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The disconnection of praxis in the contemporary production of multifamily residential buildings in Brazil: an environmental comfort approach of the Weefor Arq competition

Abstract

This paper highlights the disconnection between the debate and the contemporary production of multifamily residential buildings in Brazil, investigating the application of environmental comfort in the three winning projects of the Weefor Arq design competition. After a critical analysis of the competition's documents, the projects suitability to the Curitiba's climate conditions (ZB1) is evaluated. Computer simulations are carried out with the plug-ins Ladybug and Butterfly to assess solar radiation in the envelope, the shading of the balconies and the natural ventilation external to the buildings. The compliance with NBRs 15220 and 15575 was also evaluated regarding the envelope's thermal properties and the percentage of opening area. Results emphasize that, although the documents express clear concern with users' well-being, in practice, architects do not succeed in applying the bioclimatic strategies due to the limitations imposed by the plot dimensions, urban legislation, the housing units requested and architects' inability to deal with environmental comfort issues. The paper points out the damage caused to users when architects are excluded from the real estate development stage.

Keywords

Environmental Comfort. Bioclimatic strategies. Multifamily residential buildings. Architecture praxis.

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A DESCONEXÃO DA PRÁXIS NA PRODUÇÃO CONTEMPORÂNEA DE EDIFÍCIOS RESIDENCIAIS MULTIFAMILIARES NO BRASIL: O CONCURSO WEEFOR ARQ SOB A ÓPTICA DO CONFORTO AMBIENTAL

Resumo

Este artigo evidencia a desconexão entre o debate e a produção contemporânea de edifícios residenciais multifamiliares no Brasil, investigando a aplicação do conforto ambiental nos três projetos vencedores do concurso Weefor Arq. Partindo-se de uma análise crítica dos documentos do concurso, avalia-se a adequação das propostas às condicionantes climáticas de Curitiba (ZB1). São realizadas simulações computacionais com os *plug-ins* Ladybug e Butterfly para analisar a radiação solar na envoltória, o sombreamento das sacadas e a ventilação natural externa aos edifícios. Avaliou-se ainda o atendimento às NBRs 15220 e 15575 quanto ao desempenho térmico da envoltória e ao percentual de área de abertura. Os resultados apontam que, embora o concurso expresse clara preocupação com o bem-estar do usuário, na prática, as limitações impostas pelas dimensões do terreno, legislação urbana, número de unidades solicitadas e o despreparo dos arquitetos quanto aos aspectos de conforto ambiental comprometem a aplicação das estratégias bioclimáticas nos projetos. O artigo denuncia os prejuízos gerados aos usuários quando os arquitetos são excluídos da etapa de planejamento do empreendimento.

Palavras-chave

Conforto ambiental. Estratégias bioclimáticas. Edifícios residenciais multifamiliares. Práxis de Arquitetura.

1. Introduction

For decades, environmental comfort has been recognized as an essential aspect of architectural design. In the 1960s, Victor Olgyay already stated that the fundamental purpose of architecture is to relieve the stress of life and maximize the energy of man, which, in his view, can only be achieved by assigning the building the role of mediator between man and the climate (OLGYAY, 1963).

In Brazil, there have been many advances in the debate on environmental comfort since the first reflections of the late 19th century (SEGAWA, 2003). In the 1990s, after the creation of the National Meeting of Comfort in the Built Environment (ENCAC), the theme gained an important space in the curriculum of Architecture and Urbanism courses in the country, and today, it comprises up to four compulsory subjects in many public and state universities (NEVES, RUSCHEL, 2016).

In the last two decades, there has been a significant effort to increase the environmental quality of residential buildings in the country, with the creation of standards and regulations aimed at environmental comfort and energy efficiency, such as NBR 15220, NBR 15575 and RTQ-R.

Despite the unquestionable advances in the area, there is still a prominent gap between the debate and professional practice. This is what Linardi (2017) calls "contemporary disconnection of the praxis of architecture in Brazil", that is, the distance between "knowing", (debate, theory) and "know-how" (production, practice).

A survey of research on environmental comfort in multifamily residential buildings published in the Proceedings of the ENCAC 2009-2019 points out the low environmental performance of properties built in the country, resulting from the inefficient use of light and natural ventilation, in addition to the inadequacy of construction systems to the climatic contexts (Table1).

Table 1 – Discomfort factors in multifamily residential buildings in Brazil, according to articles by the ENCAC (2009 and 2019). Source: the authors.

RESEARCH	Insufficient natural ventilation	Excessive natural lighting	Low thermal envelope performance
LOPES, FONTENELLE, ARAÚJO (2011)			X
ANDRADE, AMORIM (2011)	X		X
PICKLER, BOGO (2015)		X	
LINS, FIRMINO, BATISTA (2017)	X		
PASSOS, LAMENHA, BITTENCOURT (2017)	X		
ZAIN, CARVALHO (2017)			X
GARCIA *et al.* (2019)			X
SILVA *et al.* (2019)	X		X
FERREIRA, BATISTA (2019)	X	X	X
TABARELLI *et al.* (2019)			X
REIS, PAIVA, OLIVEIRA (2019)	X		
FIGUEIRA, KRAI, OLIVEIRA (2019)		X	

In this context, a question arises: in addition to the lack of dialogue between academia and professional practice, which external factors, which do not depend on the awareness and training of our professionals, generate barriers to the application of comfort in architectural design?

Linardi (2017) analyzes the evolution of praxis in the field of architecture and urbanism in Brazil, seeking to understand which factors contributed to the current disconnect between "knowing" and "know-how". The author argues that this problem originates from the three main elements that make up the contemporary context: neoliberalism, as the main economic system; postmodernity, as a cultural system; and the phenomenon of globalization, as a political system that interferes and organizes other systems.

In the context of architecture, this situation radically changed the way of understanding and producing the built space. The standardization of materials, construction processes and design methods favored by globalization has generated a fertile ground for the construction of a universal architecture, attentive to the aesthetic standards of the hegemonic class (LINARDI, 2017).

The online platforms and social networks emphasize the preference for image over written information, limiting the critical analysis of the space, especially regarding its suitability for local peculiarities. The decontextualized reading of architecture leads to the inadequate replication of design solutions in diverse climatic, economic and cultural contexts, just to give the desired visual impact to its works. It is a "high degree of alienation promoted by the double removal process, of conscience without action and action without conscience" (LINARDI, 2017, p. 18).

The architecture of the Star System, produced by celebrities from the world of architecture, strongly consolidates this way of thinking unconnected with the place (LINARDI, 2017), by feeding the fetish with design solutions loaded with symbolic values.

> *The architectural work came to be seen and projected as an object of consumption, especially with regard to its external appearance, now linked to fashions and trends, which change rapidly according to the preferences of the consumer market. The visual aspect of most buildings is no longer the result of a design process based on its own laws, but is determined from the outside by people concerned with its potential for sale.* (MAHFUZ, 2003, p. 1)

It is in this context of worship of image that the developers of high-end developments find a profitable market to produce an architecture that often prioritizes aesthetics over the well-being of users. It is not by chance that more and more offices specializing in "facade architecture" appear, which are hired in the final stages of the project to propose an attractive 'epidermis' to the building, composed of symbols associated with the ruling class.

As an example, we can mention some real estate launches in 2019 in upscale neighborhoods of Rio de Janeiro, such as the Dumont 52 (Gávea), Essência (Leblon), Meet (Botafogo) and Urbano (Urca) (INVEXO, 2020). In common, these properties have facades composed of vertical wooden brises, apparently a new status symbol for society in Rio de Janeiro. A quick analysis shows that, in some cases, these elements are purely decorative, considering that the same type of sun protection is used with standard sizing and spacing for different solar orientations, in addition to being restricted to some isolated points on the facade.

It is increasingly common for developers to impose working conditions on architects through orders that arrive practically ready for the architecture firm. To maximize profits, the number and area of housing units, the architectural program and the proportion between housing types are predefined, which will generally occupy a lot whose dimensions and limitations imposed by legislation will pose many challenges throughout the design process. When excluded from decision making, the architect spends much of his/her time performing mathematical calculations to meet the demands of the developer, leaving him/her little room for maneuver to solve essential architectural issues, such as the quality of spaces and habitability.

In this way, from a professional considered important during the decision-making process, the architect becomes a mere executor of decisions taken in other areas on aspects that were previously his/her entire responsibility (MAHFUZ, 2003).

The architectural design contests represent a breath in relation to the growing restrictions imposed by the real estate market, by offering professionals and students an opportunity to exercise their original role. They encourage the exercise of creativity in their competitors and, as a place for debate, rekindle the discussion of breaking architectural patterns, in search of products with a greater identity.

In early 2019, the 1st Architecture Competition- Weefor Arq was launched, a competition promoted by the developer Weefor (Curitiba / PR) with the organization of the ASBEA-PR, which stood out as one of the rare contests in the country to have as its object of discussion a high-end multifamily residential development.

According to the announcement, "the WEEFOR ARQ competition seeks to think together with those minds that make their talent available to people, and not available to the market" (WEEFOR, 2019a). Such an emphasis aroused the interest in investigating the extent to which the winning projects are able to respond to the humanistic precepts of the competition, especially with regard to adapting the building to the complex climatic context of Curitiba.

This article aims to highlight the disconnection between the debate and the contemporary production of multifamily residential buildings in Brazil, with an emphasis on the application of the fundamentals of environmental comfort in the winning projects of the Weefor Arq competition.

2. Methodology

2.1. Step 1: Critical analysis of Weefor Arq documents

In this step, the contest is used as an object of study to illustrate the ideas presented in the theoretical foundation. Based on the ideas defended by Linardi (2017) and Mahfuz (2003), a critical analysis was made of the documents provided by the contest, such as the public notice, the terms of reference and the jury minutes.

2.2. Step 2: Analysis of the winning projects

From the boards of the first three placed in the competition (WEEFOR, 2019d), it was investigated how architects integrate their proposals to the local climate context, having as a starting point the four most recommended bioclimatic strategies for Curitiba-PR[1] (Table2).

[1] Located in the Bioclimatic Zone 1 (ZB1), Curitiba has an average monthly temperature that varies annually between 8° and 27°C and relative humidity above 80%. These climatic conditions generate discomfort due to heat in 8% of the hours of the year, discomfort due to cold in 77% of the hours of the year and thermal comfort in 15% of the year (MMA, 2020).

Table 2 - Bioclimatic strategies recommended for Curitiba.
Source: MMA, 2020.

Strategy	Applicability	
	Summer	Winter
Thermal inertia for heating	60%	46%
Passive solar heating	5%	45%
Natural ventilation	21%	4%
Shading	11%	2%

The application of the strategies in the projects was analyzed based on the reading of the justification memorials and on computer simulations, using, for these, the EPW climate file obtained in Ladybug Tools (2019) containing the data from the INMET meteorological station 838420. The remaining data used are detailed below.

• 3D modeling of buildings and surroundings

Based on the drawings presented on the boards and using the Rhinoceros software, the buildings and the immediate surroundings were modeled. The latter was represented only by the topography in addition to a tall neighboring building that will have greater impacts on the simulations. The buildings were represented without guardrails, windshields, *cobogós* (hollow brick walls) and materials whose impacts would be irrelevant.

• Analysis of solar radiation on the facades

Through the Grasshopper software and its Ladybug plug-in, simulations of direct solar radiation incident on the buildings envelope were carried out, seeking to identify whether the shape and sectorization of the environments favor the use of thermal inertia for heating and passive solar heating. The analysis interval covers the morning and afternoon hours in the two extreme periods of the year: summer and winter.

• Shading analysis on the facades

Using the Ladybug software, shade masks generated by apartment balconies are produced to check whether thermal inertia for heating and passive solar heating are unfeasible. The masks indicate the largest and smallest shadows in up to six points on the facade, considering the 6th floor, as it is the one with the greatest variation in the dimensions of the balconies in all projects. The points were positioned in the center of the openings, next to the floor.

• Analysis of the thermal performance of the envelope

In this step, with the aid of the thermal properties calculator of the ProjetEEE platform[2] (MMA, 2020), the transmittance, capacity and thermal delay of the external seals are calculated, to check if they meet the requirements of NBR 15220[3] and NBR 15575 for the ZB1.

• Analysis of natural external ventilation

Through the Grasshopper software and the Butterfly plug-in, Computational Fluid Dynamic (CFD) simulations were carried out to analyze the airflow outside the building, to identify the windward and leeward facades and analyze the potential for using natural ventilation in the buildings. The origin of the winds considered in the simulations was from the east, the dominant direction in 36% of the year in Curitiba (MMA, 2010) and the most frequent in the summer (12/21 to 3/21), a period in which natural ventilation is desirable.

For this study, it was considered a simpler geometry of the buildings and the surroundings, containing only their basic volumetry, to simplify the mesh generation stage. The only obstacle in the surrounding area was the neighboring building, as it has a gauge and implantation with the potential to obstruct the east winds. It is noteworthy that the land is located on a high elevation of the neighborhood, not suffering interference from other obstacles.

The dimensions of the rectangular computational domain are based on the recommendations of COST (2007): with H_{max} being the maximum height of the geometry, a distance of $5H_{max}$ was adopted to the upper, lateral and windward walls, and $15H_{max}$ to the leeward wall.

The speed profile used follows the ABL (Atmospheric Boundary Layer) model described by Zhang (2009):

$$u = \frac{u^*}{k} \ln\left(\frac{z}{z_0}\right)$$

A speed (u) of 3 m/s was adopted 10 m from the ground (z), the Von Karman constant (k) of 0.41 and a ground roughness (z_0) of 1, corresponding to a densely built urban area without a lot of variation in the height of buildings (LADYBUG TOOLS, 2020).

A hexahedral computational mesh was generated for the domain as a whole and the mesh close to the buildings was refined using the Snappymesh component.

Simulations were carried out in a steady flow regime, the air being an incompressible fluid. The turbulence model adopted was the RNG k-epsilon.

The analysis of the results was based on the data of pressure (Pa) and air velocity (m/s) considering horizontal planes at 10 and 20 m from the ground.

[2] The material calculation methodology adopted by PROJETEEE is available at http://projeteee.mma.gov.br/wp-content/uploads/2017/02/Biblioteca_ComponentesConstrutivos-1.pdf

[3] Although NBR 15220 is intended for Housing of Social Interest (HSI), it was decided to adopt its criteria as they indicate minimum performance parameters.

In addition to the computer simulations, it was verified whether the percentage of the opening area of the extended stay environments meets the requirements of NBR 15220 for the ZB1.

3. Results

3.1. Critical analysis of Weefor Arq documents

In 2019, the Weefor Arq was launched, a competition to contract a high-end multifamily residential development project in the city of Curitiba. The term of reference demonstrates concerns about a production system geared to the needs of the market and not to the real needs of people, and notes the necessary repositioning of the architect at the center of discussions and in in design decision making.

The contest proposal consisted of the conception of an enterprise that prioritized sustainability, technology and well-being, in addition to its integration into the city (WEEFOR, 2019b). The building should comply with the applicable rules and legislation, as well as the compliance with parameters of comfort and habitability, advising that "the solutions should favor the use of natural lighting and ventilation in indoor environments, contributing to the reduced use of energy-consuming equipment". (WEEFOR, 2019b, p.14)

The plot available for the project has 1.383,60 m² and is located in the Água Verde neighborhood (Figure 1). The legislation provides for a 50% occupancy rate, a permeability of up to 25%, a maximum height of 8 floors, a frontal recoil of 5 meters and lateral spacing according to the template.

Figure 1 – Plot and surroundings.
Source: Google Earth, 2020.

The development should contain at least 51 apartments, 55% with an area between 50 and 55 m², with up to 2 bedrooms and the other 45%, between 70 and 75 m², with up to three bedrooms. All units should have a balcony.

Estimating a total built area of about 5.255 m² occupying 691.50 m² of horizontal projection on the plot, it is estimated that the building should have approximately eight floors, which coincides with the maximum size. These limitations anticipate the challenges to be faced by candidates when defining the architectural party.

The reference term also establishes the construction system to be adopted: reinforced concrete, conventional masonry fences and drywall internal partitions. This requirement prevents the architect from defining the building components that best suit the climate context.

It is concluded that, despite the intention to resume the role of the architect in decision-making, he/she remains limited. The strictly economic decisions made by the developer can have a significant impact on the feasibility of solutions aimed at environmental comfort and energy efficiency, as we will see below.

3.2. *Analysis of the winning projects*

Six appraisers from different areas, including the real estate market, architecture platforms and architects and urban planners, formed the jury.

Eighty-seven projects were evaluated, of which three were awarded and four received honorable mentions (WEEFOR, 2019d). The 1st, 2nd and 3rd place are designed by the *Nachtergaele Navarro Arquitetos Associados* (São Paulo-SP), *Arquitetura Nacional* (Porto Alegre-RS) and *YVA Arquitetura* (Curitiba-PR), respectively.

Next, the analysis of the effectiveness of the application of bioclimatic strategies in the winning projects will be presented.

3.2.1 Passive solar heating, thermal inertia for heating and shading

Bearing in mind that the thermal inertia strategies for heating, passive solar heating and shading are closely related to the solar radiation incident on the envelope; it was decided to start the analyses based on this parameter.

The 1st place emphasizes in a justification memorial (WEEFOR, 2019d) that the architectural party in C format and with separate volumes arose, among other aspects, from the intention of favoring natural ventilation between the blocks. The use of sunlight is only mentioned in areas of public and free use, such as roof terraces.

The 2nd place speech is more focused on bioclimatic principles, emphasizing that "the primary strategy in launching the party was to create passive solutions to improve the performance of the building" (WEEFOR, 2019d). However, the insolation studies presented – without further information about the day of the year to which they refer - show more the shadows than the sunlight, which already reveals a disconnect between speech and practice.

The 3rd place adopts a T-shaped party to favor the connection of all apartments with the street and create a distance to reduce the transition of scale between the Mato Grosso Street and the building. In the memorial, there is no mention of a study that favors bioclimatic strategies.

To confront the architects' discourse and practice, studies were initially carried out on the orientation of the facades with the greatest potential for passive solar heating and thermal inertia for heating, that is, with more hours of sunshine: northwest and southwest facades (Figure 2). The northeast facade was not analyzed due to the shading generated by the neighboring building, as will be highlighted in later studies.

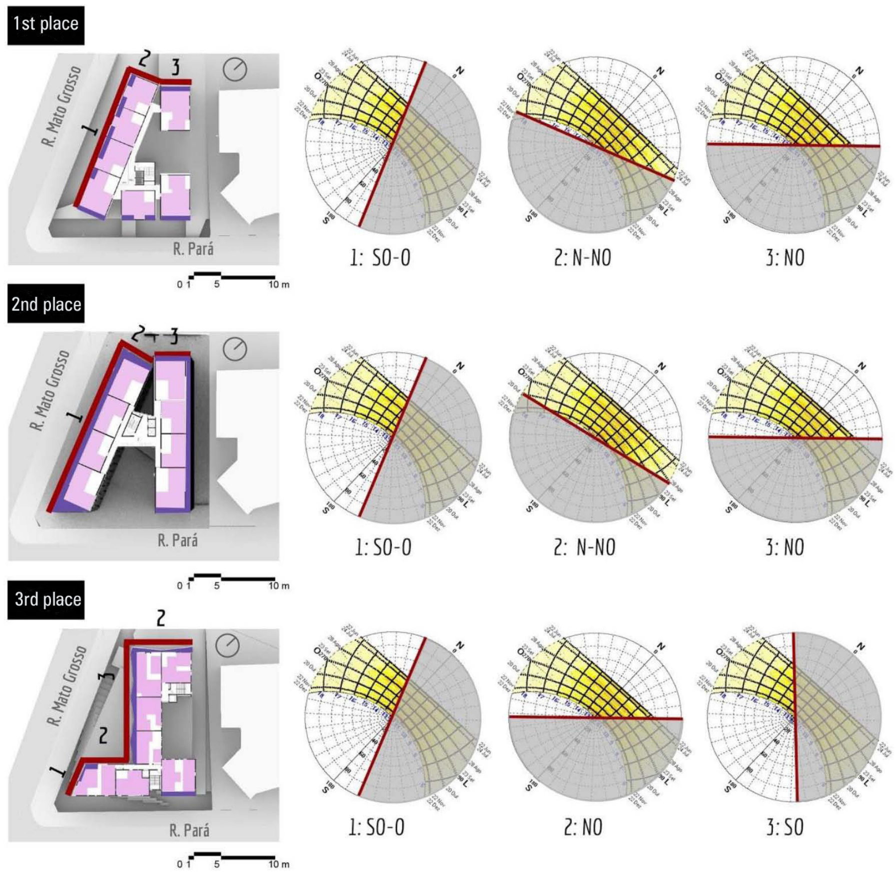


Figure 2 - Study of solar orientation of the facades. Long-stay areas indicated in pink and balconies in purple.
Source: the authors.

It is observed that all projects have apartments aimed at different orientations, favoring some units over others. On the other hand, there are large facades facing the afternoon sun, which, depending on the properties of the envelope, can favor the thermal inertia for heating (applicable all year).

All proposals have three facades aimed at the most favorable orientations, in which most of the long-stay areas are located. The exception occurs with kitchens that, in the 1st and 2nd place, are shaded by the common circulations, on the opposite facade.

It can be seen that the party adopted by the 3rd place has the potential to favor passive solar heating and thermal inertia for heating in a large part of the units (72.5%), as it has an upper envelope area aimed at the most favorable orientations. The 1st and 2nd place parties have the potential to benefit 66.6% and 63.4% of the apartments, respectively.

On the other hand, the results of the solar radiation simulations in the envelope show that these potentials are not fully utilized, due to the presence of the balconies – one of the elements required by the competition – on the facades with greater sunlight. Figure 3 shows a comparison of direct radiation in the envelope with and without the application of balconies, in summer and winter. There is an

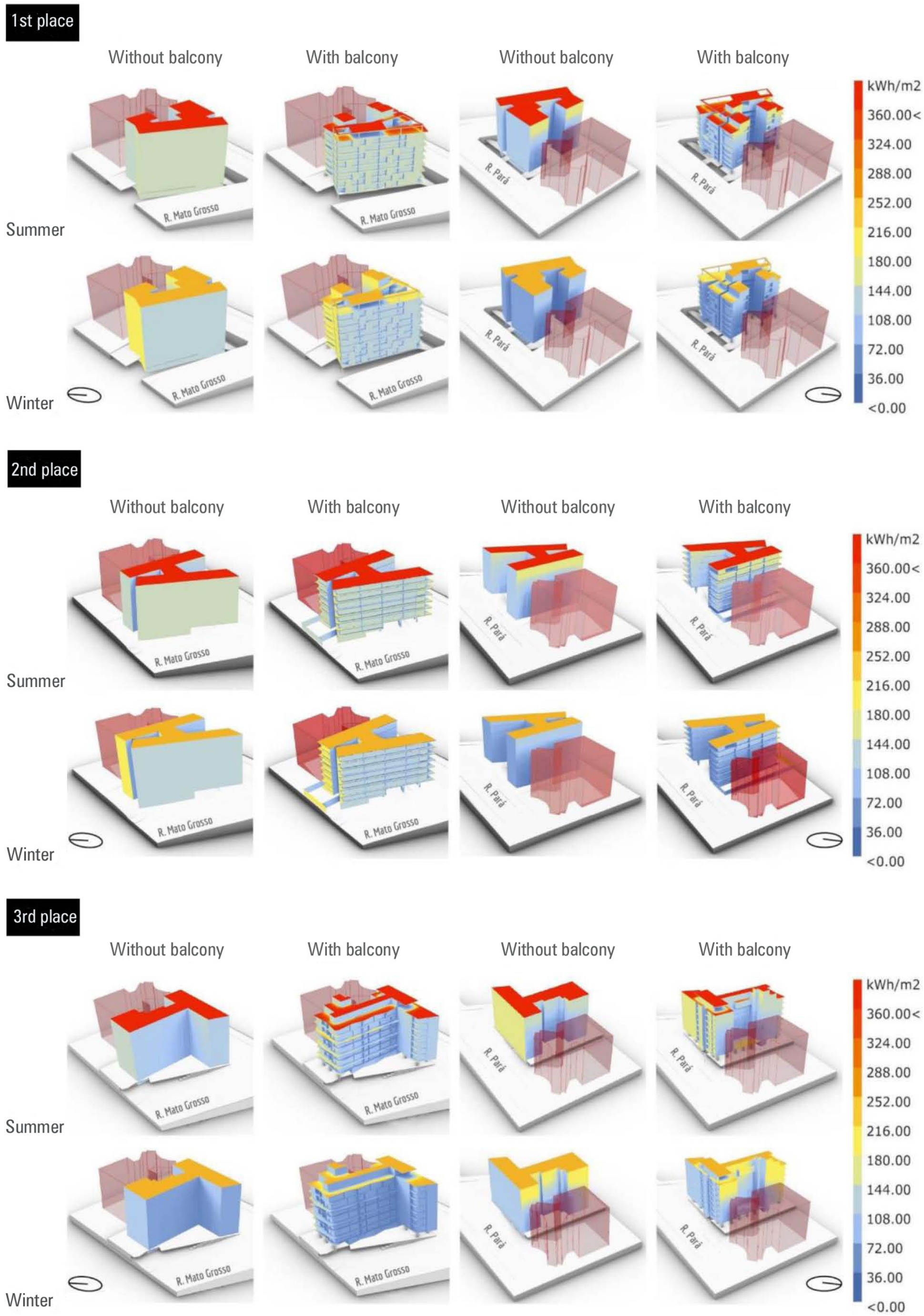


Figure 3 - Simulation of radiation in the envelope with and without balconies. Analysis period: summer (12/22 to 3/21) and winter (6/20 to 9/22).
Source: the authors.

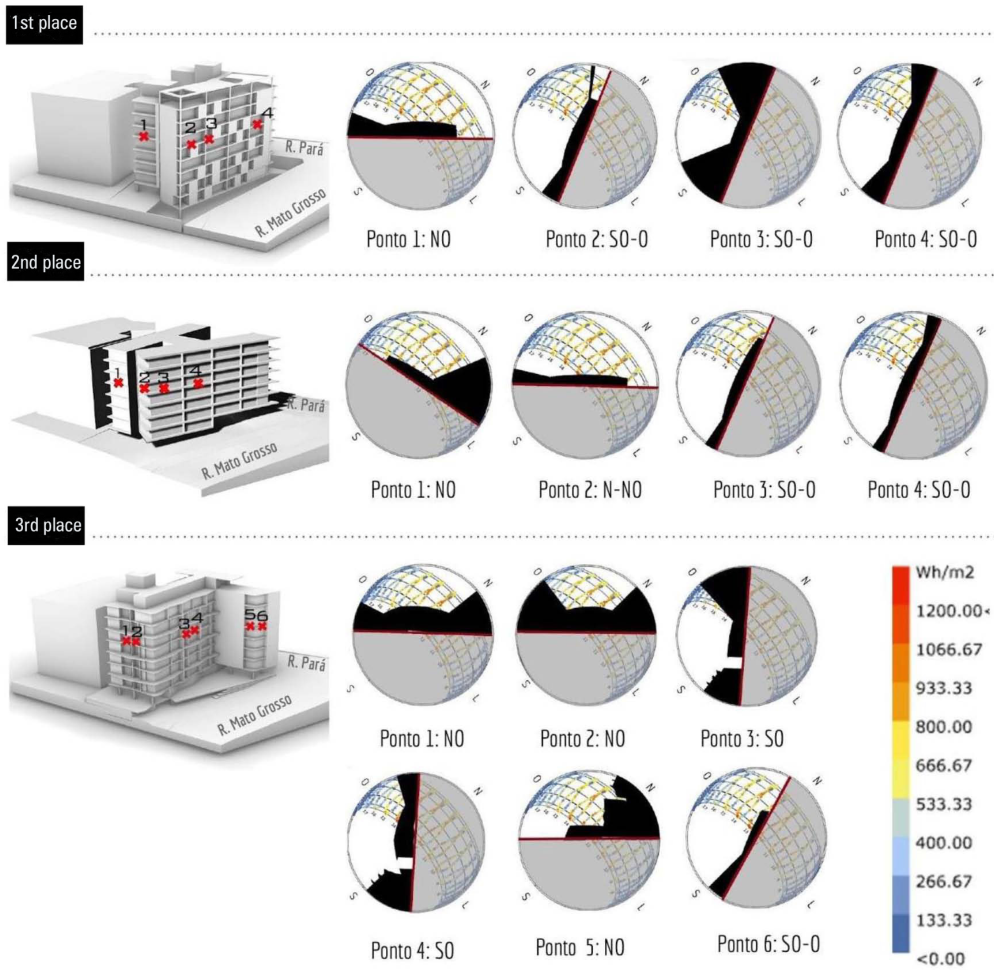


Figure 4 - Shadow masks and hours of exposure to intense radiation.
Source: the authors.

excess of shading and the consequent reduction in the potential for passive solar heating, especially in winter, when this strategy is most recommended.

It is noteworthy that, although the balcony was required in the contest's needs program, the option to design these elements "on tape" may have increased the shading effect of the facades.

Another aspect to be highlighted is the shading generated by the surroundings on the northeast facades. This loss of sunlight potential is especially observed in the 2nd place, considering that half of the units have undesirable shading in long-stay environments.

The self-shading observed in all buildings can also impair thermal comfort in some units. We highlight the solar block generated by the T shape of the 3rd place, whose volume increase towards Mato Grosso Street generates a shading on the southwest (SW) facade, especially in winter.

To check the radiation time in which the openings are subjected, the shadow masks generated by the protections and their interference in the application of bioclimatic strategies were analyzed, considering the hours of intense exposure between 9 am and 4 pm (Figure 4).

In the 1st place, in addition to the balconies, the advance of some rooms until the alignment of the balcony causes shading in the openings to the southwest-west. Although there is a use of solar radiation on the northwest facade during winter, it has a minority of units, which is repeated in the 2nd place. In addition to these factors, there is the influence of brises and fixed panels present in the 1st and 3rd place.

Table 3 shows the losses in the use of solar radiation for passive heating and thermal inertia for heating in winter due to the balcony. For the summer period, shading can be beneficial for transparent surfaces, but harmful for opaque surfaces, due to the dependence of solar radiation on thermal inertia for heating, also desirable at this time of year.

Table 3 – Hours of intense exposure to solar radiation. Source: the authors.

Proposal	Point	Winter			Summer		
		Without balcony	With balcony	Reduction (%)	Without balcony	With balcony	Reduction (%)
1st place	1	6	6	0	4	2	50
	2	3	2	33	4	2	50
	3	3	-	100	4	2	50
	4	3	1	67	4	3	25
2nd place	1	7	4,5	36	4	1	75
	2	7	6	14	5	3	40
	3	2,5	2	20	3,5	3	14
	4	2,5	1,5	40	3,5	3	14
3rd place	1	7	4	43	4	1	75
	2	7	3,5	50	4	-	100
	3	1	-	100	3,5	2	43
	4	1	-	100	3,5	2	43
	5	7	3	57	3,5	2,5	29
	6	2,5	2,5	0	3,5	3	14

To evaluate the adequate use of thermal inertia, in addition to incident solar radiation, the thermophysical properties of opaque surfaces were verified, which, in the case of external vertical fences, should be composed of conventional ceramic brick masonry (WEEFOR, 2019b). Apparently, all projects follow this requirement, including an extra layer of external cladding in some sections: the 1st place adds aluminum tile, the 2nd place, tile and wood and the 3rd place, slate.

Table 4 shows the thermophysical properties of the construction components of the envelope. It was considered a ceramic block masonry (14 x 9 x 24 cm), external coating of mortar (2.5 cm) and internal of mortar (2.5 cm) and plaster (1 cm). In the absence of details on the composition of the 1st place, some possibilities were analyzed.

In view of the recommendations for the ZB1 – U £ 2.5 W/m^2.K, CT ³ 130 kJ/m^2.K (ABNT, 2013) and j £ 4.3 h (ABNT, 2003) – it can be concluded that all opaque building components meet the standards with regard to thermal capacity and thermal transmittance. Some do not meet the maximum thermal delay,

Proposal	Vertical fences	Total thickness (cm)	Thermal delay φ (hours)	Thermal capacity CT (kJ/m².K)	Thermal Transmittance U (W/m²K)
General	Ceramic brick masonry (15 cm)	15	3,6	148,1	2,3
	Colorless monolithic glass	0,6	0,2	12,6	5,7
	Colorless insulated glass (06 cm glass)	2	0,4	25,2	0,5
1st place	Ceramic brick masonry (15 cm) + corrugated aluminum tile (3 cm)	18	4,0	151,7	2,1
	Ceramic brick masonry (15 cm) + horizontal flow air chamber (2 cm) + corrugated aluminum tile (3 cm)	20	5,1	151,7	1,6
	Ceramic brick masonry (15 cm) + aluminum tile with polystyrene (6 cm)	21	14,1	159,3	0,7
2nd place	Ceramic brick masonry (15 cm) + tile (1 cm)*	16	4,1	161,9	2,1
	Ceramic brick masonry (15 cm) + wood (1 cm)	16	4,9	156,1	2,0
3rd place	Ceramic brick masonry (15 cm) + slate (1 cm)	16	4,1	168,9	2,3

* In the absence of these materials in the ProjetEEE calculator, these were replaced with equivalent materials. Ceramic replaced tile and granite replaced slate.

Table 4 – Thermophysical properties of the construction components. Source: the authors.

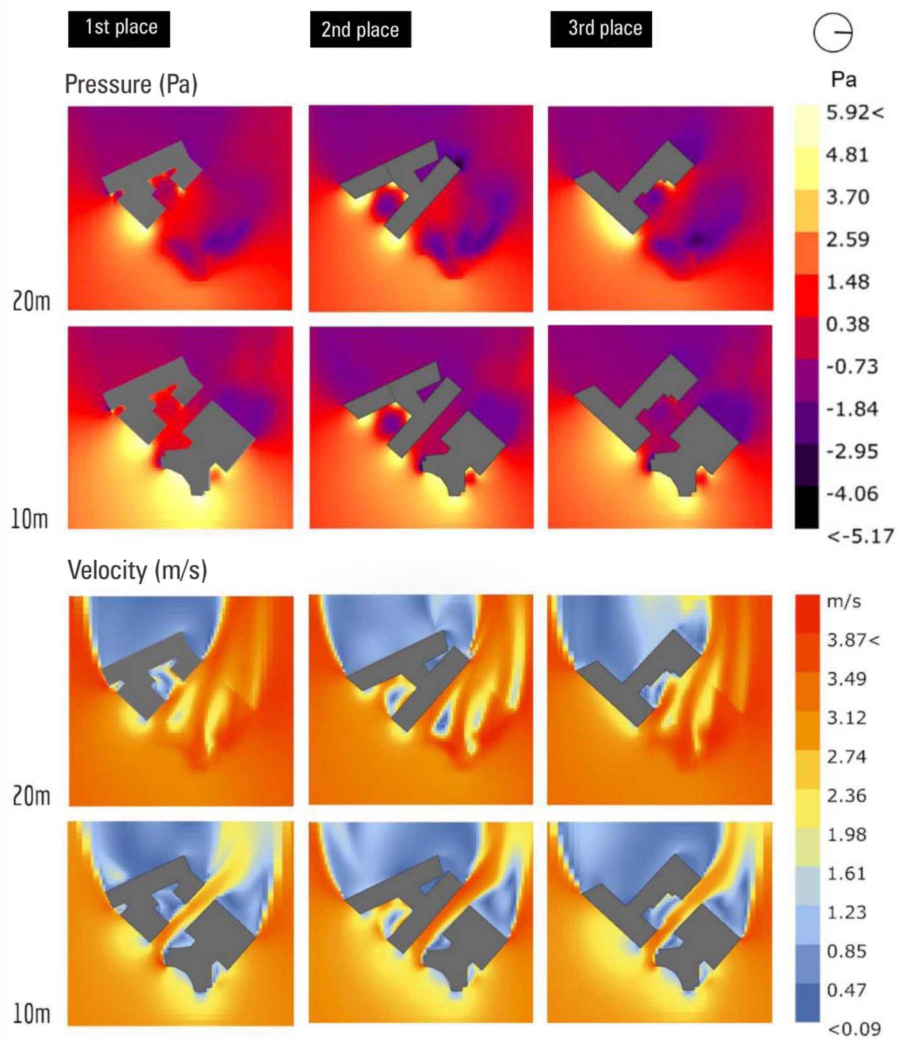
however, this parameter is questionable, considering that, depending on the orientation of the facade, a longer thermal delay may be desirable to heat the rooms at night and at dawn.

On the other hand, it should be noted that in the three proposals, the facades that receive the afternoon sun – southwest, southwest-west, northwest and north-northwest – have extensive glass surfaces, material unsuitable for thermal inertia for heating due to its low thermal capacity and delay.

4.2.2. Natural ventilation

In the justification memorials, some solutions adopted to take advantage of natural ventilation were highlighted. The fragmented formal composition adopted by the 1st place aimed to favor the circulation of secondary winds in the common circulation of the standard pavement. The architects emphasize the inclusion of ventilation shafts next to the bathrooms and kitchen, however, they do not detail how to solve cross ventilation in the housing units. The 2nd place makes no mention of this bioclimatic strategy. The 3rd place highlights that "the apartments have openings in opposite or adjacent walls, to promote cross ventilation and natural lighting throughout the day" (WEEFOR, 2019d). Although the adopted strategy widens the pressure differential between openings, Bittencourt and Cândido (2008) warn that the location of these openings according to the prevailing wind direction is of fundamental importance to ensure the efficiency of natural ventilation.

Figure 5 - Incidence of east winds on buildings in the summer (12/21 to 3/21). Source: the authors.



The results of the computer simulations show that the neighboring building generates a significant obstruction of the east winds, as predicted (Figure 5). Apparently, no implementation strategies were adopted to rid the buildings of the area of wind shadow generated by the surroundings, possibly resulting from the lack of flexibility imposed by the design constraints.

It is observed that the facade most favorable to natural ventilation due to the action of the winds is to the southeast, which is windward. All proposals have apartments facing this facade.

Secondary capture of the east winds can also occur on the northeast facade. In all projects, this facade is most benefited on the top floor (20m from the ground), when the neighboring building no longer creates obstacles to winds. There is also an increased potential for capture in the corner units of the southeast and northeast facades. This is because the chamfered shape of the neighboring building directs the flow to that end in the three buildings. However, once affecting this facade, part of the winds is captured and part is redirected, suffering a channeling effect between the building and the surroundings. In the latter case, as the winds flow parallel to the northeastern facade, their conditions of entry into the deepest apartments become increasingly complex, as pointed out by Bittencourt and Cândido (2008).

It is emphasized that the forms adopted in the three projects generate shadow of wind in some sections, which expands the facades to the leeward.

Adding the captures through the southeast and northeast facades, 43% of units with the potential to capture the prevailing winds are calculated in the 1st and 3rd place proposals, and 27%, in the 2nd place proposal.

Considering the requirements of NBR 15220 regarding the percentage of opening of the long-stay environments, it is found in the three proposals an excess of glazed surfaces in the envelope, being up to six times greater than recommended (Table 5). Although generous openings can favor natural ventilation, the standard limits the glass area of the envelope for this climatic context to avoid expressive heat exchanges with the outside environment.

Table 5 – Percentage of opening area in long-stay environments.
Source: the authors

Long-stay environment	1st place		2nd place		3rd place		NBR 15220
	Min (%)	Max (%)	Min (%)	Max (%)	Min (%)	Max (%)	
Bedroom	29	78	75	77	18	154	15-25
Kitchen	13	40	37	50	14,4	130	
Living room	65	112	32,5	33	26,6	79,2	

4. Final considerations

This research highlights how the contemporary context – neoliberal, postmodern and globalized – has contributed to the gap between the debate and the practice of bioclimatic architecture in Brazil.

The Weefor Arq Competition is a clear example of how the commitment to quality of spaces and habitability still comes up against obstacles generated by maximizing profit.

Although the competition documents highlighted the importance of environmental comfort, the pre-established design conditions, especially the dimensions and shape of the land, urban legislation and the required number of housing units do not offer great flexibility in launching a party that favors comfort conditions in all or at least most of the housing units. In view of these limitations, it seems inevitable to orient the apartments towards different solar orientations, a solution that generates great losses for the environmental performance of the building.

The analyses of the projects reveal that the architectural parties adopted by the 1st, 2nd and 3rd place have the potential to favor passive solar heating and thermal inertia for heating in 66%, 63% and 72% of the units, respectively. On the other hand, these potentials are not fully exploited due to the presence of balconies, which generate undesirable shading in up to 100% of hours of intense sun exposure in winter. Thus, although the opaque construction components adopted meet the standards with regard to thermal capacity and thermal transmittance, the potential for thermal inertia for heating is not fully explored by the proposals. It was also found that 43% of housing units have the potential to capture the dominant winds in the 1st and 3rd place proposals, and 27% in the 2nd place proposal, which is the result of a significant obstruction by the neighboring building and the generation of wind shadows by the shapes adopted.

The responsibility of architects for the inefficient exploitation of winds and solar radiation should not be excluded in the proposals presented. The justifying memorials reveal, in some cases, an unpreparedness of the architects to effectively adapt the building to the climate, in others, a clear neglect of this important aspect in the design process.

The analyses indicate that the architect has a lot to contribute in the planning stages of the project, including the choice of plot, the definition of the needs program and the number and area of the housing units. Not including these items in this decision-making process is to ignore the architect's ability to view the problem holistically and anticipate obstacles to the building's adaptation to local climatic conditions.

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