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Physico-mechanical characterization and durability of stabilized compressed earth bricks in the region of Timimoun in southwestern Algeria

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ABSTRACT

This study primarily aims to determine the physico-mechanical properties and durability of compressed stabilized earth blocks (CSEBs) made from a mixture of clay and crushed sand that meet the recommendations of the French Standard NF P13-901. The first part of this study consists of first identifying the raw materials. An experimental study was then carried out with three compositions of compressed earth bricks of dimensions ($29 \times 14 \times 9 \text{ cm}^3$) which were prepared by adding 4%, 6% and 8% of slaked lime. These bricks were prepared using the manually-operated Auram 3000 Earth Block Press to study the effects of slaked lime addition on the physical and mechanical characteristics as well as on the durability of these bricks. In addition, the durability was studied and analyzed in two different curing modes. The experimental study showed that it is possible to use stabilized compressed earth bricks as a building material for an optimal mixture of clay with 70% of crushed and stabilized sand, with a percentage addition of 4%, 6% and 8% of slaked lime.

1 Introduction

For nearly 10 000 years, earth has been one of the main building materials used on our planet. More than a third of the world's inhabitants today live in earthen habitats. There are many types of construction materials, such as adobe, compressed blocks and rammed earth, which reflect the identity of the various places [1-4].

It is widely known that earth building is quite popular because the material used is available in large quantities and can be found almost everywhere, at relatively low cost. In addition, it is ecological, recyclable and offers comfort in all seasons.

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The use of this type of material fits suitably within the framework of high environmental quality, since the processes used call for an abundant material that does not require too much energy for its transformation [5, 6].

Unfortunately, the benefits of earth as a building material have gradually been forgotten or overlooked as new materials have recently been developed. However, in the face of the ecological and social problems that arise today, people are beginning to regain awareness of the interest and benefits of earthen construction materials. Thus, the compressed earth brick (CEB) stands out as the most suitable solution. For this, several studies have been devoted to the design of CEBs and to different stabilization techniques [7-9] for the purpose of improving the mechanical strength as well as the durability of the material (porosity, resistance to erosion, etc.) [10-14].

It is widely acknowledged that lime is often used in the chemical treatment of soils. The effect of adding lime causes physical, mechanical and chemical changes in treated soils [15-21]. A number of authors have shown that the rate of these modifications is very slow [19, 22, 23]. Indeed, at room temperature, several months are necessary before the effects can be appreciated. In contrast, the granular composition of soil influences the mechanical properties and durability of compressed earth bricks [24, 25]. Moreover, it turns out that lime is an economic stabilizer.

In recent decades, there has been growing interest in raw earth as an eco-building material due to its economic character in arid areas, such as the Algerian Sahara. In this context, Algeria exhibited early interest in upgrading local materials which are biodegradable and do not harm the environment. The Algerian Center for Earthen Cultural Heritage (Centre algérien du patrimoine culturel bâti en terre – CAPTerre), which is installed in Timimoun, is divided into two technical departments; one of them deals with research on earth construction materials and related techniques. It is worth indicating that the city of Timimoun, also called the Red Oasis, is located in the middle of the Sahara. The inhabitants of this city have been using adobe in ancient buildings, commonly called Ksars, for centuries. Currently, as the Red Oasis is experiencing significant economic development but lacks infrastructure, the authorities have lately decided to build numerous structures, which has engendered a significant need for additional construction materials.

The present work aims to develop a construction material that is based on several local materials which have been widely used in the construction of several important heritage sites. For this, it was decided to design a compressed earth brick (CEB) that is stabilized with slaked lime, using clays, brought from selected sites, and crushed sand that is widely available in this region of Timimoun. It should be noted that the compressed stabilized earth brick (CSEB) is a modern form of the molded earth block (adobe). The aim is also to develop a new eco-friendly mud construction technique that meets the durability criteria.

2 Materials and technical methods

2.1 Identification of the materials used

Two materials that are found in abundance in Timimoun are targeted in this work. The first one is clay soil and the second is the crushed sand from local quarries.

2.1.1 Clay

The clay studied is generally found in the Lower Cretaceous, commonly referred to as the intercalary continental. In the first part, sediments from the Lower Cretaceous are covered by a thick layer of deposits of sand, silt, sandstone debris, quartz pebbles and anhydrite. The clay deposit under consideration is located a few kilometers southwest of the city of Timimoun; this material is red in color. Furthermore, the particle size distribution was determined by two complementary methods, namely the wet sieving and sedimentation analysis, according to Standards XP P94-041 and NF P 94-057, respectively. In addition, the plastic properties of the fine fraction, represented by particles smaller than 400 μm in size, were measured according to the recommendations of the French Standard NF P94-051. Moreover, the density of the solid particles (G_s) was measured using a pycnometer (NF P 94-054). The values obtained are summarized in Table 1.

Elemental chemical analysis carried out by the X-ray fluorescence (XRF) technique on this clay gave the chemical composition presented in Table 2. The clay is mainly composed of silicates (58.98%), aluminates (17.31%) and iron oxide (7.08%). It was found that a sufficient amount of silica and alumina (more than 50%) is present in the clay under study, which confirms that it is perfectly suitable for the manufacture of stabilized blocks, because the clay particles react chemically in the presence of suitable stabilizers, such as lime, to form cementitious gels, such as silicates and aluminates [26, 27].

The criteria used for the selection of the earth that is proposed for the manufacture of compressed earth bricks (CEBs) are based on the recommendations of the International center for earthen architecture (CRA Terre), as well as on the French Standard NF P 13-901.

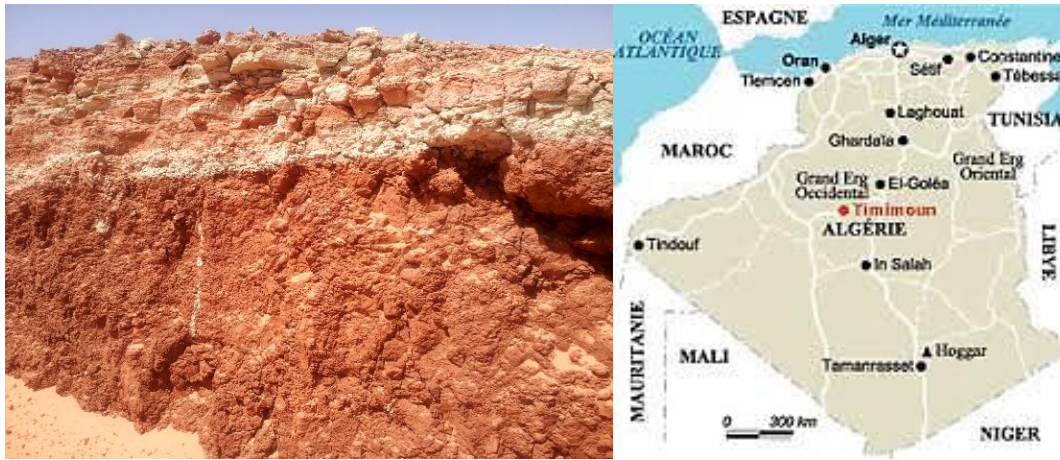


Fig.1 – Location of the clay sampling site

Table1 - Geotechnical properties of the clay used

Properties	Values
Sand ($> 0.02 \text{ mm}$) (%)	22
Silt ($0.02\text{-}0.002 \text{ mm}$) (%)	48
Clay ($<0.002 \text{ mm}$) (%)	30
Liquidity limit WL (%)	49.9
Plasticity limit WP (%)	26
Plasticity index IP	23.9
Methylene blue value	6.5
Specific weight $\gamma_s \text{ (g/cm}^3\text{)}$	2.61

2.1.2 Lime

The lime used in this study is slaked lime Ca(OH)_2 obtained after hydration of quicklime (CaO) that is manufactured in the Wilaya of Ghardaïa (Algeria).

Table 2 – Chemical composition of clay and lime (%)

Oxide (%)	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	CaO	MgO	SO ₃	K ₂ O	Na ₂ O	P ₂ O ₅	TiO ₂	Loss on fire	Cl ⁻
Clay	58.98	17.31	7.08	0.63	2.39	0.35	4.68	0.28	0.07	0.93	7.29	0.055
Lime	1.36	10.60	3.26	82.76	1.88	0.11	0.15	0.06	-	-	-	-

2.1.3 Crushed sand

The sand used is crushed sand (0/3) that was brought from a quarry located west of the City of Timimoun, in the Wilaya of Adrar, located at a distance of 44 km from the Commune of Charouine. The geotechnical characteristics of this crushed sand, determined according to AFNOR standards, are as follows: apparent density = 1.56 g/cm^3 , absolute density = 2.5 g/cm^3 , sand equivalent estimated at 50% with piston and 52% without piston, and fineness modulus = 2.77.

The particle size analyses of clay and sand are shown in Figure 2.

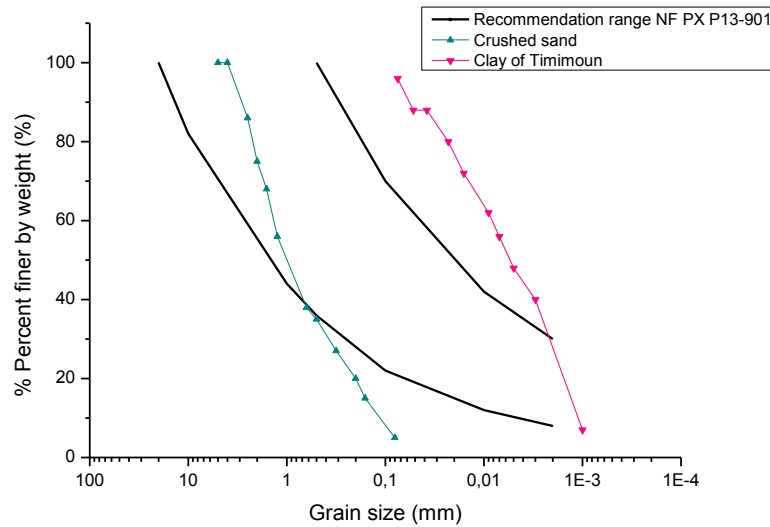


Fig. 2 –Particle size curves of clay and crushed sand

2.2 Experimental methods and techniques

2.2.1 Formulation

Houben [1] pointed out the feedback on the formulation of earth-based products and more particularly compressed earth bricks (CEBs). The reference grain size ranges were used to find out whether an earth can be compressed or not.

According to French Standard NF-XP13-90 (2001), and the recommendations of the International center for Earthen architecture, the approach applied consisted in plotting, on the same granulometric diagram, the curves of sandy and clayey soils as well as that of the desired optimum curve. This method allows getting the proportion of fine grained soil to be mixed with coarse soil in order to achieve a texture that approaches the optimum curve, which in fact would represent the mean line of the spindle. For this, a series of mixtures (clay and crushed sand), to be used in the present study, was prepared.

Furthermore, it was found that the mixture containing 30% clay and 70% crushed sand gave the composition that most closely approximated the mean line of the recommended spindle.

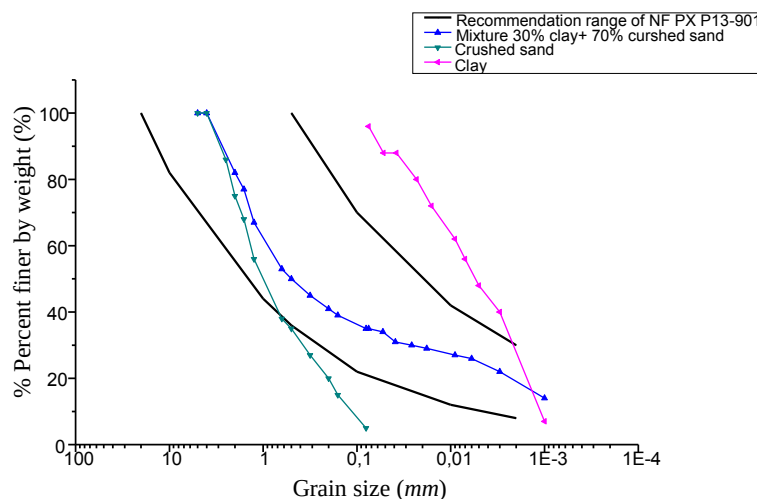


Fig. 3 – Particle size curves of (clay and crushed sand) mixtures

The initial quantity of lime necessary to stabilize the mixtures represented 4% by dry weight of the mixture; it was determined according to the method developed by Eades and Grim [28] (ASTM D 6276 - 99a) in the year 1996. In addition, the test based on the measurement of the pH made it possible to evaluate the lime content that is needed to produce a lime-saturated solution in a water suspension of soil particles and to fully satisfy the ion exchange.

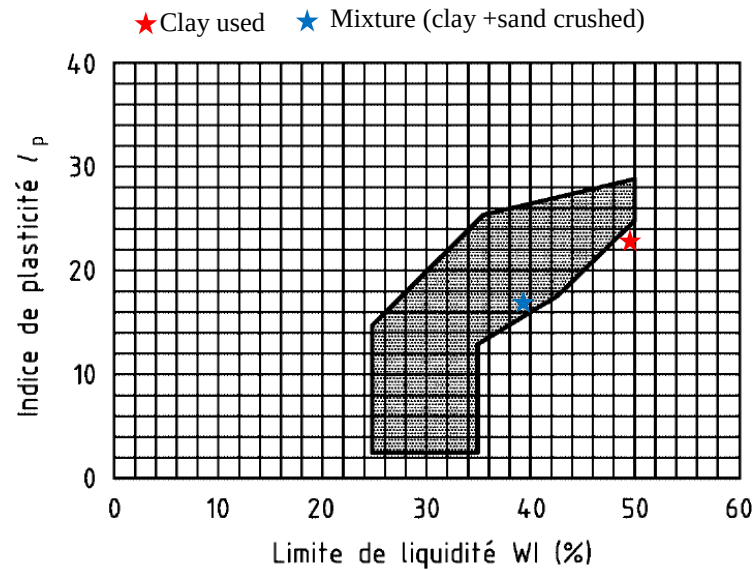


Fig.4 – Atterberg limits of the mixture studied and recommendation range of Standard NF P13-901

The threshold pH was set at 12.4. The amount of lime needed to achieve this pH is known as the lime fixation point. From this pH value, any additional lime would contribute to the development of pozzolanic reactions. The lime dosages of 4%, 6% and 8% were chosen for the mixtures (Table 3).

Table 3 – Mixture proportions of compressed earth bricks (CEB)

Clay (%)	30	30	30	With respect to the dry mixture (clay - crushed sand)
Crushed sand (%)	70	70	70	
Slaked lime (%)	4	6	8	With respect to the overall dry mixture

2.2.2 Optimization, design and manufacture of compressed earth bricks

The first phase consisted of preparing laboratory-scale samples to be studied. The choice of the brick shape fell on cylindrical specimens 5 cm in diameter and 10 cm in height. To manufacture the test pieces, the choice of a static compaction (3MPa), which aimed at fixing the water content and dry density, made it possible to reproduce the future preparation of the compressed stabilized earth brick (CSEB). The manual press that was used in the present work allowed for a simple compression of the material. The compressed earth brick press made it possible to develop a compressive stress of 3 MPa on the bricks. For this reason, this same compressive stress was selected to be used in the manufacture of the test pieces. Based on the studies conducted by Mesbah et al. [29] and P'kla A [30], static compaction would be best suited to clay soils. Also, the optimum water content for compressed earth bricks (CEBs) that was determined from the Proctor test turned out to be inappropriate because the compaction energy used is not the same as that of a static compaction that is utilized in the manufacture of compressed earth bricks. It should be noted that the static compaction mode is investigated in this study.

The study carried out by Myriam Olivier [31] served as a basis for optimizing the water content of the mixtures as well as the dry density during the manufacture of the compressed earth bricks. This same author showed that whatever the materials used and the stabilization mode applied, the compressive forces and the optimum moisture content for static compaction (Wocs) correspond to the maximum dry density and maximum compressive strength, respectively.

The lime-soil mixtures were compacted under a compacting pressure of 3 MPa, at a constant speed of 1.27 mm/min. Before compaction, the raw material was mixed with a predetermined amount of water, in a mixer, for 15 minutes. This time is sufficient to ensure good homogeneity of the mix [32]. The wet sample was then placed in a plastic bag for 24 hours to prevent water loss. This step allowed the homogeneous redistribution of water within the mixture. Finally, the wet material was introduced into a hollow cylindrical mold to obtain cylindrical test pieces 10 cm high and 5 cm in diameter, i.e. the slenderness (height /diameter) equal to 2, for each mixture.

It is important to specify that these test specimens do not have the same dimensions as those made of concrete since our maximum particle size was less than 5 mm [30]. In addition, these specimens were compacted by applying the compaction level set by the press. The material was compacted vertically at the top and at the bottom by means of two cylindrical pistons. Five test pieces were made for each mixture.

The transition from the experimental field to the industrial field made it possible to confirm the experimental data. The artisanal production chain at our disposal followed the same steps as those adopted at the Auroville Earth Institute [33].

The brick press used was brought from the Auroville Earth Institute under the reference AURAM3000; it is installed at the Algerian Center for Earthen Cultural Heritage (Centre algérien du patrimoine culturel bâti en terre – CAPTerre). It can provide a compressive force of 15 tons, or a compressive stress of 3 MPa on the expanded material.

During our various manufacturing campaigns, the materials had previously been prepared and mixed in the laboratory so as to allow the shortest preparation time possible on site and to control the water content of the material. As for lime, it was added on site once the dry material was mixed. The mixing time was set at about 15 minutes [32] in order to obtain a homogeneous mixture.

After mixing, the material was weighed and a given quantity of it was introduced into the mold that was intended for the preparation of the brick samples. This operation made it possible to attain the desired dry density after these samples were stored for the purpose of achieving certain homogeneity between the different bricks of the same formulation.

After filling the mold, the top plate was lowered and locked on the machine. The compression was then manually put into operation by means of a lever that pushed the lower part of the mold, which then triggered the compaction of the material, reduced the porosity and gave the final dimensions of the bricks ($29 \times 14 \times 9 \text{ cm}^3$).

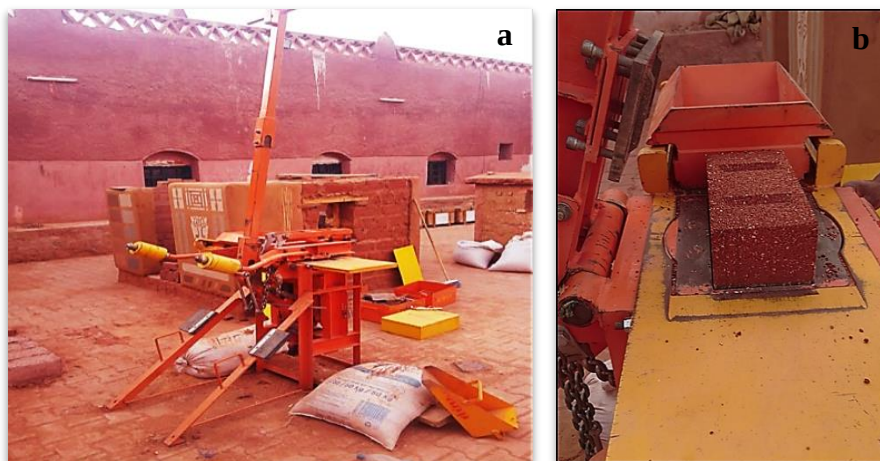


Fig.5 – Brick manufacturing: a) AURAM3000 press, b) Compressed earth brick after compression.

2.2.3 Curing condition

All bricks made from the mixture (clay + crushed sand) without binder were covered with a plastic film and stored in the laboratory at a temperature between 20 and 25 °C, until reaching a constant mass (Fig. 6.A). The stabilized bricks were thus conserved for 90 days and 180 days. In addition, the compressed earth bricks (CEBs) covered with plastic were stored in an oven at a temperature $T = 65 \text{ °C}$ for 7, 14 and 28 days (Fig.6.B). These CEBs consisted of the mixture (clay - crushed sand) to which various quantities of slaked lime were added in order to study the effects of curing time and temperature on the mechanical properties of compressed earth bricks (CEBs).



Fig. 6 – Curing conditions: A) Storage in the laboratory, B) Storage in an oven.

2.2.4 Tests performed

2.2.4.1 The dry compressive strength test

This test made it possible to determine the simple compressive strength of raw earth blocks compressed in accordance with the guidelines of Standard XP P 13-901. This test is clearly described in [34]. It consists in subjecting a sample, which is made up of two superimposed half-blocks and glued by a cement mortar joint, to a simple compression until rupture (fig.7.D).

2.2.4.2 The tensile strength test

The tensile test was performed according to the testing procedure described in [34]; it is clearly displayed in Figure 7. C. This test was derived from the tensile failure test (Brazilian test). Hence, the block was subjected to a compression, along two hardwood strips that were placed on each side of the block, thus producing a tensile stress along a vertical facet passing between these two strips. Finally, the block was divided into two half-blocks.

$$St = \frac{18F}{\pi ah} \quad (1)$$

where: F is the maximum load supported by the two half-blocks (KN), a is the specimen depth (cm), and h is its height (cm).



Fig.7 – Dry strength test: C) Dry tensile strength; D) Dry compressive strength.

2.2.4.3 The abrasion resistance test

This test consists in subjecting the blocks to mechanical erosion that was applied by rubbing a wire brush, at constant pressure, for a number of cycles, after the hardening period. Hence, after weighing the blocks (mass: m_1), the surface was brushed with a 3 kg wire brush that was adequately adjusted to the center of the surface, in accordance with the recommendations of Standard XPP 13-901. It should be noted that brushing is done back and forth, for one minute, with 60 round trips. After brushing, the width of the blocks should not exceed 25 mm which represents the brush width. Moreover, brushing was done along the entire length of the block. At the end of the brushing operation, the blocks were cleaned and weighed (mass: m_2). The abrasion coefficient (Ca) is defined as the ratio of the brushed surface (S in cm^2) to the mass of material detached by brushing ($m_1 - m_2$ in g):

$$Ca = \frac{S}{m_1 - m_2} \quad (2)$$

2.2.4.4 Testing the resistance to capillary rise

The capillary absorption test was carried out in accordance with Standard XP P 13-901. The material was first partially submerged to a depth of 5 mm. This depth was kept constant. The water absorption coefficient corresponds to the absorption rate after a period equal to 10 min. It is calculated using the following formula:

$$Cb = \frac{100W}{S\sqrt{t}} \quad (3)$$

where W is the mass of water (g) absorbed by the block during the test, S the submerged area (cm^2), and t is the immersion time of the block (minutes).

3 Results and discussion

3.1 Optimal water content and maximum density

Figure 8 shows the optimization results obtained when the mixture was subjected to static compaction of the order of 3MPa. The optimization method used is similar to that previously utilized by Olivier M. and Mesbah A. [31]. It should be indicated that the same method of static compaction was also used for the optimization of the soil mixture (clay - crushed sand) in the presence of slaked lime.

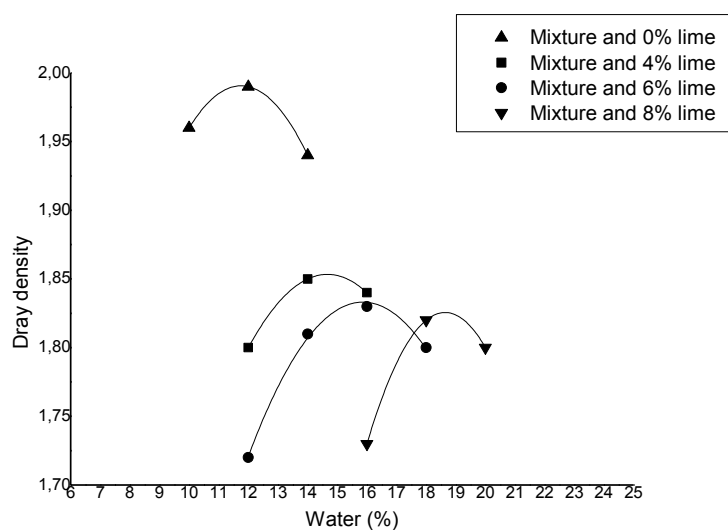


Fig. 8 – Optimization of the water content of the mixture with slaked lime

In this work, it was decided to fix the optimum water content to about 12 % and the maximum dry density of the mixture, which included local materials, to approximately 1.99. These results turned out to be in good agreement with those reported by several authors [35-37].

On the other hand, it is worth noting that increasing the proportion of lime in the mixture leads to a shift in the optimum water content for compaction towards higher water content values around 2% and a decrease in dry densities of the order of 1%. This shift from the optimum is similar to that reported in the study conducted by Le Roux [15] on the introduction of lime into a soil containing large amounts of clay. In addition, it is useful to recall that the optimal water content increases when the lime content augments [38, 39]. To this end, Figure 8 clearly illustrates the shift in the curve of the optimum static compaction of the mixture that was treated with 4%, 6% and 8% of slaked lime.

3.2 Effect of curing conditions and influence of lime on the properties of compressed earth bricks

3.2.1 Dry compressive strength

Table 4 shows the results of the effect of lime on oven-cured CEBs, at a temperature of 65 °C. It clearly shows the variation of dry compression strength as a function of lime dosage, at the ages of 7, 14, and 28 days.

This same table explicitly shows that for the stabilization of the mixture with 4%, 6% and 8% of lime, the dry compressive strength values obtained at 28 days were respectively equal to 2.5, 3.05 and 3.82 MPa. It was also noticed that the dry compressive strength of CEBs increased by around 12% when the lime content augmented. Furthermore, it was also noted that the dry compressive strength increased rapidly as the temperature went up at the ages of 7, 14 and 28 days. This increase was of the order of 12% for each lime dosage. It should also be mentioned that portlandite was formed in large quantities, in addition to calcium silicate hydrates and hydrated calcium aluminates which ensure the bonding between particles and reinforce the mechanical performance of compressed earth bricks (CEBs). This process is attributed to the presence of clays. These findings have also been observed by Bell, Moore, Locat and Eades [16, 21, 28, 38]. Moreover, it is worth noting that temperature had an accelerating effect on the kinetics of the pozzolanic reactions [22, 23, 40-42].

Table 4 – Mixture proportions of compressed stabilized earth bricks (Oven cured)

Slaked lime (%)	Retention period (Days)	Dry compressive strength (MPa)
4	7	1.7
	14	2.26
	28	2.5
6	7	1.9
	14	2.4
	28	3.05
8	7	2.8
	14	3.71
	28	3.82

Furthermore, the comprehensive dry strength of CEBs, which were cured at room temperature in the laboratory at the age of 90 days and stabilized with 4%, 6% and 8% lime, was found equal to 2.01, 2.56 and 3.10 MPa, respectively. In addition, the comprehensive dry strength increased by around 12% (Figure 9). However, the values mentioned above were obtained approximately at the age of 14 days, for CEBs cured at the temperature of 65 °C, which shows that the lime stabilization process is very slow at room temperature. Indeed, the stabilizing effects require several months and sometimes several years to be fully appreciated [19, 22, 23, 43]. In addition, the strength values obtained for the CEBs, which were stored until the age of 18 months at room temperature, were approximately double the values obtained at 90 days of age. In fact, the dry compressive strength of CEBs stabilized with 4%, 6% and 8% slaked lime, and stored until the age of 18 months in an ambient temperature, was found respectively equal to 3.42, 4.82 and 5.68 MPa (Figure 9).

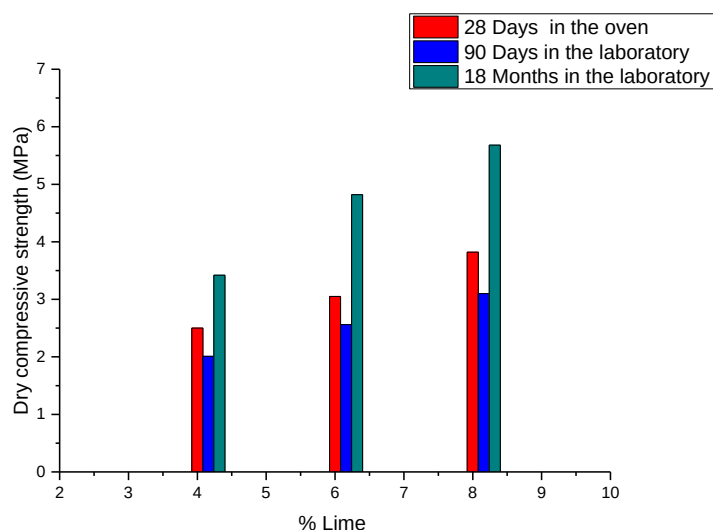


Fig. 9 – Dry compressive strength of CEBs as a function of the amount of slaked lime added, under curing conditions

3.2.2 Dry tensile strength

The tensile strength of compressed stabilized earth bricks (CSEBs) increased as the slaked lime dosage went up. For the stabilization with 4%, 6% and 8% of slaked lime, the dry tensile strength of the CSEBs cured in the laboratory, at 18 months and 90 days, was found to be equal to 0.65 and 0.39, 0.86 and 0.49, and 1.09 and 0.67 *MPa*, respectively. It is worth indicating that the maximum tensile strength was reached at 18 months with 8% slaked lime. It is useful reminding that Bell found that the reaction of clay with slaked lime was very slow [16]. In the case of a stabilization with 4%, 6% and 8% of slaked lime, the dry tensile strength of the CSEBs increased respectively by 0.52, 0.58 and 0.95 *MPa* at 28 days, for an oven curing at a temperature of 65 °C. Comparison of these values with those obtained at 90 days shows that the pozzolanic reaction of clay with slaked lime accelerated with temperature.

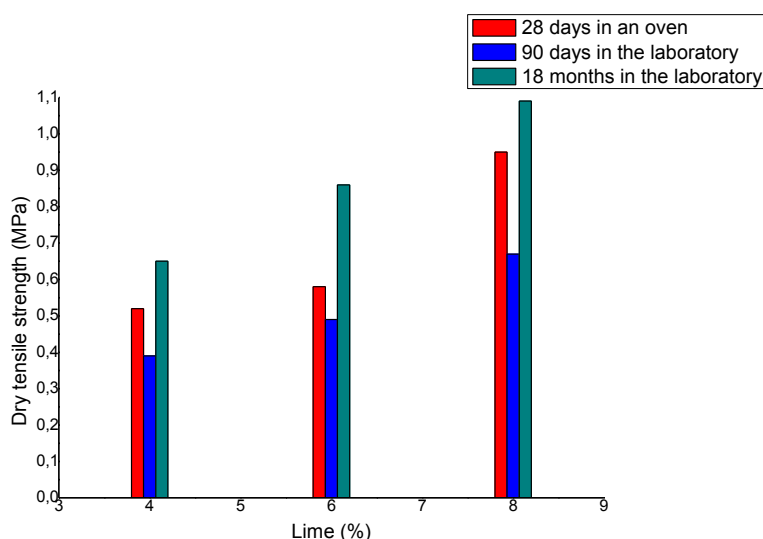


Fig. 10 – Dry tensile strength of CEBs as a function of the amount of slaked lime added, under curing conditions

3.2.3 Abrasion resistance

Abrasion resistance is an important property that may be used to find the evolution of surfaces exposed to strong winds laden with fine and hard particles of sand (sandstorm) especially in arid areas like the region of Timimoun. Abrasion resistance is associated with wind erosion [44, 45].

The results obtained showed that the abrasion resistance of CSEBs can be improved by selecting the correct curing conditions and the proportion of slaked lime used for stabilization. Indeed, the CSEBs cured in an oven at 28 days and at a temperature of 65 °C exhibited higher resistance values than those cured at 90 days in the laboratory and at room temperature. The rates of increase in the abrasion resistance for stabilization with 4%, 6% and 8% of slaked lime were found equal to 3.79, 3.69 and 8.57 cm^2/g , respectively. On the other hand, the abrasion resistance of CSEBs after 18 months of curing in the laboratory reached appreciable values; it was equal to 7.25 cm^2/g for a rate of 4%, 9.06 cm^2/g for 6% and 24.06 cm^2/g for 8% of slaked lime. It should be recognized, however, that these values remain quite low in comparison with those given by the experimental Standard NF XP13-901 (minimum value of 2 cm^2/g).

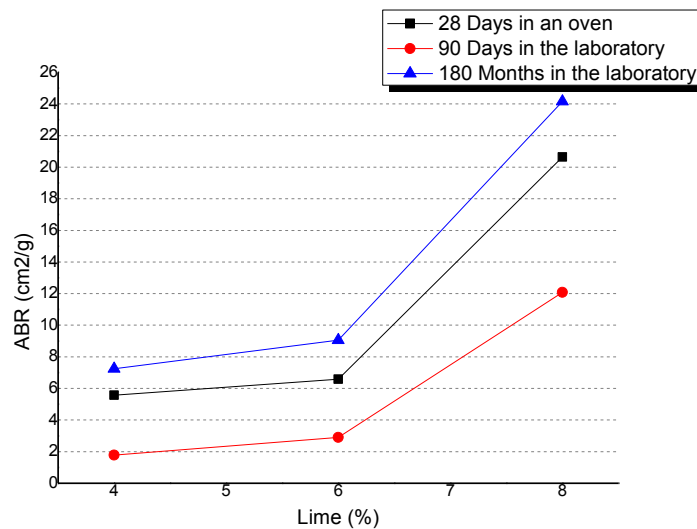


Fig. 11 – Abrasion resistance of CEBs as a function of the amount of slaked lime added, under curing conditions

3.2.4 Resistance to capillary rise of water

Figure 12 clearly illustrates the results obtained for the absorption coefficient. A clear difference was noted between compressed stabilized earth bricks (CSEBs) stored at the ages of 18 days, 90 days and 18 months, for each slaked lime dosage. For stabilization at 4, 6 and 8% slaked lime, the capillary absorption coefficient decreased by 22.58 and 25.24, 19.62 and 20.72, and 11.47 and 12.11 $\text{g}/(\text{cm}^2 \cdot \text{min}^{1/2})$ at 18 months and 28 days, respectively.

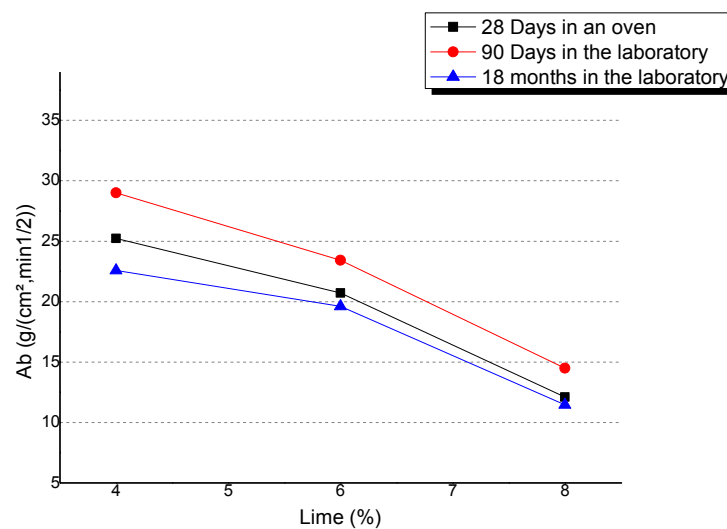


Fig. 12 – Resistance to rising water by capillary action of CEBs as a function of the amount of slaked lime added, under curing conditions

Also, the mean standard deviation was around 1.46. Moreover, according to the experimental Standard NF XP 13-901, the absorption coefficient of bricks was within the minimum class (coefficient less than 20 $\text{g}/(\text{cm}^2 \cdot \text{min}^{1/2})$).

These findings suggest that slaked lime stabilization resulted in a more compact and less porous mixture. In fact, a slight decrease in the absorption coefficient was observed at 90 days for stabilization with 4%, 6% and 8% of slaked lime. This reduction was of the order of 9.10 %. Moreover, the standard deviations between the absorption coefficients obtained at 90 days and at 18 months, with 4%, 6% and 8% of slaked lime, were respectively equal to 6.42, 3.81 and 3.03g/(cm².min^{1/2}). This can be explained by the fact that the pozzolanic reaction was quite slow at room temperature.

4 Conclusion

The main purpose of this work was to study the effect of slaked lime content on the physico-mechanical properties and durability (abrasion, water absorption by capillarity) of compressed stabilized earth bricks (CSEBs), made from local materials (clay, crushed sand).

The bricks, subjected to static manual compaction, showed a stress approximately equal to 3MPa. These same CSEBs were tested after oven curing up to 28 days (at 65 °C), and after curing in the laboratory for up to 90 days and 18 months, at room temperature. Based on the results of this experimental study, the following conclusions were drawn:

The optimum water content increased as slaked lime dosage went up. On the other hand, a decrease in the maximum dry density was observed as the slaked lime dosage went up.

Compressed stabilized earth bricks (CSEBs) with lime content greater than the minimum lime dosage, also called lime fixation point, exhibited an increase in their mechanical strength values. On the other hand, the CEBs stabilized with different percentages of slaked lime gave fairly high strength values (dry compressive strength and dry tensile strength) in the long term. This is probably due to the evolution over time of the pozzolanic reaction in the treated CEBs, at room temperature (22 to 25 °C). This indicates that this reaction was not completely finished within 90 days. Indeed, it turned out that it could continue during the 18-month period of treatment.

A curing at the temperature of 65 °C, after only 28 days, accelerated the hardening of CSEBs and gave them better mechanical strength values than those obtained at room temperature, at 90 days. In fact, the resistance of CEBs stabilized with lime, having undergone a 28-day curing period, was close to that of CEBs cured at 18 months at room temperature.

With regard to the abrasion resistance, it was found that it increased as the slaked lime dosage augmented, for both conservation methods (in an oven and in the laboratory). It should be noted that this increase was quite significant with the addition of 8% of slaked lime. However, the capillary absorption decreased with increasing slaked lime dosage, for different curing periods and temperatures.

The same observation was made regarding the durability of compressed stabilized earth bricks (CSEBs), after a curing period of 28 days, at a temperature of 65 °C. Indeed, the durability properties of CSEBs at the age of 28 days were similar to those of CSEBs at 18 months of age and at room temperature. Consequently, it may be concluded that this mode is suitable for reaching the values recommended by the Standard NF XP 13-901.

Finally, in view of these results, it can be asserted that the addition of a stabilizer, like slaked lime, remarkably improved the mechanical characteristics and durability of CEBs made from local materials, i.e. clay and crushed sand, from the region of Timimoun.

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