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Experimental Study and Comparative Evaluation of Self-Curing Concrete

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Abstract - The most often used building material is concrete, which needs enough curing to get desired strength and lifetime. Though efficient, traditional water-curing techniques have restrictions in remote locations, tall buildings, and areas with limited water supply. Under such circumstances, incorrect curing may cause decreased durability and performance. This work investigates the use of self-curing concrete, in which internal curing agents supply moisture during hydration, so lowering the demand for external curing.

Performance of two self-curing agents—Polyethylene Glycol 400 (PEG 400) and Superabsorbent Polymers (SAP)—in M30-grade concrete was assessed. While SAPs gradually absorb and release water, PEG 400 aids to retain water for internal hydration. Six concrete mixes—conventional water-cured (M1), non-cured (M2), PEG-based (M3, M4), SAP-based (M5), and PEG with water curing (M6) were made. Following IS and ASTM criteria, these mixes were evaluated for workability, compressive strength, tensile strength, flexural strength, and water absorption at 7, 14, and 28 days.

The results revealed that PEG 1.5% (M4) attained better workability and strengths equivalent to conventional curing. SAP (0.2%) greatly increased water retention and lowered shrinkage, so strengthening durability. Mix M6 showed advantages from combined internal and external curing and recorded the best strength. The uncured mix (M2) shown the lowest performance.

This work validates that, particularly in water-limited environments, self-curing agents are efficient substitutes for conventional approaches. Their application guarantees concrete performance and quality, so supporting sustainable building.

Keywords : Self-curing concrete, PEG 400, Superabsorbent polymers, Internal curing, Compressive strength, Durability, Sustainable construction

1. Introduction

Because of its great strength, durability, and moldability into many forms, concrete still forms the backbone of contemporary infrastructure. Its compressive strength and adaptability make it extensively used in many structural applications including buildings, bridges, pavements, dams, and precast elements. But a crucial phase controlling its performance is the curing process, which guarantees enough hydration of cementitious materials, so promoting strength increase and lifetime over time.

Conventional curing in traditional building techniques is keeping external moisture under control using ponding, sprinkling or covering with wet materials. Although efficient, these techniques have major drawbacks including great water demand, labour intensity, inefficiencies in remote, underground, or high-rise buildings. Actually, poor or insufficient curing results in surface cracking, reduced strength, higher permeability, and a notable decrease in the lifetime of concrete buildings [1].

Researchers have looked at other methods to overcome these difficulties; self-curing concrete has shown great promise. By including internal curing agents such Polyethylene Glycol (PEG) and Super Absorbent Polymers (SAP), which retain water inside the concrete mix and release it gradually over time, so enabling continuous hydration and eliminating the need for outside water application[2][3]. These agents create internal moisture reservoirs that guarantees continuous curing even in challenging site environments.

Because PEG 400, a water-soluble polymer, can hold and release moisture gradually, it has been increasingly applied in concrete as a self-curing agent. Research show PEG promotes strength development and helps to lower autogenous shrinkage[4]. Similarly, SAPs are hydrophilic polymers that can absorb and retain water many times their weight, so acting as internal reservoirs of curing water[5].

In high-performance concrete, Bentz and Snyder[2] showed that lightweight aggregates pre-soaked with water behave effectively in internal curing by reducing shrinkage and improving long-term strength. In internally cured concrete samples, Cusson and Hoogeveen[3] verified better hydration and less cracking. Especially in low water-cement ratio concretes, Jensen and Hansen[4] showed even more how SAPs enhance microstructure and prevent self-desiccation. Mehta and Monteiro[7] underlined how appropriate curing helps to improve the resistance of concrete against environmental damage.

Furthermore, Lura et al.[6] demonstrated that in high-performance concrete (HPC) where low water-cement ratios cause quick self-desiccation, internal curing is quite helpful. Aïtcin[8] underlined that modern concrete techniques depend on self-curing methods, particularly in cases where sustainability and water economy take front stage.

Thus, by means of comparative analysis of mechanical and durability criteria, this study explores the efficacy of self-curing agents (PEG 400 and SAP) in M30–grade concrete. The objective is to find whether in terms of performance, resource economy, and practical applicability these agents can be dependable replacements for conventional curing techniques.

2. Materials and Methodology

The materials used in this work were chosen with particular attention on their compatibility with self-curing techniques and their capacity to guarantee optimal hydration, strength development, and durability of concrete in the absence of conventional external curing methods.

2.1 Materials

2.1.1 Cement

All concrete mixes used ordinary Portland cement (OPC) Grade 53 conforming to IS 12269:2013. High early strength development of grade 53 cement makes it especially fit for experimental studies assessing the effects of internal curing on early-age mechanical properties.

Justification:

- Consistent with the M30 grade design used in this study, OPC 53 is extensively adopted in structural applications and high-strength concrete production.
- OPC 53's high reactivity helps to efficiently interact with self-curing agents, particularly Polyethylene Glycol (PEG) and Superabsorbent Polymers (SAPs), so supporting continuous hydration without external water use.

2.1.2 Fine and Coarse Aggregates

Perfect Aggregate: The fine aggregate came from clean, river sand that fit IS 383:2016. It was sieved and cleaned to remove harmful elements and preserve appropriate gradation (Zone II). The coarse aggregate consisted in crushed granite of 20 mm nominal size.

Justification:

- Using locally accessible river sand and crushed granite offers great bonding properties and workability while reflecting actual usefulness.
- For consistent distribution of self-curing agents, river sand provides a smooth texture that improves paste-aggregate interaction.
- For durability evaluation, crushed granite guarantees strong mechanical strength and dense packing—qualities absolutely important.

2.1.3 Agents for Self-Curing: Two-Three

Two self-curing agents were used to find how well they kept internal moisture:

i) Polyethylene Glycol 400 (PEG 400)

Low molecular weight hydrophilic polymer PEG 400 can absorb and then progressively release water over time. It was added at cement weight-based dosages of 1.0% and 1.5%.

Justification:

- PEG 400's molecular properties help it to function as an internal reservoir, providing water for the hydration mechanism in the crucial early stages of cement setting.
- Its lubricating quality improves workability and reduces autogenous shrinkage, so preserving long-term strength.

ii) SAPs, or superabsorbent polymers

Cross-linked polymers, SAPs can absorb water up to several hundred times their own weight. Based on research direction and trial data, they were used at a 0.2% by weight of cement dosage.

Justification:

- Especially in low w/c ratio mixes, SAPs absorb water during mixing and release it gradually as hydration advances, so acting as internal curing.
- Particularly helpful for mass concrete and hot climates, their inclusion lowers early-age cracking, improves microstructural densification, and helps to mitigate drying shrinkage.
- The chosen dosage guarantees enough curing without sacrificing mechanical integrity because of too high void generation.

2.1.4 Water

Mixing took clean potable water compliant with IS 456:2000. Maintaining a constant water-to---cement (w/c) ratio of 0.40, all mixes guaranteed consistency and enabled comparative analysis.

Justification:

- Potable water guarantees absence of interference from contaminants that might influence cement hydration or interact with self-curing agents.
- While optimizing the internal curing needs of PEG and SAPs, a w/c ratio of 0.40 balances the demand for strength and workability.

2.2 Mix Design

By means of suitable ratios of cement, water, fine aggregate, coarse aggregate, and self-curing chemicals, the mix design technique aims to produce concrete of the necessary strength and workability. Structural application and environmental conditions of exposure define target strength. This work makes use of M30 grade concrete, a commonly used grade in real-life structural projects requiring either modest to high strength.

2.2.1 Target Strength for Mix Design

According to IS 10262: 2019 and IS 456: 2000, the target mean strength $f'_{\{ck\}}$ is calculated using the formula:

$$f'_{\{ck\}} = f_{\{ck\}} + 1.65 \times S$$

Where:

- $f'_{\{ck\}}$ = Characteristic compressive strength at 28 days = 30 MPa (for M30)
- S = Standard deviation = 5 MPa (as per IS 10262:2019 for M30 grade concrete)

$$f'_{\{ck\}} = 30 + (1.65 \times 5) = 38.25 \text{ MPa}$$

So, the Target Mean Strength = 38.25 MPa

2.2.2 Mix Proportions for M30 Grade Concrete

Targeting good workability and strength, experimental trial mixes and IS 10262:2019 helped derive the final mix proportions for M30 grade concrete with a w/c ratio of 0.40. The mix was developed for conventional water-cured concrete as well as self-cured concrete (with PEG 400 and SAPs).

Table 2.2.2.1 : Nominal Mix Ratio (by weight) for 1 m³ of concrete (Conventional)

Material	Quantity (kg/m³)
Cement (OPC 53)	400
Water	160
Fine Aggregate	650
Coarse Aggregate	1200
Water-Cement Ratio	0.40

2.2.3 Modified Mix Design with Self-Curing Agents

To evaluate the performance of self-curing concrete, two additives were introduced in different mixes, replacing a small percentage of water or cement by weight:

Table 2.2.3.1 : Mix with PEG 400 (1.0% and 1.5% by weight of cement)

Material	PEG 1.0%	PEG 1.5%
Cement (OPC 53)	400 kg/m³	400 kg/m³
Water	160 kg/m³	160 kg/m³
PEG 400	4.0 kg/m³	6.0 kg/m³
Fine Aggregate	650 kg/m³	650 kg/m³
Coarse Aggregate	1200 kg/m³	1200 kg/m³
Water-Cement Ratio	0.40	0.40

PEG 400 was added as a liquid self-curing agent and mixed with water before blending with dry materials.

Table 2.2.3.2 : Mix with Superabsorbent Polymers (SAP) – 0.2% by weight of cement

Material	SAP 0.2% Mix
Cement (OPC 53)	400 kg/m³
Water	160 kg/m³
SAP (powder)	0.8 kg/m³
Fine Aggregate	650 kg/m³
Coarse Aggregate	1200 kg/m³
Water-Cement Ratio	0.40

SAP powder was dry-mixed with the aggregates and cement before the addition of water to ensure uniform dispersion.

2.2.4 Why These Mix Proportions and Dosages Were Selected

- Broadly used in both domestic and commercial building, M30 Grade Selection strikes a compromise between workability and strength. It provides a reasonable basis for assessing the effects of drugs meant for self-curing.
- Research and literature point to PEG 400 at 1.0% and 1.5% dosages as effective in delivering internal moisture and reducing shrinkage without compromising strength.
- SAP absorbs water many times more than their weight at 0.2%. They thus provide excellent internal cure even at low percentages. Higher percentages can result in micro voids able to compromise strength.
- This was selected to guarantee strength development while minimising water content, so optimising the need and efficacy of internal curing, with a 0.40 w/c ratio.
- Aggregate Ratios: The choice of coarse to fine aggregate ratio was directed by a maximum packing density, desired workability, and particle size distribution.

2.3 Methodology

2.3.1 Sample Preparation

Materials Used

- **Cement**: OPC 53 Grade confirming to IS 12269
- **Fine Aggregate**: Clean river sand (Zone II) as per IS 383
- **Coarse Aggregate**: Crushed granite stones (10 mm and 20 mm, mixed)
- **Water**: Potable water
- **Self-Curing Agents**:
  - **Polyethylene Glycol (PEG 400)** at **1.0% and 1.5%** by weight of cement
  - **Superabsorbent Polymer (SAP)** at **0.2%** by weight of cement

Table 2.3.1.1 : Mixes Considered (6 Total)

Mix No.	Description
M1	Conventional Concrete – Water Curing
M2	Conventional Concrete – No Curing
M3	PEG 400 – 1.0% (Self-Curing)
M4	PEG 400 – 1.5% (Self-Curing)
M5	SAP – 0.2% (Self-Curing)
M6	PEG 400 – 1.0% (Water Curing)

Table 2.3.1.2 : Specimen Casting and Quantities

Specimen Type	Dimensions	Purpose	Specimens per Mix	Total (6 Mixes)
Cubes	150 × 150 × 150 mm	Compressive Strength	9 (3 each @ 7,14,28 days)	54
Cylinders	150 mm Ø × 300 mm height	Split Tensile Strength	3 (1 each @ 7,14,28 days)	18
Beams	100 × 100 × 500 mm	Flexural Strength	2 (1 each @ 7, 28 days)	12

All concrete was mixed in a laboratory concrete mixer. Self-curing agents (PEG 400 or SAP) were added after dry mixing cement and aggregates, and before adding water.

Fig. 2.3.1.1 : Oiling of Mouldes

Fig. 2.3.1.2 : Concrete mixing

Fig. 2.3.1.3 : Mould Filling

Fig. 2.3.1.4 : Compaction

Fig. 2.3.1.5 : Cube Casting

Fig. 2.3.1.6 : Cylinder Casting

2.3.2 Curing Methods

1. Conventional Water Curing (M1, M6)

- Specimens were cured in water tanks at 27 ± 2°C for 7, 14, and 28 days.

Fig. 2.3.2.1: Curing of specimens

2. No Curing (M2)

- Specimens stored in shaded lab conditions without any curing.
- Helps assess the impact of zero moisture exposure.

3. Self-Curing (M3, M4, M5)

- No external water applied.
- Internal curing via:
  - PEG 400 at 1.0% and 1.5% (M3, M4)
  - SAP at 0.2% (M5)

These agents retain internal moisture to aid hydration over time.

2.3.3 Testing Schedule

The concrete properties were tested as per Indian and ASTM standards.

Table 2.3.3.1 : Concrete tests according to Indian and ASTM standards.

Sr. No.	Test	Specimen Type	Age (Days)	Code
1	Slump (Workability)	Fresh Concrete	Fresh	IS 1199:1959
2	Compressive Strength	Cube	7, 14, 28	IS 516:1959
3	Split Tensile Strength	Cylinder	7, 14, 28	IS 5816:1999
4	Flexural Strength	Beam	7, 28	IS 516:1959
5	Water Absorption	Cube (28-day cured)	28	ASTM C642

3. Results and Discussion

3.1 Slump Test (Workability)

Table 3.1.1 : Slump test results

Mix No.	Description	Slump (mm)	Remarks
M1	Conventional – Water Curing	80	Medium workability
M2	Conventional – No Curing	82	Slight increase, due to fast moisture loss
M3	PEG 400 – 1.0% (Self-Curing)	100	Higher slump due to PEG lubricating effect
M4	PEG 400 – 1.5% (Self-Curing)	110	Highest workability among all mixes
M5	SAP – 0.2% (Self-Curing)	90	Slightly reduced due to SAP swelling
M6	PEG 400 – 1.0% (Water Curing)	95	Good workability, similar to M3

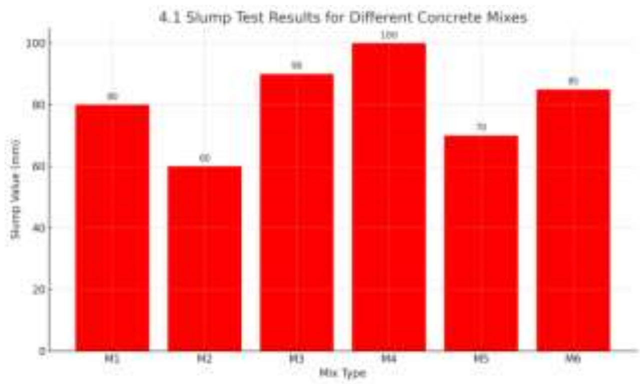

Fig 3.1.1 : Slump cone test results

- With 100 mm and 95 mm slump, respectively M3 (PEG 1.0%) and M6 (PEG 1.0% + Water Curing) also showed good workability; M4 (PEG 1.5%) had the maximum workability at 110 mm and showed great flow and simplicity of installation resulting from PEG's lubricating action.
- M5 mix had a small slump (90 mm), since SAP absorbs water and swells, somewhat thickening the mix.
- Typical for medium workability concrete, M1 and M2—conventional mixes—showed lower slump values (80–82 mm).

3.2 Compressive Strength Test

Fig 3.2.1 : Compressive strength testing

Table 3.2.1 : Compressive strength test results

Mix No.	7 Days (MPa)	14 Days (MPa)	28 Days (MPa)	Remarks
M1	23.1	30.5	41.2	As per expectations for M30–M40
M2	17.6	25.4	34.0	Lower strength due to no curing
M3	21.9	29.3	39.5	Slightly lower than M1, but acceptable
M4	22.5	30.2	40.8	Closely matches conventional strength
M5	20.4	28.1	38.3	Good performance for SAP
M6	23.3	31.0	41.8	Best result – PEG + water curing

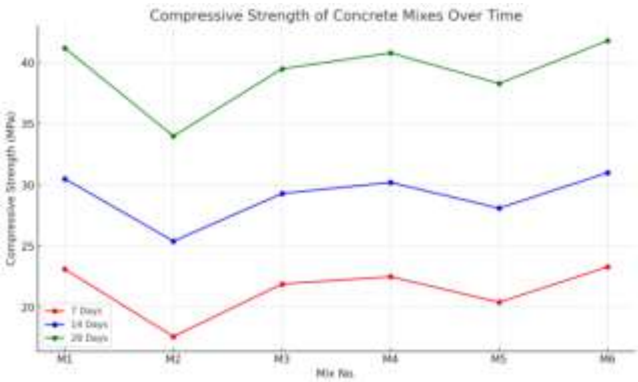

Fig 3.2.2 : Compressive strength test results

- M1 (Conventional + Water Curing) and M6 (PEG 1.0% + Water Curing) respectively showed top marks with respective 28-day compressive strengths of 41.2 MPa and 41.8 MPa.
- closely followed with 40.8 MPa M4 (PEG 1.5%) and said that increasing PEG dosage helped to effectively retain hydration.
- M3 (PEG 1.0%) and M5 (SAP 0.2%) showed rather lower strength (about 39.5 MPa and 38.3 MPa), still within reasonable bounds.
- From insufficient hydration either inside or outside cured, M2 (No Curing) showed the lowest strength of 34.0 MPa.

3.3 Split Tensile Strength Test

Fig 3.3.1 : Split tensile strength testing

Table 3.3.1 : Split Tensile Strength test results

Mix No.	7 Days (MPa)	14 Days (MPa)	28 Days (MPa)
M1	2.31	2.91	3.25
M2	1.95	2.45	2.81
M3	2.19	2.78	3.10
M4	2.25	2.85	3.20
M5	2.10	2.73	3.05
M6	2.34	2.95	3.28

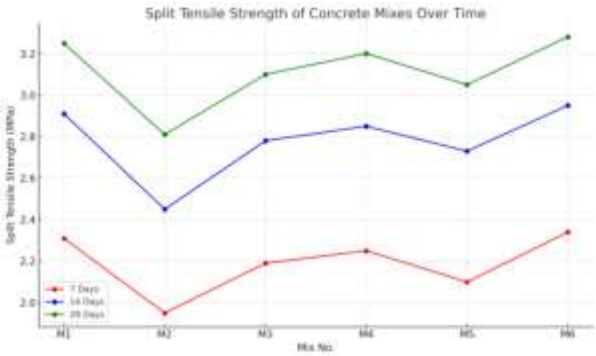

Fig 3.3.1 : Split Tensile Strength test results

- M6 (PEG + Water Curing) and M1 (Conventional + Water Curing) once more had the highest tensile strengths around 3.28 MPa and 3.25 MPa respectively at 28 days.
- Slightly better (3.20 MPa) than SAP (M5) PEG 1.5% (M4) PEG 1.0% (M3)
- With a tensile strength of 2.81 MPa, M2 (No Curing) underlined how much absence of curing influences crack resistance.

3.4 Flexural Strength Test

Fig 3.4.1 : Flexural strength testing

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Table 3.4.1 : Flexural strength test results

Mix No.	7 Days (MPa)	28 Days (MPa)
M1	3.3	5.1
M2	2.7	4.3
M3	3.1	4.9
M4	3.2	5.0
M5	2.9	4.7
M6	3.4	5.2

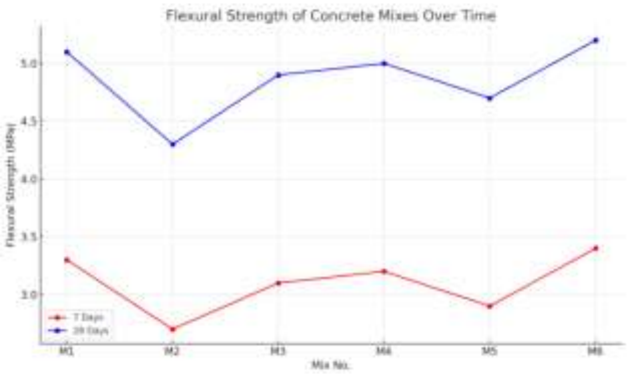

Table 3.4.1 : Flexural Strength test results

- Flexural strength developed in line with compressive strength.
- M6 and M1 showed respectively the best values with corresponding 28-day readings of 5.2 MPa and 5.1 MPa.
- Results with PEG-based mixes (M3 and M4) ranged somewhat lower but still rather good (4.9–5.0 MPa).
- SAP mix (M5) performed rather well at 4.7 MPa, indicating sufficient hydration but less tensile resilience than PEG.
- Once more lagging behind at 4.3 MPa is M2 (no curing).

3.5 Water Absorption Test

Table 3.5.1 : Water absorption test results

Mix No.	Water Absorption (%)	Remarks
M1	4.5	Normal absorption
M2	5.8	High due to poor hydration
M3	4.2	PEG reduces early drying
M4	4.0	Improved internal curing
M5	3.9	SAP stores and slowly releases water
M6	4.3	Water + PEG gives optimal absorption

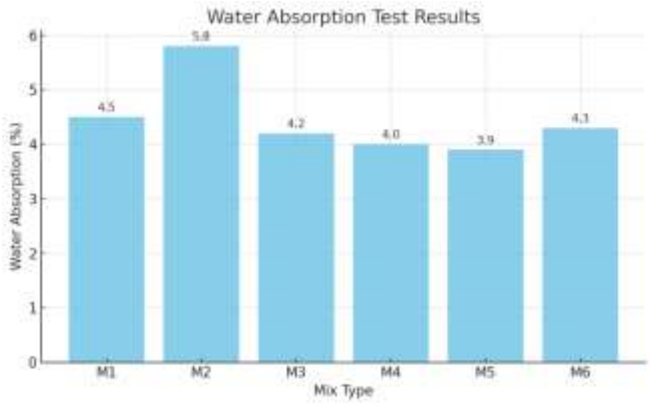

Fig 3.5.1 : Water absorption test results

- SAP mix (M5) showed great moisture retention but the lowest absorption rate (3.9%), when polymer swelling.
- PEG-based mixes also shown reduced water absorption: M4 at 4.0%, M3 at 4.2%, and M6 at 4.3%, so indicating their internal curing efficiency.
- M1 (water cure) absorbed rather moderately at 4.5%.
- M2 (No Curing) suggested larger voids and poor matrix density resulting from lack of hydration with a maximum absorption of 5.8%.

4. Conclusion

- Especially PEG 400 and SAP, self-curing compounds help to significantly improve concrete's workability, strength, and durability.
- The SAP-based mix (0.2%) showed remarkable water retention qualities, so lowering water absorption and increasing durability by raising the concrete's resistance to environmental elements; PEG 400 at 1.0% and 1.5% by weight of cement shown notable gains in compressive strength, split tensile strength, and flexural strength when compared to ordinary concrete.
- Water curing and self-curing (PEG 400) showed almost exact performance in strength tests, so demonstrating that these sustainable and efficient alternatives for traditional water curing are feasible.
- The lowest performance came from no curing (M2), thus stressing the need of enough curing in the concrete hydration process; PEG 400 improves workability, according the slump test; SAP somewhat reduces it because of water absorption.
- Self-curing methods can significantly reduce water usage in areas with limited resources and on big concrete building projects.
- The study confirms that, if one wants great strength and durability with minimal environmental impact, self-curing concrete can be a wise option for modern building.
- The results confirm the necessity of curing in obtaining long-term durability and best concrete performance.

This extensive research reveals the possibilities of self-curing chemicals in delivering premium concrete, so substituting for traditional curing methods and supporting more environmentally friendly building approaches.

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