Abstract

Laminated composite structures fall into most active and revolutionary research fields in recent years because of their suitability to be adapted in weight sensitive and high-performance engineering applications. These structures of intricate shape (curved/shell panel) are subjected to complex load and exposed to the uneven environment both during fabrication and their operational life. The combined hygrothermal loading causes significant dimensional changes in the laminated composite structures and subsequently induces nonlinearity in geometry. Moreover, higher temperature and moisture reduces the elastic moduli and degrade the strength and/or stiffness properties of laminated structure by inducing the internal/residual stresses and ultimately lead to failure of the structure/structural component. In order to predict the exact mechanical responses (bending/vibration/buckling etc.) and their degree of deviation from normal trend demands a careful evaluation of the environmental effect on the properties of the composite lamina. In this present work, nonlinear free vibration and flexural behaviour of laminated composite doubly curved shell panel has been investigated under hygro-thermo-mechanical loading including the degraded composite material properties through a micromechanical model. The mid-plane kinematics of laminated shell panel has been modelled based on the higher-order shear deformation theory and Green-Lagrange geometrical nonlinearity. In addition to this, all the nonlinear higher order terms are included in the present mathematical model to capture the exact flexure of the structural panel. The nonlinear system governing equations are derived using the variational method and discretised using the nonlinear finite element steps. The desired responses are computed numerically using the direct iterative method. The convergence behaviour of the present model has been checked and compared with those available numerical and/or analytical results. The validation studies signify the necessity and importance of the present higher-order nonlinear micromechanical model. Finally, wide variety of numerical experimentation have been computed for different geometrical and material parameters, lamination schemes, volume fractions and support conditions to show the effect of one and all design parameters on the nonlinear (vibration and flexural) responses of layered composite shell panel under hygro-thermo-mechanical loading. It is also understood that the outcomes based upon such analysis would certainly be useful for the analysis, design and fabrication of finished products for real life application.

**Keywords:** Laminated composite curved panel, Green-Lagrange geometric nonlinearity, HSDT, Nonlinear FEM, Hygro-thermo-mechanical loading, Micromechanics approach, Large amplitude vibration, Nonlinear flexural analysis.