241: Bioclimatics Strategies and Principles of the Sustainable Construction in the Recovery Center of Degraded Areas of the University of Brasilia - Brazil

LIZA ANDRADE
LASUS/FAU/UNB

Abstract

The transference of the country's Capital from the coast to the relatively isolated and demographically empty center of the country, which had a subsistence economy, brought a new social-economic structure to the region, with great impact and profound modifications of its urban-agricultural structure. The native vegetation covering of the Cerrado Biome was removed and the topography was modified. This brought such consequences as erosion, islands of heat, arid landscapes and gigantic whirlwinds, besides the reduction of the rich local biodiversity and water resources. The land in that region destined for the Recovery Center of Degraded Areas (CRAD) building, which was part of the expansion of the southern extremity of the Campus of the University of Brasilia, has relatively well preserved native vegetation because of the resilience of the Cerrado. This was taken as a guideline of our architectonical proposal, which focuses strongly on regenerative processes. Other aspects that conditioned the project were the predominant wind direction and the vegetation's constant solar exposure needs. The thermal behavior was verified through simulation with ECOTEC software. The present article aims to demonstrate the procedures and guidelines applied in the building's design which were based on sustainable construction and bioclimatic strategies.

Keywords: energy comfort, bioclimatic strategies, sustainable construction

1. Introduction

The Cerrado Biome occupies the central region of the country and is the second biggest Brazilian biome, with an area of approximately 2 million square kilometers, which encompasses 22% of the country's territorial extension. It is the world's richest savanna in terms of biodiversity, accounting for 30% of Brazil's diversity (Barradas, 2007).
However, since 1960, with the transference of the federal Capital to the central plateau and the opening of a new highway system, huge areas of Cerrado were lost to agriculture and cattle raising, replacing a so far almost untouched biodiversity. Thus, the demographical emptiness of the subsistence economy, also brought a new socio-economical structure to the region, with great impact and modifications in its urban-rural structure
According to Felfili [1] from 1954 to 1998, 335.132 ha of the original vegetation of the Federal District were chopped off, which means 57,65% of its total area. Also, the author states that loses for the Cerrado *sensu stricto* were 73,80%, 47,20% for the forests and 48,13% for the fields. Therefore, only around 25% of the original Cerrado *sensu stricto* of the Federal District still remain. Due to the accelerated process of occupation, at least 30% of the original species were extinct locally.
The removal of the vegetal covering and the modification of the original topography in the urban areas had, as consequences, environmental impacts such as erosion, islands of heat, arid landscapes and gigantic whirlwinds, besides the reduction of the rich local biodiversity and water resources.
The native vegetation of the terrain destined to the Recovery Center of Degraded Areas (CRAD), inserted in the expansion of the southern extremity of the University of Brasilia's Campus, has relatively well preserved native vegetation, due to the resilience of the vegetation of the Cerrado *sensu stricto*.
The Cerrado *sensu stricto* is characterized by the presence of short twisted trees, with irregular ramifications, and usually presenting evidences of burnings. The shrubs and subshrubs are scattered, with some species presenting perennial underground organs which allow them to sprout again after burning or being chopped off. During the rainy season, the subshrubs and herbs become exuberant, due to its fast growing.
The Forest Engineering Department of UnB conducted a research of the flowers in the area, aiming to use the remaining trees from the Cerrado *sensu stricto* in the regeneration process and landscaping of the place. The preliminary characterization detected the importance of this portion of the ecosystem to favor the connectiveness between major fragments, called *stepping stones*. (Barradas, 2007).
The Recovery Center of Degraded Areas of the Cerrado Biome (CRAD) of the University of Brasilia which we have designed will be a diffuser and catalyst of initiatives to sponsor actions to recover the biome, both in the private and public scopes. The Center will encompass the mid San Francisco River region, including the water

division in the Federal District, and the states of Minas Gerais and Bahia. The aim is to stimulate the land owners of the region to protect and recover the native vegetation of the San Francisco Basin, prioritizing actions on the Permanent Protection Areas (APP) and Legal Reservations, and spreading the results of the experiences performed in the region.

This way, the fragment of Cerrado within the Campus, where the building shall be constructed, served as an element of orientation to the urban structure of the Scientific and Technological Park and as an inspiration to the landscaping and bioclimatic aspects of the architecture, crossing the two blocks of the building.

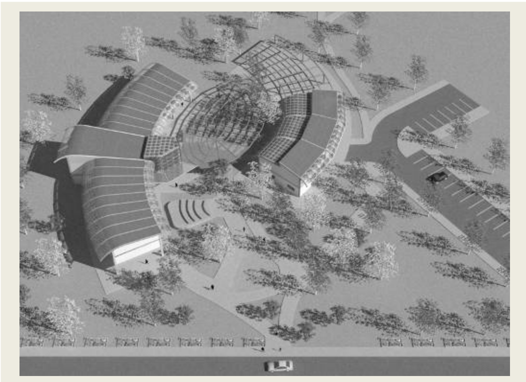

Fig. 1 – Ilustration of a fragment of Cerrado Sensu Stricto incorporated to the CRAD/UNB

Based on a research of the climatological data from Brasília, it was possible to establish some parameters which allow the evaluation of the thermal performance of the buildings when influenced by the specifics of the microclimate from its surrounding exterior.

The evaluation of environmental performance concerning orientation, thermal load and natural ventilation was developed through simulations on the ECOTECT software.The ECOTECT software is not a strong tool for simulating the thermal performance of buildings, but it is very important in the design process.

Later, the corresponding adjustments were made, so that the materials which constitute the constructed surface do not favor the elevation of temperature. Such materials usually have higher thermal capacity and conductivity than the ones found in the natural surroundings

The main objective of the present paper is to demonstrate the procedures and guidelines based on sustainable construction and bioclimatic strategies for the design of CRAD, inserted in the sustainable expansion of the southern extremity of the Campus of the University of Brasilia, in order to future implement the Scientific and Technological Park .

2. Application of the Sustainable Construction Bioclimatic Principles

2.1 Brasilia's Climate

Brasilia has weather conditions similar to the Tropical Wet during the rainy period and to the Tropical Dry, in the dry season. Due to its continentality and altitude (Central Plateau 1000 meters above sea level), the daily temperature variations are remarkable, especially in the dry season.

The wind flux has different directions according to the season. In the dry season (from April to September), the East wind prevails, with a secondary one to the *southeast direction (*September) and its velocity usually ranges from 2 to 4 m/s. In the wet season (October to April), the East wind prevails, with secondary ones to the *northwest* (December) and *northeast* (January) directions and their velocity usually ranges from 2 to 5 m/s. The Northwest quarter presents the highest incidence of winds and, in January, the prevailing winds vary between the Northeast and North quarters. The Northeast wind is the second most frequent during the year, except in December, when the secondary wind is the North. The absence of wind occupies over 33% of the year, being more frequent in the hot and humid period. The three prevailing directions, East, Southeast and Northwest were considered for the analysis.

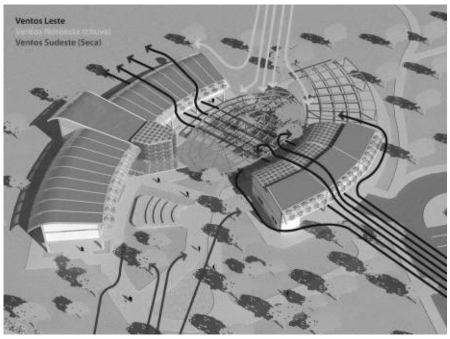

Fig. 2 – Direction of the prevailing winds in the building

However, during the whole year, there is a predominance of the East direction (January to April and September to November). These have conditioned the openings to obtain cross ventilation as well as the necessary protection to avoid dust filled wind.

Figura 3 – Evaporative Cooling with microsprinklers in the green brises - soleil

The maximum temperatures don't go over 29º C, when humidity is over 80%, at any time of the year. In the dry period, the relative humidity varies between 22% in August, and 42%in May. In July, all the occurrences of temperatures above 29º C happen at a humidity level below 30%. In the hot and humid period, the relative humidity varies between 34,4% in October and 49% in December. The main bioclimatic strategies recommended for the cold are thermal mass and passive solar gain. During hot periods, ventilation, thermal mass for cooling and evaporative cooling are the indicated strategies. The use of artificial systems is necessary only in 0,99% of the hours in a year, in the case of discomfort due to cold, and in 0,08%, in the case of heat. (ABNT NBR 15220)

Table 1 – Recommended bioclimatic strategies for Brasília

Comfort	Discomfort	Bioclimatic strategies [%]	
41,2 %	COLD 36,6 %	Thermal mass for heating	31,3
		Solar passive heating	4,37
		Artificial heating	0,99
	HEAT 22,2 %	Ventilation	21,2
		Evaporative cooling	8,38
		Thermal mass for cooling	8,29
		Air conditioning	0,08
OBS.: The percentage of discomfort by heat or cold doesn't correspond to total of strategies, as the percentage of these consider also overlaid zones.			

2.2 The design of the external area as a conditioner of the microclimate

The bioclimatic principles were applied upon two focuses: the design of the building and the design of the surrounding exterior. The architectural piece is inseparable from its surroundings, not only physically, but also conceptually, once the architecture is conceived from the location of a concrete site.

The open areas were designed as mediators between the outter climate and the interior environment from the delimitated semi-public space (pergola square).

The features to be worked in the semi-public space were divided in four major categories: the shape, the design, the surface and the surroundings. While designing the semi-public space according to a bioclimatic treatment, three characteristics of the urban environment were considered in order to allow the thermal exchange between the surroundings and the building to happen: the surroundings, the materials and the building surfaces. [2]

a) The surroundings are the closest urban space. The urban surface presents a rather more rugged aspect than the non-constructed areas, which causes more friction between the surfaces and the wind that go through it.

b) The materials which compose the urban surfaces have a much higher thermal capacity and are better conductors than the materials from the non-constructed surfaces.

c) The building surfaces act as reflector and radiators, amplifying the incident solar radiation effects.

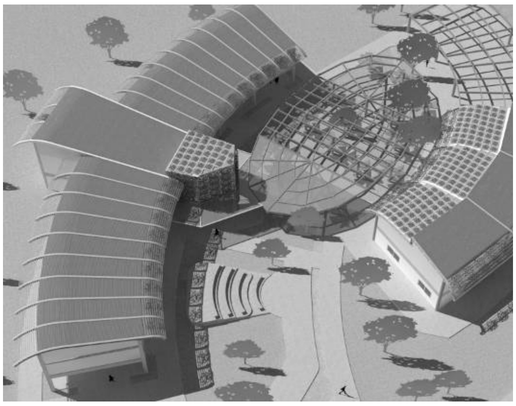

Figura 4 – Treatment of the materials which compose the building and the semi-public space.

2.3 Sustainable Construction and Bioclimatic Techniques

The bioclimatic strategies applied to the building design were based on the Brazilian Norm (NBR 15220-3 / ABNT (*Zoneamento Bioclimático Brasileiro*, 2005) for the region of Brasília, regarding the passive acclimatization for heat discomfort: the ventilation (daily and nocturnal) with shadowy mid-size openings, the evaporative cooling and humidification, and the increase in thermal mass. As for the cold related discomfort, elements such as solar gain through high thermal capacity materials were necessary.

CRAD's project was developed to attend the functional development of the program: Block 1 – exhibition space, laboratories, snack bar, administration and classrooms = 1.300m2; Block 2 – vivarium, amphitheater, organic vegetable garden (agro forest) and organic waste compost areas.

Simultaneously to the environmental performance, basic strategies of sustainable development were applied, based on the *"Agenda 21 for Sustainable Construction"* (CIB, 2000), and in researches made by the Sustainability applied to Architecture and Urbanism Laboratory – LaSUS – University of Brasilia. These are: [3] or [4]

Placing Strategies – CRAD's longitudinal implementation, in parallel with the contour lines in order to minimize land removal and take advantage of the native vegetation for shading, cooling and natural gravity drainage.

Optimal Water Use Efficiency – maintenance of the water cycle: increase in the capacity of soil infiltration, through infiltration channels, collection and storage of rainwater.

Evaporative Coling and Internal Environmental Quality – Micronized water vapor on the green shading devices to conduct the cooled air into the building; evapotranspiration system in the external infiltration channels and trees and shrubs as vegetation cover.

Energy Efficiency Strategies – passive climate strategies (ventilation and illumination) with individual equipment and system control, oblong and narrow buildings, WWR calculated sealing, light ceilings, lower and upper extremity openings (for the entrance of cool air and exit of hot air respectively) and nocturnal cooling.
Restriction of Solar Gain – external solar protection, double covering with air mattress and ventilated ceilings; covered or semi-covered sidewalks; large envelope; light or reflecting colors and green roofs. Distribution of the activities according to the use and the solar orientation.
Use of Module Structure and Low Incorporated Energy Materials – structure of the envelope: reforestation wood; construction structure: pre-molded concrete. The external sealing will be made of ceramic blocks.

Fig. 5 – Green shading devices and green facades.

3. Simulation Results

The terrain is exposed to solar radiation all year long, except the western part where there's a predominance of trees in the vegetation. The solar radiation reflected by the buildings is scarce and it doesn't suffer the multiple processes of reflection, only a small part being reflected towards the sky.
The good orientation in relation to the sun, hardly ever matches the orientation in relation to the wind. Because of this, the two blocks were positioned transversally in the east-west direction in order to take advantage of the East wind, prevailing during most of the year; and the solar incidence in the vivarium (north-south for direct sunlight). The placement of the openings in this orientation and the regeneration of the native species longitudinally will favor the cross-ventilation.

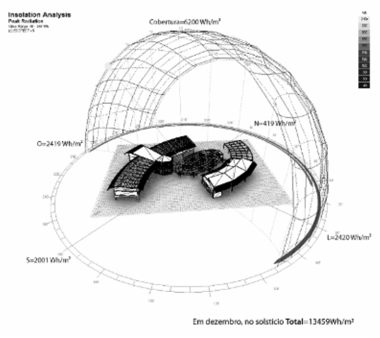

Fig 6 – CRAD Modeling in the ECOTECT software, with total solar radiation in the Summer solstice: North 419 Wh/m^2, South 2001 Wh/m^2, east 2.420 Wh/m^{2}and west 2.419 and 6.200 Wh/m^2 in the envelope, Total= 13.459 Wh/m^2)

The thermal load was diminished by intense shading areas (tree, envelope and brises-soleil) and by the shadow's envelope of pergola.The project presents many different thermal performances, based on the absorbance and the effective emission of the building. These parameters are indicated, respectively, by the natural capacity of the east/west building to heat, through its solar exposure, and to cool through the losses by long wave radiation exchange.
The radiation, absorbed and transformed in sensible heat, is dissipated by convection to the surrounding air, generating an air temperature increase, which, in turn, is mitigated by the intense shadowing provided by the vegetation (preserved and regenerated) and by the pergolas of the central square and other shading devices designed for the CRAD.

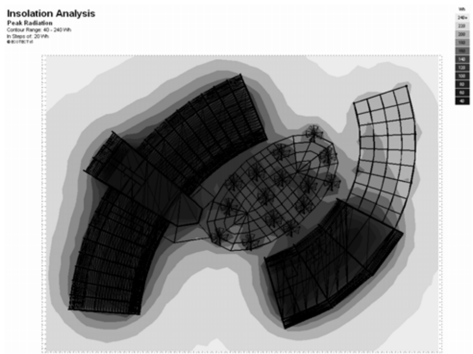

Fig. 7 Levels of radiation in the building and in the surrounding semi-public space. ECOTECT software.

The north façade receives solar radiation all day long, even during the winter solstice (21/06), corresponding to the coldest period. During the equinoxes (22/03 and 22/09), the sun shines from early morning (7 am) to 4:30 PM and in the summer solstice, the façade receives only two hour of direct radiation in the morning. Thus, the major thermal gains are registered in the winter solstice (21/06) and spring equinox (22/09)
The east façade receives solar radiation all morning, from 6:30 AM to noon, during the winter solstice (21/06), corresponding to the coldest period. There is the need of brises-soleil and/or solar protection from 11 AM to noon. The west façade receives solar radiation from noon on, every month of the year, especially in the summer solstice, when the sun sets past 6 PM, thus generating the need for shading from noon to 5 PM. There is no influence of the neighboring building over this façade.
Using the cloudiness values for each time of the year, the data corresponding to solar radiation

(Wh/m2) in the horizontal and vertical surfaces were obtained. (tables 2 and 3) [5]

Table 2: Radiação solar incidente,utilizando-se os valores de nebulosidade apresentados pelas Normais Climatológicas de1992. Programa Luz do Sol. Adaptado de Roriz (1995)

Months	Cloudiness level	Sky conditions
January	7	Partially cloudy
February	7	Partially cloudy
March	7	Partially cloudy
April	6	Partially cloudy
May	5	Partially cloudy
June	3	Clear
July	3	Clear
August	3	Clear
September	4	Partially cloudy
October	7	Partially cloudy
November	8	cloudy
December	8	cloudy

Table 3: *Amount of solar radiation (Wh/m2) over the vertical and horizontal surfaces, according to the orientation. Adapted from Roriz (1995)*

Surface orientation	Amount of Solar radiation Autumn Equinox	Summer Solstice	Spring Equinox	Winter Solstice
0^0	2099	419	3214	7190
90^0	2739	2420	4086	3360
180^0	457	2001	682	611
270^0	2738	2419	4085	3360
Covering	6664	6200	9933	7842
Total	14697	13459	22000	22363

The period when shadowing is necessary, corresponds to the time interval from 11 AM to 5 PM, except from May to July, when the need for shadowing starts at noon, due to lower morning temperatures and the need to passive solar heating.

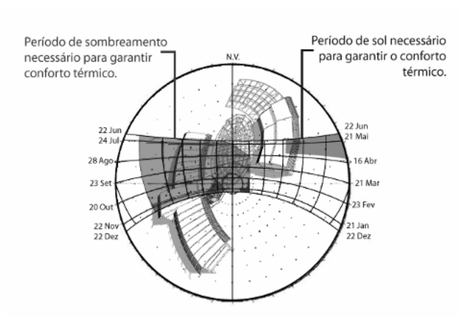

Fig 8. Sun-path diagrama for Brasília, with the necessary shadowing period to guarantee thermal comfort, highlighted in red.

4. Conclusion

The results achieved by the project demonstrate that the analytical and laboratorial methods enable all the buildings in this sector to have favorable natural ventilation, by assessing the urban-climatological consequences regarding the changes in the local wind patterns due to the existing buildings and the new CRAD to be built, thus saving energy by not using the energetic equipment to achieve thermal comfort inside. Also, the harmful effect of pollution is eliminated by the native vegetation, the social relations are valued and the city's population is inserted in a system of pathways and cycleways surrounded by trees, which go through the University's land. The project is abundant in comfortable spaces for permanence, which promote an urban feeling, thus attending the principles of sustainable construction.

5. Acknowledgements

We thank the researcher Walter Mourão from the Sustainability applied to Architecture and Urbanism Laboratory for all the images used in this paper. We would also like to thank CNPQ, Capes and Finatec.

6. References

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