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Study on Durability Characteristics of Conventional Concrete with PEG-600 as Self Curing Compound

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ABSTRACT

This investigation is aimed to utilize the benefits of self-curing compound poly ethylene glycol 600 in conventional concrete. The present investigation involves the use of self-curing compound Polyethylene glycol (PEG) of molecular weight 600 for varying dosages ranging between 0.1-2 percent. The strength class 30 MPa was considered. Workability tests such as slump test, compacting factor test and vee-bee consistency tests were conducted on the fresh concrete whereas compressive strength and sorptivity were evaluated to determine the durability properties of hardened concrete. The results indicate that PEG 600 of dosage of 1.5% gives better durability characteristics to 30MPa conventional concrete.

Key words: Self Curing Concrete, PEG, Water Retention, Sorptivity, Compressive strength

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INTRODUCTION

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. With insufficient water the hydration will not proceed and the resulting concrete may not possess the desirable strength and impermeability. The near surface region of concrete is particularly affected, failing to provide a protective barrier against ingress of harmful agents. Proper curing of concrete structures is important to meet performance and durability requirements. Enough water needs to be present in a concrete mix for the hydration of cement to take place. However, even mix contains enough water, any loss of moisture from the concrete will reduce the initial water cement ratio and result in incomplete hydration of cement especially with the mixes having low water cement ratio. This results in very poor quality of concrete

The method of applying PEG as an internal curing agent was first considered by Tak et al [1] and they carried work on internal curing composition for concrete which includes a glycol and a wax. The invention provides for the first time an internal curing composition which, when added to concrete or other cementitious mixes meets the required standards of curing as per Australian Standard AS 3799[19]. Jau [2] stated that self-curing concrete is provided to absorb water from moisture from air to achieve better hydration of cement in concrete. It solves the problem that the degree of cement hydration is lowered due to no curing or improper curing, and thus unsatisfactory properties of concrete. The self-curing agent used in this study was poly acrylic acid (PAA) and polyvalent alcohol. These two chemicals are most hydrophilic in nature. The dosage of self-curing agent was 1% and 2% by weight of cement. Compressive strength and water retentivity test was carried under different relative humidity conditions like 50%, 67.5% and 85%. This was also found that the more is the relative humidity more will be the compressive strength for self-curing concrete. El-Dieb [4] investigated water retention of concrete using water-soluble polymeric glycol as self-curing agent. Also, water transport through this concrete is evaluated and compared to conventional concrete continuously moist-cured and air-cured. The dosage of self-curing agent was 0.02% by weight of cement. The dosage was kept constant for all the self-curing concrete mixes. The investigation aimed at studying on concrete with different quantities of cement (350-450Kg/m3) at different water- cement ratios (0.3-0.4) both for self, conventional and air- curing concrete and compare the results for different test. Water sorptivity and water permeability values for self-curing concrete decreased with age indicating lower permeable pores percentage as a result of the continuation of the cement hydration. Collepardi [5**]** their research work was to make a drying shrinkage-free concrete (SFC), even in non-wet curing conditions. This concrete was produced by the combined use of a water-reducing admixture, based on polycarboxylate (PA), in order to reduce both the mixing water and cement, and increase the amount of aggregate; a special polycarboxylate (PA/SRA) including, in its molecular structure, a shrinkage-reducing admixtures (SRA) based on polyethylene glycol capable of reducing the surface tension of liquid water filling the capillary pores. El-Dieb et al [6] investigates using laboratory synthesized water-soluble polymers such as polyethylene glycol (PEG) and poly acryl amide(PAM) as self-curing agents and its effect on the degree of hydration, water absorption, permeable pores and micro structural characteristics of Portland cement mixtures without and with 8% silica fume replacement. Portland cement mixtures including PEG or PEG+PAM as self-curing agents showed a better quality compared to that of then on-cured mixtures. The results of a series of durability tests conducted on self-cure concrete. The tests were the initial surface absorption test, the potential difference (PD) chloride diffusion test, and depth of carbonation, half-cell corrosion potential and measurement of freeze / thaw resistance. The improvements in concrete durability properties are dependent on chemical dosage. At the highest dosage used in this study properties approaching, and in some cases as good as, those characteristic of the film. Kumar [8] study involves the use of shrinkage reducing admixture polyethylene glycol (PEG 400) in concrete which helps in self curing and helps in better hydration and hence strength. Golias et al [11**]** explores the potential for manufacturing internally cured concretes with lightweight aggregate (LWA).

From detailed literature review, the following points are evident: The use of self-curing compound is necessitated in normal concrete to achieve maximum hydration compared to other curing conditions. The use of hydrophilic chemicals in concrete will give better performance compared to light weight aggregate (LWA) and super absorbing polymers (SAP). LWA and SAP have less mechanical properties. So instead of these materials hydrophilic chemicals can be replaced. There is need to do work on self curing compound PEG-600 used in conventional concrete.

The objectives of the work are as follows:

- To determine the water retention capacity of all mixes by measuring weight loss of cubes at 3days, 7days, 14days, 21days and 28 days.
- To determine the compressive strength of cubes at 7days, 14days, 21days and 28 days.
- To determine the sorptivity of the cubes at 10min, 20min, 30min, 60min, 120min, 180min, 24h, 48h and 72h.

MATERIALS

Cement
Cement used in the investigation was 53 Grade Ordinary Portland cement confirming to IS: 12269 [18]. The specific gravity of cement was 3.14 and having initial and final setting time of 50 min and 560 min respectively.

Fine Aggregate
The fine aggregate was conforming to Zone-II according to IS: 383 [14]. The fine aggregate used was obtained from a nearby river source. The specific gravity was 2.62, while the bulk density of sand was 1.43 gram/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[14]. The specific gravity was 2.83, while the bulk density was 1.52 gram/c.c.

Hydrophilic Chemicals
PEG Low molecular weight was used in the study. The chemical was mixed with water thoroughly prior to mixing of water in concrete.

Nomenclature of Specimens
In the present study, the nomenclature of specimens is given as ‘B’ for 30 MPa grade concrete. PEG of molecular weight 600 is denoted as ‘V’. ‘I’ represents indoor cuing with 0% dosage and ‘W’ represents conventional/water curing with 0% dosage respectively. The percentage of dosage is taken as 0%, 0.1%, 0.5%, 1.0%, 1.5% and 2.0% percent by weight of cement. For example BV-0.1 represents specimen of 30 MPa grade concrete containing curing compound of PEG 600 with a dosage of 0.1%.

CASTING, CURING AND TESTING

The concrete mixes were prepared in a laboratory mixer with the capacity of 120kg. For each group, total of 9 samples of cube specimens with the dimension of 150 mm were prepared. The specimens were kept in laboratory conditions for 24 h until demoulding and kept for curing. To study the durability properties different tests such as water retention and sorptivity were conducted.

Fig.1 (a) Cubes after demoulding

Fig. 1 (b) Cured specimens for testing

Fig.1 (c) Tests on fresh properties of concrete

Fig.1 (d) Compressive testing machine

Fig.1(e) Applying wax to the sides of the cube specimen

Fig.1 (f) Specimens under sorptivity test

TESTS CONDUCTED

Compressive Strength

The cube specimens were tested on compression testing machine of capacity 200 Tonnes. The bearing surface of the machine was wiped off clean and any loose sand or other material removed from the surface of the specimen the load applied was increased continuously at a constant rate until the resistance of the specimen to the increasing load breaks down and no longer can be sustained. The maximum load applied on the specimen was recorded. The compressive strength results for specimens without and with self-curing compounds were tabulated and compared.

Water Retention

Water Retention is the ability of the substance to retain water. To perform the water retention test, the cubes were weighed for every 3 days from the date of casting. Weight losses for the specimens in indoor curing of conventional concrete, and weight loss in conventional concrete mix with self-curing agents are noted and their behaviour is plotted against number of days of curing.

Sorptivity:

Sorptivity measures the rate of penetration of water into the pores in concrete by capillarity suction. After curing, the specimens of each batch were taken and side surfaces were sealed, and kept in contact with water up to a depth of 5mm from bottom. To determine the absorption of water, weights of specimens are taken at regular intervals of 3 hrs, 6 hrs, 24 hrs, 48 hrs, 72 hrs, 7days, 14days and 28days. Thus Sorptivity is plotted against the square root of time of exposure. The sorptivity was obtained by using the following expression:

$$\frac{W}{A} = k\sqrt{t} \quad (1)$$

Where W = the amount of water adsorbed in (kg); A = the cross-section of specimen that was in contact with water (m^2); t = time (min); S = the sorptivity coefficient of the specimen ($kg/m^2/min^{0.5}$).

RESULTS AND DISCUSSIONS

Compressive Strength

Fig. 2 and Table-1 shows the details of Compressive Strength of conventional concrete without Self-Curing Compounds and with Self-Curing Compounds. It is very much evident from the results that there is an increase in the compressive strength with the addition of Self-Curing Compound up to 1.5% due to required moisture content that is provided by the hydrophilic compounds. It can also be said that PEG is giving optimum results compared to other curing conditions. There is a slight decrease in the compressive strength with the addition of self-curing compound at 2%.

Table-1 Average Compressive Strength in N/mm^2

MIX	7 days	14 days	21 days	28 days
BW	34.0	36.9	39.8	44.5
BI	29.3	33.1	36.9	42.5
BV0.1	27.6	32.3	34.1	38.6
BV0.5	29.3	34.5	36.8	38.6
BV1.0	30.6	33.3	38.1	40.0
BV1.5	31.9	34.0	37.3	42.4
BV2.0	26.4	30.2	33.6	35.5

Table - 2 Average Weight Loss Values at Different Ages in Grams

MIX	3 days	7 days	14 days	21 days	28 days
BV0.1	21	33	43	58	74
BV0.5	25	33	44	57	81
BV1.0	32	40	50	63	71
BV1.5	17	35	44	51	56
BV2.0	24	43	50	55	86
BI	15	32	38	53	68

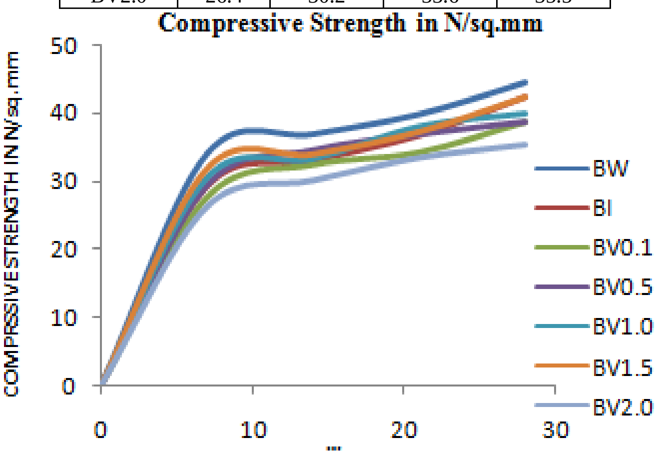

Fig. 2 Compressive strength vs. Age of curing

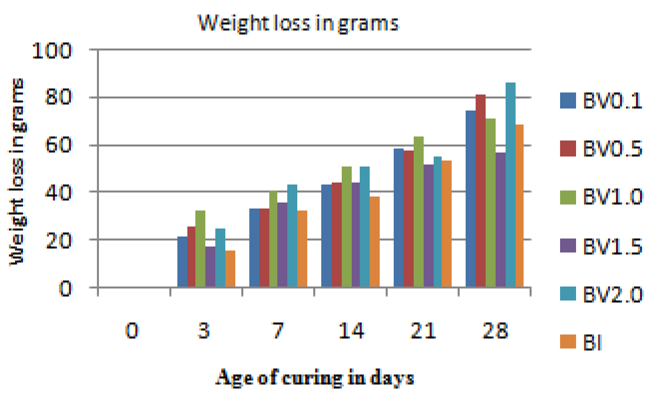

Fig. 3 Weight loss vs. age of curing

Hence it can be concluded that higher percentages of self-curing compound is suitable for low strength conventional concretes.

Water Retention

Fig. 3 and Table-2 shows the details of water retention capacity of conventional concrete without Self-Curing Compounds and with Self-Curing Compounds. It is very much evident from the results that there is a increase in the water retention capacity with the addition of Self-Curing Compounds due to increase in the moisture content that is provided by the hydrophilic compounds. It can also be said that PEG-600 is giving optimum results compared to other curing conditions.

Sorptivity

The water absorption of the specimens were calculated and plotted against the in square root of time in minutes as shown in the following Table-3 and Fig. 4. From the Fig. 4 it is clearly seen that Sorptivity decreased with the addition of self-curing compounds when compared with indoor cured specimens. From the fig. 4 it is seen Sorptivity is less for 1.5% addition of PEG 600 for conventional concrete. Sorptivity decreased with increase in percentage of PEG 600.

Table-3 Water Absorption of Specimens (kg/m^2)

MIX	10 min	20 min	30 min	60 min	180 min	360 min
BW	0.27	0.36	0.50	0.58	0.76	1.13
BI	0.24	0.42	0.56	0.66	0.88	1.28
BV0.1	0.24	0.44	0.62	0.77	0.94	1.30
BV0.5	0.38	0.52	0.76	0.86	1.06	1.29
BV1.0	0.34	0.48	0.70	0.86	1.00	1.32
BV1.5	0.26	0.38	0.54	0.67	0.78	1.16
BV2.0	0.56	0.74	0.82	1.02	1.22	1.44

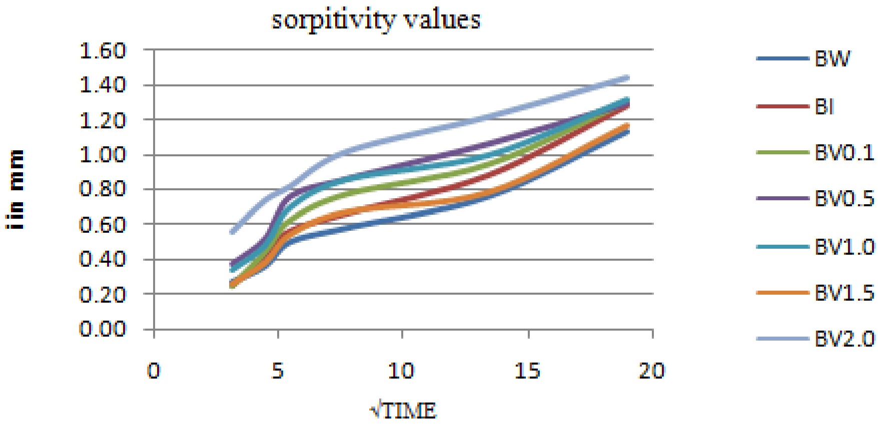

Fig. 4 I vs. time$^{0.5}$

Table-4 Sorptivity Coefficient(s)

MIX		Sorptivity coefficient(s)
BW	y = 0.0502x + 0.1547	0.0502
BI	y = 0.0589x + 0.1518	0.0589
BV0.1	y = 0.0592x + 0.194	0.0592
BV0.5	y = 0.0525x + 0.3456	0.0525
BV1.0	y = 0.0559x + 0.2876	0.0559
BV1.5	y = 0.0507x + 0.1814	0.0507
BV2.0	y = 0.0519x + 0.5064	0.0519

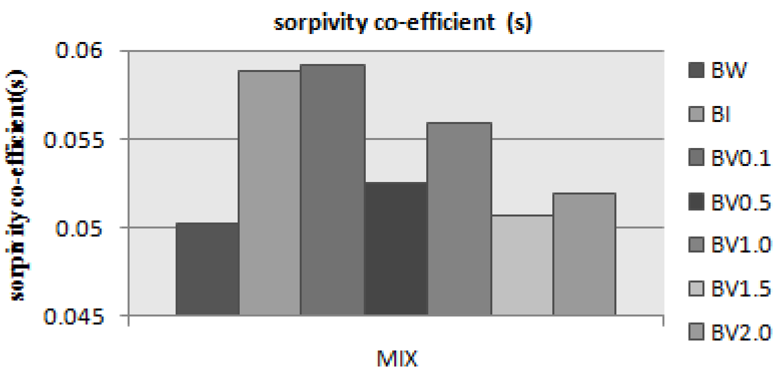

Fig. 5 Sorptivity co-efficient (s) vs. mix proportions

Among all the dosages of self-curing compounds, Sorptivity is least in 1.5% dosage of PEG 600.

CONCLUSIONS

Based on the experimental and analytical investigations, the following conclusions have been drawn:

- Higher dosage of curing compound is required for lower grades of conventional concrete.
- Sorptivity decreased with increase in dosage of PEG - 600 in low molecular weights of PEG. This is true in case of general curing also.
- 1.5 % is optimum dosage for M30 grade mix considering all the factors viz., compressive strength, water retention and sorptivity.
- The specimens which have more water retention capacity have shown better superior compressive strength, sorptivity values. Hence, it can be concluded that minimum water loss leads to better gel formation thus increasing strength.
- So, optimum dosage of self curing agent is 1.5 % of PEG 600 for water retention, sorptivity and strength point of view.
- The capillary suction of water is decreasing with the increase in percentage dosage of PEG 600. Hence it is evident that higher percentage dosages (i.e., 1.5%) of PEG 600 impart better sealing properties for the concrete.

REFERENCES

[1] Roland Tak, Yong Liang and Robert Keith Sun, Composition and Methods for Curing Concrete, Patent No.: US 6468344 BI, **2002**.

[2] Wen-Chen Jau, Self-Curing Concrete, United States Patent Application Publication, pub. No: US 2008/0072799A1, **2008**.

[3] RK Dhir, PC Hewlett and TD Dyer, Durability of 'Self-Cure' Concrete, Cement and Concrete Research, **1995**, 25 (6), 1153-1158.

[4] AS EI-Dieb, Self-Curing Concrete: Water Retention, Hydration and Moisture Transport, *Construction and Building Materials*, **2007**, 21, 1282-1287.

[5] M Collepardi, A Borsoi, S Collepardi, R Troli and M Valente, Self-Curing, Shrinage-Free Concrete, *ACI Material Journal SP*, **2006**, 234 (47), 755-764.

[6] AS EI-Deib, TA EI-Maaddawy and AAM Mohmoud, Water-Soluble Polymers as Self-Curing Agent in Silica Fume Portland Cement Mixes, *ACI Material Journal*, **2011**, 278, 1-18.

[7] S Zhuotovsky and K Kovler, Effect of Internal Curing on Durability-Related Properties of High Performance Concrete, *Cement and Concrete Research*, **2012**, 42, 20-26.

[8] MV Jagannadha Kumar, Strength Characteristics of Self-Curing Concrete, *IJRET*, **2012**, (1), 51-57.

[9] Nanak J Pamnanil, AK Verma and DR Bhatt, Comparison of Compressive Strength of Medium Strength Self Compacted Concrete by Different Curing Techniques, *International Journal of Engineering Trends and Technology*, **2013**, 4(5), 1451-1457.

[10] AF Bingol and I Tohumcu, Effect of Different Regimes on the Compressive Strength Properties of Self Compacting Concrete Incorporating Fly Ash and Silica Fume, *Materials and Design*, **2013**, 51, 12-18.

[11] M Golias, Javier Castro and Jason Weiss, The Influence of the Initial Moisture Content of Light Weight Aggregate Internal Curing, *Construction and Building Materials*, **2012**, 35, 52-62.

[12] EI-Dieb El Maaddawy and Mahmoud, Water Soluble Polymers as Self Curing Agents in Cement Mixes, *Advances in Cement Research*, **2012**, 24 (5), 291-299.

[13] MS Shetty, *Text book on Concrete Technology –Theory and Practice*, Seventh Revised Edition, S Chand Publishing, New Delhi, **Reprint 2015**.

[14] IS: 383-1970 Indian Standard Specifications for Coarse and Fine Aggregates from Natural Sources for Concrete (Second Revision), Ninth Reprint September **1993**.

[15] IS: 2386 (Part IV)) -1963 Indian Standard Methods of Test for Aggregates for Concrete (Part IV) Mechanical Properties, Tenth Reprint March **1997**.

[16] IS: 456-2000 Indian Standard Plain and Reinforced Concrete –Code of practice (Fourth Revision), **2000**.

[17] IS: 10262-1982 Indian Standard Concrete Technology-Code of Practice, **1982**.

[18] IS: 12269 Indian Standard Ordinary Portland Cement Code Practices, **2013**.

[19] Australian Standard AS 3799 for Curing Practices, **1998**.