Texture and stress transmission in binary granular composites: Comparison between simulations and existing experiments

Pawarut Jongchansitto*and Itthichai Preechawuttipong*

[*] Department of Mechanical Engineering, Faculty of Engineering
Chiang Mai University (CMU)
239 Huay Kaew Rd., Suthep, Muang district, Chiang Mai 50200, Thailand
e-mail: pawarut.j@cmu.ac.th and itthichai.p@cmu.ac.th

ABSTRACT

Previous studies on granular mechanics mainly focus on mechanical behaviours of “non-composite” granular media, i.e. made of only one type of constitutive material, despite the fact that granular materials in engineering and industrial fields could be composed of various particles in terms of different shapes, sizes, and also physical properties. No studies indeed deal with “composite” granular media. That is the reason why a few studies on this topic can be found in the literature [1-4]. Recently, thermoelastic stress analysis (TSA) based on infrared (IR) thermography was experimentally performed to measure the hydrostatic stresses in the particles of two-dimensional composite granular media [5].

The objective of this study is to systematically analyse texture and stress transmission in binary granular composites obtained from the TSA experiments and molecular dynamics (MD) simulations. These results are statistically compared through the distributions of the hydrostatic stress in the particles and of the geometrical contact orientation between particles. Three different configurations were chosen from the TSA experiments, in order to model numerical composite samples. The composite sample was constituted from two materials with a stiffness ratio of four between them (stiff and soft particles). Under a confined vertical compression in static conditions, it can be concluded that the experimental and numerical results follow the same trends in overview. Particularly in terms of the distribution law of the hydrostatic stress in the strong network, it exhibits an exponential decay for all types of particle considered in the analysis (stiff, soft, or both). This distribution law of the hydrostatic stress is consistent with the well-known force distribution law found in both non-composite [6] and composite [7] granular media. In this network, there are less than 50% of particle numbers transmitting the stress greater than the average value. Considering in terms of geometrical contact orientation of the particles, the anisotropic structure with an effort to arrange itself parallel to the direction of the external applied loading is evidently observed for the contact network between stiff and stiff particles. On the contrary, the equilibrium of the granular system is sustained by the other contact networks, i.e. soft-soft contacts and stiff-soft contacts.

REFERENCES

[1] R.I. Budeshtskii, “Mathematical model of granular composite materials”, *Strength Mater+*, **3**, 912-916 (1971).

[2] C. Daraio, V.F. Nesterenko, E.B. Herbold, and S. Jin, “Energy trapping and shock disintegration in a composite granular medium”, *Phys. Rev. Lett.*, **96**, 058022 (2006).

[3] P.J. Wang, J.H. Xia, Y.D. Li, and C.S. Liu, “Crossover in the power-law behavior of confined energy in a composite granular chain”, *Phys. Rev. E*, **76**, 041305 (2007).

[4] Y. Yang, D. Wang, and Q. Qin, “Quasi-static response of two-dimensional composite granular layers to a localized force”, *Powder. Technol.*, **261**, 272-278 (2014).

[5] P. Jongchansitto, X. Balandraud, M. Grédiac, C. Beitone, and I. Preechawuttipong, “Using infrared thermography to study hydrostatic stress networks in granular materials”, *Soft Matter*, **10**, 8603-8607 (2014).

[6] F. Radjai, M. Jean, J.J. Moreau, and S. Roux, “Force distributions in dense two-dimensional granular systems”, *Phys. Rev. Lett.*, **77**, 274-277 (1996).

[7] P. Jongchansitto, I. Preechawuttipong, X. Balandraud, and M. Grédiac, “Numerical investigation of the influence of particle size and particle number ratios on texture and force transmission in binary granular composites”, *Powder Technology*, **308**, 324-333 (2017).