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Study on the properties of Palmyra palm leaf stalk fiber reinforced composites

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ABSTRACT

Natural fiber reinforced composite materials have many advantages such as high strength to weight ratio, wear resistance, dimensional stability, thermal resistance and fatigue strength. Biodegradability, non-toxicity and light weight are the important characteristics for adding as reinforcement in composite materials. In this present study, Palmyra palm leaf stalk fiber is used as a natural fiber obtained from Palmyra (Borassus flabellifer) tree. Polyester resin is used as matrix. Composites were cut to the ASTM standards. The properties like tensile, flexural and impact are conducted with varying fiber lengths. The results showed that while increasing fiber lengths properties like tensile, flexural and impact are getting increased. Based on these results composites makes as some use of light weight materials in automotive applications.

Keywords: Palmyra natural fiber, polyester resin, alkali treatment, mechanical properties

INTRODUCTION

Natural fibers are used as reinforcements in polymer matrix due to the advantages of low cost, biodegradability, low density and high aspect ratio (1).Increasing environmental awareness throughout the world has greatly parted materials engineering and design. While using these materials there is an issue of recyclability and environmental safety. Nowadays so many of them choose synthetic fibers like glass, carbon and aramid. There are some serious drawbacks in terms of biodegradability, initial cost, recyclability, energy consumption occurs. Despite these, most of our environmental impacts alter their attention to natural fibers (2).

Natural fiber composites are used as alternatives to glass fiber reinforced composites especially in automotive and building product applications (4). These natural fibers have some limitations such as lower modulus, poor moisture resistance to absorption and low strength when compared with synthetic fibers such as glass and carbon(5). Venkateshwaran and elayaperumal (6) concluded that a mechanical property was increased and water absorption decreased due to the hybridization of composites.

The mechanical property of natural fibers was much more inferior to natural fibers, therefore essential functional strength for structural materials are not enough because it is necessary that the mechanical property of natural fiber approach that of glass fiber and natural fiber have the optional functions(3).

EXPERIMENTAL DETAILS

1. Materials

Palmyra Palm fibers were extracted from the leaf stalks of the Palmyra palm tree (Borassusflabellifer). The edges and the skin of the leaf stalk are shaved manually. Then these leaf stalks are retted in water for 20 days. After retting process the fibers were separated from the stalks by using a hammer. The separated fibers are then cleaned, washed and dried to remove the moisture and other impurities on the fiber surface. Unsaturated polyester resin, cobalt naphtha late (accelerator) and methyl ethyl ketone peroxide (catalyst) are bought from Covai Seenu and Company, Coimbatore, India. The chemicals such as sodium hydroxide pellets and dilute hydrochloric acid (HCL) which is for doing chemical treatments are bought from the precision scientific company Coimbatore.

2. Chemical treatment

(a) Alkali treatment

The fibers were immersed in 5% NaOH for 30 min. After that the fibers were cleaned several times with distilled water. Again the fibers were immersed in very dilute HCl. This will remove the NaOH adhesion to the surface of the fibers. Finally the fibers were again washed several times with distilled water and dried in an open atmosphere.

(b) Tensile test

Tensile property of randomly oriented composites was determined by using tensile testing machine with a cross head speed of 5mm/min. Tests were conducted as per ASTM: D638. The specimen size of 165mm x 20mm x 3mm was cut from the composite plate manufactured. Three specimens were tested from the composite plate and average values are reported.

(c) Flexural test

Flexural test were conducted as per ASTM: D790. The specimen size of 125mm x 13mm x 3mm was cut from the composite plate. the test was carried out by using flexural testing machine with a cross head speed of 5mm/min. three specimens were tested and average values are reported.

(d) Impact test

ASTM: D256 was used for determining the impact properties of the composites. Rectangular notched specimens of 64mm x 13mm x 3mm were cut for the testing. Three specimens were tested and average results are reported.

RESULTS AND DISCUSSIONS

(a) Tensile properties

The tensile strength and tensile modulus of the composite plate was shown in Table 1. The fiber content in 25wt% is kept at constant and varying with different fiber lengths. Due to increasing of fiber lengths the tensile strength and modulus values are increased for neat resin the tensile value is 17 MPa while adding reinforcements the value got increased to 24 MPa upon increasing the fiber length like 25, 50, 75, 160 mm the tensile strength and tensile modulus are increased to 43 MPa and 3.05 GPa respectively.

Figure 1 and 2 shows that fiber length is in X-axis and tensile strength, modulus in Y-axis. From this graph it can be proved that increasing fiber lengths, modulus and strength values are increased. Another factor that has attributed for increase in tensile property is due to alkali treatment, treatments modified the surface, which resulted in rough surfaces promoting fiber matrix interlocking leading to better stress transfer between the matrix and fibers. Finally mechanical properties of present work compared with previous work are shows in Table 2.

Table 1 Tensile property of various fiber length

Si.No	Fiber Length Mm	Tensile Strength Mpa	Tensile Modulus Gpa
1	25	24.01	2.42
2	50	28.17	2.89
3	75	28.50	2.67
4	160	43.54	3.05

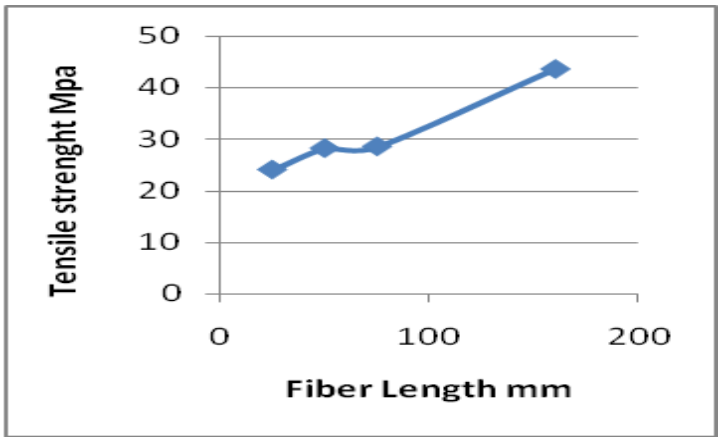

Fig 1 Tensile strength for various fiber length

Table 2 Mechanical properties compared with published works

S.No	Fiber/ Matrix	Composite fabrication method	Fiber orientation/ wt (%)	Type of chemical treatment	Tensile strength (MPa)	Tensile modulus (GPa)	Flexural strength (MPa)	Flexural modulus (GPa)	Impact strength (KJ/m^2)
1	palmyra/polyester	hand-lay up	randomly distributed/ 25%	alkali treatment	43.54	3.05	140.17	17.7	14.52
2	sisal/ polyester	hand-lay up	unidirectional/ 50%	silane	34.14	1.7	96.88	19.42	-
3	pineapple /polyester	hand-lay up	randomly distributed/40%	-	63.3	2.5	-	-	-
4	jute/ polyester	-	rovings/30%	10%NaOH	61.8	1.22	96	4.3	80
5	banana/ polyeste	compression moulding	strands/30%	-	-	-	97	6.5	-
6	coir/glass /polyester	hand-lay up	layer by layer	-	29.39	-	73.17	-	40.97
7	coir/ epoxy	hand-lay up	non-woven/30%	-	17.86	-	31.08	-	11.49
8	wildcane grass/ polyester	hand-lay up	unidirectional/39%	KMno4	159	11.84	111	7	-
9	royal palm/ epoxy	hand-lay up	unidirectional/ 20%	alkaline	42.29	2.13	62.67	4.94	116.43
10	PLA/RNCF/Talc/ polypropylene	injection molding	60/30/10%	silane	-	-	132.6	15.3	26.3
11	heneque/ polyethylene	hand-lay up	dispersed/ 46%	silane	79.3	3.95	130.5	2.72	-
12	glass/ polypropylene	compression moulding	randomly/ 40%	-	88.6	6.2	60	4.38	54.12
13	banana/ sisal/ epoxy	hand-lay up	50/50%	-	18.66	0.68	59.68	9.13	17.9

14	palmyra/glass/ rooflite	compression moulding	dispersed/ 41%	alkaline	26.2	1.39	44.45	1.38	17.5
15	palmyra/ jute/ polyester	hand-lay up	uni-directional/ 30%	alkaline	83.26	3.78	164	18.23	35

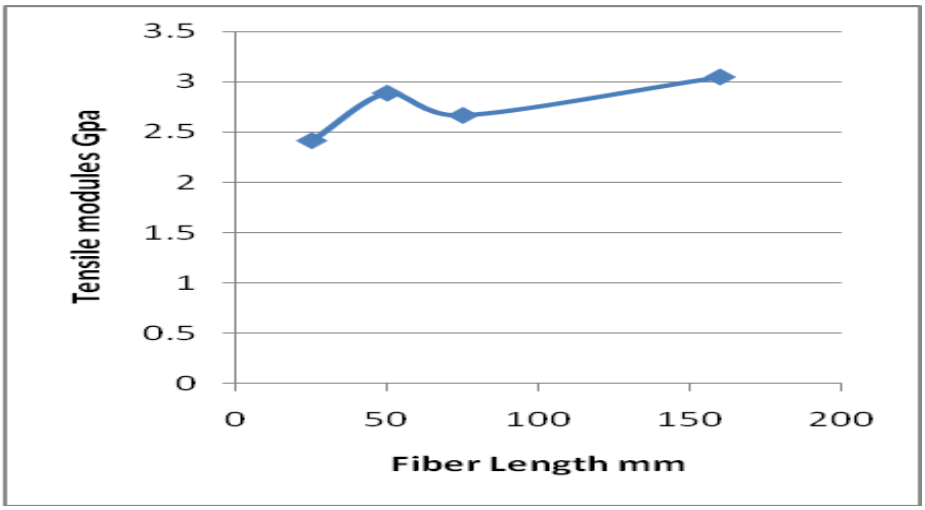

Fig 2 Tensile modulus of various fiber lengths

(b) Flexural properties

The flexural properties of the composites were shown in Figure 3, 4 and Table 3. It was observed that in all the composite materials the flexural strength increased on increasing the fiber length. Similarly the flexural modulus of the composites also increased while increasing the fiber length. It was carried out by using flexural testing machine with a cross head speed of 5mm/min. The modulus value also increased depending on the fiber content and it was shown in figure 4. Based on the fibers orientation the strength was improved. This result was compared with some other natural fibers properties. Comparison takes an interest to note superior properties were obtained by this palmyra fiber. Hence Palmyra can also be thought as potential reinforcement for manufacturing composites.

Table 4 Flexural property of various fiber lengths

Si.No	Fiber Length Mm	Flexural Strength Mpa	Flexural Modulus Gpa
1	25	47.01	3.49
2	50	59.83	4.2
3	75	51.28	3.45
4	160	140.17	17.7

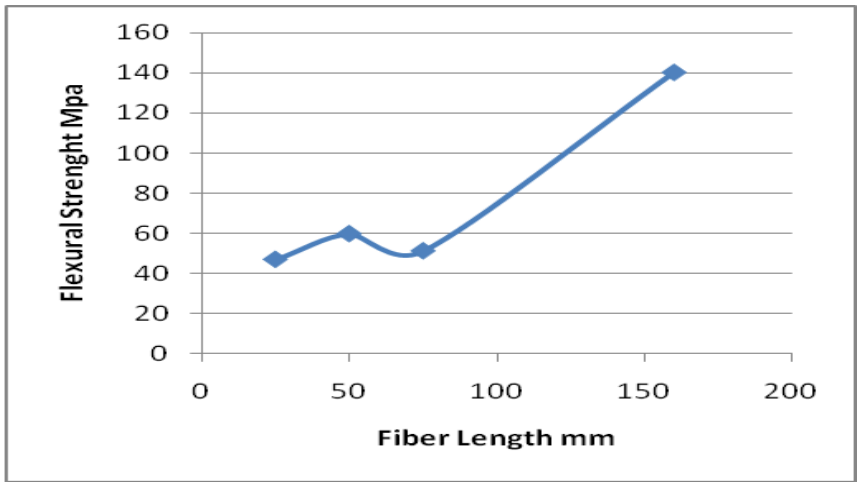

Fig 3 Flexural strength of various fiber length

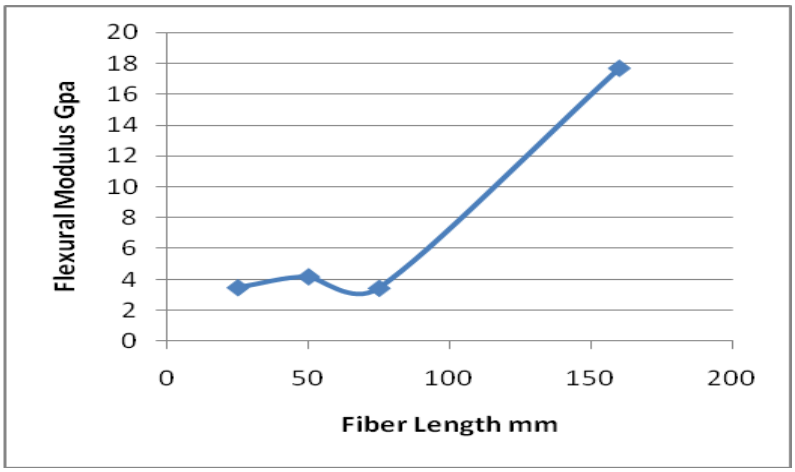

Fig 4 Flexural modulus of various fiber lengths

(c) Impact properties

The impact properties of the manufactured composites were shown in Table 4 and Figure 5, 6. It can be noted that impact strength of neat resin is less than that of reinforcement added composites. The impact strength of the composites decreased when fiber content increased. if fiber length increased, the impact strength also increased when the length of the fiber increases from 25mm to 160mm, the value increases from 10.25Mpa to 14.52Mpa. A graph was drawn between fiber length to impact strength and load. It can be shown that varying of fiber length causes impact strength to be maximum. The properties of the manufactured composites can be compared with some of the natural/synthetic fibers. This result shows that this Palmyra fiber was use as potential alternatives in place of synthetic fibers.

Table 4 Impact property of various fiber lengths

Si.No	Fiber Length Mm	Impact Strength Mpa	Impact Load Joules
1	25	10.25	0.4
2	50	12.82	0.6
3	75	6.83	0.35
4	160	14.52	0.65

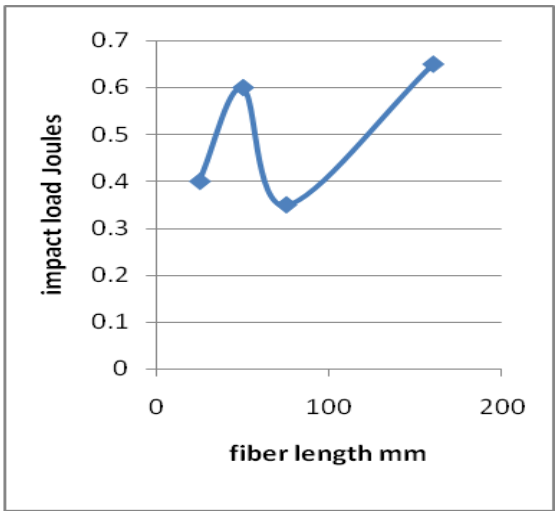

Fig 5 Impact load

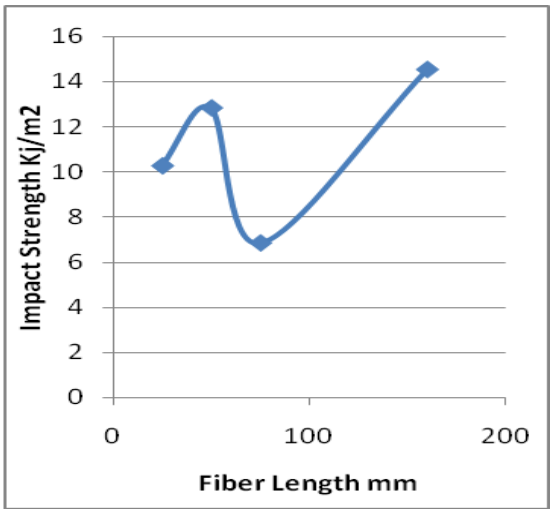

Fig 6 Impact strength

CONCLUSIONS

The natural fibers play a major role in composite materials. This project mainly deals with the properties of the composites manufactured. Specimens are machined to the ASTM standards. The tensile, flexural and impact properties are getting much better results compared to the various fibers. These results are based on fiber lengths and fiber content. Based on these results Palmyra fibers are compared with synthetic fibers like glass, carbon and aramid fibers enhanced a good alternative for the synthetic fibers.

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