Journal of Chemical Health Risks

www.jchr.org

JCHR (2025) 15(6), 471-477 | ISSN:2251-6727

Effect of New Accelerator Additives on Fast-Setting and High-Performance Ready-Mix Concrete for the Building Industry

[1] V. Vikash, [2] Dr. P.S. Vijayanand*, [3] J. Jeba Jenkin

[1] Department of Civil Engineering, Bannari Amman Institute of Technology, Sathyamangalam, Erode, Tamil Nadu, India
[2] Professor, Department of Chemistry, Bannari Amman Institute of Technology, Sathyamangalam, Erode, Tamil Nadu, India
[3] Assistant Professor, Department of Civil Engineering, DMI Engineering College, Aralvaimozhi, Kanyakumari, Tamil Nadu, India

(Received: 25 August 2025 Revised: 27 September 2025 Accepted: 07 November 2025)

KEYWORDS

Accelerator admixtures, Setting time, Early strength, non-chloride accelerators, Ready mix concrete.

ABSTRACT:

This research investigates the influence of chemical accelerators on the setting characteristics and strength development of concrete. Accelerators are widely used admixtures designed to shorten the initial and final setting times and enhance early-age strength, particularly under low-temperature curing conditions. The study evaluates various types of accelerators, including calcium chloride and non-chloride-based alternatives, with a focus on their impact on hydration kinetics, microstructure formation, and compressive strength at different curing ages. Experimental analysis demonstrates that the addition of accelerators significantly improves early strength gain without adversely affecting long-term performance when used within recommended dosages. The study provides valuable insights into selecting suitable accelerators for different construction environments.

1. Introduction

In the production of Ready-Mix Concrete (RMC), controlling the setting time is a crucial factor to ensure proper workability and transportation of concrete to the site. Retarders are a class of chemical admixtures added to concrete to delay the setting time of cement paste, allowing more time for mixing, placing, compacting, and finishing. They are particularly useful in hot weather conditions, where the rate of hydration increases rapidly, leading to premature stiffening and reduced workability.

The primary function of a retarder is to slow down the hydration reaction of tricalcium aluminate (C_3A) and other cement compounds, thereby extending the initial and final setting times. Commonly used retarders in RMC include sugars, lignosulfonates, phosphates, and hydroxylated carboxylic acids. By regulating the setting process, retarders help maintain uniform quality, avoid cold joints, and ensure that concrete retains its desired strength and durability [1] [2].

Thus, the use of retarders in RMC contributes to improved construction efficiency, surface finish, and long-term performance, especially for large-scale concreting operations and projects located in hot or remote regions where transportation delays are common [3].

The use of accelerators in concrete dates back to the early 20th century, when calcium chloride was first introduced as an effective accelerator. However, chloride-based accelerators are now restricted due to their corrosive effects on steel reinforcement. Consequently, modern research emphasizes the development and application of non-chloride accelerators, such as calcium nitrate, calcium formate, and sodium thiocyanate. Understanding the performance of these accelerators is essential for ensuring both short-term and long-term durability of concrete structures [4].

Accelerator admixtures are introduced on-site during Ready-Mix Concrete (RMC) operations to expedite curing is a practical approach to control setting time and enhance early strength development. During transportation and waiting periods, the hydration process of cement may slow down or be intentionally delayed by retarders to maintain workability. Once the concrete arrives at the site, the accelerator is introduced into the mixer drum to counteract the delay and initiate rapid hardening. This practice is particularly beneficial in projects requiring quick formwork removal, early load

Journal of Chemical Health Risks
www.jchr.org
JCHR (2025) 15(6), 471-477 | ISSN:2251-6727

application, or concreting in cold weather conditions. The accelerator dosage is carefully measured and thoroughly mixed to ensure uniform distribution and consistent performance. Non-chloride accelerators such as calcium nitrate, calcium formate, and sodium thiocyanate are commonly preferred in RMC to prevent corrosion of reinforcement while achieving desired early strength and durability [5].

2. Materials and Methods

Ordinary Portland Cement (OPC, 43 grade) was used as the base binder. Fine aggregate (river sand) and coarse aggregate (20 mm nominal size) were used in accordance with IS: 383-2016 specifications. Potable water was used for mixing. Two types of chemical accelerators were selected for comparison: calcium chloride ($CaCl_2$), a conventional chloride-based accelerator, and calcium nitrate ($Ca(NO_3)_2$), a non-chloride alternative suitable for reinforced concrete.

A constant water–cement ratio of 0.45 was maintained across all mixes, with accelerator dosages varied at 1%, 2%, and 3% by weight of cement. Tests included Vicat setting time (IS:4031 Part 5–2019), slump test, and compressive strength tests (IS:516–2018) at 1, 3, 7, and 28 days. All specimens were cured in water at 27 ± 2°C.

Sodium Carbonate: ISOCHEM Sodium Carbonate Anhydrous (500GM) Assay 99.5% Min

Aluminium Sulphate: Nice A 11429 Aluminium Sulphate, For Pharmaceuticals, 500gm, Purity - 98%

Potassium Carbonate: ISOCHEM Potassium carbonate (Anhydrous) 500GM Assay 99% Min

Sodium carbonate (Na_2CO_3), Aluminium sulphate and potassium carbonate are selected as admixtures as an accelerator role.

3. Instrumentation

The prepared concrete samples were analysed using a combination of laboratory instruments to evaluate both fresh and hardened properties. Workability was assessed using a slump cone apparatus (ASTM C143) and a flow table to determine ease of placement, while bleeding and segregation were visually monitored during casting. The compressive strength of the cured concrete cubes was measured using a SANTAM compression testing machine at a constant loading rate until failure.

4. Procedure for Cube Design

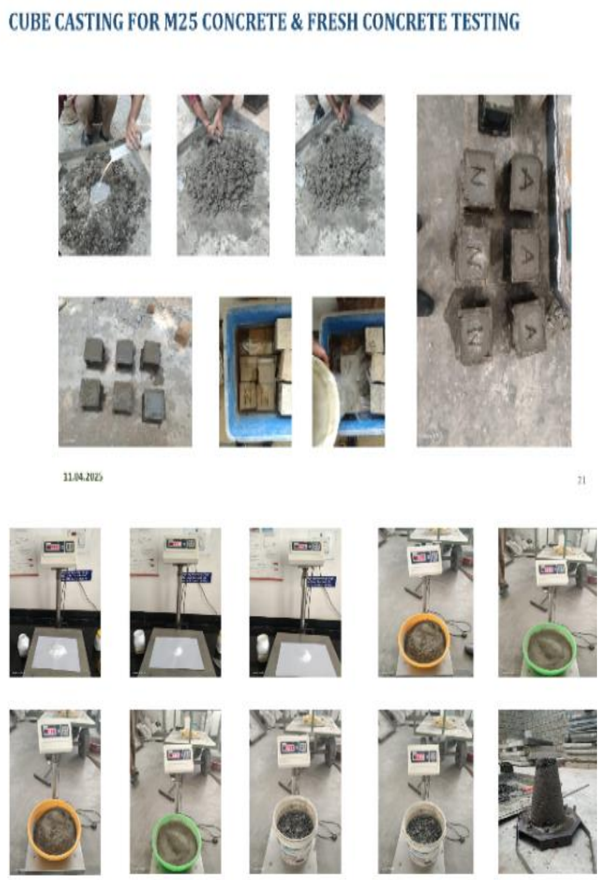

Figure 1. Cube casting and concrete testing

Concrete cubes for compressive strength testing were prepared following standard procedures. The required quantities of cement, fine aggregate, and coarse aggregate were measured according to the target mix proportion, and the designated dosages of chemical accelerators ($CaCl_2$ or $Ca(NO_3)_2$ at 1%, 2%, and 3% by weight of cement) were dissolved in the mixing water. The dry components were thoroughly mixed before gradually adding the water-accelerator solution, ensuring a uniform and workable concrete mix [6][7]. The concrete was then cast into 150 mm × 150 mm × 150 mm steel moulds in three layers, with each layer compacted using a tamping rod or vibration to remove entrapped air, and the surface levelled with a trowel. The cubes were kept in moulds for 24 hours, demoulded carefully, and subsequently cured in water at 20 ± 2°C until the designated test age (typically 7, 14, or 28 days). Compressive strength testing was conducted using a calibrated compression testing machine at a constant

Journal of Chemical Health Risks
www.jchr.org
JCHR (2025) 15(6), 471-477 | ISSN:2251-6727

loading rate, and the maximum load was recorded to calculate the strength. Observations regarding workability, segregation, and bleeding were also noted during casting to correlate fresh concrete behaviour with hardened performance [8].

Chosen Grade of Concrete is M20

Mix Proportion M20

From previous design:

Cement = 280 kg/m³

Water = 186 kg/m³

Fine Aggregate (FA) = 916 kg/m³

Coarse Aggregate (CA) = 1107 kg/m³

Table 1. Quantity Estimation for 3 Cubes

Material	Quantity (kg/m³)	Required for 0.01114 m³ (kg)
Cement	280	280 × 0.01114 ≈ **3.12 kg**
Water	186	186 × 0.01114 ≈ **2.07 kg**
Fine Aggregate	916	916× 0.01114 ≈ **10.20 kg**
Coarse Aggregate	1107	1107 × 0.01114 ≈ **12.34 kg**

For Admixture mix accelerator added 1.5 percent to the weight of cement.

5. Results and Discussion

Sodium carbonate (Na_2CO_3) acts as a chemical accelerator in concrete by altering the early hydration behaviour of cement. When added to the mix, it dissolves in water and releases carbonate ions (CO_3^{2-}), which quickly react with calcium ions (Ca^{2+}) released from the hydration of cement. This reaction forms calcium carbonate ($CaCO_3$), which precipitates and creates nucleation sites for further hydration reactions. These nucleation sites significantly speed up the hydration of tricalcium silicate (C_3S) and tricalcium aluminate (C_3A)—the two main compounds in cement responsible for early strength and setting [9].

Table 2. Results of chemical with cement Setting time

Sample	Composition	Initial Setting Time (min)	Final Setting Time (min)
Water Only	100% Water	45	460
Test 1	100% K_2CO_3	28	320
Test 2	100% Na_2CO_3	26	360
Test 3	50% Na_2CO_3 + 50% K_2CO_3	24 (interval – 2 mint)	280 (interval – 20 mint)
Test 4.a	30% Na_2CO_3 + 30% K_2CO_3 + 40% $Al_2(SO_4)_3$	21	240 (interval – 10 mint)
Test 4.b	25% Na_2CO_3 + 25% K_2CO_3 + 50% $Al_2(SO_4)_3$	22 (interval –1 mint)	220 (interval – 10 mint)

Figure: 2. Cement setting time test

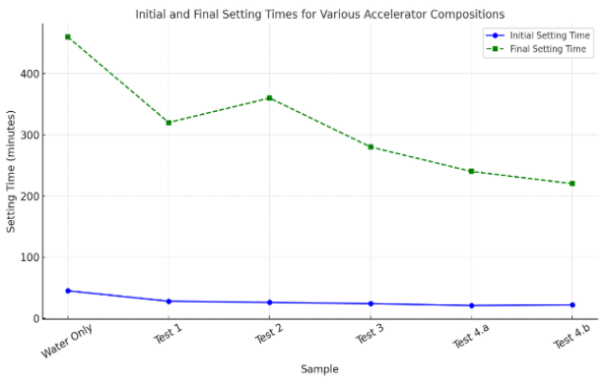

Figure 3. Curing time VS Chemical composition

Journal of Chemical Health Risks
www.jchr.org
JCHR (2025) 15(6), 471-477 | ISSN:2251-6727

As per results, Test 4.b is Better Final-Setting Time Compared to 4.a although, It has good Initial setting time.

6. Aluminium Sulfate ($Al_2(SO_4)_3$)

Aluminium sulfate is a powerful accelerator that reacts primarily with the tricalcium aluminate (C_3A) phase of cement. When added to the cement mix, it increases the availability of sulfate ions, which react rapidly with C_3A to form ettringite (AFt phase) at an accelerated rate. This speeds up the early formation of hydration products, resulting in a rapid setting effect. This property is especially beneficial in applications like shotcrete, repair works, and cold weather concreting, where fast setting is critical [10].

7. Potassium Carbonate (K_2CO_3)

Potassium carbonate accelerates cement hydration by promoting early reactions between alkaline ions (K^+) and cement compounds, especially C_3S. It increases the pH of the pore solution, which enhances the solubility of silicates and speeds up their hydration. This results in a moderate to high early strength development and a noticeable reduction in initial setting time.

8. Water Absorption Test for Durability

Figure 4. Water absorption test

Table 3. Water Absorption Test Result for Normal Mix

Specimen No.	Dry Weight (W_1) (g)	Wet Weight (W_2) (g)	Water Absorbed ($W_2 - W_1$) (g)	% Water Absorption (($W_2 - W_1$) / $W_1 \times 100$)
1	8590	8700	110	1.28
2	8640	8800	160	1.85
3	8740	8950	210	2.40
Average	**1.843**			

Segregation was observed to decrease slightly with moderate accelerator dosages. This is scientifically explained by the rapid stiffening of the cement paste, which prevents coarse aggregates from settling or rising in the mix. The higher viscosity of the paste at early ages "locks" the aggregates in place, maintaining a more homogeneous distribution. However, at excessive accelerator dosages, workability loss can hinder proper compaction, which may mimic localized segregation effects.

Bleeding, the upward movement of water in fresh concrete, was observed to reduce with increasing accelerator dosage. Faster hydration consumes water more quickly, and the paste viscosity rises earlier, preventing the free water from separating and rising to the surface. Therefore, accelerated mixes show lower bleeding rates, which also contributes to reduced segregation and improved surface quality.

The combined effect of controlled setting times, reduced segregation, improved early-age strength, and minimized bleeding leads to enhanced overall performance of the concrete at moderate accelerator dosages (1–2%). Accelerators ensure faster strength gain without severely compromising workability or uniformity. Excessive dosages can reduce handling time and risk localized defects, but optimal dosing balances early strength, homogeneity, and ease of placement, providing superior performance for practical construction applications

Table 4. Water Absorption Test Result for Accelerator Mix

Specimen No.	Dry Weight (W_1) (g)	Wet Weight (W_2) (g)	Water Absorbed ($W_2 - W_1$) (g)	% Water Absorption (($W_2 - W_1$) / $W_1 \times 100$)
1	8700	8770	70	0.804
2	8850	8970	120	1.355
3	8580	8670	90	1.04
Average	**1.066**			

Journal of Chemical Health Risks
www.jchr.org
JCHR (2025) 15(6), 471-477 | ISSN:2251-6727

9. Compressive Test Results for Accelerator Cube

Figure 5. Universal Testing machine UTM

Table 5. Compressive Test Results for Normal cube

Specimen No.	Age of Specimen (Days)	Size of Specimen (mm)	Cross-sectional Area (mm²)	Load at Failure (kN)	Compressive Strength (N/mm²)
1	28	150*150*150	22500	500	22.22
2	28	150*150*150	22500	480	21.33
3	28	150*150*150	22500	560	24.88
Average	**22.81**				

Table 6. Compressive Test Results for Accelerator cube

Specimen No.	Age of Specimen (Days)	Size of Specimen (mm)	Cross-sectional Area (mm²)	Load at Failure (kN)	Compressive Strength (N/mm²)
1	28	150*150*150	22500	580	25.77
2	28	150*150*150	22500	545	24.22
3	28	150*150*150	22500	560	24.88
Average	**24.96**				

The results confirm that both accelerators promote early strength development, with $CaCl_2$ being more effective at lower dosages. Non-chloride accelerators offer a safer alternative for reinforced concrete applications where corrosion resistance is crucial.

The improvement in early-age compressive strength is attributed to the accelerated hydration reactions induced by the chemical accelerators. $CaCl_2$, being a strong ionic accelerator, promotes rapid formation of C-S-H and $Ca(OH)_2$ crystals, which densify the microstructure at early stages. $Ca(NO_3)_2$ also enhances hydration but to a lesser extent. This densification reduces porosity and improves load-bearing capacity. Excessive acceleration, however, can create microcracking if water is insufficient or curing is inadequate, potentially affecting later-age strength.

When comparing the quality of conventional concrete with instant mix concrete and accelerator-modified ready-mix concrete, it is evident that each type exhibits distinct performance characteristics. Conventional concrete provides consistent long-term strength and workability but requires careful on-site batching, mixing, and curing, which can introduce variability and delays. Instant mix concrete, designed for rapid use, offers high convenience and early strength gain, yet it often compromises uniformity, workability, and durability due to its pre-packaged formulation and limited time for proper hydration and compaction. In contrast, ready-mix concrete incorporating moderate doses of chemical accelerators, such as $CaCl_2$ or $Ca(NO_3)_2$, achieves a superior balance between early-age strength, uniformity, and controlled setting times. The accelerators enhance early hydration, reduce bleeding and segregation, and provide sufficient workability for placement and compaction, thereby improving the overall structural performance compared to instant mixes while maintaining more predictable and reliable quality than conventional on-site concrete.

This enhancement can be scientifically attributed to the synergistic ionic interactions among Na^+, K^+, and Al^{3+} cations, along with CO_3^{2-} and SO_4^{2-} anions, which collectively modify the dissolution and precipitation kinetics of cement phases. The alkaline carbonates (Na_2CO_3 and K_2CO_3) increase the pH of the pore solution, accelerating the dissolution of tricalcium silicate (C_3S) and tricalcium aluminate (C_3A) phases. Simultaneously, $Al_2(SO_4)_3$ contributes additional Al^{3+} and SO_4^{2-} ions that promote rapid ettringite formation at early stages, providing additional nucleation sites for C–S–H gel growth. The combined effect enhances the early-stage hydration rate, resulting in faster setting and improved structural rigidity. Therefore, this ternary admixture represents an innovative and scientifically grounded approach to achieving rapid-setting cement systems with potential applications in precast, emergency, and cold-weather concreting operations.

Journal of Chemical Health Risks
www.jchr.org
JCHR (2025) 15(6), 471-477 | ISSN:2251-6727

10. Conclusion

When compared with the nominal mix prepared using only water, the formulation in Test 4.b (25% Na_2CO_3 + 25% K_2CO_3 + 50% $Al_2(SO_4)_3$) showed a remarkable reduction in both initial and final setting times of cement. The initial setting time decreased from 45 minutes to 22 minutes, resulting in a time reduction of 23 minutes approximately 51.11%, while the final setting time was reduced from 460 minutes to 220 minutes, showing a reduction of 240 minutes about 52.17%. This significant decrease indicates that the combined action of sodium carbonate, potassium carbonate, and aluminium sulfate effectively accelerates the hydration process, leading to faster stiffening of the cement paste. Such behaviour makes this combination highly suitable for applications requiring rapid setting and early strength development, including repair works, precast elements, and cold weather concreting.

This study establishes that accelerator admixtures effectively reduce setting time and improve early compressive strength in concrete. Calcium chloride provides the highest acceleration efficiency but poses corrosion risks for reinforced concrete. Non-chloride accelerators such as calcium nitrate offer a balance between performance and durability. Optimum dosages around 2% by weight of cement provide the best results without adversely affecting workability or long-term strength. The findings support the use of accelerators in precast, repair, and cold-weather concreting applications where early strength is critical.

The data clearly shows a dosage-dependent reduction in both initial and final setting times with Sodium carbonate (Na_2CO_3) forms $CaCO_3$ nucleation sites to reduce setting time and boost early strength. Aluminium sulfate ($Al_2(SO_4)_3$) rapidly reacts with C_3A to form ettringite for quick set, while Potassium carbonate (K_2CO_3) raises alkalinity to accelerate C_3S hydration and ensure stable early strength, being more effective. These changes directly affect workability, segregation, and compressive strength [11-14]

High dosages reduce workability and increase early stiffness, which can limit placement time. Segregation may decrease due to faster stiffening but can arise if compaction is inadequate. Compressive strength benefits at early ages but requires careful dosage and curing to avoid long-term strength compromise. Optimizing the type and dosage of accelerator is essential to achieve the desired balance between fresh concrete properties and hardened concrete performance.

In conclusion, the admixture formulation containing 25% Na_2CO_3, 25% K_2CO_3, and 50% $Al_2(SO_4)_3$ demonstrated a remarkable improvement in cement hydration behaviour, achieving a significant reduction in both initial and final setting times compared with the nominal mix prepared using only water. The synergistic interaction between the carbonate and sulfate ions created an optimized ionic environment that accelerated the nucleation and growth of hydration products, leading to faster strength development. This innovative ternary combination represents a major advancement over conventional single-component accelerators, providing a more efficient and controllable means of modifying cement setting characteristics. Furthermore, the formulation offers practical benefits for rapid construction applications such as precast components, emergency repairs, and cold-weather concreting, while also contributing to more energy-efficient and sustainable building practices.

References:

1. IS: 456 – 2016, Plain and Reinforced Concrete – Code of Practice, Bureau of Indian Standards, New Delhi.
2. IS: 10262 – 2019, Concrete Mix Proportioning – Guidelines, BIS, New Delhi.
3. IS: 4031 (Part 5) – 2019, Methods of Physical Tests for Hydraulic Cement – Determination of Setting Time, BIS, New Delhi.
4. IS: 516 – 2018, Methods of Tests for Strength of Concrete, BIS, New Delhi.
5. Ramachandran, V. S. (2018). Concrete Admixtures Handbook: Properties, Science, and Technology. Noyes Publications.
6. Hewlett, P. C., & Liska, M. (2019). Lea's Chemistry of Cement and Concrete. Elsevier.
7. Mehta, P. K., & Monteiro, P. J. M. (2022). Concrete: Microstructure, Properties, and Materials. McGraw-Hill Education.
8. Thomas, M. D. A. (2020). Supplementary Cementing Materials in Concrete. CRC Press.
9. Neville, A. M. (2019). Properties of Concrete. Pearson Education.

Journal of Chemical Health Risks

www.jchr.org

JCHR (2025) 15(6), 471-477 | ISSN:2251-6727

10. Rixom, M. R., & Mailvaganam, N. P. (2021). Chemical Admixtures for Concrete. CRC Press.
11. n analysis of the environmental effects of three types of concrete: Ready-mixed, reactive powder, and geopolymer - Author - L. Marini a, M.A. Mannan a, A.B.H. Kueh a b, A.A. Abdullah a, F. Abed c, K. Gunasekaran d - Ain Shams Engineering Journal - Volume 15, Issue 9, September 2024, 102926
12. A Abdulhameed H, Abdulhameed A, Mansi A, Hanoon A, Mohammed A. Study the use of nano-limestone and egg-shell ash in eco-friendly SCC: an experimental and statistical evaluation based on computer programming. Proc- Int Conf Dev eSystems Eng Dese 2021;2021:509–14.
13. Worrell E, Price L, Martin N, Hendriks C, Meida LO. Carbon dioxide emission from the global cement industry. 2001; June 2014
14. Castellanos A, Herrnstadt E. Emissions of greenhouse gases in the manufacturing sector. Congressional Budget Office; 2024