

# EXPERIMENTAL INVESTIGATION OF MECHANICAL AND DYNAMIC CHARACTERISTICS OF HYBRID NATURAL FIBER COMPOSITE

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## ABSTRACT

From decades, natural fibers in the form of reinforcements in polymer composites have been a test subject for scientists because of its growing familiarity wide range of applications. Banana (B) and Sisal(S) fibers are in good potential as reinforcement is polymer composite. The hybridisation of short Banana and Sisal fibers produces good properties compared to only Banana fiber. In this present work, an experimental study has been conducted to determine the effect of only banana fiber and effect of volume fraction namely B-S 20-20%, B-S 30-10% and B-S 10-30% on vibrational analysis parameters such as Natural frequency, damping ratio and mode shapes of Banana and Sisal fibers reinforced with epoxy resin Lapox L-12 using FFT analyzer. The nodes created on the test specimen is hit by an impact hammer causes the vibration which is detected by the sensor and converted in to V,I signal through transducer. These signals are amplified and magnified by signal conditioner generates the FRF curve and mode shapes.

**KEYWORDS** – Banana fiber, Sisal fiber, Lapox L-12, Alkaline treatment, Volume fraction, Natural frequency, Damping ratio, Mode shapes.

## INTRODUCTION

Now a day's polymeric materials are used in almost all the applications because of their specific characteristics such as light weight, self-lubrication capability and reduced noise. Natural fiber is advantageous over synthetic fibers as they are renewable, eco-friendly, low in density, biodegradable and less abrasive. The abundant availability of natural fibers and ease in composite manufacturing has triggered the interest among the researchers to study about their dynamic behaviours under hybrid reinforcement polymers. Vibration in the structure leads to hazardous effects like noise, losing of fastener and damaging of structure/machine components. To minimize the effect of vibration we need study the vibrational behaviours of the structure.

Short hybrid Banana and Sisal fibers serving as reinforcement fiber in most of the plastic matrix has shown its significant role as it is cheap, exhibiting superior properties when compared to other natural fiber.

A.E. Ismail et al [1] Studied on the dynamic characteristics of coconut fiber reinforced composites. K. Senthil Kumar et al [2] Synergy of Fiber Length and Content on Free Vibration and

Damping Behaviour of Natural Fiber Reinforced Polyester Composites Beams. Sudev. L.J et al [3] Experimental Study of Dynamic Behaviour of Hybrid Jute/Sisal Fiber Reinforced Polyester Composites. Singiresu S. Rao [4] Mechanical Vibrations” Fifth Edition.

## EXPERIMENT

### Materials

Banana fiber is extracted from stem of Banana plant by crushing method supplied from Gagana Enterprises, Shimoga, and Karnataka. Sisal fiber is extracted from leaf of Sisal plant by decortication method supplied from Chandra Prakash. Co, Jaipur, Rajasthan. Epoxy resin Lapox L-12 and hardener K-6 was supplied from UG enterprises, Bangalore, Karnataka.

### Chemical treatment

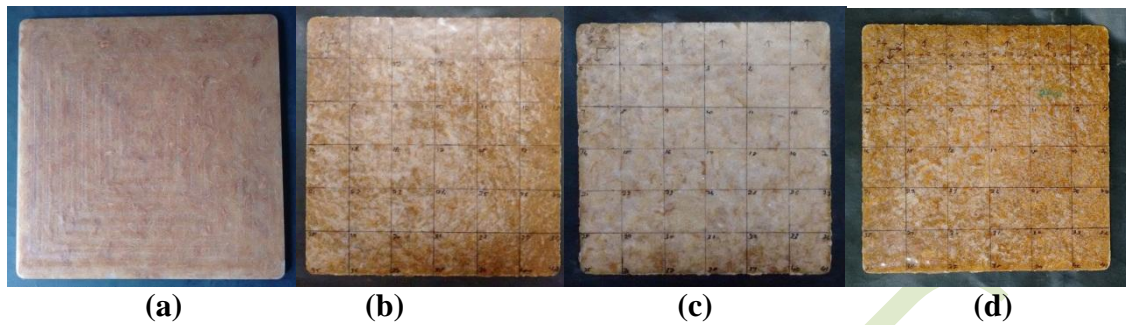
Alkali treatment or mercerization using sodium hydroxide (NaOH) is the most commonly used treatment for bleaching and cleaning the surface of natural fibers to produce high quality fibers. 5% NaOH solution was prepared using sodium hydroxide pellets and distilled water. Banana and Sisal fibers were dipped in the solution separately for 1 hour. After 1 hour fibers were washed with 1% Hcl solution to neutralize the fiber. Then it is washed with distilled water and kept in hot air oven for 3 hours at 65-70°C.

### Preparation of composite and sample

All specimens in this study were manufactured by hand layup technique. The mould that was used is made from poly propylene with dimension of  $250 \times 250 \times 5 \text{ mm}^3$  is shown in the figure. The chemical treated Banana and Sisal fibers are chopped into 10 mm length and properly weighed as per different volume fractions calculation. The epoxy resin and hardener is mixed with a ratio of 10:1 and stirred well for 5 to 10 min. While stirring, the mixture of fibers is added. Then the combined mixture is poured into the mould and flattened by the roller to level the surface. Place the release film on the mould and apply load on the mould to solidify, the solidification process takes place in 24 hours, then the laminate is released from the mould. The composite laminate of only Banana fiber and with different volume fractions are shown in figure. The vibrational analysis sample of dimension  $250 \times 250 \times 5 \text{ mm}^3$ ,



Fig 1.1 Mould dimension  $250 \times 250 \times 5 \text{ mm}^3$

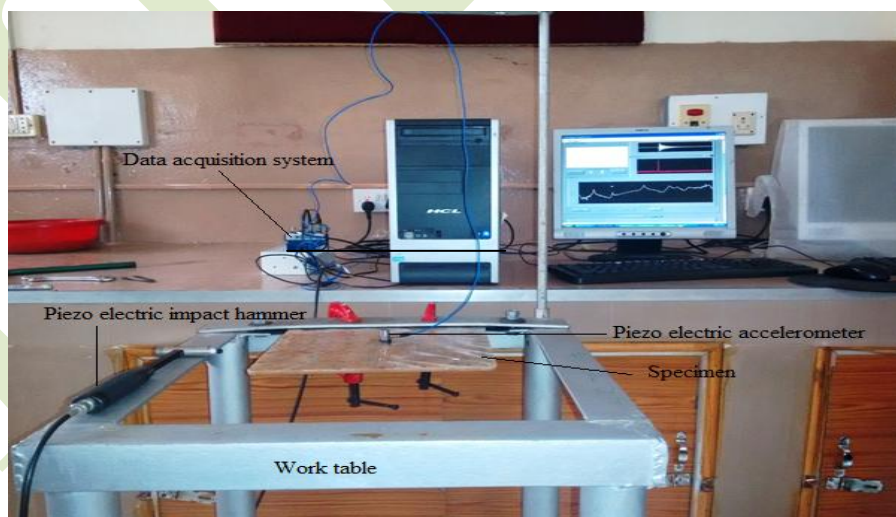


**Fig 1.2 Dynamic specimen (a) B-S 20-20% (b) B-S 30-10% (c) B-S 10-30% (d) B 40%**

### FFT analyzer dynamic test

Dynamic tests were carried out by using a FFT analyzer. Four samples namely B-S 20-20%, B-S 30-10%, B-S 10-30% and B 40%. The nodes are drawn on the test specimen is fixed to the work table with the help of C-clamp. In vibrational analysis these nodes are hit by using an impact hammer which causes the vibration of the specimen. The sensor placed in the exact centre of the specimen detects the physical motion of the body and converts to V,I signals through transducer. These V,I signals are amplified and magnified by signal conditioner generate the FRF curve in the Lab VIEW 2009 software which is displayed on the screen.

In modal analysis, required data is selected which generates the graph with both original and synthesised wave forms in between the co-ordinate of FRF magnitude and frequency. Adjust the line of curve fitting to make co-ordinate of synthesized wave to original wave to get higher peak with in a frequency range of 350 Hz. The values at the higher peaks are considered. These values indicates 4 major mode shapes namely (a) bending mode, (b) twisting mode, (c) double bending mode and (d) combined bending and twisting mode, shown below. The 3-D modal structure shows the process of deformation from original position of the specimen.



**Fig 1.3 FFT analyzer setup**

## RESULT AND DISCUSSION

By considering all types of volume fraction and Banana fiber gives a damping factor of 1.751. The hybrid composite of Banana and Sisal fibers with different volume fractions of 30-10%, 20-20% and 10-30% gives a damping factor of 3.681, 2.057 and 1.911 respectively. Therefore the volume fraction of Banana and Sisal fibers 30-10% shows maximum damping factor of 3.681.

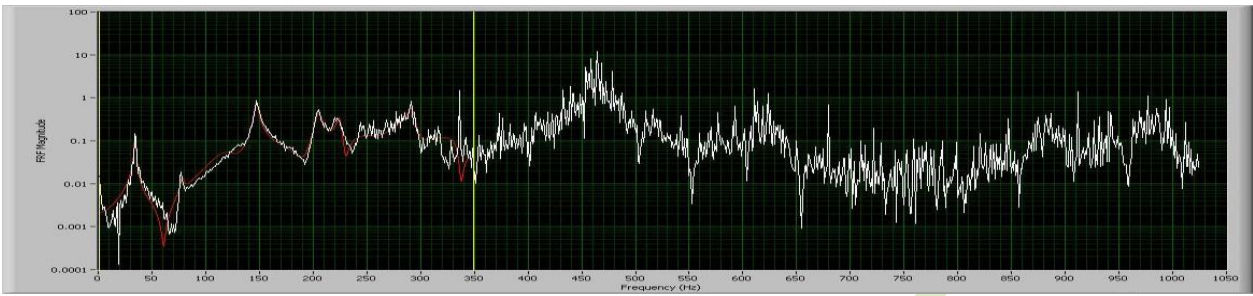
By considering all types of volume fraction and Banana fiber gives a natural frequency of 35.886 Hz. The hybrid composite of Banana and Sisal fibers with different volume fractions of 20-20%, 10-30% and 30-10% gives the natural frequencies of 34.312 Hz, 34.438 Hz and 34.868 Hz respectively. Therefore the volume fraction of Banana and Sisal fiber 20-20% show minimum natural frequency of 34.312 Hz.

**Table 1.1 Modal analysis of Banana and Sisal fibers of B-S 20-20%, B-S 30-10%, B-S 10-30% and B 40%**

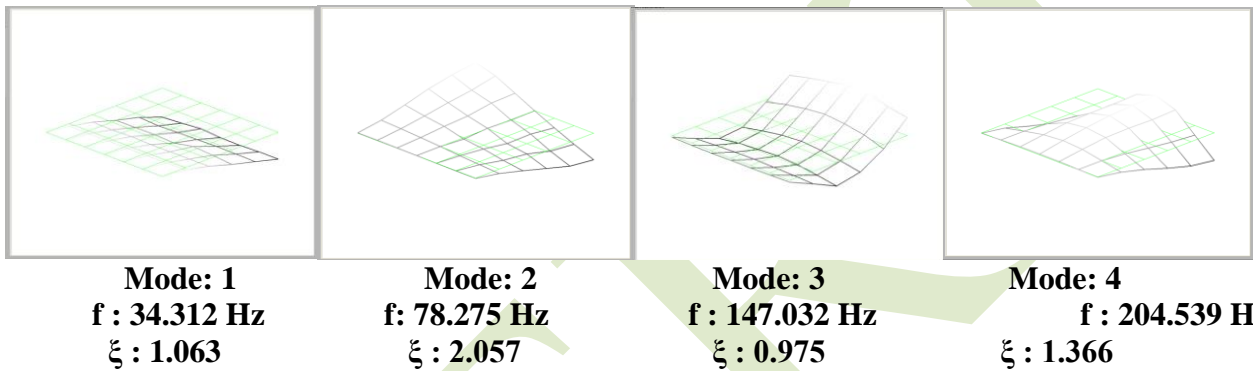
Sl no	Specimen	Mode no	Natural Frequency (f) in Hz	Damping ratio ( $\xi$ ) in %	FRF magnitude = Acceleration/Force in m <sup>2</sup> /s-N	Phase angle in Deg
1	B-S 20-20%	1	34.312	1.063	0.122	160.852
		2	78.275	2.057	0.013	3.083
		3	147.032	0.975	1.453	107.522
		4	204.539	1.366	0.327	53.183
2	B-S 30-10%	1	34.868	0.801	0.058	177.575
		2	78.251	0.789	0.022	27.774
		3	151.768	0.614	1.430	139.407
		4	221.922	3.681	1.444	146.798
3	B-S 10-30%	1	34.438	0.945	0.121	146.888
		2	79.326	0.891	0.007	27.626
		3	133.726	1.911	0.725	115.855
		4	178.881	0.891	1.137	140.156
4	B 40%	1	35.886	1.215	0.055	157.195
		2	82.741	1.139	0.053	53.236
		3	136.337	1.000	0.749	114.797
		4	171.806	1.751	0.065	61.146

Where Mode 1: Bending mode, Mode 2: Twisting mode, Mode 3: Double bending and Mode 4: Combined bending and twisting.

**Specimen B-S 20-20%**

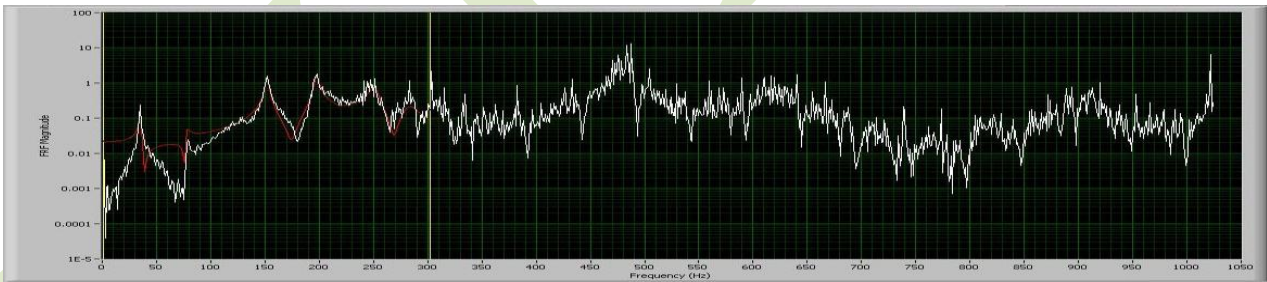


**Fig 1.4 FRF curve for B-S 20-20%**

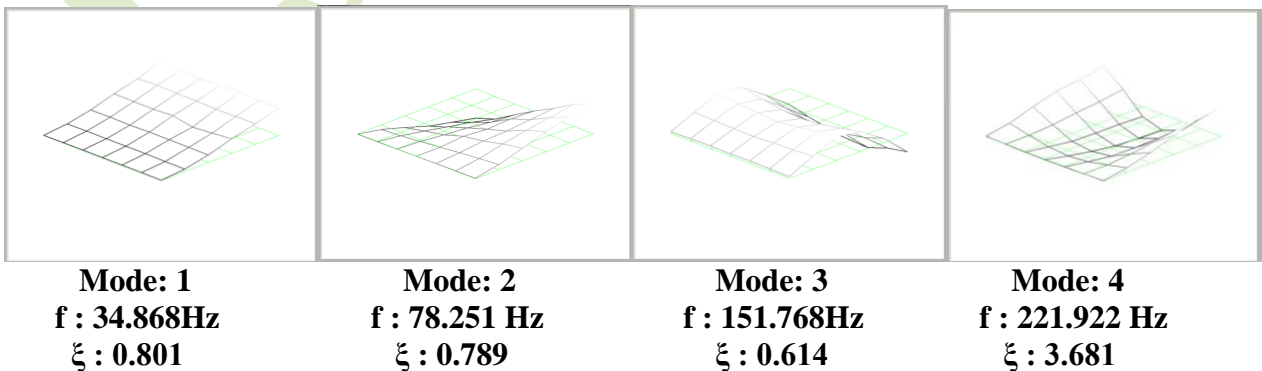


**Fig 1.5 Mode shapes**

**Specimen B-S 30-10%**

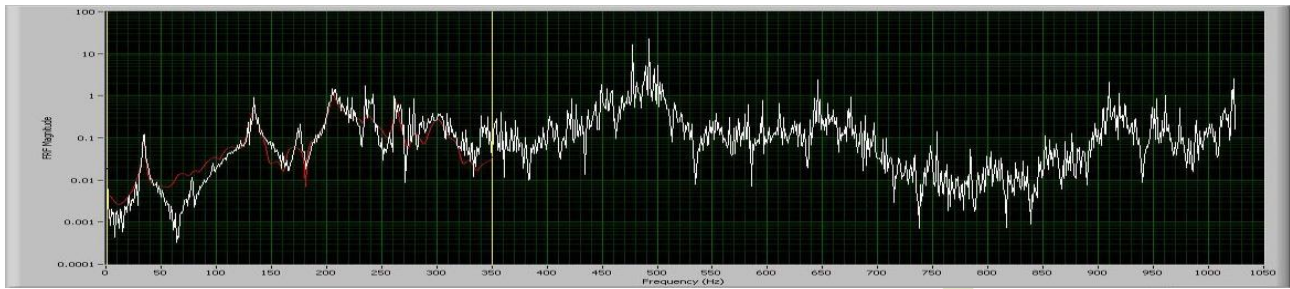


**Fig 1.6 FRF curve for B-S 30-10%**

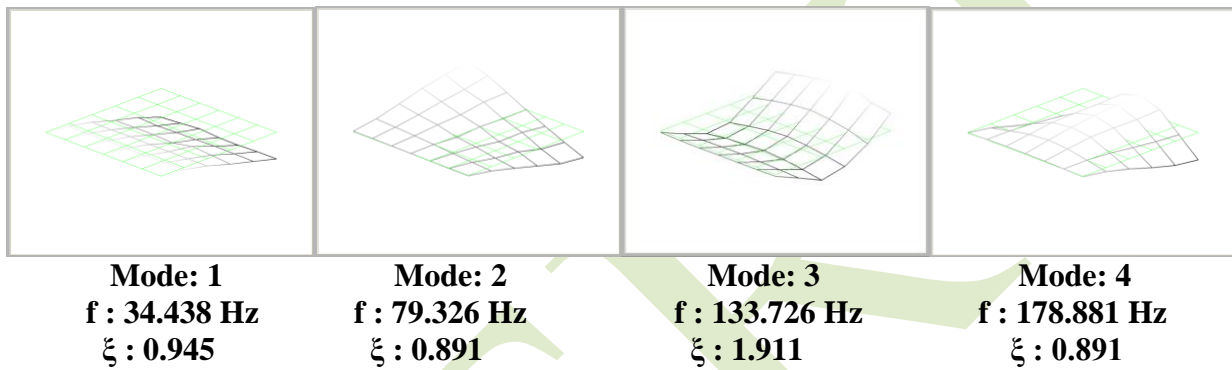


**Fig 1.7 Mode shapes**

**Specimen B-S 10-30%**

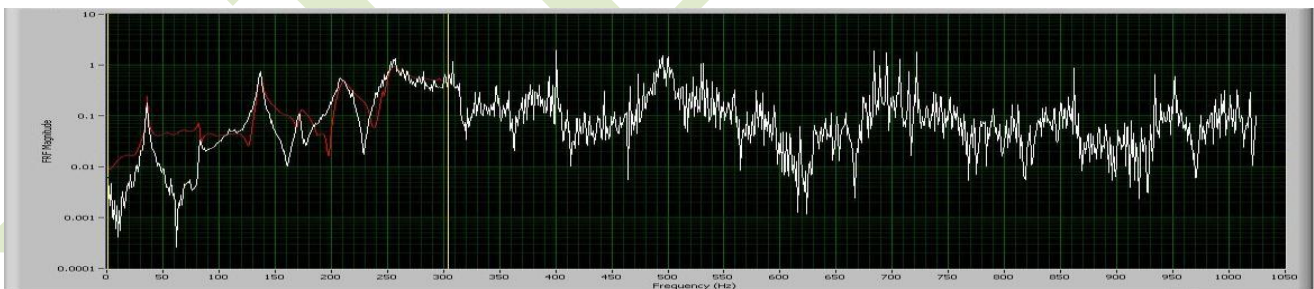


**Fig 1.8 FRF curve for B-S 10-30%**

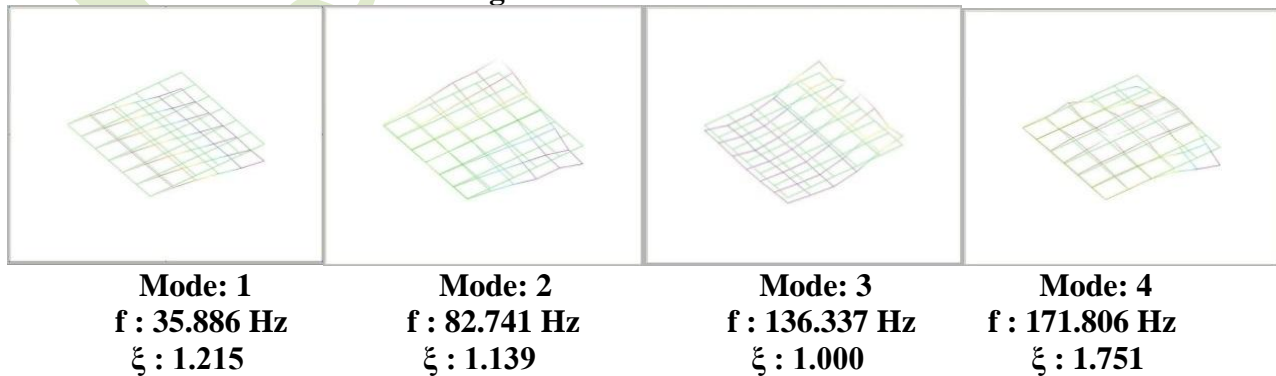


**Fig 1.9 Mode shapes**

**Specimen B 40%**



**Fig 1.10 FRF curve B 40%**



**Fig 1.11 Mode shapes**

## CONCLUSION

Under dynamic characteristics Natural frequency, Damping ratio and Mode shapes are studied. By considering different types of volume fractions, Banana fiber gives a damping factor of 1.751 and hybrid composite of Banana-Sisal fibers with volume fraction B-S 30-10% gives a maximum damping factor 3.681 which is 2.10 times higher than the damping factor 1.751 of Banana fiber laminate and gives better vibrational absorbing capacity. By considering different types of volume fraction and Banana fiber gives a natural frequency of 35.886 Hz and hybrid composite of Banana-Sisal fibers with volume fraction B-S 20-20% gives a minimum natural frequency of 34.312 Hz, gives better mechanical stiffness at reduced mass.

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