International Journal for ReseaArch in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor:6.887
Volume 5 Issue IX, September 2017- Available at www.ijraset.com

Analysis of Free Vibration with Variation in Elastic Properties in Symmetric Laminated Composite Rectangular Plate

Yogesh Pratap Singh[1],Tikam Prasad[2], Mukesh kumar[3] , Atul tiwari[4]
[1,2,3,4] *Department of Mechanical Engineering, National Institute of Technology, Raipur*

Abstract: Composite materials play a key role in aerospace and many other fields' .Normally we desire that resonance must not occur so it becomes vital to study composite properties with different elastic parameters along with different fiber direction & stacking arrangements. This paper contains all possible variations of natural vibration of a laminated angle ply composite plate with elastic properties. The study of these variations can be used to optimize material properties of composites as per given application.

Keywords: Laminate, Lamina, Cross Ply lamination, Angle ply lamination, modes

I. INTRODUCTION

Composite materials are materials constituted for two or more components, which remain independent at the macroscopic level when they become part of a structure. The main advantages for the use composite materials are high strength and high stiffness to weight ratio. These reasons put composites in service like Aerospace structures, Automobiles, Boats, Pipe lines, Buildings, Bridges etc.

A laminate is constructed by stacking a number of laminas in the thickness (z) direction. Each layer is thin and may have different fiber orientation. The fiber orientation, stacking arrangements and material properties influence the response from the laminate. For Cross Ply lamination consecutive fibers are in perpendicular directions while in Angle ply consecutive fibers are at some angle.

Free vibration analysis of plate is very important in the field of structural Engineering because of its wide application in practical life. Free vibration of the plate depends greatly on its thickness, aspect ratios (a/b) and the boundary conditions

II. THEORY OF LAMINATED PLATES

The laminated plates are widely used in aircraft structures because composites have high strength to stiffness ratio and low weight. To avoid the resonance for structures like aircraft we need to formulate the mathematical model for natural frequency for different types of laminated plates (symmetric, anti symmetric etc). Generally we prefer symmetric laminated plate because of not having tendency to bend and twist. In order to formulate the mathematical formula for free vibration of laminated plates we need to develop governing equation, those equations are already developed by theories like classical laminate plate theory, shear deformation theory etc using deflection, bending, forces and moments acting on laminate plate. In this thesis we consider CLPT. The classical laminate plate theory (CLPT) is used to analyze the mechanical behavior of the composite laminated plates. We assume that plane stress condition is valid for each ply.

These equations are solved by using analytically or numerically. In analytical approach we have methods like Ritz, Levy and Navier. These methods are used according to the boundary conditions of the plate and easy usage. The Navier solution was developed for laminated plates (square or rectangular) when all the four edges are simply supported, Levy solution was developed for plates when two opposite edges are simply supported and remaining two edges are free, simply support or fixed support and Ritz solution was developed to determine the approximate solution for more general boundary conditions.

III. PROBLEM STATEMENT

Our aim is to study variation of free vibration with Elastic properties induced in Symmetrical Angle ply Rectangular Composite laminate using ANSYS.

IV. ANALYSIS CONDITIONS

We have used ACP MODULE in ANSYS 18 for our analysis. Followings are the details of Analysis conditions:

A. Plate of Dimension 150 ×80 mm, fixed at 80mm end.

B. (45°,-45°,-0°,-45°,45°) symmetrical layup for the plate each being 0.3 mm thick as shown in figure 1(a-e)

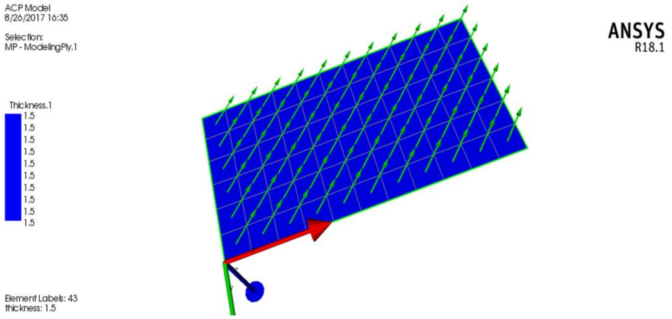


Figure1 (a): 45^0 layup

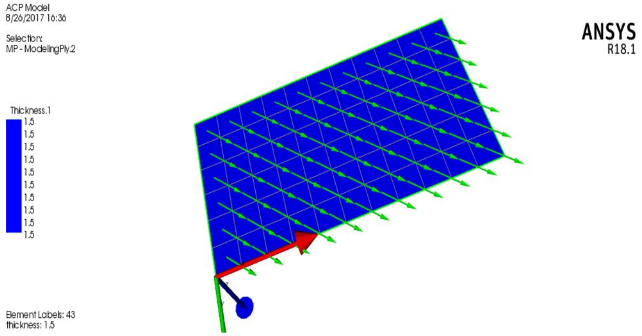


Figure2 (b): -45^0 layup

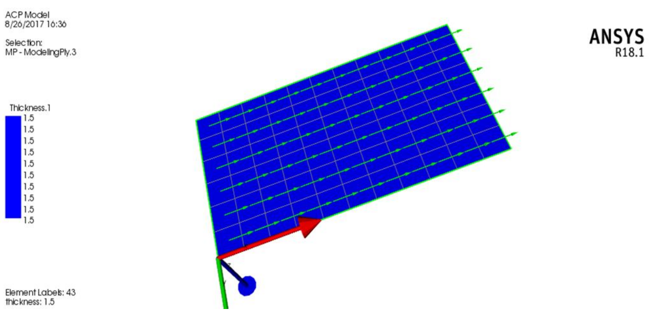


Figure1 (c): 0^0 layup

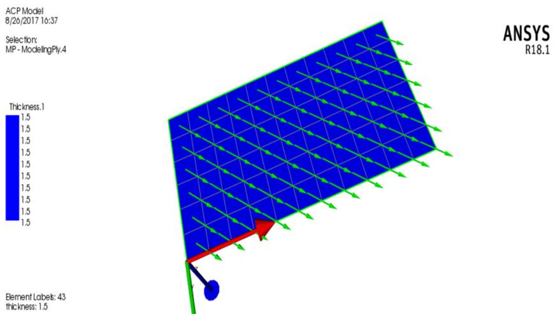


Figure1 (d): -45^0 layup

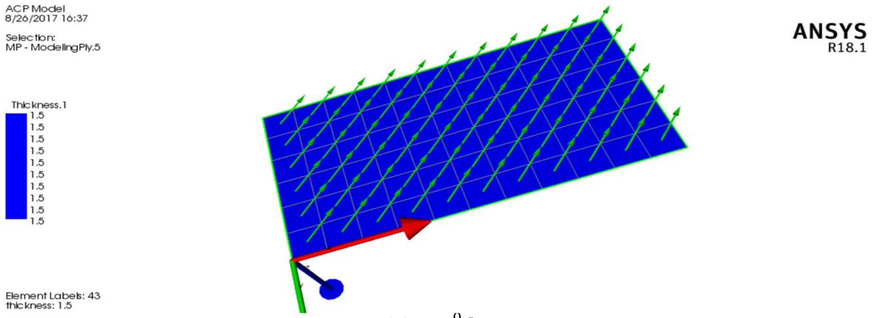
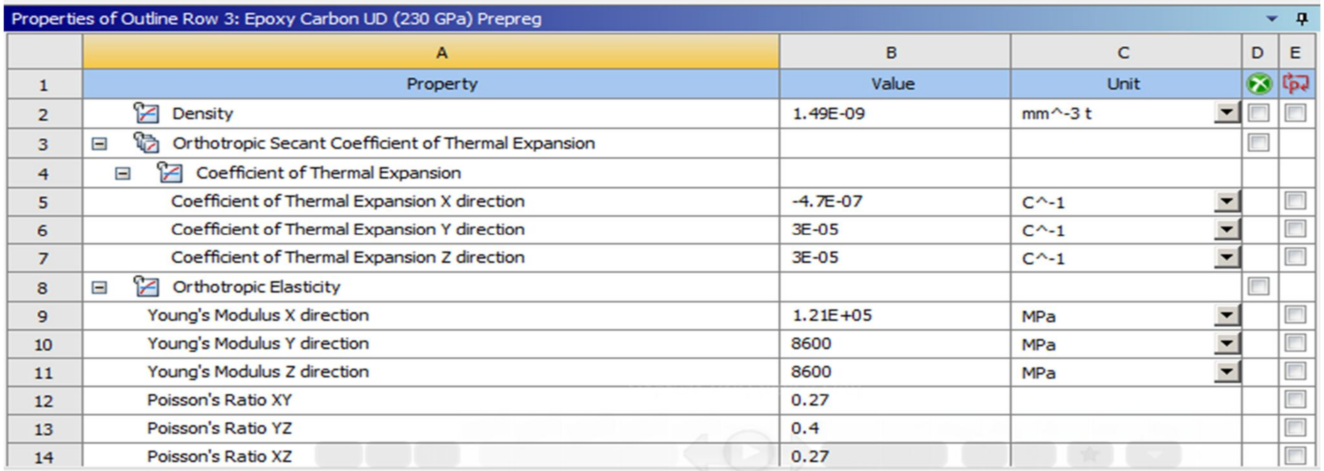


Figure1 (e): 45^0 layup

C. Material applied is Epoxy Carbon UD with properties shown in figure 2



Properties of Outline Row 3: Epoxy Carbon UD (230 GPa) Prepreg

	A	B	C	D	E
1	Property	Value	Unit		
2	Density	1.49E-09	mm^-3 t	☐	☐
3	⊟ Orthotropic Secant Coefficient of Thermal Expansion			☐	
4	⊟ Coefficient of Thermal Expansion				
5	Coefficient of Thermal Expansion X direction	-4.7E-07	C^-1		☐
6	Coefficient of Thermal Expansion Y direction	3E-05	C^-1		☐
7	Coefficient of Thermal Expansion Z direction	3E-05	C^-1		☐
8	⊟ Orthotropic Elasticity			☐	
9	Young's Modulus X direction	1.21E+05	MPa		☐
10	Young's Modulus Y direction	8600	MPa		☐
11	Young's Modulus Z direction	8600	MPa		☐
12	Poisson's Ratio XY	0.27			☐
13	Poisson's Ratio YZ	0.4			☐
14	Poisson's Ratio XZ	0.27			☐

Figure 2: Epoxy Carbon UD

V. RESULTS & CONCLUSIONS

A. Variation of free vibration along x, y and z axis with variation in Poisson's ratio is shown in figure 3(a-f)

NOTE: we have considered only the most participating mode along any axis

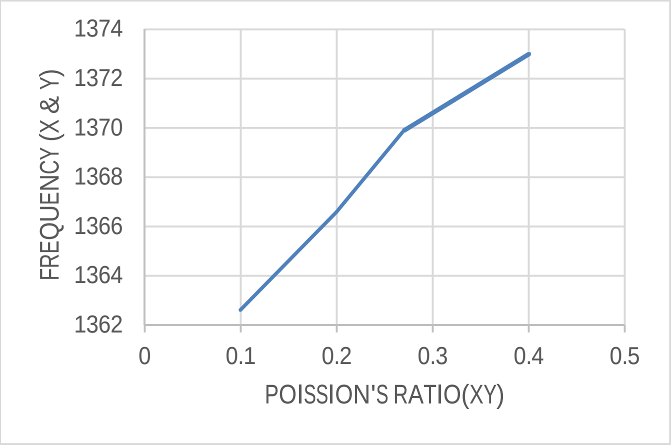


Figure 3(a)

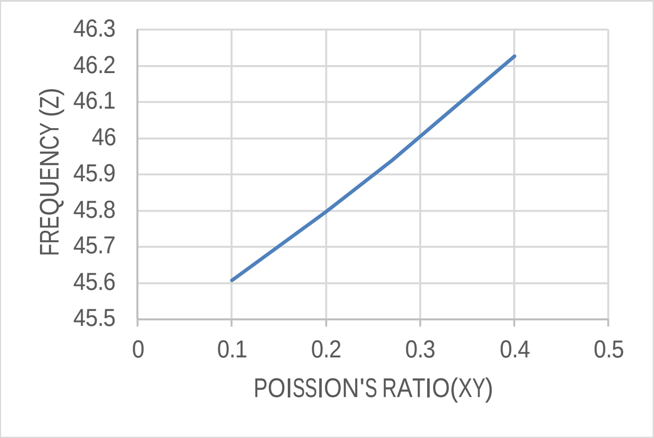


Figure 3(b)

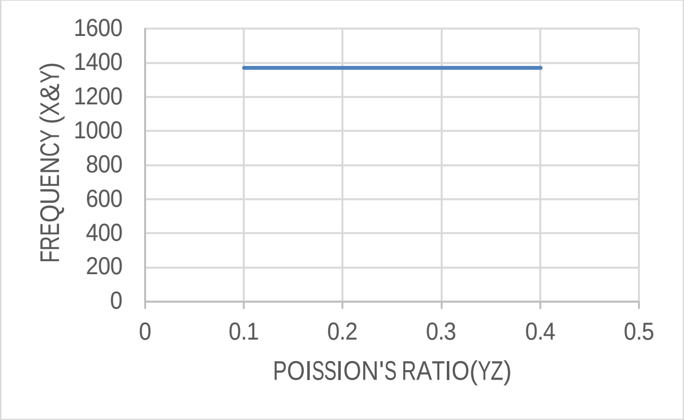


Figure 3(c)

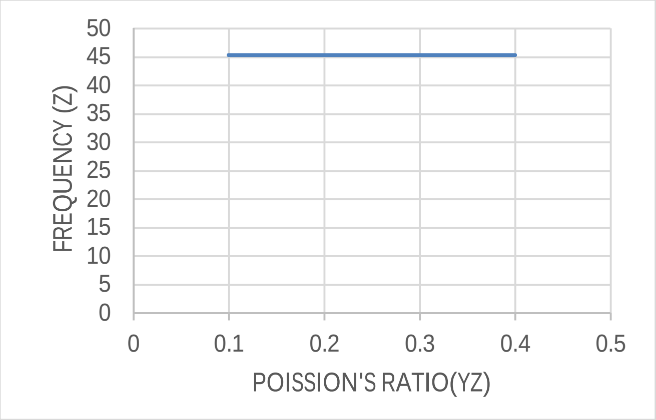


Figure 3(d)

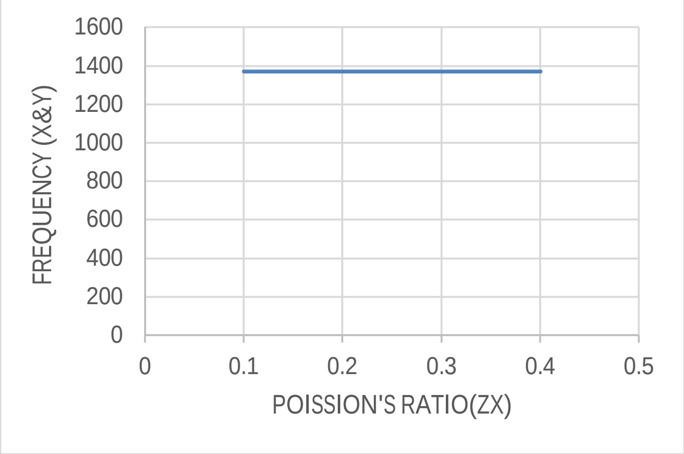


Figure 3(e)

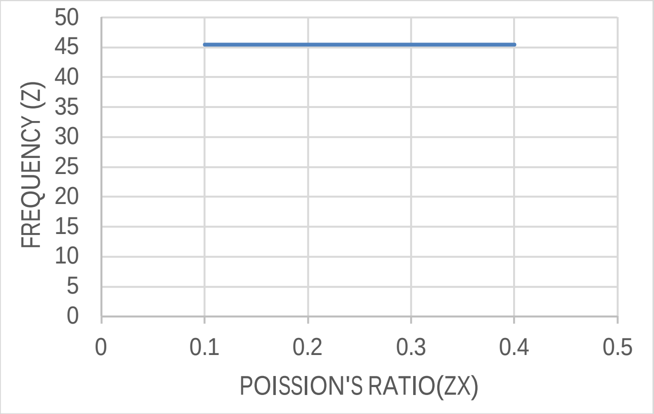


Figure 3(f)

1) With increase in value of Poisson's ratio in XY (plane of fibers), the value of natural frequency increases.
2) With increase in value of Poisson's ratio in YZ and ZX, the value of natural frequency remains constant.
3) Mode number 6 in our analysis was major participating mode for X and Y.
4) Mode number 1 in our analysis was major participating mode for Z.

B. Variation of free vibration with variation in Young's Modulus is shown in figure 4(a-f)

1) With increase in value of Young's modulus along X direction, the value of natural frequency increases.
2) With increase in value of Young's modulus along Y direction, the value of natural frequency increases.
3) With increase in value of Young's modulus along Z direction, the value of natural frequency remains constant.
4) Mode number 6 in our analysis was major participating mode for X and Y.
5) Mode number 1 in our analysis was major participating mode for Z.

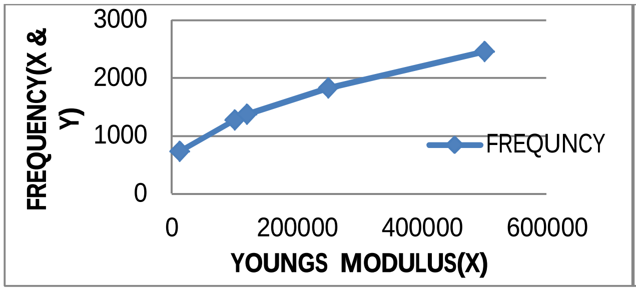


Figure 4(a)

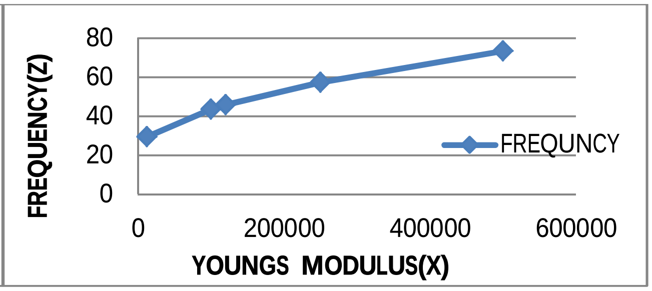


Figure 4(b)

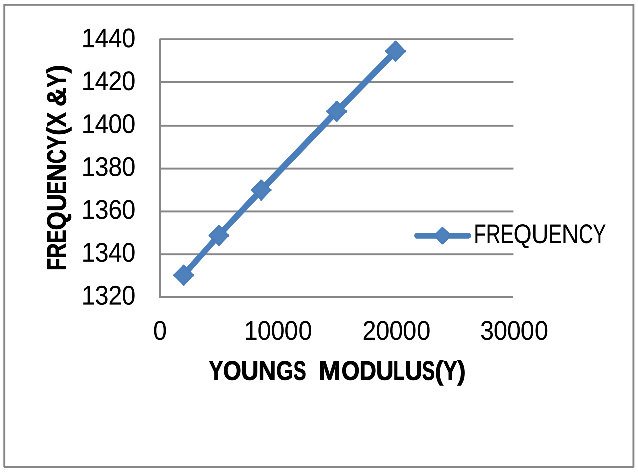


Figure 4(c)

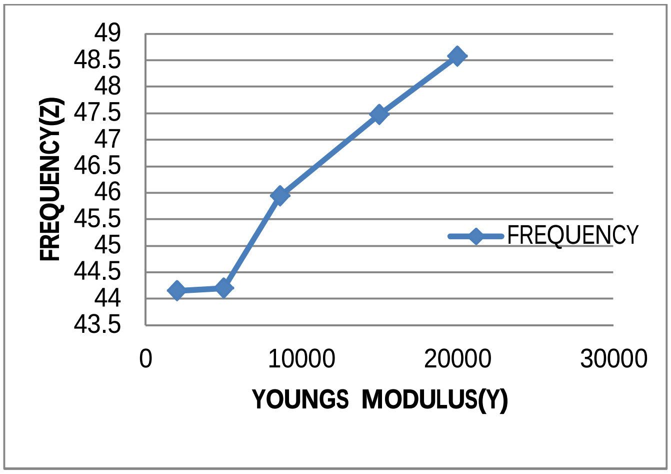


Figure 4(d)

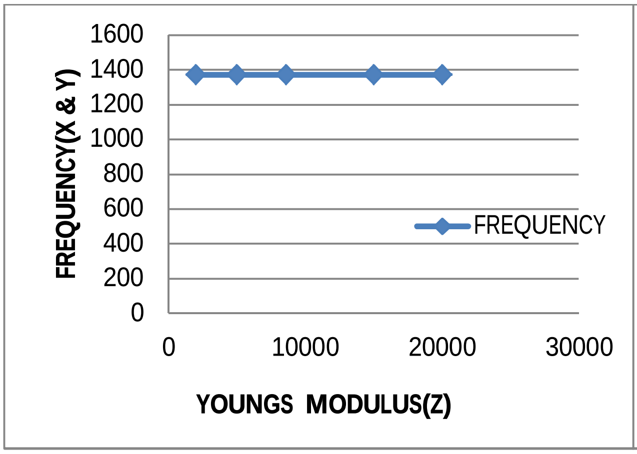


Figure 4(e)

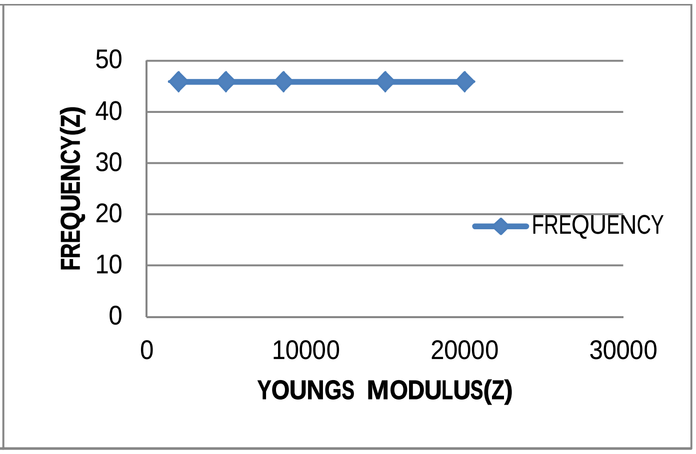


Figure 4(f)

C. Variation of free vibrations with variation in Density is shown in figure 5(a-c)

1) With increase in value of Density in any direction, the value of natural frequency decreases.
2) Mode number 6 in our analysis was major participating mode for X and Y.
3) Mode number 1 in our analysis was major participating mode for Z.

VI. FURTHER WORKS THAT CAN BE DONE

Other than what analysis we have done, we can also work on following

A. Variation of free vibrations in different laminate plate with changing thermal Conditions.

B. Variation of free vibrations in different laminate plates with change in orientation and stacking of laminas.

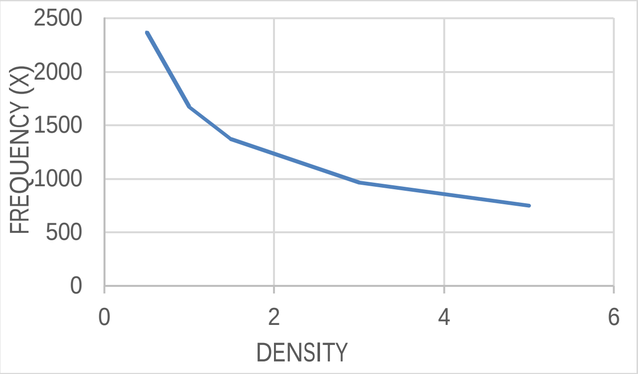


Figure 5(a)

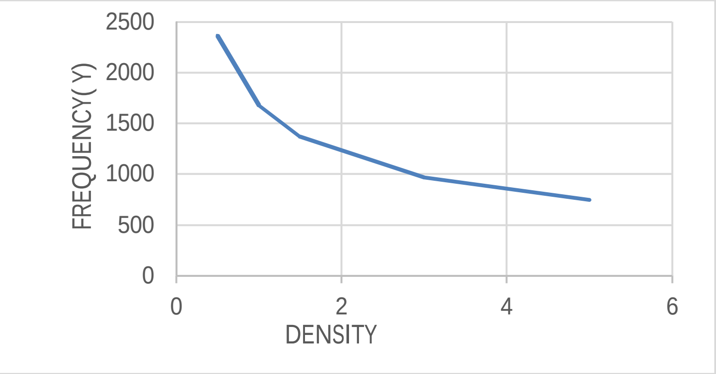


Figure 5(b)

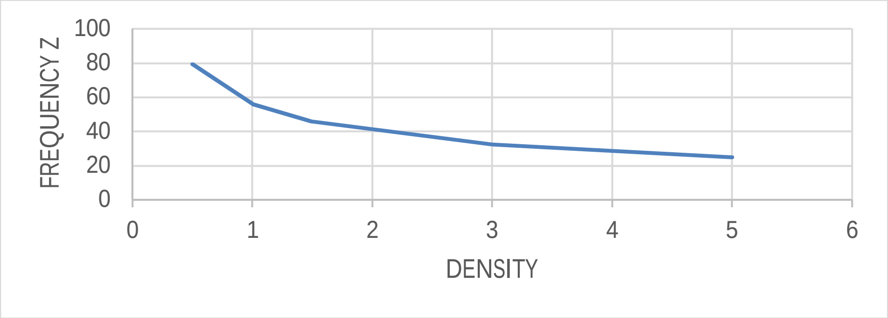


Figure 5(c)

REFERENCES

[1] JN Reddy "Mechanics of Laminated Composite Plates and Shells"

[2] The basic mechanics of of composite materials are from "Mechanics of Composite materials by Robert M.Jones"

[3] Engineering mechanics of composite materials by Isaac M.Daniel Ori ishai

[4] Mutra Raja Sekhara Reddy, Bathini Sidda Reddy, Vanguru Nageswara Reddy, Surisetty Sreenivasulu"Prediction of Natural Frequency of Laminated Composite Plates Using Artificial Neural Networks"journal of scientific research 2012

[5] S. K. Sahu P. K. Datta"Dynamic instability of laminated composite rectangular plates subjected to non- uniform harmonic in-plane edge loading"2000 journal of aerospace engineering

[6] R.A. Jafari-Talookolaei and M.T.Ahmadian "Free Vibration Analysis of a Cross-Ply Laminated Composite Beam on Pasternak Foundation"Journal of Computer Science 2007

[7] B. Sidda Reddy1, M. Raja Sekhara Reddy, V. Nageswara Reddy "Vibration Analysis of Laminated Composite Plates Using Design of Experiments approach"International Journal of Scientific Engineering and Technology 2013

[8] Rengin Kayikci, Fazil O. Sonmez"Design of composite laminates for optimum frequency response"ELSEVIER 2012

[9] Md Iftekhar Alam, Tasmeem Ahmad Khan "Comparative Analysis of Multi Layered Composite Plates using Higher Order Theories"International Journal of Science and Research (IJSR) 2013

[10] Mechanics of Laminated Composite Plates and Shells by JN Reddy page no 284

[11] The basics of of free vibration and buckling analysis of composite plates under simply supported boundary conditions are from"Mechanics of Laminated Composite Plates and Shells by JN Reddy page no 271-285"

[12] Kanak Kalita and Abir Dutta "Free vibration Analysis of Isotropic and Composite Rectangular Plates" International Journal of Mechanical Engineering and Research2013

[13] T.kant, K.swaminathan "Analytical solutions for free vibration of laminated composite and sandwich plates based on higher- order refined theory" ELSEVIER 2001

[14] Hiroyuki Matsunaga "Vibration of cross- ply laminated composite plates subjected to initial in-plane stress" ELSEVIER 2002

[15] H. Nguyen-Van , N. Mai-Duy ,T. Tran-Cong "Free vibration analysis of laminated plate/shell structures based on FSDT with a stabilized nodal-integrated quadrilateral element" ELSEVIER 2007

[16] Analysis of Stress and Strain with Variation in Elastic Properties in Symmetric Laminated Composite Rectangular Plate, IJRASET Volume 5 Issue VIII (August 2017).