CONVERGENCE RESULTS FOR A PROPOSED INITIALLY RIGID COHESIVE MODEL

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Fracture processes can be represented as either weak or strong discontinuities. Cohesive zone modelling is in the latter category. In such model, the separation of bulk material is resisted by cohesive forces, governed by the corresponding cohesive constitutive model.

A common type of cohesive constitutive model consists of an ascending branch and a descending branch. By decorating all the edges of the finite element mesh with cohesive surfaces, the crack path can be solved as part of the solution, within the resolution of the mesh [1]. As shown in [2], with this type of cohesive constitutive model, the effective elastic modulus of the bulk material is reduced to a degree depending on the level of mesh refinement. This, in turn, leads to material softening prior to crack initiation. One solution is to use an initially rigid cohesive model, i.e., a model with a vertical ascending part. This allows adaptive insertion of the surfaces by a node splitting technique. Such applications can be found in [3,4].

In our earlier work [5], it was shown that in order to obtain convergence from the finite element simulations with initially rigid cohesive surfaces, it is important that certain conditions, denoted by time continuity, are satisfied. We focus on explicit finite element methods. In this new work, we propose a model and method that is time-continuous but does not suffer from encoding into the model the interface tractions at time of activation. Some crucial implementation details are given. A numerical example of three point bending shows that our method indeed yields the correct convergence behavior as the time step is decreased.

The method is applied to a class of test-cases proposed in the recent literature for dynamic fracture of notched specimens. Effects of parameters such as strength and fracture toughness is explored, as well as dependence of the solution on mesh size and orientation.

References

[1] X. Xu and A. Needleman, "Numerical simulations of fast crack growth in brittle solids," *Journal of the Mechanics and Physics of Solids*, v. 42, p. 1397-1434, 1994.
[2] M. Falk, A. Needleman, and J. Rice, "A critical evaluation of dynamic fracture simulations using cohesive surfaces," *Journal de Physique IV*, 2001.
[3] A. Pandolfi, P. Krysl and M. Ortiz, "Finite element simulation of ring expansion and fragmentation," *International Journal of Fracture*, v. 95, p. 279-297, 1999.
[4] G. Ruiz, M. Ortiz and A. Pandolfi, "Three-dimensional finite element simulation of the dynamic Brazilian tests on concrete cylinders," *International Journal for Numerical Methods in Engineering*, v. 48, p. 963-994, 2000.
[5] K. Papoulia, C. Sam, S. Vavasis, "Time continuity in cohesive finite element modeling," *International Journal for Numerical Methods in Engineering*, in press.