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INVESTIGATION OF PINEAPPLE AND KENAF FIBER COMPOSITE WITH EPOXY RESIN

S. Dhanushharan[1,*], R. Arulraj[2], M. Babu[3]
[1]PG Student, Department of Mechanical Engineering, Mahendra Engineering College (Autonomous), Namakkal, Tamilnadu, India-637503,
[2]Assistant Professor, Department of Mechanical Engineering, Mahendra Engineering College (Autonomous), Namakkal, Tamilnadu, India-637503,
[3]Assistant Professor, Department of Mechanical Engineering, Mahendra Engineering College (Autonomous), Namakkal, Tamilnadu, India-637503

Abstract: This paper describes for the first time the tensile, impact, and hardness characteristics of pineapple leaf (PALF) and kenaf fibre reinforced with epoxy resin composites. The hand layup process is used to create the composite samples for various fibre weights. PALF has the potential to be reinforced with polymers since it is abundant, reasonably priced, and fine in cellulose. The tensile strength of kenaf fibres is higher than that of PALF. Because of such superior mechanical property, the basis material of this composite is kenaf, and the filler is PALF. The ASTM standard was followed in this investigation's mechanical characteristics testing, which included tensile, impact, and hardness tests. The results of the mechanical tests showed a consistent trend of increasing tensile, flexural, impact, and hardness qualities with the addition of natural fibres. According to the findings, the results exploit the fact that specimen 2 has a greater tensile strength, impact strength and material hardness than specimens 1 and 3.

Index terms **- Tensile, Impact, Hardness, PALF, Kenaf Fibre, ASTM standards**

1. INTRODUCTION

Composite materials are increasingly used in industries like automobile, marine, and aerospace due to their strength, weight, recyclable, cost-effectiveness, non-abrasiveness, Eco friendliness, and biodegradability. The combination of natural and synthetic materials in composites enhances their properties and offers a better alternative to existing materials. Common natural materials include banana, palm, sisal, and coir fibers, while synthetic materials like carbon, E-glass fiber, S-glass, and Kevlar are commonly used. To achieve the required properties, additional natural fibers are added to the composite. This research focuses on the strength of KENAF and PALF fiber composites, with the addition of PALF to KENAF resulting in increased mechanical strength and properties. The combination of these natural and synthetic materials leads to better output properties. The Following literatures gave a thorough explanation of Kenaf and Palf fibres, including their benefits and drawbacks.

A study by **D. Tamilvendan et al. (2020)** looks into how best to use KENAF fibre for products with additional value. Using the hand layup approach, hybrid composite test specimens were created with natural fillers such as KENAF-pineapple-Kenaf fibres. Standard experimental techniques were used to examine the composites' mechanical and physical properties. The usage of KENAF fibre improved most physical parameters, such as tensile, rupture, and wear qualities, while decreasing impact strength, according to the data. Microscopically, the surface morphology of the KENAF fibre following tensile loading was also examined. **[1].** Natural reinforcement has been used by researchers to increase biodegradability, lower costs, and improve mechanical qualities. The focus of **Chiranth S. C. et al. (2020)** is on hybrid composites made of pineapple fibre and E. Glass fabrics glued with epoxy and with varying aerial densities (200 & 400 gm). Hand layup procedures were used to manufacture the laminates. Mechanical analysis of the P-G-E composite with 200 gsm aerial density E-Glass fabric revealed improved strength in tensile, impact, and shear modes Yet the P-G-E hybrid with 400 gsm aerial density had the highest flexural strength and hardness in three-point bend and indentation modes. Broken sections were identified using scanning electron microscopy pictures of failed samples under tensile pressure **[2].**

In order to lower manufacturing costs and environmental damage, **E.S. Zainudin et al. (2009)** did a thorough investigation on the usage of biodegradable thermoplastic materials in conjunction with degradable natural fibres. Kenaf, an important natural fibre with potent mechanical qualities, is the subject of the investigation. The review addresses a number of topics, including environmental impacts, critical fibre length, Malaysian kenaf, matrix combinations, chemical treatment, processing methods, and coupling agents for stronger bonds between fibre and polymeric matrixes. The majority of research has focused on the problem of wettability in composites, which prevents further fibre loading and pull-out. In order to overcome these issues with composite manufacture, the report identifies a number of areas that require more research. Ensuring environmental safety and preservation is the aim **[3].** The mechanical qualities of an epoxy composite made of hybrid kenaf and (PALF) for engineering applications are examined in this work by **Muhammad Zuhair Mohd Abdul Rahman et al. (2022).** To find the optimal mixture in terms of maximal stress, the researchers examined several kenaf and PALF compositions. The Universal Testing Machine was used to conduct the tensile test. The highest maximum stress was observed in the hybridization of pineapple leaf fibre with kenaf fibre at a composition of 75% pineapple leaf fibre to 25% kenaf fibre, or 87.06 MPa. This hybridization outperformed earlier studies. The results indicate that because natural fibres have high mechanical qualities, they should be exploited rather than thrown away, especially in the agriculture sector. The study emphasises how natural fibres may be used in a variety of ways **[4].**

The use of natural materials in composites in place of synthetic fibres is investigated by **Prashanth S. et al. in 2021.** Using natural fibres such as Jute, Sisal, Pineapple, Bamboo, and Kenaf, they carried out in-depth research on the creation and characteristics of polymer matrix composites (PMC). Compared to glass or carbon fibre, these plant fibres have several benefits, including being low-cost, lightweight, renewable, environmentally benign, and having good specific mechanical performance. The goal of the study is to create a hybrid nano composite and utilise nanofiller to strengthen polymer composites. Because glass fibre composites have a low modulus, they are not suitable for applications that need for high natural frequency or buckling stability. Using natural fibre by itself in polymer composites is inadequate because natural fibre composites have poorer mechanical strength qualities than composites supplemented with synthetic fibres. The qualities of natural fibre may be enhanced by hybridising it with synthetic fibre within the same matrix. The study also uses glass fibre, banana fibre, and kenaf as reinforcing materials with epoxy resin in an effort to create hybrid nano composites filled and not filled with nanofiller. There will be testing for hardness, tensile strength, and compression **[5].**

P N E Naveen (2013) Constructed a fresh line of polyester composites made from natural fibres and reinforced with epoxy resin and coir. The mechanical characteristics of the composites were assessed at five distinct volume fractions and lengths. The findings demonstrated that increasing reinforcement % and fibre length had a substantial impact on the tensile, static, and dynamic characteristics of the composites. This implies that coir has the potential to be a reinforcing material for a range of applications, both structural and non-structural. The purpose of the study is to create and describe these composites **[6].** The usage of coconut husk fibres as reinforcement for composites was studied by **Kumar Naik M. (2018).** Using recycled plastics and a die with various reinforcing and matrix materials, fibre reinforced plastic composites manufactured from areca fibres were created. Mechanical testing, were performed on the composites. The composites were found to be comparable with the current plywood planks and to be successful in tapping for threading **[7].**

II. MATERIAL DESCRIPTION

The following materials were used to produce hybrid composite in this project:

- PALF Fibre
- KENAF Fibre
- Epoxy Resin

2.1 PALF Fibre

The pineapple plant's leaves are chopped and sorted into thin, stiff fibres to obtain PALF fibre. In order to make a continuous thread for hand-woven piña fabric, these fibres are manually scraped and knotted. In several areas of material science, these multicellular, lignocellulosic natural fibres are being employed as a cost-effective replacement for costly, non-renewable synthetic fibres. Pineapple fibres are waste products from pineapple farming; thus, they are inexpensive and may be blended with other allied fibres to improve their quality and applicability. The below fig 1. Represents the PALF fibre and the table 1. Represents the physical properties palf fibre.

Figure 1. PALF Fibre

Table. 1: Properties of Palf Fibre

S. No	PARAMETERS	VALUE
1	Density	1520-1560 kg/m^3,
2	Young modulus	84500 MPa
3	Poisson ration	0.35
4	Tensile strength	1627 MPa

2.2 KENAF Fibre

Hibiscus cannabinus, often known as kenaf, is a cellulosic fibre that has advantages for the environment and the economy. It takes just 150 days to grow and harvest, and it has outstanding mechanical qualities. Kenaf fibre has a better tensile strength-to-weight ratio and a lower density than synthetic fibres. It is grown in Southeast Europe, portions of Africa, Vietnam, Thailand, Indonesia, Malaysia, South Africa, Bangladesh, India, and the United States. The course (bast) and finer (core) fibres that are produced by the stems are utilised to make ropes. Rope, twine, coarse fabric, and paper are all made from kenaf fibre. The below fig 2. Represents the extract the kenaf fibre from Hibiscus cannabinus.

Table. 2: Physical properties of Kenaf Fiber

S. No	Parameters	Value
1	Density	1.4 (g/cm^3)
2	Tensile Strength	930 (MPa)
3	Elongation at break	20 (GPa)
4	Elongation at break	1.6 %
5	Cellulose content	53-57 %
6	Hemicellulose content	15-19 %
7	Lignin content	5-11 %

Figure 2. Kenaf fibre

2.3 Epoxy Resin:

This study used a bonding agent based on epoxy resin to fuse natural fibres from PALF to KENAF. Araldite AW 106, Hardener HV 953 U, Trietha Tetra-amine hardener, and the low molecular weight of the epoxy resin were all used. The fig 3. Represents the combination of resin and hardener.

Figure 3. Resin and Hardener

Properties of Epoxy:

- Elevated power
- Minimal shrinking
- Superb adherence to a range of surfaces
- Electrical insulation that works well
- Resistance to chemicals and solvents, and
- Cheap and non-toxic

III. COMPOSITE PREPARATION

The first process for creating woven composites is called hand lay-up, which includes sample preparation, antiadhesive agent release, applying a thin plastic sheet, cutting woven reinforcing layers, and infusing resin into the reinforcement surface More mats are placed on top of the polymer layer and compacted with a roller to remove any trapped air bubbles and excess polymer. The mould is closed and the pressure is released to create a single mat. After the woven composite has set at room temperature, the mould is opened and the surface is removed. With a limited production volume per mould and the capacity to make large quantities utilising many moulds, as shown in Fig 4. hand lay-up is appropriate for producing a wide range of composite goods. It is the most straightforward composite moulding technique, providing a large variety of part sizes, easy processing, and inexpensive tooling. Design modifications are simple to implement, and competent operators may achieve high production rates and reliable quality.

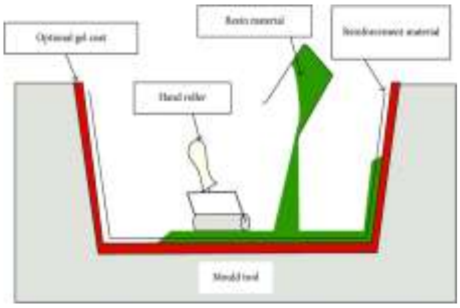


Figure 4. Hand lay-up process

Type of Composition:

Table. 3. Types of Composition

Specimen ID	Kenaf fiber	Pineapple fiber
1	40	60
2	50	50
3	60	40

These 3 differential ratios gave a 3 different type of result and it was formed by a thickness as 5mm and a mass of 500g.

IV. RESULT AND DISCUSSION

Investigating the mechanical characteristics of tensile is the primary goal of the current effort. Impact and hardness tests have been conducted on a selection of composites under three distinct material compositions, namely tensile, impact, and hardness. Tensile testing, often known as tension testing, uses tensile force to gauge a material's reaction to stress. It establishes the strength and elongation capacity of a material. ASTM D 638 specimens underwent tensile strength tests as shown in Fig 5. The tensile test results are shown in the table 4, as seen in the graphical depiction in Fig 6. After three separate specimens underwent tensile testing, specimen 2 showed a tensile strength of 23.04 MPa, 3% greater than the other two. The study indicates that specimen 2 composition exhibited a higher tensile strength compared to the other two examined specimens. This is because the fibres that make them up are a combination of 50% kenaf and 50% palf, which have a higher tensile strength by nature. These findings demonstrate how adding both Kenaf and Palf fibres to composite materials may enhance their overall functionality and tensile strength for a range of uses. According to the study, specimen 2 might be a good choice for people who need a higher tensile strength.

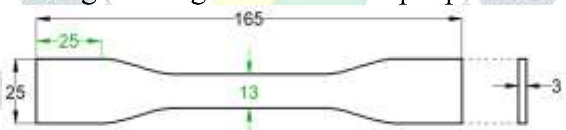
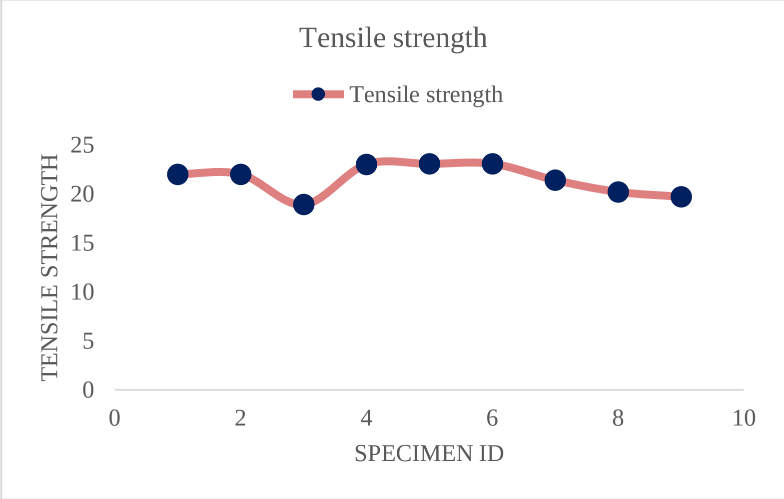


Figure 5. Tensile Test specimen (ASTM D 638)

Table. 4. Tensile test ASTM D 638

Specimen No	COMPOSITION		Specimen Results	Tensile Strength (MPa)
	KENAF	PALF		
1	40	60	22.05	22.04
			22.00	
			22.08	
2	50	50	23.00	23.04
			23.05	
			23.07	
3	60	40	23.04	22.71
			23.02	
			22.09	



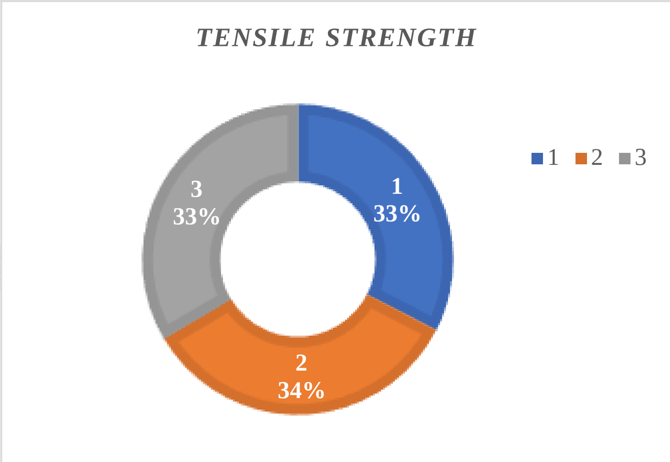


Figure 6. Tensile test results

Impact tests quantify the energy absorbed during fracture to determine a material's toughness and temperature-dependent brittle-ductile transition. They entail giving parts like dies, shafts, bolts, and anvils an abrupt, dynamic load. For the tensile test in this instance, an ASTM D 256 specimen was chosen, as shown in Fig. 7. The material's resistance to shock or impact loads is determined by its impact strength. After positioning the specimen on a work holding device, a hammer-wielding pendulum is released from a predetermined height, shattering the object. The impact testing equipment has a scale on it that displays the energy. The Izod and the Charpy are the two most commonly used types of impact testing devices. The impact test was performed in accordance with ASTM D256 using the Izod Impact Testing apparatus. As observed in the graphical representation in Fig 8, the impact test results are displayed in Table 5. Following impact testing on three different specimens, specimen 2 had an impact strength of 2J, which was 15% higher than specimen 1 and 28% higher than specimen 3. According to the investigation, the composition of specimen 2 showed a higher impact strength than the other two specimens under examination. This is due to the fact that they are composed of 50% kenaf and 50% palf fibres, with palf naturally having a higher impact strength. This implies that specimen 2's enhanced impact strength may have resulted from the composition's use of palf. The findings emphasise how crucial material composition is in defining impact resistance. Future studies may also examine the ideal proportion of kenaf to palf fibres in composite materials in order to optimise impact strength. Industries trying to increase the longevity of their goods may find this information useful.

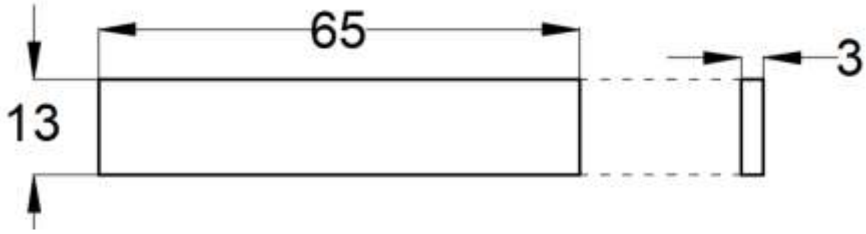
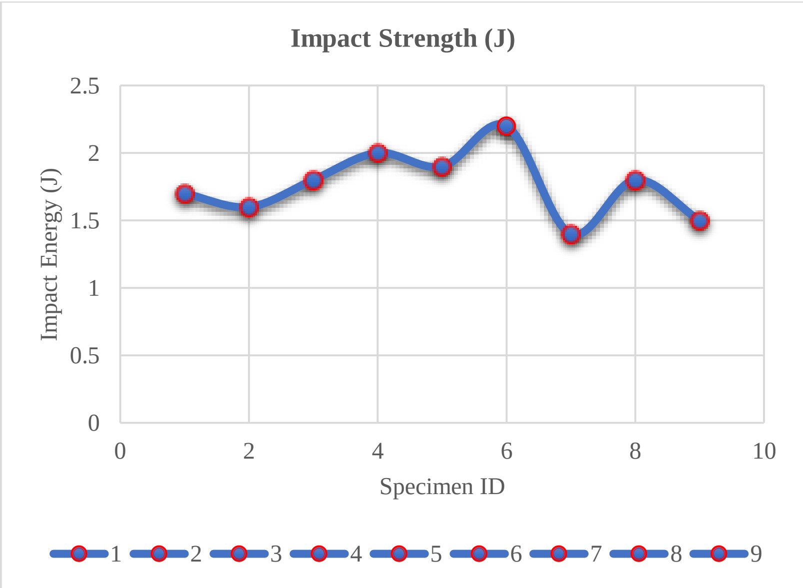


Figure 7. Impact Test specimen (ASTM D 256)

Table. 5. Impact test ASTM D 256

S. No	Material		Specimen Results	Impact Strength (J)
	KENAF	PALF		
1	40	60	1.7	1.7
			1.6	
			1.8	
2	50	50	2	2
			1.9	
			2.2	
3	60	40	1.4	1.4
			1.8	
			1.5	



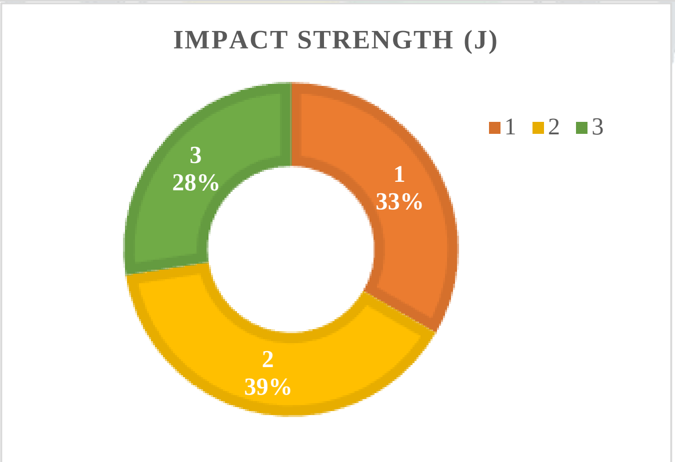


Figure 8. Impact Energy Variance

The hardest natural substance used is diamond. Hardness is defined as a material's mechanical resistance to indentation by a harder body. It is not the same as strength, which quantifies a material's ability to withstand separation and deformation. The ASTM D 785 composite standards were followed in the preparation of test specimens for the Rockwell-B hardness test and it was illustrated in fig 9. The test results are shown in Table 6, as may be seen in the graphical depiction in Fig 10. Specimen 2 had a hardness of 65 HB after three separate examples were hardened; this was 16% higher than specimen 1 and 21% higher than specimen 3. The study revealed that specimen 2's composition was harder than that of the other two specimens being studied. This is because the material that was chosen has a higher natural hardness, and it is made up of 50% kenaf and 50% palf fibres. In order to maximise hardness, future research may also look at the optimal ratio of kenaf to palf fibres in composite materials. This could result in the creation of even more robust and long-lasting composite materials.

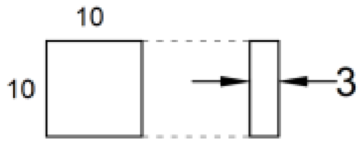


Figure 9. Hardness Test specimen

Table. 6. Hardness test ASTM D 785

S.No	Material		Specimen Results	Hardness (HB)
	KENAF	PALF		
1	40	60	54	53
			56	
			50	
2	50	50	65	66
			64	
			70	
3	60	40	52	57
			60	
			61	

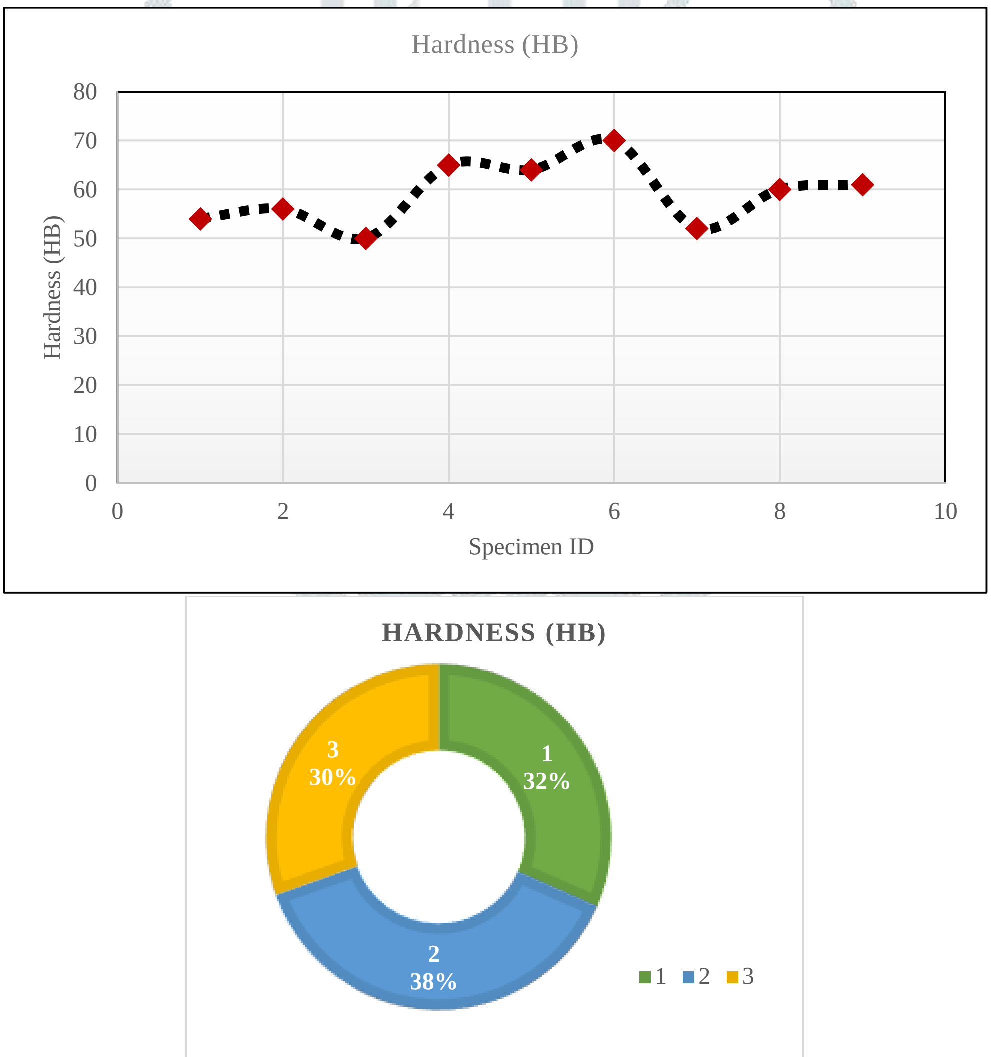


Figure 10. Hardness Test Variance

V. CONCLUSION

The study presents a composite made of Kenaf fibre, Palf fibre, and resins, suitable for various industrial applications due to their high hardness and lightweight construction. Three different material compositions were tested for tensile, impact, and hardness characteristics. The results showed that the composite with kenaf (50%) and palf (50%) had superior mechanical properties, with a tensile strength of 23.04 MPa, greater impact strength of 2J, and a hardness of 66 HB. These results imply that a robust and long-lasting composite material is produced when equal amounts of kenaf and palf fibres are combined. This composite may be especially helpful in sectors like aerospace or automotive where strong, lightweight materials are needed. In order to improve the mechanical characteristics of the composite, more study may concentrate on optimising the resin composition.

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