Three continuum forms for regularly packed particle systems and applications

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We developed three equivalent continuum forms for regularly packed particle systems, and applied for predicting dynamic characteristics and investigating a possible damping mechanism of brick systems. Particles are idealized as rigid bodies connected with linear springs, and deformations are assumed to be infinitesimal. A first order accurate continuum form was developed based on continuumnization[1], which approximates difference operations in the discrete system with differential operations in an equivalent continuum. Other two continuum forms[2] are based on a truncated and complete Taylor series, respectively. Dynamic characteristics of several regularly packed particle systems were analytically predicted. Further, based on the derived continuum forms, we implemented a finite element model to simulate small deformation and wave propagation in regularly packed brick systems.

The accuracy of the analytic predictions and the FEM implementation were verified by comparing their results with Rigid Body Spring Models (RBSM) simulations. We demonstrated that the first order continuum form can predict the properties of p-, s- and spin waves to an accuracy sufficient for engineering applications. The second order model can predict wave properties within a reasonably wide range of wave numbers. It was shown that the third continuum form based on the complete Taylor series can make near perfect predictions of dynamic characteristics up to the smallest meaningful wave length of a particle systems. This remarkable accuracy makes it ideal for applications demanding high accuracy, like those in physics.

Analytic predictions and numerical simulations show the existence of spin waves of very high frequencies. The amplitudes of these very high frequencies should rapidly decay, causing loss of energy. This loss of energy due to high frequency spins could be a source of damping in particle systems. We made some preliminary investigations to test the hypothesis that high frequency spins could be a source of damping of brick or granule systems.

Keywords: Continuum forms, particle systems, analytic predictions, damping

References

[1] Hori, M., Wijerathne, L., Chen, J. and Ichimura, T. (2016) Continuumnization of regularly arranged rigid bodies, Journal of JSCE, **4**, 38-45.

[2] Supprasert, S., Maddegedara, L., Jian, C., HORI, M., and Ichimura, T. (2016). Application of continuumnization and PDS-FEM for the analysis of wave propagation in brick structures. J. of Japan Society of Civil Engineers, Ser. A2. **72**. I_133-I_142.