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Research Article

Mixtures of Rice Straw, Clay and Cement for their Use as Building Material

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Abstract: The aim of this study is to improve the proprieties of the mixtures of rice straw and clay. Thus, we conduct this study related to the mixtures of rice straw, clay and cement for their use as building material. The clay formations represent abundant economical materials resources available in tropical and equatorial Africa. Rice straw is rich in cellulose. Consequently, few animals are able to use it as food. We have determined by experiments the mechanical and thermal properties of samples. The Interesting results obtained show that the integration of mixtures of rice straw, clay and cement in building materials are great opportunities to reduce the cost of social housing. It also improves the thermal comfort.

Keywords: Cement, clay, mechanical properties, mixture, rice straw, thermal properties

INTRODUCTION

In previous studies, we are interested in the valorization of mixture of clay with rice straw through its integration in construction material (Sow *et al*., 2014).

Thus, to improve the proprieties of these materials we interested in mixing them with Portland cement (Sow and Diokhane, 2017).

Portland cement is a 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 (Norm EN 197-1, 2001; Norm AFNOR P 15-101-1, 2001).

The rice straw and the clay are easily available in the open country (Demarquilly, 1987; BCEOM-CEBTP, 1975).

In Africa, earthen construction has become over the years an art: For example, cases-shells in Cameroon or the pyramids in Egypt. In these countries, finely chopped dried straw is a commonly used frame (Bakam *et al*., 2004).

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 a certain insulation depending on its thickness and this resistance is particularly inversely proportional to the coefficient of thermal conductivity. Thus, the main objective of this research is to optimize the properties of Portland cement mixed with materials that we have developed such as clay mixed with straw rice for possible use in the building construction.

MATERIALS AND METHODS

We used a hydraulic press to perform compression strength tests (Norm AFNOR NF P 18-411, 1981; Norm AFNOR NF P 18-412, 1981; Norm AFNOR NF P 18-406, 1995; Dupain *et al*., 2000; Gaye, 2001; Sow *et al*., 2014; Sow and Diokhane, 2017).

We used the boxes method to perform thermal conductivity tests (Voumbo *et al*., 2010; Gaye *et al*., 2004; Sow *et al*., 2014; Sow and Diokhane, 2017).

RESULTS AND DISCUSSION

Basic materials used:

Cement: The cement that we used to improve our samples is CEM I 42.5 cement from SOCOCIM in Rufisque, a town 20 km from Dakar, Senegal.

This cement is a hydraulic binder because it holds and hardens by combining with water. This reaction is called hydration. It corresponds to the chemical reaction in which water and cement combine to give rise to a solid mass.

Portland cement CEM I 42.5 is composed of 95-100% clinker and 0 to 5% fillers (Norm EN 197-1, 2001; Norm AFNOR P 15-101-1, 2001).

Fillers are "secondary constituents" of cements, so they can never exceed 5% by mass in the cement composition. They are mineral materials, natural or artificial, which act by their granulometry on the physical properties of the binders (maneuverability, water retention power).

Optimum (mixture consisting of 4.2% of rice straw and 95.8% of sébikotane clay): This mixture is the

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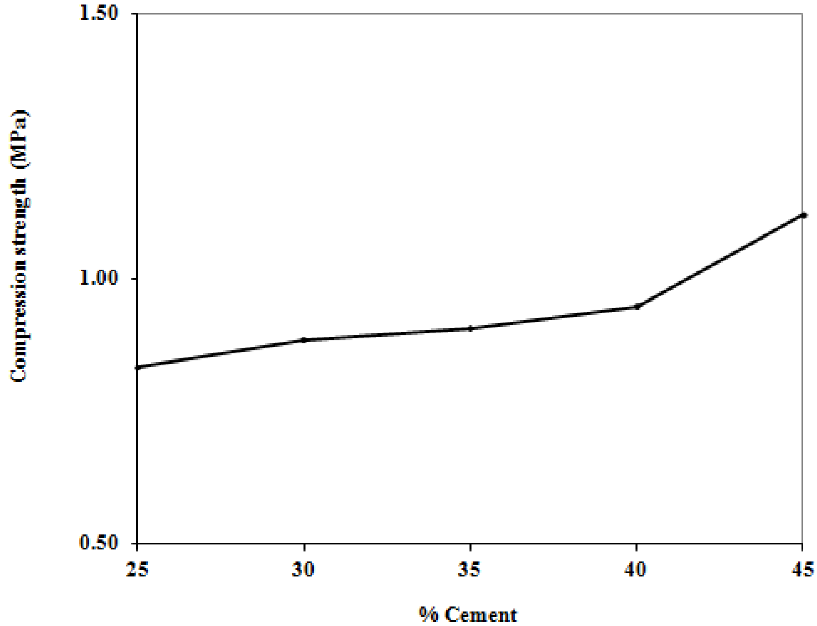

Fig. 1: Evolution of the compression strength according to the percentage of cement mixed with the optimum (clay + straw)

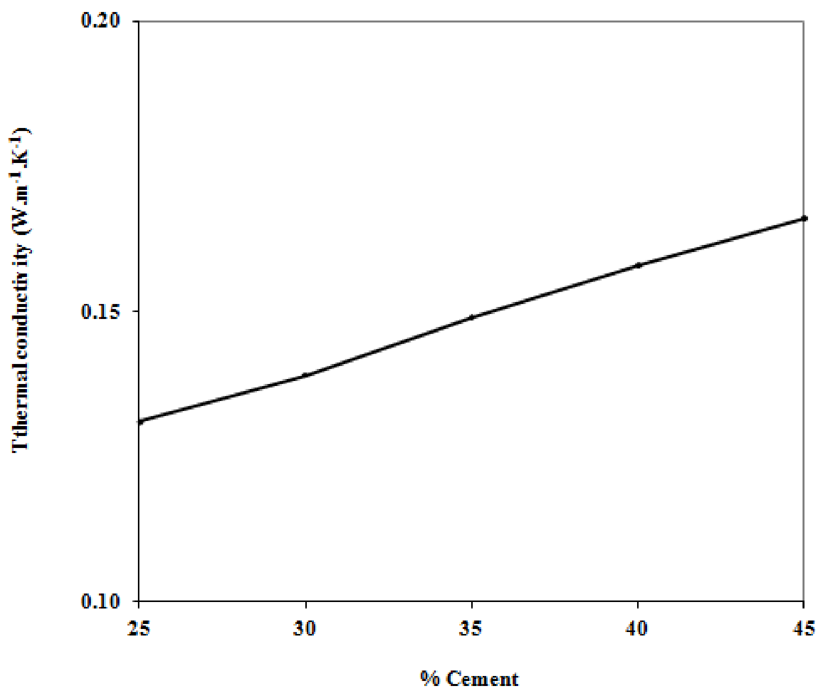

Fig. 2: Evolution of the thermal conductivity according to the percentage of cement mixed with optimum

most optimal mixture of rice straw and Sébikotane clay (Sow *et al*., 2014; Sow, 2014).

Thus, this mixture has a compressive strength of 0.863 MPa and a thermal resistance of 2.50 m^2K/W for a wall thickness of 20 cm.

To make our samples, we have chosen the rice straw of variety Sahel 108, which is locally the most available. The straw comes from Dagana town located at 408 km from Dakar (Senegal).

The clay we used to make our samples comes from Sébikotane town located at 40 km from Dakar (Senegal).

Mechanical characterization: Figure 1 shows the results of compression strength of cement mixed with the optimum. We notice, from Fig. 1, an increase of compression strength according to the percentage of cement in the mixture.

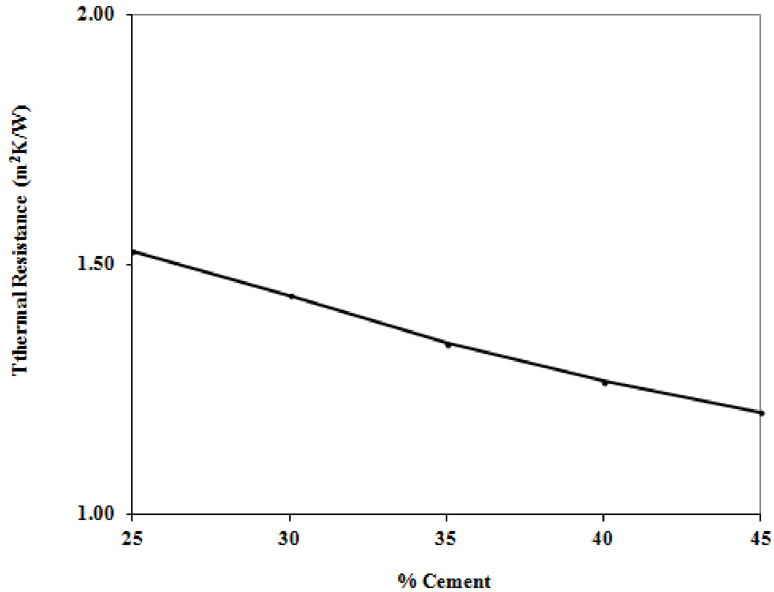

Fig. 3: Evolution of thermal resistance according to the percentage of cement mixed with the optimum for a wall thickness of 20 cm

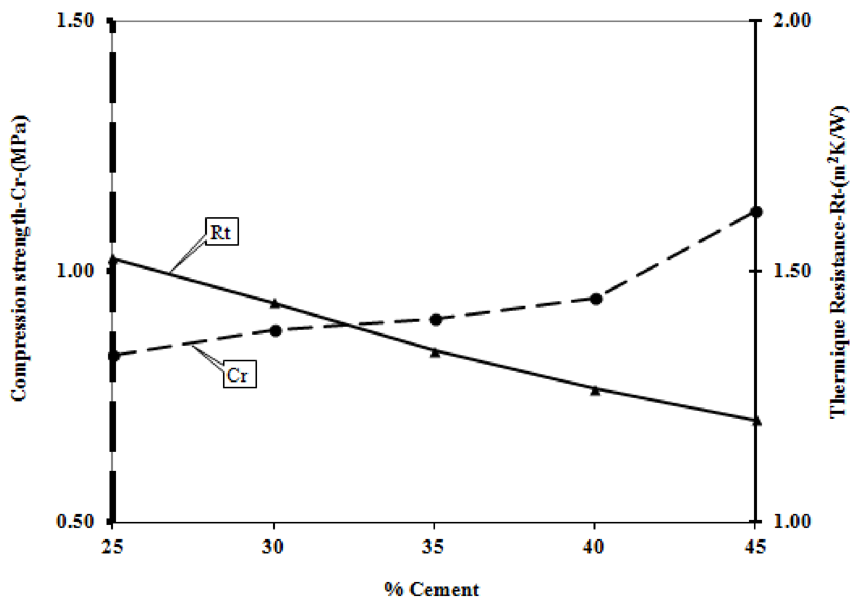

Fig. 4: Evolution of compression strength and thermal resistance according to the percentage of cement mixed with optimum for a wall thickness of 20 cm

Thermal characterization: Figure 2 shows the results of thermal conductivity of cement mixed with optimum. This Fig. 2 shows that the thermal conductivity increases, according to the percentage of cement.

Figure 3 shows the results of thermal resistance according to the percentage of cement mixed with the optimum for a wall thickness of 20 cm. We notice, from Fig. 3, a decrease of the thermal resistance decreases according to the percentage of cement.

It is important to note from 45% the material becomes less economical.

Thermo-mechanical results: To have in parallel the mechanical and thermal characteristics, we represented them in Fig. 4. This Fig. 4 shows that the most optimal mixture is composed of 32% of cement and 68% of optimum.

This most optimal mixture has a thermal resistance of 1.4 m^2K/W, for a wall thickness of 20 cm and a compressive strength of 0.9 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 with this optimal composition of 1226 kg/m^3 density. The base of the wall must have at least 0.048 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. According to our previously published works, this one is simply additional data.

CONCLUSION

At the end of our work, we note that:

- Proceeding to mixtures of cement with optimum, we were able to optimize the thermo-mechanical properties of materials.
- The most optimal mixture is composed of 32% of cement and 68% of optimum (4.2% of rice straw and 95.8% of Sébikotane clay).
- The most optimal mixture has a compression strength of 0.9 MPa and a thermal resistance of 1.4 m^{2}K/W.

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

CONFLICT OF INTEREST

We certify and declare that there is no conflict of financial or relevant interest in relation to the above-mentioned article.

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