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# Comparative Study on Normal and Steel Fibre Reinforced Concrete

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## Abstract

Steel fibre reinforced concrete (SFRC) is a composite of cement, fine aggregate, coarse aggregate, water and dispersion of discontinuous steel fibre which is one of the best crack resisting building materials. This study examines the influence of binding wire used as steel fibres on the compressive strength of M25 grade concrete. Steel fibres were incorporated at varying proportions of 0%, 1%, 1.25%, 1.5%, and 1.75% by the dry weight of cement, and cube specimens were tested at 7, 14, and 28 days in accordance with IS 516:1959. The results indicate a consistent improvement in compressive strength with the addition of fibres up to an optimum level. The maximum 28-day strength of 27.49 N/mm² was obtained at 1.5% fibre content, representing a significant enhancement over the control mix (24.67 N/mm²). This improvement is attributed to the ability of steel fibres to bridge microcracks, enhance energy absorption, and improve the concrete's load-carrying capacity. Fibre contents beyond 1.5% led to a slight reduction in strength, likely due to reduced workability and non-uniform fibre dispersion. Overall, the study demonstrates that binding wire can be effectively utilized as a low-cost steel fibre, with 1.5% identified as the optimal dosage for achieving superior mechanical performance and enhanced crack resistance.

**Keywords:** Concrete, Binding wire, Compressive strength, Cement

## Introduction

Concrete is one of the most widely used construction materials, traditionally strengthened using steel reinforcement bars. In recent decades, fibres have emerged as an effective means to enhance the ductility and crack-resisting ability of concrete. Steel fibre reinforced concrete (SFRC) is produced by incorporating small, uniformly distributed steel fibres of various shapes and dimensions into the concrete matrix, which significantly improves its mechanical performance. Earlier studies consistently indicate that steel fibres offer higher strength and toughness compared to glass, polymer, or other synthetic fibres. The present study focuses on evaluating binding wire as an alternative form of steel fibre to identify its optimum dosage for achieving improved strength while maintaining economic viability. The concept of fibre reinforcement has existed for thousands of years, with early civilizations using natural fibres in construction materials. In the early 20th century, asbestos cement became the first widely

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adopted manufactured composite, paving the way for modern fibre-reinforced materials. Today, steel fibres remain the most popular choice, although synthetic fibres are also gaining prominence. Mechanical behaviour of fibre-reinforced concrete is often described through strain-hardening where tensile stress increases after initial cracking or strain-softening, where the stress decreases after cracking. Previous works, such as Vikrant S. Vairagade (2012), examined M20 concrete containing 0–0.5% hook-end steel fibres and reported notable improvements in compressive and tensile strength compared to the control mix. Similarly, Prasad Karunakaran (2017) studied M25 concrete with 0.5% fibres and observed enhanced compressive performance. In this context, the present research aims to systematically investigate the effect of binding wire fibres on concrete properties, establish the optimal fibre content, and provide clarity on how fibre reinforcement can be effectively integrated to improve structural performance.

## Material and Methodology

### Material

#### Cement

For this study, Portland Slag Cement (PSC) of ACC brand was purchased from the local market in Dumka to ensure material availability similar to field conditions. The cement properties were tested as per IS standards, as shown in the Table 1.

Table 1: Properties of cement

| | |
|---|---|
| Type | PSC |
| Brand | ACC |
| Consistency | 33 % |
| Initial Setting Time | 39 Minutes |
| Final Setting Time | 582 Minutes |
| Fineness | 7 % |
| Soundness | 6.9 mm |
| Density | 1440 kg/m3 |

#### Fine Aggregate

Fine aggregate plays an essential role in concrete and mortar by filling the spaces between coarse particles and helping achieve better strength, workability, and surface finish. In this study, natural river sand available locally was used as the fine aggregate to reflect real construction conditions. To assess its suitability, standard tests were carried out in accordance with IS 383:1970 and IS 2386:1963. The key properties obtained from these tests are summarized in Table 2, confirming that the sand meets the necessary requirements for concrete production.

Table 2 Properties of fine aggregate

| | |
|---|---|
| Density | 1600 kg/m3 |
| Zone | II |
| Bulking of sand(Moisture) | 9 % |

**Coarse Aggregate**

Coarse aggregates form the backbone of concrete, providing essential strength, stiffness, and long-term durability. Their size, shape, and texture significantly influence the overall behaviour of the mix. In this study, crushed angular stone chips with a nominal maximum size of 20 mm were used, as they are commonly available and offer good interlocking. To ensure their suitability, standard tests were performed following IS 383:1970 and IS 2386:1963. The results of these tests, presented in Table 3, confirm the aggregate's quality for concrete production.

Table 3: Properties of coarse aggregates

| | |
|---|---|
| Density | 1800 kg/m3 |
| Impact value | 9 % |
| Fineness Modulus | 2.58 |
| Zone | IV |

**Steel Fibre**

Steel fibres are thin, uniformly distributed steel filaments added to concrete to enhance its mechanical behaviour, particularly its strength, toughness, and resistance to cracking. They are widely used in applications such as industrial floors, airport pavements, bridge decks, and tunnel linings due to their ability to improve performance beyond what conventional reinforcement alone can provide. In this study, ordinary carbon steel binding wires were cut into small pieces and used as steel fibres, offering a simple and economical alternative. The specific properties of these binding-wire fibres are listed in Table 4.

Table 4: Properties of binding wires

| | |
|---|---|
| Density | 7840 kg/m3 |
| Diameter | 0.78 mm |
| Length | 60 mm |
| Aspect ratio | 76.92 |

**Methodology**

M25 refers to a concrete mix designed to achieve a characteristic compressive strength of 25

N/mm² after 28 days of curing. Although the nominal proportion of 1:1:2 is widely used for this grade, trial mixes are essential to ensure the desired strength and workable consistency in actual conditions. In this study, all concrete specimens were prepared using this nominal mix ratio. Based on these proportions, the calculated material requirements for producing 1 m³ of concrete are presented in Table 5.

Table 5: Proportion for 1m³ concrete

| | |
|---|---|
| Grade of Concrete | M25 |
| Slump | 78mm |
| Size of Coarse aggregate | 20mm |
| Cement | 554.04 kg |

To determine the effects of binding wire as a fire on compressive strength and flexural strength of concrete, cubes of 150mm×150mm×150mm beams of size 500mm×100mm×100mm were casted without fibre and with different quantities of fibre. Hand mixing is used for mixing the concrete without and with fibres to maintain the proper quantities of fibres in each specimen. Specimens were demoulded after 24 hours and cured for 7 days, 14 days and 28 days under normal water. Details of specimens are given in Table 6.

Table 6: Detail of specimens

| Specimens | Name of test | % of Quantities of Steel Fibre (SF) added (As per dry weight of cement) | No. of specimens |
|---|---|---|---|
| Cubes 150mm×150mm×150mm | Compressive strength test | 0 | 9 |
| | | 1 | 9 |
| | | 1.25 | 9 |
| | | 1.5 | 9 |
| | | 1.75 | 9 |

**Result and Discussion**

**Compressive Strength**

The primary objective of the present study was to evaluate the effect of incorporating binding wires as steel fibres on the compressive strength of concrete. Cube specimens were prepared with varying fibre contents of 0%, 1%, 1.25%, 1.5%, and 1.75% and tested after 28 days of curing in accordance with IS 516:1959. The compressive strength of concrete was determined at 7, 14, and 28 days, and the results are presented in Tables 7. The test results revealed that the inclusion of binding wires as fibres led to a noticeable improvement in the compressive strength of concrete. The plain concrete (0% fibre) showed a 28-day compressive strength of 24.67 N/mm², while fibre-reinforced samples exhibited higher strengths of 24.97 N/mm² (1%), 25.09 N/mm² (1.25%), 27.49 N/mm² (1.5%), and 25.93 N/mm² (1.75%) in Figure 5.It was observed that the compressive strength increased progressively with the addition of steel fibres up to 1.5%, beyond which a slight reduction in strength occurred. This indicates that the optimal fibre dosage for achieving maximum compressive strength in this study is 1.5%, as it provides the most significant enhancement in concrete's load-bearing capacity and resistance to cracking.

Table 7: Compressive strength of cubes at varying proportion of steel fibre

| Compressive Strength (N/mm$^2$) | | | |
|---|---|---|---|
| Percentage of steel fibre | 7 days | 14 days | 28 days |
| 0 | 13.56 | 19.25 | 24.67 |
| 1 | 14.53 | 19.76 | 24.97 |
| 1.25 | 14.62 | 20.02 | 25.09 |
| 1.5 | 18.94 | 24.12 | 27.49 |
| 1.75 | 15.23 | 22.96 | 25.93 |

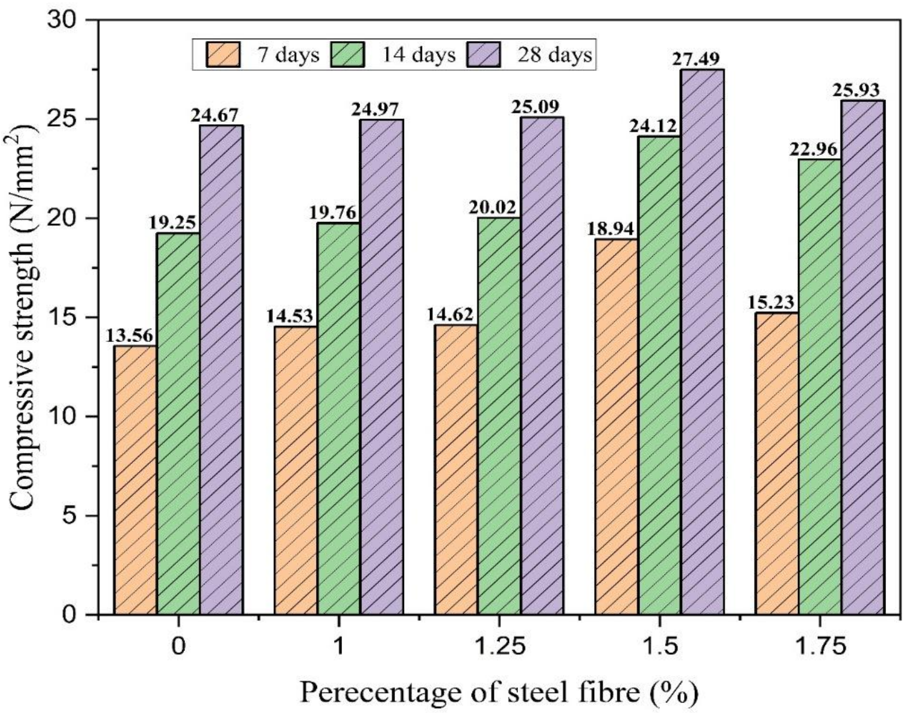


Figure 5: Comparative analysis of compressive strength

## Conclusion

From the experimental investigation, it can be concluded that the inclusion of binding wires as steel fibres in concrete significantly enhances its compressive strength and overall performance. The study was conducted with fibre contents of 0%, 1%, 1.25%, 1.5%, and 1.75%, and the test results at 7, 14, and 28 days indicate a clear improvement in strength with the addition of fibres. The maximum compressive strength of 27.49 N/mm² was achieved at 1.5% fibre content, which is identified as the optimum dosage. Beyond this percentage, a marginal reduction in strength was observed, likely due to improper dispersion and reduced workability of the mix.The results demonstrate that incorporating binding wires as fibres helps to control cracking, improve ductility, and enhance the load-bearing capacity of concrete. Therefore, the use of 1.5% binding wire fibres is recommended for achieving superior strength and durability in structural applications while maintaining cost-effectiveness. This study confirms that steel fibre reinforced concrete prepared with binding wires can serve as a sustainable and efficient alternative to conventional concrete in various construction works.

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