Influence Of Polyethylene Glycol (PEG) And Flyash On Compressive Characteristics Strength Of Concrete

Dr. U. Venkata Rathnam[1]*

Abstract

Concrete requires curing to continue with the hydration process. Self-curing concrete is one of the special concretes in mitigating insufficient curing due to human negligence paucity of water in arid areas, inaccessibility of structures in difficult terrains and in areas where the presence of fluorides in water will badly affect the characteristics of concrete. The present study involves the use of polyethylene glycol which acts as a self-curing compound. The most important aspect is that this compound is expected to maintain maximum water retention there by contributing to full hydration. The parameters in the study include grade of concrete, type and dosage of polyethylene glycol, curing conditions and age of curing. The present involves the two types of self-curing compounds PEG 400 with dosage of 1%, 2 % for M60 grade of concrete. Compressive strength, Slump cone tests were determined as a performance benchmark for the investigated curing compounds. It was reported from the study that higher dosage (1%), higher molecular weight (400) based PEG compounds act as better curing compounds in higher grade concrete.

DOI Number: 10.48047/NQ.2022.20.1.NQ22370 **NeuroQuantology2022;20(1): 874-882**

INTRODUCTION

Curing

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 is practically 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 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.

i. For the vertical member it is not possible to keep the surface moist as in case of the flat surfaces.
ii. In the places where there is scarcity of water.
iii. In the places where manual curing is not possible.
iv. A human error may lead to the formation of crack in the member and hence affects strength and durability.

Self-Curing Concrete

The concept of 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. It was found that water soluble polymers can be used as self-curing agents in concrete. Concrete incorporating self-curing agents will represent a new trend in the concrete construction in the new millennium. Curing of concrete plays, a major role in developing the concrete microstructure and Pore structure, and hence

***Corresponding Author:** Dr. U. Venkata Rathnam
Address:1*Associate Professor, Department of Civil Engineering, Malla Reddy Engineering College
Relevant Conflicts Of Interest/Financial Disclosures: The Authors Declare That The Research Was Conducted In The Absence Of Any Commercial Or Financial Relationships That Could Be Construed As A Potential Conflict Of Interest.

improves its durability and performance.

The concept of 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. The use of self-curing admixtures is very important from the point of view that water resources are getting valuable every day (i.e., each 1cu.m of concrete requires about 3cu.m of water for construction most of which is for curing).

Excessive evaporation of water (internal or external) from fresh concrete should be avoided; otherwise, the degree of cement hydration would get lowered and there by concrete may develop unsatisfactory properties. Curing operations should ensure that adequate amount of water is available for cement hydration to occur. This investigation discusses different aspects of achieving optimum cure of concrete without the need for applying external curing methods. The effect of curing, particularly new techniques such as "self-curing", on the properties of high-performance concrete isprimary importance to the modern concrete industry.

Definition of Self Curing

The ACI-308 Code states that "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 saturatedlight weight aggregates, superabsorbent polymers, or saturated wood fibers) created. 'Internal curing'is often referred as **'Self-Curing'.**

"Self-curing concrete" means that no labor work is required to provide water for concrete, or even no any external curing is required after placing which the properties of this concrete are at least comparable to and even better than those of concrete with traditional curing. Self-Curing is an "internal curing system" where a water-soluble polymer is added to the concrete mix. This method overcomes the difficulty in ensuring that effective curing procedures are employed by the construction personnel as the internal curing composition is a component of the mix.

Mechanism of internal-curing

According to R.T.Y Liang and R.K Sun, continuous evaporation of moisture takes place froman exposed surface due to the difference in chemical potentials (free energy) between the vapour and liquid phases. The polymers added in the mix mainly from 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.

External Water

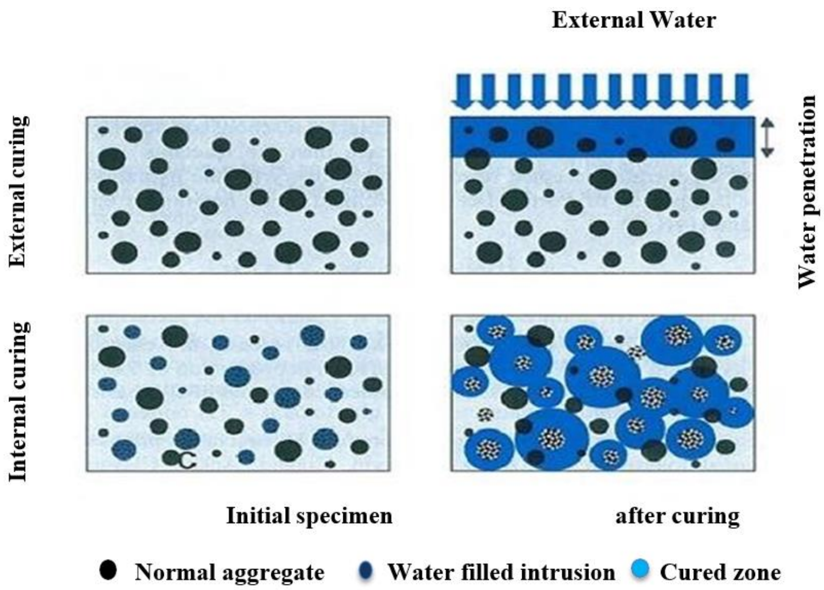


Figure 1.1: Internal and external curing of concrete

This concept of internal curing is compared and contrasted with more conventional (external) curing in Figure 1.1. Conventional external curing places water at the surface of the concrete shortly after placement that can be absorbed over time. Because water curing is often difficult to perform, curing membranes or sealers are often used; however, these approaches do not add additional needed water to the system. Further, in lower water to cement ratio systems the external curing, water cannot penetrate much beyond the surface (on the order of 3mm of movement after 18 hours). Internal curing, however, uses the fine LWA (light weight aggregate) to supply water uniformly across the cross section as shown in Figure 1.1. Proportioning procedures exist to determine the amount of lightweight aggregate to use considering both the volume of water that is to be supplied and the spatial distribution of the LWA (light weight aggregate).

The principle contribution of internal curing results in the reduction of permeability that develops from a significant extension in the time of curing.

LITERATURE REVIEW

M.V. Jagannadha Kumar, M. Srikanth, Dr. K. Jagannadha Rao

Studied that self-curing concrete is provided to absorb water from moisture from air to achieve better hydration of cement in concrete. In this shrinkage reducing admixture polyethylene glycol (PEG 400) is a self-curing compound. Two types of grades are taken i.e., M20 and M40 grades of concrete. In this study the self-curing agent is added to concrete with 0.5%, 1%, 1.5%, 2% by weight of cement. The experimental programme involves the compressive, tensile and modulus of rupture for M20 and M40 grades of concrete. For M20 grade of concrete totally 15 cubes, 15 cylinders, 15 beams are casted. Similarly for M40 grade of concrete totally 15 cubes, 15 cylinders, 15 beams are casted to evaluate the strength properties. The size of the cube is 150mm×150mm×150mm, size of cylinder is 300mm×150mm and size of beam is 100mm×100mm×400mm. The investigation aimed at studying on concrete with different quantities of cement for M20 grade of concrete is (340Kg/m3) and for M40 grade for concrete the cement content was found to be 440kg/m^3 for both for self and air- curing concrete and compare the results for different test. It was conclude that:

i) 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.
ii) As percentage of polyethylene glycol (PEG400) increases automatically slump increases for both M20 and M40 grades of concrete.

Sathanandham. T, Gobinath. R, Naveen Prabhu. M, Gnanasundar. S, Vajravel K, Sabariraja. G, Manoj kumar. R, Jagathishprabu. R

Studied that self-curing concrete is provided to absorb water from moisture from air to achieve better hydration of cement in concrete. In this shrinkage reducing admixture polyethylene glycol (PEG 4000) is a self-curing compound. Two types of grades are taken i.e., M20 grade of concrete. In this study the self-curing agent is added to concrete with 0.5%, 1%, 1.5%, 2% by weight of cement.The experimental programme involves the compressive, tensile and modulus of rupture for M20 grade of concrete. For M20 grade of concrete totally 24 cubes are casted to evaluate the compressive strength property. The size of the cube is 150mm×150mm×150mm.

The investigation aimed at studying on concrete with different quantities of cement for M20 grade of concrete is (350Kg/m3). The compressive strength results are taken at 7, 14, 28 days of curing. It was concluded that:

i) The optimum dosage of PEG4000 for maximum strengths (compressive) was found to be 1.5%for M20 grade of concrete.
ii) As percentage of polyethylene glycol (PEG400) increases automatically slump increases for both M20 and M40 grades of concrete.

Prof. Vinayak Vijapur, Manjunath. Tontanal

Investigated behavior of self cured steel fiber reinforced concrete. Fibers are used in concrete to control cracking due to both plastic and drying shrinkage which reduces the permeability of concrete and bleeding of water. In this study steel fibers are used as an admixture and pumice aggregates as an self-curing agent. The grade of concrete was found to be M30. The steel fibers are added to concrete with 2% by volume fraction and self-curing agent i.e., pumice aggregates are replaced by natural aggregates by different percentages i.e., 0%, 10%, 20%, 30%, 40%, 50%. The experimental programme involves the sorptivity, water absorption test and strength properties of concrete. In casing programme, the cubes are casted by taking the pumice aggregates in 24 hrs water absorption condition and without water absorption condition and the results are compared. It was concluded that:

In compressive strength test, flexural, split tensile, shear strength test with air curing at 30% replacement of pumice aggregates by natural aggregates gives the higher strength. If the dosage of pumice aggregates increased automatically strength decreases.

Amal Francis k, Jino John

Investigated on mechanical properties of self-curing concrete. In this shrinkage reducing admixture superabsorbent polymer (SAP) is a self-curing compound. The grade of concrete was found to be M40. In this study the self-curing agent is added to concrete with 0%, 0.2%, 0.3%, 0.4% by weight of cement. The experimental programme involves the compressive, tensile and flexural strength for M40 grade of concrete. The size of the cube is 150mm×150mm×150mm, beam dimensions are 100mm×100mm×400mm, cylinder dimensions are 300mm×150mm. The investigation aimed at studying on concrete with different quantities of cement for M40 grade of concrete is (350Kg/m3). The compressive strength, flexural, split tensile results are taken at 3, 7, 28 days of curing and compare the results with aircuring.

A.S EI-Dieb

Investigated water retention of concrete using water-soluble polymeric glycol as self-curing agent. Concrete weight loss and internal relative humidity measurements with time carried out, in order to evaluate the water retention of self curing concrete. Water transport through concrete is evaluated by measuring absorption %, permeable voids%, water sorptivity and water permeability. The water transport through self during concrete is evaluated with age. The effect of the concrete mix proportions on the performance of self curing concrete were investigated, such as cement content andwater/cement ratio. In this study water retention and hydration of concrete containing self-curing agent is investigated and compared to conventional concrete. 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.

The following could be concluded from the results obtained in this study.

i) Water retention for the concrete mixes incorporating self-curing agent is higher compared to conventional concrete mixes, as found by the weight loss with time.
ii) Self-curing concrete suffered less self-desiccation under sealed conditions compared toconventional concrete.
iii) Self-curing concrete resulted in better hydration with time under drying condition compared to conventional concrete.
iv) Water transport through self-curing concrete is lower than air-cured conventional concrete.
v) Water Sorptivity and water permeability values for self-curing concrete decreased with ageindicating lower permeable pores percentage as a result of the continuation of the cement hydration.

R.K. Dhir, P.C. Hewlett and T.D. Dyer

Reported 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.

Three mixes were used throughout the programme: one containing only OPC as a binder, one containing a 40% GGBS cement replacement and one containing PFA as a 30% cement replacement. Two dosages were used: 0.005M and 0.l00M.

Two sets of control specimens were cast, kept under damp hessian and polythene for 24 hours and then stripped. One set was cured in air at 20°C/ 60%RH for 28 days. The other set were kept for the same amount of time in the same conditions, but sealed in a water-resistant plastic film to ensure that no moisture was lost. The self-cure concrete specimens were also cured in air at 20°C/6O%RH. From their studies it can concluded that:

i) With respect to surface quality, chloride diffusion, carbonation, corrosion potential and freeze/thaw resistance self-cure concrete provides improved performance when compared to air cured specimens.
ii) 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 characteristics of the film.

Experimental Programme

General

The experimental programme was explained below:

i) To study the compressive strength, durability for M60 mix were considered. Total 4 cubes werecasted which involves different dosages (1% and 2%) of self-curing agents polyethylene glycol (PEG), under different curing conditions (indoor, conventional) and 4 cubes were casted without using PEG400.
ii) The curves between compressive strength and percentage of self-curing agent, weight loss and number of days of curing were plotted.

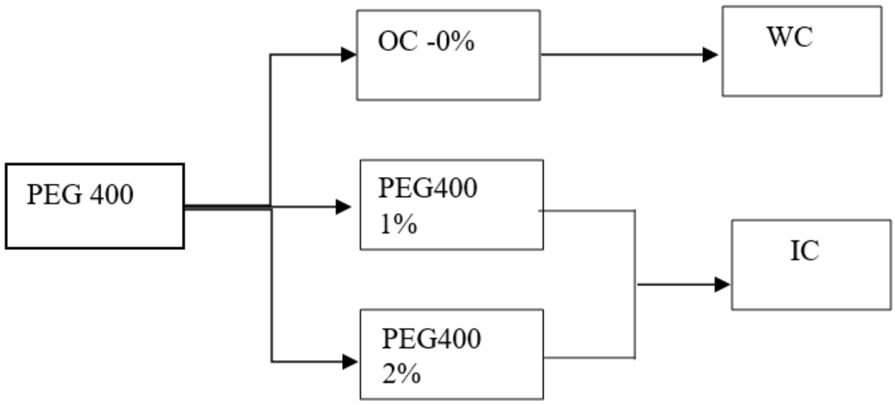


Fig 3.1: Flow chart of experimental programme for concrete

Nomenclature For Design Specimen

OC -- Ordinary concrete, IC -- Internal curing, WC – Wet curing, PEG – Polyethylene glycol

Materials Used

The different materials used in the investigation are:

Cement

Cement used in the investigation was found to be Ordinary Portland Cement (53 grade) confirming to IS: 12269 – 1987.

Fine Aggregate

The fine aggregate used was obtained from a nearby river course. The fine aggregate confirming to zone – II according to Is 383-1970 was used.

Coarse aggregate

The coarse aggregate used is from a local crushing unit having 20mm nominal size. The coarse aggregate confirming to 20mm well-graded according to IS:383-1970 is used in this investigation.

Polyethylene glycol (PEG)

Polyethylene glycol of molecular weight (400) is used in the study. The chemicals were mixed with water thoroughly prior to mixing of water in concrete.

Fosroc conplast sp430

Fosroc conplast sp430 is a super plasticizing admixture. The product has been primarily developed for applications in high performance concrete where the highest durability and performance is required.

Fly ash

Fly ash is a pozzolan, a substance containing aluminous and siliceous material that forms cement in the presence of water. When used in concrete mixes, fly ash improves the strength and segregation of the concrete and makes it easier to pump.

Moulds and Equipment

Cubes

Standard cube moulds of size 150X150 X150mm are made of cast iron were used for obtaining strength and durability properties.

Mixing

It was found that the fresh concrete was dark in colour. The amount of water in the mixture played an important role on the behavior of fresh concrete. When the mixing time was long, mixtures with high water content bleed and segregation of aggregates and the paste occurred. This phenomenon was usually followed by low compressive strength of hardened concrete. The effects of water content in the mixture and the mixing time were critical parameters which decide the concrete should be within five to seven minutes as for the concrete and while mixing the following steps should be followed:

i) First mix all dry materials in the pan mixer.
ii) Add the liquid component of the mixture at the end of dry mixing, and continue the wet mixing for another four minutes.

Fig 3.5: Cube Casting

Casting

The standard moulds were fitted such that there are no gaps between the plates of the moulds. If there are small gaps they were filled with plaster of pairs. The moulds then oiled and kept ready for casting. A pan mixer of having 90 kg capacity was used for mixing concrete and the super plasticizer was used for workability purpose as per the specifications and calculations.

This was dispersed in water in required proportion before mixing the water with the ingredients coarse, fine aggregates, cement. Water a super plasticizer along with Self-Curing agent were added subsequently. After 24hrs of a casting the moulds were kept under curing for the required number of days before casting.

Curing

After completion of casting all the specimens were kept to maintain the ambient conditions viz., temperature of 27±2 C and 90% relative humidity for 24hrs. The specimens were removed from the mould and kept in lab for indoor curing.

Detailed investigation on concrete

In this study, mix design is done by two methods:

1. IS-456 code
2. ACI-211.9.1 code

For M60 grade of concrete number of trails were conducted to obtain the desired strength and to maintain good workability (slump of about 50mm) and finally acquired a mix proportion (1:1.73:3.19) (C: F. A: C.A) with w/c ratio of 0.3.To obtain good workability and desired strength.

Slump test is the most commonly used method of measuring workability of concrete. It is not a suitable method for very wet or very dry concrete. It does not measure all factor contributing to workability.

Compressive Strength of Concrete

Compressive strength of concrete is defined as the load, which causes the failure of a standard specimen divided by the area of cross section in uniaxial compression under a given rate of loading. The test of compressive strength should be made on 150mm size cubes. Place the cube in the compression testing machine. The green button is pressed to start the electric motor. When the load is applied gradually, the piston is lifted up along with the lower plateand thus the specimen application of the load should be 300 KN per minute and can be controlled by load rate control knob. Ultimate load is noted for each specimen. The release valve is operatedand the piston is allowed to go down. The values are tabulated and calculations are done.

Materials required are listed below:

Table 3.7: Material quantities for self-curing PEG 400

S. No	Nomenclature Of Mix	No. Of Cubes	Cement (Kg)	Conplast sp430(ml)	FA (Kg)	CA (Kg)	Water (lt)	Polyethyleneglycol (ml)
1	Air curing	4	4.88	1.9	8.43	15.66	2.1	0
2	P-400-1 %	2	2.44	20	4.21	7.33	1.3	22
3	P-400-2%	2	2.44	20	4.21	7.33	1.0	22

Table 3.8: Material quantities for normal curing

S.No	Nomenclature of Mix	No. Of Cubes	Cement (Kg)	Conplast sp430(ml)	FA (Kg)	CA (Kg)	Water (lt)	Polyethyleneglycol (gm)
1	Water curing	4	4.78	42	8.6	14.7	2.2	0

Fig 3.8: compressive strength test on concrete

In this chapter, the study of materials used, their properties, mixing procedures of the concretes, the phases of experimental program and the procedures for testing of fresh and hardened concretes was discussed. The results of the experimental program discussed in this chapter is tabulated and studied in the next chapter.

RESULTS AND DISCUSSIONS

As per experimental programme results for different experiments were obtained. They are shown in table format or graph, which is to be presented in this chapter.

Study on Concrete

Slump Test

The slump test is performed to know about workability. The plot of the slump test values for different dosages of PEG is shown in Table 5.1 & Fig 5.1. The following are the observations on slump test.

i. It is been observed that in case of specimens with PEG 400 of 2% is less compared to other dosages (1%).

Table 5.1: Slump test values for different dosages of PEG

Percentage dosage ofPEG	0%	1%	2%
Slump value	50mm	52mm	50mm

Compressive Strength Test Results

a). Compressive strength result of PEG 400

As per the Table 5.2 the following are the observations on compressive strength for indoor curing and wet curing.

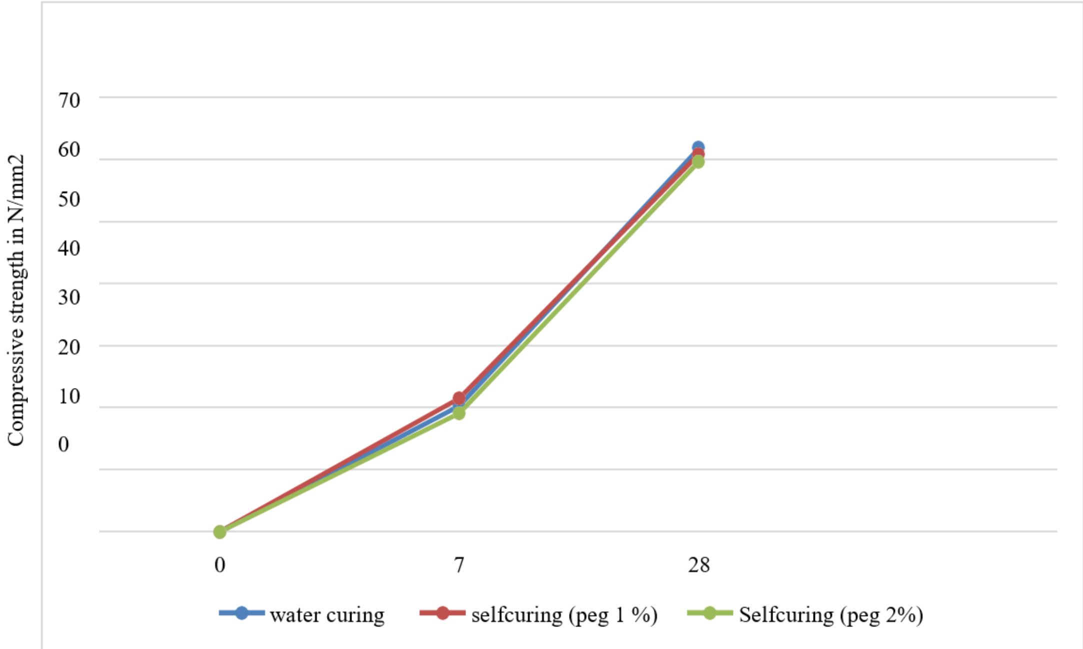
i) The compressive strength of water curing without self-curing agent is more when compared to other dosages (air curing, PEG 400-1%,2 %).

ii) The compressive strength of PEG 400-2% dosage of self-curing agent is more compared to other dosages of self-curing agent (air curing, PEG 400-1%).

iii) PEG 400-2% dosage of self-curing agent has shown better strength than air curing (1% of self- curing agent) but not so good as water curing (0% of self-curing agent).

Nomenclature of mix	7 days (N/mm^2)	28 days (N/mm^2)
Water curing	20.3	61.86
PEG-400-1%	21.5	60.9
PEG-400-2%	19.1	59.68

Table 5.2 Compressive Strength Test Results



No. of days
Graph 5.1: Compressive Strength Test Results

CONCLUSIONS

After the analysis of the result of the experimental programme the following conclusions were arrived.

1. Compressive strength of High-grade concrete with 0% dosage of Polyethylene Glycol in wet curing is equal compared to the 1 % and 2% dosage in indoor curing.
2. Compressive strength of High-grade concrete with 1% dosage of PEG 400 in indoor curing is higher when compared to the 2%.
3. In this investigation, it is noticed that High grade concrete containing Ordinary Portland Cement with 1% dosage (by cement weight) of PEG 400 gives better results when compared to the 2%dosage of PEG 400.

Future scope:

The present study the has been done with the usage of chemical admixture like Fosroc conplast sp430 type super plasticizer and self-curing compounds like polyethylene glycol (PEG) with molecular weight 400. In future work we have to use different types of self curing compounds like polyether, liquid paraffin wax etc. and mineral admixtures like GGBS.

REFERENCES

M.V. Jaganadha Kumar, M. Srikanth, Dr.K. Jaganadha Rao "Strength Characteristics of Self-curing Concrete" IJERT | Sep 2012.

Sathanandham.T1, Gobinath. R2, Naveen Prabhu. M3, Gnanasundar. S3, Vajravel. K3, Sabariraja. G3,Manoj kumar.R3, Jagathishprabu. R3 " Preliminary Studies of Self curing Concrete With the addition of Polyethylene glycol" IJERT, Vol. 2 Issue 11, November – 2013 ISSN: 2278-0181.

Prof. Vinayak Vijapur, Manjunath. G. Tontanal "An Experimental Investigation on Behaviour of Self Cured Steel Fibre Reinforced Concrete ˝ International Journal of Emerging Trends in Engineering and Development, Issue 3, Vol.5 (September 2013) , ISSN 2249-6149.

Amal Francis k#1, Jino John#2 "Experimental Investigation on Mechanical Properties of Self Curing Concrete" International Journal of Emerging Trends in Engineering and Development Issue 3, Vol.2 (March 2013), ISSN 2249-6149.

Amr S. El-Dieb, Tamer A. El-Maaddawy, Ahmed A. M. Mahmud "Water-Soluble Polymers as Self curing agents in cement mixes", Advances in Cement Research,2012, Volume 24 Issue 5.

RK. Dhir', P.C. Hewlett** and T.D. Dyer*, "Durability of Self Cured Concrete" Cement and Concrete Research, Vol. 25. No. 6, pp. 1153-1158.1995.

Semion Zhutovsky, Konstantin Kovler "Effect of internal curing on durability-related properties of high performance concrete" Cement and Concrete Research 42 (2012) 20–26.

C. Chella Gifta*1, S. Prabavathy2 and G. Yuvaraj Kumar2 "Study on Internal Curing of High Performance Concrete Using Super Absorbent Polymers and Light Weight Aggregates˝ Asian Journal of Civil Engineering (BHRC) , vol. 14, no. 5 (2013).

Ryan Henkensiefken. a, ∗, Javier Castro.b, Dale Bentz.c, Tommy Nantung.d, Jason Weiss.b "Water Absorption in Internally Cured Mortar made with Water-filled Lightweight Aggregate" Cement and Concrete Research 39 (2009) 883–892.

Ryan Henkensiefken. a, Dale Bentz.b, Tommy Nantung.c, Jason Weiss a, "Volume Change and Cracking in Internally Cured Mixtures made with Saturated Lightweight Aggregate Under Sealed Text book on "Concrete Technology- "Theory and Practice" by M.S. SHETTY.

IS-383-1970, "Specification for coarse and fine aggregates from natural sources for concrete".

IS: 516–1956 (Reaffirmed 1999), "Indian Standard Methods of Tests for Strength of Concrete". 14. IS:456.2000