Nineteen Thirties Architecture for Tropical Countries:  
Le Corbusier's Brise-Soleil at the Ministry of Education in Rio de Janeiro

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Abstract

Around 1930 the Modern Movement in Architecture had come of age in Europe. Suddenly, the architects of this movement realized that it had the potential to spread to the rest of the world and sought regions generally deprived of a firm sense of civil building procedures. To a certain extent, the tropics were one such area. Their authorities, mostly for want of social organization or techniques, welcomed the import of new industrial construction methods, seemingly efficient and unprejudiced, instead of inventing their own methods. However as modern materials had originated in temperate areas, their progress was hindered by the oppressiveness of the tropical climate. In this year-long investigation, the authors, through scientific design methods and computer simulation, would like to contribute to a careful examination of the systems conceived to overcome this major fault of modern architecture, and to provide solutions for the future. As the present study encompasses several different cultures, the case of the brise-soleil in South America will be discussed by first focusing on the figures of Le Corbusier and Lucio Costa.

Keywords: Modern tropical architecture; history of the brise-soleil; eco-architecture; lighting

1. Introduction

The brise-soleil as an experimental system proposed by Le Corbusier is in the authors opinion a mere evolution of one of his most widespread postulates for architecture, namely the "fenêtre en longueur", or longitudinally extended window. The authors will try to demonstrate in the ensuing pages that such a controversial principle, in association with a no less questionable one -the free disposition of the façade- can be traced back to the root of the more generalized use of glass-walls in modern architecture.

In the core of the discussion on the five points (1927), Le Corbusier writes: "a window may well have a longitude of 10 meters for a dwelling and of 200 meters for a mansion" [1]. This statement propitiated the advent of glazed façades throughout Central Europe. The new type of material became so popular that it was readily exported to the rest of the world.

When adapted to hot climates, though, the excess of glazed apertures proved inefficient and prejudicial; its comfort failures needed to be corrected with auxiliary systems.

The reason behind the horizontal window was said to be the quest for adequate climatic performance as in the other four postulates.

Fig.1. Comparison of the Photic Fields Generated by Horizontal and Vertical Windows of the Same Area
However, if we were to make an axiom of this lightly undertaken intent, it could lead to dangerous assumptions. Let us see why with an example. If, on a purely geometrical basis, we study the behavior of two windows of equivalent area but different positions (Fig.1.), we observe that the resulting luminous field for the same room is different, i.e. the light penetrates deeper in the vertical disposition.

Nevertheless, a window does not illuminate only as a function of its geometry but also by virtue of the transparent materials employed and through them, by the prevailing sun and sky conditions at a given time and in a given place.

In other words, we cannot tell accurately which window performs better without referring to a specific meteorological event, such as noon or an overcast sky. The authors believe that architectural geometry should never be the sole design criterion for any climate-adapted element.

It is important to note that the questions of light and heat are related to solar radiation. What is more, all of these concepts need to be studied together in order to assess or decide on the adequacy of results for any calculation model employed.

Therefore, it is always necessary to include in this kind of discussion such local features as latitude, cloudiness, orientation and sequential evolution of the environmental parameters.

2. Evaluation Procedure

According to the former, the authors suggest that sun-protection elements should always be analyzed from the point of view of architectural space. As historian Sigfried Giedion once pointed out, "In utter darkness, there is no significant difference between a rift and the Sistine Chapel" [2].

That said, it easily follows that if we want to understand interior space we have to know about its lighting in advance.

The procedure to be followed is a method based on configuration factors [3, 4] that extends the radiation properties of diffuse sources to luminous exitance of all kinds of building surfaces irrespective of their shape. These surfaces are therefore treated as radiative emitters by means of the generalized law of the projected solidangle [5]. The authors have assumed that all the materials involved in the calculations are almost perfect diffusers or Lambertian bodies.

The overall behavior of a brise-soleil is established through the analysis of the photic field produced at representative moments within a standard meteorological year. That is, the solstices and equinoxes, winter and summer at different times and under different sky conditions with due consideration to the direct solar component in each case.

The radiative transfer procedure allows quantification of the effect of inter-reflection in the different blade planes, while at the same time the portion of diffuse light that enters through the blinds can be added. Expressions for the configuration factor between inclined surfaces have been integrated at several angles to be used for the simulation.

3. The plans for the Ministério de Educação (Ministry of Education) in Rio de Janeiro

In the wake of a proposal for Badjara, Algeria (1932), Le Corbusier joined a team of Brazilian architects led by Lucio Costa for the design of a building that was to
become something of a worldwide emblem in tropical architecture: the Ministry of Education and Health in Rio de Janeiro (latitude 20° south). The authors were fortunate to obtain a copy of the original memoir of the project that was published in the 1939 number of the magazine Arquitectura e Urbanismo. As expected, in this text, there is profuse mention of climate-related design features.

In the north-northwest façade that receives solar radiation year round during working hours, the architects designed a brise-soleil composed of rotating slats. A clever mechanism was devised in order to block the sun at three possible angles, 45°, –45° and horizontal. (See Figs.5. and 6.)

For each situation the authors have calculated the effect of rotating the louvers on the photic field generated in this way. Some of the results are shown in Figs.7., 8. and 9.

These fields can be compared with the objectives specified in the project in order to assess whether or not the slats performed as expected. In the original text we read:

"The inclination of the sun in its path in relation to the exposed façade indicates that the selected protection system needs to be composed of horizontal louvers because otherwise we would be forced to adopt a diminutive window bay that would bring loss of visibility [6]. On the other hand, we checked whether fixed louvers could have solved the problem of solar radiation but found it to be less satisfactory from the point of view of day-lighting. If we had designed such blinds for clear days, the light would be dim under cloudy weather, thereby making artificial sources necessary at times of day at which, on other buildings, they could have been avoided. [...] Besides we consider that, since the sun's rays have a variable direction in relation to the wall, the best way to protect the façade from them would be a moveable system. On these grounds, and in view of the good results obtained at the Obra do Berço building, on the Rodrigo de Freitas Lake, where, due to the orientation, a vertical system was used, we have decided to follow a similar procedure that guarantees appropriate light distribution for the working requirements".

The authors have to accept the first part of Costa's statement in the sense that for a northern façade, due to the relative movement of the sun, the use of horizontal louvers is adequate.

Near the equator, the protection offered by overhangs is more effective and the slats can be designed in a way that avoids a significant reduction of the visual field. However for these types of climate the solar incidence should also be controlled in winter.

The second part of the argument is unclear and dubious. The louvers may protect from direct solar radiation but, to a lesser extent, they add reflected light in the interior space. The radiative transfer method proposed is perhaps the only one capable of accurately

![Fig.5. and 6. Views of the Mechanism used to Rotate the Louvers.](image1)

![Fig.7. December at 12 hours solar time. Clear sky plus sun. Louvers at +45°. Values in Lux.](image2)

![Fig.8. December at 12 hours. Clear sky plus sun. Louvers –45°.](image3)

![Fig.9. December at 12 hours. Clear sky plus sun. Horizontal Louvers.](image4)
Taking into account this possibility since it equates the surface of each blade to a diffuse source.

To understand the problem in detail the authors have decided to compare the lighting levels generated for different positions of the louvers with those for an unobstructed window. The date chosen was the summer solstice (December in Brazil) at 12 hours solar time.

If we plot the results on the same graph (Fig.10.) we will find that the highest lighting values are attained with the louvers turned downwards 45º, a position near the optimum if we want to prevent the sun from entering the space.

Based on the hypothesis of an overcast sky the best position would be turning the louvers upwards 45º (-45º) and in this case if the blinds were removed completely the levels would hardly increase.

The former result has been obtained from a color of the blades of RGB 165 205 215 (similar to cobalt blue). By changing the reflection coefficient it is possible to simulate other hues.

If we consider white-painted blinds, the situation is significantly altered (Fig.11.). Even under a cloudy sky, the light distribution with louvers is better than without them. As a conclusion it could be said that the reflection coefficient of a set of louvers is the more critical aspect for daylighting. Slats with a reflectivity of 0.8 or higher (white) produce better luminous output than a window without blinds, and this may hold even under an overcast sky. Therefore, blades of adequate size and finished with a light color in a northern orientation for the southern hemisphere are both a safe and necessary choice from the thermal and lighting point of view [7]. The luminous fields generated by the louvers are more stable and penetrate deeper into the room, resulting in significant energy saving.

For most of the time during the summer months, the blinds do not receive direct solar radiation. Therefore, they are not justified as a solar protection measure and their dark color impedes an optimal daylighting balance, but the authors think that the architects of the "Ministerio" were not conscious of this fact.

Looking again at the section of the brise-soleil (Fig.3.) we find that the glazed surface extends from a height of around one meter to the ceiling. The louvers are designed so that, regardless of their inclination, they do not obstruct the views of the town. This strategy may be adequate, as the authors have checked that the actual opaque surface (about one third of the façade), even if added to the window area, would not produce substantial increments of light values at the working plane (Fig.12.).

The authors have not yet discussed the vertical fins that modulate the brise-soleil. They do not reduce the visible portion of sky in the room, especially at a certain distance from the window.

Nonetheless, their utility is debatable. The authors think that these cases are devised to protect from the
sun's rays at twilight. In any case, if the horizontal louvers are turned 45° they will only work for a few minutes before sunset in winter when the solar intensity declines.

There are some more effective and discrete solutions to this problem, such as displacing the structure of the brise-soleil a few centimeters off the façade, which would avoid the disadvantage of wasted radiation and reduced performance of the horizontal louvers.

Consequently, and based on the abundance of data presented, the authors subscribe to the comment made by architect and lighting consultant William M. C. Lam on the louvers of the Ministry of Education. He claimed that:

"Their intrinsic disposition is not optimal either to distribute the light or to prevent glare. In the upper part of the window, the average reduced distance to the floor slab (reduced if we compare it with the size of the blinds) reflects with less uniformity onto the ceiling" [8].

Le Corbusier conceived the brise-soleil as an element capable of preventing the entrance of all solar radiation and so eliminating any excess in thermal loads. The subsequent analysis of sun patterns (Fig.13.) clearly shows that solar penetration can be irrelevant if the blinds are rotated appropriately.

However, the problem is not altogether solved. Daylight may possess a high luminous efficacy of more than 125 lumen per watt, but its radiant energy supposes additional warming for the space. Thus, uncontrolled light would definitely bring thermal discomfort. In warm climates, a satisfactory design is that in which the intelligent use of the solar potential of glazed apertures is achieved. Therefore in this type of design, day-lighting would suffice without significant contrasts.

In this sense, it is adequate that the project under discussion locates most of its windows in the upper part of the rooms. The offices are 9 meters deep and a maximum of light penetration should be encouraged.

To answer the pending question about whether the glazed surface is oversized or sufficient, the authors have elaborated on the hypothesis of a 50% cut of the glazing panes alternating 1 meter of opaque wall with 1 meter of window for the existing section.

The authors found in this simulation (Fig.14.) that lighting values decrease by about 60% near the façade but at the core of the room, 90% of the previous level still remains. These percentages would be even higher if in both cases the light reflected off the interior surfaces of the enclosure was included.

To sum up, for situations like this in which a high level of illumination in areas apart from the façade is sought, the best strategy is one that maximizes light penetration by virtue of clerestories or zenithal lighting, provided that direct solar radiation is constantly controlled and distributed.

The said control should be applied, for different reasons, both in summer and in winter. Contemporary examples of how to solve the problem will be presented in a coming article.

In the Ministry of Education, these objectives are accomplished only in part, and so it seems likely that, due to Corbusier's influence, the Brazilian architects were over-eager to introduce their own sun-shading devices in this emblematic building. In fact, in 1936, several months before the arrival of the European Maestro, the Roberto brothers, Milton and Marcelo, won the competition for the new venue of the Brazilian Press Association (ABI). Their project featured a vertical brise-soleil with aluminum blinds to protect the façade; this material was later replaced with concrete for budgetary reasons.
In fact, reports on the usefulness of the brise-soleil at the Ministry of Education were not entirely confident. Lucio Costa himself writes in the memoir of the project that: "Then it becomes necessary, since this new sun-protection method is not tested, to carefully study the type to be used" [6].

Though the system of louvers as such was a promising feature, unsatisfactory results in this case might be attributed to the lack of technology or long-term experience in the design of sunshades. In this way, however, Le Corbusier was able to bequeath his environmental concern to a new generation of American architects who, in turn, developed their own, new types of materials adapted to the climate. Examples of this legacy are the houses of Juan O’Gorman in Mexico, the proposal of Alfonso E. Reidy for a residential unit in Pedregulho, the interesting systems designed by the Roberto brothers at the Marquês de Herval building (albeit removed in recent years) and, above all, the stark, enthralling solutions devised by Niemeyer himself and Lucio Costa.

In other parts of the world, there were similar experiences in the late 1930’s. Southeast Asia was one such place. In the French colony of Pondicherry, between 1936 and 1944, Antonin Raymond designed and constructed a building known as Sri Aurobindo Ashram (Fig.15).

This building bears important similarities to the Ministry of Education project. Influenced by his intensive stay in Japan, a country in which he worked from 1920, Raymond was interested in the importance of the shade and reflected light of Asia, as well as in the use of natural materials adapted to the climate.

Unfortunately, the initial concern for climatic matters slowly yielded to a lack of compromise that heralded the so-called International Style. Several theories have been developed in order to explain this anomalous fact. In theirs, the authors have demonstrated the absence of objective ecological criteria and thus of scientific day-lighting tools which would have surely enabled designers to counterbalance an emergent but sturdy system of industrial prefabrication [9].

In this sense the authors can only agree with the late Japanese architect, Kunio Maekawa, when he said: "I have boarded and set sail on the vessel of modern, rationalist architecture. But I am no longer sure whether that ship should come to shore" [10].

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Endnotes
1 The quoted project "Obra do Berço" was constructed by Oscar Niemeyer in 1937. At first, vertical louvers facing diagonally in plan against the façade were used, but then he found out that this system was inefficient and built a vertical brise-soleil instead.
2 In their sketches, it can be seen very clearly that only two blinds are depicted and the sun is incident on them at noon in summer, a situation that does not happen in reality at this latitude. The authors have deduced in consequence that they had little knowledge of the techniques required to implement louvers appropriately.

Fig.15. North Façade of the Sri Aurobindo Ashram, Pondicherry, India.

4. Conclusions
The design approach for the tropical climate that the authors have described indicates a considerable degree of environmental concern among architects educated within the Modern Movement. Their mistrust of details extracted from the European milieu is evident.