Double scale numerical FEM-DEM analysis for cohesive-frictional materials

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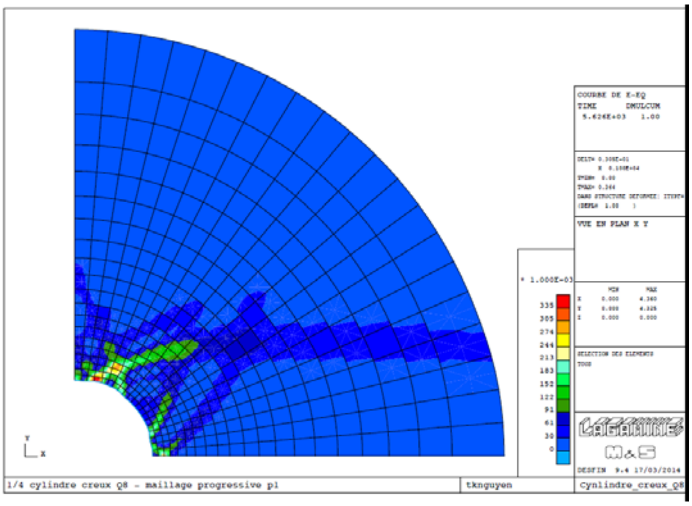
ABSTRACT

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 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. A first major advantage of two-scale FEM-DEM approach is to allow 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. A second one is that using this approach, microscale related features such as the inherent and induced anisotropy of the material, or material softening/hardening with strain, naturally flow from the microscale DEM model to the macroscale FEM model. 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 localisation in this context.



REFERENCES

[1] Nitka M., Combe G., Dascalu C., Desrues J. Two-scale modeling of granular materials: a DEM-FEM approach, *Granular Matter* vol.13 No 3, pp. 277-281, (2011)

[2] Nguyen T.K., Combe G., Caillerie D., Desrues J. FEM x DEM modelling of cohesive granular materials: numerical homogenisation and multi-scale simulation, *Acta Geophysica* vol.62 No 5, pp. 1109-1126, (2014)

[3] Guo Ning and Zhao Jidong. A coupled FEM/DEM approach for hierarchical multiscale modelling of granular media. *International Journal for Numerical Methods in Engineering* 99.11, 789-818 (2014)