

Geometrically Nonlinear Static and Dynamic Analysis of Piezoelectric Fiber Reinforced Composite Plates and Shells

Abstract

In the present research work, geometrically nonlinear static and dynamic response control of laminated composite plates and shells are investigated with and without hygrothermal environment employing piezoelectric fiber reinforced composite (Active fiber composites (AFC)/ Macro fiber composite (MFC)) lamina as a actuator. Performances of piezoelectric fiber reinforced composite actuator to control the nonlinear responses of composite plates and shells under combined mechanical and hygrothermal environment are investigated.

In the present study, finite element method is used to solve the governing differential equations of the smart composite structure. The finite element model incorporates the first order shear deformation theory and von Kármán type geometric nonlinearity with thermo-electro-elastic coupling effects. The incremental iterative (Newton-Raphson iterative method) procedure is implemented for the solution of nonlinear equilibrium equations. In the present work nonlinear time dependent equations are solved using the Newmark time integration method in association with Newton-Raphson iterative method. Negative velocity feedback control algorithm is used to control the dynamic response of the smart laminated composite plates and shells.

Developed finite element procedures are coded in C language and validated with the available published literature. The numerical examples of laminated composite plates and shells are presented to show the effects of different load cases, boundary conditions, geometric and material parameters on the nonlinear bending and transient response. Furthermore, additional numerical examples are presented to assess the performance of piezoelectric fiber reinforced actuator to control nonlinear bending and transient responses of plates and shells under hygrothermal environment. From the numerical results, it is concluded that, piezoelectric fiber reinforced composite actuator (MFC/AFC) with appropriate piezoelectric fiber orientation effectively control the nonlinear static and dynamic responses of laminated composite plates and shells.

Key words: Nonlinear, Negative velocity feedback, Hygrothermal, Actuator, Sensor, Vibration, Plate, Shell, Finite element method, PVDF, PFRC, AFC, MFC.