Incremental response of granular materials: some open issues

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ABSTRACT

In a previous conference of this series [1] we presented some results from a numerical campaign consisting of a large number of DEM stress-probe tests on a model granular material (see also [2, 3]). The tests were performed on REV's composed of a representative number of circular grains undergoing unilateral, frictional-elastic contact interactions. Our analyses concerned two different strain mechanisms, i.e. contact deformation and network rearrangement, the first one being dominant in initially well coordinated states, while the second one is characteristic of poorly coordinated ones; in the latter case, the macroscopic stress-strain relations result from averaging over several micro-instabilities by which contact networks get broken and repaired. The characterisation of the incremental response observed under biaxial testing conditions lead to the identification of separate 'elastic' and 'plastic' deformation rates, with a clearly identified, single-mechanism flow rule. The incremental response under principal stress axis rotation was also fitted (between the relevant, three-dimensional stress- and strain spaces) by a multiple-mechanism flow rule. Based on this previous numerical campaign, and on more recent tests, we propose further analyses or foci on the following issues: the range of stress probes amplitudes under which the incremental response is identified as homogeneous of degree 1; the loss of uniqueness of the incremental stress-strain relation, in terms of both, the evolution of the macroscopically-observed flow rule and the inherent microscopic mechanisms of deformation; the existence of possible REV-size effects; etc. Our deductions are discussed also in reference to recent studies from other authors [4, 5].

REFERENCES

[1] Froiio, F., Roux, J.-N. Numerical stress probing on a 2D model granular material. In : Oñate, E. and Owen, D.R.J. (eds.), *Particle-based Methods II: Fundamentals and applications*, pp. 72–82. CIMNE, 2011.

[2] Roux, J.-N. and Froiio, F. Incremental response of granular materials: DEM results. In: Masami, N. and Luding, S. (eds.), *Powders and grains 2009: proceedings of the 6th international conference on micromechanics of granular media*, AIP Conference Proceedings, Vol. 1145, pp. 385–388, 2009.

[3] Froiio, F. and Roux, J.-N. Incremental response of a model granular material by stress probing with DEM simulations. In: Goddard, J.D., Giovine P. and Jenkins J.T. (eds.), *IUTAM-ISIMM Symposium on mathematical modeling and physical instances of granular flow*, AIP Conference Proceedings, Vol. 1227, pp. 183–197, 2010.

[4] Kuhn M.R. and Daouadji A. Multi-directional behavior of granular materials and its relation to incremental elasto-plasticity. *Int. J. Solids Struct.*, Vol. **152–153**, pp. 305–323 (2018).

[5] Pouragha, M., Kruyt, N.P. and Wan, R. Fabric response to strain probing in granular materials: two-dimensional, isotropic systems. *Int. J. Solids Struct.*, Vol. **156–157**, pp. 251–262 (2019).