# Coconut Fiber-Infused Concrete: A Natural Boost For Strength And Durability

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## ABSTRACT

The growing demand for stronger and more cost-effective construction materials has led to the exploration of alternative reinforcements that improve mechanical properties while maintaining economic feasibility. Coconut fiber, an abundant natural material, has emerged as a potential reinforcement for concrete due to its ability to enhance toughness, crack resistance, and impact strength. This study investigates the effects of incorporating coconut fibers at varying percentages (1%, 1.5%, 2%, 2.5%, 3%, 3.5%, 4%, 4.5%, and 5% by cement weight) on the tensile and compressive strength of concrete. A series of controlled laboratory experiments were conducted to analyze the influence of fiber content on the structural integrity of concrete. The results reveal that the addition of coconut fiber significantly improves the tensile strength of concrete while maintaining acceptable compressive strength within an optimal fiber range. However, excessive fiber content may lead to workability challenges, affecting overall performance. The findings of this study contribute to the advancement of fiber-reinforced concrete technology by demonstrating the feasibility of utilizing coconut fiber as a sustainable and cost-effective reinforcement material. By optimizing fiber content, this research paves the way for enhanced concrete formulations that balance strength, durability, and resource efficiency in modern construction practices.

**Keywords:** Mechanical Properties, Eco-Friendly Materials, tructural ensile Strength, Coconut fiber.

## 1. INTRODUCTION

Concrete, despite its widespread use in construction, suffers from inherent brittleness, low tensile strength, and limited strain capacity, making it prone to cracking and structural failure. Traditionally, reinforcement in concrete is provided by steel bars, which help counteract tensile and shear stresses. However, fiber reinforcement offers an alternative approach by incorporating short, randomly distributed fibers into the concrete mix, enhancing its toughness, crack resistance, and durability. Among various fiber types, coconut fiber (coir) stands out as a promising reinforcement material due to its high ductility, biodegradability, cost-effectiveness, and availability. By repurposing waste fibers from coir-based industries, coconut fiber reinforced concrete (CFRC) not only improves the mechanical properties of concrete but also provides an eco-friendly solution to waste management. Research has shown that CFRC exhibits enhanced compressive strength, better energy absorption, and improved ductility, making it a viable material for structural applications. However, challenges such as uniform fiber distribution and increased mixing energy need to be addressed for optimal performance. This study explores the impact of coconut fiber addition on concrete properties, analyzing its potential as a reinforcement material in modern construction.

## 2. LITERATURE REVIEW

Coconut fibre is out there in abundance at the test site, which makes it quite viable as a reinforcement material in concrete. Further, it acts as a replacement source of income for the coconut producer who gets the advantages of the new demand generated by the development industry. In addition to the present , it's an efficient method for the disposal of coir mattress waste which can reduce the demand for extra waste disposal infrastructure and reduce the load on existing landfills and incinerators. The problem of high rate of water absorption of the fibre might be reduced by coating the fibres with oil. This has led to enhance the strength of concrete by the adoption of a natural fibre like Coconut Moreover the fibers have being natural in origin. The construction industry is revolutionizing in two major ways. One way is that the development of construction techniques, like using automated tools in construction. The other is that the advancement in high-performance construction materials, like the introduction of high strength concrete. In recent years, research and development of fibres and matrix materials and fabrication process related to construction industry have grown rapidly. Their advantages over other construction materials are their high lastingness to weight ratio, ability to be moulded into various shapes and potential resistance to environmental conditions, leading to potentially low maintenance cost. These properties make FRCB composite a good alternative for innovative construction. Their application in construction includes both upgrading existing structures and building new ones, which may apply to varied sorts of structure, for instance offshore platforms, buildings and bridges **(Thou, 2005).**

A major roadblock towards development of high performance concrete using steel fibres is that the high costs involved, availability and also problem of corrosion. Coconut fibre being the foremost ductile among all natural fibres **(Majid Ali et al.,2012)** has the potential to be used as a reinforcement material in concrete. It is biodegradable so the impact on environment will be minimal. This is also how to dispose off the fibres which are derived as waste materials from coir based manufacturing units to supply high strength materials .They are also non-abrasive in nature ,cheap and easily available. Research work is being carried out to find the possibility of coconut-fibre ropes as a vertical reinforcement in mortar-free interlocking structures. This is believed to be an economical solution to earthquakeresistant housing.

The coconut fibre is added to concrete and Plain Cement Concrete (PCC) is employed to study its effect on flexural, compressive and lastingness properties and also drying shrinkage. Fibre is coated with oil so on decrease the water absorption. Some of the benefits being observed are low-cost, rarity , reasonable specific strength, good thermal insulation, reduced wear and skill to be recycled with minimal impact on environment **(Majid Ali et al.,2011).** Thus additionally to the enhancement within the physical properties of concrete, it seems to be a sustainable waste management technique. Coconut fibre with a lastingness of 21.5 MPa is that the toughest among all natural fibres **(Munawar et al., 2003)**. They are capable of taking strains4–6 times higher than other fibres **(Munawar et al., 2003** The advantages of coconut fibre are : low cost, reasonable specific strength, low density, ease of availability, enhanced energy recovery, biodegradability, ability to be recycled in nature during a carbon neutral manner, resistance to fungi moth and decay , excellent insulation to sound, flame, moisture and dampness, toughness, durability, resilience.

Waweru nancy mugure was investigated on sugarcane fibre (1%, 2%, 3%) in concrete. He compared oven dried bagasse with sun light dried bagasse that is sun light bagasse is stronger than oven dried bagasse. Studied the fresh concrete properties like workability tests(slump cone test, compaction factor test) and harden concrete properties like compressive strength, split tension test ,flexural strength) slump values are 37 ,15,15,10 and compaction factors are0.95,0.95,0.90,0.85 for 0%, 1%,2%,3% respectively. Harden properties like Compressive strength, split tension test, flexural strengths are obtained at the age of 7,28 days. Compressive strengths at age of 28 days for 0%-15.6, 1% - 17.25, 2%-16,3%-7.For 1%-1.65MPa,2%-0.4MPa increased and for 3% it is deceased. split tension strength for 0%-1.41, 1%-1.48,2%-1.27,3%-0.42MPa.Flexural strength are for 0%-0.747,1%-1.676,2%-0.747,3%-0.687MPa. Plain concrete (control) compared with bagasse fibre reinforced concrete at 7days of curing; addition of bagasse fibre is seen to reduce the compressive strength consistently. Tests after 28days of curing show that the compressive strength increases as fibre is increased to an optimum of 1%, where the strength starts to drop with more increase of the fibre. The compressive strength is increased by up to 10.6% compared to that of the control. The tensile strength was highest at 1.48N/mm2 for a fibre content of 1% at 28days of age.

**M. Sivaraja (march 2010):** was investigated on natural fibers he was used 0.5%,1%,1.5% in concrete with aspect ratios of 30,60,90.He gives relation compressive strength, flexural strength, split tension for bagasse reinforced concrete

**Reis, ferreira (2006):** were reported that the choppe sugarcane fibers increase the fracture properties- both fracture toughness and fracture energy of concrete**. S**ugarcane fibres slightly increase the flexural strength (3.5 %).

David stephen was used 1%, 2%, 3% of sugarcane fibres in cement mortar . he said that the dry bagasse fibers float on water indicating a bulk density less than one. An approximate value of 0.5 (considered adequate for preliminary purposes) was eventually found by using a density bottle. and he studied that the standard slump cone test gave slumps ranging from 80mm for the unreinforced mix down to 35mm for the mix with 3 percent fibers. He tested compressive strength, tension strength and impact resistance for 14,42,56,84 day for air cured as well as water cured cubes. Compressive strengths are 1.34, 1.37, 1.32, 1.27 for 0%,1%,2%,3% respectively. Impact resistance values are 5.67, 10.3, 12.0, 16.0 and the percentage for plain concrete is 81,211,282 for 1%,2% and3% respectively. (a) Water cured 14 day strength 0.23, 0.25, 0.17, 0.17. 42 day strength 0.32 0.36, 0.15, 0.21. 56 day strength 0.32, 0.32, 0.19, 0.2. 84 day strength 0.40, 0.38, 0.24, 0.23 (b) Air cured 14 day strength 0.23, 0.34, 0.15, 0.19. 42 day strength 0.29, 0.41, 0.20, 0.18. 56 day strength 0.29, 0.39, 0.20, 0.17.84 day strength 0.32, 0.41, 0.23, 0.21 for 0,1,2,3% respectively. According to this thesis air cured cubes stronger than water cured cubes for bagasse fibers.control (1.41 N/mm2).The tensile strength also reduces as the fibre content is increased beyond the optimum. The flexural strength results indicate that addition of bagasse fibre increased the flexural strength of the concrete mass by up to 56.2% 9 (i.e. from 0.747N/mm2 to 1.167N/mm2) at 2% bagasse fibre content (for 28days).This is the same as was for 2% coir fibre. It is seen that at 7days of age the optimum fibre content is seen to be 2%.We use the optimum of 1% as concrete is assumed to attain its highest strength at 28days of curing. Just like as discussed above, additional of fibre increase flexural strength up to the optimum. Bhatia studied the usefulness of fibre reinforced concrete in various civil engineering applications. Fibres include steel fibre, natural fibres and synthetic fibre search of which lends varying properties to the concrete. The study revealed that the fibrous material increases the structural integrity.

**Chouw et al.** studied the viability of using coconut-fibre ropes as vertical reinforcement in mortar-free low cost housing in earth quake prone regions. The rope anchorage is achieved by embedding it within the foundation and top tie-beams. The bond between the rope and therefore the refore the concrete plays a crucial role within the stability of the structure and the rope lastingness is additionally found to be fairly high. The rope tension generated due to earthquake loading should be less than both the pull out force and the rope tensile load to avoid the structure collapse. The study concluded that the pull out energy increases with an increase in embedment length, rope diameter, cement and fibre content in the matrix. Li et al. studied fibre volume fraction by surface treatment with a wetting agent for coir mesh reinforced mortar using non-woven coir mesh matting. They performed a four-point bending test and concluded that cementitious composites, reinforced by three layers of coir mesh with a low fibre content of 1.8%, resulted in 40% improvement in flexural strength compared to conventional concrete. The composites were found to be 25 times stronger in flexural toughness and about 20 times higher in
flexural ductility. (**Kelleret al., 2005)** investigated the shear behaviour of ferroconcrete beams strengthened by the attachment of various configurations and quantities of carbon fibres. The study revealed that the strengthening by using carbon fibres increased the resistance to shear and also spalling of concrete.

**Shreeshail. B H, et al (2014)** conducted a study on concrete reinforced with coir fiber. The coir fibers of different proportions and lengths are studied. The proportions of 1, 2, 3 and 4 % weight of cement and length of 1.7 and 2.8 cm were used and considered the mix design of M30. From the study it was concluded that, 1% and 3% coconut fiber has given lesser compressive strength when compared to 2%.
Higher fiber content in CFRC might have caused voids resulting in decreased compressive strength. **Thandavamoorthy, et al (2013)** conducted a study on the concrete reinforced with steel fiber (4%), polypropylene fiber (4%), hybrid fiber that enclose (2% steel fiber and 2% polypropylene fiber). The results of those fibers were compared with standard concrete. The test results showed that the addition of steel and polypropylene fibers to concrete reveal better concert. Results of water absorption test for SFRC and hybrid specimen were same as that of normal concrete. But in the case of polypropylene fiber reinforced concrete, it was 4% booster than normal concrete.

**Srinivasa Rao et al (2012)** investigated the durability studies on glass fiber reinforced concrete
(GFRC). The results showed that there was an increase in the durability of the concrete by adding together these glass fibers in concrete. Addition of glass fibers in concrete gave a reduction in bleeding, and also enhanced the resistance of concrete to the assault of acids.

Maximum improvement in durability of concrete with different percentage of glass fibers was observed at 28 days and 90 days at 0.1% for all grades of concrete. Chloride permeability of glass fiber reinforced concrete showed less permeability of chlorides into concrete when compared with ordinary concrete.

**Venkat Rao et al (2013)** carried out an investigational study on durability of high strength self-compacting concrete (HSSCC). The sulphate attack effect on concrete and confrontation of concrete to the attack had been experienced in the laboratory, by immersing specimens of concrete cubes in the solution which encloses 5% sodium sulphate. The chemical attack effect had been estimated by taking adjustment of mass in to consideration. The sulphate attack effect on performance and properties of concrete were acknowledged. Even from the optical surveillance, the intensity of sulphate attack on cracking and the impact of breakdown were noticed.

**Vijaya Sekhar Reddy et al (2012)** conducted studies on the test specimens of 15 cm x 15 cm x15 cm cubes were immersed in 5% of sodium hydroxide solution over a period of 90 days. The effect of alkali attack on performance and properties of concrete were found out. Percentage decrease in weight after 28 days was found to be 10.32%.

**Desai et al (2012)** conducted a study on durability properties of fiber reinforced concrete on marine structures. In this study the properties of fiber reinforced concrete were compared with those of conventional concrete and also its environmental effects on durability of concrete. Results showed that the addition of polypropylene triangular fibers improved the durability of concrete. Compressive strength of concrete increases with increase in fiber dosage up to 0.3%, then it starts diminishing. So the best possible percentage fiber found from experiment was 0.3%.

**Kokseng Chia et al (2002)** accomplished an investigational study on the water permeability and
chloride permeability of high strength light weight concrete (LWC) in comparison to that of normal strength concrete with or without silica. Results were compared with LWC and NWC (Normal Weight Concrete) at a normal strength of about 30- 40MPa. The water penetrability of the LWC with a w/c of 0.55 was lower than that of the equivalent NWC, when the concrete was subject to a pressure of 4 MPa when the strength level reached 30-40 MPa. The water penetrability of the high-strength LWC and NWC with a w/c of 0.35 was of the same order regardless whether silica fume was incorporated. The results point out that the resistance to the chloride dissemination does not seem to be concurrent to the water permeability of the concrete.

**Dr. M. Sivaraja et al (2009)** accomplished an investigation and concluded that the fibers recovered from various waste stream are suitable to use as secondary reinforcement in concrete. The advantage of using such rural fibers provides generally a low cost construction than using virgin fibers and the elimination of the need for waste disposal in landfills.

**Izad Amir Bin Abdul Karim et al (2012)** made a study on the coconut fibers. They stated that
coconut fibers have in chemical composition although lignin content is higher and cellulose content is lower. The use of coconut waste from the dispose of coconut fibers

could be a useful material in the formation of an admixture for housing construction. Therefore, in-depth study will be made to ensure the appropriate use coconut wastesuch as coconut fibers by conducting some experiment so as to obtain good result.

**Yalley, P. P. and Kwan et al (2008)** The Addition of coconut fibers improves the properties of concrete, notable torsion, toughness and tensile strength. The ability to resist cracking and spalling were also enhanced. However, they concluded that the addition of fibers adversely affects the compressive strength due to difficulties in compaction which consequently led to increase of voids.

## 3. PROPOSED SYSTEM

The proposed system focuses on incorporating coconut fibers into concrete to enhance its mechanical properties, such as tensile strength, compressive strength, ductility, and crack resistance. The primary objective is to determine the optimal fiber content that maximizes strength while maintaining workability. This system involves:

1. **Material Selection and Preparation:**
   - Cement, fine aggregate (sand), coarse aggregate, and coconut fibers are selected based on standard concrete mix design specifications.
   - Coconut fibers are cleaned, treated (if necessary), and cut into uniform lengths to ensure consistency in mixing.
2. **Concrete Mix Design with Coconut Fibers:**
   - Conventional concrete is prepared using the standard mix ratio.
   - Coconut fibers are added in varying percentages (0.3% to 5% by volume) to determine their effect on mechanical properties.
   - Proper water-cement ratio is maintained to ensure workability.
3. **Mixing and Casting:**
   - The ingredients are thoroughly mixed to achieve uniform fiber distribution.
   - The fresh concrete is poured into molds for different strength tests (cube molds for compressive strength, beam molds for flexural strength, etc.).
   - The specimens are compacted to minimize voids and ensure structural integrity.
4. **Curing Process:**
   - The specimens are cured for 7, 14, and 28 days in a controlled environment to allow the concrete to gain strength.
5. **Testing and Analysis:**
   - **Compressive Strength Test:** Determines the ability of CFRC to withstand axial loads.
   - **Tensile Strength Test:** Evaluates resistance to tensile forces and crack propagation.
   - **Flexural Strength Test:** Measures the concrete’s bending capacity under load.
   - **Durability Assessment:** Evaluates resistance to environmental degradation, water absorption, and shrinkage.
6. **Comparative Analysis:**
   - The performance of CFRC is compared with conventional concrete to assess improvements in mechanical properties.

- The optimal fiber percentage is determined based on experimental results.

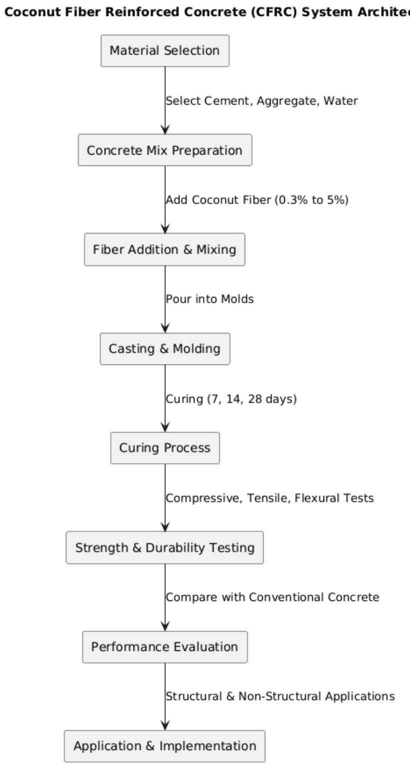


Figure 1 Presents the Block Diagram of Proposed System.

## 4. RESULTS AND ANALYSIS

### 4.1 Fresh properties of concrete

Slump Test is conducted for various concrete mix containing coconut fibre. The study on slump test helps us to know the amount of water required to obtain a concrete mix with good workability. The slump value for concrete with 1%, 1.5%, 2%, 2.5%, 3%, 3.5%, 4%, 4.5% and 5% coconut fibre. The test results given in below table 4.1.

**Table 5.1: Slump cone test**

| Cocounut fiber(%) | Slump (mm) |
|---|---|
| Control mix | 120 |
| 1 | 110 |
| 1.5 | 105 |
| 2 | 98 |
| 2.5 | 93 |
| 3 | 85 |
| 3.5 | 82 |
| 4 | 78 |
| 4.5 | 72 |

| | |
|---|---|
| 5 | 70 |

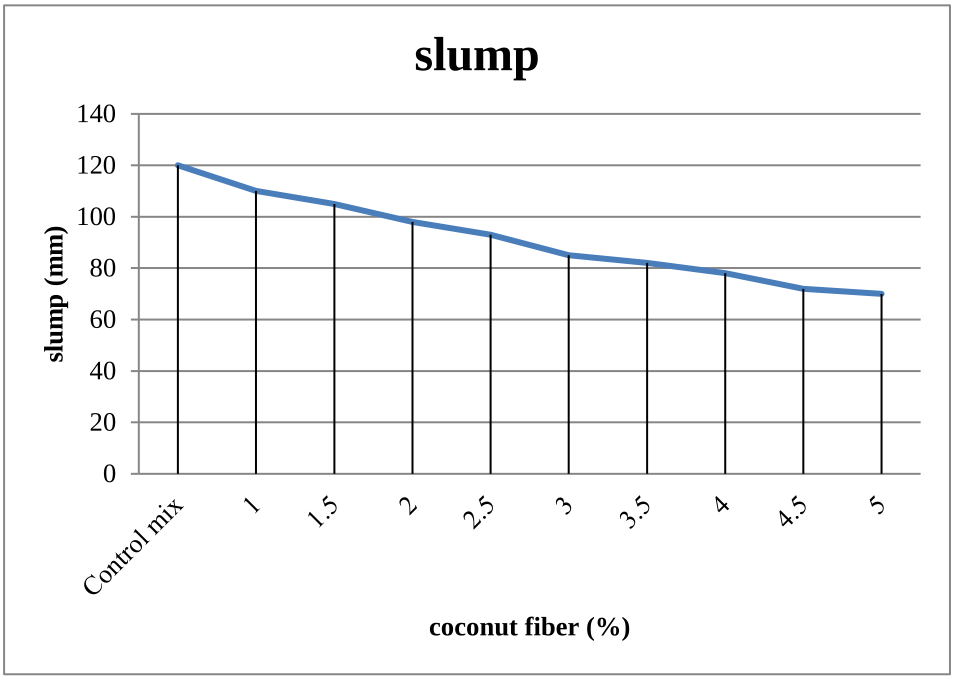


**Fig 5.1: Slump test**

The control mix has a slump value of 120 mm. It isobserved that concrete with increasing percentages of coconut fibre has decreasing slump value. Thus, lesser the amount of coconut fibre better will the workability.

### 4.2 Harden properties of concrete

### 4.2.1 Cubes Compressive strength

Compressive strength tests were conducted on standard cubes of dimension 15cm x 15cm x 15cm specimens each for plain concrete and coconut fiber reinforced concrete were cast at varying percentages of fiber (1%, 1.5%, 2% 2.5%, 3%, 3.5%, 4%, 4.5% 5%). For each combination of coconut fiber addition in concrete, nine specimens were tested.

**Table 4.2:Cubes Compressive strength (N/mm$^2$)**

| **Coconut fiber (%)** | **7days** | **14days** | **28days** |
|---|---|---|---|
| Control mix | 41 | 56.1 | 62.1 |
| 1 | 43 | 58.2 | 64.8 |
| 1.5 | 46 | 59.5 | 65.8 |
| 2 | 44 | 57 | 63.5 |
| 2.5 | 40 | 52 | 61.72 |
| 3 | 35 | 49.2 | 58.2 |
| 3.5 | 31 | 45.64 | 54 |
| 4 | 28 | 42.34 | 51.8 |

| | | | |
|---|---|---|---|
| 4.5 | 25.3 | 36.2 | 48.45 |
| 5 | 20 | 32.84 | 45 |

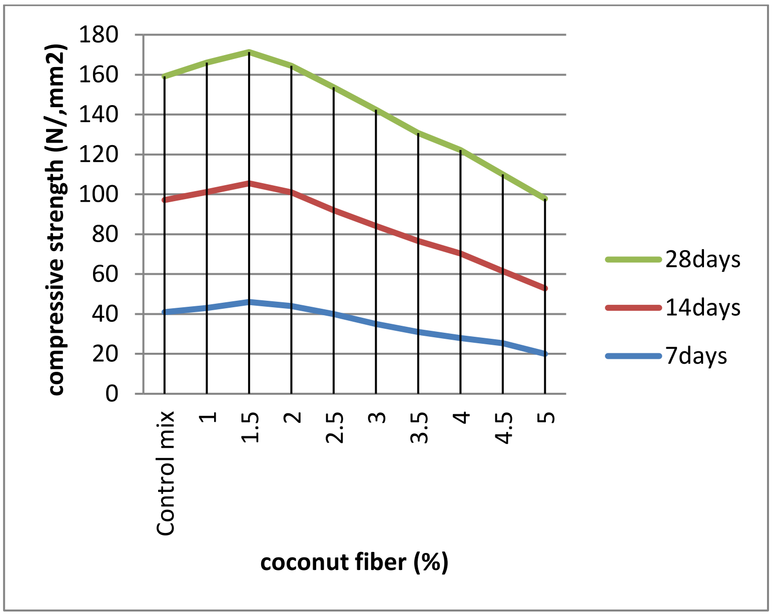


**Fig 4.2:Cubes Compressive strength**

**Fig 4.3:compressive strength test specimen**

The compressive strength of various concrete mix containing coconut fibres 1%, 1.5% & 2% got more compressive strength compare to control mix.

### 4.2.2 Cylinder tensile strength

Tensile strength tests were conducted on standard cylinders of dimension 15cm dia x 30m height specimens each for plain concrete and coconut fiber reinforced concrete were cast at varying percentages of fiber (1%, 1.5%, 2% 2.5%, 3%, 3.5%, 4%, 4.5% 5%). For each case the 28day strength values were obtained by loading under apparatus for tensile strength. For each combination of coconut fiber addition in concrete, three specimens were tested.

**4.3 Tensile strength (N/mm$^2$)**

| Cocounut fiber(%) | 28days |
|---|---|
| Control mix | 8.42 |
| 1 | 8.44 |
| 1.5 | 8.58 |
| 2 | 8.52 |
| 2.5 | 8.43 |
| 3 | 8.31 |
| 3.5 | 8.18 |
| 4 | 7.78 |
| 4.5 | 7.55 |
| 5 | 7.32 |

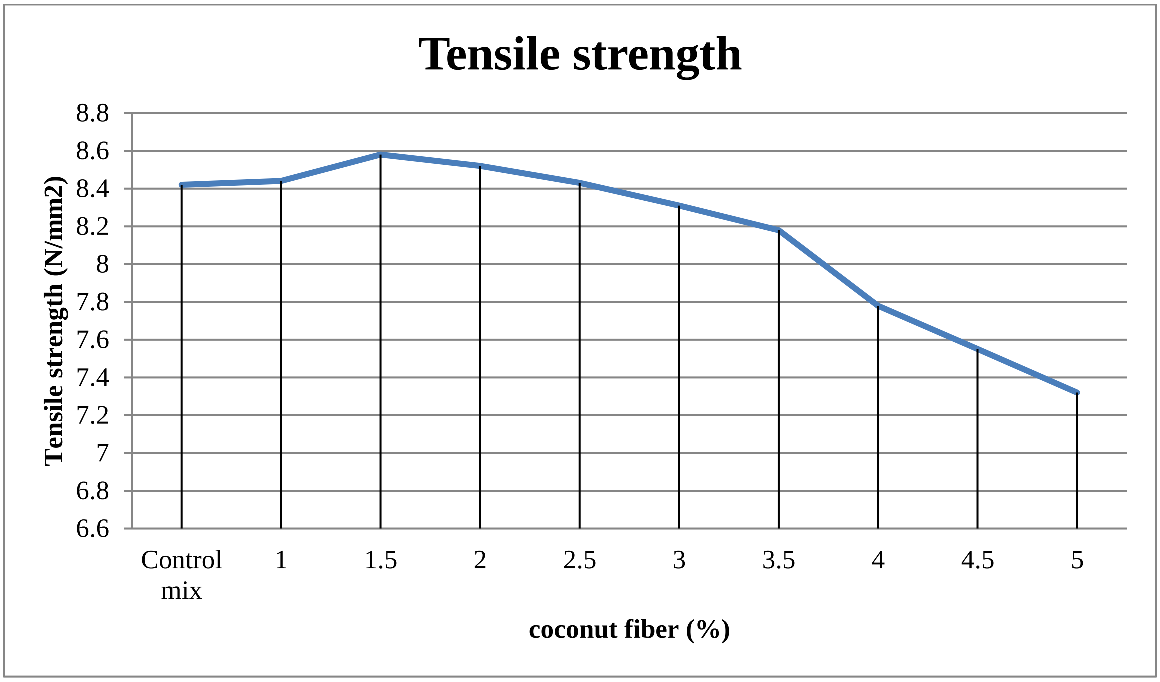


**Fig 4.4: Cylinder tensile strength**

The Tensile strength of various concrete mix containing coconut fibres 1%, 1.5% & 2% got more compressive strength compare to control mix.

## CONCLUSION

The experimental investigation on coconut fiber reinforced concrete (CFRC) highlights its potential as a viable and eco-friendly reinforcement material. The study revealed that while the workability of CFRC is slightly reduced compared to conventional concrete, adding 1.5% coconut fibers significantly enhances compressive strength. However, beyond 3% fiber content, uniform distribution becomes challenging, leading to balling effects and reduced performance. CFRC exhibits a stronger bond between the matrix and fibers, lower density, and improved crack resistance, making it a lightweight and durable alternative. Additionally, the reduced evaporation losses and minimized micro-cracking contribute to enhanced durability. Based on these findings, incorporating 1.5% coconut fiber in concrete is recommended for construction applications, offering a balance between strength, durability, and sustainability while also supporting waste management and economic benefits for coconut producers.

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