Fabrication and Investigation of Epoxy resin based Glass Fibre-Coconut Fibre Hybrid Composite Material

N.S.Mohan[1], Manjunath Shettar[2], Ritesh Bhat[3]

Abstract— Composite materials are materials made from two or more constituent materials with significantly different physical or chemical properties, that when combined, produce a material with characteristics different from the individual components. Materials made from two or more constituent materials with significantly different physical or chemical properties, that when combined, produce a material with characteristics different from the individual components are known as composite materials. Its most advanced applications are useful applications for aircrafts & spacecraft in demanding environments. A hybrid composite material consisting of coir fibres, e-glass fibres and epoxy resin was fabricated. The percentages of each material used were: 5%, 25% and 70% respectively. The coir fibre used was first treated in a sodium hydroxide solution. Three different percentages of the solution were used to treat the coir fibres: 4%, 6% and 8%. The coir fibre was immersed in the solution for a period of 4 hours. Afterwards the fibres are neutralised, washed and dried and cut; ready to be used for the fabrication of the test specimens. 3 specimens were fabricated, each containing coir fibres treated with different percentages of Sodium Hydroxide.

The specimens were tested for young's modulus, bending strength, and flexural strength and ultimate tensile strength. All properties were found to decrease when compared with a composite consisting purely of e-glass fibres and epoxy resin

Keywords— Hybrid composite material, Epoxy resin, Coir fibre, Young's modulus, Ultimate tensile strength, Water absorption.

I. Introduction

MATERIALS made from two or more constituent materials with significantly different physical or chemical properties, that when combined, produce a material with characteristics different from the individual components are known as **composite materials**.. The tensile strength of GFR-Epoxy composites with coconut coir as fillers is comparable to that of plain GFR-Epoxy composite[1]. The individual components remain separate and distinct within the finished structure. It is widely used for buildings, bridges and structures such as boat hulls, race car bodies, shower stalls, bathtubs, and storage tanks, imitation granite and cultured marble sinks and countertops [2]. Its most advanced applications are useful applications for aircrafts & spacecraft in demanding environments. In **matrix fibers**, the Matrix material surrounds and supports the reinforcement materials by maintaining their relative positions [3].

In reinforcement fibers, the reinforcements impart their special mechanical and physical properties to enhance the matrix properties. Thus, the synergism produces material properties unavailable from the individual constituent materials. **Glass fiber** composites have higher impact strength and excellent surface finish and high modulus to weight ratios compared to other fiber reinforced composite materials, and therefore extensively used in industries.[4] Because of their low specific gravity, the strength- weight ratio, and modulus-weight ratios, these composite materials are markedly superior to those of metallic materials. **Epoxy resin**, also known as polyepoxides are a class of reactive prepolymers and polymers which contain epoxide groups.. Epoxy has a wide range of applications, including metal coatings, use in electronics / electrical components, high tension electrical insulators, fiber-reinforced plastic materials, and structural adhesives etc. **Hardener** is a high viscous liquid material, mixed with resin in suitable proportion during the process of preparation of composites which helps in the solidification of the wet, smooth composite.

Coir is a natural fibre extracted from the husk of coconut fruit. The husk consists of Coir fibre and a corky tissue called pith. Natural fibres have the advantages of low density, low cost and biodegradability. However, the main disadvantages of natural fibres and matrix and the relative high moisture sorption. [5] Therefore, chemical treatments are considered in modifying the fibre surface properties).

II. Objectives And Methodology

To understand the concept of composite materials and its purpose in the modern world. For this purpose information regarding composite materials was acquired from the internet as well as from the course offered by the college. This helped in building the basic conceptual foundation of how to go about the project.

The cost of most composite materials is still relatively higher and here a filler material to compensate for the glass fiber weight was used. As coir is abundantly available and helps a lot towards cutting costs.

To prepare hybrid composite material of epoxy resin based synthetic fiber (glass fibre) with natural fibre (coir) as

N.S.Mohan[1], Professor, Department of Mechanical & Manufacturing Engineering. MIT Manipal University. Manipal-576104. E-mail: ns.mohan@manipal.edu.

Mamjunath Shettar[2], Ritesh Bhat[3], Assistant Professor, Department of Mechanical & Manufacturing Engineering. MIT Manipal University. Manipal-576104

filler by varying conc. of alkaline solution treatment. The alkaline solution treatment is done so that the resin and the coir fibres bond more effectively, if the treatment is not done the wettability is less and the fibres tend to be suspended in the resin.

A large tile of dimensions 330x330mm was made by using hand layup technique and this will further be cut into different smaller sizes according to the testing dimensions. The results from these tests will be recorded and tabulated systematically. Therefore, tests that are performed are: Impact Test, Tensile Test, Flexural Test, and Water Absorption Test. The wettability and bonding strength of natural fibres with resins, are improved by treating with different concentrations of alkaline solution (NaOH) namely 4%, 6%, and 8% by completely immersing the fibres for about 4 hours. Simple hand layup technique was used and care taken to squeeze out all the air trapped between layers. After all the layers were placed, heavy blocks were kept on top to attain the required thickness, this was kept for about 48 hours so that the reactions could complete.

III. Results And Discussion.

Fabricating a new composite material with natural fibre presence was then decided, there is abundance of natural fibres like jute, coir, hemp etc. incorporating this in a composite material will reduce the costs to an extent. The resin-fibre ratio was decided to be 2:1:1 at first , but after weighing the fibres out it was quickly evident that such a ratio was impractical because of the very light coir fibres, this would require a lot of resin to for the composite material to be completely wet and attain good strength.

A. Tensile Testing

TABLE I Tensile Test Results

Pre-load : 10 N
Speed, tensile modulus : 10 mm/min
Test speed : 10 mm/min

Test results:

Legends	Specimen	Tensile Modulus MPa	UTS MPa	ELONG @ YIELD %	THICKNESS mm	WIDTH mm
(red)	4%	339	60.1	3.1	4.97	26.33
(green)	6%	512	74.9	3.6	5.76	26.05
(blue)	8%	581	61.5	4.7	4.23	26.02

Testing Specimen size: 250mm x 25mm x 4mm (ASTM D-3039)

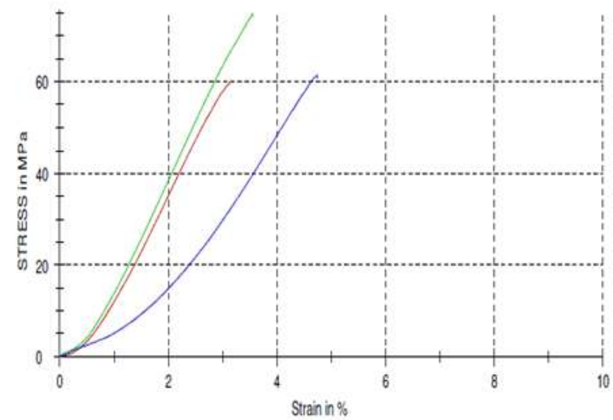

Fig 1. Tensile Test Graph

From Table 1 it can be seen that the Young's Modulus (Tensile Modulus) is the highest for the **8% treated** coir fibre specimen which had a value of 581 MPa. This means that there is a **30% reduction** in Young's Modulus when coir fibres are added. The least value was found to be for **4% treated** coir fibre specimen which had a value of 339 MPa or a **59% reduction** in Young's Modulus.

From Table 1 it can also be seen that UTS (Ultimate Tensile Strength) is highest for the **6% treated** coir fibre specimen which has a value of 74.9 MPa. This means that there is a **45% reduction** in UTS when coir fibres are added. The least value was found to be for **4% and 8% treated** coir fibre specimen both of which had a value of approximately 61 MPa or a **55% reduction** in UTS.

Because there is a significant reduction in UTS, the applications of the MCM (modified composite material) are limited. However, for every day household applications, where tensile strength is not a major factor, the MCM can replace the composite material

Fig 2 Tensile Testing Specimen

B. Impact testing:

Impact testing is done in a measurement range up to 80% of the potential energy. This is made possible by the very high ratio of instrument mass to pendulum mass. Changing between the various HIT fixtures is quick, while precision guides guarantee a continuous positive-fit to the baseplate.

Selecting impact pendulums as well as specifying the working range, which lies between 10% and 80% of potential energy, the ISO standards also stipulate that the largest appropriate impact pendulum from the series of standards must always be used for the test

TABLE III IMPACT TEST RESULTS

Nominal work capacity : 25 J
Theoretical impact velocity : 3.807 m/s

Results:

Sample	Absorbed Energy J	Impact Strength kJ/m²	Thickness mm	Width mm	Frictional Loss J
4 H-1	3.04	61.81	4.92	12.45	0.05
6 H-1	3.88	57.98	5.88	13.61	0.05
8 H-1	2.47	37.30	4.26	13.45	0.05

It can be seen from Table 3 that 4% treated coir specimen had the highest impact strength of 61.81 kJ/m^2. When compared to a GFRP which has an impact strength of 54.12 kJ/m^2, which is a 12% increase in Impact Strength. It is well known that the impact response of fibre composites is highly influenced by the interfacial bond strength, the matrix and fibre properties.

From literature review it was found that using coir fibre generally had the highest impact strength among other natural fibres. It is well known that the impact response of fibre composites is highly influenced by the interfacial bond strength, the matrix and fibre properties. Therefore it can be said that using a woven coir mat instead of randomly distributing fibres will result in a much stronger material.

C Flexural testing:

The specimens were cut from the fabricated tile to the standard size according to ASTM D7264 which is: Standard specimen thickness is 4 mm (0.16 in), standard specimen width is 13 mm (0.5 in) and standard specimen length is 20% longer than the support span. The sizes were then calculated to be 154mm x 13mm x 4mm.

TABLE IV FLEXURAL TEST RESULTS

Pre-load : 0.1 MPa
Speed, flexure modulus : 10 mm/min
Test speed : 10 mm/min

Test results:

Legends	SPECIMEN	FLEX STRENGTH MPa	L mm	THICKNESS mm	WIDTH mm
	4%	115	78	5.52	11.22
	6%	185	78	4.95	11.28
	8%	101	78	4.23	11.97

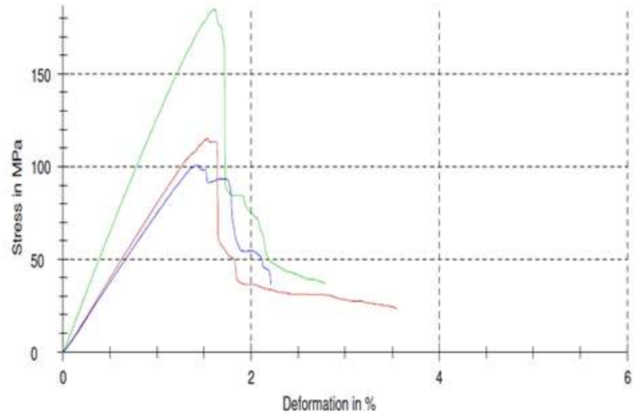

Fig 3. Flexural Test Graph

From Table 4 it can be seen that the Flexural strength is the highest for the **6% treated** coir fibre specimen which has a value of 185 MPa. This means that there is only a **1.5% reduction** in Flexural strength when coir fibres are added. The least value was found to be for **8% treated** coir fibre specimen which had a value of 101 MPa or a **46% reduction** in Flexural Strength. With reference to flexural strength, there is no significant reduction in strength. This means that wherever the composite material without coconut fiber is used, it can be replaced with the MCM [Modified Composite Material].

D. Water Absorption Test:

The specimens were weighed first and then immersed in distilled water for a period of 24 hours. After 24 hours they were removed, dried and weighed again to check for the percentage increase in weight.

TABLE VI
WATER ABSORPTION TEST DATA.

	Before	After	Percentage Increase
0%			
I	9.15	9.18	0.33
II	9.15	9.21	0.66
II	8.98	9.01	0.33
Avg. Increase			0.44
4%			
I	9.28	9.34	0.65
II	9.21	9.28	0.76
II	9.45	9.56	1.16
Avg. Increase			0.86
6%			
I	11.26	11.33	0.62
II	11.25	11.32	0.62
III	11.15	11.2	0.45
Avg. Increase			0.56
8%			
I	7.63	7.67	0.52
II	7.79	7.83	0.51
III	7.65	7.7	0.65
Avg. Increase			0.56

From Table 6 it can be seen that the water absorption is least for the **0%** specimen with a value of only **0.44%**. The lowest value could be seen in the **6% and 8%** MCM's which has a value of **0.56%**. It is evident from the data that water absorption property is very similar; there is no drastic change. Therefore once again the MCM can be a suitable replacement for composite material, where the application requires the material is required to be nonabsorbent.

IV. Conclusions

According to the results obtained for Tensile testing as seen from the graph (Fig. 1) 6% treated coir fibre specimens show the best tensile characteristics. This could be attributed to better bonding with the resin and therefore increasing strength. The Impact test results in the table 3 shows that the impact strength is highest for the 4% treated coir fibre specimens , a trend is observed in this case that as the percentage of alkali treatment of fibres increases, the impact strength decreases. From the results of the flexural test (Fig 3) it is evident that 6% treated fibres yield the best results. Once again, this could be due to the fibres bonding better with the resin. A higher percentage treatment could cause degradation to the fibres. Here a decreasing trend in strength after the 6% treated coir fibre specimens is seen i.e. a peak value is reached and then it starts decreasing. From the water absorption test, it was observed that there was no significant difference in the results for any of the specimens. This could be because in all specimens, the outer layer of the material is the epoxy resin.

References

[1] Gopinath, S, and Senthil Vadivu. "Mechnaical Behavious of Alkali Treated Fiber and Rice Husk Reinforced Epoxy Composites." International Journal of Innovative Research in Science, Engineering and Technology 3.1 (2014).

[2] Vikas Dhawan, Sehijpal Singh, and Inderdeep Singh, "Effect of Natural Fillers on Mechanical Properties of GFRP Composites," Journal of Composites, vol. 2013, Article ID 792620, 8 pages, 2013. doi:10.1155/2013/792620.

[3] Mdhukiran, J, S.Srinivasa Rao, and Madhusudan, S. "Fabrication and Testing of Natural Fiber Reinforced Hybrid Composites Banana/ Pineapple." International Journal of Modern Engineering Research 3.4 (2013).

[4] K. Natarajan, and Padma C. Balasubramanya. "Mechanical and Morphological Study of Coir Fiber Reinforced Modified Epoxy Matrix Composites." International Journal of Emerging Technology and Advanced Engineering 3.12 (2013).

[5] Inamdar, Prakash S., H. K. Shivanand, and Santosh Kumar, S. "Study on Tensile Properties of Natural Fiber Polymer Matrix Composites." International Journal of Engineering Research & Technology 2.3 (2013).