STM JOURNALS

Journal of
Polymer & Composites

ISSN: 2321-2810 (Online)
ISSN: 2321-8525 (Print)
Volume 13, Special Issue 2, 2025
DOI (Journal): 10.37591/JoPC

https://journals.stmjournals.com/jopc

Research JoPC

Mechanical and Environmental Performance of Curaua Fiber Composites: A Sustainable Alternative to Wood and PVC

G Ashwin Prabhu[1,*], Prashant Narayan Nagare[2], M L Brabin Nivas[3], Akkasali Taranath[4], Kiran C H[5], J Jesumanen[6] ,T Gavaskar[7], Ganesh M[8], Mohammed Akram K[9], Karthikeyan S[10]

Abstract

This study examines the mechanical behavior of curaua fiber composites, comparing their performance to other materials like wood and PVC. Curaua fibers, sourced from the Brazilian Amazon, demonstrate superior mechanical properties, making them a promising alternative for sustainable composite materials. The composites were fabricated using various methods and subjected to tensile, flexural, and impact tests. Results show that curaua fibers exhibit an average tensile strength of 30.7 MPa, outperforming wood (27 MPa) and matching PVC (30 MPa). Similarly, curaua fibers have a higher strain capability (5.24%) compared to wood (4.2%) and PVC (5%). In flexural tests, curaua fibers achieve an ultimate load of 0.148 kN and a maximum displacement of 16.47 mm, comparable to PVC and superior to wood. Impact tests further reveal the excellent energy absorption of curaua fibers, with an average impact resistance of 3.9 J/mm², surpassing wood (3.5 J/mm²) and aligning closely with PVC (3.7 J/mm²). Beyond their mechanical advantages, curaua fibers offer significant environmental benefits due to their natural, biodegradable, and renewable nature. This positions them as a sustainable and eco-friendly choice for applications in automotive, construction, and other lightweight industries. Their performance also approaches that of synthetic fibers like glass-E, making curaua fibers a competitive option for structural applications under light to moderate loading conditions. These findings highlight curaua fiber composites as a viable replacement for less sustainable materials in diverse engineering and industrial fields.

Keywords: Renewable, reinforcement, epoxy, resin, vibration, poly-vinyl chloride, hardener, resistance, composite

***Author for Correspondence**
G Ashwin Prabhu

[1]Assistant Professor, Department of Mechanical Engineering, St. Joseph's College of Engineering, Old Mahabalipuram Road, Chennai, Tamil Nadu, India
[2]Assistant Professor, Department of Mechanical Engineering, Amrutvahini College of Engineering, Pune - Nashik Hwy, Ghulewadi, Sangamner, Ahmednagar, Maharashtra, India
[3]Associate Professor, Department of Mechanical Engineering, Stella Mary's College of Engineering, Aruthenganvilai, Kalluketti Junction, Azhikkal Rd, Tamil Nadu, India
[4]Assistant Professor, Department of Mechanical Engineering, Ballari Institute of Technology and Management, Ballari Gnana Gangothri Campus, Ballari-Hospete Road, Near Allipur, Ballari, Karnataka, India
[5]Assistant Professor, Department of Mechanical Engineering, Alva's Institute of Engineering and Technology, Solapur Mangalore Highway, Shobhavana Campus MIJAR, Moodbidri, Mangaluru, Karnataka, India
[6]Assistant Professor, Department of Mechanical Engineering, DMI Engineering college, Kumarapuram, Aralvaimozhi, Tamil Nadu, India
[7]Assistant Professor, Department of Mechanical Engineering, St. Joseph's College of Engineering, Old Mahabalipuram Road, Chennai, Tamil Nadu, India
[8]Assistant Professor, Department of Mechanical Engineering, St. Joseph's College of Engineering, Old Mahabalipuram Road, Chennai, Tamil Nadu, India
[9]UG Scholar, Department of Mechanical Engineering, St. Joseph's College of Engineering, Old Mahabalipuram Road, Chennai, Tamil Nadu, India
[10]UG Scholar, Department of Mechanical Engineering, St. Joseph's College of Engineering, Old Mahabalipuram Road, Chennai, Tamil Nadu, India

Received Date: January 01, 2025
Accepted Date: February 07, 2025
Published Date: February 20, 2025

Citation: G Ashwin Prabhu, Prashant Narayan Nagare, M L Brabin Nivas, Akkasali Taranath, Kiran C H, J Jesumanen, T Gavaskar, Ganesh M, Mohammed Akram K, Karthikeyan S. Mechanical and Environmental Performance of Curaua Fiber Composites: A Sustainable Alternative to Wood and PVC. Journal of Polymer & Composites. 2025; 13(Special Issue 2): S467–S477p.

INTRODUCTION

Mixes are among the most ultramodern and protean engineering accoutrements. The strength of any compound is determined by the volume/ weight proportion of underpinning, the L/ D rate of filaments, exposure angles, and other variables. The current study focuses on the mechanical parcels of pure epoxy resin and arbitrary oriented glass fiber (mat) corroborated epoxy resin at 10 and 20 weight fragments of glass filaments [1]. Natural fiber corroborated polymer compound (NFPC) has a high affinity for exchange with synthetic fiber mixes. This is substantially due to advantages similar to light weight, non-toxicity, non-abrasion, ease of force, low cost, and biodegradability [2]. Tests for tensile, flexural, short ray, and nondestructive mechanical characterization were used. The obtained results demonstrated that glass fiber integration and a bigger overall fiber volume bit (Vf) improved the tensile strength and modulus [3]. The purpose of the study was to probe how functionalization with GO affected the mixes' tensile parcels. According to the results, the CF/ GOEM compound outperformed the non-GO-functionalized compound, which was used as the control CF/ EM, in terms of yield strength is around 64, tensile strength around 40, Young's modulus around 60, and durability is around 28 [4]. mixes made of natural filaments are growing in fashionability because of their robust mechanical parcels and low weight. Because of its vacancy, affordability, and wide range of uses, curaua fiber has become a competitive natural fiber [5]. Curaua polyester mixes were delved with varying fiber length (10 – 50 mm), fiber volume division (Vf) (11, 22, and 38 vol), and pretreatments (drying and washing). The results demonstrate that mechanical criteria including ductile quality, modulus, and short pillar quality are better in mixes manufactured with 50 mm long washed dried beaches and a Vf of 38 [6]. This study compares the behavior of isophthalic polyester chassis materials reinforced with unidirectional curaua fibers to those reinforced with unidirectional glass fibers mixes. These mixes are altered by their fortifying point (0°, 15°, 30°, 45°, 60°, 75°, and 90°) which results in order to examine the impact of fiber preface on compound quality [7]. Melt-mixing was used to create mixes with a styrene-butadiene-styrene triblock copolymer (SBS) frame reinforced with curaua fiber and/or a nanoparticulate fabric (montmorillonite complexion). The impact of complexion expansion on parcels similar to ductile and tear quality, bounce back versatility, flex weariness life, scraped spot mischance, hardness, and water retention of mixes with 5, 10, and 20 curaua fiber was examined in the proximity of a maleic anhydride joined styrene-(ethylene-co-butylene)-styrene triblock copolymer (Mama-g-SEBS) coupling driver [8]. In the current consider, cloth- corroborated concrete (TRC) exemplifications were made with high- performance common curaua unidirectional textures as bastion. Pozzolanic accoutrements were employed to kindly displant Portland cement, coming about in a network with dropped calcium hydroxide substance. mixes with changing layers and density were made [9]. Another vital study was whether there was an proliferation in warm diversion temperature as the fibers were included. As a result, it has been decided that these accoutrements are reasonable for operation in assiduity, encouraging reusing and perfecting extreme mechanical parcels [10]. Characteristic fiber interrogating is picking up ubiquity around the world due to its maintainability and eco-friendliness. It combines moo consistency with witching highlights. Curaua fiber is a abundant characteristic fiber with moo brought and a many operations. The mechanical parcels are exceedingly inferior on the contact grip between the fiber and the polymer frame [11]. The effect of curaua beaches on warm geste and polymer cohesiveness in a polyurethane frame was investigated using energetic mechanical warm disquisition (DMTA) and discriminational filtering calorimetry (DSC). The capacity modulus E′ and mischance modulus E″ bending have an impact on the trade between beaches and sensitive trash spaces [12]. curaua fibers were made to react with 0.25 - 2(w/v) NaOH solution beneath bendable mounding to optimize fiber-matrix grip in curaua filament epoxy resin coverings. Mixes including 40 vol. curaua beaches were obtained. The compound parcels with curaua beaches treated with 0.5 NaOH beneath ductile mounding demonstrated the greatest improvement [13]. The purpose of this study was to investigate the packages of curaua mixtures using energetic mechanical inspection. Curaua mixes with varying fiber volume divisions (11-38) were evaluated, and their capacity and mischance moduli were built up for proliferation with support content [14]. This study is centered on the progress and enhancement of structural attributes of a so-called green compound, which is created by reinforcing a cornstarch-based biodegradable goo with high-strength feature beaches obtained from a firm named curaua. Two manufacturing methods have been presented, in which elongated sections of curaua fibers are used as a bastion to improve compound quality [15]. The present study examines the tensile properties of an epoxy resin network supplemented by typical Curaua beaches. To optimize matrix fiber commerce, Curaua beaches were bathed with arrangements containing varied Sodium hydroxide molarities (NaOH) for varying Remedy periods [16]. Curaua is a top-tier fiber with firm pliable properties and water absorption packets. The structural components of the Curaua TRC were evaluated using match ductile and four-point wringing tests. The autonomous mechanical restoration was evaluated using repeated bowing and short-time bottleneck tests [17]. The use of natural fibers (sisal, curaua, coco fiber, and others) for soil improvement has been investigated in a variety of geotechnical areas, and it is a developing issue of interest in the field of ultramodern geotechnical accoutrements probing. The condition of the artificer in this sector offers promising outcomes as soil quality measurements advance and post-cracking quality (soundness) rises [18]. The GO-functionalized 30 vol curaua fiber strengthening epoxy resin compound showed better malleability and Thermal degradation characteristics, as well as superior fiber/matrix Shear force at the interface. In this extensive inquiry, energetic mechanical examination (DMA) was performed on curaua fiber reinforced epoxy resin frame (EM) mixes including more than 50% GO functionalization [19]. In order to be employed as a reinforcement in composite systems, the Curaua fibers' endurance and interface properties with various matrices must be enhanced. The current study intends to define and compare the behavior of curaua filaments in both natural and treated environments, with an emphasis on enhancing their durability and binding performance [20]. The primary goal of this study was to look into the impact of hybridization and chemical treatments on the mechanical characteristics of a new intralaminar natural fiber hybrid composite. Jute, sisal, and curaua fibers were used as natural fiber reinforcements for the epoxy matrix-based composites that were created using the hand lay-up technique [21]. The best blend was 1% PVA and 1.5% curaua, which provided strain-hardening behavior and fracture width control while using less synthetic PVA fiber. In addition, stress endurance and plasticity were estimated for the examined Composites for juxtaposition [22]. Vegetable fibers have risen as an option due to their cornucopia, moo brought and vitality application amid generation, and satisfactory mechanical rates. Curaua fiber is a factory original to Amazonas that's picked physically in marketable cultivating and is employed in the production of ropes and wicker vessel or as bastion in compound with natural network of factors for buses, motorcars, and exchanges [23]. The Stretch resistance and Flexural endurance of undressed and NaOH alkali-treated curaua and malva fiber-corroborated GP composites were measured using ASTM standards. Curaua-corroborated GP mixes had an average tensile strength of 25.71 (±) 7.11MPa and flexural strength of 18.93 (±) 4.721 MPa [24]. This study strongly says that the fabric-based cementitious matrix is used for shear strengthening of concrete buildings and its use is relatively uncommon. However, the factory's growth has focused on artificial accessories. This study proposes to examine the shear structural integrity of a cement-based emulsion supported by natural curaua textiles for use as a structural underpinning [25]. The structural attributes and micrographs indicated that the ideal expression is 20 wt. milled curaua fibers and 2 wt. poly (ethylene-g-maleic anhydride). Coupled composites have lower hygroscopicity than uncoupled composites. We infer that mixtures with curaua fibers have similar performance rates to commercially available HDPE mixes with fiberglass [26]. This study looks at the combined goods of humidity and UV light on the mechanical parcels of a crossbred emulsion made up of glass- E and curaua fibers corroborated with terephthalic polyester resin. To do this, an accelerated environmental growing chamber was erected. Tensile and three- point bending tests were used to determine mechanical rates, as well as fracture characteristics [27]. The findings demonstrated that there were interspatial gaps between the naturally linked filaments that comprise a curaua fiber. These gaps serve as an efficient underpinning for a curaua-strengthened emulsion by icing fiber face adherence to a polyester matrix [28]. This study looked at the tensile mechanical properties of curaua fibers after entrance and face treatment. Mercerization and three distinct enzyme face treatments were employed. Tensile stress data were calculated using the Weibull statistical distribution, and SEM was utilized to describe the facial changes generated by the treatments. The findings show that mercerization enhances the fibers' deformation capability [29]. Anisotropic and inhomogeneous composite materials and components require a range of mechanical and physical testing, under a range of environmental conditions. A variety of standardized mechanical tests on composite materials including high-force tension (tensile), compression, impact, flexural, shear, rheology, and fatigue are known. Interestingly, the physical testing includes density, void content, water absorption, hardness, and scratch resistance [30-31].

The mechanical characteristics of bio-composites reinforced with curaua fibers, which have not been thoroughly examined in prior research, are thoroughly investigated in this work. The special qualities of curaua fibers as reinforcing materials in high-strength concrete and polymer composites are still mainly unknown, despite the expanding corpus of research on natural fiber-reinforced composites. Although a number of natural fibers, including flax, hemp, sisal, and coir, have been the subject of earlier research, no particular study has examined the possibilities of curaua fibers in relation to the creation of bio-composite materials. The originality of this study is highlighted by this gap in the literature, which also shows how curaua fibers have the potential to provide a high-performance, affordable, and sustainable substitute for synthetic reinforcing materials. As a result, this study opens up new possibilities for the investigation and use of curaua fiber-reinforced bio-composites in the future and makes a substantial contribution to the creation of greener alternatives in material engineering.

MATERIALS AND METHODS

It was decided to use curaua fibers in the composite materials. After being procured as raw materials, these fibers were processed in order to be included into the epoxy matrix. Since curaua fibers are known for their remarkable tensile strength and low weight, they are perfect for reinforcing in composite materials. They are mechanically removed from the Ananas erectifolius plant's leaves, then cleaned and dried. The fibers underwent an alkali treatment with sodium hydroxide (NaOH) solution to improve adhesion with the epoxy matrix. This procedure improves surface roughness and the interfacial adhesion between the fibers and the resin by eliminating lignin, waxes, and contaminants. The polyoxide compound epoxy resin (LY-556) was used as the basis matrix because of its exceptional durability, chemical resistance, and mechanical strength. Reactive epoxide groups in the resin cure with a hardener to produce a solid, durable substance. The hardener utilized in this investigation, HY-951, serves as a catalyst to start the curing process. It enhances adhesion, hardness, and chemical resistance by reacting with the resin's epoxide groups. The ratio of resin to hardener determines the cured composite's characteristics, which affect mechanical performance. The curaua fibers compatibility with the epoxy resin was further improved by the sodium hydroxide (NaOH) treatment, which increased their roughness and eliminated surface impurities. Better mechanical bonding during cure was guaranteed by this procedure. The fibers were dried and ready for composite incorporation after treatment. A homogeneous composite structure was produced by carefully integrating the alkali-treated fibers into the epoxy matrix. The reinforcement materials which are used for the process are shown in the Figure 1 as a) curaua fiber plant, b) fiber after decortication process, and c) Alkali treated fibers that are ready for use. These materials were picked because of their high strength-to-weight ratio, environmental friendliness, and ability to take the place of synthetic reinforcements in composite applications, offering a high-performance and sustainable alternative.

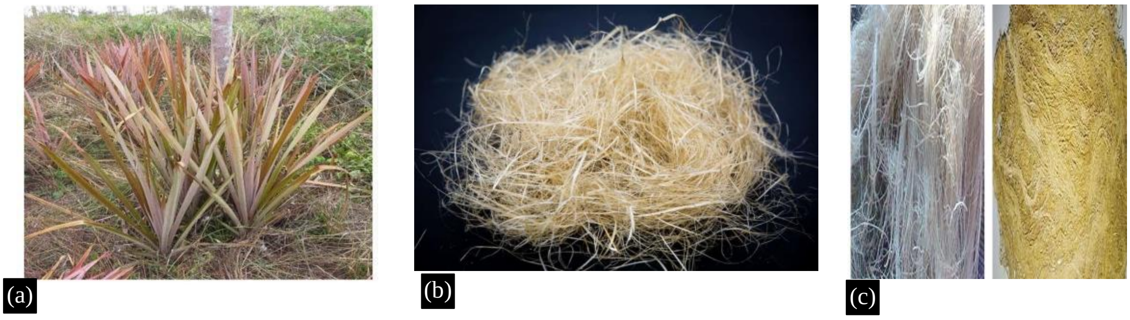

Figure 1. a) Curaua Plant b) Fiber After Decortication Process c) Alkali Treated Curaua Fiber.

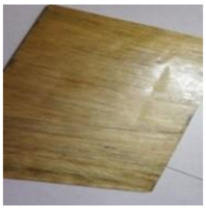

Figure 2. Sample plate after hand lay-up process.

ISSN: 2321-2810 (Online), ISSN: 2321-8525 (Print)

EXPERIMENTAL METHOD

Epoxy Resin LY- 556 tar, the framework, has a place to the epoxide family. The hardener utilized in this consideration was HY- 951. This combination offers uncommon chemical resistance and prevalent mechanical capabilities. When the LY- 556 gum guarantees no misfortune and solid grip and the HY-951 hardener empowers the pertinent remedy at room temperature, a tough compound fabric is made. For the polymer compound, curaua fibers were chosen as normal mounts. The clears out of the Amazon rainforest-native Ananas erectifolius plant are utilized to make these fibers. The birth handle starts with the clears out being accumulated. The fibers and mash are moreover isolated by mechanical decortication. After being evacuated, the fibers are gutted, dried, and brushed to deliver tough, featherlight shorelines that can be utilized in an assortment of ways. A soluble base treatment was utilized to fortify the curaua filaments' association with the epoxy gum lattice. To get soothe of lignin, waxes, and toxins, the fibers were submerged in a sodium hydroxide (NaOH) result for three to four hours. By including confront unpleasantness, this treatment moves forward the epoxy resin's interfacial grip. Taking after the antacid treatment, the fibers were watered and permitted to dry for one to two hours in the sun some time recently being utilized to deliver composites. The compound was made utilizing the direct and reasonable damp hand lay- up approach. To oil the junking of the last item, a soil secured with a discharge operator is arranged at the dispatch of the prepare. Curaua fibers were physically fitted into the soil as either woven textures or mats. The fibers were moreover significantly immersed with epoxy gum working out engagements, breakers, or spot equipment, ensuring sufficient wetting for the a la mode mechanical rates. fibers and gum were put in sequential layers, each compacted to evacuate repetitive gum and discuss bubbles. This arrangement made it conceivable to customize the mechanical packages by controlling the consistency and introduction of the fiber. Depending on the conditions of the operation, the compound plates, which were made by bedding a few layers of supporting fibers in the tar framework, by and large had a fiber substance of 30 – 50 by volume. In spite of the fact that the hand lay- up framework is adaptable, there may be a few abnormalities, counting voids or resin-rich places, which seem kindly vitiate consistency. The test plates obtained after the hand lay- up method are delineated in Figure 2, emphasizing their auxiliary cosmetics and readiness for mechanical testing and new appraisal.

MECHANICAL TESTING

The tensile, flexural, and impact tests are performed in the experimental setup depicted in Figure 3. These tests were carried out on flat composite pieces of gauge length (40mm), width (10mm), and thickness (3.5mm). The tensile test was carried out using the ASTM D638-03 standard method of testing, the flexural tests, also known as bending tests, were carried out using the three-point bending method in accordance with ASTM D790-03, and the impact test was carried out using the ASTM D256 - 05, ISO 179 standard.

RESULTS AND DISCUSSION

Tensile Properties

Three distinct curaua fiber samples were obtained, and according to ASTM D638-03 standards, the material samples' tensile test results showed consistent mechanical performance. The consistency in the mechanical performance of the three samples highlights the reliability of curaua fiber as a viable material for various industrial uses. The three curaua fiber samples tested exhibited different levels of mechanical performance, but the results were consistent enough to confirm that curaua fiber can serve as a reliable material for structural applications. The Sample 1 Demonstrated a tensile load of 2.11 kN, a maximum strain of 4.37%, and a tensile strength of 30.69 MPa. The Sample 2 Showed a tensile load of 1.77 kN, a maximum strain of 5.71%, and a tensile strength of 33.26 MPa. The Sample 3 Had a tensile load of 2.24 kN, a strain of 5.66%, and a tensile strength of 26.28 MPa. These results reflect the mechanical properties of curaua fiber in terms of its tensile strength, strain, and load capacity. It is important to note that while the samples varied slightly in terms of strain and tensile load, they all performed within a close range, showcasing the material’s overall consistency. Tensile strength refers to the maximum stress a material can withstand while being stretched before it breaks. In this study, the tensile strength of curaua fiber ranged from 26.28 MPa to 33.26 MPa, with an average of 30.7 MPa. These values are quite strong, especially when compared to other natural fibers or wood, which typically have tensile strengths in the range of 20-30 MPa. In comparison to PVC, which typically has tensile strengths around 30 MPa, curaua fiber shows competitive performance. The reason for this strength is likely due to the intrinsic structure of curaua fiber, which consists of tightly packed cellulose fibers. This structure allows curaua fiber to resist stretching and breaking under tensile forces, making it suitable for use in products that require strength and durability.

The maximum strain values recorded in the tests ranged from 4.37% to 5.71%, with an average of 5.24%. Strain is a measure of how much a material can elongate before it reaches failure. A higher strain indicates that the material can stretch more without breaking, which is important for applications that require flexibility. The tensile load refers to the maximum load the material can withstand before breaking, and the results ranged from 1.77 kN to 2.24 kN across the three samples. Sample 3, with the highest load, demonstrated that curaua fiber can support substantial loads while maintaining structural integrity. This high load capacity further enhances the fiber's potential for heavy-duty applications such as construction or automotive industries. Figure 4 illustrates the results obtained from the tensile test conducted on the samples.

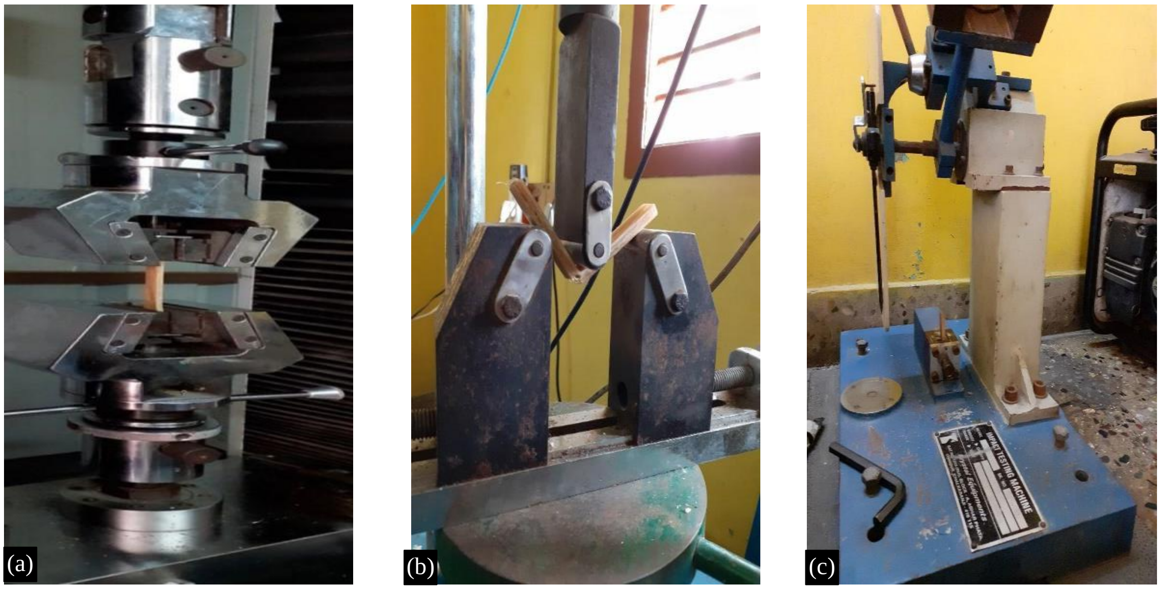

Figure 3. The experimental setup for the following tests: (a) Tensile, (b) Flexural, and (c) Impact.

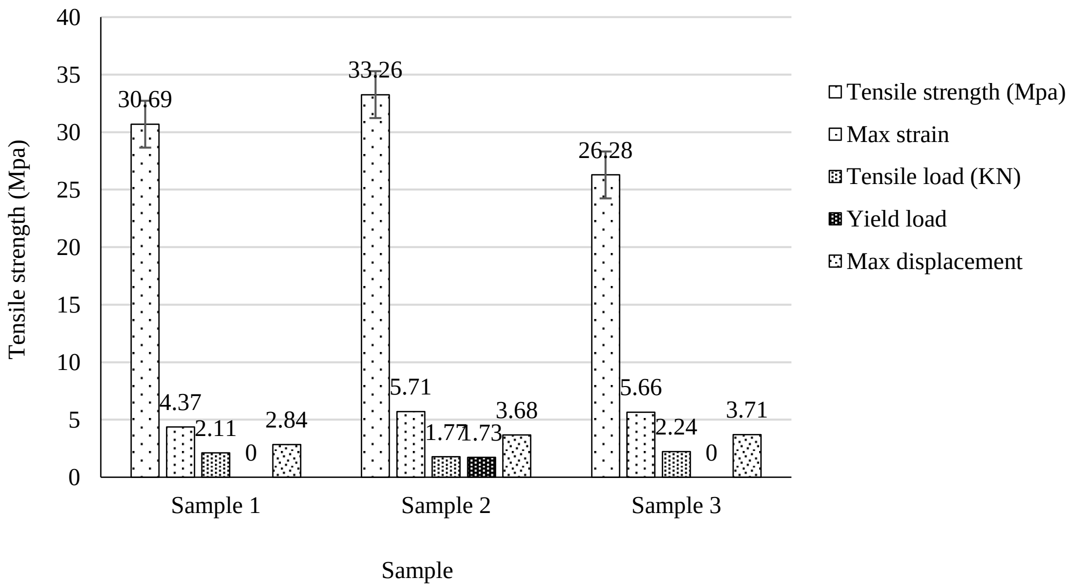

Figure 4. Tensile test results for the samples.

ISSN: 2321-2810 (Online), ISSN: 2321-8525 (Print)

Flexural Test

Flexural strength is typically higher than tensile strength due to the concentration of stress in the outer fibers during bending, which are more resistant if defect-free. In contrast, tensile failure occurs when the weakest fiber reaches its limit. The tensile strength of materials having surface flaws may be greater than the flexural strength. The flexural test for the composite samples was conducted using the three-point bending method, following ASTM D790-03 standards, to evaluate their flexural strength and deformation. Sample 1 demonstrated an ultimate load of 0.130 kN, a maximum displacement of 21.6 mm, and a flexural stress of 0.002 kN/mm². Sample 2 exhibited an ultimate load of 0.145 kN, a maximum displacement of 11.7 mm, and a flexural stress of 0.002 kN/mm². Sample 3 recorded an ultimate load of 0.170 kN, a maximum displacement of 16.1 mm, and a flexural stress of 0.003 kN/mm². The average values across the samples were an ultimate load of 0.148 kN, a maximum displacement of 16.47 mm, and a flexural stress of 0.002 kN/mm². These results highlight the uniformity in the flexural properties of the composites, showcasing their suitability for applications requiring moderate flexural strength and reliable deformation under bending forces. Figure 5 presents the results obtained from the flexural test conducted on the samples.

Impact Test

Impact tests measure the energy required to fracture a material, indicating its toughness, while yield strength is related but not directly expressed by a formula. Strain rate affects fracture behavior, and the ductile-brittle transition temperature (DBTT) represents a range where fracture energy changes. DBTT is empirically determined through absorbed energy or fracture surface analysis. Fracture surfaces reveal material behavior, with flat fractures indicating brittleness and jagged edges suggesting ductility. The impact test, conducted using the Charpy method in accordance with ASTM D256-05 and ISO 179 standards, evaluated the toughness of the composite samples. Sample 1 exhibited an impact strength of 4.0 J/mm², while Sample 2 achieved a slightly higher impact strength of 4.1 J/mm². Sample 3 showed an impact strength of 3.7 J/mm². The average impact strength across all samples was 3.9 J/mm², indicating consistent performance among the tested specimens. These results demonstrate the composites' ability to absorb energy upon impact, highlighting their toughness and resistance to fracture. The uniformity in impact properties suggests the material's suitability for applications requiring moderate impact resistance, aligning with the objectives of producing eco-friendly, reinforced composites. The values confirm that the composite material can withstand sudden loads effectively, making it a viable option for lightweight, durable structural components in industries such as automotive and construction. Figure 6 displays the results obtained from the impact test conducted on the samples.

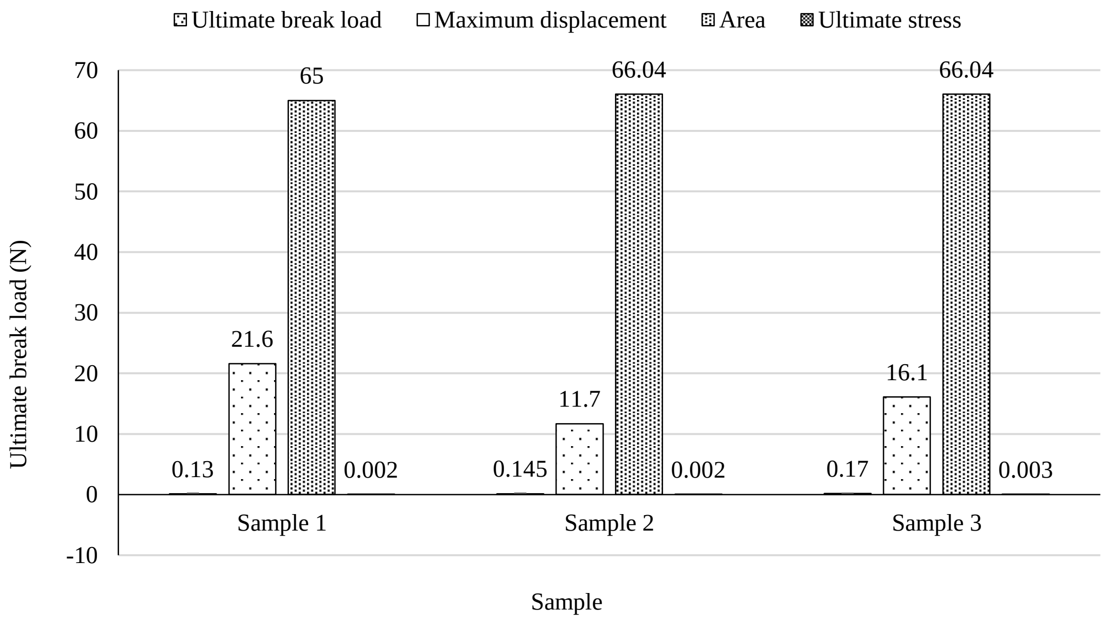

Figure 5. Flexural test for the samples.

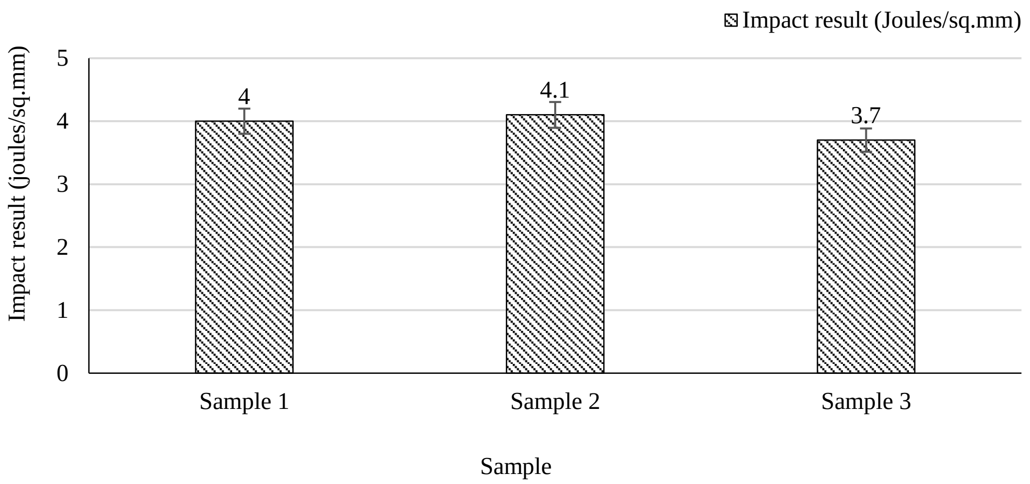

Figure 6. Impact test for the samples.

Comparative Study

The test results highlight the properties of Curaua fiber, Wood, and PVC. In the tensile test, Curaua fiber exhibits the highest tensile strength (30.7 MPa) and strain (5.24), while PVC shows comparable tensile strength (30 MPa) with lower strain. Figure 7 illustrates the comparative study of all the samples. During the flexural test, PVC demonstrates the highest displacement under maximum force (17 mm), indicating superior flexibility. The Charpy test shows Curaua fiber has the highest toughness (3.9 J/mm²), making it the most impact-resistant material. Overall, Curaua fiber stands out in strength and toughness, while PVC excels in flexibility. We can also have a comprehensive life cycle assessment in future research. This will allow us to examine curaua fiber's environmental footprint in greater detail and offer a more balanced comparison to PVC and wood, taking into account factors such as production processes, end-of-life disposal and the material's overall contribution to sustainability goals. Future research can focus on comparison of jute, hemp, and potentially other relevant natural fibers with curaua fibers. This will allow for a more detailed comparison and a clearer understanding of curaua fiber's advantages relative to other materials.

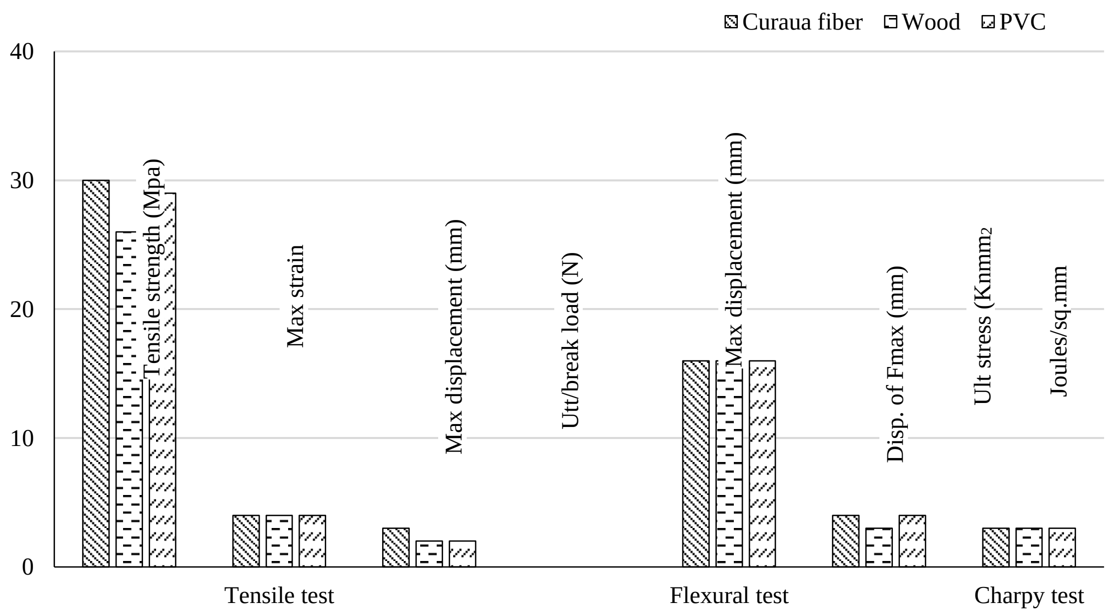

Figure 7. Comparative Study of All Samples.

ISSN: 2321-2810 (Online), ISSN: 2321-8525 (Print)

CONCLUSION

This investigation concludes that curaua fiber exhibits superior mechanical properties compared to wood and is comparable to PVC. In tensile testing, the curaua fiber demonstrated an average tensile strength of 30.7 MPa, which is higher than wood (27 MPa) and nearly equal to PVC (30 MPa). Similarly, the maximum strain for curaua fiber was 5.24, exceeding that of wood (4.2) and closely matching PVC (5.0). In the flexural test, curaua fiber achieved an ultimate/break load of 0.148 N, slightly better than wood (0.137 N) and similar to PVC (0.149 N). The maximum displacement under flexural loading was 16.466 mm, higher than wood (16 mm) and only marginally lower than PVC (17 mm). For impact resistance, curaua fiber showed an average energy absorption of 3.9 J/sq.mm, outperforming wood (3.5 J/sq.mm) and slightly exceeding PVC (3.7 J/sq.mm). These results underscore curaua fiber potential as an eco-friendly alternative to PVC and a superior substitute for wood in various applications. Curaua fiber outperforms wood in tensile strength, indicating that it has a higher resistance to deformation under tension. Wood, being an organic material, can often be weaker and more susceptible to damage from stretching, especially under high-stress conditions. The higher tensile strength of curaua fiber suggests that it is more durable in load-bearing applications compared to wood. Curaua fiber's tensile strength is on par with PVC, a synthetic material commonly used in construction, plumbing, and electrical applications. PVC is known for its durability and resistance to tension, so curaua fiber matching this strength shows its competitiveness as a substitute in applications where PVC is typically used.

The results from this investigation demonstrate that curaua fiber possesses a combination of superior mechanical properties, including high tensile strength, flexibility, impact resistance, and durability, making it a highly promising alternative to both wood and PVC. Its performance in tensile strength, strain, flexural strength, and impact resistance matches or surpasses the capabilities of these conventional materials, suggesting that curaua fiber can be used in a wide range of applications where wood and PVC are traditionally utilized. Curaua fibers faces challenges related to long-term durability, particularly when exposed to harsh environmental conditions such as extreme weather, UV radiation and moisture. While it is known for its strength and toughness, further research into its resistance to degradation over time is necessary to assess its longevity in industrial use. curaua fiber is susceptible to water absorption. Prolonged exposure to moisture may lead to swelling, weakening, or even rotting of the material. This can limit its use in applications where water resistance is critical unless treated or modified for better moisture resistance. Future research focusing on enhancing its durability, water resistance, and processing techniques will be crucial in expanding its practical uses. Moreover, curaua fiber is an eco-friendly alternative to PVC, a synthetic polymer, which is typically derived from non-renewable resources and can have a significant environmental footprint. By replacing PVC and wood with curaua fiber, industries can reduce their environmental impact while still maintaining, or even enhancing, the performance of their products. This combination of superior mechanical properties and environmental benefits underscores curaua fiber's potential as a sustainable and high-performance material for use in construction, automotive, and other industrial sectors.

Declaration of Interest

The authors(s) have disclosed no conflicts of interest.

Acknowledgements

Not Applicable

Data Availability Statement

This study does not develop nor examines any new data

Ethics Statement

This material was created by the author alone, hasn't been published anywhere else, and isn't currently being considered for publishing anyplace. It fully and properly reflects the study and analysis of the author or authors.

Funding
Funding is not available to report.

REFERENCES

1. Singh, S., Kumar, P., & Jain, S. K. (2013). An experimental and numerical investigation of mechanical properties of glass fiber reinforced epoxy composites. Advanced Materials Letters, 4(7), 567-572.
2. Lokesh P, Surya Kumari TSA, Gopi R, Babu Loganathan G (2020) A study on mechanical properties of bamboo fiber reinforced polymer composite. Materials Today: Proceedings 22:897–903.
3. Almeida JHS Jr, Amico SC, Botelho EC, Amado FDR (2013) Hybridization effect on the mechanical properties of curaua/glass fiber composites. Composites Part B: Engineering 55:492–497.
4. Costa UO, Nascimento LFC, Garcia JM, Bezerra WBA, Fabio da Costa GF, Luz FS da, Pinheiro WA, Monteiro SN (2020) Mechanical properties of composites with graphene oxide functionalization of either epoxy matrix or curaua fiber reinforcement. Journal of Materials Research and Technology 9:13390–13401.
5. Amorim F do C, Souza JFB de, Reis JML dos (2018) The Quasi-static and Dynamic Mechanical Behavior of Epoxy Matrix Composites Reinforced with Curaua Fibers. Mat Res. https://doi.org/10.1590/1980-5373-mr-2017-0828.
6. Prabhu, G.A., Selvam, R. & Kumar, K.M. Enhancing the Mechanical Properties of Basalt Fiber and Stainless Steel Wire Mesh Composites Incorporating Fire Retardants Through Response Surface Methodology Optimization. Fibers Polym 25, 1443–1455 (2024).
7. de Oliveira FH, Helfer AL, Amico SC (2012) Mechanical Behavior of Unidirectional Curaua Fiber and Glass Fiber Composites. Macromolecular Symposia 319:83–92.
8. Subramanian PM, Balamurugan L, Ashwin Prabhu G. Novel approaches in developing sustainable and cost-effective semi-active suspension systems for smart vehicles—A review. Proceedings of the Institution of Mechanical Engineers, Part E: Journal of Process Mechanical Engineering. 2024;0(0).
9. Souza LO de, Souza LMS de, de Andrade Silva F (2021) Mechanics of natural curauá textile-reinforced concrete. Magazine of Concrete Research 73:135–146.
10. Stalin, B., Arivukkarasan, S., & Prabhu, G. A. (2015). Microstructure and mechanical properties evaluation of aluminium matrix reinforced with tungsten carbide and silicon carbide. International Journal of Applied Engineering Research, 10(55), 3994-3999.
11. Amorim FC, Souza JFB, Reis JML (2018) Effects of Fiber Treatment on the Properties of Epoxy Curaua-Reinforced Composites. Advanced Structured Materials 159–168.
12. Prabhu, G. Ashwin, et al. "Static Analysis of Aluminum 6063 Alloy for Steering Knuckle Application in Student Formula Car." IOP Conference Series: Materials Science and Engineering. Vol. 923. No. 1. IOP Publishing, 2020.
13. Cardoso PHM, Bastian FL, Thiré RMSM (2014) Curaua Fibers/Epoxy Laminates with Improved Mechanical Properties: Effects of Fiber Treatment Conditions. Macromolecular Symposia 344:63–70.
14. Ornaghi HL Jr, da Silva HSP, Zattera AJ, Amico SC (2012) Dynamic mechanical properties of curaua composites. J of Applied Polymer Sci. https://doi.org/10.1002/app.36378.
15. Gomes A, Matsuo T, Goda K, Ohgi J (2007) Development and effect of alkali treatment on tensile properties of curaua fiber green composites. Composites Part A: Applied Science and Manufacturing 38:1811–1820.
16. Vidal SD, do Carmo Amorim F, Brandão de Souza JF, Reis JM (2022) Modeling the mechanical behavior of epoxy Curaua reinforced composites. Proceedings of the Institution of Mechanical Engineers, Part C: Journal of Mechanical Engineering Science 236:8049–8056.
17. Souza LO de, Souza LMS de, de Andrade Silva F (2020) Mechanical autogenous recovery and crack sealing of natural curauá textile reinforced concrete. Construction and Building Materials 235:117476.

ISSN: 2321-2810 (Online), ISSN: 2321-8525 (Print)

18. Coelho de Carvalho LM, Dal Toé Casagrande M (2019) Mechanical Behaviour of Reinforced Sand with Natural Curauá Fibers through Full Scale Direct Shear Tests. E3S Web Conf 92:12003.
19. C Murugapoopathi, S., Ashwin Prabhu, G., Chandrasekar, G. et al. Fabrication and Characterisation of Saw Dust Polymer Composite. J. Inst. Eng. India Ser. D (2023).
20. osta U, Nascimento L, Almeida Bezerra W, de Oliveira Aguiar V, Pereira A, Monteiro S, Pinheiro W (2021) Dynamic Mechanical Behavior of Graphene Oxide Functionalized Curaua Fiber-Reinforced Epoxy Composites: A Brief Report. Polymers 13:1897.
21. Martel W de NDR, Salgado IP, Silva FA (2020) The Influence of Fiber Treatment on the Morphology, Water Absorption Capacity and Mechanical Behavior of Curauá Fibers. Journal of Natural Fibers 19:642–657.
22. Cavalcanti DKK, Banea MD, Neto JSS, Lima RAA, da Silva LFM, Carbas RJC (2019) Mechanical characterization of intralaminar natural fibre-reinforced hybrid composites. Composites Part B: Engineering 175:107149.
23. Zukowski B, dos Santos Mendonça YG, Tavares IJK, Toledo Filho RD (2022) Mechanical Properties of Hybrid PVA–Natural Curaua Fiber Composites. Materials 15:2808.
24. Teixeira RS, Santos SF, Christoforo AL, Payá J, Savastano H Jr, Lahr FAR (2019) Impact of content and length of curauá fibers on mechanical behavior of extruded cementitious composites: Analysis of variance. Cement and Concrete Composites 102:134–144.
25. Sankar K, Constâncio Trindade AC, Kriven WM (2022) The influence of alkaline treatment on the mechanical performance of geopolymer composites reinforced with Brazilian malva and curaua fibers. J Am Ceram Soc 106:339–353.
26. Teixeira FP, Cardoso DCT, de Andrade Silva F (2021) On the shear behavior of natural curauá fabric reinforced cement-based composite systems. Engineering Structures 246:113054.
27. Araujo JR, Mano B, Teixeira GM, Spinacé MAS, De Paoli M-A (2010) Biomicrofibrilar composites of high density polyethylene reinforced with curauá fibers: Mechanical, interfacial and morphological properties. Composites Science and Technology 70:1637–1644.
28. Rodrigues L, Silva R, Aquino E (2012) Effect of accelerated environmental aging on mechanical behavior of curaua/glass hybrid composite. Journal of Composite Materials 46:2055–2064
29. Prabhu, G.A., Tembhekar, T.D., Gopal, V. et al. Utilizing Machine Learning for Optimizing Composite Materials Derived from Leather Trimming and HDPE Waste. J. Inst. Eng. India Ser. D (2025).
30. d'Almeida AnaLFS, Melo Filho JA, d'Almeida JRM (2012) Characterization of Raw and Treated Curaua Fibers to be Applied as Reinforcement in Composites. MSF 730–732:283–288.
31. Saba N, Jawaid M, Sultan MTH (2019) An overview of mechanical and physical testing of composite materials. Mechanical and Physical Testing of Biocomposites, Fibre-Reinforced Composites and Hybrid Composites 1–12.

