Applications of Crack Path Field and Strain Injection Techniques in Dynamic Fracture of Quasi-Brittle Materials

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ABSTRACT

Dynamic fracture processes in quasi-brittle materials strongly determine the strength, stiffness and ductility [1] which are key issues for structural design purposes. Inertia forces become dominant at high loading rates and crack propagation instabilities such as curving and branching appear when a critical crack tip velocity is exceeded [2].

In this study the physical discontinuities are simulated using Finite Elements with Embedded strong discontinuities (E-FEM) which are seen as affordable and efficient intra-elemental modeling techniques since no extra degrees of freedom are added in the onset of fracture. Previous research in static analyses of quasi-brittle materials [3,4] show that classical strain localization and strong discontinuity approaches can be considered by injecting discontinuous strain and displacement modes in the finite element formulation. The use of displacement discontinuities in the kinematics results of utmost importance in order to avoid stress locking and mesh bias dependence but requires tracking techniques which determine the position and orientation of the discontinuity. The crack path field technique [3,4] is adopted in this contribution which tackles the crack propagation problem based on the distribution of localized strains.

The above mentioned technology is adapted for dynamic simulations on a concrete specimen subjected to different loading rates. Crack branching phenomena and the variation in terms of failure modes is investigated when modeled with the strain injection and crack path field algorithms.

REFERENCES

[1] H. V. Reinhardt, Concrete under impact loading. Tensile strength and bond. *Heron* 27 (3), 1982.

[2] L. B. Freund, *Dynamic fracture mechanics*. Cambridge University Press, Cambridge, 1990.

[3] I. F. Dias, *Crack Path Field and Strain Injection Techniques in Numerical Modeling of Propagating Material Failure*. PhD thesis, Universitat Politècnica de Catalunya (BarcelonaTech), 2012.

[4] J. Oliver, I. F. Dias and A. E. Huespe, Crack-path field and strain-injection techniques in computational modeling of propagating material failure. *Computer Methods in Applied Mechanics and Engineering* 274, 289–348, 2014.