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Experimental investigation on Durability Characteristics of Self Compacting Concrete

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Abstract - Self-compacting concrete (SCC) is an innovative concrete that does not require vibration for placing and compaction. It is able to flow under its own weight, completely filling formwork and achieving full compaction, even in the presence of congested reinforcement and its engineering properties are similar to traditional concrete. The objective is to study the durability characteristic of self-compacting concrete containing manufactured sand as a substitute material for river sand and addition of fly ash with chemical admixture - Melamine based super plasticizer. The fresh and hardened properties of Self Compacting Concrete and the test methods to find the properties of SCC are presented here. Mix design for Self-compacting concrete was done based on IS 10262:2009 & "EFNARC". An experimental work has been developed and the mechanical and durability characteristics of self-compacting concrete containing fly ash are found out.

Key Words: self-compacting concrete, Fly ash, M-sand, Durability characteristics

1. INTRODUCTION

Earlier research in design of self-compacting concrete mixes began in the mid-eighties in the twentieth century in Japan. The main drive for this research were the endangered durability of reinforced concrete structures, need for easier and high quality fresh concrete placement and lack of skilled labour force. In 1986, Okamura, Kochi University, Japan, was the first to propose concrete that would be placed under the influence of self-weight only.

The new technology was possible owing to the development of concrete super plasticizers which had been developed during the previous decades.

After an extremely successful initial application in actual structures in Japan, the application of self-compacting concrete began in the entire world. Presently it is a very eagerly used material both in construction sites and in production of precast members. Extensive testing of physical and mechanical properties of SCC was carried out during the past decade.

The high cost due to scarcity of river sand in nature is forcing the engineers to go for an alternative. In that way manufacture sand is a good alternative to use in concrete. This paper presents the mechanical and durability properties of the conventional and the Mix-1. The 100% replacement of R-sand by M-sand is taken as conventional and 100% M-sand and 15% addition of fly ash with the weight of cement is taken as Mix-1

1.1 Advantages of SCC

- No vibration of fresh concrete is necessary during placement into forms.
- Placement of concrete is easier.
- Noise level on construction site is reduced.
- Energy consumption is reduced.
- Required number of workers on construction site is reduced.

1.2 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 flow ability for achieving economy; a substantial part of this powder would contain reactive powder minerals like fly ash. SCC differs from conventional concrete in that the former has more powder content and less coarse aggregate. SCC also incorporates high range water reducer (HRWR/Super plasticizer) 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 concrete mixture. The workability of SCC is "very high" when compared to the conventional concrete.

2. MATERIALS USED

CEMENT

Selection of type of cement mainly depends on the specific requirements of concrete. It determines the strength and properties of fresh and hardened concrete. The Cement used for all the specimens were ordinary Portland cement (43 grades) with a specific gravity of 3.15 and conforming to IS: 8112-2013.

FINE AGGREGATE

Among various characteristics, the most important for SCC is its grading. Fine aggregates used for SCC should be properly graded to give the minimum voids ratio. Locally

available M-sand conforming to grading zone II as per IS: 383-1970 is used. The specific gravity was found to be 2.66.

COARSE AGGREGATE

The coarse aggregate is the strongest and least porous component of concrete. Locally available blue granite stones of maximum size of 20 mm are used.

FLY ASH

The flow ability of self compacting concrete depends on the powder and paste content. Hence, in order to increase the flow ability, mineral admixtures such as fly ash has been used.

The fly ash used was class –F and it is obtained from Mettur Thermal Power Station @ Salem district of TN, India. The specific gravity was found to be 2.2.

SUPER PLASTICIZER

Super plasticizer is a chemical admixture used in concrete to give workability to SCC. Different bases of New Generation Super plasticizers or High Water Reducing Agents (HWRA) have different water reduction capacities. The super plasticizer used in the experiment is Melamine based with specific gravity 1.200 to 1.225 at 30^0C

WATER

Potable tap water from available in the laboratory with pH value 6 to 8 and conforming to the requirements of IS: 456-2000 is used for mixing concrete and curing the specimens as well.

2.1 MIX DESIGN FOR M20 CONCRETE

The mix design for SCC is done by referring the mix design as per IS: 10262-2009 for normal concrete and is verified with the conditions provided in "EFNARC 2002"- The European guidelines for SCC.

TABLE.1 MIX PROPORTION OF SCC

CEMENT	Fly Ash	CA	FA	W/C
320	48	735	1116	0.50
1	0.15	2.29	3.48	0.50

3. EXPERIMENTAL INVESTIGATION ON SCC

3.1 FRESH PROPERTIES SCC

In order to study the effect on fresh concrete properties when fly ash is added into the concrete as cement replacement, the SCC containing fly ash have been tested for Slump flow, V-funnel and L-box.

The results of various fresh properties tested by slump flow test (slump flow diameter), L-box test (ratio of heights at the two edges of L-box (H2/H1));

V-funnel test (time taken by concrete to flow through V-funnel after 10sec) for Mix-1 have been studied in detail (Table.2 and Table.3).

TABLE.2 FRESH PROPERTIES OF MORTAR

SUPERPLASTICIZER RATIO	FLOW CONE (cm)	V-FUNNEL (seconds)
	RECOMMENDED VALUE	
	24-26	7-11
1.50%	20.1	16
1.75%	22.6	14
2.0 %	25.7	11

TABLE.3 FRESH PROPERTIES OF SCC

TEST METHOD	FLYASH 15%	RECOMMENDED VALUES
SLUMP FLOW	659 mm	650-800mm
T-50cm SLUMP FLOW	5 sec	2-5 seconds
V-FUNNEL	10 sec	6-12seconds
TIME INCREASE V-FUNNEL @5minutes	4 sec	0-3 seconds
L-BOX	0.88	0.8-1

3.2 HARDENED PROPERTIES OF SCC

TEST SPECIMEN

The 150 mm size concrete cubes, 150mmX300mm cylinders and concrete beams of size 100 mm x 100 mm x 500 mm has been cast to determine the compressive strength, split tensile strength and flexural strength respectively(Fig.1 to Fig.3).

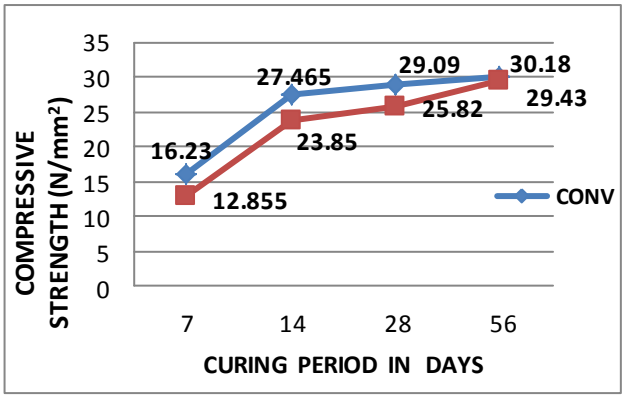

FIGURE.1 COMPRESSIVE STRENGTH

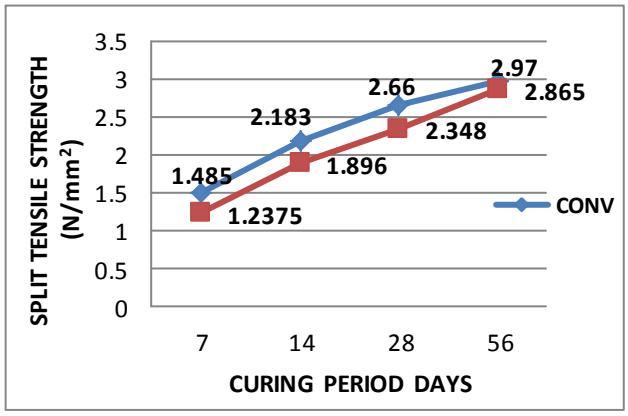

FIGURE.2 SPLIT TENSILE STRENGTH

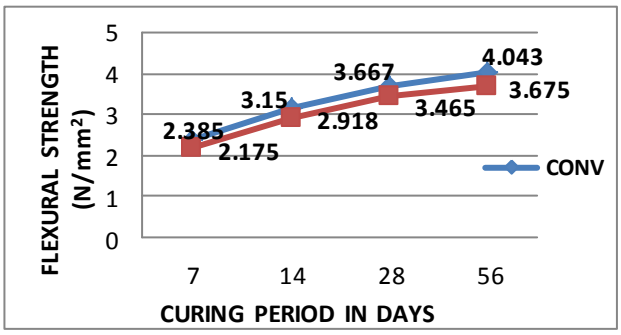

FIGURE.3 FLEXURAL STRENGTH

3.3 DURABILITY STUDIES

3.3.1 ACID RESISTANCE

Acid resistance was tested on 100 mm size cube specimens at the age of 28 days of curing. The cube specimens were weighed and immersed in water diluted with one percent by weight of sulphuric acid and hydrochloric acid for 7,14, 28 and 56 days. Then, the specimens were taken out from the acid water and the surfaces of the cubes were cleaned. Then, the weights of the specimens were found out and the average percentage of loss of weight was calculated (Fig.4 and Fig.5).

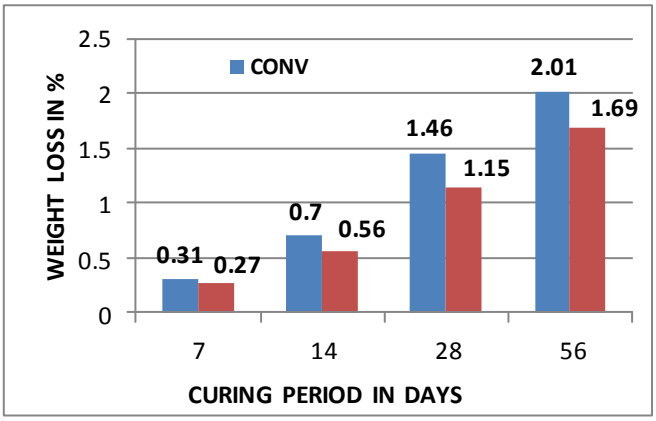

FIGURE.4 ACID ATTACK TEST (HCL)

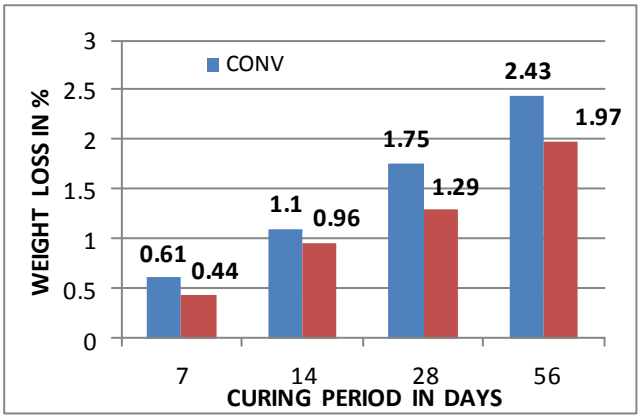

FIGURE.5 ACID ATTACK TEST (H_2SO_4)

3.3.2 SULPHATE ATTACK

The sulphate attack was tested on 100 mm size cube specimens at the age of 28 days of curing. Then, they were cured in 5% Sodium sulphate solution for 7, 14, 28, and 56 days

The degree of sulphate attack was evaluated by measuring the weight losses of the specimens at 7, 14, 28 and 56 days, respectively. The average percentage of loss of weight was calculated (Fig.6).

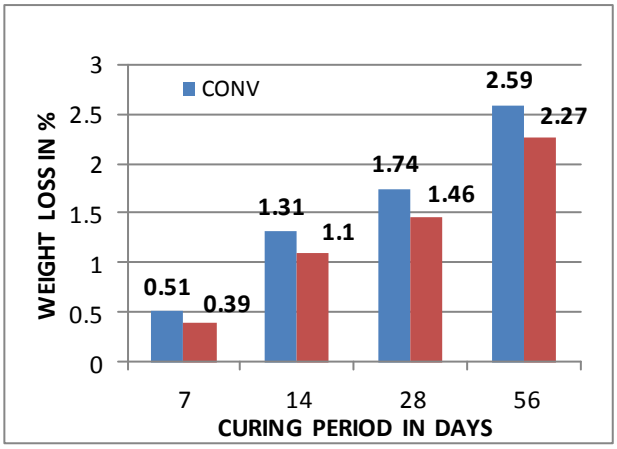

FIGURE.6 SULPHATE ATTACK TEST

3.3.3 WATER ABSORPTION

Six cubes of size 150mm were cast for two different mixes. All specimens were removed 24 hours after casting and subsequently water cured for 28 days. Samples were removed from water and wiped out any traces of water with damp cloth and difference in weight was measured (Fig.7).

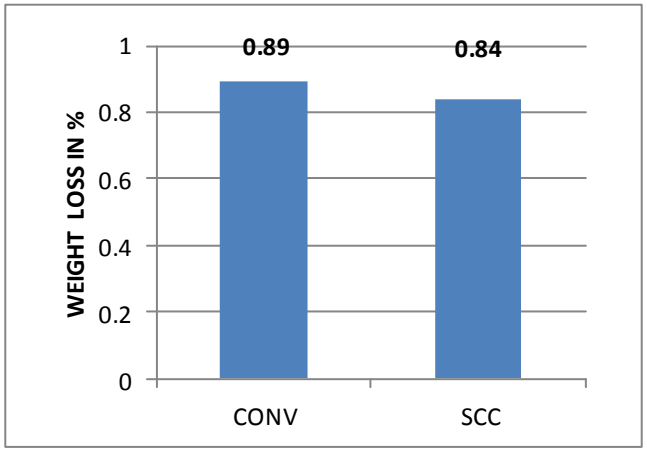

FIGURE.7 WATER ABSORPTION TEST

4. CONCLUSIONS

- SCC containing M-sand and addition of 15 percent fly ash have been tested for Slump flow, V-funnel and L-box and found that the values are within the limits prescribed by EFNARC.
- Addition of 15 percent of fly ash with the weight of cement gives the maximum compressive strength when compared to 20 and 25 percent of addition of fly ash mix
- It is found that the compressive and split tensile strength of conventional concrete and the concrete containing fly ash is approximately equal at the age of 56.
- It is found that the acid and sulphate resistance of self-compacting concrete with fly ash was high when comparing to the conventional concrete

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