

Experimental Investigation on Mechanical Behaviour of Hybrid Composite

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ABSTRACT

The use of composite material is very wide and is increasing at rapid pace in all fields of science and technology due to its desirable properties. The importance of materials in modern world can be realized from the fact that much of the research is being done to apply new materials to different components. The composite material with a composition of Kevlar, basalt and carbon fibers with a suitable epoxy resin as matrix, the composite sheet was hybridized with vacuum resin infusion technique with different composition. Various mechanical properties such as tensile strength (TS), compressive strength (CS), Flexural strength (FS), Impact Strength (IS), Which make it suitable for many applications to various fields such as in the construction, cryogenics, and bullet proofing, high energy absorbing equipment. The water absorption and soil degradation test confirm its environmental effects with the % of water absorbed whereas alkali test conducted with 50% concentrated H₂SO₄ makes it clear the behavior of composite material from any chemical degradation.

Keywords:- basalt, carbon, epoxy resin, flexural strength, Kevlar, tensile strength

INTRODUCTION

Composite materials are those materials which is having different properties as compared to the original materials from which they have been originated. There may have been different types of composite material depending upon their matrix and reinforcement. They have been put in different sections according to their fabrication type and uses. The composite material on which this study is focused is based upon hand layup method fabricated by vacuum resin infusion method. The properties of composite material are entirely different from the basic material they originated which makes it most desirable and useful for application in science and technology. It is always keen interest for the designer and manufacturer to develop and search for the different materials. The most desirable properties of the composite material are its weight to volume ratio is very low and there mechanical strength is far better than the engineering materials. They are the material for the future as all the study is being focused on finding out the newer composition of materials. The basic material from which they formed has different roles and different properties. These basic materials are discussed one by one.

1.1 Matrix Material Used

Epoxy resin

The term "epoxy resin" is a generic name for compounds that have two or more oxirane rings (epoxy groups) in one molecule, and are cured three-dimensionally by a suitable curing agent. formed by the reaction between bisphenol A and epichlorohydrin, which currently commands a 75% share of the epoxy-resin market.

Technical data sheet for our matrix used

Sr. no	Property	Unit	Epoxy resin	Hardener
1	Type		Solvent modified resin	polyamine
2	Appearance		Color less liquid	Clear liquid
3	Max viscosity	MPa-s	650(+/-)100	
4	Specific gravity	g/cc	1.15-1.18	0.98+/-0.1
5	Pot life@27°C	hours	1.5-2	
6	Storage stability	months	12 months	6 months

Table No. 1 Properties of epoxy resin

Curing of Epoxy with Hardener

Mixing ratio 100: 18p.b.w

Pot life at RT 1.5-2.5ours

Curing at RT 16-24 hours

Post Curing at 70-80° C - 2 hours (if required) in mold or conformer only to avoid warp edge.

Properties:-

HDT	o C	95
Flexural Strength	Psi	17,000
Compressive strength	Psi	16,000
Tensile strength	Psi	10,300
Impact strength	lb/in	0.45
Hardness	Shore D	70-80
Volumetric Shrinkage	%	0.01 Max

3.2 Fiber material used in our composite sheet**3.2.1 Carbon fiber**

Carbon Fiber is made of carbon crystals aligned in a long axis. This crystal alignment makes the ribbon strong in the long axis. In turn these ribbons align themselves within fibers. The fiber shape is the original shape of the material (its precursor) used to produce the Carbon Fiber. There are several methods of making carbon fiber but essentially they all begin with the making of fibers out of a carbon rich precursor material. The first steps are **carbonizing and stretching precursor fibers**, either PAN: Polyacrylonitrile, Pitch or Rayon. There are several cycles of heating at varying temperatures excluding oxygen.

Technical data sheet of carbon fiber 200GSM

characteristic	specification	Tolerance	Test method
Area (g/m ²)	200	+/-3%	ASTM D3801
Width (mm)	1000	-0/+10mm	ASTM D3774
Dry fabric thickness(mm)	0.2	+/-0.03	ASTM D1777

Table No.2 Properties of carbon fiber

3.2.2 Basalt fiber

Basalt fiber is a natural fiber which is mainly found in the sedimentary rocks. Basalt fiber is a relative newcomer to fiber reinforced polymers (FRPs) and structural composites. It has a similar chemical composition as glass fiber but has better strength characteristics, and unlike most glass fibers is highly resistant to alkaline, acidic and salt attack making it a good candidate for concrete, bridge and shoreline structures.

Properties of Basalt Fiber Fabric 320SM Plain

Fiber type	wrap	6K
	wrap	6K
Woven pattern		plain
Linear density (10mm)	wrap	4K
	welt	4K
Size (mm)	width	1000
	thickness	0.38
Area weight (g/m ²)		320

Table No.3 Properties of basalt fiber

3.2.3 Kevlar fibers

Kevlar fibers are the synthetic fibers which are made from the poly amides in which organic acid replaces one of the hydrogen in the amine group NH₃.

220GSM plane woven aramid fabric

characteristic	specification	tolerance	Test method
Area	220	(+/-)3%	ASTM D 3801
Width	900	+/-10%	ASTM D3774
Dry fabric thickness	0.32	+/-0.03%	ASTM D1777

Table No.4 properties of aramid fiber

LITREATURE REVIEW

[1]Er. Reashad Bin Kabir, Er. Nasrin Ferdous et al I 2012 “Tells about the Properties, functions and uses of Kevlar composite materials but this paper just simplifies the things as well as highlight some superb features of the Kevlar fiber. And gives us the conclusion about Kevlar mainly use for two reasons, and both are about performance”[2] Mahmood Aamir, Ma Yu et al 2015 “This paper compares the different properties of Kevlar with other materials like glass carbon fiber. They found the properties of Kevlar and recent study on Kevlar and they made conclusion that these two types of Kevlar – Kevlar 29 and Kevlar 49 have some similar properties and at the same time very different. The comparison shows that Kevlar fiber is less durable than glass fibers”.[3] Girish Gautam, Gavendra Norkey, Arun Kumar Pandey 2017 et al “In this study, Kevlar-29 fiber reinforced composite laminates were fabricated by the hand lay-up technique for evaluating their mechanical properties The acquired results showed that developed Kevlar-29 fiber reinforced polymer composite has good tensile, flexural and impact strength. These higher mechanical properties make this composite suitable for enormous applications in engineering industries.”[4]P. Ladin Broose and S. Prakash et al 2017 In his research they worked out for safety instruments alternative material such as helmet as its impact resistance is high .In this research paper a hybrid composite using a material Kevlar 29 Fabric and Fiber Glass Fabric which is to bond by using Epoxy Resin and with polyuria coating is fabricated and investigated the impact behavior of Kevlar29.”[5] Puran Singh, Vikas Malik Priyawart Lather et al 2017 “In this paper project aims at studying various composite materials used in bullet-proof vests and to analyze their effectiveness by using FEM technique. These fibers absorb and disperse the impact energy that is transmitted to the vest from the bullet, Most anti-ballistic materials, like bullet proof vests and explosion-proof blankets, are currently made of multiple layers of: Kevlar fibers.”[6]

K.K. Herbert Yeung and K.P. Rao et al 2011 “In this research the material of composite laminate was made to study the toughness and damage tolerance of Kevlar 49 Fiber has a tensile strength in between glass and carbon has been studied many mechanical properties have been studied and compared with another material theoretically. The mechanical properties of three Kevlar-49 based thermoplastic composites with fiber fraction of 61% were obtained experimentally and predicted using micromechanical models. And found the properties were increased”[7] **Fasil Mohi ud din et al 2017** “In his experimental investigation was carried out on various types of fibers to find the use of the fiber in the structural engineering in particular and civil engineering in general.. In this paper the study was conducted about engineering and mechanical properties of Kevlar Fiber and in comparison with other. It is strong but relatively light, the specific tensile strength of both K29 and K49 is 8 times Greater than that of steel. It can with stand the temperature of 450°C (800°F). → Even at very low Temperatures the Kevlar doesn't get effected and withstand the temperature of down to -196°C (-320°F).”[8] **Jagadish S P, Dr A Thimmana Gouda , Dr K R Dinesh, Dr N Prashanth , Dr Neeta PN, Bharath Desai, Shivanand N Pujar et al 2015.** “This research paper constitutes the analysis of mechanical properties of Carbon fiber polymer composite material with +/- 0° to 90° Orientation used as implant material. The composite materials are manufactured by using Vacuum bag molding method and specimens are prepared according to ASTM standards and mechanical tests are carried out and finally we will suggest this material for Bio medical field application. We found that 10% Carbon fibers Composite has compressive strength of 0.259KN/mm². 10% Carbon fibers Composite has Bending strength of 0.118KN/mm²”

2 EXPERIMENTAL PROCEDURE

2.1 EXPERIMENTAL SET-UP

After the completion of our composite sheet carbon reinforced Kevlar composite we have carried out several experiments upon the sheet under different loading condition and different condition with different specimen these test includes mechanical properties, physical properties, and chemical properties. These are as follows:-

2.1.1 TENSILE TEST:-

We have taken a specimen of size 200mm length 20mm width and 3mm thickness with a gauge length of 120mm. we kept our specimen in the universal testing machine. The test method which was carried out was ISO 527-2002. We have gradually applied load for the test to be successful with a speed of 10mm/min. We have seen that our specimen restrains a maximum load of 8.4KN and then initiation of cracks occurs. In doing this we obtain a deflection of 9mm when first crack initiated.

For calculation of Tensile strength we used.

$$\sigma_t = p/bh \dots\dots\dots(1)$$

where as

σ_t = tensile strength, b= Initial width of the specimen, h = the thickness of specimen.

p =The ultimate tensile load on specimen

$$\epsilon_t = \text{deflection /original length} \dots\dots\dots(2)$$

E= tensile stress/tensile strain

$$= 255/.075$$

$$= 3400 \text{ MPa}$$



Figure No.-1 (a) UTM machine (b) tensile test of the specimen

(Sources UIET MDU Rohtak)

And tensile strength were found to be 255MPa

2.1.2 FLEXURAL TEST

The test was performed on the UTM machine with 3 point bend test to find out the flexural strength of the specimen the dimensions of specimen was 80mm length and 20mm width and 3mm thickness Test method adopted for the test was ISO1172-1996.

The specimen was applied with a gradual compressive load with a speed of 7mm/min and the maximum deflection achieved was 9.03mm whereas the peak load before the fracture took place was 708N.



Figure No 2:- flexural test of the specimen

For calculation of the flexural strength we derived formula as:-

$$\sigma_f = 3PL/2bh^2 \dots\dots\dots (3)$$

where as

σ_f = flexural strength of the specimen, P= maximum load on the specimen

L= length of the span of specimen, b = original width of the specimen,

h= thickness of the specimen

$$\text{Flexural strain} = 6sh/L^2 \dots\dots\dots (4)$$

s = recorded deflection, h= thickness of the specimen, L= length of the specimen

$$\begin{aligned} \text{Flexural strain} &= 6 \cdot 9 \cdot 3 / 60^2 \dots\dots\dots (5) \\ &= 0.045 \end{aligned}$$

The load wearing capacity was excellent with a load of 710N before bending took place the flexural strength was found to be 356MPa

2.1.3 IZOD IMPACT TEST:-

The specimen of dimension 80mm length and 20 mm width with thickness of 3mm. A notch with size of 2mm was made at center of the specimen. The izod impact test method was done under ISO180-2000 And the impact strength was found to be 89 KJ/m²

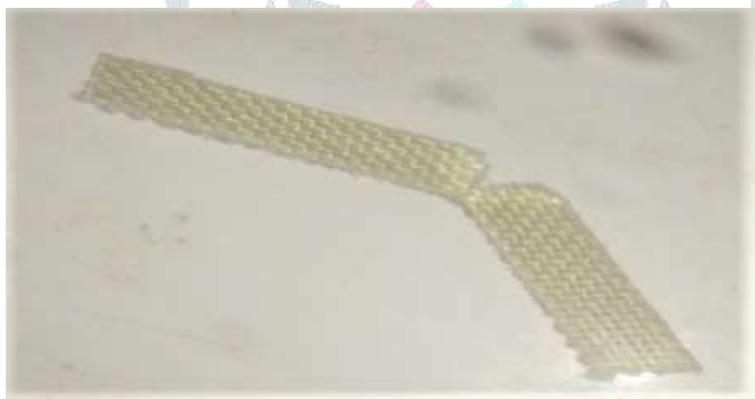


Fig 18 izod impact of specimen

This is found to be good resistance against the impact load. Impact resistance of the composite we fabricated is having good resistance to sudden load. This shows that composite is good against thrust load.

2.1.4 ALKALI TEST

We have conducted the alkali test on our specimen of size 20*20mm in a 50% concentrated H₂SO₄ solution .we completely dipped our specimen in the solution and measured its weight kept there for next 12 hours and taken after the scheduled time and again measured the weight and we found that

Number of days	1	2	3	4	5	6	7	8	9	10	11	12	13
Initial weight	00	2.57	2.78	2.76	2.68	2.63	2.67	2.69	2.68	2.72	2.7	2.68	2.77
Final weight	2.57	2.78	2.76	2.68	2.63	2.67	2.69	2.68	2.72	2.7	2.68	2.77	2.74

Table:5 shows the variation in wt. of specimen

The gain in weight was 2.57grams and we kept the specimen again in the concentrated solution for next 12 hours and repeated the whole process and measured the weight again now this time it was found to be 2.79 grams .After this the entire procedure was repeated after each 12hours weight was taken all the time. This was repeated for next 13 days .the variation in the reading for all 13days was displayed in chart for whole reading.

$$\% \text{of weight reduction} = \frac{W_f - W_i}{W_i}$$

And we made the conclusion from this test That our specimen remain un effected from any type of corrosion, material erosion do not take place, since our material was free from any kind of acid attack that is good for our specimen

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2.1.5 WATER ABSORPTION TEST:

In in this study we keep the specimen of size 25*25mm from the sheet of composite plate. We cleaned up it properly and measured the sample of specimen going under the test and keep the initial weight for comparison. Now we took one liter of fresh water in a jar and kept our sample inside it and the sample was completely immersed in water for 12 hours. After that we took the sample from the water

Number of days	1	2	3	4	5	6	7	8	9	10	11	12	13
Initial weight	0	2.74	2.8	2.82	2.78	2.8	2.85	2.82	2.81	2.82	2.78	2.83	2.84
Final weight	2.74	2.8	2.82	2.78	2.8	2.85	2.82	2.81	2.82	2.78	2.83	2.84	2.86

Table:6 shows the variation of wt.

Change in Wt. % $\frac{W_f - w_i}{W_i} \dots\dots\dots (6)$

Dried it and cleaned it in the open atmosphere for few minutes so that there is no moisture remained and after that we measured the weight of the sample and is 2.74g after measuring the weight we again kept the sample on the fresh cleaned jar free from air bubble. Sample is now completely immersed in the water for next 12 hours and then same procedure is done to find out weight. This whole process was carried out for next 13 days to get the exact variation of water absorption by the sample. The reading of weight was noted down and plotted on the graph as shown in the above graph. We see that there is not more variation in the weight of the specimen. Hence we concluded that the water absorption was in between 2.7 to 2.85g and that was good for it as it behaves like water resistant.

[3] RESULT AND DISCUSSION

After we have manufactured a square sheet of carbon reinforced Kevlar composite of thickness Of 3mm and area 300 mm*300mm as with resin infusion method which is supposed to be very good method as resin reaches the reinforcement easily and distributed equally to fibers we have used matrix material of epoxy resin which is a bisphenol- A di-glycidil ether because of its better properties we used it in the fabrication process it has many benefits for using it such as it is not effected by the environmental activities and have better mechanical properties .Due to its better adhesive properties ,and good wetting property we are able to use that

After experimental analysis we were able to find the enhanced mechanical properties of the composite sheet such

Flexural strength	356MPa
Impact strength (notched)	89KJ/m ²
Tensile strength	255MPa
Water absorption	2.7-2.8 g almost negligible
Alkali test	2.55 -2.8g almost negligible

And we have seen that our specimen is completely resistant to acid attack, soil corrosion, and almost negligible amount of water absorption this is a greater significance of composite material for their enhanced results as they can be improved for our upcoming research analysis. Therefore our motive of composite sheet fabrication is fulfilled and all the results give satisfactory results much better than expected.

[4] CONCLUSION

The composite sheet which has been prepared had excellent improvement in the mechanical properties, physical properties and chemical properties .this is mainly due to the presence of different fibers with distinct properties such as the physical properties like soil degradation and water absorption of Kevlar and carbon are superior this results in the environmental effects are almost negligible similarly thermal and other mechanical properties of basalt and Kevlar are perfect and mechanical properties are enhanced

Some of the effects are listed as follows:-

- Toughness of the composite is very high
- Material is completely behaves brittle
- Area to weight ratio are almost negligible as compared to metals
- They are quite light weight
- They have better thermal expansion properties
- Environmental effects are almost negligible
- Impact strength is much higher
- They have better surface finish

These are the basic advantages of composite material, but most important is the weight to volume ratio which is almost negligible and allow these material to be used in the high velocity vehicles, racing cars, aerospace, satellite due to their high impact strength this material can resist against high impact load this allows us to make wear items such as suits and jackets for sports And bullet proofing these were the conclusion which can be made from our research in the project

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