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Discrete Element Method modelling of non-active clays

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Soils are porous multiphase geomaterials, composed of i) a particulate solid phase, and ii) a fluid phase, hosted within the soil's porosity. Due to their complex discrete nature, the macroscopic response of soils depends on the mechanisms occurring at the particle or pore scale. The particle-to-particle interactions can be mechanical and/or electrochemical in nature, depending on the soil mineralogy and particle size distribution. These interactions affect particle arrangements and kinematics, and the evolution of the soil's fabric and pore size distribution upon loading. Understanding the mechanisms occurring at the particle or pore scale is crucial to the prediction of soil macroscopic responses under different loading conditions, where these cannot be easily reproduced using the framework of continuum mechanics.

Exploring the particle-scale mechanisms and their evolution upon loading in a direct experimental fashion is extremely challenging for fine-grained soils such as clays, due to the small (sub-micron) particle size. In the absence of particle-scale experimental evidence, a valuable alternative to explore the particle-scale behaviour is to perform "virtual"experiments, where soils are modelled as discrete particulate media using the Discrete Element Method (DEM). Here, we present an overview of the capabilities of a DEM numerical framework specifically formulated to simulate non-active clays. The inter-particle interactions implemented in the force-separation laws of the DEM model (electrochemical and mechanical interactions) are able to reflect the effect of the chemistry (pH and dielectric permittivity) of the fluid filling up the pore space on the macroscopic behaviour. The DEM framework, informed by existing experimental evidence ([1]) and proved to capture several aspects of the one-dimensional compression of non-active clays in oedometric conditions ([2]), was challenged to reproduce the behaviour of clay upon simple shear. Particular focus was given to the effect of the initial loading-induced particle orientations and fabric on the shearing behaviour, and on the evolution of both the soil's "macroscopic"porosity (e.g. void ratio) and pore-size distribution upon loading. The results of this study allowed to shed light on peculiar small (particle or pore) -scale mechanisms leading to the macroscopic observations upon which the continuum constitutive models used in conventional geotechnical engineering applications are formulated.

Participation

In-Person

References

[1] Pedrotti and Tarantino, 2017. An experimental investigation into the micromechanics of non-active clays. Géotechnique 68, No. 8, 666–683, https://doi.org/10.1680/jgeot.16.P.245

[2] Pagano, Magnanimo, Weinhart and Tarantino, 2020. Exploring the micromechanics of non-active clays by way of virtual DEM experiments. Géotechnique 70, No. 4, 303–316. https://doi.org/10.1680/jgeot.18.P.060

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