

## EXPERIMENTAL ANALYSIS OF HYBRID (ROSELLE, ALOE VERA AND GLASS) NATURAL FIBER-REINFORCED COMPOSITE MATERIAL

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### ABSTRACT

*This paper aims to evaluate the mechanical properties of Glass fiber/ Aloe Vera fiber / Roselle fiber hybrid composites. The fiber fabrics are in the seven layers of same the sequence. The epoxy resin used in this research work is LY556 with hardener HY951. The hybrid specimens are fabricating by hand layup techniques. Tensile, Flexural, Impact and hardness tests were conducted for characterization of the hybrid composites. The results show that the properties and use of the hybrid aloe Vera fibre /Roselle fiber with glass fiber reinforced composite can ameliorate. It helps as a best alternate material for GFRP composites.*

**KEY WORDS:** Hybrid Composites, Mechanical Properties, Hand Layup & Epoxy Resin

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### INTRODUCTION

Natural fiber composites are now a day's widely used instead of synthetic fibres due to their benefits like biodegradability, low weight, low cost and high specific mechanical properties. Synthetic fibers composites have far better mechanical properties than natural fiber composites but since they are highly expensive, they are justified only for aircraft and military applications. Rowell et al., (1997), Normal fiber is a hair like crude materials straightforwardly realistic from a creature, vegetable then again mineral source and convertible into nonwoven textures, for example, felt or in the wake of turning into yarns or woven material. Normal strands from vegetable filaments are gotten from different parts of the plants. Large portions of the plant strands, for example, coir, sisal, jute, banana, pineapple, and hemp discover applications as an asset for modern materials. Dittenber D B et al., (2012) shows that the Natural fibers are best alternate for synthetic fibres, more in ecological characteristics and less in respect of mechanical strength, such as glass fiber. The hybridization with synthetic fibers and applying the various chemical treatments on polymer composites help to achieve the good strength while reinforcing natural fibers under various conditions. The need for improving the strength is poor while using these treatments. Whereas, the natural fiber is weaved with different orientations, which makes the composites stronger and compatible to the synthetic fibers. The maximum increase in mechanical strength was discovered by A. Alavudeen et al., (2014) within the plain woven hybrid composites instead of in every which way headed composites. This means minimum stress development at the interface of composites owing to the distribution of load transfer on the fibre direction. Cirino M et al., (1988) states that the wear rate of the natural fibre material is varied with reference to the orientation of the fibers and once the fibre orientation is traditional to the direction of the slippery movement

the wear and tear rate is incredibly less. Alawar A et al., (2009) described The Natural fibers contain polyose, hemicelluloses, pectin and lignin and are wealthy in hydroxyl teams, natural fibers tend to be robust polar and deliquescent materials while chemical compound materials are a polar and exhibit important hydro phobicity. In different words, there are important issues of compatibility between the fiber and also the matrix as a result of weakness within the surface adhesion of the natural fibers with the artificial matrices. Therefore, surface modification of natural fibres by suggests that treatment is one among the most important areas of recent researches to enhance compatibility and surface bond strength. Jirawut Junkasem et al., (2006) states the Roselle has a comparable compound organization to Jute. Roselle strands are utilized as support fillers for an item thermoplastic. It is utilized as fortifying filler for isotactic polypropylene for the most part because of the cost-viability and commonwealth. Most astounding mechanical properties have been watched when roselle bast strands were fused. V.K. Thakur et al., (2014) says that Polypropylene is one among the foremost necessary goods polymers made on AN industrial scale because of its variety of intrinsic qualities, together with affordable mechanical performance, sensible insulating properties and superior thermal/chemical stability. polypropene also can be bolstered with each artificial and natural fibers, using appropriate compatibilizers. In the paper of Mahjoub R et al., (2014) The Chemical treatment to the fibers that utilized in the reinforcement for forty eight hours helps to enhance the mechanical properties of the composite materials and also the higher strength is exposed once the fibre composites strengthened with simplex layers, compare to the neat organic compound. The kenaf fibers pre-treated with the NaOH solutions with totally different concentration (i.e.15%, 10%, 7% and 5% in weight), for twenty-four and three hours at temperature. They ended that the five percentage alkali solution provides the best for structure and no tension on fiber texture compared to 10 percent and 15% NaOH solutions; These are all the solutions confirms the improvement of fibre matrix therefore reducing the movement of the polymers and enhancing the stress transfer by the NaOH treatment. Z.N. Azwa et al., (2013) ascertained that alkalinization causes a discount on these behaviors for the kenaf/epoxy composite. Generally, enlarged exposure time causes higher weight loss of the composites solely up to one hundred fifty degrees centigrade. At higher temperature, the period of exposure has very little influence on the weight loss. B.F. Yousif et al., (2012) concluded the flexural properties of the KFRE composite are extremely influenced by the kenaf fiber surface characteristics. NaOH treatment extremely increased the surface adhesion of the fiber with the matrix resulting in higher flexural properties compared to the untreated fibers. 36 percentage increment within the flexural strength of the epoxy composite achieved once treated kenaf fibres were used as reinforcement compared to the untreated fibers, that showed solely twenty percentage. El-Shekeil YA et al., (2012) confirmed The good tensile properties were obtained from using NaOH followed by isocyanate chemical treatment for thermoplastic polyurethane/kenaf composites. During this paper, a study of tensile and flexural properties of soil buried kenaf bast fibre bolstered thermoplastic polyurethane (TPU) composites is given. F.Z. Arrakhiz et al., (2013) studied Fiber surface treatments (e.g. alkali treatment, silane treatment) and matrix modification exploitation compatibilizers are the foremost usually used ways to boost the adhesion of fibers to matrix material. N. Saba et al., (2015) Epoxy is that the most generally used thermosetting matrix materials, showing extensive applications. But cured epoxies represent low fracture toughness, inherently low impact resistance, reduced resistance to crack initiation and propagation. Venkateshwaran N et al., (2013) reported Incompatibility is one in every of the obstacles that faces fiber compound composites. Incompatibility is caused by property of most polymers utilized in this field vs hydrophilicity of natural fibers. Araújo JR et al., (2015) says In terms of exposure to hot temperature, majority of natural fibers have low degradation temperatures that are inadequate for process with thermoplastics with process temperatures beyond two hundred degree centigrade. S.M. Sapuan et al., (2013) reported Tensile strength of kenaf fiber strengthened TPU composite dropped to 16.14 Mpa once eighty days of soil burial take a look at. it had been additionally

determined that there was no important amendment in flexural properties of soil buried kenaf fiber strengthened TPU composite specimens. R. Mahjoub et al., (2014) found Kenaf fiber are extensively been utilized in fiber bolstered compound composite sector because it displayed exceptional properties for reinforcement in composites consisting of various compound matrix underneath stress and varied flexural loading condition. Marom et al., (1978) found the Hybridization of filaments in single network gives another measurement to the potential adaptability of fiber fortified composite materials.

## **EXPERIMENTAL DETAILS**

### **Materials**

The natural fibers extracted from aloevera and Roselle plant in woven form, were prepared from Weaver Association, Anakaputhur, Chennai, India. Matrix material selected for making composite was epoxy resin LY-556(Araldite) and hardener HY-951 as a binder for the resin from Javanthi enterprises, guindi, chennai. Test specimen prepared by Alind water jet machining, Padi, Chennai. Mechanical testing was carried out at METMECH Engineers (Research Lab), Chennai, India.

### **Natural Fibers**

Natural fibers are materials that belong to a category of hair-like materials that are within the type of continuous filaments. Natural fibers are classified into 2 varieties, as plant fibers and animal fibers. They're most well-liked principally since they're eco-friendly, and conjointly obtainable in less price.

### **Aloe Vera Fiber**

Hand harvested Aloe vera Leaf fiber are thick, fleshy, and hard-surfaced, typically long and stiff, also are known as "hard" fibres, distinctive them from the commonly softer and additional versatile fibers of the bast, or "soft," fiber cluster. Their fibre is separated from the encircling leaf tissue by surgical procedure, a hand or machine scraping or peeling method, then cleaned and dried.



**Figure 1(a): Aloe Vera Plant**



**Figure 1(b): Aloe Vera Fibre**

### **Roselle Fiber**

The roselle plant (*Hibiscus Sabdariffa* L.) is used principally for its bast fibers and for its fruit, the latter being utilized for making jelly and preserves. The silky, soft and light-colored fiber obtained from this plant has practically the same chemical and physical properties as jute (*Corchorus capsularis* L.) fiber and, therefore, offers a very satisfactory jute substitute.



**Figure 2 (a): Roselle plant**



**Figure 2 (b): Roselle Fibre**

### **Glass Fiber Reinforced Polymer**

Glass fiber may be a material that contains extraordinarily fine fibers of glass. It's lightweight in weight, extraordinarily robust, and robust. It's shaped once skinny strands of silica glass are extruded into several fibers with tiny diameters. Its bulk strength and weight properties also are terribly favorable compared to metals, and it is simply fashioned using molding processes. The individual filaments are currently bundled along in massive numbers to supply a roving. In general, it's used as a reinforcing agent for composites to create a really robust and lightweight fiber-reinforced polymer (FRP) material.



**Figure 3: Glass Fiber**

### **Resin and Hardener**

Epoxy resin is employed to provide nice binding properties between the fiber layers to make the matrix. The synthetic resin used at room temperature is LY 556. Hardener (HY 951) is used to enhance the interfacial adhesion and impart strength to the composite. A resin and hardener mixture of 10:1 is employed to get optimum matrix composition.

### **Fabrication Procedure for Specimen**

The composite material is fabricated by using hand layup technique. Glass fiber layers are placed on top and bottom on the specimen and intermediate layers are stuffed by natural fibers. Resin and hardener mixture (10:1) is spilled for each layer. At first the fibers are dried in sunlight to get rid of the wetness. The mold glass surface is cleansed and cathartic agent (Paraffin) is applied. A thin Layer of resin is additionally applied on the glass board. The glass fiber woven place over the surface then fully crammed with epoxy glue, rolled to get rid of the entrapped air and to uniformly spread the mixture. during this method 5 layers of fiber placed one over other and also the top layer of glass fibre wovenroving is placed to get top and bottom layers. The air gaps formed between the layers throughout fabrication were removed out by using the rollers. Then the laminated was compressed by a load (8–10 kg) is applied for a solidification amount of twenty-four hours to get good strength.

GF(WOVENROVINGS)
ROSELLE FIBER
ALOE VERA FIBER
ROSELLE FIBER
ALOE VERA FIBER
ROSELLE FIBER
GF(WOVENROVINGS)

Figure 4: Schematic Diagram of the Hybrid Composite Material

### Specimen Preparation

After the curing process, specimens for tensile, flexural and impact tests were prepared using water jet machining. The specimens were cut to the required size prescribed as per ASTM standards.

### TESTING OF HYBRID COMPOSITES

#### Tensile Test

The fabricated hybrid composite is cut using a water jet machine to induce the dimension of the specimen for tensile testing as per ASTM: D638 standards. The schematic diagram of tensile test specimen is shown in Fig. 1. The test was meted out employing a universal testing machine at a room temperature with 40% relative humidity. Three specimens are ready and tested. The specimens are shown within the Fig. 8. The tensile stress is recorded with relevancy increase in strain. The specimen was placed within the grip of the tensile testing machine and therefore the test is performed by applying tension till it undergoes fracture. The corresponding load and strain obtained are premeditated on the graphs.

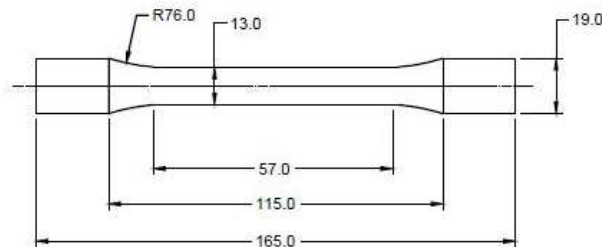


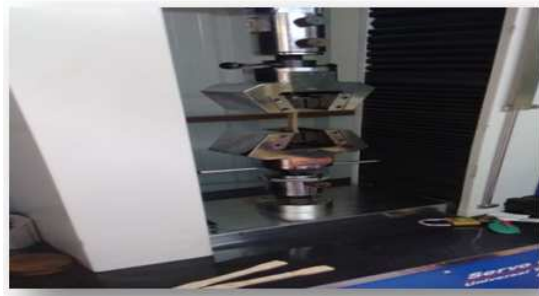
Figure 5: Schematic Diagram of Tensile Test Specimen



(a) Before Test Specimen

(b) After Test Specimen

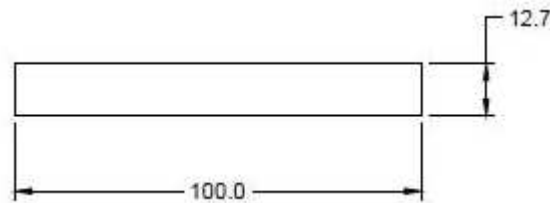
Figure 6: Tensile Test



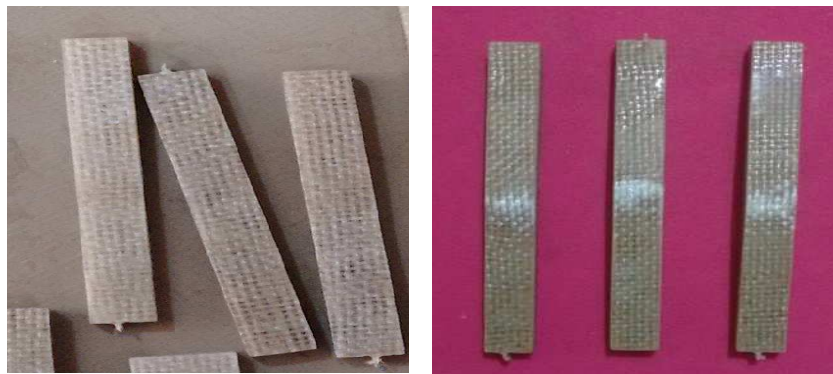
**Figure 7: Universal Testing Machine**

**Flexural Test**

The flexural test is performed using the flexural testing machine as per the ASTM: D790 standards. It is performed at room temperature and close to 40% relative humidity for three of schematic representation of flexural test specimen as shown in Fig. 10 and the specimens as shown in Fig.9. In this test, the specimen to be tested is subjected to a load at its center between the supports and until it fractures and breaks. This test determines the behavior of the specimen when it is subjected to simple beam loading. Flexural test determines the maximum stress induced in the outer most fiber.



**Figure 8: Schematic Diagram of Flexural Test Specimen**



**(a) Before Test Specimen      (b) After Test Specimen**  
**Figure 9: Flexural Test**

**Impact Test**

An impact testing machine with Izod arrangement is employed to perform the test. It is done as per the ASTM: D256 standards. It is performed at room temperature and closes to 40% relative humidity for three of the specimens as shown in Fig. 11. The specimen is subjected to an impact blow by the pendulum and the corresponding energy absorbed by the material is noted. This test gives the maximum energy that a material can absorb. Impact test determines the suddenly applied load induced in the outer most fiber.

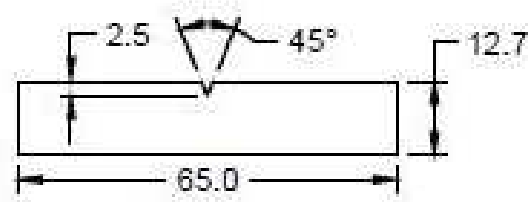
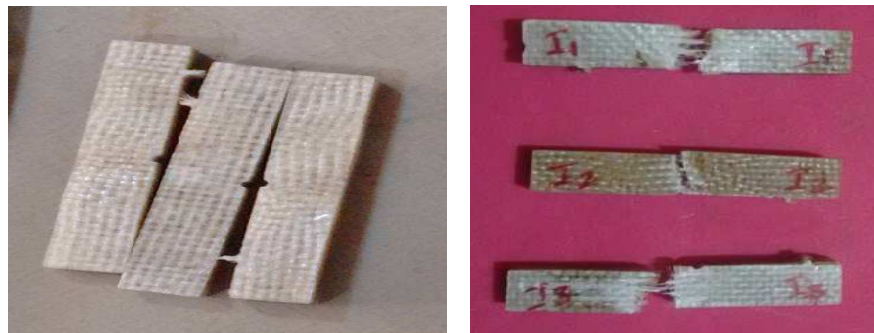


Figure 10: Schematic Diagram of Impact Test Specimen



(a) Before Test Specimen (b) After Test Specimen  
Figure 11: Impact Test

## RESULTS AND DISCUSSIONS

In this present work, the natural fibers are used as reinforcement in polymer composites for kinds of applications in automotive elements, structures and goods. The most focus of this study is employed to seek out the mechanical properties like tensile, flexural and impact strength for the woven fabric of Aloevera, Roselle and Glass fiber hybrid epoxy composites.

### Mechanical Properties

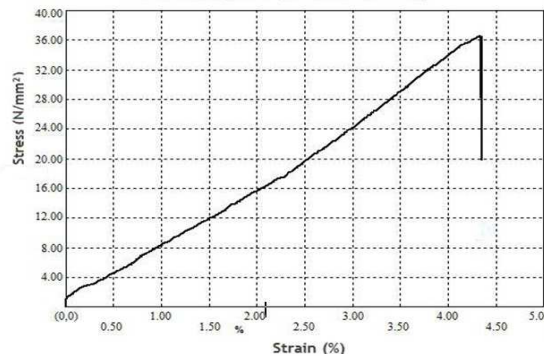
The ultimate tensile strength of hybrid composite specimen is carried out using tensile test. Tensile load obtained for the tested specimen in the tensile strength and modulus was tested using the Servo Controlled UTM Model –F 100 testing machine is presented in figure 12. The tensile properties of the fabricated specimen of GFRP-Aloevera-Roselle, are briefly given in Table 1. It is clearly seen that the tensile strength of the Aloe vera and Roselle composite is high.

Table 1: Tensile Test Results

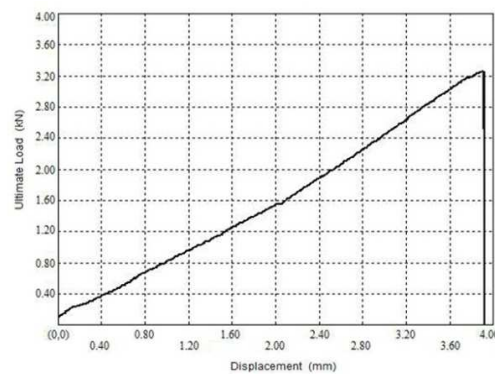
Sample	Break load (kN)	Max. Displacement (mm)	Elongation %	Tensile Strength		Tensile Modulus	
				In $\text{kN/mm}^2$	In MPa	In $\text{kN/mm}^2$	In MPa
GF/RF/AVF/RF /AVF/RF/GF(1)	2.76	3.92	5	0.0366	36.667	0.770	770.007
GF/RF/AVF/RF /AVF/RF/GF(2)	3.89	3.79	6.32	0.0438	43.844	0.920	920.724
GF/RF/AVF/RF /AVF/RF/GF(3)	2.19	3.21	5	0.0353	35.322	0.741	741.762
GF/RF/AVF/RF /AVF/RF/GF	2.95	3.64	5.44	0.0386	38.61	0.810	810.831



**Figure 12: UTM**



**Figure 13: Stress vs Strain**

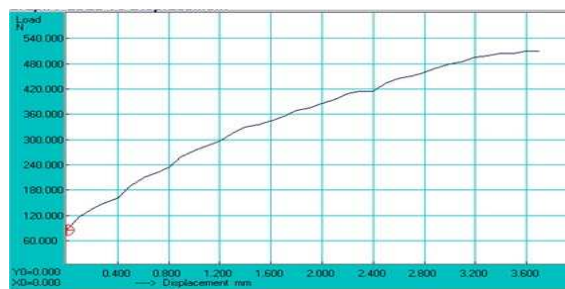


**Figure 14: A Load vs Displacement**

The Figure 13 shows the stress-strain curve of glass fiber reinforced Aloe vera-Rosell hybrid composites. It can be observed that stress increases linearly with the increase of the strain, however, when it reaches certain stress values. The results indicated that the average ultimate tensile strength is maximum for the hybrid reinforced composite and is  $38.61 \text{ N/mm}^2$  and the average displacement is  $3.64 \text{ mm}$ . The strength of the joints may be increased by using the proper proportion of the matrix and the reinforcement. The hybrid composite carries an average Ultimate load of  $3.44 \text{ kN}$ . Provided the woven fiber composite have additional features such as interlace spacing or gap, interlace point and unit cell. It has balanced properties by the interlock of fiber arrangement that increases the strength. Zhu J et al.,(2013) says The tensile strength may be increased if the fiber has undergone various chemical treatments such as mercerization, silane treatment, benzoylation, etc., before made into composites. Hence chemical treatments have improved the surface properties of natural fibres and enhance the adhesive bonding ability of the fibers with the matrix. Hence by appropriate fibre proportions, hybridization of fibers into the matrix will substantially improve the tensile property. The high strain rate for different reinforce fiber content is attributed to the nature. It is stated by Kim et al [35] that most polymeric materials tend to be strain-rate dependent.

**Flexural Properties**

The flexural properties of hybrid natural composites were conducted using a 3-point flexural test in the universal testing machine. The combination of compression and shear strength will decide the overall bending strength of the composites. The Ultimate flexural load is observed from the flexural testing is 0.538 KN, whereas the flexural load of all three samples is 0.51KN, 0.595KN and 0.51KN respectively. The maximum flexural displacement is observed from the testing results 4.6 mm for hybrid composite material which represents the good flexural strength of the material. A typical load vs displacement curve for composites specimen is shown in the Fig. 14. The results seen that the curves increase linearly with respect to displacement up to the maximum flexural load and then decreases since breakage takes place [36].



**Figure 14: Flexural Load to Displacement**

It is observed that the flexural load-carrying capacity (Strength) for the hybrid composite is 5.92 MPa., Flexural strength was clearly observed to be higher in hybrid composites (5.92 MPa) and whereas the flexural strength of all three samples is 5.604 MPa, 6.538 MPa and 5.604 MPa respectively. The flexural strength shown by other specimens are shown in Table 2. Flexural strength is a measure of stiffness. Observation on specimens indicated that, the proper binding between the fiber and matrix may increase the stiffness of the composite to little extend. By proper treatment of fibers, also the flexural strength of composite can be enhanced. It is important to note that the natural fibers can be replaced in applications where synthetic fibers are used especially in automotive and related industries. The change of polymer matrix and its concentration also influence the flexural properties, due to the change in effect of adhesion between the fiber and matrix.

**Table 2: Flexural Results**

Sample	Flexural Break load (kN)	Max. Displacement (mm)	Flexural Strength		Flexural Modulus	
			In kN/mm <sup>2</sup>	In MPa	In kN/mm <sup>2</sup>	In MPa
GF/RF/AVF/RF/A VF/RF/GF(1)	0.510	3.6	0.0056	5.604	0.122	122.931
GF/RF/AVF/RF/A VF/RF/GF(2)	0.595	4.7	0.00653	6.538	0.143	143.42
GF/RF/AVF/RF/A VF/RF/GF(3)	0.510	5.5	0.0056	5.604	0.122	122.931
GF/RF/AVF/RF/A VF/RF/GF	0.538	4.60	0.00592	5.92	0.129	129.76

**Impact Properties**

The impact properties of composites depend on the inter laminar and interfacial adhesion between the fiber and the matrix. The schematic representation of Izod specimen as shown in Fig 10. The energy absorbed by the composites specimen as shown in Fig 11. The impact test is conducted for analyzing the impact capability of hybrid composites. Here it is observed that the combination of Glass fibre-Aloevera-Roselle hybrid sample shows better impact energy than the other

samples.

The maximum Izod impact energy found is 5.6 J. The loss in energy is found using Izod impact test machine. Impact strength depends upon the fiber resistivity during fracture. This implies that, apart from parameters like fiber-matrix interface, construction and geometry of composites, as stated by others [37], the strength and structure of the individual fiber constituent is accountable for deciding the impact strength of composites. It may be observed that interfacial strength between fiber and matrix solely decides impact strength in the case of random orientation.

## CONCLUSIONS

From the above discussion, the fabricated hybrid fiber reinforced composite gives good result to withstand the nominal loads and stresses induced on the model. This study on the glass fiber and natural fiber hybrid reinforced composite best suitable for the automobile industry and household things. This paper concludes that natural fiber reinforced polymer composite is best to alternate for glass fiber and plastic fiber composites. Its bio degradable nature gives good health to nature.

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