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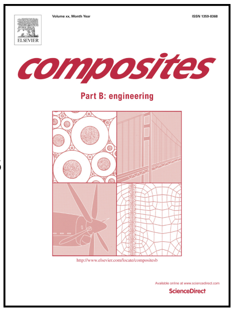

Probabilistic micromechanical spatial variability quantification in laminated composites

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Probabilistic micromechanical spatial variability quantification in laminated composites

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Abstract

This article presents a probabilistic framework to characterize the dynamic and stability parameters of composite laminates with spatially varying micro and macro-mechanical system properties. A novel approach of stochastic representative volume element (SRVE) is developed in the context of two dimensional plate-like structures for accounting the correlated spatially varying properties. The physically relevant random field based uncertainty modelling approach with spatial correlation is adopted in this paper on the basis of Karhunen-Loève expansion. An efficient coupled HDMR and DMORPH based stochastic algorithm is developed for composite laminates to quantify the probabilistic characteristics in global responses. Convergence of the algorithm for probabilistic dynamics and stability analysis of the structure is verified and validated with respect to direct Monte Carlo simulation (MCS) based on finite element method. The significance of considering higher buckling modes in a stochastic analysis is highlighted. Sensitivity analysis is performed to ascertain the relative importance of different macromechanical and micromechanical properties. The importance of incorporating source-uncertainty in spatially varying micromechanical material properties is demonstrated numerically. The results reveal that stochasticity (/ system irregularity) in material and structural attributes influences the system performance significantly depending on the type of analysis and the adopted uncertainty modelling approach, affirming the necessity to consider different forms of source-uncertainties during the analysis to ensure adequate safety, sustainability and robustness of the structure.

Keywords: composite laminate; micromechanical random field; spatially correlated material properties; stochastic natural frequency; stochastic buckling load; stochastic mode shape