

# Development of Eco-Friendly Fiber Reinforced Polymer Composite for False Ceiling

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**Abstract**— Natural fiber reinforced polymer composites has growing its interest due to its ecological and economical factors. The aim of this research was to evaluate mechanical behavior of sisal fiber reinforced epoxy based composites. Tensile strength and flexural strength of composite was evaluated using universal testing machine (UTM). The composite specimens were fabricated with simple hand layup method. Sisal fiber reinforced epoxy composite (SFREC) were made up with four different weight fraction 10%, 20%, 30% and 40% of fiber. The results revealed that tensile and flexural strength were better with 20% of weight fraction of fiber. This sisal fiber reinforced epoxy composite was suggested for false ceiling application due to its superior properties.

**Key words:** Natural Fiber, Sisal Fiber, Tensile Strength, Flexural Strength, Weight Fraction

## I. INTRODUCTION

In the recently, new material has been replaced instead of conventional materials like wood, metals. The composites materials were developed for new industrial revaluation. Man-made fibers using glass, carbon, boron, etc. are being used as reinforcing materials in the fiber reinforced plastics which have been widely accepted as materials for structural and non-structural applications. The main reason for the interest in FRP is due to their specific modulus, high stiffness, and strength to weight ratio compared to other conventional materials. However, these materials are prohibitively expensive in their use for other general purposes and applications. Nowadays natural fibers like cotton, coir, sisal, jute and other natural fibers have attracted the attention of scientists and technologists for applications in packaging, low-cost housing, and other structures [6]. It has been found that the natural fiber composites possess required mechanical strength and other properties with better electrical resistance, good thermal and acoustic insulating properties, and high resistance to shock and fracture. [10] The increasing interest in introducing degradable, renewable, and inexpensive reinforcement materials which have been environment-friendly has stimulated the use of hard cellulose fibers. The low cost, less weight, and density make the natural fibers an attractive alternative. Also they are renewable, completely or partially recyclable, and biodegradable [4]. Their availability, renewability, low density and price as well as satisfactory mechanical properties make them an attractive ecological alternative to glass, carbon and man-made fibers used for the manufacturing of composites [1]. The natural fiber-containing composites are more environmentally friendly and are used in transportation (automobiles, railway coaches, aerospace), military applications, building and

construction industries (ceiling paneling, partition boards), packaging, consumer products, etc. [3,9].

Physical and mechanical properties depend on the single fiber chemical composition (Cellulose, hemicelluloses, lignin, pectin, waxes, water content and other minors) according to grooving (soil features, climate, aging conditions) and extraction/processing methods conditions [2]. Grooving conditions is recognized as the most influent parameter for the variability of mechanical properties of the fibers. The chemical composition of several natural fibers is summarized in Table 1.

Fiber	Cellulose %	Lignin %	Diameter(μm)	Hemicellulose %	Elongation %
Coir	37	42	100-450	0.15	47
Banana	64	5	50-250	6-19	3.7
Sisal	70	12	50-200	10-14	5.1
Pineapple	85	12	20-80	16-19	2.8
Jute	71	13	15.9-20.7	13-20	3.0

Table 1: Chemical composition of natural fibers [5]

## II. MATERIALS AND METHOD

The long sisal fibers were used as reinforced material in this composite. The sisal fibers were chemically treated using 6% of NaOH solution for 24 hours. Sisal fibers web were fabricated using non needle punching machine at central coir institute Bangalore. Epoxy resin of grade 505C and hardener EH 411 was supplied by Dobeckot. The matrix material was prepared with a mixture of epoxy and hardener at a ratio of 2:1.

The sisal fiber reinforced epoxy composite was fabricated through the simple hand lay-up method. Sisal fiber reinforced epoxy composite (SFREC) were made up with three different weight fraction 10%, 20% and 30% of fiber. The sisal fibers were weighed and accordingly the epoxy resin and hardeners were weighed. Epoxy resin and hardener were mixed by using glass rod in a bicker. The subsequent fabrication process was done. Sample was left for 48 hrs to allow sufficient time for curing and subsequent hardening. Specimens of suitable dimension were cut using a grinder cutter for mechanical testing. Almost care has been taken to maintain uniformity and homogeneity of the composite.

Properties of this fiber are as follows [4]:

- Specific gravity - 1370 [Kg/m<sup>3</sup>]
- Water absorption -110 [%]
- Tensile strength -347-378 [M Pa]
- Modulus of elasticity -15 [G Pa]

### A. Advantages

- They are very well resistant against moist.

- These fibers have a good tension resistance or tensile strength.
- They are very well resistant against heat.
- Sisal short fibers delay restrained plastic shrinkage controlling crack development at early ages.
- Sisal fibers conditioned in a sodium hydroxide solution retained respectively 72.7% and 60.9% of their initial strength.

**B. Limitations**

- Decomposition in alkaline environments or in biological attack

**III. MECHANICAL TESTING**

After preparation composite specimens were subjected to various mechanical tests such as tensile and flexural tests as per ASTM standards. These tests are as follows,

**A. Tensile Strength**



Fig. 1: UTM Instron 1195

The tensile test was performed in the universal testing machine (UTM) Instron 1195. The tensile test is generally performed on flat specimens. A thin flat strip of material having a constant rectangular cross section is mounted in the grips of a mechanical testing machine and monotonically loaded in tension while recording the force. The ASTM standard test method for tensile properties of fiber resin composites has the designation D 638 with the cross head speed of 15 mm/min. The commonly used specimen for tensile test is the dog-bone type. The dimension of specimen was (128×13×4) mm.

**B. Flexural Strength**



Fig. 2: Point Bending Machine

Flexural strength is a 3-point bend test, which generally promotes failure by inter-laminar shear. The flexural tests are conducted to determine the mechanical properties of resin and laminated fiber composite materials. This test was conducted as per ASTM D790 standard using UTM with cross head speed of 1 mm/min. The loading arrangement is shown in figure 2. The dimension of the specimen is (64×13×4) mm.

**IV. RESULT AND DISCUSSION**

**A. Effect of volume fraction of fiber on tensile strength**

Sr. No.	Volume fraction of fiber in %	Tensile strength (MPa)	Flexural strength (MPa)
1	10%	22.15	28.48
2	20%	27.85	32.64
3	30%	26.71	31.57
4	40%	23.59	29.14

Table 2: Effect of volume fraction of fiber on tensile strength

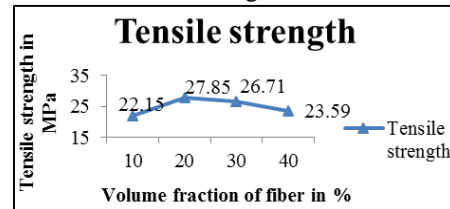


Fig. 3: Tensile strength for SFREC

The test results for tensile strengths are shown in figure 3. It is seen that the tensile strength of the sisal/epoxy composite increases with increase in fiber weight fraction up to 20 % and then trend decreases. Tensile strength of sisal/epoxy composite at 10, 20, 30 and 40 % weight fraction were 22.15, 27.85, 26.71 and 23.59 MPa respectively. The highest tensile strength was found in 20 % weight fiber of sisal/epoxy as 27.85 MPa.

**B. Effect of volume fraction of fiber on flexural strength**

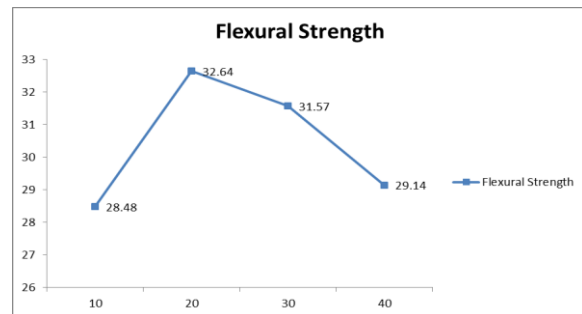


Fig. 4: Flexural strength for SFREC

Flexural strength of sisal/epoxy composite was shown in figure 4. It is seen that the flexural strength of the sisal/epoxy composite increases with increase in fiber weight fraction up to 20 % and then trend decreases. Flexural strength of sisal/epoxy composite at 10, 20, 30 and 40 % weight fraction were 28.48, 32.64, 31.57 and 29.14 MPa respectively.

**V. CONCLUSION**

Mechanical behaviors of sisal fiber reinforced epoxy composites were explored. The maximum tensile and flexural strength were found at 20% weight fraction of fiber.

Maximum tensile and flexural strength were 27.85 and 32.64 MPa respectively. The trends of tensile and flexural strength were decreased at 30% and 40% of weight fraction of fiber because of the chemical instability of sisal with epoxy. This sisal fiber reinforced epoxy composite was suggested for false ceiling application due to its superior properties.

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