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Study On High Strength Self Compacting Concrete Beams With Steel & Recron Fiber

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Abstract--Self Compacting Concrete gets dense and compacted due to its own self-weight. An experimental investigation has been carried out to determine different characters like workability and strength of Self-Compacting Concrete (SCC). Tests involving various fiber proportions for a particular mix of SCC. Test methods used to study the properties of fresh concrete were slump test, U – tube, V – funnel and L – Box. The properties like compressive, tensile and flexural strength of SCC were also investigated. For compressive strength of studies the cube size of 100mmX100mmX100mm were used. The specimens were cured and tested for 7 and 28 days for high compressive strength. The split tensile strength was studied for the same concrete mix using cylinders size 100mmX200mm. The specimens were cured and tested for 7 and 28 days. The flexural strength was studied for the same concrete mix using beam of size 100mmX100mmX200mm. The specimens were cured and tested for 7 and 28 days.The stress-strain relationship was studied for the same concrete mix using cylinders of size 150mmX300mm. The specimens were cured and tested for 7 and 28 days. Test Results shows that the workability characteristics of SCC are within the limiting constraints of SCC. The variation of different parameters of hardened concrete with respect to various fiber contents was analysed.

Keywords: self -compacting concrete, workability, segregation, aggregate, super plasticizer, flyash, steel fibre.

INTRODUCTION

Self-compacting concrete (SCC) represents one of the most outstanding advances in concrete technology during the last decade. At first developed in Japan in the late 1980s, SCC meanwhile is spread all over the world with a steadily increasing number of applications. Due to its specific properties, SCC may contribute to a significant improvement of the quality of concrete structures and open up new fields for the application of concrete.

SCC describes a concrete with the ability to compact itself only by means of its own weight without the requirement of vibration. It fills all recesses, reinforcement spaces and voids, even in highly reinforced concrete members and flows free of segregation nearly to level balance. While flowing in the formwork, SCC is able to deaerate almost completely. The use of SCC offers many benefits to the construction practice: the elimination of the compaction work results in reduced costs of placement, a shortening of the construction time and therefore in an improved productivity. The application of SCC also leads to a reduction of noise during casting, better working conditions and the possibility of expanding the placing times in inner city areas. Other advantages of SCC are an improved homogeneity of the concrete production and the excellent surface quality without blowholes or other surface defects.Often the materials costs of SCC will be higher than the equivalent material costs of a normal vibrated concrete. However, when SCC is sensibly utilized, the reduction of costs caused by better productivity, shorter construction time and improved working conditions will compensate the higher material costs and, in many cases, may result in more favourable prizes of the final product.

LITERATURE REVIEW

Dr. Rakesh Kumar & M.V. Rao —The ingredients for SCC are similar to other plastized concrete. It consists of cement, coarse and fine aggregates, water, mineral and chemical admixtures. Similar to conventional concrete, SCC can be affected by physical properties of materials and mix proportioning‖

Champion & Jost —SCC is produced with standard, readily available concrete components. The mix proportioning is based upon creating high degree of flowability while maintaining a low water cement ratio. This can be achieved through the use of new HRWR admixtures combined with stabilizing agents to ensure homogeneity of mixture‖

S.Subramanian & D.Chattobadhyay —In SCC, a major concern is flowability of the concrete without segregation. Therefore the mixture will appear deficient in coarse aggregate. In practice, a unit water content of about 200 to 220 litre will be required even when super plasticizers are used ‖

SELF COMPACTING CONCRETE

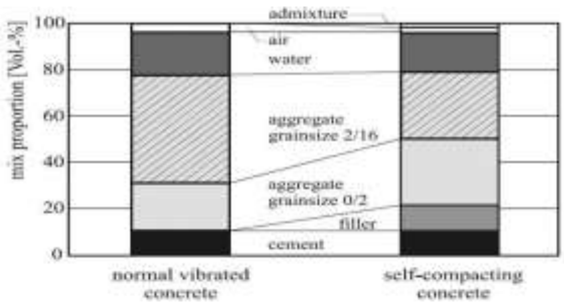
Self Compacting Concrete is a flowable concrete mixture that is able to consolidate under its own weight. It does not require any external vibration for compaction. The highly fluid nature of SCC makes it suitable for placing in difficult conditions and in sections with congested reinforcement SCC does not show segregation, bleeding and has revolutionized concrete pavement.Self Compacting Concrete is ideally suited for the concreting of the structures, which have heavily congested reinforcement or wherein the access for concrete is difficult. Self Compacting Concrete mixes contain a combination of ingredients that enhances the flow but maintains segregation resistance. Maintaining the right balance between fluidity and resistance to segregation the apparently opposing characteristics – is the key to the successful design of SCC. These characteristics of SCC mix are achieved by using higher powder content, optimizing water to powder ratio, a high volume of fine aggregate as compared to coarse aggregate, high dosage of super plasticizer.Self Compacting Concrete generally possesses a high powder content which keeps the concrete cohesive with a high flowability. For achieving economy, a substantial part of this powder could contain fly ash. In such cases, early age strength development may prove to be reused.

INGREDIENTS FOR SCC

Admixtures: Super plasticizers are an essential component of SCC to provide necessary workability. The new generation super plasticizers termed poly-carboxylated ethers (PCE) are particularly useful for SCC.Other types may be incorporated as necessary, such as Viscosity Modifying agents (VMA) for stability, air entraining agents to improve freeze-thaw resistance, and retarders for control of setting.

MIX COMPOSITION OF SCC IN COMPARISON WITH NORMAL VIBRATED CONCRETE

The basic components for the mix composition of SCC are the same as used in conventional concrete. However, in SCC a higher proportion of ultrafine materials and the incorporation of chemical admixtures, in particularly effective super plasticizers, are necessary. Filler materials like fly ash, limestone powder, blast furnace slag, silica fume and quartzite powder are used in SCC.



ACCEPTANCE CRITERIA FOR SCC

Test Methods	Unit	Minimum	Maximum
Slump flow	mm	600	800
T_{50} cm Slump flow	Sec	2	5
V – funnel test	Sec	6	12
V – funnel test at T_5 min	Sec	0	+3
U – box test	mm	0	30

MATERIALS USED AND THEIR PROPERTIES

Fly Ash

Physical Properties of Fly Ash

Sl.No.	Properties	Values
1	Fineness modules (passing through 45µ),%	78.60
2	Specific Gravity	2.10

Chemical Properties of Fly Ash:

Sl.No.	Properties	Values in %
1	Silica	59.62
2	Alumina	26.43
3	Iron oxide	6.61
4.	Calcium oxide	1.2
5.	Magnesium oxide	0.76
6.	Sulphur tri oxide	0.58
7.	Titanium oxide	1.56
8.	Loss of ignition	1.76

Admixtures

Glenium B233 and Glenium Stream 2 are confirming to the requirement of IS: 9103-1979 as a high range water reducing admixture and viscosity modifying agent was used in this study.

Steel Fibres

The steel fibres used in the project are of steel fibre of 60 mm in length and 0.75 mm in thickness. The advantages of using steel fibre to the Self Compacting Concrete is as follows:

- Improves the flexural strength and toughness.
- Improves post cracking performance in the hardened state.
- Reduces segregation.
- Increases the durability.

MIX DESIGN BY ACI METHOD

The mix design of M_{40} grade of concrete is done by using the ACI method by using the test results of the materials known.

Mix ratio obtained by ACI method is:

Water : Cement : FA : CA

166.7 l/m : 436.6 kg/m : 819.14 kg/m^3 : 892.56 kg/m^3

0.38 : 1 : 1.87 : 2.04

TRIAL MIX PROPORTIONS TO OBTAIN SCC

Mix Ratio for SCC obtained from various trials is

Water: Cement : FA :CA : Fly ash : HRWR : VMA

166.7 : 436.6 : 858 : 685 : 262 : 10.48 : 3.493

0.38 : 1 : 1.97 : 1.57 : 0.6 : 0.024 : 0.008

MIX PROPORTION OF SCC WITH 0.5% STEEL FIBRE

Mix Ratio for SCC with 0.5% steel fibre

Water : Cement : FA :CA : Fly ash : HRWR : VMA : SF

166.7 : 436.6 : 85 : 685 : 262 : 10.48 : 3.493 : 3.49

0.38 : 1 :1.97 : 1.57 : 0.6 : 0.024 : 0.008 : 0.008

MIX PROPORTION OF SCC WITH 1% STEEL FIBRE

Mix Ratio for SCC with 1% steel fibre

Water: Cement : FA : CA :Fly ash:HRWR : VMA : SF

166.7: 436.6 : 858 :685: 262 :10.48: 3.493 : 6.98

0.38 : 1 :1.97:1.57: 0.6 :0.024 : 0.008 : 0.016

The comparison of these mixes such as the SCC without steel fibre, SCC with 0.5% and 1% of steel fibre is shown in the below table

PREPARATION OF SPECIMENS

The casting of these specimen are done and after 24 hours of casting the concrete test specimens were demoulded and immersed in water until the start of tests. The tests were conducted at the age of 7and 28 days.

RESULTS AND DISCUSSIONS
FRESH PROPERTIES

The fresh properties tests such as slump flow test, T_{50} slump flow in sec, U – box test and V- funnel test are conducted. All the mixes such as controlled concrete of SCC, SCC with 0.25% , 0.5%, 0.75% and 1% of steel fibre satisfied the requirements of the limiting values for Self Compacting Concrete. The values of the test results are explained below:

SCC without Steel Fibre

The SCC without steel fibre shows the slump flow highest of 660mm (Acceptable range 600 to 800mm) compared to the slump flow of the SCC with 0.5%, and 1% of steel fibre. The time for the concrete to reach 50 cm diameter flow is noted as 3 sec (Acceptable range 2 to 5sec). The U – box test result shows the height difference between the 2 compartments as 20 mm (Acceptable range <30mm). The V – funnel test shows for the emptying the funnel is 6 sec (Acceptable range 6 to 12sec). The V – funnel T_5min test shows after setting of concrete for 5 minutes is 10 sec (Acceptable range 9 to 15sec).

The test results of the SCC without steel fibre and also the comparison with other mixes is shown in the Table.No5.1.

SCC with 0.5% Steel Fibre

The SCC with 0.5% steel fibre shows the slump flow lowest of 610mm (Acceptable range 600 to 800mm) compared to the slump flow of the SCC without steel fibre. The time for the concrete to reach 50 cm diameter flow is noted as 4sec (Acceptable range 2 to 5sec). The U – box test result shows the height difference between the 2 compartments as 30 mm (Acceptable range <30mm). The V – funnel test shows for the emptying the funnel is 7 sec (Acceptable range 6 to 12sec). The V – funnel T_5min test shows after setting of concrete for 5 minutes is 12 sec (Acceptable range 9 to 15sec).

The test results of the SCC with 0.5% steel fibre and also the comparison with other mixes is shown in the Table.No5.1.

SCC with 1% Steel Fibre

The SCC with 1% steel fibre shows the slump flow of 600 mm (Acceptable range 600 to 800mm) which is lesser compared to the slump flow of the SCC without steel fibre and SCC with 0.5% steel fibre. The

Materials	Control Mix SCC	With 0.50% SF	With 1% SF
Cement Kg/m^3	436.6	436.6	436.6
Fly ash Kg/m^3	262	262	262
Water	166.7	166.7	166.7
FA Kg/m^3	858	858	858
CA (12.5mm) Kg/m^3	685	685	685
HRWR Lit/m^3	10.48	10.48	10.48
VMA Lit/m^3	3.493	3.493	3.493
Steel fibre Kg/m^3	0	3.49	6.98

Sl. No.	Particulars	Size of Cube 150x150x150mm	Size of Cylinder 150mm dia and 300mm height	Size of Prism 500x100x100mm
1	Controlled SCC	6	6	6
2	SCC with 0.5% steel fibre	6	6	6
3	SCC with 1.0% steel fibre	6	6	6
Total		18	18	18

time for the concrete to reach 50 cm diameter flow is noted as 5 sec (Acceptable range 2 to 5sec). The U – box test result shows the height difference between the 2 compartments as 30 mm (Acceptable range <30mm). The V – funnel test shows for the emptying the funnel is 9 sec (Acceptable range 6 to 12sec). The V – funnel T_5min test shows after setting of concrete for 5 minutes is 12 sec (Acceptable range 9 to 15sec).

The test results of the SCC with 1% steel fibre and also the comparison with other mixes is shown in the Table.No5.1.

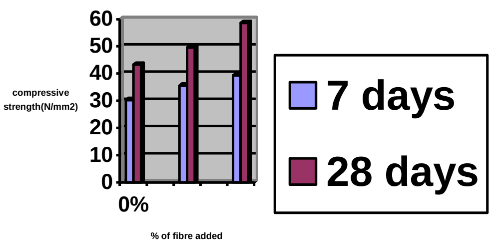
Table No: 5.1 Fresh property results of various mix

Test Methods	**SCC – Normal**	**SCC with 0.5% steel Fibre**	**SCC with 1.0% steel Fibre**
Slump flow mm	660	610	600
T_{50} cm Slump flow Sec	3	5	6
V – funnel test Sec	6	7	9
V – funnel test at T_5 min Sec	10	12	12
U – box test mm	20	30	30

HARDENED PROPERTIES

Compressive Strength

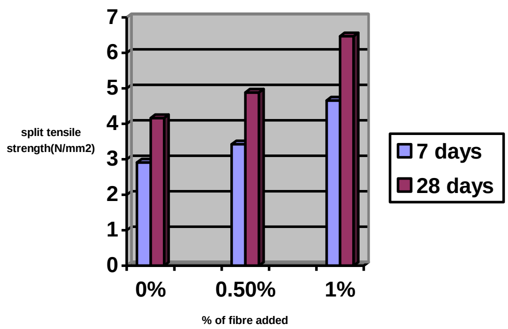
% of fibre added	**Flexural Strength of prism after 7th day curing (N/mm^2)**	**Flexural Strength of prism after 28th day curing (N/mm^2)**
0%	3.85	4.92
0.5%	4.22	5.35
1.0%	4.71	6.12

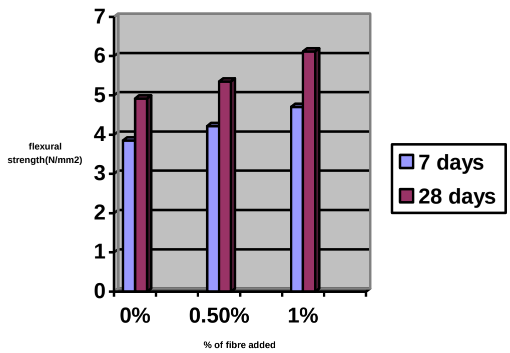


% of fibre added	**Split Tensile Strength of Cylinders after 7th day curing (N/mm^2)**	**Split Tensile Strength of Cylinders after 28th day curing (N/mm^2)**
0%	2.91	4.16
0.5%	3.42	4.88
1.0%	4.66	6.47

Split Tensile Strength

Table no. split tensile strength results of various mix





flexural Strength

Table No. flexural strength results of various mix

% of Fibre Added	**Compressive Strength of cubes after 7th day curing (N/mm^2)**	**Compressive Strength of cubes after 28th day curing(N/mm^2)**
0%	30.3	43.3
0.5%	35.6	49.6
1.0%	39.3	58.6

Stress-Strain Relationship

stress-strain results of various mixes

% of fibre added	Youngs Modulusof Cylinders after7[th] day curing (N/mm^2)	Youngs modulus of cylinders after 28[th] day curing (N/mm^2)
0%	26621.79	31390.3
0.5%	29723.49	34452.5
1.0%	28754.8	39617.8

Load And Deflection Of Beams

Load in Kn	Deflection in mm		
	conventional	1 % steel fiber	steel & recron fiber
6	0.57	0.32	0.48
12	1.3	0.71	0.86
18	2.27	1.62	1.32
24	4.6	3.61	3.04
30	5.07	5.0	5.77
36	6.67	6.39	6.02
42	**9.25**	7.53	7.11
48	9.92	9.63	9.41
54	11.5	**11.31**	**10.6**
60	13.28	12.3	11.4
66	14.07	13.80	13.5
72	**16.23**	16.07	15.5
78		**17.3**	16.3
84			17.7

90			**19.6**

CONCLUSION

The following conclusions have been made from the above experimental study:

- From the test results of hardened concrete, it is been found that all the mixes achieved the designed characteristic strength of M40 grade.
- Use of fly ash improve the setting characteristics of the SCC mix ,but do not achieve the required flow properties of SCC. A VMA is required to achieve the flow.
- The compressive strength was conducted for 0.5% , 1% ratio of fibre mixes, it was found from the results that

Comparison of stress-strain curve for 1% of fibre added SCC mix(1% of fibre added) gives better strength.

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