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A Multi-Scale Approach for the Analysis of Fiber-Reinforced Composites

Authors : Azeez Shaik, Amit Salvi, B. P. Gautham

Abstract : Fiber reinforced polymer resin composite materials are finding wide variety of applications in automotive and aerospace industry because of their high specific stiffness and specific strengths when compared to metals. New class of 2D and 3D textile and woven fabric composites offer excellent fracture toughens as they bridge the cracks formed during fracture. Due to complexity of their fiber architectures and its resulting composite microstructures, optimized design and analysis of these structures is very complicated. A traditional homogenization approach is typically used to analyze structures made up of these materials. This approach usually fails to predict damage initiation as well as damage propagation and ultimate failure of structure made up of woven and textile composites. This study demonstrates a methodology to analyze woven and textile composites by using the multi-level multi-scale modelling approach. In this approach, a geometric repetitive unit cell (RUC) is developed with all its constituents to develop a representative volume element (RVE) with all its constituents and their interaction modeled correctly. The structure is modeled based on the RUC/RVE and analyzed at different length scales with desired levels of fidelity incorporating the damage and failure. The results are passed across (up and down) the scales qualitatively as well as quantitatively from the perspective of material, configuration and architecture.

Keywords : cohesive zone, multi-scale modeling, rate dependency, RUC, woven textiles
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