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# Development of a Natural Fibre Reinforced Composite for Safety and Construction Applications

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**ABSTRACT:**

*Composite materials have occupied major part in current era due to its light weight, good stiffness, high specific strength and flexible nature. Etc. A material system composed of two or more physically distinct phases whose combination produces aggregate properties that are different from those of its constituents. Glass fibre reinforced Composites possess these qualities and are extremely versatile. A judicious combination of two or more materials that produces a synergistic effect. The short and discontinuous fibre composites are responsible for the biggest share of successful applications, these fibres are strong, light and easily withstand heat and salt water. This paper deals with preparation and investigation of hybrid composites of natural fibres in isophthalic polyester resin. Natural fibres used here are sisal, jute and coir fibres which are mixed with isophthalic polyester. This composite is manufactured using hand layup process. After composite is made, testing was carried out to find mechanical properties of the new material with high accuracy. After that, I compare the result obtained with the properties of materials used for safety and constructional application and now I am satisfied with my work. I recommend my new material to replace the ABS plastic which is now used for the fabrication of industrial helmet.*

**KEY WORDS:** *Coir, Sisal, jute Isophthalic polyester*

## 1. INTRODUCTION

Recently, the mankind has realized that unless environment is protected, he himself will be threatened by the over consumption of natural resource as well as substantial reduction of fresh air produced in the world. Conservation of forests and optimal utilization of agricultural and other renewable resources like solar and wind energies, and recently, tidal energy have become important topics worldwide. In such concern, the use of renewable resources such as plant and animal based fibre-reinforce polymeric composites, has been becoming an important design criterion for designing and manufacturing components for all industrial products. From the previous several studies, it is clear that there are large varieties of natural fibres are currently used in different engineering fields. The treatment of these fibres determines the properties obtained during the application in treatments, the alkalization treatment is the best suitable for the fibres like sisal, jute and coir. Chemical modification of natural fibres is necessary for increased adhesion between the hydrophilic fibres and hydrophobic matrix. The most promising approach seems to be one in which covalent bonds are formed between the fibre and matrix .Mechanical properties of ukam, banana, sisal, coconut, hemp and e-glass fibre reinforced laminates were evaluated to assess the possibility of using it as new material in engineering applications. Ukam and sisal composites manufactured by hand lay-up process provide an opportunity of replacing

existing materials with a higher strength, low cost alternative that is environmentally friendly.. The substitution of the traditionally used composite of natural fibres such as sisal, banana and roselle can lead to a reduction of the component's weight and furthermore to a significant improvement of specific properties like impact strength, crash behavior. One of the major fields of application for such materials can be found in structural components manufacturing of helmets. The mechanical properties in terms of the elastic modulus and ductility of these bio composites increased substantially compared to the neat polymers. The mechanical properties of most of plant-based fibre composites increased with increasing the amount of fibre into polymer matrix. However, the ultimate strength decreased as expected. From those experimental results, incorporation of the fibres gave rise to a considerable increase of the storage modulus (stiffness) and to a decrease of the tan delta values. Also it is clear that, natural fibre reinforced composite material of sisal jute and banana hybrid material has a sustainable strength for the application of industrial safety helmets. Natural fibres used with are sisal and coir fibres which are mixed with isophthalic polyester in volume fraction basis of 0.4 & 0.5. This composite is manufactured using hand layup process.. The tensile strength of sisal-glass composite is found to be better than the coir-glass composite. The flexural strength and impact strength of sisal-coir-glass hybrid composite is better.

## 2. EXPERIMENTAL SETUP

### 2.1 Materials Used

For the investigation carried out, synthetic fibre namely e-glass fibre with density 610 grams/sq.metre has been used.apart from that, two natural fibres namely sisal (agave sisalana), coir (cocus nucifera) and jute (corchorus capsularis )has been used for fabricating the composite. Isophthalic polyester resin obtained from devi chemicals ,trivandrum has been used as resin material, with methyl ethyl ketone peroxide (mekp) as a catalyst and cobalt napthanate of 1% as an accelerator.

### 2.3 Sisal Fibre

Hand extraction machine is used to extract the fibres through serrated or non-serrated knives. The fibre extracted is dried under the sun until it turns white in color and then it is made ready for knotting. Fibre is separated to various sizes and knotting is done on the other side to form long continuous strands. It is mainly used for mats, carpets and many other reinforcement materials.

### 2.3 Coir fibre

Coir (cocas nucifera) is obtained from the husk of the fruit of coconut palm. The fibres are made up of small threads ranging from 0.03-0.1 cm long and about 12-24 micrometer in diameter. They are narrow and hollow with thick walls made of cellulose. The fibre is hydrophilic in nature and has high corrosive resistance against salt water. It is used in products such as doormats, brushes, mattresses



### 2.4 Jute Fibre

Jute is a long, soft, shiny vegetable fibre that can be spun into coarse, strong threads. It is produced from plants in the genus corchorus, which was once classified with the family tiliaceae, more recently with malvaceae, and has now been reclassified as belonging to the

family sparrmanniaceae. The primary source of the fibre is corchorus olitorius, but it is considered inferior to corchorus capsular is "jute" is the name of the plant or fibre that is used to make burlap, hessian or gunny cloth

### 2.5 Isophthalic Resin

The reaction of an organic acid with an alcohol results in the formation of the ester. By using a di-functional acid and a di-functional alcohol linear polyester is produced. Properties of the polyester can be varied by using different combinations of different di-acids and glycols. One such combination produces isophthalic resin. They are produced from isophthalic acids and are characterized by greater strength, heat resistance, toughness and flexibility. The acid groups are separated by one carbon of benzene ring. This increases the opportunity to produce polymers with great linearity and high molecular weight. They are mainly used in automotive parts, bowling walls, gasoline, swimming pools, aerospace products and civil construction products

## 3. FABRICATION DETAILS

To prepare the composite the glass fibre is cropped into a required number of plies of size 350x350 mm. The technique used is hand layup process. The glass fibre is kept in the top and bottom most layer of the laminate. The natural fibres are chopped to minimal desired length to be kept in intermediate layers between the glass fibres. The natural fibre weighing around 15-20 grams is spread in the laminate. In this composite, the plies are aligned in the order of intermediate glass fibre and natural fibre which constitutes totally 13 plies (7 plies of glass fibres and 2 plies of sisal fibre 2 plies of coir fibre and 2 of jute fibre).

### 3.1 Preparation of Resin

The matrix used to fabricate the fibre material is isophthalic polyester having a density of 1.10 g/cc.to improve the rate of the reaction, an accelerator and a catalyst are added to the original matrix material. The methyl

Ethyl ketone peroxide (mekp)is added as a catalyst and cobalt napthanate is added as an accelerator, in the ratio 1:0.02:0.02.the solution is mixed and stirred before applying on the laminate

### 3.2 Fabrication Procedure For Specimen

To prepare the composite, a mica sheeted table is used. The table is cleaned with distilled water to remove the impurities. Then a coat of wax layer is applied throughout the board to facilitate easy removal of the laminate. Prior to the moulding process, an acid solution of poly vinyl acetate is applied on the surface of the table which acts as a releasing agent. This is followed by a dwell time of 5-10 minutes for the table to get dried. A coat of mixed resin is applied on the cleaned surface before placing a layer of glass fibre. Alternate layer of natural fibre is kept with a coat of resin over it. Consequent layers of natural and glass fibre are placed till the required thickness is obtained. The finished composite now is closed by wooden reapers and clamped at all the possible ends. Then a load of 50- 60 kg is applied. The composite is made to cure for 24 hours under hot conditions. After curing the composites are sized according to astm standards.

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**Figure 3.1 Finished composite**

## 4. TESTING OF COMPOSITES

### 4.1 Tensile Test

The composite is sized to the required dimension using a saw cutter. The standard used is ASTM D638- 03 the gauge length and cross head speeds are chosen according to the standard. The test is carried out in Universal Testing Machine (UTM) make FIE (Model: UTN 40, SNo, 11/98-2450) at room temperature conditions (303K) and at a speed of 2mm/min. The test involves application of tension in the work piece until it fracture

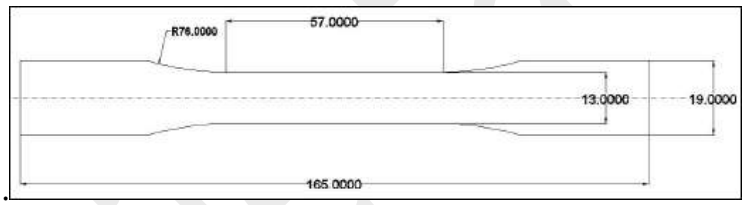


Figure 4.1 ASTM D638- 03

Figure 4.2 Tensile specimen

### 4.2 Flexural Test

Three point flexural test is the most common test carried for composite materials. The standard used for flexural test is ASTM D790.The Universal Testing Machine is used to carry

out the Flexural test. Flexural test determines the maximum stress induced in the outermost FIBRE. Testing is carried out at room temperature at 40% relative humidity. In this test specimen is subjected to load at its midway between the supports until it fractures and breaks. This test corresponds to the behavior of specimen as like a simply supported beam. The specimen used for flexural test is presented. The tests are repeated at least 3-5 times and the average values are used for the discussion

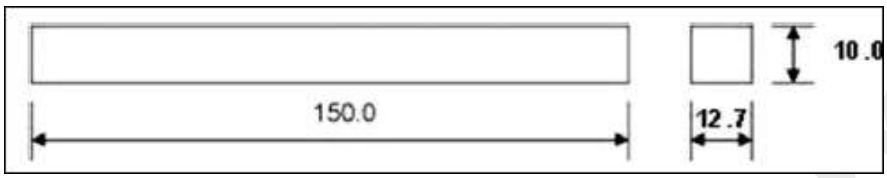


Figure 4.3ASTM D790

Figure 4.4 Flexural specimen

### 4.3 Impact Test

Impact test is carried out to find amount of energy required to break the material and to also the toughness of the material at yield strength. This test is carried out in Charpy/Izod setup and standard followed is ASTM D256-05.Thecenter of the specimen is made into a shape of V-notch and it is loaded for testing. The pendulum is present in the idle position and it is released and made to hit the V-notch repeatedly until it gets fractured.

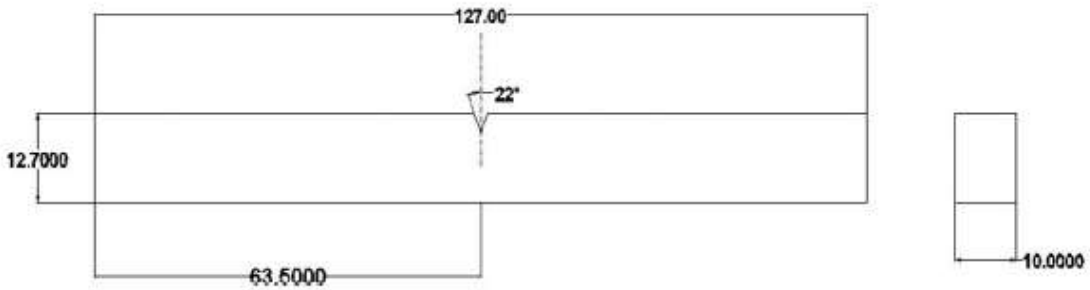


Figure 4.5 ASTM D256-05

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## 5. RESULT AND DISCUSSION

### 5.1 Tensile Properties

The fabricated composite is tested in the universal testing machine to find the tensile properties. Table 1. From the table the average value obtained was 109Mpa.since the material is of natural FIBRE, yield point cannot be obtained because of the sudden rupture. This is due to the heterogeneous nature of the composite

**Table 5.1 Tensile result**

| | | | | | |
|---|---|---|---|---|---|
| **ULTIMATE TENSILE STRENGTH(MPa (or) N/mm2)** | **1** | **2** | **3** | **4** | **5** |
| | **106.7** | **111.7** | **108.8** | **106.8** | **109.8** |

### 5.2 Impact Result

**Table 5.2 Impact result**

| **Test Parameters** | **Observed value** | | | | |
|---|---|---|---|---|---|
| Specimen size (mm) | 127*10*10 | | | | |
| Absorbed Energy - Sample 1 (Joules) | 1 | 2 | 3 | 4 | 5 |
| | 51 | 53 | 51 | 52 | 51 |

The average obtained impact strength was 51.6J.the conventional material used for industrial helmet was ABS plastic ,the impact strength of ABS plastic is 50J.the IMPACT strength is the energy absorbed by a material on a sudden impact by plastically deform without any failure.

### 5.3 Flexural Strength

**Table 5 .3 Flexural result**

| **SAMPLE** | **BREAKING LOAD** |
|---|---|
| 1 | 0.121 KN |
| 2 | 0.121 KN |
| 3 | 0.127 KN |
| 4 | 0.123 KN |
| 5 | 0.126 KN |

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## 6. CONCLUSION

From the result, the following conclusions are obtained.

| MATERIAL | ABS PLASTIC | NFRC |
|---|---|---|
| Impact strength | 50J | 51.6J |
| Flexural strength | 0.1KN | 0.12KN |
| cost | 450Rs | 250Rs |
| Biodegradability | no | yes |

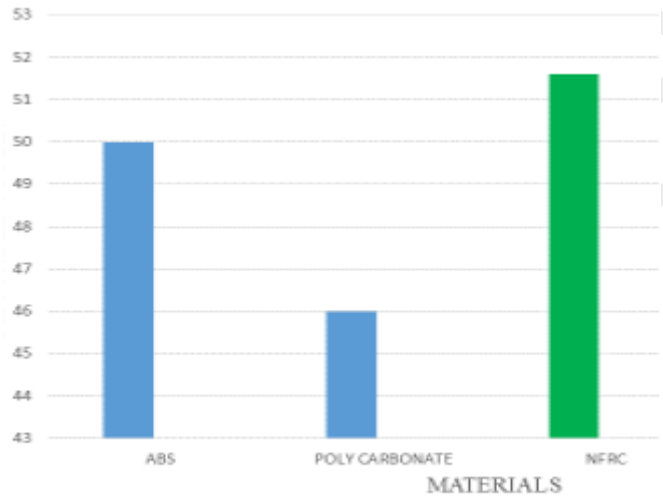


Figure 6.1 Helmet materials

- Both materials are compared under same ASTM standard in the case of industrial helmet impact and flexural strength is taken in account and obtained a better value as shown in table. So I hope that the new material is a better replacement for the conventional ABS plastic.
- Another application is in the case of plastics used in the crumple zone of the automobiles generally parts like bumper are designed to absorb a small amount of energy and then to crush.
- In the case of building application, this material is a suitable replacement for the flooring and also in the case of light weight concrete provided with suitable coating for flooring.

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