

Evaluation of Mechanical Behaviour of E – Glass and Banana Fiber Reinforced With Epoxy Resin Matrix

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Abstract- Fibre reinforced polymer composites are used in a variety of application because of their many advantages such as relatively low cost of production, easy to fabricate and superior strength. Reinforcement in polymer is either synthetic or natural. Synthetic fibre such as glass, carbon etc., has high specific strength but their fields of application are limited due to higher cost of production. Recently there is an increase interest in natural fibre based composites due to their various advantages. The objective of the present research work is to study the physical and mechanical behaviour of E – GLASS FIBER, BANANA FIBER reinforced epoxy based hybrid composites. The effect of fibre loading and length on mechanical properties like tensile strength, flexural strength, hardness of composites is studied.

1. INTRODUCTION

The development of composite materials are the important advances in the history. This development enhanced the fabrication of various kinds of materials. Composites are the material used in various fields having mechanical and physical properties and are developed and used for particular application. Composite materials having a range of advantages over other conventional materials such as tensile strength, impact strength, flexural strengths, stiffness and fatigue characteristics.

When two or more different materials with different properties are combined together, they form a composite material. Composite materials comprise of strong load carrying material (known as reinforcement) imbedded (combined) with weaker materials (known as matrix). Their primary functions of the matrix are to transfer stresses between the reinforcing fibres/particles and to protect them from mechanical and/or environmental damage. Composites can be classified depending on the type of matrix materials, composite materials can be classified into three categories such as metal matrix

composites, ceramic matrix composites and polymer matrix composites. They are normally non-metallic and processed very often at high temperature. The main objective of ceramic matrix composites is to enhance the toughness, high strength and hardness, high temperature properties, wear resistance etc.

1.1 Particle reinforced composites also called particulate composites consisting of reinforcing material that is in the form particle. The shape of reinforcing particle may either spherical, a platelet, cubic, tetragonal, or of other regular or irregular geometry. The arrangement of the particles in the composites may be either random or preferred orientation.

1.2 Fibre reinforced polymer composites also called fibrous composites consisting of fibres as the reinforcement. Now-a-days, these composites have found applications in various areas such as automotive, marine, aerospace etc. due to their high specific stiffness and strength. Fibres in polymer composites can either synthetic/man-made fibres or natural fibres.

TABLE 1.1 PHYSICAL PROPERTIES OF NATURAL FIBRES

Fibre	Tensile strength (MPa)	Young's modulus (GPa)	Elongation at break (%)	Density (g/cm ³)
Abaca	400	12	3-10	1.50
Alfa	350	22	5.80	0.89
Bagasse	290	17	-----	1.25
Bamboo	140-230	11-17	-----	0.60-1.10
Banana	500	12	5.90	1.35
Coir	175	4-6	30	1.20
Cotton	287-597	5.50-12.60	7-8	1.50-1.60
Curaua	500-1150	11.80	3.70-4.30	1.40
Date palm	97-196	2.50-5.40	2-4.50	1-1.20
Flax	345-1035	27.60	2.70-3.20	1.50
Hemp	690	70	1.60	1.48
Henequen	500-70	13.20*3.10	4.80-1.10	1.20
Isora	500-600	-----	5-6	1.20-1.30
Jute	393-773	26.50	1.50-1.80	1.30
Kenaf	930	53	1.60	-----
Nettle	650	38	1.70	-----
Oil palm	248	3.20	25	0.7-1.55
Piassava	134-143	1.07-4.59	21.90-7.80	1.40
Pineapple	1.44	400-627	14.50	0.80-1.60
Ramie	560	24.50	2.50	1.50
Sisal	511-635	9.40-22	2.0-2.50	1.50
E-glass	3400	72	-----	2.5

2. MATERIALS AND METHODS

2.1 MATERIALS:

The raw materials used in this works are

1. E – Glass fiber
2. Banana fiber
3. Epoxy Resin
4. Catalyst(Methyl Ethyl Ketone Peroxide)
5. Accelerator(Cobalt Naphthenate)

2.1.1 E-GLASS FIBER:

Glass fiber also called fiberglass is the material made from extremely fine fibers of glass. It is a lightweight, extremely strong, and robust material. The manufacture of glass fibres may be executed to the direct melting process. However, in most cases glass rods or balls are made first which then may undergo a variety of further processes.

2.1.1.1 Nozzle-Drawing:

As can be seen in Fig. 1-50, the glass fed in is melted in a heated melt tub at 1250–1400oC. Then, it emerges at the bottom of the melt tub from nozzle holes of 1–25 mm diameter and it is taken off and drawn. The filaments solidify and are finished and wound. One can find them in the shops as various kinds of “glass silk”. To make them into webs, the filaments are cut to length (mostly, between 6 and 25 mm).

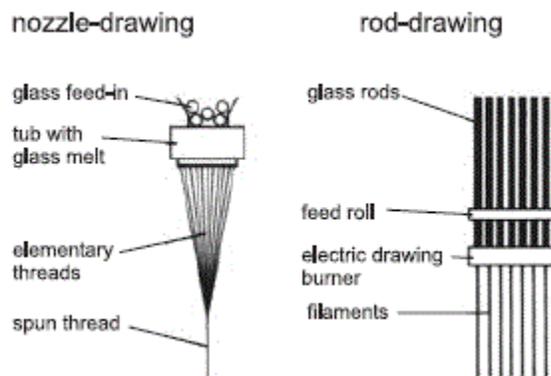


FIGURE 2.1 PROCESSES TO MAKE GLASS FIBRES

2.1.1.2 Nozzle-Blowing:

The same as with nozzle-drawing, glass balls are melted in the tub. The melt emerging from the nozzle holes is then taken by pressed air, which draws the liquid glass so as to make fibres of 6–10 um diameter. A fluttering effect is caused by the flow of

pressed air, which results in fibres of lengths from 50 to 300 mm. A lubricant is put on and the fibres are laid down on a sieve drum which sucks them in. The dry web received is held together by the long fibres, the short ones lying inbetween them as a filling material. Then, the slivers of glass fibre material are cut.

2.1.1.3 Rod-Drawing:

By means of a burner, bundles of glass rods are melted at their bottom ends. This results in drops which, as they fall down, draw filaments after them. The filaments are taken by a rotating drum, a squeegee laying them down onto a perforated belt. Thus, a dry web is received which can be wound as glass fibre slivers. – Machine performance being limited by the number of glass rods fed in, the rotating drum may be combined with nozzle-drawing, which results in drum-drawing. This multiplies machine performance. The dry web is again laiddown onto a perforated belt and solidified or, after winding it so as to receive slivers, cut for further processing on machines producing wet laid nonwovens.

2.1.2 BANANA FIBER:

Banana is cultivated in over 120 countries throughout the tropical and subtropical regions of the world. The ten largest banana-producing countries are India, Uganda, Ecuador, Brazil, Colombia, Philippines, China, Indonesia, Democratic republic of Congo, and Costa Rica.

Banana fibre extraction from the pseudo stem, the most common method followed in Indian villages is hand scrapping, i.e. to scrap the stem with blunt metal edge. An easier and quicker way of extracting fibres is to use a machine extractor, called Raspador. Banana Fiber is extracted from Banana pseudo stem sheaths. In some banana growing countries of the world like Philippines, Uganda, China, and Indonesia systematic extraction of banana fibre is being carried out. The plants are cut down as soon as the fruits are harvested. It would be desirable to separate them according to the classification, to the cleaning or stripping that would enable the artisans to market the fibres advantageously. The fibers are extracted through hand extraction machine composed of either serrated or non-serrated knives. The extracted fibers are sun-dried which whitens the fiber. To knot the fiber, each fiber is separated and knotted to the end of

another fiber manually. The separation and knotting is repeated until bunches of unknotted fibers are finished to form a long continuous strand. This fiber can now be used for making various products.

TABLE 2.1 SPECIFICATION OF BANANA FIBRES

Linear Density (D)	Average Strength (cN/tex)	Strength Unevenness (%)	Average Elongation at Break (%)	Elongation Unevenness (%)	Break Strength (cN/tex)
4.03	39.3	34.3	5.4	19.7	2.3

2.1.3 EPOXY RESIN:

Epoxy resin density of 1.15-1.20g/cm³, mixed with hardener density of 0.97-0.99g/cm³, is used to prepared the composite material resin from purchased local source

2.1.4 CATALYST (METHYL ETHYL KETONE PEROXIDE):

Methyl ethyl ketone peroxide, also known as 2-butanone peroxide, is a strongly oxidizing (caustic) organic peroxide that is commonly used in the manufacture of acrylic resins and as a room temperature hardening and curing agent for fiberglass-reinforced plastics and unsaturated polyester resins (HCN, 2002; NTP, 1993). At room temperature, it is a colourless to yellow liquid with a characteristic or mint-like odour (NIOSH, 2007; NTP, 2016).. When MEKP is used as a hardening or curing agent, the duration of the reaction is dependent on both the type of resin being cured as well as the formulation of the MEKP solution. Typical reactions contain approximately 1 - 2% MEKP. In a series of experiments, the ‘time to cure’ was roughly 40 - 50 minutes for a commercial MEKP formulation (CI, 1999). The ‘time to cure’ is the time from the initiation of the reaction to when the peak temperature is reached (often in excess of 350°F), which is not necessarily the end of the reaction. Studies of the health effects of MEKP are limited and primarily focus on short-term exposures to relatively large amounts of the chemical Direct exposure to the eyes of rabbits resulted in damage, with severe injury occurring with two drops of 40% MEKP. Three percent MEKP caused a more moderate reaction that improved after two days (Hathaway & Proctor, 2014). Several studies have examined inhalation exposure in mice and rats; the concentration needed

to kill 50% of the animals (known as the LC50) in four hours was 170 parts per million (ppm) in mice and 200 ppm in rats.

2.1.5 ACCELERATOR (COBALT NAPHTHENATE):

Accelerators are material which help the decomposition of peroxides and produce free radicals which start the propagation reaction resulting in the gelation and ultimate cure of polyesters. Soaps of Cobalt and certain amines act as accelerators in the homolytic fission of peroxides generating from radicals. Therefore, the role of organic peroxides differ in their reactivity and response to accelerators depending upon their chemical constitution Cobalt naphthenate is widely used in polyester resins and paint driers. It is used as a curing accelerator, cross linker catalyst for unsaturated polyester resins. It is also used in the production of adhesives, varnishes and waterproofing agents for textiles.

3. TESTS PERFORMED

3.1. TENSILE TEST

3.1.1 UNIAXIAL TENSILE TESTING:

The tensile testing is carried out by applying longitudinal or axial load at a specific extension rate to a standard tensile specimen with known dimensions (gauge length and cross sectional area perpendicular to the load direction) till failure. A range of universal standards provided by Professional societies such as American Society of Testing and Materials (ASTM), British standard, JIS standard and DIN standard provides testing are selected based on preferential uses. Each standard

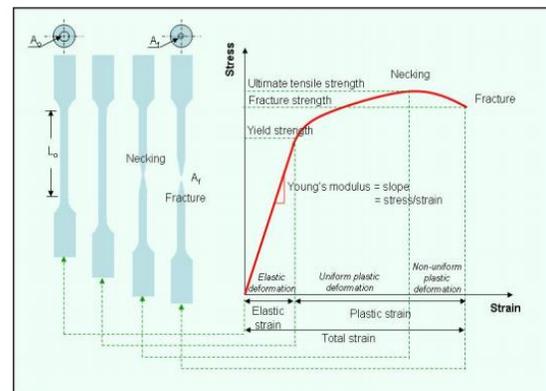


FIGURE 3.1 .Stress-strain relationship under uniaxial tensile loading

3.2 COMPRESSION TEST

Compression tests are used to determine how a product or material reacts when it is compressed, squashed, crushed or flattened by measuring fundamental parameters that determine the specimen behaviour under a compressive load. These include the elastic limit, which for "Hookean" materials is approximately equal to the proportional limit, and also known as yield point or yield strength, Young's Modulus (these, although mostly associated with tensile testing, may have compressive analogs) and compressive strength.

3.3 THE CHARPY TEST

The Charpy test is most commonly used to evaluate the relative toughness or impact toughness of materials and as such is often used in quality control applications where it is a fast and economical test. It is used more as a comparative test rather than a definitive test.

3.3.1 Charpy Test Specimens

Charpy test specimens normally measure 55x10x10mm and have a notch machined across one of the larger faces. The notches may be:
 V-notch – A V-shaped notch, 2mm deep, with 45° angle and 0.25mm radius along the base.
 U-notch or keyhole notch – A 5mm deep notch with 1mm radius at the base of the notch.

3.3.2 PROCEDURE:

The Charpy test involves striking a suitable test piece with a striker, mounted at the end of a pendulum. The test piece is fixed in place at both ends and the striker impacts the test piece immediately behind a machined notch.

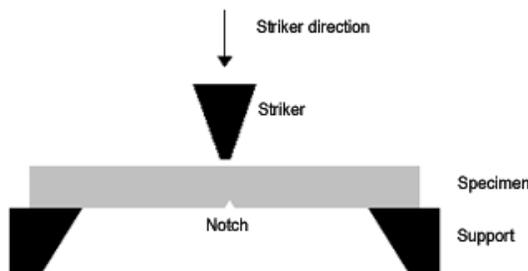


FIGURE 3.2 Schematic of the Charpy impact test.

3.4 THE BRINELL HARDNESS TEST:

The Brinell hardness test method consists of indenting the test material with a 10 mm diameter

hardened steel or carbide ball subjected to a load of 3000 kg. The diameter of the indentation left in the test material is measured with a low powered microscope. A well-structured Brinell hardness number reveals the test conditions, and looks like this, "75 HB 10/500/30" which means that a Brinell Hardness of 75 was obtained using a 10mm diameter hardened steel with a 500 kilogram load applied for a period of 30 seconds. On tests of extremely hard metals a tungsten carbide ball is substituted for the steel ball.

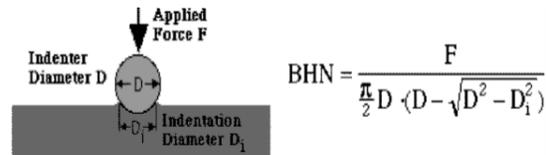


FIGURE 3.3 SCHEMATIC OF HARDNESS TEST

4. RESULT

4.1 TENSILE STRENGTH OF COMPOSITES

The value of tensile strength obtained is

TABLE 4.1 TENSILE STRENGTH RESULT

S. No	TEST DETAILS	SAMPLE 1	SAMPLE 2
1.	TESILE TEST (mpa)	49.46	52.91

4.2 COMPRESSION TEST

The compression strength is one of the important factors in shows the variations in the compression strength of composites. The value of compression test obtained is

TABLE 4.2 COMPRESSION TEST RESULT

S.No	TEST DETAILS	SAMPLE 1	SAMPLE 2
21	COMPRESSION TEST (mpa)	0.61	0.62

5. CONCLUSION

The experimental study on the hybrid composite with natural fillers on physical, water absorption, wear and mechanical behaviour test leads to the following conclusions,

TABLE 5.1 CONCLUSIONS OF TEST RESULTS

S.No	TEST DETAILS	SAMPLE 1	SAMPLE 2
1.	TESILE TEST (mpa)	49.46	52.91
2.	COMPRESSION TEST (mpa)	0.61	0.62

3.	HARDNESS TEST(BHN)	0.72,0.71,0.69	0.66, 0.67,0.65
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Compression test

Test Details

Name of Organisation & Address: MICRO LAB, Chennai
 Material Name : - Glass fiber(10 wt%)
 Banana fiber(5 wt%)
 epoxy resin (85 %)

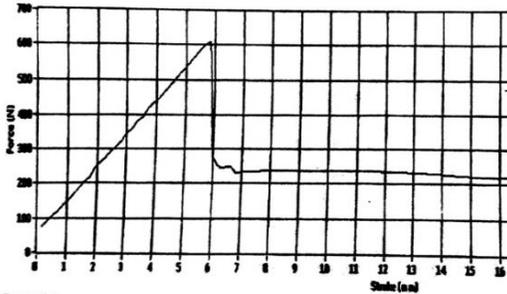
Date :
 TOCR No :

Serial No :

Input Data

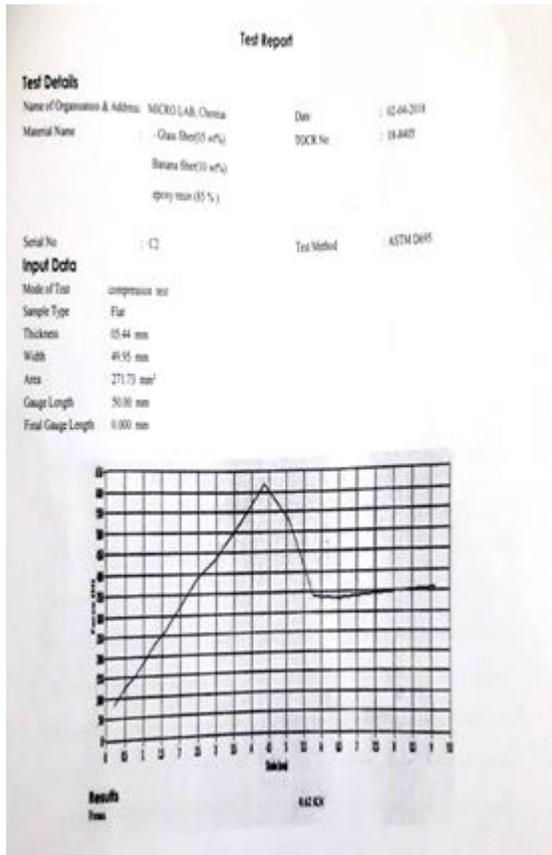
Mode of Test : compression test
 Sample Type : Flat
 Thickness : 05.44 mm
 Width : 49.95 mm
 Area : 271.73 mm²
 Gauge Length : 50.00 mm
 Final Gauge Length : 0.000 mm

Test Method :

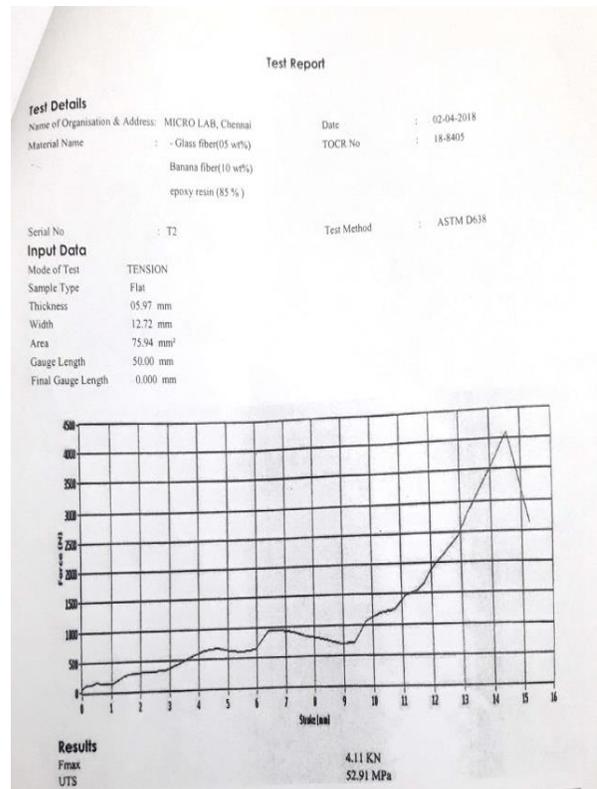
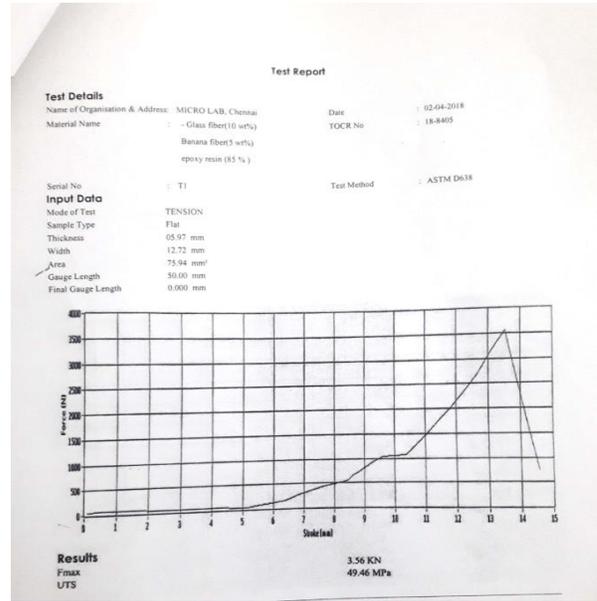


Results
 Fmax

0.61 KN



Tensile test



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