

The influence of the addition of date palm fibers on the thermo-mechanical proprieties of the earth bricks.

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Abstract— Algeria is located in an area with a high solar potentiality, and presents nearly 90 % of arid and semi-arid lands, of this fact it is important to look at the current situation of Saharan cities. The objective in the context of this work is the achievement of a level of thermal comfort with a lower energy consumption and a mechanical resistance acceptable with a reduced cost. For this, we have tried to make bricks with good thermal characteristics and mechanical basis of three local materials: namely the clay of Baldet Amer the sand dune of Sidi Khouiled and fibers of date palm.

Keywords—Saharan Regions, Thermal properties, Mechanical properties, Sand Dune, Clay, Brick

I. INTRODUCTION

The south of Algeria, and view the aridity of the climate, the buildings are responsible for more than 70 per cent of the consumption of electricity in the summer period, the solution is to install an electric air conditioning in each room to ensure comfort summery [1].

The price of construction material used therefore depends on the international market constantly destabilized by the economic crisis coupled with the energy crisis in recent times. To produce a framework of life at a lower cost, it is important, therefore, to circumvent the influence of the cost of energy by upgrading the local materials of construction.

The Saharan regions of Algeria have several local materials (clay, gypsum etc.) which are formerly proved their thermal efficiency [2]. It is important to enhance these resources by bringing in new technologies in order to comply with the requirements of time, cost and quality.

In this objective, this study is launched. Of a global point of view, the aim of our research is to fabricate a brick at base of three local materials: namely the clay, sand dune and the fibers of date palm. In later proceed with its characterizations thermal and mechanical.

II. CLIMATE ANALYSIS OF THE CITY OF OUARGLA

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The city of Ouargla extends over an area of 270030 km² and is located at a latitude of 31°57'N and longitude 5° 21' E, and at 146 meters of altitude, at a distance of 780 km from Algiers see figure 1.

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 the city of Ouargla belongs to the climate zone E4 in summer and H3c in winter, which has two main seasons: [3]

- A summer more hot and dry or the difference in temperature is important.
- A winter cold and dry, with a significant difference in temperature.

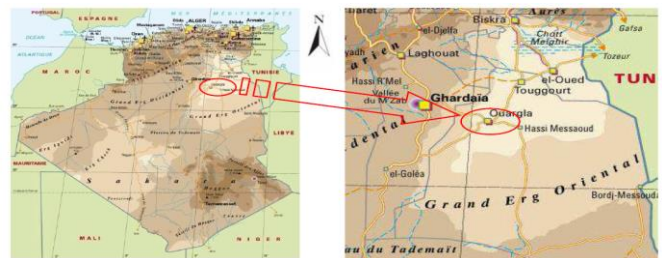


Figure.1. Geographical situation of the wilaya of Ouargla .

A. Temperature

The region of Ouargla is characterized by very high temperature; the hottest month 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 [2].

B. Average Moisture

Generally, the air of Ouargla is very sec. The humidity varies from one season to another. The average humidity is of 42.06 %. The maximum humidity is of 59.92 per cent for the month of December, the minimum of moisture is of 25.33 per cent for the month of July [2].

C. The winds

In the region of Ouargla the winds are very variables during the course of the year. They blow from the north south (sirocco) 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 4.61in.) Long m/s. The annual average wind speed is 3.62 m/s [2].

D. Energy consumption of the city of Ouargla

The air conditioning is the cause not only of the call-required load 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 the wilaya of Ouargla

TABLE 1. ELECTRICITY CONSUMPTION OF THE CITY OF OUARGLA (YEAR 2014)

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
	KWh/particip	KWh/particip	KWh/particip	KWh/particip

III. MATERIALS AND METHODS

A. The sand dunes

For our study, we used the sand dunes of Sidi-Khouiled (Ouargla). We performed the following tests:

- The mass density absolute.
- The apparent density.
- Equivalent of sand.
- Chemical analysis.

These analyzes are conducted at the laboratory of Civil Engineering from the University of Kasdi Merbah Hon. Members' Ouargla, for all the tests we used three samples in each characteristic. The results obtained are the following:

TABLE 2. PHYSICAL CHARACTERISTICS OF SAND DUNES

Test	Result
The mass density absolute	$\rho_s=2560$ Kg/m ³
The apparent density	$\rho_a=1512.5$ Kg/m ³
Equivalent of Sand	ESP=99, +23 %

Chemical Analysis

The following table shows the percentages of the chemical components of sand dunes. This analysis is carried out in the laboratory of public works of the South (L. T. P. S) Unit of Ouargla.

TABLE 3. CHEMICAL COMPOSITIONS OF SAND

Components	Percentages (%)
Fe 2O3 - AL2 O3	0.25
Ca SO4, 2H2O	2.78
SO4	0.51
Ca CO3	1.30
Insoluble	93.23
Na cl	Trace
Loss to Fire	1.16

We note that the percentage of the (CaSO₄), (SO₄) is lower than the recommended limit. Of this fact, the sand used is non-aggressive.

B. The clay

For this research, we have used the clay of Touggourt to Ouargla. We performed the following tests on the clay:

- Dry Density
- Methylene Blue
- Limit of Atterberg
- Chemical Analysis

These tests are carried out in the laboratory of public works of the South (L. T. P. S) Unit of Ouargla. The results presented in table 4.

TABLE 4. PHYSICAL CHARACTERISTICS OF SAND DUNES

Characteristics	Result
The dry bulk density (NF P 94/064)	P =2.03 g/cm ³
Methylene Blue (NF 933-9)	VBS = 8
Limit of Atterberg (NF P 94-051)	WL= 69.58 % WP = 24.71 % IP = 44.87 %

Chemical Analysis

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

TABLE 5. CHEMICAL COMPOSITIONS OF THE CLAY

Chemical Characteristics	Components	Percentages (%)
Insoluble(NF P 15 - 461)	Insoluble	63.18
Sulphates (BS 1377)	SO ₃	0.45
	Ca SO ₄ / 2H ₂ O	2.46
Carbonates (NF P 15 - 461)	CaCO ₃	18.0
Chlorides (MOHR'S method)	Cl-	0.42
	NaCl	0.68

The table shows that the elements of this clay are insoluble in percentage of approximately 64 %, the levels in sulfates and chlorides are very low.

C. The Fibers

The fibers used in this study are of vegetable fiber of date palm of dokar. Mr KRIKER [4] after the studies carried out on four types of fiber surface of palm (the fibers of dokar, deglette nour, degla bida and elghers), it was found that the fibers of dokar give the best result of point of view to tensile strength. It is for this reason our choice is door to the fibers of dokar.

1. Fiber Characteristics of Date Palm

The tests carried out on the fibers by Pr KRIKER [4] have allowed us to characterize the fibers of palm of Ouargla as result in the table:

TABLE 7. THE PHYSICAL AND MECHANICAL CHARACTERISTICS OF FIBERS USED.

Characteristics	Results
Apparent Density	$\rho_a = 512.21 - 1088.81 \text{ Kg/m}^3$
Mass density absolute	$\rho_s = 1300 - 1450 \text{ kg/m}^3$
Tensile Strength (MPa)	L= 100mm L= 60mm L=20 mm 170 ±40 240 ±30
Deformation at the rupture	E= 0,232 (fiber diameter 0. 8 MM)
Humidity	W = 9.5 - 10.5 per cent
Rate of absorption in water (after 24H)	TA = 96.83 - 202.64 PER CENT
Diameter (of fibers used)	D = varies between 0.1 - 1 mm

Tea date palm fibers have average strength high tensile strength. In addition, thesis fibers classified among the fibers, which have weak modulus of elasticity. However, it should mentioned that the high tensile strength strength depends on the specimen length, which is of prime importance regarding reinforcing efficiency. As shown in Table 6, the high tensile strength strength increases with decreasing specimen length. The latter observation also reported by Beledzeki et al.[5], who calculated the actual high tensile strength strength of a single fiber by extrapolation to zero length of the curve of high tensile strength strength, VS fiber length. This estimation method indicates a high tensile strength strength of 320 MPa for thesis fibers. Comparatively with other results [4], thesis fibers are not so dependent on the fiber test length than for the case of other natural fiber [5-13].

2. Mineralogical Compositions of fibers of Date Palm

The Spectro chemical Analysis of the powder of fibers after calcination at 400 °C to give the following items:

TABLE 8. MINERALOGICAL ANALYSIS OF THE POWDER OF FIBERS CALCINED AT 400 C

Item	The percentage (%)
SiO ₂	48.04
Al ₂ O ₃	6.12
Fe ₂ O ₃	2.51
MnO	0.05
MgO	4.88
CaO	14.21
Na ₂ O	1.81
K ₂ O	2.8
TiO ₂	0.42
P ₂ O ₅	0.45
Loss to Fire	18.08

We find that the fibers used contain a remarkable rate of the SiO₂ and CaO.

3. Analysis of Organic Materials

The analysis of organic materials of fibers of dokar, the biology laboratory of the University of Kasdi Merbah Hon. Members' Ouargla, has given on the following table the proportions of cellulose, hemicellulose and lignin.

TABLE 9. THE MAJOR CONSTITUENTS OF ORGANIC FIBERS.

Regards	Proportion (%)
Ash	1.2 ±0.3
Cellulose	43 ± 2
Hemicellulose	8 ±2
Lignin	35 ± 5

We find that these fibers have higher rates in cellulose and hemicellulose relatively low compared to that of the fibers of sisal. By contrast, rates of cellulose and lignin moves closer to that of coconut fibers given by the literature.

Remember that the cellulose is the essential element from the point of view resistance.

IV. TEST METHOD THERMAL

The thermal tests are carried out at the laboratory of civil engineering from the University Kasdi Merbah Ouargla

A. Method of measuring the thermal conductivity

We used the method of the hot wire for our experimental program, the technique of the hot wire by CT-meter [14].

The CT-Meter has been developed with the aim to assess with precision, the thermal characteristics of a number of homogeneous materials and isotropic.

The principle of operation is, thanks to the combination of a heating element and a temperature sensor (both associated in the same probe), to measure the elevation of temperature experienced by the sensor, in the course of a heating period

chosen by the user depending on the material to be tested and the type of probe used.

V. TEST METHOD MECHANICAL

The mechanical tests are performed at the laboratory of civil engineering from the University Kasdi Merbah Ouargla

A. Tensile Test by bending

The bending test 4 points is performed on a device of flexing of type CONTROLS running with a hydraulic pressure system. The value of the charge is read directly on the device. The loading is applied in a continuous manner with a speed of 0.5 KN/min up to the rupture

B. Compression Test

The compression test is performed on a device of universal compression type Oehlgass running with a hydraulic pressure system. The load is applied to the specimen in a continuous manner with a speed of 5 KN/mn

VI. RESULTS AND DISCUSSION

We have proposed to our work the eight compositions (clay+sand+fiber) following in addition the composition of reference:

- Composition C1 :70% clay +30 %sand +00% fiber (composition of reference)
- Composition C2: 69% clay +30 %sand +01% fiber
- Composition C3: 68% clay +30 %sand +02% fiber
- Composition C4: 67% clay +30 %sand +03% fiber
- Composition C5 :80% clay +20 %sand +00% fiber (composition of reference)
- Composition C6 : 79% clay +20 %sand +01% fiber
- Composition C7: 78% clay +20 %sand +02% fiber
- Composition C8: 77% clay +20 %sand +03% fiber

The tests have been performed on bricks of dimensions (200 × 100 ×50 mm); the results are grouped in tables10 and 11.

TABLE 10. THE RESULTS OF THE FOUR COMPOSITIONS FIRST

Test Piece (brick)	C1	C2	C3	C4
The mass M (kg)	1.45	1.43	1.38	1.15
The density (Kg/m3)	1803.5	1740	1697.3	1491.2
Specific heat CP (KJ/m3.K)	7620.8	7402	7175	6400.4
Thermal Conductivity λ (W/m ² c)	0.64	0.63	0.57	0.46
Thermal Resistance R th (m ² c/W)	0,070	0,071	0,075	0,093
Resistance to traction	1.34	1.19	0.98	0.82
Resistance to compression	4.81	3.2	2.18	0.97

TABLE 11 .THE RESULTS OF THE FOUR COMPOSITIONS LATEST

Test Piece (brick)	C5	C6	C7	C8
The mass M (kg)	1.38	1.36	1.10	1.05
The density (Kg/m3)	1945	1779.6	1437.4	1392
Specific heat CP (KJ/m3.K)	7833	7652	7196.8	7064.1
Thermal Conductivity λ (W/m ² c)	0.71	0.66	0.58	0.48
Thermal Resistance R th (m ² c/W)	0,060	0,066	0,072	0,087
Resistance to traction	1.2	1.05	0.93	0.77
Resistance to compression	3.45	2.47	1.72	0.82

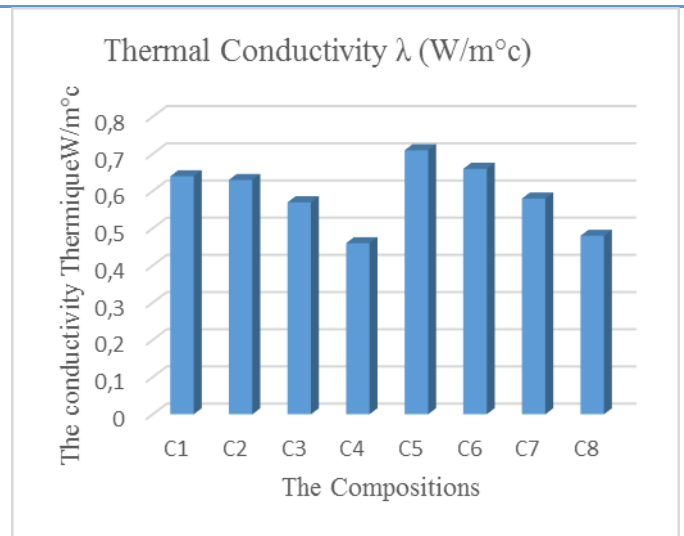


Figure. 2. The Thermal Conductivity.

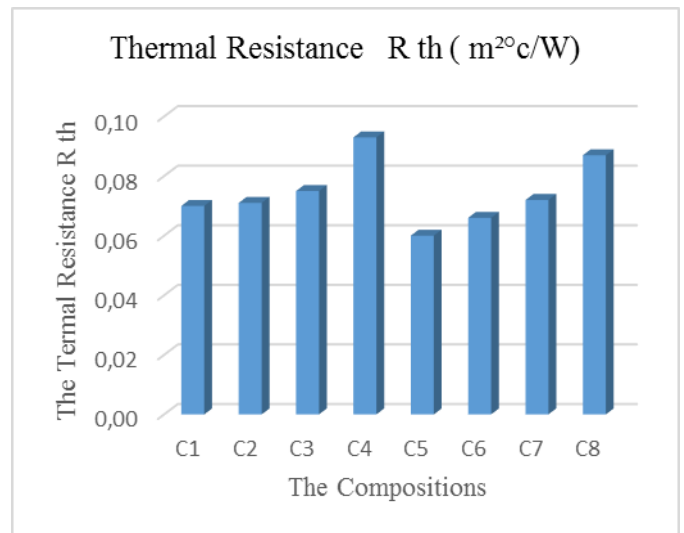


Figure.3.The Thermal Resistance.

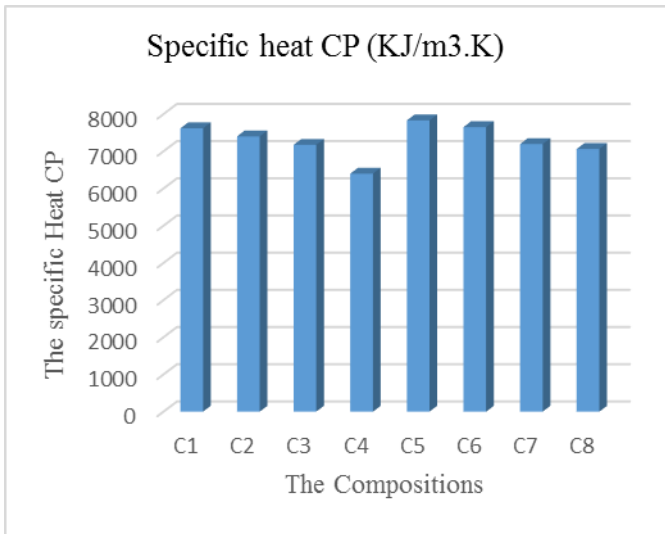


Figure.4.The specific Heat.

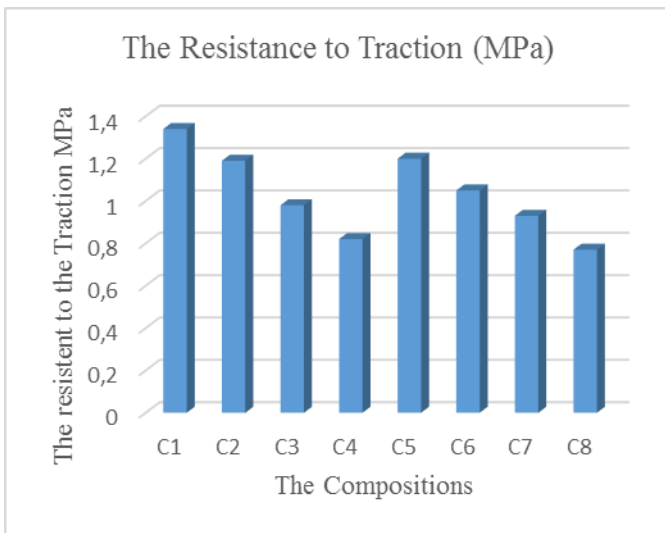


Figure.5.The Resistance to Traction

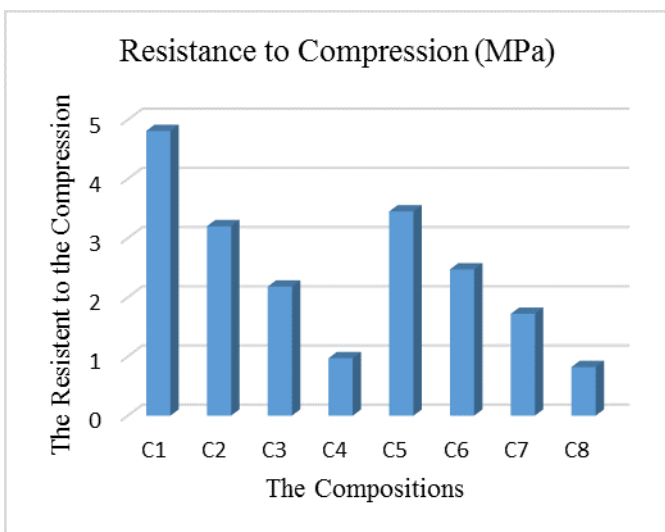


Figure.6.The Resistance to Compression.

After the results obtained we note that:

- A decrease of the conductivity as a function of the increase percentage of fibers in the mixture. The compositions (C4) and (C8) give the best results of the conductivity and the thermal resistance and this is due to the presence of the fibers, which creates empty on the inside of the brick after cooking.
- A decrease of the thermal conductivity depending on the increase of the percentage of sand in the mixture.
- The thermal resistance will automatically increase with the increase of the percentage of sand.
- The specific heat decreased in function of the increase in the percentage of sand. This is logical in view of the fact that theoretically the specific heat varies in the same direction as the thermal conductivity
- A decrease of the mass and the mass density as a function of the increase percentage of fibers in the mixture (1700 kg/m³ and mass density of intoxicating fiber 512.12 kg/m³).
- The resistance to bending the most high is that of the composition (C1) is ca is due to the absence of fibers and the good cohesion of the matrix of the mixture.
- The resistance to bending of the compositions (C1, C2, C3 and C4) is higher than that of the individual flower arrangements and (C5, C6, C7 and C8) and ca is due to the increase in the percentage of sand.
- The resistance to compression of compositions (C4) and (C8) is low and ca is due to the influence of voids created by the fibers.
- The resistance to compression of compositions (C1, C2, C3 and C4) is higher than that of the individual flower arrangements and (C5, C6, C7 and C8) and ca is due to the increase in the percentage of sand.

VII. CONCLUSION

After the experimental study on the thermal characteristics of the various compositions, we can draw the following conclusions:

- Adding the fibers of date palm in the bricks reduced thermal conductivity, specific heat, density and increases the thermal resistance.
- The increase of sand dunes has a positive impact on the increase of the thermal conductivity, specific heat.
- The absence of fibers of palm fronds and the increase of sand dunes to a positive impact on the increase of mechanical properties.
- In conclusion, concerning the brick C4 and C8 of point of view them thermal characteristics thermal best but of point of view, the mechanical compositions without fibers are the best.

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