RESEARCH PAPER

An Experimental Study Of Self Curing Concrete Using Polyethylene Glycol And Superplasticizer

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ABSTRACT

In the traditional method of curing concrete, water plays an authoritative role. Water has to be poured sporadically, to keep the columns, and beams wet during the curing course. Normally gunny bags are used to shelter the columns and beams to keep them wet. This is external curing. To circumvent the massive consumption of water, self-curing chemical agent like Polyethylene Glycol – 400 (PEG) and super plasticizer are added to the coarse mixture during the production of concrete. So Self- Cured concrete is a type of concrete which is cured without external curing. Polyethylene glycol (PEG), is a non-hazardous, biodegradable, and water-soluble polymer which helps to preserve a reliable moisture level within the concrete. PEG and superplasticizer were included in varying measures. A wide lab tests have been done with the specimens to determine compressive strength, Split tensile strength and flexural strength after 7, 14, and 28 days of curing. The tests conducted shows that the strength achieved through self-curing method is enhanced than the external curing method.

Keywords: Traditional curing, Self curing, Polyethylene glycol, super plasticizer, strength of concrete.

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INTRODUCTION

Construction of building involves a tremendous work. It needs materials such as cement, sand, coarse aggregate, steel rods and water. In the creation of concrete columns, beams and slabs a large quantity of water is vital. In the water scarce regions, it is delinquent and it rises the cost of construction. Hence building researchers have stepped to reduce the usage of water which results in the concept of self-curing concrete. Self-curing concrete is an innovative technology that eradicates the need for water or humidity during the curing process, which reforms the construction industry. Curing is very essential and if it lacks at early-stage concrete may suffer irreparable loss in strength and durability.

Different methods of curing

Water Curing

Most commonly using curing promotes hydration, absorbs heat of hydration and eliminate shrinkage. The methods of conventional curing methods are immersion or ponding or spraying or fogging or wet covering.

Membrane Curing

Membrane curing commonly uses materials like bitumen, rubber compounds, polyester or polyethylene film and waterproof paper. Water curing is

implemented for a short duration before commencement of membrane curing. This requires skilled labour and good supervision. It prevents the evaporation of moisture from concrete by generating an effective seal and is an expensive method.

Application of Heat Steam

Steam curing at ordinary pressure attains the 28th - day strength in roughly about 3 days, and high-pressure curing results in the 28th- day strength in a day. Curing by Infrared radiation is applicable in regions of cold climate and is effective for precast concrete, and the 28th - day strength is attained in 15 hrs. Electrical curing provides rapid strength gain, creates a denser microstructure, reduces cracks, improves durability, energy saving is significant, and carbon emission is low but is expensive and suitable only in the cold climate.

Rate of hydration of depends on, time and temperature of concrete. Maintaining higher temperature and adequate moisture in concrete can accelerate the rate of hydration. These two requirements can be simultaneously achieved by applying heated steam on to concrete.

Equation for strengthening of cement

The hydration of cement plays an important character in strengthening the concrete. The extent of hydration depends on the availability of moisture in the concrete, which requires large amount of water.

$2(CaO.SiO_2) + 6H_2O \rightarrow 3CaO.2SiO_2.3H_2O + 3Ca(OH)_2$

Hydration of cement starts at faster rate at the onset, but the rate of hydration slows down as time elapses. It is an Exothermic Reaction. M. S. Shetty [2010] (1) expresses curing as the process of maintaining an acceptable moisture content and a favourable temperature in concrete during the period, so that hydration of cement continues to acquire the desired properties.

Cracking of Concrete

Materials undergo tensile cracking when its internal stress exceeds the tensile strength. In the neo stage, when the concrete develops its strength, it is subjected to a volume change due to drying of concrete mass and surfaces in hostile environment. Kovler and Zhutovsky [2006] (2) proposed that the capillary and surface tension, disjoining pressure and movement of interlayer water due to moisture changes of concrete mass is one of the reasons for shrinkage crack. Chemical shrinkage like swelling due to crystallization, carbonation, dehydration, thermal and phase transition are other reasons.

Classification of Shrinkage

Plastic shrinkage happens in the initial stages of fresh concrete, in which the concrete behaves as a plastic mass. It depends largely on the loss of water due to evaporation. Autogenous shrinkage takes place when the dimension of the concrete mass changes, and is due to the process of hydration of cement. Drying shrinkage is due to loss of water from the concrete mass, and due to the influence of external atmospheric conditions like relative humidity and specimen dimensions. Carbonation shrinkage occurs due to the process of carbonation. Carbonation shrinkage takes place due to the reaction of Calcium Hydroxide [$Ca(OH)_2$] with Carbon dioxide (CO_2) in atmosphere, to Calcium Carbonate ($CaCO_3$).

The growing demand for durable and sustainable construction constituents, coupled with challenges in traditional curing methods, has driven significant research into self-curing concrete Reddy & Kumar, 2025. (3). This innovative approach aims to mitigate the inherent difficulties associated with conventional curing, such as inadequate water supply and labour intensiveness, particularly in remote or arid construction environments Makendran et al., 2022, Mousa et al (4,5). Self-curing concrete incorporates internal curing agents, such as polyethylene glycol, that retain and release moisture to facilitate continuous hydration within the concrete medium Nivethitha et al., 2020(6). Zeyad., 2019 (7) studied the impact of different curing methods and reported the compressive strength of high-strength concrete of more than 60 MPa after 28 days, irrespective of the curing method. Steam curing is the newest method of concrete curing. The steam temperature plays a chief role in developing the strength of concrete, Ramezanian pour et al., 2015. (8). The steam curing and autoclave curing methods are found to be more effective than conventional curing, for the concrete established using fly ash and GGBS Yazici et al., 2009. (9) Self-curing concrete is typically developed by means of pre-wetted aggregates by adding some polymer in the concrete. These aggregates or polymers release their moisture during the process of drying, which provides water to cementing material for complete hydration (Jensen and Hansen, 2001. (10). Different researches have been led to develop self-curing concrete by replacing the conventional coarse or fine aggregate with alternate materials. Pre-wetted lightweight aggregate has been used in self-curing concrete by several researchers, and studied its crack tendency Byard et al., 2012 (11) Wei et al., 2014 (12) utilized pre-wetted sintered fly ash as lightweight fine aggregate, whereas Savva and Petrou (2018) (13) utilized the aggregate containing micritic calcite. To control the shrinkage in concrete biomass waste is also used as self-curing concrete by Lura et al., 2014 (14). Liu et al., 2017 (15) reported that internal curing using cenospheres also improves the compressive strength of cement mortar. Kim and Lee., 2018 (16) reported that the compressive strength of concrete can be enhanced by using the bottom ash as self-curing agent. while using 5 % pre-soaked biochar as fine aggregate the degree of hydration enhances to 17 % with a very small loss of 4 % in the compressive strength Dixit et al., 2019. (17) Recently, Balapour et al., (2020) (18) found that when bottom coal ash used as internal curing agent, it releases 85 % water at 94 % relative humidity condition. Li et al., 2020 (19) found that using porous aggregate in the concrete for internal curing it lowers the compressive strength. Polymer-like polyethylene glycol 4000 and 200 were observed to improve the formation of CASAH gel, thereby improving its strength and durability says (Madduru et al., 2016).

(20) Tu et al., 2019 (21) studied the impact of super absorbent polymer on the shrinkage of alkali-activated fly ash-slag pests. The result revealed that the polymer reduces the hydration rate and thereby reduces autogenous shrinkage and the superabsorbent may be anionic, or cationic, or a non-ionic group.

Zhong et al., 2019. (22) has been detected that the superabsorbent with both anionic and cationic groups or with the anionic group in high density are excellent internal curing agents. It has been observed that the superabsorbent polymer with a smaller particle size could provide water for hydration for a comparatively long time. Wyrzykowski et al., 2020 (23) found the superabsorbent polymers are very effective in controlling the shrinkage of CSH-seeded low water-cement ratio mortar. The literature of this study says that most of the researchers have utilised water-soluble polymers like superabsorbent, polyethylene glycol, polyvinyl alcohol, paraffin emulsion, hydrocarbon resin, acrylic resin, and polyacrylamide as internal curing agents.

MATERIALS AND METHODOLOGY

Materials

1. Cement: Ordinary Portland Cement of grade 53 (OPC) cement is used for this testing.
2. Aggregates:

Fine aggregate: River sand (Zone II) the fineness of the fine aggregate is 3.32 and the specific gravityis2.64.

Coarse aggregate: Crushed granite (20mm, 10mm).

3. Water: In concrete production, potable water is used.
4. PEG 400: The structure of Polyethylene Glycol is H-(O-CH2-CH2) n -OH where n is the average number of repeated oxyethylene groups. Average molecular weight of PEG is 400.
5. Superplasticizer:

A super plasticizer is a chemical additive for concrete that dramatically enhances the fluidity without adding more water which results in stronger, denser and more durable. The water-soluble polymers work by coating cement particles, causing them to repel each other and creates a smooth flow mix. Common types of plasticizers are Polycarboxylate ethers, Sulphonated melamine formaldehyde, and Sulphonated naphthalene formaldehyde.

Methodology

For the preparation of M50 grade concrete incorporating PEG 400, the mix design was based on IS 102622009 specifications, using a ratio proportion of 1:1.89:3.6. The concrete was mixed in a tilting drum type concrete mixer, ensuring uniformity in the blend of cement, fine aggregate (sand), coarse aggregate, and water. Specific doses of PEG 400 were added to the mix as 0%, 1.0%, and 1.5% by weight of cement to create different specimens. It was mixed for 3- 5 minutes to achieve a homogeneous consistency. Before starting casting of specimens, the moulds should be oiled and then tightened. The size of the cubes to be casted is 150mm x 150mm x 150mm and the size of the cylinder to be casted is 200mm height and 100mm diameter. To identify the specimens, they were labelled as CC (0% - peg) for conventional concrete, SCC (1% - PEG) and SCC (1.5%-PEG) for self-curing concrete. This method ensures accurate assessment of the performance of PEG 400 on M50 grade concrete. This CC samples require external curing but the other samples SCC do not need any external curing.

Casting of specimens: Before starting casting of specimens, the moulds should be oiled and then tightened. The size of the cubes to be casted is 150mm x 150mm x 150mm. The size of the cylinder to be casted is 200mm height and 100mm diameter.

TESTS CONDUCTED

Workability (Slump):

PEG (%)	Slump (mm)
0	70
0.5	85
1.0	95
1.5	80

Table.1 shows the workability of slump for various additions of PEG (0%, 0.5,1%,1.5%). The workability range increases from medium to high.

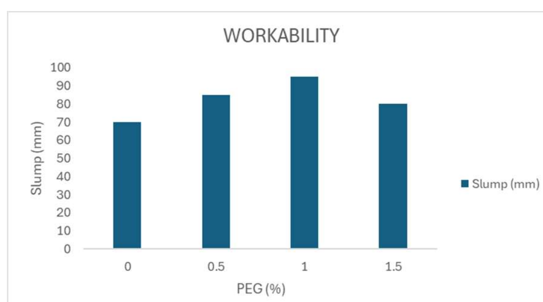

Figure 1. Shows the workability for various percentage of PEG addition

From the Fig.1, it is observed that the workability is maximum 95 mm for 1% PEG addition.

Compressive Strength (MPa):

Figure 2. Compressive strength test

The compressive strength values obtained are tabulated in Table.2. PEG value of 1% addition has given the maximum strength of 44.5 MPa for 28 days curing.

Table.2. Compressive strength for different PEG values for 7 ,14,28 days curing.

PEG (%)	7 days	14 days	28 days
0	25.8	33.5	41.2
0.5	24.9	32.1	39.6
1	26.3	35	44.5
1.5	25	33	40.1

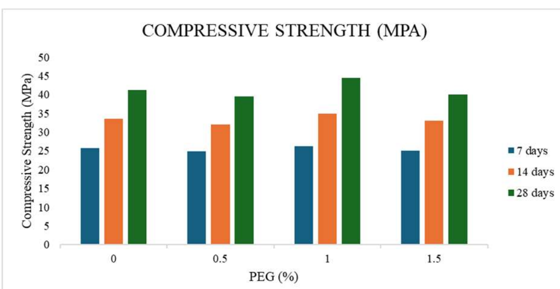

Figure 3. Shows the compressive strength of concrete for the different addition of PEG

Above figure.3 shows that the 28th day strength is maximum in all the cases. 1% addition of PEG has the highest strength value.

Split Tensile Strength (MPa)

Figure 4. shows the split tensile strength test

Table.3 For different PEG values and the split tensile strength for 7 ,14,28 days curing.

PEG (%)	7 days	14 days	28 days
0	2.1	2.6	3.2
0.5	2	2.5	3.1
1	2.2	2.7	3.4
1.5	2	2.6	3

The tabulated values show that 3.4 MPa is maximum for 1% addition of PEG.

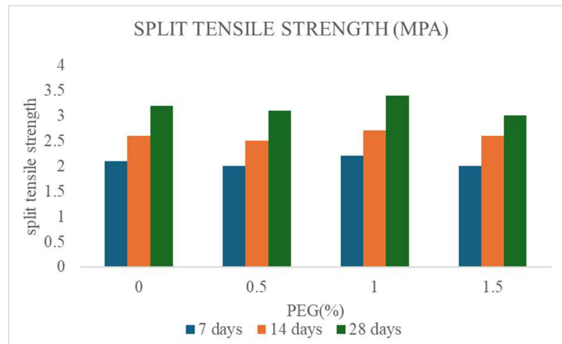

Fig.5 shows the split tensile strength comparison for varying PEG addition

From the above Fig.5, it is seen that the 28th day split tensile strength is maximum between the four cases.

Flexural Strength (MPa)

Table.4 shows that different PEG values addition and the flexural strength for 7, 28 days curing and further flexural strength is maximum for 1% PEG addition.

Table.4 For different PEG values and the flexural strength for 7,28 days curing

PEG (%)	7 days	28 days
0	3.8	4.6
0.5	3.7	4.5
1	4	4.9
1.5	3.6	4.3

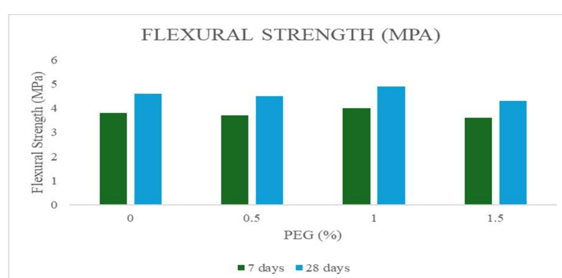

Fig.6 shows the comparison of flexural strength of specimens for differing values of PEG addition

Flexural strength has a peak value for the 28 days curing for 1% addition of PEG.

RESULT & DISCUSSION

The workability is maximum for the addition of 1% PEG. The compressive strength is 41.2 MPa for CC sample and 44.5 MPa for SCC for 28 days. The split tensile strength is 3.2 MPa for CC sample and the SCC sample has 3.4 MPa for 28 days. The CC sample has flexural strength of 4.0 and the SCC sample has a value of 4.1 for 28 days.

Finaly, it can be concluded that the addition of PEG and Super plasticizer offer self-curing and provide more strength to the M50 grade concrete than the conventional curing method. Utilisation of water and manpower is condensed. The cost of construction is automatically reduced.

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