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AN EXPERIMENTAL STUDY ON THE UTILIZATION OF CHEMICAL ADMIXTURE (PEG-400) FOR INTERNAL CURING OF CONCRETE

Panneerselvam S [1], Uma Maheswari GK [2]

[1]*Assistant Professor, Department of Civil Engineering, Vivekanandha College of Technology for Women, Tamil Nadu, India.*
[2] *UG Student, Department of Civil Engineering, Vivekanandha College of Technology for Women, Tamil Nadu, India.*

Abstract - *As water is becoming a scarce material day-by-day, there is an urgent need to do research work pertaining to saving of water in making concrete and in constructions. Curing of concrete is maintaining satisfactory moisture content in concrete during its early stages in order to develop the desired properties. However, good curing is not always practical in many cases. Curing of concrete plays a major role in developing the concrete microstructure and pore structure and hence improves its durability and performance. Keeping importance to this, an attempt has been made to develop internal-curing concrete by using Poly Ethylene Glycol (PEG-400). In this experimental investigation the strength characteristics of high strength concrete, cast with the self-curing agent PEG-400 have been studied and compared with the corresponding conventionally cured concrete. IS method of mix design was adopted, M50 grade of concrete is designed on trial and error basis. For producing internal-curing concrete trial dosage of 1%, 2% and 3% of PEG-400 by weight of cement was used and tested. It was observed that after implementation of new technique the water consumption for curing was significantly reduced by 100%. The findings of this study provide valuable insights into the effectiveness of PEG-400 in self-curing concrete, offering implications for construction practices.*

Keywords: *Internally Cured Concrete, Self-Curing Concrete, PEG-400, Self curing Agent.*

1.INTRODUCTION

Self-curing concrete has emerged as a promising solution to address common challenges associated with traditional curing methods. Conventional methods often suffer from issues like incomplete hydration, surface cracking, and high labor costs. In contrast, self-curing concrete utilizes internal water reservoirs to maintain moisture levels, thereby promoting optimal hydration and improving overall performance. Polyethylene Glycol (PEG-400), a water-soluble polymer, has shown potential as a self-curing agent due to its ability to retain water within the concrete matrix. This study aims to explore the effectiveness of PEG-400 in enhancing the self-curing properties of concrete, particularly in terms of strength development and durability.

Concrete has long been and will continue to be the most adaptable materials utilized in building for a significant duration of time. Concrete possesses a distinct advantage over alternative construction materials due to its exceptional capacity to assume diverse forms in a range of applications, regardless of whether it is manufactured on-site or produced as a pre-cast product in a factory setting. Over the past twenty years, there has been a significant advancement in concrete technology. The conceptualization of a universe devoid of tangible entities is unattainable. Concrete is an essential component of infrastructures. Concrete is essential for enhancing the structural integrity of buildings. Traditional concrete, consisting of a combination of cement, fine aggregate, coarse aggregate, and water, necessitates a curing process in order to attain the desired level of strength. A minimum curing period of 28 days is necessary to ensure enough hydration and attain the desired level of strength. Inadequate curing can have a detrimental impact on contemporary concrete, which undergoes self-curing by preserving moisture content.

Given the increasing scarcity of water, it is imperative to do research on water conservation in concrete production and building. The curing process of concrete plays a significant role in enhancing its strength and hardness, hence resulting in improved durability and performance. The process of concrete curing involves the maintenance of an appropriate moisture content in concrete during its first stages, with the aim of achieving the ideal qualities. The hydration process occurs when cement is mixed with water, necessitating the presence of water for the purpose of cooling. In the absence of water, concrete undergoes shrinkage, leading to the formation of cracks. Hence, it is important to administer water as a means of treatment for a specific length. In numerous instances, the attainment of effective treatment is hindered by the unavailability of high-quality water and various other practical challenges.

Internal curing of concrete has been increasingly popular in recent decades and is steadily advancing from the laboratory to the area of practice. Internal curing is the phenomenon in which the hydration of cement takes place due to the presence of supplementary internal water that is not present in the mixing water. This process is commonly known as self-curing.

The effectiveness of PEG-400 as a self-curing agent has been studied extensively in recent years. Li et al. (2018) investigated the impact of PEG-400 on the mechanical properties and microstructure of concrete. Their findings revealed that the addition of PEG-400 improved the compressive strength and reduced drying shrinkage, indicating enhanced durability. Similarly, Zhao et al. (2020) conducted a study on the self-curing efficiency of PEG-400 in concrete mixes with different water-to-cement ratios. They observed that PEG-400 significantly reduced the autogenous shrinkage and increased the hydration degree, leading to improved mechanical properties.

Moreover, Zhang et al. (2019) explored the influence of PEG-400 on the chloride ion penetration resistance of concrete. Their results demonstrated that PEG-400 incorporation effectively reduced chloride ion penetration depth, enhancing the durability of concrete structures in aggressive environments. These studies collectively suggest that PEG-400 holds great potential as a self-curing agent for concrete, offering benefits in terms of strength, durability, and shrinkage reduction.Wang, et al. (2018) investigated the effects of PEG-400 on the mechanical properties and microstructure of concrete. Sharma and Singh (2019) explored the influence of PEG-400 on the hydration process and pore structure of concrete. Liang and Cui (2020) conducted a comparative analysis of various self-curing agents, including PEG-400, to assess their efficiency in reducing shrinkage and improving durability. Zhang, et al. (2021) studied the long-term performance of self-curing concrete incorporating PEG-400 under different environmental conditions. Chen and Li (2019) investigated the compatibility of PEG-400 with different types of cement and its influence on the setting time of concrete. Gupta, et al. (2022) reviewed the recent advancements in self-curing concrete technology and highlighted the potential of PEG-400 as a sustainable solution.

2 MATERIALS AND METHODOLOGY

CEMENT:

The present study used Portland Pozzolana Cement (PPC) 43 Grade. The Bureau of Indian Standards (BIS) acknowledged the Building Material in accordance with IS 1489 (Part 1 & Part 2): 2015.It has become a crucial material in modern building, providing a harmonious combination of long-lasting quality, environmental friendliness, and cost efficiency. Minimization of heat hydration and mitigation of fracture formation. The presence of pozzolanic components enhances the long-term durability of the material, resulting in greater resistance to alkali-silica reaction and sulfate assault.

FINE AGGREGATE:

There has been a notable transition within the construction sector towards the adoption of sustainable and innovative building materials and methods. An instance of technological progress involves the incorporation of Manufactured Sand (M-Sand) in the production of self-curing concrete. M-Sand, which is obtained by the process of crushing hard granite stones, presents a potentially viable substitute for natural river sand. This alternative material holds promise in resolving environmental issues while simultaneously improving the longevity and effectiveness of concrete constructions. The fine aggregate has a specific gravity of 2.58.

COARSE AGGREGATE:

The term "coarse aggregate" is commonly employed in the field of construction to denote the particles of greater size that constitute the majority of concrete mixtures. Typically, the size of these particles exceeds 4.75 mm. Aggregates are of paramount importance in the manufacturing of concrete, since they significantly contribute to the enhancement of its strength and durability. The dimensions and morphology of aggregate particles exert a substantial impact on the amount of cement necessary in concrete compositions. The fine aggregate has a specific gravity of 2.63.

WATER:

In order to achieve sufficient hydration of cement particles without inducing excessive water, which may lead to concrete weakening, it is imperative to maintain the appropriate water-cement ratio. Commence the curing process promptly following placement to avoid premature desiccation and fissures.

POLY ETHYLENE GLYCOL:

Polyoxyethylene (POE) is the predominant polyether known for its industrial significance as a self-curing agent. Polyethylene glycol is a polymer formed from the condensation of ethylene oxide and water, resulting in a general formula H(OCH2CH2)nOH. The average number of repeated oxyethylene groups, denoted as n, typically ranges from 4 to around 180. The acronym (PEG) is commonly used in conjunction with a numerical suffix that denotes the mean molecular weights.

Figure 1 Sample of PEG

2.1 Mix Design

The mix design for M50 grade concrete, as outlined in the IS code standards (IS 10262:2019), entails the determination of the appropriate amounts of cement, fine aggregate, coarse aggregate, and water. This study aims to assess the impact of incorporating PEG-400 into the cement mixture at different weight percentages (1%, 2%, 3%, and 4%) on the self-curing capabilities. The mix designs are formulated by a series of procedures as follows:

• Material selection: In the selection process, the quality and compatibility of cement, fine aggregate, coarse aggregate, and PEG-400 are taken into consideration.
Proportioning refers to the process of determining the appropriate ratios of components in order to attain specific concrete properties, such as strength and workability.
• Mixing: The components are meticulously blended using established protocols to guarantee even dispersion of PEG-400 throughout the concrete matrix.
The process of casting involves the placement of concrete mixes into molds, which are subsequently subjected to controlled conditions in order to replicate real-world applications.

3. EXPERIMENTAL PROCEDURE

The experimental procedure involves preparing multiple batches of M50 grade concrete with varying proportions of PEG-400. The mix proportions follow the guidelines provided by the Indian Standard IS 10262:2019. The mix proportions are taken as, 1:1.87:2.37 (Cement:FA:CA). The water binder ratio was 0.40. Each batch is subjected to standard tests, including compressive strength, flexural strength, and water permeability. The tests are conducted at regular intervals to assess the influence of PEG-400 on the mechanical properties and durability of the concrete.

3.1 Compressive Strength

The various types of cubes of different mix were tested under compression testing machine (CTM) at 7 days, 14 days & 28 days as recommended in IS code. The average compressive strength of conventional cured and internally cured concrete work found out using compressive strength testing machine. Compressive test results are listed in Table 1.

Table1 Test results on compressive test

Mix	Average compressive strength(N/mm^{2})			
	3 d	7d	14d	28 d
CC	32.58	41.84	50.08	54.23
1% PEG	34.20	44.36	51.21	56.85
2% PEG	37.56	45.65	53.01	58.12
3% PEG	38.44	46.39	54.23	59.38
4% PEG	36.52	44.21	50.23	57.36

Compressive strength results are depicted in Figure 2. After 28 days, the compressive strength ranged from 56.85 N/mm^2 to 58.12 N/mm^2. The compressive strength of conventional concrete was 54.23 N/mm^2. 3% of PEG mixed concrete attained the highest compressive strength. The strength was improved by 9.49% than conventional mix.

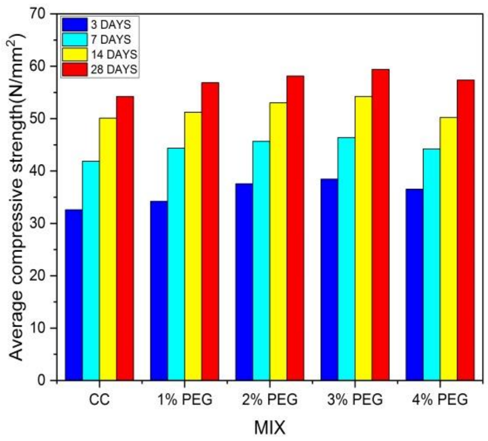

Figure 2 Compressive strength of specimens

3.2 Split tensile strength

The testing procedure typically involves preparing cylindrical concrete specimens with standard dimensions, often following the guidelines specified by relevant standards such as ASTM or IS. These specimens are cured under controlled conditions until they reach the desired testing age, which commonly includes testing at 7, 14, and 28 days. Table 2 depicts the test results of split tensile strength

Table 2 Test results on split tensile test

Mix	Split tensile strength(N/mm^{2})		
	7d	14d	28 d
CC	3.98	5.20	6.78
1% PEG	4.18	5.94	7.05
2% PEG	4.90	6.25	7.25
3% PEG	5.23	6.78	8.56
4% PEG	4.85	5.97	7.45

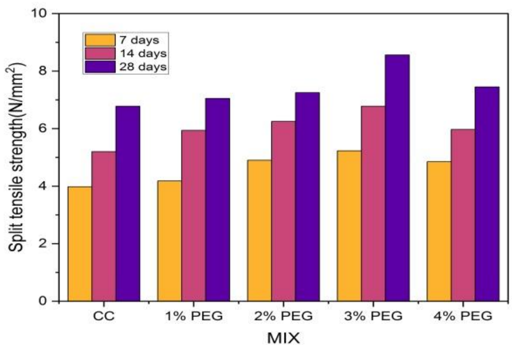

Figure 3 Split tensile strength of specimens

Figure 3 illustrates the split tensile strength of different mixtures. The splitting tensile strength of typical concrete was measured to be 6.78 N/mm^2 following a 28-day testing period. The mixture containing 3% PEG achieved the highest split tensile strength, after which it started to decrease.

3.3 Flexural strength

The flexural strength test is conducted using a two-point loading setup, where a load is applied at two points along the top surface of the prism specimen. The load is gradually increased until failure occurs. The rate of loading is controlled to ensure uniform application of force and to capture the load-deflection behaviour of the specimen. Table 3 and figure depicts the test results of flexural strength of concrete.

Table 3 Test results on Flexural strength test

Mix	Flexural strength(N/mm^{2})		
	7days	14days	28 days
CC	3.78	5.19	7.48
1% PEG	4.09	5.30	7.68
2% PEG	4.56	5.90	8.13
3% PEG	5.10	6.44	8.95
4% PEG	4.37	6.08	7.45

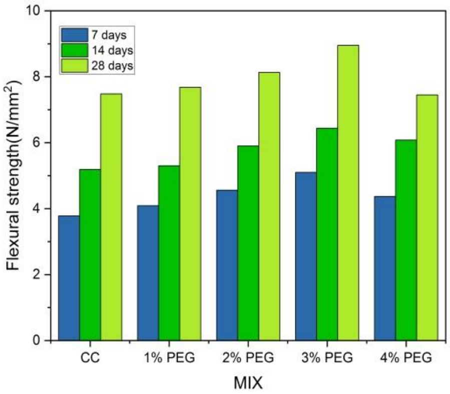

Figure 4 Flexural strength of specimens

Based on the data shown in Figure 4, it can be observed that 3% of PEG exhibited the maximum flexural strength. The flexural strength of the conventional mix exhibited a range of 7.45 N/mm^2 to 7.68 N/mm^2, with a specific value of 7.48 N/mm2.

4. CONCLUSION

This study demonstrates the potential of Polyethylene Glycol (PEG-400) in enhancing the self-curing properties of concrete. By effectively retaining moisture within the concrete matrix, PEG-400 contributes to improved strength development and durability. The findings of this research offer valuable insights for engineers and practitioners seeking to optimize concrete mix designs for enhanced performance and sustainability. The self-curing agent PEG-400 was found to be effective. The 3% of PEG mix attained the better mechanical strength properties.

The study's findings indicate that the utilization of a 3% PEG mix formulation is a highly effective approach in attaining enhanced mechanical strength characteristics in M50 grade concrete. The potential for enhancing the performance and durability of concrete structures, as well as contributing to developments in construction materials and methods, exists with the implementation of this optimum dosage.

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BIOGRAPHIES

Mr.Panneerselvam S,
He is Currently working as an Assistant Professor in *Department of Civil Engineering, Vivekanandha College of Technology, Tiruchengode, for Women, Tamil Nadu, India.*

Uma Maheswari GK
Final year B.E Student,
Department of Civil Engineering, Vivekanandha College of Technology, Tiruchengode, for Women, Tamil Nadu, India.