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# Experimental Investigation on the Mechanical Strength of Concrete Wall Panels Reinforced With Bamboo Fibers and Fishing Nets

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**ABSTRACT:** This study looked into using bamboo fibers and discarded fishing nets as eco-friendly alternatives to fine aggregates in concrete wall panels. With the push for greener construction materials, the goal was to see how these natural and recycled reinforcements affect concrete strength. Concrete samples were made with different amounts of bamboo fiber (1%, 1.5%, 2%) and fishing nets (1%, 3%, 5%), including some combinations. A total of 48 cylindrical specimens were tested for compressive and tensile strength at 7, 14, and 28 days of curing, plus an extra test after being exposed to 100°C for 24 hours. Results showed that the standard mix (with no fibers) had the highest strength at 28 days (16.44 MPa), but mixes with 1.5% bamboo fiber (15.62 MPa) and 1% fishing nets (15.00 MPa) came close. For tensile strength, the control mix reached 2.27 MPa, with the 1% bamboo fiber mix just behind at 2.22 MPa. However, higher replacement levels, like the 2% bamboo and 5% fishing net combo, led to lower strengths (11.68 MPa compressive, 2.13 MPa tensile). Statistical analysis (Two-Way ANOVA) showed that both bamboo and fishing nets significantly affected strength, but their combined effect wasn't significant which means they worked independently. Heat exposure lowered strength across all mixes: the control dropped to 13.98 MPa, and the most heavily modified mix fell to 9.17 MPa.

**KEYWORDS:** Sustainable concrete, bamboo fiber, discarded fishing nets, fine aggregate replacement, compressive and split tensile strength

## I. INTRODUCTION

The construction industry is a major contributor to environmental damage, largely due to its heavy use of natural aggregates and cement. As infrastructure demands continue to grow, there's an urgent need for more sustainable alternatives that reduce our reliance on raw materials and lessen the industry's ecological impact. While concrete remains the most widely used building material for its strength and durability, its production takes a toll on the environment especially through quarrying, which can damage ecosystems and cause erosion and flooding (Esguerra et al., 2008). This highlights the need for greener practices, including the use of recycled or natural materials as substitutes.

In line with the push for a circular economy, turning waste into usable construction materials is gaining momentum. These "green" materials can help cut costs and reduce environmental harm, but they must still meet structural performance standards. One promising option is the use of discarded fishing nets and bamboo fibers as alternatives to fine aggregates in concrete. Though many studies have examined other recycled materials like plastics, glass, and agricultural waste, little research has explored this specific combination. This study fills that gap by testing how bamboo fibers and fishing nets both widely available and often discarded can work together to reinforce concrete. The findings offer fresh insights into sustainable building solutions, especially for coastal and resource-limited areas.



## II. METHODOLOGY

### Research Design

This study employed an experimental research design to investigate the mechanical performance of concrete wall panels reinforced with bamboo fibers and discarded fishing nets. The primary objective was to assess how varying proportions of these alternative materials affect the compressive and split tensile strength of concrete. The experiment utilized a factorial design to evaluate individual and combined effects of the reinforcements at different curing periods and under thermal exposure.

### Materials and Mixture Proportions

Ordinary Portland cement (Type I), river sand as fine aggregates, and crushed gravel as coarse aggregates were used. The reinforcing materials included natural bamboo fibers, manually cut to uniform lengths, and recycled fishing nets, cleaned and shredded into fine strands. These materials were partially substituted for fine aggregates at the following proportions:

Bamboo fiber: 1%, 1.5%, and 2% by weight of sand

Fishing nets: 1%, 3%, and 5% by weight of sand

Combinations: 1% BF + 1% DFN, 1.5% BF + 3% DFN, 2% BF + 5% DFN

A total of 16 different concrete mixes, including a control mix with no fiber, were prepared. The water-cement ratio was held constant at 0.50.

### Specimen Preparation and Curing

For each mix, three cylindrical specimens (150 mm diameter × 300 mm height) were cast for compressive and split tensile tests at each curing period: 7, 14, and 28 days, resulting in 48 test specimens. All specimens were cured in a water tank at room temperature (25–28°C) and tested at the specified intervals. An additional set of samples was oven-dried at 100°C for 24 hours to evaluate the effect of elevated temperatures.

### Testing Procedures

Compressive strength tests were conducted using a universal testing machine (UTM) following ASTM C39, while split tensile strength followed ASTM C496. Each specimen was loaded until failure, and the peak load was recorded to calculate the corresponding strength.

### Statistical Analysis

Data were analyzed using Two-Way Analysis of Variance (ANOVA) to determine the significance of the bamboo fiber and fishing net contents, as well as their interaction, on concrete strength. The level of significance was set at  $p < 0.05$ .

## III. RESULT AND DISCUSSION

### Physical and Mechanical Properties of Materials

The physical and mechanical characteristics of sand, gravel, bamboo fibers, and discarded fishing nets were assessed to ensure they met acceptable engineering standards. Properties such as particle size distribution, specific gravity, unit weight, and water absorption were determined using standard test methods. Bamboo fibers and fishing nets demonstrated lower specific gravities and higher water absorption compared to conventional aggregates, indicating their lightweight and fibrous nature, which may influence workability and bonding within the concrete matrix.

### Concrete Mix Design with Bamboo Fibers and Fishing Nets

Sixteen mix designs were developed using varying percentages of bamboo fibers and discarded fishing nets as partial replacements for fine aggregates. Each design maintained a consistent water-cement ratio and was evaluated for homogeneity and workability during mixing. Mix designs included single and combined reinforcements to assess the independent and synergistic effects on mechanical performance.

### Compressive and Split Tensile Strengths

At 28 days, the control mix exhibited the highest compressive strength (16.44 MPa), while mixes with 1.5% bamboo fiber (15.62 MPa) and 1% fishing nets (15.00 MPa) showed slightly lower but acceptable values. For tensile strength, the control reached 2.27 MPa, with 1% bamboo fiber close at 2.22 MPa. Mixtures with higher reinforcement levels (2% BF + 5% DFN) showed significant strength reductions (11.68 MPa compressive, 2.13 MPa tensile), suggesting limits for effective reinforcement content.



### Summary of Compressive Strength Means (in MPa)

% Replacement	7 Days	14 Days	28 Days
0% (Control)	9.505	11.19	16.44
1% BF	8.525	10.261	15.787
1.5% BF	8.475	10.31	15.623
2% BF	8.367	9.324	14.8
1% DFN	9.156	10.717	15.198
3% DFN	7.025	9.952	14.636
5% DFN	8.351	10.523	13.946
1% BF + 1% DFN	7.953	10.798	13.96
1.5% BF + 3% DFN	6.021	7.987	12.228
2% BF + 5% DFN	5.608	7.712	11.681

### Split Tensile Strength Means (in MPa)

% Replacement	7 Days	14 Days	28 Days
0% (control)	1.715	1.872	2.27
1% BF	1.635	1.793	2.224
1.5% BF	1.656	1.797	2.213
2% BF	1.597	1.709	2.154
1% DFN	1.693	1.861	2.161
3% DFN	1.758	1.766	2.142
5% DFN	1.623	1.816	2.019
1% BF + 1% DFN	1.579	1.839	2.125
1.5% BF + 3% DFN	1.371	1.579	1.958
2% BF + 5% DFN	1.654	1.786	2.135

#### Thermal Resistance Evaluation

Concrete samples subjected to 100°C for 24 hours showed a general decrease in mechanical properties. The control dropped to 13.98 MPa in compressive strength, while the most heavily reinforced mix decreased to 9.17 MPa. Despite the reduction, moderate replacement mixes (1.5% BF or 1% DFN) maintained acceptable post-heat strengths, indicating thermal resilience at lower replacement levels.

**Compressive Strength Means (in MPa)**

% Replacement	7 Days	14 Days	28 Days
0% (control)	7.991	9.509	13.973
1% BF	6.498	9.282	13.261
1.5% BF	6.123	9.754	12.497
2% BF	5.439	7.77	11.1
1% DFN	6.249	8.927	12.753
3% DFN	5.45	7.786	11.123
5% DFN	4.388	6.181	8.781
1% BF + 1% DFN	6.219	8.885	11.249
1.5% BF + 3% DFN	4.324	5.935	8.48
2% BF + 5% DFN	4.491	6.416	9.165

**Split Tensile Strength Means (in MPa)**

% Replacement	7 Days	14 Days	28 Days
0% (control)	1.715	1.872	2.27
1% BF	1.635	1.793	2.224
1.5% BF	1.656	1.797	2.213
2% BF	1.597	1.709	2.154
1% DFN	1.693	1.861	2.161
3% DFN	1.758	1.766	2.142
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2% BF + 5% DFN	1.654	1.786	2.135

**Statistical Analysis**

Two-Way ANOVA revealed that both bamboo fiber and fishing net contents significantly affected compressive and tensile strength ( $p < 0.05$ ). However, their interaction effect was statistically insignificant, implying independent contributions to concrete behavior. The results affirm the reliability of using either material in isolation for strength enhancement while cautioning against excessive combination ratios.

**Theory Generation**

From the findings, the study proposes the "Synergistic Reinforcement Theory of Hybrid Fibers in Concrete." It suggests that moderate, balanced inclusion of bamboo fibers and fishing nets can enhance tensile behavior without severely compromising compressive strength especially relevant for sustainable construction in resource-constrained or coastal regions.

**IV. CONCLUSIONS**

This study confirmed that bamboo fibers and discarded fishing nets are physically and mechanically suitable for use in concrete. Bamboo is lightweight and porous, while fishing nets are moisture resistant making both promising eco-friendly materials.



Concrete mixes were successfully created using 1%–2% bamboo fibers and 1%–5% fishing nets as partial fine aggregate replacements. These maintained proper workability, especially when adjusted for the water absorption of bamboo fibers.

Mechanical testing showed that low fiber content (1%–1.5% bamboo and 1%–3% nets) can match or slightly improve strength, especially in tensile capacity. However, higher fiber content particularly when combined, reduced strength due to poor bonding and mix compaction.

When exposed to heat (100°C for 24 hours), all mixes showed a drop in strength. Lower fiber mixes performed reasonably well, while higher hybrid mixes lost significant strength, showing that excessive fiber content reduces heat resistance.

Statistical analysis confirmed significant differences in strength across mixes. Low reinforcement levels performed close to the control, while higher or combined fibers led to noticeable strength losses—both under normal and elevated temperatures.

## V. RECOMMENDATIONS

1. **Use Sustainable Alternatives:** Bamboo fibers and fishing nets are viable eco-friendly substitutes for sand, especially in coastal or rural areas where they are readily available.
2. **Stick to Optimal Dosages:** For best results, use 1%–1.5% bamboo and 1%–3% fishing nets. Higher amounts, especially when combined, can weaken the concrete.
3. **Apply in Non-Critical Structures:** These mixes are best used for non-load-bearing structures or those not exposed to high heat.
4. **Study Long-Term Durability:** Further research should explore how these concrete mixes perform over time under real world conditions like rain, heat and freeze thaw cycles.
5. **Improve Workability:** When using higher fiber content, consider adding admixtures or superplasticizers to maintain workability without sacrificing strength.
6. **Support Green Construction:** Policymakers and builders should support the adoption of waste-based concrete through pilot projects, incentives, and integration into green building codes.

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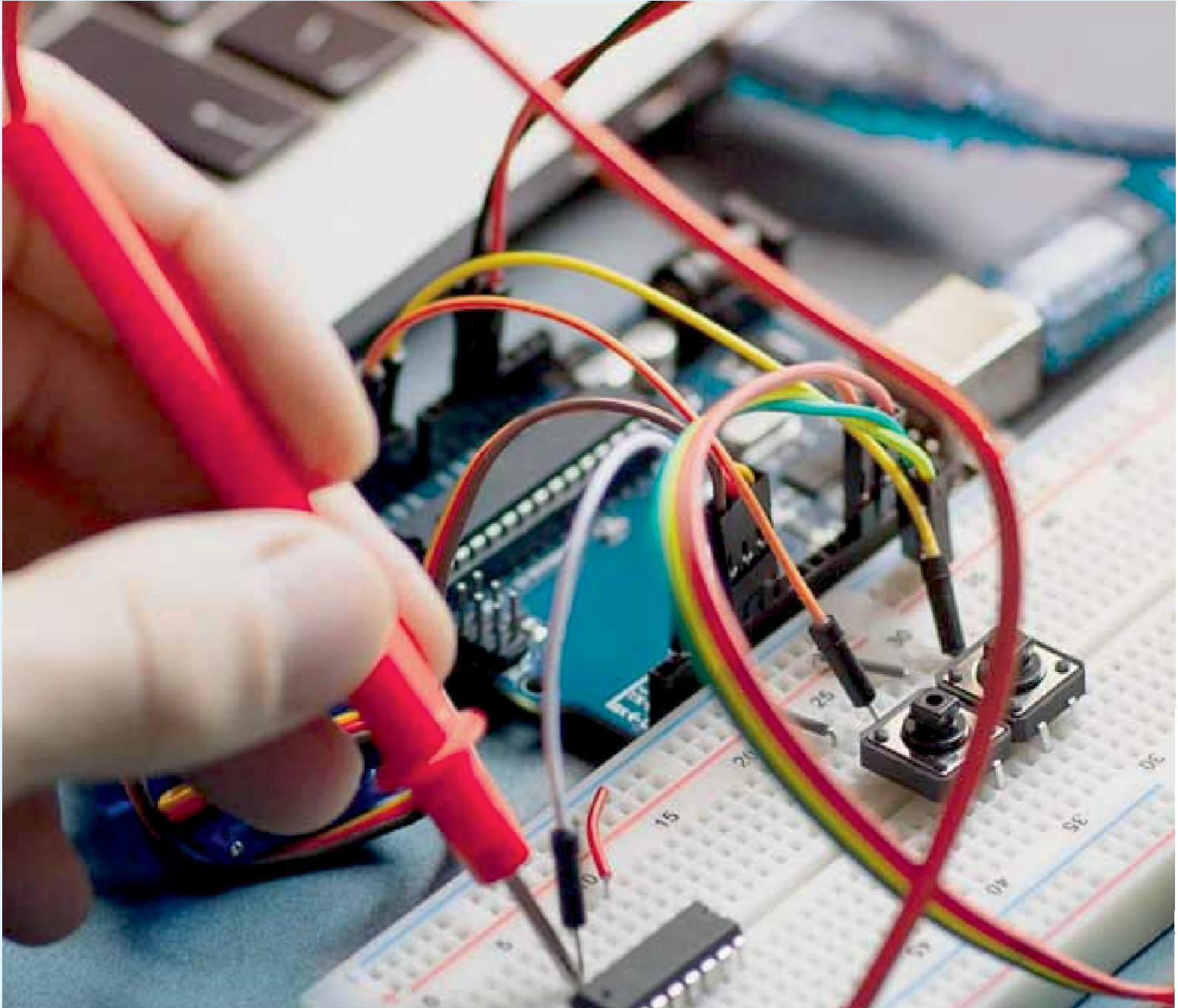
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