Bioclimatic architecture concepts applied to CEFET's building

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ABSTRACT

This paper shows the building of the Intelligent Energy Research Center - CPEI, built at the Federal Center of Technological Education of Minas Gerais (CEFET-MG). This center was conceived with many strategies of bioclimatic architecture in a way to minimize the energy consumption besides improving the thermal gain and luminous comfort. To achieve this purpose many procedures were taken since the beginning of the design stage. The architecture solution is very important to improve the thermal and luminous performance. The orientation of the surfaces, the chosen materials, the colors of the surfaces and the architectural elements were fundamental. The existence of a zenithal dome in the center of the building besides many glass windows and doors made a luminous environment. The purpose of the building is to use bioclimatic techniques that could save energy and give comfort for the users besides given support for the researches in the rational use of energy.

1. INTRODUCTION

Regions with different climates may have to develop comfort indices and standards taking into account specifically the acclimatization of the population, as well as its standard of living and experiences. Many building design strategies, as well as passive and low-energy cooling systems can provide indoor comfort in hot climates without air absorption. The materials of which a building envelope is constructed determine the relationship between the outdoor temperature and solar radiation conditions. Solar energy striking and absorbed at the walls and roof surfaces during the daytime hours, causes an elevation of the indoor average temperature above the outdoors average. Using design details is a better way to control the effect of solar radiation. The response to striking solar radiation is determined by a basic property of the surface: its absorptivity, which depends mainly on the external color of the building and its shading conditions (Givoni, 1998).

The climate for hot-humid regions is such an uncomfortable environment at summer season and it's difficult to ameliorate by design. Most of these regions are in developing or poor countries, which aggravate the systematic research in this kind of weather. The air conditioning becomes a luxury that the majority of people cannot afford. The appropriate building design is fundamental because it could help to save energy and give human comfort.

The tropical storms call for heavy construction systems (high-mass building). At summer season occurs a significant diurnal elevation of the ambient vapor content with the rising temperature. The discomfort is inevitable and the design objective is to improve the comfort of the inhabitant besides reduce the energy consumption for cooling in summer.

The main design objectives in hot-humid regions can be: Minimizing solar heating of the buildings; providing effective natural ventilation; preventing rain penetration. The following topics affect these objectives: building layout; orientation of the main rooms and openings; size and details of windows and doors; organization and subdivision of the indoor space; shading of openings and walls; roof type and details; thermal and structural properties of walls and roof; site landscaping (Givoni, 1998).

To design the building of CPEI many of these concepts were taken to achieve the main purpose of using passive systems that could save energy and give human comfort. At winter season at the location of the building predominates a temperate dry weather.

2. BUILDING DESCRIPTION

The building is located at CEFET-MG Campus in Belo Horizonte city (20º South Latitude), Brazil. The chosen place has a deciduous tree with a wide canopy that could provide solar protection of the building at summer season and sun at winter. The topography has accommodated to the level curves making possible to assemble the building with a minimum earth movements (Fig. 1).

The building was planned to be without air conditioning and to rely on natural ventilation. A building layout, that provides good potential for cross-ventilation, is more suitable for public buildings allowing good ventilations conditions. The building has large openable windows enables better natural cross-ventilation and daylighting. The air entering the building through many openings in one room has to be able to flow with minimum restriction through the other rooms. The internal arrangement of room's partitions and internal doors enable airflow through the various rooms of a building. There is potential natural ventilation with any wind direction.

The laboratories are located at the 1st and 2nd floor and the classroom is in the 3rd above them. The wind direction and the solar orientation were studied carefully, as it can be seen in Figure 2.

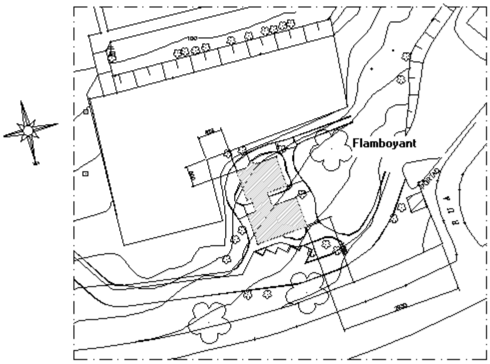

Figure 1: Building implantation.

The wind direction was studied to determine the location of the main rooms during the design stage. To provide optimal ventilation in the building, it is important to catch the predominant wind from the east. To achieve that, the northern facade has external fixed shading devices. It also provides the solar protection against the solar radiation.

To enable independent cross-ventilation to every individual room in the building, each room has at least two large windows, in different walls. The divided glass area among a number of windows spaced along the wall gave a better distribution of light for the same area of glass (Hopinkson, 1963; Hopinkson et al, 1984). The openings are composed by clear glass and fixed venetians blinds, allowing natural ventilation and daylighting.

From the ventilation viewpoint the highly effective height facilitates the chimney-effect in natural ventilation, especially during windless hours (Givoni, 1998). The chimney-effect ventilation was achieved by fixed vertical Venetian blinds on the top of the central corridor (Figs. 3 and 5).

The bilateral sidelighting obtained by clear glass is highly transparent and very effective for

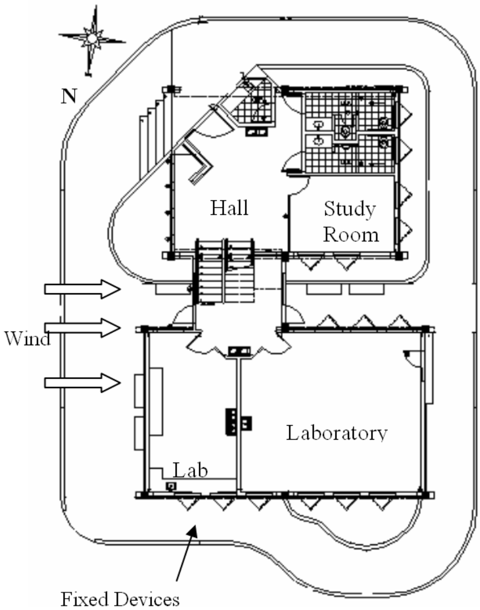

Figure 2: Plan of building - 1st and 2nd floors.

supply the daylighting needs. Every room has many openings in different walls improving the illuminances levels (Fig. 4).

The skylight by a dome in the center of the building adds more daylight (Fig. 5).

Effective prevention of solar heating of the building is critical for providing indoor comfort (Lam, 1986; Lamberts et al, 1997). The solar radiation load was controlled by fixed vertical shading devices with overhang of the openings and the light external color of the opaque walls. For northern and western windows the vertical fins extending above the windows height, they provide protection from the late afternoon sun (Fig. 6).

The internal walls and the ceiling were painted with clear color, the purpose is to elevate the iluminance levels (Bracarense, 2003; Bracarense et al, 2002; Hopinkson et al, 1984).

A western facade is shaded by a big tree that effectively absorbs a low level of radiation. The high trunk and the wide canopies near the building provide effective shade over the roof and walls. Dense plants near the building on the western side provide effective protection from solar gain in summer (Fig. 7). At winter season the tree (deciduous plant) loses its leaves providing heating inside the building (Fig. 8).

Acoustic privacy is much more difficult to provide in the room which are ventilated by airflow passing through other spaces of the

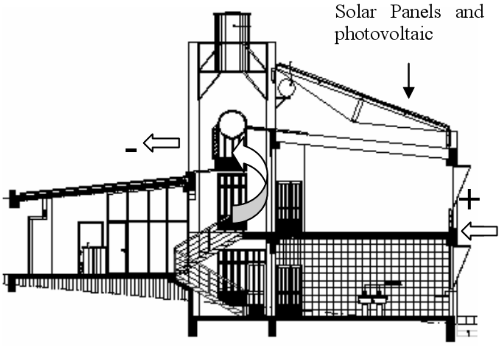

Figure 3: Building section.

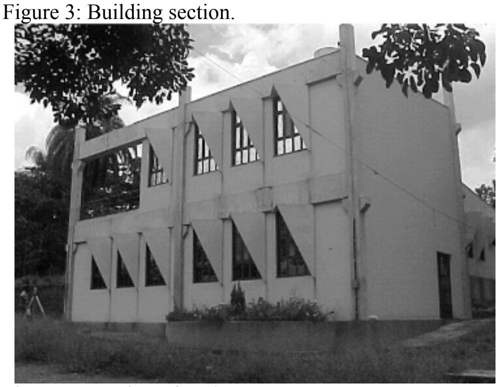

Figure 4: Northern facade.

Figure 5: Dome and venetian blinds.

Figure 6: Fixed devices – western facade.

Figure 7: Deciduous tree: passive cooling at summer season.

Figure 8: Deciduous tree: passive heating at winter season.

building. A large and noise avenue is located nearby the building that makes a task to solve. The roof is made with galvanized steel corrugated sheets to minimize the thermal gain. Under this roof there is a special type of concrete with tubes inside that improves the thermal and acoustic performance.

The building materials and the construction elements were chosen with the purpose to achieve human comfort and minimize the energy consumption (Table 1).

The electrical system was conceived to attempt the standards and the efficiency requests

Table 1: Building materials.

DescriPtion	Materials
Structure	Concrete Block
Slab	Alveolar type – tube of PVC
Roof	Corrugated metallic sheets with thermal-acoustic insulation Dome in polycarbonate
Wall	Special type of Brick (*Sical)*
Windows type	Vertical line operation and glass. The Eastern Facade windows have venetian blind on the bottom
Doors type	Iron and glass with venetian blind on the bottom
Brise-soleil	Metallic Slab
Floor	Plaques of little peaces of pressed marble *(Marmorite)*
Ceiling paint	Clear color
Covering paint (walls)	Clear color

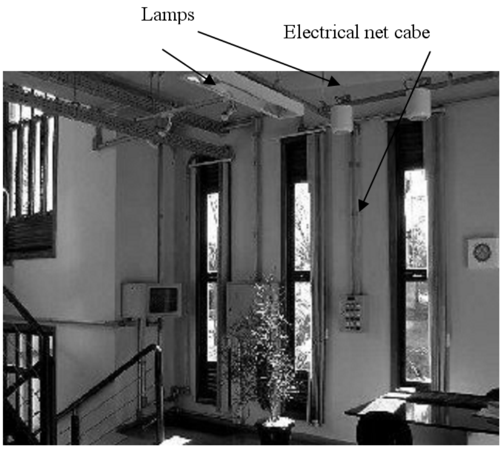

Figure 9: Eletrical system.

(ABNT; NBR-5413, 1982; CEMIG, 1998). It is composed by 28W fluorescents lamps, electronic reactor and high efficiency metallic luminary reflector. Electrical net cable is outside the walls to make easier the maintenance. In each room there are separated electrical systems by work point. The electrical system has different types of lamps to demonstrate their efficiency and how they behave (Fig. 9).

There is a prevision of a solar hot water system and photovoltaic panels on the top of the building. They will be located at an angle of 20º north. These systems will supply the building energy needs and will be object of research.

3. RESULTS

The building has been occupied since June 2002. To evaluate the building thermal performance, a system called Confortímetro Sensu is monitoring the center. It is a kind of equipment that measures the comfort index of internal environment. Many variables are collected such as: air temperature, air velocity, humidity, etc (Fig. 10).

To evaluate the luminous performance, a palm top equipment is being development. The illuminance levels measurements will be done with the equipment and the presence of glare will be evaluated.

The previous data analysis showed that the building has good thermal and luminous conditions. The chosen bilateral side lighting provided both view and better distribution of light.

Figure 10: Thermal monitoring system – *Confortímetro.*

The top lighting provided the most uniform light levels hence the minimum impact on HVAC. The translucent glassing skylights introduce less heat per unit of light than commercially available electric lamps (Moore, 1991).

The west orientation experience large summer heat gain at unwanted times, while providing passive solar contribution in winter. The deciduous tree was used to shade hard-to-control low angle west sun in the summer.

A presence of discomfort glare was detected in few work points but it does not interfere with the visibility. Shade sunlight to prevent glare and excess heat gain was achieved by the external fixed shading devices and internal movable persians with manual controls.

The utilization of many windows was efficiency for the airflow inside but noise comes with it. The building is nearby a high way and the road noise impact is quite big. The acoustic quality is poor and the attenuation of the noise levels must be achieved by vegetation and other strategies.

4. CONCLUSIONS

Bioclimatic strategies in hot humid climate to reestablish the thermal and luminous comfort conditions is fundamental to generate spaces that could improve the quality of life in poor countries. To achieve this goal, many strategies were used since the design stage. They showed good results for the thermal and luminous performance. To achieve this purpose, crossed ventilation, the chimney effect, solar protections, appropriate materials and colors were used. It was used an energy efficient light system with reflexive fixtures which is helping to decrease the heating gain.

The previous data analysis showed that the wind is lowering the indoor temperature at summer season. The skylight contribution and the bilateral side lighting were essential for the luminous environment achieved indoors.

This example demonstrates the feasibility of projects with low environment impact and high-energy efficiency implementing bioclimatic strategies and interacting solar systems in architecture. The building projects contribute for an efficient product avoiding air conditioning use and waste of electric energy, besides a nice environment for the users.

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