Contribution to study influence of water quality on the mechanical properties of bricks based ontraditional gypsum stabilized by cement

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Abstract:

The aim of the work presented is to study the possibility of using traditional gypsum, which is found in considerable quantities in southern Algeria, to prepare bricks with sufficient mechanical characteristics to qualifythem for the various applications and uses in construction. The improvement of the mechanical properties of traditional gypsum was carried out in two phases: the first phase by adding white cement with different mass ratios of 0, 1, 2, 3, 4 and 5%. The results showed that the addition of 2% of white cement gave the best value to make the bricks more resistant to traction and compression.The second phase of the study aims to study the durability and knowledge of the effect of water on traditional plaster bricks and white cement. After determining the best C2 sample of 98% traditional plaster and 2% cement, we placed these samples in drinking water baths and the others in aggressive water baths in 7 days, 14 days, 21 days, 28 days, 60 days and 90 days. After applying the mechanical tests of all the samples on the specified dates, we found that the mechanical results increased with time

Keywords: brick, traditional plaster, cement, aggressive water, mechanical properties.
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1 Introduction

Algeria with its vast surface area encompasses a heterogeneity of local materials that deserve to be valorized, for example those located in the southern region of the country, namely: sand dunes, clays, tuff, gypsum and others that are still poorly valorized. Most of the building materials currently used in the Saharan regions are poorly adapted in terms of climatic and environmental conditions, sustainability and economics.

And in order to gain a better understanding of the behaviour of local materials in the field of civil engineering and building construction. It is important to estimate their resources and study their physical, chemical, mechanical and thermal properties.

In this respect, the objective set in this work is the characterisation and valorisation of a local material which is the traditional plaster known as "Timchemt" and thus the improvement of the mechanical characteristics of Timchemt based bricks, studying the effect of the addition of white cement in precise percentages, which vary up to 5%. Also, the experimental study of the influence of the aggressiveness of water (drinking water, aggressive water) on different compositions of traditional plaster bricks.

2 Methods and materials

Traditional Plaster (Temchemt)

Traditional plaster is burned in traditional ovens. These ovens are rudimentary constructions, built in thick timchent, vertical oven 1.5 m high and 1 m in diameter, and the second horizontal oven 1 m high and 4 m in diameter in a courtyard.
For this a worker goes down into the hole and places a row of large blocks of temchemt around the bottom (wait in front of the opening).Then he places a second row, a little set back towards the centre, fills the sides with smaller pieces and climbs on this second seat; a third is placed in the same way and then, with a large block, the middle is blocked: in short, a vault has been built; the worker continues to fill the oven until it is above ground level,

where it ends up in a dome, a dome almost one metre high in the centre, above ground level.

The fire is then started: through the opening that connects the bottom of the oven with the trench, dry wood is introduced, the fire is started, when the fire is well established it is fed with branches of wood with the fibres of palm trees. This fire is maintained for 6 to 8 hours after it is broken up and crushed with a pestle, which is the traditional plaster (temchemt).

Figure. 1 Traditional ovens used for cooking Temchemt

We are studying this material physically and chemically at the civil engineering laboratory of Kasdi Merbah Ouargla University.

The table below presents the results of the physical tests:

Table 1 the results of the physical tests on the Timchemt.

Essay	Results
Apparent density	1.39 g/cm^3
Absolute density	2.18 g/cm^3
Test blue value passing to.	0.68
Landing limit	WL=41.10
	WP=34.42
	IP=6.68
Sand equivalent	Esv=38.80
	Esp=37.17

According to the NF P 94-068 standard, our sample is between 0.2 and 2.5, which means that it is not very adsorbent, not very plastic and sensitive to water. According to Atterberg and Burmister, we can classify our Timchemt by its plasticity index IP=6.68 the nature of this traditional plaster is not very plastic, with a natural density of 1.51g/cm3 the result belongs to the range 1.4 to 1.8 according to the classifications, this material is classified as loose despite the distinction observed between them.

X-ray diffraction (XRD)

The Mineralogical analysis of Timchemt was made with the aid of the x-ray diffraction (XRD). This technique allows you to identify the crystalline phases present in this traditional plaster and determine the parameters of mesh associated. These applications are possible thanks to the interference of X-rays with the matter.

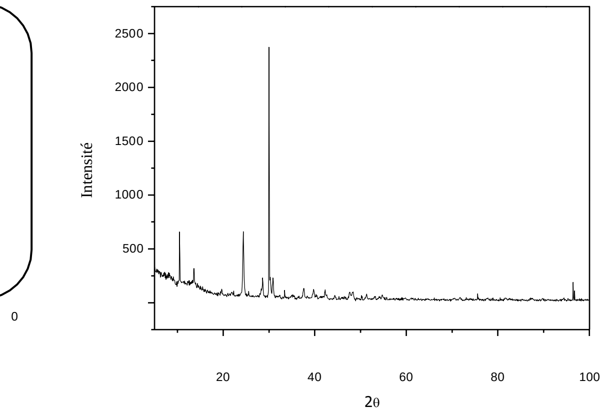

Figure 2. The X-ray diffraction (XRD) of Temchemt

What must be remembered in this diffractogram is that our Temchemt is sulphated throughout the course of the peaks obtained, we can see the following:
Sulphate $CaSO_4$ forms a large part of the minerals with a percentage of 96%
NaOH found with low percentages around 4%
The results of the chemical analyses are presented above.

Table 2 Chemical analyses of traditional gypsum (temchemt)

	Components	Values
Insolubles NF P 15 - 461	Insolubles	27 %
	$SO3^{-2}$	14.09 %
	$Ca\ SO_4 / 2H_2O$	75.71 %
Sulfates BS 1377	$SO4^{-2}$	16.93 %
Carbonates NF P 15 - 461	$CaCO_3$	2 %
Chlorides MOHR method	Cl^-	0.845 %
	NaCl	1.385 %

The table presented shows that the elements in the sample is gypsum in percentage about 75.71% with the insoluble of

27%, the levels of sulphates and chlorides are very low. Cement .The cement used is portland cement NA 442-CEM I 52.5R (MALAKI).

Table.3 The chemical analysis of cement

Chemical analysis	Values
Fire damage (%)	**3 ± 2.5**
Sulphate content (SO_3)	**2.8 ± 0.8**
Magnesium oxide content MgO (%)	**1.8 ± 0.8**
Chloride content (%)	**< 0.1**

Table.4 Compressive strength of cement

Compression resistance	Values
2 days (Mpa)	**≥ 30**
28 days (Mpa)	**≥ 55**

Table.5 cement setting time

Setting time at 20°.	Valuers
Start of setting (min)	140 ± 40
End of take (min)	210 ± 40

3 Result and Discussion

The aim of the present research is to valorise this local material (traditional plaster) by adding white cement in construction in order to improve the mechanical properties of building materials in the Saharan regions (southern Algeria).
The experimental study of our work consists in determining the thermal characteristics and the mechanical characteristics of the bricks. For this purpose we carried out various tests on these bricks.
The specimens used are prismatic specimens which must comply with the NF P 18-400 standard. For the preparation and conservation of the specimens, please refer, depending on the category of the test, to that of the NF P 18-404 standards.
We prepared six samples on bricks of dimensions (4x4x16) cm3 for the determination of the mechanical properties. They are composed of (traditional plaster and white cement), then we calculated the weights of the compositions as follows:

Table.6 the compositions used

	C_0	C_1	C_2	C_3	C_4	C_5
Timchemt (%)	100	99	98	97	96	95
Cement (%)	0	1	2	3	4	5

The following figure shows the variation in the density of bricks as a function of the percentage of white cement in the brick manufacture.

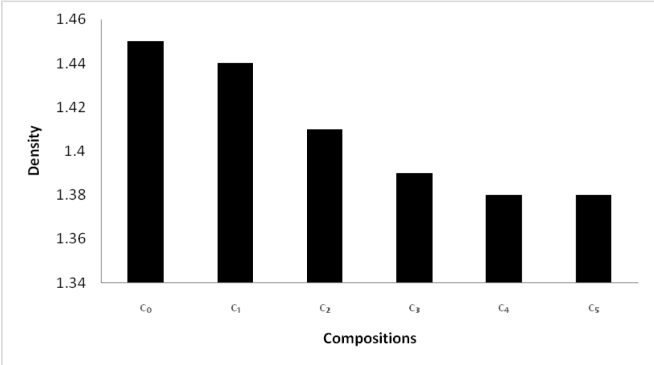

Figure.3 Density variations as a function of percentage of cement

The figure shows us that:
The density decreases as a function of the percentage of cement in all compositions because of the loss of water, and because of the low weight of cement which increases each time.
The density of the reference sample (C0) is higher than the other compositions due to the absence of cement.
The variation in the bending strength of the bricks according to the proposed compositions is shown in the following figure:

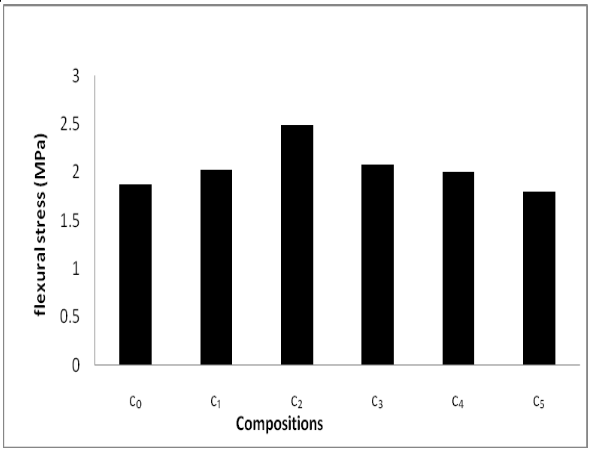

Figure.4 flexural strengths as a function of cement dosage

The results shown in figure3 show that the compressive strength is increased as a function of the increase in cement content up to 2% at the maximum value equal to 2.48 MPa and beyond this threshold a decrease up to 5% at the minimum value equal to 1.8 MPa, the increase is all the more important when going from the white cement content of 0 to 2% and the decrease is all the more important when going from the content of 2 to 5%.
The variation of the compressive strength of the bricks according to the proposed compositions is represented in the following figure:

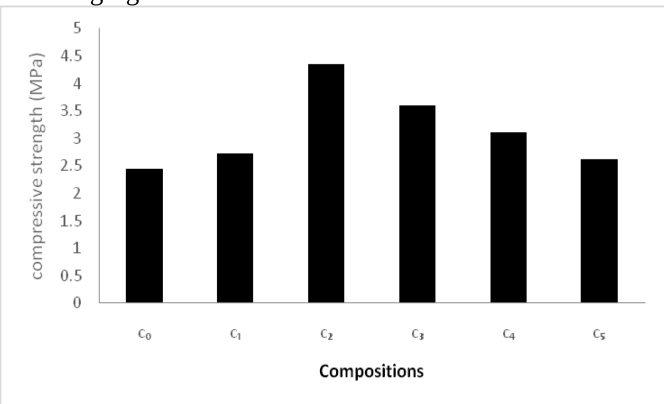

Figure.5 Compressive strengths as a function of cement dosage

The results shown in figure 5 show that the compressive strength is increased as a function of the increase in cement content up to 2% at the maximum value equal to 4.35 MPa and beyond this threshold a decrease up to 5% at the minimum value equal to 2.62 MPa. The increase is all the more important when going from the white cement content of 0 to 2% and the decrease is all the more important when going from the content of 2 to 5%.

The variation of the speed of propagation of the sound of bricks according to the proposed compositions is represented in the following figure:

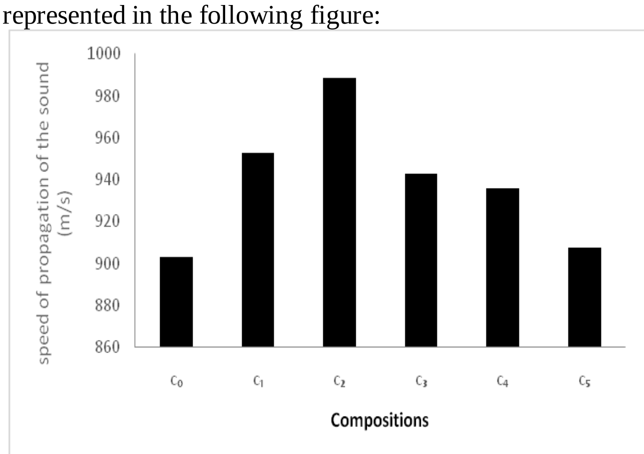

Figure.6 speed of propagation of the sound as a function of cement dosage

A marked increase in the speed of sound propagation which exceeds the speed of the control composition at the maximum value equal to 988.33 (m/s) at C2 and then decreases to 907.33 (m/s) at C5.We concluded that the composition of C2 was homogeneous.

The variation of the thermal conductivity (λ) of the bricks according to the proposed compositions is represented in the following figure:

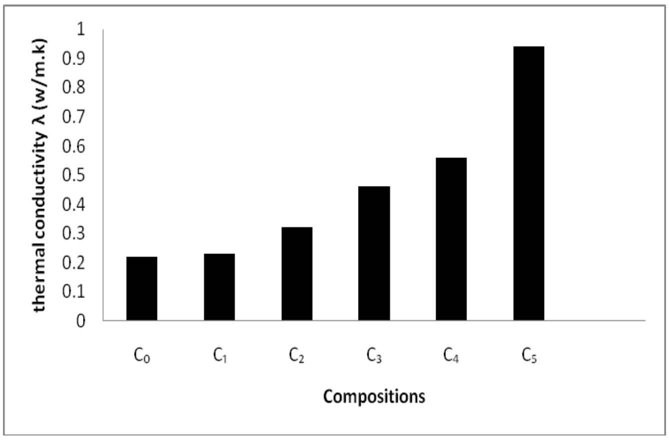

Figure .7 the thermal conductivity (λ) of bricks as a function of the percentages of cement

According to the following figure, an increase in thermal conductivity is observed as a function of the increase in white cement.This increase is due to the high conductivity of the cement.Material properties are strongly related to the types of bonds between atoms and the increase in thermal conductivity observed in our case is due to the strong atomic bonds between the atoms in the matrix.
The variation of the thermal resistance (Rth) of the bricks according to the proposed compositions is shown in the following figure:

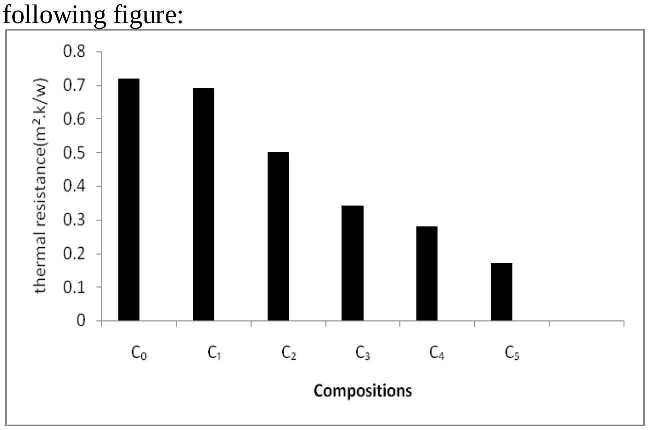

Figure.8 the thermal resistance of bricks as a function of the percentages of cement

- according to figure.8 indicates that the thermal resistance is decreased because it is inversely proportional to the thermal conductivity.

The results obtained show that traditional plaster (C0) , has a better thermal insulating capacity than other components.

-the addition of white cement improves the mechanical resistance but reduces its thermal resistance. From the previous tests we conclude that the traditional plaster bricks stabilized with 2% white cement are marked as the best that gives good results in compressive and flexural strength compared to the different percentage.

So we studied the durability of these test tubes in the open air and under the effect of drinking water and aggressive water on the one.

There are three ways of preserving the specimens:

1st mode: storage of the test tubes in the open air for 7, 14, 21, 28, 60, 90 days.

2nd mode: storage of test tubes in drinking water for 7, 14, 21, 28, 60, 90 days.

3rd mode: storage of the test tubes in aggressive water for 7, 14, 21, 28, 60, 90 days.

Figure.9 Specimen preservations in drinking water and aggressive water

The variation of the density of bricks according to the conservation media as a function of time is shown in the following figure:

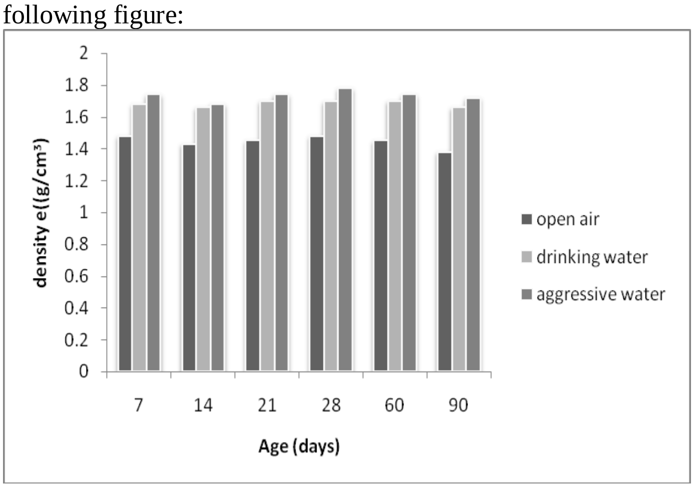

Figure.10 variations of brick density as a function of time

According to Figure.10 it can be seen that the density of compositions preserved in drinking water is higher than that of other compositions preserved in the open air; and for compositions preserved in aggressive water higher than that of other compositions preserved in drinking water. Since in the open air the evaporated mixing water and consequently causes voids and pores which reduce the density of the test specimens, on the other hand, drinking water and aggressive water occupy the pores which increase the mass.

The variation of the bending strength of the bricks according to the conservation media as a function of time is shown in the following figure:

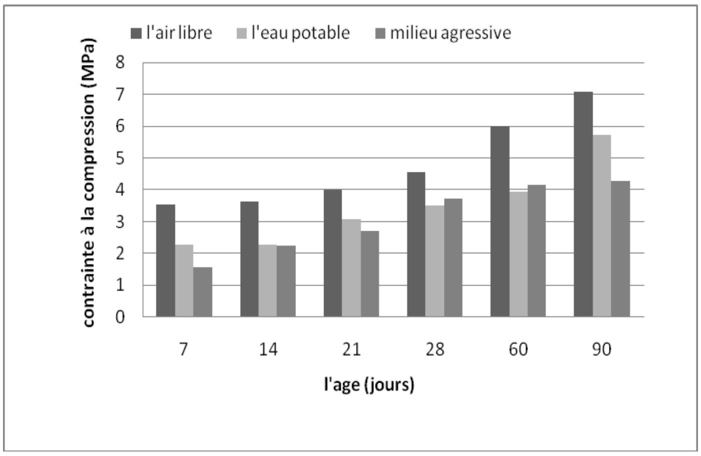

Figure.11 bending strength as a function of time

According to Figure.11 it can be seen that the bending tensile stress of the compositions stored in the open air is higher than that of the other compositions stored in drinking water; and the compositions stored in drinking water is higher than that of the other compositions stored in aggressive water.

For the flexural tensile strength of all specimens as a function of time, a clear increase is noted. This shows that white cement shows an improvement in strength.

The variation of the compressive strength of the bricks according to the conservation media as a function of time is shown in the following figure:

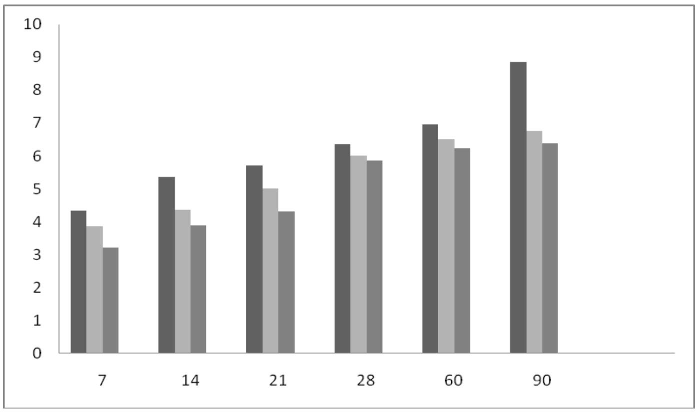

Figure.12 variations of the compressive strength of bricks as a function of time

According to Figure.12 it can be seen that the compressive stress of the compositions stored in the open air is higher than that of the other compositions stored in drinking water; and the compositions stored in drinking water is higher than that of the other compositions stored in aggressive water. The compressive strength of all specimens increases as a function of time. This shows that white cement improves mechanical resistance.

The variation of the sound propagation speed of bricks according to the conservation media as a function of time is shown in the following figure:

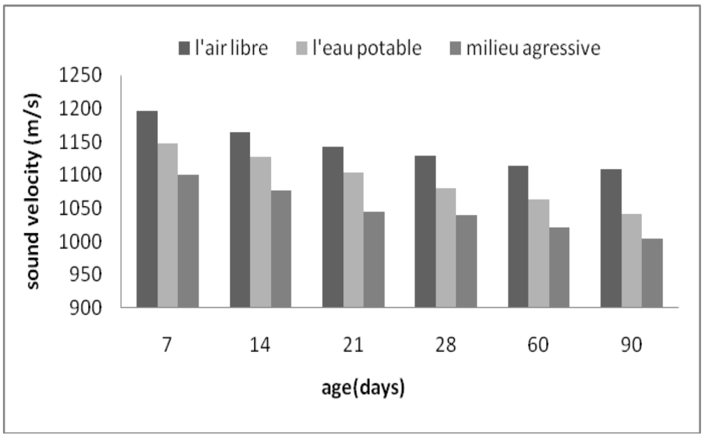

Figure .13 variations of sound speed as a function of time

From this figure we see that the values of sound propagation speed are decreased as a function of time. The values of speed of propagation of sound are maximum in the open air for example in 7 days equal to 1195.33 m/s and minimum in the aggressive medium equal to 1100.33 m/s because of the conservation medium.

4 Conclusion

The idea of producing a technical guide for the rehabilitation of the built heritage in Algeria was born out of the awareness of the dangers threatening this heritage. Therefore, the objective is to elaborate a scientific and technical basis that allows an adequate intervention with this heritage, while respecting its architectural and patrimonial characteristics. The analysis and interpretation of the results obtained after having carried out the tests for the determination of the mechanical and thermal properties of the bricks made, has allowed us to draw the following conclusion:

The composition C_2 stabilized by 2% white cement is marked as the best that gives good results in compressive and flexural strength and the sound velocity test confirms the mechanical results.

The addition of cement improves the mechanical strength but reduces its thermal resistance.

White cement retains its positive effect on the mechanical resistance of the traditional plaster brick depending on the weather in the open air, in drinking water and in aggressive environments.

If we compare our resistance results with the results of the references, we can say that our bricks are average to acceptable from the resistance point of view.

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