iJRASET
International Journal For Research in Applied Science and Engineering Technology

# INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

**Volume:** 6 **Issue:** IV **Month of publication:** April 2018

**DOI:** http://doi.org/10.22214/ijraset.2018.4729

www.ijraset.com

Call: 08813907089 | E-mail ID: ijraset@gmail.com

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
*ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887*
*Volume 6 Issue IV, April 2018- Available at www.ijraset.com*

# Finite Element Analysis of Laminated Composite Plates with Circular and Square Openings

Sruthi Mohan[1], Gayathri Suja[2]
[1]*PG Scholar, Department of Civil Engineering, SVNCE*
[2]*Asst.Professor, Department of Civil Engineering, SVNCE*

***Abstract:*** ***Laminated composites are widely used nowadays in variety of industrial areas like aerospace, marine structures, electrical appliances etc. Thorough study about the dynamic behaviour of such structures is necessary for the sound design of these structures since most of these structures are subjected to dynamic loading. In this paper, the dynamic analysis of such laminated composite plates with different types of openings and fibre orientations are done using ANSYS 17.0 software. The results are then compared inorder to determine the most preferable shape of cut-out that can be used in a composite plate.***
***Keywords: Reinforcing phase, graphite epoxy composite, carbon aluminium composite, finite element analysis, free vibration analysis, ANSYS 17.0***

## I. INTRODUCTION

A laminated composite is an assembly of layers of composite materials which are joined together inorder to attain specific desired properties. The two constituents of a composite are fibre and reinforcement. The reinforcing phase provides required strength and stiffness. The matrix provides proper fibre orientation and protects the layers from external abrasion etc. Nowadays the laminated composites in the form of plates are being widely used in many industrial areas including aerospace, marine structures, electrical appliances etc. In most cases these plates are provided with openings and are generally subjected to dynamic loads and the behaviour of these plates strongly depends on the vibrations, displacements etc. Hence, the study about the dynamic behaviour of the structure is necessary for the safe and sound design of the structures. Hence, the present study deals with the finite element analysis of graphite epoxy and carbon aluminium laminated composite plates with circular and square openings having different fibre orientations.

## II. SUMMARY OF LITERATURE REVIEW

The dynamic behaviour of the plate is dependent on the orientation of the laminas in the laminated composite plate. Also, the behaviour of the plate alters when a hole is provided on the plate for various purposes. From the reviews, the following inferences can be drawn in general. By properly orienting the fibres in a laminated composite plate, the maximum deflection of the plate when it is subjected to loading can be reduced significantly. For single layer composite plates subjected to uniform uniaxial external loading, the strength of the plates are highly dependent on the fibre orientation angle. Also, it was noted that the boundary conditions of the plate plays an important role in the free vibration of plates with openings. When openings are provided on composite plates, stresses and deformations of steep gradient are induced around these openings. The strength of the plates is considerably decreased by the circular holes and in-plane deflection and stresses are lesser for larger size of cut-outs the Further, it was noted that the best location for opening is at the extreme edges of the plate. And some general conclusions made from the reviews are that the frequency increases with an increase in the number of layers, modulus ratio of the plate and angle of lamina; but it decreases with increase in aspect ratio, thickness ratio, cut-out size and distance between cut-outs.

## III. MEHODOLOGY

### *A. Analysis of Graphite epoxy composite Plate*

Graphite epoxy composite plates are used increasingly for numerous applications. The graphite epoxy composite have many advantages including low weight, high structural stiffness etc and hence the use is increasing rapidly.

*1) Details of the plate:* The graphite epoxy composite for modal analysis is prepared by using shell 181 element of the ANSYS 17.0 software. The analysis is done using rectangular plate of dimension 3000mm X 2000mm with overall thickness of the plate 20mm. The dimension details of the plate is as shown in the table I.

TABLE I DETAILS OF THE PLATE

| Parameter | Value |
|---|---|
| Length of plate | 3000 mm |
| Width of plate | 2000 mm |
| Total thickness of plate | 20 mm |
| Thickness of each layer | 4 mm |
| Total number of layers | 5 nos |
| Diameter of circular opening | 500 mm |
| Edge of square opening | 500 mm |
| Orientations considered | 0/0/0/0/0, 30/0/30/0/30, 45/0/45/0/45, 90/0/90/0/90 |
| Mesh size adopted | 50 mm |

## IV. RESULT AND DISCUSSIONS

### *A. Modal response of the plates*

Modal analysis is the free vibration analysis of laminated composite plate which is carried out inorder to obtain the frequency of vibration of the plates in Hz. The results are obtained for different modes of vibration. Modal responses of the graphite epoxy laminated composite plates with no opening, circular opening and square openings of various fibre orientations i.e. $0^0$, $30^0$, $45^0$ and $90^0$ are shown in table 2.

TABLE 2 FREQUENCIES (HZ) OF GRAPHITE EPOXY COMPOSITE PLATES

| Type of opening | Modes | Orientations | | | |
|---|---|---|---|---|---|
| | | 0/0/0/0/0 | 30/0/30/0/30 | 45/0/45/0/45 | 90/0/90/0/90 |
| No opening | 1 | 38.821 | 32.783 | 26.763 | 18.658 |
| | 2 | 47.581 | 43.894 | 40.549 | 34.686 |
| | 3 | 70.469 | 67.611 | 63.86 | 39.372 |
| | 4 | 104.82 | 86.009 | 66.892 | 58.236 |
| | 5 | 105 | 90.677 | 79.246 | 61.19 |
| | 6 | 107.3 | 96.844 | 88.957 | 76.731 |
| Circular opening | 1 | 37.487 | 31.861 | 26.881 | 19.269 |
| | 2 | 47.934 | 44.232 | 39.957 | 32.574 |
| | 3 | 72.499 | 67.878 | 60.61 | 45.358 |
| | 4 | 77.172 | 69.391 | 63.149 | 52.142 |
| | 5 | 88.026 | 83.485 | 78.578 | 60.788 |
| | 6 | 102.27 | 97.038 | 91.06 | 73.502 |
| Square opening | 1 | 37.961 | 31.705 | 25.902 | 19.725 |
| | 2 | 46.571 | 42.46 | 38.438 | 32 |
| | 3 | 68.944 | 62.464 | 57.399 | 46.702 |
| | 4 | 79.397 | 70.98 | 63.275 | 52.23 |
| | 5 | 83.862 | 80.914 | 76.478 | 61.201 |
| | 6 | 99.465 | 91.535 | 85.302 | 72.277 |

The frequency curves showing the variations of frequencies for each orientations of respective plate openings are as shown in figure 1.

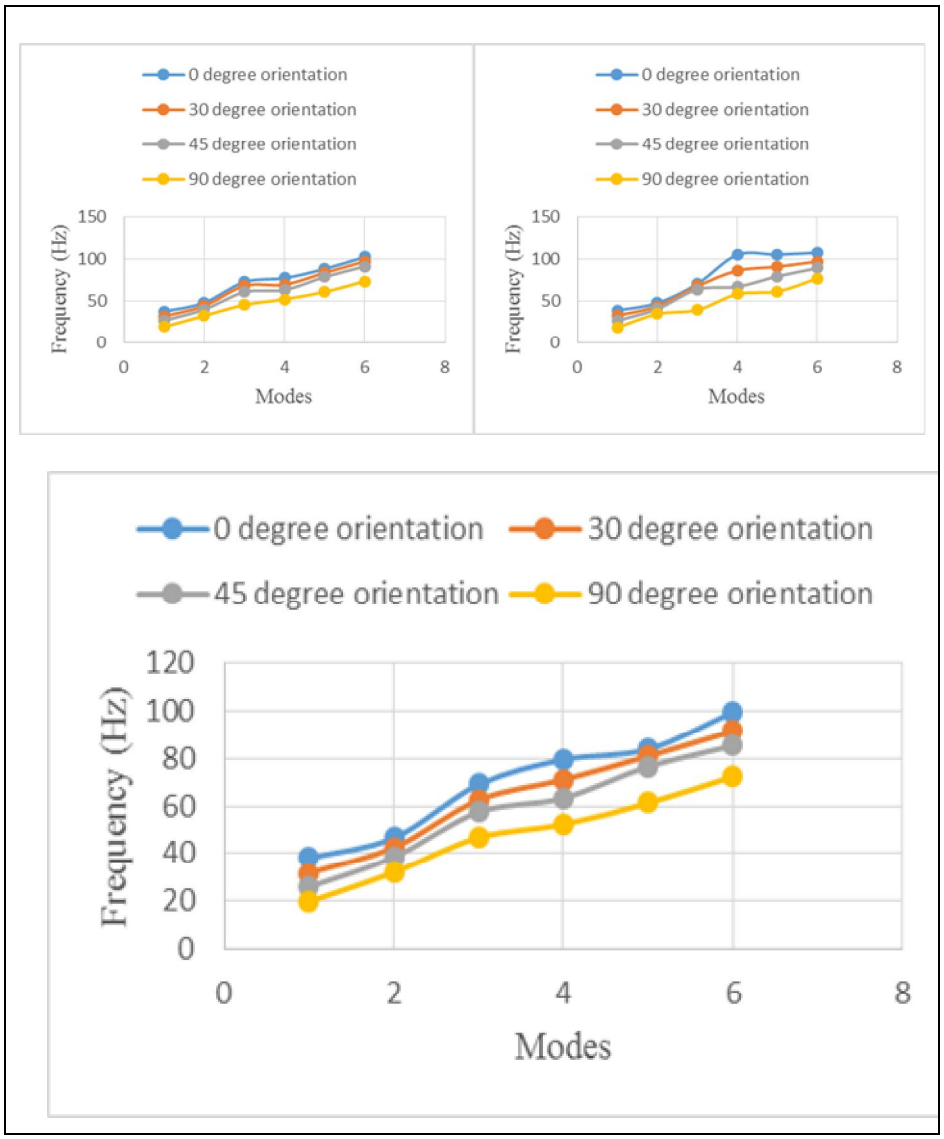



Fig. 1 Modal responses of graphite epoxy laminated composite plates without opening, with square opening and circular opening

From the frequency responses shown in the table and curves, it can be concluded that the frequency of vibration of the plates decreases with increase in the orientation angle of the plates. From the above results, the frequencies of the plates increased when opening is provided on the plate. So, plates without openings is preferable. But obviously, it is not possible to avoid an opening on the composite plate whenever it becomes necessary. So, on comparing the results obtained for a square and a circular opening, the frequency values of circular opening is slightly smaller than that of square opening. But the difference is very smaller, hence it can be concluded that the square and circular openings have almost same effect on the dynamic behaviour of a laminated composite plate.

*B. Analysis of Carbon Aluminium Composite Plate*

*1) Details of the plate:* The Carbon Aluminium composite for modal analysis is also prepared by using shell 181 element of the ANSYS 17.0 software. The analysis is done using rectangular plate of dimension 3000mm X 2000mm with overall thickness of the plate 20mm. The dimension details of the plate is same as shown in the table I.

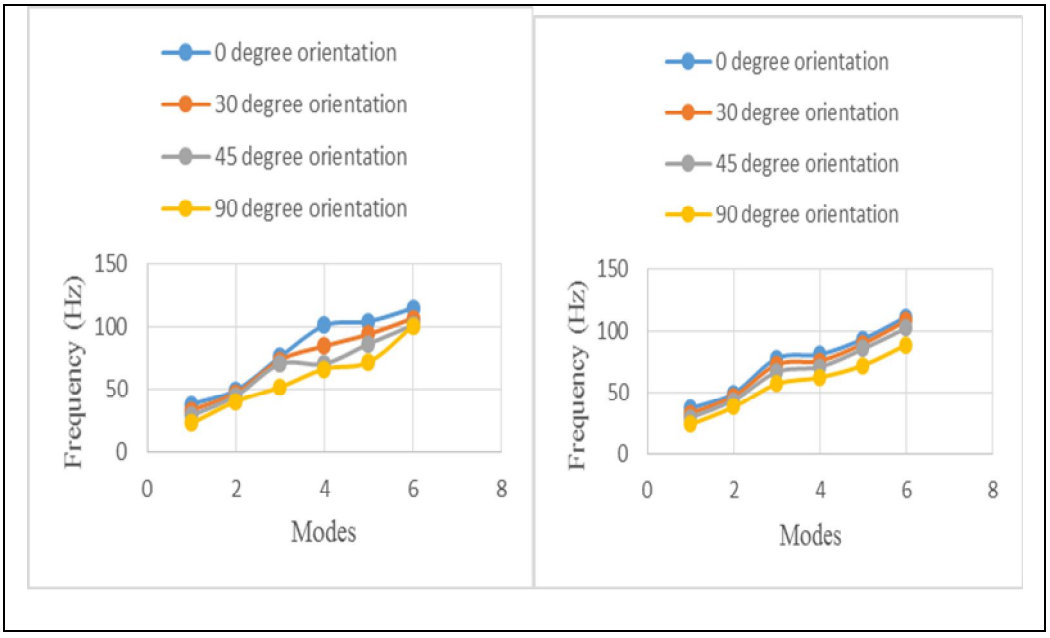
*C. Modal Response of the Plate*

Modal responses of the carbon aluminium laminated composite plates with no opening, circular opening and square openings of various fibre orientations i.e. 00, 300, 450 and 900 are shown in table 3.

TABLE 3
FREQUENCIES (HZ) OF CARBON ALUMINIUM COMPOSITE PLATES

| Type of opening | Modes | Orientations | | | |
|---|---|---|---|---|---|
| | | 0/0/0/0/0 | 30/0/30/0/30 | 45/0/45/0/45 | 90/0/90/0/90 |
| No opening | 1 | 37.898 | 33.098 | 28.718 | 22.748 |
| | 2 | 49.175 | 46.934 | 44.623 | 40.003 |
| | 3 | 75.972 | 73.418 | 70.28 | 51.722 |
| | 4 | 100.82 | 84.486 | 70.338 | 66.409 |
| | 5 | 104.02 | 93.872 | 86.262 | 71.683 |
| | 6 | 114.58 | 106.54 | 100.99 | 100.49 |
| Circular opening | 1 | 36.83 | 32.866 | 29.316 | 23.989 |
| | 2 | 49.493 | 46.849 | 43.781 | 38.045 |
| | 3 | 77.848 | 72.837 | 66.897 | 57.031 |
| | 4 | 81.046 | 75.857 | 71.061 | 62.414 |
| | 5 | 93.396 | 89.642 | 85.37 | 72.195 |
| | 6 | 111.34 | 108.2 | 102.25 | 88.7 |
| Square opening | 1 | 37.422 | 32.836 | 28.839 | 24.174 |
| | 2 | 48.454 | 45.932 | 43.004 | 37.423 |
| | 3 | 73.637 | 68.624 | 64.437 | 57.587 |
| | 4 | 82.667 | 76.89 | 71.268 | 62.376 |
| | 5 | 89.758 | 87.38 | 83.729 | 72.574 |
| | 6 | 108.7 | 103.54 | 97.985 | 86.791 |

The frequency curves showing the variations of frequencies for each orientations of respective plate openings are as shown in figure 2.



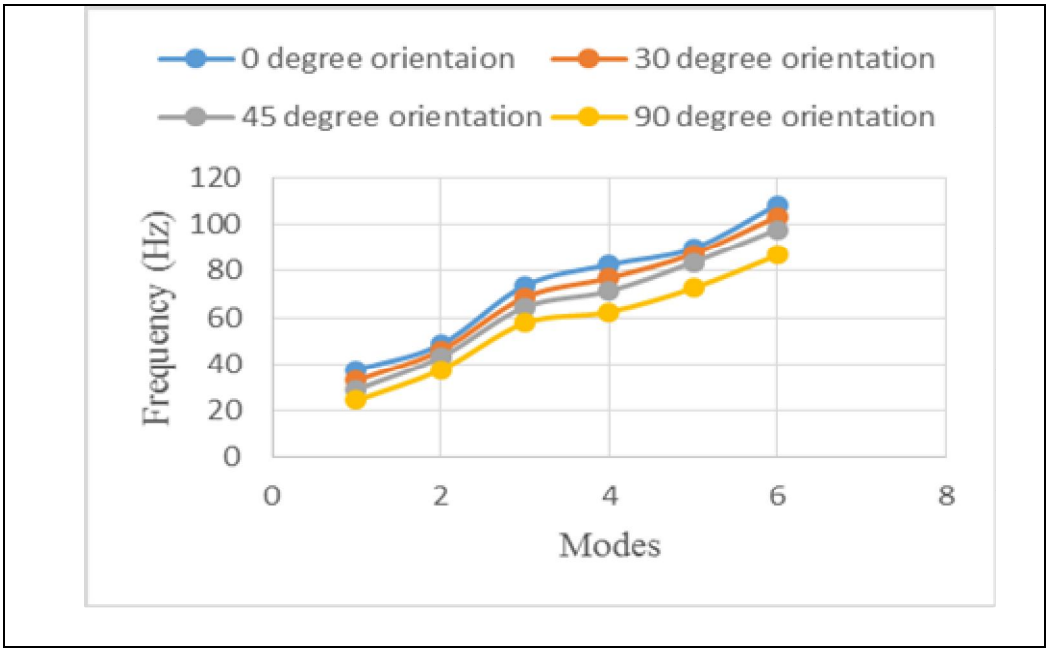
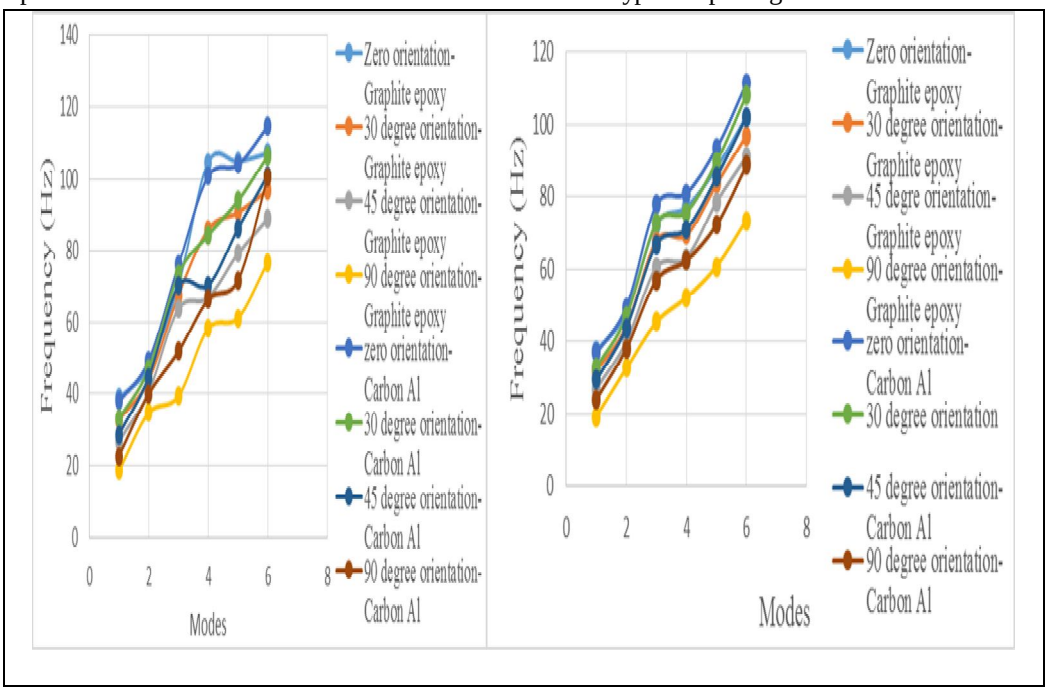



Fig. 2 Modal responses of carbon aluminium laminated composite plates without opening, with square opening and circular opening

From the frequency responses shown in the table and curves, it can be concluded that there is a decrease in frequency of vibration of the plates with increase in its orientation angles. Also, the frequencies of the plates with zero degree and 30 degree fibre orientation for circular opening is smaller than that of square opening and plate without opening. Hence, for a $0^0$ and $30^0$ fibre oriented plate, circular opening is the best preferable type of opening. But for the other orientations, circular as well as square openings have almost same effect on the dynamic behaviour of the laminated composite plate.

*D. Graphite epoxy Vs Carbon aluMinium Composite Plate*

From the obtained values of modal responses, a comparison can be made between the two types of composite materials selected for the study. The comparison curves are drawn for the two materials for each type of opening which are as shown in the figure 3.



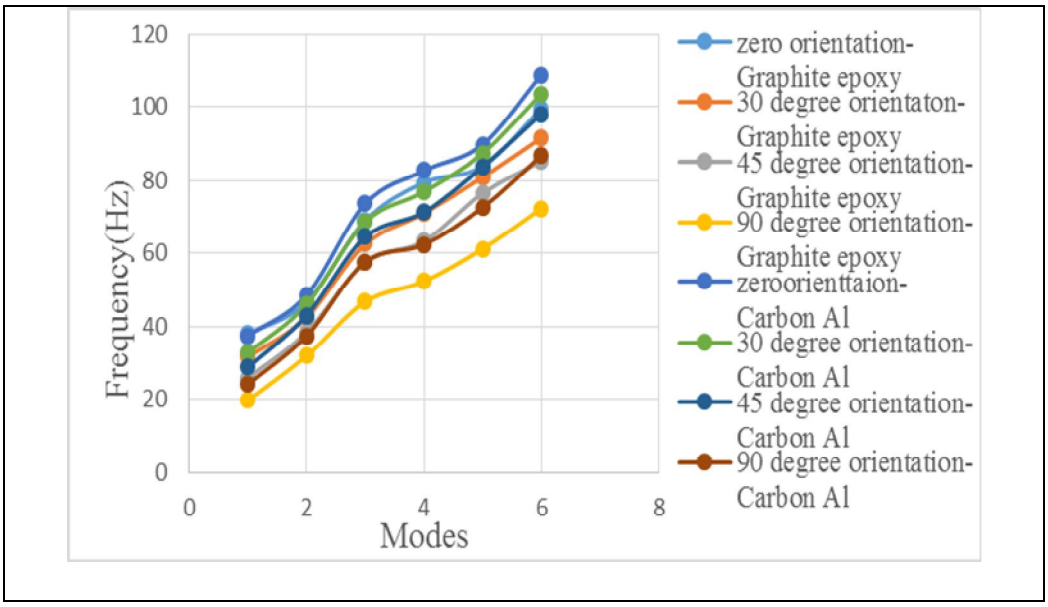



Fig. 3 Comparison of graphite epoxy and carbon aluminium laminated composite plates without opening, with square and circular opening

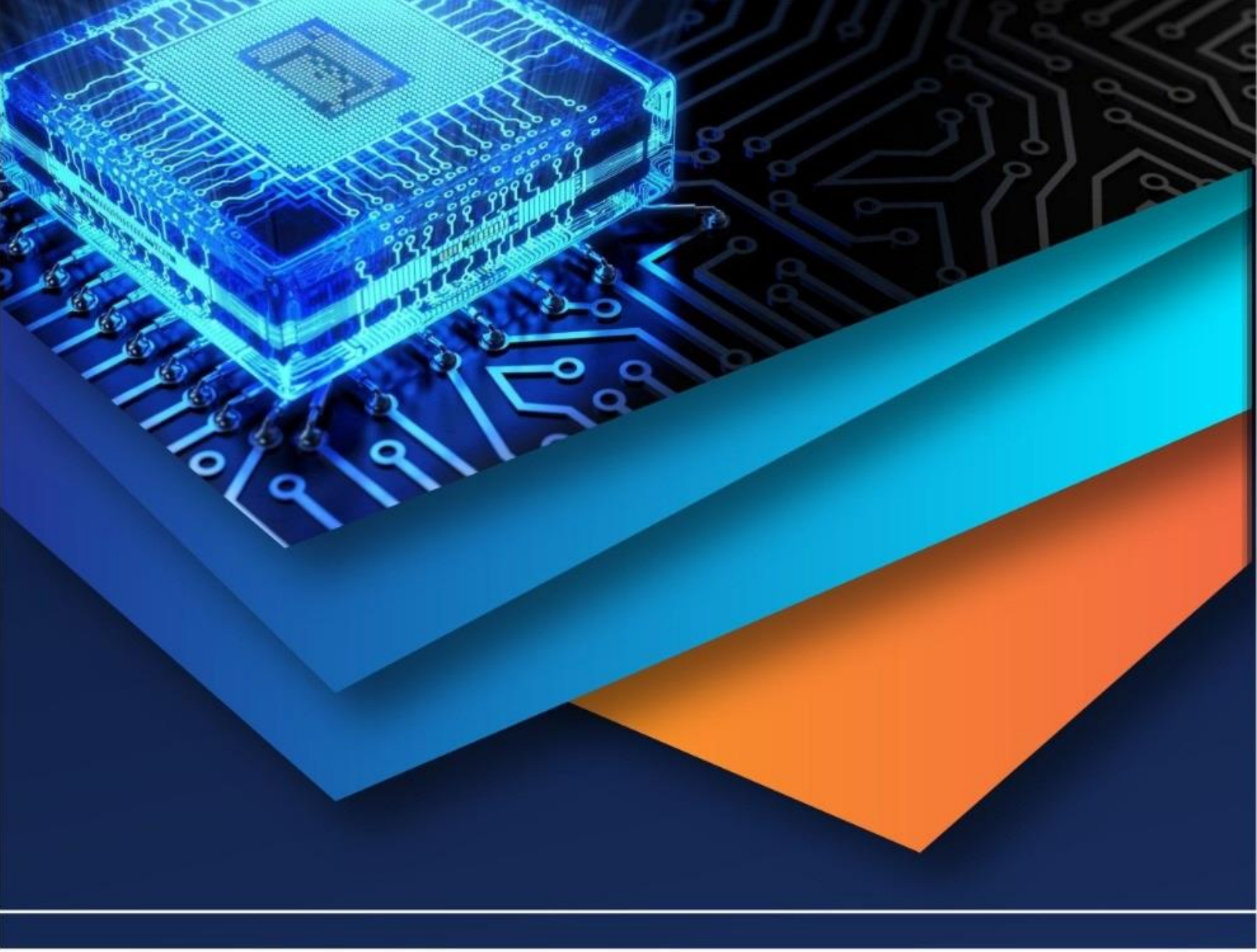
From the above curves, it is clear that the frequency of vibration for composite plates made of carbon aluminium composites are higher than that of graphite epoxy composite plates for all of the fibre orientations. Hence, graphite epoxy is the most recommended type of composite plate other than carbon aluminium.

## V. CONCLUSION

For graphite epoxy composite plate, the frequency of vibration decreased with increase in the orientation angle and it increased when opening is provided on the plate. The frequency values of circular opening is slightly smaller than that of square opening, but since the difference is very smaller, it can be concluded that the square and circular openings have almost same effect on the dynamic behaviour of a graphite epoxy composite plate. Now for carbon aluminium composite, the frequency decreased with increase in orientation angles and circular opening is preferable for 00 and 300 fibre oriented plate. But for other orientations, circular as well as square openings have almost same effect on the dynamic behaviour. On comparing both the materials, graphite epoxy is the most recommended type of composite plate than carbon aluminium.

## REFERENCES

[1] Abdelhak Khechai, Finite element analysis of stress concentrations and failure criteria in composite plates with circular holes, Frontiers of Mechanical Engineering, 2014.
[2] Ahmet Avci, Omer Sinan Sahin and Mesut Uyaner, Thermal buckling of hybrid laminated composite plates with a hole, Journal of Composite Structures, 2004.
[3] Beena S and Aiswarya S, Dynamic analysis of laminated carbon composite, International Journal of Science and Research,vol 5.,2016.
[4] Deepanshu Bhatt, Yogesh Mishra and P.K. Sharma, Model analysis of centre circular cut-out of laminated composite plate and square skew plate by using FEM, International Journal of Engineering Sciences & Research Technology, vol 3., 2014.
[5] Harsh Kumar Bhardwaj, Jyoti Vimal and Avadesh Kumar Sharma, Study of free vibration analysis of laminated composite plates with triangular cut-outs, Journal Engineering Solid Mechanics, 2014.
[6] Kuo-Yen Chang, Sheng Liu And Fu-Kuo Chang, Damage tolerance of laminated composites containing an open hole subjected to tensile loadings, Journal of composite materials, vol 25., 2013.
[7] Labeas , Belesis and Stamatelos, Interaction of damage failure and post-buckling behaviour of composite plates with cut-outs by progressive damage modelling, Journal of composite Engineering, 2008.
[8] Maithry K and Chandra Mohan Rao B D V, Dynamic analysis of laminated composite plates, International Journal of
[9] Rahul Sen, S K Kushwaha and Ahmad Ali Khan, Dynamic analysis of laminated composite plate with hole, Innovative Journal of Engineering and Technology, vol 3., 2015.
[10] Ramazan Karakuzu, Cihan Rıza Caliskan, Mehmet Aktas and Bulent Murat Icten, Failure behaviour of laminated composite plates with two serial pin-loaded holes, Journal of Composite Structures, vol 82., 2008.



10.22214/IJRASET

45.98

IMPACT FACTOR: 7.129

IMPACT FACTOR: 7.429

# INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY