Studies on Tensile and Compression Characteristics of Silk-Cotton Reinforced Composites

R. Manjunatha[1]
[1] Research Scholar,
Department of Mechanical Engineering,
SSHAE, Tumakuru, Karnataka

Dr. Sangeevmurthy[2]
[2] Professor,
Department of Mechanical Engineering,
SSHAE, Tumakuru, Karnataka

***Abstract*— Natural fibers have as of late turned out to be interesting to engineers, scientists and researchers as an elective reinforcement for fiber reinforced polymer composites (FRPCs). Because of their minimal effort, genuinely great mechanical properties, high explicit quality/modulus, nonabrasive, eco-accommodating, and biodegradability attributes, they are utilized as a swap for the engineered fiber, for example, glass, aramid, and carbon. Silk is one of the most valuable, filaments among every material fiber and it has a wide scope of employments, for example, sewing strings, in garments, home/specialized materials, and as decorative uses. FRP's are the new set of composites in which fiber material will be molded with matrix material for better mechanical properties. In this context silk and cotton materials were used as fibers along with Polyester resin (CX 132) in the preparation of composites and tensile behavior of these composites prepared with different combinations of silk and cotton were evaluated. As per this study composites with 20% silk and 20% of cotton have resulted in better tensile properties and composites with 5% silk and 5% cotton have shown poor tensile properties.**

Keywords:- Component; formatting; style; styling; insert

I. INTRODUCTION

So as to moderate characteristic properties and conserve energy, alterations in the weight is been the principle focal point of automobile companies in the present situation. Weight decrease can be accomplished basically by the incorporation of better material, design advancement and better fabrication procedures. The advancements in the composite materials made it conceivable to decrease the weight of the different components without altering the weight carrying capacity and stiffness of these materials. The composite materials have progressive strain (elastic) energy restoring capacity and increased strength to weight ratio. The composite material offers wide spread opportunities for significant weight reducing but not the cost effective than the parts made of steel [1]. Composite materials are new age materials to fulfill the needs of fast development in the industrial sector with the innovative changes. These are the engineering materials produced using at least two constituent's materials that remain isolated and particular on macroscopic level while framing a single segment. It comprises of short and delicate collagen strands inserted in a mineral matrix called apatite [2]. Hybrid composites contain more than one kind of fiber in a individual matrix system. On a fundamental level, a few distinct kinds of filaments might be combined together to fabricate hybrid composites, however almost certainly, combination of two kinds of fibers are considerably more beneficial. They have been built up a sensible spin-off of regular composites containing one fiber. Crossover composites have one of kind highlights that can be utilized to meet different plan necessities in a more efficient manner than regular composites. This is on the grounds that costly filaments like graphite and boron can be in part supplanted by more affordable fiber like kevlar [3]. Naturally derived from plants, animals and geological processes are incorporated to fabricate natural fiber reinforced composites (NFRC's). They are biodegradable after some time. Vegetable filaments are commonly based on the positioning of cellulose, regularly with lignin (Some of the plant fibers are jute, cotton, flax and so on), but animal fibers are especially made of proteins. Some of the available animal fibers are silkworm fiber, spider silk fiber and many more. And mineral fibers consist of asbestos, which is a main and only naturally occurring element in the mineral fiber [4]. Hybrid composites typically contain high modulus, high quality and many more good properties. The congenital mechanical properties of both fiber materials offer raise to one of a kind basic material regarding toughness and strength [4]. The tensile properties of pineapple leaf fiber and sisal incorporated polyester composites are improved due to the addition of small quantity of glass fibers in these composites, and this will demonstrate positive hybrid impact [5].

The characteristics of natural fiber strengthened composites materials can be improved by joining it with manmade synthetic strands and making it hybrid polymer composite. The bamboo-glass fiber incorporated polymer composite exhibited better mechanical properties like hydro-thermal aging and tensile strength property [6]. The epoxy matrix incorporated with glass fiber and bamboo leaf determined SiC improves tensile characteristics of the composite [7]. The jute and E glass incorporated polyester composite demonstrated an impressive improvement by joining the E glass as extraordinary glass plies [8]. Less research has been directed in the field of kevlar and natural fiber incorporated composite materials [9]. Panthapullakkal and Sain examined the mechanical and thermal properties of hemp/glass polypropylene composite materials. They have seen that the utilization of hybrid composites improves the tensile properties. What's more they have seen that the expansion of glass fiber into hemp-PP composites brought about improved thermal characteristics just as the hydrophobic property of the composites [13]. Idicula et al. [14] has

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 8 Issue 10, October-2019

considered the thermo-physical properties of natural fiber incorporated composites. They have shown that the natural fiber with glass permits a fundamentally better heat transfer capacity for the composites. All in all, in this examination composition of two natural fibers for example silk and cotton were used in the fabrication of NFRC's.

The motivation behind this examination is to research the potential use of silk and cotton in polyester composites and the impact of silk and cotton content on the tensile and compressive parameters of the composites will likewise be explored.

II. MATERIALS AND METHODS

This part portrays detail and properties of materials utilized as filler and matrix. In the present work silk and cotton are used as the filler with varying proportions (as mentioned in table 1) along with Polyester resin (CX 132) as a matrix system and Hardener (araldite) HY 951. This chapter likewise covers the testing techniques pursued and the standard system of testing.

A. Materials

- **Cotton Fibers**: Cotton is a characteristic cellulosic fiber. It is broadly utilized characteristic fiber. It is a delicate, cushy staple fiber that develops in a boll, or defensive case. The fiber is practically unadulterated cellulose. Cotton plants of the variety gossypium in the mallow family malvaceae. The cotton strands contain 91.00% of Cellulose, 0.55% of Protoplasm, Pectin, 0.40% of oil, Waxes and Fatty Substances, 0.2%m of Mineral Salts, 1% of protein and 6.85% of water.

Figure 1: Cotton fibers

- **Silk Fiber:** Silk is a characteristic protein fiber, a few types of which can be woven into materials. The protein fiber of silk is made mostly out of fibroin and is created by certain creepy crawly hatchlings to frame cases. The silk fiber comprises of 75% of Fibroin 22.5% of Sericin 1.5% of fat and wax 0.5% Ash of Silk Fibroin 0.5% Mineral Salt.

Figure 2: Silk Fiber

B. Matrix system (Polymer resin and Hardner)

The matrix system consists of a medium viscosity Polyester resin (CX 132) and a room temperature curing Hardener (araldite) HY 951 supplied by Yuje marketing, Malleswaram, Bangalore. Polyester resin was selected as the material for the matrix system because of its wide application, good mechanical properties, excellent corrosion resistance and ease of processing.

- **Polyester Resin (Polyester resin (CX 132)):** Polyester resin (CX 132) made by CIBA GUGYE Limited, having the extraordinary properties like, Excellent grip with various materials, Great quality, durability obstruction, Excellent protection from synthetic assault and to dampness, Excellent mechanical and electrical properties, Odorless, boring and totally nontoxic, Negligible shrinkage, Light weight, Resists most antacids and acids, Resists breaking at stress, Retains firmness and adaptability, Low dampness retention, Non-recoloring, Easily prepared.
- **Hardener**: In the present work Hardener (araldite) HY 951 is utilized. This has a thickness of 10-20 balance at 25^0C. Hardener is a relieving operator for polyester or fiberglass. Polyester sap requires a hardener to start restoring; it is likewise called as impetus, the substance that solidifies the glue when blended with tar. It is the particular choice and blend of the polyester and hardener segments that decides the last qualities and reasonableness of the polyester covering for given condition.

C. Methodology

Selection of raw materials such as Silk & cotton are easily available and they might be exhibiting superior properties. After selection of raw material, fabrication is done by compression moulding process. Testing is carried out by using ASTM standard. Below figure shows the steps involved in the selection and fabrication of composites. Figure 3 shows the flow of methodology adopted in this work.

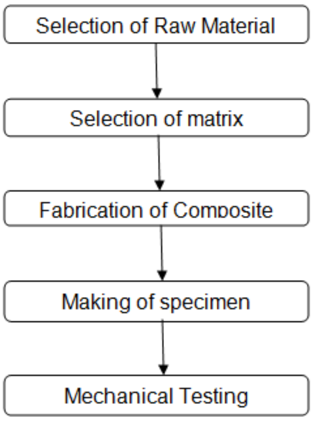

Figure 3: Selection of Raw Material

D. Speciman Preparation

In this work composites were prepared in the form of plates using hand layup process by many of the researchers and academicians. In this work cotton fibers of different types have been selectively chosen and are used in the fabrication of composites along with the silk as another fiber. Polyester resin (CX 132) has been utilized in the fabrication of the composites with cotton and silk fibers.

Special concentration was given on reducing the voids which may occur during the fabrication of composites because of insufficient/improper surface wetting of fibers. Because of this insufficient wetting of fibers air bubbles

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 8 Issue 10, October-2019

might be entrapped inside the composite and this will lead to the low-quality composites. Hence the curing procedure was finished following 48 hours in room temperature 16°C and 47% mugginess. Next, the parts of the bargains were cutoff to shape symmetrical edges and the coupons for malleable and bowing tests have been checked and cut utilizing wet slice hardware as indicated by the standard ISO 14125: 1998(E) as appeared in Figure 4. When marking the specimens, areas of material discontinuity, surface anomalies and areas with voids have been avoided. The gross dimensions of the coupons prepared for tensile testing were:

Figure 4: Sample preparation by wet hand layup process

Initially rectangular plates have been prepared as per the weight ration as given in following table. From these rectangular plates, dog bone shaped tensile samples were cut with the help of wire hacksaw blade. Below table 1 shows the different weight calculations for different combination composites.

Table 1: Weight ratio of sample plates

Sample Plate	Weight Ratio	Silk (%)	Cotton (%)	Matrix (%)
1	10:90	5%	5%	90%
2	20:80	10%	10%	80%
3	30:70	15%	15%	70%
4	40:60	20%	20%	60%

Figure 5 shows the sample dimensions for the tensile test which where was cut into flat shape (250x25.4x5) mm, in accordance with ASTM standards [16] from the rectangular plates prepared previously. And figure 6 shows the sample specimen which was cut from the rectangular plates (prepared specimen for tensile test).

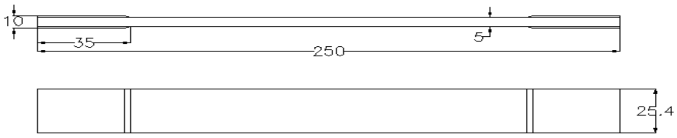

Figure 5: tensile test specimen

Figure 6: Fabricated and prepared sample as per ASTM for tensile test

E. *Speciman Preparation*

The samples are cut to the following dimensions as per ASTM standards for testing shown in following table 2.

Table 2: ASTM D3039 specifications for samples.

Sl. No	ASTM Code	Mechanical Test	Sample Dimensions (mm)
1	ASTM-D 3039 [16]	Tensile	250 x 25.4 x 5
2	ASTM-D 3410 [17]	Compression	127 x 10 x 4

According to ASTM, the specimen is cut into required dimension (250×25.4×5) mm using diamond wheel saw and is finished to size using emery paper. Aluminum end tabs are mounted at the both ends of the specimen for the purpose of gripping. The geometry of the test specimen is shown in figure 5. The tensile tests were carried out using a universal mechanical testing machine INSTRON 8500 with load cell of 5 KN. As per ASTM standards D 3039 the specimens of 250 mm length and 25.4 mm wide were cut from the laminates such that warp yarns were oriented along the length of the specimen. The specimen is placed onto two supports with a span to depth ratio of 16:1 and the speed of the jaws was set to 1 mm/min.

F. *Tensile test on Cotton and silk composites*

The tensile strength of a material is the maximum amount of tensile stress that it can take before failure. The commonly used specimen for tensile test is the dog-bone type. During the test a uniaxial load is applied through both the ends of the specimen. The dimension of specimen is (250 x 25.4 x 5) mm. typical points of interest when testing a material include: ultimate tensile strength or peak stress; offset yield strength which represents a point just beyond the onset of permanent deformation; and the rupture or fracture point where the specimen separates into pieces. The tensile test is performed in the universal testing machine (UTM) Instron 8500 and results are analyzed to calculate the tensile strength of composite samples.

Figure 7: Universal test setup

G. *Compression test on cotton and silk composites*

Specimens were fabricated for the compression tests as per the ASTM standards [17] given in the table 2 (127×10×4). And test was conducted similar to that of tensile test. Some of the minute changes as well as pre-conduct of test in this compression test were explained below.

Take the measurements of width and thickness of the sample specimens at a few areas along the length of the specimen. Place the specimen in the grips provided in the universal testing machine. Fix the specimen in the test rig with the help of tightening screw through the grips provided in the specimens. Start applying the compressive load gradually in stepwise manner at the mean time UTM will capture the load and displacement values as graphs in the software provided. Load is applied till the sample specimen breaks and values of load v/s displacement are recorded.

III. TESTING AND RESULTS

A. *Tesile test results*

Figure 8 shows the characteristic curve (load v/s Elongation) for the 5% silk and 5% cotton reinforced composites. And the different properties like yield strength, yield stress, tensile strength, peak load and percentage elongations were recorded for different specimens.

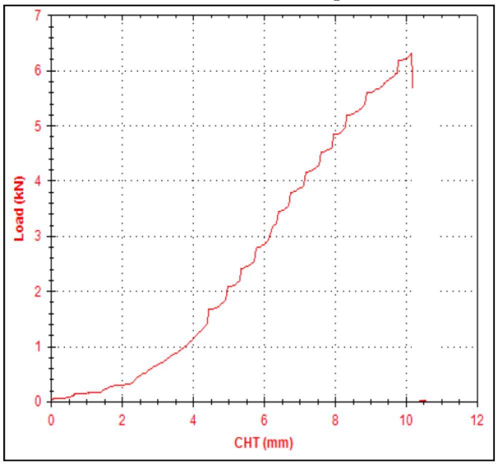

Figure 8: Load v/s Elongation for 5% silk and 5% Cotton reinforced composites

Figure 8 is the typical load v/s elongation curve for the composite made with 5% cotton and 5% silk. In the test rig used for tensile test was with load measurement in kN and elongation/displacement measurements in mm. For every combination of composites five specimens were prepared and all are tested in the UTM. And the average value of all the five tests were presented in the below table 3.

Table 3: Tensile characteristics of silk and cotton composites with different combinations

Type of Sample	Load at Yield (KN.)	Yield Stress (N/mm2)	Load at Peak (KN)	Tensile Strength (N/mm2)	Elongation (%)
5% Silk + 5% Cotton	5.25		6.31	54.90	2.10
10% Silk + 10% Cotton	5.45	39.05	6.29	44.93	1.15
15% Silk + 15% Cotton	9.44	51.53	11.14	60.80	2.88
20% Silk + 20% Cotton	11.56	51.78	14.20	63.15	6.90

Table 3 gives the information about the yield load, yield point, peak load, tensile strength and percentage elongation of the composites made with silk and cotton with different combinations. Figure 9 through 11 these properties have been depicted and compared with one and other as given in the following figures.

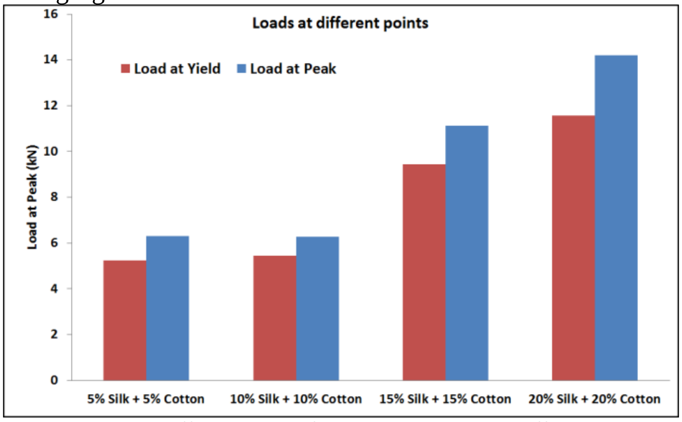

Figure 9: Loads at different points of composites made with different combinations of silk and cotton

Figure 9 shows the comparison between the load at yield and peak loads of different combinations of silk and cotton composites. From the above figure it was observed that, both yield and peak loads have shown incremental values for the raise in the silk and cotton percentage. Least values for the both yield load and peak loads have been identified for composites made with 5% silk and 5% cotton and highest values have been observed for composites with 20% silk and 20% cotton.

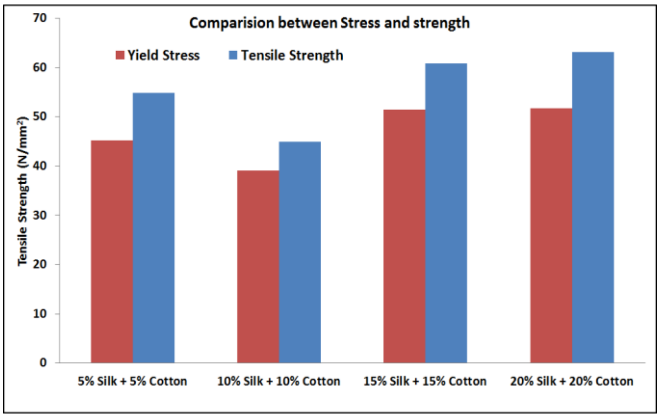

Figure 10: Comparison between stress and Strength of different combinations of silk and cotton

Similarly, figure 10 shows the comparison between the yield stress and tensile strength of different combinations of silk and cotton composites. From the above figure it was observed that, both yield stress and tensile strength values were high for the composites with 5% silk and 5% cotton. But, further addition of silk and cotton have shown fall in the yield stress and tensile strength values. Then the highest values of yield stress and tensile strength were observed for 20% silk and 20% cotton reinforced composites. Least values for the both yield load and peak loads have been identified for composites made with 10% silk and 10% cotton.

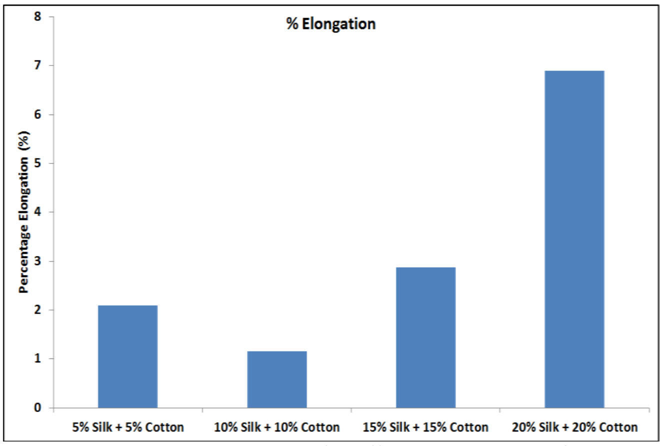

Figure 11: Percentage Elongation for different combinations of silk and cotton

Figure 11 shows the variation in the percentage elongation of the composites made with silk and cotton with varying percentages. From the above figure it was observed that, initially these composites have exhibited moderate elongation properties for 5% of silk and cotton but it went on decreasing for the further addition of these fibers. Later on, this property was found to be drastically increasing for the increase in silk and cotton percentages.

Define abbreviations and acronyms the first time they are used in the text, even after they have been defined in the abstract. Abbreviations such as IEEE, SI, MKS, CGS, sc, dc, and rms do not have to be defined. Do not use abbreviations in the title or heads unless they are unavoidable.

B. Compression test results

Table 4 shows the variation in the percentage of fibers (natural fibers such as silk and cotton) in the NFRC's and displacement of cross head of the UTM while the compressive load is applied on to the prepared specimen under compression test. In this study cotton and silk fiber combinations were varied in percentage and relevant displacement values have been recorded.

Table 4: Results on Compression studies of cotton and silk composites

% of fiber	Displacement (mm)
2	3.061
4	2.81
6	2.727

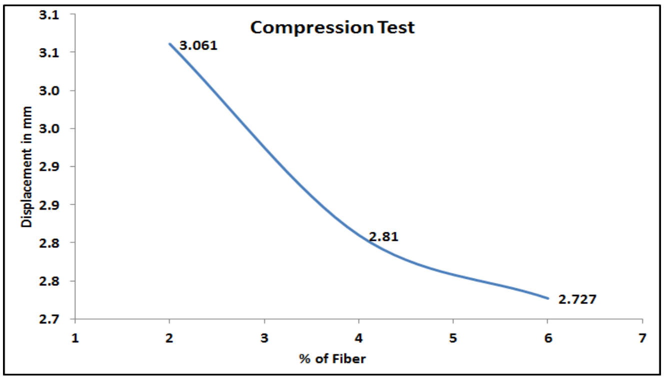

Figure 12: variation in the displacement of silk and cotton composites with variation in the fiber percentage

Figure 12 shows the variation in the compression behavior of the silk and cotton reinforced polyester resin composites. In this graph displacement value for the different combinations of the silk and cotton composites have exhibited different values. That is growth in the fiber percentage resulted in the reduced displacement values. This means as the fiber percentage increases with the composite volume the compressive behavior of the composite improves.

IV. CONCLUSION

Out of all combinations of silk and cotton reinforced composites, 20% silk and 20% cotton fiber composites have shown better tensile properties as compared to all other combinations. All kind tensile characteristics of silk and cotton reinforced composites were found to be increasing with the increase in silk and cotton percentage combinations. But better results were observed form maximum combinations of silk and cotton. Tensile strength was found nearly equal for 15% and 20% combinations of silk and cotton reinforcements respectively. And for the compression test, displacement value for the different combinations of the silk and cotton composites have exhibited different values. That is growth in the fiber percentage resulted in the reduced displacement values. This means as the fiber percentage increases with the composite volume the compressive behavior of the composite improves.

REFERENCES

[1] N O Warbhe, Ramakant Shrivastava, P S Adwani, "Mechanical Properties of Kevlar/Jute Reinforced Epoxy Composite", IJIRSET ISSN:2319-8753, Vol.5, Issue 9, September 2016.

[2] M Nayeem Ahmed, P Vijayakumar, H K Shivanand, Syed Basith Muzammil, "A Study on Flexural Strength of Hybrid Polymer Composite Materials in Different Matrix Material by Varying its Thickness", IJMET, ISSN 0976-6340, Vol.4, Issue 4, July- August 2013, pp.274-286

[3] M Nayeem Ahmed, Mohammed Salman Mustafa, "A Study on tensile and compressive strength of hybrid polymer composite materials with epoxy resin 5052 by varying its thickness", IJMET, ISSN 0976-6359, Vol 6, Issue 4, April 2015, pp.17-26

[4] M Nayeem Ahmed, P Vijayakumar, H K Shivanand, Syed Basith Muzammil, " A Study on the effect of variation of thickness on tensile properties of hybrid polymer composites and GFRP composites", IJERA, ISSN;2248-9622, vol.3, Isuue 4, July-Aug 2013, pp.2015-2024.

[5] Glass Fibre Reinforced Polymer Matrix Hybrid Composite", journal of material science,2000, 19:1873-1876.

[6] M R Sanjay, B Yogesha, " Studies on Mechanical Properties of Jute/ E glass Fibre Reinforced Epoxy Hybrid Composites", JMMCE, 2016,4,15-25

[7] Moethwe and Kinliao, " Charecterisation of Bamboo- PNB Reis, JAM Ferreira, JDM Coata, M J Santos, Fibres and Pol.13 (2012) 1292-1299

[8] C Velmurugan, R Raja Karthikeyan,B Prabhu,R Naveen kumar, " Experimental Investigation on Mechanical Properties of Jute Glass Fibre Reinforced Epoxy Resin Hybrid Composite", MEJSR, 24 (S1): 11-15, 2016

[9] Thingujam Jackson Singh, Sutanu Samanta,"Charecterisation of Kevlar Fibres and its Composites: A Review", Materials Today: Proceedings 2 (2015): 1381-1387

[10] Vivek Mishra, Sandhyarani Biswas, "Physical and Mechanical Properties of Bi- Directional Jute Fibre Epoxy Composites", Procedia Engineering 51 (2013) 561-566

[11] Panthapullakkal, Sain M, "injection molded short hemp/ glass fibre reinforced polypropylene hybrid composites- mechanical, water absorption and thermal properties", J Appl Polym Sci2007;103:103;2432-41

[12] Idicula G, Cristaldi G, Recca G, Ziegmann G, EI- Sabbagh A, Dickert M, et al. “properties and performances of various hybrid glass/ natural fibre composites for curved pipes. Mater Des 2009;30;2538-42.

[13] Standard Test Method for Tensile Properties of Polymer Matrix Composite Materials. ASTM D3039 / D3039M – 17.

[14] Standard Test Method for Compressive Properties of Polymer Matrix Composite. Designation: D 3410/D 3410M – 03.