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# Influence of Weight Fractions on Mechanical, Water Absorption and Corrosion Resistance Behaviors of Untreated Hybrid (Coir/Banana) Fiber Reinforced Epoxy Composites

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Engineering, Tiruchengode, Namakkal, India. Abstract : In today's world, the focus is towards alternate material sources which are environmentally acceptable and biodegradable in nature. Out of those materials, composite

environmentally acceptable and biodegradable in nature. Out of those materials, composite materials field is rapidly increasing in engineering. Due to low cost, light weight and biodegradable properties, natural fiber reinforced composites are employed. Therefore, the current work addresses the influence of weight fractions on mechanical, corrosion and water absorption behaviors of untreated coir-banana hybrid fiber reinforced epoxy composites. Here, epoxy resin – araldite LY556 and hardener – araldite HY951 were used as a matrix material. According to ASTM standards and by using hand lay-up technique, the specimens were made with the weight fractions of 0/40, 15/25, 20/20, 25/15 and 40/0 of coir/banana fibers, and maintaining constant fiber length of 5mm. It has been noted that, the tensile and impact strength of hybrid combinations were greater than the pure banana composite. Scanning electron microscope was done on those samples, to ascertain the mode of failure. **Keywords**: Fiber, Coir, Banana, Hybrid, Composites, Epoxy, Hardener.

# Introduction

A composite can be defined as materials that consist of two or more physically and chemically different interface separated by distinct interfaces. It is the combination of two materials called the reinforcing phase and the matrix phase. The reinforcing materials commonly used are metal, ceramic or a polymer and the matrix materials commonly used are (a) Thermosets - Epoxy resins and Polyester resins and (b) Thermoplastics -Nylon 66 and Polypropylene. The matrix acts as a load transfer medium between fibers. The matrix is more ductile than the fibers and thus acts as a source of composite toughness. Composites are widely used in both military and civilian industries. They are used in the manufacture of variety of products ranging from aircrafts, spacecraft, satellites, missiles, sports goods, marine equipment's and automobile components. Hybrid composite materials are formed by reinforcing two or more materials of varying properties. The behavior of hybrid composites is a weighed sum of individual components used. Also using hybrid composite that contains two or more materials, the advantages of one material could complement with the properties lacking in the other. As a consequence, balance in cost and performance can be achieved through proper design of the materials. Natural fiber composites have gained increasing interest due to their eco-friendly properties. Natural fibers like coir, sisal, jute, banana are inexpensive, abundant, renewable, high toughness, light weight, low density and mainly biodegradable<sup>1</sup>. The combination of different natural fibers found to give better mechanical and physical properties<sup>2</sup>. The main chemical constituents of banana fibers are hemicellulose and lignin. Lignin acts as a binder for the cellulose fibers and behaves as an energy storage system. Coir is the most interesting product, because it has the lowest thermal conductivity and bulk density<sup>3</sup>. Coir fiber has more life when compared to other natural fibers due to its high lignin content<sup>4</sup>. Under dry conditions, coir fiber shows very high interfacial adhesion character<sup>5</sup>. Coir fibers are more efficient and superior in reinforcement performance when compared to other reinforcement composites<sup>6</sup>. The polymer banana reinforced natural composites is the best natural composite among the various combinations<sup>7</sup>. The strength of the hybrid composites increases with increase in weight fraction of the fiber. From their investigation, it was found that most of all the hybrid natural fiber composites show increase in mechanical properties for 40% of the fiber reinforcements<sup>8</sup>. Hybrid composites provide better flexibility as compared to single fiber containing composites<sup>9</sup>. The hybrid composites provide better resistance to water absorption, when compared to individual fiber composites<sup>10</sup>. In future various other natural reinforcing material could be used to mix with banana fiber to form a better hybrid composite which has a better mechanical properties and as well as cost effective<sup>11</sup>. If the weight fraction increases, then the percentage of moisture uptake also increases due to high cellulose content. He also found that, the tensile and flexural properties of composite decreases with increase in percentage of moisture uptake<sup>12</sup>. The tensile and flexural strength of banana fiber is higher than the jute fiber reinforced epoxy composites<sup>13</sup>. The alkali treated banana-coir epoxy hybrid composite has less flexural strength than the untreated banana-coir epoxy hybrid composites<sup>14</sup>. Although there are several reports in the literature which discuss the mechanical behavior of natural fiber reinforced composites, very limited work has been done on the influence of weight fractions on tensile, flexural, impact, hardness, water absorption and corrosion<sup>15-28</sup> resistant behavior of coir/banana fiber reinforced epoxy hybrid composites without treatment. Against this background, the present project work has been undertaken, with an objective to improve the mechanical behaviors of coir/banana fiber reinforced epoxy hybrid composite without treatment.

## **Experimental procedure**

The raw materials used in this experimental work are (i)Natural fibers (coir & banana) (ii) Epoxy resin – LY556 and (iii) Hardener–HY951. The mould box of size 210mm x 210 mm x 3mm for the preparation of required composite. Initially, the fibers and polymer-hardener mixture are weighed and taken in the ratio 60:40. The resin and hardener are taken in the ratio 10:1. By using hand lay-up technique, for various weight fractions, the composite plates were prepared. A hacksaw blade with frame was used to cut each composite plate into various test samples according to ASTM standards.

## **Experimental Investigation**

### Tensile test

The uniaxial load was applied at both the ends of the specimen until deformation was observed. The corresponding value of the load was noted down for the deformation of the test sample. During the gradually applied load, the specimen breaks at the specified point known as rupture or the fracture point. The sample after tensile test was shown in figure 1.



Figure 1 Sample after tensile test

## **Flexural test**

It was the 3-point bending method to study the behavior and ability of the material under bending load. The load was gradually applied from the top roller until the deformation was observed. The load value at maximum deformation was noted. The sample after flexural test was shown in figure 2.



Figure 2 Sample after flexural test

#### Impact test

The impact strength is the mechanical parameter which is the kinetic energy needed to initiate fracture until the specimen is broken. The test samples for impact test were shown in the figure 5. Sample was fixed; the load was applied by an arm, which was released during testing. The arm breaks the sample by giving load. The load for the breakage of the sample was noted. The sample after impact test was shown in figure 3.



Figure 3 Sample after impact test

## Hardness test

The hardness is the mechanical parameter which is the ability to oppose to indentation. The hardness test was performed with a 1/16 ball indenter, with an applied load of 100 kgf.

#### Water absorption test

The test was conducted by immersing the test samples in the distilled water at room temperature  $30^{\circ}$ C. The pH value of distilled water was 6.0. The samples were taken out and weighed at regular time intervals of 24, 48, 72 and 96 hours. After wiping out the water from the surface of the samples, they were weighed using precise three digit weight balance to find out the content of the water absorbed until constant weight was reached. During the water absorption test, the weight of the sample gets increased from the actual weight. The percentage increase in the weight was calculated by using the given formula,

W (%) =  $(m_t - m_0)/m_0 \times 100$ 

Where  $m_0$  and  $m_t$  were the weight of the samples at initial and after time (t).

#### **Corrosion test**

Corrosion test was used to determine the amount of weight loss of the test samples during the chemical treatment. Initially, the 5% NaOH solution was prepared by dissolving 50grams of NaOH pellets in the 1 liter of distilled water. The pH value of the solution was 12.6. The test samples were immersed in the solution and were taken out and weighed at regular time intervals of 24, 48, 72 and 96 hours. After removing the samples from the solution, the samples were dried using hot-air oven at 70°C for 1 hour. Then the samples were weighed using precise three digit weight balance to find out the loss in weight.

## **Results and Discussions**

#### Tensile strength test

For various weight fractions of the samples, the test was carried out and the corresponding readings were noted. From the figure 4, it has been noted that, the tensile strength of untreated pure banana fiber composite shows poor results i.e., 8.937 N/mm<sup>2</sup> only. By adding 15% weight fraction of coir fiber into pure banana fiber composite, the strength has been improved of about 10.624 N/mm<sup>2</sup>. And also, by adding 20%, 25% weight fractions of coir fiber into pure banana fiber composite, the strength was increased.



Figure 4 %Weight fractions vs tensile strength

For the hybrid combinations, the maximum strength was attained at the weight fraction of 25% coir and 15% banana, of about 14.587 N/mm<sup>2</sup> which was also less than the strength of pure coir fiber composite i.e., 14.705 N/mm<sup>2</sup>. Finally it has been identified that, in the untreated pure banana fiber composite, if the %weight fractions of untreated coir fiber gets increases, the tensile strength also increases. This is due to very high lignin content of coir fiber than the banana fiber.

## **Flexural strength test**

It has been noted that, the flexural strength of untreated pure banana fiber composite shows better results than the other combinations. From the figure 5, it has been observed that, the flexural strength of untreated pure banana composite was 34.11 Mpa. By adding untreated coir fiber with the weight fractions of 15%, 20% and 25% into untreated pure banana composite, the strength has been decreased. The untreated pure coir composite shows the minimum flexural strength of 22.415 Mpa only.



Figure 5 % Weight fractions vs flexural strength

Finally it has been observed that, the untreated pure banana composite possess better flexural strength and flexural modulus than the other hybrid combinations. Due to high cellulose and hemicellulose content in banana fiber, it provides better flexural properties. And also flexural strength depends upon the amount of individual fiber content. Due to lesser diameter and light weight of individual banana fiber, it possesses better flexural behavior.

## Impact strength test

It has been noted that, the untreated hybrid fibers with the weight fractions of 20% coir and 20% banana, can withstand the maximum impact energy of 0.85 J, which was higher than the other combinations. The untreated pure coir and pure banana fiber composites possess nearly equal impact energy of 0.50 J and 0.55 J respectively.



Figure 6 %Weight fractions vs impact strength

Therefore, it has been observed from the figure 6, those untreated coir/banana hybrid fiber composites with equal weight fractions of 20% each, can able to withstand high impact load than the other hybrid weight fraction combinations. Impact properties are depends upon the cellulose content in the fibers. Therefore, equal composition of banana and coir fiber in a particular composite can withstand sudden impact load.

### Hardness test

From the figure 7, the pure banana fiber composite possesses minimum hardness value and the pure coir fiber composite possesses maximum hardness value. It has been identified that, the addition of coir fiber into the pure banana fiber composite, the hardness value was increased but the hardness of hybrid composites were less than the hardness of pure coir fiber composite.



Figure 7 %Weight fractions vs Rockwell hardness

Generally, fibers that increase the moduli of composites increase the hardness of the composite. Because, hardness is a function of relative fiber volume and modulus. Therefore, the modulus of coir fiber is more than the modulus of banana fiber. Hence, hardness is more for coir fiber composite.

#### Water absorption test

By immersing composite samples in 1 liter of distilled water and those samples were weighed by weighing machine (0.001 calibrations) at the regular intervals of 24h, 48h, 72h and 96h respectively. From the figure 8, it has been noted that, the untreated pure banana fiber absorbs large amount of water than the other combinations. The percentage gain of water for pure coir fiber composite was minimum. Meanwhile, all the samples nearly reach the saturation point at the time interval of 96 hours. Therefore, it has been identified that, the pure banana fiber shows more water absorption behavior. Further addition of coir fiber into pure banana fiber composite, with the weight fractions of 15%, 20%, 25% there was a decrease in the % gain of water.



Figure 8 %Weight fractions vs %Gain of water

Finally, pure coir fiber composite shows less % gain of water than other combinations. This is due to less cellulose content in coir fiber than the banana fiber. This causes the coir fiber to absorb not much quantity of water. Hence, it easily reaches the saturation level.

## **Corrosion test**

The composite samples were immersed in 5% of NaOH solution and those samples were weighed by weighing machine (0.001 calibrations) at the regular intervals of 24h, 48h, 72h and 96h respectively.



Figure 9 %Weight fractions vs %Loss in weight

From the figure 9, it has been noted that, the untreated pure coir fiber composite shows minimum corrosion effect than the other combinations. The pure banana fiber composite shows maximum corrosion effect. Further addition of coir fiber into pure banana fiber composite, with the weight fractions of 15%, 20%, 25% the corrosion effect becomes gradually decreases. Due to high density and less diameter of banana fiber, the corrosion rate was higher when compared to coir fiber. Hence, the banana fiber shows maximum corrosion effect.

### Morphological analysis

Morphological analysis was carried out on the specimens which undergone tensile test. The specimens after tensile test were analyzed under scanning electron microscope. The hybrid fiber with the weight fraction of 15% coir & 25% banana composite after tensile test was analyzed under scanning electron microscope as shown in the figure 10.



Figure 10 SEM of 15% Coir & 25% Banana composite

From the figure 10, the composite failure occurs due to presence of voids which was created due to fiber pull out. As the above combination, the image resembles that banana fiber was more in number than the coir fiber. During failure, the voids are so much created on the banana fiber than the coir fiber. Due to the small addition of coir fiber, the formation of voids becomes moderate. Hence, it provides better tensile behavior than the pure banana composite.

The hybrid fiber with the weight fraction of 20% coir & 20% banana composite after tensile test was analyzed under scanning electron microscope as shown in the figure 11. From the figure 11, the composite failure occurs due to presence of voids which was created due to fiber pull out. As the above combination, the image resembles that, there was an equal separation of coir fibers and banana fibers respectively. During failure, the voids are so much created on the banana fiber than the coir fiber. Due to the equal addition of coir fiber, the formation of voids becomes moderate. Hence, it provides better tensile behavior than above combinations.



Figure 11 SEM of 20% Coir & 20% Banana composite

# Conclusions

The fabrication of pure banana, pure coir and hybrid (coir/banana) fiber reinforced epoxy composites with various weight fractions were successfully done by hand lay-up technique. The tensile, flexural, impact, hardness, corrosion and water absorption tests were conducted successfully on those untreated pure banana, pure coir and hybrid fiber reinforced epoxy composites. It has been observed that, untreated pure banana fiber composite shows poor tensile strength. By adding coir fiber, the strength has been increased, but still it was less than pure coir fiber composite. Therefore to obtain better tensile and impact strengths, some other natural fibers could be added to banana fiber composite as a hybrid combination. The untreated pure banana fiber composite shows maximum flexural strength. It has been noted that, the hardness, corrosion and water absorption behavior were well satisfied on 25% coir & 15% banana hybrid combinations.

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