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Special Guest Lectures

Computational Modeling of Woven Composites

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Abstract:
The focus of this study is directed toward developing detailed three-dimensional (3D) finite element models of woven Ceramic Matrix Composites (CMCs) and Polymer Matrix Composites (PMCs). We develop a new systematic methodology of representing the intricate fiber bundle architecture and matrix layer topology in plain and satin weave composites with the aid of generalized mathematical shape functions. Particular attention is focused on describing the fiber bundle and matrix layer geometry within a requisite Repeating Unit Cell (RUC) of such materials. These functions are capable of addressing the geometric intricacies observed in both CMCs and PMCs. The geometry models are developed in conjunction with hierarchical homogenization methods and 3D finite element based thermo-mechanical boundary value problems. The formulation of the mechanical-elastic boundary value problems is aimed at establishing the macroscopic linear elastic mechanical response of both PMC and CMC plain and satin weave systems. At the same time, the fundamental 3D thermo-elastic boundary value problems are formulated with the objective of assessing the effects of thermal expansion constituent dissimilarity and temperature changes on the mechanical and fracture behavior of woven CMCs. A generalized non-dimensional modeling framework is employed as needed to establish a broad range of requisite solutions. Thermo-mechanical finite element solutions are used to compute the localized high stress concentrations near the vicinity of large macroscopic matrix voids (also known as "open porosity") in woven CMCs. These findings are then employed in failure models aimed at computing the proportional limit strength and establishing broad failure loci of these advanced materials under different combinations of in-plane mechanical and thermal loading. Rigorous model calibration provides strong evidence of agreement with experimental and other analytical/numerical data available in the literature and confidence in the use of the models developed herein in field design environments.

Speaker's Bio:
Prabhakar Rao received his Ph.D. in mechanical engineering from the University of Maryland Baltimore County; Master of Engineering from the University of Bombay, India; and Associates degree from The Institution of Engineers in Kolkata, India. He is a member of the American Society of Mechanical Engineers and was the recipient of the UMBC Graduate School Dissertation Fellowship in 2005.