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EXPERIMENTAL STUDY ON SELF COMPACTING CONCRETE WITH STEEL FIBRE REINFORCEMENT

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Abstract - **Self-compacting concrete (SCC) is defined as a flowing concrete mixture which has the ability to consolidate under its own weight. The flowing nature of SCC makes it suitable for placing it in difficult conditions and in congested reinforcement sections. The purpose of this research is based on the investigation of the use of steel fibres in self-compacting concrete to enhance the physical and mechanical properties of self-compacting concrete. The objective of the study was to determine and compare the differences in properties of Normal concrete, SCC containing without steel fibres and SCC with steel fibres at different proportions. This experimental investigation was carried out to study the compressive strength, flexural strength, Split tensile strength of steel fibre reinforced concrete (SFRC) containing fibres of 0%, 0.4%, 0.8% and 1.2% volume fraction of end hooked steel fibres. Steel fibre of aspect ratio 75 was used. The result data obtained has been analyzed and compared with a specimen having 0% steel fibre. The workability of SCC significantly reduced as the fibre dosage rate increases. The research paper proposes that due to these properties of steel fibre reinforced self-compacting concrete, it can be used at places where compaction is not possible and for the design of curvilinear forms.**

Index Terms- compressive strength, flexural strength, SCC, steel fibers, , split tensile strength.

I. INTRODUCTION

In the present scenario, concrete is the most common and widely used structural material in construction field, apart from steel. The development of Self-Compacting Concrete (SCC) is a successful achievement in the construction industry in order to overcome placing difficulties and problems associated with cast-in-situ concrete. SCC is not affected by skills of labours, the shape and the arrangement of a structure or the amount of reinforcement. Due to its high fluidity and resistance to segregation it can be pumped longer distances. The concept of SCC was proposed in 1986 by Professor Hajime Okaruma, but the prototype was first developed in 1988 in Japan, by Professor Ozawa (1989) at the University of Tokyo.[5]

In plain concrete, there is weakness due to the presence of micro cracks in the mortar-aggregate interface. This weakness can be removed or can be made negligible by the inclusion of steel fibres in the mixture. Different types of fibers such as polymer, glass, etc., can also be used in composite materials which can be introduced into the concrete mixture to increase its toughness, or ability to resist crack growth. The concrete in which the fibres help to transfer loads at the internal micro cracks is called a fibre-reinforced concrete (FRC).

II. Significance and advantages

In plain concrete, structural cracks (micro cracks) develop even before loading, particularly due to drying shrinkage. Cracks may be caused even due to other volume change I due to expansion and shrinkage. The width of these initial cracks is in the range of microns. When concrete is loaded these micro cracks will propagate and open up. Due to stress concentration, additional micro cracks are formed. The micro cracks are the main cause for elastic deformation in concrete. Fibre reinforced concrete were developed to overcome these cracks and to provide additional strength. Self-Compacting Concrete is cast so that there is no additional vibration, necessary for the compaction. It has a high flowing property and has a very smooth surface level after placing. SCC has several advantages over normal conventional concrete and so thus SCC reinforced with steel fibre. It can flow easily in congested reinforced areas such as in beam column joints. Hence, the combination of SCC with steel fibre is a concrete mixture with dual advantage.

III. MATERIALS

Ordinary Portland cement of 53 grade was used in making the concrete. The OPC 53 grade cement has a specific gravity of 2.65. The specific gravity of fine aggregate used was 2.8. Coarse aggregates used in experimentation were less than 20mm passing sieve size of 20mm and their specific gravity was found to be 2.8 and bulk density of 1.452Kg/lit. For different percentage of the fibres, 4 each beams, cubes and cylinders were casted in order to get average strength. Formwork was removed after 24 hours. Beams, cubes and cylinders were immersed in water for curing period of 28 days. They were later taken to the material testing laboratory and tested. Cubes and cylinders were tested in the Compression-Testing Machine by keeping perpendicular to the direction of compaction. Beams were tested on Universal Testing Machine by two point loading test.

A. End Hooked Steel fiber

Table-I
Properties of steel fiber

Sr. No.	Property	Values
1.	Diameter	0.67mm
2.	Length	50mm
3.	Deformation	End-hooked
4.	Aspect Ratio	75
5.	Tensile strength	1050MPa
6.	Modulus of elasticity	200GPa
7.	Specific gravity	7.8

B. Mix design of concrete

IS method of SCC mix designed was used as per ACI 318-08. The quantities of ingredient materials and mix proportions as per design are as under.

Table-II
Mix proportion of SCC

Material	Proportion by weight
Cement	1
Fly-ash	0.43
Coarse aggregate	1.44
Fine aggregate	2.15
Water	0.5
Admixture	0.02

IV. EXPERIMENTS

A. Compressive strength test:

For compressive strength test, the dimension of cubes is 150 x 150 x 150 mm. Amount of super plasticizers added was 0.02% by weight of cement as per ACI 318-08. It was then added with different proportions, i.e.; 0%, 0.4%, 0.8% and 1.2% fibres. The moulds were filled. No Vibration was given to the moulds because it is self-compacting. The top surface of the specimen was levelled and finished. The samples were kept undisturbed for 24 hours. After 24 hours the specimens were demoulded. The cube samples were transferred to curing tank. The samples were allowed to cure for a period of 28 days. After 28 days curing, these cubes were tested on the compression testing machine as per I.S. 456-2000. The failure load was noted. For each percentage of fibre, three cubes were tested and their average value was obtained. The same was done for cylinders to compute the compressive strength. The compressive strength can be calculated using the following formula given below.

Compressive strength of cube/cylinder(MPa) = Failure load / cross sectional area of cube/cylinder.

B. Flexural strength test:

For flexural strength test, 16 beam specimens, 4 each of 0%, 0.4%, 0.8% and 1.2% were casted. The dimension of each beam is 100x100x500 mm. The specimens were kept undisturbed for a period of 24 hours and then demoulded. The specimens were transferred to curing tank and are allowed to cure for a period of 28 days. These flexural strength specimens were tested on the Flexural testing machine under two point loading as per I.S. 516-1959, over an effective span of 400 mm. Loads and corresponding deflections were noted up to failure. For each percentage of fibre, three beams were tested and their average value was obtained. The flexural strength can be calculated as follows.

Flexural strength of beam (MPa) = (P x L) / (b x d^2), Where,
P = Failure load,
L = Centre to centre distance between the support = 400mm
b = width of specimen,
d = depth of specimen.

C. Split tensile strength test:

For splitting tensile strength test, 16 cylinder specimens, 4 each of 0%, 0.4%, 0.8% and 1.2% were casted. Cylinder specimens are of dimension 150 mm in diameter and 300 mm in depth. The specimens were casted and kept undisturbed for 24 hours. It was then demoulded. The specimens were transferred to curing tank wherein they were allowed to cure for a period of 28 days. These specimens were tested under compression testing machine as per IS 456-2000. For each percentage of fibre, three cylinders were tested and their average value was obtained. Split Tensile strength can be calculated as follows as

Split Tensile strength of cylinder(MPa) = 2P / π DL,
Where,
P = failure load,
D = diameter of the cylinder,
L = length of the cylinder.

V. TEST RESULTS AND VARIATIONS

A. Slump test

Table-III
Slump value corresponding to % fibre

Sl. No.	% fibre	Slump value(mm)
1.	0	149
2.	0.4	142
3.	0.8	132
4.	1.2	122

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Fig. a: %fibre V/S slump value

B. Compressive strength test on cubes

Table-IV
Compressive strength of SCC with 0%, 0.4%, 0.8% and 1.2%.

Sl. No.	% fiber	Avg. compressive strength(N/mm2)
1.	0	18.40
2.	0.4	27.09
3.	0.8	44.97
4.	1.2	39.70

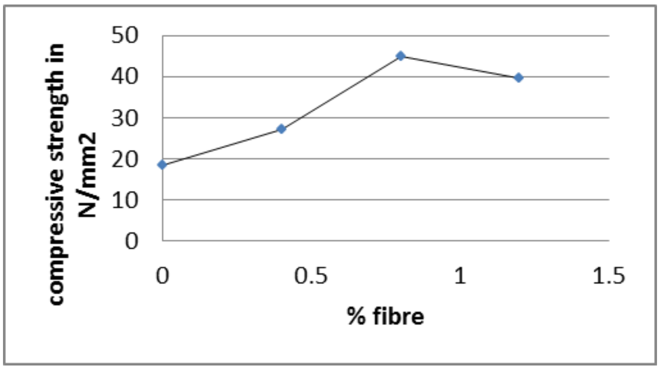

Fig. b: % fiber V/S compressive strength

C. compressive Strength test on cylinders

Table-V
Compressive strength of SCC with 0%, 0.4%, 0.8% and 1.2%.

Sl. No.	% fibre	Avg. compressive strength(N/mm2)
1.	0	6.67
2.	0.4	15.36
3.	0.8	40.74
4.	1.2	28.14

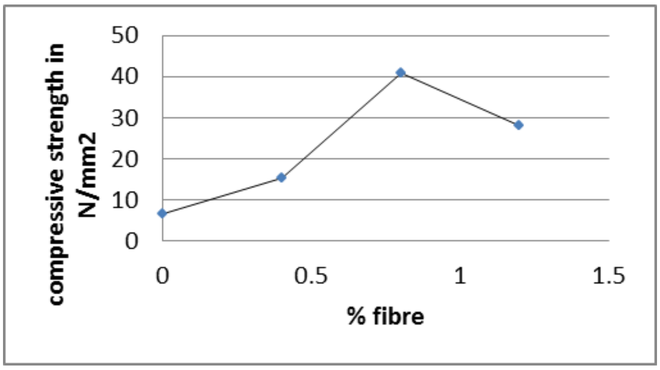

Fig. c: %fibre V/S compressive strength

D. Splitting Tensile Strength test for cylinders

Table-VI
Splitting tensile strength of SCC with 0%, 0.4%, 0.8% and 1.2%.

Sl. No.	% fibre	Avg splitting tensile strength in N/mm^2
1.	0	2.22
2.	0.4	2.57
3.	0.8	3.72
4.	1.2	3.19

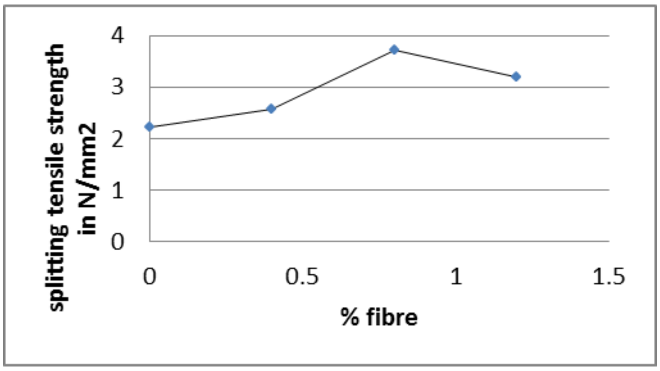

Fig. d: %fibre V/S splitting tensile strength

E. Flexural strength

Table-VII
Flexural strength of SCC with 0%, 0.4%, 0.8% and 1.2%.

Sl. No.	% fibre	Avg. flexural strength in N/mm^2
1.	0	3.95
2.	0.4	6.46
3.	0.8	8.73
4.	1.2	7.61

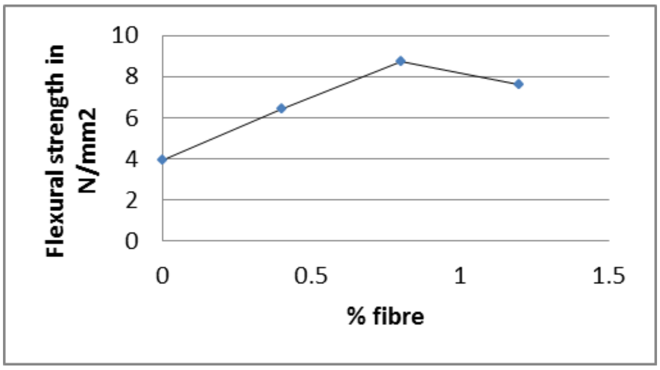

Fig. e: %fibre V/S Flexural strength

F. Normal concrete M20 mix

Table-VIII
Properties of M20 mix

Properties	Values
Slump value	78mm
Compressive strength(cube)	13.94N/mm^2
Comp. strength (cylinder)	7.47N/mm^2
Splitting tensile strength	1.847N/mm^2
Flexural strength	4.8N/mm^2

V. CONCLUSION

Based on the laboratory test following conclusions are made:

A. The slump value decreases as fibre quantity increases. Thus, workability decreases with increase in fibre content.

B. The variation in compressive strength, splitting tensile and flexural strength between normal mix concrete and SCC with 0% fibre is negligible. There is a slight increase in flexural strength.

C. From the charts, it is clear that the addition of steel fibre into the SCC significantly increases the flexural strength, compressive strength and splitting tensile strength up to a certain extent and then decreases.

D. The results obtained is maximum for 0.8% of fibre, hence being the most desirable quantity of steel fibre.

E. Ductility of SCC is found to increase with the increase in the fibre content. Thus, the width of cracks is found to be less in steel fibre reinforced SCC than that compared to plain cement concrete.

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