# Development of Fabrication Materials for Low Cost Housing Using Sisal Fibers Composite

**Rahul Kapse[1], Vaishnavi Mudkanna[2], Jay Jadhav[3] , Prachi Bhoinallu[4] , Prerana Jogdand[5] , Mansi Jadhav[6]**

[1]*Assistant Professor Civil Engineering, RMD Sinhgad School of Engineering, Warje, Pune, Maharashtra, India*
[2]*Student Civil Engineering, RMD Sinhgad School of Engineering, Warje, Pune, Maharashtra, India*
[3]*Student Civil Engineering, RMD Sinhgad School of Engineering, Warje, Pune, Maharashtra, India*
[4]*Student Civil Engineering, RMD Sinhgad School of Engineering, Warje, Pune, Maharashtra, India*
[5]*Student Civil Engineering, RMD Sinhgad School of Engineering, Warje, Pune, Maharashtra, India*
[6]*Student Civil Engineering, RMD Sinhgad School of Engineering, Warje, Pune, Maharashtra, India*

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**Abstract –** *Sisal fiber is a natural and sustainable material that has gained attention in recent years due to its various applications in different industries. This abstract focuses on the development of wall panels or sheets using sisal fiber as a primary component. The development process involves several steps, starting with the extraction of sisal fibers from the leaves of the Agave sisal an a plant. These fibers are then cleaned, dried, and processed to remove impurities and enhance their strength and durability. Various treatments, such as chemical or mechanical methods, can be employed to modify the properties of the fibers to suit specific requirements. Next, the processed sisal fibers are mixed with a suitable binder, such as a polymer or cement-based material, to form a composite material. The fiber-to-binder ratio and other additives can be adjusted to achieve the desired mechanical properties, such as strength, flexibility, and fire resistance. The composite mixture is then molded into the desired shape and size using techniques like compression molding or extrusion. The panels or sheets can be further enhanced by incorporating additional materials, such as fillers, reinforcements, or pigments, to improve their aesthetic appeal and functional characteristics. The developed sisal fiber-based wall panels or sheets offer several advantages over traditional materials. Firstly, sisal fiber is renewable and biodegradable, making it an environmentally friendly alternative to synthetic materials. Additionally, sisal fiber exhibits excellent thermal and acoustic insulation properties, contributing to energy efficiency and noise reduction in buildings. The panels also possess good impact resistance and can withstand harsh weather conditions. Furthermore, sisal fiber-based wall panels or sheets can be easily installed and maintained. They can be customized to meet specific design requirements and can be painted or coated with different finishes to match various architectural styles.*

***Key Words***: *Sisal Fiber, Sustainable Material, Wall Panels, Composite Material, Biodegradable.*

## 1. INTRODUCTION

The Sisal fiber has been widely used as a reinforcement material in various applications, including composite materials and cement composites. The use of sisal fiber as reinforcement in construction materials is well-known in the some prior art. Use of resin matrix to bind sisal fibers in a composite panel is a well-known technique in the field of fiber-reinforced composites. The combination of sisal fibers and resin matrix is an obvious choice for creating a strong and lightweight panel.

Sisal is the natural fibers extracted from the leaves of sisal plant. Sisal fiber is a highly pliable material with high aspect ratio. Currently, there is a big attention in maximizing the utilization of leaf-based fibers for conventional and technical applications because of their sustainability Features.

The main advantages of composite materials are their high strength and stiffness, combined with low density, when compared with bulk materials, allowing for a weight reduction in the finished part. Natural fibers have special appeal in the field of civil engineering. The cost of natural fibers is expected to be price competitive. The advantages of natural fibers materials are strength, better durability, competitive cost, environmental compatibility and bio degradability.

By incorporating sisal fiber into wall panels/sheets, the mechanical properties of these materials can be enhanced. Sisal fiber has high tensile strength and stiffness, which can improve the overall strength and durability of the panels/sheet. Sisal fiber is relatively low-cost compared to other reinforcing materials like glass or carbon fibers. This can potentially lower the production costs of wall panels/sheets, making them more affordable and accessible for construction projects.

Overall, the use of sisal fiber as a reinforcing material in wall panels/sheets represents an innovative step towards sustainable construction.

## 2. Literature review

Rabi [1] The present study was carried out as an attempt to produce durable fiber-cement roofing tiles (approximate dimensions: 500 mm long, 275 mm wide, 8 mm thick) by slurry dewatering technique and using sisal (Agave) Kraft pulp as reinforcement. Effects of accelerated carbonation on physical and mechanical performances of vegetable fiber reinforced cementations tiles were evaluated along with their consequent behaviors after ageing. Cement raw materials mixture was prepared with approximately 40% of solids (comprising 4.7% sisal pulp, 78.8% cement, and 16.5% ground carbonate material).

Ramakrishna et.al[2] Based on the comprehensive experimental investigations carried out and on the range of various parameters considered in the this study, are summarized below: Sisal fibers corrugated roofing sheets of (mortar / composites) couldn't match the high strength exhibited by the commercial type corrugated roofing sheet considered in this study, with respect to the flexural and splitting loads and within the range of sisal fibers contents (0 - 2%) and fly ash contents (0 - 30%) considered.

Reddy [3] In the study herein, the applicability of jute textile FRP as a strengthening material was investigated through various experimental works of mechanical characterization of the FRP, and strengthening effects provided by bonding of jute textile FRP to beams over bonding of carbon textile FRP and glass textile FRP.

Vijaychandrakanth [4]The study of this investigation was find out the behavior of sisal fiber in concrete, thereby optimum amount of sisal fiber that can be used in various application such as pavements, industrial floors, etc. thus enhance the concrete quality.

Kavin [5] They invented the influence of sisal fibers on the minimizing of plastic shrinkage in the pre-hardened state, on tensile, compressive and bending strength in the hardened state of mortar mixes improved. Development of production techniques for manufacture keeping in view that it must be cost-effective. Physical and mechanical properties, impact and abrasive resistance, water absorption, shrinkage, chemical resistance, acoustic requirements, thermal performance and durability of sisal fibers cement based products should be thoroughly evaluated so as to arrive at a series of composites to be used in rural and civil construction. Design procedures must also be standardized. The results show that the composites reinforced with sisal fibers are reliable materials to be used in practice for the production of structural elements to be used in rural and civil construction.

Joseph et.al[6] Experimental characterization of sisal fibers reinforced concrete showed that incorporating fibers into the concrete mixture is beneficial. Optimum performance for a matrix having sisal fibers as reinforcement is at 3% fibers volume fraction, with 70mm fibers length and at a water cement ratio of 0.6.

Augustine et.al [7] Thermal conditioning of woven sisal fibers was carried out, followed by the development of woven sisal fibers reinforced polymer composite system, and its tensile and flexural behavior was characterized. It was observed that thermal conditioning improved the tensile strength and the flexural strength of the woven sisal fibers composites, which were observed to bear superior values than those in the untreated ones.

Reddy et.al [8] They invented the, Concrete reinforced with sisal fibers and using Iraqi bauxite exhibited improvement in flexural strength and splitting tensile strength while a small reduction in compressive strength was reported. The addition of sisal fibers improved the flexural strength and splitting tensile strength of plain concrete. The increase in flexural strength at age of 28 day represented by (7.7%, 13.6% and 9.1%) for concrete reinforced with sisal fiber with (0.5%, 1.0% and 1.5%) respectively and at age of 90 day the improvement in flexural strength represented by (15.3%, 16% and 5.2%) for the same percentage of fibers respectively.

Rawi [9] He invented the study of sisal fibers as concrete reinforcement material in cement based composites. A brief description on the use of the cement based composite materials as building products has been included. The influence of sisal fibers on tensile, compressive and bending strength in the hardened state of mortar mixes was discussed. The durability of natural fibers in cement based matrices was of particular interest and was also highlighted. From the hysteresis stress-strain curves it was noticed no signs of degradation for maximum stress level .For maximum stress levels; there was an increase in the hysteresis area and decrease in the Young´s modulus.

## 3. OBJECTIVES

### 1. To develop a systematic approach for fabricating construction components from sisal fibers.

To fabricate the sisal fibers composite epoxy matrix is used. This fabrication will be carried either by vacuum bagging technique or hand layup technique as both gives good result.

### 2. To fabricate and test plate type structure panel.

The panel of sisal fibers will be fabricated by using epoxy matrix. The fabricated panels will be tested for Impact strength, Flexural strength and Axial strength. The properties of sisal panel will be compared with plywood panel of same size i.e. 30cm X 30cm.

### 3. To fabricate and test plate type structure of box beam and rod.

The sisal fibers box beam and rod composite will be fabricated .The composite will be tested for Flexural strength and Axial strength.

### 4. To develop process for various application for low cost housing, rapid housing, interior decoration etc.

Making sisal fibers fabrication like boxes, rods and panel are developed by using Epoxy chemical. The panels are directly make from by vacuum bagging technique or hand layup technique different size of panels will be made depend on their requirement in particular application. For roof panel by using bamboo frame, in that frame that panel is placed and they are used as roof sheet. Also for box and rod we can use empty boxes or rod and above that sisal fibre composite will placed or packed that equipment. After that we only remove that box or rod then we will get that particular shaped box or rod. That shaped box or rod of sisal fibers composite is then we can used for decorated purpose as interior.

## 4. Materials and Methodology

### 4.1Materials

**1. Sisal fiber:** Sisal is a vegetable fiber that comes from the leaves of the Agave sisal an a plant. Sisal is a strong, coarse, and inflexible fiber with a tough texture. It's known for its high strength, durability, and ability to stretch. Sisal has a real density of 1.45 g/cm, an apparent density of 1.20 g/cm, and a porosity of 17%. It's also known for its resistance to wear, acid, base, and corrosion.

**2. Epoxy resin:**Epoxy resins are a class of thermosetting polymers that contain at least two epoxide groups. They are tough, chemically resistant, and have strong adhesion. Epoxy resins are used in a variety of consumer and industrial products. Epoxy resins are made by reacting epichlorohydrin (ECH) and bisphenol-A (BPA). Other raw materials, such as aliphatic glycols, phenol, and o-cresol novolacs, can be used to produce specialty resins. Epoxy resins can be obtained in either liquid or solid states. Epoxy resins are used in many industries, including manufacturing and construction.

**3. Hardener:** Epoxy hardeners, also known as curing agents or catalysts, are chemical compounds that help epoxy resins cross-link. When mixed with liquid epoxy resins, hardeners start the curing process, which transforms the resin into a durable, solid material. Epoxy hardeners are made from a polycarboxylic anhydride that is synthetically compounded with renewable resources. Some common curing agents for epoxy resins include: Polyamines, Polyamides, Organic acids, Anhydrides, Boron trifluoride, Tertiary amine catalysts.

### 4.2 Methodology

1.Material Selection: Identify the type of sisal fiber to be used (natural or treated), determine the appropriate resin or binder for the composite material, and select any additional additives for enhancing properties.

2.Fiber Treatment: If using natural sisal fiber, it may need to be treated to improve its compatibility with the resin. Treatments such as alkali treatment or surface modification can be considered.

3.Composite Formulation: Determine the optimal ratio of sisal fiber to resin/binder, as well as any additives, fillers, or reinforcements to be included in the composite material.

4.Mixing Process: Mix the sisal fiber with the resin/binder and any other additives using appropriate equipment and techniques to ensure uniform distribution and good bonding between the components.

5. Molding Process: Choose a suitable molding technique (e.g., compression molding, injection molding) to form the wall panels/sheets. Apply pressure and heat as needed to achieve proper consolidation and curing of the composite material.

6.Testing and Evaluation: Conduct tests to assess the mechanical properties (e.g., tensile strength, flexural strength), thermal and acoustic insulation properties, impact resistance, and other relevant characteristics of the developed wall panels/sheet.

## 5. Testing of Pannel

### 5.1. Impact resistance test on surface of sisal fibre composite sheet

The capability of the material to withstand suddenly applied load is its impact strength. The composite sheet of 30cm x 30cm and thickness 8mm was tested using a Impact test setup. This setup contains steel ball and dial gauge. The panel is simply supported at four corners. The steel ball of 5cm diameter and weight 450 gm. is dropped from 100 cm height.

### 5.2. Sound Absorption test on Sisal fibre Composite panel

Sisal fibre composite and Plywood of size 30 X 30 cm and thickness 8 mm were tested for sound absorption test using FFT Analyzer. Fast Fourier transform equipment is used to measure the sound frequency passing through the Sisal fibre composite. This equipment is having the micro phone at its tip which absorbs sound waves and generates the graph of Acoustics pressure vs Time for the absorbed sound Sisal fibre composite of size 30 X 30 cm is taken for the experimentation on. On one side of Panel the circular pipe is kept through which sound is transmitted in proper channel. On the other side microphone is placed which is very sensitive.

### 5.3 Test for bending on Sisal fibre composite and plywood:

The Sisal fibre composite panels are prepared in size 20 x 50cm and plywood sheets of same size are prepared. These panels are tested under Flexural Testing Machine so as to calculate the bending strength and deflection of both the panels. The deflection is measured by using the Dial Gauges of 0.01mm least count. The panels fabricated are tested under the FTM to measure the maximum load it can sustain under the bending. Thus using the parameters such as Load and Deflection of the tested panel the Flexural rigidity is calculated.

## RESULT AND DISCUSSION

### 1. Impact resistance test on surface of sisal fibre composite sheet

Deflections at four different points after free fall of steel ball on Sisal Fibre Composite:

| Point No. | Deflection in mm |
|---|---|
| 1 | 5.4 |
| 2 | 5.7 |
| 3 | 5.6 |
| 4 | 5.4 |
| **Average Deflection** | **5.53** |

### 2. Sound Absorption test on Sisal fibre Composite panel: FFT analyzer

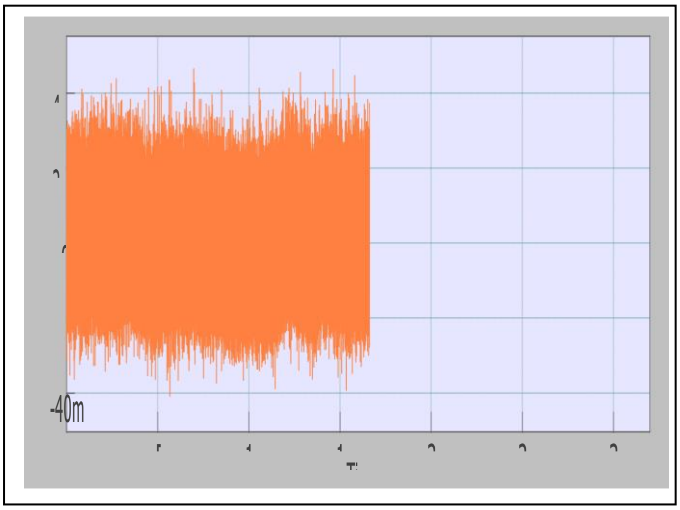

**Fig-** Time v/s acoustics pressure plot for Sisal fibre composite

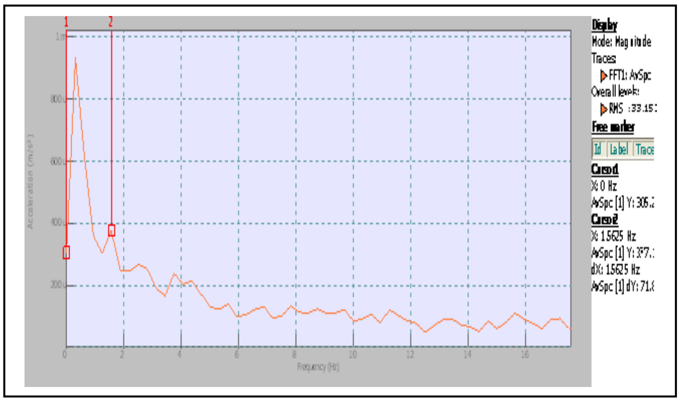

**Fig-** Frequency v/s accostic pressure plot for Sisal fibre composite.

### 3. Test for bending on Sisal fibre composite

| Sr No. | Load in KN | Deflection in mm | Flexural rigidity in Nm2 | Flexural Strength in N/mm2 |
|---|---|---|---|---|
| 1 | 9 | 35 | 257.14 | 351.56 |
| 2 | 8.1 | 31 | 261.29 | 316.40 |
| 3 | 7.6 | 27 | 281.48 | 296.87 |

### 4. Test for Determination of moisture content in Sisal Fibre Composite block

| Sample No | Duration of immersion | Thickness | Dry Wt. in gms | Wet Wt. .in gms | Moisture Content (%) |
|---|---|---|---|---|---|
| A | 24hr | 0.55 | 47.86 | 49.50 | 3.42 |
| B | 24hr | 0.50 | 41.20 | 43.47 | 5.50 |
| C | 24hr | 0.50 | 45.42 | 47.62 | 4.15 |
| D | 24hr | 0.60 | 38.88 | 40.92 | 5.24 |

## CONCLUSIONS

The fabrication and experimentation of Natural sisal fiber composite is carried out. The work in this thesis is carried out in two parts. first part is focused on fabrication of natural fiber composite material, whereas in second part, experimentation of fabricated composite is carried out, in which tensile and shear strength and flexural strength of composite is determined, also tensile strength of beams and strips is calculated.

Following conclusions are drawn from the work:

1.Fabrication process of natural fiber reinforced composite is developed to fabricate the sisal fiber reinforced composite. The hand lay-up technique is used for fabrication.

2.Experimental work is carried out to find the Structural strength of plate, beams, and strips also bonding strength of composite. The Structural properties such as tensile strength, flexural strength and impact strength are calculated. These experimental results are compared with the result of plywood for its strength. The flexural strength of sisal fibre is composite takes 351.56 N/mm2 loads that of plywood panel is 117.18 N/mm2.

3.The panels fabricated using Sisal fibre Composite exhibit more strength, Impact resistance and flexibility as compared to the plywood of same size and thickness. The deflection developed in the Sisal fibre Composite panel was more as compared to the plywood but there were no cracks developed at the point of maximum deflection.

4.The panels are very good in sound absorption as compared to the plywood. When sound was passed through the Sisal fibre Composite panel and the plywood, the Sisal fibre Composite panel shows 30% more sound absorption capacity than plywood.

5.The materials used in fabrication of Sisal fibre Composite panels are of much cheaper cost. The panels cost almost 10% to 15% less than plywood of same thickness. The per square ft rate of Sisal fibre Composite panel is 310 Rs whereas Waterproof plywood of same thickness costs 420 Rs per square ft.

## Future Work

Current study about fabrication and development of natural fiber composite material resulted in following future work:

1. There is wide scope to study or compare the surface treatment effect on fiber surface with chemical or mechanical process of treatment.

2. There is wide scope to study strength of single fiber as there is variation observed from literature.

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## BIOGRAPHIES

**Rahul Kapase**
Assistant Professor
RMD SSOE Warje,Pune.

**Vaishnavi Mudkanna**
Student Civil Enggineering Dept.
RMD SSOE Warje, Pune.

**Prachi Bhoinallu**
Student Civil Enggineering Dept.
RMD SSOE Warje, Pune.

**Prerana Jogdand**
Student Civil Enggineering Dept.
RMD SSOE Warje, Pune.

**Jay Jadhav**
Student Civil Enggineering Dept.
RMD SSOE Warje, Pune.

**Mansi Jadhav**
Student Civil Enggineering Dept.
RMD SSOE Warje, Pune.