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Investigation of Different Mechanical Properties on Various Hybrid Natural Fiber Based Polymer Composites

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ABSTRACT
The recent era of material belongs to the composite materials because of its numerous numbers of advantages. Several researches have been done on different natural fiber composites. But different mechanical properties on various hybrid natural fiber based polymer composites still uncovered to us. Therefore, in this present research work macrostructural analysis of different mechanical properties like tensile, flexural strength and water absorptivity on natural fibers (jute, murta and bamboo) as hybrid composite in three combinations (jute-bamboo, bamboo-murta and jute-murta) are studied. Each combination consists of two natural fibers where each has two layers of woven fiber. Epoxy resin as matrix material and hardener with natural fibers as the reinforcement material is used to make the specimens. Hand lay-up technique is used to fabricate the specimens. After testing the specimens it is found that the jute-bamboo hybrid composite has superior mechanical properties and better water absorption property as compared to the other hybrid composites.

Keywords: Hybrid, Matrix, Reinforcement, Tensile, Flexural.

1. Introduction

The advancement of mankind is defined in terms of the development in materials i.e. the stone age, the bronze age, and the iron age. The recent era of material belongs to the composite materials because of its numerous numbers of advantages. The word 'composites' derived from the Latin word compositus, which means put together signifying something made by putting together different parts or materials [1]. A composite is a material made when two or more different materials are combined together to create a superior and unique material. Composite material consists of strong carry-load materials which are embedded in a weaker material. The stronger material is commonly referred as reinforcement and the weaker material is referred as matrix. The two materials works together to give the composites unique properties. However, within the composites the material does not dissolve or blend into each other. The reinforcement provides the strength and rigidity which helps to support the structural load. The matrix or the binder helps to maintain the position and orientation of the reinforcement and is somewhat more brittle [2]. The reinforcement materials such as Fibers are thin and but integrity is not maintained. In matrix materials, strength values are less and hence fibers or matrix alone cannot find its application as a structural material but when these two materials are combined we get a composite materials which is light weight, stiff, strong and tough [3]. There are different types of composite. Fiber composite is one of them. When two or more type of fibers is used in composites as reinforcement fillers is called as hybrid fiber composites. These types of composites have great applications in mankind. It has achieved a major breakthrough in the construction of low weight structures. Moreover, it has high specific strength, toughness and stiffness. It is moderately heat and fire resistive. It is ecofriendly in nature as it is fully bio-degradable. It is costeconomic as atural fibers are abundantly available and it is renewable. A lot of research work has been done by researchers on different natural fibers. Jacob Olaitan Akindapo, Umar Alhaji BINNI, Olawale Monsur have made roofing sheet by using groundnut sell particles and epoxy resin as composite Material. They have tested different tests like water absorptivity test, flexural strength, tensile Strength, impact strength [4]. Jochen Gassan and Andrzej K. Bledzki have investigated different properties of a jute-polypropylene composite. They also worked on improving different properties like tensile and impact strength [5]. Madhukiran.J, Dr.T.Venkateswara Rao, Dr.S.Madhusudan, Dr. R.Umamaheswara Rao have worked on jute-coir hybrid natural fiber composites. They have done different tests like tensile test, flexural tests and shown that jute-coir fiber hybrid composites exhibited superior properties when compared to pure composites [6]. So, several researches have been done on different natural fiber composites. But still there are different kinds of fibers which properties are not uncovered to us. In this paper different mechanical properties of jute, bamboo and murta fiber as hybrid composite in three different compositions have been revealed. So it is undoubtedly a new addition in research of composite material.

2. Materials and Methods

2.1 Materials and Equipments

Materials and equipments used in fabricating composite are given below:

2.1.1 Jute Fiber

Jute is a natural fiber which has many inherent advantages like high tensile strength, lustier, moderate heat, low extensibility, long staple lengths and fire resistance. It is one of the most available natural fibers in our country. Woven jute fiber is collected from the local shop.

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2.1.2 Bamboo fiber

In our country bamboo is another easily available natural fiber which is used in versatile products manufacturing. It has high compressive and tensile strength. It is collected as woven bamboo mat.

2.1.3 Murta fiber

Murta fiber also known as pati bet is one kind of natural fiber which is the raw material for making shitalpati, a traditional bed mat of Bangladesh. It is also known as 'patipata', 'mostak', paitara', in different parts of Bangladesh. [7]. It is collected as woven mat.

(a) (b) (c)

Fig. 1 (a) woven jute fiber (b) woven bamboo fiber (c) woven murta fiber.

2.1.4 Resin and Hardener

Resin acts as the matrix material in composite to bind the reinforcing fiber together. On the other hand hardener is a chemical substance which is added to something in order to harden it. In this experiment Araldite AW 106 is used as epoxy resin and HV 953 IN is used as hardener which is collected from local traders. The mixing ratio of resin and hardener is 1:1 by volume.

2.1.5 Mould

Generally a mould is used for making parts in hand lay-up process where the layers are placed to get desired shape. Two stainless steel plates of 30cm length and 27.5 cm width are used as mould.

2.1.6 Other Equipments

Some equipments like mug, polythene cover, hand gloves, lubricating oil, roller, acetone, laminating paper, some weights etc. are used in fabricating composite.

2.2 Laminate Fabrication Method

Hand lay-up process is used to fabricate the samples of hybrid composite. Each sample consists of two pairs of two different fibers.

2.3 Measurements

2.3.1 Mechanical Testing

Two different mechanical properties of the composites analysed in the present work are tensile and flexural strengths. Tensile test is conducted according to the ASTM D-638 standard while the flexural (three-point bending test) is conducted according to the ASTM D-790 standard on a universal testing machine.

2.3.2 Water Absorptivity Test

The percentage water absorptivity is calculated and recorded against each mass fraction.

$$m = (w\text{-}w_0) / w_0 * 100\%$$

Where m, w, w_0 are the moisture absorption content, weight of dried and wet composite material respectively.

3. Results and Discussion

3.1 Macrostructural analysis

In this analysis some typical cross-sectional view of different composite surface are investigated.

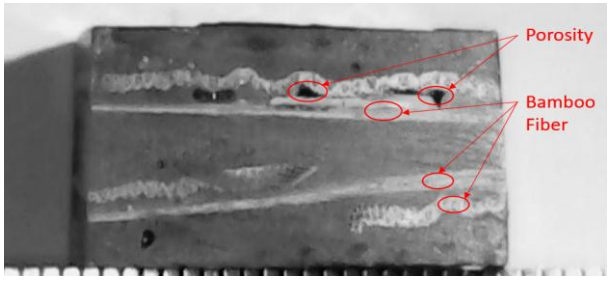

Fig. 2 Cross-sectional view of a jute-bamboo hybrid composite surface

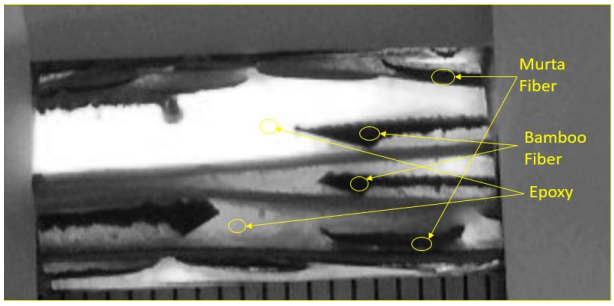

Fig. 3 Cross-sectional view of a bamboo-murta hybrid composite surface.

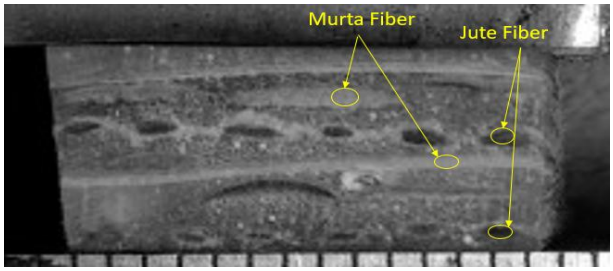

Fig. 4 Cross-sectional view of a jute-murta hybrid composite surface

From these figures fiber distribution in the epoxy matrix are seen. In fig. 2 bamboo fiber and some void areas are found in the jute-bamboo composite. But jute fiber is not seen properly in this structure. In figure 3 both bamboo and murta fiber are seen in the matrix material and in this case no void area is found. In figure 4 both jute and murta fibers are identified.

3.2 Volume fraction

Table 1 Volume fraction of the different constituents of composites.

Composite Name	Volume of jute fiber (%)	Volume of murta fiber (%)	Volume of bamboo fiber (%)	Volume of epoxy resin (%)	Volume of void space (%)
Jute-bamboo	11.65		30.2	56.95	1.2
Jute-murta	17.78	26.15		54.37	1.7
Murta-bamboo		22.62	24.23	52.48	0.67

From table 1 it is seen that jute-murta composite has highest void space and bamboo-murta composite has the least in it's composition. Again jute-bamboo composite has the highest amount of epoxy material and least amount of fiber in it's composition and bamboo-murta fiber has the least amount of epoxy material and highest amount of fiber in it's composition.

3.3 Water Absorptivity Test

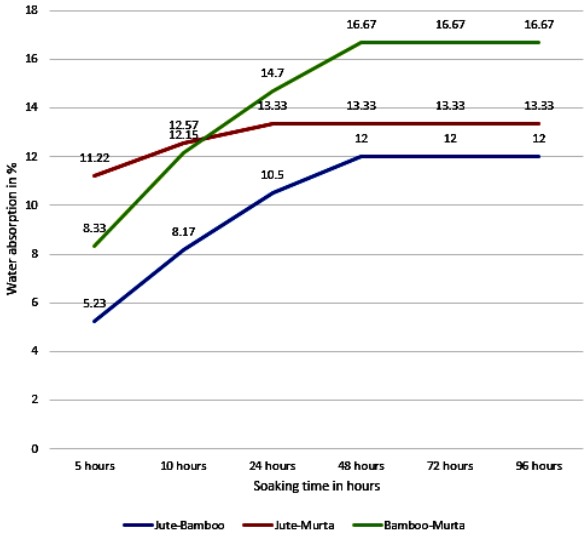

Fig. 5 Water absorption rate of different composites.

From fig 5 we can see jute-bamboo composite has absorbed lowest amount of water and bamboo-murta composite has absorbed the highest. Water absorption rate is high in both jute-bamboo and bamboo-murta composite but jute-murta composite has the lowest rate of water absorption.

3.6 Flexural Strength Test

Flexural stress-strain diagram and flexural strength are shown below.

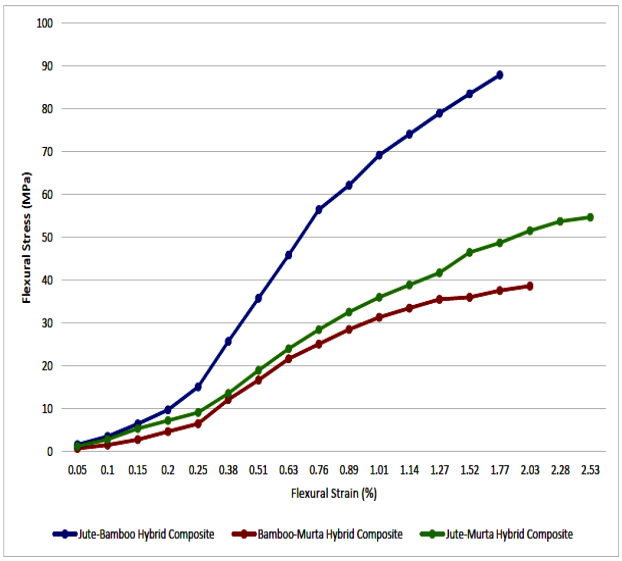

Fig. 6 Flexural stress-strain diagram for different composites

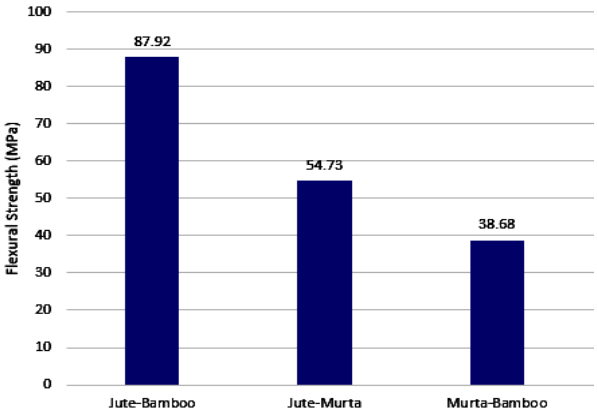

Fig. 7 Flexural strength of different composites

From fig 7 it is seen that jute-bamboo composite has the highest flexural strength and murta-bamboo composite has the lowest flexural strength.

3.7 Tensile Strength Test

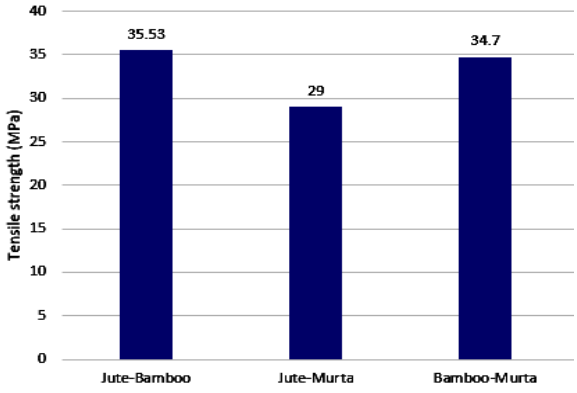

Fig. 8 Tensile strength of different composites

From fig. 8 it is seen that jute-bamboo composite has the highest tensile strength and jute-murta composite has the lowest tensile strength.

4. Conclusion

From macrostructure analysis and volume fraction that the composite has some void areas inside it which is responsible for decreasement of fatigue strength. So strength properties can be improved by reducing the void areas. From mechanical testing and water absorptivity test it can be concluded that jute-bamboo fiber reinforced hybrid composite has the best flexural and tensile strength but it has the highest water absorption rate.

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