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Experimental Study and Durability Properties of Textile Fibre Reinforced Concrete

V. Akash [1], Dr. A. Vennila [2], S. Vishnu Prasad [3]

PG student[1,3], Assistant Professor[2]

Department of Civil Engineering, Kumaraguru College of Technology, Coimbatore, Tamil Nadu, India.

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ABSTRACT:

In present scenario, natural fibres including jute, banana stem, coir, and bamboo fibres are often employed as natural reinforcing materials to enhance the mechanical qualities of concrete and mortar. Instead of using steel bars as reinforcement, textile reinforced concrete uses fibers. It has been demonstrated that textile-reinforced concrete is a reasonably priced composite material. This paper goes into detail regarding textile-reinforced concrete's characteristics. The use of these fibers will aid in reducing steel bar-related corrosion. The marked reduction of (1) concrete consumption (by about 60-85%), (2) embodied energy of building components (entails reduced production, transportation, erection, and application costs), and (3) end-of-life waste (by about 60%) is responsible for the rising popularity of TRC-based prefabrication solutions. It was found that textile fibre reinforcement reduced 60% of concrete in a structural element when compared to use of steel reinforcement. Experimental investigation is to be conducted to find the mechanical properties and the structural behaviour component such as wall panel.

Keywords: Textile Reinforced Concrete, Natural Fibres, Sustainability, Mechanical Properties, Durability.

INTRODUCTION:

Textile fibre reinforced concrete is just that—concrete strengthened with textile fibers rather than steel bars (TFRC). There are several advantages to adopting TFRC over conventional concrete, such as enhanced tensile strength, reduced weight, enhanced flexibility, and improved impact resistance. Research has shown that textile reinforcement is a sustainable building material that can take the place of steel in the building sector. Reducing greenhouse gas emissions, preserving resources, and enhancing the long-term resilience of our built environment are just a few of the numerous benefits of sustainable construction.

LITERATURE REVIEW:

Nithin Sam et.al., (2016) The document discusses the durability properties of concrete reinforced with coir fibre. The study concludes that concrete reinforced with coir fibers shows improved durability compared to concrete without fibre content. The document also provides information on the materials used for the study, such as fine aggregate, coarse aggregate, coir fibre, and PPC cement. The properties of these materials are discussed, including grain size analysis and cement properties.

Babar Ali et.al., (2022) Fiber-reinforced concrete (FRC) developed with recycled aggregates (RA) and waste coconut fibers (CF) can lead to the production of a cheap and eco-friendly FRC. The addition of CF improved the shear strength of plain concrete by 40% and 60% with and without the use of a superplasticizer (SP), respectively. The combined use of CF and SP provided recycled aggregate concrete (RAC) with higher mechanical performance compared to plain natural aggregate concrete (NAC). The permeability of CF-reinforced mixes was controlled by the addition of SP, reducing chloride permeability and water absorption.

Adewumi John Babafem et.al., (2019) The inclusion of 0.5% and 1% coir fibre in concrete had no effect on its density. Coir fibre slightly improved the compressive strength of concrete, especially at 0.5% content. The tensile strength of concrete was only slightly improved at an early age. The resistance to sulphate attack was improved at 1% coir fibre content. Fibers in concrete generally enhance its toughness, ductility, shear strength, energy absorption capacity, damage tolerance, stress distribution, and volume changes.

Ali Raza et.al., (2020) The findings demonstrate that when the fiber concentrations varied from 6.5%–17.4% for the coconut and 5.8%–17.1% for the basalt fibers RC samples, the thermal insulation improved the most. 10% to 2.5%. The proportion of natural fibers rises. The TGA of the plain concrete samples and the natural fibers RC samples. The test's temperature (°C) range, which is 30 °C to 250 °C, indicates that it is the lowest. In the case of a simple concrete sample, heat deterioration is present 2.79 of the (100% mass), the coconut fiber RC samples show the most degradation (around 8.87% of total mass) and the RC samples of jute, sugarcane, and sisal show a moderate degree of heat deterioration, whereas the RC samples' basalt fibers.

M Sivaraja et.al., (2010) From this extensive experimental study, it is well known that natural fibres enhance the strength and flexibility of concrete. The effect of curing ages on mechanical properties and microstructural properties have been analysed and discussed. Natural fibres like coir and sugarcane fibres improve various strength and performance measures of concrete. The rate of strength improvement is lower in natural fibre reinforced concrete compared to conventional concrete at later curing ages.

Dhanya Sathyan et.al., (2020) This study delves into the impact of sugarcane bagasse fibre on the hardened state and durability of foam concrete, setting it apart from prior research. Optimal pressure, set at 450 kPa, is crucial for stable foam, as extremes yield slurry foam. A low fibre content (1%) curbs micro-crack development, enhancing strength compared to 3% and 5% blends, where higher fibre content creates more air voids, diminishing strength. High fibre content resists specimen shrinkage, limiting alterations in dimensions. Sugarcane fibers, even treated, absorb water; 5% content absorbs more than 3% and 1%. Following acid attack, foam concrete loses approximately 25% of its strength, further decreasing over time. These findings highlight the intricate interplay between fibre content, pressure, and durability in foam concrete.

Naraindas Bheel et.al., (2021) This paper explores the impact of nylon and jute fibers on cement concrete's engineering properties. Combined, these fibers decrease concrete workability due to increased specific surface area and higher fibre content requiring more cement mortar. Density decreases with fibre addition, attributed to lower fibre density, and increased entrapped air. Water absorption peaks at 2% fibre content. Concrete with 1% fibre content exhibits significant strength enhancements (compressive, split tensile, and flexural) at 90 days, controlling crack formation. Strengths decline beyond 1% due to increased air spaces and poor compaction. Modulus of elasticity consistently improves with fibre content, making the concrete stiffer. Nylon and jute fibers reduce drying shrinkage by enhancing bond strength and physically constraining shrinking. These findings shed light on the intricate relationship between fibre content and diverse properties of cement concrete.

Muhammad Affan et.al., (2022) This study uses jute fibre-reinforced concrete (JFRC) at a 5% ratio. With increasing cycles, void propagation rises, causing a higher mass loss (up to 1.86%) in JFRC due to jute fibre water absorption. Damping ratio increases (up to 6.19%) with mass loss, indicating JFRC's better tolerance to cycles. Mechanical properties improve with more cycles, showing JFRC's enhanced split tensile and flexural strengths (up to 4% and 11%, respectively) but reduced compressive strength (up to 16%). Bonding between jute fibers and concrete persists, even after cycles. SEM analysis reveals decreased bonding in plain concrete (PC) compared to JFRC. JFRC allows a 19% reduction in pavement thickness compared to PC, showcasing its potential for freeze-thaw resilience in concrete pavements.

M.K. Haridharan et.al., (2021) The study concludes that adding 1% fibre increases compressive strength, while 2% results in a decrease due to poor bonding and the influence of fly ash. Split tensile strength peaks at 1% fibre content, showing better performance. Increasing fibre content reduces drying shrinkage due to the hydrophilic nature of fibers. Sorptivity is lower with added fibers, resisting water movement, and reducing chloride penetration. In acid attack, control specimen strength drops by 40.625%, while 1% and 2% fibre additions decrease strength by 35.77% and 39.39%, respectively. Single fibre strength test indicates good bonding and resistance to crack formation. Jute fibers in High-Performance Concrete (HPC) improve mechanical properties and durability, offering an eco-friendly alternative to polymer fibers.

M Kalaivani et.al., (2020) Increasing the volume percentage of jute fibre in concrete reduces workability, as indicated by this experimental study. The research highlights that replacing 10% of fine aggregate with PET plastic yields higher strength. The optimal composition for compressive strength includes 10% PET aggregate and 0.25% jute fibre volume fraction, while split tensile strength benefits from 0.5% jute fibre. For flexural strength, the optimum mix involves 10% PET aggregate and 0.5% jute fibre. Using PET plastic as a fine aggregate replacement not only reduces natural aggregate usage but also addresses plastic waste concerns. The study concludes that incorporating jute fibre and plastic waste aggregates enhances overall concrete efficiency.

S.D. Gupta et.al., (2021) The chemical composition of rice husk suggests its potential as a pozzolanic material for enhancing concrete compressive strength. Introducing jute fibre not only boosts compressive strength but also reduces shrinkage cracks. The use of natural waste (rice husk) and natural fibre (jute fibre) offers cost savings and reduces greenhouse gas emissions. Conclusions drawn from tests include a 0.1%-0.3% addition of 13mm jute fibre and 5%-15% rice husk increases compressive strength by 0.14%-2.03% compared to plain concrete. Optimal results are achieved with 10% rice husk and 0.2% jute fibre, yielding a maximum 2.03% improvement at 28 days. Higher percentages of jute fibre and rice husk show slight compressive strength reduction but remain comparable to plain concrete. Introducing 0.3% jute fibre minimizes shrinkage cracks, while 15% rice husk as cement replacement achieves up to 7% cost savings, with 10% rice husk being the most promising mix for compressive strength and shrinkage crack considerations, offering a 4.7% cost-saving.

Ismail Shah et.al., (2021) The study reveals that the incorporation of natural fibre reduces concrete slump, with increasing fibre concentration further decreasing slump values across all specimens. Hybrid natural fibre significantly enhances compressive and split tensile strength compared to sisal and coir fibre reinforcement. Several factors, including fibre length, structure, treatment, and hybridization, influence the mechanical properties. Optimal compressive strength for sisal and coir fibre occurs at 1% concentration and 10 mm length, with improvements of 24.86% and 33.94%, respectively. Hybrid fibre concrete attains the best compressive strength (35.98%) at 20 mm length and 0.5% concentration compared to plain concrete. While most fibre mixes improve split tensile strength, the highest improvement (25.48%) is observed in hybrid fibre-reinforced concrete with 1% fibre content and 20 mm length. Coir and sisal fibers also enhance split tensile strength, reaching up to 24.65% and 11.80%, respectively, under specific conditions.

Mohammad S. Islam et.al., (2018) Increasing jute fibre content in concrete decreases the slump, more pronounced with 20 mm fibers than 10 mm. Compressive strength improves with 0.25% jute fibre, while 0.10% shows a decrease. The impact of 0.50% jute fibre varies; 10 mm enhances compressive strength, while 20 mm has a negative effect. Jute fibers don't significantly influence 28 and 90-day split tensile strength, except slightly higher values for 0.25% and 0.50% fibre. A negative impact on flexural strength is observed with 20 mm jute fibers, while the effect with 10 mm depends on fibre volume. Factorial analysis attributes 40% each to fibre length and volume for slump, with 20% from their combined effect. Jute fibre length contributes 38.25% to split tensile strength at 28 days, decreasing to 8.3% at 90 days. Interaction of length and volume increases from 22.70% to 55.10%. In flexural strength, the interaction contributes 46.90%, volume 36.35%, and length 16.75%. Jute fibers reduce crack number and width, enhancing concrete flexural toughness. Future studies should explore smaller jute fibers and chemically treated fibers in normal and self-consolidating concrete.

Rahesh Hari et.al., (2019) This study explores the impact of hybridizing sisal with Nylon 6 in Self-Compacting Concrete (SCC). Fibers at 0.1%, 0.2%, and 0.3% volume fractions, and hybrid proportions of 25/75, 50/50, and 75/25 are investigated. Moisture absorption by hydrophilic natural fibers reduces workability, but fibre addition improves cracking resistance. Hardened properties, including mechanical strength and durability, are analysed. Fiber addition reduces compressive strength due to uneven load transfer beyond optimal content. Hybridization enhances ductility for earthquake applications. Performance-based analysis considers severe exposure conditions, using Portland Pozzolana Cement (PPC) and alkali-treated sisal for durability. While nylon improves mechanical properties, water absorption and acid attack affect durability. ANOVA analysis confirms hybridization and fibre volume effects. Natural fibers are deemed excellent for lightweight, low-cost secondary structural components, but challenges like flammability, inconsistency, and moisture absorption require careful consideration and proper treatment, indicating potential for multifarious applications in structures.

Abass Abayomi Okeola et.al., (2018) The investigation on Sisal Fiber Reinforced Concrete (SFRC) reveals reduced workability due to sisal fibre's hygroscopic properties, limiting free-water cement and increasing pore spaces. While compressive strength decreases with sisal fibre, it significantly improves split tensile strength, reducing concrete density. Modulus of elasticity prediction is challenging, defying linear relations with compressive strength and density. The recommended optimum mix includes 1.0% sisal fibre, providing 33.55 MPa compressive strength and 3.463 MPa split tensile strength at 28 days.

Senthil Selvan Subramanian et.al., (2022) The study on various fibre-reinforced concretes (FRC) concludes that an optimal fibre addition of 1.5% for steel, carbon, and sisal, 1.0% for glass, and 2.0% for coir and jute improves compressive strength up to the optimum percentage. Steel fibre-reinforced concrete exhibits a notable 10.37% increase in split tensile strength, with longer fibers showing higher strength. Flexural strength is significantly enhanced, particularly in carbon fibre-reinforced concrete, promoting ductility and post-cracking behaviour. Natural fibre-infused concrete exhibits slightly higher water absorption due to natural fibers water absorption capacity. FRC with various fibers shows low chloride permeability, and despite higher weight loss in acidic environments for natural fibre-added concrete, overall durability surpasses conventional concrete. Both artificial and natural fibre-reinforced concretes exhibit improved mechanical properties, while artificial fibers excel in durability due to surface treatment, highlighting the potential for diverse applications.

CONCLUSION:

The study explores the durability of coir fibre-reinforced concrete, finding enhanced durability compared to fibreless concrete. Materials, including fine aggregate, coarse aggregate, coir fibre, and PPC cement, are detailed with discussions on properties. Fiber-reinforced concrete, incorporating recycled aggregates and waste coconut fibers, demonstrates cost-effective and eco-friendly potential. Coir fibre improves shear strength and overall mechanical performance, particularly in recycled aggregate concrete. Thermal insulation improves with varied fibre concentrations, showcasing benefits in fibre-reinforced samples. Sugarcane bagasse fibre in foam concrete influences strength, shrinkage, and durability, revealing complexities in fibre content, pressure, and material response. Nylon and jute fibers in cement concrete impact workability, density, and strength, providing insights into fibre-content relationships. Jute fibre-reinforced concrete exhibits enhanced strength, reduced shrinkage, and resistance to acid attack, demonstrating its potential for eco-friendly construction. Hybridization of sisal with Nylon 6 in self-compacting concrete reveals considerations for moisture absorption, mechanical properties, and durability in diverse applications. Sisal fibre-reinforced concrete (SFRC) shows reduced workability but improved split tensile strength, indicating potential for SFRC production. The comprehensive investigation on various fibre-reinforced concretes concludes with optimal fibre additions, emphasizing the mechanical and durability improvements in both artificial and natural fibre-reinforced concrete.

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