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Modal Analysis of Silicon Carbide - Banana Fiber Epoxy Composites using an Experimental Set Up

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***Abstract:** Natural fibers have been used since antiquity to strengthen materials. As of late, they are being used in composites as they are cheaper than the artificial fibers, environment friendly, non-hazardous, As of now, numerous types of natural materials have been examined for use in composites as reinforcement materials such as flax, hemp, jute straw, wheat, stick (sugar and bamboo), grass, reeds, kenaf, ramie, palm, sisal, coir, water hyacinth, pennywort, kapok, banana fiber, pineapple leaf fibers which have found a wide variety of applications. But the organic fiber composites have poor strength than that of inorganic fiber composites.*

To further improve the properties, reinforcements such as metals or alloys in the form of either whiskers or in the form of particles are introduced into the composites thereby improving their properties and reducing their short comings. This new type of composites combines the properties of both the natural and metallic reinforcements with a unique set of properties that differ from the composites made out of the natural fibers. Also, the resultant composites possess properties that are not found in the individual reinforcements originally.

This work describes the fabrication and the mechanical behaviour of banana fiber reinforced polymer composite at varying fiber composition (25%, 30%,35%) with that of silicon carbide at 4%, 8%, 12% respectively. Also, the test such as the tensile test, hardness test and the bending test are carried out and the mechanical properties of the composite material are studied.

Keywords: Composite, banana fibers, silicon carbide epoxy, Tensile strength, frequency

I. INTRODUCTION

Composite technology has undergone a huge transformation during the past fifty years as evident from the present level of consumption of composite materials nearly approaching 2.5 MT per year, which sows their tremendous potential in various fields ranging from structural materials in construction to automobile bodies due to their light weight and high specific strength. Currently, there are about 50,000 composite products that are available for use in an array of applications in diverse sectors of the industry all over the world.

It is found that all the hybrid natural fiber composites show maximum mechanical properties for 40-50% of the fiber reinforcements. The hybridization also increases the mechanical properties [1]. The effect of fiber content and alkali treatment on mechanical properties of roystonea regia-reinforced epoxy partially biodegradable composites and showed that alkali treatment of natural fibers improves the overall properties thereby enhancing the properties of the composite [2]. The hybridization process can increase the mechanical properties of single FRP composites and reduced its limitations. Mechanical properties of natural FRP composite are found to increase due to incorporation of either synthetic fiber or natural fiber having comparably high elongation [3-4]. In dynamic mechanical analysis, Laly et al [5] have investigated banana fiber reinforced polyester composites and found that the optimum content of banana fiber is around 40% for good strength properties. studies show that the hybridization of the natural fibers provides considerable improvement of tensile strength when compared to individual reinforcement; this is mainly due to transfer of loads and shearing of loads among the fibers [6].

II. MATERIALS AND METHODS

Banana fibrers were obtained from Hyderabad, Telangana, India. The fiber has a diameter of 0.005- 0.1 mm. The Epoxy Resin (LY 550) and the hardener (HY 917), and Silicon Carbide (grit 220) are collected from a local supplier. A steel mould having the dimensions 210 mm x 110 mm x 12 mm is used for composite fabrication.

A. Mechanical Properties

1) *Tensile Testing:* Tensile test specimens were made in accordance with ASTM D638 to measure the tensile properties. The sample was made according to the ASTM standards. The samples were tested at a cross-head speed of 0.5 mm/min and the strain was measured using an extensometer

2) *Flexural Testing:* Three-point bend tests were performed in accordance with ASTM D 638 to measure flexural properties. The specimen made according to the ASTM standard. In three-point bending test, the samples were tested at a strain rate of 0.5 mm/min. A three-point bend tested was chosen because it requires less material for each test and eliminates the need to accurately determine center point deflections with test equipment.
3) *Modal Testing:* Modal testing of the specimen is performed using a Vibration Testing Machine using D 638-08. In modal testing the frequency response search is performed in the frequency range of 200-2000Hz at the rate of 1 octave/min.

III. FINITE ELEMENT ANALYSIS USING ANSYS

A. Introduction

Finite Element Analysis (FEA) is a computer-based method of analysing the behaviour of engineering structures and components under a variety of conditions. It is an advanced engineering tool that is used in design and to augment/replace experimental testing.
The method comprises of three stages

1) Pre-processing, in which the analyst develops a finite element mesh of the geometry and applies material properties, boundary conditions and loads
2) Solution, during which the program derives the governing matrix equations (stiffness x displacement = load) from the model and solves for the displacements, strains and stresses. This is the case in implicit code applications. Alternatively, explicit codes can be used, mostly for high strain rate engineering problems.
3) Post-processing, in which the obtained results usually in the form of deformed shapes, contour plots etc. are processed and compared with the standard test results which help to check the validity of the solution.

FEA is widely accepted in almost all engineering disciplines. The method is used as an alternative to the experimental test method which is a costly and time taking process. The technique is based on the premise that an approximate solution to any complex engineering problem can be reached by subdividing the structure/component into smaller more manageable (finite) elements.

B. ANSYS Workbench

ANSYS Workbench environment is an intuitive analysis tool with Graphical User Interface (GUI) that can be used in conjunction with CAD systems. ANSYS Workbench is a software environment for performing structural, thermal, and electromagnetic analyses. Geometry creation and optimization, attaching existing geometry is the special feature of Workbench. Each type of analysis has a separate module which contains the designing, assigning properties, model set up including meshing, application of boundary conditions, applications of loads, solving and post processing processes. For the current study, the module modal analysis is used.

IV. RESULTS AND DISCUSSION

The results of experimental values and analysis of the continuous fiber reinforced epoxy composite are done with mechanical tests and also using software of computational; fluid dynamics. The ratios of samples with Silicon Carbide are matched with banana fibre and then accordingly epoxy ratio is fixed. Table 1 gives the details of the ratio.

Table 1: Ratio of Composition

Samples with different Ratios	Banana Fiber	Silicon Carbide
Sample 1	32%	4%
Sample 2	27%	8%
Sample 3	23%	12%

A. Tensile Test

The specimens (23%, 37%, 32%) are prepared as per the ASTM standards and to find out the ultimate tensile strength as shown in below. The load varies between 2 to 10 KN. And accordingly, values are detailed in Table 2. The Table 2 shows beneficial results in sample 3.

Table 2: Tensile Test Values with Elongation

Samples with different Ratios	Tensile Strength (N/mm^2)	Elongation %
Sample 1	1.414	0.14
Sample 2	3.432	0.211
Sample 3	7.342	0.35

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B. Flexural Test

The specimens (25%, 30%, 35%) are prepared as per the ASTM standards and to find out the flexural strength as shown in below. The Table 3 gives the values obtained. The table 3 shows the beneficial results for sample 3

Table 3: Flexural Test Values

Silicon Carbide (weight %)	E_x (GPa)	E_y (GPa)	E_z (MPa)	G_{xy} (GPa)	G_{yz} (GPa)	G_{xz} (GPa)	Γ_{xy}	Γ_{yz}	Γ_{xz}
4	9.7	1.076	0.485	0.695	0.165	0.466	0.292	0.184	0.173
8	10.37	1.15	0.518	0.743	0.177	0.498	0.2929	0.171	0.192
12	11.155	1.237	0.557	0.799	0.19	0.536	0.314	0.181	0.187

C. Modal Testing

The specimens (25%, 30%, 35%) are prepared as per the ASTM standards and to find out the flexural strength as shown in below. The Table 4 gives the values obtained. The table 4 shows the lowest frequency for sample 3

Table 4: Modal Test Results

Samples with different Ratios	Mode 1 (Hz)	Mode 2 (Hz)
Sample 1	1013.8	1205.5
Sample 2	553.5	713.7
Sample 3	499	585

D. Modal Analysis

The Modal analysis of the samples from 1 to 3 using ANYSYS 16 for the three samples. The results obtained from modal analysis Fig 1-6 show the effect on the frequency of the composite due to the amount of Silicon Carbide in the sample. The composition of Silicon Carbide has major effect on the mechanical properties of the composites like tensile strength and flexural strength and also on the modal frequencies. It can be observed the lowering of the modal frequencies from sample 1 to sample 3 due to the increase in the composition of Silicon Carbide. The modal frequency is lowest in sample 3 compared to the other two samples.

Hexahedral meshing of the model is considered to obtain accurate results. The modal analysis is performed in the frequency range of 200-2000 Hz. Table 5 show the Mode frequencies for three samples. The least mode frequencies can be observed for sample 3.

Table 5: Results from Modal Analysis

Samples with different Ratios	Mode 1 (Hz)	Mode 2 (Hz)
Sample 1	1006.4	1207.8
Sample 2	547	710
Sample 3	489	578

V. CONCLUSIONS

A. From the current experiments results, it has been observed that fiber ratio has major effect on the mechanical properties of the composites like as hardness, tensile strength, flexural strength and impact strength.

B. It has been observed that the better mechanical properties found for composites having banana fiber at 35%.

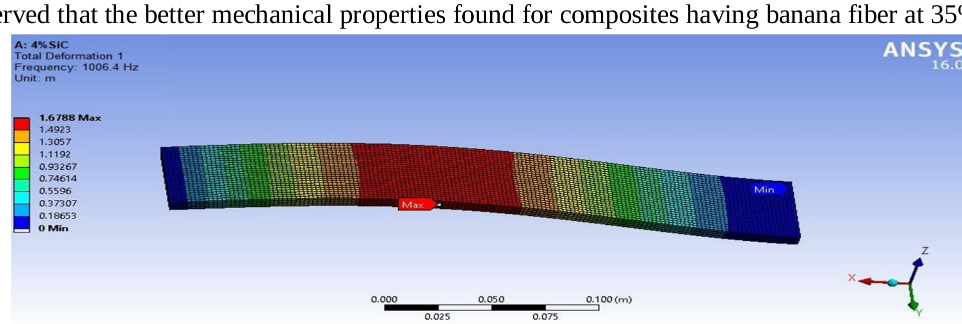

Figure 1: Total Deformation plot at first mode frequency sample 1

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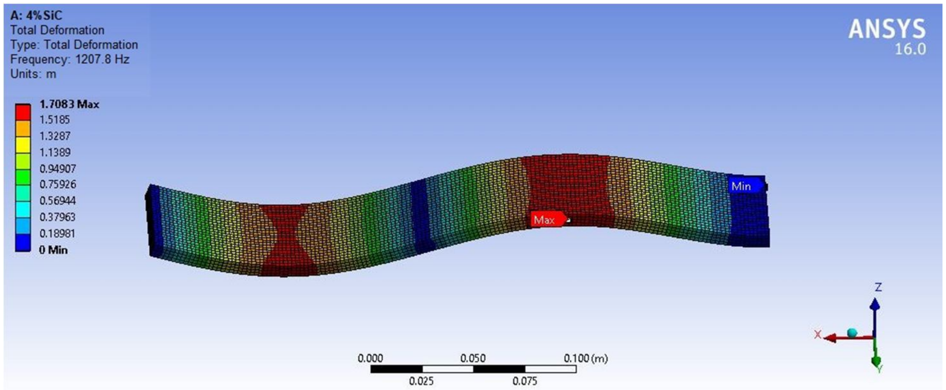
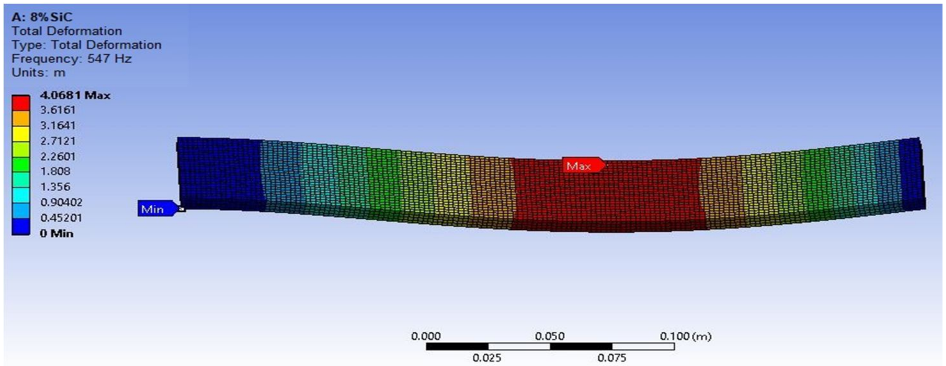


Figure 2: Total Deformation plot at second mode frequency sample 1



Total Deformation plot at first mode frequency sample 2

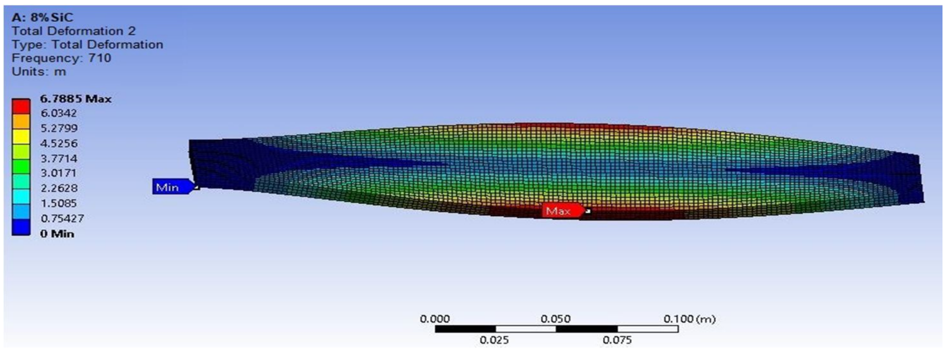


Figure 4: Total Deformation plot at second mode frequency sample 2

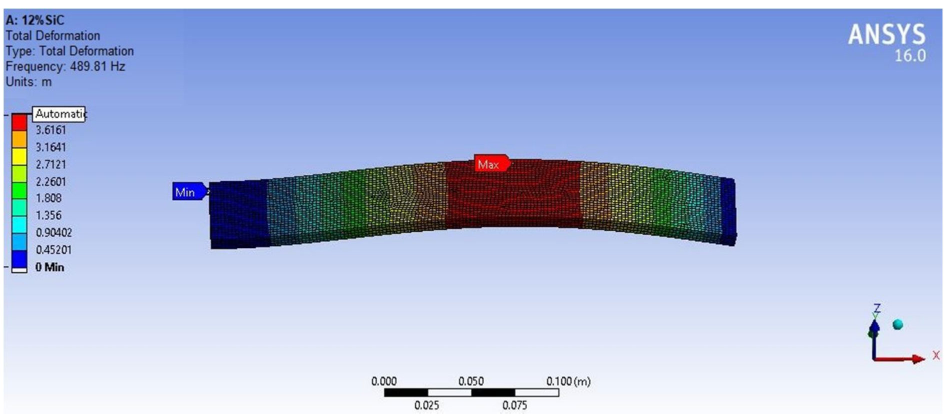


Figure 5: Total Deformation plot at first mode frequency sample 3

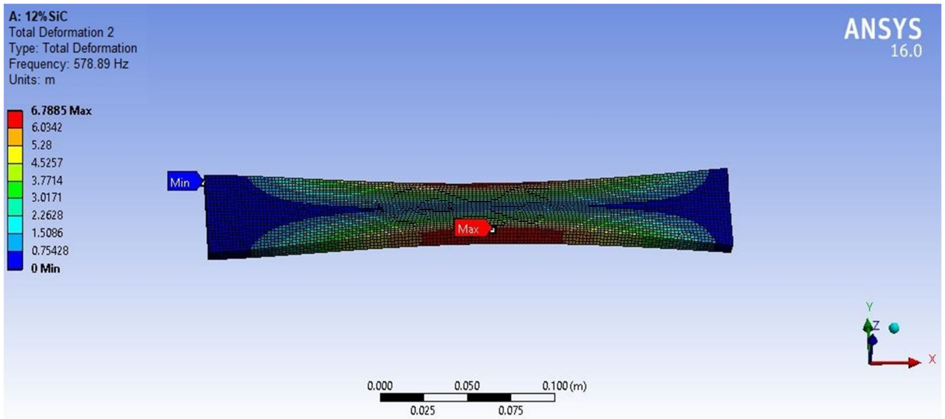


Figure 6: Total Deformation plot at second mode frequency sample 3

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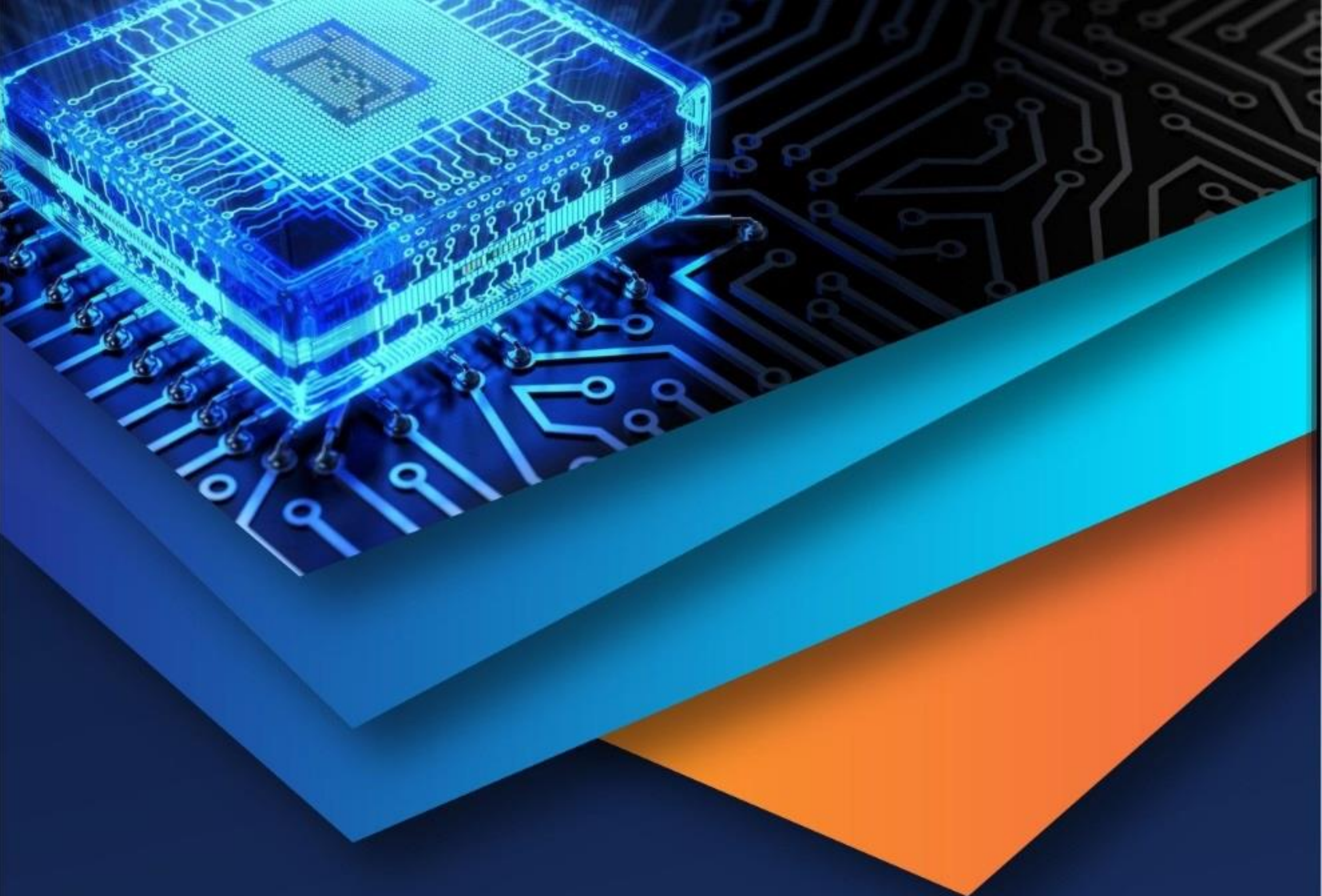

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