International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 07 Issue: 09 | Sep 2020 www.irjet.net p-ISSN: 2395-0072

An Experimental Study on Building Components using Phase Change Material

Dhanalakshmi E[1], Arul Mozhi Bharathi D V[2], Vimal D[3]

[1]*PG Student, Dept. of Civil Engineering, Veltech Engineering College, Tamil Nadu, India*
[2]*PG Student, Dept. of Civil Engineering, Veltech Engineering College, Tamil Nadu, India*
[3]*Assistant Professor, Dept. of Civil Engineering, Veltech Engineering College, Tamil Nadu, India*

Abstract - *Phase Change Materials have been widely used in building applications as a thermal storage medium for passive thermal regulation. The applications have shown great potential in reducing energy demand or peak loads for both heating and cooling in buildings. Some of the other applications of phase change materials are under investigation of mechanical properties of hardened concrete. 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. This review focuses on the use of PCMs as an additive or replacement material in typical concrete mixtures for building applications. Several phase change materials, including polymeric glycol and paraffin wax, can act as self-curing compounds. This project 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 optimum dosages of Liquid paraffin wax were found to be 0.1% by weight of cement. M40 grade concrete was used to cast the cubes, cylinders, beams. They are tested at its 7,14, 28 days of curing period to check out its mechanical properties and it was compared with conventional curing method. From the experimental investigation, the results have been shown that, there was a fall in compressive strength, split tensile strength, flexural strength by 1.48%, 6.39%, 5.15% than conventional curing. It can be concluded that the potential of using PCM in concrete still requires further research, to study solutions that allow increasing the amount of PCM that is effectively incorporated into concrete*

***Key Words*: Curing of Concrete, Liquid Paraffin Wax, Phase Change Material, Self Curing Concrete.**

1. INTRODUCTION

Curing is the process of maintaining sufficient moisture and temperature in the concrete after it is placing in position, which is absolutely necessary for its complete hydration. If concrete or mortar is not cured properly, material will ever gain desired strength. Curing of concrete is the last and one of the most important activities required to be taken in the Process of concrete construction. This last step plays a very significant role in concrete performance and needs the full and minute attention of the persons involved in construction and those involved with quality assurance. One should know the actual role of water in concrete. Unfortunately, people add more water while making concrete and use less water after concreting. Actually, it should be a reverse. There should be sufficient water available in concrete so that the chemical reaction takes place between water and cement called "Hydration". Because of hydration process, heat is generated called heat of hydration. Therefore, temperature increases inside the concrete and water evaporate from the concrete and concrete becomes dry.

The object of curing is to control the temperature inside the concrete, continuing hydration process and to prevent dryness of concrete. It is necessary that sufficient quantity of water should be available in concrete till attains its full strength. Phase change materials have an ability to store and release large amounts of energy, in the form of latent heat. Although phase changes can occur among any combination of the three phases of a substance - gas, liquid, or solid the most commercially viable transition is between the liquid and solid phases. When a PCM is in its solid phase it can absorb heat, providing a cooling effect and when a PCM is in its liquid phase it can release heat, providing a warming effect.

2. LITERATURE VIEW

Madduru et al. (2016)[9] investigated the use of paraffin wax as an internal curing agent in the preparation of self-compacting concrete. Here the fresh, hardened and microstructural properties have been studied with and without paraffin wax. The authors have concluded that the water loss from the concrete was minimum at the age of 90 days and the optimum dosage of the curing agent under lower and heavy molecular weight was found to be 0.1% and

1% based on weight of cement. In addition to that the strength remains more or less same for the concrete under both curing regimes as per their notice.

Jagannadha Rao and coworkers (2012)[6] utilize the shrinkage reducing admixture PEG 400 in concrete which helps in self - curing and helps in better hydration. The effect of admixture (PEG 400) on compressive strength, split tensile strength and modulus of rupture by varying the percentage of PEG by weight of cement from 0% to 2% were studied both for M20 and M40 mixes. It was found that PEG 400 could help in self-curing by giving strength on comparing with conventional curing. It was also found that 1% of PEG 400 by weight of cement was optimum for M20, while 0.5 % was optimum for M40 grade concretes for achieving maximum strength.

Phase change materials (PCM) can be used in passive building applications to achieve near zero energy building goals. For this purpose **H Paksoy, et al (2017)**[7]investigated on the addition of PCM in building structures and materials in different forms. Direct incorporation, form stabilization and microencapsulation are different forms used for PCM integration in building materials. In addition to thermal properties of PCM itself, there are several other criteria that need to be fulfilled for the PCM enhanced building materials. Mechanical properties, corrosive effects, morphology and thermal buffering have to be determined for reliable and long term applications in buildings. This paper aims to give an overview of characterization methods used to determine these properties in PCM added fresh concrete mixes. Thermal, compressive strength, corrosion, and microscopic test results for concrete mixes with PCM are discussed.

M. Hunger et al (2009)[3] analyzed the behavior of self-compacting concrete containing micro-encapsulated phase change materials. In order to evaluate the effect of PCM on the thermal conductivity of concrete they prepared three mixes containing 1% PCM, 3% PCM and 5%. Two samples of 100 mm×100 mm× 50 mm of every mixture were prepared for the measurements. Their results for thermal conductivity measurements are presented in figure below. From the graph it is clear that the addition of PCM particles into the mass of the concrete results in a reduction of thermal conductivity. The reduction in thermal conductivity is due to increased air content and because of the use of low thermal conductivity material like paraffin. Among the different types of PCMs, organic compounds have been found to be the most promising candidates for applications in mortars due to their chemical stability, non-corrosive nature, reproducible melting and crystallization.

3. MATERIALS USED

From the methods discussed in the above literature, those methods which use compounds like Poly ethylene glycol, Paraffin wax etc., 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 program 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 (1:1.13:2.34) and (1:1.16:2.40) with water cement ratio of 0.40 and dosage of liquid paraffin wax used was 0.1% (by weight of cement).

3.1. CEMENT

Ordinary Portland Cement (O.P.C) of 53 grade that is confirming to the code IS: 12269 – 1987 has been used in the investigation. It is observed that 3.14 is the specific gravity of cement which was used in the study and surface area was 225 m^2/g. The initial and final setting time of cement were 40 and 560 minutes.

3.2. FINE AGGREGATE

The sand or fine aggregate used in the experiment was collected from a nearby river course. The fine aggregate confirming to the zone – II was according to the code IS: 383-1970. The specific gravity was 2.65 and the bulk density was 1.45 g/cm^3.

3.3. 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 confirming 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^3.

3.4. WATER

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

3.5. LIQUID PARAFFIN WAX

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 1800C and specific gravity is more than 1. The chemical was mixed with water thoroughly prior to mixing of water in concrete.

3.6. CONPLAST

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 300C. 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.

4. 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 phase change material 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.

4.1. 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.

4.2. 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.

4.3. 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.

4.4. 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.

Figure 1: Casting of Cubes, Cylinders and Beams

5. RESULTS AND DISCUSSIONS

5.1. SLUMP TEST

Table 1: Slump Test Results

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

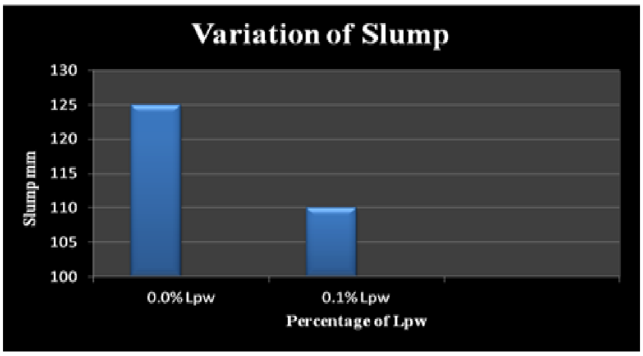

Figure 2: Variation of Slump due to Liquid Paraffin Wax

From table 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.

5.2. COMPRESSIVE STRENGTH TEST RESULTS

Table 2: Compressive Strength Test Results

Nomenclature of mix	Curing Period		
	7 days (N/mm^2)	14 days (N/mm^2)	28 days (N/mm^2)
OPC + 0.3% Conplast (Water curing)	21.92	34.28	46.63
OPC + 0.1% lpw+ 0.3% Conplast (Air curing)	20.58	33.24	44.29

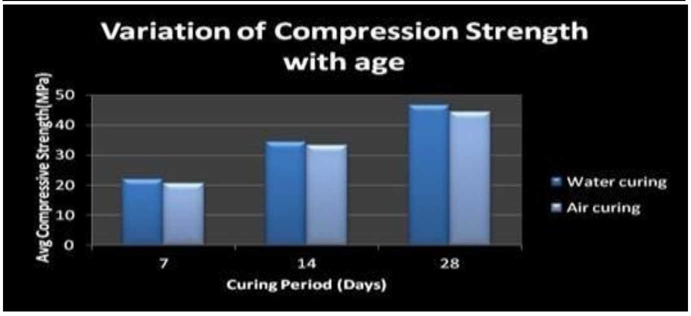

Figure 3: Variation of Compressive Strength with Age

- From table 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.
- From table 2, it was observed that there was reduction in compressive strength of self-curing (air curing) of 2.83% when compared to conventional concrete (water curing) at 14 days.
- From table 2, it was observed that there was reduction in compressive strength of self-curing (air curing) 1.48% when compared to conventional concrete (water curing) at 28 days.

5.3. SPLIT TENSILE STRENGTH RESULTS

Table 3: Split Tensile Strength Results

Nomenclature of Mix	Curing Period (N/mm^2)		
	7 days	14 days	28 days
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

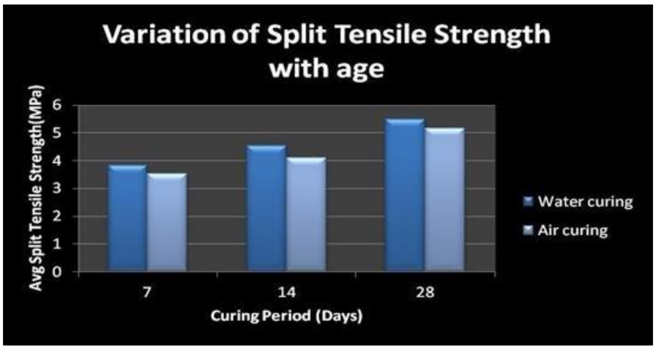

Figure 4: Variation of Split Tensile Strength with Age

- From table 3, it was observed that, there was increase in split tensile strength of self-curing concrete (air curing) by 7.60% when compared to conventional concrete (water curing) at 7 days.
- From table 3, it was observed that, there was increase in split tensile strength of self-curing concrete (air curing) by 9.96% when compared to conventional concrete (water curing) at 14 days.
- From table 3, it was observed that, there was increase in split tensile strength of self-curing concrete (air curing) by 6.39% when compared to conventional concrete (water curing) at 28 days.

5.4. FLEXURAL STRENGTH TEST RESULTS

Table 4: Flexural Tensile Strength Results

Nomenclature of Mix	Curing Period (N/mm^2)		
	7 days	14 days	28 days
Water curing	5.22	6.41	8.56
Air curing	5.65	6.28	8.13

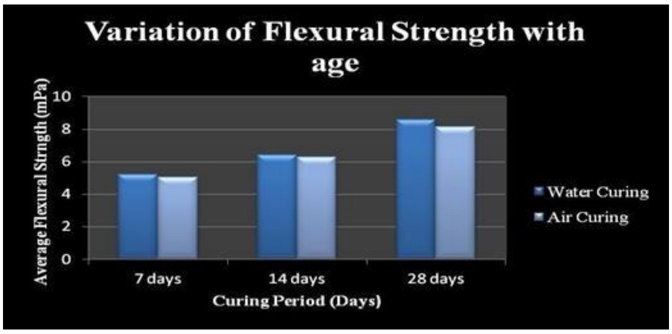

Figure 5: Variation of Flexural Strength with Age

- From table 4, it was observed that, there was reduction in Flexural strength of self-curing concrete (air curing) by 3.31% when compared to conventional concrete (water curing) at 7 days.
- From table 4, it was observed that, there was reduction in Flexural strength of self-curing concrete (air curing) by 2.04% when compared to conventional concrete (water curing) at 14 days.
- From table 4, it was observed that, there was reduction in Flexural strength of self-curing concrete (air curing) by 5.15% when compared to conventional concrete (water curing) at 28 days.

6. CONCLUSIONS

- The slump of Self Curing Concrete was decreased by 12% when compared to conventionally cured concrete.
- The compressive strength of Self curing concrete decreased by 1.48% when compared to conventionally cured concrete. The split tensile strength of Self curing concrete decreased by 6.39% when compared to conventionally cured concrete.
- The flexural strength of Self curing concrete decreased by 5.15% when compared to conventionally cured concrete.
- The strength of Self curing concrete is on par with conventionally cured concrete.
- From the study, concluded that using of Liquid Paraffin Wax as Self curing agent can show significant variation in strength of concrete.

7. REFERENCES

[1] Sathanandham.T1,Gobinath.R2,NaveenPrabhu.M 3,Gnanasundar.S3,Vajravel.K3,Sabariraja.G3,Man oj kumar.R3, Jagathishprabu.R3, “Preliminary Studies of Self curing Concrete With the addition of Polyethylene glycol” IJE T, Vol. 2 Issue 11, November – 2013 ISSN: 2278 -0181.

[2] D.P. Bentz, R.Turpin, Potential applications of phase change materials in concrete technology, Cem. Concrete. Compos. 29 (7) (2007) 52 7 –532.

[3] M. Hunger , A.G. Entrop, I. Mandilaras, H.J.H. Brouwers, M. Founti, The behavior of self-compacting concrete containing micro - encapsulated Phase Change Materials, Cement & Concrete Composites 31 (2009) 731 –743.

[4] T. Xu, Q. Chen, Z. Zhang , X. Gao, G. Huang, Investigation on the properties of a new type of concrete blocks incorporated with PEG/SiO2 composite phase change material, Building and Environment 104 (2016) 172177.

[5] D. Zhou, C.Y. Zhao, Y. Tian, Review on thermal energy storage with phase change materials (PCMs) in building applications, Applied Energy 92 (2012) 593 -60.

[6] M.V.Jagannadha Kumar, M. Srikanth, K. Jagannadha Rao, “Strength characteristics of Self- Curing Concrete”, International Journal of Research in Engineering and Technology Volume: 01 pp 51 – 57, Sep - 2012.

[7] H. Paksoy et al (2017), “Characterization of Concrete Mixes Containing Phase Change Materials”, IOP Cong. Ser.: Mater. Sci. Eng. 251.

[8] 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 ",International Journal Of Engineering Research & Technology (IJERT), (2013), Vol. 2 Issue 11.

[9] Madduru Sri Ramu Chand et al (2016), “Effect of Self Curing Chemicals in Self Compacting Mortars”, Construction and Building Materials, March 2016, 107:356 -36.