iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 13 Issue: V Month of publication: May 2025

DOI: https://doi.org/10.22214/ijraset.2025.71075

High Strength Concrete Using Jute Fibre as Reinforcement

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Abstract: The incorporation of natural fibres in concrete is emerging as a sustainable approach to enhance mechanical properties and durability, while reducing environmental impact. This study focuses on the use of jute fibre as a natural reinforcement in high-strength concrete (HSC). Various proportions of jute fibres (0.5%, 1.0%, and 1.5% by volume) were added to a M60 grade concrete mix, and their effects on mechanical performance were evaluated. Tests included compressive strength, split tensile strength, flexural strength, workability, and durability. Results demonstrated that jute fibres improve crack resistance and post-cracking ductility, with the optimum fibre content found at 1.0%. The findings suggest that jute fibre is a viable, eco-friendly reinforcement alternative that can contribute to cost-effective and sustainable construction practices.
Keywords: High Strength Concrete, Jute Fibre, Natural Fibre Reinforcement, Mechanical Properties, Sustainable Concrete, Durability

I. INTRODUCTION

Concrete remains the most extensively used construction material worldwide due to its strength, versatility, and cost-effectiveness. However, traditional concrete suffers from brittleness and low tensile strength, making it prone to cracking under tensile and flexural stresses. These limitations restrict its application in structures requiring higher ductility and toughness.

To overcome these challenges, researchers have explored the use of fibres to reinforce concrete. While synthetic fibres such as steel, polypropylene, and glass fibres are effective, their production involves high energy consumption and environmental concerns. In contrast, natural fibres such as jute, coir, sisal, and hemp are renewable, biodegradable, and abundantly available, especially in India. Jute, in particular, offers high tensile strength and rough texture that enhances mechanical interlocking within the concrete matrix.

This study aims to investigate the effectiveness of jute fibre as reinforcement in high strength concrete, focusing on improvements in strength, crack resistance, durability, and workability. The environmental benefits and cost advantages of jute fibres further motivate this research.

II. MATERIALS AND METHODS

A. Materials Used

1) Cement: Ordinary Portland Cement (OPC) of 53 Grade conforming to IS 12269 standards was used as the binding material.
2) Fine Aggregate: Clean river sand passing through a 4.75 mm sieve was used to ensure proper grading and good particle packing.
3) Coarse Aggregate: Crushed angular granite with a maximum size of 20 mm was selected to provide adequate mechanical strength and bonding.
4) Water: Potable water free from impurities was used for mixing and curing.
5) Superplasticizer:Conplast SP430 was added to improve the workability and reduce water content without compromising strength.
6) Jute Fibre: Locally sourced raw jute fibres were chemically treated to remove lignin and impurities, then cut to an average length of 30 mm for uniform dispersion and bonding within the concrete matrix.

B. Mix Design

The mix design targeted M60 grade high-strength concrete, following IS 10262:2019 guidelines. The water-cement ratio and aggregate proportions were optimized for strength and durability. Jute fibres were introduced at volume fractions of 0.5%, 1.0%, and 1.5% to assess their influence on mechanical and durability properties.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 13 Issue V May 2025- Available at www.ijraset.com

Mix ID	Cement (kg/m³)	Fine Aggregate (kg/m³)	Coarse Aggregate (kg/m³)	Water (kg/m³)	Jute Fibre (%)
M0	450	620	1175	160	0
M1	450	620	1175	160	0.5
M2	450	620	1175	160	1.0
M3	450	620	1175	160	1.5

C. Testing Procedures

The following standardized tests were conducted to evaluate mechanical and durability performance:

1) Compressive Strength: Tested on 150 mm concrete cubes at curing ages of 7, 14, and 28 days following IS 516:1959.
2) Split Tensile Strength: Conducted on 150 mm diameter and 300 mm length cylinders to assess tensile capacity.
3) Flexural Strength: Tested using 100 x 100 x 500 mm beams under third-point loading to evaluate resistance to bending stresses.
4) Workability: Measured by slump cone test to assess fresh concrete flow and ease of placement.
5) Durability: Water absorption tests and acid resistance assessments were performed to gauge long-term performance.

III. RESULTS AND DISCUSSION

A. Compressive Strength

The addition of jute fibre significantly influenced compressive strength development. The control mix (M0) achieved a 28-day compressive strength of 60.4 MPa. Incorporation of 1.0% jute fibre (M2) enhanced strength to 68.0 MPa, representing a 12% improvement. This gain is attributed to the fibre's ability to bridge micro-cracks and restrain crack growth, improving the concrete's load-bearing capacity. At 1.5% fibre content (M3), a slight reduction was observed due to fibre clumping and increased porosity.

B. Split Tensile Strength

Split tensile strength improved progressively with fibre addition, owing to the effective stress transfer between fibres and concrete matrix. Mix M2 recorded a 5.5 MPa tensile strength, 15% higher than the control mix (4.8 MPa). Jute fibres help control crack propagation by distributing tensile stresses, thus enhancing toughness.

C. Flexural Strength

Flexural strength, a critical parameter for beams and slabs, showed noticeable improvement with jute fibre inclusion. Mix M2 achieved 6.4 MPa flexural strength compared to 5.5 MPa for the control. The fibres contribute to post-cracking load capacity and ductility, preventing sudden failure.

D. Workability and Durability

Workability decreased with increased fibre content, as indicated by slump values reducing from 85 mm (M0) to 40 mm (M3). However, M2's slump of 55 mm was still within acceptable limits for practical use, especially with superplasticizer addition.

Water absorption slightly increased with fibre inclusion but remained within permissible limits, indicating no major compromise in durability. Acid resistance tests showed that jute fibre concrete maintained integrity, suggesting suitability for harsh environmental conditions.

Property	M0	M1	M2	M3
28-day Compressive Strength (MPa)	60.4	65.2	68.0	63.5
Split Tensile Strength (MPa)	4.8	5.3	5.5	5.1
Flexural Strength (MPa)	5.5	6.1	6.4	6.0
Slump (mm)	85	65	55	40

IV. CONCLUSION

The experimental investigation clearly demonstrates that jute fibre reinforcement enhances the mechanical performance of high strength concrete, especially in tensile and flexural behavior. Key conclusions are:

1) The optimum jute fibre content for M60 concrete is 1.0% by volume, balancing strength gain and workability.
2) Jute fibres improve post-cracking ductility and toughness by controlling crack initiation and propagation.
3) Workability decreases with higher fibre content but remains manageable with admixture use.

4) The natural and biodegradable nature of jute fibres offers a sustainable, eco-friendly, and cost-effective alternative to synthetic fibres.
5) Jute fibre reinforced concrete is a promising solution for green construction and low-cost infrastructure in tropical regions like India.

Future research directions include exploring chemical surface treatments of jute fibres for enhanced bonding, hybrid fibre combinations, long-term durability assessments under various environmental exposures, and large-scale structural performance.

V. CONFLICT OF INTEREST

The authors declare no conflicts of interest related to this research.

VI. AUTHOR CONTRIBUTIONS

1) C. Hariharan: Conceptualization, experimental methodology, data collection, initial drafting.
2) Dr. P. Kalaiselvi: Supervision, validation, critical review, and editing.
3) Dr. S. Krishnapriya: Resource coordination, data analysis, and manuscript refinement.

VII. FUNDING

This research received no external funding or financial support.

VIII. ACKNOWLEDGMENTS

The authors express gratitude to AAA College of Engineering & Technology for providing laboratory facilities and technical support throughout the project.

IX. DATA AVAILABILITY STATEMENT

The datasets generated and analyzed during this study are available from the corresponding author upon reasonable request.

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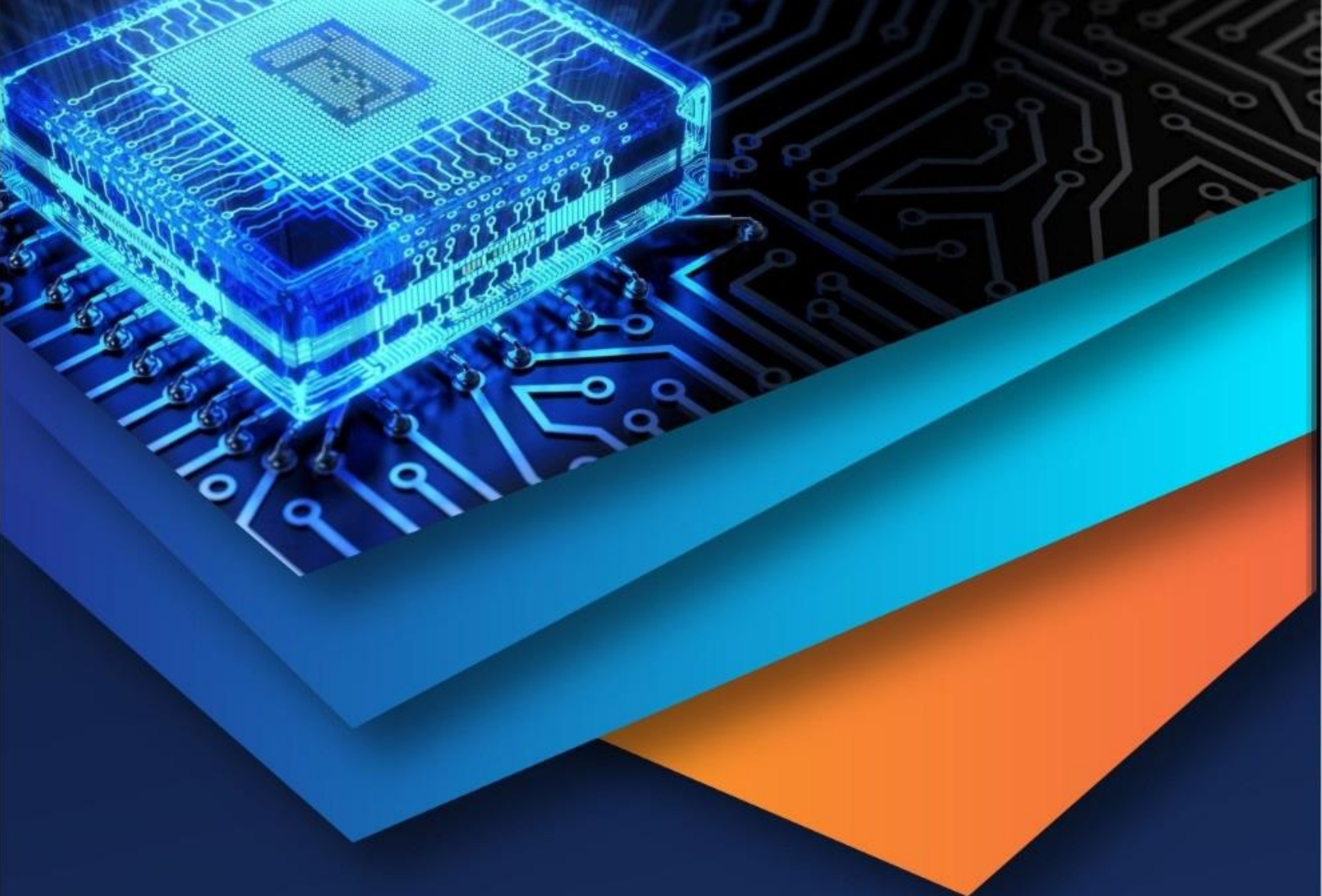

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