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Characteristic of Natural Fiber Composite Using Sugarcane Bagasse for Body Part Fender Application

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Abstract

Natural fibre composites have emerged as a promising alternative to traditional composite materials due to their eco-friendly nature, abundance, and desirable mechanical properties. This research focuses on characterising natural fibre composites utilising sugarcane bagasse for body part fender application. Sugarcane bagasse, a byproduct of the sugar industry, presents an environmentally friendly and renewable source of natural fibre. The purpose of the tests is to analyse and determine the mechanical properties of the material. Sugarcane bagasse was mixed with epoxy resin by three different percentages, including 10 %, 15 % and 20 % with a ratio of epoxy resin: hardener was 3: 1. The specimen fabrication was done in mould method, which is with the mould 20 cm x 20 cm x 0.3 cm. using spray WD-40, for easier the sugarcane bagasse left from the mould. A hand grinder was used to make the specimen follow the ASTM dimension. The detailed description starts with the specimen testing by ASTM D638 for the tensile property and ASTM D790 for the flexural property of the composite. Followed by specimen testing using ASTM D256 for the impact strength. From the experiment that has been conducted, the best percentage ratio is 20 %. Tensile strength and impact test at 20 % of sugarcane bagasse composite shows the best results with 13.92 MPa and 14.06 MPa respectively. These fibres may provide a noticeable improvement over the 10 % and 15% ratio. By serving as reinforcement, the fibres strengthen the material's structure without reducing its flexibility or making it brittle. The results demonstrate the potential of sugarcane bagasse composites as a suitable material for fender applications, offering desirable mechanical performance, reduced weight, and improved sustainability. The findings contribute to the advancement of natural fibre composites and provide insights into their application in automotive components, supporting the shift towards eco-friendly and lightweight materials in the automotive industry.

1. Introduction

In the modern era, engineers and scientists are always trying to build the best product based on sustainability, quality and eco-friendliness. The material used is the important thing in selection to create the best product. In this study, natural fibre is the material used to apply the body part of Fender car. The natural fibre will convert to composite. In fact, the use of natural fibre as a composite material dates back to 3,000 years, when clay walls were strengthened with straw [1]. Natural fibre was categorised as a renewable resource, like minerals, plants, and other living things[2]. Natural fibres are resilient, reasonably priced, and lightweight [3]. The area of the car's body that encircles the wheel well is referred to as the fender, often known as a wing or quarter panel. It protects the wheel and tires from foreign objects, as well as adds visual appeal to the overall design of the car. Wheels and tires are shielded by fender from splashes of water, dirt, and other road debris. It helps prevent damage to the body and other components of the vehicle from being hit by any strong contact [4]. The material for the fender also plays an important role where if the material is good, the damage that will occur in the fender will be less.

2. Material and Method

2.1 Preparation Raw Material

Sugarcane was taken from the market in Pagoh Jaya. Fig. 1(a) shows the sugarcane residue should be dried under the sun for 48 hours to completely dry. The sugarcane bagasse needs to be prepared in smaller sizes. The expected sugarcane bagasse chopped size should be between 0.15 and 0.30 mm. Fig. 1(b) shows the final product of sugarcane bagasse fibre.

Fig. 1 (a) *Sugarcane dried under the sun* ***(b)*** *Final Product Sugarcane bagasse*

2.2 Chemical Treatment

The sugarcane bagasse fibre undergoes an alkaline treatment process for dewaxing by immersing it in 2 % sodium hydroxide (NaOH) for 72 hours. The immersed solution was a 6 L distilled water mixture with 120 g solid sodium. Precision weighing (Mettler Toledo) was used to measure 2 % of NaOH. The fibre was rinsed with distilled water containing a small amount of acetic acid after being immersed in a 2% sodium hydroxide (NaOH) to neutralise any residual sodium hydroxide. Finally, the fibre is cleaned and dried using fresh distilled water. To eliminate all moisture content within the fibres, the sugarcane bagasse fibre is dried in a Heavy-duty universal oven at 60°C for 72 hours

2.3 Compounding Process

The different ratios of 10 %, 15% and 20 % were calculated by following the mould size of 20 cm x 20 cm x 0.3 cm. The total weight used for sugarcane bagasse fibre with resin and hardener was 120g. Three different ratios that being to measure was 10 %, 15 % and 20 %. The Ratio of Epoxy resin was 3:1. Table 1 shows the exact calculation with three different ratios.

Table 1 *The calculation of different ratios for compounding*

Sugarcane Bagasse Percentage (%)	Weight of Sugarcane Bagasse (g)	Resin (g)	Hardener (g)	Total Weight (g)
10	12	81	27	120
15	18	76.5	25.5	120
20	24	72	24	120

2.4 Specimen Fabrication

Fig. 2 displays the final product after the fibre, resin, and hardener mixture was made. The method for specimen fabrication involved the following steps, all completed in the past: Firstly, resin and hardener were compounded and mixed until smooth, then left for one minute. Next, the surface of the mould was sprayed with WD-40. Sugarcane fibre was then added to the mould according to the specified percentage ratio. After that, the mixture of resin and hardener was entered, applied to all surfaces, and flattened with a roller to ensure even distribution between the sugarcane bagasse fibre, resin, and hardener. The surface of aluminium paper was sprayed, and this paper was used to cover the surface, with weights placed on top to compress the mixture. This process was repeated for all the different ratios. The mould was then dried for 24 hours.

Fig. 2 *Fabricate the mixture of sugarcane bagasse fibre with resin and hardener*

2.5 Tensile Test

The dimensions of the specimens adhere to the standards set by ASTM D638. The compound of sugarcane bagasse fibre composite was cut by using a hand grinder and sandpaper. The specimen dimension ASTM D638 has been followed. Figure 3.11 shows the final product of sugarcane bagasse fibre as Figure 3.

Fig. 3 *ASTM D638 sugarcane bagasse fibre composite*

The specimens used for testing were composed of a natural fibre composite with panels measuring 3 mm in thickness and 120 mm in length. To ensure the specimens do not fail under the grips, the width of the specimen tabs at both ends was 19 mm, while the width at the shaft was 6 mm. The sugarcane bagasse fibre composite specimens had varying concentrations of sugarcane bagasse to resin ratio. The specimens were placed into a Victor Material Testing Equipment. This machine was running at the speed of 10mm/min.

2.6 Bending Test

Bending test experiment was conducted by the ASTM D790 standard testing method. The test was running at the Automotive System Laboratory in UTHM. Fig. 4 shows the actual after cut following the ASTM D790. The specimens used for testing were composed of a natural fibre composite with dimensions of 127 mm in length, 13 mm in width, and 3 mm in thickness. The specimens were made of sugarcane bagasse fibre composite and had different concentrations of sugarcane bagasse to resin ratio. To ensure compliance with the ASTM D790 standard, the specimens were placed into a testing machine capable of performing the required measurements. With a load of up to 1kN, the crosshead's speed was 10 mm/min. The compression and bending properties of the specimens were measured using a Victor Material Testing Equipment. The specimen was loaded until it bent or fractured while being supported on two points or while being mounted on a three-point bending device. Bending testing reveals information on the material's flexural strength.

Fig.4 *Sugarcane bagasse fibre composite ASTM D790*

2.7 Impact Test

A specimen of 80 mm in length, 12 mm in width, and 4 mm in thickness was created for the impact test. Every sample was individually nicked with a knife to make the V notch (45^{o} angle, radius 0.25mm). Fig. 5 shows a Sugarcane bagasse fibre composite specimen for the impact test. An experimental study was conducted following the ASTM D256 standard testing method to evaluate the impact properties of sugarcane bagasse fibre composite specimens. Each specimen was composed of different concentrations of sugarcane bagasse to resin ratio. 50 J of energy was delivered, and the pendulum hammer 7600.250 Izod ISO/ASTM was mounted at a 150 angle. Every ratio has the same set of parameters. The specimen was placed into the slot and securely fastened to begin the test. The notch is located precisely at the edge of the gripping point, and the specimen is held standing on the edge in a particular orientation. After that, the specimen is broken to determine the impact strength by releasing the hammer. The pendulum hammer was raised to a 150-degree angle and then released to strike the specimen at the location of the notch. Upon impact, the specimen fractured, and the amount of energy absorbed by the specimen was recorded as a measure of its impact resistance.

Fig. 5 *Sugarcane bagasse fibre composite specimen for the impact test*

3. Result and Discussion

The mechanical performance of the sugarcane bagasse fibre composite for body part fender fabrication was covered in this chapter based on the information gathered. The tensile, bending, and impact tests were used to discuss the mechanical properties. For each test, a total of 27 samples were used. The outcomes of each specimen at different ratios of 10 %, 15 % and 20 % respectively will be deliberated upon

3.1 Tensile Strength Test

Three different percentage ratios of sugarcane bagasse fibre composite have been tested, including 10 %, 15 % and 20 %, respectively. Fig. 6 shows the graph bar chart for sugarcane bagasse's tensile strength (MPa) with different percentages. At the 10 % ratio, the tensile strength that has been recorded was 13.45 MPa, followed by the 15 % ratio was 11.16 MPa and for the 20% ratio was 13.92 MPa. The tensile strength graph for sugarcane bagasse fibre composites with ratios of 10 %, 15 %, and 20 % reveals intriguing fluctuations in material performance. At a 10 % ratio, the tensile strength was recorded at 13.45 MPa, indicating a relatively high strength level. However, as the ratio increases to 15 %, there is a noticeable decrease in tensile strength to 11.16 MPa. At a 20 % ratio, the graph shows the best tensile strength with 13.92 MPa. This unexpected reduction suggests that introducing a higher percentage of a specific constituent may not necessarily enhance tensile strength. The decrease could be attributed to various factors. This could result from improper fabrication or inadequate interfacial bonding between the nappy waste composite and epoxy resins.

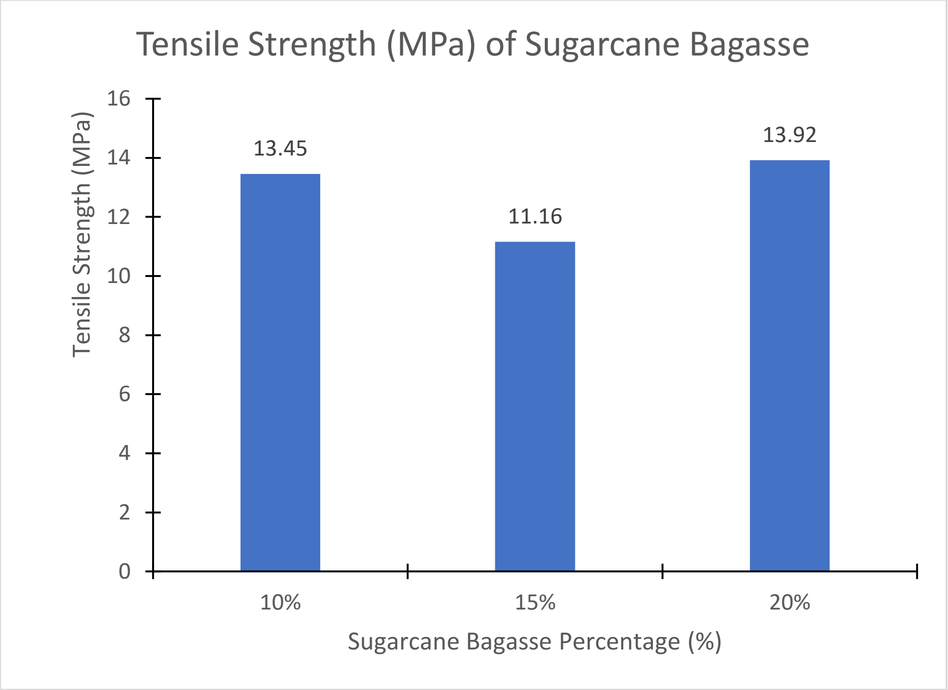

Fig. 6 *Bar chart tensile strength (MPa) of sugarcane bagasse*

Previous researcher has done two different percentage ratio and have two different lengths. The result was 10 % for the tensile strength for 1 inch, which was 7.82 MPa, and for 2 inches, it was 10.42 MPa. At a ratio of 20 %, 1 inch was recorded at 16.97 MPa, and 2 inches were recorded at 17.57 MPa. It can be seen that if the length of the material is increased, the tensile properties will increase [5]. Compared to this study, the tensile strength increased from a 10 % to a 20 % ratio. More fibre in the specimen will increase the tensile strength. At a 15 % ratio, the sugarcane bagasse fibre composite's surface is not flattened because the epoxy resin is not perfectly absorbed.

Fig. 7 shows the plots of graph strain-stress of sugarcane bagasse fibre with different percentages. The blue graph is 10 %, the red graph is 15 %, and the yellow graph is 20 %. It can be seen that the higher strain was at a ratio of 20 % with 5.23 %, followed by a ratio of 10 % with 4.72%, and the lower strain was at a ratio of 15 % with 3.56 %. The higher strain capacity at 20% could be attributed to more effective stress distribution within the composite, possibly due to an improved fibre-matrix interaction at this concentration. This interaction is crucial, as it determines how well the fibres reinforce the matrix material. The lower strain at 15% suggests a non-optimal interaction between the fibres and matrix, possibly due to factors like fibre alignment, distribution, or bonding quality. These observations underscore the complexity of designing composite materials. The non-linear relationship between fibre content and mechanical properties highlights the need for a nuanced understanding of how composite constituents interact. Optimising fibre content is crucial for applications that require materials to undergo significant deformation without failing, such as in flexible construction materials or certain automotive parts.

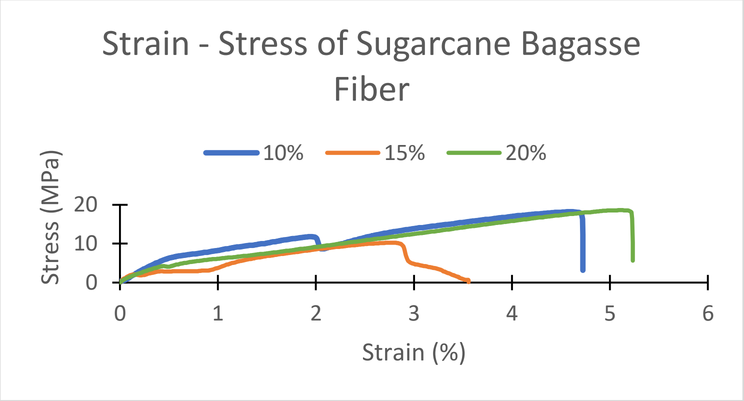

Fig. 7 *Graph strain-stress of sugarcane bagasse fibre*

The Young's Modulus graph of sugarcane bagasse fibre composites, illustrating different fibre ratios (10 %, 15 %, and 20 %) shows at Fig. 8, presents a fascinating insight into the material's stiffness and how it is influenced by fibre content. Young's Modulus is a critical measure in material science, indicating a material's ability to withstand deformation under stress. In this case, the values were 6.14 MPa for 10 %, 5.58 MPa for 15 %, and 9.29 MPa for 20 %. The graph reveals a non-linear relationship between fibre content and stiffness. The highest stiffness, indicated by Young's Modulus, is observed at a 20 % fibre ratio, suggesting that at this concentration, the fibres are most effective in reinforcing the composite, making it more resistant to deformation. Conversely, the decrease in stiffness at 15% fibre content is particularly intriguing. This unexpected dip could be attributed to various factors, including the distribution and orientation of fibres within the composite or the bonding quality between the fibres and the matrix material. Anomalies in these aspects at the 15% fibre concentration could lead to reduced effectiveness in load transfer, resulting in lower stiffness.

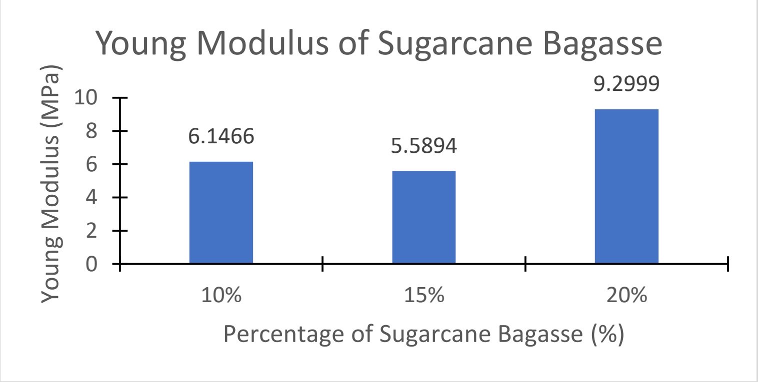

Fig. 8 *Young modulus of sugarcane bagasse fibre with different ratio*

3.2 Bending Strength Test

Three different ratios have been tested in this experiment for the bending strength test. This test compared the force until the sugarcane bagasse composite was broken between three ratios. Fig. 9 shows the graph bending strength for different percentages of sugarcane bagasse fibre. It can be seen that the graph was declined. The higher bending strength was at a ratio of 10 % with a 39.88 MPa, followed by a ratio of 15 % with 29.91 Map, and the last was a ratio of 20 % with 23.26. The bending strength decreases as the ratio of the fibre increases. The lower bending strength was at a 20 % ratio because of sugarcane bagasse's higher amount of natural fibre compared to the ratio of 10 %. It also can be the reason because the surface of the sugarcane bagasse fibre composite at 20 % is not flat compared to the ratio of 10%. Poor adhesion between the composite and the uneven distribution of epoxy resin within the sugarcane bagasse fibres decreased the ability of the resin and the fibre to transfer stress.

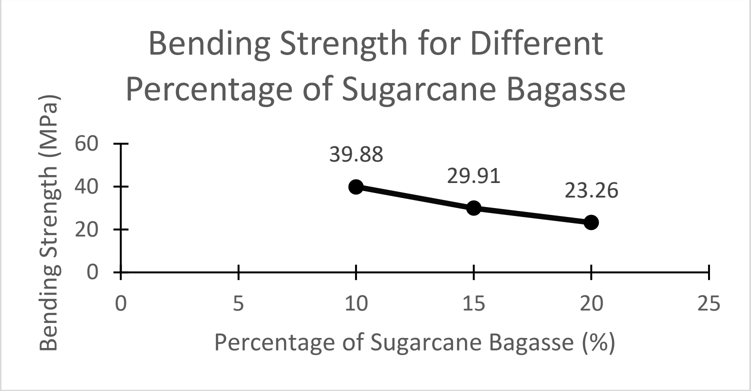

Fig. 9 *Bending strength with different ratios of sugarcane bagasse fibre*

It was demonstrated that Sugarcane Bagasse fibre particles were less effective in enhancing flexural characteristics than tensile ones. The adverse geometrical properties of the material could only cause the flexural strength to either remain constant or decline[6]. It may be argued that by raising the fibre weightage, sugarcane bagasse particles have solved the issue of short fibres being too compact to be evenly distributed inside the matrix. The short fibber's ability to convey stress decreases as its weight increases.

3.3 Impact Strength Test

The amount of effort required to shatter a test specimen is measured by impact energy. The specimen absorbs the energy from the hammer blow until it yields. In this experiment, three different percentages of sugarcane bagasse fibre composite have been tested. Fig. 10 shows the result impact energy for each different ratio. It can be seen that the graph fluctuated. At the ratio of 10 %, the value data collected was 9.76 J/m, followed by a ratio of 15 % with 8.88 J/m and the last at 20 % with 14.06. The highest impact energy was at a ratio of 20 % with 14.06 J/m because the weight of fibre and total mixture with epoxy resin makes the material stronger compared to the other ratio. The weak impact energy was at a ratio of 15%. It can be causing the specimen at 15% is not flatten.

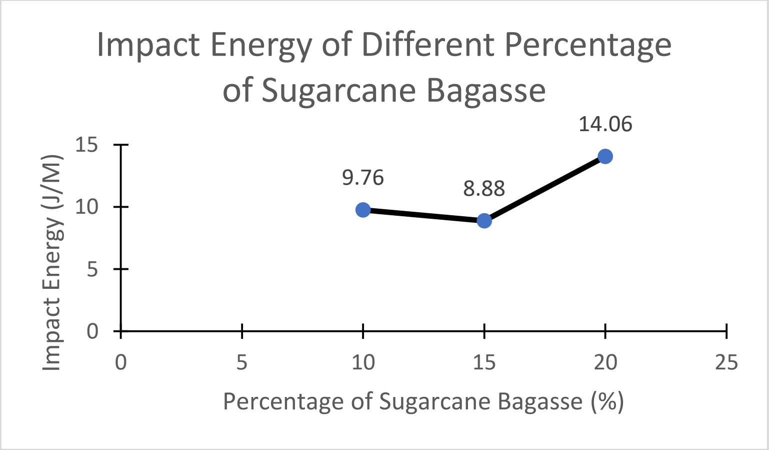

Fig. 10 *Impact energy with a different percentage ratio of sugarcane bagasse*

Fig. 11 shows the relationship between energy absorption and impact energy with different ratio percentages. According to the graph, the graph was fluctuated with increasing ratio percentage. The highest impact strength was recorded at a ratio of 20% with 1.16 kJ/m2. Followed by a 10% ratio with 0.81 kJ/m2, and the lower impact energy was at a ratio of 15% with 0.73 kJ/m2. The variation in fracture toughness with increasing filler loading was linked to this tendency. As the number of fibres increases, more paths are available for dispersing and absorbing impact energy. This could stop cracks from forming in the material or slow down their propagation. When a force is applied, the fibres help to distribute the stress, preventing it from concentrating in one area and reducing the possibility of cracks propagating. According to Lakshmi (2023), the value of impact energy increased when the weight of sugarcane bagasse fibre ratio was increased [7]. The previous study shows that in the sample, 40 % of sugarcane bagasse is more absorbed impact energy other than less ratio of sugarcane bagasse. At the weakness ratio of 15 %, that is because the sugarcane bagasse fibre composite does not mix well. The Epoxy resin does not compound well during the fabrication step. The surface of bagasse fibres is often coated with waxes and lignin, which can make them less receptive to epoxy resin. Surface treatment of the fibres may be necessary to improve adhesion.

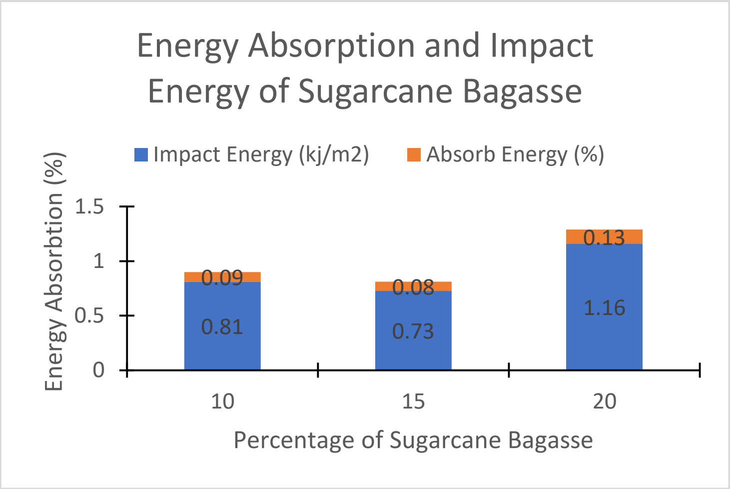

Fig. 11 *Relationship between the energy absorption and impact energy*

4. Conclusion

In this study, three different ratios to conduct an experiments to study the mechanical properties of sugarcane bagasse fibre composites for possible use in automotive body part fenders have been achieved. These composites performance and applicability were examined. The findings suggest that composites made of sugarcane bagasse fibre have the potential to be a substitute material for car fenders. The best ratio percentage between the three different ratios was 20%, with 13.92 MPa for the tensile strength test and 14.06 J/m for the impact strength test. The composites showed good epoxy resin compatibility, which is essential for guaranteeing structural integrity in vehicle parts. Testing of mechanical properties such as impact resistance, flexural strength, and tensile strength showed that the fibre content ratio affected the composites' mechanical performance. Improved mechanical strength was often correlated with higher fibre content, emphasising the significance of striking the ideal balance between resin and fibre content to get the required performance. Furthermore, sugarcane bagasse composites showed promise for reducing weight in automobile components. Their lower environmental effect and increased fuel efficiency can be attributed to their lightweight nature compared to older materials because sugarcane bagasse fibres are renewable and biodegradable.

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