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Mechanical Properties of Hybrid Composite Polyester Matrix Reinforced Glass Fibres

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A R T I C L E I N F O

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A B S T R A C T

The mechanical properties of hybrid composite material i.e. polyester matrix composites (ECMAS 411) reinforced with BS3496 E-glass fibres i.e. woven roving, chopped strand mat (CSM) fibers were evaluated. There are indications that the incorporation of both glass fibers into a single matrix which is polyester resin will stabilize mechanical properties and lowering manufacturing costs. In this research the impact strength, tensile strength, flexural strength, and compressive strength of GFRP hybrid composite material were studied.

Introduction

Composite material is a material consisting of two or more physically and (or) chemically distinct phase, suitably arranged or distributed. In the past few decades, research and engineering interest has been shifting from monolithic materials to fibre-reinforced polymeric composite construction. Glass fibres are most widely used to reinforce plastics due to their advantage such as low weight, corrosion resistance, high fatigue strength, faster assembly etc.

[3] Fibre-Reinforced Composites often aim to improve the strength to weight and stiffness to weight ratios (i.e. desire light-weight structures that are strong and stiff). Fibres are available in 3 basic forms: Continuous fibres are long, straight and generally layed-up parallel to each other. Chopped Fibres are short and generally randomly distributed (fibre glass), woven fibres come in cloth form and provide multidirectional strength.

s.irfan sadaq et al [1] prepared composite laminates with glass fiber and epoxy resin are tested to find the strength of the laminate and also its mechanical properties by using FEA (Ansys 11.0).

Ali I. Al-Mosawi et al [2] studied the impact strength, tensile strength, flexural strength, and hardness for composite material reinforced with hybrid fibers for palms and Kevlar.

2.0 Methodology

Materials used: woven roving, chopped strand mat (BS3496), polyester resin (ECMAS 411).

Table 1: individual mechanical properties of CSM,WR

Property	Tensile Strength (Mpa)	Compressive Strength (Mpa)	Bend Strength (Mpa)	Impact strength (KJ/m2)
CSM	100	150	150	75
WR	120	150	250	125

Fabrication details:

- woven roving = 600g
- chopped strand mat=650g
- polyester resin = 1.5kg
- cobalt accelerator = 30g
- MEKP catalyst = 10ml

Fabrication of hybrid composite laminate:

The hybrid composite laminate fabrication is done by hand lay-up process. Hand lay-up is the method of cutting lengths of fibre reinforcement off of rolls. The reinforcement most often comes in the form of chopped fibre, woven fibre, or stitched fibre. Once a layer is placed in the mould, resin is applied either by pouring on by hand, or it can be sprayed on with a mixing gun. The layers are consolidated and air bubbles are removed by using squeegees and hand rollers.

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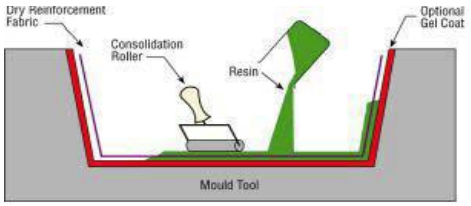


Fig 1: Hand lay-up method

The mould is applied with wax poll such that during the release of the piece there does not be any problem of blow holes or air gaps. And later it is cleaned using cotton, and after cleaning poly vinyl alcohol is applied so that the laminate is removed without any difficulty. Firstly, on the prepared mould chopped strand mat (0.75mm) is placed and Polyester resin which is mixed with cobalt accelerator and MEKP catalyst is applied on the CSM and rolling is done by using a roller such that air gaps are avoided .Later after the rolling is done woven roving (0.45mm) is placed and similar steps are followed, this is continued for 7 to 8 layers of each CSM and roving but the initial and final one should be CSM. The prepared laminate of dimensions 300mmX300mm is allowed for curing for 5 to 6 hours and later it is grinded to get a good surface finish.

Fig 2: Hybrid composite laminate

3.0 Mechanical Tests

The tensile, compressive and flexural test specimens prepared in accordance with ASTM standards were loaded on a computer controlled Universal Testing Machine (Model: UTV 40PC, Max Capacity: 400KN). The tests were closely monitored and conducted at room temperature. Since it is difficult to detect the first point of damage in laminates, the ultimate tensile compressive and flexural strength recorded corresponds to the maximum load the hybrid composite specimen can withstand. The impact test specimens also prepared according to ASTM standards, charpy and izod tests were conducted at room temperature.

Fig 3: UTM setup **Fig 4: Impact testing m/*C***

3.1 Tensile test

The hybrid composite material fabricated is cut into required dimension using a saw cutter and the edges finished by using emery paper for mechanical testing. The tensile test specimen is prepared according to the ASTM standards. The dimensions, gauge length and cross-head speeds are chosen according to the ASTM standard. A tensile test involves mounting the specimen in a machine and subjecting it to the tension. The testing process involves placing the test specimen in the testing machine and applying tension to it until it fractures. The tensile force is recorded as a function of the increase in gauge length. During the application of tension, the elongation of the gauge section is recorded against the applied force.

3.2 Compression test

The compression specimen is prepared as per the ASTM standard. A compression test involves mounting the specimen in a machine and subjecting it to the compression along the fibre orientation and across the fibre orientation. The compression process involves placing the test specimen in the testing machine and applying compress to it until it fractures. During the application of compression, the compress force is recorded and maximum compressive strength is obtained.

Fig 5: Compression test specimen

3.3 Flexural test

The flexural specimens are prepared as per the ASTM standard. The 3-point flexure test is the most common flexural test for hybrid composite materials. Specimen deflection is measured by the crosshead position. Test results include flexural strength and displacement. The testing process involves placing the test specimen in the universal testing machine and applying force to it until it fractures and breaks.

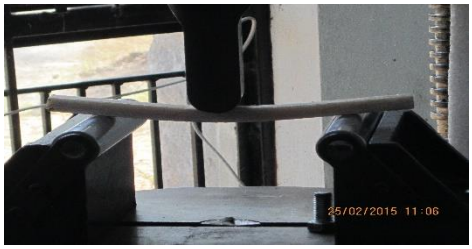


Fig 6: specimen under flexural test

3.4 Impact test

The impact test specimens are prepared according to the required dimension following the ASTM standard and both charpy and izod tests were conducted. During the testing process, the specimen must be loaded in the testing machine and allows the pendulum until it fractures or breaks. Using the impact test, the energy needed to break the material can be measured easily. The pendulum striking angle for the charpy test is 145° and for izod test is 85°.

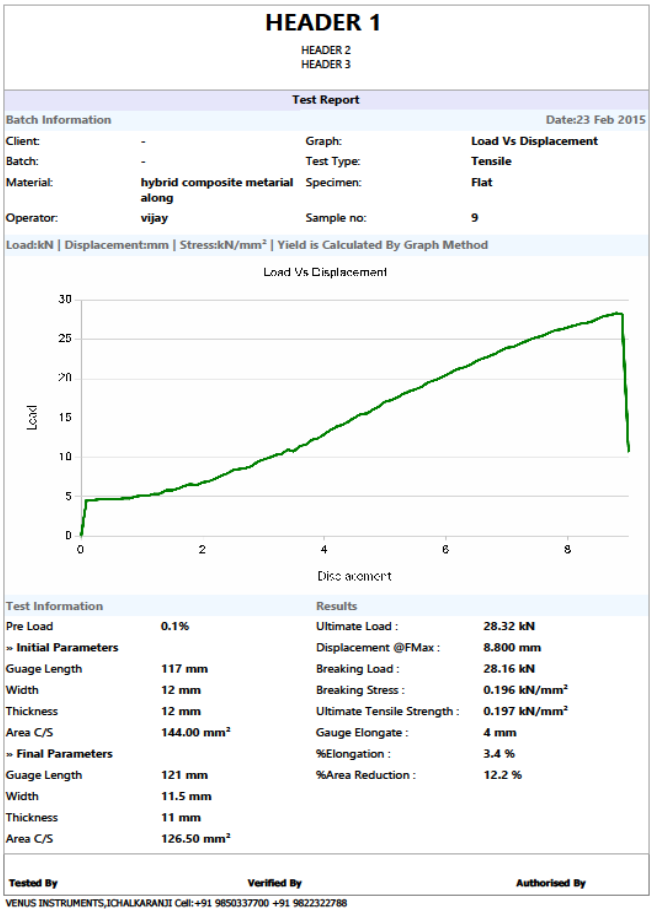
Fig 7: impact test specimens before and after striking the pendulum

4.0 Results and Discussions

The use of composite materials in the different fields is increasing day by day due to their improved properties. Engineers and Scientists are working together for number of years for finding the alternative solution for the high solution materials. In this paper effect on mechanical properties of hybrid composite reinforced glass fiber material is evaluated and tabulated.

4.1 Tensile properties

The hybrid composite specimen sample of size 260X12x12mm is tested in the universal testing machine (UTM) and the sample is left to break till the ultimate tensile strength occurs. The sample graph generated directly from the machine for tensile test with respect to load and displacement for hybrid composite polyester matrix reinforced glass fibres. The results indicated that hybrid composite specimen gives ultimate tensile strength of 197Mpa with respect to maximum applied load of 28.32KN and the displacement of 8.800mm respectively.



HEADER 1

HEADER 2
HEADER 3

Test Report

Batch Information			Date:23 Feb 2015
Client:	-	Graph:	Load Vs Displacement
Batch:	-	Test Type:	Tensile
Material:	hybrid composite metarial along	Specimen:	Flat
Operator:	vijay	Sample no:	9

Load:kN | Displacement:mm | Stress:kN/mm² | Yield is Calculated By Graph Method

Test Information		Results	
Pre Load	0.1%	Ultimate Load :	28.32 kN
» Initial Parameters		Displacement @FMax :	8.800 mm
Guage Length	117 mm	Breaking Load :	28.16 kN
Width	12 mm	Breaking Stress :	0.196 kN/mm²
Thickness	12 mm	Ultimate Tensile Strength :	0.197 kN/mm²
Area C/S	144.00 mm²	Gauge Elongate :	4 mm
» Final Parameters		%Elongation :	3.4 %
Guage Length	121 mm	%Area Reduction :	12.2 %
Width	11.5 mm		
Thickness	11 mm		
Area C/S	126.50 mm²		

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Fig 8: Tensile strength

4.2 Compression properties

The compression test is conducted on two specimens of 10.5X10.5X11size one along the fibre orientation and another across the fibre orientation. The sample graphs are generated directly from the machine for compression test with respect to load and displacement for hybrid composite polyester matrix reinforced glass fibres. The results indicated that hybrid composite specimens gives compressive strength along the fibre orientation is 600Mpa with respect to maximum applied load of 69.06KN and the displacement of 2.8mm and compressive strength across the fibre orientation is 182.5Mpa with respect to maximum applied load of 21.08KN and the displacement of 2.1mm respectively.

Fig 9: Compressive strength along the fibre orientation

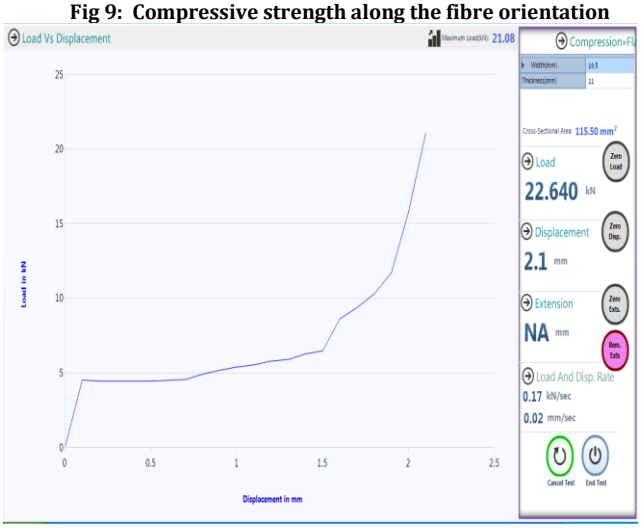

Fig 10: Compressive strength across the fibre orientation

4.3 Flexural properties

The flexural test specimen of size is 220x14x12.5mm and the span of flexural test is 155mm. The sample graph generated directly from the machine for flexural test with respect to load and displacement for hybrid composite polyester matrix reinforced glass fibres. The results indicated that hybrid composite specimen gives flexural strength of 36.8Mpa with respect to maximum applied load of 6.44KN and the displacement of 8.9mm

respectively. Also if we observe the graph the maximum applied load is 6.44KN and after that it tends to decrease.

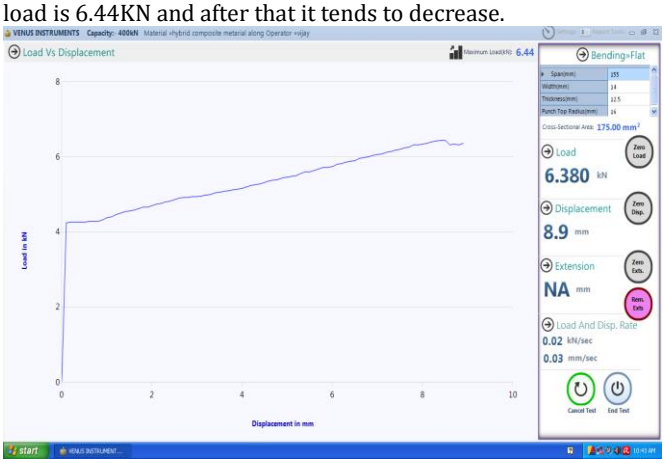

Fig 11: Flexural strength

4.4 Impact properties

The impact test carried out for both Charpy and izod test specimens. The results indicated that the maximum impact strength obtained for the charpy test is 160KJ/m^2 for hybrid composite polyester matrix reinforced glass fibre of size 55x10x10mm and maximum impact energy absorbed by the specimen is 16J. For izod test the size of the test specimen is 75x10x10mm and maximum impact energy absorbed by the hybrid composite specimen is 12J and maximum impact strength obtained is 120 KJ/m^2.

Table 2: Obtained mechanical properties of hybrid composite reinforced glass fibre material

Name of the test	Property	Maximum Strength
Tension test	tensile strength (Mpa)	197
Compression test	Compressive strength (Mpa) i) along the fibre ii) across the fibre	 600 182.5
Flexural Test	flexural strength (Mpa)	36.8
Impact Test	Impact strength (KJ/m^2) i) charpy test ii) izod test	 160 120

5.0 Conclusions

In this work hybrid composite polyester matrix reinforced glass fibre laminate is fabricated and tests are carried out to analyze the effect of mechanical properties such as tensile, compression, flexural and impact strengths. Based on the results, the following conclusions are drawn:

- The results indicated that hybrid composite polyester matrix reinforced glass fibre specimen gives high tensile strength compare to the tensile strengths of CSM and Woven roving individually. The Maximum tensile strength of hybrid composite material is 197Mpa.
- The compression test results of hybrid composite material indicates that very high compressive strength along the fibre orientation is 600Mpa, followed by high compressive strength across the fibre orientation is 182.5Mpa compare to the compressive strengths of CSM and Woven roving individually.
- The flexural test results of hybrid composite material indicates that very low flexural strength i.e.36.8Mpa compare to the flexural strengths of CSM and Woven roving separately.
- The impact test results of hybrid composite material indicates that high impact strength of 160KJ/m^2 is obtained by conducting charpy test and low impact strength of 120 KJ/m^2 is obtained by izod test.

In this research by conducting different mechanical tests on hybrid composite polyester matrix reinforced glass fibre we can also conclude that this hybrid composite laminate has very high compressive strength along the fibre orientation as 600Mpa followed by tensile strength of 197Mpa, compressive strength across the fibre orientation 182.5Mpa, impact strengths of 160 KJ/m^2 &120 KJ/m^2 and flexural strength of 36.8Mpa.

6.0 Acknowledgement

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