Abstract

The prolific advancement and ever increasing growth of composite materials in various weight efficient designs of laminated plate structures in a wide range of applications such as aerospace, nuclear, marine and automotive industries has drawn a considerable amount of attention due to its excellent specific modulus/strength properties, high corrosion resistant and unique flexibility in design tailoring. However, the low shear modulus compared to extensional rigidity makes the composite plate structures weak in shear and hence, the role of shear deformation is quite significant. In sandwich construction, the effect of transverse shear deformation becomes more critical because of the wide variation in material properties between core and face layers. Moreover, the inter-laminar continuity conditions are also required to be satisfied in order to accurately predict the inter-laminar behavior of the multilayered composite and sandwich structures. Therefore, it is essential to model these complicated effects correctly. Hence, the computationally efficient non-polynomial zigzag theories are developed in the present work for accurate analysis of laminated composite/sandwich plate structures. The in-plane displacement fields of these models are assumed to be the combination of a non-polynomial shear strain shape function and a linear zigzag function with different slopes at each layer. The transverse displacement is assumed to be constant throughout the plate thickness. These models satisfy the inter-laminar continuity conditions at the layer interfaces and the traction-free boundary conditions on the surfaces of the plate. These theories incorporate the realistic non-linear distribution of transverse shear stresses on the surface of the plate. An efficient C^0 finite element model is employed to investigate various structural responses of laminated composite and sandwich plates. The plate structures are integral part of many real life structures, hence the structural analyses of plates, which involve bending, free vibration, static stability and dynamic stability analysis become important in practical applications. Moreover, these analyses should be performed accurately to get the displacement field, stress field, natural frequencies, and critical buckling loads under the action of external loads, especially for the aerospace and marine structures for which the structures are very sensitive for shape changes. Also, these structures are subjected to dynamic loads so the dynamic instability characteristics are of high technical importance for understanding dynamic systems under periodic in-plane loads. Therefore, the present work focuses on the prediction of these responses accurately and efficiently by implementing newly developed non-polynomial zigzag theories. Furthermore, the structural analysis is accomplished on a conventional way assuming the deterministic behavior of system parameters. However, the real structural systems are characterized by inherent uncertainties in the definition of the structural parameters. The effect of these uncertainties on the response of laminated composite/sandwich plates is studied by modeling the macro-mechanical material properties as basic random variables. An efficient stochastic C^0 finite element formulation in conjunction with a mean-centered first order perturbation technique is developed for the models in stochastic environment and some new results are presented in the current research.

Keywords: laminated composite, sandwich plates, zigzag theory, shear deformation, finite element method, isoparametric formulation, static, free vibration, buckling, dynamic stability, stochastic analysis, perturbation technique, Monte Carlo simulation