Volume-Averaged Stress States for Idealized Granular Materials using Unbonded Discrete Spheres in LS-DYNA®

By Michael T. Davidson[1], Jae H. Chung[1], Hailong Teng[2], Zhidong Han[2], Vinh Le[1]

[1]Bridge Software Institute, University of Florida, P.O. Box 116580, Gainesville, Florida, 32611, United States

[2]Livermore Software Technology Corporation, 7374 Las Positas Rd., Livermore, CA, 94551, United States

The discrete element method (DEM) has advantages of studying the kinetics of microscopic particles through use of contact mechanics, which has been used by numerous researchers to investigate kinematically admissible deformation fields observed in laboratory tests of Representative Elementary Volumes (REV) of granular masses. In this study, newly-implemented discrete element analysis (DEA) features of LS-DYNA are used to simulate three-dimensional stress states for idealized bodies of granules subjected to quasi-static loading conditions. Manual calculation of the local stresses that develop within select regions of a collection of unbonded discrete element spheres (UDES) in a 3-dimensional spatial domain are compared to the volume-average of the dyadic product of contact forces and branch vectors under body forces (as obtained from the LS-DYNA simulation results). As demonstration of the LS-DYNA DEM capabilities, and as a means of showcasing recently implemented stress calculation algorithms for UDES, relevant macroscopic parameters of granular materials are quantified using a step-by-step numerical procedure of the direct shear test (i.e., ASTM D3080-98) for a collection of UDES with various diameters. The as-demonstrated DEA using LS-DYNA is applied to modeling of in-situ field conditions, where confining geostatic stresses can be explicitly studied per micro-mechanical contact parameters.