UPSCALED MODELS OF RANDOM HETEROGENEOUS MATERIALS VIA PROBABILISTIC CHARACTERIZATION OF LOCAL STRUCTURE-PROPERTY RELATIONSHIPS

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Abstract

Failure of most brittle materials is driven by the initiation, propagation and coalescence of microcracks originating from pre-existing microstructural defects, such as grain boundaries or processing-induced pores/inclusions. Under static loading, cracks associated with the largest, most deleterious defects govern the behavior, so that Weibull statistics provide a suitable construct for identifying macro-scale strength. Under high-rate loading, however, cracks associated with a wide range of defects are mobilized; therefore, the extreme-value assumption inherent in the Weibull model is no longer valid for dynamic strength. The current work upscales a micromechanics model linking the randomly varying local defect population to the randomly varying local constitutive response. This micromechanics model serves as the basis for a constitutive model associated with the local defect population underlying individual integration points in a macro-scale analysis. Challenges arise in addressing model efficiency when tracking the crack growth of multiple families at each integration point, in incorporating coalescence of cracks, and in addressing the anisotropy of material compliance associated with preferential directions of crack growth. Results show that representation of random local variations in the constitutive behavior is key to obtaining physically reasonable results.