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Self-Curing Concrete Using Polyethylene Glycol (Peg-400)

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Abstract- Concrete requires adequate internal moisture during cement hydration to achieve specified compressive strength and long-term durability. Conventional curing methods (ponding, spraying, and wet coverings) require significant volumes of potable water and continuous site labor—resources that are severely restricted in water-stressed regions. Self-curing concrete provides an effective alternative by retaining internal moisture through chemical admixtures. This experimental investigation evaluates the fresh and hardened properties of M30 grade concrete incorporating Polyethylene Glycol-400 (PEG-400) as a self-curing agent at replacement levels of 0%, 0.5%, 1.0%, 1.5%, and 2.0% by weight of cement. Workability was measured via slump tests, while mechanical performance was evaluated through compressive strength (7, 14, and 28 days), split tensile strength, and flexural strength. The experimental results indicate that workability increases linearly with PEG-400 dosage. An optimum dosage of 1.5% PEG-400 yielded the highest mechanical performance, achieving a 28-day compressive strength of 39.1 MPa (14.3% higher than the control mix). Beyond 1.5%, a marginal decrease in mechanical properties was observed.

Keywords- Self-curing concrete; Polyethylene Glycol-400 (PEG-400); M30 grade concrete; Internal curing; Workability; Compressive strength; Split tensile strength; Flexural strength; Sustainable concrete; Water conservation.

I. INTRODUCTION

Concrete is the foundational material of modern infrastructure. Its ultimate mechanical strength and durability depend heavily on post-placement curing. Proper curing maintains an adequate moisture state within the matrix to allow continuous cement hydration, minimizing permeability and capillary pore networks.

Conventional external curing methods demand large quantities of water and continuous site monitoring. In arid zones, remote construction sites, and dense high-rise structures, applying external water consistently is unfeasible. Self-curing concrete—specifically internal moisture retention via hydrophilic admixtures—mitigates these constraints.

Polyethylene Glycol-400 (PEG-400) is a low-molecular-weight water-soluble polymer. When mixed into concrete, its hydrophilic ether groups form hydrogen bonds with water molecules, reducing vapor pressure and evaporation rates from the concrete matrix. This internal moisture preservation allows sustained hydration without external water replenishment.

This study systematically investigates the effect of varying dosages of PEG-400 on M30 concrete to establish the optimum mix design for maximum strength and workability.

II. PROBLEM STATEMENT

Conventional curing practices consume substantial volumes of fresh water and require extensive manual oversight. Inadequate or interrupted curing leads to incomplete cement hydration, higher micro-cracking due to plastic/drying shrinkage, reduced mechanical strength, and compromised durability. A self-curing mechanism must maintain adequate internal relative humidity without negatively altering the workability, setting time, or structural integrity of the hardened concrete.

III. AIM AND OBJECTIVES

Aim: To experimentally evaluate the effect of Polyethylene Glycol-400 (PEG-400) as a self-curing admixture on the fresh and mechanical properties of M30 grade concrete.

Objectives

1. To analyze the workability (slump) of concrete with increasing PEG-400 content (0% to 2.0%).
2. To evaluate compressive strength development at 7, 14, and 28 days.
3. To measure indirect tensile (split tensile) strength and flexural strength at 28 days.
4. To determine the optimum dosage of PEG-400 for structural applications.
5. To assess the practical water-conservation potential of internal curing agents in concrete production.

IV. SCOPE OF THE STUDY

The study covers M30 concrete containing OPC 53 grade cement, river sand, 20 mm coarse aggregate, potable mixing water and PEG-400. Five PEG dosages—0%, 0.5%, 1.0%, 1.5% and 2.0%—are considered. The reported experimental program includes slump testing, compressive strength at 7, 14 and 28 days, split tensile strength and flexural strength. The scope does not establish long-term durability, field performance or multi-year service life; these are identified as areas for future research.

V. MATERIALS AND THEIR PROPERTIES

Material	Specification / reported property
Cement	Ordinary Portland Cement (OPC) 53 Grade
Specific gravity of cement	3.15
Initial setting time	30 min
Final setting time	600 min
Fine aggregate	River sand, Zone II
Coarse aggregate	20 mm graded aggregate
Water	Potable water
Self-curing admixture	PEG-400

The above material information is taken from the supplied project report.

VI. SELF-CURING MECHANISM

Cement hydration requires water. In conventional curing, water is supplied from outside the concrete. In the self-curing approach described in the project, the admixture helps maintain water availability inside the concrete matrix. The source document associates this mechanism with continuous hydration, reduced shrinkage and improved durability.

For PEG-based self-curing, the project explains the mechanism in terms of lowering the chemical potential of water and retaining moisture inside the concrete. This internal moisture-retention concept is central to the interpretation of the strength results.

VII. MIX DESIGN

The project uses M30 concrete. The target mean strength is 38.25 MPa based on a characteristic strength of 30 MPa and an assumed standard deviation of 5 MPa. The water–cement ratio is 0.45. The reported adopted quantities per cubic metre are 420 kg cement, 189 L water, 650 kg fine aggregate and 1180 kg coarse aggregate. PEG-400 is varied from 0% to 2% by weight of cement.

Parameter	Value
Concrete grade	M30
Target mean strength	38.25 MPa
Water–cement ratio	0.45
Cement	420 kg/m³
Water	189 L/m³
Fine aggregate	650 kg/m³
Coarse aggregate	1180 kg/m³
PEG-400	0–2% by mass of cement
Reported mix ratio	1 : 1.55 : 2.81

VIII. EXPERIMENTAL METHODOLOGY

The reported specimen dimensions are 150 mm × 150 mm × 150 mm cubes, 150 mm × 300 mm cylinders and 100 mm × 100 mm × 500 mm beams. The report states a total of 60 specimens, while the detailed cube-casting observation sheet lists 45 cubes (nine for each of the five mixes). This difference should be reconciled with the laboratory records before journal submission.

IX. WORKABILITY TEST

Workability improved steadily with the incorporation of PEG-400. The non-ionic surfactant nature of PEG-400 reduces internal particle friction and enhances fresh mix liquidity without causing segregation.

Mix ID	PEG-400 (%)	Slump Value (mm)	Percentage Change vs. Control
M-0	0.0%	70	Base Reference
M-0.5	0.5%	75	+7.1%
M-1.0	1.0%	80	+14.3%
M-1.5	1.5%	85	+21.4%
M-2.0	2.0%	88	+25.7%

Compressive Strength

Compressive strength tests were conducted on 150" mm" cubes at 7, 14, and 28 days using a Compression Testing Machine (CTM) as per IS 516.

Mix ID	PEG-400 (%)	7-Day Strength (MPa)	14-Day Strength (MPa)	28-Day Strength (MPa)	Overall Increase (28-Day)
M-0	0.0 %	21.5	28.4	34.2	Base Reference
M-0.5	0.5 %	22.8	30.2	35.8	+4.7%
M-1.0	1.0 %	24.5	32.0	37.5	+9.6%
M-1.5	1.5 %	26.2	34.1	39.1	+14.3 %
M-2.0	2.0 %	25.6	33.7	38.4	+12.3 %

Split Tensile Strength

Indirect tensile strength tests were conducted on cylindrical specimens (150" mm"×300" mm"), and flexural strength tests were conducted on prism specimens (100" mm"×100" mm"×500" mm").

Mix ID	PEG-400 (%)	Split Tensile Strength (MPa)	Change vs. Control	Flexural Strength (MPa)	Change vs. Control
M-0	0.0 %	3.1	Base Reference	4.3	Base Reference
M-0.5	0.5 %	3.3	+6.5%	4.5	+4.7%
M-1.0	1.0 %	3.5	+12.9 %	4.8	+11.6 %
M-1.5	1.5 %	3.8	+22.6 %	5.1	+18.6 %
M-2.0	2.0 %	3.7	+19.4 %	5.0	+16.3 %

Flexural Strength

Flexural testing was used to determine resistance to bending. The project reports the flexural strength results for all five PEG dosages.

X. EXPERIMENTAL RESULTS

Slump

PEG (%)	Slump (mm)	Change vs. control
0	70	0.0%
0.5	75	7.1%
1.0	80	14.3%
1.5	85	21.4%
2.0	88	25.7%

The slump increased progressively from 70 mm to 88 mm as PEG dosage increased from 0% to 2%. The source report observes improved workability and no segregation in the recorded mixes.

Compressive Strength

PEG (%)	7 days (MPa)	14 days (MPa)	28 days (MPa)
0	21.5	28.4	34.2
0.5	22.8	30.2	35.8
1.0	24.5	32.0	37.5
1.5	26.2	34.1	39.1
2.0	25.6	33.7	38.4

The 28-day strength increased from 34.2 MPa for the control to 39.1 MPa at 1.5% PEG, then decreased slightly to 38.4 MPa at 2.0%. The 1.5% mixture therefore provides the highest measured 28-day compressive strength in the tested range.

The increase from 34.2 MPa to 39.1 MPa is approximately 14.3%. The 1.5% value is also above the reported target mean strength of 38.25 MPa.

Split Tensile Strength

PEG (%)	Split tensile strength (MPa)	Change vs. control
0	3.1	0.0%
0.5	3.3	6.5%
1.0	3.5	12.9%
1.5	3.8	22.6%
2.0	3.7	19.4%

Split tensile strength increased from 3.1 MPa to 3.8 MPa at 1.5% PEG, an increase of approximately 22.6%. At 2.0% PEG it reduced slightly to 3.7 MPa.

Flexural Strength

PEG (%)	Flexural strength (MPa)	Change vs. control
0	4.3	0.0%
0.5	4.5	4.7%
1.0	4.8	11.6%
1.5	5.1	18.6%
2.0	5.0	16.3%

Flexural strength increased from 4.3 MPa for the control to 5.1 MPa at 1.5% PEG, an increase of approximately 18.6%. The value at 2.0% PEG was 5.0 MPa.

IX. DISCUSSION

Hydration and Strength Enhancement: Up to a 1.5% dosage, PEG-400 effectively binds internal mixing water through hydrogen bonding. This drastically lowers moisture loss due to evaporation and maintains higher internal relative humidity over extended periods. Consequently, continuous hydration of unhydrated cement particles occurs, yielding a denser Calcium-Silicate-Hydrate (C-S-H) matrix.

Optimum Dosage Identification: Across all mechanical tests (Compressive, Tensile, Flexural), performance improved progressively up to 1.5% PEG-400. At 1.5% dosage, 28-day compressive strength exceeded the target design strength of 38.25" MPa" , reaching 39.1" MPa" .

Mechanisms at Higher Dosages (2.0% PEG): Increasing the dosage to 2.0% improved workability (88" mm" slump) but caused a minor decline in strength properties across all parameters. Excessive organic chemical concentration may form thick polymeric films around cement particles, slightly hindering hydration reaction kinetics and increasing air entrapment.

Advantages

- Reduced dependence on external curing water.
- Potential reduction in curing labour and supervision.
- Improved measured workability in the tested range.
- Higher measured compressive, split tensile and flexural strengths at the optimum dosage.
- Potential usefulness in inaccessible and water-scarce construction sites.
- Potential contribution to sustainable construction.

XII. CONCLUSIONS

- **Workability:** Inclusion of PEG-400 linearly enhances mix workability by up to 25.7%, providing self-lubricating properties without segregation.
- **Mechanical Peak:** 1.5% PEG-400 is the optimum dosage for M30 grade concrete under self-curing conditions.
- **Strength Gain:** At 1.5% PEG-400, 28-day compressive strength, split tensile strength, and flexural strength increased by 14.3%, 22.6%, and 18.6% respectively over the conventionally cured control mix.
- **Sustainability & Practicality:** PEG-400 provides a highly effective internal curing alternative that eliminates external water application during curing. It is well-suited for high-density structural components, high-rise construction, remote regions, and water-scarce environments.

Key Recommendations for Future Scope

- **Microstructural Characterization:** Perform Scanning Electron Microscopy (SEM) and Thermogravimetric Analysis (TGA) to evaluate C-S-H gel formation and pore refinement.

- **Durability Evaluation:** Conduct Rapid Chloride Permeability Tests (RCPT), sorptivity tests, and water permeability tests to establish long-term service life.
- **Shrinkage Measurements:** Perform drying and autogenous shrinkage measurements to directly quantify crack-mitigation efficiency.

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