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A STUDY ON MECHANICAL PROPERTIES OF SELF-COMPACTING CONCRETE BY PARTIALLY REPLACING PORTLAND SLAG CEMENT WITH FLYASH

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***Abstract*— The greatest challenge before the construction industry is to serve the two pressing needs of human society namely the protection of the environment and meeting the infrastructure requirement of our growing pollution and consequential needs of industrialization and urbanization. It is looking for the ways and means to develop building products, which will increase the life span and quality. Therefore, it should be obvious that certain scale cement replacement with industrial by products is highly advantageous from the stand point of cost, economy, energy efficiency, durability and overall ecological and environmental benefits. Experimental investigation on strength aspects like compressive, flexural and split tensile strength of self-compacting concrete (SCC) containing different levels of fly ash and workability tests for different mineral admixtures (slump, L-box, V-funnel and T_{50}) are carried out. The methodology adopted is that mineral fly ash is replaced by 10%, 20%, 30%, 40%, 50%, 70% for Portland slag cement and performance is measured and compared.**

***Index Terms*— Cost, economy, durability, SSC, PSC, compressive, flexural, split tensile strength.**

I. INTRODUCTION

In view of global warming, efforts are on to reduce the emission of CO_2 to the environment. Cement industry is a major contributor in the emission of CO_2 as well as using up high levels of energy resources in the production of cement. By replacing cement with a material of pozzolanic characteristic, such as the fly ash, the cement and concrete industry together can meet the growing demand in the construction industry as well as help in reducing the environmental pollution. One of the most outstanding advances in the concrete technology over the last decade is “self-compacting concrete” (SCC). Self-compacting concrete is a highly flowable, stable concrete which flows readily into places around congested reinforcement, filling formwork without any consolidation and significant segregation. The hardened concrete is dense, homogeneous and has the same engineering properties and durability as that of traditional vibrated concrete. The use of SCC eliminates the need for compaction thereby saves time, reduces labour costs and conserves energy. Furthermore use of SCC enhances surface finish characteristics. One of the disadvantages of SCC is its cost, associated with the use of chemical admixtures and use of high volumes of Portland cement. One alternative to reduce the cost of SCC is the use of additions.

II. METHODOLOGY

To examine the influence of fly ash in SCCs on the fresh, mechanical and durability properties when PPC cement was used. The water–binder ratio for all the mixes was taken as constant at 0.30. In mixes SCC10, SCC20, SCC30, SCC40, SCC50 and SCC70 cement content was replaced with 10%, 20%, 30%, 40%, 50% and 70% fly ash (by mass) respectively. The essential component of SCC is a high range water reducer (HRWRA) which is also known as superplasticizer. SCC mixtures include a high-range water-reducing admixture (HRWRA) to ensure concrete is able to flow under its own mass. Several trial mixes were conducted to determine the optimum dosage of superplasticiser for each of mixtures in order to achieve the required self-compacting properties as per EFNARC standards.

Tests on fresh concrete which are Slump flow value, V-funnel flow time, L-box blocking ratio are investigated and hard concrete tests such as Compressive strength for Cube of standard size 150mmx150mmx150mm (length x breadth x depth) were casted and tested for 7, 28, 60 & 90 days, Flexural strength for Prisms of standard size 500mmx100mmx100mm (length x breadth x depth) were casted and tested for 7, 28, 60&90 days. Split tensile strength for Cylinders of standard size 150mmx300mm (diameter x height) were casted and tested for 7, 28, 60&90 days.

III. MIX PROPORTIONS

According to (EFNARC 2005) guidelines powder content ranges from 380-600. By considering this, fix the total cementitious material (TCM) content. (Preferable TCM is assumed around 550kg/m^3)

The concrete mix design has been done as per IS method.

Six different mixes (SCC10, SCC20, SCC30, SCC40, SCC50 and SCC70) were employed to examine the influence of fly ash in SCCs on the fresh, mechanical and durability properties of PPC cement was used. The water–binder ratio for all the mixes was taken as constant at 0.30. In mixes SCC10, SCC20, SCC30, SCC40, SCC50 and SCC70 cement content was replaced with 10%, 20% 30%, 40% 50% and 70% fly ash (by mass) respectively.

IV. MIXING AND CASTING

The materials were mixed using a pan mixer with a maximum capacity of 80litres. The materials were nourished into the mixer in the order of coarse aggregate, PPC, fly ash and sand. The materials were mixed dry for 1.5 min. Subsequently three-quarters of the water was added, followed by the superplasticiser and the remaining water while mixing sustained for a further 6 min in order to obtain a homogenous mixture. Upon discharging from the mixer, the self-compatibility tests were conducted on the fresh properties for each mixture. The fresh concrete was placed into the steel cube moulds and trodden without any vibration. Finally, surface finishing was done carefully to obtain a uniform smooth surface.

V. TESTS ON SPECIMEN

V.I FRESH CONCRETE TESTS:

For determining the self-compatibility properties (slump flow, T50 time, V-funnel flow time, L-box blocking ratio) tests were performed on all the mixtures. The order of testing was:

(a) Slump flow test and measurement of T50 time.

(b) V-funnel flow test.

(c) L-box blocking test, respectively.

The tests were performed in accordance with EFNARC standards.

V.II HARDENED TESTS:

The unconfined compressive strength was obtained, at a loading rate of 2.5 kN/s at the age of 7, 28 and 60 days on 3000kN machine. The average compressive strength of three specimens was considered for each age. The split tensile strength was also tested on the same machine at the age of 7, 28 and 60 days. The flexural strength was tested on Universal testing machine at the age 7, 28 and 60 days as per Bureau of Indian Standards 516:1959.

VI. RESULTS

By conducting the tests on slump, cubes and cylinders. We gets the values of slump, compressive strength, split tensile strength and flexural strength, by using the values drawn the following graphs and represented below

Table: Fresh properties of the Self compacting concrete

Concrete name	T 50 (s)	Slump flow (mm)	V-funnel flow time (s)	L-box blocking ratio
SCC00	6	780	35	1
SCC10	6	655	32	0.79
SCC20	6	670	29	0.82
SCC30	5	680	27	0.88
SCC40	5	695	26	0.90
SCC50	5	705	25	0.92
SCC70	6	680	28	0.85

Table: Compressive Strengths of All Mixes For Different Ages Of Concrete

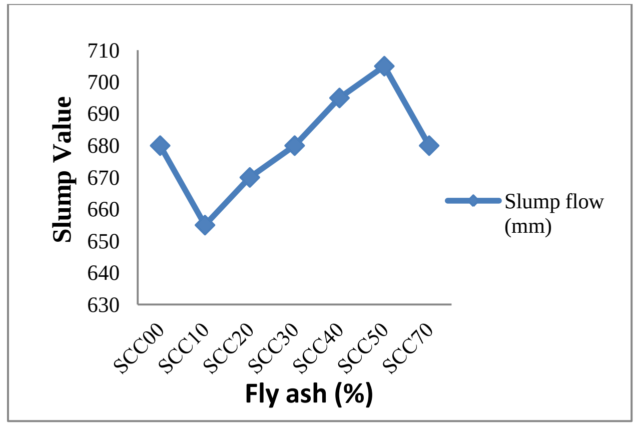
Concrete name	Compressive strength (MPa)		
	7 day	28 day	60 day
SCC00	43.76	57.95	65.26
SCC10	42.66	60.88	63.11
SCC20	44.36	60.24	62.66
SCC30	34.60	43.55	52.88
SCC40	33.77	42.66	49.33
SCC50	20.42	32.88	42.66
SCC70	12.84	22.32	30.44

Table: Split Tensile Strengths of All Mixes For Different Ages Of Concrete

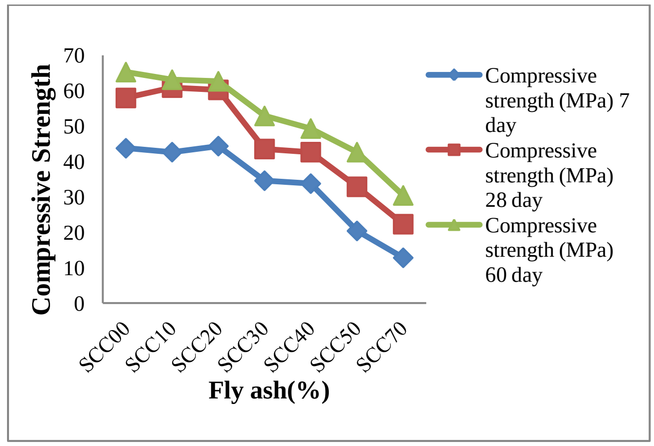
Concrete name	Splitting tensile strength (Mpa)		
	7 day	28 day	60 day
SCC00	3.1	3.87	3.98
SCC10	2.9	3.67	3.82
SCC20	3.1	3.53	3.61
SCC30	2.55	2.89	3.27
SCC40	2.33	2.76	3.11
SCC50	2.24	2.58	2.89
SCC70	1.98	2.25	2.42

Table: Flexural Strengths of All Mixes For Different Ages Of Concrete

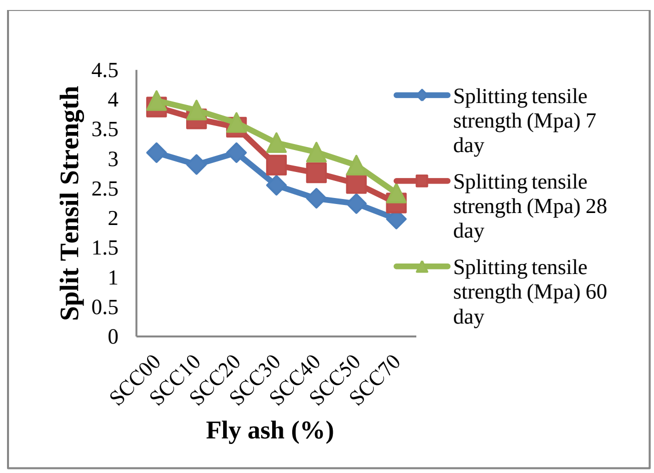
Concrete name	Flexural strength (Mpa)		
	7 day	28 day	60 day
SCC00	6.2	6.74	7.25
SCC10	6	6.64	7
SCC20	6.2	6.4	6.8
SCC30	5.4	5.8	6.4
SCC40	5.28	5.64	6.04
SCC50	4.84	5.36	6
SCC70	3.6	4.2	4.58



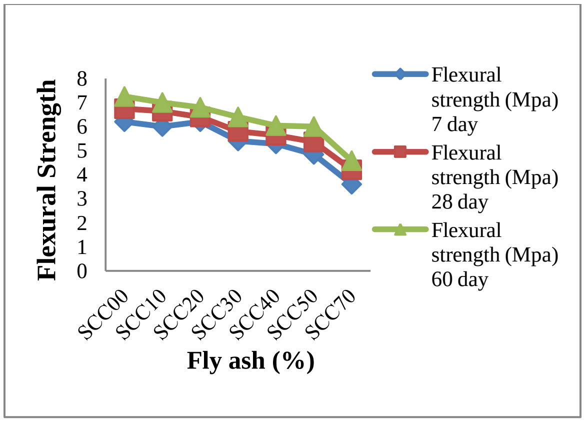
Slump Vs Fly ash(%)



Compressive strength Vs Fly ash (%)



Slip tensile strength Vs Fly ash (%)



Flexural strength Vs Fly ash (%)

VII. CONCLUSION

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 10% - 50% the slump flow value is also increasing, at 70% of increase of fly ash in cement the slump flow value is decreased. For 10% - 50% increasing of fly ash in cement (PSC) values of V-funnel and L-box tests are decreasing, at 70% of increase in fly ash these values are increased. At 50% replacement of fly ash in PSC has shown maximum flow value, L-box blocking ratio and minimum V-funnel flow time. It can be observed that fly ash replacements of around 10-40% will be ideal for developing SCCs when Portland slag cement was used. As the replacements levels of fly ash (10%, 20%, 30%, 40%, 50%, 70%) in cement is increasing the Compressive strength, Split tensile strength & Flexural strengths are decreasing. High percentage of fly ash (more than 40%) cannot be used to produce SCC when PSC was used, and 10% replacement of fly ash exhibited the highest compressive strengths, splitting tensile strengths and flexural strengths.

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