of granular materials has been studied in the past decades, showing that the stress state has a significant effect on the elastic shear modulus of a granular assembly.

In this research work, we want to investigate the effect of the stress path, as combined with the stress state of the material, on the maximum shear modulus (G_{max}) of granular samples. We approach the problem from both experimental and numerical point of view and highlight the relation between macroscopic observations and microscopic phenomena.

In the experimental part of the work, cylindrical samples (10 cm in diameter and 20 cm in height) of glass beads (1.25 mm diameter) are prepared by dry pluviation, assembled in a resonant column device and then subjected to isotropic, triaxial compression and constant-k0 stress paths. Along the three stress paths the maximum shear modulus G_{max} is measured by using the resonant column. Results show that the effect of stress-induced anisotropy on the elastic shear modulus (G_{max}) is strongly related to the stress paths experienced by the sample.

Experimental measurements of the small strain stiffness (G_{max}) are assumed not to cause any fabric change. Therefore the contact network (and the contact forces) must control the response of the granular packing at microscopic level. In a second stage, we use the Discrete Element Method, in combination with our experimental measurements, to characterize the shear response of the samples from the micromechanical point of view. A numerical sample made of 10000 particles is first isotropically compressed, then deformed along the same three stress paths as in the experiments, and finally probed to calculate G_{max}. Final goal is to link the maximum shear modulus to the contact network and the orientation of the normal and tangential contact forces.