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Tensile Properties of Fiber Reinforced Epoxy Composites for various Fiber loading and Fiber length

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Abstract: For the past ten years research is going on to explore possible composites with natural fiber like plant fibers and animal fibers. The main properties of composites are their stiffness, hardness and light in weight. In the present work, epoxy (Araldite LY-556) is used as resin and 'Emu' bird feathers as fiber to prepare the composites. The composites were prepared by varying weight percentage of fiber (P) of 'Emu' feathers ranging from 1 to 5 percent and length (L) of feather from 1 to 5 cm. The objective the work is to investigate the effect of length and weight percentage of feather on tensile strength of "Emu" feather fiber reinforced epoxy composites.

Key words: Epoxy resin, animal feathers, fiber loading, tensile strength.

1. Introduction

Composite materials are produced by combining two different materials to form a new material that may be well suited for a specific application than the individual material alone. The main properties of the composites are their stiffness and less weight. The manufacturing cost of composites is also less when compared with the conventional methods. Now a days use of synthetic fibres is limited due to restricted biodegradability. Presently research work is going on natural fiber reinforced composites. The natural fiber reinforced polymer composites are used in many fields especially in automotive industry. The Studies reveal that the final properties of composites depend upon the properties of fiber and the interfacial bonding of matrix & reinforcement, method of manufacturing and curing. The interfacial bonding plays major role between the matrix and the fiber. In the present paper the waste feathers of "Emu" bird was selected as fibers and the epoxy as a resin. Jeffrey W.Kock [1] carried out the work on mechanical properties of chicken feather composites. The natural fibres has the potentiality to substitute the synthetic fibres [2-6] in natural fiber reinforced polymer composites.

2. Preparation of composites

The unused 'Emu' feathers collected from the neighbouring places, is washed many times with water then soaked in 5% percent Sodium hydroxide (NaOH) solution for half an hour. The soaked feathers then washed with soap water and then followed by pure water and finally dried in sun rays. A clean fiber which is free from dust and mud are obtained.

Hand layup technique is used for preparation of laminates. Composite laminates are prepared from hardener and epoxy mixed in the ratio of 1:10 by weight. To fabricate the composite specimens, these fibers in predetermined length and weight proportion (maximum five cm & five %) are reinforced into the synthetic resin. Blocks of size 200 mm x 20 mm x 3 mm for tensile test were prepared.The mould is placed on a flat glass plate after thorough cleaning for dirt and moisture from the mould. For easy removal of the cast after curing, wax is applied on the base plate and inner walls of the mould.

After applying the wax, the proportionate mixture of hardener and resin (1:10 by weight percentage) is taken and is poured into the mould to make a consistent layer and then fiber is placed with uniform spacing. When the fiber gets wet in the layer of resin, the mixture of hardener and resin is poured over it till desired thickness is obtained. Due to thin slab thickness of 3mm, only one layer of fiber is placed in the present experimental work.

For proper curing, the prepared specimens were kept under load for 24 hours at room temperature. After this process, the specimens were further cured at 70^0C for three hours in a furnace. The Tensile strength (TS), is evaluated by conducting the tests on Universal Testing Machine (UTM) on the prepared 'Emu' feather fiber Epoxy composites.

2.1. Tensile Strength

The maximum stress that a material can with stand before breaking when it is stretched is known as Tensile strength. The materials which break sharply without any deformation are brittle in nature. However, ductile materials bear deformation before the fracture. Usually the tensile strength will be expressed in Pascal, $Newton/m^2$ or $Newton/mm^2$. Tensile strength can be calculated with the help of stress-strain curve obtained during tensile test on Universal Testing Machine (UTM).The UTM used for finding the tensile strength is shown in fig1.

Fig.1. Computerized Universal Testing Machine

The tensile test was carried out as per ASTMD 638 standards on the Universal Testing Machine. The test was conducted at a speed of 5mm/min on UTM maintained at 50% humidity with 22^0C. In each case 3 samples were tested and the average values were considered. Specimen used for tensile test is shown in fig.2.

Fig.2 Specimen for Tensile test

2.1.1. Effect of fiber loading (P) and fiber length (L) on Tensile strength

Table.1 shows the response table for Tensile strength. From the response table it can be ascertained that the percentage of fiber loading is the main parameter which affect the tensile strength. The difference between maximum value and minimum value of response parameter is called as 'Delta'.

Table.1. Response table for tensile strength

Level	Tensile Strength (TS) in MPa	
	P	L
1	26.81	23.94
2	24.21	23.51
3	22.91	23.14
4	21.72	22.80
5	20.17	22.43
Delta	6.64	1.51
Rank	1	2

The effect of fiber loading and fiber length on tensile strength is shown in figure 3. It can be observed that the tensile strength is decreasing gradually with increase of fiber loading and fiber length. The higher value of 'Delta' has been assigned as rank 1. From the table 1, the value of 'Delta' is more for fiber loading, than the fiber length. Hence, fiber loading plays significant role on tensile strength than the fiber length.

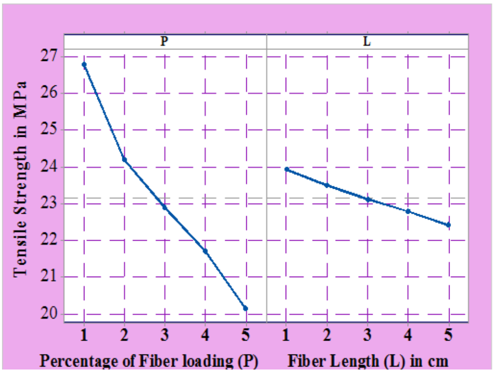

Fig. 3 Response graph for Tensile strength

3. Results and Analysis

Ultimate tensile strength often called as tensile strength. It is the maximum stress that a material can withstand while being stretched or pulled before breaking. Tensile strength is usually determined by performing a tensile test and recording the stress versus strain. It is the highest point of the stress-strain curve in the ultimate tensile strength. It does not depend on the size of the test specimen. But it depends on different factors, like the preparation of the specimen, the presence of surface defects and temperature of the test environment. The effect of weight percentage of fiber loading as well as fiber length on tensile strength is presented in table 2. A graphical representation of the above values is shown in Figure 4 and figure 5.

Table.2. Effect of fiber loading and fiber length for Tensile strength

Sl. No.	Tensile strength (TS) at constant of 3% fiber loading			Tensile strength (TS) at constant of 3 cm length of fiber		
	P	**L**	**TS**	**P**	**L**	**TS**
1	3.00	1.00	23.615	1.00	3.00	26.611
2	3.00	2.00	23.210	2.00	3.00	24.560
3	3.00	3.00	22.820	3.00	3.00	22.820
4	3.00	4.00	22.470	4.00	3.00	21.400
5	3.00	5.00	22.130	5.00	3.00	20.300

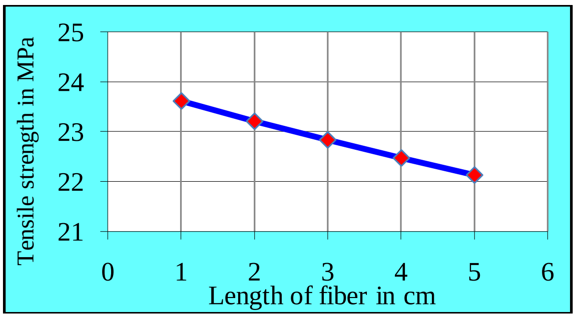

Fig.4 Effect of fiber length on Tensile strength at constant of 3% fiber loading

The graphs are drawn with the help of response surface model developed for tensile strength. In this graph one parameter is varied by keeping the other parameter as constant at middle level. Fig 4 represents the variation of tensile strength with respect to fiber length at constant values of fiber volume. From the graph, it is observed that there is very slight decrease in tensile strength with increase in fiber length.

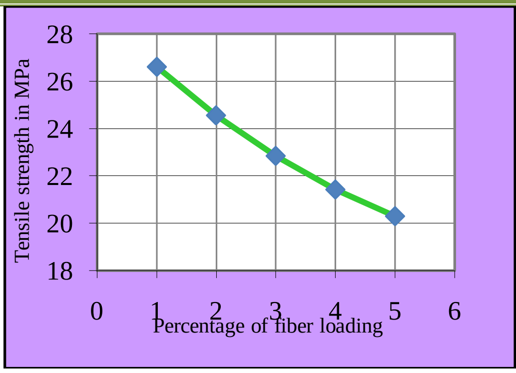

Fig: 5 Effect of fiber loading on Tensile strength at constant value of 3 cm fiber length

Fig. 5 represents the variation of Tensile strength with respect to fiber loading at constant values of fiber length. From the graph, it is observed that tensile strength is decreasing with increase in percentage fiber load. Similar trend can be observed for the remaining percentage of fiber loading and fiber lengths, for flexural strength and flexural modulus. Details of Tensile strength are shown in table 3. Fig. 6 represents the variation of tensile strength with respect to fiber length for various fiber loadings.

Table.3 Tensile strength of composites

S. No	P in %	L in cm	Tensile strength (Mpa)	S. No	P in %	L in cm	Tensile strength (MPa)
1	1	1	28.28	14	3	4	22.79
2	1	2	27.37	15	3	5	22.31
3	1	3	26.95	16	4	1	22.21
4	1	4	26.11	17	4	2	21.81
5	1	5	25.34	18	4	3	21.63
6	2	1	24.57	19	4	4	21.53
7	2	2	24.65	20	4	5	21.40
8	2	3	24.08	21	5	1	21.00
9	2	4	23.94	22	5	2	20.63
10	2	5	23.81	23	5	3	20.28
11	3	1	23.64	24	5	4	19.64
12	3	2	23.08	25	5	5	19.30
13	3	3	22.74				

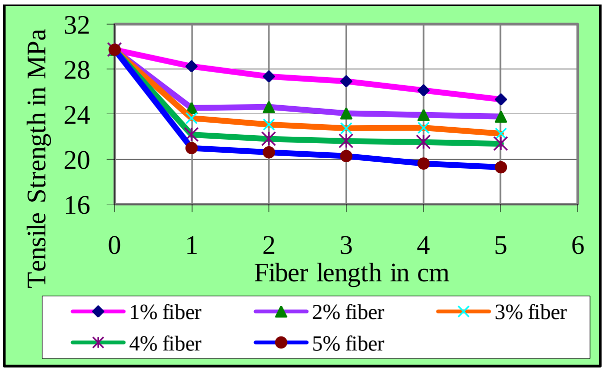

Fig.6 Graphical representation of Percentage of fiber loading and fiber length vs Tensile strength

From the table 3 and fig. 6, the prepared Emu feather fiber epoxy composites have maximum tensile strength of 28.28 MPa at one percent of fiber loading and one centimeter length of fiber. Minimum tensile strength of 19.30 MPa can be observed for 5 percent of fiber loading and 5 centimeter length of fiber. Nearly

31.75 percentage drop in tensile strength was observed by introducing the Emu feather fiber. Details of Percentage elongation is shown in table 4.

Table.4 Details of Percentage elongation

S. No	P in %	L in cm	% Elongation	S. No	P in %	L in cm	% Elongation
1	1	1	2.12	14	3	4	3.68
2	1	2	2.33	15	3	5	3.88
3	1	3	2.65	16	4	1	2.69
4	1	4	3.06	17	4	2	3.07
5	1	5	3.26	18	4	3	3.62
6	2	1	2.21	19	4	4	3.99
7	2	2	2.51	20	4	5	4.18
8	2	3	2.85	21	5	1	2.89
9	2	4	3.25	22	5	2	3.46
10	2	5	3.46	23	5	3	3.89
11	3	1	2.41	24	5	4	4.29
12	3	2	2.73	25	5	5	4.45
13	3	3	3.36	26	Pure Epoxy		2.05

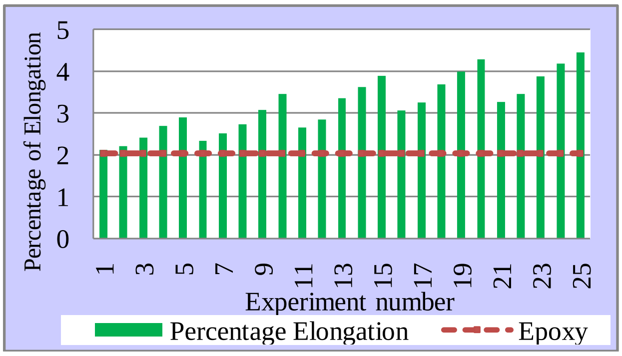

Fig. 7 Effect of fiber loading and fiber length on percentage of elongation

Materials will elongate when they were subjected to tensile load. Percentage elongation is the ratio of change in elongation to original length when subjected to tensile load. A graph drawn between fiber loading and fiber length vs percentage of elongation is shown in Fig. 7.

Elongation is defined as the increase in the original length of a specimen as a result of tensile force applied on the specimen. Elongation is inversely proportional to hardness, tensile strength and Young's modulus. Greater the material's hardness, tensile strength and modulus, less will be the elongation under stress. It takes more force to stretch a hard material having high tensile strength and high modulus than to stretch a soft material with low tensile strength and low modulus.

From the graph is drawn between the experiment number and percentage of elongation it is clear that the percentage of elongation for the emu feather reinforced epoxy composites is higher than that of pure epoxy. The tensile strength is decreasing for emu feather reinforced epoxy composites since the tensile strength is inversely proportional to the elongation. The same trend has been noticed when chicken feather fibers were reinforced in vinyl ester and polyester resins by Uzan et al. [8].

The decline in tensile strength is due to the following reasons. One possibility is that due to the presence of pores present in the matrix which were formed during manufacturing, the other is due to non circularity of fiber which results in stress concentration. The decrease in the tensile strength may also be attributed to the improper interfacial bonding between the fiber and the matrix due to the protein present on the surface of the feathers.

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