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POST-OCCUPATION EVALUATION OF A BUILDING IN A MARITIME CONTAINER FROM THE PERSPECTIVE OF THERMAL PERFORMANCE IN PALMAS – TO

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ABSTRACT
This study aims to evaluate the environmental, comfort, functional and constructive aspects of a container house located in a rural area in the city of Palmas – TO. The methodology combined with NBR 15.220/2005, 15.220/2023 and NBR 15.575/2013, Post-Occupation Evaluation of the building, as for its thermal performance in the housing process, data collection and field research, thermal analysis equipment was used, in order to understand the ways in which the material acts in the face of the city's climate. Based on the results of the post-occupation research, it was possible to analyze the possibilities of use, generate possible solutions for these structures in order to contribute to the development of the field of Architecture and Urbanism.

Keywords: APO. Thermal Performance. Maritime Container. Sustainable Housing.

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INTRODUCTION

The transformation of shipping containers into habitable buildings emerges as an innovative response to environmental concerns in civil construction. Campos (2010) highlights the need to discuss the conditions of steel structures, emphasizing the importance of Post-Occupancy Assessment (POE) as an essential practice in civil construction. POE plays a crucial role in feeding back design decisions, providing inputs for databases and advancing on construction qualifications, influencing indicators related to human behavior and the built environment, as pointed out by Ornstein and Romero (1992).

Modular construction stands out as a sustainable and creative alternative for the reuse of container structures, expanding their constructive flexibility. However, this demands a differentiated architectural approach, exploring aesthetic and functional possibilities. In cities in bioclimatic zone 7, such as Palmas-TO, the APO gains relevance from the perspective of environmental comfort, where thermal comfort indicators emerge as a critical aspect to be evaluated, considering the challenges of the hot and dry climate.

The reuse of containers for habitable spaces not only offers a sustainable solution, but also addresses the logistical problem generated by the large number of these abandoned structures in Brazilian ports (Calory, 2015). However, its implementation in places with specific characteristics, such as Palmas-TO, requires a careful approach to construction measures and bioclimatic strategies. In Palmas, due to its thermal amplitude, in constructions of this type it is necessary to combine different constructive measures and bioclimatic strategies, the fence alone may not be effective according to notes by Omena, Macedo and Oliveira (2023). Thus, the research sought to discuss how NBRs 15575/2013, 15220/2023 and 15.20/2015 can support the thermal comfort issues of buildings of this type of containers, located in the city of Palmas-TO.

LITERATURE REVIEW

ISO 668 (1995) is a Brazilian standard that discusses containers, classifications, dimensions and capacity, and defines that a cargo container is "a permanent transport equipment, strong enough to be used repeatedly". This characteristic positions them as structures adaptable to a variety of construction applications.

That said, modular construction shares fundamental characteristics and purposes with the use of containers in civil construction, both embrace standards of dimensions, materials and processes, aiming at efficiency and effectiveness in the execution of projects

(Ferreira, 2010). The advance in construction, driven by concerns about social equality and environmental quality, shows the growing approximation of sustainable construction practices (Bragança *et al*., 2011).

In this context, APO is an essential tool to diagnose thermal performance and also acoustic, luminous and functional aspects, providing subsidies to improve the quality of architectural projects (França, 2011). Thus, architecture with less environmental impact depends on design solutions for environmental comfort and energy efficiency. This relationship between environmental comfort and energy efficiency is especially crucial in projects that incorporate specific strategies, such as fitting, orientation, shape, and configuration of the envelope (Gonçalves; Duarte, 2006).

METHODOLOGY

NBR 15575/2013 is adopted as a determining guideline in the initial requirements that buildings must meet, as well as the other standards mentioned therein when it comes to performance in the use of various aspects of housing construction. Houses with non-common materials are entitled innovative constructions and, for the purpose of verification, clarified by the criteria and minimum requirements of comfort and thermal performance determined by the Performance Standard. Thus, a residential building with a temporary permanence structure, with a maritime container structure in the city of Palmas – TO was chosen to adopt the methodology described by NBR 15220/2005, NBR 15220/2023 and NBR 15575/2013.

The building (figure 1) is located in a rural area of the municipality of Palmas, TO. It is a two-storey house, front façade facing west. The roof is made of isothermal tiles with expandable polystyrene (EPS), which offer thermal insulation. In the vertical and horizontal enclosure, no thermal insulation materials are used, only plasterboard and the steel structure of the shipping container.

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Figure 1 - Main West Façade of the building.

Source: Authors, 2024.

In the research, two types of collection were carried out: the first had the purpose of validating the methodology, in this stage the identification of the physical environment of the study and its surroundings was also carried out. It was carried out in the week prior to the measurement period, in order to verify and understand the operationalization of the equipment and data, in addition to mitigating possible problems during the measurements.

In the final collection, as determined by NBRs 15220 and 15575, there are two evaluative parameters: the simplified method, for the analysis of the sealing and roofing systems, and the on-site measurement, where the requirements and criteria were carried out through the measurements taken. These measurements were carried out between July 11 and 13, 2023, from 8 a.m. to 7 p.m., interspersed hourly, on 3 consecutive days, which had the same climatic characteristics.

EVALUATION PARAMETERS

The simplified method is used to verify compliance with façade and roof requirements and standards, as stipulated in NBR 15575-4, which applies to interior and exterior vertical fencing systems (SVVIE) and roofing systems. In the case of SVVIE, three parameters are considered: the thermal transmittance (U) of the external walls, the thermal capacity (TC) of the external walls and the presence of ventilation openings. The values of these parameters are determined in accordance with NBR 15220-2/2023 and are compared with the established requirements in order to verify compliance. The parameter related to ventilation openings is calculated according to the method described in NBR 15575/2013.

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The only requirement considered in the roofing system is thermal transmittance. The standard establishes maximum acceptable values and takes into account the downward flow of heat based on bioclimatic zones. For the scope of this study, both the sealing systems and the roofing system were analyzed until the thermal transmittance requirement was reached.

In *the on-site measurement,* according to NBR 15575-1/2013, the thermal performance must have the maximum daily temperature of the indoor air in the environments of prolonged stay. These criteria apply to a typical summer day with measurements taken in the shade. In zones such as 7, the criteria are mainly focused on summer conditions, when indoor heat is the main challenge.

Concomitant with the requirements of NBR 15575-1/2013, data collection was carried out in the environment with the highest number of exposed walls, as it is a two-story building, this collection took place in a unit on the top floor. The analysis in the summer specifies that the maximum daily internal temperature is always less than or equal to the maximum daily external temperature in the prolonged stay environment, as shown in Table 4.

Table 1 - Thermal performance evaluation criteria for summer conditions.

Performance level	Criteria	
	Zones 1 to 7	Zone 8
Minimum	Ti,max. ≤ Te,max.	Ti,max. ≤ Te,max.
Intermediary	Ti,max. ≤ (Te,max. – 2ºC)	Ti,max. ≤ (Te,max' – 1ºC)
Superior	Ti,max. ≤ (Te,max' – 4ºC)	Ti,max. ≤ (Te,max. – 2ºC)
Ti,max. is the maximum daily value of the air temperature inside the building, in °C. Te, max. is the maximum daily value of the air temperature outside the building, in °C. NOTE - Bioclimatic zones according to ABNT NBR 15220-3/2005.		

Source: Adapted from ABNT NBR 15.575-1/2013, 2024.

In the measurement of data collection on the performance of housing environments, it is necessary to evaluate data such as temperature, humidity, indices such as wet bulb and external and internal thermal stress, air velocity, among others. Therefore, for the temperature measurements in the container building, the Digital Globe Thermometer with Highmed datalogger, model HMTGD-1800, was used, meeting the international thermal performance standards ISO 7243/2017 and ISO 7726/1998.

Chart 1 summarizes the results obtained in the simplified procedure, presenting the calculations of the thermal transmittance of the materials that make up the seals in order to evaluate the thermal performance of the building and determine whether the characteristics meet the admissible values recommended by the NBR 15220-3/2005 standard.

Table 1 - Results of the evaluation by the simplified procedure.

	Critério avaliado	Calculado	Recomendado
Parede (Pesada)	Transmitância [W/m².K]	2,68	≤ 2,2
	Absortância Solar	0,80	α≤0,8
Cobertura (Pesada)	Transmitância [W/m².K]	0,98	≤ 2
	Absortância Solar	0,50	α≤0,4

Source: Adapted NBR 15575/2013, 2024.

For the vertical sealing system (walls) of the building, the value calculated for the thermal transmittance (U) was 2.68 W/m².K. However, the NBR 15220-3/2005 standard establishes that, in Bioclimatic Zone 7, the maximum limit for thermal transmittance is 2.2 W/m².K. Therefore, based on the simplified procedure, the vertical sealing system of the building does not meet the thermal performance criteria established in the standard.

As for the roofing system, the value calculated for the thermal transmittance of the roof with metal tile was 0.98 W/m². K, which is below the maximum value allowed by NBR 15220-3/2005, which is 2 W/m².K. Therefore, in this case, the thermal performance of the roofing system meets the criteria established in the standard through the simplified procedure.

According to the NBR 15575/2013 standard, the classification of performance levels is determined based on the project's compliance with the criteria established therein, divided into three categories: level M (minimum), maximum internal temperature is less than or equal to the maximum external temperature; level I (intermediate), where the maximum internal temperature must be 2ºC lower than the maximum external temperature; or S (upper) level, the maximum indoor temperature must be 4ºC lower than the maximum outdoor temperature.

According to the results presented in Table 1, the evaluated building meets only the minimum level of thermal performance. This means that it does not offer the desired thermal comfort during extreme heat conditions, which is important for occupant comfort and energy efficiency. Therefore, it is recommended to consider additional insulation measures or HVAC systems to improve the thermal performance of the building. However, the maximum air temperature measured in the container building was lower than the external air temperature, as shown in Table 1.

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Table 1 - Compliance with NBR 15.575/2013 by *on-site measurement*, on the third day of measurement.

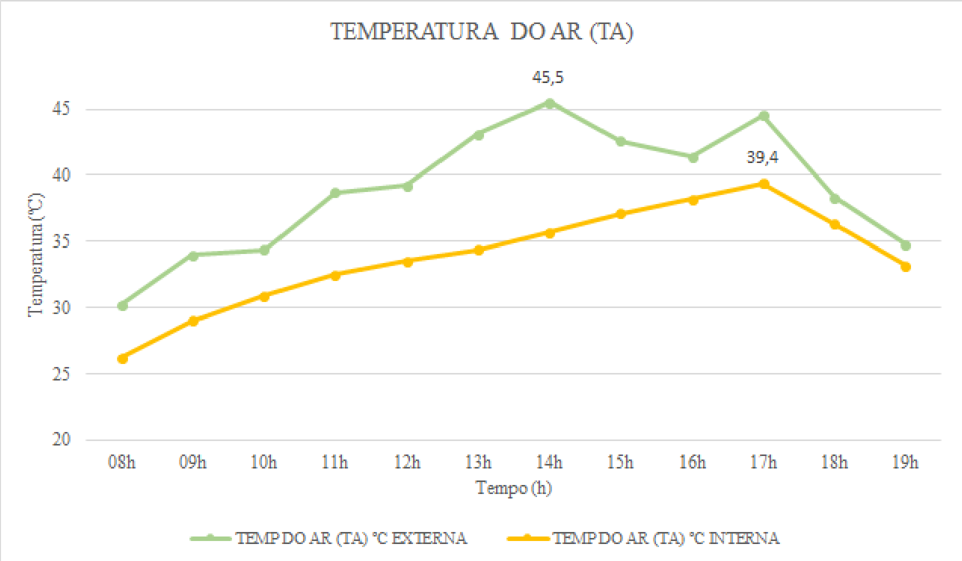
Período Avaliado	Condições verificadas		Amplitude (°C)	Resultado
	Ti,máx (°C)	Te,máx (°C)		
11/jul	50,04	38,02	12,02	Não atende
12/jul	47,1	43,5	3,6	Não atende
13/jul	39,4	45,5	6,1	Atende, requisito superior (S)

Source: Authors, 2024.

ANALYSIS OF THE RESULTS

Graph 1 highlights the comparison of air temperatures, recorded at 1-hour intervals, over the third day. There is a consistency in temperature trends, however, measurements indicate that temperatures in the outdoor environment are systematically higher than those in the indoor environment throughout the day. The maximum thermal amplitude, which represents the difference between the maximum and minimum temperature, reached 9.8°C, being recorded at 2 pm. This value reflects the thermal variation throughout the day and shows the relationship between external climatic conditions and the internal temperatures of the building.

Graph 1 - Data obtained regarding the air temperature on the 3rd day of measurement.



Source: Authors, 2024.

It is worth mentioning that the orientation of the facades of the analyzed environment is to the north, resulting in solar incidence throughout the day. The east façade receives direct sunlight from 8 am to 11 am, while the west façade is impacted from 1 pm to 6 pm.

As for the relative humidity of the air, measured as a percentage, there is a considerable variation every hour, reaching a minimum of 31.5% at 2 pm. This behavior is strongly correlated with air temperature, as evidenced in Graph 2, where the temperature

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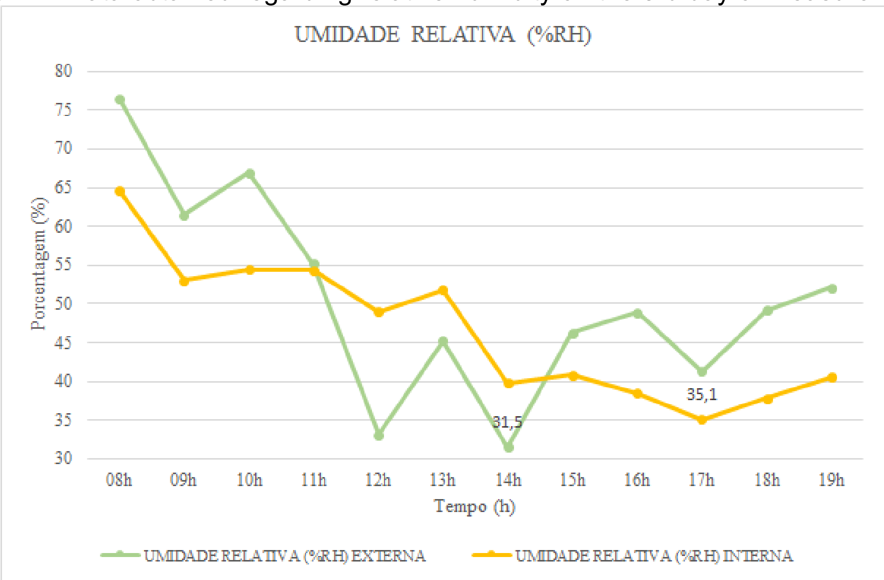
reaches its highest point, registering 45.5ºC. This relationship demonstrates the direct influence of temperature on relative humidity.

Graph 2 - Data obtained regarding relative humidity on the 3rd day of measurement.



Source: Authors, 2024.

Uneven humidity variation outdoors is susceptible to a number of factors that require in-depth technical consideration. Critical variables include, but are not limited to, the characteristics of the surrounding vegetation, prevailing climatic conditions, and thermal exchange mechanisms such as radiation, conduction, and convection.

Specific geographic aspects of the building, including its proximity to Lake Palmas (approximately 20 meters), a swimming pool (approximately 5 meters), and the presence of diverse forms of surrounding vegetation, emerge as prominent influences on the humidity data. A deeper understanding of these elements is crucial to properly interpret the observed variations.

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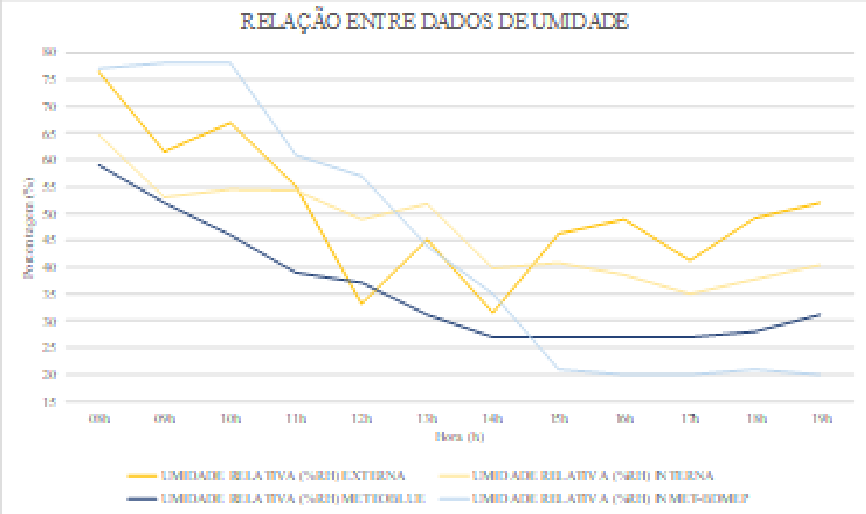
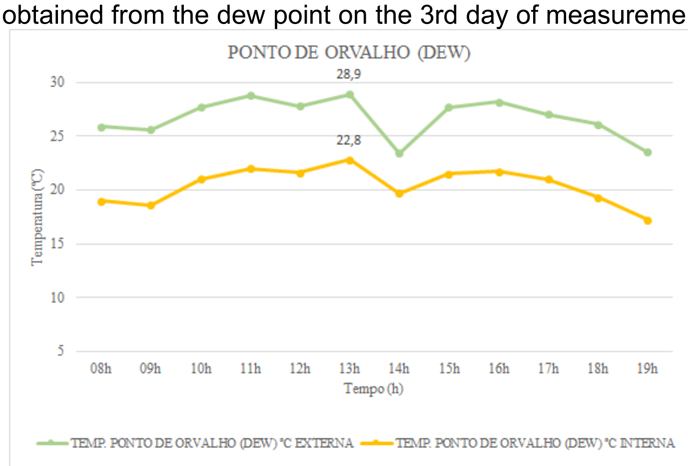
Graph 3 - Relationship of humidity data on the 3rd day of measurement.



Source: Adapted with data from Meteoblue and Inmet, 2024.

Graph 4 refers to the maximum amount of water that the air can withstand, the dew point. This presents a trend of similarity, having an average temperature range of 6.1ºC at 1 pm.

Graph 4 - Data obtained from the dew point on the 3rd day of measurement – 07/13/2023.



Source: Authors, 2024.

BIOCLIMATIC STRATEGIES

As for the ventilation openings, the calculation was made only for the upper floor and west façade, since it is the only one that has an opening. For each space of prolonged stay, the following ratio is considered: AA - effective area of ventilation opening of the environment in m²; AP - floor area of the environment in m². Based on this assumption, for the west-facing environment we have:

- AA = (2.34 x 0.745) = 1.7433 m²
- AP = 6.22 x 2.56 = 14.06 m²

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- A = 100 x (1.7433 ÷ 14.06) = 12.39 %

The Construction Code Law No. 45/90, of Palmas, regarding ventilation, establishes a minimum opening of 1/6 (one sixth) of the floor area of prolonged stay environments and NBR 15575/2013 requires that buildings located in bioclimatic zone 7 have ventilation openings ≥ 7%. Chart 1 shows the results measured.

Table 1 - Result of the minimum openings for ventilation.

<table>
<tr><td rowspan="4">Description</td><td rowspan="2">Room</td><td rowspan="2">Miter type</td><td rowspan="2">Opening for existing ventilation</td><td colspan="2">% Aperture</td><td rowspan="4">Result</td></tr>
<tr><td>Lei Municipal nº45/90 – Art. 56</td><td>NBR 15575-4:2013</td></tr>
<tr><td rowspan="2">6.22m x 2.56m x 2.45m</td><td>Sliding door 4 glass leaves</td><td rowspan="2">2.34 m x 0.745 m</td><td rowspan="2">10% to 15% of the floor</td><td rowspan="2">≥ 7%</td></tr>
<tr><td>2.45m x 1.80m</td></tr>
<tr><td>Area</td><td>14.06 m²</td><td>4.41m²</td><td>1.7433 m²</td><td>12,39%</td><td>12,39%</td><td>Answer</td></tr>
<tr><td>Volume</td><td>39,011 m³</td><td colspan="5"></td></tr>
</table>

Source: Authors, 2024.

To calculate the effective ventilation area, only the openings that allow free air circulation are taken into account. Internal door areas are not computed. Based on this calculation, it can be stated that these environments are in compliance with NBR 15575/2013, but the analyzed environment does not have the presence of windows, making it impossible to renew the air in the environment, affecting its air quality and enabling excessive heating and imbalance in the temperature of the space.

Shading strategies are recommended in regions with a hot and dry climate. It can be implemented through the use of vegetation, specific construction elements, among others. The north façade receives sun for a good part of the year during the dry season, that is, its façade is fully exposed to the sun, with only medium-sized vegetation. The west façade receives sunlight in the afternoon, between 1 pm and 6 pm, but is shaded by the extension of the existing balcony.

The evaporative cooling indicator involves the evaporation of water as a tool to reduce the occupants' sense of heat and increase the relative humidity of the room. A specific analysis of the location of the building in question shows that it is surrounded by medium and large trees on its west façade. In addition, the building is close to the lake of Palmas - TO, and has the presence of a swimming pool on its side.

The thermal mass strategy is based on the delay of heat transfer, without the use of a heat source and the application of materials with high thermal inertia, because the greater

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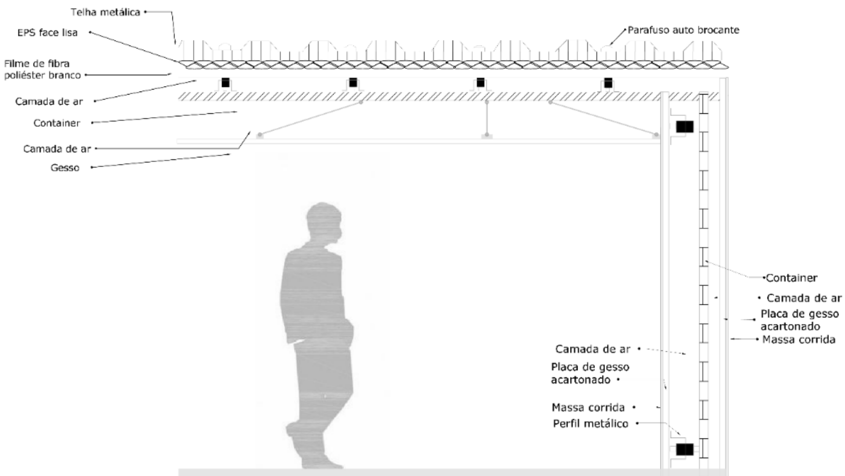
the thermal mass, the greater the heat stored in the material. When there is a reduction in the external or internal temperature, this heat will be released and returned to the environment, bringing thermal comfort to its users. In Figure 3, we can observe the layers and thermal mass of the wall and roof of the environment.

Figure 3 - Schematic Drawing of the Roof and Wall Section.



Source: Authors, 2024.

The roof of the building, made of EPS, acts as thermal insulation, absorbing heat during the day and releasing it at night. This characteristic contributes to an efficient control of heat transfer, which makes the building more thermally efficient (figure 4).

Figure 4 - Organizational chart of materials used in the layers.

Cobertura	Vedação Oeste	Vedação Norte e Leste
Telha metálica	Massa corrida	Massa corrida
EPS face lisa	Placa de gesso acartonado	Placa de gesso acartonado
Filme de poliester	Perfil metálico	Perfil metálico
Perfil metálico	Container	Container
Container	Camada de ar	
Camada de ar	Placa de gesso acartonado	
Arame galvanizado	Massa corrida	
Gesso		

Source: Authors, 2024.

The absence of insulation, which reduces the amount of thermal mass transferred to the interior, and the thickness of the material are crucial to improving thermal inertia performance. Opting for a material with a high heat storage capacity is essential to absorb heat during the day, regulating internal temperature variations and improving the thermal comfort of the building.

It is important to point out that in the analyzed environment there are no windows, only a glass door and an internal door that leads to the bathroom. This lack of windows prevents the renewal of air in the environment, which results in temperature imbalances bringing excessive heating. The ventilation of buildings is also highly related to their energy performance, and in hot climates, it can be a passive alternative for the removal of thermal loads and consequently cooling of interior spaces (Shaviv *et al.*, 2001).

With the data obtained, it can be noted the absence of a window in the west orientation, which does not meet the normative, so there is a need. The walls do not meet NBR 15220-2/2023 in terms of thermal transmittance, as well as the north and east facades of the environment, so it is necessary to adapt both in favor of thermal balance and air renewal in the environment.

The roof has thermal insulation in its composition, EPS, which resulted in the reduction of its thermal transmittance value, making it comply with the regulation in question, however its absorption exceeds the value indicated in the regulation, making it adequate.

As for the thermal mass, it is possible to assess that the sealing layer of all facades does not meet the minimum necessary transmittance, where it is necessary to increase the thermal mass of the environment, reflecting this for the building as a whole. That said, Koski (2014, p. 40) comments that the thermal insulation of a residence built in a container ends up being one of the most important steps to be carried out, since steel, the material in which the container is formed, has a high heat conduction factor.

FINAL CONSIDERATIONS

In this study, the evaluation of thermal performance was conducted based on the normative methods of NBR 15575 and NBR 15220. Using the simplified procedure of NBR 15220-3/2023, where it was found that the environment met the minimum recommendations of NBR 15.575/2013, although it presented a significantly higher internal temperature than the external one in the first and second days of measurement. However, on the third day, the sealing system met the minimum requirements of the standard.

It is noteworthy that the building has a minimum area of openings for ventilation, but lacks openings that allow cross ventilation. The vertical sealing system only meets the

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thermal transmittance criteria. The objective of the study is to identify the causes that led the sealing system to not meet regulatory requirements and propose adaptations to ensure compliance and thermal comfort.

The thermal amplitude in Palmas highlights the complexity of solving thermal comfort problems only with material choices, requiring active and passive strategies. Thermal transmittance, related to heat conduction, highlights the importance of thermal insulation for good performance.

Based on the results of NBR 15575/2013, the vertical sealing system meets the minimum requirements, but the thermal performance may vary according to weather conditions and the behavior of the material in relation to the night temperature. The study concludes that the construction system of the container analyzed presented lower thermal performance in relation to external conditions, requiring insulating materials, solar geometry analysis and ventilation improvements.

The research aims to fill gaps in knowledge about the thermal performance of buildings based on maritime containers in Palmas, contributing to future studies in the region. The importance of more comprehensive and in-depth analyses to better understand the characteristics of these constructions and optimize them to provide thermal comfort in various climatic conditions is highlighted.

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REFERENCES

1. ABNT. Associação Brasileira de Normas Técnicas. (2005). NBR 15220-1: Desempenho térmico de edificações: Definições, símbolos e unidades. Rio de Janeiro.

2. ABNT. Associação Brasileira de Normas Técnicas. (2023). NBR 15220-2: Desempenho térmico de edificações: Métodos de cálculo da transmitância térmica, da capacidade térmica, do atraso térmico e do fator solar de elementos e componentes de edificações. Rio de Janeiro.

3. ABNT. Associação Brasileira de Normas Técnicas. (2005). NBR 15220-3: Desempenho térmico de edificações: Definições, símbolos e unidades. Rio de Janeiro.

4. ABNT. Associação Brasileira de Normas Técnicas. (2013). NBR 15575-1: Edificações habitacionais de até cinco pavimentos — Desempenho: requisitos gerais. Rio de Janeiro.

5. ABNT. Associação Brasileira de Normas Técnicas. (2013). NBR 15575-2: Edificações habitacionais de até cinco pavimentos — Desempenho: requisitos para os sistemas estruturais. Rio de Janeiro.

6. ABNT. Associação Brasileira de Normas Técnicas. (2013). NBR 15575-4: Edificações habitacionais - Desempenho: Requisitos para os sistemas de vedações verticais internas e externas - SVVIE. Rio de Janeiro.

7. ABNT. Associação Brasileira de Normas Técnicas. (2013). NBR 15575-5: Edificações habitacionais - Desempenho: Requisitos para sistemas de coberturas. Rio de Janeiro.

8. Bragança, L., Mateus, R., & Gouveia, M. (2011). Construção sustentável: o novo paradigma do setor da construção. Universidade do Minho.

9. Calory, S. Q. C. (2015). Estudo de uso de contêineres em edificações no Brasil (Trabalho de conclusão de curso de Engenharia Civil). Universidade Tecnológica Federal do Paraná, Campo Mourão.

10. Campos, H. C., & Souza, H. A. D. (2010). Avaliação pós-ocupação de edificações estruturadas em aço, focando edificações em light steel framing. In Congresso Latino-Americano da Construção Metálica, 1 (pp. 1-17). São Paulo: Construmetal.

11. Ferreira, B. L. A. (2010). Construção de edifícios sustentáveis: Contribuição para a definição de um processo operativo (Dissertação de Mestrado). Faculdade de Ciências e Tecnologia da Universidade Nova de Lisboa. Disponível em https://run.unl.pt/handle/10362/4141?locale=en. Acesso em: 01/06/2023.

12. França, A. J. G. L. (2011). Ambientes contemporâneos para o ensino-aprendizagem: Avaliação pós-ocupação aplicada a três edifícios escolares públicos, situados na região metropolitana de São Paulo (Dissertação de Mestrado em Engenharia Civil). Faculdade de Arquitetura e Urbanismo, Universidade de São Paulo, São Paulo.

13. Gonçalves, J. C. S., & Duarte, D. H. S. (2006). Arquitetura sustentável: uma integração entre ambiente, projeto e tecnologia em experiências de pesquisa, prática e ensino. Ambiente Construído, 6(4), 51-81. Porto Alegre.

14. Instituto Nacional de Meteorologia (INMET). (2023). Banco de Dados Meteorológicos para Ensino e Pesquisa. Disponível em: https://bdmep.inmet.gov.br/. Acesso em: 19 de nov. de 2023.

15. International Standard Organization. (1995). ISO 668:1995. Series 1 freight containers-Classification, dimensions and ratings. ISO.

16. Koski, G. A. (2014). A adaptação do contêiner na arquitetura residencial: o estudo de tipologias flexíveis e modulares (Monografia de Graduação). Universidade Vila Velha, Vila Velha. Disponível em: <www.issuu.com>. Acesso em: 23 out. 2023.

17. Meteoblue. (2023). Histórico Climático. Disponível em: https://www.meteoblue.com/pt/tempo/historyclimate/weatherarchive/aeroporto-de-palmas%E2%80%93brigadeiro-lysias-rodrigues_brasil_7668441?fcstlength=-15&year=2023&month=7. Acesso em: 19 de nov. de 2023.

18. Omena, T. H., Macedo, L. M. de P., & Oliveira, M. C. A. de. (2023). Comparação do desempenho térmico em vedações por alvenaria convencional e steel frame em Palmas -TO. Peer Review, 5(8), 215-234. https://doi.org/10.53660/437.prw1104. Disponível em: https://peerw.org/index.php/journals/article/view/437. Acesso em: 27 maio de 2023.

19. Ornstein, S. W., & Romero, M. A. (1992). Avaliação pós-ocupação (APO) do ambiente construído. São Paulo: Studio Nobel/Usp. Acesso em: 26 maio de 2023.

20. Palmas. (1990). Lei Municipal nº 45, de 1990. Código de Edificações do Município de Palmas. Palmas.

21. Shaviv, E., Yezioro, A., & Capeluto, I. G. (2001). Thermal mass and night ventilation as passive cooling design strategy. Renewable Energy, 24, 445-452.