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Tensile Strength Analysis of Woven Bamboo as an Alternative Material for Boat Hulls

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Abstract

This study aims to investigate the tensile strength of woven bamboo as an alternative material for boat hull construction. Bamboo was selected for its favourable mechanical properties, including its lightweight strength, elasticity, and environmental friendliness. The method used in this study is an experimental approach conducted at the Mechanical Engineering Laboratory of Universitas Abulyatama and the Laboratory of Politeknik Negeri Lhokseumawe. The research stages included selecting bamboo raw materials, cutting, drying, and fabricating woven structures using traditional techniques. Subsequently, tensile testing was performed on a tensile testing machine in accordance with ASTM D3039 to determine the ultimate tensile strength, yield stress, and strain of the tested specimens. The study was conducted from December 10, 2025, to January 14, 2026. The test results indicate that each specimen exhibited variations in tensile strength values. Specimen A3 demonstrated the best performance, with a maximum tensile stress of 94.73 MPa and a strain of 44.40%. In contrast, specimen A1 showed the lowest performance, with a proportional limit stress of 12.75 MPa and a strain of 25.88%. Based on these results, woven bamboo shows considerable potential as an alternative material for boat hull construction, offering cost-effectiveness and environmental advantages over conventional materials such as fibreglass.

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1. Introduction

Indonesia is an archipelagic country with abundant natural resources, particularly in the fisheries sector. As a nation with one of the longest coastlines in the world, Indonesia has significant potential to increase fish production, estimated to reach 12 million tons per year based on the Decree of the Minister of Marine Affairs and Fisheries No. 19 of 2022. However, despite its abundant natural resources, the Indonesian fisheries sector faces significant challenges in fishing technology and the quality and efficiency of fishing vessels. These challenges are partly due to issues related to material selection for boat construction, including dependence on limited resources such as ulin wood and teak, which are increasingly scarce and have limitations in durability, along with rising production costs (Suhartini, 2021; Nizar et al., 2025; Muzakki & Putro, 2025).

Boats are one of the traditional means of water transportation that play an important role in the lives of coastal communities in Indonesia. As an archipelagic country with more than 17,000 islands, the need for boats extends beyond fishing activities to include inter-regional transportation, tourism, and coastal economic activities (Suhartini, 2021; Almardhiyah, Mahidin, Fauzi, Abnisa, & Khairil, 2025; Pranoto, Rusiyanto, & Fitriyana, 2025). Generally, the primary materials used for boat hull construction are wood and fibreglass. These materials are chosen because they are considered to have sufficient strength and resistance to seawater pressure and extreme environmental conditions. However, the use of these materials presents several problems from economic, environmental, and raw material availability perspectives (Prasetyo & Hartanto, 2020; Mufti, Irhamni, & Darnas, 2025; Selvakumar, Maawa, & Rusiyanto, 2025).

The availability of wood as the main material for boat hulls continues to decline due to excessive forest exploitation. Logging activities that are not balanced with reforestation have led to a scarcity of high-quality timber, which, in turn, increases boat production costs (Putra & Lestari, 2022; Rosdi, Maghfirah, Erdiwansyah, Syafrizal, & Muhibbuddin, 2025; Muhibbuddin, Hamidi, & Fitriyana, 2025). In addition, the widespread use of fibreglass in modern boats introduces new environmental concerns. Fibreglass is difficult to decompose naturally, produces hazardous chemical waste, and poses a risk of marine pollution (Trunojoyo, 2023; Fitriyana, Rusiyanto, & Maawa, 2025; Khalisha, Caisarina, & Fakhrana, 2025). Therefore, there is a need to explore alternative materials that are more environmentally friendly, cost-effective, and capable of providing adequate mechanical strength to replace some of the functions of wood or fibreglass in boat hull construction.

One material with great potential as an alternative in boat construction is bamboo. Indonesia is known as one of the countries with the highest diversity of bamboo species in the world, and this material is widely available across various regions at relatively low cost (Santoso, 2020; Bahagia, Nizar, Yasin, Rosdi, & Faisal, 2025; Yana, Mufti, Hasiany, Viena, & Mahyudin, 2025). Bamboo possesses attractive technical characteristics, including being lightweight, strong, elastic, and easy to shape. Its tensile strength can reach up to 3250 MPa, which is comparable to certain types of mild steel, making it a promising material for withstanding loads and dynamic pressures such as those experienced by boat hulls (Trunojoyo, 2023; Gani et al., 2025; Irhamni, Kurnianingtyas, Muhtadin, Bahagia, & Yusop, 2025).

Furthermore, bamboo has a natural fibre structure arranged in a parallel, dense configuration, providing good resistance to bending and compressive forces (Hidayat, 2020; Maghfirah, Yusop, & Zulkifli, 2025). This property can be utilised in woven bamboo, which evenly distributes loads and improves resistance to wave pressure and water impact. The woven structure also provides additional flexibility, allowing the boat to adapt to pressure changes without experiencing excessive cracking or deformation (Wijaya & Pratama, 2022; Gani, Zaki, Bahagia, Maghfirah, & Faisal, 2025; Selvakumar, Gani, Xiaoxia, & Salleh, 2025).

From an economic and social perspective, the use of woven bamboo as a substitute material for boat hulls can also improve the welfare of local communities. The production process of bamboo does not require advanced technology and can be carried out by traditional craftsmen, thereby creating employment opportunities in rural areas (Kurniawan, 2023; Zaki, Adisalamun, & Saisa, 2025; Efremov & Kumarasamy, 2025). Given this significant potential, research on the tensile strength of woven bamboo as a substitute material for boat hulls is essential. This study is expected to provide scientific insight into the extent to which woven bamboo can replace part of wooden or fibreglass structures in terms of tensile strength. The findings are expected not only to contribute to the development of innovative and sustainable boat material technology but also to serve as a practical solution for coastal communities to build boats at lower cost, with greater durability, and with improved environmental sustainability (Hidayat, 2020; Li, Ikram, & Xiaoxia, 2025).

2. Methodology

Time

This study was conducted from December 10, 2025, to January 14, 2026, with a total duration of approximately 1 month. During this period, several important stages of the research were carried out systematically and in a well-planned manner. The process began with initial preparation, including developing the research plan, determining appropriate methods, and preparing the required tools and materials. This was followed by the data collection stage, conducted carefully and thoroughly to ensure the obtained information accurately reflected the actual conditions.

Location

The fabrication and preparation of the specimens were carried out at the Mechanical Engineering Laboratory of Universitas Abulyatama, located in Kota Baro District, Aceh Besar Regency, Aceh Province. Meanwhile, the tensile testing of the samples was conducted at the Laboratory of Politeknik Negeri Lhokseumawe.

Tools and Materials

This study utilised various tools and materials, including a Universal Testing Machine (UTM), a vernier calliper, a length-measuring instrument, a cutter, Yucalak resin, moulds, woven bamboo (10 mm), and fibreglass mat (300 and 450).

Testing Method

The tensile testing process began with the preparation of woven bamboo specimens that had been processed with Yucalak resin and layered with fibreglass. The prepared specimens were then placed in a tensile testing machine, which applied a controlled load at a constant rate until the material failed. During the test, data on the applied load and the change in specimen length were recorded to determine the tensile strength and maximum strain. The results of the tensile test provide information on the woven bamboo's ability to withstand tensile loads, which is crucial for its use as a structural material in boat hulls. In addition, the tensile test provides data on the modulus of elasticity and yield stress, two important parameters for understanding bamboo's durability under dynamic loads such as ocean waves.

To obtain accurate results, tensile testing generally follows international standards such as ASTM D3039, which is widely used for testing composite materials and natural fibres. This testing method can also be adapted to the size and shape of the bamboo specimens being studied, for example, as strips or woven sheets. In this study, the tensile testing machine measures the strength and elasticity of woven bamboo as a substitute material for boat hulls. The test results indicate the extent to which woven bamboo can withstand tensile loads, which serves as an important indicator of the boat's structural strength (Lamappasessu & Rahmalina, 2022).

Fig. 1. Galdabini Tensile Testing Machine Used in This Study.

Fig. 1 shows the Galdabini tensile testing machine used in this study to evaluate the mechanical properties of the woven bamboo composite specimens. This machine operates by applying a controlled tensile load to the specimen through upper and lower grips until failure occurs. The alignment and gripping system play a crucial role in ensuring that the load is distributed uniformly along the specimen's gauge length, thereby minimising experimental errors. During testing, the machine records the applied force and the corresponding material elongation, which are then used to determine key parameters such as tensile strength, yield stress, and strain. The use of a standardised, calibrated testing machine, such as the Galdabini, ensures the reliability and accuracy of the experimental data, making it suitable for assessing the feasibility of woven bamboo as a substitute for boat hull construction.

3. Result

Tensile Test Material

Tensile testing was conducted to determine the mechanical properties of the woven bamboo composite, including ultimate tensile strength, yield stress, and strain. The test was conducted at the Material Testing and Characterisation Laboratory, Department of Mechanical Engineering, Politeknik Negeri Lhokseumawe, using a GALDABINI tensile testing machine with a maximum capacity of 100 kN. Based on the tensile test results of five specimens, variations were observed in tensile load, maximum tensile stress, and strain values. The quality of the bamboo weaving influences these variations, as does the uniformity of the resin and the bonding between the composite layers. The test results are presented in **Table 1**.

Table 1. Tensile Testing Process and Results of Woven Bamboo Composite Specimens

Specimen	Before Testing	Testing Procedure	Test Results
A1			
A2			
A3			
A4			

Specimen	Before Testing	Testing Procedure	Test Results
A5			

Table 1 shows the process and results of tensile testing for five woven bamboo specimens used as a substitute material for boat hulls. Each specimen (A1-A5) was tested on a tensile testing machine to measure its tensile strength and elasticity. The “Before Testing” column records the initial condition of each specimen, while the “Testing Process” column describes how the specimen was positioned in the testing machine. The results presented in the final column indicate the changes in the specimens after testing, providing important data on maximum tensile strength, strain, and the material’s resistance to tensile forces.
Based on the visual observations presented in **Table 1**, all specimens experienced noticeable deformation and fracture after the tensile testing process, as indicated in the “Results” column. The failure generally occurred at the reduced cross-sectional (gauge) area, which is typical in tensile testing and indicates that the load was effectively concentrated in the intended region. The fracture patterns also suggest that the bonding between the woven bamboo fibres and the resin matrix played a crucial role in determining the failure mode. Specimens with more uniform fracture surfaces tend to indicate better stress distribution and stronger interfacial bonding, whereas irregular or uneven fractures may indicate defects, such as voids or weak adhesion. These visual results support the quantitative data, confirming that variations in material quality and fabrication processes directly influence the mechanical performance of the woven bamboo composite.

Tensile Strength Test Results
Table 2 presents the results of tensile testing of woven bamboo composite materials based on laboratory test data. The data include yield load (Fy), yield stress (σy), maximum load (Fu), ultimate tensile stress (σu), and elongation. The tensile test results of the woven bamboo composite material are shown in Table 2. Based on **Table 2**, it can be observed that specimen A3 exhibits the highest maximum tensile stress of 9.66 kN/mm² at a strain of 44.40%. This indicates that the weaving quality and resin bonding in this specimen are superior to those of the others. The ultimate tensile strength reached an average value of 73.94 MPa, with the highest value recorded in specimen A3 at 94.73 MPa, and an average strain of 30.36%. These values represent the maximum tensile load capacity of the material before a reduction in strength. The variation in values among specimens is influenced by the quality of the weaving, resin uniformity, and interlayer bonding within the composite.

Material Test	Spesimen	F_y (Kgf)	σ_y (Kgf/mm²)	σ_y (MPa)	F_u (Kgf)	σ_u (Kgf/mm²)	σ_u (MPa)	Strain (%)
Composite (Woven Bamboo & Resin)	A1	158.14	1.30	12.75	644.89	5.16	50.60	25.88
	A2	172.29	1.40	13.73	800.53	6.40	62.76	15.05
	A3	197.76	1.60	15.69	1208.05	9.66	94.73	44.40
	A4	189.27	1.50	14.71	1168.43	9.35	91.69	24.14
	A5	177.95	1.40	13.73	891.09	7.13	69.92	42.33
	Average	**179.08**	**1.44**	**14.12**	**942.60**	**7.54**	**73.94**	**30.36**

Specimen A1 has a proportional limit stress (σy) of 12.75 MPa and an ultimate tensile stress (σu) of 50.60 MPa, with a strain of 25.88%, indicating that the material can undergo considerable elongation before failure. Specimen A2, with σy of 13.73 MPa and σu of 62.76 MPa, exhibits a lower strain of 15.05%, suggesting that although it is stronger, it undergoes less deformation. Specimen A3 demonstrates the highest strength, with σy of 15.69 MPa and σu of 94.73 MPa, along with a very high strain of 44.40%, indicating excellent elasticity. Specimen A4, with σy of 14.71 MPa and σu of 91.69 MPa, shows a strain of 24.14%, slightly lower than A3 but still indicating significant strength. Finally, specimen A5, with σy of 13.73 MPa and σu of 69.92 MPa, exhibits a high strain of 42.33%, indicating good elongation capability despite having lower strength compared to A3 and A4.
The differences in results among specimens, as shown in the table, may be attributed to several factors. These include variations in specimen size and dimensions, differences in the quality of the bamboo material used, which can affect tensile strength and elongation, and inconsistencies in the manufacturing process, such as weaving arrangement and resin thickness. Additional factors include imperfections in the drying process that may lead to uneven moisture content, as well as variations in tensile testing machine settings, which may influence the results. All these factors contribute to the variation in yield stress and ultimate tensile stress among specimens, even when they have similar dimensions.

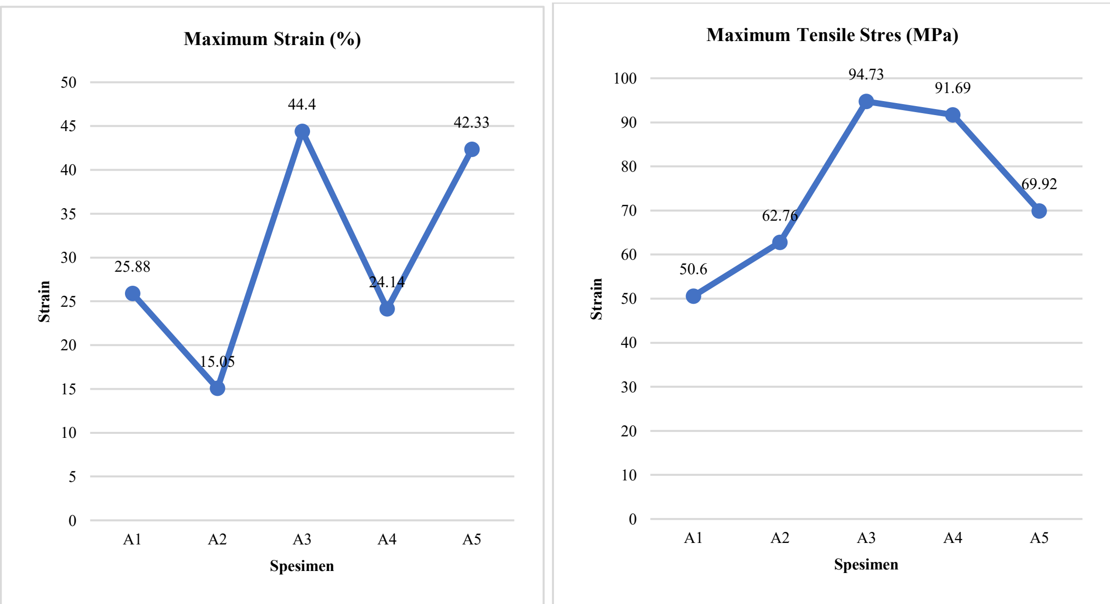

Fig. 2. Maximum Strain (%) and Maximum Tensile Stress (MPa) of Woven Bamboo Composite Specimens.

Fig. 2 illustrates the variation in maximum strain and maximum tensile stress among the woven bamboo composite specimens (A1–A5). The results show that specimen A3 exhibits the highest maximum strain of 44.40%, followed by A5 at 42.33%, indicating a high deformation capacity before failure. In contrast, specimen A2 shows the lowest strain of 15.05%, suggesting a more brittle behaviour than the other specimens. Specimens A1 and A4 demonstrate moderate strain values of 25.88% and 24.14%, respectively. These differences indicate that the composite's ductility is strongly influenced by its internal structure, including the weaving pattern and the quality of fibre–resin bonding.
In terms of maximum tensile stress, specimen A3 again shows the highest value at 94.73 MPa, followed closely by A4 at 91.69 MPa, indicating superior load-bearing capacity. Specimen A5 records a moderate tensile stress of 69.92 MPa, while A2 and A1 show lower values of 62.76 MPa and 50.60 MPa, respectively. The trend suggests that specimens with higher tensile strength do not always correspond to lower strain, as A3 demonstrates both high strength and high elongation, reflecting an optimal balance between strength and ductility. This performance is attributed to better fibre

alignment, more uniform resin distribution, and stronger interfacial bonding, which collectively enhance the mechanical properties of the woven bamboo composite.

4. Discussion

Based on the research results, it can be observed that specimen A3 exhibits the highest maximum tensile stress of 9.66 kN/mm² at a strain of 44.40%. This indicates that the weaving quality and resin bonding in this specimen are superior to those of the others. The ultimate tensile strength reached an average value of 73.94 MPa, with the highest value recorded in specimen A3 at 94.73 MPa, and an average strain of 30.36%. These values represent the maximum tensile load capacity of the material before a reduction in strength. The variation in values among specimens is influenced by the quality of the weaving, resin uniformity, and interlayer bonding within the composite.

One example of a bamboo composite application is in ship hull construction. Research conducted by Nurisa Sharani (2025) shows that petung bamboo fibre (Dendrocalamus asper) can be used as the primary material for ship hull manufacturing, serving as a substitute for fibreglass. However, the study also indicates that bamboo fibre-reinforced composites produced by vacuum infusion have not met the Indonesian Classification Bureau (BKI) standard of 150 MPa, making them unsuitable as a replacement for fibreglass in ship construction. Nevertheless, this research contributes to the development of sustainable ship construction solutions.

Additionally, research by Pohan et al. (2023) revealed that bamboo fibre composites with variations in fibre arrangement, woven, random, and unidirectional, demonstrate that unidirectional fibre arrangement provides the highest tensile strength, reaching 1.33 Kgf/mm² with a load of 18.92 Kgf. In impact testing, the unidirectional fibre arrangement also showed the highest impact value of 0.0166 Joule/mm and absorbed energy of 1.6643 Joule. Scanning Electron Microscopy (SEM) analysis indicated that increased variation in fibre arrangement reduces the occurrence of voids (air cavities) in the composite (Pohan et al., 2023).

Novriyanti Talango and Wawan Rauf researched the tensile strength of composites made from Mayan bamboo fibre with polyester and epoxy resin matrices. Variations in fibre-to-resin ratios resulted in different tensile strength values, determined by the bonding between bamboo fibres and the resin matrix. Their findings indicate that both fibre composition and resin type significantly influence the tensile strength of composite materials (Talango & Rauf, n.d.).

The research results indicate that bamboo fibre-reinforced composites can withstand relatively high tensile loads while elongating before fracture. This suggests that bamboo fibre composites exhibit ductile behaviour and do not fail suddenly. This ductility is crucial for boat hulls, as they are subjected to dynamic loads such as waves and vibrations during operation. Ductile materials are safer because they can absorb energy and deform under load without sudden failure. These findings are consistent with those of Aminur et al., who stated that bamboo fibre-reinforced composites exhibit good tensile strength and deform before fracture, making them suitable for structures subjected to dynamic loading (Aminur et al., n.d.).

In general, the results show that the tensile strength of woven bamboo composites is significantly influenced by the type of bamboo, weaving pattern, thickness of bamboo strips, and the type of resin used as the matrix. The woven bamboo serves as the primary reinforcement, resisting tensile loads, while the resin binds the fibres and distributes the load evenly throughout the composite structure. Several studies suggest that bamboo fibre composites with good weaving quality and uniform resin bonding can achieve relatively high tensile strength, although it is still lower than that of certain fibreglass materials. However, woven bamboo composites offer other advantages, such as environmental friendliness, availability of raw materials, and lower production costs, making them a potential alternative material for reinforcing boat hulls subjected to dynamic loads such as waves and vibrations during operation.

Compared with fibreglass materials such as Chopped Strand Mat (CSM), woven bamboo composites exhibit distinct mechanical characteristics. Fibreglass generally has higher tensile strength and more homogeneous properties. However, bamboo, as a natural fibre, offers good flexibility and energyabsorption capability. With proper processing and design, woven bamboo composites can become a viable alternative material for non-structural to semi-structural applications in traditional boat hulls. The results of this study indicate that the use of woven bamboo as a substitute reinforcement material for boat hulls has promising prospects. The use of local materials, such as bamboo, can reduce reliance on imported materials and support the development of environmentally friendly technologies.

5. Conclusion

Based on the research findings, woven bamboo has demonstrated strong potential as an alternative material for boat hull construction. Woven bamboo composites combined with Yucalak resin and fibreglass exhibit high tensile strength and ductility, making them resistant to brittle failure. Tensile test results indicate that specimen A3 achieved the highest ultimate tensile strength (σu) of 94.73 MPa with a strain of 44.40%, while specimen A1 showed the lowest proportional limit stress (σy) of 12.75 MPa with a strain of 25.88%. Overall, woven bamboo exhibits sufficient strength and flexibility to withstand dynamic loads such as ocean waves, making it an environmentally friendly and cost-effective alternative material for small- to medium-scale boat hull applications.

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References

Almardhiyah, F., Mahidin, M., Fauzi, F., Abnisa, F., & Khairil, K. (2025). Optimization of Aceh Low-Rank Coal Upgrading Process with a Combination of Heating Media to Reduce Water Content through Response Surface Method. International Journal of Science & Advanced Technology (IJSAT), 1(1), 29–37.

Aminur, Sudarsono, Sisworo, R. R., Aksar, P., Syah, C. Y., & Hamundu, W. O. N., 2023, "Studi sifat mekanik komposit polimer serat bambu dengan struktur berlapis," vol. 21, no. 1.

Bahagia, B., Nizar, M., Yasin, M. H. M., Rosdi, S. M., & Faisal, M. (2025). Advancements in Communication and Information Technologies for Smart Energy Systems and Renewable Energy Transition: A Review. International Journal of Engineering and Technology (IJET), 1(1), 1–29.

Efremov, C., & Kumarasamy, S. (2025). Optimisation of Microgrid by HOMER Pro Software Design: Innovative Approach and Performance Evaluation. International Journal of Engineering and Technology (IJET), 1(1), 120–130.

Fitriyana, D. F., Rusiyanto, R., & Maawa, W. (2025). Renewable Energy Application Research Using VOSviewer software: Bibliometric Analysis. International Journal of Science & Advanced Technology (IJSAT), 1(1), 92–107.

Gani, A., Saisa, S., Muhtadin, M., Bahagia, B., Erdiwansyah, E., & Lisafitri, Y. (2025). Optimisation of home grid-connected photovoltaic systems: performance analysis and energy implications. International Journal of Engineering and Technology (IJET), 1(1), 63–74.

Gani, A., Zaki, M., Bahagia, B., Maghfirah, G., & Faisal, M. (2025). Characterization of Porosity and Pore Volume in EFB Samples through Physical and Morphological Parameters. International Journal of Engineering and Technology (IJET), 1(1), 90–99.
Hidayat, R., 2020, "Analisis Kelayakan Ekonomi Penggunaan Kayu Lokal pada Industri Perahu Tradisional," Jurnal Teknologi Maritim, vol. 7(2), pp. 45-52.
Irhamni, I., Kurnianingtyas, E., Muhtadin, M., Bahagia, B., & Yusop, A. F. (2025). Bibliometric Analysis of Renewable Energy Research Trends Using VOSviewer: Network Mapping and Topic Evolution. International Journal of Engineering and Technology (IJET), 1(1), 75–82.
Khalisha, N., Caisarina, I., & Fakhrana, S. Z. (2025). Mobility Patterns of Rural Communities in Traveling Traveling from The Origin Area to the Destination. International Journal of Science & Advanced Technology (IJSAT), 1(1), 108–119.
Kurniawan, A., 2023, "Inovasi Material Ramah Lingkungan pada Konstruksi Maritim," Jurnal Rekayasa Material, vol. 11(1), p. 12–20.
Lamappasessu, A., & Rahmalina, D, 2022, "pengembangan Material Bambu untuk Pembuatan Bodi Speed Boat," Jurnal Teknobiz, Universitas Pancasila.
Li, D., Ikram, M., & Xiaoxia, J. (2025). A brief overview of the physical layer test system: Development of an IoTbased energy storage and electrical energy distribution system. International Journal of Engineering and Technology (IJET), 1(1), 131–140.
Maghfirah, G., Yusop, A. F., & Zulkifli, Z. (2025). Using VOSviewer for Renewable Energy Literature Analysis: Mapping Technology and Policy-Related Research. International Journal of Engineering and Technology (IJET), 1(1), 83–89.
Mufti, A. A., Irhamni, I., & Darnas, Y. (2025). Exploration of predictive models in optimising renewable energy integration in grid systems. International Journal of Science & Advanced Technology (IJSAT), 1(1), 47–61.
Muhibbuddin, M., Hamidi, M. A., & Fitriyana, D. F. (2025). Bibliometric Analysis of Renewable Energy Technologies Using VOSviewer: Mapping Innovations and Applications. International Journal of Science & Advanced Technology (IJSAT), 1(1), 81–91.
Muzakki, M. I., & Putro, R. K. H. (2025). Greenhouse Gas Emission Inventory at Benowo Landfill Using IPCC Method. International Journal of Science & Advanced Technology (IJSAT), 1(1), 18–28.
Nizar, M., Syafrizal, S., Zikrillah, A.-F., Rahman, A., Hadi, A. E., & Pranoto, H. (2025). Optimizing Waste Transport Efficiency in Langsa City, Indonesia: A Dynamic Programming Approach. International Journal of Science & Advanced Technology (IJSAT), 1(1), 10–17.
Pohan, H., Sari, D., & Putra, R., 2023, " Studi Eksperimen Komposit Berpenguat Serat Bambu dengan Variasi Susunan Serat Anyaman, Acak, dan Lurus Memanjang," Jurnal Teknik Mesin, vol. 12(2), pp. Tersedia di: https://repositori.untidar.ac.id/index.php?bid=16650&fid=41722&p=fstream-pdf.
Pranoto, H., Rusiyanto, R., & Fitriyana, D. F. (2025). Sustainable Wastewater Management in Sumedang: Design, Treatment Technologies, and Resource Recovery. International Journal of Science & Advanced Technology (IJSAT), 1(1), 38–46.
Prasetyo, M., & Hartanto, F., 2020, "Kekuatan Bambu untuk Struktur Konstruksi di Lingkungan Perairan.," Jurnal Ilmu Konstruksi, vol. 12(4), pp. 82-88.
Putra, D., & Lestari, N., 2022, "Dampak Penggunaan Material Fiberglass terhadap Lingkungan," Jurnal Lingkungan dan Teknologi, vol. 9(3), p. 88–95.
Rosdi, S. M., Maghfirah, G., Erdiwansyah, E., Syafrizal, S., & Muhibbuddin, M. (2025). Bibliometric Study of Renewable Energy Technology Development: Application of VOSviewer in Identifying Global Trends. International Journal of Science & Advanced Technology (IJSAT), 1(1), 71–80.
Santoso, B. , 2020, "Kekuatan Tarik dan Lentur Bambu pada Aplikasi Struktur," Jurnal Teknik Sipil Nusantara, vol. 8(1), p. 23–30.
Selvakumar, P., Gani, A., Xiaoxia, J., & Salleh, M. R. (2025). Porosity and Pore Volume Analysis of EFB Fiber: Physical Characterization and Effect of Thermal Treatment. International Journal of Engineering and Technology (IJET), 1(1), 100–108.

Selvakumar, P., Maawa, W., & Rusiyanto, R. (2025). Hybrid Grid System as a Solution for Renewable Energy Integration: A Case Study. International Journal of Science & Advanced Technology (IJSAT), 1(1), 62–70.

Suhartini, H., 2021, "Tantangan dan Peluang Pengembangan Industri Perikanan di Indonesia," Jurnal Ekonomi dan Perikanan, vol. 6(1), pp. 15-23.

Suhartini, H., 2021, "Tantangan dan Peluang Pengembangan Industri Perikanan di Indonesia," Jurnal Ekonomi dan Perikanan, vol. 6(1), pp. 15-23.

Talango, N., & Rauf, W., 2023, "Analisis Kekuatan Tarik Material Komposit Berbahan Serat Bambu Mayan," vol. 13, no. 2.

Trunojoyo, M, 2023, "The Effect of Shipbuilding Material on Biofouling Growth at Boom Marina, Banyuwangi," Jurnal Kelautan Universitas Trunojoyo.

Wijaya, P., & Pratama, R., 2022, "Uji Kekuatan Anyaman Bambu terhadap Beban Tekan dan Lentur," Jurnal Riset Konstruksi, vol. 10(4), pp. 77-84.

Yana, S., Mufti, A. A., Hasiany, S., Viena, V., & Mahyudin, M. (2025). Overview of biomass-based waste to renewable energy technology, socioeconomic, and environmental impact. International Journal of Engineering and Technology (IJET), 1(1), 30–62.

Zaki, M., Adisalamun, A., & Saisa, S. (2025). Analysis of the concentration microplastics on waste generation in the beach: A case study Banda Aceh City, Indonesia. International Journal of Engineering and Technology (IJET), 1(1), 109–119.