Experimental Investigation of Self Curing of Concrete with Polyethylete Glycol

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ABSTRACT

Self-curing concrete, often referred to as internal curing concrete, represents a cutting-edge method aimed at keeping moisture locked within the concrete matrix during hydration. This approach significantly reduces the chances of early-age cracking and boosts long-term durability. Traditional curing methods can fall short, especially in dry climates, tight reinforcement spaces, or hard-to-reach structures. Self-curing techniques make use of materials like lightweight aggregates, superabsorbent polymers (SAPs), and various chemical admixtures to maintain internal moisture without relying on external water sources. This paper explores the mechanisms, materials, and effectiveness of self-curing agents, as well as their impact on the mechanical and durability characteristics of concrete. The study highlights the promise of self-curing concrete in improving construction quality, particularly in areas with scarce water resources or where standard curing methods are not feasible.

INTRODUCTION

Curing plays a crucial role in concrete construction, ensuring that the cement stays properly hydrated, which is essential for achieving the strength and durability we aim for. Traditionally, curing methods involve applying water from the outside, whether by ponding, spraying, or using wet coverings. However, these techniques can be challenging to implement, especially in remote areas, tight spaces with lots of reinforcement, or places where water is scarce. If curing isn't done correctly or thoroughly, it can lead to issues like plastic shrinkage, surface cracks, weakened strength, and long-term durability problems.

To tackle the drawbacks of conventional curing, self-curing concrete—often referred to as internally cured concrete—has emerged as a promising solution. This innovative type of concrete is designed to hold moisture within the mix, ensuring that the cement particles stay hydrated even without external water sources. This is made possible by using materials that can absorb and gradually release water, such as lightweight aggregates, superabsorbent polymers (SAPs), and specific chemical admixtures.

BACKGROUND ON SELF-CURING CONCRETE

Curing of concrete is an essential process that allows the cement hydration to continue, affecting the material strength, durability, and performance. Conventional curing techniques, such as water ponding, spraying, or wet covering, depend greatly on off-site moisture supply and site conditions. In most construction situations, such as arid environments, vertical structures, or inaccessible locations, it is difficult to maintain suitable curing conditions, resulting in early-age cracking, inadequate development of strength, and compromised service life.

In an effort to solve these limitations, self-healing concrete, which is also referred to as internally cured concrete, has been conceived. This technology entails the incorporation of water-retaining materials in the concrete matrix. These products, such as lightweight aggregates, superabsorbent polymers (SAPs), and chemical admixtures like polyethylene glycol (PEG), serve as reservoirs within. During curing, they release preserved moisture over a period of time, facilitating controlled hydration of cementitious materials independently of external sources of water.

The self-curing mechanism greatly minimizes autogenous shrinkage and internal stresses, particularly in high-strength and high-performance concretes with low water-to-cement ratios. Additionally, self-curing helps to enhance durability, microstructure, and sustainability by minimizing the requirement for continuous water application.

Since the construction industry is looking for better and more reliable techniques for improving concrete performance, self-curing concrete presents a valuable option, especially for buildings where standard methods of curing are not practical or resource-hungry.

LITERATURE REVIEW

Self-curing concrete has developed as a response to the limitation of using traditional curing techniques, particularly in dry areas or in buildings with restricted access for external curing. A number of self-curing agents have been researched, such as lightweight aggregates, superabsorbent polymers, and water-soluble chemicals.

Among the self-curing agents of chemical type, Polyethylene Glycol (PEG) has been found very effective because of its hygroscopicity and cementitious compatibility. Research work by Muthu Kumar and Ramamurthy (2003) demonstrated that PEG-400, when used in small dosages, enhanced the internal water retention and increased early-age strength of concrete. Comparable studies by Selvaraj et al. (2011) pitted PEG-400 against PEG-600, with the latter potentially providing greater water retention because of its higher molecular weight, although it might slightly decrease workability at higher concentrations.

PEG acts by soaking up water and gradually releasing it into the cement matrix as hydration advances. This process provides constant moisture supply internally, thus minimizing shrinkage and enhancing more complete hydration.

Yet, the existing body of knowledge has shortcomings. There is a lack of sufficient data concerning long-term longevity and microstructural transformation induced by PEG-based self-curing. Moreover, limited research presents an in-depth comparison of varying molecular weights and dosages of PEG on the same terms. Environmental influences and economic viability are also some areas that need further investigation in order to understand the sustainability of using PEG on a larger scale.

This research proposes to fill in these gaps through a comparative investigation of PEG-400 and PEG-600 at different dosages on the basis of strength, toughness, and effectiveness as an internal curing agent.

MATERIAL USED

1. Cement: 43-grade Ordinary Portland Cement (OPC) as per IS 8112:2013 was employed.

2. Fine Aggregates: 4.75 mm sieve passing natural river sand and as per IS 383:2016, Zone II.

3. Coarse Aggregates: 20 mm nominal size crushed angular granite aggregates as per IS 383:2016.

4. Water: Impurity-free potable tap water was utilized for mixing and curing purposes.

5. Polyethylene Glycol (PEG): PEG-400 and/or PEG-600 was utilized as the self-curing agents. PEG was introduced in different dosages (e.g., 0.5%, 1%, and 1.5% by weight of cement) to assess its effectiveness in curbing water evaporation.

6. Superplasticizer (optional): Polycarboxylate ether-based superplasticizer was employed to enhance workability, if necessary.

METHODOLOGY

Mixing: Dry mixing of concrete ingredients was done in a pan mixer for 1 minute. Water and PEG (dissolved in mixing water) were added, and the mixing was further continued for 2 minutes.

Casting: Cube (150 mm), cylinder (150 mm × 300 mm), and prism specimens (100 mm × 100 mm × 500 mm) were cast.

MIX PROPORTION

The proportion of concrete mix is the proportion of cement, water, fine aggregate (sand), and coarse aggregate employed in the mix. The right mix design is necessary to provide the desired workability, strength, durability, and economy of the concrete.

The proportions of concrete mix are usually established on the basis of the following important factors:

1. Strength Requirements: The required compressive strength (e.g., M20, M25, etc.) determines the quantity of cement and water.

2. Workability: Based on conditions of placement and method (pump, manual, etc.), the mix needs to provide satisfactory flow without segregation.

3. Durability: Conditions of exposure (e.g., industrial, marine) affect the water-cement ratio and materials used to provide resistance against deterioration.

4. Economy: Optimum mix design reduces cost without sacrificing quality by optimally adjusting material ratios.

MIX PROPORTION FOR M-30 GRADE

As per IS 10262:2019 and IS 456:2000 standards, M30 is a design mix (not a nominal mix), meaning its proportions are determined through lab trials for specific performance criteria.

Target Mean Strength Calculation:

Characteristic compressive strength (fck): 30 MPa

Standard deviation (S): 5 MPa (from IS code for good quality control)

Target mean strength (f’ck) = fck + 1.65 × S = 30 + 1.65 × 5 = 38.25 MPa

Assumed Parameters:

Maximum aggregate size: 20 mm

Degree of workability: 75–100 mm slump

Exposure condition:

Moderate Water-cement ratio (W/C): 0.45

Cement type: OPC 43 Grade

Specific gravity: Cement – 3.15, Sand – 2.65, Coarse Aggregate – 2.70

Proposed Mix Proportion (by weight):

Mix Ratio (by weight):

1 : 1.63 : 3.00 (Cement : Sand : Coarse Aggregate)

Water-cement ratio: 0.45

SPECIMEN PREPARATION

Concrete was blended with a pan mixer for homogenous distribution of all materials. The process was as follows:

1. Dry Mixing: Fine aggregate, coarse aggregate, and cement were thoroughly mixed for 2 minutes.

2. PEG Addition: The specified dosage of PEG-400 or PEG-600 was dissolved in mix water and added progressively to the dry mix.

3. Wet Mixing: Mixing for another 3 minutes ensured that the mix is homogenous.

Fresh concrete was filled in 150 mm × 150 mm × 150 mm cube moulds in three layers and each was compacted by means of a tamping rod as per IS 516:1959. The top surface was properly finished with a trowel.

The specimens were, after casting, covered with plastic sheets and allowed to remain undisturbed for 24 hours.

CURING PROCEDURE

Traditional Curing: Control specimens were removed from the mould after 24 hours and submerged in a room temperature water tank until the test day (7, 14, and 28 days).

* Self-Curing: Specimens with PEG were demoulded after 24 hours and stored in ambient laboratory conditions (~27±2°C and 60±5% RH) without any external water curing

ENVIRONMENTAL AND ECONOMIC CONSIDERATION

Utilization of Polyethylene Glycol (PEG) in self-healing concrete has significant environmental and economic considerations, especially in areas where water conservation and cost effectiveness are of essence in construction.

Cost-Effectiveness of PEG

Although PEG is costlier than water on a unit basis, its low dosage requirement (0.5%–1.0% by cement weight) contributes to only a small rise in total material costs. For example, 1.0% PEG added means approximately 4–5 kg per cubic meter of concrete, depending on the mix. This expense can be compensated by:

Removal of the requirement for external curing equipment (e.g., water tanks, curing blankets, labor).

Minimization of curing-induced defects, which reduces repair and maintenance costs.

Improved early gain in strength, which can minimize construction time and formwork cycles.

PEG-based self-curing is economically advantageous in large-scale or distant projects where water supply and curing man-power are expensive or not practical.

Sustainability Implications

PEG-assisted self-curing concrete offers several environmental benefits:

Water Conservation: Conventional curing involves a lot of water. Substituting this with water internal curing agents such as PEG saves thousands of liters per building, yielding sustainable water management, particularly in desert regions.

Lower Carbon Footprint: Better hydration and lower microcracking improve durability, which can increase the service life of structures, thereby minimizing the requirement for repeated repair or reconstruction.

Low Toxicity and Biodegradability: PEG is biodegradable in most forms and is non-toxic, with little environmental risk when applied in the right amounts.

Large-scale environmental analysis is limited. More research is required to assess the life-cycle effect of PEG production, transportation, and incorporation into concrete supply chains.

COMPRESSIVE STRENGTH TEST

Compressive Strength tests showed that PEG-assisted self–curing concrete achieved comparable or better strength than conventional curing at early and later ages

PEG Dosage(%)	7 Days (MPa)	14 Days (MPa)	28 Days (MPa)
0	28.5	34.2	39.8
0.5	29.8	35.6	41.2
1.0	30.5	36.4	42.5

1.5	28.0	34.0	39.2

- Optimal strength gain was observed at 1.0%PEG, attributed to effective internal curing
- At 1.5%, strength slightly dropped, likely due to over-retension of moisture, diluting cement hydration

FUTURE SCOPE

The future potential of self-curing concrete with polyethylene glycol (PEG) is bright, particularly in the context of the growing emphasis on sustainability and durability in the construction sector. PEG, being an internal curing agent, assists in providing the required moisture for cement hydration without depending excessively on external water supply. This is especially useful in dry areas and in massive projects where constant water curing is not feasible.

One of the biggest benefits fueling future application is the possibility of substantial water conservation. With world water shortages being a concern, the use of PEG-based self-curing concrete can help promote environmentally friendly building practices and assist in achieving green certifications like LEED. This fits with the construction industry's move toward more sustainable materials and methods.

The evolution of PEG-based self-healing concrete also owes a lot to advancements in material science. Investigation into different molecular weights of PEG is refining its effectiveness and its compatibility with different categories of cement and concrete blends. Integration with nanomaterials or self-sensing technology also offers a prospect for smart concrete applications in infrastructure monitoring.

As new construction increasingly embraces technologies such as 3D printing and modular precast systems, PEG-based curing agents provide a real-world solution to curing issues in these forms. For instance, in 3D printed structures, it is hard to implement external curing uniformly, so self-curing additives become critical to providing strength and durability.

Another important feature of PEG's future potential is its capacity to minimize shrinkage-induced cracking of concrete. Through preservation of internal moisture, it prevents plastic and autogenous shrinkage, enhancing structural performance and durability. This amounts to saving in maintenance and repair expenditures during the lifetime of concrete structures.
In the commercial sector, further research will make PEG increasingly cost-efficient and widely available. Enhanced formulation and dispersion methods will be developed, making it more convenient to use at building sites. With increasing awareness and documented performance gains, PEG-based self-curing concrete will potentially become a mainstream option for high-performance use.

Regulatory trends will also have an important impact on its future. With growing scientific evidence confirming its effectiveness, it is set to be integrated into construction standards and codes, leading to greater industry use. Industrial and academic research partnerships are set to hasten the process by furnishing data and case studies to support the long-term advantages of PEG in concrete.

REFERENCE

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Although not specific to PEG, this code highlights the importance of curing in concrete. PEG-based self-curing is increasingly being considered as an enhancement to standard practices.

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5. D. Bentz et al. (2001)
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