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Study of Compressive Strength of SFRC with Different Grade of Concrete

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Abstract: In this study the compressive strength of concrete is analyzed by using steel fibers. Concrete being good in compression but various admixtures are now a day used to increase its compressive strength. Steel fiber reinforced concrete (SFRC) is one of the most trending subject. In this research the compressive strength of M30, M50 and M60 (M1, M2 and M3 respectively) grade of concrete is compared with different percentage of fiber.As the grade of concrete increases, the percentage increase in compressive strength decreases. The workability of the concrete is also tested for different grade of concrete with percentage variation. For M30 grade of concrete with 1% of steel fiber the percentage increase of the compressive strength as compared to plain concrete is 33% where as when the compressive strength of M60 grade of concrete with same percentage of fiber is compared the result is 14%.

Keywords: Compressive strength, SFRC, Steel fibers, Workability.

1. Introduction

The properties of concrete have variation in tension and compression. Concrete is strong in tension but very weak in compression. It shows insufficient ductile behavior. Internal micro cracks are inherently present in concrete and its weak tensile strength is due to the propagation of such micro cracks. Hence, the use of normal concrete as a structural material is limited to situation where significant tensile stresses and stain do not develop. It is well known that high strength concrete is more brittle that normal strength concrete. The failure will be sudden, which are subjected to earthquake, blast or suddenly applied loads. Plain, unreinforced concrete is a brittle material, with low tensile strength and a low strain capacity.

The growth of concrete cracks and their nucleation may be abated to some extent by the use of fibers that are uniformly distributed in the body of concrete, Fibers resist the formation and propagation of cracks through various reinforcing mechanism. The uniform distribution of fibers throughout the concrete provides isotropic strength properties, which are not exhibited by conventional reinforced concrete. Segregation or balling is one of the problems encountered during mixing and compacting SFRC. The energy required for mixing, conveying, placing and finishing of SFRC is slightly higher.

In this study, steel fibers are used for making concrete named as SFRC – "Steel Fiber Reinforced Concrete". SFRC contains steel fibers. SFRC and mortar made with hydraulic cements and containing fine or fine and course aggregates along with discontinuous discrete steel fibers are considered in this report. SRFC is a composite material having fibers as the additional ingredients, dispersed uniformly at random in small percentages, i.e between 0.3% and 2.50% by volume in plain concrete. The use of randomly distributed discontinues steel fibers improves the thesis strength of concrete by inhibiting propagation of cracks and thereby impart characteristics like crack control, toughness and impart resistance to thereby impart characteristics like crack control. As a result, this ability to arrest cracks, SFRC possesses increased extensibility and tensile strength at first crack and ultimate loads, particularly under flexural loading. Though steel fiber reinforced concrete usually do not take much part in the compressive strength but it shows a good effect on the flexural strength of the beam.

Concrete mix of M30, M50 and M60 grade is concrete is taken having a percentage variation of 0%, .5%, .75% and 1%. Straight steel fibers are used for this research. The aspect ratio of the fibers used is fixed. Many research have prove the aspect ratio 75 as optimum one. The results of compressive strength and workability are compared and graph is plotted.

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2. Material Used

Steel fiber reinforced concrete is made up by combine cement and aggregate (course and fine) with water having some percentage of fiber to increase the strength of concrete. In this research super plasticizers are also used for the proper workability of concrete.

2.1 Steel Fiber Reinforced Concrete:

The properties of fiber reinforced concrete depend on the type of fiber used, length-to-length diameter ratio (aspect ratio); the amount of fiber, the strength of the matrix, the size, shape and method of preparation of the specimen and the size of aggregate. Different types of fibers are available such as glass fibers, Steel Fiber, Polypropylene Fiber, Asbestos Fibers, Carbon Fibers, and Organic Fibers. Out of different types of fibers available, steel fibers are selected for this study.

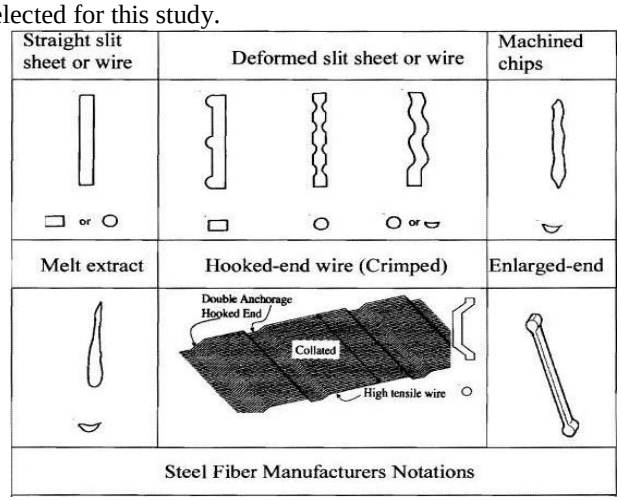

Fig 1: Shapes of fiber

Fig 2: Steel Fiber Used

3. Methodology

Metals moulds were used to prepare the specimen. The Cube specimen of mix M1 was prepared in the ratio of 1:1.6:3.4 with the percentage of fiber used 0%, 0.5%, 0.75%, 1%. Firstly, dry mix has been prepared. Then the concrete is mixed properly with the help of spade. After the preparation of concrete, cube have been casted of size 150mm*150mm*150mm. Before casting of cubes the bolts of mould wastightened and then oiling was done. After this, cube has been casted and kept for 24 hours at room temperature and then it was kept in water for curing. Similarly the cube specimen M2andM3is prepared by using same percentage of fibers but different concrete mix ratio.

4. Results

4.1 Initial and final setting time:

The initial and final setting time is determined by Vicat's Apparatus

Initial setting time: 35 Min

Final Setting time: 600 min

Fig 3: Vicat's apparatus

4.2. Compressive strength:

The compressive strength of the mixes is tested on compressive testing machine. The strength is determined and the percentage variation in different concrete mix is calculated and the graph among them is plotted. The results are shown below.

Table 4.1
Cube compressive strength of specimens

Mix	Percentage of fibers			
	0	0.5	0.75	1.0
	Compressive strength, N/mm^2	Compressive strength, N/mm^2	Compressive strength, N/mm^2	Compressive strength, N/mm^2
M1	34.0	37.5	39.65	42.35
M1	34.5	38	40.25	47.6
M1	35.5	38.64	41.02	49.01
M2	46.5	49.3	52	55.4
M2	47	49.6	52.8	56.0
M2	48	50.9	54.6	59.0
M3	58	60.84	63.9	67.0
M3	60.0	62.5	66.9	68
M3	59.5	61.0	65.3	68.6

Table 4.2
Percentage increase in Compressive strength of SFRC as compared to plain concrete

Mix	**Percentage of fibers**		
	0.5%	0.75%	1%
M1	9.81	16.7	33.72
M2	5.3	11.8	19.6
M3	3.97	10.61	14.9

Fig 4: Crack formation of SFRC

4.2.1.Cube compressive strength: The cube compressive strength of M1, M2 and M3 mix is shown in the graphs below. The percentage variation of the compressive strength is calculated by the average of the 3 values that are determined during the test and graph between different values of one mix is plotted.

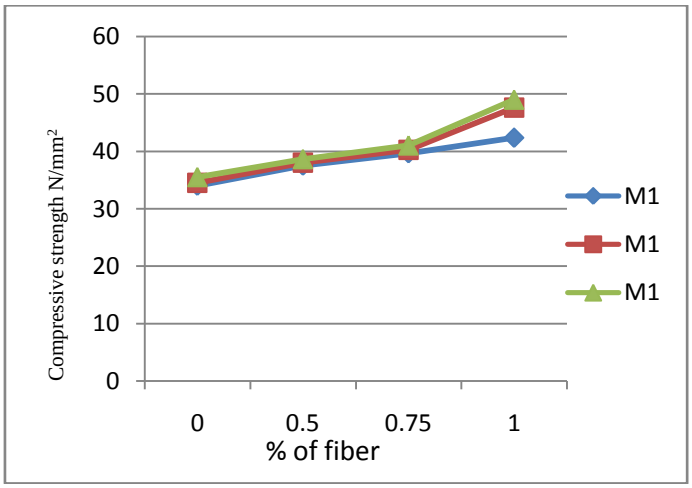

Fig 5: Compressive strength of M1 Mix

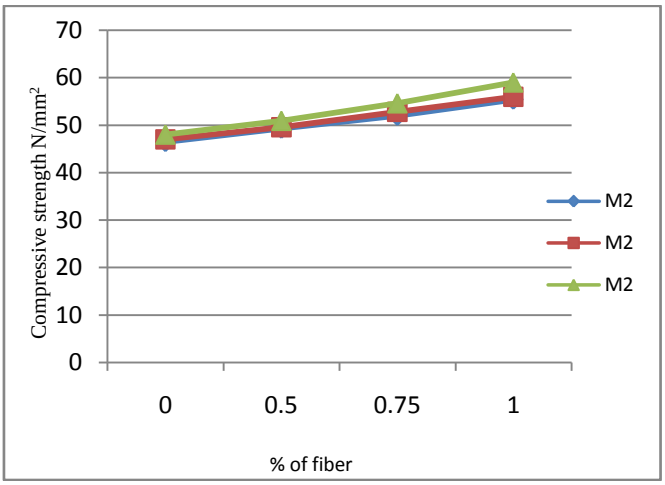

Fig. 6: Compressive strength of M2

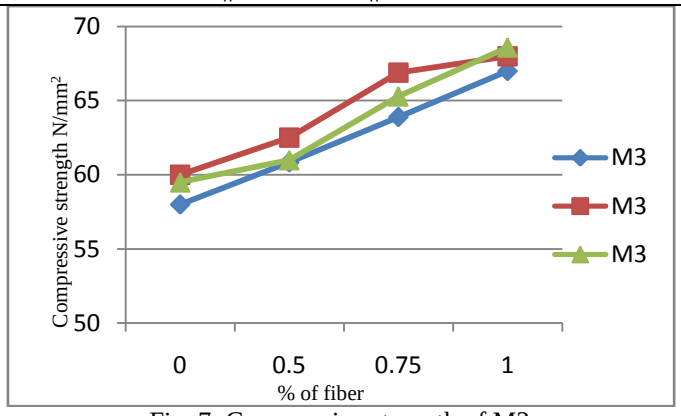

Fig. 7: Compressive strength of M3

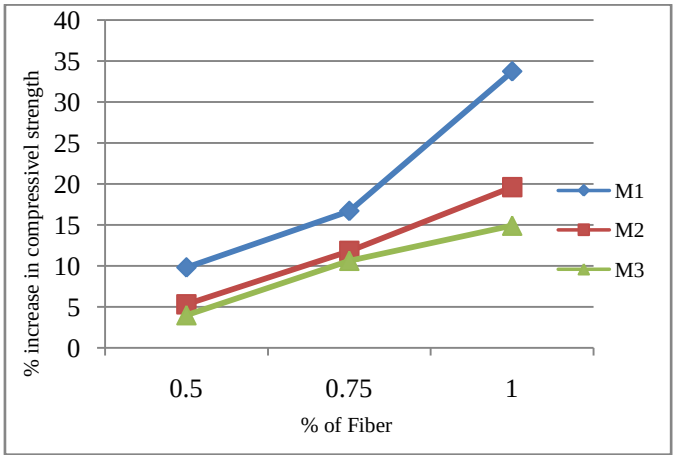

Fig 8: Percentage increase of SFRC as compared to plain concrete

5. Analysis and discussion

5.1. Failure mode

In case of plain concrete specimen of normal strength, visible cracks appeared near about the crushing load and the failure was almost sudden. While in case of high strength plain concrete explosive failure at maximum load was observed.

The failure of SFRC specimens was triggered by a number of cracks of small widths. SFRC specimens didn't break into separate piece due to ductile nature of the material, which is a characteristic feature of SFRC. The popping sound of fibers failing by pulling out is one of the special phenomena for high strength SFRC.

5.2 Comparative Strength of Plain concrete and SFRC

It is observed from Table 4.1 that, the compressive strength results show significant increase in strength with increase in fiber content.

The inclusion of fibers make the mix compacted and thereby reducing the gaps between the cement and aggregate causing increase in compressive strength. The failure of concrete specimens under uniaxial compression is due to the formation of tensile cracks in the direction of loading. The inclusion of randomly oriented fibers in the specimen arrests the propagation of tensile cracks, thereby increasing the compressive strength.

6. Conclusion

1. Presence of fibers reduces the workability therefore use of plasticizers is compulsory to make the concrete workable.
2. With increase in grade of concrete and percentage of fibers, though strength increases but in post cracking zone response of higher percentage of fibers is comparatively poorer.

3. In the normal strength concrete compressive strength increases by 9.81% , 16.7% and 33.7% for fiber content of 0.5%, 0.75% and 1% of fibers, respectively. Whereas in higher grades of concrete such increase is found to be in the range of 3.97%, 10.6% and 14.9% only.

4. In ordinary grade of concrete, fibers are observed to be more effective as compared to higher grades of concrete.

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