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Vibration Analysis of Composite Plate

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Absrtact: *Most of the structural components are generally subjected to dynamic loadings in their Working life. Very often these components may have to perform in severe dynamic environment where in the maximum damage results from the resonant vibrations. Susceptibility to fracture of materials due to vibration is determined from stress and frequency. Maximum amplitude of the vibration must be in the limited for the safety of the structure. Hence vibration analysis has become very important in designing a structure to know in advance its response and to take necessary steps to control the structural vibrations and its amplitudes. The present study involves extensive experimental works to investigate the free vibration of woven fiber Glass/Epoxy composite plates in free-free boundary conditions. The specimens of woven glass fiber and epoxy matrix composite plates are manufactured by the hand-layup technique. Elastic parameters of the plate are also determined experimentally by tensile testing of specimens. An experimental investigation is carried out using modal analysis technique, to obtain the Natural frequencies. Also, this experiment is used to validate the results obtained from the FEA using Ansys. The effects of different parameters including aspect ratio, and fiber orientation of woven fiber composite plates are studied in free-free boundary conditions in details. This study may provide valuable information for researchers and engineers in design applications.*

Keywords: *Finite element Analysis, Frequency Response function, Modal Analysis, Woven composite,*

I. Introduction

Literature review is focused on the different types of analysis of composite materials [1]. Due to the requirement of high performance material in aerospace and marine structures, the prospect of future research of composite material, such as FRP (Fibre Reinforced Plastic) is very bright. Analysis of natural frequency and properties of composite plate has started from 40 years ago. The combination of different materials has been used for many thousands of years to achieve better performance requirements. There are nowadays many examples in the aeronautical and automobile industries, and yet the application of composite materials is still growing, including now areas such as nautical industries, sporting goods, civil and aerospace construction. The affects of different parameters on natural frequency is important analysis.

In this present work, Vibration analysis of Glass/Epoxy composite plate under Free Free boundary condition is carried out for analyze the effect of factors such as No. of layers, Fiber orientation angle and aspect ratio on the natural frequency.

1.1 Scope

The scope of the study includes the following:

- Fabrication of Woven Roving Glass/Epoxy composite plates less than 7 mm thickness
- Experimental Modal analysis work carried out on FFT analyzer.
- Affecting parameters are Fiber orientation angle and Aspect ratio

II. Methodology

In the present study, it is very necessary to develop proper composite plate fabrication method. In this hand layup fabrication method is developed. Proper experimental plan is necessary to achieve good results in conducting research. Simulation is carried out using Ansys Software. FRF results, DOE data, and simulation results are compared.

2.1 Experimentation

2.1.1 Geometrical Property

In choosing the types of specimens to construct and test, woven fibered Glass/Epoxy composite plates are taken. Seven woven fibre Glass/Epoxy composite plates are taken. Plates prepared to cast as free one by hand layup. The maximum length of plate is 25 cm. The average thickness of all specimens was measured by a screw gauge having a least count of 0.01mm.

2.1.2 Fabrication Method

The resin serves as the matrix for the reinforcing glass fibers, much as concrete acts as the matrix for steel reinforcing rods. The percentage of fibre and matrix was 50:50 in weight. Contact moulding in an open mould by hand lay-up was used to combine plies of WR in the prescribed sequence. A flat plywood rigid platform was selected. A plastic sheet was kept on the plywood platform and a thin film of polyvinyl alcohol was applied as a releasing agent by use of spray gun. Laminating starts with the application of a gel coat (epoxy and hardener) deposited on the mould by brush, whose main purpose was to provide a smooth external surface and to protect the fibers from direct exposure to the environment. Ply was cut from roll of woven roving. Layers of reinforcement were placed on the mould at top of the gel coat and gel coat was applied again by brush. Any air which may be entrapped was removed using serrated steel rollers.[3]

2.1.3 Determination of Material Constants

The characteristics of woven fiber Glass/Epoxy composite plate which can be defined completely by two material constants: E and υ. For material characterization of composites, laminate having 8 layers is manufactured to evaluate the material constants.[2] The constants are determined experimentally by performing tensile tests on specimens as described in ASTM standard: D 638-08 and D 3039/D 3039M – 2006. The specimens were cut from the plates themselves by diamond cutter or by hex saw. After cutting in the hex saw, it was polished in the polishing machine. At least three replicate sample specimens were tested and mean values adopted.

2.2 Testing

2.2.1 Test Setup

The connections of Data acquisition system, computer, and accelerometer, amplifier, modal hammer, and cables to the system are done as per the guidance manual. The plate was excited in a selected point by means of a small impact hammer. The plate is at Free-Free condition as shown in fig.

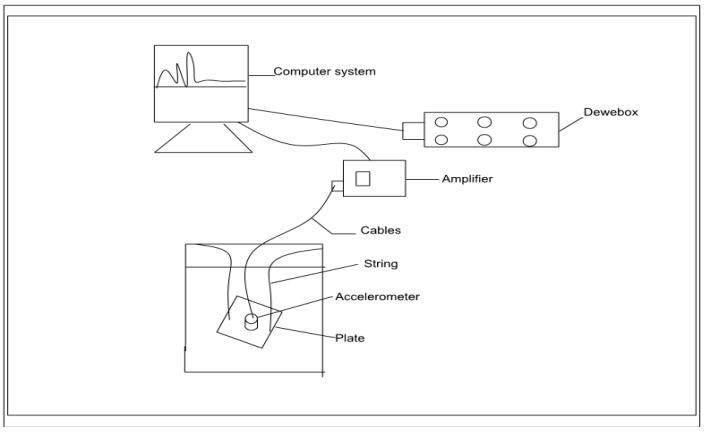

Fig. Schematic of experimental setup

2.2.2 Test procedure

The resulting vibrations of the plate in a select point are measured by an accelerometer. The accelerometer is mounted by means of bees wax. The signal was then subsequently input to the second channel of the analyzer, where its frequency spectrum was also obtained. The response point was kept fixed at a particular point and the location of excitation was varied throughout the plate. Both input and output signals are investigated by means of FFT and resulting frequency response functions are transmitted to a computer for modal parameter extraction. The output from the analyzer was displayed on the analyzer screen by using DEWESoft 6 software. Various forms of Frequency Response Functions (FRF) are directly measured.

2.3 Ansys FEA Model

FEA involves three stages of activity:

- Preprocessing,
- Processing and
- Post processing.

In this study, finite element analysis is conducted using ANSYS software. To model the composite plate Linear layer Shell 99 element is used and it is modal analysis. The plate is at free free boundary condition. Degrees of freedom are UX, UY, UZ, ROTX, ROTY, ROTZ.

III. Data Analysis

Plate	Mode no.	Experimental Frequency (Hz)	Simulation Frequency (Hz)	Error (%)
Glass/Epoxy plate with aspect ratio 1:1	1	224.6	210.7	6.18
	2	576	618.0	7.29
	3	1298	1197	7.78

Plate	Mode no.	Experimental Frequency (Hz)	Simulation Frequency (Hz)	Error (%)
Glass/Epoxy plate with aspect ratio 1:1.5	1	332	283	14.75
	2	791	881	10.21
	3	1562	1467	6.11

Plate	Mode no.	Experimental Frequency (Hz)	Simulation Frequency (Hz)	Error (%)
Glass/Epoxy plate with aspect ratio 1:2	1	400.4	308	21
	2	927.7	960	3.61
	3	1845	1787	3.14

Plate	Mode no.	Experimental Frequency (Hz)	Simulation Frequency (Hz)	Error (%)
Glass/Epoxy plate with aspect ratio [45/-45] orientation	1	224.6	223.86	0.32
	2	478	584	18.15
	3	1093	1037	5.12

Plate	Mode no.	Experimental Frequency (Hz)	Simulation Frequency (Hz)	Error (%)
Glass/Epoxy plate with aspect ratio [30/-60] orientation	1	255.13	262	2.67
	2	661	634	3.36
	3	1296	1214	6.3

IV. Result And Discussion

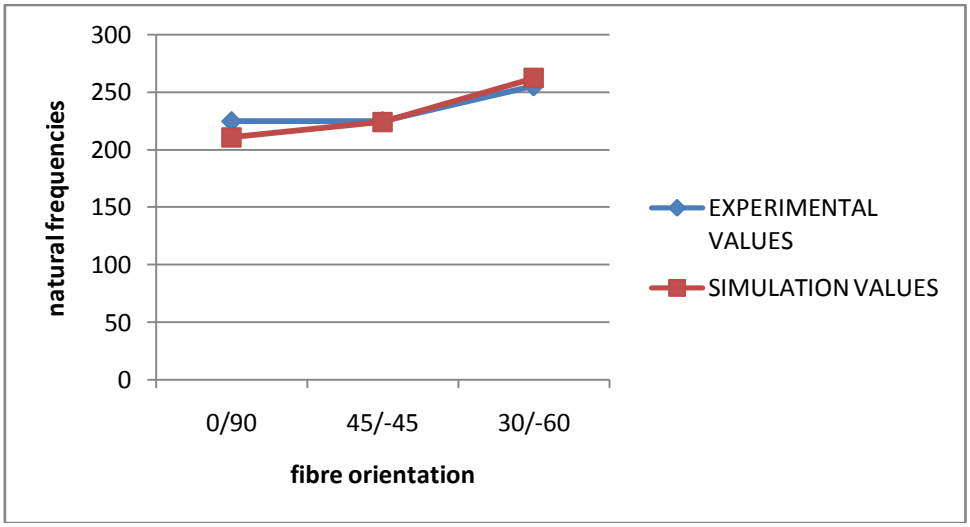

Fig. Effect of Fiber orientation on Natural frequencies.

Fiber orientation Vs Natural frequency graph. It shows lower value for [45/-45] fiber orientation. And increased frequency for [30/-60]. The maximum error for comparison between experimental and simulation is 6%.

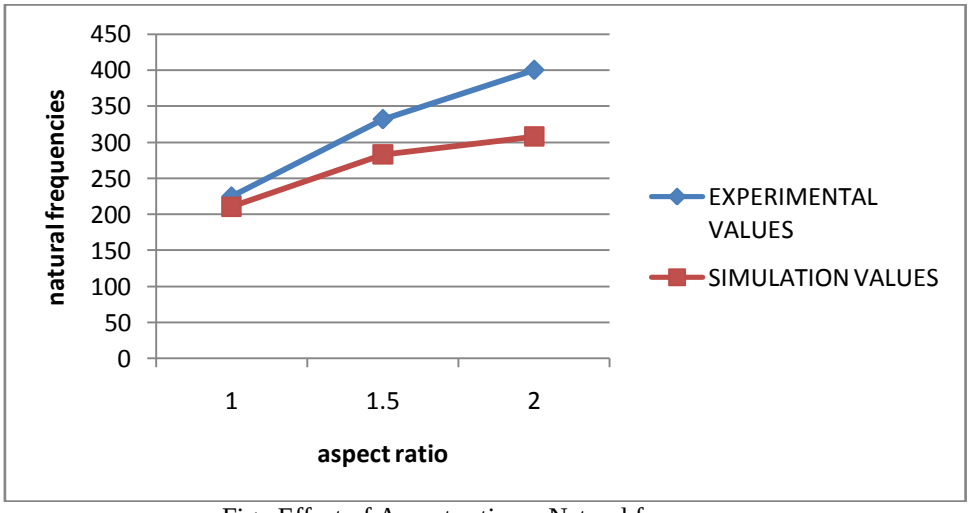

Fig. Effect of Aspect ratio on Natural frequency.

Natural frequency increases with increase in aspect ratio. It gives parabolic curve. The error may occur due to un-damped natural frequency is considered in the program and damping was present in the system.

4.1 Result Discussion

Natural frequencies of woven fiber Glass/Epoxy composite plates are measured by data acquisition system for free-free boundary condition. There are three different parameters such as aspect ratio of plate and fiber orientation. The program developed by FEA is used to measure the natural frequencies of those plates. experimental values and simulation study are compared with each other. In experimental result, natural mode of frequency sometimes varies within a range as shown in Tables. It shows that an approximate agreement with the FEA based program. As the mode no increases, the percentage error between experimental value and programming value decreases. But the differences between compared results are reasonable. The reasons for differences are may be:

The standard size of the specimen is dog-boned shape. There may be variation of elastic properties of the plate, as the sample cut from the plate was different from the plate used in the case vibration testing.

Tensile properties may vary with specimen preparation and with speed and environment of testing. Present specimens couldn't align in the centre of the jaw, because there is a diamond shaped hole where slippage was occurred. Specimens were fixed one of the sides of the jaw. So, there may be a chance of decrease of elastic modulus (Young's modulus).

V. Conclusion

5.1 Parametric Study

The Glass/ Epoxy laminated composite plates are manufactured and modal testing is done for free-free boundary condition by using Data acquisition System. Frequency Response Functions are obtained by FFT. Quantitative results are presented to show the effects of different parameters like aspect ratio and fibre orientation.

The experimental frequency data is in fair agreement with the program computation. The Percentage of error between experimental value and ANSYS package is within 15%. The difference is probably due to uncertainty in elastic properties and other described reasons. For Free-free boundary condition it is found that the natural frequency of plate increases with the increasing of aspect ratio. Natural frequency decreases as the ply orientation increases up to [45/-45] and again increases up to [30/-60].

5.2 Future scope

The present approach is devoted that the major affecting parameter on natural frequency. As the composite material are made of two or more distinct phase materials. Manufacturing consideration plays an important role in design part. I have to analyse the affect of different fabrication factors such as curing time, curing temperature and volume fraction ratio so as to optimise the fabrication process.

VI. Acknowledgment

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