8th. World Congress on Computational Mechanics (WCCM8)
5th. European Congress on Computational Methods in Applied Sciences and Engineering (ECCOMAS 2008)
June 30 – July 5, 2008
Venice, Italy

IMPROVING THE ACCURACY OF XFEM CRACK TIP FIELDS IN LINEAR ELASTIC AND COHESIVE MATERIALS

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KEY WORDS: *XFEM, HCE, Statically admissible stress recovery, Asymptotic fields at the tip of traction-free and cohesive cracks.*

ABSTRACT

The major advantages of XFEM in its application to crack growth problems are that it avoids (i) meshes conforming to the cracks, and (ii) adaptive re-meshing as they grow by enriching local FE approximations along the crack faces and crack tips based on the partition of unity concept. Thus, there is no mesh bias and, more importantly, accurate results, that would require a very fine mesh in conventional FE, can be obtained using a relatively coarse mesh. However, in crack problems the accuracy of local fields at crack tips is strongly dependent on the choice of the enrichment functions [1]. The closer these functions are to the exact asymptotic fields, the better the accuracy. The exact asymptotic fields are however known only for very simple crack geometries and loadings. In general, one has to use arbitrary branch functions to enrich FE approximations at crack tips. The accuracy of local fields obtained by the XFEM suffers. As the crack growth paths are determined by the local stress fields, it is necessary to improve the accuracy of the latter.

We shall discuss a method for such improvement proposed in [2]. It is based on a statically admissible stress recovery (SAR) scheme using basis functions that meet the equilibrium equations within the finite element *and* the local traction conditions on its boundary coupled with moving least squares strategy to fit stresses at the quadrature points obtained by the XFEM. The role of important parameters that control the accuracy of the crack tip fields obtained by the XFEM and SAR will be highlighted and it will be shown that this combined approach indeed improves the accuracy of local stress fields. This strategy will be extended to cohesive cracks [3] for which the asymptotic crack tip fields analogous to Williams' fields for traction-free cracks were first obtained in [4].

The accuracy of linear elastic crack tip fields can be further enhanced by the XFEM version of the so-called enriched finite element method [1, 6], and by integrating the XFEM with the hybrid crack element (HCE) to exploit the advantages of the two [5]. For the latter, we shall first discuss briefly how to a) obtain the correct variational formulation of the HCE, b) use it to obtain accurately the coefficients of the singular and higher order crack tip asymptotic fields, c) recover the coefficients corresponding to rigid body translations and rotation which are suppressed during the variational formulation, and d) implement it on a standard quadrilateral mesh. The accuracy of the improved HCE has been confirmed independently by others using the fractal finite element, scaled boundary element and collocation methods [7].

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