Vol. 24, No. 3(2025) Mat25638
Revista Mexicana de Ingeniería Química

Influence of the retardant additive on the compressive strength of concrete

Influencia del aditivo retardante en la resistencia a la compresión del hormigón

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Received: July 30, 2025; Accepted: September 15, 2025

Abstract
Concrete is the most widely used construction material globally, and its performance can be tailored through the incorporation of various admixtures. Chemical additives for concrete preparation have achieved great success in recent decades. Proper use of admixtures can improve the quality and properties of concrete mixes. This experimental study investigates the effect of a retardant additive on the compressive strength of the concrete. The water and aggregates used were characterized and their accordance with standard requirements was confirmed before their use in concrete mixtures. Standard cubic specimens of 15x15x15cm were prepared in accordance with relevant specifications to achieve the desired concrete grade (C20/25). A comparative analysis was conducted using concrete samples with and without additive. Compressive strength tests were performed at 3, 7 and 28 days. The results indicate that the use of the retardant additive contributes positively to the enhancement of the compressive strength of the concrete over time.
Keywords: concrete, retardant additive, compressive strength, aggregate, PSD.

Resumen
El hormigón es el material de construcción más utilizado a nivel mundial, y su rendimiento puede ajustarse mediante la incorporación de diversos aditivos. Los aditivos químicos para la preparación del hormigón han alcanzado un gran éxito en las últimas décadas. El uso adecuado de aditivos puede mejorar la calidad y las propiedades de las mezclas de hormigón. Este estudio experimental investiga el efecto de un aditivo retardante en la resistencia a la compresión del hormigón. El agua y los agregados utilizados se caracterizaron y su conformidad con los requisitos estándar se confirmó antes de su uso en mezclas de hormigón. Se prepararon muestras cúbicas estándar de 15x15x15cm de acuerdo con las especificaciones pertinentes para lograr el grado de hormigón deseado (C20/25). Se realizó un análisis comparativo utilizando muestras de hormigón con y sin aditivo. Se realizaron pruebas de resistencia a la compresión a los 3, 7 y 28 días. Los resultados indican que el uso del aditivo retardante contribuye positivamente a la mejora de la resistencia a la compresión del hormigón a lo largo del tiempo.
Palabras clave: hormigón, aditivo retardante, resistencia a la compresión, agregado, PSD.

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https://doi.org/10.24275/rmiq/Mat25638
ISSN:1665-2738, *issn-e*: 2395-8472

1 Introduction

Currently, there is an increasing demand for building new homes, buildings and public spaces. Thus, the construction industry requires resources and raw materials to satisfy these requirements, leading to high demand for concrete, steel, glass, red brick, geopolymers, and other materials (Torres-Ochoa *et al*., 2019). Among them, concrete is the most widely used construction material in the world due to its durability and low cost (Al-Adili, 2009). It offers several advantages, including high compressive strength, long-term durability, and ease of application (Jonbi *et al*., 2022). Concrete is produced by mixing water, cement, aggregates and admixtures (Al-Adili, 2009). With the rise in building activities across both developing and developed countries, the demand for concrete continues to grow (Fayadh *et al*., 2020). The total amount of concrete used globally, by weight, is more than twice the combined usage of aluminum, steel, wood, and plastics. Consequently, the concrete industry has evolved into a massive commercial enterprise (Jawad *et al*., 2023). Concrete structures are expected to fulfill their intended functions throughout their entire service life. In this context, economic and environmental considerations play a critical role in ensuring long-term durability. Durability is a key factor not only in the design and construction of new structures but also in assessing the condition and performance of existing ones. The ability of concrete to resist chemical attack, abrasion, weathering action and other forms of deterioration is crucial throughout the service life of a structure. The materials used in its composition play a key role in determining this resistance. Among the primary components of concrete, chemical admixtures are particularly important, as they significantly influence the performance and durability of the final product (Liu *et al*., 2019).

Admixtures are additional ingredients introduced into concrete beyond the conventional wet-mixed components of water, cement and aggregate (Mohammed & Nariman, 2023). They play a vital role in enabling the production and application of high-performance, ready-mix and precast concretes (Liu *et al*., 2019). Chemical admixtures are commonly used to impart specific durability characteristics to concrete, tailoring it to meet particular performance requirements (Liu *et al*., 2019). Today, it is widely recognized that achieving concrete with specialized properties is only possible through the inclusion of carefully selected chemical additives. As a result, nearly every modern concrete production facility incorporates various admixtures into their mixes, significantly enhancing quality characteristics while also influencing the setting and hardening behavior of the concrete. Depending on the intended performance, experts typically classify concrete additives into six main categories: superplasticizers, strength accelerators (which reduce hardening time), sealants, mobility regulators, antifreeze agents and modifiers (Bekturganova & Kolesnikova, 2025). The effectiveness of a given admixture is influenced by several variables, including the type and quantity of cement, water content, mixing time, slump and ambient temperature during placement (Mohammed & Nariman, 2023). The use of admixtures arises complex relationship between the performance demands placed on modern concrete and the limitations of its basic components. As construction techniques advance and technical standards become more demanding, the need for specialized concrete formulations continues to grow – driving both research and the adoption of a wide variety of additives. Ramirez-Arreola *et al*., 2020 have studied the effect of sugar cane bagasse ash addition as partial replacement of Portland cement in the concrete recipe toward the corrosion behavior of steel reinforcement bars embedded in concrete. They concluded that the addition of 15% sugar cane bagasse ash as partial replacement of Portland cement in the concrete mix inhibes the corrosion of the steel rebar, thus prolonging the life of the concrete structure. Ungsson-Nieblas *et al*., 2023 have studied the effect of polycarboxylate-based superplasticizer with added silica sub-microspheres in Portland cement materials. They concluded that the hydration process of Portland cement modified with additives slowed down significantly and the compressive strength of the mortars for each cuing age was increased.

This study aims to investigate the effect of the Mapetard admixture on the compressive strength of concrete produced by using locally sourced aggregates.

2 Materials and methods

2.1 Materials

2.1.1 Aggregates

In this experimental work, three coarse aggregates with different particle size distributions were used, respectively 12.5-25mm, 5-12.5mm and 2-10mm. As fine aggregate was used sand with a granulometry of 0-5mm.

2.1.2 Cement

The cement used in this study was CEM II 42.5R, sourced from the Kruja-Cem factory. It was stored in a dry environment, well-protected from dampness to prevent any premature hydration and hardening.

Table 1.Technical data of the Mapetard additive used in concrete mix.

PRODUCT IDENTITY/ TECHNICAL DATA	
Consistency	Liquid
Colour	Brown
Density according to ISO 758 (g/cm^3)	1.08±0.02 at +20ºC
Main action	Retarding of initial hydration; retention of workability
Collateral action	High range water reduction and/or increased workability
Classification according to EN 934-2	Set retarding admixture
Classification according to ASTM C494	Type B
Chlorides soluble in water according to EN 480-10 (%)	<0.1 (absent according to EN 934-2)
Alkali content (Na_2O equivalent) according to EN 480-12 (%)	<3.0
pH	6.0±1.0

2.1.3 Water

The water used in this study was tap water. Prior to its use, the water was tested to ensure its suitability for concrete mixing. The water was tested in accordance with the standard BS EN 1008:2002 requirements.

2.1.4 Additive

The additive chosen for this experimental work was Mapetard, a liquid admixture used as a retardant for concrete and mortar with a plasticizing effect. In addition to its retarding effect, Mapetard helps maintain the workability of the concrete mix, making it easier to handle and place, especially during extended work periods.The technical data of the mapetard used in this experimental work are given in table 1. The product is produced from Mapei company, Milan, Italy.

2.2 Methodology

2.2.1 Grain size distribution analysis

The grain size distribution analysis for the aggregates was conducted using the sieve analysis method in accordance with the standard BS EN 933-2:1996. The sample for each aggregate was prepared according to standard BS EN 932-1:1997.

2.2.2 Density test

The density of the aggregates was tested in accordance with the standard requirements outlined in BS EN 1097-6:2013.

2.2.3 Water absorption test

The water absorption test for the aggregates was carried out in accordance with the standard BS EN 1097-6:2013.

2.2.4 Sulphate and chloride test

The tests on the sulphate and chloride content for all the aggregates used in this study were performed according to BS EN 1744-1:2009+A1:2012 standard requirements.

2.2.5 Preparation of the mixes, casting and curing

The mix design involves the calculation of the required materials to produce a specific volume of concrete. In this research, the goal was to achieve a concrete grade C20/25 using a mix proportion that ensures the desired strength and durability. Three cubes with dimensions 15x15x15cm were used to cast the concrete samples for compressive strength testing. The details of the concrete mix proportion required to achieve the desired concrete grade are shown in table 2. The concrete mix was prepared according to the standard BS EN 206-2013 +A1:2016.

After one day of casting, the concrete cubes were carefully removed from the moulds. To ensure proper curing and strength development, the cubes were then transferred to a water tank for continuous curing under water until they were ready for compressive strength testing.

Table 2. Mix design of the concrete.

Component	Unit	Amount
Cement	kg/m^3	310
Water	lt/m^3	178
Additive	kg/m^3	2.48
Aggregate 12.5-25mm	kg/m^3	663.6
Aggregate 5-12.5mm	kg/m^3	94.8
Aggregate 2-10mm	kg/m^3	189.6
Aggregate 0-5mm	kg/m^3	948
Total weight of fresh concrete	kg/m^3	2386

2.2.6 *Compressive strength testing*

The concrete cubes were cured under standard conditions, and compressive strength testing was conducted at 3, 7 and 28 days. Three cubes were tested at each curing age and the average value of the three tested cubes was taken as the final compressive strength. The tests were carried out according to the standard BS EN 12390-3.

3 Results and discussion

3.1 *Properties of water used in this experimental work*

The properties of water that was used in this experimental work are presented in table 3. The table includes key parameters such as pH, impurities and other relevant characteristics of the water that could impact the quality of concrete mix. According to the standard requirements and the obtained experimental results, the water properties fell within the acceptance range. This confirmed that the water was suitable for use in the concrete mix.

Table 3. Results of water tests used in experiments.

Parameters	Unit	Results	Standard requirements
Source		Tap water	
Color		Transparent	
Density at 19ºC	kg/l	1.0026	0.9982
Hardness ($CaCO_3$)	mg/l	2.83	
Sedimentation at 180ºC	mg/l	2.16	≤ 4
pH		7.91	≥ 4
Cl^- content	mg/l	632.3	≤1000
SO_4^{2-} content	mg/l	1212.1	≤2000
NaCl content	mg/l	62.5	≤100

3.2 *Properties of the aggregates*

The sieve analysis results for all the aggregates are shown in figure 1. All the aggregates fell within the standard requirements, indicating that their particle size distribution was in accordance with the standard grading criteria.

To create a dense concrete with the required grade, the aggregates were proportioned according to the standard using the advanced computer software ED TOP MIX from Mapei company. The software takes the upper and lower limits of the standard as input and calculates the necessary percentage for each aggregate to be included in the mix.

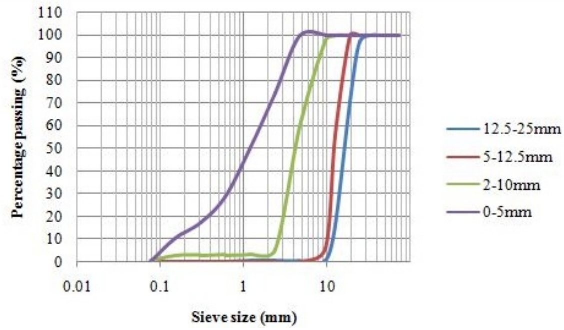

Figure 1. Particle size distribution curves for the aggregates used in this experimental work.

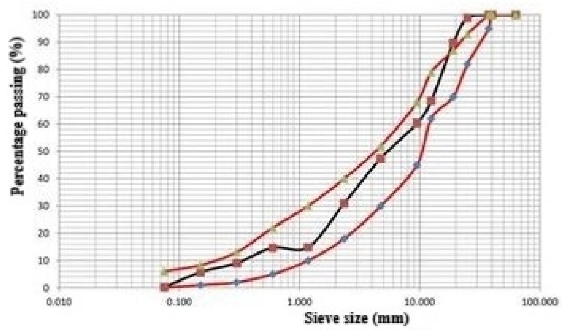

Figure 2. Gradation curve for concrete mix.

The software's recommendation led to the formulation of the concrete mix, which is presented in table 2. In figure 2, the optimal mixing combination of the aggregates is presented, as suggested by the software. In abscise are set the sieve size (mm) and in the ordinate are set the percentage passing (%) values.

The figure shows the grading curve, which is crucial for determining the proper distribution of aggregate sizes in the concrete mix. Green triangle curve represents the upper limit of the standard grading requirements, blue square curve represents the lower limit of the standard grading requirements. The black line illustrates the actual blending of aggregates that will be used in the concrete mix. This line is positioned within the bounds of the upper and lower limits, indicating that the selected aggregate blend complies with the standard grading requirements. This ensures that the aggregates are well-suited for the concrete mix, meeting the expected performance characteristics, such as strength and durability. If the black line were positioned outside the upper or lower limits, it would be a signal a potential issue with the aggregate mix. In that case, adjustments would need to be made to the proportions of the different aggregates in the blend to bring it within the acceptable range.

3.3 *Density test*

The results of the density testing for all the aggregates indicated that the aggregates fell within the standard range requirements. The standard limit for the density of aggregates is set at 3g/cm^3 and the tested aggregates

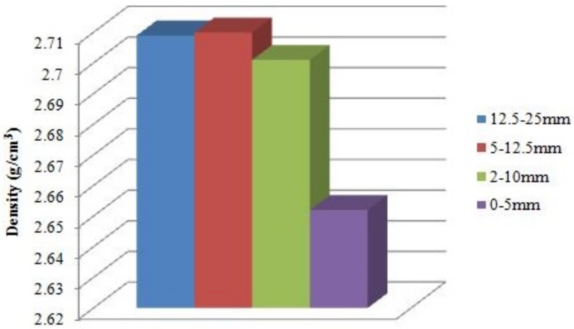

Figure 3. Density values for aggregates used in this experimental work.

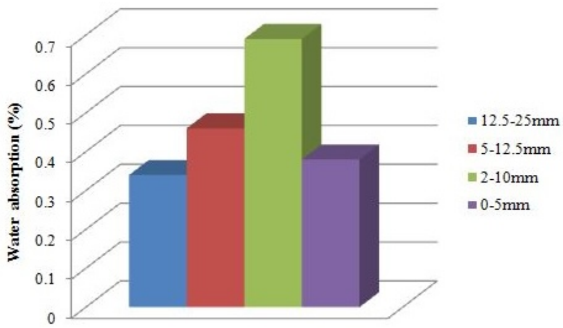

Figure 4. Water absorption values for aggregates used in this experimental work.

met this requirement. The results are presented in figure 3.

3.4 *Water absorption*

The results of the water absorption test for all the aggregates are presented in figure 4. The standard limit for water absorption is up to 1.5%.

The results of the water absorption tests for all the aggregates indicated that the absorption values fell within the standard limit, confirming that the aggregates were suitable for the concrete mix.

3.5 *Chloride and sulphate content*

The experimental results for the chloride and sulphate content of the aggregates used in this study are presented in table 4.

Table 4. Chloride and sulphate content of the aggregates.

Aggregate	Unit	Result for sulphate	Result for chloride
12.5-25mm	%	0.015	0.003
5-12.5mm	%	0.019	0.005
2-10mm	%	0.011	0.002
0-5mm	%	0.021	0.0043

The results of the chloride and sulphate content tests were in accordance with the standard requirements. According to the standard, the sulphate content should be less than 0.2% and the chloride content should be less than 0.01%. All aggregates used in this study met these standards and were therefore suitable for use in the concrete mix.

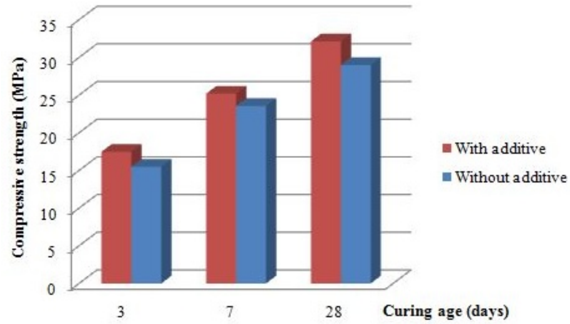

Figure 5. Compressive strength results of the concrete with and without additive.

Table 5. Results of the compressive strength in MPa, for concrete C20/25 with and without additive.

Curing age (days)	3	7	28
No additive	15.49	23.56	28.98
With additive	17.48	25.19	32.12

3.6 *Compressive strength*

The results of the compressive strength tests for concrete samples with and without the retardant additive are presented in figure 5 and in table 5.

In general, it was observed that the compressive strength of the concrete samples was increased with the age of curing. Additionally, the compressive strength values of the samples containing the additive were consistently higher than those without additive. This indicates that the retardant additive has a positive effect on enhancing the compressive strength of concrete over time.

Conclusions

Based on the results of this experimental study, the following conclusions can be drawn:

- The water used for concrete preparation met the standard requirements and was suitable for use.
- Both the coarse and fine aggregates fulfilled the standard requirements and were appropriate for use in concrete mixes.
- The compressive strength of the samples was increased with curing time, reaching its highest value at 28 days.
- The inclusion of the retardant additive extended the setting time of the concrete and significantly improved its compressive strength.

- Therefore, the same concrete mix, incorporating the retardant additive, can be recommended for producing more durable and workable concrete, particularly in high-temperature conditions where rapid cement hydration is a concern.

References

Akindahunsi, A. A. and Uzoegbo, H. C. (2015). Strength and durability properties of concrete with starch admixture. *International Journal of Concrete Structures and Materials*, 9, 323-335, https://doi.org/10.1007/s40069-015-0103-x

Al-Adili, A. S. (2009). Effect of different wastes additives on compression strength of concrete. *HBRC Journal*, vol.5, no.1, pp. 8-17.

Bekturganova, N. Y. and Kolesnikova, I. V. (2025). Effect of polymer additives on improvement of concrete properties. *Advances in Polymer Technology*, https://doi.org/10.1155/adv/6235216

BS EN 1008: 2002 Mixing Water for Concrete. Specification for sampling, testing and assessing the suitability of water, including water recovered from processes in the concrete industry, as mixing water for concrete.

BS EN 932-1: 1997 Tests for general properties of aggregates. Methods for sampling.

BS EN 933-2:1996 Tests for geometrical properties of aggregates. Determination of particle size distribution. Test sieves, nominal size of apertures.

BS EN 1097-6:2013 Tests for mechanical and physical properties of aggregates. Determination of particle density and water absorption.

BS EN 1744-1:2009 + A1:2012 Tests for chemical properties of aggregates. Chemical analysis.

BS EN 206:2013 +A1:2016 Concrete. Specification, performance, production and conformity.

BS EN 12390-3 Compressive strength of test specimens for testing hardened concrete.

Fayadh, O. K., Qasim, O. A., Farhan, O. S. (2020). Experimental comparative study of effect of different additive materials on concrete mix alkalinity and heat generation. *3rd International Conference on Sustainable Engineering Techniques*, 881, https://doi.org/10.1088/1757-899X/881/1/012041

Jonbi, Meutia, W., Tinumbia, N., Rafliansyah, F. (2022). Effect of using different types of additives against the compressive strength of cement paste. *Journal Infrastruktur*, 8(2):79-84

Jawad, R. K. M., Kadhim, M. J., Kamal, H. M. (2023). A review of the effect of additives on the mechanical properties of lightweight concrete. *Journal of Engineering and Sustainable Development*, vol. 27, no. 6, ISSN 2520-0917, https://doi.org/10.31272/jeasd.27.6.4

Liu, J., Yu, C., Shu, X., Ran, Q., Yang, Y. (2019). Recent advance of chemical admixtures in concrete. *Cement and Concrete Research*, vol. 124, https://doi.org/10.1016/j.cemconres.2019.105834

Mohammed, I. I. and Nariman, N. A. (2023). Natural and chemical admixtures in concrete – A review. *Eurasian Journal of Science and Engineering*, vol. 9, no. 3, 108-123, https://doi.org/10.23918/eajse.v9i3p11

Ramírez-Arreola, D. E., Aranda-García, F. J., Sedano-de la Rosa, Camacho-Vidrio A. M., Silva, R. V. (2020). Corrosion behavior of steel reinforcement bars embedded in concrete with sugar cane bagasse ash. *Revista Mexicana de Ingeniería Química*, vol. 19, sup.1, 469-481, ISSN: 1665-2738, issn-e: 2395-8472, https://doi.org/10.24275/rmiq/Mat1651

Torres-Ochoa, J. A., Osornio-Rubio, N. R., Jiménez-Islas, H., Navarrete-Bolaños, J. L., Martínez-Gonzáles, G. M. (2019). Synthesis of a geopolymer and use of response surface methodology to optimize the bond strength to red brick for improving the internal coating in burner kilns. *Revista Mexicana de Ingeniería Química*, vol. 18, No. 1, 361-373, issn-e: 2395-8472, https://doi.org/10.24275/uam/izt/dcbi/revmexingquim/2019v18n1/TorresO

Ungsson-Nieblas, M. J., Rubio-Rosas, E., Vargas-Ortíz, R. A., Bórquez-Mendivil, A., Cabrera-Covarrubias, F. G., Castro-Beltran, A., García-Grajeda, B. A., Almaral-Sánchez, J. L. (2023). Polycarboxylate-based superplasticizer with added silica sub-microspheres for use in Portland cement materials. *Revista Mexicana de Ingeniería Química*, vol. 22, No. 3, Proc2348, ISSN: 1665-2738, issn-e: 2395-8472, https://doi.org/10.24275/rmiq/Proc2348