RICE STRAW AND CEMENT IN BUILDING MATERIALS MIXTURES

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Abstract - The objective of this study is to compare the performances of rice straw and cement by mixing them with clay. This allowed us to propose properties of samples for building materials. The clay formations represent an abundant economical material resource available in tropical and equatorial Africa. Agriculture is among the economic sectors that produce more waste. For rice straw waste, its high content of cellulose makes it difficult to digest. So, few animals can use it as food. The cement is a hydraulic binder. The Interesting results obtained show that the integration of rice straw in building materials improves the thermal comfort and recycles the straw. The integration of cement in building materials improves the compression strength. Also, the comparison of performances of materials makes it possible to indicate ranges of properties that we can use in the construction of buildings. This work enabled us to propose new materials according to their thermo-mechanical properties.

Keywords - Building Materials, Cement, Clay, Compare, Rice Straw Waste, Thermo-Mechanical Properties

I. INTRODUCTION

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 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. In these countries, finely chopped dried straw is commonly used frame. The soil is the oldest material of construction used economically on the spot for millennia, in a mixture form of clay, gravel, sand and silt. More than 30 % of the worldwide population habitats are made of soil. Whether raw, cooked, army of straw or otherwise stabilized. The varieties of earthen architectures abound since the appearance of humans throughout the world [1-2].
Rice straw is rich in cellulose. Consequently, only animals capable of digesting cellulose (rabbit, horse, etc.) use it as food. The majority is lost, buried, burned, or used as bedding [3].
The Portland cement 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 [4-5].
The thermal resistance of a material gives it a certain insulating depending on its thickness, and this resistance is particularly inversely proportional to the coefficient of thermal conductivity. Also, the resistance to compression of materials is one of the properties used in the design of buildings. Thus, in this research, after comparing we propose new materials for possible use in buildings construction.

II. MATERIALS AND METHODS

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

The straw, variety Sahel 108, comes from Dagana, town located at 408 km from Dakar (Senegal).

The clay soil comes from Sébikotane, town located at 40 km from Dakar (Senegal) [6].
We used:

- the particle size analysis that processes the identification for the classification of a material from the grain size [7-9].
- the hydraulic press to perform compression strength tests [10-12].
- the boxes method to perform thermal conductivity tests [13-16].

III. RESULTS AND DISCUSSION

Particle size analysis

The size analysis of this clay soil shows 3 % of coarse sand, 24 % of fine sand, 15 % of silt, 58 % of clay and 90 % of the grains mass pass the sieve 80 µm (Figure 1).

Thus, the effects of particle size distribution on the behavior of clay soil are not very important [7].

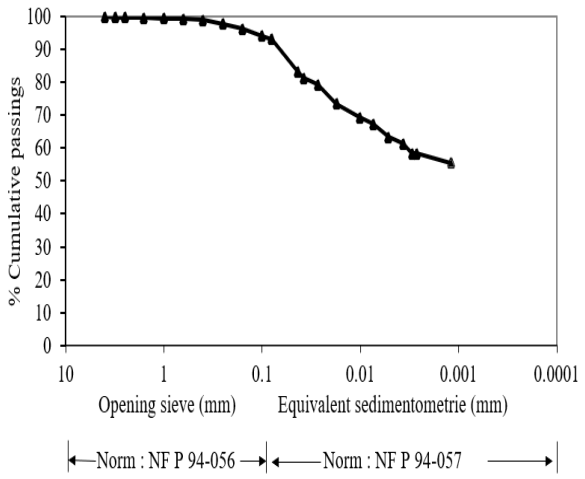


Figure 1: Size analysis of Sebikotane's clay

Mechanical characterization

Figure 2 shows, for the clay mixed with the straw, an increase in compressive strength depending on the percentage of straw in the mixture from 2% to 4.2%. From 4.2% of straw, the compression strength starts to decrease. It is important to note that from 5% of straw, the mixing of mixtures is almost impossible. Thus, from 2% to 4.2% the straw plays the role of reinforcement in the mixture, from where an increase in compressive strength.

Figure 2 shows also, for the clay mixed with the cement, an increase in compressive strength as function of the percentage of cement from 15% to 45% in the mixture. Therefore, straw and cement can help to reinforce the skeleton of the clay. But, for the mixture of clay and straw it is valid from 2% to 4.2% of straw in the mixture.

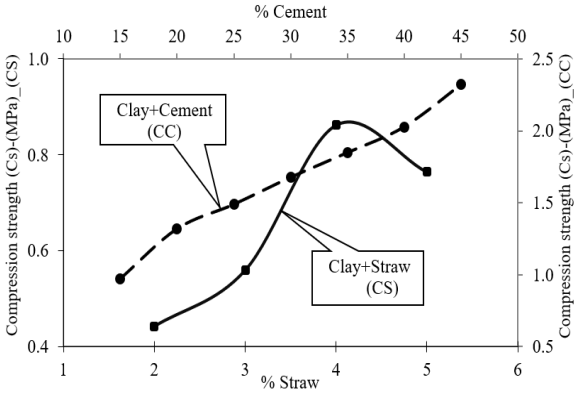


Figure 2: Evolution of compression strength according to the percentage of straw mixed with clay and according to the percentage of cement mixed with clay.

Thermal characterization

The Figure 3 shows, for the clay mixed with the straw, that the thermal conductivity decreases according to the percentage of straw from 2% to 5% in the mixture.

The Figure 3 shows, for the clay mixed with the cement, that the thermal conductivity increases according to the percentage of cement from 15% to 45% in the mixture.

The Figure 4 shows the evolution of thermal resistance based on the percentage of the straw mixed with the clay and based on the percentage of the cement mixed with the clay, for wall thickness of 20 cm.

We note that, the thermal resistance of the clay mixed with the straw increases as a function of the percentage of straw added, from 2% to 5%.

We also note that, the thermal resistance of the clay mixed with the cement decreases as a function of the percentage of cement added, from 15% to 45%.

Thus, the straw has a thermal conductivity lower than that of the clay. So, it appears that the straw only is an excellent thermal insulation. This confirms the importance of the thermal insulation when designing a house of straw ballot: wood-frame with a filling straw (technique known as Austrian).

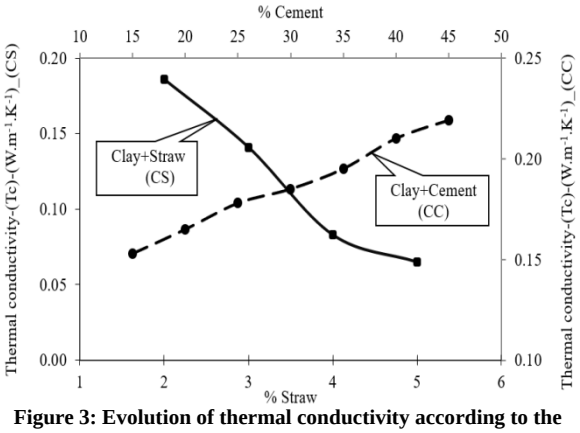


Figure 3: Evolution of thermal conductivity according to the percentage of straw mixed with clay and according to the percentage of cement mixed with clay.

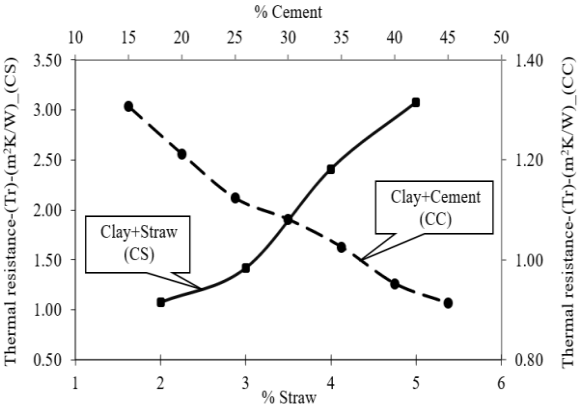


Figure 4: Evolution of thermal resistance according to the percentage of straw mixed with clay and according to the percentage of cement mixed with clay, for a wall thickness of 20 cm.

Thermo-mechanical results

To better compare the effects of straw and cement, mixed with clay, we represent in Figure 5 the evolutions of the thermal and mechanical characteristics.

We can consider that, if we favor thermal comfort, we can take the clay mixed with 2.6% to 5% of the straw. On the other hand, if we favor mechanical resistance, we can take the clay mixed with 15.6% to 45% of the cement.

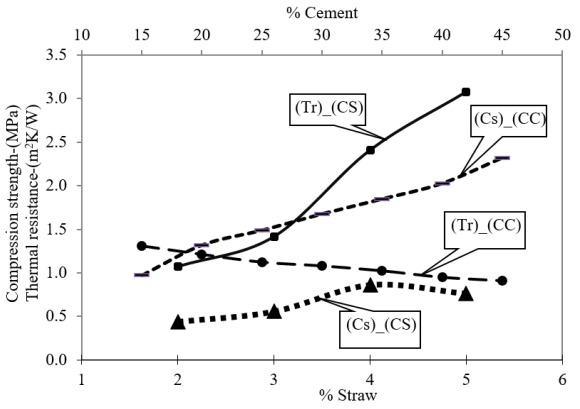


Figure 5: Evolution of compression strength and thermal resistance according to the percentage of straw mixed with clay and according to the percentage of straw mixed with clay, for a wall thickness of 20 cm.

CONCLUSION

At the end of our study, we note that:

- It is advisable to choose clay and cement mixtures should be chosen if the priority is mechanical resistance. In this case the cement must be between 15.6% to 45% in the mixture. This makes it possible to have a thermal resistance of between 1.20 MPa to 2.32 MPa
- Clay and straw mixtures should be chosen if the priority is thermal resistance. In this case the percentage straw must be between 2.6% and 5% in the mixture. This makes it possible to have a thermal resistance of between 1.22 m^2K/W and 3.08 m^2K/W, considering a wall 20 cm thick.
- This work can therefore help us choose between mixtures of clay and rice straw waste or mixtures of clay and Portland cement, depending on the priorities of social housing designers.

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