Article-4

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SELF COMPACTING CONCRETE USING FLY ASH OF THERMAL POWER PLANTS

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ABSTRACT

Fly ash is one of the residues generated in combustion and comprises the fine particles that rise with the flue gases. In the past, fly ash produced from coal combustion was simply entrained in flue gases and dispersed into the atmosphere. This created environmental and health concerns that prompted laws which have reduced fly ash emissions to less than 1% of ash produced. The use of fly ash as concrete admixture not only extends technical advantages to the properties of concrete but also contributes to the environmental pollution control. In India alone, we produce about 75 million tons of fly ash per year, the disposal of which has become a serious environmental problem. Therefore, the effective utilisation of fly ash in making concrete is attracting serious considerations of field engineers. This paper outlines the study of materials, methods, mix proportion, workability tests and mechanical properties of Self Compacting Concrete (SCC). SCC is a special type of concrete having more powder content containing cement, fly ash, aggregates apart from chemical admixtures. Super plasticizer and Viscosity Modifying Agent (VMA) are used to impart filling ability, passing ability and resistance to segregation. In this system, the coarse aggregate and fine aggregate contents are fixed and self-compactibility is to be achieved by adjusting the water/powder ratio and super plasticizer dosage. The cube compressive strength, cylinder compressive strength, split tensile strength, flexural strength were determined adopting conventional testing procedure. The present study indicates that self compacting concrete can be produced with the above mentioned waste material of thermal power plant and this concrete will be helpful to place the concrete in congested reinforcement area.

KEY WORDS : Self compacting concrete, Fly ash, Super plasticizer, Viscosity modifying agent, Compressive strength, Split tensile strength, Flexural strength

INTRODUCTION

Nowadays global warming and environmental destruction have become the major issue. The production of one metric tonne of cement leads to the emission of one metric tonne of CO_2, which is a powerful green house gas responsible for the global warming. One way of reducing this environmental problem is to reduce the consumption or production of cement. Since the cement is the basic material which is used in construction industry, it is essential to find a suitable material for the replacement of cement. The fly ash obtained from thermal power plants can be used as partial replacement of the cement.

When compared to conventional concrete self compacting concrete is a relatively new type of concrete with high flow ability and cohesiveness. Self compacting concrete was first introduced in the late 1980's by Japanese researchers. SCC replaces manual compaction with a modern semi-automatic placing technology. By the way, SCC improves health and safety at construction site as well as in surroundings.

In this system, the coarse aggregate and fine aggregate contents are fixed and self-compatibility is

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to be achieved by adjusting the water / powder ratio and super plasticizer dosage. 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. The use of fly ash offers a low priced solution to the environmental problem of depositing industrial waste.

Materials

The properties of SCC making materials such as cement, fine aggregate, coarse aggregate, fly ash were determined and results are tabulated.

Cement

The Ordinary Portland Cement of 53 grade conforming to IS: 12269-1987 was used for the present experimental study. Physical properties of cement are listed in Table 1.

Table 1. Physical properties of cement

Name of the test	Value obtained
Fineness (m^2 / kg)	305
Specific gravity	3.15
Standard Consistency (%)	29
Initial Setting time (Min)	35
Final Setting time (Min)	560

Fine aggregate

Locally available natural sand with 4.75 mm maximum size conforming to IS: 383 – 1970 was used as fine aggregate. Physical properties of sand are listed in Table 2.

Table 2. Physical properties of sand

Name of the test	Value obtained
Fineness modulus	2.84
Specific gravity	2.58
Bulk density (kg / m^3)	1760
Water absorption (%)	0.80

Coarse aggregate

Crushed stone aggregate of size 12.5 mm was used as coarse aggregate as per IS 383-1970. Physical properties of coarse aggregate are listed in Table 3.

Table 3. Physical properties of coarse aggregate

Name of the test	Value obtained
Specific gravity	2.60
Aggregate impact value (%)	11.2
Aggregate crushing value (%)	24.8
Bulk density (kg / m^3)	1640
Fineness modulus	7.12
Water absorption (%)	0.40

Water

Ordinary potable water available in the laboratory was used.

Admixture

Class F fly ash was used as admixture in this study which was collected from Mettur Thermal Power Plant, Tamilnadu. Fly ash is added to make SCC at replacement level of 20% by weight of cement. The chemical composition of fly ash is given in Table 4.

Table 4. Chemical composition of fly ash

Chemical Composition		
Constituent	World Standard (%)	Fly ash used in this study (%)
Silica(SiO_2)	62.57	54.92
Alumina (Al_2O_3)	31.45	23.04
Ferric Oxide (Fe_2O_3)	1.87	-
Titanium Dioxide (TiO_2)	1.45	-
Manganese Oxide (MnO)	0.005	-
Calcium Oxide (CaO)	0.40	3.84
Magnesium Oxide (MgO)	0.38	2.82
Sodium Oxide (Na_2O)	0.05	-
Potassium Oxide (K_2O)	0.82	-
Iron (Fe_2O)	-	6.62
Phosphorus (P_2O_5)	-	0.30
Alkali metal's Oxide	-	2.70
Sulphur Trioxide (SO_3)	-	0.76
Magnesium oxide (MgO)	-	2.82
Loss on Ignition	1.0	2.88

Superplasticizer

High-performance super plasticiser based on polycarboxylic ether (Glenium B233) was used as superplasticizer and added at various dosage levels from 0.25% by weight of cement

Viscosity Modifying Agent

Glenium Stream 2 was used as viscosity modifying agent at 1% by weight of cement for test specimens.

Experimental investigation

Mix proportion for 1 m^3 of SCC of M40 mix are given in Table 5 and Table 6

Table 5. Mix proportion for 1 m^3 of SCC

Water	Cement	FA	CA
158.2	447.073	955.16	830.06
0.35	1	2.45	1.80

Acceptance criteria tests

Tests on fresh concrete were performed to determine the workability of SCC with various proportions of super plasticizer and viscosity modifying agent. The acceptance criteria for the fresh properties of SCC are given in Table 7.

Slump flow test

The slump flow test is conducted to assess the horizontal flow of concrete in the absence of obstructions. It is a most commonly used test and gives good assessment of filling ability. The cone is placed on a horizontal plate. SCC is filled in the cone, without aided compaction. Then the cone is lifted and concrete is allowed to spread. The time taken to reach a diameter of 50 cm and final spread is noted.

L-box test

The L-box is used to measure passing ability and segregation of concrete. The vertical part is filled with concrete and allowed to remain therein for 1 minute. The gate is then opened and concrete is allowed to pass through the blocking bars. The height of concrete on either end of obstructions is measured.

Fig. 1. Slump flow test

V-funnel test

The V-funnel flow test is to evaluate the fluidity of self compacting concrete to change its path and to pass through a constrict area. SCC is filled in the funnel. The funnel is opened and the time for flowing of concrete through the bottom aperture is noted.

U-box test

The U-Box is used to determine the degree of compactability. Concrete is made to flow through

Table 6. Proportion of Constituents of SCC

S.No	Mix	Cement	F.A	C.A	FlyAsh	Water	S.P	VMA
1	SCC-1	80%	2.45	1.80	20%	0.35	1.0%	1.0%
2	SCC-2	80%	2.45	1.80	20%	0.35	1.25%	1.0%
3	SCC-3	80%	2.45	1.80	20%	0.35	1.50%	1.0%
4	SCC-4	80%	2.45	1.80	20%	0.35	1.75%	1.0%
5	SCC-5	80%	2.45	1.80	20%	0.35	2.0%	1.0%
6	SCC-6	80%	2.45	1.80	20%	0.35	2.25%	1.0%
7	SCC-7	80%	2.45	1.80	20%	0.35	2.50%	1.0%

Table 7. Acceptance criteria for SCC

Mix	SCC 1	SCC 2	SCC 3	SCC 4	SCC 5	SCC 6	SCC 7	Recommended value	
								Min.	Max.
Slump Flow (mm)	687	677	680	697	710	703	700	650	800
Slump Flow T_{50cm} (Sec)	3	3	3	3	3	2	4	2	5
L-Box (mm)	0.83	0.85	0.84	0.86	0.88	0.89	0.91	0.8	1.0
V-Funnel (Sec)	8	7	8	10	9	7	9	6	12
V-Funnel T_5 min (Sec)	2	2	3	3	3	2	3	0	+3
U-Box (mm)	18	18	19	23	20	19	21	0	30

Fig. 2. L-box test

Fig. 3 V-funnel test

Fig. 4 U-box test

the bars on opening the trap door under the influence of its own self weight. The filling height of concrete is noted.

Table 8. Cube compressive strength at 7 days and 28 days

S. No.	Mix	7 day compressive strength (N/mm^2)	28 day compressive strength (N/mm^2)
1	SCC 1	27.82	42.42
2.	SCC 2	28.21	43.21
3.	SCC 3	28.93	45.10
4.	SCC 4	28.03	44.22
5.	SCC 5	30.85	47.14
6.	SCC 6	28.83	45.46
7.	SCC 7	28.92	45.25

Table 9. Cylinder compressive strength at 7 days and 28 days

S. No	Mix	7 day compressive strength (N/mm^2)	28 day compressive strength (N/mm^2)
1	SCC 1	22.68	34.52
2.	SCC 2	22.59	35.56
3.	SCC 3	23.12	36.23
4.	SCC 4	22.41	37.45
5.	SCC 5	24.62	39.25
6.	SCC 6	23.10	36.32
7.	SCC 7	23.35	37.26

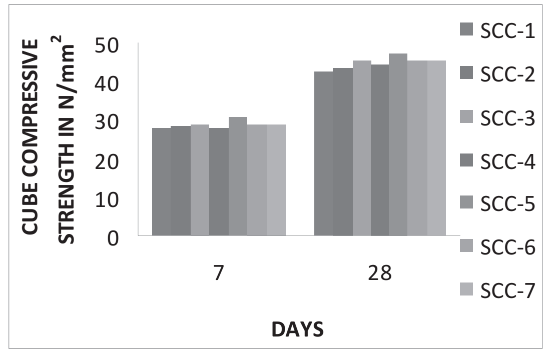

Fig. 5. Comparison of cube compressive strength at 7days and 28days

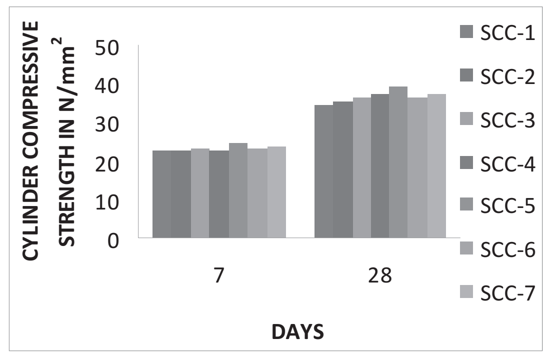

Fig. 6. Comparison of cylinder compressive strength at 7 days and 28 days

The tests for fresh properties of SCC such as slump flow test, T_{50} slump flow, U – box test and V-funnel test were conducted. All the mixes of SCC satisfied the requirements of the limiting values. The values of the test results are tabulated below:

Mechanical properties

The SCC hardened concrete property tests such as cube compressive strength, cylinder compressive strength, split tensile strength and flexural strength tests were conducted and results are tabulated below.

DISCUSSION

The fundamental tests were conducted for all ingredients of SCC and the results were tabulated. The flow properties were checked by conducting the acceptance criteria tests like slump flow, U box, V funnel and L box tests and the values were recorded table-6. The cube compressive strength, cylinder compressive strength, split tensile strength and flexural strength of SCC obtained after 7 days, and 28 days curing and the results were shown in tables 8,9,10 & 11 respectively. The corresponding

Table 11. Flexural strength at 7 days and 28 days

S. No.	Mix	7 day flexural strength (N/mm^2)	28 day flexural strength (N/mm^2)
1	SCC 1	4.71	5.26
2.	SCC 2	4.77	5.37
3.	SCC 3	4.85	5.54
4.	SCC 4	4.97	5.65
5.	SCC 5	5.18	5.79
6.	SCC 6	4.95	5.65
7.	SCC 7	4.84	5.60

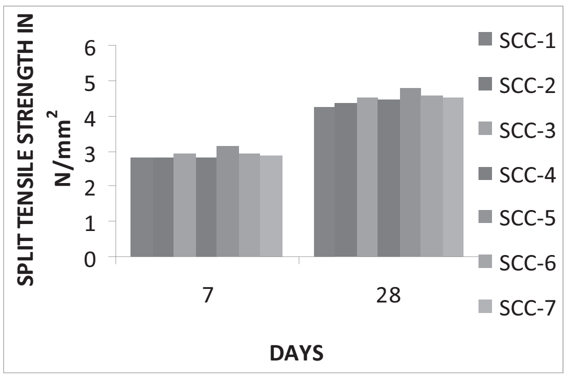

Fig. 7. Comparison of split tensile strength at 7 days and 28 days

Table 10. Split tensile strength at 7 days and 28 days

S. No.	Mix	7 day split tensile strength (N/mm^2)	28 day split tensile strength (N/mm^2)
1	SCC 1	2.81	4.25
2	SCC 2	2.83	4.34
3	SCC 3	2.92	4.52
4	SCC 4	2.81	4.45
5	SCC 5	3.12	4.78
6	SCC 6	2.90	4.54
7	SCC 7	2.89	4.52

comparison charts were presented in Fig. 5, 6, 7, & 8. Powder and aggregate content was kept constant and dosage of super plasticizer was gradually increased from 1% to 2.5% at interval of 0.25%. From these results, it was observed that the mix SCC–5 which has 2% dosage of super plasticizer satisfied the acceptance criteria as well as mechanical properties such as cube compressive strength, cylinder compressive strength, splitting tensile strength and flexural strength.

CONCLUSION

From the results presented in this paper, using different dosages of super plasticizer and viscosity mofifying agent, the following conclusions were arrived.

- Fly ash at dosage of 20% as cement replacing material produces SCC as per the mix design.
- All the SCC mixes satisfied the acceptance criteria.
- Mix SCC-5 which has 2% dosage of super plasticizer satisfied the acceptance criteria and gave the better results for mechanical properties such as cube compressive strength, cylinder compressive strength, splitting tensile strength and flexural strength.
- The presence of VMA gave the better results in both fresh and hardened state when compared with conventional concrete.

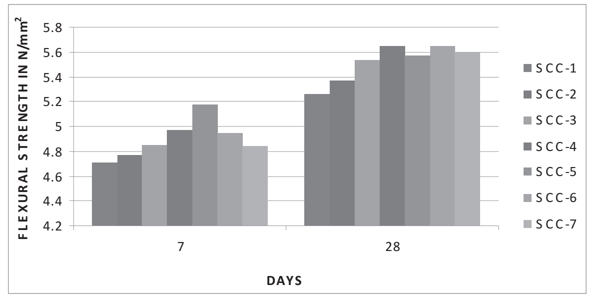

Fig. 8. Comparison of flexural strength at 7 days and 28 days

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