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Comparison of Strength between Steel Fiber Reinforced Concrete and Conventional Concrete

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Abstract: The new age structures are being built massive, taller and complicated in shape. These requirements cannot be fulfilled by conventional concrete, as it possess a very low tensile strength, limited ductility and little resistance to cracking, internal micro cracks are inherently present in the concrete and its poor tensile strength is due to propagation of such micro cracks, eventually leading to brittle fracture of the concrete. It is well known that the use of steel fibers improves the ductility of concrete."Steel fiber reinforced concrete is a composite material consisting of mixtures of cement, mortar and concrete and discontinuous, discrete, uniformly dispersed suitable steel fibers." The properties of steel fiber reinforced concrete are Flexural strength, Tensile strength, Compressive strength that issuperior to that of the conventional concrete. Steel fibers are one of the most commonly used fibers. The role of randomly distributed discontinuous fiber is to bridge across the cracks and provides some post cracking ductility. The applications of Steel Fiber Reinforced Concrete generally include precast elements, Slabs and pavements on ground, Spillways, Seismic resistant structures, Highway and road, Shotcrete in mining, etc. The inclusion of steel fiber in the concrete mix leads to an improvement in mechanical properties and a better resistance to heating effects. It also increases crack resistance to a high extent.

In the present experimental investigation steel fibers have been used to study the effect on flexural strength on M30 grades of concrete. With the addition of 0.75%, 1.5% and 2% steel fibers to conventional concrete, it has been observed that the flexural strength increases for 0.75% and 1.5% of steel fibers in conventional concrete whereas it decreases in case of 2%. Therefore addition of steel fibers up to a certain extent only increases its flexural strength.

Keywords- *Glass fiber,Steel fiber,strength,concrete,conventional,micro cracks*

I. INTRODUCTION

1.1History: The concept of using fibers as reinforcement is not new. Fibers have been used as reinforcement since ancient times. Historically, horsehair was used in mortar and straw in mudbricks. In the early 1900s, asbestos fibers were used in concrete, and in the 1950s the concept of composite materials came into picture and fiber reinforced concrete was one of the topics of interest. There was a need to find a replacement for the asbestos used in concrete and other building materials once the health risks associated with the substance were discovered. By the 1960s, steel (SFRC), glass, and synthetic fibers such as polypropylene fibers were used in concrete and research into new fiber reinforced concretes continues today. Historically, many types of fibers have been used to reinforce brittle materials. Straw was used to reinforce sun-baked bricks; horsehair was used to reinforce plaster and more recently, asbestos fibers are being used to reinforce Portland cement. At various intervals since the time of the 20th century, short pieces of steel have been included within concrete in an attempt to increase the tensile strength and ductility. Studies to determine strength properties of SFRC and mortar began in the laboratories of the Portland Cement Association in the late 1950's. During the late 1960's and early 70's, fiber reinforced concrete was studied and tested extensively, and subsequently was used in a variety of demonstration projects in the USA.Although the technology has been broadly accepted and the advantages of the SFRC are well recognized, the actual practical usage in South Africa is still in its young stages. The real usage of SFRC started in 1992, when a hundred segmented SFRC rings (with fiber dosage of 50 kg/m3) were used in the Delivery Tunnel North (D.T.N.) section of Lesotho High Water Project (L.H.W.P.).

1.2 Need for SFRC: Plain, un-reinforced concrete is a brittle material, with a low tensile strength and a low strain capacity. The role of randomly distributes discontinuous fibers is to bridge across the cracks that develop provides some post-cracking "ductility". If the fibers are sufficiently strong, sufficiently bonded to material, permits the FRC to carry significant stresses over a relatively large strain capacity in the post-cracking stage. There are, of course, other (and probably cheaper) ways of increasing the strength of concrete. The real contribution of the fibers is to increase the toughness of the concrete (defined as some function of the area under the load vs. deflection curve), under any type of loading. That is, the fibers tend to increase the strain at peak load, and provide a great deal of energy absorption in post-peak portion of the load vs. deflection curve.

1.3 Steel fiber reinforced concrete: Different types of steel fibers can be used to reinforce concrete. Steel fibers are generally classified depending on their manufacturing method. Hooked end stainless steel has proven to give the best performance. The addition of steel fibers to concrete necessitate an alteration to the mix design to compensate for the loss of workability due to the extra paste required for coating the surface of the added steel fibers. While many technical and economical advantages are benefited from using SFRC, drawbacks can also be found. They are however not likely to cause major problems. The amount of fibers added to a concrete mix is measured as a percentage of the total volume of the composite (concrete and fibers) termed Vf. Vf typically ranges

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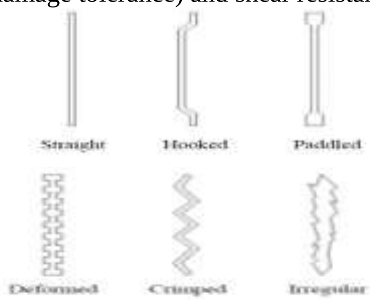
from 0.1 to 3%. Aspect ratio (l/d) is calculated by dividing fiber length (l) by its diameter (d). Fibers with a non-circular cross section use an equivalent diameter for the calculation of aspect ratio. This research focuses on steel fibers. Steel fiber length ranges from 1/4 to 3 inches (1.5 to 75 mm) and aspect ratio ranges from 30 to 100. Fiber shapes are illustrated in Figure 1.1. The effects of steel fibers on mechanical properties of concrete are depicted in Figure 1.2. As shown in the Figure, addition of steel fibers does not significantly increase compressive strength, but it increases the tensile toughness, and ductility. It also increases the ability to withstand stresses after significant cracking (damage tolerance) and shear resistance.



1.1 shapes of steel fibers

1.3 Toughness: Toughness enhancement is among the most important contributions of steel fibers to concrete. Toughness or energy absorption capacity is the area under a load-deflection, moment-rotation, or stress-strain curve, as shown in Figure 1.3. This is especially important for structures subjected to large energy inputs such as earthquakes, blast loads, impact loads, and other dynamic loads.

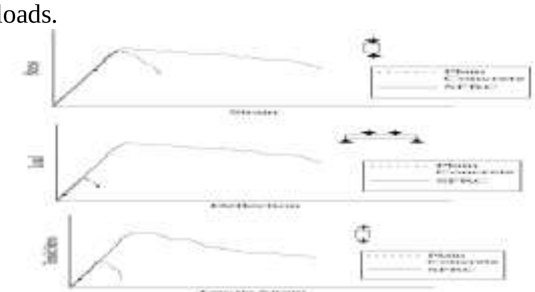


Figure 1.2 Properties of SFRC

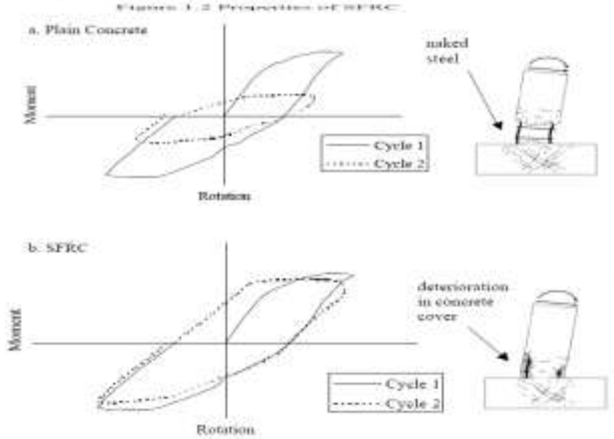


Figure 1.3 Improvements in joint behavior resulting from SFRC

2. EXPERIMENTAL PROGRAM

2.1 Objectives: It is planned to cast a steel fiber reinforced concrete and conventional concrete beam of size 500mm X 150mm X 150mm of M30 grade and test the specimens after 7, 14 and 28 days of curing in lab under water for flexural strength.

2.2 Specimen details: The beam moulds shall confirm to IS: 10086-1982 In assembling the mould for use, the joints between the sections of the mould shall be thinly coated with mould oil and a similar coating of mould oil shall be applied between the contact surfaces of the bottom of the mould and the base plate in order to ensure that no water escapes during the filling. All the baseline concrete material used in this study is shown in table.

Sr. no.	***Baseline Element***	***Type***
1	Cement	53 grade Ordinary Portland Cement
2	Sand	Standard Sand
3	Coarse Aggregate	20mm- 4.75 mm size coarse aggregate.
4	Fine Aggregate	4.75 mm- 2.36 mm size fine aggregate.

2.3 Dry mix

First weight batching is done and dry mix is prepared as per requirement. SF is also added during the dry mixing process. The water is then added in the dry mix simultaneously maintainworkability. Six numbers of Beam Moulds — the mould of 150mmx150mmx500mm size conforming to IS: 10086-1982.

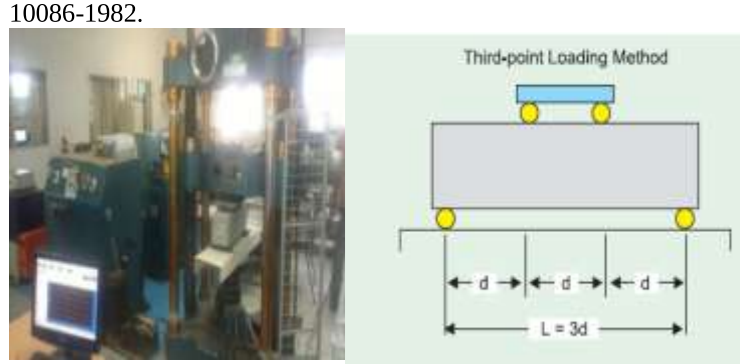


Fig No.2.1 Arrangement for Two-Point loading.

The Flexural strength is determined by formula,

$$F = M/Z = 6PL / 4BD^2$$

Where

F = Flexural strength in N/mm^2, M = Moment of resistance in N.mm, Z = $bd^2/6$ = Modulus of section in mm3, b =Width in mm, d =Depth in mm, L = Supported span in mm.

3. Determination of Results of Conventional Concrete

Flexural strength of conventional concrete of Cross sectional Area ***750cm²***

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Days	Cube	Flexural Strength(kg/cm2)
7	Cube 1	44.39
	Cube 2	44.78
14	Cube 1	46.85
	Cube 2	46.36
28	Cube 1	50.66
	Cube 2	50.78

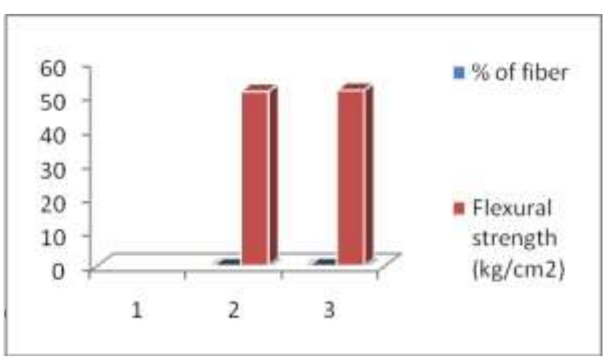
(Before)

(After) Fig.3.1 Test Analysis of Beam

3.1 Determination of Results of Steel Reinforced Concrete Result Shown in Tables.

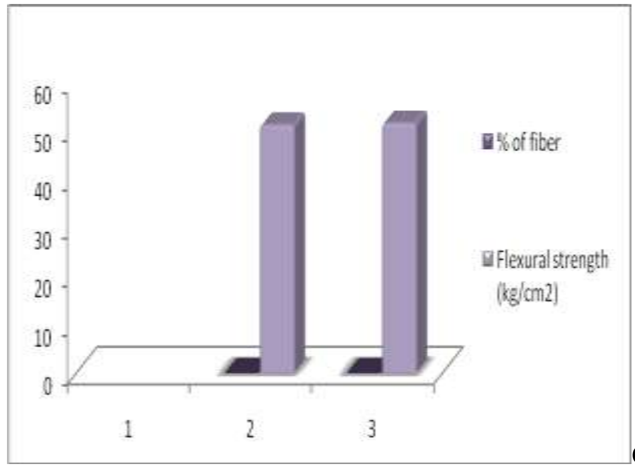
7 Days Flexural Strength (0.75 % Steel fiber)

% of fiber	Cross sectional area (cm2)	Flexural strength (kg/cm2)
0.75%	750	56.26
0.75%	750	56.46



14 Days Flexural Strength (0.75 % Steel fiber)

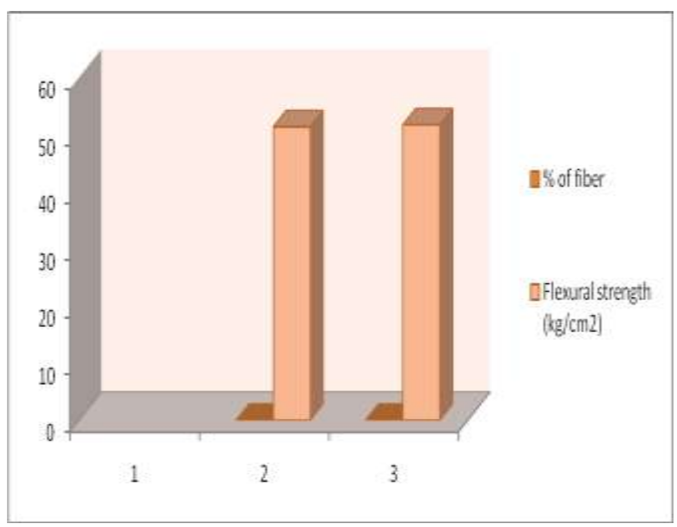
% of fiber	Cross sectional area (cm2)	Flexural strength (kg/cm2)
0.75%	750	58.62
0.75%	750	57.81



Graph 3.2 14 Days Flexural Strength (0.75% Steel fiber)

28 Days Flexural Strength (0.75 % Steel fiber)

% of fiber	Date of Casting	Date of Testing	Cross sectional area (cm2)	Flexural strength (kg/cm2)
0.75%	11/02/2014	12/03/2014	750	58.39
0.75%	11/02/2014	12/03/2014	750	59.16



Graph 3.3 28 Days Flexural Strength (0.75% Steel fiber)

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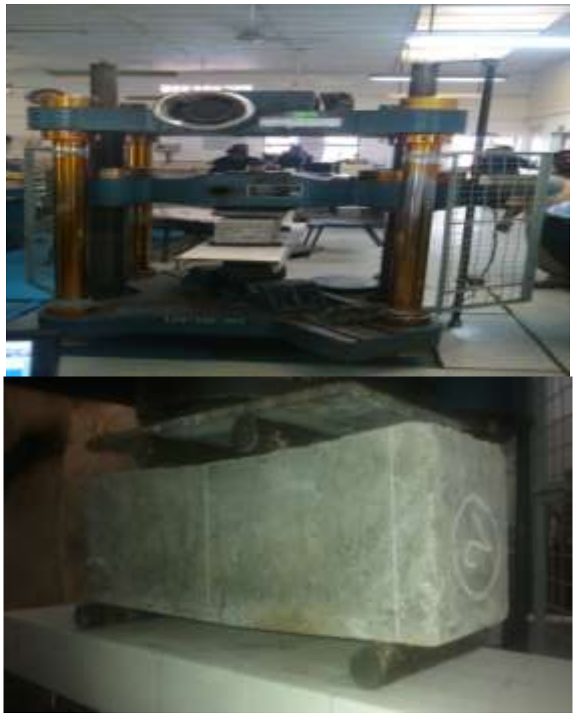
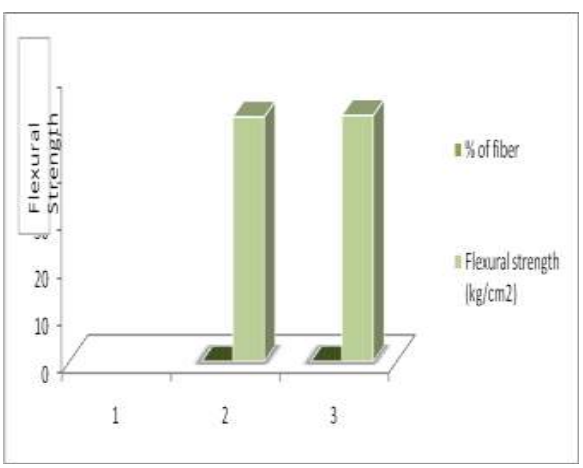


Fig 3.2 Testing of flexural strength of steel fiber reinforced Beam

7 Days Flexural Strength (1.5 % Steel fiber)

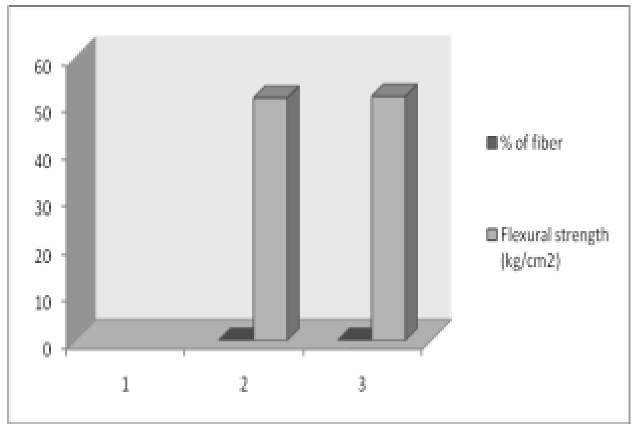
% of fiber	Date of Casting	Date of Testing	Cross sectiona l area(cm	Flexural strength (kg/cm2
1.5%	15/02/14	23/02/14	750	56.32
1.5%	15/02/14	23/02/14	750	58.62



Graph 3.4 7 Days Flexural Strength (1.5% Steel fiber)

14 Days Flexural Strength (1.5 % Steel fiber)

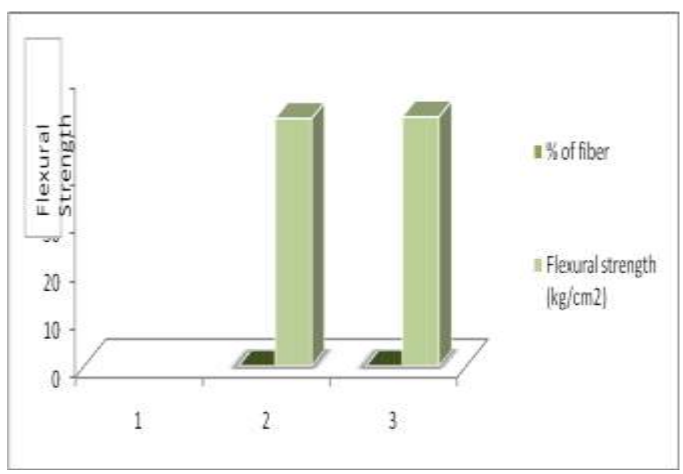
% of fiber	Date of Casting	Date of Testing	Cross sectional area(cm2)	Flexural strength (kg/cm2)
1.5%	13/02/2014	28/02/2014	750	59.44
1.5%	13/02/2014	28/02/2014	750	58.74



Graph 3.5 14 Days Flexural Strength (1.5% Steel fiber)

28 Days Flexural Strength (1.5 % Steel fiber)

% of fiber	Date of Casting	Date of Testing	Cross sectional area (cm2)	Flexural strength (kg/cm2)
1.5%	11/02/2014	12/03/2014	750	63.33
1.5%	11/02/2014	12/03/2014	750	62.89



Graph 3.6 28 Days Flexural Strength (1.5% Steel fiber)

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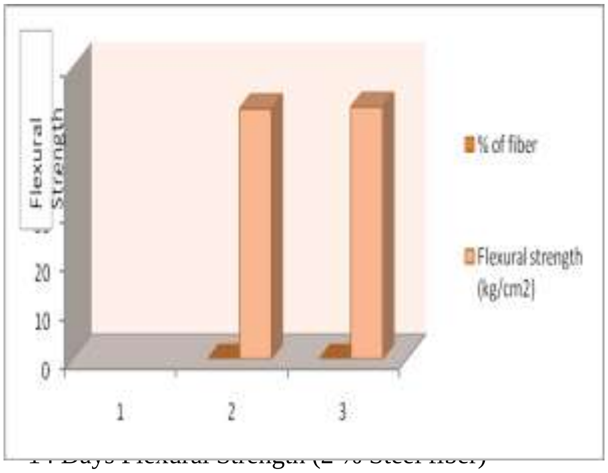
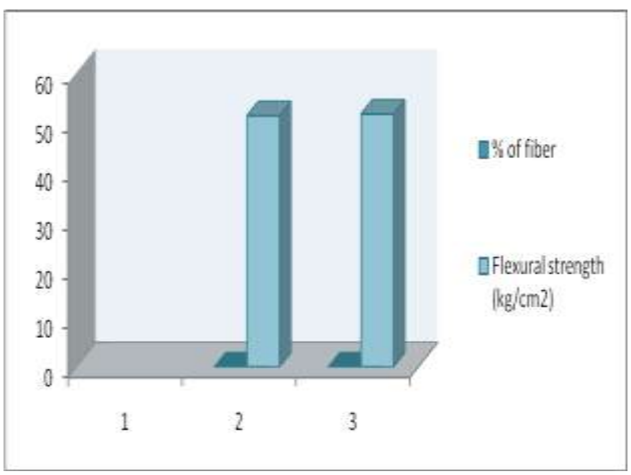
7 Days Flexural Strength (2 % Steel fiber)

% of fiber	Date of Casting	Date of Testing	Cross sectional area (cm2)	Flexural strength(kg/cm2)
2%	15/02/14	23/02/14	750	50.93
2%	15/02/14	23/02/14	750	50.12



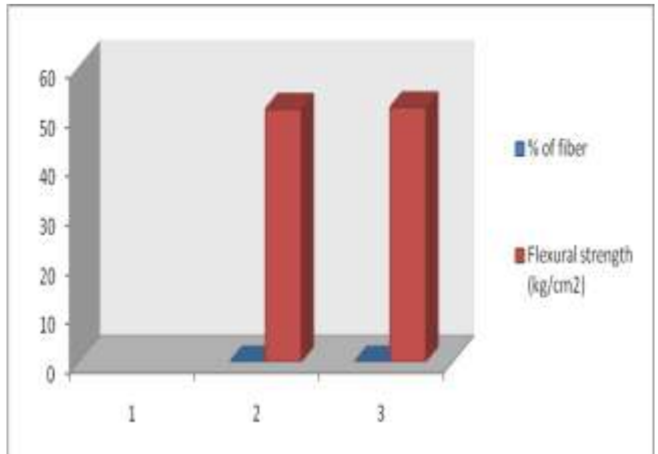
14 Days Flexural Strength (2 % Steel fiber)

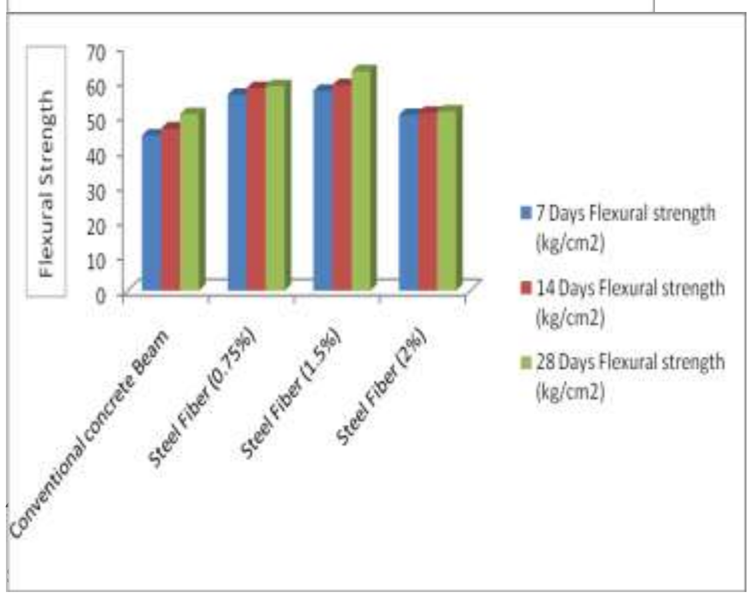
% of fiber	Date of Casting	Date of Testing	Cross sectional area (cm2)	Flexural strength (kg/cm2)
2%	13/02/14	28/02/14	750	51.21
2%	13/02/14	28/02/14	750	50.97



28 Days Flexural Strength (2 % Steel fiber)

% of fiber	Date of Casting	Date of Testing	Cross sectional area (cm2)	Flexural strength (kg/cm2)
2%	11/02/2014	12/03/2014	750	51.33
2%	11/02/2014	12/03/2014	750	51.68





reinforced concrete is used for sustainable and long-lasting concrete structures. Steel fibers are widely used as a fiber reinforced concrete all over the world. Addition of fibers to conventionally reinforced beams increases the fatigue life and decreases the crack width under fatigue loading. It is found that the addition of steel fibers into concrete increases its flexural strength with increase in fiber content after 7, 14 and 28 days of curing. It has been observed that the flexural strength increases for 0.75% and 1.5% of steel fibers in conventional concrete whereas it decreases in case of 2%. Therefore addition of steel fibers up to a certain extent only increases its flexural strength.

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