Mechanical Properties of Sisal Fibres Reinforced with Epoxy Resin

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Abstract: The use of fibres as reinforcement is as old as Human civilization. Traces of natural fibres such lax,Cotton,Silk,Wool& plant fibres have been located in ancient civilizations all over the globe. For example, the recorded usage of flax can be dated back to 5000 B C; it is considered the oldest natural textile fibre. Natural fibres are abundance in nature and can be used to reinforce polymer to obtain light and strong materials. It would be very useful if natural fibres could be used instead of glass fibres as reinforcement. Increasing need for different engineering applications invite the development of new materials. In recent years, Polymer based composite materials are being used in many applications such as Automotive, Sporting goods, Electrical, Industrial, Household application etc.Nowadays, the natural fibres such as Sisal, Banana, and Roselle have the potential to be used as a replacement for Glass and other traditional reinforcement materials in composites. Other advantages include low density, high toughness, comparable specific strength properties, reduction in tool wear, ease of separation, decreased energy of fabrication. Composites are materials that comprise strong load carrying material (known as reinforcement) imbedded in weaker material (known as matrix). Reinforcement provides strength and rigidity, helping to support structural load. The matrix or binder (organic or inorganic) maintains the position and orientation of the reinforcement. They have high specific properties such as stiffness, flexibility, impact resistance and modulus. In addition they are available in large amount, and are renewable and bio degradable. Other desirable properties include low cost and low density. Usesof these fibres satisfy both economic and ecological interests.

Keywords: Fibres, Reinforcement, Mechanical Property

I.INTRODUCTION

Extensive research work has been carried out in past decade on the natural fibre reinforced composite materials. Natural fibres have many advantages compared to glass fibres like low density, recyclable and biodegradable. Common fibre reinforced composites are composed of fibres and matrix. Fibres are main reinforcement the main source of strength.

One such natural fibre is Sisal fibre. It is very strong enough, low density, recyclable and biodegradable. The sisal plant has 7 to 8 year life span and typically produces 200 to 250 commercially usable leaves sisal plants consist of rosette of sword shaped leaves about 1.5 to 2 meters tall. Each leaf contains an average of around 1000 fibres. Sisal has good potential as reinforcement in polymer(thermoplastics, thermosets and rubbers) composites due to low density. One more advantage, this plant is available in almost all part of the world.

Sisal fibre is one of the most commonly used leaf fiber in composites owing to its interesting mechanical properties(example strength/elongation characteristic)and has been traditionally used in ropes and carpets. The use of sisals composites in automotive components and other furniture is gaining popularity.

Our work involves preparation of such type composite, which consists of sisal fibres and study of different mechanical properties so as to use it for different applications mainly in automotive industries.

II.COMPOSITE MATERIALS

A. Sisal Fibres

Sisal is valued for cordage use because of its strength, durability, ability to stretch, affinity for certain dyestuffs, and resistance to deterioration in saltwater. Three grades of sisal wires are used in the industry. The lower-grade fibres is processed by the paper industry because of its high content of cellulose and hemicelluloses. The medium-grade fibres is used in the cordage industry for making ropes, baler and binders twin. Ropes and twins are widely employed for marine, agriculture, and general industrial use. The higher-grade fibre after treatment is converted in to yarns and used by the carpet industry.

Uses of sisal

Products made from sisal are being developed rapidly, such as furniture and wall tiles made of resonated sisal. A recent development expanded the range, even to car parts for cabin interiors. Other products developed from sisal fibres includes spa products, cat scratching posts, lumbar support belts, rugs, slippers, clothes and disc buffers. Sisal wall covering meets the abrasion and tearing resistance standard of American society for testing materials and of the national fire protection association. Apart from ropes, twines and general cordage, sisal is used in low cost and speciality paper, dartboards biffing the cloths, filters, geo textiles, mattresses,carpets, handicrafts, wire rope, cores and macramé.in recent years, sisal has been utilized as strengthening agent to replace Asbestos and fibreglass as well as an environmentally friendly component in the automobile industry. Product made from sisal fibres are purchased throughout the world and for used by the military, universities, churches and hospitals.

III. Preparation of Specimen

The materials used for preparation of specimen are

1. Sisal fibre
2. Mould
3. Epoxy resin and hardener

The preparation of specimen includes the following steps:

Step 1: Abstracting of the sisal fibres.
Step 2: Weaving the continuous fibres.
Step 3: Mould preparation.
Step 4: Resin and Hardener selection.
Step 5: Preparation of specimen.

A. Step1: Abstraction of the Sisal fibres

- ➢ Sisal fibres can be extracted from its leaves by retting, boiling and mechanical extraction methods.
- ➢ Water retting is the traditional biodegradation process involving microbial decomposition(breaking of the chemical bonds) of sisal leaves. Which separates the fibre from the pith.
- ➢ Sisal fibres are extracted from the leaves of sisal plants. Leaves are taken out from the sisal plant and left in the water for 8 to 10 days, then wetted leaves are beaten to get thin fibres this process is called retting.
- ➢ The fibres are washed and allowed to dry under the sunlight, this process takes the 15-21 days for a single cycle of extraction and degrades the qualities of fibre.

B. Step2: Weaving the Continuous fibre

In order to increase the strength of the composite materials, extracted fibres are woven. Weaving is done by hand justlike the weaving of ropes. Fibres are woven with a thickness in range of 1.7 to 2.2 mm.

Fig I :weaved sisal fibre rope wounded on the stick

C. Step3:Mould Preparation

Mould material: wood

Standard dimensions of different specimens of material testing lab, such as impact, tensile, bending, shear and compression test moulds are prepared as follows. The mould is laminated by plastic to avoid stick of adhesive with wooden mould.

C. (a) Tensile Test

Dimensions

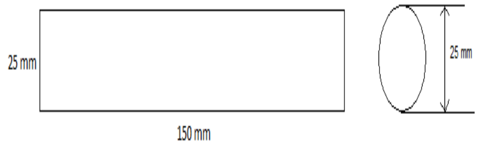


Fig II:Tensile Test Mould Made of Wood with Dimensions

C. (b) Bending Test

Dimensions

Fig III:Bending Test Mould Made Of Wood with Dimensions

C. (c) Compression Test

Dimensions

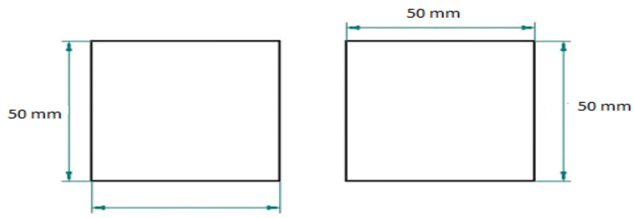


Fig IV: Compression Test Mould Made of Wood with Dimensions

C. (d) Shear Test

Dimensions

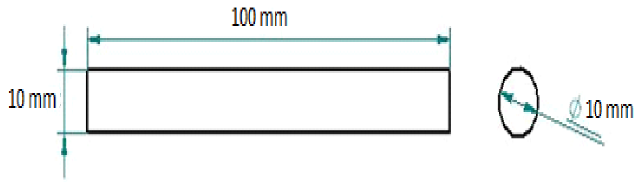


Fig V: Shear Test Mould Made of Wood with Dimensions

C. (e) Impact Test

Dimensions

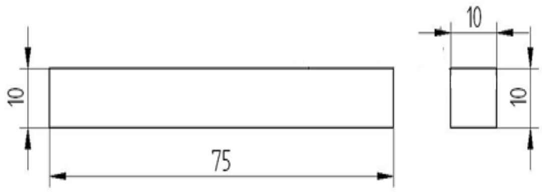


Fig VI: Impact Test Mould Made of Wood with Dimensions

D. Step4: Selection of Resin and Hardener

Resin: Standard epoxy
Hardener: Standard epoxy

Fig VII: Resin and Hardener

A. Mixture of Epoxy and Hardener

The mixing ratio of epoxy and Hardener is 1:1 that is both are equal in proportion.

B. Properties of Standard Epoxy Adhesive

- Water- proof
- Heat- proof
- Stress- proof
- Resistance to most chemicals
- Non corrosive
- Non toxic

E. Step5: Preparation of the Specimen

Fibre reinforced polymer matrix composites are produced from basic building blocks, namely, fibre, resin, filters and plastic coat etc. Following processes are available for the production of the desired products

- Open moulding process.
  i.Hand lay-up process.
  ii. Spray-up process.
- Bag moulding process.
  i. Pressure bag moulding.
  ii. vacuum bag moulding.
  iii. Auto clave.
- Compression moulding.
- Matched die moulding or resin transfer moulding.
- Vacuum assisted resin transferred moulding.
- Filament Winding.
- Injection moulding.
- Thermoforming.
- Blowmoulding.

A. Hand lay-up Process

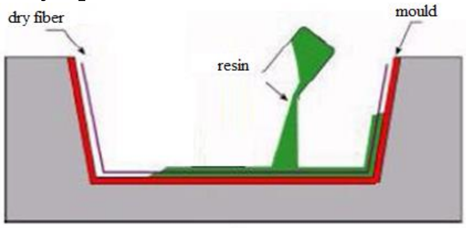


Fig VIII: Hand Lay-Up Process

The base plate is fixed inside the frame for fabricate the natural fibre composites 70% of rein hardener mixture and remaining natural fibres are used. The mixed resin and hardener is filled in the pattern. The prepared natural fibres are randomly poured in the resin hardener mixture without any gap. The roller is rolled in the mould. Again the mould is filled in the pattern by next layer and fibres poured randomly. This process is simultaneously done till the height of the mould 10mm. The lid is fixed on the top of the frame for distribute the load evenly on the mould. The set up is kept in the dry place for 24 hours. After 24hours the mould is take away from the pattern, finally the natural fibre is fabricated.

The steps for preparation of specimen are as follows:

- Before the epoxy is laid upon the mould the mould should be cleaned and dried because of release agent is laid upon the mould.
- Insert the woven sisal fibres into mould in specific orientation.
- Using a special brush or by hand laying method pouring of epoxy mixture in to the mould.
- The mould is closed once pouring is done up to required level. Then it is kept 20-24 hours for drying purpose.

- After the specimen is fully dried, it is separated from the mould.
- The specimen is ready for testing.

Prepared Specimens

(a) Tensile

Fig IX: Tensile Specimen

(b)Bending

Fig X:Bending Specimen

(c) Shear

Fig XI: Shear Specimen

(d) Compression

Fig XII: Compression Specimen

(e) Impact

Fig XIII: Impact Specimen

IVTESTING AND RESULTS

Testing machine: UTM

A. Tensile Test

In tensile test the operation is accomplished by gripping opposite ends of the piece of material and pulling it apart in a tensile test that specimen elongates in a direction parallel to the applied force as shown in fig

Fig XIV: Specimen Held for Tensile Test

Brittle material fails at the ultimate tensile strength point and specimen breaks but ductile materials begin to decrease rapidly a well-defined neck leading to fracture.

Observations

1. Diameter of the specimen, $D = 25\ mm$
2. Cross sectional area of the specimen, $A = 490.87\ mm^2$
3. Length of the specimen, $L = 150\ mm$

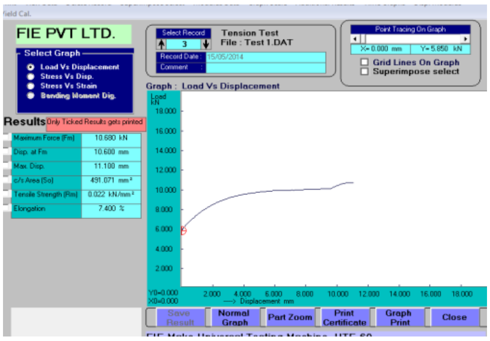
Calculation

Results are taken by integrating computer software with UTM

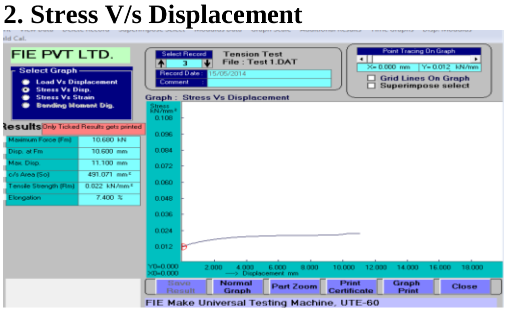
1. Maximum force $F_m = 10.68\ KN$
2. Displacement at $F_m = 10.6\ mm$
3. Maximum displacement = $11.1\ mm$
5. Tensile strength = $22\ N/mm^2$
6. Elongation = 7.40%

Fig XV: Graphs

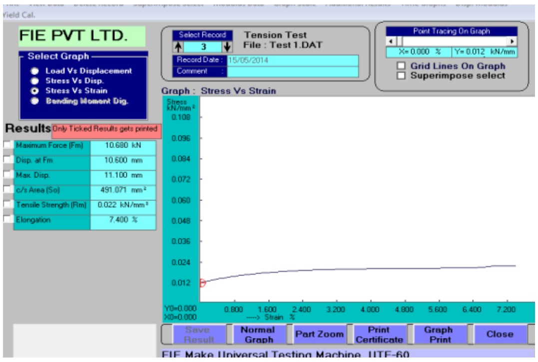
1.LoadVs Displacement



2. Stress V/s Displacement



Stress V/s strain



Type of Shear	Diameter (d in mm)	Area (A in mm^2)	Fracture load (F in KN)	Ultimate strength (N/mm^2)
Single shear	11	95.03	10.97	115.433
Double shear	11	95.03	11.35	59.716

B. Izod Impact Test Result

The purpose of test is to study the toughness of material. Toughness means the ability to absorb the energy during the plastic deformation when subjected to suddenly applied loads. Impact strength is the resistance of the material to shocks or suddenly applied loads.

Brittle materials have low toughness since they have no plastic deformation before fracture and hence brittle materials are dangerous as a structural material. In this test the pendulum that acts as swinging hammer strikes the cantilever end of the specimen grips vertically in the vice as shown in fig.

Fig XVI: Specimen Held for Impact Test

Observation

1. Cross sectional area of the specimen, $A = 10 \times 10 = 100\ \mathrm{mm}^2$
2. Angle of drop, ϴ = 90˚
3. Energy absorbed = 4 joules

Calculation

Impact strength $I = \frac{K}{A} = 0.04\ \mathrm{J/mm}^2$

C. Shear Test

A type of force which causes or tends to cause two contiguous parts of the body to slide relative to each other in a direction parallel to their plane of contact is called shear force. The stress required to produce fracture in the plane of cross-section, acted on by the shear force is called shear strength.

Fig XVII: Specimen Held for Shear Test

Observation

1. Shear force for single shear, $F_s = 10.97\ KN$
2. Shear force for double shear, $F_d = 11.35\ KN$
3. Diameter of specimen, $D = 11\ mm$
4. Cross sectional area of the specimen, $A = 95.03\ mm^2$

Calculation

1. Single shear

$$\tau = \frac{F_s}{A} = 115.433\ \mathrm{N/mm}^2$$

2. Double shear

$$\tau = \frac{F_d}{2A} = 59.716\ \mathrm{N/mm}^2$$

D. Compression Test

Composite material is stronger in compression when load is applied parallel to the grains than the material load applied perpendicular to the grain because the material fiber resists the compressive load by giving lateral support to the other, so we preferred test for load along the grains.

Fig XVIII: Specimen Held for Compression Test

Observation

Along the grains

1. Length of the specimen, $L = 45\ mm$
2. Breadth of the specimen, $B = 45\ mm$
3. Thickness of the specimen, $t = 45\ mm$
4. C/s area of the specimen, $A = L \times B = 45 \times 45$

$= 2025\ mm^2$

5. Maximum compressive load = 54.66 KN

Calculation

$$Compression\ stress\ along\ the\ grain, \sigma = \frac{F}{A}$$

$$= 26.99\ N/mm^2$$

E. Bending Test

If forces act on piece of material in such a way that they tend to introduce compressive stresses over one part of a cross section of the piece and tensile stresses over the remaining part of neutral axis passes through the centroid in bending stress are proportional to the distance from the neutral axis within the proportional.

Fig XIX: Specimen Held for Bending Test

Observation

1. Length of the specimen, $L = 160\ mm$
2. Breadth of the specimen, $b = 38\ mm$
3. Depth of the specimen, $d = 15\ mm$
4. Total concentrated load, $P = 3180\ N$

Calculation

1. Moment of inertia, $I = \frac{bd^3}{12} = 10{,}687.5\ \text{mm}^4$
2. Modulus of elasticity, $E = \frac{PL^3}{48\ I\ y_{max}}$ $= 3.385\ \text{kN/mm}^2$
3. $Bending\ strength$ $\frac{3PL}{2bd^2} = 89.26\ \text{N/mm}^2$
4. $Maximum\ bending\ moment, M_{max} = \frac{PL}{4}$ $= \frac{3180 \times 160}{4} = 127200\ \text{N} - \text{mm}$ $= 127.2\ \text{N} - \text{m}$
5. $Shear\ force, V = \frac{P}{2} = \frac{3180}{2} = 1590\ N$
6. $Reaction\ force\ at\ bearing\ point, R = \frac{P}{2} = \frac{3180}{2}$ $= 1590\ N$

F:Test Results

Properties	Strength(N/mm^2)
Tensile	22
Impact	0.04
Single Shear	115.43
Double Shear	59.716
Compression	26.99
Bending	89.26

V. SCOPE FOR FUTURE WORK:

(1) In order to increase the strength one can change the orientation of the fiber for example (0°,45°,90°), (45°,90°) etc.

(2) Using different grades of resin and hardener with different composition, strength of composite may increase.

(3) We can also test for the fatigue, torsion and thermal tests for different applications.

VI. CONCLUSIONS

The present work deals with the preparation of sisal fiber reinforced epoxy composite. A laboratory study has been carried out to determine the mechanical properties of sisal fiber reinforced epoxy composites by different methods and the following conclusions are drawn.

(1) With the successful fabrication of a new class of epoxy based composites reinforced with sisal fiber.

(2) Due to the low density of the natural fibers used compared to the synthetic fibers (Glass fibers, carbon fibers, etc...), the composites can be regarded as a useful light weight Engineering Material.

(3) In the study of mechanical behaviour of sisal fiber composite with epoxy it is found these composite have considerable strength to weight ratio.

(4) Tensile strength of sisal fiber composite material is more than coir and husk fiber composites.

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