

# Study of natural fibers and their utilization in concrete

D. Leela Durga<sup>1</sup>, Ch. Srinivas<sup>2</sup>, Batchala Venkataramana<sup>3</sup>, Sheik Imran<sup>4</sup>, Lothugedda Karthik<sup>5</sup>, Chinta Yajna Rajesh<sup>6</sup>

<sup>1</sup>Assistant Professor, <sup>2</sup>Assistant Professor and Head of the Department, <sup>3,4,5,6</sup>U.G. Student  
Department of Civil Engineering, Godavari Institute of Engineering & Technology (A),  
Rajamahendravaram. Andhra Pradesh-533296

**Abstract**— Concrete has good compressive but low in tensile strength. The addition of natural fiber into fresh concrete can increase the ductility of the concrete matrix. This research aims to investigate the tensile strength of concrete with 0.50% addition of coconut fiber based on cement weight. To increase the strength of concrete. The replacement is divided into four different percentages namely 10%, 20% and 30% based on the weight of fine aggregate. The experimental work consisted of casting 13 different types of concrete to be compared in term of splitting tensile strength at the age of 7, 14 and 28 days. In general the tensile strength of coconut fibre reinforced concrete is comparable to that of Normal Concrete. Natural fibers, derived from renewable sources such as plants, animals, or minerals, possess unique properties that make them suitable for use as reinforcing agents in concrete. Plant-based fibers, such as jute, coir, sisal, flax, and hemp, as well as animal-based fibers like wool and silk, are characterized by high tensile strength, flexibility, and biodegradability. These fibers, when integrated into concrete, improve its toughness, impact resistance, ductility, and post-cracking behavior by acting as micro-reinforcements within the cement matrix. Additionally, they offer sustainability benefits by reducing dependency on synthetic alternatives and contributing to the circular economy through the utilization of agricultural by-products.

**Index Terms**— Natural Fibers, Coconut Fibers, Peach Fibers, Concrete Reinforcement, Sustainable Construction, Mechanical properties, Durability properties.

## I. INTRODUCTION

### 1. INTRODUCTION

Natural fibers are materials derived from plants, animals, or minerals that have been used for thousands of years in various human applications. These fibres are highly valued for their sustainability, biodegradability, and versatility. As the world faces challenges related to environmental degradation and the overuse of synthetic materials, the significance of natural fibers has grown substantially in recent years. They play an essential role in industries ranging from textiles and construction to automotive and medical

applications. The study of natural fibers involves understanding their properties, sourcing methods, processing techniques, and diverse applications. Common examples include cotton, wool, flax, jute, hemp, and silk, each with unique characteristics that make them suitable for specific uses. Cotton, for example, is renowned for its softness and breathability, while jute is valued for its strength and low cost. Animal-based fibers like wool and silk are prized for their warmth and luxurious feel. Utilization of natural fibres extends beyond traditional uses in fabric and clothing. They are increasingly incorporated into eco-friendly products, offering alternatives to synthetic materials that often contribute to pollution and waste. Natural fibers are also being explored in the fields of biocomposites, biodegradable plastics, and medical applications, showcasing their potential in innovative technologies. The research and development of natural fibers not only contribute to more sustainable industries but also create opportunities for rural economies and agricultural practices. Understanding the properties and potential of natural fibers is essential for fostering a more sustainable future. As we continue to look for ways to reduce our environmental footprint, the importance of natural fibers will only continue to grow.

### 1.1. Background of Work

Natural fibers, derived from plants and animals, have been increasingly recognized as a sustainable alternative to synthetic fibres in concrete. Natural fibers offer several benefits, including:

1. Renewable resource: Natural fibers are derived from renewable resources, reducing dependence on non-renewable resources.
2. Biodegradable: Natural fibers are biodegradable, reducing waste and environmental pollution.
3. Low carbon footprint: Natural fibers have a lower carbon footprint compared to synthetic fibers.
4. Cost-effective: Natural fibers are often cheaper than synthetic fibers.

### 1.2. Research Gap

Despite the growing interest in natural fibers, there is a need for further research on their utilization in concrete. Specifically:

1. Mechanical properties: There is a need for further research on the mechanical properties of natural fibers-reinforced concrete (NFRC).

2. Durability properties: There is a need for further research on the durability properties of NFRC.

3. Optimization of fibre content and fiber length: There is a need for further research on the optimization of fiber content and fibre length for NFRC.

### 1.3. Research Objectives

The main objectives of this research study

1. To investigate the mechanical properties of NFRC: This includes evaluating the compressive strength, tensile strength, and flexural strength of NFRC.

2. To evaluate the durability properties of NFRC: This includes evaluating the water absorption, acid resistance, and freeze-thaw resistance of NFRC.

3. To optimize the fibre content and fiber length for NFRC: This includes evaluating the effect of fiber content and fiber length on the mechanical and durability properties of NFRC.

## II. LITERATURE SURVEY

### 2. LITERATURE

2.1 S Palanisamy, K. Vijayananth, TM Murugesan... - International Journal of (2024) - Elsevier

This research explores natural fiber composites (NFCs) as alternatives to traditional materials such as fiberglass. By examining fibers like abaca, bamboo, banana, coir, flax, hemp, jute, kenaf, pineapple leaf (PALF), sisal, and others, we emphasize their lower weight, cost-effectiveness, competitive mechanical properties, commendable specific strength, and potential for biodegradability. NFCs offer practical and eco-friendly substitutes for conventional composite fibers in industries like construction, automotive, and packaging.

2.2 RA Kurien, MM Anil, SLS Mohan, JA Thomas - Materials Today (2023) - Elsevier

Since synthetic fibers have been polluting the environment for a long time, researchers are searching for better environmentally friendly replacements like natural fibers. Natural fibers refer to the fibers obtained from plants and animals. Natural fibers such as bamboo, hemp, jute

and oil palm can potentially replace synthetic fibers to produce biodegradable and lightweight composites with improved mechanical properties.

2.3 Mepal j. Et.al, (2020)

Investigated a study on bamboo reinforced concrete beams. Bambusa tulda was this splinted in the mention splinted and striped coating are two types of bamboo splints are prepared or plain and tor is used. Tor is increasing life cycles of bamboo. In between steel is not used than bamboo traded as the reinforcing material. The concrete mix and water cement ratio of required quantity is adopted. Bamboo splints are then tested for flexure, tautness and moisture content. Based on results obtained, we can manage better flexural performance by increasing the number of reinforcement diameter of the bar and shear links to the bamboo reinforced beams. The deflection in the mid span is reduced and also flexural strength is increased.

2.4 Ram sur et.al, (2019)

They were conducted an experimental analysis on flexural strength of laminated bamboo beams. Bamboos tulda is type of species in bamboo used in India. This strip is very sticky and Polyvinyl Acetate Adhesive. This mechanism adopted in machine just like cutting etc. this soffit contain worming in water and laminated by hydrogen peroxide for 3 hours and is preventing measurement is boric acid used for preventing bamboo and the Finally, the water is evaporated and salts are settled in the bamboos which limited the 5% with last 2 months.

2.5 Khalil, H. P. S. A., & A. M. K. Ismail (2019).

"Natural fiber composites in construction: A review." Construction and Building Materials, 226, 122842. A review focusing on the use of natural fibers, including jute, hemp, and flax, in construction materials like concrete.

2.6 Kumar, P., & P. R. Bansal (2018). "Natural fibers in concrete: A review." Journal of Building Engineering, 20, 125-136.

A comprehensive review focusing on natural fibers, their types, and their impact on concrete strength and durability.

2.7 Thiruvengadaravi, A. A., & S. Senthilkumar

(2017). "Sustainable development through natural fibers reinforced concrete: A review." Journal of Cleaner Production, 142, 2274-2287.

This paper discusses the sustainability of using natural fibers in concrete and their environmental advantages.

2.8 Chand, S., & S. Gupta (2015). "Effect of natural fibers on properties of concrete."

International Journal of Engineering Research and Applications, 5(7), 48-54.

This article focuses on the impact of natural fibers such as bamboo, coir, and jute on the mechanical properties of concrete.

2.9 Baba, A., & L. I. Dufresne (2014). "Natural fiber-reinforced concrete composites: A comprehensive review." Composites Part B: Engineering, 62, 174-183.

This paper provides a detailed review of the properties, benefits, and challenges of using natural fibers in concrete.

### III. METHODOLOGY FOR EXPERIMENTS

#### 3.1 OBJECTIVE

The objective of studying natural fibers and their utilization in concrete is to explore the potential benefits of incorporating sustainable, renewable materials into construction to improve the performance, environmental impact, and economic feasibility of concrete structures. This research aims to:

1. Enhance the mechanical properties of concrete by investigating the influence of natural fibers on strength, durability, and flexibility, thereby potentially reducing the need for synthetic fibers or additives.
2. Improve the sustainability of concrete production by replacing or supplementing conventional materials with renewable, biodegradable fibers, leading to reduced carbon footprint and environmental impact.
3. Develop eco-friendly alternatives to traditional construction materials, which could help in waste management by utilizing agricultural or industrial by-products as fibers sources.

#### 3.2 Durability Properties of NFRC

have also been investigated, including:

1. Water absorption: The water absorption of NFRC has been shown to decrease with increasing fiber content (Savastano et al., 2005).
2. Acid resistance: The acid resistance of NFRC has been shown to improve with the addition of natural fiber (Agopyan et al., 2005).

3. Freeze-thaw resistance: The freeze-thaw resistance of NFRC has been shown to increase with increasing fiber length (Jain et al., 2017).

#### 3.3 Applications of NFRC

NFRC has several potential applications, including:

1. Building construction: NFRC can be used for building walls, floors, and roofs (Mohammed et al., 2015).
2. Infrastructure development: NFRC can be used for infrastructure development, including roads, bridges, and highways (Agopyan et al., 2005).
3. Sustainable housing: NFRC can be used for sustainable housing, including low-cost housing and disaster-resistant housing (Jain et al., 2017).

#### 3.4 Experimental Design:

In studies exploring the use of natural fibers in concrete, the aim is typically to evaluate the effects of different fibers on the properties of concrete, such as its strength, durability, and sustainability. Below is an explanation of the experimental design, including variables, sample preparation, and testing procedures.

##### 1. Variables:

###### a. Independent Variables:

These are the variables that are deliberately changed or manipulated in the experiment:

- Type of Fiber: The natural fiber used (e.g., jute, hemp, coconut, bamboo, flax, sisal, etc.). Different types of fibers may have varying mechanical properties, lengths, and surface textures.
- Fiber Content (Dosage): The proportion of fibers added to the concrete mix. This can be in terms of weight (percentage of total cement weight) or volume (volume fraction of concrete).
- Fiber Length and Aspect Ratio: The length and shape of the fiber can influence the concrete properties. Longer fibers or fibers with higher aspect ratios (length to diameter ratio) may behave differently in terms of improving strength or durability.
- Concrete Mix Design: The specific formulation of the concrete (i.e., mix of cement, aggregates, and water). The mix can be varied to observe how fibers interact with different concrete compositions.

###### b. Dependent Variables:

These are the outcomes that are measured in response to the independent variables:

- Mechanical Properties:

Compressive Strength: Measurement of the concrete's ability to withstand axial loading.

Tensile Strength: Measurement of the concrete's ability to resist tension.

Flexural Strength: Measurement of the concrete's ability to resist bending forces.

Modulus of Elasticity: The stiffness of the concrete.

- Durability Properties:

Water Absorption: How much water the concrete can absorb, indicating its porosity.

Shrinkage and Creep: The deformation of concrete over time.

Freeze-Thaw Resistance: Concrete's ability to resist cycles of freezing and thawing.

Workability: The ease with which the concrete can be mixed, placed, and finished.

c. Control Variables:

These are the factors that are kept constant throughout the experiment to ensure that observed changes in the dependent variables are due to changes in the independent variables:

- Cement Type: Type of cement used in all mixes.
- Aggregate Size and Type: The type and size of coarse and fine aggregates.
- Water-Cement Ratio: Ensuring consistency in the water-to-cement ratio for each mix.
- Mixing Time and Method: Standardizing how the concrete is mixed to avoid inconsistencies.
- Curing Conditions: The temperature and humidity under which the concrete samples are cured.
- Fiber Content (Dosage): The proportion of fibers added to the concrete mix. This can be in terms of weight (percentage of total cement weight) or volume (volume fraction of concrete).
- Fiber Length and Aspect Ratio: The length and shape of the fiber can influence the concrete properties. Longer fibers or fibers with higher aspect ratios (length to diameter ratio) may behave differently in terms of improving strength or durability.
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#### IV. RESULTS AND DISCUSSIONS

4.1 Compressive strength is a measure of the ability of a material, typically concrete, to withstand axial loads that reduce its size. In simpler terms, compressive strength indicates how much force a material can handle before it breaks or deforms permanently under compression.

How It's Measured:

For concrete, the compressive strength is typically tested by placing a cylindrical or cubic specimen (usually 150 mm x 150 mm x 150 mm or 6 inches x 6 inches x 6 inches for cubes) under a compression testing machine. The specimen is loaded at a constant rate until failure, and the maximum load it can bear is recorded. The compressive strength is calculated as:  

$$\text{Compressive Strength} = \frac{\text{Maximum Load}}{\text{Area of Cross Section}}$$

Advantages and Disadvantages:

Advantages:

- I. Improved flexural strength (resistance to bending).
- II. Enhanced tensile strength and durability.
- III. Eco-friendly as coconut fibers are a renewable resource and waste material from coconut processing.
- IV. Can reduce the weight of concrete, making it useful for lightweight applications.

Disadvantages:

- I. Lower compressive strength compared to conventional concrete.
- II. The fibers may decompose over time, leading to long-term durability concerns.
- III. Improper dispersion of fibers can lead to uneven strength distribution.

While coconut fiber concrete may not reach the compressive strength of conventional concrete, it offers other benefits like better tensile and flexural strength, making it suitable for specific applications like low-load-bearing structures, paving blocks, or sustainable building materials. Engineers and researchers are exploring ways to optimize its performance by experimenting with different fiber treatments, mix designs, and curing methods.

4.2 Observations:

- Fiber Content: The compressive strength generally decreases as the fiber content increases, with a

noticeable reduction in strength at higher percentages of fibers (3% and above).

- Fiber Length: Shorter fibers generally result in higher compressive strength. Longer fibers disrupt the concrete mix more, reducing the load-bearing capacity.

- Fiber Treatment: Soaking or treating the fibers can slightly improve the compressive strength by enhancing the bond between the fibers and the cement matrix.

## V. CONCLUSIONS

The study of natural fibers and their integration into concrete demonstrates promising advancements in sustainable construction practices. Natural fibers such as jute, coir, hemp, flax, and bamboo have shown potential to enhance concrete's mechanical properties, including its tensile strength, durability, and crack resistance. These fibers, being biodegradable and environmentally friendly, provide an eco-efficient alternative to synthetic fibers, contributing to reducing the environmental impact of concrete production. Natural fibers also help in improving the overall workability of concrete, reducing the need for chemical additives, and improving energy efficiency during manufacturing. Furthermore, the utilization of these fibers promotes a circular economy by using renewable resources and minimizing waste. Despite these benefits, challenges such as fibers distribution, compatibility with cement, and potential for degradation over time must be addressed to optimize their use in concrete. However, ongoing research is continuously improving the understanding of their behaviour under various conditions, helping overcome these limitations.

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