Exact Solution for Free Vibration of Orthotropic Laminated Composite Plates

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Abstract

Composite materials play a vital role in design of complex and light weight structures due to its special properties that can't be attained using conventional materials. Significant research work has been done to understand the behavior of laminated composite plates under static and dynamic load using computational techniques. Limited literature is available on obtaining exact solution of laminated orthotropic plated subjected to dynamic loading.

In this study, an exact solution for free vibration of thin to moderately-thick laminated orthotropic composite plate is obtained using the separation of variables method based on first-order shear deformation theory using. The method was then extended to obtain results for thick plates through the inclusion of shear correction factor. Three major boundary conditions i.e. simple support (S), clamped (C) and free (F) edges are used alone or in combinations to represent complex boundary conditions.

Characteristic equation for three-ply laminated plates is derived using equilibrium condition and then transformed to eigen-problem. The eigen-problem is solved to get fundamental frequencies and their corresponding mode shapes. The validity of these equations is confirmed by reducing them to that of isotropic laminated plates. The first eight fundamental frequencies parameters are obtained for combined boundary conditions such as SSSS, SCSC, SFSF, SCSF, SSSF, SSSC, CCCC, CFCF, CSCC, CCCF and CSCF. A computer program is developed using MATLAB software to obtain exact solution and results are compared with those reported in literature. Further to this, the commercial finite element analysis software ABAQUS is used to model the same problem and compared with exact solution.

The effects of the thickness ratio, aspect ratio, stacking sequence and the boundary conditions are investigated. The current results are in excellent agreement with the Liew result where the p-Ritz method is used. The finite element method yields values with error when compared to exact solution.