Fast two-scale computational model for progressive damage analysis of fiber reinforced composites

Ibrahim Kaleel[1], Marianna Maiarù[2], Marco Petrolo[1], Erasmo Carrera[1], and Anthony M. Waas[3]

[1] *Department of Mechanical and Aerospace Engineering, Politecnico di Torino,10129 Torino, Italy*
[2] *Department of Mechanical Engineering, UMass Lowell, Lowell, MA 01854 , USA*
[3] *Department of Aeronautics and Astronautics, University of Washington, Seattle, WA 98195-2400, USA*

ABSTRACT

A fast two-scale finite element framework based on refined finite beam models for progressive damage analysis (PDA) of fiber reinforced composite is presented. The framework consists of a macro-scale model to define the structural-level components, interfaced with a second sub-scale model at the fiber-matrix level. Refined finite beam elements are based on Carrera Unified Formulation (CUF), a hierarchical formulation which offers a procedure to obtain refined structural theories that account for variable kinematic description [1]. The representative volume element (RVE) at the sub-scale is modeled with real material, e.g., fiber and matrix with details about packing and heterogeneity. Component-Wise approach (CW), an extension of refined beam kinematics based on Lagrange-type polynomials, is used to model the constituents in the sub-scale. Each consitutent in the sub-scale is modeled by the same finite element in the framework of the CW. The energy based crack band theory (CBT) is implemented within the sub-scale constitutive laws to predict the damage propagation in individual constituents [2, 3]. The communication between the two scales is achieved through exchange of strain, stress and stiffness tensor at every integration point in the macro-scale model. The efficiency of the framework is derived from the ability of CUF models to provide accurate displacement and stress fields at a reduced computational cost (approximately one order of magnitude of degrees of freedom less as compared to standard 3D brick elements). Numerical predictions are validated against the experimental results.

Keywords: Multiscale; CUF; Refined beam models; Progressive Damage Analysis; Crack Band

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