Mesoscopic characterization of SVEs and macroscopic field realization for fracture and elastic properties

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The fracture response of quasi-brittle materials is highly sensitive to their microstructural formation. We used Voronoi tessellation-based statistical volume elements (SVEs) to characterize a scalar fracture strength field. In a similar study, SVEs containing microcracks were used to again characterize a scalar fracture strength field. Therein, the effect of SVE size on macroscopic fracture patterns was studied. The Karhunen-Loeve method was used to generate macroscopic fracture strength fields. However, our previous approaches cannot directly be generalized to problems with correlated random fields.

In addition to Voronoi tessellation-based SVEs, we use square SVEs to characterize underlying fracture strength and elastic stiffness parameters. In the second approach, a 2D finite element mesh is directly generated from the microstructural model using the Conforming to Interface Structured Adaptive Mesh Refinement (CISAMR), which is a non-iterative algorithm that exactly tracks material interfaces and yields high-quality conforming meshes with advanced adaptive operations. In both approaches the statistics (including the first and second moments) of fracture strengths and elastic stiffness parameters are derived. We will discuss how the SVE size affects the statistics of the homogenized fields. We use this numerically generated database to construct random field models for elastic and fracture properties that are consistent with the observed statistics. To that end, instead of Karhunen-Loeve method, we model the elasticity tensor as matrix-valued random field for which the probabilistic description is constructed based on the maximum entropy principle and random matrix theory. Using this approach, the realization of the correlated random field material properties are efficiently generated and in turn used for macroscopic elastodynamic simulations by a spacetime discontinuous Galerkin method. This allows us to estimate the probabilistic description of macroscopic response. The effect of the underlying random field on macroscopic response will be discussed.