Replacement of Reinforcement in Slabs using Steel Fibers

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ABSTRACT

Replacement of reinforcement in slabs using steel fibers has major advantages in structural element. Generally concrete will fail in compression, tension and flexures. Adding of steel fiber in concrete will increase the compression, tension and flexure strength.

The research focuses on experimental investigation on the structural behavior of SFRC (Steel fiber reinforcement concrete) and replacement of reinforcement in slabs using steel fibers. In this study, the hooked end steel fibers with aspect ratio (l/d) of 50 were used. The volume of steel fibers of 1.5% was added by volume of M25 concrete. After 7, 14 and 28 days of curing compressive, split tensile and flexural strength were determined. It was found that inclusion of steel fibers affect the compressive, split tensile and flexural strength of concrete. Four different types of volume of steel fibers were added in minimum reinforcement slabs according to plastic hinge length. This plastic hinge length can be determined by according to Mattock and priestly, plastic hinge length expression. The results are compared experimentally.

Keywords—Steel fiber reinforced concrete, Aspect ratio

I. INTRODUCTION

Concrete is most widely used construction material in the world due to its ability to get cast in any form and shape. It also replaces old construction materials such as brick and stone masonry. The strength and durability of concrete can be changed by making appropriate changes in its ingredients like material, aggregate and water and by adding some special ingredients. Hence concrete is very well suitable for a wide range of applications.

With the advancement of technology and increased field application of concrete and mortars the strength, workability, durability and other characteristics of the ordinary concrete is continually undergoing modifications to make it stronger.

1.1 Steel Fiber reinforced concrete

The presence of micro cracks in the mortar-aggregate interface is responsible for the inherent weakness of plain concrete. The weakness can be removed by inclusion of fibers in the mixture. Different types of fibers, such as those used in traditional composite materials can be introduced into the concrete mixture to increase its toughness, or ability to resist crack growth. The fibers help to transfer loads at the internal micro cracks. Such a concrete is called fiber-reinforced concrete (FRC), the FRC in which Steel fibers are used is called Steel fiber-reinforced concrete (SFRC).

1.2 Plastic Hinge

A plastic hinge is a zone of yielding due to flexure in a structural member. At those sections where plastic hinges are located, the member acts as if it were hinged, except with a constant restraining moment plastic limit. Just like any ordinary hinge, the plastic hinge allows the rotation of members on its two sides without change in curvature of members. The plastic hinge is capable of resisting rotation until fully plastic moment is developed and then permitting rotation of any magnitude while the bending moment remaining constant at plastic limit.

II. METHODOLOGY

2.1 Materials

The materials used in concrete is generally cement, fine aggregate, coarse aggregate in which steel is added here.

2.1.1 Cement

The cement used for this study is Portland Pozzolanic Cement is conforming to Indian Standard IS 12269 – 1987 of grade 53.
2.1.2 Fine Aggregate

The sand is used as fine aggregate and it is collected from nearby area. The sand has been sieved in 4.75 mm sieve.

2.1.3 Coarse Aggregate

The coarse aggregate is chosen by shape as per IS 2386 (Part I) 1963, surface texture characteristics of aggregate is classified as in IS 383 - 1970. The maximum size of aggregate taken is 20 mm.

2.1.4 Steel Fibers

Steel fiber with hooked ends is made using high-quality low-carbon steel wire as shown in figure 1. A kind of high-performance steel fiber, with the characteristics of the high tensile strength, good toughness, low prices, etc. The product is widely used in concrete strengthening.

III. STRENGTH CHARACTERISTICS

The study presents the compressive strength, split tensile strength and flexure strength of plain cement concrete and steel fiber concrete and also one point load on slabs.

3.1 Compressive strength

The Compression strength of plain cement concrete and steel fiber concrete is shown in figure 3.

3.1.1 Cube Specimens

Cube of size 150 × 150 × 150 mm is used for making both conventional concrete and steel fiber reinforced concrete specimens.

Table 1: Compressive Strength at 7, 14, 28 days curing

<table>
<thead>
<tr>
<th>Concrete Type</th>
<th>7 days Compressive strength (N/mm²)</th>
<th>14 days compressive strength (N/mm²)</th>
<th>28 days compressive strength (N/mm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional Concrete</td>
<td>18</td>
<td>24</td>
<td>27</td>
</tr>
<tr>
<td>Steel fiber</td>
<td>21</td>
<td>31.17</td>
<td>33.64</td>
</tr>
</tbody>
</table>

The compressive strength of the concrete is shown in Table 1. In normal conventional concrete, the compressive strength is attain up to 27 N/mm² for 28 days and in steel fiber reinforced concrete, the compressive strength attains up to 33.64N/mm² for 28 days is shown in figure 2.

Figure 2: Comparison of compressive strength between conventional concrete and steel fiber concrete

Figure 3: Compressive test of cube

3.2 Split Tensile Strength

The split tensile strength of plain cement concrete and steel fiber concrete is carried out.

3.2.1 Cylinder Specimen

Cylinder of size 150 × 300 mm is used for making both conventional concrete and steel fiber concrete specimens.

Table 2 Split Tensile Strength of concrete for 7, 14 and 28 days.
Concrete Type | 7 days Tensile Strength (N/mm²) | 14 days Tensile strength (N/mm²) | 28 days Tensile strength (N/mm²)
--- | --- | --- | ---
CC | 2.24 | 2.62 | 3.08
Steel fibers | 2.75 | 2.92 | 3.22

The split tensile strength of the concrete is shown in Table 2. In normal conventional concrete, the split tensile strength is attain up to 3.08 N/mm² for 28 days and in steel fiber reinforced concrete, the split tensile strength attains up to 3.22 N/mm² for 28 days as shown in figure 4.

3.3 Flexure Strength

The flexure strength of plain cement concrete and steel fiber concrete is shown in figure 5.

3.3.1 Beam Specimen

Beam of size 100 × 100 × 500 mm is used for making both conventional concrete and steel concrete specimen.

Table 3: Flexure Strength at 7, 14, 28 days curing

<table>
<thead>
<tr>
<th>Concrete type</th>
<th>7 days Flexure strength (N/mm²)</th>
<th>14 days Flexure strength (N/mm²)</th>
<th>28 days Flexure strength (N/mm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CC</td>
<td>2</td>
<td>2.75</td>
<td>3.5</td>
</tr>
<tr>
<td>STEEL FIBER</td>
<td>3</td>
<td>4.5</td>
<td>5.25</td>
</tr>
</tbody>
</table>

The flexure test of the concrete is shown in Table 3. In normal conventional concrete, the flexural strength is attain up to 3.5 N/mm² for 28 days and in steel fiber concrete, the flexure attains up to 5.25 N/mm² for 28 days as shown in figure 5.

IV. TESTING OF SLAB

Based on the results of compressive strength, split tensile strength and flexure strength of the specimens, the load carrying capacity of steel fiber concrete is high when compared to normal M25 concrete.

4.1 Slab Specimen

Slab of size 810 × 400 mm is used for making RCC slab, SFRC slabs, SFRC slabs (According to mattock), SFRC slabs (According to priestly and park).

4.2 RCC Slabs

The slab size of 810mm × 400mm was casted with the depth of 60mm (according to IS 456:2000) by providing minimum reinforcement.
4.3 RCC Slabs with Steel Fibers

The slab size of 810mm × 400mm was casted with 1.5% of steel fiber by volume of M25 concrete.

4.4 Mattock Plastic Hinge Expression

According to Mattock, the plastic hinge length can be calculated by the expression of \((0.5d + 0.05z)\). From this expression plastic hinge length of slab is 50mm at its center.

4.5 Priestley And Park Plastic Hinge Expression

According to Priestley and Park, the plastic hinge length can be calculated by the expression of \((0.08z + 6d_b)\). From this expression plastic hinge length of slab is 100mm at its center.

Eight slabs were casted in M25 grade concrete with 1.5% of steel fiber was added according to plastic hinge expression and the ultimate load and deflection of the slab were taken by one point loading on 28 days of curing. Finally the test results were compared.

The one point load test on slab is shown in figure 10. In RCC slab, SFRC slabs, Mattock plastic hinge length (100mm) slab, priestely and park plastic hinge length(50mm) slab attains the ultimate load up to 44.14kN, 53.95kN, 51.50kN and 46.59kN respectively.

In RCC slab, SFRC slab, Mattock plastic hinge length(100mm) slab, Priestely and Park plastic hinge length (50mm) slab attains the deflection up to 7.6mm, 11mm, 10.9mm and 9.6mm respectively on one point loading.
### Table 4: One point load test on slabs

<table>
<thead>
<tr>
<th></th>
<th>RCC Slab (M25 grade)</th>
<th>SFRC Slab</th>
<th>Plastic hinge length (100 mm)</th>
<th>Plastic hinge length (50 mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>DEFLECTION (mm)</strong></td>
<td>7.6</td>
<td>11</td>
<td>10.9</td>
<td>9.6</td>
</tr>
<tr>
<td><strong>LOAD (KN)</strong></td>
<td>44.14</td>
<td>53.95</td>
<td>51.50</td>
<td>46.59</td>
</tr>
</tbody>
</table>

**REFERENCES**


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**V. CONCLUSION**

As per IS 10262: 2009 and IS 456:2000, the concrete mix design was carried out for concrete grade M25. The Compressive strength, split tensile strength and flexure strength of concrete is higher for steel fiber concrete at 7, 14 and 28 days curing in the ratio of 1.5% of the volume of M25 concrete. In slabs volume of steel fibers can be decreased according to plastic hinge length. From the comparison of results, the ultimate load and deflection of priestly and park plastic hinge length (100mm) is equal when compared to SFRC slab.