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Effect of the Dimensions of Natural Fibers on the Mechanical Characteristics of Clay Matrix Composites

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ABSTRACT/RESUME

Abstract: *The use of natural fibers in clay matrices is a reinforcement technique used for centuries in construction. Natural fibers incorporated into cement matrices require various specific treatments to overcome the problem of incompatibility between natural fibers and cement paste, due to the sugars contained in the plant. This article is focused on optimization the dimensions of diss and alfa fibers in clay matrices based on mechanical properties. For this, we used fibers of these materials with dimensions of 4, 6 and 8 cm. The three-point bending and compression tests with measurement of deformations have shown that the composites have a very ductile behavior, due to the presence of natural fibers which really play the role of reinforcement for the composite, while the pure clay paste exhibits low resistance and fragile behavior.*

The dimensions of the fibers have a great influence on the mechanical behavior of the clay matrix composites, and it has been found that the fibers give the best flexural strengths between 6 and 8 cm, and that the compression increases considerably without damage to stresses around 12 MPa, this is due to the great capacity of the fibers to take up the lateral tensile stresses in composites.

I. Introduction

Reinforcement of building materials (concrete, mortar and composite) with fibers is a technique that is increasingly used in order to improve their mechanical performance, especially their tensile and cracking strengths.

When biodegradable composite materials are reinforced with vegetable fibers, these materials remain biodegradable and can also be used in situations where they are subjected to loads.

The treatment with boiling water of flax fibers used as aggregates in composites with a cement matrix, considerably improves mechanical strength [1]

The highlighting of the composites of fibers diss boiled and unboiled in clay matrices; shows that unboiled diss fibers give better mechanical performance than boiled diss, because the hydrothermal treatment modifies the morphology of the fibers, and therefore causes a bond at the fiber / matrix interface much more fragile [2]. The use of plant fibers in their natural state in clay matrices does not require any prior treatment, whereas in the case of the cement matrix, hydrothermal treatment is essential to eliminate the water-soluble constituents responsible for the delay in setting and the loss of resistance.

The dissolution of sugar by the vegetal fibres acts like a retarding agent for the cement paste. Some authors [3-4] report problems of delay in the setting or even no setting at all when mixing vegetable particles and mineral binder. Aggregate extracts, indeed, consist mainly of hemicellulose-type polysaccharides whose retarding effects on the setting of cement paste has been described in many studies [3].

Natural fibers do not interact well with cement paste because of the water-soluble inhibitory substances and particularly sugars, which generally manifest themselves as a delay in setting, and the loss of resistance of the material. This effect disappears completely with the clay matrices. With the same objective, other work has been carried out on diss concrete, highlighting the inhibitory effect that diss fibers exerted on the binder [3].

The use of clay or the clay-lime combination in composites based on natural fibers such as diss can overcome the inhibition phenomena that occur in the case of a cement matrix [3].

Natural fibers do not interact well with cement paste because of the water-soluble inhibitory substances and particularly sugars, which generally manifest themselves as a delay in setting, and the loss of resistance of the material. This effect disappears completely with the clay matrices. With the same objective, other work has been carried out on diss concrete, highlighting the inhibitory effect that diss fibers exerted on the binder [4].

The effect of the boiling water treatment of Diss fibers on the mechanical properties of a mortar incorporating this reinforcement consists in eliminating the extractables by distillation in water. They noted a strong improvement in the flexural strength of the composite of treated fibers compared to that of natural fibers [5].

The work which focused on the optimization of cement composites based on Diss fibers with the application of different treatments [6]. It is clear that if the treatment with boiling water increases the performance of the composite thanks to the elimination of the water-soluble compounds, but the coating with linseed oil of the fibers previously boiled is by far the most powerful of those which have been tested. For similar composite bulk densities, the compressive and tensile strengths of diss fibers coated with linseed oil composites (Tr3) are higher than those obtained with boiling diss fibers (Tr2). This is explained by the fact that the spinous structure is always present during the treatment (Tr3). In addition, the fibers are placed horizontally and in parallel, which tends to increase their role of reinforcement.

The diss fibres coated with bitumen (Tr4) gave lower compressive and traction strengths, because of disappearance of the spines and the random disposition of fibres in the composite.

These results show clearly the interest to use such a material as resistant fillings and even as structural elements for structures situated in seismic zones, because of their lightness, resistance and high ductility.

This research consists in varying the dimensions of the vegetable fibers of Diss and Alfa in a clay matrix. This study concerns the feasibility but also the evaluation of the physico-mechanical properties of a building material, and its use in the field of application of "lighweight concretes".

Building materials, of bio-sourced types, have been the subject of several research studies. In addition to their low densities, they have interesting thermal and acoustic properties. However, their sensitivity to water is an obstacle to their industrial development. To overcome this phenomenon of water absoption, physical treatments of impregnation or surface coating of inclusions have been studied [7].

In the same context, other work on the formulation of concrete and / or mortar, based on agro-resources, has shown that the performance of the latter depends on the nature of the plant fibers and their dimensions [8] [9]. In addition, their incorporation improves the tensile strength, ductility or post-fracture behavior of composites.

In this field, bio-sourced materials (based on plant particles) consitute a potential response to the need for materials compatible with sustainable construction, meeting regulatory requirements,

Kesikidou F and Stefanidou M [10] studied the physical characteristics and mechanical of three types of natural fibers (jute, coconut and kelp) in cement and lime matrices.

II. Materials and Experimental Methods

The Diss used was collected in the Souk-Ahras region, and the Alfa from the Tebessa region, cities in eastern Algeria. They are annual plants, and have very good tensile strengths. The diss fibers have a tensile strength of around 100 MPa, and a spiny external structure, and the alfa fibers have a tensile strength of around 70 MPa, with a smooth structure.

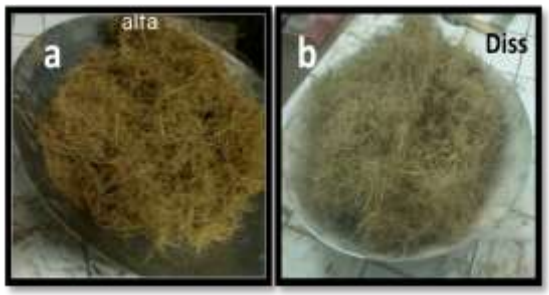

Figure 1. *Crushed fibers (a: Alfa, b: Diss)*

The bending tensile tests of natural fiber composites are carried out using a three-point bending bench, equipped with an automatic data acquisition system, on prismatic test pieces (4 * 4 * 16 cm) (fig 2-a).

The compression tests are carried out on half of the test specimens in bending, and the resistances were determined according to standard ASTM D 695 (fig

2-b).
The two tests were carried out using a Zwick/Roell 20KN type machine.

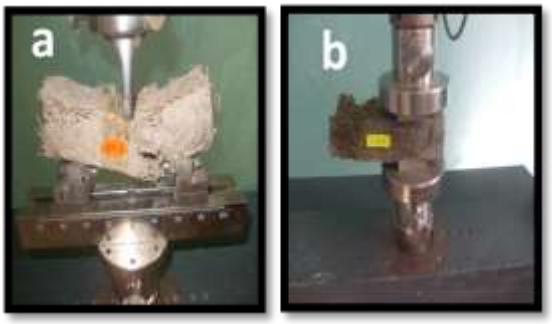

Figure 2. *Setup Test (1-a: Assembly of Flexion, 1-b: Compression)*

III. Results and discussion

The results of the three-point bending and compression tests of composites based on Alfa and Diss fibers in clay matrices are shown in Figures 3 and 4.

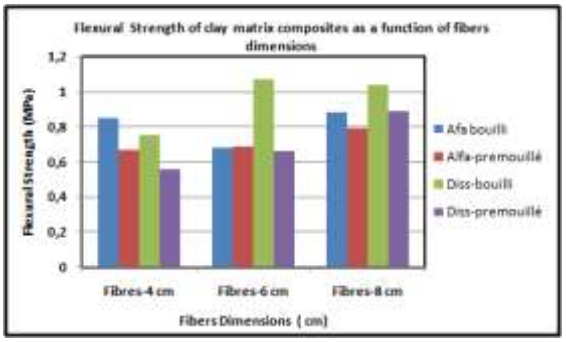

Figure 3. *Flexural strengths of clay matrix composites as a function of fiber dimensions.*

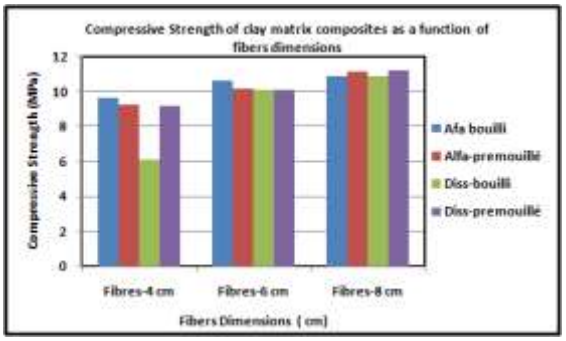

Figure 4. *Compressive strengths of clay matrix composites as a function of fiber dimensions.*

The best flexural strengths of clay matrix composites of boiled and pre-wetted diss composites are given for fibers with dimensions of 8 cm, this shows that the longer the fibers, the more important the anchoring surface of the fibers in the matrix, which provides the composite with better strengths, generated by the high tensile strength of the fibers.
The stress-strain curves in bending of composites based on Alfa and Diss with clay matrix have a ductile behavior.
The best compressive strengths are found for fibers between 6 and 8 cm in size. The resistances are also important because of the high compressibility of the clay paste.
The pre-wetting does not affect the flexural and compressive strengths, this shows that this treatment of the fibers is not very useful in the case of composites with a clay matrix.

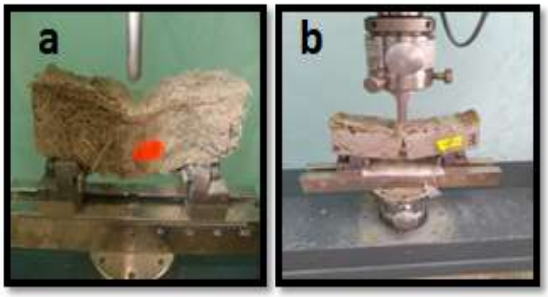

Figure 5. *Photographs of the condition of the Composites after flexion failure (a: with Alfa fibers, b: with Diss Fibers)*

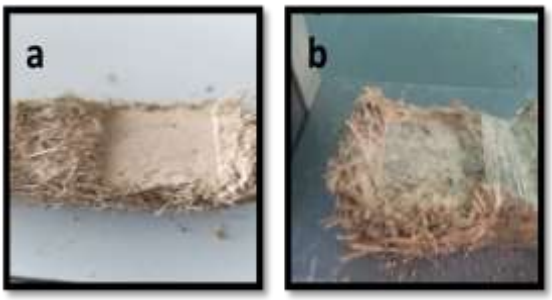

Figure 6. *Photographs of the condition of the Composites after Compression failure (a: with Alfa fibers, b: with Diss Fibers)*

IV. Conclusion

The tests carried out on composites based on Alfa and Diss fibers in the clay matrices and different dimensions of the fibers, which vary from 4 to 8 cm, gave greater flexural strengths for the 8 cm fibers, and the the most important compressive

strengths for clay matrix composites, produced by fibers varying between 6 and 8 cm for both boiled dried fibers and pre-wetted boiled fibers.

It is also noted that the resistances of the composites of Diss and Alfa with a clay matrix give very high compression values, because of the good compressibility of the clay paste. The composites obtained have a very low density, which makes it possible to classify the composites based on natural fibers as light materials, with a very ductile behavior, which lets consider using these materials as filler in seismic zones.

It is noted in all cases that the flexural strengths of diss fiber composites are greater than those of Alfa fibers, because of the thorny structure of diss fibers and its more tensile strength.

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