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A Study on Hair and Coir Reinforced Polymer Composite

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Abstract: Natural fibers have earned its reputation in composites industry due to its ease of availability and biodegradability and less toxic nature. Many studies of have been done to investigate the properties of bamboo, sisal, jute, banana fibers in composites. Our work aims to study the mechanical properties of hair and coir reinforced with epoxy resin. Tensile, Flexural and Impact tests were conducted on specimens with different combinations of hair and coir in epoxy resin. Results indicate that the tensile strength of the composite increased due to hair reinforcement.
Keywords : Hair, Coir, Epoxy, Composite. Mechanical properties.

Introduction:

In recent days, Natural fibers are used as reinforcement in producing polymer composites. Natural fibers are produced from Plants and Animals. Usage of natural fibres in day to day products still more contribute to a eco-friendly planet, as these fibres are a renewable resource and are completely biodegradable, which shows that they can be reproduced easily and also we can assure that won't pollute or produce greenhouse gases. Many properties of natural fibre composites were compared favourably with that of synthetic fibre Glass[1]. Coir is reinforced with polymer to bring reduction in weight, corrosion resistance, ability to tailor designing, manufacturing process flexibility[2] Various advantages of natural fibers over the traditional reinforcing material are low density, low cost, good thermal properties, acceptable specific strength and enhanced energy recovery[3] Natural fibres are found easily in all countries abundantly at economical cost. Because of such advantages natural fibres become more popular over synthetic fibre such as glass fiber, carbon and other man-made fibers. The mechanical properties of a natural fiber-reinforced composite depend on so many factors such as such as fiber strength, fiber length, modulus, fibre matrix interfacial bond strength and orientation. A tough fiber-matrix interface bond is always found to be critical for high mechanical properties of the composites. A good interfacial bond is required for effective stress transfer from the matrix to the fiber whereby maximum utilization of the fiber strength in the composite is achieved[4]. Alteration to the fiber may also improve the resistance to moisture induced degradation of interface and composite properties[5]. Another result shows that when the Mechanical test i.e. tensile test were performed on UTM, the results shows that tensile and compressive strength of various unidirectional natural fiber reinforced epoxy polymer composites are fair enough[6].

Human Hair is a natural fibre that can be found abundantly in all parts of the world. It is a proteinaceous fiber with a strong keratin chains. The Primary component of hair fibre is known as keratin. Keratins are proteins consisting of long chains (polymers) of amino acids. Hair contains a high amount of sulphur because the amino acid cysteine is a key component of the keratin proteins in hair fibre. The sulphur in cysteine molecules in adjacent keratin proteins link together in disulfide chemical bonds. These disulfide bonds are very strong and very difficult to break apart. These disulfide chemical bonds linking the keratins together are the key factor in the durability and resistance of hair fibre to degradation under environmental stress. They are largely resistant to the action of acids.The exceptional properties of human hair such as its unique chemical composition, slow degradation rate, thermal insulation, high tensile strength [7].Thompson R.M.[8] manufactured a hair-based composite material by manipulating a plurality of cut lengths of hair to form a hair mat and combining said mat of hair or web with a structural additive in order to form composite material. Hence we can say that human hairs are found in relative abundance in nature and are non-degradable thereby providing a new era in the field of Fibre Reinforced Composite materials.

A research was carried out to find out the static and water absorption performance of randomly oriented coir fibers that are mixed with reinforced polyester composites. The static and water absorption properties of fibres are highly dependent on volume percentage. In general, the composites having volume of 5% coir fiber showed notable result when compared to high fiber loading composites due to the effect of material stiffness. The chemically treated fibers having more tensile strength when compared to untreated coconut coir fibers[9].When Human hair is added to the concrete, it not only amends several properties of concrete like tensile strength, compressive strength but also enhances the binding properties, increases spalling resistance and micro cracking control. The crack width is reduced to a greater extent [10]. As included in his book by Chawla [11], the idea of composite material is not new or recent one. Nature is full of examples wherein the idea of composite material is used. The coconut palm leaf, for example, is essentially a cantilever using the concept of fiber reinforcement. Bone is yet another example of natural composite. Weiner and Weigner [12], gives a good description of structure and properties of bone. The structure-function relationships in the plant and animal kingdom, can be referred from the Elices [13] and Wainwright et al [14]. We are indeed surrounded by composites, be it natural or artificial.

The first level of classification for composite is generally made with respect to the matrix constituent as given in his book by Zweben [15]. The major composite classes involves the Organic Matrix Composites (OMCs), Metal Matrix Composites (MMCs) and Ceramic Matrix Composites (CMCs). The term organic matrix composite generally include two classes of composites, namely Polymer Matrix Composites (PMCs) and carbon matrix composites commonly referred to as carbon composites.

The second level of classification refers to the reinforcement form- fibre reinforced composites, laminar composites and particulate composites. Fibre Reinforced composites (FRP) can be further divided into those containing discontinuous or continuous fibres.

This work aims to find the enhancement of mechanical properties by the addition of hair in epoxy resin and epoxy resin reinforced with coir and hair fibre.

Materials and Methods:

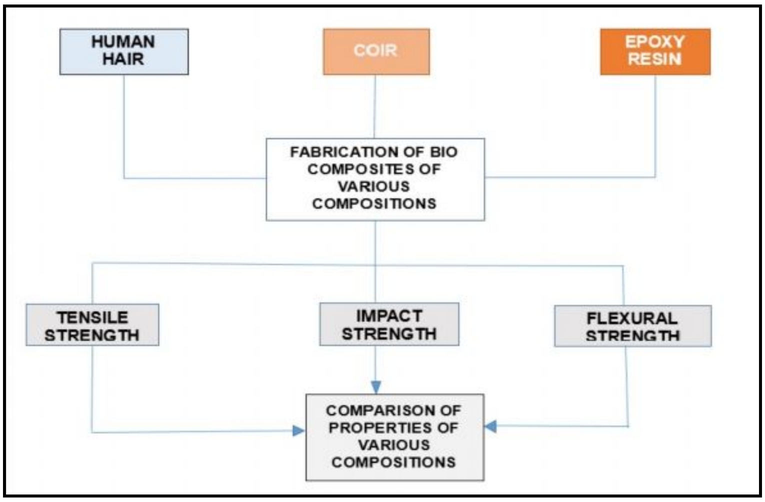

Figure 1: Flowchart of work procedure

Figure 2: Coir Fibre cut into small lengths

Figure 3: Human hair dried

The materials used for fabrication of composites are coir (coconut fibre) , Human Hair, Epoxy Resin and Hardener. The methodology used here is simply shown in the flowchart Figure.1. Coir which is shown in figure.2 is got from coconut fibres and treated to remove moisture and cut into lengths of 5mm to 10mm. And human hair is collected from Barber shop and they are cleaned and dried in order to remove moisture from it. This is shown in the figure.3.

Fabrication process is done by hand layup of the resin and fibre followed by compression moulding technique. Required amount of coir, hair, epoxy resin and hardener are mixed for appropriate percentages.The Epoxy Resin used for fabricating plates is of the type LY556 and the Hardener is of the type HY951.Then the mixture is poured in the mould and then compressed well for a period of 6 hours. The following figures 4, 5, 6 represents the fabricated plates done for various compositions of hair and coir in epoxy resin.

Figure 4: Composite plate of 30%coir and 70% epoxy resin

Figure 5: Composite plate of 10% coir and 10% hair with 80% epoxy resin

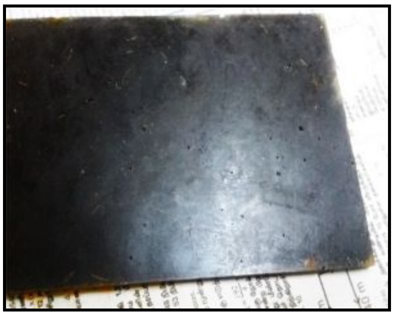

Figure 6: Composite plate of 90% hair and 10% epoxy resin

All the above plates are then cut into respective dimensions as per ASTM standards for the further process of Mechanical testing.

Mechanical Properties Testing:

The mechanical properties of composites depends upon the numerous variables such as fiber loading, fiber length, type of fibre, orientation of fibre etc. In general, Tensile strength is defined as a measurement of the force required to pull something such as rope, wire, or a structural beam to the point where it breaks. The tensilestrength of a material is the maximum amount of tensile stress that it can take before failure, for example breaking.

According to ASTM standard of D3039-76 test models, the tensile test of composites is carried out by employing Universal Testing Machine (UTM) Instron 1195. A load was connected to the both sides of composite samples for the testing. According to ASTM D790, the flexural test was conducted on the composite specimen, which is a 3 point bending test. The figures 7 and 8 shows the specimens that are cut to the required dimensions for testing. The specimen for tensile test and its experimental set up is shown below.

Figure 7: Cut section of coir reinforced composite plate

The general definition for flexural strength (modulus of rupture) is the stress in a material just before it yields in a bend test. The flexural test of composites is carried out utilizing Universal Testing Machine as shown in the figure 9. For the testing, the cross head rate is kept as 2 mm per min and a span of 60 mm is kept up.

Figure 9: Universal Testing Machine

Figure 10: Impact Tester

Figure 11: Tested samples for impact, tensile and flexural strengths.

Tensile strength is a measurement of the force that is required to pull a material to the point where it breaks. The tensile strength for a material is the maximum amount of the tensile stress that it can take before failure, for example breaking. This tensile test is also done in Universal Testing Machine (figure 9).

The impact tests are now carried out as per ASTM D 256 using an impact tester. The experimental set up for impact test is shown in the figure 10. In the figure 11, shows the samples that are tested for impact, tensile and flexural strengths..

Results and Discussions:

Figure 12 and 13, shows the Load vs Displacement graph for the composite with the mixture of coir, hair and epoxy. It can be observed that the material did not undergo brittle or sudden fracture, but the displacement keeps increasing after yielding. Epoxy being a thermoset, undergoes brittle fracture, whereas the reinforcement of coir and hair reduced its brittle nature.

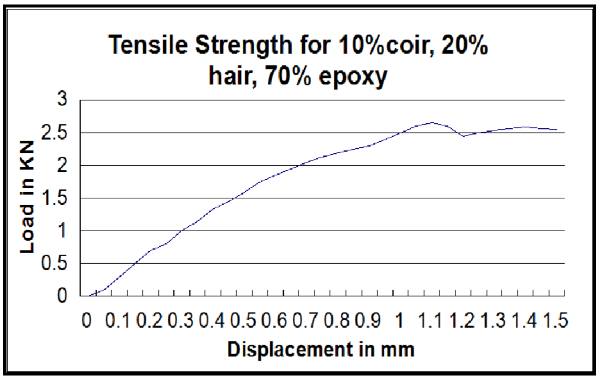

Figure 12: Load Vs. Displacement graph for Tensile Strength of 10% coir, 20% hair and 70% epoxy

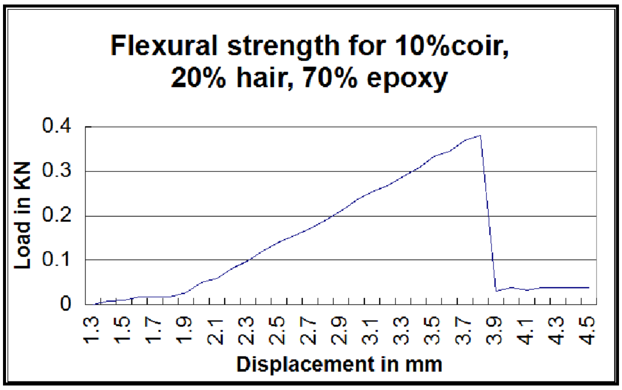

Figure 13: Load Vs. Displacement graph for Flexural Strength of 10% coir, 20% hair and 70% epoxy

Moreover the sample could take up a load around 2.7KN during tensile testing. Figure 15,shows the flexural strength for the same percentage of combination of reinforcement. The failure of the material during bending load was instant and the maximum load it could carry was less than 0.4N.

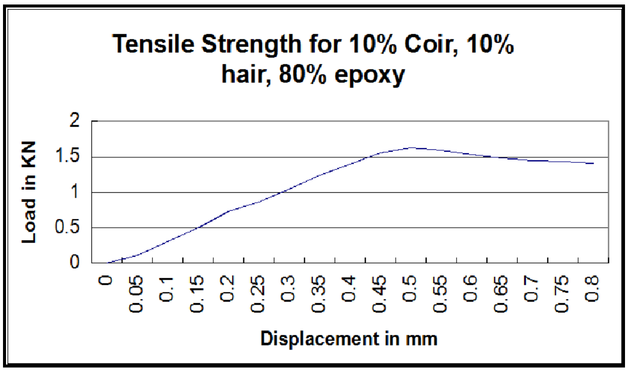

Figure 14: Load Vs. Displacement graph for Tensile Strength of 10% coir, 10% hair and 80 %epoxy

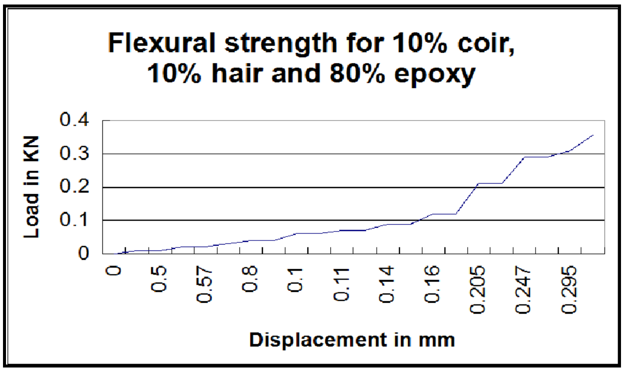

Figure 15: Load Vs. Displacement graph for Flexural Strength of 10% coir, 10% hair and 80 %epoxy

The tensile strength for 10%coir, 10% hair and 80% epoxy composition is less since the content of hair is less. The maximum tensile load the sample could take up is less than 2 KN. It is evident that the decrease in load bearing capacity is due to the decrease in hair content compared to the previous case. The load taken during flexure remains the same. However, the specimen started yielding at a very lesser load.

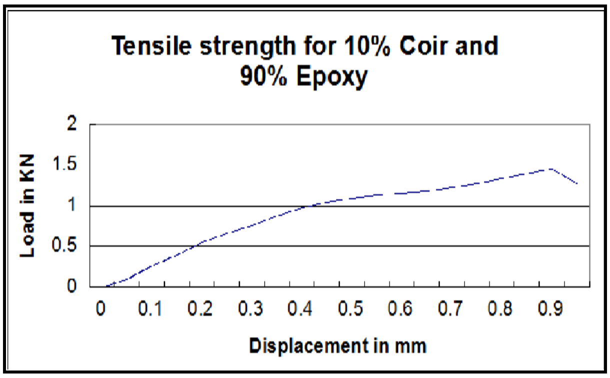

Figure 16: Load Vs. Displacement graph for Tensile Strength of 10%coir and 90%epoxy

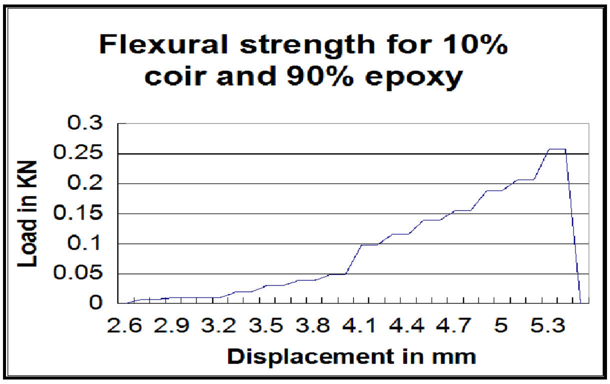

Figure 17: Load Vs. Displacement graph for Flexural Strength of 10% coir and 90% epoxy

Figure shows the tensile and flexural graph for 10% coir reinforcement. In both cases it could be observed that the displacement is more at a very lesser load.

The results obtained from the tests are tabulated in Table 1.

Table 1: Tensile strength, Flexural strength and Impact strength for various compositions .

Experiment No	**Composition of reinforcement with epoxy**	**Tensile Strength (MPa)**	**Flexural Strength (MPa)**	**Impact Strength (Joule)**
1	10% hair	9	43.3	4
2	10% coir	9	35.09	2
3	20% hair	12	38.52	5
4	20% coir	10	31.09	3
5	30% hair	15	25.06	6
6	30% coir	11	26.2	4
7	10% coir+20% hair	16	35.73	4
8	10% coir+ 10% hair	10	36	2

It was observed that all the mechanical properties are higher when hair is reinforced when compared to coir reinforcement. More amount of reinforcement of coir or hair individually, reduced the overall flexural strength as less epoxy is available to hold the fibres together. More the content of coir or hair gives more Tensile strength as both coir and hair has high tensile strength. Thus, for high tensile strength quantity of coir or hair can be increased. Hence we can say from compositions of coir or hair of 10%, 20% and 30% that increase in percentage of either coir or hair with epoxy resin results is increase tensile strength and impact strength, but flexural strength gets decreased. When 10% coir and 20% hair is combined with 70% of epoxy resin, tensile strength is more when compared to other combinations. flexural strength and impact strength also seems to be decent due to increased quantity of epoxy resin. The combination of 10% coir, 10% hair and 80% epoxy resin has Tensile and impact strength lesser when compared to the previous combination.

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