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An adaptive multiscale method for three-dimensional crack propagation in elasto-plastic media

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ABSTRACT

The extended finite element method (XFEM) introduced by MOËS *et al.* [1] is a well established method to handle complex crack geometries. In contrast to the standard FEM, crack geometries can be represented via level sets while their mechanical behavior is captured by nodal enrichment functions, such that cracks are modeled independent of the FE mesh. Thus, advancing crack fronts do not require remeshing. With the assumption of elasto-plastic material behavior, stresses are bounded yielding different enrichment functions than in linear elastic fracture mechanics (LEFM) as introduced by ELGUEDJ *et al.* [2]. This flexibility makes the XFEM to the method of our choice.
The interaction integral or the J-integral are frequently used to evaluate the criterion for crack propagation as well as the direction of crack growth in LEFM. Unfortunately, such an integral based energy release suffers accuracy in three-dimensional elasto-plastic fracture mechanics. An elegant way to release energy for propagating cracks and to avoid an integral formulation around the crack front is the introduction of a non-local damage model. Combining elasto-plasticity, damage and discrete crack growth in a standard FEM framework was introduced by MEDIAVILLA *et al.* [3]: A new crack segment is inserted once a critical damage threshold is reached. With the introduction of a simplified damage model, this mechanical model is applied to the XFEM.
Considering micro cracks in an efficient numerical manner necessitates the application of a multiscale method. Most multiscale methods, as e.g. the FE^2 method or the *variational multiscale method*, are not able to capture localization effects occurring naturally in crack propagation problems. The so-called *multiscale projection method* by LOEHNERT & BELYTSCHKO [4] accommodates these effects and is therefore utilized in this work.

REFERENCES

[1] N. Moës, J. Dolbow and T. Belytschko. A finite element method for crack growth without remeshing. *Int J Numer Meth Eng*, Vol. **46**, 135–150, 1999.

[2] T. Elguedj, A. Gravouil and A. Combescure. Appropriate extended functions for X-FEM simulation of plastic fracture mechanics. *Comput Method Appl M*, Vol. **195**, 501–515, 2006.

[3] J. Mediavilla, R.H.J. Peerlings and M.G.D. Geers. Discrete crack modelling of ductile fracture driven by non-local softening plasticity. *Int J Numer Meth Eng*, Vol. **66**, 661–688, 2006.

[4] S. Loehnert and T. Belytschko. A multiscale projection method for macro/microcrack simulations. *Int J Numer Meth Eng*, Vol. **71**, 1466–1482, 2007.