International Journal of Research in Advent Technology (IJRAT)
(E-ISSN: 2321-9637)
Special Issue National Conference "CONVERGENCE 2018", 09th April 2018

Performance of Steel Fiber Reinforced Concrete in Compression Member

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Abstract -- Research has shown that the addition of steel fibers can improve many of the properties of concrete elements including tensile resistance, fracture toughness and crack control. These enhancements in performance result from the influence of the randomly oriented fibers in arresting cracks and the resulting improvements in the post-cracking resistance of the concrete. Although a large body of research on the structural applications of steel fiber reinforced concrete (SFRC) exists, the potential of using this material in load-carrying structural elements has yet to gain wide acceptance in construction. In this paper effect of fibers on the strength of concrete for M 30 grade have been studied by varying the percentage of fibers in concrete. Fiber content were varied by 0%, 0.5%, 1%, 1.5% by volume of cement.colum specimen of size(150 mm x 150 mm x 600 mm) to check compressive strength at 7 and 28 days of maturity in normal water curing. The results of fiber reinforced concrete for 7days and 28days curing with varied percentage of fiber were studied and it has been found that there is significant strength improvement in steel fiber reinforced concrete. Also, it has been observed that with the increase in fiber content up to the optimum value increases the strength of concrete. Slump cone test was adopted to measure the workability of concrete. The Slump cone test results revealed that workability gets reduced with the increase in fiber content.

Keywords—SFRC; workability; compressive strength; tensile resistance;

1. INTRODUCTION

Steel Fibre reinforced concrete (SFRC) is defined as concrete made with hydraulic cement containing Fine and coarse aggregate and discontinuous discrete fiber. In SFRC, thousands of small fibers are dispersed and distributed randomly in the concrete during mixing, and thus improve concrete properties. SFRC is being increasingly used to improve static and dynamic tensile strength, energy absorbing capacity and better fatigue strength. Over the years the use of the steel fiber has been considerably increased in all over the world, The technique by adding the steel fibers in the concrete mix and enhances the performance of the concrete has been very popular among the engineers and contractors . Steel fibers has been already used in many large project involving constructions of industrial floors, overlays, pavements, highways, tunneling , slope stabilization etc . Addition of the randomly oriented steel fiber in the concrete mix has been very effective in controlling the propagation of micro cracks in the concrete, thus there has been a fair chances of improving the Strength and ductility of the concrete. Generally the hooked steel fiber has been used for the construction of the FRC columns, but in this experimental programme crimped steel fibers has been used. In this experimental programme every specimen has been tested and analyzed and Comparison has been done to investigate the behavior and the effectiveness of each specimen. Based on the result Normalized load Vs Normalized Strain curve , the load Vs strain curve has been plotted and discussed . By the result it has been noticed the use of the steel fiber enhances the toughness and strain at peak load of the concrete.

Why SFRC?

1. To eliminate many undesirable property and to enhance many desirable property of the plain concrete.
2. To increase the density and strength of transition zone. Toughness and strain at peak stress.
3. To study the helping behavior of fiber to transfer loads at the internal micro cracks.
4. To improve the fatigue strength property at all stress levels.
5. To arrest the early spelling of the cover and increase the load taking capacity as well as the ductility of the columns over that of comparable non fiber-reinforced specimens.
6. To study the structural behavior of steel fiber reinforced concrete column having

square in cross section of size 150mm X 150mm X 600 mm under axial loading.

7. To study the effect of transverse reinforcement on column performance.

2. LITERATURE REVIEWS

Prashant Y.Pawade, [1] studied in the research work a series of compression tests were conducted on 150mm, cube and150mm x 300mm, cylindrical specimens using a modified test method that gave the complete compressive strength, static, dynamic modulus of elasticity, ultrasonic pulse velocity and Stress strain behavior using silica fume with and without steel fiber of volume fractions 0, 0.5, 1.0, and 1.5 %, of 0.5mm Ø of aspect ratio of 60 on Portland Pozzolona cement concrete. As a result the incorporation of steel fibers, silica fume and cement has produced a strong composite with superior crack resistance, improved ductility and strength behavior prior to failure. Addition of fibers provided better performance for the cement based composites, while silica fume in the composites may adjust the fiber dispersion and strength losses caused by fibers, and improve strength and the bond between fiber and matrix with dense calcium silicate hydrate gel. The results predicted by mathematically modeled expressions are in excellent agreement with experimental results. On the basis of regression analysis of large number of experimental results, the statistical model has been developed. The proposed model was found to have good accuracy in estimating interrelationship at 28 and 90 days age of curing.

Similarly, S. A. Mahadik, [2] experimented in the research work that the Cement concrete is the most extensively used construction material in the world. The reason for its extensive use is that it provides good workability and can be moulded to any shape. Ordinary cement concrete possesses a very low tensile strength, limited ductility and little resistance to cracking. Internal micro cracks, leading to brittle failure of concrete. In this modern age, civil engineering constructions have their own structural and durability requirements, every structure has its own intended purpose and hence to meet this purpose, modification in traditional cement concrete has become mandatory. It has been found that different type of fibers added in specific percentage to concrete improves the mechanical properties, durability and serviceability of the structure. It is now established that one of the important properties of Steel Fiber Reinforced Concrete (SFRC) is its superior resistance to cracking and crack propagation. In this paper effect of steel fibers on the strength of concrete for M 40 grade have been studied by varying the percentage of fibers in concrete.

Similarly, J. A. O. Barros [3] studied the results of the uniaxial compression tests performed under displacement control condition, a stress-strain relationship for fiber concrete in compression was derived. Three-point bending tests on notched beams were carried out in order to simulate the post-cracking behavior and to evaluate the fracture energy. Based on the constitutive relationships derived from the experiments, a layered model for the analysis of steel fiber reinforced concrete cross sections was developed.

Ehab m. Lotfy [4] experimented investigation of the a xial behavior of small scale square reinforced concret e columns with fiber reinforced polymer (FRP) bars, as a solution to overcome the corrosion problems, wh ere this material represents a relatively new technolog y; therefore much research is needed to determine its characteristics and gain confidence to be accepted by engineers for practical application.Increasing of chara cteristic strength of concrete has significant effect on the behavior of tested columns where increase toughn ess and ductility of tested columns.So GFRP bars can be used as main reinforcement in columns with incre asing the transverse reinforcement along columns len gth and using high strength concrete

3. MATERIAL USED

- Cement.
- Fine Aggregates.
- Coarse Aggregate.
- Super plasticizer.
- Steel fibers.
- Water

3.1. Cement.

In this present investigation Ordinary Portland Cement (OPC) of 53-grade obtained from AMBUJA Cements Pvt. Ltd was used conforming to IS 12269–2004 was used. As per IS 4032 for the chemical composition of OPC 53. Specific Gravity was found out 3.04 for OPC of 53-grade cement

Fine Aggregates

Locally available sand from man river with 4.75 mm maximum size was used as fine aggregate with specific gravity 2.55, Fineness Modulus = 2.65.confirming to IS 383– 1987. The sieve analysis has confirmed that fine aggregate is of zone II. Its average water absorption was found to be 1

3.2. Coarse Aggregate

Locally available crushed stone with maximum size 20mm was used as coarse aggregate with specific gravity of 2.78, fineness modulus=6.78 confirming to IS 383–1987. Coarse aggregates having a maximum size of 20mm were used in this project work where 40% of it was passing through 20mm IS sieve and retaining on 12.5mm IS sieve and 60% was passing on 12.5mm IS sieve and retained on 4.75mm sieve.

3.3. Super Plasticizer

Commercially available super plasticizer CICO Plast Super C 300 obtained from CICO Technologies Ltd. Pune has been used as super plasticizer. Super plasticizer was mixed in the amount of 2 % of cementitous material confirming to IS 9103-1999. The specific gravity and pH of super plasticizer used are 1.12 and 5.0 respectively. Super plasticizers are introduced in SFRC to obtain the fluidity. Nevertheless, a high dosage near the saturation amount can increase the proneness of the concrete to segregate.

3.4. Steel fibers

High Tensile Hook End Steel Fibers procured from KASTURI METAL COMPOSITES Pvt. Ltd. Amravati. was used in this experimental work. The properties of the Steel Fibers used are given in Table

Table 1: Properties of Steel Fibers

Fiber Type	**Aspect Ratio**	**Length (mm)**	**Diameter (mm)**	**Tensile Strength N/mm^2**
Crimped Type	20-100	50	1	750 N/mm^2 to 1100 N/mm^2

3.5. Water

In this study, normal tap water available in the concrete laboratory was used. Water conforming to the requirements of water for concreting and curing as per IS: 456-2000.

4. MIX DESIGN

Ordinary Portland cement of 53 grade was used. The coarse aggregates used were crushed aggregate passing through 20 mm sieve size and retaining on 4.75 mm sieve size. The fine aggregate used was uncrushed sand. The mix design was confirming to IS 10262:2009. Water cement ratio of 0.45 was adopted. Throughout the test the concrete used was M30 grade and end hooked steel fiber have been used. Commercially out there super plasticizer CICO Plast Super C 300.

Table 2: Mix Proportion For Trial Mix

Mix	Trial -I	Trial-I	Trial-I
Cement kg/m^3	350	388.88	318.18
Fine Aggregate kg/m^3	896	849.24	949.08
Coarse Aggregate kg/m^3	1140	1153.69	1114.13
Water kg/m^3	140	140	140

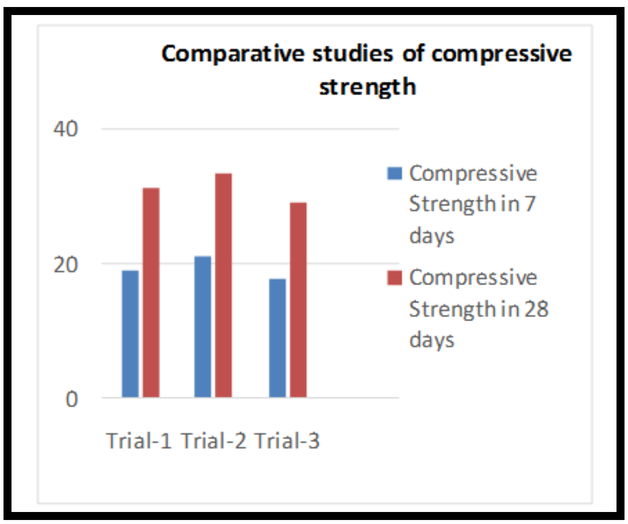

Fig.1: Comparative Study of Compressive Strength

5. PREPARATION OF SFRC MIXES

The mixing is done manually as hand mixes. The coarse and Fine aggregates are dried for about 30s. This is then followed by the addition of Cement. After mixing is done remaining water along with super plasticizer are added and mixed thoroughly and then the mixes were checked for fresh properties and the casted in specimen moulds for checking the hardened mixes. This wet composition is allowed to mix for four minutes. During the process, fiber was sprinkled uniformly in the wet mixture. The moulds were filled with the mix prepared. After 24 hours the specimens are demolded and are transferred to curing tank for normal water curing at 7 and 28 days of maturity.

After 24 hours of casting, specimens are kept for 28 days normal water curing without disturbance until it attains a hardened state. Fibers are added in the proportions of 0.0% (reference mix), 1%, 1.5%, 2% with the replacement of cement and Fly Ash is added (30% by weight of cement) was added to this for all mixes to cast various SFRC specimens.

Table 3: Compressive Strength with different fiber content

Mix		M 0	M 0.5	M 1	M 1.5
Fiber content		0	0.5	1	1.5
Compressive strength	7days	21.1	26.17	27.16	26.43
	28days	33.5	33.91	35.4	34.22

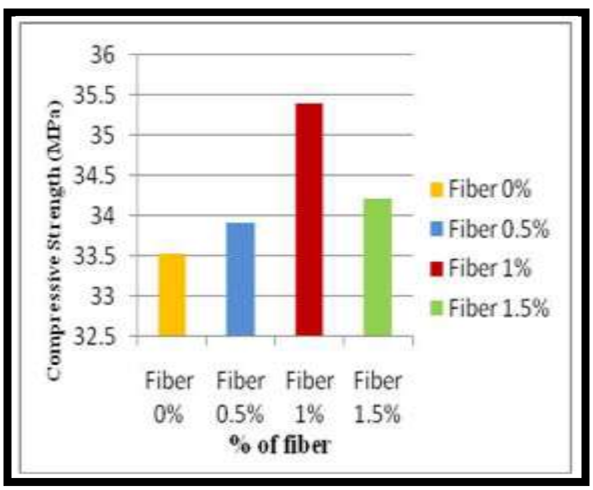

Fig.2: Comparative Study of Compressive Strength

6. LOAD- DEFORMATION BEHAVIOUR AND DUCTILITY

The load was applied gradually at the rate of 50KN/min and the deformation readings were taken at regular intervals. The column was gradually loaded up to the ultimate load till failure. As the load level was increased in each interval, the observed displacement was greater than that it was in earlier interval. The ductility value has been calculated as the ratio of ultimate or maximum deformation to the yield deformation.

Table 4: Ductility of columns

Type of column	SFRC with 0%	SFRC with0.5%	SFRC with 1%	SFRC with1.5%
Ultimate load Carrying capacity	539.5	900	976	919
Ductility Factor	2.24	2.40	2.84	2.43

7. CONCLUSION

- It is observed that the workability of steel fiber reinforced concrete gets reduced as the percentage of steel fibers increases
- Compressive strength goes on increasing by increase in steel fiber percentage up to the optimum value. The optimum value of fiber content of steel fiber reinforced concrete was found to be 1%.
- While testing the specimens, the plain cement concrete specimens have shown a typical crack propagation pattern which leaded into splitting of beam in two piece geometry. But due to addition of steel fibers in concrete cracks gets ceased which results into the ductile behavior of SFRC. Generally it's found that SFRC column has higher values of malleability as compared to plain RCC column. SFRC column could also be required for earthquake resisting structures.
- The columns posses fiber exhibited less fluctuations of the load as compared to the plain reinforced columns
- As the percentage of the fiber increases , the load resisting capacity against cracking of the column specimen increases
- The steel fiber columns exhibited better toughness and higher strain at peak load in comparison to the plain concrete columns

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