A Research Paper on Experimental Investigations of Mechanical Properties of Composite Material (Epoxy and Graphite fibers) used for Manufacturing Industry Application

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Abstract— In this research composite material is manufactured by using hand layup method and mechanical properties are investigated. By using natural fibers with the epoxy and graphite fibers, the mechanical properties of the composite material show better results. The advantage of composite materials over conventional materials are largely from their higher specific strength, stiffness and fatigue characteristics, which enables structural design to be more versatile. By definition, composite materials consist of two or more constituents with physically separable phases. Tensile strength and bending strength after testing found is very high as compared other composite material with natural fibers. At the end it is found that, this graphite/epoxy/coconut coir composite material is feasible for the mechanical application. Also it is found that tensile and bending strength is high. Fiber-reinforced polymer composites have played a dominant role for a long time in a variety of applications for their high specific strength and modulus. The fiber which serves as a reinforcement in reinforced plastics may be synthetic or natural. Past studies show that only synthetic fibers such as glass, carbon etc., have been used in fiber-reinforced plastics. Although glass and other synthetic fiber-reinforced plastics possess high specific strength, their fields of application are very limited because of their inherent higher cost of production. In this connection, an investigation has been carried out to make use of coconut coir, a natural fiber abundantly available in India. Natural fibers are not only strong and lightweight but also relatively very cheap.

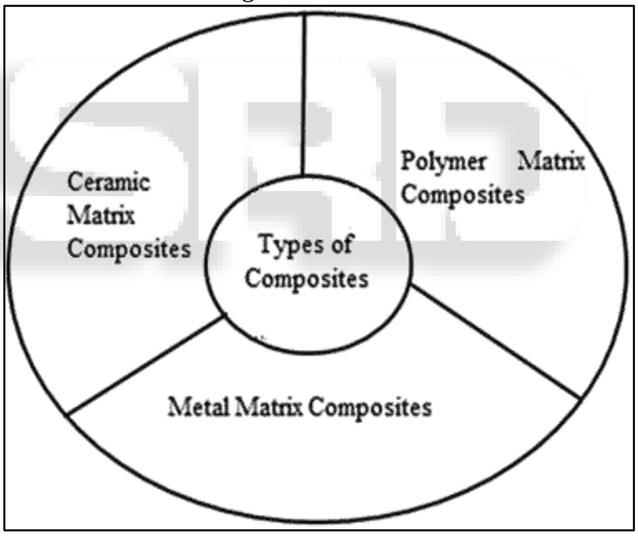
Keywords: Composite Material, Properties of Composite Material

I. INTRODUCTION

The advantage of composite materials over conventional materials are largely from their higher specific strength, stiffness and fatigue characteristics, which enables structural design to be more versatile. By definition, composite materials consist of two or more constituents with physically separable phases. Composites are materials that comprise strong load carrying material (known as reinforcement) embedded in weaker material (known as matrix).Reinforcement provides strength and rigidity, helping to support structural load. The matrix or binder (organic or inorganic) maintains the position and orientation of the reinforcement. Significantly, constituents of the composites retain their individual, physical and chemical properties; yet together they produce a combination of qualities which individual constituents would be incapable of producing alone. The reinforcement may be platelets, particles or fibers and are usually added to improve mechanical properties such as stiffness, strength and toughness of the matrix material. Long fibers that are oriented in the direction of loading offer the most efficient load transfer. This is because the stress transfer zone extends only over a small part of the fiber-matrix interface and perturbation effects at fiber ends may be neglected. In other words, the ineffective fiber length is small. Popular fibers available as continuous filaments for use in high performance composites are glass, carbon and pyramid fibers.

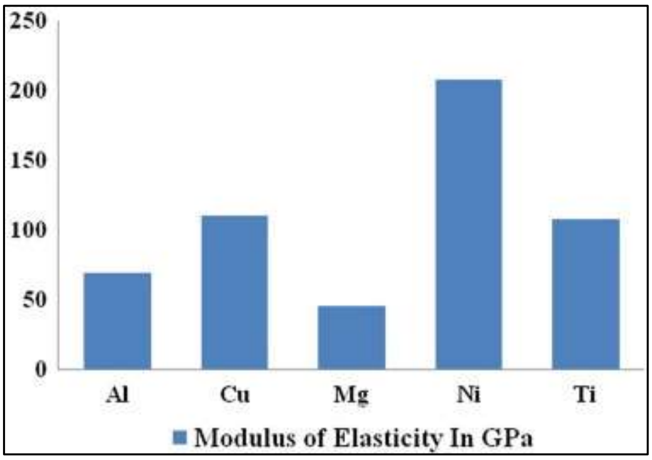
A. *Types of Composites*

For the sake of simplicity, however, composites can be grouped into categories based on the nature of the matrix each type possesses .Methods of fabrication also vary according to physical and chemical properties of the matrices and reinforcing fibers.



1) *Metal Matrix Composites (MMCs)*

Metal matrix composites, as the name implies, have a metal matrix. Examples of matrices in such composites include aluminium, magnesium and titanium. The typical fiber includes carbon and silicon carbide. Metals are mainly reinforced to suit the needs of design. For example, the elastic stiffness and strength of metals can be increased, while large co-efficient of thermal expansion, and thermal and electrical conductivities of metals can be reduced by the addition of fibers such as silicon carbide.[11]

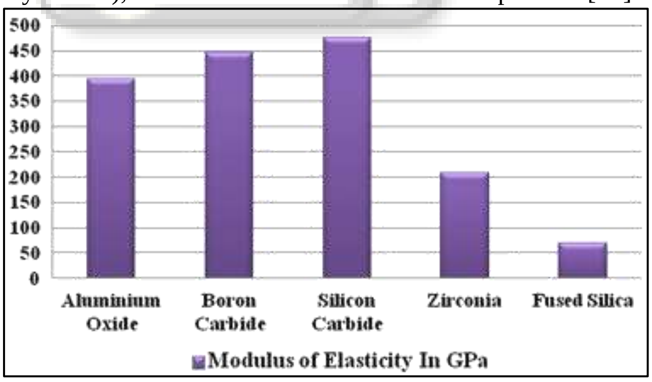


2) Ceramic Matrix Composites (CMCs)

Ceramic matrix composites have ceramic matrix such as alumina, calcium, alumino silicate reinforced by silicon carbide. The advantages of CMC include high strength, hardness, high service temperature limits for ceramics, chemical inertness and low density. Naturally resistant to high temperature, ceramic materials have a tendency to become brittle and to fracture.

Composites successfully made with ceramic matrices are reinforced with silicon carbide fibers. These composites offer the same high temperature tolerance of super alloys but without such a high density. The brittle nature of ceramics makes composite fabrication difficult.

Usually most CMC production procedures involve starting materials in powder form. There are four classes of ceramics matrices: glass (easy to fabricate because of low softening temperatures, include borosilicate and alumino silicates), conventional ceramics (silicon carbide, silicon nitride, aluminum oxide and zirconium oxide are fully crystalline), cement and concreted carbon components.[11]



3) Polymer Matrix Composites (PMCs)

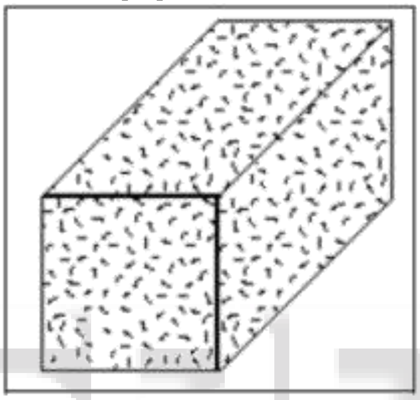
The most common advanced composites are polymer matrix composites. These composites consist of a polymer thermoplastic or thermosetting reinforced by fiber (natural carbon or boron). These materials can be fashioned into a variety of shapes and sizes. They provide great strength and stiffness along with resistance to corrosion. The reason for these being most common is their low-cost, high strength and simple manufacturing principles.

Due to the low density of the constituents the polymer composites often show excellent specific properties.[11]

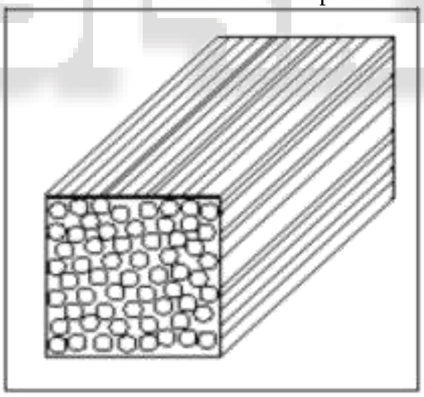
B. Composites Based on Reinforcing Material

1) Fibrous Composite:

A fiber is characterized by its length being much greater compared to its cross-sectional dimensions. The dimensions of the reinforcement determine its capability of contributing its properties to the composite. Fibers are very effective in improving the fracture resistance of the matrix since are enforcement having a long dimension discourages the growth of incipient cracks normal to the reinforcement that might otherwise lead to failure, particularly with brittle matrices. Man-made filaments or fibers of non polymeric materials exhibit much higher strength along their length since large flaws, which may be present in the bulk material, are minimized because of the small cross-sectional dimensions of the fiber. In the case of polymeric materials, orientation of the molecular structure is responsible for high strength and stiffness.[11]



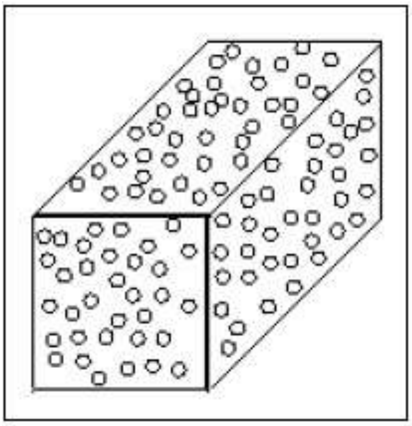
Short-fibre reinforced composites



Long- fibre reinforced composites

2) Particulate Composites:

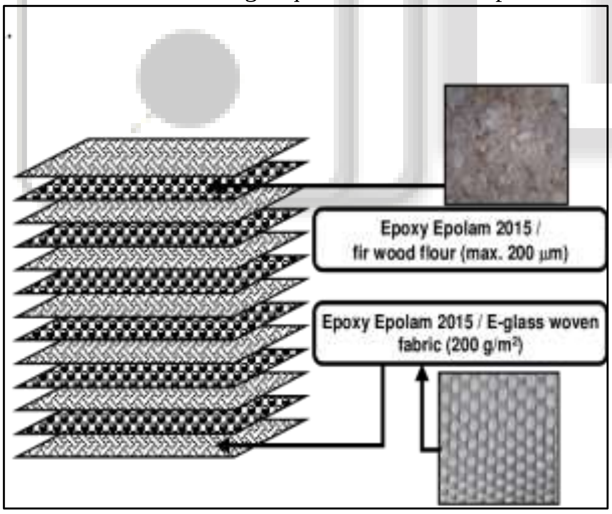
In particulate composites the reinforcement is of particle nature. It may be spherical, cubic, tetragonal, a platelet, or of other regular or irregular shape. In general, particles are not very effective in improving fracture resistance but they enhance the stiffness of the composite to a limited extent. Particle fillers are widely used to improve the properties of matrix materials such as to modify the thermal and electrical conductivities, improve performance at elevated temperatures, reduce friction, increase wear and abrasion resistance, improve machinability, increase surface hardness and reduce shrinkage.[11]



Particulate Composites

3) Hybrid Composite

Hybrid composites are more advanced composites as compared to conventional FRP composites. Hybrids can have more than one reinforcing phase and a single matrix phase or single reinforcing phase with multiple matrix phases or multiple reinforcing and multiple matrix phases. They have better flexibility as compared to other fiber reinforced composites. Normally it contains a high modulus fiber with low modulus fiber. The high-modulus fiber provides the stiffness and load bearing qualities, whereas the low-modulus fiber makes the composite more damage tolerant and keeps the material cost low. The mechanical properties of a hybrid composite can be varied by changing volume ratio and stacking sequence of different plies.[11]



C. Natural Fiber Composites

Fiber-reinforced polymer composites have played a dominant role for a longtime in a variety of applications for their high specific strength and modulus. The manufacture, use and removal of traditional fiber–reinforced plastic, usually made of glass, carbon or aramid fibers–reinforced thermoplastic and thermoset resins are considered critically because of environmental problems. By natural fiber composites we mean a composite material that is reinforced with fibers, particles or platelets from natural or renewable resources, in contrast to for example carbon or aramide fibers that have to be synthesized. Natural fibers include those made from plant, animal and mineral sources.[6]Natural fibers can be classified according to their origin.

II. Literature Review:

Samson Rwawiire et al expressed that optimum curing temperature of bio-degradable bark cloth reinforced green epoxy composites was shown to be 1200C. The static properties showed a tensile strength of 33 MPa and flexural strength of 207 MPa and the dynamic mechanical properties showed excellent fiber-matrix bonding of the alkali treated fabric with the green epoxy polymer with glass transition temperature in the range of 1600C to 1800C.Treatment of the fabric with alkali positively influenced the mechanical properties of the fabric reinforced bio-composites [1].

Chandra Mohan et al concentrates on biomaterials progress in the field of orthopedics. An effort to utilize the advantages offered by renewable resources for the development of bio-composite materials based on bio epoxy resin and natural fibers such as Agave sisalana; Musa sepientum; Hibiscus sabdariffa and its application in bone grafting substitutes. Tensile strength of composites is four to six times greater than that of steel or aluminium (depending on the reinforcements), improved torsional stiffness and impact properties, higher fatigue endurance limit (up to 60% of ultimate tensile strength) and 30% - 40% lighter for example any particular aluminium structures designed to the same functional requirements [2]

Savita Dixit et al expressed that natural fiber reinforced polymer composite material are replacing synthetic materials to a great extent due to its eco-friendly, non-toxic and biodegradable nature. This material is cheap and has good insulation property, machine wear, low density and abundance in quantity. The chemically treated natural fibre shows better improvement in properties than untreated fibers because of fiber has improved interfacial adhesion between fibre surface and polymer matrix and have shown better results in impact toughness and fatigue strength [3].

T. Madhusudhan et al suggested that, hybridization of natural fibers with synthetic fibers decreases the maximum absorption and increases the mechanical properties of the composites. Epoxy resin can be preferred first among the polyester resin and vinyl ester resin will result in the strong bond for the materials. By adding the filler material silicon carbide to the composite material we can further improve the performance of composites. The increasing in filler content tended to increased modulus and hardness but decreased tensile strength of the composite. Natural rubber/jute untreated can improve mechanical properties of composite more than natural rubber/jute treated [4]

Layth Mohammed et al said that, using natural fibers as reinforcement for polymeric composites introduces positive effect on the mechanical behavior of polymers. This paper evaluates the characteristics and properties of natural fiber reinforced polymer composites: mechanical, thermal, energy absorption, moisture absorption, biodegradability, flame retardancy, tribology properties. Viscoelastic behavior and relaxation behavior of NFPCs are researched. The effects of chemical treatment of the natural fiber properties were also addressed. The physical and mechanical properties of these NFPCs can be further enhanced through the chemical treatment, while moisture absorption of the NFPCs can be reduced through surface modification of fibers such as alkalization and addition of coupling agents [5]

Vinay K Singh et al. suggested that, experimental results showed that density, ultimate strength, modulus of elasticity and % elongation decreases with wt% of shell particle with in this range wt% 20-35 of reinforcement. Tensile strength of 25 MPa and modulus of elasticity of 654 MPa were retained even after of 35% reinforcement. Properties were comparable for application only with compromising slightly with matrix property. Increase of wt% of reinforcement requires pressurized fabrication technique or addition of any adhesion increasing additive. Increase of proportion of particle size less than 200µm would be helpful to increase density as well as tensile properties [6]

Guido D Bella et al. said that Natural fibers are mainly attractive for the following reasons: specific properties, price, health advantages and recyclability. Particularly, industry is getting more and more interested in environment-friendly products and therefore the research on natural fiber based on composite materials is gaining importance. Some of the benefits linked to the usage of such natural composites are their low density and good specific properties. Mechanical, physical and even chemical properties of these fibers are strongly harvest-dependent, influenced by climate, location, soil characteristics, and weather circumstances polymer matrix. In. the last few years several new components based on natural fiber composites have been mainly developed by industries in the automotive field; i.e. in 2003 around 43,000 tonnes of natural fiber have been used by the European automotive industry as composite reinforcement. This interest is due to the excellent tensile mechanical properties of fiber obtained from plants such as flax, hemp and the stinging nettle.[7]

S. Saravanan et suggested that this work shows that successful fabrication of a Palm tree fiber reinforced epoxy composites by simple hand lay-up technique. Mechanical characteristics of these composites can be successfully analyzed. It found that polymer reinforced Palm tree natural composite is the best natural composites among the various combination. It can be used for manufacturing of automotive seat shells, plywood, automobile body, construction board, insulation board, flooring and manufacturing of chair and seat among the other natural fiber Combition.[8]

Nayeem Ahmed et al found that the Hybrid Composite exhibited more tensile and mechanical properties when compared to the Glass Fiber composites irrespective of their thickness. When the comparison was carried out between the hybrid & GFRP composites of the different thicknesses, the difference between the tensile strengths of hybrid & GFRP composites of 4mmthickness is less when compared to the difference of strengths of 2mm & 3mm thick composites, which shows the weak bond of 4mm thick hybrid composite lamina. Addition of graphite in composite enhances the thermal properties of the composite as graphite is the good conductor. With this study it is concluded that composition of multiple materials leads to the improvement in mechanical and thermal properties [9].

Abu Bakar1 et al suggested that the mechanical properties and thermal degradation temperature of EFB-filled PVC-U composites were strongly affected by the EFB fiber contents, whereas the glass transition temperature (Tg) only showed significant improvement at high fiber contents (40 phr). Meanwhile an insignificant change in the HDT was found when the fiber content increased from 0 to 40 phr. The increase in EFB fiber content in the PVC-U matrix improved the flexural modulus and caused a slight increase in glass transition temperature. On the other hand, the impact and flexural strength decreased with EFB fiber content and EFB fibers are also found to accelerate the thermal degradation of the composites and the degradation temperature (T5%) decreased with fiber content [10].

Zhaoqing Li et al indicated that after being infiltrated with EP, the bending strength and tensile strength of the GF/PF/EP composites increased by 30% and 42.8%, respectively. Moreover, the flexural strength and tensile strength of the GF/PF/EP composite increased with the increase of the glass fiber content. More importantly, the three-phase composites showed high electrical properties. Significant improvement in the dielectric constant, electric breakdown strength, and resistivity with the increase in the content of glass fiber was observed [11].

S. PADMA PRIYA et al suggested that tensile and flexural properties of silk fabric-reinforced composites are observed to have improved by the incorporation of glass fabric in it, showing a positive hybrid effect. At the optimum loading of both glass fabric and silk fabric (i.e., 50/50), the strength seemed to have almost doubled. It is also observed that the water absorption tendency of composites decreases by the process of hybridization. It has also been observed that the properties increase with the increase in the weight fraction of reinforcement content to the maximum extent. Thus silk-glass/epoxy hybrid composites resulted in having enhanced mechanical properties [12].

III. Objectives of the Project:

The knowledge gap in the existing literature review has helped to set the objectives of this research work which are outlined as follows:

- To develop a new class of coconut coir reinforced Epoxy based composites to explore the potential of coconut coir
- Experimental investigation of mechanical properties such as tensile strength and flexural strength of coconut coir fiber reinforced epoxy resin composite. Mechanical Study help to assess strength of composite material.
- To study the effect of various thicknesses of the sample with constant fiber length and variable volume fraction of coconut coir reinforced Epoxy composites.
- Comparison of experimental mechanical properties of coconut coir fiber reinforced with epoxy resin composite to other composites.

– Comparison of experimental mechanical properties of coconut coir fiber reinforced Epoxy resin composite to FEA.

IV. MATERIALS AND METHODOLOGY

The raw materials used in this work are

1) Coconut coir fibers.
2) Graphite fibers.
3) Epoxy resin

A. *Coconut coir fiber :*

Coir is a lignocelluloses natural fiber. It is a seed-hair fibe robtained from the outer shell, or husk, of the coconut, the fruit of Cocosnucifera, a tropical plant of the Arecaceae (Palmae)family.

PROPERTIES	COCONUT COR FIBRE
Moisture content %	10-11
Density (kg/m^3)	1104
Flexural modulus (GPa)	2-5
Lumen size (mm)	5
Tensile strength (MPa)	15-327
Young"s modulus (GPa)	4-6

B. *Graphite fibers:*

Carbon fiber is defined as a fiber containing at least 92 wt % carbon, while the fiber containing at least 99 wt % carbon is usually called a graphite fiber [1]. Carbon fibers generally have excellent tensile properties, low densities, high thermal and chemical stabilities in the absence of oxidizing agents, good thermal and electrical conductivities, and excellent creep resistance.

Density gm/cc	Density 1.42gm/cc
Flexural Strength(N/mm^2)	424
Maximum Deflection, mm	1.94

C. *Epoxy Resin:*

Epoxy resins are polyether resins containing more than one epoxy group capable of being converted into the thermo set form. These resins, on curing, do not create volatile products in spite of the presence of a volatile solvent.

Characteristics	Epoxy Resin
Flexural strength	Best
Tensile strength	Best
Elongation %	Lowest
Water Absorption	Lowest
Hardness	Best
Cure Time	5-7 Days
Working Time	in- 6 Hours

V. PREPARATION OF MOULD :

Wooden mould having dimensions of 300x300x7mm3and 300x300x10mm3is used for composite fabrication.

A. *Determination of coconut coir fiber volume fraction (30%)for 300x300x7 mm3mould :*

From the definition the fiber volume fraction Vf

$$V_f = \frac{v_f}{v_c} \quad \text{.... (1)}$$

Where, Vf= volume fraction of fiber
vf = volume of fiber
vc= volume of mould
The volume of mould Vc= 0.300 x 0.300 x 0.007 = 6.3 x 10-4 m3

Vf =Vf* Vc .... (2)
Density of fiber = mf/vf .... (3)
Mass fraction mf= 1.104 x 189=208.656 grams

B. *Determination of coconut coir fiber volume fraction (40%)for 300x300x10 mm3mould:*

From the definition the fiber volume fraction Vf

$$V_f = \frac{v_f}{v_c} \quad \text{.... (1)}$$

Where, Vf= volume fraction of fiber
Vf = volume of fiber
Vc= volume of composite
The volume of composite Vc= 0.300x0.300x0.010 = 9x10-4 m3

Vf =Vf* Vc .... (2)
Density of fiber = mf/vf .... (3)
Mass fraction mf= 1.104x360=397.44grams

C. *Determination of Graphite fiber volume fraction (15%) for 300x300x7 mm3mould:*

From the definition the fiber volume fraction Vf

$$V_f = \frac{v_f}{v_c} \quad \text{.... (1)}$$

Where, Vf= volume fraction of fiber
Vf = volume of fiber, Vc= volume of composite

Vf =Vf* Vc .... (2)
Density of fiber = mf/Vf .... (3)
Mass fraction mf= 1.42x94.5=134.19 grams

D. *Determination of Graphite fiber volume fraction (20%) for 300x300x10 mm3mould:*

From the definition the fiber volume fraction Vf

$$V_f = \frac{v_f}{v_c} \quad \text{.... (1)}$$

Where, Vf= volume fraction of fiber
Vf = volume of fiber
Vc= volume of composite

vf =Vf* vc .... (2)

Density of fiber = mf/vf .... (3)

Mass fraction mf= 1.42x180=255.6grams

VI. DENSITY OF EPOXY RESIN:

Density of epoxy resin used for manufacturing coconut coir and graphite fibers composite is 1.15 gm/cc

VII. MANUFACTURING OF COMPOSITE :

Step 1: Personal preparation
Step 2: Weighing of fibers
Step 3:- Pour wax in mould
Step 4: Lay on the fiber layers and Wet out the Layer
Step 5: placing the release paper on the layer
Step 6: applying load
Step 7: Trimming and Cutting

VIII. ANALYSIS OF TEST SPECIMEN

The present work deals with the characterization of composite specimen prepared by performing various mechanical tests like tensile loading and Flexural Loading (3 point loading)

A. *Mechanical Tests*

The mechanical testing has been done on the composite laminate specimens as per the guidelines given in ASTM standards for the respective tests.

B. *Tensile Test*

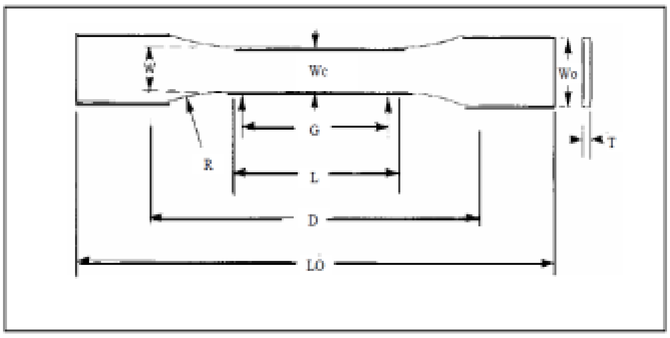
Tensile test is a measurement of the ability of a material towithstand forces that tend to pull it apart and to what extent the material stretchesbefore breaking.

1) *Test type*

According to ASTM D638, tensile testing has been carried out. The specimen with the gauge length of 115 mm was considered for the investigation of tensile properties

2) *Test specimen*

According to ASTM (D638), dumbbell shape specimen is needed for reinforced composite testing.



C. *Flexural Test (3 Point Loading) :*

Flexural strength also known as modulus of rupture is a mechanical parameter for brittle material defined as the material's ability to resist deformation under load. The flexural strength represents the highest stress experienced within the material at its moment of rupture. This test method determines the flexural properties of specimen under defined condition.

IX. FORMULA USED:

Flexural stress, =σ= $\frac{3PL}{2bd2}$ ... (8)

σ= stress in the outer specimen at midpoint, MPa
P= applied load force, in Newton, N
L= support span, mm
b= width of beam tested, mm
d= depth of beam tested, mm

X. FINITE ELEMENT METHOD

A. *Analysis of Composite Material by Using Ansys:*

1) The solid model of composite material is created in CATIA V5. It is is a feature based modeling (FBM) software. Many CAD packages use FBM method. It is easy and gives model tree for completed part, so that modification at any point at any branch can be passed through whole model.
2) Thus FBM is suited for parameterization of model. It will be helpful to generate similar models from existing one just by changing the parameter values.
3) It is proposed to use FBM using CATIA V5 because of its user friendly and availability of parametric functions.
4) The fig shows the specimen of composite model in CATIA V5

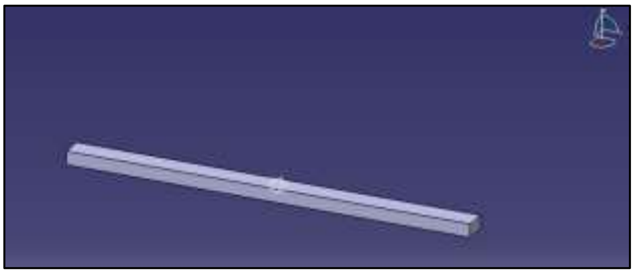


Fig. 10.1: CAD model of specimen of composite

– The CAD model of composite specimen was saved in .igs format for importing it into ANSYS workbench for the analysis purpose.
– The material used for the composite specimen is epoxy/graphite/coconut coir which isotropic behavior.

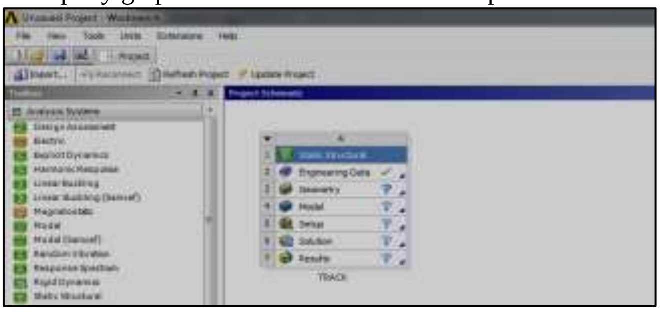


Fig. 6.9: Analysis type

Meshing is the process in which your geometry is discretized into elements and nodes. This mesh along with material properties is used to mathematically represent the stiffness and mass distribution of the structure. The element size is determined based on number of factors including overall model size, body curvature and the complexity of the feature.

B. Element Type Selection: Hexahedron type

1) Hexahedron Element Description:

In computational solutions of partial differential equations, meshing is a discrete representation of the geometry that is involved in the problem. Essentially, it partitions space into elements (or cells or zones) over which the equations can be approximated. Zone boundaries can be free to create computationally best shaped zones, or they can be fixed to represent internal or external boundaries within a model. The basic 3-dimensional element are the tetrahedron, quadrilateral pyramid, triangular prism, and hexahedron. They all have triangular and quadrilateral faces.

A hexahedron, a topological cube, has 8 vertices, 12 edges, bounded by 6 quadrilateral faces. It is also called a hex or a brick. For the same cell amount, the accuracy of solutions in hexahedral meshes is the highest. The pyramid and triangular prism zones can be considered computationally as degenerate hexahedrons, where some edges have been reduced to zero. Other degenerate forms of a hexahedron may also be represented.

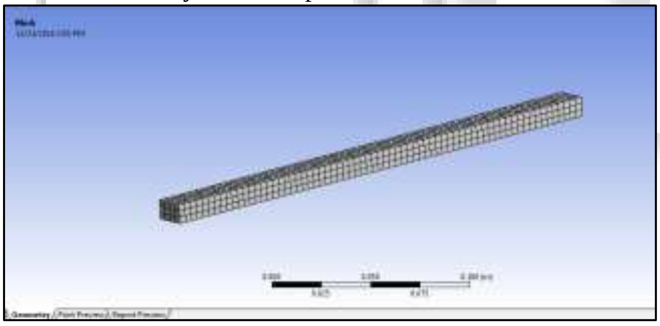


Fig. 10.2: Meshed Geometry

1) Theboundary condition is the collection of different forces, pressure, velocity, supports , constraints and every condition required for complete analysis. Applying boundary condition is one of the most typical processes of analysis.
2) A special care is required while assigning loads and constraints to the elements.
3) Boundarycondition of composite specimen is fixed left face of specimen, displacement and load of 63750 N to be applied on wheel
4) Fixed support was represented in blue color, and load applied in red color.

C. Load applied on composite

In below fig. show load applied to the model is tensile at both ends A & B.

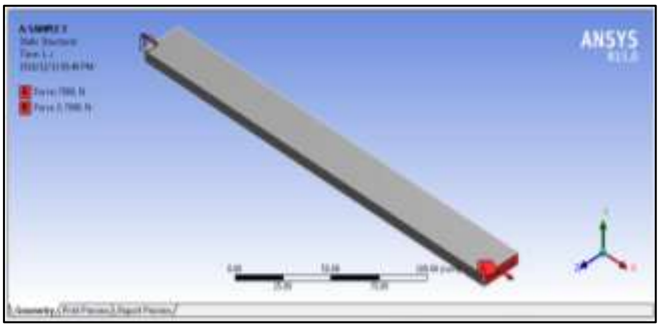


Fig. 10.3: Tensile Load applied on sample1.

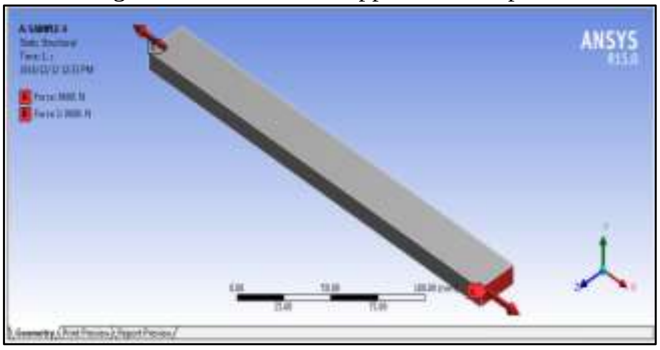


Fig. 10.4: Tensile Load applied on sample2.

Fig. Shows flexural load is applied at centre, end A and B are fixed.

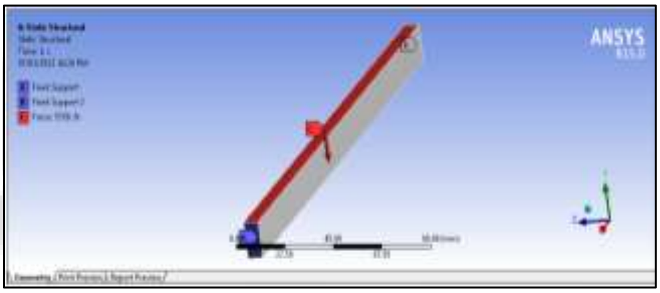


Fig. 10.5: Flexural Load applied on sample1.

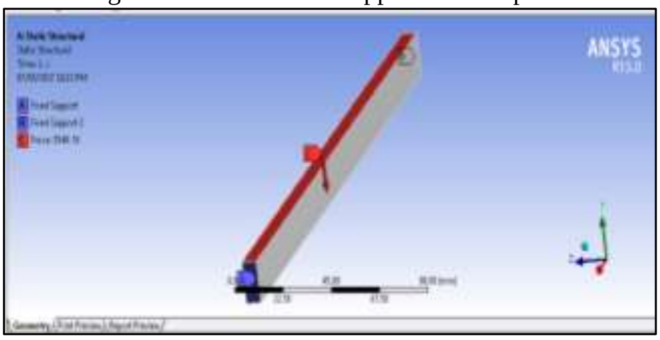


Fig 10.6: Flexural Load applied on sample2.

In structural analysis, after specification of meshing, material properties, boundary conditions and application of loads, solution is obtained in terms of tensile and bending strength of composite specimens.

XI. EXPERIMENTAL RESULTS:

The tensile strength of a material is the maximum amount of tensile stress that it can take before failure. The tensile test is carried out on standard size specimen by applying load and the elongation of the specimen over the span distance is measured.

A. *Result Table:*

Load (KN)	Tensile Strength (MPa)	Tensile Modulus (MPa)	Elongation (mm)	% Elongation
5.00	28.39	$13.9x10^3$	0.1	0.21
5.4	30.66	$13.8x10^3$	0.3	0.22
5.6	31.80	$13.6x10^3$	0.4	0.23
5.7	32.37	$13.4x10^3$	0.6	0.24
5.8	32.94	$10.2x10^3$	0.8	0.32
6.2	35.21	$7.3x10^3$	1.2	0.48
6.4	36.34	$5.04x10^3$	1.8	0.72
6.8	38.62	$4.3x10^3$	2.2	0.88
7.00	39.75	$3.2x10^3$	3.1	1.24
7.00	39.75	$3.01x10^3$	3.3	1.32
7.1	40.32	$2.19x10^3$	4.6	1.84
7.2	40.89	$1.23x10^3$	8.3	3.32
7.4	42.03	$1.05x10^3$	10	4.00
7.6	43.16	$0.963x10^3$	11.2	4.48
7.9	44.87	$0.919x10^3$	12.2	4.88

Table 11.1: tensile properties of 7mm thickness composite

Load (KN)	Tensile Strength (MPa)	Tensile Modulus (MPa)	Elongation (mm)	% Elongation
5.00	20.00	$7.6x10^3$	0.1	0.28
5.2	20.8	$7.5x10^3$	0.3	0.29
5.4	21.6	$7.3x10^3$	0.6	0.30
5.7	22.8	$7.1x10^3$	0.8	0.32
5.9	23.6	$5.9x10^3$	1.0	0.40
6.2	24.76	$5.16x10^3$	1.2	0.48
6.3	25.15	$3.93x10^3$	1.6	0.64
6.6	26.4	$2x10^3$	3.3	1.32
6.8	27.18	$1.51x10^3$	4.5	1.80
7.1	28.20	$0.86x10^3$	8.2	3.28
7.4	29.6	$0.74x10^3$	10	4.00
7.9	31.55	$0.68x10^3$	11.6	4.64
8.2	32.54	$0.55x10^3$	14.7	5.88
8.6	33.90	$0.52x10^3$	16.3	6.52

Table 11.2: tensile properties of 10mm thickness composite

Following graphs shows the results of tensile strength:

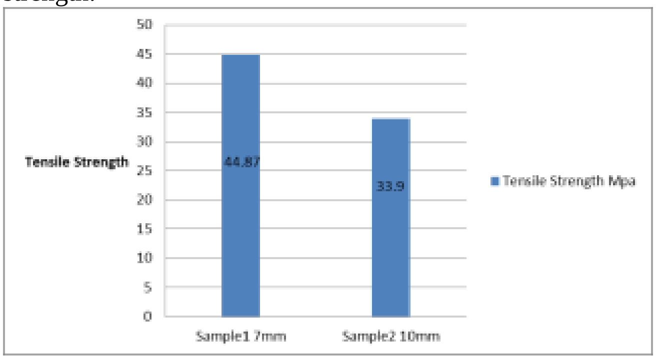


Fig. 11.3.1: Tensile strength of the composite material.

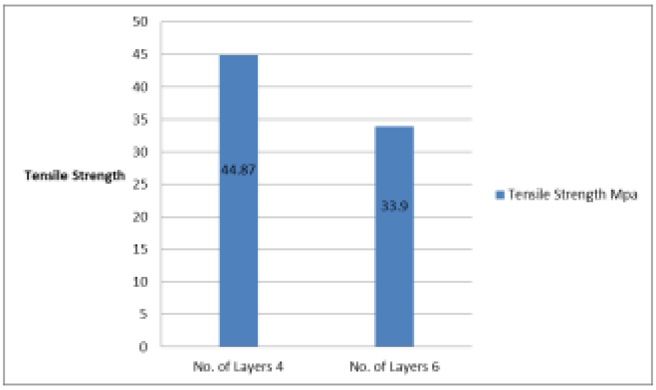


Fig. 11.3.2: Tensile strength of the composite material for varying layers.

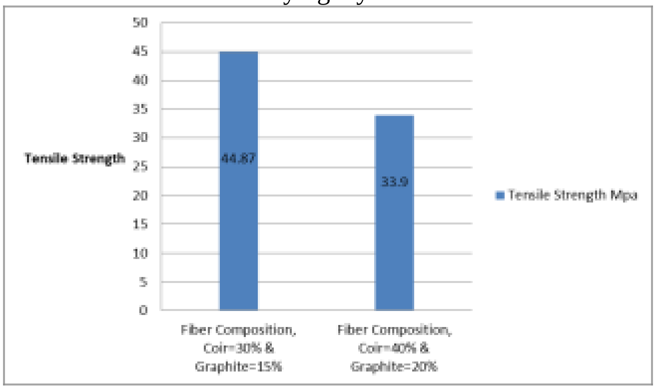


Fig. 11.3.3: Tensile strength of the composite material for varying fiber proportion.

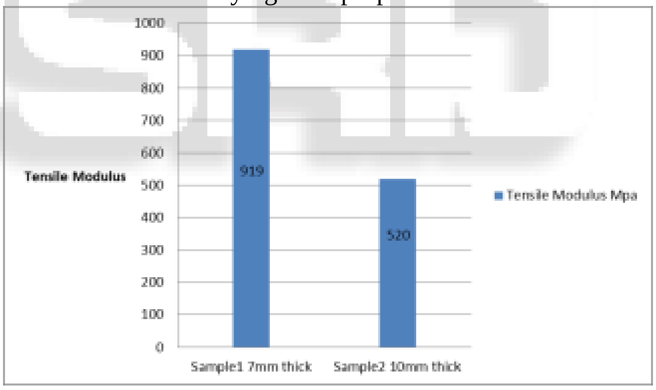


Fig. 11.3.4: Tensile modulus of the composite material

Composite combination	Thickness of composite	Tensile strength (MPa)	Young's modulus (MPa)	Fiber proportion content	Author
Glass fiber and banana fiber with epoxy resin	7mm	33.30	--------------------	20% glass fibers and 30% banana fibers	R.Sakthivel et al
Coconut shell and	5mm	31.00	--------------------	25% coconut	S.I.Durowaye et al

palm fruit				shell and 25% palm fruit	
Epoxy with bark cloth	7mm	33	3Mpa	50% bark cloth	S.Rwawiireet al
Abaca fiber with epoxy	6mm	53.00	--------------	40% abaca fiber	R.Sridharet al
Coconut coir and graphite fibers with epoxy resin	7mm	44.87	$0.919x10^3$	30% of coconut coir fiber and 15% graphite fibers	J.K.Romanet al

Table 11.2: Comparison of the tensile properties of various composites fibers with present work

B. *Flexural Test Results :*

Load (KN)	FLEXURAL Strength (MPa)	FLEXURAL Modulus (GPa)	Elongation (mm)	% Elongation
5.5	3030.6	52602.76	0.1	0.037
5.5	3030.6	4782.06	1.1	0.407
5.5	3030.6	1753.42	3	1.11
5.5	3030.6	1195.517	4.4	1.628
5.5	3030.6	751.468	7	2.59
5.52	3041.6	527.94	10	3.7
5.56	3063.67	409.050	13	4.81
5.6	3085.71	366.843	14.6	5.402
5.6	3085.71	252.637	21.2	7.844
5.7	3140.8	247.798	22	8.14

Table 11.3: Flexural properties of 7mm thickness composites

Load (KN)	FLEXURAL Strength (MPa)	FLEXURAL Modulus (GPa)	Elongation (mm)	% Elongation
5.2	1404	1698.66	0.1	0.037
5.28	1425.6	862.39	0.2	0.074
5.28	1425.6	143.73	1.2	0.44
5.3	1431	108.2	1.6	0.592
5.3	1431	52.4	3.3	1.22
5.3	1431	38.4	4.5	1.665
5.3	1431	32.66	5.3	1.961
5.3	1431	28.38	6.1	2.257
5.34	1441.8	27.25	6.4	2.368
5.36	1447.2	21.35	8.2	3.034
5.4	1458	17.63	10	3.7
5.4	1458	17.126	10.3	3.811
5.42	1463.4	15.26	11.6	4.292
5.42	1463.4	14.878	11.9	4.403
5.46	1474.2	12.133	14.7	5.439
5.48	1479.6	11.25	15.9	5.883
5.5	1485	11.022	16.3	6.031
5.52	1490.4	10.9951	16.4	6.068
5.54	1495.8	10.968	16.5	6.105

Table 11.3: Flexural properties of 10mm thickness composites

Following graphs shows results of flexural strength:

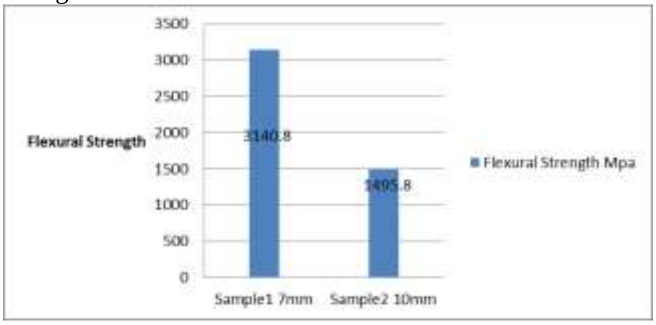


Fig. 11.3.1: flexural strength of the composite material

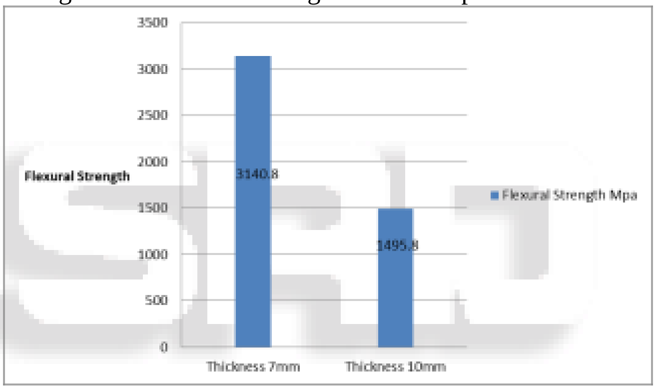


Fig. 11.3.2: flexural strength of the composite material for varying thickness.

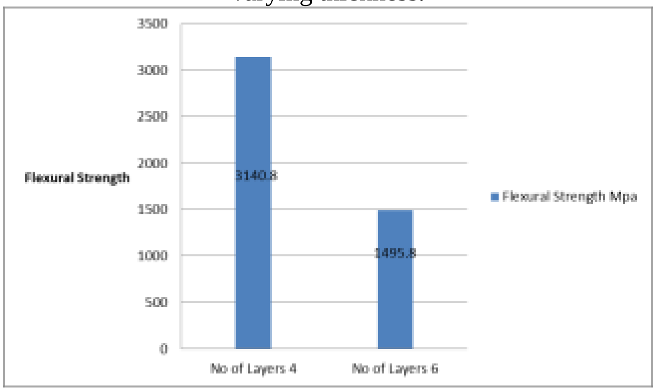


Fig. 11.3.2: flexural strength of the composite material for varying layers.

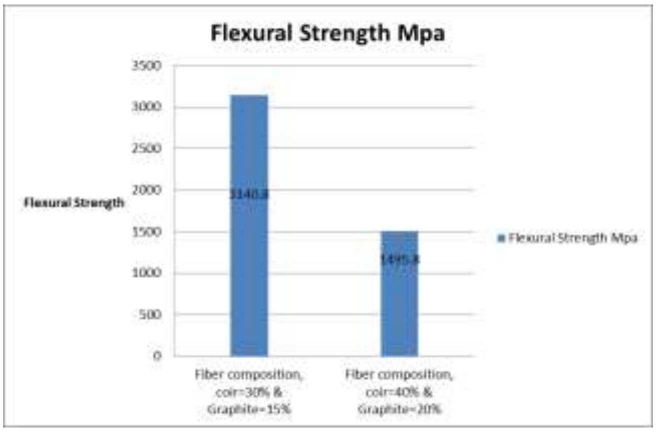


Fig. 11.3.4: flexural strength of the composite material for varying fiber proportion.

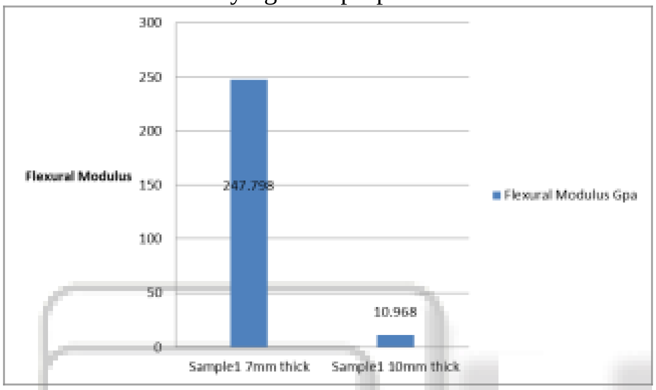
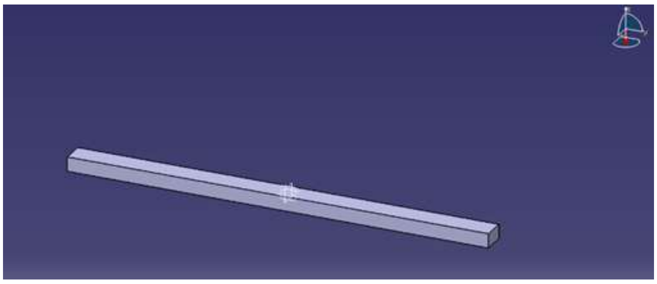


Fig. 11.3.5: flexural modulus of the composite material

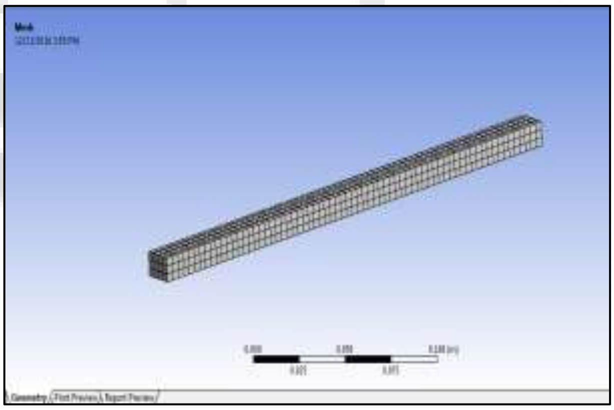
Composite combination	Thickness of composite	Flexural strength (MPa)	Young's modulus (GPa)	Fiber proportion &content	Author
Glass fiber and banana fiber with epoxy resin	7mm	163.1	---------------	20% glass fibers and 30% banana fibers	R.Sakthivelet al
Coconut shell and palm fruit	5mm	38.328	--------------------	25% coconut shell and 25% palm fruit	S.I.Durowaye et al
Glass & graphite with epoxy	4mm	716.50	--------------	26% glass and 26% graphite	G.Rathnakaret al
Epoxy with bark cloth	7mm	207	1.4	50% bark cloth	S.Rwawiireet al
Coconut coir and graphite fibers with epoxy resin	7mm	3140.8	247.798	30% coconut coirand 15%graphite fiber content	J.K.Roman et al

Table 11.4. shows the results of other composites which is compared with Coconut coir and graphite fibers with epoxy resin.

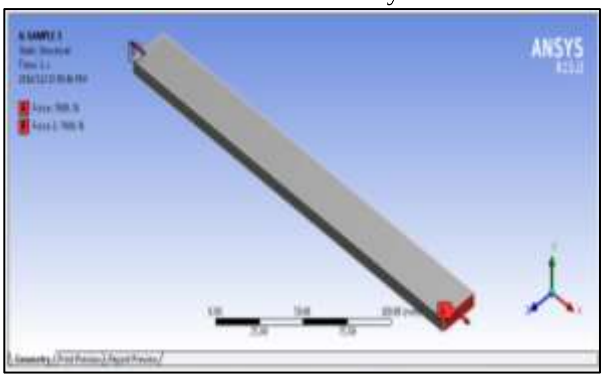
XII. Analysis of Composite Material By Using Ansys:



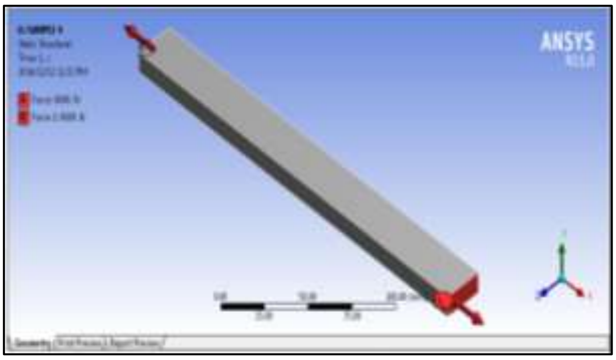
The solid model of composite material is created in CATIA V5



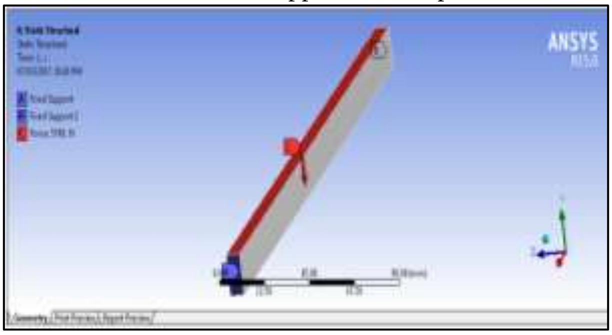
Meshed Geometry



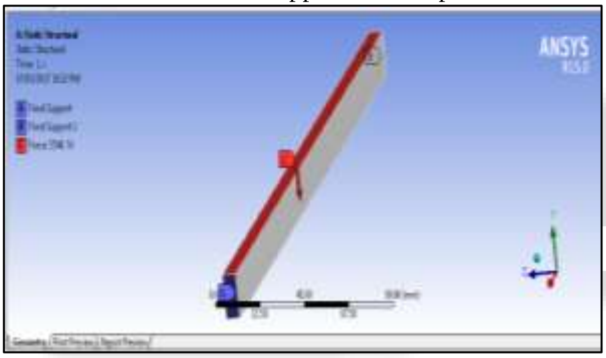
Tensile Load applied on sample1.



Tensile Load applied on sample2



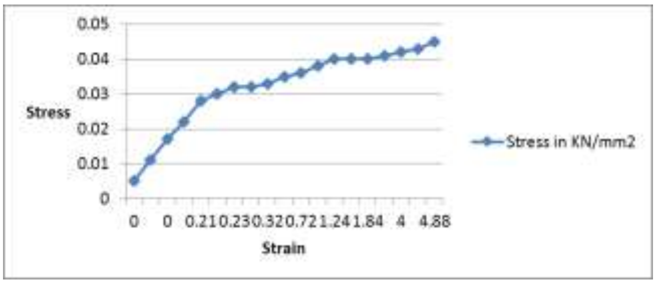
Flexural Load applied on sample1



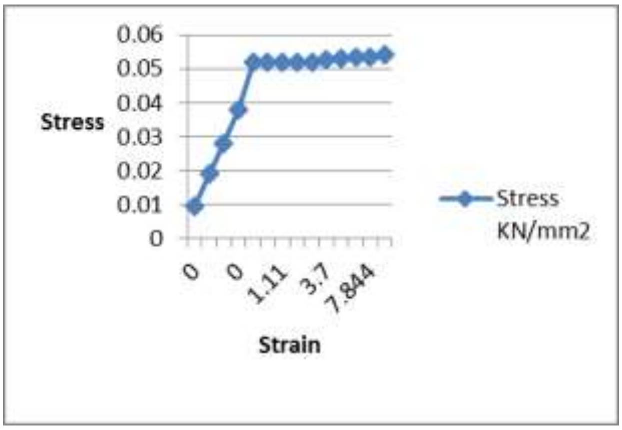
Flexural Load applied on sample2.

XIII. FEA RESULTS

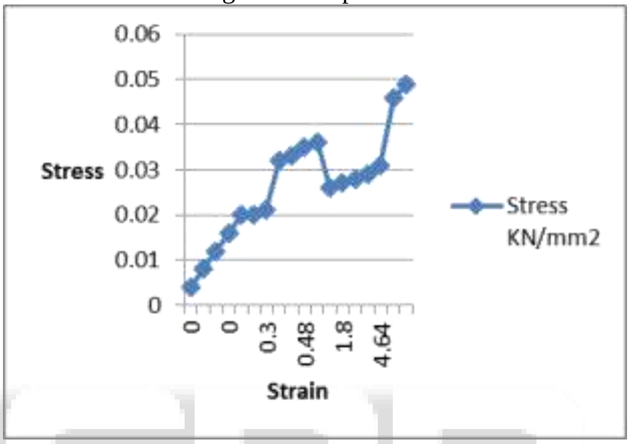
A. Stress – strain graph:



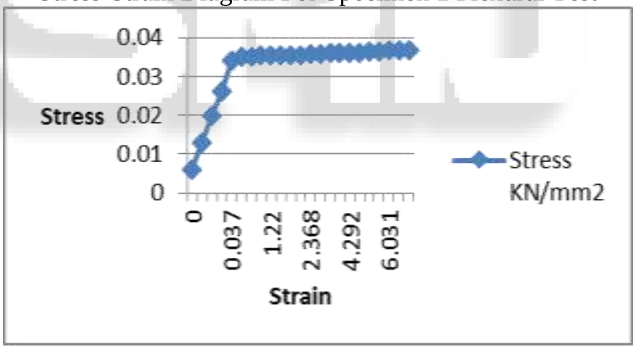
Stress-Strain Diagram For Specimen 1 Tensile Test



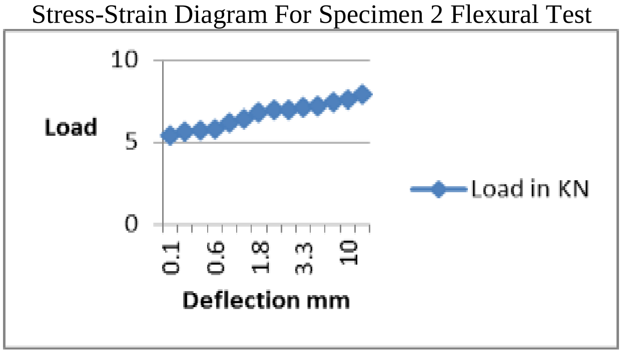
Stress-Strain Diagram For Specimen 2 Tensile Test



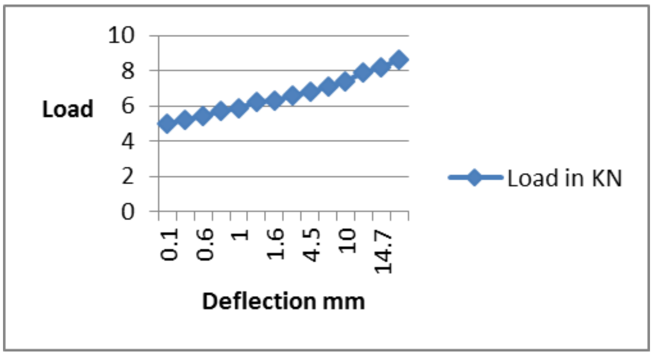
Stress-Strain Diagram For Specimen 1 Flexural Test



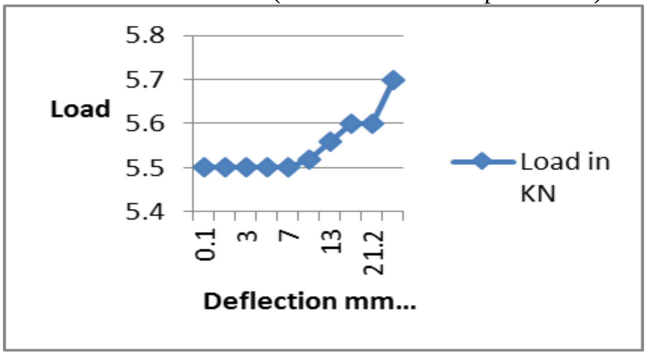
Stress-Strain Diagram For Specimen 2 Flexural Test



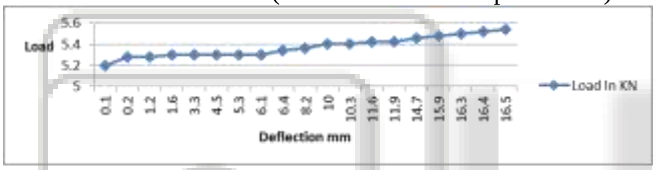
Load V/S Deflection (Tensile Test For Specimen 1)



Load V/S Deflection (Tensile Test For Specimen 2)



Load V/S Deflection (Flexural Test For Specimen 1)



Load V/S Deflection (Flexural Test For Specimen 2)

XIV. Finite Element Analysis Results:

Types of Strength	Composite Specimen	
	Sample 1	Sample 2
Tensile Strength	44.857 MPa	32.571 MPa
Flexural Strength	3062.4 MPa	1488.7 MPa

A. Comparisons of results obtained :

Types of Strength	Sample specimen 1		Sample specimen 2		% of difference between experimental and FEA	
	Experimental	FEA	Experimental	FEA	Sample 1	Sample 2
Tensile strength (MPa)	44.87	44.857	33.90	32.571	0.028 %	3.9 %
Flexural strength (MPa)	3140.80	3062.4	1495.8	1488.7	2.4 %	0.47 %

XV. Conclusion

By FEA analysis, maximum tensile strength for 7mm composite is 44.857 MPa. Maximum tensile strength for 10mm composite is 32.571 MPa.

By FEA analysis, maximum flexural strength for 7mm composite is 3062.4 MPa. Maximum flexural strength for 10mm composite is 1488.7 MPa.

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