



THE USE OF CALCINED SEDIMENTS AND LIMESTONE FILLERS AS PARTIAL REPLACEMENTS OF CEMENT TO OBTAIN LOW-CARBON CEMENTITIOUS BUILDING MATERIALS

Mokhtar Achour^{*1}, Rachid Hadj Sadok² and Nadia Belas³

¹Laboratory of Instrumentation and Advanced Materials, Department of Civil Engineering, Nour Bachir University Center. El-Bayadh, Algeria.

²Department of Civil Engineering and Architecture, Faculty of Sciences and Technology, Djilali Bounaama University, Khemis Miliana, Algeria.

³Construction, Transport and Environment Protection Laboratory (LCTPE), Department of Civil Engineering, Faculty of Science and Technology, Abdelhamid Ibn Badis University Mostaganem, Algeria.

¹<https://orcid.org/0009-0008-4957-9136>, ²<https://orcid.org/0009-0007-9401-6693>, ³<https://orcid.org/0000-0003-0102-7937>

Email: m.achour@cu-elbayadh.dz, rachid.hadj-sadok@univ-dbk.m.dz, nadia.belas@univ-mosta.dz

ARTICLE INFO

Article History

Received: February 12, 2026

Reviewed: April 20, 2026

Accepted: May 20, 2026

Published: June 30, 2026

Keywords:

Calcined sediments,
Calcination,
Limestone fillers,
Sustainability,
Mortar.

ABSTRACT

Nowadays, the recycling materials is essential, when it is related to the sustainable development. Reducing raw material consumption, recycling, and reuse are the three fundamental pillars of sustainable building practices. Common Portland cement, which is used extensively in the building sector, emits a large amount of greenhouse gases and uses a lot of natural resources. Nevertheless, CO₂ emissions can be lessened by substituting some of the cement with pozzolanic materials. Concrete's strength and durability, both in a long or short time, are enhanced by this substitution. The objective of this study is to probe the effectiveness of the use toward the calcined sediments and limestone fillers as substitutes for cement in mortars. Various tests were conducted on fresh and hardened samples, with a focus on durability. The incorporation of limestone fillers in mortar formulations have shown a positive impact on compressive strength. Furthermore, over a 180-day, the compressive strength of different types of mortars, composed of calcined sediments and limestone fillers, showed a consistent increase. However, the calcined sediments and limestone fillers have demonstrated good short-term durability. In conclusion, the incorporation of calcined sediments and limestone fillers as alternatives to conventional clinker in the manufacturing process helps in the fight against climate change by reducing the quantity of carbon dioxide discharged into the atmosphere.



Copyright ©2026 by authors and Galileo Institute of Technology and Education of the Amazon (ITEGAM). This work is licensed under the Creative Commons Attribution International License (CC BY 4.0).

I. INTRODUCTION

Today, recycling materials is highly recommended in the logic of sustainable development. The typical Portland cement used in the building sector releases a significant amount of greenhouse gases and uses a number of natural resources [1]. Significant amounts of carbon dioxide are released into the atmosphere during the manufacturing of clinker as a result of the rise in cement usage. Nonetheless, CO₂ emissions can be decreased by substituting some pozzolanic materials for some of the cement [2]. Additionally, this replacement can increase strength and durability over the long run as well as in the short term [3]. Dredged sediments from dams have been the subject of several recent studies that have investigated the value of these materials in a variety of domains, such as durability [4], mechanics [5], and physicochemical characterization [6]. These studies show that these sediments have the potential to be used as raw materials in civil engineering, especially if they are used to replace cement partially [4], [5], [7]. Dredged sediments can be used as secondary raw materials in many different areas of civil engineering, such as foundation layering for roads [8], producing bricks for construction [9], and using them as substitute materials for some of the cement or sand in concrete [8]. In order to explore the potential for monetizing these sediments, [10] conducted an industrialization model based on a life cycle assessment. According to [7], the thermal treatment of sediments might make them more reactive, which makes it possible to employ them in the manufacturing of clinker.

In order to show that the addition of sediments decreased mortar shrinkage, [11] examined the hydration and shrinkage of cement pastes containing 20%, 30%, and 40% dredged sediments calcined at 865°C. It was also determined that the calcined sediments (from the harbour of Antwerp, Belgium) exhibited pozzolanic reactivity at temperatures of 820°C, 865°C, and 905°C [12]. Cement can also be substituted with limestone fillers at a rate of 15–20% [13]. They react with water when powdered finely to generate calcium silicate hydrate, which strengthens and extends the life of concrete [14]. Ternary cement, which is frequently used to lower the clinker content, is made up of calcined clay, clinker, and limestone filler [14]. When compared to regular Portland cement, this mixture also enhances workability and strength [15]. Limestone fillers are inexpensive resources that are readily available in considerable quantities locally [15]. For many years, they have been effectively substituted for some of the Portland cement in concrete [14]. It is commonly acknowledged that concrete that has these fillers in it is a strong structural material. However, the design of durable concrete is challenged by the restricted availability of these additives [16]. In order to produce concrete that is more durable and emits less CO₂, the construction industry frequently substitutes these ingredients for cement. According to recent research, calcined clay and limestone combined may raise clinker replacement levels by as much as 50% [17]. Calcium hydroxide (CH) and these siliceous and aluminous minerals interact chemically [14].

II. MATERIALS AND METHODS

II.1. MATERIALS

II.1.1 Cement

Following the recommendations of the European standard EN 197-1 (2012), Portland cement CEMI 42.5 N from the Saida cement plant in western Algeria, was utilized for this investigation [18]. Tables 1 and 2 provide the chemical compositions of cement and the mineralogical compositions of clinker.

Table 1: Chemical composition of used cement and mineral additions (%).

Elements	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	CaO	MgO	SO ₃	Na ₂ O	K ₂ O	P.F
Content %	19.72	5.09	3.18	63.03	1.08	2.32	0.05	0.98	3.8

Source: Authors, (2026).

Table 2: Mineralogical composition of clinker [%].

Elements	C ₃ S	C ₂ S	C ₃ A	C ₄ AF
Content %	56.71	12.24	7.37	8.86

Source: Authors, (2026).

Table 3: Summary table of the physical characteristics of the cement used.

Characteristics	Values
Absolute density of cement (g/cm ³)	3.13
Fineness according to Blaine's method (cm ² /g)	3685

Source: Authors, (2026).

II.1.2 Calcined Sediments

The calcined sediments used in this study were dredged from the Chorfa II dam in western Algeria. The sediments meant to be used in the formulation of mortar were first dried at 40°C in an oven, and then they were crushed and sieved to an 80 µm granulometry [19]. After that, they underwent calcination. The temperature was raised by 5 °C every minute until it reached 750°C, which was held for 5 hours in order to prevent thermal shocks [9], [20], [21]. Calcined sediments, the finished product, was carefully kept out of the air and moisture in a dry atmosphere [22-24] (figure 1). Tables 4 and 5 provide the chemical compositions and mineralogical characteristics of the calcined sediments.



Figure 1: The calcined sediments appearance both before and after calcination.

Source: Authors, (2026).

Tables 4: The chemical characteristics of the sediment before and after calcination.

Composition of oxides	Raw sediments	Calcined sediments
SiO ₂	40.04	48.52
Al ₂ O ₃	10.58	11.78
Fe ₂ O ₃	4.40	4.48
CaO	20.11	21.36
MgO	1.93	2.45
SO ₃	0.30	0.40
K ₂ O	0.92	1.32
Na ₂ O	0.25	0.69
CL	0.06	0.08
PF	23.08	3.80
CaCO ₃	/	/

Source: [25].

Table 5: Physical characterization of materials.

Settings	Raw sediments	Calcined sediments
Absolute density	2.44	2.62
Fineness according to Blaine's method (cm ² /g)	3658	6095

Source: [25].

The original sediments XRD mineral analysis revealed the presence of quartz, kaolinite, calcite, and dolomite peaks. The calcination of kaolinite into metakaolin makes the silica and aluminium potentially reactive with pozzolanic activity. According to [26], quartz, calcite, feldspar, and clay minerals, particularly kaolinite and illite, are the main mineral phases of the original sediments [27], [28]. Figures 2a and 2b represent the XRD and SEM analysis carried out on raw and calcined sediments.

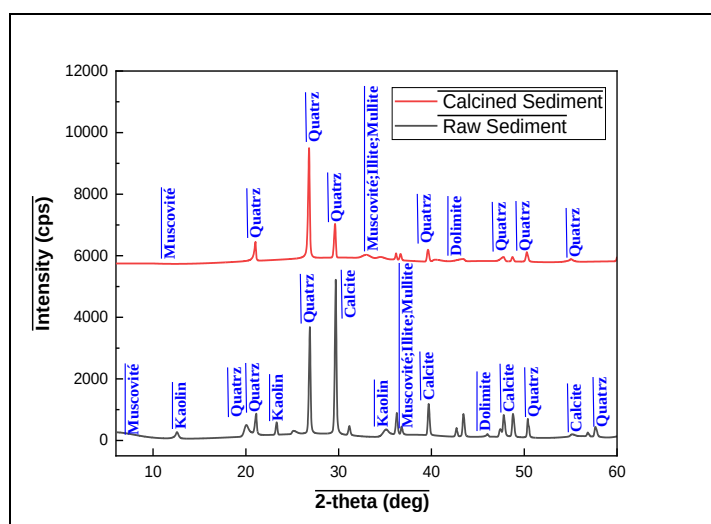


Figure 2a: Raw and Calcined Sediment XRD.

Source: Authors, (2026).

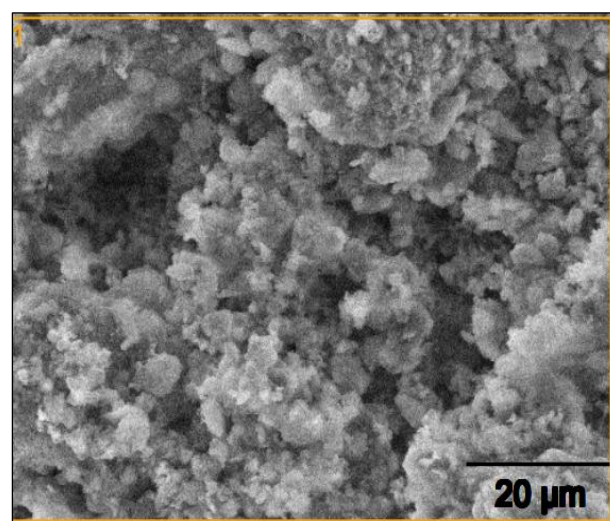


Figure 2b: SEM analysis of calcined sediment.

Source: Authors, (2026).

Observation imaging with scanning electron microscopy (SEM) revealed that the sediment contained irregular particles of varying sizes, which demonstrated that spherical particles of pure kaolin, making up about 20% of the final product, have diameters ranging from 10 μm to 20 μm. Similarly, [29] showed that rapidly calcined sediments contain submicron agglomerates of kaolin particles.

II.1.3 Limestone Fillers

The limestone fillers from the Antar quarry in Mecheria, along with the physical characteristics of these limestone fillers, are presented in Tables 6a and 6b and Observation imaging with scanning electron microscopy (SEM) (figure 3a and 3b).

Table 6a: Chemical characterization of materials.

Composition of oxides	Limestone Filler
SiO ₂	3.54
Al ₂ O ₃	1.47
Fe ₂ O ₃	0.64
CaO	44.82
MgO	6.51
SO ₃	0.03

K₂O	0.27
Na₂O	/
CL	0.01
PF	/
CaCO₃	108.37

Source: [25].

Table 6b: physical characterization of materials.

Settings	Limestone Filler
Absolute density (g/cm ³)	2.52
Fineness according to Blaine's method (cm ² /g)	2994

Source: [25].

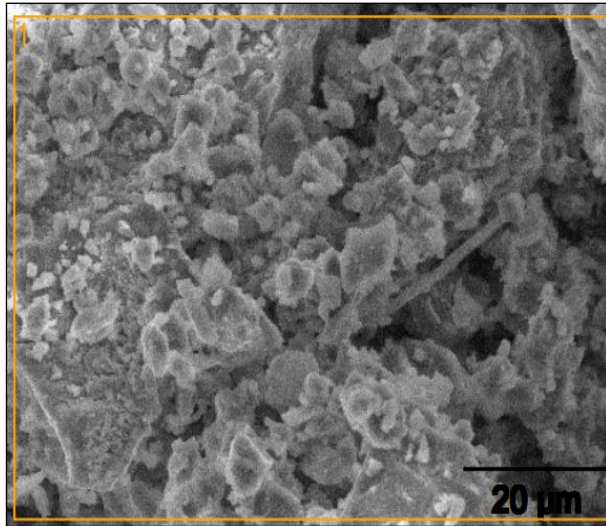


Figure 3a: SEM analysis of limestone fillers.

Source: Authors, (2026).

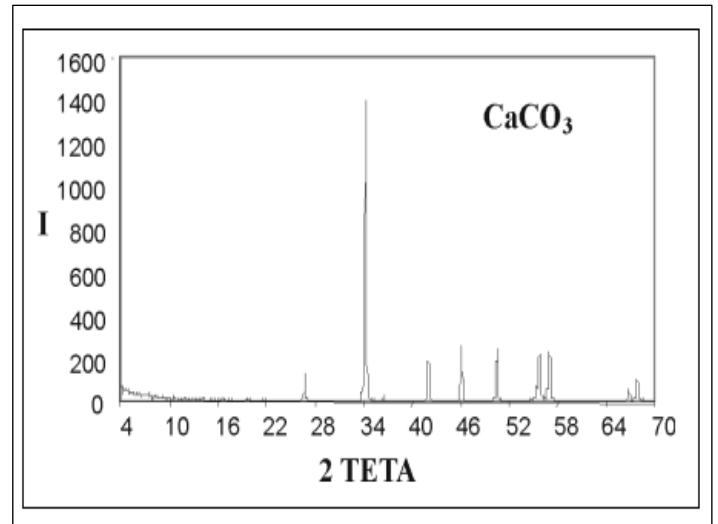


Figure 3b: limestone fillers XRD.

Source: Authors, (2026).

Figure 3a displays the X-ray diffraction (XRD) pattern of a calcium carbonate (CaCO₃) sample, while Figure 3b shows particles exhibiting irregular shapes with angular edges. Such morphology is characteristic of limestone fillers obtained through mechanical grinding.

II.1.4 Admixture

During our study, we used a water-reducing plasticizer adjuvant, PLASTIMENT BV40, for mortar formulations based on additives (sediment, perlite, and limestone filler). It has a density of 1.180 g/cm³ ± 0.025 and a dry extract percentage of 38.5% ± 1.9%.

II.2 METHODS

II.2.1 Formulations of Pastes and Mortars Used

Various mortar compositions were developed by combining CEM I 42.5 N cement with calcined sediments. Following the approach of Hadj Sadok's previous work, a 15% sediment proportion was adopted to determine the optimal sediment concentration for achieving the highest performance [20]. To evaluate the flexural and compressive strength of the mortars, prism samples measuring 4 × 4 × 16 cm were prepared. Five fresh mortar formulations were created using CEM I 42.5 N according to NF EN 196-1 (2016) [30]. The W/B ratio (0.5), along with the proportions of calcined sediments and limestone filler, are detailed in Table 7.

Table 7: Formulations of mortar.

Mortars				Sand	Water	BV 40	W/binder
	Binders						
	CEM I 42,5	SD	LF				
MT	450	0	0	1350	225	0	0.5
M15S	382,5	67.5	0	1350	223.09	1.91	0.5
MS5L	360	67.5	22.5	1350	223.56	1.44	0.5
MS15L	315	67.5	67.5	1350	223.3	1.70	0.5
MS25L	270	67.5	112.5	1350	223.11	1.89	0.5

Source: Authors, (2026).

II.2.2 Fresh State Characterization Tests

II.2.2.1 Initial Setting Time and Final Setting Time of Pastes

Consistency and setting time tests on standardized pastes are conducted to determine the so-called "normal" consistency using a Vicat apparatus equipped with a probe, as per the NF EN 196-3 (2017) standard. Setting times are measured with a setting meter in accordance with the same standard, NF EN 196-3 [31]. The setting time test was carried out using the setting time measurement device (figure 4).



Figure 4: Setting time measurement device.
Source: Authors, (2026).

II.2.3 Physical Properties

II.2.3.1 Water-Accessible Porosity

This test aims to determine the percentage of voids within the mortar mass that are connected to the surface in accordance with standard NF P 18-459 [32]. The porosity of prismatic specimens with dimensions of $4 \times 4 \times 16 \text{ cm}^3$ was measured after 28 days of curing. The water-accessible porosity ε is expressed as a percentage of the total volume.

III.2.3.2 Capillary Absorption

The test was conducted on prismatic mortar samples ($4 \times 4 \times 16 \text{ cm}^3$) that were preconditioned for 28 days according to the recommendations of the AFREM AFPC, 97 procedures [33]. After this preconditioning, the capillary absorption test was carried out. The specimens were immersed in water contained in a vessel to a maximum height of 5 mm, using spacers. At each stage, the samples were removed from the vessel, wiped with a damp sponge, weighed, and then placed back into the vessel.

II.2.4 Hardened State

II.2.4.1 Compressive Strength of Mortars

The compressive strength of mortars, determined through the thirty-point flexion test and in accordance with EN 196-1 [30], is a fundamental parameter of this study. The compressive strength was measured after various hardening periods (2 days, 7 days, 28 days, 56 days, 90 days, and 180 days). The study included one test mortar (TM) with 100% cement (C100% + SD0%) and four mortars with partial replacements using calcined sediments and limestone fillers: M15S (C85% + SD15%), MS5L (C80% + SD15% + LF5%), MS15L (C70% + SD15% + LF15%), and MS25L (C60% + SD15% + LF25%). The dosage of the BV40 water-reducing plasticizer varied from 0% to 4.05%. The three-point bending test and the measurement of compressive strength were conducted using the mortar compression device (figure 5).



Figure 5: The mortar compression device.
Source: Authors, (2026).

III. RESULTS AND DISCUSSIONS

III.1 FRESH STATE (PASTES, MORTARS)

The results of the initial and final setting times of the different cement pastes are presented in Table 8 and illustrated in Figure 6.

Table 8: initial and final setting times of the different cement pastes.

Pastes Type	Initial setting time (min)	Final setting time (min)
CP	173	231
P15S	265	304
PS5L	328	412
PS15L	325	396
PS25L	230	281

Source: Authors, (2026).

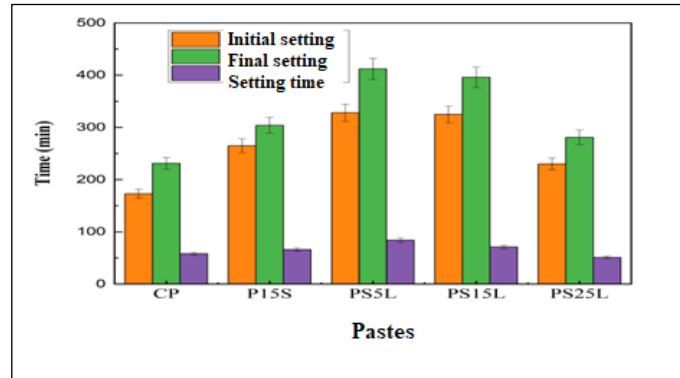


Figure 6: Initial and final setting times of the different cement pastes.

Source: Authors, (2026).

Figure 6 illustrates the inverse relationship between setting time and additive content in various cement pastes, regardless of the presence of additives. The increased reactivity of calcined clays may explain why mixtures with higher replacement levels exhibit faster setting times. The structure and fineness of calcined clay necessitate more water for limestone-calcined clay blends to achieve the same flow as OPC. However, the limestone particles can partially offset the additional water demand. The authors concluded that incorporating limestone and calcined clay as partial substitutes for OPC in cement paste can potentially enhance the setting time and other properties of the resulting mixture. [34] These observations are consistent with the findings of studies conducted by [35], [36].

III.2 HARDENED STATE

III.2.1 Compressive Strength (2, 7, 28, 90, and 180 Days)

Figure 7 illustrates the compressive strength of concrete in MPa over time. During this period, the intensity of the MS5L mortar surpassed that of the reference mortar (CM), with a strength of 46,28 MPa recorded on the 28th day. The MS15L and MS25L mortars exhibited lower intensity compared to the reference mortar. This difference is attributed to the pozzolanic reaction of the calcined sediment and limestone filler, which contributes to strength development. These results are consistent with those in the literature [13], [37]. After 7 days [38] concluded that the partial replacement of cement with calcined sediment and limestone filler improves compressive strength compared to a reference mix. The authors explain that this increase is due to the reaction of portlandite with the calcined sediment and limestone filler, leading to microstructural densification and a reduction in pore connectivity [39].

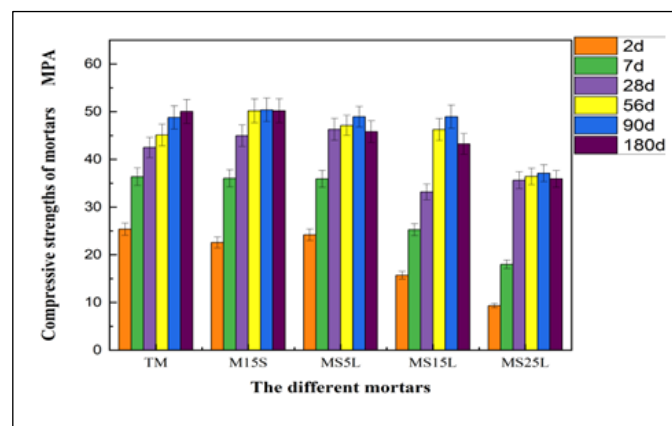


Figure 7: Compressive Strength (2,7, 28, 90, and 180 Days).

Source: Authors, (2026).

III.2.2 Flexural Resistance of Mortar

Figure 8 demonstrates the impact of incorporating limestone filler and calcined sediments on the flexural strength development of the mortar samples. It is obvious that the flexural tensile strength of all the mortars consistently increases over time, with no observed decrease in strength.

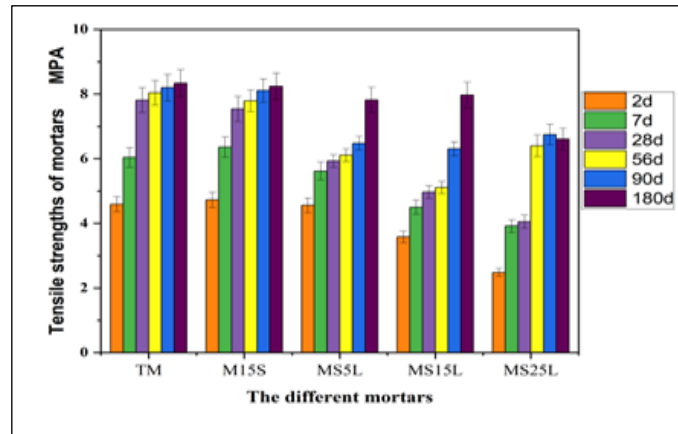


Figure 8: Flexural resistance (2,7, 28, 90, and 180 Days).
Source: Authors, (2026).

III.3 CAPILLARY ABSORPTION

The capillary absorption of mortars MT, M15S, and MS15L ulstered in the figure 9, along with their absorption kinetics, varies over periods ranging from 2 to 168 hours. During the initial phase of 2 to 8 hours, a slight increase in capillary absorption and absorption kinetics is observed. Notably, the reference mortar (MT) shows higher capillary absorption than the other mortars at 4, 8, 24, and 168 hours, which can be attributed to its high porosity and insufficient adhesion between the cement paste. When comparing the capillary absorption coefficients of mortar M15S with those of the reference mortar, it is evident that M15S exhibits lower values. The results show that capillary absorption gradually increases over time for both mortars. The MS15L mortar, on the other hand, demonstrates a significant reduction in absorption rate, reaching a level similar to that of the reference mortar after 168 hours. This decrease is attributed to the addition of calcined sediments and limestone fillers, which contribute to the densification of the interfacial transition zone. These results are consistent with recent studies by [40], [37].

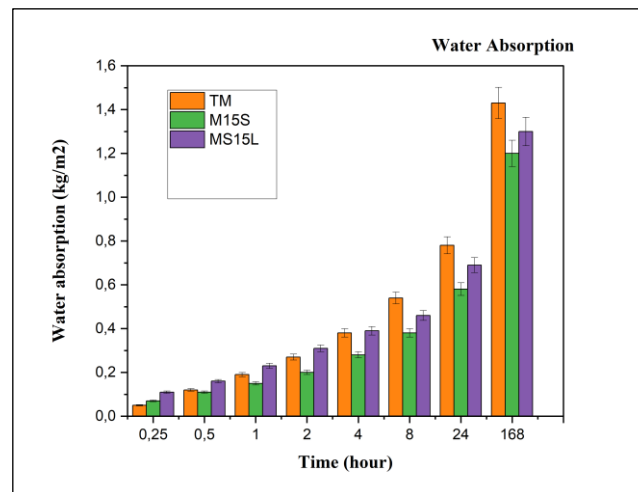


Figure 9: The capillary absorption of mortars.
Source: Authors, (2026).

III.4 ACCESSIBLE WATER POROSITY

After 28 days of dry curing, Figure 10 presents the porosity results obtained for the selected mortars. The M15S mortar exhibited lower porosity compared to the reference mortar. Additionally, the incorporation of calcined sediments and limestone (MS15L) as a partial replacement for Portland cement led to a 5.58% reduction in water-accessible porosity after 28 days, compared to the reference mortar. These results are consistent with the findings of [41]. Analyzing the results of the studied mortars, it can be concluded that mortars containing ternary mineral additives show a decrease in water-accessible porosity compared to the reference mortar. Furthermore, the presence of pozzolanic or hydraulic additives contributes to a long-term reduction in porosity.

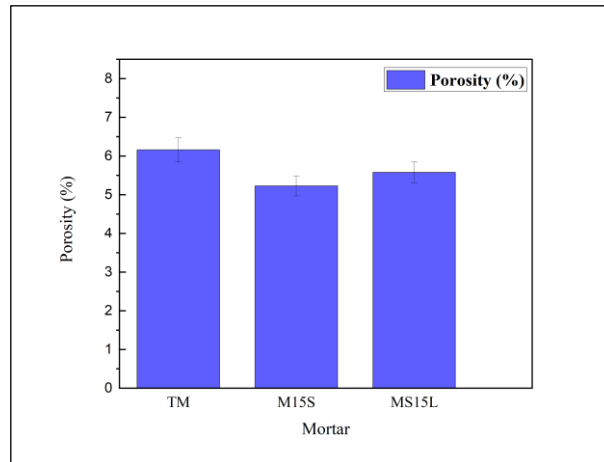


Figure 10: Accessible water porosities.
Source: Authors, (2026).

IV. CONCLUSIONS

The objective of this study is to evaluate the effectiveness of using calcined sediments and limestone fillers as substitutes for cement in mortars. Various tests were conducted on fresh and hardened samples, with a focus on durability. The main conclusions of the experiments are as follows:

- A potential solution to address the siltation of dams is to replace cement with fine materials such as calcined sediments and limestone fillers.
- X-ray diffraction (XRD) analysis highlights the importance of thermal treatment of sediments, as it transforms kaolinite into metakaolinite, promoting the desired pozzolanic behavior.
- The incorporation of limestone fillers in mortar formulations has shown a positive impact on compressive strength.
- Over a 180-day, the compressive strength of different types of mortars, composed of calcined sediments and limestone fillers, showed a consistent increase.
- The reuse of sediments from the Chorfa II dam effectively reduces greenhouse gas emissions and natural resource consumption.
- The dredged sediment and limestone filler have demonstrated good short-term durability.

The reduced carbon footprint of calcined sediments and limestone is one of their key environmental benefits. When compared to the conventional cement production process, the synthesis of these materials can cut carbon emissions by as much as 40%, as shown by Malacarne et al. [42].

- The incorporation of calcined sediments and limestone fillers as alternatives to conventional clinker in the manufacturing process allows for this reduction.
- Calcined sediments and limestone filler have a lower carbon intensity than clinker, this helps in the fight against climate change by reducing the quantity of carbon dioxide discharged into the atmosphere.

PERSPECTIVES

More investigation is required to assess the long-term durability and resistance of mortar or concrete containing cementitious materials, such as calcined sediments and limestone filler, to environmental factors like chemical attacks, alkali-silica reactions, and freeze-thaw cycles. Full life cycle studies comparing cement with additives, like calcined sediments and limestone fillers, to traditional cement are necessary to obtain a more precise understanding of the environmental benefits of cement during the construction process.

V. AUTHOR'S CONTRIBUTION

Conceptualization: Mokhtar Achour.

Methodology: Mokhtar Achour, Rachid Hadj Sadok and Nadia Belas.

Investigation: Mokhtar Achour, Rachid Hadj Sadok and Nadia Belas.

Discussion of results: Mokhtar Achour, Rachid Hadj Sadok and Nadia Belas.

Writing – Original Draft: Achour Mokhtar.

Writing – Review and Editing: Rachid Hadj Sadok and Nadia Belas.

Resources: Rachid Hadj Sadok and Nadia Belas.

Supervision: Mokhtar Achour, Rachid Hadj Sadok and Nadia Belas.

Approval of the final text: Mokhtar Achour, Rachid Hadj Sadok and Nadia Belas.

VI. ACKNOWLEDGMENTS

This experimental work was conducted by the Laboratory of Instrumentation and Advanced Materials, Department of Civil Engineering, Nour Bachir University Center, El Bayadh, and the Laboratory of Construction, Transportation, and Environmental Protection, Abdelhamid Ibn Badis University, Mostaganem.

VII. REFERENCES

- [1] Huedo P, Mulet E, López-Mesa B. A model for the sustainable selection of building envelope assemblies. *Environ Impact Assess Rev* 2016; 57:63–77. <https://doi.org/10.1016/j.eiar.2015.11.005>.
- [2] Huntzinger DN, Eatmon TD. A life-cycle assessment of Portland cement manufacturing: comparing the traditional process with alternative technologies. *J Clean Prod* 2009; 17:668–75. <https://doi.org/10.1016/j.jclepro.2008.04.007>.
- [3] Skibsted J, Snellings R. Reactivity of supplementary cementitious materials (SCMs) in cement blends. *Cem Concr Res* 2019; 124:105799. <https://doi.org/10.1016/j.cemconres.2019.105799>.
- [4] Bouhamou NE, Mostefa F, Mebrouki A. The Influence of Dredged of Natural Waste on Shrinkage Behavior of Self Compacting Concrete for Achieving Environmental Sustainability. *Key Eng Mater* 2015; 650:91–104. <https://doi.org/10.4028/www.scientific.net/KEM.650.91>.
- [5] Safhi AEM, Benzerzour M, Rivard P, Abriak N-E, Ennahal I. Development of self-compacting mortars based on treated marine sediments. *J Build Eng* 2019; 22:252–61. <https://doi.org/10.1016/j.job.2018.12.024>.
- [6] Belguesmia K. Optimization of an Eco-BAP Based on Dredged Sediment of Fresh, Hardened and Durability, Thesis Abdelhamid Ibn Badis University of Mostaganem 2018.
- [7] Aouad G, Laboudigue A, Gineys N, Abriak NE. Dredged sediments used as novel supply of raw material to produce Portland cement clinker. *Cem Concr Compos* 2012; 34:788–93. <https://doi.org/10.1016/j.cemconcomp.2012.02.008>.
- [8] Semcha A. Valorisation des sédiments de dragage : Applications dans le BTP, cas du barrage de Fergoug 2006.
- [9] Cappuyns V, Deweirt V, Rousseau S. Dredged sediments as a resource for brick production: Possibilities and barriers from a consumers' perspective. *Waste Manag* 2015; 38:372–80. <https://doi.org/10.1016/j.wasman.2014.12.025>.
- [10] Hadj Sadok R, Belas Belaribi N, Mazouzi R, Hadj Sadok F. Life cycle assessment of cementitious materials based on calcined sediments from Chorfa II dam for low carbon binders as sustainable building materials. *Sci Total Environ* 2022; 826:154077. <https://doi.org/10.1016/j.scitotenv.2022.154077>.
- [11] Van Bunderen C, Snellings R, Vandewalle L, Cizer Ö. Early-age hydration and autogenous deformation of cement paste containing flash calcined dredging sediments. *Constr Build Mater* 2019; 200:104–15. <https://doi.org/10.1016/j.conbuildmat.2018.12.090>.
- [12] Snellings R, Cizer Ö, Horckmans L, Durdziński PT, Dierckx P, Nielsen P, et al. Properties and pozzolanic reactivity of flash calcined dredging sediments. *Appl Clay Sci* 2016; 129:35–9. <https://doi.org/10.1016/j.clay.2016.04.019>.
- [13] Dhandapani Y, Santhanam M. Assessment of pore structure evolution in the limestone calcined clay cementitious system and its implications for performance. *Cem Concr Compos* 2017; 84:36–47. <https://doi.org/10.1016/j.cemconcomp.2017.08.012>.
- [14] Shamseldeen Fakhri R, Thanon Dawood E. Limestone powder, calcined clay and slag as quaternary blended cement used for green concrete production. *J Build Eng* 2023; 79:107644. <https://doi.org/10.1016/j.job.2023.107644>.
- [15] Alloul A, Amar M, Benzerzour M, Abriak N-E. Developing mortar using limestone flash-calcined dredged sediment/millstone-clay cement binder (LFC). *J Build Eng* 2023; 76:107346. <https://doi.org/10.1016/j.job.2023.107346>.
- [16] Juenger MCG, Siddique R. Recent advances in understanding the role of supplementary cementitious materials in concrete. *Cem Concr Res* 2015; 78:71–80. <https://doi.org/10.1016/j.cemconres.2015.03.018>.
- [17] Basavaraj AS, Muni H, Dhandapani Y, Gettu R, Santhanam M. Limestone-Calcined Clay (LC2) as a supplementary cementitious material for concrete. *RILEM Tech Lett* 2023; 8:12–22. <https://doi.org/10.21809/rilemtechlett.2023.172>.
- [18] AFNOR. AFNOR NF EN 197-1, N.E. 197-1-A. Cement—Part 1: Composition, Specifications and Conformity Criteria for Common Cements—Ciment; French Standard Institute: Paris, France, 2012. n.d.
- [19] Benzerzour M, Amar M, Abriak N-E. New experimental approach of the reuse of dredged sediments in a cement matrix by physical and heat treatment. *Constr Build Mater* 2017; 140:432–44. <https://doi.org/10.1016/j.conbuildmat.2017.02.142>.
- [20] Hadj Sadok R, Belas N, Tahlaiti M, Mazouzi R. Reusing calcined sediments from Chorfa II dam as partial replacement of cement for sustainable mortar production. *J Build Eng* 2021; 40:102273. <https://doi.org/10.1016/j.job.2021.102273>.
- [21] Sallai HH, Bouhamou NE, Marouf H, Belghit A, Aydin AC. Influence of calcined dam mud on the thermal conductivity of binary and ternary self-compacting concrete mixtures using the equivalent mortar method. *Stud Eng EXACT Sci* 2024; 5:501–24. <https://doi.org/10.54021/seesv5n1-029>.
- [22] Moon H, Kim J-H, Lee J-Y, Kim S-G, Chung C-W. Evaluation of Pozzolanic Activity for Effective Utilization of Dredged Sea Soil. *Int J Concr Struct Mater* 2017; 11:637–46. <https://doi.org/10.1007/s40069-017-0215-6>.
- [23] Zeraoui A, Maherzi W, Benzerzour M, Abriak N, Aouad G. Development of Flash-Calcined Sediment and Blast Furnace Slag Ternary Binders. *Buildings* 2023; 13:333. <https://doi.org/10.3390/buildings13020333>.
- [24] Safer O, Amer AAM, Belaribi O, Belguesmia K, Belas N, Chemmam M, et al. Study of the impact of sediments on the mechanical behavior of concrete and towards the penetration of carbon dioxide. *Stud Eng EXACT Sci* 2024; 5:3022–55. <https://doi.org/10.54021/seesv5n1-151>.
- [25] Achour M, Belas N, Sadok RH. L'effet de l'incorporation des sédiments calcinés et de la perlite comme remplacement partiel du ciment sur le comportement des mortiers. *J Eng Exact Sci* 2024; 10:18696. <https://doi.org/10.18540/jcecvl10iss2pp18696>.
- [26] Laoufi L, Senhadji Y, Benazzouk A. Valorization of mud from Fergoug dam in manufacturing mortars. *Case Stud Constr Mater* 2016; 5:26–38. <https://doi.org/10.1016/j.cscm.2016.06.002>.

- [27] Hyeok-Jung K, Kang S-P, Choe G-C. Effect of Red Mud Content on Strength and Efflorescence in Pavement using Alkali-Activated Slag Cement. *Int J Concr Struct Mater* 2018; 12:18. <https://doi.org/10.1186/s40069-018-0258-3>.
- [28] SAFER, O.; BELAS, N.; BELARIBI, O.; BELGUESMIA, K.; MEBROUKI, A., HAMADACHE, Study of the behavior in the fresh and hardened state of an ecoconcrete based on dredged sediments. *Journal of Materials and Environmental Sciences*, v. 8, n. 6, p. 2026–2033, 2017. <http://www.jmaterenvironsci.com> 2017.
- [29] Claverie M, Martin F, Tardy JP, Cyr M, De Parseval P, Grauby O, et al. Structural and chemical changes in kaolinite caused by flash calcination: Formation of spherical particles. *Appl Clay Sci* 2015; 114:247–55. <https://doi.org/10.1016/j.clay.2015.05.031>.
- [30] AFNOR. AFNOR NF EN 196-1, N.E. 196-1 Methods of Testing Cement—Part 1: Determination of Strength; French Standard Institute: Paris, France, 2016. n.d.
- [31] AFNOR. AFNOR NF EN 196-3: Methods of Testing Cement - Part 3: Determination of Setting Times and Soundness (2017). n.d.
- [32] AFNOR. AFNOR NF P18-459 Concrete - Test for hardened concrete - Porosity and density test August 2022. n.d.
- [33] AFPC-AFREM. [AFPC, 1997] AFPC-AFREM, recommended operating mode, accelerated carbonation test, measurement of the thickness of carbonated concrete, in Report of the technical days AFPC-AFREM Durability of concrete, “recommended methods for measuring associated quantities to sustainability”, Toulouse, pp153-158. December 11 and 12, 1997 1997.
- [34] Barbhuiya S, Nepal J, Das BB. Properties, compatibility, environmental benefits and future directions of limestone calcined clay cement (LC3) concrete: A review. *J Build Eng* 2023; 79:107794. <https://doi.org/10.1016/j.job.2023.107794>.
- [35] A. Ali Aichouba. Natural pozzolans effect on the properties of cement based on calcium. USTMB, 2005.
- [36] Chaib O, Mouli M, Benosman AS, Hamadache M. Study of the effects of shrinkage on concretes based on pozzolana and perlite. *Asian J Civ Eng* 2018 ;19:287–94. <https://doi.org/10.1007/s42107-018-0025-4>.
- [37] Dhandapani Y, Sakthivel T, Santhanam M, Gettu R, Pillai RG. Mechanical properties and durability performance of concretes with Limestone Calcined Clay Cement (LC3). *Cem Concr Res* 2018; 107:136–51. <https://doi.org/10.1016/j.cemconres.2018.02.005>.
- [38] Du H, Pang SD. High-performance concrete incorporating calcined kaolin clay and limestone as cement substitute. *Constr Build Mater* 2020; 264:120152. <https://doi.org/10.1016/j.conbuildmat.2020.120152>.
- [39] Avet F, Scrivener K. Investigation of the calcined kaolinite content on the hydration of Limestone Calcined Clay Cement (LC3). *Cem Concr Res* 2018; 107:124–35. <https://doi.org/10.1016/j.cemconres.2018.02.016>.
- [40] Garboczi EJ. Permeability, diffusivity, and microstructural parameters: A critical review. *Cem Concr Res* 1990; 20:591–601. [https://doi.org/10.1016/0008-8846\(90\)90101-3](https://doi.org/10.1016/0008-8846(90)90101-3).
- [41] Chihaoui R, Khelafi H, Senhadji Y, Mouli M. Potential use of natural perlite powder as a pozzolanic mineral admixture in Portland cement. *J Adhes Sci Technol* 2016; 30:1930–44. <https://doi.org/10.1080/01694243.2016.1171568>.
- [42] Salvi Malacarne C, Rubens Cardoso Da Silva M, Danieli S, Gonçalves Maciel V, Paula Kirchheim A. Environmental and technical assessment to support sustainable strategies for limestone calcined clay cement production in Brazil. *Constr Build Mater* 2021; 310:125261. <https://doi.org/10.1016/j.conbuildmat.2021.125261>.