Experimental Analysis of Steel Fiber Reinforced Self Compacting Concrete

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Abstract- Unrivaled exhibitions of Self-Compacting Concrete (SCC) in new state to accomplish a more uniform dispersion support the addition of fibers in Concrete which is an inspiration for basic utilization of fiber fortified cement. Steel fiber utilized as a part of the Self Consolidating Steel Fiber Reinforced Concrete (SCSFRC) is to improve the execution of the solid material. Be that as it may, SCC has inherent low ductility and poor toughness which limit the fields of use of SCC. The disadvantage of SCC can be evaded by strengthening with arbitrarily appropriated intermittent fibers. Actualizing huge favorable circumstances in the supply of self-compacting concrete (SCC) is essential due to the, negative elements of SCC. Cases of these components are the ductility issue alongside the high cost of its constituted materials. It is currently settled that one of the critical properties of steel fiber strengthened cement (SFRC) is its better resistance than breaking and split spread. Thus of this capacity to capture cracks, fiber composites have expanded extensibility and rigidity, both at the first break and at the extreme, specific under flexural stacking; and the filaments can hold the matrix together even after broad splitting. The net consequence of all this is to confer to the fiber composite articulated post – cracking ductility which is unfathomable in customary cement. The change from a fragile to a pliable sort of material would increment generously the vitality retention attributes of the fiber composite and its capacity to withstand over and again connected, shock or impact loading. In our work we for the most part centered on the examination of mechanical properties like compressive strength, and flexural strength. Trial work has been done to evaluate the compressive strength and flexural strength of Concrete by differing amounts of strands and the outcomes were exhibited. It was watched that there is an increment in compressive strength by 25.75% and increment in flexural strength by 19.47% of SFRSCC over ordinary SCC for the fiber substance by 1.75%.

I. INTRODUCTION

Self-compacting concrete (SCC) is a streaming concrete blend that can combine under its own weight. The exceptionally liquid nature of SCC makes it reasonable for setting in troublesome conditions and in areas with congested reinforcement. Utilization of SCC can likewise help limit hearing related harms on the work site that are prompted by vibration of concrete. Another favorable position of SCC is that the time required to place expansive segments is extensively decreased. Construction of durable concrete structures requires skilled labor for setting and compacting concrete. Self-Compacting Concrete accomplishes this by its remarkable crisp state properties. Self-consolidating concrete or self-compacting concrete is portrayed by a low yield stress, high deformability, and moderate viscosity necessary to ensure uniform suspension of solid particles amid transportation, placement (without outer compaction), and from that point until the slide sets. In the plastic state, it streams under its own weight and homogeneity while totally filling any formwork and going around congested reinforcement. In the solidified state, it levels with or exceeds expectations standard concrete concerning strength and durability. At the point when the development business in Japan encountered a decrease in the accessibility of talented work in the 1980s, a need was felt for a solid that could defeat the issues of blemished workmanship. This prompted the improvement of self-compacting concrete, fundamentally through the work by Okamura. A council was framed to concentrate the properties of self-compacting concrete, including a principal examination on the workability of concrete, which was completed by Ozawa et al. At the University of Tokyo. The primary usable variant of self-compacting cement was finished in 1988 and was named "Superior Concrete", and later proposed as "Self Compacting High Performance Concrete". In Japan, the volume of SCC in development has risen relentlessly throughout the years. Information show that the offer of use of SCC in precast Concrete industry is more than three times higher than that in the prepared blended Concrete industry. This is owing to the higher cost of SCC. The evaluated normal cost of SCC provided by the RMC business in Japan was 1.5 times that of the customary Concrete in the year 2002. Look into studies in Japan are additionally advancing new sorts of uses with SCC, for example, in cross section sort structures, throwing without a pump, and passage linings.

1.1 MATERIALS FOR SCC

Blend extents for SCC vary from those of conventional concrete, in that the previous has more powder substance and less coarse aggregate. Besides, SCC fuses high range water reducers (HRWR), Super-plasticizers in bigger sums and often a viscosity modifying agent (VMA) in little measurements. The inquiries that overwhelm the determination of materials for SCC are:

- ✓ Limits on the amount of marginally unsuitable aggregates, that is, those deviating from ideal shapes and sizes,
- ✓ Choice of HRWR,
- ✓ Choice of VMA, and
- ✓ Interaction and compatibility between cement, HRWR, and VMA. These are discussed below.

1.2 AGGREGATES

On account of SCC, rounded aggregates would give a superior flowability and less blocking potential for an offered water-to-powder proportion, contrasted with angular and semi-rounded aggregates. Additionally, the nearness of flaky and prolonged particles may offer ascent to blocking issues in kept regions, and furthermore increment the base yield stress (theological terms are talked about in the following segment). Consolidation of aggregate shape in the blend configuration would empower the determination of proper glue content required to conquer these challenges. It is conceivable that the exceedingly valuable nature of SCC could permit a higher extent of flaky aggregates contrasted with ordinary concrete. In any case, this perspective should be checked.

1.3 ADMIXTURES

SCC constantly consolidates chemical admixtures - specifically, a high range water, reducing admixture (HRWRA) and some of the time, viscosity-modifying agent (VMA). The HRWRA helps in accomplishing superb flow at low water substance and VMA decreases draining and enhances the stability of the concrete mixture. An effective VMA can likewise cut down the powder prerequisite and still give the required stability. Besides, SCC quite often incorporates a mineral admixture, to upgrade the deformability and stability of cement.

1.4 HIGH RANGE WATER REDUCERS

Various reviews have been led on the utilization of various sorts of HRWRAs with or without viscosity changing agents in self-compacting concrete. These reviews appear to show those that HRWRAs that work on the standard of „steric hindrance‟ require a lower measurements contrasted with those in view of „electrostatic repulsion‟. Expressed at the end of the day, acrylic copolymers (AC) and polycarboxylate ethers (PCE) are compelling at lower doses contrasted with choked out condensates of melamine (SMF) or naphthalene (SNF) formaldehyde. At present, SNF-based admixture is estimated lower (in India) than that in view of AC and PCE In the sentiment of the creators, SNF-based admixture is by all accounts ideal that in view of PCE.

1.5 VISCOSITY MODIFYING AGENTS

The regular technique for enhancing the strength of streaming SCC is to build the fines content by utilizing a lot of filler, receptive or inert. Recently, be that as it may, endeavors are being made to lessen the fines substance (and glue substance) to the levels of typical concrete (in doing as such, decreasing the potential for creep and shrinkage) and utilize viscosity modifying agents (VMAs) to enhance the stability.

Ebb and flow, examine demonstrates that SCC created with low powder substance and VMA had comparative fresh concrete properties as SCC with high powder substance delivered without VMA.

1.6 ADMIXTURE COMPATIBILITY

Having low water content. Jolicoeur and Simard have concentrated the association amongst SNF and concrete. In concretes having low water substance and high super plasticizer dose, gypsum (show in concrete) may precipitate out, bringing on an untimely hardening of the glue and ensuing loss of slump. Be that as it may, SCC blends normally may have a water substance of 170 – 200 liters/m3 and the similarity issues related with low water substance may not emerge. Here and there super plasticizers are mixed with retarders or lignosulfonates (which may have sugar in them), for droop maintenance in hot climate conditions.

At the point when a VMA is utilized alongside such mixed superplasticizers, concrete may not set for almost twenty hours. This issue might be stayed away from by utilizing immaculate SNF based super plasticizers. The retarding impact of the VMA itself will be sufficient for broadening the droop maintenance time.

1.7 MIXTURE PROPORTIONING METHODS

Self-compacting concrete mixtures ought to be intended for a mix of filling capacity, resistance to segregation, and capacity to go through and around support without blockage. Previously, SCC blends have had high cementitious materials substance, giving a high level of strength to the mixtures. Thus, water substance of SCC mixtures were around 190 – 220 liters/m3. With the advancement of VMA particularly suited for SCC applications, notwithstanding, it has been conceivable to diminish the substance of cementitious materials, cutting down the water substance to qualities nearer to ordinary cement (160–190kg/m3).

1.8 BACKDROP REGARDING SELF-COMPACTING CONCRETE

Cement based items are the almost all abundant of all man-made items as are extremely basic design products, in reality it is more than likely that they'll go ahead to claim comparative incentive later on. In any case, these outline and furthermore anatomist items need to meet new and furthermore bigger requests. When battling with inconveniences of generation, general economy, beat quality and furthermore setting, climate safe go up against some other outline items for example plastic material, material and furthermore timber. Only one bearing inside this progression is for the most part to self-compacting concrete (SCC), some kind of enhanced item that will, without extra compaction imperativeness, passes and furthermore solidifies inebriated by its bodyweight.

1.9 REQUIREMENT FOR SCC

Foundry fine sand and furthermore rosy hued resemble a magnet has pozzolanic houses henceforth expanding the holding houses and gives the higher quality strength simultaneously this limits the charge issues. In addition limits this issues, Foundry waste transfer. All through transfer property end up being inefficient. It begins contaminating the groundwater. Subsequently it should be used in some supportive design. That may request in a couple of methodologies Help out with showing signs of improvement top nature of cement. For endless years, the issue on the toughness of solid set ups has turned into a noteworthy issue postured to have the capacity to architects. To produce dependable solid set ups, plentiful compaction ends up plainly essential. Compaction planned for consistent cement is finished through vibrating. More than vibration can surely bring about isolation. All through normal solid, it's hard to make certain homogeneous item best quality and furthermore gainful thickness in extraordinarily reinforced spots.

1.10 STEEL FIBRES

Steel fiber is somewhat cutting-edge composite material, which is most broadly utilized for cement fortifying in development and designing work these days. Certain dose of steel fiber in cement can bring about subjective change on cement's physical property, extraordinarily expanding breaking resistance, affect resistance, exhaustion resistance, twisting resistance, industriousness, sturdiness and different properties. The steel strands for the most part utilized as a part of cement are comprised of carbon steel and are fabricated in different shapes and sizes. Steel filaments blended into the solid can give a contrasting option to the arrangement of ordinary steel bars or welded texture in a few applications.

1.11 OBJECTIVE OF THE WORK

The objective of this study is to optimize the Steel Fiber Reinforced Self Compacting Concrete (SFRSCC) in the fresh and in hardened state. But the literature indicates that some studies are available on plain SCC but sufficient literature is not available on SFRSCC with different mineral admixtures. Hence an attempt is made in this work to study the mechanical properties of both plain SCC and SFRSCC.

II. MATERIALS AND METHODOLOGY

For the present study ordinary Portland cement of 53 Grade, Natural sand from confirming IS 383-1970 along with potable water and natural aggregates were used for preparation of concrete. The super plasticizer used for the present study was supplied by the manufacturer Sika India Pvt. Ltd., Mumbai complies IS: 9103- 1999. The viscosity modifying agent (VMA) was also supplied by the manufacturer Sika India Pvt. Ltd. Dramix steel fibers conforming to ASTM A820 type-I are used for experimental work. Dramix RC - 80/60 - BN are 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. Fly Ash (FLA) which is available in dry powder form and is procured from Dirk India Pvt. Ltd., Nashik. It is available in 30Kg bags, colour of which is light gray under the product name "Pozzocrete 60" was used for the present study.

2.1 METHODOLOGY

After performing all required tests on the ingredients of concrete such as cement, sand, coarse aggregates etc. mix design for SCC was done.

Rational method is used for mix design of M-30 grade of concrete. The optimum percentage of fly ash to give maximum compressive strength was achieved by making trial mixes with fly ash at a constant interval of 3% by weight of cement. The trial mixes were made for fly ash from 12% to 36%. The compressive strength went on increasing up to 33% at it decreased at 36%. The maximum compressive strength was achieved at 33%. Hence, fly ash at 33% by weight of cement was added to concrete in this experiment. Figure-1. shows the SCC Mix Design Procedure.

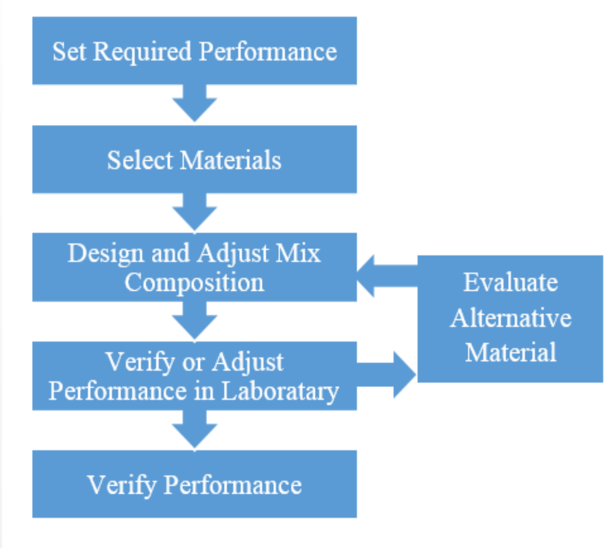

Figure-1. SCC Mix Design Procedure

At the end after performing the entire test following mix proportion was used for the present study. The quantities of ingredient materials and mix proportions as per EFNARC guidelines are shown in the Table-1.

Table-1. Quantity of Materials per Cubic Meter of Concrete

Material	Proportion by Weight	Weight in Kg/m3
Cement	1	450.00
F.A	2.19	985.5
Fly Ash	0.34	153
C.A(<12mm)	1.79	805.5
W/C	0.41	184.5

After finalizing the proportion of ingredients following mix proportions with different designations according to Steel Fiber content were used. The details are shown in Table-2.

Table-2. Mix Designations Used

S.No	Mix Design-Ation	Flyash (%)	Steel Fiber Content (%)	W/C Ratio
1	M0	34.0	0.0	0.41
2	M1	34.0	0.5	0.41
3	M2	34.0	1.0	0.41
4	M3	34.0	1.25	0.41
5	M4	34.0	1.5	0.41
6	M5	34.0	1.75	0.41
7	M6	34.0	2.0	0.41
8	M7	34.0	2.25	0.41
9	M8	34.0	2.5	0.41
10	M9	34.0	2.75	0.41
11	M10	34.0	3.0	0.41

The specimens used were cubes, beam specimens.
Dimensions of each test specimen are as under:
Cube: 100 mm x 100 mm x 100 mm
Beam: 100 mm x 100 mm x 500 mm
Above specimens were used to determine the compressive strength test and flexural strength test respectively.

III. TEST RESULTS AND DISCUSSION

3.1 Compressive Strength Test on Cube

A cube compression test was performed on standard cubes of plain and SFRSCC of size 100 x 100 x 100 mm after 7 days and 28 days of immersion in water for curing. Results are shown in Table-3. And graphical presentation between compressive strength and percentage fiber volume fraction is shown in Figure-2.

Table-3 Compressive Strength of Normal SCC and

S.N.	% of Steel Fiber	Compressive Strength (fcu) Mpa		% Variation in Compressive Strength Over Control Mix	
		7 Days	28 Days	7 Days	28 Days
1	0	35.56	45.64	0	0
2	0.5	35.76	48.42	0.62	6.093
3	1	36.93	50.34	3.855	10.257
4	1.25	37.04	52.15	4.164	14.268
5	1.5	37.86	54.96	6.47	20.426

6	1.75	38.93	57.39	9.478	25.752
7	2.0	39.50	61.76	11.084	35.329
8	2.25	39.69	63.83	11.618	39.865
9	2.5	40.85	65.90	14.881	44.402
10	2.75	41.98	68.98	18.06	51.152
11	3.0	43.15	70.05	21.351	53.497

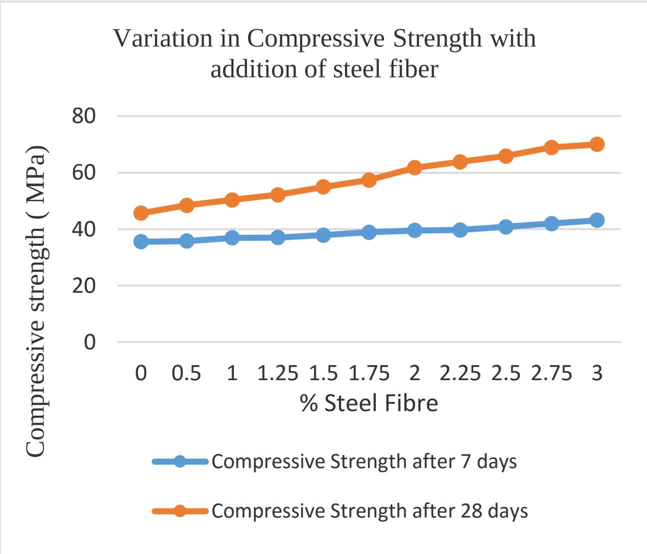

Figure-2. Graph between Compressive Strength at 7 days and 28 days with addition of Steel Fibre

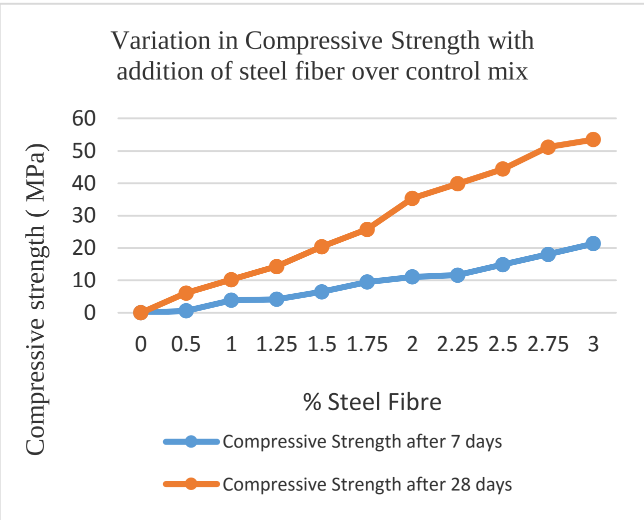

Figure-3. Graph between Compressive Strength at 7 days and 28 days with addition of Steel Fibre over control mix

4.2 Flexural Strength Test on Beam:

A Flexural Strength test was performed on standard beam of plain and SFRSCC of size 100 x 100 x 500 mm after 7 days and 28 days of immersion in water for curing. Results are shown in Table-4. And graphical presentation between compressive strength and percentage fiber volume fraction is shown in Figure-4.

Table-4. Flexural Strength of Normal SCC and SFRSCC,

S.NO	% OF STEEL FIBER	STRENGTH (fcu) MPa		% Variation in Compressive Strength over control mix	
		7 Days	28 Days	7 Days	28 Days
1	0	4.32	5.3	0	0
2	0.5	4.47	5.56	3.49	4.92
3	1	4.64	5.87	7.43	10.78
4	1.25	4.75	5.95	9.98	12.29
5	1.5	5.03	6.14	16.48	15.88
6	1.75	5.42	6.33	25.53	19.48
7	2	5.46	6.45	26.46	21.74
8	2.25	5.61	6.49	29.94	22.5
9	2.5	5.75	6.69	33.18	26.28
10	2.75	6.03	6.98	39.68	31.77
11	3	6.12	7.15	41.77	34.98

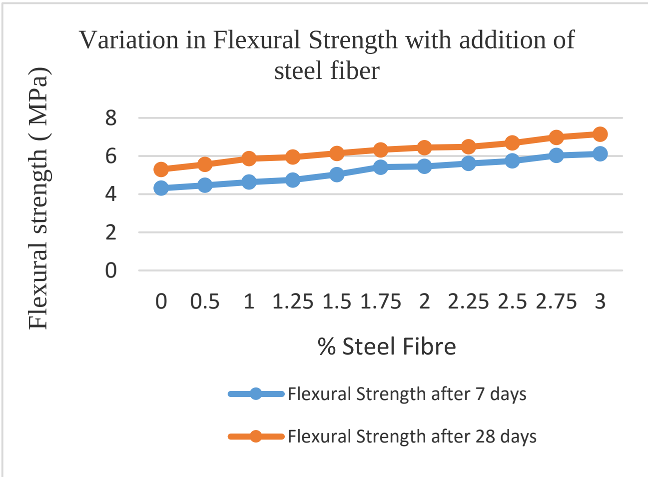

Figure-4. Graph between Flexural Strength at 7 days and 28 days with addition of Steel Fibre

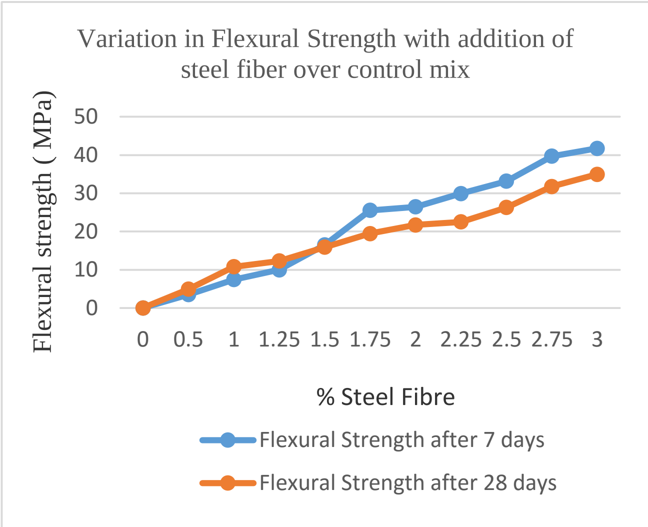

Figure-5. Graph between Flexural Strength at 7 days and 28 days with addition of Steel Fibre over control mix

DISCUSSION ON TEST RESULTS

Results of compressive strength are shown in Table 3. It indicates the optimum volume fraction of fibers which gives maximum strength at 28 days is 3.0%. The percentage increase in strength at this volume fraction of fibers over normal SCC at 7 and 28 days is 21.351% and 53.497% respectively. Cracks occur in microstructure of concrete and fibers reduce the crack formation and propagation. Also fly ash improves the microstructure of concrete. Here, this might be the reason for the enhancement of compressive strength. From above Table 4, it is observed that the flexural strength increases with increase in fiber content up to 3.0%. The maximum values at 7 and 28 days are 6.12 and 7.15 respectively.

IV. CONCLUSION

Following conclusion are drawn based on the result discussed above

a) In general, the significant improvement in various strengths is observed with the inclusion of Hooked end steel fibres in the plain concrete. However, maximum gain in strength of concrete is found to depend upon the amount of fibre content. The optimum fibre content to impart maximum gain in various strengths varies with type of the strengths.
b) In general the compressive strength and the flexural strength increase with increase in the percentage of fibre content.
c) In addition to the compressive strength and the flexural strength on the concrete split tension test was also performed on the SFRSCC the results of which are not mentioned in the paper (because the scope is limited to compressive and flexural strength of the SFRSCC) and it was found that the split tensile strength went on increasing with the addition of fibers. The optimum fiber content for increase in split tensile strength is 1.75% and percentage increase is 24.49% of SFRSCC over normal SCC.
d) The increase in compressive strength is 25.75% and increase in flexural strength is 19.47% of SFRSCC over normal SCC for the fibre content of 1.75%.
e) Satisfactory workability was maintained with increasing volume fraction of fibers by using super plasticizer.
f) With increasing fiber content, mode of failure was changed from brittle to ductile failure when subjected to compression and bending.

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