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Other Conference Item

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Publication date:
2021-07

Permanent link:
https://doi.org/10.3929/ethz-b-000497923

A Hybrid Finite Element – Spectral Boundary Integral Method for 3D Dynamic Fracture Simulation

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Modeling dynamic fracture of a weak interface in a 3D unbounded domain is a useful tool to study fundamental aspects of fracture mechanics related to problems such as the onset of friction and earthquake rupture propagation. Typically, such a simulation involves solving the elasto-dynamic wave equation on a finely discretized domain with an explicit time integration scheme. If the domain is purely elastic and homogenous, one can apply boundary-element methods [1], which are efficient and limit discretization to the weak interface only. However, if the solid is inelastic or heterogeneous, discretization of the full domain is required and boundaries need to be far enough to approximate an unbounded domain [2]. This results in a very large number of degrees of freedom and thus large computational cost. We propose a hybrid method, which combines the finite-element method with the spectral-boundary-integral method [3]. The discretized finite-element domain describes accurately all non-uniformities near the weak interface but is truncated and coupled with an infinite boundary condition, which absorbs all incident waves. The infinite boundary condition is provided by the spectral-boundary-integral method, which is based on a semi-analytical solution of the elasto-dynamic impulse response of an infinite elastic half space. The semi-analytical nature provides very accurate wave absorption and the spectral representation provides computational efficiency due to the independent response of each wavelength. We compare the developed hybrid method with full finite-element simulations of established benchmark simulations and determine the potential increase in computational efficiency.

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