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MECHANICAL BEHAVIOUR OF SILK FABRIC REINFORCED ECO FRIENDLY POLYMER MATRIX COMPOSITE

S. PRAKASH[*], D. LOGANATHAN[a], K. SURENDRA BABU, G. DILLI BABU, V. GOPALA KRISHAN and G. GOPI

Department of Mechanical Engg, Aarupadai veedu Institute of Technology, CHENNAI (T.N.) INDIA
[a]Jaya Engineering College, CHENNAI (T.N.) INDIA

ABSTRACT

The objectives of this study were to fabricate natural composite material and testing the strength of it. Woven natural silk fabric has been commonly used in textile industries for centuries. Irrespective of their mechanical and environmental merits, their utilizations as reinforcement material for composites structures are very rare. Therefore, this work is focused on the use of woven natural silk as a reinforcement material in composites materials. In laminated composite tensile strength, flexural strength, compression strength of woven natural silk fabric reinforced epoxy (WNS/Epoxy) were investigated. Composite material, prepared in configurations of 10, 15, 20, 25 and 30layers with orientation of 0 degree and 45 degree of WNS and tested under a UTM (Universal Testing Machine) analyzed. Tensile strength and flexural strength were investigated. An increased Tensile strength was observed with increase in number of WNS ply**.**

Key words: Silk fibre composite, Eco-friendly, Tensile strength, Flexural strength, Compressive strength.

INTRODUCTION

A composite is a material made by combining two or more dissimilar materials in such a way that the resultant material is endowed with properties superior to any of its parental ones. Fiber-reinforced composites, owing to their superior properties, are usually applied in different fields like defense, aerospace, engineering applications, sports goods, etc. Nowadays, natural fiber composites have gained increasing interest due to their eco-friendly properties. A lot of work has been done by researchers based on these natural fibers. Natural fibers such as jute, sisal, silk and coir are inexpensive, abundant and renewable, lightweight, with low density, high toughness, and biodegradable. Natural fibres such as silk have the

[*]Author for correspondence; E-mail: prakash_mech94@yahoo.co.in

potential to be used as a replacement for traditional reinforcement materials in composites for applications which requires high strength to weight ratio and further weight reduction. Silk has been an important fabric in the textiles industry due to its luster and superb mechanical properties.

EXPERIMENTAL

Silk fibre

Apart from the plant-based fibres, animal-based fibres become other alternatives for producing biodegradable, biomedical and bio-resorbable composite materials for bioengineering and orthopaedic applications. Cocoons are natural polymeric composite shells made of a single continuous silk strand with length in the range of 1000-1500 m and conglutinated by sericin. This protein layer resists oxidation, is antibacterial, ultra-violet (UV) resistant, and absorbs and releases moisture easily. Since this protein layer can be cross-linked, copolymerized, and blended with other macromolecular materials, especially artificial polymers, to produce materials with improved properties. In average, the cocoon production is about 1 million tonnes worldwide, and this is equivalent to 400,000 tonnes of dry cocoon. Table 1 shows the natural and synthetic fiber mechanical properties.

Table 1: Mechanical properties of common natural and synthetic fibres

Types of fibre	Material	Density (g/cm^3)	Tensile strength (Mpa)	Young's modulus (Gpa)	Elongation at failure (%)
Natural fibre	Spider silk	1.3	1300-2000	30	19-30
	Enhanced B. Mori silk	1.3-1.38	600-700	12.2	30-35
	B. Mori silk	1.3-1.38	500	8.5-8.6	15
	Flax	1.45	500-900	50-70	1.5-4.0
	Hemp	1.48	350-800	30-60	1.6-4.0
Synthetic fibre	Kevlar 49	1.44	3600-4100	130	2.8
	Carbon	1.4	4000	235	2
	E – glass	2.5	3100-3800	76-79	4.8
	Dyneema	0.97	2300-3500	550	2.7-4.5
	High grade steel	7.8	1000	200	30

Polymer

Epoxy resin (Araldite LY 556), having the following outstanding properties has been used.

1. Excellent adhesion to different materials
2. Great strength, toughness resistance
3. Excellent resistance to chemical attack and to moisture
4. Outstanding electrical insulating properties
5. Absence of volatile on curing
6. Negligible shrinkage

Hardener

In the present work Hardener (araldite) HY 951 is used. This has a viscosity of 10-20 poise at 25^oC.

Preparation of composite

Polymer-hardener mixture

For the making of good composite the measurement of the samples should be accurate and the mixture should be very uniform. We take accurate amount of polymer which we have calculated earlier and 10% of its hardener. Then this mixture is stirred thoroughly till it becomes a bit warm. Bit extra amount of hardener is taken for the wastage in the process. Hardener should taken very minutely because little extra amount of hardener can spoil the composite

Die preparation

The Die completely cleaned and dust free surface is made then plastic sheet is placed over the surface of the die, a wax applied on entire surface of the plastic sheet so that polymer matrix do not stick on the die surface, transparent tape is applied on the side beading (wall) of the die, once again a wax material applied on side beading now die ready for pouring polymer hardener mixture

Silk fabric preparation

Silk fabric prepared by cutting the silk fabric according to the Die size. In this project according to the ASTM die size is 300 x 300 mm. number of layer of silk fabric decided by polymer matrix ratio.

Calculation

Volume ratio of polymer and silk fabric

1. Composite volume = 30 x 30 x 0.3 cm = 270 cc
2. 1 layer of silk fabric (30 x 30 cm) = 5 gram
3. 10 layers of silk fabric (30 x 30 cm) = 50 gram
4. Volume % silk fiber = (volume of silk/volume of composite) x 100%

   = $(\text{mass/density})_{silk}$/LxBxt) x 100%
5. 5. For 10 layer of silk fiber = (50/1.3) / 270 = 14.26%
6. For 15 layer of silk fiber = (75/1.3) / 270 = 21.36%
7. For 20 layer of silk fiber = (100/1.3) / 270 = 28.49%
8. For 25 layer of silk fiber = (125/1.3) / 270 = 35.6%
9. For 30 layer of silk fiber = (150/1.3) / 270 = 42.73%

Casting of composite

Hand layup method

The polymer hardener mixture poured into the die and allowed mixture to form of gel coat layer then silk fabric of size 300 mm x 300 mm placed on gel coat layer of resin, next another layer placed on resin like that it continues until the required layers need. The silk fiber due to its light weight and high volume than polymer gets swelled up and voids and air bubbles may form which is to be removed by gently rolling the material by using metal roller. These voids can make real hindrance in future. These voids weaken the composite and makes testing difficult. For the composite of perfect dimension weight should be carefully put above it. Weight should be put in such a way that no polymer hardener mixture seeps out of the die.

A fly press is used to compress the composite material so that excess materials squeezed out from the die cavity and required shape and size (thickness) is obtained by pressing the composite material in die cavity.

After 24 hours of compressed state in room temperature, laminates are prepared by curing and pressure applied on it, after 24 hours of curing the composite material is ready for testing and inspection, the Fig. 2.1 shows cured composite.

Fig. 2.1: Picture of silk composite

Water jet cutting

Silk composite is to be cut to the required size by water jet cutting. According to ASTM the test specimens are cut. For tensile and compression test 250 x 25 mm specimen size, for flexural test 154 x 13 mm specimen size. Water jet cutting is used to cut composite laminates which does not affect the metallurgical property of material and also this cutting provides smooth and satin finish to specimens. Fig. 2.2 shows photo during cutting.

Fig. 2.2: Photo during cutting

Testing setup

In this test specimen of its tensile, flexural and compression strength are tested in universal testing machine.

Fig. 3.1 shows test specimen for tensile test.

Fig. 3.1: Tensile test specimen

Tensile test

Test specimen is placed in UTM machine and tensile test is carried out. Total length of specimen is 250 mm and gauge length is 150 mm, to find percentage of elongation initial length and final length of specimen is measured.

Fig. 3.2: Tensile test

Flexural test

Flexural setup is fitted in UTM to test flexural test for this 154 mm x 13 mm size specimen is placed in between two roller support and knife edge plunger is used to test specimen

RESULTS AND DISCUSSION

Tensile strength

The tensile strength of the composites was measured by using an UTN 40 SR NO 11/98 model 2459 instrument. Tensile properties of woven natural fiber composites with 25 layers with orientation of 0 degree & 45 degree and 30 layers with 0 degree & 45 degree are presented in Table 4.1 from the table, it is seen that as the number of layers increases (30 layer) shows higher tensile strength and also 45 degree woven silk fabric shows higher strength than 0 degree.

Flexural strength

Flexural strength was determined by using an UTN 40 SR NO 11/98 model 2459 Instrument. The variation of flexural strength with more number of layers and 0 & 45 degree were examined. Tested laminates are tabulated in Table 4.1. It is observed from the table that the 45 degree and more number of layers composites have higher flexural strength.

Table 4.1: Testing results of 25 layer and 30 layer silk composite

Silk composite	25 Layers		30 Layers	
	0 degree	45 degree	0 degree	45 degree
Tensile strength (Mpa)	20.75	23.68	29.37	49.65
Flexural load (KN)	0.11	0.14	0.13	0.15
Compressive load (KN)	11.70	14.72	18.28	20.56

Compressive strength

Compressive strength was determined by using an UTN 40 SR NO 11/98 model 2459 Instrument. Results are tabulated in Table 4.1. From this table it is observed that as the number of layers increases, increases the compressive strength of composite and also 45 degree composites have higher strength than 0 degree.

CONCLUSION

The natural fiber composites of silk epoxy composites were prepared with varying numbers of layers with 0 degree and 45 degree. The variation of tensile strength, flexural strength, and compressive strength of silk epoxy composites has been studied as a function of percentage of volume of silk fiber in composite material. It is observed that increasing the number of layers and in 45 degree of silk composite are having higher tensile, flexural, and compressive strength.

REFERENCES

1. M. R. Ahmad, W. Y. W. Ahmad, J. Salleh and A. Samsuri, Effect of Fabric Stitching on Ballistic Impact Resistance of Natural Rubber Coated Fabric Systems, Mater. Design, **29**, 1353-1358 (2007).
2. S. Ataollahi, S. T. Taher, R. A Eshkoor, A. K Ariffin and C. H. Azhari, Energy Absorption and Failure Response of Silk/Epoxy Composite Square Tubes: Experimental, Composites Part B: Engg., **43**, 1-7 (2011).
3. K. Bourzac (October 2010). Transgenic Worms Make Tough Fibers, In: Kraigslabs, 01.03.2011, Available from: http: //www.technologyreview.com /biomedicine/26623.
4. C. R. Cork, P. W. Foster, The Ballistic Performance of Narrow Fabrics, Int. J. Impact Engg., **34**, 495-508 (2005).
5. O. Hakimi, D. P. Knight, F. Vollrath and P. Vadgama, Spider and Mulberry Silkworm Silks as Compatible Biomaterials, Composites: Part B, **38**, 324-337 (2007).
6. M. Keefe, M. P. Rao, Y. Duan, B. M. Powers and T. A. Bogetti, Modeling the Effects of Yarn Material Properties and Friction on the Ballistic Impact of a Plain-Weave Fabric, Composite Structures, **89**, 556-566 (2009).
7. K. M. Kelvin Loh and C. K. Willy Tan, Natural Silkworm Silk-Epoxy Resin Composite for High Performance Application, Metal, Ceramic and Polymeric Composite for Various Uses, Chapter – 16, 325-340 (2011).
8. J. Mussig, (Ed.), Industrial Applications of Natural Fibres, John Wiley & Sons, Ltd, 386 (2010), ISBN 978-0-470-69508-1, United Kingdom.
9. Noorunnisa Khanam, G. Ramachandra Reddy, K. Raghu and S. Venkata Naidu, Tensile, Flexural and Compressive Properties of Coir/Silk Fabric-Reinforced Hybrid Composites, J. Reinforced Plastics and Composites, **29**, 2124-2127 (2010).

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