Sustainable recommendations for the faculty of technology of the University of Brasilia - Brazil

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ABSTRACT
The present paper describes the beginning of a sustainable requalification program devised for some buildings of the University of Brasilia, located in the city of Brasilia (latitude 15° south). The Requalification comprehends actions for implementing of old functions with reutilization of the existing building and landscape patrimony, a change in the patterns of consumption, an improvement in energy efficiency and a concern with the alternatives for optimum use of the spaces. In order to achieve environments that are both energetically efficient and adequate to the comfort of the users, the strategies were thought of considering Brazilian Bioclimatic zoning for the region of Brasilia.

1. INTRODUCTION

The city of Brasilia is located at latitude 15°52' south with 1200m altitude and almost 1000 km distant from the sea. It's climate can be classified as Tropical of Altitude where two very distinct seasons can be identified: hot and humid (October to April) and dry (May to September). The average air temperature is 21,6°C. The daily averages are relatively low varying between 14,6°C, in July, and 21,1°C in October, characterizing, thus, a predominance of mild temperatures.
The average relative humidity is 70%. The driest month is August, with 56%. The absolute minimum relative humidity registered is 8% in September.
The main wind is coming from the East during almost all year long with average speed between 2 and 3 m/s.
The solar radiation is of 2600 hours annually. During the summer (21/12 at 12am), the levels of illuminance in the horizontal plan are of 98.000 lux, while in Autumn (21/3 at 12am) they are 101.000lux, both with partially cloudy sky. In winter (21/06 at 12am) with clear sky, we have 96.000 lux.
Table 1 summarizes the bioclimatic analyses of Brasilia's climate and the indicated strategies. The hygrothermal conditions remain within comfortable limits during 41% of the hours of the year. The percentage of discomfort caused by cold is higher than that caused by heat due to night conditions.
The main bioclimatic strategies indicated for the heat are ventilation, thermal mass and evaporative cooling. The use of air conditioning is necessary only in 0,08% hours of the year. (Table 1)

Table 1: Recommended bioclimatic strategies

Comfort	**Discomfort**	**BIOCLIMÁTIC STRATEGIES [%]**	
41,2 **%**	COLD 36,6 %	Thermal mass	31,3
		Solar passive heating	4,37
		Artificial heating	0,99
	HEAT 22,2 %	Ventilation	21,2
		Evaporative chillness	8,38
		Thermal mass	8,29
		Air conditioning	0,08

The building from the Faculty of Technology (FT) of the University of Brasilia, built in the seventies, is composed of three similar blocks situated in different levels and connected by covered pathways, which result in a set of pleasant spaces. (Fig. 1, 2)
Each block is composed of two stories. On the top floor, which covers the ground floor only partially, are the remaining professor's rooms. The biggest part of the roof is plane, made of concrete slab covered with metal plate. A program of sustainable requalification was proposed for this building. The concept of sustainable requalification is directly linked to the recovery of degraded areas and damaged elements, and the improvement of the environment quality, creating, therefore, a renewed interest in the collective space and the use of open areas.

Figure 1: Faculty of Technology, University of Brasilia, aerial view

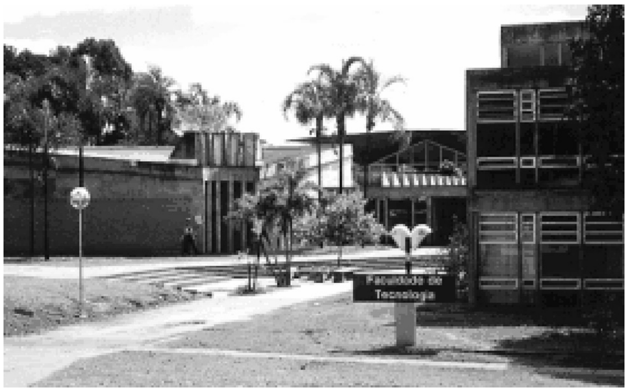

Figure 2: Faculty of Technology

It was proposed the beginning of a sustainable requalification program for the building.

2. METHOD

The evaluation was developed, at first instance, through a sensorial analysis organized as a checklist, containing categories and subcategories of performance such as thermal, luminous and acoustic comfort. which adequateness values were credited.

Thus, indicators for the constructed environment were defined (directly related to the environmental performance results) according to its use, the needs, the local climatic conditions and the characteristics of the architectonical project - given its great morphologic diversity. For the **Stage of Planning** four environments were selected. Fig. 3, 4, 5, 6.

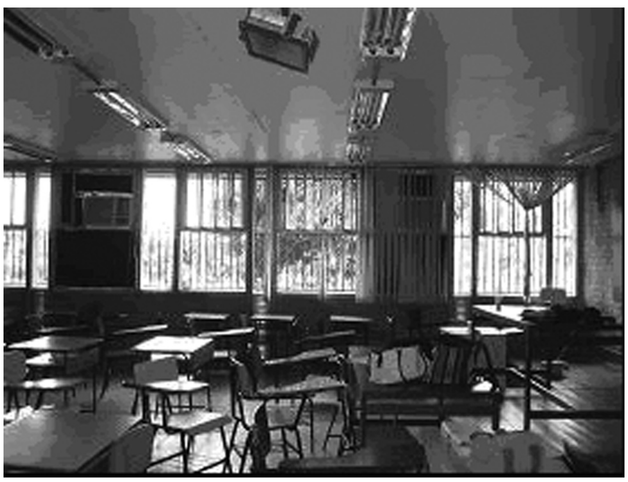

Figure 3: Classroom located on the ground floor with openings directed towards east.

Figure 4: Professor's room on the ground floor – west orientated

Figure 5: Professor's room on the top floor (east)

Figure 6: Professor's room top floor (west)

The selection aimed to embrace the main facades of the building. (Fig. 7)

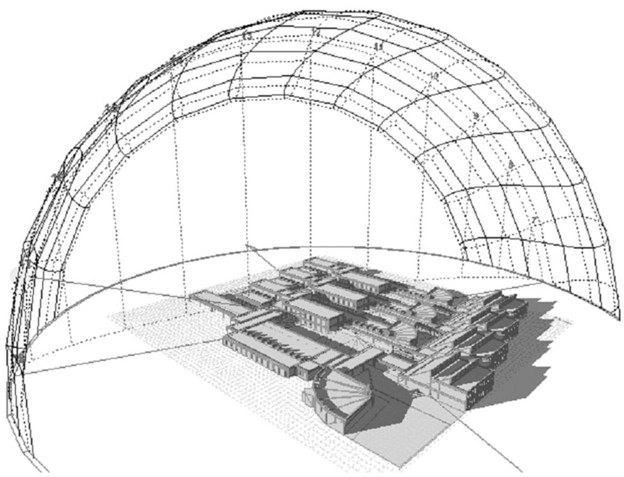

Figure 7: The sun path during the year and the shadows on 23rd of September at 5 pm. (Ecotect)

In the **Stage of Verification***,* the sensorial analysis with the above mentioned indicators and the analysis of the ventilation (according to prevailing winds) were included. Also, measurements and simulation of selected environments of the building were performed. The survey, the evaluation and the definition of indicators were developed by checklist of the covering materials (considering each selected space as a typical space of the building) and a sensorial appreciation of the thermal, acoustic and luminous comfort of the environment in question. The checklist of *the Components and Materials of the Typical Spaces* identifies the main external walls (and its orientation), types of covering, lining and floor, as well as the equipment and furniture found there, taking into account its characteristics according to surface material, window frames, doors, colors and types and size of the openings.
Thermal comfort was analyzed using information about the temperature, the ventilation, the humidity, solar radiation and heat gains through walls, ceilings, equipment and occupation.
The luminous comfort was assessed according to the intensity and distribution of illuminance and luminance of natural light as well as the existence and quality of the external visibility.
The acoustic comfort was evaluated by the type and localization of the noise (external and internal) and the reverberation.
The measurements of thermal variables were performed with measures of temperature (external and internal), humidity, and superficial temperatures throughout two days (one with clear sky and other cloudy), at 9 am, 12 am, 2 pm and 5 pm.
For the simulations two softwares were used: ECOTECT for analysis of thermal performance and RAYFRONT for analysis of the natural illumination (Fig. 8, 9).

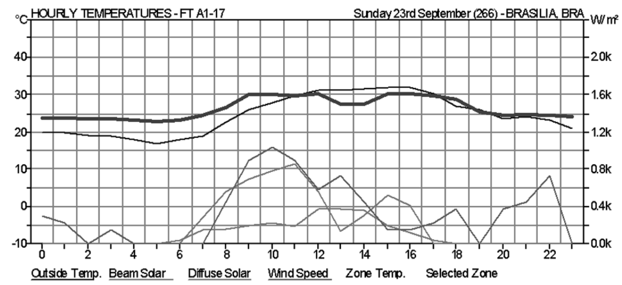

Figure 8: Example of the simulations made with ECOTEC. Temperatures in the classroom on 23rd of September.

Figure 9: Example of the simulations with Rayfront. Natural illumination in the classroom.

3. ANALYSIS OF THE RESULTS

3.1 Ventilation performance

The predominant wind all year long is the East wind. In the dry period (winter), there is a secondary direction, although less frequent: the Southeast wind. In this period the predominant speed of the wind varies between 2 and 4 m/s. (Fig. 10)
In the humid period (summer) the secondary winds are Northwest and the Northeast with speeds varying from 2 to 5 m/s. The absence of wind takes 33% of the year, which is more often in hot and humid months. During the analysis, three prevailing winds were considered: east, southeast and northwest. (Fig. 6)

3.1.1 Classroom, ground floor, east (Fig. 3)

It receives the East and Southeast wind directly, and does not receive the Northwest wind. The crossed ventilation is possible through zenithal window. However, the windowpanes for ventilation are placed at 1,60m above the ground, so the sitting person does not feel so much the effects of the breeze.

Figure 10: The building and the prevailing winds

3.1.2 Professor's room, west (Fig. 4)
This facade doesn't receive any of the analyzed wind directly because the building itself works as a barrier. The Northwest wind is canalized by the corridor formed by the outside walls of the building, making the direct entrance of air into internal spaces all the more difficult.

3.1.3 Professor's room, top floor, east (Fig.5)
It receives the East wind directly, but the crossed ventilation is only possible with the door open. However, the type of window with a fixed windowpane at the bottom and a ventilation flap at the top, hinders the incoming wind.

3.1.4 Professor's room, west (Fig. 6)
The Southeast and the East winds come indirectly in this room when the door is open. The room's narrow window, partly with a fixed windowpane and partly with a ventilation flap.

3.2. Natural illumination performance
The small distance between the neighboring blocks of the building project shadows in the rooms. West orientated rooms (Fig. 4 and 6) have tall and narrow windows with azimuth of 200° that prejudice even more the entrance of natural light.
The shape of the openings doesn't contribute to a uniform and efficient distribution of the natural light, once they are located only in one end of the room. This ends up bringing direct sunlight into the room, which dazzles people. In the east side, the openings are larger (Fig 3 and 5), promoting high incidence of solar radiation in the morning, which provokes excessive and dazzle strong contrasts on the work surfaces.
In other periods the levels of illuminance are constant, however, with average values under the 300 lux, value established for the classrooms by the NBR 5413 [3].
The existence of a Zenithal opening (shed) in the classroom, at the top opposite to the side opening, don't not raise considerably the levels of illuminance throughout the period in which the measurements were made.
The east orientated openings receive all the solar radiation directly in the morning having high levels of illuminance. The west orientated rooms (Fig. 4 and 6) present smaller levels of illuminance in the morning and the display of the side openings hinders a greater distribution of the lighting.

3.3 Thermal performance
The sensorial analysis and measurements took place only in November. Therefore, computer simulations for the equinox and the solstice were made in order to verify thermal performance in other seasons.

3.3.1 Classroom, ground floor, east (Fig. 3)
The classroom has window with 60% WWR and the external horizontal shading device of 90 cm.
The internal temperatures are within the limits of thermal comfort in the early morning. In the afternoon, however, it reaches 30ºC, which is still lower than the outside temperatures.
Simulations indicated that the shading device is not large enough, allowing heat gains related to the direct solar radiation of approximately 2.000 W/h between May and September (during 8 and 9 am). However, the highest thermal gains (reaching 18 Watts/m^2) result from the room's occupancy (40 people + artificial illumination). The temperatures may increase 4,5ºC due to such factors. Heat gains from conduction reach 1.200 W/h in the hot and sunny days.

3.3.2 Professor's room, west (Fig. 4)
This room has a high and narrow window with azimuth of 200°, which allows little or no direct solar radiation in the room. The temperature levels remained within the limits of thermal comfort (18-29°C). According to the simulations, the temperatures inside the room would be within the limits all year long if it were not for the internal temperature gains of 44 Watts/m^2 that elevate the internal temperature in approximately 6ºC.

3.3.3 Professor's room, top floor, east (Fig.5)
This room has three surfaces exposed to solar radiation: two walls and the ceiling. The east orientated window occupies 65% of external wall. The horizontal shading device of 90 cm is inefficient, as the simulations demonstrated high thermal gains related to the direct solar radiation. When the room is occupied, the internal heat gains reach up to 57 Watts/m^2, elevating internal temperatures by 4ºC. The gains related to the conduction of the opaque

surfaces are relatively low.

3.3.4 Professor's room, west (Fig. 6)

The temperature measurements confirmed the sensorial analysis, detecting temperatures within the limits of thermal comfort in the morning but higher in the afternoon. The simulations demonstrated that there is no direct sunlight in the room during the months of May, June, July and August. The main temperature gain is internal and reaches 55 Watts/m^2 when the room is fully occupied. The gains related to the conduction are relatively low, showing that external opaque surfaces have a reasonable thermal inertia. Internal temperatures exceed the limits of thermal comfort during the hottest and sunniest days. In order to achieve energetically efficient environments that are also adequate to the comfort of the users, a series of recommendations were elaborated based on the results of the sensorial analysis, the measurements and the computer simulations. The recommendations are in accord with the existing Brazilian regulations regarding thermal and luminous comfort. (ABNT, 1992, 2005)

4. RECOMMENDATIONS FOR SUSTAINABLE REQUALIFICATION

4.1 Improvement of thermal comfort

The building posses a relatively good thermal mass which improves its thermal performance. The horizontal shading device is insufficient. Most of the time, the windowpanes do not allow the desired openings to provide ventilation. The internal loads are significant in most rooms. Thus, it is recommended enlarge the shading devices and diminish the building's thermal load whenever. The installation of cooling devices based on evaporation and micro-sprinklers can also be recommended. In order to diminish the ceiling's thermal load we propose the installation of a low weight double-cover, overlaid on the original roof (Fig. 11).

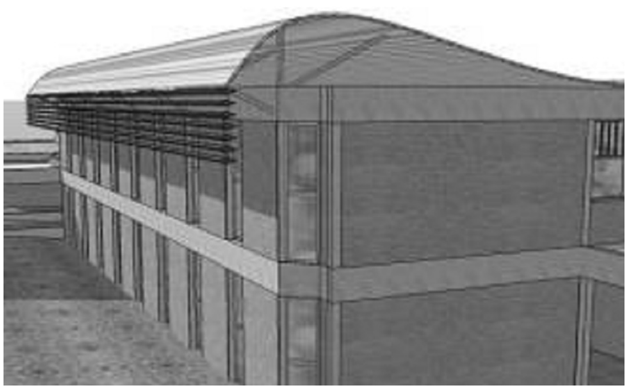

Figure 11: Lightweight cover overlaid to original cover.

On some parts of the roof, the use of green roof can be recommended. The cooling system would use sprinklers located next to windows and classroom corridors - approximately 3 meters high.

4.2 Promotion of the efficiency and sustainability

The promotions of efficiency and sustainability would be achieved in various fronts: Water efficiency: collect and reuse rainwater; Energy efficiency: diminish the artificial air conditioning and lighting and introduce a system of independent light controls and efficient lights; Accessibility improvement: use anti-sliding materials on ramps and stairs.

4.3 Promotion of the acoustic comfort

The acoustic comfort can be promoted by using absorbing materials and acoustically adequate linings to inhibit long periods of reverberation, which make the understanding of the spoken word difficult.

4.4 Optimal use of natural light

The optimal use of natural light can be achieved with elements to redirect the direct solar light and the efficient distribution of diffuse light.

Another suggestion is the replacement of the ordinary glass present in the openings by more advanced systems in terms of technology. These systems could be fixed or mobile elements, and can provide the same solar protection normally achieved by using external shading devices, thus reducing the building's internal temperatures.

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