Modeling of damage to crack transition using a coupled discontinuous Galerkin/cohesive extrinsic law framework

L. Wu[1]*, G. Becker[2], L. Noels[1]

[1] Computational & Multiscale Mechanics of Materials, University of Liege
Chemin des Chevreuils 1, B4000 Liege, Belgium L.Wu@ulg.ac.be
[2] Department of Aeronautics & Astronautics, Massachusetts Institute of Technology
77 Massachusetts Avenue, Cambridge, MA 02139-4307, USA

One current challenge related to computational fracture mechanics is the modelization of ductile fracture and in particular the damage to crack transition. In this paper we propose to achieve this goal by combining

1. A non-local damage model
2. The hybrid discontinuous Galerkin (DG)/extrinsic cohesive law (ECL) formulation

As classical damage models for finite element formulations lose the solution uniqueness and face the strain localization problem when strain softening of materials is involved, the damage model is herein formulated in a so-called implicit non-local approach, following the developments in [**?**]. In this formulation, a new non-local variable, the non-local accumulated plastic strain eg, representative of an internal variable and its derivatives, results from the resolution of a new boundary value problem. Besides the advantage of using C^0 elements, although the elements have now one additional degree of freedom per node, this approach also possesses the feature of being fully non-local.

The hybrid DG/ECL method was recently proposed [**?**] to circumvent the drawbacks of the cohesive element methods. Indeed, with this DG/ECL method, prior to fracture, the flux and stabilization terms arising from the DG formulation at interelement boundaries are enforced via interface elements in a way that guarantees consistency and stability, contrarily to traditional extrinsic cohesive zone methods. Upon the onset of fracture, the traction–separation law (TSL) governing the fracture process becomes operative without the need to modify the mesh topology as the the cohesive elements required to integrate the TSL are already present. This DG/ECL method has been shown to be an efficient numerical framework that can easily be implement in parallel with excellent scalability properties to model fragmentation, dynamic crack propagation in brittle and small-scale yielding materials, for 3D problems and for thin structures [**? ?**].

In this work, the DG/ECL method is extended to account for the damage process, as described in the non-local setting. One main advantage of the DG/ECL formulation is the existence of interface elements in which the damage model can be solved, the hydrostatic pressure can be resolved, and through which discontinuities can easily be introduced with a physically-based criterion.

References

[] R. Peerlings, R. de Borst, W. Brekelmans, S. Ayyapureddi, Gradient-enhanced damage for quasi-brittle materials, Int. J. Numer. Meth. Engng 39 (1996) 3391–3403.

[] R. Radovitzky, A. Seagraves, M. Tupek, L. Noels, A scalable 3D fracture and fragmentation algorithm based on a hybrid, discontinuous Galerkin, cohesive element method, Computer Methods in Applied Mechanics and Engineering 200 (2011) 326–344, doi:DOI: 10.1016/j.cma.2010.08.014.

[] G. Becker, L. Noels, A full discontinuous Galerkin formulation of non-linear Kirchhoff-Love shells: elasto-plastic finite deformations, parallel computation & fracture applications, International Journal for Numerical Methods in Engineering 1 (2013) 80–117, doi: 10.1002/nme.4381.