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Simulation and Experimental Study of Fiber Reinforced Polymer

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Abstract:- Fiber reinforced polymer composites have played a dominant role for a long time in a variety of application for their high specific strength and modulus. The fiber which serves as a reinforcement in reinforced polymer may be synthetic or natural. In studies show that only synthetic fibers such as glass, carbon have been used in fiber-reinforced polymer. Although the synthetic fiber-reinforced polymer possess less load, high specific strength and stability. The present work describes the development and characterization of a synthetic fiber based polymer composite consisting of glass fiber as reinforcement and epoxy resin as matrix. Fiber reinforced polymer (FRP) composites have become important materials for the new structures and application. Experiments are carried out to study the mechanical properties of FRP.

Keywords:- *FRP, Composite, Fiber reinforcement.*

I. INTRODUCTION

The materials used in civil structures for restoration or firming up the elemental constituent are the fiber-reinforced polymer (FRP) composites. FRP is a compound made up of reinforced fibers of polymer matrix. These are like glass, aramid, basalt and carbon, wood, paper, asbestos etc. FRP composite materials have a significant advantages that includes high stiffness and tensile strength properties, low weight, easy to use, adaptableness to curved surfaces and corrosion proof. Further it is realized that the use of FRP is often governed by strain limits, due to its brittle characteristics. In 1994, Saadatmanesh and Schwegler, were the first researchers to examine the use of FRP for the consolidation of masonry structures. Since then, FRPs are used to strengthen structural masonry components as walls, vaults, arches and to confine columns. Under such conditions, the mechanical properties of FRP involving Young's Modulus, tensile strength, toughness, etc. may suffer great changes. Therefore, the investigation of the mechanical properties of FRP composites under dynamic loadings and different temperatures is essential to design the structures with this kind of materials.

II. EXPERIMENTAL SETUP

FRP is a compound made up of reinforced fibers of polymer matrix. The collection of FRP bars for depends on numerous matters according to structural point of view. Fiber plastics have various application due to its corrosion resistance, light weight, and non-magnetic property with high tension strength, good toughness, less mechanical reduction and resistance in high fatigue5.Generally, due to its initial and maintenance cost these composite materials were restricted in RC construction use. Excessive corrosion due to climate of coastal belt and continuous use as ice reducing material on roads and bridges are sufficiently captivated so as to study for corrosion less FRP materials. Numerous types of FRP bars for structural purposes having mass-produced now a days starting from 1-D bars and cables to 2-Dlattices and network Formation of FRP is done using hand layup methods shown below

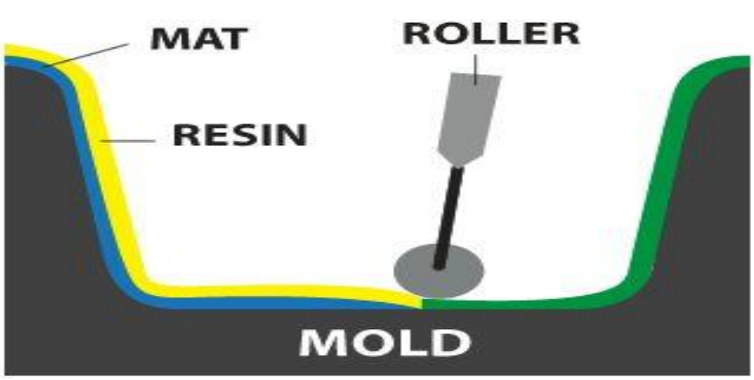

Fig 1:- Hand Lay Up Method

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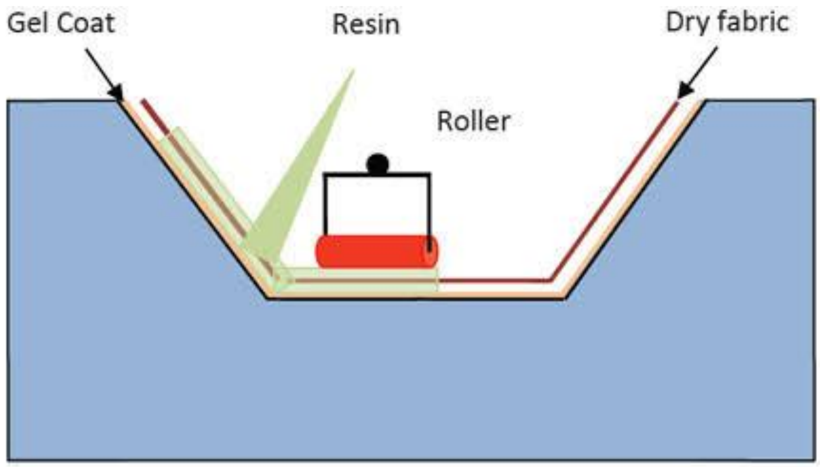


Fig 2:- Hand Lay Up Method

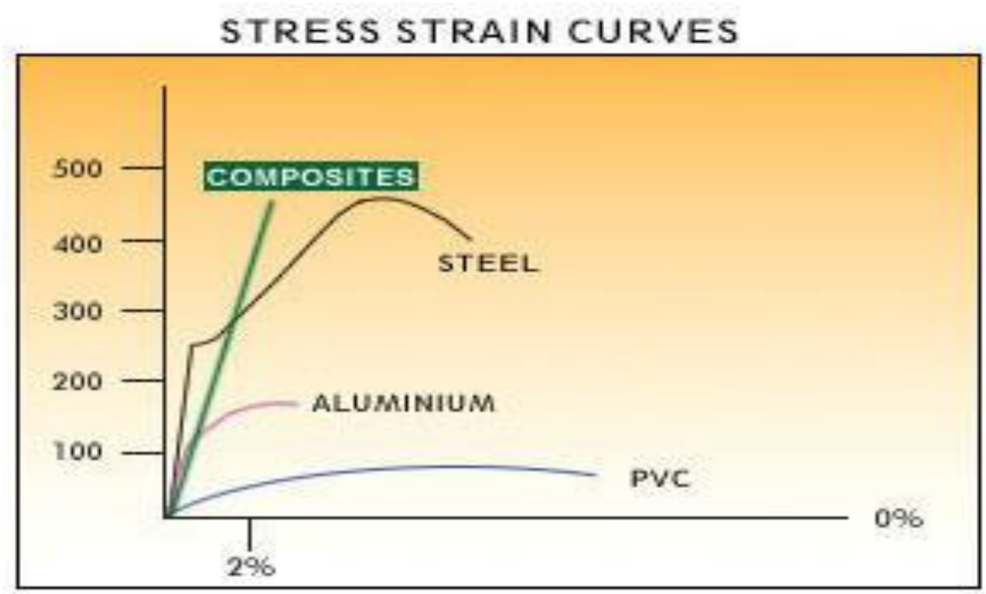
The characteristics of GFRP and CFR reinforcements and tendons with steel bars are highlighted in Table 1.

Tensile Propeties	Steel Bar	Steel Tendon	GFRP Bar	GFRP Tendon	CFRP Tendon
Ultimate Strength, ksi	70 - 100	200 - 270	75 - 175	200 - 250	240 - 350
Elastic Modulus, ksi	29,000	27 - 29,000	6 - 8,000	7 - 9,000	22 - 24,000
Specific Gravity	7.9	7.9	1.5 - 2.0	2.4	1.5 - 1.6
Tensile Strain, %	>10	>4	3.5 - 5.0	3.0 - 4.5	1.0 - 1.5
Thermal Coeff. $x10^{-6}$/°F	Longitudinal: 6.5	6.5	5.5	5.5	0.38 to -0.68

Table 1: Physical Properties of FRP Composites and Steel bars

III. THE FORMATION OF FRP

Basically, there are two processes through which a polymer is established: step-wise polymerization and additive polymerization. Composite plastics are molded when a group of consistent material possessing different properties are combined to form a concluding product having wished characteristics in mechanical way. These are of two types, fiber reinforced and particle reinforced. Fiber reinforced plastic belongs to that category of mechanical strength and elasticity as incorporated in fiber materials. The matrixes the core material which is devoid of fiber reinforcement. It is hard but relatively weaker and must be hardened through the addition of powerful reinforcing fibers or filaments. This fiber is critical in differentiating the FRP parental polymer. Most of these plastics are made through different molding methods wherein a mold or a tool is used to put the fiber pre-form, constructing dry fiber or fiber holding a specific resin proportion. "Curing" occurs by „wetting" dry fibers with resin, wherein the matrix and fibers assume the molds form. There is irregular activities of pressure and heat in this stage. The various processes comprise bladder molding, compression molding, autoclave, mandrel wrapping, wet layup, filament winding.



Graph 1: Schematic Diagram of stress vs strain with respect to behavior of Composites in comparison with Steel, Aluminium, PVC

IV. COMMON PROPERTIES OF FRPS

These composite components generally indicate high strength and low weight8. These components are very strong and these are used by the automotive industry for replacing some of the metal in cars. Fiber reinforced plastic are as strong as some metals but they are lighter and more fuel efficient. The characteristics of fiber reinforced plastics are customized to suit a wide range requirement. FRP composites have compressive and impressive electrical properties. They display high grade environmental resistance. The manufacturing process is an important factor and it is quite cost effective. This process makes FRP materials a favorite among various industrial sectors. The productivity rate is medium to high and a ready bonding is indicated with different components. The other independent characteristic of fiber reinforced plastics include laudable thermal insulation, fire hardness, structural integrity along with UV radiation stability, resistance to chemicals and other eroding materials. The properties of fiber reinforced plastics are subjected to some factors like the relative volume of both these components, mechanical properties of the fiber and matrix, and the length of the fiber and orientation within the matrix.

V. COMMON FIBERS INCLUDE

A. Glass

It is a good insulating component. It constructs glass reinforced plastic or fiberglass, when mixed with the matrix. It is less strong, less rigid, less brittle, and less expensive than carbon fiber.

Fig 3:- Glass fiber

B. Carbon based fiber reinforced plastics

Temperature, high tensile strength, tolerance, stiffness, chemical resistance are offered by carbon based fiber reinforced plastics along with low thermal expansion and weight. The carbon atoms construct crystals which lie usually along long axis of the fiber. The ratio of strength to volume is made high by this classification. This classification makes the material strong.

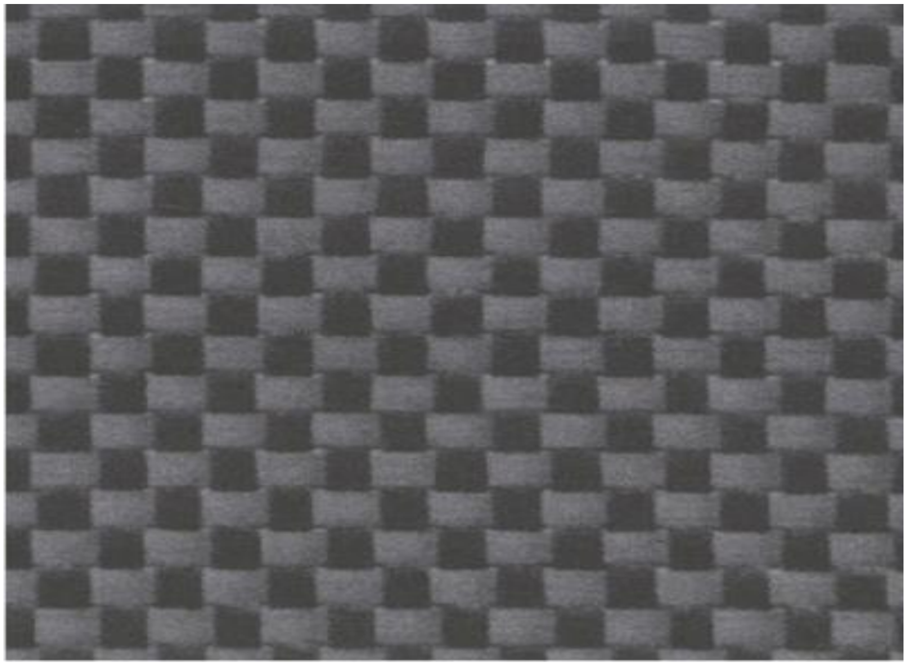


Fig 4:- Carbon fiber

C. Aramid

It has vast usefulness in various industries. Robust and heat-resistant synthetic fibers are the results of aramid fiber components.

Fig 5:- Carbon Aramid Hybrid Fabric Cloth

D. Epoxy

It is used to transmit loads between the fibers which holds the fibers tightly and protect the fibers from damages occurs from environmental and mechanical conditions.

Fig 6:- Seamless Epoxy Floor Resurface Covers Damaged Floors

E. Filler

It is used to improve the performance by lowering the compound cost. They control the shrinkage, make the surface smooth and it is used as a crack resistance.

F. Additive

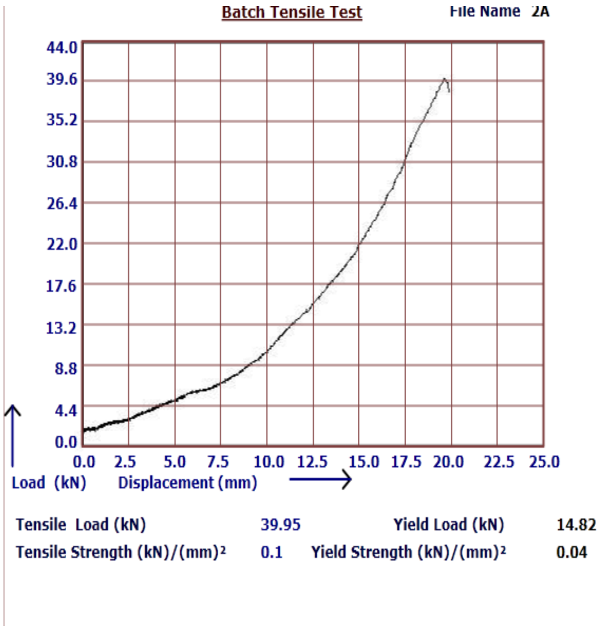
It enhance the durability and usefulness of the polymer.

VI. RESULT AND DISCUSSION

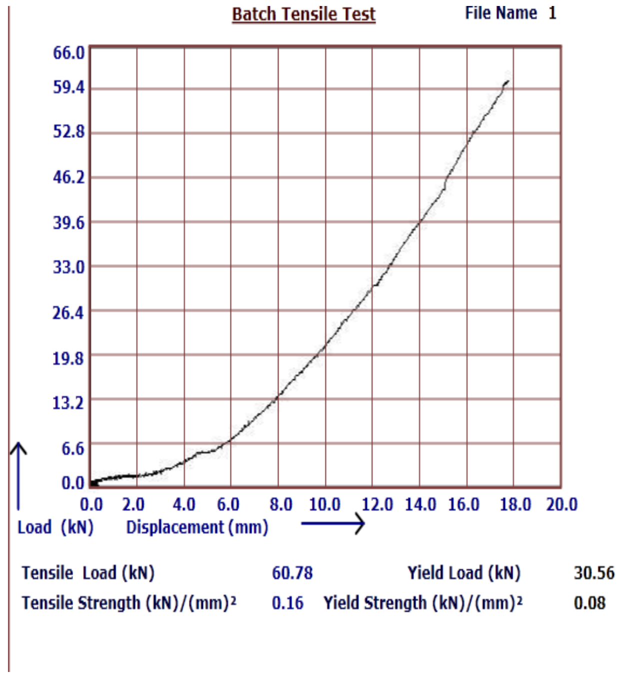
A. Strain Rate Effect On Tensile Properties

The primary physical properties for GFRP considered for the design is

- Ultimate tensile strength
- Strain at break
- Modulus of elasticity
- Maximum tensile strength is 160 N/mm^2
- Minimum tensile strength is 140 N/mm^2



Graph 2: Load Vs Displacement for Specimen 1



Graph 3: Load Vs Displacement for Specimen 2

VII. SCANNING ELECTRON MICROSCOPE

A scanning electron microscope (SEM) is a type of electron microscope that produces images of a sample by scanning the surface with a focused beam of electrons. The electrons interact with atoms in the sample, producing various signals that contain information about the sample's surface topography and composition. The electron beam is scanned in a raster scan pattern, and the beam's position is combined with the detected signal to produce an image. SEM can achieve resolution better than 1 nanometer. Specimens can be observed in high vacuum in conventional SEM, or in low vacuum or wet conditions in variable pressure or environmental SEM, and at a wide range of cryogenic or elevated temperatures with specialized instruments.

VIII. THE MICROSCOPIC IMAGE

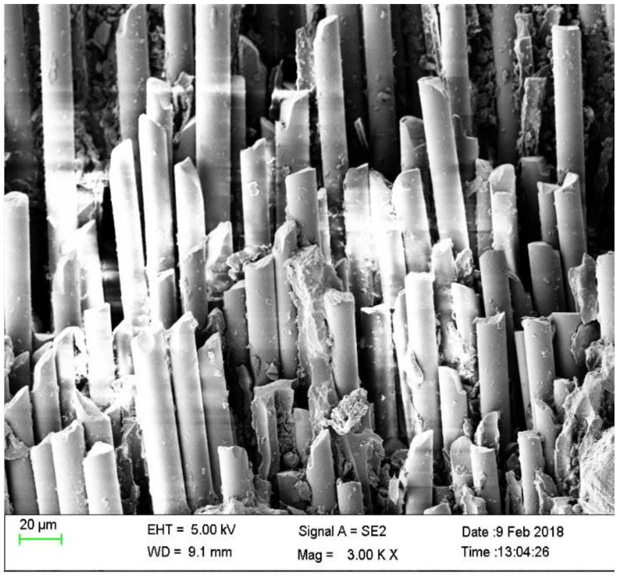


Fig 7:- Magnification 3000X

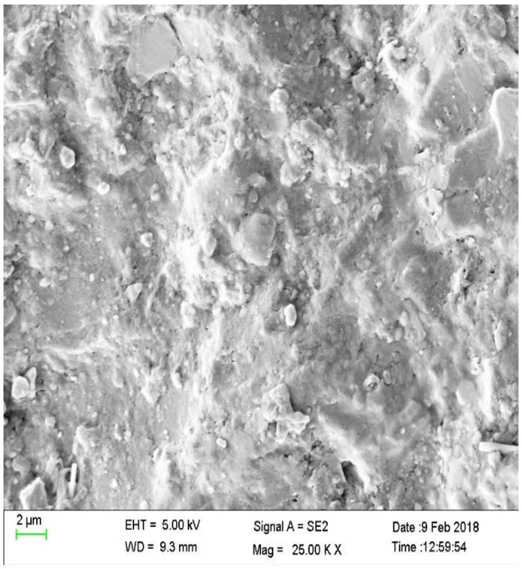


Fig 8:- Magnification 25000X

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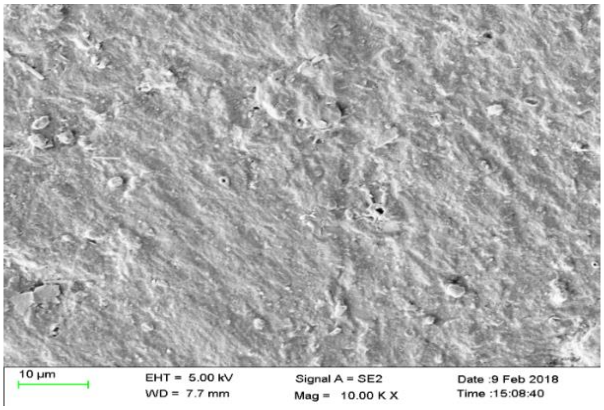


Fig 9:- Magnification 3000X

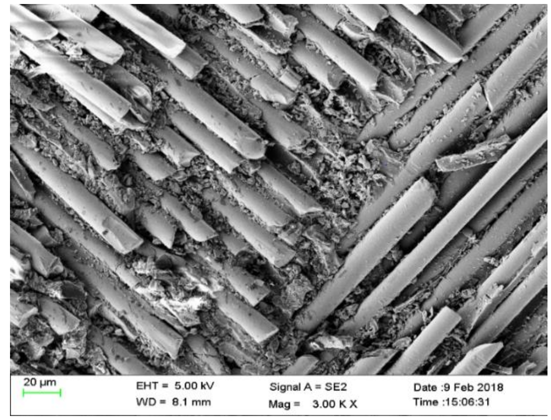


Fig 10:- Magnification 10000X

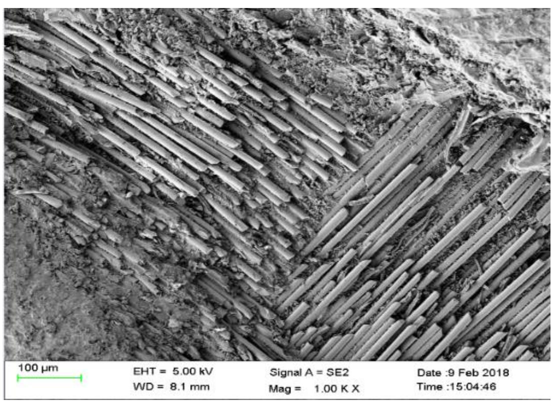


Fig 11:- Magnification 1000X

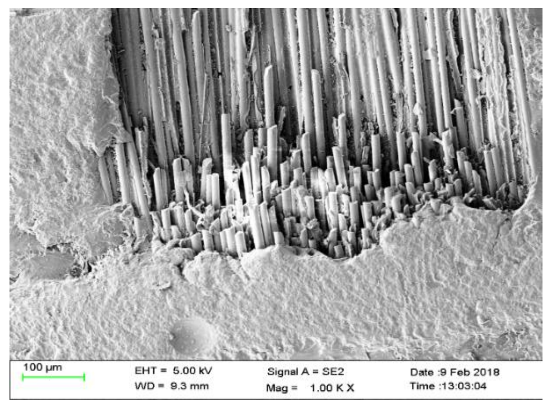


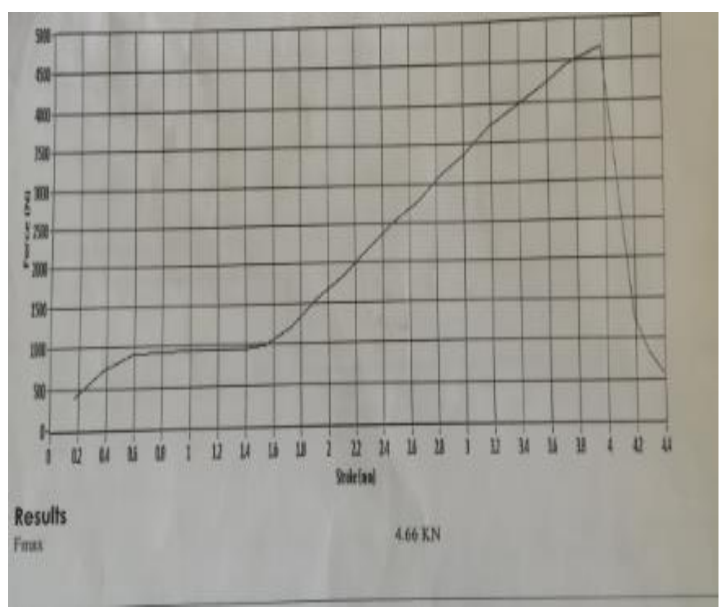
Fig 12:- Magnification 1000X

IX. FLEXURAL STRENGTH

Flexural strength, also known as modulus of rupture, or bend strength, or transverse rupture strength is a material property, defined as the stress in a material just before it yields in a flexure test. The transverse bending test is most frequently employed, in which a specimen having either a circular or rectangular cross-section is bent until fracture or yielding using a three point flexural test technique. The flexural strength represents the highest stress experienced within the material at its moment of yield. It is measured in terms of stress, here given the symbol.

Mode of test	: Compression
Sample type	: Flat
Thickness	: 14.68mm
Width	: 24.78mm
Area	: 363.77mm^2
Gauge length	: 100.00mm

X. FLEXURAL LOAD GRAPH



Graph 4: Stroke (mm) vs Force (N)

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Maximum Flexural load of GFRP (Fmax) = 4.66KN

XI. BARCOL HARDNESS

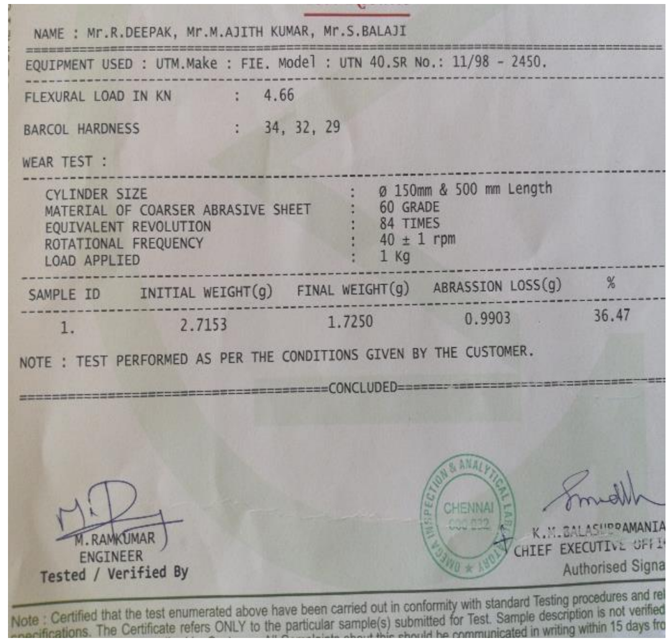
The Barcol hardness test characterizes the indentation hardness of materials through the depth of penetration of an indenter, loaded on a material sample and compared to the penetration in a reference material. The method is most often used for composite materials such as reinforced thermosetting resins or to determine how much a resin or plastic has cured. The test complements the measurement of glass transition temperature, as an indirect measure of the degree of cure of a composite. It is inexpensive and quick, and provides information on the cure throughout a part.

BARCOL HARDNESS of GFRP: 34, 32, 29

XII. WEAR TEST

Wear is related to interactions between surfaces and specifically the removal and deformation of material on a surface. Mechanical wear is caused by most use of metal by sliding, impact, cutting etc. The wear percentage of FRP is 36.47% surface as a result of mechanical action of the opposite

Fig 13:- Wear Specimen



NAME : Mr.R.DEEPAK, Mr.M.AJITH KUMAR, Mr.S.BALAJI

EQUIPMENT USED : UTM.Make : FIE. Model : UTN 40.SR No.: 11/98 - 2450.

FLEXURAL LOAD IN KN : 4.66

BARCOL HARDNESS : 34, 32, 29

WEAR TEST :

CYLINDER SIZE : ø 150mm & 500 mm Length
MATERIAL OF COARSER ABRASIVE SHEET : 60 GRADE
EQUIVALENT REVOLUTION : 84 TIMES
ROTATIONAL FREQUENCY : 40 ± 1 rpm
LOAD APPLIED : 1 Kg

SAMPLE ID	INITIAL WEIGHT(g)	FINAL WEIGHT(g)	ABRASSION LOSS(g)	%
1.	2.7153	1.7250	0.9903	36.47

NOTE : TEST PERFORMED AS PER THE CONDITIONS GIVEN BY THE CUSTOMER.

CONCLUDED

M.RAMKUMAR
ENGINEER
Tested / Verified By

CHENNAI

K.M.BALASUBRAMANIA
CHIEF EXECUTIVE OFFI
Authorised Signa

Note : Certified that the test enumerated above have been carried out in conformity with standard Testing procedures and rel
specifications. The Certificate refers ONLY to the particular sample(s) submitted for Test. Sample description is not verified
should be communicated in writing within 15 days fro

Fig 14:- Wear Result

XIII. SIMULATED VALUES

Ansys Workbench is a software environment performing structural, thermal, electromagnetic, analyses. The classes focuses on geometry creation and optimization, attaching existing geometry setting up a finite element model, solving and reviewing results.

TENSILE VALUES:

SPECIMEN

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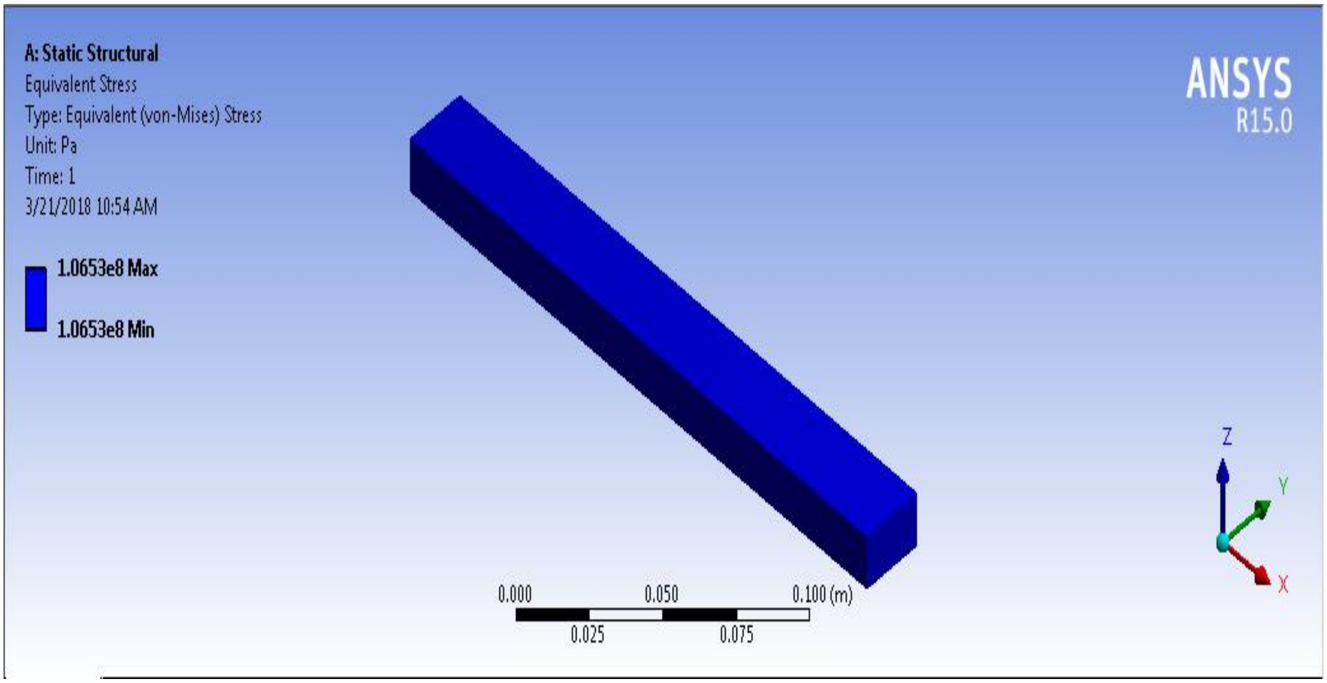

Fig 15:- Maximum Stress for Specimen 1

Maximum Tensile strength value is 106.53 MPa

SPECIMEN 2

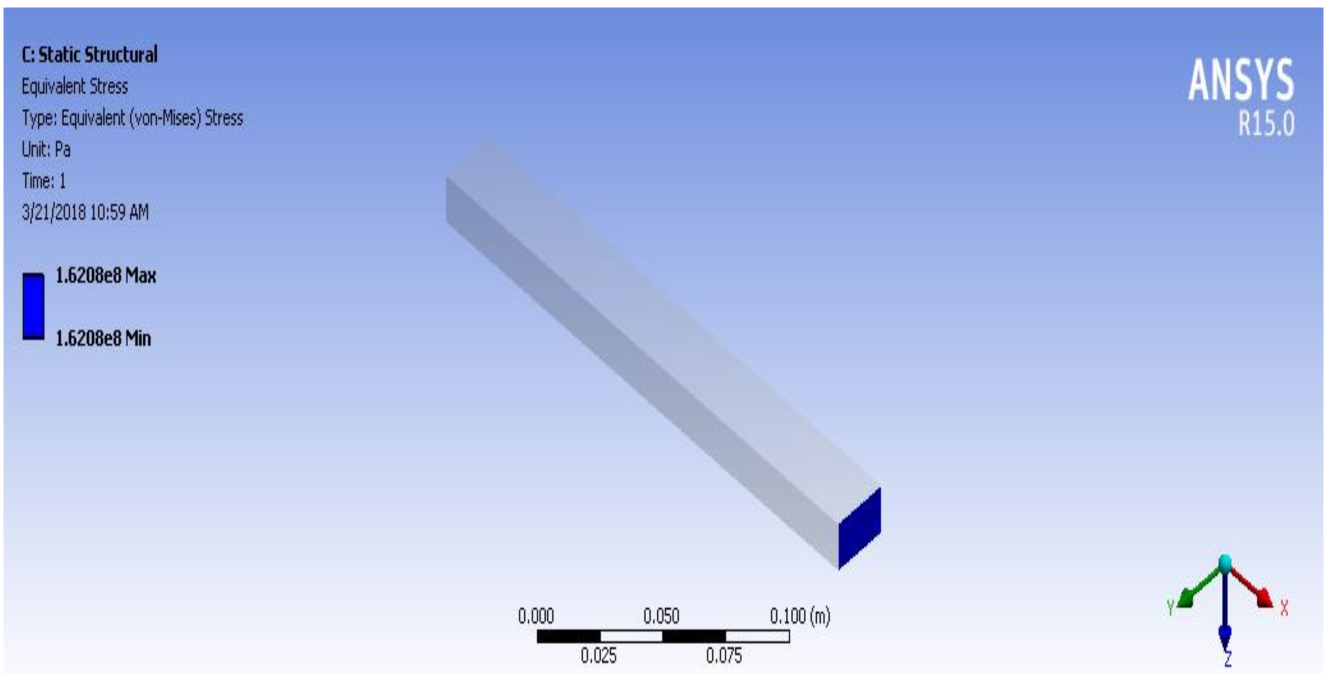

Fig 16:- Maximum Stress for Specimen 2

Maximum Tensile strength value is 162.08 MPa

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XIV. FLEXURAL TEST

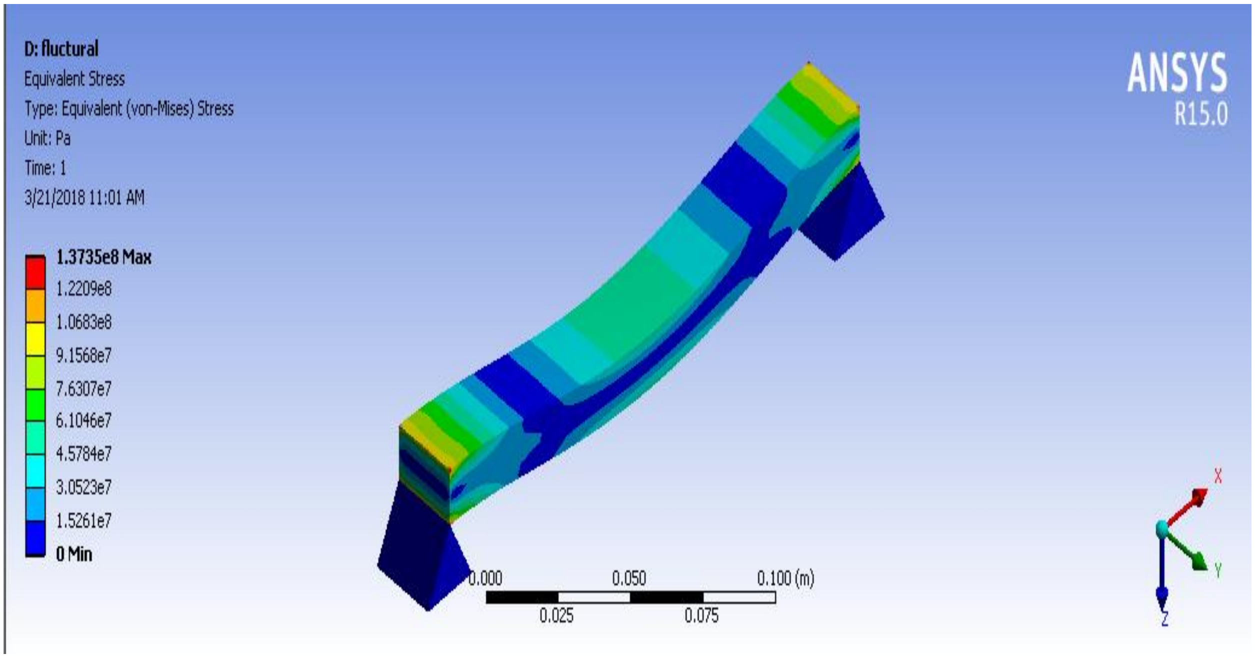

Fig 17:- Maximum Flexural Strength

Maximum Flexural strength is 137.35MPa

XV. COMPARISION OF TENSILE RESULTS

TEST	SPECIMEN 1		SPECIMEN 2	
	THEORITICAL	EXPERIMENTAL	THEORITICAL	EXPERIMENTAL
TENSILE STRENGTH (MPa)	106.53	100	162.08	160

Table 2: Comparison of tensile results Theoretical Vs Experimental

XVI. COMPARISION OF FLEXURAL RESULTS

TEST	SPECIMEN	
	THEORITICAL	EXPERIMENTAL
FLEXURAL STRENGTH (MPa)	137.35	130.89

Table 3: Comparison of Flexural results Theoretical Vs Experimental

XVII. CONCLUSION

From the above information we have conclude that, we are undergoing a various mechanical test. In that we obtain a tensile strength of 162.08, 106.53 MPa in theoretically 160,100 MPa in experimentally. In our material the percentage of fiber is more than the percentage of epoxy resin we have added which gain more tensile strength even though tensile strength increases with increase in composition on epoxy resin. But in our material it is mainly due to alternative arrangement of the fiber. Flexural strength of FRP is 137.53 MPa theoretically 130.89 experimentally. From the analysis of FRP we get an experimental value near to the theoretical value. Due to its high strength and low weight, FRP is mostly used in Helicopters, Aerospace industries, Wind mill Blades. The wear rate of FRP is also low. The hardness number of FRP is 34, 32, 29 which shows the resins are perfectly cured.

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