Extended Finite Element Method with Global Enrichment

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Key words: XFEM, geometrical enrichment, conditioning, 3D

ABSTRACT

A variant of the extended finite element method is presented which facilitates the use of enriched elements in a fixed volume around the crack front (geometrical enrichment) in 3D fracture problems. The major problem associated with geometrical enrichment is that it significantly deteriorates the conditioning of the resulting system matrices, thus increasing solution times and in some cases making the systems unsolvable. For 2D problems this can be dealt with by employing degree of freedom gathering [1] which essentially inhibits spatial variation of enrichment function weights. However, for the general 3D problem such an approach is not possible since spatial variation of the enrichment function weights in the direction of the crack front is necessary in order to reproduce the variation of solution variables, such as the stress intensity factors, along the crack front. The proposed method solves the above problem by employing a superimposed mesh of special elements which serve as a means to provide variation of the enrichment function weights along the crack front while still not allowing variation in any other direction. The method is combined with special element partitioning algorithms [2] and numerical integration schemes [3] as well as techniques for the elimination of blending errors between the standard and enriched part of the approximation in order to further improve the accuracy of the produced results.

Additionally, a novel benchmark problem is introduced which enables the computation of displacement and energy error norms as well as errors in the stress intensity factors for the general 3D case. Through this benchmark problem it is shown that the proposed method provides optimal convergence rates, improved accuracy and reduced computational cost compared to standard XFEM.

REFERENCES

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