Improving the prediction ability of simplified discrete element models on complex loading paths

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ABSTRACT

Discrete element method has been proved to be an effective method in predicting quantitatively the constitutive response of soils, even in the case of complex loadings (with rotation of principal stress directions, or loading/unloading cycles) where conventional elasto-plastic constitutive relations may fail to simulate realistic responses [1]. For granular soils with a narrow grading, a direct representation of soil grains by polyhedral particles or with the level set method is possible [2], whereas for finer soils, or soils with a wider grading, alternative solutions should be considered. Spherical particles with enriched contact laws (e.g. by introducing rolling resistance at the contact) or rather simplified clumps of spheres can be used.

This study aims to compare such different approaches. On one hand this comparison is done in terms of the prediction abilities at the macroscopic scale of the constitutive responses of soils, in particular for complex loading paths. On the other hand, the comparison at the microscopic scale highlights the possible different local physics simulated with each approach.

Three kinds of discrete models are considered: (i) spherical particles with a rolling resistance, (ii) simple clumps made of 2 to 6 spheres, (iii) polyhedral particles. The models are calibrated from two drained triaxial compressions on dense and loose Hostun sand samples. They are then assessed, according to both the macroscopic response and the local physics, on loading paths strongly different from the calibration loading paths (isochoric compressions, circular stress paths in the deviatoric strain plane, constant deviatoric stress path, …).

The objective is to produce an optimized discrete element model in terms of prediction ability with respect to the computational cost, able to represent natural soils with possibly a wide particle size distribution, in order to tackle boundary value problems (as geotechnical structures) subjected to complex loadings.

REFERENCES

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