IMPACTS OF FORM-DESIGN IN SHADING TRANSITIONAL SPACES: THE BRAZILIAN VERANDA

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Summary

Shading transitional spaces are a common characteristic in countries with hot climates or hot seasons, and forms part of a natural climate system. In Brazil, with latitudes ranging from 0 to 32°-S, and therefore predominantly tropical climates, verandas are the most common of these shading transitional spaces. The objective of this study is to analyze how the application of design variables related to formal dimension affects the incidence of solar radiation, increasing or decreasing the efficiency of the system. After contextualizing the importance and use of shaded transitional spaces in Brazilian architecture, we defined a standard model of a veranda and subjected it to changes in six aspects of its formal definition. Then, with the help of Heliodon 2, software, we performed simulations to analyze the impact of shadow and solar radiation on floors and walls that should be protected by verandas. We compared different latitudes of the Brazilian territory for each orientation. The results are presented in a comparative chart that shows the impact of each aspect of formal design in the shading and exclusion of solar input. We conclude that aspects usually neglected by architects may be critical in achieving the desired effects of bioclimatic and sustainable design.

Keywords: transitional spaces, veranda, shading, solar protection, Brazilian architecture

1 Introduction

Certain spaces in architecture cannot be qualified as interior or exterior and exist without a precise or specific utility. They are often called intermediate or transitional spaces and are an important element in many architectural types worldwide [1].

Several classical authors, including Olgyay, Givoni and Konya [2,3,4], agree that high levels of solar radiation, sky luminance and abundant rainfall in tropical climates makes it desirable to create covered and shaded spaces attached to buildings. Transitional spaces in climates with long warm periods are as important as - and sometimes even more important than - the interior spaces, and should therefore receive the full attention of designers [5]. These spaces can help to ensure environmental quality in buildings, while rationalizing the use of energy and materials.

In Brazil, a country with a predominantly warm-humid (or semi-humid) climate, the most common transitional space in architecture is the veranda, a shaded space like a porch or gallery that has been present in the country's architecture from the outset. It was introduced by the Portuguese and has been gradually adapted to the tropical conditions.

With the introduction of modern architecture in the twentieth century, it became even more widespread. Characterized as a solution originating from the traditional architecture, the veranda has been definitively incorporated into the lexicon of local architecture by the design strategies of Brazilian architects. While they sought visual permeability through the transparency of pure volumes, the powerful solar radiation and the wide availability of natural light made it necessary to seek protective glass closures. The use of *brise-soleils* was one of the most widespread solutions, but another important alternative was to create deep shadows using horizontal planes. This solution protects vertical surfaces and simultaneously creates shaded, open and ventilated transitional spaces. Through a large number of different solutions, verandas are a common aspect of modern life in Brazil.

Fig. 1 Traditional Brazilian veranda

Fig. 2 Modern Brazilian veranda

Fig. 3 Present-day Brazilian veranda

Though the importance of verandas is recognized, they are used by architects in an almost intuitive and empirical way, possibly due to the lack of specific studies on the environmental impact of their design. This study is a part of a broader research project on all aspects of the aesthetic dimension and the environmental impact of veranda design in Brazilian architecture. The specific objective of the study is to analyze how the application of design variables related to the formal dimension affects the incidence of solar radiation, increasing or decreasing the efficiency of the system, in order to create a better method for adopting the bioclimatic approach to design.

2 A typical transitional shaded space of Brazil: the veranda

Interacting between interior and exterior, transitional spaces are also known as intermediate or interstitial spaces and are classified according to their spatial characteristics: semi-outdoor, semi-open or semi-closed. They can also be considered according to their degree of integration in the main part of the building: fixed or aggregate. For Kapstein, the transitional space is a "mediator, a link between the interior spaces, with light and climate controlled and the natural environment—climate, sun, wind and rain—uncontrolled" (my translation) [6]. Moreover, the transitional space offers a set of design possibilities, sometimes even determining essential characteristics for the typological architectural definition. These spaces can be exemplified by courtyards, cloisters and atriums, which are fully involved in the horizontal plane, or by balconies, conservatories, porches and verandas connected to the exterior of the building.

Verandas are a specific type of transitional space, acting as filters of countless environmental conditions between interior and exterior. They acquire multiples functions in housing, forming sites of family life, leisure, entertainment, social meetings and events, and even work. All these activities are protected from contact with the sun, wind, rain, natural light and the surrounding environment of the city or nature.

From the environmental perspective, the veranda can be concisely conceptualized as a habitable, covered intermediate space added to a building and open to the outside on one or more sides. It provides protection from rainfall and undesired radiation for both the envelope of the building and the space it creates. Furthermore, it offers ventilation with outside air and, by reducing the light intensity, also reduces the contrast of light with the adjoining interior spaces.

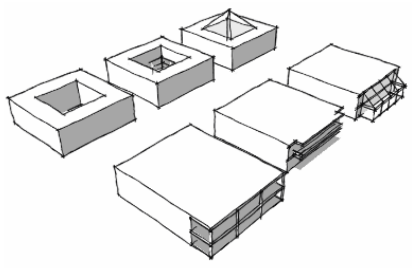

Fig. 4 Typical transitional spaces, after CADIMA, 2000

Fig. 5 A typical Brazilian veranda

In addition to its potential to provide shade, fresh air and filtered light, the veranda helps to extend the perception of the exterior from the interior, whilst creating more privacy in the interior. It affects the comfort of both the interior and the intermediate space formed by it, helping to minimize or eliminate the need for artificial thermal conditioning.

3 The veranda as a natural system of environmental control

Coch & Serra classify the environmental control system by their function: as collectors of solar radiation, they use the effect of thermal inertia, improve conditions for ventilation and air conditioning of the indoor environment and provide protection against excessive solar radiation [7]. The question to be examined is the effect achieved by the veranda in relation to these functions and interactions. Obviously, as verandas are intended to provide shade, their most significant impact is on solar radiation, which is the greatest input of energy in a building. However, they also have an impact on other aspects, such as daylight and natural ventilation.

People and material surfaces in the shade of verandas are protected against the effects of direct sunlight, which can considerably increase the effective temperature. Their action in blocking the radiation is directly related to the formal and spatial characteristics of their design. The total radiation incident on a building consists of a sum of radiations, of which direct sunlight is the most important. The veranda's role as part of sun protection systems is to avoid the incidence of radiation on the building, preventing overheating of the interior, especially when outside temperatures exceed the comfort zone.

Solar protection systems consist of components such as *brise-soleils* or transition spaces connected to the interior, such as the verandas. While *brise-soleils* mainly protect the building envelope, a veranda is a type of *umbraculum* that creates usable shaded spaces interposed between the solar radiation and the indoor. In addition to the environmental impact, these spaces usually acquire other important functions in the home.

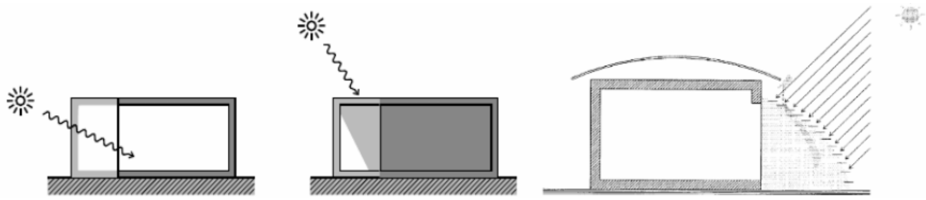

Fig. 6 The veranda as a shaded space, an *umbraculum*

Radiation affects surfaces and objects according to their orientation and reheating potential. This effect is always a combination of different modes of transfer of heat by radiation, such as:

- Direct solar radiation (short-wave), in situations of clear sky;
- Diffuse radiation from the sky (short-wave), in situations of overcast sky;
- Radiation reflected by the ground or nearby surfaces (short-wave);
- Radiation re-emitted by the ground, surrounding objects and surfaces (long-wave), resulting from heating under the action of solar radiation.

While the first three are easily related to the effect of natural light, the fourth is often overlooked though it can result in significant amounts of heat.

Regarding its design, the study identified eight main projection strategies used by Brazilian architects to create verandas: extension of the cover, specific cover, setback walls, subtraction forms, pilotis areas, structural interspaces, interconnection and mobile and adjustable devices.

Tab. 1 Summary of the forms of incidence of radiation on verandas

Incidence → / **Intervening ↓**	**Direct (short-wave)**	**Diffuse (short-wave)**	**Reflected (short-wave)**	**Absorbed and reissued (long-waves)**
Environmental relations	- solar altitude angle (latitude, season, time)	-sky conditions	- solar altitude angles (latitude, season, time) - geometric relations	
Veranda variables	- orientation - height x depth ratio - length - position of the building	- part of sky visible (height x depth).	- characteristics of the surfaces (albedo); - geometric position of reflective surfaces	- surface absorption and emittance (veranda and environment) - area (and distance)

4 Methodology for determining formal design impacts

We developed simulations in order to determine solar radiation impacts according to architectural variables. We used a veranda model with the dimensions 6.0x3.5x2.5 m without columns and protruding from the building facade. First, the model was compared with and without a veranda situation to check its impact, and then with the following characteristic variations: shorter, shallower depth (equivalent to the increase in height), inserted and with columns. Finally, it was compared with a veranda with lattices and one with external obstacles, like a wall.

The model was tested at different latitudes intended to represent the situations found in Brazil (0o, 15oS and 30oS, corresponding to the northern, central and southern regions). Moreover, the model was tested at summer solstice on three different periods of the day (8 h, 12 h and 16 h) and with different orientations (north, south and west). The variants were analyzed at 15oS, the median, as compared to the typical model, plus all the other situations of hours and orientations.

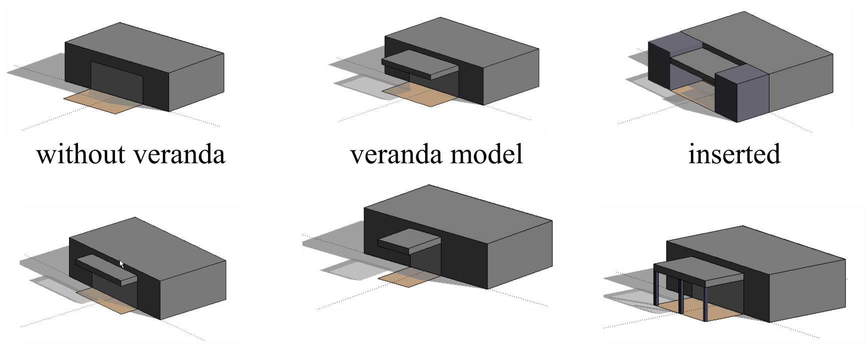

Fig. 7 The model and its variations

The model and its variants were analyzed with the program Heliodon 2, version 2009, which was used to construct the sunpaths at different latitudes and to analyze the impact of direct and diffuse solar radiation, taking into account the masking of the veranda produced by the model and its variants. The program proved useful for studying variations with different projections (shaded plan, stereograph, isochronous) and graphs. As it is easy to use and offers many options for analysis (the attribute highlighted by the creators), it is complementary to other programs such as those used for ray tracing and radiosity [7].

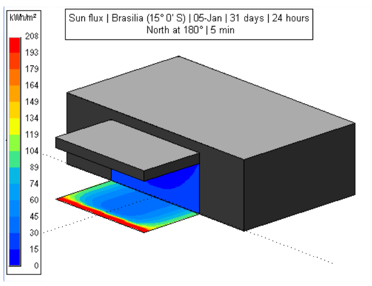

Fig. 8 Solar radiation on floor and wall from Dec. to Jan.

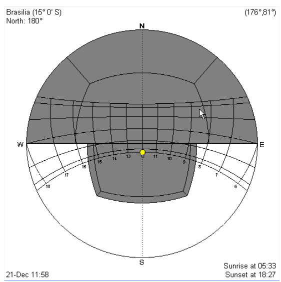

Fig. 9 Masking graph

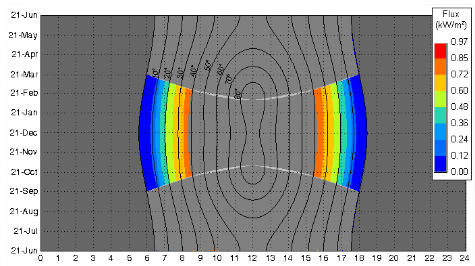

Fig. 10 Isochronous projection of solar radiation flux during one year

The calculations were carried out on two selected surfaces: the vertical surface immediately below the veranda (6x2.5 m) and the horizontal surface formed by the horizontal projection of the veranda (6x3.5 m), one representing the windows or walls, and the other representing the floor protect by veranda. The simulations considered by latitude are approximations to the cities of Boa Vista on the Ecuador, Brasília and Porto Alegre. Figures 8-10 show examples of the simulation results.

5 Results

The first result of the simulation performed at latitude 15ºS shows a very high accumulated yearly reduction in radiation: between 73% and 83% on the wall and between 52% and 69% on the ground. The graphs show that the wall and floor with south orientation, the side that receives the lower intensity of radiation, are those with a smaller contribution on solar radiación.

Regarding the variation in latitude, the graphs of the simulation results also confirm that the northern orientation is the most sensitive and receives increasing radiation with increasing latitude. The increase in solar radiation on the graph means a loss of efficiency of the veranda. Thus, the decrease in the impact of a veranda between 0° and 30°S is about 45% to the wall and 35% to the floor, resulting from more days of exposure and a lower altitude of the sun.

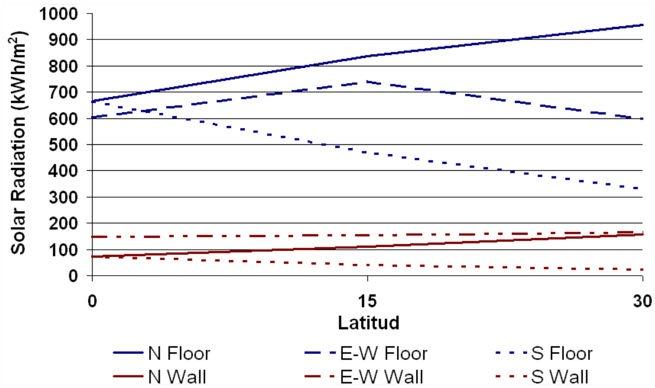

Fig. 11 Effect of latitude on total incident solar radiation in a year

The results of the other variations can be summarized as follows:

- The deeper the veranda, the more efficient the shade is, especially in the east and west and in the north.
- Very short verandas with unprotected sides are less efficient; the shorter they are, the lower the efficiency of their shade.
- The shade on the walls is practically insensitive to the existence of normal columns. Columns do create shade on the floor, but it is not significant.
- The more inserted the veranda is, the less likely are the floor and wall protected by it to receive sunlight, as the incidence of oblique rays and lateral rays most common in low-lying east and west sides is almost completely prevented.
- The shade provided by verandas is very insensitive to external and nearby walls, except on the ground on the east-west orientation.
- The usefulness of the lattice as a complementary filter, increasing the shade mainly on east and west orientation, is confirmed.

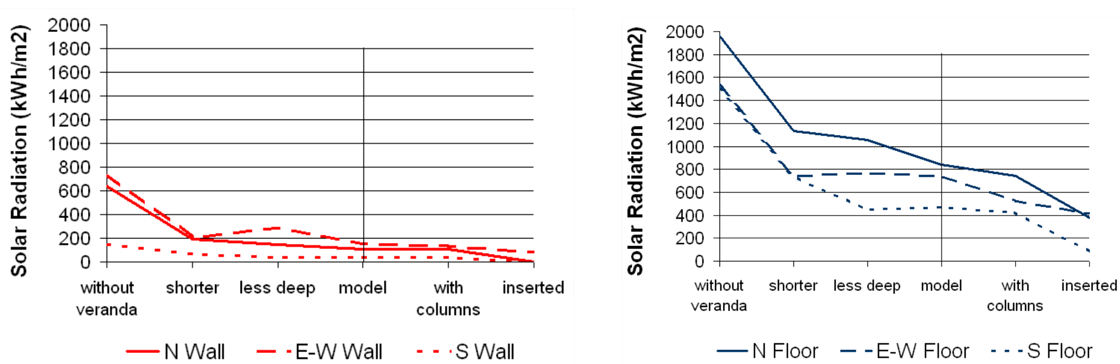

Fig. 12 Overall comparison of total annual incidence of solar radiation at 15ºS.

6 Conclusions

Compared with the veranda considered, the variations studied on a model with intermediate size and characteristics, ranging from totally exposure surfaces to a totally inserted veranda, showed the incident solar radiation graded according to the efficiency of the shade provided by the veranda.

The more external, less deep and shorter a veranda is, and the less support it has, the lower its impact on blocking solar radiation should be. Therefore, the greatest amount of shade is provided by long, deep, inserted and with more columns verandas.

No designs decisions can be based on a sole factor, so the usefulness of this analysis is merely that of providing benchmarks that can aid the design process. This study shows the importance and utility of verandas for reducing direct sunlight in buildings, which is so important in hot climates such as that of Brazil. This aspect should not be neglected by architects as it can be critical in achieving the desired effects of bioclimatic and sustainable design.

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