Adaptive Discrete-Continuous Modelling of Evolving Discontinuities

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The present study focuses on development of a method enabling to model entire structures on a large scale, at the same time taking into account localised nonlinear phenomena of the discrete microstructure of quasibrittle granular materials. Structures can be modelled efficiently on a large scale with continuum methods, such as the finite element method (FEM), as long as solutions are smooth. However, when discontinuities like cracks and fragmentation appear and evolve, application of models that take into account (evolving) microstructures may be advantageous. An appropriate model to simulate behaviour of granular materials is the discrete element method (DEM).

Even if the microscale is very close to the macroscale, discrete element methods are computationally expensive and can only be applied to relatively small specimen sizes and time intervals. Hence, a method is required that combines efficiency of FEM with accuracy of DEM by adaptively switching from the continuous to the discrete model where necessary.

An existing method which allows smooth transition between the methods is the quasi-continuum method [1], developed in the field of atomistic simulations. This method is taken as a starting point and its concepts are extended to applications in structural mechanics.

The kinematics in our method is obtained from FEM whereas DEM yields the constitutive behaviour. Spherical particles arranged regularly with quadratic potentials acting upon attraction and repulsion are assumed to build the microstructure of the granular material (in two dimensions). With respect to the constitutive law, three element types are used which differ in their size and accuracy of reflecting the behaviour of the microstructure.

Adaptive mesh refinement allows restriction of detailed computations to areas of large deformation gradients. In all other regions, an approximated continuum solution with a rather coarse mesh is accurate enough. This is illustrated in the example in Fig. 1.

The overall concept combines model adaption with adaptive mesh refinement with the aim to obtain a most efficient and accurate solution.

REFERENCES