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Stabilization Study Of Earth Bricks Reinforced By Date Palm Fibers With Lime.

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ABSTRACT

The south of Algeria have a hot and dry climate in summer, cold and dry in winter. The building materials commonly used in these regions are concrete, which have poor thermal properties. The objective of this work is to achieve a level of thermal comfort with reduced energy consumption and acceptable mechanical strength with reduced cost. For this, we tried to make bricks with good thermal and mechanical characteristics based on local materials. This research is the result of experimental work in two major areas of applied science — building mechanics and building thermals. The objective of this work is the study of the mechanical and thermal properties of clay bricks chosen as a reference material reinforced with lime stabilized date palm fibers. Within this framework, seven lime contents (5, 10, 15, 20, 25, 50, 75%) were used in the making of the bricks, followed by mechanical and thermal tests at the end to obtain a general synthesis.
Keywords: Thermal Properties, Mechanical Properties, Sand, Clay, Lime, Fibers, Brick.

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INTRODUCTION

The Algerian south, and seen the aridity of the climate, buildings are responsible for more than 70% of the consumption of electricity in summer, the solution is to install an electric air conditioning in each room to ensure summer comfort.

The price of building materials used therefore depends on the international market constantly destabilized by the economic crisis coupled with the energy crisis in recent times. To produce a living environment at lower cost, it is important to avoid the influence of energy costs by upgrading local building materials.

The Saharan regions of Algeria possess several local materials (clay, gypsum ...) which are formerly proven their thermal efficiency. It is important to upgrade these resources by combining new technologies to meet the time, cost and quality requirements.

In this objective, Exploitation and Valorization of Natural Resources in Arid Zones Laboratory launches this study. From a global point of view, the goal of our research is to make a brick based on local materials: clay, dune sand, lime and date palm fibers. Then proceed to its thermal and mechanical characterizations.

Climatic analysis of Ouargla city

The city of Ouargla covers an area of 270030 Km^2 and it located at a latitude of 31°57 N and longitude 5°21 E, and at 146 meters altitude, at a distance of 780 km from the capital Algerian. The situation of Ouargla, in an area limited to the south by the Sahara with its arid climate and north by its temperate climate, allows it to have specific characteristics.

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Figure 1: Location of the wilaya of Ouargla.

Temperature

The region of Ouargla is characterized by very high temperatures; the warmest month is July with 48°C and the minimum average temperature of the coldest month is 15°C in January. The average annual temperature is 30.73°C.

Average humidity

Generally, the air of Ouargla is very dry. The humidity varies from one season to another. The average humidity is 42.06%. The maximum humidity is 59.92% for the month of December, the minimum humidity is 25.33% for the month of July.

The winds

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

Energy consumption of Ouargla city

Air conditioning is the cause not only of the demand of load requested but also the triggering of the feeders following the overheating of the drivers thus causing incidents of power cuts.

Table 1: Electricity consumption of the city of Ouargla (2018).

The month	January	February	July	August
Consumption (KWh)	30.782.338	25.552.829	44.639.145	65.824.670
Number of subscribers	73381	73991	75192	75448
Consumption / subscriber	419	345	594	872

MATERIALS AND METHODS

Sand dunes

For our study we used the sand from the dunes of the south of Algeria (Ouargla). We performed the following tests:

- Absolute density
- The apparent density
- Equivalent of Sand
- Chemical analysis

The results obtained are as follows:

Figure 2: Dune sand.

Table 2: Physical characteristics of sand dunes

Testing	Result
Absolute density	$\rho a=2559\ kg/m^3$
The apparent density	$\rho s=1512\ kg/m^3$
Equivalent of Sand	ESp=98%

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Chemical Analysis

The following table shows the percentages of the chemical components of dune sand.

Table 3: Sand chemical compositions

Components	Percentages (%)
$Fe\ 2O_3$ - $AL2\ O_3$	0.25
$Ca\ SO_4$, $2H_2O$	2.78
SO_4	0.51
$Ca\ CO_3$	1.30
Insoluble	93.23
NaCl	Trace
Fire loss	1.16

We note that the percentage of ($Ca\ SO_4$), (SO_4) is below the recommended limit. As a result, the sand used is not-aggressive.

X-ray Diffraction

The curve represents the results obtained for dune sand.

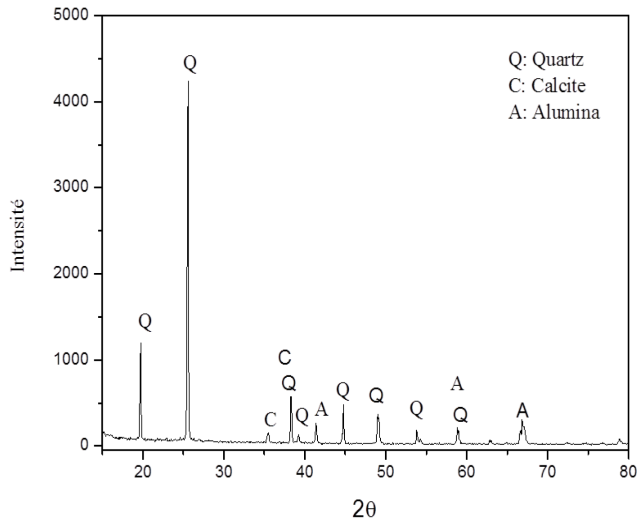

Figure 3: Diffractometric analysis of dune sand.

Depending on the measurements made from the diffractogram, the following can be observed:

- Quartz forms a large part of the minerals with a percentage of 80%.
- Gypsum is found in the form of fine, whitish grains with a percentage of about 3%.
- Feldspar and calcite are present with low percentages in the 10% range

The clay

For our study we used Ouargla clay. We performed the following tests on this clay:

- Dry density
- Methylene blue

- Atterberg limit
- Chemical analysis

Figure 4: The Clay

The results are presented in Table 4.

Table 4: Physical characteristics of clay.

Characteristics	Results
Dry density (NF P 94/064)	P =1.99 g/cm^3
Methylene blue (NF EN 933-9)	VBS = 8
Atterberg limit (NF P 94-051)	W_L= 69.58 % W_P = 24.71 % I_P = 44.87 %

Chemical Analysis

The main results of the chemical analysis carried out are grouped in the following table:

Table 5: Chemical compositions of clay

Chemical Characteristics	Components	Percentages (%)
Insoluble (NF P 15 – 461)	Insoluble	63.18
Sulfates (BS 1377)	SO_3 $Ca\ SO_4$ / $2H_2O$	0.45 2.46
Carbonates (NF P 15 – 461)	$CaCO_3$	18.0
Chlorides	Cl NaCl	0.42 0.68

The table shows that the elements of this clay are insoluble in percentage of about 64%, the contents of Sulfates and chlorides are very low

X-ray Diffraction

The curve represents the results obtained for clay.

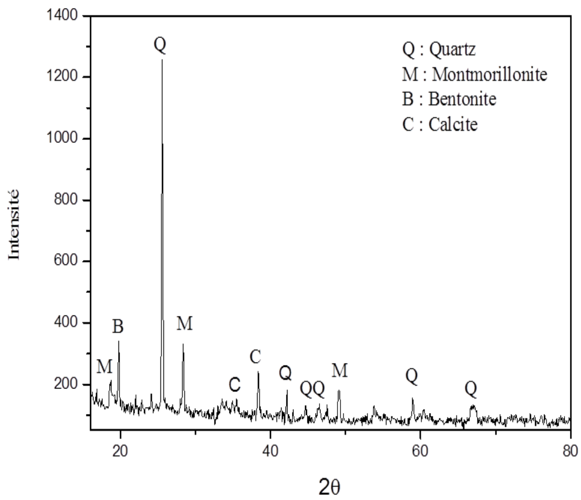

Figure 6: Diffractometric analyses of clay.

The sample consists essentially of associated minerals of quartz and Montmorillonite, as well as other phases that are not to be ruled out. The intensities of this diffractogram show that quartz is the dominant phase, in fact peaks 42.20, 55.02, 60.36, 76.04 (2 θ) , are characteristic of this material, as is Montmorillonite, its presence in the sample is determined by the main peaks at 19.76, 24.11, 35.53 and 53.87 (2θ)

Fibers

The fibers used in this study are date palm fibers from dokar.Mr KRIKER after these studies on four types of date palm surface fiber (dokar, deglette nour, degla bida and elghers fibers) , he found that dokar fibers give the best result in terms of tensile strength. This is why our choice is made for dokar fibers.

Figure 7: (a)The face-lif after it has been pulled out of the date palm (b) Fibers cut into pieces.

Characteristics of Date Palm Fibers

The tests carried out on the fibers by Mr KRIKER made it possible to characterize the date palm fibers of Ouargla as a continuation in the table 6:

Table 6: The physical and mechanical characteristics of the fibers used

Characteristics	Results
Apparent density	ρa= 512.21 - 1088.81 Kg/m^3
Absolute density	ρ s= 1300 - 1450 Kg/m^3
Tensile strength [MPa] Deformation at break Humidity level Water absorption rate (after 24H) Diameter (fibersused)	L=100mm L=60 mm L=20 mm 170 240 290 ε= 0.232 w = 9.5 - 10.5 % TA = 96.83 - 202.64 % d = 0.1 - 1 mm

Mineralogical compositions of Date Palm Fibers

Spectra chemical analysis of the fiber powder after calcination at 400°C gave the following:

Table 7: Mineralogical analysis of calcined fiber powder at 400°C.

Element	Percentage(%)
SiO_2	48.04
$Al2O_3$	6.12
$Fe2O_3$	2.51
MgO	4.88
CaO	14.21
Na2O	1.81
Fire loss	18.08

We find that the fibers used contain a remarkable rate of SiO_2 and CaO.

Analysis of Organic Materials

The analysis of the organic materials of the dokar fibers, gave in the following table the proportions of cellulose, hemicellulose and lignin.

Table 8: The main organic constituents of fibers.

Material	Proportion (%)
Ash	1.2 ± 0.3
Cellulose	43 ± 2
hemicellulose	8 ± 2
lignin	35 ± 5

We find that these fibers have relatively low levels of cellulose and hemicellulose compared to that of sisal fibers. On the other hand, the cellulose and lignin levels are similar to those of the coconut fibers given by the literature. Remember that cellulose is the essential element from the point of view of resistance.

Results and Interpretation

We have proposed for our work the following compositions (clay + sand + fiber + lime) in addition to the reference composition A (67% clay + 30% sand + 03% fiber):

- Composition C0: A;
- Composition C1: A + 5% Lime;
- Composition C2: A + 10% Lime;
- Composition C3: A + 15% Lime;
- Composition C4: A + 20% Lime;
- Composition C5: A + 25% Lime;
- Composition C6: A + 50% Lime;
- Composition C7: A + 75% Lime.

Density

A variation of the density of the bricks according to the different percentages of lime is presented on fig.8.

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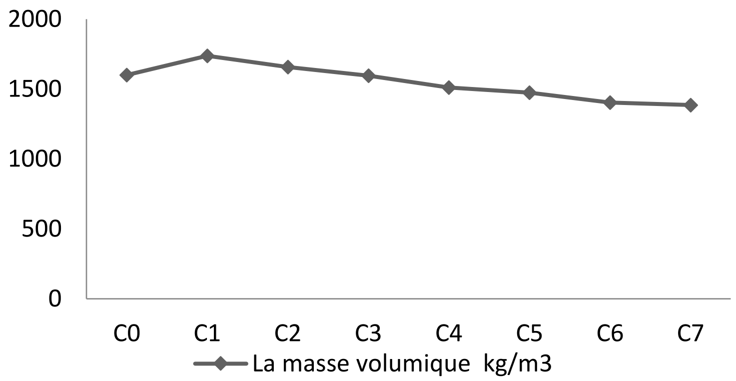

Figure 8: Variation of the density

We notice a reduction in the density of the bricks according to the increase in the percentages of the lime, in fact the density of clay is greater than that of lime.We notice that the density of the samples (C1) is the highest with 5% lime

Flexural Strength

Figure 9 represents the variation of the flexural strength as a function of the variation of the percentage of lime.

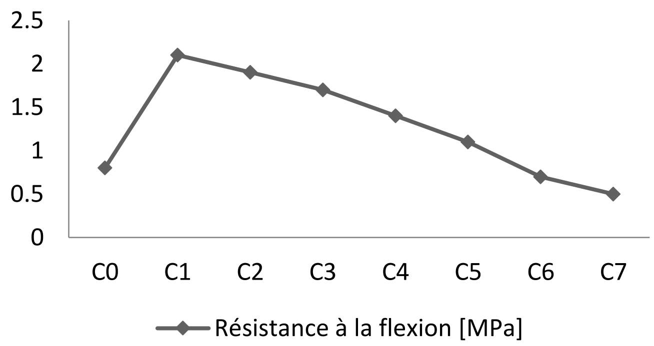

Figure 9: Flexural strength of clay bricks

We can see a reduction of the flexural strength of the bricks compared to the control bricks (Rf= 0.8MPa) where ca maximum value is noted in the composition C1 with Rf= 1.9MPa which means that the cohesion and adhesion of the matrix is high.

- There is a slight decrease in the flexural strength of the bricks after reaching the maximum value.
- The flexural strength of the samples (C2 C3 C4 C5 C6 C7) is lower than that of the sample (C1), this is due to the presence of lime with higher contents.

Compressive strength

From figure 10 a decrease in the compressive strength of the bricks compared to the control bricks (Rc= 0.8MPa) is noted in the composition C1 with Rc= 2.1MPa as proof of the good adhesion between these grains.

It should be noted that the compressive strength values up to C4 with 20% of the lime, are always higher than those of the control bricks.

An increase in the resistance outside the addition of lime with a percentage of 5% improves the behaviour of the clay.

A decrease of the resistance according to the increase of the percentages of lime more than 5% is due to the density of the smaller lime.

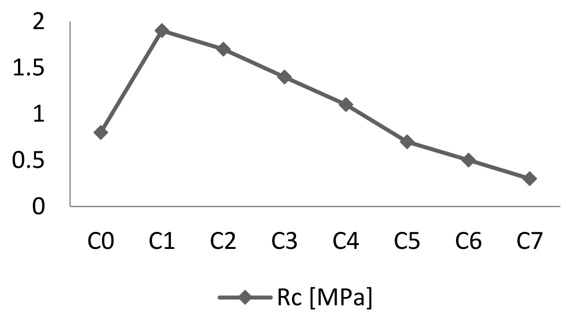

Figure 10: Compressive strength

Sound propagation speed

From figure 11 we see an increase in the speed of sound propagation from C1 as a function of the increase in the percentages of lime.

The speed of propagation of sound in bricks is an index that defines the void rate in the matrix, which has a direct influence on the density , the compressive strength and the thermal insulation.

The choice of the bricks depends on the speed of the sound which gives a suitable compression resistance.

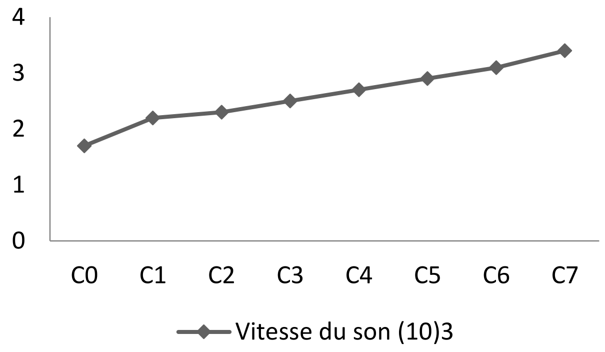

Figure 11: The sound propagation speed.

The thermal conductivity

According to figure 12, a reduction in the thermal conductivity can be seen as a function of the increase in the cement dosage.

From the results of this figure we can observe that the conductivity varies in the opposite direction to the increase in the % of lime.

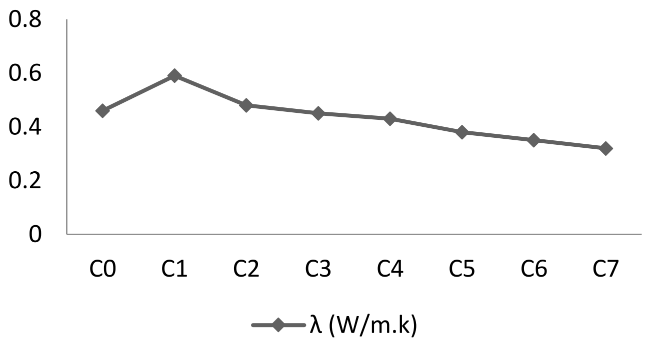

Figure 12: Thermal conductivity

Thermal resistance

The figure 13 shows that the thermal resistance has automatically increased because it is inversely proportional to the thermal conductivity.

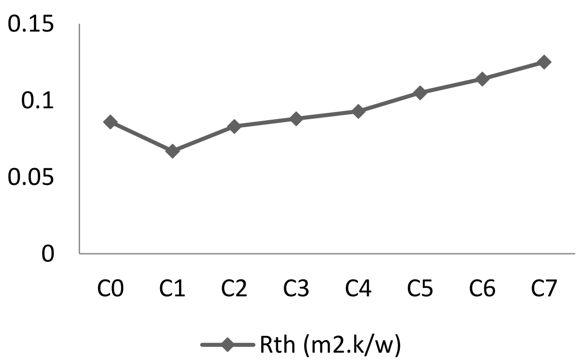

Figure 13: Thermal Resistance

Specific heat

From figure 14 it can be seen that the specific heat decreases according to the percentage of lime in the mixture. This is logical because theoretically Cp varies in the same direction as the thermal conductivity λ.

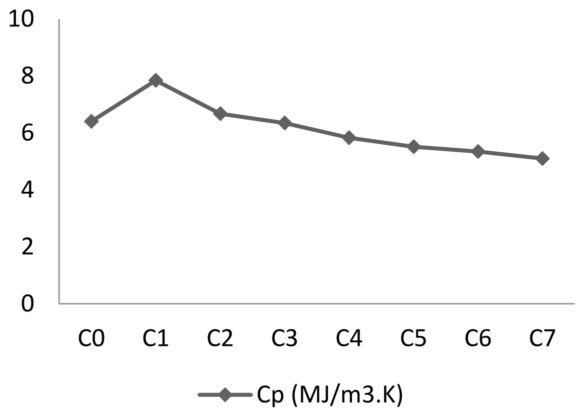

Figure 14: Specific heat

CONCLUSION

In this work, the effect of the addition of lime on mechanical properties was studied. After the analysis of the results we can formulate the following conclusions:

- The increase in the percentage by mass of the additions significantly improves the flexural strength and the compressive strength of the bricks, especially those treated with lime.
- The addition of lime in the bricks decreases the density and the thermal conductivity which increases the thermal resistance. The C2 composition gave the best thermo-mechanical result.
- The results of the propagation speed of ultrasonic waves confirm our results of mechanical resistance.

The high percentage of lime has a negative effect on bricks made from a mechanical point of view In the thermal side, high percentage of lime give good results that is to say a reduced energy consumption with the exploitation of natural resources

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