

Analysis of Mechanical Properties of Silk/Flax Hybrid Epoxy Composite Material

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ABSTRACT: The fibers from the natural sources provide indisputable advantages over synthetic reinforcement materials such as low cost, low density, non-toxicity, comparable strength, and minimum waste disposal problems. In the present experiment, silk & flax fiber reinforced epoxy composites are prepared and the mechanical properties of these composites are evaluated. The composite samples with different fiber weight ratio were prepared by using the compression moulding process with 1500 psi pressure at 80⁰ C temperature. The samples were subjected to the mechanical testing such as tensile, flexural and impact loading.

KEYWORDS : The matrix may considerably influence the hygral, thermal, electrical, magnetic and several other properties of a composite.

I. INTRODUCTION

Composites are made up of individual materials referred to as constituent materials. There are two main categories of constituent materials: matrix and reinforcement. At least one portion of each type is required. The matrix material surrounds and supports the reinforcement materials by maintaining their relative positions. The reinforcements impart their special mechanical and physical properties to enhance the matrix properties. A synergism produces material properties unavailable from the individual constituent materials, while the wide variety of matrix and strengthening materials allows the designer of the product or structure to choose an optimum combination

The reinforcements, which are stronger and stiffer, are dispersed in a comparatively less strong and stiff matrix material. The reinforcements share the major load and in some cases, especially when a composite consists of fibre reinforcements dispersed in a weak matrix (e.g., carbon/epoxy composite), the fibres carry almost all the load. The strength and stiffness of such composites are, therefore, controlled by the strength and stiffness of constituent A variety of moulding methods can be used according to the end item design requirements. The principal factors impacting the methodology are the natures of the chosen matrix and reinforcement materials. Another important factor is the gross quantity of material to be produced. Large quantities can be used to justify high capital expenditures for rapid and automated manufacturing technology. Small production quantities are accommodated with lower capital expenditures but higher labour and tooling costs at a correspondingly slower rate.

Many commercially produced composites use a polymer matrix material often called a resin solution. There are many different polymers available depending upon the starting raw ingredients. There are several broad categories, each with numerous variations.

The most common are known as polyester, vinyl ester, epoxy, phenolic, polyimide, polyamide, polypropylene, PEEK, and others. The reinforcement materials are often fibres but also commonly ground minerals. The various methods described below have been developed to reduce the resin content of the final product, or the fibre content is increased. As a rule of thumb, lay up results in a product containing 60% resin and 40% fibre, whereas vacuum infusion gives a final product with 40% resin and 60% fiber content. The strength of the product is greatly dependent on this ratio.

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II. MATRICES

Typically, most common polymer based composite materials; including fiberglass, carbon fiber, and Kevlar, include at least two parts, the substrate and the resin.

Polyester resin tends to have yellowish tint, and is suitable for most backyard projects. Its weaknesses are that it is UV sensitive and can tend to degrade over time, and thus generally is also coated to help preserve it. It is often used in the making of surfboards and for marine applications. Its hardener is peroxide, often MEKP (methyl ethyl ketone peroxide). When the peroxide is mixed with the resin, it decomposes to generate free radicals, which initiate the curing reaction. Hardeners in these systems are commonly called catalysts, but since they do not re-appear unchanged at the end of the reaction, they do not fit the strictest chemical definition of a catalyst.

II. REINFORCEMENTS

Reinforcement usually adds rigidity and greatly impedes crack propagation. Thin fibers can have very high strength, and provided they are mechanically well attached to the matrix they can greatly improve the composite's overall properties.

Fiber-reinforced composite materials can be divided into two main categories normally referred to as short fiber-reinforced materials and continuous fiber-reinforced materials. Continuous reinforced materials will often constitute a layered or laminated structure. The woven and continuous fibre styles are typically available in a variety of forms, being pre-impregnated with the given matrix (resin), dry, uni-directional tapes of various widths, plain weave, harness satins, braided, and stitched

Typical properties of some high performance thermoplastics

Properties	Polyether ether ketones (PEEK)	Polyamide-imide	Polyether-imide	Polysulfone	Polyphenylene sulfide
Density, kg/m ³	1300	1400	1270	1240	1340
Tensile strength, MPa	104	138	115	70	76
Tensile modulus, GPa	4.21	4.48	3.38	2.48	3.31
Poisson's ratio	0.35	0.35	0.35	0.35	0.35
Coefficient of thermal expansion, 10 ⁻⁶ m/m K	-	56	50	86 .40	88
Maximum service temperature, K	630	-	490	490	565

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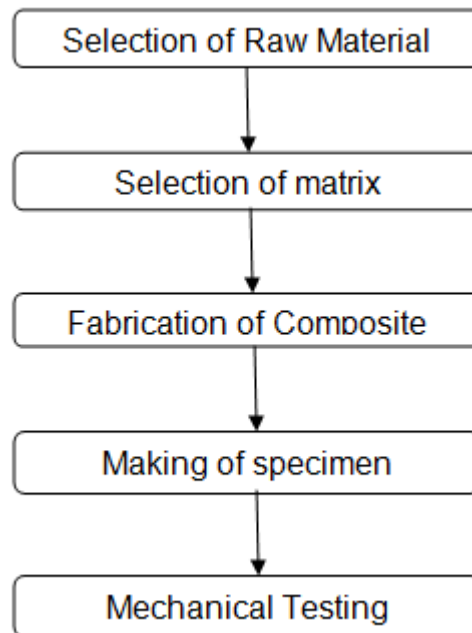
Vol. 4, Special Issue 6, May 2015

Typical properties of some thermosetting resins

Properties	Epoxies	Polyesters	Phenolics	Polyimides
Density, kg/m ³	1100-1400	1200	1200-1300	1400
Tensile strength, MPa	35-100	50-60	50-60	100-130
Tensile modulus, GPa	1.5-3.5	2-3	5-11	3-4
Poisson's ratio	0.35	0.35	0.35	0.35
Coefficient of thermal expansion, 10 ⁻⁶ m/m K	50-70	40-60	40-80	30-40
Service temperature, K	300-370	330-350	440-470	550-750

III. METHODOLOGY

Selection of raw material (Silk & Flax) is mostly good in all properties and easily available. After selection of raw material, fabrication is done by compression moulding process. Testing is carried out by using ASTM standard.



Selection of Raw Material

The natural fibers selected for the making of composites are

- 1.Silkfiber
- 2.Flaxfiber

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(An ISO 3297: 2007 Certified Organization)

Vol. 4, Special Issue 6, May 2015



Silk fiber



Flax fiber

Silk fiber

Silk is a natural protein fiber, some forms of which can be woven into textiles. The protein fiber of silk is composed mainly of fibroin and is produced by certain insect larvae to form cocoons. The best known silk is obtained from the cocoons of the larvae of the mulberry silkworm *Bombyx mori* reared in captivity (sericulture). The shimmering appearance of silk is due to the triangular prism like structure of the silk fibre, which allows silk cloth to refract .

Flax fiber

Flax fibres are taken from the stem of the plant and are two to three times as strong as those of cotton. As well, flax fibers are naturally smooth and straight. Europe and North America depended on flax for vegetable-based cloth until the nineteenth century, when cotton overtook flax as the most common plant used for making rag-based paper. Flax is grown on the Canadian Prairies for linseed oil, which is used as a drying oil in paints and varnish and in products such as linoleum and printing inks.

The flax fibres have a relatively low price compared to glass fibres. In addition, glass fibres are suspected of causing lung cancer, but there is no such problem for natural fibres. The thermal recycling of the flax fibres (burning of flax fibres with little slag left) has a great advantage over glass fibres.

Weight ratio of sample plates

Sample plate	Weight ratio	Silk (%)	Flax (%)	Matrix (%)
1	40:60	20	20	60
2	35:65	17.5	17.5	65
3	30:70	15	15	70

IV. EXPERIMENTAL RESULT AND DISCUSSION

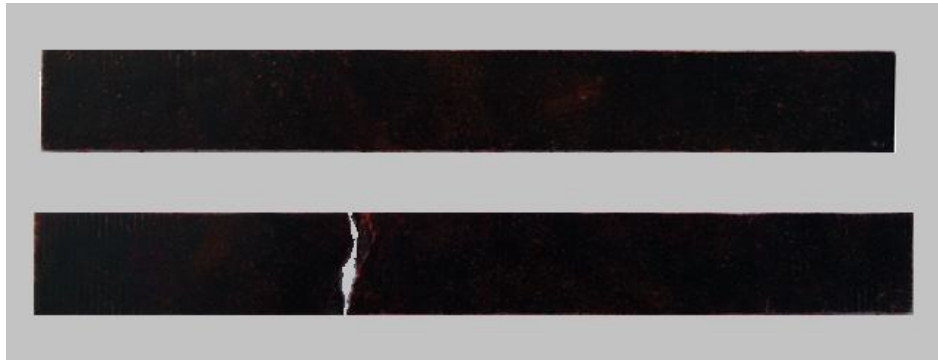
Tensile Test Result

Tensile testing of specimen prepared according to ASTM D 3039, using electronic tensile testing machine with cross head speed of 2 mm/min and a gauge length of 150 mm. The tensile modulus and elongation at the break of the composites were calculated from the stress strain curve. Three specimens were tested for each set of samples and the mean values were reported. The first samples gave good results when compared with the other samples.

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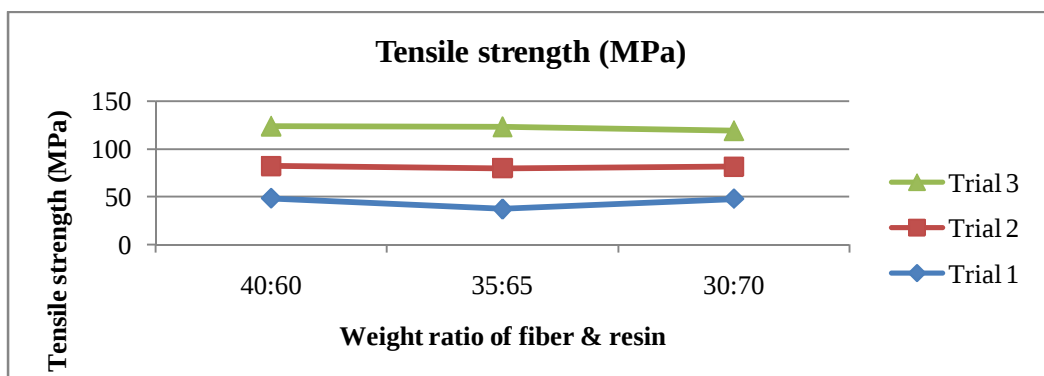
Vol. 4, Special Issue 6, May 2015



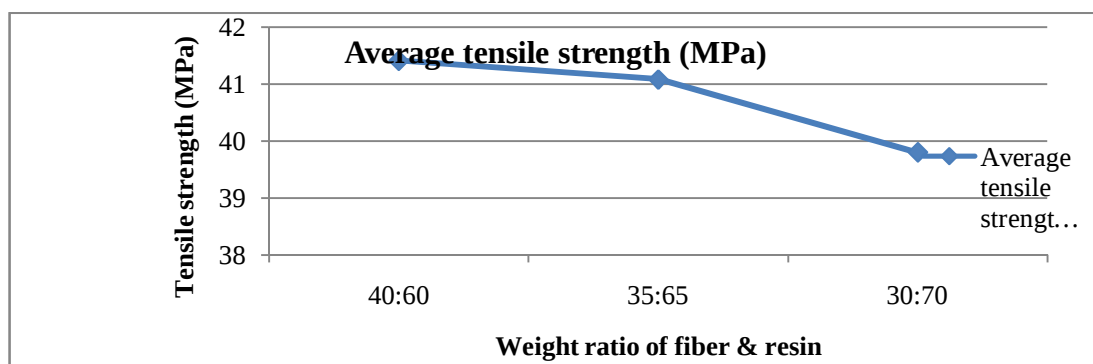
Tensile test specimen before and after the testing

Tensile strength of various specimens

Fiber& resin weight ratio	Trial 1	Trial 2	Trial 3	Average tensile strength(MPa)
40:60	48.712	33.729	41.800	41.414
35:65	37.602	42.585	43.066	41.084
30:70	48.344	33.540	37.523	39.802



Flexural strength comparisons of Silk &Flax fiber composite samples



Comparison of average tensile strength Silk &Flax fiber composite samples

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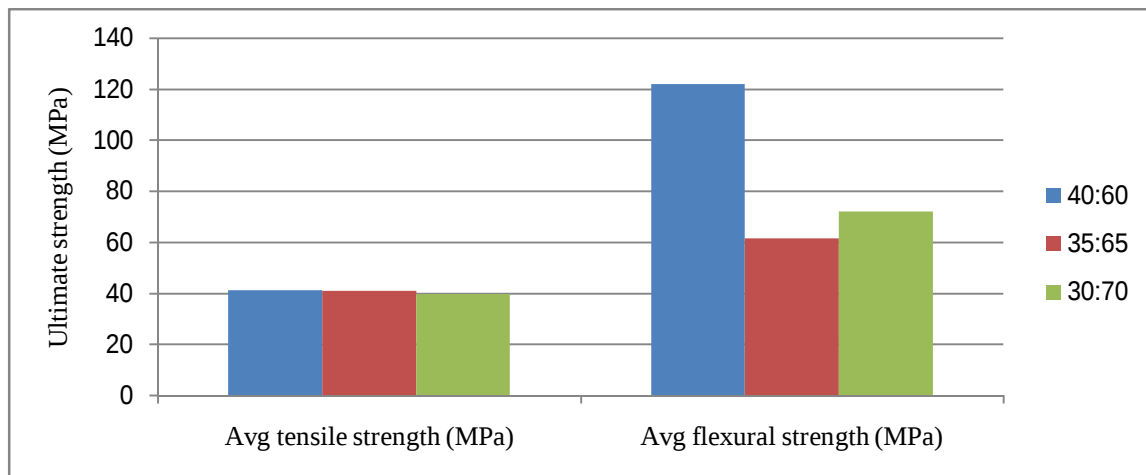
Vol. 4, Special Issue 6, May 2015

Comparison of tensile strength and flexural strength

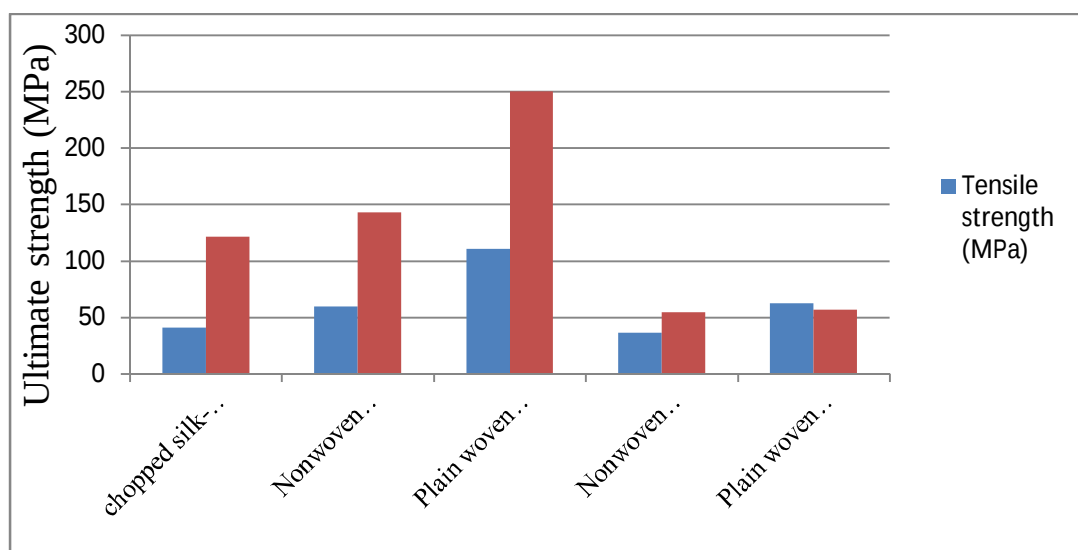
The average tensile strength and average flexural strength of test specimens compared then the result of comparison is given below.

Average tensile & flexural strength

Ultimate strength	40:60	35:65	30:70
Average tensile strength (MPa)	41.414	41.084	39.802
Average flexural strength (MPa)	121.866	61.497	72.122



Comparison of tensile and flexural strength



Comparison of Tensile & Flexural strength of various structured composites

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(An ISO 3297: 2007 Certified Organization)

Vol. 4, Special Issue 6, May 2015

Tensile & Flexural strength of various structured composites

Composite	Tensile strength (MPa)	Flexural strength (MPa)
Chopped silk-flax-epoxy	41.414	121.866
Nonwoven silk-epoxy	60	143
Plain woven silk-epoxy	111	250
Nonwoven flax-epoxy	37	55
Plain woven flax-epoxy	63	57

V. CONCLUSION

This experimental examination of mechanical behaviour of silk fiber and flax fiber based hybrid epoxy composites indicates to the many conclusions

The fiber & resin ratio 40:60 having more tensile strength, flexural strength and impact strength. This hybrid composite having good flexural strength. The impact strength is better when it compared with other natural fiber composite materials.

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