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Experimental Investigation of Self Curing Concrete Incorporated with Polyethylene Glycol and Fly Ash

Kambale Vijay Bhaskar, Paradhi Yogesh Ramnath, Kakad Anant Rohidas, Ghuge Mahesh Sunil
Prof. Kolhe A. S., Dr. Mulajkar R. M, Prof. Kutal P. C.
Department of Civil Engineering.
Vidya Niketan College of Engineering, Bota

Abstract: *Concrete requires proper curing to achieve the desired strength and durability, but conventional water curing is often difficult due to water scarcity and site limitations. This study investigates the performance of self-curing concrete using Polyethylene Glycol (PEG-400) as an internal curing agent and fly ash as partial cement replacement. M25 grade concrete mixes were prepared with 20% fly ash and varying PEG-400 dosages (0.5%–2%). The study focuses on evaluating workability, strength, and moisture retention properties. The results indicate that self-curing concrete improves internal hydration, reduces moisture loss, and enhances overall concrete performance. This method offers a practical and sustainable alternative to traditional curing, especially in areas with limited water availability*

Keywords: Self-curing concrete, Polyethylene Glycol (PEG-400), Fly Ash, Internal Curing, Compressive Strength, Sustainable Construction

I. INTRODUCTION

Concrete is one of the most widely used construction materials in civil engineering because of its high compressive strength, durability, versatility, and cost-effectiveness in structural applications such as buildings, bridges, pavements, and dams [1]. The performance and service life of concrete largely depend on proper curing, which ensures continuous hydration of cement and helps in developing the required mechanical strength and durability properties [2].

Curing is the process of maintaining adequate moisture and temperature in concrete during its early stages so that hydration can continue effectively. Conventional curing methods, such as ponding, sprinkling, and wet covering, require a continuous external supply of water for several days [3]. However, in many practical construction situations, especially in remote locations, large infrastructure projects, and water-scarce regions, maintaining proper external curing becomes difficult and expensive [4]. Insufficient curing may lead to incomplete hydration, surface cracking, reduced strength, increased permeability, and poor durability of concrete structures [5]. To overcome these limitations, the concept of self-curing concrete, also known as internally cured concrete, has gained importance in modern construction practices. Self-curing concrete contains materials or chemical admixtures that help retain internal moisture and gradually release water required for hydration without depending entirely on external curing methods [6].

Among various self-curing agents, Polyethylene Glycol (PEG) has emerged as an effective and economical option. PEG is a water-soluble polymer that reduces water evaporation from concrete by lowering the surface tension of water, thereby improving moisture retention within the concrete matrix [7].

In addition to self-curing agents, the use of supplementary cementitious materials has become essential for sustainable construction. Fly ash, a by-product of thermal power plants, is widely used as a partial replacement for cement due to its pozzolanic properties [8]. Fly ash reacts with calcium hydroxide released during cement hydration to form additional cementitious compounds, which improve long-term strength, reduce permeability, and enhance durability. Its utilization also helps in reducing cement consumption and minimizing environmental pollution caused by industrial waste disposal [9].

The research contributes toward developing a sustainable, water-efficient, and durable concrete mix suitable for modern construction requirements, particularly in regions where conventional curing is difficult to implement [10].

II. PROBLEM STATEMENT

Concrete requires proper curing to achieve the desired strength and durability, but in many construction sites conventional water curing is difficult due to water scarcity, labor dependency, and inaccessible structural locations. Improper curing often results in incomplete hydration, shrinkage cracks, reduced strength, and lower service life of concrete structures. At the same time, the construction industry faces increasing pressure to adopt sustainable materials and reduce environmental impact. Although fly ash can partially replace cement and improve long-term durability, it requires adequate moisture for effective pozzolanic reaction. Therefore, there is a need to develop an efficient self-curing concrete system using Polyethylene Glycol (PEG-400) and fly ash that can retain internal moisture, reduce water consumption, and improve the overall performance of concrete under limited curing conditions.

III. OBJECTIVES

- To study the effect of Polyethylene Glycol (PEG-400) on the self-curing behavior of concrete.
- To evaluate the workability of concrete with different percentages of PEG-400.
- To analyze the compressive strength of self-curing concrete incorporating fly ash.
- To compare the performance of self-curing concrete with conventionally cured concrete.
- To identify the optimum PEG-400 dosage for improving strength and durability of concrete.

IV. LITERATURE SURVEY

Srinivas Kumar and Suresh Babu (2015) presented an important study in their paper "A Study on Behaviour of Self-Curing Compounds on Strength and Durability of Concrete," where they investigated the effect of self-curing agents such as PEG on concrete performance. Their results showed that PEG improved internal moisture retention, compressive strength, and durability compared to conventionally cured concrete.

Ankith M.K. (2015) discussed self-curing concrete in the paper "Self-Curing Concrete with Lightweight Aggregate," where lightweight aggregates were used as internal curing agents to provide continuous moisture for cement hydration. The research demonstrated improved strength and reduced shrinkage in concrete. However, the method required special aggregate preparation, which increased complexity and cost.

J. Saran Kumar and T. Suresh Babu (2016) presented their findings in "Effect of Self-Curing Compound Using PEG-400 on Concrete," where PEG-400 was used in varying proportions to evaluate its impact on concrete properties. The study reported improved workability and better compressive strength under air-cured conditions.

Safwan Bhadki et al. (2016) carried out research in "An Experimental Investigation on Internally Cured Concrete," focusing on internal curing techniques to reduce moisture loss and improve hydration. Their study showed that internally cured concrete developed better mechanical properties and reduced cracking.

M. V. Jagannadha Kumar et al. (2017) investigated self-curing concrete in the paper "Strength Characteristics of Self-Curing Concrete Using PEG," where different PEG percentages were tested to determine the optimum dosage. The results indicated enhanced compressive and tensile strength along with reduced shrinkage.

K. V. S. Gopalakrishna Sastry and P. Sravana (2018) presented a study titled "Effect of Fly Ash on Self-Curing Concrete," where fly ash was used as partial cement replacement along with self-curing admixtures. Their research showed that fly ash improved durability and reduced permeability while PEG ensured adequate internal hydration.

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Comparison Table

Author & Year	Method Used	Advantages	Limitations
Srinivas Kumar (2015)	PEG self-curing	Better strength, durability	Limited long-term study
Ankith M.K. (2015)	Lightweight aggregate curing	Reduced shrinkage	Higher cost
Saran Kumar (2016)	PEG-400 curing	Improved workability	Limited dosage study
Safwan Bhadki (2016)	Internal curing	Less cracking	No fly ash used
Jagannadha Kumar (2017)	Different PEG %	Higher strength	Conventional concrete only
Sastry (2018)	Fly ash + self-curing	Better durability	Slow early strength

V. WORKING OF SYSTEM

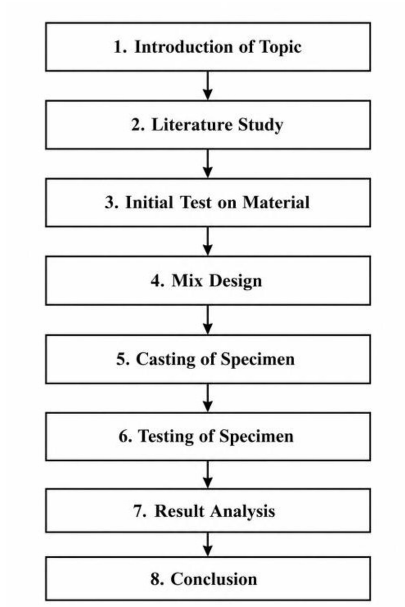

Fig 1: Flowchart

1. Introduction of Topic

The project begins with selecting and understanding the research topic, namely self-curing concrete using Polyethylene Glycol (PEG-400) and fly ash. The importance, need, and scope of the study are identified at this stage.

2. Literature Study

Previous research papers, journals, and technical articles related to self-curing concrete, PEG, and fly ash are studied to understand existing work, methodologies, and research gaps.

3. Initial Test on Material

All raw materials such as cement, fine aggregate, coarse aggregate, water, fly ash, and PEG-400 are collected and tested for their physical and chemical properties to ensure suitability for concrete preparation.

4. Mix Design

Concrete mix proportions are designed for M25 grade concrete. Different percentages of PEG-400 and fly ash are selected to prepare multiple concrete samples for comparison.

5. Casting of Specimen

Concrete is mixed thoroughly and poured into standard moulds to cast specimens such as cubes, cylinders, or beams. Proper compaction is ensured to avoid air voids.

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6. Testing of Specimen

After setting and curing, the specimens are tested for mechanical properties such as compressive strength, split tensile strength, flexural strength, and workability.

7. Result Analysis

The test results are recorded and compared for different mix proportions. The influence of PEG-400 and fly ash on strength, durability, and moisture retention is analyzed.

8. Conclusion

Based on experimental results, conclusions are drawn regarding the effectiveness of self-curing concrete and the optimum dosage of PEG-400 for improved concrete performance.

VI. SYSTEM DESIGN

System Design

The system design of this experimental study focuses on preparing and analyzing self-curing concrete using Polyethylene Glycol (PEG-400) and fly ash as key materials.

1. Material Selection

1.1 Cement

Fig.2.Cement

Ordinary Portland Cement (OPC) is used as the primary binding material in concrete. It reacts with water during hydration and provides strength and bonding to the concrete mix.

1.2 Fine Aggregate

Fig.3.Fine Aggregate

Fine aggregate consists of natural sand passing through a 4.75 mm sieve. It fills voids between coarse aggregate particles and improves the workability and density of concrete.1.3 Coarse Aggregate

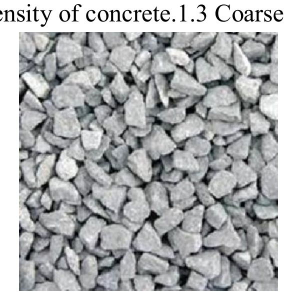

Fig.4.Coarse Aggregate

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Coarse aggregate consists of crushed stone of suitable size. It provides bulk strength, stiffness, and improves the load-bearing capacity of concrete.

1.4 Water

Clean potable water is used for mixing concrete. It initiates the hydration process of cement and helps achieve proper workability of the concrete mix.

1.5 Fly Ash

Fig.5.Fly Ash

Fly ash is used as a partial replacement for cement due to its pozzolanic properties.

1.6 Polyethylene Glycol (PEG-400)

Fig.6.PEG-400

PEG-400 acts as a self-curing admixture in concrete. It helps retain internal moisture by reducing water evaporation, ensuring continuous hydration and improving strength and durability.

2. Concrete Mix Design

An M25 grade concrete mix is designed for the experimental investigation. In this mix, 20% of cement is replaced by fly ash to improve sustainability and reduce cement consumption. PEG-400 is added in varying proportions of 0%, 0.5%, 1.0%, 1.5%, and 2.0% by weight of cement to study its effect on concrete properties.

3. Self-Curing Mechanism

The core design principle is internal curing. PEG-400 forms hydrogen bonds with water molecules and reduces evaporation by lowering vapor pressure. This allows the concrete to retain moisture internally, ensuring continuous hydration even without external water curing.

4. Specimen Preparation

The selected materials are mixed thoroughly according to designed proportions. Fresh concrete is poured into standard moulds to cast specimens such as cubes, cylinders, or beams. Proper compaction is carried out to remove air voids and ensure uniformity.

5. Testing and Performance Evaluation

After casting and curing, specimens are tested to evaluate:

• Workability
• Compressive strength
• Split tensile strength
• Flexural strength
• Moisture retention behavior

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The results obtained from each mix are compared to determine the optimum PEG-400 dosage for achieving better strength and durability.

VI. RESULTS

The experimental results show that the addition of PEG-400 improved the performance of self-curing concrete by enhancing internal moisture retention and promoting continuous hydration. Concrete containing PEG-400 exhibited better workability and higher strength compared to conventional concrete. Among all mixes, the specimen with 1.5% PEG-400 showed optimum performance.

1. Compressive Strength (28 Days)

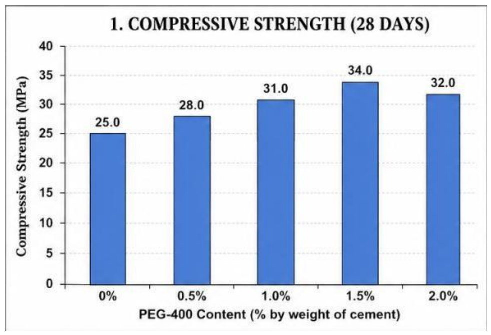

Fig.7.Graph 1

The compressive strength increased with PEG dosage up to 1.5%, after which a slight reduction was observed at 2%.

Compressive Strength

28-day compressive strength for different PEG percentages. 091827360%0.5%1.0%1.5%2.0%

Observation: Maximum compressive strength was observed at 1.5% PEG-400.

2. Split Tensile Strength

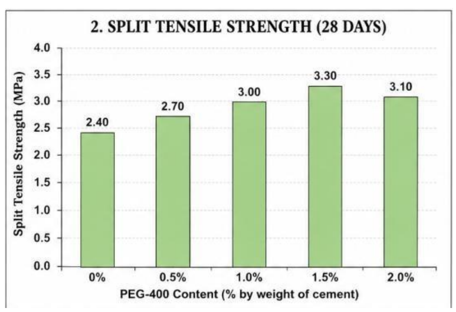

Fig.8.Graph.2

Split tensile strength also improved due to reduced internal cracking and better hydration.

Split Tensile Strength

Variation in split tensile strength with PEG dosage. 00.91.82.73.60%0.5%1.0%1.5%2.0%

Observation: Tensile strength increased gradually and peaked at 1.5% PEG.

3. Flexural Strength

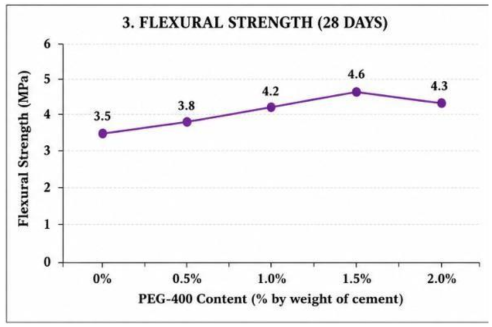

Fig.9.Graph.3

Flexural strength improved because PEG reduced shrinkage cracks and enhanced bonding.

Flexural Strength

Flexural strength trend for different PEG proportions. 3.23.644.44.80%0.5%1.0%1.5%2.0%

Observation: Flexural strength improved significantly with self-curing admixture.

4. Moisture Retention / Water Loss

Water loss reduced as PEG content increased, showing effective self-curing behavior.

Moisture Retention

Water loss decreases with increasing PEG content. 3%6%9%12%15%0%0.5%1.0%1.5%2.0%

Observation: 1.5% PEG-400 showed the lowest water loss and best moisture retention.

VII. CONCLUSION

This study concludes that the use of Polyethylene Glycol (PEG-400) as a self-curing agent along with fly ash as partial cement replacement significantly improves the performance of concrete. The addition of PEG-400 helped retain internal moisture, ensured continuous hydration, and reduced water loss, resulting in better workability and enhanced strength properties. The experimental results showed that self-curing concrete performed better than conventional concrete under limited curing conditions. Among the various proportions tested, 1.5% PEG-400 with 20% fly ash provided optimum results in terms of strength and durability. Therefore, self-curing concrete can be considered an effective and sustainable solution for construction in water-scarce regions.

VIII. FUTURE SCOPE

The future scope of this study lies in exploring the performance of self-curing concrete with different grades of concrete, alternative self-curing admixtures, and various supplementary cementitious materials. Further research can focus on long-term durability tests such as resistance to chemical attack, shrinkage, and crack formation under different environmental conditions. Advanced testing on large-scale structural elements can also be carried out to evaluate real-world applications. In addition, optimizing the dosage of PEG-400 for different construction requirements may help develop more efficient, economical, and sustainable concrete for modern infrastructure.

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