P1.9 - Airflow, building height diference and wind tunnel test.

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ABSTRACT

This paper presents wind tunnel simulation as a tool to verify how changes to height and positioning of buildings close to the sea coast affect airflow in the area. The simulations were made for an area of the city of Santos, Pompéia, between Channels 1 and 2, on the southern shore of Sao Paulo State, Brazil. The area and blocks were chosen due to the the existence of tall buildings (in comparison with others) in the area, as well as its current urban configuration. The configuration in this area encompasses tall buildings (between 15 and 17 floors) on the sea coast, which form a wall for the areas beyond them, and lower-height buildings in an intermediate area (central square, from 6 to 8 floors), with 2 to 3-floor buildings on the limit-area (avenue / railway tracks). The wind-tunnel simulations were conducted at the LNEC (Laboratório Nacional de Engenharia Civil), in Portugal, with the erosion-figure technique, to verify the influence of new buildings in the natural ventilation conditions at the user / pedestrian level. Changes were proposed to certain points, based on the existing occupation, basically on the second block behind the sea-coast wall, to verify changes in wind speed and direction. As the area is seeing the appearance of buildings with 26 floors, it was decided to insert this height in the block posterior to the sea-coast. The simulations enabled verification of what happens in the existing situation and with the proposed changes and were made with seven configurations. Buildings were placed according to the developing occupation. These simulations are valid for this type of change. New simulations have to be conducted for specific proposed changes. The wind-tunnel simulations showed and confirmed that changes to the height and positioning of buildings changed wind pattern in the area under study.

Keyword: Wind tunnel test, city of Santos/Brazil, tall buildings, airflow.

1. INTRODUCTION

The wind-tunnel simulations were conducted, for this paper, to verify changes to the wind pattern brought about by changes in the height and positioning of buildings close to the sea shore.

For the simulations an area – of a few blocks – in Bairro da Pompéia (between Canal 1 and Canal 2), city of Santos, Brazil, was used. Santos is located on the south coast of the state of São Paulo - latitude 23º 57’ 35” and longitude 46º 19’ 56” – with an altitude of 2 metres above seal level, with 5.5 km of shore in a total of six beaches.

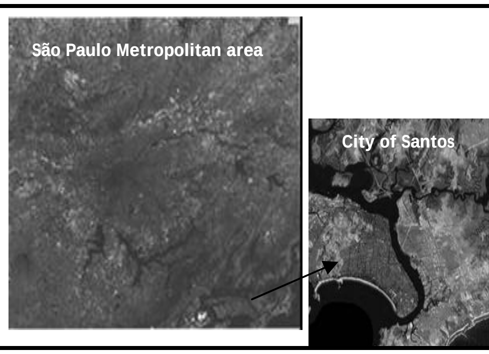


Figure 1: Location of the city of Santos, Brazil.
Source: Prata, 2005.

Santos was chosen due to the changes in its building height pattern and lack of information on the impacts – positive or negative – of such a change.

The area was chosen for presenting an urban configuration with different typologies, ranging from tall buildings (around 15 stories) on the sea shore – forming a wall for the posterior areas – to buildings of lesser height in an intermediate area (around 6 stories) and 2 and 3-story buildings in the limit-area (avenues) (Figure 2). The proposed grid change presents buildings of up to 26 stories.

Figure 2: Buldings in the study area
Source: Prata, 2005.

2. WIND-TUNNEL SIMULATIONS

Wind-tunnel simulations are used to verify wind effects on changes to open spaces, groups of buildings, pollutant / odor dispersion, pedestrian comfort / safety, as well as for the analysis of buildings (structure), etc.

For wind-tunnel simulations the model’s scale depends on the dimension of the tunnel section, the area in study, the type of simulation to be made (structural, building, urban environment) and on the similarity criteria.

Different techniques can be used for qualitative and quantitative visualization of air-flow:

- Qualitative: Smoke over the model and/or erosion figure techniques can be used and, with photographic records, the effects on the desired points can be observed for analysis.
- Quantitative: Hot-wire anemometers and/or Pitot tubes can be used, which allow measurements of the flows inciding on the model.

There are various measuring techniques to determine the air-flows (direction, speed and intensity of turbulence) in aerodynamic tunnels. For this study the method of visualization through erosion-figures was chosen.

The wind-tunnel chosen for the simulations was that of the LNEC – Laboratório Nacional de Engenharia Civil, Lisbon/Portugal – built in a closed system and possessing a simulation chamber 3.00 metres long and a straight section (basically rectangular) with 1.00 metre height by 1.25 metre width (JANEIRO BORGES, 1968).

(a) (b)

Figure 3: LNEC Wind-Tunnel - (a) external view; (b) internal view.
Source: Prata, 2005.

2.1 Model

For the building of the model it was necessary to define the scale, the blocks and the height and dimensions of the buildings.

The model was built to a 1:1,000 scale, generating a board with 1.0 metre diameter, to be placed in the tunnel.

The blocks and street lay-out were defined enabling, through fitting, the alteration of every block. The model was covered with a sheet of cork, useful for the visualization of the erosion simulations.

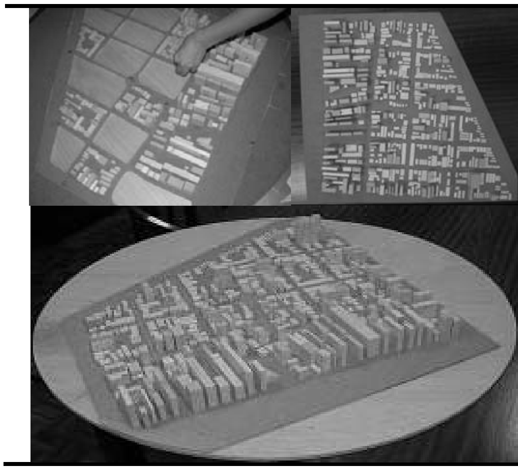
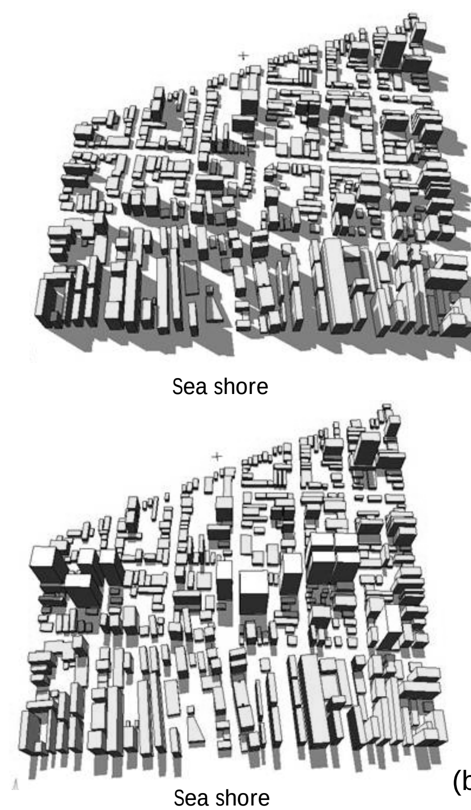


Figure 4: Model.
Source: Prata, 2005.

A- Figure 5 demonstrates the simulated situations: (a) current situation with the urban configuration of the study area; (b) situation with changes to the number of buildings and with the height of 26 stories. It can be seen in (b) the buildings which were added to the block posterior to the sea shore.



(a) (b)

Figure 5: Models of the study area - (a) current situation; (b) situation with lay-out changes.
Source: Prata, 2005.

2.2 Simulations - Erosion Figure Technique

The erosion figure technique consists of spreading a thin layer of sand on the model's floor (area to be analyzed). Upon introduction of the air-flow erosions are formed, which simulate the intensity of wind around the buildings. The erosion figures are used for the visualization of the velocity-field at ground-level (JANEIRO BORGES et al, 1979).

If movement is verified by the model's elements and not in the test area, it results from the influence of the elements which make the speed increase around them. From the moment in which the sand in the test area is displaced, the erosion figures result not only from the acceleration caused by the elements, but also from the movement cause by the flow applied in the tunnel. With the increase of velocity by the fan, isolines are formed which represent the directions of air flow over the model (PREATA et al., 2005).

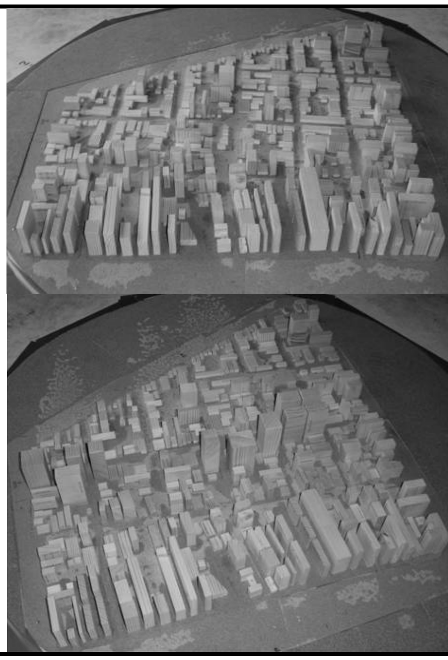


Figure 6: Models in wind-tunnel.
Source: Prata, 2005.

It is worth noting that the accumulation of sand (non-eroded sand), in certain points, represents areas with whirlwind problems, dust retention and/or areas which do not suffer influence of wind at velocities considered sufficient to remove the sand (Figure 7).

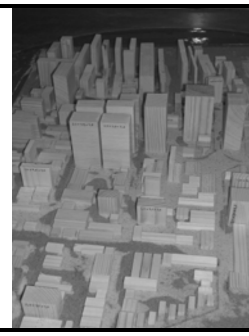


Figure 7: Model with visualizattion of sand acumulation.
Source: Prata, 2005.

3. RESULTS OBTAINED

It can be seen, in Figure 8 (a) the fields of velocity caused by the current urban configuration and (b) the changes proposed for the wind direction from south-east in relation to north. The model was rotated in the tunnel for this direction.

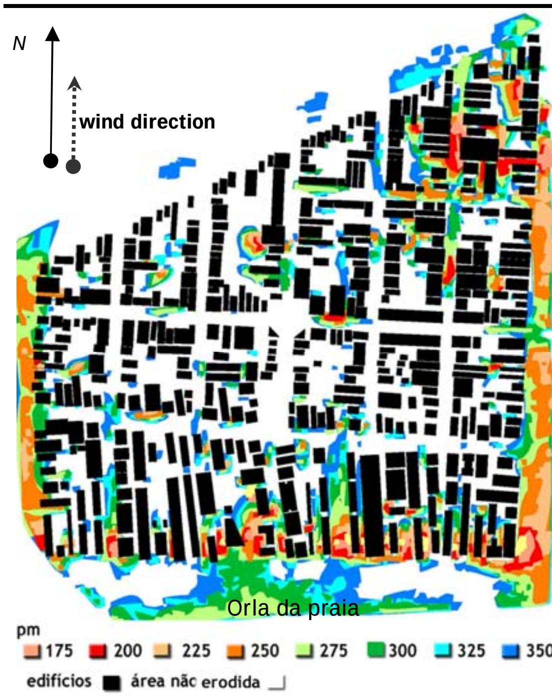


Figure 8 (a): Simlation for the wind direction from south to current situation.
Source: Prata, 2005.

For Figure 8 (a) it can be observed that in the area's central points there is no sand movement. Thus, for this configuration, there are non-eroded zones in the central part of the model, more precisely in the second block, which shows the influence of the barrier formed by the buildings on the sea shore. However, the rugosity represented by the second block itself causes movement from the third block on.

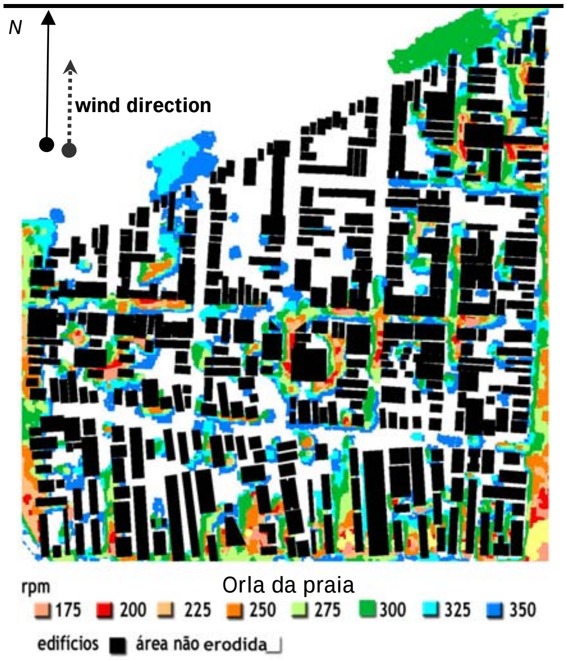


Figure 8 (b): Simulation for the wind direction from south to situation with changes.
Source: Prata, 2005.

For direction south, with all the changes, it can be seen that – with the addition of new buildings – there was an increase of air-flow in the second block, in the central part of the area, with a slight reduction of flow for the central area of the third block.

It can also be seen that, due to the height of the new buildings – there is wind movement close to them. And, also, the presence of border effects and channeling near these buildings.

For the simulations in which there was an accumulation of sand and which, consequently, are areas with little ventilation, it is advised to have openings in the architectural elements, to aid in air extraction. These openings can be obtained inserting open spaces (green areas, squares), with better use of the block, making use and built areas compatible.

The movements on the models' borders can be disconsidered, for the urban configuration around the simulated area was not contemplated.

With the simulations it was possible to define the internal points of the area for the in loco measurements, where the measured variables (direction and wind velocity and air humidity) were used for the application of the thermal neutrality index (MONTEIRO et al, 2005) applied for verification of the thermal sensation of users/pedestrians.

4. CONCLUSION

The city climate is the most evident form of climate change inadvertently caused by man (LOPES, 2003).

Architectural design solutions for buildings, such as pilotis, partial empty spaces in some floors, shapes, must also be studied, not only in the pursuit of better natural ventilation in the installation of new buildings in areas with existing constructions, such as the study area, but also in the cases of sea shores where the process is still in initial stages.

The decision for changes to the urban soil not only involve the question of local wind flow pattern but also must consider the use and shape of the buildings, green areas, placement relative to climate factors (sun, rain...), as well as the city's capacity (infra-structure) to absorb new buildings.

With the use of models and wind-tunnel simulations, it is worth pointing that – for the area in study – the results obtained are only valid for the simulation's conditions. Any new projects to be implemented must be simulated if a clear idea of their impact is to be had.

The wind-tunnel simulations enabled verification and confirmation that changes in position and height of buildings, in the urban configuration, changed the wind pattern in the study area and where the influence of new buildings would reach.

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