A STUDY ON INTERNAL CURING OF SELF COMPACTING CONCRETE USING ADMIXTURE PEG (400) & SUPERPLASTICIZERS

Mr. Ram Lohar [1], Mr.Bhagwat Deokar [2] , Mr.Ambadas Kale[3]

[1,2,3] *BE Student, Department of Civil Engineering Parvatibai Genba Moze College Of Engineering , Wagholi , Pune, Maharashtra, (India)*

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

I INTRODUCTION

Self-compacting concrete is basically a concrete which is capable of flowing in to the formwork. 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. 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). The empty pores created during self-desiccation induce shrinkage stresses and also influence the kinetics of cement hydration process, limiting the final degree of hydration. The strength achieved by IC could be more than that possible under saturated curing conditions. Often specially in HPC, it is not easily possible to provide curing water from the top surface at the rate required to satisfy the ongoing chemical shrinkage, due to the extremely low permeability often achieved.

 ISBN: 978-93-86171-12-2

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 or saturated wood fibers) Created.„Internal curing‟ is often also referred as „Self–curing.‟

1.1 Need of Study

The need for going in for self-curing self-compacting concrete raised due to the following points:

Due to scarcity of manpower

Non-mechanization of construction industry

Non availability of water for curing and also difficulty in placing the concrete in congested and difficult positions.

A very limited work is reported from this area having the benefits of both self-curing as well as self-compaction. The future for this type of concrete is very bright due to scarcity of skilled man power, non-mechanization of construction industry, abundant availability of construction materials available at very low cost. The properties of this type of concrete, if found satisfactory would be a great step in concrete technology compiling the advantages of both internal curing as well as self-consolidation.

1.2 Objective of work

The objective of the investigation is to use the water soluble polymeric glycol, selected from a group consisting of polyethylene glycol (PEG) of average molecular weight (M.W) from 200 to 10000 as self-curing agent and to decide the optimum dosage for different curing conditions under arid atmospheric conditions.

The objective is to study the compressive strength and water retention by varying the percentage of PEG from 0% to 1% by weight of cement for self-compacting concrete and compare it with conventional SCC. Concrete weight loss with time was evaluated to determine the water retention capacity. Slump flow test, J ring test, L box test and V-Funnel test were carried out on the fresh concrete to evaluate the workability of concrete. Polyethylene glycol (PEG) of molecular weight 400 was used as a self-curing agent in concrete. The concrete mix with and without Self curing agent were subjected to different types of curing i.e. conventional and indoor curing to study the above mention parameters.

Other objectives were to compare the effect Polyethylene glycol (PEG) on other grades of SCC and to find out the optimum dosage for each grade.

1.3 Scope of work

Some specific water soluble chemical such as polyethylene glycol is added during the mixing can reduce water evaporation from and within the set concrete make it self curing. The scope of the work to study the effect of polyethylene glycol (PEG 400) on strength characteristics of the self curing concrete. In this project seminar we also study the stress strain relation curve at a different proportions.

II LITERATURE REVIEW

Manishkumar et al. (Vol.1, 2012, 51 -57)

They studied the effect of polyethylene glycol (PEG 400) on strength characteristics of Self-curing concrete. The objective was to study the mechanical characteristics of concrete such as workability, compressive strength, split tensile strength and modulus of rupture by varying the percentage of PEG from 0% to 2% by weight of cement for both M20 and M40 grades of concrete. The experimental program was designed to investigatethe strength of self-curing concrete by adding poly ethylene glycol PEG400 @ 0.5%, 1%, 1.5% and 2% by weight of cement to the concrete. The plain samples were cured for 28 days in water pond and the specimens with PEG400 were cured for 28 days at room temperature by placing them in shade. Test specimen: The size of each cube is 150 x150 x 150 mm. The size of each cylinder is 150 mm in diameter and 300 mm in height. The size of each prism is 100 x100 x 400 mm. He concluded that, The optimum dosage of PEG400 for maximum strengths (compressive, tensile and modulus of rupture) was found to be 1% for M20 and 0.5% for M40 grades of concrete. Further increasing the dosage resulted in decreased strengths. As percentage of PEG400 increased slump and compacting factor increased for both M20 and M40 grades of concrete. But, the rate of increase of slump & compaction factor for M40 concrete is less than that of M20 concrete. Strength of self-curing concrete is on par with conventional concrete.

Nanak et al. (Volume4,May 2013)

He compared the compressive strength of medium strength self-compacted concrete by different curing techniques. Three different methods of curing were chosen:

1. Traditional immersion or ponding method
2. Application of Wax based external coating
3. Using chemical for internal curing

The conclusions reached were: Immersion method seems to be the best method for curing giving maximum strength. External curing with curing compound method gives @9% less compressive strength at 28 days than immersion curing. While internal curing with Polyethelyne Glycol gives only @5% lesser compressive strength than immersion curing. In case of internal curing the initial strength gain at early age is much lesser (@33%) than immersion curing, however at later age the difference is not much. He concluded that, Use of PEG as a self-curing agent resulted in better hydration of concrete. It can give strength on par with concrete with conventional curing methods. Good workability can be achieved with the use of PEG. Lower water loss and increased relative humidity can be expected. Lower water permeability and sorptivity achieved. Reduces self dessication, autogenous shrinkage and chemical shrinkage to a maximum extent. Overall better performance of concrete. Lower workability observed in case of Polyacrylamide (PAM) due to the formation of gelatinous structure. Lower dosage of PEG more efficient than higher dosage. Lower molecular weight PEG more effective than higher molecular weight PEG. SCC with silica fume performs satisfactory than SCC with Fly Ash from strength point of view. SCC requires initial water curing to achieve desirable properties.

Nanak et al. (Volume 2, February 2014)

They compared the effect of three non-water-based curing techniques on mechanical properties such as compressive strength, split tensile strength, flexural strength and shear strength of M30 grade self-compacting concrete. For compressive strength it was observed that immersion method for curing gives maximum compressive strength while the lowest compressive strength was for no curing. Polyethylene film curing gives second highest strength at 28 days. Similarly for split tensile strength, flexural strength & shear strength, the maximum strength was also with immersion method of curing. It was concluded that although pond immersion method is best for curing, Polyethylene film and curing compound can deliver more than 90% compressive and other strengths compared to immersion method.

S.M.Junaid et al. (Volume 1, Special Issue , Vivruti 2015)

The study involves the use of shrinkage reducing admixture polyethylene glycol (PEG-4000, 1% weight of cement) in concrete (grade ratio = 1:2.23:3.08) which helps in self-curing and in better hydration and hence strength and compared with that of conventional cured concrete. When concrete is exposed to the environment evaporation of water takes place and loss of moisture will reduce the initial water cement ratio which will result in the incomplete hydration of the cement and hence lowering the quality of the concrete. Evaporation in the initial stage leads to plastic shrinkage cracking and at the final stage of setting it leads to drying shrinkage cracking. Curing temperature is one of the major factors that affect the strength development rate. At elevated temperature ordinary concrete losses its strength due to the formation of the cracks between two thermally incompatible ingredients, cement paste and aggregates. When concrete is cured at high temperature normally develops higher early strength than concrete produced and cured at lower temperature, but strength is generally lowered at 28 days and later stage. They concluded that, PEG-4000 was used as self-curing agent. . It has been observed during testing, cubes of Normal Mix +PEG-4000 shows less crack and doesn'tbroke down even after throwing from almost 1m of height which is not in case of Conventional Mix alone. There is less shrinkage and good bonding observed in Normal+PEG-4000 which is not in case of Conventional Mix alone.

K. Kavithaa, D. Suji, S. Raghuraman. (Volume 1, 2015)

they studied that to assess the effect of minimise the quantity of water required and to involves the use of shrinkage reducing admixture polyethylene glycol in concrete which helps in self curing and helps in better hydration and hence strength. They studied the mechanical characteristics of concrete such as compressive strength, split tensile strength and flexural strength by using M20 grade of concrete. They study compressive, tensile and flexural strength of self-curing concrete for 7 and 28 days is found out and compared with conventional concrete of similar mix design. He concluded that, Self-curing agents is to reduce the water evaporation from concrete and hence increase the water retention capacity of the concrete compared to conventional concrete. Self curing concrete is the answer to many problems faced due to lack of proper curing. The properties of the materials are found to be good and the mix design was done based on IS specifications. The target mean strength was achieved. The optimum dosage of PEG600 for maximum strengths (Compressive, Tensile and Flexural strength) was found to be 1% for compared to conventional concrete for M20 grade.

Dhir et al. (Vol.27, 1994, 606-615)

They focused on achieving optimum cure of concrete without the need for applying external curing methods. The chemical ability to reduce evaporation from solution and to improve water retention in OPC was measured by weight loss. Initial surface absorption and compressive strength tests were made to determine surface permeability and strength development. The scanning electron microscope was used to determine the influence of admixtures on cement paste microstructure. Improved water retention does not always lead to a proportionate increase in degree of cement hydration and hence better concrete properties, although in many cases it does. A number of chemicals improved concrete surface characteristics. It appears that the presence of the chemical is enhancing hydration beyond that achieved by water retention.

Collepardi et al. (vol. 27, 2005, 704–708)

They shows the advantages of the combined use of SRA and CaO-based expansive agent to produce shrinkage-compensating concrete even in the absence of an adequate wet curing. Neither expansive agent nor SRA, when used separately, can definitively and safely avoid the risk of cracking caused by drying shrinkage in real concrete structures under the practical conditions of curing on many job-sites. The expansive agent used in the study was Cao and the SRA was propylene glycol. The dosage of propylene glycol and Cao was 1.15% and 10% by weight of cement respectively. w/c ratio adopted was 0.45.

Mixes adopted:

a. Mix A (with Cao only)
b. Mix B (with Cao only)
c. Mix C (with Cao and SRA)
d. Mix D (with SRA only)

In the presence of SRA there was a significant reduction in the drying shrinkage due to reduced surface tension of water. Surprisingly SRA does not reduce the water evaporation from concrete when exposed to unsaturated air. They concluded that, There is a synergistic effect in the combined use of SRA and a CaO-based expansive agent in terms of more effective expansion in the absence of wet curing and lower shrinkage after removing the polyethylene sheet used to simulate the protection from drying before the demolding on the job site. These interesting results should be confirmed by using different type of SRA and/or CaO expansive agent. Preliminary results indicate that this synergistic effect does not exist when a sulfo-aluminate expansive agent is used to form ettringite.

III METHODOLOGY

The experimental program is designed to investigate the strength of self-curing self-compacting concrete by adding poly ethylene glycol PEG400 @ 0.5%, 1.0% and 1.5% 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 7,14 and 28 days. The cubes were weighed for 7,14, 28 days from the date of demoulding to investigate the water retention capacity. In this investigation the maximum dosage of self-curing agent was restricted to 1.5% and minimum dosage to 0.5%. Two different mixes with 28 days cube compressive strengths of concrete were aimed i.e.50MPa.

IV 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 $(OCH_2CH_2)_nOH$, 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.

ISBN: 978-93-86171-12-2

Figure 1 Slump Flow Test

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.

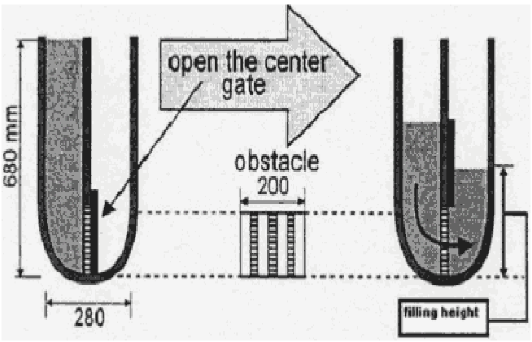


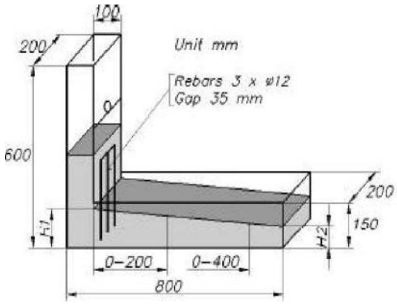
Figure 4.3 U-Box test Apparatus

L box Test

The method aims at investigating the passing ability of SCC. It measures the reached height of fresh SCC after

 ISBN: 978-93-86171-12-2

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.



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.

REFERENCES

1. R.K. Dhir, P.C. Hewlett and T.D. Dyer," Durability of „Self-Cure" Concrete", Cement and Concrete Research, Vol. 25. No. 6, 1153-1158, 1995.
2. Roland Tak Yong Liang, Robert Keith Sun, "Compositions and Methods for CuringConcrete", Patent No.: US 6,468,344 B1, Date of Patent Oct. 22, 2002.
3. Mario Collepardi, Antonio Borsoi, Silvia Collepardi, Jean Jacob Ogoumah Olagot, Roberto Troli, "Effects of shrinkage reducing admixture in shrinkage compensating concrete under non-wet curing conditions", Cement & Concrete Composites vol. 27 (2005) 704–708.
4. M. Collepardi, A. Borsoi, S. Collepardi, R. Troli and M. Valente, "Self-Curing, Shrinkage-Free Concrete", ACI Material Journal SP 234-47 (2006) 755-764.
5. A.S.El-Dieb, "Self-curing Concrete: Water Retention, hydration and moisture transport", Construction and Building Materials Vol.21 (2007) 1282-1287.
6. Wen-Chen Jau, "Self-curing Concrete", United States Patent Application Publication, Pub. No: U.S. 2008/0072799 A1, Pub.date: Mar. 27, 2008.
7. Bart Craeye , Matthew Geirnaert , Geert De Schutter,"Super absorbing polymers as an internal curing agent for mitigation of early-age cracking of high-performance concrete bridge decks", Construction and Building Materials vol. 25 (2011) 1–13.
8. Garje Rajesh Kumar, "Self Curing Concrete", International RILEM conference on advances in construction materials through science and engineering, Hong Kong, China 5-7 september 2011, pp.116-123.
9. Marianne Tange Hasholt , Ole Mejlhede Jensen , Konstantin Kovler , Semion Zhutovsky,"Can superabsorent polymers mitigate autogenous shrinkage of internally cured concrete without compromising the strength?", Construction and Building Materials vol. 31 (2012) 226–230.
10. Raghavendra Y.B and Aswath M.U," Experimental investigation on concrete cured with various curing Methods-A Comparative Study", International Journal of Advanced Scientific Research and Technology, Issue: 2, Vol.3 (2012) 577-584.
11. Jagannadha Kumar M.V, Srikanth M, Rao K.Jaganndha,"Strength Characteristics of Self-curing Concrete", International Journal of Research in Engineering & Technology,Issue:1,Vol.1(2012) 51 -57.
12. A.S. El-Dieb, T.A. El-Maaddawy and A.A.M. Mahmoud, "Water-Soluble Polymers as Self-Curing Agent in Silica Fume Portland Cement Mixes", ACI Material Journal Vol.278 (2011) 1-18.