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Study of Mechanical Behavior of Coir Reinforced Epoxy Composite

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Abstract

In order to conserve natural resources and economize energy, weight reduction has been the main focus of machine parts manufacturers in the present scenario. Weight reduction can be achieved primarily by the introduction of better material, design optimization and better manufacturing processes. The coir fiber reinforced composite is one of the potential items for weight reduction of about 20% - 30%. The introduction of coir fiber composite materials was made it possible to reduce the weight without any reduction on load carrying capacity, more elastic strain energy storage capacity and high strength to weight ratio as compared with those of steel. The objective of this project is to fabricate the new class of epoxy based composites reinforced with short coir fiber in different proportion like 5%, 10% and 15%. Evaluate the mechanical properties such as tensile strength and hardness of prepared coir reinforced composite.

Keywords: Coir Fiber, Epoxy resin, Composite.

1. INTRODUCTION

In this part a technical and historical introduction on composites is presented. An overview of the most common production process is given. At the end an integrated design process, typical for composites, is discussed. At the end the relevance of composites for industrial and socio-economic development in developing countries is discussed. Composites are hybrid materials made of a polymer resin reinforced by fibers, combining the high mechanical physical performance of the fibers and the appearance, bonding and physical properties of polymers, the short and discontinuous fiber composites are responsible for the biggest share of successful application, whether measured by number of parts or quantity of material used. Less visible however, but growing enormously since the last decade, are the application of continuous fiber reinforced polymers.

2. LITERATURE SURVEY

S.M. Sapuan et al. [1] were carried out the experiments of tensile and flexural (three-point bending) tests using natural fibre with composite materials (Musaceae/epoxy). it was found that the maximum value of stress in x-direction is 14.14 MN/m2, meanwhilethe maximum value of stress in y-direction is 3.398 MN/m2. For the Young s modulus, the value of 0.976 GN/m2 in x-direction and 0.863 GN/m2 in y-direction were computed. As for the case of three-point bending (flexural), the maximum load applied is 36.25 N to get the deflection of woven banana fibre specimen beam of 0.5 mm. The maximum stress and Young s modulus in x-direction was recorded to be

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26.181 MN/m2 and 2.685 GN/m2, respectively. Statistical analysis using ANOVA-one way has showed that the differences of results obtained from those three samples are not significant, which confirm a very stable mechanical behaviour of the composites under different tests. Z.N. Azwa et al. [2] evaluates the characteristics of several natural fibre composites exposed to moisture, thermal, fire, and ultraviolet degradation through an extensive literature review. The effects of chemical additives such as fibre treatments, fire retardants and Ultraviolet (UV) stabilizers are also addressed. Based on the evaluation conducted, optimum fibre content provides strength in a polymer composite but it also becomes an entry point for moisture attack. They concluded that an optimum blend ratio of chemical additives must be employed to achieve a balance between strength and durability requirements for natural fibre composites. J. Rout et al. [3] Surface modifications of coir fibres involving alkali treatment, bleaching, and vinyl grafting are made in view of their use as reinforcing agents in general-purpose polyester resin matrix. The mechanical properties of composites like tensile, flexural and impact strength increase as a result of surface modification. Among all modifications, bleached (65 C) coir-polyester composites show better flexural strength (61.6 MPa) whereas 2% alkali-treated coir/polyester composites show significant improvement in tensile strength (26.80 MPa). Hybrid composites comprising glass fibre mat (7 wt.%), coir fibre mat (13 wt.%) and polyester resin matrix are prepared. Hybrid composites containing surface modified coir fibres show significant improvement in flexural strength. Thi-Thu-Loan Doan et al. [4] Jute fibres were surface treated in order to enhance the interfacial interaction between jute natural fibres and an epoxy matrix. The fibres are exposed to alkali treatment in combination with organosilane coupling agents and aqueous epoxy dispersions. The surface topography and surface energy influenced by the treatments were characterized. Single fibre pull-out tests combined with SEM and AFM characterization of the fracture surfaces were used to identify the interfacial strengths and to reveal the mechanisms of failure. S. Harish et al. [5] an investigation has been carried out to make use of coir, a natural fiber abundantly available in India. Natural fibers are not only strong and lightweight but also relatively very cheap. In the present work, coir composites are developed and their mechanical properties are evaluated. 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. These results indicate that coir can be used as a potential reinforcing material for making low load bearing thermoplastic composites. D. Verma et al. [6] discusses the use of coir fibre and its current status of research. Many references to the latest work on properties, processing and application have been cited in this review. Tara Sen et al. [7] made a review among the various natural fibres such as, sisal fibres, bamboo fibres, coir fibres and jute fibres are of particular interest as these composites have high impact strength besides having moderate tensile and flexural properties compared to other lignocellulosic fibres. Among the various natural fibres, sisal fibre reinforced composite, bamboo fibre reinforced composite, coir reinforced composite and jute fibre reinforced

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composite are of particular interest as these composites have high impact strength besides having moderate tensile and flexural properties compared to other lignocellulosic fibres. Gopinath et al. [8] made studies on the use of natural fibers as replacement to man-made fiber in fiber-reinforced composites have increased and opened up further industrial possibilities. Natural fiber-reinforcced composites can be applied in the plastics, automobile and packaging industries to cut down on material cost. So in this work, natural fibers such as coir fiber and rice husk are selected as reinforced in epoxy resin. Brown coir fibers and rice husk are treated with 6% of NaOH separately to increase the fiber strength and the treated natural fibers are reinforced in epoxy matrix to fabricate the composite. The ratio in which the coir fiber and rice husk are mixed is varied and the tensile behavior of composites made from various combination ratios are analyzed. Factors such as tensile strength, elongation at the break are determined and the ratio with optimum mechanical strength characteristic is predicted. Significant difference is found on the mechanical properties of various combinations. S JAYABAL et al. [9] were developed the woven coir–glass hybrid polyester composites and their mechanical properties were evaluated for different stacking sequences. Scanning electron micrographs of fractured surfaces were used for a qualitative evaluation of interfacial properties of woven coir–glass hybrid polyester composites. These results indicated that coir–glass hybrid composites offered the merits of both natural and synthetic fibres. C.H.Chandra Rao et al. [10] has been investigate the wear behavior of treated and untreated coir dust filled epoxy resin matrix composite. it is found that the treated fiber composite shows better wear resistance than the untreated fiber composites. Abrasive wear rate is decreased with increasing the coir dust amount. As the load increase the wear rate increases also observed similar trend also observed in velocities also. The knowledge gap in the present literature review has helped us to set the objectives of this research work like fabrication of a new class of epoxy based composites reinforced with short coir fibres. Evaluation of mechanical properties such as tensile strength and hardness of the fabricated composites has been done.

3. COMPOSITE FABRICATION

The coir fiber used for the preparation of composites is arranged from local resources. First of all the coir fibers are segregated finely and they cut into pieces of length about 12 mm. The Epoxy resin Araldite AY 103 and hardener HY 991 is taken as matrix binder. Commonly epoxy resin has poor mechanical and thermal properties. For getting the properties to be improved, the resin should undergo curing reaction in which the liner epoxy resin structure changes to form three-dimensional cross-linked thermoset structure. This curing reaction takes place by adding a curing agent called hardener in a ratio of 10:1 to epoxy resin. The following reaction is an exothermic reaction in which homopolymerisation of resin takes place. In order to get improved mechanical and physical characters of the composites, coir fiber is subjected to alkali treatment process. In alkali treatment, fibers are firstly prewashed with huge amount of distilled water and dried at constant temperature of 50^{o}C. The alkalization process consisted of immersing coir fibers of certain weight in a 5% (w/v) NaOH aqueous solution for 3 h at 70^{o}C as shown in the figure 1. After that,

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fiber is removed from alkali solution and is dipped in 5 % acetic acid solution for neutralizing. Then it is washed with plenty of distilled water and is dried in an electric oven at a temperature of 110 for 2 hours. The prepared coir fiber is shown in the below figure 2.

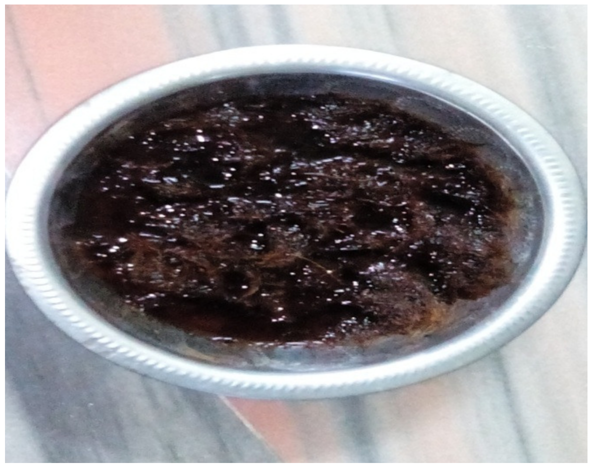

Figure 1 NaOH treatment of coir fiber

Figure 2 Prepared coir fiber

Fabrication of composite is done by conventional method called hand lay-up method. Epoxy resin with its corresponding hardener in a ratio of 10:1 is thoroughly mixed. Mold releasing silicon spray is applied to mold releasing sheet and then the chopped fiber, mixed with the resin is gently poured on the sheet which is placed inside the mold. The purpose of releasing agent is to facilitate easy removal of the composite from the mold after curing. The mixture is allowed to set inside the mold for a period of 24 hours under a pressure of 20kg over the cast. Then the specimen is cut into appropriate dimension for mechanical and thermal tests. In this fabrication procedure, three classes of composites are made with different compositions are shown in the table 1.

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Figure 3 Fabricated specimen at 0% fiber

Figure 4 Fabricated composites at 5% fibers

Figure 5 Fabricated composites at 10% fibers

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Figure 6 Fabricated composites at 15% fibers

Table 1: Designation of Composites

Sl. No	Epoxy (Wt %)	Alkali treated Coir (Wt %)
1.	100	0
2.	95	5
3.	90	10
4.	85	15

4. TESTS AND ANALYSIS

4.1 Tensile Strength

The tensile test of the composites has been performed as per the ASTM D3039 standards. The test will be complete using a universal testing machine. A universal testing machine (UTM), also known as a universal tester, materials testing machine or materials test frame, is used to test the tensile stress. It is named after the fact that it can perform many standard tensile tests on materials, components, and structures.

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Figure 7 Tensile Test

Dimension of the specimen in mm = 250x25x2.5
Area of the specimen = 62.5 mm²
Tensile strength = Load/ Area

Table 2: For specimen at no fiber

Strength	Load kg			Tensile Strength (N/mm²)		
	A	B	C	A	B	C
Elastic	35	36	35	5.49	5.65	5.49
Yield	41	40	42	6.44	6.28	6.59
Plastic	49	48	48	7.69	7.53	7.53
Ultimate	54	54	56	8.48	8.84	8.79
Breaking	65	64	67	10.2	10.05	10.52

Mean Tensile strength = 10.26 N/mm²

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Table 3: For specimen at 5% fiber

Strength	Load kg			Tensile Strength (N/mm²)		
	A	B	C	A	B	C
Elastic	39	39	38	6.12	6.12	5.96
Yield	48	47	48	7.53	7.38	7.53
Plastic	56	56	55	8.79	8.79	8.63
Ultimate	67	65	64	10.52	10.2	10.05
Breaking	75	74	74	11.77	11.62	11.62

Mean Tensile strength = 11.67 N/mm²

Table 4: For specimen at 10% fiber

Strength	Load kg			Tensile Strength (N/mm²)		
	A	B	C	A	B	C
Elastic	46	45	46	7.22	7.06	7.22
Yield	55	55	55	8.63	8.63	8.63
Plastic	63	64	63	9.89	10.05	9.89
Ultimate	71	73	72	11.14	11.46	11.3
Breaking	84	86	86	13.18	13.51	13.51

Mean Tensile strength = 13.4 N/mm²

Table 5: For specimen at 15% fiber

Strength	Load kg			Tensile Strength (N/mm²)		
	A	B	C	A	B	C
Elastic	50	48	52	7.85	6.87	8.161
Yield	58	58	61	9.10	9.10	9.57
Plastic	72	73	75	11.30	11.45	11.77
Ultimate	80	84	84	12.56	13.18	13.18
Breaking	94	94	96	14.75	14.75	15.06

Mean Tensile strength = 14.85 N/mm²

Table 6: Average Tensile Strength

Sl. No	Epoxy (Wt %)	Alkali treated Coir fiber (Wt %)	Tensile Strength (N/mm²)
1.	100	0	10.26
2.	95	5	11.67
3.	90	10	13.4
4.	85	15	14.85

The tables 2 to 5 show the tensile strength of the prepared composites at different combinations. The table 6 shows the average tensile strength of each combination of the specimen. From the obtained result, Epoxy based polymer composite with 15% coir fiber attains the maximum strength of 14.85 N/mm^2.

4.2 Rockwell Hardness

Rockwell Hardness ASTM D785 test is a hardness measurement based on the net increase in depth of impression as a load is applied. Hardness numbers have no units and are commonly given in the R, L, M, E and K scales. Higher numbers indicate harder materials. A standard specimen is placed on the surface of the Rockwell Hardness tester. A minor load is applied and the gauge is set to zero. The major load is applied by tripping a lever. After 15 seconds the major load is removed. The specimen is allowed to recover for 15 seconds and then the hardness is read off the dial with the minor load still applied. The table 7 shows the obtained hardness value of the prepared specimen and in which the specimen without fiber produce high hardness value when compared with other specimens.

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Figure 8 Rockwell hardness setup

Table 7: Hardness Property

Sl. No.	Epoxy (Wt %)	Alkali Treated Coir fiber (Wt %)	Indenter	Load(kg)	RHN			Mean RHN
					A	B	C	
1.	100	0	1/16 inches Ball	150	116	115	113	114.67
2.	95	5	1/16 inches Ball	150	112	105	113	110
3.	90	10	1/16 inches Ball	150	111	109	104	108
4.	85	15	1/16 inches Ball	150	113	108	111	110.67

5. CONCLUSION

A detailed study has been conducted on the mechanical behavior of coir/epoxy composite on the basis of different weight concentration of fiber and filler. The study led to the conclusions mentioned below.

- Epoxy resin reinforced with alkali treated fiber and untreated fiber has been fabricated by hand lay-up method. Coir Epoxy composite hasbeen fabricated with same technique.
- Mechanical properties such as tensile strength and hardness of the composites have been evaluated.

- The tensile strength of the coir fiber based epoxy composite with 15% designation contributes a maximum tensile strength of 14.85 N/mm². But the hardness of the material is reduced when the percentage of fiber is increased.

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