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EFFICIENT HIGH-FIDELITY TWO-SCALE COMPUTATIONAL MODEL FOR PROGRESSIVE FAILURE ANALYSIS OF FIBER REINFORCED COMPOSITES VIA REFINED BEAM MODELS

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An efficient high-fidelity two-scale computational model for progressive failure analysis of fiber reinforced composite is presented. The computational model is based on a class of refined beam finite elements called Carrera Unified Formulation (CUF), a generalized hierarchical formulations which yields refined structural theory via variable kinematic description [1]. The two-scale framework consists of a macro-scale model to describe the structural level components (e.g: open-hole specimens, coupons) and a sub-scale micro-structural model encompassed with a representative volume element (RVE). The RVE is modeled with real composite constitutents, e.g., fiber and matrix with details about packing and heterogeneity. Various classes of RVE architecture is taken into account by randomly embedding multiple fibers in the constituent matrix. Component-Wise approach (CW), an extension of CUF beam model based on Lagrange-type polynomials, is used to model the constituents in the RVE. CW model enables one to use a detailed physical desciption of RVE by placing the problem unknowns on it's physical surface. The two scales are interfaced through the exchange of strain, stress and stiffness tensors at every integration point in the macro-scale model. The energy based crack band theory (CBT) is implemented within the sub-scale model to predict the progressive damage growth in the individual constituents [2, 3]. Mesh objective results are obtained by scaling the post-peak softening slope of stress-strain constitutive relationship. The ability of CUF beam models to obtain accurate 3D-like stress fields at a reduced computational cost(approximately one order of magnitude of degrees of freedom less as compared to standard 3D brick elements) leads to a computationally efficient framework. Numerical predictions includes failure parameters such as stress-strain response,damage contours and ultimate strength and are validated against experimental results.

References

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