Mechanical Testing of Hybrid Composite Material (Sisal and Coir)

G.Velmurugan[1], S.P.Venkatesan[2], P.V.Prakash[3] ,N.Sathishkumar[4] N.Vijayakumar[5]

[1,3,4,5]Assistant Professor, Excel College of Engineering & Technology, Tamil Nadu
[2]Associate Professor, Excel College of Engineering & Technology, Tamil Nadu

Abstract- The global demand for wood as a building material is steadily growing, while the availability of this natural resource is diminishing. This situation has led to the development of alternative materials. Of the various synthetic materials that have been explored and advocated, polymer composites claim a major participation as building materials. There has been a growing interest in utilizing natural fibres as reinforcement in polymer composite for making low cost construction materials in recent years. Natural fibres are prospective reinforcing materials and their use until now has been more traditional than technical. Among this paper concern Evaluation of mechanical properties such as tensile strength, flexural strength and impact strength for different fibre length and fibre volume fraction Specimen1 [3mm] Sisal (25%) - coir (15%), Specimen 2 [3mm] Sisal (20%) - coir (20%), Specimen 3[5mm] Sisal (20%) - coir (20%). Sisal and coir fibers used as reinforcement materials with matrix of Epoxy resin to manufacturing of composite plate by hand lay-up process and cut into that as per ASTM for testing the materials.

Index Terms- fiber, sisal, coir, tensile, flexural, impact

I. Introduction

Natural fibres are economical less weight and environmentally superior alternatives to synthetic fibres. The specific properties of the natural fibre composites were in some cases better than synthetic fibres. This suggests that natural fibre composites have a potential to replace in many applications like automobile and aircraft industry. The artificial fibres posses twice the weight of natural fibres and more cost, cause damage to human beings and energy for extraction is more compared to natural fibres. In this connection the sisal and coir fibre are a natural fibre that used to prepare the reinforced composite with suitable matrix of Epoxy. The composites are prepared by various fibre length and volume fraction. The mechanical properties are analyzed and find the optimum fibre parameter.

II. METHODOLOGY

•To find out the new class of less-weight material for automotive and house holding applications (sisal and coir)

• Fabrication of sisal and coir fibre reinforced polymer based composites.

• Evaluation of mechanical properties such as tensile strength and modulus flexural strength and modulus, compressive strength, machining parameters for different fibre volume length and fibre volume fraction.

• Besides the above objectives is to develop new class of composite by incorporating fibre reinforcing phases into a polymeric resin.

III. MOULD PREPARATION

For the sample preparation the first and foremost step is the preparation of the mould which ensures the dimension of 300×300×30 mm the composite to be prepared. We have to prepare moulds for the preparation of 20% sisal and 20% coir and another 25% sisal and 15% coir fibre of the composite having 3mm and 5mm fibre length. A clean smooth surfaced wooden board is taken and washed thoroughly. The Steel plate (as shown in figure 3.1) was covered with a mould release sheet

Figure 3.1 Moulds for Making Composite Plates

3.1 SISAL AND COIR CHOPPED FIBRE REINFORCED COMPOSITE

In this Reinforced composite the different volume fraction of composite plate such as 20% of sisal and 20% of coir as shown in Figure 3.2 (a) and 25% of sisal and 15% of coir as shown in Figure 3.2 (b) in 3mm fibre length and the same proportion is carried with 5mm fibre length as shown in Figure 3.2 (c) and Figure 3.2 (d) Calculated the amount of epoxy resin and hardener (ratio of 4:1 by weight) was thoroughly mixed with gentle stirring to minimize air entrapment. For quick and easy removal of composite sheets, mould release sheet was put over and below the mould cavity and wax was applied at the inner surface of the mould. After keeping the mould on a glass sheet a thin layer (≈ 1 mm thickness) of and matrix (4:1) were poured into the mould. The bundles of short continuous fibres were arranged random direction into the mould. Then again the matrix was poured above the fibres and care was taken to avoid formation of air bubbles. Pressure was then applied from the top and the mould was allowed to cure at room temperature for 24 hrs. After 24 hrs the samples were taken out of the mould, cut into different sizes as per the ASTM D standards and kept in air tight container for further experimentation.

Fig 3.2.1(a)

Fig 3.2.1(b)

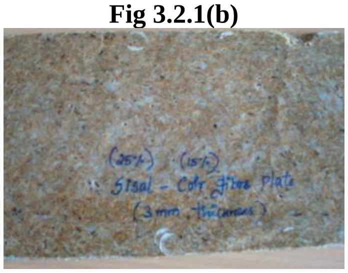


Fig 3.2.1(c)

Fig 3.2.1(d)

IV. MECHANICAL TESTING

After fabrication the test specimens were subjected to various mechanical tests as per ASTM standards. The mechanical tests that we carried out are tensile test, impact test and flexural test. The specimen size and shape for corresponding tests are as shown in table 4.1

Sl.no	Test	ASTM Standard	Specimen size (mm)
1	Tensile test	D638-03	250 X 25 X 3
2	Flexural properties	D790	154 X 13 X 3
3	Impact testing	D256	64 X 12.7 X 3

Table 4.1 ASTM Standard for Specimen Preparation

4.1 TENSILE TEST

After the fibres reinforced composite was dried, it was cut using a saw cutter to get the dimension of specimen for mechanical testing. The tensile test specimen was prepared (Figure 4.1.1 and 4.1.2) according to ASTM D3039; the most common specimen for ASTM D3039 has a constant rectangular cross section, 25 mm (1 in) wide and 250 mm (10 in) long. The specimen was mounted in the grips of the Instron universal tester with 10 mm gauge length. The stress strain curve was plotted during the test for the determination of ultimate tensile strength and elastic modulus. All the test results were taken from the average of two tests.

Figure 4.1.1 Specimen plate with 25% of sisal and 15% of coir

Figure 4.1.2 Specimen plate with 20% of sisal and 20% of coir

4.2 FLEXURAL TEST

Flexural test were using the 3-point bending method according to ASTM D7264. Flexural test was conducted to study the behavior and ability of material under bending load. The load was applied to the specimen until it is totally break. The flexural test was conducted for different types of fibres length and volume fractions of composite (as shown in figure 4.2.1).

Figure 4.2.1 Specimen for flexural test

4.3 IMPACT TEST

Impact is a single point test that measures a materials resistance to impact from a swinging pendulum. Impact is defined as the kinetic energy needed to initiate fracture and continue the fracture until the specimen is broken. This test can be used as a quick and easy quality control check to determine if a material meets specific impact properties or to compare materials for general toughness. The standard specimen for ASTM is 64 x 12.7 x 3 mm .The most common specimen thickness is 3 mm, because it is not as likely to bend or crush (as shown in figure 4.3.1)

Figure 4.3.1 Specimen for impact test

V. RESULTS AND DISCUSSION

5.1 TENSILE TEST RESULTS

Tensile test was carried out the sisal and coir reinforced hybrid fibre epoxy composites by applying tensile load on the specimen which was mounted in an Electronic Tensometer as shown in figure 5.1(a). The test was conducted by varying the volume fraction of the composite. A set of twenty five readings were from the volume fraction of composites and the average values were obtained. The Table 5.1 shows parameters were observed at the time tensile testing of composite.

i) Maximum stress (N/mm2)
ii) Maximum strain
iii) Maximum load (N)
iv) Maximum displacement (mm)

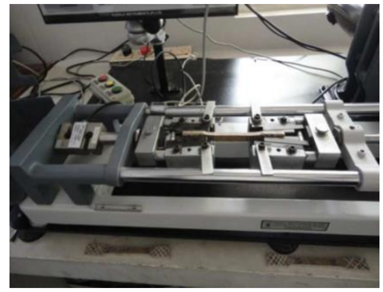


Figure 5.1(a) Specimen in Tensometer

Figure 5.1(b) Tested Tensile Specimen

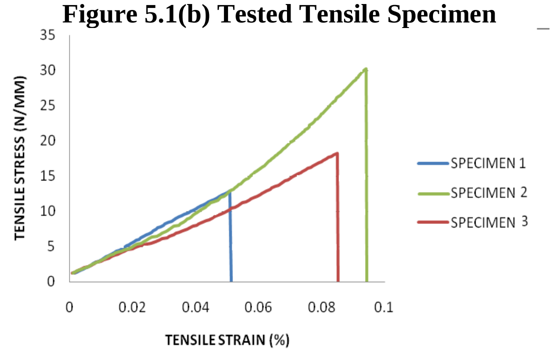


Figure 5.2 Graph Showing Tensile Stress Versus Tensile Strain

Material	Maximum Stress (N/mm2)	Maximum Strain	Maximum Load (N)	Maximum Displacement (mm)
Specimen1 [3mm] Sisal (25%) - coir (15%)	13.20	0.0536	676.48	2.986
Specimen 2 [3mm] Sisal (20%) - coir (20%)	30.00	0.0965	1610.28	5.812
Specimen 3[5mm] Sisal (20%) - coir (20%)	19.30	0.0825	935.00	4.782

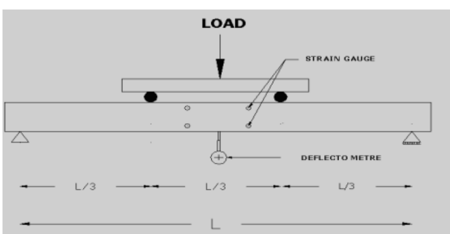
Table 5.1 Tensile properties of Sisal fibre reinforced composites

The random directional alkali treated 20% of sisal and 20% of coir with 3mm fibre length has higher tensile strength compared than other volume fraction of sisal and coir fibre with different fibre length and also untreated composite fibre. The random directional alkali treated composite is increased by 25.08%. Here we carried on alkali treatment of 5% NaOH.

5.2 FLEXURAL TEST RESULT

Flexural properties such as flexural strength and modulus are determined by ASTM Test method D790. In this test composite beam specimen of rectangular cross section is loaded in three-point bending mode. We calculated for three specimens as shown in figure 5.4 In that specimen had a highest breaking load point compared with others it has a higher strength. It will Illustrated in the Table 5.2. Tests were carried out at room temperature and as per the Indian standards. Structural properties are ascertained by conducting middle third loading test. The testing arrangement is shown in Fig.5.2.1. Four point bending was applied on reinforced concrete beams of beam span 1.8 m through hydraulic jack of capacity 100kN. The specimens were placed on a simply supported arrangement of 100 T Loading frame. The beams were suitably instrumented for measuring deflections at several locations including the midspan deflection with dial gauges and LVDTs. To avoid the excessive deformation at the support locations, additional dial gauges 45 were placed at the top and bottom faces of ends. DEMEC (Demoundable mechanical strain gauge) was used to measure the concrete strain readings at top as well as the bottom fibre on mid section of the beam.

Fig. 5.2.1 For a rectangular sample under a load in a three-



point bending setup

$$\sigma = \frac{3FL}{2bd^2}$$

- *F* is the load (force) at the fracture point
- *L* is the length of the support span
- *b* is width
- *d* is thickness

Material	Ultimate Breaking load / (N)	Actual deflection (mm)	Flexural Strength (Mpa)	Flexural Strength (Mpa)
Specimen 1	68.67	10.7	81.705	22.25
Specimen 2	83.38	10.56	92.599	36.26
Specimen 3	73.57	7.06	87.158	27.68

Table 5.2 Flexural Test Result

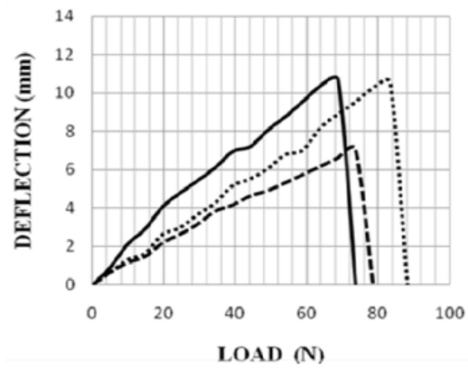


Figure 5.2.2 Graph showing Flexural Load Vs Deflection Graph

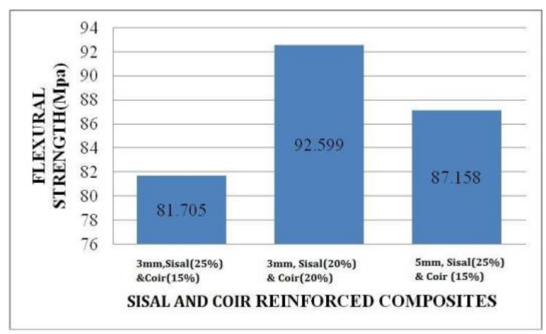


Figure 5.2.3 Graph showing Flexural Strength Graph

The random directional alkali treated 20% of sisal and 20% of coir with 3mm fibre length has higher flexural strength compared than other volume fraction of sisal and coir fibre with different fibre length and also untreated composite fibre. The random directional alkali treated composite is increased by approximately10%. This indicates the maximum bending strength available in that composite.

5.3 IMPACT TEST RESULT

Izod impact test are performed on commercially available machines in which a pendulum hammer is released from a suitable height to contact beam specimen with a kinetic energy. Whereas vertical cantilever beam specimen is used in the Izod test.

The energy absorbed in the breaking specimen. Usually indicated by the position of a pointer on a calibrated dial attached to the testing machine equal to the difference between the energy of the pendulum hammer at the instant of impacting that three ratios of specimen 40%wt of sisal and coir fibre obtained the withstanding capacity of 6.8 joules compared with others it is high as shown in figure 5.3(a) and 5.3(b)

(A) FORMULA USED

Impact strength = [(Energy absorbed) / (Area of the cross section)] Kj/cm2

(B) SPECIFICATION OF THE COMPOSITE SPECIMEN

- Length of the bar = 64mm
- Breath of the bar = 12.7mm
- Thickness of the bar = 3.2 mm
- Area of the cross section of bar = 40.64 mm^2

Figure 5.3(a) Specimen after Impact Test

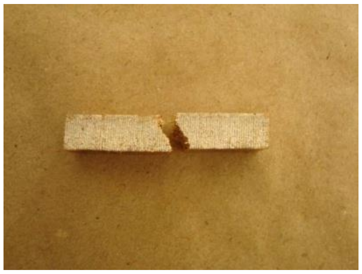


Figure 5.3(b) Specimen after Impact Test

Sl.no	Material	Energy absorbed force (a) Kj	Energy spend to break the specimen (b) Kj	Energy absorbed by the specimen (a-b) Kj	Impact strength Kj/cm2
1	Specimen 1	16	14.8	1.2	2.95
2	Specimen 2	16	14.2	1.8	4.42
3	Specimen 3	16	14.6	1.4	3.44

Table 5.3 Impact Test Result

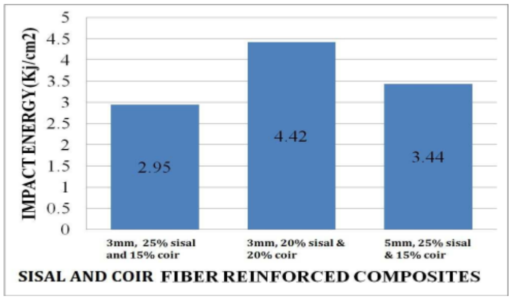


Figure 5.3(c) Graph showing Impact Strength Graph

The random directional alkali treated 20% of sisal and 20% of coir with 3mm fibre length has higher impact strength compared than other volume fraction of sisal and coir fibre with different fibre length and also untreated composite fibre. The random directional alkali treated composite is increased by approximately 32%. This indicates the maximum energy absorbed at the time of load acting and withstands the maximum possible strength available in that composite.

VI. CONCLUSION

The mechanical properties of sisal and coir natural fibre composites were prepared by epoxy resin matrix. The composite were prepared with different volume fractions. The following conclusions are made from the results and discussion.

- The tensile strength of the discontinuous fibre composite is higher at 20% sisal and 20% coir having 3mm fibre length of composites.
- The tensile strength of the random directional composite higher at 20% sisal and 20% coir having 3mm fibre length, the maximum strength was obtained at 5% NaOH alkali treatment.
- The flexural strength & impact strength of the composite is higher at 20% sisal and 20% coir having 3mm fibre length of composites and their modulus also.

It has been found that at the 20% sisal and 20% coir having 3mm fibre length in a composite produce optimum tensile strength and modulus, flexural strength and modulus and also impact strength. Mechanical properties of the composite depend upon the fibre volume fraction of the composite.

The results obtained from this study conclude that 20% sisal and 20% coir having 3mm fibre length is suitable for light weight and low load applications. Composite properties further improved by fibre surface treatment, which enhances adhesion between fibre and matrix.

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AUTHORS

First Author – G.Velmurugan, Assistant Professor, Excel College of Engineering & Technology, Tamil Nadu, Email ID: gvelmurugan06@yahoo.co.in

Second Author – S.P.Venkatesan, Associate Professor, Excel College of Engineering & Technology, Tamil Nadu, Email ID: spvens@gmail.com

Third Author – P.V.Prakash, Assistant Professor, Excel College of Engineering & Technology, Tamil Nadu, Email ID: prakki.pv@gmail.com

Fourth Author – N.Sathishkumar, Assistant Professor, Excel College of Engineering & Technology, Tamil Nadu, Email ID: sathismech45@gmail.com

Ffith Author – N.Vijayakumar, Assistant Professor, Excel College of Engineering & Technology, Tamil Nadu, Email ID: mnvijayakumar01@gmail.com