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THERMAL ANALYSIS OF CEMENT PANELS WITH LIGNOCELLULOSIC MATERIALS FOR BUILDING

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Introduction

The use of lignocellulosic material residues to produce cement composites used in building constructions is considered as a good option for new lignocellulosic cement formulations. Agricultural lignocellulosic material cement-based panels can be considered as alternative building materials because they allow a better thermal behaviour of the composite since they offer more significant potential for insulation (Teixeira et al., 2018).

This paper aimed to compare three kinds of cement composites panels reinforced with the following residues agricultural lignocellulosic materials: Coffee husk, Coconut shell, and Banana pseudostem based on their thermal properties.

Material and Methods

The lower part of the thermal chamber contains the heat source (incandescent lamp) connected to a thermostat that maintained the temperature at 48.0 ºC. The system had four thermocouples: the lamp temperature controller, the ambient temperature, the temperature before entering the sample, and the temperature after exiting the sample.

The system was connected to an Arduino microcontroller that was programmed to collect and storage the collected data at every 5 seconds. To validate the system, the heat output was verified with an infrared sensor camera, Fluke TI55FT20/54/7.5, with an accuracy of ±0.05 ºC.

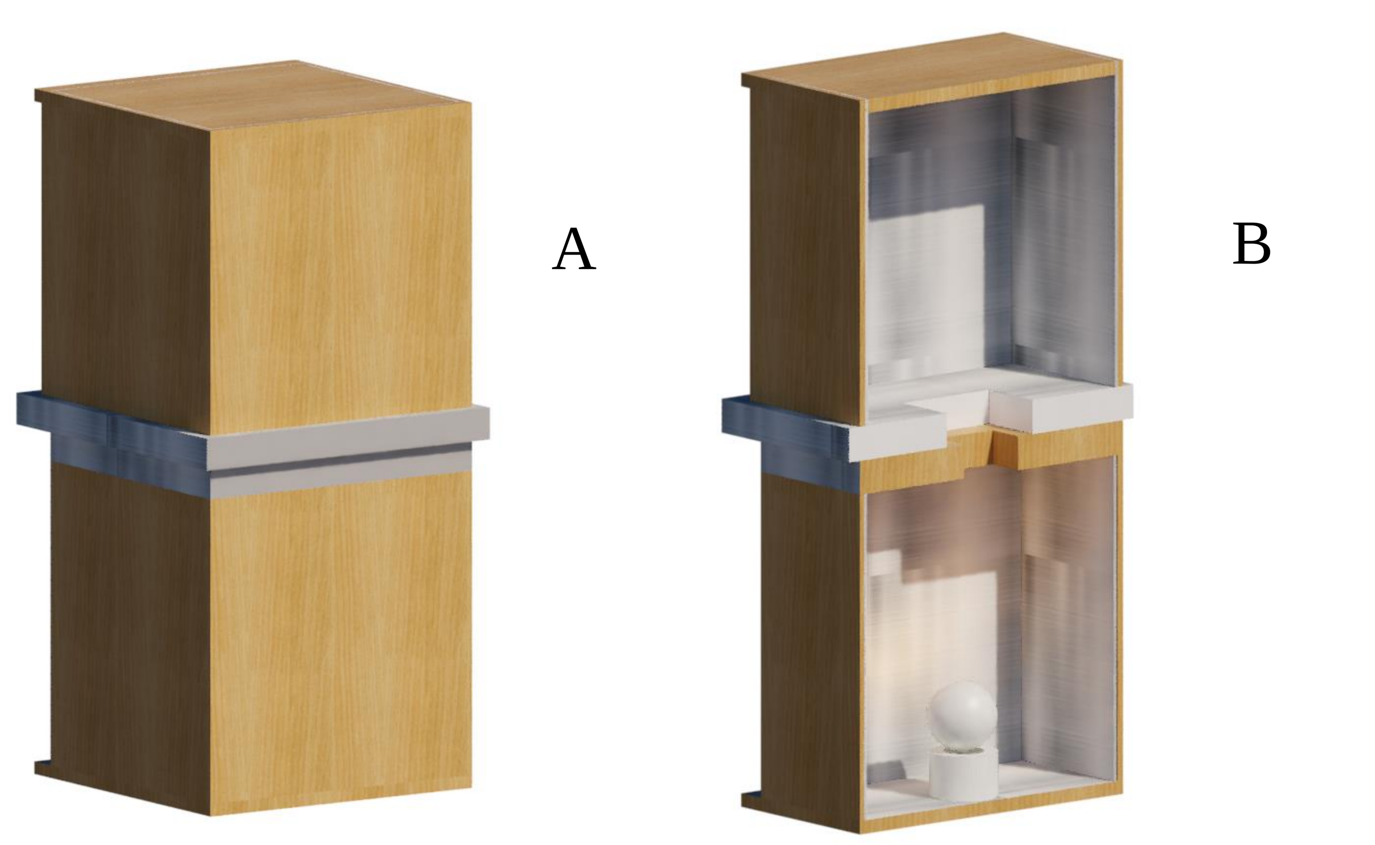

Figure 1. Schematic draw of the external side of the thermal chamber (A) and the internal side of the thermal chamber (B).

Results and Discussion

Table. 1 shows the air temperature results for the thermophysical properties

Material	t (mm)	Porosity (%)	Density g/cm³	λ (W m⁻¹K⁻¹)	U (W m⁻²K⁻¹)	R (m² K W⁻¹)
Coffee husk	16 b (0.6)	52.5 b (9,7)	1.267 a (79,757)	0.0325 b (0.000)	2.027 a (0.017)	0.493 b (0.004)
Coconut shell	16 b (0.3)	62.8 b (2,7)	0.984 c (82,010)	0.0321 c (0.000)	2.005 b (0.010)	0.499 a (0.002)
Banana pseudostem	17 a (0.8)	87.5 a (2,7)	1.003 b (22,055)	0.0340 a (0.000)	1.988 b (0.007)	0.503 a (0.002)
P value	0.000	0.0015	0.0024	0.0000	0.0002	0.0002
CV (%)	0.000	9.53	6.31	0.59	0.60	0.6

Table 1. Thermophysical properties of the evaluated lignocellulosic panels.

After analyzing the thermophysical properties of the evaluated lignocellulosic panels, an additional study has been carried out to analyze the heat flows exchanged between the internal (on contact with the heat source) and external (without contact with the heat source) panels surface. Surface temperatures and heat-flux rate through the test panels are shown in Fig. 2 and Table 2.

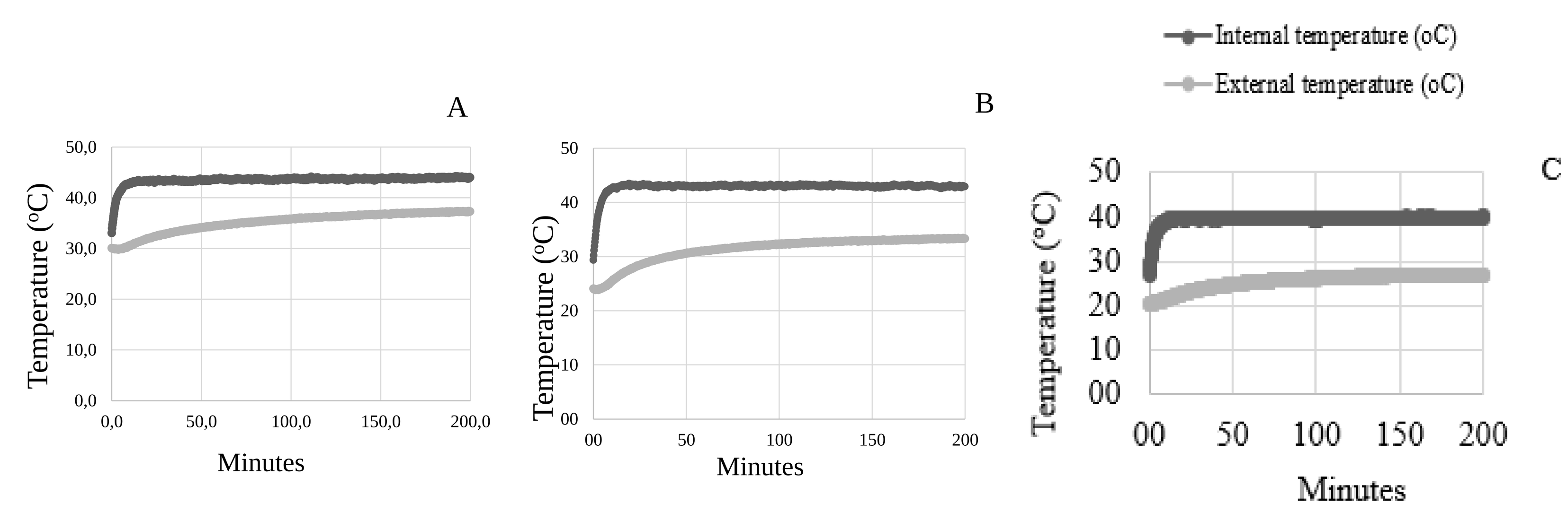

Figure 2. Internal and external temperature surface of the lignocellulosic panels (A) Coffee husk, (B) coconut shell, (C) banana pseudostem during 200 minutes of heat.

Material	$T_{int} - T_{ext}$ (ºC)	$T_{int} - T_{ext}$ (K)
Coffee husk	8.09 b (2.36)	281.24 b (2.360)
Coconut shell	11.14 a (1.37)	284.29 a (1.367)
Banana pseudostem	13.59 a (1.08)	286.74 a (1.076)
P value	0.0002	0.0002
CV (%)	15.47	0.6

Table 1. Table 2. Difference between the internal and external temperature surface of the lignocellulosic panels (A) Coffee husk, (B) coconut shell, (C) banana pseudostem during 200 minutes of heat.

Figure 2 and Table 2 indicate that coconut shell and banana pseudostem presented no statistical difference, and they presented the highest difference surface temperature and highest R-value (Table 2). The R-value is a measure of how well an envelope resists the heat-flow (Desogus et al., 2011). Based on these results, it is possible to affirm that Table 2 and Figure 2 confirm the results of Table 1.

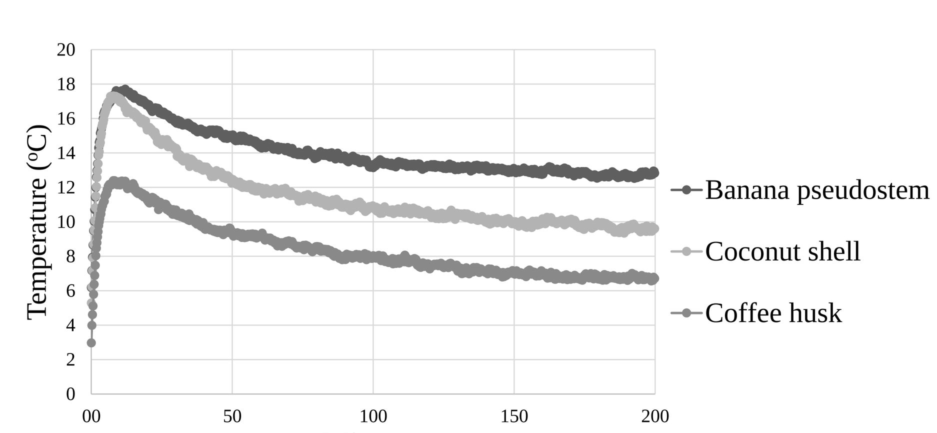

Figure 3. Difference of internal (in contact with the heat source) and external (without contact with the heat source) temperature surface of the evaluated lignocellulosic panels.

Fig. 3 allows us to notice that the surface temperature difference, in the three evaluated panels, becomes stable after a period.

Conclusions

According to the results of the current work, the coconut shell panel presented the best thermal conductivity (0.0321 W m⁻¹K⁻¹).

Besides, coconut and banana pseudostem panels presented the best results of thermal transmittance and thermal resistance.

Acknowledgements

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