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## Fabrication of Jute–Pine Apple leaf reinforced hybrid composites: Validation of mechanical properties through ANSYS

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### ABSTRACT

*There is a huge need for new materials in all fields of engineering; this invites the development of new materials which suits the need. Utilization of biodegradable materials i.e. natural fibers for various applications to preserve the environment from synthetic fibers invites the development of natural fiber reinforced polyester composites. In a country like India which is producing an enormous amount of agricultural solid waste (in the form of leaf, fruits, stems etc.) there is lack of marketing for the above-said wastes if this can be improved the farmers may get benefited. Natural fiber reinforced composites are preferred than conventional materials because of their advantages like low density, lightweight, high strength to weight ratio, low cost, high toughness, and biodegradability. The present investigation deals with the preparation of jute, pineapple leaf fiber and jute-pineapple leaf fiber (Hybrid) reinforced polyester composite and to determine the tensile, flexural and impact properties with increase in percentage weight fraction of the fiber and to compare the properties of the composites. Further, the experimental results will be validated through ANSYS software.*

**Keywords**— Natural fibers, Pineapple Leaf Fiber (PALF), Jute fiber, Hybrid composite, Polyester resin, Catalyst, Accelerator

### 1. INTRODUCTION

Materials scientists and engineers all over the world have focussed their attention on Natural fiber-reinforced polymer composites due to their attractive features like lightweight, low material cost, moderate strength, high specific modulus, lack of health hazards, and environmentally friendly [1]. Many studies have been conducted to investigate the properties of natural fiber reinforced composite and to replace the conventional metals for certain applications [2]. Composite materials are composed of two or more phases one of the phases is termed as the matrix phase, which is continuous and surrounds the other phase which is often called the dispersed phase or reinforcement phase. The reinforcement is usually much stronger and stiffer than the matrix and gives the composite good properties [3]. Natural fibers offer good opportunities as a reinforcement material. Composites provide a positive benefit to the ecological and environmental advantage and the attractive mechanical properties [4]. Jute fibers are the natural fibers light in weight and many researchers have already identified the possibilities of fully biodegradable polymers with jute fiber reinforcement [5-6].

[7] These fibers often contribute greatly to the structural performance can provide significant reinforcement. The stiffness and strength can be overcome by structural configurations and better arrangement in the sense placing the fibers in specific locations for highest strength performance [8]. Fiber reinforced composites are used in almost in every advanced engineering structure, with their usage ranging from aircraft, helicopters, spacecraft through to boats, ships and offshore platforms and to automobiles [9]. The use of natural fibers in matrices is highly beneficial because the strength and toughness of resulting composites are greater than unreinforced plastics. So, it is found good to use natural fibers in place of plastics and other environmentally unfriendly materials [10]. Natural fibers are of great importance, low availability of natural products like wood leads towards the need of alternatives with similar properties and these fibers are also a good alternative to plastics because of properties like biodegradability, recyclability [11]. Natural fibers are introduced as a replacement for synthetic fibers in order to reduce the environmental impact of non-biodegradable materials [12].

Various natural fibers such as bamboo, sisal, jute, flax, hemp, Pineapple leaf fiber, coir etc are used as a reinforcement and thermoset or thermoplastic materials are used as a matrix [13]. Recently, the research community has shown great interest in using natural fibers to reinforce thermoplastic and thermoset polymer composites due to their excellent mechanical properties compared to those of other natural fibers [14]. Natural fiber composites can also be very cost-effective material for application in

building and construction areas (e.g. walls, window, and door frames), storage devices (e.g. bio-gas container etc.), furniture (e.g. chair, table, tools, etc.) [15]. Natural fibers reinforced composite not only exhibits but also excellent mechanical and dielectric properties, contribute to environmental advantages such as recyclable, biodegradable, hence, the use of natural fibers in composite materials industry can reduce environmental pollution and waste disposal problems [16].

## **2. MATERIALS USED, FABRICATED AND TESTING**

The basic raw materials used to prepare the composites are jute and pineapple leaf fibers procured from GO Green products, 129, Cathedral Garden Road, Nungambakkam, Chennai, Tamilnadu, 600034, India.

Polyester Resin, catalyst, and accelerator are purchased from BINDU AGENCIES H.NO 59-13-34/1, Shop No. 182, City Heart Towers, Main Road, Gayathri Nagar, Vijayawada – 520008.

### **2.1 Jute Fiber**

The industrial term for jute fiber is raw jute, the plants grow up to and 1–4 meters (3–12 feet) long in two or three-month time, and such plants are cut, tied up in bundles and kept under water for several days for fermentation. It is a natural fiber popularly known as the golden fiber. It is one of the cheapest and the strongest of all-natural fibers. Jute is the second most common natural fiber, cultivated in the world and extensively grown in Bangladesh, China, India, Indonesia, and Brazil.

**Table 1: Properties of Jute Fiber**

<b>Fiber</b>	<b>Density/cm<sup>3</sup></b>	<b>Elongation%</b>	<b>Specific Modulus (Gpa)</b>
Jute	1.3	1.7	39

### **2.2 Pineapple Leaf Fiber (PALF)**

Pineapple is the third most important fruit in the world after banana and citrus. Due to the development of fruit production industries (jam industries), the cultivation of pineapple is increased. The use of Pineapple Leaf fiber (PALF) as a reinforcement material can reduce environmental pollution, waste disposal problems and ecological concerns. Pineapple leaf fiber has excellent mechanical strength but due to lack of knowledge, it is still not utilized properly.

**Table 2: Pineapple Leaf Fiber (PALF) Properties**

<b>Fiber</b>	<b>Density/cm<sup>3</sup></b>	<b>Elongation%</b>	<b>Specific Modulus (Gpa)</b>
Pineapple leaf	1.4	1.6	34

### **2.3 Polyester resin**

ECMALON 4411 is an unsaturated polyester resin of ortho-phthalic acid grade with clear colorless or pale yellow color.

A large number of polyester structures that have found use in industry today, displays a wide variety of properties and applications. Polyesters are one of the most versatile synthetic copolymers. Polyesters are produced in high volume that exceeds 30 billion pounds a year worldwide.

Most unsaturated polyester resins consist of a solution of polyester in styrene monomer. The styrene serves two purposes: firstly, it acts as a solvent for the resin and secondly it enables the resin to be cured from a liquid to a solid by curing with polyester resin. This curing is achieved at room temperature by adding a catalyst (or initiator), plus an accelerator (or promoter).

### **2.4 Catalyst**

The catalysts used are invariably organic peroxides. Since these are chemically unstable as a class of compounds, of which some can decompose explosively in the pure form, they are mostly supplied as solutions, dispersions or pastes in a plasticizer or as a powder mixed with an inert filler to stabilize them.

This indicates that they have been made safer to handle or stabilized with a plasticizer. Since organic peroxides are hazardous materials to handle, due note should be taken off the safety recommendations.

### **2.5 Accelerator**

The most commonly used accelerators are either those based on a cobalt soap or those based on a tertiary amine. Other types of accelerators may be used for specific applications and include quaternary ammonium compounds, vanadium, tin and zirconium salts. Accelerators are usually used at between 0.5 and 4% based on the resin weight.

### **2.6 Preparation of Composite specimens**

Many techniques are available in industries for manufacturing of composites such as compression molding, vacuum molding, pultruding, and resin transfer molding are few examples. The hand layup process of manufacturing is one of the simplest and easiest methods for manufacturing composites. A primary advantage of the hand layup technique is to fabricate very large, complex parts with reduced manufacturing times. Additional benefits are simple equipment and tooling that are relatively less expensive than other manufacturing processes. Different steps involved in the making of composites are a collection of fibers and resin, preparation of mould, making and extraction of the composite from the mould. Initially, the base plate (tile) has to be cleaned by scrubbing with sandpaper. Then the surface is allowed to dry after cleaning it with a thinner and the wax has to be applied to the mould (acrylate) sheet for the easy removal of the specimen. After that, the fibers are cut down as per the ASTM Standards and then take the polyester resin, catalyst, accelerator and mix in the proportion of 100:1:1 and place the fibers in the mould (acrylate) sheet and applied resin. This process is continuing up to 8-11 layers. After preparing the laminates of weight is

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placed on the laminates (100 kg). After 24 hours, the weight is removed, the cured specimens are removed and they are cleaned & inspected.



**Fig. 1: Mould (acrylate sheet) for tensile and bending test specimens**



**Fig. 2: Mould (acrylate sheet) for Impact test specimens**



**Fig. 3: Specimens of jute – polyester- resin for tensile, flexural and impact**



**Fig. 4: Specimens of Pine Apple Leaf Fiber – polyester resin for tensile, flexural and impact**



**Fig. 5: Specimens of jute-pineapple leaf fiber-polyester resin Hybrid Composite for tensile, flexural and impact**

## 2.7. Tests for mechanical properties

**2.7.1 Tensile Test:** The tensile test has been performed on A 2-ton capacity – Electronic tensometer, METM 2000 ER-I model is used to find the tensile strength of composites. Its capacity can be changed by load cells of 200kg is used for testing composites. Self-aligned quick grip chuck is used to hold the composite specimen. A digital micrometer is used to measure the thickness and width of composite, Tensile strength, the tensile modulus is determined after conducting the tensile test.



**Fig. 6: Tensometer**

**2.7.2 Flexural Test:** The flexural test was performed on the same electronic tensometer as shown in figure 6. The three-point bending test was conducted. Load, deformation values are noted and Flexural modulus and flexural strength values are determined.

**2.7.3 Impact Test:** The Izod impact test of the composite was tested and a cross-section having 45° V-notch and 2mm deep were used for the test. Each test is repeated three to four times and the average values are taken for calculating the impact strength



Fig. 7: Impact Test

### 2.8 Validation of results in finite element analysis

In the study of the Micromechanics of fiber reinforced materials, it is convenient to use an orthogonal coordinate system that has one axis aligned with the fiber direction. The 1-2-3 Coordinate system shown in figure 8 is used to study the behavior of the unit cell. The 1 axis is aligned with the fiber direction, the 2 axis is in the plane of the unit cell and perpendicular to the fibers and the 3 axis is perpendicular to the plane of the unit cell and is also perpendicular to the fibers. The isolated unit cell behaves as a part of a large array of unit cells by satisfying the conditions that the boundaries of the isolated unit cell remain plane.

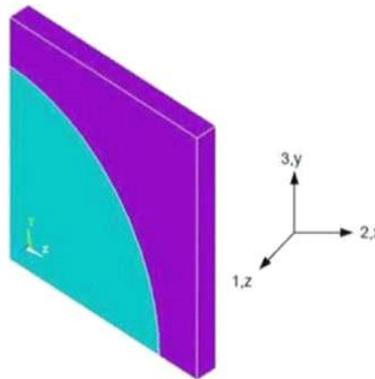


Fig. 8: One-fourth portion of the Unit cell

Due to symmetry in the geometry, material, and loading of the unit cell with respect to the 1-2-3 coordinate system, it is assumed that one-fourth of the unit cell is sufficient to carry out the present analysis.

The 3D Finite Element mesh on one-fourth portion of the unit cell is shown in figure 9.

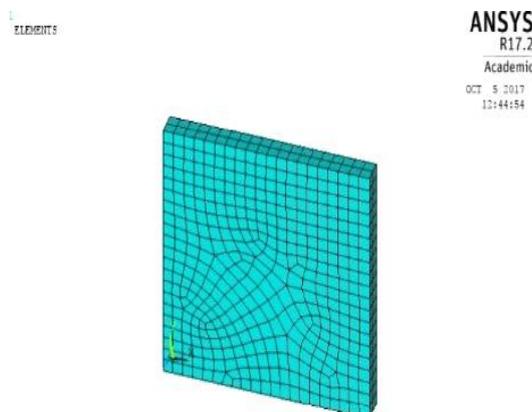


Fig. 9: Finite Element Mesh Model

### 2.9. Material properties

The materials properties that were used for the calculation of the Elastic properties of the resin- jute-pineapple composite are listed in table 3. The properties of the resin are taken from experimental results and jute, pineapple leaf fibers properties collected from the literature.

**Table 3: Material Properties of Constituents for FEA**

S. No.	Material	Young's Modulus E (Mpa)	Poisson's Ratio
1	Jute Fibre	26500	0.3
2	Pineapple Leaf Fiber	6260	0.3
3	Polyester Resin	36000	0.35

**3. Geometry, element type and boundary conditions**

**3.1 Geometry**

The dimensions of the finite element model are taken as:

- X = 100 units,
- Y = 100 units,
- Z = 10 units

**3.2 Element type**

The element SOLID 20 node 186 of ANSYS 17.2 used for present analysis is based on a general 3D state of stress and is suited for modeling 3D solid structure under 3D loading. SOLID 20 node 186 is a higher-order version of the 3D 20-node solid element that exhibits quadratic displacement behavior. It can tolerate irregular shapes without as much loss of accuracy. SOLID186 elements have compatible displacement shapes and are well suited to model curved boundaries. SOLID186 has plasticity, creep, stress stiffening, large deflection, and large strain capabilities. The element has 20 nodes having one degree of freedom, i.e., temperature and with three degrees of freedom at each node: translation in node X, Y, Z directions respectively

**3.3 Boundary Conditions**

Due to the symmetry of the problem, the following symmetric:

Boundary conditions are used:

- At X = 0,  $U_x = 0$
- At Y = 0,  $U_y = 0$
- At Z = 0,  $U_z = 0$

In addition, the following multi point constraints are used.

- The  $U_x$  of all the nodes on the area at X=100 is same.
- The  $U_y$  of all the nodes on the area at Y=100 is same.
- The  $U_z$  of all the nodes on the area at Z=10 is same.

**3.4 Calculating Tensile Modulus**

- For calculating the tensile modulus of the developed model, the deformation value in the fiber direction is to be considered.
- In this case, the deformation value in Z-direction is considered for  $E_1$  value by dividing it with its original value i.e. 10 units and divides the stress value with obtained strain value.

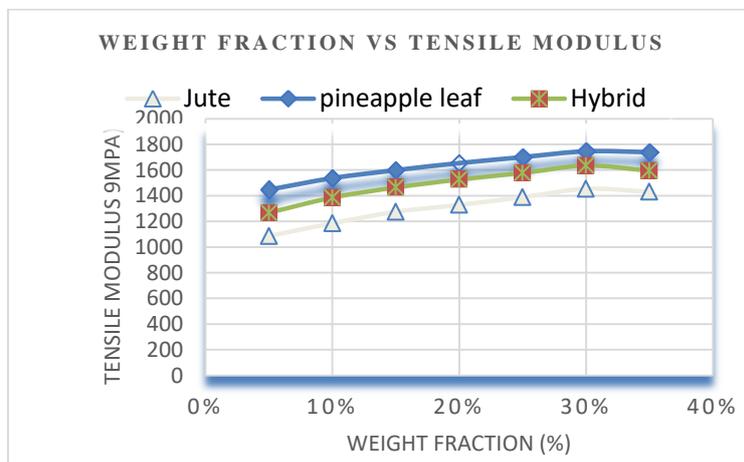
**3.5 Analysis of E1 values**

Tensile modulus is analyzed with the help of finite element software ANSYS 17.2. The analysis draws the following is as shown figures.

**4. RESULTS AND DISCUSSION**

**4.1 Tensile Test**

From tensile test young's modulus and tensile strength of jute- polyester, pineapple leaf fiber – polyester and hybrid (jute – pineapple leaf fibers-polyester) composites are determined. The specimen dimensions for tensile test are 160 mm x 12.5 mm x 3 mm as per the (ASTM D638-89) Standard.



**Fig. 10: Weight fraction vs. tensile modulus**

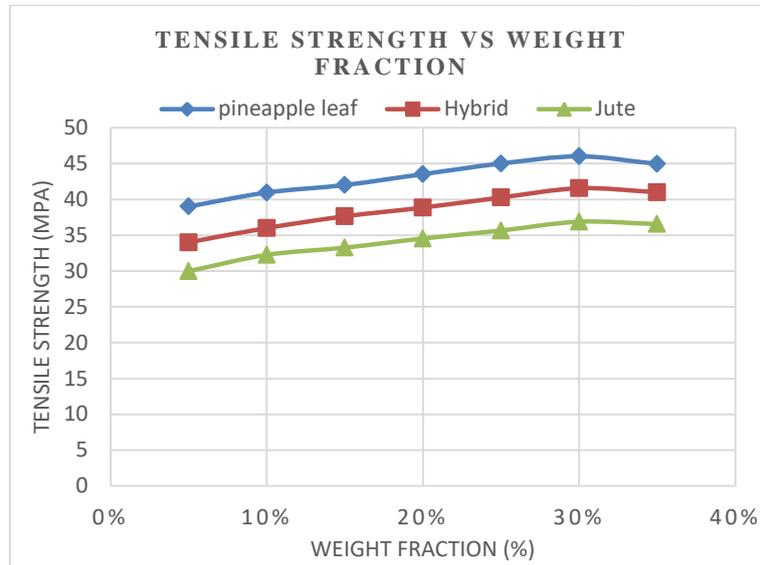


Fig. 11: Weight fraction vs. Tensile strength

#### 4.2 Flexural Test

By conducting the flexural test, flexural modulus and flexural strength of jute- polyester, pineapple leaf fiber – polyester and hybrid (jute – pineapple leaf fibers-polyester) composite are determined. The specimen dimensions are 100 mm x 25 mm x 3 mm as per (ASTM D79-86) standard.

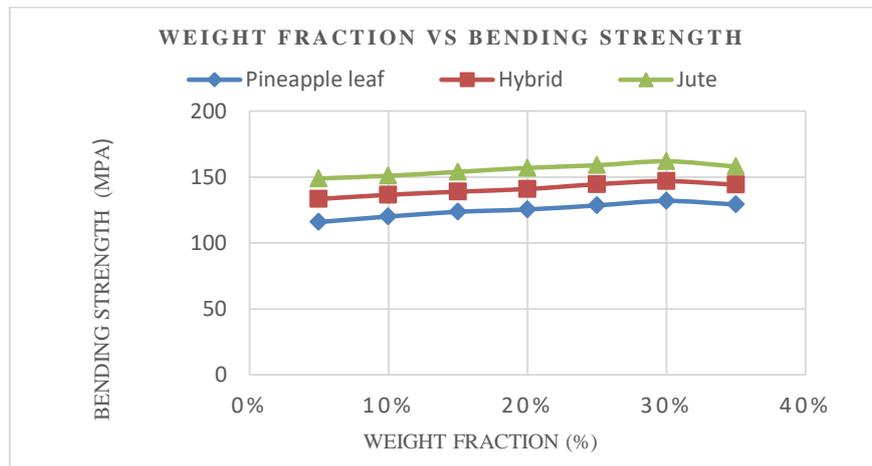


Fig. 12: Weight fraction vs. Bending strength

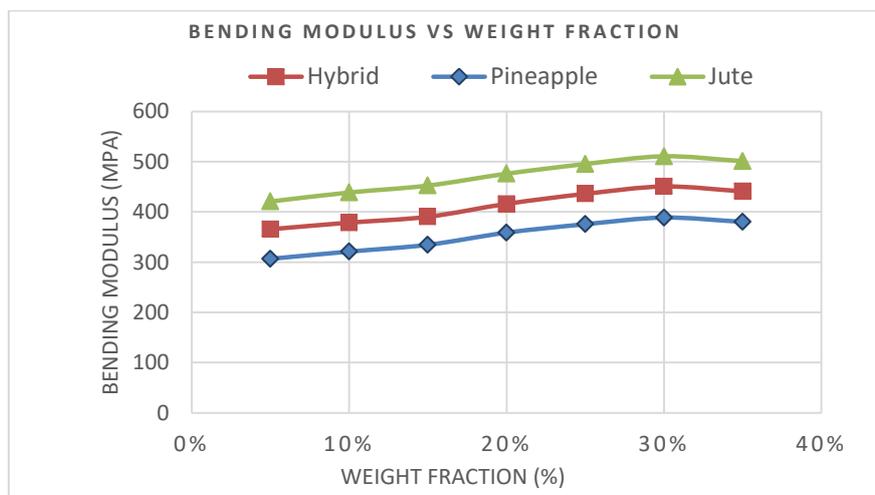


Fig. 13: Weight fraction vs. bending modulus

#### 4.3 Impact Test

The impact test is conducted on jute- polyester, pineapple leaf fiber – polyester and hybrid (jute – pineapple leaf fibers-polyester) composite. To determine impact strength as per the (ASTM D 256-97) standard. The specimen dimensions are 63.5 mm x 12.7 mm x 3 mm.

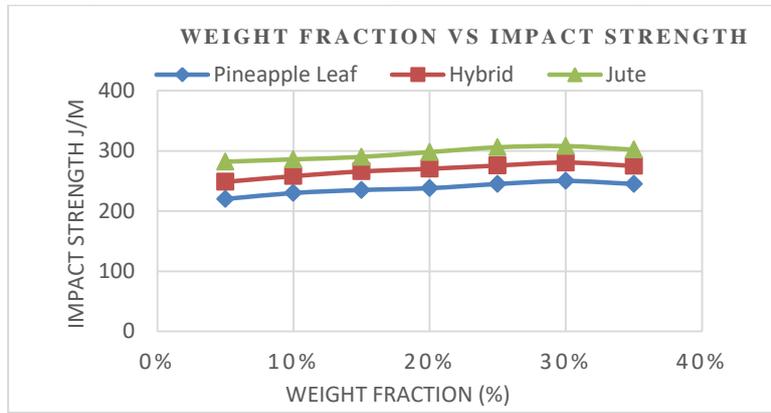


Fig. 14: Weight fraction vs. impact strength

5. RESULTS FROM ANSYS

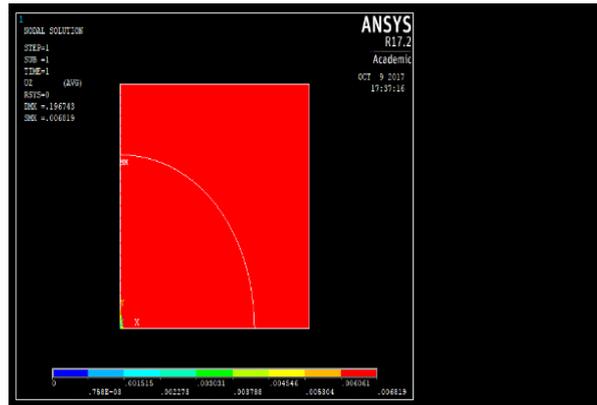


Fig. 15: Results plot of E1 for sample Pineapple leaf fiber model

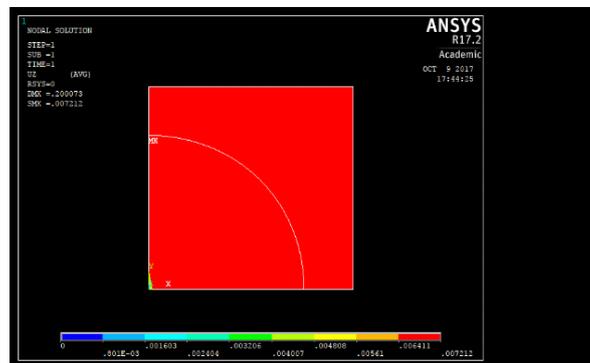


Fig. 16: Results plot of E1 for sample Jute fiber model

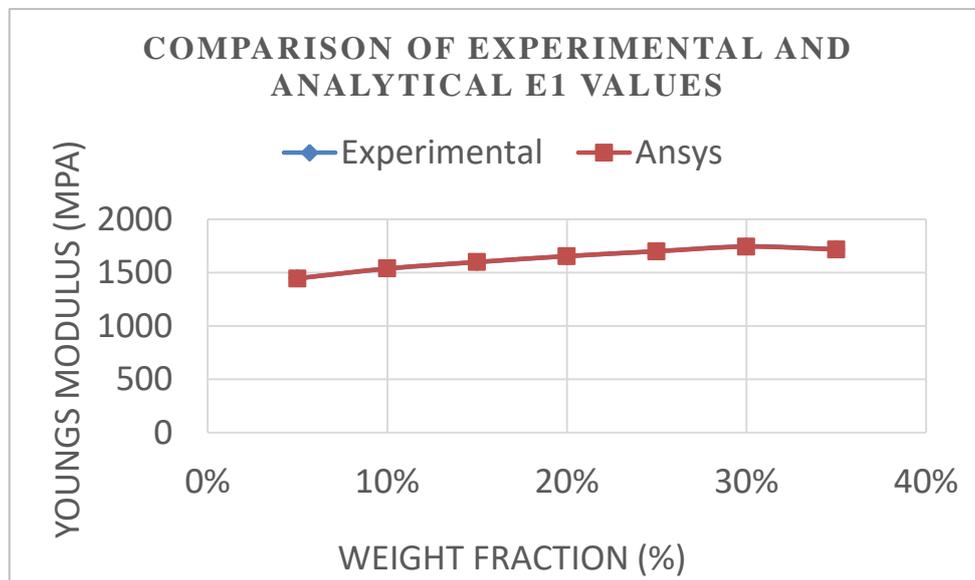


Fig. 17: Comparison of tensile modulus values determined experimentally with ANSYS results

**Table 4: Comparison values of E1 for Pineapple Leaf fiber**

S. no.	Fiber Weight Fraction	Pineapple Leaf Fiber Tensile Modulus (E <sub>1</sub> ) (Mpa)	
		Experiment	Ansys
1	5%	1446.89	1445.51
2	10%	1536.48	1538.93
3	15%	1598.52	1599.48
4	20%	1653.58	1655.08
5	25%	1701.26	1699.81
6	30%	1745.68	1743.17
7	35%	1739.24	1737.57

**Table 5: Comparison values of E1 for Jute fiber**

S. no.	Fiber Weight Fraction	Jute Fiber Tensile Modulus (E <sub>1</sub> ) (Mpa)	
		Experiment	Ansys
1	5%	1085.54	1086.11
2	10%	1185.26	1187.50
3	15%	1274.58	1275.18
4	20%	1327.82	1325.55
5	25%	1388.48	1386.57
6	30%	1453.38	1451.80
7	35%	1430.48	1432.04

**Table 6: Comparison values of E1 for Hybrid**

S. no.	Fibre Weight Fraction	Hybrid Tensile Modulus (E <sub>1</sub> ) (Mpa)	
		Experiment	Ansys
1	5%	1267.42	1269.52
2	10%	1385.62	1387.84
3	15%	1464.38	1465.28
4	20%	1526.53	1528.64
5	25%	1577.26	1579.32
6	30%	1634.72	1636.21
7	35%	1595.24	1596.47

## 6. CONCLUSIONS

- The tensile strength, Young's modulus, bending strength, bending modulus and impact strength of the composite increases with an increase in weight fraction of the fiber (up to 30%) and decrease with further increase in the weight fraction (35%).
- The Pineapple Leaf Fiber - Polyester composite has maximum Young's modulus and tensile strength when compared to the jute-polyester and hybrid fiber composite.
- The Jute - polyester composite has maximum flexural modulus and flexural strength when compared to the Pineapple leaf fiber - polyester and hybrid composite.
- Similarly, the impact strength of jute - polyester composite has maximum when compared to the pineapple leaf fiber and hybrid composite.

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## 8. REFERENCES

- [1] Muthu Kumar, V., R. Venkatasamy, A. Sureshbabu, and D. Arunkumar. "A Study on Mechanical Properties of Natural Fiber Reinforced Laminates of Epoxy (Ly 556) Polymer Matrix Composites." International Journal of Production Technology and Management Research 2, no. 2 (2011):
- [2] Sreenivasan V.S., Ravindran D., Manikandan V., and Narayanasamy R. (2011). "Mechanical Properties of Randomly Oriented Short Sansevieria Cylindrical Fibre/Polyester Composites." Materials and Design.
- [3] Mishra S, Mohanty AK, Drzal LT, Misra M, Parijaci S, Nayak SK, et al. "Studies on mechanical performance of biofiber/glass reinforced polyester hybrid composites." SciTechnol 2003; 63(10):1377–85.
- [4] David Plackett, Tom LogstrupAndersan, Walther BatsbergPerdersen, and LotteNielsen, "Biodegradable composite based on L-poly lactide and jute fiber Composite." Science and Technology, 2003; 63:1287-1296.
- [5] Smith Thitithanasarn, Kazushi Yamada, Yew Wei Leong, Hiroyuki Nishimura, and Hiroyuki Hamada, "Effect of surface treatment on thermal and mechanical performance of recycled natural fiber reinforced composites." Proceeding of the International Conference on Composite Materials 18th, 2009.
- [6] Kathleen Van de Velde and Paul Kiekens, "Thermoplastic pultrusion of natural fiber reinforced composites." Composite Structure, 2001; 54:355-360.
- [7] Ahmed KS, Vijayarangan S, et al. "Mechanical behavior of isothalic polyester-based untreated woven jute and glass fabric hybrid composites." Journal of Reinforced Plastic Composites 2006; 25: 1549.

- [8] Srivastava, A.K., Behera, M.K. and Ray, B.C., "Loading Rate Sensitivity of Jute/Glass Hybrid Reinforced Epoxy Composites- Effect of Surface Modifications." *Int. Jou. of Reinforced Plastics and Composites*, 2007, 26:851-860.
- [9] Bisen, K. B., K. Sahu, and M. M. Krishna. "Mechanical behavior of banana and pineapple hybrid composites reinforced with epoxy resin." *Int J IT, EngApplSci Res* 4, no. 2 (2015): 2319-4413p.
- [10] Mehmet AKGUL, Cengiz GULER, Yalcın COPUR, (2010) "Certain physical and mechanical properties of medium density fiberboards manufactured from blends of corn (*Zea mays indurata*Sturt.) stalks and pine (*Pinusnigra*) wood." *Turk J Agric For*34. 197-206.
- [11] M. A. Maleque\*, F. Y. Bela (2007) "MECHANICAL PROPERTIES STUDY OF PSEUDO-STEM BANANA FIBER-REINFORCED EPOXY COMPOSITE." Volume 32, Number 2B, the Arabian Journal for Science and Engineering.
- [12] Rajesh, M., JeyarajPitchaimani, and N. Rajini. "Free vibration characteristics of banana/sisal natural fibers reinforced hybrid polymer composite beam." *Procedia Engineering* 144 (2016): 1055-1059.
- [13] A.V. Ratna Prasad, K. Mohana Rao "Mechanical properties of natural fiber reinforced polyester composites: Jowar, sisal, and bamboo". Elsevier, March2011.
- [14] Siregar, JanuarParlaungan, TezaraCionita, DandiBachtar, Mohd Ruzaimi Mat Rejab, and Mohd Ruzaimi. "Tensile Properties of Pineapple Leaf Fibre Reinforced Unsaturated Polyester Composites." *Applied Mechanics and Materials* 695 (2014): 159.
- [15] T. Srinag, V.B.K. Murthy, and JS Kumar Suresh. "Micromechanical analysis of hybrid discontinuous fiber reinforced composites for longitudinal loading." *International Journal of Applied Engineering Research* 3, no.7 (2008).
- [16] M. Rajesh, T. Srinag, P. PhaniPrasanthi, K. Venkatrao. "Finite Element Analysis of Coir/Banana Fiber Reinforced Composite Material." *International Journal of Advanced Research in Mechanical Engineering & Technology (IJARMET)*.