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Reusing polyethylene terephthalate bottles (PETBs) for sealing panels manufacturing: The influence of bottle types on their thermal performance

Walfrido Alonso Pippo[1]*, Ivan Dario Gomez Araujo[1], Oswaldo Hideo Ando Junior[2] and Luciano Ari Fiamonzini[3]

[1]Universidade Federal da Integração Latino-Americana (ILATIT), Curso de Engenharia de Energias Avenida Tancredo Neves, 6731, Jardim Itaipu Foz do Iguaçu, Paraná, Brasil.
[2]Universidade Federal Rural de Pernambuco, Unidade Acadêmica do Cabo do Santo Agostinho, Departamento de Engenharia Elétrica e Eletrônica, Rua Cento Sessenta e Três, 300 - Cohab, Cabo de Santo Agostinho –PE, Brasil.
[3]Universidade Federal da Integração Latino-americana. Secretaria de Apoio Científico e Tecnológico Tancredo Neves, 6731. Jardim Itaipu Foz do Iguaçu, Paraná – Brasil.

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This study aims to investigate the influence of PET bottle type used during PET panel manufacturing on their thermal performance. Used PETBs are an increasing threat to the environment. Plastic wastes cause air pollution, and water and soil contamination. Nowadays, vast amounts of such waste are unsafely disposed of in Brazil. The reuse of PETBs for PET panel manufacturing may contribute to minimizing or eliminating their recycling costs and reduce solid waste pollution. The classification and characterization of the most frequently commercialized PETBs were carried out. A PET panel prototype, adjustable to the PETB types most commonly used in Brazil, was designed and built. The influence of PETB type on PET panels' thermal performance was evaluated by measuring the PET panel prototype's equivalent thermal resistance with an unfilled air chamber and with the air chamber filled with 5-, 2-, 1-, and 0.5-L PETBs, respectively. The null hypothesis, which corresponds to the equal variability between the equivalent thermal resistance for the filled and unfilled PET panel prototype's air chamber, was tested. F-tests were used. The Null hypothesis for 5-L PETB may be accepted and rejected for 2-, 1-, and 0.5-L PETBs. The thermal transmittance of PETB panels manufactured with all PETB types included in this work meets the requirements established by law for any Brazilian bioclimatic subzone.

Key words: Solid waste, PET bottles disposal, resource reuse, heat transfer, low-cost housing, circular economy.

INTRODUCTION

The use of polyethylene terephthalate bottles (PETBs) began in the 1950s. Since then, the massive introduction of this type of packaging has been constantly increasing. Some of the reasons encouraging the use of this type of packaging are PET's chemical stability, relatively low cost, low toxicity, and mechanical resistance. About 40% of all packaging in the world is made of plastic. In 2021, the National Association for PET Container Resources

(NAPCOR) documented the largest amount of postconsumer PET ever collected; bottle collection in the U.S. exceeded 1.9 billion pounds for the first time (NAPCOR, 2022).

Brazil is the fourth largest producer of plastic in the world, after the US, China, and India. Brazil produces annually around 11.3 million tons of plastic waste (mostly PETBs), but only 1.28% is recycled. Every year, over 2.4 million tons of plastic are disposed of incorrectly in open refuse dumps in Brazil, without treatment. 7.7 million tons of such materials are sent to sanitary landfills and over 1 million tons do not receive any disposal treatment (Purificatta, 2020; CEMPRE, 2019). Moreover, the recycling cost of a PETB in Brazil is estimated to be six times higher than producing a new PETB (Figueiredo, 2022).

Huge quantities of PETBs are not disposed of sustainably in Brazil. In this scenario, an important line of research for the recycling cost reduction and pollution mitigation generated by the disposal of solid waste and by the construction industry refers to the study of innovative construction methods and the reuse of PETBs, minimizing their recycling costs (Ecoinclusion, 2014; Valencia, 2016; Esbry, 2017; Saxena and Singh, 2013).

Several authors and international organizations have expressed their concern and presented proposals aimed at mitigating the growing threat posed by plastics in general and by PETBs in particular (ABRELPE, 2021; Deutsche, 2022; World Wildlife Fund, 2019; Robleh et al., 2021; Abouhadid et al., 2019; Berwanger, 2021; Kühtz, 2011; Resende et al., 2024; Kazemi et al., 2021; Ma et al., 2021). Most publications have agreed that, the use of PETBs for sealing panels manufacturing is feasible from the mechanical strength standpoint (Pradeep et al., 2022; Shrimali, 2017; Kim et al., 2019). Moreover, most studies on the issue have indicated the partial replacement of sand and/or gravel with PET powder and crushed PET bottles, respectively, for blocks and bricks production. PET powder or crushed PETB is generated from recycled PETB, increasing power consumption.

However, so far none of the published research and papers on the subject have provided a detailed analysis of how the thermal performance of PETB panels depend on the most commonly used PETB types. The main reason for this situation is that most of the existing methods are not suitable for the evaluation of new construction methods and more specifically for the reuse of waste plastics (PETBs) during panel manufacturing.

The present study used only PETBs without any pretreatment or further unitary operation, that is, “as received ([a.r])” for panel manufacturing. This way, energy saving on PETBs milling and sieving is made possible (Figueiredo, 2022).

The feasibility of reusing PETBs[a.r] for panel manufacturing depends on PETBs properties such as height, length, shape, and material thickness, as well as other variables such as panel manufacturing costs, number of unitary operations, panel standardization, durability, and absorption, among others.

This study aimed to investigate the influence of the PET bottle types used during the PETB panel production on their thermal performance by determining the equivalent thermal resistance variability.

MATERIALS AND METHODS

The influence of each PETB type on the PET panel’s thermal behavior was performed in four steps:

First step: Designing and building a PETBs[a.r] -universal panel prototype;
Second step: PET panel prototype thermal properties calculation considering only the unfilled air chamber (without PETBs[a.r]);
Third step: PETBs[a.r] panel prototype's equivalent thermal resistance experimental determination with air chamber filled with different PETB types;
Fourth step: Statistical treatment and results analysis.

Plastic bottles (PETBs)

Plastic bottles (PETBs) used in Brazil have various shapes, types, and colors since the leading companies that produce such type of packaging continue to develop new types of preforms such as plastic closure only (PCO) or carbonated soft drinks (CSD) for PETBs. The more straightforward classification for PETBs is their standard capacity, ranging from 200 mL to 5 L (Figure 1) which shows the model used in this study to better understand the bottles' dimensions. Table 1 shows a characteristic summary of the PETBs most commonly used in Brazil.

PETB panels

PET bottle panels are made in various ways in Brazil. For this purpose, firstly, the wood frame and secondly the steel frame is used. The first one usually originates from discarded wooden pallets, and the second one from scrap or leftover metal.

Typically, PET panel dimensions depend on the project, which might be a bus stop, an artistic stage, or a low-cost house, and also on PETB-type availability.

The large diversity of PET bottle types, combined with the multiple uses of PET panels has added difficulties for their thermal characterization. It requires enormous testing and measurement efforts, making it virtually impossible to draw any practical conclusions.

Overcoming these difficulties, a PETB’s[a.r] panel prototype

*Corresponding author. E-mail: walfridoalonso@gmail.com.

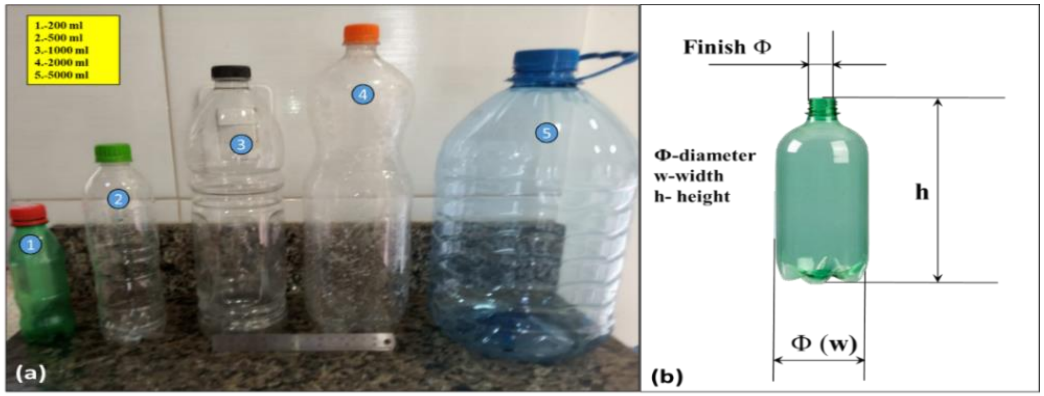

Figure 1. (a) Plastic Bottles (PETBs) capacity most common in Brazil; (b) Model dimensions.
Source: Authors.

Table 1. Dimensions and properties of PETBs most commonly used in Brazil.

Dimensions and properties	**Units**	**PET properties**
		Material: Polyethylene Terephthalate (Formula:($C_{10}H_8O_4$)n)
Density amorphous	kg/m^3	1370
Density crystalline	kg/m^3	1455
Thermal conductivity	W/(m·K)	0.24
Young's modulus(E)	MPa	2800–3100

Water and soda PET bottles for		**Bottle standard capacity [Liter]**							
		0.2	**0.5**	**0.6**	**1**	**1.5**	**2**	**2.5**	**5**
inish Φ *	mm.	24-28							45-48
h- Height *	mm.	170-171	200-205	225-233	269-275	309-321	341-346	351-354	323
w- Width *	mm.	54-55	62-65	69-71	82-84	87-89	98-100	108-111	155±1
Weight *	kg.	0.0145-0.0175	0.0174-0.0194	0.023-0.024	0.035-0.037	0.032-0.037	0.0436-0.0477	0.0518-0.0532	0.084-0.094
PET-Thicnecks *	mm.	0.03	0.04	0.046	0.05	0.05	0.06	0.06	1

Source: TRIDENT Component (2022) and Author measurements.

was designed and built (Figure 2). The PET panel prototype was adjustable to all types of PETBs and composed of two layers of traditional plaster (interior and exterior with a 2100 kg.m^{-3} density).

An additional criterion taken into account during the prototype sizing was the similarity in dimension to the

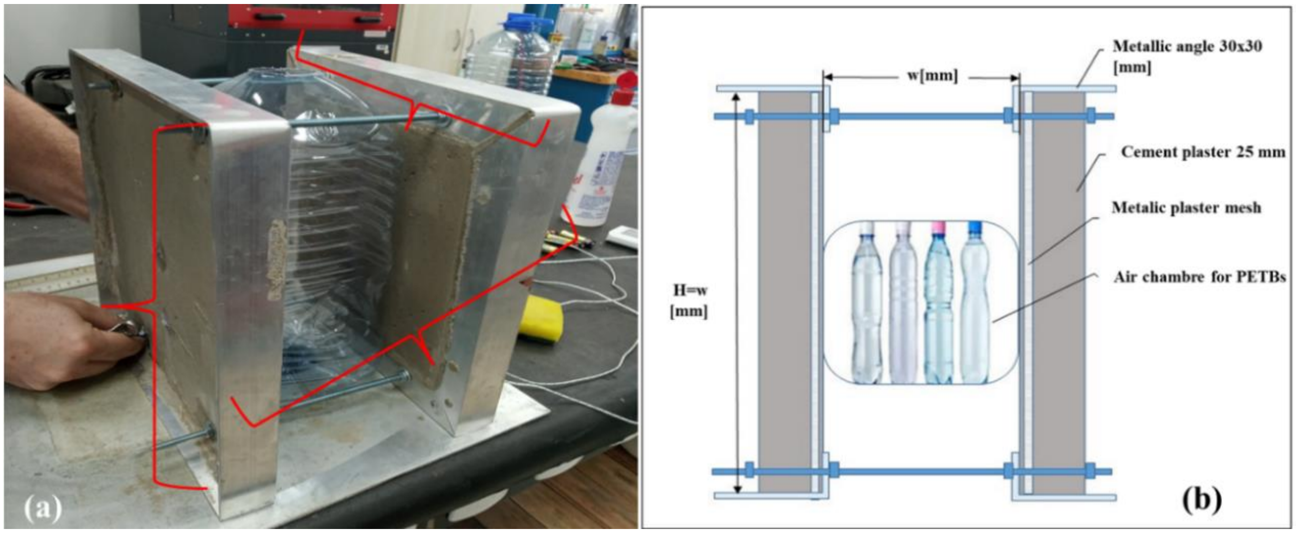

Figure 2. (a) Metal frame panel prototype with (H=W=300 mm); (b) PETB metal frame panel prototype with plastering cement; PETBs$^{a.r}$ panel prototype for thermal tests (Cross-section) adjustable from 114 to 250 mm.
Source: Authors.

concrete blocks and ceramic bricks most commonly used in Brazil defined by standards (NBR 7170, 1983; NBR6136, 2016).

For non-structural walls, the mentioned standard recommends a concrete hollow block type D-M 7.5 actual height-H=190 mm × width-W=390 mm. The selected PETBs$^{a.r}$ panel prototype has an actual height-H =270 mm × actual width-W = 270 mm. This is a 0.074 and 0.073 m^2 functional surface, and a 13.6 and 7.8 kg weight for hollow block and PETBs$^{a.r}$ panel prototype, respectively.

PETBs panel thermal properties calculation

The polyethylene terephthalate's thermal characteristics are known. However, no studies discussing the thermal performance (thermal Resistance *Rt* [m^2.K.W^{-1}], or Thermal Transmittance U [W. $(m^2.K)^{-1}$] (ABNT, 2003) of PETBs$^{a.r}$ panel has been found. The following publications on thermal performance ought to be highlighted due to their similarities to the aim of this study (Laurenti et al., 2003; Ha et al., 2022; Bienvenido-Huertas et al., 2020; Peng and Wu, 2008; Jorge, 2011).

The cited studies classify thermal characterization methods differently and according to other criteria. Among them are *in situ* determination, analytical determination, and experimental methods in a transitive regime or steady state. Two methods were used in this study: thermal variables calculation for hollow concrete blocks (ABNT, 2003), and PETBs$^{a.r}$ panel prototype's equivalent thermal resistance's indoor analytical-experimental determination for the PETBs types considered in the study.

For calculating the PETBs$^{a.r}$ panel prototype's thermal properties, a double-wall model with concrete plates and an air chamber without ventilation was adopted. Such model corresponds to the situation shown in the prototype cross-section (Figure 2).

For this case, the main Equations are (ABNT, 2003):

$$R_t = \frac{e_{p\ Ext}}{\rho_{p\ Ext}} + R_{ar} + \frac{e_{p\ Int}}{\rho_{p\ Int}} \qquad (1)$$

$$R_T = R_{sInt} + R_t + R_{sExt} \qquad (2)$$

$$U = \frac{1}{R_T} \qquad (3)$$

where R_t, R_{ar}-Thermal resistance of component *t* [$(m^2.K).W^{-1}$] and regarding an air chamber, respectively; $e_{p\ Ext}$ = $e_{p\ Int}$ =25 - Exterior and interior plaster thickness [mm], respectively; $\rho_{p\ Ext}$ = $\rho_{p\ Int}$ - Exterior and interior plaster thermal conductivity; R_T - Total thermal resistance of tested element; $R_{sExt} = 0.04$ $(m^2.K).W^{-1}$ and R_{sInt} =0.13 $(m^2.K).W^{-1}$ - Exterior and interior surface resistance, respectively, both defined by the standard (ABNT, 2003); U - Thermal transmittance of tested element.

PETBs$^{a.r}$ panel prototype's equivalent thermal conductivity analytical-experimental determination

The method used measured the Equivalent Thermal Conductivity ($kT_{.\ equiv}$)- and Equivalent Thermal Resistance $(R_T equiv)$ by simulating solar irradiation on a panel with a dichroic lamp until the heat transfer regime reaches a steady state between the radiated wall (external surface) and the shaded wall (internal surface) (Figure 3a and b). Heat transfer under these conditions has two stages. The first stage is heat transfer by radiation (Equation 4): lamp-external wall and deals with the heat rate calculation of

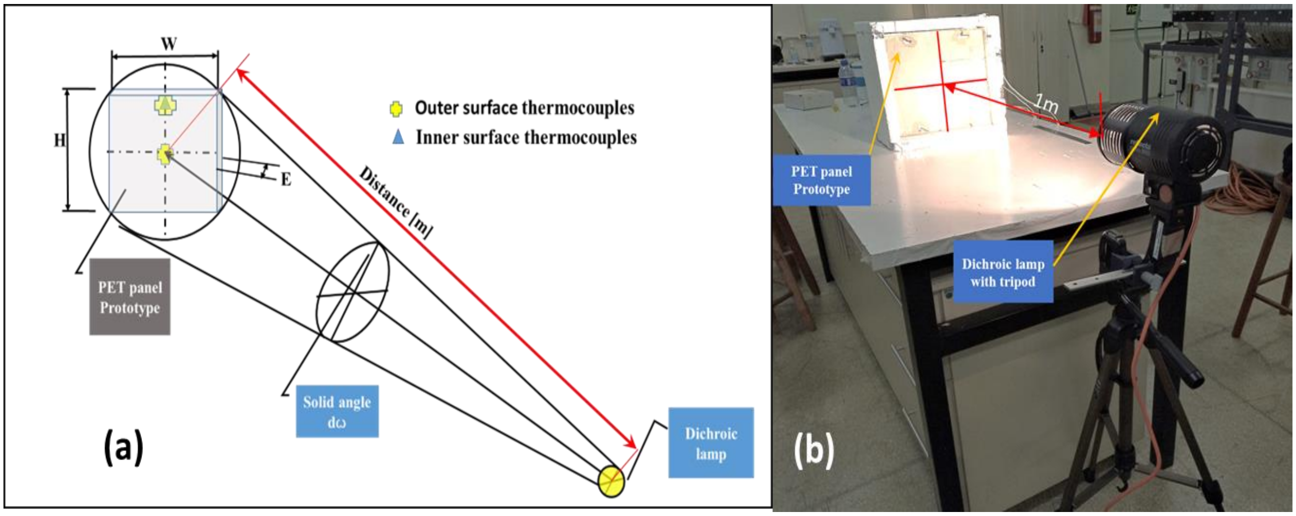

Figure 3. (a) Experiment bench's component layout diagram; (b) Experiment bench picture.
Source: Author.

energy reaching the radiated wall. The second one is heat transfer by conduction (Equation 5): heat rate transferred from the external surface to the internal surface of PETBs$^{a.r}$ panel prototype under one-dimensional heat flux conditions (Bergman et.al.,2011)

$$q_{rate} = I_{Lamp} . A_{Lamp} . \cos(\theta) . \omega_{Lamp-wall} \quad (4)$$

$$kT_{equiv} = \frac{q_{wall}}{\Delta T} . E_{wall} \quad (5)$$

where q_{rate} is heat flow rate hitting the wall [watt]; I_{Lamp} is lamp radiation intensity hitting the wall [watt. (m^2.sr) $^{-1}$]; A_{Lamp} is emissive area of the lamp[m^2]; ϴ is zenith angle [º]; ω is solid angle lamp-wall [sr]; $kT_{.equiv}$ is equivalent thermal conductivity; $q_{wall} = \frac{q_{rate}}{A_{wall}}$; ΔT is internal-external temperature difference [°C]; and E_{wall} is wall thickness.

The PET panel prototype was thermally isolated with Expanded Polystyrene (EPS) to prevent unwanted heat transfer from the top, bottom, and lateral sides (Figure 3b). The temperature difference between external and internal surfaces was recorded at 15-min intervals during the entire measurement time (10-12 h using a data logger. 500-watt was the lamp power.

RESULTS AND DISCUSSION

PETBs$^{a.r}$ panel prototype's thermal resistance (Rt) conventional calculations

All variables in Equations 1 to 3 were determined in the standard (ABNT, 2003), which recommends a R_{ar1} = 0.17, under the following conditions: ε > 0.8, E ≤ 50 mm chamber thickness, and internal and external surfaces temperature difference <15°C. In other words, from zero to 50 mm, the total thermal resistance would be constant (R_T = 43.818). Among the published studies on R_{ar} calculation, one carried out in Algeria in 2013 recommended R_{ar2}=0.217 for E ≤ 100 mm, air temperature between 0 and 60°C, and ε > 0.9. In this case, the result was R_T = 43.865 (Bekkouche et al., 2013).

That is, both methods were insensitive to determine how the air chamber thickness affects R_{ar}. Therefore, the R_T will be the same for any PET bottle type in a wide range of their standard capacity.

According to these results, existing standard methods are unable to evaluate the influence of PETB type on thermal performance. Similar published standards have addressed the issue holistically. For this reason, to study the influence of PETB type on the prototype PETBs$^{a.r}$ panel's thermal performance, several assays on the unfilled air chamber and the air chamber filled with different standard capacities PETB were performed.

Radiation heat transfer (heat flow determination- q_{rate})

The PETBs$^{a.r}$ panel prototype and the lamp were 1 m apart (Figure 3b). Due to H=W= 27 cm, the PETBs$^{a.r}$

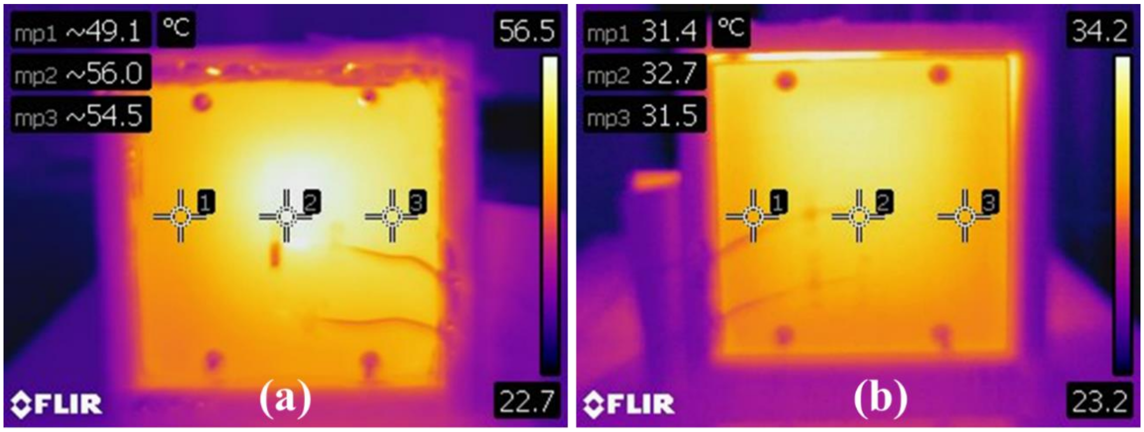

Figure 4. Thermal photos wall thickness 151 mm. (a) External surface; (b) Internal surface.
Source: Author.

panel prototype's irradiated area was A_{wall} = 0. 073 $m^{2.}$

Under conditions of wavelength ranged from λ_1=0.4 µm to λ_2=0.76 µm and azimuthal Φ and zenithal θ were=0, the problem was reduced to determining the spectral intensity, which depends on λ and temperature color [K] of the emitting source (lamp). The Stefan-Boltzmann law determined the Total Emissive Power E (λ). Then, the emissive power of a real surface was quantified by the spectral intensities using Equations 6, 7, and 8 from Table 12.12 of the book (Bergman et al., 2011).

$$E_\lambda(\lambda) = q''_\lambda(\lambda) = \int_0^{2\pi}\int_0^{2\pi} I_{\lambda,e}(\lambda,\theta,\emptyset)\cos\theta \; sen\theta \; d\theta \; d\emptyset \quad (6)$$

$$E_\lambda(\lambda) = \pi I_{\lambda,e}(\lambda) \quad (7)$$

$$E = \pi I_e \quad (8)$$

The Lamp used (STUDIO 8002) has a temperature color (T_k = 3400°K), an emissivity of tungsten (dichroic lamp filament) ε =0.2 and A_{Lamp} =π. (1 cm)^2. E_{Total} and I_{Lamp} were calculated using Equations 9 to 11, respectively.

$$E_{Total} = \sigma . T_k^4 \quad (9)$$

$$E_{lamp} = \varepsilon . E_{Total} \quad (10)$$

$$I_{Lamp} = \frac{E_{lamp}}{\pi} \quad (11)$$

where σ – is Stefan Boltzmann coefficient 5.76 × 10^{-8} [W.($m^2.K^4$)$^{-1}$].

To determine the heat flow rate (q_{rate}) hitting the external wall of PETBs[a.r] panel prototype, the calculated values of solid angle lamp-wall $\omega_{Lamp-wall}$ = A_{wall} / Distance^2 = 0.073 [sr] and radiation intensity lamp I_{Lamp} = 4.9 × 10^5 W. (m^2.sr)$^{-1}$ were placed into Equation 4. Consequently, the q_{wall} =153.946 [W.m^{-2}] was the heat flow adopted during all assays.

Steady state heat transfer

The transient heat flow response to the steady state was 2.5 to 3.5 h. During all assays, the temperature difference between the external and internal surfaces of the PET panel prototype was also recorded with a thermal camera (FLIR E6) (Figure 4).

Conduction heat transfer (PETBs[a.r] panel prototype's equivalent thermal resistance-experimental determination - (NAPCOR)

Using the PETBs[a.r] panel prototype and the method described earlier, two assays were carried out for each PETB standard capacity (5000, 2000, 1000 and 500 ml). One assay used the unfilled air chamber, and the other one used the air chamber filled with PETBs of 5000, 2000, 1000 or 500 ml, respectively. During the measurements with the unfilled air chamber, its thickness (E) remained equal to the diameter of the tested PETB

Table 2. 5000 ml PET bottle measurement results.

PETB standard capacity 5000 ml									
Air chamber thickness (E) 192 [mm]									
PET panel air chamber	**Filled with 2PET**		**Unfilled**		**PET panel Air chamber**	**Filled with 2PET**		**Unfilled**	
Temperature differencial [K]	**ΔT**	**Rt Filled [m2.K/W]**	**ΔT**	**Rt Unfilled [m2.K/W]**	**Temperature differencial [K]**	**ΔT**	**Rt Filled [m2.K/W]**	**ΔT**	**Rt Unfilled [m2.K/W]**
No. Measurement					**No. Measurement**				
1	14.2	0.092	6.55	0.0425	23	25.6	0.166	15.8	0.1026
2	20.35	0.132	10.5	0.0682	24	25.6	0.166	15.75	0.1023
3	24.15	0.157	12.4	0.0805	25	25.65	0.167	15.65	0.1017
4	25.45	0.165	14.15	0.0919	26	25.5	0.166	15.65	0.1017
5	25.85	0.168	14.55	0.0945	27	25.55	0.166	17	0.1104
6	26.05	0.169	15.4	0.1000	28	25.5	0.166	17.15	0.1114
7	26.05	0.169	15.3	0.0994	29	25.55	0.166	17.5	0.1137
8	26.75	0.174	15.55	0.1010	30	25.45	0.165	17.45	0.1134
9	25.95	0.169	16	0.1039	31	25.65	0.167	17.5	0.1137
10	26.6	0.173	15.6	0.1013	32	25.45	0.165	17.45	0.1134
11	26.25	0.171	15.65	0.1017	33	26.15	0.170	17.5	0.1137
12	25.9	0.168	15.65	0.1017	34			17.45	0.1134
13	26	0.169	15.95	0.1036	35			17.55	0.1140
14	25.95	0.169	15.85	0.1030	36			17.5	0.1137
15	25.9	0.168	15.9	0.1033	37			17.5	0.1137
16	25.85	0.168	15.8	0.1026	38			17.6	0.1143
17	25.75	0.167	15.85	0.1030	39			17.6	0.1143
18	25.8	0.168	15.85	0.1030	40			17.6	0.1143
19	25.8	0.168	15.85	0.1030	41			17.6	0.1143
20	25.75	0.167	15.8	0.1026	42			17.65	0.1147
21	25.65	0.167	15.8	0.1026	43			17.65	0.1147
22	25.75	0.167	15.8	0.1026	**Average**	25.08	11.500	25.080	0.163

type. That is, 192 mm for 5000 ml PETB, 151 mm for 2000 ml, 133 mm for 1000 ml and 115 mm for 500 ml.

Table 2 shows the measurements for the maximal standard capacity (5000 ml) of the PETBs tested. The measurements were performed in the same way for the PETBs of 2000, 1000 and 500 ml.

To determine the influence of the type of PETB on the PETBs $^{a.r}$ panel prototype's thermal performance, two hypotheses were formulated: Null Hypothesis H_0 - PETBs influence the PETBs$^{a.r}$ panel prototype's equivalent thermal resistance's variability; Alternative Hypothesis H_1- PETBs do not influence the PETBs$^{a.r}$ panel prototype's equivalent thermal resistance's variability.

F-Test was carried out with a α=0.05 significance level for all PETBs types. The results are shown in Table 3. Table 3 shows that the Null Hypothesis may not be rejected for 5000 ml PETBs ($F_{test} < F_{critical}$ and P= 0.30 > α=0.05). For this PETB capacity, there was no statistically significant variability of *Rt* between filled and unfilled air chamber of PETBs$^{a.r}$ panel prototype. However, for 2000, 1000, and 500 ml PETBs, there was statistically significant variability of *Rt* between filled and unfilled air chamber of PETBs$^{a.r}$ panel prototype, and the H0 may be rejected. For all tested PETB capacities smaller than 500 ml F-test showed ($F_{test} > F_{critical}$) and P≈ 0.00 < α=0.05 or very small P=12%.

In contrast, the R_T values for all tested PETB types were very similar. This may be due to two facts; first the PETB$^{a.r}$ panel prototype has two plaster layers with a thermal conductivity of $kT_{.\ equiv.plaster}$ =1.15. [W. (m.K)$^{-1}$] and 25 mm thickness each, representing between 24 and 27% of PETB$^{a.r}$ panel's average *Rt* filled for all tested PETB type. Second, the $R_{sExt}+R_{sInt}$ =0.17 (m^2.K). W^{-1} represents about 50% of the PETBs$^{a.r}$ panel average R_T for all tested PETBs types.

Measurements considering continuous PETB capacity variations would be required to accurately determine the

Table 3. F-Test results for PETBs (statistical significance level α=0.05).

F-test: Two variable samples	PET 5000 ml		PET 2000 ml		PET 1000 ml		PET 500 ml	
	Rt Filled (2PETB)	Rt Unfilled	Rt Filled (3PETB)	Rt Unfilled	Rt Filled (4PETB)	Rt Unfilled	Rt Filled (6PETB)	Rt Unfilled
Average	0.164048	0.103608	0.179576	0.171028	0.142574	0.166283	0.160175	0.130951
Variance	0.000211	0.000179	0.000285	0.000002	0.000694	0.001021	0.000959	0.000214
Sample Size	33	43	36	30	37	37	36	37
Degrees of fredom	32	42	35	29	36	36	35	36
F	1,180,721		177,444,975		0.679407		4,470,875	
P(F<=fone tail)	0.303694		0.00000		0.125474		0.000010	
F critical one tail	1,718,079		1,826,764		0.573732		1,747,838	
H0	Reject		Reject		Reject		Reject	
H1								
RT [(m^2.K).W^{-1}]	0.33405		0.34958		0.336	0.313	0.33018	
U[(m^2.K)$^{-1}$.W]	2.99358		2.86061		2.974	3.20E+00	3.02869	

capacity at which the *Rt* variability becomes significant. On the other hand, the standard capacity of PETBs has a discrete magnitude. Overcoming this would require costly and complex experiments, which are not within the present study's scope.

Therefore, the results are not conclusive. Further studies and experiments must be performed to obtain answers that lead to elaborating a standard for this novel and crucial constructive element.

Table 3 shows that in all measurements performed with filled air chamber, the PETBs$^{a.r}$ panel transmittance U ranged from 2.860 to 3.028 [W. (m^2.K)$^{-1}$] regardless of PETB type. Such results indicated that the thermal performance of a PETB-made panel corresponds to either to that of a light wall (U≤ 3.00 W. (m2.K) -1 or a light-reflecting wall U≤ 3.60W.(m2. K)-1 determined by the Brazilian standards (ABNT, 2003). It means that the thermal transmittance of PETBa.r panel manufactured with these PETB types meets the requirements established by law for any Brazilian bioclimatic subzone.

Comparison with the other studies on wall thermal performance

The thermal behavior of the walls has been studied by several authors. Due to their similarity with the present work, the following should be mentioned (Bekkouche et al., 2013; Abouhadid et al., 2019; Tarabieh et al, 2020). Bekkouche et al (2013) concluded that the most economical air chamber configuration depends on the thermal emissivity and the insulation material used. Abouhadid et al. (2019) compared the thermal performance of the brick room with the PETB room and pointed out some advantages and disadvantages of both. Khaled's research (Tarabieh et al., 2020) carried out a computer simulation of PETB wall thermal performance and concluded that: "PETB walls can substitute brick walls as they are good isolators, especially when using large bottles instead of small bottles to increase the thermal mass of the wall and still, they provide acceptable structural properties". All cited studies recommend further or complementary research on the subject.

However, none of the earlier literature has shown a detailed analysis of how PETB panels' thermal performance depends on the PETB types most commonly used as was done in the present study. The indication about the possibility of using PETB panels in any part of Brazil matches the conclusions in the references (Tarabieh et al, 2020; Abouhadid et al., 2019). The aforementioned studies use different methods and materials which is why it is difficult to compare them with the present work.

Conclusion

PETBs take hundreds of years to decompose, prompting a pressing need to remove plastic debris from the environment. It is and will continue to be a trend for decades to come. The present study is one more step in that direction.

The present study addressed the reality and complexity of such issue in Brazil, where PETBs are manufactured to meet consumption needs, not considering their most efficient disposal.

Existing thermal performance evaluation methods have been developed considering traditional building elements such as concrete blocks and ceramic bricks. The thermal characterization of components such as PETBs$^{a.r}$ panel requires the development of new methods or the adaptation of existing ones to unique needs.

The design and construction of PETBs[a.r] panel prototype adjustable to all PETB types marketed in Brazil is an innovation that may speed up research in the construction elements field.

From the results obtained, the PETB type appears to influence on the thermal behaviour of the PETBs[a.r] panel. The results made it impossible to reach definitive conclusions on the subject. Further research is required.

ABBREVIATION

R**,** Thermal resistance (m^2.K.W^{-1}); ***U*****,** thermal transmittance (W. (m^2.K) $^{-1}$); ***ρ*****,** plaster thermal conductivity (W. (m.K)$^{-1}$); ***e*****,** thickness (mm); ***λ*****,** wave length (µm); **H_0, H_1,** null and alternative hypothesis; **PETBs,** polyethylene terephthalate bottles; **PET panel,** polyethylene terephthalate panel; **F-test,** statistical test of Ronald Fisher; **a.r,** as received; ***t*****,** thermal resistance of tested component *t*; ***T,*** total thermal resistance of wall; ***ar,*** thermal resistance regarding air chamber; ***pExt*** **and** ***pInt*****,** exterior and interior plaster layers; ***sExt*** **and** ***sInt*****,** exterior and interior wall surfaces.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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