

# DURABILITY ASSESSMENT OF SELF-CURING CONCRETE CONTAINING HYDROGEL AND CALOTROPIS GIGANTEA LATEX AS SELF-CURING AGENTS

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## ABSTRACT

*In today's age of infrastructure advancement, the durability of concrete structures is a key concern for all engineers. Durability can be assessed by using various methods, out of which the Rapid Chloride Penetration Test (RCPT) has been analyzed in the present research. In this experimental research, the durability of M45 grade self-cured concrete was tested by using hydrogel, which is a superabsorbent polymer, and Calotropis gigantea latex, a naturally derived substance, in the proportion of 0.2% and 0.3%, respectively, by the weight of cement, which is intended to improve the internal curing in concrete. All the specimens containing self-curing agents underwent RCPT in accordance with ASTM 1202-2019 to quantitatively assess chloride ion penetration after 90 days of self-curing, which is a very important factor for evaluating the durability of self-cured concrete. Tests have been performed on the samples containing 0.2% hydrogel and 0.3% calotropis gigantea latex by the weight of cement. Results indicated that all the specimens exhibited low chloride ion penetration, as the charge passed varies from 1400 to 1600 coulombs. This study highlights the promise of incorporating self-curing agents in M45-grade concrete to meet the durability requirements for building sustainable infrastructure, prolonging the life span of concrete structures. .*

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**Keywords:** Self-curing, durability, hydrogel, Calotropis gigantea, Rapid Chloride Penetration Test, concrete.

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## INTRODUCTION

Concrete durability is widely acknowledged as a fundamental factor influencing the long-term performance, safety, and sustainability of modern infrastructure systems. A durable concrete structure is capable of retaining its intended strength and functionality throughout its service life, thereby reducing the need for frequent maintenance, repair, and rehabilitation activities. Among the various factors affecting durability, the curing process plays a vital role, as it governs the hydration of cementitious materials within the concrete matrix. Proper curing ensures continuous hydration, which contributes to the formation of a dense microstructure and improves resistance against environmental deterioration mechanisms such as sulfate attack, freeze-thaw cycles, and carbonation [10, 11]. Additionally, effective curing enhances mechanical properties and minimizes early-age cracking, thereby significantly improving the overall durability of concrete structures.

However, conventional curing techniques—including water ponding, steam curing, wet coverings, and spraying—may not always be feasible or effective under practical field conditions. In large-scale constructions, internal moisture loss

due to self-desiccation cannot be adequately compensated by surface curing alone. Furthermore, in structures with complex geometries, limited accessibility, water scarcity, or extreme environmental conditions, maintaining continuous external curing becomes challenging. Inadequate curing under such circumstances leads to incomplete hydration, increased porosity, weak interfacial transition zones, and the development of microcracks, all of which adversely affect the durability and service life of concrete structures [4]. To address these limitations, self-curing (internal curing) has emerged as an effective alternative to conventional curing practices [2,4]. In this approach, internal curing agents such as lightweight aggregates, superabsorbent polymers, and polyethylene glycol are incorporated directly into the concrete mix. These materials act as internal reservoirs of water, gradually releasing moisture during hydration, particularly at early ages. This mechanism compensates for internal moisture loss and ensures uniform hydration throughout the concrete matrix. Consequently, self-cured concrete exhibits reduced shrinkage, lower internal stresses, improved microstructural characteristics, and enhanced durability performance.



Figure. 1 Various self-curing agents.

Among the various internal curing agents, hydrogels—classified as superabsorbent polymers (SAPs)—have attracted significant attention due to their exceptional ability to absorb and subsequently release water within the concrete matrix during hydration [4,7]. These materials can retain several times their own weight in water and gradually release it, thereby maintaining internal relative humidity and supporting continued

hydration. This mechanism contributes to reduced early-age cracking, more uniform moisture distribution, and refinement of the pore structure, ultimately improving resistance to chloride ion ingress.

Despite these advantages, the use of hydrogels presents certain limitations. Many commercially available hydrogels are synthetic in nature, which may increase material costs and raise concerns

regarding environmental sustainability. Consequently, their long-term applicability in

sustainable construction requires careful consideration and further evaluation.



*Figure. 2 Hydrogel*

With the growing emphasis on sustainable and environmentally responsible construction practices, there has been a noticeable shift from synthetic polymers toward the use of natural, plant-based additives as alternative or supplementary internal curing agents. Natural biopolymers offer several advantages, including renewability, biodegradability, low toxicity, and cost-effectiveness, making them highly suitable for sustainable concrete applications.

Among the various plant-derived materials, *Calotropis gigantea* has emerged as a promising biopolymer due to its adhesive, film-forming, and

moisture-retention characteristics. The latex extracted from this plant has the ability to retain water within the concrete matrix and gradually release it during the hydration process, thereby supporting continuous hydration. This mechanism enhances microstructural development and improves resistance to moisture-related deterioration. Furthermore, as a naturally sourced material, *Calotropis gigantea* latex contributes to reducing dependency on synthetic curing agents, making it a viable and eco-friendly option for internal curing in concrete.



*Figure. 3 Calotropis Gigantea plant with latex*

While synthetic hydrogels are known for their high-water absorption capacity and controlled release characteristics, *Calotropis gigantea* latex offers the advantage of sustainability as a natural, eco-friendly material. Therefore, a hybrid self-curing approach that combines the water-retention capability of hydrogels with the moisture-regulating properties of *Calotropis gigantea* latex can be considered a promising strategy. Such a composite system is expected to enhance internal curing efficiency, ensure continuous hydration, and improve the overall durability performance of concrete, while also addressing environmental and economic concerns associated with conventional materials.

The present experimental study focuses on evaluating the durability performance of self-cured concrete incorporating hydrogel and *Calotropis*

*gigantea* latex as internal curing agents, added as a percentage of cement weight. Key durability-related parameters, including water absorption, permeability, and resistance to aggressive environmental conditions, have been systematically investigated along with microstructural characteristics. The outcomes of this study aim to assess the feasibility, effectiveness, and long-term performance of these self-curing agents, thereby contributing to the development of durable and sustainable concrete suitable for modern construction applications.

#### LITERATURE SURVEY

The durability of concrete structures is primarily governed by adequate curing, refinement of pore structure, and resistance to chloride ion ingress under aggressive environmental conditions [10,

11]. Conventional curing methods often fail to ensure sufficient moisture availability in practical scenarios due to limitations such as water scarcity, complex geometries, and site constraints [4]. To address these challenges, the concept of internal curing (self-curing) has been developed, which ensures a continuous supply of moisture within the concrete matrix, thereby promoting sustained hydration. According to ACI 308R guidelines, internal curing involves the provision of additional water within the concrete to facilitate proper cement hydration [6]. Early work by Philleo [1] introduced the concept of “curing from within,” emphasizing its effectiveness in mitigating autogenous shrinkage even in low water-cement ratio concrete.

The fundamental principle of internal curing is based on maintaining internal relative humidity during hydration. Jensen and Hansen [2] demonstrated that the presence of internal moisture reduces capillary stresses and significantly minimizes autogenous shrinkage. Furthermore, Bentz et al. [3] reported that internally cured systems exhibit enhanced hydration kinetics, refined pore structure, and reduced cracking potential. These improvements contribute directly to durability enhancement by limiting the ingress of aggressive ions such as chlorides and sulfates.

Among various internal curing agents, superabsorbent polymers (SAPs), such as hydrogels, and natural bio-based materials like *Calotropis gigantea* latex have gained considerable attention. SAPs are cross-linked polymer networks capable of absorbing and releasing large quantities of water during hydration. Mechtcherine and Schröfl [8] demonstrated that SAP incorporation improves hydration and mitigates shrinkage cracking, while Lura [5] reported that SAP-based internal curing reduces permeability and enhances compressive strength. Microstructural studies have further confirmed that internal curing leads to the formation of additional hydration products and reduction in capillary porosity, thereby improving durability [12]. The durability performance of such systems is commonly evaluated using the Rapid Chloride Penetration Test (RCPT), as per ASTM C1202 [7], which measures resistance to chloride ion penetration. Previous studies consistently indicate that internally cured concrete exhibits lower chloride permeability compared to conventionally cured concrete, thereby enhancing long-term durability.

In recent years, there has been a growing emphasis on sustainable construction materials, leading to the exploration of natural bio-admixtures as

alternatives to synthetic polymers. Among these, *Calotropis gigantea* latex has emerged as a promising material due to its moisture retention, adhesive, and film-forming properties. Experimental studies suggest that the incorporation of CG latex improves workability and contributes to strength development at optimal dosages. Additionally, recent research on hydrogel-based internal curing systems highlights significant improvements in resistance to chloride ion penetration and chemical attack due to enhanced hydration and pore structure refinement [4].

The combined use of hydrogel and *Calotropis gigantea* latex is expected to produce synergistic effects in self-curing concrete. Hydrogels provide controlled water release, ensuring continuous hydration, while CG latex enhances moisture retention and interfacial bonding within the cementitious matrix. This combined mechanism has the potential to reduce shrinkage, minimize cracking, and improve durability performance, particularly in high-strength concrete.

Despite extensive research on individual self-curing agents, there remains a significant research gap concerning hybrid systems combining synthetic and natural materials. In particular, limited studies address durability parameters such as chloride diffusion, resistance to aggressive environments, and long-term microstructural evolution. Therefore, advanced characterization techniques such as scanning electron microscopy (SEM), thermogravimetric analysis (TGA), and X-ray diffraction (XRD) are essential to understand the interaction between internal curing agents and cementitious materials. Consequently, a systematic investigation into the durability performance of self-cured concrete incorporating hydrogel and *Calotropis gigantea* latex is necessary to establish its feasibility for sustainable and durable construction applications.

## **MATERIALS AND METHODS**

Ordinary Portland Cement (OPC) of 53 grade was used as the primary binding material, and its physical and chemical properties were characterized prior to use in accordance with relevant standards [10, 11]. Locally available fine aggregate conforming to Zone II and coarse aggregates of size 10–20 mm were utilized, and their properties were evaluated as per standard specifications before casting. Potable water satisfying the requirements of IS 456:2000 was used for mixing and curing purposes [8].

In this experimental investigation, two types of internal curing agents were incorporated based on

their high-water absorption and desorption capacities, namely hydrogel (a commercially available superabsorbent polymer, SAP) and *Calotropis gigantea* (CG) latex, a naturally derived bio-based material. The use of SAP as an internal curing agent has been widely reported to enhance hydration and reduce shrinkage through controlled water release within the concrete matrix [4, 5].

The concrete mix of M45 grade was designed in accordance with IS 10262:2019 guidelines [9], and

different mixes were prepared by incorporating the selected self-curing agents and compared with the conventional control mix. All specimens were cast and tested at curing ages of 7, 14, and 28 days. The control specimens were subjected to conventional water curing, whereas the self-cured specimens were maintained under ambient conditions without any external curing, allowing internal curing mechanisms to govern hydration [6]. The details of mix proportions and sample identification are presented in Table 1.

**Table 1 Sample ID**

S.No.	ID	Self-curing agent	% of Self-curing agent
1	M0	-	-
2	M1	Hydrogel	0.2
3	M2	CG Latex	0.3

The fresh properties of concrete were evaluated using the slump cone test to assess workability, while the hardened properties were determined through compressive strength and split tensile strength tests conducted at specified curing intervals. These tests provide a comprehensive understanding of the mechanical performance of concrete and its behavior under loading conditions [10,11].

For durability assessment, the Rapid Chloride Penetration Test (RCPT) was carried out in accordance with ASTM C1202 to evaluate the resistance of concrete against chloride ion ingress, which is a critical parameter influencing the long-term durability of reinforced concrete structures [7]. The total charge passed during the test was used as an indicator of permeability and resistance to aggressive environmental conditions.

The experimental results obtained from self-cured concrete mixes were systematically analyzed and compared with those of conventional concrete to assess the effectiveness of internal curing agents. This comparative evaluation facilitated the identification of the optimum dosage of hydrogel and *Calotropis gigantea* latex for achieving improved mechanical and durability performance.

## RESULTS AND DISCUSSIONS

The experimental results obtained from the incorporation of hydrogel and *Calotropis gigantea* (CG) latex indicate that internal curing agents have a significant influence on both the mechanical and durability properties of concrete, primarily due to enhanced hydration and pore structure refinement within the cementitious matrix [3, 4].

### WORKABILITY

The workability of M45 grade concrete incorporating internal curing agents, namely 0.2% hydrogel and 0.3% *Calotropis gigantea* (CG) latex, was evaluated using the slump cone test and compared with that of conventional concrete. The results are presented in Table 2 and illustrated in Fig. 4. The hydrogel-modified concrete exhibited a slight reduction in workability, which can be attributed to its high-water absorption capacity that reduces the availability of free water in the mix [4, 5]. In contrast, the CG latex-incorporated concrete showed an increase in workability due to its moisture-retaining and lubricating characteristics, which enhance the flowability of the mix. Similar trends have been reported in previous studies, where superabsorbent polymers tend to reduce slump, whereas bio-based additives improve workability through improved dispersion and water retention [4].

**Table 2 Workability results**

S.No.	ID	Workability
1	M0	140 mm
2	M1	130 mm
3	M2	180 mm

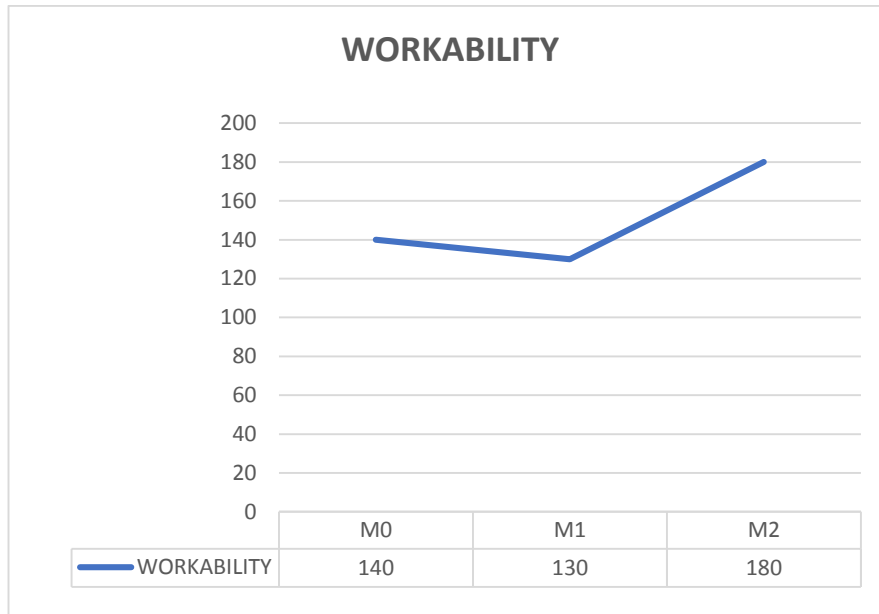


Figure. 4 Workability

### Compressive Strength

The compressive strength of self-cured M45-grade concrete was evaluated using 150 mm cube specimens at curing ages of 7, 14, and 28 days. The tests were conducted using a Compression Testing Machine (CTM) for both conventional and self-cured concrete mixes, following standard testing procedures [10, 11]. The experimental results are presented in Table 3 and illustrated graphically in Fig. 5.

Table 3 Compressive strength results

S.No.	No. of Days	M0	M1	M2
1	7	41.22	43.61	34.89
2	14	44.62	51	35.91
3	28	46.69	53.78	39.96

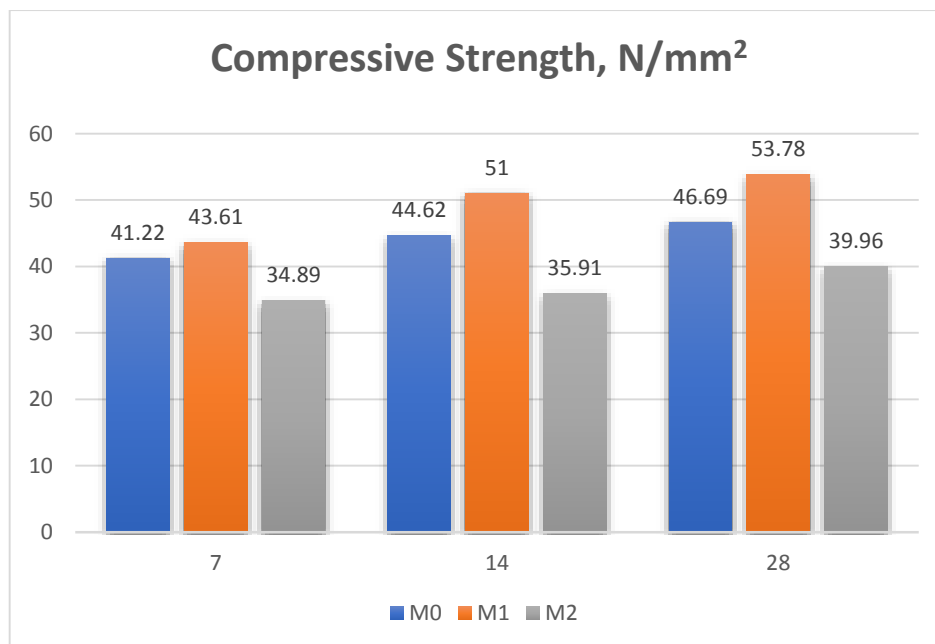


Fig. 5 Compressive Strength

The compressive strength results indicate that all three concrete mixes exhibit a progressive increase in strength with curing age; however, the

incorporation of self-curing agents significantly influences their performance. Mix M1, containing 0.2% hydrogel, demonstrated the highest

compressive strength at all curing ages (7, 14, and 28 days), reaching a maximum value of 53.78 MPa, which is higher than that of conventional concrete. This enhancement can be attributed to the effective internal curing provided by hydrogel, which ensures continuous moisture availability for hydration, leading to improved microstructural development and reduced porosity [4, 5]. In contrast, the control mix (M0) exhibited a normal strength development pattern, while Mix M2, containing 0.3% *Calotropis gigantea* (CG) latex, showed comparatively lower compressive strength. Although CG latex contributes to improved bonding and moisture retention within the matrix, its influence on strength development at the selected dosage appears to be less effective than that of hydrogel. Similar observations have

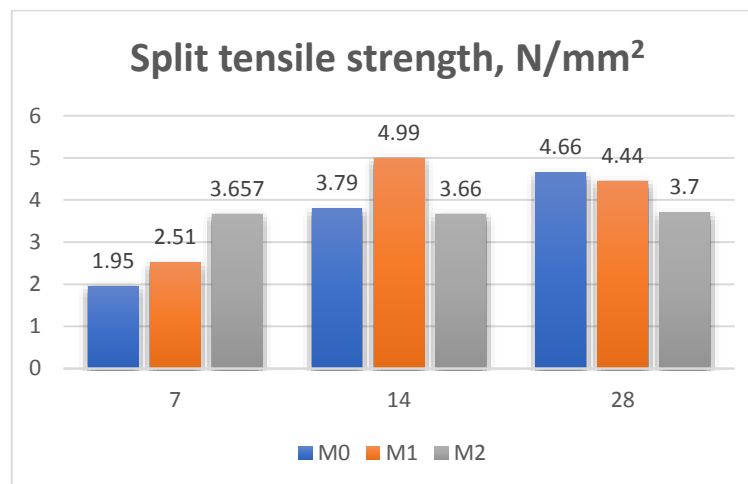
been reported in previous studies, where superabsorbent polymers enhance strength through internal curing, whereas bio-based additives require optimization to achieve comparable mechanical performance [4].

### Split Tensile Strength

The split tensile strength of internally cured M45 grade concrete was evaluated using cylindrical specimens of size 300 mm × 150 mm at curing ages of 7, 14, and 28 days. The test was conducted using a compression testing machine (CTM) for both conventional and self-cured concrete mixes in accordance with standard testing procedures [10, 11]. The experimental results are presented in Table 4 and illustrated graphically in Fig. 6.

**Table 4 Split tensile strength results**

S.No.	No. of Days	M0	M1	M2
1	7	1.95	2.51	3.657
2	14	3.79	4.99	3.66
3	28	4.66	4.44	3.7



**Fig. 6 Split Tensile Strength**

The split tensile strength results presented in Table 4 and Fig. 6 clearly demonstrate the influence of curing age and mix composition on the tensile performance of concrete. At 7 days, Mix M2 exhibited the highest strength (3.657 MPa), followed by M1 (2.51 MPa) and the control mix M0 (1.95 MPa), indicating that the incorporation of internal curing agents enhances early-age tensile strength. This improvement may be attributed to better moisture retention and early hydration within the matrix [4]. At 14 days, Mix M1 achieved the maximum strength of 4.99 MPa, surpassing both M0 (3.79 MPa) and M2 (3.66 MPa), suggesting that hydrogel-based internal curing is particularly effective during the intermediate stage of hydration by promoting sustained moisture

availability and improved microstructural development [5]. However, at 28 days, the control mix M0 attained the highest strength (4.66 MPa), while M1 (4.44 MPa) showed comparable performance and M2 (3.70 MPa) exhibited relatively lower strength. Overall, the results indicate that Mix M2 enhances early-age tensile performance, whereas Mix M1 provides optimum strength during intermediate curing periods. The control mix, however, demonstrates superior long-term tensile strength. These findings highlight the importance of optimizing internal curing agent dosage to achieve a balanced performance between early-age strength and long-term mechanical properties, consistent with observations reported in previous studies [4].

### Durability Test - Rapid Chloride Penetration Test

The resistance of concrete to chloride ion penetration was evaluated using the Rapid Chloride Penetration Test (RCPT) in accordance with ASTM C1202-2019, which is widely adopted for assessing durability performance in aggressive environments [7]. The cumulative electrical charge passed through the specimens over a duration of six hours was considered an indicator of permeability and overall durability.

For the mix containing 0.2% hydrogel, the measured charge-passed values were 1450.53, 1557.27, and 1459.80 coulombs. In comparison, the concrete incorporating 0.3% *Calotropis gigantea* latex exhibited slightly higher values of 1492.65, 1622.88, and 1654.11 coulombs. The relatively lower average charge passed in the hydrogel-modified mix suggests a greater resistance to chloride ion ingress when compared to the latex-modified concrete. Based on ASTM classification, all recorded values fall within the range of 1000–2000 coulombs, indicating a **low level of chloride ion penetrability**, which reflects the development of a relatively dense and less permeable concrete matrix [7].

The improved performance observed in the hydrogel-incorporated concrete can be attributed to its ability to provide internal curing through

gradual water release, which enhances the degree of hydration and contributes to pore structure refinement [4, 5]. This results in reduced pore connectivity and limits the pathways available for chloride ion movement. Similar observations have been reported in previous studies, where the use of superabsorbent polymers led to significant improvements in durability due to enhanced microstructural characteristics [4].

The current flow recorded during the test followed a typical increasing pattern over time. At the initial stage, lower current values indicated restricted ionic mobility within the concrete. As the test progressed, a gradual rise in current was observed due to the continuous movement of ions under the applied voltage. Nevertheless, the overall current levels remained moderate, suggesting that the concrete possesses relatively low permeability.

In summary, both hydrogel- and latex-modified concrete mixes demonstrated adequate resistance to chloride ion penetration. However, the hydrogel-based system exhibited comparatively better performance, highlighting its effectiveness in improving durability characteristics. These findings indicate that the incorporation of hydrogel as an internal curing agent can be considered a reliable approach for enhancing the long-term performance of concrete structures exposed to chloride-rich environments [4].

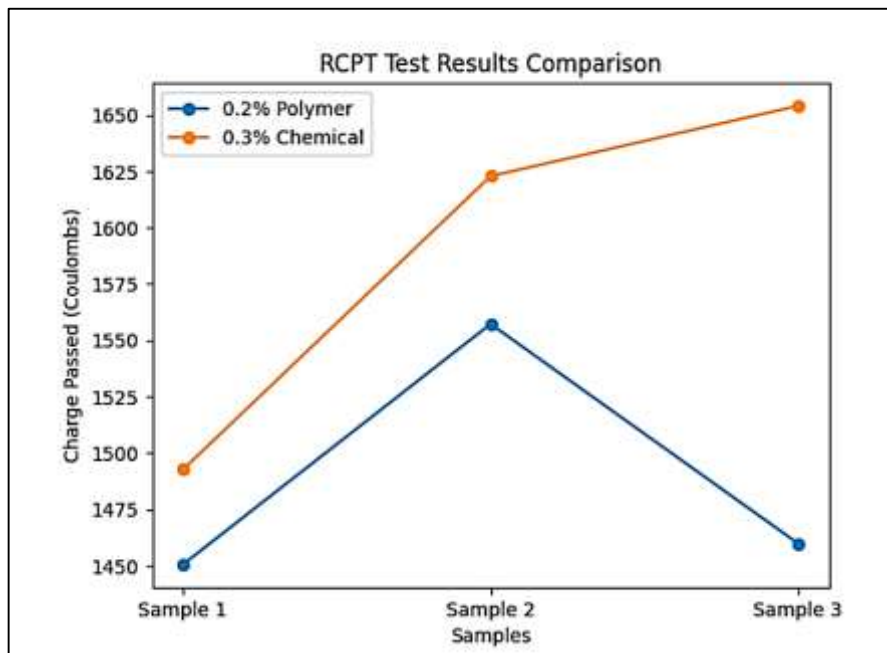


Figure 7 RCPT test results comparison

Figure 7, Rapid Chloride Penetration Test (RCPT) results showing the average charge passed (in coulombs) for concrete mixes containing 0.2% polymer and 0.3% chemical admixtures. Error bars

represent the standard deviation of three samples. The polymer-modified concrete exhibits lower charge-pass values compared to the chemically treated concrete, indicating improved resistance to

chloride ion penetration and enhanced durability performance in accordance with ASTM C1202 classification.

## CONCLUSION

The present investigation evaluated the performance of M45 grade self-curing concrete incorporating hydrogel (0.2%) and *Calotropis gigantea* latex (0.3%) as internal curing agents, with particular emphasis on durability characteristics assessed through the Rapid Chloride Penetration Test (RCPT). The results clearly demonstrate that the incorporation of internal curing agents has a significant influence on both mechanical and durability properties of concrete.

The hydrogel-based mix exhibited a marginal reduction in workability due to its high-water absorption capacity; however, it significantly enhanced compressive strength at all curing ages, achieving the highest strength among all mixes. This improvement is primarily attributed to sustained internal curing, which promotes continuous hydration, reduces autogenous shrinkage, and results in a denser and more refined microstructure. In contrast, *Calotropis gigantea* latex improved the workability of concrete due to its water-retaining and lubricating properties but showed comparatively lower compressive strength, indicating the need for optimization of its dosage for structural applications.

The durability assessment through RCPT indicated that all mixes fall within the “low chloride

### Data availability

Mangal, P., Juremalani, J. (2026). The dataset for “Durability Assessment of Self-Curing Concrete Containing Hydrogel and *Calotropis Gigantea* Latex as Self-Curing Agents” is not available.

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### Author contributions

P.M. and J.J. contributed to the research design and implementation, as well as the data analysis and manuscript writing.

### Clinical Trial

The study is not clinical trial.

penetrability” category (1000–2000 coulombs) as per ASTM C1202-2019, confirming their suitability for exposure to chloride environments. Notably, the hydrogel-modified concrete exhibited relatively lower charge-passed values compared to the latex-modified mix, signifying enhanced resistance to chloride ion ingress. This behavior can be attributed to improved pore structure refinement and reduced permeability resulting from effective internal curing.

From an overall performance perspective, hydrogel proved to be a more effective internal curing agent in enhancing both strength and durability, whereas *Calotropis gigantea* latex demonstrated potential as a sustainable and eco-friendly alternative, particularly in improving workability and contributing to durability. The findings of this study highlight the feasibility of utilizing self-curing agents to overcome the limitations of conventional curing methods, especially in conditions where external curing is difficult to implement.

In conclusion, self-curing concrete incorporating hydrogel and natural latex presents a promising approach toward the development of durable and sustainable construction materials. Further research is recommended to explore hybrid combinations, optimize material proportions, and perform advanced microstructural and long-term durability studies to fully establish their applicability in real-world engineering practices.

**Competing interests**

Not Applicable

**Ethics approval**

Not Applicable

**Consent to participate**

Not Applicable

**Consent to publish**

Not Applicable

**Code availability**

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