

DESIGN CRITERIA FOR WARM HUMID CLIMATES. A CASE STUDY

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ABSTRACT

Natural cross ventilation to take advantage of air velocity in getting comfort, and solar protection, are the main design criteria traditionally proposed for warm humid climate.

Usually, priority is given to natural ventilation related to design decisions, such as orientation and windows (size, location and type). However, the wind is the most variable climatic factor, also affected by the urban context, the architectural shape and even, opening and closing windows and doors.

On the other hand, to achieve comfort in some warm humid climatic conditions, according to traditional criteria, high indoor air velocities are needed. But these high air velocities (above 1.5m per second) are very difficult to achieve indoors and, if it were possible, it should be annoying.

These and other usual climatic design recommendations for warm humid regions, which don't fit appropriately to traditional compact urban zones are discussed on the paper, by a case study of a housing building project located in the historic centre of Matanzas city in Cuba.

KEY WORDS

Low Energy Architecture; Bioclimatic Architecture.

INTRODUCTION

Bioclimatic design is an important way to achieve more comfortable indoor environment for human beings, with low energy consumption, and then, a basic principle for the sustainable built environment. However, it has been a lack of these approaches in Cuban Architecture and Urbanism during the last. In some cases, because the actors have no enough knowledge about that, in others, because these issues are considered as less important, and even because they are considered as complex aspect which limit the architectural aesthetics.

These arguments are not valid and in many cases they are used to justify easier solutions or the copy of foreign models imposed by the "first world propaganda".

Nevertheless, many national institutions have been trying along the years, without success, to show the possibilities, advantages and necessity of architectural and urban solutions fitted to the local climatic conditions. The National Competition for Habitat Design, sponsored by the National Institute of Housing, the NGO SUR (from Spain) and the National Association of Architecture in 1999, with the subject of "Design of Urban Bioclimatic and Progressive Housing in Matanzas City", constituted a new intend on this way.

COMPETITION BASES

Among its main goals, the National Habitat Design Competition in 1999 asked bioclimatic and progressive urban housing. The present paper exposes the basic concepts followed in the winning project, as well as the results achieved in its simulation, applying the DEROB-LTH Program, developed in the Lund University in Sweden.

BASIC CONCEPTS

The Site

The project site is located in the historic centre of Matanzas City, very close to the place where it was founded. The excellent relations with the central urban areas where the main social facilities and architectural and urban values are concentrated, as well as its character as a boundary respect to the San Juan River, assign the place a great potential for recreational and tourist activities at the city scale.

Steps for the Urban Solution

The proposal includes two main steps. The first consists on the execution of the proposed building, according to the Competition Bases, and the second includes the repairmen, maintenance and reconstruction of the building in regular and good conditions, as well as the construction of new buildings on the empty plots, as a consequence of the precipitation or demolition of the building in bad conditions.

To reduce the excessive radiation prevailing on the site, appropriate vegetation is included, transforming the street existing on the northern edge of the river into a park-street. The vehicular access is aloud to the ground floor of the buildings located on the corners, where the parking areas are located.

The building height is mainly conditioned by the context and the remaining buildings, looking for transitions and recovering the presence of the tallest buildings on the corners. The irregular urban profile benefit ventilation by the turbulent airflow.

On these bases, a four housing storey building with a public ground floor is proposed for the first plot, while on the second one, a two housing storey building also with a public ground floor is located. New upper stories could be added to this building in one third step. That's why it has a horizontal flat roof.

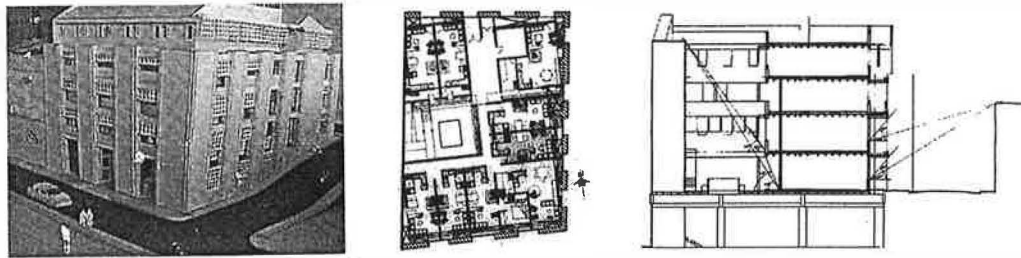


Fig. 1,2 and 3. Model, Plan level 0.00, and Section of the Building 1

Progressive Housing Concept

A “shell type” solution is proposed, because of the context features (central and compact urban area), where the final building image is very important from the beginning. This alternative of progressive housing is combined with the “improvable type”, to be developed by the family.

MAIN BIOCLIMATIC DESIGN TOOLS

Bioclimatic design principles are not considered in a general way in Cuba. Nevertheless, some specialists, really concern about these issues, still recommend some traditional principles from the classic international manuals, but not appropriated for urban context.

- The classic model recommended for warm – humid climates on the manuals developed on the 50’s and the 60’s, when the effects of the urban microclimate were not considered, is only possible in rural or sub – urban open areas, but not in compact urban contexts, as the traditional city centre is. The main bioclimatic design tools applied in the project as well as their relative importance are subordinated to this condition.

Reducing heat gain

This goal is achieved, on the first term, by the VOLUMETRIC SOLUTION, that provokes the MINIMUM EXTERNAL SURFACES (HORIZONTAL AND VERTICAL) EXPOSED to the solar radiation (Gonzalez, 1998).

Housing in the building 1 are arranged surrounded an internal courtyard, as in the historic local tradition. Each dwelling has a double exposure to the outdoors: to the public space on the street and to the semi – public space in the courtyard. Because of that, their proportions are relatively deep and narrow. It propitiates an optimum land use, but at the same time, it needs the use of certain bioclimatic resources to guarantee good natural ventilation and daylighting in the point Fareast from the external walls. That’s why ventilation and daylighting conduits are used.

Since the dwelling access is through the internal corridor surrounding the courtyard, two storeys flat have been used. According to this solution, the gallery is produced each two floor and it doesn’t affects the duelling privacy.

The stair case is located to an extreme in the courtyard, and an sculpture with a climbing plant remembering a tree (which is not possible to grow in these conditions) is located on the centre, to improve the environmental conditions in the courtyard.

Another way to reduce thermal gain by the volumetric solution consists on TO AVOID HORIZONTAL FLAT ROOFS EXPOSED TO THE SUN. Slope roofs used in the building 1 are better to evacuate and collect the rain water and the solar radiation received is less than in an horizontal one, mainly if they are oriented to the North, as in this project. There is a portion of horizontal flat roof, which is partially shaded by the water tank and a contrasting structure to hang and dry clothes, as people traditionally do. Horizontal flat roof are used in the building 2, to facilitate a further growing in high, to maintain the continuity of the horizontal urban profile, and to aloud the use of the roof. Nevertheless, this flat roof is protected from the solar radiation by a structure which at the same time, also facilitate the developing of other different functions.

Besides the volume, solar gain is also reduced by the MAXIMUM SOLAR PROTECTION OF EXTERNAL WALLS AND WINDOWS, according to the orientation imposed by the urban context to each facade. For that, the concept of SECOND SKIN OR EXTERNAL SKIN is applied. This skin avoids direct solar radiation, but at the same time, aloud light and air to pass through. It complements the protection offered by the context to the East and West facades which are the most difficult to protect.

The partially remaining walls from the former existing building compose the second skin in the building 1. With this solution it is possible to avoid the costs for demolition and transportation of rubbish, to take advantage of the walls material and its embodied energy, to reduce the costs for excavation and construction of new foundations. At the same time, this second skin aloud a dialog between old and new, keeping the historical memory. THE NEW BUILDING IS ROTATED RESPECT TO THE EXISTING SKIN to use the plot as much as possible, creating outdoor spaces protected from the sun, which facilitate ventilation and daylighting.

Daylighting

Window areas needed to satisfy daylighting requirements, as well as their location were estimated considering the designed solar protection and applying the stereographic method. The adopted solution ensures the minimum required daylighting level its uniformity and, at the same time, an appropriate distribution of wins flow. Since the solar protection is guarantee by the external shade, glass windows are used, to take as much advantage as possible of daylighting and visuals.

To increase daylighting in those points further from the external walls, a little light conduit are proposed (50 x 50 cm section). Their internal surfaces are highly reflective and according to its proportions, it was assumed a reduction coefficient of 0.45 (6).

The pavement of the courtyard in the building 1 includes recycled bottles, which aloud daylighting to the ground floor.

Natural Ventilation

Despite wind direction, cross ventilation is guaranteed in the social spaces of the dwelling. When it is not possible in bedrooms, with only one external wall, windows are located separated on the extremes of the wall to increase air movement indoor (4). Ventilation conduits are mainly used to ensure hygienic ventilation of bathrooms not directly related to outdoors, taking advantage of "ventury effect".

SIMULATION

The project solution has been evaluated applying DEROB – LTH Program, a software originally developed in the School of Architecture of the University of Texas, and further developed to suit the local needs at the Department of Building Science at Lund Institute of Technology. It allows calculating values for temperature, heating and cooling loads, and gives the Predicted Mean Vote, Predicted Percentage of Dissatisfied indexes, as well as global and direct operative temperatures. (González, 1999)

To evaluate the effect of shading on climatic conditions indoors, three basic cases were considered:

- 1- **Shaded Building:** Besides the protection against solar radiation offered by the compartmented walls and roof, and by the courtyard, this model includes the external shading elements used in the project. The compartmented walls and roof were considered as a very insulated wall with a very low U value.
- 2- **Not shaded building:** The same conditions in compartmented walls and roof, as well as the courtyard, but without the external shading devices.
- 3- **Isolated house:** Considering the flat as an isolated two story house, without the protection against solar radiation offered by the compartmented walls and roof, or the courtyard, or the external shading devices, or even the existing buildings in the context.

These three cases were modelled with and without natural cross ventilation, to evaluate the effect of ventilation on indoors climatic conditions and to estimate the energy consumption if air-conditioning is used.

There are six volumes in the model. Three of them were studied in detail, because of their main functions in the house, and because of their relationship with outdoors:

- Volume 1: It is a unique public space on the first floor of the house, including living room, dining-room and kitchen. It has two opposite external walls one facing east and the other facing west; so cross ventilation is possible.
 - Volume 3: It is a bedroom located to the street, facing east, on the second floor of the house.
 - Volume 6: It is a bedroom located to the courtyard, facing west, on the second floor of the house.
- Volume 4 is a space for internal circulation, not related to outdoors and Volume 5 is a bathroom, connected to outdoors by a conduit. Volume 2 is a little service yard connected to the kitchen and to the courtyard.

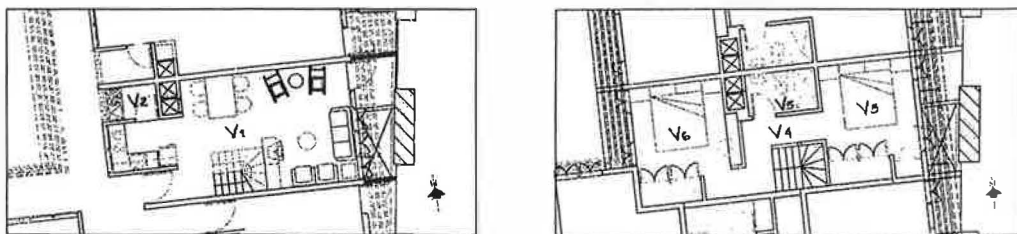


Fig. 4 and 5. Selected dwelling. Level 0.00 and + 3.20. Studied volumes are indicated

RESULTS

ONLY IN THE SHADED BUILDING OT IS BELOW THE OUTDOOR AIR TEMPERATURE, MAINLY DURING THE HOTTEST PERIOD (FROM 10.00 AM TO 4.00 PM), which means that surrounding surfaces are colder than the space, because they are protected from direct solar radiation, and so, they are absorbing radiant heat from the space.

The irregular performance of the isolated case may be due to the assumptions for compartmented walls and roof. The maximum OT value is obtained in the three models at 3.00pm, when the RH (in August) reaches values of about 70%. In that moment, OT in the isolated as well as in the not shading cases is almost the same.

Considering the indoor air velocity as approximately 2m/s (as it was got from PFS), and plotting these values on a Thermal Comfort Chart for 0.6 clo and 1.0 met activity (Markus, 1980), it can be seen that the values for the shaded building (considering OT) are inside the comfort zone for 80% of the people, while the values for the not shaded or the isolated building fall outside this comfort zone. It means that it is possible to achieve comfort for most of the people in the shading building, even during the hottest hours in August, if they can bear the high indoor air velocity that could be reached with this solution.

THERMAL ENVIRONMENT IS MORE STABLE IN SPACES LESS RELATED TO OUTDOORS It means, lower temperatures during day and higher during night, despite comfort is not achieved. It should not be good for ventilation, but it is impossible to estimate its effect with DEROB. Nevertheless, the thermal sensation could be improved by mechanical ventilation, and of course, this stable condition is better for air-conditioning.

CONSIDERING AIR-CONDITIONING IN NOT OPEN AND VENTILATED SPACE, IT IS EVIDENT THE INFLUENCE OF SHADING DEVICES ON ENERGY CONSUMPTION in the three analysed volumes.

The major influence of solar protection in energy consumption is produced in Volume 1, because it is bigger and faces two opposite orientations (east and west). There are two peaks, the highest in the morning, because of the influence of solar radiation on the unprotected east facade, and the other in the afternoon, because of the influence of solar radiation on the western facade, that is more protected by the courtyard. The second value is achieved in the volume facing outdoors, where the main difference is produced at 10.00 p.m., because of the east orientation of the facade, and the lower difference is obtained in the volume protected by the courtyard.

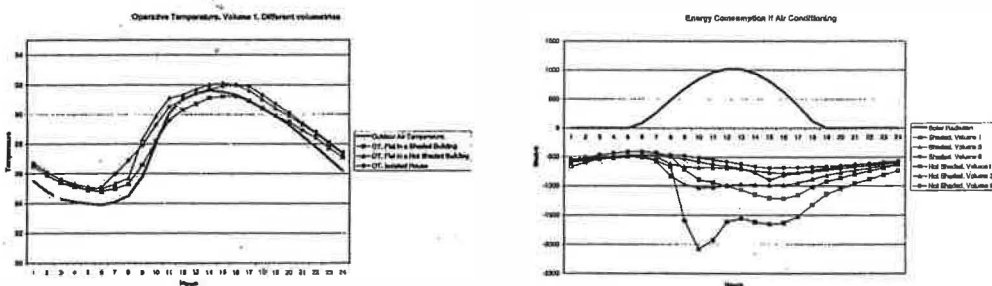


Figure 6 and 7. Operative Temperature in Volume 1 and Energy consumption

FINAL CONSIDERATIONS

The project gives an example of solution to the problems exposed on the Competition Bases. It applies some concepts developed by the author during the last twenty years as well as some successful international experiences.

They are shown some possibilities for interventions in rehabilitation zones, based on bioclimatic and global economy criteria, taking as much advantage as possible of land use, recovering the traditional architectural typology, but adapted to the present social needs. Taking advantage of the remaining structure as an external skin is a good example of that.

The simulation process has confirmed the initial hypothesis respect to the probable influence of the adopted volumetric and spatial solution over the indoor environment. The next step in the research, before starting the building process will be the model study of the performance of the conduits to improve their design. The building should be modelled, once built.

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