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Characterization of the Traditional Materials in Archeological Bioclimatic Constructions

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***Abstract*— This work presents an experimental study concerning the characterization of materials in old build on bioclimatic earth their climatic comfort requires the respect for their initial architectures and the knowledge of the characteristics of the used materials. The architecture in earth evolved through the generations by using local materials. The material is in hiding proved its validity in weather and its efficiency in architectural solutions and the capacity of conception suited against the influence of the climatic and environmental factors. She meets the needs of the population and their social, cultural and economic development. For that purpose, our study aims at characterizing mineralogical composition and at determining the physico-mechanical properties of building materials taken in various places of the ksour Tinerkouk of Algeria. The results of the physical and mechanical and structural characteristics, showed successful and compatible characteristics with the materials of bioclimatic construction**

***Index Terms*— Bioclimatic Architecture, Archeological Construction, Material Characteristic, Climatic Earth,Performance**

I. INTRODUCTION

The earth is the simplest natural material which we have at our disposal. It is used by the man in the construction since thousands of years to build buildings through all the continents [1], with techniques and traditions which are a real testimony living on the history , the cultures of the peoples and the identity of places [2].

This material was very depreciated during numerous years and we realize today that the former had included well several qualities of the earth for the manufacturing of houses while keeping the natural environment [3] [4]. The earth canbe used only if it offers a good clean cohesion, mainly owed to the presence of clay which plays the role of natural sociable disposition [5] .

The earth is a natural material and a piece of furniture, a mixture of gravels, sand and clays, it is an extremely heterogeneous material, the characteristics of which are very diverse from a region to an other one. His characteristics were, until very recent period, relatively badly known because of the varieties of the traditional modes of construction in earth [6].

Algerian Sahara belongs to the vastest desert of the world. Southward, it reaches subsahélienne Africa. It is good the aridity which characterizes the Saharan climate, the hydric deficit at every level, is due to the weakness of the precipitation, to the intense evaporation, to the strong temperatures and to the big luminosity. In these conditions we find the Southwest region of Algeria, compoundof four wilayas which are: the wilaya of Béchar, Tindouf, Tamanrasset and Adrar. The latter is in approximately 1540 km from Algiers. She is characterized by her relatively flat topography, as well as by a desert geomorphology. In these zones the man developed techniques of construction from the local earth which makes the transactions between the requirements of the human life and the dry climatic environment.

The example prototype which we can quote, ksour Tinerkouk of the wilaya of Adrar of Algeria, They was built brick-built of raw earth built in the mortar of earth. The bricks of raw earth (clay, sand and various additions) would have been realized at the level of careers of earth situated outside the city of Adrar.

The objective of this study consists in determining the properties of bricks, mortars and fillers of ksour Tinerkouk, to identify their thermal and climatic performances.

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II. EXPERIMENT

To arrive at our objective, we took several samples of ksour let us be groupedin three categories: bricks, mortars, every category is constituted by several fragments. On that wall, we took the composite of adobe and we performed the characterization of its mineralogical compositions. This we realized with a diffractometer of the type Philips MPD X PERT Pro. The pétro-physical parameters such as: the apparent bulk density by hydrostatic weighing (NF P 98.250-6) and specific to water (NF P 94-054), and then calculated its total porosity of the composite.

To make mechanical tests (flexion and compression) on the taken bricks, it was necessary to cut every Adobe in four test tubes of dimension 4x4x16 cm so that they are shaped to the standard (NF P-196).

The determination of the potential hydrogenates taken samples was made by means of a PH measure.The carbonate content is determined with the calcimeter of Bernard, according to standard NF P 94-048.

III. RESULTS AND DISCUSSION

A. Mineralogical composition

The results of mineralogical analysis realized by diffraction of the X-rays of the taken samples are given by radio-telegrams represented by the following figures :

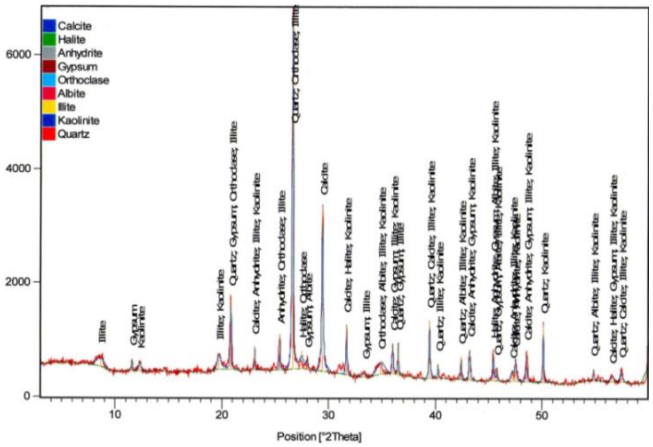

Fig.1. *Mineralogical analysis of bricks in earth of the walls of the ksour*

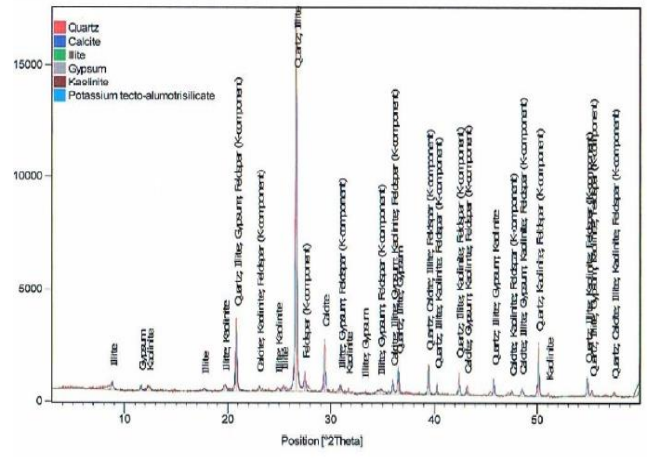

Fig.2. *Mineralogical Analysis of the mortar of jointement*

Bricks in earth contain of the quartz, illite, calcite, albite and orthose, gypsum, anhydrite and kaolinite, what means that the raw material results from the same quarry and contains globally (sand, salt, carbonates, plastic clayey materials and feldspar) [7].

The compositions of the raw materials of bricks walls are sand-colored 75 % and 25 % clay. Mortars of jointement they too contain of the quartz, illite, calcite, gypsum or of the anhydrite, albite or of the kaolinite, what shows mortars are prepared with the raw material (clayey career) with various proportions and additions of the sand of the region.

B. Characteristics of building materials

The other and physical and mechanical results of the characterization of the taken samples are presented in the table 1:

Table 1. *Summary table of the characteristics of the materials of ksour*

Characteristics	Brick in earth	Mortar
Density (g/cm^3) 2.17	2.06	
Specific mass (g/cm^3)	2.47	2.28
Fold resistance (MPa)	0.39	/
Compression resistance	0.42	/
Humidity (%)	1.21	2.07
PH	8.87	8.93
CaO (%) +	4.43	

We notice that samples have a PH between (8.87 - 8.93) what shows the basic character of clays due to the mineralogical composition. All the samples contain the presence of the free lime, the proof of the presences of the carbonated materials [8]. The mortar ripe jointement contain 4.43 % of free lime, what suggests the addition of the air lime as stabilizing, where the percentage of the carbonates of calcium in the raw material is important.

The bricks of construction work much more by the compression. We note that the maximal values of compression are 0.41 Mpa for the compression and 0.39 Mpa for the flexion, what explains well the function of the latter.

The density varies between (2.06 in 2.17 g/cm ^{3}) and the specific mass varies between (2.28 in 2.43 g/cm ^{3}), what shows that the variation of porosity is little porous has very porous [9]. The values of the humidity of samples are considered weak ones she is between (1.21 % and 2.07 %), this is due to what samples were taken stored and then measured in an environment where the temperature is raised and the humidity is very low.

C. Characterization of the hygrothermal behavior

The objective of this protocol consists in following the temperature and the humidity in approximately of the ksar by thermo hygro buttons in situ, and in determining the variation of the temperature and the humidity from the outside and inside the ksar.

This variation informs us about the type and the mode of thermal exchange through the adobe of construction of the ksar, as well as the various characteristics of the material Adobe (structure and texture) and the techniques of construction of the ksar in raw earth.

3.3.1 Experimental protocol

Six buttons have were commission at the university of Boumerdes, during three months of the summer (in June 09th on August 30th, 2015), with a gap from the measure of every 30 minutes, buttons are implanted outside and inside the ksar (material of construction: brick in raw earth)

Buttons are implanted in various climatic atmospheres of the ksar in earth (inside and outside of the construction) to conclude the thermal behavior of this material.

We commission our thermo Buttons by means of the software thermo track which are made to facilitate the task, and give the maximum of information in a minimum of time, connected in USB to the desk on PC Windows where on the ground with the flash Touch Pen, the software thermo track allow you to settle the frequency of measure and clock, a Countdown and the level of the alarms and their temporization.

The results are represented in the figure 3 :

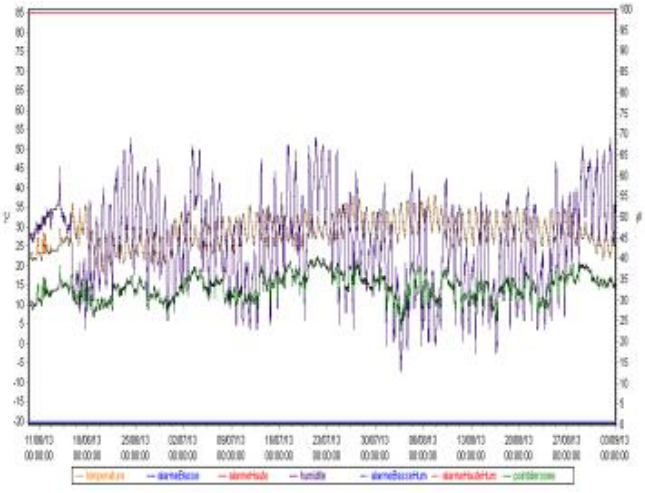

Fig.3. *Evolution of the temperature and the humidity in approximately of the ksar*

The figure 3 shows that the dew point is to entour of 5°c in 15°C of temperature, is understandable the approximately wet. The dew point is the temperature, in which the air is saturated by steam and in which there is a condensation in case of additional contribution of steam or cooling of the air [10] .

The comparative study of the results of temperature and the humidity (internal and external) of the construction with the traditional materials in earth , led us of Comprendre his thermal behavior :

- The former built takes advantage of the site in which it joins to manage its air, its temperature and its steam inside. Fundamental differences are so added in his constructive mode, in particular by its very heavy inertia and the microporosity of its materials of shell [11] [12] .
- The mass of the forme rstructures (walls and floors) brings a strong slowness to the building . In summer, she allows to store then to distribute the night-freshness with a phase shift which can reach a dozen hours at the hottest moment of the day.

In a parallel to the temperature, the humidity is a very important size of trial. The relative humidity of the ambient air, for example, has a considerable influence on our well-being and our health.

It is essential to check the humidity of the air where the steam contained in the air causes or influences chemical, physical or biological reactions.

The results of the characteristics of the adobe, chosen as traditional material of construction in raw earth showed that this material has better performances for the thermal regulation.

IV. Conclusion

Clays are hydrated aluminosilicates having the capacity to become plastic and to swell in touch with some water. Kaolinite (7-10 angstrom), illite (10-14 angstrom), montmorillonite (14-20 angstrom), we notice that the red clay making up(composing) main thing of bricks is not a very plastic clay of the fact which it does not contain of the montmorillonite, the red color is mainly due to the presence of oxides of irons.

The rough composition of raw materials used for the elaboration of bricks is 25 % clay and sand-colored 75 %. They are local, taken raw materials not far from the monument or from its neighborhood. Bricks have a 2.17 g / cm³ density and specific mass of 2.28 g / cm ³, what means that they are little porous, what allowed that their damages or change under the influence of the water do not have in an advanced stadium.The various properties of the traditional materials of ksour approach in that in the modern bioclimatic constructions, what explains their climatic comfort.

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