Mechanical Behavior of Natural Fiber Composite Material

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ABSTRACT

The use of natural fibers as reinforcement in polymeric composites is increasing thanks to the improvements in properties that fibers can provide to the merchandise. Composites materials were prepared by compression molding technique with hand layup process. Treatment of fiber with 2% NaOH was carried out in order to improve the interfacial bonds between fiber and matrix leading to better mechanical properties of the spathe-fiber-reinforced composite laminates. Filler loading as 5% by volume of coir fiber or epoxy resin composites have been formulated. The fiber length was chosen as 5mm, 10mm & 15mm and the ratio of epoxy resin: hardener was maintained as 10:0.8. A total three plates with dimension as 300 mm x 300 mm x 4 mm were produced and specimens as per the varied ASTM standard were tested to determine the ultimate tensile strength, strain energy, flexural strength, strain energy and micro hardness value for different configuration. It was observed that the lastingness of epoxy resin/ coir fiber composites was maximum at 15mm fiber length (16.27 N/mm^2). The charpy notch impact strength was also maximum at 15mm fiber length (10.87 kJ/m^2). The results show good mechanical properties and hint us as a replacement for conventional materials in industrial applications.

Keywords: Coir Fiber, Fiber Length, Mechanical Properties, Volume Fraction.

1 Introduction

The composite materials provide a many benefit as compared to conventional material such as stem largely from their higher specific strength, stiffness and fatigue characteristics, which enables structural design to be more versatile. By definition, composite materials are combination of two or more constituents with physically separable phases. However, only when the composite phase materials have different physical properties, it is recognized as being a composite material. Reinforcement provides rigidity and strength, helping to support structural load. The matrix or binder (organic or inorganic) keeps the orientation and position of the reinforcement. Significantly, constituents of the composites retain their individual, physical and chemical properties; yet together they produce a combination of qualities which individual constituents would be incapable of producing alone. The reinforcement may be platelets, particles or fibers and are usually added to improve mechanical properties such as stiffness, strength and toughness of the matrix material. Long fibers which oriented in the direction of loading offer the most efficient load transfer. The reason for this is the stress transfer zone extends only over a small part of the fiber-matrix interface and perturbation effects at fiber ends may be neglected. In other words, ineffective fiber length is small. Popular fibers are available as continuous filaments for use in high performance composites are glass, carbon and aramid fibers. The advantage of modern composite materials is that they are light as well as strong. By choosing a correct matrix combination and reinforcement material, a new material can be made that exactly meets the requirements of a particular application. A composite also gives design flexibility because many of them can be molded into complex shapes. The downside is often the cost. Although the resulting composite product is more efficient, the raw materials are often expensive. The incorporation of coir as a component in polymer composites is not satisfactory in some perspective compared to other natural fiber because of its low cellulose content (36–43%), high lignin content (41–45%) and high micro fibrilar angle.

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A researcher carried out a Morphological investigation on coir fibers reveals that the external sheath of lignin obstructs the cellulose to make interfacial bond with the polymers. The removal of this peripheral layer of lignin generally brings about more stable and superior interfacial bond. To achieve this, there are several treatments that are widely established such as alkali treatment, bleaching and graft copolymerization etc. by which the surface properties of natural fibers are enhanced. The coir industry in India, Sri Lanka and Brazil is much developed. The coir fiber polymer has many applications in structural systems in housing, electrical panels, ducting etc. The main feature of coir fibers are its low electrical and thermal conductivity. Thus, the coir composites can be used as low temperature insulating materials in electronic packaging and household applications.

2 Materials and Methods

Manufacturing of Laminates by Compression molding Technique: The coconut fiber which has been taken as reinforcement in this study is collected from local sources. The coir fibers were treated with alkaline treatment using 2 % NaOH. This was to remove wax, lignin, oils and other fiber constituents that may reduce adhesion between the matrix and fibers thereby constituting a weak boundary layer. The mould have been prepared of dimensions of 300 × 300 × 4 mm. The coconut fiber of different lengths chosen as 5 mm, 10 mm and 15 mm has been mixed with epoxy resins of their respective weights by simple mechanical stirring and mixture are poured in the mould, keeping the view on testing condition and characterization standards. The composites set of three different compositions have been prepared. A releasing agent (wax) has been use on mould sheet give easy removal of composites from the mould after curing. The air trapped is removed by sliding roller and the mould has been closed at temperature 30˚ C for 24 hour and at a constant load of 50 kg.

3 Theory and Calculation

3.1 Mechanical Testing

a. Tensile Testing

This test is used to determine strength, ductility, resilience, toughness and several other material properties. The test was done using a universal testing machine and performed according to ASTM D-3039. The test specimen size was 200 x 20 x 4 mm. A record of load acting on specimen with progressive extension of specimen is obtained. Test is conducted up to failure of specimen and various observations are recorded.

Figure 1: *Tensile Test Specimens before fracture*

Figure 2: *Tensile Test Specimens After fracture*

Results of Tensile Test:

Table 1: *Tensile Test Results*

Composites	Tensile strength (MPa)	
	Trial 1	Trial 2
C1	13.34	12.846
C2	14.02	13.86
C3	16.27	15.81

b. Flexural Testing

This testing method measures the behavior of materials subjected to simple bending loads. Similar to tensile modulus, flexural modulus (stiffness) is calculated from the slope of the bending load vs. deflection curve. Flexural testing involves the bending of a material, rather than pushing or pulling, to determine the relationship between bending stress and deflection. Flexural testing is used on brittle materials such as ceramics, stone, masonry and glasses. It can be used to know the behavior of materials which are intended to bend during their useful life, such as wire insulation and other elastomeric products the three points bending flexural test. The main advantage of three point flexural test is the ease of the specimen preparation and testing. However, this method has some disadvantages: the results of the testing method are sensitive to specimen and loading geometry and strain rate. The three point flexural test was conducted according to ASTM D-790 and the specimen size was 100 x 13 x 4 mm. These tests are generally used to determine the flexural modulus or flexural strength of a material. The material is laid horizontally over two points of contact (lower support span) and then a force is applied to the top of the material through either one or two points of contact (upper loading span) until the sample fails in test. The maximum recorded force is the flexural strength of particular sample.

Figure 3: *Flexural Test Specimens before fracture*

Figure 4: *Flexural Test Specimens After fracture*

Results of Flexural Test:

Table 2: *Flexural Test Results*

Composites	Flexural strength (N/mm^2)	
	Trial 1	Trial 2
C1	26.11	26.59
C2	29.58	28.45
C3	30.47	29.98

c. Impact Testing (Charpy)

Charpy Impact Test was carried out to determine the toughness of the composite's samples according to ASTM D-256 using Charpy principle and the specimen size was 65 x 12.7 x 4 mm.

Figure5: *Impact Test Specimens before Fracture*

Figure6: *Impact Test Specimens after Fracture*

Results of Impact Test:

Table 3: *Impact Test Results*

Composites	Impact Energy (kJ/m^2)	
	Trial 1	Trial 2
C1	8.2	8.1
C2	9.3	9.1
C3	10.7	10.87

4 Results and Discussion

Mechanical Properties of Coir composite laminates.

Table 4: *Mechanical Properties*

Composites		C1	C2	C3
Tensile Strength	Trial 1	13.34	14.02	16.27
	Trial 2	12.846	13.86	15.81
Flexural Strength	Trial 1	26.11	29.58	30.47
	Trial 2	26.59	28.45	29.98
Impact Strength	Trial 1	8.2	9.3	10.7
	Trial 2	8.1	9.1	10.87

The above results shows that mechanical properties of coir composites are gradually increasing as we increase the fiber lengths but the increment is not sudden so a further detailed analysis is needed to know the change in effect

5 Conclusions

A detailed study has been conducted on the mechanical behavior of coir/epoxy composite on the basis of different fiber lengths. Alkali treatment of the coir fiber has also been done. The study led to the conclusions mentioned below.

1. Epoxy resin reinforced with alkali treated fiber can be fabricated by hand lay-up method.

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2. In tensile testing, tensile strength are gradually increases with increasing fiber length. It is also found that alkali treated fiber loaded composites shows excellent tensile strength. As a result, the maximum tensile strength obtained in case of 15 mm fiber length.
3. In flexural testing, flexural strength are gradually increases with the increasing fiber length. High flexural strength is obtained at 15 mm fiber length.
4. In impact testing, impact strength are gradually increases with the increasing fiber length. It also shows the brittle nature of fractured surface.

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