MICROMECHANICAL ANALYSIS OF RANDOM NON-HOMOGENEOUS COMPOSITES USING MOVING-WINDOW GMC

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The analysis of composite materials with random microstructures usually assumes that homogenized or equivalent effective properties can be used to represent the average material behavior, while neglecting localized variation due to spatial randomness in composition. When local extreme effects arise, this assumption will not be adequate for the accurate prediction of failure mechanisms such as plastic yielding or crack initiation. In such cases, a probabilistic approach can be used to include such effects [1]. In the case of nonhomogeneous composites, this concern is accentuated by the fact that the probabilistic information (i.e., mean and/or probability density function) can vary between spatial locations.

An analysis approach that accounts for spatial microstructural variation in a probabilistic framework is presented. The technique involves digital image analysis and a computational micromechanics model, the moving-window generalized method-of-cells (MW-GMC) [2]. The generalized method-of-cells approach is different from traditional finite element methods in that it assumes average continuity of displacements and tractions, rather than point-wise displacement continuity. This approximate formulation provides a computationally efficient and accurate way of deriving the material properties at any given location by defining a repeating volume-element unit cell (or window) as a representation of a periodic microstructure. Local fields of the effective material properties can be generated [3].

An investigation of the method's effectiveness is provided by applying the micromechanics approach to both digitally generated samples (using probabilistic algorithms) and actual images of nonhomogeneous composites under a finite element application. The accuracy and computational efficiency of this approach are compared to brute-force finite element analysis of a full sample. The sensitivity of the resulting local stress distributions with respect to window size is investigated for two-dimensional images generated using a probabilistic framework that incorporates the simulation of non-Gaussian, non-stationary samples [4].

References

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