

# AN EXPERIMENTAL STUDY ON SELF CURING CONCRETE USING LIQUID PARAFFIN WAX

M.Pavan Kumar<sup>1</sup>, Sunkara Pavan Ayyappa<sup>2</sup>, G.T.Naidu<sup>3</sup>

<sup>1</sup>Assistant Professor, Department of Civil Engineering, SVP Engineering College, Andhra Pradesh, India, [pavanidea@gmail.com](mailto:pavanidea@gmail.com), 919291634473

<sup>2</sup>P.G Student, Department of Civil Engineering, SVP Engineering College, Andhra Pradesh, India, [spavanayyappa@yahoo.com](mailto:spavanayyappa@yahoo.com), 9059785678

<sup>3</sup>Associate Professor, HOD, Department of Civil Engineering, SVP Engineering College and Research Scholar at GITAM University, Andhra Pradesh, India, [gtpnaaidu@gmail.com](mailto:gtpnaaidu@gmail.com), 919490753466

## Abstract

The most regularly and abundantly used construction material is concrete because of its superior compressive strength and stability. Curing is one of the major parameter which helps in improving water retention capacity of concrete which in turn helps in developing the microstructure of the concrete. The curing involves in retaining adequate moisture content from the time of placing the concrete until final stage, at that point of time the concrete develops the satisfied properties by promoting optimum cement hydration immediately after placement. Properly cured concrete has improved durability and surface hardness, and is less permeable. Prevention of loss of moisture is important not only for strength development but also to prevent plastic shrinkage, for decreased permeability and to improve resistance to abrasion. Good and complete curing is not always possible for several reasons such as human errors, vertical members and places where there is scarcity of water. In such cases using self-curing concrete is very adaptable and helps in mitigating this problem. The basic notion of self curing concrete is to make sure that the concrete is free from water evaporation, and hence improve its water withholding capacity when compared to usual curing. Several hydrophilic materials, including polymeric glycol and paraffin wax, can act as self-curing compounds. This study investigates the role of liquid paraffin wax as a self curing agent and compares this with the effect of different curing regimes simulating traditional methods of curing. The dosage of liquid paraffin wax compound taken is 0.1%. The parameters include grade of concrete, dosage of paraffin wax, curing conditions and age of curing. The strength parameters namely compressive strength, split tensile strength and flexural strength are determined as a performance benchmark for the investigated curing compounds.

**Keywords:** Curing of Concrete, Self Curing Concrete, Hydrophilic Materials, Liquid Paraffin Wax

\*\*\*\*\*

## 1. INTRODUCTION

Water is most commonly and frequently used raw material in construction field for aspects such as mixing and curing. This natural resource is also one of the important commodities used in many industries as well as in day to day needs in human life. As a result of this, water is about to become scarce. If this situation prevails, then the cost construction will reach to a point where common man cannot afford to build a home. Hence to mitigate this water problem in construction field, self curing concrete came into existence. According to the ACI Code-308 “the internal curing is the procedure which involves in the hydration of cement which takes place due to the availability of excessive internal water (which is not part of the mixing water)”. ‘Internal curing’ is also known as ‘Self Curing’. The Self curing concrete means that no labour work is required to provide water for concrete or even no external curing is required after placing, where the properties of this concrete are at least comparable to and even better than those of concrete with traditional curing. The Self Curing is an “internal curing system” in which a Hydrophilic material

such as Polyethylene Glycol, Paraffin wax or Acrylic acid, the polymer that is soluble in water is allowed to mix in the prepared concrete. By following the above mentioned method, the complexity in making sure that effective curing procedures are carried out by the construction site in charges becomes very easy because the hydrophilic material such as liquid paraffin wax are used as curing composition in the component of concrete mix. Poly ethylene glycol of lower molecular weight is more efficient as a self curing agent when compared to the Poly ethylene glycol of higher molecular weight. Low dosage of Poly ethylene glycol is more efficient for achieving self curing concrete when compared to the higher dosages as per Garje Rajesh Kumar (2011)<sup>[3]</sup>.

M.V.Jagannadha Kumar, along with his two other colleagues (2012)<sup>[4]</sup> has concluded that the mixing of Poly ethylene glycol in measured quantity will significantly increases the strength parameters. In the experimental study, the dosage of poly ethylene glycol to be added was found to be 1% and 0.5% for M20 and M40 grades respectively. As the dosage of polyethylene glycol increases automatically

slump values increases for the above grades of concrete simultaneously. Semion Zhutovsky, Konstantin Kovler (2012)<sup>[7]</sup> has concluded that the sorptivity of concrete with internal curing at 1 day is approximately 20% more when compared to reference concrete for all w/c ratios but it reduced with the time. Internal curing maximizes the Sorptivity and which is more efficient in smaller w/c ratios. Air permeability of concrete without self curing remains at unchanged, but has a little decline in concrete with w/c ratio of 0.33 from 1 to 7 days. On the other hand, air permeability of concrete with internal curing, which is more on first day considerably reduces with the age and is 50-60% lower than that of normal concrete. Chloride diffusivity is low for internal cured specimens than that of normal cured specimens and it is low high w/c ratio. Specimens containing pre-saturated LWA have higher mass loss and it increases with increase in w/c ratio.

Amal Francis k, Jino John (2013)<sup>[1]</sup> has researched in his study and concluded that the most convenient percentage of SAP for high strength parameters (such as compressive, flexural, split tensile strength) was found to be 0.3% for M40 grade of concrete. Prof. Vinayak Vijapur, Manjunath, G. Tontanal (2013)<sup>[5]</sup> has concluded that in compressive strength test, flexural, split tensile and 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. In compressive strength test, flexural, split tensile, shear strength test with water curing at 0% replacement of pumice aggregates by natural aggregates gives the higher strength. If the dosage of pumice aggregates increased automatically strength decreases.

As per Sathanandham.T (2013)<sup>[6]</sup> the desired amount of polyethylene glycol for high strength parameters was found to be 1.5% for M20 grade of concrete. As the amount of polyethylene glycol increases automatically slump increases in both grades of concrete respectively. C.Chella Gifita, S.Prabavathy, G.Yuvraj Kumar (2013)<sup>[2]</sup> has studied and concluded that the compressive strength is more for normal concrete at 3 days but after the completion of 28 days concrete having LWA has higher compressive strength than remaining mixes. Tensile and flexural strength is also higher for the concrete mix containing LWA as an internal curing material but the concrete with SAP is also closer to that of LWA. Durability studies showed that internal curing by means of SAP has less chloride penetration than the specimens with LWA. The coefficient of permeability of mix M<sub>2</sub> was less than all other mixes.

## 2. EXPERIMENTAL PROGRAMME AND MATERIALS

From the methods discussed in the above literature, those methods which use compounds like Poly ethylene glycol e.t.c. seem to be very productive. By using this method it enables to control the evaporation of moisture content from the concrete. In this ongoing study, the experimental programme is carried out to establish the suitability of a

curing compound with standard dosage and standard grade of concrete i.e., M40 to investigate the compressive strength, flexural strength, split tensile strength. The experiment was done considering concrete mix (1:1.45:2.95) with water cement ratio of 0.40 and dosage of liquid paraffin wax used was 0.1% (by weight of cement).

### Materials of experimental study

The various materials used in the present experimental study are discussed below.

#### Cement

Ordinary Portland Cement (O.P.C) of 53 grade that is conforming to the code IS: 12269 – 1987 has been used in the investigation. It is observed that 3.15 is the specific gravity of cement which was used in the study and surface area was 225 m<sup>2</sup>/g. the initial and final setting time of cement were

#### Fine Aggregate

The sand or fine aggregate used in the experiment was collected from a nearby river course. The fine aggregate conforming to the zone – III was according to the code IS: 383-1970. The specific gravity was 2.66 and the bulk density was 1.45 g/cm<sup>3</sup>.

#### Coarse Aggregate

The coarse aggregate used has been obtained from a crushing division available in the locality having 20mm and 10mm nominal sizes. The coarse aggregate conforming to 20mm and 10mm are well-graded according to IS: 383-1970. The specific gravity was 2.83 and the bulk density was 1.52 g/cm<sup>3</sup>.

#### Water

Ordinary potable water without acidity and alkalinity was used in the experimental work.

#### Liquid Paraffin wax (LPW)

Liquid Paraffin wax of clear and colorless liquid was used in the study. This hydrophilic compound is used for promoting internal curing in concrete. The flash point of LPW is more than 180°C and specific gravity is more than 1. The vapour density is less than 0.01 mmHg at 2.0°C. The chemical was mixed with water thoroughly prior to mixing of water in concrete.

#### Conplast SP 430

Conplast SP 430 is a super plasticizing admixture. Conplast SP 430 is an admixture of a new generation consisting of Sulphonated Naphthalene Polymers and supplies as brown colored liquid and will be dispersible in water instantly. The product has been primarily developed for applications in high performance. The specific gravity varies from 1.220 to 1.225 at 30°C. This admixture is used to maintain the workability of concrete in the absence of adequate amount of water and to produce high quality concrete of reduced permeability.

## EXPERIMENTAL WORK

The present experimental study involves in two different types of curing namely air curing and conventional curing.

In both types of curing, liquid paraffin wax of dosage 0.1% (by weight of cement) has been used. The effectiveness of the hydrophilic compound used is determined by studying the workability properties and strength parameter properties of concrete like compressive strength, split tensile strength and flexural strength. The use of liquid paraffin wax is supposed to minimize the evaporation of water from concrete specimen and thus maximize the water holding capacity of hydration process. The use of self curing compound has to ensure to satisfy the above parameters as well as to show required strength properties.

### SLUMP TEST

Slump test has been carried out to find the workability of self curing concrete. The apparatus used for doing slump test are Slump cone and tamping rod. Slump test is carried out as per IS: 1199 – 1959.

### COMPRESSIVE STRENGTH TEST

This test is conducted on compression testing machine. The cubes prepared for testing are 150mm x 150mm x 150mm. The cube was placed in the compression testing machine and the load on the cube is applied at a constant rate up to the failure of the specimen according to IS 516-1959 and the ultimate load is noted. The cube compressive strength of the concrete mix is then computed. This test has been carried out on cube specimens at 7, 14 and 28 days age. In each case three cubes were tested and their average value is recorded.

### SPLIT TENSILE STRENGTH TEST

This test is conducted on compression testing machine. The cylinders prepared for testing are 150 mm in diameter and 300 mm height. After noting the weight of the cylinder, diametrical lines are drawn on the two ends, such that they are in the same axial plane. Then the cylinder is placed on the bottom compression plate of the testing machine. Then the top compression plate is brought into contact at the top of the cylinder. The load is applied at uniform rate, until the cylinder fails and the load is recorded according to IS 5816-1999. From this load, the splitting tensile strength is calculated for each specimen. This test has been carried out on cylinder specimens at 7, 14 and 28 days age. In each case three cylinders were tested and their average value is recorded.

### FLEXURAL STRENGTH TEST

This test is conducted on Universal Testing machine. The beam element of dimension 100 x 100 x 500 mm was cast. The specimens were demolded after 24 hours of casting and were transferred to curing tank where in they were allowed to cure. These flexural strength specimens were tested under two point loading as per IS 516-1959, over an effective span of 400 mm on flexural testing machine. Load and corresponding deflections were noted up to failure. This test

has been carried out on beam specimens at 7, 14 and 28 days age. In each case three beams were tested and their average value is recorded.

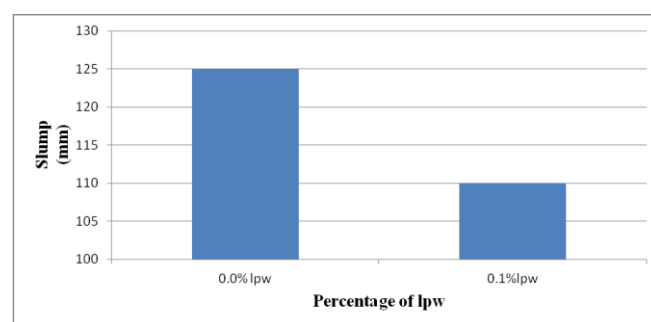
## 3. RESULTS AND DISCUSSIONS

### 3.1 Slump Test

The slump test is performed to know about workability. The following are the observations on slump test.

**Table 3.1** Slump test results

Nomenclature of mix	Slump (mm)
OPC + 0.3 % Conplast	125 mm
OPC + 0.1 % lpw+ 0.3 % Conplast	110 mm



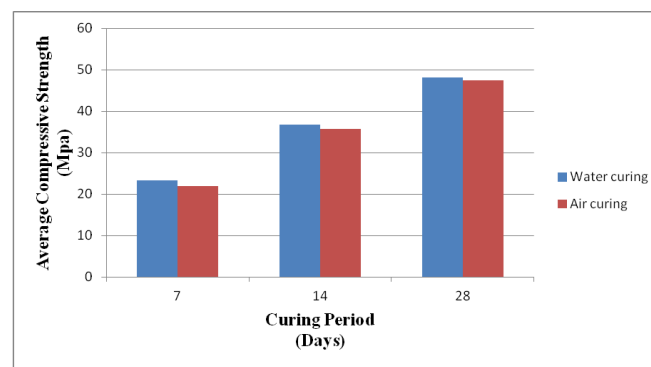
**Figure 3.1:** Variation of slump due to liquid paraffin wax

From table 3.1, it was observed that, there was a decrease in the percent of slump of 12% in self curing concrete when compared to conventional concrete.

### 3.2 Compressive Strength Test Results:

**Table 3.2** Compressive Strength Test Results

Nomenclature of mix	Curing Period		
	7 days (N/mm <sup>2</sup> )	14 days (N/mm <sup>2</sup> )	28 days (N/mm <sup>2</sup> )
OPC + 0.3% Conplast (Water curing)	23.30	36.78	48.07
OPC + 0.1% lpw+ 0.3% Conplast (Air curing)	21.96	35.74	47.36



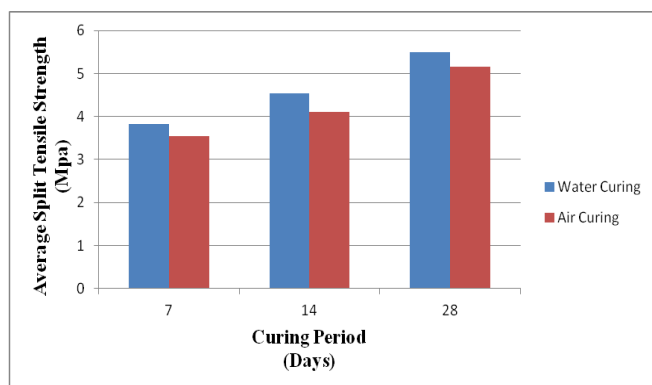
**Figure 3.2** Variation of Compressive strength with age

- i) From table 3.2, it was observed that there was reduction in compressive strength of self curing concrete (air curing) of 5.75% when compared to conventional concrete (water curing) at 7 days.
- ii) From table 3.2, it was observed that there was reduction in compressive strength of self curing concrete (air curing) of 2.83% when compared to conventional concrete (water curing) at 14 days.
- iii) From table 3.2, it was observed that there was reduction in compressive strength of self curing concrete (air curing) of 1.48% when compared to conventional concrete (water curing) at 28 days.

**3.3 Split Tensile Strength Test Results:-**

**Table 3.3** Split Tensile Strength results

Nomenclature of mix	Curing Period		
	7 days (N/mm <sup>2</sup> )	14 days (N/mm <sup>2</sup> )	28 days (N/mm <sup>2</sup> )
OPC + 0.3% Conplast (Water curing)	3.82	4.53	5.49
OPC + 0.1% lpw+ 0.3% Conplast (Air curing)	3.54	4.10	5.15



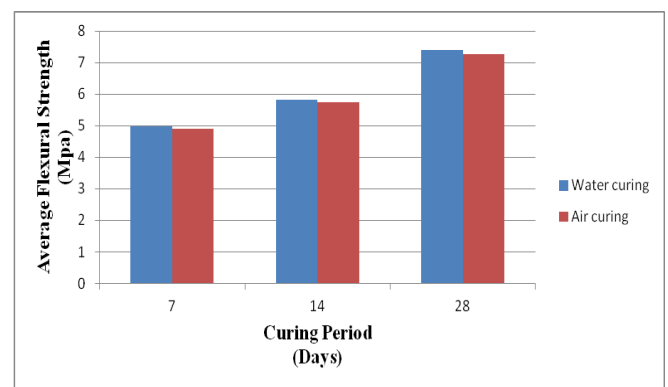
**Figure 3.3** Variation of split tensile strength with age

- i) From table 3.3, it was observed that, there was increase in split tensile strength of self curing concrete (air curing) by 7.33% when compared to conventional concrete (water curing) at 7 days.
- ii) From table 3.3, it was observed that, there was increase in split tensile strength of self curing concrete (air curing) by 9.49% when compared to conventional concrete (water curing) at 14 days.
- iii) From table 3.3, it was observed that, there was increase in split tensile strength of self curing concrete (air curing) by 6.19% when compared to conventional concrete (water curing) at 28 days.

**3.4 Flexural Strength Test Results:**

**Table 3.4** Flexural Strength results

Nomenclature of mix	Curing Period		
	7 days (N/mm <sup>2</sup> )	14 days (N/mm <sup>2</sup> )	28 days (N/mm <sup>2</sup> )
OPC + 0.3% Conplast (Water curing)	4.98	5.81	7.41
OPC + 0.1% lpw+ 0.3% Conplast (Air curing)	4.91	5.75	7.26



**Fig 3.4** Variation of Flexural strength with age

- i) From table 3.4, it was observed that, there was reduction in Flexural strength of self curing concrete (air curing) by 1.41% when compared to conventional concrete (water curing) at 7 days.
- ii) From table 3.4, it was observed that, there was reduction in Flexural strength of self curing concrete (air curing) by 1.03% when compared to conventional concrete (water curing) at 14 days.
- iii) From table 3.4, it was observed that, there was reduction in Flexural strength of self curing concrete (air curing) by 2.02% when compared to conventional concrete (water curing) at 28 days.

**4. CONCLUSIONS**

- Following are the major conclusions drawn from the study:
- a) The slump of Self Curing Concrete was decreased by 12% when compared to conventionally cured concrete.
  - b) The compressive strength of Self curing concrete decreased by 1.48% when compared to conventionally cured concrete.
  - c) The split tensile strength of Self curing concrete decreased by 6.19% when compared to conventionally cured concrete.
  - d) The flexural strength of Self curing concrete decreased by 2.02% when compared to conventionally cured concrete.
  - e) The strength of Self curing concrete is on par with conventionally cured concrete.
  - f) From the study, concluded that using of Liquid Paraffin Wax as Self curing agent can show significant variation in strength of concrete.

## REFERENCES

- [1] Amal Francis k, Jino John “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.
- [2] C. Chella Gifta, S. Prabavathy and G. Yuvaraj Kumar “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).
- [3] Garje Rajesh Kumar “Self Curing Concrete” RILEM Publications SARL, 2011, ISBN No. 978-2-35158-116-2.
- [4] M.V.Jaganadha Kumar, M.Srikanth, Dr.K. Jaganadha Rao “Strength Characteristics of Self-curing Concrete” IJERT | Sep 2012.
- [5] 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.
- [6] Sathanandham T, Gobinath R, NaveenPrabhu M, Gnanasundar S, Vajravel k, Sabariraja.G, Manoj Kumar R , Jagathishprabu R “ Preliminary Studies of Self curing Concrete With the addition of Polyethylene glycol” IJERT, Vol. 2 Issue 11, November – 2013 ISSN: 2278-0181.
- [7] Semion Zhutovsky, Konstantin Kovler “Effect of internal curing on durability-related properties of high performance concrete” Cement and Concrete Research 42 (2012) 20–26.

## BIOGRAPHIES



**M.Pavan Kumar** M.E (SENDM), (Ph.D) Assistant Professor in Civil Engineering Department, S.V.P Engineering College, Visakhapatnam. He is doing Ph.D in Andhra University and Licensed Structural Consultant in Visakhapatnam. He has published several research papers in various journals



**S.Pavan Ayyappa**, Student M.E (Structural Engineering) Department of Civil Engineering, Sanketika Vidya Parishad, Visakhapatnam, Andhra Pradesh, India.



**G.T.Naidu**, Assoc. Professor, HOD, department of Civil Engineering in Sanketika Vidya Parishad Engineering College, Visakhapatnam. He is a Research scholar in GITAM University and is having 26 years of industrial experience, guiding the students at graduate and post graduate levels. He is the member in various professional bodies like FIV, MIE