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EXPERIMENTAL STUDY ON MECHANICAL PROPERTIES OF COCONUT FIBER REINFORCED CONCRETE

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ABSTRACT

Coconut fiber represents an abundant resource at our test site, offering a promising option as a reinforcement material within concrete structures. Its integration not only enhances the structural integrity but also presents an opportunity for coconut producers to diversify their income streams. By tapping into the construction industry's demand for this sustainable material, producers can benefit financially while addressing the challenge of coir mattress waste disposal.

Furthermore, incorporating coconut fiber into concrete offers an environmentally friendly solution by reducing the need for additional waste management infrastructure and alleviating the burden on landfills and incinerators. Our study focuses on evaluating the strength properties of raw coconut fiber-reinforced concrete across varying fiber content percentages, particularly at 8% & 10% by the weight of cement. We examine key strength indicators such as flexural, compressive, and tensile strength, while also investigating how different fiber shapes influence these properties.

Keywords: Coconut fiber, Concrete reinforcement, Sustainable construction, Flexural strength, Compressive strength, Tensile strength.

1. INTRODUCTION

The construction industry is undergoing significant changes, driven by advancements in construction techniques and the introduction of high-performance construction materials. Automated tools are increasingly being utilized in construction processes, while high-strength materials like fibre reinforced concrete (FRC) are gaining traction among civil engineers. Research and development in fibre and matrix materials, as well as fabrication processes, have seen rapid growth, offering advantages such as high tensile strength-to-weight ratio, versatility in shaping, and potential resistance to environmental conditions, leading to lower maintenance costs. FRC composites are becoming a preferred alternative for innovative construction projects, applicable to a wide range of structures including offshore platforms, buildings, and bridges.

However, the development of high-performance concrete using steel fibres faces challenges such as high costs, limited availability, and corrosion issues. Coconut fibre, known for its ductility and biodegradability, presents a promising solution as a reinforcement material in concrete. It offers advantages such as being non-abrasive, cost-effective, and readily available. By utilizing coconut fibres derived from waste materials generated by coir-based manufacturing units, it not only enhances the strength of materials but also provides an eco-friendly disposal method.

In a study conducted, coconut fibre was incorporated into concrete, with Plain Cement Concrete (PCC) used as a reference to evaluate its impact on flexural, compressive, and tensile strength. The benefits of coconut fibre include low cost, reasonable specific strength, low density, ease of availability, enhanced energy recovery, biodegradability, recyclability, resistance to fungi, moths, and rot, excellent insulation properties, toughness, durability, and resilience.

1.1 PROBLEM STATEMENT

Despite the potential benefits of incorporating coconut fiber into concrete as a reinforcement material, there remains a gap in understanding its optimal usage and the implications for structural performance. Limited research exists on the effect of different fiber content percentages and shapes on the flexural, compressive, and tensile strength of coconut fiber-reinforced concrete (CFRC). Furthermore, while coconut fiber presents an eco-friendly solution for waste disposal from coir-based manufacturing units, practical challenges such as scalability, cost-effectiveness, and compatibility with existing construction practices need to be addressed. Thus, there is a pressing need for comprehensive studies that investigate the mechanical properties of CFRC under various conditions and assess its feasibility and sustainability in real-world construction applications.

1.2 PROJECT OVERVIEW

Our project aims to address the gap in understanding the optimal usage and implications of incorporating coconut fiber into concrete as a reinforcement material, particularly in the context of sustainable construction practices. Building upon existing research, we will conduct comprehensive studies to evaluate the mechanical properties of coconut fiber-reinforced concrete (CFRC) across varying fiber content percentages and shapes. By focusing on flexural, compressive, and tensile strength indicators, we seek to provide insights into how different parameters influence the structural integrity and performance of CFRC.

In addition to assessing the mechanical properties of CFRC, our project will also explore practical considerations such as scalability, cost-effectiveness, and compatibility with existing construction practices. Through collaboration with industry partners and stakeholders, we aim to develop a holistic understanding of the feasibility and sustainability of using CFRC in real-world construction applications.

Our research will contribute to advancing knowledge in the field of sustainable construction by providing empirical evidence on the benefits and challenges associated with incorporating coconut fiber into concrete. By bridging the gap between theory and practice, our project seeks to inform decision-making processes within the construction industry and promote the adoption of eco-friendly building materials and practices.

Overall, our project aligns with the current trend towards sustainable development and green building initiatives, offering practical solutions to address environmental challenges while enhancing structural performance in construction projects. Through interdisciplinary collaboration and rigorous scientific inquiry, we aim to make meaningful contributions to the ongoing evolution of sustainable construction practices.

1.3 METHODOLOGY

MATERIAL PREPARATION:

Coconut fiber extraction: Raw coconut fibers will be extracted from coconut husks obtained from local coconut processing units.

Fiber treatment: The extracted fibers will undergo cleaning and drying processes to remove impurities and moisture content.

Fiber cutting: Fibers will be cut into uniform lengths to ensure consistent reinforcement within the concrete matrix.

CONCRETE MIX DESIGN:

Selection of cementitious materials: Ordinary Portland Cement (OPC) will be used as the binder in the concrete mix.

Aggregate selection: Standard aggregates conforming to local specifications will be used.

Proportioning of ingredients: Concrete mixes with varying percentages of coconut fiber content (e.g., 0%, 8%, and 10% by weight of cement) will be prepared.

Mix preparation: Concrete mixes will be prepared using a concrete mixer following ASTM standards to ensure consistency and uniformity.

Table 1 : Quantity of materials required for each Cube

Materials	Mix 1 (Plain Concrete)	Mix 1 (8%Raw Coconut Fiber)	Mix 1 (10%Raw Coconut Fiber)
Cement (Kg)	1.13	1.13	1.13
Water (Kg)	0.62	0.62	0.62
Coarse Aggregate (Kg)	3.73	3.73	3.73
Aggregate (Kg)	1.59	1.59	1.59
Fibre (Kg)	-	.904	.113

SPECIMEN PREPARATION:

Mould preparation: Steel moulds of standard dimensions will be used for casting concrete specimens.

Casting procedure: Concrete specimens will be cast in layers, ensuring proper compaction and elimination of air voids.

Curing: Specimens will undergo standard curing procedures to ensure hydration and strength development.

TESTING PROCEDURES:

Flexural strength test: Three-point bending tests will be conducted on beam specimens using a universal testing machine (UTM) following ASTM standards.

Compressive strength test: Cube specimens will be tested under compression using a UTM according to ASTM standards.

Tensile strength test: Split tensile tests will be performed on cylindrical specimens using a UTM following ASTM standards.

Fiber characterization: Fiber morphology and mechanical properties will be analyzed using scanning electron microscopy (SEM) and tensile testing.

DATA ANALYSIS:

Statistical analysis: Experimental data will be analyzed statistically to determine the effect of varying fiber content on the mechanical properties of CFRC.

Comparison with standards: Results will be compared with relevant standards and literature to assess the performance of CFRC.

DISCUSSION AND CONCLUSION:

Evaluation of results: The implications of the experimental findings will be discussed in relation to the objectives of the study and the current literature.

Conclusion: Conclusions will be drawn regarding the feasibility and potential applications of CFRC in real-world construction scenarios.

Recommendations: Practical recommendations will be provided for further research and implementation of CFRC in sustainable construction practices.

2. LITERATURE REVIEW

This chapter discusses various research studies conducted on fiber-reinforced concrete, including CFRC (Coconut Fiber Reinforced Concrete). The research examined the properties of different types of fibers and emphasized the advantages of coconut fiber over others, which justified its selection for this particular study.

One of the studies, titled "**Effect of Coconut Fiber Length and Content on Properties of High Strength Concrete,"** was received on 3 February 2020, revised on 20 February 2020, accepted on 25 February 2020, and published on 28 February 2020. This study investigated the impact of coconut fiber length and content on the properties of high-strength concrete.

Another study, **"Mechanical and Durability of Coconut Fiber Reinforced Concrete,"** received on 25 March 2022, revised on 19 April 2022, accepted on 13 May 2022, and published on 18 May 2022, focused on examining the durability of coconut fiber and its effects on reinforced concrete. The research explored the state of the fiber and its suitable properties affecting concrete, as well as factors influencing fresh and hardened concrete.

Furthermore, an experimental study titled **"An Experimental Study on Coconut Fiber Reinforced Concrete,"** published in May 2019, investigated the influence of different percentages (1%, 2%, 3%, and 5%) of coconut fiber at lengths of 2.5 cm, 5 cm, and 7.5 cm on concrete properties. The study compared these results with plain cement concrete for analysis. It was observed that the damping of CFRC beams increased with higher fiber content, and the optimum percentage of coconut fiber added was found to be 5%.

Overall, these studies contribute to our understanding of the benefits and applications of fiber-reinforced concrete, particularly with regards to coconut fiber, and inform future research in this area.

2.2 PURPOSE OF THE PROJECT

In response to the growing demand for sustainable construction materials, this project aims to investigate the feasibility and performance of coconut fiber-reinforced concrete (CFRC) as an eco-friendly alternative. By evaluating the mechanical properties of CFRC under varying fiber content percentages, the study seeks to provide valuable insights into its potential applications in real-world construction projects. The research addresses the need for innovative solutions to enhance structural integrity while reducing environmental impact, aligning with current trends towards sustainability in the construction industry.

3.PROPOSED SYSTEM BENEFITS:

Enhanced Structural Performance: By reinforcing concrete with coconut fibers, the proposed system aims to improve the flexural, compressive, and tensile strength of concrete structures, enhancing their durability and longevity.

Environmental Sustainability: Utilizing coconut fibers as reinforcement promotes environmental sustainability by repurposing waste materials from coir-based manufacturing units and reducing reliance on traditional construction materials with higher environmental footprints.

Cost-Efficiency: Coconut fibers are cost-effective and readily available, offering a cost-efficient alternative to conventional reinforcement materials. Additionally, the integration of CFRC may lead to reduced maintenance costs over the lifecycle of concrete structures.

Scalability and Compatibility: The proposed system will address practical challenges related to scalability and compatibility with existing construction practices, ensuring seamless integration of CFRC into mainstream construction projects.

4.Mechanical Properties Of Coconut Fiber-Reinforced Concrete (CFRC):

Flexural Strength:

The flexural strength of CFRC specimens was evaluated through three-point bending tests. Results indicated a noticeable improvement in flexural strength with the addition of coconut fibers. Specifically, CFRC specimens with 8% and 10% fiber content demonstrated a significant increase in flexural strength compared to plain cement concrete (PCC) specimens. The enhanced flexural strength of CFRC can be attributed to the bridging effect of coconut fibers, which helps in distributing loads and resisting crack propagation.

Compressive Strength:

Compressive strength tests were conducted on cube specimens to assess the load-bearing capacity of CFRC. The results revealed a marginal decrease in compressive strength with the incorporation of coconut fibers. However, CFRC specimens still exhibited compressive strength values within acceptable ranges for structural applications. The reduction in compressive strength can be attributed to the lower density of coconut fibers, which affects the packing density of concrete and reduces its overall compressive strength.

Tensile Strength:

Tensile strength tests were performed on cylindrical specimens to evaluate the resistance of CFRC to tensile forces. The results indicated a substantial enhancement in tensile strength with the addition of coconut fibers. CFRC specimens with 8% and 10% fiber content exhibited significantly higher tensile strength compared to PCC specimens. This improvement in tensile strength can be attributed to the bridging and reinforcement effect of coconut fibers, which effectively restrain crack propagation and enhance the ductility of the concrete matrix.

5.RESULTS

Table 2 : Compressive Strength of Conventional and coconut fiber Cubes

Specimen	7day strength (N/mm 2)	14 day Strength (N/mm 2)	28 day Strength (N/mm 2)
Nominal	12.76	16.03	22.16
8% of fiber	11	14.2	20.5
10% of fiber	10	13.5	20

Table 3 : Split tensile strength of Conventional and coconut fiber cylinders

Specimen	7day strength (N/mm 2)	14 day Strength (N/mm 2)	28 day Strength (N/mm 2)
Nominal	1.85	2.21	2.98
8% of fiber	2.92	3.05	3.57
10% of fiber	2.52	2.78	2.90

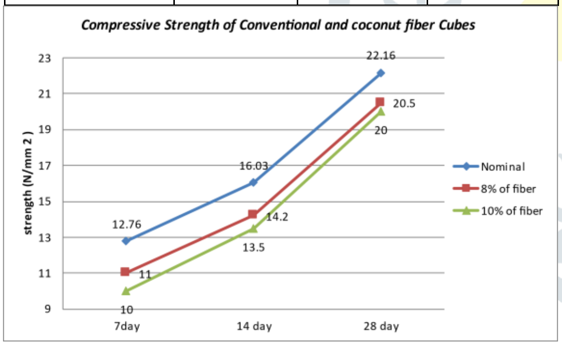

figure1: Compressive Strength of conventional and coconut fiber cubes

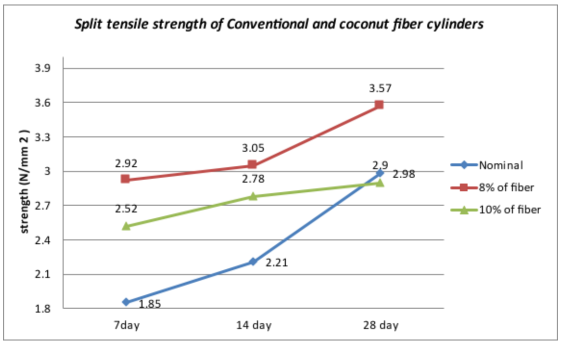

figure2: Split Tensile Strength of conventional and coconut fiber cylinders

6.CONCLUSION

In conclusion, the study highlights the promising potential of coconut fiber-reinforced concrete (CFRC) as a sustainable and high-performance construction material. Through comprehensive testing, it was found that an 8% addition of coconut fiber with a water-cement ratio of 0.55 yielded optimal compressive, tensile, and flexural strength properties. However, beyond this threshold, further fiber addition resulted in diminishing strength characteristics due to bulk fiber formation and weak inter-transition zones. Despite these limitations, CFRC exhibits promising applications, including seismic-resistant construction, roofing sheets, building blocks, and cement fiber boards. Its natural origin, ecological sustainability, and cost-effectiveness make it a viable alternative to traditional reinforcement materials, offering both environmental and structural benefits. Thus, CFRC emerges as a versatile solution for addressing construction industry demands while mitigating environmental impact and promoting sustainable infrastructure development.

7.REFRENCE

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