Computing the generalized stress intensity factors of 3D singularities Application to the coupled criterion for fracture of brittle materials

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ABSTRACT

The coupled stress-energy criterion [1] proved to be one of the most successful in the past 15 years in predicting crack nucleation in brittle and quasi-brittle materials. Until recently, it was dedicated to 2D problems and was presented in two versions, one relying on an asymptotic approach and the other based on full FE computations. It was recently extended to 3D [2,3], mainly in the full FE version. The asymptotic approach requires knowing the leading terms of the 3D Williams' expansion in the vicinity of a singular point. While there are methods to calculate exponents and associated modes of this expansion [4,5], the determination of generalized stress intensity factors is more tricky. Until now, this was mainly done by a least-square identification from a FE solution [4,5]. We propose here to generalize the 2D method based on dual singularities. If λ denotes the primal singularity exponent, the dual singularity is defined by the exponent $-\lambda-1$ (instead of $-\lambda$ in 2D) [4]. This dual mode acts like an extraction function when applied, through a path independent integral, to the FE solution to a 3D problem of structure. The dual singular mode can be calculated using the same tool used to calculate the primal singularity, then the path independent integral is implemented in Abaqus in an automatic procedure.

In a first step it is checked that the path independence holds true and, based on known solutions, it is shown that the method provides accurate results and gets rid of difficulties met in case of multiple modes. In a second step, the asymptotic approach of the coupled criterion is implemented and compared to fracture experiments [5].

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