Nanotechnology Perceptions
ISSN 1660-6795
www.nano-ntp.com

To Study and Evaluate the Tensile Strength, Impact Strength and Flexural Strength of Randomly Oriented Short Banana and E-glass Fiber Composite Materials

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Fiber reinforced polymer composites are having superior strength, easy to fabricate and, their production cost is low compares with neat polymer resins, so these are majorly used in many variety of applications. Reinforcement used in composite is either natural or synthetic. Synthetic fiber such as carbon, glass, etc. is higher cost of production so there applications are in limited fields. Even though they have high specific strength. Recently due to many advantages of natural fiber-based composites, their applications are more in various fields. This paper explores mechanical properties in randomly oriented short fiber composites. Banana fiber and E-Glass fiber having length of 6 mm are used as reinforcement and epoxy resinis used as matrix in composites. Different samples are made by using volume fraction method. Samples are prepared according to ASTM Standards. The Mechanical properties such as Tensile Strength, Impact Strength and Flexural Strength were tested. The present investigation revealed that the Banana and E-Glass fiber composites properties are increase as the volume fraction increased. E-glass fiber compositeis greatly influence the banana composite.
Keywords: Mechanical Properties, Banana fiber, E-glass fiber, Short fiber, Randomly Oriented, Epoxy Resin.

1. Introduction

Composites materials are progressively utilized as substitute for much conventional material. Due to rapid development of technology in industries, observing the progress of inventive material designs for replacement is imperious. Consequently polymer composites are recognized as an eminent substitute material because of its low weight and higher strength, with economically feasible aspects. [1] Development of natural fiber-reinforced polymer composites has become a trend in material development. Material Scientists are developing many polymer composites using many available natural fibers. Some of the past research works are discussed here,A.Balaji[1] in their work, a few mechanical properties and thermal strength of epoxy composites reinforced with banana fiber were investigated, it was found that 15 wt% was the most suitable banana fiber reinforcement. Maddigatla Vinod Kumar Reddy [2] in their work, they prepared composites of banana fiber and glass/banana hybrid composites to investigate the influence of glass fiber on banana fiber in mechanical properties, it was found that the glass fiber greatly influenced the banana composite. R.H. Rao[3] in their work, mechanical properties of untreated/alkali treated banana fiber epoxy composites were investigated, it was found that fiber loading and length have major effects on mechanical properties of composites. J. Santosh [4] in their work, untreated/treated banana fiber/epoxy, untreated/alkali treated banana fiber/vinyl ester composites were investigated, it was found that the surface modification by alkali treatment has improved the mechanical properties than untreated fiber composites. N. Venkateshwaran[5] in their work, they compared the experimentally observed tensile properties of banana/epoxy composite with those obtained using various theories of reinforcement, it was found that values predicted using the MRoM are in close agreement with experimental ones. Zin M. H [6] in their work, the effects of alkaline treatment on mechanical and chemical properties of banana fiber were investigated, it was found that tensile strain increases with higher NaOH concentration. J.Madhukiran[7] in their work, the mechanical properties of banana-pineapple fiber reinforced epoxy hybrid composites was investigated. Anshida Haneefa[8] in their work, tensile and flexural properties of short banana/glass fiber reinforced polystyrene composites were studied, it was found that tensile strength and young’s modulus increase with increase in volume fraction of glass fiber. Nikunj Patel [9] in their work, mechanical properties in randomly oriented short natural fiber reinforced composites and the type of pre-treatment applied to the natural fiber to improve the properties of the composites was studied. Md. Shariful Islam [10] in their work, the mechanical properties of banana and rattan fiber were investigated, it was found that the tensile strength of banana fiber composite is 2.57 times higher than the rattan fiber composites. C.H.Naveen Reddy [11] in their work, mechanical and physical properties of unidirectional banana/glass fiber reinforced hybrid composites were investigated, it was observed that the mechanical properties have been improved with increased glass fiber content. S.M.Sapuan[12] in their work, mechanical properties of woven banana fiber reinforced epoxy composites was investigated. William Jordan [13] in their work, the properties of banana fiber reinforced polymeric composites were improved by treating the fibers, it was found that peroxide and permanganate treatment serves to enhance the interfacial bonding of banana-pseudo stem fibers to their LDPE matrix. Danish Ahmad Reshi[14] in their work, mechanical testing was done of e-glass fiber with epoxy resin reinforced matrix, by the results obtained from the test it was found that the glass fiber composite materials possess greater strength to weight ratio .A.Balakrishna[15] in their work, the effect of process parameters on the tensile strength of short and randomly oriented bent grass fiber reinforced composites were studied, it was found that mechanical properties of bent grass fiber reinforced composite is greatly influenced by fiber length, fiber volume fraction and alkali treatment time. G.Devendhar Rao [16] in their work, mechanical properties of e-glass fiber reinforced epoxy composites with SnO2 and PTFE were investigated, it was observed that the mechanical properties like elasticity and flexural strength were improved with SnO2 nana powder in E-glass long fiber. R.D.Hemanth[17] in their work, mechanical properties of e-glass and coconut fiber reinforced with polyester and epoxy resin matrices were investigated, e-glass reinforced composites showed better mechanical properties. FenarthananM.P[18] in their work, mechanical properties of e-glass and Aloe Vera fiber reinforced with polyester and epoxy resin matrices were evaluated, e-glass reinforced epoxy resin composites showed better mechanical properties.Hitesh Jariwala [19] in their work, studied the effect of fiber architecture to determine the mechanical properties of composites. This study shows the unidirectional continuous fiber reinforced composites shows maximum mechanical properties at 40 % fiber loading.

2. Experiment Details

2.1Materials Procurement

From the bark of the banana tree, a type of bastfiber, named banana fiber is extracted. Banana fibers are purchased from Esha Biodegradable, Anand, Gujarat. E-Glass fibers is a manmade fiber purchased from Monika International, Jaipur, Rajasthan. Banana Fibers and E-Glass fibers having a length of 5-7 mm.Epoxy resin and Hardenerwas purchased from Sundaram Chemicals, Surat, Gujarat, India. Table 1 given shows the banana fiber, E-Glass fiber and Epoxy Resin properties.

Table 1Physical and mechanical properties of Banana Fiber, E-Glass Fiber and Resin

Material	Density (g/cm3)	Tensile Strength (MPa)	Tensile Modulus (MPa)	Elongation at break (%)	Diameter (µm)
Banana Fiber	1.45	400-600	16000-20000	7-12	50-100
E-Glass Fiber	2.55	1800-2000	65400-72400	1.8-3.2	8-16
Epoxy	1.15	10	300	7-12	-



Fig.1 Banana Fiber Fig.2 E-Glass Fiber Fig.3 Epoxy Resin

2.2Treatment of materials

The extracted banana fibers were subsequently sun-dried for 24 hours and also dried in the oven at 105º C to remove the moisture present in the fiber. The fibers were further treated with 10 % NaOH solution for 1 hour. The results showed that composite with NaOH treatment has a better tensile strength and flexure strength compared to untreated fiber.[20] Banana fiber composite treated with 10% NaOH concentration has the highest tensile strength, flexure strength and Impact Strength.

2.3 Die preparation

The die was prepared using GI [BOX PIPE] to withstand heavy load and heat resistance with the inner dimension of 250 mm length, 190 mm width and 10 mm thickness. Wax was applied on the walls, upper and lower surfaces of the die to avoid stickiness of polymer to the surface and for the better finishing of the products. Die was used to do the functions of cover, compress the fibers with resin and to avoid leakages of resin during compression.


Fig.4Die Components Fig.5Die

2.4 Fabrication of composites

Composites were prepared using Hand layup method. Banana fibers which are going to be used as reinforcements were placed at the surface of the mould and they are spread randomly all over the mould surface such that there is not any void left. Next the epoxy resin and hardener which is going to be used as matrix is mixed and it is poured in the mould evenly. These two materialswere thoroughly mixed in 10:1 weight ratio and stirred atlow speed until it becomes uniform matrix.The matrix material was poured into the mouldslowly to avoid air trapping.Thematrix material is uniformly spread with the help of the brush. After pouring the matrix the mould is closed with the lid and the weight is kept on the mould for the removal of any air present in it and for the better surface finish. Curing time takes 30-32 hours during Experiment. Generally Hand layup method is used for making of composite materials as it is affordable and does not require capital and infrastructure. After curing, the composite specimens were taken out of the mould. Similarly the specimens of E-Glass fibers were prepared. As per ASTM standards, the fabricated composite specimens were cut to the required sizes to evaluate the tensile, flexural and impact strength. The details of the fiber content and resin content are given below in Table 2.

Table 2 Designation and Composition of Composites

Specimen	Composition	Volume Fraction (VF %)
B 1	Banana fiber (6mm) + Epoxy Resin	10
B 2	Banana fiber (6mm) + Epoxy Resin	20
B 3	Banana fiber (6mm) + Epoxy Resin	30
B 4	Banana fiber (6mm) + Epoxy Resin	40
B 5	Banana fiber (6mm) + Epoxy Resin	45
G 1	E-Glass fiber (6 mm) + Epoxy Resin	10
G 2	E-Glass fiber (6 mm) + Epoxy Resin	20
G 3	E-Glass fiber (6 mm) + Epoxy Resin	30
G 4	E-Glass fiber (6 mm) + Epoxy Resin	40
G 5	E-Glass fiber (6 mm) + Epoxy Resin	45

2.5 Calculation of Volume Fraction

For obtaining volume fraction the weighted short fibers were poured with desired quantity of resin as per the following procedure.

Specimen-1

Weight of Fiber (W_f) = 30 gm Weight of Composite (W_c) = 225 gm

Weight Of Matrix (W_c - W_f)= 225–30 = 195 gm

Density ofFiber (ϱ_f) =1.35 gm/mm^3 Density of Matrix (ϱ_m) =1.25 gm/mm^3

Volume of Fiber (v_f)= $\frac{\text{Weight of Fiber (Wf)}}{\text{Density Of Fiber }(\varrho f)} = \frac{30}{1.35}$ = 22.22 mm^3

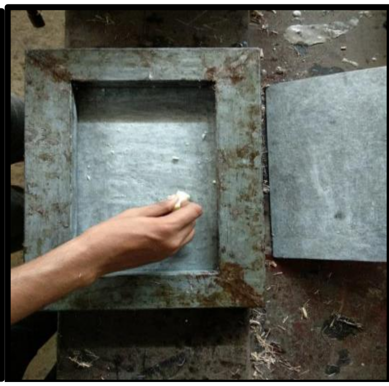
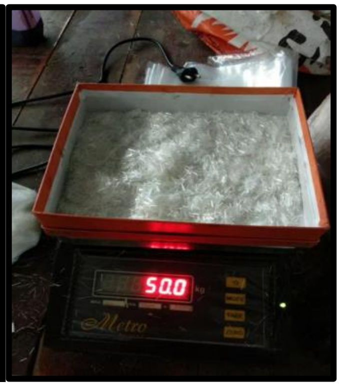
Volume of Matrix (v_m)= $\frac{\text{Weight of Matrix (Wf)}}{\text{Density Of Matrix }(\varrho f)} = \frac{195}{1.25}$ = 156 mm^3

Volume of Composite (V_c)= v_f + v_m = 22.22 + 156 = 178.22 mm^3

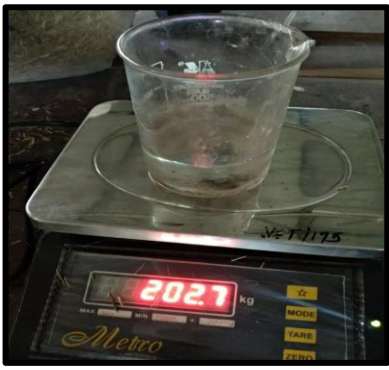
Volume of Fraction (V_f) = $\frac{\text{Volume of Fiber (vf)}}{\text{Volume of Matrix (vm)}} = \frac{22.22}{178.22}$ = 0.1246 = 12.46 %

The same procedure was done for different quantity of resin for obtaining different volume fraction specimen.

2.6 Fabrication of Composites

Step: - 1 Prepare the Die Step: - 2 Apply Wax Step: - 3 Weight
Fiber




Step: - 4 Weight Resin Step: - 5 Prepare Matrix Step: - 6 Apply Fiber
(Resin + Hardener) in 10:1 RatioRandomly on Die



Step: - 7 Apply Matrix Step: - 8 Apply Load Uniformly Step: - 9 Final Composite

3. Testing Of Composites

Mechanical behavior such as tensile test, flexural test and impact test were conducted and their procedures are reported. These test were carried out for 120 composite sample specimens. Total 5 tests were done for each volume fraction specimens and their average value was taken.

3.1 Tensile Test of Composites

As per the standard recommended by ASTM D 3039, the composite sample specimens were made to evaluate the tensile strength. The dimensions of composite specimens were 250 mm length, 25 mm width and 2.5 mm thickness respectively. Tensile test were conducted using universal testing machine. The specimens were fixed in the jaws of universal testing machine.

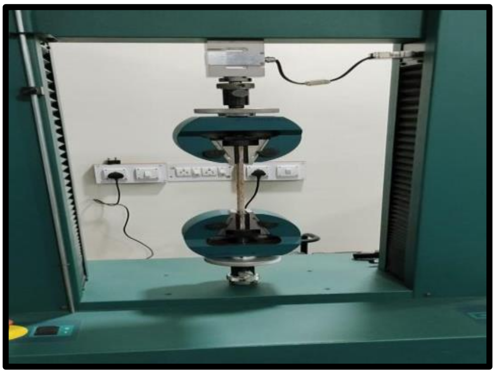


Fig.7Tensile Test on Universal Testing Machine

3.2 Flexural Test of Composites

As per the standard recommended by ASTM D 790, the composite specimens were made to evaluate the flexural strength. The dimensions of the composite specimens were 125 mm length, 12.7 mm width and 3.2 mm thickness respectively. Flexural test were conducted using universal testing machine.

Fig.8Flexural Test on Universal Testing Machine

3.3 Impact Test of Composites

As per the standards recommended by ASTM D256, the composite specimens were made to evaluate the impact strength. The dimensions of composite specimens were 63.5 mm length, 12.7 mm width and 3.2 mm thickness respectively. Izod impact test was conducted to determine the impact resistance of composites. The Izod impact test determines the Impact Resistance of materials. A pivoting arm is raised to specific height and then released. The arm swings down hitting a notched sample and breaks the specimen.

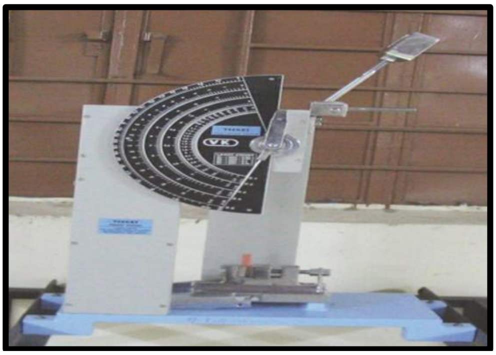


Fig.9Impact Test onIzod Impact Test

4. Results and Discussion

4.1 Tensile test

The mechanical behaviour of banana fiber based epoxy composites is based on Volume Fraction. After testing of fabricated composites it was found that the tensile strength of banana fiber composites increases with the increase in Volume fraction. The minimum tensile strength is 9.067 MPa. The maximum tensile strength is 23.250 MPa of the VF = 40. Fig. 10 and Table 3 shows the tensile strength of short banana fiber composites.

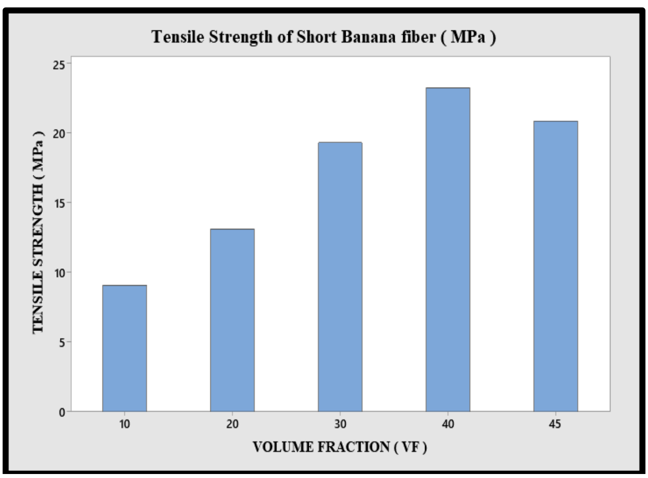


Fig. 10 Tensile strength of Banana fiber Composites

SPECIMEN	VOLUME FRACTION (VF %)	TENSILE STRENGTH (MPa)
B 1	10	09.067
B 2	20	13.120
B 3	30	19.310
B 4	40	23.250
B 5	45	20.870

Table 3 Tensile strength of Banana fiber Composites

The tensile strength of E-Glass fiber composites was also found to be increasing with the increase in Volume Fraction. The minimum tensile strength is 10.93 MPa. The maximum tensile strength of E-Glass fiber composites is 23.87 MPa. The tensile test results of E-Glass fiber are shown in Fig. 11 and Table 4 respectively.

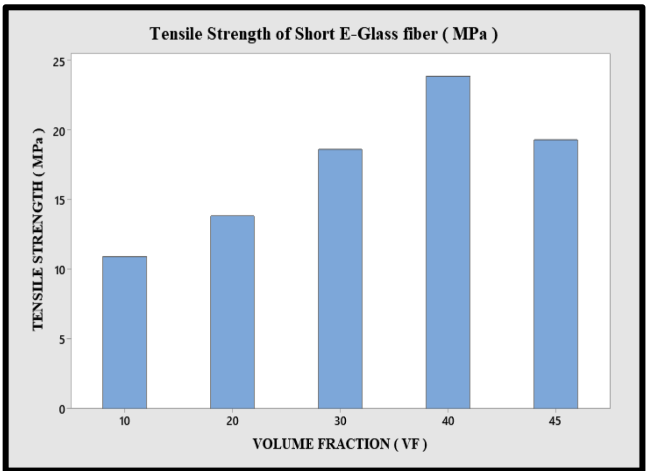


Fig. 11 Tensile strength of E-Glass fiber Composites

Table 4 Tensile strength of E-Glasss fiber Composites

SPECIMEN	VOLUME FRACTION (VF %)	TENSILE STRENGTH (MPa)
G 1	10	10.93
G 2	20	13.84
G 3	30	18.63
G 4	40	23.87
G 5	45	19.31

4.2 Flexural Test

Flexural property of fabricated composites is shown in Fig 17 and Fig 18 respectively. Flexural strength of Banana fiber and E-Glass are found to be increasing with the increase in Volume Fraction. The minimum flexural strength for Banana fiber composites is 29 MPa. The maximum flexural strength of banana fiber composites is 62.4 MPa. The minimum flexural strength of E-Glass fiber composites is 68 MPa. The maximum flexural strength of E-Glass fiber is 136 MPa.The test results of banana fiber composite and E-Glass fiber composite are shown in Fig. 12, Table 5 and Fig. 13, Table 6 respectively.

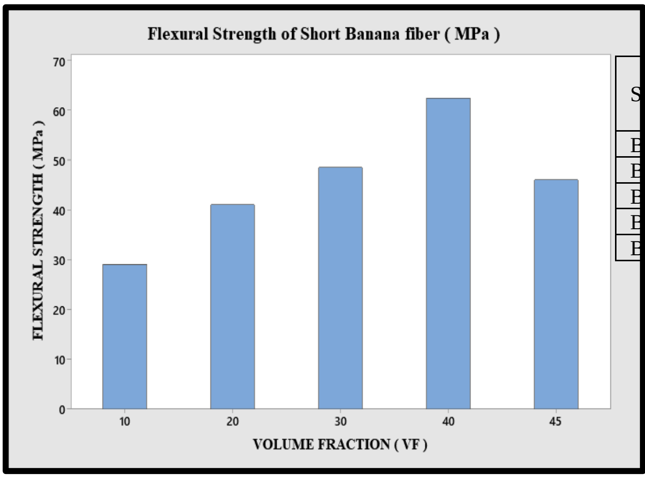


Fig. 12 Flexural strength of Banana Fiber Composites

SPECIMEN	VOLUME FRACTION (VF %)	FLEXURAL STRENGTH (MPa)
B 1	10	29
B 2	20	41
B 3	30	48.5
B 4	40	62.4
B 5	45	46

Table 5 Flexural strength of Banana Fiber Composites

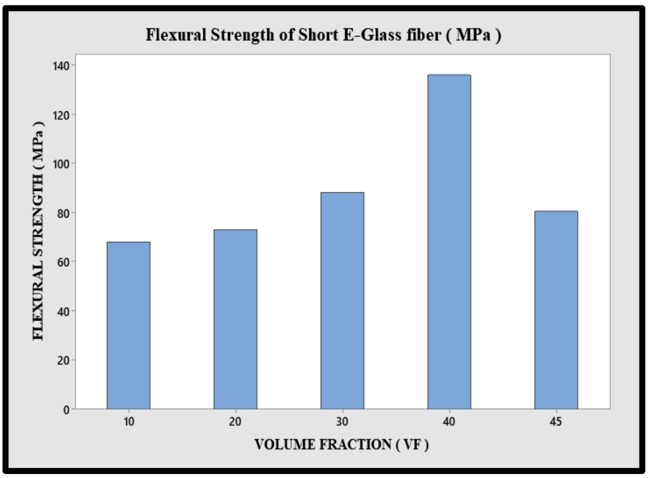


Fig. 13 Flexural strength of E-Glass Fiber Composites

SPECIMEN	VOLUME FRACTION (VF %)	FLEXURAL STRENGTH (MPa)
G 1	10	68.0
G 2	20	73.1
G 3	30	88.2
G 4	40	136
G 5	45	80.6

Table 6 Flexural strength of E-Glass Fiber Composites

4.3 Impact Test

The Impact test results are shown in below Fig 19 and Fig 20 respectively. The Impact strength of banana fiber and e-glass fiber was also found to be increasing with the increase in Volume Fraction. The minimum impact strength of banana fiber composites is 1.24 J. The maximum Impact strength of banana fiber composites is 2.18 J. The minimum Impact strength of e-glass fiber composites is 2.35 J. The maximum Impact strength of e-glass fiber composites is 8.45 J.The test results of banana fiber composite and E-Glass fiber composite are shown in Fig. 14, Table 7 and Fig. 15, Table 8 respectively.

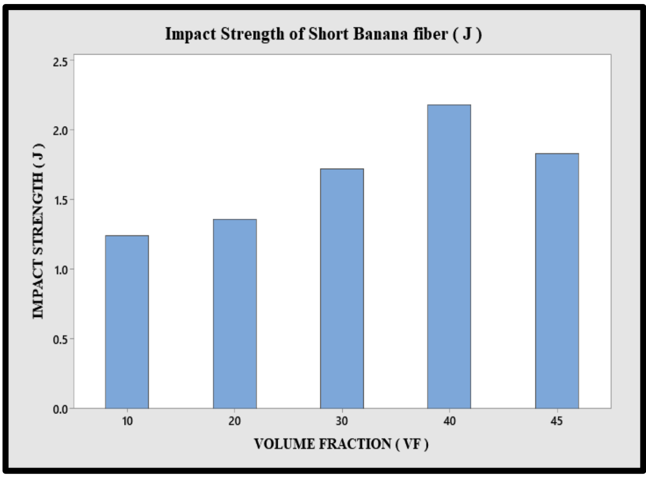


Fig. 14 Impact strength of Banana Fiber Composites

SPECIMEN	VOLUME FRACTION (VF %)	IMPACT STRENGTH (J)
B 1	10	1.24
B 2	20	1.36
B 3	30	1.72
B 4	40	2.18
B 5	45	1.83

Table 7 Impact strength of Banana Fiber Composites

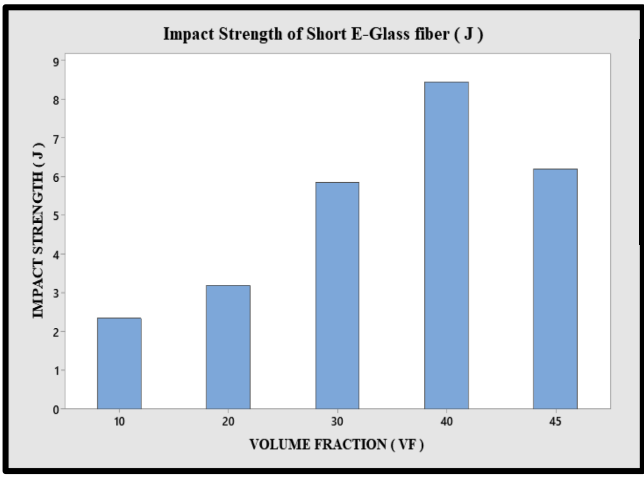


Fig. 15 Impact strength of E-Glass Fiber Composites

SPECIMEN	VOLUME FRACTION (VF %)	IMPACT STRENGTH (J)
G 1	10	2.35
G 2	20	3.20
G 3	30	5.85
G 4	40	8.45
G 5	45	6.2

Table 8 Impact strength of E-Glass Fiber Composites

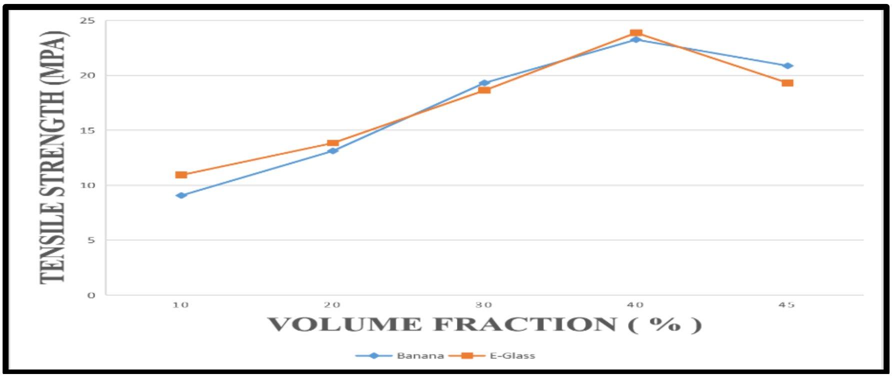


Fig. 16 Tensile Strength of Banana & E-Glass Fiber Composites

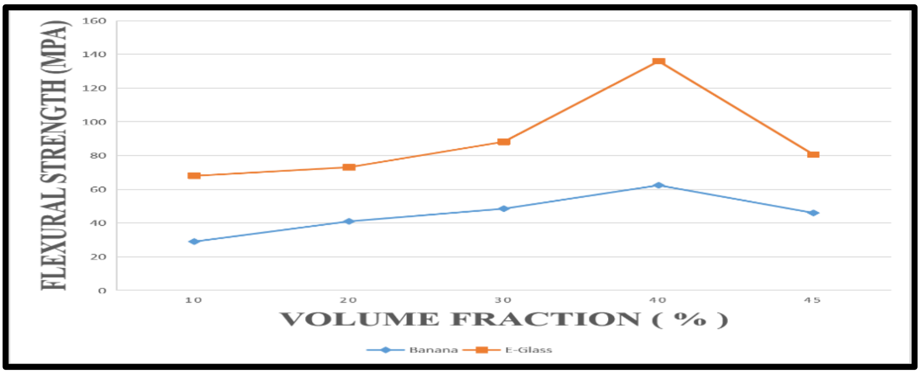


Fig. 17 Flexural Strength of Banana & E-Glass Fiber Composites

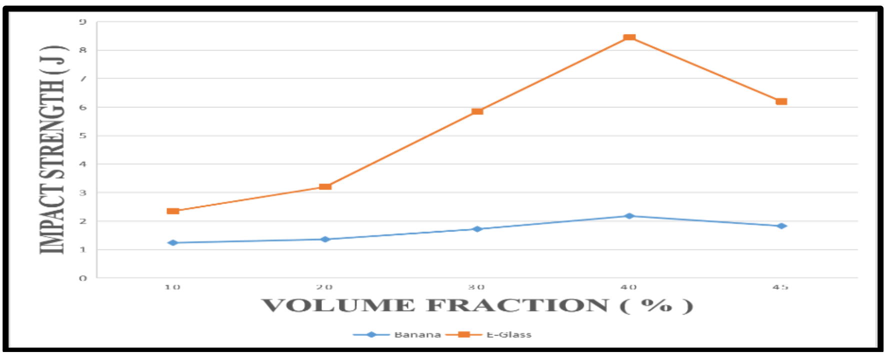
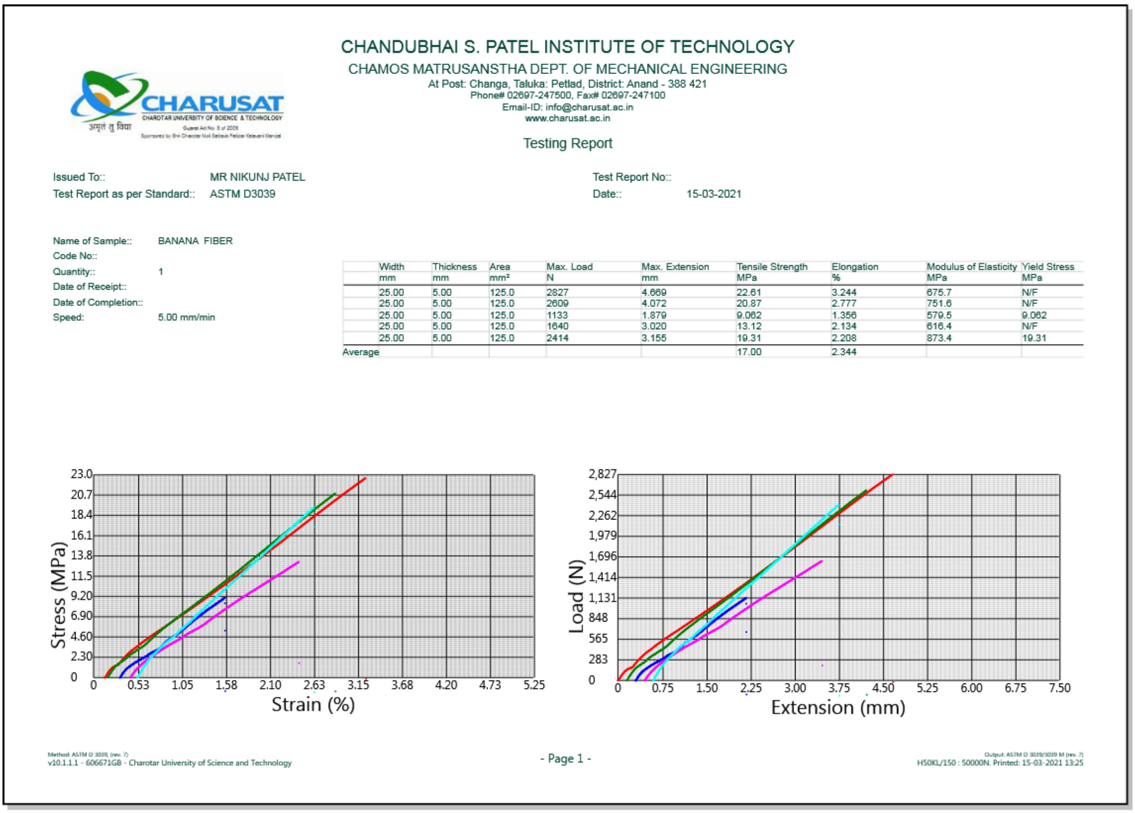


Fig. 18 Impact Strength of Banana & E-Glass Fiber Composites



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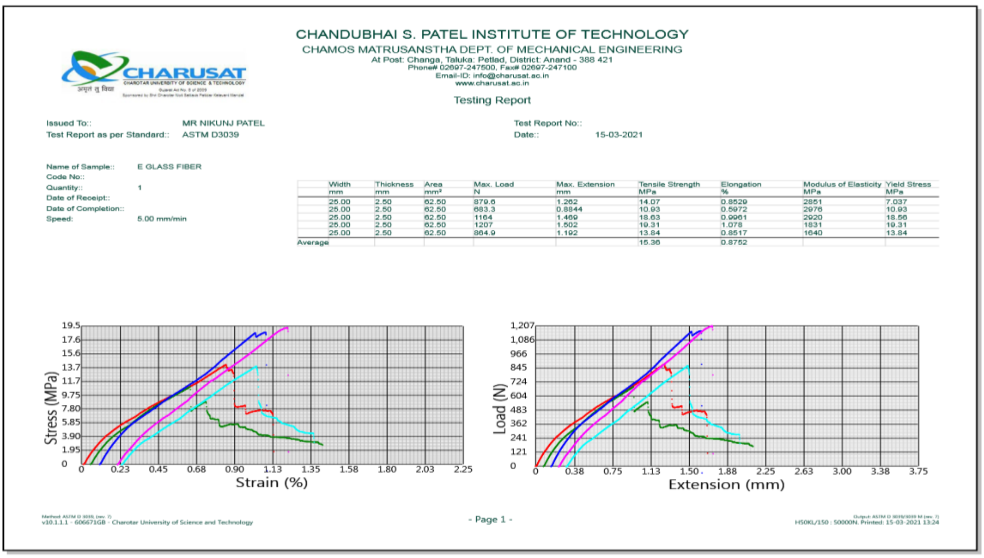
Testing Report

Issued To:: MR NIKUNJ PATEL
Test Report as per Standard:: ASTM D3039
Test Report No::
Date:: 15-03-2021

Name of Sample:: BANANA FIBER
Code No::
Quantity:: 1
Date of Receipt::
Date of Completion::
Speed: 5.00 mm/min

	Width mm	Thickness mm	Area mm²	Max. Load N	Max. Extension mm	Tensile Strength MPa	Elongation %	Modulus of Elasticity MPa	Yield Stress MPa
	25.00	5.00	125.0	2827	4.669	22.61	3.244	675.7	N/F
	25.00	5.00	125.0	2609	4.072	20.87	2.777	751.6	N/F
	25.00	5.00	125.0	1133	1.879	9.062	1.356	579.5	9.062
	25.00	5.00	125.0	1640	3.020	13.12	2.134	616.4	N/F
	25.00	5.00	125.0	2414	3.155	19.31	2.208	873.4	19.31
Average						17.00	2.344		

Fig. 19 Stress-Strain Curve of Tensile Strength of Banana Fiber Composites



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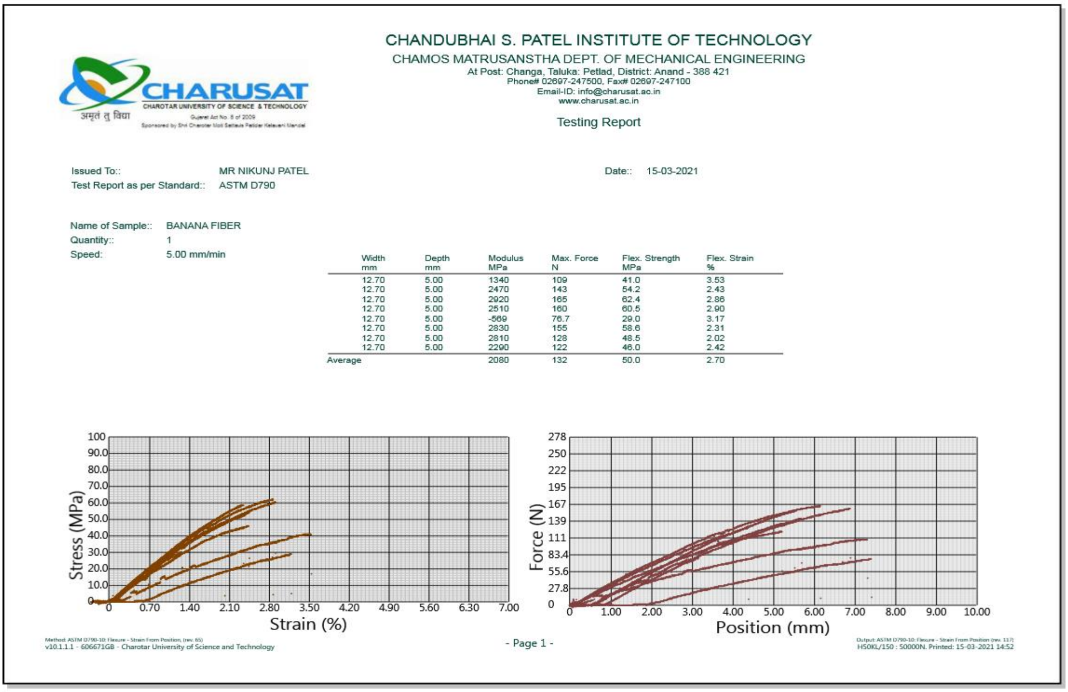
Testing Report

Issued To:: MR NIKUNJ PATEL
Test Report as per Standard:: ASTM D3039
Test Report No::
Date:: 15-03-2021

Name of Sample:: E GLASS FIBER
Code No::
Quantity:: 1
Date of Receipt::
Date of Completion::
Speed: 5.00 mm/min

	Width mm	Thickness mm	Area mm²	Max. Load N	Max. Extension mm	Tensile Strength MPa	Elongation %	Modulus of Elasticity MPa	Yield Stress MPa
	25.00	2.50	62.50	879.6	1.262	14.07	0.8529	2851	7.037
	25.00	2.50	62.50	683.3	0.8844	10.93	0.5972	2976	10.93
	25.00	2.50	62.50	1164	1.469	18.63	0.9961	2920	18.56
	25.00	2.50	62.50	1207	1.502	19.31	1.078	1831	19.31
	25.00	2.50	62.50	864.9	1.192	13.84	0.8517	1640	13.84
Average						15.36	0.8752		

Fig. 20 Stress-Strain Curve of Tensile Strength of E-Glass Fiber Composites



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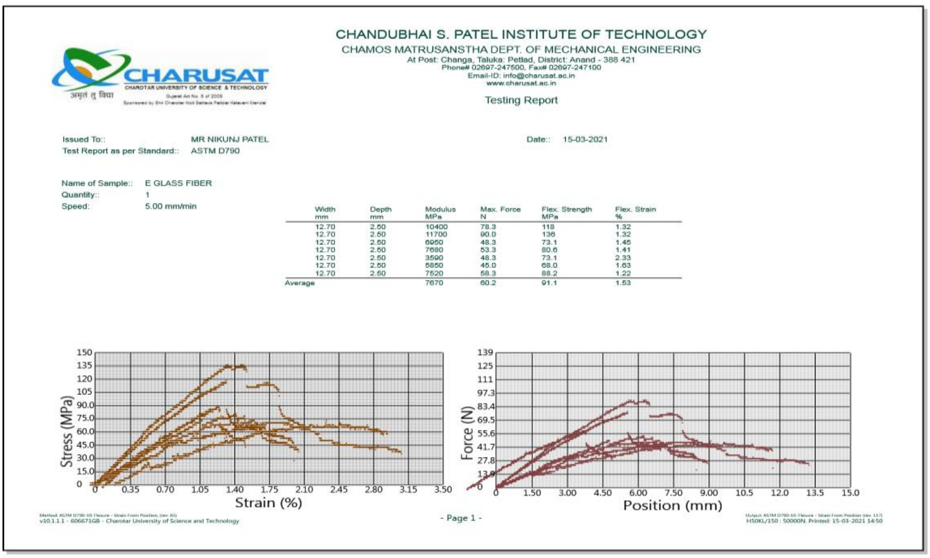
Testing Report

Issued To:: MR NIKUNJ PATEL
Test Report as per Standard:: ASTM D790
Date:: 15-03-2021

Name of Sample:: BANANA FIBER
Quantity:: 1
Speed: 5.00 mm/min

	Width mm	Depth mm	Modulus MPa	Max. Force N	Flex. Strength MPa	Flex. Strain %
	12.70	5.00	1340	109	41.0	3.53
	12.70	5.00	2470	143	54.2	2.43
	12.70	5.00	2920	165	62.4	2.86
	12.70	5.00	2510	160	60.5	2.90
	12.70	5.00	-569	76.7	29.0	3.17
	12.70	5.00	2830	155	58.6	2.31
	12.70	5.00	2810	128	48.5	2.02
	12.70	5.00	2290	122	46.0	2.42
Average			2080	132	50.0	2.70

Fig. 21 Stress-Strain Curve of Flexural Strength of Banana Fiber Composites



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Testing Report

Issued To:: MR NIKUNJ PATEL
Test Report as per Standard:: ASTM D790
Date:: 15-03-2021

Name of Sample:: E GLASS FIBER
Quantity:: 1
Speed: 5.00 mm/min

	Width mm	Depth mm	Modulus MPa	Max. Force N	Flex. Strength MPa	Flex. Strain %
	12.70	2.50	10400	78.3	118	1.32
	12.70	2.50	11700	90.0	136	1.32
	12.70	2.50	6950	48.3	73.1	1.45
	12.70	2.50	7680	53.3	80.6	1.41
	12.70	2.50	3590	48.3	73.1	2.33
	12.70	2.50	5850	45.0	68.0	1.63
	12.70	2.50	7520	58.3	88.2	1.22
Average			7670	60.2	91.1	1.53

Fig. 22 Stress-Strain Curve of Flexural Strength of E-Glass Fiber Composites

6. Conclusions

The composites specimens were prepared by increasing the volume fraction. From the results, it was observed that the maximum tensile strength of banana fiber composites is 23.25 MPa and e-glass fiber composites is 23.87 MPa obtained at VF = 40. The maximum flexural strength of banana fiber composites is 62.4 MPa and e-glass fiber composites is 136 MPa obtained at VF = 40. The maximum impact strength of banana fiber composites is 2.18 J and e-glass fiber is 8.45 J obtained at VF = 40.

The mechanical properties increase with the increase in volume fraction of the composites. The maximum mechanical properties are obtained at VF = 40. After that the mechanical properties starts decreasing after VF = 40.

From the experimental results and graphical analysis it was found that the short e-glass fiber composites show better mechanical properties than short banana fiber composites. While the tensile strength was little higher than the short banana fiber composites, the flexural and impact strength were found to be much better than the short banana fiber composites.

Stress strain curve is intrinsic property of material. It seen in testing report of composites. From the stress-strain curve we can find the elastic modulus, elongation and deformation.

Composite materials reinforced with short fibers combine the unique properties of traditional polymer compositematerials and the high technological capability of production by casting under pressure in forms. These materials canbe used for production of parts of any difficult geometrical form while maintaining high mechanical characteristics at alow specific weight of product.

7. Future Scopes

Current Research area is a Wide area to work in future. For the same fibers Thermal, Tribologicaland compression properties cananalyse. Preparing Hybrid Composites using different reinforcements in varyingproportions and various mechanical properties of thesecomposites can be compared.

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