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Tensile and Impact Strength Analysis of Natural Fiber Reinforced Polymer Composites for Building Structural Applications

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Abstract—*In recent years, the concept of 'eco-materials' has gained key importance due to the need to preserve our environment. Particulate fillers are of considerable interest, not only from an economic viewpoint, but also modifiers especially the mechanical properties of the polymer. The interest in natural fiber reinforced composites is growing rapidly in building structural applications due to their availability, renewability, low density and price as well as satisfactory strength properties.*
In this research work, three different natural fibers such as saw wooden dust, short coir fiber and short chemically untreated banana fibers are used as reinforcement filler for epoxy based polymer composite. Samples are prepared with 50% weight compositions of natural fibers under same environmental conditions. Tensile test and Impact test was carried out to determine the tensile strength and impact strength of composite samples. The acquired results show that the tensile strength and impact strength of short chemically untreated banana fibers reinforced polymer composite is greater than wooden dust and short coir fiber reinforced polymer composites.

Keywords*: Natural fibers, wooden dust, short coir fiber, short banana fibers, tensile strength, Impact strength.*

1. INTRODUCTION

For a long time the fiber-reinforced composites have dominate in a variety of applications due to of their high specific strength and modulus. Material Scientists now focus on the use of natural materials instead of synthetic polymer and synthetic reinforcing fibers like glass, carbon, and nylon for the development of composite materials. The attention is due to their renewable and ecological characteristics. The potentiality of natural fiber-based composites using cellulose, jute, wood, coir, banana, sisal, kenaf and hemp, etc., as reinforcing fiber in a thermosetting resin matrix has received considerable attention among scientists all over the world for their excellent specific properties. Natural fibers present cheap and sustainable alternative to the metallic and synthetic fibers used as building materials. Light weight, low environmental impact and bio-degradability are other important advantages of natural fibers. There are mainly two strategies explored till date for the use of natural fibers in structural applications. In the first approach, natural fiber reinforced polymeric composites have been developed for the different parts of building [1], whereas the second approach explores the use of natural fibers for concrete reinforcement

Natural fibers can replace the traditional fibers as reinforcing elements for polymer-based composites because of their lower cost, renewability, acceptable specific properties, lower density, ease of preparation, lower energy requirements for processing, biodegradability, wide availability and relative non abrasiveness over traditional reinforcing fibers such as carbon, aramid etc [2, 3]. Instead of many advantages of natural fibers, they also have some limitations such as the lower allowable processing temperatures, They have lower strength properties, particularly its impact strength and have variable qualities, depending on unpredictable influenced such as weather, and high moisture absorption of the fibers and the resulting swelling of the manufactured composite [4].

Harish et. al. [5] developed coir composites and evaluate their mechanical properties. Scanning electron micrographs obtained from fractured surfaces were used for a qualitative evaluation of the interfacial properties of coir/epoxy and compared with glass fiber/epoxy and obtained results indicate that coir can be used as a potential reinforcing material for making low load bearing thermoplastic composites. Naveen and Raju [6] described the development and characterization of a new set of natural fiber based polyester composite consisting of coir as reinforcement and epoxy resin. The mechanical properties of coir composites evaluated at five different volume fraction and experimental results showed tensile, static and dynamic properties of the composites were greatly influenced by increasing the percentage of reinforcement and indicate that coir can be used as potential reinforcing material for many structural and non-structural applications.

Kulkarni et. al. [7] reported that the mechanical properties of banana fiber, such as initial modulus, UTS and breaking strain as function of the fiber diameter, test length and speed of testing. It is found that Young modulus, UTS and % elongation showed little variation in their values for fibers of diameter ranging from 50 to 250 µm.

Pothan et. al. [8] analyzed the dynamic mechanical behavior of banana fiber reinforced polyester composites with special reference to the effect of fiber loading, frequency and temperature. The intrinsic properties of the components, morphology of the system and the nature of interface between the phases determine the dynamic mechanical properties of the composite. The loss modulus and damping peaks were found to be lowered by the incorporation of fiber. Cole–Cole analysis was made to understand the phase behavior of the composite samples. A master curve was constructed based on time–temperature super position principle, which allows the prediction of long-term effects.

Sapuan et. al. [9] performed tensile and flexural (three-point bending) tests for woven banana fiber composites of different geometries. From the Statistical analysis of obtained results, using ANOVA-one way has showed that the differences of results obtained from samples are not significant, which confirm a very stable mechanical behavior of the composites under different tests. This shows the importance of this product and allows many researchers to develop an adequate system for producing a good quality of woven banana fiber composite which may be used for household utilities.

In the present work, three different natural fibers such as saw wooden dust, short coir fiber and short chemically untreated banana fibers are used as reinforcement filler for epoxy based polymer composite. Samples are prepared with 40% weight compositions of natural fibers under same environmental conditions and the tensile strength and impact strength of composite samples are investigated.

2. EXPERIMENTAL PROCEDURE

2.1 Materials

The basic raw materials for any composite are the reinforcement and the matrix materials. Reinforcements are the principle of load bearing members and matrix forms the continuous phase in the composites. The important functions of the matrix are; to transverse stresses between the fibers, to provide a barrier against an adverse environment and to protect the surface of the fibers from mechanical abrasion. In this research work epoxy LY 556 resin is used as the matrix material and the low temp curing epoxy resin (Araldite LY 556) and corresponding hardener (HY951) are mixed in a ratio of 10:1 by weight as recommended. 3 samples was prepared with 50% weight compositions of different natural fibers such as saw wooden dust, short coir fiber and short chemically untreated banana fibers under same environmental conditions. The mixture is stirred manually to disperse the fibers in the matrix.

2.2 Specimen preparation

The fabrication of composite samples is carried out through the hand lay-up technique. A mild steel mould with plywood sheet placed in the inner surface was used for fabrication. As a debonding agent wax is applied on the plywood sheet and the composite specimen is casted in the mould. The inner cavity dimension of the mould is 300 mm x 100 mm x 10 mm. The upper plate is bolted to the mould and the setup is left to cure for 24 hours at room temperature. The cast of each composite is cured under a load of about 50 kg for 24 hours before it removed from the mould to avoid and eliminate the air bubbles. Then this cast is post cured in the air for another 24 hours after removing out of the mould. Specimens of suitable dimension are cut for mechanical testing as per ASTM standards.

2.3 Tensile Testing

Tensile test are performed for several reasons. The results of tensile tests are used in selecting material for engineering applications. Tensile properties frequently are included in material specification to ensure quality. The strength of interest may be measured in terms of either the stress necessary to cause appreciable plastic deformation or maximum stress that the material can withstand. Specimens for tensile testing are cut as per ASTM D3039 standard shown in Fig. 1 and tensile testing is carried out on Universal Testing Machine with rate of loading of 2mm/min for testing. Tests were conducted on three identical specimens for each type of fiber separately and average result is obtained.

2.4 Impact Testing

Charpy impact test is used to measure the impact strength, which may be defined as toughness or ability of material to absorb energy during plastic deformation. Here the direction of the applied force is perpendicular to the fiber orientation. Impact strength of composite depends on the amount of fiber. An impact testing machine with Charpy arrangement is employed to perform the test as per the ASTM D256 standards. The specimens were 70mm length 10mm width and 3mm wide. The specimen is subjected to an impact blow and the corresponding energy absorbed by the material is obtained. This test gives the maximum energy that a material can absorb when it is subjected to heavy impact load. Specimens after impact test are shown in Fig. 2.

Fig. 1: Specimen for tensile test

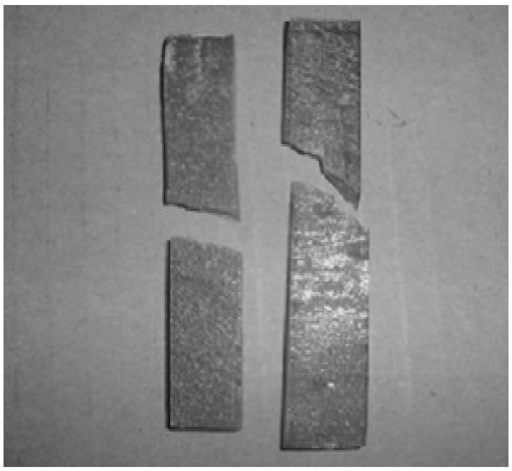

Fig. 2: Specimen for impact test

3. RESULT AND DISCUSSION

Mechanical properties of the composites generally rely upon matrix nature, fiber orientation and fiber-matrix interface tensile test was conducted according to American Society of Testing Method standard D3039 for plastics. Three specimens of each type fiber were obtained from the composite sheet and were tested in a universal testing machine with a maximum gauge length of 180mm. The average values of these three specimens were taken as the strength of the composite. The values of tensile strength of each specimen for wooden dust, short coir fiber and short chemically untreated banana fibers reinforced composites are mentioned in table 1 and the comparison of average tensile strength is plotted in Fig. 3. For wooden dust, short coir fiber and short chemically untreated banana fibers reinforced composites the average maximum tensile strength of the specimen was found to be approximately 120 MPa, 157 MPa and 290 MPa respectively. Average peak load was found to be 950N, 1220N and 1700N and average displacement was 3.20mm, 3.85mm and 4.30mm respectively.

Table 2 presents the measured impact strength values of the various particulate filled composites under this investigation. The average values of impact strength for the wooden dust, short coir fiber and short chemically untreated banana fibers reinforced composites was found to be approximately 9.3 J/m, 14.3 J/m and 18.3 J/m respectively plotted in Fig. 4.

Table 1 Tensile Test Results of Specimens

S. No.	Sample	Tensile Strength (MPa)		
		Wooden Dust	Short Coir Fiber	Banana Fiber
1	A	118.36	154.40	208.33
2	B	120.30	161.25	211.56
3	C	121.53	156.75	209.13
Average		120.06	157.46	209.67

Table 2 Impact Test Results of Specimens

S. No.	Sample	Impact Strength in J/m		
		Wooden Dust	Short Coir Fiber	Banana Fiber
1	A	9	13	16
2	B	10	14	18
3	C	9	16	19
Average		9.3	14.3	18.3

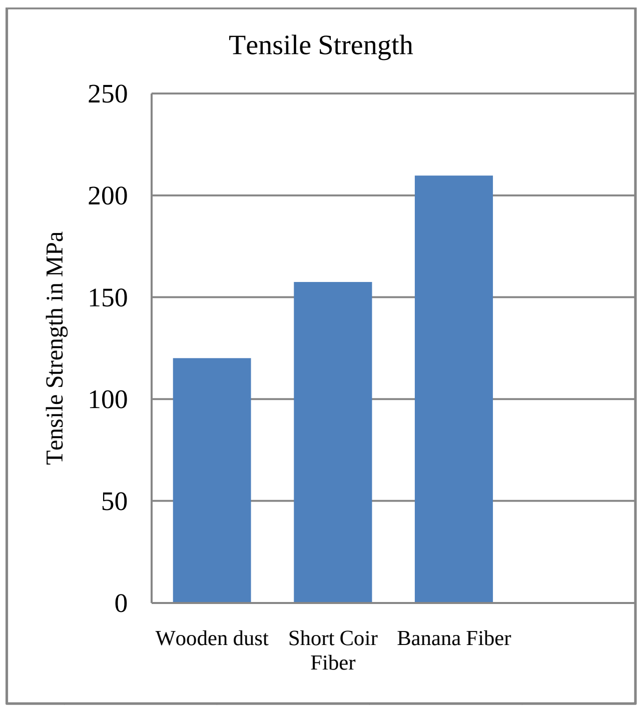

Fig. 3: Average tensile strength of Specimens

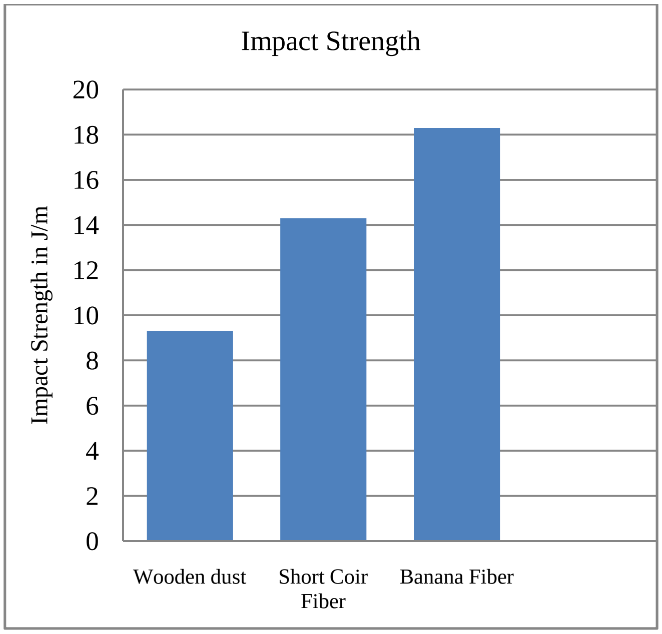

Fig. 4: Average impact strength of Specimens

4. CONCLUSION

In this study, Natural fibers reinforced polymer composite samples fabricated by the hand lay-up technique and evaluate their tensile strength and impact strength. The results obtained from experiments shows that the tensile strength and impact strength of the short chemically untreated banana fibers reinforced composite samples is more than the other composite samples for 50% weight compositions. This work can also be extended for range of different volume fraction percentage of natural fiber because it is observed in literature survey that volume fraction percentage of fiber affected the mechanical properties of composite significantly.

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