Abstract

The present work deals with the nonlinear bending and stability behaviours of thin and moderately thick, flat and curved panels. The first order shear deformation theory in combination with Marguerre-von Kármán strain-displacement assumptions is employed to model the flat plates and shallow shell panels on rectangular planform, while Sanders’ shell theory is used to analyze shallow conical shell panels. Element free Galerkin (EFG) method with moving kriging (MK) shape functions is employed to transform the governing integral weak form into a set of algebraic equations. An in-house MATLAB code is developed to solve the linear/nonlinear equations of equilibrium for flat and curved panels. Nonlinear equilibrium paths are obtained using the modified Riks technique in conjunction with Newton-Raphson method.

At the beginning, the efficiency of the present numerical technique (EFG with MK shape function along with the relevance / effectiveness of associated parameters, e.g., the support domain) in dealing with the “shear locking problem of Reissner-Mindlin plates”, and “membrane locking problem of curved panels” is examined by a series of convergence studies and comparison of the present numerical results with available analytical or numerical solutions. Thereafter, several new problems on bending, buckling and vibration behaviours of thin structural panels made up of isotropic and laminated composite materials are taken up for investigation, with particular focus to non-rectangular geometry, for which research publications are limited. An attempt is made to provide the numerical results on the “bending and buckling of structural panels” in the “non-dimensional form”, so that they can be easily used as “benchmark solutions” by engineers and researchers in the future.
Abstract

First, the flexural (bending and buckling) behaviours of various flat panels (rectangular, skew, trapezoidal and arbitrary straight-sided quadrilateral) under a variety of practical loading and boundary conditions (edge supported, corner supported, continuous over multiple spans, supported on elastic foundation) are examined.

Next, the nonlinear bending and stability characteristics of various curved shell panels with rectangular planform (cylindrical, spherical, hypar and conoidal) and non-rectangular planform (conical) are studied for different geometrical parameters (circular angular angle, radius-to-span ratio, span-to-thickness ratio, semi-vertex angle, etc.) and boundary conditions. Attempts are made to obtain the representative snap-through responses (hardening to softening) and possible equilibrium configurations of various curved panels under different cases of symmetric and un-symmetric bending.

Finally, the present numerical technique (EFG method with MK shape function) is extended for the free flexural vibration analysis of flat panels in contact with bounded fluid. The fluid is assumed to be ideal and the effect of free surface waves is neglected. Potential flow theory is assumed and the velocity potential is used to calculate the added mass effect due to the fluid. The effect of various structural and fluid domain parameters on natural frequencies of thin isotropic and laminated composite skew/trapezoidal bottom of a rectangular tank filled with fluid is investigated in detail.