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Fiber Reinforced Concrete Fencing Poles

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Abstract

The paper discusses the historical use of fencing poles constructed from diverse materials like timber, wood, stone, RCC and plastic. It highlights the drawbacks of certain materials, such as timber being susceptible to termites. In modern times, RCC (Reinforced Cement Concrete) fencing poles are extensively used, but they lack high flexural strength. The study proposes adding fibres (coconut and steel) to the concrete to enhance flexural strength, addressing the weakness of concrete in tension. The goal is to produce economical and eco-friendly concrete poles with improved properties compared to conventional ones. The research involves casting poles with different fibre types and volume fractions, conducting tests on compressive and flexural strength with M25 grade concrete. Overall, the study aims to provide a better alternative to traditional concrete poles by incorporating fibres and optimizing their proportions for enhanced strength and durability.

Keywords: Reinforced Cement Concrete (RCC) • Fine aggregate • Coarse aggregate • Coconut fibres • Cement

Introduction

Fencing poles, serving as a vital component in various construction applications and has evolved over time with diverse materials to meet structural demands. This research mainly involves in the exploration of various materials utilized for fencing poles and highlights the problems with the common materials used such as wood, stone, concrete and plastic. The advantages of Fiber reinforced materials include high strength-to-weight ratio, corrosion resistance, and high fatigue resistance [1]. Notably, timber's vulnerability to termites and RCC's inherent limitation in flexural strength have spurred the need for innovative solutions to increase the performance of these essential elements in construction [2].

In the contemporary construction practices, Reinforced Cement Concrete (RCC) poles have gained significant importance but their deficiency in high flexural strength remains a notable concern [3]. Acknowledging the drawbacks, current study proposes a progressive approach to increase in the mechanical properties of RCC fencing poles by incorporating fibers into the concrete mix. Specifically, coconut and steel fibers are identified as potential reinforcements, offering the promise of addressing the tension-related weaknesses inherent in conventional concrete. The goal of this research is to develop economical and eco-friendly concrete poles that surpass the limitations of traditional alternatives. However, a limited number of research studies have been conducted on the application of coconut fibre for the reinforcement of fencing poles. By strategically introducing fibers, this study aims to enhance the flexural strength of the poles, thus bolstering their overall durability and performance [4]. This research aims to develop a method that offers a viable alternative to conventional concrete poles, addressing their shortcomings and striving for an improved, sustainable solution. To achieve these objectives, the study employs a meticulous research methodology involving the casting of poles with varying types and volume fractions of fibers. Subsequent comprehensive testing, particularly focusing on compressive and flexural strength, is conducted with M25 grade concrete. Through this systematic approach, the research endeavors to pinpoint the most effective combination of fiber types and quantities that will yield superior strength characteristics. By contributing insights into the integration of fibers, the study aims to pave the way for the development of fencing poles that not only surpass the traditional counterparts but also align with economic and eco-friendly principles [5].

Materials and Methods

Cement: The cement utilized for this work was 53 grade ordinary Portland cement, which acts like a binding material in the concrete.

Fine aggregate: Fine aggregate refers to material with a size smaller than 4.75 mm. In this experimental work, sand is used as the fine aggregate, which provides a greater surface area for the binding

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material film to adhere and spread. The sand used in this is passed through 4.75 mm sieve and retained of 2.35 mm sieve [6].

Coarse aggregate: Coarse aggregate refers to the material with size larger than 4.75 mm. In this experimental work, gravel is used as the coarse aggregate, which covers a major volume in the concrete and provides more strength to the concrete. The gravel used in this work passes through the 20 mm sieve and retained on 12 mm sieve.

Steel reinforcement: The steel reinforcement employed in the steel-reinforced concrete comprises of steel bars, commonly referred as rebars. In this work, 8 mm diameter bars are used as longitudinal bars and 6 mm diameter bars are used as stirrups.

Steel fibres: Crimped steel fibres are used in this work. Crimped steel fibres, made from high-strength steel, reinforce concrete. Their wave-like structure bolsters tensile strength and toughness, which reduces cracks and improves durability [7,8].

Coconut fibres: Coconut fibres, extracted from coconut husks, which act as natural reinforcement in various applications. Their strong and durable nature add toughness to materials like concrete. These fibres, also known as coir fibres, offer eco-friendly and sustainable solutions for improving tensile strength in concrete (Table 1).

Table 1. Specific gravity of different materials.

Materials	Specific gravity of materials
Cement	3.15
Fine aggregate (sand)	2.65
Coarse aggregate (gravel)	2.8

The process begins with the mixing of binding material, such as cement, alongside fine aggregate (sand), coarse aggregate (gravel), water and reinforcing fibres. This results in a carefully prepared concrete mix. The next step involves casting this prepared mix into cubes and beams, ensuring uniformity and precision in the shaping process.

Following the casting, the cubes undergo a crucial curing period of 28 days. This duration is essential for the concrete to attain its optimal strength and durability. Curing involves maintaining specific environmental conditions, typically involving moisture and temperature control, to facilitate the chemical reactions within the concrete mixture.

After the curing period, the cubes and beams are subjected to testing, to calculate their compressive strength and flexural strength respectively.

Results and Discussion

Tests conducted

Compressive strength: Cubes measuring 100 × 100 × 100 mm are cast using the appropriate M25 mix proportions determined by the mix design. These cubes are then cured 28 days and the compressive strength of these cubes are determined using a compressive testing machine with a capacity of 400 KN (Tables 1-9) [9].

Calculation

Compressive strength=P/A

Whereas

P=Load

A=Area

Flexural strength

Beams measuring 500 × 100 × 100 mm are cast using the appropriate M25 mix proportion determined by mix design. These prisms are then cured for 28 days and the flexural strength of these prisms are determined using a Universal Testing Machine with a capacity of 40 tonnes (Tables 2-9 and Figures 1-6) [10,11].

Calculation

Flexural strength= $PL/(bd^2)$

Where as

P=load

L=Length of the prism

b=Breadth of the prism

d=Depth of the prism

Table 2. Flexural strength analysis for plain cement concrete.

Sample	Weight (kgs)	Load (KN)	Flexural strength (N/mm^2)	Average flexural strength (N/mm^2)	Crack from the nearer support (cm)
1	12.27	56 × 0.25=14	7	6.7	22
2	12.5	50 × 0.25=12.5	6.25		17
3	12.3	55 × 0.25=13.75	6.875		16

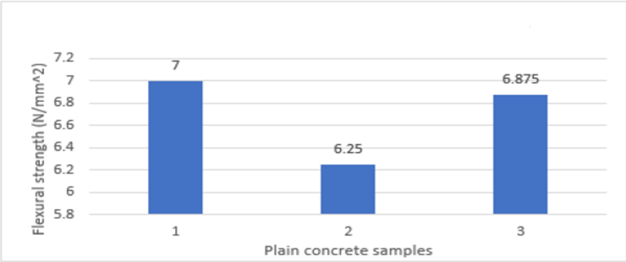

Figure 1. Flexural strength of prisms of 28 days.

Table 3. Compressive strength analysis of plain cement concrete.

Sample	Weight (kgs)	Load (KN)	Compressive strength (N/mm^2)	Average compressive strength (N/mm^2)
1	2.614	282	28.2	27.9
2	2.5	276	27.6	
3	2.6	279	27.9	

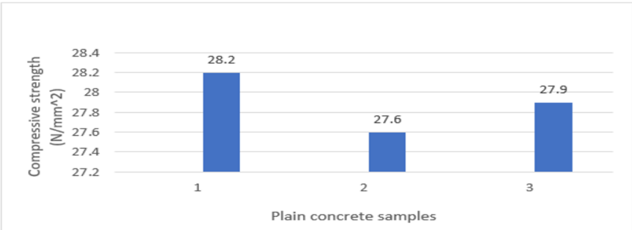

Figure 2. Compressive strength of cubes for 28 days.

Table 4. Conventional steel reinforced concrete flexural strength results.

Sample	Weight (kg)	Load (KN)	Flexural strength (N/mm^2)	Average flexural strength (N/mm^2)	Crack in cm from the nearer support
1	13.27	31	15.5	15	13.6
2	13.5	30	15		13
3	13	29	14.5		14

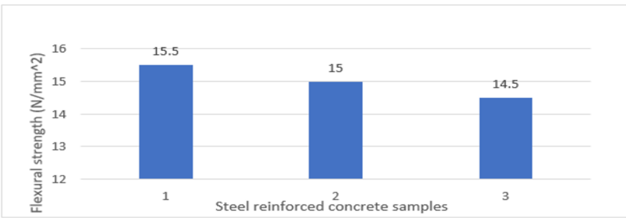

Figure 3. Flexural strength analysis of prisms for 28 days.

Table 5. Steel fibre reinforced concrete flexural strength results.

Percentage of fibers	Weight (kgs)	Load (KN)	Flexural strength (N/mm^2)	Average flexural strength (N/mm^2)	Crack in cm from the nearest support (cm)
0.50%	12.67	59 × 0.25=14.75	7.25	6.91	17.8
0.50%	12.64	50 × 0.25=12.50	6.25		18.5
0.50%	12.01	58 × 0.25=14.50	7.25		17.7
0.75%	13.305	76 × 0.25=19.00	9.5		14
0.75%	12.75	66 × 0.25=16.50	8.25	8.25	16
0.75%	12.69	56 × 0.25=14.00	7		16.5

1%	12.73	73 × 0.25=18.25	9.13		18.5
1%	12.95	71 × 0.25=17.75	8.88	9.13	15.5
1%	13.44	75 × 0.25=18.75	9.38		16.5

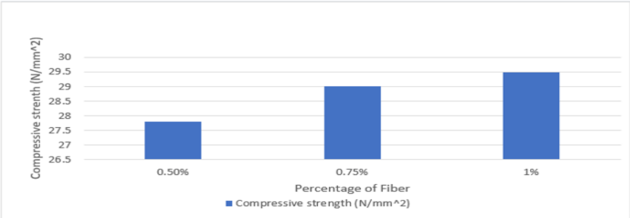

Figure 4. Percentage of fiber *vs.* compressive strength (N/mm^2).

Table 6. Steel fibre reinforced concrete compressive strength results.

Percentage of fibers	Weight (kgs)	Load (KN)	Compressive strength (N/mm^2)	Average compressive strength (N/mm^2)
0.50%	2.688	260	26	27.46
0.50%	2.646	274	27.4	
0.50%	2.649	300	30	
0.75%	2.714	306	30.6	29
0.75%	2.41	304	30.4	
0.75%	2.542	260	26	
1%	2.754	274	27.4	29.4
1%	2.554	300	30	
1%	2.504	310	31	

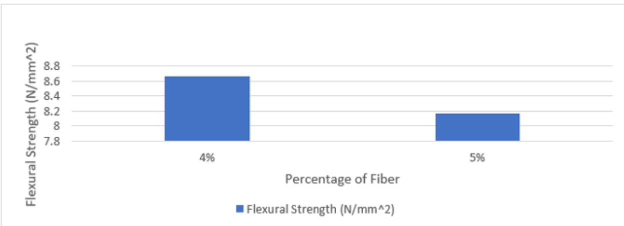

Figure 5. Percentage of fiber *vs.* flexural strength (N/mm^2).

Table 7. Coconut fibre reinforced concrete flexural strength results.

Percentage of fibres	Weight (kgs)	Load (KN)	Flexura strength (N/mm^2)	Average flexural strength (N/mm^2)	Crack in cm the nearest support (cm)
4%	11.5	17 × 1=17	8.5	8.66	16
4%	11	19 × 1=19	9.5		12.5
4%	11.23	16 × 1=16	8		21
5%	11.86	16 × 1=16	8	8.16	16.5
5%	11.5	16 × 1=16	8		23
5%	11.42	17 × 1=17	8.5		15.5

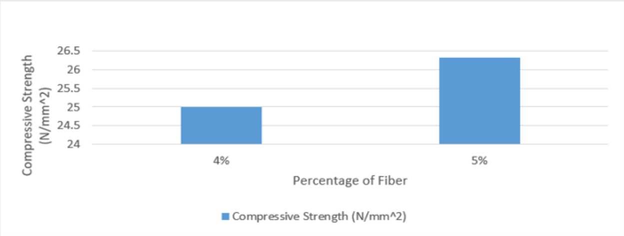

Figure 6. Percentage of fiber *vs.* compressive strength (N/mm^2).

Table 8. Coconut fibre reinforced concrete compressive strength results.

Percentage of fibers	Weight (Kgs)	Load (KN)	Compressive strength (N/mm^2)	Average compressive strength (N/mm^2)
4%	2	250	25	25
4%	2.05	240	24	
4%	2.12	260	26	
5%	2.15	280	28	26.33
5%	2.22	250	25	
5%	2.3	260	26	

Table 9. Cost analysis for different types of fencing poles.

Type of fencing pole	Cost of fencing pole in Rs
Steel reinforced concrete	420/-
Steel fiber-reinforced	305/-
Coconut fiber-reinforced	110/-

Conclusions

The following conclusions are derived from the experiments that are conducted on various fiber reinforced concrete:

- The flexural strength of the steel fiber-reinforced concrete increases up to 0.75% of fibers. However, beyond 0.75% of steel fibers, the flexural strength of the steel fiber-reinforced concrete begins to decrease.
- The compressive strength of steel fiber-reinforced concrete continues to increase with the addition of percentage of steel fibers, even beyond 0.75% of steel fibers, however the maximum percentage of steel fibers that be used in the concrete is 1% of the total volume of the concrete.
- The steel fiber-reinforced concrete achieved a flexural strength of 65% that of conventional reinforced concrete while costing 27% less than steel-reinforced concrete.
- The flexural strength of the coconut fiber-reinforced concrete increases with the increase in the percentage of coconut fibers.
- The compressive strength of the coconut fiber-reinforced concrete also increases with the increase in the percentage of the coconut fibers, but as the percentage of coconut fiber increases, it becomes difficult to integrate them into the concrete.
- The coconut fiber-reinforced also achieved a flexural strength of 65% that of conventional reinforced concrete while costing 73% less than the steel-reinforced concrete.

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