STUDY AND ANALYSIS OF THE GEOTECHNICAL PRORIETES OF SOIL USED IN THE PREPARATION OF EARTHEN CONCRETES

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Abstract

Earthen concrete is a building material based on clay mud, traditionally known as rammed earth or mud. It is estimated that 30% of the buildings in the world are earth-based. Efforts have been directed towards the development of new construction methods using local materials designed for this purpose. Eco-materials will have to replace the usual materials in order to provide an adequate response to housing crises.

Our study consists in the geotechnical, physical and chemical properties of a sandy clay soil used to prepare compressed earth block and to analyze their mechanical properties.

Keywords: earth, chemical analysis, eco materials, environment

1. INTRODUCTION

Earth, a natural raw material, has been used by man in construction for thousands of years. Remember the Great Wall of China, Aztec Pyramids or Moroccan Kasbahs. Its transformation into a habitat material requiring little energy and its almost immediate availability, still give it an indisputable success today. It is estimated that 30% of dwellings in the world are built from earth [1].

1.The structure of the earth

The constituents of the earth are more or less disposed, opened or bound. The method of assembling the solid constituents, at a given moment, defines the structure of a soil. There are three types of structure: (Figure I). Particle structure: gravelly type, very weak clay bond between inert elements. Fragmentary structure: lumpy, clay bonding into gravely bundles that are interconnected Continuous structure: of the pudding type, the inert elements are taken from a mass of silt clay.

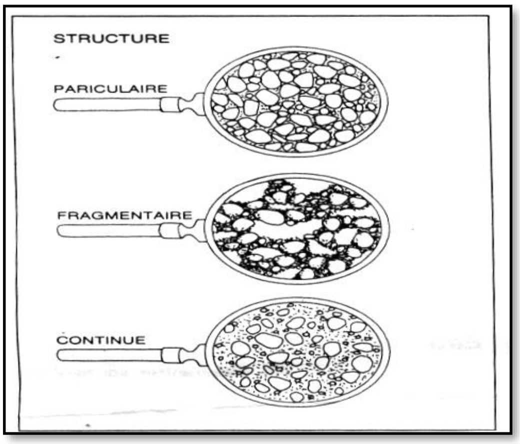

Figure I. The structure of anearth.

2.The texture of earth

It is the granular composition of earth. The texture influences the properties because each fraction of grains has specific characteristics which can define those of the earth if it contains in sufficient quantity. 10% clay sufficient to give a property of cohesion and plasticity to the earth. 40 to 50% fine clay gives an earth that has the properties of a clay. There are five types of textures: (Figure 2).

 Organic earth: peat for example.

 Gravelly earth: predominance of gravel and pebbles, appearance of a concrete.

 Sandy earth: predominance of sand, appearance of a mortar.

 Silty earth: predominance of silt, fine, slightly cohesive and silky-looking earth.

 Clay soil: predominance of clay, very cohesive, sticky and moldable soil in the wet state.

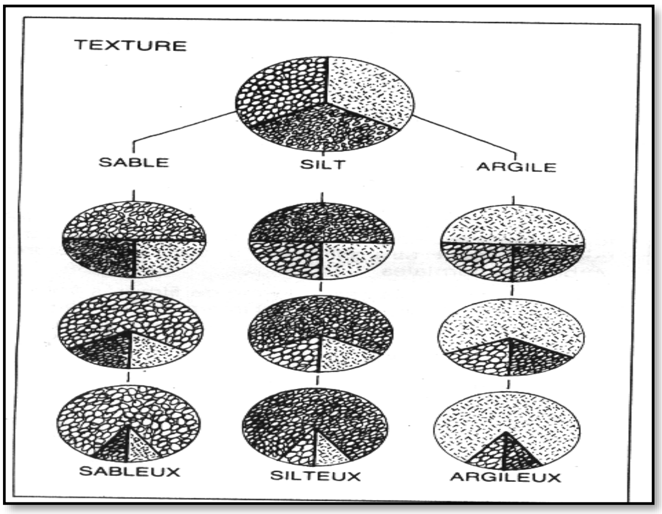

Figure 2: the texture of an earth.

3. Link strength

Clay plays the role of cement. It keeps all the grains inert and ensures much of the cohesion of the earth. The cohesive forces of the most important clay micelles are electrostatic forces.It can be established between clay micelles surface-side links, because of attractive forces.

But it can also be a negatively charged surface-to-surface or a side-to-side bond. The theory of flocculation (inverse of dispersion) explains these phenomena: soil water is a binding agent, It is charged with positive ions, or cations (Na^+, Ca^{++}, Al^{+++}) that are numerous enough to balance the negative charges particles: the system is electrically neutral. Depending on their hydration, cations give rise to chains of water molecules that connect the ion and the surface of the particle. Similarly, an ion can act as a bridge between two adjacent clay particles [7].

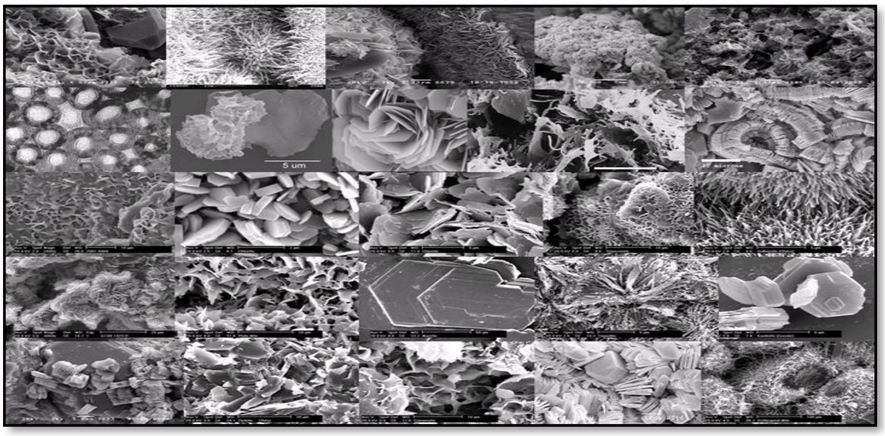

Figure 3. The microstructure of clays.

4.Chemical properties of the earth

From one land to another land, the properties can be very variable. It is often the dominant fraction of a land that governs the fundamental properties of the material.

The chemical properties of the land depend on the chemical construction of the components of the earth. Among the elements, the most chemically influential include salts, whether soluble or insoluble. The high salinity of a soil can induce very marked chemical properties.

These properties are also dependent on the mineralogical nature of minerals and their constitutive chemistry, the nature and quantity of organic matter: these unstable components, undergoing chemical and biochemical evolution, can change the very structure of the earth. by producing precipitates of different kinds, colloids and kinds of humic and bacterial sticky pastes. Similarly, the amount of iron, magnesium or calcium oxides, carbonates and sulphates can characterize the earth from a chemical point of view. Calcium sulfate, particularly swelling with hydration can be very harmful; its solubility in water (selenitic water) can increase the sensitivity of clays. Metal oxides can be very influential. For example, in a lateritic soil, iron oxide may accelerate some solidification processes. Likewise, an abundance of aluminum oxide can reduce resistance with age. Note also the importance of measuring the pH of a soil that specifies the concentration of H + or OH- ions, and its acidic or basic nature [8].

2. The earthen concrete

Earthen concrete or adobe concrete or geo concrete is, as its name suggests, a concrete made of raw earth (tuff). This concrete also consists of three components: aggregates: gravel and sand, a binder: in this case silt and clay and mixing water.Rather than talking about land, it is "concrete of land" that should be spoken. Like concrete cement, the earth is indeed an assembly of various aggregates (pebbles, gravel, sand, silt or silts) which owes its cohesion to an adhesive that is not cement but clay, finest fraction of the soil [1]

1. Implementation techniques

From the tradition of building earth, there are many ways of construction with infinity of variants that reflect the identity of places and cultures. Of these, six are very commonly employed [4]

2. Adobe

Sun-dried brick is more commonly known as adobe. The adobe bricks are molded from a malleable soil often added with straw. Originally, these bricks were formed by hand. Later (and still today) they will be made manually using molds with various prismatic shapes in wood or metal. Currently, machines are also used (Figure 4).

3. Earth-straw

For this technique, the earth used must have good cohesion. It is dispersed in water until a homogeneous slip is obtained, which is poured on straw, until each strand is coated. On drying, a material is obtained whose texture is essentially that of straw (Figure 5).

4. The rammed earth

The ground stabilized with lime is compressed with a pneumatic ram or pestle, in metal shuttering dams (traditionally all this material was in wood and the shelling was manual). The filling of the banches is done in successive layers of about 15cm thick before pounding. Then we go back the banches for the upper banches and so on until the desired height.

The advantages of rammed earth are to produce homogeneous walls quickly, with a low shrinkage on drying and a total absence of rot and parasites. On the other hand, this technique is sensitive to moisture, either rain or runoff, or capillary rise since the foundation[5]. (Figure 6)

5. The daub

A mixture earth-straw or earth-fiber plant is used in filling a structure with half-timberings and wooden racks. This clay soil forms the walls of the building.

This is a very fast technique; the mud combines with the disadvantages of rammed earth, a significant drying shrinkage, rotting in case of moisture and poor insulation [5].

6.Compressed earth blocks

The blocks of the lime stabilized earth are poured into a mold and then compressed. Traditionally, these blocks were molded in wood and then piled or dropping a heavy lid. Today the technique has been improved from a compression and efficiency point of view with mechanization. We then use either manual presses that use a large lever arm to slide plates that compress the earth, or hydraulic presses (Figure 7).

7. Cob

This process consists of stacking earth balls one on top of the other and compacting slightly with the hands or feet to make monolithic walls. Usually, the earth is modified with fibers of various kinds (Figure 8).

Figure 4. Adobe brick.

Figure 5. Earth-straw walls.

Figure 6. Rammed earth

Figure 7. Compressed earth blocks

Figure 8. Cob

3. Experimental methods

1. Materials used and tests

In this study, we use a clay-sandy soil of the Souk-Ahras region whose main physical and chemical characteristics are given in Tables 1 and 2 and Figure 1 shows its particle size analysis.

Figure 9. The soil used

2. Chemical characteristics of the earth

Chemical analyzes were carried out at the agronomic laboratory of FLEURIAL, Algeria.

Table 1: Chemical composition of the earth used for making concrete.

Chemical components of the earth	sample
K (ppm)	187.30
Na (meq /100)	0.47
Mg (meq/100)	1.50
Ca (meq/100)	39.03
Polsen (ppm)	2.60
N (%)	0.023
Carb Total (%)	42.65
M. Organique (%)	0.211
E. Saturée (ms/cm)	*/
Cal. Actif (%)	16.18
PH	7.31
Conductivité (µs/cm)	95.010

3.Physical characteristics of the earth [NF EN 1097-3]

Table 2: Physical characteristics of the earth used.

Characteristics	Unite	Value
Apparent volumetric mass **[NF EN 1097-3]**	kg/m3	1278
Liquiditylimit (w l)	-	49
Limit of plasticity (w p)	-	32
Plasticity index (I p) **[NF P 94-051]**	-	17
Blue value (VBS) **[NF P 94-068]**	-	3,70

Figure10. Apparatus for the determination of Atterberg limits.

Figure 11.Methylene blue test equipment.

We can see that:

- The blue value (VBS = 3.70) shows that the land used is classified between clay soils and very clay soils.
- Plasticity index (15 <I p = 27 <40): the earth used is a plastic ground.

Table 3: The percentages of different constitutions of the earth.

	Sand%	Clay%	Silt %
Sample	38	40	22

Figure 12. Reading test grain density.

According to the different percentages, it is concluded that the land used is sandy clay.

4. Sieve size analysis [NF P 18-560]

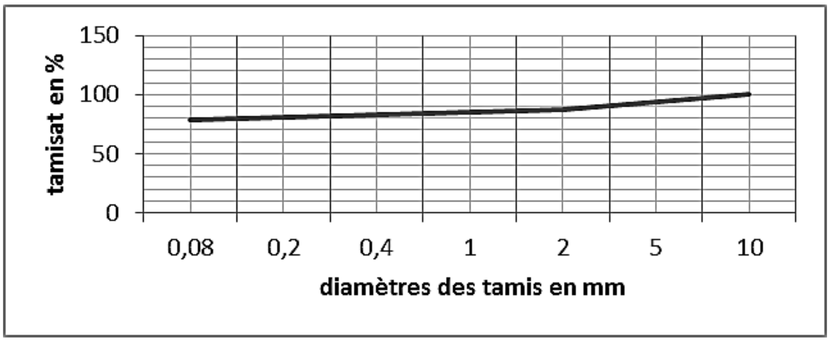

Figure 13.Granulometric curve of the earth.

5. Sedimentation granulometric analysis [NF P 94-057]

Table 4: Granulometric analysis by sedimentation of the earth.

Reading time	R Reading densimeter	temperature(° C)	Ct Correction M	P% On sieveat 80µ	P% On sieveat50 mm	D (µm)
-	24	19	+ 0.09	24,09	76,09	0,075
1	23	19	+ 0.09	23,09	72,93	0,55
2	21,5	19	+ 0.09	21,59	68,19	0,038
5	20,5	20	+ 0.22	20,72	65,03	0,025
10	19,5	20	+ 0.22	19,72	62,28	0,017
20	18	20	+ 0.22	18,22	57,55	0,012
40	17	20	+ 0.22	17,22	54,39	0,0085
80	16,5	21	+ 0.36	16,86	53,25	0,006
-	15	21	+ 0.36	15, 36	48,51	0,003
-	10,5	18	+ 0.06	10,56	33,35	0,002

2. Determination of moisture content of soil to prepare compressed earth block

In order to determine the water content of soils, the test which, a priori, seemed the most appropriate, was the normal and / or modified Proctor test. But this test proved to be of little use and not representative of the conditions of manufacture of the compressed bricks. Indeed, on the one hand, it is almost impossible to manufacture test pieces from the Proctor mold, but above all, there seems to be no relation between the "Proctor energy" and the compressive force. [5;6] (Figure 14)

For this, the raw materials dosed in the necessary amount are homogenized to dry for 3 min to obtain a mixture as homogeneous as possible with a good distribution of particles in the volume of the test piece. Then knead for 2mm.

The test specimens used in this study are cylindrical in shape (11 × 13 cm). The specimens, after the implementation, undergo a compressive stress of 5 KN and a compacting speed of 0.02 mm / s.(Figure 15)

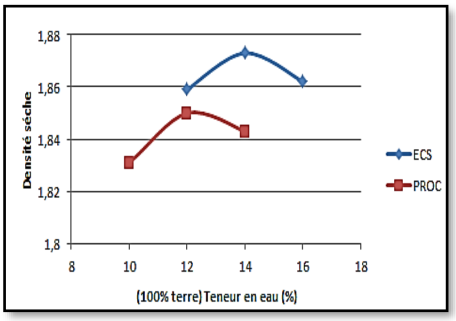

Figure 14. Comparison of water content by Proctor test and static compaction test.

Figure 15. Sample preparation by static compaction (to determine water content).

4. General conclusion

The earth-based materials have remarkable properties compared to many other materials. They can be used in the different constructions. The reinforcing means of these materials are diverse in order to improve their mechanical properties, their ductility and their durability

The analyzes show a clay-sandy soil that can be used for the production of earthen concrete. However, the means of strengthening and stabilizing this material are various

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