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RESEARCH ARTICLE

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STUDY AND ANALYSIS OF SELF-CURING CONCRETE USING POLYETHYLENE GLYCOL

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ABSTRACT

Maintaining necessary moisture content in concrete during its early ages, is very important to develop the required properties. To achieve this excessive evaporation from the concrete surface should be prevented. Failure to do this leads to lower degree of cement hydration and results concrete with unsatisfactory properties. This paper presents an attempt made to achieve optimum cure of concrete without applying external curing methods. The present investigation involves use of water soluble lower molecular weight polyethylene glycol (PEG 200) as self-curing agent. The dosage of PEG 200 was 0.1, 1 and 2% by weight of cement. In this investigation the main variable parameter was w/c ratio. For each w/c ratio two concrete mixes were cast, one which includes the self curing agent and the other is conventional mix. Two curing regimes were considered for conventional concrete mixes without self-curing agent, continuously moist-curing under water and air-curing. Compressive strength and concrete weight loss measurements with time were carried out to evaluate strength development and water retention ability. Comparative studies of workability, water retention and compressive strength were done for specimens cured under different methods of curing.

Keywords: Water soluble polymer; Self-curing agent; Self-curing concrete; Water retention

INTRODUCTION

The term “curing” is frequently used to describe the process by which hydraulic-cement concrete matures and develops hardened properties over time as a result of the continued hydration of the cement in the presence of sufficient water and heat [1]. Adequate curing is essential for concrete to obtain structural and durability properties and therefore is one of the most important requirements for optimum concrete performance. Curing of concrete is the process of maintaining the proper moisture conditions to promote optimum cement hydration immediately after placement [2]. 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 [3]. 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. 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. This situation is

intensified in HPC (compared to conventional concrete) due to its generally higher cement content, reduced water-cement (w/ c) ratio and the pozzolanic mineral admixtures (fly ash, silica fume) [4]. The scope of the paper is to study the effect of water soluble polymer polyethylene glycol (PEG) on strength characteristics and water retention of Self-curing concrete. The objective is to study the compressive strength and water retention and to decide the optimum dosage for different curing conditions by varying the percentage of PEG from 0.1% to 2% by weight of cement. To compare the efficiency of different self-curing compounds used in concrete [5].

Experimental Details:

Materials Used:

- Cement
- Fine Aggregate
- Coarse Aggregate
- Polyethylene glycol

Nomenclature for Specimen:

MIX A - 1:1.4:2.6:0.35

MIX B - 1:1.4:2.6:0.45

O - Ordinary Portland cement (OPC)

L - PEG 200 (Lower Molecular Weight)

I - Indoor Curing

W - Wet/Conventional Curing

S.C.A- Self-Curing Agent

- For example sample with name AOI represents Mix A with ordinary Portland cement and without PEG and subjected to indoor curing.
- Similarly, AOW represents Mix A with ordinary Portland cement and without PEG subjected to conventional water-curing.
- BL-1 represents Mix B with 1% dosage of PEG 200 by weight of cement and subjected to indoor curing.

Experimental setup:

To study the workability, water retention and compressive strength two mixes were considered. One mix is designed to give strength of about 40 mpa and other mix to give strength of about 60 mpa. The main variable parameter in this study was w/c ratio. For each w/c ratio two concrete mixes were cast, one which includes the self curing agent and the other is conventional mix. Total 90 cubes (150x150x150) mm were cast which involves different dosages 0.1%, 1% and 2% of self-curing agents (PEG-200) under different curing conditions. Two curing regimes were used for conventional concrete mixes without self-curing agent, continuously moist-curing under water and air-curing. The flow chart shows the experimental program as shown in the figure 1.

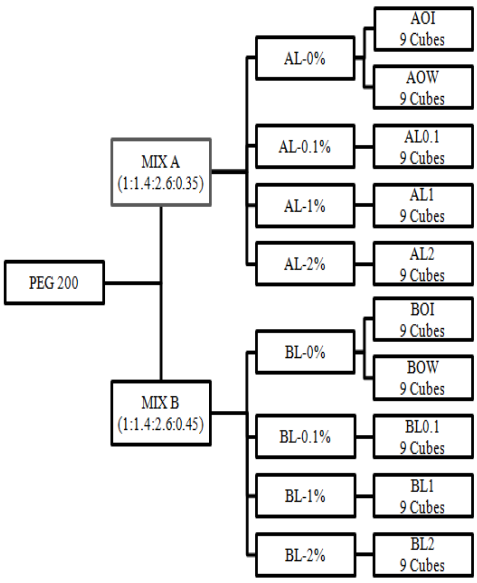

Fig 1: Flow chart for experimental program

Workability Test:

Compacting Factor Test

It is more precise and sensitive than the slump test and is particularly useful for concrete mixes of very low workability as are normally used when concrete is to be compacted by vibration. Such dry concrete are insensitive to slump test. This test works on the principle of determining the degree of compaction achieved by a standard amount of work done by allowing the concrete to fall through a standard height. The degree of compaction, called the compacting factor is measured by the density ratio i.e. the ratio of the density actually achieved in the test to density of same concrete fully compacted.

Table1: Compacting factor test of concrete

Percentage Dosage of PEG	Compacting Factor	
	AL	BL
0.1	0.947	0.979
1	0.945	0.97
2	0.955	0.971

Water Retention Test:

Water Retention is the ability of the substance to retain water. Weight loss with age was measured to evaluate the water retention of the mix. In both mixes, the weight loss for mix without self-curing agent is more than mix including self-curing agent. This shows better water retention for self-curing mixes.The weight of cubes at different ages for BOI, BOW, BL0.1, BL1, BL2, AOI, AOW, AL0.1, AL1 and AL2 are shown in the Table 2 &3.

Designation	Curing Period, Days							Weight loss Ratio
	0	3	7	10	14	20	28	
A0W	0	-	0.025	-	0.035	-	0.023	
A0I	0	-0.058	-0.067	-0.067	-0.069	-0.077	-0.084	1
AL 0.1	0	-0.017	-0.023	-0.052	-0.060	-0.053	-0.037	0.440
AL 1	0	-0.027	-0.033	-0.058	-0.062	-0.060	-0.040	0.476
AL 2	0	-0.029	-0.035	-0.060	-0.063	-0.065	-0.045	0.535

Table 2: Average weight loss of cubes for Mix A

Designation	Curing Period, Days							Weight loss Ratio
	0	3	7	10	14	20	28	
BOW	0	-	0.100	-	0.117	-	0.120	
BOI	0	-0.109	-0.116	-0.122	-0.127	-0.139	-0.136	1
BL0.1	0	-0.071	-0.084	-0.096	-0.096	-0.105	-0.120	0.882
BL1	0	-0.079	-0.089	-0.099	-0.100	-0.110	-0.122	0.897
BL2	0	-0.070	-0.078	-0.089	-0.090	-0.100	-0.114	0.838

Table 3: Average weight loss of cubes for Mix B

Compressive Strength:

The self-curing concrete is subjected to air-curing (AL and BL) and conventional concrete is subjected to air-curing (AOI and BOI) and water-curing (AOW and BOW).

Results and Discussions:

Workability:

The graphical representation of Compaction Factor results was shown in Fig.2. As the percentage dosage of SCA was increased the Compaction Factor was found to decrease up to 1% after that again it increased. This trend is same for both the mixes. However, the increase in Compaction Factor beyond 1% is significant in mix with w/c ratio 0.35.

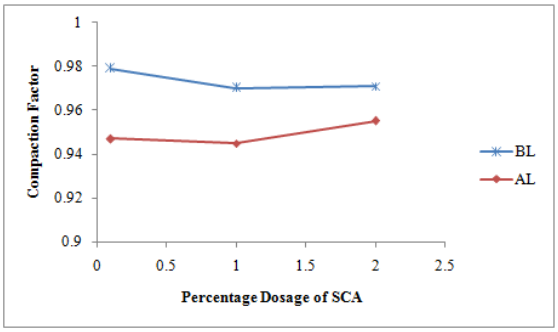

Fig 2: Compacting Factor of Concrete for different dosage of PEG 200

Water Retention:

From the figure 3 it is clear that the Mix A self-curing concrete with 0.1% dosage of lower molecular weight polyethylene glycol (PEG 200) shows least weight loss compare to other dosages (1% and 2%). Similarly from Mix B self-curing concrete with 2% dosage of PEG 200 shows better water retention compare to other dosages. But when mix with lower w/c ratio together with super-plasticizer shows better water retention (lower value in weight loss) compare to mix with higher w/c ratio and without super-plasticizer.

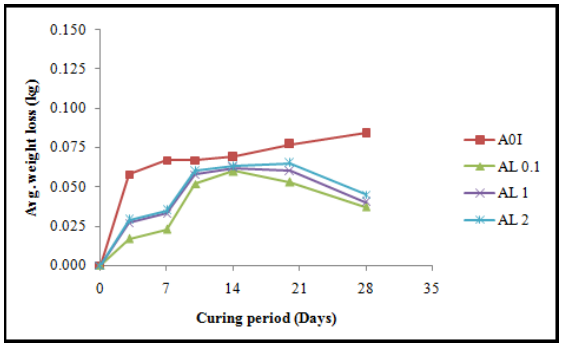

Fig 3: Weight loss with time for Mix A

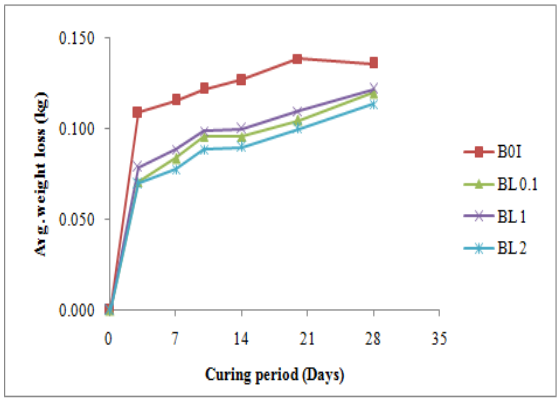

Fig 4: Weight loss with time for Mix B

The variation of average weight loss of cubes with percentage dosages of PEG 200 is shown in Fig 5 & 6. In Mix A with increase in dosage of PEG 200 average weight loss increased. But in Mix B average weight loss first increased up to 1% and then decreased as the dosages of PEG 200 was increased.

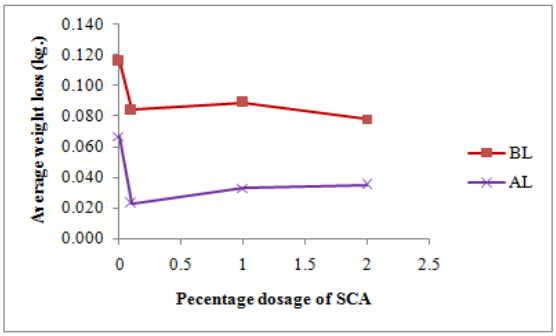

Fig 5: Variation of 7D Avg. weight loss with dosages of PEG 200

In Mix A, the average weight loss of self-curing concrete with 0.1% dosage of PEG 200 and subjected to air-curing decreased up to 14 days of curing period then it again increased up to 28 days of curing period when compared to conventional concrete subjected to air-curing. But in Mix B the average weight loss of self-curing concrete with 0.1% of PEG 200 decreased with curing period up to 28 days when compared to conventional concrete and subjected to air-curing.

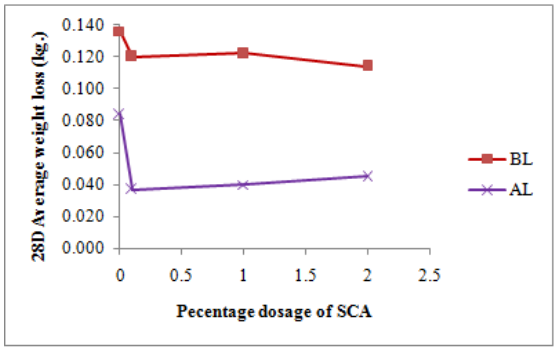

Fig 6: Variation of 8D Avg. weight loss with dosages of PEG 200

Compressive Strength:

Self-curing concrete with 0.1% dosage of PEG 200 gives higher strength when compared with control concrete cured continuously under water. There is a significant increase in strength of about 4.37% and 3% respectively. At 14 days of age, self-curing concrete with 0.1% dosage of PEG 200 gives a comparable result to control concrete subjected to water-curing. However, the 28 days compressive strength of conventional concrete subjected to air-curing is higher than that of control concrete cured continuously under water. Self-curing specimens with 0.1% dosage of PEG 200 give higher compressive strength compare to specimens with other dosages.

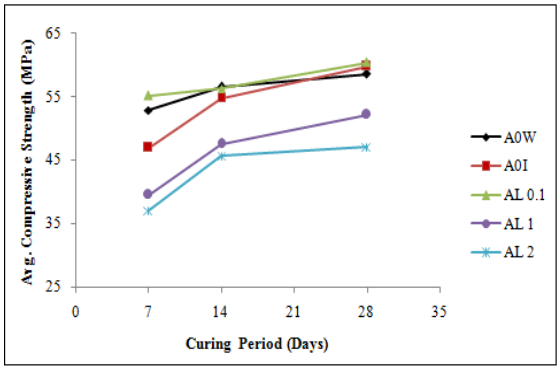

Fig 7: Compressive Strength of Mix A

From the figure 8 it was seen that at 7 days of age, self-curing specimens containing PEG 200 show higher compressive strength compare to conventional air-cured specimens. However, the strength of concrete containing 0.1% dosage of PEG 200 was on par with conventional concrete cured continuously under water. At 14 days of age, self-curing specimen with 0.1% dosage of PEG 200 shows higher strength compare to other dosages, but shows less strength than conventional concrete subjected to air and water curing. At 28 days of age, self curing concrete give compressive strength comparable to conventional concrete subjected to air-curing but when compared with conventional concrete cured continuously under water, there is a reduction of about 21%.

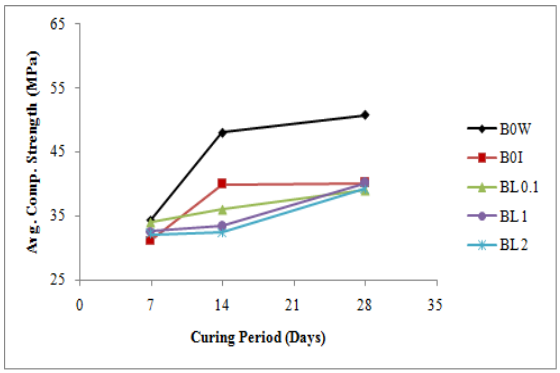

Fig 8: Compressive Strength of Mix B

CONCLUSIONS:

Effectiveness of self-curing concrete is affected by w/c ratio and percentage dosages of self-curing agent. The workability of concrete with low w/c ratio together with super-plasticiser has significant effect due to lower molecular weight polyethylene glycol (PEG 200). Water retention of concrete mixes incorporating PEG 200 is higher compared to conventional concrete mixes. The compressive strength of concrete with low w/c ratio and lower dosages of self-curing agents is beneficial. Concrete with low w/c ratio and lower dosages of self-curing agents shows better water retention. Concrete mixes incorporating self-curing agents show better water retention compared to conventional concrete mixes. High grade concrete with 0.1% dosage of higher molecular weight polyethylene glycol (PEG 4000) shows good compressive strength and better water retention. Low grade concrete with 0.1% dosage of poly-acrylic acid shows good compressive strength and better water retention.

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