

Effect Of PEG-400 on Self-Curing Behaviour of the M-Sand based Sustainable Concrete

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ABSTRACT - Proper curing is essential for achieving the desired strength and durability of concrete. However, conventional curing methods rely heavily on the continuous application of water, which can be difficult to maintain in many construction environments, particularly in regions facing water scarcity. Self-curing concrete has been developed as an alternative approach to ensure adequate moisture availability within the concrete without the need for external curing. In this research, self-curing concrete was prepared by incorporating suitable self-curing agents into the concrete mix to facilitate internal water retention during the hydration process. Various mix proportions were designed and concrete specimens were cast to evaluate their mechanical performance. The compressive strength of the specimens was determined at curing periods of 7, 14, and 28 days. Here we focused on the design mix of M35 grade of concrete as per IS10262 2019. The results obtained from the experimental investigation were analyzed and compared to the effectiveness of the self-curing mechanism. The findings reveal that the inclusion of self-curing agents improves internal moisture availability and contributes to better hydration of cement, leading to satisfactory strength development around 6-8% then the conventional. This study highlights the potential application of self-curing concrete as a sustainable and efficient alternative to conventional curing practices in modern construction.

In this research of self-curing concrete, PEG-400 functions by reducing the vapor pressure of water in the pores of concrete, thereby minimizing water loss due to evaporation. As a result, the concrete retains more moisture for a longer period, which promotes better hydration and improves the development of strength and durability. This characteristic makes PEG-400 particularly useful in regions where water scarcity or inadequate curing conditions are common.

M-sand as a fine aggregate, filling the voids between coarse aggregates and contributing to the overall strength and stability of the mix. The particles of M-sand are generally angular and rough in texture, which helps improve the bonding between the cement paste and aggregates. This improved interlocking enhances the compressive strength and durability of concrete.

M-sand supports sustainable construction practices by reducing dependence on river sand and minimizing environmental damage caused by excessive sand mining. Due to these advantages, M-sand has become an important component in the production of high-performance and self-curing concrete used in modern infrastructure projects

KEYWORDS: Sustainable Self-curing concrete; Polyethylene Glycol (PEG-400); Internal curing; Hydration process; Water scarcity;

I. INTRODUCTION

In modern infrastructure development, concrete plays a fundamental role as the primary construction material used in buildings, bridges, roads, dams, and various other structural works. Its widespread use is mainly attributed to its high compressive strength, durability, and ability to be moulded into different shapes and sizes. Despite these advantages, the quality and long-term performance of concrete structures depend greatly on the curing process carried out after casting. Curing ensures that sufficient moisture and favourable temperature conditions are maintained so that the hydration of cement can proceed effectively. Proper hydration leads to the development of desired mechanical properties such as strength, durability, and resistance to environmental effects.

Adequate curing is essential for maintaining the integrity and durability of concrete structures. During the hydration process, cement reacts with water to form compounds that

provide strength to the concrete. If sufficient moisture is not available during this process, hydration becomes incomplete, resulting in poor strength development and increased susceptibility to cracking and permeability. Proper curing helps maintain internal moisture levels, allowing cement particles to hydrate completely and improving the overall quality of concrete. Therefore, curing is considered one of the most important stages in concrete construction.

Traditional curing practices commonly involve the external application of water to the concrete surface for a specified period. Methods such as ponding, sprinkling, covering with wet materials, and membrane curing are widely used in construction sites to maintain moisture on the concrete surface. Although these techniques are effective in promoting hydration, they require a continuous supply of water and careful monitoring throughout the curing period. In many real

construction situations, particularly in areas facing water scarcity or in structures where access is limited, maintaining continuous curing becomes difficult. As a result, insufficient curing can lead to incomplete hydration of cement, which ultimately reduces the strength and durability of concrete structures.

To overcome these limitations, researchers have introduced the concept of **self-curing concrete**, also referred to as **internal curing concrete**. This technique involves incorporating materials into the concrete mix that are capable of retaining water within the concrete matrix and gradually releasing it during the hydration process. By providing an internal source of water, self-curing concrete ensures that cement particles continue to hydrate even in the absence of external curing methods. This internal curing mechanism improves hydration efficiency, reduces shrinkage, and enhances the overall performance of concrete.

Among the various materials used for internal curing, **Polyethylene Glycol (PEG-400)** has gained considerable attention in concrete research. PEG-400 is a water-soluble polymer that helps reduce the evaporation of water from the concrete pores by lowering the vapor pressure of water present in the system. When incorporated into the concrete mix, PEG-400 retains moisture within the concrete structure and supports the continuous hydration of cement. This process promotes better strength development and minimizes the formation of shrinkage cracks. Due to these beneficial properties, PEG-400 is widely used as a self-curing admixture in experimental studies on internally cured concrete.

Apart from curing techniques, the selection of appropriate fine aggregate is another important factor influencing the performance of concrete. Traditionally, natural river sand has been used as fine aggregate in concrete mixtures. However, excessive extraction of river sand has resulted in serious environmental problems, including riverbed degradation and depletion of natural resources. These concerns have led to the search for alternative materials that can replace natural sand without affecting the quality of concrete.

As a sustainable solution, **Manufactured Sand (M-sand)** has been introduced as an alternative fine aggregate in concrete production. M-sand is produced by crushing hard rocks into fine particles that closely resemble natural sand in terms of size and grading. It generally possesses a uniform particle size distribution and is free from impurities such as clay, silt, and organic matter. The angular shape and rough surface texture of M-sand improve the bonding between cement paste and aggregates, thereby enhancing the mechanical properties of concrete.

Furthermore, the use of M-sand contributes to sustainable construction practices by reducing the dependence on natural river sand and minimizing environmental damage caused by excessive sand mining. Due to its consistent quality and improved bonding characteristics, M-sand has become an

important component in the production of high-performance concrete.

The present study focuses on the development of **self-curing concrete using PEG-400 as an internal curing agent and M-sand as fine aggregate**. Different concrete mix proportions are prepared and tested to evaluate their compressive strength at curing ages of **7, 14, and 28 days**. The objective of this research is to analyze the effectiveness of PEG-400 in maintaining internal moisture within the concrete and to study the influence of M-sand on the strength performance of self-curing concrete.

The findings of this research are expected to demonstrate the effectiveness of self-curing concrete as a practical alternative to conventional curing methods, particularly in regions where water resources are limited. In addition, the use of M-sand supports environmentally sustainable construction by reducing reliance on natural river sand while maintaining the desired mechanical properties of concrete.

II.METHODOLOGY

Self-curing concrete is an innovative type of concrete that is capable of retaining sufficient internal moisture to support continuous hydration of cement without the need for external curing. In this study, M35 grade concrete was prepared by incorporating Polyethylene Glycol (PEG-400) as a self-curing agent and Manufactured Sand (M-sand) as the fine aggregate. The materials used in the preparation of concrete include Ordinary Portland Cement, M-sand, coarse aggregates, potable water, and PEG-400.

Concrete mixes were designed according to standard guidelines, and several mix proportions were prepared to evaluate the influence of PEG-400 on the mechanical properties of concrete. A control mix without PEG-400 was also prepared for comparison with the self-curing mixes. The concrete ingredients were mixed thoroughly to obtain a uniform mixture, and the fresh concrete was placed into standard cube moulds of size 150 mm × 150 mm × 150 mm. Proper compaction was carried out to remove air voids and ensure uniform density.

After casting, the specimens were kept undisturbed for 24 hours and then demoulded. The control specimens were subjected to conventional water curing, while the specimens containing PEG-400 were maintained under ambient conditions without external curing, allowing internal curing through the self-curing agent.

The compressive strength of the concrete specimens was determined using a compression testing machine (CTM) at curing ages of 7, 14, and 28 days. The results obtained from the tests were analyzed and compared to evaluate the effectiveness of PEG-400 as a self-curing agent and to assess the influence of M-sand on the strength characteristics of self-curing concrete.

III. OBJECTIVES OF WORK

To investigate the feasibility of producing self-curing concrete using Polyethylene Glycol (PEG-400) as an internal curing agent.

To examine the ability of PEG-400 to retain internal moisture and support proper hydration of cement in concrete.

To evaluate the suitability of Manufactured Sand (M-sand) as a replacement for natural river sand in concrete production.

To study the compressive strength behaviour of M35 grade self-curing concrete at curing periods of 7, 14, and 28 days.

To compare the mechanical performance of self-curing concrete with conventionally cured concrete.

To assess the potential of self-curing concrete in reducing dependency on external curing water.

To promote sustainable construction practices by reducing water consumption and encouraging the use of alternative materials in concrete production.

IV. MATERIALS

Cement:

Ordinary Portland Cement (OPC) of suitable grade was used as the binding material in the concrete mix. The cement was tested for its physical properties such as specific gravity and fineness according to standard procedures.

Fine Aggregate:

Manufactured Sand (M-sand) was used as the fine aggregate in the concrete mix. M-sand was selected due to its uniform particle size distribution and absence of impurities such as clay, silt, and organic matter. The angular shape and rough texture of M-sand help improve bonding between cement paste and aggregates.

Coarse Aggregate:

Crushed stone aggregates of suitable size were used as coarse aggregate. The aggregates were clean, hard, and free from dust and organic impurities.

Water:

Potable water free from harmful impurities was used for mixing and preparation of concrete.

Self-Curing

Agent:

Polyethylene Glycol (PEG-400) was used as the internal curing agent. PEG-400 is a water-soluble polymer capable of retaining moisture within the concrete matrix, thereby reducing water evaporation and promoting continuous hydration of cement.

Properties of PEG-400 Useful for Self-Curing Concrete

1. High Water Solubility

PEG-400 is highly soluble in water, which allows it to mix uniformly with the concrete mix. This property ensures even distribution of the self-curing agent throughout the concrete, enabling effective internal curing.

2. Moisture Retention Capability

PEG-400 has the ability to retain water within the pores of concrete by reducing the evaporation rate. This retained moisture helps maintain adequate water for the hydration process of cement.

3. Reduction of Water Evaporation

One of the most important properties of PEG-400 is its ability to **reduce the vapor pressure of water** present in the concrete pores. This reduces moisture loss due to evaporation and helps maintain internal curing conditions.



Fig-1: PEG-400

4. Improved Hydration of Cement

By retaining moisture within the concrete matrix, PEG-400 ensures continuous hydration of cement particles. This leads to better strength development and improved microstructure of the concrete.

5. Reduction in Shrinkage Cracks

The internal curing action provided by PEG-400 minimizes early age shrinkage caused by rapid moisture loss. This helps reduce the formation of cracks in concrete.

6. Compatibility with Concrete Materials

PEG-400 is chemically stable and does not adversely react with cement or aggregates. It can be easily incorporated into the concrete mix without affecting the normal mixing and placing process.

7. Enhancement of Concrete Durability

By improving hydration and reducing moisture loss, PEG-400 contributes to better durability of concrete structures by improving density and reducing permeability.

8. Ease of Application

PEG-400 can be easily added during the mixing process without requiring special equipment or complicated procedures, making it practical for field applications.

V. TEST RESULTS:

Table 1: Compressive Strength Results

Mix Type	7 Days Strength (N/mm ²)	14 Days Strength (N/mm ²)	28 Days Strength (N/mm ²)
Conventional Concrete	20.29	28.80	35.50
PEG 0.5	23.11	31.63	38.07
PEG 1	17.48	24.07	29.78
PEG 1.5	16.29	22.30	28.07
PEG 2	18.81	26.37	31.63
PEG 2.5	19.78	27.19	32.89



Graph-1: Compressive Strength of various Design Mix Proportions for 28 days

The graph illustrates the 28-day compressive strength of self-curing concrete prepared with different dosages of Polyethylene Glycol (PEG-400) and

compares them with conventional concrete. The horizontal axis represents the different concrete mixes, including the conventional mix and the mixes containing varying percentages of PEG-400 (0.5%, 1%, 1.5%, 2%, and 2.5%). The vertical axis represents the compressive strength of concrete in N/mm² (MPa).

From the graph, the conventional concrete exhibits a compressive strength of approximately 35 N/mm² at 28 days.

When PEG-400 is introduced as a self-curing agent, the compressive strength initially increases at 0.5% PEG dosage, reaching the maximum strength of about 38 N/mm². This improvement indicates that a small quantity of PEG-400 effectively retains internal moisture within the concrete matrix, thereby enhancing the hydration process of cement.

However, as the dosage of PEG-400 increases beyond this level, a gradual reduction in compressive strength is observed. At 1% PEG, the strength decreases to approximately 30 N/mm², and at 1.5% PEG, the strength further reduces to around 28 N/mm², which is the lowest value among the mixes tested. This reduction may be attributed to the excessive presence of the self-curing agent, which can affect the bonding characteristics and microstructure of the concrete.

When the PEG content increases to 2% and 2.5%, the compressive strength shows a slight recovery, reaching approximately 31 N/mm² and 33 N/mm², respectively. Although these values are lower than the maximum strength obtained at 0.5% PEG, they still demonstrate that the concrete maintains acceptable strength levels.

Overall, the graph clearly indicates that the optimum dosage of PEG-400 for self-curing concrete in this study is around 0.5%, where the compressive strength is higher than that of conventional concrete. The results suggest that self-curing concrete using PEG-400 can effectively enhance strength development when used in appropriate proportions, while excessive dosage may lead to a reduction in strength. This highlights the importance of selecting the optimum amount of self-curing agent to achieve improved performance and durability of concrete.



Fig-2: Testing of specimen

VI. CONCLUSION:

Based on the experimental investigation carried out on self-curing concrete using Polyethylene Glycol (PEG-400) and Manufactured Sand (M-sand) as fine aggregate, the following conclusions can be drawn:

The study demonstrates that the incorporation of PEG-400 as a self-curing agent is effective in maintaining internal moisture within the concrete matrix, which supports the continuous hydration of cement even in the absence of external curing. This internal curing mechanism contributes to the proper development of compressive strength in concrete.

The results obtained from the compressive strength tests at 7, 14, and 28 days indicate that self-curing concrete exhibits strength values comparable to conventional concrete. Among the various mixes investigated, the concrete containing 0.5% PEG-400 achieved the highest compressive strength at 28 days, exceeding that of the conventional concrete mix. This indicates that an optimum dosage of PEG-400 can significantly enhance the performance of concrete.

However, it was also observed that increasing the dosage of PEG-400 beyond the optimum level resulted in a gradual reduction in compressive strength. This may be attributed to the excessive presence of the self-curing agent, which can influence the internal structure and bonding characteristics of the concrete matrix.

The use of Manufactured Sand (M-sand) as a complete replacement for natural river sand proved to be effective, as it provided adequate workability and strength while also contributing to sustainable construction practices by reducing dependence on natural sand resources.

Overall, the results of this study indicate that self-curing concrete prepared with PEG-400 and M-sand can serve as a viable and sustainable alternative to conventional concrete, particularly in regions where water availability for curing is limited. Proper selection of the self-curing agent dosage is essential to achieve optimal strength and performance in concrete structures.

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