

Tensile Properties of Hybrid Short Silk and Bamboo Fibre/Epoxy Composites

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ABSTRACT

This study addresses the challenges associated with short fibres in composite materials, particularly their reduced stiffness, lower tensile strength, and limited reinforcing ability compared to long fibres. These limitations significantly influence the mechanical performance of composites. To overcome these issues, the research explores the relationship between fibre length and tensile properties, aiming to identify the optimal fibre size to enhance mechanical performance. The study uses fixed fibre lengths (1 cm, 2 cm, and 3 cm) with a constant 3% weight fraction in an epoxy/resin matrix. Tensile tests are conducted on individual short silk and bamboo fibre composites to determine the optimal fibre length for each material. These optimal fibre sizes are then combined in varying weight ratios to create hybrid composites, which are also subjected to tensile testing. Results demonstrate that fibre size plays a critical role in mechanical performance. Silk fibre composites exhibit varying tensile strengths depending on fibre length, while bamboo fibre composites show size-dependent variations in tensile properties. Notably, hybrid composites with a 2% silk fibre and 1% bamboo fibre weight ratio achieve superior tensile strength. This research provides valuable insights into the design of hybrid fibre composites, emphasizing the importance of optimizing fibre size and weight ratios to achieve enhanced tensile properties in composite materials.

Keywords: Silk fibre; bamboo fibre; short fibre; hybrid composite; epoxy; tensile strength

INTRODUCTION

Natural fibres have increasingly been recognised as viable alternatives to conventional reinforcements such as glass, carbon, and aramid fibres. Their key advantages include biodegradability, sustainability, low density, and reduced abrasiveness. Beyond mechanical performance, natural fibres also exhibit favourable attributes such as comfort, breathability, and recyclability, making them attractive for a wide range of applications (Britannica 2023; Salih et al. 2019).

From a mechanical perspective, the ability of natural fibres to withstand strain and stress is an important consideration for their utilisation in various sectors, including textiles, construction, and biomedical applications. Essential mechanical characteristics include tensile strength, stiffness, and elasticity (Mohammed 2022). Tensile strength describes a fibre's resistance to fracture under tensile loading, stiffness refers to its

resistance to deformation, while elasticity denotes the fibre's capability to return to its original shape once the applied load is removed.

In recent years, natural fibre-reinforced composites have gained considerable attention owing to their environmental benefits, low cost, and favourable mechanical properties. Among these, hybrid composites—comprising two or more types of natural fibres—have demonstrated notable potential in improving the performance of polymer matrices. By strategically combining fibres with complementary characteristics, hybridisation can enhance tensile strength, flexibility, and durability, thereby broadening the applicability of these materials in engineering fields. Silk and bamboo fibres are two notable examples, each possessing distinctive attributes. Silk fibres exhibit excellent tensile strength and flexibility due to their protein-based structure, while bamboo fibres, being lignocellulosic in nature, provide high stiffness and low density (Zulkifli 2019; Darus et al.

2020). When incorporated together, the synergistic interaction between silk and bamboo fibres can significantly improve the tensile behaviour of epoxy composites. The selection of epoxy resin as the matrix material further complements this hybrid system, given its well-established adhesion, thermal stability, and mechanical performance. The combination of silk and bamboo fibres within an epoxy matrix not only mitigates the limitations associated with single-fibre composites but also aligns with the global emphasis on sustainable materials and environmentally responsible engineering.

This study therefore focuses on evaluating the tensile properties of hybrid short silk/bamboo fibre–epoxy composites. By varying fibre content and orientation, the work aims to investigate the synergistic effects arising from hybridisation within the epoxy matrix. The results are anticipated to provide useful insights for potential applications of such materials in sectors such as automotive, construction, and aerospace, where lightweight and high-strength materials are increasingly required. Furthermore, this research contributes to the expanding literature on sustainable composite systems and supports the ongoing transition towards greener engineering solutions. Table 1 summarises the key mechanical properties of selected natural fibres, demonstrating their suitability for sustainable composite and other advanced engineering applications.

TABLE 1. Mechanical properties for natural fibre

Natural Fibre	Density (g/cm ³)	Tensile Strength (MPa)	Young Modulus (GPa)
Cotton	1.5-1.6	287-597	4.2-12.6
Wool	1.3-1.4	120-180	2.3-3.4
Silk	1.3-1.38	650-750	16
Linen	1.4-1.5	345-1035	27.6-45
Hemp	1.48	550-900	50
Jute	1.3-1.46	393-800	13-26.5
Bamboo	0.6-1.1	540-630	11-17

SILK FIBRE

Silk fibres, particularly those derived from the domesticated silkworm *Bombyx mori*, are among the most historically significant and versatile natural fibres. Renowned for their distinctive texture and exceptional mechanical properties, silk has been highly valued for millennia, forming a key commodity of the ancient Silk Road trade networks. While *B. mori* silk is produced through controlled sericulture, wild silk—commonly known as Tussah—is obtained from caterpillar species that cannot be domesticated, resulting

in naturally variable characteristics and unique aesthetic qualities (Ude et al. 2014).

Structurally, silk fibres consist of two protein-based components: the inner fibroin core, which provides mechanical strength, and the outer sericin coating that protects and binds the fibroin strands. To extract usable silk, the sericin must be removed through a degumming process involving hot water or alkaline treatment, which releases continuous fibroin filaments. Degumming not only enhances softness and lustre but also prepares the material for spinning into yarns (Lee 2005).

Mechanically, silk exhibits outstanding performance and is frequently cited as one of the strongest natural materials. Its tensile strength is comparable to that of certain steel alloys, enabling silk to withstand significant loads without rupture. In addition, silk combines high strength with notable elasticity, allowing elongation up to approximately 20% of its original length without permanent deformation. This unique balance of strength and flexibility enables silk to perform effectively under dynamic loading, making it suitable for applications where precision and resilience are required (Li 2021).

Beyond its mechanical advantages, silk is lightweight, biocompatible, and biodegradable, factors that have expanded its applications into biomedical engineering and advanced materials research. Silk fibroin has been widely explored for sutures, wound dressings, and tissue scaffolds due to its favourable biological response. Its natural sheen, moisture absorption, and thermal regulation further enhance silk's suitability for high-performance and luxury textiles. Wild silk varieties, including Tussah, possess additional attributes such as higher ultraviolet (UV) resistance, coarser texture, and natural pigmentation, making them suitable for outdoor fabrics and specialised composite applications. The renewable and environmentally benign nature of silk production also aligns well with current sustainability initiatives aimed at reducing dependence on synthetic materials. The versatility of silk is increasingly exploited in hybrid composite systems, where it is combined with other natural fibres such as bamboo to achieve materials with enhanced strength-to-weight ratios. Such composites are gaining interest in sectors including aerospace, automotive, and sporting equipment, where lightweight yet high-strength materials are essential.

In summary, silk fibres represent an outstanding natural material that merges high mechanical performance, elasticity, and sustainability. Whether utilised in traditional textiles, biomedical devices, or advanced composite technologies, silk continues to be a source of innovation and remains synonymous with both luxury and high performance across diverse industries.

BAMBOO FIBRE

Bamboo refers to more than 1,250 species of large woody grasses, with heights ranging from approximately 10 cm to up to 40 m depending on the species (Scurlock 2000). Noted for its extraordinary growth rate—certain species can grow as much as 91 cm in a single day—bamboo is considered the second-largest forestry resource globally. Owing to its versatility and adaptability, bamboo plays a central role in sustainable forestry, with applications spanning construction, textiles, papermaking, and composite material development. Structurally, bamboo is recognised as one of the most functionally graded natural composite materials, characterised by a distinctive distribution of fibres across its cross-section. For example, in a 1 mm² section, approximately two fibres may be present near the inner periphery compared to roughly eight near the outer region, resulting in a mechanically stronger outer surface (Ray 2005). This architectural gradient contributes significantly to bamboo's high strength-to-weight ratio, making it comparable to certain advanced engineering materials.

Bamboo fibres also exhibit excellent moisture absorption and desorption characteristics together with high air permeability, properties that are particularly beneficial in applications requiring moisture regulation and breathability (Yao 2011; Rajan et al. 2024). Extracted from a rapidly renewable source, these fibres combine notable mechanical strength, biodegradability, and resource abundance. Their environmental advantages further stem from bamboo's ability to sequester carbon dioxide at higher rates than many tree species. In addition, bamboo requires minimal water input, does not depend on pesticides, and can regenerate after harvesting, enabling repeated cultivation without significant ecological disturbance. Consequently, bamboo represents a highly sustainable alternative to synthetic and non-renewable materials.

Given these attributes, bamboo fibres are being increasingly adopted across sectors such as textiles, construction, and composite engineering (Rajan et al. 2024). Bamboo-reinforced composites, for example, have gained momentum because of their low density, high tensile strength, and cost efficiency. In textile applications, bamboo fibres are prized for their softness, antibacterial behaviour, and sustainability profile. Their incorporation in hybrid composite systems—for instance, in combination with silk—further highlights bamboo's adaptability and capacity to enhance the performance of eco-friendly material systems.

In the present work, buluh semantan, scientifically known as *Gigantochloa scortechinii* (Salih et al. 2022), will be used as one of the reinforcing fibres. This species,

native to Southeast Asia and widely recognised in Malaysia, is valued for its strength, straight tubular geometry, and durability, which make it suitable for construction, scaffolding, furniture, handicrafts, and other traditional as well as modern uses.

In summary, bamboo fibres represent a compelling example of nature's structural ingenuity and offer considerable promise for sustainable material development. Their distinctive properties, combined with renewability and reduced environmental impact, underscore bamboo's growing importance in developing advanced, sustainable composite materials capable of meeting modern industrial demands while supporting ecological preservation.

EPOXY MATRIX

Epoxy resin, a widely used thermosetting polymer, has become a fundamental matrix material in composite fabrication owing to its excellent mechanical, thermal, and chemical properties. Its strong adhesion capability and high chemical resistance enable effective bonding with reinforcing fibres, thereby enhancing the overall structural performance of composites. In addition, epoxy facilitates uniform stress distribution across the reinforcement, which improves load transfer efficiency and mechanical reliability under different service conditions. A major advantage of epoxy resin is its dimensional stability and long-term durability, which are crucial for maintaining composite integrity throughout prolonged use. Unlike several other polymeric matrices, epoxy undergoes minimal curing shrinkage, reducing the likelihood of residual stress formation and improving dimensional accuracy—an essential characteristic in applications requiring high precision.

Epoxy resin is compatible with numerous types of reinforcements, including synthetic fibres such as carbon and glass as well as natural fibres such as silk and bamboo. Its strong interfacial bonding with natural fibres enhances key mechanical properties such as tensile strength, stiffness, and impact resistance. This compatibility supports the fabrication of lightweight, high-performance hybrid composites with a reduced environmental footprint. Furthermore, the excellent thermal stability of epoxy allows it to withstand elevated temperatures without significant degradation, making it suitable for demanding fields such as aerospace, automotive, and marine engineering. Its resistance to moisture and corrosive chemicals also enables reliable performance in harsh environments, including saltwater exposure and chemically aggressive settings.

In hybrid natural fibre composites, epoxy resin plays a central role in enhancing mechanical and functional

characteristics. When combined with short silk and bamboo fibres, epoxy contributes to improved tensile behaviour, flexural strength, and durability. The synergistic interaction between natural fibres and epoxy supports the development of materials that offer both structural efficiency and environmental sustainability. The use of renewable and biodegradable fibres such as bamboo and silk contributes to reducing the overall carbon footprint of composite systems, while epoxy provides the mechanical robustness required for advanced applications. Beyond composite reinforcement, epoxy resin has broad applicability, including structural repair and protective coatings in civil engineering, and as an insulating medium in electronic systems. Its adaptability to various fabrication techniques, such as casting, moulding, and filament winding, further underscores its importance in modern manufacturing processes.

This study therefore aims to investigate the performance of hybrid short silk/bamboo fibre–epoxy composites for advanced engineering applications. These hybrid systems are expected to demonstrate enhanced mechanical characteristics—including tensile strength, impact resistance, and fatigue performance—while contributing to sustainable material development through the incorporation of renewable natural fibres.

METHODOLOGY

SAMPLE PREPARATION

The hand lay-up technique will be employed for the fabrication of the composite specimens. This method, recognised for its simplicity and cost-effectiveness, is one of the oldest and most commonly used approaches in composite manufacturing. It is particularly suitable for small-scale production and prototyping as it provides considerable flexibility in fibre placement, orientation, and material selection. Importantly, it enables precise control over fibre arrangement, which is essential for achieving the desired mechanical characteristics in the final composite material.

The process begins with the preparation of the mould, which serves as the base for laying the reinforcing fibres. The mould surface is first coated with a suitable release agent to facilitate easy demoulding following the curing stage. In this study, silk and bamboo fibres are manually positioned on the mould in predetermined orientations (longitudinal direction) to maximise their reinforcing effects, particularly in enhancing tensile strength, stiffness, and load-bearing capacity. After fibre placement, epoxy resin is applied and manually impregnated into the fibres to ensure complete saturation and minimise the formation

of voids. The laminate is then compacted using a roller or brush to eliminate entrapped air and achieve a uniform thickness. This careful compaction step improves mechanical performance, durability, and surface finish.

The hand lay-up process offers clear advantages for hybrid composites, such as those combining silk and bamboo fibres, because it allows customisation of fibre-to-resin ratios and the arrangement of different fibre types. Through tailored fibre placement, the complementary properties of silk and bamboo—namely tensile strength and stiffness—can be effectively utilised. Nevertheless, the technique presents several limitations, including its dependence on manual labour and potential inconsistencies between samples. It is also less suitable for complex geometries or high-volume production. Despite these limitations, it remains highly practical for laboratory-scale fabrication and experimental investigations due to its low cost, ease of execution, and adaptability.

In the present study, the hand lay-up technique will be used to prepare hybrid short silk/bamboo fibre–epoxy composites with varying fibre orientations and weight fractions. This approach enables systematic evaluation of the mechanical behaviour of the resulting composites and facilitates a comprehensive assessment of their potential for advanced engineering applications. Figures 1 and 2 show the silk and bamboo fibres, while Figures 3 and 4 illustrate the epoxy resin, hardener, and tensile mould used in this experiment.



FIGURE 1. Silk fibre



FIGURE 2. Bamboo fibre



FIGURE 3. Epoxy resin and hardener

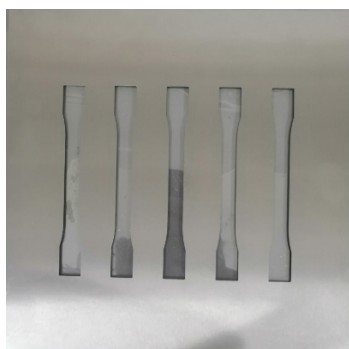


FIGURE 4. Tensile mould

The dimensions of the specimens are defined by the mould design. For each test, short silk and short bamboo fibres are incorporated in three predetermined fibre lengths—1 cm, 2 cm, and 3 cm. Both fibre types are used at a constant weight fraction of 3% relative to the epoxy matrix. The fibres are mixed with epoxy resin to produce short silk and bamboo fibre-reinforced composites. Fibre-reinforced composites derive their mechanical behaviour, particularly tensile strength, from the effective transfer of applied load from the matrix to the fibres. Fibre length plays a critical role in this load-transfer mechanism. While short fibres are easier to handle and distribute, excessively short fibres may not provide sufficient reinforcement due to limited stress transfer. Conversely, overly long fibres may overlap or entangle, leading to void formation and non-uniform distribution. The selected lengths of 1–3 cm therefore represent a practical and balanced range for achieving efficient reinforcement while maintaining ease of fabrication.

Previous studies on short-fibre composites commonly employ fibre lengths ranging from several millimetres to a few centimetres, identifying this range as crucial for optimising mechanical performance. Fibre lengths below 1 cm generally provide limited reinforcement due to inadequate fibre-matrix interfacial bonding, whereas lengths greater than 3 cm often lead to processing

challenges, including uneven distribution and higher void content. Findings in natural fibre composites consistently highlight intermediate lengths as most effective in enhancing tensile properties such as strength and stiffness. The hand lay-up method utilised in this work requires manual placement and impregnation of fibres. Fibre lengths of 1 cm, 2 cm, and 3 cm are manageable for consistent arrangement, which helps minimise fibre clustering and random orientation that could negatively affect tensile behaviour. These lengths also enable a controlled experimental setup in which fibre alignment and distribution can be systematically maintained.

By selecting these three lengths, the study aims to identify the optimum fibre length for tensile performance. Shorter fibres (1 cm) are expected to disperse more uniformly but may be less effective in transferring loads across the matrix. Medium-length fibres (2 cm) are anticipated to achieve a balance between effective dispersion and reinforcement. Longer fibres (3 cm) are included to evaluate potential limitations such as alignment difficulties and reduced interfacial bonding efficiency. Figures 5 and 6 illustrate the respective sizes of the bamboo and silk fibres used in this study.

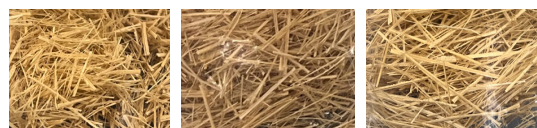


FIGURE 5. Bamboo fibre with sizes of 1 cm, 2 cm and 3 cm



FIGURE 6. Silk fibre with sizes of 1 cm, 2 cm & 3 cm

EXPERIMENTAL PROCEDURE

The tensile properties of pure short silk and bamboo fibre epoxy/resin composites will be evaluated using a universal testing machine (UTM). The study will first analyze the tensile properties of both materials individually to determine the optimum fibre size. Subsequently, the optimum sizes of short silk and bamboo fibres will be combined to fabricate hybrid epoxy/resin composites with three different weight percentage ratios: 1% short silk fibre with 2% short bamboo fibre, 1.5% short silk fibre with 1.5% short bamboo fibre, and 2% short silk fibre with 1% short bamboo fibre. The hybrid composites will then undergo tensile testing using the UTM.

During the tensile test, the specimen is loaded into the machine, and the load is gradually increased at a speed of 5 mm/min. To ensure accuracy, 4-5 specimens for each configuration will be tested, and the average tensile properties will be calculated. Any anomalies or errors in the results will prompt retesting to obtain reliable data. The universal testing machine (UTM) used in this study is shown in Figure 7.



FIGURE 7. Universal Testing Machine

RESULTS AND DISCUSSION

SILK FIBRE/EPOXY COMPOSITES TENSILE TEST RESULT

Table 2 below displays images of the short silk fibre/epoxy composite samples before and after undergoing tensile testing. The average tensile stress values, along with the bar chart representation of the tensile stress results for different fibre sizes, are presented in Table 3 and Figure 8.

TABLE 2. Images of short silk fibre/epoxy composite before and after tensile testing

Size	Before undergoing tensile test	After undergoing tensile test
1 cm		
2 cm		
3 cm		

TABLE 3. Result of short silk fibre/epoxy composite tensile stress at maximum load

Specimen	1cm (MPa)	2cm (MPa)	3cm (MPa)
1	40.30	43.38	40.83
2	34.94	45.19	40.82
3	38.57	48.85	40.99
4	37.90	46.54	44.30
Average	37.93	45.99	41.74

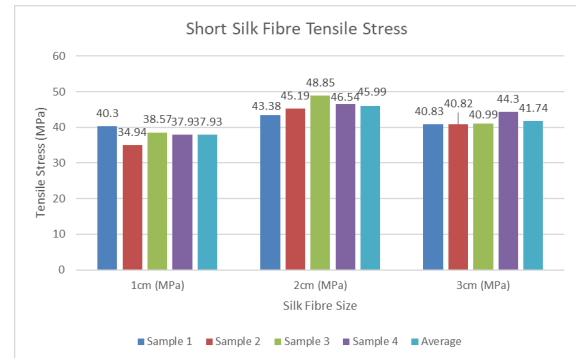


FIGURE 8. Bar chart of short silk fibre/epoxy composite tensile stress

When comparing the tensile test results for silk fibre composites of varying sizes (1 cm, 2 cm, and 3 cm), noticeable differences in tensile strength are observed. The 1 cm specimens exhibit an average tensile stress of 37.93 MPa, with values ranging from 34.94 MPa to 40.30 MPa. For the 2 cm specimens, the tensile stress ranges between 43.38 MPa and 48.85 MPa, resulting in an average value of 45.99 MPa. Meanwhile, the 3 cm specimens demonstrate a tensile stress range of 40.82 MPa to 44.30 MPa, with an average of 41.74 MPa. These results indicate that the 2 cm specimens achieve the highest average tensile stress of 45.99 MPa, surpassing the 1 cm (37.93 MPa) and 3 cm (41.74 MPa) specimens.

BAMBOO FIBRE/EPOXY COMPOSITES TENSILE TEST RESULT

Table 4 presents images of the bamboo fibre/epoxy composite samples before and after undergoing tensile testing. The average tensile stress values, along with a bar chart representing the tensile stress results for each fibre size, are displayed in Table 5 and Figure 9.

TABLE 4. Images of short bamboo fibre/epoxy composite before and after tensile testing

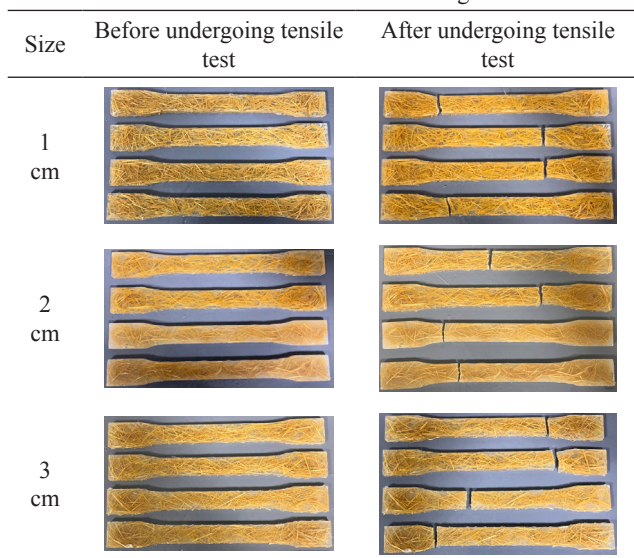


TABLE 5. Short bamboo fibre/epoxy composite tensile stress at max load

Specimen	1cm (MPa)	2cm (MPa)	3cm (MPa)
1	43.86	37.26	29.80
2	36.64	36.39	26.10
3	40.54	20.27	32.06
4	31.65	35.29	33.62
Average	38.17	32.30	30.40

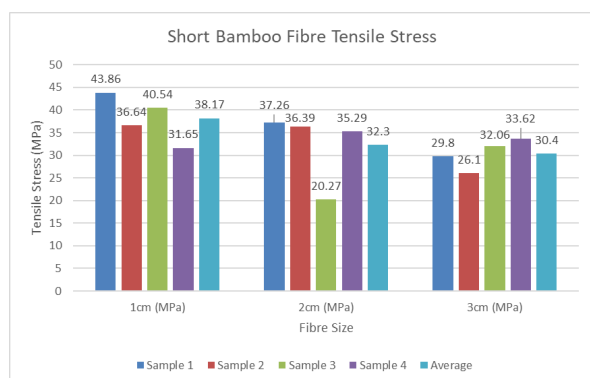


FIGURE 9. Bar chart of short bamboo fibre/epoxy composite tensile stress

The tensile stress values for the 1 cm specimens have an average of 38.17 MPa, ranging from 31.65 MPa to 43.86 MPa. For the 2 cm specimens, the average tensile stress is 32.30 MPa, with a range between 36.39 MPa and 37.26 MPa. The 3 cm specimens exhibit tensile stress values ranging from 26.10 MPa to 33.62 MPa, with an average of 30.40 MPa. Based on the comparison, the 1 cm specimens demonstrate superior tensile strength, averaging 38.17 MPa, compared to the 2 cm specimens (32.30 MPa) and the 3 cm specimens (30.40 MPa).

RESULT OF HYBRID SILK AND BAMBOO FIBRE/EPOXY COMPOSITE TENSILE TEST

The tensile test results for the hybrid composite, comprising 1 cm bamboo and 2 cm silk fibres, are derived from the average data of four specimen samples. The selected specimens demonstrated higher tensile stress values for both 1 cm bamboo and 2 cm silk fibres. Three distinct sample sets were prepared, each with varying weight percentages of silk and bamboo fibres:

1. 1% silk fibre + 2% bamboo fibre
2. 1.5% silk fibre + 1.5% bamboo fibre
3. 2% silk fibre + 1% bamboo fibre

This approach systematically investigates how varying weight percentages influence the hybrid composite's tensile properties, providing insights into the interaction between silk and bamboo fibres at different ratios. Table 6 includes images of the hybrid composite specimens before and after undergoing the tensile test. Meanwhile, Table 7 and Figure 10 present the tensile test results for each fibre composition, including the average tensile stress and a bar chart summarizing the findings.

TABLE 6. Images of hybrid short silk and bamboo fibre/epoxy composite before and after undergoing the tensile test

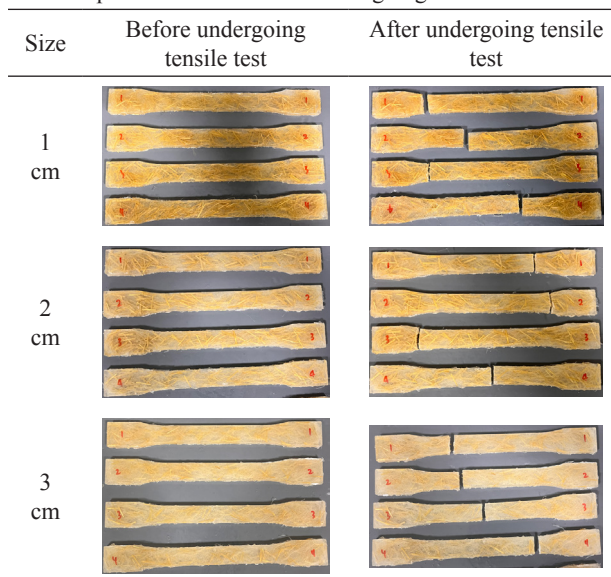


TABLE 7. Result of hybrid short silk and bamboo fibre of tensile stress at max load

Specimen	1%S + 2%B (MPa)	1.5%S + 1.5%B (MPa)	2%S + 1%B (MPa)
1	37.61	39.62	43.41
2	39.54	39.38	38.21
3	39.83	38.66	38.85
4	39.59	39.06	39.45
Average	39.14	39.18	39.98

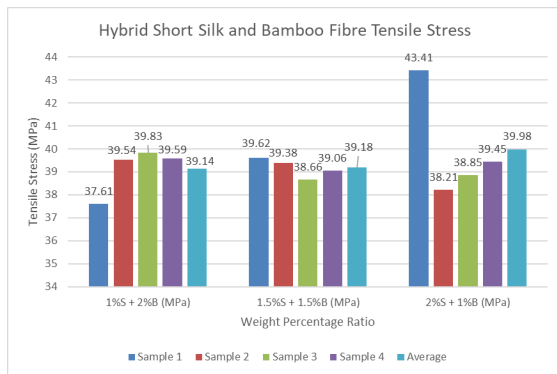


FIGURE 10. Bar chart of hybrid short silk and bamboo fibre/ epoxy composite tensile stress

Upon evaluating the tensile test results for hybrid silk and bamboo fibre composites, which involved three different weight ratios; 1% silk fibre + 2% bamboo fibre (1%S + 2%B), 1.5% silk fibre + 1.5% bamboo fibre (1.5%S + 1.5%B), and 2% silk fibre + 1% bamboo fibre (2%S + 1%B) notable variations in tensile strength were observed. For the 1%S + 2%B specimens, the tensile stress values ranged from 37.61 MPa to 39.83 MPa, with an average of 39.14 MPa. The 1.5%S + 1.5%B specimens exhibited tensile stress values between 38.86 MPa and 39.62 MPa, resulting in an average of 39.18 MPa. Meanwhile, the 2%S + 1%B specimens showed tensile stress values ranging from 38.21 MPa to 43.41 MPa, with the highest average tensile stress of 39.98 MPa. This comparison demonstrates that the 2%S + 1%B specimens achieved the highest tensile strength (39.98 MPa), followed by the 1.5%S + 1.5%B specimens (39.18 MPa) and the 1%S + 2%B specimens (39.14 MPa).

CONCLUSION

The tensile testing results demonstrated noticeable differences in strength among the silk fibres, bamboo fibres, and their corresponding hybrid composites. For the silk fibre specimens, those with a length of 2 cm exhibited the highest tensile stress, with an average value of 45.99 MPa, exceeding the performance of the 1 cm and 3 cm specimens. In contrast, the bamboo fibre tests revealed that the 1 cm specimens achieved the highest tensile strength, with an average of 38.17 MPa, indicating that fibre length plays a crucial role in determining tensile behaviour.

In the hybrid composite tests, which incorporated 1 cm bamboo and 2 cm silk fibres at different weight ratios, the samples containing 2% silk and 1% bamboo achieved the highest average tensile stress of 39.98 MPa. This result highlights the importance of fibre interaction and demonstrates that the relative proportions of each fibre type

significantly influence the overall tensile performance of the composite.

These findings suggest that careful selection and adjustment of fibre length and weight ratio are essential for tailoring tensile properties to meet specific performance requirements. Systematic optimisation of these parameters can lead to hybrid composites with improved tensile characteristics. Overall, the study demonstrates the synergistic behaviour resulting from combining silk and bamboo fibres and emphasises that balancing fibre dimensions and compositions is key to achieving desirable tensile properties. The outcomes of this research provide valuable insight for the development and design of hybrid fibre composites intended for advanced engineering applications.

DECLARATION OF COMPETING INTEREST

None.

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