Impact Factor 5.8701 (ICI)
International Journal of Engineering Research-Online
A Peer Reviewed International Journal
Articles available online http://www.ijoer.in; editorijoer@gmail.com
Vol.6., Issue.6, 2018
Nov-Dec

RESEARCH ARTICLE
ISSN: 2321-7758

EVALUATION AND COMPARISON OF FLEXURAL STRENGTH OF CARBON FIBER/EPOXY RESIN LAMINATES BY THREE POINT BEND AND FOUR POINT BEND TEST METHODS

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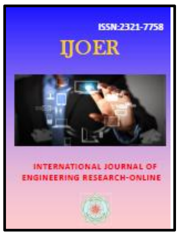


ABSTRACT

Fiber reinforced plastics have been widely used for manufacturing aircraft and spacecraft structural parts because of their particular mechanical and physical properties such as high specific strength and high specific stiffness.

The present investigation was undertaken to determine the influence of Resin & Thickness of Laminates graphite fiber Epoxy and Carbon fiber Epoxy laminates and carbon fiber polyester resin under 3- point bend test and 4-point bend test.

The composite laminate specimens are prepared using the filament winding process and the specimen are subjected to 3 point bending load and 4 point bending load on a simply supported pins and the investigation is carried out as per the ASTM D7264 standards.

Flexural properties evaluated are flexural strength and stiffness of the composites system appropriate conclusions was drawn. The purpose of this work is to experimentally analyze the progressive failure process of laminated composites subjected to flexural loads, Flexural loading causes stresses in the composites, which vary through the thickness and reinforcement material used.

This research indicates that Flexural strength is mainly dependent on the Type of Resin used & thickness of laminated polymer composites. Index Terms— Laminate, Flexural Strength, Resin, Three point bending, Four point bending, Stiffness.

Keywords : FRP, Epoxy resins, filament winding process

1. INTRODUCTION

1.1 COMPOSITE MATERIAL

A composite material (also called a composition material or shortened to composite) is a material 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.

The individual components remain separate and distinct within the finished structure. The new material may be preferred for many reasons: common examples include materials which are stronger, lighter, or less expensive when compared to traditional materials.

More recently, researchers have also begun to actively include sensing, actuation, computation and communication into composites, [1] which are known as Robotic Materials.

Typical engineered composite materials include:

- mortars, concrete
- Reinforced plastics, such as fiber-reinforced polymer
- Metal composites

Ceramic composites (composite ceramic and metal matrices)

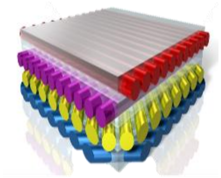


Fig 1 Compostie FRP

1.2 ADVANTAGES OF COMPOSITE MATERIALS:

- Compare to metals they exhibit high strength
- They are having low specific gravity
- Stiffness of the material is improved
- At high temperatures also they maintain the weight
- Toughness is also improved
- Production is lower
- Fabrication is also cheaper
- Fatigue strength and creep is better
- Oxidation and corrosion resistance
- Measured electrical conductivity is possible

1.3 DISADVANTAGES OF COMPOSITE MATERIALS:

- Compare with the wrought metals, composites are more brittle and they are easily damaged
- Cast metals also tend to be brittle
- During the time of transportation material requires chilling.
- Special equipment's are required and hot curing is also necessary
- For curing process it requires time for cold or hot process.
- After the completion of last rivet the process is done.
- The rivets are removed without causing any damage
- Pressure and tooling are required to repair at the original cure temperature
- Before starting the repair the composite must be cleaned

1.4 PARTICLE REINFORCED

Particle reinforcing in composites is a less effective means of strengthening than fibre reinforcement. Particulate reinforced composites achieve gains in stiffness primarily, but also can achieve increases in strength and toughness. In all cases the improvements are less than would be achieved in a fibre reinforced composite

Particulate reinforced composites find applications where high levels of wear resistance are required such as road surfaces. The hardness of cement is increased significantly by adding gravel as reinforcing filler. The principal advantage of particle reinforced composites is their low cost and ease of production and forming.

Example: Concrete, Cermets

Fig 2 concrete cerments

1.4.1 FIBRE REINFORCED

A **fiber-reinforced composite** (FRC) is a composite building material that consists of three components:

- The fibers as the discontinuous or dispersed phase
- The matrix as the continuous phase
- The fine interphone region, also known as the interface.

This is a type of advanced composite group, which makes use of rice husk, rice hull, and plastic as ingredients. This technology involves a method of refining, blending, and compounding natural fibers from cellulosic waste streams to form a high-strength fiber composite material in a polymer matrix. The designated waste or base raw materials used in this instance are those of waste thermoplastics and various categories of cellulosic waste including rice husk and saw dust.

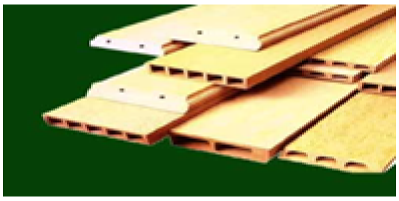


Fig 3.Fiber-reinforced composite

FRC is high-performance fiber composite achieved and made possible by cross-linking cellulosic fiber molecules with resins in the FRC material matrix through a proprietary molecular re-engineering process, yielding a product of exceptional structural properties

Example: Glass-fiber, carbon-fiber

1.4.2 STRUCTURAL

It is one of a class of metallic materials consisting of a laminate of several thin metal layers bonded with layers of composite material.

This allows the material to behave much as a simple metal structure, but with considerable specific advantages regarding properties such as metal fatigue, impact, corrosion resistance, fire resistance, weight savings, and specialized strength properties.

Being mixtures of monolithic metals and composite materials, FMLs belong to the class of heterogeneous mixtures.

Examples of FMLs include armed fibers and GLARE.

Fig4 .Fiber-reinforced composite Example: Wood, sheet

2. FIBRE

Fiber or **fibre** (from the Latin fibra) is a natural or synthetic substance that is significantly longer than it is wide. Fibers are often used in the manufacture of other materials. The strongest engineering materials often incorporate fibers, for example carbon fiber and ultra-high-molecular-weight polyethylene.

Synthetic fibers can often be produced very cheaply and in large amounts compared to natural fibers, but for clothing natural fibers can give some benefits, such as comfort, over their synthetic counterparts

They are two type of fibre

- ❖ Natural fibre
- ❖ Manmade fibre

2.1 NATURAL FIBRE:

Natural fibers develop or occur in the fiber shape, and include those produced by plants, animals, and geological processes. They can be classified according to their origin:

- Vegetable fibers are generally based on arrangements of cellulose, often with lignin: examples include cotton, hemp, jute, flax,ramie, sisal, bagasse, and banana. Plant fibers are employed in the manufacture of paper and textile (cloth), and dietary fiber is an important component of human nutrition.
- Wood fiber, distinguished from vegetable fiber, is from tree sources. Forms include ground wood, lacebark, thermo mechanical pulp (TMP), and bleached or unbleached kraft or sulfite pulps. Kraft and sulfite (also called sulphite) refer to the type of pulping process used to remove the lignin bonding the original wood structure, thus freeing the fibers for use in paper and wood products such as fiberboard.
- Animal fibers consist largely of particular proteins. Instances are silkworm silk, spider silk, sinew, catgut, wool, sea silk and hair such as cashmere, mohair and angora, fur such as sheepskin, rabbit, mink, fox, beaver, etc.
- Mineral fibers include the asbestos group. Asbestos is the only naturally occurring long mineral fiber. Six minerals have been classified as "asbestos" including chrysotile of the serpentine class and those belonging to the amphibole class: amosite, crocidolite, tr emolite,anthophyllite and actinolite. Short, fiber-like minerals include woll as tonite and paly gorskite.
- Biological fibers also known as fibrous proteins or protein filaments consist largely of biologically relevant and biologically very important proteins, mutations or other genetic defects can lead to severe diseases. Instances are collagen[3] family of proteins, tendon, muscle proteins like actin, cell proteins like microtubules and many others, spider silk, sinew and hair etc

2.2 MANMADE FIBRE

Man-made fibers or chemical fibers are fibers whose chemical composition, structure, and properties are significantly modified during the manufacturing process. Man-made fibers consist of regenerated fibers and synthetic fibers.

i. Semi-synthetic fibers
ii. Cellulose regenerated fibers
iii. Synthetic fibers
iv. Metallic fibers
v. Carbon fiber
vi. Silicon carbide fiber
vii. Fiberglass
viii. Mineral fibers
ix. Polymer fibers
x. Microfibers

3. FORMING PROCESSES

FORMING PROCESS: A rigid structure is usually used to establish the shape of FRP components. Parts can be laid up on a flat surface referred to as a "caul plate" or on a cylindrical structure referred to as a "mandrel". However most fibre-reinforced plastic parts are created with a mold or "tool. Molds can be concave female molds, male molds, or the mold can completely enclose the part with a top and bottom mold. The moulding processes of FRP plastics begins by placing the fibre perform on or in the mold.

The fibre perform can be dry fibre, or fibre that already contains a measured amount of resin called "prepreg". Dry fibres are "wetted" with resin either by hand or the resin is injected into a closed mold. The part is then cured, leaving the matrix and fibres in the shape created by the mold. Heat and/or pressure are sometimes used to cure the resin and improve the quality of the final part.

The different methods of forming are

- Bladder moulding
- Compression moulding
- Autoclave and vacuum bag
- Mandrel wrapping
- Wet layup
- Chopper gun
- Filament winding
- Pultrusion
- Resin transfer molding

3.1 FILAMENT WINDING

Filament winding is a fabrication technique mainly used for manufacturing open (cylinders) or closed end structures (pressure vessels or tanks).

The process involves winding filaments under tension over a rotating mandrel. The mandrel rotates around the spindle (Axis 1 or X: Spindle) while a delivery eye on a carriage (Axis 2 or Y: Horizontal) traverses horizontally in line with the axis of the rotating mandrel, laying down fibers in the desired pattern or angle.

3.2 FILAMENT WINDING: PROCESS TECHNOLOGY

To begin with, a large number of fibre roving is pulled from series of creels into bath containing liquid resin, catalyst and other ingredients such as pigments and UV retardants.

Fibre tension is controlled by the guides or scissor bars located between each creel and resin bath.

Just before entering the resin bath, the roving are usually gathered into a band by passing them through a textile thread board or stainless steel comb.

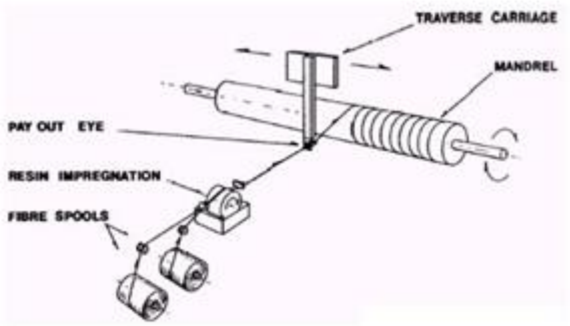


Fig 5. Filament winding process

Schematic representation of the wet filament winding process

At the end of the resin tank, the resin-impregnated roving are pulled through a wiping device that removes the excess resin from the roving and controls the resin coating thickness around each roving.

The most commonly used wiping device is a set of squeeze rollers in which the position of the top roller is adjusted to control the resin content as well as the tension in fibre roving.

Another technique for wiping the resin-impregnated roving is to pull each roving separately through an orifice.

The latter method results in better control of resin content. Once the roving have been thoroughly impregnated and wiped, they are gathered together in a flat band and positioned on the mandrel.

Band formation can be achieved by passing through a stainless steel comb and later through the collecting eye. The transverse speed of the carriage and the winding speed of the mandrel are controlled to create the desired winding angle patterns.

After winding, the filament wound mandrel is subjected to curing and post curing operations during which the mandrel is continuously rotated to maintain uniformity of resin content around the circumference. After curing, product is removed from the mandrel, either by hydraulic or mechanical extractor.

4. EPOXY RESIN

EPOXY RESIN

Epoxy resins are low molecular weight pre-polymers or higher molecular weight polymers which normally contain at least two epoxide groups.

The epoxide group is also sometimes referred to as a glycidyl or oxirane group.

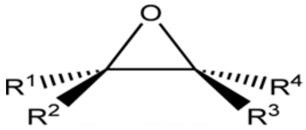
Epoxy is a term used to denote both the basic components and the cured end products of **epoxy resins**, as well as a colloquial name for the epoxide functional group.

Epoxy resins, also known as **polyepoxides**, are a class of reactive prepolymers and polymers which contain epoxide groups. Epoxy resins may be reacted (cross-linked) either with themselves through catalytic homo polymerisation, or with a wide range of co-reactants including polyfunctional amines, acids (and acid anhydrides), phenols, alcohols and thiols.

These co-reactants are often referred to as hardeners or curatives, and the cross-linking reaction is commonly referred to as curing.

Reaction of polyepoxides with themselves or with poly functional hardeners forms a thermosetting polymer, often with high mechanical properties, temperature and chemical resistance.

Epoxy has a wide range of applications, including metal coatings, use in electronics / electrical components, high tension electrical insulators, fiber-reinforced plastic materials and structural adhesives.



- Bisphenol A epoxy resin
- Bisphenol F epoxy resin
- Novolac epoxy resin
- Aliphatic epoxy resin
- Glycidylamine epoxy resin

4.1 CURING EPOXY RESIN

In general, uncured epoxy resins have only poor mechanical, chemical and heat resistance properties. However, good properties are obtained by reacting the linear epoxy resin with suitable curatives to form three-dimensional cross-linked thermo set structures.

This process is commonly referred to as curing or gelation process. Curing of epoxy resins is an exothermic reaction and in some cases produces sufficient heat to cause thermal degradation if not controlled.

Curing may be achieved by reacting an epoxy with itself (homopolymerisation) or by forming a copolymer with polyfunctional curatives or **hardeners**. In principle, any molecule containing a reactive hydrogen may react with the epoxide groups of the epoxy resin.

Common classes of hardeners for epoxy resins include amines, acids, acid anhydrides, phenols, alcohols and thiols. Relative reactivity (lowest first) is approximately in the order: phenol < anhydride < aromatic amine < cycloaliphatic amine < aliphatic amine < thiol.

Whilst some epoxy resin/ hardener combinations will cure at ambient temperature, many require heat, with temperatures up to 150 °C being common, and up to 200 °C for some specialist systems.

Insufficient heat during cure will result in a network with incomplete polymerisation, and thus reduced mechanical, chemical and heat resistance. Cure temperature should typically attain the glass transition temperature (Tg) of the fully cured network in order to achieve maximum properties.

Temperature is sometimes increased in a step-wise fashion to control the rate of curing and prevent excessive heat build-up from the exothermic reaction.

Hardeners which show only low or limited reactivity at ambient temperature, but which react with epoxy resins at elevated temperature are referred to as **latent hardeners**.

When using latent hardeners, the epoxy resin and hardener may be mixed and stored for some time prior to use, which is advantageous for many industrial processes. Very latent hardeners enable one-component (1K) products to be produced, whereby the resin and hardener are supplied pre-mixed to the end user and only require heat to initiate curing.

One-component products generally have shorter shelf-lives than standard 2-component systems, and products may require cooled storage and transport.

The epoxy curing reaction may be accelerated by addition of small quantities of accelerators. Tertiary amines, carboxylic acids and alcohols (especially phenols) are effective accelerators. Bisphenol A is a highly effective and widely used accelerator, but is now increasingly replaced due to health concerns with this substance.

4.2 HARDENER

It is a none that hardens

Hardener is a curing agent for epoxy resin. Epoxy resins require a hardener to initiate curing. It is also called the catalyst, the substance that hardens the adhesive when mixed with resin.

It is the specific selection and combination of the epoxy and hardener components that determine the final characteristics and suitability of the epoxy coating for a given environment.

In general, uncured epoxy resins have poor mechanical, chemical and heat-resistance properties. However, good properties are obtained by reacting the linear epoxy resin with suitable curatives to form three-dimensional cross-linked thermo set structures known as curing.

Curing of epoxy resins is an exothermic reaction, and in some cases produces sufficient heat to cause thermal degradation if not controlled.

Curing may be achieved by reacting an epoxy with itself or by forming a copolymer with polyfunctional curatives or hardeners. In principle, any molecule containing a reactive hydrogen may react with the epoxide groups of the epoxy resin.

Common classes of hardeners for epoxy resins include:

- Amines
- Acids
- Acid anhydrides
- Phenols
- Alcohols
- Thiols

Optimum levels of a hardener are used to formulate epoxy coatings. The ratio differs from product to product.

The use of an improper hardener may result in an undercatalyzed or overcatalyzed product.

Many epoxy coatings require a specified induction time to fully compatibilize the epoxy resin and the hardener.

2. Back Ground

It has been proved that the optimal shape profile for a filament wound dome is a isotensoid [1, 6], on the basis of the netting theory [2]. The isotensoid, which provides the dome structure with the minimum weight and maximum carrying capacity, implies that all the rovings show uniform tensions throughout their length. It can be designed in such a way that the major stresses are carried only by the fibers of the laminate [3]. A number of studies have been conducted on the design of such structures. de Jong [4] presented the geometry and structural properties for isotensoid pressure vessels with the aid of the continuum theory, in which the behaviour of matrix in composites has been taken into account.

The primary aim of this paper is to manufacture a composite cylinder with conductive polymer layer for Solid Rocket Motor Casing. Studies are carried out to characterize the conductive polymer properties and studied in different material like CFRP with Carbon Nanotube and Copper Nano-powder and their enhancement of properties.

3. SCOPE OF EXPERIMENT

"Evaluation and Comparison of Flexural strength of carbon fiber/epoxy resin laminates by Three point bend and Four point bend test methods".

OBJECTIVE:

1. To understand what is a composite material and how it is made.
2. To prepare carbon fiber/epoxy resin laminates.
3. To understand and derive 3 point bend test and 4 point bend test.
4. Specimen cutting as per ASTM standard.
5. Evaluation of flexural strength and flexural modulus of carbon fiber/epoxy resin

laminate on 3 point and 4 point bend tests method by ASTM standard on UTM machine.

6. Comparing the flexural strength and flexural modulus of 3 point and 4 point test methods.

5 EXPERIMENTATION

MATERIALS: carbon roving , epoxy resin epofine 1555 and hardener(FH972)

PROCESS: take 1.5 kg resin and 405 gms hardener (ratio resin 100gm : hardener 27gm)

First take the hardener and heat it to 95 degrees. At this temperature the hardener turns from solid to liquid state. At this state mix the resin by constantly stirring until proper mixing takes place. Then cool down this mixture till room temperature. Pour this mixture in the resign impregnator provided in the machine.

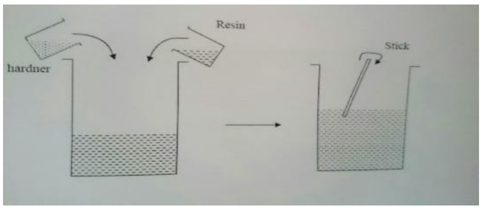


Fig 6. Preparation process

Take the flat mandrel shaft. Clean it thoroughly with acetone. Then apply wax on both sides of the flat surfaces which acts as releasing agent. Then keep this flat mandrel shaft in the 3 jaw check of the machine and fix it tightly. Then give the program the following commands

One roving
No of layers = 4
Program band width = 1.8mm
Rpm = 30

Fig 7. Preparation process

Then start the machine. It takes around 3 to 4 hrs to complete the task.

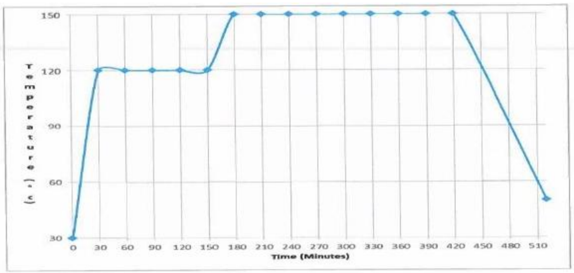
Fig 8. Preparation process

After the roving is done remove the mandrel from the 3 jaw check. This is taken for the next step.

CURING

After Filament winding, the laminate is cured in an oven having accurate temperature control. The flat mandrel is placed inside the oven on metal stands. The following cure cycle (as shown in Fig. 3) was followed

1. Raise temperature of the oven from room temperature to 120°C in 3minutes with heating rate of 2 to 4°C per minute
2. Hold the temperature at 120°C ±5°C for 2hours.
3. Raise temperature of the oven from 120°C to 150°C in 3 minutes with heating rate of 2 to 4°C per minute.
4. Hold the temperature at 150°C ±5°C for 4 hours
5. Switch off the oven and allow the component to cool naturally.
6. Open the door and remove mandrel when it is below 40°C



CUTTING THE PLATE IN REQUIRED SAMPLE PIECES:

Take the plate and mark the plates for the dimensions. Then keep the plate in the cutting machine and cut it according to the marked dimensions. The cutting blade used in the machine is diamond coated steel blade.

Fig 9.Laminates

Testing the obtained samples for flexure strength using 3point and 4 point setup on a UTM machine

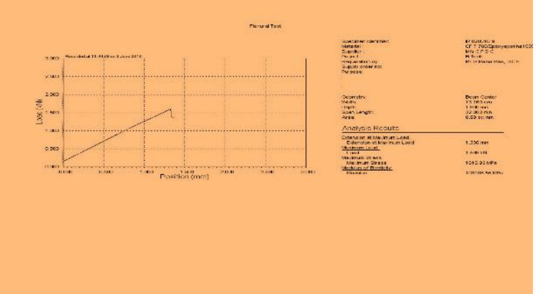
6. OBSERVATION AND TABULATION

POINT BENDING TEST

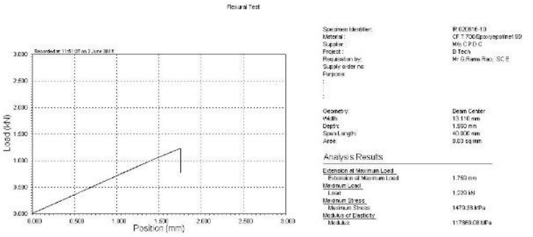
Arrange the utm machine with 3point setup and test the samples for flexure strength and note down the observations in the following table

Fig 10.3-point bending machine

S.NO	Dimensions (width*thickness) Mm	Maximum Displacement Mm	Maximum Load KN	Flexure Strength MPa	Flexure Modulus GPa	Result according to standards
3 POINT BENDING						
Span Length 32mm						
1	13.1*2.10	1.995	1.740	1594	94	C,A,M
2	12.90*1.80	2.143	1.444	1685	116	C,A,M
3	13.00*1.90	1.672	1.685	1702	104	C,A,M
4	13.17*2.00	1.399	1.736	1582	94	C,A,M
5	13.2*2.0	1.519	1.730	1573	93	C,A,M
6	13.16*1.9	1.330	1.599	1615	103	C,A,M



Span Length 40mm						
1	**13.11*1.95**	**1.759**	**1.229**	**1479**	**117**	**C,A,M**
2	**13.24*1.95**	**1.623**	**1.360**	**1621**	**117**	**C,A,M**

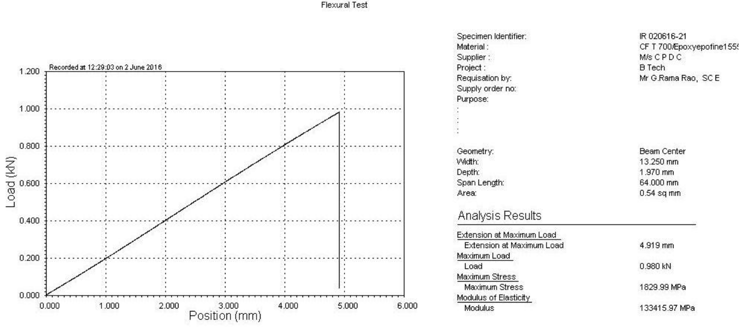


Specimen Identifier: IR 020616-10
Material : CF T 700/Epoxyepofine155
Supplier : M/s C P D C
Project : B Tech
Requisation by: Mr G.Rama Rao, SC E
Supply order no:
Purpose:

Geometry: Beam Center
Width: 13.110 mm
Depth: 1.990 mm
Span Length: 40.000 mm
Area: 0.03 sq mm

Analysis Results
Extension at Maximum Load
Extension at Maximum Load 1.759 mm
Maximum Load
Load 1.220 kN
Maximum Stress
Maximum Stress 1479.38 MPa
Modulus of Elasticity
Modulus 117869.08 MPa

Span Length 64mm						
1	**13.15*2.01**	**4.919**	**0.980**	**1829**	**133**	**C,A,M**
2	**13.25*1.97**	**4.919**	**0.980**	**1829**	**133**	**C,A,M**



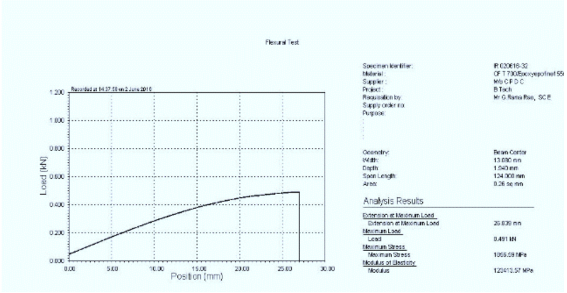
Specimen Identifier: IR 020616-21
Material : CF T 700/Epoxyepofine155
Supplier : M/s C P D C
Project : B Tech
Requisation by: Mr G.Rama Rao, SC E
Supply order no:
Purpose:

Geometry: Beam Center
Width: 13.250 mm
Depth: 1.970 mm
Span Length: 64.000 mm
Area: 0.54 sq mm

Analysis Results
Extension at Maximum Load
Extension at Maximum Load 4.919 mm
Maximum Load
Load 0.980 kN
Maximum Stress
Maximum Stress 1829.99 MPa
Modulus of Elasticity
Modulus 133415.97 MPa

Span Length 80mm						
1	13.16*1.96	7.129	0.737	1.748	139	C,A,M
2	13.19*1.97	5.873	0.647	1516	134	C,A,M
3	13.16*2.03	5.959	0.694	1536	131	C,A,M
4	13.16*2.03	5.959	0.694	1536	131	C,A,M
5	13.56*2.02	5.712	0.690	1498	128	C,A,M
6	13.21*1.90	6.964	0.657	1652	133	C,A,M

Span Length 128mm						
1	13.28*2.08	15.207	0.414	1407	121	C,A,M
2	13.08*1.94	26.839	0.491	1856	123	C,A,M
3	13.25*2.05	23.599	0.532	1778	117	C,A,M
4	13.00*2.08	23.987	0.525	1823	121	C,A,M
5	13.26*1.99	20.807	0.480	1702	126	C,A,M
6	13.16*2.06	17.218	0.461	1537	116	C,A,M



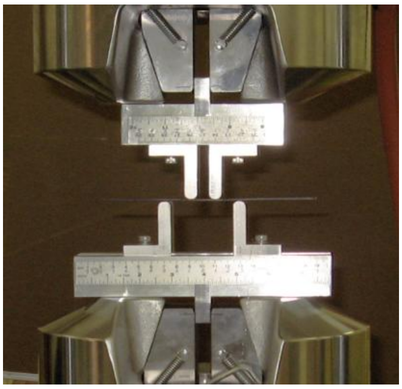
Specimen Identifier: IR 020616-32
Material : CF T 700/Epoxyepofine155
Supplier : M/s C P D C
Project : B Tech
Requisation by: Mr G.Rama Rao, SC E
Supply order no:
Purpose:

Geometry: Beam Center
Width: 13.080 mm
Depth: 1.940 mm
Span Length: 124.000 mm
Area: 0.26 sq mm

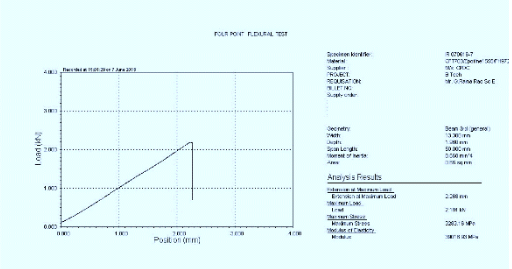
Analysis Results
Extension at Maximum Load
Extension at Maximum Load 25.839 mm
Maximum Load
Load 0.491 kN
Maximum Stress
Maximum Stress 1856.59 MPa
Modulus of Elasticity
Modulus 123413.57 MPa

4-POINT BENDING TEST

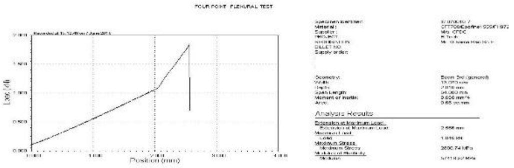
Arrange the UTM machine with 4point setup and test the samples for flexure strength and note down the observations in the following table



4. POINT BENDING TEST						
Span Length 50mm						
1	13.21*1.86	2.642	2.048	1768	114	S,U,R
2	13.14*1.96	2.883	2.278	1711	125	S,U,R
3	13.26*1.93	2.909	2.204	1782	132	S,U,R
4	13.15*1.98	2.823	2.368	1850	119	S,U,R



Span Length 64mm						
1	13.07*2.01	2.566	1.846	1674	132	S,U,R
2	12.92*1.92	2.474	2.191	1987	145	S,U,R
3	13.22*1.92	2.409	1.828	1657	125	S,U,R
4	13.37*2.08	2.903	2.262	2051	135	S,U,R
5	13.26*1.9	2.967	2.522	2287	139	S,U,R



Span Length 80mm						
1	13.08*1.96	3.981	3.637	4123	142	S,U,R
2	13.13*1.96	3.861	3.080	3959	134	S,U,R
3	13.11*2.06	3.621	2.830	3491	139	S,U,R
4	13.21*2.02	2.817	2.801	3208	145	S,U,R
5	13.21*2.02	2.851	3.080	3221	133	S,U,R

DENSITY TEST

Density test depends on “Archimedes’ principle”.

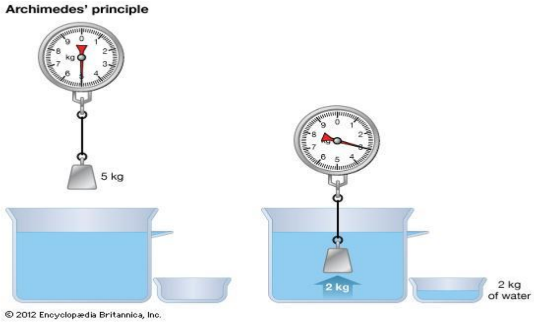
ARCHIMEDES’S PRINCIPLE: indicates that the upward buoyant force that is exerted on a body immersed in a fluid, whether fully or partially submerged, is equal to the weight of the fluid that the body displaces and it acts in the upward direction at the centre of mass of the displaced fluid.

Archimedes' principle is a law of physics fundamental to fluid mechanics.

CFT700/EPOXY EPOFINE 1555/FH972 CURIED COMPOSITE 4-LAYER

Raw material Used:

- Epoxy resin
- Hardener (fh972)
- Tow Fiber



The difference between these data's gives the weight loss in water by Archimedes Principle.

Weight of the solid specimen in air = W1

Weight of the solid specimen in water =W2

Weight loss of the specimen in water =(W1-W2)

Density of the specimen = $\frac{w_1}{w_1-w_2} x\rho water$

DENSITY TEST:

Weights	Sanple1	Sanple2	Sample3
Weights in air W1 in gm/cc	0.7310	0.7067	0.7263
Weights in distilled water W2 in gm/cc	0.2727	0.2640	0.2677
Weight loss in dis.water(W1-W2)	0.4583	0.4427	0.4586
Density=w1/(w1-w2) gm/cc	1.59	1.59	1.59

Then after the specimens immersed in the nitric acid with help of crucible and weight the crucible observation for 24hrs.

By arc method process separates the nitric acid and fibre contect.

The fibre content is dry for 2-3hrs due to remove the moxiture contect and weight crucible noted it.

` Crucible weight of laminate = C1

Crucible weight of fibre = C2

Fibre weight $=\frac{C_2-C_1}{C1}$

FIBRE TEST:

Weights	Sample1	Sample2	Sample3
Crucible weight of laminate	53.0190	64.2877	51.6433
Crucible weight of fibre	53.5597	64.8153	52.1634
Fibre weight $\frac{C_2-C_1}{C1}$	0.01019	0.008206	0.00722

Average density of fibre (ρ_f) =1.78

Average density of composite (ρ_c) =1.596

Average weight of fibre (W_f) =0.00855

Percentage of fiber = $W_f*\rho_c/\rho_f$=0.00855*1.596/1.78 =65.6Percentage of Resin =1- percentage of fibre =100-65.6

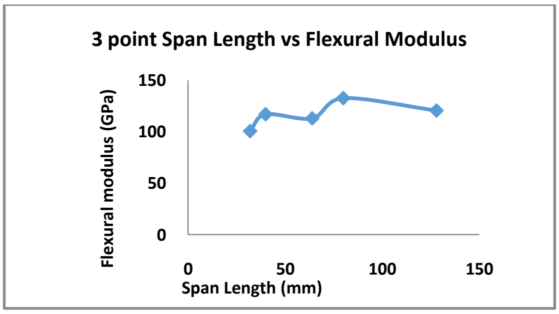
=35.4

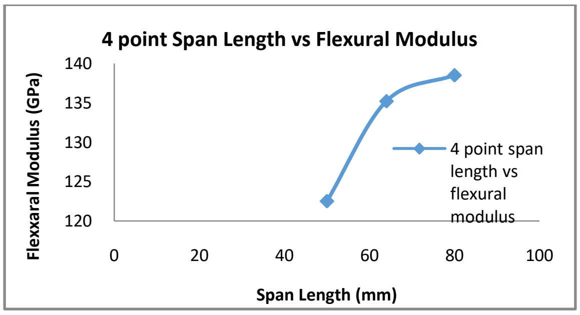
CONCLUSION

Average values of 3 point and 4 point bend test methods are as follows

S.No	Sample Length(mm)	Flexure Strength (MPa)	Flexure Modulus (GPa)
3 Point Test			
1	32	1625.1	100.66
2	40	1550	117
3	64	1829	113
4	80	1581	132.66
5	128	1683.8	120.6
4 Point Test			
1	50	1777.75	122.5
2	64	1931.22	135.2
3	80	3600.4	138.5

Comparing the flexure modulus of both the test methods by the following graphs

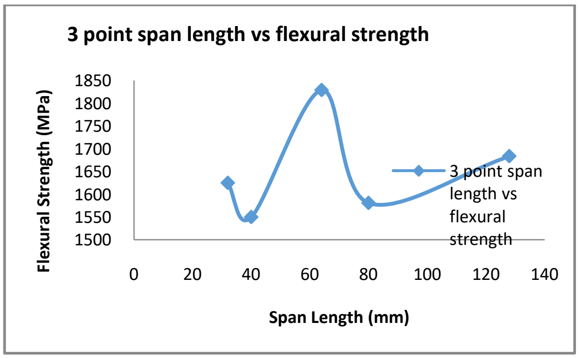


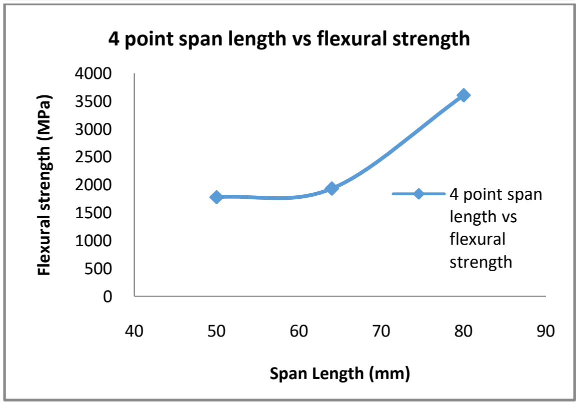


By comparing the above two graphs we can conclude

1. In 3 point test there is an increase and decrease in flexure modulus depending on the span length
2. In 4 point test ther is increase in flexure modulus with increase in span length.

Comparing flexure strength of both tests by following graphs





1. In 3 point test method there is there is a great variation in strength depending on span length.
2. In 4 point test method there is a gradual increase in small change in length and a steep increase when the span length increase is higher.

The following conclusions can be made by studying both test

1. In 3 point test both bending and shearing of material takes place.
2. In 4 point test pure bending takes place.
3. In 3 point test the modes of failure are compression , breaking of material at applied load point and usually at the middle.
4. In 4 point test modes of failure are inter laminar shear, right or left of the material

On conducting density test the following result is obtained

Percentage of resign in laminate is 65.6.

Percentage of fiber in laminate is 35.4.

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