Influence of friction coefficient on the elastic moduli of granular materials

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ABSTRACT

Understanding the mechanical stiffness of closely packed, dense granular systems is of interest in many fields, such as soil mechanics, material science and physics. The main difficulty arises due to discreteness and disorder in granular materials at the microscopic scale which requires a multi-scale approach. The Discrete Element Method (DEM) is a new, powerful tool to inspect the influence of the microscopic contact properties of its individual constituents on the bulk behavior of granular assemblies [1,2].

In this study, assemblies of polydisperse, linearly elastic frictionless and frictional spheres are isotropically prepared using DEM . In a second stage, several static, relaxed configurations at various volume fractions above jamming are generated and tested. We investigate the effects of inter-particle contact friction on the elastic bulk and shear modulus by applying isotropic and deviatoric perturbations. The amplitude of the applied perturbations has to be small enough to avoid particle rearrangement and to get the elastic response [2], whereas large amplitudes develop plasticity in the sample due to contact and structure rearrangements between particles [3]. As expected, both the bulk and shear modulus increase with volume fraction [2]. Interestingly, we observe that both the bulk and shear modulus decrease by increasing the friction coefficient. We find that both elastic moduli for frictionless material show a qualitatively different behavior than for frictional samples due to the absence of tangential forces, see Fig.1.

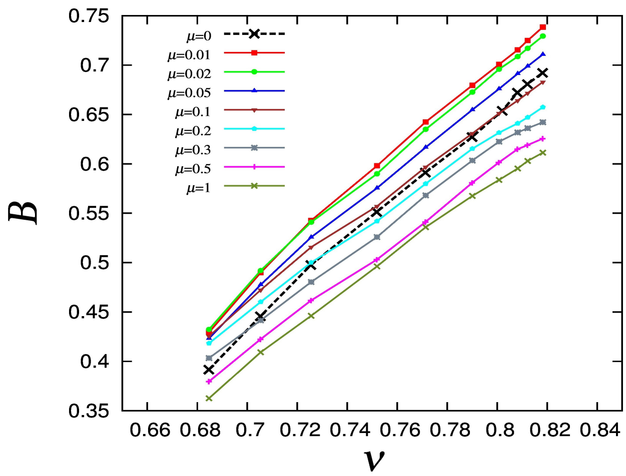

Figure 1: Evolution of the bulk modulus with volume fraction for different assemblies with friction coefficient given in the legend.

Finally, the evolution of macroscopic quantities (stress and fabric tensors) are studied as a functions of friction, volume fraction and strain rate at different deformation modes. The obtained results and the elastic moduli are used to develop and calibrate a simplified constitutive model. Further work will focus on predicting the plastic response of a granular assembly under large deformation.

REFERENCES

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