International Journal of Advances in Scientific Research and Engineering (ijasre)
ISSN: 2454-8006 [Vol. 03, Issue 5, June -2017]
www.ijasre.net

INFLUENCE OF TENSILE TEST THREE POINT BENDING TEST IMPACT TEST BRINELL HARDNESS TEST WATER ABSORPTION TEST ON COIR/GLASS FIBER EPOXY COMPOSITE

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ABSTRACT

Composites materials are made up of two more constituents that when combine together gives better properties than the individual materials. When more than two constituents are mixed to form a composite, it is called hybrid composites. The present paper, investigates the mechanical properties of a hybrid composites which comprises of Epoxy matrix reinforced with Coir fiber and E glass fiber. The composite specimens of different proportion has been fabricated by hand layup technique and evaluated mechanical properties by conducting Tensile, Bending, Impact, Brinell hardness and water absorption test. The results revealed that the composition 3: 8% coir, 4% glass and 88% epoxy has better properties compared to the others compositions.

Keywords: *Coir fiber, glass fiber, Epoxy, hand layup technique, Tensile, Bending, Izod Test, Charpy Test, Brinell Hardness Test, water absorption Test.*

1. INTRODUCTION

Composite materials are basically experimented to reduce the density and to increase the strength of the material. The usage of composite material initially started in aircraft industries, where the structures require high strength and low density. When more than two constituents are mixed to form a composite, it is called hybrid composites. The tensile strength of Epoxy composites with coir as fillers is comparable to that of plain Epoxy composite. Coir is a natural fiber extracted from the husk of coconut fruit. Natural fibers have the advantages of low density, low cost and biodegradability. However, the main disadvantages of natural fibers and matrix are the relative high moisture absorption. Glass fiber composites have higher impact strength and excellent surface finish and high modulus to weight ratios compared to other fiber reinforced composite materials, and therefore extensively used in industries. Girisha et al.[1]Studied the effects of water absorption on the mechanical properties of natural fibers like coconut coir (short fibers) and sisal fibers (long fibers). They were used in hybrid combination and the fiber weight fraction of 20%, 30% and 40% were used for the fabrication of the composite. It is found that higher fiber content samples have a greater diffusivity because of higher cellulose content. Also at elevated temperature there is a 33% higher moisture absorption for the 40% combination of sisal-coir fiber reinforced composites.Senthilnathan et al. [2] conducted a study on the Glass, coconut and human hair fiber based hybrid composites, the epoxy resin is used as binding material. It is found out that the CCRP(coconut coir reinforced plastics) have the maximum tensile load capacity. The HCGHRP(Human hair - Coconut coir – glass – human hair hybrid composite) shows almost maximum double shear strength comparing to other composites.Fairuz I. Romli et al.[3]presented a paper onfactorial analysis on the tensile strength of a coir-based composite. Three interested parameters in this study are fiber volume fraction, curing time and compression load applied during fabrication of the composite. Overall, the results from analysis of variance on the test data shows that coir fiber volume fraction and interaction effect between curing time and coir fiber volume fraction are the prominent factors to the tensile strength of the composite. In that regard, the factorial effects of the coir fiber volume, curing time and compression load have been analyzed.Chandra et al.[4]In present investigation the wear behavior of treated and untreated coir dust filled epoxy resin matrix composites were studied. The effect of treated and un treated coir dust concentration (10%, 20% and 30%), varying loads (10, 20 and 30N) and varying velocities (300, 400 and 500) on the abrasive wear rate of composite has been analyzed. The treated and untreated coir successfully be utilized to produce composite by suitably bonding with resin for value added product. As the percentage of treated and untreated coir fiber increases the wear resistance also increases load and wear rate in both treated and untreated coir composites.

2. METHODOLOGY

2.1 EPOXY

Epoxy resin L-12 is a liquid, unmodified epoxy resin of medium viscosity which can be used with various hardeners for making fiber reinforced composites. The properties of the epoxy resin are listed in the table 1. The choice depends on the processing method to be used and on the properties required of the cured composite. The curing agent used K-6 is a low viscosity room temperature curing liquid hardener. Being rather reactive, it gives a short pot life and rapid cure at normal ambient temperatures.

Table.1: properties of epoxy

Viscosity at 25°Cμ (cP)	1200-
Density p (g.cm-3)	1.1-1.2
Heat Distortion Temperature HDT (°C)	1.16
Modulus of elasticity E (Gpa)	5.0
Flexural strength (Mpa)	60
Tensile strength (MPa)	73
Maximum elongation(%)	4

Fig 1: Epoxy resin

2.2 Coir fibers

Coir or coconut fibre, is a natural fibre extracted from the husk of coconut and used in products such as floor mats, doormats, brushes and mattresses. Coir is the fibrous material found between the hard, internal shell and the outer coat of a coconut. Other uses of brown coir are in upholstery padding, sacking and horticulture. White coir, harvested from unripe coconuts, is used for making finer brushes, string, rope and fishing nets .The longer length fiber is chopped to required length with the help of knife rotary mill. The properties of coir fibers are listed in the table 2.

Table.2: properties of coir fiber

Diameter	0.48mm
Specific Gravity	0.87
Water Absorption	104%
Density	2057kg/m3
Elastic Modulus	2.8X103MPa
Tensile strength	210MPa
Elongation at Failure	27.4%

Fig 2: Coir fiber

2.3 Glass fiber

Table.3: properties of glass fiber

Density(g/m3)	2.59
Tensile Strength (Mpa)	1380-2070
Tensile Module (Gpa)	72.45
Linear Coefficient of Thermal	5.0-6.0
Expansion (10-6/K)	
Elongation at break (%)	3-4

Glass fiber has roughly comparable mechanical properties to other fibers such as polymers and carbon fiber. Although not as strong or as rigid as carbon fiber, it is much cheaper and significantly less brittle when used in composites. Glass fibers are therefore used as a reinforcing agent for many polymer products; to form a very strong and relatively lightweight fiber-reinforced polymer (FRP) composite material called glass-reinforced plastic (GRP), also popularly known as "fiberglass.

FIG 3: GLASS FIBER

The specimens for tests are fabricated according to the corresponding ASTM standards. The composites are fabricated by hand layup method. It is preferred because of its simplicity and minimum usage of equipment's. The specimen were manufactured in three different compositions. The compositions are specified in the table 3.

Table.4: composition of constituents

Constituents	Coir fiber %	Glass fiber %	Epoxy %
Composition 1	4	4	92
Composition 2	6	4	90
Composition 3	8	4	88

3. EXPERIMENTS AND RESULTS

3.1 Tensile test

Tensile strength is the maximum stress that a material can withstand on the application of tensile load before failure. The peak point of the stress-strain curve is the ultimate tensile strength of the specimen. The test specimens were prepared as per ASTM: D3039 standard sample dimension is (250×25×3mm).

Table.5: Tensile test results

Composition(1) 4%Coir 4%Glass 92%Epoxy	Max load (KN)	Tensile strength (N/mm^2)
Specimen(1)	5.140	68.533
Specimen(2)	4.640	61.866
Composition(2) 6%Coir 4%Glass 90%Epoxy		
Specimen(1)	5.540	73.866
Specimen(2)	5.620	74.933
Composition(3) 8%Coir 4%Glass 88%Epoxy		
Specimen(1)	5.800	77.333
Specimen(2)	5.760	76.800

Composition 1: 4%Coir 4%Glass 92%Epoxy

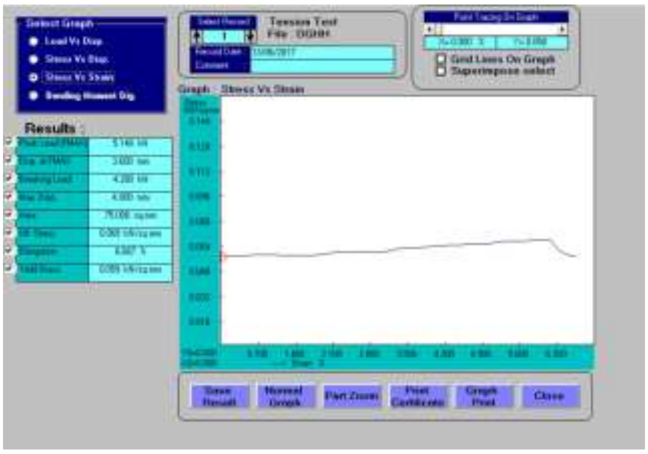

Fig 4: stress v/s strain diagram

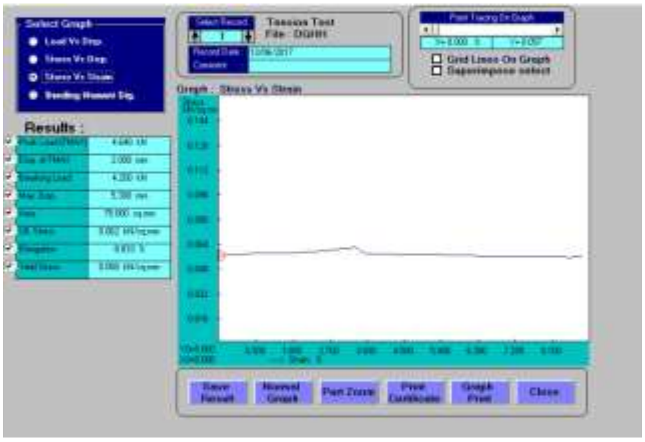

Fig 5: stress v/s strain diagram

Fig 4 illustrated that the peak load is 5.41kN and the displacement is 3.60, breaking load is recorded as 4.28 kN. The ultimate stress and elongation are 0.069 kN/sq mm and 6.667% respectively. Fig 5 shows that the peak load is 4.640 KN and the displacement 2.0, breaking load is recorded as 4.20 kn. The ultimate stress and elongation are 0.062 kn/sq mm and 8.833% respectively.

Composition 2: 6%Coir 4%Glass 90%Epoxy

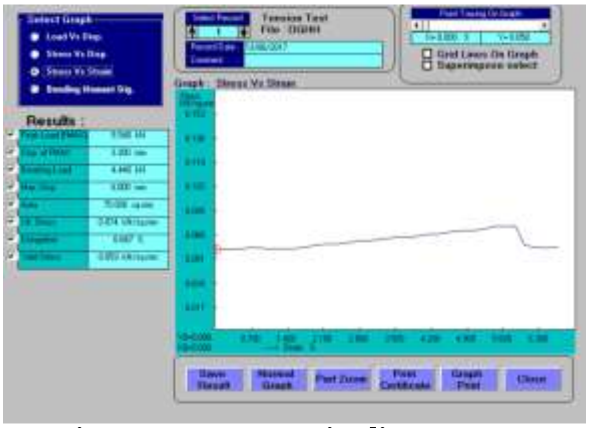

Fig 6: stress v/s strain diagram

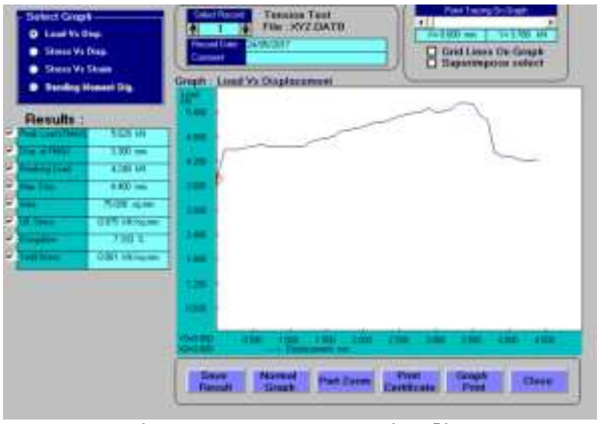

Fig 7: stress v/s strain diagram

Fig. 6 shows, peak load is 5.540 KN and the displacement 3.30, breaking load is recorded as 4.440kN. The ultimate stress and elongation are 0.074 kN/sq mm and 6.667% respectively. Fig. 7 demonstrated that, the peak load is 5.620 kN and the displacement 3.30, breaking load is recorded as 4.240kN. The ultimate stress and elongation are 0.075 kN/sq mm and 7.33% respectively.

Composition 3: 8%Coir 4%Glass 88%Epoxy

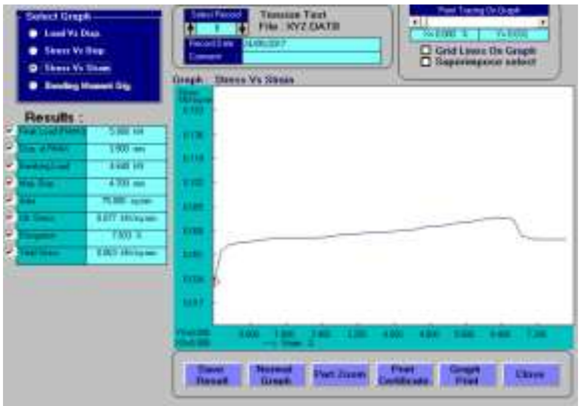

Fig 8: stress v/s strain diagram

Fig 9: stress v/s strain diagram

From the fig 8 graph it is observed that the peak load is 5.80 kN and the displacement 3.90, breaking load is recorded as 4.640 kn. The ultimate stress and elongation are 0.077 kN/sq. mm and 7.833% respectively.

From the fig 9 graph it is clear that the peak load is 5.75kN and the displacement 3.90, breaking load is recorded as 4.260 kN. The ultimate stress and elongation are 0.077 kN/sq. mm and 7.667% respectively.

4.1 BENDING TEST

Bending strength is conducted to determine material's ability to resist deformations under bending load. The transverse bending test is conducted to calculate the bending strength of a composite specimen, in which a specimen is bent until

International Journal of Advances in Scientific Research and Engineering (ijasre)
ISSN: 2454-8006 [Vol. 03, Issue 5, June -2017]
www.ijasre.net

fracture. The flexural test is done in a three point bending setup as per ASTM: D790 standard (sample dimension is 62 ×12.5 × 3 mm).

Flexural Strength $= \frac{3PL}{2bd^2}$ …….(1)

P is the maximum load applied in N

L is the length of the support span in mm

bis width in mm

dis thickness in mm

Table.6: bending test results

Composition(1) **4%Coir 4%Glass 92%Epoxy**	**Load (KN)**	**Bending strength (N/mm^2)**
Specimen(1)	4.160	4.060
Specimen(2)	3.980	3.656
Composition(2) **6%Coir 4%Glass 90%Epoxy**		
Specimen(1)	4.280	4.212
Specimen(2)	4.420	4.060
Composition(3) **8%Coir 4%Glass 88%Epoxy**		
Specimen(1)	4.400	4.330
Specimen(2)	4.480	4.115

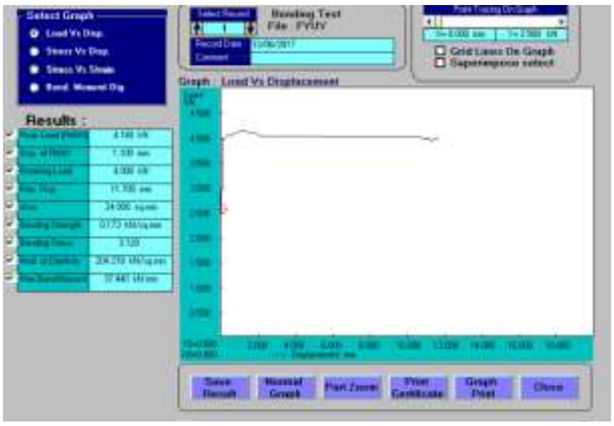

Fig 10: Load v/s displacement diagram

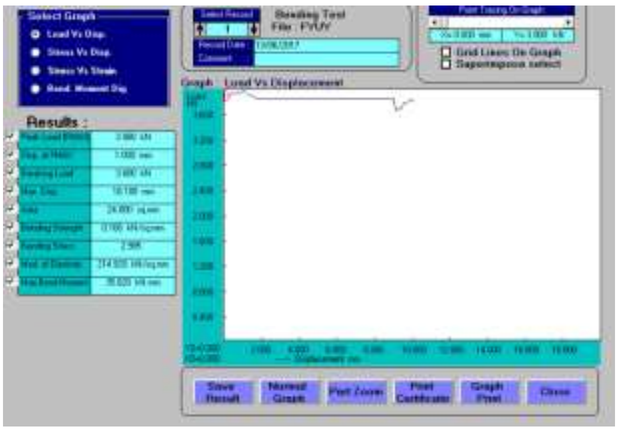

Fig 11: Load v/s displacement diagram

From the Fig. 10 observed that, the displacement is directly proportional to the load until the peak load. At the peak load the specimen fractures and is recorded as 4.16 kN the displacement and breaking load is show 1.10 mm and 4.0 kN respectively, the bending strength is 0.173 kN/mm^2.

The graph Fig 11 reveals that the displacement is proportional to the load until the peak load. The peak load ofthe specimen is recorded as 3.980 kN the displacement and breaking load is show 1.00 mm and 3.80 KN respectively, the bending strength is 0.166 kN/mm^2.

Composition 2: 6%Coir 4%Glass 90%Epoxy

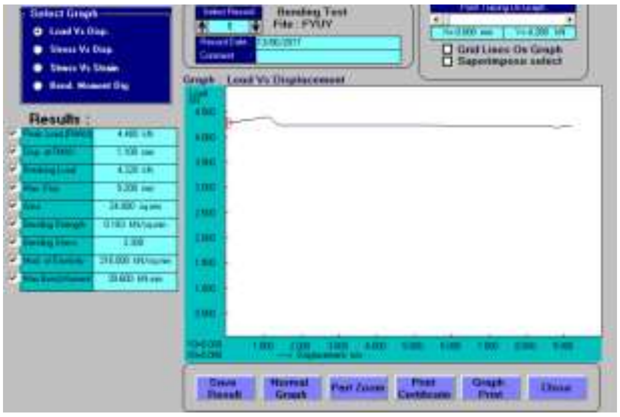

Fig 12: Load v/s displacement diagram

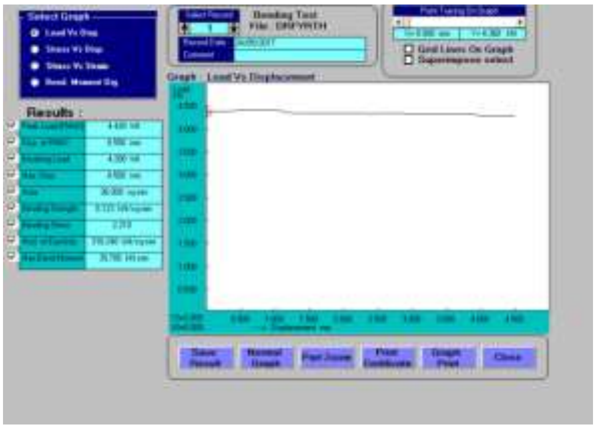

Fig 13: Load v/s displacement diagram

From the fig 12 graph it is observed that, the displacement is directly proportional to the load until the peak load. At the peak load the specimen fractures and is recorded as 4.40 kN the displacement and breaking load is 1.10 mm and 4.22 KN respectively, the bending strength is recorded as 0.183 kN/mm^2.

The fig 13 shows that the displacement is directly proportional to the load until it fractures which is recorded as 4.42 kN the displacement and breaking load is 0.50 mm and 4.28 KN respectively, the bending strength is 0.123 kN/mm^2.

Composition 3: 8%Coir 4%Glass 88%Epoxy

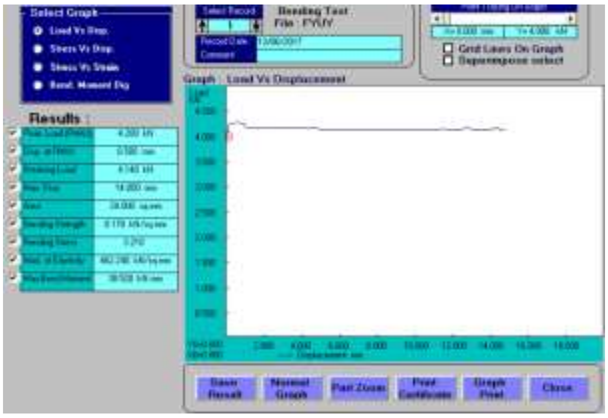

Fig 14: Load v/s displacement diagram

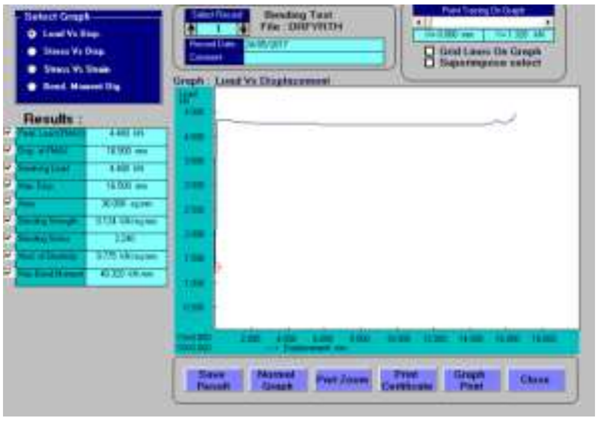

Fig 15: Load v/s displacement diagram

From the fig 14 graph it can be concluded that, the displacement is directly proportional to the load until the peak load. At the peak load the specimen fractures and is recorded as 4.28 kN the displacement and breaking load is show 0.500 mm and 4.14 kN respectively, the bending strength is 0.178 kN/mm^2.

From the fig 15 graph it is observed that the displacement is directly proportional to the load until the peak load which is recorded as 4.48 KN the displacement and breaking load is show 1.60 mm and 4.48 kN respectively, the bending strength is 0.124 kN/mm^2.

5.1IMPACT TESTS

The izod and charpy test is carried out in an impact setup as per ASTM: D256 standard (sample dimension is $65\times12.7\times3\ mm^3$). The specimen is loaded in the testing machine and a low velocity impact testing process is carried out with a pendulum type impact tester until the specimen fractures. The loss of energy during impact is the energy absorbed by the specimen during impact. The values are tabulated and it shows comparison between energy absorbed by the different combination of composites. Polymer matrix composites were developed of dimensions 63*12.7*10 mm and subjected to impact test such as izod and charpyin impact testing machine. the specimen are placed at an angle of 90 degree for izod test and 130 degree for charpy test. Impact strength in three hybrid set of specimens are described below.

Composition 1: 4%Coir 4%Glass 92%Epoxy

Energy absorbed by specimen 1 = 1.7 J. impact strength =44.61KJ/mm

Energy absorbed by specimen 2 = 1.6 J. impact strength =41.98KJ/mm

Composition 2: 6%Coir 4%Glass 90%Epoxy

Energy absorbed by specimen 1 = 1.9 J. impact strength =49.85 KJ/mm

Energy absorbed by specimen 2 = 1.8 J. impact strength =47.23KJ/mm

Composition 3: 8%Coir 4%Glass 90%Epoxy

Energy absorbed by specimen 1 = 2.1 J. impact strength =55.10KJ/mm

Energy absorbed by specimen 2 = 2.0 J. impact strength =52.48KJ/mm

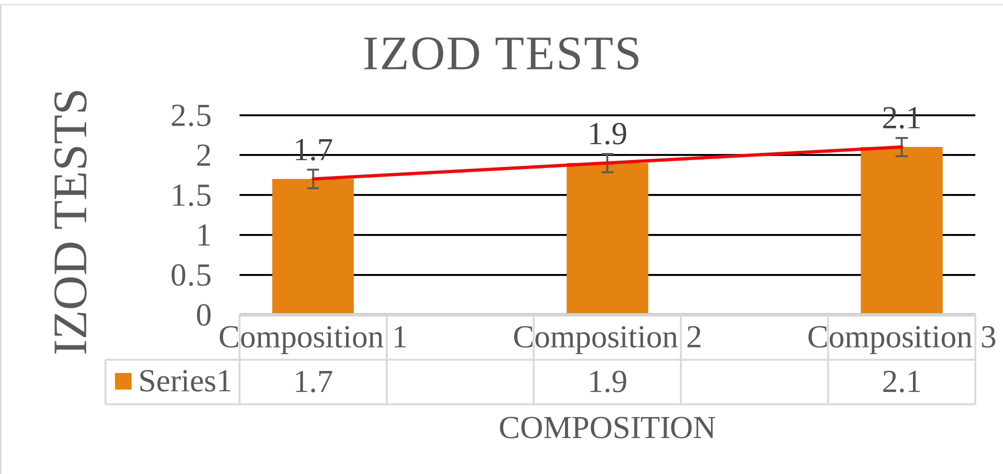

Fig 16 Comparison graph for Izod test

It is observed that the composition 3 absorbed more energy and have high impact strength.

Composition 1: 4%Coir 4%Glass 92%Epoxy

Composition 2: 6%Coir 4%Glass90%Epoxy

Composition 3: 8%Coir 4%Glass 88%Epoxy

Table.7: impact test results

Composition	Izod Strength(J)
01	1.7
02	1.9
03	2.1

Fig 17: izod specimens

6.1CHARPY TESTS

Composition 1: 4%Coir 4%Glass 92%Epoxy

Energy absorbed by specimen 1= 1.4J. Impact strength =33.39KJ/mm

Energy absorbed by specimen 2= 1.8 J. impact strength =47.23KJ/mm

Composition 2: 6%Coir 4%Glass 90%Epoxy

Energy absorbed by specimen 1= 1.6J. Impact strength =41.98KJ/mm

Energy absorbed by specimen 2= 1.9 J. impact strength =49.85KJ/mm

Composition 3: 8%Coir 4%Glass 88%Epoxy

Energy absorbed by specimen 1= 2.2J. Impact strength =52.48KJ/mm

Energy absorbed by specimen 2= 2.5 J. impact strength =59.63KJ/mm

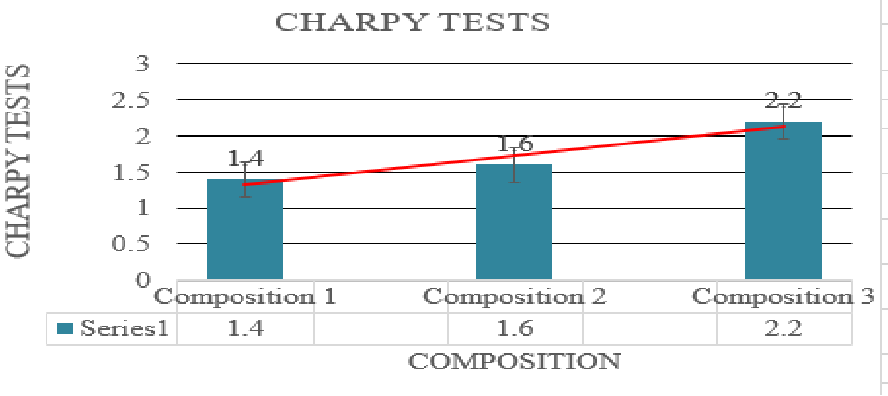

Table.8: charpy test results

Composition	Charpy strength(j)
01	1.4
02	1.6
03	2.2

Composition 1: 4%Coir 4%Glass 92%Epoxy

Composition 2: 6%Coir 4%Glass 90%Epoxy

Composition 3: 8%Coir 4%Glass 88%Epoxy

From the charpy, it is concluded that the composition 3 has more charpy strength.

7.1 WATER ABSORPTION TEST

Water absorption test determines the relative amount of water absorbed when immersed in distilled water .specimens of dimension 25*25*3mm were fabricated and conditioned before immersing in distilled water. Conditioned specimens is immersed in container containing distilled water for 24 hour. Specimens are removed one after the other after 24 hours and checked its weight to determine its water absorbing percentage with the help of below equation. And reconditioned of the specimen is done to determine its soluble percentage.

$$Increase\ in\ weight\ \% = \frac{wet\ weight - conditioned\ weight}{conditioned} X100 \ldots.(1)$$

$$Soluble\ matter\ lost\ \% \frac{wet\ weight - conditioned\ weight}{conditioned} X100 \ldots.(2)$$

Table.9: water absorption test results

Composition(1) 4%Coir4%Glass92%Epoxy	Conditioned Weight [gm]	Wet Weight [gm]	Re conditioned Weight	Increase in Weight	Soluble Matter Lost [%]
Specimen(1)	3.86	3.88	3.86	0.51	0
Specimen(2)	4.12	4.17	4.12	1.21	0
Composition(2) 6%Coir4%Glass 90%Epoxy					
Specimen(1)	1.51	1.54	1.51	1.98	0
Specimen(2)	1.67	1.70	1.67	1.79	0
Composition(3) 8%Coir4%Glass 88%Epoxy					
Specimen(1)	2.01	2.05	2.01	1.99	0
Specimen(2)	1.97	2.01	1.97	2.03	0

From the above table, it is clear that 8%Coir 4%Glass 90%Epoxy the percentage of water absorption is more compared to the other two combinations.

8.1 BRINELL HARDNESS TEST

Hardness is the property of the materials and it is defined as resistance to indentation. Specimen of size 50*50*3 mm is developed for both normal and hybrid composition and subjected to Brinell hardness test .The full load is normally applied for 10 to 15 seconds. The diameter of the indentation left in the test sample is measured with a help of low powered microscope.

$$BHN=\frac{F}{\frac{\pi}{2}D\ (D-\sqrt{D2-Di2})}$$

F is the applied force
D is the Indenter diameter
D_i is the Indentation diameter.

Composition(1) 4%Coir4%Glass92%Epoxy	Diameter of Indentation (D_i)	BHN in Kg-f/mm^2
Specimen(1)	1.7	38.17
	1.8	33.28
Composition(2) 6%Coir4%Glass 90%Epoxy		
Specimen(1)	1.65	43.97
	1.70	46.71
Composition(3) 8%Coir4%Glass 88%Epoxy		
Specimen(1)	1.60	43.33
	1.68	46.62

From the above table, it is evident 8%Coir 4%Glass 90%Epoxy the percentage hardness is more compared to the other two combinations.

9. CONCLUSION

1) From the observation of Tensile test experiment it can be concluded that the composite with 88% Epoxy+8% Coir+4% glass can absorb more energy compared to90% Epoxy+6% Coir+4% glass and 92% Epoxy+4% Coir+4% glass.
2) From the observation of Bending test experiment it can be concluded that the composite with 88% Epoxy+8% Coir+4% glass can absorb more energy compared to 90% Epoxy+6% Coir+4% glass and 92% Epoxy+4% Coir+4% glass.
3) From the observation of Charpy impact test experiment it can be concluded that the composite with 88% Epoxy+8% Coir+4% glass can absorb more energy compared to90% Epoxy+6% Coir+4% glass and92% Epoxy+4% Coir+4% glass.
4) From the observation of water absorption test experiment it can be concluded that the composite with 92% Epoxy+4% Coir+4% glass got low water absorbing capacity compared to 88% Epoxy+8% Coir+4% glass and to 90% Epoxy+6% Coir+4%.

5) From the observation of Brinell hardness test experiment it can be concluded that the composite with 88% Epoxy+8% Coir+4% glass got higher BHN for load 100kg compared to90% Epoxy+6% Coir+4% glass and 92% Epoxy+4% Coir+4% glass.

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