Characterization of Glass Fibre – Coconut Coir– Human Hair Hybrid Composites

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Abstract — A composite material is a combination of two or more materials arranged in the form of layer one on the other layer using binding material through some prescribed methods. In the Glass fibre coconut fibre human hair hybrid composite method, the epoxy resin is used as binding material, in which one layer is formed of glass fibre, followed by coconut fibre and then by human hair. By using hand layup method and by changing the above arrangement of layers, six types of laminates are prepared by using the resin of LY556 and hardness HY951.The six types of laminates are Glass fibre reinforced plastic (GFRP)Coconut coir reinforced plastic(CCRP),Human hair reinforced plastic(HHRP),Glass – Coconut coir - human hair- Glass hybrid composite (GCHGRP),Coconut coir-glass- human hair-coconut coir hybrid composite (CGHCRP) and human hair-coconut coir-glass-human hair hybrid composite (HCGHRP) . As per ASTM standard, specimens are prepared in the above said six conduct various tests such as tensile, flexural, shear, impact and hardness tests. From the characterization of Glass-coconut coir-Human hair hybrid composite, it is observed that Eco-friendly coconut coir and human hair inclusion in the Glass fibre laminates have significantly influenced the mechanical properties.

Key words — Coconut fibre, Glass fibre, Human hair, Hybrid composites, and Mechanical properties.

I. INTRODUCTION

The composite materials is basically experimented to reduce the density of the basic material and to increase the strength of the material. The usage of composite material is initially started with aircraft materials, where the material requires high strength and low density. Thousand of experiments have been conducted for finding out the properties of the composite material and also to achieve the desired quality in the characteristics of composite material. In this experiment, it is tried to see the change in characteristics of glass reinforced composite fibre. Chanakan Asasutjarit et al [1] found the mechanical properties of coir based glass fibre based on preheating the coir. Wang Wei and Huang Gu [2] experiment natural coconut fibres composites to find the tensile strength, fineness, weight distribution. Comparing to coconut coir fibre, the human hair reinforced glass fibre has comparatively higher ultimate stress. Moreover other properties are also found enhanced comparing to coconut coir reinforced glass fibre. M. Brahmakumar [3]et al found the effect of natural waxy surface layer of the fibre on the fibre and the strength of composites. From the above articles, it was observed that the strength of the coconut fibre reinforced composites could be increased by increasing the bonding material, temperature and other parameters, etc. Shinichiet al. [4] has investigated the effects of the volume fraction and lengths of natural fibers on flexural properties of biodegradable composites. Kenaf and bagasse were mixed with corn-starch biodegradable resin, and composite flexural specimens were fabricated by press forming. The flexural modulus of the natural fiber composite made from Kenaf and bagasse increased, with an increase in fiber volume fraction up to 60% for Kenaf, and up to 66% for bagasse. Maries et al. [5] investigated the thermal conductivity, diffusivity and specific heat of polyester/natural fiber (banana/sisal) composites as a function of filler concentration and for several fiber surface treatments. Guohua et al. [6] studied the nano mechanical properties of human hair including hardness, elastic modulus and creep, using the nano indentation technique. Geethamma et al. [7] have studied the dynamic mechanical behavior of natural rubber and its composites reinforced with short coir fibers. Sapuan and Leenie[8]carried out experiments using tensile and flexural (three-point bending) tests of natural fibers reinforced with composite materials (Musaceae/epoxy). Harriette et al. [9] Studied the mechanical properties of flax/polypropylene compounds, manufactured both with a batch kneading and an extrusion process and compared the properties with those of Natural fiber Mat Thermoplastic (NMT) composites. Sanjay Choudhahry and Bhawana Pandey et al. [10] studied the mechanical behavior of

Polypropylene and Human Hair Fibres and Polyproylene Reinforced polymeric composites and find that composite with 3 to 5 wt% of bio fibre shows higher flexural strength, flexural modulus and Izod impact strength than non-reinforced polymer. They also find that the tensile and flexural properties decrease when the fibre loading percentage increases. C.Y. Lai et al. [11] determine that it is possible to enhance the properties of fiber-reinforced composites through fibre surface modification. R.V. Silva et al. [12] have investigated on fracture toughness on natural fibers and have found that for the coconut fiber composites the fracture toughness increases with the alkaline treatment. A.L. Martı´nez-Herna´ndez et al. [13] has made thermal analysis on polymeric composites reinforced with keratin biofibers from chicken feathers and has found that keratin biofibers composites have good thermal stability. T. Kunanopparat et al. [14] has suggested the fiber lignin content is a parameter influencing deplasticization, even if more studies have to be conducted in the future. Shiv Kumar and Dr. B. Kumar et al. [15] have found that elasticity of coir based epoxy composite decreases with increase of coir and ultimate strength decreases with increase in particle weight percentage. Huag Gu[16] has experimented and concluded that higher alkali concentration would deteriorate the fibre strength, higher the concentration, the greater the damage to the fibre. J. Rout et al.[17] has found that the adhesion between coir fibre and polyester matrix is poor, but by surface modification of coir fibres improves adhesion which in turn increases the mechanical properties of the composites. Mulinari D.R. et al. [18] have experiment and have found that fatigue behavior in composites presented a decrease in fatigue life when was applied greater tension. S.N. Monteiro et al. [19] have tested and found that random oriented coir fibre-polyester composites are low-strength materials, but can be designed to have set of flexural strengths that enable their use as non-structural building elements. Sandhyarani Biswas et al. [20] have experiment and found that the hardness is decreasing with the increase in fibre length up to 20 mm. However, on further increase in fibre lengh increases the micro harness value up to 16.9 Hv. G. L. Easwara Prasad et al. [21] have used Artificial Neural Network for prediction of characteristics of Coir Fiber Reinforced Composite. The fiber length and width distributions of the fibers from the compounds were determined and used to model the expected properties of the materials, which led to reasonable predictions of the interfacial shear stress. The major problem identified with natural fibers during incorporation in hydrophobic polymers is their poor compatibility. To alleviate this problem, various types of laminates contain in natural fibres and artificial fibers are proposed and tested which results in improvement of performance of the resulting composite. To check the characteristics of the above composites tensile test, double shear test, flexural test, impact and hardness test were carried out.

II. MATERIALS

The composite material is made of four layers namely glass fibre, human hair and coconut coir fibres by various combinations as glass fibre-coconut coir-human hair-glass fibre, coconut coir-glass fibre-human hair-coconut coir, etc. The materials properties are mentioned below;

2.1 COCONUT FIBRE

It is naturally available fibre extracted from the coconut. It is widely used in the form of ropes, mats and other house-hold applications due to insulating property and fibre properties. It is of 12 to 24 microns in diameter. It is readily available natural resource especially in the coastal areas of Western India.

2.2 HUMAN HAIR

It is a natural fibre formed by Keratin i.e. a protein having much content of sulphur. The physical properties of human hair are elasticity, smoothness and softness. Hair is surprisingly strong. Cortex keratin is responsible for this propriety and its long chains are compressed to form a regular structure which, besides being strong, is flexible. This property is much used for making this composite material much flexible**.**

2.3 GLASS FIBRE

Glass fiber is a material consisting of numerous extremely fine fibers of glass. Glass wool which is commonly known as fiber glass today was invented as a material to be used as insulation, nowadays due to its optimum properties it is used in manufacturing various composite materials. In general, the weight needed to produce a natural hair thread rupture is 50-100 g. An average head has about 120,000 threads of hair and would support about 12 tons. The resistance to breakage is a function of the diameter of the thread, of the cortex condition, and it is negatively affected by chemical treatments

III. SPECIMEN PREPARATIONS

The specimen is prepared by a method called hand-lay method which is very easy for batch production and small quantity production. It is a production method suitable for model making such as prototype and low volume production of fiber composite material parts. The hand lay-up process may be divided into four basic steps such as mould preparation, gel coating, lay-up and finishing. Mould preparation is one of the critical and the most important steps in the lay-up process. Moulds can be made of wood, plastics, composites or metal depending on the number of parts, cure temperature, pressure, etc. but for our experimentation aluminium sheet with wooden frame is used as mould. Here the mould design is based on the size, adhesive materials etc. Gel

coating is a process of applying a coating on the surface of the mould so that the mould can be separated easily after curing. Lay-up is the method in which the chopped strand mat, fabric in the form of reinforcement is brushed or applied to the gel coat surface. The six types of laminates namely glass fibre reinforced plastics (GFRP), coconut coir reinforced plastics (CCRP), Human hair reinforced plastics (HHRP), Glass-Coconut coir-Human hair -glass hybrid composite (GCHGRP) Coconut coir - Glass –human hair – Coconut coir hybrid composite(CGHCRP) and Human hair - Coconut coir – glass – human hair hybrid composite (HCGHRP) are prepared by using the hand layup method. The composite is completely cured under the ambient conditions and with the aid of external load for minimum of 24 hours duration. Finishing is the desired machining work to be carried out to make the specimen ready for the test. The test samples were cut to the required sizes prescribed in the ASTM standards.

IV. RESULT AND DISCUSSION

Though there are number of mechanical tests, which are necessary to determine the suitability of a metal, the following important tests have been performed in the present investigation such as tensile test, double shear test, impact test, flexural test, hardness test, etc.

4.1 TENSILE STUDY

This test is conducted to determine the tensile properties of the material particularly composites. The tensile specimens are prepared as per ASTM – D638-03 (9” x 0.75”x 0.5”) .This specification gives the drawing of the specimen to be prepared for conducting the test with tolerances. The prepared tensile specimen were inspected after machining and loaded in the tensile testing machine and the tensile force was observed during the test. The stress Vs strain curve is generated till the specimen is broken.

From the Figure 1, it is observed as following

- The HHRP and HCGHRP exhibit the same characteristics under tensile load test.
- The HHRP exhibits less tensile load capacity and maximum strain capacity
- The nature CCRP exhibits high tensile load capacity comparing to other composites.
- The composite HCGHRP exhibits slightly higher tensile load capacity and lesser strain capacity comparing to HHRP composite.

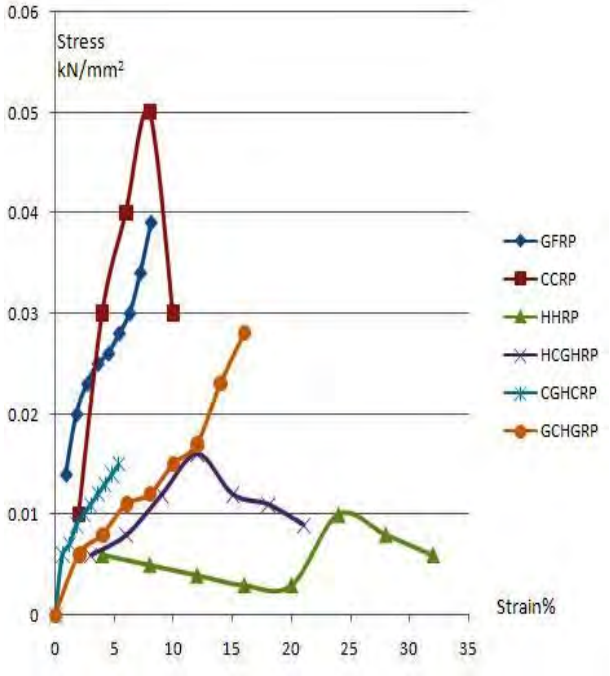

Fig.1. Stress Strain Curve (Tensile Load Test)

From the Table I, the following characteristics are observed

- The ultimate load for GCHG is observed to have maximum value, still HGCHRP could be considered, since it is eco-friendly and GCHCRP is hazardous in nature.
- The HGCHRP displacement is observed to be close to GCHGRP composite.

TABLE I
Comparative Tensile Study

Sample ID	Ultimate Load (N)	Displacement (mm)	Ultimate Stress (N/mm^2)
GFRP	2010	4.9	38
CCRP	580	6.3	5
HHRP	720	15.2	10
HGCHRP	1400	7.1	16
CGHCRP	1190	3.2	15
GCHGRP	2020	8.9	10

- The ultimate stress for HGCHRP is overall maximum comparing to other composites.
- The displacement of HHRP composite has the highest displacement among the other composites.

4.2 FLEXURAL STUDY

This test is also called bend test with the suitable fixture as given in the specifications as per ASTM-D 790 (0.125" x 0.5" x 5.0") and subjected to flexural test. The Test is conducted in the universal testing machine in compression mode. The sample is kept on bending fixture and the compressive load is given under specified conditions and the curve generated till the failure of the sample takes place.

From the Figure 2, the following characteristics are observed.

- The HCGHRP is found to exhibit more flexibility comparing to other composites
- The natural fibre CCRP composite is less flexible next to GFRP.
- The HCGHRP exhibits comparatively same characteristics as HHRP.
- The CCRP could not withstand high flexural load as shown in the Figure 2.

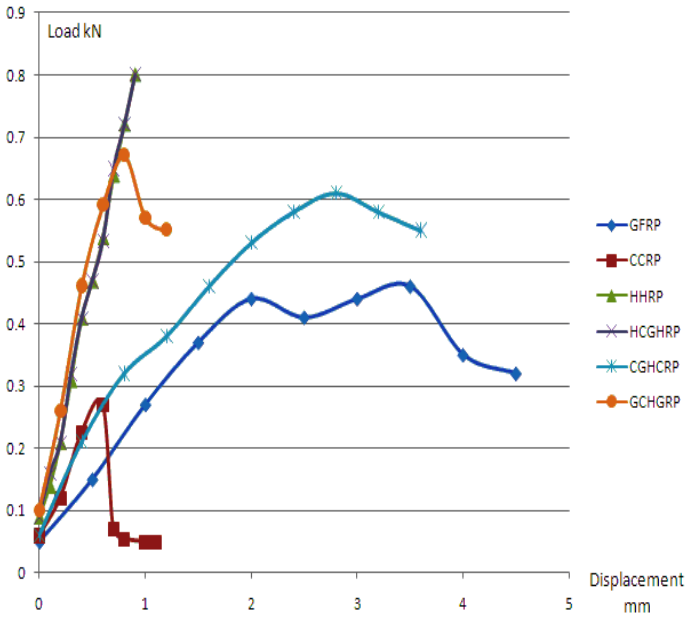

Fig. 2. Load Displacement Curve (Flexural Test)

TABLE II
Comparative Flexural Study

Sample ID	Ultimate Load (N)	Displacement (mm)	Ultimate Stress (N/mm^2)
GFRP	470	4.6	9
CCRP	275	1.1	2
HHRP	330	5.4	4
HGCHRP	820	1	7
CGHCRP	620	3.5	7
GCHGRP	665	1.2	7

The Ultimate loads and the Ultimate strength for six types of laminates are tabulated as shown in Table II.

- Human hair reinforced plastics (HHRP) has shown more Ultimate stress comparing to Coconut coir reinforced plastics (CCRP)
- Even if the orientation is changed, the ultimate stress remains constant.
- Human hair – glass - coconut coir - Human hair hybrid composite (HGCHRP) it was Observed that the maximum ultimate load comparing to other types of hybrid composite
- Human hair reinforced plastics (HHRP) is investigate that having the maximum deflection among the other types of hybrid composite

4.3 IMPACT STUDY

The impact test is the ability of the material to withstand the sudden shock loads. This test is conducted in a Impact testing machine with the specimen as per ASTM D 256 (2½" x ½" x 1/8 "). The machine consists of a loading striker which on releasing possesses fixed kinetic energy. The specimen made as per the specification would be kept in the machine and the load will be released. The absorbed energy would be indicated in the dial.

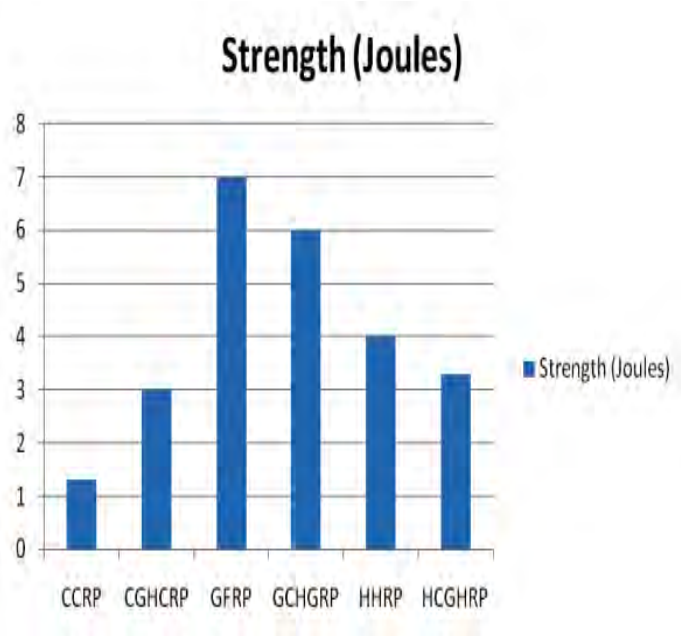

Fig. 3. Comparative Impact Load Test

From the Figure 3 the following results are observed

- Even though GFRP and GCHGRP exhibit the maximum impact load strength, the next feasible composite is HHRP.
- HHRP and HCGHRP exhibit more or less same impact strength load.
- Comparing to CCRP, CGHCRP has improved its impact load strength.
- The eco-friendly HCGHRP is having considerable impact strength.

4.4 SHEAR STUDY

This test is conducted in universal testing machine. The specimen as per ASTM D 7617M-11(length of 225 mm with 5mm centre gap with support on either sides) is prepared for a suitable cross-section and fixed in a fixture and the shear force is applied till the3 sample is completely sheared. The load Vs deflection curve is generated and the peak load indicates the shear strength

From the Figure 4, the following observations are seen

- The GFRP is having the maximum double shear capacity.
- The HCGHRP and GCHGRP are exhibiting the same characteristics under double shear test.

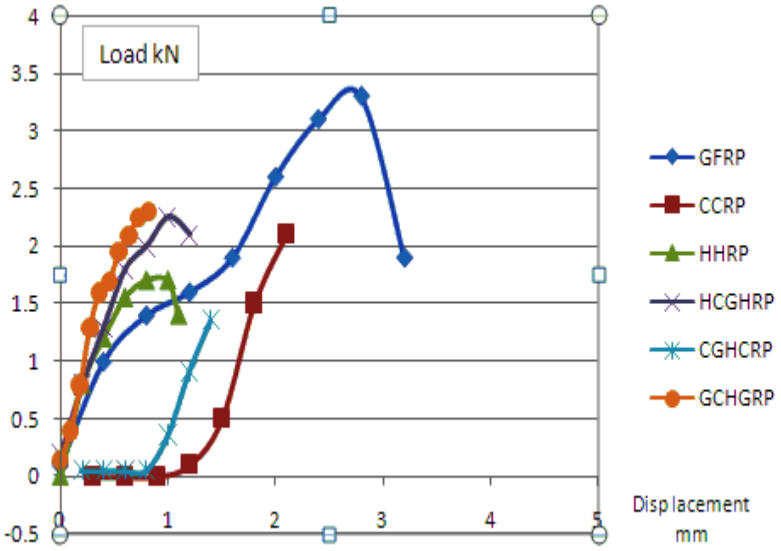

Fig. 4. Load Displacement curve (Shear test)

- The CCRP and CGHCRP are initially show high displacement and they could withstand load from 1.5 KN to 2 KN.
- The HHRP is more strained for less load of about 1.5 KN load.

TABLE III
Comparative Double Shear Study

Sample ID	Ultimate Load (N)	Displacement (mm)	Ultimate Stress (N/mm^2)
GFRP	3515	3.2	107
CCRP	2125	2.3	29
HHRP	1695	1.1	24
HGCHRP	2235	1.2	27
CGHCRP	1345	1.4	14
GCHGRP	2290	0.9	25

From the Table III, the following observations are seen

- Glass-Coconut coir-Human hair -glass hybrid composite (GCHGRP) has the maximum ultimate stress comparing to the composite.
- Coconut coir - Glass –human hair – Coconut coir hybrid composite/Reinforced Plastics (CGHCRP) has the maximum displacement among the composites.
- CGHCRP has the minimum ultimate load among the composites.
- Comparing both CGHCRP and GCHGRP, the ultimate stresses as well as the ultimate load are observed to be same.

4.5. HARDNESS TEST RESULTS AND COMPARISON:

Rockwell "G" Scale

TABLE IV
Comparative Rockwell Hardness Study

Sample ID	Location 1	Location 2	Location 3	Average
GCHGRP	574	532	529	545
HCGHRP	626	739	719	695
CGHCRP	708	729	719	719
CCRP	548	462	604	538
GFRP	594	631	652	626
HHRP	421	507	487	472

From the Table IV the following observations are noted

- HHRP is having less hardness capacity
- Comparing to GCHGRP, HCGHRP is having more hardness characteristics.
- CCRP and GFRP are having more or less same hardness values.
- CGHCRP is having the highest hardness characteristics.

V. CONCLUSIONS

From the investigation carried out on glass – Coconut coir – Human hair Hybrid composite, it was concluded that;

- CCRP is having the maximum tensile load capacity.
- HCGHRP exhibits highest flexible test characteristics.
- The HCGHRP shows considerable impact strength values comparing to other composites.
- The HCGHRP shows almost maximum double shear strength comparing to other composites.
- CGHCRP hybrid composite has the higher hardness value, then the other laminates.

From the above characteristics it is clear that HCGHRP is more suitable for highly flexibility, impact and double shear strength loads and more over it is eco-friendly and it can be applied where the above characteristics are required in aircrafts, automobiles and other areas of manufacturing. Finally it can be concluded that Eco – friendly coconut coir and Human hair inclusion significantly influenced the mechanical properties.

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