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Considerations on Fractured Edge Dislocations of Mechanical Tested Hand Laid Hemp Flax GFRP Hybrid Polymer Composites with SEM Verifications

Kousik Kumaar R.[1,*], Boopathy G.[2], Bovas Herbert Bejaxhin A.[3], Ramanan N.[4]

Abstract

In this research study, three types of composite samples are made. Hemp-Glass Fiber (C1), Flax-Glass Fiber (C2), and Hemp-Flax-Glass Fiber Hybrid Composite (C3). For proper fibre-to-fiber adhesion and bonding, a 10:1 mixture of glue (LY556) and brace (HY951) was used. Tensile, flexural, impact, double shear, and hardness research is conducted among all the specimen samples. According to ASTM standards, the comparison is made among C1, C2 and C2 respectively; the results revealed that the category C3 Hybrid Composite is attained with good mechanical characteristics. The microscopic evidences of tested sample fibers in composites are studied using a scanning electron microscope revealed the comprehensible results. In this research, reinforcement is achieved with perfect bonding by using hemp and flax added to plain-woven glass strands. The twain fibers seen in nature have high-strength due to their high cellulose content. Fabrications of composites with entirely different fibre orientations, as well as estimate of composite mechanical properties, have been undertaken for this reason.

Keywords: Sustainable Development, Green Material, fracture surface, shear fracture

INTRODUCTION

Demand for technological advancements has been rising as of late due to predictions of progress in the next generation. As a result, to attract and retain customers, a product needs to be both high-quality and affordable. Composite, a seven-letter term, is currently one of the most recent and important advancements in material technology that seems to have a considerable influence. Matrix and reinforcement are the two stages. Composites combine the qualities of reinforcement and matrix to create materials that are stronger and stiffer than the component materials operating alone. They're made up of two or more component materials that have quite diverse physical and chemical characteristics. A unique reinforcement (in the form of fibers/particles/whiskers/fabric) is dispersed in a matrix, binder, or resin in composites. Nanomaterials, smart materials, and metamaterials are examples of the types of engineering materials currently dominating the market. Numerous new materials have emerged in recent years. Materials rangesis type range from polymers and metals to ceramics and composites. Significant efforts have

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been launched in material science [1–2]. The recent rise in popularity of composite materials is indicative of the field's progress in material technology. They require a lot of attention and have a big influence in the industry. They have both reinforcement and matrix characteristics. A hybrid construction is lightweight, stable, environmentally benign, non-corrosive, and has many other advantages [3–4]. Glass, carbon, and aramid fiber applications for polymers have become increasingly diverse. Typically, the fibers will have a unidirectional, bidirectional, or omnidirectional structure. There are essentially two distinct categories for polymers. There are two types of plastics, thermoplastic and thermosetting [5–6]. Because of their useful structural properties, thermoplastics were discovered to be use in every industry. Acrylics, nylons, polycarbonates, polyvinyl chloride, etc., are all examples of thermoplastics. Polyester, phenolic, polyamides, vinyl esters, bismaleimide, epoxies, etc. are all examples of thermosetting plastics [7–8]. Hybrid composites made of natural fiber and aluminum sheeting have been developed. Vacuum-assisted resin transfer molding (VARTM) was used in the production of composites. As an EM shield, this mixed composite did remarkably well. The hybrid composites' mechanical characteristics were unaffected by the addition of aluminum sheets. As a result of the internal bond testing, it was determined that the interfacial bonds were robust. The effect of mechanical properties was investigated for both hemp fibers and unidirectional fiber/epoxy composites [9–10]. When the lignin in hemp fibres was oxidized by Laccase, these consequences were investigated. Mechanical characteristics such as tensile stress, heat resistance, and so on were studied on the oxidized fibres. They found that the tension stress, firmness, and heat resistance of the laccase-treated fibers were all improved. There was no evidence of laccase cross-linking. Hemp fibers' increased properties can be traced back to the rapid polymerization of lignin [11–12].

For their research, they focused on the characterization of the hemp-polyurethane composite interface. The researchers investigated how altering the surface of the fiber influenced its form, mechanical conductivity, and thermal conductivity. Several techniques were used to examine hemp fibers treated with varying concentrations of sodium hydroxide, including infrared Fourier transform spectroscopy, X-ray diffraction, mechanical tensile testing, and scanning electron microscopy. Before analysis, the same was silane-treated. According to the researchers, the alkali treatment caused various modifications in the fiber composite, including the removal of lignin and wax. As a result, tensile strength and Young's modulus improved. The thermal conductivity of the treated composites was also improved [13–14]. Flax reinforced epoxy composites tensile and compressive damage response SEM pictures were used to investigate the damage response of this fibre. We measured stiffness and permanent deformation by repeatedly loading and unloading the specimens. According to the results, the damages manifested themselves as strain accumulation and modulus degradation [15–16] studied natural fiber composite structural channel sections, with an eye toward compressing their design and optimizing their geometry. To prevent local buckling, geometric stiffeners were incorporated into the channel's design, leading to wider cross-sections with greater compression strength. Wall studs made of steel and wood were tested for compression strength. They determined that the composite they had made could be used safely in residential building. The range of section slenderness values seen in the experimental data from the plain channel and stiffened channel is substantial [17–18]. We looked at what happens to an epoxy composite with flax fiber reinforcement after it cures. Up to 150 degrees Celsius after curing, composites maintained their original characteristics. Both the temperature at which the composite glass transitioned and the pace at which it cross-linked increased after curing. They also learned that a rise in the specific modulus led to a marked change in the material's other properties. It was discovered that flax fibers are very vulnerable to heat treatment, but that this severe loss of features might be minimized by employing a resin that could cure at a low temperature quickly [19–21]. Graphite in the electrolyte improves the Material Remove rate and decreases toll wear. Graphite's Toll wear rate drops, and its material strength rises when an electrolyte is added [22]. Hemp and flax, both plant-based materials, were used as reinforcement in this study, along with plain-woven glass fibers. The high cellulose concentration gives these two natural fibers exceptional strength. For this reason, efforts have been made to fabricate composites with completely diverse fibre orientations and to evaluate the mechanical properties of such materials [23].

The mechanical characteristics of laminates constructed of hemp/epoxy and flax/epoxy were examined in a study. The tensile, bending, and impact characteristics of these laminates were assessed using both experimental and computational techniques. The study's conclusions support the feasibility of building structural components out of natural fiber-reinforced polymer. The outcomes also highlight the possibility of utilizing natural fibers in the design and fabrication of composite materials [24]. Characterization was done on hybrid biocomposites made from hemp and flax fibers. Three different designs of biocomposite plates were produced using compression molding to create hybrid biocomposites made from hemp/polypropylene and flax/polypropylene fibers. By varying the number of layers and stacking configuration, biocomposites' mechanical performance can be altered [25].

EXPERIMENTAL WORK: HAND LAYUP METHOD

Figures 1(a), 1(b), and 2 depict the materials used in this study project. Figure 3 depicts the tools utilized. Hemp and flax, as well as glass fibre reinforced polymer, were employed as natural fibres. At different levels, fibres and GFRP have been employed. The first layer is hemp fibre at zero degrees, the second is hemp fibre at 90 deg, third layer becomes GFRP, layer number 4 is hemp fibre at 45 deg, the fifth layers GFRP, 6th layer is hemp fibre at 90 deg, and layer 7 is hemp fibre at 0 degrees are utilized in the first category. Flax fibre at 0 degrees, flax fibre at 90 degrees, GFRP on the third layer, flax fibre at 45 degrees, GFRP on the fifth layer, flax fibre at 90 degrees, and flax fibre at 0 degrees are used in category 2. In the latter group, we have hemp fiber at 0 degrees, flax fiber at 90 degrees,

Figure 1. (a). Hemp fibre.

Figure 1. (b). Flax fibre.

Figure 2. Glass fibre reinforced polymer.

glass fiber reinforced plastic (GFRP) in the third layer, hemp fiber at 45 degrees in the fourth, GFRP again in the fifth, flax fiber at 90 degrees in the sixth, and hemp fiber at 0 degrees in the seventh. 13 Mg/WC composites with reinforcement levels of 0%, 5%, 10%, and 15% were produced using stir casting. The results of the tests demonstrated that the composites made from AZ31B with 15% WC exhibit better tribological behavior than the magnesium matrix AZ31B alloy. Adding WC to produced composites improves their micro-hardness, flexural strength, tensile strength, and yield strength. In SEM pictures, the WC particles can be seen to be uniformly spread throughout the Mg matrix.

To begin, catalyst for release such as poly-vinyl alcohol was placed on a flat sheet to allow the composite to be easily removed. A thin coating of organic material (ARALDITE LY556) was placed over this layer. To remove the flakes from hemp and flax fibers, the natural fibers were dried and combed. In the first group, the first layer was 0 degrees hemp fiber, the second layer was 90 degrees hemp fiber, the third layer was glass fiber reinforced plastic (GFRP), the fourth layer was 45 degrees hemp fiber, the fifth layer was GFRP, the sixth layer was 90 degrees hemp fiber, and the seventh layer was 0 degrees hemp fiber. The fiber and GFRP were inserted into each layer in the correct orientation, and then the glue and hardener mixture were rolled over the entire structure. Then it was put out to dry. After 7-10 hours with no interference, a 20 kg weight was placed on top of the entire gizmo. The load was used to prevent air bubbles from entering the GFRP layers. This was done in the same way as the second category was accomplished by swapping flax for hemp. In the third category, the first layer was hemp fibre at 0 degrees, the second layer was flax fibre at 90 degrees, the third layer was GFRP, the fourth layer was hemp fibre at 45 degrees, the fifth layer was GFRP, and the sixth layer was flax fibre at 90 degrees. Hemp fibre was inserted at 0 degrees on the seventh layer, and the rest was done according to the first category. Each layer was 1 mm thick, with dimensions of length 300 millimeters, breadth300 millimeters, 7 mm in width, and 7 mm in width. Consequently, the optimum intra-layer hybrid composite material was created, which was subsequently machined to the required dimensions. Figures 3 and 4 depict the tools and steps involved in the hand layup process for fabricating specimens. The model of orientations of layers of fibres are shown in Figure 5

Figure 3. Utensils used for hand layup process.

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Figure4. (a) Mixing of Resin and hardener with lamination sheet

Figure 4. (b) Spreading of fibers on resin and resin on fibers.

Figure 4. (c) Fixing glass fibers on resin and resin on glass fibers.

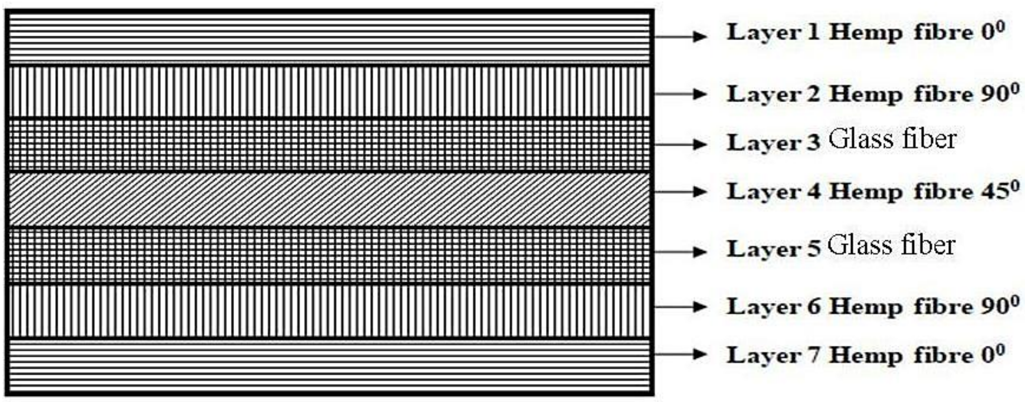

Figure 5. Fibre alignments and layers of first category (C1) fibre arrangement.

Table 1 shows the particulars of groupings and orientation of fibres. Category 1 contains only hemp fibres in different layers whereas category 3 contains both hemp and flax fibres in different layers to make hybrid composite.

Table 1. List of categories and orientation of fibres (HF-Hemp Fibre, FF-Flax Fibre, and GF-Glass Fibre)

Layers	Class 1	Class II	Class III
	Hemp Composite	***Flax Composite***	***Hemp Flax Hybrid Composite***
Layer-1	HF (0°)	FF (0°)	HF (0°)
Layer-2	HF (90°)	FF (90°)	FF (90°)
Layer-3	GF	GF	GF
Layer-4	HF (45°)	FF (45°)	HF (45°)
Layer-5	GF	GF	GF
Layer-6	HF (90°)	FF (90°)	FF (90°)
Layer-7	HF (0°)	FF (0°)	HF (0°)

FINDINGS AND COMMENTS

To investigate the mechanical and wear characteristics, numerous trials were carried out. There were three samples gathered from each of three different groups throughout this analysis. Hybrid composites composed of hemp and glass fiber are represented by the letter "C," while hybrid composites made of flax and glass fiber are represented by the letter "C" in the second group.

Each classification was ranked using tensile strength, flexural strength, impact strength, double shear strength, and hardness. Dry sliding conditions were employed to establish wear characteristics for each group, with the applied load, sliding velocity, and sliding distance being recorded. The goal of this research is to determine the ideal wear parameters to maximize numerous performance indicators such as wear loss and friction. In the workpiece, an L27 Taguchi orthogonal array was built and optimized for the testing using Gray Relational Analysis (GRA) and Gray Relational Grade (GRG). An ANOVA analysis was then used to alter the results.

Tensile Test

The results of a tensile test analyzed a material's tensile strength and determine the maximum stress it can endure before collapsing. At both ends of the specimen, the specimen was exposed to a uni-axial load. The constructed composite was cut into the dimensions necessary for the tensile test using a saw cutter, as per the ASTM-D638 standard. Figure 9(b) is a simplified diagram of the tensile test specimen. A Universal Testing Machine (UTM: Make: Fuel Instruments and Engineers-FIE; Model: UTN 40) was used to perform the tensile test at room temperature and 40% relative humidity. The data was gathered in response to an increase in strain. In the testing machine, the specimen was exposed to tension until it broke. The tensile force was calculated in relation to the expansion of the gauge length. The gauge length elongation was measured against the applied force while tension was applied. For the manufacture of vetiver fibre – epoxy composites, a hand lay-up technique was used. Composites with random orientation were prepared using this technique. In this study, fibres were treated with aqueous solutions of 1%, 3% NaOH, with fibre lengths of 10 mm, 20 mm, and fibre volume of 10%, 30% for the fabrication of various composites for flexural and impact tests. The optimal composition was found, and the best specimens were made and cryogenically treated. The composite's cryogenic behaviour under tensile load will be investigated. .

First, second, and third samples of hybrid composites C1, C2, and C3 were tested with universal testing equipment to establish their tensile properties. Table 2 displays the tensile values of the manufactured composites. C1 undergoes a tensile test, depicted in Figure 6(a). According to the data, the tensile strength of S2 is 36 N/mm^2, which is greater. Figure 6(b) depicts S1's 22 N/mm^2 tensile strength. The tensile strength of C3 S2 is depicted in Figure 6c to be 40 N/mm^2. Figure 6(d) depicts the increased tensile value of 38 N/mm^2 for the hybrid composite. The tensile results show that the hemp/flax fiber composite is the strongest option. A linear relationship between stress and strain is observed during tensile testing, with stress increasing in direct proportion to strain. Due to worse mechanical performance, C2 flax has a lower tensile strength than hemp.

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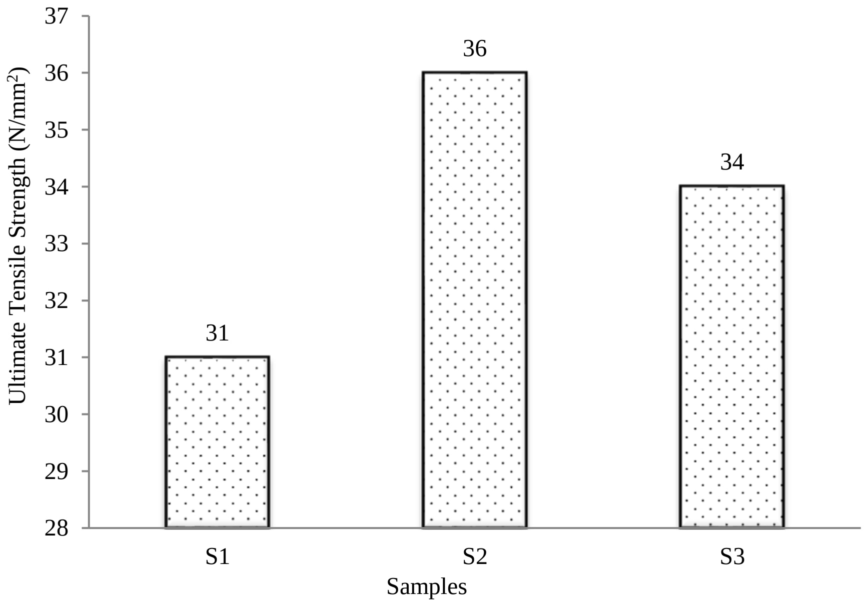
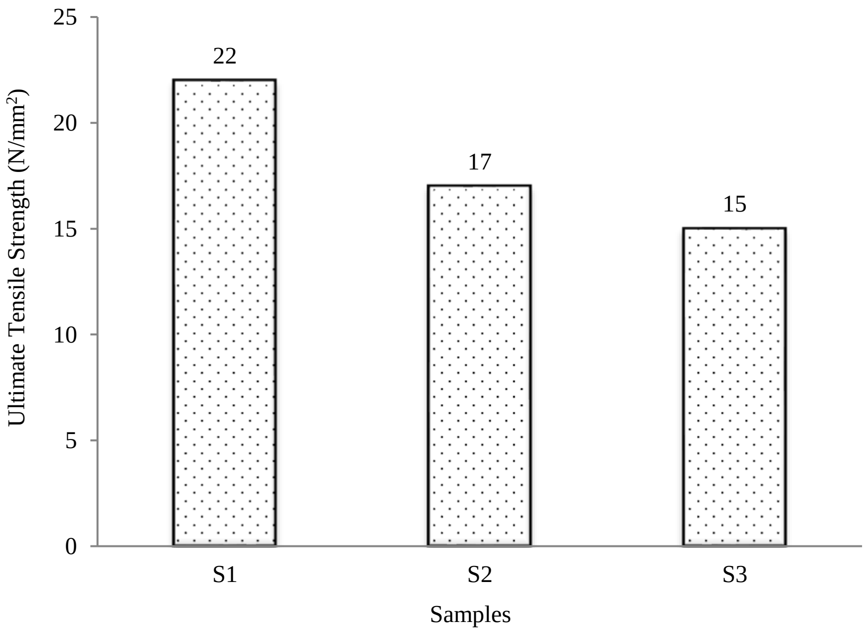
Table 2. Samples of tensile test in Classes C1, C2 and C3

S.N.	Group	Samples	Crucial Tensile Load (kN)	Crucial Tensile Strength (N/mm^2)	Crucial Tensile Strength (N/mm^2) (Average)
1	C1	S1	3.16	32.00	34
		S2	3.20	42.00	
		S3	3.22	44	
2	C2	S1	4.20	42	18
		S2	4.55	17.00	
		S3	3.27	25.00	
3	C3	S1	3.24	42.00	38



(a)



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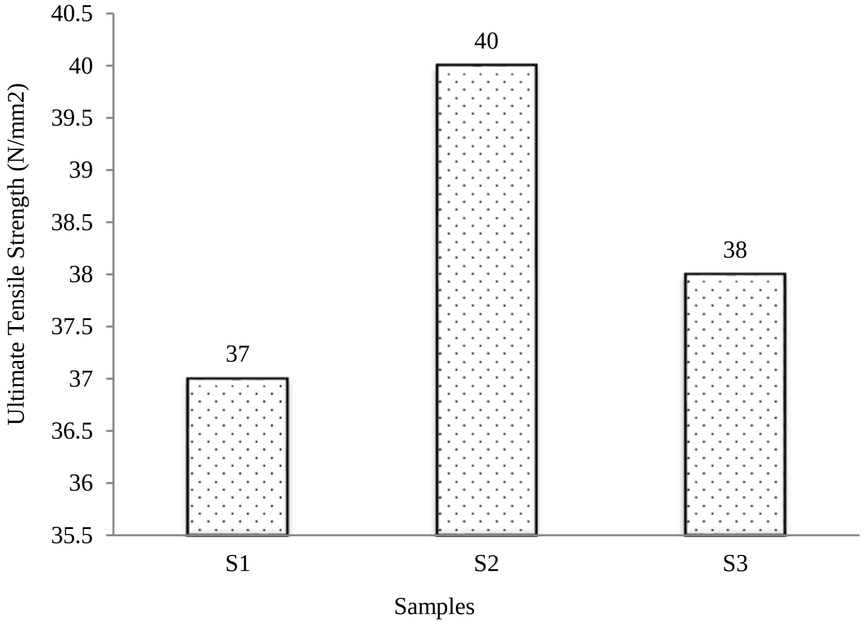
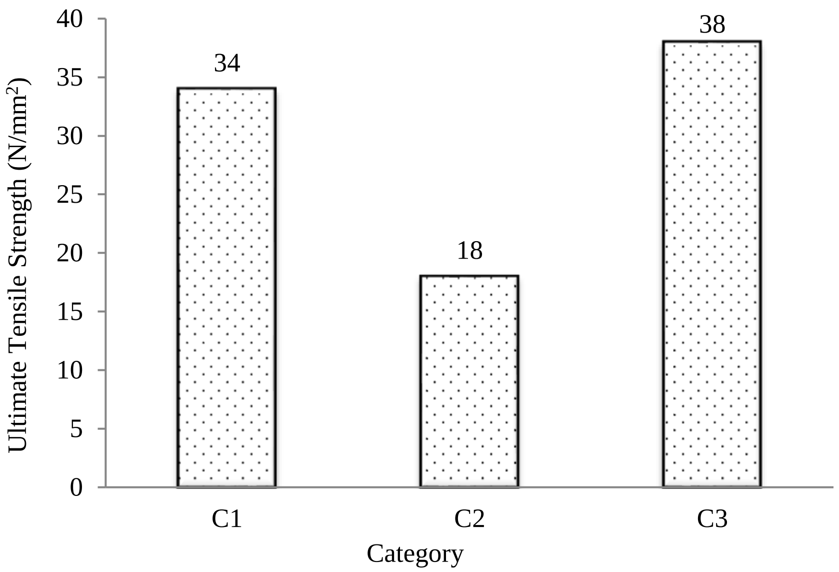


(c)



(d)

Figure 6. (a) Tensile strength of C1 Specimen (b) Tensile strength of C2 Specimen (c) Tensile strength of C3 specimen (d)Average tensile strength

Flexural Trial

The tensile and flexural tests were both performed using the same Universal Testing Machine. The flexural strength of a material can be measured by doing a tensile test. A saw cutter was used to make thin slices of the specimen in line with ATSM: D70. Flexural strength was calculated by seeing how far the material could bend before breaking. Here, in the exam, till failure, the specimen was loaded in the middle of the supports. The flexural analysis showed that the outer fiber was stressed [15]. Four different types of the utilization of organic materials create hybrid composites that were subsequently reinforced using the hand-layup technique. Regarding its mechanical characteristics, the data demonstrated that the Kevlar/Aloevera/palm/epoxy hybrid composite performed well. Table 3 lists the flexural values of the fabricated composites.

Samples of hybrid materials S1, S2, and S3 from Classes C1, C2, and C3 were tested with a standardized instrument to establish their flexural characteristics. The flexural strength of finished composites is listed below. The flexural test for C1 is depicted in Figure 7(a). The data demonstrates that the S2 has a greater flexural strength, specifically 100.23 N/mm^2. The flexural strength of C2 and S1 is shown to be 40.36 N/mm^2 in Figure 7(b). Figure 7(c) demonstrates the average flexural strength of 88.26 N/mm^2 for the hemp composite, with S2 exhibiting the higher value. According to the flexural finding, hemp fiber helped boost flexural strength. The results of the flexural test are linearly related to strain thanks to the stress-strain relationship.

Impact Test

FIE IT30 Charpy testing equipment was used for the impact test. The specimen's resistance to impact was measured by means of this test. This conforms to the ASTM standard of D256. This quality is crucial to the building's longevity. This is a standardized strain rate test. As stated in Table 4, it also determines how much energy was lost because of the material's decomposition. After being struck by the pendulum, the specimen absorbed the force until it cracked. This test establishes the maximum power output that can be taken in by the material. Adjustments in quality can be seen by comparing the results of the UTM, Impact, Flexural, and Tensile tests to PLA polymer basis approximations.

Table 3. Samples of flexural testing categories C1, C2 and C3

S.N.	Class	Samples	Ultimate Flexural Strength (N/mm^2)	Middling Ultimate Flexural Strength (N/mm^2)
1	C1	S1	76.06	88.26
		S2	96.03	
		S3	68.49	
2	C2	S1	42.32	39.51
		S2	39.41	
		S3	42.15	
3	C3	S1	42.11	86.26
		S2	48.11	
		S3	32.45	

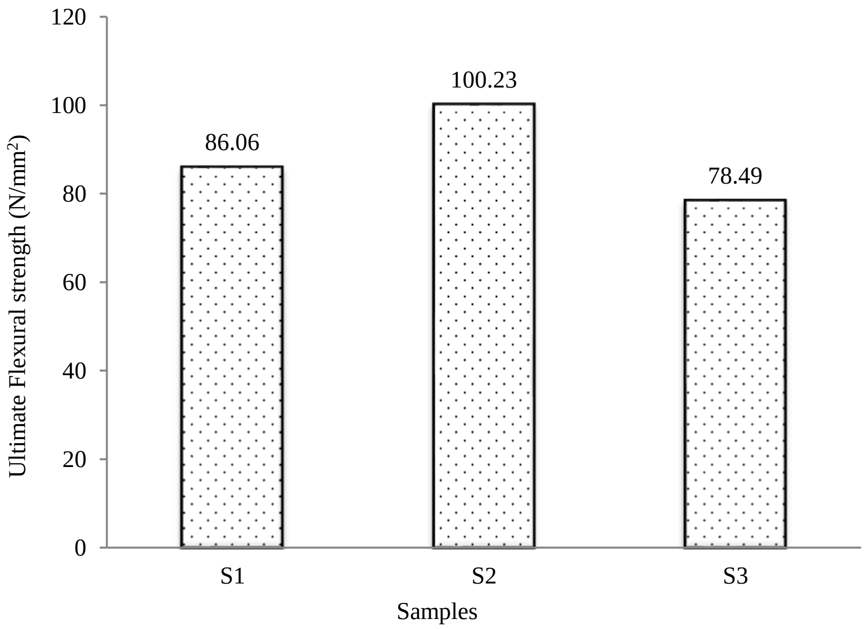


Figure 7. (a) Flexural strength of specimen C1.

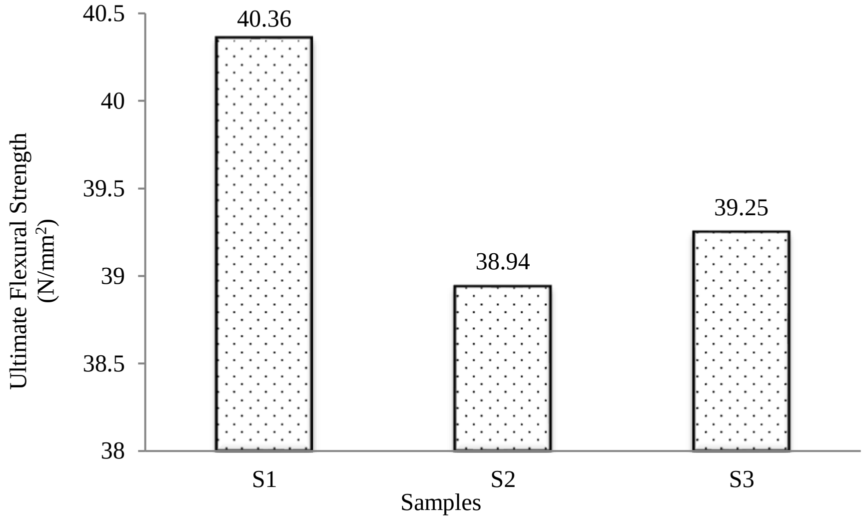


Figure 7. (b) Flexural strength of specimen C2.

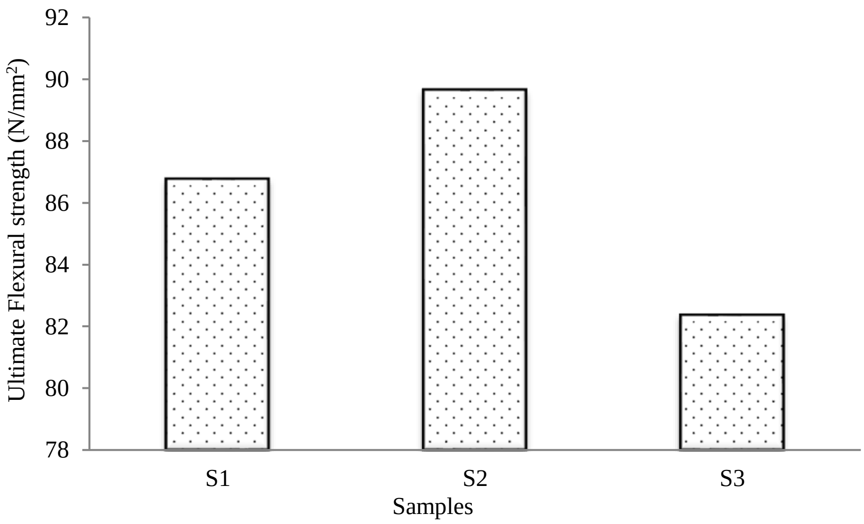


Figure 7. (c) Flexural strength of specimen C3.

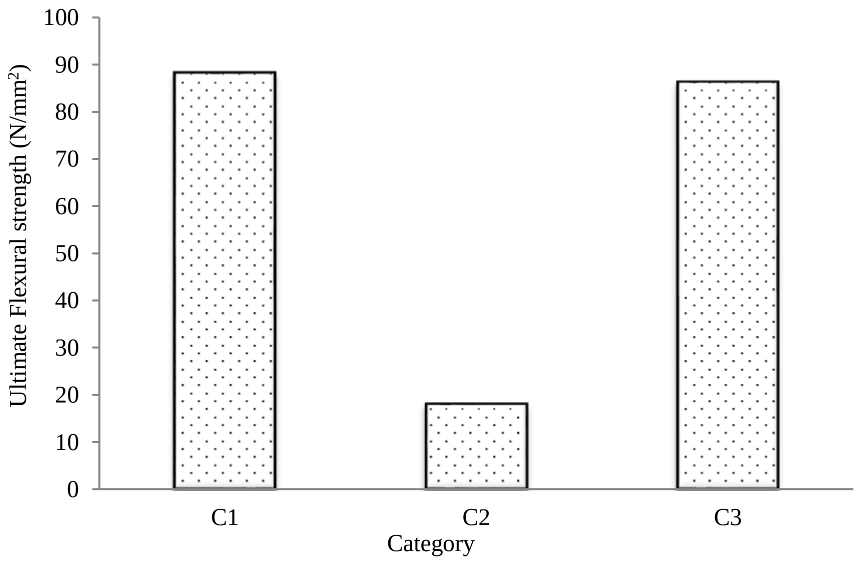


Figure 7. (d) Average flexural strength.

Table 4. Samples of Impact tests in categories C1, C2 and C3

S.N.	Class	Sample	Force absorbed (j)	Middling force Absorbed (J)
1	C1	S1	3	2
		S2	5	
		S3	6	
2	C2	S1	5	4
		S2	7	
		S3	6	
3	C3	S1	3	2
		S2	4	
		S3	3	

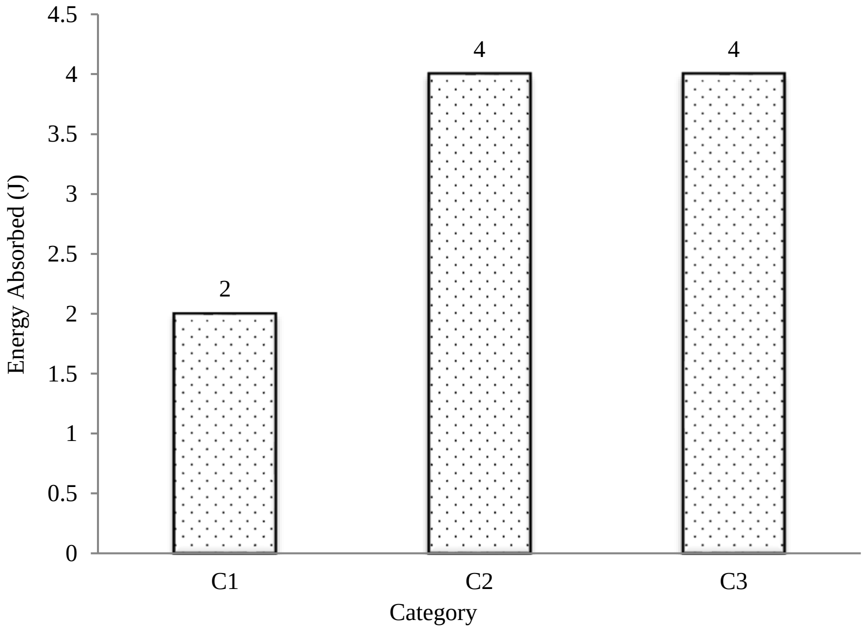


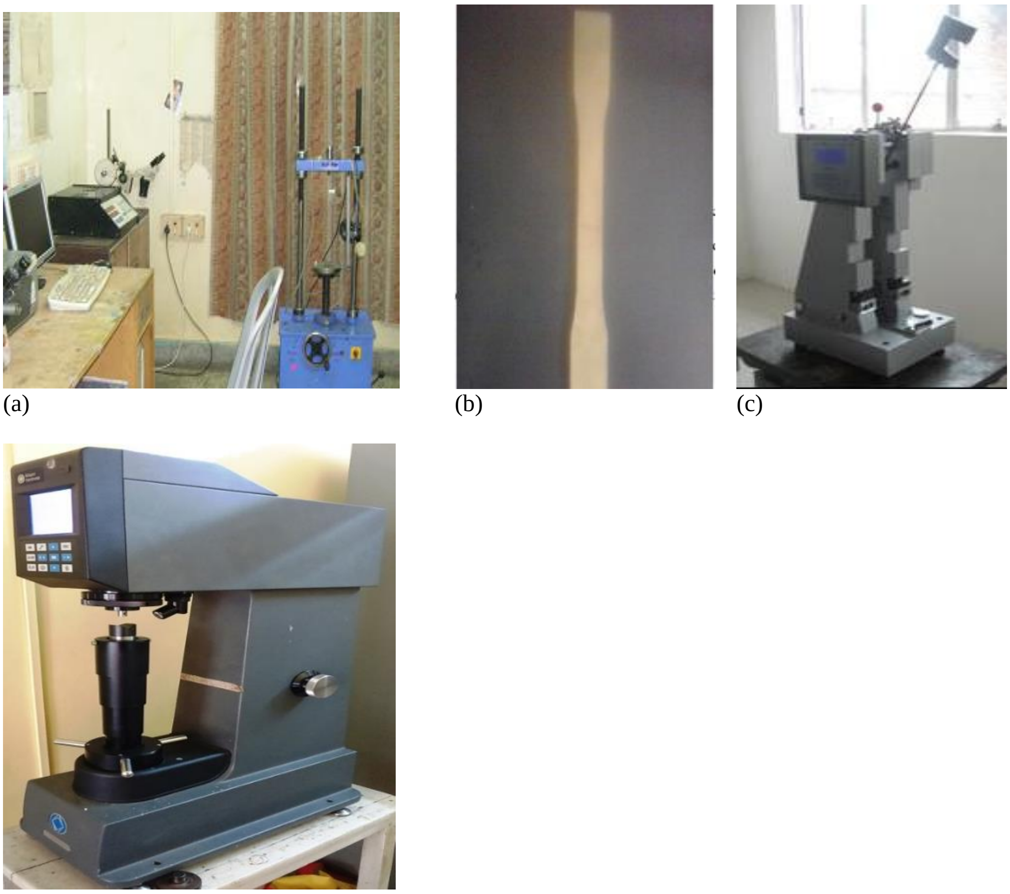
Figure 8. Average impact strength.

Samples S1, S2, and S3 of hybrid composites from Classes C1, C2, and C3 were subjected to Charpy impact testing to establish their respective impact strengths. The developed composites' impact value is listed in Table 4. According to Figure 8, the C2 has a greater average impact strength of 4 J. This demonstrates that flax fibre is superior to the other two composites in terms of impact strength. The impact behavior of the three classes is closer to one another because strength often depends on fibre characteristics rather than fibre orientation.

Dual Shear Test

The dual shear test was repeated the same UTM machine, as illustrated in Figure 9 (a), in accordance with the ASTM: D5379 standard. Figures 9(a) and (b) illustrate the machine and a schematic diagram of the double shear test specimen and the shear strength determined from the test.

Under typical conditions, shear stress is far lower than bending stress when the beam is loaded. Some design calculations, however, require it. Certain specialized fittings were used to conduct the test. Shear stress was applied in both directions to the specimen until it cracked. A graph of load versus deflection was made, and the breaking load was noted. Rockwell hardness testing and the Charpy test in an impact machine were also performed on the specimen, as illustrated in Figure 9 (c) and (d).


(a) (b) (c)

(c) (d)

Figure 9. (a) UTM Machine fot Tensile test and Double shear test (b)Primed Tensile speimen (c) Charpy arrangement in Impact testing machine (d) Hardness testing (Rockwell).

We were able to determine the double shear parameters of hybrid composite S1, S2, and S3 samples from classes C1, C2, and C3 using conventional equipment. The double shear value of produced composites is shown in Table 5. C1's twofold shear strength is depicted in Figure 10(a). According to the results, the S3 has a higher double shear strength of 1.056 kN. Figure 10(b) depicts the dual shear strength of C2, whereas S3 depicts the stronger double shear strength of 0.849 kN. Figure 10(c) depicts the double shear strength of C3. The results show that S3 has double the strength of 1.350 kN. Figure 10(d) shows that the hybrid composite has a greater strength (1.273 kN) than the other two mixes. In a dual shear test, the stress is proportional to the square of the strain, according to the stress-strain relationship.

Table 5. Samples of Dual shear test of first, second and third categories

S.N.	Class	Sample	Break Load (kN)	Middling of Break Load (kN)	Utmost Displacement (mm)	Middling Maximum Displacement (mm)
1	C1	S1	0.868	0.955	2.91	2.92
		S2	0.941		2.83	
		S3	1.056		3.03	
2	C2	S1	0.729	0.787	3.28	3.3
		S2	0.784		3.22	
		S3	0.849		3.40	
3	C3	S1	1.196	1.273	3.46	3.47
		S2	1.274		3.36	
		S3	1.350		3.60	

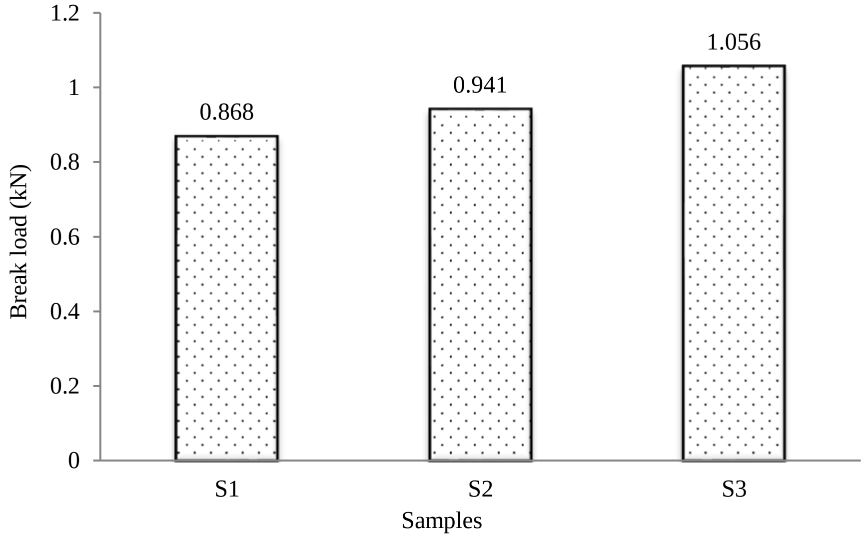


Figure 10. (a) Dual shear strength of C1.

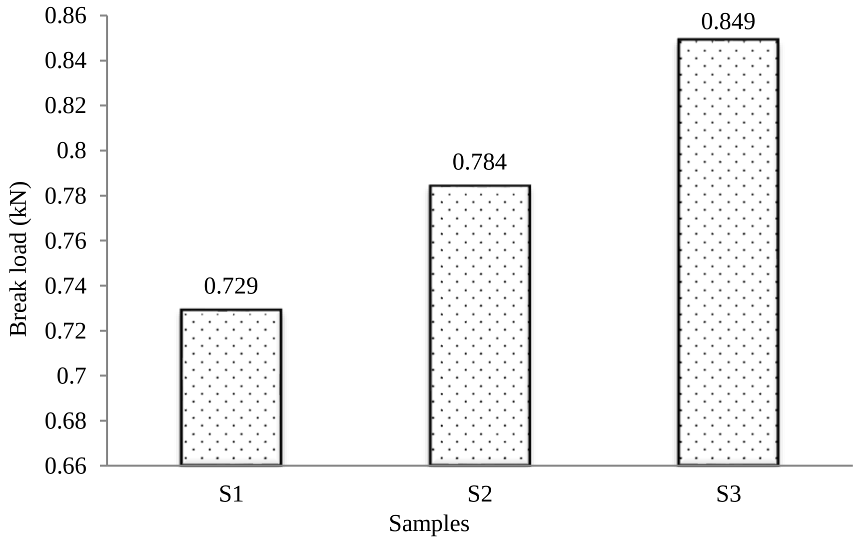


Figure 10. (b) Dual shear strength of C2.

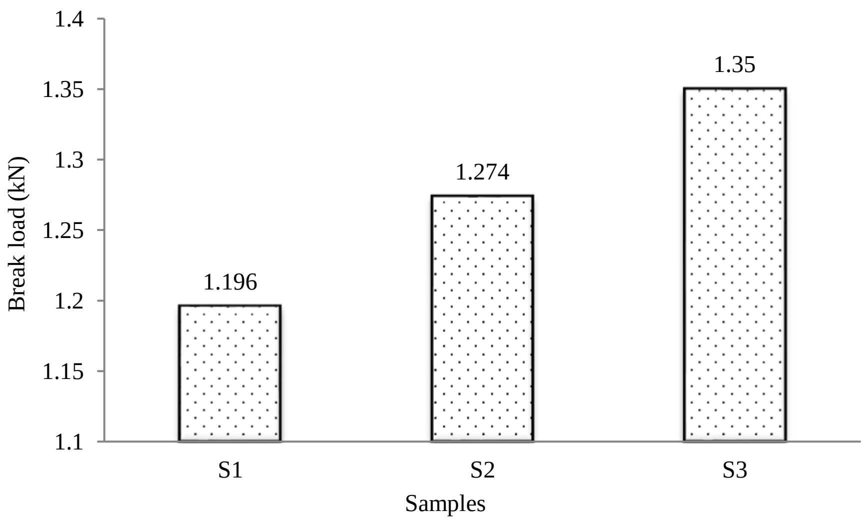


Figure 10. (c) Dual shear strength of C3.

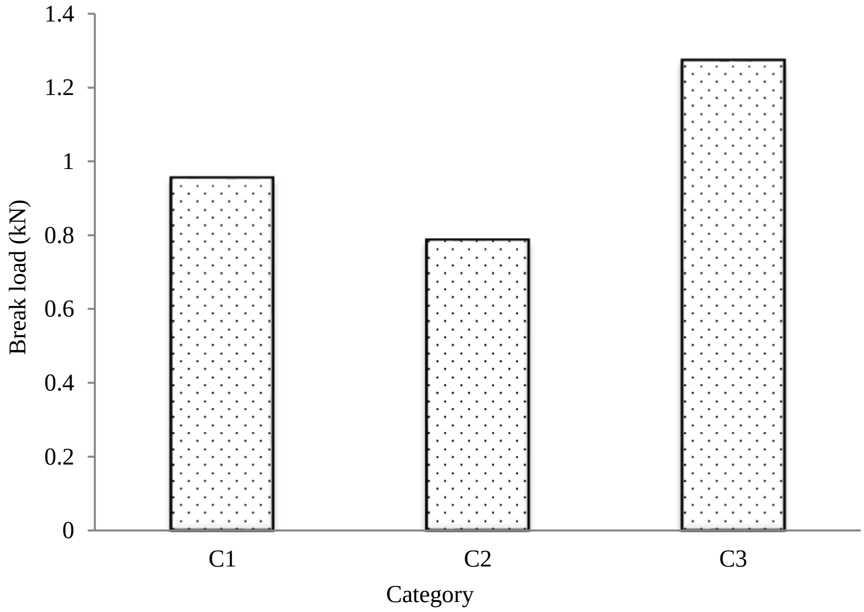


Figure 10. (d) Average break load

Hardness Test

To examine the specimen, first a hardness test in accordance with ASTM: D2583 was taken. The material's hardness is measured to determine its resilience in the face of mechanical shock. Table 6 depicts the hardness values of the composites.

Table 6. Hardness test of Classes C1, C2 and C3.

S.N.	Class	Hardness Value (HRL)
1	C1	85.26
2	C2	88.56
3	C3	84.28

The hardness of a material is proportional to the proportion of the substance that is designed to dampen the impact. The values for each class of hardness are listed in the table. Hardness measurements reveal that C1 measures in at 85.26 HRL, C2 at 88.56 HRL, and C3 at 84.28 HRL. C3, a cross composite, has a upper hardness rating compared to the other composites. Aluminum 6061 and stainless steel 430F were tested for their mechanical qualities using a variety of methods, including hardness, impact, bend, and pull load tests, in addition to the friction welding technique. Multiple regions of the samples were tested for hardness, and it was found that the weld contact had the highest value. As friction force and burn off length increased, toughness and bending strength increased while pulling strength decreased for both low and high upset forces.

FRACTURE SURFACE ANALYSIS: AFTER MECHANICAL TEST

To study morphology, a scanning electron microscope was utilized. The SEM was utilized to probe the material's internal surface characteristics. An ion-sputter coater was used to provide a gold coating between 15 and 20 nm thick to each sample after it was collected, dried, and analyzed. Thus, samples were examined using a scanning electron microscope. Figure 11(a)-(d) is a scanning electron micrograph depicting the interfacial adhesion between the matrix and the fiber.

Figure 11(a) depicts the resin buildup that resulted from unevenly dispersing the resin and hardener mixture across the tested samples. Selecting the right mixing ratio and curing time of laminates underweight can prevent this from happening. Figure 11(b) shows fibre pullout caused by inadequate

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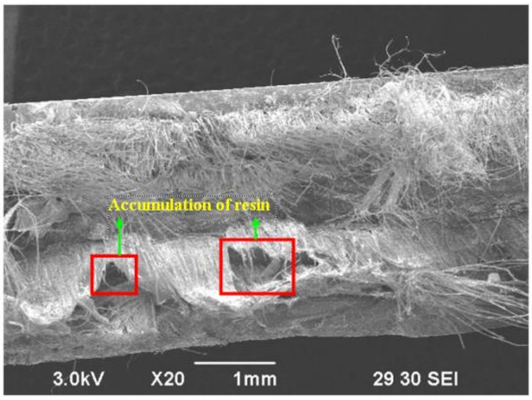
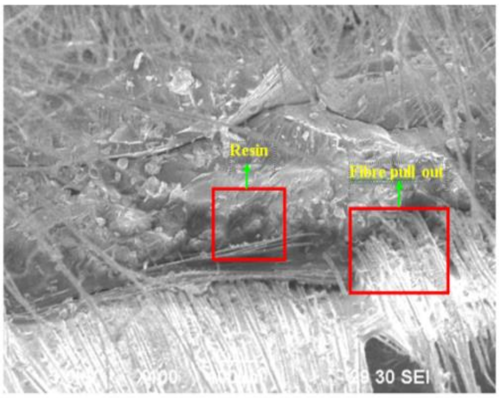
packing of fibres in the composite material. Figure 11(c) shows fiber breaking caused by poor handling. The tensile strength and other mechanical properties of composites suffer as a result. This can be avoided with well-prepared and manufactured fibers. Al Composites with metal matrices and ceramic reinforcement particles, or SiC, are more rigid and thermally stable than their unreinforced alloy counterparts. Welding causes plastic deformation and frictional heating, and SEM analysis of the area reveals dynamic recrystallization in the form of grain refinement of the aluminum matrix and breakage of reinforcement particles.

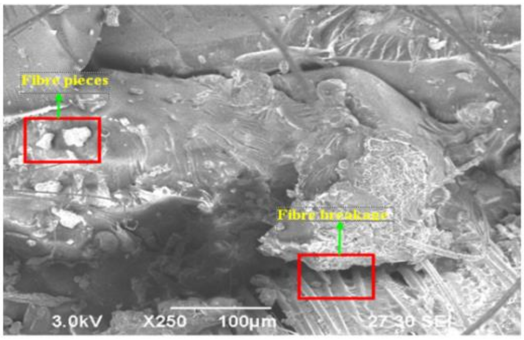
Figure 12(a) shows fiber breakage that might have been caused by inadequate curing time during composite laminate fabrication. Keeping an eye on the fibre shear allows for a more efficient manufacturing process. Fibre breakage is easily seen in Figure 12(d). It happens when the glue and fibers don't stick together well enough. The correct choice of resin fiber volume fraction will prevent this.



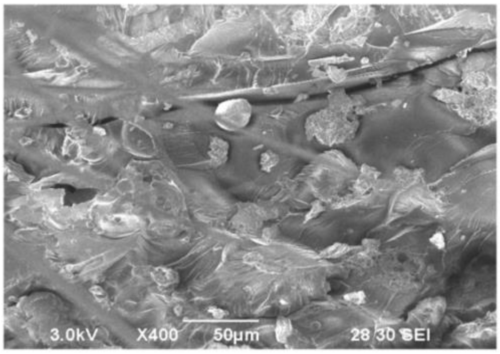
(a) @ Magnification of X20



(b) @ Magnification of X100

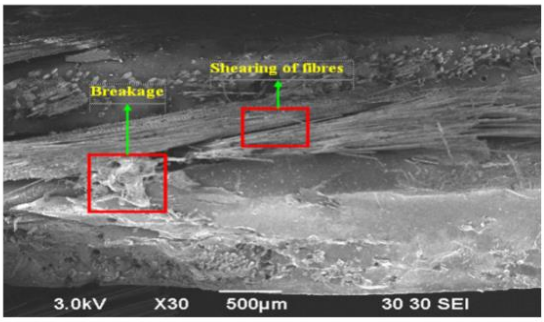


(c) @Magnification of X250

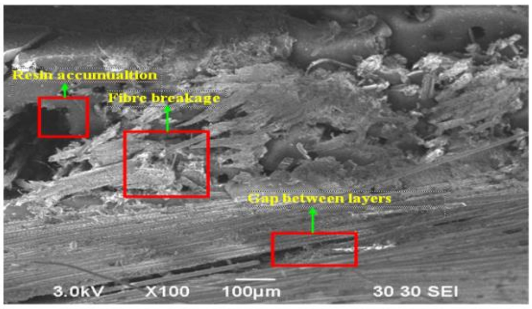


(d) @ Magnification of X400

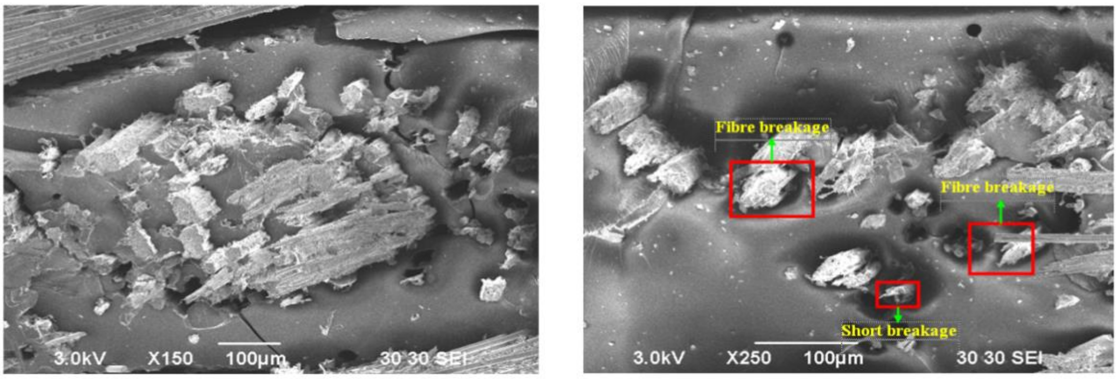
Figure 11. SEM images of C1 after tensile test.



(a) @ Magnification of X30

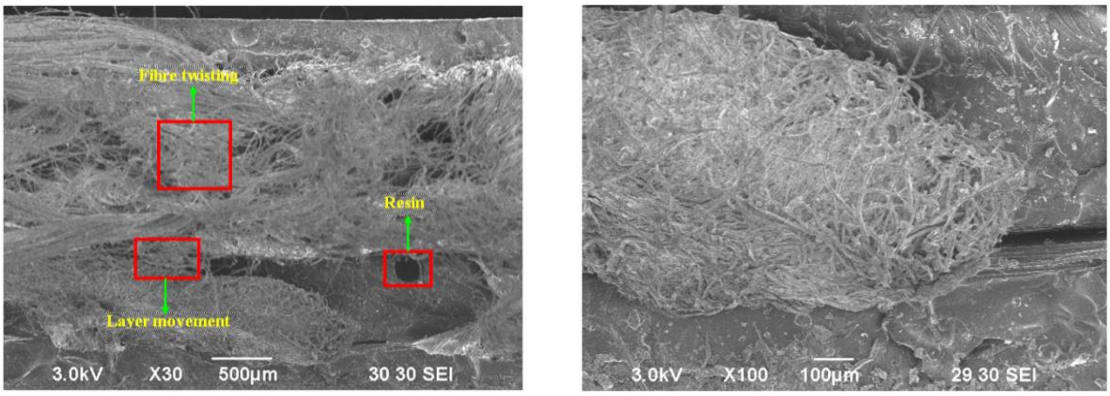


(b) @ Magnification of X100

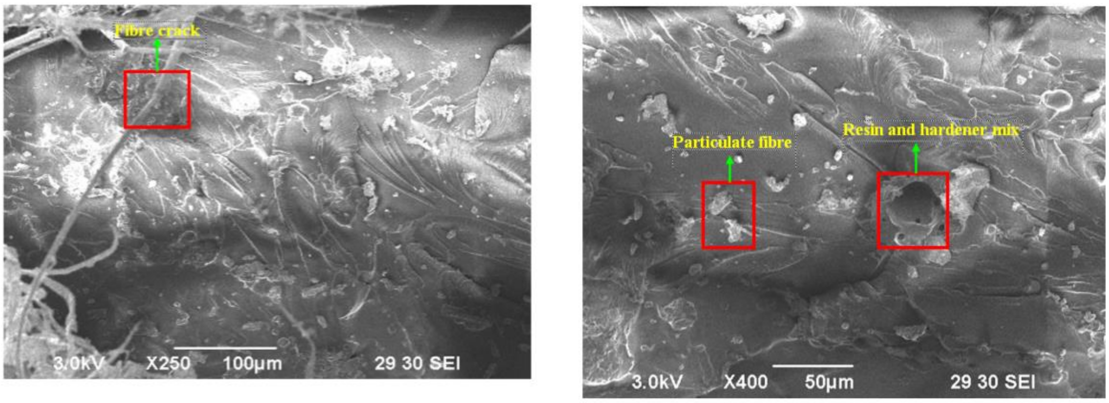


(c) @ Magnification of X150 (d) @ Magnification of X250

Figure 12. SEM images of sample C2 after tensile test.



(a) @ Magnification of X30 (b) @ Magnification of X100



(c) @ Magnification of X250 (d) @ Magnification of X400

Figure 13. SEM images of sample C3 after tensile test.

Load-induced motions of the fibre layer are depicted in Figure 13. The fibre layers shouldn't shear in this way if the packing and curing processes are followed correctly. To avoid this, the curing process and the load applied to the composite laminate must be chosen with care. Incorrect fiber combination also accounts for some observable bending of fibers. If the blending is done right, the fibers won't twist, making for a stronger composite laminate. The accumulation of resin can be reduced if resin is distributed evenly throughout the manufacturing process. In Figure 13(c), a fiber break can be seen that resulted from a tensile load. Fibre cracks may usually be prevented during laminate fabrication if the fibers are packed tightly enough. Treating the fiber before using it to make composite laminate can also help prevent this problem. Figure 13(d) shows the accumulation of resin and hardener mix that occurs when the two are not mixed properly. Careful consideration of the resin and hardener mixture ratio and application to the fibre layers prior to solidification may help prevent this.

STATEMENT OF NOVELTY

To study the connection between substances composition and the mechanical performance or properties of the composites, sugarcane bagasse, coconut fibre, and Kevlar fibre were hand-mixed layer by layer to create a fiber-reinforced composite. HEMP and glass fibres with intricate inclinations of 00, 450, and 950 are used in multiple layers to create these fibre composites with GFRP, which is a novel method of construction. Additionally, the HEMP and FLAX composites with the Glass fibre components have been incorporated into the three categories of composites in all layers. Comparisons between these three-layered specimens have been made. It is lightweight, corrosion-free, and has a good mechanical performance. It will be utilized based on sustainable manufacturing and the production of water tanks, fibre panels for machinery, windmill blades, etc.

CONCLUSION

Here, we use a Universal Testing Machine to measure the tensile strength of hybrid composite samples across categories C1-C3. The tensile strength of C1 of S2 is higher, at 36 N/mm^2, according to the tests. In addition, 22 N/mm^2 is the tensile strength of S1. Tensile strength is higher (40 N/mm^2) in S2 C3. This proves that the hybrid composite's tensile strength is higher by 38 N/mm^2. Tests of tensile strength show that the hemp and flax fibre composite outperforms the other two. To determine their flexural properties, samples of hybrid composites from categories C1 through C3 were tested in a universal testing machine. C1 of S2 has a flexural strength of 100.23 N/mm^2, according to the results. C2 of S1 has a 40.36 N/mm^2 flexural strength. The flexural strength of C3 of S2 is 89.66 N/mm^2, which is higher than the rest of the specimen. As a result, the hemp composite has a higher flexural value on average, at 88.26 N/mm^2. Hemp fiber, according to the flexural findings, is primarily responsible for the increased strength. Charpy impact testing is performed to assess the impact resistance of hybrid composite samples S1, S2, and S3 across C1, C2, and C3. According to the findings, the impact energy of all three samples (S1, S2, and S3) is 2 J. C2 typically has an effect value of 4 J. The third group has a value of 2 J for energy absorption. As a result, the third group, with an average value of 4 J, may have greater effect strength. In terms of impact strength, the flax fiber composite outperforms the other two composites. Hybrid composite samples S1, S2, and S3 from groups C1, C2, and C3 were examined for dual shear characteristics using standardized tools. S3's dual shear strength is 1.056 kN, greater than S2's C1. S3 C2 has 0.849 kN double shear strength, higher than S1. C3 of S3 is doubly stronger than 1.350 kN. A part's shock absorption determines its hardness. C1 has 92.6 HRL, C2 90.6, and C3 94.8. Hybrid composite C3 is the hardest. Experiment 1 performed better in the wear test.

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