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RESEARCH ARTICLE OPEN ACCESS

Flexural Behaviour of Steel Fiber Reinforced SCC Beams using Fly ash and Pond ash.

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ABSTRACT
Self Compacting Concrete (SCC) is a flowing concrete mixture that is able to consolidate under its own weight, without the need for vibration. The highly fluid nature of SCC makes it ideal for placing in difficult conditions and in sections with congested reinforcement. Mixture proportions for SCC differ from those of ordinary concrete, in that the former has more powder content and less coarse aggregate. Supplementary cementitiuous materials such as fly ash, silica fume, blast furnace slag and pond ash are normally used to produce SCC. In addition, SCC also incorporates chemical admixtures, such as HRWR (High Range Water Reducer).Large amount of fly ash and pond ash is being generated from thermal power stations in India annually and hence there is a strong need to use this byproduct, in large proportions in concrete which also makes the concrete cost effective. In the present investigation, an experimental study was made on the properties of SCC incorporating fly ash and pond ash. SCC mix was arrived for M60 grade concrete based on ACI method and EFNAARC guide lines. Slump flow test, V-funnel test and L-box tests were carried out to confirm the self-compact ability of concrete. An attempt has also been made to study the effect of addition of steel fibres on the strength and behavior of SCC beams under flexure. Totally four beams were cast out of which one is a control SCC beam without fibres and the remaining three beams were cast with steel fibres each containing volume fraction of 0.25 %, 0.5% and 0.75% of fibres respectively. All the beams were subjected to two point bending test and the load deflection characteristics were obtained. The first crack load, ultimate load, ductility and energy absorption were measured and thus a comparison was made between control SCC beam and fibre added SCC beams.

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I. INTRODUCTION

Self compacting concrete (SCC) is a flowing concrete mixture, which is able to consolidate under its own weight. The highly fluid nature of SCC makes it ideal for placing in difficult conditions and is sections with congested reinforcement. This 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, aggregate, water and mineral admixtures like fly Ash, pond ash etc and chemical admixtures to take care of specific requirements such as, high-flowability, high workability, compressive strength, enhanced resistances to chemical or mechanical stresses, lower permeability, durability, resistance against segregation, and possibility under dense reinforcement conditions .The main characteristic of SCC is the higher cement matrix aggregate ratio with respect to an ordinary concrete. In other words, the volume of cement matrix responsible for the mobility of the concrete mixture must be increased in order to push the aggregate under the gravity action or under the pressure of a pumping system. On the other hand, the volume of the aggregate in particular the coarse aggregate must be reduced in terms of both volume and maximum size, to improve the mobility and the segregation-resistance of the fresh mixture.

II. COMPARISON OF SCC AND CONVENTIONAL CONCRETE

- The ingredients used in SCC are the same as those used in conventional concrete.
- SCC generally possesses a high powder content which keeps the concrete cohesive with high flowability. For achieving economy, a substantial part of this powder could contain reactive powder minerals like fly ash, silica fume, pond ash etc.,
- SCC differs from conventional concrete in that the former has more powder content and less coarse aggregate.
- SCC also incorporates high range water reduces (HRWR/ Superplasticizers) in large amounts

and a viscosity modifying agent (VMA) in small doses. HRWR helps in achieving excellent flow at low water contents. VMA reduces bleeding and improves the stability of the concrete mixture.

- The workability of SCC is "Very high" when compared to the conventional concrete.

III. CONSTITUENT MATERIALS

3.1 Materials Used

The ingredients used in SCC are the same as those used in conventional concrete. But, for concrete to be flow able and stable to achieve self compact ability, a high volume of paste is required to keep the concrete cohesive. Hence the requirement of high powder content is essential.

The following ingredients are used for manufacturing self-Compacting Concrete:

i. Cement
ii. Fly ash
iii. Pond ash
iv. Fine aggregate
v. Stone chips
vi. Glenium

3.2 Cement

Portland pozzalonic cement (Grade 43) was used. Table 1 shows the chemical composition and physical properties of cement.

TABLE 1 *Physical Properties of Cement*

Physical Properties	**Results Obtained**	**IS 8112 – 1989, Specifications**
Fineness	2%	Should not exceed 10%
Normal consistency	32%	-
Initial setting time	95	30 min
Final setting time	335	600 min (max)
Specific gravity	3.15	-

3.3 Pond Ash

Pond ash obtained from Mettur Thermal Power Station, Tamil Nadu, India. The Chemical composition of pond ash is tested by Sona Starch. Table 2 shows the physical Properties and chemical composition of pond ash.

TABLE 2 Physical and Chemical Properties of Pondash

Parameter	Experimental Values
Physical Properties	
Specific gravity	2.31
Particle size	10 – 50 µm
Surface area	425 m^2 / kg
Chemical Properties	
Silica(SiO2)	48.23%
Calcium Oxide(CaO)	0.45%
Magnesium Oxide(MgO)	0.13%
Iron Oxide(Fe2O3)	2.59%
Aluminium Oxide(Al2O3)	10.14%
Sodium Oxide(Na2O)	0.11%
Potassium Oxide(K2O)	0.70%
Loss of Ignition(L.O.I)	9.35%

3.4 Fly ash

Fly ash obtained from "Mettur Thermal Power Station, Tamil Nadu, India. The Chemical composition of fly ash is tested by Sona Starch. Material used for this experiment inestigated CaO content is less than 5%, fly ash is Class F.Table 3 shows the physical Properties and chemical composition of fly ash.

TABLE 3 Physical and Chemical Properties of Flyash

Parameter	Experimental Values
Physical Properties	
Specific gravity	2.72
Particle size	75 – 90 µm
Surface area	300 m^2 / kg
Chemical Properties	
Silica(SiO2)	63.74%
Calcium Oxide(CaO)	2.90%
Magnesium Oxide(MgO)	1.14%
Iron Oxide(Fe2O3)	2.80%
Aluminium Oxide(Al2O3)	21.64%
Sodium Oxide(Na2O)	0.23%
Loss of Ignition(L.O.I)	0.76%

3.5 Aggregates

Locally available natural river sand was used as fine aggregate, having specific gravity, fineness modulus and stone chips with 10mm maximum size . The results of sieve analysis of stone chips and fine aggregate are shown in table 3.5 and 3.6 respectively. Both fine aggregate and stone chips conformed to Indian Standard Specification IS: 383-1970.

3.6 Water

Water is an important ingredient of concrete as it actively participates in the chemical reaction with cement. The quantity and quality of water are required to be watched very carefully so that it can form the strength giving cement gel.

Because the water quantity level influenced the strength of the concrete. If the water quantity level is decreased means then also the strength of concrete is increased. Portable water available in the laboratory was used for making concrete. pH value of potable water is 7+1.0 and conforming to the requirements of IS 456-2000.

3.7 Admixture

GLENIUM B233 is an admixture of a new generation based on Modified Polycarboxylic Ether. GLENIUM B233 is free of chloride and low alkali. It is compatible with all types of cements. Table 3.9 shows the properties of Glenium admixture. Fig.3.3 shows the sample of Glenium.

IV. MIX PROPORTION

Based on the EFNARC guidelines and literature, the mix proportion for self compacting concrete is arrived. The six mix constituents of SCC mix is arrived by valuing ingredients in SCC. Table 4 shows the various mix combination.

***TABLE 4** Mix Combination of SCC*

Mix designation	Cement (Kg/m^3)	Fly ash (Kg/m^3)	Fine Aggregate (Kg/m^3)	Pond ash (Kg/m^3)	Stone chips (Kg/m^3)	Water (Kg/m^3)	Super Plasticizer (% total powder content)
M1	450	-	820	-	750	210	1.1%
M2	450	-	820	-	750	210	1.1%
M3	405	45	738	82	750	210	1.1%
M4	**360**	**90**	**697**	**123**	**750**	**210**	**1.1%**
M5	**315**	**135**	**656**	**164**	**750**	**210**	**1.1%**
M6	**270**	**180**	**615**	**205**	**750**	**210**	**1.1%**

V. RESULTS AND DISCUSSION

5.1 Test results on Fresh Self Compacting Concrete

The fresh properties of SCC such as Slump flow test, V-funnel test, L-Box test are conducted. Table 5 shows the test result on fresh properties of SCC.

TABLE 5 Test results on fresh properties

Mix proportion Tests	M1	M2	M3	M4	M5	M6	Acceptable Limit
Slump flow(mm)	0	480	615	**685**	**735**	**780**	600-800
L-Box (mm)	-	-	-	**0.89**	**0.903**	**0.91**	0.8-1.0
U – Box (mm)	-	-	-	**19**	**22**	**27**	0-30
V funnel (sec)	-	-	-	**7**	**10**	**11**	6-12

Slump value varies between 0 to 780 mm for the mix M1 to M6. In V-funnel test the concrete passes from 7 to 11 secs. But the acceptable limit is 6 to 12 secs. Therefore M4, M5 and M6 only achieved the acceptable limit.

V.2 Compressive Strength of Concrete

Compressive strength test is conducted for the hardened self-compacting concrete and the results are interpreted for 28 days strength of concrete cubes. Figure 1 and 2 shows the test results of compressive strength for 7 and 28 days

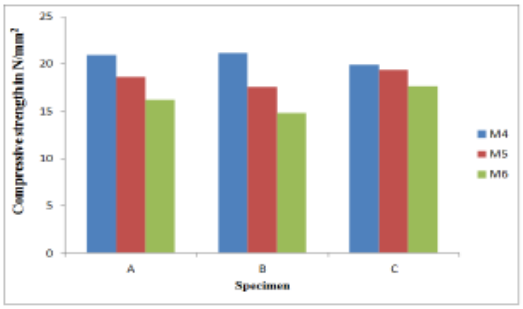

***Fig 1** Compressive Strength at 7 days*

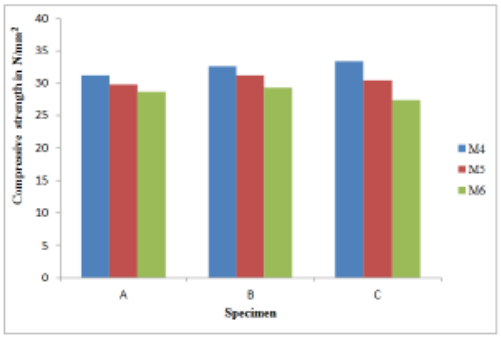

***Fig 2** Compressive Strength at 28 days*

The Compressive strength value for M4 concrete is varies from 31.3N/mm^2 to 33.4 N/mm^2 ,compressive strength for M5 concrete is varies from 29.8 N/mm^2 to 30.5N/mm^2 and compressive strength for M6 concrete is varies from 28.6 N/mm^2 to 27.4 N/mm^2. The mix M4 and M5 is attained the compressive strength of 32.4N/mm^2 and 30.5 N/mm^2 at 28 days which satisfies the M30 grade of concrete.

V.3 Split tensile strength

Split tensile strength test is conducted for the hardened self-compacting concrete and the results are interpreted for 28 days strength of concrete cylinder. Figure 3 shows the test result of split tensile strength for 28 days.

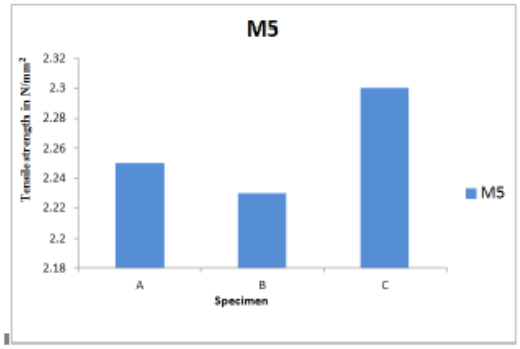

Fig 3 Split Tensile Strength at 28 days

V.4 Flexural Strength Test

Flexural strength test is conducted for the hardened self-compacting concrete and the results are interpreted for 28 days strength of concrete beam. Figure 4 shows the test results of flexural strength for 28 days

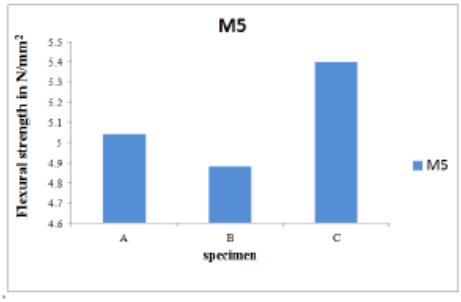

Fig 4 Flexural Strength at 28 days

V.5 Modulus of Elasticity of Concrete

Modulus of Elasticity is conducted for the hardened self-compacting concrete and the results are interpreted for 28 days strength of concrete cylinder. Figure 5 shows the test results of Modulus of Elasticity for 28 days

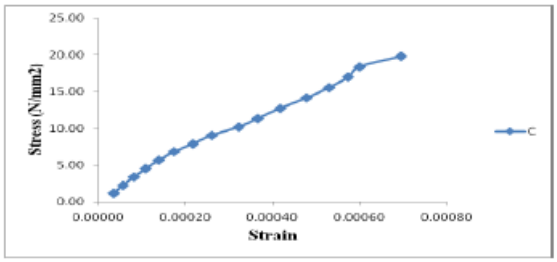

Fig 5 Modulus of Elasticity of Concrete

VI. CONCLUSION

A SCC mix was arrived at based on available guide lines and using number of trial mixes. An experimental study is made on the properties of SCC incorporating fly ash and Pond ash partially replacing cement .Slump flow test, V – Funnel test, L – box test and U-box test were carried out to confirm the self compactability of concrete. Compressive strength test, Flexural strength test, split tensile strength test and modulus of elasticity test were carried out on concrete. The test results confirm that the mixes developed in the present investigation satisfy the requirements for SCC.

The following conclusions can be drawn from the present experimental study.

- The polluting materials like fly ash and pond ash can be effectively used in SCC.
- M30 grade of mix design is arrived for SCC. All SCC mixes have shown adequate strength development at 28 days
- By replacing the materials like fly ash and pond ash partially replacing cement and stone chips, it reduces the cost in manufacturing of SCC.
- SCC can be used for any structural applications especially when there is heavy congestion of reinforcement without any vibration.

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