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AN EXPERIMENTAL STUDY OF SELF COMPACTING CONCRETE WHEN PORTLAND SLAG CEMENT IS REPLACED BY FLY ASH

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ABSTRACT:* This study addresses an experimental investigation on strength aspects like compressive and split tensile strength of self compacting concrete (ssc) containing varying quantities of class "F" fly ash which is replaced by (0%,10%,20%,30%,40%,50%,60%,70%) for Portland slag cement and performance is measured and compared, and workability tests (slump, L-box,V-funnel) are carried out. Self compacting concrete has to fulfill contradictory requirements of high flowing ability when it is being cast and high viscosity when it is at rest, in order to prevent segregation and bleeding use of mineral and chemical admixtures essential for self compacting concrete, optimum dosage of super plasticizer used was Master Glenium Sky and viscosity modifying agent included in it, which enhance the flow property of the concrete. The influence of fly ash on the workability, compressive strength split tensile strength of self compacting concrete was investigated.

I. INTRODUCTION

The invention of self-compacting concrete (SCC) can be considered as a major evolution in the construction industry. Self-compacting concrete is a concrete which has little resistance to flow so that it can be placed and compacted under its own weight without any external vibration. SCC offers many advantages compared to ordinary concrete. The main advantage is in the elimination of mechanical compaction. The high fluid nature of SCC makes it suitable for placing in difficult conditions and also in slender sections with congested reinforcement. SCC can also help in on the workability characteristics and strength parameters of SCC containing fly ash. The mix composition is chosen to satisfy all performance criteria for the concrete in both the fresh and hardened states.

II. EXPERIMENTAL INVESTIGATION

CEMENT

The cement used for the investigation was Portland Slag Cement (PSC) of brand Maha sakthi cement. The results of the tests on cement are listed in Table 5.1

Table 1. Physical properties of cement

S.NO	Properties	Test Values	Standard Values (IS)
1	Specific gravity	2.9	
2	Fineness (%)	2.4	< 10
3	Initial setting time (min)	180	>30
4	Final setting time(min)	225	<600

FLY ASH

It is generated as a byproduct of combustion of coal in thermal power plants.

In present research the fly ash used is obtained from NATIONAL THERMAL POWER CORPORATION (NTPC) VISAKHAPATNAM DISTRICT. The physical properties of fly ash are given in Table 2

Table 2. Physical properties of fly ash

S.NO	PROPERTY	VALUES
1	Specific gravity	2.45
2	Bulk density Loose state Compacted state	 1324.63 kg/m^3 1565.72 kg/m^3
3	Fineness (%)	2.5
4	Colour	Light grey

III. FINE AGGREGATE

The fine aggregate used in the present experimental programme is sand confirming to zone-I. it is clean and free from organic matter, silt and clay. The physical properties of sand are given in Table 3

Table 3. physical properties of the fine aggregate.

S.NO	PROPERTY	VALUES
1	Specific gravity	2.5
2	Bulk density Loose state Compacted state	 1526.35 kg/m^3 1685.23 kg/m^3
3	Fineness modulus	2.387

Table 4 Sieve analysis for fine aggregate

Total weight of sample taken = 1000gm					
S.NO	IS SIEVE (mm)	WEIGHT RETAINED (gms)	%WEIGHT RETAINED	CUMULATIVE % WEIGHT RETAINED	% PASSING
1	10	0	0	0	100
2	4.75	18	18	1.8	98.2
3	2.36	29	47	4.7	95.3
4	1.18	142	189	18.9	81.1
5	0.6	202	391	39.1	60.9
6	0.3	381	772	77.2	22.8
7	0.15	198	970	97.0	3

$$\text{Fineness modulus} = \frac{238.7}{100} = 2.387$$

IV. COURSE AGGREGATE

The course aggregates are used for this experiment are 20mm, 10mm. the course aggregate used in the experiment are sieves in the standard sieve sizes. The physical properties of aggregates are given in the table 5.

Table 5. physical properties of the course aggregate.

S.NO	PROPERTY	VALVES
1	Specific gravity	2.76
2	Bulk density Loose state Compacted state	 1534.85 kg/m3 1723.25 kg/m3
3	Impact valve	15.2%
4	Crushing valve	20.35%
5	Elongation index	22.13%
6	Water absorption	0.89%
7	Fineness modulus	8.25

Table 6 Sieve analysis for coarse aggregate

Total weight of sample taken = 5000gm					
S.NO	IS SIEVE (mm)	WEIGHT RETAINED (gms)	%WEIGHT RETAINED	CUMULATIVE % WEIGHT RETAINED	% PASSING
1	80	0	0	0	100
2	40	0	0	0	100
3	20	1323	26.46	26.46	73.54
4	12.5	3607	72.14	98.6	1.4
5	10	70	1.4	100	0
6	4.75	0	0	100	0
7	2.36	0	0	100	0
8	1.18	0	0	100	0
9	0.6	0	0	100	0
10	0.3	0	0	100	0
11	0.15	0	0	100	0

$$\text{Fineness modulus} = \frac{825.06}{100} = 8.25$$

CHEMICAL ADMIXTURES

Chemical admixtures modify the properties of concrete, improve the quality of concrete and reduce the cost of construction, transportation. Now a days two types of high range water reducer admixture (HRWRA) are using. They are naphthalene and polymers. In this experiment polymer based HRWRA chemical admixture are used.

POLYCARBOXYLATE ETHER- SUPERPLASTICIZERS

Poly carboxylate ether(PCE)-based superplasticizer (SP) Master Glenium SKY
8630 was used in the self-compacting concrete mixtures. It is an F-type high-range water reducer, in conformity with ASTM:C 494, IS 9103:1999 & IS 2645:2003. are given in the table 7.

Table 7 Physical properties of PCE

S.NO	PROPERTY	TEST VALUES
1	Aspect	Light brown liquid
2	Relative density	0.08±0.01 at 25^{o}
3	Ph	≥6 at 25^{o} C

WATER

The water used for cement mixing was potable water collected from the laboratory taps confirming to IS 456-2000.

CASTING

The cube specimens of standard size 150mm x 150mm x 150mm (length x breadth x depth) and cylinders of 150mm x 300mm (diameter x height) were casted for Compressive strength are tested for 7 and 28 days.

The specimens are casted for Split tensile strength for Cylinders of standard size 150mmx300mm (diameter x height) were casted and tested for 7 and 28 days.

V. MIX DESIGN PROPORTIONS

Table 8 Details of Mix proportions in Kg/m3

CONSTITUENTS	SCC0	SCC10	SCC20	SCC30	SCC40	SCC50	SCC60	SCC70
PSC	500	450	400	350	300	250	200	150
FLYASH	0	50	100	150	200	250	300	350
WATER	150	150	150	150	150	150	150	150
WATER/BINDER RATIO	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
SAND	710.43	713.71	708.75	699.75	696.71	693.11	689.62	682.8
10MM AGGREGATE	435.73	433.59	434.7	429.18	427.31	425.11	422.97	420.62
20MM AGGRAGATE	522.88	520.31	521.64	515.06	512.78	510.13	507.56	504.75
CHEMICAL ADMIXTURE	6.5	6.5	6.5	6.5	6.1	6.1	6.1	6.1

(a) Fresh state properties of self compacting concrete (SCC)

Slump flow test

The fresh concrete is poured into a cone. When the cone is upwards the time from commencing upward movement the cone to when the concrete has flowed to a diameter of 500 mm is measured; this is the T50 time. The largest diameter of the slow spread of the concrete and the diameter of the spread at right angles to it are then measured and the mean is the slump-flow.

(b) V-funnel flow test

Close the gate of V- funnel and pour the sample of concrete into the funnel, without any vibration or rodding, then strike off the top with the straight edge so that the concrete is with the top of the funnel. Place the container under the funnel in order to retain the concrete to be passed. After a delay of (10±2) s from the filling funnel, open the gate and measure the time tv, to 0.1 s, from the opening the gate to sec passes vertically through the funnel into the container below for the first time, tv is the V-funnel flow time.

(c) L-box blocking test

Test procedure is to support the L-box on a level horizontal base and close the gate between the vertical and horizontal sections. Pour the concrete from the container into the filling hopper of the box and allow to stand for (60±10) s. When movement has ceased, measure the vertical distance, at the end of the horizontal section of the L-box, between the top of the concrete and the top of the horizontal section of the box at three positions equally spaced across the with of the box. By difference with the height of the horizontal section of the box, these three measurements are used to calculate the mean depth of concrete as H2 mm. The same procedure is used to calculate the depth of concrete immediately behind the gate as HI mm. The passing ability is calculated from the following equation

PA=H2/H1.

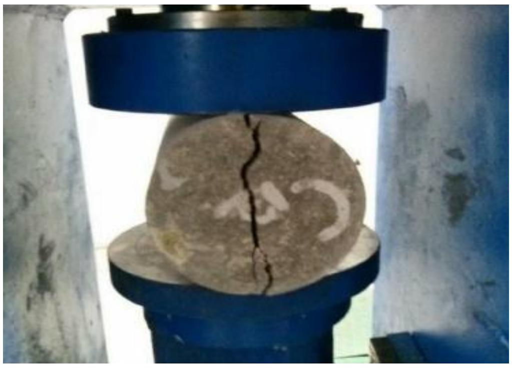
Table 9 Fresh properties of the Self compacting concrete.

MIX NOTATIONS	T 50 (s)	Slump Flow (MM)	L-Box Blocking ratio	V-Funnel flow time (s)
SCC0	6	640	0.73	33
SCC10	6	645	0.75	34
SCC20	6	655	0.79	31
SCC30	6	660	0.82	28
SCC40	5	670	0.91	27
SCC50	5	675	0.94	24
SCC60	5	680	0.93	25
SCC70	5	675	0.92	28

HARDENED CONCRETE TEST

Compressive test

Split tensile test



Ultrasonic Pulse Velocity (UPV) TEST

Rebound Hammer Test

Table 10 Compressive strength for different proportion cylinders.

Mix notations	Compressive strength	
	7 days	28 days
SCC0	25.34	31.89
SCC10	24.32	39.34
SCC20	21.31	36.51
SCC30	19.23	24.38
SCC40	16.14	22.78
SCC50	14.23	18.92
SCC60	18.12	18.67
SCC70	10.89	14.12

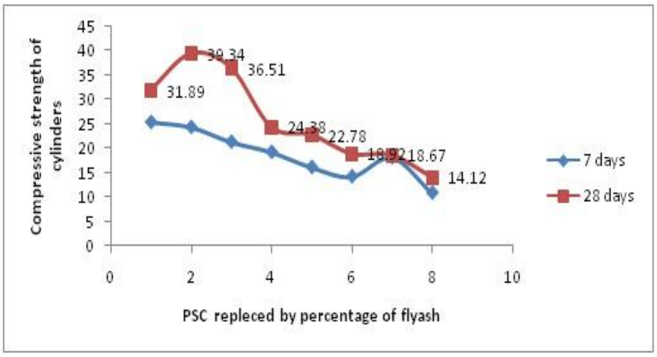


Figure 1 Compressive strength of cylinders Vs percentage of Flyash replaced by PSC.

Table 11 Split tensile strength for different proportion cylinders.

Mix notations	Split tensile strength	
	7 days	28 days
SCC0	3.1	3.38
SCC10	2.9	3.55
SCC20	3.01	3.43
SCC30	2.65	2.87
SCC40	2.32	2.65
SCC50	2.18	2.35
SCC60	2.05	2.31
SCC70	1.98	2.18

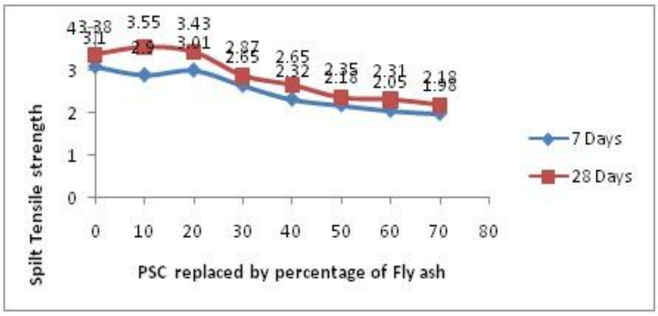


Figure 2 Split tensile strength of cylinders Vs percentage of Flyash replaced by PSC.

Table 12 Comparing Split tensile strength and Compressive strength of different proportion cylinders for 7 days.

Mix notations	7 days	
	Split tensile strength	Compressive strength
SCC0	3.1	25.34
SCC10	2.9	24.32
SCC20	3.01	21.31
SCC30	2.65	19.23
SCC40	2.32	16.14
SCC50	2.18	14.23
SCC60	2.05	18.12
SCC70	1.98	10.89

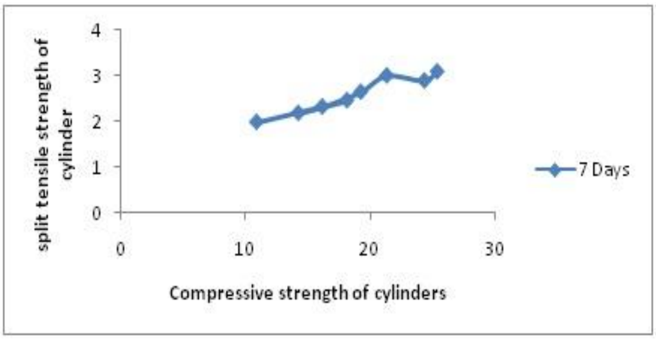


Figure 3 Split tensile strength Vs Compressive strength of cylinders for 7 days.

Table 13 Comparing Split tensile strength and Compressive strength of different proportion cylinders for 28 days.

Mix notations	28 days	
	Split tensile strength	Compressive strength
SCC0	3.38	31.89
SCC10	3.55	39.34
SCC20	3.43	36.51
SCC30	2.87	24.38
SCC40	2.65	22.78
SCC50	2.35	18.92
SCC60	2.31	14.67
SCC70	2.18	14.12

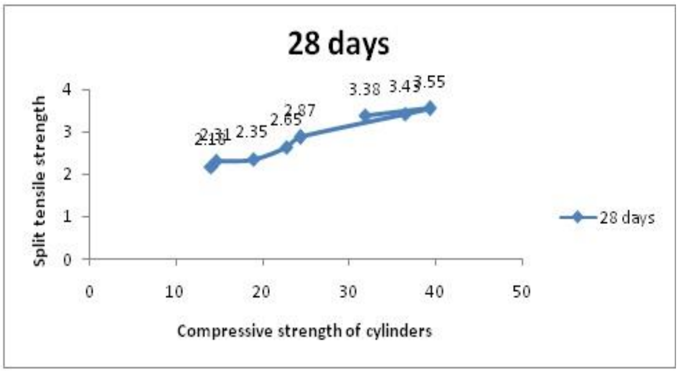


Figure 4 Split tensile strength Vs Compressive strength of cylinders for 28 days.

Table 14 Ultrasonic Pulse Velocity for cylinders

Mix notations	Ultrasonic Pulse Velocity (m/s)	
	7 days	28 days
SCC0	2432	2468
SCC10	3980	4423
SCC20	4231	4489
SCC30	4336	4523
SCC40	4450	4508
SCC50	4567	4576
SCC60	4682	4694
SCC70	4479	4532

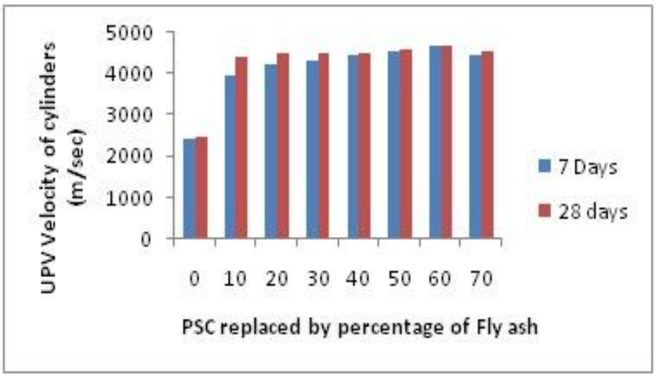


Figure 5 Ultrasonic Pulse velocity Vs PSC replaced by percentage of flyash.

Table 15 Rebound Hammer Test for cylinder.

Mix notations	Ultrasonic Pulse Velocity (m/s)	
	7 days	28 days
SCC0	107	152.32
SCC10	121	161.28
SCC20	108.24	115.29
SCC30	112.01	114.17
SCC40	119.2	120.28
SCC50	125.14	119.48
SCC60	131.53	126.01
SCC70	119.25	121.24

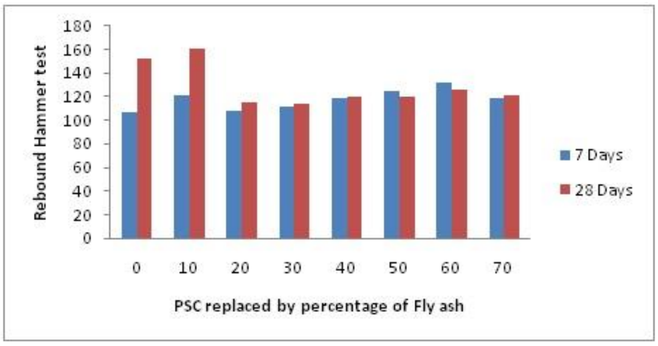


Figure 6 Rebound Hammer Test Vs PSC replaced by percentage of flyash.

VI. CONCLUSIONS

The main conclusions of the study are:

- The workability tests on fresh concrete such as Slump flow, V-funnel, L-box are measured. As the percentage replacement of fly ash is increasing in cement (PSC) from 0% - 60% the slump flow value is also increasing, at 70% of increase of fly ash in cement the slump flow value is decreased.
- At 50% replacement of fly ash in Portland slag cement has shown minimum V-funnel flow time.
- At 50% replacement of fly ash in Portland slag cement has shown maximum flow value of L-box blocking ratio.

- Slump flow of 650 ± 50 mm is required for SCC, and all the concretes developed here have satisfied the requirements.
- The compressive strength of cylinder when flyash is replaced by Portland slag cement is increases first and then it is decreases with increase of flyash.
- The split tensile strength of concrete cylinders is gradually decreases with increase of percentage of flyash to Portland slag cement of self compacting concrete.
- The ultrasonic pulse velocity is gradually increases from 10% to 60% of flyash replaced by PSC while compared to 0% of flyash replacement of PSC and there is sudden flow down of velocity at 70% of flyash.
- The rebound hammer test show that the strength increases from 7 days to 28 days as the strength at 0% to 40% increases from 7 days to 28 days therefore it is concluded that the strength at 50%, 60% and 70% increases for7 days and decreases at 28 days due to the percentage increases in fly ash.

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