Experimental Study of Mechanical Properties of Glass and Carbon Fibers

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Abstract— This article shows the investigation details of the glass fiber and carbon fiber it mainly deals moderate strength. the properties of these composites are tested by conducting experiments on tensile and compression on universal testing machine and impact on izod impact machine. Lightweight, excellent corrosion characteristics and rapid installation capabilities created tremendous opportunities for these composite panels in automobile industries.

Key words: Fiber-reinforced polymer, Glass fiber, synthetic, Composite Panels

I. INTRODUCTION

International researcher's efforts are frequently trying to invent construction materials with good and efficient properties. In this research work the scientists are trying to get better the properties of material and there efficient utilization in various fields like in civil engineering and transportation. But due to the introduction of new materials with better properties, it makes a challenge to the engineers to utilize the properties of materials in perfect field. In the fields like construction of aerospace, marine, architectural and transportation industry many types of pack in panels are being utilized over the past years. These merged panels are being used in the industry because of the properties like lightweight, good corrosion characteristics and fast installation capabilities. This form of pack in panels makes the user to utilize the each and every properties of every material up to its limit. It also offers very high stiffness to weight ratio. These materials can be utilized as the single material for structural system, without any aid of other materials, so it increases flexural rigidity of structure. The structural models with merged materials are having excellent acoustical, fatigue potency and thermal insulation.

II. MATERIAL SELECTION FOR COMPOSITE STRUCTURES

There are two major considerations that one has to look into before selecting a material that can be used in a composite construction. These are as follows

A. Structural Considerations

1) Strength:

There are some cores and facing materials that are directional with regard to mechanical properties and care must be taken to ensure that the materials are oriented in the panel to take the best advantage of this attribute.

2) Stiffness:

Sandwich structures are frequently used to maximize stiffness at very low weights. Because of the relatively low shear modulus of most core materials, however, the deflection calculations must allow for shear deflection of the structure in addition to the bending deflections usually considered.

3) Longevity:

Various studies have shown that the strength of various GFRPs do not reduce much over a period of time as compared to other materials like steel. The chart shown below depicts the behaviour of various materials over the years.

III. COMPOSITES & FIBERS

A. Glass Fiber Introduction

This paragraph provides an overview on different types of polymer matrix, fiber configuration, mechanical properties of this material and their contribution in composites manufactured from them. A brief insight is provided on different fabrication methods such as hand lay-up compression moulding, protrusion etc. used in this study for composite manufacturing. Additionally, coupon sample preparation is described for tension test, bending test etc. More than one phase blended together IS generally a composite material. A composite in which one of the fillers is glass fiber than the composite is the glass fiber composite. Mixture of various materials like polymer, metal, glass or ceramic is a matrix. The high strength and modulus of glass fiber makes them useful as reinforcement for polymer, metals, and glass and ceramic even though they are brittle. In composites, matrix acts as a biding agent and protects the fiber while transferring any applied load as shown in fig 3.1

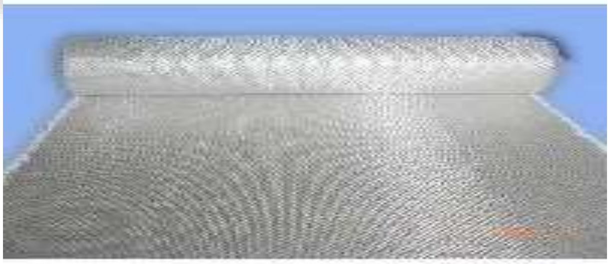

Fig. 3.1: Woven Roved Glass Fiber Sheet

B. Carbon Fiber Introduction

The newest form of high potency material is the carbon fibers as shown in figure 3.2. It consists of 90% carbon which is gained by the pyrolysis of appropriate fibers. In the beginning of 1879 scientist Edison brought out patent which showed the existence of carbon fibers by producing the carbon filaments by using in electric lamps. But in the early days of 1960 continuous production was started but on the requirement of the industries like aerospace like military aircrafts. But now days these have huge application in various other areas such as the aerospace, civilian aircraft, transportation field. The members of Advanced Composites Materials Association unrestricted the statistics of industries in 1997. But, there was slow down into his demand of carbon fibers between 1997 to 1999. Almost 11 million lb. of carbon fiber is consumed for sporting goods stated by the Mitsubishi Rayon ltd Japan. At present, almost 60% of world manufacturing carbon fiber is utilized by the United States of America. The Japanese produce almost 50% of world production. Toray Industries of Japan is the largest producer of the carbon fiber. The largest production is made by the Japan companies.

Fig. 3.2: Woven Roved Carbon Fiber

IV. What are Carbon Fibers & How They Are Produced?

Carbon fiber, alternatively graphite fiber, carbon graphite or CF, is a material consisting of fibers about 5–10 μm in diameter and composed mostly of carbon atoms. Crystals formed are due to bonding of carbon atoms, but these are not so perfectly aligned comparable with the fiber axis. The fiber has high strength to volume ratio and is strong comparable to it size due to the crystal alignment.

Poly (acrylonitrile) is type of polymers which have carbon connected to each other in the form of chain. These polymers are stretched to align parallel with the fiber axis. Than between 200 to 300 degree Celsius in air oxidation treatment is given to convert the polymer in to non-melt-able precursor fiber. Then in nitrogen atmosphere this precursor fiber is heated. The volatile products are let off due to the increase in temperature, this carried out till the carbon fiber is composed of minimum of 92% carbon. Depending upon the required property of carbon fiber the temperature is set to treat the fibers usually between 1000 degree Celsius and 2500 degree Celsius.

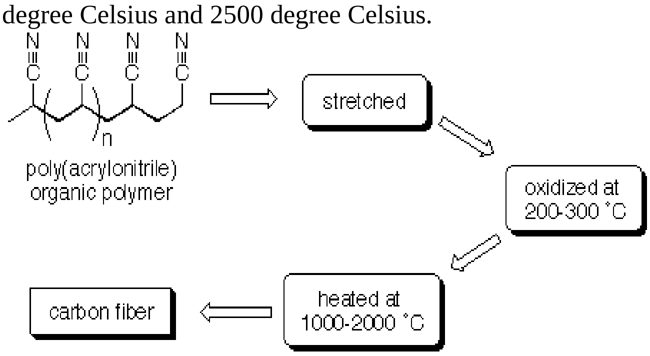

Fig. 4.1: Schematic Showing the Process for Making Carbon Fiber

V. Literature Survey

S.Kocaoza et al; The characterization of fiber reinforced polymer (FRP) bars for concrete reinforcement is necessary for design purposes as required by structural engineers, and for quality control/optimization purposes as required by bar manufacturers. The advantageous properties of fiber reinforced polymer (FRP) such as high strength-to-weight ratio, and corrosion and fatigue resistance create an interest in engineers. Tibor Czigany(2004); Short fiber reinforced polypropylene hybrid composites were investigated to determine their mechanical properties in case of reinforcing fiber types and also he investigated the fatigue failure modes of fiber/elastomer composites were observed and a new principal failure mechanism was used to design new materials with sufficient longevity for bearing applications.

G.Kalaprasad and Sabu Thomas; this paper provides an insight into the mechanical properties and failure behaviour of hybrid fiber reinforced polymer composites. There are indications that the reinforcement of two types of fibres into a single matrix often leads to better properties that would be expected from the consideration of the rule of mixtures The recent developments in hybrid fibre reinforced polymer composites have been discussed These include the properties of synthetic fibre. The effect of orientation of the fibres an tensile strength was also studied. It was found that the composites containing longitudinally oriented fibres exhibit better tensile properties than those with randomly oriented ones. Hughes Brothers Carbon Fiber Reinforced Polymer (CFRP) Laminates are used to structurally strengthen existing concrete, wood, or masonry members in flexure and shear. The Aslan 400 CFRP Laminate is a pre-cured plate with a surface texture on one face, which helps improve bond with the structural adhesives. Structures that are deficient due to either a structural flaw, deterioration or because of a change in use can often be brought to a useful capacity using Aslan 400. Externally bonded FRP strengthening is analogous to steel plate bonding. Successful implementation of CFRP plate bonding is dependent on proper surface preparation, leveling and bond of the structural adhesive to the concrete and CFRP plate interfaces. Externally bonded CFRP Laminates work best in overhead applications for flexural strengthening where sufficient bond and development lengths can be achieved.

M. Grujicic et al ; The ability of light-weight all fiber-reinforced polymer-matrix composite armor and hybrid composite-based armor hard-faced with ceramic tiles to withstand the impact of non-Armor- Piercing (non AP) and AP (Armor Piercing) projectiles by using a transient non-linear dynamics computational analysis. The results obtained confirm experimental findings that the all-composite armor, while being able to successfully defeat non-AP threats, provides very little protection against AP projectiles. Lei, Charles the concepts of geometric hybrids and material hybrids for sic/Al composites. In this study tensile, notched beam 3-point bending and compact tension tests were conducted in order to study the hybrid effect on 3-d braided composites.

VI. Methodology

The methodology of the present work divided into three phases and is set as under:

A. *Methodology of the Work*

1) *Phase I: Formulation of Test Scheme and Preparation of Specimens*

- To formulate Experimental compression analysis tests under different loading conditions.

- Preparation of composite specimens with two different fibers such as glass and Carbon with Different thick using Hand layup technique.

2) Phase II: Experimentation on Tensile, Compression Impact and Wear Characteristics of this Composite Panel

- Evaluate Tensile, Compression Impact and Wear parameters of composite panels of different fibers by varying load under different boundary conditions.

3) Phase III: Results and Analysis

- Analysis of the experimental results such as tensile strength, compressive strength and impact strength.

VII. RESULTS & DISCUSSIONS

A. Results

1) Tensile Test

Tensile properties indicate how the material will react to forces being applied in tension. A tensile test is a fundamental mechanical test where a carefully prepared specimen is loaded in a very controlled manner while measuring the applied load and the elongation of the specimen over some distance. Tensile tests are used to determine the modulus of elasticity, elastic limit, elongation and reduction in area, tensile strength, yield point, yield strength and other tensile properties. The main aim of the tensile test is to determine the elastic modulus of the composited material of glass & carbon fiber as shown in figure

Fig. 7.1: Glass & Carbon fiber specimen used for tensile testing

2) Tensile Test Results

Sl no.	Composites	Ultimate Load kg	Tensile strength N/mm^2	Load at yield N
1	Glass /Epoxy	301.85	73.114	1880.67
2	Carbon /Epoxy	69.34	24.916	240.05

Table 1: Tensile Test Results

Sl no.	Composites	Yield Stress N/mm2	%Elongation	%Reduction
1	Glass /Epoxy	46.40	4.86%	18.51%
2	Carbon /Epoxy	8.75	3.85%	8.54%

Table 2: Tensile Test Results

B. Compression Test

Sl No.	Composites	Ultimate Load kN	Compressive strength N/mm^2	Displacement at Ultimate Load, mm
1	Glass /Epoxy	2.52	2.191	1.2
2	Carbon/Epoxy	5.88	5.113	1.7

Table 3: Compression Test

C. Results of Impact Test Charpy

Specimen	Cross section area in mm	Striking velocity in m/s	Effective weight of pendulum in kg	Angle of drop in ^{0}	Energy absorbed by specimen(K) in J	Impact strength of specimen (I)=K/A in J/mm^2
Glass	50	3.99	21.3	120	8	0.16
Carbon	50	3.99	21.3	120	30	0.6
Carbon & glass	50	3.99	21.3	120	14	0.28

Table 4: Impact Test Charpy

D. Results of Impact Test izod

Specimen	Cross section area in mm	Striking velocity in m/s	Effective weight of pendulum in kg	Angle of drop in ^{0}	Energy absorbed by specimen(K) in J	Impact strength of specimen (I)=K/A in J/mm^2
Glass	50	3.99	21.3	90	5	0.1
Carbon	50	3.99	21.3	90	12	0.24
Carbon & glass	50	3.99	21.3	90	10	0.125

Table 5: Impact test izod

E. Wear Test of Glass fiber

Normal load Kg	Disc speed (n) rpm	Specimen weight before experiment (W) gm	Specimen weight after Experiment (w) gm	Reduced Weight (W-w) gm
0	850	4.312	4.310	0.002
1	850	4.310	4.307	0.003
2	850	4.307	4.302	0.005

Table 6: Wear Test of Glass fibers

F. Wear Test of Carbon Fiber

Normal load Kg	Disc speed (n) rpm	Specimen weight before experiment (W) gm	Specimen weight after Experiment (w) gm	Reduced Weight (W-w) gm
0	850	3.785	3.784gm	0.001gm
1	850	3.784	3.782gm	0.002gm
2	850	3.781	3.778gm	0.003gm

Table 7: Wear Test of Carbon Fiber

VIII. Discussions

Tensile and compressive tests for glass and carbon were conducted by using the UTM. The results are tabulated as shown in above tables. It can be observed from compression test the compressive strength as well as ultimate load of the carbon is much higher than glass fiber for the same loading and boundary condition. In addition, from table 3 we can infer that carbon fiber having high value of compressive strength and fiber failure were noticed during the test. Graphs indicated above are plotted with load Vs displacement for all types of specimens and on observation, the specimens are able to withstand compressive load up to a particular point (yield point) and the curve suddenly drops where specimens are no longer able to take the load. At this time, the maximum displacement is recorded. Tensile Tests were also conducted as per standard procedure to estimate the tensile strength of glass and carbon fiber composite specimens and is shown in table 1 & 2.From impact test we can observe that impact strength of carbon fiber is more than glass fiber. From wear test we can conclude that by minting the same boundary conditions for glass and carbon fibre the wear of material is observed more in the glass fibre as comparable to carbon fibre with reference to table no 6& 7.

IX. Conclusions

After conducting all the experiments or tests on the fusion merged material made of carbon-glass fiber reinforced epoxy, the conclusion found as follows,

The composite which was planned to form by utilising the carbon-glass fiber toughened epoxy was done successfully. And in result it was found that the characteristics and the behaviour properties of the merged product is influenced by the loads of fiber and also due to the orientation.”

This work shows that successful fabrication of glass fiber and carbon fiber reinforced with epoxy composites with varying thickness is possible by simple hand lay-up technique.

It has been noticed that the mechanical properties such as tensile strength, compressive strength, of the FRP composites are also greatly influenced by the effect of various thickness of the slab.

The failure study of glass fiber reinforced epoxy composite after the tensile test, compression test, impact test has been done. From this study it has been concluded that the effect of thickness and fracture toughness is responsible for low mechanical properties.

The results that are obtained show that a hybrid material shows a good strength than the regular one.

We can reduce the cost of carbon fiber by reinforcing with glass fiber which are available in easily.

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