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Effect Of Kevlar Fibre Ly-556 Epoxy Resin on Tensile, Impact, Compressive and Flexural Strength Properties of Fibre Reinforced Plastics

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Abstract:- The main objective of this paper is fabrication and analysis of mechanical properties of FRP composites, comparison of mechanical properties of Kevlar fibre mild steel. A Test piece with kevlar fibers & Epoxy resin LY-556 are fabricated and various mechanical testing is done on both the test pieces and the results have to be compared.
The fabrication is done using the dimensions according to the ASTM standard. The test pieces are tested using Universal Testing Machine. The main purpose of the paper is to determine the best FRP composite from the two test pieces by comparing the tensile strength, flexural strength and impact strength and compressive strength.

Keywords:- Fabrication, Analysis, FRP Composite, Kevlar Fiber, Epoxy Resin LY-556.

I. INTRODUCTION

Composite materials are materials made from two or more constituent materials with significantly different physical or chemical properties, that when combined, produce a material with characteristics different from the individual components. Composite structures, used to meet the demand for lightweight, high strength/stiffness and corrosion-resistant materials in domestic appliances, aircraft industries and fields of engineering composites, have been one of the materials used for repairing the existing structures owing to its superior mechanical properties. Applications of composite materials have been extended to various fields, including aerospace structures, automobiles and robot systems.

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.

FR composites materials offer a combination of strength and elasticity that are better than conventional metallic materials. Composites are superior because of their low specific-gravities, strength-weight ratios. Structural materials such as steel and aluminum alloys are considered isotropic since they exhibit nearly equal properties irrespective of the direction of measurement. Composites consist of two or more phases that are usually processed separately and then bonded, resulting in properties that are different from those of either of the component materials. For many years glass composites have had a distinct strength to weight advantage. Although the rapid evolution of carbon and aramid fibers has gained advantages, glass composite products have still prevailed in certain applications. Resin is a generic term used to designate the polymer, polymer precursor material, and/or mixture or formulation thereof with various additives or chemically reactive components. The resin, its chemical composition and physical properties, fundamentally affect the processing, fabrication and ultimate properties of composite materials. Fillers are inert substances added to reduce the resin cost and/or improve its physical properties, viz., hardness, stiffness and impact strength. Commonly used fillers are iron flakes, calcium carbonate, hydrated alumina and clay.

II. FABRICATION OF FRP COMPOSITES

FRP fabrication consists of suitably combining reinforcement material (Kevlar fiber or carbon fiber) with a matrix material (resin) by a suitable production, process and of curing the resulting moulding into the required product. Fabrication Techniques of composites are (i) making the product by moulding it into shape(ii) making the product by winding the filaments(iii)Making the product by continuous on line production methods(iv)Making the product by centrifugal casting. Hand Lay-up Process is used for the fabrication of the test pieces.

2.1 Procedure of Making the Test Pieces

A mould is prepared for fabrication of the test pieces. The process used is Hand Lay-up process. The mould should be in such a way that the thickness of the test pieces should be 3-4mm as per the ASTM D 638-02a standards. After preparing the mould, 400gms of Epoxy resin should taken and mixed thoroughly with 10 % (20gms) of Hardener. LY-556 is the type of epoxy resin used and K6 is the hardener which is a low viscosity room temperature curing liquid hardener. It is common employed for hand layup applications. The choice of hardener depends on the processing method to be used and on the properties required of the cured composite. Hardener K6 being rather reactive, it gives a short pot life and rapid cure at normal ambient temperatures. Laminates can be subjected to operating temperatures of 100 °C.

Test Piece 1 (Epoxy Resin with Kevlar Fiber): In a mixing jar or pot, 400gms of Epoxy resin and 20gms of K6 hardener as per the ASTM standards is taken. The mixture should be mixed thoroughly with a long stick and a mask should be weared while mixing the resin as Epoxy is very harmful for health if it is inhaled. It should be mixed completely so that the resin is uniform in every part of the mixture. Before mixing it, the Kevlar fibers should cut and should be kept ready. The type of Kevlar fiber used is Kevlar 49. Four no of Kevlar fiber cloths are used for fabrication. As per ASTM 638-02a Standards and the requirement of 3.2mm thickness, 4 pieces of Kevlar type are taken. Kevlar type is found to have 400 gms in weight. The four types of Kevlar fibers should be cut with a dimension of 250*200mm (or) 25*20cm. These Kevlar fibers types should be placed in a specific order as per ASTM D638-02a standards. The order is as follows:

Remover →Kevlar →Resin→ Roving → Kevlar → Resin →Roving → Kevlar →Resin → Roving → Kevlar →Resin → Roving → Kevlar →Resin → Roving → Kevlar

Now the mould is cleaned with Waxpol so that the epoxy resin will not stick to the mould. After applying Waxpol, the mould surface should be cleaned thoroughly by fresh cotton. Then PVA should be applied to the surface of the mould so that the test piece can be easily removed without any loss of material. After applying PVA, it should be kept untouched for 15-20 mins, so that the PVA is fully dried. After that the Epoxy resin mixture should be applied on the surface of the mould with the dimensions of 25*20cm. Place the Kevlar type on it first and then Epoxy resin & the above order should be followed. After Kevlar mat, apply the resin again on it and with the help of a roller, the air bubbles or irregularities should be avoided. This process is continued till the last Kevlar type (see the above order). After the last Kevlar type is placed, the epoxy resin is applied on it and quickly the mould is closed. It will take nearly a whole day for this test piece to dry completely. Next day when the test piece is fully dried, we have to keep it for curing for 7-8 days at room temperature. Only after curing, we should cut our test piece for testing with required dimensions according to the ISO Standards.

Test Piece 2 (Epoxy resin with Kevlar Fibers):- The above is the procedure for the Test piece FRP of Epoxy Resin and Kevlar Fibers. Second Test piece is FRP of Epoxy resin with Kevlar Fibers with different thickness. In a mixing jar or pot, 400gms of Epoxy resin and 20gms of K6 hardener as per the ASTM D256-10 standards is taken. The mixture should be mixed thoroughly with a long stick and a mask should be weared while mixing the resin as Epoxy is very harmful for health if it is inhaled. It should be mixed completely so that the resin is uniform in every part of the mixture. Before mixing it, the Kevlar fibers should cut and should be kept ready. The type of Kevlar fiber used is Kevlar-49. Four type of Kevlar fiber cloth are used for fabrication. As per ASTM D256-10 Standard and the requirement of 6mm thickness are taken. Kevlar type is found to have 400 gms in weight. The four types of Kevlar fibers should be cut with a dimension of 250*200mm (or) 25*20cm. These glass fibers types should be placed in a specific order as per ASTM D256-10 standards. The order is as follows:

Remover → Kevlar → Resin →Roving → Kevlar → Resin →Roving → Kevlar → Resin →Roving → Kevlar → Resin →Roving → Kevlar → Resin →Roving → Kevlar → Resin→ Roving.

	Thickness	**Width**	**Gauge Length**
Units	(mm)	(mm)	(mm)
Epoxy & Kevlar Fibers (Test Piece)	3.2	14.5	50

Now the mould is cleaned with Waxpol so that the epoxy resin will not stick to the mould. After applying Waxpol, the mould surface should be cleaned thoroughly by fresh cotton. Then PVA should be applied

to the surface of the mould so that the test piece can be easily removed without any loss of material. After applying PVA, it should be kept untouched for 15-20 mins, so that the PVA is fully dried. After that the Epoxy resin mixture should be applied on the surface of the mould with the dimensions of 25*20cm. Place the Kevlar type on it first and then Roving cloth & the above order should be followed. After Kevlar
mat, apply the resin again on it and with the help of a roller, the air bubbles or irregularities should be avoided. This process is continued till the last Kevlar type (see the above order). After the last Kevlar type is placed, the epoxy resin is applied on it and quickly the mould is closed. It will take nearly a whole day for this test piece to dry completely. Next day when the test piece is fully dried, we have to keep it for curing for 7-8 days at room temperature. Only after curing, we should cut our test piece for testing with required dimensions.


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III. ANALYSIS OF MECHANICAL PROPERTIES OF FRP COMPOSITES

The performance of a material is judged by its properties and behaviour under tensile, flexural and shear constraints. These properties are also known as static mechanical properties of the materials.

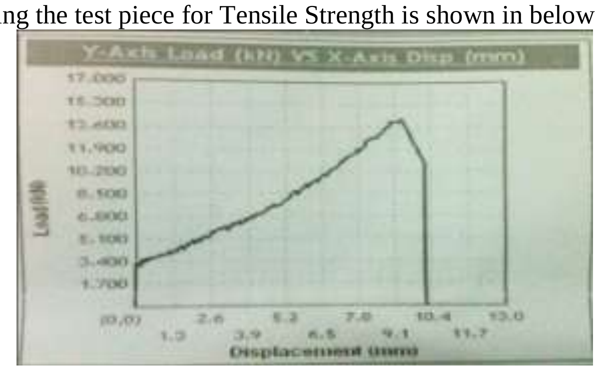
Tensile Properties of Test Piece :

Specimen for Testing Tensile Strength

The Tensile Strength Testing was done at **Jyothi Spectro Analysis Ltd**, Hyderabad. The Input or the dimension of test piece & Gauge Length is shown in below table:

	Max. Force	**Max. Disp.**	**Max. Stress**	**Max. Strain**	**Modulus**
Units	N	mm	N/mm^2	%	N/mm^2
Epoxy & Kevlar Fibers	14250.0	6.6	403.857	13.200	18007.1

The Result we got after testing the test piece for Tensile Strength is shown in below table:



Graph showing the Tensile Strength of Test Piece

Flexural Properties of Test Piece:

The Flexural Strength Testing was done at **Jyothi Spectro Analysis Ltd**, Hyderabad. The Input or the dimension of test piece & Gauge Length is shown in the following table:

	Thickness	Width	Gauge Length
Units	(mm)	(mm)	(mm)
Epoxy & Kevlar Fibers	2.0	12.7	50.8

The Result we got after testing the test piece for Flexural strength is shown in below table:

Sample ID	Bend load (3-point bending) "N"
300 mm * 45 mm * 25 mm KEVLAR FIBRE	100

Impact Strength of Test Piece 1:

The Impact Strength Testing was done at **Jyothi Spectro Analysis Ltd**, Hyderabad. The Input or the dimension of test piece & Gauge Length is shown in below table:

	Thickness	Width	Gauge Length
Units	(mm)	(mm)	(mm)
Epoxy & Kevlar Fibers	6.0	12.7	63.5

The Result we got after testing the test piece for Impact test with the test method ASTM D256-10is shown in below table:

Sample ID	Observed values
100 mm * 20 mm * 6 mm	510J

Compressive Properties of Test Piece:

The Compressive Strength Testing was done at **Jyothi Spectro Analysis ltd**, Hyderabad. The Input or the dimension of test piece & Gauge Length is shown in below table:

	Thickness	Width	Gauge Length
Units	(mm)	(mm)	(mm)
Epoxy & Kevlar Fibers	3.2	30	240

The **Result** we got after testing the test piece for Compressive Strength is shown in below table:

Sample ID	Compressive Load N
240 mm * 30 mm *3.2 mm Kevlar fibre	300
150 mm * 20mm * 2 mm Kevlar fibre	120

IV. CONCLUSIONS

TEST	MILD STEEL	KEVLAR FIBRE
TENSILE STRENGTH	210 Mpa	403Mpa
COMPRESSIVE LOAD	222 N	300 N
BENDING LOAD	70 N	100 N
IMPACT STRENGTH	299 J	510 J

Table.6.1 Comparison of Mechanical Properties of Mild steel and Kevlar fibre

The manufacturing and testing of the specimens have been done and the following conclusions have been drawn

In Universal Testing Machine the tensile strength was found out and it was found that it is greater than mild steel. The tensile strength of Kevlar fibre is 403 Mpa whereas for mild steel it is 210Mpa. In compression test the compressive load was calculated and it was come to known that it is greater than mild steel. The compressive load for Kevlar fibre is 300 N where as for mild steel it is 222 N. In flexural strength the bending load is calculated and it was found to be greater than mild steel. The bending load of Kevlar fibre is 100N where as for mild steel is 70 N. In calculating the impact strength Kevlar fibre exhibits more energy. For Kevlar fibre it is 510 J where as for mild steel it is 299 J.

So we conclude that the Kevlar fibre with LY-556 Epoxy resin give good tensile strength, flexural strength and impact strength which are most useful in aircraft and automobile bodies that reduces weight and gives more strength.

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