IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

Internal Curing Of Concrete By Using Polyethylene Glycol (Peg-400) – M25

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Abstract: This research examines the application of Polyethylene Glycol (PEG-400) as an internal curing agent for M25 grade concrete. PEG-400 was incorporated at 0%, 1%, 1.5%, and 2% dosages by weight of cement, and the mixes were evaluated for workability, strength, and durability. Tests included slump cone for fresh properties, compressive, split tensile, and flexural strength for hardened properties, as well as durability assessments such as water absorption and mass loss. A cost comparison between conventional and self-curing concrete was also carried out. The results indicated that mixes containing 1–1.5% PEG-400 achieved improved workability, strength, and durability, with 1% PEG-400 proving to be the most economical.

Keywords: Self-curing concrete, PEG-400, Compressive strength, Durability, Cost analysis

I. Introduction

Concrete is the most widely employed construction material because of its versatility, high strength, and durability. However, the performance and service life of concrete depend heavily on proper curing. Inadequate curing often leads to incomplete hydration of cement particles, resulting in higher permeability, micro-crack formation, and reduced structural strength.

To overcome these shortcomings, self-curing concrete has been developed. This type of concrete incorporates compounds such as Polyethylene Glycol (PEG-400), which retain internal moisture and ensure continuous hydration without external curing.

Several researchers have studied the role of PEG-400 in improving concrete properties. Mousa et al. [1], Khan et al. [2], and Vijayan et al. [3] demonstrated that PEG-400 improves water retention, compressive strength, and durability. Bentz and Snyder [4] emphasized the effectiveness of internal curing for high-performance concrete, while El-Dieb [8] highlighted its role in reducing moisture loss. Recent investigations have further confirmed improvements in microstructure [12], flexural strength [11], and durability [13].

The present study investigates the performance of PEG-400 in M25 grade concrete with varying dosages. Mix design was carried out as per IS 10262:2019 [5], and the experimental program included fresh, mechanical, and durability tests to determine the optimum dosage for achieving strength, durability, and cost-effectiveness.

II. Literature Review

Research on self-curing concrete has confirmed the advantages of using PEG-400 as a curing agent. Mousa et al. [1] reported that PEG-based mixes retained more water and showed improved durability compared to conventional mixes. Khan et al. [2] and Vijayan et al. [3] observed that PEG-400 increased compressive and tensile strengths, while Bentz and Snyder [4] explained the role of internal curing in minimizing shrinkage cracks.

El-Dieb [8] showed that self-curing concrete reduces moisture transport and ensures continuous hydration, enhancing long-term durability. Ganesan and Meyyappan [9] suggested that the dosage of PEG-400 is critical for balancing workability and durability. Patil and Anadinni [10] also confirmed the effectiveness of PEG-400 in improving the elastic properties of concrete.

Other researchers have reported that PEG enhances microstructural properties [12], improves flexural performance of reinforced elements [11], and provides better resistance to durability-related deterioration [13]. These studies collectively demonstrate that PEG-400 is a reliable self-curing agent capable of improving hydration and mechanical performance of concrete.

III. Scope of the Project

The aim of this study is to evaluate the effect of PEG-400 as a self-curing compound in M25 grade concrete. The work includes investigation of fresh properties (slump), hardened properties (compressive, split tensile, and flexural strength), and durability aspects (water absorption, mass loss, and permeability). Different dosages of PEG-400 (0%, 1%, 1.5%, and 2% by weight of cement) are tested to identify the most effective proportion. The ultimate objective is to establish the suitability of PEG-400-based self-curing concrete for structures exposed to moisture or water-retaining conditions.

IV. Materials and Methodology

4.1 Materials

Ordinary Portland Cement (OPC), fine and coarse aggregates, and potable water were used in the mixes. PEG-400 served as the internal curing compound. Other potential agents such as Super Absorbent Polymers (SAP), lightweight aggregates (LWA), and fibers were considered in the literature as alternatives [1], [3], [4]. In some cases, supplementary materials like fly ash and plasticizers were incorporated to enhance performance.

4.2 Mix Proportioning

The M25 mix was designed as per IS 10262:2019 [5]. The water–cement ratio was selected to achieve the required strength and workability. PEG-400 was added in varying dosages (0.5–2% by weight of cement), with mix adjustments made to maintain consistency.

4.3 Mixing

Cement and aggregates were first dry mixed thoroughly. PEG-400 was then introduced, followed by gradual addition of water. Mixing continued until a homogeneous mixture with uniform workability was obtained.

4.4 Casting

Concrete was placed into standard molds and compacted to eliminate air voids. The surfaces were finished to ensure proper leveling.

4.5 Curing

Specimens with PEG-400 were cured under ambient conditions to simulate self-curing. Conventional control specimens were water-cured as per standard practice [1], [8].

4.6 Testing

Mechanical tests included compressive strength, split tensile strength, and flexural strength [3], [4]. Durability tests such as water absorption, sorptivity, and mass loss were also conducted to evaluate long-term performance [8], [12], [13].

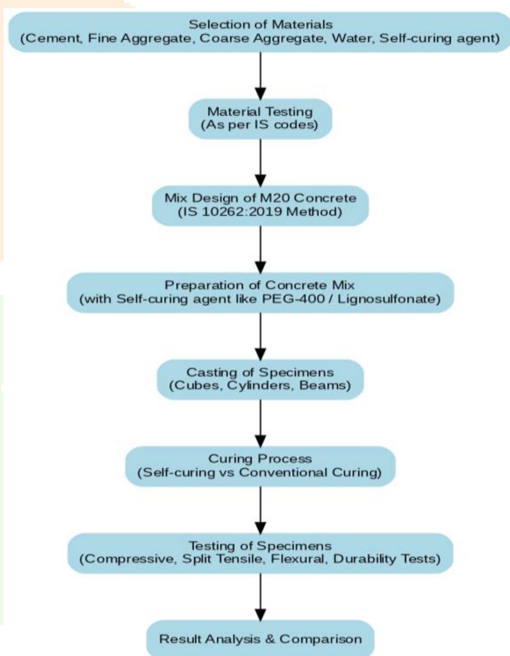

Figure 4.6.1: Experimental Methodology Flowchart

V. Physical Properties of Materials

Table 5.1 Cement properties : -

Parameter	Value
Specific gravity	3.11
Initial setting time	36 min
Final setting time	544 min

Table 5.2 Fine and Coarse Aggregate Properties:

Property	Fine Aggregate	Coarse Aggregate
Water absorption (%)	1.18	0.42
Specific gravity	2.65	2.71
Bulk density (kg/m³)	1662	1452

Table 5.3 Polyethylene Glycol (PEG-400) Properties:

Property	Value
pH	6.5
Specific gravity	1.08
Molecular weight	400
Density (g/cm³)	1.125
Appearance	Clear liquid

VI. Mix Design

Table 6.1 Mix Design (M25)

Item	Quantity
Cement (kg)	438
Fine aggregate, FA (kg)	672
Coarse aggregate, CA (kg)	1111
Water (lit)	191

VII. Test Results and Observations

7.1 Workability – Slump Cone Test

Table 7.1.1: slump Cone Test Result

PEG %	Slump (mm)
0%	80
1%	85
1.5%	95
2%	105

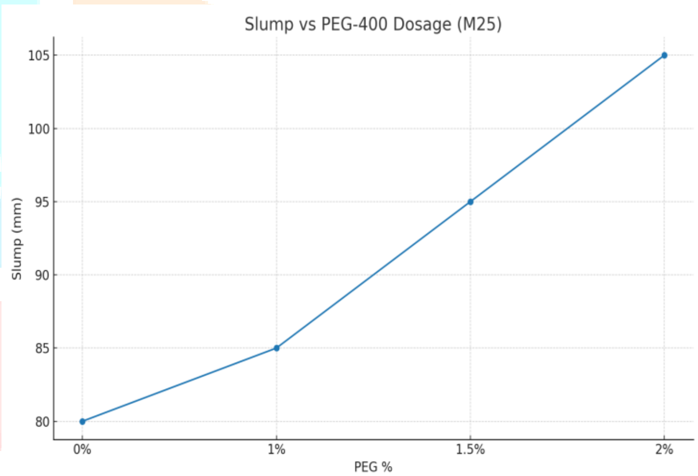

Figure 7.1: Slump vs Dosage (M25)

The slump cone test results indicate that the workability of concrete improves progressively with increasing PEG-400 dosage. The control mix (0% PEG) recorded a slump of 80 mm, while the mix containing 2% PEG-400 achieved the highest slump of 105 mm. The enhanced workability is attributed to the water-retaining and lubricating effect of PEG molecules, which improve the flow and ease of placement [1], [3].

7.2 Mechanical Properties

Table 7.2.1 Comparison between M25 for normal concrete compressive strength test 1%,1.5% & 2% PEG-400 compressive strength test

DAYS	CONVENTIONAL CONCRETE	1% PEG-400	1.5% PEG-400	2% PEG-400
7 DAYS	21.62	22.88	22.5	22.00
14 DAYS	29.88	31.75	32.38	31.75
28 DAYS	32.00	35.25	34.62	33.88

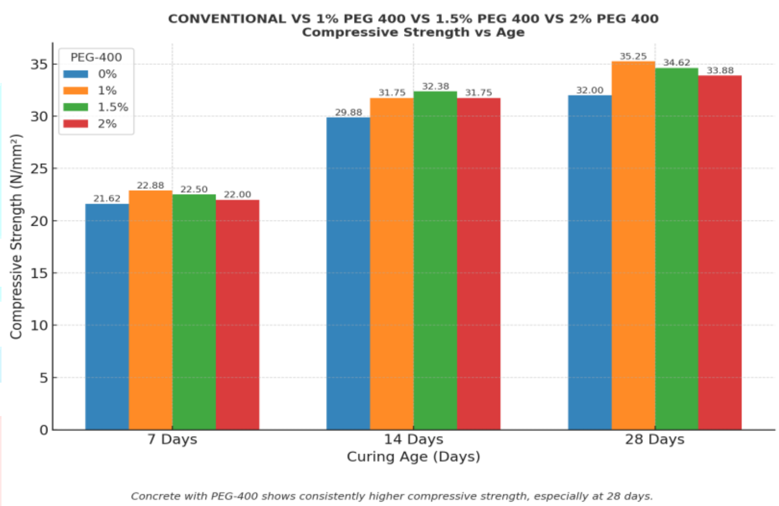

Figure 7.2.1: Variation of Compressive Strength of Concrete with PEG-400 Dosage at Different Curing Ages

PEG-400 incorporation improves compressive strength at all curing ages compared to conventional concrete. The mix with 1% PEG-400 achieved the maximum 28-day strength of 35.25 N/mm², approximately 10% higher than the control mix. Strength slightly decreased at 1.5% and 2% dosages, indicating an optimum compressive strength at 1% PEG-400 [1], [3], [9].

Table 7.2.2 Comparison between M25 for normal concrete split tensile strength test strength test 1% ,1.5% and 2% PEG-400 split tensile strength test

DAYS	CONVENTIONAL CONCRETE	1% PEG-400	1.5% PEG-400	2% PEG-400
7 DAYS	2.41	2.51	2.48	2.45
14 DAYS	3.34	3.47	3.44	3.39
28 DAYS	3.71	3.86	3.81	3.76

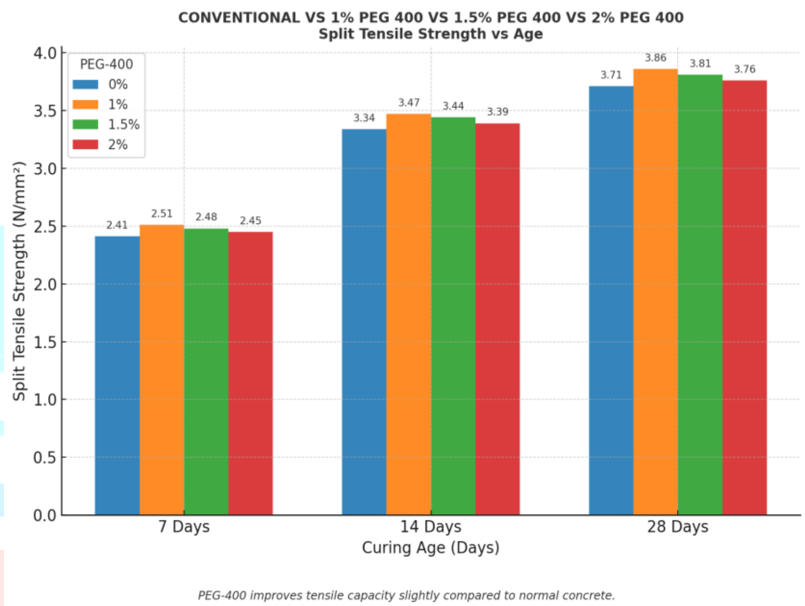

Figure 7.2.2: Variation of Split Tensile Strength of Concrete with PEG-400 Dosage at Different Curing Ages

Split tensile strength improved marginally with PEG-400 addition. The 1% PEG-400 mix gave the highest value at 28 days (3.86 N/mm²), showing about 4% improvement over the control mix. Higher dosages (1.5% and 2%) showed minor reductions, confirming 1% as the optimum dosage for tensile performance [2], [10].

Table 7.2.3 Comparison between M25 for normal concrete flexural tensile strength test 1%,1.5% and 2% PEG-400 flexural tensile test

DAYS	CONVENTIONAL CONCRETE	1% PEG-400	1.5% PEG-400	2% PEG-400
7 DAYS	3.56	3.69	3.81	3.62
14 DAYS	4.47	4.50	4.69	4.44
28 DAYS	5.00	5.19	5.31	5.06

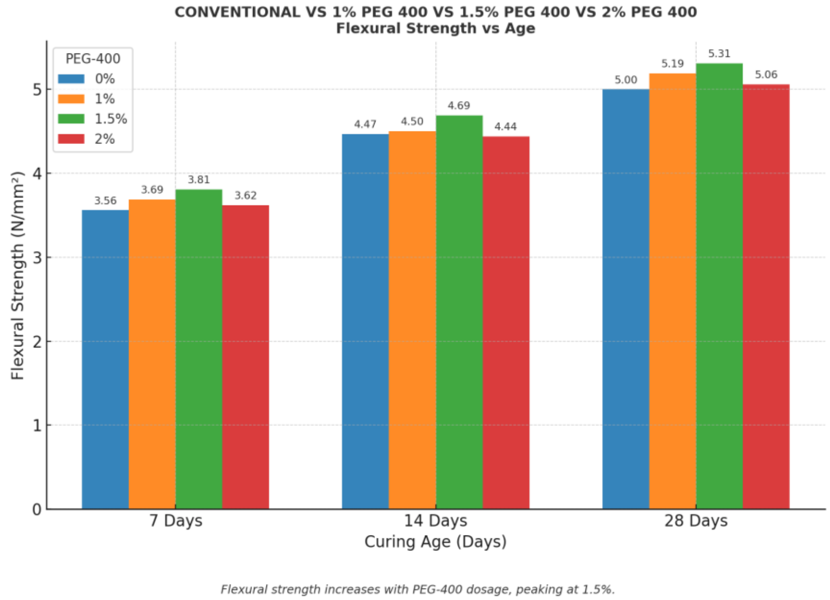

Figure 7.2.3: Variation of Flexural Strength of Concrete with PEG-400 Dosage at Different Curing Ages

7.3 Durability:

Flexural strength increased with PEG-400 addition. The peak strength was observed at 1.5% PEG-400 (5.31 N/mm² at 28 days). Dosages above 1.5% showed slight reductions but remained above the control mix. The optimum flexural performance was achieved at 1.5% PEG-400 [11].

Table 7.3.1 Comparison of Mass Loss (%) for Normal Concrete and PEG-400 (1%, 1.5% & 2%)

PEG-400 Dosage	Mass Loss (%)
Conventional Concrete (0%)	1.36
1% PEG-400	1.28
1.5% PEG-400	1.26
2% PEG-400	1.19

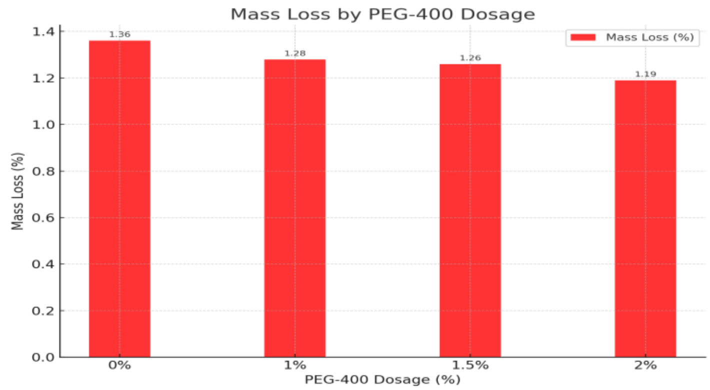

Figure 7.3.1 Variation in Mass Loss of Concrete with Different PEG-400 Dosages

Mass loss decreased consistently with PEG-400 addition, indicating improved durability. The 2% PEG mix showed the lowest mass loss (1.19%), highlighting enhanced resistance to deterioration [8], [12].

7.3.2 Table Comparison of Water Absorption (%) for Normal Concrete and PEG-400 (1%, 1.5% & 2%)

PEG-400 Dosage	Water Absorption (%)
Conventional Concrete (0%)	1.38
1% PEG-400	1.30
1.5% PEG-400	1.28
S2% PEG-400	1.19

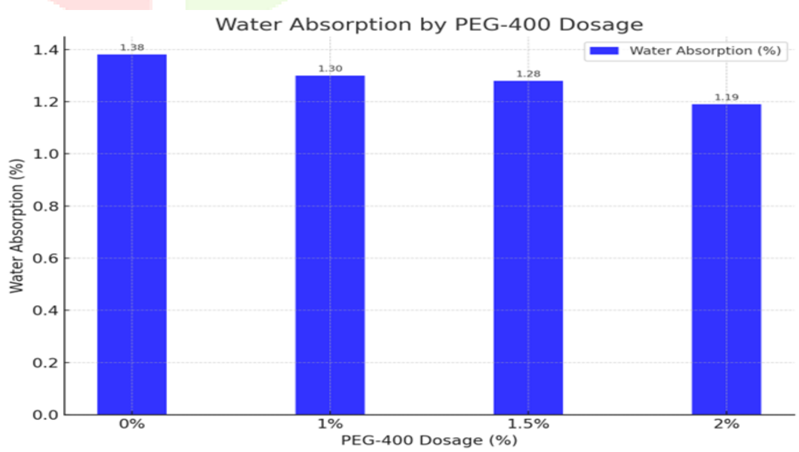

Figure 7.3.2 Variation in Water Absorption of Concrete with Different PEG-400 Dosages

Water absorption decreased with PEG-400 dosage, demonstrating better pore refinement and reduced permeability [8], [13].

7.3.3 Table Permeability Test Results of M25 Concrete with PEG-400 (as per IS 3085)

Sample No.	PEG 400 (%)	Test Pressure (bar)	Duration (hrs)	Water Flow (ml)	Penetration Depth (mm)	Permeability k (cm/s)
1	0 (Control)	7	96	26	18.5	4.6×10^{-8}
2	1.0	7	96	20	15.0	3.6×10^{-8}
3	1.5	7	96	17	11.5	2.9×10^{-8}
4	2.0	7	96	14	8.0	2.2×10^{-8}

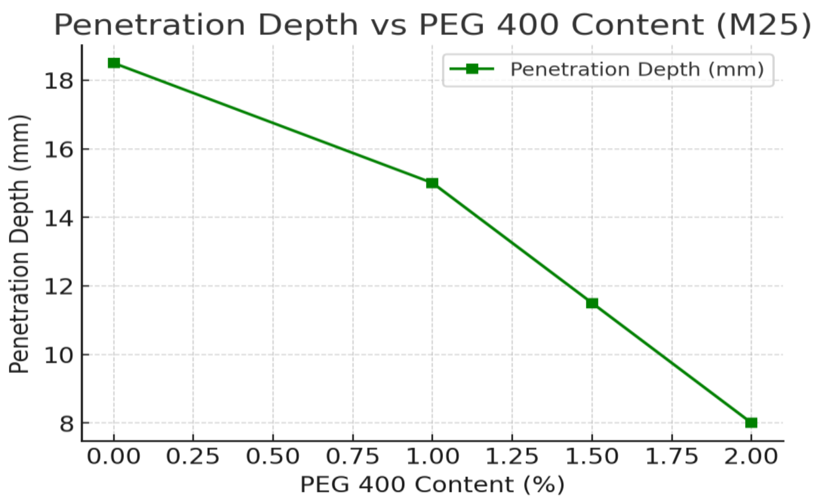

Figure 7.3.3 Reduction in Penetration Depth with Increasing PEG-400 Content

The permeability of concrete decreased with increasing PEG-400 content. All specimens were within the IS 3085 permissible limit (penetration ≤ 25 mm). The 2% PEG-400 mix exhibited the lowest penetration (8 mm), minimum water flow (14 ml), and the lowest permeability coefficient (2.2×10^{-8} cm/s), showing the highest impermeability and durability [1], [8].

VIII. Cost Comparison

Table 8.1 Normal concrete casting cost: -

GRADE	REQUIREMENTS	QUANTITY	ANALYSIS	AMOUNT
M25	**Concrete**	$1m^3$	1 x 3800	3800/-
	Water	$3m^3$ 2 rupees/ lit	2 x 3000	6000/-
			total	9800/-

Table 8.2 1% PEG-400 Concrete casting cost required: -

GRADE	REQUIREMENTS	QUANTITY	ANALYSIS	AMOUNT
M25	Concrete	1m^3	1 x 3800	3800/-
	PEG-400	4 Lit	4x 700	2800/-
			TOTAL	6600/-

Table 8.3 1.5 % PEG-400 Concrete casting cost required: -

GRADE	REQUIREMENTS	QUANTITY	ANALYSIS	AMOUNT
M25	Concrete	1m^3	1 x 3800	3800/-
	PEG-400	6 Lit	6 x 700	4200/-
			TOTAL	8000/-

Table 8.4 2% PEG-400 Concrete casting cost required: -

GRADE	REQUIREMENTS	QUANTITY	ANALYSIS	AMOUNT
M25	Concrete	1m^3	1 x 3800	3800/-
	PEG-400	8 Lit	8 x 700	5600/-
			TOTAL	9400/-

IX. Results & Discussion

8.1 Workability:

The slump cone test indicates that concrete workability improves progressively with increasing PEG-400 content. The control mix (0% PEG) recorded a slump of 80 mm, while 2% PEG-400 achieved 105 mm. This improvement is attributed to the water-retaining and lubricating effect of PEG molecules, enhancing flow and ease of placement [1], [3].

8.2 Mechanical Properties:

•Compressive Strength: PEG-400 addition increased compressive strength at all ages. The 1% PEG mix achieved the highest 28-day strength of 35.25 N/mm², about 10% higher than the control. Dosages above 1% showed slight reductions, indicating 1% PEG as optimal [1], [3], [9].

•Split Tensile Strength: 1% PEG-400 gave the maximum improvement at 28 days (3.86 N/mm²), ~4% higher than control. Higher dosages caused minor reductions, confirming 1% as optimum for tensile performance [2], [10].

•Flexural Strength: Flexural strength increased with PEG-400, peaking at 1.5% (5.31 N/mm² at 28 days). Dosages above 1.5% slightly decreased strength but remained higher than control, suggesting 1–1.5% PEG for optimal flexural performance [11].

8.3 Durability:

•Mass Loss: Decreased with PEG content; the lowest (1.19%) was observed at 2% PEG, indicating enhanced resistance to deterioration [8], [12].

•Water Absorption: Reduced progressively with PEG, showing improved pore structure and lower permeability [8], [13].

•Permeability: Water flow, penetration depth, and permeability coefficient decreased with higher PEG dosage. The 2% PEG mix had the lowest penetration (8 mm), water flow (14 ml), and permeability (2.2×10^{-8} cm/s), demonstrating superior impermeability and durability [1], [8].

X. Conclusion:

Polyethylene Glycol (PEG-400) effectively enhances the workability, strength, and durability of M25 concrete. Optimal mechanical performance is achieved at 1–1.5% PEG-400, with 1% providing maximum compressive and tensile strength, and 1.5% yielding peak flexural strength. Durability, indicated by reduced mass loss, water absorption, and permeability, improves with higher PEG dosage, with 2% showing the best performance. The 1% PEG mix is also the most economical, making PEG-400-based self-curing concrete suitable for water-retaining and moisture-prone structure.

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