# Study of Mechanical Properties of Natural Fiber Sandwich Based Composite

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**Abstract: The development of renewable and eco-friendly materials as an alternative to non-biodegradable and non-renewable materials that pollute the environment is the primary focus of research in the rapidly developing world. In this work, three composites layers are manufactured utilizing cotton stalk fibre and sorghum stalk fibre as the primary supporting materials and epoxy pitch as the framework to expand the viability of the regular fiber. The composite samples are made using the hand layup method and have various fiber volume fractions. These natural fiber composites have been subjected to testing for tensile, flexural, impact, flammability and water absorption test. Beginning ideal length and weight not entirely settled. The testing of the mechanical properties yields the results, which are then compared across each of the three combinations. The epoxy matrix composite with cotton stalk and sorghum stalk fibre as reinforcement has the highest tensile, flexural, and impact strengths. Additionally, this composite has a lower capacity for water absorption.**

**Keywords: Cotton stalk fibre, sorghum stalk fibre, composite**

## I. INTRODUCTION

A material that is made from two or more different components to take advantage of the advantages of the components and produce a material with better properties than individual components is known as a composite material. In terms of history, simple natural composite fiber materials have been around for a very long time. It is found in wood where lignin holds the cellulose fibers together. In plants and trees, adequate strength and density are due to the connection of cellulose. In today's world, the composite material industry is growing rapidly, with numerous remarkable achievements and new inventions. However, in addition to development, numerous negative issues have emerged, particularly the detrimental effects on human health and the environment. Natural fiber composite (NFC) research and development therefore hold interest. The use of natural fibers as reinforcement in composite materials has significantly increased over the past few years due to their numerous valuable features and benefits, including their low specific gravity, low production costs, relatively high strength and stiffness, and especially their eco-friendliness and biodegradability [1-2], which is less harmful to humans and the environment. All fibers derived from animals, plants, and minerals are considered natural fibers [3]. In the degree of this review, center around examining and understanding the mechanical properties of regular plant derived filaments. Cotton, jute, flax, hemp, sugarcane, bamboo, and many other plant fibers are examples of natural fibers made from cellulose. These fibers come from a variety of plant parts, including the seeds (cotton fibers), the leaves (sisal fibers), the bark (flax, hemp, jute, rattan, or even fibers from bananas and sugarcane), the fruits (coconut fibers from coconut husks), and the stems (bamboo, grass, and wood fibers) [3]. The fibers from the bark and stem, which were mentioned earlier, will have the best mechanical properties and have a lot of potential for use in the process of making reinforced fibers from natural fiber composites (NFCs).

## II. METHODOLOGY

The objective of this study is to determine the different mechanical properties of a composite material consisting of cotton stalk and sorghum. The results of the tests help in determining the potential applications of the composites and their manufacturing feasibility.

Cotton stalks and sorghum stalk fibre were collected from Nagpur region which is located in Maharashtra, India. These stalks were collected after the harvesting of cotton.

2.1 Fibre Extraction and Characterization

Fibres were extracted by retting for a period of five days in a drum filled with normal tap water. Fibres were extracted by manual decortications method by beating the fibres with a rubber coated hammer and then carrying out hackling and scutching to remove adhering particles on the fibres. For Characterization of extracted fibres, tests were carried out such as fibre length, fibre tenacity, moisture regain, fibre density and linear density to determine the mechanical and physical properties of the fibre. The fibres were conditioned under standard atmospheric conditions for a period of 24hours prior to testing and characterized according to the part of the cotton stem.

Table 2.1: Properties of cotton stalk fiber and sorghum stalk fiber

| Properties | Cotton stalks fibre | Sorghum stalks fibre |
|---|---|---|
| Cellulose (%) | 39 | 35.40 |
| Hemicellulose (%) | 44 | 19.41 |
| Lignin (%) | 7.3 | 10.27 |
| Moisture content (%) | 7.1 | 11.20 |

2.2 Fabrication procedure

In this study, manual hand layup method is used for preparing composite laminates. First of all the fibres are treated with the NaOH solution to remove the moisture content, then fibres are set to dry under direct sunlight for removing moisture present in it. The fibres are in the form of sheets are put on each other with epoxy and hardener mixture in between forming the sandwich structure. Continuous pressure is applied on the sheets to remove the extra binding material. The aim during the fabrication is to keep the amount of the fibre high and amount of epoxy is to be kept as low as possible. Three layers of such combinations are formed such as cotton stalk- Sorghum stalk- Cotton stalk in inclination of arrangement of sorghum fibre is $0^0$,$45^0$,$90^0$. After the fabrication is done, the composite is left to cure for two to three days by applying some continuous pressure on it. The composite sheet then obtained is removed and cut into different specimen according to ASTM Standard for testing. Cotton stalk fibre + $0^0$ inclination of arrangement of Sorghum Fibre + Cotton stalk fibre (S-1), Cotton stalk fibre + $45^0$ inclination of arrangement of Sorghum Fibre + Cotton stalk fibre (S-2), Cotton stalk fibre + $90^0$ inclination arrangement of Sorghum Fibre + Cotton stalk fibre ( S-3).

## III. TESTING OF COMPOSITES

The mechanical properties, water absorption and flammability analysis are carried out by different instruments for the fabricated composites.

3.1 Tensile Test:

The tensile test is done by cutting the composite specimen as per ASTM: D638 standard. A universal testing machine with maximum load rating of 300kN is used for testing. The specimen is held in the grip and load is applied and the corresponding deflections are recorded. Load is applied until the specimen breaks and break load, ultimate tensile strengths are noted.

Table 3.1: Tensile properties of composites

| Composite Sample | Break Load (KN) | Maximum Displacement (mm) | Percentage Elongation | Ultimate Stress (MPa) |
|---|---|---|---|---|
| S-1 | 4.8 | 8.3 | 13.6 | 28 |
| S-2 | 5.8 | 10.2 | 17.5 | 34 |
| S-3 | 5.2 | 7.3 | 11.2 | 31 |

3.2 Flexural Test:

The Flexural test is done in a three point flexural setup based on ASTM: D790 standard. The specimen is bends and fractures when the load is applied at the middle of the beam. This test is carried out in the universal testing machine from which the breaking load is noted.

Table 3.2: Flexural Properties of composites

| Composite Sample | Break Load (KN) | Maximum Displacement (mm) | Ultimate Stress (MPa) |
|---|---|---|---|
| S-1 | 3.2 | 2.8 | 12.3 |
| S-2 | 2.1 | 3.4 | 15.2 |
| S-3 | 1.5 | 2.1 | 10.2 |

3.3 Impact Test:

The impact test set up consists of a pendulum which is dropped from an angle of $135^0$ to impact the specimen and to fracture it. Charpy impact is employed in this impact work. The amount of Energy absorbed during the breaking of specimen is noted. The specimens are prepared as per ASTM: D256 standards.

Table 3.3: Impact Properties of Composites

| Composite Sample | Energy Absorbed (J) |
|---|---|
| S-1 | 13 |
| S-2 | 21 |
| S-3 | 15 |

3.4 Double Shear Test:

The double shear test is performed by applying shear load along two directions simultaneously. This test is done on the Universal testing machine and a special fixture is required for carrying out this test. Test specimen is prepared as per ASTM: D5379 standards. The specimen is held in the fixture and load is applied until the specimen breaks.

Table 3.4: Double Shear Properties

| Composite Sample | Break Load (KN) | Maximum Displacement (mm) |
|---|---|---|
| S-1 | 7.3 | 4.3 |
| S-2 | 8.2 | 3.6 |
| S-3 | 4.6 | 3.1 |

3.5 Water Absorption Test:

The specimen is kept in the water for more than 24hrs and the following results are obtained shown in table 3.5.

Table 3.5: Water absorption Test values

| Sample | Composite Weight of Specimen before testing (gm) | Weight of the specimen after testing (gm) | Difference In Weight (gm) | Percentage Of Water Absorption (%) |
|---|---|---|---|---|
| S-1 | 13.5 | 14.1 | 0.6 | 4.44 |
| S-2 | 13.8 | 14.2 | 0.4 | 2.81 |
| S-3 | 13.6 | 13.1 | 0.5 | 3.67 |

3.6 Flammability:

Flammability of Polymer composites were studied by a horizontal burning test and a vertical burning test according to UL-94 testing standards. These numbers are obtained from measurements of the after-flame time or from the amount of material burned in a specific length of time. After flame time refers to the length of time, in seconds and minutes are noted for a material continues to burn after removal of the ignition source. The amount of material burned refers to the length of sample that burns in a specified period of time. According to UL-94 standard the composite materials are cut into required dimension (130 mm * 15 mm * 4 mm).

Table 3.6: Flammability Test Result

| Sample No Test criteria | V-1 | V-2 | V-3 | H-1 | H-2 | H-3 |
|---|---|---|---|---|---|---|
| Burning time of each specimen (s) | 22 | 25 | 24 | 38 | 32 | 35 |
| Total combustion time (min) | 3.3 | 5.2 | 4.8 | 6.3 | 11.5 | 11.5 |
| Dripping of burning specimens (specimen completely burned | No | No | No | No | Yes | Yes |
| Combustion up to holding clamp | Yes | No | No | No | Yes | Yes |

*V-1.V-2,V-3=Sample hold in vertical position, *H-1.H-2,H-3=Sample hold in Horizontal position

## IV. CONCLUSION

In this experimental study, cotton stalk fibre and sorghum stalk fibre are used as reinforcing materials in an epoxy matrix. Mechanical tests like tensile, flexural, impact, flammability and water absorption have been applied to the composites that have been made and tested. The maximum tensile strength of composite is 34 Mpa. The maximum flexural rigidity of the composite is 15.2 Mpa. The maximum energy absorb is 21J. The maximum displacement of double shear is 4.3mmThe highest percentage of water absorption is 4.44%. The highest fire retardation time is 5.2minute in vertical holding and 11.5 minute in horizontal holding.

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