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FABRICATION AND ANALYSIS OF NATURAL FIBER HYBRID COMPOSITES

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ABSTRACT

Natural fiber composites are nowadays being used in various engineering applications to increase the strength and optimize the weight and the cost of the product. Hybridization is a process of incorporating synthetic fiber with natural fiber to get the better material properties. The important and exclusive properties of natural composite are its renewability and biodegradability. These properties with low cost fulfill the economic interest of industries. These materials are eco-friendly and use of green materials in these composites also provides an alternative way to deal with agricultural residue. The objective of the present research work is to study the mechanical properties of banana/glass fiber reinforced epoxy-based hybrid composites. The six trials laminates of banana/glass fabric of dimension 240*240*3 mm3 is fabricated by hand layup method and finally, curing is done at room temperature. Experiments are carried out as per ASTM standards. The effect of fiber loading and length on mechanical properties like hardness, density, flexural strength, and inter laminar shear stress of composites is studied. The application of natural composites includes for parcel shelves, door panels, instrument panels, armrests, headrests and seat shells, decks, docks, window frames and moulded panel components, the passenger car bumper beam in under-floor protection for passenger cars. There is need to improve the damage tolerant properties particularly fracture toughness and ductility in Hybrid Composites. Work should be done to produce high quality and low-cost reinforcements from industrial wastes and by-products. Efforts should be made on the development of Hybrids based on non-standard fibers & matrices . It has been observed that the various properties of the composites are greatly influenced by the fiber loading and fiber length.

I. INTRODUCTION

The mechanical behaviour of a natural fiber-based polymer composite depends on numerous factors, for example, fiber length and quality, matrix, fiber-matrix adhesion bond quality and so forth. The strong interface bond between fiber and matrix is paramount to show signs of improvement mechanical properties of composites. Merlini et al. [6] have studied the effect surface treatment on the chemical properties of banana fiber and reported that treated banana fiber gives higher shear interfacial stress and tensile strength when compared with the untreated fiber. Dhieb et al. [7] have studied about the surface and sub-surface degradation of unidirectional carbon fiber and have given many conclusions such as under sliding in demineralized water, the simplest degradation was detected on sliding in anti-parallel direction. Shankar et al. [8] have studied and reported that the ultimate tensile strength value maximum at 15% and then decreases with increasing in fiber starting from 15% to 20%. They also reported that the flexural strength value decreasing from 5% to 10% (87.31Mpa) and after that the value increased from fiber. Sumaila et al. [9] have investigated the influence of fiber length on the mechanical and physical properties of nonwoven short banana, random oriented fiber and epoxy composite and they described that the tensile properties and percentage elongation of the composite attained a maximum in composite fabricated from 15 mm fiber length. They have also reported that the impact energy whereas the compressive strength increases decreased with increasing fiber length, also the mean flexural properties of the composite increased with increasing in fiber length up to 25mm. The banana fibers characteristic depending on the variation of diameter, mechanical characteristic and the effects of the stresses performing on the fracture morphology. The stress-strain curves for changed strain rates were found and fractured surfaces were inspected by SEM [10]. Pothan et al. [11] have investigated on the influence of fiber content and length on short banana fiber reinforced polyester composite material. Laban et al. [12] has studied on the physical and mechanical behavior of banana fiber reinforced polymer composite and noticed that kraft mashed banana fiber material has better flexural strength. The tensile strength is detected maximum at 30 mm fiber length whereas the impact strength is noticed maximum at 40 mm length of fiber. Consolidation of 40% untreated banana fibers gives

20% rise in the tensile strength and 34% rise in impact strength. Prasanna and Subbaiah [13] reported that composites material having 20% treated fiber loading possess maximum values for above-mentioned properties than untreated composites, 10% and also 30% treated fibers composites. The interfacial area having main role in influential the strength of polymer material since fiber procedures a separate interface with the matrix. The effects of this study uncovered that short zig-zag fiber composites with great rigidity and element mechanical properties might be effectively ready utilizing banana fiber as reinforcement in a polyurethane matrix inferred from castor oil. The treated banana fiber demonstrated higher shear stress and tensile strength when contrasted with the untreated fiber, showing a solid association between the treated strands and the polyurethane matrix [6]. The hybridization of these reinforcement in the composite shows more terrific flexural quality when contrasted with singular kind of characteristic strands strengthened composites. Comparable patterns have been watched for flexural modulus, entomb laminar shear quality and break burden values [14]. There are many researches who have evaluated the mechanical, chemical and physical behavior and banana fiber reinforced with epoxy composite. Many studied and compared of effect of treated and untreated banana fiber reinforced with thermoplastic and thermosetting polymer [15-19]. Joseph et al. [20] studied and compared the mechanical behavior of phenol formaldehyde composites which was reinforced with glass fiber and banana fiber. Selzer and Friedrich et al. [21] studied the carbon fiber reinforced polymer composites and reported that the brittle materials demonstrate a lot of delimitation's also interlinear splitting throughout weariness. The disappointment of this material was dictated by a restriction of disappointment. This implies that in composites with a exceptionally intense grid and great fiber-network bond, various splitting, which ingests a higher measure of vitality, is anticipated, with the goal that at last confined disappointment happens at easier levels than anticipated. There is wide range of research in these fields; many researchers have investigated the natural fiber composite reinforced with various type of polymer [22-24]. The banana and glass fiber bio-composites may be fabricated for outdoors and indoors applications wherever high strength is not necessary, additionally it can consider as the replacement to wood materials and protect the forest resources [25]. Maleque et al. [26] have studied the mechanical properties of banana fiber-based epoxy composite and it was observed that the tensile strength is increased by 90% of the pseudo-stem banana fiber reinforced epoxy composite associated to virgin epoxy. In his results the impact strength of pseudo-stem banana fiber improved by approximately 40% compare to the impact strength of neat epoxy. The impact strength value is higher which indications to higher toughness value of the material. They are also reported that when banana woven fiber was used with epoxy material then the flexure strength is increased There are many reports available on the mechanical and physical properties of natural fiber reinforced polymer composites but, the effect of fiber length on mechanical behavior of banana fiber and e-glass reinforced polymer composites is scarcely being reported. To this end, the current work has undertaken with the objectives to investigate the mechanical properties of banana fiber and E-glass based epoxy composites.

II. MATERIALS AND METHODS

Materials Used

Reinforcements

- E-glass fabric
- Banana fabric

Matrix

- Epoxy resin (LY 556)
- Hardener (HY951)
- Mix ratio (100:10)
- Phenolic resin
- Para toluene sulphonic acid (PTSA) (catalyst for phenolic resin)

Vacuum bagging Materials

- Polyester Breather fabric
- Release film (PTFE coated glass fabric)
- Vacuum bagging film (Nylon film)
- Sealant tape (Butyl rubber)

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Solvents

- Acetone

Surface preparation materials

- Emery paper
- Wax polish
- Banian cloth

Hand lay-up

- Surgical gloves
- Cutting blades
- Measuring scale
- Marker pens

Properties of Reinforcement and Matrix

Properties of E-glass fabric (13 mil)

Thickness (0.0254x13) : 0.33 mm
Areal density : 440 ± 25 g/m2
Breaking strength
Warp : 185 kg/inch
Weft : 125 kg/inch

Properties of Epoxy resin and Hardener

Table.1 Properties of Matrix

Ingredients	Trade name	Chemical name	Density (g/cm3)	Viscosity (cp)
Epoxy Resin	LY 556	Diglycidal Ether of bisphenol A (DGEBA)	1.16	6000 -8000
Hardener	HY 951	Triethylenetetramine (TETA)	0.95	-

Methodology

Trial-1

- Banana fiber a type of bast fiber, is extracted from the Pseudo-stem of banana tree.

FIG.1 Pseudo-Stem

FIG.2 Banana Fiber

- Initially, banana fiber of about 120gm by weight is dipped in acetone for 48hrs and then heated in oven at 50°C for 30min. This acetone treatment removes wax, hemicellulose, lignin and some other impurities hiding in the surface of the fiber.
- After heating the fiber is made fine by using comb and cut in the length of 300mm.

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FIG.3 Acetone Dipping

FIG.4 Oven Curing

Fig. 5 fine banana fiber

Table.2 Weight Loss of Banana Fiber of 300mm Length

S.no.	Banana fiber	Weight(grams)
1.	Initial weight	120
2.	After oven heating	100
3.	Fine facing	60
4.	Cut into 300mm length	55

Epoxy resin (LY 556) is a low temperature curing resin taken as matrix material. Epoxy resin (HY 556) and corresponding Hardener (HY 951) are mixed in a ratio of 10:1 by weight as recommended i.e. 1000gm of epoxy is mixed with 100gm of hardener by mechanical stirring.

- Now, E-glass fabric (13mill grade) having diameter 0.4mm and 350gsm is taken of about 1m length and epoxy resin is coated by using hand layup method. Then, the E-glass is cut into dimension of 300×300mm2.

FIG.6 E-glass Fabric with Epoxy Resin Hand Layup

- To prepare the composite a surface plate is used. The surface plate is cleaned with acetone to remove the impurities. Then a coat of wax layer is applied throughout the plate to facilitate easy removal of the laminate. This is followed by a dwell time of 5-10 minutes for the plate to get dried. Alternate layer of natural fiber is kept with a coat of resin over it. Consequent layers of glass and natural fiber are placed till the required thickness is obtained. Three laminates are prepared by using different designations.

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Fig.7 Laminate1 (L1) *Laminate2 (L2)* *Laminate3 (L3)*

Table.3 Designation of Three Laminates

Laminates	Designation	Laminates Composition
L1	G+G+G+G+G+G	6 layers
L2	B	35grams
L3	G+B+G	1layer+20grams+1layer

- Then the laminates are covered by release film followed by Breather sheet to absorb excessive resin. Later the laminates are sealed with vacuum bag sheet over the wet laid-up laminate on to the tool. The air under the bag is extracted by a vacuum pump under atmospheric pressure in order for the compacting and hardening process to take place. The outer atmospheric pressure caused through the vacuum within the closed system will compress the laminate and excess resin is sucked out of the wet laminate.
- The curing process is allowed for 4 hrs in the vacuum bag at a pressure of 0.9bar. Finally, the laminates get cured.

FIG.8 Vacuum Bagging of Laminates

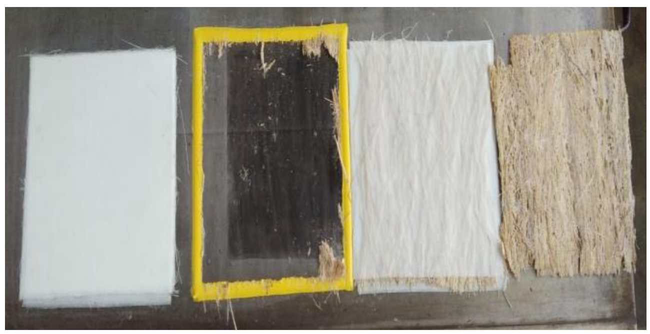

FIG.9 After Curing

Trial-2

In this trial, two hybrid laminates of dimensions (300x300mm2) are prepared by using same as above mentioned procedure but, by using different designations and weights.

- Initially, the fine banana fiber of about 70gms by weight is taken after acetone treatment and oven curing and is cutt in the length of 300mm.
- Epoxy resin (HY 556) and corresponding Hardener (HY 951) are mixed in a ratio of 10:1 by weight as recommended i.e. 500gm of epoxy is mixed with 50gm of hardener by mechanical stirring.
- Now, E-glass fabric (13mill grade) having diameter 0.4mm and 350GSM is taken of about 1m length and epoxy resin is coated by using hand layup method. Then, the E-glass is cutted into dimension of 300×300mm2.
- To prepare the composite a surface plate is used. Then a coat of wax layer is applied throughout the plate to facilitate easy removal of the laminate. This is followed by a dwell time of 5-10 minutes for the plate to get dried.

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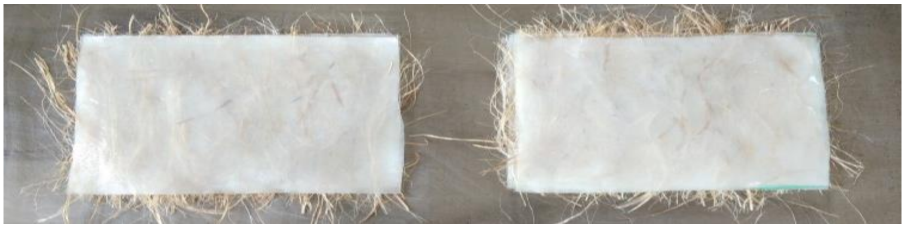

Fig.10 Laminate1 (L1) Laminate2 (L2)

- The L1 laminate is prepared by using four E-glass fabric layers and three banana fabric layers of weight 10grams each are laid. Alternate layer of natural fiber is kept with a coat of resin over it. Consequent layers of glass and natural fiber are placed. While in L2 laminate five E-glass fabric layers and four banana fabric layers of weight 10grams each are laid.
- Then the laminates are covered by Release film followed by Breather sheet to absorb excessive resin. Later the laminates are sealed with vacuum bag sheet over the wet laid-up laminate on to the tool. The air under the bag is extracted by a vacuum pump under atmospheric pressure in order for the compacting and hardening process to take place. The outer atmospheric pressure caused through the vacuum within the closed system will compress the laminate and excess resin is sucked out of the wet laminate.

Table.4 Designation of Two Laminates

Laminates	**Designation**	**Layers**		**Banana Weight(grams)**
		Glass	**Banana**	
L1	G+B+G+B+G+B+G	4	3	30
L2	G+B+G+B+G+B+G+B+G	5	4	40

FIG.11 Vacuum Bagging

- The curing process is allowed for 4hrs in the vacuum bag at a pressure of 0.9bar. Finally, the laminates get cured.

FIG.12 After Vacuum Curing

Trial -3

In this trial, mould is used for preparing the specimens by using short banana fiber of length 10mm.

- Firstly, the banana fiber after acetone treatment and oven curing is cut into short length fiber of about 10mm and of weight 10grams
- Then, Epoxy resin (HY 556) and corresponding Hardener (HY 951) are mixed in a ratio of 100:10 by weight as recommended i.e. 90gm of epoxy is mixed with 9gm of hardener by mechanical stirring. The short banana fiber is mixed in the about resin mixture by using stirrer rod.

FIG.13 Mixing of Short Banana Fiber with Epoxy Resin Mixture

- The mould is cleaned with the acetone and wax coat is applied to the both side of the mold. Then, the mixture i.e. fiber and resin is hand lay upped into the cavity thoroughly i.e. dumble shape and it is undisturbed for 30-45min.

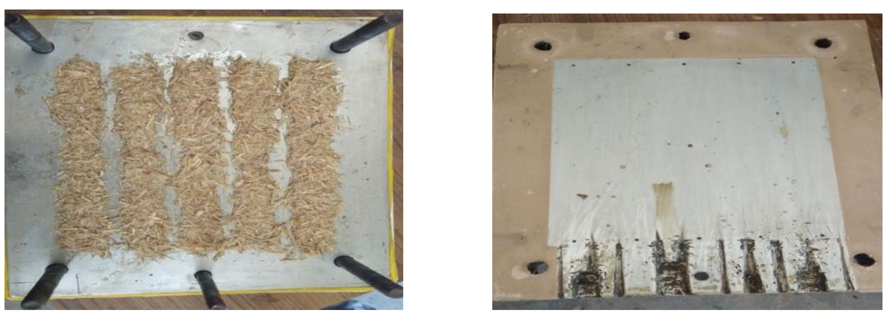

FIG.14 Mold Cavity Filled with Mixture of Epoxy and Banana Fiber

- The mold is fastened tightly by using adjustable spanner and allowed it for curing for 24hrs. After, curing the mold is removed and the specimens are taken out of the mold cavity. Thus, the specimens get cured.

FIG.15 Specimen After Curing

Trial-4

In this trial, laminates are prepared by using both mold and surface plate with short banana fiber of length 10mm and also, hybridization is done with both reinforcement and matrix.

- Firstly, the banana fiber after acetone treatment and oven curing is cut into short length fiber of about 10mm.

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- Then, Epoxy resin (HY 556) and corresponding Hardener (HY 951) are mixed in a ratio of 100:10 by weight as recommended i.e. 500gm of epoxy is mixed with the short banana fiber of about 15grams and 50grams of hardener is added and mixed by mechanical stirring.
- The paste is uniformly laid on the E-glass fabric and cutted into the dimensions of 250×250mm2, it is undisturbed for 30-45minutes.

FIG.16 Spreading of the Epoxy Paste over the E-glass fabric

- Similarly, the phenolic resin and corresponding hardener powder is mixed in a ratio of 100:20 by weight i.e. 1000grams phenolic resin is mixed with the short banana fiber of about 15grams and 20grams of hardener powder is added and mixed by using mechanical stirring.
- The paste is uniformly laid on the E-glass fabric and cut into the dimensions of 250x250mm2, it is undisturbed for 30-45minutes.

FIG.17 Spreading of The Phenolic Paste Over The E-Glass Fabric

- The mold is cleaned with acetone and wax coat is applied to the mold. Then, firstly one layer of epoxy and correspondingly two layers of phenolic and finally one layer of epoxy is laid on the mold.
- This is followed by a dwell time of 1hr for the layers to get partially cured. At last, the mold is made tight by using c-clamps equally at all the corners and allowed it for curing about 24hours.
- The surface plate is cleaned with acetone and wax coat is applied to the surface plate. Then, same as above firstly one layer of epoxy and correspondingly two layers of phenolic and finally one layer of epoxy is laid on the surface plate. This is followed by a dwell time of 1hr for the layers to get partially cured. At last, the laminate is covered with release film and load about 25kg is applied on the laminate and allowed it for curing about 24hours.

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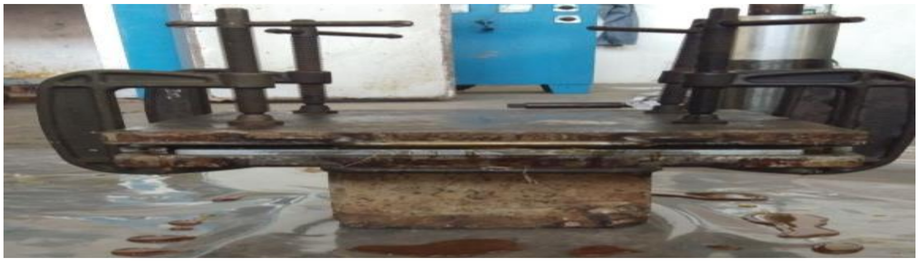

FIG.18 Laminate Inside the Mold

FIG.19 Laminate on the Surface Plate

- After curing, post curing is done by heating the both laminates in oven at 120℃ for 2hrs.

FIG.20 (a) Top Surface of Plate Laminate **(b)** Bottom Surface of Plate Laminate

FIG.21 (a) Top Surface of Mold Laminate **(b)** Bottom Mold of Laminate

Trial-5

In this trial, laminate is prepared by using surface plate with short banana fiber of length 10mm with epoxy resin. Total four layers of epoxy resin and banana fiber are used to prepare laminate.

- Firstly, the banana fiber after acetone treatment and oven curing is cut into short length fiber of about 10mm.

FIG.22 Mixing of Short Banana Fiber With Epoxy Resin Mixture

- Then, Epoxy resin (LY 556) and corresponding Hardener (HY 951) are mixed in a ratio of 100:10 by weight as recommended i.e. 640gm of epoxy is mixed with the short banana fiber of about 20grams and 64gm of hardener is added and mixed by mechanical stirring.
- The paste is uniformly spread on the E-glass fabric.

FIG.23 Spreading of The Epoxy Paste Over The E-Glass

- The E-Glass Fabric then, it is cut into the dimensions of 250x250mm2 and it is undisturbed for 30-45minutes.

FIG.24 Lamina of Dimension 250x250mm2

FIG.25 Laminate Covered with Release Film

- The surface plate is cleaned with acetone and wax coat is applied to the surface plate. Then, one layer of epoxy and consequent three layers are laid on the surface plate. This is followed by a dwell time of 1hr for the layers to get partially cured. At last, the laminate is covered with release film and load about 40kg is applied on the laminate and allowed it for curing about 24hours.
- Finally, the laminate gets cured after 24hrs curing.

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FIG.26 (a) Top Surface of Laminate *(b) Bottom Surface of Laminate*

Trial-6

In this trial, laminate is prepared by using surface plate with short banana fiber of length 10mm with epoxy resin. Total three layers of epoxy resin and banana fiber are used to prepare laminate.

- Firstly, the banana fiber after acetone treatment and oven curing is cut into short length fiber of about 10mm.
- Then, Epoxy resin (HY 556) and corresponding Hardener (HY 951) are mixed in a ratio of 100:10 by weight as recommended i.e. 400gm of epoxy is mixed with the short banana fiber of about 15grams and 40gm of hardener is added and mixed by mechanical stirring.
- The paste is uniformly laid on the E-glass fabric and cut into the dimensions of 250x250mm2, it is undisturbed for 30-45minutes.

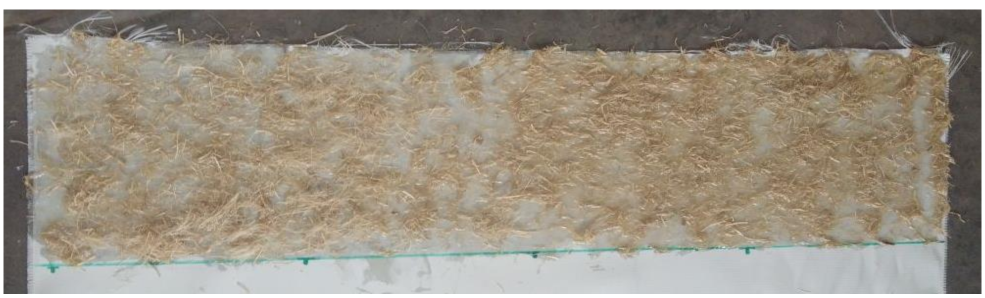

FIG.27 Spreading of the Epoxy Paste over the E-glass fabric

- The surface plate is cleaned with acetone and wax coat is applied to the surface plate. Then, one layer of epoxy and consequent three layers are laid on the surface plate. This is followed by a dwell time of 1hr for the layers to get partially cured. The laminate is covered with release film and followed by a breather sheet and a caul plate is placed over the sheet. Later the laminate is sealed with vacuum bag sheet over the wet laid-up laminate on to the tool. Vacuum is applied after 2hrs to arrest the resin bleed out. After 2hrs full vacuum is applied and maintained for 4hrs. The outer atmospheric pressure caused through the vacuum within the closed system will compress the laminate and excess resin is sucked out of the wet laminate.

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FIG.28 Vacuum Bagging

Finally, the laminate gets cured after 4hrs. In this trail, the laminates get desiredthickness of about 6mm and glassy surface finish is achieved on both sides.

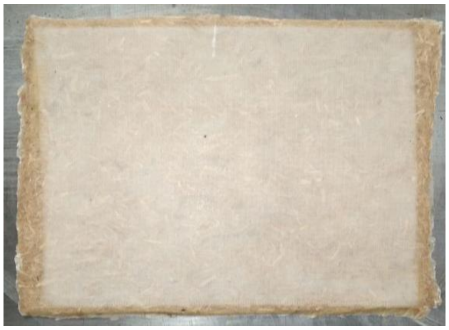

FIG.29 After Curing (a) Top Surface *(b) Bottom Surface*

III. RESULTS AND DISCUSSION

As the composites industry has grown there has become a bit of a divide between the language of the composite design engineer and the composite fabricator. The discussion herein relates to wet resin lay-up techniques. Here the fabrication process will wet out the fibers with a wet resin system, i.e. wet lay-up, resin infusion processes and resin injection processes. The basic engineering properties of a composite material can be determined by either experimental stress analysis (testing) or theoretical mechanics (micromechanics). The micromechanics approach utilizes knowledge of the individual fiber and resin properties, and the proportionality of fibers to the resin in the lamina. A rule of mixtures approach can best be used to derive the majority of the composite lamina properties.

Physical and Mechanical Properties Test Results

- **Hardness Test Result**

In this, hardness tests the comparison between the hardness of both hybrid laminates i.e. E-glass/banana fiber with epoxy resin and E-glass/banana fiber with epoxy/phenolic resin is done. The hardness range in E-glass/banana fiber with epoxy resin is greater than E-glass/banana fiber with epoxy/phenolic resin. The hardness ranges are [86-94] HV and [83-92] HV respectively. The following hardness valves at four different positions are shown in the following below table.

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Table.5 Hardness Test Report

S.no.	E-glass/Banana fiber/Epoxy resin		E-glass/Banana fiber/Epoxy/Phenolic resin	
	Top Surface	Bottom Surface	Top Surface	Bottom Surface
1.	94	86	90	90
2.	90	90	91	92
3.	90	90	83	88
4.	92	90	90	86

- **Density Test Result**

Density is the term used to describe the relationship between the weight of the substance and its size. Density is a physical property of every substance, and different substances have different densities. Density can be measured in a variety of units, including grams per cubic centimetre and pounds per cubic foot. The experimental density for E-glass/banana fiber with epoxy resin laminate is less than E-glass/banana fiber with epoxy/phenolic resin laminate. The corresponding average density valves are 1.236g/cc and 1.26g/cc respectively. The following density test report for three specimens are tabulated below.

Density of Glass/epoxy: 1.9- 2.0 g/cc and Density of Glass/phenolic: 1.8- 1.9 g/cc

Table.6 Density Test Report For E-Glass/Banana Fiber /Epoxy Resin Laminate

Trial no.	Weight in air, (W1)	Weight in Water (distilled water) (W2)	W1-W2	σ = W1/[W1- W2] *density of water (g/cc)
1.	1.0438	0.1897	0.8541	1.22
2.	1.0636	0.2079	0.8557	1.24
3.	1.0631	0.2137	0.8494	1.25
				Average=1.236

Table.7 Density Test Report For E-Glass/Banana Fiber /Epoxy/Phenolic Resin Laminate

Trial no.	Weight in air, (W1)	Weight in Water (distilled water), (W2)	W1-W2	σ = W1/[W1- W2] *density of water, (g/cc)
1.	1.0818	0.2280	0.8538	1.26
2.	1.0854	0.2258	0.8596	1.26
3.	1.0113	0.2117	0.7996	1.26
				Average=1.26

- **Inter Laminar Shear Stress[ILSS] Test Result**

In this, inter laminar shear stress test the maximum shear delamination is in E-glass/Banana fiber /Epoxy/Phenolic resin laminate and minimum shear delamination is in E-glass/Banana fiber /Epoxy resin laminate. The corresponding average ILSS valves are 12.89Mpa and 11.60Mpa respectively. The following ILSS test reports for both laminates of each five specimens are tabulated below.

Span Length=22mm; Cross Head Speed =1 mm/rev.

Formula for ILSS = 3 Pmax / (4*b*d)

Where, Pmax = Maximum load (N), Breadth= width (mm), Thickness= depth (mm)

Minimum thickness of specimen is 4 mm & Maximum thickness is 6.4 mm.

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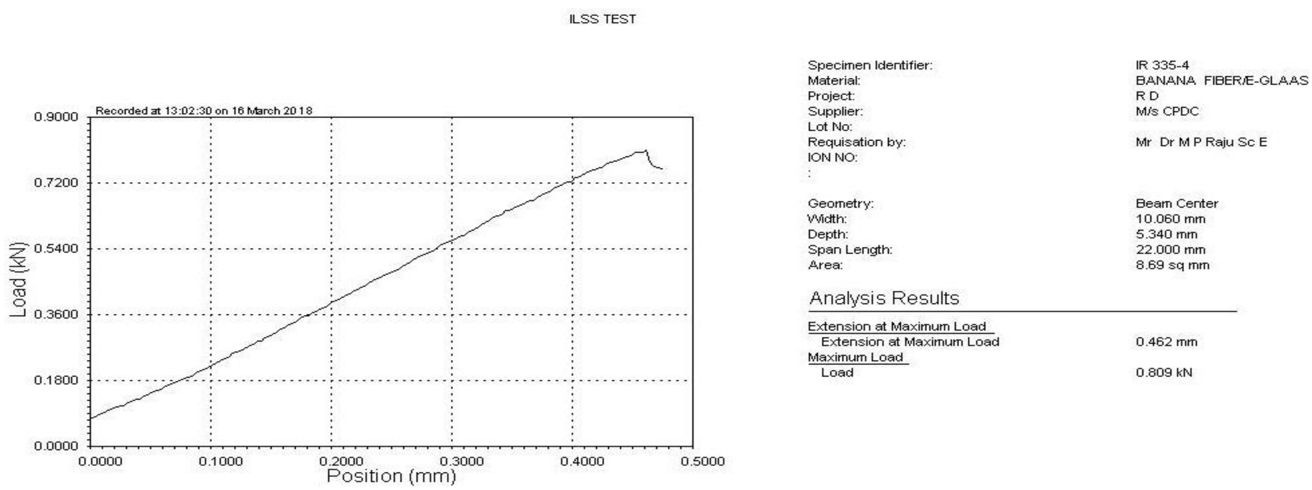
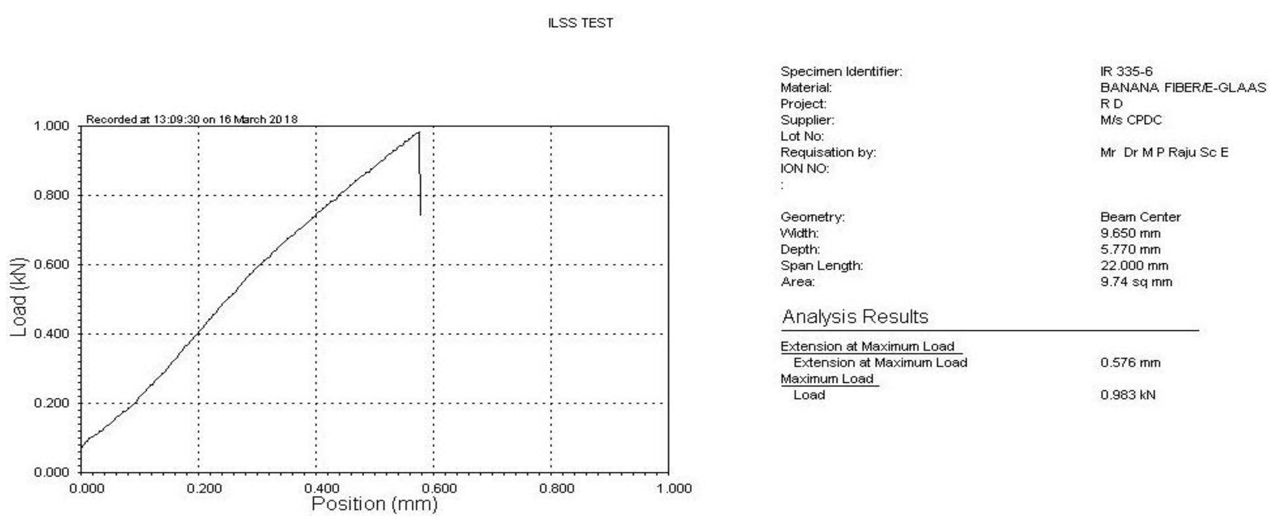
Table.8 ILSS Test Report For E-Glass/Banana Fiber /Epoxy/Phenolic Resin Laminate

S.no.	Dimensions (mm)	Maximum Displacement (mm)	Maximum Load (KN)	ILSS (Mpa)
1.	10.28x5.21	0.776	0.766	10.76
2.	10.16x5.65	1.019	1.140	14.89
3.	10.19x4.99	0.572	0.871	12.85
4.	10.06x5.34	0.462	0.809	11.29
5.	10.28x5.02	0.693	1.012	14.70
				Average=12.89



(a)



(b)

FIG.30 ILSS Test Graph For E-Glass/Banana Fiber /Epoxy/Phenolic Resin Specimen
(a) Maximum ILSS graph (b) Minimum ILSS graph

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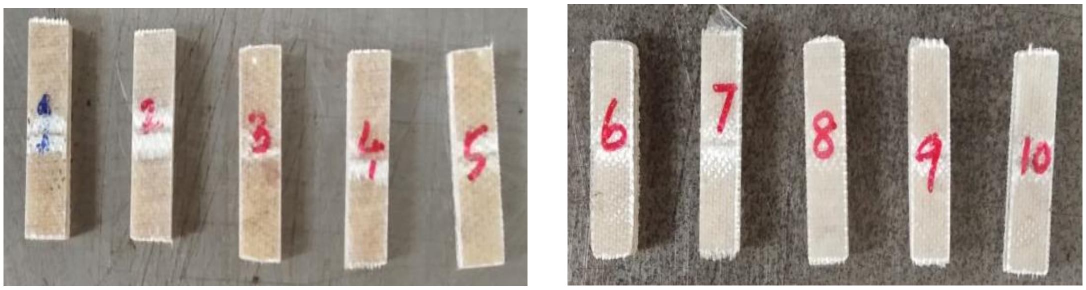

(a) *(b)*

FIG.31 Tested Specimens of ILSS

(a) E-glass/Banana fiber with Epoxy/Phenolic Resin Tested Specimens (b) E-glass/Banana fiber with Epoxy Resin Tested Specimens

Table.9 ILSS Test Report For E-Glass/Banana Fiber/Epoxy Resin Laminate

S.no.	Dimensions (mm)	Maximum Displacement (mm)	Maximum Load (KN)	ILSS (Mpa)
1.	9.65x5.77	0.576	0.983	13.24
2.	9.52x5.74	0.599	0.847	11.62
3.	9.39x5.69	0.419	0.737	10.34
4.	9.34x5.70	0.522	0.8	11.27
5.	9.47x5.82	0.513	0.848	11.53
				Average=11.60

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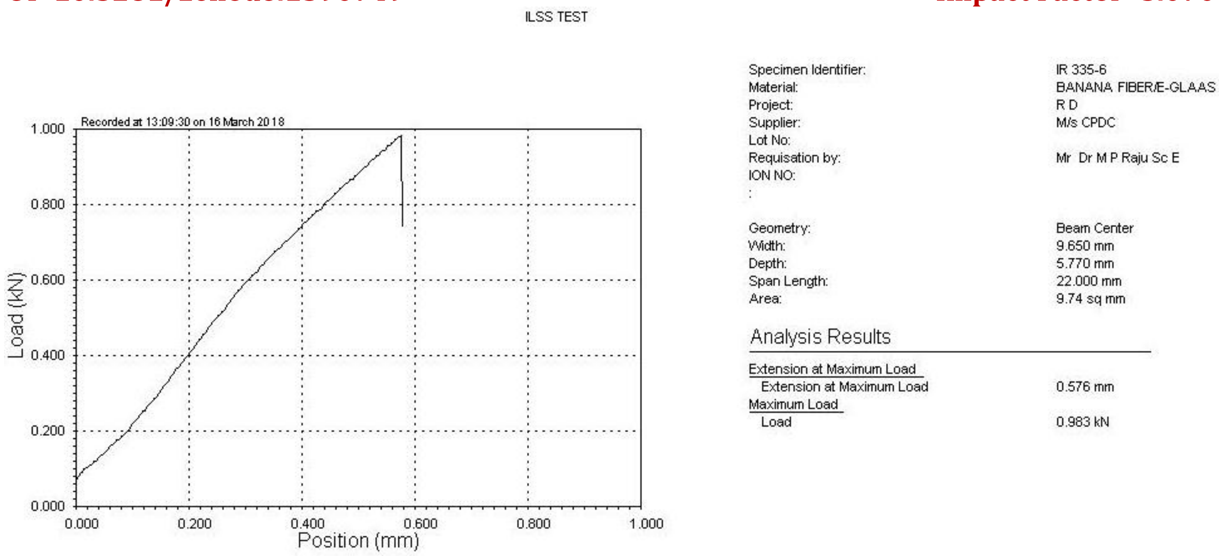
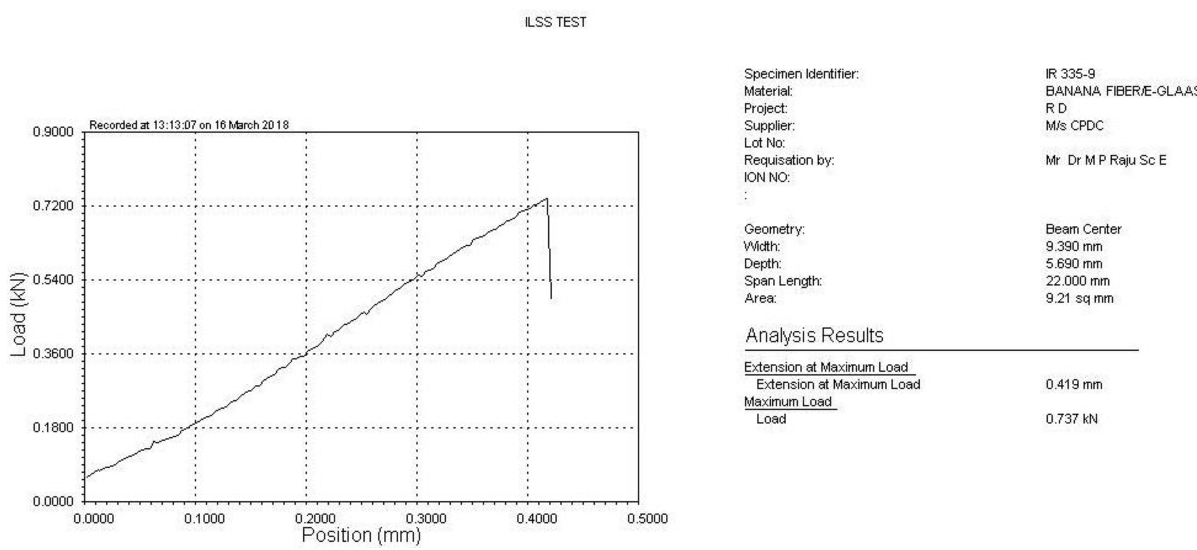


(a)



(b)

FIG.32 ILSS Test Graph For E-Glass/Banana Fiber /Epoxy Resin Specimen
(a) Maximum ILSS Graph
(b) Minimum ILSS Graph

IV. CONCLUSION

The fabrication process and comparison of mechanical properties of the hybridized natural fiber composites i.e. banana/E-glass fiber reinforced epoxy resin and banana/E-glass fiber reinforced epoxy/phenolic resin composites were studied in this work. The composites were fabricated by hand layup technique and tested according to ASTM standard. From the experiment the following conclusions have been drawn. It has been observed that the various properties of the composites are greatly influenced by the fiber loading and fiber length. From the ASTM mechanical property tests, density decreases with decrease in the weight of the matrix, hardness increases with decrease in the weight of the matrix, and Inter laminar shear stress in E-glass/Banana fiber /Epoxy/Phenolic resin laminate is greater than E-glass/Banana fiber /Epoxy resin laminate. Recently, banana fiber reinforced composites are coming into in interest due to the innovative application of banana fiber in under-floor protection for passenger cars. Automobile parts such as rear-view mirror, visor in two-wheeler, billion seat covers, indicator cover, cover L-side, name plate was fabricated using fibers hybrid composites.

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