Journal of Engineering and Applied Sciences
MEDWELL PUBLICATIONS SINCE 2000

Contribution to the Study of the Thermomechanical Properties of the Adobe. (Case of the South of Algeria Ouargla)

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Key words: Adobe, Saharan regions, thermal properties, mechanical properties clay, dune sand, gravel

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Page No.: 3424-3428
Volume: 15, Issue 19, 2020
ISSN: 1816-949x
Journal of Engineering and Applied Sciences

Abstract: As part of the recovery of local materials in arid and semi-arid areas, the adobe will be chosen as a reductive object. This research topic consists of the use of clay for construction. The latter is abundant in the south of Algeria and has properties that appear to be suitable for building design. The purpose of this project is to evaluate the behaviour of clay-based Adobe by adding dune sand, gravel 8/15 and gravel 3/8 by different percentages. This technical study is based on the application of tests for the physical and mechanical characterization of the latter. This study is launched with the aim of characterizing a clay based on local materials from the Ouargla region, namely Baldat Amor clay, sand from the dune of Sidi khouiled, gravel from Ouargla.

INTRODUCTION

The most well-known and most often cited definition is that of F. Cointeraux in “Ecole d'architecture rurale et'économique, Paris 1790”[1]: “Adobe is a process according to which houses are built with earth without being supported by any piece of wood and without mixing it neither straw nor stuffing. It consists in beating, bed by bed, between boards, to the ordinary thickness of the rubble walls, the earth prepared for this purpose. Thus beaten it binds, takes on consistency and forms a homogeneous mass that can be “raised to the heights necessary for a dwelling”.

Adobe is, therefore, a monolithic clay wall masonry technique, composed of superposed layers of compacted Earth. The resulting wall is a load-bearing wall. It is 50 cm thick on average, sometimes more. The density of traditional adobe is about 1.7-1.9 rpm[2]. Adobe buildings commonly have two levels. Some, particularly in urban areas, may have three or even four levels.

Our research work, consists in valorizing the clay and sand of the dunes of the Ouargla region by incorporating it and using it to make a Adobe. In our work, we have chosen gravel to make a adobe based on these materials. The south of Algeria is an example of the hot and dry regions of our country is also an example of a region where the past has been built of Earth and local stones (Ksores) but unfortunately in recent times concrete has been built, a material not adapted to climatic conditions.

To this end, this study has been launched. From a global point of view, the aim of our research is to make a Adobe based on local materials. Then proceed to its thermal and mechanical characterizations.

MATERIALS AND METHODS

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

Table 1: Physical characteristics of dune sand

Test	Results
The absolute density	$\rho_2 = 2559$ kg m^{-3}
The apparent density	$\rho_2 = 1513$ kg m^{-3}
Sand equivalent	ESp = 99%

Table 2: Chemical analysis of dune sand

Components	Percentage
Fe_2O_3-AL_2O_3	0.25
$CaSO_4$, $2H_2O$	2.78
SO_4	0.51
$CaCO_3$	1.30
Insoluble	93.23
NaCl	Trace
Loss on Fire	1.16

Table 3: Physical characteristics of clay

Characteristics	Results
Dry density (NF P 94/064)	P = 2.03 g cm^{-3}
Methylene blue (NF EN 933-9)	VBS = 8
Atterberg limit (NF P 94-051)	$W_L = 69.58\%$
	$W_P = 24.71\%$
	$I_P = 44.87\%$

Le sable des dunes: For our study we used the sand from the dunes of the South of Algeria (Ouargla) (Table 1 and Fig. 1). We performed the following tests:

- The absolute density
- The apparent density
- Sand equivalent
- Chemical analysis
- X-ray diffraction

Chemical analyses: Table 2 shows the percentages of chemical components in dune sand[3]. We note that the percentage of ($CaSO_4$), (SO_4) is below the recommended limit. As a result, the sand used is non-aggressive.

X-ray diffraction: The curve represents the results obtained for dune sand (Fig. 2). 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.

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

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

According to Atterberg and Burmister, we can classify our clay by its plasticity index (IP = 44.87) the nature of the clay is a very plastic clay (Table 3 and Fig. 3).

Fig. 1: Dune sand

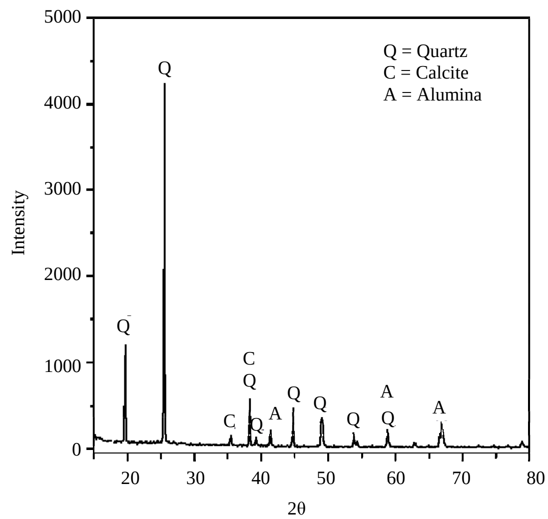

Fig. 2: Diffractometric analysis of dune sand

Fig. 3: Beldat amor clay

Analyse chimique: The main results of the chemical analysis are presented in Table 4. Table 4 shows that the elements of this clay are insoluble in percentage of about 64%, the sulfate and chloride contents are very low.

Table 4: Chemical analysis of clay

Chemical characteristics	Components	Percentage
Insolubles (NF P 15-461)	Insolubles	63.18
Sulfates (BS 1377)	SO_3	0.45
	Ca $SO_4/2H_2O$	2.46
Carbonates (NF P 15-461)	$CaCO_3$	18.0
Chlorides (MOHR method)	Cl-	0.42
	NaCl	0.68

Table 5: Physical characteristics of gravel

Test	Classe 3/8	Classe 8/15
Absolute density (kg m^{-3})	2613	2661
Apparent density (kg m^{-3})	1506	1460
Micro-Deval test	10	11.2
Los Angeles test	20	25

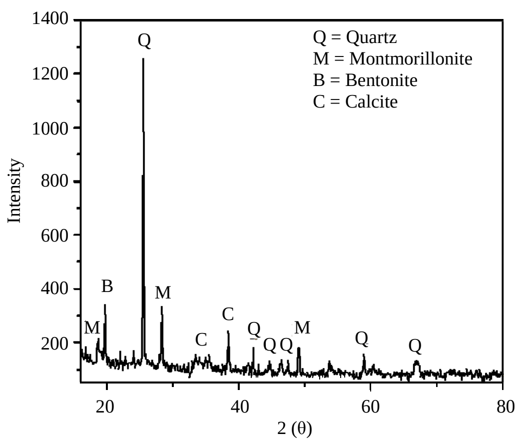

Fig. 4: Diffractometric analyses of clay

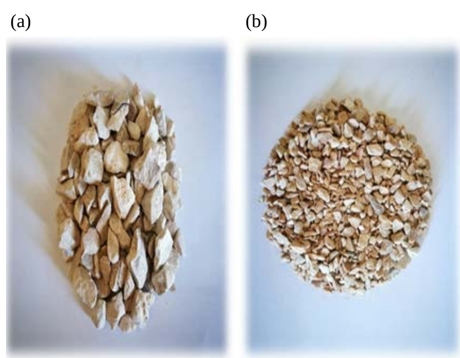

Fig. 5(a, b): Gravel

X-ray diffraction: The curve represents the results obtained for 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 (2 θ) (Fig. 4 and 5).

Table 6: Used compositions

Variables (%)	C1	C2	C3	C4	C5	C6	D1	D2	D3	D4	D5
A	25	25	25	25	25	25	25	25	25	25	25
S	25	25	25	25	25	25	25	25	25	25	25
G	25	30	35	40	45	50	20	15	10	5	0
g	25	20	15	10	5	0	30	35	40	45	50

A = clay; S = Sand; G = Gravel 8/15; g = Gravel 3/8

Gravel: Gravel has origins similar to those of sand, 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 crushed sand (Fig. 5 and Table 6). The results obtained are as follows.

RESULTS AND DISCUSSION

The experimental study of our work consists in determining the thermal and mechanical characteristics of the adobe based on local materials of dimensions (7×7×28) cm, then different tests were carried out on the made samples[4].

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.

According to Proctor's tests, the optimal amount of water for the production of Adobe based on this clay is 18% (Fig. 6).

The compositions used are indicated in Table 6. Figure 7 shows the variation in the density of the Adobe as a function of the different percentages of gravel. From Fig. 7, we can see that: an increase in density as a function of the percentage of gravel in the compositions is due to the higher density of the gravel than the others. A decrease in density as a function of the decrease in the percentage of gravel in the compositions. The density of the composition (C6) is higher than other compositions[5]. The densities of the other compositions are similar. The results of the compressive strength test are shown in Fig. 8.

From Fig. 8, we see that, an increase and decrease in the first six compositions (C). This phenomenon can be explained in two phases.

Phase 1: An increase in compressive strength in terms of an increase in the percentage of gravel to the top which is due to the good cohesion of the mixture.

Phase 2: Decrease in compressive strength due to the increase in the percentage of gravel due to the existence of voids created by the gravel.

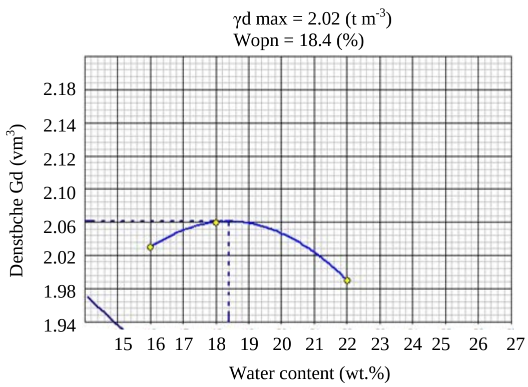

Fig. 6: Clay proctor curve

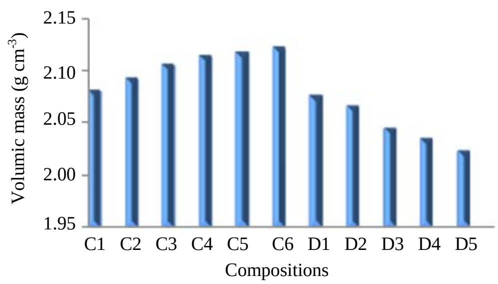

Fig. 7: Volumic mass results

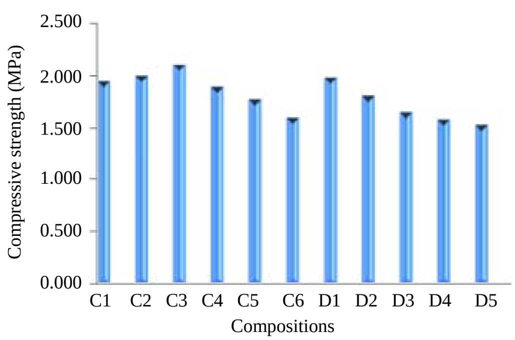

Fig. 8: Compression results

A decrease in the compressive strength of the compositions (D) in terms of an increase in the percentage of gravel 3/8 which creates voids and inconsistency of the sample. The compressive strength of the sample (C3) is higher than that of the sample (D1) and this is due to the increase in the percentage of gravel[6].

The compressive strength of sample (C6), (D5) is low by one mechanical point and this is due to the influence of voids resulting from granular gradient is not appropriate. The compressive strength of samples (C3) and (D1) are acceptable. The results of the flexural strength test are summarized in Fig. 9. From Fig. 9, we see that:

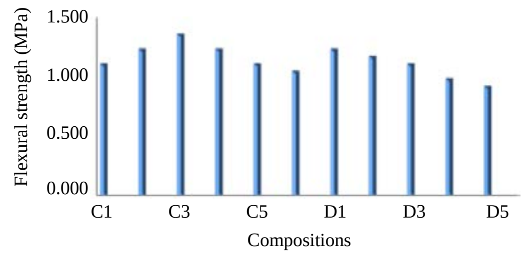

Fig. 9: Flexural strength

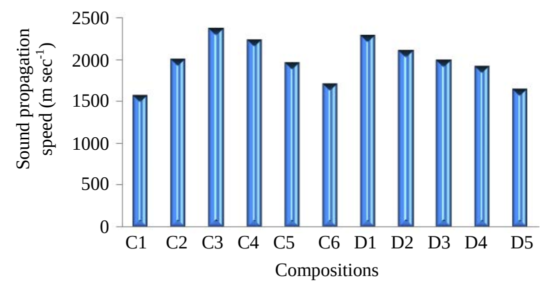

Fig. 10: Results of the sound propagation speed

Compositions (C3) and (D1) give better flexural strength and this is due to the good cohesion of the mixture. The Flexural strength of all compositions is similar. The flexural strength of the sample (C3) is higher than that of the sample (D5) and this is due to the increase in the percentage of grivlette. The flexural strength of samples (C2) and (C4) is lower than that of samples (D2) and (D3) and this is due to the fact that the gravel 8/15 is higher than the gravel 3/8 which creates voids[7].

The results of the ultration test are summarized in Fig. 10. The sound propagation speed tests confirmed the compression and Flexural strength results. The C3 sample gave the best result. Figure 11 shows the variation in the thermal conductivity of the Adobe as a function of the different percentages of clay and sand in the dunes, gravel 8/15 and gravel 3/8.

From Fig. 11, some samples were broken, it's due to transport. A decrease in conductivity as a function of the increase in the percentage of gravel in the mixture. This is attributed to voids left by the gravel. The samples (C4) and (D2) give a lower thermal conductivity, due to the presence of voids between the components of these compositions, the results of the thermal resistance are summarized in Fig. 12.

From Fig. 12, we see: the thermal resistance has automatically increased because it is inversely proportional to the thermal conductivity. An increase in thermal resistance as a function of the increase in the percentage of gravel. The highest thermal resistance is that of bricks containing gravel (C6) while the sample (D5) is the lowest and this is due to the absence of gravel. A convergence of the thermal resistance in the sample (C2) and the sample (D2).

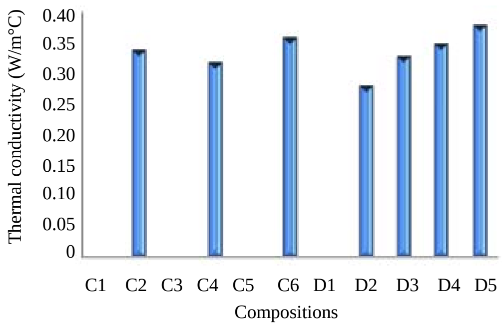

Fig. 11: Variation of the thermal conductivity

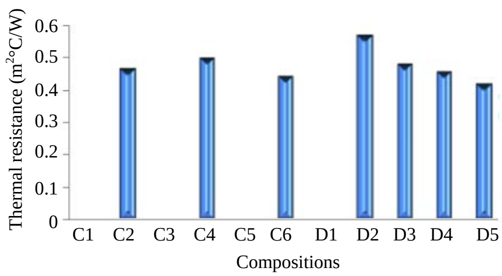

Fig. 12: Variation of thermal resistance

CONCLUSION

We recall the purpose of this work was to contribute to the production of a local material with good mechanical and thermal properties for which we made a mix based on local materials, after having carried out a series of thermal and mechanical tests on these mixes, we can say.

Clay extracted from the Ouargla South Algerian deposit which is characterized by: the nature of this clay is very plastic and consists essentially of minerals associated with quartz and kaolinite and is also characterized by a high proportion of silt granulometry (90%).

The sand used is sand from the dunes extracted from Ouargla which is characterized by: a very tight granulometry; consists essentially of minerals associated with quartz, calcite and alumina; this sand is a very fine sand after the experiment, we drew the following conclusion.

The addition of gravel increases the density of the sample. The samples that have the best granular analysis give us the best result in terms of pressure resistance and bending strength. Economically, the use of these materials helps to reduce the amount of imported materials and reduce the energy consumption required to use the materials studied in home construction.

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