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Influence of Acidic and Alkaline Environments on the Mechanical Properties of Cement Mortars

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Abstract

Cement-based materials are exposed to various internal and environmental aggressions of acidic and alkaline nature that may affect their durability. This study investigates the influence of aggressive environments on the mechanical and physical behavior of cement mortars. Mortar specimens (4 × 4 × 16 cm^3) were prepared with a water-to-cement (w/c) ratio of 0.5 and cured in water at pH 7 for 28 days. Additional specimens were exposed to sulfuric acid solutions at pH 2, 3.5, and 5, as well as alkaline solutions at pH 11 and 12.5. The findings indicate that mortars deteriorate significantly when exposed to acid. Mass losses can reach 20%, compressive strength losses range from 31% to 47%, and tensile strength losses range from 16% to 34%, depending on the acidity. In contrast, alkaline exposure results in a little expansion, which can raise mass and volume by as much as 2.3%. Both the tensile and compressive strength losses remain below 11% and 16%, respectively. In order to clarify degradation mechanisms and guide the development of more resilient cement-based materials, this study compares the behavior of mortar in extremely acidic and alkaline environments.

Keywords

cement, mortar, concrete, aggressive environment, pH, sulfuric acid solution, resistance

1 Introduction

Normally, construction materials such as mortars and concretes are subject to various chemical attacks depending on their environment. Zivica and Bajza [1] were among the early researchers to investigate the durability of cementitious materials exposed to aggressive chemical environments. Neville [2] is also widely recognized as a fundamental reference in concrete technology, particularly regarding testing methods and concrete performance under aggressive exposure conditions. Later, Mehta and Monteiro [3] provided an in-depth analysis of the behavior of cement-based materials in unstable environments, especially under acidic conditions, highlighting concrete's central role as a structural material.

High-performance concrete (HPC), particularly when reinforced with steel microfibers, has significantly advanced civil engineering due to its enhanced mechanical properties. However, Boutiba et al. [4] demonstrated that in marine environments, HPC may deteriorate more rapidly because of internal corrosion processes. Mlinárik and Kopecskó [5] further examined the combined use of silica fume (SF) and metakaolin (MK), analyzing their influence on durability and resistance to chemical attack. Similarly, Vořechovská et al. [6] modeled the service life of concrete structures exposed to acid attack, emphasizing the strong link between environmental conditions and durability performance. They highlighted that concrete strength and long-term behavior are highly dependent on the surrounding medium, particularly in acidic or alkaline environments, where chemical reactions progressively compromise structural integrity.

In acidic environments, deterioration primarily results from the dissolution of cement hydration products, especially calcium silicate hydrate (C–S–H), the main binding

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phase in concrete. The instability of C–S–H at low pH leads to a gradual loss of mechanical strength and cohesion. Raghunathan [7] examined the effects of acid rain and acidic river water, particularly in industrial areas, and provided a detailed analysis of C–S–H degradation mechanisms under acidic exposure. Awrahman conducted a 30-day experimental study on fiber-reinforced concrete exposed to 5% H_2S_4O (acid attack) and 5% $MgSO_4$ (sulfate attack), with varying steel fiber contents (0%, 0.1%, and 0.2%). The results showed that specimens containing 0.2% steel fibers exhibited superior resistance to chemical attack and improved durability [8].

Acid attack commonly occurs when environmental pH decreases, such as in the case of acid rain ($pH < 5.6$). Howard [9] evaluated rainfall pH levels and their potential impact on concrete durability. Acidic environments, including industrial effluents, promote calcium lixiviation from the cement matrix, causing progressive deterioration and disintegration. In this context, Barbhuiya and Kumala [10] demonstrated that the addition of pozzolanic materials improves matrix compatibility and resistance to chemical attack by slowing C–S–H degradation. Zhang et al. [11] have highlighted the negative effects of severe acid rains on concrete structures in Hangzhou, as well as the need of maintenance strategies that take into account degradation rates. Akcay et al. [12] has also reported that métakaoline improves durability by fine-tuning the shape of pores and reducing capillary microfissuration under chemical exposure.

Another important consideration is the durability of the reinforcement. Benamara et al. [13] discovered that glass fibre reinforced polymer (GFRP) bars might deteriorate due to interface degradation between the reinforcement and the cement matrix. In contrast, Wang et al. [14] shown that natural fibers can significantly reduce degradation in harsh environmental circumstances. Luan et al. [15] have also demonstrated that the development of gypsum plaster in acidic environments destabilizes C–S–H, accelerating resistance loss. Similarly, Ahmed et al. [16] confirmed that the inclusion of silica fumes improves the long-term resistance to aggressive exposure.

To counteract these negative effects, numerous studies have looked into strategies for improving durability in acidic circumstances. Cyr [17] reported that floating fly ash and other complementary materials improve chemical resistance due to matrix densification and reduced permeability. Nas and Kurbetci [18] have also demonstrated that natural zeolite improves both mechanical performance and long-term durability.

Asaad et al. [19] have highlighted that corrosion of steel remains one of the most critical degradation mechanisms of reinforced concrete, frequently resulting in severe structural damage or failures. Salhi et al. [20] demonstrated that mineral mixtures improve chloride resistance, reduce water absorption, and improve performance in challenging environments. Poornamazian and Izadinia [21] demonstrated that the addition of slag improves the microstructure and reduces the degradation caused by chloride. Benfrid et al. [22] investigated the eco-concrete including glass powder and discovered that high temperatures have a negative impact on the durability and structural performance.

Tongaria et al. [23] reported that pH fluctuations have a significant impact on the corrosion of steel in armored concrete. Similarly, Lee et al. [24] demonstrated that chloride ions reduce the lifespan of HPC under various pH settings. Cementitious additives such as fly ash, ground granulated blast furnace slag (GGBFS), natural pozzolan, and natural zeolite have consistently demonstrated that they improve acid resistance by fine-tuning the structure of pores and lowering the content of portlandite, there by limiting chemical dissolution [25]. Preventive methods like corrosion inhibitors and surface coatings help to further reduce acid penetration.

In contrast to acid exposure, alkaline environments include different degradation mechanisms. Although less aggressive than strong acids, exposure to a high pH can nevertheless impact durability. Carbonation, a reaction between calcium hydroxide and CO_2, reduces alkalinity and increases the risk of corrosion by reinforcement. Hargis et al. [26] reported that the production of calcium carbonate can affect chloride transport and binding capacity. $CaCO_3$ precipitation can temporarily increase mechanical resistance by locally densifying the surface. Abed and Nemes [27] discovered that perlite powder improved HPC performance when exposed to pH-related conditions.

However, high alkalinity can cause expansion reactions such as the alkali-silica reaction (ASR). Liu et al. [28] demonstrated that appropriate mineral substitutions prevent ASR crack formation and improve resistance to alkali damage. Thomas and Harilal [29] demonstrated that cold-related aggregates improve matrix stability and reduce permeability, whilst Nas and Kurbetci [30] confirmed that microstructural refinement improves resistance to chemical and chloride attacks. Yıldırım and Özhan [31] reported that glass powder contributes to the attenuation and densification of fissures, whereas Kubissa et al. [32] demonstrated that mineral additives effectively limit chloride penetration even in the fissured concrete. Dufka et al. [33] added that certain chemical mixtures promote the production of crystals in the matrix, reducing porosity and fissure propagation.

Overall, these studies demonstrate that the proper mixture formulation in which includes mineral additions, chemical mixtures, and surface treatments significantly improves acid and alkaline resistance. By reducing permeability and limiting ion transport, these strategies extend the life of concrete structures exposed to aggressive environments [33].

Despite extensive research, the majority of studies focus on acidic and alkaline environments separately, with limited direct comparisons in identical circumstances. Furthermore, the relationship between degradation mechanisms and the corresponding changes in mechanical and physical properties remains unclear.

To close this gap, the current study compares the behavior of cement mortiers in highly acidic and alkaline environments. The quantitative analysis seeks to identify the key parameters governing degradation, to establish correlations between degradation mechanisms and property changes, and to provide advice on how to optimize mixture formulations to improve durability under severe chemical exposure.

Thus, a systematic experimental program was implemented. The mortier samples were prepared under controlled conditions and then immersed in extremely low and high pH solutions. The degradation was assessed using mass variation measurements, compression resistance and traction resistance variation. Additional analyses were conducted to identify the primary degradation mechanisms.

The experimental results were then analyzed to determine the primary factors influencing degradation and to propose formulation adjustments aimed at improving durability in highly aggressive chemical environments.

2 Materials and procedure

2.1 Materials

2.1.1 Cement

Two types of cement were used in this study:

1. Type 1: CPJ-CEM II/B 42.5 N Chamil Portland cement from LAFARGE Cement, Algeria.
2. Type 2: CPJ-CEM II/B 32.5 N Chamil Portland cement from LAFARGE Cement, Algeria.

They exhibit mechanical performance and physicochemical characteristics (Tables 1 and 2) compliant with the EN 197-1:2011 standard [34].

2.1.2 Sand

The sand used is natural sand from the Guelta Laghouat quarry. It has a grain size class (*d*/*D* = 0/4 mm (Fig. 1)), a fineness modulus of 2.2, optimal expansion values (water

Table 1 General characteristics of Matine cement (42.5 N)

Mineralogy of clinker		Setting time at 20 °C	
C_3S (%) : 60 ± 3	C_3A (%) : 7.5 ± 1	Start (min) : 150 ± 30	End (min) : 230 ± 50
Chemical analyses			
Loss on ignition (%) : 13.0 ± 2	SO_3 (%) : 2.5 ± 0.5	MgO (%) : 1.7 ± 0.5	[Cl^-] (%) : 0.02–0.04
Physical properties			
Normal consistency (%) : 26.5 ± 2.0	Grinding fineness (cm^2/g) : 3700 to 5200	Shrinkage at 28 days (µm/m) : <1000	Expansion (mm) : ≤ 3

Table 2 General characteristics of Algerian Portland cement (32.5 N)

Mineralogy of clinker		Setting time at 20 °C	
C_3S (%) : 60 ± 3	C_3A (%) : 7.5 ± 1	Start (min) : 150 ± 30	End (min) : 250 ± 50
Chemical analyses			
Loss on ignition (%) : 10.0 ± 2	SO_3 (%) : 2.5 ± 0.5	MgO (%) : 1.7 ± 0.5	[Cl^-] % : 0.02–0.04
Physical properties			
Normal consistency (%) : 27 ± 2.0	Grinding fineness (cm^2/g) : 4300 to 5500	Shrinkage at 28 days (µm/m) : <1000	Expansion (mm) : ≤ 3

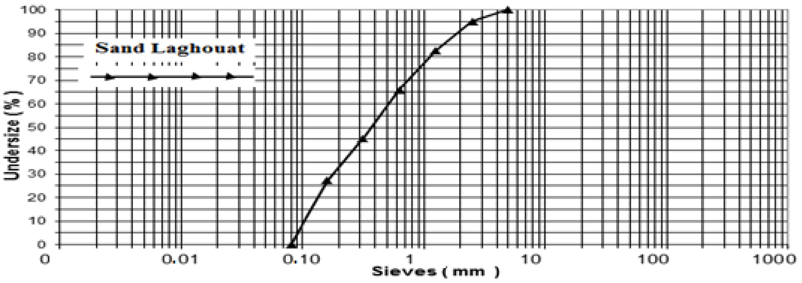


Fig. 1 Granulometric curves of Laghouat sand

content of 4%, bulk density of 1047 kg/m^3), an absolute density of around 2500 kg/m^3, and a sand equivalent (SE = 76%). This sand is ideal for producing high-quality mortar or concrete.

2.1.3 Mixing water

The water used to prepare the mortars is tap water. The results of the chemical analysis of this water are shown in Table 3. This water meets the requirements of the XP P 18-303 [35] and EN 1008:2002 [36] standards, following the same experimental procedures as those described in Samir et al. [37].

2.1.4 Aggressive solution

Sulfuric acid

Sulfuric acid (H_2SO_4 or H_2O_4S) is primarily produced by humans in industrial settings, but it can also be found naturally in the environment, particularly in the form of acid rain. It can form naturally in the atmosphere through the oxidation of sulfur dioxide (SO_2), which is produced in volcanic areas, by burning fossil fuels, or near industrial areas where SO_2 emissions are common. This sulfur dioxide combines with oxygen and water in the air to form sulfuric acid, which is then found as acid rain [38]. Regardless of the source, SO_2 dissolves in rainwater to give sulfurous acid, which is eventually oxidized by oxygen to sulfuric acid with a very high dissociation constant [39].

$$SO_2 + H_2O \rightarrow H_2SO_3 \tag{1}$$

$$2H_2SO_3 + O_2 \rightarrow 2H_2O_4S \tag{2}$$

$$H_2O_4S \rightarrow 2H^+ + SO_4^{2-} \tag{3}$$

The acid proposed in this work is sulfuric acid H_2O_4S; 96–98% (Fig. 2), with a molar mass of 98.07 g/mol ± 0.006 and a density d = 1.84, an acidity constant (Ka or noted pKa −3.0 and 1.9), is a quantitative measure of the strength of an acid in solution with the structure shown below.

Sodium hydroxide

Sodium hydroxide (NaOH) is a strong base (pH = 14 at 1 mol/L), with a molar mass of ≈ 40 g/mol in Fig. 3, so its aqueous solution contains a large amount of hydroxide ions (OH$^-$). It dissociates completely in water [40].

Table 3 Composition of mixing water (tap water from the town of Tiaret, in mg/L)

Cl^-	NO_3^-	Zn^{2+}	SO_3^{2-}	pH
75	0	0	0	7

Fig. 2 Structure of sulfuric acid 98% (pKa −3.0 and 1.9)

Fig. 3 Sodium hydroxide used (Microbiotech, Algeria) molar mass ≈ 40 g/mol

$$NaOH \rightarrow Na^+ + OH^- \tag{4}$$

Sodium hydroxide used is supplied by Microbiotech, Algeria, with a molar mass of ≈ 40 g/mol.

The pH solutions used in this study (pH = 11 and 12.5) were prepared according to Eqs. (5) to (8):

$$\text{By definition: } pH + pOH = 14, \tag{5}$$

$$C = [OH^-] = 10^{-pOH}, \tag{6}$$

$$n = C \times V, \tag{7}$$

$$m = n \times M, \tag{8}$$

where:

- C = molar concentration (mol/L);
- n = amount of substance (mol);
- m = mass of NaOH to be dissolved (g);
- M = molar mass of NaOH = 39.997 g/mol (≈ 40 g/mol);

Therefore (for 1 L of solution):

- For pH = 11: pOH = 3, $[OH^-] = 10^{-3}$ mol/L, and $n = 0.001$ mol/L. Therefore, $m \approx 0.04$ g. It is sufficient to dissolve 0.04 g of NaOH in 1 L of water.
- For pH = 12.5: pOH = 1.5, $[OH^-] = -1.5$, and $n = 0.03162$ mol/L. Therefore, $m \approx 1.26$ g/L. It is sufficient to dissolve 1.26 g of NaOH in 1 L of water.

2.2 Procedure

2.2.1 Preparation of aggressive solutions

Sulfuric acid (H_2O_4S) solutions with pH = 2.5, pH = 3.5, and pH = 5 were prepared in the laboratory and measured using an electronic pH meter as shown in Fig. 4. The pH values considered allow for the generation of short-term accelerated mortar or concrete degradation test.

2.2.2 Preparation of the specimens

The w/c ratio of 0.5 was adopted to produce a control (reference) mortar of type 1/2 (one mass of CPJ CEMII/B 42.5N cement with two masses of sand [41] (Table 4). Additives and admixtures were not used. EN 196-1:2016 [42], which provides a detailed description of the test process, was followed in the preparation of the test specimens. They are prismatic in shape, measuring 16 cm in length and $4 \times 4 \times 16$ cm^2 in surface area (see Fig. 5 (a) and (b)). They are commonly referred to as $(4 \times 4 \times 16)$ cm^3. After a day, they have to be taken out of the molds and either preserved or submerged in water.

The following criteria were examined in order to build alternative mortars while keeping in mind the formulation of this control mortar:

- Impact of storage pH: the control cement CPJ CEM II/B 42.5 Matine was used, and the w/c ratio was fixed at 0.5. pH = 2, pH = 3.5, pH = 5, pH = 7, pH = 7.8, pH = 11 and pH = 12.5 were the values that were utilized. The extreme and average circumstances typical of each ecosystem under study are represented by the chosen pH values.
- Cement type influence: CPJ CEM II/B 32.5N CHAMIL and CPJ CEM II/B 42.5N Matine were the only cement types that were changed in this parameter. The w/c ratio remained constant at 0.5. At a pH of 2, the specimens were kept in H_2O_4S acid. In our nation's construction industry, these two varieties of cement are most frequently used.

The impact of the w/c ratio was examined by varying it from 0.45 to 0.5 to 0.55. CPJ CEM II/B 42.5 Matinee control cement was the type of cement used. The samples were kept in acid (H_2O_4S at a pH of 2). By choosing these E/C ratios, cement hydration can be varied, producing mortars with varying consistencies and, as a result, unique microstructures.

Three molds were made for each parameter under study, for a total of nine specimens.

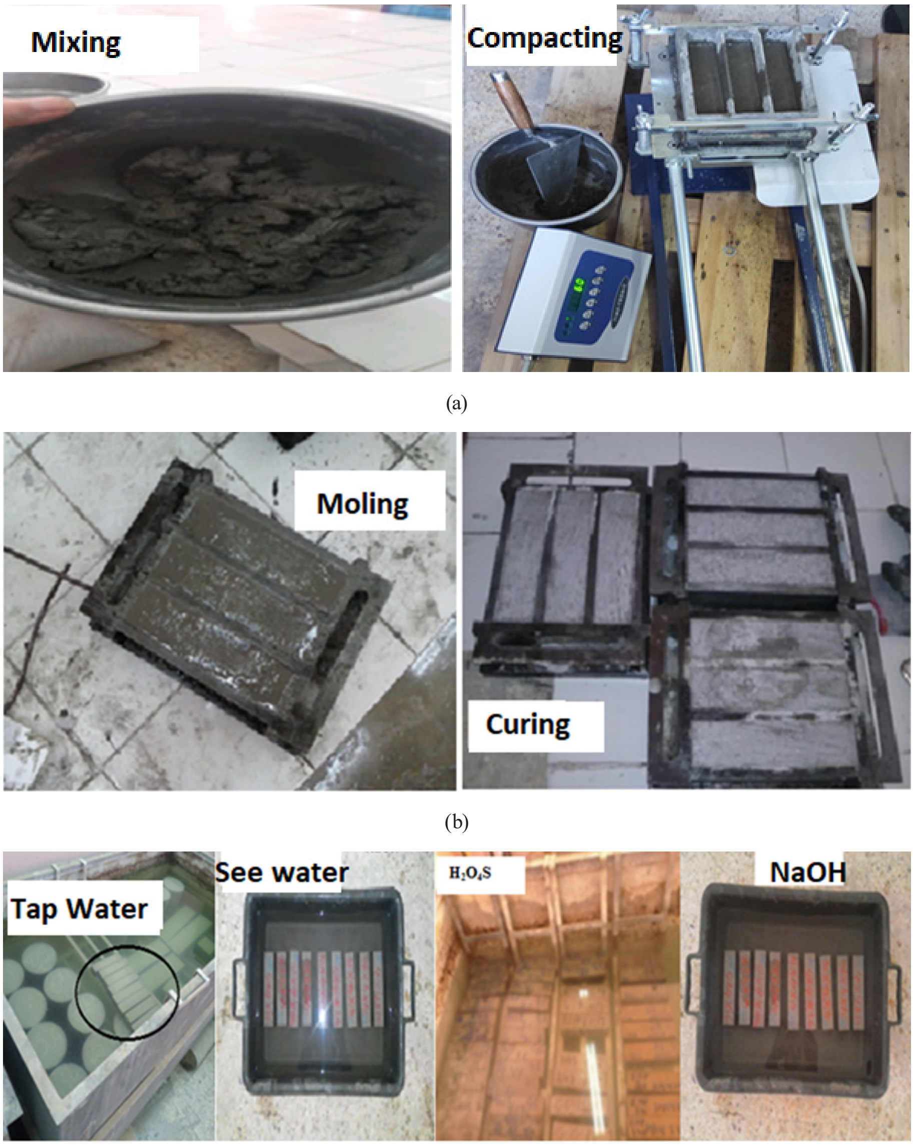
2.2.3 Mechanical tests

After 28 days of curing, flexural tensile and compressive strength tests (Fig. 6) were carried out in accordance with ASTM C109/C109M-21 [43], following the same experimental procedures as those applied in previous studies [41, 44].

Fig. 4 Preparation of different pH values of the acid solution H_2O_4S

Table 4 Control mortar formulation

Mortars	Cement CEM II/B 42.5 (g)	Sand (g)	Water (g)	w/c	Storage pH	Tests (days)
Widnes	450	1350	225	0.5	7	28 days



(a)

(b)

(c)

Fig. 5 Steps for preparing 4 × 4 × 16 cm^3 mortar specimens: (a) Mixture of the mortar and compacting filling of the prismatic molds; (b) Molding and curing of the prismatic molds; (c) Preservation of test specimens hardened in various aggressive solutions

Fig. 6 Tensile tests by bending and compression tests on hardened specimens

3 Results

A colored indicator (phenolphthalein), also known as a pH indicator, was used to verify and assess the residual alkalinity of concrete or mortar, particularly in studies on carbonation or acid/base attacks. In concrete, it is generally employed to measure the depth or surface of carbonation (colorless zone). To do this, the solution is applied to the fractured internal surface after a compression or flexural test. Phenolphthalein is colorless at a pH below 8.2 and dark pink at a pH above 9.5.

Fig. 7 shows the condition of mortar samples after 28 days of storage in tap water. The phenolphthalein test results are negative: the purple coloring indicates that the material remains alkaline, with no signs of oxidation or carbonation. These observations confirm that the samples are not carbonated; therefore, the phenomena studied subsequently concern only acid and alkaline attacks. Fig. 8 also shows that acid attacks the entire volume of the samples, reducing not only their cross-section but also their length. The difference in attack is particularly pronounced between a very strong acid (pH = 2) and a weaker acid (pH = 5). The degradation is reduced due to the variation in mass and, consequently, the mechanical strength decreases. As a result, the roughness of the surface of the mortar samples because of the porosity, comparatively the increase in acid volume the porosity increases. Tables 5 and 6 show the reduction of the mass and the mechanical strength of mortar. Its results are obtained by 9 samplers.

As can be seen from the results in Tables 5 and 6, as well as the clear illustrations in Figs. 9 to 11, After 28 days, the mechanism of the mortar is severely degraded by the pH of and loosens its hardness. When the pH went from neutral (pH = 7) to very acidic (pH = 2), the mortar began to reduce the mechanical and durable performance. a loss of mass noted about 20%, the tensile strength decreased by 33.7% (from 5.90 to 3.91 MPa), and the compressive strength decreased by more than 46.5% (from 36.25 to 19.38 MPa).

These results highlight the strong vulnerability of mortar to highly acidic environments. Alongside this deterioration, the specimen's cross-section significantly shrank along its whole length, which helps to explain why mechanical performance was reduced. Mass and strength loss can be ascribed to the gradual disintegration of the mortar matrix, which is mostly caused by the creation of expansive or soluble salts and the dissolution of cement hydration products such portlandite and C–S–H.

Such degradation is especially important in settings where contact to organic or inorganic acids is frequent, such as subterranean, industrial, or agricultural settings.

By contrast, a much lesser strength loss after 28 days occurred when the pH was raised from 7 to 12.5 (very alkaline), with a modest volume increase of around 2%

Fig. 7 Phenolphthalein test for specimens of the control mortar (stored in tap water pH = 7)

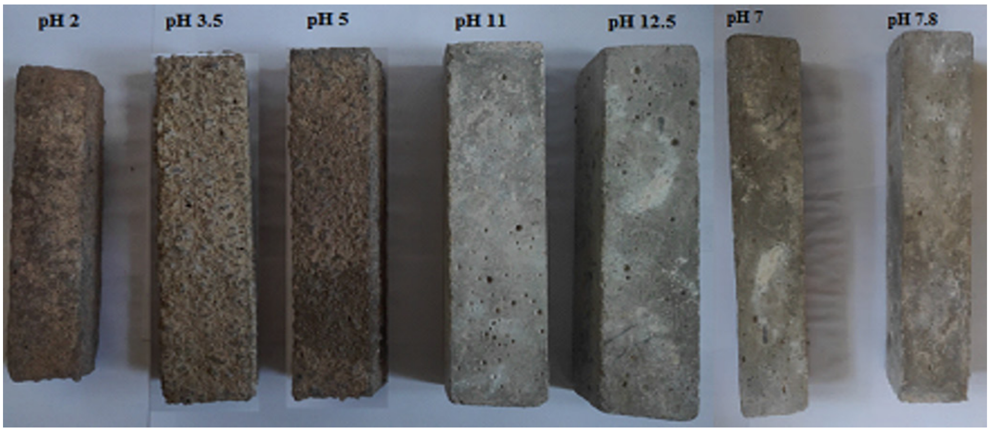


Fig. 8 Representative specimens from each series immersed in laboratory-prepared solutions at different pH levels (cement type 1, w/c = 0.5)

Table 5 Results (test mortar specimens preserved in different basic medium)

Data					Results			
Mortars	Cement used	Solution	pH	w/c	ΔP (g)	ΔP (%)	R_c (Mpa)	R_t (Mpa)
M1 – Witness	Type 1: CEM II/B 42.5 N	Tap water	7	0.5	5.0	0.94	36.25	5.90
Cement type (strength class)								
M2	Type 2: CEM II/B 32.5 N	Sea water	7.8	0.5	11.0	2.09	28.75	5.01
M3	Type 1: CEM II/B 42.5 N	Sea water	7.8	0.5	9.33	1.76	33.75	5.74
Variation in pH (basicity of the medium)								
M4	Type 1: CEM II/B 42.5 N	Sea water	7.8	0.5	9.33	1.76	33.75	5.74
M5	Type 1: CEM II/B 42.5 N	NaOH	11.0	0.5	12.0	2.23	31.88	5.44
M6	Type 1: CEM II/B 42.5 N	NaOH	12.5	0.5	12.5	2.36	30.62	5.27
Variation of the w/c ratio								
M7	Type 1: CEM II/B 42.5 N	Sea water	7.8	0.4	9.0	1.71	35.00	5.89
M8	Type 1: CEM II/B 42.5 N	Sea water	7.8	0.5	9.33	1.76	33.75	5.74
M9	Type1: CEM II/B 42.5 N	Sea water	7.8	0.6	11.3	2.14	29.38	4.99

Table 6 Results (test mortar specimens preserved in different acid environments)

Data					Results			
Mortars	Cement used	Solution	pH	w/c	ΔP (g)	ΔP (%)	R_c (Mpa)	R_t (Mpa)
M1 – Witness	Type 1: CEM II/B 42.5 N	Tap water	7	0.5	5.0	0.94	36.25	5.90
Cement type (strength class)								
M2	Type 2: CEM II/B 32.5 N	H_2O_4S	2	0.5	−109	−20.3	16.88	3.76
M3	Type 1: CEM II/B 42.5 N	H_2O_4S	2	0.5	−108	−20.0	19.38	3.91
Variation in pH (acidity of the medium)								
M4	Type 1: CEM II/B 42.5 N	H_2O_4S	2	0.5	−108	−20.0	19.38	3.91
M5	Type 1: CEM II/B 42.5 N	H_2O_4S	3.5	0.5	−91	−16.8	21.9	4.83
M6	Type 1: CEM II/B 42.5 N	H_2O_4S	5	0.5	−73.7	−13.6	25.0	4.96
Variation of the w/c ratio								
M7	Type 1: CEM II/B 42.5 N	H_2O_4S	2	0.4	−103	−18.7	20.00	4.10
M8	Type 1: CEM II/B 42.5 N	H_2O_4S	2	0.5	−108	−20.0	19.38	3.91
M9	Type 1: CEM II/B 42.5 N	H_2O_4S	2	0.6	−113	−21.0	15.0	3.45

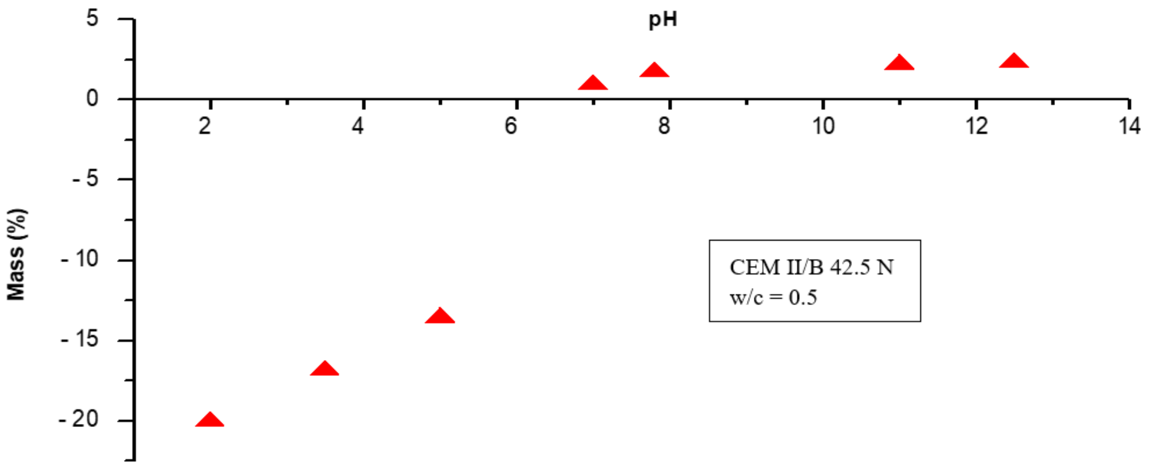


Fig. 9 Variation of mass as a function of the pH of the medium (acidic and basic)

and a strength loss of roughly 16% in compression and 11% in tension. These results imply that mortar strength is not always negatively impacted by an alkaline environment; according similar research's Alkalinity may even

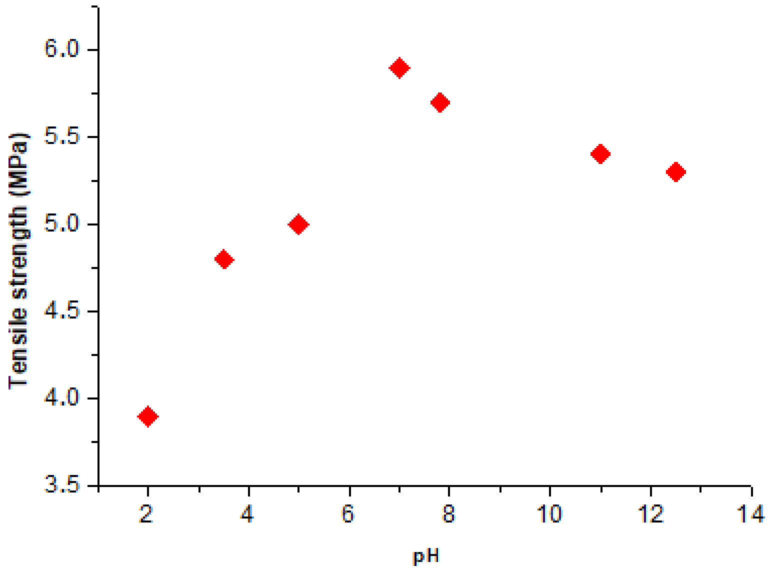


Fig. 10 Variation of tensile strength as a function of the pH of the medium (acidic and basic)

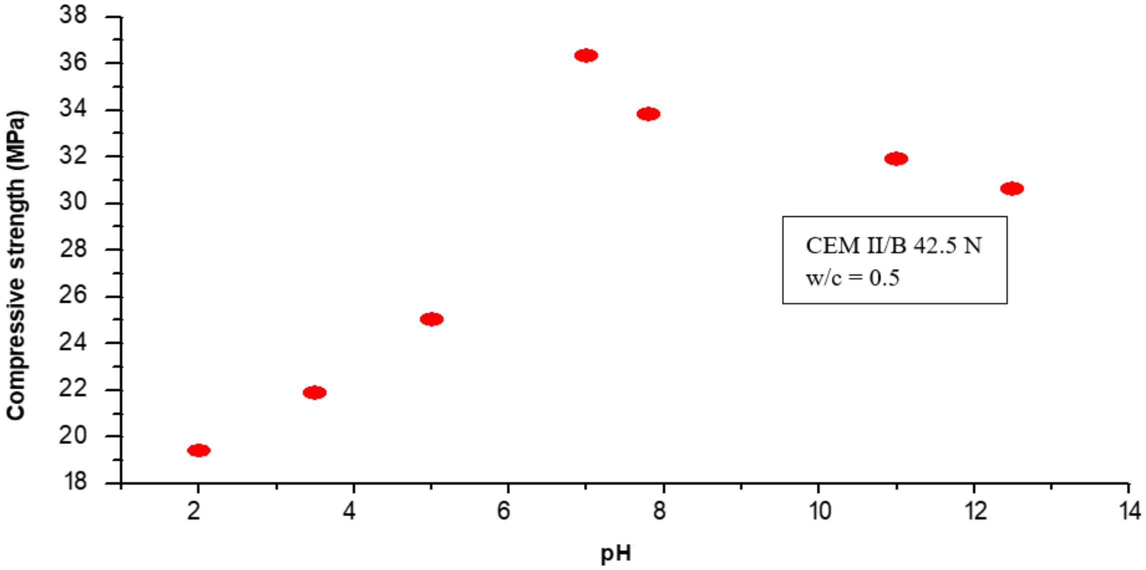


Fig. 11 Variation of compressive strength as a function of the pH of the medium (acid and basic)

encourage the development of a passive protective layer on the surface of concrete or mortar. Long-term durability can nevertheless be jeopardized by an alkali-silica interaction caused by excessive or improperly managed alkalinity.

Additionally, Tables 5 and 6 demonstrate that the type of cement affects mass variation and mechanical qualities. Higher-strength cement (CEM II-42.5) exhibits less mass loss than lower-strength cement (CEM II-32.5). Additionally, the mortar's strength and interior structural compactness are adversely affected when the water-to-cement ratio is increased from 0.4 to 0.6.

To combat this, we suggest using low-alkali cements, namely Portland composite cements of type CEM III, which lessen the development of secondary ettringite and the alkali-silica reaction. We also recommend adding pozzolanic additives, like fly ash, silica fume, and granulated blast furnace slag, which may efficiently absorb free alkalis and reduce porosity to densify the microstructure. Finally, to control interior moisture, it is recommended to use non-alkaline admixtures to reduce the water-to-cement ratio (for instance, from 0.25 to 0.30 instead of 0.50 in our study). This technique ensures greater strength and durability by compacting the microstructure and reducing its permeability to harsh chemicals.

Finally, as shown in Fig. 8, the absence of phenolphthalein response indicates an acid attack on the mortar's surface, the intensity of which is dictated by the acidity level of the surrounding environment, rather than a major internal reaction.

4 Conclusions

The experimental results clearly show that the composition of the material and the pH of the surrounding environment play a very important role in the strength and durability of cement-based mortars. Acidic environments degrade the microstructure of the cementitious matrix, mass loss and negative influence mechanical performance.

Furthermore, alkaline conditions can be favorable or unfavorable, depending primarily on the nature and concentration of the alkaline components of the material itself, as well as the storage environment.

The compactness of the microstructure of the mortar obviously influences the quality of the mortar It is introduced in its total performance as a mortar. The use of high quality cement and the permanent w/c ratio control maintains the density and decreases the internal permeability and gives a more durable mortar.

In addition, pozzolan improve the internal cohesion between the mortar components and reduce the presence of alkalis, and also give a perfect resistance to aggressive environments.

The results of this work make it possible to precisely orient the manufacture of more durable mortars capable of resisting strong acid or alkaline exposure. The results of this article help researchers to maintain long-term control of Portland cement-based structures and also to manufacture good mortar resistant to chemical reactions.

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