Experimental analysis of Physical Characteristics of Composite Material Reinforced by Natural-fibers

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Abstract - The increasing environmental demands have led to a shift towards the use of the most suitable composite materials instead of steel for roofing. Researchers are currently studying and developing materials that shows the necessary properties while also being environmentally friendly. Natural fiber composites, which reveal similar properties to synthetic fibers, are being integrate with a matrix to produce ideal results. The hybrid composite materials are a mixture of natural and synthetic fibers which are each in same proportion ratio to have desired properties. This present research work deals with the study mechanical properties of basalt fiber mat composites having bamboo fibers pulps and glass fiber to which reinforced with epoxy resin as the matrix. In this work we are carrying tensile test and flexural test and Hardness test to evaluate the mechanical properties of composite roof sheet. and analysis of heat flux compared with original roof material with natural fibers. The Hybrid composites resulted in enhanced mechanical properties for the overall structure when compared to the original roof material.

Key Words: Composite Materials, Design, Mechanical Properties, Natural Fiber.

1.INTRODUCTION

The combining of the physical as well as the chemical properties of more than one materials occur as a result, the material has features that are distinct from the separate components. Particular units rely on being distinct and divides in the last module, that separates composites from being mixes and solid mixture. It combines to provide features that are superior to the separate elements properties. Matrix and filler/fiber are the two components of composite material (reinforcing phase). Fibers, sheets, and particles can all be used to strengthen different phases. The matrix phase surrounds it. In the production of composites, metals, ceramics, non-metals, and polymers can be employed as reinforcing and matrix materials. The composite fiber is stiffer and stronger than the matrix material which serves as load bearing components. The load transfer medium between fibers/fillers is the composite's continuous phase (matrix). Because the matrix is more ductile than the fibers, it provides toughness. When examined in adequate detail, all materials are made up of distinct subunits, hence the phrase composite could mean practically anything if taken at face value. Composite materials are heavily being used in the different fields of the technology like mechanical, aeronautical, etc. The high strength-to-density and hardness-to-density ratios of composite materials have led to widespread use in industry. The ability to improve these properties utilizing cutting-edge technology and a variety of manufacturing methods has broadened the scope of these materials' applications.

Composite materials were first used in the aerospace industry in the 1970s, but they are now used in almost every industry after only three decades. Meanwhile, the automotive sector, which is regarding the industry in each country, has profited from the capabilities and properties of these modern materials. Metallic parts are being phased out in favour of composites as technology advances.

Properties of Composite materials

1. Materials made from composites exhibit mechanical characteristics where the tensile stress is 4-6 times greater than that of conventional materials such as steel and aluminum.

2. The tensile strength and stiffness of the composite matrix are far superior.

3. It is capable of enduring significant deformation.

4. Composites are, on average, 30–45 percent more cost-effective than aluminum structures with similar features.

5. Compounds composed of various elements.

6. It also requires less energy to be embedded.

7. Composites generate lower levels of vibrations during operation.

8. The materials are also significantly more flexible.

2. LITERATURE REVIEW

Rami Eid [4] has conducted tests on six FRPTRP-encased reinforced concrete columns subjected to compressive axial forces and examined the performance of circular, square, and rectangular columns. The more FRP layers present, the greater the compressive strength of the concrete, along with the associated strain, which is extensively documented in the existing literature. of Marijn R. et al., (1999), Laura De Lorenzis et al., (2003), Silvia Rocca et al., (2008).

Nadeem A. Siddiqui [5] tested the impact of hoop and longitudinal Carbon Fiber Reinforced Polymer (CFRP) bands on minimizing sideways bending and enhancing the durability of thin circular Reinforced Concrete (RC) columns, conducting tests on a total of 12 miniature circular RC columns, each with a 150 mm diameter. The findings indicated that CFRP hoop bands offer both compression to the concrete and lateral reinforcement to the longitudinal fibers, thereby augmenting the durability of both short and thin RC columns. Nonetheless, the influence of hoop bands on the durability of columns was more pronounced for the short columns compared to the slender ones.

Marinella Fossetti (2018) In this paper a generalized criterion for the determination of the increase in strength, in ductility, and in dissipated energy for varying corner radius ratios of the cross section and liber volumetric ratios is shown. Numerical results using a finite element analysis, calibrated on the basisof experimental data available in the literature, are carried outto calibrate the new analytical models and results shows that the strength increase does not require definition of the lateral confinement pressure.

Thomas Vincent (2015) experimented on the influence of shrinkage on compressive behaviour of concrete filled FRP of FRP-confined normal- and high-strength concrete (NSC and HSC). A total of 30 aramid FRP (AFRP) confined concrete specimens With circular cross-sections were manufactured. Six of the specimens were instrumented to monitor long term shrinkage strain development of the FRP- confined NSC and HSC, With three specimens allocated to each mix. The remaining 24 specimens were tested under axial compression, where nine of these specimens were manufactured With NSC and the remaining 15 With HSC and results shows that there is a decrease in strength enhancement ratiowhereas it leads to a significant increase in strain enhancement ratio and also decrease in the ratio of the ultimate axial strains obtained from mid*section and full-height I-VDTs (MLVDT/ FLVDT) due to a partial or complete loss of bond at the interface between the concrete core and FRP shell.

Manal K_ Zaki (2011) experimented on cylindrical reinforced concrete (RC) columns confined With fiber reinforced polymer (FRP) composites. The columns studied are under combined axial loads and biaxial bending moments. The fiber method modeling (FMM) together With finite element analysis (FEA) are adopted to investigate the behavior of such columns and results shows that a remarkable increase in the tension zone can be achieved due to the contribution of the longitudinal direction of the FRP in flexural capacity. For columns under uniaxial bending, a remarkable increase in Mu and Fxu are recorded by FRP confining. The increase in column capacity of the FRP confined columns compared to the reference columns increases as the balance point is approached

Classification of natural fiber

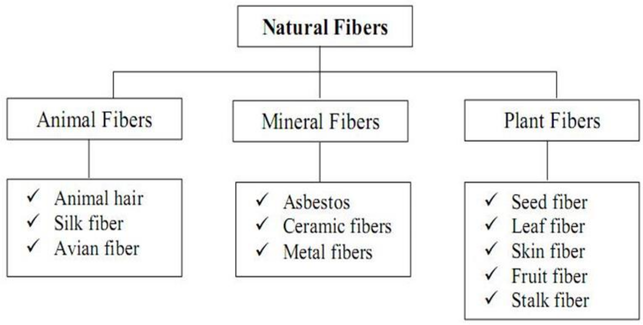

Figure 1: Classification of natural fiber

FIBERS AND RAW MATERIAL USED

In this research work we used following fibers

1. Bamboo Fiber
2. Basalt Fiber
3. Glass Fiber

5.1. Bamboo Fiber

The term “fiber” is often used to describe a long, thin, and flexible material with many applications in the manufacturing industry. Natural and synthetic fibers derived from plants, animals, and minerals are all fair game Bamboo fiber, one of several types of natural fiber, is produced from the cellulose of the bamboo plant. Bamboo is a rapidly reproducing plant and therefore is getting extreme attention. In recent years, bamboo fibers have gained popularity as a sustainable alternative to more conventional fibers like cotton and polyester due to their robust, long-lasting, and adaptable properties.

Figure 2: Bamboo fiber

5.2. Basalt Fiber

Basalt fiber (BF) is a high-performance inorganic silicate fiber made from natural basalt ore by high-temperature melting and drawing, and it is a kind of green fiber that does not create environmental pollution or pose a cancer risk. Compared with traditional glass fiber (GF), BF has better mechanical properties, as well as high-temperature and corrosion resistance. Compared with carbon fiber (CF), BF has a lower cost and is one of the best choices to replace GF and CF, basalt fiber-reinforced polymers (BFRPs) have been widely used in the petrochemical, construction, aerospace, automobile, ship, and other industries.

Figure 3: Basalt Fiber

2. Glass Fiber

Glass fiber is a substance made up of many very fine glass strands. It shares similar strength characteristics with other materials like polymers and carbon fiber. While it's not as stiff as carbon fiber, it's much more affordable and less prone to breaking when used in mixtures. As a result, it's often added to polymers to enhance their strength and create a lightweight composite material known as glass-reinforced plastic (GRP), also referred to as "fiberglass." The primary type of glass fiber utilized in fiberglass is E-glass, which is a type of alumino-borosilicate glass with less than 1% of alkali oxides, primarily used in the production of glass-reinforced plastics.

Basalt fiber is a continuous fiber made of melting. Stone at 1450 to 1500 degree through platinum rhodium alloy bushing. New Environment protection fiber which is known as the twenty-first Century ‘Volcano rock silk’, it is also called golden fiber because it’s Golden brown.

Bamboo fiber is made by a mechanical-bacterial process similar to retting flax into linen fibre. In this way, the woody part of the bamboo is crushed mechanically before a natural enzyme retting and washing process is used to break down the walls and extract the fibre. This blast fibre is then spun into yarn.

Epoxy Resin

Epoxy Resin comes in two parts: a resin and a hardener. Mixing the resin and hardener to gether prompts a chemical reaction between the two, transforming them from a liquid into solid. Measuring accurately and mixing thoroughly is essential to ensure your epoxy resin cures properly

Experimental Sample preparation

The 200 mm x 200 mm x 10 mm composite was manufactured using hand-layup method. The resin was coated with brush and roller and kept between the200 mm x 200 mm pressing plates. A polyester film layer between the plate and the composite surface was provided for easy release and for smooth and uniform surface surfaces on the composites. Araldite LY556 to HY951 hardener in the ratio of (3:1) and mixed well and to different percentages .Alternative Two layers of basalt fabric bamboo fabric and glass fiber are fabricated with epoxy resin mixed one above the other until the desired thickness is achieved. The composites were then left at room temperature for 24 hours be solidified. Composites were then removed from the mold following the curing process.

Testing of Composite material:

The specimens are derived from the fabricated material and subjected to different mechanical testing processes to determine their performance under various loading conditions. The results are then analysed and further the materials are engineered to improve the characteristics so that a better product can be achieved.

A. Tensile test.
B. Flexural test.
C. Hardness test

A. Tensile test.

It is one of the most commonly used testing processes to evaluate the mechanical properties of the material. The tests help to evaluate the properties related to elasticity and strength. In a tensile testing process, a specimen is obtained according to a prescribed standard and loaded under uniaxial force applied at two ends until the matrix is fractured.

Figure 4:Test Specimen

Table-1: Tensile test result of natural and hybrid composite material

Material	Maximum load (KN)	Ultimate Tensile stress (Mpa)	Young's Modulus (Mpa)
Basalt and bamboo fiber	10	105.2	4900.66
Basalt, bamboo, and glass fiber	12	115.79	5150.5

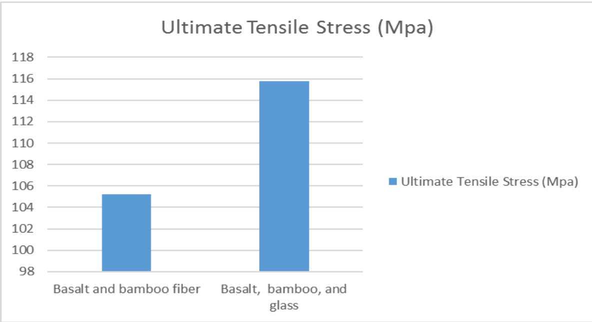

Chart -1: Comparison of materials for ultimate tensile strength

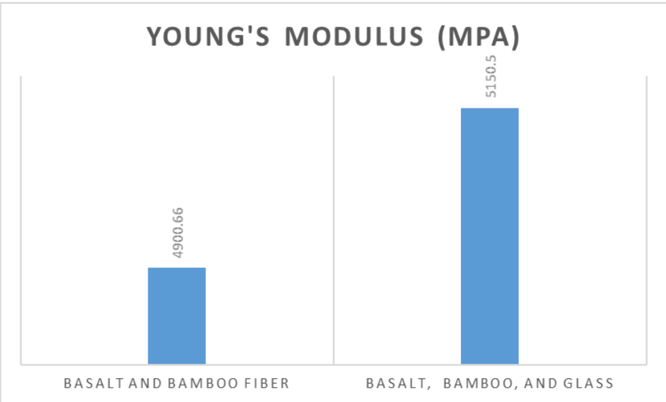

Chart -2: Comparison of Materials for Young's Modulus

Every sample was made according to the guidelines, and the direction was kept steady at 0º during the making process. For the initial mix (Basalt + bamboo), the highest load it could handle was 10.00 KN, with a maximum tensile stress of 105.20 MPa and a Young's modulus of 4900 MPa. The next sample (Basalt + bamboo + glass) saw the load raised to 12.00 KN, with a maximum tensile stress of 115 MPa and a Young's modulus of 5150 MPa.

B. Flexural Test

The specimens used in the testing process are generally rectangular in geometry without any bond or notches. The flexural test helps us to determine the strength in brittle material because when the same material is gripped and loaded for testing would easily breakdown. Within the elastic range, a linear relation between a load and deflection can be noted. The failure first begins on a thin layer of the surface which initiates the cracking process and at-last leads to the specimen break point.

Figure 5: Flexural test

Table 2: Flexural test results

Materials	Maximum load (KN)	Maximum bending stress at maximum load (Mpa)	Young's Modulus (Mpa)
Basalt and bamboo fiber	490	198.78	9342.14
Basalt, bamboo, and glass fiber	550	210.74	10735.37

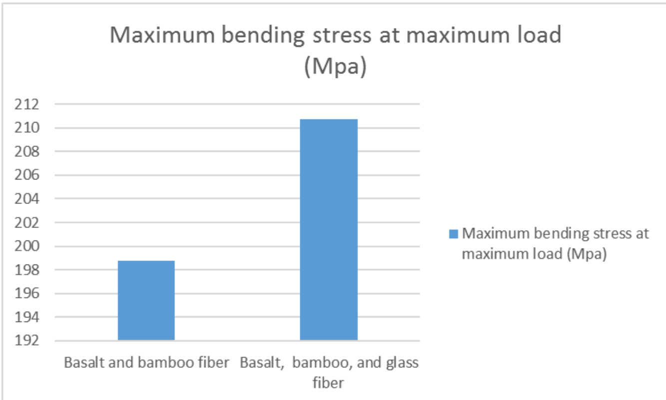

Chart - 3: Comparison for maximum flexural strength

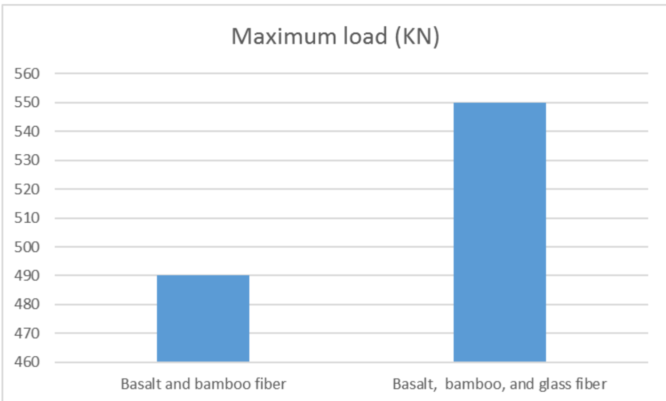

Chart - 4: Comparison for maximum flexural strength

All the specimens being tested have a fixed orientation of 0°. For the specimen of (Basalt + bamboo + glass) the maximum bending stress is recorded at 210Mpa with Young's modulus of 10735 Mpa for a maximum applied load of 550.00 KN.

C. Hardness Test

Hardness is the mechanical property of the material which helps it to resist the indentation. Hardness is one of the important parameters in the designing of a material. The process of measuring the hardness is by measuring the depth of the indentation mark left on the material when load of known pressure is applied on it. Hardness is a typical property of a material. Hardness is defined as the resistance to indentation, and it is determined by measuring the permanent depth of the indentation caused on the surface of the test material. The least RHN is for the combination of (Basalt + bamboo) i.e. 68. And when E-glass fiber is present along with the combination of (Basalt + bamboo and glass) the RHN is 72 which signifies the strength imparted by the glass fiber to the Composite.

Table 4: Hardness test results

Materials	Hardness(RHN)
Basalt and bamboo	68
Basalt, bamboo and glass	72

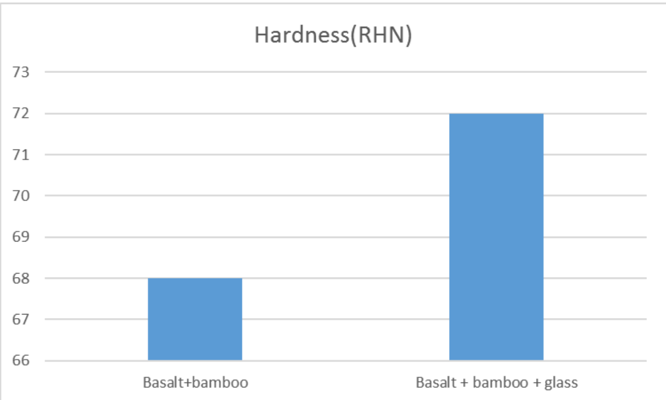

Chart - 5: Comparison by Rockwell Hardness Number

When applying a constant force (load) and a specific indenter, the smaller the resulting indentation, the tougher the material. Each sample is kept at a consistent angle of 0°. Referring to the table above, the Relative Hardness Number (RHN) for the mixture of Basalt, Bamboo, and Glass is 72, surpassing that of samples containing only Basalt and Bamboo fibers. The lowest RHN value is observed for the mixture of Basalt and Bamboo, which is 68. Additionally, when E-glass fibers are incorporated into the mixture of Basalt and Bamboo, the RHN value remains at 72, indicating the added strength provided by the E-glass fibers to the composite.

Heat Flux Analysis of Steel Sheet and Natural Fibers using CAD design:

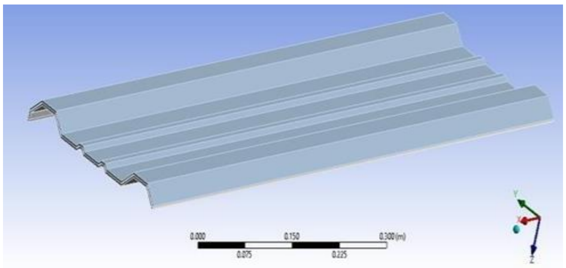

Figure: Analysis of Steel Sheet and Basalt, Bamboo and Glass Fibers using creo

Table 5: Heat flux for Steel Sheet and Basalt, Bamboo and Glass Fibers

	Steel Roof Heat Flux W/m2	Basalt, Bamboo & Glass Fiber Heat Flux W/m2
Minimum	0.0305673	11.8301009
Maximum	2372.5	1142.2
Average	1186.265284	577.0150505

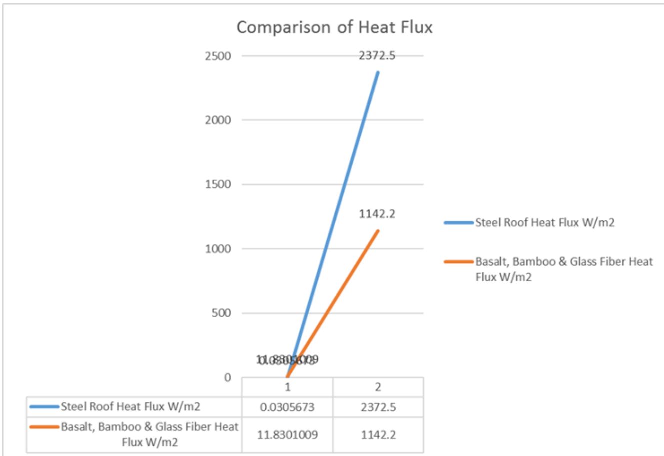

Chart - 6: Heat flux for Steel Sheet and Basalt, Bamboo and Glass Fibers

CONCLUSIONS

The eco-friendly composite materials made from bamboo, basalt fibers and glass fibers are created by mixing them with epoxy resin as the base material, using the conventional manual lay-up method. The physical characteristics like tensile strength, bending strength, hardness, are measured through tests. The orientation of the fibers during fabrication is maintained at 0º throughout the process. During the manufacturing process, the alignment of the fibers is kept at a constant angle of 0º. The findings indicate that materials containing particulate fillings exhibit superior mechanical characteristics when contrasted with those without such fillers. In tests of tensile strength, the hybrid composites demonstrated the highest ultimate tensile stress among the other composite types. Based on these findings, it can be inferred that materials with particulate fillers in their composite matrices possess a strong potential for enhanced overall properties. It was also seen that basalt, bamboo and glass fibers composites had better performance than that of basalt and bamboo fibers which implies that the addition of particulates are desirable till a certain extent and when the limit is exceeded the increase of strength is in a smaller quantity.

This is because the connections created between particles and reinforcements are significantly stronger compared to the connections between particles when they are just interacting with each other. In other words, the interaction between particles and reinforcements is more robust than the interaction between particles themselves, which occurs when there are more particles in the material. Therefore, composites with particles as reinforcements exhibit strong mechanical characteristics and better performance, meeting the demands of today's industrial sector. The production cost can be reduced when made in large quantities, making it a preferable option for improving and stabilizing performance.

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BIOGRAPHIES

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