APCOM & ISCM
11-14th December, 2013, Singapore

The micromechanics of heat flow in compressed granular media

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In this paper, we present a micromechanical framework for heat flow in compressed granular materials. We defined two heat flow regimes dominated by different heat transfer modes, namely solid conduction via grain contacts and gap conduction via the interstitial gas region. Through the development of the thermal discrete element method, we demonstrated relations between these heat flow regimes and applied loading conditions, including compressive stresses and gas pressure. Transitions between the overall heat flow modes are determined by the loading conditions and properties of granular materials, which are constructed in a group of dimensionless numbers. A numerical parametric study has been performed to verify the regimes of heat flow modes extracted from the dimensionless analysis. Finally, a transient analysis of heat transfer is studied to show effects from thermal expansion of individual grains and thermal pressurisation of gas at elevated temperature on the overall heat flow modes.

Keywords: multi-scale simulation, granular materials, heat transfer, effective conductivity, discrete element method