VARIATIONAL ASYMPTOTIC METHOD FOR POST-BUCKLING DYNAMICS OF THERMALLY LOADED COMPOSITE PLATES

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The phenomenon that thin plates under the action of elastic stresses may demonstrate a sudden dynamic change of their buckling modes when loaded deeply into the post-buckling regime is often called mode jumping. When compared with its mechanically-loaded counterparts, the secondary bifurcation or mode jumping of the thermally loaded plate demonstrates much stronger geometrical nonlinearity due to the extensive coupling between the flexure deformation and boundary constraints [1]. Although many researches have been dedicated to the study of this dynamic snapping phenomenon of isotropic plates after Stein's initial experimental observation, mode jumping of composite laminated plates, which has also been reported in several experiments, has by comparison received little attention, despite its significant applications in new materials and aerospace engineering.

With regard to the investigation of post-buckling behavior of composite laminated plates, most concurrent approaches use either the classical lamination plate theory or the first and higher order shear deformation theories. As pointed in reference [2], all the above plate models are based upon ad hoc assumptions such as a priori distribution of displacement field through the thickness that cannot be reasonably justified for composite structures and should be avoided in the construction of an accurate two-dimensional plate model from three-dimensional elasticity.

In the present paper, a method for the post-buckling analysis of thermally loaded composite laminated plates is developed based upon an asymptotically correct plate theory which is derived by applying the variational asymptotic method (VAM) proposed in [2] and [3]. Kinematic relations and dynamic governing equations are derived strictly from VAM which splits rigourously the three dimensional anisotropic elastic problem into a linear one-dimensional normal-line analysis and a nonlinear two-dimensional "plate" analysis. Post-buckling equilibrium branches are obtained by the numerically solving of resulting PDEs using the continuation method under the parameter variation of the temperature. A quasi-dynamic sweeping scheme is then used to capture the dynamic jump phenomenon. Natural frequencies of small vibrations around the stable equilibrium branches are obtained by the locally linearizing the dynamic system and solving the associated eigenvalue problem. Both static and dynamic results are compared with the three dimensional finite element analysis.

References

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