Heliodon's Use for the Development of Bioclimatic Architecture Projects in for the city of Araras, São Paulo - Brazil

Juliana M. A. do Nascimento
Architect and Urbanist, Araras, SP, Brazil.
juli_nascimento@yahoo.com.br

Helenice M. Sacht
PhD Professor, Civil Engineering of Infrastructure, Federal University of Latin American Integration, Foz do Iguaçu
helenice.sacht@unila.edu.br

Luís Bragança
PhD Associate Professor, School of Engineering, Department of Civil Engineering, Guimarães, Portugal
braganca@civil.uminho.pt

ABSTRACT: Bioclimatic architecture consider that the climate is an important variable in the design process. In this context, environment comfort can be naturally obtained for the users of buildings by using bioclimatic strategies, which depending on the climate, the construction techniques and the type of use. In this process, the sun is an important aspect, leading the architects and engineers to focus their attention towards this parameter. In this way, the sun has been a part of the problem, as well a solution for buildings: too much sunlight will lead to heating and daylighting excessive. Considering these aspects, the main objective of this work is to identify the potential of the use of heliodon by means of a case study, in order to evaluate the bioclimatic strategies for buildings for the climate of the city of Araras, São Paulo State – Brazil, mainly on aspects related to the design of shading devices. The heliodon, used in this sudy, is an equipment that allows the analysis of sunlight effects on physical models of constructions or urban design, aiming the reproduction of the actual direction of sunlight in relation to a building. As a results, the heliodon have shown to be a reliable tool for architects and students to be used in the development of projects in bioclimatic architecture because it allows the visualization and calculation of solar effects at the window, buildings or urban design, showing the solar patterns, insolation and shadings effects in the buildings for clear sky conditions.

Keywords *Bioclimatic Architecture; Heliodon; Insolation, Shading devices.*

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1. INTRODUCTION

The architecture has sought throughout history the development of environmental control tools that can provide shelter and comfort for the man, and the climate of each city has been the determining factor in defining the used architectural concepts, materials and construction techniques. In this way, the study of climate and its relation to the design practice is increasingly becoming a differential in the architectural field.

There are different terms related to bioclimatic architecture as Green Architecture", "Ecological Architecture", "Bioconstruction", "Bioclimatic Architecture", "Eco-Efficient Architecture" and "Passive Solar Architecture." There are also different ways of relating architecture with the environment by using similar or close meanings, and they are directly related to the sustainable architecture subject.

In the context of bioclimatic architecture, there are two major parameters: (i) a multidisciplinary approach that requires the development of efficient projects and (ii) its insertion into the sustainability subject, searching an efficient passive design. In this way, is necessary to understand that there is not a perfect solution and this concept can be applicable to all situations. However, numerous mechanisms can be selected in order to find an appropriate solution for a given problem (Lanham et al, 2004), and this will give birth to a more sustainable architecture.

Considering these aspects, the study of strategies for bioclimatic architecture is extremely important to the current context of buildings and urban environment. In this context, the design and use of shading devices in buildings is highlighted since an adequate design can maximize shading during summer while allowing direct sunlight and heat gain during the winter. For the hottest climates, the need for shading throughout the warm season generates the greatest energy savings.

In Brazil, the knowledge of solar geometry is critical for engineers and architects once the most part of the territory has warm summers with long periods of sunshine, having the shading as one of the most suitable bioclimatic strategies. In this way, the solar protections are used when direct solar radiation is not desired within the environment. The design of the protections (or brises) requires knowledge of the movements of the Sun and Earthand its effects in the eye of the observant, that can be described as a point, a line, a plane as a wall or window or volume (in the case of a building) (Lamberts et. al, 2011). Thus, to developed this type of study, an equipment called Heliodon can be used in order to simulate the "apparent movement of the sun" (Fig. 1).

Figure 1. Heliodon

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Reference: Heliodon - Simulador da Trajetória Solar, 2014.

Solar radiation can be understand as a short electromagnetic wave, responsible for the energy on the planet because is their main source. The elliptical path of the Earth around the Sun, with the rotation of the earth, determines the variations in the intensity of radiation throughout the year and during the day, respectively.

Insolation study is one of the most important aspects of the thermal comfort of a building. In this context, the Heliodon, that is an equipment for the test of sunlight effects on physical models of constructions or urban design that reproduces the actual direction of sunlight in relation to a building, can be used. The Heliodon can be considered as an useful analysis tool of insolation in architectural projects. the is. In this study, an equipment available in Laboratory of Environmental Comfort of University Center Dr. Edmundo Ulson - UNAR was used, and it allows the observation of apparent trajectory of the sun in the desired latitude in significant periods of the year, corresponding to the spring and autumn equinoxes, and the summer and winter solstices.

Thus, the main objective of this work was to identify the potential of the use of Heliodon for the study of bioclimatic strategies for buildings considering the climate of the city of Araras, countryside of São Paulo State, Brazil, mainly on the aspects related to the design of shading devices.

2. METHODOLOGY

In this work, the study of insolation, performed with the use of Heliodon, followed the steps herein presented: (i) study of the area of buildings recently constructed in the city of Araras/São Paulo; (ii) idealization and construction of the models; (iii) tests of the models by using the heliodon and (iv) analysis of results.

2.1 Survey about residential projects approved in the city of Araras-SP

A survey was carried out in order to obtain average building area for new constructions in the city of Araras. Later, this data was used to simulate the average building area in heliodon. According to the obtained results, among 100 the new constructions sites found in the city of Araras, 76% were single-story and 24% of two-storey. The distribution of types by number of pavements and bedrooms (1B, 2B, 3B and 4B) is presented in Figure 2.

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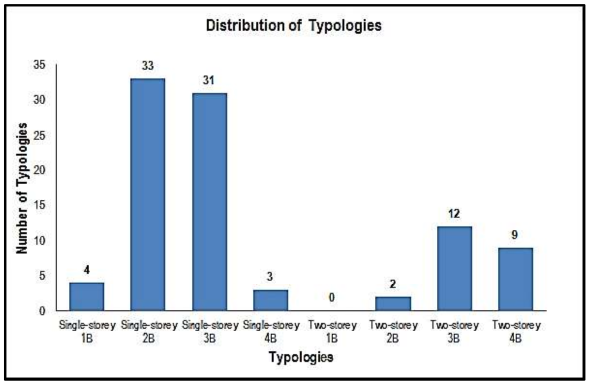

Figure 2. Distribution of typologies by number of bedrooms.
B= Bedroom

For single-story typologies, 15% of the data were discarded, which corresponds to 11 typologies, considering the extreme values of areas (higher and lower than its average). Then, an average area of 137.78 m^2 was considered in the simulation, as shown in Figure 3.

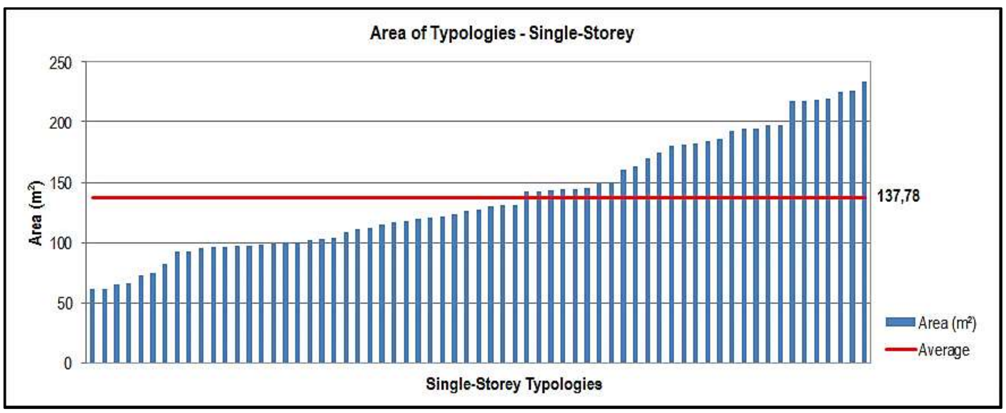

Figure 3. Average area of single-storey typologies.

As 56% of typologies are rectangular, this format will be used in the simulation of the models. For the two-storey typologies, 10% of the data were discarded, which corresponds of 2 typologies. In this case, the larger area ratios were discarded since they are above of the data average. Thus, an average area of have 295,47m^2 was used in the simulation of the two-storey buildings, as shown in Figure 4.

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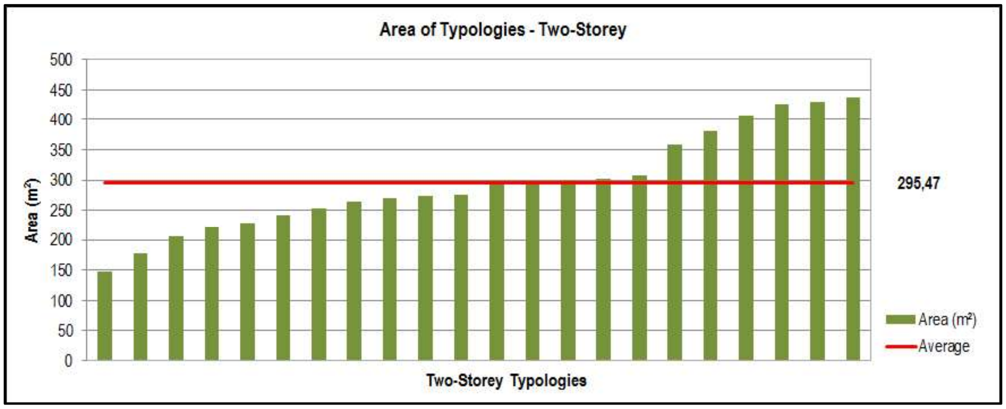

Figure 4. Average area of the two-storey typologies.

2.2 Idealization and construction of the models

For the construction of the single-storey and two-storey models, with the respective areas of 137.78 and 295.47 m², it was taken into consideration the minimum area of a residential lot for Araras, that should present, according to the Urban Master Plan, the dimensions are 10m x 25m (250m²). Also, the buildings should present 1.50m on the sides and 4.00 m of front setback.

The size of each model was based on the geometry of the Golden Rectangle (Fig. 5), that can be obtained by drawing a perpendicular line to the longer side of the rectangle, obtaining a square with sides of the same extent as the lower side of the original rectangle, and another straight rectangle with the rectangle proportional to the original measurements.

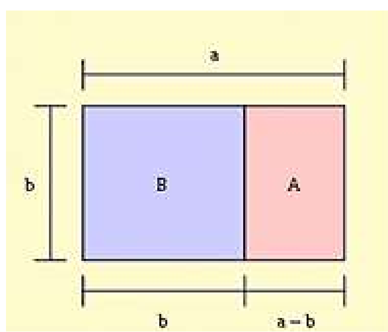

Figure 5. Golden Rectangle.

According to the golden rectangle rule, "b" is equal to 7.00m, obtaining a 'B' equal to 49.00m² (i.e., 7 x 7), and "A + B" = 137.78m², so "A" is equal to 88.78m². Thus, "a" is equal to 19.68 meters for the single-story model,. That is, the first model of deck should be 7.00 x 19.68m.

The model with two floors should have a total of 295.47m². Considering the two floors, each one must contain 147.73 m². If "B" is equal to 49.00 square meters, then "A" is equal to 98.73 meters (i.e., from 147.73 to 49.00). Thus, "a" is equal to 21.10 meters. Therefore, the model should floor 27.00 x 21.10 meters in each floor. In this study, a scale model of 1: 100 was used in the construction of the models, as shown in Figure 6.

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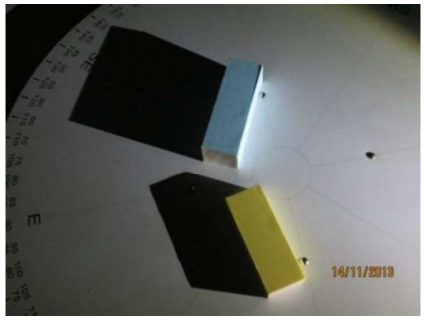


Figure 6. Models of single storey type (yellow) and two foors (blue).

3. RESULTS

In this work, the simulations in Heliodon were made for the following days: June 21 (8:00/12:00/16:00 hours) (Winter Solstice) and 21 December (8:00/24:00/16:00) (Summer Solstice), and the solar orientations vary during the tests. Thus, this variation was analysing by photographing them.

3.1 Use of the Heliodon

The insolation patterns are presented in Tables 2 to 6. During the image capture, there was a problem and some of specific hours data were corrupted and could not be used. However, the obtained images provide happens better understanding of insolation in typologies, considering that for each orientation were simulated three different schedules. For June, Heliodon was configured as shown in Table 1. The images obtained were presented in the Tables 2 and 3. For December, Heliodon was configured as shown in Table 4 and the images obtained were presented in the Tables 5 and 6.

Table 1. Configuration of Heliodon for June 21 in Araras, SP.

Schedules	8:00	12:00	16:00
Solar Height	15.82	44.15	15.80
Azimute	55.7	0.0	55.7

Table 2. Simulations on Heliodon of single-storey on 21 June.

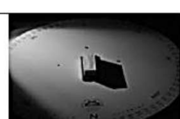
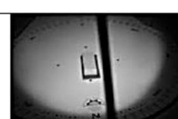
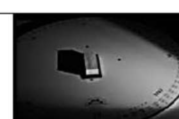
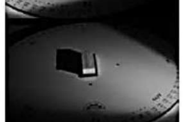
Solar Orientation \ Hour	8:00	12:00	16:00
North			
East			
South			-
West			

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Table 3. Simulations on Heliodon for 2 floors model on 21 June.

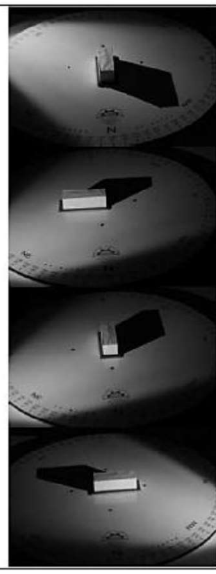
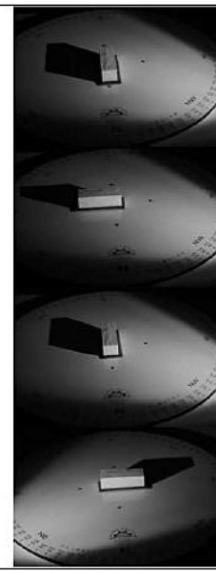
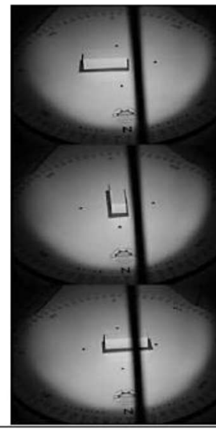
Solar Orientation \ Hour	8:00	12:00	16:00
North		-	
East			
South			
West			

Table 4. Configuration of Heliodon for December 21 in Araras, SP.

Schedules	8:00	12:00	16:00
Height solar	28.02	88.96	35.14
Azimute	78.7	179.2	103.7

Table 5. Simulations on Heliodon for single-storey modelon 21 December.

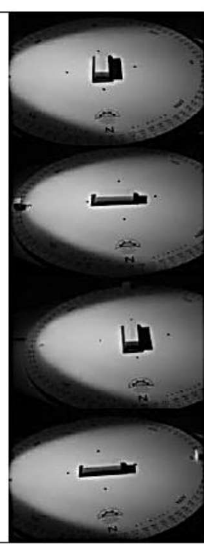
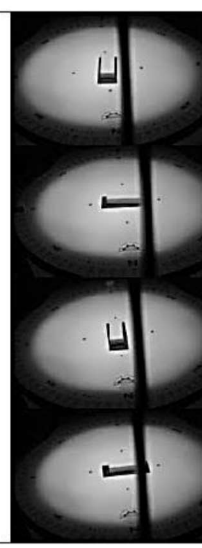
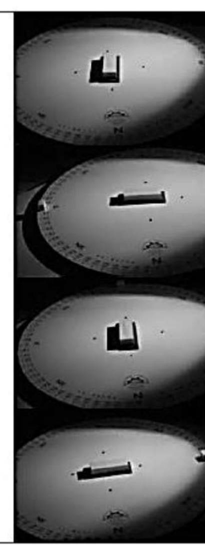
Solar Orientation \ Hour	8:00	12:00	16:00
North			
East			
South			
West			

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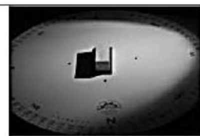
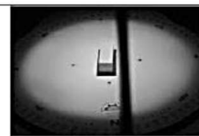
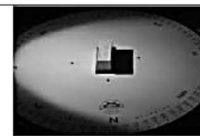
Table 6. Simulations in Heliodon for 2 floors model on 21 December.

Solar Orientation \ Hour	8:00	12:00	16:00
North			
East			
South			
West			

3.2 Indication of solar protection devices

The design of the solar protection devices that forms the elements of the building's facade should be done during the architecture design. The study of their effectiveness is not always verified, compromising the the comfort and sustainability of the building . So, it is necessary to evaluate the apparent trajectory of the sun at every point on the planet and then design the solar protection devices in order to not allow the sun radiation entry into the building in warm periods and allow the entry of radiation when it is desirable. The study of the solar protection device, in this case, the brise soleil type, and its dimensions is performed in function of desired efficiency. Therefore, a brise will be considered effective when preventing the entry of sunlight in the desirable period.

In order to obtain a more detailed study is always important to use the solar chart. By the SOL-AR software, for example, it is possible to achieve the solar chart of the specified latitude, aiding in the design of shading devices through graphical visualization the angle of projection desired on the protractor of angles, which can be plotted for any orientation angle. Figure 7 shows the solar chart the city of Araras.

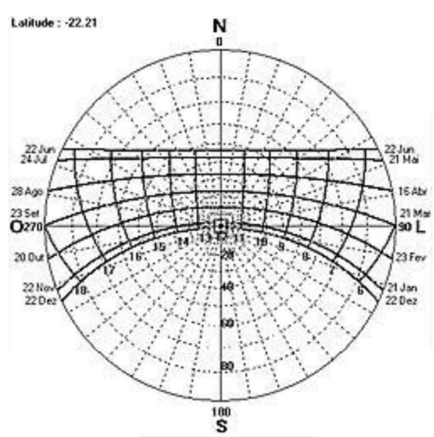


Figure 7. Solar Chart of Araras,SP city. Reference: SOL-AR 6.2 Software (2014)

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Table 7 presents the types of brise soleil that can be used, or constructed, in the buildings, according to the face of the façade for the main directions (Northern, Southern, Eastern and Western) for the latitude of Araras (South Hemisphere).

Table 7. Type of shading devices for buildings according to solar orientation.

Face of the terrain	Brise soleil type	Observations
Northern	Horizontal	This device provides shading and may be composed of a single element or multiple small components.
Southern	Indifferent	For this solar orientation occurs low incidence of light to Araras, requires practically no brise soleil, unless it is for aesthetic reasons.
Eastern	Horizontal, Vertical or mixed	The use of horizontal brise soleil occurs when is wanted protection for a certain schedule, because usually in the early morning the radiation is desirable for the morning sun. The vertical brise soleil completely covers the aperture, and the mixed brise soleil includes both vertical and horizontal.
Western	Vertical or mixed.	The vertical brise soleil is efficient to protect openings positioned on the eastern and western directions, and if is movable the efficiency is even higher. In the case of being mixed, includes the characteristics of the horizontal and vertical brise soleil.

The shading of the northern façades includes horizontal elements. Using this type of device it is possible to prevent solar gain in the summer, allowing the entry of radiation in the winter.

The ideal is to obtain the compatibility of the protection elements of the northern solar orientation with the eastern and the western, when the openings are adjacent. In this case, for instance, the horizontal brise soleil placed in the eastern should be extended and in the western should be introduced vertical elements. The protection elements also should take care for the eastern and western to the solar orientation northern once to the permanent environments with glazing oriented to north receive large amount of solar radiation.

The southern façade receives low incidence of radiation (South hemisphere) thus practically, is not necessary to use the brise soleil, unless you desire a similar aesthetic effect to other facades. If the option is open glazed openings to heat up the environment during the winter, this orientation is not a correct option, instead it shall be well insulated and have few glazings.

To shade the east facade the horizontal brise soleil are recomended. As in most cases it is not intended to obtain the total shading of the façade (but in a certain schedule and specific dates, for example, in summer), it not make sense to use a vertical protection element, because the same provides shading from the beginning of the sunrise, period that the usually radiation is desired.Therefore, the objectives of the sun protection element should be analysed.

For the shading of the west facade a pivoting vertical brise soleil, positioned across the all glazing height, is recommended in order to protect the building especially during the hottest months of the year. On the other hand, during the winter and during the day, it is ideal that the element could be deactivated to allow the entry of solar radiation and the consequent passive heating of the environment.

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4. CONCLUSIONS

It was observed that the heliodon is a very useful tool for analysis of the solar trajectory for the study of architectural project. Some recommendations can be made, for example, in relation to the use of equipment: is ideal that the North be always visible in the model; for evaluating, the user should take pictures always in the same position, or with the use of a tripod, in order to avoid mistakes in their interpretation due to the difference in angles view.

According to the obtained results some conclusions were made in relation the limitations given by the heliodon: the only existing arc, even allowing movement, often gets in front of the shade that need to be photographed (mostly for schedules next noon day), limiting the visualization of it to certain solar orientation and schedules. However, the fact that is a mobile arc, that rotates with the base and allows the movement of light to any schedule, allows a good amount of analysis.

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