

# **Experimental Investigation on Flexural Behavior of Self-Compacting Concrete Slabs**

**Seethalakshmi T<sup>1</sup>, Saravanakumar M<sup>2</sup>**

Assistant Professor, Department of Civil Engineering, Government College of Engineering, Tirunelveli,  
Tamil Nadu, India<sup>1</sup>

P.G. Student, Department of Civil Engineering, Government College of Engineering, Tirunelveli, Tamil Nadu, India<sup>2</sup>

**ABSTRACT:**Self compacting concrete has gained wide use for placement in congested reinforced concrete structures with difficult casting conditions. For such applications, fresh concrete must possess high fluidity and good cohesiveness. The proposed study was made on the self compacting concrete panels using steel fibers and fly ash to ensure the increase in strength against the post cracking behavior and fresh concrete properties. Self compacting concrete are comparatively more durable than the conventional concrete. Conducting acid test and water absorption test would ensure the durability of self compacting concrete. The experimental work on the self compacting concrete panels are to conduct tests for bending, compressive strength and post cracking behavior. For this work panel of size 800x400x80mm is proposed to be used. The analytical work of panel is done using Ansys Civil FEM.

**KEYWORDS:**self-compacting,fresh concrete,steel fiber,fly ask.

## **I. INTRODUCTION**

Self-Compacting Concrete (SCC) can be defined as a concrete that is able to flow in the interior of the formwork, filling it in a natural manner and passing through the reinforcing bars and other obstacles, flowing and consolidating under the action of its own weight. SCC was originally developed with the intention of simplifying casting operations in Civil Engineering constructions of large dimensions, where high percentage of reinforcement or complex geometries difficult concrete flow. Soon it became clear, though, that the great productivity increase associated to SCC technology also habitates it as a good solution for housing construction, precast industry and other applications. The fresh SCC requirements are mainly resumed to the filling ability, the passing capacity and the resistance to segregation. These properties are evaluated at the mix design stage, based on a series of tests in fresh samples with distinct apparatus. Self-compacting ability in concrete depends on the performance level reached by the fresh mix in these tests. The introduction of steel fibers in concrete is another issue of interest on the concrete technology. Steel fibers proved to have the potential to increase the post-cracking energy absorption capacity of cement based materials, enhancing the ductile character of concrete structures behavior, mainly of those with high redundant support. The advantages associated to the addition of steel fibers to concrete mixes may be joined with the ones resulting from the self-compacting ability concept in concrete, with the formulation of steel fiber reinforced concrete mixes exhibiting self-compacting ability. The resulting material is, in this work, designated by Steel Fiber Reinforced Self Compacting Concrete (SFRSCC) and, when compared to conventional concretes, presents clear technical advantages in terms of costs/benefits ratio. There exist, however, some drawbacks associated to the SFRSCC formulations, and the most relevant one is related to the strong perturbation effect produced by steel fibers on the flowing ability of fresh concrete. On one side, it is clear that the fluid properties of the fresh SCC formulations are beneficial for the inclusion and homogeneous dispersion of steel fibers. On the other side, steel fibers are rigid and, consequently, do not easily accommodate to the dynamically changing shape of the bulk paste located between the particles constituting the

# International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

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Vol. 8, Issue 12, December 2019

granular skeleton structure.

As a result, the design procedure and the optimization technique followed to achieve self-compacting requirements must be sensible to the fiber content, as well as to the geometrical and material properties of the fibers. In the present work, the procedure followed to develop a cost effective and high performance SFRSCC is briefly described. The hardened SFRSCC performance in terms of material and structural behavior at early ages is assessed. Compression and flexural tests were carried out with the objective of showing that it is possible to formulate relatively low-cost SFRSCC mixes, exhibiting good mechanical behavior and other relevant properties for structural applications. The developed composition was designed to be applied on the precasting industry, in the fabrication of façade lightweight panels. When compared to the solutions currently used, SFRSCC has some advantages, such as: higher productivity and healthier labor conditions; initial and long term larger toughness; better quality control of the final products; lower costs. This study also dedicates some attention to the exploration of the structural behavior of SFRSCC lightweight panel prototypes under punching and flexural loading.

A smeared crack constitutive model, based on the material fracture parameters and implemented into a computer program able to simulate the material nonlinear behavior of laminar concrete structures, was used to appraise its applicability on the simulation of the punching behavior of SFRSCC panels. The fracture parameters, required to describe the SFRSCC post-cracking constitutive law, were derived from an inverse analysis of the results obtained, for the same material and at the same testing age, at three-point flexural tests in panels.

Superplasticizer which is also known as high range water reducers are chemical admixtures used where well-dispersed particle suspension is required mainly in self compacting concrete. Usage of superplasticizer becomes famous nowadays since it possesses advantages for both fresh and hardened concrete. In the rest state, utilization of superplasticizer will normally produces fluidity though there is a reduction in water cement ratio or water content of concrete. In the case of hardened concrete the use of superplasticizer will increase compressive strength by reduction in water cement ratio and enhancing the effectiveness of compaction to produce denser concrete

The particle size distribution of cement is varying from micrometres (10-6 m) to nanometers (10-9 m). Therefore, cement is, at least partly, a colloidal system i.e. cement is dispersed in water. The prominent force in a colloidal system is Van der Waals attraction system which leads to flocculation of cement particles. When the cement particles form as floc, a particular quantity of water gets entrapped between them. This results in an ineffective usage of water which reduces the workability of concrete.

The basic requirement for the self compacting concrete is that the paste must have high flowability, but also must be stable. This requirement can be fulfilled using a binder with a high content of fine particles. To achieve high flowability and stability at the same time, particles finer than cement have to be added to the paste called as mineral admixture. Following are the additions commonly used in SCC due to the need for substantial contents of fine particles. Civil FEM for ANSYS is the most advanced, comprehensive and reputable finite element analysis and design software package available for civil engineering projects. Civil FEM Multidiscipline includes all the specialized modules developed for Civil FEM (INTRO, Geotechnical, Bridges and Civil Non-linearities, and Advanced Prestressed Reinforced Concrete Modules), providing users with a complete solution that will suit all their civil engineering needs. The objective of the study is to overcome the complication in placing the reinforcement and compaction of normally vibrated concrete, to pour the concrete in proper place and fill the formwork corners and avoid the small voids between reinforcement bars by means of its own weight, to improve the tensile strength, ductility, toughness, energy absorption capacity and as well as fracture toughness and to attain high durability in high sulphate attack. Analytical work is done using ANSYS by conducting two point loads on panels.

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Vol. 8, Issue 12, December 2019

## II. MATERIALS AND METHODS

Characteristics of the materials used for concrete like Flyash, Viscocrete, Coarse aggregates, water, manufactured sand and details of mixproportions are presented. OPC 43gradeconfirming IS 8112 : 1989 with specific gravity of 3.15 was used. Class F fly ash with a specific gravity of 2.08 was used in this study. Fly ash used for the present study is collected from Tuticorin thermal power plant. The chemical composition of fly ash is given in Table 1.

**Table 1. Chemical Composition of Class F Fly ash**

CHEMICALS	% COMPOSITION
SiO <sub>2</sub>	50.18
Al <sub>2</sub> O <sub>3</sub>	26.31
Fe <sub>2</sub> O <sub>3</sub>	13.68
MgO	1.29
SO <sub>3</sub>	0.02
Na <sub>2</sub> O	0.32
K <sub>2</sub> O	0.53
TiO	1.66
SrO	0.30
P <sub>2</sub> O <sub>5</sub>	1.55
Mn <sub>2</sub> O <sub>3</sub>	0.09

Fine aggregate with specific gravity 2.61 and confirming to Zone - II. As per IS 383-1970 is used whose Fineness Modulus is 3.645. The coarse aggregate is used primarily for the purpose of providing bulkiness to concrete. In this study, crushed granular aggregate of 12.5mm size conforming to IS 383:1970 with a specific gravity of 2.74 is used as coarse aggregate. The fineness modulus of coarse aggregate is found to be 6.595. Superplasticizer which is also known as high range water reducers are chemical admixtures used where well-dispersed particle suspension is required mainly in self compacting concrete. Super plasticizers confirming IS 9103 is used for the water reducing purpose. Addition of steel fibers into the concrete improves the crack resistance (or ductility) capacity of the concrete. Traditional rebars are generally used to improve the tensile strength of the concrete in a particular direction, whereas steel fibers are useful for multidirectional reinforcement. This is one of the reasons why steel fiber reinforced (shotcrete form) concrete successfully replaced weld mesh in lining tunnels. The diameter of steel fiber is 0.75mm. The length of steel fiber is 600mm.

The mix M30 grade was designed as per IS 10262 – 2019, and the mix proportion is mentioned in Table 2.

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Vol. 8, Issue 12, December 2019

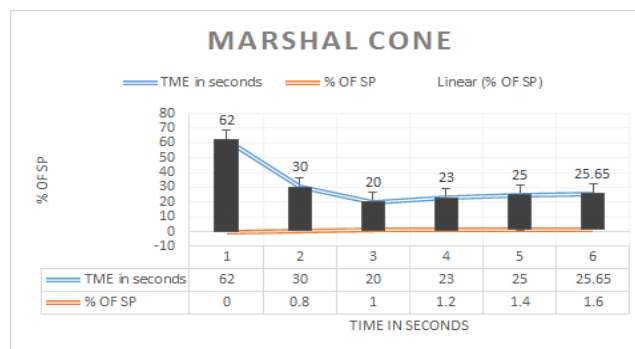
**Table 2.Mix Proportion**

Quantity	Cement	Fly ash	Fine aggregate	Coarse aggregate	Water	Chemical admixture	Free water-cement ratio	Powder content	Water powder ratio by volume
Per m <sup>3</sup> (kg)	323	139	936	729	208	5.54	0.45	565	1.1
Per bag of cement (kg)	50	21.5	145	113	32	1		87.5	
Mix proportion	1	0.43	2.90	2.26	0.64	0.02		1.75	

### III. TEST AND RESULTS

#### Marsh Cone Test

The Marsh funnel is a simple device for measuring viscosity by observing the time it takes a known volume of liquid to flow from a cone through a short tube. It is standardized for use by mud engineers to check the quality of drilling mud. Other cones with different geometries and orifice arrangements are called flow cones, but have the same operating principle.



**Fig.1 Marshal Cone test results**

#### Fresh concrete test

Higher the flow value, greater its ability to fill formwork under its own weight. A value of at least 650mm is required for SCC. In case of severe segregation, most coarse aggregate will remain in the centre of the pool of concrete and mortar and paste at the periphery of concrete.

#### V-funnel test

About 12 litre of concrete is needed for the test. Set the V-Funnel on the firm ground. Moisten inside of the funnel. Keep the trap door open to remove any surplus water. Close the trap door and place a bucket underneath. Fill the apparatus completely with concrete. No compaction or tamping is done. Simply strike off the concrete level. Open within 10 seconds the trap door and record the time taken for the concrete to flow down. Record the time taken for emptying. This can be judged when the light is seen when viewed from top. The flow time should be between 8 and 12 seconds. The whole test is to be performed within 5 min.

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## L-box test

About 14 litre of concrete is required for this test. Ensure that sliding gate can open freely and then close it. Moisten the inside surface, remove all surplus water. Fill the vertical section of the apparatus with concrete. Leave it standing for 1 minute. Lift the sliding gate and allow the concrete to flow out into the horizontal section. When the concrete stops flowing, the height H1 and H2 are measured. Calculate, H2/H1, the blocking ratio. The whole test has to be performed within 5 minutes.

## U-box test

About 20 litres of concrete is needed for this test. Ensure that sliding gate can open freely and then close it. Moisten the inside surface and remove any surplus water. Fill the one compartment of the apparatus with about 20 litre concrete. Leave it to stand for 1 minute. Lift the sliding gate and allow the concrete to flow to the other compartment. Once the concrete has come to rest, measure the height of the concrete in other compartment. Once the concrete has come to rest, measure the height of the concrete in the second compartment in two places. Calculate the mean. Let it be H2. The height of concrete in the 1st compartment be H1. Calculate H1-H2 the filling height. The whole test has to be completed within 5 minutes.

## IV. TESTS AND RESULTS

**Table 3 Compression test results**

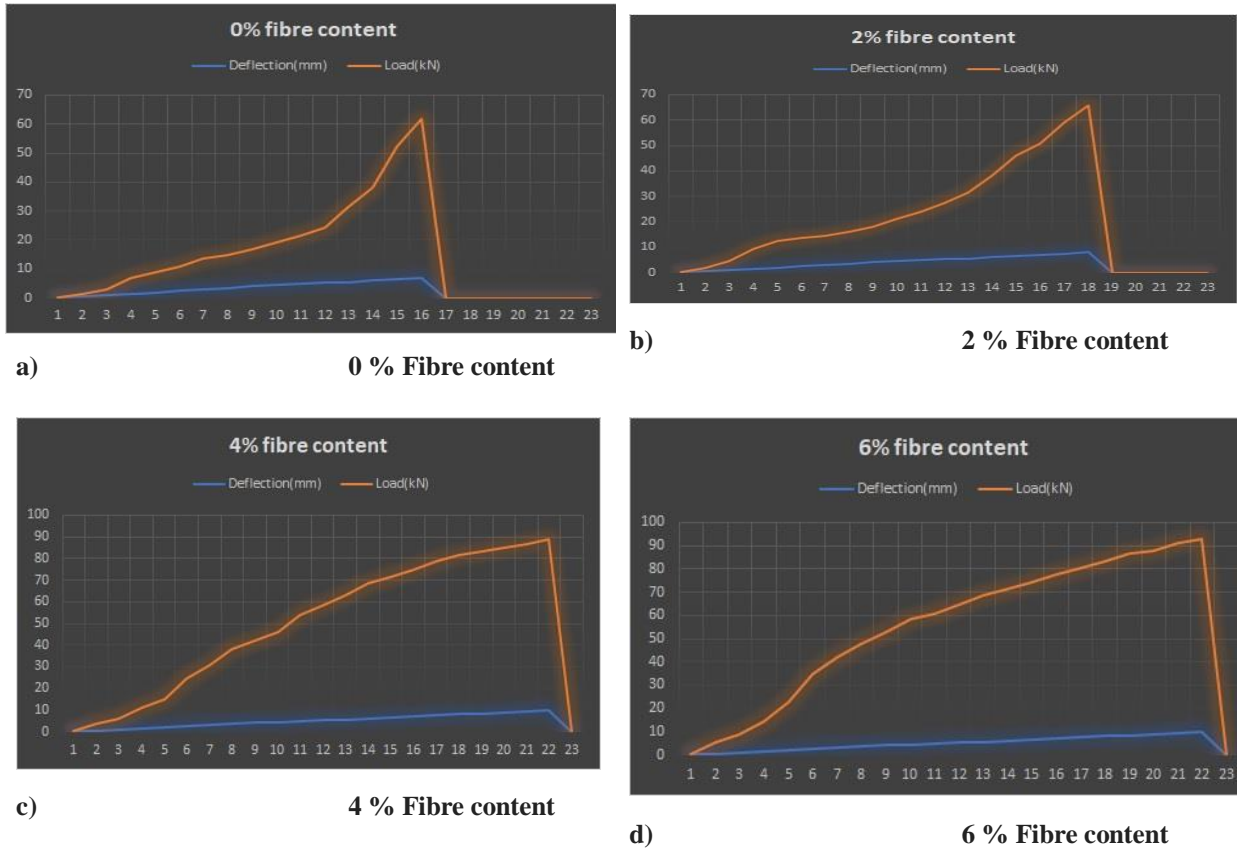
S. No.	% of fibre contents	Average compression strength at 7 days (N/mm <sup>2</sup> )	
		@ 7 days	@ 28 days
1	0	17.4	27.46
2	2	18.3	29.20
3	4	19.1	30.95
4	6	20.92	33.13

As per IS456:2000, the compressive strength @ 7 days and 28 days should be range between 60-65% and 98-99% of target mean strength.

There were totally eight self compacting concrete slabs of various proportions of steel fibers. Flexural behavior of the slabs was determined by using two-point bending test. All slabs were simply supported over a span of 800 mm. The slabs were tested and loaded to failure.

**Table 5 Results of 14 day test on slab**

% of fibre content	Flexural toughness index	Ductility	Stiffness at first crack	Stiffness at ultimate
0	4.67	1.4	3.3	7.86
2	5.13	1.68	4.32	7.82
4	6.5	2.11	6.1	8.94
6	7.1	3.33	13	8.3



**Fig. 2** Graphical representation of load and deflections of 14 days test on slabs of various proportions of steel fibre content

**Table 6** Results of 28 days test on slabs

% of fibre content	Flexural toughness index	Ductility	Stiffness at first crack	Stiffness at ultimate
0	7.23	2.16	5.26	8.17
2	6.74	2.39	7.78	9.19
4	8.07	3.1	12.07	10.11
6	9.5	4.48	18.4	8.75

### V. CONCLUSION

Literature survey had been conducted to know about the behavior of self compacting concrete panels using FRP and analytical work. The analytical results shows that the strength of the self compacting concrete slab withstand the theoretical load. The behavior of the SCC panel in bending to the applied loading condition is studied analytically. Conducting two point load test on self compacting concrete panels, the results of the test shows that the increase in fibre content increases the flexural strength, ductility and stiffness.



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