Effect Of Self Curing Compound On Self Compacting Concrete

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Abstract- *Concrete is a heterogeneous material which consists of cement matrix, aggregate phase and interface between cement matrix and aggregate. To ensure a good concrete, it should possess good mechanical as well as durability properties. The understanding of micro structure is important in assessing the performance of concrete. Concrete in microstructural terms is an extremely complex system of solid phases, pores and water with a high degree of heterogeneity. Ordinary Portland cement contains basic oxides such as lime (CaO) and acidic oxides, such as silica (SiO2), Alumina (Al2O3) and iron oxide (Fe2O3). These four oxides together constitute about 90% by weight of cement. The remaining 10% are called minor oxides such as magnesia (MgO), alkali oxides (Na2O and K2O), titanium (TiO2), phosphorus pentoxide and gypsum. The four principal compounds of cement in the anhydrous state are alite (impure tri calcium silicate C3S), belite (impure dicalcium silicate C2S), and the aluminate and ferrite phases which have average compositions of C3A and C4AF, respectively. The minerals react with water to give a variety of hydrates.*

I. INTRODUCTION

The When water is added, the reactions which occur are mostly exothermic. We can get an indication of rate at which minerals are reacting by monitoring the rate at which heat is evolved using a technique called Conduction Calorimeter.Almost immediately on adding water some of the clinker sulphates and gypsum dissolve producing an alkaline, sulfate-rich, solution. Soon after mixing, the (C3A) phase (the most reactive of the four main clinker minerals) reacts with the water to form an aluminate-rich gel (Stage 1 on the heat evolution curve). The gel reacts with sulfate in solution to form small rod-like crystals of ettringite. (C3A) reaction is with water is strongly exothermic but does not last long, typically only a few minutes, and is followed by a period of a few hours of relatively low heat evolution. This is called the dormant, or induction period (Stage 2).The first part of the dormant period, up to perhaps half-way through, corresponds to when concrete can be placed. As the dormant period progresses, the paste becomes too stiff to be workable.

II. LITERATURE REVIEW

1. General:

Chapter-1 gave an introduction regarding Self Compacting Concrete, Self-Curing Concrete and potential materials for Self-Curing Concrete. Present chapter covers the detailed literature review on Self Compacting Concrete and Self-Curing Concrete and micro structural investigation on concrete.

2. Literature review on Self Compacting Concrete:

Nan Su, Kung-Chung Hsu and His-Wen Chai [1], proposed a simple mix design for Self Compacting Concrete. First, the amount of aggregates required is determined, and the paste of binders is then filled into the voids of aggregates to ensure that the concrete thus obtained has flowability, self-compacting ability and other desired SCC properties. The amount of aggregates, binders and mixing water, as well as type and dosage of superplasticizer (SP) to be used are the major factors influencing the properties of SCC. Slump flow, V-funnel, L-flow, U-box and compressive strength tests were carried out to examine the performance of SCC, and the results indicate that the proposed method could produce successfully SCC of high quality. Compared to the method developed by the Japanese Ready-Mixed Concrete Association (JRMCA), this method is simpler, easier for implementation and less time-consuming, requires a smaller amount of binders and saves cost.

3. Literature review on Self-Curing Concrete:

Ronald tak yong liang and Robert keith sun[14]:

The objective of the research was to produce Self-Curing Concrete by using hydrophilic chemicals like polyethylene glycol and paraffin wax. They have done many experiments on ordinary concrete like compressive strength at different days of curing and also at different proportions of PEG and wax. They have investigated using three internal curing compositions and are shown in Table 2.1.

Table 1. Internal curing compositions

Curing material	Curing membrane	Internal curing Composition 1	Internal curing Composition 2	Internal curing Composition 3
Base material	Solvent borne Resin with dye	water,wax Emulsion and High MW Polyethylene oxide	Water, paraffin Wax& Polyethylene glycol	Water based polyether's

Claims on internal curing compositions 2:

A cementitious mix comprising of cement and an aggregate, further including an internal curing concentrate which includes a glycol, a wax and water. The cementitious mix wherein the glycol was a polyethylene glycol of molecular weight 200 and wax was selected from the group consisting of paraffin wax.A cementitious mix including an internal curing concentrate wherein the internal curing concentrate comprises about 10% polyethylene glycol, about 57% paraffin wax, and about 33% water.A cementitious mix wherein the internal curing composition was present in the cementitious mix in an amount of about 5 l/m3.

III. SCOPE AND OBJECTIVES OF THE STUDY

The use of Self-Curing compounds is necessitated in normal and Self Compacting Concrete to achieve maximum hydration compared to other curing conditions particularly useful in water scarce areas.The use of hydrophilic chemicals in concrete will give better performance compared to Light Weight Aggregates (LWA) and Super Absorbing Polymers (SAP). LWA and SAP have low mechanical properties. So instead of these materials hydrophilic chemicals can be used to improve the properties of concrete.There is a need to work on high grade concrete with curing compound inclusion.

1. Objectives of the study:

To develop SCC mix design methodology for mix A (70MPa) and mix B (60MPa).To evaluate the workability of concrete, tests on fresh properties (slump flow test, J-ring test, V- funnel test and L-box test).To study the effect of Self-Curing compound and its dosage on fresh properties of Self Compacting Concrete.To determine the water retention capacity of all mixes by measuring weight loss of cubes at 3, 7, 14, 21, 28 and 56 days.To determine the compressive strength of cubes at 7, 28 days.Chapter-4 deals with development of Self Compacting Concrete using Nan Su method and mix proportion calculations and final mix proportion values.

IV. EXPERIMENTAL STUDY

1. General

In this chapter, Nan SU mix design calculations will be discussed in detail and develop 70MPa and 60MPa Self Compacting Concrete (Appendix I and II). The fresh properties are verified to meet EFNARC specifications. Introduction to experimental study: The experimental study consists of arriving at suitable mix proportions that satisfies the fresh properties of 70Mpa and 60Mpa Self Compacting Concrete (SCC) mixes as per EFNARC specifications by casting several trail mixes. The program consists of casting and testing of 70Mpa and 60Mpa plain Self Compacting Concrete and SCC with additions of four different Self-Curing compounds of 1% by weight of cement each. The Self-Curing compounds used in this experimental study are PEG4000, PEG200, light weight liquid paraffin wax and heavy weight liquid paraffin wax. A total of 12 batches, (6 batches for 70MPa SCC mix and 6 batches for 60Mpa SCC mix) were casted. 10 cubes were casted for each batch, Out of which in each mix, 2 batches are of plain SCC i.e. without Self-Curing compound inclusion and remaining 4 batches are SCC, each with 1% Self-Curing compounds inclusion.Standard cube moulds of 150mm x 150mm x 150mm made of cast iron were used for casting standard cubes. The standard moulds were fitted such that there is no gap between the plates of the moulds. The moulds were then oiled and kept ready for casting. The materials were quantified on weight basis. After 24hrs of casting, specimens were demoulded and transferred to a room where standard room temperature is maintained. One set of plain SCC batch (without Self-Curing compound) from each mix were transferred to curing tank wherein they were immersed in water for the desired period of curing. While the other batch of Plain SCC is kept in indoor curing. The mix proportion for both 70Mpa and 60Mpa Self Compacting Concrete mixes were designed by using modified nansu method. A flowchart showing the details of experimental program is shown in figure

2. Tests conducted:

Weights of all the cubes except plain SCC wet curing specimens, were taken on 1 day, 3 day, 7 day, 14 day, 21 day and 28 day age of concrete. 5cubes of each batch were tested for compressive strength on 7day and 28day age of concrete. The micro structural investigation was done using Scanning electron microscope(SEM), (TESCAN; MODEL:VEGA 3 LMU) coupled with energy dispersive X-ray (EDX),(Penta

FET precision, oxford instruments X-act) microanalysis. Secondary electron image (SEI) and back scattered electron image (BSE) was taken at micro level zoom for all fractured surfaces of samples of two mixes at the age of 28days. The details of the specimen's cast are shown in Table 4.1 & 4.2.

3. Materials used:

The different materials used in this study are

a) Cement: Cement used in the investigation was 53 Grade Ordinary Portland cement confirming to IS: 12269. The specific gravity of cement was 3.14 having initial and final setting time of 40 min and 560 min respectively.
b) Fine Aggregate: The fine aggregate was conforming to Zone-2 according to IS: 383. The fine aggregate used was obtained from a nearby river source. The specific gravity was 2.65, while the bulk density of sand was 1.45 gram/c.c.
c) Coarse Aggregate: Crushed granite was used as coarse aggregate. The coarse aggregate was obtained from a local crushing unit having 20mm nominal size, well graded aggregate according to IS: 383. The specific gravity was 2.8, while the bulk density was 1.5 gram/c.c.
d) Water: Potable water was used in the experimental work for both mixing and curing companion specimens.
e) Super plasticizer: High range water reducing admixture confirming to ASTM C94 commonly called as super plasticizer was used for improving the flow or workability for decreased water-cement ratio without sacrifice in the compressive strength. These admixtures when they disperse in cement agglomerates significantly, decreases viscosity of the paste forming a thin film around the cement particles. In the present investigation, water-reducing admixture CHRYSO FLUID OPTIMA P-77 (poly carboxylic ether based) obtained from Chryso Chemicals, India was used.

Properties of Chryso Fluid Optima P-77:

The physical Properties of Chryso Fluid Optima P-77 are listed in

Table 2. physical Properties of Chryso Fluid Optima P-77.

Physical Properties	
Form	Liquid
Color	Transparent to slight turbid
Specific Gravity	1.10 + 0.02
pH	Minimum 7.0
Air entrainment	<1.0 % over control mixes.
Chloride Content	Nil (As per BS: 5075)
Water Reduction	Up to 40 %

Norms & regulations :

CHRYSO Fluid Optima P-77 conforms to IS: 9103 and ASTM–C-494 Type G.

f) Hydrophilic chemicals:

PEG Low molecular and high molecular weight, Liquid paraffin wax and solid paraffin wax were used in the study. The chemicals were mixed with water thoroughly prior to mixing of water in concrete.

Table 3.Physical and Chemical properties of Paraffin Wax

Sr. No.	**Characteristics**	**Liquid Paraffin Light**	**Heavy Liquid Paraffin**
1	Specific gravity @ 25ºc	Between 0.820 to 0.860	Between 0.850 to 0.880
2	Dynamic viscosity @ 20ºc	Between 25 to 80 mpa	Between 110 to 230 mpa
3	Appearance	Clear colour less liquid.	Clear colour less liquid.
3	Solubility	Passes	Passes
4	Sulphur compounds	Compiles as per standards	Compiles as per standards
5	Solid paraffins	Compiles as per standards	Compiles as per standards
6	Flash point (PMCC), ºc	Min. 150 ºc	Min 200 ºC
7	Acidity / alkalinity	Passes	Passes
8	Light absorption @ 240-280 nm	Less than 0.1	Less than 0.1
9	Readily carbonisable	Passes	Passes

4. Mix Design proportions:

Self Compacting Concrete was developed based on modified Nansu method. The mix proportions of MIX- A and MIX-B were confirmed after several trail mixes. Table 4.6 & 4.7 shows the mix proportions of 70Mpa and 60Mpa self-compacting mixes concrete respectively.

5. Basic Properties of SCC:

Fresh SCC must possess at required levels the following key properties

a) Filling ability: This is the ability of the SCC to flow into all spaces within the formwork under its own weight.
b) Passing ability: This is the ability of the SCC to flow through tight openings such as spaces between steel reinforcing bars under its own weight.
c) Resistance to segregation: The SCC must meet the required levels of properties (a) & (b) while its composition remains uniform throughout the process of transport and placing. Many tests have been used in successful applications of SCC. However, in all the projects the SCC was produced and placed by an experienced contractor whose staff has been trained and acquired experience with interpretation of a different group of tests. In other cases, the construction was preceded by full-scale trials in which a number, often excessive, of specific tests was used (Ouchi et al., 1996). The same tests were later used on the site itself.

6. Tests for Fresh Properties of Self Compacting Concrete

The final selection of recommended test methods was based mainly on their relation to one or more of the key properties of SCC (filling ability, passing ability, and resistance to segregation) as well as on reproducibility and repeatability. the slump flow combined with T50 was selected as the first priority test method for the filling ability of SCC. The V-funnel or Orimet tests are recommended as second priority alternatives to the T50 measurement.The passing ability of fresh SCC can be tested by L-box or J-ring. There is some, but not very good, correlation between their results. The repeatability and reproducibility are acceptable to good for both tests. For the L-box test, a long practical experience was available, which led to a well-documented blocking criterion and correlation with the behavior in real construction elements was shown to be good. For the J-ring test, no clear information is available on the blocking criterion, but it could be a potential method for combining the measurement of the different properties of filling and passing ability. After detailed evaluation, the consortium selected both L-box and J-ring as the test methods for passing ability with equal priority. It is important to note that recommendations only go as far as proposals for the test methods for standardization. No acceptance criteria were formulated in this project, but these have subsequently been considered by a European group of organizations representing concrete producers and users, in which several of the project consortiums participated.These However, from practical considerations, it seems logical that the acceptance testing on-site could be based on the slump test solely (possibly combined with T50); while for initial type testing all test methods listed in first priority could be used. For particular purposes, the reference test methods could be extended or replaced by one or more of the alternative methods.

Table 4. Details of specimens cast for Mix-A.

S.NO	70MPa(Mix A)		
	Type of Concrete	**Percentage of Self-Curing compound**	**No. of cubes cast150x150x150mm**
1	Indoor curing SCC without Self-Curing compound (**AI 1**)	0%	10
2	Wet curing SCC without Self-Curing compound (**AW 1**)	0%	10
3	Indoor curing SCC with PEG4000 Self-Curing compound (**AH 1**)	1%	10
4	Indoor curing SCC with PEG200 Self-Curing compound (**AL 1**)	1%	10
5	Indoor curing SCC with lightweight liquid paraffin wax Self-Curing compound (**AV 1**)	1%	10
6	Indoor curing SCC with heavy weight liquid paraffin wax Self-Curing compound (**AP1**)	1%	10
TOTAL SPECIMENS			**60**

Table 5. Details of specimens cast for Mix-B.

S.No	60Mpa (Mix B)		
	Type of Concrete	**Percentage of Self-Curing compound**	**No. of cubes cast150x150x150mm**
1	Indoor curing SCC without Self-Curing compound (**BI 1**)	0%	10
2	Wet curing SCC without Self-Curing compound (**BW2**)	0%	10

3	Indoor curing SCC with PEG4000 Self-Curing compound (**BH1**)	1%	10
4	Indoor curing SCC with PEG200 Self-Curing compound (**BL 1**)	1%	10
5	Indoor curing SCC with lightweight liquid paraffin wax Self-Curing compound (**BV 1**)	1%	10
6	Indoor curing SCC with heavy weight liquid paraffin wax Self-Curing compound (**BP 1**)	1%	10
TOTAL SPECIMENS			**60**

IV. RESULTS AND DISCUSSIONS

1. Compressive strength:

The compressive strength of Mix-A and Mix-B with and without Self-Curing compounds under indoor and wet curing are listed below.

MIX-A:

The compressive strength results of 70Mpa Self Compacting Concrete with and without Self-Curing Concrete inclusions are listed in Table 5.1 and the graphical comparison was shown in figure 5.1. It can be clearly said that the 28day strength of AW specimen that are kept for wet curing show the maximum compressive strength than other batches with Self-Curing compound inclusions.

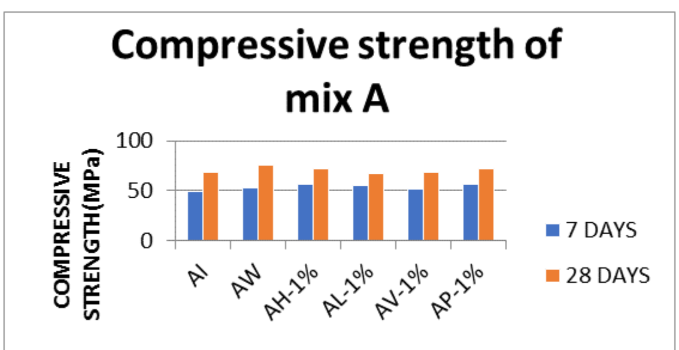

Figure 1. Average compressive strength graph of MIX-A

MIX-B:

The compressive strength results of 60Mpa Self Compacting Concrete with and without Self-Curing Concrete inclusions are listed in Table 5.2 and the graphical comparison was shown in figure 5.3. It can be clearly said that the 28day strength of BW specimen.The least value of compressive strength was shown by SCC with light weight liquid paraffin wax specimens. The percentage increase in strength gain from 7days to 28days is maximum in wet cured plain SCC specimen with an increase of 38.8%.

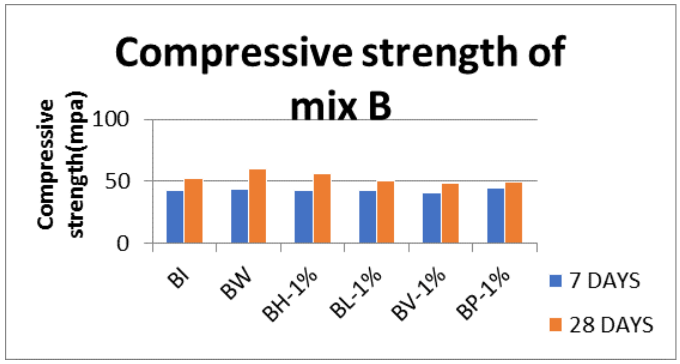

Figure 2. Average compressive strength graph of MIX-B

2. Water retention or Weight loss test:

The water retention test was conducted on the cubes kept in indoor curing and weighed on 1 day, 3day, 7 day, 14 day, 21 day and 28 day from the date of casting. Weight losses for MIX-A and MIX-B specimens are listed in table 5.3 & 5.4 and their behaviour is plotted on graph against number of days of curing in figure 5.5 & 5.6 respectively.

Mix-A:

Average weight loss of MIX-A with and without Self-Curing compound.

Table 6.

MIX-A	0days	3days	7days	14days	21days	28days	56days
AH 1	0	48	57	66	74	80	126
AL 1	0	60	70	78	89	100	147
AV 1	0	78	91	102	114	120	157
AP 1	0	63	76	88	100	111	144
AI	0	54	68	80	94	109	150

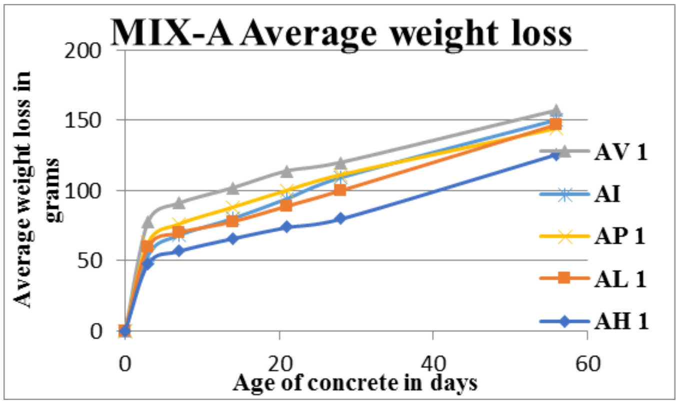

Figure 3. Average weight loss graph of MIX-A with and without Self-Curing compound.

MIX-B:

Average weight loss of MIX-B with and without Self-Curing compound.

Table 7.

MIX-B	0days	3days	7days	14days	21days	28days	56days
BI	0	45	76	90	110	124	159
BH 1	0	30	43	65	82	94	133
BL 1	0	80	105	126	138	145	170
BV 1	0	94	117	139	150	156	187
BP 1	0	75	101	120	131	140	156

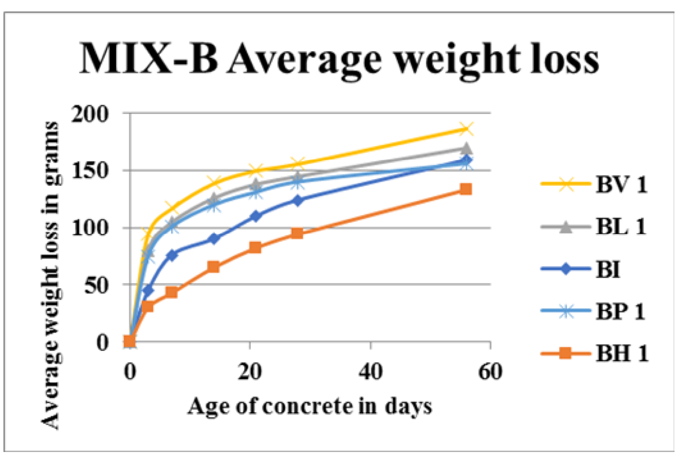

Figure 4.

V. CONCLUSION

The results of this study has demonstrated that the laboratory synthesized water-soluble polymer PEG can be used effectively to produce Self Compacting Concrete with properties superior to those of non-cured mixes.All the tests for fresh properties of Self Compacting Concrete are within range of EFNARC specifications for both mixes.Among all the Self-Curing agents investigated in this work, PEG4000 is more effective in improving the degree of hydration and water retention capacity in both mix-A and mix-B compared to other type of curing compounds.The optimum dosage of PEG4000 for maximum compressive strength was found to be 1% for both Mix-A and Mix-B. It attains a maximum of 4% and 7% increase in 28 days compressive strength results when compared to indoor curing plain SCC for mix-A and mix-B respectively.Wet cured sample SCC specimens have shown better compressive strength results because the pozzolanic admixtures (micro silica and fly ash) have thirst of water for hydration with CH crystals and the demand for supply was met through continuous wet curing.The average weight loss is more for both SCC mixes with light weight liquid paraffin wax throughout the age of indoor curing. It indicates the water retention capacity is lower than other Self-Curing compounds. However all specimens of 60Mpa concrete show more weight loss when compared to 70MPaconcrete due to higher water cement ratio.For both mixes SCC with PEG4000 specimens have shown less average weight loss throughout the age of curing and have undergone less shrinkage loss.

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