A unified interfacial damage and contact model for dynamic fracture and fragmentation

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We describe a unified model for interfacial damage and contact with applications to rate-dependent brittle failure and impact problems. The sharp-interface damage model is distinct from bulk-damage representations of fracture processes and is an alternative to cohesive models with traction-separation relations. We use a spacetime interfacial damage field, D, to describe transitions between intact and fully debonded conditions on fracture surfaces. A delayed-damage relation [1] governs the evolution of D and includes a relaxation time scale to capture rate-dependent response. Using the local value of D, we first interpolate between Riemann solutions for intact and de-bonded interfaces at each point on a fracture surface. The resulting interfacial Riemann solution field is then weakly enforced within a spacetime discontinuous Galerkin finite element model. This approach preserves the characteristic structure of the underlying hyperbolic system and handles crack closure and impact, with distinct response for contact-stick and slip conditions with friction [2].

Numerical solutions for impact problems are typically marred by prolonged nonphysical oscillations or under/overshoots at contact and fracture-mode transitions unless nonphysical stabilization is added to the model. We demonstrate that the dynamical consistency of our Riemann solutions delivers high-fidelity solutions with almost no artifacts at mode transitions. In contrast to intrinsic cohesive models, our model generates no artificial compliance in the undamaged state at any level of grid refinement. It also avoids the non-smooth response that can complicate numerical implementations of extrinsic cohesive models. We discuss parameter selection for realistic fracture response and present applications to fragmentation and spalling.

References

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