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Enhancing the Performance of Self-Curing Concrete Using Polyethylene Glycol as an Internal Moisture Retention Agent

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Abstract: This study explores the use of Polyethylene Glycol (PEG-400) as an internal curing agent in concrete, offering a sustainable substitute for traditional water-curing methods. It focuses on addressing water scarcity challenges in the construction industry by introducing a self-curing system that maintains adequate internal moisture for prolonged cement hydration. PEG-400, a water-soluble polymer, was added to concrete mixes in different proportions to assess its influence on hydration kinetics, shrinkage control, and overall mechanical properties.

The experimental findings indicate that an optimal amount of PEG-400 promotes improved hydration, reduces early-age shrinkage, and enhances compressive strength. However, higher dosages were found to adversely affect strength due to disruption in the formation of the cement matrix. The results confirm that a carefully controlled dosage of PEG-400 can effectively achieve internal curing, resulting in durable and sustainable concrete. This method contributes to environmentally friendly construction by lowering the need for external water while preserving the required strength and durability.

Keywords—Self-curing concrete, Polyethylene glycol(PEG-400), Internal curing, Water scarcity, Durability, Sustainable construction.

I. INTRODUCTION

Concrete is the most extensively utilized construction material worldwide due to its superior compressive strength, durability, and versatility in meeting various structural requirements. However, the long-term performance of concrete is strongly influenced by proper curing, which ensures sufficient cement hydration during the hardening stage. Inadequate or improper curing can result in undesirable characteristics such as reduced strength, higher permeability, and premature cracking. These limitations highlight the necessity of developing efficient curing methods that guarantee uniform hydration and consistent strength gain while minimizing dependence on conventional water-curing practices.

According to ACI 308R-01 (2001) [1] and ASTM C31 (2015) [2], curing is defined as the process of maintaining appropriate moisture and temperature conditions in freshly placed concrete to facilitate proper hydration and the development of desired mechanical properties.

These polymers absorb and release water gradually during the hydration process, thereby maintaining adequate internal moisture even in the absence of external curing [3]. Consequently, the use of such self-curing agents provides a practical and sustainable alternative to traditional external curing techniques, particularly in regions facing water scarcity or where external curing conditions are difficult to control.This study explores the effect of polyethylene glycol (PEG-400) as a self-curing compound in concrete and evaluates its performance against conventional curing methods. Experimental results indicate that an optimum dosage of 1% PEG-400 (by weight of cement) provides the highest compressive strength, split tensile strength, and flexural strength. A further increase in dosage beyond 1% led to a decline in strength values. Compared with conventionally cured concrete, self-curing concrete demonstrated improved strength characteristics, as PEG-400 reduces water evaporation and lowers the surface tension of water within the concrete matrix. This mechanism enhances the water-retention capability of the mix, thereby supporting continuous hydration and contributing to better mechanical performance.[4]Overall, self-curing concrete represents a promising solution for the construction industry, as it enhances efficiency, lowers curing-related costs, and improves the long-term durability of structures.

II. LITERATURE REVIEW

Sharma and Gupta (2024) investigated the performance of self-curing concrete incorporating PEG and reported that the addition of PEG significantly improved compressive strength and reduced shrinkage. Their findings indicated that an optimum dosage of around 1% to 1.5% by weight of cement enhances hydration without adversely affecting the microstructure.

S. G. Virupakshappa et al. (2024) develop models to analyze strength and durability of concrete using PEG-400. Their study showed that PEG significantly improves hydration and durability properties, and advanced techniques like artificial neural networks can accurately predict performance.

Shah and Mehta (2024) studied sustainable concrete using PEG in combination with mineral admixtures and observed improved durability characteristics, including reduced permeability and enhanced resistance to sulphate attack. The study highlighted that PEG-based internal curing is particularly effective in improving long-term durability.

Bentur et al. [5] explored internal curing methods, including chemical admixtures like PEG, in high-strength concrete. They reported that such admixtures improve hydration, reduce autogenous shrinkage, and enhance long-term durability.

M. Manoj Kumar, D. Maruthachalam,[6] studies on self- curing concrete, he used super absorbent polymer for self-curing concrete, increasing volume stability, resistance to freezing, throwing effects, water rightness, abrasion resistance. Curing may be achieved in several ways and the most appropriate means of curing may be dictated by the site or construction method.

R. Sethuraman, S. Srumathi. (2020) Self-curing concrete extracts water fromthe environment to help the cement in the concrete hydration. It solves the problem of hydration in cement concrete induced by improper or no curing of the concrete by utilizing self-curing agent such as polyacrylic acid, which provides the moisture needed by the concrete. PEG is an industrial-to-medicinal polyether compound with many uses. Due to its molecular weight, it was often known as polyethylene oxide. a superplasticizer (complasrsp 430) is used to improve workability without the usage of water.

N. Kumar and P. Reddy (2020)[10] investigated the mechanical properties of self-curing concrete with PEG-400 as a curing compound. The compressive strength at 28 days improved by 10% compared to externally cured samples. The results confirmed that PEG contributes to better hydration and microstructure development.

D. P. Reddy et al. (2019)[12] observed that concrete mixes with 1.5% PEG-400 and superplasticizer (0.8%) attained 56 MPa compressive strength and 9% higher density. The internal curing efficiency factor (ICE) was measured at 0.92, showing effective moisture retention.

Recent research conducted in 2025 further confirmed that PEG-600 at 1.5% dosage provided maximum compressive strength compared to conventional concrete. The study also emphasized that self-curing concrete exhibited lower water absorption and improved resistance to microcracking due to uniform moisture distribution within the matrix**.**

III. MATERIAL AND METHODOLOGY

A. Material Used:

1) Polyethylene Glycol (PEG) is a water-soluble widely used as an internal curing agent in concrete.The general formula for polyethylene glycol (PEG) is H-(O-CH2-CH2)n-OH, where 'n' represents the number of repeating oxyethylene groups with an average value of (4 to 180).The polyethylene glycol appears to be the water-soluble nature. The abbreviation (PEG) is called in combination with a numerical suffix that indicates the average molecular weight.

Fig. 1 Polyethylene Glycol 400 (PEG 400)

2) Aggregate (fine + coarse)
- Cement
- Water

Fig. 2 Mix Proportion

B. Methodology
- Slump test
- Compressive strength test

1) Brief Steps Involve in The Experiment

a) Workability (Slump Test)
- Fill the slump cone with the concrete mix in three layers.
- Compact each layer with 25 strokes of a tamping rod.
- Remove the cone carefully and measure the slump.

b) Compressive Strength test
- Conduct on standard concrete cubes or cylinders using a universal testing machine (UTM).
- Measure the maximum load applied before failure and calculate compressive strength:

$$F_{ck} = P/A$$

Where, P=load at failure
A = cross-sectional area.

IV. RESULT AND DISCUSSION

A. Fresh Properties

1) Workability (Slump Test)

The slump value decreased from 110 mm for normal concrete to the 75 mm for 1% fiber content the value with corresponding fiber content is as shown in the table and figure show the variation of slump with the change in the fiber content.

TABLE:1 SLUMP TEST

PEG-400 Content (%)	Water cement ratio	Slump(mm)
1.5	0.45	78
2		96

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Fig.:4 Slump Test

B. Hardent Properties

1) *Compressive Strength Test*

TABLE:3 COMPRESSIVE STRENGTH TEST

PEG-400 content (%)	Compressive Strength (N/mm2)	
	7 Days	28 Days
1.5	25.5	36
2	22.6	33.8

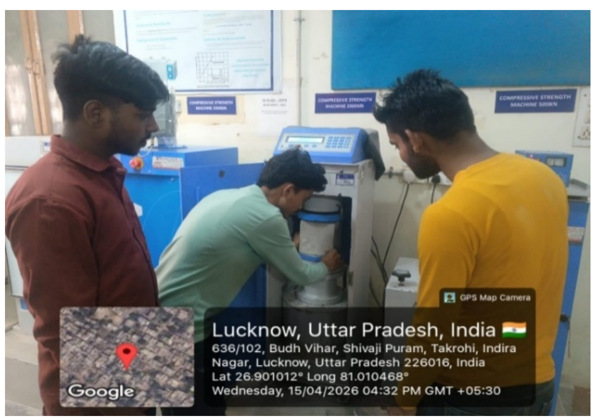

Fig:5 Compressive Strength Test

V. CONCLUSION

The study concludes that the use of polyethylene glycol (PEG) as an internal curing agent at dosages of **1.5% and 2% by weight of cement** significantly influences the performance of self-curing concrete.

At **1.5% PEG**, the concrete exhibits **optimum performance**, showing improved workability, better hydration, and higher compressive, tensile, and flexural strengths compared to conventional concrete. The internal moisture retention at this dosage is sufficient to support continuous cement hydration, leading to a denser microstructure and reduced shrinkage cracks.

At **2% PEG**, although workability further increases due to higher water retention, there is a **slight reduction in strength properties** compared to 1.5%. This is mainly due to excess internal moisture, which may create micro-voids and weaken the bond between cement paste and aggregates. However, durability characteristics such as reduced shrinkage and improved resistance to cracking still remain better than conventional concrete.

Overall, the results indicate that **1.5% PEG is the optimum dosage** for achieving a balance between strength and durability, while **2% PEG enhances workability and curing efficiency but may slightly compromise strength**.

In conclusion, polyethylene glycol proves to be an effective self-curing agent, and its controlled use (preferably around 1.5%) can significantly improve the performance and sustainability of concrete, especially in conditions where conventional curing is difficult.

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