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Thermal performance of biosourced materials on Buildings: The case of Typha Australis

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Abstract. Developing countries are facing population growth, which leads, on the one hand, to increased requirements for buildings and, on the other hand, to the depletion of fossil fuels along with exposure, of people living in those areas, to some detrimental consequences of climate change. Because of these factors, we propose approaches to control energy consumption in buildings. In some countries, the architectures adopted are not adequate to the environment and climate, resulting in discomfort in those buildings, in such circumstances, residents resort to the use of energy systems, such as heating, ventilation, and air conditioning, which leads to exorbitant electricity bills. Housing consumes 40% of the world's energy and is responsible for a third of greenhouse gas emissions. Optimizing energy needs in buildings is a solution to overcome these problems. For this purpose, there are solutions such as: the design of the building characterized by its shape and envelope, while using less energy-consuming equipment. For several years, the building materials sector has been developing with a particular focus on bio-source materials, which are generally materials with good thermal performance. In order to highlight the thermal performance of bio-source materials, we will study the case of Typha Australis which is a plant of the Typhaceae family that grows abundantly in an aquatic environment mainly in the Senegal River valley.Recent studies showed that Typha Australis has good thermal insulation properties. In order to determine the impact of Typha Australis on a building, a dynamic thermal simulation was carried out using the Trnsys software according to specific scenarios, the Typha was mixed with other local materials and used as a wall insulation panel, the result of the study shows that this fiber has allowed us to optimize energy consumption in a building. Mixing Typha with other materials (e. g. clay) is a promising solution for energy efficiency in buildings.

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1 Introduction

Developing countries are facing an exponentially increasing rate of urbanization, hence the need for the development of social and decent housing. Given certain problems such as the emission of greenhouse gases and the depletion of fossil resources, it will be important to reduce the development of energy-intensive. Housing alone consumes 40% of the world's energy [1-2]. The implementation of social and less energy-intensive housing can be achieved through the design of a sustainable and bioclimatic housing.

This is done through the thermal inertia of the housing, thermal insulation, architecture, sobriety (use of less energy-intensive household appliances) [3]. Thermal insulation is a concept that is increasingly developing and can be made either by phase change materials or bio sourced materials.

Several African countries have a particular interest in bio sourced materials, thanks to their availability and they have proven to have good thermal performance [4-5].

The physical-thermal characterization of several biosourced materials gives a low thermal conductivity. These include the incorporation of peanut shells into the plaster in different percentages that have reduced the thermal conductivity of the composite [6]. The mixing of straw and weeds to make high-strength clay bricks increases the durability of the materials and gives good thermal performance [7]. Our study will focus on the exploitation of this plant as bio-sourced and isolation materials. A characterization study of this material has been done by some researchers [8-9].

Our simulation has been done with Trnsys, a dynamic thermal simulation software that has been used by several researchers around the world to evaluate the thermal effects of buildings [10].

Our main objective is to determine the thermal performance of a composite which is the mixture of clay, a local material with Typha which is a biosourced material, taking concrete as a reference habitat.

The next section of this paper presents our analysis and modelling approach, then we introduce our findings in the section results and discussion. We end this paper with some conclusions.

2 Analysis and Modelling

Two buildings were chosen and they are offices located in Nouakchott (Mauritania). The buildings are 4m-high with a double glazed window and a wooden door, the dimensions of the two buildings are identical as well as their doors and windows. The dimensions are shown in Table 1.

The two buildings chosen differ in the composition of their walls and roofs. The first building is in breeze block and the second in clay, this clay is mixed with typha (22.9% typha).

We study two scenarios and each scenario corresponds to a building type: scenario 1 to the breeze block building which is a classical building (reference building) and scenario 2 to the clay building. The simulation of these two buildings was carried out on Trnsys over one year (8760h) with a 1-hour step.

Tables 2 and 3 show the composition of the walls and roof for the scenario 1 (breeze block habitat) and Table 4 and 5 for the scenario 2 (clay habitat).

Table 1. Size of habitat

	Length	width
Walls and roofs	15	0.95
Door	2	1.5
Window	1	1.38

For scenario 1 :

Table 2. Composition of walls for scenario 1

Composition	Thickness (cm)	Thermal conductivity (W/mk)
Breeze block	15	0.95
Cement mortar	2	1.5
Plaster	1	1.38

Table 3. Composition of roof for scenario 1

Composition	Thickness (cm)	Thermal conductivity (W/mk)
Breeze block	15	0.95
Cement mortar	2	1.5
Plaster	1	1.38

For scenario 2:

Table 4. Composition of walls for scenario 2

Composition	Thinckness (cm)	Thermal conductivity (W/mk)
Clay+ Typha	17	0.46
Plaster	1	1.38

Table 5. Composition of roof for scenario 2

Composition	Thinckness (cm)	Thermal conductivity (W/mk)
Clay+ Typha	17	0.46
Plaster	3	1.38

the utilization of both buildings are identical for both building scenarios (breeze block and mixed clay and typha), Table 6 presents the use case.

Table 6. Use scenario

Internal charge	Numbers	sensitive powers	The duration
Persons	3	75 W	8h to 18h (Monday to Friday)
devices (computer)	3	230 W	8h to 18h (Monday to Friday)
Light	1	10 W/m2	8h to 18h (Monday to Friday)

the ventilation used is natural ventilation with a rate of 2h/m3 and the set point temperature has been fixed at 22°C. The energy system is put into operation during office occupancy (see Table 6).

3 Results and Discussion

The outdoor temperature of the site is presented in Figure 1 in order to give an idea of the climatic conditions of the site. We can see in Figure 1 that the temperature varies between 13 and 40°C, which means that we do not need heating as an energy system. We will therefore study the impact of the use of the mixture of Typha and clay on the energy needs for air conditioning.

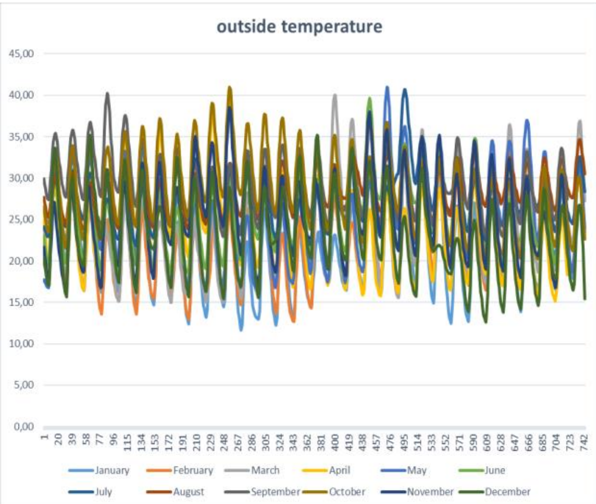

Fig.1. Variation in outside temperature for each month

Figures 2 and 3 show the change in the building's Air temperature (TAIR) and operative temperature (TOP) respectively after setting a set point temperature.
By definition, the operating temperature is the average between the average radiant temperature and the air temperature.
The air temperature inside the house is slightly lower than the outside temperature when it is less than or equal to 22 or when the building is unoccupied, these cases correspond to the non-use of energy systems, particularly air conditioning.

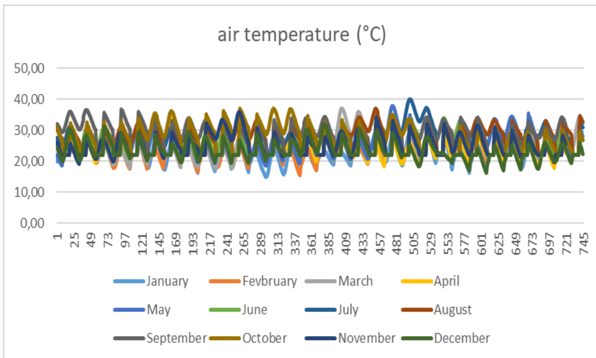

Fig.2. Air temperature inside the habitat

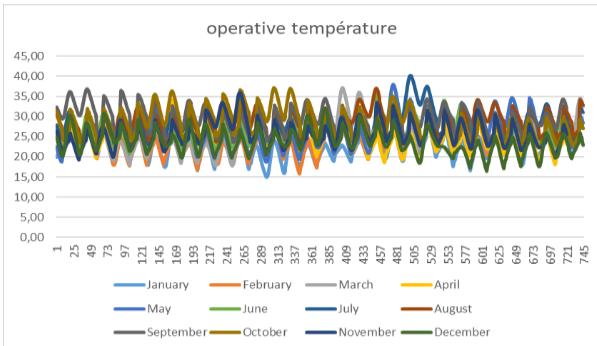

Fig.3. Operative temperature inside the habitat

Figure 4 shows the variations in air conditioning requirements according to the scenarios. By comparing the two buildings, we can see in Figure 4 that during the summer we have a large difference in energy demand, but a small difference in winter (December, January, February). This could be due to the low use of energy systems during this period.

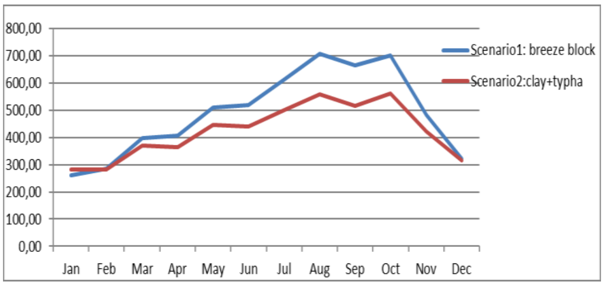

Fig.4. Air conditioning energy requirement (kwh)

By replacing Scenario 1 (breeze blocks) with Scenario 2 (in a mixture of clay and typha), the energy requirements for air conditioning decrease, which is explained by the thermal conductivity of the wall and roof compositions in Scenario 2, which is relatively lower than that in Scenario 1. Table 7 shows that the mixture of clay and typha has reduced the energy requirements for air conditioning by 14%.

Table 7. Reduction rate

Scenarios	Energy requirement (kwh)	Reduction rate
Scenario 1 (breeze block habitat)	5878,10	0% (reference)
Scenario 2 (clay habitat)	5067,567	14%

Conclusion

In this article, two buildings of different compositions were studied, the first in breeze block, which is the reference building, and the second in clay and typha mixture. Then a simulation on Trnsys was carried out to evaluate the thermal performance of these two buildings, in particular the impact of the use of typha and clay mixture. This study showed the interest of using bio-sourced materials, in particular typha, because its mixture with clay has reduced energy requirements by 14%, which proves that the mixture of a local material and a bio-sourced material, in our case clay and typha, is a supporting composite for construction due to their thermal performance.

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