A COMPARATIVE ANALYSIS OF FINITE ELEMENT MODELING AND EXPERIMENTAL IMPACT TESTING ON KENAF AND BANANA FIBERS

Putti Venkata Siva Teja[1], Kavilikatta Pavan Kumar[2], Dukkipati Bala Nagesh[3], Sravanth Kondeti[4]

[1,2,&3]Assistant Professor, Mechanical Engineering Department,
Dhanekula Institute of Engineering & Technology, Ganguru, Andhra Pradesh, India
[4]CAE Engineer, Cyient, Hyderabad, Telangana, India

---***---

Abstract - *The utilization of composite materials in the engineering field is experiencing a steady and significant growth. A composite material is formed by combining two or more micro or macro constituents that differ in form and chemical composition, and they are essentially insoluble in each other. These composite materials are progressively replacing conventional materials due to their superior properties, including high tensile strength, an exceptional strength-to-weight ratio, and low thermal expansion. Composites primarily comprise two essential components: the matrix and the fibers. The fibers can consist of polymers, ceramics, metals such as nylon, glass, graphite, aluminum oxide, boron, and aluminum. Furthermore, natural fibers such as jute, coir, silk, banana, bamboo, and even animal feathers are now being utilized as fibers. In this study, polyester is employed as the matrix material, while kenaf and banana fibers are used as reinforcing fibers to fabricate the composites. Specimens are prepared by varying the weight percentages of the fibers, namely 11% kenaf and 9% banana, 10% of each fiber, and 9% kenaf and 11% banana, respectively. The mechanical properties, particularly impact strength, are carefully validated. Furthermore, the stresses and strains occurring under various weight fractions of the fiber are analyzed using ANSYS software, and the obtained results are compared with experimental data to ensure accuracy and reliability.*

Key Words: Polyester(epoxy resin), Natural fiber, Kenaf fiber, Banana fiber, Ansys.

1.INTRODUCTION

In recent years, there has been a growing environmental consciousness and a greater emphasis on sustainable development, leading to an increased interest in utilizing natural fibers as replacements for synthetic fibers in polymer composites. Natural fibers offer numerous advantages, including their low cost, low density, abundant and sustainable availability, and minimal wear on processing machinery [1].

Kenaf (Hibiscus cannabinus L.) is a traditional crop found predominantly in developing countries. It is emerging as a promising source of annually renewable industrial materials. The use of natural fibers in composites has gained significant attention due to their ability to reduce the weight of components, ultimately replacing metallic materials. Studies have demonstrated that the tensile modulus, impact strength, and ultimate tensile stress of kenaf-reinforced polypropylene composites increase with higher fiber weight fractions. In comparison, banana fiber composites exhibit relatively lower mechanical properties but possess higher impact strength compared to jute and kenaf composites. Evaluating the mechanical properties of both kenaf and coir fibers will provide valuable insights into their structural strength [2–5].

Extensive research has been conducted to explore the potential of natural fibers as reinforcements in polymers. These investigations have revealed that while natural fibers show promise as replacements for glass fibers in plastics, they generally do not achieve the same level of mechanical performance [2–6].

2. MECHANICAL PROPERTIES OF BANANA AND KENAF FIBER

The mechanical properties of banana and kenaf fibers have been the focus of numerous studies. Understanding these properties is crucial in assessing the potential of these natural fibers as reinforcements in composite materials.

Banana fibers have shown to possess favorable mechanical properties, particularly in terms of impact strength. Despite displaying relatively lower mechanical properties compared to other natural fibers like jute and kenaf, banana fibers exhibit higher impact strength. This characteristic makes them suitable for applications requiring resistance to sudden loads or impacts.

On the other hand, kenaf fibers have demonstrated notable mechanical properties, including tensile modulus, impact strength, and ultimate tensile stress. As the weight fraction of kenaf fibers increases in composite materials, these mechanical properties tend to improve. This indicates that higher kenaf fiber content contributes to enhanced structural strength and durability of the composites.

By evaluating and comparing the mechanical properties of banana and kenaf fibers, researchers can gain insights into their suitability as reinforcement materials in various industries and applications.

Overall, the mechanical properties of both banana and kenaf fibers play a significant role in determining their performance and effectiveness as reinforcing agents in composite materials. Further investigations and analysis are needed to fully understand and harness the potential of these natural fibers in the development of sustainable and high-performance composite materials. The Table 1 shows the Mechanical properties of banana and kenaf fiber.

TABLE I: Mechanical Properties Of Banana And Kenaf fiber

Fibre	Strength (MPa)	% of elongation	Young's modulus (Gpa)
Kenaf	890–960	5–9	53
Banana	470–550	4–6	12

3. COMPOSITE FABRICATION

The fabrication of composites began by taking a rectangular rubber sheet with dimensions of 300 mm in length and 10 mm in thickness. This rubber sheet was then cut to create a rubber mold, following the specifications outlined in the ASME E23 standard for impact test machines. Figure 1 illustrates the preparation of the rubber mold. To ensure easy release of the composite from the mold without sticking to the mold walls, kerosene was applied to the inner sides of the mold. Next, the appropriate quantity of fibers (kenaf and banana) was carefully placed in the mold, ensuring that the polyester mixture would completely cover the fibers. The initial layer of the mold was filled with the polyester mixture, and another layer of polyester was poured over the fibers, resulting in the starting and ending layers being composed of polyester.

A plastic releasing film was placed on top of the uncured mixture, and efforts were made to remove any trapped air bubbles by using a roller. The composite was then subjected to a compression pressure of 0.05 MPa and cured at room temperature for 24 hours, ensuring even distribution of pressure. Specimens with a weight fraction of 20% fiber were prepared, following the dimensions specified in ASTM E23: 55 mm in length, 10 mm in width, and 10 mm in thickness. Figure 2 shows the final specimens after preparation. This fabrication process ensured the proper incorporation of fibers within the polyester matrix, resulting in composite specimens ready for testing according to the ASTM standards [2].

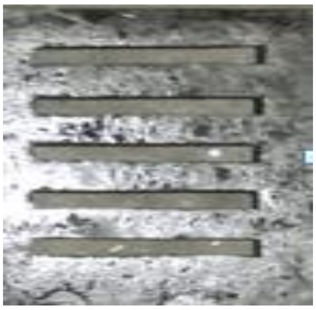


Fig 1: Rubber Mould

kenaf 11%&banana9% kenaf 9%&banana11% Kenaf & banana 10%

Fig 2: Final Specimens

4. MECHANICAL TESTS

To evaluate the impact strength of the composite specimens, a Charpy test machine was utilized. Impact test specimens were prepared following the specified dimensions of 55 mm length, 10 mm width, and 10 mm thickness, as outlined in the ASTM standard [2]. During the testing process, the specimen was securely loaded into the testing machine and positioned to interact with the pendulum. The pendulum was then released, allowing it to strike the specimen. The impact force applied to the specimen was measured, and the test continued until the specimen fractured or broke. This measurement of the force required to fracture the material provided a means to assess the toughness of the composite material [2,3]. By conducting the impact tests, valuable information regarding the ability of the composite specimens to withstand sudden loads and impacts was obtained. These tests served as a crucial measure of the material's resistance to fracture and provided insights into its overall mechanical performance [2,3].

5. RESULTS AND DISCUSSION

A: Impact test result for experimental:

From experimental calculations , Toughness is calculated for three different compositions.

For kenaf 10% and banana 10% ,

Energy absorbed = Initial – final readings

=300-2 =298 J

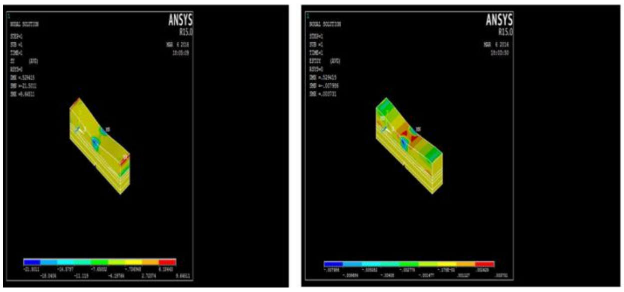
As we know ,

Toughness = Energy absorbed /Notch cross sectional area, J/mm^2

=298/(13*10) =2.29 J/mm^2

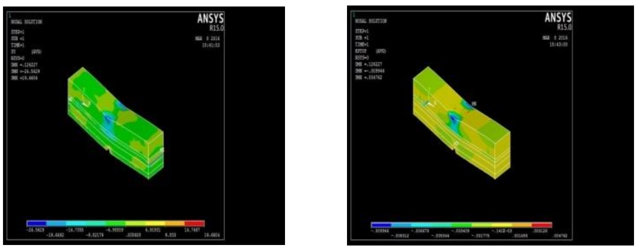
B: Impact test result for ansys:

The ASTM standard mandates the utilization of specific specimens for conducting impact tests. These specimens typically possess a rectangular shape with a centrally positioned notch. During the test, a radial load is simultaneously applied to both sides of the specimen. The length of the test section should measure precisely 55 mm. Subsequently, the obtained impact test results, encompassing stress and strain data, are subjected to thorough analysis. Figure 3 depicts the stress-strain graphs of Kenaf 10% and banana 10%, while Figure 4 showcases the stress-strain graphs of Kenaf 11% and banana 9%. Finally, Figure 5 displays the stress-strain graphs of Kenaf 9% and banana 10%.



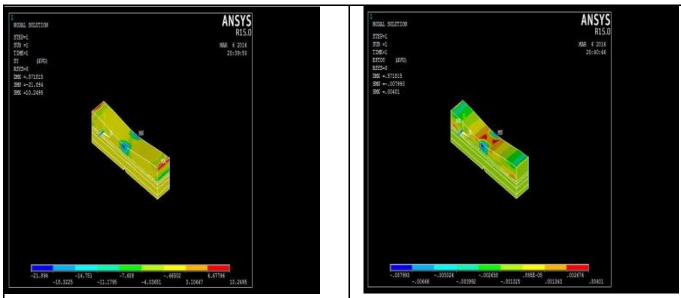
Stress (N/m^2) **strain**

Fig 3: Kenaf 10% and banana 10%



stress(N/mm^2) **strain**

Fig 4: Kenaf 11% and banana 9%



stress(N/mm^2)	**strain**

Fig 5: Kenaf 9% and banana 10%

This study involves the fabrication of natural fibers, followed by the evaluation of their impact properties. These properties are then compared to the analytical values obtained through ANSYS analysis. The impact test results are presented in Table 2. And figure 6 shows comparison of visualize the analytical and experimental results of impact test.

TABLE II: ANALYTICAL AND EXPERIMENTAL RESULTS OF IMPACT TEST

Fiber(%)	**Experimental toughness (j/mm^2)**	**Analytical toughness (j/mm^2)**
Kenaf 10% & banana 10%	2.29	1.97
Kenaf 11% & banana 9%	2.3	2.27
Kenaf 9% & banana 11%	2.3	5.14

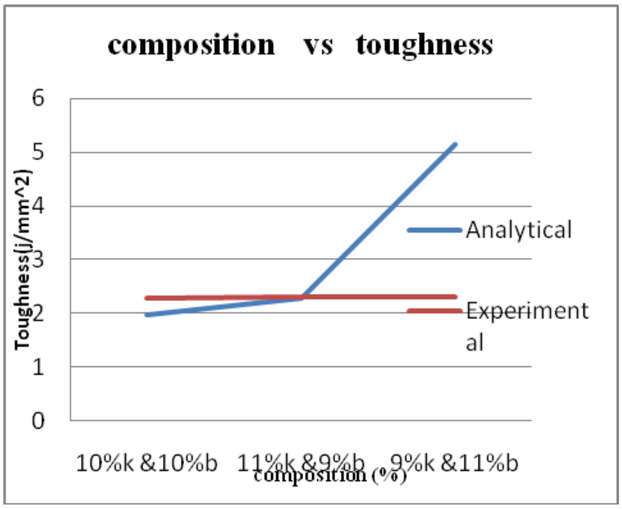


Fig 6: comparison of visualize the analytical and experimental results of impact test.

6. CONCLUSION

The mechanical properties of natural fiber-reinforced composites were investigated using both analytical and experimental methods. For the analytical approach, the software ANSYS 15 was employed to solve the analytical equations. A mixture of kenaf, banana fibers, and polyester was prepared following the rule of mixture, and composite plates were fabricated by combining these materials.

The primary focus of this project was to assess the toughness of the natural fiber composite. ASTM (D638) specimens were utilized for conducting the impact tests. The experimental results were obtained using a Charpy test machine. Through comparison tables, it was demonstrated that the impact behavior of the composite, as determined by the ASTM test, aligns well with the predictions from ANSYS software, exhibiting a lower error percentage. The expensive and time-consuming process of manufacturing plates and conducting destructive real-time experiments can be effectively replaced using the methodology proposed in this project. As a result, this project provides a valuable framework for researchers to analyze the impact properties of various fiber and resin combinations with the derived procedure.

REFERENCES

[1] A Lves C, FerrãoPmc, Silva Aj, Reis Lg, Freitas M, Rodrigues Lb, Alves De. (2010) Ecodesign of Automotive Components Making Use of Natural Jute Fiber Composites. J Cleaner Prod 2010:18;313–327.

[2] Naveenkumar, Sharun, Dhanasakkaravarthi, Paul TheophilusRajakumar,(2015),Comparative Study On Jute And Kenaf Fiber Composite Material.

[3] Syed Altaf Hussain, Dr.V. Pandurangadu, (2011) Mechanical Properties of Green Coconut Fiber Reinforced Hdpe Polymer Composite ,2011.

[4] Gu H. Tensile Behaviours Of The Coir Fiber and Related Composites After Naoh Treatment.(2009) Mater Des 2009:30;3931-3934.

[5] Ochi S.(2008) Mechanical Properties Of Kenaf Fibers And Kenaf/Pla Composites. Mechanics Mater 2008; 40: 446-452.

[6] Teja PVS, Ooha B, Sravanth K. (2021), Vibrational analysis on hemp and okra fibres mixed glass fiber polyester composite. International Journal of Research and Review.; 8(11): 55-62.

[7] Mulinari, Baptista, Souza, Voorwald ,(2011), Mechanical Properties of Coconut Fibers Reinforced Polyester Composites,2011.

[8] G.Velmurugan, D.Vadivel, R.Arravind, S.P.Vengatesan, A.Mathiazhagan(2012), Tensile Test Analysis of Natural Fiber Reinforced Composite ,2012.