Keynote lecture

Simulation of penetration problems in Geomechanics

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ABSTRACT

Numerical simulations of penetration problems in porous granular materials face important challenges due to the large strains and displacements associated with this process (geometrical nonlinearity) as well as the nonlinearity of the mechanical behaviour of geomaterials. The constraints arising from the interface between granular media and the penetrating object adds to the complexity of the problem. In the lecture, two different approaches (continuum and discrete) are explored.

The continuum approach is based on the Particle Finite Element Method (PFEM) in which a cloud of particles define a finite element domain and the mesh is regularly updated adding, if required, new nodes in the zones with large plastic dissipation [1]. After each updating the mesh is smoothed, the state variables are transferred to the new mesh and the domain boundary is newly identified. Because of the presence of fluids in the pores of geomaterials, the method incorporates a coupled hydromechanical formulation that allows the determination of the pore pressure field at all stages of penetration. The effects of penetration rate and contact friction are evaluated and discussed.

The second approach involves the use of the Discrete Element Method (DEM) to simulate penetration of an object in a granular material [2]. An upscale procedure to reduce computational costs has been successfully adopted. It is shown that the DEM analyses are capable of recovering a number of the observed features of penetrations tests in sands. The approach is further extended to include the possibility of penetration into granular material made up of crushable grains, a key feature in some engineering problems such as the foundation of offshore structures [3].

The lecture closes with a comparative discussion of advantages, limitations and perspectives of the two approaches.

REFERENCES

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[3] M.O. Ciantia, M. Arroyo, F. Calvetti and A. Gens, "An approach to enhance efficiency when modelling soils with crushable grains in DEM", *Géotechnique*, 65(2), 91-110 (2015)