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This research work presents a computationally efficient and accurate platform for virtual testing of composites. The present model is based on a class of refined one-dimensional (1D) theories referred to as the Carrera Unified Formulation (CUF), a generalized hierarchical formulation that yields refined structural theories through a variable kinematic description [1]. 1D CUF models can provide accurate 3D-like stress fields at a reduced computational cost, e.g., approximately one to two orders of magnitude of degrees of freedom less as compared to standard 3D brick elements. The virtual testing platform consists of a variety of computational tools such as failure index evaluations using component-wise modeling approaches (CUF-CW), CUF-CW micromechanics, CUF^2 multiscale framework, and interface modeling. The Component-Wise approach (CW) is utilized to represent various components of the RVE in the CUF-CW micromechanics module [2]. The crack band theory is implemented to capture the damage propagation within the constituents of composite materials and the pre-peak nonlinearity within the matrix constituents is modeled using the J_2 von-Mises theory. A novel multiscale framework, CUF^2, is developed for nonlinear analysis of fiber-reinforced composites. The two-scale framework consists of a macro-scale model to describe the structural level components, e.g, open-hole specimens, coupons, using CUF-LW models and a sub-scale micro-structural model encompassed with a representative volume element (RVE). The two scales are interfaced through the exchange of strain, stress and stiffness tensors at every integration point in the macro-scale model. Explicit finite element computations at lower scale are efficiently handled by the CUF-CW micromechanics tool. A novel higher-order interface modeling approach is utilized to model delamination. The tools mentioned above are employed to obtain accurate material response across various scales of composite modeling. The efficiency of the proposed computational platform is assessed via comparison against the traditional approaches found in the literature.

References

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