Second-order Computational Homogenization of Granular Materials

***X.K. Li[1], X. Zhang[1,2], Y.B. Liang[1] and Q.L. Duan[1]**

[1]The State key Laboratory for Structural Analysis of Industrial Equipment, Dalian University of Technology, China.
[2] School of Engineering, University of Newcastle, Callaghan, NSW 2308, Australia

*Corresponding author: xikuili@dlut.edu.cn

A second-order computational homogenization scheme for two-scale constitutive modeling of heterogeneous granular materials is presented. In the scheme gradient Cosserat continuum and the representative volume element of discrete particle assembly with its effective classical Cosserat continuum are respectively adopted in macro- and micro- scales. A generalized Hill's lemma for micro-macro homogenization modeling of gradient Cosserat continuum is presented to perform the scale transitions (downscaling and upscaling) via the boundaries between the coarse and fine scales. The micromechanically informed macroscopic constitutive model and corresponding rate forms of the macroscopic stress–strain relation defined at the sampling point of gradient Cosserat continuum, taking into account the local microstructure and its evolution, are formulated with neither need of specifying the macroscopic constitutive relation nor need of providing macroscopic material parameters. The capability of the gradient Cosserat continuum model in capturing the size effect and revealing its micro-structural mechanisms are demonstrated.

Keywords: Gradient Cosserat continuum, discrete particle assembly, granular material, Second order computational homogenization, Hill's lemma