Testing Of Sisal Fiber Reinforced Epoxy Composites At Different Orientations For Tensile And Compression

Mallikarjun B K[1], Arun S K[2], Nagaraj[3], Ravindra A R[4], Ashok[5]

[1] *Asst. professor, Mechanical Engineering, NNRG, Hyderabad, Telangana, INDIA*
[2] *Asst. professor, Mechanical Engineering, NNRG, Hyderabad, Telangana, INDIA*
[3] *Asst. professor, Mechanical Engineering, KVGCE, Sullia, Karnataka, INDIA*
[4] *Asst. professor, Mechanical Engineering, NNRG, Hyderabad, Telangana, INDIA*
[5] *Asst. professor, Mechanical Engineering, NNRG, Hyderabad, Telangana, INDIA*

ABSTRACT

Aim of this work is to investigate the mechanical properties such as tensile strength and compressive strength of the sisal fiber reinforced polymer composites. The strength analysis of the sisal fiber reinforced polymer composites has been made with volume fraction and different combinations such as unidirectional and orientations. The specimens were prepared by hand layup technique and are as per the ASTM standards. The experimental results showed that the tensile strength of the sisal fiber reinforced polymer composites with unidirectional gives better results as compare to orientation composites, but the compression strength is better for orientation composites.

Keyword: - *Sisal fibe, Epoxy L12, K6 Hardener, Hand looming*

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1. INTRODUCTION

A composite material is a plainly visible mix of at least two particular materials, having a conspicuous interface between them. Composites are utilized for their auxiliary properties, as well as for electrical, thermal, tribological, and environmental applications. Current composite materials are typically streamlined to accomplish a specific adjust of properties for a given scope of uses. Given the wide range of materials that might be considered as composites and the n number of uses for which composite materials might be produced, we cannot conclude a single and simple definition. In any case, as a typical useful definition, composite materials might be confined to underline those materials that contain a continuous matrix constituent that binds together and gives shape to a variety of a stronger, stiffer reinforcement constituent.

The subsequent composite material has auxiliary properties that are better than constituent material alone. It enhances the auxiliary properties by load sharing mechanism. In spite of the fact that composites advanced for other useful properties could be delivered from totally unique constituent mixes than fit this basic definition, it has been found that composites created for auxiliary applications likewise give alluring execution in these other useful territories also. Thus, this basic definition for basic composites gives a helpful definition to most current useful composites.

In this way, composites commonly have a fiber or particle phase that is stiffer and stronger than the consistent matrix phase. Many types of reinforcements like fibers, flakes, whiskers, filler materials are used to get the good properties like thermal resistance, corrosion resistance, directional properties, as well as great wear resistance etc.

1.1 CLASSIFICATION OF NATURAL FIBERS

Natural Fibers	Plant	Abacá, Bamboo, Coir, Cotton, Flax (Linen), Hemp, Jute, Kapok, Kenaf, Piña, Raffia palm, Ramie, Sisal, Wood
	Animal	Alpaca, Angora, Bison down, Byssus, Camel hair, Cashmere, Catgut, Chiengora, Guanaco, Llama, Mohair, Pashmina, Qiviut, Rabbit, Silk , Sinew, Spider silk, Wool, Vicuña, Yak
	Mineral	Asbestos

1.2 PROPERTIES OF SOME FIBERS

Fiber type	Density g/cm3	Tensile strength, MPa	Elongation at break, %	Young's Modulus GPa	Moisture absorption, %
Kenaf	1.5	350-600	2.5-3.5	40	-
Hemp	1.48	300-900	1.6	30-70	8
Jute	1.46	400-800	1.8	10-30	12
Sisal	1.33-1.45	510-700	2.2-2.9	9-38	11
Cotton	1.51	400	3-10	12	8-25
Flax	1.4-1.5	500-1500	1.2-2.4	50-80	7
Rayon	1.5	700-800	13-15	20	8

2. SISAL FIBRE

Among all the above natural fibers, the sisal fiber to be selected because of the following special properties of sisal fiber:

- Low density, light weight structures
- High energy absorption
- Comparatively high modulus can be used in stiff but not lad bearing structures
- Low thermal expansion, can be combined with e.g. carbon fiber

The sisal fibers come under organic classification i.e. biodegradable and it further comes under plant species and the fiber is processed from stem and the processing of fibers from sisal leaves is discussed in further chapters. Since the fibers come from stem, less energy is required to process the leaves to get the fibers.

2.1. AGAVE AMERICANA (SISAL) PLANT

Sisal is an agave that yields a stiff fiber traditionally used in making twine, rope, and also dartboard. The term may refer either to the plant or the fiber depending on context. It is sometimes incorrectly referred to as sisal hemp because sisal hemp was for centuries a major source for fiber, so other fibers were sometimes named after it. Agave Americana fibers are made from Sisal plant. The word sisal means cold water. Agave Americana fiber occupies 6th place among fiber plants, which represent 2% of the world's production of plant fibers (plant fibers provide 65% of the world's fibers).

The Agave Americana plant has the common name Agave and it comes from the family Agavaceae. The Agave Americana plant produces approximately 200-250 leaves throughout its productive period. The life span of Agave Americana plant is 7-10 years. The shape of Agave Americana leaves is like sword and is about 1.5 to 2 meters tall. Young leaves may have some of tiny teeth along their edges, yet lose them as they develop. A decent Agave Americana plant yields around 200 commercial utilized leaves with each leaf having a mass composition of 4% fiber, 0.75% cuticle, 8% other dry matter and 87.25% moisture. Thus, a normal Agave Americana leaf weighs about 3% of total weight with each leaf containing about 1000 fibers. The fiber is extracted from the leaf either by retting, by scraping or by retting followed by scraping or by mechanical means using decorticators. Diameter of the fiber varies from 100mm to 300mm.

The Fig 2.1 is the captured image of one of the species of Agave Americana (Sisal) plant in the wild. The leaves have grayish/ash color and there are approximately 20 leaves present in the plant again the extraction of fibers

Fig:2.1 Agave Americana (Sisal) Plant

2.2. CHEMICAL COMPOSITION OF AGAVE AMERICANA FIBER

Chemical Property	Quantity
Moisture	11%
Ash	0.8%
Lignin	10%
Hemi cellulose	11.2%
Cellulose	56%
Wax	2%
Pectin	9%

3. EXPERIMENTAL WORK

The experimentations were carried out on the laminated composite material with different combinations such as unidirectional and orientation.

Materials Required:

Matrix Material
Reinforcement (Sisal fibers)

3.1. MATERIALS

- In the present work Lapox-12 (L-12) Epoxy Resin is used as Matrix material, with K-6 Hardener as curing agent.
- Epoxy is a high strength adhesive, often made of two different materials that must be mixed together just prior to use.
- Reinforcement is the part of the composite that provides strength, stiffness and the ability to carry a load and the sisal fibers (Agave Americana fiber) are used as reinforcement materials
- Most of the natural fibers have a maximum fiber density of about 1.5 g/cc and sisal fiber has a density of 1.36 g/cc.

3.2. SPECIMEN PREPARATION

- In this experiment to prepare the specimen already extracted fibers are collected.

- Fibers are cut into required length (400 to 600 mm)

Fig: 3.1 Sisal Fibers

- Alkali treatment is carried out because the fibers contain major amount of cellulose in them and the excess cellulose has to be removed to make the fibers usable.
- In this treatment we use 95% of water and 5% of NaOH sol (approximately 1kg of fibers were placed in 24L of NaOH solution)

3.3. FABRICATION PROCESS

- This process basically deals with preparation of laminated composites by the use of epoxy resin and hardener mixture by hand-layup method as shown in fig 3.2
- The mats are prepared using looming machine.
- Initially keep the OHP sheet on plane surface and then apply epoxy resin on OHP sheet and put one layer of mat then apply epoxy on that mat and similarly add layer by layer of mats and simultaneously apply the epoxy and finally at the last layer add one OHP sheet with epoxy for smoothing of last layer.
- Finally composite specimens with different orientations of fibers are prepared as shown in the fig. 2.3

Fig: 3.2 Hand Lay-up method

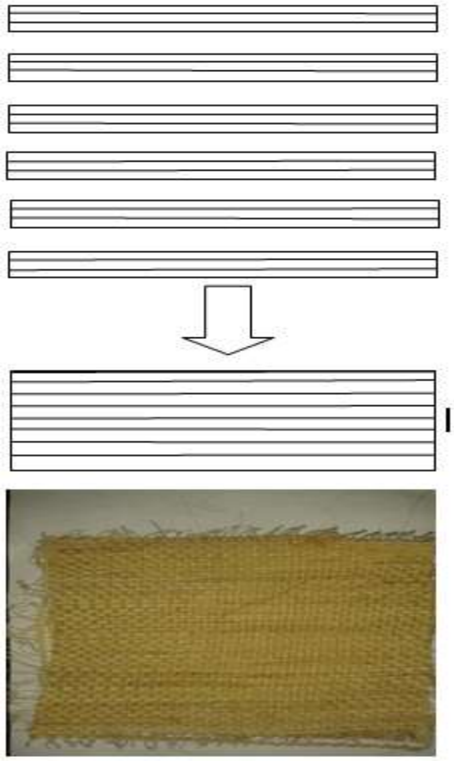

Fig: Unidirectional fiber mat

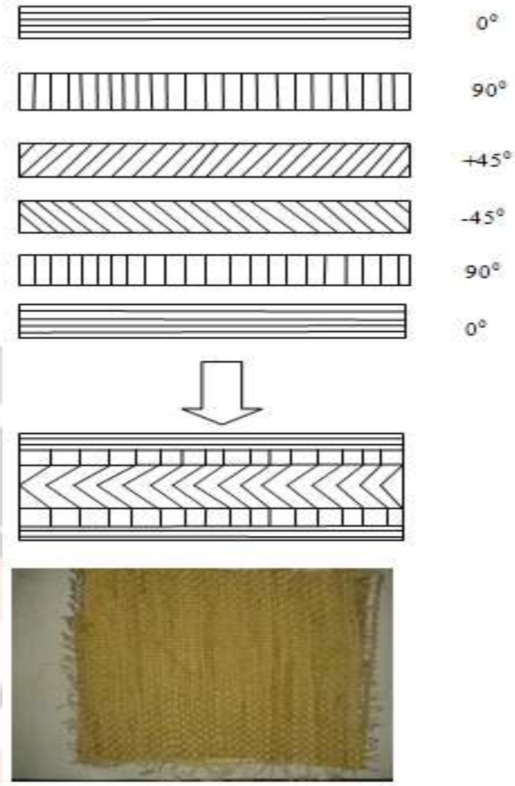

Fig: Fibers arrangement in orientation specimen

Fig: 3.3 Different orientations of sisal fibers

3.4. DIFFERENT ORIENTATIONS OF FIBERS

0° Orientations of fibers

90° Orientations of fibers

+45° Orientations of fibers

-45° Orientations of fibers

Fig: 3.4 Specimens prepared by different orientations of sisal fibers

3.5. SPECIMEN TESTING

Experimental Setup:

Machine : Universal Testing Machine (UTM)
Specimen used : Rectangular shape
Specimen dimension : 180 mm × 50 mm × 15 mm

Tensile test

- In this both unidirectional and orientation involves same procedure
- Take the specimen and fit in to UTM and adjust the dial indicator.
- Start the machine and take the readings up to breaking point. The below fig.3.5 shows the specimen after testing.

Fig: 3.5 Specimen after tensile test

Compression Test

- The procedure for compression testing is same for both unidirectional and orientation.
- The specimen fitting in UTM is same as tensile test. The below fig.3.6 shows the compression tested specimen.

Fig: 3.6 Specimen after compression test

4. RESULTS COMPRESSION

4.1. TENSILE TEST

Table: 4.1 Comparison of unidirectional and orientation specimen for tensile results

Material	Average Load in KN	Average Stress in N/mm^2	Average Strain
Unidirectional	20.94	1.18	0.0642
Orientation	6.3	0.39	0.344

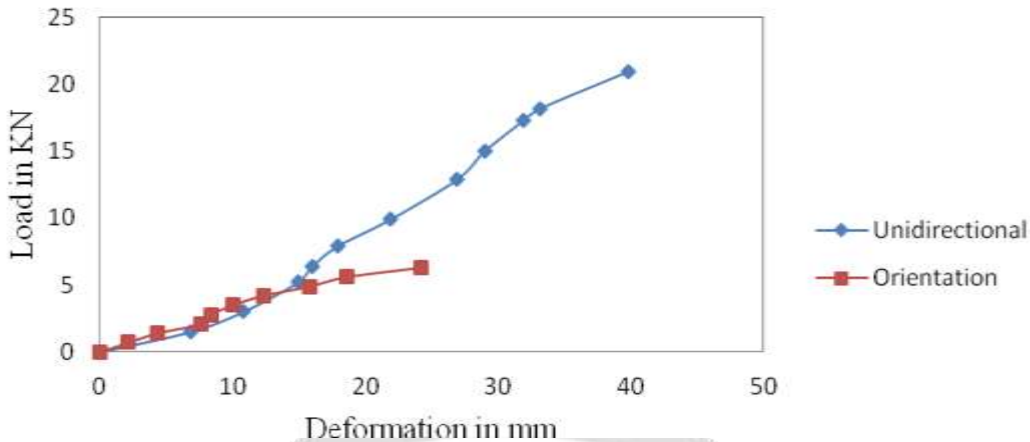

Fig: 4.1 Comparison of results of tensile test specimens

4.2. COMPRESSION TEST

Table: 4.2 Comparison of unidirectional and orientation specimen for compression results

Material	Average Load in KN	Average Stress in N/mm²	Average Strain
unidirectional	8	0.716	0.0128
orientation	10.75	0.937	0.03

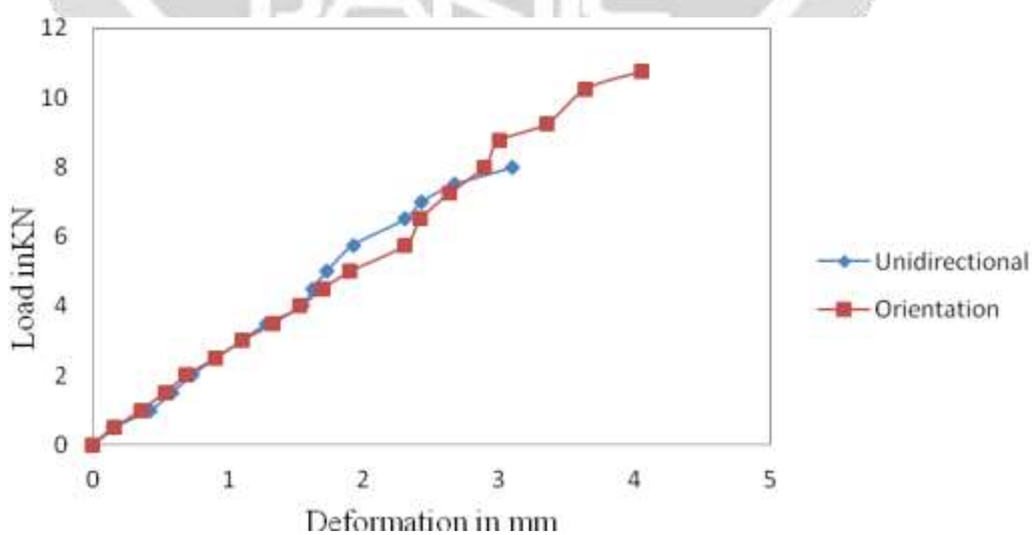

Fig: 4.2 Comparison of results of compression test specimens

5. CONCLUSIONS

In the present investigation, the tensile and compression tests were carried out on two different combinations such as unidirectional and orientation specimens. From the results conclude that for tensile test, unidirectional specimen sustain more load compared to orientation specimen this indicates that the unidirectional specimen has better tensile strength than orientation specimen. But in compression test of orientation composites showed better results as compare to unidirectional composites.

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