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Vibration Analysis of Natural Hybrid Composites by Experimental Approach

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Abstract: Presently a-days the composite materials have been supplanted the conventional materials. The utilization of natural fibers in industry so far is little since accessibility of a solid semi-completed item with steady quality is an issue. Late innovative work has shown that these fibers can be enhanced extensively. Realizing that characteristic fibers are low and have a superior firmness for each weight than glass fibers, which brings about lighter parts, the developed enthusiasm for regular strands is spotless. The ecological effect is littler since the common fiber can be reused and strands originate from a sustainable asset. Their direct mechanical properties control the strands from utilizing them in cutting edge applications, however for some reasons they can contend with glass fibers. This show test contemplate goes for taking in the Dynamic investigation of arbitrarily situated blended cross breed regular fiber support polymer composite material, for example, sisal and banana fibers with epoxy resin(ER) as a lattice in car applications. The test examples must be set up according to ASTM D3039 D3039 Standard by changing volume division (B30S20, B20S30, B25S25, and B15S35). The examples are tried tentatively for mechanical properties, for example, ductile and modular examination with the assistance of MEScopeVES.

1.Introduction

Conventionally in automotive, aerospace and packaging industries synthetic fibre reinforced composites are widely used because of their greater strength and stiffness. But they are expensive and not eco-friendly. So, of late natural fibres are replacing synthetic fibres which are extensively used as reinforcements in composites and these materials are gaining popularity as potential structural materials because they are abundantly available renewable, sustainable, biodegradable, non-abrasive, light weight, economical and eco-friendly^[1]. Due to population explosion, there is a constant need for new materials which are renewable, economical and sustainable. Natural fibres are reinforced composites constitute one such group of materials ^[2].



Table 1.1 Properties of Natural Fiber.

Type of fiber	Density (g/cm ³)	Elongation (%)	Tensile strength (MPa)	Young's modulus (GPa)	Specific gravity	Specific modulus (GPa)
Sisal	1.3-1.6	1.9-15	400-700	8.5-40	1.45	6.5-30.8
Banana	0.5-1.5	2.4-3.5	711-789	4.0-32.7	1.1-1.2	3.6-27.3

2. Literature Review & Objective

Modal analysis is a study of dynamic properties of a structure under vibration. It is well known that any structure can resonate, that is small forces can result in a large deformation due to which damage can be induced in the structure. The majority of structures can be made to resonate or to vibrate with an oscillatory input of frequency same as the natural frequency of the structure. Resonant vibration is mainly caused by an interaction between the inertial and elastic properties of the materials within a structure. To better understand any structural vibration problem, the resonant frequencies of a structure need to be identified and quantified. Today, modal analysis has become a widespread means of finding the modes of vibration of a structure.

To better understand the concepts involved in modal analysis consider the example of a simple plate with an accelerometer mounted on one end and a force applied to other end. The force applied to this plate is sinusoidal in nature with constant amplitude but the frequency of oscillation is increased in a timely manner and the vibration response of the plate is monitored with help of the accelerometer, now when the output response of the plate is measured and a graph of amplitude of the plate vibration as a function of time is plotted. It is very interesting to notice the amplitude of vibration increases even though the input force amplitude is kept constant this indicates the amplitude of vibration is also dependent on the frequency of excitation. When Fourier transform is applied to the time domain plot we will get the frequency plot, with which a clearer pattern emerges and the frequencies at which the vibration amplitudes are maximum can be determined the frequency plot. **K. Senthil Kumar, I. Siva, P. Jeyaraj**, carried work on Dynamic Behaviors of Banana and Sisal Hybrid Composites Reinforced With Epoxy, an experiment has been conducted to determine the effect of banana fiber and effect of different volume fraction, vibration analysis parameters such as Natural frequency and mode shapes of Banana and Sisal fibers reinforced with epoxy resin Lapox L-12, it has indicated that banana fibers makes ductile in nature for the final product. **Mukherjee P.S. and Satyanarayana, K.G** carried research work on Dynamic Behaviors of Jute and Sisal Hybrid Composites Reinforced with Epoxy. The hybrid jute-sisal specimens are prepared by hand lay-up method using untreated woven jute and sisal as reinforced materials and commercially available polyester resin as a matrix material. A cantilevered rectangular symmetric plate of hybrid jute-sisal fabric reinforced polyester composite having aspect ratio of 0.83 with 5 layers of cloth for hybrid jute-sisal laminate with fibre direction orientation at $[+90^\circ/+45^\circ/0^\circ/-45^\circ/-90^\circ]$ laminate is prepared. In the analysis, a frequency domain model is used along with Frequency Response Function (FRF) measurements obtained from the plate but the jute fibers haven't given significant results for damping properties for automobile application. **K.L. Pickering a, M.G. Aruan Efendya**, reviewed a recent developments in natural fiber composites and their mechanical performance recently, there has been a rapid growth in research and innovation in the natural fiber composite (NFC) area. Interest is warranted due to the advantages of these materials compared to others, such as synthetic fiber composites, including low environmental impact and low cost and support their potential across a wide range of applications. Much effort has gone into increasing their mechanical performance to extend the capabilities and applications of this group of materials.

In this paper the experimental investigation on Sisal & Banana Fiber reinforced composites could offer some interesting results. This paper reports the fabrication of the hybrid composites with different percentage of fibers and the on these specimens different tests were conducted according to ASTM D3039 standard with these tests mechanical properties were revealed

3. .Methodology

Specimen Preparation: All specimens are made in study are made by hand lay-up process the mould box uses in study are made up of metal $300 \times 300 \times 3$. Untreated banana and sisal fibers are used as reinforce material are chopped in 30mm of length & Properly weighed as per volume calculations. Hardener and resin with weight ratio of 10:1 and by using compression moulding method by the known weight ratio of resin, and hardener mixer was stirred 3-5 minute. Then mixture of fibers is added. The combined mixture is poured into the mould and flattened by the roller to level the surface. Then 100 Bars pressure was applied on the mould to compress the laminates uniformly. After allowing 24 hour of curing the composite was removed from the mould then these laminates were cut in the size of $50 \times 200 \times 3 \text{ mm}^3$ for bending test, twisting test, and double bending test.



Figure 3.1 Moulded Specimens.

Finally the composite were obtain as shown in figure above and post-cured at room temperature for 10 days. Silicon spray, mould releasing agent was used to fascinate easy removal of the specimen from mould box. Specimen of suitable dimension of $50 \times 200 \times 3 \text{ mm}$ were cut using ban saw for dynamic testing. Utmost care was taken to maintain uniformly and homogeneity of the composite. The detail composition and designation of the composites are mention in table3.1.

Table 3.1 Designation and Compositions

Composite (specimen)	Sisal fiber (Wt. %)	Banana fiber (Wt. %)	Resin (Wt. %)
Case 1 (A1,A2)	35	15	50
Case 2 (B1,B2)	30	20	50
Case 3 (C1,C2)	20	30	50

Case 4 (D1,D2)	25	25	50
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Cutting of Laminates into Samples of Desired Dimension

A band saw blade was used to cut each laminates in to smaller piece and precise cutting is done with carpentry tool such as try square and chisel. Dynamic test sample was cut into rectangular shape (50*200) in according with ASTM D3039 standards.



Figure 3.2 Cut out Specimen (50*200)

Dynamic Testing

Dynamic test is carried out from research laboratory at NAL Bangalore. The setup is shown in figure 3.3. USB carrier for DAQ (Cdaq-9174, Compact DAQ chassis (4 slots USB))

- Accelerometer (PCB general purpose 10mV/g)



Figure 3.3 Dynamic Testing Setup.

The standard methods are followed while preparing the specimen for experimental. At least eight replicated specimen with different fiber composition are tested & the result were presented as an avg. of test specimens. The test was conducted at standard laboratory. The specimens were loaded with sensors for the determination of the natural frequency and damping factor. This vibration data used to identify the beam fundamental mode of vibration. MEscapeVes software is used to measure and record the beam vibration and to analysis the natural frequency graph. This has been done by fixing the specimen on a rigid support with one of its side free to vibrate as a cantilever beam. The impact hammer was used to the input load (pulse) to the specimen and the spectrum analyser was set from 0Hz-100Hz. The output is captured by accelerometer together with the input signal were amplified and original damping ratio were calculated from vibration waveform obtain.

4.Results

4.1 Case I

Specimen A1: Analysis of Sisal 35%, Banana 15% and Resin 50%

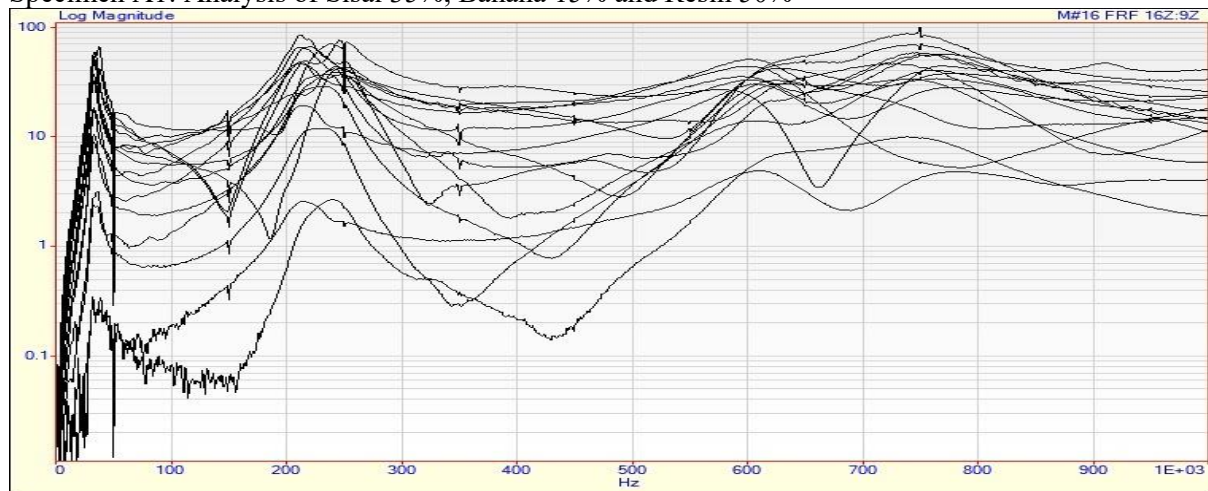


Figure 4.1 Magnitude v/s Frequency

Table 4.1 Shape Table

Mode No.	Frequency (or Time)	Damping	Units	Damping (%)
01	33.7	2.53	Hz	3.51
02	215	13.9	Hz	3.86
03	244	9.21	Hz	3.77

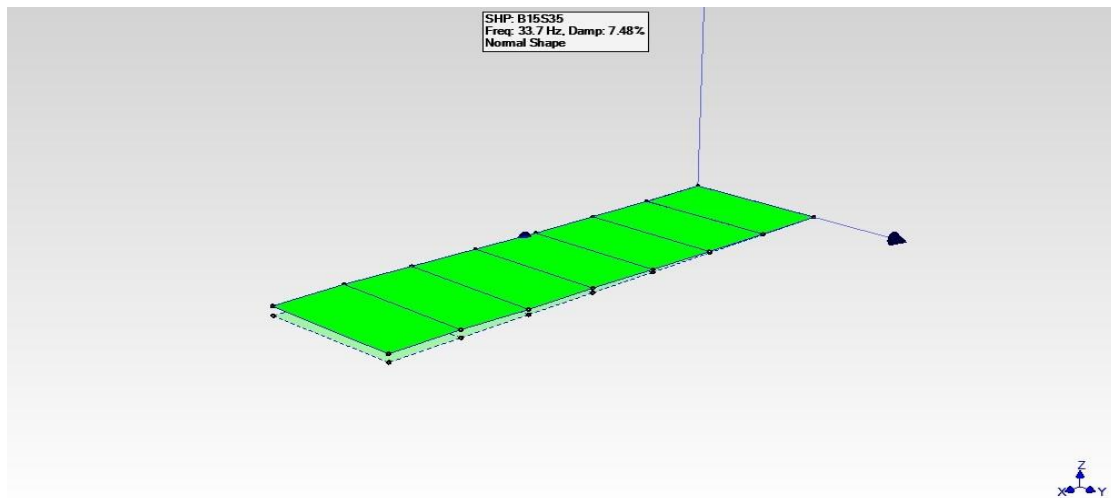


Figure 4.2: Bending Mode

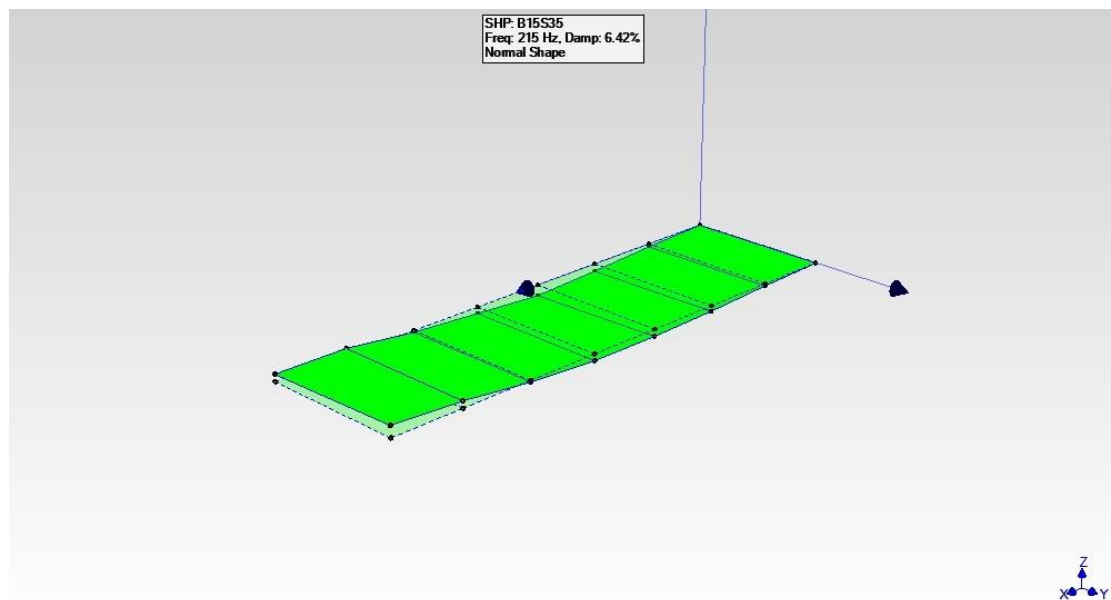
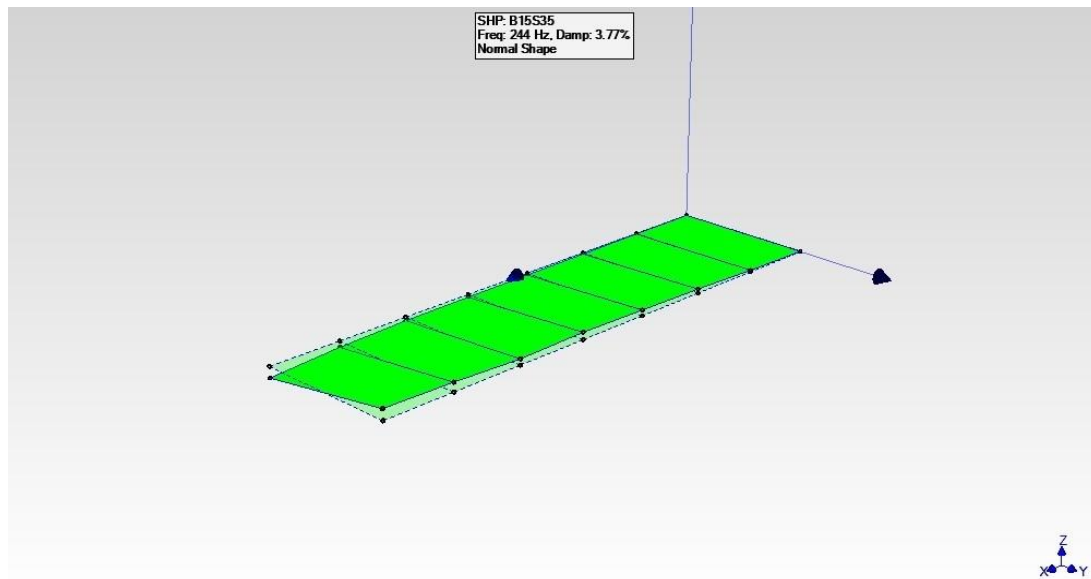


Figure 4.3: Double Bending Mode

**Figure 4.4:** Twisting Mode

Specimen A2

Analysis of Sisal 35%, Banana 15% and Resin 50%

Table 4.2 Shape Table

Mode No.	Frequency (or Time)	Damping	Units	Damping (%)
01	32.8	2.41	Hz	3.91
02	219	18.1	Hz	4.1
03	253	5.56	Hz	2.2

The average natural frequency value obtained for specimen A for Mode 1 is 33.25 Hz, Mode 2 is 217 Hz and Mode 3 is 248.5 Hz. The average damping ratio for Mode 1 is 3.7%, Mode 2 is 3.98% and Mode 3 is 2.98%.

4.2 Case II

Specimen B1: Analysis of Sisal 30%, Banana 20% and Resin 50%

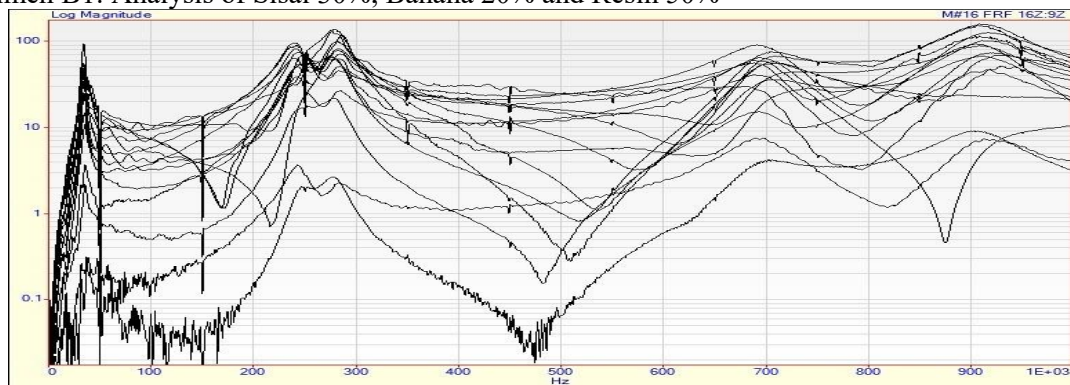
**Figure 4.5** Magnitude v/s Frequency

Table 4.3 Shape Table

Mode No.	Frequency (or Time)	Damping	Units	Damping (%)	Label	MPC
01	34.8	1.55	Hz	4.45	Global-Poly	0.859
02	243	11.7	Hz	4.8	Global-Poly	0.983
03	282	4.94	Hz	1.75	Global-Poly	0.913

Specimen B2

Analysis of Sisal 30%, Banana 20% and Resin 50%

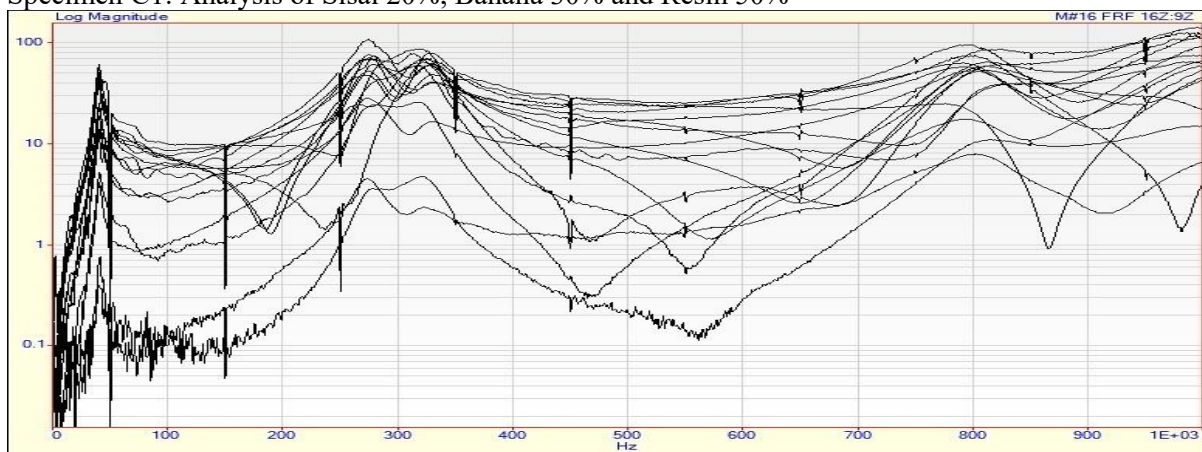
Table 4.4 Shape Table

Mode No.	Frequency (or Time)	Damping	Units	Damping (%)	Label	MPC
01	35.8	1.33	Hz	3.72	Global-Poly	0.818
02	237	10.5	Hz	4.44	Global-Poly	0.973
03	289	13.8	Hz	4.77	Global-Poly	0.978

The average natural frequency value obtained for specimen A for Mode 1 is 35.3 Hz, Mode 2 is 240 Hz and Mode 3 is 285.5 Hz. The average damping ratio for Mode 1 is 4.08%, Mode 2 is 4.62% and Mode 3 is 3.26%.

4.3 Case III

Specimen C1: Analysis of Sisal 20%, Banana 30% and Resin 50%

**Figure 4.6** Magnitude v/s Frequency**Table 4.5** Shape Table

Mode No.	Frequency	Damping	Units	Damping
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	(or Time)			(%)
01	40.6	2.32	Hz	7.33
02	273	15.4	Hz	5.62
03	320	16	Hz	4.97

Specimen C2: Analysis of Sisal 20%, Banana 30% and Resin 50%

Table 4.6 Shape Table

Mode No.	Frequency (or Time)	Damping	Units	Damping (%)	Label	MPC
01	35.8	2.81	Hz	6.64	Global-Poly	0.994
02	227	15.6	Hz	6.84	Global-Poly	0.975
03	285	18.8	Hz	6.57	Global-Poly	0.987

The average natural frequency value obtained for specimen A for Mode 1 is 38.2 Hz, Mode 2 is 250 Hz and Mode 3 is 302.5 Hz. The average damping ratio for Mode 1 is 6.98%, Mode 2 is 6.23% and Mode 3 is 5.77%.

4.4 Case IV

Specimen D1: Analysis of Sisal 25%, Banana 25% and Resin 50%

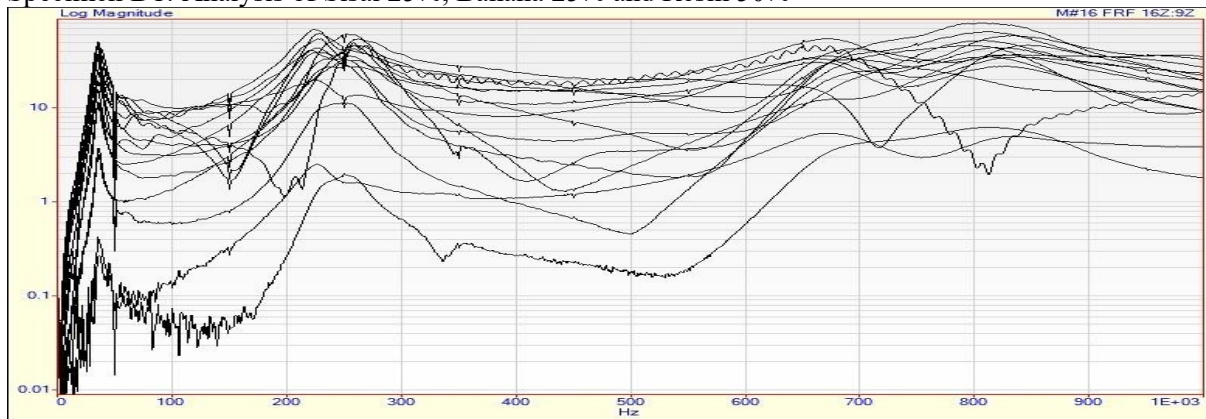


Figure 4.7 Magnitude v/s Frequency

Table 4.7 Shape Table

Mode No.	Frequency (or Time)	Damping	Units	Damping (%)	Label	MPC
01	35.7	2.62	Hz	7.10	Global-Poly	0.845
02	225	15	Hz	6.62	Global-Poly	0.876
03	258	9.98	Hz	3.86	Global-Poly	0.963

Specimen D2: Analysis of Sisal 25%, Banana 25% and Resin 50%

Table 4.8 Shape Table

Mode No.	Frequency (or Time)	Damping	Units	Damping (%)	Label	MPC
01	38	2.53	Hz	6.41	Global-Poly	0.92
02	262	17.3	Hz	6.59	Global-Poly	0.972
03	288	15.4	Hz	5.33	Global-Poly	0.968

The average natural frequency value obtained for specimen A for Mode 1 is 36.85 Hz, Mode 2 is 243.5 Hz and Mode 3 is 273 Hz. The average damping ratio for Mode 1 is 6.76%, Mode 2 is 6.60% and Mode 3 is 4.59%.

5. Discussions

Table 5.1 Dynamic analyses of Sisal and Banana fibers of 35-15%, 30-20%, 20-30% & 25-25%

Mode No	Case 1 S-B (35-15%)		Case2 S-B (30-20%)		Case3 S-B (20-30%)		Case4 S-B (25-25%)	
	Natural frequency In Hz	Damping Ratio %	Natural frequency In Hz	Damping Ratio %	Natural frequency In Hz	Damping Ratio %	Natural frequency In Hz	Damping Ratio in %
1	33.25	3.7	35.3	4.08	38.2	6.98	36.85	6.76
2	217	3.98	240	4.62	250	6.23	243.5	6.60
3	248.5	2.98	285.5	3.26	302.5	5.77	273	4.59

Mode 1: Bending.

Mode 2: Double bending'

Mode 3: Twisting.

By considering all types of volume fractions for the natural hybrid composite of different volume fractions (35-15%, 30-20%, 20-30% and 25-25%) gives a damping factor range of 3.98, 4.62, 6.98 and 6.76 respectively. Therefore the volume fraction of Sisal & Banana fibers 20-30% shows maximum damping ratio of 6.98. By considering different volume fractions for the hybrid composite of Sisal and Banana fibers with different volume fractions of 35-15%, 30-20%, 20-30% and 25-25% gives the

first natural frequencies of 33.25 Hz, 35.30 Hz, 38.2 Hz and 36.25 Hz respectively. Therefore the volume fraction of Sisal and Banana fiber 35-15% show minimum natural frequency of 33.25 Hz.

6. Conclusion

Natural fibers are relatively economical to purchase and fabricate. Compression moulding technique is used to fabricate the natural hybrid composite made by sisal and banana to investigate the free vibration characteristics.

The natural frequencies for specimen A, B C & D are shown in table 5.1, it is observed that for CASE I the first natural frequency is low & for the CASE III the value is large, It shows that as the % of banana fiber increases the material behaves more in to ductile and the increase in natural frequency is observed, similarly for next set of natural frequencies also. But the mode shapes looks similar for all the 3 cases. The damping ratio observed to be more in CASE III because of higher ratio of banana fibers.

For application, when damping ratio is below 10% then such materials will be used in for structural application and if damping ratio is in the range of 20-25% then materials are used in automobile suspension, if it's greater than 30% then it will be utilized in heavy duty suspension.

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