Available online www.jsaer.com

Journal of Scientific and Engineering Research, 2018, 5(5):598-602

Research Article

ISSN: 2394-2630
CODEN(USA): JSERBR

Mechanical and Thermal Properties of Building Materials: Mixture of Montrolland's Laterite and Cement

Djibril Sow[1]*, Astou Diokhane[1], Macodou Thiam[1], Alan Carter[2]

[1]Institut Universitaire de Technologie de l'Université de Thiès, Sénégal
[2]Génie de la construction de l'Ecole de Technologie Supérieure de Montréal, Canada

Abstract The aim of this study is to improve the proprieties of the mixtures of laterite. Thus, we conduct this study related to the mixtures of laterite and cement for their use as building material. The lateritic formations represent the most abundant economical materials resources available in tropical and equatorial Africa. We have determined by experiments the mechanical and thermal properties of cement modified laterite specimens. This work enabled us to determine the optimal blend according to their thermo-mechanical properties. The interesting results obtained show that the integration of mixtures of laterite and cement in building materials are great opportunities to reduce the cost of social housing. It also improves the thermal comfort.

Keywords Cement, Laterite, Mechanical properties, Mixture, Thermal properties

1. Introduction

Local soil is used economically on the spot for millennia. More than 30 % of the population habitats worldwide are made of soil. Whether raw, cooked or stabilized, varieties of earthen architectures have abounded since the appearance of humans throughout the world [1].

The range of materials used in the habitat is relatively large. But, due to the high cost of construction materials, it is possible to make simple disposition in order to decrease the cost of construction.

In Africa, earthen construction has become over the years an art: For example, cases-shells in Cameroon or the pyramids in Egypt.

The soil is generally used in laterite or clay states and which represent the most abundant and economical materials resources in Africa. The laterite is easily available in the open country [2].

Thus, to improve the proprieties of the laterite its interesting to mix it with cement.

The cement that was used is an hydraulic binder. It is the product obtained by reducing clinker powder consisting essentially of hydraulic calcium silicates and a small quantity of gypsum (hydrated calcium sulphate). Gypsum is a mineral used to delay and regulate the taking and hardening of cement [3 - 4].

The resistance to compression of materials is one of the properties used in the design of buildings. The thermal resistance of a material gives it certain insulation depending on its thickness and this resistance is inversely proportional to the coefficient of thermal conductivity. Thus, the main objective of this research is to optimize the properties of cement mixed with laterite for possible use in building construction.

2. Materials and Methods

The laterite that was used comes from Montrolland town located at 87 km from Dakar (Senegal).

To make specimens, we used the fraction of this laterite passing the 5 mm sieve.

The gradation analysis of this laterite soil has shown 25% of gravel, 15% of coarse sand, 25% of fine sand, 6% of silt, 29 % of clay and 52 % of the grains mass pass the 80 µm sieve (Fig.1).

Since the effects of particle size distribution on the behaviour of lateritic soil are important [5-6].

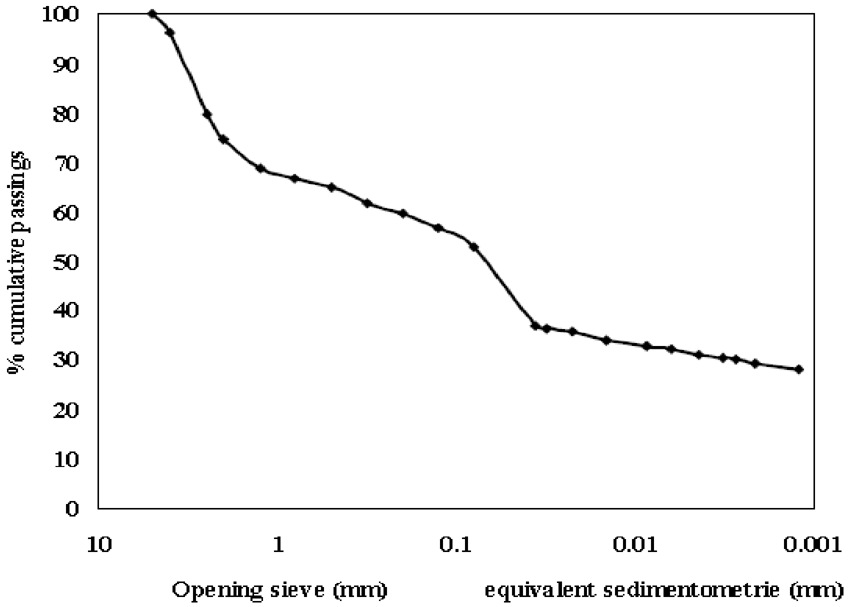

Figure 1: Size analysis and sedimentation analysis of Montrolland's laterite

The cement that was used to improve our samples is CEM II / B-LL 32.5R cement from SOCOCIM in Rufisque, a town 20 km from Dakar, Senegal.

We used a hydraulic press to perform compression strength tests [7-10].

We used the boxes method to perform thermal conductivity tests [11-14].

3. Results and Discussion

3.1. Mechanical Characterization

Fig. 2 shows the results of compression strength of cement mixed with the laterite after 28 days of cure.

This Fig. 2 shows that the compressive strength increases, but slowly between 15% and 25% of cement in the mixture. This means the effect of cement on mechanical strength begins above 25%.

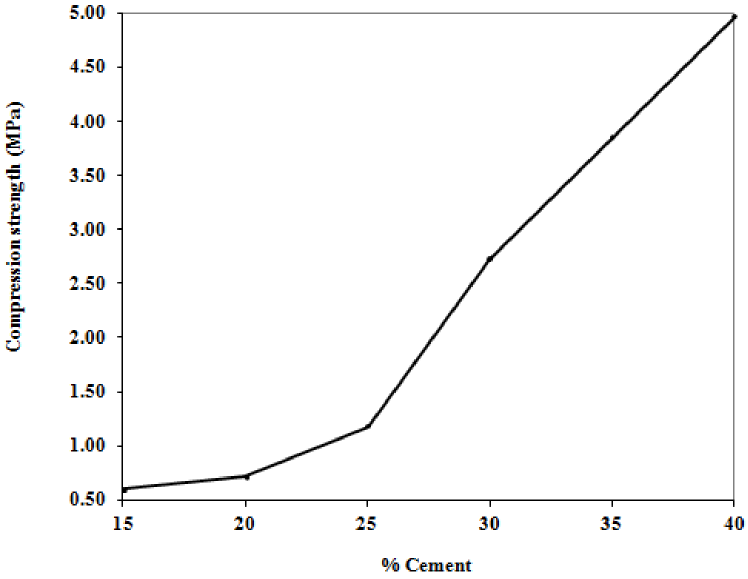

Figure 2: Evolution of the compression strength according to the percentage of cement mixed with the laterite after 28 days of cure

3.2. Thermal Characterization

Fig. 3 shows the results of thermal conductivity of cement mixed with the laterite after 28 days of cure.

This Fig 3 shows that the thermal conductivity increases, according to the percentage of cement. It's due to the fact that the effect of cement on thermal conductivity begins above 15%.

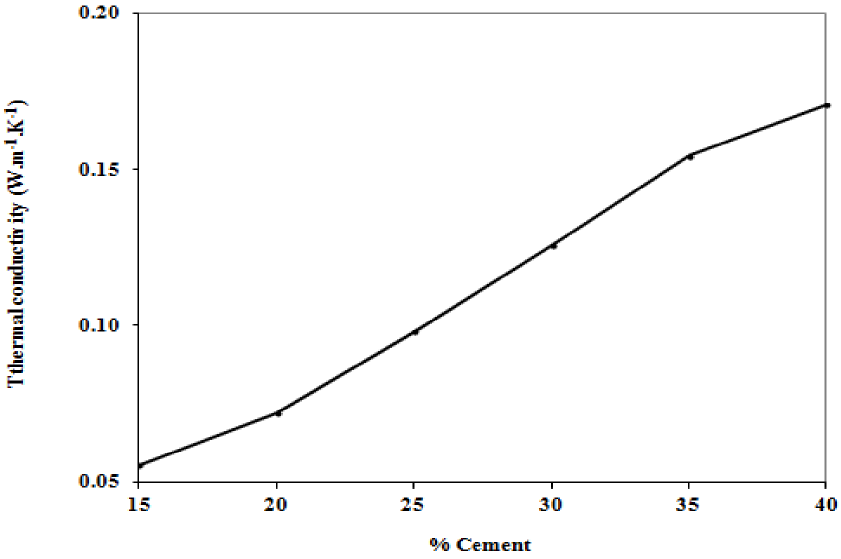

Figure 3: Evolution of the thermal conductivity according to the percentage of cement mixed with the laterite after 28 days of cure

Fig. 4 shows the results of thermal resistance according to the percentage of cement mixed with the laterite for a wall thickness of 20 cm after 28 days of cure.

This Fig. 4 shows that the thermal resistance decreases according to the percentage of cement. Furthermore, it is important to note from 40% the material becomes less economical.

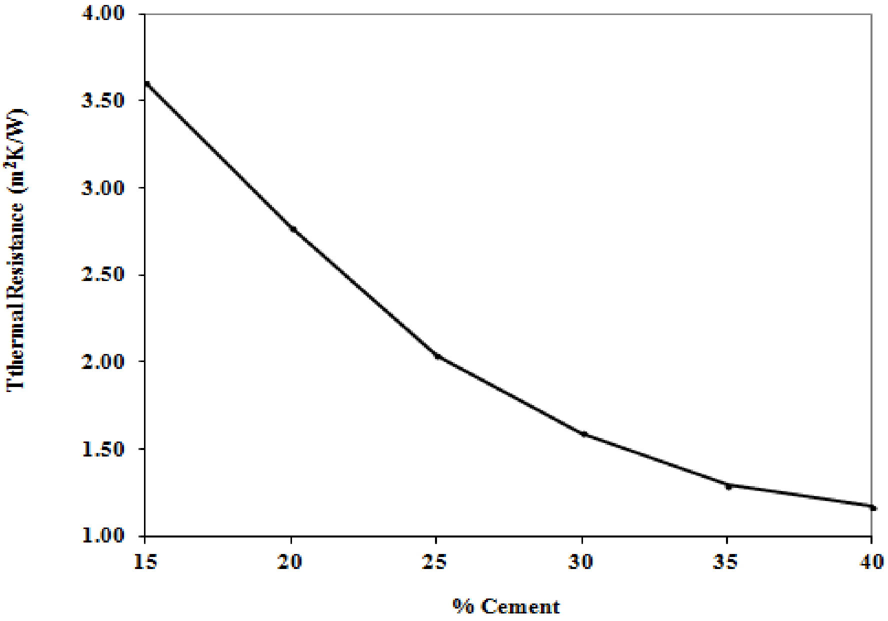

Figure 4: Evolution of thermal resistance according to the percentage of cement mixed with the laterite for a wall thickness of 20 cm after 28 days of cure

3.3. Thermal-Mechanical Results

To have in parallel the mechanical and thermal characteristics, we represented them in Fig. 5.

This Fig. 5 shows that the optimal mixture is composed of 27% of cement and 73% of laterite.

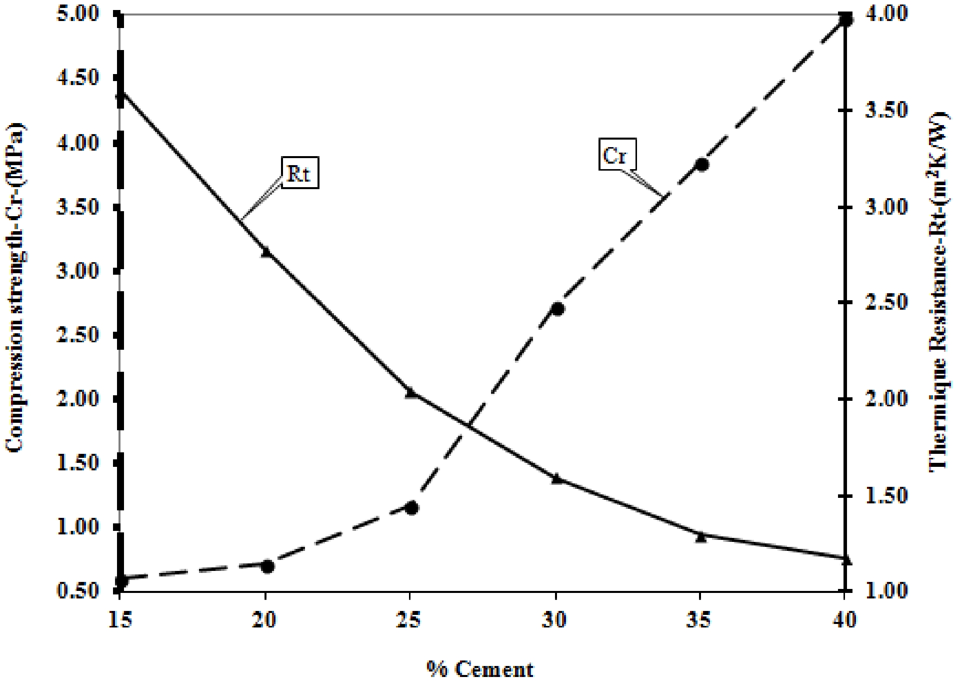

Figure 5: Evolution of compression strength and thermal resistance according to the percentage of cement mixed with laterite for a wall thickness of 20 cm after 28 days of cure

This optimal mixture has a thermal resistance of 1.85 m^2K/W, for a wall thickness of 20 cm, and a compressive strength of 1.75 MPa.

However, in order to justify this choice of optimal mixture, we can calculate the minimum mechanical strength we need to build a non-bearing wall with this material.

If we consider a 4 m high non-bearing wall built with this optimal composition of 1754 kg/m^3 density.

The base of the wall must have at least 0.07 MPa compression strength. This is much lower than the mechanical compression strength of the optimal formulation.

This optimal mixture has a good thermal resistance and a mechanical resistance to the compression, which is above what is required for a filling wall of a building.

4. Conclusion

At the end of our work, we note that:

- Proceeding to mixtures of cement with Montrolland's laterite, we were able to optimize the thermo-mechanical properties of materials.
- The optimal mixture is composed of 27% of cement and 73 % of laterite.
- The optimal mixture has compression strength of 1.75 MPa and thermal resistance of 1.85 m^2K/W.

Finally, the interesting results obtained allow to reduce the cost of social housing and to improve thermal comfort.

References

[1]. Bakam, A. B., Kor Ndikontar, M., et Konfor Njilah, I., 2004. Essais de stabilisation de la latérite avec les fibres cellulosiques. African Journal of Science and Technology (AJST). Science and Engineering Series Vol. 5, No. 1, pp. 22 - 28.

[2]. BCEOM-CEBTP, 1975 (l'ouvrage a été réalisé par une équipe de rédaction comprenant Messieurs Gomar, Lepetit, Lombard, Maurat, Odier, Parker, Rouveyrol et Testet du Bureau Central d'Etudes pour les Equipements d'Outre-Mer (BCEOM), Messieurs Liautaud, Remillon, Sabatier, Serfass du Centre

Expérimental de Recherches et d'Etudes du Bâtiment et des Travaux Publics (CEBTP), et avec Monsieur Giraud comme Conseil). Manuel sur les routes dans les zones tropicales et désertiques, Tome 2. Edition du ministère de la coopération Française. Etudes et construction, pp: 480.

[3]. Norme EN 197-1, 2001: composition, spécifications et critères de conformité des ciments courants

[4]. Norme AFNOR P 15-101-1, 2001: Composition, spécifications et critères de conformité des ciments courants

[5]. Norme AFNOR P 18-560, 1990 : Analyse granulométrique per tamisage

[6]. R. D. Holtz et W. D. Kovacs, 1991. Introduction à la géotechnique. Edition de l'Ecole Polytechnique de Montréal

[7]. Sow, D., M. Ahmat Chafadine, S. Gaye, M. Adj et I.K. Cisse, 2014. Integration of Agricultural Waste in Local Building Materials for their Exploitation: Application with Rice Straw. Research Journal of Applied Sciences, Engineering and Technology 7(15): 3030-3035. Maxwell Scientific Publication Corp.

[8]. Norme AFNOR NF P 18-406, 1995: Béton essai de compression

[9]. Dupain, R., R. Lanchon and J.C. Saint Arronoman, 2000. Caractérisation des matériaux de génie civil par les essais de laboratoire. Edition Casteilla, Paris.

[10]. Gaye, S., 2001. Caractérisation des propriétés mécaniques, acoustiques et thermiques de matériaux locaux de construction au Sénégal. Ph.D. Thèse, d'Etat ès Sciences. FST-UCAD.

[11]. Bal, H., 2001. Modélisation et mesure de propriétés thermiques d'un milieu poreux humide: Brique de latérite avec gousse de mil. Ph.D. Thèse, ESP- UCAD.

[12]. Voumbo, M.L., A. Wereme, S. Gaye, M. Adj and G. Sissoko, 2010. Characterization of the thermophisical properties of kapok. Research Journal of Applied Sciences, Engineering and Technology 2(2): 143-148. Maxwell Scientific Organisation.

[13]. Gaye, S., Y. Bathly, V. Sambou and M. Adj, 2004. Optimization of the thermo-mechanical characteristics of building materials: Application in geoconcrete. Association Models and Simulation in Engineering, Economics and Management and General Applications (AMSE); Special Issue MS'2004-France, pp: 72-81.

[14]. Sow, D., 2014. Caractérisation thermomécanique des mélanges de paille de riz et de matériaux à base d'argile en vue de leur utilisation dans l'habitat social. Ph.D. Thèse, ESP-UCAD.