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# Internal Curing of Self Compacting Concrete using Polyethylene Glycol

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***Abstract*— Self-curing is done in order to fulfill the water requirements of concrete whereas self-compacting concrete is prepared so that it can be placed in difficult positions and congested reinforcements. This investigation is aimed to utilize the benefits of both self-curing as well as self-compacting. The present investigation involves the use of self-curing agent viz., polyethylene glycol (PEG) of molecular weight 400 (PEG 400) for dosages ranging between 0.1 to 1% by weight of cement added to mixing water. Comparative studies were carried out for compressive strength for conventional SCC and self-cured SCC. The optimum dosage of PEG-400 for maximum strength was observed to be 1%. It were observed that increase in dosage of PEG shows that also increases strength of SCC.**

***Keywords*— self-curing, polyethylene glycol (PEG), water retention, compressive strength**

## INTRODUCTION

Self-compacting concrete is basically a concrete which is capable of flowing in to the formwork, without segregation, to fill uniformly and completely every corner of it by its own weight without any application of vibration or other energy during placing. In SCC, 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 coarse aggregate content in concrete is generally fixed at 50 percent of the total solid volume, the fine aggregate content is fixed at 40 percent of the mortar volume and the water /powder ratio is assumed to be 0.9-1.0 by volume depending on the properties of the powder and the super plasticizer dosage. The required water /powder ratio is determined by conducting a number of trials.

Curing is the maintenance of a satisfactory moisture content and temperature in concrete for a period of time immediately following placing and finishing so that the desired properties may develop. Sometimes it's become very difficult to use conventional curing method due to the shortage of water, water contains fluoride and other constituents which may harmful for concrete, in vertical member it is difficult to keep the surface moist in case of flat surface. Internal curing refers to the process by which the hydration of cement occurs because of the availability of additional internal water that is not part of the mixing Water. Conventionally, curing concrete means creating conditions such that water is not lost from the surface i.e., curing is taken to happen from the outside to inside. In contrast, internal curing is allowing for curing from the inside to outside through the internal reservoirs (in the form of saturated lightweight fine aggregates, superabsorbent polymers) Created. Internal curing is often also referred as Self–curing. When the mineral admixtures react completely in a blended cement system, their demand for curing water (external or internal) can be much greater than that in a conventional ordinary Portland cement concrete. When this water is not readily available, due to depercolation of the capillary porosity, for example, significant autogenous deformation and (early-age) cracking may result. Due to the chemical shrinkage occurring during cement hydration, empty pores are created within the cement paste, leading to a reduction in its internal relative humidity and also to shrinkage which may cause early-age cracking. So we need a self curing.

Mechanism of internal curing- Continuous evaporation of moisture takes place from an exposed surface due to the difference in chemical potentials (free energy) between the vapour and liquid phases. The polymers added in the mix mainly form hydrogen bonds with water molecules and reduce the chemical potential of the molecules which in turn reduces the vapour pressure, thus reducing the rate of evaporation from the surface.

## METHODOLOGY

The experimental program is designed to investigate the strength of self-curing self-compacting concrete by adding poly ethylene glycol PEG400 @ 0.1%, 0.5% and 1% by weight of cement to the concrete. The experimental program is aimed to study the workability, compressive strength and water retention capacity. The slump flow test, J ring test, U box test, L box and V-Funnel test were conducted for all mixes to know the fresh property of concrete. Compressive strength test was conducted at 7 and 28 days. The cubes were weighed for 7, 28 days from the date of demoulding to

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investigate the water retention capacity. In this investigation the maximum dosage of self-curing agent was restricted to 1% and minimum dosage to 0.1%. Two different mixes with 28 days cube compressive strengths of concrete were aimed i.e.50MPa.

EXPERIMENTAL DETAILS.

*1. MATERIAL USED*

The different types of material used in this investigation are given below:

1. Cement
2. Fine Aggregate
3. Coarse Aggregate
4. Polyethylene Glycol (PEG -400)
5. Polycarboxylate Ether (Superplasticizer)
6. Water

1. Cement- Cement used in the investigation was 53 grade Ordinary Portland cement (OPC) confirming IS: 12269-1987.

Physical Properties of Cement

| | | |
|---|---|---|
| 1 | Specific gravity | 3.14 |
| 2 | Initial setting time | 40 min |
| 3 | Final Setting time | 560 min |

2. Fine Aggregate –The fine aggregate conforming to zone II according to IS: 383-1970 was used. The fine aggregate used was obtaining from a nearly river course.

3. Coarse Aggregate – The coarse aggregate used is procured from a local crushing unit having 20mm nominal size. 20mm well-graded aggregate according to IS-383 is used in this investigation.

Physical properties of coarse aggregate

| | | |
|---|---|---|
| 1 | Fineness modulus | 7.3 |
| 2 | Bulk density | 1.5 gm/cc |
| 3 | Specific gravity | 2.80 |

4. Polyethylene Glycol – Polyethylene glycol is a condensation polymer of ethylene oxide and water with general formula H (OCH2CH2)nOH, where n is average number of repeating oxyethylene groups typically from 4 to 180 . The abbreviation (PEG)is termed in combination with a numeric suffix which indicate the average molecular weight.

5.Polycarboxylate Ether – High range water reducing admixture commonly called as superplasticizer was used for improving the flow or workability for decreased water-cement ratio without sacrifice in the compressive strength.

6.Water – Potable water was used in the experimental work for both mixing and curing purposes.

MATERIAL

| | | |
|---|---|---|
| 1 | Cement | 560.85 kg/m3 |
| 2 | Fine Aggregate | 196.3 litre |
| 3 | Coarse Aggregate | 945.34 kg/m3 |
| 4 | Chemical admixture | 786.271 kg/m3 |
| 5 | Water | 11.21 litre |
| 6 | Water/Cement ratio | 0.35 |

2. TESTS.

*Workability Test*

*Slump flow Test*

The slump flow test, using the traditional slump cone, is the most common field test. The slump cone is completely filled without consolidation, the cone lifted, and the spread of the concrete measured. The spread can range from 550 to 850 mm. During the slump flow test, the viscosity of the SCC mixture can be estimated by measuring the time taken for the concrete to reach a spread diameter of 500 mm from the moment the slump cone is lifted up. This is called the $T_{20}$ ($T_{50}$) measurement and typically varies between 2 and 10 seconds for SCC. Figure 1 show the slump flow test.

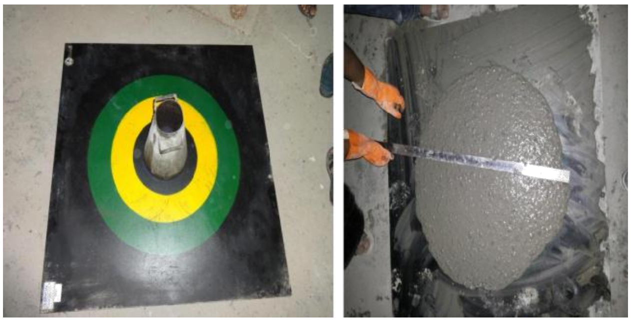

Figure 1 Slump Flow Test

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*J ring test*

The J-ring test aims at investigating both the filling ability and the passing ability of SCC. It can also be used to investigate the resistance of SCC to segregation by comparing test results from two different portions of sample. The J-ring test measures three parameters: flow spread, flow time $T50_J$ (optional) and blocking step. The J-ring flow spread indicates the restricted deformability of SCC due to blocking effect of reinforcement bars and the flow time $T50_J$ indicates the rate of deformation within a defined flow distance. The J-ring test is shown in Figure 2.


Figure 2J-ring test

*U box test*

The U Shape Box is used to determine the confined flowing ability and the capacity of SCC concrete to flow within confined space. The box is made of steel frame consisting of three bars. In this test the degree of compatibility can be indicated by the height that the concrete 37 reaches after flowing through an obstacle. The quality of the concrete can be judged by the height reached.

*L box Test*

The method aims at investigating the passing ability of SCC. It measures the reached height of fresh SCC after passing through the specified gaps of steel bars and flowing within a defined flow distance. With this reached height, the passing or blocking behaviour of SCC can be estimated. Figure 3 shows the L-box apparatus.

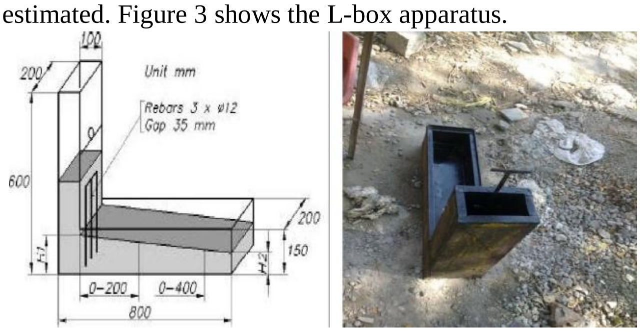


Figure 3 L-Box Test

*V Funnel test*

The V-funnel flow time is the period a defined volume of SCC needs to pass a narrow opening and gives an indication of the filling ability of SCC provided that blocking and/or segregation do not take place; the flow time of the V-funnel test is to some degree related to the plastic viscosity. Figure 4 shows the V-funnel test

Figure 4 V-Funnel Test

*Test for hardened Properties of concrete*

*Water Retention Test*

Water Retention is the ability of the substance to retain water. To perform the water retention test, the cubes were weighed at 3, 7, 14, 21, 28 and 56 days from the date of demoulding. Weight loss for the specimens in indoor curing, and weight gain for the conventional curing were noted and their behaviour was plotted in graph against number of days of curing.

*Compressive Strength of Concrete*

The compressive strength test is conducted after 7 days and 28 days.

## RESULT AND DISCUSSION

Slump flow test

| Dosage of PEG 400 | Slum flow range (550-850mm) |
|---|---|
| 0% | 655 |
| 0.1% | 570 |
| 0.5% | 620 |
| 1% | 560 |

T50 test

| Dosage of PEG 400 | T50 value (2-5sec) |
|---|---|
| 0% | 2.7 |
| 0.1% | 2.455 |
| 0.5% | 3 |
| 1% | 3.6 |

J ring test

| Dosage of PEG 400 | J ring value (0-10mm) |
|---|---|
| 0% | 8 |
| 0.1% | 7 |
| 0.5% | 7 |
| 1% | 7 |

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L box test

| Dosage of PEG 400 | L box value(0.8-1.0sec) |
|---|---|
| 0% | 0.87 |
| 0.1% | 0.875 |
| 0.5% | 0.887 |
| 1% | 0.889 |

V Funnel test

| Dosage of PEG 400 | V Funnel value (6-12mm) |
|---|---|
| 0% | 9.67 |
| 0.1% | 5.98 |
| 0.5% | 6.34 |
| 1% | 8.24 |

*Test for Hardend properties of concrete*

Weight loss

| Designation | 7 days weight (gm) | 28days weight (gm) |
|---|---|---|
| AI | 138.00 | 183.24 |
| AH0.1% | 172.40 | 216.80 |
| AH0.5% | 156.80 | 186.71 |
| AH 1% | 135.70 | 177 |

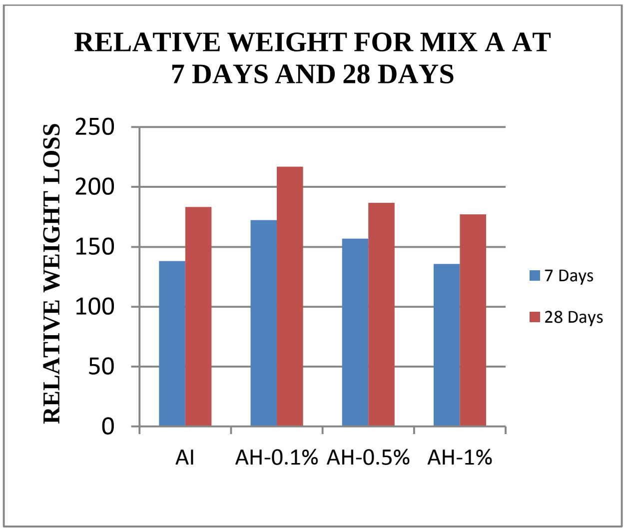


Figure 5 Relative Weight Loss For Mix A At 7 And 28 Days

Compressive strength test

| Designation | 7 days Strength (N/mm2) | 28 days Strength (N/mm2) |
|---|---|---|
| AI | 34.88 | 50.37 |
| AW | 39.31 | 54.25 |
| AH0.1% | 36.31 | 45.17 |
| AH0.5% | 33.29 | 46.11 |
| AH1% | 34.31 | 46.85 |

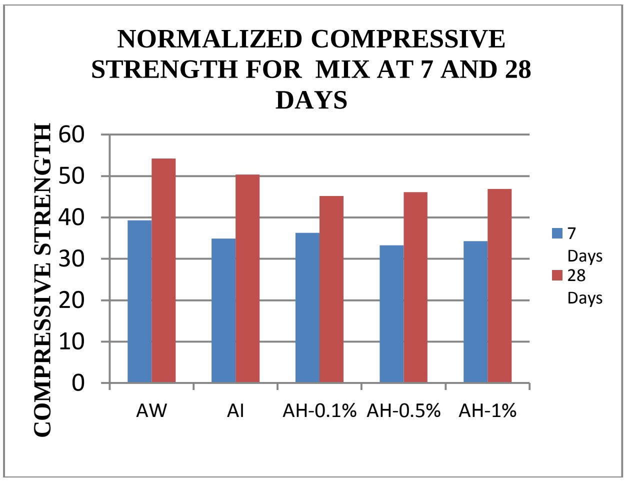


Figure 6 Compressive Strength For Mix A At 7 And 28 Days

## CONCLUSIONS

Increasing the percentage dosage of PEG-400 increases the weight loss for lower w/c ratio. Thus lower dosage showing better water retention for lower w/c ratio.

Compressive strength of SCC with high w/c ratio does not show favorable results and were observed to be less than indoor curing for all the dosages. Thus addition of PEG-400 for high w/c ratio is insignificant.

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