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STRENGTHING OF SELF COMPACTING CONCRETE WITH STEEL FIBRE REINFORCEMENT

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ABSTRACT

The use of steel fiber reinforced self-compacting concrete, SFRSCC, probably, will swiftlyincrease in the next years, since this composite material introduces several advantages on the concrete technology. In fact, the partial or total replacement of the conventional bar reinforcement by discrete fibres optimizes the construction process. The assembly of the reinforcement bars in the construction of concrete structures has a significant economic impact on the final cost of this type of constructions, due to the man-labour time consuming that it requires. In the modern societies, the cost of the man-labour is significant, so diminishing the man-labour will decrease the overall cost of the construction. In the fresh state, SFRSCC homogeneously spreads due to its own weight, without any additional compaction energy. Driven by its own weight, the concrete has to fill a mould completely without leaving entrapped air, even in the presence of dense steel bar reinforcement.Due to these reasons, SFRSCC is a very promising construction material with a high potential of application, mainly in the cases where fibres can replace the conventional reinforcement. At the present time, however, the SFRSCC technology is not yet fully developed and controlled, and, much less, the mechanical behaviour of the SFRSCC material.

I INTRODUCTION

Self-compacting concrete was first developed in Japan, in 1988, aiming to improve the durability of concrete structures. The durability of concrete is intimately related to the level ofcompaction achieved while casting. Therefore, the development of a self-compacting concrete capable of being compacted purely by its own weight, i.e. without the need of any external vibration system, and into some extent independent from the man-labour's quality, started to seem a feasible alternative to be developed (Okamura and Ozawa 1996). The employment of self-compacting technology renders great benefits, mainly, when used to improve construction systems previously based on conventional concrete, which require compaction operations. Moreover, the vibration systems commonly used in compaction can easily cause segregation of concrete, thus jeopardizing its quality. The durability and reliability of a concrete structure is dependent on the compaction made by skilled workers, and if the aim is to achieve durable concrete structures independently from the man-labour's quality, vibration compaction systems should be discarded.Steel fibres are introduced in the concrete mix in order to improve this behaviour and produce a more ductile material as well as enhance the concrete materials properties especially by its contribution against crack propagation. These positive effect of fibre addition leads to research work done to investigate its ability to replace conventional reinforcement

Structural Applications of SFRSC

The structural application of SFRSC is still at an early stage but nevertheless, the properties offers significant advantage in the concrete technology. Owing to the effective use of steel fibres in the mix to partially or totally replace conventional reinforcements as well as the flow ability of the SCC, has brought this material to a wider range of application in the construction industry. The flow ability of SCC allows the mix to easily flow through the corners of the moulds and in between reinforcement bars. Furthermore, the casting process that requires no compaction or vibration, provides a healthier environment for labour’s and requires less dependency on skilled workers to perform the task.

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.

II 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. Fordifferent 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 1

Properties of steelfiber

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

III 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, threecubes 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

Test Result and Variations : 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

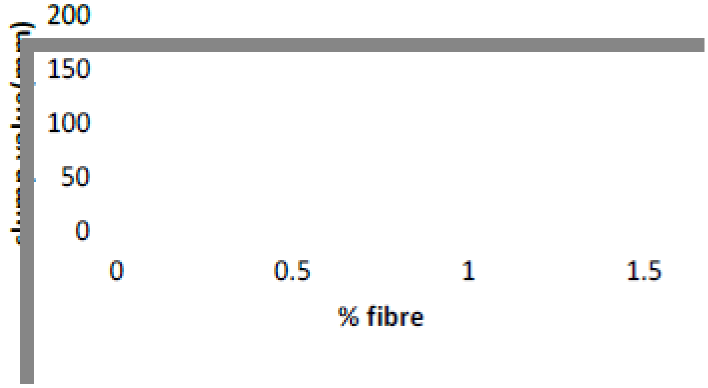

Fig. a: %fibre V/S slump value

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

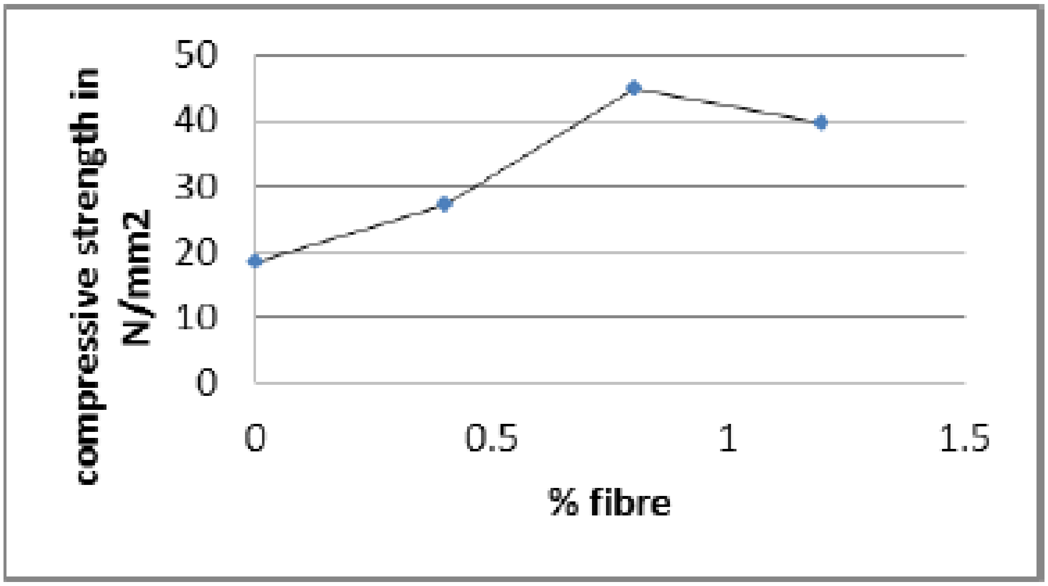

Fig. b: % fiber V/S compressive strength

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

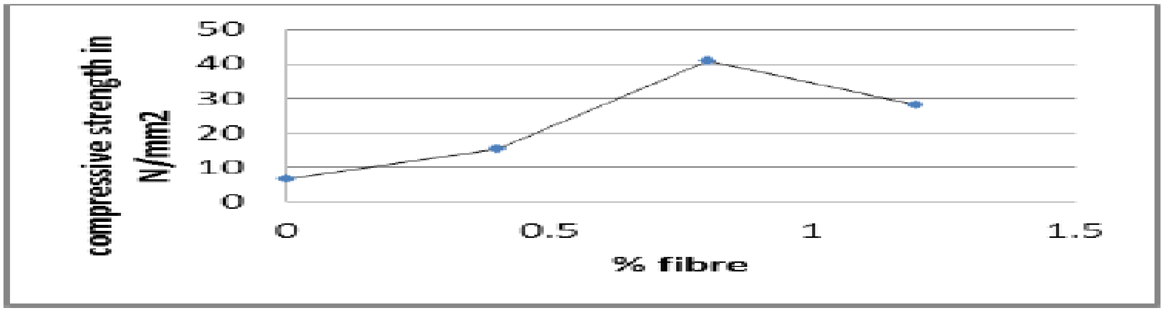

Fig. c: %fibre V/S compressive strength

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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

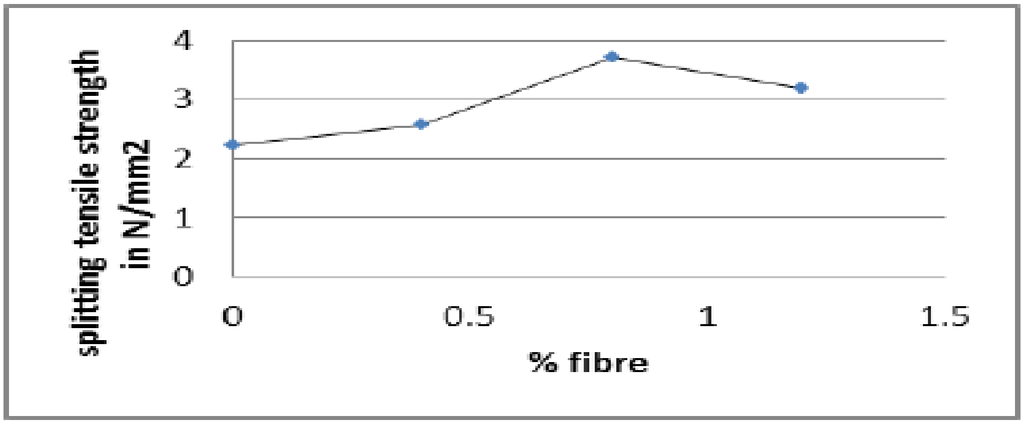

Fig. d: %fibre V/S splitting tensile strength

IV CONCLUSION

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.

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