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FROM DISCRETE TO CONTINUUM APPROACH OF BVP IN GEOMECHANICS: FEM-DEM INTEGRATED APPROACH

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1 ABSTRACT

Recently, multi-scale analysis using a numerical approach of the homogenisation of the microstructural behaviour of materials to derive the constitutive response at the macro scale has become a new trend in numerical modelling in geomechanics. Considering rocks and soils as granular media with cohesion between grains, a two-scale fully coupled approach can be defined using FEM at the macroscale, together with DEM at the microscale [1,2,3].

In this approach, the micro-scale DEM boundary value problem attached to every Gauss point in the FEM mesh, can be seen as a constitutive model, the answer of which is used by the FEM method in the usual way. In this presentation, we illustrate several remarkable features of the FEM-DEM approach :

- it allows one to perform real-grain-size micro-structure modelling on real-structure-size macroscopic problems, without facing the intractable problem of dealing with trillions of grains in a fully DEM mapped full-field problem [4];
- using this approach, microscale related features such as the inherent and induced anisotropy of the material, and material softening/hardening with strain, naturally flow from the microscale DEM model to the macroscale FEM model [5,6];
- the intrinsic variability of the local micro structure of granular matter deposits can be easily taken into account [7];
- the Continuum Mechanics advanced methods already developed in the FEM framework like e.g. second gradient regularization to insure mesh-independency in the context of strain localization, or Multiphysics coupling macro-scale formulations, can be used directly together with this kind of DEM-based numerical homogenized law for the granular skeleton;
- Future developments of DEM-based approaches, for improved modelling of grain shape, roughness, grain crushing and other micro-scale features that today’s multi-scale experimental methods put in the foreground, can be readily implemented in the double-scale approach with no extra cost than plugging the improved micro-model in the already developed FEM-DEM framework.

Arguably, multi-scale numerical approaches may suffer from computational cost penalty with respect to

mono-scale one. However, high performance computing using parallel computation schemes offers solutions to mitigate the computational cost issue.

An implementation of the FEM-DEM method in a well-established, finite strain FEM code is presented, and representative results are discussed, including aspects related to strain localization in this context. High Performance Computing implementation and performances are illustrated.

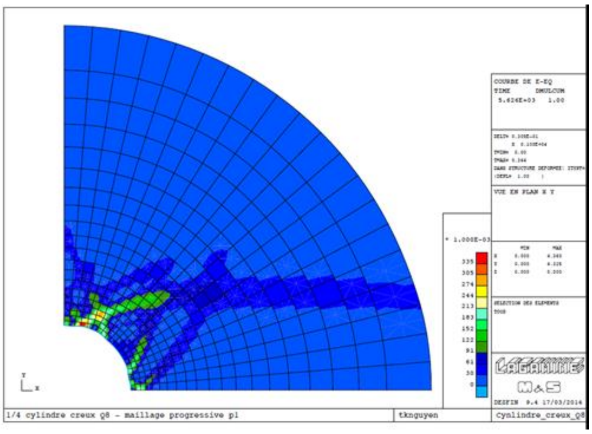

Figure 1*: FEM-DEM double scale model of a pressuremeter test in a granular soil*

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