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Cohesive zone (or crack) models have been extensively used in the study of localisation and failure in engineering structures. Elices et al. [1] have discussed the advantages and limitations of these models. De Borst et al. [2] have given a concise overview of the various ways in which the cohesive zone methodology can be numerically implemented. The recently developed extended/ generalized finite element method (XFEM) (see, e.g., Daux et al. [3], Strouboulis et al. [4], and Karihaloo and Xiao [5]) provides a proper representation of the discrete character of cohesive zone formulations avoiding any mesh bias. Moes and Belytschko [6] and Wells and Sluys [7] analysed a continuous cohesive crack that runs through an existing finite element mesh without mesh bias. Remmers et al. [8] further studied the possibility of defining cohesive segments that can arise at arbitrary locations and in arbitrary directions and thus allow for the resolution of complex crack patterns including crack nucleation at multiple locations, followed by growth and coalescence.

Rubinstein [9] has shown that relatively small errors in the determination of the crack path deflection angle can lead to a significant cumulative deviation of the crack path over a finite crack length. Therefore a reliable analysis of crack propagation requires not only a suitable criterion of crack growth but also an accurate evaluation of the crack tip field. The latter will be addressed in this contribution.

We will first make a detailed analysis of the asymptotic field at the tip of a cohesive crack in quasi-brittle materials for typical cohesive laws. This analysis will help us understand the structure of the crack tip field, and at the same time, provide us with suitable crack tip enrichment functions for the corresponding cohesive cracks. For traction free cracks, it has been shown that the implementation of the accurate crack tip field as enrichment functions gives most the accurate crack tip field using the XFEM (Liu et al. [10]).

We will then consider general cohesive cracks for which asymptotic fields are difficult to obtain, and enrichment functions at the crack tip can only be chosen to meet the local displacement conditions adjacent to the tip. In order to obtain accurate stresses, the statically admissible stress recovery (SAR) scheme of Xiao and Karihaloo [11, 12] will be extended to cohesive cracks. SAR uses basis functions, which meet the equilibrium equations within the domain and the local traction conditions on the boundary, and moving least squares (MLS) to fit the stresses at sampling points (e.g., quadrature points) obtained by the XFEM. It has been shown to be very powerful for traditional FEM as well as XFEM for linear elastic problems with traction-free boundary segments.

Typical cohesive crack problems with linear and nonlinear cohesive laws will be analysed and compared with available results in the literature to illustrate the accuracy and applicability of the methodology developed in this paper.

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