International Journal for Research in Engineering Application & Management (IJREAM)
ISSN : 2454-9150 Vol-04, Issue-10, Jan 2019

Steel Fiber Reinforced Self Compacting Concrete

Suma Paralada, Assistant professor, Department of civil engineering, New Horizon college of engineering, Bangalore, India, suma2825@yahoo.in

Abstract : Self-compacting concrete (SCC) is an innovative concrete that does not require vibration for placing and compaction. It is able to flow under its own weight, completely filling formwork and achieving full compaction, even in the presence of congested reinforcement. The hardened concrete is dense, homogeneous and has the same engineering properties and durability as traditional vibrated concrete. The inclusion of fiber reinforcement in concrete, mortar and cement paste can enhance many of the engineering properties of the basic materials, such as fracture toughness, flexural strength and resistance to fatigue, impact, thermal shock and spalling. In recent years, a great deal of interest has been created worldwide on the potential applications of natural fiber reinforced, cement based composites. Investigations have been carried out in many countries on various mechanical properties, physical performance and durability of cement based matrices reinforced with steel fibers. These fibers help to transfer loads at the internal micro cracks. The behavior of SCC as a structural material can be improved if adequate steel fiber reinforcement is added to SCC mix composition. The fiber reinforcement mechanisms can convert the brittle behavior of the cement based material into a pseudo-ductile behavior up to a crack width that is acceptable under the structural design.

Keywords – FRSCC – Fiber reinforced self compacting concrete, SCC – Self compacting concrete, VMA – Viscosity Modifying Agent

I. INTRODUCTION

The development of new technology in the material science is progressing rapidly. In last three decades, a lot of research was carried out throughout globe to improve the performance of concrete in terms of strength and durability qualities. Consequently concrete has no longer remained a construction material consisting of cement, aggregate, and water only, but has become an engineered custom tailored material with several new constituents to meet the specific needs of construction industry. The growing use of concrete in special architectural configurations and closely spaced reinforcing bars have made it very important to produce concrete that ensures proper filling ability, good structural performance and adequate durability. In recent years, a lot of research was carried out throughout the world to improve the performance of concrete in terms of its most important properties, i.e. strength and durability. Concrete technology has under gone from macro to micro level study in the enhancement of strength and durability properties from 1980‟s onwards. Till 1980 the research study was focused only to flow ability of concrete, so as to enhance the strength however durability did not draw lot of attention of the concrete technologists. This type of study has resulted in the development of self-compacting concrete (SCC), a much needed revolution in concrete industry. Self-compacting concrete is highly engineered concrete with much higher fluidity without segregation and is capable of filling every corner of form work under its self-weight only (Okamura 1997). Thus SCC eliminates the needs of vibration either external or internal for the compaction of the concrete without compromising its engineering properties.

This concrete was first developed in Japan in late 80‟s to combat the deterioration of concrete quality due to lack of skilled labors, along with problems at the corners regarding the homogeneity and compaction of cast in place concrete mainly with intricate structures so as to improve the durability of concrete and structures. After the development of SCC in Japan 1988, whole Europe started working on this unique noise free revolution in the fieldofConstruction industry. The last half of decade 1991-2000 has remained very active in the field of research in SCC in Europe. That is why, Europe has gone ahead of USA in publishing specifications and guidelines for self-compacting concrete (EFNARC 2002). Now, all over the world, a lot of research is going on, so as to optimize the fluidity of concrete with its strength and durability properties without a drastical increase in the cost.

Self-compacting concrete is basically a concrete which is capable of flowing in to the formwork, without segregation, to fill uniformly and completely every corner of it by its own weight without any application of vibration or other energy during placing. SCC plays a major role in precast concrete where the speed of placing and the removal of elements from forms at the earliest are essential requirements, at the same time having a defect free surface. SCC is a solution that solves most of the challenges and problems, which come across the concrete industries.

 DOI : 10.18231/2454-9150.2018.1394

SCC has gained wide use in many countries for different application and structural configurations. SCC requires high slump, which can easily be achieved by incorporating several chemical admixtures. In particular, Super plasticizer and Viscosity Modifying Agent (VMA).

The super plasticizer influences the rheological behavior, the viscosity and yield value of fresh concrete in certain concrete mix. The super plasticizer ensures high fluidity and reduces water-powder ratio. Super plasticizer greatly improves the pumpability and the slump value. The use of VMA increases the segregation resistance of concrete and increases the deformability without segregation and then to lead high optimum self compactability.

SCC plays a major role in increasing the use of industrial by-products like slag, fly ash, silica fume and granite dust obtained during sawing process of granite rocks. SCC offers possibility for utilization of dust which are currently waste products demanding with no practical application and which are costly to dispose

II. NEED FOR STUDY

For several years, the problem of the durability of concrete structures has been a major problem posed to engineers. To make durable concrete structures, sufficient compaction is required. Compaction for conventional concrete is done by vibrating. Over vibration can easily cause segregation. In conventional concrete, it is difficult to ensure uniform material quality and good density in heavily reinforced locations. If steel is not properly surrounded by concrete it leads to durability problems. This is the problem mainly with heavily reinforced sections where a very high congestion of reinforcement is seen. In this case, it becomes extremely difficult to compact the concrete. Then what can be done to avoid honeycombing?

The answer to the problem may be a type of concrete which can get compacted into every corner of form work and gap between steel, purely by means of its own weight and without the need for compaction. The SCC concept was required to overcome these difficulties.

The SCC concept can be stated as the concrete that meets special performance and uniformity requirements that cannot always be obtained by using conventional ingredients, normal mixing procedure and curing practices. The SCC is an engineered material consisting of cement, aggregates, water and admixtures with several new constituents like colloidal silica, pozzolanic materials, chemical admixtures to take care of specific requirements, such as, high-flowability, compressive strength, high workability, enhanced resistances to chemical or mechanical stresses, lower permeability, durability, resistance against segregation, and possibility under dense reinforcement conditions.

The properties, such as, fluidity and high resistance to segregation enables the placement of concrete without vibrations and with reduced labour, noise and much less wear and tear of equipment. Use of SCC overcomes the problem of concrete placement in heavily reinforced sections and it helps to shorten construction period.

Self-compacting concrete is growing rapidly, especially in the pre-cast market where its advantages are rapidly understood and utilized. Super plasticizer enhances deformability and with the reduction of water/powder segregation resistance is increased. High deformability and high segregation resistance is obtained by limiting the amount of coarse aggregate.

However, the high dosage of super-plasticizer used for reduction of the liquid limit and for better workability, the high powder content as „lubricant" for the coarse aggregates, as well as the use of viscosity-agents to , as well as the use of viscosity-agents to increase the viscosity of the concrete have to be taken into account.

III.EXPERIMENTAL PROGRAMME

This chapter deals with the properties of the materials used in this study, details of the mixes tested in this study and the methodology adopted for the experimental work. Experimental investigations were done to achieve the flowing concrete(SCC) through its key property i.e., flowability by slump flow test. Tests are also carried out for compressive strength, flexural strength and split-tensile strength as these are necessary for white topping concrete.

Concrete was first designed by absolute volume method, which assumes that the volume of compacted concrete is equal to the sum of the absolute volume of all ingredients. The mix is designed for M40 grade concrete with water-cement ratio of 0.4 to get minimum slump of 600mm. in this study trial mixes are done for different paste volume to achieve SCC and also to get an ideal mix with good strength for white topping.

Super plasticizer is used to achieve good slump. In this study silica fume and GGBS is used as a filler material for good bonding in concrete. The cementitious material, super plasticizer, VMA and water content was kept constant with varying percentages of steel fibers.

III.1. PROPORTIONING OF SCC

Absolute volume method is adopted for mix proportioning in this study, where cementitious material, super plasticizer, VMA, and water content was kept constant with varying percentages of steel fibers of 0.5%, 1%, 1.5%.

- Cement content is fixed to 380kg/m^3
- Water content is fixed to 152 liters.
- Water-cement ratio is fixed for 0.4
- Water-powder ratio is fixed to 0.27

III.2. MATERIALS USED

- **CEMENT:** Ordinary Portland cement of 53 grade

 DOI : 10.18231/2454-9150.2018.1394

ISSN : 2454-9150 Vol-04, Issue-10, Jan 2019

confirming to IS 8112:1989.

- **COARSE AGGREGATE:** 20mm down size aggregate confirming to IS 383-1970
- **FINE AGGREGATE:** Manufacturing sand confirming to IS 383-1970
- **MINERAL ADMIXTURE:** Mineral admixture used in this project were silica fume and ground granulated blast furnace slag(GGBS)
- **SUPER PLASTICIZER:** Super plasticizer used is glenium 8233
- **PERCENTAGES OF STEEL FIBERS:** 0.5, 1, 1.5
- **VISCOSITY MODIFYING AGENT:**0.2%

Fig 1: Materials used

Fig 2: Hooked Steel fibers

Table: 1. Mix for SCC

PARTICULARS	VOLUME IN kg/m^3
CEMENT	380
WATER	152
COARSE AGGREGATE	932.8
FINE AGGREGATE	783.36
SILICA FUME	58
GGBS	112

Physical characteristics of materials:

Table: 2. Physical characteristics of Cement

TESTS	OBTAINED VALUES
SPECIFIC GRAVITY	3.14
STANDARD CONSISTENCY	30%
INITIAL SETTING TIME FINAL SETTING TIME	55 min 7 hours

Table: 3. Physical characteristics of FA (MSand)

TESTS	OBTAINED VALUES
FINENESS MODULUS	2.8
MOISTURE CONTENT	1.4

Table: 4. Physical characteristics of CA

TESTS	OBTAINED VALUES
SPECIFIC GRAVITY	2.65
MOISTURE CONTENT	0.196%
SIEVE ANALYSIS (FINENESS MODULUS)	6.0
BULK DENSITY	compacted-1.63g/cm3 Uncompacted-1.501g/cm3

Table: 5. Specific gravity of Silica fume and GGBS

TESTS	OBTAINED VALUES
Silica fume	2.2
GGBS	2.75

IV.PROPERTIES OF SCC

The 3 main properties of SCC in plastic state are

1. Filling ability (excellent deformability)
2. Passing ability (ability to pass reinforcement without blocking)
3. High resistance to segregation.

1. *Fillingability*

Self compacting concrete must be able to flow into all the spaces within the formwork under its own weight. This is related to workability, as measured by slump flow test.

The filling ability or flowability is the property that characterizes the ability of the SCC of flowing into formwork and filling all space under its own weight, guaranteeing total covering of the reinforcement. The mechanisms that govern this property are high fluidity and cohesion of the mixture.

2. *Passingability*

Self compacting concrete must flow through tight openings such as spaces between steel reinforcing bars under its own weight. The mix must flow freely during placement.

The passing ability is the property that characterizes the ability of the SCC to pass between obstacles gaps of reinforcement, holes, and narrow sections, without blocking. The mechanisms that govern this property are

 DOI : 10.18231/2454-9150.2018.1394

ISSN : 2454-9150 Vol-04, Issue-10, Jan 2019

moderate viscosity of the paste and mortar, and the properties of the aggregates, maximum size of the coarse aggregate. Stability or resistance to the segregation is the property that characterizes the ability of the SCC to avoid the segregation of its components, such as the coarse aggregates. Such a property provides uniformity of the mixture during transport, placement andconsolidationThe mechanisms that govern this property are the viscosity and cohesion of the mixture. This is measured using L-box and U-box test

3. *High Resistance to Segregation*

Self compacting concrete must meet the requirements of 1 and 2 while its original composition remains uniform. The key properties must be maintained at adequate levels for the required period of time (e.g.20 min) after completion of mixing. It is the property of passing ability and resistance to segregation that constitute the major advance, form a merely super plasticized fresh mix which may be more fluid than self compacting concrete mix.

Latest developments in accordance with the objectives of the European SCC project aim to limit the admixtures used for general purpose SCC by using new types and combinations of polymers. Experience has shown that such an admixture may be added to generate and maintain compacting concrete using less liable materials.

V.EXPERIMENTAL PROCEDURE

The cement, sand, silica fume, GGBS and coarse aggregates were weighed according to the mix proportion. To this dry mix the required quantity of water was added and thoroughly mixed. To this the superplasticizer and VMA was added and mixed intimately. The entire mix was thoroughly mixed once again. At this stage, almost the concrete was in a flowable state. Now, the flow characteristic experiments for self compacting concrete like slump flow test, V-funnel test,U- box test and L-box test wereconducted.

After conducting the flow characteristic experiments the concrete mix was poured in the moulds required for the strength assessment. After pouring the concrete into the moulds, no compaction was given either through vibrator or through hand compaction. Even, the concrete did not require any finishing operation. After 24 hours of casting, the specimens were demoulded and were transferred to the curing tank wherein they were allowed to cure for 28 days.

For compressive strength assessment, cubes of size 150mmX150mmX150mm were prepared. For tensile strength assessment, cylinders of diameter 150mm and length 300mm were prepared. Indirect tension test (Brazilian test or split tensile test), was carried on these cylindrical specimens. For flexural strength assessment, the beams of size 100mmX100mmX500mm were casted. After 28 days of curing the specimens were tested for their respective strengths

VI.TESTS ON CONCRETE

Table: 6. Test results of fresh concrete

SL. NO	SLUMP FLOW (mm)	V FUNNEL FLOW sec	L BOX (H2/H1)	% OF STEELFIBERS
1	630	15	0.8	0
2	610	20	0.75	0.5
3	610	24	0.72	1.0
4	600	24	0.72	1.5

Test results of hardened concrete

Table: 7. Compressive strength of concrete

% OF STEEL FIBERS	FAILURE LOAD(KN)		COMPRESSIVE STRENGTH(Mpa)	
	7 DAYS	28 DAYS	7 DAYS	28 DAYS
0	675.67	949.5	30.03	42.20
0.5	812.25	1105.4	36.1	49.13
1	843.33	1200	37.4	53.33
1.5	850	1226.66	37.77	54.51

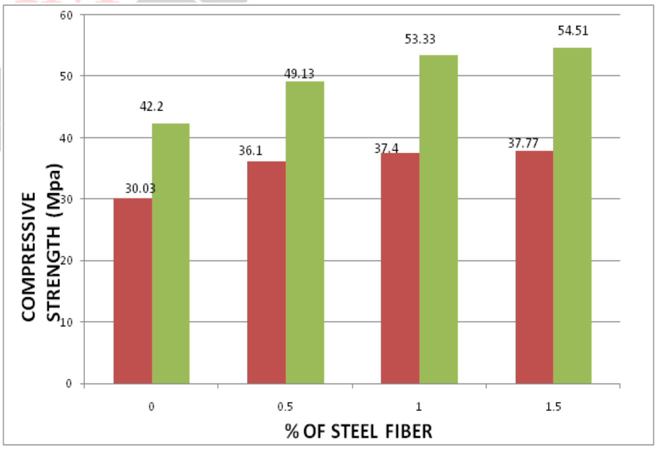


Table: 8. Split tensile strength of concrete

% OF STEEL FIBERS	FAILURE LOAD(KN) 28 DAYS	SPLIT TENSILE STRENGTH(Mpa) 28 DAYS
0	196.97	2.77
0.5	333.33	4.71
1	370	5.23
1.5	376.66	5.32

 DOI : 10.18231/2454-9150.2018.1394

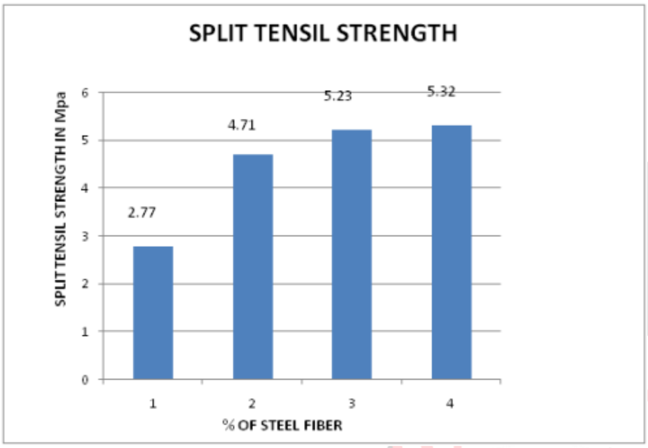
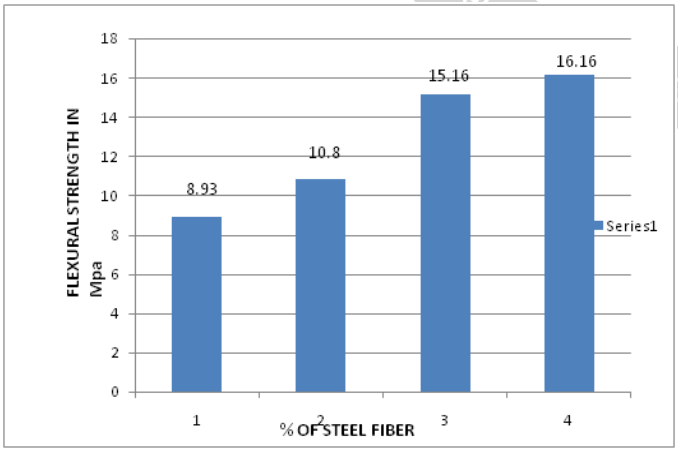


Table: 9. Flexural strength of concrete

% OF STEEL FIBERS	FAILURE LOAD(KN) 28 DAYS	FLEXURAL STRENGTH(Mpa) 28 DAYS
0	22.33	8.93
0.5	27	10.8
1	30.33	15.16
1.5	32.3	16.16



VII.CONCLUSIONS

In present scenario there is a greater need for self compacting concrete due to sickness of member and architectural requirement, also to improve durability of the structure.

Now the world is going to face a greater need of high performance concrete, as the conventional way of compacting may not be always useful under different site condition. Hence self compacting concrete proves to be more efficient and durable than conventional concrete.

IX. OBSERVATION

- It was found that the compressive strength for SCC with 0% steel fiber was 30.03Mpa and 42.20Mpa on 7days and 28 days respectively. Compressive strength for the SCC with 1.5% steel fiber was 37.77Mpa and 54.51Mpa on 7 days and 28 days respectively. It was observed that there was an increase in the strength when steel fibers were added.
- Split tensile strength for SCC with 0% steel fiber was 2.77Mpa on 28 days and was found to be 5.32Mpa on 28 days for SCC with 1.5%.
- Flexural strength for SCC with 0% steel fiber was 8.93Mpa on 28 days and was found to be 16.16Mpa on 28 days for SCC with 1.5%.
- Therefore the strengths gradually increased as the steel fibers were added in percentages and was found that the optimum percentage of steel was 1%.

REFERENCES

[1] H. Okamura, “Self Compacting High Performance Concrete – Ferguson Lecture for 1996,” Concrete International, Vol. 19, No. 7, 1997, pp. 50 –54.

[2] K. Ozawa, K. Maekawa, and H. Okamura, “Development of theHigh Performance Concrete,” Proceedings of JSI, Vol. 11, No. 1, 1989, pp. 699 –704.

[3] H. Okamura and M. Ouchi, “Applications of Self-Compacting Concrete in Japan,” Proceedings of the 3rd International RILEM Symposium on Self- Compacting Concrete, O. Wallevik and I. Nielsson, Ed., RILEM Publications, 2003, pp. 3 –5.

[4] Brite-Euram Project No. BE96-3801/Contract BRPR-CT96-0366,1998.

[5] A. Skarendahl and O. Petersson, “State of the Art Report ofRILEM Technical Committee 174-SCC, Self-Compacting Concrete,” Paris, RILEM Publications S.A.R.L, 2000, 154p.

[6] Testing SCC: Measurement of properties of fresh SCC, Contract GRD2- 2000-30024,2000.

[7] EFNARC: Specifications and Guidelines for SCC, EFNARC, Hampshire, UK, 2001, 29pp.

[8] N. Mishima, Y. Tanigawa, H. Mori, Y. Kurokawa, K. Terada, and T. Hattori, “Study on Influence of Aggregate Particle onRheological

[9] Property of Fresh Concrete,” Journal of the Society of Materials Science, Japan, Vol. 48, No. 8, 1999, pp. 858

 DOI : 10.18231/2454-9150.2018.1394

– 863.
[10] Y. Kurokawa, Y. Tanigawa, H. Mori, and K. Nishinosono, "Analytical Study on Effect of Volume Fraction of Coarse Aggregate onBingham's Constants of Fresh Concrete," Transactions of the Japan Concrete Institute, Vol. 18, 1996, pp. 37 –44.
[11] S. Grunewald and J. C. Walraven, "Parameter-Study on the Influence of Steel Fibres and Coarse Aggregate Content on the Fresh Properties of Self-Compacting Concrete," Cement and Concrete Research, Vol. 31,No. 12, 2001, pp. 1793 –1798.
[12] L. J. O'Flannery and M. M. O'Mahony, "Precise Shape Grading of Coarse Aggregate," Magazine of Concrete Research, Vol. 51, No. 5, 1999, pp.319
[13] M. Nehdi, "Why Some Carbonate Fillers Cause Rapid Increases of Viscosity in Dispersed Cement-Based Materials," Cement and Concrete Research, Vol. 30, No. 10, 2000, pp. 1663 –1669.
[14] V. B. Bosiljkov, "SCC Mixes with Poorly Graded Aggregate and High Volume of Limestone Filler," Cement and Concrete Research, Vol. 33, 2003, pp. 1279 –1286.
[15] T. Sedran and F. de Larrard, "Optimization of Self Compacting Concrete Thanks to Packing Model," First International RILEM Symposium on Self Compacting Concrete, RILEM Proceedings, 1999, pp. 321 –332.
[16] V. Senthil Kumar and M. Santhanam, "Particle Packing Theories and Their Application in Concrete Mixture Proportioning," Indian Concrete Journal, Vol. 77, No. 9, 2003, pp. 1324 –1331.
[17] D. W. S. Ho, A. M. M. Sheinn, C. C. Ng, and C. T. Tam, "The UseofQuarry Dust for SCC Applications," Cement and Concrete Research, Vol. 32, No. 4, 2002, pp. 505 – 511.
[18] K. H. Khayat and A. Yahia, "Effect of Welan Gum – High Range Water Reducer Combinations on Rheology of Cement Grout," ACI Materials Journal, Vol. 94, No. 5, 1997, pp. 365 –372.
[19] M. Sari, E. Prat and J. –F. Labastire, "High Strength Self Compacting Concrete: Original Solutions Associating Organic and Inorganic Admixtures, "Cement and Concrete Research, Vol. 29, No. 6, 1999, pp.813– 818
[20] M. Lachemi, K. M. A. Hossain, V. Lambros, P. –C. Nkinamubanzi, and N. Bouzoubaa, "Performance of New Viscosity Modifying Admixtures in Enhancing the Rheological Properties of Cement Paste," Cement and Concrete Research, In Press,2003.

 DOI : 10.18231/2454-9150.2018.1394