# Behavioral Analysis on High Strength Crimped Steel Fiber Reinforced Concrete For Grade M90

**Prathamesh K. Sarpate[1],S. K. Nalawade[2]**
[1]Dept of Civil Engineering
[2]Assistant Professor, Dept of Civil Engineering
[1, 2] JSPM's Imperial College of Engineering and Research, Wagholi, Pune- 412207

***Abstract-*** *The use of High Strength Concrete (HSC) is increasing. HSC is very strong in compression but it is relatively brittle in content and weekly stress. Crimped steel fibers are added to improve its durability by completing internal cracks. Experimental studies are carried out to evaluate the mechanical properties of high strength fibre reinforced concrete (HSFRC) for M90 grade. The DOE mix design method is made of high cementity contract (HSC) suitable cementitious material i.e. cement, fly and Ash and silica Fiber volume fraction 0 to 4% is used at 0.5% intervals. A total of 54 members were cast and tested for bond strength with 12 mm steel bars (100 X 100 X 100) mm, cylinder (150 X 300) mm and cubic (100 X 100 X 100) mm each. The total members were cured for 7 to 28 days for treatment in the tanks of the Civil Engineering Concrete Technology Laboratory.*

***Keywords***- Compressive Strength, Fly Ash, HSFRC, Silica fume, Steel Fibres, Workability

## I. INTRODUCTION

Now, high strength concrete (HSC) is becoming an attractive alternative in terms of traditional general strength concrete (NSC) for critical works as well as for tall buildings. High strength concretes 60 MPa are often used in a wide range of applications. High strength concrete (HSC) is hardened due to its low efficiency. It has high strength and high durability.ACI (American Concrete Institute) defines HSC as high strength concrete in which specific characteristics are developed for specific applications and environments.

Sustainability is optional under the ACI definition, and this has led to the emergence of many HSC structures that, in theory, represent problems related to sustainability throughout their lives.ACI also defines a high-strength concrete because it has a comparable strength specified for a design of 6,000 psi (41 MPa) or higher.With increasing industrial activity and the construction industry, cement can mold high-strength concrete to any desired size. It has to do with more and more people and their daily lives and it is widely used all over the world as a building material and it is a little difficult to find another material for versatile constructions as high strength concrete.

Hardening a mixture of cement, sand, coarse-grained water, water, and sometimes mineral and chemical mixtures, is nothing more than artificial stone without high-strength concrete. Admixtures and cementitious material also enhances the properties of high strength concrete in fresh and hardened state. Thousands of small fibers are randomly dispersed and randomly distributed in high-strength concrete when mixed to improve the properties of high-strength concrete in all directions. Fiber - Helps to improve post-crop durability performance, pre-crack tensile strength, impact strength, fatigue strength and temperature and shrinkage cracking High strength concrete is naturally a brittle material, low tensile and limited shrinkage. Because of these properties, ordinary high-strength concrete has some limitations to applications in highly impermeable structures, such as tall buildings, road sidewalks, long bridges, and chimney constructions. High strength concrete not only increases the strength of the concrete but also reduces the permeability. High strength concrete is commonly used to increase durability, tensile strength, modulus of elasticity and elastic strength of concrete.

## II. NEED

- They have more flexibility modules
- They have good relationship with the steel bar embedded in it.
- They can used to control plastic shrinkage cracking.
- They help in saving material due to providing less cross section.
- They provide tough and durable

## III. OBJECTIVES

This investigation relates to the behaviour of crimped steel fibers with fractions of different volumes on high strength fiber reinforced concrete (HSFRC). The purpose of this study is to investigate the following properties:

1. To investigate the strength properties of high strength fiber reinforced concrete composites with different volume fractions. Such as Compressive Strength, Split Tensile Strength and Bond Strength.
2. To compare the properties of this special controlled concrete with that of ordinary concrete

## IV. CRIMPED STEEL FIBRES

Crimped steel fibers are made of either carbon steel or stainless steel. The scarcity of metals makes it possible to convert them from metal to wire through the die, the latter being smaller. They are a very hard material and this hardness imposes the mechanical properties of high strength fiber reinforced concrete.

However, the elasticity of a material is a function of its proportional cross-sectional area.As the diameter of the rod is reduced by one-half, its elasticity is increased by four factors. Tensile strength ranges from 345 to

Different types of steel fibres used in HSFRC

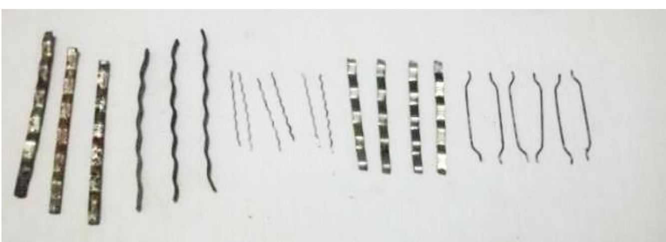

Figure 1.

**FIBRE REINFORCED CONCRETE**

1380 MPa. The minimum power specified in the ASTM is 345 MPa. The elastic modulus for steel fiber is 200 GPA. Melting point $1600^0$ s. C. Cramped fiber cross section can be round and weaving in cross section. Although more fiber is used, the length of the fiber is generally less than 150 mm. The length-diameter ratio is usually 30 to 100 or more.The effective reinforcement of the matrix and the efficient transfer of stress between the matrix and the fiber depend on many factors. Many of these factors are intimately dependent and use profound but complex effects on composite properties.

The components are stated as follows:

- The relative fibre matrix stiffness
- Fibre matrix interfacial bond
- Strain compatibility between fibre and the matrix.
- Shape of fibres
- Strength of fibres
- Fibre orientation
- Specimen size
- Span of specimen
- Spacing of fibres

## V. LITERATURE SURVEY

Recently there has been an urgent need to improve the properties of high strength concrete in terms of strength, durability, durability and performance as a structural material containing cement to meet the structural requirements such as strength, durability. This is because conventional plain high strength concrete has high compressive strength, low tensile strength, poor impact strength, durability and low resistance to cracking and low resistance to chemical attack.

Therefore these defects of high strength concrete must be overcome. Continuous research by high-strength concrete technologists to improve and develop the properties of concrete has resulted in new types of concrete. Introduced fiber inside concrete to improve strength, durability, hardness and toughness, known as fiber reinforced high strength concrete. Fiber-reinforced high-strength concrete can be defined as a composite material that consists of cement, sand, fly, Ash, silica fume, GGBS, aggregate and discontinuous, discrete, evenly distributed suitable fibers. Continuous mesh, woven fabrics and long wires or rods are not considered discrete fibers .

Mulik, Walia and Sharma [6] studied the inclusion of randomly distributed, discrete, short polypropylene (PP) fibers in the matrix and the effect of three-dimensional crack arrest and crack control systems in high strength concrete. Polypropylene (PP) fibers are an economical alternative to alkali-proof, rust-free and steel fibers. More rigidity and shock absorption capacity are observed with relatively higher elastic strength, improved impact, fatigue and abrasion resistance.

Bernard [8] model of flexural resistance underlines most methods of thickness design for high-strength concrete slab-on-grade and other high-strength concrete plate elements subject to point loading. The author points out that the peak in load resistance associated with cracking of the bent FRC slab cannot be determined solely as a simple function of the modulus of rupture (MOR). Singh S. P. And Kaushik S [10] worked to relieve the fatigue of steel fiber reinforced concrete in the flexural member

## VI. EXPERIMENTAL PROGRAM

Normal Portland cement has a 7-day compressive strength of 45.20 MPa and confirms that it is 12269-1987 A total aggregate was used in a 4.75 mm sieve and a coarse sieve passing through a 10 mm sieve confirming 383-1970. The microscopic modulus of sand was 2,803 and a total of 7.52 in 10 mm roughness was measured in the laboratory. All materials were tested in the laboratory according to the relevant IS code. 0.23: 1: 0.99: 1.52 i.e. W / C ratio 0.23: For M-90 grade of high quality concrete.

The following templates and patterns were created for the purpose of testing :

- For compression (100 x 100 x 100) mm size cubes.
- Diameter diameter cylinder (150 x 300) mm length.

All samples Steel fibers contain 0% to 4% of the weight of the cement with a gap of 0.5 % difference. The content of fly content is 23% by weight of cement and 7% by silica dust. Each material is weighed on an accurate weaving gauge before the dry mix is prepared. Efficiency was measured each time for wet concrete using a slide cone test. Six samples were prepared for each of the 7 and 28 day trials
All of these samples were processed using 25 blows of a tamping rod on each layer and table vibrator to prevent the fibers from bowling. Samples of normal high strength concrete and high strength fiber reinforced concrete were cured to cure the tank for 7 and 28 days at normal temperature. Total samples were tested on a 2000 KN compression testing machine in accordance with IS 516-1959.

Cube Casting Schedule

Total number Of Specimen =108

Table No.1

| Mix design | Silica Fume | Fly Ash | FlatFibre content % | W/C | Compressive Test | | SplitTensile Test | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Days | | | |
| | | | | | 7 | 28 | 7 | 28 |
| M-90 | 7% | 23 % | 0.0 | 0.23 | 3 | 3 | 3 | 3 |
| M-90 | 7% | 23 % | 0.5 | 0.23 | 3 | 3 | 3 | 3 |
| M-90 | 7% | 23 % | 1.0 | 0.23 | 3 | 3 | 3 | 3 |
| M-90 | 7% | 23 % | 1.5 | 0.23 | 3 | 3 | 3 | 3 |
| M-90 | 7% | 23 % | 2.0 | 0.23 | 3 | 3 | 3 | 3 |
| M-90 | 7% | 23 % | 2.5 | 0.23 | 3 | 3 | 3 | 3 |
| M-90 | 7% | 23 % | 3.0 | 0.23 | 3 | 3 | 3 | 3 |
| M-90 | 7% | 23 % | 3.5 | 0.23 | 3 | 3 | 3 | 3 |
| M-90 | 7% | 23 % | 4.0 | 0.23 | 3 | 3 | 3 | 3 |

Physical Properties Of Coarse Aggregate

Table No.2

| Sr. No. | Particulars | Coarse Aggregate |
|---|---|---|
| 1 | Density (compacted in Kg/cum) | 1830 |
| 2 | Fineness Modulus | 7.53 |
| 3 | Specific Gravity | 2.78 |
| 4 | Water absorption(%) | 1.60 |
| 5 | Surface moisture | Nil |

Physical Properties Of Fine Aggregate

Table No.3

| Sr. No. | Particulars | Coarse Aggregate |
|---|---|---|
| 1 | Density (compacted in Kg/cum) | 1918 |
| 2 | Fineness Modulus | 2.85 |
| 3 | Specific Gravity | 2.58 |
| 4 | Water absorption(%) | 1.21 |
| 5 | Surface moisture | Nil |

**Physical Material Of Crimped Steel Fiber**

Stevoles crimped steel fiber was being used for experimental work. Fibers are high tensile cold draw wires and are specially engineered for use in concrete

Physical Properties Of Steel Fibre

Table No.4

| S r. No. | Property | Value |
|---|---|---|
| 1 | Diameter | 0.25 |
| 2 | Length of fibre | 30 mm |
| 3 | Appearance | Bright in clean wire |
| 4 | Average aspect ratio | 120 |
| 5 | Shape of the Fibre | Hooked ends bundles |
| 6 | Virgin fibre tensile strength | 1050 M Pa |
| 7 | Modulus of Elasticity | 200 GPa |
| 8 | Specific Gravity | 7.86 |

Properties Of Silica Fume Used

Table No.5

| Sr. No. | Chemical Composition | | |
|---|---|---|---|
| | Parameters | Specification | Analysis |
| 1 | Sio2 | Min. 85% | 91.0 |
| 2 | Moisture Content | Max. 3% | 0.7 |
| 3 | Loss of ignition @975C | Max. 6% | 1.4 |
| 4 | Carbon | Max. 2.5% | 0.8 |
| 5 | > 45 micron | Max. 10% | 0.4 |
| 6 | Bulk Density | 500-700 $Kg/m^3$ | 640 |

Properties Of Fly Ash Used

Table No.6

| SR .NO | Parameters | Specification |
|---|---|---|
| 1 | Presentation | Finely dry powder |
| 2 | Colour | Greyish white |
| 3 | Bulk weight | 0.65tonne/m3 |
| 4 | Specific density | 2.3metric ton per cubic metre |
| 5 | Loss of ignition | <2.5% |
| 6 | Particle size | Less than 5% retained on 25 micron sieve |
| 7 | Particle shape | Spherical |
| 8 | Package | 30kg bags |
| 9 | Water demand | 8 to 10% Reduction |

**Mixed design of concepts :**

The DOE method of mix design was used for M-grade 90 grade of concrete. The components and mix properties are as follows.

Mix Design Ratios

Table No. 7

| Sr. No. | Material | Proportion by Weight | Weight in Kg |
|---|---|---|---|
| 1 | Cement | 1 | 695 |
| 2 | F.A | 0.99 | 688 |
| 3 | C.A | 1.52 | 1057 |
| 4 | W/C Ratio | 0.23 | 160 |

Fly by Shane replaced cement by 23% respectively

## VII. SPECIAL TEST

The efficiency of wet concrete is determined by the test of the slump cone and a large density is measured by taking the weight of the concrete cylinder in the wet state. The table shows the performance results and the wet density results of different concrete mixes. The compressive strength of the cubes is determined after 7 days and 28 days using a compressive testing machine (CTM) of 2000 KN capacity. Split tensile test, flexible test is carried out on a universal testing machine with a capacity of 40 tons.

## VIII. COMPRESSION CONTROL TEST ON SOLID

Plain concrete and HSFRC samples were treated with simple standard HSFRC sizes measuring 100 x 100 x 100 mm after 7 days and 28 days in curing water. Tested solid

compression on. The results are shown in Table (2.2) and the graphical presentation between the graphical presentation and the percentage of fibers shown on the bar chart in fig. (1.1).
The compressive strength of the sample was measured by the following formula:

$$Fcu = Pc/A \qquad ...(1)$$

*Where, Pc = Failure load in compression, KN*
*A = Loaded area of cube,* $mm^2$

Compressive Test on Concrete Cube

Fig.No.2.

## IX. SPLIT TENSILE TEST ON CYLINDER

The split tensile test is the most popular test, which is used indirectly to determine the tensile strength of concrete. Due to the difficulties involved in conducting direct stress testing, many indirect methods have been developed to determine the tensile strength of concrete.

Tensile strength is held on the cylinder. They live in the CTM using two steel rods, the bottom and the top to create tensile strength as members. Concrete has tensile strength when it fails when loaded. The test arrangement is shown in the photo along with the pattern of failure. The cylinder has split tensile strength

Calculated according to the following formula.

$$ft = 2P / \pi LD \qquad ...(2)$$

*ft = Tensile strength, MPa ,*
*P = Load at failure,*
*N L = Length of cylinder, mm,*
*D = Diameter of cylinder, mm.*

Split Tensile Test on Cylinder

Fig.No.3

## X. EXPERIMENTAL ANALYSIS

Tests on rigid concrete are carried out in accordance with the relevant standards where applicable. The effects of different forces are calculated according to the power of physical theory. The various tables presented in this paper show the results obtained from the variety

Tests on hardened concrete. The results of hard high HSFRC are discussed compared to ordinary high strength concrete.

**COMPRESSIVE STRENGTH TEST ON CUBE**

The results of compressive strength on squares with crimped steel fibers are obtained using Equation (1). Sample tests have been performed in accordance with IS per 16-1 as is per and are presented in the table numbers in and for 2 days of cured in the drinking water available in the concrete technology laboratory.

Compressive Strength Of Concrete, Mpa

Table No 8

| Sr. No . | Mix design | Microsilica&Fly ashcontent(% ) | FibreContent (Vf) % | Compressive Strength(fcu)( MPa) | |
|---|---|---|---|---|---|
| | | | | 7days | 28 days |
| 1 | M0 | 7 + 23 | 0.0 | 63.50 | 90.02 |
| 2 | M1 | 7 + 23 | 0.5 | 64.70 | 90.10 |
| 3 | M2 | 7 + 23 | 1.0 | 65.78 | 91.40 |
| 4 | M3 | 7 + 23 | 1.5 | 65.80 | 91.60 |
| 5 | M4 | 7 + 23 | 2.0 | 66.10 | 92.30 |
| 6 | M5 | 7 + 23 | 2.5 | 66.20 | 92.50 |
| 7 | M6 | 7 + 23 | 3.0 | 66.35 | 93.15 |
| 8 | M7 | 7 + 23 | 3.5 | 66.40 | 94.30 |
| 9 | M8 | 7 + 23 | 4.0 | 66.10 | 93.10 |

The effects of solid compressive strength are shown in the table above. The comparative strength of 7 days and 28 days is continuously increased with an increase in the amount of fiber3.5% of the fiber volume content in HSC.

The maximum strength is 66.40 MPa and 94.30 MPa at 3.5% of the fiber volume fraction in HSC. Therefore fibers are suitable for improving the compressive strength of high strength structural concrete.

**SPLIT TENSILE STRENGTH ON CYLINDER**

The effect of split tensile strength on concrete with crimped steel fiber is obtained from Equation (2). Sample tests are performed according to IS as 16-1 as is per and are cured in pure water for Table 9.9 and 2 Table days which are available in the concrete technology laboratory.

Split Tensile Strength On Cylinder, (Mpa)

Table No 9

| Sr. No . | Mix design | Microsilica&Fly ashcontent(% ) | Fibre Content (Vf) % | Split Tensile Strength Of Concrete (Ft) (MPa) | |
|---|---|---|---|---|---|
| | | | | 7days | 28 days |
| 1 | M0 | 7 + 23 | 0.0 | 5.50 | 7.22 |
| 2 | M1 | 7 + 23 | 0.5 | 6.44 | 7.95 |
| 3 | M2 | 7 + 23 | 1.0 | 7.54 | 8.11 |
| 4 | M3 | 7 + 23 | 1.5 | 7.90 | 9.07 |
| 5 | M4 | 7 + 23 | 2.0 | 8.11 | 9.62 |
| 6 | M5 | 7 + 23 | 2.5 | 8.65 | 10.43 |
| 7 | M6 | 7 + 23 | 3.0 | 9.25 | 11.26 |
| 8 | M7 | 7 + 23 | 3.5 | 8.91 | 10.12 |
| 9 | M8 | 7 + 23 | 4.0 | 8.77 | 9.76 |

From the table above, the fiber volume in HSC is 9.25 MPa and 11.26 MPa for fiber reinforced concrete with 7-28 days spliable tensile strength at a rate of 3% of the fiber content. This means that the tensile strength increases with an increase in the percentage of fiber content in the HSC. Therefore the fibers are suitable for improving the split tensile strength of structural concrete by completing cracks under the concrete.

## XI. CONCLUSION

Further findings are based on experimental studies and the results obtained.

The maximum percentage increase of comp fiber volume fractions is 3.5. %% and split tensile strength is obtained at fiber% fiber volume fractions.

The split test shows that the fibers appearing on the failure part of the cylinder are sliding along the length of the cylinder.

## XII. GO FOR FUTURE WORK

The present work has good scope for future research :

Some of the research areas are as follows.

1. Behavior of HSFRC with low amount of fiber fraction.
2. Behavior under crawling and compression.
3. Behavior that has an effect on temperature for the same fiber content.
4. Behavior resulting from freezing and melting.
5. Same parameters with recycled aggregate.
6. Fracture mechanic.

## REFERENCES

[1] S. Bhaskar, RavindraGettu, B. H. Bharatkumar and M.Neelamegam, "Strength, bond and durability relate properties of concrete with mineral admixtures", Indian Concrte Journal, February- 2012, pp.09-16.

[2] VivekBindiganavile, FarnazBatool and Narayana Suresh, "Effect of fly ash on thermal properties of cement based foams evaluated by transient plane heat source", Indian Concrte Journal, November, 2012, pp.07-13.

[3] SubhashMitra, Pramod K. Gupta and Suresh C. Sharma, "Time- dependant strength gain in mass concrete using mineral admixtures", Indian Concrte Journal, November, 2012, pp.15-22.

[4] Avinash S. Pant and Suresh R. Parekar, "Steel fibres reinforced concrete beams withour reinforcement under combined bending, shear and torsion", Indian Concrete Journal, April, 2012, pp.39-43

[5] D. G. Kadkade and P. K. Mishra." Fly ash blended cement for concrete pavements", Indian Concrete Journal, March, 2012, pp.17-24

[6] Mullick A. K., Walia P. and Sharma S. N., "Applications of Polypropylene Fiber reinforced High strength concrete(PFRC) With Vacuum Processing", Advances in Bridge Engineering, Vol. 8, No. 2, 2006, pp.123-129.

[7] Bernard, "Influence of toughness on the apparent cracking load of fibre reinforced high strength concrete slabs",Journal of Structural Engineering ASCE, Vol. 132, No. 12, 2006.

[8] Job Thomas and AnanthRamaswamy, "Mechanical Properties of Steel Fiber-Reinforced Concrete", Journal of Materials in Civil Engineering, Vol. 19, No. 5, May 1, 2007, pp. 385-389.

[9] Concrete Technology by M. S, Shetty