Experimental Study of SIFCON Produced by Low Tensile Strength Steel Fiber

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Abstract—Slurry Infiltrated Fibrous Concrete (SIFCON) is a special type of fiber reinforced concrete (FRC) which have large amount of fiber. FRC contain fiber only 2% to 5% by volume of cube because of balling and clustering problem but in SIFCON we can use fiber from 5 to 20% of volume of cube. In this research work we are going to use 6%, 12% and 18% of steel fiber by volume of 150mmx150mmx150mm cube to find out the maximum strength and compare it with the strength of normal concrete by using the grade of M30 at the days of 7 days, 14 days & 28 days. For this purpose 27 cube of SIFCON and nine controlled cube of M30 grade were casted. This research therefore is an investigation of the performance of the concrete made of 6%, 12% & 18% of steel fiber.

Key words: SIFCON, OPC, Compressive Strength, Admixture

I. INTRODUCTION

SIFCON stands for SLURRY INFILTRATED FIBROUS CONCRETE with higher amount of low tensile strength steel fiber. Slurry Infiltrated Fibrous Concrete is a relatively new high performance & advanced material which can be considered as a special type of Steel Fibrous Reinforced Concrete (SFRC). In FRC fibers are added dry or wet mix of concrete but in SIFCON cement slurry is poured over preplaced fibers. SIFCON has no coarse aggregate but high cementous content. However it may contain fine sand and additive such as fly ash, fine glass powder. To improve the flow characteristics a controlled quantity of super plasticizer may be used. The strength of the SIFCON is high with the flexural strength and is suitable for earthquake prone areas. In this study Low tensile strength steel fibre (Binding wire) of 1mm diameter with aspect ratio 50 is used. SIFCON has been successfully used for Pavement rehabilitation and precast concrete products, seismic and explosive resistant structure, security concrete application (safety vaults, strong room), aerospace launching platforms, military application such as anti-missile hangers, underground shelters and Sea protective works.

This technique of slurry infiltrated fibrous concrete was first proposed by Haynes (1968). Further Lankard (1979) modified the method used by Haynes and concluded that if percentage of steel fibers in cement matrix is increased high strength concrete can be obtained.

II. MATERIAL USE

A. Cement:

Ordinary Portland cement of 43 grades is used.

<table>
<thead>
<tr>
<th>S.No</th>
<th>Characteristics</th>
<th>Test Result</th>
<th>Standard Result (As Per Is Code)</th>
</tr>
</thead>
<tbody>
<tr>
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</tbody>
</table>

B. Fine Aggregates:

Sand conforms to zone II as per the specifications of IS 383:1970 is used as fine aggregate.
- Specific gravity = 2.62
- Fineness modulus = 2.81

C. Steel Fiber

Low tensile strength steel wires which is used in binding the reinforcement (binding wire) of 1mm diameter and 50 aspect ratio was used as steel fibre. The ultimate strength was 390 N/mm².

D. Water:

Water plays a very important role in concrete. Hydration of concrete depends on water. Hence the quantity and quality of water is required to be looked into very carefully. In this work clean potable water is used.

E. Admixture:

Super plasticizers (CICO Plast super HS) are usually distinctive in their nature, and they make possible the production of concrete which, in its fresh and hardened state, is substantially different form of concrete made using the water reducing admixture.

III. MIX DESIGN FOR M-30 GRADE CONCRETE

A. Design Stipulations:

Characteristic Compressive Strength required at the end of 28 days: 30 N/mm²
Maximum size of Aggregate: 20 mm
Type of Exposure: Severe
Degree of Quality Control: Good

B. Test Data For Materials:

Specific Gravity of Cement: 3.157
Specific Gravity of Coarse Aggregate: 2.70
Specific Gravity of Fine Aggregate: 2.62

C. Target Mean Strength of Concrete:

For a tolerance factor of 1.65, the obtained target mean strength for the given grade of concrete

Table 1 Physical property of cement

<table>
<thead>
<tr>
<th>S.No</th>
<th>Consistency</th>
<th>Test Result</th>
<th>Standard Result (As Per Is Code)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
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<td>2</td>
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<td>4</td>
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<td></td>
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<tr>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
= 30 + 5 * 1.65 = 38.25 N/mm²

D. Selection of Water Cement Ratio:
The free water cement ratio for the obtained target mean strength is 0.45. This is equal to the value prescribed for Moderate conditions in IS 456-2000.

<table>
<thead>
<tr>
<th>Water</th>
<th>179.41</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cement</td>
<td>398.68</td>
</tr>
<tr>
<td>Fine aggregate</td>
<td>669.84</td>
</tr>
<tr>
<td>Coarse aggregate</td>
<td>1175.24</td>
</tr>
<tr>
<td>Admixture</td>
<td>3.98</td>
</tr>
</tbody>
</table>

Table 2: The mix proportion of Control specimen

IV. TEST PROGRAMME
Twenty seven SIFCON cube specimen of 150 * 150 * 150 mm with 6, 12 and 18% volume of fibers with 50 aspect ratio were casted and tested. The proportion of cement to sand is taken as 1:2. In addition, nine M-30 grade plain concrete specimens were casted and tested as control.

V. FABRICATION, CASTING AND TESTING
Twenty seven cube were cast with w/c of 0.45. Initially required volume of fiber was placed in mold randomly and then cement sand slurry is infiltrated over the fibers. To increase the workability of cement sand slurry 1% super plasticizer by weight of cement was used. All the casted specimen were taken out from the mold after 24 hours and water-cured for 28 days.

1) Compressive Strength
The compressive strength is one of the most important design parameters required for concrete. This series of tests determines the strength attained by the concrete whose cement quantity is replaced with glass powder varying from 5% to 25% and addition of steel fiber at the constant rate. The average value of the three cubes tested at each age and each percentage of glass powder. The results plotted on the graphs. Compressive strength is defined as resistance of concrete to axial loading. Cubes are put in the machine and after tighten its wheel start button is pressed as pressure is begin to apply. Reading of meter is note down when cracks are there on cubes. Compressive strength is calculated by following formula:

\[ \text{Compressive Strength} = \frac{P}{A} \]

Where P is load and A is area of cube.

Loading arrangement to test of the specimen for compressive strength is shown in the figure 1.

A compression testing machine of 2000 KN determined the cube compressive strength at 7, 14 and 28 days.

2) Flexural Strength
For flexural test beams of 150x150x700 mm3 size were adopted. The load was applied without shock and was increased until the specimen failed, and the maximum load applied which is on the meter to the prism during the test was recorded. The appearances of the fractured faces of concrete failure were noted. Three-point load method was used to measure the flexural strength of SIFCON.

The flexural strength of the prisms was calculated as per given equation,

\[ \text{Modulus of rupture, } f_b = \frac{PL}{bd} \]

Where \( P \) = Maximum load applied, \( N \)
\( L \) = Supported length of the specimen, mm
\( b \) = Measured width of the specimen, mm
\( d \) = Measured depth of the specimen at the point of failure, mm

Nine SIFCON beam specimen of 150*150*150 mm with 6, 8, 12 percent volume of fibers and three control beam of M-30 grade concrete were cast and tested. Loading arrangement to test the specimen is shown in figure.

Fig. 2: Nine SIFCON beam specimen

VI. RESULT
A. Compressive Strength Test
Compressive strength of SIFCON and control specimen of M-30 grade after 7, 14 and 28 days are presented in table

<table>
<thead>
<tr>
<th>Designation Of Mix</th>
<th>Compressive Strength After 7 Days N/mm²</th>
<th>Compressive Strength After 14 Days N/mm²</th>
<th>Compressive Strength After 28 Days N/mm²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>28</td>
<td>31</td>
<td>39</td>
</tr>
</tbody>
</table>
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Table 3 Compressive strength of SIFCON

<table>
<thead>
<tr>
<th>Designation of Mix</th>
<th>S-6%</th>
<th>S-12%</th>
<th>S-18%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flexural Strength After 7 Days</td>
<td>26.66</td>
<td>35.12</td>
<td>33</td>
</tr>
<tr>
<td>Flexural Strength After 14 Days</td>
<td>33</td>
<td>42.44</td>
<td>38.22</td>
</tr>
<tr>
<td>Flexural Strength After 28 Days</td>
<td>40</td>
<td>48</td>
<td>44.44</td>
</tr>
</tbody>
</table>

Table 4: Flexural Strength Test

<table>
<thead>
<tr>
<th>Designation of Mix</th>
<th>Flexural Strength After 7 Days N/Mm²</th>
<th>Flexural Strength After 14 Days N/Mm²</th>
<th>Flexural Strength After 28 Days N/Mm²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>3.74</td>
<td>4.05</td>
<td>4.41</td>
</tr>
<tr>
<td>S-6%</td>
<td>4.48</td>
<td>5.60</td>
<td>6.50</td>
</tr>
<tr>
<td>S-12%</td>
<td>7.20</td>
<td>8.80</td>
<td>10.25</td>
</tr>
<tr>
<td>S-18%</td>
<td>5.75</td>
<td>7.10</td>
<td>8.33</td>
</tr>
</tbody>
</table>

VII. CONCLUSION

Based on the study carried out on the strength behavior of SIFCON the following conclusions are drawn:

A. SIFCON in compression

It can be observed that the compressive strength increases with increasing volume percentages of fibre up to certain limit beyond which compressive strength decreases. This is also in conformity with results of previous investigations. Compared to M-30 grade reference mix, compressive strength of SIFCON at 6%, 12% and 18% of low strength steel fibre is more than the compressive strength of M-30 grade reference concrete. Optimum compressive strength is achieved at 12% of steel fibre which is 48 N/mm² after 28 days curing.

B. Flexural Strength of SIFCON

From the result it can be concluded that flexural strength also increases with increases in percentage of steel fiber. It means addition of steel fiber definitely contribute the flexural strength.

Compared to M-30 grade reference mix, flexural strength of SIFCON at 6%, 12% and 18% of low strength steel fibre is more than the flexural strength of M-30 grade reference concrete. Optimum compressive strength is achieved at 12% of steel fibre which is 10.25 N/mm² after 28 days curing.

REFERENCE

