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ADAPTIVE MODELING OF EVOLVING DISCONTINUITIES WITH SMOOTH TRANSITION BETWEEN DISCRETE AND CONTINUOUS METHODS

Malte von Scheven, Annika Sorg and Manfred Bischoff

Institut fr Baustatik und Baudynamik, Universitt Stuttgart,
Pfaffenwaldring 7, 70550 Stuttgart, Germany
{mvs,sorg,bischoff}@ibb.uni-stuttgart.de, http://www.ibb.uni-stuttgart.de

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The purpose of the present study is to develop a method to model entire structures on a large scale, at the same time taking into account localized non-linear phenomena of the discrete microstructure of cohesive-frictional materials. Finite element (FEM) based continuum methods are generally considered appropriate 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.

One popular model to simulate behavior of cohesive-frictional materials is the discrete element method (DEM). However, even if the microscale is 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 desirable that combines efficiency of FEM with accuracy of DEM by adaptively switching from the continuous to

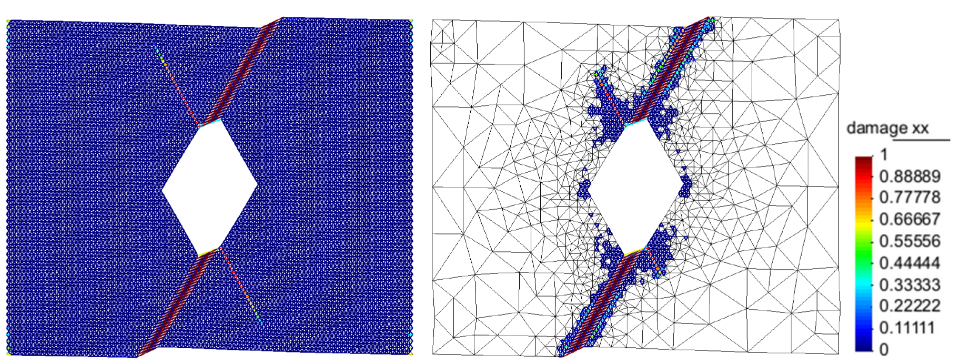

Figure 1: Horizontal tension test of a regular microstructure with damage of bonds. Reference solution (DNS) and approximate solution with the developed method.

the discrete model where necessary. An existing method which allows smooth transition between discrete and continuous models is the quasicontinuum method [1], developed in the field of atomistic simulations. It is taken as a starting point and its concepts are extended to applications in structural mechanics.

The kinematics in the method is obtained from FEM whereas DEM yields the constitutive behavior. Spherical particles of equal size arranged regularly with quadratic potentials acting upon attraction and repulsion are assumed to build the microstructure (in two dimensions). With respect to the constitutive law, three levels of resolution continuous, intermediate and discrete are introduced. In the homogeneous case, where all springs have the same stiffness, Cauchy-Born rule can be applied to the microstructure in order to determine the substitute stiffness of the transition elements. This is, however, no longer possible if the spring stiffnesses are heterogeneously distributed. For such cases, a strategy involving solution of a local subproblem for each transition element is newly proposed.

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

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