

A STUDY ON STRENGTH CHARACTERISTICS OF M20 GRADE CONCRETE USING RICE STRAW FIBERS

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Abstract - The increasing demand for sustainable construction materials has encouraged researchers to explore the use of agricultural waste as fiber reinforcement in concrete. Among these materials, rice straw, a by-product of rice cultivation, has emerged as a promising eco-friendly material due to its wide availability, low cost, and potential to improve the mechanical performance of concrete. This study investigates the effect of incorporating rice straw fibers in M20 grade concrete under Saturated Surface Dry (SSD) conditions to enhance compressive and tensile strength characteristics.

Rice straw fibers were collected, cleaned, and cut into suitable sizes to ensure uniform distribution within the concrete matrix. Before mixing, the fibers were brought to SSD condition to prevent excessive absorption of mixing water and to maintain the desired water-cement ratio. Concrete specimens were prepared by adding rice straw fibers into the mix and casting them into standard cube and cylinder moulds. After casting, the specimens were demoulded after 24 hours and placed in water for curing. The samples were tested at curing periods of 7, 14, 21, and 28 days to study strength development over time.

The inclusion of rice straw fibers improved crack resistance by acting as micro-reinforcement that bridges cracks and delays their propagation. This resulted in improved tensile performance and overall toughness of concrete. In addition, the use of rice straw fibers helps reduce agricultural waste and promotes sustainable construction practices. Therefore, rice straw fibers can be considered an economical and environmentally friendly reinforcement material for M20 grade concrete.

Key Words: M20 Grade Concrete, Rice Straw Fibers, Sustainable Construction, Fiber Reinforced Concrete, Compressive Strength, Split Tensile Strength, Agricultural Waste, Saturated Surface Dry (SSD) Condition.

1. INTRODUCTION

Concrete is one of the most commonly used construction materials in the world. It is widely preferred because of its strength, durability, and ability to be moulded into different shapes. Concrete is made by mixing cement, fine aggregate (sand), coarse aggregate, and water. When these materials are properly mixed and cured, concrete gains high compressive strength. Due to these properties, concrete is used in various structural elements such as beams, columns, slabs, and foundations. Among different grades, M20 grade concrete is commonly used for residential buildings, pavements, and small structural works. M20 grade concrete means that it achieves a compressive strength of 20 MPa after 28 days of curing.

Despite its advantages, concrete has low tensile strength and behaves in a brittle manner. Because of this, cracks may develop when concrete is subjected to tensile stress, shrinkage, temperature changes, or heavy loads. These cracks reduce the durability of concrete structures and allow water to enter, which may cause corrosion of reinforcement and reduce the life of the structure. To overcome these problems, different reinforcement methods such as steel bars, synthetic fibers, and admixtures are used.

Recently, fiber-reinforced concrete has become popular for improving the performance of concrete. The addition of fibers helps to control cracking, improve tensile strength, and increase durability. Usually, steel fibers, glass fibers, and synthetic fibers are used for this purpose. However, these fibers are costly and not environmentally friendly. Due to increasing environmental concerns, researchers are now focusing on natural fibers as sustainable alternatives.

Rice straw is an agricultural waste material that is easily available in large quantities, especially in rural areas. It is lightweight, biodegradable, low-cost, and environmentally friendly. In many places, rice straw is burned after harvesting, which leads to air pollution and environmental problems. Using rice straw fibers in concrete can help reduce waste and promote sustainable construction. Rice

straw fibers also help in controlling cracks and improving tensile strength and toughness of concrete.

Therefore, this study focuses on the strength characteristics of M20 grade concrete using rice straw fibers. The main aim is to evaluate the effect of rice straw fibers on compressive strength and split tensile strength of concrete and to determine its suitability as an eco-friendly construction material.

1.1 HISTORY OF RICE STRAW FIBERS

Rice straw is an agricultural by-product obtained after harvesting rice (*Oryza sativa*), one of the oldest cultivated crops in the world. Rice cultivation began around 8,000–10,000 years ago, mainly in countries like India and China. Since then, large quantities of rice straw have been produced as residue after separating the rice grains.

Traditionally, rice straw has been widely used in rural areas for various purposes. Farmers commonly used it as animal fodder, roof thatching, bedding for livestock, and as fuel. It was also used for mulching and composting to improve soil fertility and crop productivity. In many Asian countries such as India, China, and Thailand, rice straw has played an important role in agriculture and rural livelihoods for centuries.

In recent years, with growing environmental concerns, researchers have started exploring rice straw for use in construction materials. Rice straw fibers are now being used in fiber-reinforced concrete because they are easily available, low-cost, lightweight, and eco-friendly. These fibers help control cracks and improve the tensile performance of concrete, making them suitable for sustainable construction practices.

1.2 OBJECTIVES OF THE STUDY

1. The main objective of this study is to evaluate the feasibility of using rice straw fibers as reinforcement in concrete.
2. The study also aims to examine the effect of rice straw fiber addition on the compressive strength of concrete and to investigate its influence on the tensile strength.
3. Another objective is to compare the strength performance of fiber-reinforced concrete with conventional concrete.
4. Additionally, the study aims to determine the optimum percentage of rice straw fibers required for improving the strength characteristics of concrete.

1.3 SCOPE OF THE PROJECT

1. This project is limited to the use of rice straw fibers as reinforcement in concrete. Rice straw fibers are added in

proportions of 0.25%, 0.5%, and 0.75% by weight of cement.

2. The fibers are soaked in water for 24 hours and used in Saturated Surface Dry (SSD) condition during concrete mixing.
3. The study mainly focuses on evaluating the compressive strength and split tensile strength of concrete.
5. Concrete specimens with and without rice straw fibers are cast and tested at standard curing ages.
6. The scope of this study does not include durability studies, long-term performance, or structural behavior of concrete.

2. LITERATURE REVIEW

1. Ahmed et al. (2020) investigated the compressive behavior of concrete reinforced with rice straw fibers for rigid pavement applications. A mix ratio of 1:2:4 with a water-cement ratio of 0.6 was used as the reference concrete. Rice straw fibers with a length of 25 mm were added at 1% by wet volume. Experimental results showed that the inclusion of rice straw improved the energy absorption capacity, toughness index, and resistance to micro-shrinkage cracking. The compressive strength remained comparable to conventional concrete, indicating that rice straw fiber reinforced concrete can be effectively used in rigid pavement construction while enhancing durability and sustainability.
2. Aya Nafea (2021) conducted research on the Behavior of Natural Fiber Reinforced Concrete Using Rice Straws with 30 MPa concrete. Rice straw fibers of 25 ± 5 mm length were added at 1.5% and 2.5% with raw and chemically treated fibers. The results indicated that compressive strength and workability decreased, but tensile and flexural strength increased with fiber addition. Treated fibers showed better bonding and improved strength compared to untreated fibers, and 1.5% fiber content provided optimum performance.
3. C.S. Ezenkwa, A. N. Ede, and C. K. Ogbaga (2024) published in IOP Conference Series: Earth and Environmental Science investigated the influence of rice straw ash as a partial replacement for cement in concrete. Rice straw collected from Enugu, Nigeria, was calcined through open burning to produce rice straw ash (RSA). Cement was replaced at 0%, 5%, 10%, 15%, 20%, and 30% in M25 grade concrete. The results showed that increasing RSA content reduced workability. However, compressive strength improved slightly at lower replacement levels, with 5% and 10% RSA showing strength higher than the design strength at 28 days. Higher replacement levels (15–30%) significantly reduced strength. The study concluded that 10% RSA is the

optimum replacement level for structural reinforced concrete.

4. Eduardo Cesar Pachla et al. (2021) investigated the sustainable use of rice husk and rice straw in cellular concrete composites to improve thermal and acoustic properties. The results showed that adding rice straw enhanced bending strength and sound absorption but slightly reduced compressive strength. The optimal mixture contained 15% rice straw of 3 cm length, providing better thermo-acoustic performance. The study concluded that rice straw can be effectively used in lightweight and sustainable concrete materials, particularly for insulation and non-structural applications.

5. Feraidon Ataie (2018) investigated the Influence of Rice Straw Fibers on Concrete Strength and Drying Shrinkage using normal strength concrete with water-cement ratios of 0.42 and 0.54. Rice straw fibers of 2 mm and 5 mm length were added in percentages of 1%, 2%, and 3%. Both washed and unwashed fibers were tested. The study found that increasing fiber content reduced compressive and flexural strength and increased drying shrinkage, although 1% fine fiber showed compressive strength nearly equal to control concrete. Washing the fibers slightly improved strength and reduced shrinkage.

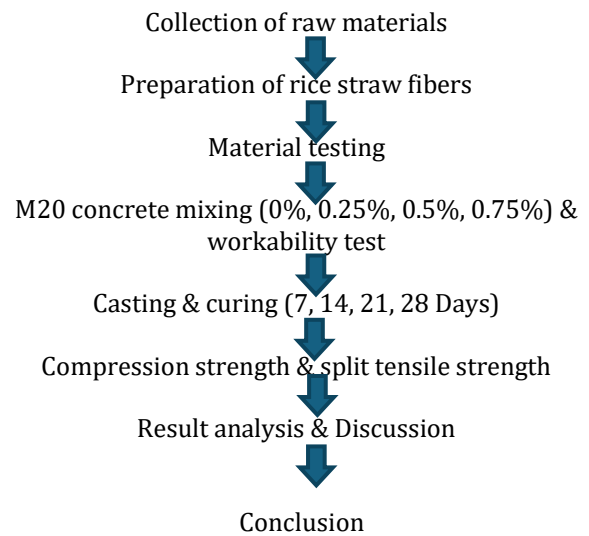
6. G. Thongchua et al. (2023) investigated the utilization of rice straw waste in cement-based construction materials for sustainable development. The study examined the effect of incorporating rice straw in lightweight concrete blocks produced using a cold press technique. The researchers compared rice straw in as-received condition and saturated surface dry (SSD) condition. Results showed that rice straw in SSD condition improved bonding with the cement matrix and enhanced compressive strength compared to untreated straw. The study concluded that rice straw can be effectively used as an eco-friendly material in concrete products while also reducing agricultural waste.

7. Hesam Doostkami, David Hernández-Figueirido, Vicente Albero, Ana Piquer, Pedro Serna and Marta Roig-Flores (2025) conducted an Experimental Study on the Valorization of Rice Straw as Fiber for Concrete using high-strength concrete greater than 30 MPa. Rice straw fibers of 79 mm length were used with contents of 10 kg/m³ and 15 kg/m³. Fibers were treated with sodium hydroxide (NaOH), potassium hydroxide (KOH), and thermal treatment. The results showed that rice straw fibers slightly improved peak flexural strength but reduced workability, and higher fiber dosage negatively affected other concrete properties.

8. Mohamed M. Mahdy, Sameh Y. Mahfouz, Ahmed F. Tawfic and Mohamed A. E. M. Ali (2023) studied the Performance of Rice Straw Fibers on Hardened Concrete Properties under Effect of Impact Load and Gamma

Radiation using M30 concrete. Rice straw fibers were added at 0.25%, 0.5%, and 0.75% by volume without chemical treatment. The study found that 0.75% fiber content increased compressive strength by about 7%, tensile strength by 17.1%, flexural strength by 25.8%, and impact resistance by 48.6% compared to control concrete

3. METHODOLOGY



3.1 PREPARATION OF RICE STRAW FIBRES

Rice straw was collected from farms and cleaned to remove dirt. The dried straw was then chopped into 15–20 mm lengths for uniform mixing. After that, it was soaked in water for 24 hours and drained to achieve a saturated surface dry (SSD) condition, ensuring no free surface water remained. The straw was then left exposed for 15 minutes before being mixed into the concrete.



Fig -1: Dry rice straw



Fig -2: Chopping of rice straw



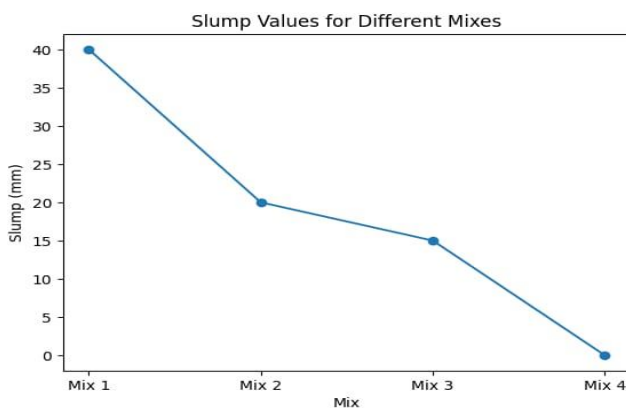
Fig -3: 24hrs soaked Fibers Fig -4: rice straw In SSD Cond.

Table -1: Different Percentage Of Rice Straw Added For 1m³ Concrete Mix

MIX	% of rice straw added (added based on cement weight)	Quantity of Rice Straw added for 1 m ³ of concrete
Cement quantity for 1 m ³ of concrete = 403.2 kg's		
Control mix	0	0
1 mix	0.25%	1 KGS
2 mix	0.5%	2 KGS
3 mix	0.75%	

4. RESULTS

4.1 FRESH CONCRETE VALUES



4.2 COMPARISON B/W COMPRESSION TEST VALUES

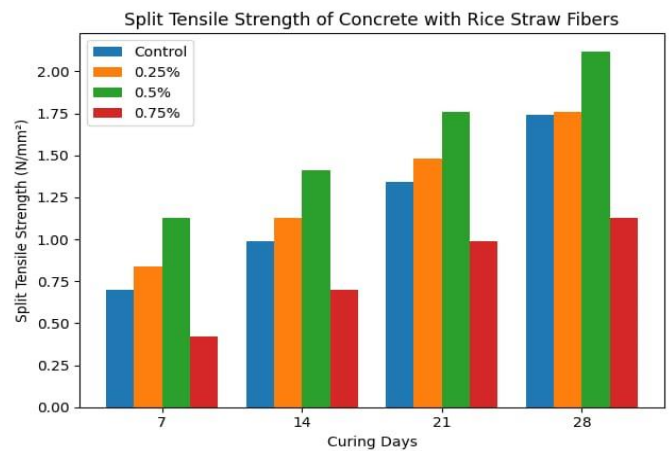


Chart -2: Comparison B/W Compression Test Values

4.3 COMPARISON B/W SPLIT TENSILE STRENGTH TEST VALUES

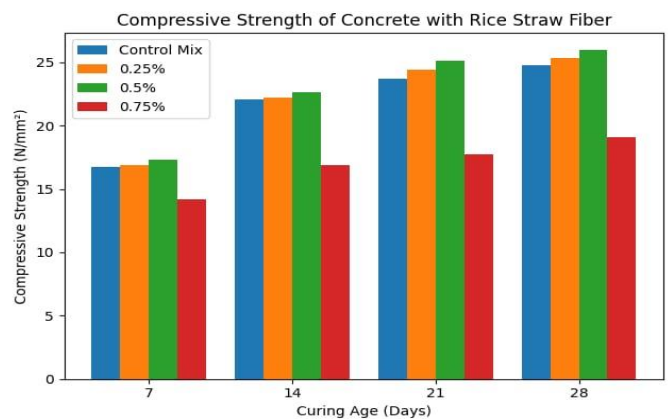


Chart -3: Comparison B/W Split Tensile Strength Test Values

5. CONCLUSIONS

1. The control mix showed 40 mm slump, but after adding SSD rice straw fibers, slump decreased to 20 mm (0.25%), 15 mm (0.5%), and very low at 0.75%, indicating reduced workability.
2. Even in SSD condition, increasing fiber content caused higher internal friction and

stiffness, making the concrete mix less workable, especially at higher percentages.

3. At 0.25% fiber content, compressive strength showed a slight increase compared to control mix: about 0.8% (7d), 0.6% (14d), 3.0% (21d), and 2.4% (28d).
4. At 0.5% fiber content, strength improvement was more significant: around 3.5% (7d), 2.6% (14d), 5.8% (21d), and 5.1% (28d), indicating better performance.
5. At 0.75% fiber content, compressive strength decreased drastically: about -15.1% (7d), -23.6% (14d), -25.1% (21d), and -22.8% (28d) compared to control mix.
6. Overall, adding SSD rice straw fibers improves strength up to 0.5%, but higher content (0.75%) leads to significant reduction due to poor bonding and fiber clustering.
7. At 0.25% fiber content, split tensile strength increased compared to control by about 20.0% (7d), 14.1% (14d), 10.4% (21d), and 13.5% (28d).
8. At 0.5% fiber content, the increase was significant, around 61.4% (7d), 42.4% (14d), and 31.3% (21d), and 36.8% (28d), showing maximum improvement.
9. At 0.75% fiber content, strength decreased by about -40.0% (7d), -29.3% (14d), -26.1% (21d), and -27.1% (28d) compared to control mix.
10. Overall, adding SSD rice straw fibers improves split tensile strength up to 0.5%, but higher content (0.75%) leads to reduction due to poor bonding and fiber clustering.

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BIOGRAPHIES



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