Experimental Investigation of Steel Fiber Reinforced Concrete

[1]Ansari Shadab Ahmed [1]Balkawade Siddharth [1]Jahagirdar Arafat [1]Parkar Shoaib [1]Shaikh Ruman [2]G.N. Supe

[1] UG student, Trinity Academy of Engineering, Pune. [2] Assistant Professor, Trinity Academy of Engineering, Pune.

Abstract: In traditional or standard concrete, due to the drying shrinkage and reason as other volumetric changes, micro-cracks tend to start developing when or before the structure is put under loading. Elastic deformation is occurred due to the reason of cracks spreading and opening up which also results in elastic bending. Fiber reinforced concrete (FRC) is prepared by mixing randomly distributed small steel fibers in cement-concrete. These steel fibers are mainly used to transfer the load to the internal micro-cracks. SFRC tends to have astounding engineering properties like compressive strength, tensile strength, impact confrontation, and excellent permeability and due to this reason; it has started being successfully used in the construction sector and industry. It is a very effective way to increase the overall life span of concrete, the shock resistance, and the resistance to cracking of the mortar. This paper gives an experimental investigation on the applications of Steel Fibers on concrete with the testing and results.

Keywords: Steel Fibers, micro cracks.

I. INTRODUCTION

FRC is a relatively a new type of concrete that is being adapted in the field of construction and engineering and is starting to be used rapidly. FRC is can be defined as a composite material that is prepared by mixing Portland cement, sand, aggregate, incorporating discrete discontinuous fibres. The addition of these fibrous materials to the concrete is for a simple reason that is to improve and enhance the various properties of the concrete. Unreinforced concrete happens to be a weak and brittle material that has very low tensile strength and its strain capacity is tends to be low as well. Due to this, a lot of cracks are usually formed in the concrete. In order to tackle this problem, steel fibers are added to the concrete in a discontinuous distributed manner. This provides ductility to the concrete post cracking and reduces the crack formation as well, if the steel fibers are strong and properly bonded to the rest of the materials. This permits the composite concrete in the post cracking stage to carry significant stresses over a larger strain capacity

Overall strength of the concrete can be increased by various other methods for example, adding additives to the mixture but that necessarily won't provide the concrete with toughness. So the main contribution of the steel fibers is to add toughness to the concrete and this can be seen in the load vs. deflection curve under various types of loading. That means, the steel fibers are increasing the strain at the peak loading and also providing the concrete with good energy absorption post-peaking. Steel Fibers when added to the concrete, they tend to act as rigid inclusions in the concrete matrix that are also effective. Since the fibrous inclusion can be related with the aggregate inclusion, it cannot be considered as a direct replacement for the conventional concrete reinforcement; even though the presence of these fibrous materials in the concrete body can improve the body's resistance to deflection, cracking and also other serviceability conditions that the body can undergo in its lifespan. The steel fiber can be used in a 3-dimentionally randomly distributed manner throughout the member that will enable the member to utilize the properties like crack control and shear resistance

A steel fiber is a small piece material that is used for reinforcing that has various characteristic properties. They are usually circular or flat in shape. In order to select the type of fiber, one needs to be familiar with the concept of 'aspect ratio, as it is defined by this parameter. Aspect ratio is basically the ratio of its length to the diameter of the fiber. The aspect ratio of a typical fiber can range from 30-150.

Small fibers are predominantly used where the control of cracks is the most important design criteria. To permit finer distribution, high fiber count of steel fiber reinforcement should be used throughout the concrete matrix. This finer distribution of steel fiber will provide better crack controlling.

Steel fiber increases the engineering properties of the concrete member when added to the member. Properties such as flexure, tension, impact resistance, fatigue. It also increases the load bearing capacity of the member when SF is added to it.

II. LITERATURE REVIEW

B. Miloud presented a research paper on "Permeability and porosity characteristics of steel fiber reinforced concrete" in 2003. This paper presents the results of an experimental study that was carried out to examine the influences of steel fiber addition on the permeability and porosity of a concrete prepared mainly from local materials.

Sabir Khan, Saiful Islam, Zarghaam Rizvi presented a research paper on "Innovation in steel fiber reinforced concrete-A review" in 2013. This paper gives a review of research performed on steel fiber reinforced concrete such as tensile strength, flexural strength, impact and cracking. We studied the engineering properties of fiber reinforced concrete.

Vasudev R, Dr. B G Vishnuram presented a research paper on "Studies on Steel Fiber Reinforced Concrete - A Sustainable Approach" in 2013. The purpose of this paper is to show a comparative study on SFRC and ordinary concrete.

Abdul Ghaffar presented a research paper on "Steel Fiber Reinforced Concrete" in 2014. The purpose of this study was based on investigation of the use of steel fibers in structural concrete to enhance the mechanical properties of the concrete.

Aiswarya Sukumar Elson John presented a research paper on "Fiber addition and its effect on concrete strength" in 2014. In this paper an experimental investigation on the behaviour of concrete specimens reinforced with steel fibers and subjected to compressive and flexural loading is presented. Tests were conducted on specimens with three different fiber volume fractions. It was observed that SFRC specimens showed enhanced properties compared to that of normal specimens.

Er. Gulzar Ahmed and Er. Kshipra Kapoor presented a research paper on "A review study on use of steel fiber as reinforcement material with concrete" in 2016. In this paper, they studied the usefulness of fiber reinforced concrete in various Civil Engineering applications is thus unquestionable. This review study is a trial of giving some highlights for presence of steel fibers especially in terms of using them with new types of concrete.

Shashwat Sharda, 1, a, Manvendra Singh1, band Sarbjeet Singh1 presented a research paper on "A review on Properties of Fiber Reinforced Cement-based materials" in 2016. A comprehensive overview of the published literature on the use of fibers in cement-based material is being presented. Effect of fibers on properties of cement-based material such as workability, compressive strength, flexural strength, split tensile strength, shrinkage, impact resistance, fatigue behavior and durability has been presented.

E. Arunakanthi presented a research paper on "Experimental Studies on Fiber Reinforced Concrete (FRC) in 2016. The main aim of the study is to study the effect of glass fiber and steel fibers in the concrete. FRC has the high tensile strength and fire resistant properties thus reducing the loss of damage during fire accidents. In the present work the strength studies are carried out to compare the glass and steel fiber concrete.

Mohd. Gulfam Pathan and Ajay Swarup presented a research paper on "A Review on Steel Fiber Reinforced Concrete" in 2017. In this study it was concluded that ordinary cement concrete possesses very low tensile strength, limited ductility and less resistance to cracking. Hence theapplication of SFRC and its use does improve the strength of concrete with improved resistance to cracks.

Marcos Meson, Victor; Michel, Alexander; Solgaard, Anders; Fischer, Gregor; Edvardsen, Carola; Skovhus presented a research paper on "Corrosion resistance of steel fiber reinforced concrete" in 2018. In this research, it was determined that there is a continuous growth of FRC in structural applications due to its property of high toughness.

III. RESEARCH METHODOLOGY

The materials used for casting the cubes were cement, sand, coarse aggregates, fine aggregates and steel fiber.

The method adopted for casting the concrete was wet mix method manually. The materials were selected and taken into proportion according to the Mix Design of concrete for grade M25.

In the wet mixing method, all the materials (cement, sand, fine aggregates, coarse aggregates and steel fiber) are placed in predetermined proportions on a platform. Then, thoroughly they are mixed in dry state by the use of shovels. Steel fibers in percentage of 1, 1.5 and 2% were added by replacing the cement quantity. After this, water in predetermined quantity is added gradually while continuous mixing of concrete is kept.

This process is continued until a concrete mix of consistency is obtained.

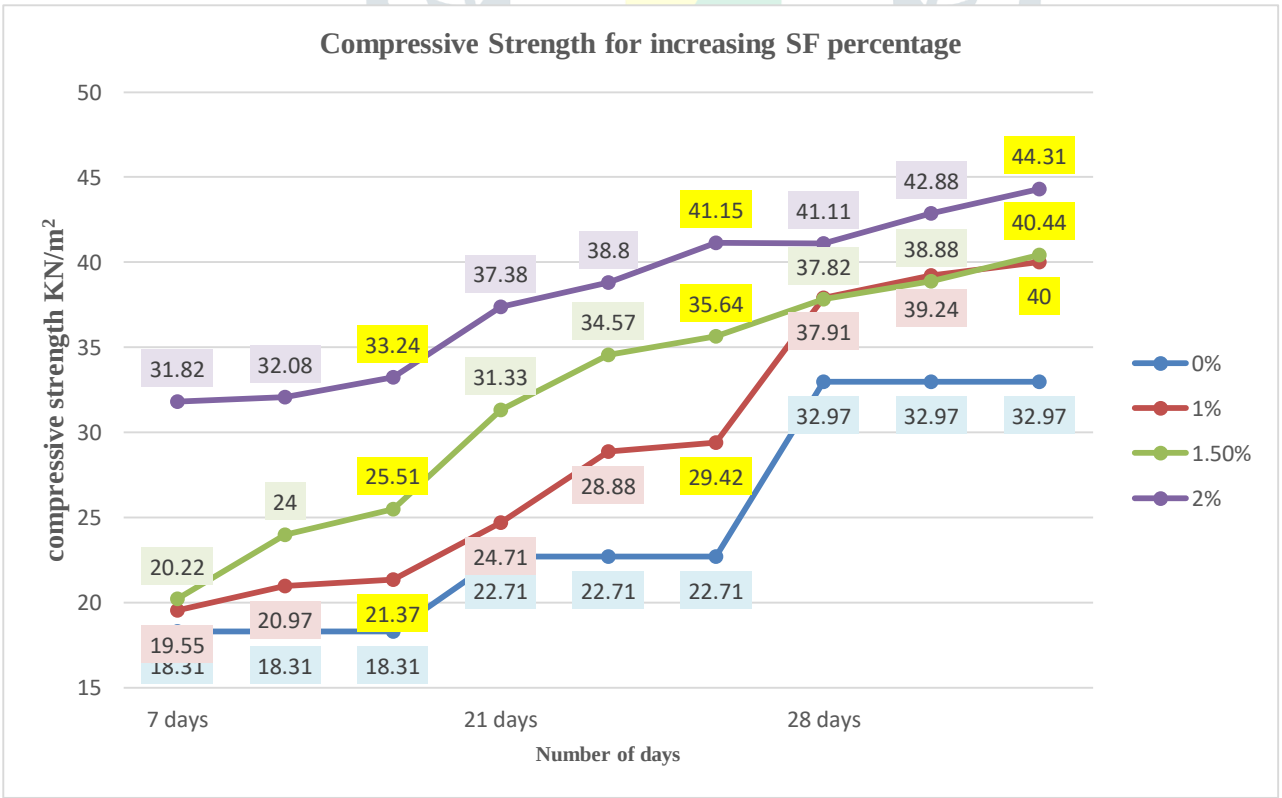
After casting the cubes, they were kept for about 24 hours to set and after that, all the 27 cubes were kept for curing.

The compression testing of cubes was carried out on compression testing machine after curing of 7 days, 21 days and 28 days respectively for achieving different results and strength.

IV. RESULTS AND DISCUSSIONS

The results obtained after the compression testing were absolutely unpredictable. The table may give us a clear idea of the results of SFRC cubes after 7, 21 and 28 days respectively.

Days	Steel Fiber Percentage and Relative Compressive Strength			
	0%	1%	1.5%	2%
7 days	18.31	19.55	20.22	31.82
	18.31	20.97	24	32.08
	18.31	21.37	25.51	33.24
21 days	22.71	24.71	31.33	37.38
	22.71	28.88	34.57	38.8
	22.71	29.42	35.64	41.15
28 days	32.97	37.91	37.82	41.11
	32.97	39.24	38.88	42.88
	32.97	40	40.44	44.31



The graph shows comparative results of compressive strength of SFRC cubes of 7 days, 21 days and 28 days in Kn/m^2

V. CONCLUSION

To tackle the problems which act on concrete, we studied the uses and applications of steel fibers, and reinforced them in concrete by replacing cement in a small volumetric proportion; and the conclusion was the concrete gained a lot of additional strength after addition of steel fibers.
The compressive strength of concrete was increased to a greater extent.
The compressive strength of SFRC cubes was greater than 0% concrete cubes.
Hence, steel fibers can be reinforced in concrete and can be used for greater structures and big projects as it increases the life span and strength of concrete.
The overall life span of concrete is also increased. Compared to other fibrous materials like, steel fiber has showed the most progress and tends to be the most promising material that gave maximum results.
According to the analysis and investigation, it is showed that the addition of steel fiber in concrete exponentially increases the performance of the member as compared to the conventional methods.

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