ABSTRACT

Functionally graded structures have gained considerable attention in numerous engineering applications such as in space shuttle, advanced aircraft, combustion chamber and nuclear power plants, etc. due to their advantages of being able to withstand severe high temperature gradient while maintaining their structural integrity. The functionally graded materials are microscopically inhomogeneous in which the mechanical and the thermal properties vary smoothly and continuously with respect to the spatial coordinates in a preferred direction by gradually adjusting the volume fractions of the constituent materials. These type of structures are very often influenced to large amplitude vibrations, instability and large static deformations due to external mechanical and thermal loading during their service life, and experience the significant consequences on the nonlinear structural responses. Additionally, the large deformation of the structure is responsible for basic geometry change and consequently, affects the stiffness of the structure. Therefore, large deformation analysis is indispensable to obtain the responses of the structure accurately. Furthermore, the superior properties of the graded material generally associate with uncertainties in their constituent material properties. These parameters must be accounted for to obtain the accurate prediction of structural response, and reliability of the structures.

In the present study, the nonlinear deterministic and stochastic modelling of functionally graded plates is developed based on the modified higher order structural kinematics. The geometric nonlinearity is modelled using Green-Lagrange nonlinear strain theory. A suitable nonlinear finite element formulation is proposed and combined with direct iterative technique, and probabilistic method to accomplish the deterministic and stochastic responses. The effects of different system parameters on large amplitude vibration, buckling/postbuckling strength, and large static deformation are examined in details. The comparison study suggests the importance of the present investigation in both the deterministic and stochastic environments. New results have been presented which may be treated as benchmark for future studies in this area and would be definitely advantageous for the researchers, scientists, and designers.

Keywords: Large amplitude vibration, Postbuckling, Nonlinear bending, Functionally graded plate, Improved higher order kinematics, Geometric nonlinearity, Green-Lagrange, C^0 finite element, Perturbation technique, Uncertain material properties.