Mesoscale models characterizing material property fields used as a basis for predicting fracture patterns in quasi-brittle materials

Katherine A. Acton,[a] Sarah C. Baxter, [a] Bahador Bahmani, [b] Philip L. Clarke, [b] Reza Abedi [b]

[a]School of Engineering, University of St. Thomas, 2115 Summit Ave, St. Paul, MN 55105
[b]Mechanical, Aerospace & Biomedical Engineering, University of Tennessee Knoxville (UTK) / Space Institute (UTSI), 411 B. H. Goethert Parkway, Tullahoma, TN 37388

To accurately predict fracture patterns in quasi-brittle materials, it is necessary to accurately characterize heterogeneity in the properties of a material microstructure. This heterogeneity influences crack propagation at weaker points. Also, inherent randomness in localized material properties creates variability in crack propagation in a population of nominally identical material samples. In order to account for heterogeneity in the strength properties of a material microstructure, a mesoscale model is developed. A central challenge of characterizing material behavior at a scale below the representative volume element (RVE), is that the stress/strain relationship is dependent upon boundary conditions imposed. To mitigate error associated with boundary condition effects, statistical volume elements (SVE) are characterized using a Voonoi tessellation based partitioning method. A moving window approach is used in which partitioned Voronoi SVE are analysed using FEA to determine a limiting stress criterion for each window. Results are obtained for hydrostatic, pure and simple shear uniform strain conditions. A method is developed to use superposition of results obtained to approximate SVE behavior under other loading conditions. These results are used to determine a set of strength parameters for mesoscale material property fields. These random fields are then used as a basis for input in to a fracture model to predict fracture patterns in quasi-brittle materials.