DISCRETE MODEL FOR DYNAMIC FRACTURE OF BRITTLE STRUCTURES

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The current strong interest in elaborate, discrete models for describing the fracture of heterogeneous brittle materials is spurred by ever increasing performance of available computational tools. The real advantage of handling the physics of the problem with such an approach is achieved when one starts with the microscale in order to more easily describe the microstructure of the material and capture the failure mechanisms of micro-cracks. Several recent works have explored this kind of approach. However, a number of questions related to computational modeling issues are nonetheless left open, some of them addressed in this work. The main novelties introduced herein concern the following:
(i) The construction of the beam lattice network representing the cohesive forces which employs the geometrically nonlinear beam model of Reissner (e.g [2]); the beam model of this kind, which includes the shear deformation, allows to easily represent all the fracture mechanisms leading to either crack opening displacement or crack sliding displacement, the latter not being available for Euler-Bernoulli beam lattice. Moreover, the ability of the present model to handle large rotations is important for representing the behavior of a heavily damaged zone as well as the displacement patterns of an assembly of several connected particles which split from the main structure. The constitutive model for cohesive forces obtained from analysis of interface between the neighboring particles can be implemented within the framework of reduced integration of Reissner's beam.
(ii) 1D discrete interface models of Delaplace [1], where the mechanical properties are considered as random variables, are here extended to structures with an arbitrary crack orientation; it is shown that the analysis of this kind can be brought to bear upon the identification of intrinsic material properties, such as internal length parameter for fracture, and development of irreversible damage phenomena; furthermore, the results obtained by this kind of models pertaining to instability producing localization problems can be interpreted through the appropriate studies of response fluctuation and statistical distribution of avalanches.
(iii) The constantly increasing demand to generalize the heterogeneous models of this kind in order to make them applicable in the analysis of structures requires establishing the link between the micromechanics models of this kind with the standard phenomenological models developed at macroscale. This work can be carried out without major difficulties only for elastic response; the fracture process can no longer be represented in detail at macroscale, where crack patterns are 'smeared' and artificial characteristic length parameters must be introduced. The potential direction shortly explored in this work concerns the models of beam lattice network constructed at mesoscale, where both elastic and inelastic fracture response can be developed in a systematic manner.
The numerical solution of test cases is carried out by the time-integration scheme [2] which is capable to control the high-frequency numerical noise by energy dissipation. Several illustrative examples will be presented at the conference.

References

[1] A. Delaplace, S. Roux and G. Pijaudier-Cabot, Damage cascade in a softening interface, *Int. J. Solids Structures*, **36**, pp. 1403–1426, 1999
[2] A. Ibrahimbegovic and S. Mamouri, Energy conserving/decaying implicit time-stepping scheme for nonlinear dynamics of three-dimensional beams undergoing finite rotations, Comput. Methods Appl. Mech. Eng., 191, pp. 4241-4258, 2002