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Robust computation of stress intensity factor within eXtended Finite Element Method context

N. Chevaugeon - N. Moës - H. Minnebo

*GeM - Institut de Recherche en Genie Civil et Mecanique
Ecole Centrale de Nantes - Université de Nantes - CNRS UMR 6183
1, rue de la Noë, BP 92101 - 44321 Nantes Cedex 3 - FRANCE*

The extended finite element method (X-FEM), coupled to the level set method form a natural framework for the numerical resolution of complex three-dimensional fracture mechanics problems [1]. The robust computation of the “J” integral within this context is a crucial point to obtain accurate stress intensity factor for industrial applications [2,3].

We will present three family of methods for this post-treatment analysis, as adapted to the context of the X-fem. The first two methods are local methods where the stress intensity factor is computed at each point by performing a domain integral. For the first of the two, the domain integral is computed on a domain independent of the mesh, e.g. a regular box or sphere or cylinder around the point. For the second method, the domain is defined as the inside of a hull defined by elements of the computational mesh at a given topological distance to the point under consideration. The last method, adapted from the “G- θ ” or Parks [4] type of method is a global method where a new finite element problem is defined over the crack front to compute the J integral. Careful study of the convergence of the three methods, on structured and unstructured meshes, conform or not to the crack will be provided for both topological and geometrical enrichment. A discussion will follow on the compared virtues and vices of the three methods in view of the quality of the results, the implementation complexity and robustness in an industrial context. We will further discuss on the necessity of taking into account element in the direct neighborhood of the crack tip, where the integration could become fussy and lead to numerical instabilities. The discussion will be followed by the presentation of an industrial case coming from the aerospace industry : computation of stress intensity factor around a cracked inside a bladed-disc of an aircraft engine.

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