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To Study the mechanical properties of coconut coir fiber reinforced with epoxy resin AW 106 & HV 953 IN

Abdul Nazeer[1]

Assistant Professor, Department of Mechanical Engineering, SECAB Institute of engineering and technology Bijapur(Karnataka), INDIA

Abstract: *In this study the Mechanical Properties of Coconut coir Fiber is reinforced with epoxy resin of different lengths (5mm,10mm,15mm) and coir fibers by treating the fiber with NaOH by fraction of 5 % are studied here. All samples were made using hand layup technique and specimens were prepared as per ASTM standard D3039. The samples were tested according to ASTM D3039 standard using Universal testing machine (UTM). The significant findings of the research showed that NaOH treatment improved the tensile properties, ductility and hardness of the composite further Increase in length of fibers was found to increase the tensile strength. The maximum tensile strength was found for 15 mm length of coir fibers.*

Keywords*: Coconut fiber, Composites, Sodium hydroxide treatment, Mechanical properties, mechanical testing*

I. Introduction

Over a past few decade a lot research is going on composite material for replacement of existing engineering materials. The composite materials have grown rapidly to very high extent and replace almost all engineering materials. Today composite materials consist of many materials in day to day use and also being used in sophisticated applications while composites have already proven their worth as weight saving materials the current challenge is to make them durable in tough conditions to replace other materials and also to make them cost effective. Due to its light weight and low cost composite has given a way to industries.

Green coconuts, harvested after about twelve months on the plant, contain pliable white fibres. Brown fiber is obtained by harvesting fully mature coconuts when the nutritious layer surrounding the seed is ready to be processed into copra and desiccated coconut. Coconut trees are tall – commonly 25 meters high – and this fibrous layer around the seedpod is a strong shock-absorbing mesh that protects the seed from damage.

Composites: A definition A composite material is made by combining two or more materials to give a unique combination of properties, one of which is made up of stiff, long fibers and the other, a binder or 'matrix' which holds the fibers in place

Composites Properties: Natural fibres are now considered as a suitable alternative to glass fiber, due to their advantages, which include low cost, high strength-to-weight ratio, and recyclability. Combining natural fibres with glass fiber also decreases the usage of glass fiber. In this investigation, hybrid glass-/sisal-fiber composites were fabricated using the hand lay-up method.

Epoxy resins: Epoxy resins are characterized by the presence of more than one1, 2- epoxide groups per molecule. Cross-linking is achieved by introducing curatives that react with epoxy and hydroxyl groups situated on adjacent chains

Reinforcement:The objective of the reinforcement in a composite material is to enhance the mechanical properties of the resin system. All of the distinct fibers that are used in composites have distinct properties and so affect the properties of the composite.

II. Experimental

The Coconut fiber (coir) and epoxy resin were selected for this project and fabricated according to the ASTM standard (D3039). As per the dimension the Coconut fiber and epoxy composite is manufactured with different lengths of fiber. The prepared specimens were tested by using Universal Testing Machine (UTM).

III. Materials

Preparation of the fiber: The Coconut Husk was dried under sunlight and fibers were extracted manually from the coconut husk. To ensure proper interaction between fiber and matrix material, the outer most wax layer of the coir was removed by soaking the coir in hot water.

Table 1: Physical Properties of Coir Fibres

Material Property	**Values**
Density	1.2g/cm^3
Elongation at break	30%
Youngs modulus	4-6 Gpa

Methods of preparation: There are two method one by treating the fibers with NaoH solution and another is directly using the coir fiber The prepared coir fibers were cut into short length fibers of about 5mm, 10mm, 15mm and divided into separate portions. One portion was chemically pretreated with alkali (NaOH). 5% NaOH was used to treat the fibers in a beaker for 24 hours. The fibers, were then washed in distilled water and finally dried. This was used to prepare the composite.
The second portion of the fibers was untreated, with different lengths of fibers(5mm,10mm &15mm).

Formulations According to ASTM Standards, we are making the mould box of 250×110×3 mm dimension. The mould box was made using Thermopolis as a base surface and plywood as the side boundary. Using Tape, the surface of the mould box was covered to prevent the leakage of the epoxy resin. The mould box is shown below

Fig 1: Mould Box fibers and resin mixture

Sample preparations

There are two types of methods we have used, they are

1. Treated Fibers

The solution of 5% aq. NaOH and 95% of water was prepared (100g NaOH and 2litre water). Fibers of 30g are soaked in the solution for 24 hours.

Fig 2:100g of NaoH

Fig 3: Fibers soaked in solution

After 24 hours, fibers were removed from solution and washed with distilled water 2 to 3 times to remove waste particles. These fibers were dried under the sunlight for 24 hours.

Fig 4: Dried Fibers

The fibers were then cut in different dimensions of 5, 10 and 15 mm in length. Here Epoxy Resin (Araldite AW 106 and Hardener HV 953 IN) was used. The mixture of Araldite and Hardener was prepared (91g Araldite and 39g Hardener). The fibers of 5 mm in length and weight 5g are added to the mixture and mixed well. The mixture was then poured into the mould box. The mixture was properly spread all over the mould box and proper surface finish was given. The mould box was kept at room temperature for 1 day to dry the mixture. After that, the specimen was removed from the mould box.

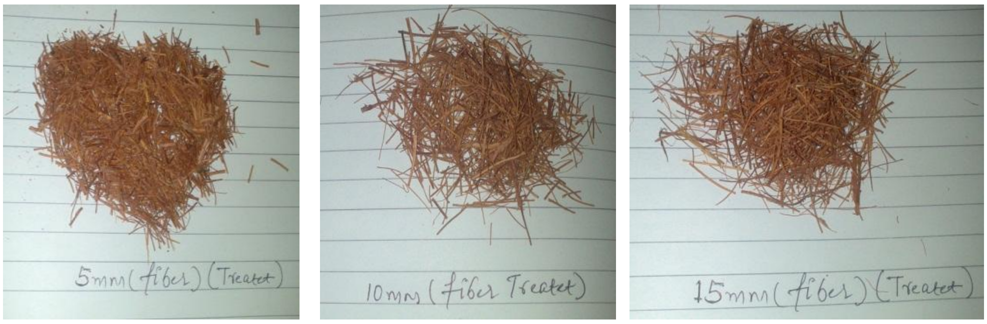

Fig 5: Different lengths of treated fibers

Fig 6:-Epoxy Resin and Hardener

Fig 7: Mould Box with treated fibers and resin mixture

After removing the specimen from mould box, it was cut as per the ASTM Standard D3039, that is 250×25×3 mm. From this mould box 4 specimen of 250×25×3 mm dimension were obtained as shown in figure below for each length of fiber for testing of all specimen and taking average value.

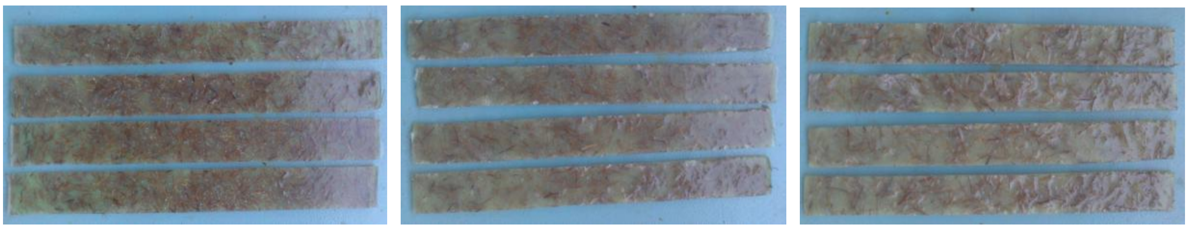

Fig 8: Specimens Treated fibers

2. Un-Treated Fibers

The fibers were directly extracted from coconut husk which are already dried. According to the ASTM Standard D3039, a mould box was prepared of dimension 250×110×3 mm. The fiber length of 5, 10 and 15 mm cut and mixed with Epoxy resin and Hardener. The mixture was then poured inside the mould box and spread. The mixture in the mould box was dried for 24 hours and then the specimen was removed. The specimen was further cut as per ASTM Standard D3039. 4 specimens were obtained of dimension 250×25×3 mm.

Fig 9: Mould Box with Un-Treated fibers and resin mixture

Fig 10: Specimens of 5 mm length

Fig 11: Specimens of 10 mm length

Fig 12: Specimens of 15 mm length

Testing

The prepared specimen were fixed in the UTM machine for tensile test After fixing the specimen in the UTM, load was applied on the specimen. The load is applied gradually on the specimen. For every 5 division (0.2 kN), note down the corresponding deflection until the specimen breaks.

Fig 13: Testing of Specimen

IV. Result And Discussion

Treated Fibers

The table below shows the deflection of composite specimen for different lengths of fibers, and its the variation of deflection with respect to different loads.

Table:1 Different loads and deflection readings for treated fibers

5mm length of fiber		10 mm length of fiber			15 mm length of fiber		
LOAD kN	Deflection (mm)		LOAD kN	Deflection (mm)		LOAD kN	Deflection (mm)
0.2	0.5		0.2	0.5		0.2	0.5
0.4	0.75		0.4	0.75		0.4	0.75
0.6	1		0.6	1		0.6	1
0.8	1.9		0.8	3.25		0.8	3.19
1	2.9		1	3.65		1	4
1.2	3.75		1.2	4.25		1.2	5.25
1.4	4.4		1.4	5.65		1.4	6.25
1.6	5		1.6	6.5		1.6	6.8
1.8	5.3		1.8	7.5		1.8	7.4
2	5.65		2	8.25		2	8
2.2	6.4		2.2	8.65		2.2	8.55
2.4	7.13		2.4	9.15		2.4	9
			2.6	9.65		2.6	9.75
						2.8	10.25
						3	10.79

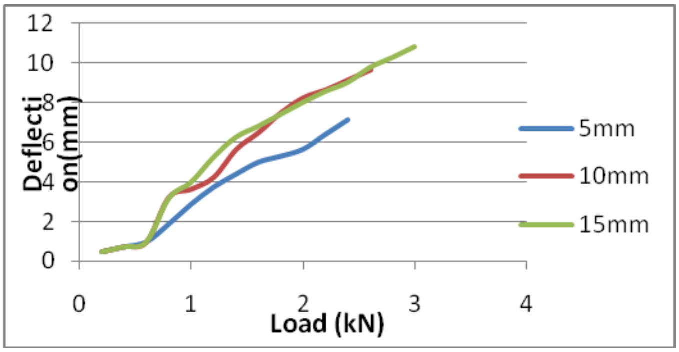

Fig 14: The graph of load versus deflection of the corresponding table

The graph shows the comparison of deflection with different lengths of fiber. It is observed that initially between the load of 0.2kN to 0.6 kN the deflection remains same for all three lengths of fiber. Further increase in load the deflection increases with respect to increase in length of fiber. It is observed that the maximum deflection occur at fiber length of 15mm. the deflection also increases until the break point of specimen is reached. As shown in graph, as we increase the length of fibers in the composite (5-15 mm), deflection also increases.

For 5 mm length of fibers in the composite, the ultimate load was 2.4 kN and the corresponding deflection was 7.13 mm. For 10 mm length of fibers in the composite, the ultimate load was 2.6 kN and the corresponding deflection was 9.65 mm. For 15 mm length of fibers in the composite, the ultimate load was 3 kN and the corresponding deflection was 10.79 mm. With this it is concluded that with increasing the length of fiber the deflection also increases.

Table 2: Table below shows the tensile strength of composite for different length of fibers are

5 mm length of fibers	10 mm length of fibers	15 mm length of fibers
Tensile Strength	Tensile Strength	Tensile Strength
3.2	3.2	3.2
6.4	6.4	6.4
9.6	9.6	9.6
12.8	12.8	12.8
16	16	16
19.2	19.2	19.2
22.4	22.4	22.4
25.6	25.6	25.6
28.8	28.8	28.8
32	32	32
35.2	35.2	35.2
38.4	38.4	38.4
	41.6	41.6
		44.8
		48

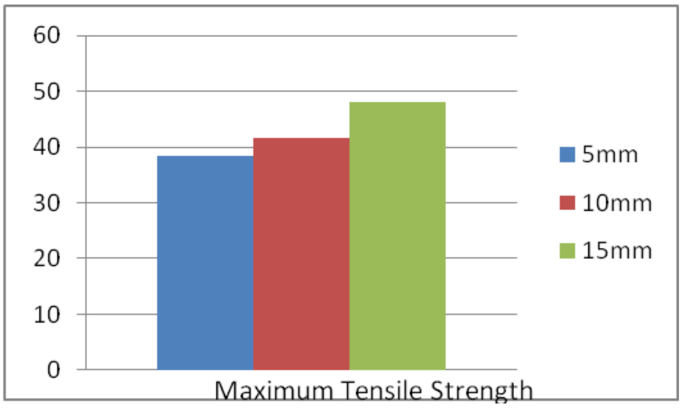

Fig 15: Figure shows the compression of tensile strength by varying the length of fiber

From the figure it can be seen as the length of fiber increases the tensile strength of the composite material is also increases.

Untreated Fibers

The fibres were directly extracted from coconut husk which are already dried. According to the ASTM Standard D3039, a mould box was prepared of dimension 250×110×3 mm. The fibre length of 5, 10 and 15 mm cut and mixed with Epoxy resin and Hardener, also mixed well. The mixture was then poured inside the mould box and spread. The mixture in the mould box was dried for 24 hours and then the specimen was removed. The specimen was further cut as per ASTM Standard D3039. 4 specimens were obtained of dimension 250×25×3 mm.

Table 3: Table shows Different loads and deflection readings for Un-Treated fibers

5mm length of fibers		10 mm length of fibers			15 mm length of fibers		
LOAD kN	Deflection (mm)		LOAD kN	Deflection (mm)		LOAD kN	Deflection (mm)
0.2	0.5		0.2	0.5		0.2	0.5
0.4	1		0.4	0.75		0.4	0.75
0.6	1.75		0.6	1		0.6	1
0.8	2.5		0.8	2.15		0.8	2.5
1	3.25		1	3.5		1	3.5
1.2	3.75		1.2	4.75		1.2	4.25
1.4	4.25		1.4	5.25		1.4	4.75
1.6	4.75		1.6	6		1.6	5.25
1.8	5.25		1.8	6.65		1.8	5.65
2	6		2	7.25		2	6.1
2.2	6.3		2.2	8		2.2	6.5
2.4	6.8		2.4	8.3		2.4	7.25
			2.6	8.8		2.6	7.9
						2.8	8.5
						3	9

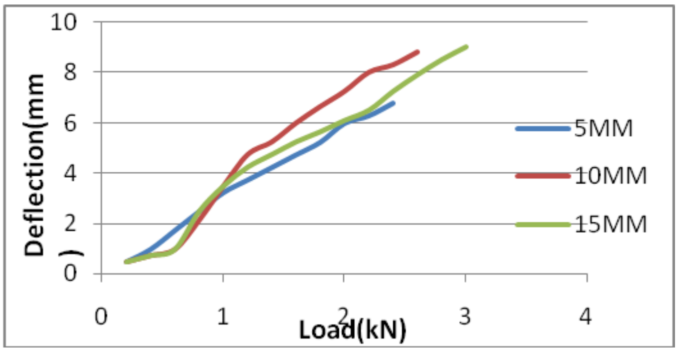

Fig 16: It shows the load versus deflection for different lengths of fiber

From the graph it is observed that the deflection of untreated fiber is same as treated fiber. The graph shows the comparison of deflection with different lengths of fiber. It is observed that initially at the load of

0.2kN the deflection remains same for all three lengths of fiber. Further increase in load the deflection increases with respect to increase in length of fiber. It is observed that the maximum deflection occur at fiber length of 15mm. For 5 mm length of fibers in the composite, the ultimate load was 2.4 kN and the corresponding deflection was 6.8 mm. For 10 mm length of fibers in the composite, the ultimate load was 2.6 kN and the corresponding deflection was 8.8 mm. For 15 mm length of fibers in the composite, the ultimate load was 3 kN and the corresponding deflection was 9 mm. With this it is concluded that the deflection is more for treated fiber than untreated fiber. As it is treated with NaoH the ductility of fiber increases which increases the deflection.

Table 4: Table shows the tensile strength for different lengths of Un-Treated fibers

5 mm length of fibres	10 mm length of fibres	15 mm length of fibres
Tensile Strength	Tensile Strength	Tensile Strength
3.2	3.2	3.2
6.4	6.4	6.4
9.6	9.6	9.6
12.8	12.8	12.8
16	16	16
19.2	19.2	19.2
22.4	22.4	22.4
25.6	25.6	25.6
28.8	28.8	28.8
32	32	32
35.2	35.2	35.2
38.4	38.4	38.4
	41.6	41.6
		44.8
		48

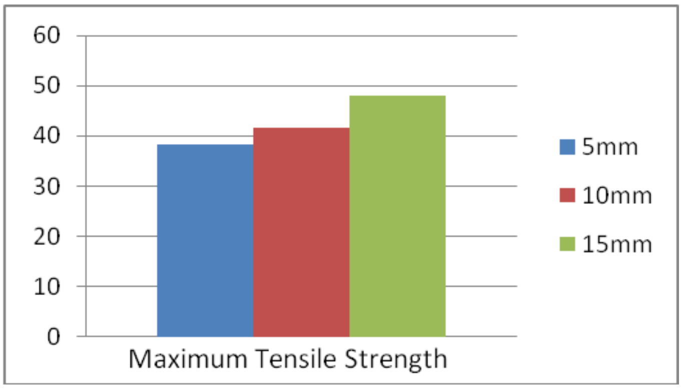

Fig17: Figure shows the compression of tensile strength by varying the length of fiber

Table 5: Comparison between Treated and Un-Treated Fiber Composite

	5mm				10mm				15mm	
Load	Treated	Untreated		Load	Treated	Untreated		Load	Treated	Untreated
0.2	0.5	0.5		0.2	0.5	0.5		0.2	0.5	0.5
0.4	0.75	1		0.4	0.75	0.75		0.4	0.75	0.75
0.6	1	1.75		0.6	1	1		0.6	1	1
0.8	1.9	2.5		0.8	3.25	2.15		0.8	3.19	2.5
1	2.9	3.25		1	3.65	3.5		1	4	3.5
1.2	3.75	3.75		1.2	4.25	4.75		1.2	5.25	4.25
1.4	4.4	4.25		1.4	5.65	5.25		1.4	6.25	4.75
1.6	5	4.75		1.6	6.5	6		1.6	6.8	5.25
1.8	5.3	5.25		1.8	7.5	6.65		1.8	7.4	5.65
2	5.65	6		2	8.25	7.25		2	8	6.1
2.2	6.4	6.3		2.2	8.65	8		2.2	8.55	6.5
2.4	7.13	6.8		2.4	9.15	8.3		2.4	9	7.25
				2.6	9.65	8.8		2.6	9.75	7.9
								2.8	10.25	8.5
								3	10.79	9

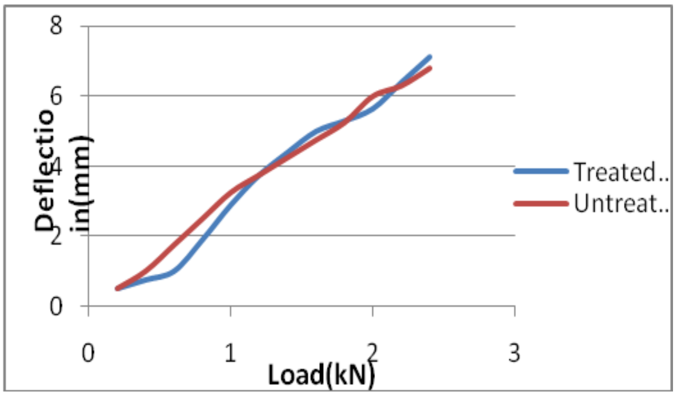

Fig 18: figure shows the compression for load versus deflection for treated and untreated 5mm length of fiber

From the above Figure we observe that, As we increase the load, deflection also increases. The blue line in the graph represents the treated fibers of length 5 mm and the red line in the graph represents the un-treated fibers of length 5mm. The deflection obtained from treated fibers specimen was 7.13 mm, while the deflection from untreated fibers specimen was 6.8 mm.

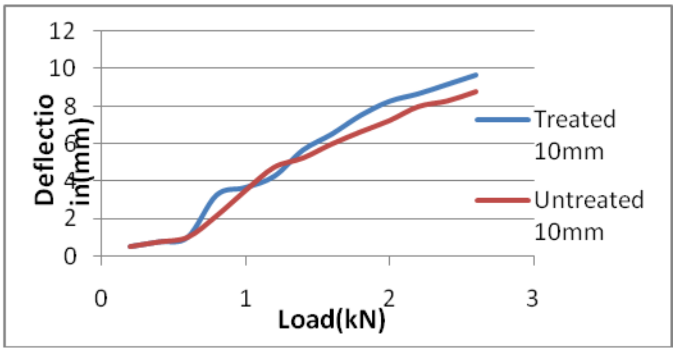

Fig 19 Comparison between Treated and Un-Treated Fiber Composite (10 mm)

From the above Figure we observe that, As we increase the load, deflection also increases. The blue line in the graph represents the treated fibers of length 10 mm and the red line in the graph represents the un-treated fibers of length 10 mm. The deflection obtained from treated fibers specimen was 9.65 mm, while the deflection from untreated fibers specimen was 8.8 mm. which indicates that the ductility of fiber is increased when it is treated with NaoH solution.

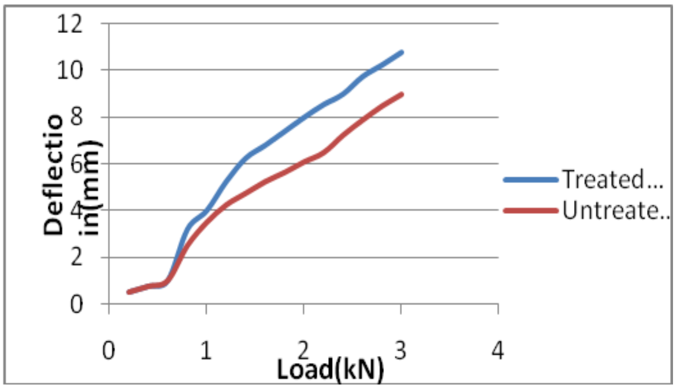

Fig 20: Comparison between Treated and Un-Treated Fiber Composite (15 mm)

From the above Figure we observe that, As we increase the load, deflection also increases. The blue line in the graph represents the treated fibers of length 15 mm and the red line in the graph represents the un-treated fibers of length 15 mm. The deflection obtained from treated fibers specimen was 10.79 mm, while the deflection from untreated fibers specimen was 9 mm.

Table 6 Properties of composite for various length of treated fibers

Treated				
Sl.No	Property	5mm	10mm	15mm
1	Density(kg/m³)	1557.7	2048	1934.8
2	Tensile Strength(Mpa)	38.4	41.6	48
3	Youngs Modulus(Mpa)	1346.4	1077.7	1112.4
4	Tensile Strain at break	0.02852	0.0386	0.04316
5	Extension at break(mm)	7.13	9.65	10.79
6	Load at Break(N)	2400	2600	3000

Table 7 Properties of composite for various length of un-treated fibers

UNTreated				
Sl.No	Property	5mm	10mm	15mm
1	Density(kg/m³)	13953.2	1446.4	1779.2
2	Tensile Strength(Mpa)	38.4	41.6	48
3	Youngs Modulus(Mpa)	1411.765	1181.818	1333.333
4	Tensile Strain at break	0.0272	0.0352	0.036
5	Extension at break(mm)	6.8	8.8	9
6	Load at Break(N)	2400	2600	3000

The above two tables shown gives the mechanical properties of the composite like Density, Tensile strength, Young's modulus, Tensile strain at break, Extension at break and load at break for treated and un-treated coir fibers.

V. Conclusion

- The mechanical properties of polyester composites reinforced with coir fiber have been studied and discussed here. The following conclusions can be drawn from the present study. Here, we have used randomly discontinuous fiber layout in the composite, so that the ratio of fibers in the composite is high.
- This investigation shows that increase in length of fiber increases the tensile strength.
- The NaOH treatment on coir fiber would remove the impurity and rougher fiber surface may result after treatment. This would increase the adhesive ability of the coir fiber with the matrix in the fabricated composite resulting in good tensile strength.
- The treated fiber have better reinforcing property than un-treated fiber.
- It is observed that the tensile strain at break for treated fibers is more than un-treated fibers, which shows deflection of treated fibers is more than un-treated fibers, which conclude that by treating the fibers with NaOH increase the property of ductility.
- It is observed that by changing the length of fibers the mechanical property of the composite changes increase in length of fiber increase the mechanical property.
- The investigation resulted that if the fibers are treated, then the extension of composite at break is more than un-treated fibers and extension of composite increases with increase in fiber length.
- The load at break increases with increase in fiber length

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