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Formulation of a Composite Rice Straw/Cement: Elaboration of a Treatment of Straws by Earth Solutions (Sand Laterite Clay)

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Introduction

In a sustainable development context, the recovery value recovery of waste in building materials is becoming a recurring practice. As a result, there are many materials incorporating agricultural waste that were previously the source of bushfires. In Côte de D'Ivoire, rice cultivation occupies a prominent place, especially with some food autonomy (MINAGRI, 2007). It is therefore interesting to consider the recycling of waste from rice farms, especially in building materials. However, straws are characterized by a large amount of water absorption equivalent to three times the mass of straws (SERIFOU et al., 2019). To reduce this parameter, a treatment based on their soaking in soil solutions was considered. This work aims to know the influence of this treatment on a composite rice straw /cement. Specifically, the question is how the treatment affects the absorption rate of rice straw (RS) and what its effects are on the resulting composite. This paper will present successive methodology, results discussed, conclusion and perspectives to this study.

I. Methodology

I. 1. Treatment

The soil solutions used to treat RS were obtained by mixing soil with water for a concentration of 100 g/l. Three soils were used: sand, clay and laterite. The RS were cut into 20 mm strands and added to the solution in accordance with the mass ratio P/S-0.03 (P denoting the mass of the straws and S that of the soil). After a 2-hour stay in the solution, the RS are dried in the open until the mass stabilizes.

I. 2. RS absorption rate

The water absorption coefficient of RS was determined for treated and untreated straws using the method described by MAGNIONT (2010) in its thesis. After a 24-hour immersion period in water, the straws were superficially dried using a manual centrifuge to remove inter-fibre and adsorbed water. The water absorption coefficient is determined by the following equation:

$$A_b = \frac{m_2 - m_1}{m_1} \times 100$$

m1 and m2 refer to the mass of RS, respectively dry and after spin. Then, the rate of reduction in absorption was calculated to assess the influence of treatment using Formula 2. Ab1 refers to the absorption rate obtained for treated straws and Ab as for control straws.

$$R_d = \frac{Ab_1 - Ab}{Ab} \times 100 \qquad (2)$$

I. 3. Composite characterization

Composites were made with RS and cement in the following proportions: P/C equal to 1% and E/C equal to 0.3 with P, C and E designating respectively the masses of RS, cement and water. The mechanical characterization of the samples was done through compression and traction tests by bending three points. The flexing traction resistance is obtained with the following formula:

$$R_f = \frac{3Fl}{2bh^2} \qquad (3)$$

where F the maximum contrainte, the length between the supports, b the thickness and h the height of the sample. Compression resistance is achieved with Formula 6 below where F represents the maximum stress and S the sample surface.

$$R_c = \frac{F}{S} \qquad (4)$$

The physical properties were obtained as a result of the hydrostatic weighing. It was used to determine the porosity and density of composites using the following formulas:

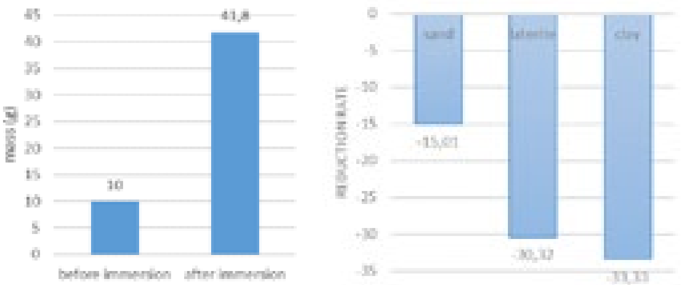
$$Porosity = \frac{m_{air} - m_{sec}}{m_{air} - m_{eau}} \times 100 \qquad (5)$$

$$density = \frac{m_{sec}}{m_{air} - m_{eau}} \times 100 \qquad (6)$$

II.Results

II. 1. Absorption

Figure 1 summarizes the results of the absorption of the different samples.



(a) (b)

Figure 1: Absorption test results (a) PDR absorption rate; (b) reduction rate due to different treatments

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The absorption rate of RS is about 318%. This large absorption is observed in other plant families (CHABANNES, 2015), (BENMANSOUR, 2015), (PHUNG, 2018). In Figure 1b, there is a reduction in RS absorption depending on the aggregate used. The treatment of RS therefore helps to reduce the absorption of RS. The high absorption of fibers is due to their porosity (THI, 2008). The action of the aggregates would also result in adhesion on the walls of the RS thus altering their surface area. The degree of water absorption can be greatly reduced by changing the fiber surface. Changing the surfaces results in a reduction in roughness. According to ZHENG (2011) roughness would increase the wetting of hydrophilic surfaces by absorbing water from troughs. Based on this theory, one could conclude that the treatment leads to reduced the roughness of RS . KOUAKOU et al. (2018) have described the surface of the raw RS as being rough with many asperities. Reducing the roughness of the surface of RS would then be best achieved with treatment in the clay solution.

II. 2. Physical properties

Density and porosity are shown in Figure 2.

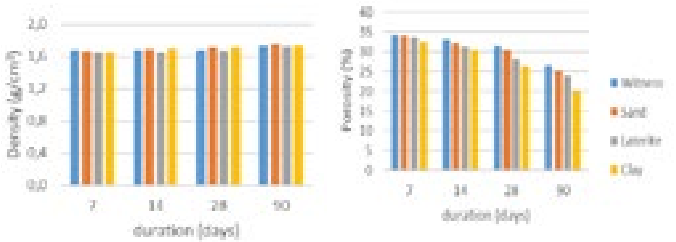

Figure 2: Variation in physical properties

In Figure 2, it appears that the treatment of RS does not have a significant effect on composite density because the recorded variations are less than 2%. However, the treatment leads to the reduction of the porosity of the samples. Indeed, on all dates, the porosity of the treated samples is lower than that of the controls. In addition, porosity varies depending on the aggregates used. Thus, the porosity of the straws follows that of the composites because the cement matrix has not undergone any treatment.

II. 3. Mechanical properties

Mechanical properties such as compression resistance and bending resistance are represented on figure 3.

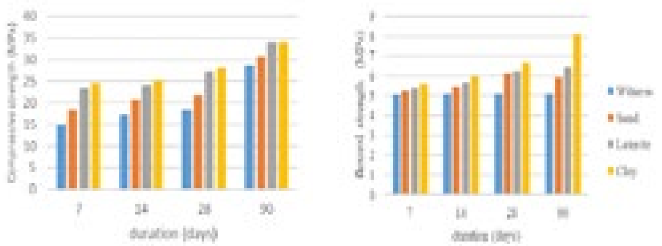

Figure 3: Variation in Mechanical Properties

Analysis of this figure reveals that RS treatment is beneficial for the mechanical properties of composites. Indeed, the values of compression and traction resistances by bending three points of control are always lower than those of composites containing treated straws. In addition, resistance values change inversely with the rate of absorption of RS: the less water the straws absorb, the better the mechanical properties of composites. This improvement could be due to the improvement of the rice-cement straw interface (ROKBI and OSMAN, 2011). Similarly, many treatments have improved the mechanical properties of composites. These treatments have improved interfacial adhesion between the fibers and the matrix (HAJJ, 2018). In our case, it could be concluded that the land used facilitates adhesion between RS and cement.

Conclusion

RS are characterized by more than 300% water absorption. This limits its use in cement materials. Physical soaking treatment in earthen solutions has helped overcome this problem by reducing the roughness of the RS surface. Reducing the water absorption of these plant fibres leads to an improvement in the physical properties of the composites that contain them. Of the three soil types used clay is the one that leads to the best results followed by laterite and then sand. It would be interesting to consider the influence of treatment on the tenacity of RS.

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