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Contribution to study of influence of different additions on thermo-mechanical properties of Adobe based on El Hadjira clay.

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Abstract

Our current research is oriented towards the valorization of local materials and the reduction of energy consumption with the aim of judicious use of these materials, and in front of the world economic crisis that also affects our region is that it is necessary to coexist with, and at the same time ensure the balance of nature by solving the problem of pollution that allows the survival of several species that constitute the important links for the balance of nature.

This research topic consists in the use of local materials for construction. The aim of this project is to evaluate the behavior of Adobe based on El-Hadjira clay by the addition of lime, white cement and plaster by different percentages from 1% up to 5%. This technical study is based on the application of tests for the mechanical and thermal characterization of the latter.

The results of these tests have shown that the percentage increase of plaster improves and decreases 5.75% of energy consumed. On the other hand, the addition of white cement increases 11.5% of energy consumed.

Keywords: Adobe, Clay, Gravel, Thermal characteristic, Energy consumption.

1. Introduction

In Algeria, earth construction has been widespread throughout its long history, particularly in rural and arid areas. Today, there is a renewed interest in this material. For a rational exploitation of the earth in the constructions of our region and more precisely in the production of Adobe, in order to manufacture building materials of quality, of affordable cost and which adapts itself with the severe climatic conditions of certain regions of Algeria and this to improve the situation of the population in front of the shortage of the habitat especially in the rural zones.

With this objective, this study is launched. From a global point of view, the aim is to study the influence of several additions on the thermo-mechanical properties of Adobe based on El Hadjira clay and the reduction of energy consumption.

2. Materials and methods

In this section, we study the characteristics of the different materials used in the manufacture of Adobe.

2.1. El-Hadjira clay

Raw clay generally contains elementary particles whose grain diameter is less than 2 micrometers (<2µm) which represent the crystalline individuals (pure mineral phase) called clay minerals responsible for its properties such as swelling, plasticity and adsorption properties.For our study we used El Hadjira clay.

Figure 1. clay of El Hadjira.

We performed the following tests on clay:

- Granulometric sedimentation analysis;

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- Chemical analysis;
- X-ray diffraction;
- Atterberg limit;
- Dry density;
- Methylene blue.

The results of sieve size analysis (the NF P 94-056 standard) and sedimentation sieve size analysis (the NF P 94-057 standard) are represented on the following curve:

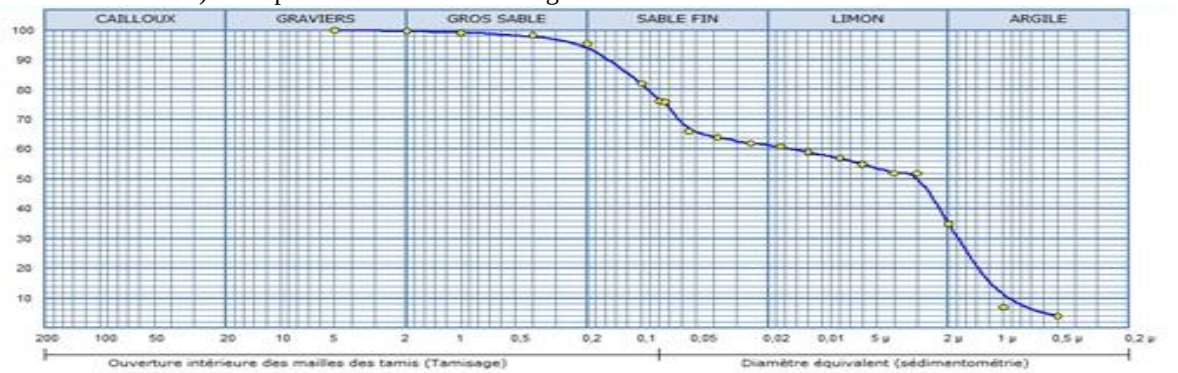

Figure 2. Particle size curve of clay of El Hadjira.

The results of the granulometric analysis by sedimentation show that our soil consists of approximately: 05% coarse sand, 33% fine sand, 27% silt and 35% clay.The results obtained are as follows:

Table 1. physical characteristics of clay

Characteristics	Résultat
The dry density (NF P 94/064)	P =2.06 g/cm^3
Methylene Blue (NF EN 933-9)	VBS = 4.8
Atterberg Limit (NF P 94-051)	WL= 46.50 % WP = 21.21 % IP = 25.29 %

According to Atterberg and Burmister, and by its plasticity index (IP = 25.29) our clay has a high plasticity.The main results of the chemical analysis are presented in the following table:

Table 2. Chemical analysis of clay

	Composants	Percentages(%)
Insolubles NF P 15–461	Insolubles	84
Sulfates BS 1377	SO_3	1
	Ca SO_4 / $2H_2O$	3
Carbonates NF P 15–461	SO_4	1
Chlorures méthode de MOHR	NaOH	10
	NaCl	1

X-ray diffraction (XRD)

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

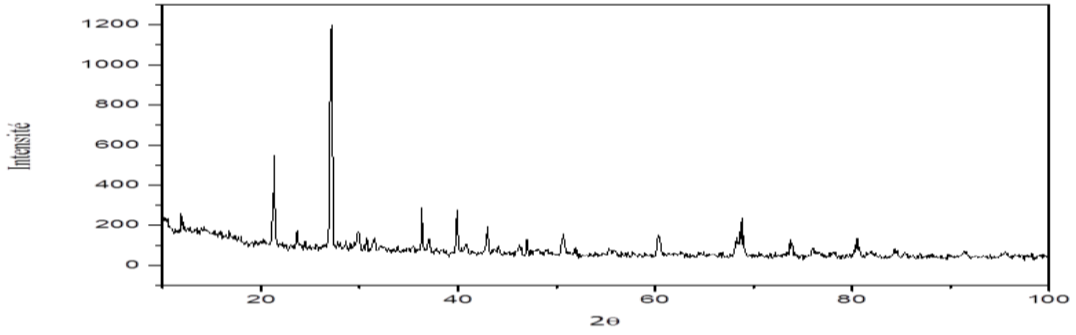

Figure 3. Diffractometric analyses of El Hadjira clay.

We note that the clay sample consists essentially of quartz and Montmorillonite associated minerals, as

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well as Bentonite.

2.2. Gravel

Gravel has origins similar to those of a sac rushed sand and, it comes from the disintegration of rocks. The maximum size of the aggregates is determined, on the one hand, by the minimum distance to be achieved and, on the other hand, by the minimum distance between the various reinforcements of the structure. The 3/8 fraction is considered as.

Figure 4. Gravels of Ouargla.

The results obtained are as follows:

Table 3. Physical characteristics of gravels

Test	classe 3/8	classe 8/15
The absolute density (kg/m^3)	2613	2661
The apparent density (kg/m^3)	1506	1460
Micro-Deval Test	10	11.2
Los Angeles Test	20	25

3. Results and Interpretations

The experimental study of our work consists in determining the thermal and mechanical characteristics of the Adobe based on local materials of dimensions (7x 7 x28) cm ,then different tests were carried out on the made samples. These tests are carried out at University of Ouargla ,Civil Engineering Laboratory, under the following conditions: Temperature (30 ± 5°C), and relative humidity RH= 35 ± 3%.

3.1. Obtaining the mixing water

Proctor tests

The purpose of the Proctor test is to determine the optimal moisture content for a given backfill soil to which it must be compacted to obtain the maximum dry density and fixed compaction conditions, which leads to the best possible compaction or maximum bearing capacity.

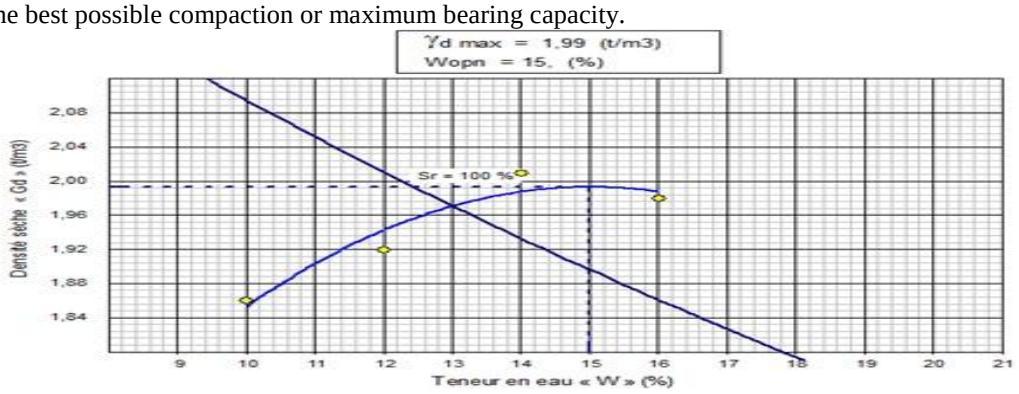

Figure 5. Clay Proctor Curve.

According to Proctor's tests, the optimal amount of water for the production of adobe based on El-Hadjira clay is 15%.

3.2. Adobe Treated by Lime

We proposed for our work the following five compositions (clay+ gravel (3/8 and 8/15) + lime):

Table 4. Used compositions based on Adobes Treated by Lime.

	Ch 0	Ch 1	Ch 2	Ch 3	Ch 4	Ch 5
clay %	**50**	**49**	**48**	**47**	**46**	**45**
Gravel 8/15 %	**10**	**10**	**10**	**10**	**10**	**10**
Gravel 3/8 %	**40**	**40**	**40**	**40**	**40**	**40**
Lime%	**00**	**01**	**02**	**03**	**04**	**05**

- **The reference composition: C0: 50% clay +10% gravel (8/15) +40% gravel (3/8).**

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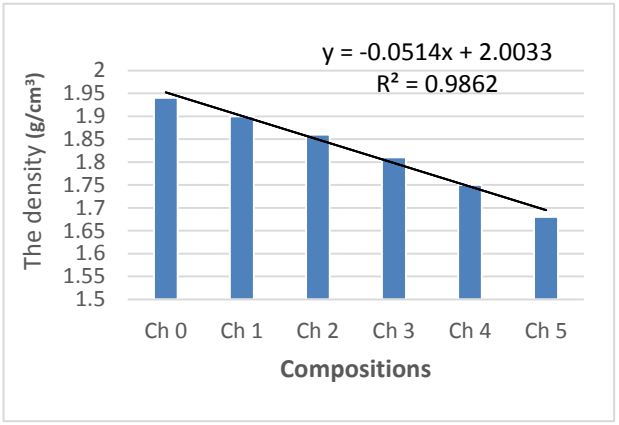
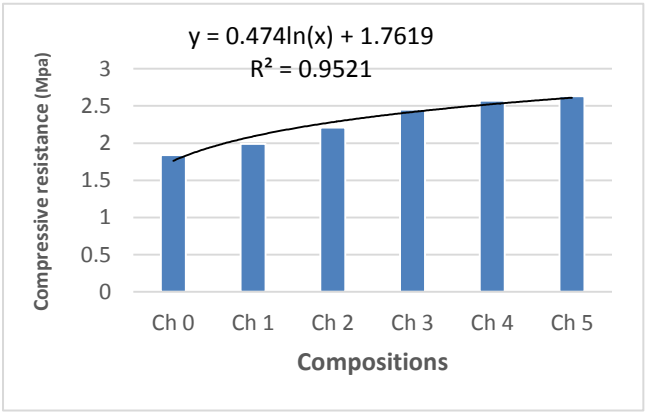
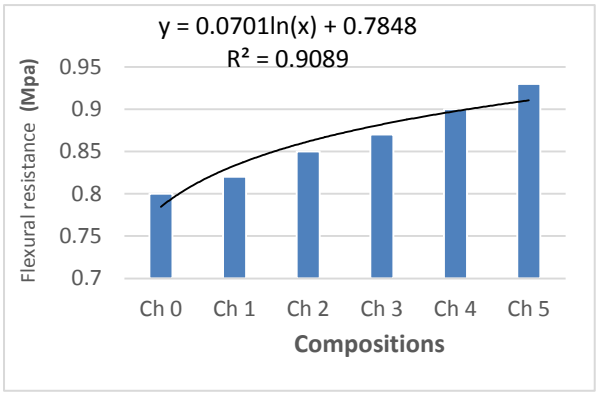
The following four histograms are displayed gives Figure 6: Shows the variation of the density of Adobes according to the different percentages of lime.

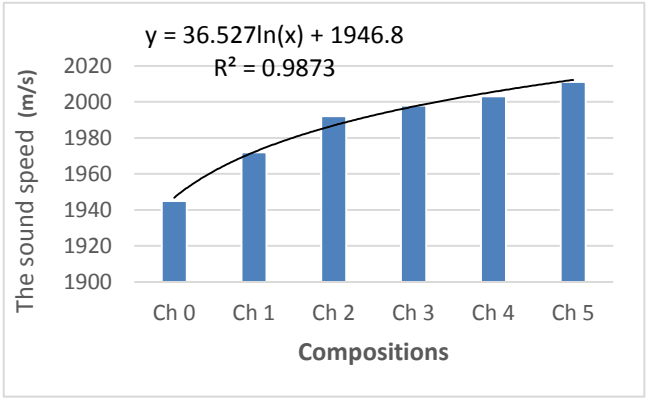
The results of the compressive resistance, Results of flexural resistance and Results of sound speed.





a. The variation of the density of Adobes (g/cm3). b. The compressive resistance (MPa).





c. The flexural resistance (MPa). d. The sound speed (m/s).

Figure 6. Results of the mechanical tests of Adobes Treated by Lime.

According to the experimentation one notices:

Note on curve (1) that the values are decreasing, and this is a return because the density of the clay is greater than the density of the lime.

The addition of lime gives a positive influence from a mechanical point of view (compression and bending).

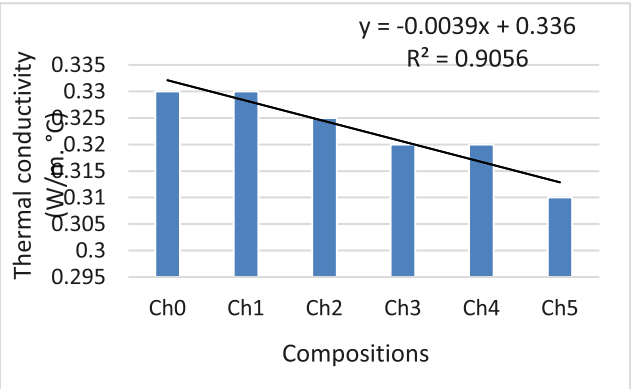
The compressive strength of Sample Ch5 has increased up to 43% compared to the reference sample Ch0.

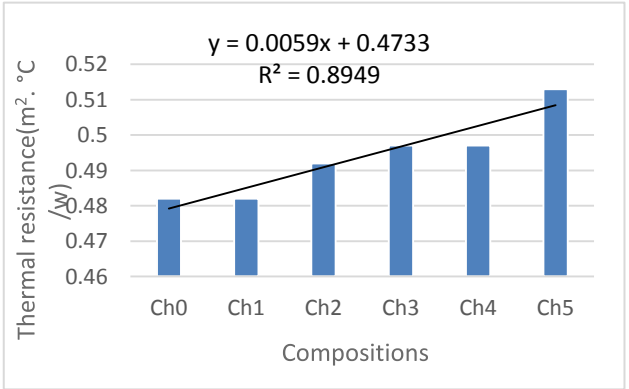
The Ch5 composition gives better results.

The test of the speed of sound confirmed the results of the mechanical tests (compressive and flexural strength).

The three following histograms are displayed gives Figure 7:

Shows the variation of the thermal properties of Adobes according to the different percentages of Lime.





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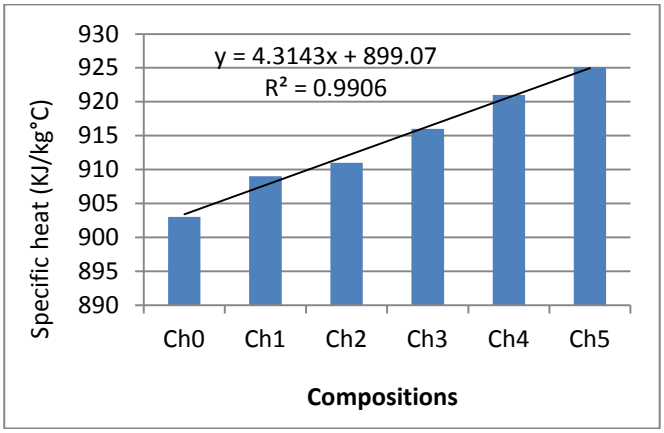
a. Thermal conductivity (W/m. °C). b. Thermal resistance (m2. °C /W).



c.Specific heat (KJ/kg°C).

Figure 7. Results of the thermal tests of Adobes Treated by Lime.

According to the experimentation one notices:

A convergence of the thermal results.

The treatment of Adobe with lime gives a positive influence from a mechanical point of view, but does not influence the thermal side.

The thermal resistance is almost stable in spite of the increase of the percentage of lime.

The samples generally give a good thermal behavior.

3.3. Adobe stabilized by white cement

We proposed for our work the following five compositions (clay + gravel (3/8 and 8/15) + white cement):

Table 5. Used compositions of Adobe stabilized by White Cement.

	Cb0	Cb 1	Cb 2	Cb 3	Cb 4	Cb 5
Argile%	**50**	**49**	**48**	**47**	**46**	**45**
Graviers 8/15%	**10**	**10**	**10**	**10**	**10**	**10**
Graviers 3/8%	**40**	**40**	**40**	**40**	**40**	**40**
Ciment blanc %	**00**	**01**	**02**	**03**	**04**	**05**

- **The reference composition: C0: 50% clay +10% gravel (8/15) +40% gravel (3/8).**

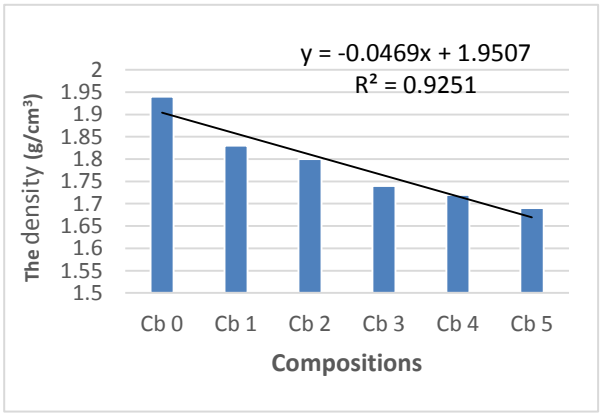
The following four histograms are displayed gives Figure 8:

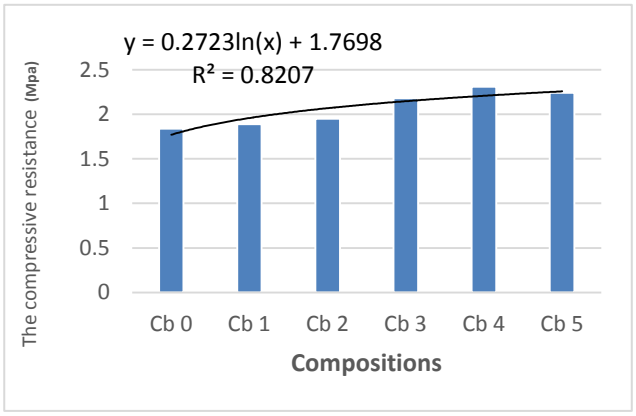
Shows the variation of the density of Adobes according to the different percentages of lime.

The results of the compressive resistance.

Results of flexural resistance.

Results of sound speed.





a. The variation of the density of Adobes (g/cm3). b.Thecompressive resistance (MPa).

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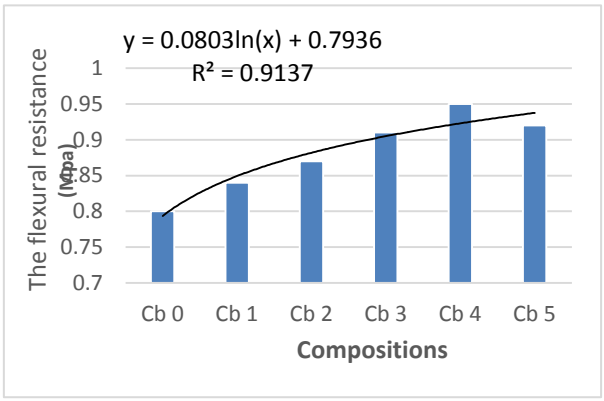
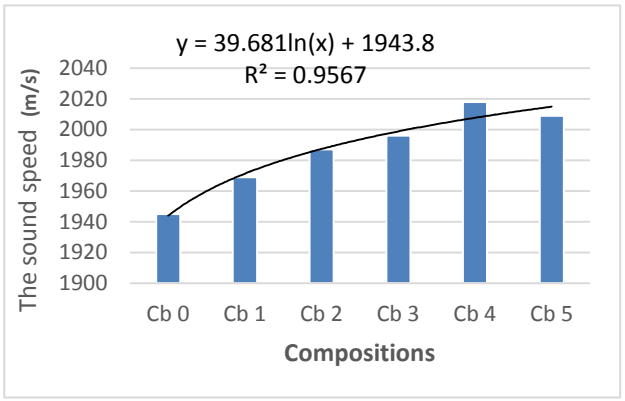




c. The flexural resistance (MPa). d. The sound speed (m/s).

Figure 8. Results of the mechanical tests of Adobe white cement stabilized.

According to the experimentation one notices:

Note on curve (1) that the values are decreasing, and this is a return because the density of clay is higher than the density of white cement.

The compressive strength of all compositions is very close and is acceptable according to Table I.1 (Rc=1.89< 2Mpa).

The compressive strength of the Cb4 Sample has increased up to percentage 25% compared to the reference sample Cb0.

The white cement acted as a binder, which increased the flexural and compressive strength (giving a positive influence from a mechanical point of view) by up to 4%.

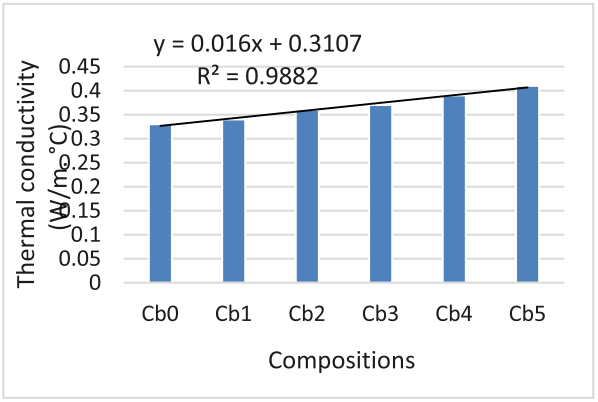
The C4 composition gives better results.

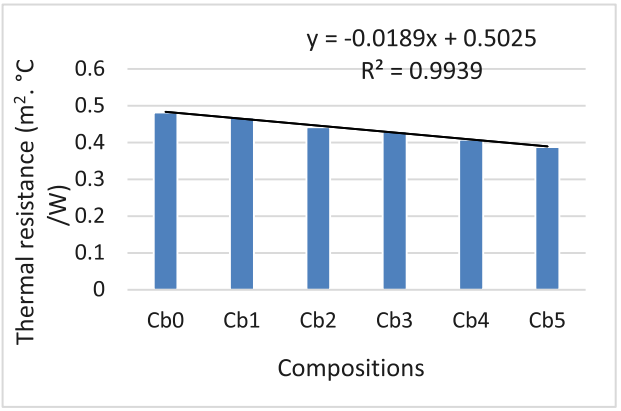
The flexural and compressive strength of the sample (C5) is low from a mechanical point of view, and this is due to the white cement coating for the sample granules, which reduced their strength.

The sound velocity test confirmed the results of the mechanical test (compressive and flexural strength).

The three following histograms are displayed gives Figure 9:

Shows the variation of the thermal properties of Adobes according to the different percentages of white cement.





a.Thermal conductivity (W/m. °C). b. Thermal resistance (m2. °C /W) .

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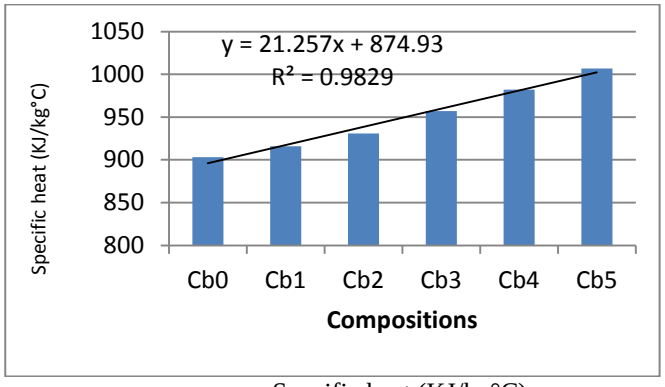


c. Specific heat (KJ/kg°C).

Figure 9. Results of thermal testing of Adobe white cement-stabilized.

According to the experimentation one notices:

The addition of white cement has a positive influence on the mechanical side, but a passive influence on the thermal side.

The passive influence of white cement addition is due to its weakness on the thermal side.

In spite of the imperfect results it is still acceptable.

3.4. Adobe stabilized by plaster

We proposed for our work the following five compositions (clay + gravel (3/8 and 8/15) + plaster):

Table 6. Used compositions based on Adobe stabilized by plaster.

	P 0	P 1	P 2	P 3	P 4	P 5
Argile %	50	49	48	47	46	45
Graviers 8/15 %	10	10	10	10	10	10
Graviers 3/8 %	40	40	40	40	40	40
Plâtre %	00	01	02	03	04	05

- **The reference composition: P0: 50% clay +10% gravel (8/15) +40% gravel (3/8).**

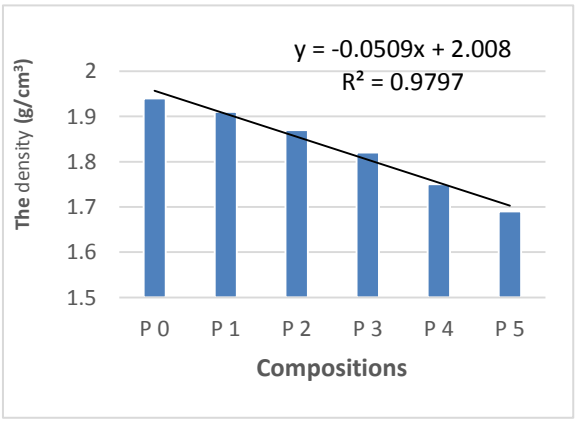
The following four histograms are displayed gives Figure 10:

Shows the variation of the density of Adobes according to the different percentages of gypsum.

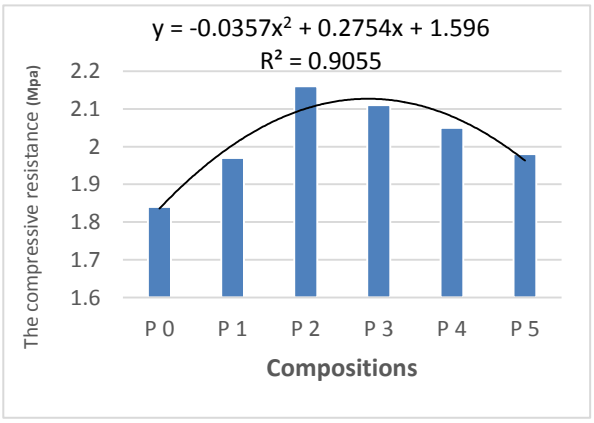
The results of compressive strength.

The results of flexural strength.

The results of sound speed.



a. The variation of the density of Adobes (g/cm3).



b. The compressive resistance (MPa).

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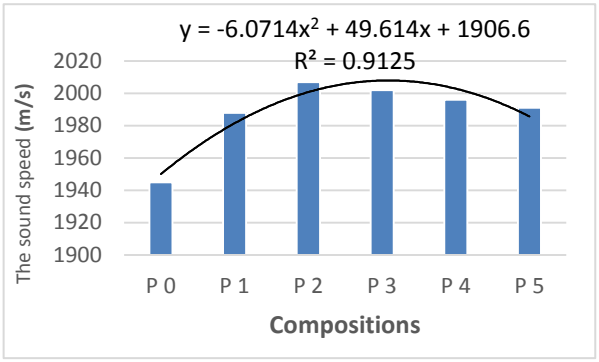
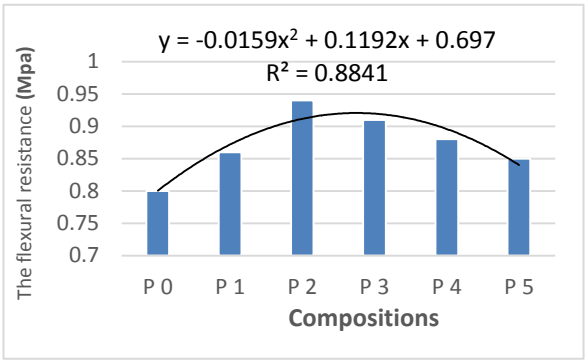


d. The sound speed (m/s).



c. The flexural resistance (MPa)

Figure 10. Results of the mechanical tests of Adobe stabilized by plaster.

According to the experiment one notices:

Note on curve (a) that the values are decreasing, and this is a return because clay density is higher than plaster density.

An increase and decrease in the values of compressive and flexural strength, This phenomenon is explained in two phases :

- Phase 1: An increase in compressive and flexural strength in terms of increasing the percentage of plaster up to 2%, which is under the influence of the plaster that ensures a good cohesion of the mixture.

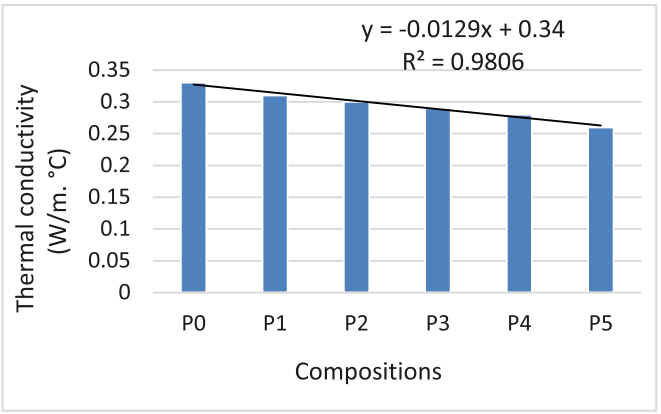
- Phase 2: Decrease in compressive and flexural strength from the percentage 3% the plaster in this phase plays a passive role between the aggregates of the compositions (the plaster coats the granules of the samples).

The compressive and flexural strength of the samples is acceptable.

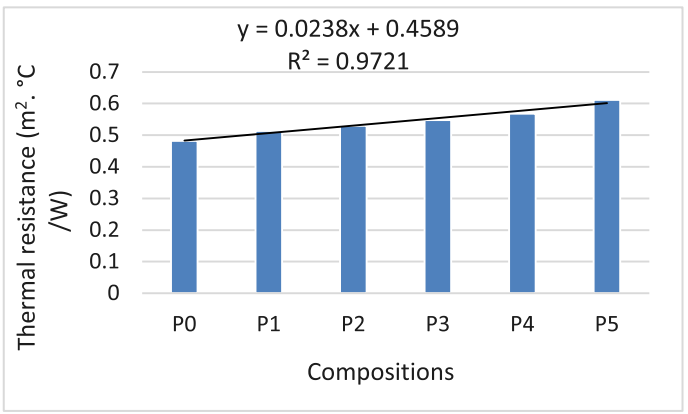
P2 composition gives better results.

The three following histograms are displayed gives Figure 11:

Shows the variation of the thermal properties of Adobes according to the different percentages of plaster.



a.Thermal conductivity (W/m. °C).



b.Thermal resistance (m2. °C /W)

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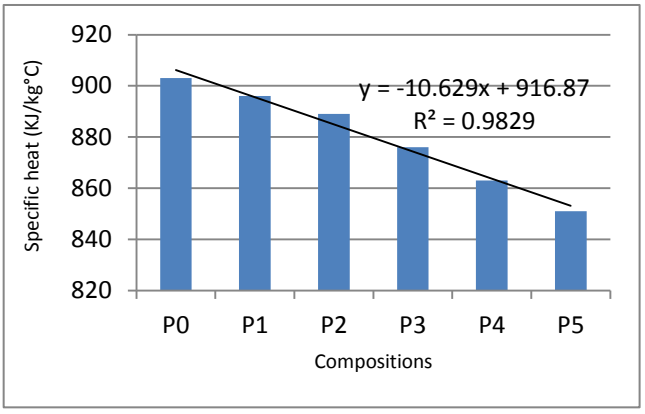

c.Specific heat (KJ/kg°C).

Figure 11. Results of the thermal tests of Adobe stabilized by plaster.

According to the experiment one notices:

An increase in thermal resistance in terms of the increase in the percentage of plaster (The addition of plaster gives a positive influence on the thermal side).

The positive influence of the addition of plaster is due to the thermal conductivity of the plaster.

The thermal resistance has automatically increased because it is inversely proportional to the thermal conductivity.

4. Energy consumption

4.1. Climate Analysis of Ouargla city

Ouargla city extends over an area of 270030 km2 and is located at a latitude of 31°57N and longitude 5° 21 'E, and at 146 meters of altitude, at a distance of 780 km from Algiers. The situation of Ouargla, in a limited area to the south by the Sahara with its arid climate and to the north by its temperate climate, allows him to have specific characteristics. According to the classification given by architectural Recommendation Ouargla city belongs to the climate zone E4 in summer and H3c in winter, which has two main seasons:

A summer more hot and dry, or the difference in temperature is important.

A winter cold and dry, with a significant difference in temperature.

Figure 12.Geographical situation of the wilaya of Ouargla.

4.2. Temperature

The region of Ouargla is characterized by very high temperatures; the months most hot is the month of July with 44.68 °C and the average temperature minimum of the coldest month is of 15°C in the month of January. The average annual temperature is 30.73°C .

4.3. The winds

In the region of Ouargla the winds are very variables during the course of the year. They blow from the north-south and dominate in the region of study in summer and can cause damage, especially in the absence of vegetation cover with a maximum speed of 4.61 m/s. The annual average wind speed is 3.62 m/s

4.4. Energy consumption of Ouargla city

The air conditioning is the cause not only of the call requested relief but also to the triggering of the departures of supply after the overheating of conductors causing incidents of power cuts

In the following we give some statistical data obtained of the mines branch of Ouargla city

Table 7. Electricity consumption of Ouargla city.

The month	January	February	July	August
Number of subscribers	73381	73991	75192	75448
Consumption /subscriber	419	345	594	872

KWh/subscriber

Unit calculations relating to the components of the walls and measurement of the necessary parameters (Tmax=49.1 et Tconf=30).

$$Q = m\ cp\ (\ tf - ti) \quad \text{.....(1)}$$

The figure shows the variation in energy consumed as a function of the percentage of additions.

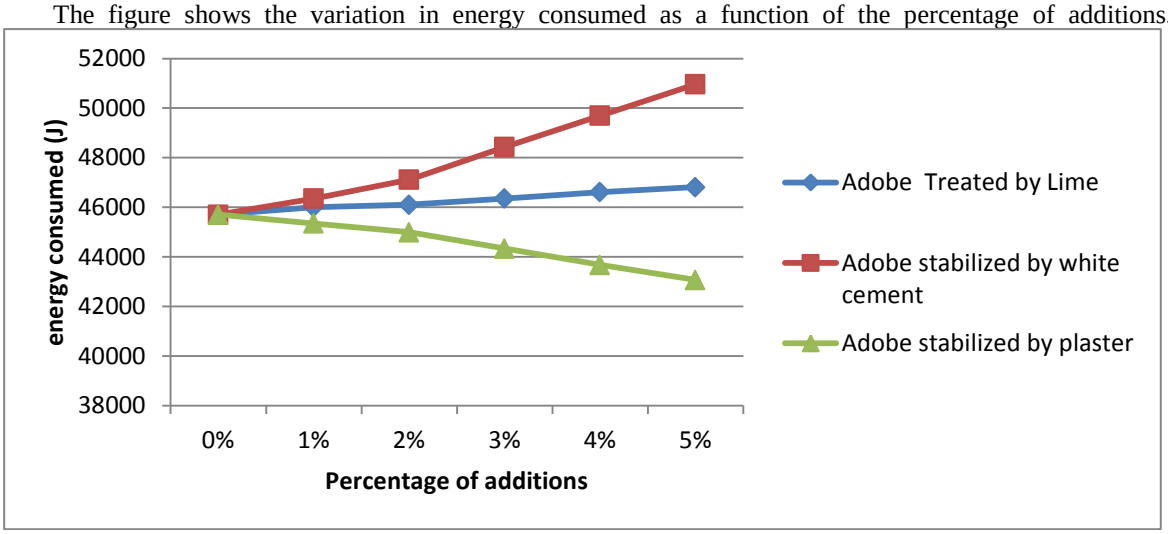

Figure 13. The variation in energy consumed as a function of the percentage of additions.

According to these results, it is observed that.

The addition of cement has a negative influence on the thermal behavior that automatically influences energy consumption, we notice an increase of 11.5% in the energy consumed.

The addition of gypsum reduces the energy consumption due to its thermal properties, we notice a decrease of 5.75% of the consumed energy.

5. Conclusion

According to the experimental study on the thermal and mechanical properties of different compositions, the following conclusions can be drawn:

The influence of the addition of stabilizer results in a lighter Adobe and better thermal and mechanical performance.

The compressive strength of Adobe increases up to 43% compared to the reference sample in the case of Lime Treatment.

The percentage increase in plaster is useful to improve thermal properties.

The addition of white cement increases the compressive strength by up to 25%.

The addition of white cement increases the energy consumed (11.5%), the addition of white cement decreases the energy consumed (5.75%).

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