COMPARATIVE STUDY ON EFFECT OF DIFFERENT TYPES OF STEEL FIBRES ON STRENGTH PARAMETERS OF SELF COMPACTING CONCRETE

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Abstract : The main objective of this research is analyze the effect of different types of steel fibers on strength parameters of self compacting concrete for M-40 grade of concrete by using fibers like straight fiber, crimped fiber and hooked fiber. Self-compacting concrete is a type of concrete which flows under the influence of gravity without segregation is used in reinforced structural members. It avoids the need of vibration. Steel fibers can resistance to crack, impact and fatigue resistance, reduce shrinkage and toughness. This project investigates the strength studies of self-compacting concrete using steel fibers as reinforcement to enhance. Various tests are to be performed to determine the properties of fresh and hardened concrete such as workability test, compressive test, flexure and tensile test of SSC containing fibers of 1%, 2% and3%, by volume of cement.

***Keywords* - self-compacting concrete, different types of steel fibers, M40 grade concrete, properties of fresh and hardened concrete.**

I. INTRODUCTION

Self Compacting Concrete was first developed in Japan in the year 1980. Prof. H. Okamura of University of Tokyo, Japan; is mainly responsible for initiating and initial development of this concrete and is now regarded as the Father of SCC. The need for the development of SCC arose from the skilled labour and man power in Japan during 1980's. Self-compacting concrete has been represent "the most progressive improvement in concrete development". Self-compacting concrete is a concrete which exhibits good flow properties, good passing ability, and segregation resistance. No vibration is required to compact the concrete since the SCC has the capability of compacting under its own weight after being placed. it has proved to be beneficial for the Speedier development, Reduction in site labour, Better surface , Easier putting, Improved durability, Greater flexibility in outline, Thinner concrete sections, Reduced noise level, Safer working environment.

Self-Compacting Concrete often produced with lesser water-cement ratio yielding early strength and hence faster use of structures. Then, the elimination of vibrating equipment can reduce noise and vibrations. Moreover, to ensure high filling ability and flow without blockage, Self-Compacting Concrete should take lesser coarse aggregate contents and high cement content which can increase the cost and temperature during hydration which leads to creep and shrinkage

The importance of self-compacting concrete is that maintains all concrete's durability and characteristics, meeting expected performance requirements. Compaction is hard to be done in conditions where there are dense reinforcement and large placing area. The addition of fibers in concrete upgrade the tensile strength, flexural strength, toughness, drying shrinkage, and failure pattern of the concrete. The Steel fibre concrete is a composite material made of cement, fine aggregate and coarse aggregates and steel fibers. In tension steel fibre concrete fails only after the steel fibre breaks out of the cement matrix. The Steel fibre concrete possess many dynamic performances such as high resistance to explosion and penetration as compared to traditional concrete.

Besides, depending on the structures, the use of steel fibers can reduce the required amount of conventional steel reinforcement. However, the addition of steel fibers into SCC may affect the fluid property of the concrete. Such as, if the fibers is increased in volume fraction and aspect ratio will decrease the flow of slump and ability to pass, while increasing the flow time of SCCS. For that reason, this study helps to recognize the effect of selected steel fibers on the workability of SCC and how it can affect the hardened properties of concrete especially in mitigating crack propagation.

1.1 NECESSITY TO CHOOSE SCC

SCC is considered as a preferred option due to its well known properties of flowability, passing ability and compatibility. SCC is an excellent repair material for concrete encasement because of its ability to flow through narrow openings. Care shall be taken to avoid shrinkage of concrete by adding shrinkage compensating admixtures since bonding of new concrete with the old concrete is a requirement in repair works.

1.2 Aim And Objective

Additional strengthening method is required to improve the resistance of concrete structures under the extreme loads. The aim of this study is to investigate the strengthening effect of fibers on Self Compacting concrete and find out the mechanical behaviour of steel Fiber reinforced concrete as a material with specific end hooked steel fibre.

The main objectives of this study are:

- To improve the Compressive strength.
- Delaying propagation of micro- or macro-cracks according to geometrical parameters of fibers.
- To increase the toughness of the concrete.
- Impact and fatigue resistance

II. METHODOLOGY

The present research aims at studying the effect of straight fibre, crimped fibre and hooked fibre on strength parameters of self compacting concrete for M-40 grade of concrete. The mix design was carried out using IS:10262-2009. Concrete is strong in compression and weak in tension and also it has brittle character. The concept of using steel fibers reinforced concrete is to improve the characteristic strength of construction material. Three types of fibers with a different length, longitudinal shapewere used in the investigation. Nine mixes contained combination of each fibre type with the amount equal to 1%, 2% and 3%. The analysis was focused on determination of the compressive and parameters of SFSCC mixes.

2.1 Properties Of Used Materials-

Cement- Ordinary Portland cement (OPC) is by far the most important type of cement. It has adequate resistance to dry shrinkage and cracking, but has less resistance to chemical attack. OPC 53 grade Ultra Tech cement is used in this experimental work confirming to IS12269-2013.

Table 1- properties of cement

Property	Value observed in investigation	Standard value for OPC
Fineness (%)	5	Not exceed 10
Specific gravity	3.15	-
Consistency (%)	31	-
Initial setting time(min)	170min	>30
Final setting time(min)	280min	<600
Soundness (mm)	2.00	Not more than 10mm
Compressive Strength 3 Days 7 Days 28 days	34.42 46.52 62.71	Not less than 27 Not less than 37 Not less than 53

Fine Aggregate- It may be natural sand, crushed stone or crushed gravel sand. The minimum particle size of fine aggregate is 0.075 mm and the maximum particle size is 4.75 mm.

Table 2- properties of fine aggregate

Properties	Magnitude	Standard value as per Is 2386
Specific gravity	2.6	2.6-2.8
Grading zone	Zone II	-
Fineness modulus	2.8	2.6-2.9
Water absorption (%)	1.32	2

Coarse Aggregate- In project the aggregate passing from 20mm and retained on 10mm IS sieve are used. Course aggregate confirming to IS code 383-1970 is used.

Table 3- Properties of Coarse Aggregate

Properties	Coarse aggregate	Standard value as per Is 2386
Particle size	20mm	--
Particle shape	Angular	--
Specific gravity	2.93	2.5-3.0
Bulk density	1340 kg/cu.m	1200 – 1750 kg/ cu.m
Fineness modulus	6.01	6 - 8

Water absorption (%)	0.42	2
Flakiness Index (%)	22.13	25
Elongation index (%)	20.63	25
Impact value (%)	6.06	10
Crushing value (%)	19.63	-

TYPES OF STEEL FIBERS

1. Straight Steel Fibers: Obtained by cutting drawn wires, and fibers with different types of indentations, and shapes to increase mechanical bond. Used for overlays and over slabbing for roads, pavements, airfields, bridge decks, and industrial and other flooring.

Fig -1: straight steel fibre

2. Crimped Steel Fibers: The crimped steel fibers are made of either carbon steel or stainless steel. The crimped fibre cross section may be circular and waving in cross sections. The length of the fibre is normally less than 150 mm even though longer fibers have been used.

Fig -2: crimped steel fibre

3. Hooked Steel Fibers: Cold-drawn hooked end steel fibre is manufactured by quality base steel bar, which has excellent mechanical properties including high tensile strength. Owing to high strength and uniform distribution of fibers, stresses can be fully dispersed and cracking propagation be effectively controlled.

Fig -3: hooked steel fiber

Water-It is the very important and cheapest ingredient of concrete. The mixing water is utilized in the hydration of cement to form the binding matrix in which the inert aggregates are held in suspension until the matrix has hardened.

Admixture-Super Plasticizer: The purpose of Super Plasticizer is to improve the workability of fresh concrete. AUROMIX 400 INBNG1, a super plasticizer manufactured by FOSROC constructive solutions, was used in the present work. Typical Properties of Auro-mix 400 Super Plasticizer

Table 4- properties of Auro-mix 400 super plasticizer

Properties	**Result**
Appearance	Light Yellow colored liquid
PH	Min 6
Volume mass @ 20◦C	(1.09)Kg Per Liter
Chloride Content	Nil

Alkali content	< 1.5 g Na2o Proportionate liter of admixture

III. RESULTS AND DISCUSSION

In this project, the slump flow tests were conducted which is a primary testing on fresh concrete used in the field because of the ability to show the initial condition of the concrete mixture. This test show some information on the flowability and segregation of fresh SCC and SCCSF through measurement. As for the hardened concrete, the cubic specimens were moulded 24 hours after casting and then cured for 7 days and 28 days in water. Subsequently, the compressive tests were obtained to check the strength of the concrete.

3.1Slump flow test- The slump flow test for fresh SCC and SCCSF were conducted in accordance with BS EN 12350-8- 2010. Basically, the procedure begins with keeping the slump on plane platform. then filling the slump mould in a single layer without compaction and then the mould is raised immediately and slowly in a vertical direction. The value of the slump flow is the average of the largest slump flow diameter, d1 and the second diameter d2 that is perpendicular to the first measured diameter, d1. As per "The European Guidelines for Self Compacting Concrete" the acceptance criteria is between 550 mm and 850 mm.

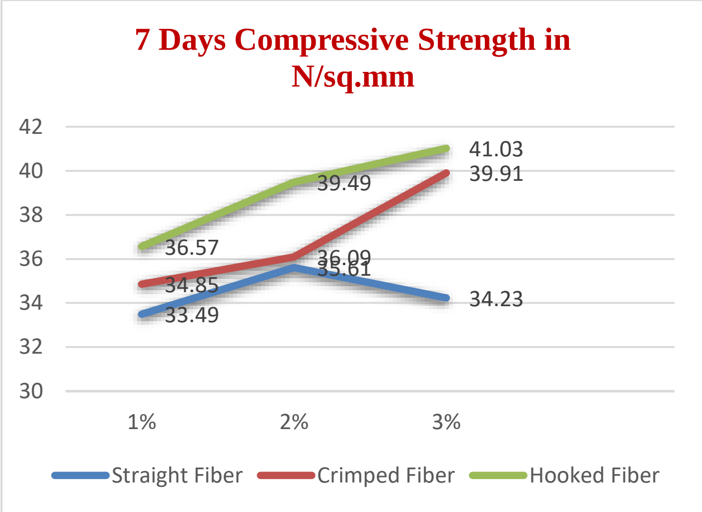
Table 5- Slump Value

Sr. No.	Types Of Steel Fiber	Steel Fibre Content (%)	Slump of concrete in mm
1.	SCC	0 %	775
2.	Straight Fiber	1%	750
		2%	690
		3%	640
3.	Crimped Fiber	1%	735
		2%	685
		3%	620
4.	Hooked Fiber	1%	720
		2%	660
		3%	620

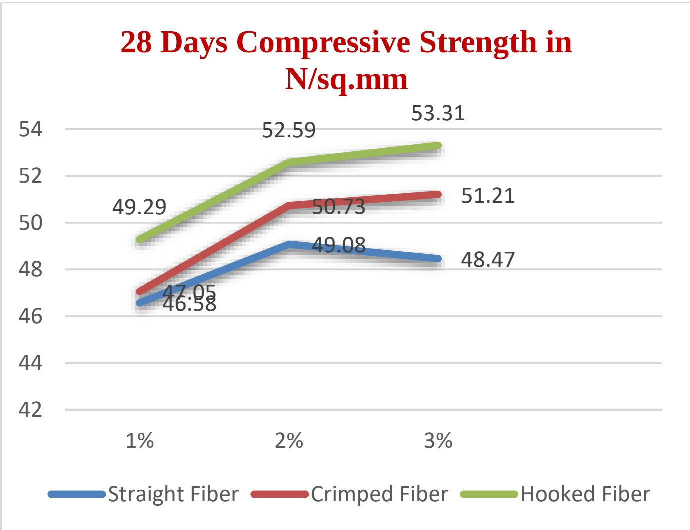
3.2 Compressive strength test- The compressive tests were conducted using the Compression Testing Machine with a capacity of 3000 kN. The test was performed based on the requirements by BS EN 12390-3:2009. This test gives the value of strength of all cubes specimens.

Table 5- 7, 28, 56 and 90 days compressive strength

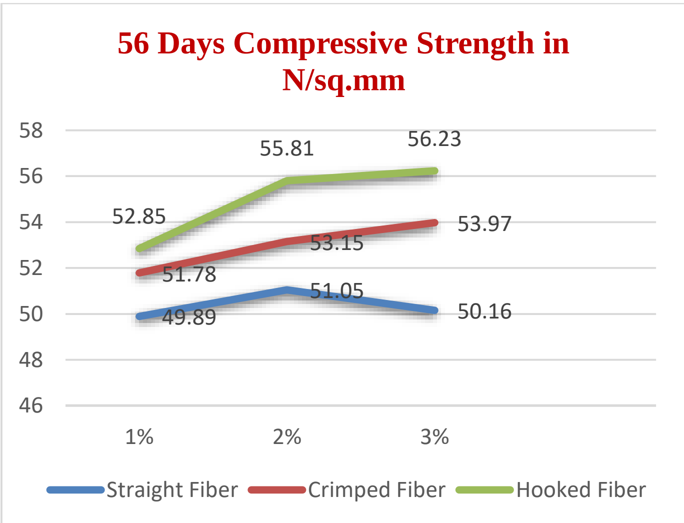
Sr. No.	Types Of Steel Fiber	Steel Fibre Content (%)	Average Compressive strength N/Sq.mm			
			7 Days	28 Days	56 Days	90 Days
1.	SCC	0 %	32.33	41.49	44.16	45.41
2.	Straight Fiber	1%	33.49	46.58	49.89	51.12
		2%	35.61	49.08	51.05	53.9
		3%	34.23	48.47	50.16	52.67
3.	Crimped Fiber	1%	34.85	47.05	51.78	52.53
		2%	36.09	50.73	53.15	54.29
		3%	39.91	51.21	53.97	55.17
4.	Hooked Fiber	1%	36.57	49.29	52.85	53.63
		2%	39.49	52.59	55.81	57.11
		3%	41.03	53.31	56.23	58.19



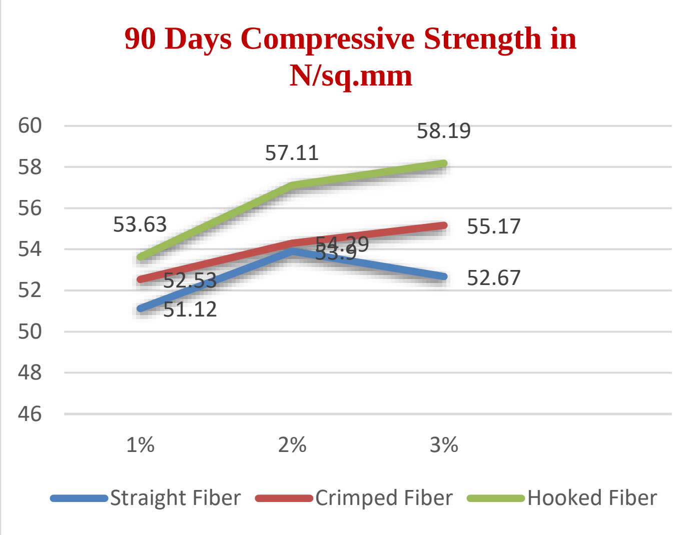
graph 1. combine result of 7 days compressive strength of concrete



graph 2. combine result of 28 days compressive strength of concrete



graph 3. combine result of 56 days compressive strength of concrete

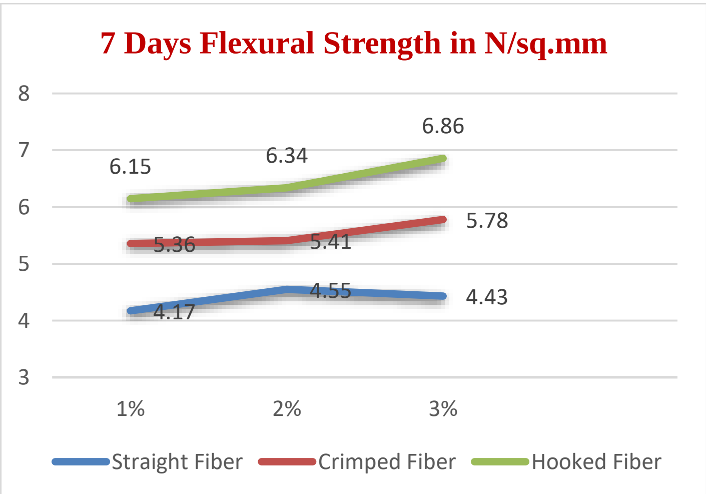


graph 4. combine result of 90 days compressive strength of concrete

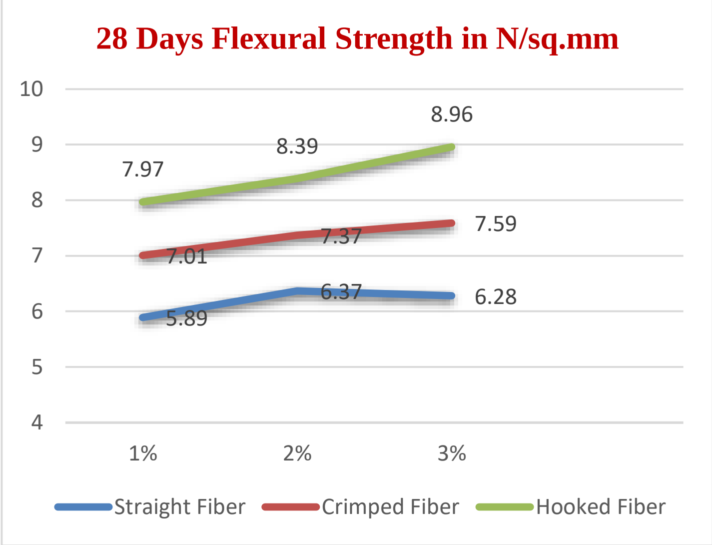
Flexural strength: Flexural beam test is another indirect method of testing and evaluating the tensile strength of the concrete. For each batch numbers of beams were casted to be tested under compression load. The beams had the cross section dimension of 150×150×700mm. the clear span was set to 600mm and the upper bearer distance was set to 200mm. The displacement at the centre of the beam was measured by the use of two displacement transducers at both sides of the beam.

Table 6- 7, 28, 56 and 90 days Flexural strength

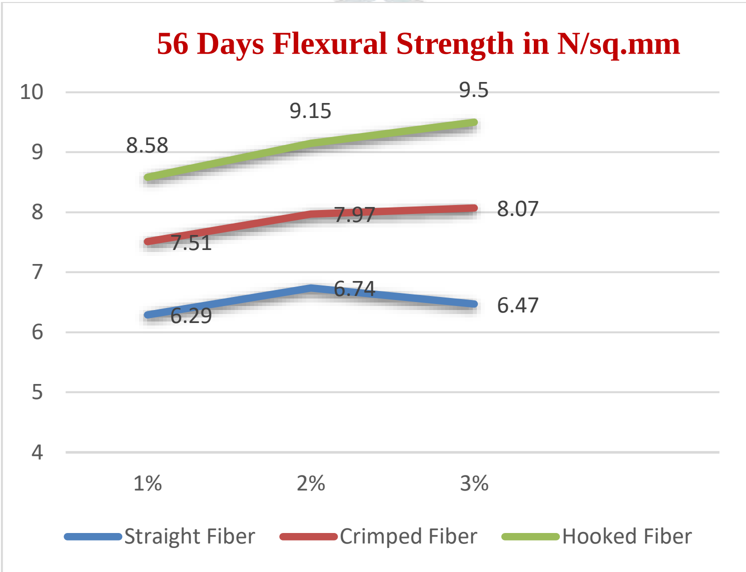
Sr. No.	Types Of Steel Fiber	Steel Fibre Content (%)	Average Flexural strength MPa			
			7 Days	28 Days	56 Days	90 Days
1.	SCC	0 %	2.48	4.38	5.04	5.74
2.	Straight Fiber	1%	4.17	5.89	6.29	6.64
		2%	4.55	6.37	6.74	7.0
		3%	4.43	6.28	6.47	6.85
3.	Crimped Fiber	1%	5.36	7.01	7.51	7.85
		2%	5.78	7.59	8.07	8.21
		3%	5.78	7.59	8.07	8.21
4.	Hooked Fiber	1%	6.15	7.97	8.58	8.97
		2%	6.34	8.39	9.15	9.54
		3%	6.86	8.96	9.50	9.89



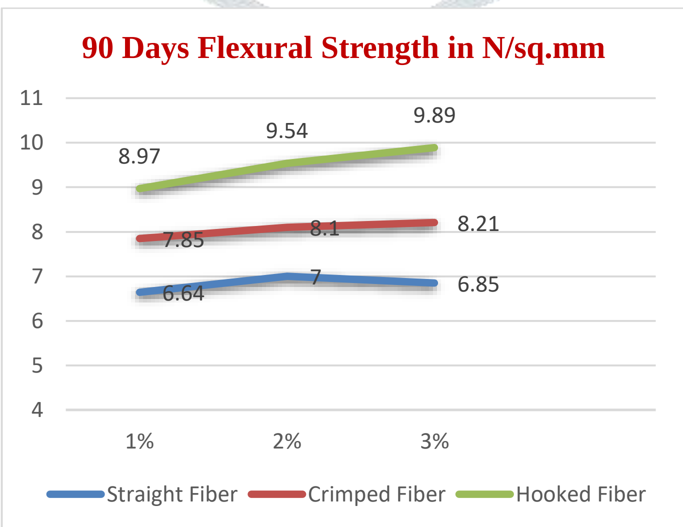
graph 5. combine result of 7 days compressive strength of concrete



graph 6. combine result of 28 days compressive strength of concrete



graph 7. combine result of 56 days compressive strength of concrete



graph 8. combine result of 90 days compressive strength of concrete

IV. **CONCLUSION:** This procedure with the given mix proportions has led to an SCC mix that was able to flow and fill the moulds without any need of vibration. The following conclusions were obtained from this study.

- To establish this mix design in concrete, we did flowability test, passing ability test. Which gives a positive result.

- The 7, 28, 56 and 90 day's compressive strength of self-compacting concrete with hooked steel fibers is maximum at a fiber percentage of 3%.
- The 7, 28, 56 and 90 day's flexural strength of self-compacting concrete with hooked steel fibers is maximum at a fiber percentage of 3%.
- The optimum percentage of different type of steel fiber was found to be 3 percentage.
- Hooked steel fibers at 3% addition to SCC was found to be the most efficient mix.
- The inclusion of steel fibers in SCC have increased the compressive strength as well as flexural strength of concrete and changes the failure modes.
- With increasing fiber content, mode of failure is changed from brittle to ductile when subjected to compression

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