

Evaluation of The Mechanical Properties on Sisal-Coir Hybrid Natural Fiber Composites

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ABSTRACT: - The usage of natural fiber reinforced composites is growing at a faster rate and is actively being considered as an alternate material for synthetic fiber. In the present work an attempt has been made to fabricate the sisal-coir fiber randomly oriented hybrid composites and to evaluate the mechanical properties such as tensile strength and flexural strength. Three types (sisal-coir) of hybrid laminate and two pure laminate composites are fabricated using manual layup technique. Epoxy (Ly556 and HY951) resin is used as matrix material in the present work. The specimens are prepared according to ASTM standards and the experiments were conducted on an universal testing machine (UTM). From the experimental results, it has been observed that the sisal-coir fiber hybrid composites exhibited superior properties when compared to pure composites.

Keywords:- Coir & Sisal fibers, Epoxy, Hybrid polymer matrix composite, Hand layup.

I. INTRODUCTION

Hybrid composite materials are made by combining two or more different types of fibers in single matrix phase or single reinforcing phase with multiple matrix phases or multiple reinforcing and multiple matrix phases [1]. Normally it contains a high modulus fiber when it combined with low modulus fiber it enhances the high strength. In addition the expensive of preparation of composite material is low. The mechanical properties of hybrid composites depend on the fiber length, fiber orientation, weight fraction of the reinforcement, interaction between fiber and matrix [4]. Natural fiber as a reinforcement has recently attracted the scientists and researcher's because of their advantages like high specific strength, light weight, low density, low cost, ecofriendly nature, fully biodegradable, abundantly available and renewable[3]. Plant fibers have some disadvantages such as high moisture absorption and low thermal stability. Several natural fibers are available such as banana, coir, sisal, bamboo, hemp, cotton, jute, pineapple etc [16]. These fibers are derived from plants; they are ligno cellulose in nature.

The hybrid natural fiber-reinforced polymer composite materials may replace or reduce utilization of synthetic fibers in automobile and building construction industries [2]. Naga Prasad Naidu et al. [6] presented the tensile and flexural strengths of Glass-sisal polyester hybrid composites. Tensile strength and flexural strength for the composite laminates were about 12.35 MPa and 53.46MPa. Yan Li et al. [5] In their paper conclude that sisal and glass fibers can be combined to produce hybrid composites which takes full advantage of the best properties of the constituents. Abdul Khalil H.P.S. et al. [7] in their paper mechanical and physical properties of oil palm empty fruit bunch/glass hybrid reinforced polyester composites were studied and showed hybrid composites exhibited good properties.

Palanikumar et al. [8] the properties such as tensile strength, flexural strength and impact strength studied detail the results show that the addition of sisal and jute in the glass fibre composite materials make the composite hybrid and it improves the properties. Sreekala et al. [9] investigated the performance of mechanical properties of oil palm fiber with glass fiber and used phenol formaldehyde as resin. The results shows the maximum performance observed at 40%wt loading. Girisha et al.[14] fabricated composites consisting of reinforcement in the hybrid combination such as sisal- coconut spathe, sisal-ridge gourd and coconut spathe-ridge gourd with fibers varying from 5% to 30Wt%. The tensile strength reached a maximum value of 22 MPa at 25% weight fraction of fibers. This result explained that the incorporation of different natural fibers (instead of a synthetic and a natural fibre) as reinforcements is also a very Practical approach.

The above literature reveals the very few works have been done on hybrid natural fibres. An attempt has been made to investigate mechanical characterization on coir-sisal hybrid natural fiber composites.

II. MATERIALS AND METHODS

A. Materials

Coir fiber: Coir (*cocos nucifera*) fiber is obtained from the husk of coconut fruit fiber. Coir fiber has more life when compared to other natural fibers due to more lignin content. Coir fiber was collected from local resources.

Sisal fiber: Sisal (*Agavaceae*) fiber is extracted from the leaves of sisal plant. The fibers are extracted through hand extraction machine composed of either serrated or non-serrated knives. Sisal fiber was purchased from “Perfect banana fibers and articles”, Dharmapuri District Tamil Nadu.

Resins: Epoxy Ly556 (Diglycidyl ether of biphenyl-A) and HY951 (Triethylenetetramine) hardener was purchased from Shakti glass fibers and traders Chennai.



Fig.1: Coir& Sisal fibers



Fig.2: Epoxy resin & Hardener

B. Fiber preparation

Here discontinuous and continuous fibers are used for fabrication of the composite. The obtained fibers are cleaned with water. The cleaned fibers are dried in the sunlight. Both the fibers are combed several times to separate the fibers in to individual strands. Then fibers are cut in the length of 5mm.Later both the fibers are weighted accurately.

C. Mould preparation

A mould with dimensions of 210 x 210 x 4 mm is used for the fabrication of composite. A clean smooth surfaced wooden board is taken and washed thoroughly.



Fig.3: Cutting of fibers



Fig.4: Wooden mould



Fig.5: Composite preparations



Fig.6: Final composite laminates

D. Fabrication of composite

Coir fibers and sisal fibers were reinforced in epoxy resin for the fabrication of composite using hand layup method. The natural fiber composites comprising 60% (Resin+Hardner) and 40% fibers were used [13]. Fibers were weighed and proportionately resin and hardener are mixed. Epoxy and hardener was mixed using glass rod in a bowl. Proper care has been taken to avoid formation of bubbles. A releasing film on the mould surface is applied before manufacturing of the composite. Fibers ply of one kind were placed and resin was poured followed by proper rolling. Similarly another type of ply was placed and rolling is applied. This procedure was repeated until four alternating fibres ply have been laid. On the top of the last ply a polymer coating is done which serves to ensure a good surface finish. Then a releasing sheet was put on the top; a light rolling was carried out. Finally, a 20 kg weight was applied on the composite. Five different kinds of specimen are fabricated according to the fibers used. i.e. Pure coir (0-40),sisal-coir(10-30),sisal-coir (20-20),sisal-coir (30-10) and pure sisal(40-0).

III. Testing Of Composites

A. Tensile test

The composite specimens are cut into required dimension using a jig saw cutter and the edges are finished using emery paper for mechanical testing. The tensile test specimen is prepared according to the ASTM D638 standard [10].The testing process involves placing the test specimen in the testing machine and applying tension to it until it fractures. The tensile test is performed on Universal Testing Machine (UTM). The fabricated specimen for tensile test is presented in Fig. 7. Six specimens are tested in each case and the average values are reported for discussion.

B. Flexural test

A 3-point flexure test is the most common flexural test for composite materials. The flexural specimens are prepared as per the ASTM D790 standards [11]. Specimen deflection is measured by the crosshead position. Test results include flexural strength and displacement. The testing process involves placing the test specimen in the universal testing machine and applying force to it until it fractures. Following formula has been used to calculate flexural strength and flexural modulus.

$$\text{Flexural strength } f = (3PL) / (2bd^2), \text{ flexural modulus } Ef = (L^3m) / (4bd^3) \text{ ----- (1)}$$



Fig.7: Tensile testing specimens

Fig.8: Flexural testing specimens

IV. RESULTS AND DISCUSSION

A. Tensile strength

TABLE 1. Summary of Tensile Properties for Different Composites.

Composites	% Weight fraction	Tensile Strength (Mpa)	Tensile Modulus (Mpa)
Pure Coir	0-40	8.611	2.66
Sisal-Coir	10-30	13.78	3.22
Sisal-Coir	20-20	17.92	3.97
Sisal-Coir	30-10	16.46	3.46
Pure Sisal	40-0	17.05	3.73

Table 1 shows the summary of tensile strength and modulus values. Fig 9 shows the tensile strength trend with respect to various weight fractions of the composite. The results indicated that for (20-20) composite the tensile strength is 17.92Mpa, sisal-coir specimen gives better tensile strength than the other four types of composites. This behavior can be correlated to hybridization effect as both fibers contributed to the higher tensile strength of the composite. The tensile strength of the pure coir and pure sisal composites are 8.611 Mpa and 17.05Mpa respectively. Hybrid combination of sisal-coir (10-30) and (30-10) composite tensile strengths are 13.78 Mpa and 16.46 Mpa. The effect of hybridization is found to be negligible for the above two composites. Similar observations were reported by N. Venkateshwaran, et al. [12].

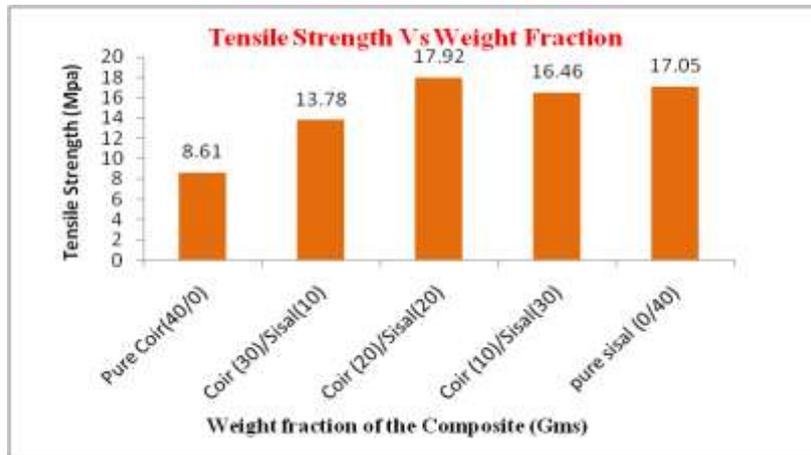


Fig.9: Tensile strength Vs Weight fraction

Fig: 10 shows the tensile modulus of sisal-coir fiber hybrid composites. The results indicated that the (sisal-coir) 20-20 hybrid composite exhibits higher tensile modulus, than the other reinforced composites. The sisal-coir hybrid composite tensile modulus values are (10-30) 3.22 Mpa and (30-10) 3.46 Mpa respectively [15].

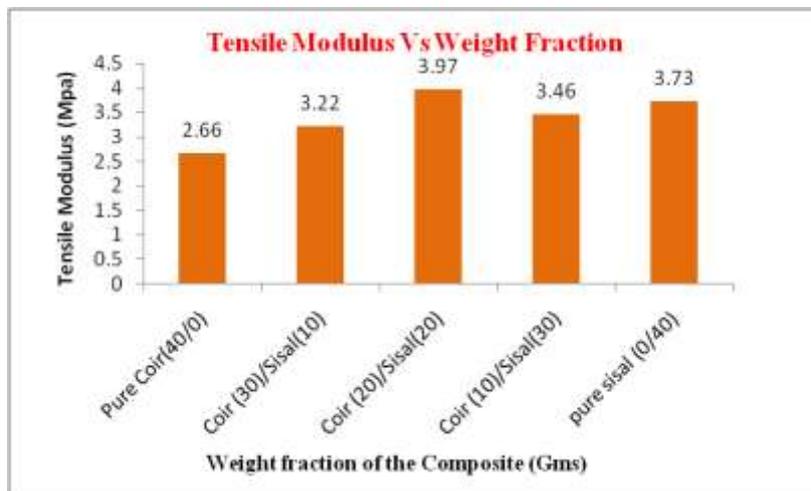


Fig.10: Tensile modulus Vs Weight fraction

B. Flexural strength:

Table 2. Summary of Flexural Properties for Different Composites

Composites	% Weight fraction	Flexural Strength (Mpa)	Flexural Modulus (Mpa)	% Elongation
Pure Coir	0-40	37.60	211.02	4.63
Sisal-Coir	10-30	81.46	540.94	4.83
Sisal-Coir	20-20	170.76	1054.06	5.27
Sisal-Coir	30-10	144.13	891.44	5.22
Pure Sisal	40-0	62.66	374.33	5.11

Table 2 shows the summary of flexural properties of different composites. Fig: 11 the load vs. displacement curve observed for the various composites tested. The results indicated that the displacement increases with the inverse of load. The results indicated that sisal-coir (20-20) hybrid composite shows better results among the others. It has been observed that pure sisal and pure coir composite values are 37.60 Mpa and 62.66 Mpa, these composite values are low when compared to other hybrid composites. The increase of flexural strength is due to the increased area of bonding at the interfacial region of the matrix to transmit and distribute the applied stress to the sisal fibers resulting in higher strength. Similar trends have been observed J.madhukiran.et.al [9].

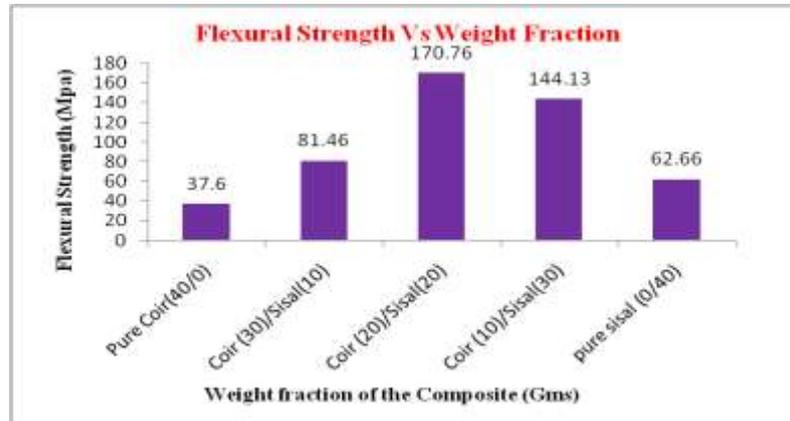


Fig.11: Flexural strength Vs Weight fraction

The combination of fibers used in sisal-coir hybrid composite. The below figure clearly indicates the gradual increase in both tensile modulus and flexural modulus with the fiber weight fraction. It is evident that incorporation of sisal fiber improves the load bearing capacity and the ability to with stand the bending of the composite. Coir-sisal fiber increases to maximum value of (20-20) 1054.6 Mpa. The hybrid composites of sisal-coir (30-10) and (10-30) values are high compared pure composites. The flexural modulus observed for pure coir and pure sisal values are 211.02 Mpa and 374.33 Mpa respectively.

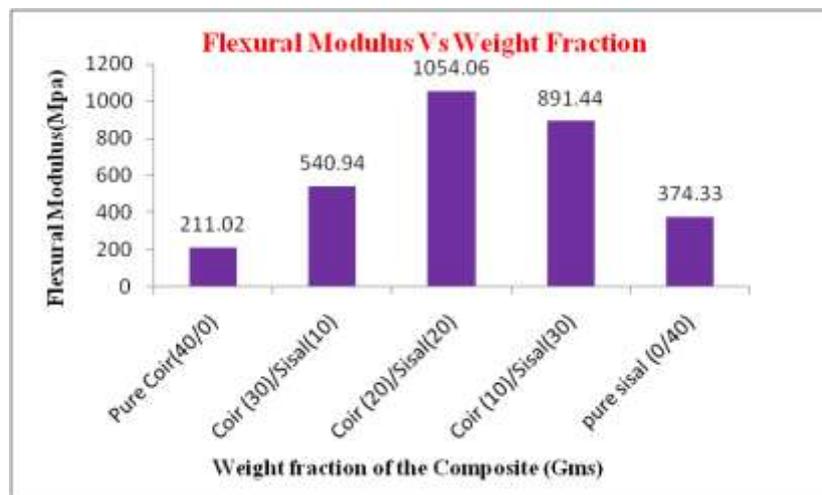


Fig.12: Flexural modulus Vs Weight fraction

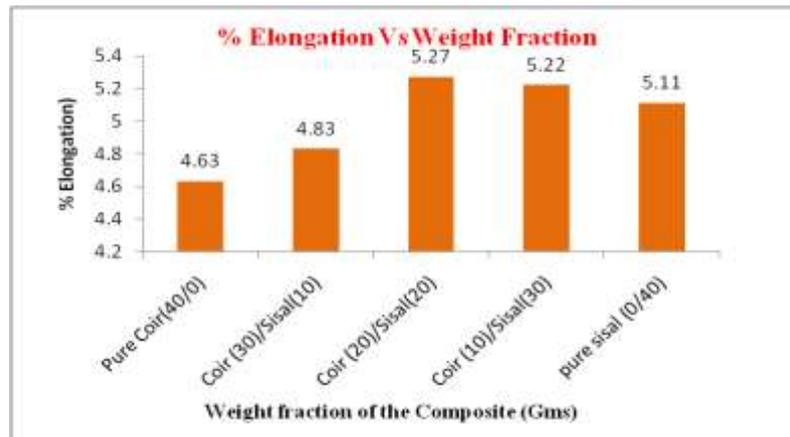


Fig.13: Elongation Vs % Weight fraction

It can be observed that the higher tensile strength and higher elongation was found. The percentage elongation of coir-sisal composite is found to be higher than other composites; hence it is found to be more ductile in nature. This can be attributed to hybridization effect as both fibers contributed higher strength and elongation of the hybrid composite.

V. CONCLUSIONS

After determining the material properties of natural fiber reinforced epoxy hybrid composites with five different weight fractions of the materials, the following conclusions can be made.

1. Due to hybridization effect the mechanical properties of the coir/sisal hybrid composites are higher than the pure composite.
2. Sisal-coir fiber reinforced epoxy hybrid composites are successfully fabricated using hand layup technique.
3. It can be observed that Coir-sisal (20-20) weight fraction hybrid composite samples possess good tensile strength and can withstand the strength up to 17.92Mpa.
4. Randomly oriented short coir-sisal 5mm length fiber hybrid composite having fiber contents of 40 wt% and 60% matrix exhibit the maximum flexural strength.
5. The hybrid natural fiber composites can be regarded as a suitable for the medium load applications such as interior parts of the car body.

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