International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878 (Online), Volume-9 Issue-2, July 2020

Exploration of Characteristics of Steel Fiber Reinforced Concrete and Its Influence on Regular Concrete

Dhruv Deepak, P. R. Minde

Abstract: Concrete is the most widely used product in the construction sector mainly because of its properties and its capability to be moulded to any size. Plain concrete has low tensile strength and forms internal micro cracks. It has been proven that with the addition of natural fibers and synthetic fibers in concrete, it helps in the durability and functionality of structure. The steel fibers are added to the concrete in very low volume doses and it has been effective in decreasing the plastic shrinkage in cracking and also acting as a crack arrestor. In this journal, experimental analysis on steel fiber reinforced concrete is done on M30 and M50 mix with 0.5%, 1%, 1.5% and 2% volume fraction of steel fiber content and is compared with samples of 0% steel fiber content and these samples are investigated on their compressive, split tensile and flexural strengths.

Keywords: Compressive strength, Flexural Strength, Resistance, Steel fibers, Tensile strength

I. INTRODUCTION

The steel fiber has been around for many decades. They are the best reinforcement in terms of safety and cost efficiency. They can be used in structural applications such as foundations to non structural application such as floors. If we added steel fibers to the concrete, they act as a micro reinforcement. The act will form at the same load but the structure won't fall apart, it will be held together by fiber reinforced concrete. The SFRC doesn't make the concrete stronger but it makes it hold together longer. The steel fiber increases the post cracking strength which can be called as the toughness of the structure. The fiber doesn't stop the cracks from forming but the fibers keep the cracks small. Adding the steel fiber reinforcement to the concrete helps to absorb stresses and to formation of the cracks which increases the load bearing capacity and the ductility of the concrete structure. The steel fibers act to bridge over the cracks and the role is to be a crack arrestor. Steel fiber reinforced concrete is more durable, serviceable and transfer stress than conventional reinforced concrete. Steel fiber helps in increasing the tensile strength of concrete by eliminating micro cracks which forms in the concrete under exterior force and load effects.

Manuscript received on May 25, 2020.
Revised Manuscript received on June 29, 2020.
Manuscript published on July 30, 2020.
* Correspondence Author
Dhruv Deepak, Student, Department of Civil Engineering, Dr. Vishwanath Karad MIT World Peace University, Pune, India.
Pravin Minde, Assistant Professor, Department of Civil Engineering, Dr. Vishwanath Karad MIT World Peace University, Kothrud, Pune, India.

With the addition of steel fiber in concrete, it transforms the brittle material to a ductile system able to develop tensile load carrying capacity. The steel fiber uniformly distributed in the matrix helps in bonding the concrete very tightly; the steel fibers can effectively inhibit the formation of any tiny cracks and helps in improving the cracking strength of the structure.
The steel fibers in concrete have excellent durability, crack resistance, bending resistance, impact resistance and other characteristics. With the inclusion of steel fibers in concrete, it helps in reducing the permeability and the bleeding of water in concrete is also reduced. The amount of fibers to be added into the concrete mix is calculated for the percentage of total volume termed as the volume fraction.

A. Why Steel Fiber?

The steel fiber act within the concrete matrix absorbing the tensile stresses and helps in reducing the formation of cracks. In steel fibers, the catastrophic failure is actually eliminated because the steel fibers help in supporting the load of structure after the cracking occurs. When using a transit mix, the fiber should be added last to the wet concrete. The finishing operations are essentially the same as that of plain cement concrete, perhaps more care should be taken. In most situations, we add steel fiber reinforcement to improve the strength in concrete. The reinforcement within concrete helps in creating a composite material.

B. Research Objectives

- To compare compressive strength, split tensile strength and flexural strength between plain cement concrete and concrete with fiber content of 0.5%, 1%, 1.5%, 2% as per IS standards on 7th, 14th and 28th day of curing.
- To determine a graphical relationship for the compressive strength, flexural strength, split tensile strength in concrete.
- To determine the influence of steel fiber dosage in the properties of concrete with grades M30 and M50 respectively.
- To identify the optimum volume percentage content of inclusion of steel fibers in concrete when subjected to load.

II. LITERATURE REVIEW

Tejas R Patil, Kavita S Kene et.al (2012)[1] This paper deals with experimental investigation for M20 grade of concrete to study the compressive strength and tensile strength of steel fiber reinforced concrete containing fibers of 0% and 0.5% in volume of hooked end steel fibers of aspect ratio 50 and 53.85 used.

The steel fibers are distributed around aggregate particles and so they reduce the workability while the mix becomes more cohesive. The fibers are randomly distributed in the concrete during mixing and thus improve the properties of concrete in all directions. The result data obtained is analysed and compared with the control sample with 0% fiber.
The result data shows the percentage increase in 7 and 28 days of compressive strength and tensile strength for M20 grade of concrete. By the addition of 0.5% hooked end steel fibers, it increases the compressive strength of concrete up to 10% and the split tensile strength of fiber reinforced concrete depends on the length of fiber used. Also the addition of 0.5% of steel fibers reduces the slump value of fresh concrete and it is studied that the workability and flow property of concrete can be overcome by using admixtures such as super plasticizers.

Nithin D'Souza, Nayana Patil et.al (2019)[2] concluded that the steel fiber matrix can together hold the extensive cracking and possess increased strength and extensibility. Here laboratory investigations have been done to study the effect of concrete with different steel fiber percentage of 0%, 0.5%, 1%, and 1.5% on mechanical, durability and impact properties. Slab specimens are casted with and without the steel fibers and these specimens are casted, cured and tested after 28days. The results of SFRC samples and plain cement concrete samples are discussed for M25 Grade of concrete with hooked end steel fiber dosages. The steel fiber are added to concrete in dosages of 0.5%, 1%, 1.5% provides better strength, durability and impact load resistance. Due to the addition of steel fibers, there was a reduction in displacement also.
Dr.S. Suriya, Suman Naaz Shaikh et.al (2015)[3] have mentioned in this paper that the addition of steel fiber in concrete helps in improving both the flexural and compressive strength in concrete and polymer modified SFRC is resistant towards weathering action. Fiber can be natural, steel or polymer materials and the main aim is the modification of cracking mechanism. Here the cracks will be small in width, reducing the permeability in concrete and increasing the fatigue strength, the load carrying capacity and toughness. The polymer concrete (SBR latex) expresses itself as one of the most versatile materials and has many improved properties and it is highly resistant to weathering action, so it is extensively used in lying of pavements. The results have observed that by adding up steel fibers to concrete will have an improvement in its compressive and flexural strength and with inclusion of SBR latex and steel fiber in M25 mix, there is a considerable amount increase in flexural strength as compared to other matrix used.

III. RESEARCH METHODOLOGY

1. Selection of Topic
2. Literature Review
3. Identification of Research Gap
4. Setting up of Research Objectives and Problem Statement
5. Data Collection
6. Experimental Work
7. Result and Discussion
8. Conclusion

A. Data Collection

The standard of OPC 53 grade cement has been used in the experimental study.OPC 53 offers structures with a high strength and durability due to their best size and superior crystallized structure being of high resistance cement. The cement was provided from SAI RMC batching plant Pune along with the coarse aggregate, fine aggregate and natural sand required for the experimental work. The steel fibers were collected from hardware markets and it is a widely available product. The zone of fine aggregate was zone 3 after the sieve analysis process. Recycled crushed stones of 20mm size were handed as the coarse aggregate which had a specific gravity 2.62. The steel fibers acquired were of 0.5mm diameter and 30mm length. The steel fibers have a specific gravity of 7.8 and are straight end steel fibers. Since the steel fibers are of 0.5mm diameter and 30mm length, the aspect ratio is found to be 60.

IV. EXPERIMENTAL WORK

A. Slump Test

Slump tests are performed to decide workability of concrete. The more the addition of steel fibers in concrete, the greater the effect will be there on the workability of concrete. The slump test is also used to find the consistency of the mix as well. The test is performed on standard apparatus which have bottom diameter of 10cm upper diameter, 20cm lower diameter and height 30cm, it includes low cost and provides immediate results.

Table- I: Slump values for M30 and M50 mix

Steel Fiber %	Slump for M30 mix	Slump for M50 mix
0	72.7mm	107.4mm
0.5	63.4mm	98.4mm
1	58.5mm	91.2mm
1.5	51.1mm	84.5mm
2	43.6mm	72.7mm

B. Compressive Strength Test

Cube samples of size 150 x 150 x 150 mm are made for both M30 and M50 mixes. Steel fibers of aspect ratio 60 (30mm length and 0.5mm diameter) were filled in the mould with 0%, 0.5%, 1%, 1.5%, 2% fibers. 3 cubes are taken for each classification. On filling the mould with concrete, the compaction is carried out in 3 layers, with each layer having strokes of 25 each with a 16mm rod. The surface is then leveled well and given a good finish. After which the cubes are allowed to rest and then demoulded. The demoulded cubes are then placed in the curing tank for 7, 14 and 28 days after which the cubes will be taken for testing. Testings are done on a compressive strength machine (digital) and the load is noted at which the cube cracks i.e. when the failure occurs. The average values of the three cubes are taken into account.

Table- II: Compressive Strength for M30 and M50

Steel fiber %	Split Tensile Strength (MPa)			Avg.
0	3.8	3.6	3.9	3.7
1	4.3	4.7	4.4	4.5
2	4.9	5.2	5.1	5

I-Days of Curing, **II**-% Steel Fibers

C. Flexural Strength Test

Beam samples of size 150x150x500mm are casted for M50 grade concrete. Steel fibers are added at 1% and 2% of concrete in the moulds. Three beams are taken for each classification. The moulds are leveled and allowed to rest, after which the samples are demoulded and kept for 28 days of curing in the curing tank. The flexural strength is then calculated and the loaded device applies load at a rate of 170kg/min until the specimen gets cracked. The average of the three beams is taken and two point loading system is taken into account here.

Table- III: Flexural Strength of concrete

Steel fiber %	Flexural Strength (MPa)			Avg.
0	8.1	8.6	8.4	8.3
1	9.3	9.8	9.4	9.5
2	10.2	9.9	10.3	10.1

D. Split Tensile Strength

Cylinder samples which have a diameter of 150mm and 300mm length are utilized here to predict the split tensile strength. The cylinders are placed longitudinally and testing is done by applying the force on the compressive testing machine. The demoulded cylinder was cured for 28 days and then the split tensile test is carried out on grade M50 with different percentage of steel fibers of aspect ratio 60. The maximum load applied is noted and the type of crack is noted. Three cylindrical samples are prepared here.

Table- IV: Split tensile strength of concrete

I	7 days		14 days		28 days	
II	**M30**	**M50**	**M30**	**M50**	**M30**	**M50**
0	32.2	51.3	35.1	54.6	40.6	55.6
0.5	35.5	54.6	38.2	58.3	42.1	61.7
1	39.8	59.7	42.1	62.9	44.3	64.2
1.5	42.6	62.1	44.7	64.5	47.7	69.7
2	39.5	59.2	40.9	61.8	44.5	63.8

Figure- I: Split tensile strength of concrete of M50

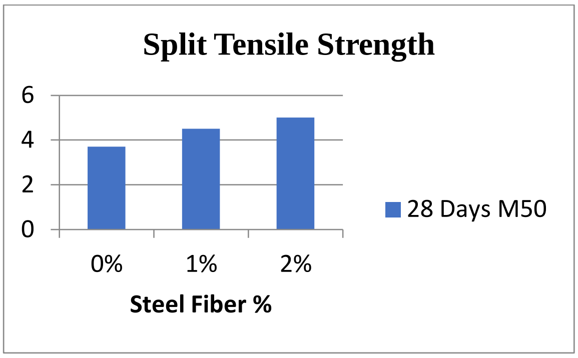


Figure- II: Flexural Strength of concrete

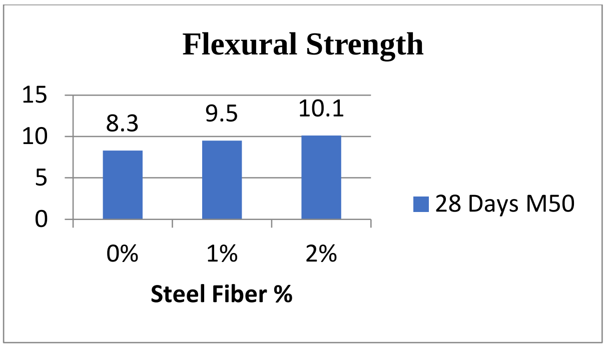
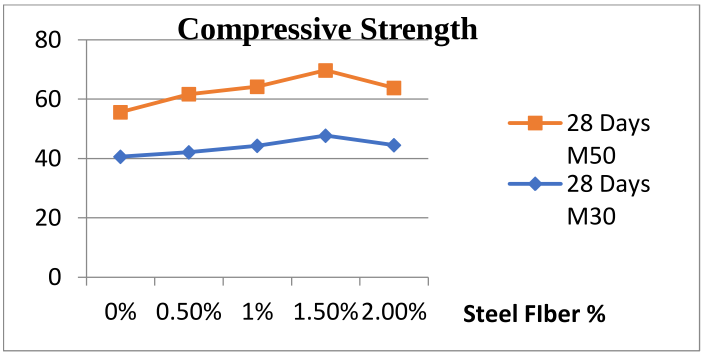


Figure- III: Compressive Strength of concrete



V. RESULTS AND DISCUSSIONS

1. It is known from the experiment that the compressive strength is higher for 1.5% addition of steel fibers in concrete when compared to 0.5% and with 1% addition of steel fibers, the increment in the compressive strength from 0% to 1.5% can be observed and then a gradual decrease in compressive strength at 2% addition of steel fibers in plain cement concrete and the properties are observed to be on the high side with 1.5% addition of steel fibers.

2. For M30 mix concrete, there is a gradual increment from 14% to 24% with inclusion of straight end fibers and for M50 mix, there is an increment for compressive strength as 17% to 32% with inclusion of the steel fibers in it.

3. The split tensile strength has a significant increase as the percentage of steel fiber increases and it is similar to both M30 and M50 grade of concrete and the split tensile strength has an increment from 10% to 27% with addition of steel fibers.

4. The flexural strength of concrete after 28 days of curing has an increase of 6% to 17% with an addition of steel fibers and that with the addition of steel fibers in plain cement concrete, there is reduced crack opening.
5. From the above result, it can be concluded that workability of the steel fibers in plain cement concrete decreases with an increase in percentage of the steel fibers in concrete and the steel fibers increases the tensile properties and provides improvement to resistance to cracking.

VI. CONCLUSION

The steel fiber reinforced concrete is defined as the concrete made with the hydraulic cement which consists of coarse and fine aggregates and the straight end steel fibers. In the SFRC, the steel fibers are randomly distributed within the cement mix during mixing and it improves the properties of concrete. Nowadays, the steel fiber reinforced concrete is very much used to improve the static and dynamic tensile strength, energy absorbing capacity and better fatigue. The SFRC also helps in increasing the ultimate strength and capacity. Also, the workability decreases with the fiber content. Ductility of concrete is found to increase with inclusion of fibers at higher fiber content and the width of cracks is found to be less in SFRC than that of plain cement concrete. In general, the satisfactory improvement in various strengths is observed with the inclusion of steel fibers in the plain concrete. The optimum steel fiber content to impart maximum gain in various strengths varies with the type of strength.

REFERENCE

1. Ashfaque Ahmed Jhatial, Samiullah Sohu, Nadeem-ul-Karim Bhatti, Muhammad Tahir Lakhiar, "Effect of steel fibers on the compressive and flexural strength of concrete", International Journal of Advanced and Applied Sciences, 2018, Vol 05(10)
2. Pramod Kawde, Abhijit Warudkar, "Steel fiber reinforced concrete: A review", International journal of engineering sciences and research technology, 2017, Vol 06(01)
3. Virat Choudhary, "A research paper on the performance of synthetic fiber reinforced concrete", International Research Journal of Engineering and Technology (IRJET), 2017, Vol 04, Issue 12
4. J Novák and A Kohoutková, "Fiber reinforced concrete when exposed to elevated temperature", IOP Conf. Series Materials Science and Engineering, 2017
5. Nafisa Tabassum, Pranta Biswas, Dr. Md. Saiful Islam, "Study on the compressive and strength behavior of steel fiber reinforced concrete beam", International Journal of Advanced Research, 2018, Vol 06(08)
6. A.M. Shende, A.M. Pande, M. Gulfam Pathan, "Experimental Study on steel fiber reinforced concrete for M40 grade", International Refereed Journal of Engineering and Science (IRJES), 2012, Volume 1, Issue 1
7. Dr.S. Suriya, S. Sownmiya Sadhana, Suman Naaz Shaikh, "Study of modified steel fiber reinforced concrete, International Journal of Advanced Research in biology, Science and technology, 2015
8. E. Arunakanthi,J.D.Chaitanya Kumar, "Experimental Studies on fiber reinforced concrete", International Journal of Civil Engineering and Technology (IJCIET), 2016, Volume 7, Issue 5
9. Rachit Silawat, Anil Kumar, "Studies on fiber reinforced concrete", International Journal for scientific research and development,2018, Vol 4, Issue 7
10. Avinash Joshi, Pradeep Reddy, Punith Kumar, Pramod Hatkar, "Experimental work on steel fiber reinforced concrete", International journal of scientific and engineering research, 2016, Vol 7, Issue 10

AUTHORS PROFILE

Dhruv Deepak, is an M-tech student at the department of Civil Engineering from Dr. Vishwanath Karad MIT World Peace University, Pune, India and the area of specialization includes Construction Management and Engineering. He completed his bachelor's degree from Sree Narayana Guru College of Engineering and Technology, Payyanur, Kerala.

Pravin Minde, Assistant Professor, School of Civil Engineering, Dr. Vishwanath Karad MIT World Peace University, Kothrud, Pune, India. He currently pursuing Ph.D. in Civil Engineering from department of Technlogy (S.P. Pune University). He received his Bachlor degree in Civil Engineering from Pune University, India in 2012 and completed the Masters degree in Construction and Management from the same university in 2014. His current research interest includes Total Quality Management in construction industry and Sustainable construction management.