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Testing the Mechanical Behaviour of Flax/Carbon Reinforced Hybrid Composites

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ABSTRACT: This article is mainly focused on the combination of flax fiber and carbon fiber by using a matrix material epoxy resin to produce hybrid composite material. And to study the mechanical properties of flax/carbon fiber reinforced hybrid composites. Because the flax fiber is the strongest of the natural fiber and the carbon is the strongest of synthetic fiber so by combining these two fibers producing a hybrid composite and testing the mechanical behaviour of the fiber such as tensile strength, impact strength, flexural strength

KEYWORDS: Flax/Carbon hybrid composites, Mechanical properties

I. INTRODUCTION

A composite is combination of two materials in which one of the materials, called the reinforcing phase, is in the form of fibers, sheets, or particles, and is embedded in the other materials called the matrix phase. The reinforcing material and the matrix material can be metal, ceramic, or polymer. Composites typically have a fiber or particle phase that is stiffer and stronger than the continuous matrix phase and serve as the principal load carrying members. The matrix acts as a load transfer medium between fibers, and in less ideal cases where the loads are complex, the matrix may even have to bear loads transverse to the fiber axis. The matrix is more ductile than the fibers and thus acts as a source of composite toughness. The matrix also serves to protect the fibers from environmental damage before, during and after composite processing.

The physical properties of composite materials are generally not isotropic (independent of direction of applied force) in nature, but rather are typically anisotropic (different depending on the direction of the applied force or load). A recently developed concept of composite is that the composite should not only be a combination of two materials, but the combination should have its own distinctive properties. In terms of strength, heat resistance, or some other desired characteristic, the composite must be better than either component alone.

II. LITERATURE REVIEW

S.M. Sapuan et al. (2012)

Mechanical properties of woven banana fibre reinforced epoxy composites” were carried out the experiments of tensile and flexural (three-point bending) tests using natural fibre with composite materials (Musaceae/epoxy). it was found that the maximum value of stress in x-direction is 14.14 MN/m², meanwhile the maximum value of stress in y-direction is 3.398 MN/m². For the Young's modulus, the value of 0.976 GN/m² in x-direction and 0.863 GN/m² in y-direction were computed. As for the case of three-point bending (flexural), the maximum load applied is 36.25 N to get the

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Vol. 8, Issue 3, March 2019

deflection of woven banana fibre specimen beam of 0.5 mm. The maximum stress and Young's modulus in x-direction was recorded to be 26.181 MN/m² and 2.685 GN/m², respectively. Statistical analysis using ANOVA-one way has showed that the differences of results obtained from those three samples are not significant, which confirm a very stable mechanical behaviour of the composites under different tests.

Z.N. Azwa et al. (2013)

This paper evaluates the characteristics of several natural fibre composites exposed to moisture, thermal, fire, and ultraviolet degradation through an extensive literature review. The effects of chemical additives such as fibre treatments, fire retardants and Ultraviolet (UV) stabilizers are also addressed. Based on the evaluation conducted, optimum fibre content provides strength in a polymer composite but it also becomes an entry point for moisture attack. They concluded that an optimum blend ratio of chemical additives must be employed to achieve a balance between strength and durability requirements for natural fibre composites.

Thi-Thu-Loan Doan et al. (2012)

In this work, natural fibers such as carbon and flax fiber and rice husk are selected as reinforced in epoxy. Brown carbon and flax fibers and rice husk are treated with 6% of NaOH separately to increase the fiber strength and the treated natural fibers are reinforced in epoxy matrix to fabricate the composite. The ratio in which the carbon and flax fiber and rice husk are mixed is varied and the tensile behavior of composites made from various combination ratios are analyzed.

D. Verma et al. (2013)

Made a review among the various natural fibres such as, sisal fibres, bamboo fibres, carbon and flax fibres and jute fibres are of particular interest as these composites have high impact strength besides having moderate tensile and flexural properties compared to other lignocellulosic fibres.

III. PREPARATION OF SAMPLES

For carrying out this work, the flax fibre and the carbon fiber has been chosen for preparing hybrid composite structure. Epoxy resin has been selected as matrix materials. The mechanical properties of the selected fibers and resin materials have been tabulated below in table 3.1.

S.No.	Properties	Flax Fiber	Carbon Fiber	Epoxy Resin
1.	Young's Modulus (GPa)	60	230	3
2.	Poisson's Ratio	0.4	0.3	0.4

Table 3.1: Mechanical properties of fiber and matrix materials

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Vol. 8, Issue 3, March 2019

Composite material fabrication can be broadly classified into following categories:

- Hand lay up
- Vacuum bag moulding
- Compression moulding
- Pressure bag moulding

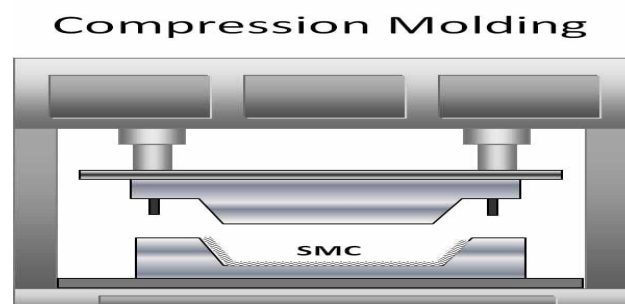


Figure:3.2 compression moulding

Composites are formed by placing fibers impregnated in resin on to female mould and applying pressure using a male mould to eliminate any excess resin from the ACM compression moulding is useful for fabrication such as boat hulls. In this project compression moulding process is used for fabrication of composite. The size of the composite sheet that is to be fabricated is 300*150*5 the materials used for fabrication are:

- Die- 300*150*5
- Epoxy LY556& hardener HY951
- Flax fiber
- Carbon fiber

The die is used to fabricate the composite in the cross section of 300*150*5. Initially the grease is applied over the female die. After that OHB sheet is placed over it. The hardener grade 951 will be added to the epoxy resin. Which is used to increase the hardness of the epoxy resin.

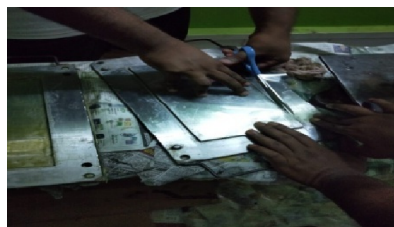


Figure: 3.3 preparation of die

The flax fiber and carbon fiber is cut in dimension of 300*150mm the epoxy resin is mixed in the ratio of 10:1 and stirred slowly in order to avoid air bubbles. The various layers are used for making the specimen First the resin is equally poured on the die and carbon fiber will be placed above the die with correct dimension. Again the resin is equally distributed over the fiber. After that the specimen is allow them to dry for 24 hours in compression moulding. It gets the single layer of the composite specimen. The cycle is repeated to obtained the required layers of composites.

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Vol. 8, Issue 3, March 2019

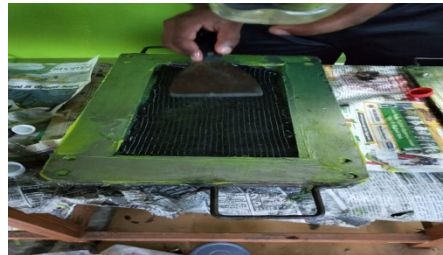


Figure: 3.4 layer formation



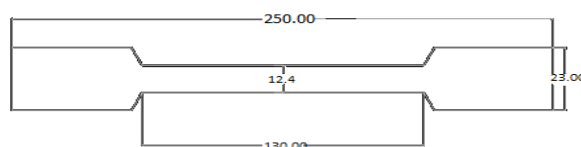
Figure:3.5 fabricated material

And thus fabrication is completed by means of compression moulding. The finished specimen is used to under go the strength analysis for analysing its mechanical behaviour such as tensile strength, flexural strength, impact strength and water absorption.

IV. EXPERIMENTAL ANALYSIS

Mechanical properties like ultimate compressive strength, ultimate tensile strength, impact strength, hardness, flexural strength and water absorption test will be evaluated.

Tensile test: Tensile testing, also known as tension testing, is a fundamental materials science and engineering test in which a sample is subjected to a controlled tension until failure. Properties that are directly measured via a tensile test are ultimate tensile strength, breaking strength, maximum elongation and reduction in area.



all dimensions are in mm

Figure 5.1: Tensile ASTM A378

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Vol. 8, Issue 3, March 2019

Samples	Ultimate Load (N)	Max Displacement (mm)	Ultimate Stress (Mpa)
1 Flax	1290	1.50	18.510
2 Flax	2990	2.03	36.986
3 Flax	4760	3.70	48.912
1Flax/1Carbon	5300	2.80	67.800
2Flax/2Carbon	5870	5.17	61.439

Table 5.1: Tensile strength result

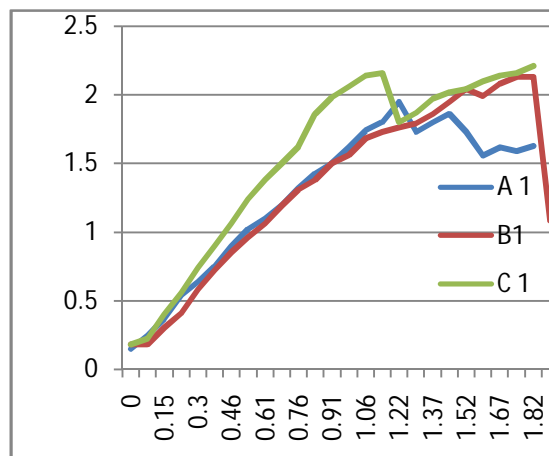


Figure 5.2: Load vs displacement curve single layer

The above chart shows the effect of reinforcements on UTS of the Fibers reinforced composites as can clearly see the increase in the ultimate tensile strength in single layer carbon fiber composite. A1,B1,C1 are the single flax and carbon layer samples which are tested under the different load. The graph is plotted between load vs elongation of specimen i.e .displacement.

Impact test:

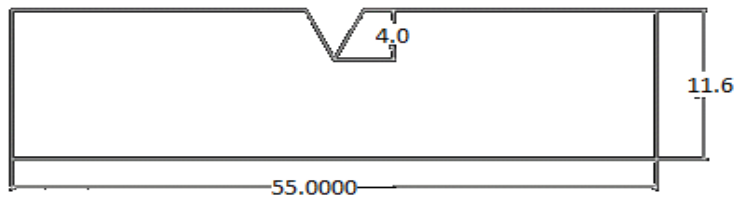
The apparatus consists of a pendulum of known mass and length that is dropped from a known height to impact a notched specimen of material. The energy transferred to the material can be inferred by comparing the difference in the height of the hammer before and after the fracture.

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Visit: www.ijirset.com

Vol. 8, Issue 3, March 2019

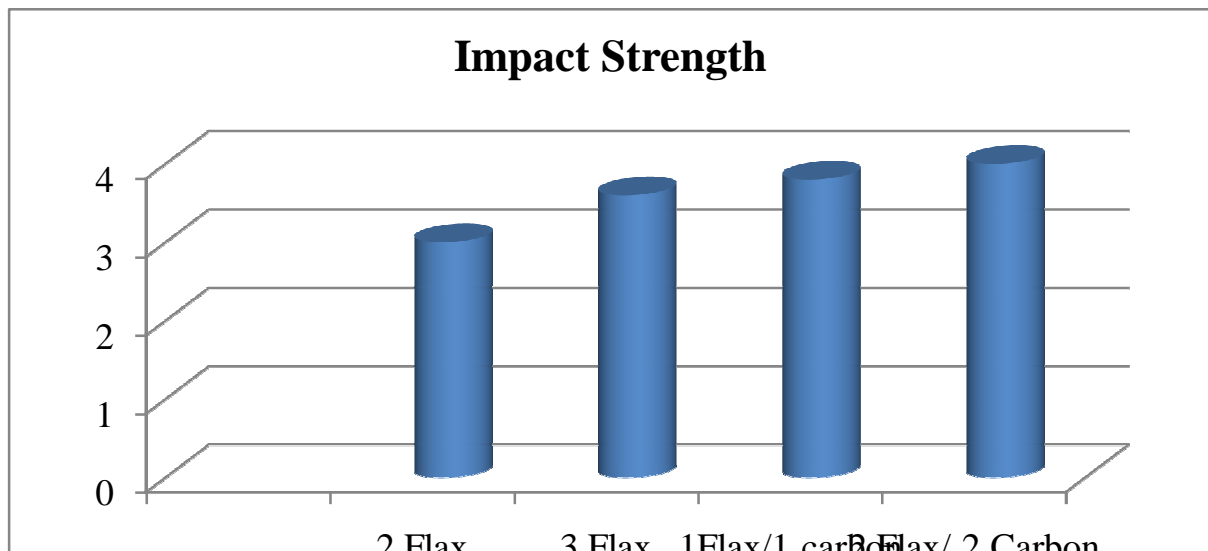


all dimensions are in mm

Figure 5.3: Impact test ASTM standard

S.No	Material	Behaviour	Energy Absorbed by Material	Impact Strength(J/mm ²)
1	2 Flax	Broken	2	3.63×10^{-3}
2	3 Flax	Broken	3.6	6.54×10^{-3}
3	1 Flax/ 1 Carbon	Broken	3.8	6.9×10^{-3}
4	2 Flax / 2Carbon	Broken	4	7.27×10^{-3}

Table 5.2: Impact test result



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Vol. 8, Issue 3, March 2019

Flexural strength:

Flexural strength, also known as modulus of rupture, bend strength, or fracture strength a mechanical parameter for brittle material, is defined as a material's ability to resist deformation under load. The transverse bending test is most frequently employed, in which a rod specimen having either a circular or rectangular cross section is bent until fracture using a three point flexural test technique.

Samples	Ultimate Load (N)	Max Displacement (mm)	Compressive Strength (Mpa)
1 Flax	90.0	10.81	2.296
2 Flax	180.0	9.25	2.583
3 Flax	180.0	10.51	2.946
1Flax/1Carbon	360.0	13.38	4.424
2Flax/2Carbon	210.0	6.32	3.9

Table 5.3: Flexural test result

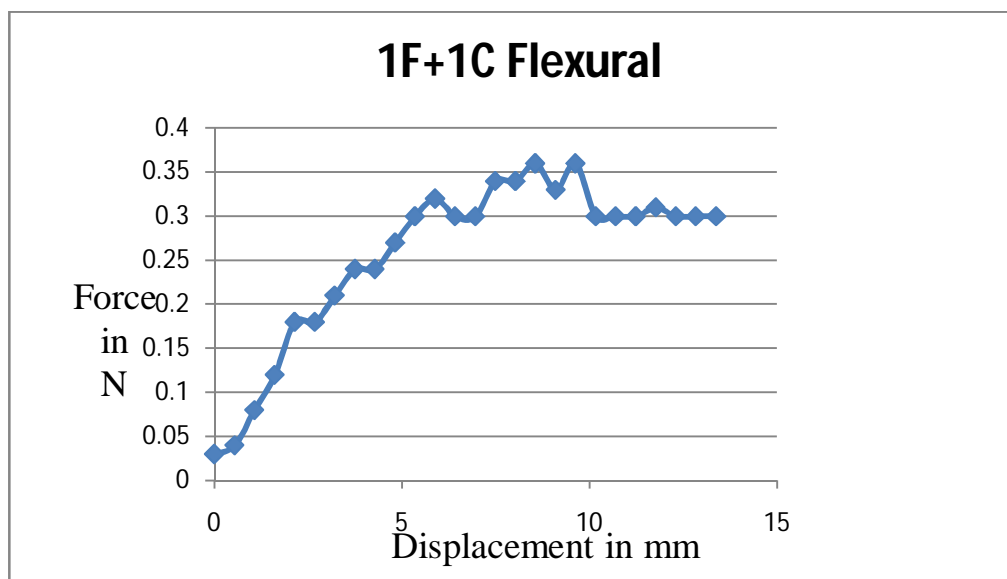


Figure 5.3: Load vs displacement curve

The graph was drawn between the load and displacement. From the above graph the load increases the flexural strength decreases. The above graph is the single layered flax/carbon fiber sample which is tested.

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Vol. 8, Issue 3, March 2019

V. CONCLUSION

By comparing Tensile stress Results of Experimental Analysis and numerical analysis. From the test results of carbon fiber composites based on mechanical tests conducted a conclusion is reached from the study. All the result are compared to various proposition of flax and carbon fiber to increase the strength. From the study it's concluded that the composites used in aerospace and aeronautical applications abundant and highly reliable. Flax/carbon fiber composite material result of tensile strength [67MPa] is increase with increase of carbon fiber layer .

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