Homogenization and Stochastic Fracture Simulation of Quasi-brittle Materials

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The response of brittle and quasi-brittle materials is greatly influenced by their microstructural architecture. Models that assume spatially uniform fracture strength miss the effect of microscale inhomogeneities on eventual crack patterns and the scatter in certain macroscopic measures, such as ultimate load and absorbed energy.

We use two different approaches for creating *Statistical Volume Elements* (SVEs). In the first approach, a 2D finite element mesh is generated from microstructure images and *Conforming to Interface Structured Adaptive Mesh Refinement* (CISAMR) [1] algorithm that exactly tracks inclusion boundaries with advanced mesh adaptive operations. In the second approach, a Voronoi tessellation-based method [2] is used to create SVEs that unlike the first approach are not square-shaped and do not cut through inclusion boundaries. The results from the two approaches will be compared and the effect of boundary condition and SVE size on homogenized elastic and fracture properties will be discussed.

The statistics of the fracture strength field and the Karhunen-Loeve method will be used to generate consistent realizations of homogenized fracture strength field. Two macroscopic fracture models are used for dynamic fragmentation analysis of such realized material fields. In the first approach, an interfacial damage model is used to explicitly represent nucleated cracks from weak points in the material and subsequent crack propagations. In the second approach, a rate-dependent bulk fracture is used to implicitly model material degradation processes. The spacetime discontinuous Galerkin method and advanced mesh adaptive operations [3] are used to track crack paths and/or sharp moving fronts in these two approaches. The effect of loading rate, underlying SVE size, and fracture model and parameters on macroscopic measures such as fracture pattern and dissipated fracture energy will be discussed.

References:

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