

Abstract

In this dissertation, performance of the distributed actuators made of piezoelectric fiber reinforced composite (PFRC) materials for controlling the geometrically nonlinear deformations of smart laminated structures has been investigated. First, the task of finding the analytical solutions for nonlinear static analysis of simply supported laminated cross-ply/angle-ply plates integrated with a layer of PFRC material has been accomplished. The von Kármán type nonlinear strain-displacement relations and the first-order shear deformation theory are used for formulating the problems. The results of the analytical solutions clearly illustrate the capability of the activated PFRC layer to counteract the nonlinear deformations caused by transverse mechanical load. It has also been shown by analytical solutions that the activated PFRC layer significantly affects the distribution of all in plane stresses across the thickness of the substrate cross-ply/angle-ply plates. The significant effect of variation of piezoelectric fiber orientation angle on the control authority of the PFRC layer has also been investigated. Next the performance of the patches made of the PFRC material as the distributed actuators for counteracting the geometrically nonlinear deformations of laminated composite plates has been demonstrated by the finite element analysis. The von Kármán type nonlinear strain displacement relations and the first-order shear deformation theory are used for deriving the coupled electromechanical finite element model. The results obtained by finite element analysis also indicate that the patches made of the PFRC material efficiently act as the distributed actuators in controlling geometrically nonlinear deformations of laminated composite plates. The effect of variation of piezoelectric fiber orientation angle in the PFRC patches on the distributions of in plane stresses across the thickness of the substrate plates and also on the actuation capability has been illustrated.

Finally, the dynamic performance of the layer of the PFRC material as the distributed actuators of smart structures in controlling geometrically nonlinear transient vibrations has been investigated. The investigation is performed by

accomplishing the task of active constrained layer damping (**ACLD**) of smart laminated thin composite plates and shallow shells. The constraining layer of the **ACLD** treatment has been considered to be made of **PFRC** material. For the time domain analysis, the viscoelastic layer is modeled by the Golla-Hughes-McTavish (**GHM**) method. Three dimensional nonlinear finite element models have been developed to model the closed loop dynamics of the smart laminated composite plates and shallow shells integrated with the patches of **ACLD** treatments. It has found that the active constraining layer made of the **PFRC** material significantly annuls the geometrically nonlinear vibrations of symmetric and anti-symmetric cross-ply and angle-ply laminated plates and shallow shells. Emphasis has also been placed on studying the significant effect of variation of piezoelectric fiber angle in the constraining **PFRC** layer on the attenuating capability of the **ACLD** treatments. The values of the fiber orientation angle in the constraining **PFRC** layer of the **ACLD** treatment which causes maximum,attenuation have also been determined.