

Modal analysis of fibrous composite plates with central circular hole

N. K. Jain

*Associate Professor, Department of Mechanical Engineering, National Institute of Technology, Raipur, CG, India

Abstract. A finite element study is made for the analysis of effect of fibre orientation on natural frequency (ω) for different mode shape in the simply supported and fixed rectangular fibrous composite plates with central circular hole. Study is carried out for three different D/A ratios (where D is hole diameter and A is plate width) to analysis the variation of natural frequency with respect to D/A ratio. The analytical treatment of such type of problem is very difficult; hence, finite element method is adopted for whole analysis. The finite element formulation is carried out in ANSYS package. The work is most appreciated in aerospace and marine industry where the study will provide the guidelines technique to designer for laminate configuration as per their requirements.

Introduction

The fibrous and laminated composite plates with central circular hole have found widespread applications in various fields of engineering such as aerospace, marine, automobile and mechanical. For the design of such composite plates, accurate knowledge of stress and vibration is required. In order to cater the wide applications of such plates, dynamic analysis especially, knowledge of vibration characteristics become important to improve upon the reliability of their design. An exhaustive literature review on vibration of plates has been given by Leissa [1] in his monograph. The conventional Navier and Levy type solution methods [2, 3] can be extended to orthotropic plates having either all edges simply supported or two opposite edges simply supported. Rayleigh-Ritz method, one of the well-known methods is widely used to provide approximate solutions to natural frequencies of orthotropic plates [4-6]. Shastry and Raj [7] have analyzed the effect of fiber orientation for a unidirectional composite laminate with FEM by assuming a plane stress problem under in plane static loading. Jain and Mittal [8] have studied a laminated plate with central hole upon the effect of fiber orientation on SCF under transverse loading. The hole is treated as a virtual plate in which the mass density and the Young's modulus are set to zero in this study. Literature on vibration analysis shows that the natural frequencies are affected by the presence of defects in the form of cracks or holes. In this article a study of rectangular fibrous composite plate with central hole upon the effect of fiber orientation on natural frequency is made. The analytical treatment for such type of problem is very difficult and hence the finite element method adopt for whole analysis. **Fig. 1** shows the basic model of the problem.

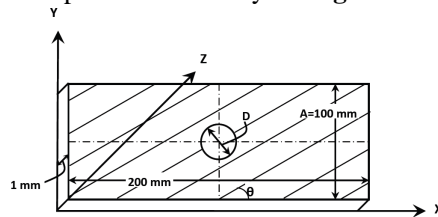


Figure 1: A fibrous plate with central hole

Result and Discussion

The numerical results are presented for solid and hollow plates for different D/A ratios with different boundary condition. The material for the composite plate is taken as Boron Epoxy. The natural frequencies are calculated for different modes. It has been also seen that the natural frequency is most sensitive to material properties and directly depend on the ratio of E_x/E_y and E_x/G_{xy} . This work will find its application in design, marine and aircraft industries.

References

- [1] Leissa AW., 1969, Vibration of Plates (NASA SP-160), Washington DC, Government Printing Office.
- [2] Szilard R (2004) Theories and applications of plate analysis. New jersey: John Wileyand Sons.
- [3] Xing YF and Liu B (2009) New exact solutions for free vibrations of thin orthotropic rectangular plates. Composite structures 89: 567-574.
- [4] Bhat RB (1985) Natural frequencies of rectangular plates using characteristics orthogonal polynomials in the Rayleigh -Ritz method. Journal of Sound and Vibration 102(4):493-499.
- [5] Dickinson SM and Di Blasio A (1986) On the use of orthogonal polynomials in the Rayleigh-Ritz method for the study of the flexural vibration and buckling of isotropic and orthotropic rectangular plates. Journal of Sound and Vibration 108(1): 51-62.
- [6] Marangoni RD, Cook LM and Basavanhally N (1978) Upper and lower bounds to the natural frequencies of vibration of clamped rectangular orthotropic plates. International Journal of Solids and Structures 14: 611-623.
- [7] Shastry BP and Raj GV (1977) Effect of fibre orientation on stress concentration in a unidirectional tensile laminate of finite width with a central circular hole. Fibre Science and Technology, 10: 151-154.
- [8] Jain NK and Mittal ND (2008) Effect of fibre orientation on stress concentration factor in a laminate with central hole under transverse static loading. Indian Journal of Engineering and Material Science, 15: 452-458.