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Article

Simulation of urban growth near the green area of "Avenida Brasil" in Antofagasta midtown, Chile

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Abstract: Vertical cities growth is argument of discussion world-width. Population increases and a better soil use is needed, in terms of efficiency and density, in many cities of the world. However, an excessive vertical growth seems to be dangerous, especially near the green areas of midtowns. In this paper the case of Antofagasta is studied.

Keywords: vertical growth, green areas, urban sustainability

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1. Introduction

Town of Antofagasta locates in the north desert coast of Chile, in a typical arid climate, latitude 23° south and longitude 70° west. Green areas are quite precious in arid climates, and have to be protected by building overheating effect. In the last 20 years, in Antofagasta have been constructed almost 30 new towers, more than 70 meters high. At least 7 of these new towers are negatively affecting nowadays the "Avenida Brasil" area, a green park of 70 meters large and one kilometer long, which is the principal green area of the city center. Paper studies two possible future evolutions: one following the actual trend, and other one proposing new building concept, limited in vertical dimension and integrated in the environment. Parameters analyzed are: temperature, humidity, solar radiation, wind speed and direction in the green area. Results show the impact of building growth in terms of overheating and wind reduction on the ground area studied.

Additionally, social impact of living in towers is also discussed in the paper, searching for better design in order to guarantee user's comfort, satisfaction and stimulation in their residences. Thermal, visual and acoustical effects produced by towers are considered in the critical evaluation of the Antofagasta city evolution. Part of this work relates to architectural laboratory "energy and architecture" currently on-going at School of Architecture of the Northern Catholic University.

2. Methodology

Figure 1 shows the location of Antofagasta city, in the Atacama Desert close to the Pacific Ocean. Climate is typical of desert coast, with high solar radiation levels, no precipitation, average temperatures between 15 and 25 degrees Celsius during the whole year.

Figure 1. Antofagasta emplacement in the North of Chile, on the Pacific Ocean.

In the city center the green park of Avenida Brasil is one of the icons of Antofagasta. Figure 2 shows the park form, S-N oriented, surrounded by the city, but quite close to the sea. Building growth near this site has been uncontrolled during years. Of the ancient Antofagasta buildings only few houses are used nowadays. These traditional houses have 2 floors for a total high of about 8 meters. Expecially during the last 20 years in the city center have been constructed more than 30 towers and others are under construction. Economical growth of Antafagasta signified an important population growth and the center area has been transformed in order to attend the new needs of the residents. However, uncontrolled built area improvement is dangerous for the sustainability of the site, especially considering the low presence of vegetation in the city. Avenida Brasil is an area with delicate relations between houses, plants, sky and sea. To modify the environment could cause for example an excessive increase in the shadow zone, or a wind deviation from natural movement.

Figure 2. Antofagasta midtown area with green area of Avenida Brasil

For this reason, in the School of Architecture of the local University, UCN, we focused a laboratory to understand the possible future scenarios of the city and started investigations using different simulation tools to obtain some microclimatic data of different areas potentially affected. In this paper we present Ecotect models and simulations of solar incoming radiation, temperatures and wind deviation in the Avenida Brasil area. Figure 3 shows Ecotect model for actual situation, with some towers concentrated in the central west zone and others disposed in more disperse locations.

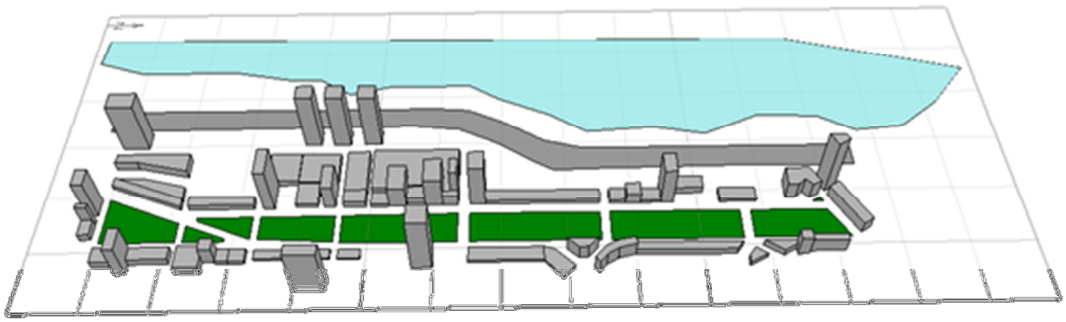

Figure 3. Ecotect model for actual situation in Avenida Brasil area.

Future predictions were done considering actual trend or a change in terms of sustainable use of green areas and reasonable building high. Figure 4 shows Ecotect model for the actual trend simulation and figure 5 shows Ecotect model for new trend characterized by sustainable design of new construction, permitting a maximum of 6 floors and incorporating green area and natural ventilation concepts.

Figure 4. Ecotect model for actual trend

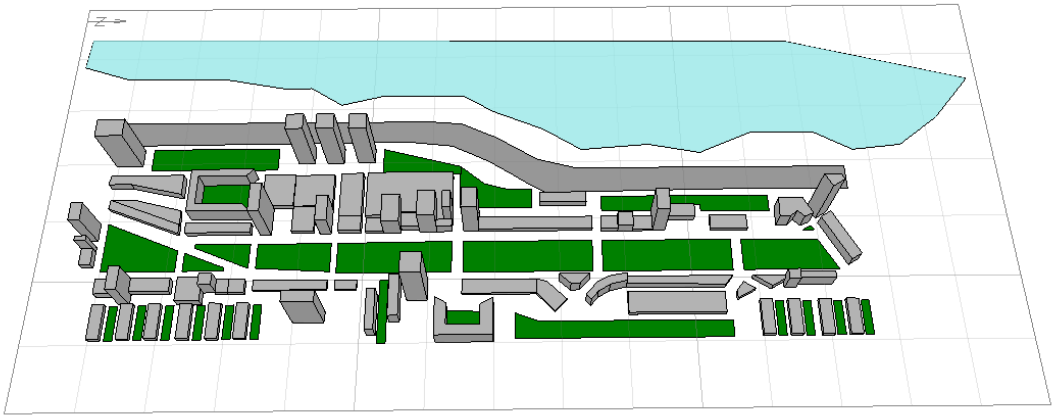

Figure 5. Ecotect model for sustainable development of the area

Respects to laboratory, students were asked to respond to the question of the urban habitability analyzing the following factors:

- Urban light, acoustic and climatic environment

- Building needs in terms of operability, services, public and private zones

- Integration of energy and comfort concepts

Laboratory is currently on going and first results shows that current construction is not responding to required parameters, especially environmental factors are ignored in Antofagasta urban development. Principal factor (or the only one in most cases) taken in to account is the usefulness of a site – thus, how to put more people in less square meters.

Student's opinions respect to this fact is obviously that a new paradigm of the architecture is needed, in order to reach a sustainable city, with green areas, sun exposition studied in the first design stages, acoustic integration in natural environment and limitation of urban noise, climatic approach in orientation and internal distribution design of buildings, etc.

3. Results and discussion

Simulation results are presented in the following order:

- Shadows and solar exposition
- Temperature and humidity
- Wind protection and natural ventilation

Respect to shadows, park area of Avenida Brasil is today partially obstructed on the west, but it is exposed to the sun on the north. This fact signify a relatively usefulness of the green area during the morning, and a general user dissatisfaction during the afternoon, when wind and shadows combines. In the summer, with high solar radiation and Sun to the zenith, green area is too much exposed and people prefer to stay in the protected zones near the buildings.

Actual trend of construction can generate shadows in the east side of the park, and it will be dangerous because the morning sun is desired by users and seems to be the actual value of the park. Park area is divided in 8 parts in the Ecotect model. Figure 6 shows the sun-path diagrams for the 4^{th} part (in the center) in the actual situation and in the future following the actual trend in construction.

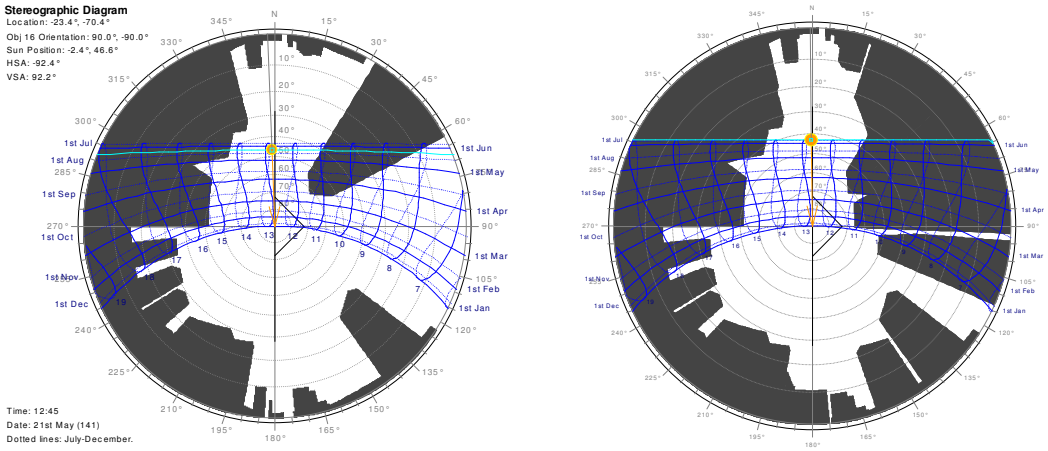

Figure 6. Shadow range for actual and uncontrolled future situation

Figure 7 exposes the mean radiant temperature distribution for the summer solstice in the uncontrolled urban growth case. Radiant temperature depends strongly by the soil, as detailed in the picture, where asphalt road has a temperature of about 30 °C and the green area almost 22 °C. Building presence affects the green area radiant temperature that is perceived at 1.8 m high in the range of 24-28 degrees, with ambient temperature of 24.

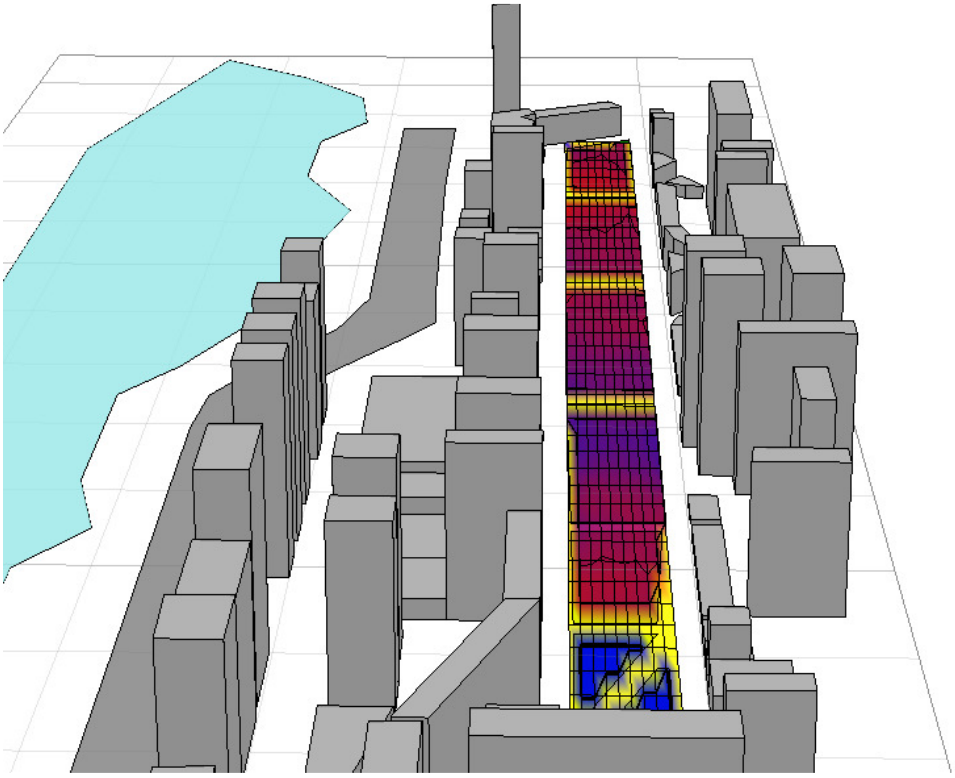

Figure 7. Mean radiant temperature in the park area for future situation

One of the most important effects of the new construction will be wind desviation from the actual situation. At the moment, air is flowing from the ocean (south – east) and is entering in the park from south and leaving it in the north.

Sustainable construction have to consider the overheating effect caused by the sun radiation in this location, and ventilate appropriately the facades and the roofs. Figure 8 shows air flows in the area, with controlled transversal flows in the new built areas.

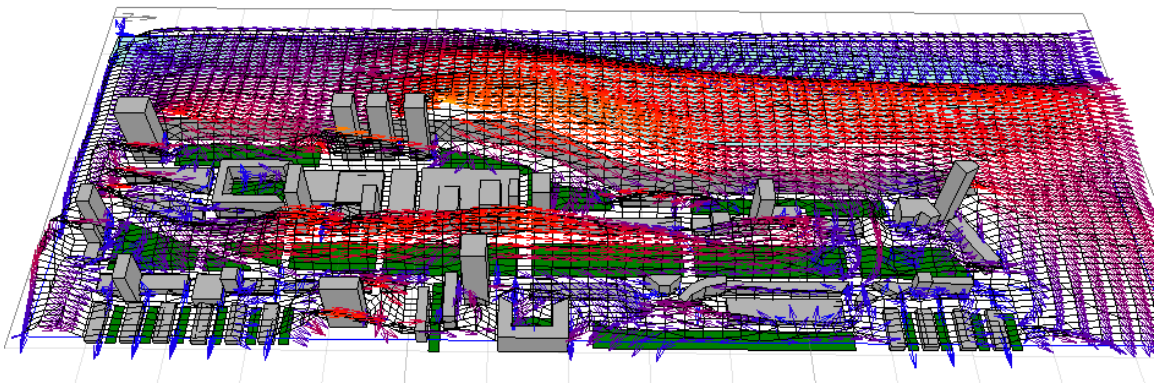

Figure 8. Air flow in the area (future prediction for sustainable development case)

Figure 9 shows the complicate situation of urban environment in the case of following the actual trend without sustainable considerations. In the north part of the area wind is generating turbulences and air velocity is increased by some tunnel effects. East part of the area presents buildings that can be not correctly ventilated.

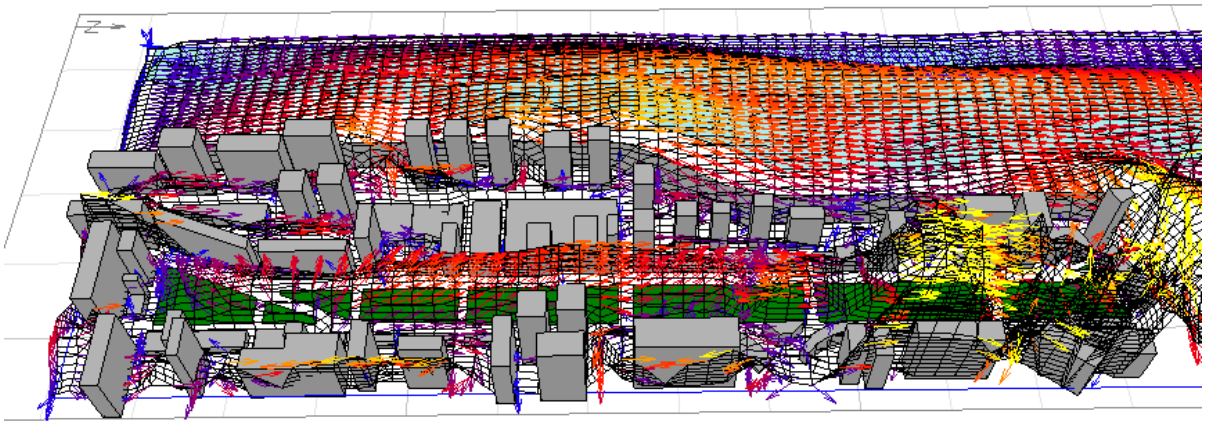

Figure 9. Air flow in the area (future prediction for actual trend)

Figure 10 shows a detail of the natural ventilation strategy in the east side of the park area. New constructions have been designed considering maximum 6 floors of vertical growth and orientation S-N of the principal fachades. Green areas are alternatively inserted between residential blocks. Results is a good ventilation, controlled and used to evacuate overheating in summer.

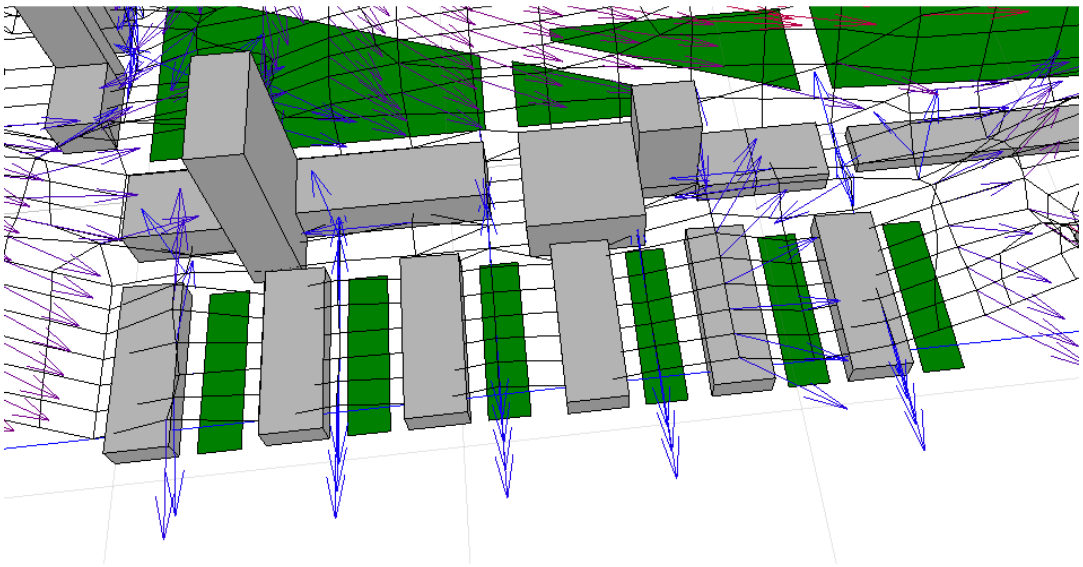

Figure 10. Detail of natural ventilation strategy in sustainable development of the area

Other results includes acoustics and social consideration on the urban life stile. Toweres are exposed to mid and high range noise, expecially the last floors. People meets only in elevators and social activity is reduced to go up and down to supermarket, parking, etc.

A controlled building development have to consider a correct insertion of small commercial areas, services, green parks. Respect to dwelling distribution in the blocks, it is important to consider a double exposition (S-N) and place the stairwells outside or in an intermediate space, avoiding anonimus internal elevators and using better the built space.

Figure 11 shows a student interpretation of urban noise distribution in the entire neighbor. Strategy of analyzing first the existing environmental stimulation is absolutely needed in order to decide how to use it or how to protect better from it.

Figure 12 shows the actual construction of the first of the five towers that will probably seriusly corrupt the east sun exposition of the central area of Avenida Brasil park.

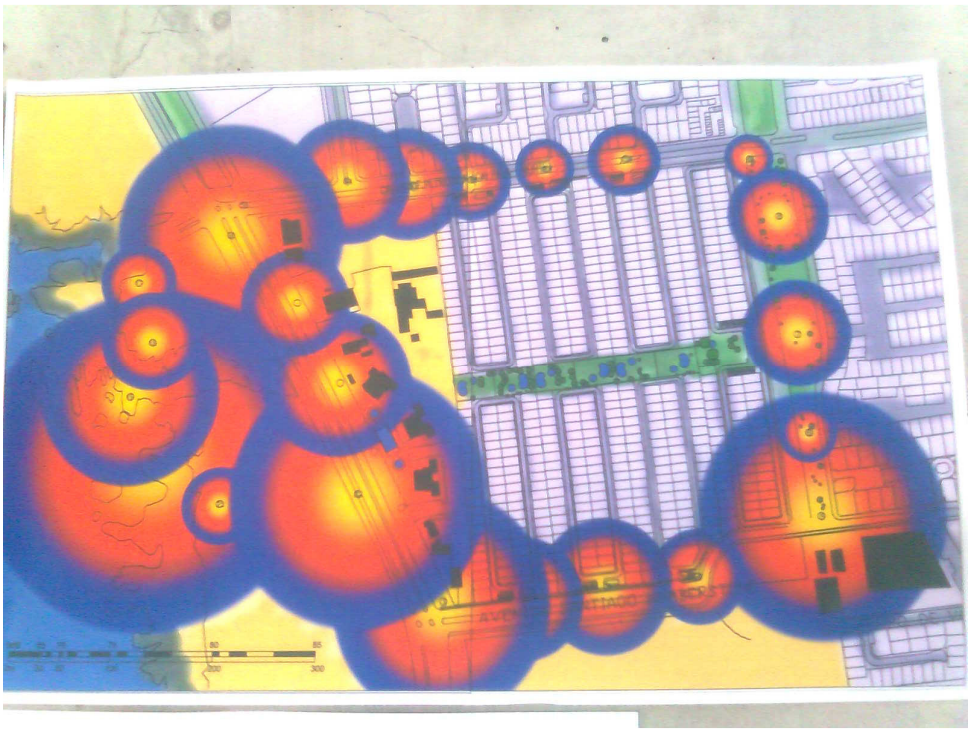

Figure 11. Noise distribution study for urban sustainable development

Figure 12. First tower of a proyect of five blocks near the park area.

4. Conclusions

In conclusion, we can assume that it appears very dangerous the actual trend in the Antofagasta urban development. Buildings are expanding on the entire city, without any consideration about history, sky line integration, environmental sustainability, acoustics, etc. The only parameter taken in to account is the economic growth.

As teachers and students on architecture, in the UCN School we are working on a different proposal, a city that is expanding with certain degree of equilibrium between green areas, services and residential blocks, medium sized, that have to improve the social life in the city center.

This new city concept can be regarded as more sustainable, resilient and robust. Robust design seems to be an important concept to use facing variability in climate, environmental condition and user's behavior. As described in some articles [1], [2], [3], [4], robust and resilient cities can be the low-tech answer to a critical situation of unsustainable development, especially in the countries of the south hemisphere, where economic inversion in sustainable high-tech management is quite poor.

Conflict of Interest

The authors declare no conflict of interest.

References and Notes

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