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Development of a digital-based fiber tensile testing apparatus to enhance fiber testing accuracy

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ABSTRACT

Natural fibers are increasingly used in various industries due to their eco-friendly properties and cost-effectiveness. However, current methods for testing the mechanical properties of these materials, such as tensile strength, often face limitations in accuracy and efficiency. This study aims to develop an innovative digital-based fiber tensile testing apparatus to enhance the precision of tensile testing. The research involves the design and construction of the apparatus, utilizing components such as ST37 steel, stepper motors, and Arduino technology. The apparatus was tested using two types of natural fibers, *Cocos nucifera* L. (coconut fiber) and Sansevieria, to assess their tensile properties. The results showed that although Sansevieria fibers have a smaller diameter, they exhibited higher tensile stress compared to coconut fibers. The developed digital testing apparatus enables more accurate and efficient fiber testing, contributing to the development of stronger and more sustainable materials for industrial applications. The findings of this study highlight the potential of advanced testing equipment in supporting the use of natural fibers in manufacturing and environmental sustainability.

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1. INTRODUCTION

Natural fibers have gained significant attention in various industries due to their eco-friendly and cost-effective properties. Materials such as coconut husk, bamboo, and hemp are widely used in the production of composite materials, offering a sustainable alternative to synthetic fibers like glass and carbon [1]–[7]. The use of natural fibers is aligned with global initiatives aimed at reducing environmental degradation and waste generation, as these fibers are biodegradable and sourced from renewable resources [1], [2].

However, the use of natural fibers in composite manufacturing faces several challenges, particularly in evaluating their mechanical properties [2], [5], [6], [8]–[10]. Tensile testing is one of the most critical methods for assessing the strength and durability of fiber-based materials [11]–[15]. Traditional tensile testing methods, though widely used, often suffer from limitations in precision and efficiency, especially when it comes to testing small-diameter fibers. These limitations are primarily due to the lack of digital data acquisition, leading to inaccuracies and inefficiencies in the testing process [16]–[20].

To address these challenges, the development of an advanced, digital-based fiber tensile testing apparatus is necessary. Such a system would provide more accurate measurements, enhance testing efficiency, and enable real-time data analysis. The primary objective of this study is to design and develop a digital-based fiber tensile testing apparatus that improves the precision of tensile testing for natural fibers.

This paper presents the design, development, and testing of the apparatus using two natural fibers, *Cocos nucifera* L. (coconut fiber) and Sansevieria as test subjects. The findings of this study are expected to contribute to the field of natural fiber testing by offering a more efficient and reliable method for evaluating fiber properties, which will support the wider adoption of natural fibers in various industrial applications.

2. LITERATURE REVIEW

2.1. Characteristics of natural fibers

Natural fibers, derived from diverse plants and animals, are naturally occurring materials found in their native environment [21]. Plant-derived materials include an assortment of sources such as banana stems, bamboo, roselle, pineapple, coconut, and palm fronds (palm fiber), among others. These fibers are present in different parts of the plant, like wood, leaves, seeds, fruit, stems, and various types of grass. Animal-derived fibers like wool and silk also contribute to this spectrum of natural fibers.

In recent years, natural fibers have garnered significant attention from materials scientists due to their favorable properties, including low density and high specific strength. These fibers offer several advantages, such as cost-effectiveness, accessibility, recyclability, and often being non-toxic. Indonesia, in particular, has abundant natural fiber resources, with different physical characteristics as described in Table 1. This table compares the properties of various natural and synthetic fibers.

Table 1. Comparison of some properties of natural and synthetic fibers [22]

Fiber	Density (g/cm)^3	Elongation at break (%)	Elastic modulus (Young) (IPK)	Tensile strength (MPa)
Aramid	1.4	3.3-3.7	63-67	3,000-3,150
Carbon	1.4	1.4-1.8	230-240	4,000
E-glass	2.5	0,5	70	2,000-3,000
Lenan	2.5	2.8	86	4,570
S-glass	1.2-1.5	2.0-4.5	2	40-90
Polyester	1.1-1.4	1-6	3-6	35-100
Cotton	1.2-1.6	7-8	5.5-12.6	250-500
Coconut fiber	1.2	24-51	6(40)	140-593
Lenan	1.2-2.4	2.3-3.2	27.6-80	500-1,500
Hemp	1.3	2-40	45(70)	690(530-1,100)
Hemp	1.2-1.8	1.5-2.5	10-55	325-800
Kenaf	1.2-1.6	1.6	41(53)	745-930
Sisal	1.2-1.5	2-3.2(8)	9.4-22	310-855
Abaka	1.5	3.4	41	410-810
Henequen	1.4	4.8	13.2	500
Pineapple	1.5	0.8-3.2	82	1,020-,1600
Bananas	1.3	2-3.7	27-32	720-910
Nettle	1.5	1.7	38	650
Hemp	1.4	1.2-3.7	23-44	500-915

2.2. Tensile strength and strain of a single fiber

In the field of material strength, understanding the tensile strength and stiffness of a single fiber specimen, described by a cylindrical shape with a cross-sectional area A_0, subjected to a tensile force F, is a fundamental aspect of evaluating fiber materials [15], [23], [24]. Tensile strength refers to the maximum load that a fiber can withstand before breaking, which reflects the inherent strength of the fiber material. As the highest load that a fiber can withstand increases, its tensile strength also increases. Figure 1 shows the design stages, including the preliminary sketches and detailed conceptualization of the testing apparatus.

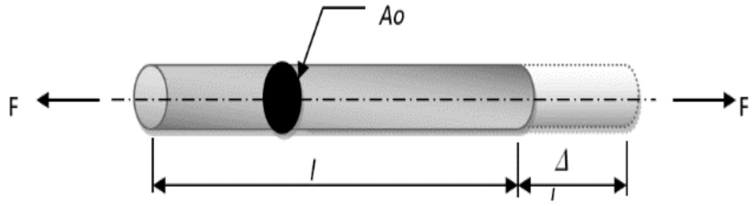

Figure 1. Illustration of a single fiber specimen receiving a tensile load

3. RESEARCH METHOD

This research employs a systematic, multi-stage design approach that covers several phases to ensure a comprehensive and rigorous methodology. These phases include material selection, component manufacturing and assembly, single-fiber testing, analysis of test results, and conceptual design using Autodesk Fusion 360 [25], [26]. Figure 1 provides an illustration of the outlined research stages, including the careful design of tool components dedicated to tensile testing, selection of appropriate fibers, fabrication, and assembly of components, testing procedures, and evaluation of results. The primary goal of this methodology, as outlined in the flowchart in Figure 2, is to develop a digitally enabled fiber tensile testing apparatus that ensures accuracy and efficiency in assessing the mechanical properties of fiber composite materials.

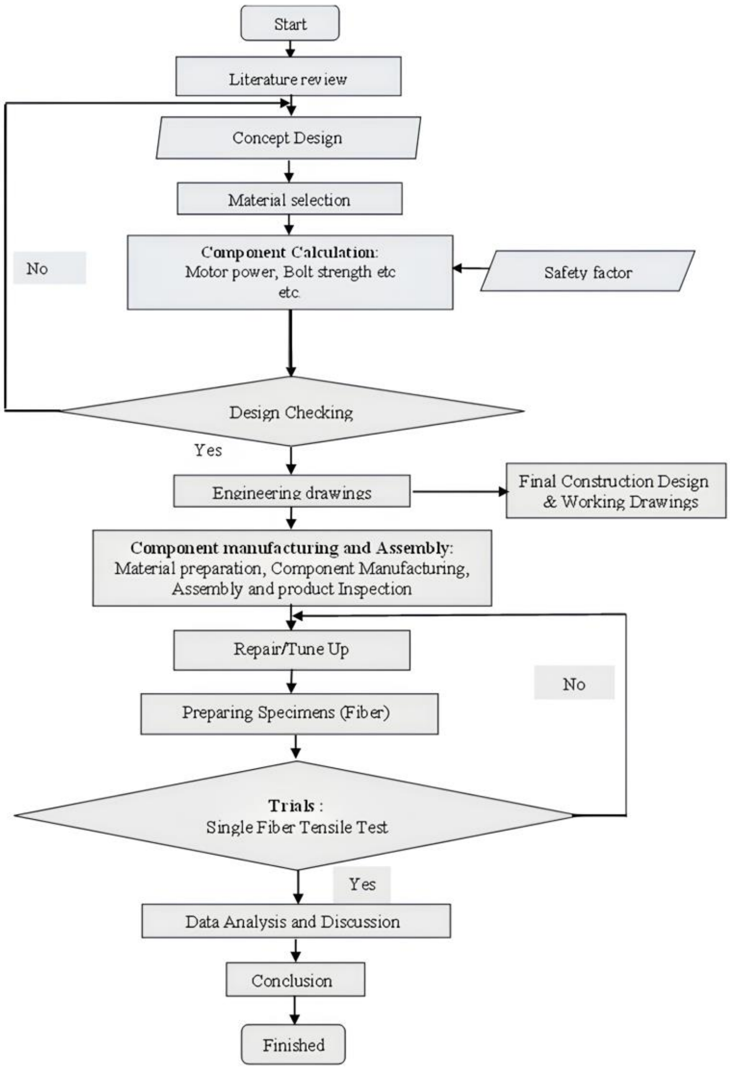

Figure 2. Research the stages of design and construction of fiber tensile testing equipment

3.1. Planning stage

The planning stage involves developing the components and sub-component design for the digital single-fiber tensile tester. Several important considerations must be addressed during this phase:

i) The planning stage is crucial for ensuring the design's feasibility and efficiency. Initially, detailed visual representations of the digital single fiber tensile tester are created using Autodesk Fusion 360 software. These sketches provide an overview of the device's structure and key components, enabling further evaluation of design feasibility. Feasibility calculations are then conducted to assess the strength and durability of the materials used, ensuring they meet the necessary specifications for reliable fiber testing, as illustrated in Figure 3.

ii) Component feasibility calculation: after the sketches, feasibility calculations are performed to assess the suitability of the components to be used in the tensile tester. This includes strength and dimension calculations for structural parts, such as steel plates, angle iron, and bolts. These calculations ensure that the components meet the required specifications and are durable enough for reliable fiber testing. The drive system is a critical component of the fiber tensile tester. As illustrated in Figure 4, this system plays a key role in ensuring the smooth and controlled application of tensile force on the fiber specimen. The drive system, as shown in Figure 4, is a critical component that ensures the precise movement of the gripper. This system is powered by a stepper motor that controls the speed and force applied to the fiber specimen. Figure 4 illustrates the key components of the drive system, including the motor, gears, and control mechanism.

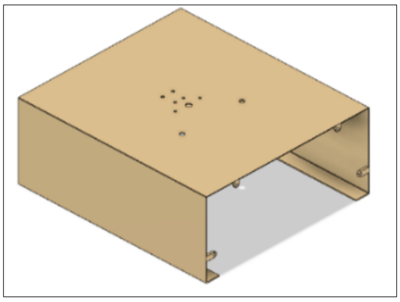

Figure 3. Box construction design of the fiber tensile tester

Figure 4. Drive system of the fiber tensile tester

By conducting these thorough design evaluations, the digital single-fiber tensile tester is developed to meet the required standards. Accurate calculations and strict design protocols ensure the tool's capability to measure the tensile strength of individual fibers accurately. The next step is to establish concepts for each component of the tool based on the initial design, ensuring precision in the final prototype. Figure 5 presents the complete design of the fiber tensile testing apparatus. This detailed diagram highlights the structural layout and the critical components that facilitate accurate testing.

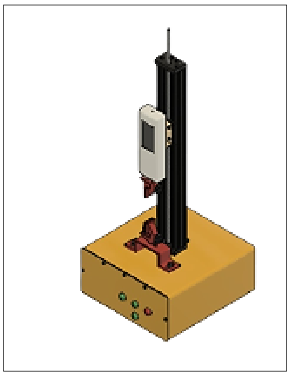

Figure 5. Design of fiber tensile test apparatus

3.2. Assembly stage

Once the design phase is complete, the production process for the digital single-fiber tensile tester begins. Transitioning from conceptual design to a fully functional device requires careful adherence to technical standards throughout the manufacturing process to ensure tool performance and quality. Key steps in the assembly process include: i) preparing frame components and assembling pillar structures with threading, ii) attaching the pillar to the main frame, then assembling the force meter bracket and gripper mechanism, and iii) installing the stepper motor, connecting cables to the Arduino, and programming the Arduino Uno for automation.

The assembly of the device is critical to ensure alignment, precision, and functionality. Any misalignment or incorrect component assembly can compromise the accuracy of testing. The following modifications were made to enhance performance:

i) Addition of exhaust fan blower and air ventilation holes: to reduce heat build-up from the stepper motor, microprocessor, and power supply, ventilation holes and an exhaust fan blower were added. This improvement ensures the components operate at a stable temperature, preventing overheating.
ii) Addition of stanchions for reinforcement: reinforced frame pillars with stanchions were added to increase stability and minimize the risk of bending or tilting. These modifications ensure that the tool maintains high precision during operation.
iii) Development of operation panel: the control panel was upgraded from three to four buttons, allowing more flexibility and precision in tool operation. The addition of a stop button, an up-moving gripper button, a down-moving gripper button, and a slow-motion button (1 mm/min) enhanced the ease of use.
iv) Addition of power on/off switch: the addition of a power on/off switch ensures safer and more convenient operation, compared to the previous design, which required a manual connection to a power source.
v) Expansion of drive system and control system box room: expanding the space for the drive system and control system box allows easier maintenance and repair. Reinforcements to the upper box wall increase strength and prevent vibration, ensuring smooth operation.

3.3. Preparation process

For the accurate preparation of coconut coir fiber specimens, a detailed procedure was followed: i) extraction of fibers: fibers were extracted from coconut husks, cleaned, and cut to a standardized length of approximately 90 mm and ii) diameter measurement: the fiber diameter was measured using a digital microscope, ensuring consistency; and iii) specimen preparation: fibers were affixed to paper using fox glue following ASTM standard 3379-02 [27]–[29].

For accurate fiber testing, the preparation of the specimen is essential. Figure 6 shows the preparation process, where the fibers are aligned and secured for tensile testing. An example of a natural fiber tensile test specimen is shown in Figure 7, illustrating the dimensions and alignment needed for the testing procedure. The completed digital tensile tester, as depicted in Figure 8, incorporates several enhancements, including an automated system for fiber loading and data collection.

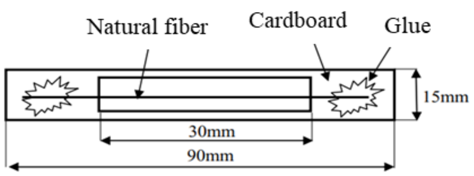

Figure 6. Natural fiber tensile test specimen

Figure 7. Example of natural fiber tensile test specimen

Figure 8. The result of making a digital tensile tester

3.4. Testing process

To ensure the reliability of the results, the tensile testing process was conducted with careful attention to detail: i) Initial setup: the force gauge was calibrated, and the specimen was securely mounted onto the gripper; ii) Test activation: the test was initiated by pressing the "up" button, causing the gripper to move and apply tensile force on the fiber; and iii) Monitoring and data collection: throughout the testing phase, the specimen's behavior was closely monitored. Upon reaching the breaking point, the test was stopped by pressing the "stop" button, and the resulting data was displayed on the screen. Figure 9 illustrates the testing process, showing the setup, monitoring, and data collection procedures involved in evaluating the tensile strength of the fiber specimen.

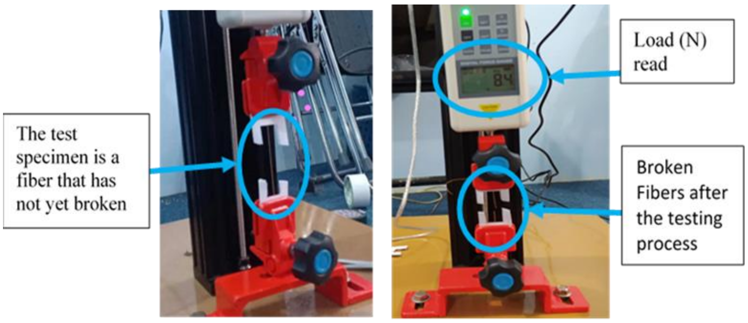

Figure 9. Testing process

4. RESULTS AND DISCUSSION

4.1. Fiber material testing data

Performance testing of the tensile testing equipment using two different types of natural fibers, Sansevieria fiber (SLM) and coconut coir fiber (SSK), provides valuable insights into their tensile characteristics. The tensile test results, shown in Tables 2 and 3, reveal significant differences in both breaking force and tensile stress between the two fiber types. Despite the larger diameters and higher breaking forces observed in coconut coir fibers, Sansevieria fibers demonstrated superior tensile stress values, indicating better stress resistance per unit area.

Table 2. Tensile test results of Sansevieria materials

No	Specimen code	Diameter ($d\bar{X}$)	Wide cross-section	Tensile force	Tensile stress (MPa)
1	SLM 1	0.11	0.009	2.00	223.93
2	SLM 2	0.07	0.004	2.10	497.45
3	SLM 3	0.12	0.011	4.30	380.40
4	SLM 4	0.09	0.006	2.30	361.72
5	SLM 5	0.08	0.005	2.70	585.17
6	SLM 6	0.09	0.006	1.30	220.48
7	SLM 7	0.06	0.003	1.70	539,90
8	SLM 8	0.06	0.003	1.90	603.42
9	SLM 9	0.13	0.013	5.60	422.12
10	SLM 10	0.12	0.011	3.30	300.00

Table 3. Tensile test results of coconut fiber material

No	Specimen code	Diameter ($d\bar{X}$)	Wide cross-section	Tensile force	Tensile stress (MPa)
1	SSK 1	0.11	0.009	2.00	223.93
2	SSK 2	0.47	0.173	12.00	69.20
3	SSK 3	0.37	0.106	10.90	103.28
4	SSK 4	0.58	0.261	21.20	81.21
5	SSK 5	0.33	0.084	7.10	84.76
6	SSK 6	0.39	0.117	13.20	112.47
7	SSK 7	0.45	0.117	6.60	56.23
8	SSK 8	0.48	0.157	11.20	71.51
9	SSK 9	0.56	0.181	9.10	50.31
10	SSK 10	0.62	0.246	19.00	77.18

This research offers a detailed investigation into the mechanical properties of two different natural fibers: SLM and SSK. The test results presented in Tables 2 and 3 show significant differences in the magnitude of the breaking force and tensile stress between these two fiber types, despite differences in specimen diameter size. Analysis of the results:

i) Breaking force and tensile stress: SSK demonstrated larger diameters and higher breaking forces than SLM. For example, coconut fiber specimen SSK 10, with a diameter of 0.62 mm, exhibited a breaking force of 32.90 N, whereas Sansevieria fiber specimen SLM 7, with a diameter of 0.06 mm, broke at a force of only 1.70 N. While the coconut fibers exhibited larger braking forces, the tensile stress values revealed a different trend. Sansevieria fibers, despite their smaller diameters, showed a higher average tensile stress value. This indicates that Sansevieria fibers can withstand higher stress per unit area compared to the thicker coconut fibers.
ii) Tensile stress comparison: the average tensile stress of Sansevieria fibers, despite having a smaller diameter, was higher on average compared to coconut fibers. This suggests that Sansevieria fibers have a superior capacity to resist stress, making them more efficient under high-stress conditions when compared to their thicker counterparts. These findings align with studies such as Wantahe and Bigambo [30], who also observed higher tensile strength in Sansevieria fibers compared to coconut fibers, despite the differences in fiber treatment methods. Additionally, Abdullah *et al.* [31] also reported increased tensile strength in Sansevieria fibers even after blending treatments. These studies support the current findings, highlighting the mechanical advantage of Sansevieria fibers in terms of tensile strength per unit area.
iii) Effect of fiber diameter on tensile strength: the fiber diameter plays a crucial role in determining the breaking force, as observed with SSK, showing higher breaking forces due to its larger diameter compared to SLM. However, as indicated by the tensile stress values, this does not directly correlate to better overall performance in terms of stress resistance. Smaller fibers, such as Sansevieria, can perform better in certain applications due to their ability to handle higher stress levels per unit area.

4.2. Significance of digital testing equipment

The development of the digital single-fiber tensile testing machine is crucial for obtaining accurate and consistent tensile data of individual fibers. This advanced equipment enables precise measurement and real-time data collection, significantly improving the reliability and efficiency of fiber testing. Consequently, it provides valuable insights into fiber behavior, supporting the development of stronger, sustainable materials for industrial applications.

4.3. Future directions and implications

The results of this study open new avenues for future research in the field of natural fiber testing. One potential direction is to explore the tensile properties of a wider range of natural fibers, including other fiber types such as hemp and jute, which are also widely used in composite materials. Further investigations could focus on the impact of fiber treatments, such as chemical or physical modifications, on tensile strength and stress resistance. Moreover, the integration of this testing equipment in industrial settings could lead to the development of more durable and sustainable materials, paving the way for the wider adoption of natural fibers in commercial applications. This study underscores the potential for digital-based tensile testing equipment to revolutionize how natural fibers are tested and utilized in the manufacturing of eco-friendly composite materials.

5. CONCLUSION

This study presents the development of a digital-based fiber tensile testing apparatus designed to enhance the accuracy and efficiency of tensile testing for natural fibers. The key findings reveal that while coconut coir fibers exhibit higher breaking forces, Sansevieria fibers, despite their smaller diameter, demonstrate superior tensile stress. The innovation of this testing apparatus significantly contributes to improving fiber testing precision, enabling better material characterization for industrial applications. Future research can explore the tensile properties of a broader range of natural fibers, including modified fibers, and assess the applicability of this testing system in various industries. This advancement promises to support the development of stronger, more sustainable materials for eco-friendly composite manufacturing.

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AUTHOR CONTRIBUTIONS STATEMENT

This journal uses the Contributor Roles Taxonomy (CRediT) to recognize individual author contributions, reduce authorship disputes, and facilitate collaboration.

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Ahmad Nurul Muttaqin	✓	✓	✓		✓	✓	✓		✓	✓				✓

C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

CONFLICT OF INTEREST STATEMENT

This research is funded by Politeknik Negeri Ujung Pandang through the DIPA program, which requires research outputs to be published in reputable international journals. Therefore, we chose to submit this article to the International Journal of Advances in Applied Sciences (IJAAS), which aligns well with our field and meets the required quality standards. Publishing in this journal is crucial for us not only to fulfill our research reporting obligations but also to support the academic promotion process and advance our professional career development.

DATA AVAILABILITY

The data that support the findings of this study are available from the corresponding author, [MI]. upon reasonable request. These data include detailed tensile testing results of natural fibers (Sansevieria and coconut fiber), design specifications, assembly procedures, and calibration data from the developed digital-based fiber tensile testing equipment. Due to the proprietary nature of some design components and the potential sensitivity of the experimental data, the dataset is not publicly available in repositories. However, all relevant data needed to reproduce the results and validate the findings will be made available to qualified researchers for academic, and non-commercial purposes. Requests for access to the data may be addressed to the author by email at ahmadnurulmuttaqin@poliupg.ac.id.

REFERENCES

[1] T. Väisänen, O. Das, and L. Tomppo, “A review on new bio-based constituents for natural fiber-polymer composites,” *Journal of Cleaner Production*, vol. 149, pp. 582–596, Apr. 2017, doi: 10.1016/j.jclepro.2017.02.132.

[2] N. M. Nurazzi *et al.*, “A review on mechanical performance of hybrid natural fiber polymer composites for structural applications,” *Polymers*, vol. 13, no. 13, Jun. 2021, doi: 10.3390/polym13132170.

[3] S. Vigneshwaran *et al.*, “Recent advancement in the natural fiber polymer composites: a comprehensive review,” *Journal of Cleaner Production*, vol. 277, Dec. 2020, doi: 10.1016/j.jclepro.2020.124109.

[4] S. M.R., S. Siengchin, J. Parameswaranpillai, M. Jawaid, C. I. Pruncu, and A. Khan, “A comprehensive review of techniques for natural fibers as reinforcement in composites: preparation, processing and characterization,” *Carbohydrate Polymers*, vol. 207, pp. 108–121, Mar. 2019, doi: 10.1016/j.carbpol.2018.11.083.

[5] A. Karimah *et al.*, “A review on natural fibers for development of eco-friendly bio-composite: characteristics, and utilizations,” *Journal of Materials Research and Technology*, vol. 13, pp. 2442–2458, Jul. 2021, doi: 10.1016/j.jmrt.2021.06.014.

[6] M. R. Sanjay, P. Madhu, M. Jawaid, P. Senthamaraikannan, S. Senthil, and S. Pradeep, “Characterization and properties of natural fiber polymer composites: a comprehensive review,” *Journal of Cleaner Production*, vol. 172, pp. 566–581, Jan. 2018, doi: 10.1016/j.jclepro.2017.10.101.

[7] I. Elfaleh *et al.*, “A comprehensive review of natural fibers and their composites: an eco-friendly alternative to conventional materials,” *Results in Engineering*, vol. 19, Sep. 2023, doi: 10.1016/j.rineng.2023.101271.

[8] S. Kumar *et al.*, “Physical and mechanical properties of natural leaf fiber-reinforced epoxy polyester composites,” *Polymers*, vol. 13, no. 9, Apr. 2021, doi: 10.3390/polym13091369.

[9] A. R. Bhat, R. Kumar, and P. K. S. Mural, "Natural fiber reinforced polymer composites: a comprehensive review of tribo-mechanical properties," *Tribology International*, vol. 189, Nov. 2023, doi: 10.1016/j.triboint.2023.108978.
[10] R. B. Ashok, C. V. Srinivasa, and B. Basavaraju, "Dynamic mechanical properties of natural fiber composites—a review," *Advanced Composites and Hybrid Materials*, vol. 2, no. 4, pp. 586–607, Dec. 2019, doi: 10.1007/s42114-019-00121-8.
[11] H. Qin *et al.*, "Evaluation of tensile strength variability in fiber reinforced composite rods using statistical distributions," *Frontiers in Built Environment*, vol. 10, Jan. 2025, doi: 10.3389/fbuil.2024.1506743.
[12] K. Kartikeya, H. Chouhan, A. Ahmed, and N. Bhatnagar, "Determination of tensile strength of UHMWPE fiber-reinforced polymer composites," *Polymer Testing*, vol. 82, Feb. 2020, doi: 10.1016/j.polymertesting.2019.106293.
[13] E. Huguet, S. Corn, N. Le Moigne, and P. Ienny, "Single-fibre tensile testing of plant fibres: set-up compliance as a key parameter for reliable assessment of their mechanical behaviour," *Industrial Crops and Products*, vol. 222, Dec. 2024, doi: 10.1016/j.indcrop.2024.119762.
[14] F. Mesquita, C. Breite, S. V. Lomov, and Y. Swolfs, "In-situ synchrotron computed tomography tensile testing of composite specimens to estimate fibre strength weibull parameters," *Composites Science and Technology*, vol. 229, Oct. 2022, doi: 10.1016/j.compscitech.2022.109710.
[15] J. Yan, E. Demirci, and A. Gleadall, "Single-filament-wide tensile-testing specimens reveal material-independent fibre-induced anisotropy for fibre-reinforced material extrusion additive manufacturing," *Rapid Prototyping Journal*, vol. 29, no. 7, pp. 1453–1470, Jul. 2023, doi: 10.1108/RPJ-09-2022-0301.
[16] B. Fazlali, S. V. Lomov, and Y. Swolfs, "Reducing stress concentrations in static and fatigue tensile tests on unidirectional composite materials: a review," *Composites Part B: Engineering*, vol. 273, Mar. 2024, doi: 10.1016/j.compositesb.2024.111215.
[17] F. Alhussainy, H. A. Hasan, M. N. Sheikh, and M. N. S. Hadi, "A new method for direct tensile testing of concrete," *Journal of Testing and Evaluation*, vol. 47, no. 2, pp. 704–718, Mar. 2019, doi: 10.1520/JTE20170067.
[18] Q. Zhou, Y. Kan, F. Yu, M. Sun, and Y. Li, "A new small punch test method to predict tensile properties of steels: representative stress–strain method," *Theoretical and Applied Fracture Mechanics*, vol. 133, Oct. 2024, doi: 10.1016/j.tafmec.2024.104587.
[19] S. F. Resan, S. M. Chassib, S. K. Zemam, and M. J. Madhi, "New approach of concrete tensile strength test," *Case Studies in Construction Materials*, vol. 12, Jun. 2020, doi: 10.1016/j.cscm.2020.e00347.
[20] J. Liu *et al.*, "Evaluating a new method for direct testing of rock tensile strength," *International Journal of Rock Mechanics and Mining Sciences*, vol. 160, Dec. 2022, doi: 10.1016/j.ijrmms.2022.105258.
[21] M. A. Suyuti, D. B. Darmadi, Winarto, and P. H. Setyarini, "Enhancing the tensile strength and morphology of sansevieria trifasciata laurentii fibers using liquid smoke and microwave treatments: an RSM approach," *Scientific Reports*, vol. 15, no. 1, Feb. 2025, doi: 10.1038/s41598-025-88791-x.
[22] M. Brebu, "Environmental degradation of plastic composites with natural fillers—a review," *Polymers*, vol. 12, no. 1, Jan. 2020, doi: 10.3390/polym12010166.
[23] L. Teng, H. Huang, K. H. Khayat, and X. Gao, "Simplified analytical model to assess key factors influenced by fiber alignment and their effect on tensile performance of UHPC," *Cement and Concrete Composites*, vol. 127, 2022, doi: 10.1016/j.cemconcomp.2021.104395.
[24] S. Sabri *et al.*, "Tensile strength and fracture behavior of single abaca fiber," *Journal of Natural Fibers*, vol. 19, no. 14, pp. 8796–8810, Oct. 2022, doi: 10.1080/15440478.2021.1967832.
[25] R. Nur, A. N. Muttaqin, B. Nasrullah, and Dermawan, "The effect of volume, ball diameter, and milling time through the ball mill process of corncob," in *Proceedings of 7th International Conference on Industrial, Mechanical, Electrical and Chemical Engineering 2021 (ICIMECE 2021)*, AIP Publishing LLC, 2023, doi: 10.1063/5.0116172.
[26] A. H. Razak, A. N. Muttaqin, Y. Basongan, and R. Nur, "Enhancing the efficiency of rice harvesting: a study on the design and evaluation of ripper type rice harvesters," *E3S Web of Conferences*, vol. 517, Apr. 2024, doi: 10.1051/e3sconf/202451705001.
[27] V. Y. Palagala, J. D. Bhanushali, and M. Nithyadharan, "Characterization studies on calcium silicate boards and fibre cement boards used as sheathing in light gauge steel framed systems," *Structures*, vol. 51, pp. 684–706, May 2023, doi: 10.1016/j.istruc.2023.03.036.
[28] L. Pyl, K.-A. Kalteremidou, and D. Van Hemelrijck, "Exploration of specimen geometry and tab configuration for tensile testing exploiting the potential of 3D printing freeform shape continuous carbon fibre-reinforced nylon matrix composites," *Polymer Testing*, vol. 71, pp. 318–328, Oct. 2018, doi: 10.1016/j.polymertesting.2018.09.022.
[29] V. H. Martínez-Landeros, S. Y. Vargas-Islas, C. E. Cruz-González, S. Barrera, K. Mourtazov, and R. Ramírez-Bon, "Studies on the influence of surface treatment type, in the effectiveness of structural adhesive bonding, for carbon fiber reinforced composites," *Journal of Manufacturing Processes*, vol. 39, pp. 160–166, Mar. 2019, doi: 10.1016/j.jmapro.2019.02.014.
[30] E. Wantahe and P. Bigambo, "Review of sansevieria ehrenbergii (SE) leaf fibers and their potential applications," *Cellulose*, vol. 30, no. 15, pp. 9241–9259, Oct. 2023, doi: 10.1007/s10570-023-05481-5.
[31] A. Abdullah, M. Abony, M. Islam, M. Hasan, M. Oyon, and M. B. Rahman, "Extraction and proximate study of sansevieria trifasciata L. as fibre source for textile and other uses," *Journal of the Asiatic Society of Bangladesh, Science*, vol. 46, no. 2, pp. 155–162, Jun. 2021, doi: 10.3329/jasbs.v46i2.54411.

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