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Fabrication and Mechanical Characterization of HEMP mat, SISAL mat and E-GLASS Mat Reinforced Hybrid Composite Materials

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Abstract:

The main objective of this study is to fabricate and check the mechanical performance like tensile strength, Impact strength and Hardness of a Hybrid reinforced composites by using Hemp mat, Glass mat and Sisal mat with Epoxy resin Matrix LY556 and Hardener LY591.

For Water absorption, weight measurement test is also done at various conditions. By using Hand layup technique, the sample of Hemp/Sisal/Glass mat fiber is fabricated as per ASTM standards. The Tensile test is carried out on a fully digital UTM machine (ASTM D638). Impact energy test is carried out on Charpy impact energy testing machine while hardness testing is carried out by digital hardness machine.

It has been observed that the composites made from the Mat fiber (bidirectional) of Hemp/Sisal/Glass shows superior properties than the use of uni-directional fiber. The experimental result shows the high strength and the composite materials made of Hemp/Sisal/Glass Mat plays a vital role in the industry of Automobiles, Aerospace, Bio-engineering, Chemical engineering, structural engineering and sports.

Keywords: Hemp Mat fiber, Sisal Mat Fiber, Glass Mat Fiber , HGSHC, Epoxy, Hand Layup Technique, Mechanical Characterization.

1. INTRODUCTION

Natural fibers mat are used as reinforcement because of its various attractive properties like environmental friendly, low in cost as compared to other metals, renewable, and biodegradability. The biodegradability of plant fibers contributes a major role in healthy eco-friendly system. The reinforcement in composite provides high strength and stiffness with continuous fibers. The mat of natural fibers provides more strength as compared to unidirectional natural fibers [1].

When two or more materials having different physical or chemical properties are mixed in proper proportion, produced material is known as composite materials. Hybrid reinforced composite materials are widely used in industries due to its good characteristics of its strength to density, lighter in weight and less expensive [2].

Hybrid reinforced composites are used in Aerospace (Wings, fan blade, Tail cones, & Interiors), Automobiles (Chassis& Interiors), Marines (Hull, decks & fly bridge), Wind turbines (Wind blades and spinners) and in various industry components like bath tubs, doors, windows, roofing etc.

In this paper the Hemp fiber mat, Sisal fiber mat and Glass fiber mats are used to prepare the reinforced composite with help of Epoxy. The mechanical property like tensile test is carried out on a fully digital UTM machine (ASTM D638). Impact energy test is carried out on Charpy impact energy testing machine. While hardness test were carried out by digital hardness machine.

2. EXPERIMENTAL PROCESS

2.1. Materials.

For this experimental work, Bidirectional Hemp fiber mat, Sisal fiber mat and Glass fiber mat are purchased from Viruska composites, Vijaywada, India. Epoxy Araldite LY556 and Hardener HY951 are supplied by Singhal Traders, Meerut. These fiber mats are incorporated to produce a Hybrid composite plate by Hand Lay-up method.

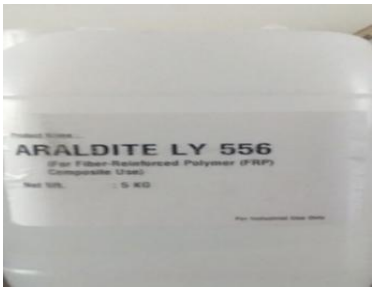

Fig.1(a): Epoxy

Fig.1(b): Hardener

The various researchers' reports [2],[3],[4] about the chemical properties, physical properties and mechanical properties of hemp fiber, Sisal fiber and glass fiber are listed below:

Physical Properties	Hemp	Sisal	Glass
Density (g/cm^3)	1.4-1.6	1.5	2.5-2.6
Tensile Strength (MPa)	200-1040	400-700	1900-2200
Stiffness (GPa)	17.6-70	38.05	79
Elongation at Break (%)	1.6	2-3	
Young Modulus (GPa)	30 - 60		70 – 80

Table 1: Physical properties of Hemp, Sisal and Glass

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Chemical Properties	Hemp	Sisal
Cellulose (wt %)	68-77	65-68
Hemicelluloses (wt %)	7-22.4	10-22
Lignin (wt %)	2-10	9.9-14
Moisture content (wt %)	6.2-12	10-12

Table 2: Chemical properties of Hemp and Sisal

Fig.2: Sisal Plant and Sisal fiber Mat ($0^0/90^0$ orientation)

Fig.3: Hemp and Hemp fiber Mat ($0^0/90^0$ orientation) **Fig.4: E Glass Mat ($0^0/90^0$ orientation)**

2.2. Fabrication of Hybrid Composites

First, prepare a mould of dimension 500 X 300 weighing 50 kg of load. Clean the inner surfaces of mould with thinner chemical after removing the dust and impurities with the help of brush. Put a 0.2 mm thick transparent plastic sheet at both inner surfaces of mould. Now the wax coating was done on the surfaces of transparent sheet and coated sheet were kept under ambient temperature for 15 minutes. Prepare two wooden frames which ensure the dimension of 400 X 200 X 5 mm each. Put this wooden frame over the plastic sheet. Epoxy resin and hardener were mixed in the ratio of 10:1 and uniform mixing was done till the mixture gets the milky colour. Place the Hemp fiber mat on the flat surface of wooden frame. Pour the well mixed matrix on hemp fiber mat.

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Roll the roller to remove air. Now put the glass fiber mat over the hemp fiber and fill the frame with matrix again. Again roll the roller over it to remove air. Now put the Sisal fiber mat over the glass fiber and again fill the frame with matrix. Again roll the roller over it to remove air. The upper part of the mould is now placed over the transparent sheet and pressure is applied. After curing at room temperature for 24 hours, the mould is opened. Now the Hybrid composite sheet of Hemp /Glass/Sisal mat [HGSHC] is obtained which can be further tested.

Figure 5: Mould

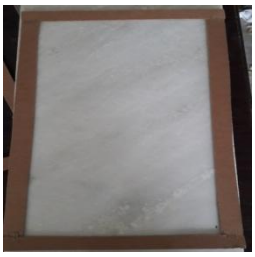

Figure 6: Frame

3. Mechanical Characterization

3.1. Tensile Test

After the fabrication of composite plate (HGSHC), three specimens as per ASTM D 3039, were prepared for tensile testing. A digital universal testing machine, model AMT 40, having maximum capacity of 400 KN, manufactured by ASI sales private limited is used for testing the tensile behavior of HGSHC sheet. The graph between force and displacement is directly obtained by the digital universal testing machine [8], [11].

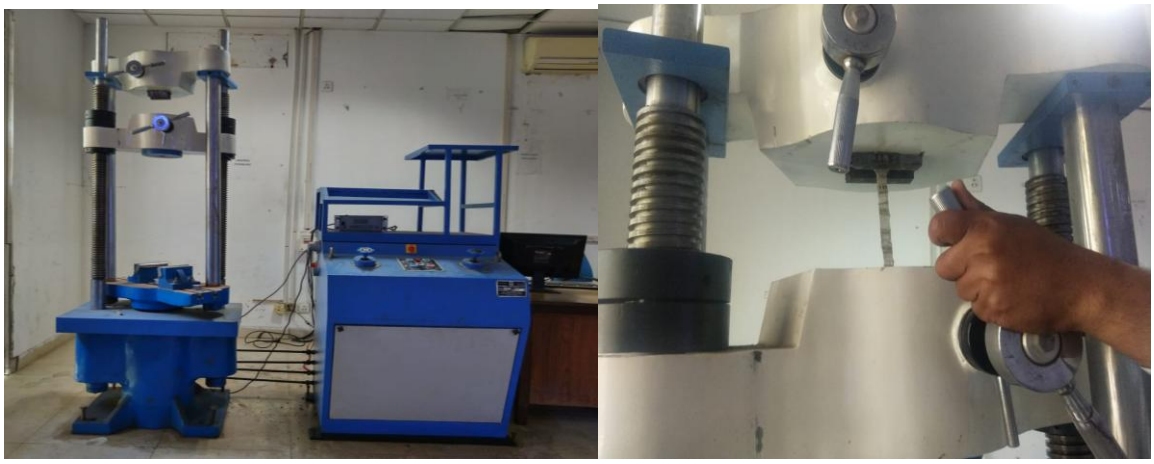

Fig. 7: Digital UTM Machine

Fig.8 (a): Tensile Specimen before Fracture **Fig.8 (b): Tensile Specimen after Fracture**

3.2. Impact Test

By Impact test, the impact energy absorbing capacities of HGSHC were examined. For impact test three different impact specimen were prepared as per ASTM D256 standard.

Fig. (9): Impact Machine **Fig.9 (a): Specimen Before Fracture** **Fig.9 (b): Specimen after Fracture**

The side surfaces of sample were finished by the emery paper. A V-notch was cut on the any side of sample. Vertical cantilever beam specimens were used for impact test (IZOD test). Weight of hammer which is allowed to break the specimen is 20 kg. Specimen prepared for Impact testing is shown in given figure.

3.3. Hardness Testing

Hardness testing of HGSHC sheet were performed on DIGITAL Rockwell Hardness Tester, model RBHT- M Scale. The maximum capacities of DRHT were 100 kg-f. Here ¼" ball indenters were used at M scale having a load capacity of 100 kg-f.

Fig. 10: Digital Hardness Machine M Scale

3.4. Water Absorption test

The HGSHC sheet, after fabrication is cut in size of 30 X 30 X 6 mm by a diamond tip hand cutter for water absorption test. The specimens were prepared as per ASTM standard D5229. The water absorption test is carried out on four different types of water i.e. Normal Water, Bore Water, Distilled Water and Sea water [6].

These types of water were kept in a beaker with same proportion of 250 ml. The different samples are immersed in water for a period of 36 hours and reading of sample weight is carried out after a regular interval of 4 hours.

The weights of samples were carried out with the help of a weighing machine having a least count of 0.01 gm.

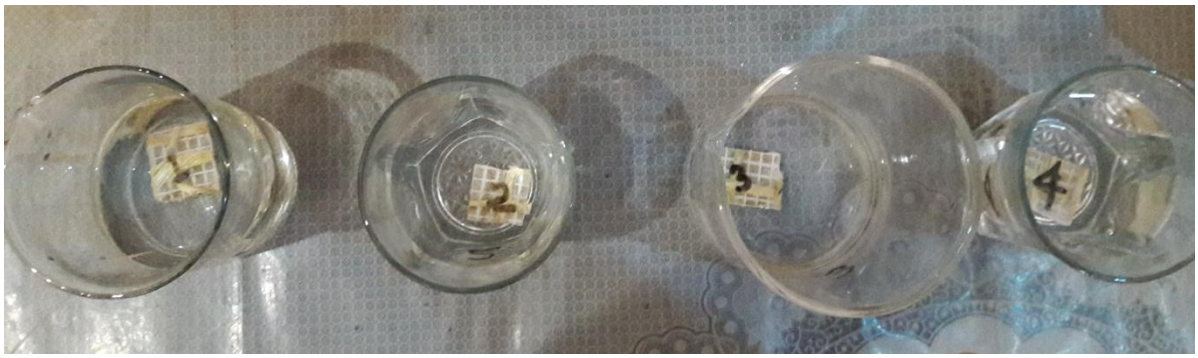

Fig.11: Specimens under water absorption

4. Result and discussion

The mechanical characterization like tensile test, Impact test and Hardness testing of Hemp/Glass/Sisal hybrid composite were evaluated in this process. Water absorption in percentage has been also investigated in this process. The table shows test result of Hemp/Glass/Sisal mat hybrid reinforced composite.

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Hemp/Glass/Sisal Mat hybrid reinforced composite sheet	Tensile Strength (MPa)	Impact Energy (Joule/m)	Hardness HRM (M Scale)
Specimen 1	72	39.10	45.9
Specimen 2	70	38.95	43.6
Specimen 3	74	39.05	42.2
Mean Value	**72**	**39.03**	**43.9**

Table 3: Evaluation of Mechanical properties

4.1. Tensile Test

Tensile test was carried out on the Hemp/ Glass/ Sisal reinforced hybrid mat epoxy composite by applying the tensile load on the specimen with the help of digital universal testing machine, model AMT 40, having maximum capacity of 400 KN. The graph between tensile Stress and Tensile Strain is shown in figure. From the above observed tensile test reading of Hemp/Glass/Sisal Mat fiber shows the better tensile properties varies from 70 MPa to 74 MPa. Thus these hybrid reinforced composites are suitable for Aerospace, Automobiles, Marines, Wind turbines and in various industry components like bath tubs, doors, windows, roofing etc.

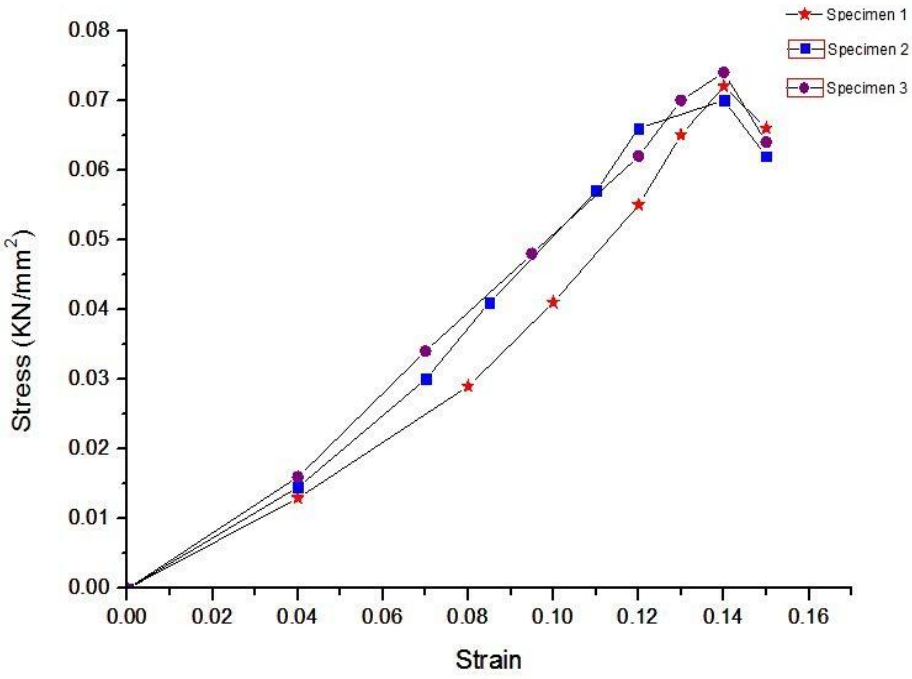

Fig.12: Tensile Stress Strain curve for Hemp/Glass/Sisal mat reinforced hybrid composite

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4.2. Impact Test

The withstand capability of Hemp/ Glass/ Sisal reinforced hybrid mat composite was tested by the impact test. To obtain the impact strength of hybrid composite material IZOD test is performed as per ASTM D256 standard. The mean value of impact strength of this composite material is found to be 39.03 J/m, which shows better impact strength than composite fiber sheet.

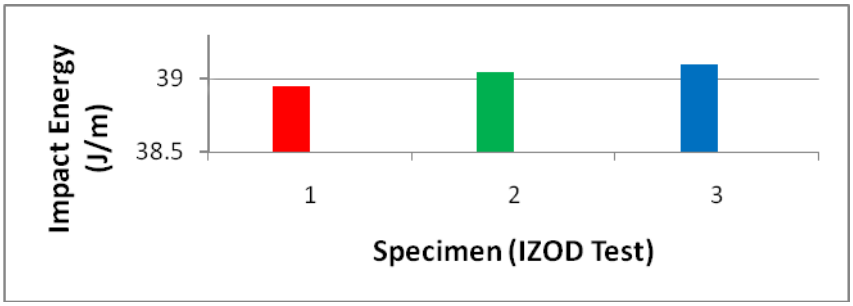

Fig.13: Impact Energy absorption graph

4.3. Hardness Test

Hardness test is performed on Hemp/Glass/Sisal Mat hybrid composite by a digital hardness testing machine. Ball indenters having the size of ¼" and a load capacity of 100 kgf was used at M scale to observe the hardness of hybrid composite sheet. It is observed the at M Scale the hardness of Hemp/Glass/Sisal Mat hybrid reinforced composite sheet varies from 42.2 to 45.9.

4.4. Water absorption Test

The water absorption test is carried out on four different types of water i.e. Normal Water, Bore Water, Distilled Water and Sea water. The different samples are immersed in 250 ml of water for a period of 36 hours and reading of sample weight is carried out after a regular interval of 4 hours.

Specimen	Initial Weight (gm)	Final Weight (gm)	Change of weight (gm)	% Moisture Absorbed
1. Distilled Water	2	2.05	0.05	2.5
2. Normal Water	2	2.06	0.06	3.0
3. Sea Water	3	3.03	0.03	1.0
4. Bore Water	2	2.04	0.04	2.0

Table 4: Water absorption Test Result

Graphs have been plotted for moisture absorption v/s the immersion time duration of 4 hours for different types of water was shown below.

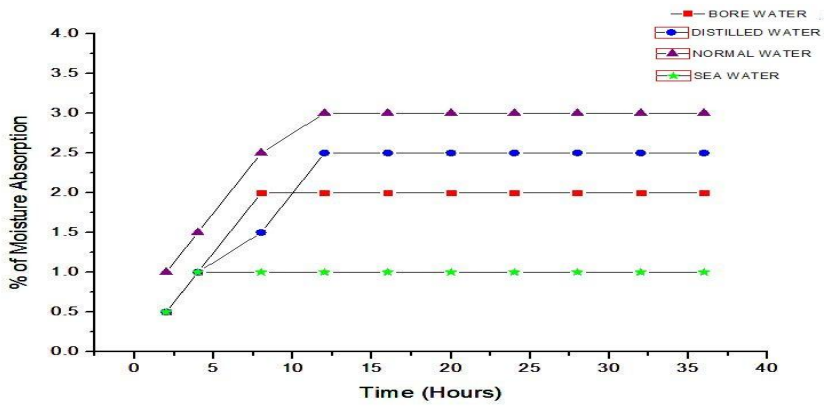

Fig.14: Graph showing the result of water absorption test

5. CONCLUSIONS

The present investigation a hybrid composite (HGSHC) is made with matrix (Epoxy Resin). Various mechanical tests are performed as per ASTM standards.

1. The Ultimate tensile strength of Hemp/Glass/Sisal Hybrid Reinforced Composites have more tensile stress (72 MPa) by adding glass in comparison to Hemp and Sisal fiber (24.7 MPa) natural hybrid composite. [2]
2. There is slight improvement in impact strength of Hemp/Glass/Sisal Hybrid Reinforced Composites (HGSHC) and the value is 39.03 J/m as compared to hybrid composed of Hemp and Sisal fiber.
3. The hardness of HGSHC mat was observed 45.9 at M-scale.
4. The water absorption for Hemp/Glass/Sisal Hybrid Reinforced Composites mat (HGSHC) was gradually increases from 0 to 15 hours and became constant for next 21 hours.

Thus the hybrid reinforced composites made of HGSHC are used in Aerospace (Wings, fan blade, Tail cones, & Interiors), Automobiles (Chassis& Interiors), Marines (Hull, decks & fly bridge), Wind turbines (Wind blades and spinners) and in various industry components like bath tubs, doors, windows, roofing etc.

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