EXPERIMENTAL INVESTIGATION OF PHYSICAL AND MECHANICAL PERFORMANCE OF BAMBOO AND PALMYRA FIBER-REINFORCED HYBRID COMPOSITE

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ABSTRACT

In this rapidly developing world, researchers bother about environmental pollution, and non-biodegradable, and non-renewable resources. So, the researchers are attracted to advancing materials that are eco-friendly leads to having a huge affinity to replace chemically made synthetic composite materials. Natural fibers provide various advantages like eco-friendly, low cost, ease of availability, less weight, and non-toxic compared to artificial reinforced materials. In this present experiment, the composite laminate with four reinforcement weight percentages (10, 20, 30) of Bamboo and palmyra fibers is fabricated by the Hand lay-up method. Several structural and physiological performances of composites, like weight, water absorption, tensile strength, bending strength, and impact strengths are observed by carrying out these tests on specimens under the test procedure laid down in ASTM standards. It is observed that 30%wt. reinforcement composite of Bamboo and Palmyra fibers gives optimum properties than the remaining combinations.

Keywords—Composite material, laminate, reinforcement.

1. INTRODUCTION

Natural fibers like Bamboo, Palmyra, Jute, Sisal, Hemp, Coir, Coconut-shell powder, Cotton, etc. Collected from various resources are used as reinforcement with epoxy matrices to make epoxy natural composites. They are cheaper and substitute for synthetic fibers like glass and have various advantages like low density, high toughness, high specific strength, easy separation, and biodegradable. From several years composite materials, ceramics, and plastics have been essential materials. Usage of composites has been increasing rapidly due to their properties like low density and weight. The present challenge to the researchers is to make them cost-effective. This results in various innovative manufacturing technologies. Not only the technology, however, a coordinated approach in terms of supply, technique, and tools are crucial and design process which gives quality assurance and manufacturing of composites which leads to competition and alloys.

That composites sector had started that examine its possibilities commercially and should make composites of much more effective opportunity owing to shipping industry's enormous scale, over its aircraft industry. Through integrating our special strong reinforced fibers plus adhesive polymeric resins Nano composites, composite applications have changed from the aerospace sector to some other commercial uses. Their quantity of usage of those cutting-edge metals has been rising steadily. Expenses should decrease mainly the function of the increasing quantity.

There can be found in a few applications like composite armoring to resist explosive effects, windmill blades, drive shafts in industries, and supportive beams of highway bridges. Using these certain composites results in cost and weight savings as compared to metals.

These composites are also used for lighter construction with resistant structures which decrease the weight and absorb shocks and vibrations. Environmentally sustainable composite material products, demand is becoming strong. These composite materials based on natural fibers are considered solids for sustainable applications. Natural fiber reinforcement composites are strong, non-toxic, and lightweight. Hence, they can be used as strong composites in shipping, the automobile sector, etc.

2. LITERATURE REVIEW

V. Nagaprasad Naidu et al [1] in their paper bending and tensile properties of sisal and glass fiber reinforced composites This also discovered that sisal/glass fibre hybrids materials performed significantly better in terms of stress but also bending strength. Along with the epoxy, pure chalked dust is applied as in specified amounts by weight of resin respectively.

K. Murali Mohan Rao et al [2] in their investigation on Vakka, rattan, wood, even bananas fibre combinations are manufactured then tested. It had being noted while its tension capabilities in Vakka fibre composites rise little relation to such content percent of fibre but even are also greater which of jute but bananas. In terms of the quantity portion of fibre, the Vakka fibre matrix has a better bending power than a fruit fibre matrix and is nearer to a jute fibre matrix. In contrast, the bending integrand of Vakka fibre polymers is far greater than which of fruit but also sisal fibre fibres and also incredibly near that of wood fibre polymers. Contrary to raffia, wood, and plantain hybrids, the electrical stability of Vakka fibre combination improves as the volumetric proportion of fibre in the combination does.

N. Venkateshwaranet al. [3] conducted research to study the Tensile characteristics of composites made using natural and synthetic fibres predicted. The Rule of Hybrid Mixtures (Rohm's) equation which was used to predict both tension toughness but also elasticity of shorter, spherical particles organic fibres mixed polymers. This was found that its material strength of polymer matrix anticipated by the Electronics formula were slightly better then calculated observations. This likelihood that granting may occur between the fibers and matrices during in the creation of composites has effect on their tensile properties.

The characteristics of laminated hybrids made of glasses plus Mulberry fibre debris were assessed by R. Users to check et al. Laminated sheets containing between 30 and 70 percent by mass of fiber debris are investigated. Overall tension, bending, shearing, and contact strengths of hybrids with 58–65 wt% fibre loss were 28 MPa, 42.2 MPa, 6 MPa, and 3.58 J/cm2 respectively. Although it study shown while adding pfw to the matrices did little enhance various structural parameters including shearing, twisting, etc contact, it had a poor reimbursing on tension strength. Structural parameters of organic fibre bonded polyamide polymers: Precipitate, jute, bamboo by A.V. Ratna Prasad et al. In comparison to traditional sisal and bamboo composite, these research shows how employing Kheer fibres with reinforcing in a polyamide matrices might effectively generate a hybrid materials in aspects both great toughness and stiffness for ultralight purposes. Moisture absorbing the structural characteristics of Jute Fibre Organic FIbres compounds were examined by Girisha et al. [6]. The impact of humidity retention also on structural characteristics of hybrids urethane compounds made of drying sisal and tropical fibres. Torsion and bending toughness improved with an elevation in ductility under dry weather. Torsion and bending rigidity are significantly reduced under moist environments. In order to achieve the beneficial blended impact and create an optimised carbon fibre, it is necessary to comprehend the wetness absorbing attributes of organic fibres bolstered fusion composites. Exposed to humidity induced a substantial fall in any material qualities due to its deterioration of fibre interaction.

Torsion, bending, and contact capabilities of Tropical Spathe fibres and KenafBast dispersion urethane polymeric matrices materials has been studied by Vijay Kumar et al [7] in varying ratios. The majority of Kenaf fibre contents and the values were near to 27 MPa, which improve the

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tension capabilities of urethane fibre made with Kenaf sickest fibre and Fruit Prelim fibre. When Kenaf and coconut husk are bonded combined, its bending qualities were worse, but its stiffness is increased till the hybrids character is diminished. Purified coconut reinforcing had the highest quality, and straight kenaf reinforcing had the next-highest value. Fresh coconut Prelim reinforcing was shown to have significantly better contact qualities, whereas the rest materials behaved similarly as in Specimen testing. V.K. Singh and Sushil Kumar Choudhary et al [8] studied that, The structural qualities of a hybrid construction have been enhanced by this bamboo fibre reinforcements with in polyester resin.

Varanasi Lakshmi Narayana, Siva Bhaskara Rao Devireddy, and coworkers [8] noted that its structural and structural qualities of cannabis and papyrus were impacted by the stacked order and fibre %. **fibres are enhanced. The water absorption percentage of specific stacking was shown.**

OBJECTIVES

The objective is to fabricate the composite laminates and to evaluate basic structural and physiological properties of such materials, including their weight, rates of moisture uptake, tensile, flexural, and impact strengths observed by carrying out these tests on specimens under the test procedure laid down in ASTM standards.

3. EXPERIMENTAL DETAILS

3.1 Materials required:

- Natural fibers (Bamboo and Palmyra fibers)
- Epoxy resin
- Hardener

Natural Fibers:

Bamboo fiber is a highly sustainable crop that grows very fast and needs less care. Bamboo lasts for decades or even longer if it is well taken care of. Palmyra fiber is a natural fiber extracted from a palm tree and is long-lasting, eco-friendly, and low-priced.

Table 1: Fiber characteristics of Bamboo and Palmyra

Property	Bamboo	Palmyra
Density (kg/m3)	1100	1030
Tensile strength (MPa)	183	290-350
Tensile modulus (GPa)	32	5-5.4
Hemi celluloses (%)	12-73.3	18


(a)


(b)

Figure 1: (a) Bamboo fiber and (b) Palmyra fiber.

3.2 Epoxy Resin:

Epoxy resins are polymeric or semi-polymeric materials, for certain applications high purity grades of epoxy can be produced in a wide range. The raw material of epoxy resin is produced by petroleum derivatives.

3.3 Hardener:

It is a curing substance for epoxy resin. To initiate the curing of epoxy resin, a hardener is required. It acts as a catalyst, i.e., this component which, once combined by resins, renders glue rigid.

4. METHODOLOGY

Step-1: Matrix content

- Its Alkoxy family's Polyester LY-556 resins were used for its substrate.
- Like a curing agent, HY 951 were used.

Step-2: Reinforcement

- Bamboo and palmyra We use organic fibres as reinforcements.
- Palmyra is extracted from palmyra tree. The extraction process of bamboo fiber is shown below:

Collecting Bamboo sticks

↓

Soaked in water for days

↓

Hand peeling of fibers

↓

Fibers dried in sun for a day

↓

Cutting fiber length of 300mm

Figure 2: Extraction of Bamboo

Step-3: Preparation of Composite

- ➢ The simplest method to prepare composite is the Hand Lay-up technique due to its less infrastructural equipment.

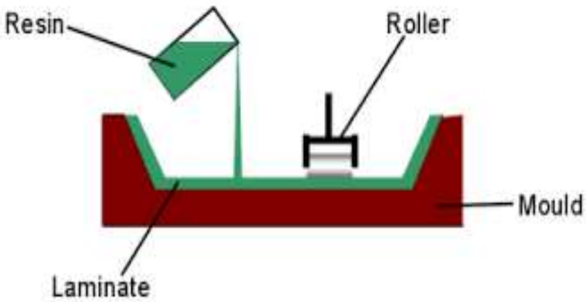

Figure 3: Hand Lay-up technique

- ➢ The steps involved in processing composite are very simple.

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- The mold release sheets were sprayed with mold release spray to remove the hybrid composite easily from the mold which gives a better surface finish to composite laminate.
- The epoxy resin and selected hardener are blended with a ratio of 10:1 by imparted pressure that creates a strong connection among both fiber strands.
- Nine different layers of each fiber were prepared as shown in the figure and for a single laminate three layers of each fiber were used.

(a)

(b)

Figure 4: Individual layers (a) Bamboo fiber and (b) Palmyra fiber.

- The layers of Bamboo and palmyra are placed one by one upon each other unidirectionally and then matrix material is applied in between them with a brush.

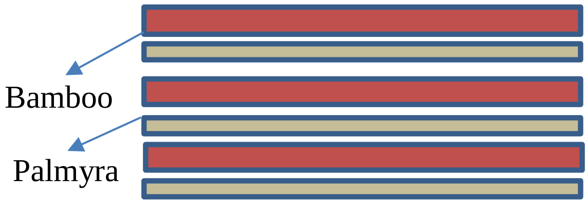

Figure 5: Orientation of fiber layers

- A roller is supposed to roll on the fiber layers during composite fabrication for the removal of air gaps and voids.
- After that, the mould is closed and then applied compressive pressure with some loads placed on it for proper curing at the room temperature for 24 hours.
- Total of three different composite laminates with a varying weight percentage of reinforcement 10%, 20%, and 30% with 300mm X 300 mm dimensions.

Figure 6: Fabricated composite laminate

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- These composite laminates are being made to become the required specimen with the necessary proportions specified in the ASTM guidelines during their drying phase in order to determine the qualities.

Figure 7: Specimens

Table 2: Composition oriented in laminates.

Composite	Bamboo (wt.%)	Palmyra (wt.%)	Matrix (wt.%)
C1	5	5	90
C2	10	10	80
C3	15	15	70

5. TESTING OF HYBRID COMPOSITES

Physical properties:

5.1 Density:

According to the ASTM D 638-89 guideline, the actual density (ρca) of fiber composites was found by Archimedes' principle. Both volume percentage and weights of the component components are used to calculate the hypothetical volume of fibre mixtures.

The following equation is used to find the density.

$$\rho ct = \frac{1}{(Wf\,h / \rho f\,h) + (Wf\,p / \rho f\,p) + (Wm / \rho m)}$$

Where,

Wf h = Weight ratio of Hemp fiber
ρf h = Density of Hemp fiber
Wf p = Weight ratio of Palmyra fiber
ρf p = Density of Palmyra fiber
Wm = Weight ratio of Matrix material
ρm = Density of Matrix phase

5.2 Void percentage:

The ASTM D 2734 -70 guideline states that the void percentage of fiber composite with actual density and theoretical density.

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This vacancy % is calculated using its given formula.

$$\text{Void Content (Vc)} = \frac{\rho_{ct} - \rho_{ce}}{\rho_{ct}}$$

Where,

ρ_{ct} = theoretical density of a composite,

ρ_{ce} = experimental density of composite

5.3 Water Absorption:

According to ASTM D 570-98 standard, the water absorption tests are performed with the specimen dimensions of 60mm X 10mm X 4mm. These hybrids laminate samples was submerged in space liquid. to measure the water absorption percentage. For every 24 hours specimens removed from the water and the gain in weight is noted after wiping to make it dry.

Figure 8: Specimens dipped in water.

The below equation is utilized to measure the water absorption rate percentage.

$$\%W = \frac{(Wt - Wo)}{Wo} \times 100$$

Where,

Wt = weight of the specimen in particular time.

Wo = weight of specimen after taking out of water.

5.4 Tensile test:

According to ASTM D 790 standard, the specimen with dimensions of 153mm X 12.7mm X 4mm. The Tensometer is used to conduct tensile tests by the applied uniaxial load on ends of the specimens with a loading ratio of 5mm/min. With respect to gauge length, the tensile force was noted.

Figure 9: Tensometer

5.5 Flexural test:

According to ASTM guidelines, the 3 bending tests on a tensile tester is made to measure the torsional stiffness of composites materials on a samples having parameters of 100mm X 12.7mm X 4mm specimens with the unloading rate of 5mm/min with respect to gauge length, and the bending force is calculated.

5.6 Impact test:

The specimen with the measurements 64mm X 12.7mm X 4mm is in compliance with ASTM D 256 standards. The high affect strength of composite specimens is assessed using the Izoid purpose of measuring, making it simple to determine how much energy is needed to shatter the compound material.

Figure 10: Impact Tester.

6. RESULTS AND DISCUSSION

6.1 Density and Void percentage

Due to its lower volumes, hybrid composites will displace traditional techniques, making height one of the more crucial considerations. This is discovered that the densities of natural fibres like Bamboo and palmyra fibers are 1100 kg/m3, 1030 kg/m3,. This wood and papyrus fibres composite's predicted and empirical thicknesses, as well as the vacancy %, are shown in the chart follows.

Table 3: Intensities that are conceptual, observational, actual vacuous proportions.

Composite	Theoretical density (kg/m^3)	Experimental density (kg/m^3)	Void percentage (%)
C1	1140.7	1123.0	1.55
C2	1139.6	1117.0	1.98
C3	1122.7	1090.0	2.91

As we observed that the void percentage of hybrid composites increases due to the nature of natural fibres. Its empty proportion rises to 2.91% for 30% weight of fibre. The theoretical densities observed from the table are more than the actual densities. Such was assumed that these materials were free of holes and imperfections when calculating the drawing on theories, whereas in the experiment we can observe void content in the composite.

6.2 Water Absorption:

The effect of fiber weight percentage on the water absorption in bamboo and palmyra fiber-reinforced epoxy composites. We observed that the water absorption rate increased with the increase in fiber content. i.e., 30% fiber wt.% composite laminate absorbed more water than the remaining three laminates. The 30% fiber weight composite water absorption percentage is 11.324.

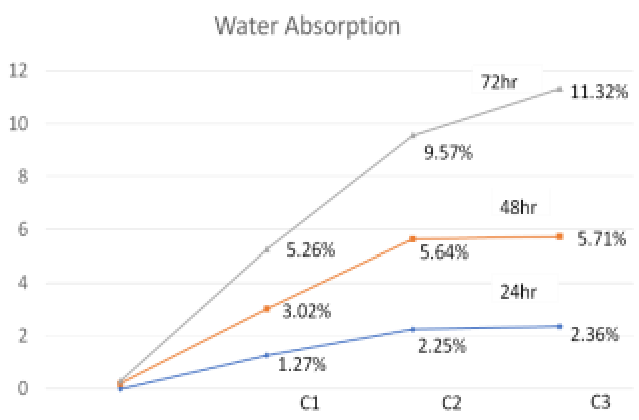

Figure 11: Water Absorption

6.3 Tensile strength:

Solid resin has its flexural hardness of 32.28Mpa. The image illustrates that this proportion of fibre affects its compressive power of raqqa with wood fibres. This hybrids composite's compressive modulus rises by up to 30% of fibre mass. To 47.63Mpa, its tension toughness improves.

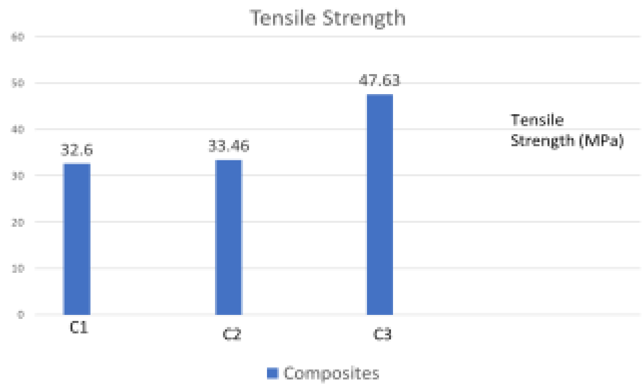

Figure 12: Tensile strength

6.4 Flexural strength:

This hybrid composite specimen is stressed both normally also shearly in this flexural test. The figure below shows that composites' flexural strength increases up to 30% fiber weight composite with 184.72Mpa.

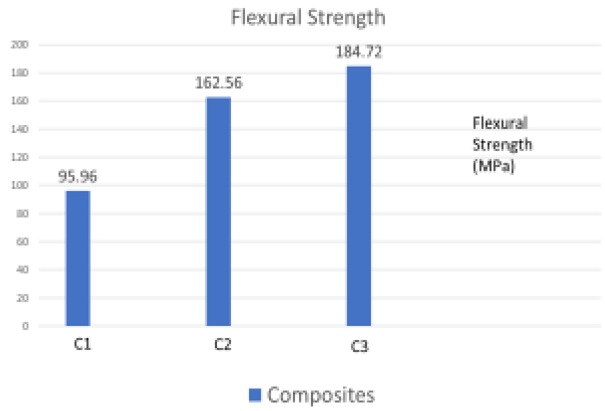

Figure 13: Flexural strength

6.5 Impact strength:

The impact energy depends on certain factors like reinforcement-matrix interface, individual constituents, and geometry. The impact energy of the composites is shown in the below diagram. The impact energy goes on to increase up to 30%fiber weight composite as 2.37 J.

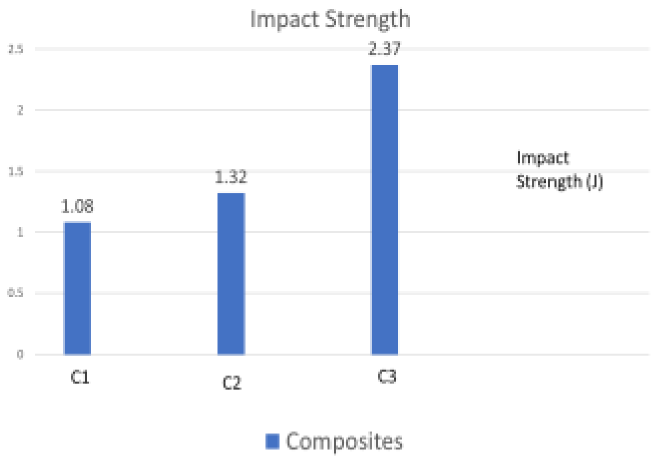

Figure 14: Impact strength

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CONCLUSION

After successful reinforcement of bamboo and palmyra fibers with epoxy resin by hand layup method, the tensile strength, bending strength and impact strengths are observed.

- In comparison to a clean base material, the fiber-reinforced hybrid composites has excellent physical capabilities.
- Its hybrids composite's physical characteristics having a 30% weight-to-fiber ratio give optimum values as compared to the remaining fiber weight percentage composites.
- Tensile strength of 47.63Mpa, Flexural strength of 184.72Mpa, and Impact strength of 2.37 J were observed from 30% fiber weight epoxy composite.
- A polymer has demonstrated strong waterproofing, that qualifies these in outdoors uses. The water has very little effect on these composites.
- There is a scope in the future for Bamboo and Palmyra fiber epoxy composites which can replace car dashboards due to their more bending strength compared to ABS plastic, which can lead to reducing the usage of Plastic for the sake of our environment.

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