International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2013): 6.14 | Impact Factor (2013): 4.438

Flexural Behavior of Steel Fibre Reinforced High Strength Concrete Beams

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Abstract: ***Plain concrete possess a very low tensile strength and limited ductility and little resistance to cracking internal micro cracks are inherently present in the concrete and its poor tensile strength is due to the propagation of such micro cracks eventually leading to brittle fracture of concrete, and so to enhance the performance of concrete steel fibers are added to the concrete to gain required strength. The steel fibers are generally used as a resistance of cracking and strengthen of concrete, in this study hooked end steel fibers of length 35mm with thickness of 0.5mm diameter is used. In this program consist of tests on steel fiber reinforced high strength concrete [SFRHSC] beams with conventional reinforcement and reinforced high strength concrete [m_{25}] beams was conducted under flexural loading . Steel fiber reinforced high strength concrete [SFRHSC] beams include two different volume fraction. i.e.1% & 2% the cross sectional dimensions and span of beams were fixed. The dimensions of the beam were 2500×250×150mm used to cast and tested offer 24 hours the test wears conducted offer 28 days are ultimate load, load deflection, crack width are conducted with and without steel fibers.***

Keywords: steel fiber reinforced concrete, silica fume, mix design, steel fibers

1. Introduction

Fiber reinforced concrete is a port land cement concrete reinforced with more or less randomly distributed fibers and dispersed in the concrete during mixing. And thus improve concrete properties in all directions. Fiber reinforced concrete is cement based composite material that has been developed in recent years it has been successfully used in construction with its excellent flexural tensile strength, resistant to splitting, impact resistance and excellent permeability and frost resistance. It is an effective way to increase toughness, shock resistance and resistance to plastic shrinkage cracking of the mortar,. Fiber is a small piece of reinforcing material possessing certain characteristics properties. They can be circular, triangular or flat in cross section. The fire is often described by a convenient parameter called aspect ratio. The aspect ratio of the fiber is the ratio of its length to its diameter .the principle reason for in corpora ting fibers into cement matrix is to increase the toughness and tensile strength and improve the cracking deformation characteristics of the resultant composite. For fry to be used as a construction material its must be able to complete economically with existing reinforced system.

2. Materials

In this investigation high strength concrete of 25 Mpa was used and it is designed as per the ASI method.

2.1 Silica Fume

It is one of the most widely used supplementary cementations materials in the production of high strength concrete is silica fume. It is also known as micro silica; silica fume is a byproduct of producing silica metal or ferrosilicon alloys. As an admixture in HSC, IT makes concrete stronger and more durable. Silica fume consist of very fine particles about 100 times smaller than the average cement particles. The extreme fineness of the silica fume particles allows it to fill the micro scope voids between cement particles. Silica fume concrete does not just happen. a specified must make a conscious to include it in concrete to achieve concrete properties. Assistance in specifying silica fume concrete for high strength or increased durability can be obtained from the major admixture

2.2 Steel Fiber Reinforced Concrete

The use of steel fiber reinforced concrete has received much attention in concrete industry as more research is beading for formed and more is being understood about its material properties and behavior. When steel fibers are added to high strength concrete to increase the fiber volumetric ratio results in an increase in the compressive strength of the concrete and a considerable amount of increasing in the tensile strength of the fiber reinforced specimens is observed in split cylinder tests

2.2.1 Properties of Concrete Improved By Steel Fibers

Flexural strength: flexural bending strength can be increased of up to 3 times more compared to conventional concrete.

- Fatigue resistance: almost 1 ½ times increase in fatigue strength.
- Impact resistance: greeter resistance to damage in case of a heavy impact.
- Permeability: the material is very less porous.
- Absorption resistance: more effective composition against absorption and spelling.
- Shrinkage: shrinkage crakes can be eliminated.
- Corrosion: corrosion may affect the material but it will be limited in certain areas

2.2.2 Different types of steel fibers:

According to ASTM classification provides different types of steel fibers are Aspect ratio for the steel fibers are varied from 20 to 100

1. Deformed
2. Crimped
3. Irregular
4. Straight
5. Hooked
6. Paddled

2.2.3 Advantages of Steel Fibers Used in Steel Fibers

1. More ductile concrete with a high load bearing capacity resulting in thinner slabs with equal conformance than their mess counters parts.
2. Efficiency crack control is about 3200 fiber on average per kg.
3. Quick and easy application added to the concrete directly at the site.
4. Efficiency and cost is effective about 10 to 15% less than the actual concrete it is more durable.

2.3 Cement

Ordinary Portland cement of grade -53 conforming to Indian standard IS: 12269-1987 has been used in the present study. The specific gravity of cement used is 3.15

2.4 Fine Aggregate

Sand that is available in nearby locality has been used as fine aggregate. Other foreign matter present in the sand has been separated before use. The specific gravity of sand used in this investigation is 2.75

2.5 Coarse Aggregate

Crushed stone aggregate of maximum size 12.5mm available from local area had been used. Course aggregate has been sieved through IS: 150 micron sieve to remove dirt and other foreign materials. The specific gravity of sand used in this investigation is 2.806.

Table 2.1: Properties of Aggregates

Basic tests	*Fine aggregates*	*Course aggregates*
Specific gravity	2029	2.806
Water absorption	1.21%	0.39%
Bulk density	1710kg/cum	1530kg/cum
Fineness modules	3.03	6.26

2.6 Silica Fume

Silica fume is a waste by-product of the production of silicon and silicon alloys. Silica fume is available XTR3 in different forms, of which the most commonly used is in a demystified form. In developed countries it is already available in blended with cement. With silica fume it is easier to make HPC of strengths between 60-98 Mpa. In the present study silica fume content of about 9 % by weight of cement for partial replacement of cement was mixed to obtain high strength concrete.

2.7 Water

According to ACI water used for preparing concrete should be of portable quality. In this investigation ordinary tap water which is fit for drinking, has been used in preparing all concrete mixes and curing

2.8 Super Plasticizers

Super plasticizers help us to increase the work ability of concrete without addition of extra quality of water. It means that we can use less water without reducing the workability at the same cement content. This is added to avoid formation flakes, due to less quantity of water. Use of plasticizers is economical as the cost incurred on then is less than the cost of cement saved. Super plasticizer used in this study was Gallium B-233

2.9 Steel Fiber

For improving the mechanical bond between the fiber and matrix indented crimped machined and hooked ended fibers are normally produced. Fibers made from mild steel drawn wire conforming to IS: 280-1976 with the diameter of wire 0.5mm has been used.

2.9.1 Properties of Steel Fibers:

Flexural bending strength can be increased of up to 3 times more compared to conventional concrete. Fatigue resistance almost 1 ½ times increase in fatigue strength. Greater resistance to damage in case of a heavy impact. The material is less porous. The given below table shows the properties of steel fiber.

Table 2.2: Properties of steel Fibers

Fiber properties	*Steel Fiber*
Length (mm)	35mm
Shape	Hooked end
Size/diameter (mm)	0.5mm
Aspect ratio	60
Density(kg/m^3)	7850
Young's modulus (G pa)	210
Tensile strength (M pa)	532

Steel the main reinforcement used for the specimen was tor steel of diameter 12mm in tension side and 8mm in compression side. The strip was used of mild steel of diameter of 6mm. the yield stress of 415 M pa.

3. Proportions of Concrete Mix Design

Concrete mix IDs for all beams are taken from the mix design as per the ACI codal provision, respectively. Detailed concrete mix proportions are provided in Table

Table 3.1: concrete mix proportions for the test beams

Materials	*Control*	*1% steel fiber*	*2 % steel fiber*
Cement(kg)	27.19	27.19	27.19
Fine aggregates(kg)	25.725	25.725	25.725
Coarse aggregates(kg)	44.7	44.7	44.7
Water(kg)	7.905	7.905	7.905
Silica fume (kg)	2.675	2.675	2.675
HRWR(kg)	0.5145	0.5145	0.5145
Steel fibers(kg)		3.1725	6.365

3.1 Details of Specimen

And the other two beams were 1% and 2% OF the steel fiber reinforced high strength concrete beams.

S.No	Specimen name	Details
1	Control beam	Without fiber
2	Beam-1	1% steel fibers
3	Beam-2	2% steel fibers

Length of beam	2500 mm
Depth of beam	250 mm
Width of beam	150 mm
Steel bars	10 mm, 8 mm, 6 mm
Stirrups	6 mm dia @200 mm
Clear cover	30 mm

4. Results

4.1 Compression Strength Test

Casting, curing and testing of cylindrical concrete specimens for each pair of beam specimens or single beam specimen, the cylindrical specimens with a size of 150x150x150mm were casted. However, because main intension of the cylinder test was to determine compressive strength which is not significantly affected by the presence of fibers, the use of a smaller cylinder size was believed to be adequate. To endure those cylinders were uniformly loaded. The cylinders were tested using a compression testing machine.

Table 4.1: compressive strength of concrete

	% OF Steel fibers	Compressive strength N/mm^2
HSC	0	26.32
SFRC-1	1	27.08
SFRC-2	2	29.32

4.2 Flexural Strength Test

For flexural strength test beam specimens of dimensions 15×15×70 cms were cast. The specimens were remolded after 24 hours of casting and were transferred to curing tank where in they were allowed to cure for 7 days. These flexural strength specimen were tested under two points loading as per I.S.516-1959,over an effective span of 600mm divide into three equal parts and rest on flexural testing machine . The load increased &failure load is noted at cracking of beam specimen. In each category two beams was tested and their average valve is reported. The flexural strength was calculated as follows. Flexural strength (Mpa) = $(P\times L)/(b\times d^2)$, Where P=failure load, L=centre to centre distance between the support=600mm,b=width of specimen =150mm, d=depth of specimen=150mm.

Table 4.1: flexural strength of concrete

	% OF Steel fibers	flexural strength N/mm^2
HSC	0	3.6
SFRC-1	1	4.2
SFRC-2	2	4.9

5. Experimental Data of Test Beams

5.1 Ultimate Load

Table 5.1: ultimate load of concrete

Beam Designation	Control beam	1% steel fibers	2% steel fibers
Ultimate load (KN)	23.412	28.4	31.845
Yield load (KN)	15.415	16.25	17.73
Deflection (mm)	11.25	8.75	9.52
Crack width (mm)	0.49	0.435	0.443

The deflections at ultimate load and at yield load are presented in above Table-3.1. The deformation characteristics of high-strength concrete beams improved significantly with the addition of fibers. The deflection increased with increase in loads. These influences were more pronounced for SFRC beams and larger deflections occur after yield stage and before failure. From Figs, it is observed that the SFRC beams exhibit increase in deflection with increase of fiber content at ultimate load when compared to control beam. The increase in ultimate deflection of SFRC beam with 2.0% steel fiber content has high strength compared with control beam and 1% of the beam.

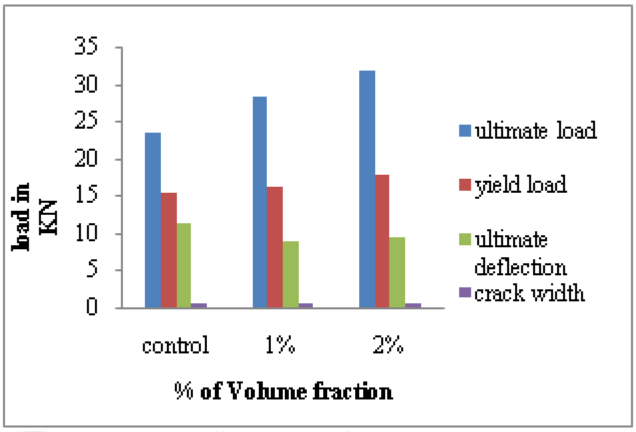

Figure 1: Ultimate load of concrete

5.2 Ductility

Table shows the deflection ductility compared control beams and SFRHSC beams exhibits the enhanced ductility. The increase in the energy ductility of SFRC is very high compared to HSC.

Table 7: Deflection Ductility

Specimen designation	Yield load(KN)	Ultimate load(KN)	Ductility
Control	15.42	23.4	0.632
1-% steel	16.25	23.34	0.675
2-%steel	17.5	32.62	0.782

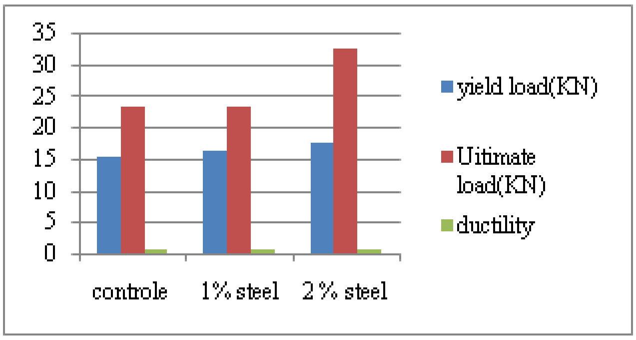

Figure 2: Deflection Ductility

6. Conclusions

Based on the experimental results, the following conclusions are drawn.

- The steel fiber volume fraction of 2% significantly improves the overall performance of high strength reinforced concrete beams.
- The increase in ultimate load was found to be high strength concrete is compared to the steel fiber reinforced high strength beams.
- The high strength steel fiber reinforced concrete beam exhibit greater reduction in crack width at all load levels when compared to the control beam.
- The maximum reduction in crack width at ultimate load was found to be when compared to the control beam beater performance
- The steel fiber reinforced concrete beam has the high strength compared to the plane high strength concrete beam.
- The deflection ductility is compared to the HSC beams and SFRHSC beams show the enhanced properties.
- It was noticed that the failure of HSFRC beams was not sudden, which means the mode of failure of beam was flexural mode.

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