

# **Le Corbusier's Solar Shading Strategy for Tropical Environment: A Sustainable Approach**

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## **Abstract**

In warm and tropical climates, excess solar gain may result in high cooling energy consumption. Shading is a simple method to block the sun before it can get into the building. The 'brise-soleil', or 'sun-breaker' solution refers to a permanent sun shading technique, like the simple patterned concrete walls popularized by Le Corbusier. Le Corbusier in his design of buildings in tropical climate wanted to make a 'pact with nature' unlike his earlier works of the cold climates where he was to 'combat the nature'. Le Corbusier's solar shading strategy in Unit De Habitation and Capitol complex in Chandigarh are pioneering example for his approach towards dealing with the harsh tropical climate. This paper tries to rediscover the climate consciousness of the master architect in terms of Brise Soleil as his solar shading strategy for the tropical environment. The methodology adopted in the research is through qualitative analysis. In this paper an attempt has been made to analyse Brise soleil as a solar shading strategy with reference to the tropical architecture of Le Corbusier. The application of Brise Soleil in Le Corbusier's tropical works such as Ministry of education in Rio de Janeiro, Unité d' Habitation in Marseilles and Capitol Complex in Chandigarh has been studied. The relevance of shading in today's context with reference to climatic control and energy conservation and sustainability has also been discussed. Incorporation of Brise Soleil as a solar shading technique in buildings will certainly reduce our dependency on artificial means for thermal comfort and minimize the environmental problems due to excessive consumption of energy and will evolve a built form, which will be more climate responsive and more sustainable.

## **Keywords**

Le Corbusier

Brise Soleil

Shading

Tropical Climate

## Introduction

Brise soleil in French means 'sun breaker', refers to permanent sun-shading techniques ranging from the simple patterned concrete walls popularized by Le Corbusier to the elaborate wing-like mechanism devised by Santiago Calatrava for the Milwaukee Art Museum or the mechanical, pattern-creating devices of the Institut du Monde Arabe by Jean Nouvel. The brise-soleil concept is used to prevent a heavily glazed facade from overheating during the summer. Its typical form employs horizontal projections extending from the sun side facade of the building. The sun-breakers generate shade to prevent the high-angle summer sun falling on the facade, but also allow the low angle winter sun to provide some passive solar heating (Reyner, 1975). It is a sun-screen comprised of horizontal and vertical compartmental screens often found incorporated into the facades of buildings in sunny countries notably Brazil and Egypt, so as to keep the glare of the sun out, while still admitting light and air and allowing a view from the window. The brise-soleil was first used in architecture in a design for a block of offices to be built in Algiers in 1933 by le Corbusier. In 1937 Le Corbusier was also consultant to the Brazilian architects who incorporated the brise-soleil device into the offices of the Ministry of Education in Rio de Janeiro. Prominent examples of the 'brise-soleil' concept incorporated are the Ministry of Education in Rio de Janeiro (1943) by Lucio Costa, Oscar Niemeyer, Le Corbusier and other architects, and the 'Unité d'Habitation' in Marseilles (1947-1952) by Le Corbusier and Capitol Complex at Chandigarh (1951-54).

Le Corbusier's development of 'brise-soleil' (sun-breakers) as architectural elements resulted from his study of North African & Arab vernacular architecture. He had seen that fixed or moveable screens could be arranged to provide a 'valve' capable of allowing sun to enter in the winter, while providing shade in the summer (Sobin, 2011). Brise soleil is the most important device invented by Le

Corbusier based on the precedent of wooden screen *mashrabiya* of Arab buildings and brick louvered *claustra* of Morocco. He was attracted to the effectiveness of those vernacular devices to provide shading, reduce the glare and facilitate natural ventilation. Thus he wanted to create a modern device with the equivalent performance. Brise soleil was such a product. The deep reinforced concrete embrasures were attached to the outer surfaces so that they can cool the interior with shade and draughts. Beyond the environmental function, however, what is more important for the usage of brise soleil is the expression of the worship to the sun's primacy, as the following lithograph shows (Ivan, 1997):

*"The sun is the master of our life/far off indifferent/ He is the visitor - a lord -/ he enters our house".*

## Brise Soleil: Rediscovering Le Corbusier's Shading Strategy for the Tropical Environment

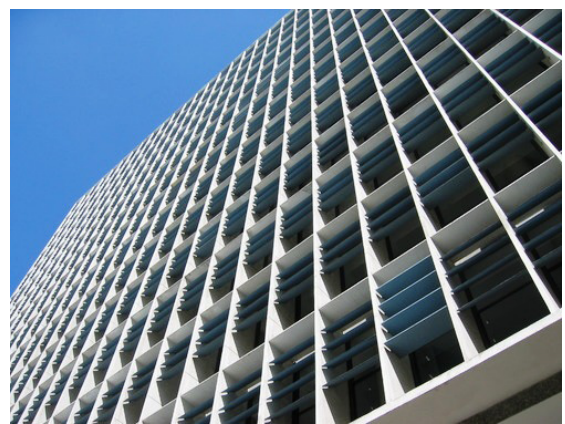
Le Corbusier consideration for the climate was the major concern in his tropical works. Le Corbusier in his design of buildings in tropical climate in India wanted to make a 'pact with nature' unlike his earlier works of the cold climates where he was to 'combat the nature'. Writing about his Ahmedabad designs, he emphasized the coupling of shade and air movement as the critical response to the climate: "Comfort is coolness, it is the current of air, it is the shade" (Corbusier, 1957). On his first visit to India in 1951, Le Corbusier noted in his sketchbooks for Chandigarh: "do not hesitate to make grand empty naves [full] of shadow and air currents". He also paid attention to the shading strategies of residential buildings, noting the relationship between roof and shadow, sun and depth of penetration (Corbusier, 1981).

Daylight and temperature during different times and seasons, monsoon rain and prevailing winds all were considered by the architect with due respect. Le Corbusier's scientific approach involved collecting detailed climatic and geographic data, identifying the architectural problems related to the tropical

composite climate, and then devising solutions. The first part of this solution was called the 'Climate Chart' or 'Grille Climatique' which had three main columns. The first one listed the values of the existing environmental factors (temp., humidity, etc.); the second was the values of the same factors needed for comfort, and the third included the architectural solution/element, which will help provide the comfort condition. Sun path and sun charts were thoroughly consulted for each building. The type and angle of the interlaced array of sun-breakers are also determined according to the sun path diagram and the climate grid (Boesiger, Stonorov & Bill, 1970). The following major projects discuss Le Corbusier's shading strategy in the tropical environment.

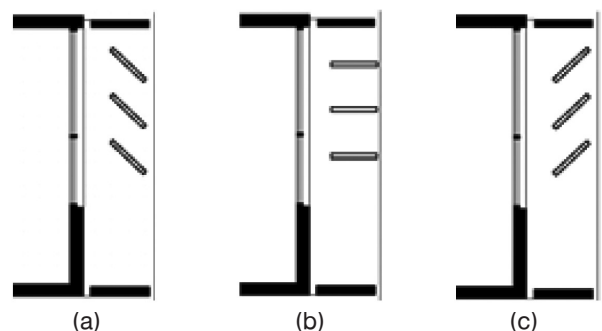
### Ministry Of Education In Rio De Janeiro

The Ministério da Educação e Saúde Pública (MESP) building is located in Rio de Janeiro. In March 1936, Lucio Costa was in charge to lead the team composed by Affonso Eduardo Reidy, Carlos Leao, Jorge Moreira, Ernani Vasconcelos and Oscar Niemeyer. At that time when Brazilian Modern Architecture reached notable characteristics, it was also identified the need of protecting buildings under a tropical climate. This architecture had as its basic principles the transparency of glazed facades and the relationship between inside and outside environment. Le Corbusier's brise-soleil, which was firstly used in MESP building, is emerged as an alternative to apply modern principles in Brazil (Giedion, 1941). The building is characterized by two big walls coated with granite, one in each external blind facade of the main block (Figure 1), contrasting with the southeast facade, totally glazed, and the northwest facade protected by horizontal movable brise-soleil (Mindlin & Giedion, 1999). The use of brise-soleil brought the innovation of avoiding heat loads and reflection caused by glazed surfaces, which was possible through the use of many external types: horizontal, vertical, fixed or movable and mixed shading devices.



**Figure 1.** Brise-soleil in the Ministério da Educação e Saúde Pública (MESP) building.

The solar protection system used in the MESP building is composed by vertical fixed elements made of concrete slabs and connected to the floors and horizontal elements. These horizontal elements are 0.5m away off the window, configuring a void between the facade and the brise-soleil where air circulates free (Figure 2). Vertical elements have just two contact points with the horizontal structure. This position minimizes the thermal bridges.



**Figure 2.** MESP brise-soleil: (a) 45° (b) 90° and (c) and - 45°

## Unité D' Habitation

The Unité d'Habitation at Marseilles (1947-1952) was the first project Le Corbusier built after the Second World War. Aesthetically, it marked a radical break in his architectural style. The abstract plane, the smooth surfaces and the slender columns of his purist style were abandoned in favour of muscular and sculptural forms (Figure 3). The Unité d'Habitation was designed as an independent structural framework into which the individual units could be slotted. The basic idea of this design was the principle that these units could have been mass produced and a steel framed prototype was developed which proved this possibility (Weston, 2004).

The Unité d'Habitation included a simple forced air heating system, which was used a simple type of smaller diffuser called the 'Véga'. The device is similar in concept and size to the type of adjustable small air nozzle that is used today in the dashboard of a car or in the cabin of a commercial jet.



**Figure 3.** The horizontal and vertical concrete slabs as Brise-soleil are fitted to the loggias on the south, east and west facades in the Unité d' Habitation, Marseilles.

After his experience with the Unité d'Habitation in Marseilles, Le Corbusier started to experiment with larger scale cooling fans which also functioned at an architectural scale. They were used like a visible expression of natural airflow, passive ventilation and as a sign of quality in terms of human comfort (Sobin, 2007). In front of glass walls of each apartment two types of brise-soleil are created. The horizontal concrete slabs are fitted to the loggias on the south, east and west facades. The vertical concrete blades are laid perpendicular to horizontal brise soleil slabs on east and west facades at shopping gallery level. The west facade is cut just beneath centre line by this horizontal row of vertical sun breaks to protect shopping gallery from sun's glare. The double height glass walls bring bright streams of light pouring in, controlled by loggias' horizontal sun breaks. The unit and brise-soleil separated by operable windows, allowing air circulation into each unit.

## Brise-Soleil in Capitol Complex, Chandigarh

In 1951, French architect Le Corbusier was commissioned to design Chandigarh, the new capital city for the Indian Punjab. Chandigarh basically hot dry monsoon climate, Le Corbusier incorporated brise soleil in all the three buildings of the capitol complex i.e. The Assembly Building, Secretariat and the High Court.

### *The Legislative Assembly*

The Legislative Assembly building, designed by Le Corbusier is the most prominent building in Chandigarh. It boasts Le Corbusier's major architectural philosophies and style. It was completed in 1962, and was conceived as a horizontal rectilinear structure square in plan with a monumental portico facing the main plaza. At the outermost layer of the space and along the edges of the building, there are many supporting offices and committee rooms, which are covered by large sun protecting louvers or brise-soleil for protecting glazing against sun (Figure 4). The



sun-shading along the offices provides a frame for inhabitants into the surrounding site while the portico opens to the adjacent landscape and the distant Himalayas. The study by Ali (Ali, 1998).showed that there have been provided good solar radiation in the Assembly building. She stated: “Use of the brise soleil cuts direct radiation from coming inside the building. Glare protection is also good with adequate natural light in the offices. Monsoon and early summer are comfortable in the offices inside the building. On very hot humid summer days it is sufficiently comfortable with the help of fans in these spaces.



**Figure 4.** The Legislative Assembly bestows the free facade via sun protecting brise-soleil.

### **High Court Building**

On the main facade of the High Court, fixed egg crate concrete screens or brise-soleil which is 4ft. 7 in. deep gives a strong and scale less pattern to the building, and only human beings and the unobtrusive courtroom doors can be used as visual keys for reading the dimensions of the surface (Figure 5). It is the concrete screen which gives the main facade its overall unity, so that it is perceived not as an assemblage of floor levels and courtroom

chambers, but as a single entity of plastically interwoven elements, in which the horizontal ground line, repeated in the two roof levels, is countered by the powerful upward thrust of the entrance piers and the pillars between the courtrooms, whose vertical line is echoed in the roof supports. Le Corbusier commented, “here the brise-soleil take the place of the weather-drips on a classical facade, but they cover not only the windows but the entire facade, and influence the whole structure”.



**Figure 5.** Four feet and seven inches deep fixed concrete brise-soleil in the High Court, Chandigarh.

Behind the brise-soleil, the windows of the courtrooms are of fixed glass, but between are narrow vertical spaces containing shutters which open and close on hinges, a ventilating devise which Le Corbusier began developing for the Mediterranean coast. Once while visiting the high court with an acquaintance, the architect indicated the courtroom wall and said, “You see, it is all glass. But the sun will never be dangerous. He will not be the enemy but the friend (High court of Punjab and Haryana, 2011).

## The Secretariat

The Secretariat, built during 1953-59, is the tallest and largest among all the other monuments in Chandigarh. The building is a long, horizontal concrete slab form, 254 meters long and 42 meters high composed of six eight storeyed blocks which bears close resemblance to the Marseilles apartment block one of Le Corbusier's earlier projects. The Secretariat is a simpler and more conventional in form is reproduced two-dimensionally in the very elaborate and distinctive louvered screens design of 'brise soleils'. The whole structure is constructed in 'beton brut' (rough concrete) with Corbusier's signature 'brise-soleil' facade. The rough concrete interposes in the fenestration of the two main facades having more than 200 units of unique design of brise soleil. An endless rhythm of balconies and louvers on its linear facades is punctuated in a subtle way by a deliberately asymmetrical composition of brise-soleil (Figure 6).



**Figure 6.** Corbusier's signature 'brise-soleil' facade in the Secretariat, Chandigarh.

## Role of Shading in Climatic Control and Energy Conservation in Buildings

In warm and tropical climates excess solar gain may result in high cooling energy consumption. The most important passive cooling strategy, regardless of mass, is shading. Shading is like putting a hat on the building. Givoni analysed the efficiency of various types of fixed shading devices in different orientations and concluded that in all orientations, horizontal shading is more effective than a vertical one. Other advantages of horizontal projections over vertical projections are; (i) vertical device is not applicable for shading the whole length of facade (ii) vertical device reduces daylight penetration more than horizontal projection (iii) vertical projections will reduce the extent of external view (Givoni, 1976). The criteria of shading for various climatic zones are given in Table 1.

**Table 1.** Criteria of Shading for Various Climatic Zones.  
(Bansal, Sodha & Kumar, 1988)

Climatic zones	Requirements
Hot and Dry	Complete year round shading
Warm and humid	Complete year round shading, but design should be made such that ventilation is not affected
Temperate	Complete year round shading but only during major sunshine hours
Cold and cloudy	No shading
Cold and sunny	Shading during summer months only
Composite	Shading during summer months only

Kumar, Garg and Kaushik evaluated the performance of solar passive cooling techniques such as solar shading, insulation of building components and air exchange rate. In their study they found that a decrease in the indoor temperature by about 2.5°C to 4.5°C is noticed for solar shading. Results modified with insulation and controlled air exchange rate showed a further decrease of 4.4°C to 6.8°C in room temperature. The analysis suggested that solar shading is quite useful to development of passive cooling system to maintain indoor room air tempera-

ture lower than the conventional building without shade (Kumar, Grag & Kaushik, 2005). In a research conducted at Division of Energy and Building Design at Lund University by Rosencrantz investigated the performance of various internal and external shading devices in offices compared to outdoor measurements by using the simulation software ParaSol version 2.0. ParaSol is a dynamic energy and solar transmittance simulation software for comparison of various solar shading devices. One study showed that both the cooling load and the annual cooling demand could decrease by a factor of two by using external solar shadings. For internal solar shadings the cooling load and the cooling demand decreased only by one third. The general conclusion of this study is that external shadings are much more efficient than internal shadings. This can also affect the design of the HVAC-system, leading to smaller installations (Rosencrantz, 2005).

### **Solar Shading: A Step Towards Environmental Sustainability**

Nowadays there is a growing consciousness about sustainability and green architecture. Fossil fuels are burned to produce the cooling energy demand, which causes green house gas emissions and hence global warming. Research has proved that global warming and climate change are two interrelated phenomena. Hansen and others have shown that recent incidents of extreme weather in different parts of the world are almost certainly the result of global warming (Hansen, Sato & Ruedy, 2012). Hence by implementing energy reduction measures, we can reduce electricity demand and climate-altering emissions. According to Building Services Research and Information Association (BSRIA) definition of sustainable construction as 'the creation and management of healthy buildings based upon resource efficient and ecological principle' (Edwards & Hyett, 2001). Sustainable architecture is an approach to design where building technology is integrated with

the concept design and has the potential to reduce the need for high-tech systems and reduce the energy consumption of buildings. There are many different methods to reduce the cooling load in buildings, but shading of buildings is one of the most simple and sustainable methods. Since air conditioning is recognized as a significant factor in global warming and climate change, shading proves to be both technically and economically viable alternative in most of the climatic conditions of tropical climate where the cooling requirement is around 7-8 months of the year.

### **Conclusion**

Le Corbusier's environmental strategies in architecture in the tropical environment were synthesis of the input he had obtained from the context, his own experiences and ideas. His expressions were modern and his very own, but fitted well with the climate and the society of the place. The Brise-soleil concept is used to prevent a heavily glazed facade from overheating during the summer. Brise soleil is a solar shading technique which minimizes the incident solar radiation and cool the building effectively and hence affect building energy performance. Shading devices such as brise soleil reduces the peak-cooling load in buildings, thus reducing the size of the air conditioning equipment that will run fewer hours and consume less energy. Energy savings can range anywhere from 10 to 40 percent. Mechanical devices such as fans and evaporative coolers can supplement our cooling needs and cost less to install and run the air conditioners. In present day architecture, it is essential for architects and building engineers to incorporate brise soleil as a shading technique in buildings, which would certainly reduce our dependency on artificial means for thermal comfort and minimize the environmental problems due to excessive consumption of energy and other natural resources and will evolve a built form, which will be more climate responsive, more sustainable and more environmental friendly buildings of tomorrow.

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