Impact on Mechanical Strengths of Glass - Hemp Fibre Reinforced Epoxy Composites

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Abstract.

The objective of this study is to produce hemp and glass fiber incorporated composites with epoxy resin polymer matrix and to determine the mechanical strengths like, impact strength and tensile strength of the different samples. The hemp and glass fibres reinforced composite material components and products plays a major role in the field of automobile and construction sectors. By using hand layup process the different composite samples are fabricated as per the ASTM standards and the specimens were tested with aid of UTM tensile testing machine and charpy impact energy testing machine. The experimental reading of tested samples indicates that the hemp and glass fibres composite exhibit the excellent tensile and impact strengths.

***Keywords*:** Hemp fibre, Glass fibre, Hand layup process, Mechanical testing,

1. Introduction

Composite materials are the new materials for emerging applications in various engineering field, because of its mechanical, structural and functional properties. Bunsell & Harris [1]were the first to combine carbon and glass fibre in epoxy resin to create a hybrid material. This material combined the advantages of both the fibres and neutralizing their disadvantages. Later Marom et al. [2] found that the hybrid effect may be positive or negative depending on the relative fibre volume-fraction of the fibres (glass and carbon), stacking sequence of the layers and their loading configurations. Thus, it is considered that the hybrid composites could allow the wider use of more expensive materials like carbon fibre. Sonparote & Lakkad [3] report that the properties such as moduli, impact strength and interlaminar shear strength of hybrid laminates have values, in between the respective properties of CFRP and GFRP depending on their proportion. The tensile properties of hybrid composites produced using glass and carbon fibres as reinforcement with epoxy as matrix were evaluated by Manders & Bader[4]. It was found that the failure strain of the carbon phase increased as the relative proportion of carbon fibre decreased. The flexural and tensile strength of unidirectional glass/carbonepoxy hybrid composite was studied by Dong & Davies[5]. It was found that the maximum hybrid effect can be achieved for a hybrid ratio (volume of carbon:glass) of 0.25 in flexural

and 0.125 in the case of tensile. Tita et al. [6] used the hand-layup process followed by molding under pressure and heating, to prepare the fiber (glass) reinforced polymer (epoxy resin) composite. Volkan Arikan and Onur Sayman [7] explained in detail about impact response of composites reinforced with glass fiber using epoxy and polypropylene were tested and from the results it was observed that the type of resin is very important critical parameter for impact response of the composites. Paul Wambua et al [8] worked on the mechanical properties of the different natural fibers (sisal, kenaf, hemp, jute and coir) composites and compared with glass fabric reinforced polypropylene composites. It was observed that kenaf, hemp and sisal composites depicted comparable results in tensile strength and modulus, but in impact hemp out-performed kenaf. Lowest mechanical properties were noticed in coir fiber reinforced composites, but impact strength was higher than that of jute and kenaf composites. From the observation it was concluded that the natural fibre composites were found to be compare favorably with those of glass. Sahoo et al[9] studied the plain woven fabric glass-epoxy composites, which were developed to study the fracture behavior of composites. In this investigation, two types of glass fiber were used with 360 and 600 gsm. It was concluded that 600 gsm glass fibers is more resistance to fracture than 360 gsm glass fiber when they used as a fiber with the same matrix. From SEM observation the plain woven fabric composite with lesser strand width has higher inter-laminar fracture properties compared to the plain woven fabric composite with more strand width. Raju and Balakrishnan[10] were evaluated the mechanical properties of hybrid glass and palm fiber using epoxy resin. In his result, tensile strength of the prepared composite has increased as increasing of the phase ratio of fiber. Hybrid fibers showed more advantage in the flexural test compared with the available composite. High strength to low weight application showed by his hardness studied. Polymer–Matrix Composites (PMC) with the continuous glass/ carbon/ boron fibers are extensively utilized in lightweight structures. Damping can be improved in the PMC materials (1) by utilizing the viscoelastic layer or the interleaved layers in the interlaminar region of the laminated structures, and (2) by the tailoring of essential resources of the structure itself such as the fibers and the matrix materials[11]

2. *Experimental Process*

Materials

For this experimental work the hemp/glass fibre incorporated composite plates were manufactured by hand lay-up method. The raw hemp and glass fibres. The other matrices like, epoxy resin (Grade: 758), hardener (Grade: HY911), accelerators and waxes are procured from M/s. Go green products Ltd., Chennai. Tamilnadu, India. The chemical constituents, physical properties and mechanical properties of hemp fibre, glass fibre and epoxy resins are reported by various researchers are listed in the following Tables 1 and 2.

Table 1. Chemical properties of hemp

Chemical properties	Hemp fiber
Cellulose (wt %)	68–77
Hemicelluloses (wt %)	7–22.4
Lignin (wt %)	2–10
Micro-fibrillar angle (deg)	2–6.2
Moisture content (wt %)	6.2–12
Pectin (wt %)	1-25
Biomass (Mg DM/ha/y)	7–34.0

Table 2. Physical properties of hemp fibres, glass fibres and epoxy resin

Physical properties	Hemp fiber	Glass fiber	Epoxy resin
Density (g/cm^3)	1.4–1.6	2.50-2.60	1.1–1.3
Tensile Strength(MPa)	200–1040	1956	55–130
Stiffness (GPa)	17.6-66	79	2.7–4.1
Tensile modulus (GPa)	23.5–90	2000-3500	--
Specific tensile strength (MPa)	210–510	--	--
Young's modulus (GPa)	30–60	70-80	--
Specific Young's modulus (GPa × cm^3/g)	20–41	27-32	--
Diameter(µm)	270–900	--	--
Length (mm)	8.3–14	--	--
Aspect ratio (length / diameter)	549	--	--
Percentage of elongation (%)	1–3.5	--	--
Failure strain (%)	2-5	2.5	--

Preparation of composites

The top surfaces of the base plates were cleaned by applying thinner chemical after removing the dust and burns on the surfaces by scrubbing with aid of an emery sheet. The wax coating was given on the surfaces of base plate after cleaning, and then the coated plates were kept under ambient conditions for 15 minutes for hand lay-up process [1].The matrices were prepared by mixing the epoxy resin and hardener with the ration of 10:1 and uniform mixing was done with regular interval of time period. The pot life of these matrices was identified as 30 minutes based on the standard laboratory readings given in the chart. At the initial stage, hemp fibres were kept under sun light for 8 hours to remove the moisture content presents in the fibres. The composite laminates were fabricated by applying the matrices between the glass and hemp fibres with constant weight. Each laminate consists the five layers of hemp and glass fibre by hand lay-up process. The glass fibre mat was used

on the top and bottom layers of these composite laminates. The dimensions of the fabricated composite laminates were restricted as 300 x 300 x 3 mm. Then the fabricated laminates were dried under room temperature with aid of the compressive load for one day. The following figures 1,2,3,4 and 5 are shows the fabrication process of composite laminate with raw hemp plant fibre and glass fibre.

Figure 1. Raw glass fibre

Figure 2. Raw hemp fibre

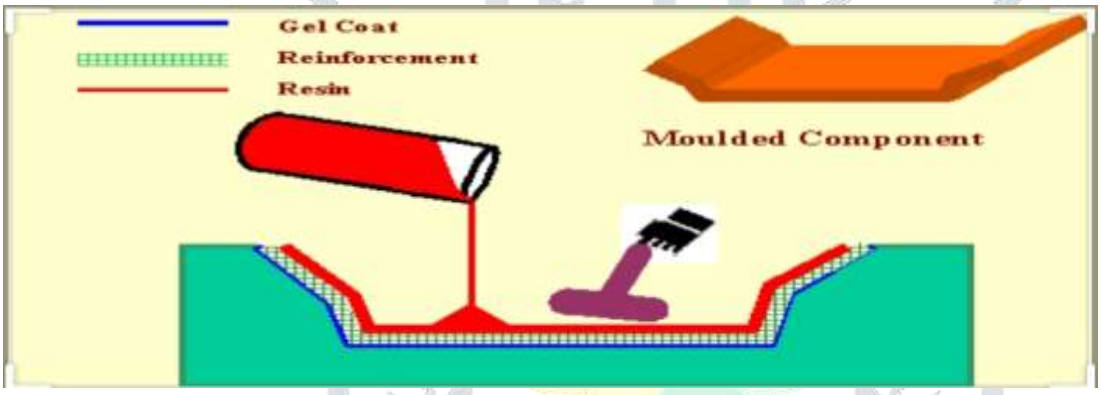

Figure 3. Hand layup process

Figure 4.Processing of Hemp fibre

Figure 5. Processing of Glass fibre

Mechanical strengths of Composites

Tensile testing

From the fabricated composite plates, three different tensile test samples were prepared as per the standard ASTM D3039. There are three specimen were used from each laminates for testing the tensile behavior of composite plates. The tensile test has been conducted on the computerized UTM machine, by applying equal and opposite pull load on the prepared samples until to get fracture and the corresponding readings are noted. The same methodologies were applied for remaining samples which produced in the same composite plates to get the ranges of tensile strength for comparison of tensile results

Impact testing

From the fabricated composite plates, three different impact test samples were prepared as per the standard ASTM D256 and the sides of the samples are finished by emery sheets. The three impact test samples were prepared from hemp/glass fiber incorporated composite plates for examining the impact energy absorbing capacity during its failure. These prepared samples were tested by meams of charpy testing machine and the energy stored to break the samples were observed for result analysis and comparison.

3. *Results and discussion*

In this experiment, the hemp fibers were incorporated with glass fibers and different composite plates were fabricated to conduct the mechanical properties. After that the test samples were prepared as per ASTM standards with required finishing from the fabricated composite plates. Then the mechanical testing of composites like tensile, and impact test has been conducted with aid of computerized UTM machine and impact test machine. The mechanical test results of different tested samples were listed in Table 3.

Table 3. Test results of hemp and glass samples

SAMPLES	ULTIMATE TENSILE STRENGTH (UTS)		ENERGY ABSORBED VALUES		TENSILE LOAD VALUES	
	GLASS	HEMP	GLASS	HEMP	GLASS	HEMP
Sample-1	168.45	38.19	16.45	4	23	4
Sample-2	172.4	39.26	15.98	3.78	26	3.85
Sample-3	173.2	36.65	16.89	3.69	24	3.95
Sample-4	174.3	35.45	16.55	4	23	4
Sample-5	172.45	36.3	16.88	4	24	4
Average	**172.16**	**37.17**	**16.55**	**3.16**	**24**	**4.0**

Ultimate Tensile strength analysis

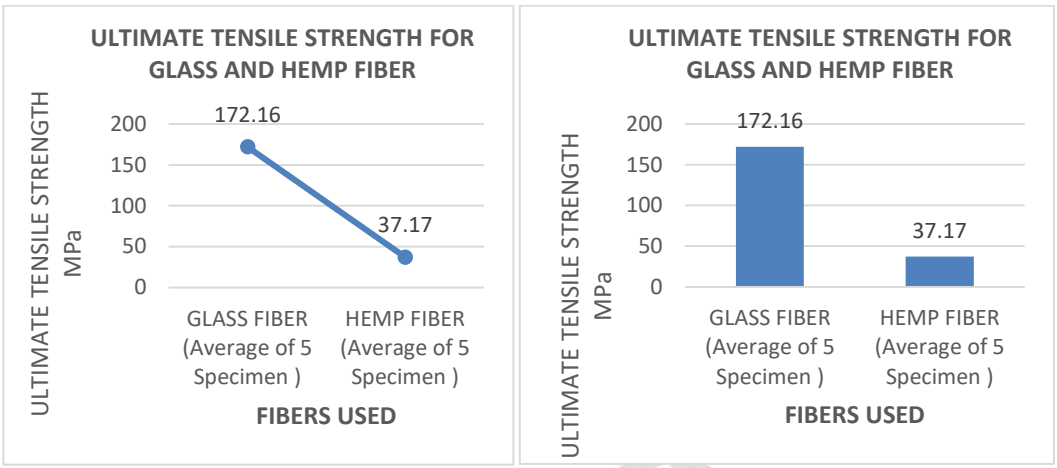

Fig.6 . Line and column graph for tensile test

The samples prepared as per standard from the composite plates were tested by digital UTM machine and the generated graph between force and displacement has been obtained directly from the machine by applying pull load. The tensile test readings of different samples were presented in Table 3. From the observed tensile test readings of hemp and glass fibres composite samples shows above following result, the glass fiber exhibits very high ultimate tensile property as compare to Hemp fiber the better tensile property it varies from 37.17 MPa to 172.16 MPa. These composite components are suitable for structural applications in home appliance furniture's and interior parts of automobile vehicles.

Impact strength analysis

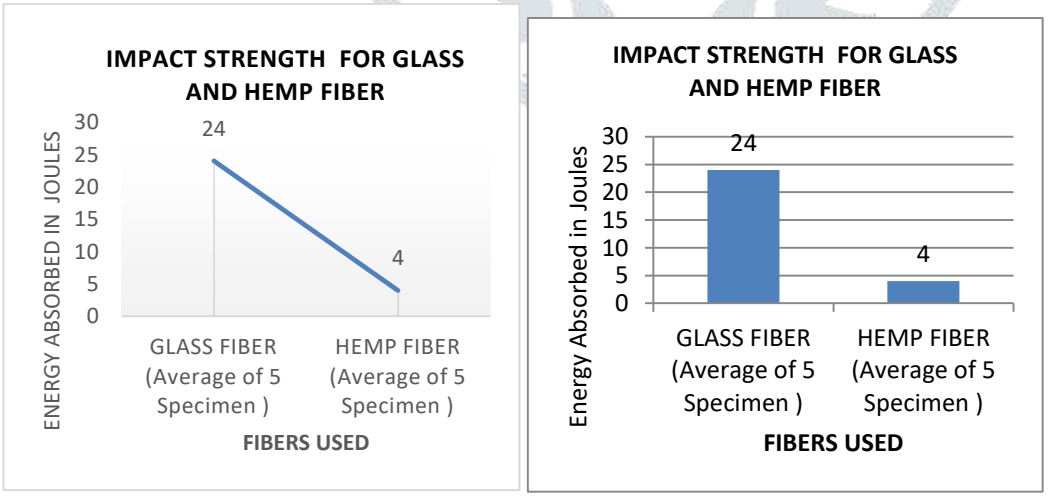

Fig 7. Line and column graph for impact strength

The impact test was conducted for examining the impact energy/load withstanding capability of the hemp and glass fibres composite samples and the charpy test method was used in this experimental investigation. The energy absorbed to break the unnotched composite samples during

impact testing were presented in the Table.3.The impact results of tested samples exhibits nominal impact strength which suitable to holds the less impact load on automobile structural components and it varies from 4 Joules to 24 Joules. It clearly shows as compare to hemp fiber glass fiber samples are absorbing more energy, which is also suitable for household applications and aerospace applications

Tensile load analysis

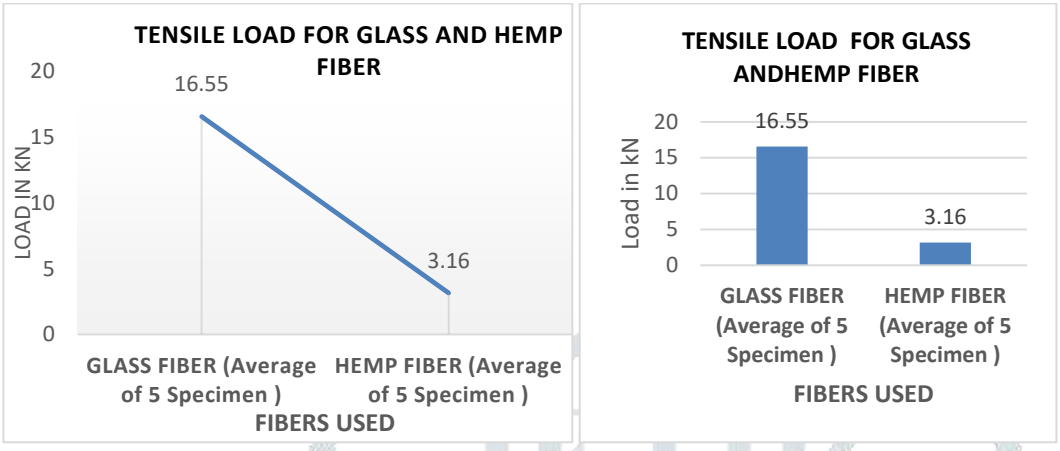

Fig 8 . Line and column graph for tensile load

The digital UTM machine and the generated graph between force and displacement has been obtained directly from the machine by applying pull load. The tensile test readings of different samples were presented in Table 3. From the observed tensile test readings of hemp and glass fibres composite samples shows the better load property it varies from 3.16kN to 16.5 kN. From this observation naturally the natural fiber like hemp sustain a lower load as compare to glass, so respective of load usage we finding the right fibers these composite components are suitable for civil applications, wood application, and interior parts of automobile vehicles.

4. *Conclusion*

The researchers focusing their research work in the field of composite materials to fabricate the ecological based natural composites without compromising to replace the man-made material components or traditional material components in the field of automobile sectors. The hemp and glass fiber incorporated composites were fabricated and the tensile property, flexural property and impact property of these composite samples were noted and analyzed. Based on the observed mechanical readings the following conclusions are made for these experimental studies.

- The glass fibers composite samples withstand the maximum tensile property which holds the maximum value of 172.16MPa. Similarly, the impact strength of 24Joules was observed.

- The maximum impact energy of the composite samples varies from 4Joules to 24Joules.The.

- It is suggested that it helps to knowing the independent strength of a fibers and to use of their respective application. Some of the application the hemp fibers incorporated epoxy composite materials can be replaces the man-made/synthetic fiber incorporated composite material.

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