An efficient discrete strong discontinuity approach for simulation of fracture based on minimum enhanced degrees of freedom

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Abstract

Several new techniques have been presented in recent years for modelling discrete fracture. In many cases, such as in concrete structures reinforced with steel fibres, the ability to precisely predict failure strongly relies on the interaction of cracks and strain localisation that can lead to early failure. In this case, the simulation of the discrete behaviour of cracks becomes crucial and needs to be properly accounted for in numerical models. There are, however, still drawbacks that have prevented discrete models to gain traction in wide structural applications, which include in the case of: i) models based on interface elements, the computational cost, excessive number of degrees of freedom, and crack paths constrained to propagate along element edges; ii) models based on XFEM and some embedded approaches, the complex procedures to enrich elements and/or nodes and computational cost. This paper proposes a new efficient approach to enrich elements handling discrete cracks as separate entities, which is not only computationally efficient but also requires minimal degrees of freedom and simplifies enrichment procedures. Benchmarks presented show that less than half of the number of additional degrees of freedom are required to reach comparable accuracy with the new embedded when comparing with standard embedded approaches based on global nodes, and less than a third when compared to standard XFEM.

Keywords: Fracture, embedded discontinuities, discrete cracks, enhanced degrees of freedom