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Research Article

Damped Free Vibration Analysis of Woven Glass Fiber-Reinforced Epoxy Composite Laminates

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Woven glass fiber reinforced with epoxy matrix composites are manufactured considering different glass/epoxy proportions and vibration analyses of the laminated composite plates subjected to free vibrations have been examined. The tensile and flexural strength of composites were evaluated by following ASTM standards. Free vibration of the composite specimen characteristics is studied using a Fast Fourier Transform analyzer, accelerometer using impact hammer excitation. The fast response functions are studied in order to clearly understand the vibration characteristics of the specimens. The experimentally obtained results of the rectangular composite plates are compared with the analytical results obtained from Nastran. The results showed a good agreement. It was observed that as the number of layers of the composite specimen increased, the frequency response also increased.

1. Introduction

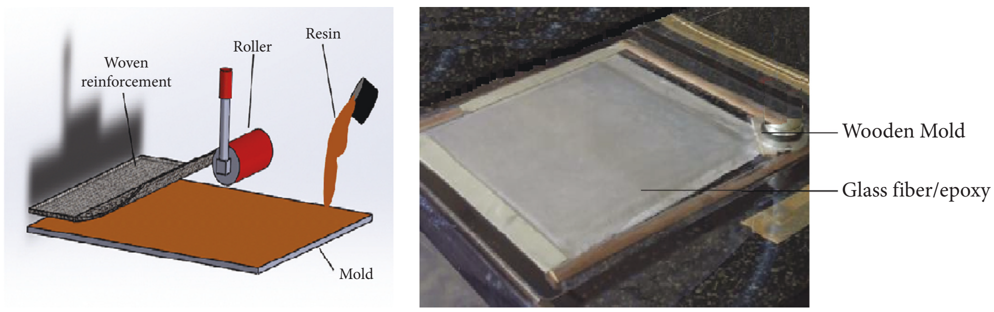
The composite material which consists of continuous glass fibers have applications like automobile component, pistons for diesel engines, wheels, clutch plates, brakes, interior and exterior panels, rotors, drive shafts, etc. In modern engineering, cables for suspension bridges and fiber reinforced cements are replaced by composite materials [1, 2]. Every motion dissipates energy in one form or another. Damping is associated with energy dissipation, i.e., damping is the resistance offered by a body to the motion of a vibrating system. The resistance may be applied by a liquid or solid internally or externally. Because of this resistance vibrations die out over a few cycles of motion. Mishra and Sahu [3] conducted experiments to measure the free vibration of glass/epoxy composite plates under free-free boundary conditions. The effect of an individual geometrical parameter on was measured in the study. Later, these experimental results were used to validate the results of numerical analysis which was based on the first order shear deformation theory. Alexander et al. [4] were experimentally determined natural frequencies of the multilayered composites made of carbon/epoxy and basalt/epoxy resins. The influence of material properties, laminate thickness, and boundary conditions were evaluated and compared. Xu et al. [5] studied the effect of the woven structure on mechanical and vibration properties of glass/epoxy composites. The dynamical behaviors of the fabricated composites were measured using a dynamic mechanical analyzer and a vibration test technique. The study concluded that the performance of the composites in vibration is greatly affected by the woven structure which has influence on fiber volume fraction and wrap architecture. Bhattacharjee and Roy [6] focused their study on FE formulation of woven E glass/epoxy composites reinforced with Al2O3 particles; these were verified with experiments and noticed good convergence. The study was extended to measure the effect of structural and geometrical parameters on dynamic characteristics of the fabricated composites. Hybrid composites exhibit superior properties than the particulated composite. Hadiji et al. [7] evaluated the dynamic properties of natural fiber reinforced polypropylene composites, measured the effect of reinforcement, matrix-fiber weight ratio, fiber orientation, porosity content, etc., on its damping property. Also, the vibration study was conducted to measure their natural frequency and loss factor. Investigators noticed that composites reinforced with natural fibers showed higher loss factors than the glass polypropylene composite. Pandit et al. [8] measured the effect of shear deformation of free undamped vibration of isotropic and fiber-reinforced laminated plates using the first order shear deformation theory. Sahu et al. [9] measured the effect of geometrical parameters such as angle of twist, aspect ratio, etc., to investigate the vibration and stability behavior of twisted composite panels. Outcomes of the study revealed that these parameters influence the performance of composites to a greater extent. Sinha et al. [10] studied the free vibration characteristics of woven glass fiber composites by varying stiffener numbers, types and orientation, depth of stiffener to thickness of plate ratio, boundary conditions of plates, etc. The experimental and FE analyses were compared and found to be in good agreement with each other. Venkateshappa et al. [11] measured the effects of the skew angle and aspect ratio on the natural frequencies of isotropic cylindrical skew panels. Experimental values of all frequencies are in good agreement with FE analysis for both isotropic and laminated composite panels. Grover et al. [12] predicted natural frequencies using the new shear deformation theory for sandwich plates under free vibration condition. Huu-Tai and Seung-Eock [13] studied free vibration of laminated composite plates using Hamilton's principle. The study concludes that natural frequencies of laminated composite plates are accurate and predicted from the proposed theory. Natural frequency values were compared with Hamilton's principle. Zhang et al. [14] studied the vibration analysis of embedded shape memory alloys with laminated composite plates. They showed the effects of natural frequency and vibration analysis on embedded shape memory alloys with composite plates. Alsaadi et al. [15] investigated the carbon/kevlar/epoxy composites reinforced with nano silica particles for vibration and damping behavior. The study resulted in a significant effect on dynamic properties in terms of natural frequency and damping ratio due to improved interfacial stress between the particles/epoxy/fiber. Mutra et al. [16] studied the natural frequency of laminated composite plates; the artificial neural network was used to predict free vibration frequency of laminated composite plates for clamped boundary conditions. Jodeiri and Tabrizi [17] studied the nonlinear vibration using variational approach for laminated composite plates. Von Karman's nonlinear deformation theory was used for nonlinear terms. Srinivasa et al. [18] measured the free vibration characteristics laminated composite skew plates. A simply supported and clamped boundary was used for the determination of natural frequency for laminated composite skew plates. The experimental result and finite element method results were compared and were found to be in close agreement. Sinha et al. [19] conducted experimental and numerical studies on free vibration analysis of fiber/epoxy composites by varying weight fractions, number of layers, orientation, and aspect ratio. It was noticed that there was a good agreement between experiment and analysis and also that above said parameters greatly influence the natural frequencies of the composites. Cihan et al. [20] showed the hybridization of flax/E-glass fibers results in an increase in damping from 1.97% to 2.63% for the best hybrid; however, it was noticed that the compromise in tensile strength is significant from 473.28 MPa to 166.53 MPa. Kanak et al. [21] measured the natural frequency of isotropic and composite rectangular plates and analyzed for mode frequencies using ANSYS with different boundary conditions like clamped, simply-supported, and free edge. It was observed that the thickness, aspect coefficients, and the boundary conditions depends on natural frequency. Mode frequencies of an isotropic and composite rectangular plate were found using ANSYS computer package. Shaker et al. [22] tested glass/vinyl ester composites reinforced by silica microparticles for the tensile and flexural strength, short beam shear, impact resistance, and barcol hardness. Results cleared that the inclusion of silica microparticles enhanced the properties if the composites. The composites without silica particles have exhibited failures like matrix cracking, delamination, and reinforcement failure during tensile and flexural tests. Silica-reinforced composites showed only matrix cracking and reinforcement failure, indicating a substantial increase in the matrix strength and interfacial adhesion. Sahu and Das [23] investigated the composite beam with transverse cracks experimentally and analytically for the vibration characteristics. Results of both the studies showed that natural frequencies in the composite beams are significantly influenced by the location and size of the cracks. Also, study results clearly indicates that the natural frequencies are decreased with an increase in fiber orientation and cracks in the beam. In this present study, glass/epoxy composite plates were fabricated using hand layup procedure, then they were subjected to mechanical and free vibration studies. Vibration modal testing of these fabricated composite plates were tested experimentally and compared with analytical results of NASTRON.

2. Fabrication and Experimental Procedure

2.1. Fabrication. Two methods are used for composite material fabrication, namely, hand layup method and spray-up method. The hand layup method is the oldest method and simplest method. A composite material where glass is used as a reinforcement and epoxy is used as a matrix for the

Table 1: Details of the fabricated composites.

Sample	Glass fiber (vol. %)	Epoxy resin (vol. %)	Number of layers of glass fiber	Mass of epoxy resin (gm)
A	50	50	19	220.05
B	60	40	23	176.04
C	70	30	27	132.03



(a) (b)

Figure 1: (a) Schematic of hand lay-up procedure. (b) Actual setup.

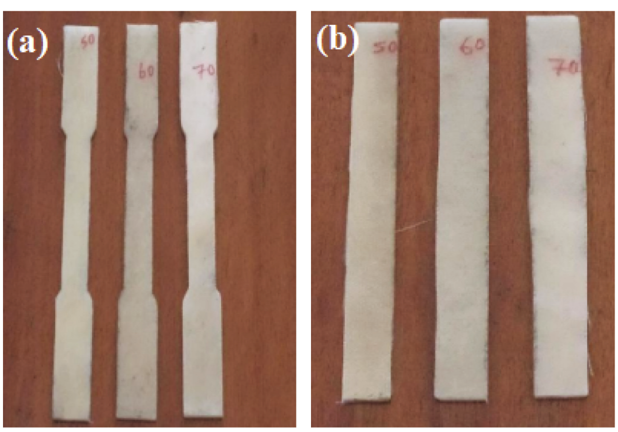


Figure 2: Composite specimens prepared for (a) tensile test and (b) flexural test.

fabrication of composites. The glass fiber is bidirectional with 0°/90° orientation. The glass fiber and epoxy are supplied from Yuje enterprises, Bangalore. The hardener is polyamine hardener (K6) and epoxy is LAPOX 12 which is supplied from Yuje enterprises, Bangalore. The percentage of glass fiber and matrix was 50/50, 60/40, and 70/30% in weight as tabulated in Table 1. The epoxy and hardener ratio was maintained 10 : 1. In the plywood platform, a plastic sheet is kept and a thin film of Vaseline and coconut oil is applied over the surface of it. The dimensions of the plate were length 300 mm, width 300 mm, and thickness of 3, 3.5, and 4 mm based on the number of layers. Alternative layers of glass fiber and epoxy were applied until reaches desired thickness. On the top, the composite is covered with a plastic sheet which was coated with a film of Vaseline and coconut oil for easy removal. The hand layup procedure followed in the study is shown in Figure 1. The calculated amount of weight is placed on the composite and is kept undisturbed for 24 hours for complete curing. Specimens cut into the required shape for tensile and flexural tests are shown in Figure 2. For the tensile and the three point bending test, specimens are cut according to ASTM D 638 and ASTM D 790, respectively.

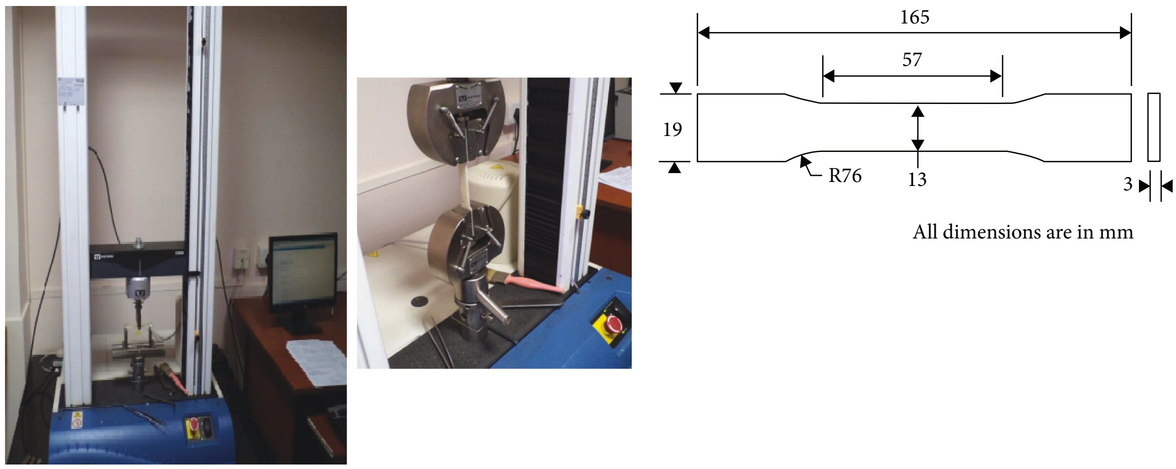
2.2. Experimentation

2.2.1. Mechanical Testing

(1) Tensile Strength. For the structural applications, the most important and widely used property is tensile stress. Tensile stress is the ability to resist breaking. From this, tensile test maximum load for failure, maximum stress, and young's modulus are obtained. Young's modulus of different compositions of the composite plate were used for analytical solutions. Tensile test setup (model: Instron 3366) and specimen dimension as per ASTM D 638 are shown in Figures 3(a) and 3(b).

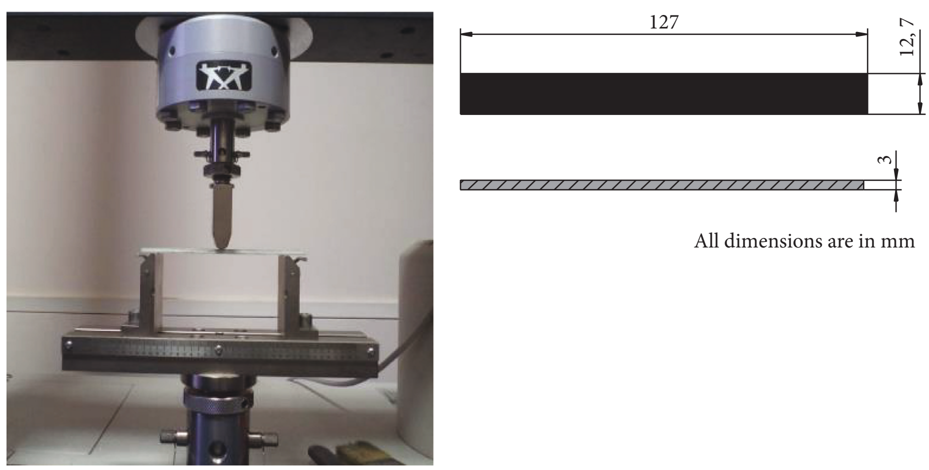
(2) Flexural Strength. In the present study, a three-point bending test was used to measure the flexural strength. Three-point bending test setup (model: Instron 3366) and specimen dimensions as per ASTM D 790 are shown Figures 4(a) and 4(b).

2.2.2. Vibration Studies The FFT analyzer setup consists of a modal hammer (PCB type), accelerometer, FFT analyzer, and computer with pulse software (pulse lab view version 3.0). Using the impact hammer (Model PCB), a fixed end of the specimen is excited and a free end of the FFT test setup is connected with an accelerometer (YMC121A100 IEPE) using bee wax as shown in Figure 5(a). The input signal is measured by a force transducer fixed on the hammer. A frequency spectrum of the signal is obtained from the analyzer. The response point of the signal is kept at one end and varied throughout the plate. A spectrum analyzer will



(a) (b)

Figure 3: (a) UTM test setup. (b) Specimen dimensions as per ASTM D 638.



(a) (b)

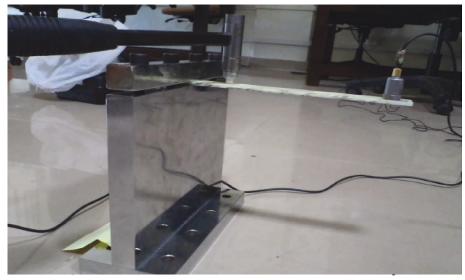
Figure 4: (a) Three point bending test setup. (b) Specimen dimensions as per ASTM D 790.

investigate the input, output signals, and frequency response functions that are transmitted to the computer for the vibration modal analysis. For cantilever boundary conditions, the length of the composite plate specimen is 200 mm. Effective length is 180 mm and 20 mm of composite plate specimen is fixed at one end. For cantilever boundary conditions, one end is fixed and the other end is free. Frequency response functions (FRF) are directly measured in various forms. Nevertheless, the composite plates showed very rapidly to have frequencies above 2000 Hz, which are difficult to excite with enough energy by means of a hammer. The dimensions of a composite material for the FFT test is $200 \times 20 \times 3$ mm. The value of mode 1 frequency of different composite plate matches both for impact hammer excitation and free hand vibration. Free hand vibration where the accelerometer is connected to the FFT test setup but impact hammer is not excited. The output signal from impact hammer excitation is shown in pulse software. A pulse software result consists of frequency v/s amplitude, frequency v/s phase, and time v/s amplitude. Vibration mode is linear and free vibration. The range of frequency from 0 to 2000 Hz. Different mode value frequency is obtained from the output result for different compositions of the composite plate. Pulse lab view version 3.0 software key was used for the FFT test. The accelerometer is YMC121A100 IEPE type and temperature range is from −40 to 121°C. The range of frequency is 0.5 to 8000 Hz for the accelerometer. Response frequency of the accelerometer is greater than 25 kHz. The dimension of the accelerometer is 13×22 mm and mounting type is M5. The test environment has 22°C temperature and 60% humidity.

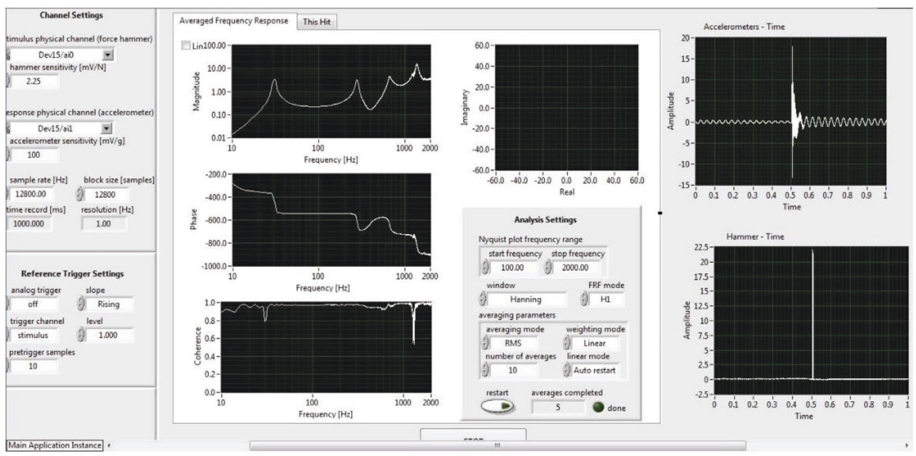
3. Result and Discussions

3.1. Mechanical Behavior

3.1.1. Tensile Test. The dog bone-shaped specimen is subjected to a tensile test and fixed between two arms where the load acts on the specimen till the specimen undergoes failure. This ultimate load value is noted down and is used to

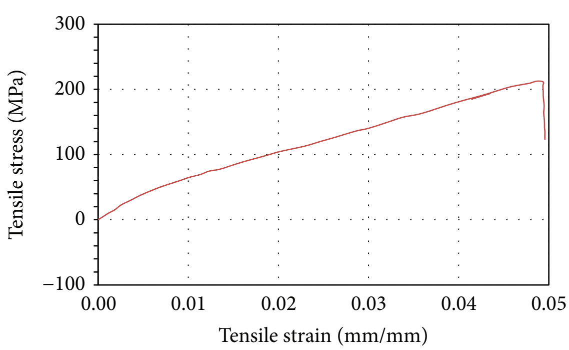


(a)

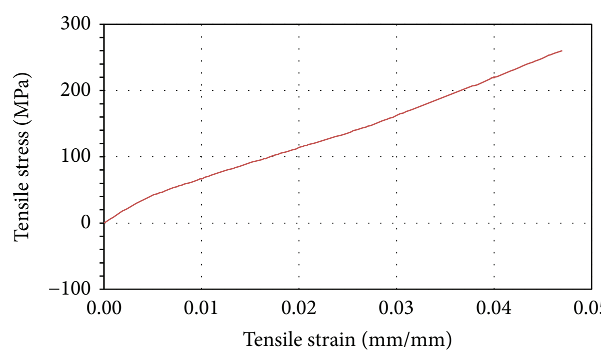


(b)

Figure 5: (a) FFT analyzer setup with an accelerometer (YMC121A100 IEPE). (b) Pulse software.



(a)



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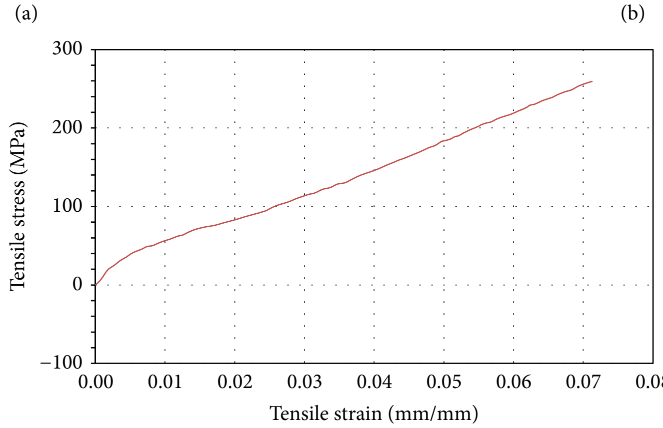
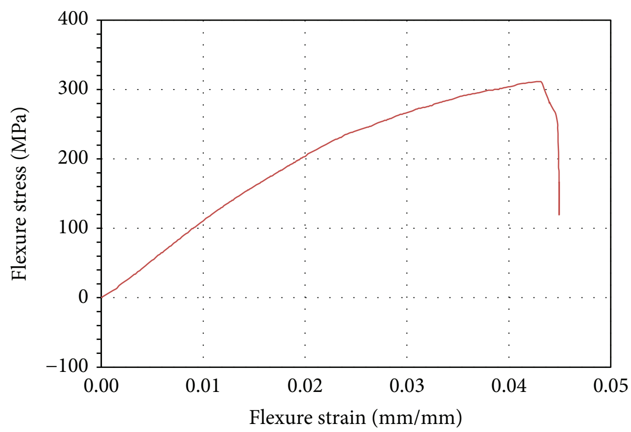


(c)

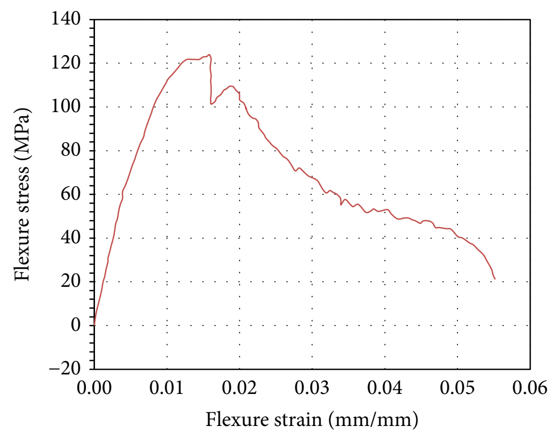
Figure 6: Tensile behavior of (a) 50/50%, (b) 60/40%, and (c) 70/30% glass/epoxy composite.

Table 2: Tensile stress and modulus for glass/epoxy composites.

Proportions (%)	Max. load (N)	Tensile stress at maximum load (MPa)	Modulus (automatic) (MPa)
50/50	8405.605	215.528	6663.183
60/40	10308.725	264.326	6973.786
70/30	10156.643	260.426	3690.652



(a)



(b)

Figure 7: Flexural behavior of (a) 50/50% and (b) 60/40% glass/epoxy composite plate.

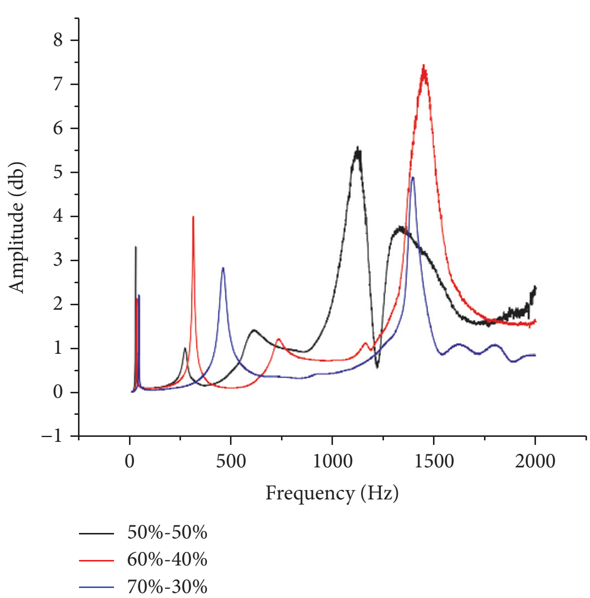


Figure 8: Combined frequency v/s amplitude curve for 50/50%, 60/40%, and 70/30% glass/epoxy composite plates.

calculate ultimate tensile stress. From the stress strain curve, Young's modulus is calculated. From the graph values like maximum load, tensile stress at maximum load, and Young's modulus are found out.

The maximum load carrying capacities and Young's modulus of 50/50, 60/40, and 70/30% glass/epoxy composites plates are 8.4 kN, 12.3 kN, 11.1 kN and 6.6 GPa, 6.9 GPa, and 3.6 GPa, respectively. The ultimate tensile strength is found to be maximum for the 60/40% glass/epoxy composite plate. This is because the bonding between reinforcement and matrix is best at that percentage. Tensile behavior of 50/50, 60/40, and 70/30% glass/epoxy composite plates are shown in Figure 6. Table 2 shows the tensile stress and modulus for glass/epoxy composites.

3.1.2. Three-Point Bending Test. To conduct three-point bending test, the specimen is mounted in a simply-supported manner. The load is acting at the center and is perpendicular to the axis. The ultimate bending strength of the specimen is noted and repeated for second and third specimens with varying weight percentage of glass and epoxy. Young's modulus of 50/50, 60/40, and 70/30% glass/epoxy composites is 11.62 GPa, 15.97 GPa, and 20.54 GPa, respectively. The ultimate tensile strength is maximum for 60/40% glass/epoxy composite, due to adequate bonding between reinforcement and matrix at that percentage. The flexural behaviors of 50/50, 60/40, and 70/30% glass/epoxy composite plates are shown in Figure 7.

3.2. Vibration Studies

3.2.1. FFT Test. (1) Combined frequency analysis.

Figure 8 shows the variation of amplitudes on different frequencies for 50/50, 60/40, and 70/30% glass/epoxy composites. The frequency is the highest for the 70/30% glass/epoxy composite and it goes on decreasing for 60/40 and 50/50% glass/epoxy composite plates. The highest frequency for each glass/epoxy composite plate is critical

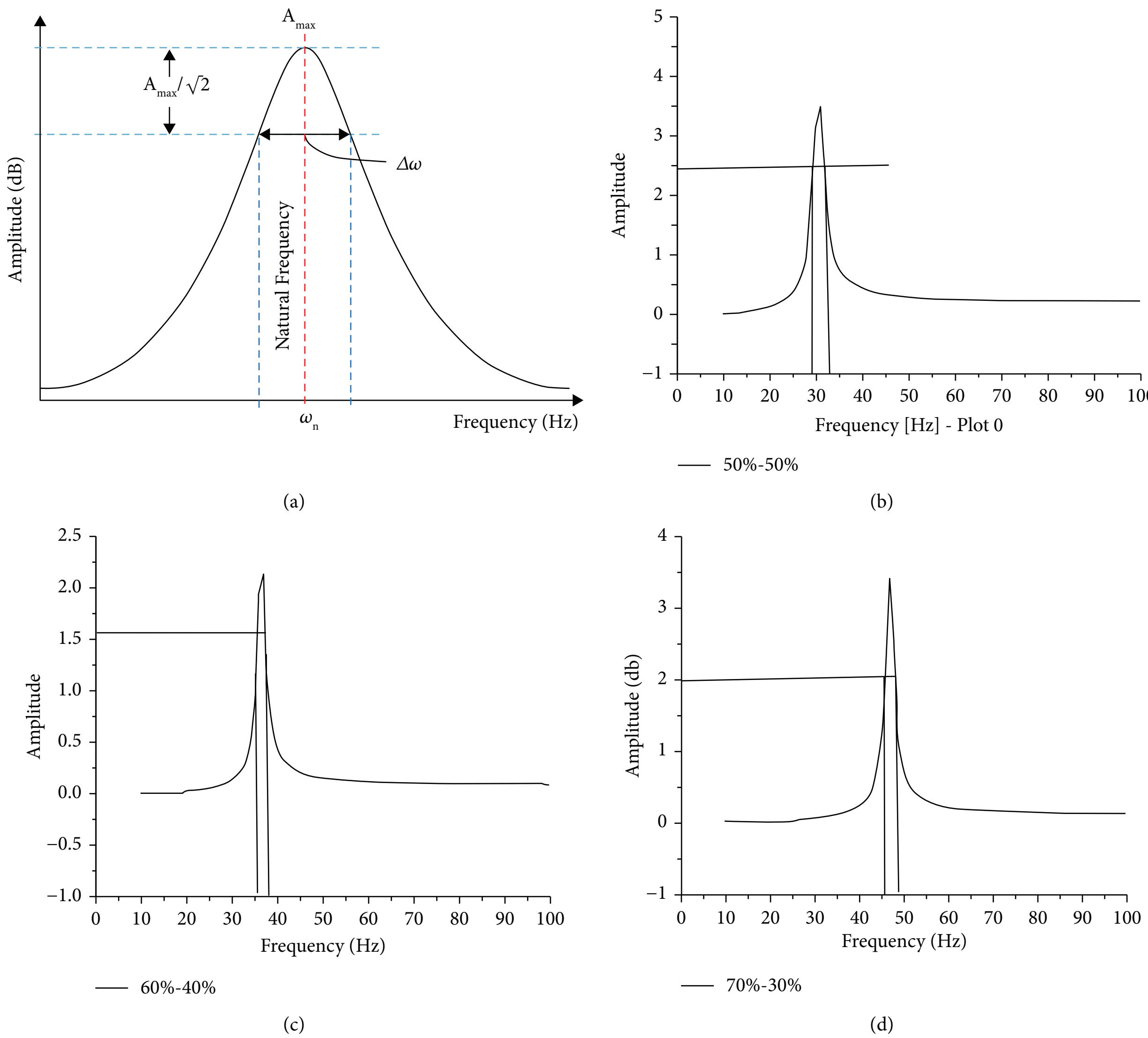


Figure 9: (a) Half power bandwidth graph; frequency v/s amplitude curve of (b) 50-50%, (c) 60-40%, and (d) 70-30% glass/epoxy composites for Mode 1.

Table 3: Dimensions and properties of glass/epoxy composite plates.

Composition glass/Epoxy	Number of layers	Young's modulus (GPa)	Density (kg/m^3)	Dimensions of the plate (mm) (Length × Width × Thickness)
50/50%	19	11.62	1954.54	200 × 20 × 3
60/40%	23	15.97	2061.53	200 × 20 × 4
70/30%	27	20.54	2193.33	200 × 20 × 4.5

frequency. Variation in the frequency is due to unavoidable sound and noise.

(2) Calculation of damping coefficient and logarithmic decrement from the FFT test for glass/epoxy composites.

The variation of frequency v/s amplitude for the 50/50% glass/epoxy composite plate for mode 1 is as shown in Figure 9(b). The frequency, logarithmic decrement, and damping coefficient for 50/50% glass/epoxy composite for mode 1 can be calculated as follows: the half power bandwidth is shown in Figure 9(a).

From the above graph, $f_n = 31.02\text{Hz}, f_{n1} = 29.77Hz, f_{n2} = 32.44\text{Hz}$

Damping coefficient, $\xi = (\text{fn2} - \text{fn1})/2\text{fn}, \xi = 0.044$

Logarithmic decrement, $\delta = 2\pi\xi\sqrt{1 - \xi 2} = 0.28$

The variation of frequency v/s amplitude for the 60/40% glass/epoxy composite plate for mode 1 is as shown in Figure 9(c). The frequency, logarithmic decrement, and damping coefficient for 60/40% glass/epoxy composite for mode 1 can be calculated as follows:

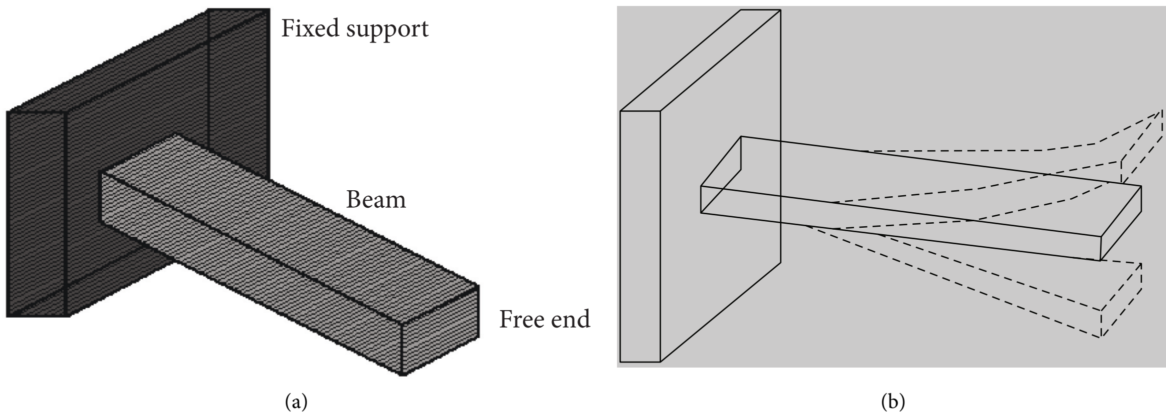


FIGURE 10: (a) Fixed cantilever beam. (b) Beam subjected to vibration.

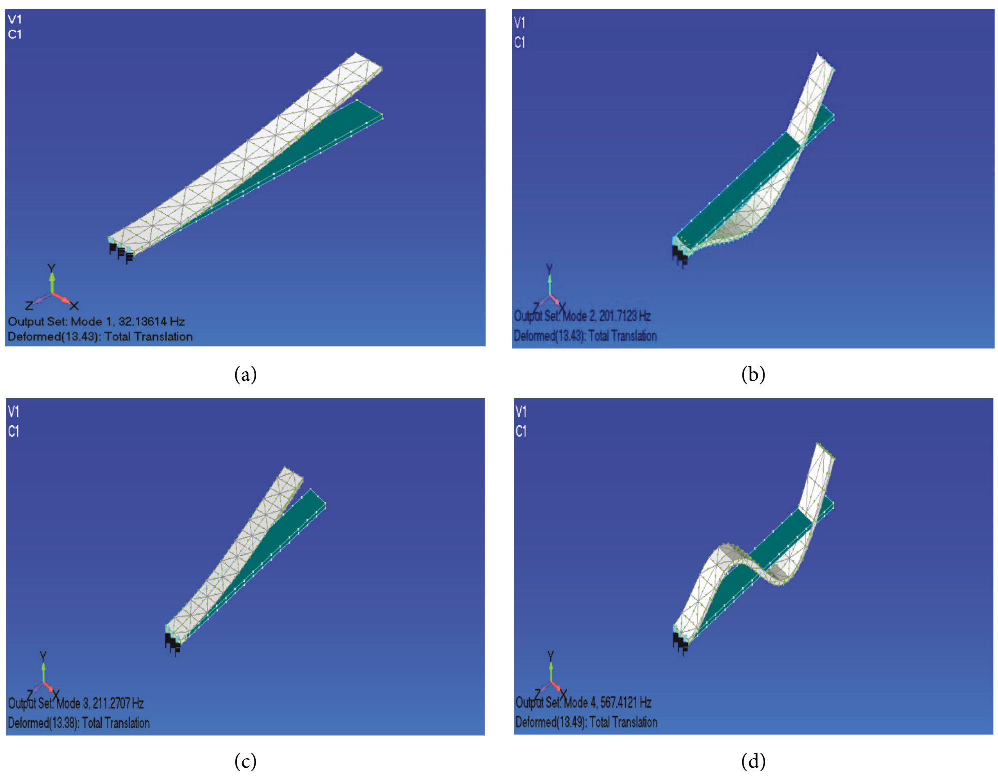


FIGURE 11: Vibration analysis of 50/50% glass/epoxy composite plate. (a) Mode 1, (b) Mode 2, (c) Mode 3, (d) Mode 4.

From the above graph, $fn = 37.02$ Hz

$fn1 = 35.610$ Hz

$fn2 = 37.610$ Hz

Damping coefficient, $\xi = (fn2 - fn1)/2fn, \xi = 0.030$

Logarithmic decrement, $\delta = 2\pi\xi/\sqrt{1 - \xi 2} = 0.19$

The variation of frequency v/s amplitude for the 70/30% glass/epoxy composite plate for mode 1 is as shown in Figure 9(d). The frequency, logarithmic decrement, and damping coefficient for 70/30% glass/epoxy composite for mode 1 can be calculated as follows:

From the above graph, $fn = 47.18$ Hz

$fn1 = 46.34$ Hz, $fn2 = 48.009$ Hz

Damping coefficient $\xi = (fn2 - fn1)/2fn, \xi = 0.019$

Logarithmic decrement, $\delta = 2\pi\xi/\sqrt{1 - \xi 2} = 0.12$

The parameters like dimensions of plate, density, number of layers, and Young's modulus for different compositions of glass/epoxy composite materials are shown in Table 3. Density and Young's modulus of the three-point bending test for different compositions of glass/epoxy composite materials goes on increasing. The density and Young's modulus were found to be increasing as the number of layers of glass/epoxy composition increases. The fixed cantilever beam and beam subjected to vibration are shown in Figure 10.

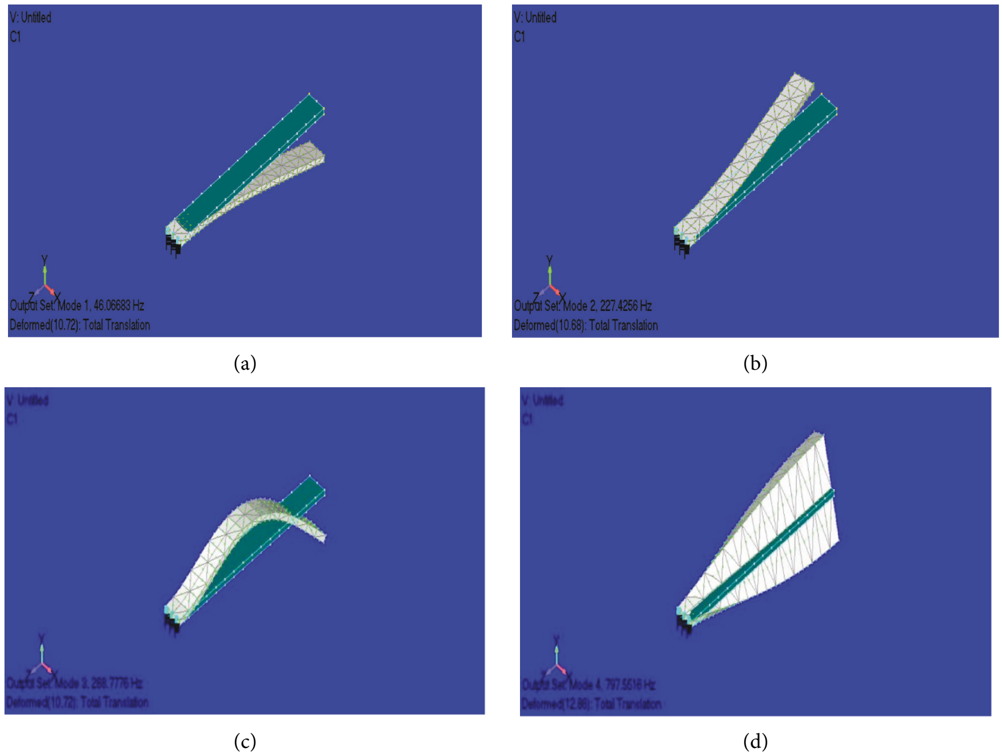


FIGURE 12: Vibration analysis of 60/40% glass/epoxy composite plate. (a) Mode 1, (b) Mode 2, (c) Mode 3, (d) Mode 4.

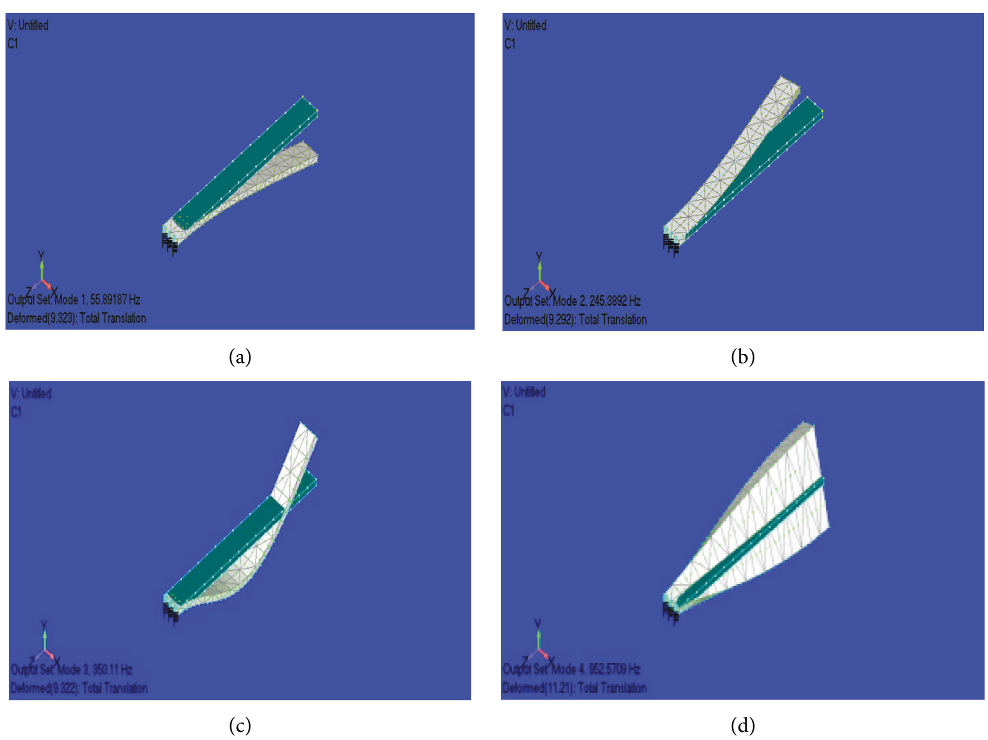


FIGURE 13: Vibration analysis of the 70/30% glass/epoxy composite plate. (a) Mode 1, (b) Mode 2, (c) Mode 3, (d) Mode 4.

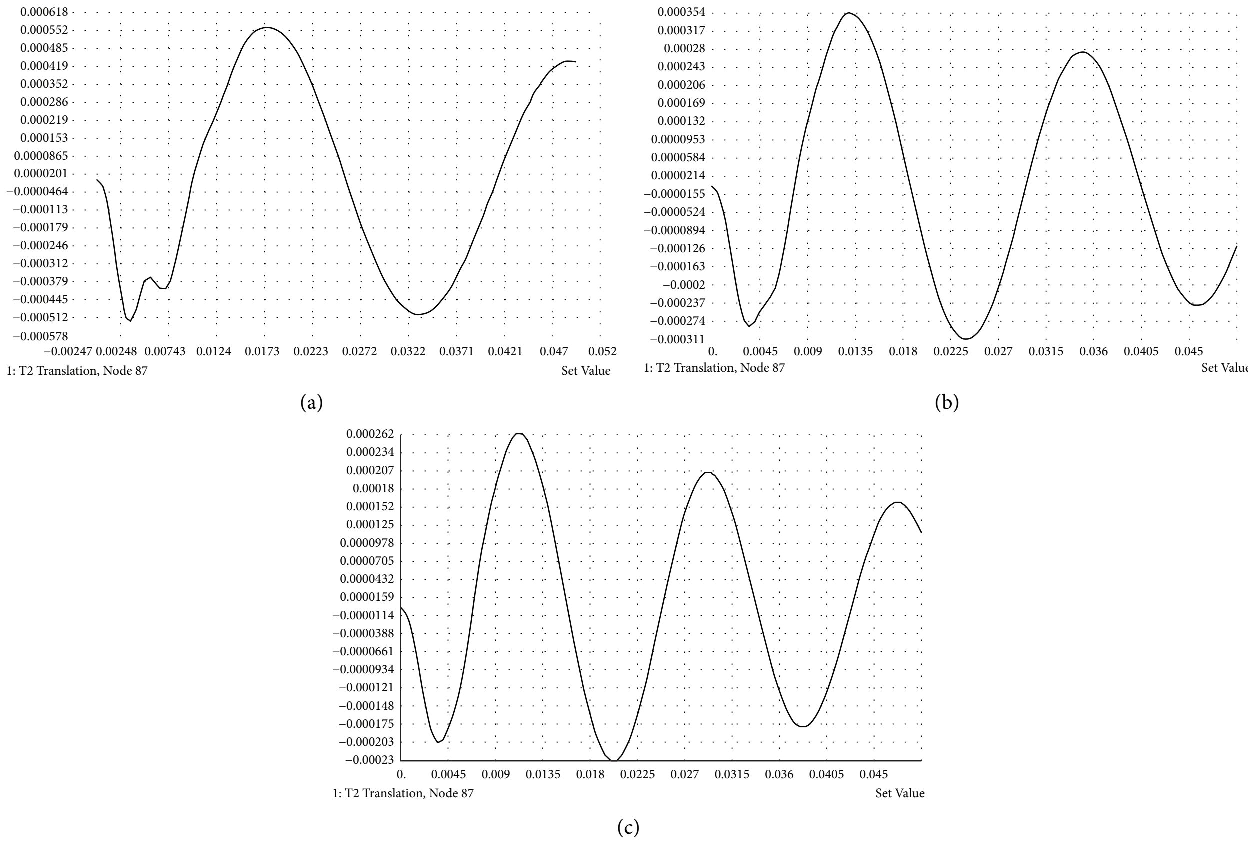


FIGURE 14: Amplitude v/s time for (a) 50-50%, (b) 60-40%, (c) 70/30% glass/epoxy composite plate.

TABLE 4: Values of frequency for mode 1, logarithmic decrement, and damping coefficient.

Composition glass/epoxy	Frequency for mode 1, f_n (Hz)		Logarithmic decrement δ		Damping coefficient ξ	
	Experimental	Analytical	Experimental	Analytical	Experimental	Analytical
50/50%	31.02	32.13	0.28	0.26	0.044	0.042
60/40%	37	46.06	0.19	0.23	0.030	0.036
70/30%	47.18	55.89	0.12	0.18	0.019	0.029

3.2.2. FE Analysis. (1) Vibration analysis of the 50/50% glass/epoxy composite plate.

From Nastran analysis, it is observed from Figure 11 that frequency for mode 1 of 50/50% glass/epoxy composite plate is found to be 32.13 Hz, logarithmic decrement is 0.042, and damping coefficient is 0.26. The logarithmic decrement graph is shown in Figure 14(a). Moment of inertia $I = 5.4 \times 10^{-10}\,\text{m}^4$, angular frequency $\omega n = 201.26$ rad/sec, and natural frequency $fn = 32.08$ Hz. The theoretical and analytical results showed good agreement.

(2) Vibration analysis of the 60/40% glass/epoxy composite plate.

Figure 12 shows the vibration analysis of the 60/40% glass/epoxy composite plate under different modes. From Nastran analysis, it is observed that frequency for mode 1 of the 60/40% glass/epoxy composite plate is found to be 46.06 Hz, logarithmic decrement is 0.036, and damping coefficient is 0.23. The logarithmic decrement graph is shown in Figure 14(b). Moment of inertia $I = 1.06 \times 10^{-10}\,\text{m}^4$, angular frequency $\omega n = 289.15$ rad/sec, and natural frequency $fn = 46.02$ Hz. The theoretical and analytical results showed good agreement.

(3) Vibration analysis of 70/30% glass/epoxy composites.

Figure 13 demonstrates the vibration analysis of the 70/30% glass/epoxy composite plate for different modes. From the analysis, it is observed that frequency for mode 1 of the 70/30% glass/epoxy composite plate is found to be 55.89 Hz, logarithmic decrement is 0.029, and damping coefficient is 0.18. The logarithmic decrement graph is shown in Figure 14(c). Moment of inertia, $I = 1.51 \times 10^{-10}\,\text{m}^4$, angular frequency, $\omega n = 350.97$ rad/sec, and natural frequency, $fn = 55.86$ Hz. The theoretical and analytical results showed good agreement.

From Figure 14(a), for the first cycle $n = 1$, maximum amplitude $X_1 = 0.000563$, minimum amplitude $X_2 = 0.00043$, logarithmic decrement $\delta = 0.26$, and damping coefficient $\xi = 0.042$. From Figure 14(b), for the first cycle $n = 1$, maximum amplitude $X1 = 0.000354$, minimum amplitude

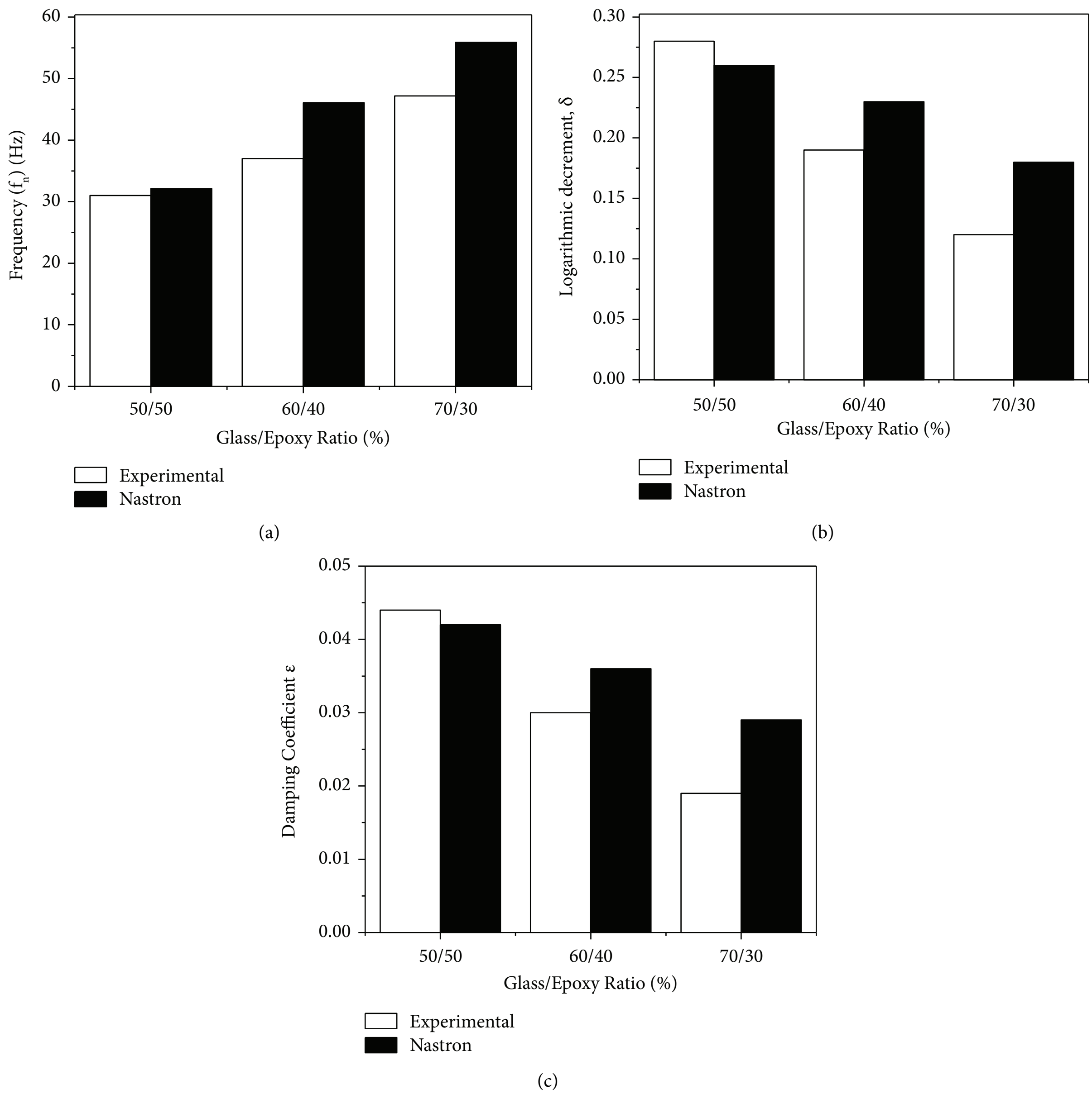


Figure 15: Comparison between the experimental and analytical values of (a) frequency, (b) logarithmic decrement, and (c) damping coefficient for mode 1.

Table 5: Comparison of experimental and analytical frequency values of 50/50, 60/40, and 70/30% composites.

Experimental and analytical frequency values of the 50/50% composite plate				
Frequency (Hz)	Mode 1	Mode 2	Mode 3	Mode 4
Experimental	31.02	278.18	285.23	672.89
Analytical	32.13	201.71	211.27	567.41
Experimental and analytical frequency values of the 60/40% composite plate				
Experimental	37	313.13	346.98	732.47
Analytical	46.06	227.42	288.77	797.55
Experimental and analytical frequency values of the 70/30% composite plate				
Experimental	47.18	369.61	413.82	1030.70
Analytical	55.89	245.38	350.11	952.57

$X2 = 0.00028$, logarithmic decrement $\delta = 0.23$, and damping Coefficient $\xi = 0.036$. From Figure 14(c), for the first cycle $n = 1$, maximum amplitude $X1 = 0.000253$, minimum amplitude $X2 = 0.000208$, logarithmic decrement $\delta = 0.18$, and damping coefficient $\xi = 0.029$.

Values of frequency for mode 1, logarithmic decrement, and Damping coefficient.

The experimental and analytical values of frequency for mode 1, logarithmic decrement, and damping coefficient are shown in Table 4. From the table, it is clear that the frequency increases as number of layers or composition of the glass/epoxy composite material increases, and also, it is observed that logarithmic decrement and damping coefficient values decrease as the number of layers increases. The bar charts of frequency for mode 1, logarithmic decrement, and damping coefficient for different compositions of the glass/epoxy composite material are shown in Figure 15.

3.2.3. Comparison of Frequency Values. The experimental and analytical frequency values for 50/50, 60/40, and 70/30% composites are as shown in Table 5. As the composition of glass/epoxy increases, the frequency values increases. The difference of value between the experimental and analytical value may be due to unwanted noise and sound.

4. Conclusions

The woven glass fiber reinforced epoxy composites were fabricated and were successfully subjected to mechanical and damp-free vibration analysis. From the study, the following conclusions were made:

(1) Mechanical testings revealed that woven glass fiber-reinforced epoxy composites with 60/40% showed noticeable tensile and flexural strength improvements in comparison with other two proportions (50/50 and 70/30%) used in the study.

(2) It was observed from the modal analysis that vibration frequency is higher for composites having q glass/epoxy ratio of 70/30% than the 60/40 and 50/50%. There was a gradual decrease. Also, it was noticed that the logarithmic decrement is maximum for composites having 50/50% and it was decreased for 60/40 and 70/30% glass/epoxy composite plates.

(3) Modal analysis also described that the damping ratio is maximum for composites having 50/50% and it is minimum for 60/40 and 70/30% glass/epoxy composite plates, or in other words, the damping ratio decreases as the number of layers of glass/epoxy composite material increases.

(4) Analytical results obtained from Nastran are found to be in close agreement to experimental results of vibration frequencies, logarithmic decrement, and damping ratio values for 70/30, 60/40, and 50/50% glass/epoxy composites.

Data Availability

All data used to support the findings of this study are included within the article.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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