Moving beyond continuum based numerical model for geomechanics

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Abstract

Classical continuum theory can provide an adequate description of the macroscopic mechanical response of most manmade materials. However, they will break down when facing many critical problems of geomechanics, e.g. progressive failure and strain localization, due to the discontinuous nature of rock masses and granular soils. To tackle these problems, discontinuum based models, e.g. Discrete Element Model (DEM) and Discontinuous Deformation Analysis (DDA), have been developed. These discontinuum based models have been increasingly applied to many geomechanics problems arisen from civil, mining, hydropower, to petroleum engineering. In this presentation, a newly developed discontinuum based numerical framework, Distinct Lattice Spring Model (DLSM), for rock dynamics is presented. In DLSM, material is discretized into mass particles of different sizes and macro mechanical response is represented by contact between particles. It is a more physical representation for shale compared with the continuum based approaches. The presented model is different from the conventional lattice spring models in that a shear spring is introduced to model the multi-body force by evaluating the spring deformation from the local strain rather than the particle displacement. By doing this, the proposed model can represent the diversity of Poisson's ratio without violating the rotational invariance. Because of explicitly representing the microstructure, DLSM is able to model dynamic fracturing problems and can be used to study the microstructure influences. The main advantages of DLSM are: i) it can directly use macroscopic parameters without any requirement for calibration; ii) it uses only half of the Degree of Freedoms (DOFs) compared with Discrete Element Method (DEM), and iii) it is easily amenable to parallelization of the algorithm. The DLSM has been proven to enable prediction of correct dynamic cracking velocity in brittle materials, the correct Mode-II dynamic cracking angle in metals, the reasonable compressive failure pattern of rock, etc.

Keywords: Distinct Lattice Spring Model, Rock Dynamics, Fracturing, High performance computing

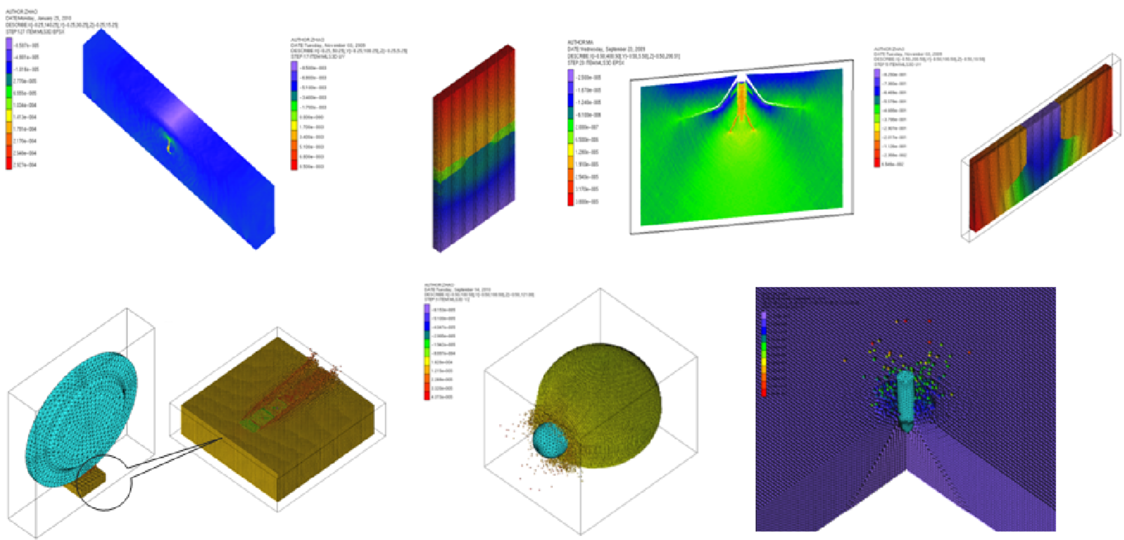

Figure 1. Numerical simulation using DLSM.