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To Prepare and Compare the Mechanical Characteristics on Various Glass Fiber Reinforced Laminates

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ABSTRACT : *GFRP composites are generally produced by various manufacturing process, such as RTM , hand layup , vacuum bag moulding methods which provide the scope to producing components of expect geometric shape and with close dimensional tolerences as per industrial applications. The present work in this paper fabricate and investigate to evaluate the mechanical characteristics on different types of GFRP composite laminate plates . In this view specimens are prepared in the laboratory to varying the volume fraction and fabricated by compression moulding process of different bi-woven roved polyester glass fiber reinforced plastic, Uni- Directional glass fiber reinforced plastic and Chopped strand glass fiber reinforced plastic laminate plates of same sizes. The specimens are prepared for testing as per ASTM standards to estimate the mechanical characteristics . The tests are conducted on UTM machine . The investigation is carried out as per the ASTM D790 standards and ASTM D 638 standards. The graphs that are obtained from the tests are documented , Finally is to determine the best FRP composite from the two test pieces by comparing the tensile strength, flexural strength and . The results are good for application of boat hulls, wind turbine blades, automobile and aerospace applications.*

Keywords: Glass *Fiber reinforced plastic, hand layup compression moulding technique, tensile strength, flexural strength, hardness test, impact strength.*

I. INTRODUCTION

A composite is a structural material that consists of two or more combined constituents that are combined at a macroscopic level and are not soluble in each other. One constituent is called the reinforcing phase and the one in which it is embedded is called the matrix. The reinforcing phase material may be in the form of fibers, particles, or flakes. The matrix phase materials are generally continuous. Each of the various components retains its identity in the composite and maintains its characteristic structure and properties. The duty of reinforcements is attaining strength of the composite and the matrix has the responsibility of bonding of the reinforcements. There are recognizable interface between the materials of matrix and reinforcements. The composite materials, however, generally possess combination of properties such as stiffness, strength, weight, high temperature performance, corrosion resistance, hardness and conductivity which are not possible with the individual components. Composite materials are not homogeneous. Their properties are dependent on many factors, the most important of which are the type of fiber, quantity of fiber (as volume fraction) and the configuration of the reinforcement. They are generally completely elastic up to failure and exhibit neither a yield point nor a region of plasticity. The properties of composites are dependent on the properties of the fiber and the matrix, the proportion of each and the configuration of the fibers. If all the fibers are aligned in one direction then the composite relatively stiff and strong in that direction, but in the transverse direction it has low modulus and low strength. When a unidirectional composite is tested at a small angle from the fiber axis, there is a considerable reduction in strength. A similar but less significant effect occurs with the tensile modulus.

II. LITERATURE REVIEW

FRP composites can be simply described as multi-constituent materials that consist of reinforcing fibers embedded in a rigid polymer matrix. The fibers used in FRP materials [3] can be in the form of small particles, whiskers or continuous filaments. Most composites used in engineering applications contain fibers made of glass, carbon or aramid. Jane Maria Faulstich de Paiva [4] investigated a mechanical (flexural, shear,

tensile and compressive tests) and morphological characterizations of four different laminates based on 2 epoxy resin systems (8552TM and F584TM) The results show that the F584-epoxy matrix laminates present better mechanical properties in the tensile and compressive tests than 8552 composites . Roberto J. Cano and Marvin B. Dow [5] In this study, the unidirectional laminate strengths and modeling , notched (open-hole) and unnotched tension and Compression properties of quasi-isotropic laminates, and compression after- impact strengths of five carbon fiber/toughened matrix composites, IMT/E7T1-2, IMT/X1845, G40-800X/5255-3, IM7/5255-3, and 1M7/5260, have been evaluated. This investigation found that all five materials were stronger and more impact damage tolerant than more brittle carbon/epoxy composite materials currently used in aircraft structures. José Ricardo Tarpani [6] Quasi-static tensile
properties of four aeronautical grade carbon-epoxy composite laminates, in both the as-received and pre fatigued
States have been determined and compared. The materials also displayed a significant tenacification (toughening) after exposed to cyclic loading, resulting from the increased stress (the so-called wear-I phenomenon) and/or strain at the maximum load capacity of the specimens. With no exceptions, two dimensional woven textile (fabric) pre-forms fractured catastrophically under identical cyclic loading conditions imposed to the fiber tape architecture, thus
Preventing their residual properties from being determined.

III. PREPARATION OF COMPOSITE LAMINATE BY COMPRESSION MOULDING TECHNIQUE:

In this work the composite laminate is prepared using compression moulding technique. The mould is manufactured by procuring of EN8 material in the form of square plates of sizes 30X30X8 and rectangular billet of size 28X28X10.The mould is made to attain a desired shape by welding all the pieces. The chopped strand, uni-directional and bi-woven fabrics, are available in the standard form of 450 GSM, 610GSM and 850 GSM. The volume fractions for various GFRP laminates are : The chopped strand GFRP matrix and fiber 30:70, uni-directional GFRP is 30:70 and bi-woven fabrics GFRP is 30:70 Volume fraction was found out from burning test. Initially the glass fiber is to be cut in required shape of the size 30 × 30 cm of required orientation. Two plies of positive orientation (anti-clockwise) and other two in negative orientation (clockwise) are to be prepared. A thin plastic sheet is used at the top and bottom of the mould in order get good surface finish for the laminate. The mould has to be cleaned well after that PVA (Poly Vinyl Acetate) is applied in order to avoid sticking of the laminate to the mould after curing of the laminate. . These are stacked layer by layer of about 4 layers to attain the thickness around 8 mm as per the ASTM D 3039 Standard Specimen. Bonding agent (polyester resin) is applied to create bonding between 4 layers of sheet Sufficient amount of resin which is prepared beforehand (hardener of quantity 10% of the resin is to be mixed with the resin and get stirred well) is poured over the ply. The resin poured in to the mould uniformly and it is rolled in order to get the required bonding [4] using a rolling device. Enough care should be taken to avoid the air bubbles formed during rolling. Then on this ply, other ply of negative orientation (clock wise) is placed, after this, other two plies are placed and rolling is done. After the rolling of all plies, the covering sheet (plastic sheet) is placed and the mould is closed with the upper plate. The compression is applied on the fiber- resin mixture by tightening the two mould plates uniformly. Enough care should be taken to provide uniform pressure on compression is applied the laminate while fixing plates. After enough curing time (7-10 hrs) the laminate is removed from the mould plates carefully Mold release agent is applied to Mylar sheet of 75 micron.

3.1: TO PREPARATION OF GFRP LAMINATE PLATES

The mould is manufactured by procuring of EN8 material in the form of square plates of sizes 30X30X10 and rectangular billet of size 29X29X12.The mould is made to attain a desired shape by welding all the pieces.

Fig 1.1: The mould

Fig 1.2:The preparation of Gfrp laminate

Step-1 Cutting Of Fiber into Required Shape, **Step-2** Placing Of Mylar Film In The Mould
Step-3 Coating of Matrix on Film, **Step-4** Stacking Of Fibers, **Step-5 C**uring Of Stacked,
Step-6 Removal of Composite from Mould

IV. ANALYSIS ON MECHANICAL PROPERTIES OF DIFFERENT GFRP COMPOSITE SPECIMENS:

After preparing the laminate, in order to find the ultimate tensile strength and deflection tests of the composite laminate on UTM machine.and the specimen is prepared using ASTM standards ASTM D638-03 and ASTM D790. The specimen is prepared in dog-bone shape which has a gauge length of 150 mm. The test conducted for the samples of unidirectional, chopped strand and woven roved type of glass fiber reinforced composites and corresponding graph is plotted. The fabricated specimen for tensile test is presented in the fig. The tests are repeated at least 3-5 times and the averages values are used for the discussion .The specimens prepared are now tested on the UTM machine and the ultimate tensile strength of the each specimen is determined. As there is a difference in their orientation, each specimen exhibits a definite behavior during failure.

4.1. TENSILE TEST

The composite is sized to the required dimension using a saw cutter. The standard used is ASTM D638-03 the gauge length and cross head speeds are chosen according to the standard. The test is carried out in Universal Testing Machine (UTM) make FIE (Model: UTN 40, SNo, 11/98-2450) at room temperature conditions (303K) and at a speed of 2mm/min.The test involves application of tension in the work piece until it fracture. The tensile stress recorded according to strain. The test conducted for the samples of unidirectional, chopped strand and woven roved type of glass fiber reinforced composites and corresponding graph is plotted. The fabricated specimen for tensile test is presented in the fig. The tests are repeated at least 3-5 times and the average values are used for the discussion.

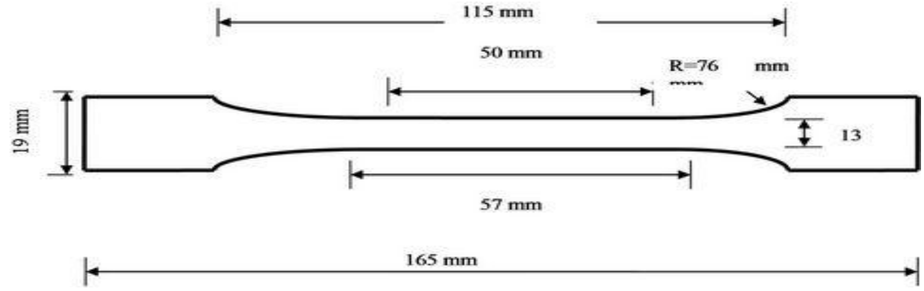
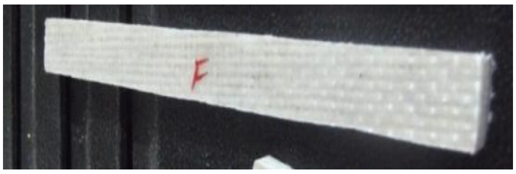


Fig 2.1: Tensile test specimens

Fig 2.2: Tensile test Rig

4.2. FLEXURAL TEST



Length = 119.5mm, width = 12mm, thick = 5mm

Fig 3.1: Flexural test specimens

Three point flexural tests is the most common test carried for composite materials. The standard used for flexural test is ASTM D790.The Universal Testing Machine is used to carry out the Flexural test. Flexural test determines the maximum stress induced in the outermost fiber. Testing is carried out at room temperature at 40% relative humidity. In this test specimen is subjected to load at its midway between the supports until it fractures and breaks. This test corresponds to the behavior of specimen as like a simply supported beam. The specimen used for flexural test is presented. The tests are repeated at least 3-5 times and the average values are used for the discussion.

Fig 3.2: Flexural test specimens

Fig 3.2: Tensile test Rig

4.3. HARDNESS TEST

The hardness test is conducted on the samples with a specimen size of 5X5cm on a Rockwell hardness machine .This test is conducted using diamond indenter with black scale as reference. The test was conducted using Rockwell L- scale, which is especially for plastic materials, bakelite and vulcanized rubber. The indenter chosen is of steel ball of 1/4th inch diameter. A load of 60 kg was used for the test. The test involves selection of proper scale as per the material and then placing the specimen on the table, unloading and loading of the machine using lever to make indentation on the specimen to determine the hardness.

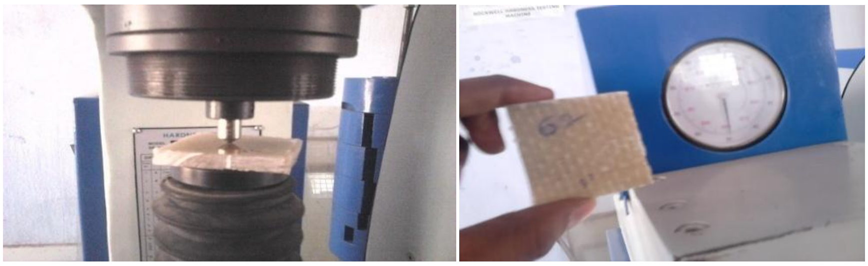


Fig 4.1: Hardness test Rig

4.4. IMPACT TEST

In this test, the impact behavior of different coal ash reinforced polymer composites is presented. The Impact test was carried out on Izod Impact testing machine, as per the ASTM standards. The test specimens are prepared as per ASTM D256 (64X12X4) mm. The six specimens were subjected to Impact test and their values were reported. Standard test method, ASTM D256, for impact properties of glass fiber reinforced polymer matrix composite has been used to test composite test specimen. The specimens are prepared to the dimensions of (64x12x4) mm with a V- notch

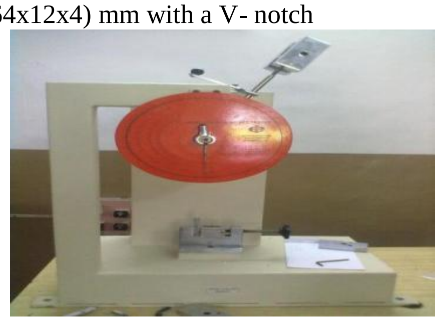


Fig 5.1: Izod Impact testing machine

Fig 5.2: Specimens after Impact Test

V.RESULTS AND DISCUSSION

TENSILE TEST:

NAME OF THESAMPLE	Thickness (in mm)	Ultimate Tensile load (in KN)	Ultimate Tensile Strength(N/mm2)
1.Bi-directional	6.89	24.080	263.775
2.Bi-directional	6.79	26.120	284.315
3.Bi-directional	6.93	24.920	275.329
4. Chopped Strand	7.24	3.080	31.535
5.Choaped Strand	7.05	2.680	28.829
6. Chopped Strand	7.2	2.680	28.113
7. Uni-directional	5.62	8.480	115.092
8. Uni-directional	5.55	8.240	113.765
9. Uni-directional	5.88	8.560	108.726

Table 1.1: Tensile Test Results

FLEXURAL TEST RESULTS:

	SPECIMEN NAME	FORCE (KG)	DEFLECTION (mm)	M (KG/mm)	Flexural Strength (Kg/mm.mm)
1	UNIDIRECTIONAL	0.6982288	0.01	94.3	3530.67
2	UNIDIRECTIONAL	0.6836803	0.07	90.9	400.08
3	UNIDIRECTIONAL	0.91835897	0.03	97.6	1391.44
4	CHOPPED STRAND	0.5049578	0.01	34.6	1379.72
5	CHOPPED STRAND	0.3711438	0.01	36.1	529.6
6	CHOPPED STRAND	0.6868170	0.01	65.6	1159.02
7	BI-DIRECTIONAL	0.93033279	0.01	104.9	1713.83
8	BI-DIRECTIONAL	0.441598	0.01	67.1	1390
9	BI-DIRECTIONAL	1.87081	0.01	264.5	6568.5

Table 1.2: Flexural Test Results

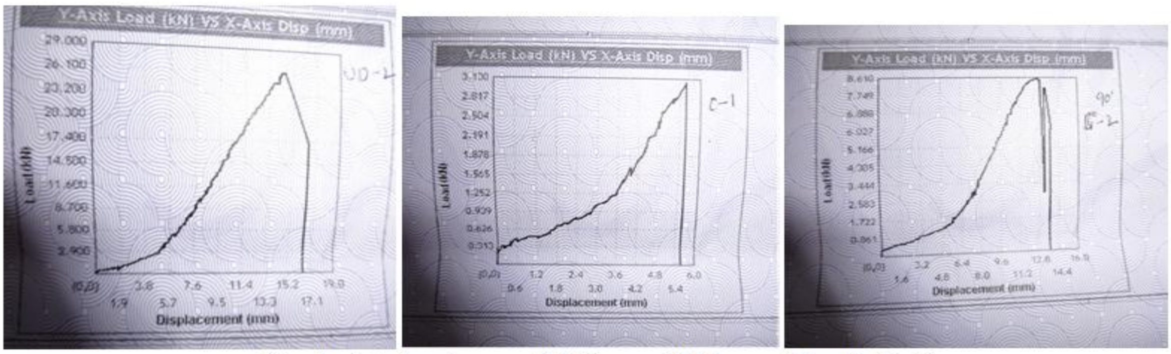
SAMPLE NAME	TEST TRIALS			AVERAGE ROCKWELL HARDNESS NUMBER
	I	II	III	Average
.Uni-directional	42	44	59	48.34
Chopped Strand	80	82	72	78
Bi-directional	80	72	59	72
Mixed	63	67	75	68.33

Impact strength of various GFRP laminates:

Types of GFRP laminates	Impact strength in(J/mm^2)
CHOPPED STRAND	0.156
UNI-DIRECTIONAL	0.172
BI-DIRECTIONAL (+90^0,-90^0)	0.165

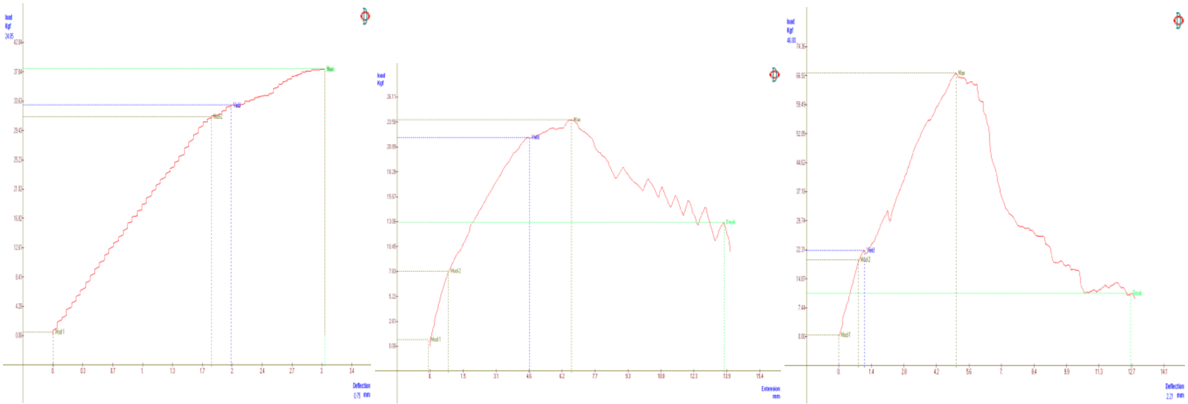
Table 1.3: Flexural Test Results

TENSILE TEST GRAPHS:



Graph: 1.1: Specimens of 6.79 mm Thickness (Tensile Test)

FLEXURAL TEST GRAPHS:



Graph1.2: Specimens of 6.79 mm Thickness (Flexural test)

VI. CONCLUSION

1. From the obtained graphs we can observe that the bi directional laminate has more ultimate load and tensile strength that the remaining samples.
   2.We can observe from the obtained graphs that the load withstanding capacity is more for bi– directional laminate than others types .
3. The deflection is maximum in case of uni-directional laminate than other types.
4. From the table of hardness test we can observe that chopped strand is more harder than other types
5. Experimental investigation on tensile, flexural, hardness and impact behavior of GFRP composites with 30 percentages of chopped, unidirectional and bidirectional laminates have been carried out in the present research work. The conclusions drawn from the graphs and values are, the maximum tensile strength is obtained for
6. The tensile strength and flexural is found to be more in case of bi-directional (0^0-90^0) when compared to uni -directional and chopped strand composites laminates
   7. The uni -directional composite is found to exhibit maximum deflection whereas chopped strand composite is found to be the hardest one among the others
   8. The impact strength is slightly more in unidirectional GFRP composites among the others.

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