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RESCUE OF A BIOCLIMATIC SINGLE-FAMILY RESIDENCE IN SOUTHER BRAZIL

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Abstract: The architecture using bioclimatic principles and passive solar conditioning, although it was the object of theoretical and practical studies at the end of the 20th century worldwide, in the regional scope of the North of Rio Grande do Sul, even in the current context, presents few examples. of your application. The present work rescues a work from the mid-1980s, executed in the city of Passo Fundo – RS; it is a single-family residence whose conceptual premise was to provide thermal comfort to users with the lowest possible energy consumption. These concepts anticipated contemporary concerns about sustainable construction and energy efficiency. Within this proposal, natural means were used for air conditioning, water heating and lighting. In this article, the basic concepts adopted and their respective characteristics are recovered from a qualitative analysis, as well as from the perspective of the theoretical frameworks that guided its conception and execution as an interpretive research. Initially, the passive solar architecture is contextualized and its validations to the local climate context. For that, the local climatic characterization and the parameters and design strategies applicable to these characteristics are presented. From a scientific point of view, a way is pointed out to prove its as-built performance, adopting contemporary monitoring and simulation methodologies. Thus, even though the application was based on some empirical variables, given the limited availability of data and tools in the early 1980s, with the adoption of architectural principles using passive natural resources, the residence reaches a differentiated thermal performance in relation to that normally found for its complex climatic characterization, fully meeting the needs of users, contrary to constructive and architectural standards in which environmental comfort requirements are generally neglected, and only achieved with the insertion of partial active conditioning.
Keywords: Passive Solar Architecture. Sustainable construction. Thermal comfort. Energy Efficiency.

INTRODUCTION

The environmental behavior of buildings has been a theme that takes up the Vitruvian thought of the conceptual balance between the tripartite model: architecture, climate and comfort, present in the "Ten Books of Architecture" (VITRUVIUS, 2002) and throughout the entire production of buildings. for all functional typologies (BUTTI; PERLIN, 1985). However, from the 1960s onwards, Victor Olgyay (1998) proposes the inclusion of a new element in the process: technology (figure 1), developing the concepts of Bioclimatic Architecture, in which climate analysis procedures and their interrelationship are established. -relationship with the comfort conditions of users, considering that man is the fundamental referential measure in Architecture, and his refuge is designed to satisfy his biological needs.

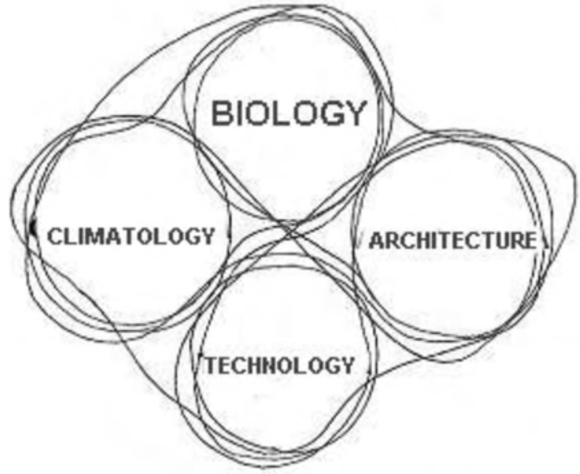


Figure 1 - Interrelated fields of climate balance (OLGYAY, 1998, p. 12).

Also making the theoretical reference of Banham (1975) makes a relationship between the history of architecture according to the relationship between buildings and nature: a) the conservative modality of thermal storage characteristic of dry and cold climates; b) the selective modality, which uses the structure not only to retain the environmental conditions, but to admit the convenient conditions from the outside. This modality is used in humid climates. The author comments that traditional construction has always had to merge these two modalities. However, in the 20th century, the regenerative modality, which consumes artificial energy and automatically controls the atmospheric variables of temperature, humidity and purity, gained wide use, forgetting the dialogue between architecture and nature.

Banham (1975, p. 321) reflects on the production of knowledge that Architects began to develop at the end of the 60s: forms that are not a prop borrowed from distant technology, but forms that are adequate to the environmental proposal made, and concludes by saying that only when these appropriate forms are commonly accessible will the architecture of the bien air-conditioned environment become as convincing as the millenary architecture of the past. Hawkes (1996, p. 23) highlights Banhan's contribution to the discovery of a rich, and perhaps more elaborate, order for contemporary architectural production.

It is in this theoretical and practical context in which contemporary architectural production has been developed, with some crossroads between the proposals without considering the local, climatic/social/cultural context and those that are closer to the premises of the aforementioned authors. On the one hand, the result of an architecture of "consumption, of buildings with artificial air conditioning" (MONTANER, 2016, p. 112), on the other, those "which later became the criteria of a versatile and resilient architecture, according to the environment and that, to be sustainable, it has needed to renew itself".

Different authors currently corroborate this essential and essential return to a conservative architecture, in the terms of Banham, with numerous concrete experiences, seeking sustainable construction, a term adopted from the 1990s onwards by different authors such as Kibert (2005), Braungart and McDonough (2009), Roaf, Fuentes and Thomas (2009), among others.

However, this work aims to rescue a concrete example, still under the critical and unexplored horizon of the "Bioclimatic Architecture" of the 1980s. A work implanted in an urban context in the city of Passo Fundo - RS. As a conceptual basis, the Casa N project adopts theoretical references until the early 1980s (BARDOU; ARZOUMANIAN, 1980; IZARD; GUYOT, 1981), in this sense the article researches the relationships with these bibliographic references and makes a descriptive and qualitative analysis of the edification. In addition, it investigates the local climate characterization, whether those available at the time of the project (FRANDOLOSO, 1997), or the most contemporary methodologies.

Finally, from these theoretical references, the work points out new perspectives for the evaluation based on the available modeling and simulation methodologies, as well as the application of methods to verify the results of the energy quality level.

In this sense, the rescue of Casa N allows us to reflect on the local architectural production, unfortunately disconnected from its climatic context in order to promote habitability conditions through passive systems, instead of a contribution increasingly based on active systems, with the expansion of the use of artificial conditioning and, consequently, the expenditure of energy resources.

METHODOLOGICAL PROCEDURES

The research uses both interpretive and qualitative research as methodological references, according to the strategies defined by Groat and Wang (2002) for specific investigation in the fields of Architecture and Urbanism.

The analysis of the building used the design references, based on graphic and descriptive elements, as well as monitoring the detailing and execution. The work identified the bibliographic reference bases (BARDOU; ARZOUMANIAN, 1980; IZARD; GUYOT, 1981) used by the team of authors of the project, expanding to the contextualization of the previous bibliographic panorama on the theme of Bioclimatic Architecture (BANHAM, 1975; OLGYAY, 1998;) and more contemporary authors.

Initially, for the climatic characterization, the concepts represented by the Psychrometric Chart were applied (GIVONI, 1992) and using the software as a graphical tool *Climate Consultant* (LIGGET; MILNE, 2012). For the present work, the analyzes were based on theoretical references and on the quantitative assessment of design actions and strategies. In a simultaneous step, the results obtained *as-built* were qualitatively evaluated, comparing them equally with the bibliographic references adopted in the project.

THE LOCAL CLIMATE CONTEXT AND PROJECT GUIDELINES

The climatic characteristics of Passo Fundo were studied by Frandoloso (2001), which evaluated all the information from the climatological normals considering temperatures, relative humidity, wind direction and speed, solar radiation, among other environmental variables. By the climate classification of Köppen, modified by Trewartha (1980, p. 223-238) the local climate is considered as humid subtropical humid mesothermic - Caf, that is, with average temperatures in the coldest month between 18ºC and 0ºC and in the warmest month above 22ºC, with a well-distributed rainfall regime throughout the year. (FRANDOLOSO, 2001; 2018).

Figure 2 presents the Psychrometric Chart (GIVONI, 1992) with the indication of passive solar strategies, according to the climatic characteristics of Passo Fundo calculated by the *Climate Consultant* 5.4 software. (LIGGET; MILNE, 2012); it is worth mentioning that in only 20.5% of the year the comfort conditions are adequate (1,796 hours), according to the ASHRAE (2004) regulations and the adaptive comfort models (from DEAR; BRAGER, 2002; ASHRAE, 2009). In addition, the program indicates the passive guidelines for the design and achievement of thermal comfort, with the presentation of examples for each of the zones/strategies.

Although aimed at buildings of social interest, the thermal performance standard NBR15220 (ABNT, 2005), prescribes the basic conditions of the envelope for external enclosures (walls and roofs) and the respective thermal transmission coefficients U (W/m^2K), the thermal delay φ (hours) and solar heat factor FCS (%) indicated for each of the Brazilian Bioclimatic Zones – ZB. Figure 3 represents the parameters indicated for the ZB2 where Passo Fundo falls; it also indicates passive strategies for winter and summer conditions.

It is important to note that for the elaboration of the project under study, the data on the environmental variables of Passo Fundo available were restricted, referring to information from Porto Alegre. This

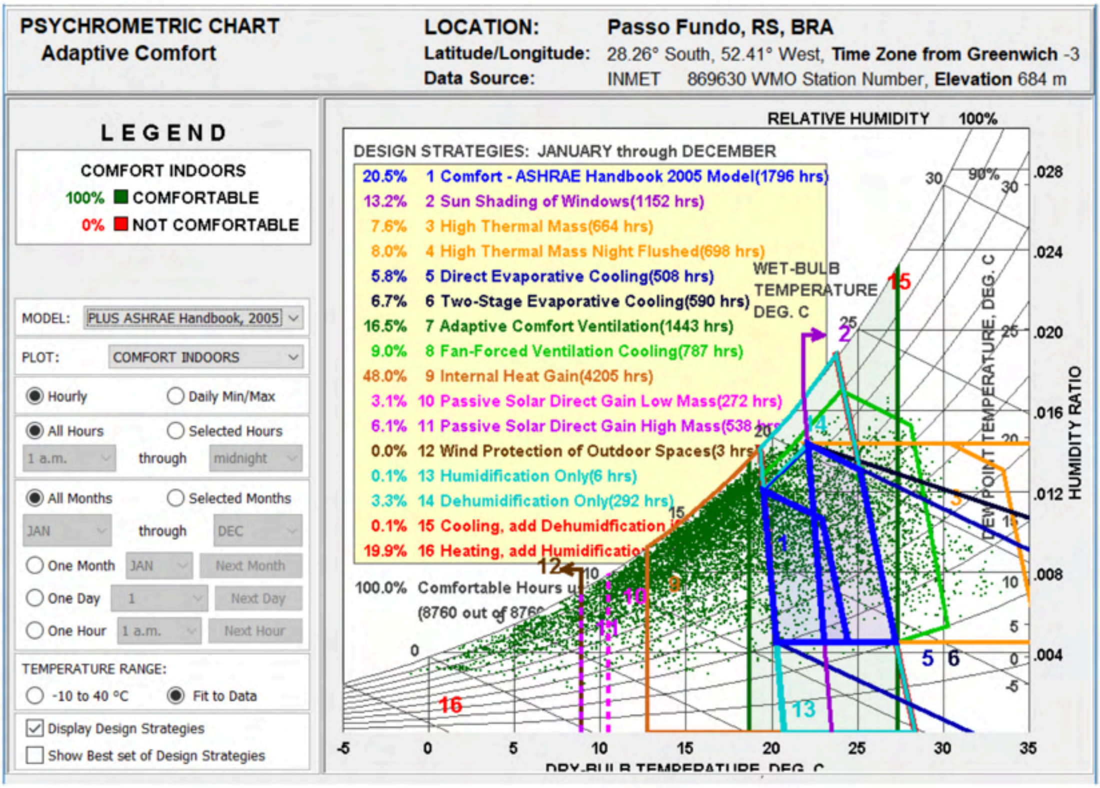


Figure 2 - Psychrometric Chart for Pass Background (FRANDOLOSO; CUNHA; BURGOS, 2021, from LIGGET; MILNE, 2012).

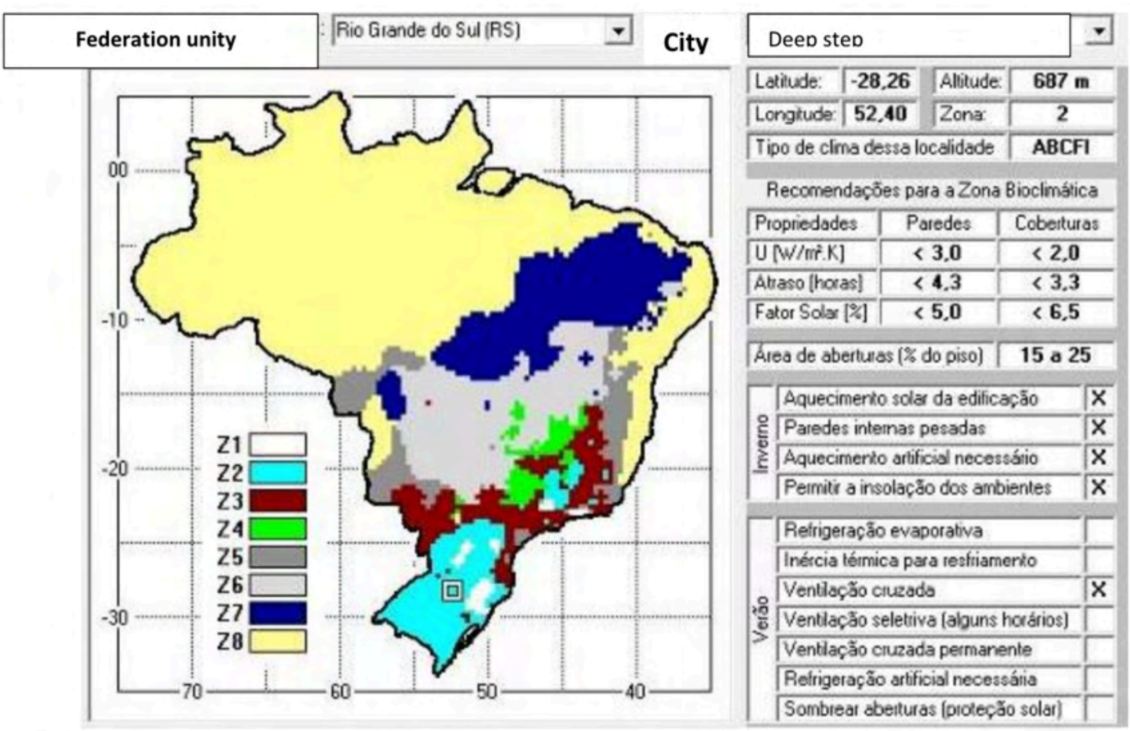


Figure 3 - Brazilian Bioclimatic Zoning Map and guidelines for Passo Fundo -RS - ZB2 (FRANDOLOSO, 2018, from RORIZ, 2004).

situation is evident with the observation of the dominant wind direction, estimated as Southwest, in the generalization to the Plateau (AROZTEGUI, 1977, p. 51-53), but effectively in the Northeast direction.

ANALYSIS OF HOUSE N

PROJECT GUIDELINES

The building was clearly based on the principles of Bioclimatic Architecture, a permanent single-family residence designed in 1985, with a built area of 120.46 m2, located on a farm located on the edge of the urban perimeter, with the use of organic waste through a system digester, producing biogas and fertilizers.

Casa N (Figure 4) had as a project premise that it must "have all the comfort, but the lowest possible energy consumption and maintenance", contained in the original explanatory memorandum (DOS SANTOS, 1987). In this sense, the Architects' proposal was to avoid the use of mechanical means, with the implementation of passive guidelines for air conditioning, water heating and lighting.

For the expansion of the comfort zone through construction, based on the Psychrometric chart by Givoni (1992) applied to Passo Fundo, thermal insulating materials were used: double walls in brick masonry with 21 holes, spaced 4 cm apart, as well as glass and roofing in clay tiles with 25mm expanded polystyrene insulation.

According to figure 5, a solar collector wall was built, with an inclination of 60° oriented to the Northeast. This wall was built with basalt stones, a regional material and widely applied by vernacular architecture, measuring 25x50x15 cm, conveniently arranged in order to increase the surface for capturing solar radiation, also enlarged with black paint. This wall is protected by 3mm glass frames, also double, also functioning as a thermal battery for the maintenance of the system at night, with silica gel between the sheets, in order to avoid condensation.

The principle for the desired air conditioning is the circulation of air inside the collector wall, through lower and upper openings, by temperature difference: in summer conditions, the air that passes through the sensor is directed to the outside, by means of a control located at the top; in winter conditions this air, then heated by solar radiation, returns to increase the internal temperature, represented schematically by figure 6.

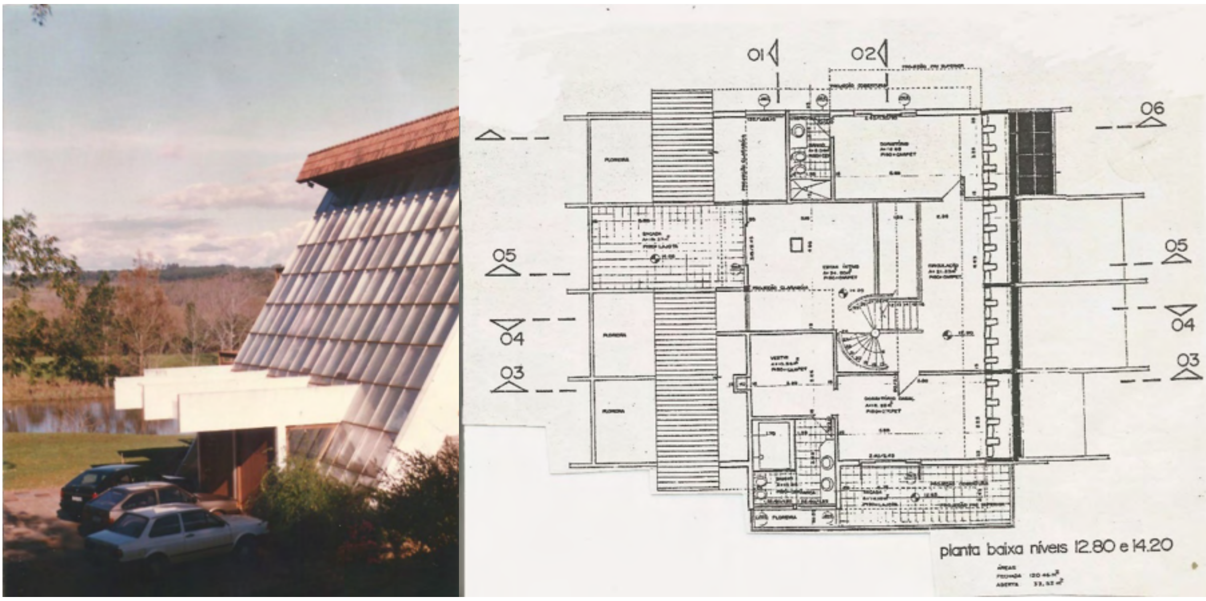
The entrance of outdoor air for the summer situation would be carried out through the Southwest facing facade, promoting cross ventilation, in winter it works as a closed system, only promoting hygienic ventilation for air renewal, according to the schemes presented in Figure 7 .

All the premises of the residence were equipped with adjustable wooden shutters, which allow hygienic ventilation in winter and comfort in summer (figure 8).

Additional heating systems were also used: a fireplace on the lower floor, with a hood and metallic exhaust ducts, seeking to dissipate heat in the environments by convection, and water heating, through a coil placed inside the wood stove, used for heating. of the couple's bedroom with serpentine installed on the floor and radiator, such strategies are represented by the figure 9.

The heating of the water used for consumption comes from systems that can work either isolated or interconnected. The bathrooms in the bedrooms are supplied by a solar capture system, while in the kitchen, laundry and toilet the supply would come from a methane gas storage heater obtained from the biodigester.

Due to the use of the Northeast orientation to capture solar radiation, the natural lighting



(a) (b)

Figure 4 (a) - View of the Northeast Facade – collecting wall and surroundings (FRANDOLOSO, 1997); (b) Floor plan levels 12.80 and 14.20 (DOS SANTOS, 1987).

Figure 5 - External views of the work in progress: SE and NE facades; NE and NO facades. (DOS SANTOS, 1987).

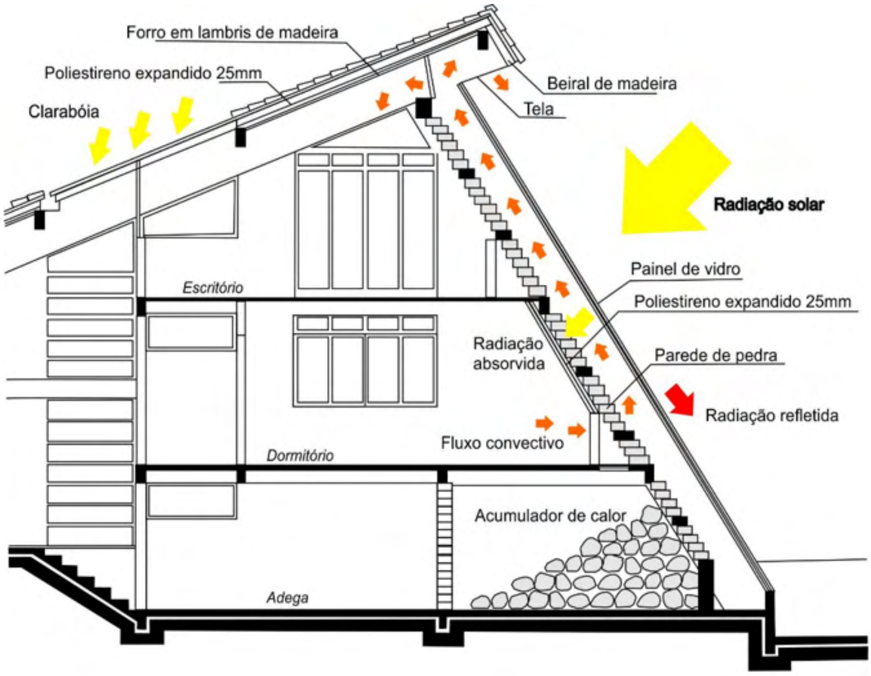


Figure 6 Schematic of the solar collector wall. (adapted from FRANDOLOSO, 1997).

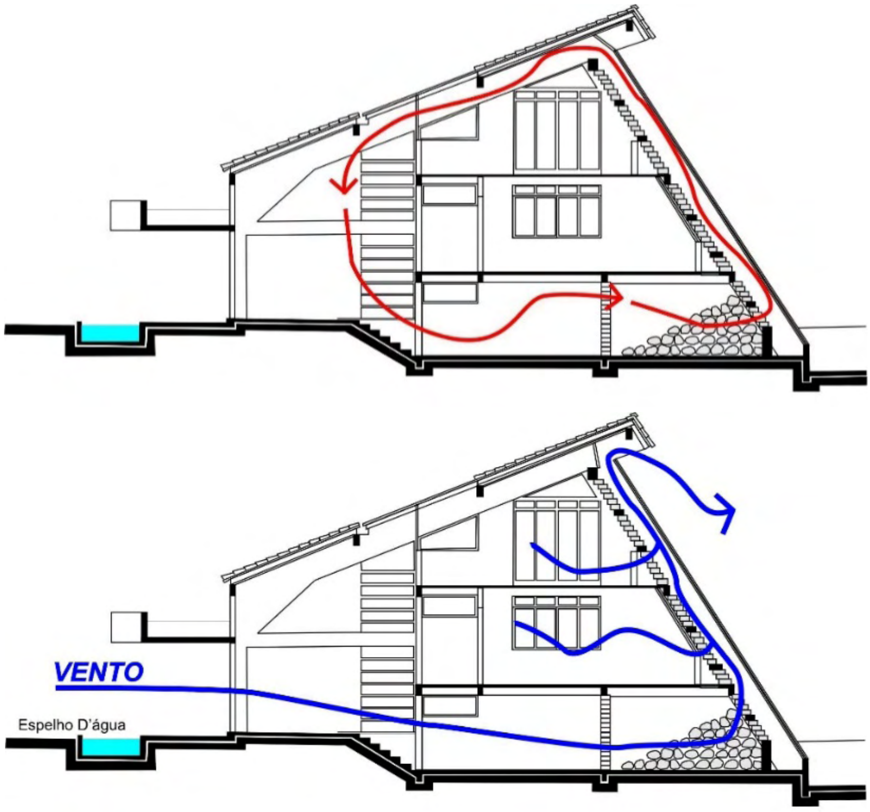
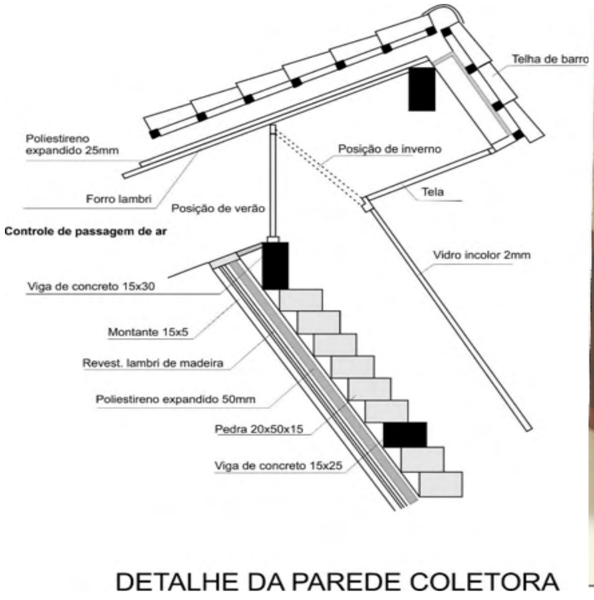


Figure 7- Air circulation systems in winter and summer. (adapted from FRANDOLOSO, 1997).



(a)

(b)

Figure 8 – (a) Construction detailing upper ventilation and collecting wall (adapted from DOS SANTOS, 1987); (b) Interior frames and ventilation for summer and winter (FRANDOLOSO, 1997).

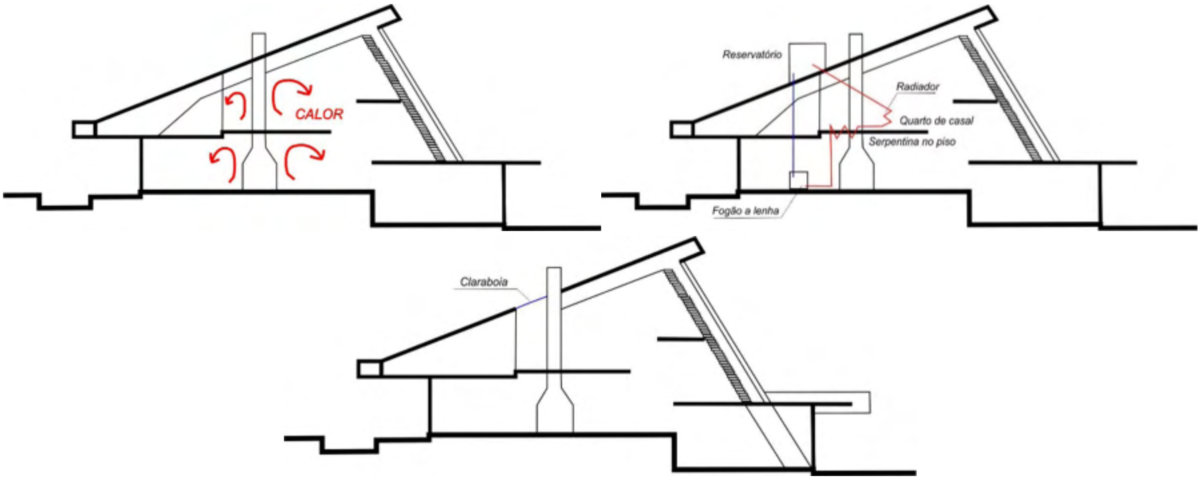


Figure 9 - Complementary heating and natural lighting schemes (adapted from FRANDOLOSO, 1997).

solution was zenith, through two glass skylights.

REFERENCE BASES

It can be seen that the architectural solution used appears in studies of application of bioclimatic architecture, which for Bardou and Arzoumanian (1980) corresponds to the model "massive wall behind glass (frame with glass), also called "Trombe-Michel wall", according to the sun/thermal mass/ space principles. The heat transfer processes are shown in figure 10 and figure 11.

According to the authors, initially the work did not perform as expected, as the minimum and maximum temperatures were accentuated, corrected with the installation of double glazing for the winter situation and external blinds for the summer conditions. With the appropriate corrections, the authors achieved about 85% of the heating needs. The sum of the advantages raised by the authors, combining them resulted in a greater efficiency of the system.

Regarding this sum of criteria and advantages, dos Santos' proposal combined the Kelbaugh House model with others, for example, the 60° inclination of the collector wall and making use of heat accumulators with loose round stones on the lowest floor. , for situations in which the solar collector no longer transmits heat, such as at night or on cloudy days, as shown in Figure 6.

According to Izard and Guyot (1980), the

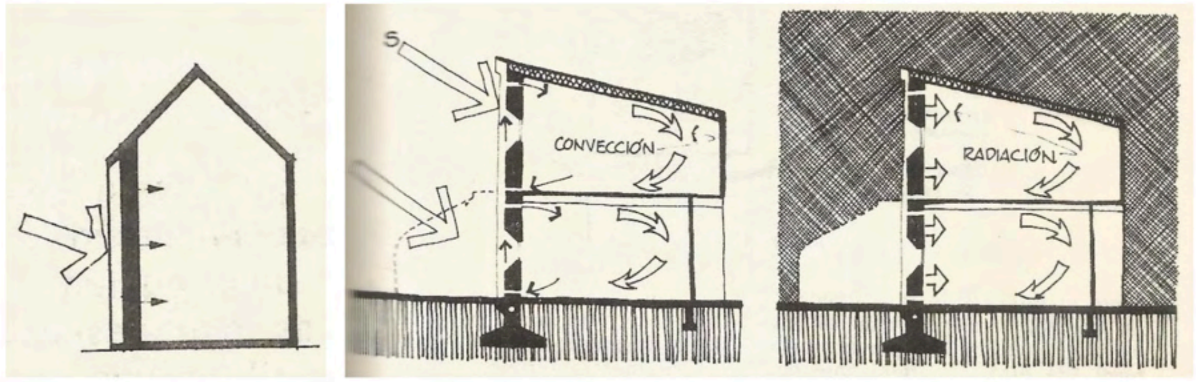


Figure 10 - D. Kelbaugh House – Solar Gain Schemes (BARDOU; ARZOUMANIAN, 1980, p. 61; 93).

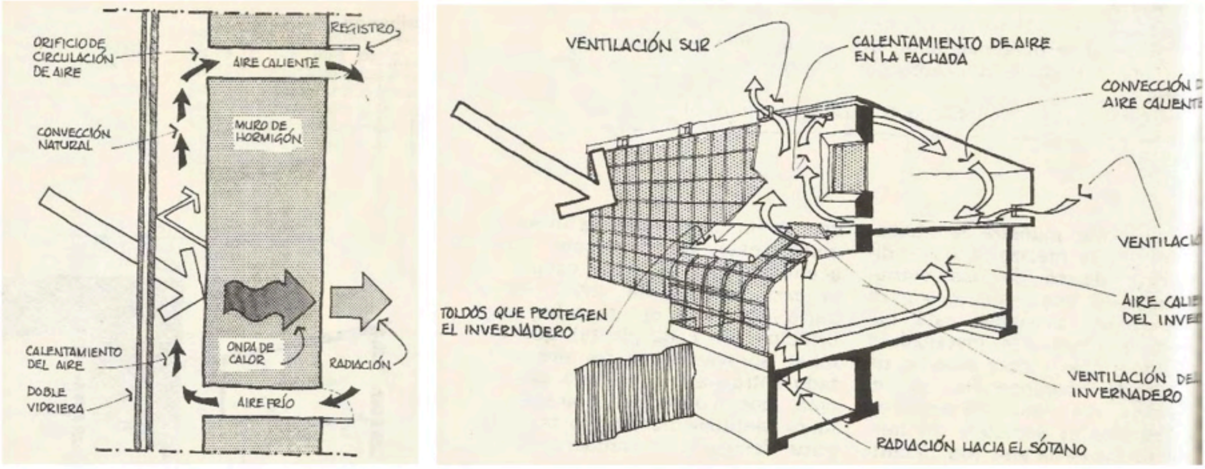


Figure 11 - House D. Kelbaugh – heat transfer processes. (BARDOU; ARZOUMANIAN, 1980, p. 94).

adoption of collector walls encompasses the functions of capturing, accumulating and returning the radiant heat of the sun, implying the correct dimensioning of the wall thickness and the material absorption factor, fulfilling the indications of the Psychrometric Chart of Givoni.

However, an as-built analysis (FRANDOLOSO, 1997) indicates that the orientation for the use, in design, of dominant winds in hot periods, through the entrance of air through the openings in the Southwest orientation, opposite to the collecting facade, resulted in the reduction of the system's efficiency, as the prevailing winds in the Passo Fundo region are northeastward; the use of the Southwest orientation was due to the generalization at the time of climatic data from Porto Alegre and Planalto Gaúcho (AROZTEGUI, 1977).

Another factor observed, which could be technically solved, referred to the solar radiation that falls through the skylights, causing an overheating of the compartments, easily minimized with the placement of mobile blinds, also implemented in the Kelbaugh House.

According to the owners' statements, the points mentioned above do not detract from the project's merit, as the feeling of comfort was greater than in conventional constructions of the time, as the thermal inertia recommended by Givoni was applied, resulting in efficiency.

As already mentioned, the requirements indicated by the bibliographies available at the time of the project, 1985, were essentially international, with restricted examples built for the regional climatic context of humid subtropical climate.

Likewise, the design guidelines of NBR15220 (ABNT, 2005) are later than the design, as well as the Performance Standard NBR15575 (ABNT, 2013), much more recently. New assessment processes and methodologies are indicated by current national (BRASIL, 2012) and international regulations, especially allowing the modeling and simulation of thermal, comfort and energy performance by means of software (EnergyPlus, DesignBuilder, etc.), with precision of results in the conception and design phases, anticipating design decisions, and in the execution and operation phases.

In the international context, the Passivhaus concepts (PASSIVE HOUSE INSTITUTE, 2012; COTTEREL; DADEBY, 2012) present criteria for the envelope of buildings, as well as for energy consumption, although originally established for Central Europe, but with several application studies. to warmer climates, including checking their suitability for Brazilian conditions (TUBELO; RODRIGUES; GILLOTT, 2013).

House N proves to be feasible for monitoring the conditions of thermal, light and energy comfort. Investigations such as these allow an appropriation of theoretical concepts, transforming them into concrete examples of the validity and feasibility of passive solar strategies for the regional climate context. This opens up a horizon for future academic research, with a significant impact on improving the quality of the existing built park and to be designed and executed.

FINAL CONSIDERATIONS

From the case analysis carried out, it can be understood that, in order to achieve efficiency in the application of the principles of bioclimatic architecture, it is essential to correctly define the climatic factors at the local level, because in extreme cases, the generalization of data, or even of empirical definitions, can make a project unfeasible, from the point of view of environmental comfort. Depending on the case, it can generate the need to use mechanical or active means to condition the environments, when natural or passive means could have been efficient, with a consequent reduction in the energy consumption of the building.

The use of pre-conceived models must be cautious, being essential to raise all the parameters involved, making the necessary corrections for the local characteristics.

However, Casa N constitutes a landmark for regional architectural production, as it may have been a precursor of a concern with an architecture more suited to the local context and to what would later be conceptualized as architecture or sustainable construction. The rescue of this work thus seeks to bring up the discussion of passive solar procedures and strategies, combining solutions and vernacular materials with technology.

Casa N, with its premise of providing comfort conditions, can be a contribution to emphasize that the current production mostly neglects the factors that allow the relationship of the building with the local climatic complexity, with large daily and seasonal thermal amplitudes. Unfortunately, buildings are not adapted to this context: cold in winter and/or hot in summers, even with the contribution of active thermal conditioning systems, also generally meeting partially the habitability needs, whether in residential spaces, as well as study, work or leisure.

As presented, these references open perspectives for quantitative diagnoses adopting current methodologies and tools, in order to prove the performance achieved, considering that the qualitative evaluation of Casa N showed a positive result, especially by the residents.

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