Available online www.jsaer.com

Journal of Scientific and Engineering Research, 2018, 5(12):322-329

Research Article

ISSN: 2394-2630
CODEN(USA): JSERBR

Valorization of the Attapulgite Clay as a Mineral Addition in Sand Concrete

Keinde Dame, Prince Momar Guèye, Fabrice Ndèye Awa Sène, Abdou Karim Dieng

LMGC-Laboratory of Civil Engineering Materials ESP / UCAD Sénégal

Abstract This work falls within the framework of recycling local products and wastes as mineral additions in the manufacture of cementitious building materials such as sand concretes, in order to improve their performance. The study concerns the very abundant attapulgite clay in Senegal in the region of Thiès. The objective of this work is the characterization and the study of its influence in the properties of the concrete. For this purpose, we studied tests on the fresh and hardened concrete, on the one hand by varying the rate of attapulgite addition irrespective of its absorption coefficient and, on the other hand, keeping the same rates but adding water. A comparison of the results with a control sample of sand concrete without the addition of attapulgite has been made. With regard to the workability of the concrete, spreads are acceptable but decrease as the percentage of attapulgite addition increases. For the mechanical resistance tests, we had resistances exceeding or close to 25 MPa in compression.

Keywords Valorization, Attapulgite, Mineral Addition, Sand Concrete

1. Introduction

The use of mineral binders is a long-applied practice, Greeks and then Romans used to add volcanic ash or, failing that, fired-clay tiles to their lime mortar to make them waterproof. In the second half of the 19th century, the increase of industrial production, contemporary with the generalization of the use of hydraulic cement offered the mineral addition new and abundant resources. The blastfurnace slag would become the first mineral addition. The development of waste production and industrial by-products and the increase of environmental constraints throughout the 20th century, would lead to series of researches on the valorization of by-products in cement or concrete [1 – 4].

The cement sector allows two types of valorization widely practiced: on the one hand the energy recovery that uses alternative fuels for the production of cement, and on the other hand the valorization of a material operated at the level of the raw material or constituents. In order to find new additions to obtain a more efficient cementitious material, researchers are constantly working on the issue [1]. It would therefore be interesting to study sand concrete with the addition of attapulgite clay, which we find in certain areas in Senegal such as Pout, Fouloum, Nianning, Mbodiène by determining the characteristics of the associated concrete. The objective of this work is to valorize attapulgite powder baked at 800 ° C as a mineral addition in sand concrete. For this, we will determine the mechanical properties of sand concrete containing attapulgite clay, through tensile strength tests by flexion, compression tests. We will verify the workability of each mixture as well as their air content.

2. Materials and Methods

Materials

Composition of the control sand concrete

The materials selected for the composition of the concrete are:

- SOCOCIM brand cement in Class 42.5 **[5];**
- dune sand.

The composition in masses retained for 1m3 of concrete is presented in **table 1**:

Table 1: Quantities of materials used for the control

Constituents	Mass (Kg)
Sand	1116.500
Cement SOCOCIM 42.5	545
Admixture BV40	1.5 % of the mass of the binder
Water	336.38

The formulation in table 1 will be used to determine the composition of concrete samples with the addition of attapulgite.

Compositions of sand concrete with attapulgite clay

The amount of attapulgite varies from one batch to another in intervals of 5%. The attapulgite used for these formulations is first recovered in the form of rock and then it is crushed as shown in Figure 1. The powder obtained is poured into a sieve of 80 microns, to have a fine texture and it will be baked at 800° using an oven (Figure 2).

Figure 1 : Attapulgite in the form of rock

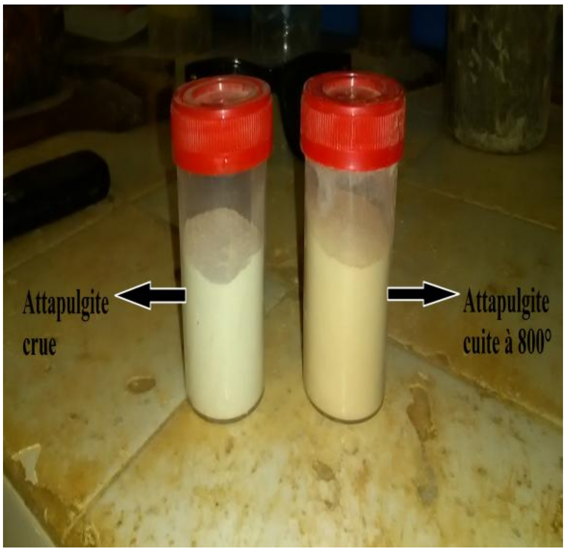

Figure 2 : Powdered attapulgite

Table 2 shows the chemical composition of the attapulgite in the region of Thiès.

Table 2: Chemical composition of the attapulgite

Major contents	Values in %
SiO_2	57
Al_2O_3	13
Fe_2O_3	2
CaO	Traces
MgO	14.4
Loss on ignition	11.4

A semi-quantitative X-ray diffraction analysis in table 3 gives the mineralogical composition of attapulgite.

Table 3: Mineralogical composition of attapulgite [6 – 7]

Minerals	%
Attapulgite	90
Quartz	3
Truscottite	3
Calcite	2
Dolomite	2

Methods

Execution of the mixing with the mortar mixer

The mixing is done in the laboratory to ensure the homogeneity of sand concrete. To do so, the constituents such as sand, cement, attapulgite, water and the admixture are introduced into a metal tank. Then, using the mortar mixer, two mixings of 1 minute and 30 seconds each will be performed, separated by a break of 15 seconds, time to do a manual scraping. The mixture must be homogeneous at the mixer outlet.

Preparation of test pieces

The filling procedure of the specimens is done as quickly as possible to maintain good workability and is as follows:

• humidification of molds with three cells of size 4 x 4 x16 using a fat to facilitate mold release;
• fill the mold in one layer and place it in the shaking table;
• level the upper part of the mold.

For each formulation, 9 test pieces are made (Figure 3). Mold release of the test pieces will be done 24 hours after the confection before immersing them in water and crushings will be done on the 3rd, 7th and 28th days.

Figure 3 : Filled mold

Physical and mechanical characterisation of the sand concrete with attapulgite addition

Consistency test

This test is a measure that allows to assess the spreading of sand concrete, to see its maneuverability before its implementation. For this purpose we have used a plastic funnel in which the concrete is filled up to the mark. Then it is lifted so that the concrete can fall under its own weight. The spread is thus obtained by measuring with a ruler the diameter of the surface occupied by the concrete (Figure 4). The verification of the handling is done just before the manufacture of test pieces. A sample from each mixture is used to measure the spread.

Figure 4 : Checking of the sand concrete spreading

Entrapped air

For this test, we used the mortar aerometer. It has been shown that the mechanical properties of the cement are optimal when it contains 3 to 4% air by volume. So we will see how the amount of air changes each time the attapulgite is added. The device consists of a tank with a volume of 0.75 l or 1 l which is hermetically sealed during the test thanks to a tight cover.

The flexural tensile strength test

For the determination of the bending strength, we used the press shown in Figure 5. This machine gives us information on the force and stress exerted on the test piece. To do this test just place the test piece in the bending device with a molding side face on the support rollers. From there we can start the press which will stop when there is a break. The results obtained represent the average of three test pieces. This test was carried out in total on 90 test pieces.

Figure 5 : Flexion tests machine of 250 KN class 1

The compression test

For compressive strengths we used the compression device as shown in Figure 6. Two crushes will be done for each test piece.

Figure 6 : Compression tests machine of 250 KN class 1

3. Results and Discussion

Characterisation with the Consistency Test

The spreading values measured on the concretes are summarized in table 4. These values are in cm and FIG. 7 shows the variation of the spreading according to the percentage of additions.

Table 4: Result of spreads in cm

Formulation	Control concrete	Substitution at 5%	Substitution at 10%	Substitution at 15%	Substitution at 20%	Substitution at 25 %
Without addition of water	21	15	11	8	5	0
With addition of water	21	15	15	15	15	15

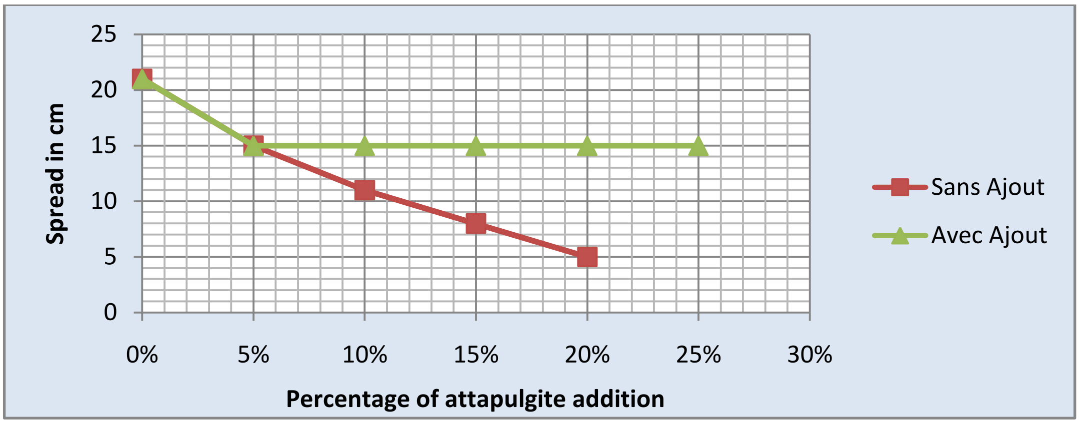

Figure 7 : Fluctuation of the spread according to the percentage of attapulgite addition

From the results obtained, we notice that the spread, for the formulations without addition, decreases as the percentage of addition of attapulgite increases. Attapulgite has a high absorption capacity, and for this reason the more it is increased the more the spread decreases. By contrast, for the one with the addition of water, the spreading decreases with respect to the control when 5% of attapulgite is added and remains constant up to 25%. This can be explained by the fact that if 100% of the attapulgite mass is increased in water each time the attapulgite is increased, the spread will remain the same.

The sand concretes studied are able to flow out from the funnel under their own weight, so the spreads obtained are satisfactory.

The spreading of the control concrete is always higher in all cases, with addition as without addition of water. This is explained by the fact that in the control concrete there is no attapulgite and no significant absorption.

We note that the spreads obtained for concretes with added water are higher than those for concretes to which no water has been added.

Characterisation with the Compression Test

The results of compressive strength tests carried out on sand concrete containing different percentages of attapulgite clay are shown graphically at 3, 7 and 28 days in Figures (8, 9) for both formulation types with and without addition of water.

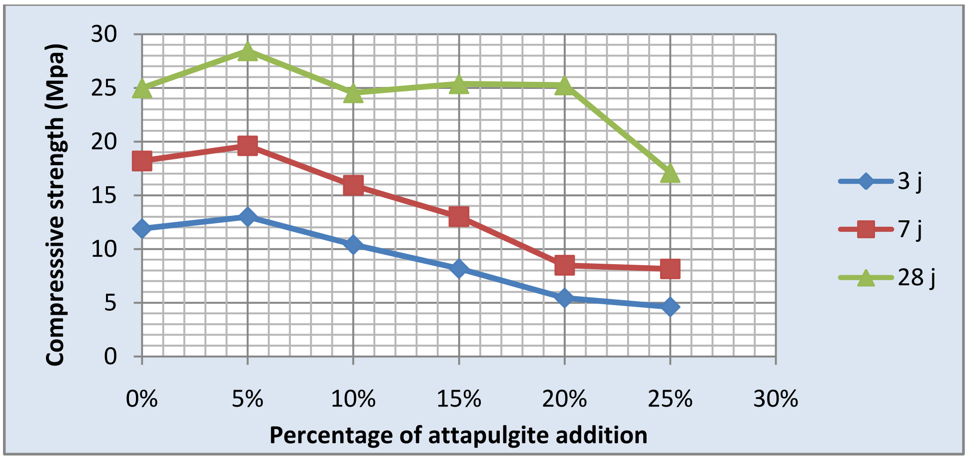

Figure 8 : Variation in compressive strength according to the percentage of attapulgite addition at different ages for formulations with added water

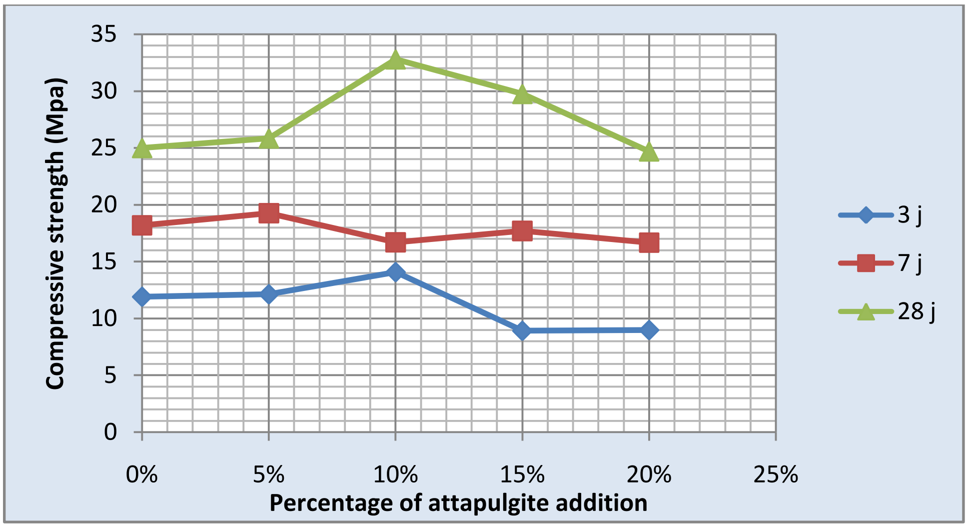

Figure 9 *: Evolution of the compressive strength as a function of the percentage of attapulgite addition at different ages for the formulations without addition of water*

At 3 and 28 days the optimal resistance is obtained at 10% addition of attapulgite for the formulations without addition of water and 5% for those with addition. At 7 days it is obtained at 5% for both types of formulation. These observed optima reflect a better compactness of these mixtures. The amount of attapulgite increases the strength of the concrete for a given percentage (10 and 5%). Beyond these percentages, this resistance tends to decrease. The amount of water added for the second part of the formulations is at the origin of the decrease of the resistance. The excess water causes the creation of internal vacuums, cracks will then be created and the elements will lose strength.

The ratio E / C being fixed at 0.61 for all the formulations, thus increasing the quantity of water, one exceeds this ratio, which causes the fall of the resistances.

Characterisation with the Flexural Tensile Strength Test

The changes in flexural tensile strength, with and without additions, at different ages (3, 7, and 28 days) are shown in Figures 10, 11 and 12.

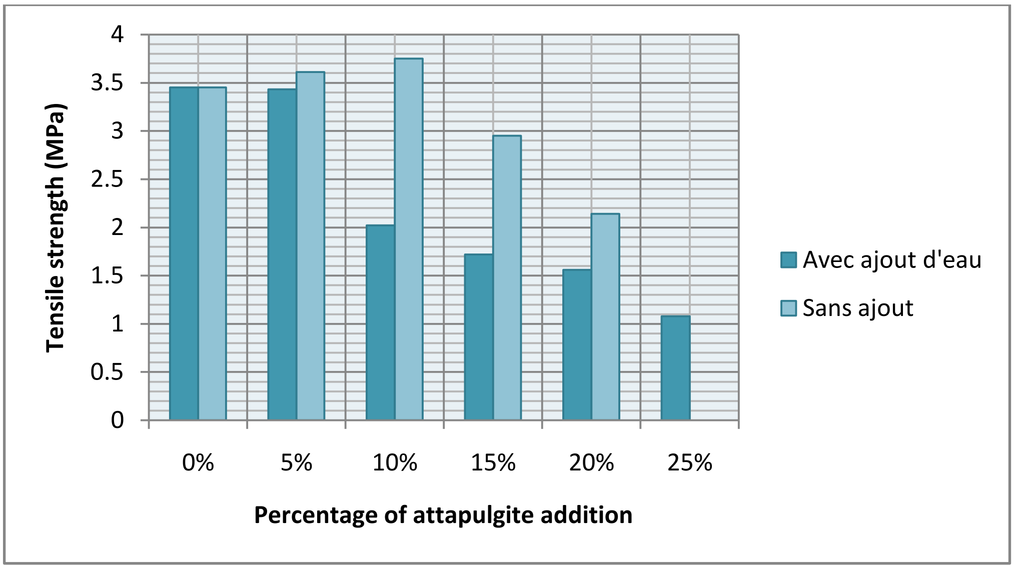

Figure 10: Variation of bending tensile strength according to the percentage of attapulgite addition at 3 days

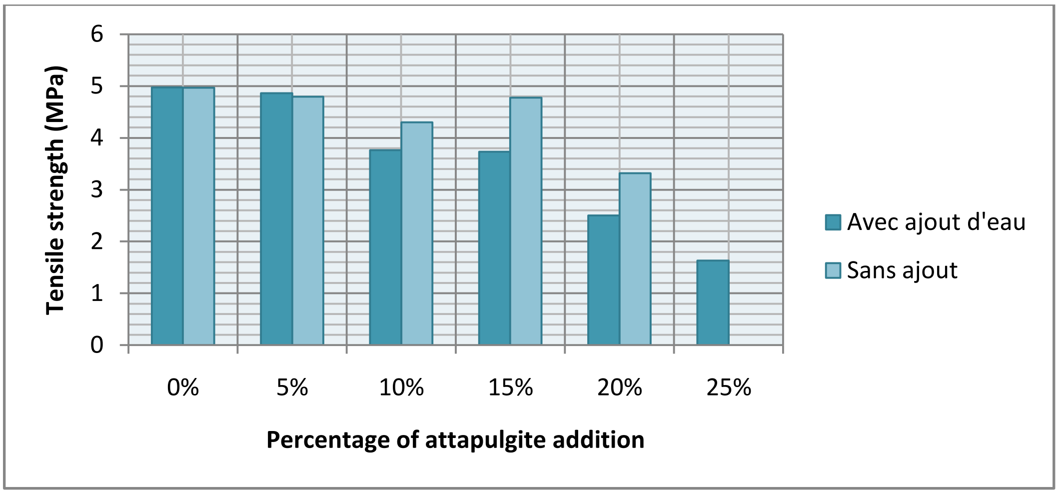

Figure 11: Variation of bending tensile strength according to the percentage of attapulgite addition at 7 days

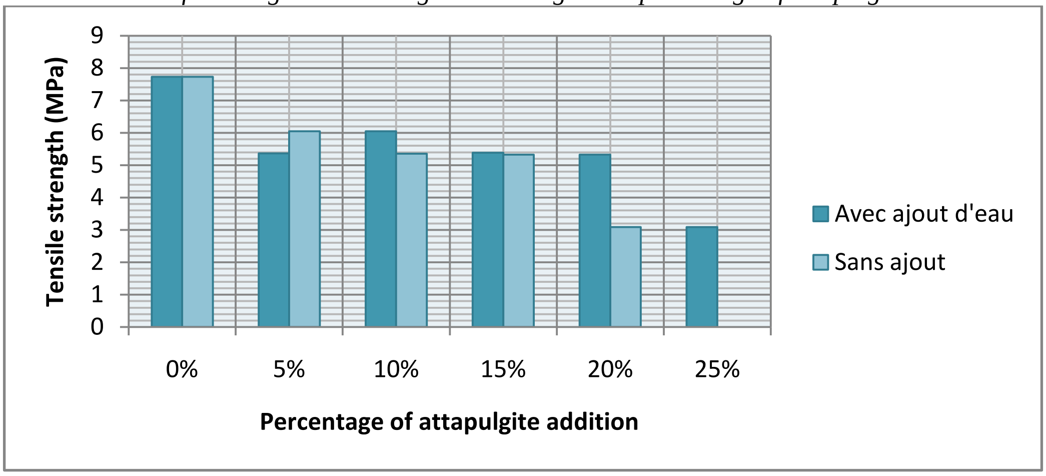

Figure 12: Variation of bending tensile strength according to the percentage of attapulgite addition at 28 days

At the level of the three graphs, for the formulations with addition of water, we note the same variation of the resistance on the 3rd and the 7th day. It decreases as the attapulgite is increased from 5%. On the 28th day, we did not notice any evolution even if all the resistances are lower than that of the control concrete. For formulations without added water, flexural tensile strength is maximal at 10% of attapulgite addition. Compared to the control concrete, the addition of 5, 15 and 20% of attapulgite decreases the resistance. This means that it is at 10% that we have a good concrete compactness. At 7 days, still for the formulations without additions of water, the maximum resistance is obtained with 5% addition of attapulgite and closely matches that of the control concrete. On the other hand with 10, 15 and 20%, the resistance is low.

In summary, for this test of flexural tensile strength we can deduce that for formulations with added water, none of the resistances obtained exceeds the control except that with 5% addition which reaches almost 5 MPa at 3 and 7 days. This means that excess of water has a detrimental effect on the concrete because it causes internal vacuum.

For formulations without added water, at 3 and 28 days we have optimal resistance at 10% attapulgite addition. This can be explained by the fact that we have a good concrete compactness at this percentage.

4. Conclusion

In the light of the above, we note that the incorporation of attapulgite clay at a certain percentage contributes positively to the mechanical performance of sand concrete. For the other percentages of addition, they closely match the control concrete. But as to its workability, this incorporation has a negative effect unless we take into account the absorption coefficient of attapulgite. It should be noted that these additions increase the absorption of the mixture.

References

[1]. La Saga des matériaux, Valorisation des coproduits et des déchets, filières ciments et béton, n° %1894, 2008-2009.
[2]. A. Nagoudhi et N. Bélhocine, (2014) Etude expérimentale d'un mortier avec ajout minéraux, Ourgla.
[3]. M. Chikouche, M. Siline, M. Bibi et E. Ghorbel, (2013) Valorisation d'une marne argileuse comme ajout dans les matériaux cimentaires.
[4]. M. Bibi, B. Belouahri, M. Chikouche et M. Hattab, (2009) Etudes des propriétés mécaniques et Physico Chimiques de l'argile vaseuse et de l'argile gréseuse provenant de la région de M' Sila, M'Sila.
[5]. Soccocim, Fiche technique du Ciment 42, 5 R, Dakar, 2015.
[6]. O. Serranno, S. B. D. R, D. E et S. R, Notices explicative de la cartographie multi couches àn 1/50 000 et à 1/20 000 de la zone d'activité du Cap Vert, Dakar, 2009.
[7]. Paul leberre, BRGM, Les attapulgites et sépiolites, France, 1989.