International Journal of Research
Available at https://edupediapublications.org/journals
e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 04 Issue 14
November 2017

Fabrication and Analysis of Coconut Coir Fiber Reinforced Epoxy Composite with Cement as Filler

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Abstract: Over the past two Decades there has been many researches on coir fiber based composites and hybrid materials and further researches are being carried out on the same as coir is found to a replacement for many syntactic fibers as it abundantly available in nature, specially in India and Asian countries, research on different materials as fillers in coir fiber composites for different purposes such as Roofing tiles, Epoxy flooring, Helmet shells etc are being Carried. The present work is a small effort on testing Portland cement as filler material in the Coir/Epoxy composite and finding out whether the fabricated composite can be a suitable material for preparation of Safety helmet. Different combinations of coir and cement is taken in constant epoxy content and are tested for different mechanical properties such as Tensile strength, Impact Strength and Shore Hardness and it can be said that cement as filler has significant effect on the above mechanical properties of a coir/epoxy composite.

Key Points: Coir Fiber, Epoxy & Hardener, Cement, Mechanical Tests, Helmet shell.

1. Introduction:

In this Modern Era, we find various applications of composite materials right from a small pan in our kitchen to the space technology. Over few decades natural fibers gained a lot of importance in the field of composites and the study of natural fiber composites has also increased significantly because of low cost, high availability, good mechanical properties, low density, low conductivity, CO_2 Neutrality, Bio-Degradability, and many other such reasons. A great work and study has been done world-wide on mechanical properties of these natural fiber materials and how they interact with various plastics (thermo-sets and thermoplastics). Coir has cellulosic fibers along with hemi cellulose and lignin as bonding material for fibers. Coir has very high lignin content which makes the fiber stiffer, tougher and stronger when compared to other natural fibers. When compared to other natural fibers,

Coir is one of the promising fibers because of its low cost, high availability, low density and environment friendly nature. In general, Coir fiber is the biological waste obtained after the use of Coconut in different industries such as Coconut oil Industries and this coir fiber is used as combusting material which causes Environmental pollution, therefore, research and development efforts have been made to find new areas to use this Coir fiber mainly as a reinforcing material in Composites. Few such researches are done by Geetanjali Das et al. [1] studied the Physical, Mechanical and Water absorption behavior of Coir fiber reinforced Epoxy composite with and with-out Al_2O_3 powder as filler and found that the Tensile strength of composite material raises with the increase in reinforcement up to certain point and then decreases where as hardness increases with increase in the filler content.

Fairuz I. Romlia et al. [2] have given us the Factorial Study on the Tensile Strength of a Coir Fiber- Reinforced Epoxy Composite. They have presented a factorial analysis of a coir fiber base composite on the tensile strength. Three main parameters presented in their study are Fiber volume fraction, curing time and compression load applied during fabrication of the composite. They found that the most dominant factor which has

impact on the tensile strength of the composite is the Coir fiber Volume fraction. The curing time and its combined effect with the setting of coir fiber volume fraction will also play the significant role in tensile test of composite and it has to be considered in the fabrication process of the composite. On the contractor end the compression load have the insignificant effect on tensile strength.

D. Verma et al**. [**3**]** have given us a review on Coir Fiber Reinforcement and Application in Polymer Composites .The day by day increase in global warming is really a concern for many and have made scientist to focus on natural resources rather than artificial materials which have harmful effects on environment. Abdul Nazeer [4] has given us a study on the Mechanical Properties of Coconut Coir Fiber Reinforced Composite with Epoxy Resin AW106 and HV 953 IN Hardener in both Treated Fiber and Untreated Fiber Cases. By the research the author of this paper found that the NaOH treatment improved the mechanical properties of the composite materials such as Tensile Property, Ductility and Hardness, more over the increase in lengths of fiber is observed to increase the tensile strength. At the length of 15mm of Coir Fibers the tensile strength is found to be maximum. Chizoba Obeli and Edith Ishidi [5] have prepared Helmet shell using Coir Fiber reinforced Epoxy Resin and tested for Mechanical properties of same. Coir Fiber/Epoxy resin composites have been formulated using various filler loadings by weight (10, 20, 30, 40 & 50 weight %) for possible helmet shell fabrication. In this research the authors have kept the fiber length constant i.e., 30mm and the ratio of epoxy and hardener as 1:0.8 respectively and they have concluded that the composite mixture with 30wt% of fiber have the highest tensile and Impact strengths and It is also found that the impact strength is least at 50wt% and second least at 10wt%. The epoxy/coir fiber composites have the sustainable mechanical properties to form a industrial safety helmet and the mechanical properties also compare well with that of mechanical properties of traditional helmet shell materials such as ABS and PC which are most commonly used materials for preparation of industrial shell helmet.

Akhil Kumar Sen and Sandeep Kumar [6] have developed Coir-Fiber based fire retardant nano filler for epoxy composites. Initially the coir is treated with saturate bromine i.e., the coir fiber is brominated and then it is treated with stannous chloride solution and it is let to dry. After drying the fiber is ground into fine nano dimension and is mixed thoroughly with epoxy resin for the preparation of composite material. Low amount of heat change is shown in thermo gravimetry during degradation of BC fiber and is even lower for SBC fiber when compared to Normal coir Fiber. The thermal ability of BC and SBC fiber will not affect the overall the thermal stability of epoxy resin composites though the thermal stability of BC and SBC fibers are lower compared to Coir Fiber. The fire retardant properties of epoxy resin composites such as LOI and smoke density properties improves notably in final composite in spite of presence of small quantity of bromine and tin in the same and because of the same reason a strong interfacial adhesion also takes place between the matrix and the filler material.

S.M. Suresh et al [7] Had studies on Mechanical, Thermal and Dynamic mechanical properties of Untreated and Treated coconut sheath fiber reinforced epoxy composites. Fabrication of both untreated an treated coconut sheath fiber reinforced epoxy composite using hand layup technique and is followed by compression mould technique. Different techniques such as FTIR, DMA, TGA and SEM are used to characterize the specimens prepared. For measuring tensile flexural and impact strengths the specimens which were prepared are cut as

per ASTM standards and the testing stated were done using Universal testing Machine and Izode Impact tester. Better Fiber Matrix bonding and absence of voids are found in case of treated coconut sheath fiber composites in SEM analysis when compared to untreated sheath fiber composites which indeed results in higher mechanical strength and thermal stability for treated sheath fiber composite.

Though the major constituents of a composite material are Reinforcement and Resin material, filler also plays a very important role in the strength of composite materials. Fillers influence significantly the mechanical properties of composite material. The improved performance of polymer and their composites in industrial and structural applications by the addition of particulate fillers has shown a great promise and so has lately been a subject of considerable interest. Portland cement which is easily available and environment friendly material is chosen as the filler material in this experimentation, Cement has good ceramic properties and it is fire and heat resistant material and it is cheap when compared to any other traditional filler material. With an excellent combination of properties and a reasonable price, cement is chosen as the filler material in this experimentation.

Although a lot of research has been done on the coir fiber based polymer composite, this experimentation is a small effort made to study the mechanical properties of Coir Fiber reinforced epoxy composite with Cement as the filler material.

2. Objective

As stated above Coir Fiber Composites Find large applications in the field of constructions such as roofing tiles and epoxy flooring

These days composites are used in the preparation of safety helmet shell preparation

In this experimentation a small effort is made to fabricate a material by using Coir fiber and Cement filler Epoxy composite and finding out its properties and checking out whether it is a suitable material for fabrication of a safety helmet shell.

The Properties such as Hardness and Impact Strength of fabricated material is compared to that of traditional helmet shell material.

3. Experimental Details

a. *Composite Fabrication*

Coconut Coir fiber of considerable length and Cement filler is taken as reinforcement and Epoxy as matrix material. The Coir fiber and Cement is obtained from local sources and epoxy and hardener is bought online from Amazon.in. The fabrication of composite slabs is done by traditional hand lay-up process. The mould with dimension of 180X40X20mm is taken for preparation of the sample. Three composite specimens were made by varying the fiber and filler content by weight (5% and 15%, 10% and 10%, 15% and 5% of fiber and filler by weight) are made. The cast of each composite material is cured under atmospheric pressure for 24 hours before it is removed from mould, then the specimens of suitable dimensions are cut for various testing. The specimen and its respective composition is shown in following table1. And Fig 1, 2 ad 3 shows Coir Fiber, Cement and Fabricated material respectively.

Fig 1 Coir Fiber

Fig 2 Cement

Fig 3 Fabricated Sample

Designation	% of Resin by wt	% of fiber by wt	% of filler by wt
Specimen A	80	5	15
Specimen B	80	10	10
Specimen C	80	15	5

b. Mechanical Tests

The Mechanical Tests conducted on any specimen can be of both Dynamic Tests and Static tests. Static tests are those which are conducted with constant loads or constantly varying loads such as Tensile strength. Dynamic Tests are those in which a sudden load is applied on the specimen such as Impact test. Hardness test is conducted to find out the Hardness of the given specimen. All the tests are Conducted At Jyothi Spectro Labs, Balanagar.

Tensile Test:

Tensile tests are conducted on all three specimens with varying loads where Ultimate load and Tensile Strengths are found out for each composition. The tests are conducted according to ASTM D638 procedure and the specimens prepared are cut according the same standards. Fig 4 Shows the Cut Specimen and Fig 5 Shows Specimen after the Test.

Fig 4: Cut Specimen

Fig 5 : Specimen After Tensile Test

Impact Test

Impact test is a dynamic load test in which a sudden load or dynamic load is applied on the specimen. A standard test procedure of ATSM D-256 Izod impact test is used. The specimens are cut according to the given standards. The procedure of test is as follows

Test Procedure: Impact Test fixture is used in which the specimen is climbed with the notch side facing the striking edge. To hit the specimen the pendulum is released. If the specimen doesn't break heavier pendulum is used for the purpose. The experiment is carried out at the room temperature.

Hardness Test:

Durometer Hardness is used to determine the relative hardness of soft materials, usually plastic or rubber. The test is used to measure the penetration of a specified indentor into the material under specified conditions of time and force. The hardness value is often used as a quality control measure on lots of material or to specify or

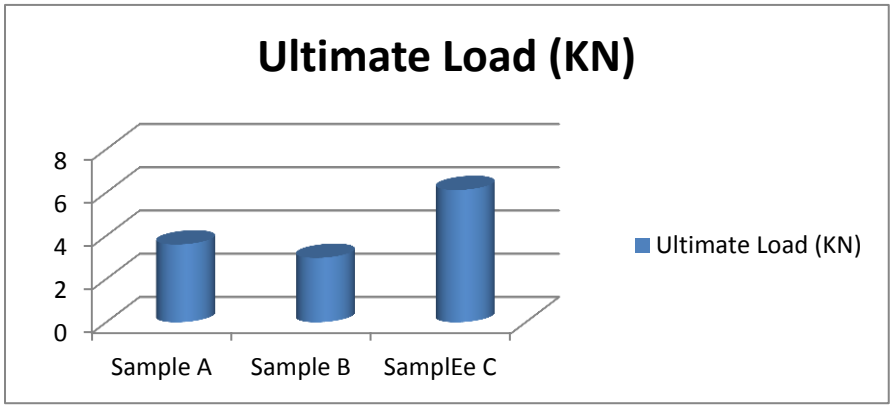
e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 04 Issue 14
November 2017

identify a particular hardness of elastomers. The standard procedure of ASTM D-2240:2003 is used to determine the Shore hardness of the specimens And the specimen sizes are taken according to the given standards.

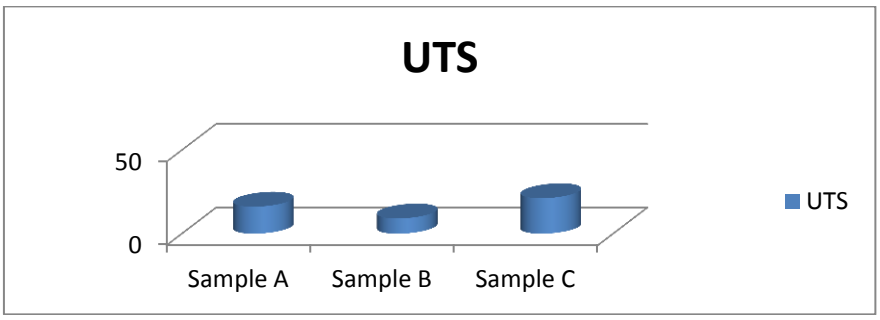
c. Results And Discussion

The results of Different mechanical Tests are shown in the following table and the Graphs of comparison are also drawn for the same

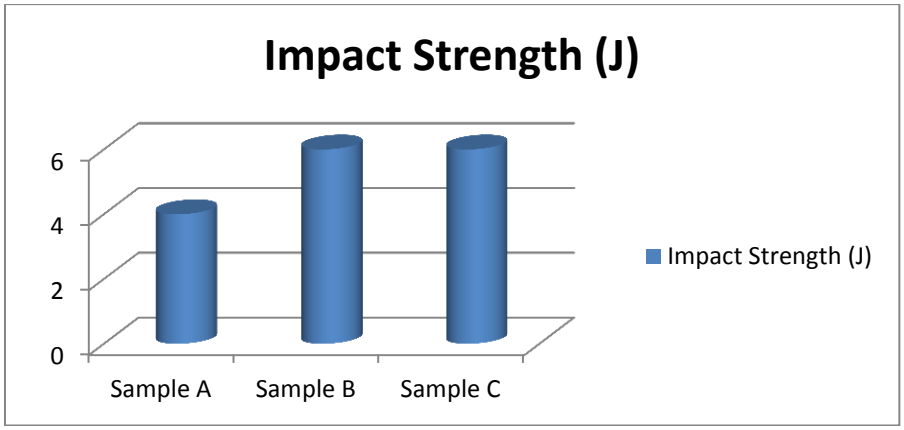
Specimen	Ultimate Load (N)	UTS (N/mm^2)	Impact Strength (Joules)	Hardness
Specimen A	3.60×10^3	16.171	4	59.5
Specimen B	2.98×10^3	9.116	6	57.5
Specimen C	6.12×10^3	21.237	6	57.5



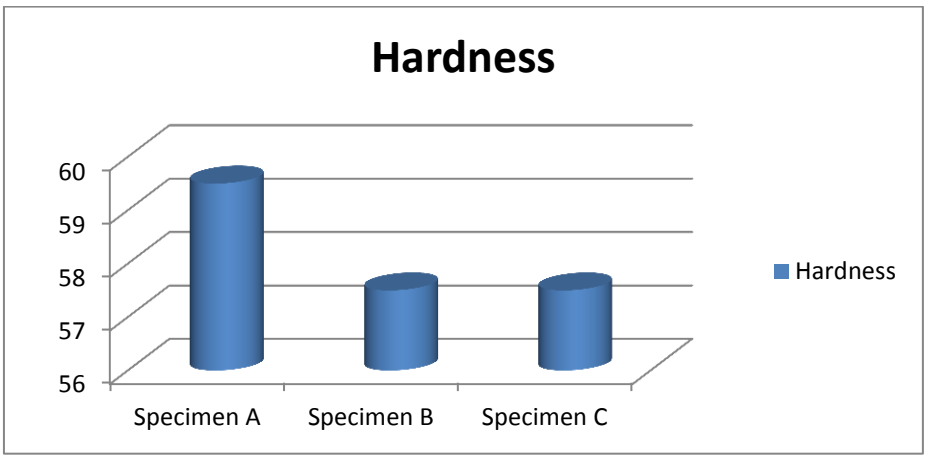
Comparison of Ultimate Load



Comparison of Ultimate Tensile Strength



Comparison of Impact Strengths



Comparison Of Hardness

From the above scenario we can see that Ultimate Load amd Ultimate Tensile Strength are higher in case of higher fiber level.

Impact strength increases with increase in both Fiber and filler material, it can be explained by the constant impact strength in the case of both B and C samples as we have increased fiber content and the increased weight is compensated by decreasing the filler content.

The basic Izod impact strength of traditional Helmet shell materials such as Polycarbonate (PC) and Acrylonitrile Butadiene Styrene are 6.41-8.54J/cm and 0.908-4.11 J/cm so it can be seen that the Impact strength of fabricated material is near to that of traditional Helmet shell materials The Shore D Hardness of these traditional materials PC and ABS are 80-90(For both materials).The cost of such fabricated material is much lesser when compared to that of traditional material.

Conclusion

In this experimentation we have tried to find out the effect of cement as the filler material and fiber in Coir fiber Epoxy composite by varying the combination of filler and fiber in the composite and found out that the Tensile strength is more dependent upon the fiber content and increases with increase in fiber content where as it is also affected by the filler content it decreases with decrease in the same but the affect of filler is less when compared to the effect of fiber content on the tensile strength.

Impact strength also increases with the increase in both filler and fiber content and decreases with the decrease of same.

Hardness of material decreases with increase in the fiber material.

It can also be observed that the Impact strengths of fabricated material is similar to that of Traditional Helmet shell material, whereas the shore-D hardness is a bit lower when compared to same. Hence further research is required to improve the properties of the material (Cement filler coir fiber reinforced epoxy composite) so that it can match the properties traditional helmet shell materials.

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