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Mesoscale Material Strength Characterization for use in Fracture Modeling

K. Acton, B. Bahmani, R. Abedi

In order to accurately simulate crack initiation and propagation, it is necessary to account for small-scale randomness in the properties of a material. It is important to characterize apparent properties of Statistical Volume Elements (SVE), which are below the scale of a Representative Volume Element (RVE). Apparent properties at the mesoscale cannot be uniquely defined for an SVE, in the manner that unique effective properties can be defined for an RVE. Therefore both elastic constitutive behavior and material strength properties in SVE must be statistically characterized. The choice of boundary conditions in an SVE analysis (for example, kinematically uniform, statically uniform, periodic or mixed) has been widely studied and shown to affect the properties obtained. However, the choice of geometrical partitioning method can also be critically important in affecting the probability distributions of mesoscale material property parameters. In this work, a Voronoi tessellation based partitioning scheme is applied to generate SVE at multiple length scales. The resulting material property distributions are compared with those from SVE generated by square partitioning. In particular, this work focuses on the proportional limit stress of the SVE, which is used to approximate SVE strength. A method based on superposition of elastic results is used to obtain failure strength distributions from boundary conditions at variable angles of loading.