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Characteristics Of Musa Acuminata Stem Fibers Reinforced Polyester Matrix Composite Fiberglass

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ABSTRACT
Natural fiber based composites are drawing in numerous researchers and scientists due to a great extent accessible in nature and specific properties Banana (Musa acuminata stem fiber) (MASF)) is one of the characteristic fiber with better mechanical properties. MASF reinforced polyester matrix composites (PMC) fiberglass with 10, 20, 30 and 40% fiber content were prepared and tested. The composites were characterized for tensile strength, tensile modulus and water absorptions properties using ASTM D 638-76 and ASTM D 570-81 standards, respectively. The highest mechanical performance of composites was achieved at 20 mm of fiber length composites followed by 30 % and 40 % fiber contentnt. This research showed that the optimum tensile stress of 560 MPa, tensile modulus of 785 MPa occurred at 30 % and 20 % fiber content respectively. The optimum properties of water absorption of were achieved at 40 % fiber content.

KEYWORDS*: Polyester Matrix Composites Fiberglass; Musa Acuminata Stem Fiber; Tensile Strength; Tensile Modulus; Water Absorptions.*

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I. INTRODUCTION

Research on natural fiber reinforced polyester matrix materials has been carried out in recent years. The results of this study indicate that the natural fiber reinforced composites exhibit superior properties compared to conventional composites. Lots of research has shown that the addition of natural fiber reinforcement can significantly improve mechanical properties such as stiffness and strength of many properties [12, 13]. The key to getting significant property enhancements is with a homogeneous spread of fibers, that is, individual Musa acuminata stem fiber (MASF) in the polyester matrix to be taken advantages of high aspect ratio and surface area. The affinity between the polyester matrix and MASF is determined, to some extent, by the polarity of the function group. Surface affinity of polymer of MASF is very important to promote the profitable interaction to obtain a high level of mechanical properties. All of these properties make the material suitable for a wide range of applications such as construction, automotive, electronics, packaging, etc. [14]. Development and application of a light sandwich structure elements is a growing trend in the construction industry around the world because of its high strength to weight ratio, reduced weight, and good thermal insulation characteristics [6]. The polyester matrice composit reinforced natural fibers present a great potential application in the automobile industry, especially in the bumper of automobiles, bus and trucks. The future perspective for the use of natural fibers is very good also in other areas. For instance, the textile industry is now with expansion international market. In the last years, use of natural fibers as, coconut, sisal, rami, sugar-cane pulp, jute and pineapple as reinforcement in polymeric material had an accelerated growth. They are source of renewable natural resource [2, 11]. The rear bumper is one part of the vehicle that has a very important role, apart from being aerodynamic and aesthetically pleasing to attract consumers, the bumper also functions as a collision damper from the rear that occurs in the vehicle. Therefore, the material used as the rear bumper often gets damaged during a collision, so it requires a material that has good impact toughness, is light, ductile and corrosion resistant. Natural fibers present low cost, are biodegradable, recycled, no poisonous and can be incinerated. They are being used as reinforcement in polymeric and substitute synthetic fibers partially as asbestos, Kevlar, boron, carbon, nylon and glass. In spite of these good mechanical characteristics, they present a high cost, are abrasive to the processing equipment's, possess high density, generate products with very high recycling cost, besides some of those fibers commit human health [1, 9].

Matrices have as main purpose to transfer the stresses imposed on the composite material to the fibers, as well to serve as a support and protection of the fibers. Generally, composite matrices of thermosetting resins are used because they have great mechanical properties and dimensional stability. They are also resistant to chemical attack and have high thermal resistance [10]. According to Bento [3] the matrix has three main functions which are: to protect the surface of fibers from damage by abrasion that would lead to fracture, adhere in the surface in order to transfer the force has applied to the same fiber, to separate the fibers each other in order to improve the resistance of propagation of transverse cracks to other fibers. The importance of this mechanical analysis is based on determining the strength of the structural design to provide confidence in the safety of use. The description above shows that impact strength is important to assess. Factors that greatly influence the increase the strength of natural fiber composites is a factor of fiber volume fraction or fiber content. In principle, all fiber nature has a fairly high strength (above 100 MPa). The low-strength composite behavior is usually caused by uncontrolled fiber reinforcing content. The research on polyester pineapple fiber composites shows that treatment of pineapple fiber by immersion in alkaline solution (NaOH) 10%, 20%, 30% and 40% for 2 hours have a better tensile strength than the tensile strength at the same treatment for 4 hours [5, 6]. Treatment of pineapple fiber by soaking in 10%, 20%, 30% ethanol solution and 40% for 2 hours is also better than treatment for 4 hours. Pineapple fiber treatment with soaking alkaline solution (NaOH) and ethanol (C2H5OH) 10%, 20%, 30% and 40% for 2 hours and 4 hours against the best compatibility (interfacial shear stress) of pineapple fibers on fibers that have been treated for 4 hours [10]. The addition of maleic anhydride was shown to improve properties of the biocomposite. Tensile strength of the PBS-MA and PLA-MA treated biocomposites as well as the biocomposites SEBS-MA and Mapp treatments are increasing [3]. This is evidenced by the fault section that occurs at SEM photo-micro results. The modulus of elasticity (E) also increased compared to the biocomposite who do not experience treatment. This proves that with this treatment the interfacial bond increasing, which will have an impact on increasing the mechanical properties and thermal properties of the biocomposite.

The mechanical properties of hybrid composites banana / kenaf fiber with a polyester matrix using Sodium Laulryl Sulfate (SLS) treatment. Research result showed that SLS treatment can improve the mechanical properties of hybrid composites compared to alkaline treatment [4, 7, 8]. The SLS treatment has improved the mechanical properties, tensile, bending and impact strength of the hybrid. Random fiber composites and woven fibers were better than those with alkaline treatment.

This study aims to determine the mechanical properties (tensile stress, tensile modulus) and water absorption of Musa acuminata stem fiber reinforced polyester matrix composites, for the feasibility of these composites as an alternative solution to the replacement material for vehicle bumpers categorized as Multi Purpose Vehicle (MPV) which in its application is closely related to safety usage. especially in the automotive sector.

II. MATERIAL AND METHODS

2.1. Materials

The research materials are Musa acuminata stem fiber, Polyester matrix type 157 BQTN and G3253T, MEKPO catalyst. The equipment used are universal tesing machine for tensile test digital scales, macro photos, SEM and composite fabrication equipment.

a **ʒure 1** a. Musa acuminata stem. b. Musa acuminata stem b

Table 1. Chemical composition of Musa acuminata stem fiber

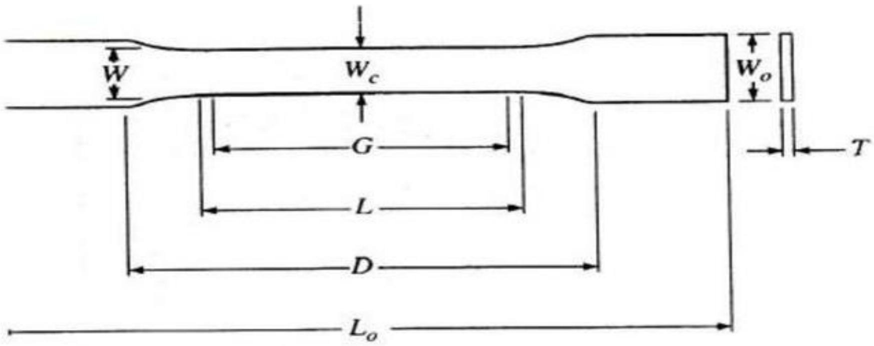
Constituents	Composition (%)
Cellulose	55.3
Lignin	39.8
Extractive	4,9

Table 2. Mechanical Properties of Musa acuminata stem fiber

Constituents	
Tensile Strength	600 Mpa
Young Modulus	17, 85 GPa
Flexure Strength	76, 53 Mpa
Density	1 -1,5 g/cm^3
Elongation	4,5 – 6,5 %
Moisture Absorption	10 – 11

2.2.Methods

Composite panels are made by using the press mold method. Variable this study is the volume fraction of Musa acuminata stem fibers by 5%, 10%, 15%, and 20%. The composite tensile test specimen was 12.7 thick mm refers to the ASTM D638-90 standard, as shown in Figure 2. The fracture section of the test specimen is subjected to a macro photo to identify the pattern failure.



Dimensions for type I specimen

			in	mm
W	=	width of narrow section	0.5	13
L	=	length of narrow section	2.25	57
W_o	=	width overall, min.	0.75	19
L_o	=	length overall, min.	6.5	165
G	=	gage length	2.0	50
D	=	distance between grips	4.5	115
R	=	radius of fillet	3.0	76

Figure 2 Tensile test specimen ASTM D638-90 standard

III. RESULT AND DISCUSSION

The mechanical test.

The results of the tensile test are in the form of tensile strength value curve versus fiber length and stress - strain curve are shown respectively in Figure 3. and 4. In the case of MASF reinforced polyester matrix composites (PMC), as the MASF 10 – 30 mm length, tensile stress showed an initial rapid increase but the MASF 40 mm length showed tensile stress decrease change, as shown respectively in Figure 3. The tensile strength gradually increases with an increasing amount of MASF at the optimum amount in composites. This may be due to the good interfacial adhesion between the polymer matrix and MASF. Elongation at break decreased significantly upon incorporation of MASF. This may be due to the increase in discontinuity of polymer matrix with an increase in the disperse phase (MASF).

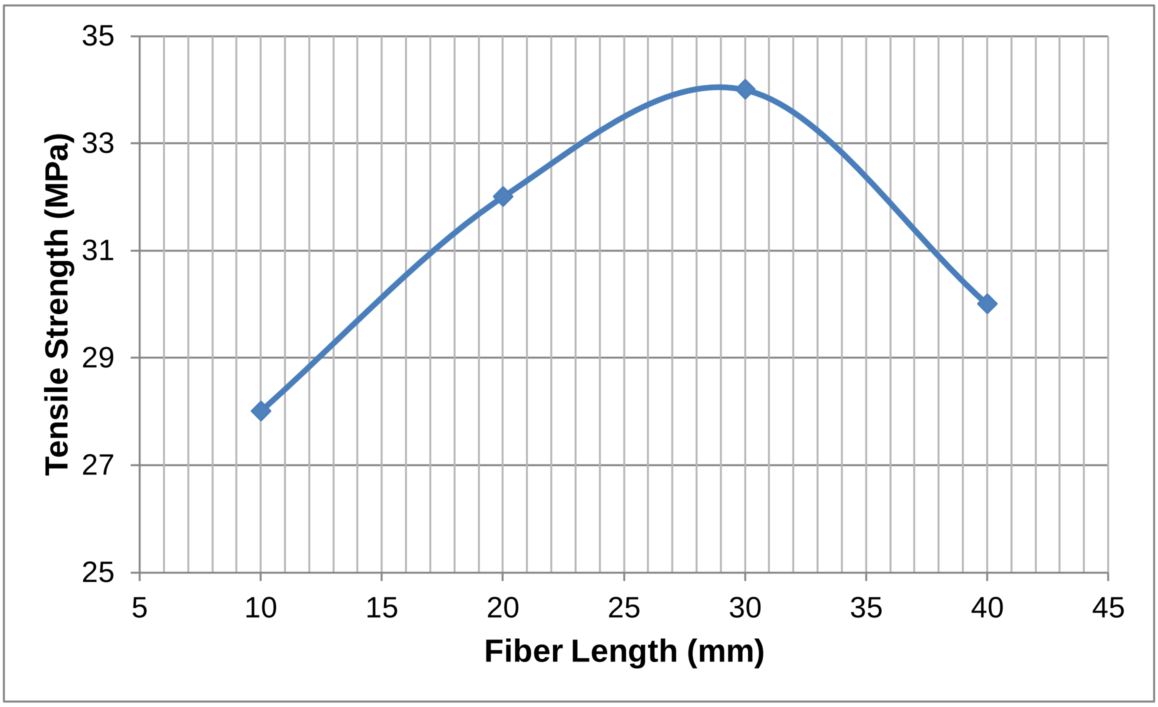


Figure 3. Effect of fiber length on the tensile strength of MASF

The tensile properties are given in Figure 4. The experimental results showed that MASF reinforced PMC composites showed an increase of tensile strength 560 MPa (maximum) at 40% MASF. Tensile strength increased continuously and the trend was continued in 10 % , 20%, 30T% and 40%. The addition of MASF to PMC tends to increase the strain of the composite material. The maximum strain of 0.08 occurs at an additional 40% MASF, at the stress of 560 MPA. At the stress of 325 MPA below the maximum strain of 0.07 in the addition of 10% MASF, the minimum strain of 0.019 at the same stress occurs in the addition of 20% MASF. PMC material with the best effectivity was obtained at the addition of 40% MASF, the lowest ductility at the addition of 20% MASF.

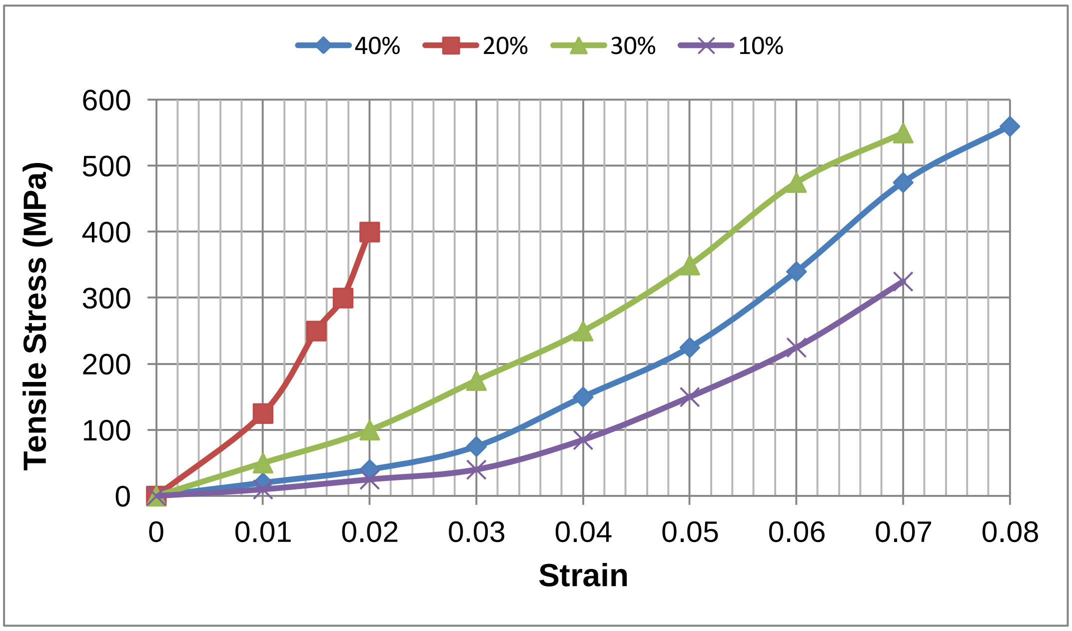


Figure 4 Stress strain curve of MASF reinforced polyester matrix compocite

Effect fiber content on tensile modulus of MASF reinforced polyester matrix compocite, as shown in Figure 4. Tensile modulus of the MASF reinforced PMC, 0 - 5% tends to decrease, 10 - 20% tends to increase and 30-40% is constant, not affecting for the tensile modulus. The highest tensile modulus of 785 MPA occurred at the addition of 20% MASF. The lowest of 100 MPA occurs at an additional 7.5% MASF. The increase in tensile modulus occurs because the addition of 10 - 20% MASF causes the tensile strength to increase, 10 - 20% MASF tensile strength decreases and 30 - 40% MASF ductility increases so that the tensile modulus is constant.

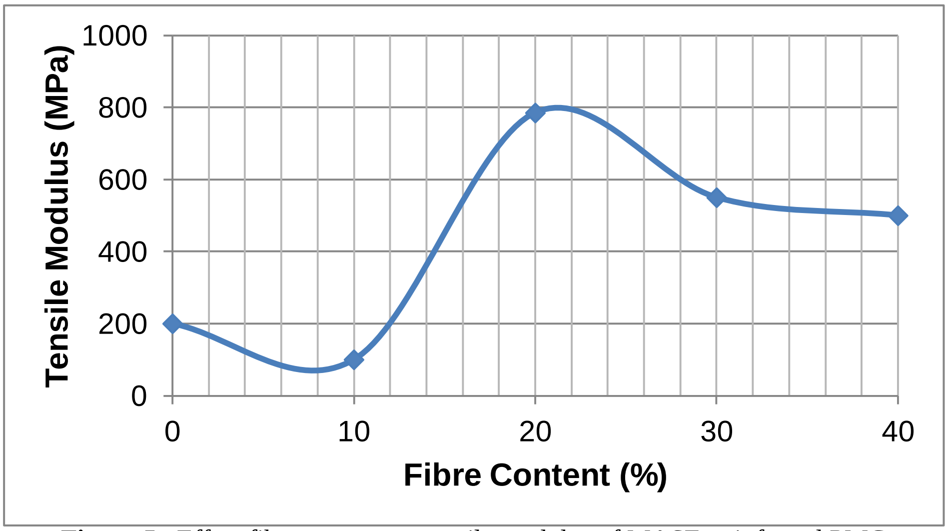


Figure 5. Effect fiber content on tensile modulus of MASF reinforced PMC

Water absorption

Composites of same weight and thickness were taken in which one set of composites were immersed in boiling water for 5, 10, 15, 20, 25 and 30 day and at room temperature, respectively. The weight and the thickness of such composites were measured again, and the
results are shown Figure 6. Water absorption percent can be calculated as follows :

$$\text{Water absorption } \% = \frac{W_w - W_i}{W_i} \, x \, 100 \, \%$$

where Wi and Ww are the initial and wet weights of the composites, respectively. This test was measured according to the method of D 570–81 ASTM.

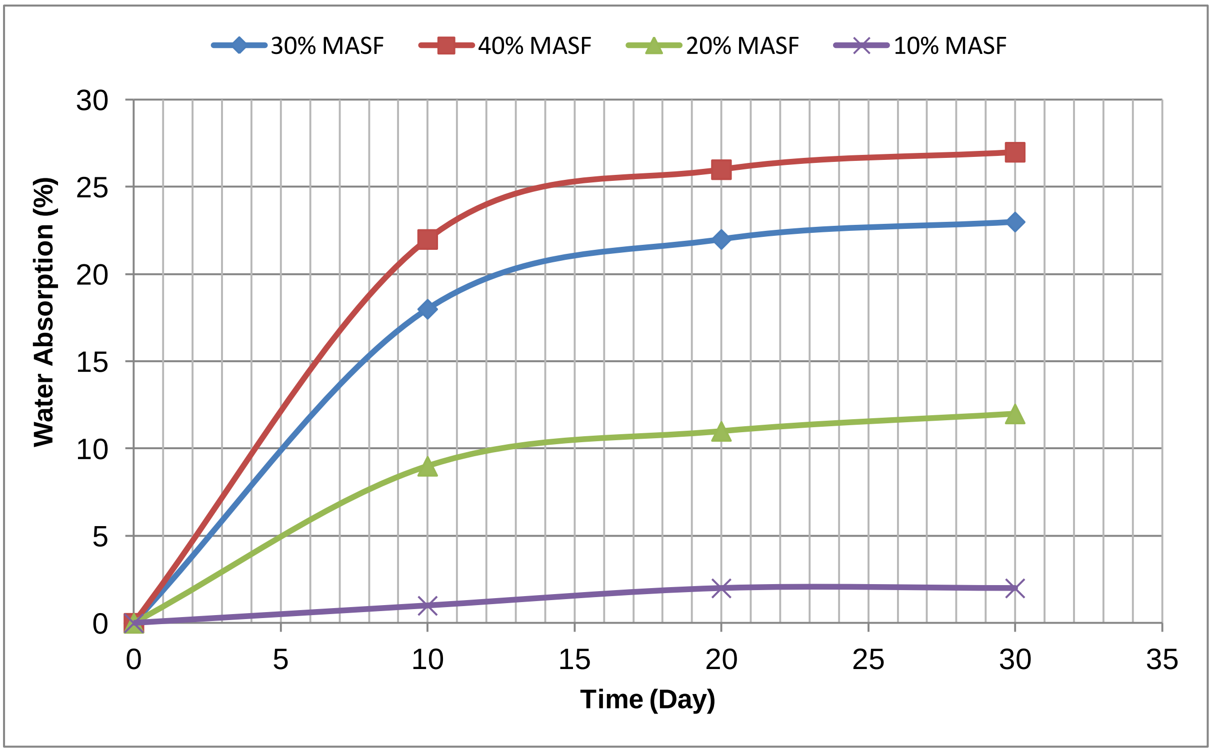


Figure 6. Water absorption of MASF reinforced polyester matrix compocite

The highest water absorption occurred at 40% MASF, at 30% immersion time of 30 days, the least water absorption occurred at PMC with 10% MASF fiber reinforcement, at 10%, immersion time of 30 days. The greater the percentage of MASF in PMC material, the higher the percentage of water absorption. The water absorption rate increased over a period of 0 to 10 days, at PMC with 20%, 30% and 40% MASF fiber reinforcement. For PMC with 10% reinforcing fiber, the water absorption rate is constant. Increase the percentage of MASF the greater the percentage and rate of water absorption. The phenomenon shows that MASF is hygroscopic, so that in the PMC structure there are a kind of gaps or cavities so that water particles can infiltrate or diffuse into the PMC. So that it can be applied as a sound suppressor or vibration dampening material.

3.2.Analysis of specimen failure.

Analysis of the Scanning Electron Microscope (SEM) was carried out after testing the impact strength to determine the bond structure between the fibers (fiberglass - MASF) as reinforcement with polyester as a binder (matrix). From Figure 5d, the volume fraction with the 20% volume fraction of MASF, matrix 80% mixture shows that the fibers adhere well, it can be seen that after damage to the composite surface after the impact test, there is still a little visible fibers that are pulled out and cause pores, indicating the strength of the matrix bond is getting better. From Figure 7a. Filler comparison of 5% volume fraction of MASF, 95% matrix shows the strength of the matrix bond is decreasing and you can see the fibers are pulled out, and there are many pores, this is because there is no good bond between the fiber and the matrix in the composite material. Based on the fracture macro photo Figure 7. shows the fracture at the bottom of all specimens test. This is because during the tensile test, the upper part of the specimen was subjected to a compressive load while the lower part was subjected to a tensile load resulting in a fracture at the bottom. as shown in Figure 7. From Figure 7 it can be seen that the specimen with a fiber content of 5% has a fracture smaller fracture when compared to specimens with a fiber content of 10%, 15% and 20%. This matter because the longer the fiber, the greater the reinforcement given to it matrix so that the matrix fiber bonds are getting stronger. The fracture form is dominated by brittle fracture

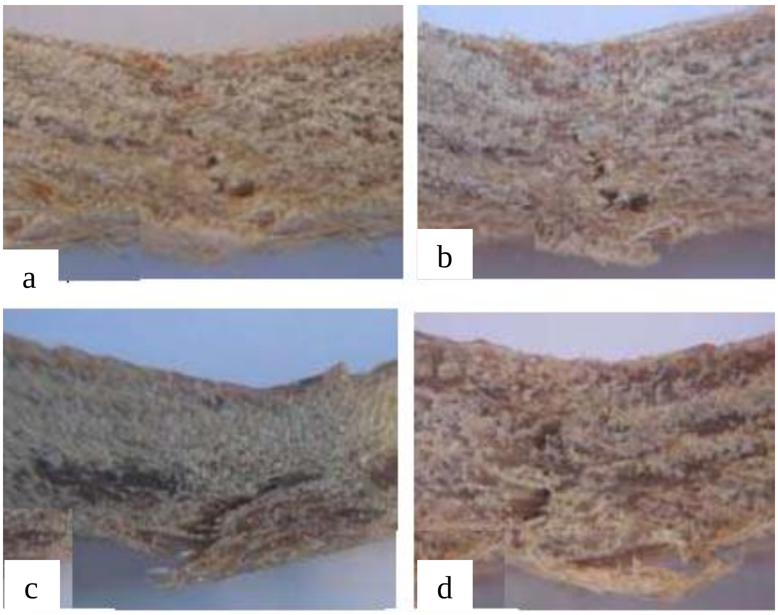


Figure 7. Macro Structure Failure of Speciment. a. 5 % MASF, b. 10 % MASF, c. 15 % MASF, d. 20 % MASF

IV. CONCLUSION

MASF has good potential as reinforcing PMC due to its good cellulose content and a good hygroscopic material. It is promising as a substitute for timber in building industry and vehicle equipment. The stress strain behavior in tension indicated that the addition MASF makes the PMC more ductile. The tensile strength of PMC was found to increase with increasing percentage of MASF after in initial decrease tensile stress for 10% loading. MASF serves as an effective reinforced PMC on fiber length of 25-30 mm and fiber content 30%. These properties together with the inexpensive nature of the indigenous MASF make the PMC attractive for industrial application. The surface topology of the MASF reinforced PMC shows wood-like appearance. It has smooth surface finish and resemble wood. The results suggest it have an edge over the conventional material used in building industry.

Compliance with ethical standards

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Disclosure of conflict of interest

No conflict of interest.

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