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Retraction

Retracted: Mechanical Characterization of Biocomposites Reinforced with Untreated and 4% NaOH-Treated Sisal and Jute Fibres

Advances in Materials Science and Engineering

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This article has been retracted by Hindawi, as publisher, following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of systematic manipulation of the publication and peer-review process. We cannot, therefore, vouch for the reliability or integrity of this article.

Please note that this notice is intended solely to alert readers that the peer-review process of this article has been compromised.

Wiley and Hindawi regret that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

References

[1] D. P. Archana, H. N. Jagannatha Reddy, and B. Paruti, "Mechanical Characterization of Biocomposites Reinforced with Untreated and 4% NaOH-Treated Sisal and Jute Fibres," *Advances in Materials Science and Engineering*, vol. 2022, Article ID 7777904, 11 pages, 2022.

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Research Article

Mechanical Characterization of Biocomposites Reinforced with Untreated and 4% NaOH-Treated Sisal and Jute Fibres

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Composites reinforced with natural fibres have gained popularity compared to synthetic fibre-reinforced polymer composites due to their environmental sustainability, despite their reduced stiffness and load-bearing capability. In this work, the biocomposites reinforced with sisal and jute fibres which are made by hand layup technique were investigated for mechanical and water absorption characteristics. The effect of a 4 percent NaoH treatment concentration on the aforementioned properties was investigated. The specimens' tensile and flexural broken surfaces were morphologically characterized to investigate microstructural failures. The experimental results show that, compared to untreated fibre-reinforced composites, the biocomposites reinforced with 4 percent NaoH-treated fibre exhibit higher tensile, flexural, and impact strengths, as well reduced water absorption rate. These composites are aimed to be used for strengthening existing civil structures as a retrofitting element.

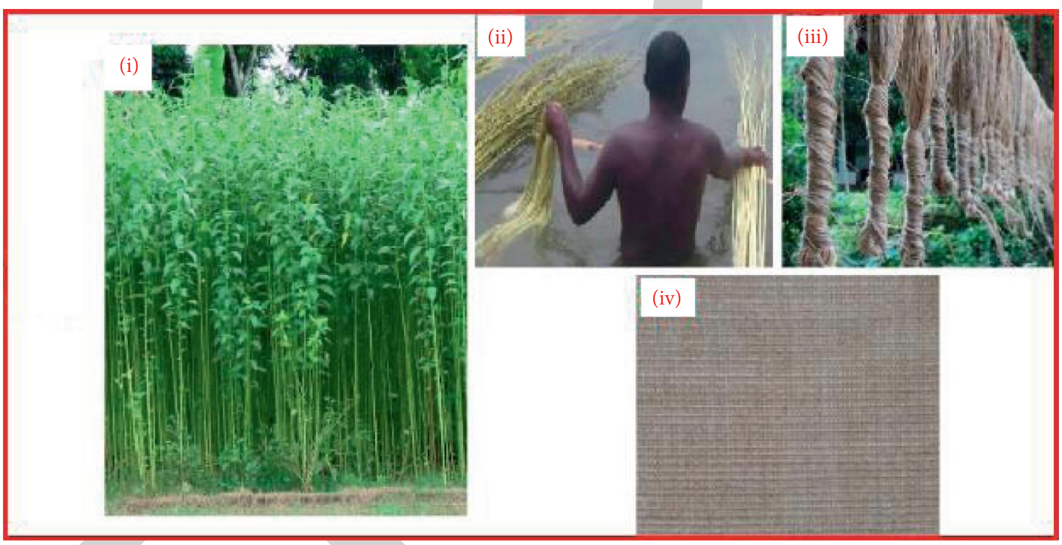
1. Introduction

Fibre-based composites have been widely investigated from the past many years, and a thorough study into their features and characteristics has permitted their use in a variety of engineering fields [1]. Apart from the major benefits of biocomposites, they also have some drawbacks, such as high moisture absorption, less strength than synthetic composites, incompatibility with fibres and matrices, limitation in processing temperature, quality variability, and less durability. Physical and chemical treatment of fibre is a viable method for overcoming the aforementioned drawbacks [1]. Natural fibre-reinforced composite (NFRC) materials are attracting a lot of attention right now because of its light weight, long life cycle, biodegradability, low cost, and excellent mechanical qualities [2]. These composites are more environmental friendly than synthetic fibre, with lower toxicity, pollution, and recyclability. NFRCs are preferred over synthetic fibre-reinforced composites for current applications because of the aforementioned economic and environmental benefits [3]. NFRCs have been shown to be a good alternative for synthetic fibre-based polymer composites and are used in a variety of advanced applications in engineering [4]. Due to the intrinsic features of natural fibre, researchers are confronted with various hurdles in the development and implementation of NFRCs. The main challenges include fibre quality, water absorption capacity, thermal stability, and incompatibility in polymer matrices. In view of sustainability, eco-friendliness, and economic standpoint, Khalid et al [2] examined some of the major breakthroughs related to NFRCs. It also involves several chemical treatment processes, as well as the hybridization with synthetic fibres of NFs, which is a highly efficient means of increasing the mechanical characteristics of NFRCs. Vignesh et al [4] used a compression moulding process to make natural fibre polymeric composites with varied weight percents and then examined their properties. Increases in fibre weight percent resulted in improved properties, and the material was able to endure temperatures of up to 84°C in a heat deflection test. Supian et al [5] looked into the characteristics of hybrid composites that might be used for nonstructural and semistructural purposes. Das et al [6] pointed out that the stacking sequence and fibre hybridization had a substantial impact on the hybrid laminates' mechanical and thermo-mechanical characteristics. M. Glavind [7] conducted a research that endeavors promoting technology for achieving sustainability in the field of civil construction. They have focused on materials for replacement of cement, manufacturing of concrete structures and their life cycle, utilization, as well as on the concrete demolition and recycling choices. Upcoming trends and issues related to construction materials which are sustainable in nature were also discussed. According to Vilaplana et al [8], the goal of sustainable development in product design and materials could only be achieved through the crop growth sustainability integration, extraction of raw material, synthetic fibre replacement and modification procedure, methods of product manufacturing and material processing, service life application, and appropriate management of waste materials. Madurwar et al [9] found that the diverse agro-waste-based composite materials were comparatively cheaper construction materials, were light in weight and durable, have reduced thermal conductivity, and were eco-friendly, based on many works of literature offered in their study. As a result, the research, which focused on the use of agro-waste, was extremely useful for developing countries. P. Kandachar [10] conducted a thorough investigation into the significance of natural fibre in achieving the goal of social sustainability, concluding that these raw materials had the potential to contribute to the social sustainability of people in developing countries like India through appropriate policy matter measures and design approaches in a scientific manner. The usage of natural fibre based fabrics, according to Cristaldi et al [11], has significant environmental and cost benefits. The study also stated that the use of natural fibre mats, as well as their hybridization with various textiles and different layups, as well as various manufacturing techniques, should all be investigated and developed in order to capture all of the benefits associated with natural fibre utilization. Sapuan et al [12] tested woven banana fibre composites of various geometries for tensile and flexural properties and found them to be very stable. A. C. Milanese et al [13] investigated woven sisal fibre in polyurethane and phenolic matrices individually. Untreated woven sisal fibres were employed, and they were compression moulded after being thermally treated at 60°C for 72 hours to produce composites. Investigations to determine the effect of moisture content on the mechanical behaviour of sisal fibres have been considered. Sisal/phenolic composites exhibited a higher tensile strength than the sisal/polyurethane composites, according to the findings. Ratna Prasad et al [14] tested jowar fibre-reinforced polymer composites for their properties. Because jowar composites exhibited good strength and rigidity, for light-weight applications, they can be used as an alternative to sisal and bamboo fibre. Munikenche Gowda et al [15] found that jute as a reinforcing material has better qualities such as nonhazardous to health, nontoxic, eco-friendly, less cost, and easy availability compared to conventional fibre such as glass and Kevlar. Jute fibre composites also outperformed numerous wood composites and some polymers in terms of strength. Present research revealed that the strength of NFRPs can be improved by the fibre treatment [16–21]. Ray et al [22] did a study and found that treating jute fibre with 5% of NaOH at room temperature for varied periods of time improved their characteristics overall. According to A. Stocchi et al [23], alkali-treated jute fabric composites under stress for 4 hours showed a considerable improvement in stiffness. The research found that alkali-treated jute cloth composites had the highest strength values, regardless of the treatment period. Jawaid et al [24] stated that improvement in tensile and flexural properties of hybrid composites can be improved by incorporating woven jute fibres in pure oil palm. Fung et al [25] found that adding 10 wt. % sisal fibres to polypropylene matrix found increased tensile strength by roughly 10%, thus highlighting the potential of sisal fibres. But, when the composites were reinforced with sisal fibre that had been treated with high silane concentrations, Herrera-Franco et al [26] in their investigation found that the tensile strength of the composites has not improved to the considerable extent. Barreto et al [27] noticed that treating sisal fibre with NaOH solution has improved thermal stability in comparison with its raw form. Archana et al [28] reviewed various natural fibres owing to their structural and mechanical properties and described their potential for strengthening of existing structures. Hota et al [29] presented a comprehensive analysis of materials for civil engineering structures and innovation. They have focused on the sustainability and durability of civil structures. The work revealed that FRP composite materials are used for civil structures with regard to energy-efficient modular structures. The work highlights the processing methods and characterization of natural FRP composites. Archana et al [30] have studied the properties of biodegradable composites to suit the strengthening of the existing structure. They noticed that heat-treated fibre-reinforced composites have resulted in better properties than the untreated fibre composites. Based on their performance under tests, they were concluded that natural fibre-reinforced polymer composites can be used as a substitute for artificial fibre-reinforced polymer composites. Archana et al. [31] showed experimentally that jute NFRC system can be used for posttensioned beam strengthening in the civil application, and it can be a better choice for replacing artificial fibre composites. Sen et al [32] studied the efficacy of jute FRP composite for retrofitting of existing beams, and they have compared it with the artificial fibre systems such as carbon and glass FRP. Results were witnessed that jute FRP could provide good results under shear behaviour. Sen et al. [33] investigated the RC beams strengthened with natural and artificial FRP systems. Natural sisal FRP demonstrated noticeable performance in comparison with artificial glass and carbon FRP under flexural strengthening. This paper elucidates the significance and applicability of NFRCs such as sisal and jute fibre-reinforced polymer composites, which helps the researchers for future research works.

2. Materials and Methods

2.1. Preparation of Composites. Here, in this research work, two natural fibres mats are considered, namely Agave sisalana and Corchorus olitorius fibres, procured from Extraweave Pvt. Ltd., Kerala. Agave sisalana fibre is extracted from plant leaves, and Corchorus olitorius fibre is extracted from the stem of the matured plant. Figures 1(a) and 1(b) show the Agave sisalana fibre and Corchorus olitorius fibre extraction process. For

(a)



(b)

FIGURE 1: Fibre extraction process. (a) Extraction of sisal fibre, (i) sisal plant, (ii) fibre extraction process, (iii) a bundle of fibre, and (vi) fibre mat used in the study. (b) Extraction of Jute fibre, (i) jute plant, (ii) fibre extraction process, (iii) a bundle of fibre, and (vi) fibre mat used in the study.

composite fabrication, diglycidyl ether bisphenol A (LAPOX L12) epoxy resin was used along with the hardener triethylene tetra amine (TETA), procured with M/s Yuje Enterprises, Bengaluru, India. For the fabrication of composites, hand layup technique was used. Before manufacturing, the fibre mats were alkali treated with 4% NaOH solution [28], following standard procedure. A wooden mould coated with the releasing agent of 300 × 150 × 3.5 mm size was used. The required quantity of resin and hardener was mixed. This mixture is poured into the mold where the fibre mat is placed. The mould setup is allowed for infiltration during which matrix is infiltered into the fibre. The entrapped air was removed using a roller. Thereafter, a pressure of 0.2616 Kgf/cm^2 was applied. The mould is allowed for 24 hours at room temperature undisturbed for curing. Figure 2 shows the process of composite preparation. Figure 3 demonstrates the methodology adopted for the work.

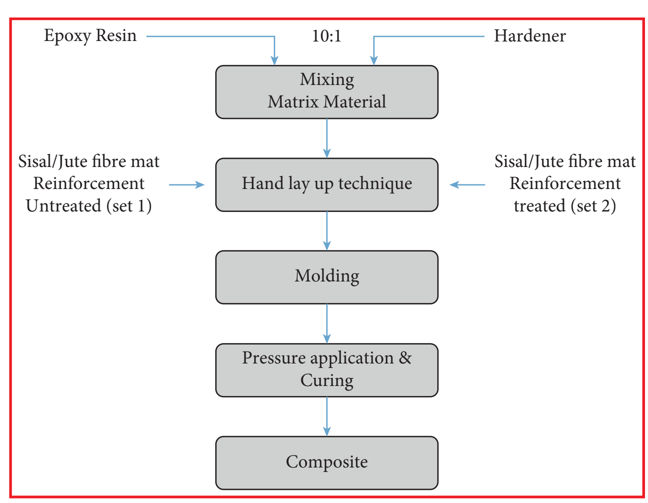


FIGURE 2: Flowchart of Composite preparation.

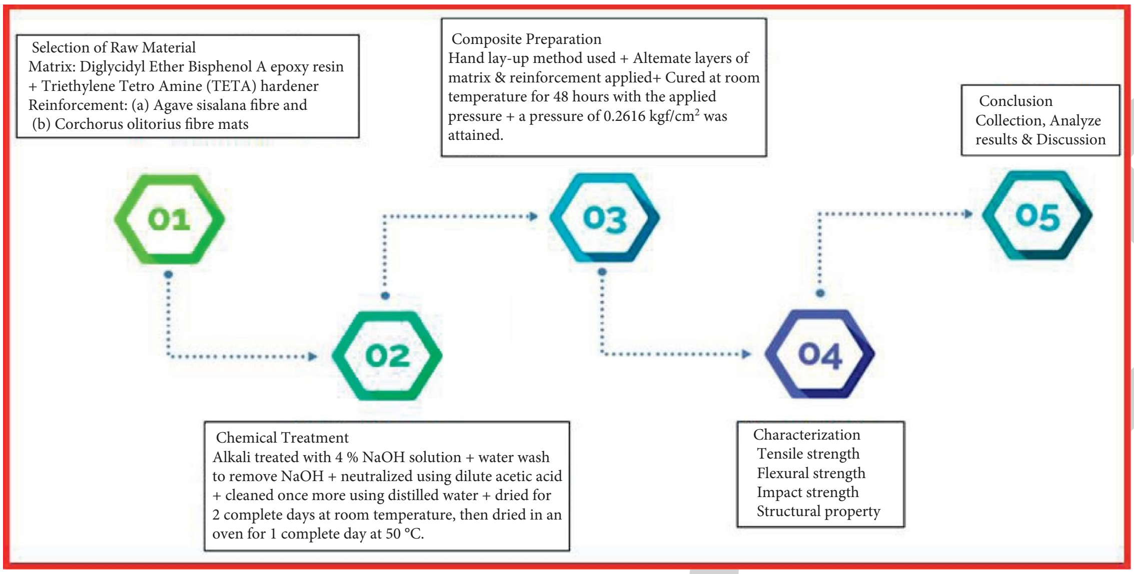


Figure 3: Methodology adopted for the work.

2.2. Surface Treatment of Fibre. In past, researchers have considered various chemical treatments to treat the natural fibres, and their effect on associated properties was studied [16, 34]. In this chemical treatment, hydroxyl groups (OH) react with chemical agents. In this study, cellulose fibres are treated with alkali (NaOH). Alkali removes hemicellulose lignin partially and also wax and other impurities. The concentration of NaOH and soaking time are used as a measure of effectiveness based on the effect they create. Figure 4 describes the preparation, treatment, and testing of prepared NFRCs.

2.3. Characterizations

2.3.1. Mechanical Tests. The tensile test was performed using the universal testing machine (make: Kalpak Instruments and Controls, Pune, Model: KIC-2-1000-C, 100 kN capacity), as shown in Figure 5, at a 2 mm/min cross-head speed and a 50 mm gauge length, as per ISO 527-4:1997(E) Part-4. The flexural test was carried out as per ISO 14125 : 1998 standard with the help of a three-point bending rig at a 2 mm/min cross-head speed and a 50 mm gauge length. The impact test was carried out as per ISO 18039 using an Izod impact machine, demonstrated in Figure 6. Specimen dimensions are shown in Figure 7. All the above-mentioned tests were conducted at room temperature. In each combination, three samples were tested, and average values were taken.

2.3.2. Water Absorption Test. The water absorption test was carried out as per the ASTM D570 standard. The specimen was weighed in a dried condition using a digital scale (mass m_1) before being immersed in water in a beaker. After withdrawing the sample from the water for 12 hours, it was weighed (mass m_2). The percent water absorption was calculated. For this purpose, difference in weight between samples before and after immersion in water was considered. The % absorption is given according to

$$(\%)\text{absorption} = \left(\frac{W_2 - W_1}{W_1}\right) * 100, \quad (1)$$

where W_2 refers to the weight of the specimen in grams after it has been removed from the water, while W_1 refers to the weight of the specimen before it has been soaked in water. Using mass balance testing, the weight of the specimen was estimated with a precision of 0.0001 g.

2.3.3. Electron Microscopy. The failure mechanism and microstructure of the prepared composites were analyzed using a Vega 3 Tescan which is a scanning electron microscope. Images were acquired with an SEM at a voltage of 26 kV at a working distance of 30 to 40 mm. To study the fracture morphology, samples were cut from the broken end of the composite surface.

3. Results and Discussion

3.1. Water Absorption Behaviour. From the present research work, it is seen that water uptake in lignocellulose fibre-based composites can be minimized by chemically treating the fibres to improve bonding between the hydrophilic lignocellulose fibres and the hydrophobic matrix system. Water intake of 4% NaOH-treated FRCs was found to be lower than that of the untreated FRCs. This demonstrated that the 4% NaOH-treated fibres exhibit better interfacial adhesion with the epoxy matrix.

3.2. Effect of Chemical Treatment on Tensile Strength. Figure 8(a) shows the effect of surface treatment with 4% concentration of NaOH solution of sisal and jute fibres on the tensile strength of composites. For the proportions evaluated in the study, treated fibre-reinforced composites show a higher value of tensile strength compared to untreated fibre-reinforced composites for both fibres, which

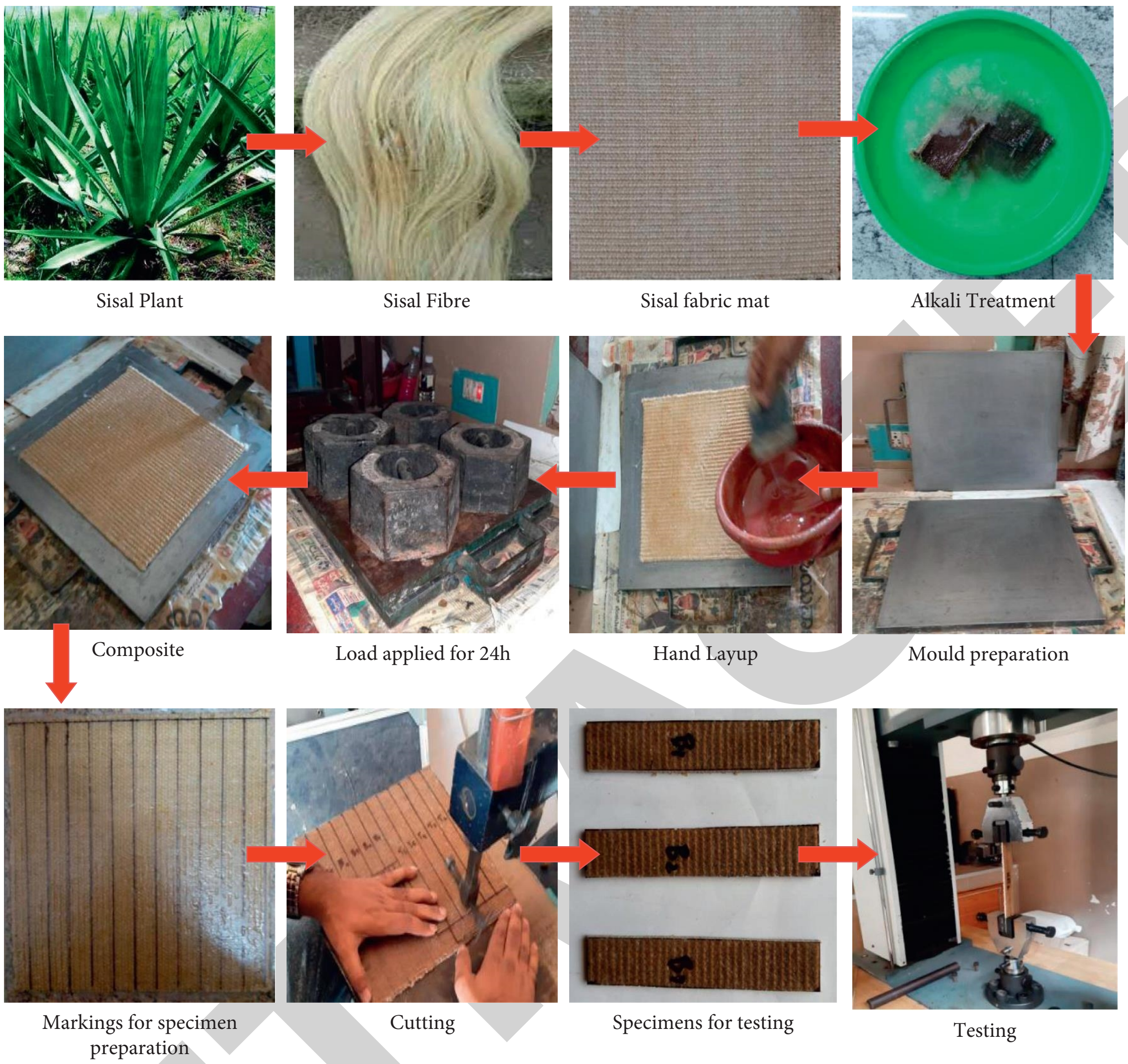


FIGURE 4: Preparation and testing of sisal fibre-reinforced composites.

was about 28 and 23 percent greater than the untreated composite reinforced with respective fibre. This demonstrates that the fibres that had been treated with NaOH exhibited greater epoxy matrix interfacial adhesion. Improved adhesion between the fibre and the matrix enhances stress distribution, increases load-carrying capacity, and improves tensile strength of the composites. Removal of hemicellulose and lignin from the fibre surface caused by treatment with alkali resulted in the formation of micropores on the fibre surface.

3.3. Effect of Chemical Treatment on Flexural Strength. The sisal and jute fibres were treated with a 4 percent concentration of NaOH solution which improves the flexural characteristics of the SNFRC and JNFRC, and the results are presented in Figure 8(b). The flexural strengths of sisal and jute fabric-reinforced composites treated with 4% NaOH were found to be higher, about 10 and 13 percent greater than the untreated composite reinforced with respective fibre. This could be because the fibres and epoxy matrix have better interfacial adhesion.

3.4. Effect of Chemical Treatment on Impact Strength. The material's impact strength determines how well it absorbs energy under high impact loads. The impact strength of composites depends on fibre reinforcement, filler-matrix interface, void presence, filler influence, and testing conditions. Figure 8(c) illustrates the effect of treatment on the impact strength of untreated and also 4 percent NaOH-treated SFRC and JFRC, respectively. It observed that, like the tensile and flexural characteristics, the impact strength of treated fibre-reinforced composites improved significantly. The impact strength of the composites reinforced with 4% NaOH-treated sisal and jute fibres was 1.69 J/mm^2 and 1.28 J/mm^2, respectively, which was 6.39 and 14 percent greater than the untreated composite reinforced with respective fibre. Due to the existence of microfractures in the interfacial region, the incorporation of untreated fibres in the epoxy

Figure 5: (a) Universal testing machine used for the tensile and flexural test (Make: Kalpak Instruments and Controls, Pune, Model: KIC-2-1000-C with the capacity of 100 kN). (b) Tensile test arrangement. (c) Bending test arrangement.

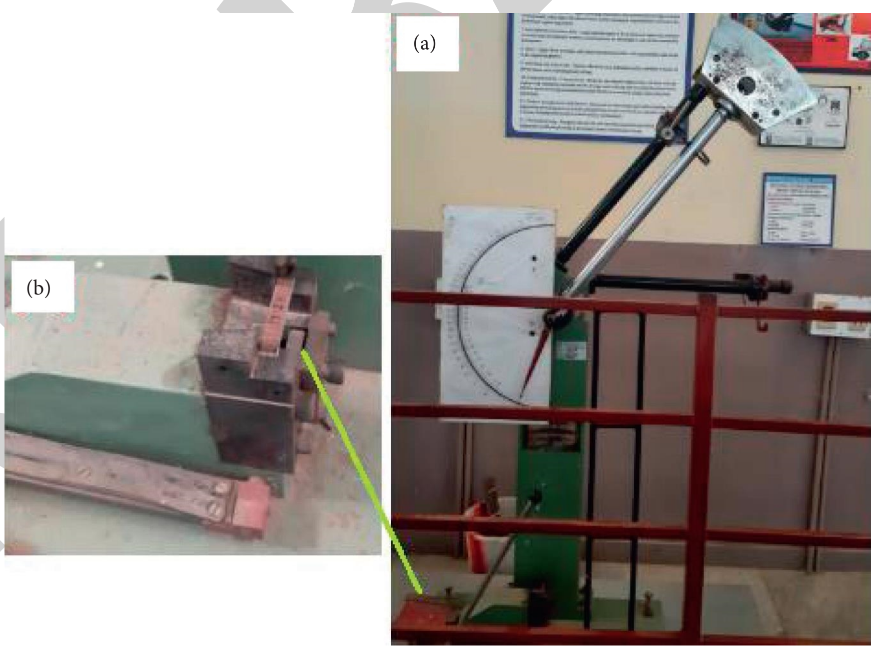


Figure 6: (a) Impact testing machine. (b) Izod test arrangement.

matrix led to poor interfacial adhesion, resulting in reduced mechanical characteristics [35]. When the material is loaded, the microcracks act as a failure mechanism, which causes the failure of composites completely. Furthermore, the impact behaviour of composites is largely determined by fibre pullout [36]. Due to strong interfacial adhesion between the fibre and matrix, the 4 percent of NaOH-treated composites show reduced fibre pullout, resulting in higher impact strength. Properties of prepared composites measured in the laboratory are tabulated in Table 1.

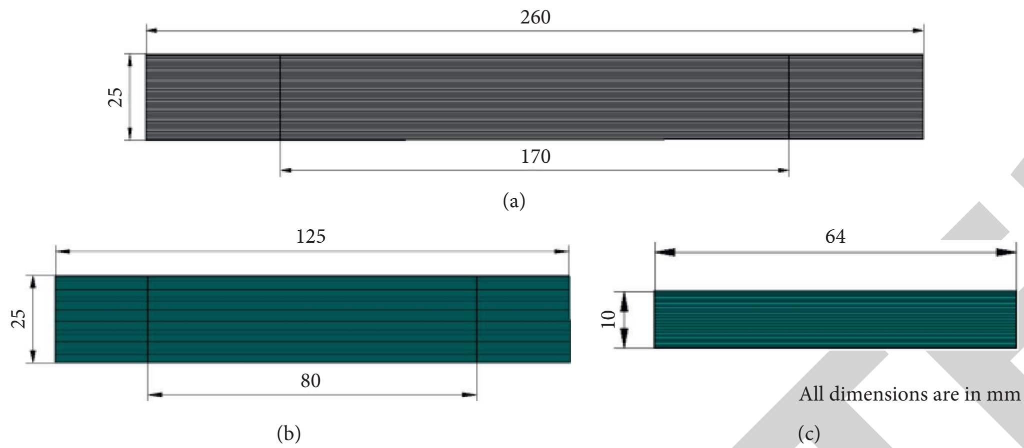


Figure 7: Specimen dimensions as per standards. (a) Tensile test specimen. (b) Flexural test specimen. (c) Impact test specimen.

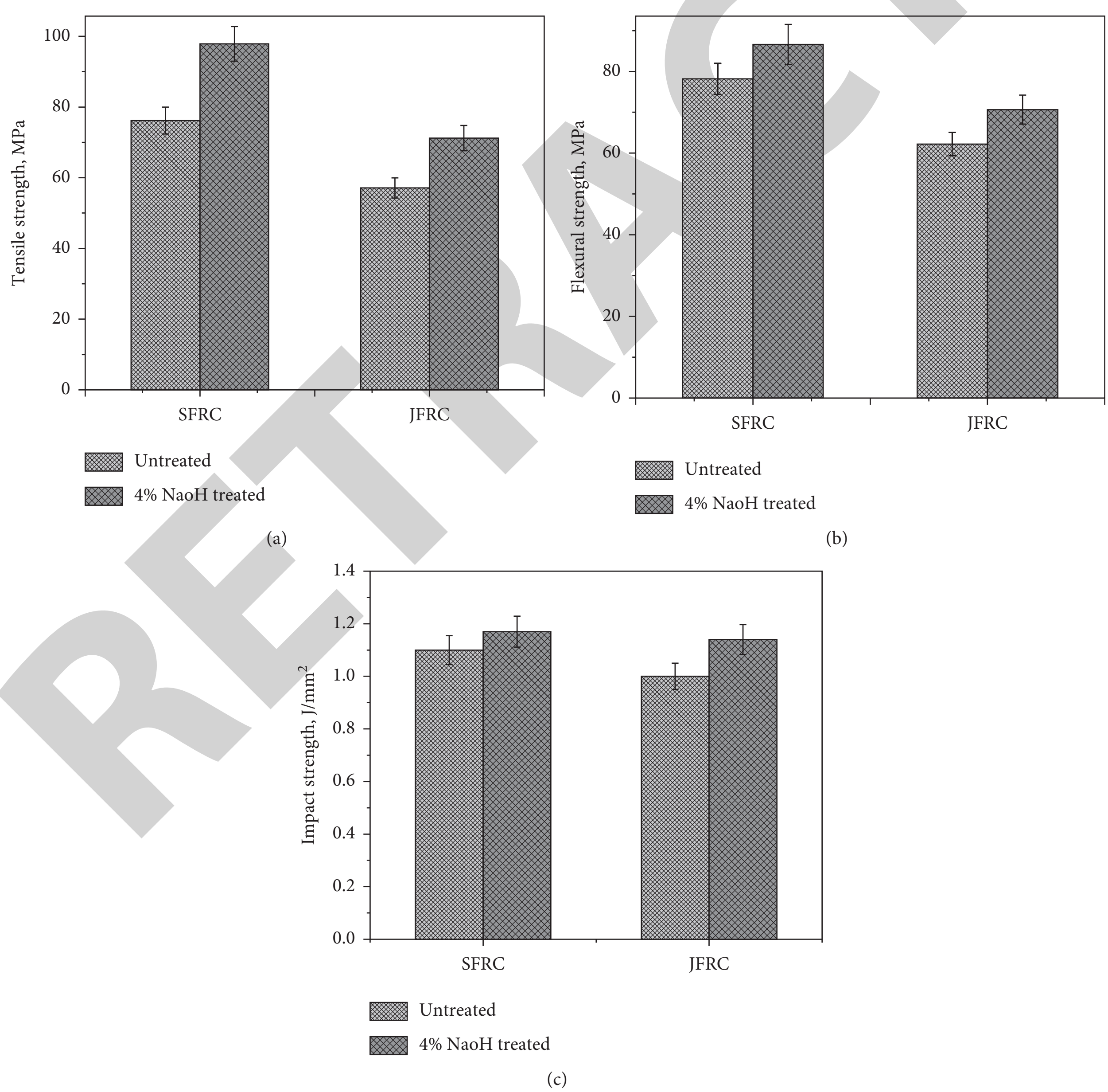


Figure 8: Characteristics of SFRC and JFRC. (a) Tensile strength. (b) Flexural strength. (c) Impact strength.

Table. 1: Properties of fabricated composites.

Composite	Tensile strength (MPa)		Flexural strength (MPa)		Impact strength (J/mm^2)	
	Untreated	4% NaoH treated	Untreated	4% NaoH treated	Untreated	4% NaoH treated
SNFRC	76.14	97.88	78.19	86.64	1.1	1.17
JNFRC	57.12	71.21	62.22	70.65	1.0	1.14

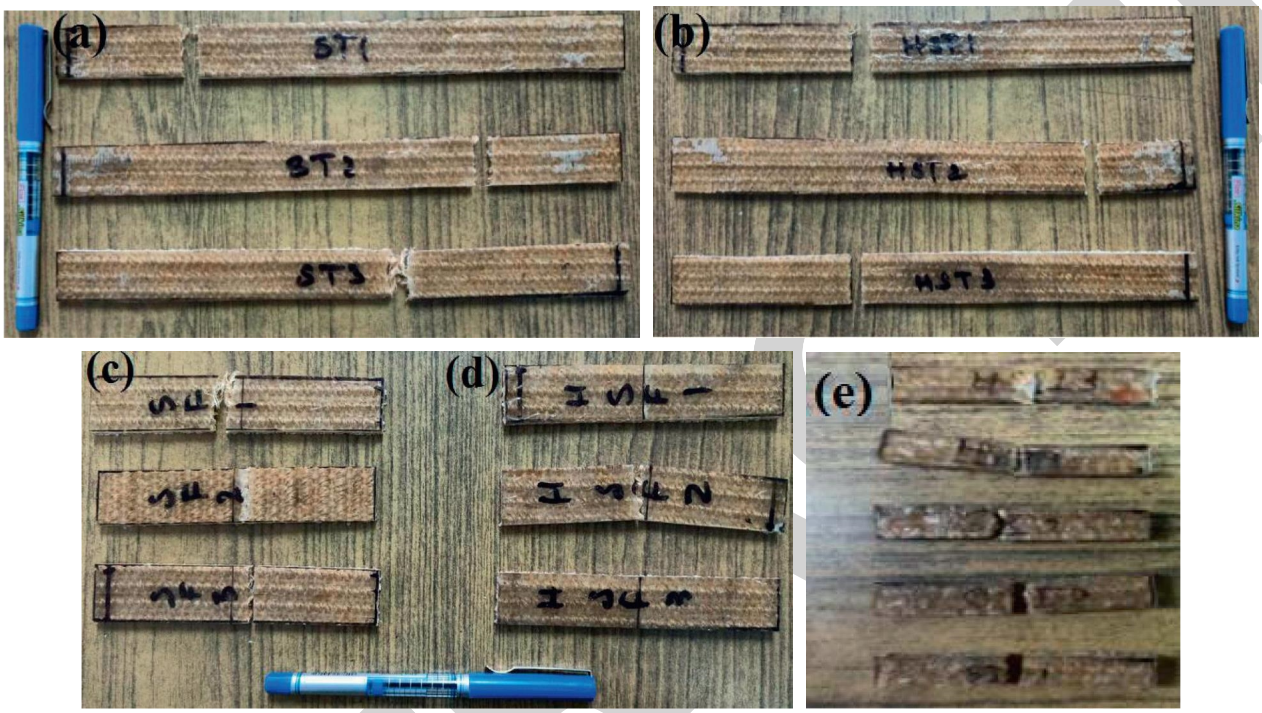


Figure 9: Sisal fabric-reinforced composites. (a) Untreated-fractured tensile specimens. (b) Heat-treated-fractured tensile specimens. (c) Untreated-fractured flexure specimens. (d) Heat-treated-fractured specimens undergo flexural failure. (e) Impact test fractured specimens.

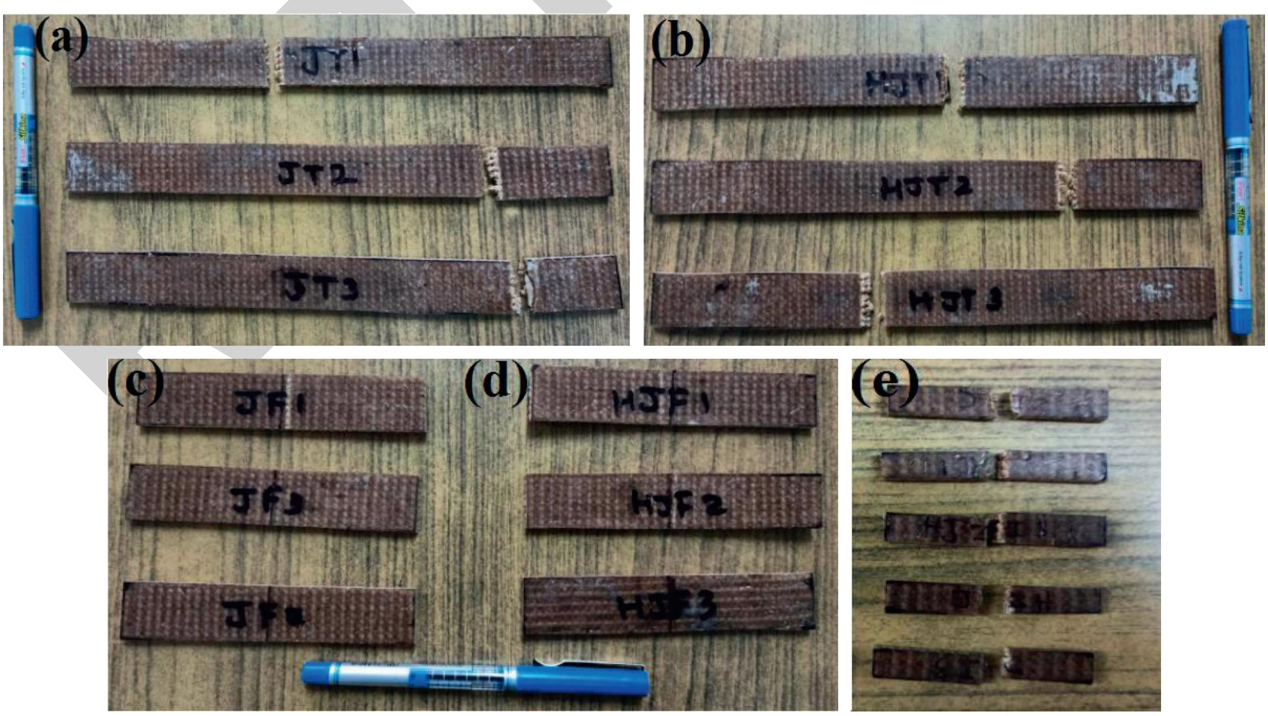


Figure 10: Jute fabric-reinforced composites. (a) Untreated-fractured tensile specimens. (b) Heat-treated-fractured tensile specimens. (c) Untreated-fractured flexure specimens. (d) Heat-treated-fractured specimens undergo flexural failure. (e) Impact test fractured specimens.

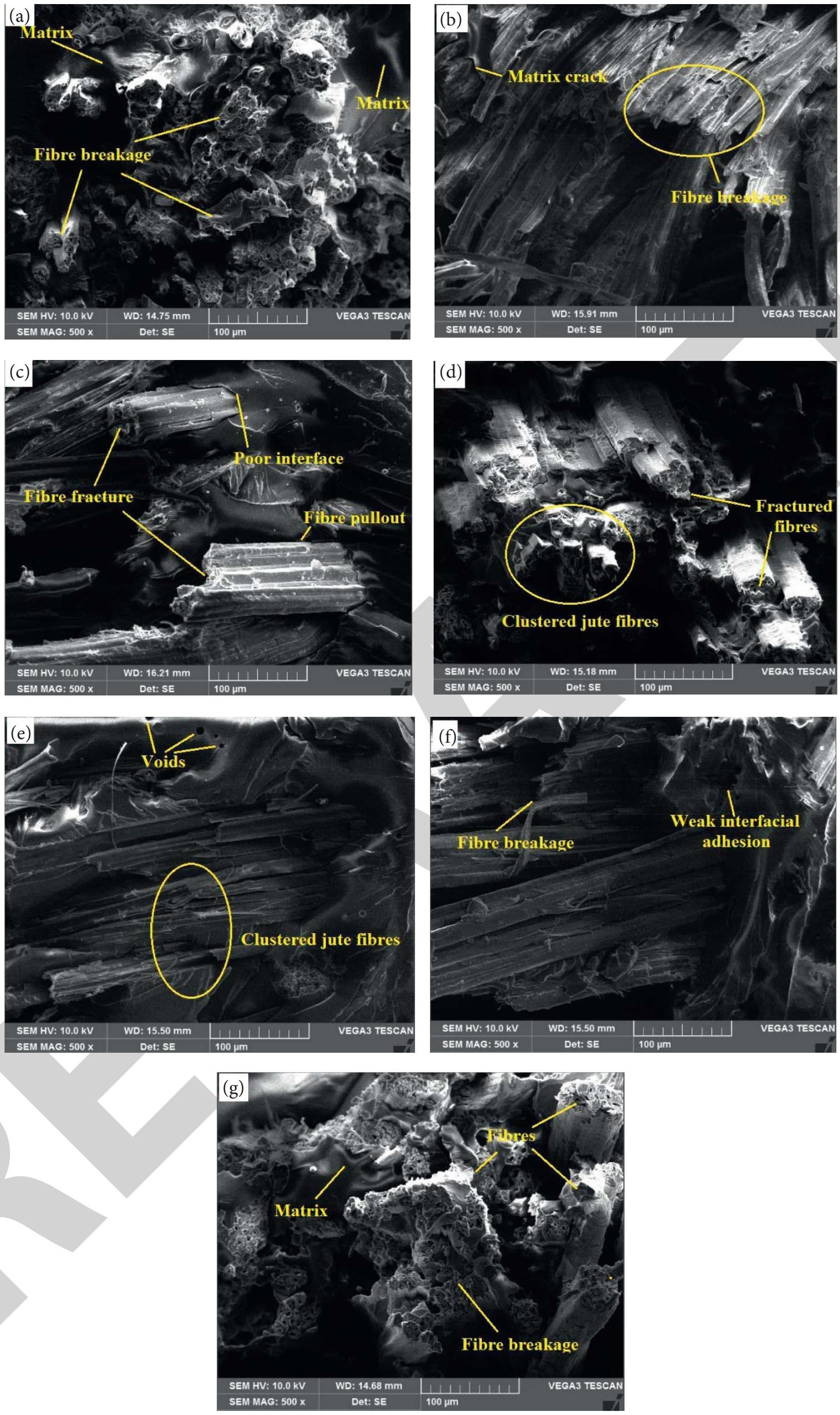


FIGURE 11: Fracture surfaces of tensile and flexural test specimens. (a) Sisal-untreated tensile. (b) Jute-untreated flexural. (c) Sisal 4% NaoH-treated tensile. (d) Jute 4% NaoH-treated tensile. (e, f) Jute 4% NaoH-treated flexural. (g) Sisal 4% NaoH-treated flexural.

3.5. Scanning Electron Microscope (SEM) Analysis. SEM images of tensile and flexural-tested specimens (shown in Figures 9 and 10) were taken to investigate tensile failure in composites. They were used to study the interfacial characteristics, fractured specimen interior structure, and the development of internal cracks. The fracture surface appearance of the modified sisal and jute fibre-reinforced composites is shown in Figure 11. Because of the weak bonding between the matrix and the fibre in fracture surfaces, fibre pullout may be seen in micrographs. The alkali treatment improves, somewhat, the bonding between fibre and the matrix. The pullout of fibres leaves just a few holes, owing to poor compatibility between the hydrophilicity of the untreated fibre and the hydrophobicity of the matrix [37]. After the modification, the holes are reduced, and more number of fibre breaks are appeared, indicating that the composite has a good interface. This modification procedure is particularly effective since an alkali and heat treatment may help the composite material develop a good interface [38].

4. Conclusions

The hand layup approach was used to effectively fabricate natural fibre-reinforced polymer composites (SNFRC and JNFRC), and the tensile, flexural, impact, and water absorption characteristics were examined. In the research, the influence of NaOH treatment on the above properties was investigated, and the following findings were obtained.

(i) Composites with 4% NaOH-treated sisal and jute fibre reinforcement had better mechanical properties such as tensile, flexural, and impact characteristics which is because of improved adhesion between the fibre and matrix interface.

(ii) The morphological analysis demonstrated that using treated fibre-reinforced composite systems increased the bonding and resulted in superior mechanical properties.

(iii) In both SNFRP and JNFRP cases, the treated fibre-reinforced composites demonstrated decreased water absorption rates due to improved hydrophobicity of the composites compared with untreated fibres.

From the present work, it can be concluded that the sisal and jute fibre treated with 4% NaoH are the best reinforcements for the development of epoxy-based matrix composites. These composites may be used in both domestic and industrial applications for low and medium loads.

Data Availability

The data used to support the findings of this study are included within the article.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

References

[1] S. Sekar, V. Shanmugam, S. Kumar et al., "Effects of water absorption on the mechanical properties of hybrid natural fibre/phenol formaldehyde composites," *Scientific Reports*, vol. 11, 2021.

[2] M. Y. Khalid, A. Rashid, and Z. U. Arif, W. Ahmed and H. Arshad, Natural fiber reinforced composites: sustainable materials for emerging applications," *Results in Engineering*, vol. 11, p. 100263, 2021.

[3] D. K. Rajak, D. D. Pagar, P. L. Menezes, and E. Linul, "Fiber-reinforced polymer composites: manufacturing, properties, and applications," *Polymers*, vol. 11, no. 10, p. 1667, 2019.

[4] V. Vignesh, A. N. Balaji, N. Nagaprasad, M. R. Sanjay, A. Khan, and A. M. Asiri, G. M. Ashraf and S. Siengchin, Indian mallow fiber reinforced polyester composites: mechanical and thermal properties," *Journal of Materials Research and Technology*, vol. 11, pp. 274–284, 2021.

[5] A. B. M. Supian, M. Jawaid, B. Rashid et al., "Mechanical and physical performance of date palm/bamboo fibre reinforced epoxy hybrid composites," *Journal of Materials Research and Technology*, vol. 15, pp. 1330–1341, 2021.

[6] S. C. Das, D. Paul, S. A. Grammatikos et al., "Effect of stacking sequence on the performance of hybrid natural/synthetic fiber reinforced polymer composite laminates," *Composite Structures*, vol. 276, p. 114525, 2021.

[7] M. Glavind, "Sustainability of cement, concrete and cement replacement materials in construction," *Sustainability of Construction Materials*, Woodhead Publishing Limited, Cambridge, UK, 2009.

[8] F. Vilaplana, E. Stromberg, and S. Karlsson, "Environmental and resource aspects of sustainable biocomposites," *Polymer Degradation and Stability*, vol. 95, no. 11, pp. 2147–2161, 2010.

[9] M. V. Madurwar, R. V. Ralegaonkar, and S. A. Mandavgane, "Application of agro-waste for sustainable construction materials: a review," *Construction and Building Materials*, vol. 38, pp. 872–878, 2013.

[10] P. Kandachar, "Materials and social sustainability," *Materials Experience*, Delft University of Technology, Book Chapter, 2014.

[11] G. Cristaldi, *Alberta Latteri, Giuseppe Recca and Gianluca Cicala, Composites Based on Natural Fibre Fabrics, Woven Fabric Engineering*, InTech, Sciyo, Book Chapter, 2010.

[12] S. M. Sapuan, A. Leenie, M. Harimi, and Y. K. Beng, "Mechanical properties of woven banana fibre reinforced epoxy composites," *Materials & Design*, vol. 27, no. 8, pp. 689–693, 2006.

[13] A. C. Milanese, M. O. H. Cioffi, and H. J. C. Voorwald, "Mechanical behavior of natural fiber composites," *Procedia Engineering*, vol. 10, pp. 2022–2027, 2011.

[14] A. V. Ratna Prasad and K. Mohana Rao, "Mechanical properties of natural fibre reinforced polyester composites: jowar, sisal and bamboo," *Materials & Design*, vol. 32, no. 8-9, pp. 4658–4663, 2011.

[15] T. Munikenche Gowda, A. C. B. Naidu, and R. Chhaya, "Some mechanical properties of untreated jute fabric-reinforced polyester composites," *Composites Part A: Applied Science and Manufacturing*, vol. 30, no. 3, pp. 277–284, 1999.

[16] M. M. Kabir, H. Wang, K. T. Lau, and F. Cardona, "Chemical treatments on plant-based natural fibre reinforced polymer composites: An overview," *Composites Part B: Engineering*, vol. 43, no. 7, pp. 2883–2892, 2012.

[17] F. Sarasini, J. Tirillo, C. Sergi, M. C. Seghini, L. Cozzarini, and N. Graupner, "Effect of basalt fibre hybridisation and sizing removal on mechanical and thermal properties of hemp fibre reinforced HDPE composites," *Composite Structures*, vol. 188, pp. 394–406, 2018.

[18] J. Bessa, J. Matos, C. Mota et al., "Influence of surface treatments on the mechanical properties of fibre reinforced thermoplastic composites," *Procedia Engineering*, vol. 200, pp. 465–471, 2017.

[19] V. Fiore, T. Scalici, and A. Valenza, "Effect of sodium bicarbonate treatment on mechanical properties of flax-

reinforced epoxy composite materials," *Journal of Composite Materials*, vol. 52, no. 8, pp. 1061–1072, 2018.

[20] U. Huner, "Effect of chemical surface treatment on flax-reinforced epoxy composite," *Journal of Natural Fibers*, vol. 15, no. 6, pp. 808–821, 2018.

[21] C. M. Wu, W. Y. Lai, and C. Y. Wang, "Effects of surface modification on the mechanical properties of flax/β-polypropylene composites," *Materials*, vol. 9, no. 5, pp. 314–411, 2016.

[22] D. Ray, B. K. Sarkar, A. K. Rana, and N. R. Bose, "The mechanical properties of vinyl ester resin matrix composites reinforced with alkali-treated jute fibres," *Composites Part A: Applied Science and Manufacturing*, vol. 32, no. 1, pp. 119–127, 2001.

[23] A. Stocchi, B. Lauke, A. Vazquez, and C. Bernal, "A novel fiber treatment applied to woven jute fabric/vinylester laminates," *Composites Part A: Applied Science and Manufacturing*, vol. 38, no. 5, pp. 1337–1343, 2007.

[24] M. Jawaid, H. P. S. Abdul Khalil, and A. Abu Bakar, "Woven hybrid composites: tensile and flexural properties of oil palm-woven jute fibres based epoxy composites," *Materials Science and Engineering A*, vol. 528, no. 15, pp. 5190–5195, 2011.

[25] K. L. Fung, X. S. Xing, R. K. Y. Li, S. C. Tjong, and Y. W. Mai, "An investigation on the processing of sisal fibre reinforced polypropylene composites," *Composites Science and Technology*, vol. 63, no. 9, pp. 1255–1258, 2003.

[26] P. J. Herrera-Franco and A. Valadez-Gonzalez, "Mechanical properties of continuous natural fibre-reinforced polymer composites," *Composites Part A: Applied Science and Manufacturing*, vol. 35, no. 3, pp. 339–345, 2004.

[27] A. C. H. Barreto, D. S. Rosa, P. B. A. Fechine, and S. E. Mazzetto, "Properties of sisal fibers treated by alkali solution and their application into cardanol-based bio composites," *Composites Part A: Applied Science and Manufacturing*, vol. 42, no. 5, pp. 492–500, 2011.

[28] D. P. Archana, H. N. Jagannatha Reddy, R. Prabhakara, M. U. Aswath, and A. Chandrashekar, "Processing and properties of biodegradable composites to strengthen structures," *Journal of the Institution of Engineers: Series C*, vol. 103, pp. 39–52, 2021.

[29] G. Hota and R. Liang, "Advanced fiber reinforced polymer composites for sustainable civil infrastructures," in *Proceedings of the International Symposium on Innovation & Sustainability of Structures in Civil Engineering*, Xiamen University, Xiamen, China, 2011.

[30] D. P. Archana, H. N. Jagannatha Reddy, N. Jeevan, R. Prabhakara, M. U. Aswath, and B. Paruti, "Natural jute fibre reinforced polymer composite system for post tensioned beam strengthening in flexure," *Advances in Materials Science and Engineering*, vol. 2021, pp. 1–14, 2021.

[31] D. P. Archana and H. N. Jagannatha Reddy, "Potential of natural fibres for strengthening existing structures - a Review," *International Journal of Structural Engineering and Analysis*, vol. 4, no. 2, 2018.

[32] T. Sen and H. Jagannatha Reddy, "Efficacy of bio derived jute FRP composite based technique for shear strength retrofitting of reinforced concrete beams and its comparative analysis with carbon and glass FRP shear retrofitting schemes," *Sustainable Cities and Society*, vol. 13, pp. 105–124, 2014.

[33] T. Sen and H. N. J. Reddy, "Flexural strengthening of RC beams using natural sisal and artificial carbon and glass fabric reinforced composite system," *Sustainable Cities and Society*, vol. 10, pp. 195–206, 2014.

[34] S. Kalia, B. S. Kaith, and I. Kaur, "Pretreatments of natural fibers and their application as reinforcing material in polymer composites-A review," *Polymer Engineering & Science*, vol. 49, no. 7, pp. 1253–1272, 2009.

[35] T. P. Sathishkumar, P. Navaneethakrishnan, S. Shankar, and R. Rajasekar, "Investigation of chemically treated randomly oriented sansevieria ehrenbergii fiber reinforced isophthallic polyester composites," *Journal of Composite Materials*, vol. 48, no. 24, pp. 2961–2975, 2013.

[36] S. Siddika, F. Mansura, and M. Hasan, "Physico-mechanical properties of jute-coir fibre reinforced hybrid polypropylene composites," *Int J Chem Mol Nucl Mater Metall Eng*, vol. 7, pp. 60–65, 2013.

[37] M. Fazeli, J. P. Florez, and R. A. Simao, "Improvement in adhesion of cellulose fibers to the thermoplastic starch matrix by plasma treatment modification," *Composites Part B: Engineering*, vol. 163, pp. 207–216, 2019.

[38] J. B. Dawit, Y. Regassa, and H. G. Lemu, "Property characterization of acacia tortilis for natural fiber reinforced polymer composite," *Results in Materials*, vol. 5, p. 100054, 2020.