Ventilation and urban morphology relation:
Two neighbourhoods in Rio de Janeiro city, Brazil

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ABSTRACT: *This work presents a comparative study between blocks of Copacabana and Ipanema neighbourhoods, both of them located in Rio de Janeiro city. These studies were developed with the aid of experimental simulations in a wind tunnel, taking into account the urban morphology and its relations to open spaces. A diagnosis was produced through the exam of the wind effects in relation to the volume of built and non-built spaces. The effects were classified as positive or negative, in relation to the tropical climate. At first, both of the blocks studied – one in Ipanema and one in Copacabana - were selected according to common characteristics which establish a relation between the two regions, for example, the distance to the beach, the presence of a public square etc. The results confirmed our expectations showing Ipanema as a more ventilated area.*
Keywords: ventilation, wind tunnel, urban morphology, urban micro-climate

INTRODUCTION

This work is part of the studies developed by Wind Tunnel Laboratory, School of Architecture and Urbanism at Federal University of Rio de Janeiro - UFRJ. Experimental simulations were developed in architecture and urbanism aiming to evaluate actual and possible future scenarios, including proposed changes to promote increased ventilation [1].

Specific models representing buildings and urban areas were developed to the simulations using the Wind Tunnel. These models must comply with the appropriate size in relation to the test table of Wind Tunnel and also be sufficiently resistant to deal with the velocities inside the tunnel. The results are used to give a qualitative diagnosis of the region measured in relation to the wind effects at the pedestrian level. The visualization method used was the wind erosion or sand drag. From these experiments, the effects of wind in the vicinity of built volumes, of vegetation and open spaces, are classified as positive or negative, in relation to the tropical climate, for the various proposals and existing urban provisions. Through experiments it is possible to select the best setting, which is the one that presents more intense and distributed ventilation.

The proposal presented in this article refers to a comparison between the blocks of the neighbourhoods of Copacabana and Ipanema, in the southern city of Rio de Janeiro. It takes into account the urban morphology and its relation to the free spaces.

During the beginning of their occupation, Copacabana and Ipanema [4], both on the seaside area, were subject to different zoning laws [5,6], and this fact is reflected in their current morphology (urban networks).

Even being so close physically (Fig. 1), some striking variations were able to define these two neighbourhoods in a so different way. In this work one city block of each one was analysed in relation to the ventilation inside the Wind Tunnel.

Figure 1: Copacabana (in yellow) and Ipanema (in red) neighbourhoods, side by side.

In practice it is observed more intense and better distributed ventilation in internal blocks of Ipanema if compared to the ones of Copacabana. Although both neighbourhoods are located in front of a beach, in Ipanema it is not observed the immense wall of buildings along the waterfront as it can be noticed in Copacabana. In the blocks inside the neighbourhood of Ipanema there is also a distance between the buildings and they are not, in most cases, as close as it can be observed in Copacabana. The intention here was to observe through experimental simulations how the urban morphology is able to interfere with the results of the permeability of the urban mesh in relation to the wind.

The results confirmed our expectations showing Ipanema as a more ventilated area, for the velocities and directions studied.

BRIEF CHRONOLOGY EXAMINATION

The occupation in Copacabana's area occurred later if compared to the rest of the city of Rio de Janeiro. The urbanization, properly, began in 1892 and the basic road network was already designed in 1894 [6], although it was not implemented.

This late occupation may have been generated, at least, in part, because of the location of the neighbourhood. There was a narrow strip of land by the sea and it is surrounded by hills: Cabritos, São João, Babilônia and Cantagalo. These hills make the access to the area difficult, since the barriers of mountains, by one side, and the edge of the sea, by the other side, let just a narrow strip of land.

In the late nineteenth century, when other neighbourhoods of the city were occupied, a large area of sand, called Sacopenapan (name in Tupi), was populated only by poor fishermen's houses and their small fields [5]. The appearance in this area, by the seventeenth century, of an image of Our Lady of Copacabana, holy worshipped in the Lake Titicaca region, was the causative factor of the change of name of the region. So it started being called Copacabana, which means "blue belvedere" in the Quechua language [5].

The opening of the Tunnel Real Grandeza, currently Alaor Prata tunnel, known as Old Tunnel, in 1892, facilitated the access to Copacabana. Previously the access was only possible through the Ladeira do Barroso, currently Ladeira do Leme, the first land access to Copacabana.

Also in 1892, the tramway company Ferro Carril Botanical Garden opened access to the neighbourhood. Initially there was the extension of a line of trams, still in animal traction, to the Serzedelo Correia's Square, and later, new extensions have been expanded to meet the two ends of the narrow strip of land, crossing all the beach: from Leme until the end of Nossa Senhora de Copacabana street (Posto VI).

In the case of Ipanema area, the lack of drinking water or constant flooding which the region was subjected may have discouraged the occupation of the neighbourhood. However, in terms of access, it was easier to be attained in comparison to Copacabana.

The intense occupation of Copacabana could already be observed in 1956, and in the case of the elevation of the buildings, its design were already very similar to that found nowadays [4]. Figure 2 and Figure 3 show the evolution of urban occupation in both areas until the 1970s.

Figure 2: The images of the seafront of Copacabana (1930).

Figure 3: Ipanema, taken in 1930. Both photografs show a big difference in the occupation of these two regions.

METHODOLOGICAL PROCEDURES

The studied blocks, one of each of the neighbourhoods, were selected according to factors that allowed establishing a relationship between the two regions: proximity between regions, distance to the beach, presence of a central square and surrounding density and compactness of the region (Fig. 4).

For the two-dimensional (2D) data, the plants of the Rio de Janeiro city were used [7] and then it was done an on-site survey of the region: urban morphology; pedestrian and vehicles routes; lining of the natural and artificial urban; presence of water mirrors etc.

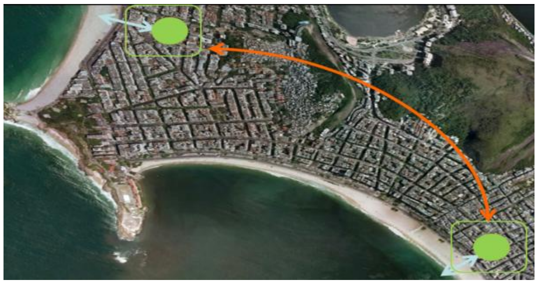
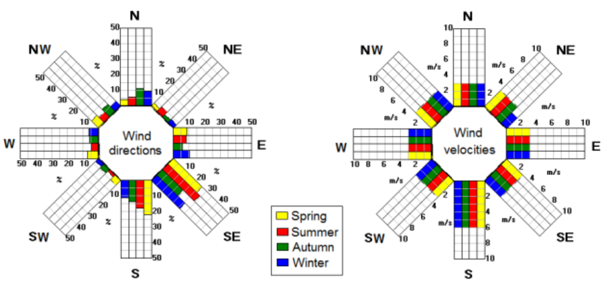


Figure 4: Relationship between the two regions: proximity between regions, distance to the beach, presence of a central square and surrounding density and compactness region.

For the next stage of the survey it was necessary to obtain the climate data for the experimental simulations. The wind velocities and directions for the city of Rio de Janeiro were obtained using the software SOLAR [8] and are shown in Figure 5. For the experiments it was adopted the highest frequency of winds from the south-east in summer and the maximum speed of 3 m/s. Indeed, the predominance of south-east winds occurs in all seasons.



(a) **(b)**

Figure 5: Wind velocities (a) and directions (b) for the city of Rio de Janeiro were obtained using the software SOLAR [8].

From these data the models were generated (Figure 6) for the experiments with the proper dimensions to the test table and the proper materials. The materials should be sturdy enough for the experiments, and the colours should be selected to allow better visualization.

The models were built in paper "*Paraná*" (strong paper) and the black background is the plan reversed, i.e., the lines of demarcation of land and streets are white. Thus the visualization of the white sand is more immediate.

(a) *(b)*

Figure 6: Models: Copacabana (a) and Ipanema (b).

Once the experiments were performed, image files were generated with the simulation results for analysis and presentation.

RESULTS AND DISCUSSIONS

In Figures 7, 8, 9, 10 and 11 the results for the experimental simulations can be seen by adopting these wind directions: southeast, south, east, west and southwest, respectively. The arrow inside the figures indicates the wind direction for each case.

(a)

(b)

Figure 7: South-east: Copacabana (a) and Ipanema (b).

The south-east wind direction is the most present in Rio de Janeiro city in all seasons of the year.

The results obtained for this wind direction (Fig. 6) show that the ventilation in Ipanema area (b) was able to reach even the internal streets farther from the sea.

The South wind direction presents also an important incidence in this region, and is the direction was found the highest wind velocities.

(a)

(b)

Figure 8: South: Copacabana (a) and Ipanema (b).

(a)

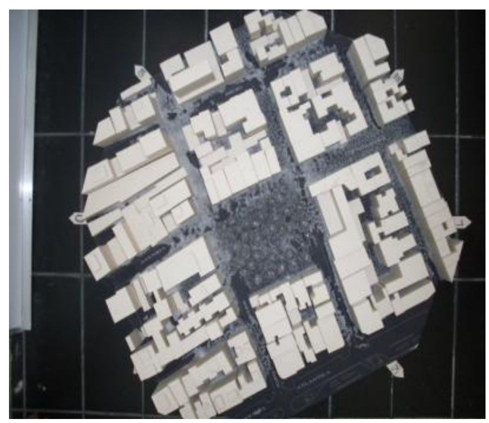
(b)

Figure 9: East: Copacabana (a) and Ipanema (b).

(a)

(b)

Figure 10: West: Copacabana (a) and Ipanema (b).



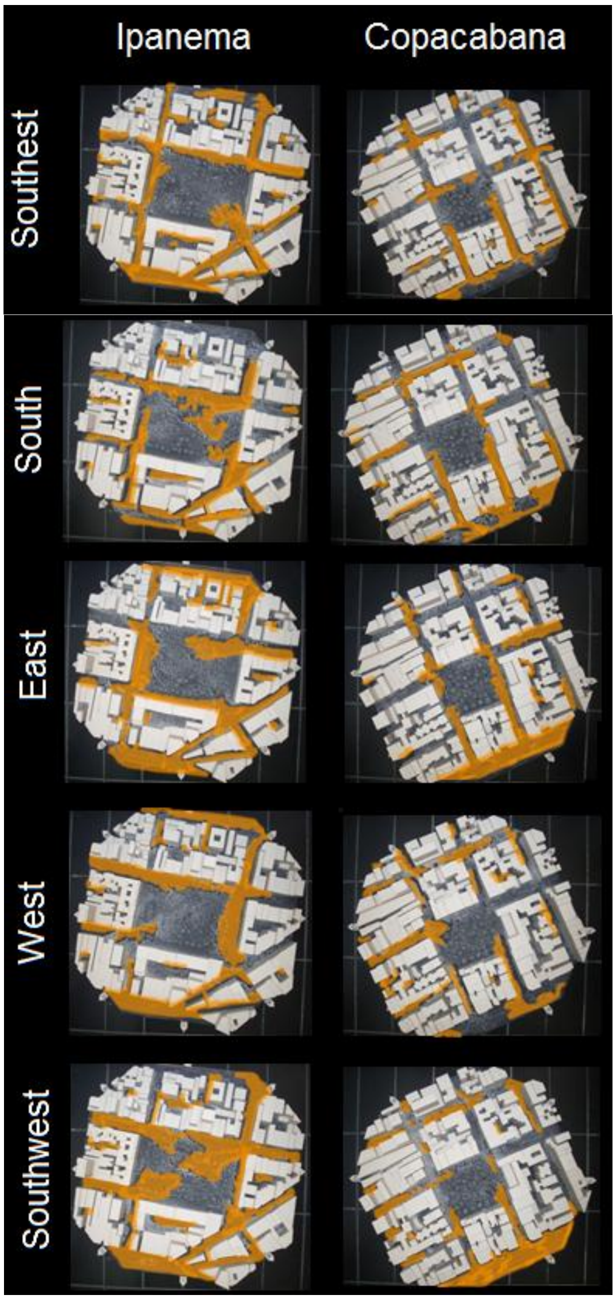
(a)

(b)

Figure 11: Southwest: Copacabana (a) and Ipanema (b).

For all wind incidences, i.e., south-east, south, east, west and south-west, the results of experimental simulations indicated the best distribution of ventilation in blocks from Ipanema neighbourhood. The wind was able to penetrate the streets that make up the study area. It was observed a lower incidence of stagnant areas resulting in reduced possibility of forming heat islands.

In Figure 12, the results for all wind directions are shown and they can be observed side by side with the ventilated areas marked for better viewing.



(a) (b)

Figure 12: South-west: Ipanema (a) and Copacabana (b).

CONCLUSION

From the results it is possible to observe that the urban morphology is able to represent a strong influence on the direction and strength of winds. The permeability of the wind across the urban mesh is essential to improve ventilation on the internal areas of the neighbourhood.

In the case of Copacabana, where a barrier of buildings with virtually the same height blocked the entrance of the wind, there is a depletion of ventilation in the innermost areas of the district. Even in the region of Serzedelo Correa's Square and its surroundings, the occurrence of areas of stagnation can be observed.

If these areas are associated with heatstroke, it may result in higher heating, which does not contribute to the dispersion of gases emissions from buses and cars.

In Ipanema, ventilation has a broader scale and allows the ventilation to penetrate the innermost part of the neighbourhood. For all wind directions tested the results allowed the observation of the penetration of wind in the uttermost parts of the neighbourhood.

Thus, it is important to perform studies related to the height of buildings, urban occupation and ventilation for both deployment of new cities or even for intervention in existent neighbourhoods. Urban morphologies that allow barriers may impair the passage of winds, but design strategies can redirect winds contributing to the environmental comfort of the users of urban spaces. The vegetation is a great ally because it functions as an area of shading and contributes to lowering the temperature.

The Wind Tunnel is an important tool to aid design decisions. It allows the evaluation of different configurations still in the design phase, both in urban and architectural models. This is an important factor in reducing design flaws resulting in reduced financial and environmental costs.

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