Comparison of a peridynamics and a phase-field approach to dynamic fracture

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Peridynamics and the phase-field fracture are two non-local methods to efficiently compute fracturing solids. While cracks in a solid are sharp two-dimensional hypersurfaces, the phase-field approach regularizes the material discontinuities with smooth transitions between broken and unbroken states. The evolution of the phase-field follows an equation where the driving forces of crack growth are derived from an energy minimization principle, typically based on an Ambrosio-Tortorelli type functional. Modifications allow accounting for the irreversible constraint of crack evolution and, especially important, for the asymmetry of fracture, i.e., cracks only grow under tensile loadings but not under compression [1,2]. Further modifications consider the evolution problem at finite strains using energy densities, which are polyconvex functions of the deformation, and/or at the regime of specific crack driving forces [2,3].

In this contribution, we focus particularity on pressure induced fracture. Different approximations will be presented, and dynamic finite element simulations of brittle fracture will be compared [3,4,5].

As an alternative to finite-element dicretizations, the particle based peridynamics will be discussed. The classical particle and bond-based peridynamics will be introduced and extended to a new geometrically precise framework, the continuum-kinematics-based peridynamics. This new formulation extends the classical method by introducing surface- or volume-based interactions, providing an exact geometrical method and a convenient way to simulate dynamic fracture. We will show that our recently introduced damage model [6] for the continuum-kinematics-based peridynamics effectively manages crack propagation under dynamic loading conditions with large deformations.

The main objective of this study is to illustrate the possibilities of dynamics fracture computations with the two methods. We will study the relationships of critical non-local fracture parameters and we will compare the phase-field fracture approach and the continuum-kinematics-based peridynamic framework in simulating wave propagation, superposition and cracking at critical states. The comparison will focus on the efficiency and accuracy of the two methods in capturing the critical fracture load and managing crack propagation under dynamic loading conditions with significant fragmentation.

References

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