Learning from the past: The Traditional Compact City in Hot-humid Climates

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ABSTRACT: This paper shows that it is possible to maintain the contextual and structural coherence of the traditional compact city of Havana, not only on the basis of the importance of its well known historical and cultural values, but also because of the comfort that can be sensed in urban spaces and indoor environments and the economical advantages of its layout. These conclusions are based on field research and personal experience of the authors in different urban typologies in Havana.
The positive design features of Havana's traditional architecture related to thermal comfort are explained as well as the negative impact that, in urban and indoor climate, caused not well performed rehabilitations and new buildings (glazed façades, isolate buildings, incorrect sizing of patios…), which endanger the morphological coherence and microclimatic stability of this tissue. The importance of the street width, the irregular profile, the dimensions of plazas and parks, the compact urban block with openings to patios or ducts , the common dividing walls, porches, windows type, and others specific characteristics of the traditional city are discussed giving also design recommendations for further actions.

Keywords: traditional city, comfort, design recommendations.

1. INTRODUCTION

The City of Havana presents a diversity of areas with different urban and architectural peculiarities. Among them the traditional compact zones stands out, not only because of their historical and cultural values but also for the remarkable coherence of its urban morphology and favourable microclimatic behaviour that differentiates them from the rest of the city. These characteristics make this morphology an interesting research objective and meritorious of a deeper investigation.

Most of the international studies of bioclimatic architecture that have been carried out focus their attention on the climatic behaviour of isolated buildings and dispersed urban models, but very little explanation has been given to the climatic response perceived in compact urban typologies. This issue motivated an investigation in the context of Havana's traditional areas with a compact urban morphology, study that was later extended to other predominant urban typologies of this city, not investigated before. This allowed a comparison of their behaviour and facilitated the elaboration of a theory that explains the basis of microclimatic considerations on heritage conservation.

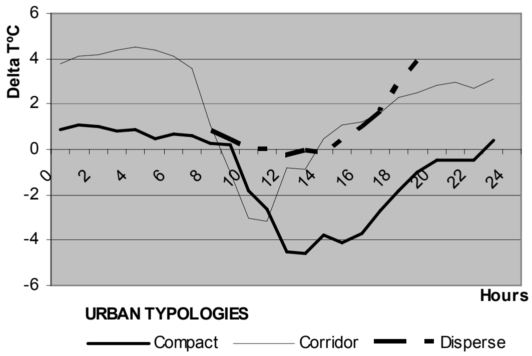
2. BACKGROUND

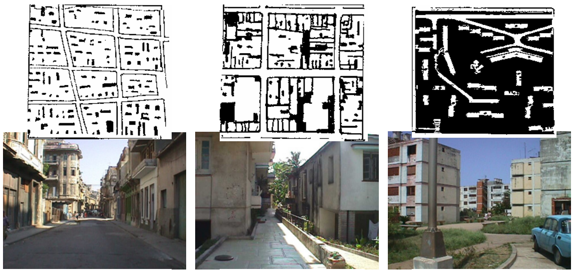
The reforms in the field of architecture and urbanism that took place in Europe during the XX century had its fundaments in the lack of proper living conditions of the population, need of ventilation, health and security. Recognition of the link between dwelling conditions and public health increase the understanding of the problem and the improvement of city environments began to take place: built limitations within interior of the blocks, ventilation and illumination requirements, heating and construction, provision of sanitary services, garbage collection, among others [1]. The new Act which regulates among other city planning, lead to a dispersed urban pattern that evolved in opposition to the unhealthy, dense and compact block. This new model expanded, first for all Europe, later to America and the rest of the world.

The Masters of Modern Architecture studied and set new approaches for the architecture that was coming up. Innovative concepts of thermal regulation sustained by this theory were equally applied to new cities, renewal projects or new buildings in existing urban settlements.

Researches made in a hot and humid climate as Cuba conclude that many of these precept applications not always had the expected reasonable results. The new buildings, with natural cross ventilation and solar control, in general, didn't reach the wanted microclimatic effectiveness.

The most critical situation presented was when applying these thermal regulation concepts to the traditional compact city. New designs, in addition of its incompatible image with the patrimonial values of these areas, performed a more adverse interior climate in comparison with traditional buildings of this urban typology - with heavy sharing-walls, patios, high ceiling, balconies, galleries, louvered windows-. Furthermore, comparisons made between summer indoor air temperatures in more than thirty buildings of each different urban typologies -compact, corridor, disperse- (Fig.1) reveal the better performance of those located in the compact morphology.





Compact typology

Corridor typology

Disperse typology

Figure 1: Differences of Indoor air temperature in buildings located in different urban typologies related to the meteorological station (Casablanca). Outstands the better performance of the compact morphology.

Based on this finding it was a necessity to discover the real thermal behaviour of this urban fabric and building types and find practical, effective and scientifically based design recommendations and solutions that will help planners and architects to design a more appropriate bioclimatic architecture in these contexts.

The microclimatic advantages of the traditional city, has become a more and more convincing issue. It is essential to give an answer to urban regulations and strategies that established the necessity to compact the City of Havana and to revitalize old central districts.

3. THE TRADITIONAL COMPACT CITY

3.1 Urban and architectural features.

Havana's traditional compact city has a land occupation between 80 and 85%. Its profile is irregular. Buildings are associated mainly by sharing-walls and courtyards, densely assembled in a rectangular o semi - rectangular blocks. Plots are usually narrow and deep, except those on the corners. This layout forces each building to have just one façade looking to the street; only those around plazas and commercial paths have porches as a transitional space. (Fig. 2)

The main element that characterizes this architecture is the patio, with a strong cultural and climatic meaning. It is placed centrally, lateral or dispersed in the layout (with smaller dimensions) and it is considered the heart of the house [2].

Wall materials are masonry or bricks. The roof is composed mainly of wood or beam - slab system; although in latest buildings can be find reinforced concrete.

Ceilings heights were around 5,50m in the ground floor and a little less in the uppers. Doors and windows are wide with elongated proportions. They are made of wood, have different designs, some of them, with louvers, stained glasses or "lucetas" in the upper part. Traditional windows have demonstrated their climatic effectiveness along all this years. They allow air, lighting, visual and sound control integrated in a functional design.

Figure 2: Compact urban morphology. Dense built area with irregular profile. Narrows streets with balconies and overhangs to produce shadows.

3.2 Case study selection.

For the analysis was considered buildings of different height, orientation, internal-external relation; courtyards of different proportion, orientation, finishing material; also exterior spaces adjacent to the buildings. The morphologies considered were: compact (Old Havana and Central Havana), with corridors around buildings (Almendares) and disperse (Via Tunel).

The research includes measurements of air temperature, relative humidity, wind. Also laboratory test and the opinion of the inhabitant of the buildings evaluated.

The data from the Meteorological Station of Casablanca was considered as the general reference and the stations at each zone as local references.

3.3 Thermal behavior of the traditional compact city.

In the compact city the block can be considered the climatic unit in the same way the building is, in a disperse morphology. Any alteration of its structure – changes in the buildings association, clear up of plots or central areas of the block, new building typologies- can produce an unbalance in the natural thermo-regulatory system and destroy its microclimatic performance with its advantages and disadvantages.

The compactness of the urban tissue, narrow streets and relative small open spaces produces shadows not only for the pedestrian, but also for the others buildings and open spaces. The presence of balconies and porches increments this benefit, also important for rain protection.

The urban and architectural configuration of the compact city transform the laminar wind flow and produces turbulences, increased by the non-uniform building and roof geometries. Air flows along the street canyons and plazas. Depending on the urban pattern orientation, the building geometry, the canyon aspect ratio, the wind speed and direction and the solar radiation over the surfaces, the airflow inside the canyons can have different distribution and speed, varying the pressure field over the buildings envelope that generates air movement through the façade and inner patios. Because of the turbulence effect air can have unusual directions, for that reason sometimes patios acts as inwards (suction), and other times as outwards (pressure).

The observed air temperatures in buildings were several degrees below outside (even up to 4º Celsius), while relative humidity was similar. Places at the ground floor were fresher than those on higher levels, in correspondence with less radiation and limited air exchange with the street or plazas which have a hotter environment. There is a reduction in the air temperature inwards the building, also more shadowy and quiet.

3.4 Interior courtyards.

Proportions, dimensions, location and finishing materials, prove to be the most significant design attributes in courtyard thermal behavior, as well as permeability, and existence of vegetation and water[3].

In big patios situated in the centre of the building, air temperature was in close proximity to the local reference station; whereas lowest in the smallest ones, as well as more stable. Differences in mean and maximum air temperature data between patios and local reference (Δt(pf)), is shown in Table 1, considering height (h) and width (d) ratios. Patios in compact morphologies are fresher than backyards located in the core of blocks as happens in others urban typologies, where the warm air penetrates into the backyards from streets and hotter urban spaces increasing the temperature in dependence of the permeability of the blocks. Usually those spaces have no trees and paved concrete floors which increase discomfort.

Table 1: Differences between mean and maximum air temperature in patios located in compact and corridors morphologies with respect to local reference [3].

OPEN SPACE	h/d	Δtpf	Δtpf max
Small patios or conducts (*)			
Águila 707	8	-0.8	1.8
Estrella 59	14.5	-2.0	0.6
Medium patios (*)			
Maloja 24-26	5.4	-2.1	-1.7
Maloja 117	2.25	2.9	4.2
Big patios (*)			
Capitanes Generales	0.64	-1.5	0.6
Palacio Aldama	1.52	-1.9	-0.4
Backyards			
57 A e/ 92B Y 92D	1,25	2,6	4,6
59 e/ 92B Y 92D	0,41	2,5	4,1

(*) Patios in compact zones.

Patios with more elongated proportions, whose axis is oriented East-West, are hotter than the ones oriented North-South. When proportions are nearer 1:1 this attribute is not significant.

Analyzing several cases of rectangular interior courtyards it's interesting that those with length (L)/ width (D) ratio of 1:4, oriented North-South, have a better behavior (Fig. 3). This tendency is also observed when the volume and height of the patio increases. A higher correlation is obtained when the axis is North-South (Fig.4).

Patios in the compact city due to its small permeability to wind have more microclimatic stability, which can be an advantage if their design contributes to a temperature reduction of the air and surfaces.

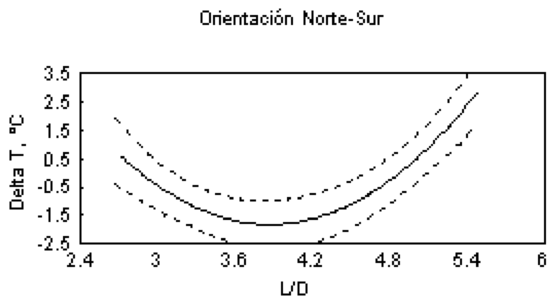


Figure 3: Differences of air temperature in rectangular inner patios with respect to local reference station data. Temperature tends to decrease with L/D=1:4.

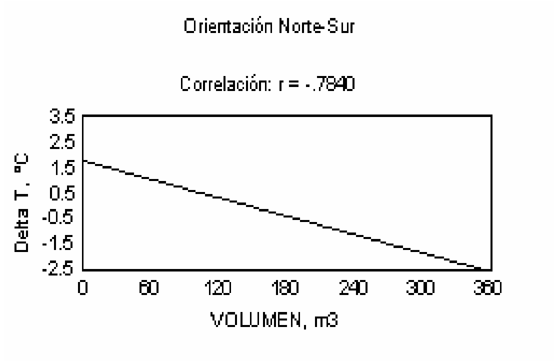


Figure 4: Differences of air temperature in rectangular inner patios with respect to local reference station data. Temperature tend to decrease when volume and height increases.

Benefits of water in patios were verified when comparing with others without it, or completely or partially paved. This demonstrates that this passive cooling technique is also effective in hot humid climates and does not introduce significant increment of humidity in the air. Measurements report this parameter slightly below or similar to the local reference stations.

Some recent solutions in renewed buildings covered the patio but this is unusual in our traditional architecture, it can modify negatively its climatic performance and create a very uncomfortable indoor environment. People working in these buildings experienced discomfort through all the year. When the solution consider the courtyard roof 1,00 – 1,50m above the building, it is made of a low transmittance material and have side-openings at the top, the temperatures are more comfortable but lighting and ventilation are not as effective as when it is uncovered.

As in any other open space, surface materials have great influence in the thermal performance of patios as well as vegetation. An example of the influence of greenery in air temperature is shown in Figure 5. One patio –General Captain Palace- 35% of the floor covered and another –San Carlos Seminar- with 80% are compared. The last includes a tree with dense foliage.

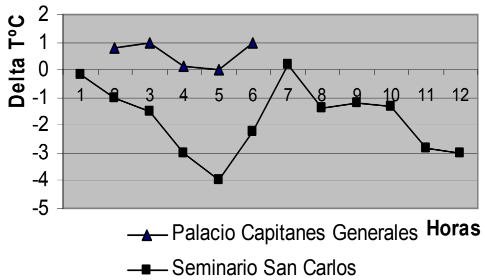


Figure 5: Differences of air temperature in patios with different quantity of vegetation, respect to the local reference station data; Capitanes Generales Palace, 35% and San Carlos Seminar, 80%.

Field measurements demonstrate that, with more than 60% of trees foliage covering the total area of the patio, temperature decreases maximum 3 to 4ºC.

3.5 Spaces associated to patios.

An important feature in Havana's traditional architecture was that, at least, every room has a connection to the outside environment, mainly through a patio.

It is interesting how, in the colonial houses, a gentle transition occurs between a hot and luminous outside atmosphere to a fresher and shady interior. From the street to the porch, then to the "zaguan", you can reach the patio where you find a pleasant microclimate. If you continue inside the house the space become darker, but then a second and smaller courtyard appears creating a new light well that also improves the interior air flow. This air temperature is below the existent at the street, as it moves mainly between patios and roof. The upper floors are slightly warmer.

In general, this typology occupies the corners of the block, but sometimes the half or the whole block.

Houses with lateral courtyards mainly present two situations: when the room communicates directly to the patio or to the gallery around the patio. The first situation is thermally and visually better. To help a convective ventilation and lighting with privacy from the courtyard, appeared a movable opening on the top of the doors and windows, called "luceta".

In addition, in wider plots, small patios were built. In this solution rooms had two connections with the outside, improving to great extent ventilation and lighting.

Later, at the end of the XIX Century, began the construction of speculative multifamily buildings and existent houses transformed in tenant houses or citadels. Although the patios were respected, interior subdivisions generated spaces without or with minimum ventilation and lighting, also with a negative hygienic consequence. As a solution to these problems appear the conducts or wells, most of the times not enough in number neither in dimension to be a satisfactory climatic answer.

In these cases the room air temperature fluctuation depended on the functions of the spaces connected to the small patio or conduct. The worst situation happens with kitchens. The heat and others contaminants deteriorate the duct microclimate and consequently the rest of the rooms connected to it. This can be appreciated in Figure 6; the room associated directly to the conduct is the most negative, the one link to a big patio has a better behavior.

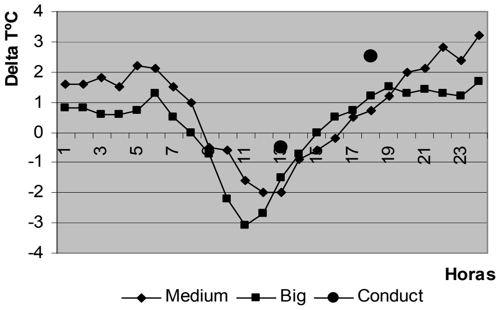


Figure 6: Comparison of air temperature in spaces connected to a big and medium courtyards and a conduct with respect to the local reference station data.

4. LESSONS LEARNED

A lot can be learned from the traditional compact city gradual climatic adaptation. In the book The Compact City: Architecture and Microclimate, the authors of this paper discuss in detail the climatic response of this morphology in Havana and give recommendations for open space, architecture, building envelope and components, courtyards and conducts design [4].

To summarize it can be said that it is important to maintain:

- The urban pattern, the irregular profile and the physical compact structure of the blocks.
- The courtyards system as the most important climatic component.
- The porches, balconies, overhangs and any other elements projected from the façade.
- Materials of high thermal insulation and great heat capacity for the envelope, with special attention to the roofing system selection.

All these characteristics generate climatic benefits as:

- Sun and rain protection in streets.
- Solar control by urban geometry.
- High thermal inertia in the urban block.
- Low heat gain.
- Sufficient hygienic air changes in rooms.
- Favourable air and surface temperatures.

The main features that new designs have to transform due to their negative effects are:

- Scarce urban wooded open spaces.
- Low illuminance levels in rooms.
- Water absorption by capillarity in building elements.
- Confluence of odours, heat and contaminants in courtyards and ducts connected to bedrooms and living rooms.
- Low ceiling height.

5. CONCLUSION

The present paper shows a brief and general overview of the climatic performance of the traditional compact morphology in Havana. The researches that support these results prove the enormous possibility of thermal regulation that this urban model and its architecture has. It concludes accurate ways to improve environments and makes them more comfortable.

These criteria are not only valid for interventions in the traditional city, that we need to rescue and protect, but also for new urban development as an alternative to the isolated or disperse model whose environmental emptiness is rejected by the residents.

REFERENCES

[1] Grimberg, D. Housing in The Netherlands 1900-1940. Delft UN. Press, 1977.
[2] Weiss, J. La Arquitectura Colonial Cubana. Ed. Letras Cubanas, La Habana, 1979. (Tomos I y II)
[3] Diaz Gisela. Régimen térmico en espacios abiertos intraurbanos de Ciudad de Las Habana. PhD Thesis, CUJAE, Habana, 1998.
[4] Alfonso, A., Gisela Díaz y Ana Ma. de la Peña. La Ciudad Compacta: Arquitectura y Microclima. Ediciones CUJAE. 2da Edición revisada y ampliada, La Habana, 2005.