Experimental Study on Effect of Carbon Steel Fiber on Strength of Concrete

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Abstract— Fibres are generally used as resistance of cracking and strengthening of concrete. According to various research papers, it has been found that steel fibres give the maximum strength in comparison to other fibres. Fibre reinforced concrete has been successfully used in slab, beam, shotcrete, footing, hydraulic structure, structures in seismic regions and many other applications. The main objective of this research work is to study the effect of carbon steel fibre reinforcement with different percentage of fibre 0 %, 0.5%, 1%, 1.5% and 2% by volume for M-25 grade of concrete with aspect ratio-50. The carbon steel fibre reinforced concrete will be tested for compressive strength, flexural strength and split tensile strength. The percentage increase through utilization of carbon steel fibres will be reported.

Key words: Carbon steel fibre, Flexural Strength, Compressive strength, Tensile strength, Aspect ratio

I. INTRODUCTION

Concrete is mostly used as a construction material in world wide. The basic ingredients are used in concrete mix is sand, gravel (aggregate), cement (binding material) and water.

Concrete is strong in compression but there are numerous drawbacks such as very less tensile strength, nature of brittle failure, low crack resistance, etc. The weakness in tension of concrete can be reducing by the use of conventional reinforcement bars and to some extent by the addition of a sufficient volume of certain fibres.

These fibres are dispersed and distributed randomly in the concrete during mixing, and Thus improve concrete properties in all directions, which named as fibre reinforced concrete.

FRC has been successfully used in construction due to its excellent flexural-tensile strength, resistance to spitting, impact resistance and excellent permeability and frost resistance. Using fibres in concrete is an effective way to increase toughness, shock resistance and resistance to plastic shrinkage cracking.

The most commonly used fibres are Steel fibre, Carbon steel fibre, Glass fibre, Carbon fibre, Natural fibre, Synthetic fibre.

Carbon steels also known as plain carbon or ordinary or straight carbon steels. Carbon steel is that steel which is having very less content of elements other than carbon, except those which are added for deoxidation like silicon and aluminum. Silicon and Manganese can be added more than those required to meet the criteria of carbon steel so that the upper limits for these are generally, 0.60% for silicon and 1.65% for manganese.

II. MATERIAL COLLECTION

A. Carbon Steel Fibre:

It is a cold drawn steel wire fibre with Electroplated Zinc coating.

Specification:

<table>
<thead>
<tr>
<th>Base Material</th>
<th>High Carbon Steel Wire</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fibre type</td>
<td>Corrugated</td>
</tr>
<tr>
<td>Length</td>
<td>25 mm</td>
</tr>
<tr>
<td>Diameter</td>
<td>0.5 mm</td>
</tr>
<tr>
<td>Aspect ratio (l/d)</td>
<td>50</td>
</tr>
<tr>
<td>Tensile Strength</td>
<td>1400 N/mm²</td>
</tr>
</tbody>
</table>

B. Cement:

Cement is a binding material for concrete and mortar as well as plaster. Which type of cement is suitable for particular work is depend on the overall requirements of concrete, such as strength, durability, etc. OPC-53 grade cement is generally used in construction. This OPC-53 grade cement is easily available in market so use of it is world-wide. When Portland cement is mixed with water, a series of chemical reactions occur between water and cement which is responsible for hardening of concrete. Reactions between water and cement are termed as hydration.

C. Coarse Aggregates:

For maintain quality of concrete, hard and strong aggregates should be used, it should not contain any undesirable impurities, and it should be chemically non-reactive. Rough-textured aggregates, angular shaped aggregate require more amount of water to produce workable concrete. Whereas smooth and rounded shaped aggregate require less amount of water. Flat shaped aggregates are not good for bonding so that it must be avoided or limited about 15% by weight of the total aggregate for good quality concrete.

D. Fine Aggregates:

Fine aggregate is basically sands which are originate from the excavated land or the marine environment. Generally used Fine aggregates are natural sand and crushed stone. Particle size of fine aggregate is less than 9.5mm.
E. Water:
An important ingredient for making concrete is Water. Because it is the main reason for chemical reaction with cement and produce cement gel. Therefore the quantity and quality of water is playing an important role because it affects directly the strength. From Indian standards we can say that, if water is fit to drink it can be used for concrete. For concrete of better quality, water should satisfy all criteria of drinking water.

III. EXPERIMENTAL WORK

A. Compressive Strength Testing:
For compressive strength test, concrete cube specimens of size 150mm x 150mm x 150 mm were cast for M25 grade of concrete. Carbon steel fibre with 0.5%, 1%, 1.5% and 2% was used. For compression test, 9 cubes of Plain concrete and 9 cubes of each proportion of CSF concrete were casted. These cubes were tested at 7 days, 14 days and 28 days respectively as per IS 516-1959 and the failure load was observed. In each category 3 cubes were tested and their average value will be reported. The compressive strength was calculated by following formula.

\[
\text{Compressive strength (MPa)} = \frac{\text{Failure Load}}{C/S \text{ Area of Cube Specimen}}
\]

B. Flexural Strength Testing:
For flexural strength test, concrete beam specimens of size 150mm x 150mm x 700mm were cast. For flexural strength test, 9 beams of Plain concrete and 9 beams of each proportion of CSF concrete were casted. Carbon steel fibre with 0.5%, 1%, 1.5% and 2% was used. These flexural strength specimens were tested on three point flexural testing machine at 7 days, 14 days and 28 days as per IS 516-1959 and failure load was noted. In each category three beams were tested at 7 days, 14 days and 28 days and their average value is reported. The flexural strength was calculated as follows.

\[
\text{Flexural strength (MPa)} = \frac{3P \times L}{2b \times d^2}
\]

C. Split Tensile Strength Testing:
For Split tensile strength test, cylinder specimens of size 150 mm diameter and 300 mm length were cast. For Split tensile test, 9 cylinders of Plain concrete and 9 cylinder of each proportion of CSF concrete were casted. Carbon steel fibre with 0.5%, 1%, 1.5% and 2% was used. The specimens were demoulded after 24 hours of casting and were transferred to curing tank. These cylinders were tested under compression testing machine. In each category three cylinders were tested at 7 days, 14 days and 28 days and their average value is reported. Split Tensile strength was calculated as follows.

\[
\text{Split Tensile strength (MPa)} = \frac{2P}{\pi DL}
\]

IV. RESULT ANALYSIS

A. Compressive Strength Testing:
In compressive strength test, concrete cube specimens of size 150mm x 150mm x 150 mm were used. The test was performed on Universal Testing Machine.

The testing result of 0%, 0.5%, 1%, 1.5% and 2% at 7 days, 14 days and 28 days are as follows.
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V. CONCLUSION

From the various laboratory tests performed on various carbon steel percentages, the conclusions of it as follow:

- It is observe that, Compressive strength, split tensile strength and flexural strength was increased with increasing amount of carbon steel fibre.
- Addition of carbon steel fibre within FRC is better for the flexural strength and split tensile strength than the compressive strength.

<table>
<thead>
<tr>
<th>Amount of CSF</th>
<th>Compressive Strength</th>
<th>Flexural Strength</th>
<th>Split tensile Strength</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5 %</td>
<td>4.3%</td>
<td>56.52%</td>
<td>34.51%</td>
</tr>
<tr>
<td>1 %</td>
<td>6.15%</td>
<td>91.30%</td>
<td>49.00%</td>
</tr>
<tr>
<td>1.5 %</td>
<td>7.44%</td>
<td>99.51%</td>
<td>94.11%</td>
</tr>
<tr>
<td>2 %</td>
<td>1.74%</td>
<td>103.8%</td>
<td>105.3%</td>
</tr>
</tbody>
</table>

Table 1: Strength increases in percentage

- During split tensile strength test, the normal concrete specimen has split into two pieces laterally while the CSF concrete specimen retained the integrity between partially separated parts. As shown below-

REFERENCES

[7] https://www.academia.edu/
[8] www.theconstruction.org