Comparative Study on Behavior of Medium and High Strength Concrete Beam With and Without Fiber under Flexure

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Abstract

An experimental investigation of the behaviour of concrete beams reinforced with conventional steel bars and steel fibers and subjected to flexural loading is presented. An experimental program consisting of tests on steel fiber reinforced concrete (SFRC) beams with conventional reinforcement and reinforced concrete (RC) beams was conducted under flexural loading. SFRC beams include two types of beams containing steel fibers in two different volume fractions i.e. one percent and 1.5 percent. The cross sectional dimensions and span of beams were fixed same for all types of beams. The dimensions of the beams were 125mm x 150mm x11000mm.Tests on conventionally reinforced concrete beam beams showed enhanced properties compared to that of RC beams. The ultimate loads obtained in the experimental investigation were also compared with the theoretical loads for all types of beams specimens, containing steel fibers in different proportions, have been conducted to establish load –deflection curves. The various parameters, such as, first crack load service load ultimate load, of beams with and without steel fibres have been carried out and a quantitative comparison was made on significant stages of loading.

Keywords; *SFRC beams, RC beams, Steel fibres, Flexural loading.*

1. Introduction

Concrete is by far one of the most important building materials and its consumption is increasing in all countries and regions around the globe[1]. The reasons are many such as: its components are available everywhere and relatively inexpensive, its production may be relatively simple, and its application covers large variety of building and civil infrastructure works. In addition, it has the lowest cost to strength ratio compared to other available materials[2].

One of the characteristics of the plain concrete is low tensile strength, and low tensile strain capacities; that is, concrete is a brittle material.[3] Thus concrete require reinforcement before it can be used extensively as construction material. Historically this reinforcement has been in the form of continuous reinforcing bars which could be placed in the structure at the appropriate locations to withstand the imposed tensile and shear stresses. Fibers, on the other hand, are generally, short discontinuous, and are randomly distributed throughout the concrete to produce a new construction material, known as Fiber Reinforced Concrete (FRC). Fibers used in cement-based materials are primarily made of steel, glass, and polymer or derived from natural materials. Since fibers tend to be more closely spaced than conventional reinforcing bars, they are better at controlling cracking[4]. It is important to recognize that, in general, fiber reinforcement is not a substitute for conventional reinforcement. Fibers and steel bars have different roles to play in modern concrete technology, and there are many applications in which both fibers and continuous reinforcing bars should be used. Initially, fibers are used to prevent and control plastic and drying shrinkage in the concrete. After some research and improvement, the addition of fibers material in the concrete can also improve the other concrete properties such as flexural toughness, flexural strength fatigue resistance, impact resistance, and post-crack strength.

The type of fibers which will be used in this study is Steel Fiber. Steel fibers are the most popular material for the reinforced concrete. The performance of the Steel Fiber Reinforced Concrete (SFRC) has shown a significant improvement in flexural strength and overall toughness if compared to plain reinforced concrete.[2]

2. Research significance

A comparative study has been undertaken to investigate into the flexural behaviour of medium and high strength concrete with M25 and M50 grade of concrete using fibers at 0%, 1% and 1.5% by volume of concrete the size of the beam is kept constant (125 x 150 x 1100mm). 16 beams are casted and tested under 4 point bending ($1/3^{rd}$ two point loading). Keeping the size of beam constant the main variables grade of concrete of M25 and M50 variation of percentage of reinforcement at 0.85% and 1.65% then variation of fiber at 0%, 1% and 1.5% by volume of concrete.

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3. Objective

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4. Laboratory Tests

4.1 Materials & Mix proportions

Ordinary Portland cement of 53 grade satisfying the requirements of IS 8112-1989, from single batch has been used in the present investigation. The coarse fraction consisted of equal fractions of crushed stones of maximum size of 20mm. Fine aggregate used was natural sand with grading conforming to Zone II. High range water-reducing admixture (HRWA) of type Conplast SP-430 is used in the present investigation to enhance workability. Steel fibers of round crimped type with diameter 0.55mm and length 30mm (aspect ratio = 54) has been used in the present investigation.

Mix proportions

Trial mixes were optimized, experimentally to achieve M25 grade concrete and M50 grade concrete with water to cementitious ratio of 0.50and 0.35 in order to achieve workability High range water-reducing admixture (HRWA) of type Conplast SP-430 has been used in the present investigation. The dosage of superplasticizer used was 0.8% by weight of cementitious materials for Non fibrous and fibrous concrete respectively.

Table 1 Mix proportion of M25 grade concrete

Ingredients	Proportion
Water (kg/m^3 of concrete)	186
Cement (kg/m^3 of concrete)	372
Fine Aggregate (kg/m^3 of concrete)	662.03
Coarse Aggregate (kg/m^3 of concrete)	1136.43
Mix Proportion	W : CM:Fine Agg : Coarse Agg
	0.50:1.0:1779:3.054

Table 2 Mix proportion of M50 grade concrete

Ingredients	Proportion
Water (kg/m^3 of concrete)	180
Cement (kg/m^3 of concrete)	514.28
Fine Aggregate (kg/m^3 of concrete)	433.10
Coarse Aggregate (kg/m^3 of concrete)	1251.25
Mix Proportion	W : CM:Fine Agg : Coarse Agg
	0.35:1.0.842::2.433

4.2 Test procedure and test results

a) Compressive strength

Cube specimens of size 150mm×150mm×150mm were used for determining compressive strength. 28days compressive tests are given in table 3, where each value represents the average of three specimens

Table 3 Compressive strength results

Type of concrete M25	Compressive strength in N/mm^2
	28 days
Cvc(nf)	36.59
Sfrc 1%	41.15
Sfrc 1.5%	48.50

Type of concrete M50	Compressive strength in N/mm^2
	28 days
Cvc(nf)	58.86
Sfrc 1%	68.30
Sfrc 1.5%	78.48

b) Testing of beams

Fig. 1: Test Setup for Beam

16 beams are casted and tested, after the curing period was completed, the beams were white washed before Mounting on the loading frame. All the beams were tested in the loading frame Capacity of 1000kn. The beams were simply supported. A typical loading Arrangement is shown in fig 1. The load was applied by 500kN hydraulic Jack through steel section and steel plates with two point loads. The deflection Of the beam were measured using dial gauges, before the application of the load, Initial reading were recorded, then the load was gradually applied with constant Increment of 2KN and the corresponding deflection was recorded for every Increment of the load, the beam surface was checked for any visible cracks, the Load at which first crack is observed is noted as cracking load (Pcr) and the corresponding deflections was also noted. Then with increment of the load the Occurrence of different cracks and corresponding loads were noted, also the Zone in which the crack occurred are noted. The loads were also recorded with the progress of the crack from lower side

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towards upper side with there nature. The load (Pu) along with corresponding deflection.

The test results of the beam are given in table-3. reinforcement provided as Ast =0.85% with 2-10mm @ 100mm and 2-6mm @ 100mm and Ast2=1.65% with 2-2-12mm @ 100mm and 1-10mm @ 100mm and 2-6mm @ 100mm.

Table 3: Test result on Beams

BEAM	Width b (mm)	Depth d (mm)	First crack load Pcr (KN)	Ultimate load Pu (KN)	MODE OF FAILURE
B1/M25/AST1/NF	125	150	26	70	Flexure
B2/M25/AST1/NF	125	150	24	68	Combined Flexure and Shear
B3/M25/AST2/NF	125	150	28	116	Combined Flexure and Shear
B4/M25/AST2/NF	125	150	52	100	Flexure
B5/M25/AST1/WF/1%	125	150	26	88	Flexure
B6/M25/AST1/WF/1.5%	125	150	34	90	Flexure
B7/M25/AST2/WF/1%	125	150	38	110	Combined Flexure and Shear
B8/M25/AST2/WF/1.5%	125	150	40	116	Combined Flexure and Shear
B9/M50/AST1/NF	125	150	20	80	Flexure
B10/M50/AST1/NF	125	150	28	78	Flexure
B11/M50/AST2/NF	125	150	28	100	Flexure
B12/M50/AST2/NF	125	150	56	116	Combined Flexure and Shear
B13/M50/AST1/WF/1%	125	150	34	88	Flexure
B14/M50/AST1/WF/1.5 %	125	150	48	98	Flexure
B15/M50/AST2/WF/1%	125	150	32	122	Flexure
B16/M50/AST2/WF/1.5 %	125	150	34	130	Combined Flexure and Shear

*NF-non fiber
*WF-with fiber

First letter indicates the mark on the beam, second number indicates the grade of concrete, third indicates the percentage of longitudinal steel, last indicates the percentage of fiber.

Failure pattern of Beams

Figure 2: Cracking Pattern of Beam B1/M25/AST1/NF

Figure 3: Cracking Pattern of Beam B2/M25/AST1/NF

Figure 4: Cracking Pattern of Beam B3/M25/AST2/NF

Figure 5: Cracking Pattern of Beam B4/M25/AST2/NF

Figure 6: Cracking Pattern of Beam B5/M25/AST1/WF/1%

Figure 7: Cracking Pattern of Beam B6/M25/AST1/WF/1.5%

Figure 8: Cracking Pattern of Beam B7/M25/AST2/WF/1%

Figure 9: Cracking Pattern of Beam B8/M25/AST2/WF/1.5%

Figure 10: Cracking Pattern of Beam B9/M50/AST1/NF

Figure 11: Cracking Pattern of Beam B10/M50/AST1/NF

Figure 12: Cracking Pattern of Beam B11/M50/AST2/NF

Figure 13: Cracking Pattern of Beam B12/M50/Ast2/Nf

Figure 14: Cracking Pattern of Beam B13/M50/AST1/WF/1%

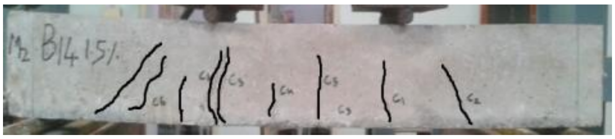


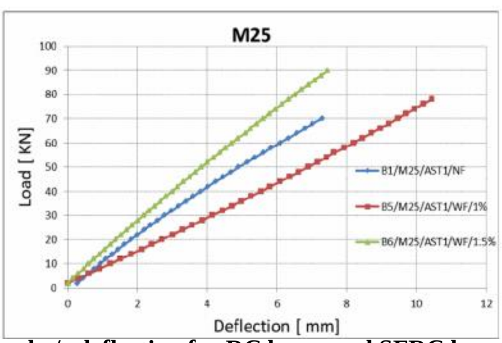
Figure 15: Cracking Pattern of Beam B14/M50/AST1/WF/1.5%

Figure 16: Cracking pattern of beam B15/M50/AST2/WF/1%

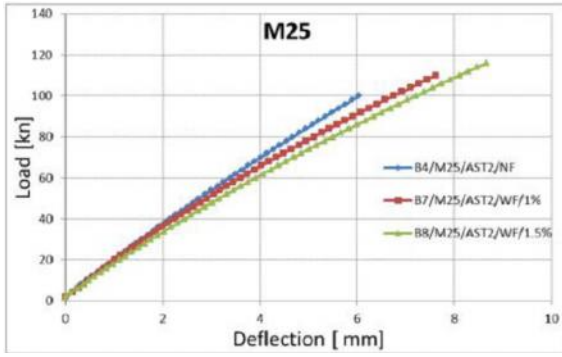
Figure 17: Cracking Pattern of Beam B16/M50/AST2/WF/1.5%

5. Result and Comparison

a) Comparison of load v/s deflection of M_{25} concrete beams 0%, 1% and 1.5%.

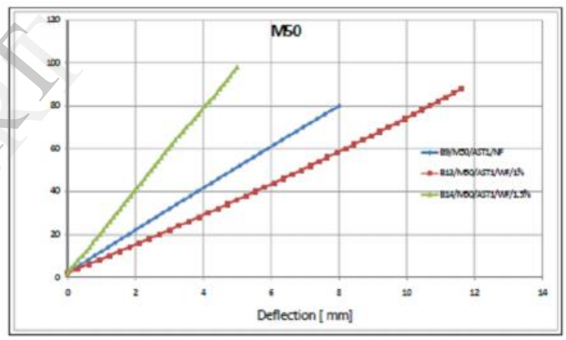


Load v/s deflection for RC beam and SFRC beams B1 and B5 and B6

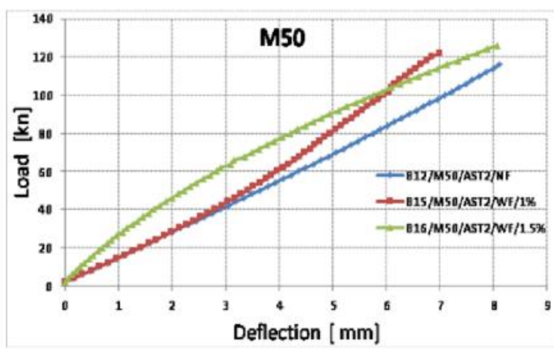


Load v/s deflection for RC beam and SFRC beam B4 and B7 and B8

b) **Comparison of load v/s deflection of M_{50} concrete beams 0%, 1% and 1.5%**



Load v/s deflection for RC beam and SFRC beams B9 and B13 and B14



Load v/s deflection for RC beam and SFRC beams B12 and B15 and B16

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6. Conclusion

Following conclusion can be drawn:

1. Result of control specimen
   a) Compressive strength: The percentage increase compression strength for M25 concrete with 1% and 1.5% were found to be 13.44%, and 32.54% respectively.
   b) The percentage increase compression strength for M50 concrete with 1% and 1.5% were found to be 16.03%, and 33.33% respectively.

2. The load v/s deflection behaviour observed to be non linear upto till the failure of the beams.

3. It is observed that as the percentage of fibres increased from 0%, 1% and 1.5% the load as well as the deflection of the beam increased. There is also further increase in load capacity and deflection from M25 to M50 grade concrete.

4. It is seen that as the percentage of fibres increased the load as well as the deflection of the beam increased with increase in reinforcement. But with increase in reinforcement Ast2 the variation was not large as observed with Ast1 (0.85%) with variation of fibers.

5. It is observed that with increased in fibre there is a corresponding increase in load for M50 concrete than M25 concrete beam. I is observed that with increased in fibre there is a corresponding increase in load for M50 concrete than M25 concrete beam also with increase in reinforcement there is increase in the load capacity of beam.

6. There is a increase in load carrying capacity of beam with increase in reinforcement from Ast1 to Ast2 both for M25 and M50 concrete beam. along with there is a increase in load carrying capacity of beam with increase in reinforcement from Ast1 to Ast2 both for M25 and M50 concrete beam. There is a corresponding increase load capacity.

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