Investigation of the length and percentage fiber influence of Typha Australis on biosourced composites

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Abstract. This paper discusses the influence and content of Typha Australis fibers on the thermal and mechanical properties of clay composites. The objective is to find a better combination of length and percentage of fibers. This combination will allow to have a good compromise between thermal and mechanical properties. The results found at the end of this study are conclusive. Indeed, the increase of the length and the percentages of fibres improve the thermal properties but the values of the compressive resistances decrease.

1 Introduction

The building sector is one of the most energy-intensive sectors [1]. It is responsible for one third of the greenhouse gas emissions [2]. Alternative solutions are being implemented to address this issue. Among these solutions, there is the sobriety, energy efficiency ... etc [3]. In this study we will focus on the building envelope to better insulate it. For this insulation we will use biosourced materials. Indeed, biosourced materials are used in sustainable construction [4, 5]. In this work, we will focus on the Typha Australis. which is a plant that grows in abundance in the Senegal River valley [6]. This plant has good thermophysical properties, it has a thermal conductivity about 0.06 W/mk [7]. This article aims to show the impact of the length of plant fibers and their percentages on the thermal and mechanical properties. We have studied the case of Typha Australis. The following part shows the experimental protocol followed for the tests.

2 Experimental protocol

2.1 Materials

Two essential materials are used: Typha Australis and clay. Both were sampled at the same site in the Diawling National Park in the lower delta of Mauritania on the Senegal River. The clay was crushed and then sifted with a 5mm sieve. The Figure 1 show the Typha Australis on site and the figure 2 show the clay after drying.

Fig. 1. *Typha Australis*

Fig. 2. Clay

Table 1 gives the physical properties of the raw materials. The bulk density and absolute density are determined respectively according to the following standards NF P 94-053 and NF P 18-554.

Table 1. Material characteristics

Materials	Bulk density (kg/m3)	Absolute density (kg/m3)	Porosity (%)
Clay	1120	2151.9	48
Typha Australis	60	461.53	87

2.2 Methods

2.2.1 preparation of specimens

The dried fibers were immersed in water until saturation. They were introduced into the mixer which previously contained clay. Method of mixing in the mortar mixer has been adapted to the NF ISO 18650 standard, which consists in putting the mixture (binder + fibers in this case) in the bowl and mixing at 1minute but in order to avoid that the fibers are crushed. We reduced the mixing to 30 seconds at slow speed then the quantity of water was added and mixing at 30 seconds at slow speed was followed by mixing at 1minute at fast speed. the percentage of fiber was varied (30% and 55%) by substitution of the binder which is the clay. The following table gives the formulations made.

Table 2. Specimen composition

Formulation	Water/Clay (in mass)	*Typha Australis* (%)	Clay (%)
AT_{30}^{70}	0.33	30	70
AT^{45}_{55}	0.33	55	45

2.2.2 Themal properties

Erreur ! Source du renvoi introuvable. shows the experimental devices used for thermal characterization. The transient plane source thermal characterization (TPS) technique is becoming an important tool for determining the thermal properties of a variety of materials because of its robust design, fast characterization time and ability to simultaneously measure the thermal conductivity and thermal diffusivity of complex materials, such as nanocomposites [8].

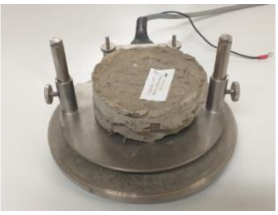

Fig. 4. 3R press for compression

Fig. 5. 3R press for bending

Fig. 3. Sandwich sample

2.2.3 Mechanical properties

The specimens were subjected to single compression and three-point bending tests using the 3R presses shown in the Fig. and Fig. .

3 Results

3.1 Thermophysical properties

Table 3 shows the results of the thermal properties, especially the thermal conductivity as a function of the percentages and the length of the fibers. We can observe that the increase of the percentage of fibers and the increase of the length has a positive effect. Indeed, by increasing these two parameters, we increase the micropores and macropores in the composites. These pores are made of air which is an insulator. Therefore, the increase in porosity in the composite improves the thermal conductivity of these composites.

Table 3. thermo-physical properties of the composites

Fiber length	Formulation	Bulk density (Kg/m^3)	Thermal conductivity (W/m.K)	Thermal diffusivity (mm^2/s)	Volume capacity (MJ/m^{3}K)
Fiber 1 cm (Clay +*Typha Australis*)	AT^{70}_{30}	842.89±19.66	0.335±0.018	0.903±0.013	0.370±0.010
	AT^{45}_{55}	465.62±16.26	0.146±0.012	0.784±0.017	0.187±0.011
Fiber 3 cm (Clay +*Typha Australis*)	AT^{70}_{30}	761.43±10.93	0.165±0.010	0.300±0.013	0.552±0.010
	AT^{45}_{55}	365.18±20.49	0.113±0.010	0.638±0.011	0.178±0.010

3.2 Mechanical properties

From the results obtained in Table 8, we can affirm that the increase of the percentages and the lengths of the fibers decrease the mechanical properties for the compressive strength. Indeed, this increase in porosity in the composite decreases the density of the material. Following the law of mixing, a part of the dense material is substituted by a less dense material, which results in a lower compressive strength. Although this increase in fiber percentages is not equally beneficial to the tensile strength, the increase in fiber length increases the tensile strength. This is explained by the fact that the flexural strength of the fibers governs the flexural strength of the matrix.

Table 2. Mechanical properties

Fibers length	Formulation	Compressive strength (MPa)	Flexural strength (MPa)
Fiber 1 cm (Clay +*Typha Australis*)	AT^{70}_{30}	4.36±0.026	1.02±0.030
	AT^{45}_{55}	3.89±0.052	0.75±0.020
Fibers 3 cm (Clay +Typha Australis)	AT^{70}_{30}	4.09±0.040	1.21±0.026
	AT^{45}_{55}	3.62±0.032	1.00±0.020

4 Conclusion

In this article we have elaborated materials composed of Typha Australis and clay by varying the percentage and the length of the fibers. The results showed that these increases significantly improve the thermal properties. Nevertheless, when these two parameters increase the values of the mechanical resistance decrease. The results showed that increasing the fiber length improves the tensile strength.

In conclusion, these results are promising for the use of these innovative materials as thermal insulators in construction.

5 Reference

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