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INVESTIGATION OF BEHAVIOUR OF STEEL FIBER REINFORCED SELF COMPACTING CONCRETE

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ABSTRACT

Self-compacting concrete (SCC) is considered as a concrete which can be placed and compacted under its self weight with little or no vibration effort and which is at the same time cohesive enough to be handled without segregation or bleeding. Chemical admixtures are, however, expensive, and their use may increase the materials cost. Savings in labor cost might offset the increased cost, but the use of mineral admixtures such as fly ash, blast furnace slag, or limestone filler could increase the slump of the concrete mixture without increasing its cost.Fly ash has high pozzolanic reactivity and low price as compared to silica fume and fly ash as it is a manufactured product. It reduces free drying shrinkage and restrains the shrinkage cracking width. It also helps in enhancing the compressive strength and durability of concrete.

The objective of this study is to optimize the Steel Fiber Reinforced Self Compacted Concrete (SFRSCC) in the fresh and in hardened state. But the references indicate that some studies are available on plain SCC but sufficient literature is not available on SFRSCC with different steel fibers & different aspect ratio.Steel Fiber-reinforced self-compacting concrete (SFRSCC) is a new type of concrete mix that can mitigate two opposing weaknesses poor workability in fiber-reinforced concrete and cracking resistance in plain SCC concrete.

Keywords: Self-compacting ,Fly ash, Aspect Ratio , Pozzolanic.

I. INTRODUCTION

Self-compacting concrete (SCC) is considered as a concrete which can be placed and compacted under its self weight with little or no vibration effort and which is at the same time cohesive enough to be handled without segregation or bleeding. It is used to facilitate and ensure proper filling and good structural performance of restricted areas and heavily reinforced structural members. SCC was developed in Japan in the late 1980s to be mainly used for highly congested reinforced structures in seismic regions. Recently, this concrete has gained wide use in many countries for different applications and structural configurations. SCC can also provide a better working environment by eliminating the vibration noise. There are many advantages of using SCC, especially when the material cost is minimized. Chemical admixtures are, however, expensive, and their use may increase the materials cost. Savings in labor cost might offset the increased cost, but the use of mineral admixtures such as fly ash, blast furnace slag, or limestone filler could increase the slump of the concrete mixture without increasing its cost.

Plain concrete possess a very low tensile strength, limited ductility and little resistance to cracking. Internal micro cracks are inherently present in the concrete and poor tensile strength is due to the propagation of such micro cracks, eventually leading to brittle fracture of the concrete. In plain concrete and similar brittle material, structural cracks develop even before loading, particularly due to drying shrinkage or other causes of volume change. The width of these initial cracks seldom exceeds a few microns, but their other two dimensions may be of higher magnitude.

Self-compacting concrete (SCC) offers several economic and technical benefits; the use of steel fibers extends its possibilities. Steel fibers acts as a bridge to retard their cracks propagation, and improve several characteristics and properties of the concrete. Fibers are known to significantly affect the workability of concrete. Therefore, an investigation was performed to compare the properties of plain normal compacting concrete (NCC) and SCC with steel fiber.

II. LITERATURE REVIEW

Joaquim et al [1] has developed a mix design for SFRSCC for application in light weight panel as building facades. Concrete precast industry is one of the most sited industries for the use of SFRSCC, as it has the potential not only to use the mix composition but also other steps leading to make structural elements. Since precast elements demoulding should be carried out as soon as possible for economic reasons, the influence of age on mechanical properties of SFRSCC was assessed by compression and flexural tests. Compression and monotonic cyclic tests were also performed to assess performance of the mix

Jain et al. [2] proved that SCC is the right solution to build the narrow and deep portion between two girders of a fly over in Mumbai. To provide least hindrance to the heavy traffic, an innovative method of superstructure construction was devised, in that girder segment were precast and erected on piers and the central temporary staging. The girder segments were joined over the central staging with the use of SCC. As this portion was narrow and deep and had congested reinforcement, SCC was the correct choice. The prestressing schedule needed SCC to be designed as high-early strength SCC, achieving a compressive strength of 38 MPa at 5days. Durability tests performed in laboratory and field samples showed that both water and chloride ion penetration values of SCC were low.

Rame Gowda et al. [3] used Granite fines or rock dust is a by-product obtained during crushing of granite rocks and as also called quarry dust. By using quarry dust as an alternative to fine aggregate in SCC and reports the strength behavior and hardened properties of such SCCs. Although in normal concretes, introducing QD increasing the pouring heights of an SCC, the compressive strength and splitting tensile strength of concrete were unaffected

Lakshmipathy et al. [4] found that SCC is one of the high performance concretes with excellent strength and durability properties. However, its mix proportioning and testing methods for flow characteristics are different from those of the ordinary concrete. SCC has high powder content and a super plasticizer for enabling flow while keeping coarse aggregate in viscous suspension. The powder is usually cement and filler in powder influences the properties of SCC both in fresh and hardened state. An attempt has been made to develop cost –effective SCC with supplementary cementations materials such as fly ash (25%), GGBS (20%) and Silica flume (5%) and examine its strength properties in comparison to the conventional concrete

Subramania et al. [5] focused on the workability characteristics and strength parameters of SCC containing fly ash. The cement used for the study was 43 grade ordinary Portland cement and was partially replaced by 0%, 25%, 50%, and 75% of fly ash. Based on the guidelines of European Federation of producers and contractors of specialist products for structures (EFNARC), the mix proportions were chosen and the cement content alone was varied without varying the aggregate content. The water powder ratio was kept at 0.4 throughout the study. Water reducing admixture and VMA used to improve the workability characteristics.

Mattur et al. [6] presented the initial experimental efforts for development of SCC mixes employing high-volume of fly ash additionally admixed with other mineral admixtures such as additionally admixed with other mineral admixtures such as Ground Granulated Blast furnace slag (GGBFS) and silica fume etc. can ensure the required concrete properties are studied in fresh state. In the first set of mixes are prepared by admixing

20% of GGBS with 50% of fly ash as replacement to cement. The third set of mixes ternary blend and use 50% fly ash, 20% GGBS and 5% of silica fume. The total content of the cementations materials has been fixed at 600 kg/m^3 in all properties of fresh SCC mixes in terms of viscosity and stability.

III OBJECTIVES OF INVESTIGATION

- To investigate the properties of Fresh Concrete such as Workability.
- To compare the properties of SFRSCC with that of Normal SCC.
- To study the Compressive Strength, Split Tensile Strength properties of SFRSCC composite.

IV. MATERIALS

1. Cement: The cement used in this experimental work is “ACC 43 grade Ordinary Portland Cement”. All properties of cement are tested by referring IS 8112 - 1989 Specification for 43 Grade Ordinary Portland Cement.
2. Fine aggregate: Locally available river sand conforming to Grading zone II of IS: 383–1970. Fineness modulus was found to be 2.76, Specific gravity was 2.59.
3. Super Plasticizer: The properties of SP supplied by the manufacturer Sika India Pvt. Ltd., Mumbai in the literature is given in Table (3.4) which compiles IS: 9103- 1999 (Amended 2003).
4. Water: Potable water available in laboratory is used.
5. Steel Fiber: Dramix steel fibers conforming to ASTM A 820 type-I are used for experimental work. Dramix HK **- 80/60** is high tensile steel cold drawn wire with hooked ends, glued in bundles & specially engineered for use in concrete. Fibers are made available from Shakti Commodities Pvt. Ltd.; New Delhi.
6. Crimped Type Steel Fiber (CR 50/30): Crimped type steel fibers conforming to ASTM A 820 type-I are used for experimental work. CR 50/30 is high tensile steel cold drawn wire with crimped types, glued in bundles & specially engineered for use in concrete. Fibers are made available from Kasturi Composite Pvt. Ltd.; Amravati (Maharashtra).
7. Straight Steel fiber: Rounded type steel fibers conforming to ASTM A 820 type-I are used for experimental work. **SF- 50/80** (Tomato wire) **is** high tensile steel cold drawn wire with crimped types, glued in bundles & specially engineered for use in concrete. Fibers are made available from Kasturi Composite Pvt.

V. METHODOLOGY

Testing Of Concrete: Research Work is divided into 2 parts:

Part A: Testing the properties of Normal Compacted Concrete with and without different types of Steel Fiber.

Part B: Testing the properties of Self Compacted Concrete with and without different types of Steel Fiber.

Test Conducted On Normal Concrete: In present study cube compression test, flexural test on beams ,Cylindrical split tensile test and Shear and Torsion test on beam on plain and different types of steel fiber concrete (SFC) with constant fraction were carried out.

VI. TESTING PROGRAM

Compressive strength test: A cube compression test is performed on standard cubes of plain and SFC of size 150 x 150 x 150 mm after 3, 7 and 28 days of immersion in water for curing. The compressive strength of specimen is calculated by the following formula:

$$\mathbf{f_{cu} = P_c / A}$$

Where

P_c = Failure load in compression kN

A = Loaded area of cube, mm^2

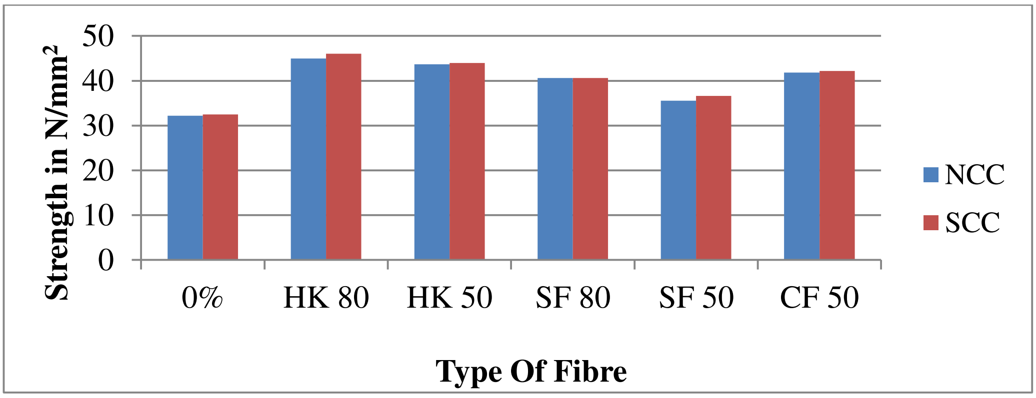
Fig. 1 - Compression Test Setup

Table No. 1: Compression Test of Cubes of Normal Concrete at the End of 28 Days

Sr. No.	Type Of Fiber	Compressive Load (N)	Avg. Compressive Strength (N/ mm2)
1.	0%	705×10^3	32.20
		744×10^3	
		726×10^3	
2.	HK 80	1017×10^3	44.96
		1006×10^3	
		1012×10^3	
3.	HK 50	977×10^3	43.64
		987×10^3	
		982×10^3	
4.	SF 80	908×10^3	40.60
		919×10^3	
		914×10^3	
5.	SF 50	805×10^3	35.51
		802×10^3	
		790×10^3	
6.	CF 50	947×10^3	41.80
		934×10^3	
		941×10^3	

Table No. 2: Compression Test of Cubes of SSC at the End of 28 Days

Sr. No.	Type Of Fiber	Compressive Load (N)	Avg. Compressive Strength (N/ mm2)
1.	0%	790×10^3	32.50
		762×10^3	
		642×10^3	
2.	HK 80	1020×10^3	46.00
		1050×10^3	
		1035×10^3	
3.	HK 50	972×10^3	43.96
		977×10^3	
		968×10^3	
4.	SF 80	936×10^3	40.60
		900×10^3	
		905×10^3	
5.	SF 50	791×10^3	36.62
		857×10^3	
		824×10^3	
6.	CF 50	945×10^3	42.20
		942×10^3	
		946×10^3	



Graph No.1: Comparative Chart of Compressive Strength at the end of 28 days

SPLIT TENSILE TEST

The split tensile test is well known indirect test used to determine the tensile strength of concrete. Due to difficulties involved in conducting the direct tension test, a number of indirect methods have been developed to determine the tensile strength of concrete. In these tests, in general a compressive force is applied to a concrete specimen in such a way that the specimen fails due to tensile stresses induced in the specimen. The tensile strength at which failure occurs is the tensile strength of concrete. In this investigation, the test is carried out on cylinder by splitting along its middle plane parallel to the edges by applying the compressive load to opposite edges. The arrangement for the test is shown in photo with the pattern of failure. The split tensile strength of cylinder is calculated by the following formula,

$$\mathbf{f_t = 2P / \pi LD}$$

Where

f_t = Tensile strength, MPa
P = Load at failure, N
L = Length of cylinder, mm
D = Diameter of cylinder, mm

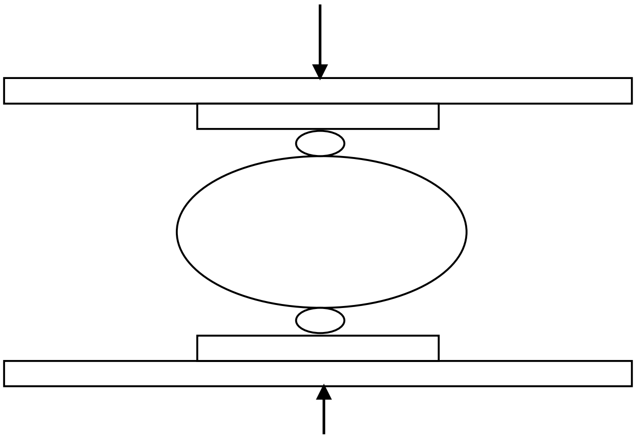


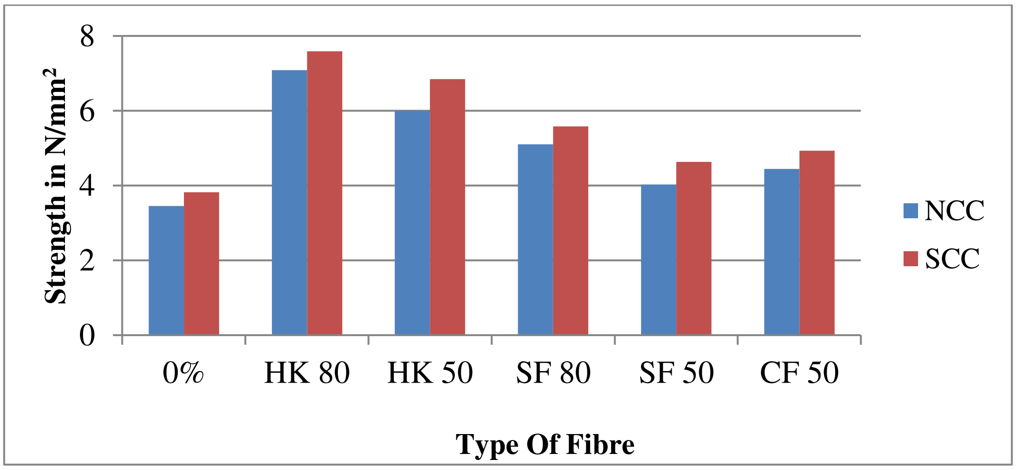
Figure No.2: Cylinder Split Tensile Test Setup

Table No. 3: Split Tensile Strength on Cylinder of Normal Concrete at the End of 28 Days

Sr. No.	Type Of Fiber	Load (N)	Split Tensile Strength (N/ mm^2)
1.	0%	251×10^3	3.55
		237×10^3	3.36
		244×10^3	3.49
2.	HK 80	505×10^3	7.14
		510×10^3	7.21
		490×10^3	6.93
3.	HK 50	400×10^3	5.65
		431×10^3	6.10
		418×10^3	5.92
4.	SF 80	347×10^3	4.90
		376×10^3	5.32
		360×10^3	5.10
5.	SF 50	272×10^3	3.85
		292×10^3	4.13
		290×10^3	4.10
6.	CF 50	350×10^3	4.96
		319×10^3	4.52
		276×10^3	3.90

Table No. 4: Split Tensile Strength on Cylinder of SSC at the End of 28 Days

Sr. No.	Type Of Fiber	Load (N)	Split Tensile Strength (N/mm^2)
1.	0%	282×10^3	3.55
		297×10^3	3.36
		273×10^3	3.49
2.	HK 80	537×10^3	7.60
		525×10^3	7.43
		533×10^3	7.54
3.	HK 50	485×10^3	6.86
		468×10^3	6.23
		470×10^3	6.65
4.	SF 80	415×10^3	5.86
		370×10^3	5.23
		400×10^3	5.65
5.	SF 50	318×10^3	4.50
		292×10^3	4.13
		313×10^3	4.42
6.	CF 50	301×10^3	4.25
		283×10^3	4.00
		252×10^3	3.56



Graph No. 2: Comparative Chart of Split Tensile Strength at the End of 28 Days

VII. CONCLUSIONS

- The SCC developed compressive strengths ranging from 17.98 to 22.60Mpa at the end of 3 days, from 23.99 to 29.70Mpa at the end of 7 days and from 32.50 to 46.00Mpa, at the end of 28 days and NCC developed compressive strengths ranging from 17.07 to 22.00Mpa at the end of 3 days, from 23.53 to 28.47Mpa at the end of 7 days and from 32.20 to 44.96Mpa, at the end of 28 days.
- The SCC developed split tensile strengths ranging from3.82 to7.59Mpa at the end of 28 days and the NCC developed split tensile strengths ranging from3.45 to7.09Mpa at the end of 28 days.

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