Brasília: daylighting analysis of public buildings designed by Oscar Niemeyer

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ABSTRACT: The architects Oscar Niemeyer, Lúcio Costa, the Roberto brothers and Affonso Eduardo Reidy are considered by some authors as Brazilian pioneers on sustainability, all belonging to the so called "Carioca School" hosted in Rio de Janeiro and mentors of the dissemination and prestige of the Brazilian modern architectural development. The building of the Ministry of the Education and Health (1936) became reference for the Brazilian modern architecture as owning an original language and also as an attempt at architectural fitness for tropical climates, thanks to its judicious siting and orientation, its pilotis and the pioneer use of shading devices in its northeast façade.
Twenty years later, in 1956, Lucio Costa became the urban planner of the new Brazilian capital city, Brasilia The new capital had economic, geographic, and climatic contexts completely different from Rio de Janeiro. The city is situated at 15º52 south latitude, and the climate is classified as altitude tropical, with two well defined seasons: hot-humid (October to April) and dry (May to September).
The present paper focuses essentially on the modern architecture of Brasília analyzing some public buildings designed by Oscar Niemeyer, as the Itamaraty Palace, the Cathedral and the Ministry of Culture and Environment. The aim is to verify if the present sustainability concerns of the designs was influenced by the first design of the Ministry of Education in Rio de Janeiro, especially regarding daylighting and insolation. The first results show that these buildings have a poor environmental performance, presenting many comfort problems, indicating that there was no effort to adapt the projects to the local climate.

Keywords: Brazilian architecture, comfort, sustainability, daylighting, insolation

1. INTRODUCTION

Brazil is a country with continental dimensions: with an area of 8.547.403,5 km2 (including ocean islands), and a wide range of climates: from humid equatorial to humid and dry tropical, to humid subtropical in the South of the country [3]. Brazil offers a varied span of natural light availability. For example, in Natal, a city near the Equator, there is approximately 100 thousand lux in summer at midday, while in São Paulo, in the Southeast, there is approximately 45 thousand lux during the same season.

Along its history Brazilian architecture has sought to produce works adapted to the several Brazilian climates [4]. During the thirties and forties an important fact took place in the country's architectural development: the introduction of the principles proposed by the Modern Movement. How did Brazilian architecture stand in face of this movement? Among the natural light usage proposals of the Modern Movement one finds, on the one hand, those of universal nature that propose a model applicable to any region as, for example, the projects by Mies van der Rohe and Walter Gropius; and on the other hand those of local nature, that design proposals taking local context into consideration, as in the works by Frank Lloyd Wrigh and Aalvar Aalto [9]. When studying the Brazilian architecture of this period, and also of the following periods, it is clear that both trends have always been present, the ideas of Le Corbusier being predominant – though not the purist Le Corbusier, but that Le Corbusier that is willing to face the challenges of climate, as can be seen in his proposal for the city of Argel dated 1933 [1].

Two samples of Brazilian architecture will be studied in this paper: the building of the Ministry of Education and Health, dated 1936 and carried out with Le Corbusier's consultancy in Rio de Janeiro, a city that was the Brazilian capital from 1764 to 1936, and two Ministerial buildings projected for the new capital, inaugurated after 1000 days of construction on April 21, 1960, by the President Juscelino Kubitschek.

2. THE MINISTRY OF EDUCATION AND HEALTH BUILDING

The Ministry of Education and Health Building is considered truly a watershed in Brazilian architecture, as stated by the architect and historian Carlos Lemos [7]. The project was developed by the architects Afonso Eduardo Reidy, Carlos Leão, Ernani Vasconcelos, Jorge Moreira, and Oscar Niemeyer,

coordinated by Lúcio Costa and counted with Le Corbusier as consultant.

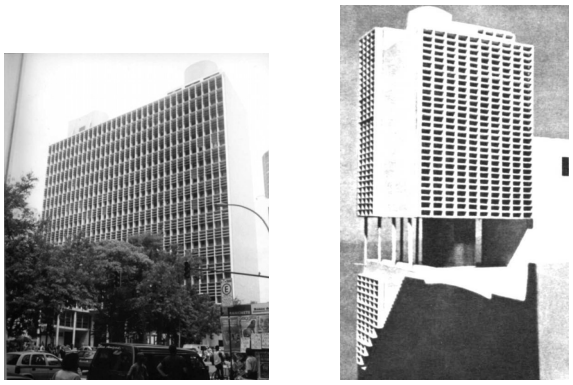

Figure 1: Ministry: Northwest façade and Le Corbusier's project for Argel

The northwest façade shows a brise-soleil obviously inspired in Le Corbusier's proposal for Argel's reurbanization, but it is clearly an attempt at coping with local conditions, as adjustable horizontal blades of fiber-cement were used, fixed to large concrete vertical blades. The light created by this louvre is not universal, but has a local character, a light that is adapted to the reality of Brazil and Rio de Janeiro, a light that does not contradict the Modern Movement's dictates, while still questioning its universality. Brazil's great and original contribution to modern architecture is the mastering of heat and light by means of external light breakers or Venetian blinds, wrote Goodwin in the introduction of his book Brazil Builds, on Brazilian modern architecture. [6].

Which was the technical reasoning behind the development of the project for the louvres? The team of architects considered that the southwest façade was insolated in the morning only during a short period of the year, which produced little influence on working hours, and thus thought of designing it with large glass windows so to let in the most light, according to the guidelines of the Modern Movement, and also to secure a good view of the bay. Yet, it was clear that the other side had to be protected, and thus the idea of the brise-soleil, proposed by Corbusier in 1933 for the city of Argel. Studies of the local conditions led to the choice of the type to be adopted, much different from that imagined by the French-Swiss master for a Mediterranean country: a fixed brise-soleil, formed by an octagonal net of concrete blades [2].

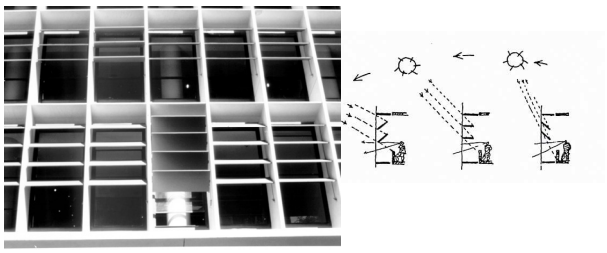

Figure 2: Detail of the lumiere and sketch by Lúcio Costa showing the way it works.

The project of the brise divided the façade into boxes measuring 5m x 2m, with 1,3m depth, and 3 horizontal panels fixed to the sides, projecting themselves 50cm beyond the window. The louvres were devised for the mid-day sun in summer, and for a 45 degree winter sun, Strategies for dispelling the heat that formed between the sun-breaker and the interior of the building were found necessary, thus the 50 cm space between the brise and the window.

The team of architects that built the Ministry saw the problems that would arise due to the direct application of the Modern Movement's proposals for the use of light in Rio de Janeiro, namely: the excess of luminance, the inconvenience of insolation, and excessive heat. Their solution for this problem, the use of an architectural element that could control and filter light, was intended to be practical in the first place, but it was transformed into an attitude that left deep marks in Brazilian architecture [10], leading it to the issue of contextualization, without giving up the search for light, a feature of the Modern Movement.

Twenty-four years later, Brasília, the new capital, was created according to a project developed by Lúcio Costa, who had coordinated the Ministry Building project, and with public buildings designed by Oscar Niemeyer, who had been part of the team that developed the Ministry's project. Were the guidelines of the Ministry of Education and Health Building still present in the architecture of the new capital?

3. THE NEW CAPITAL: BRASÍLIA

Since the colonial period the transference of the Brazilian capital to the central plateau had been considered, both for economic and security reasons.

In the fifties president Juscelino Kubitschek called a competition to choose a urban plan for the city. Lúcio Costa won the competition and the public buildings of the Monumental Axis were assigned to the architect Oscar Niemeyer.

Lúcio Costa organized the city in axes, as a reference to the idea that axes are the guiding elements in architecture. Along these axes the city's functions are distributed, and they mark repetition, and zones, according to the modernist influence. One of the axes, called "Monumental Axis" (9,75 km) divides the city in two symmetric parts that correspond to the South and North Wings, similar in size and composition, extending 14,3 km from north to south. Along the Monumental Axis are set the most important buildings and palaces of the city, such as the Ministries (18 buildings), the Itamaraty Palace, the Planalto Palace, and the Ministry of Justice.

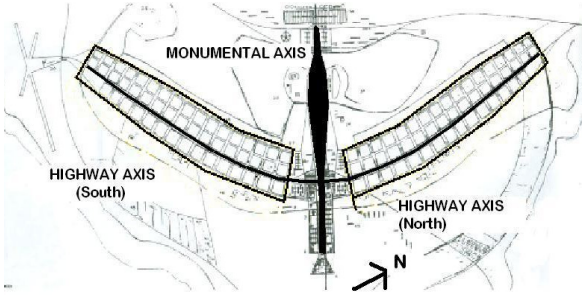

Figure 3: Pilot Plan with Monumental and Highway Axes

Brasília has a tropical highland climate, marked by a hot and humid season from October to May, and a dry season from April to September. The mean temperature is 21,6°C. The daily mean temperatures are relatively low, varying between 14,6 °C in July, and 21,1 ºC in October, which indicates that milder temperatures are predominant. The mean relative humidity of the air is 70%, and in August, the driest month, 56%. East winds predominate during most of the year, with mean speed of 2 and 3 m/s.

Annual insolation is of 2400 hours. Along the four seasons high horizontal plain illuminance rates are found: at midday on March 22 (autumn equinox) we find 98.500 lux under partially cloudy skies; on June 22 (winter solstice) under clear skies we have 85.500 lux; on September 23 (spring equinox), with partially cloudy skies the illuminance rate is 98.000 lux; and for December 22 (summer solstice), with cloudy skies, we have 21.000 lux [9].

According to several studies [11] the climate in Brasilia allows the use of passive climatization strategies, by means of controlled cross ventilation, thermal inertia of the building, insolation protection, when necessary, and evaporative cooling.

4. STUDY OF TWO PUBLIC BUILDINGS IN BRASÍLIA

For the present study two public buildings designed by Oscar Niemeyer were chosen in order to delve deeper into the analysis of issues related to environmental comfort and energetic performance: the Itamaraty Palace and the Ministry of Culture and Environment, both on the Monumental Axis. The Itamaraty Palace adopts an architectural solution similar to other monumental buildings of the city, such as the Planalto Palace, and the Ministry of Justice, all presenting ample glass façades, partially protected by shading devices. The Ministry of Culture and Environment building has the same architectural design as the other 17 ministries of the Esplanade (Monumental Axis), thus both projects are representative of the architecture of modernist public buildings of Brasília, designed to host office activities.

The analyses were conducted by means of the following procedures, carried out along 2003 and 2004 [1], [2]:

- Gathering of the most information possible on the architectural designs, installations, functional aspects, and other features of the buildings;
- Visits to the buildings and observation of user's activities and reactions;
- Measurements of natural light, temperature of the air and relative humidity for at least 3 days;
- Interviews with users of the building on work place environmental comfort issues.

4.1 Itamaraty Palace

This is a rectangular building inaugurated in 1968. Its 20.142 m2 are distributed in 4 floors containing offices, exhibition rooms, a central hall, auditorium, etc. The façades are positioned southeast, northwest, northeast, and southwest, lined all around with fumé 6 mm glass windows framed in aluminum. The roof and arches of the façade are of exposed concrete, forming 6 meter eaves. The internal workspaces are lined in dark wood. Work-hours extend from 9 AM to 7 PM.

Figure 4: Main entrance and southeast façade of the Itamaraty Palace. (Photos: personal archive)

The building has a central air conditioning system that is turned on from 9 AM to 7 PM daily and serves the entire building except for the central hall. Some offices of the ground floor and second floor have window air conditioners as a complement. The energy consumption in 2000 – 2002 was of 153 kWh/m2 yearly (mean), of which 30% are for air conditioning and 50% for artificial lighting, according to estimates.

Figure 5: Analyzed environments: offices on the NW and SE façades.

Users complain of the excessive incidence of direct solar light on the offices, which leads them to constantly close the blinds to exclude natural light, which in turn activates the automatic system that turns on the electric lights most of the day. The eaves are not enough to protect the façades and the fumé glass, and this makes the heat in the offices stronger. Illuminance measurements (only natural light, with blinds open) produced positive evidence of the excessive light (over 3000 lux in some spots, and 50 lux in other ones), mainly for the southeast and northwest façades, alternately during the day.

4.2 Ministry of Culture and Environment

This is a 9 floor building inaugurated in 1958 that presently hosts the Ministries of Environment and Culture. It has two main façades positioned southeast and northwest, and these façades are lined with maxim-air clear glass windows. Later the northwest windows were equipped with vertical mobile metallic louvres painted green.

Figure 6: Northwest and southeast façades of the Ministry of Culture and Environment with protective elements

Horizontal circulation is accomplished by means of a central corridor running along each floor, and offices are on either side facing the two façades. For the present analysis we selected two rooms on the 5th floor of the building, one facing southeast and the other northwest. Openings are on the upper and lower part of the façade, with projecting windows (maxim-air). Nevertheless, cross ventilation is not possible due to the internal lay-out of the building. The energy consumption of this building is approximately 170,8 kWh/m2 yearly, and nearly 60% is spent on air conditioning.

The users interviewed complained of the heat, deficient ventilation and glare from the sky in some positions. The positioning of the building makes it difficult to control excessive insolation, leading to thermal comfort problems and high electricity consumption. Also inadequate are the excessive use of glass and the vertical louvres of the northwest façade, as they must be held closed in order to adequately protect the building during the needed periods. Direct insolation of the southeast façade during the morning does not allow for opening the blinds, which must also be kept closed during the afternoon on the northwest façade. Lighting measurements (only natural light with blinds open) taken on April 26 found a maximum light of 4500 lux during the morning near the window, and a minimum value of 238 lux 6 meters from the window, which indicates lack of uniformity and high incidence of direct light. This is why windows and blinds remain closed and air-conditioning on the whole day.

5. CONCLUSION

During the thirties the architectural proposal of the Ministry of Education and Health Building led Brazilian architecture to come forward as a pioneer regarding sustainability, even if this concept did not yet exist officially. Did Brazilian architecture learn the lesson of rendering buildings suitable to climate?

The study conducted in the buildings in Brasília show that these lessons were only partly learned. Oscar Niemeyer tried to make these buildings adapted to the climate by means of generous eaves, as in the case of the Itamaraty Palace, or by means of louvres, even if after inauguration, as in the case of the Ministry of Culture and Environment building. But the environmental performance and user-comfort problems that were detected clearly demonstrate that his intentions were not followed by the necessary technical development, a problem that was already present in the building of the Ministry of Education and Health, where the rooms protected by sun-breakers are dark, and the rooms facing the other side present the opposite problem.

It is comprehensible that the building in Rio de Janeiro should present such mistakes, after all, at that point there was no experience or technology for calculating and producing adequate solutions. But why were these problems not solved decades later, and why do the buildings still present similar problems?

The answer is not simple. It involves variables such as the designers' ignorance of technologies, and the little importance given to architecture as a climate mediating element – which led to the adoption of active strategies such as air conditioning and artificial lighting in order to correct the problems presented by these buildings.

The Esplanade where the ministries are located was declared a World Heritage Site by UNESCO, and this brings many problems regarding later interventions in their façades. Nevertheless, the proliferation of air-conditioners, the application of solar protection films in several colors, and even the application of aluminum foil to the windows of these Ministries (as seen presently) also generates visual "pollution" and fails to offer lasting solutions for the existing problems. The adoption of internal protection measures, such as curtains that remain closed the whole day long, hinders the use of natural light, which is highly recommendable for work places.

It is vital to create new norms and regulations that allow environmental rehabilitation of the modern public buildings, also contributing to maintain the original architectural features while effectively solving the problems these buildings present. Also desirable is the greater dissemination of technical knowledge that would allow these buildings to be better designed, considering the availability of natural light and the conditions imposed by local climate, with more emphasis given to the suitability of architecture to climate.

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