Influence of the surroundings areas in the microclimates of Santo André City – Brazil and Indication of Bioclimatic Strategies for Buildings

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Abstract. The characterization of the climate of Santo André and its weather data are essential instruments for the study of implantation, both of new buildings and solutions of retrofit, as well as for the elaboration of projects of urban interventions or degraded areas occupation. In this study, meteorological weather data were obtained by meteorological stations in Santo André, a municipality located in the region of ABC Paulista (São Paulo State), for five different points of the city in order to evaluate the different microclimates and the influence of the surroundings in microclimates and an climate file in .epw format was developed for analysed bioclimatic strategies for buildings. Results show temperature and humidity variations among the five microclimates analyzed, as a consequence of the following actions: replacement of vegetation by constructions, asphalt, concrete and other impermeable surfaces, increased air pollution which cause a great absorption of solar radiation, forming a barrier for air circulation and of pollutant gases into the atmosphere creating urban heat island effects.

1 Introduction

The study of the climate and its relation to the project practice is increasingly a differentiator of environmentally sustainable projects. The integration of climatic characterization with energy information is an essential instrument for land and environmental planning as a subsidy for the implementation of buildings and urban interventions projects.

The thermal comfort is directly related to the climate and the ideal is to use it as a prerequisite to propose solutions, both in terms of building and in relation to urban projects. Throughout history, environmental control methods have been developed to offer shelter and comfort to men, and climate has been the determining factor in the definition of architectural conceptions, materials and construction techniques.

The study of the climate and its relation with the project practice is increasingly a differential of the environmentally sustainable projects. The integration between architecture and climate is a matter of great relevance for reducing energy consumption and reducing the need for energy production. Thinking about these issues from design to building is critical to mitigating the adverse effects of climate change.

In terms of urban comfort, when buildings are not planned in such a way as to have an optimal interaction with the environment, the so-called heat island in the urban area is triggered, which is manifested by the increase in air temperature compared to less urbanized regions, especially at night. The demographic and industrial growth contributes to the formation of the heat island, as it substantially alters the characteristics of the urban space by reducing green areas, occupation of the urban environment by concrete and asphalt alterations that albedo, industrial pollution and car circulation [1].

1.1 The Municipality of Santo André-SP

The municipality of Santo André, for which the study was carried out, is located in the region called "ABC Paulista", in the southeast of the Metropolitan Region of São Paulo, considered one of the most important regions of the state, due to its industrial profile and economic dynamism. However, since the 1990's, the dynamic process of transforming the cities of ABC Paulista presents productive changes that have led to a "de-industrialization", leading them to the "city of the tertiary" [2].

In addition, the Municipality of Santo André was one of the focuses of the industrialization process from the

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1940's and today faces the deactivation of industries, with environmental liabilities as sequels. This type of area, after undergoing revitalization actions that include soil remediation, waste removal, pumping and treatment of contaminated groundwater, constitute technologically viable solutions and allow the human occupation of these areas safely [3].

These abandoned areas are located in urban centres with infrastructure are generated by these liabilities and are called "brownfields", while the urban slum expansion occurs in the peripheries and reach sensitive areas such as water supply sources [4].

Nowadays, there is a scenario in which there is a growth in the number of residential buildings, as is the case of the municipality of Santo André, which is acquiring a "dormitory town" profile, where a good part of the workers reside, but they carry out their activities in São Paulo city. In the case of Santo André, 237,773 residents (35.15% of the total population) moved to other cities, 10.62% to São Paulo and 10.32% to São Bernardo [5]. In these new housing initiatives and adaptations, common solutions are repeated, without considering local and bioclimatic aspects. Figure 1 presents a Santo André city location map.

Fig. 1. Location Map - Santo André [6].

The development of this study is based on the climate analysis, through the collection of weather data that represent the average pattern (climate characteristics) for the Santo André city. Five microclimate from different points of the Santo André city were analysed in order to evaluate the influence of the surroundings in it characteristics and yet, an climate file in .epw format was developed and analysed for obtain bioclimatic strategies for buildings.

2 Methodology

2.1. Microclimatic Characterization

The weather data of meteorological stations of the municipality of Santo André were obtained from the

Serviço Municipal de Saneamento Ambiental de Santo André (Semasa) (Municipal Service of Environmental Sanitation of Santo André), which is an autarchy created in 1969 to take care of water supply and sewage collection in Santo André. Semasa has five meteorological weather stations (Figure 2), which measure precipitation, temperature, relative air humidity, direction and wind speed and solar radiation. However, such weather data began to be measured since 2011, so the data obtained from Semasa included the period from 01/01/2011 to 04/18/18, on an hourly basis, which is the most complete and meteorological variables measured in the same meteorological station, available for the municipality of Santo André. Therefore, these weather data will allow the knowledge of the average compartment of the meteorological variables in the available period for each microclimate, and not the climatic characteristic from climatological normals, which requires at least 30 years of available data.

Fig. 2. Location Map - Santo André Weather Stations [7].

The hourly meteorological data were analyzed in order to characterize the seasonal cycle of temperature and relative humidity variables. The mean was calculated for each month of the year, from 2011 to 2018. In the case of air temperature, the maximum, average and minimum daily values were first identified, obtaining the series of monthly averages used to calculate the mean value for each month in any period, featuring the seasonal cycle of temperature and humidity. It was also analyzed the variation of air temperature and relative humidity in relation to Station 01 - Camilópolis (Utinga). Afterwards, the diurnal cycle average was determined for the whole period, with analysis of the temperature and relative humidity data, and also the variation of the diurnal cycle average for temperature and relative humidity in relation to Station 01-Camilópolis (Utinga).

2.2 Bioclimatic Strategies for Santo André-SP

The microclimatic characterization served to make a specific analysis of different points of the city. However, the .epw format file of the Station 01 Camilópolis (Utinga neighborhood) was used to indicate constructive strategies, because it is the place that stands out most in terms of predominance of housing construction, according to information obtained in The Municipal Government of Santo André.

Climate Consultant 6.0 program was used for the climate assessment and indication of constructive strategies. This software is based on graphics, that assists in understanding the local climate. Through the use of an .epw format file containing climate data, the program recommends bioclimatic strategies. The program translates this climate data into charts for analysis of what occurs in each climate and indicates constructive/urban solutions [8].

In the present work was considered in the Climate Consultant 6.0 - the Adaptive Comfort Model of the ASHRAE 55 Standard 2010 - which is a renowned model in the area of environmental comfort and used internationally. In the ASHRAE 55 Adaptive Comfort model 2010 (Adaptive comfort model in ASHRAE 55 Standard 2010), they are considered to be naturally ventilated spaces, and it is still considered that occupants can adapt their clothing to thermal conditions, and verify if they are sedentary, varying the metabolic rate between 1.0 and 1.3 met. The parameters (criteria) of the chosen model, considering the use of natural ventilation and acceptable comfort limit of 80%, in the case of Santo André are: the minimum average outdoor monthly temperature is 14.7 ° C and the maximum average monthly temperature outside of 24.1 ° C. The minimum operating temperature will be 19.9 ° C and the maximum operating temperature of 27.8 ° C.

3 Results

3.1. Microclimatic characterization

In the results meteorological data were analyzed in order to characterize the seasonal cycle of temperature and relative humidity variables.

3.1.1 Average monthly: Temperature and Relative Humidity

Figure 3 shows the average monthly temperatures for the data of all the weather stations. For almost the whole year, the temperature is higher for Station 01 - Camilópolis (Utinga), reaching an average of 20.46 ° C. This is explained, because Station 01 - Camilópolis (Utinga) is located in an area occupied by several housing typologies. In this area stands out constructions, asphalt, concrete and other impermeable surfaces in the surrounds. Station 03 – Tanque de Detenção is noteworthy because it shows the highest temperature observed in February and Station 04 - Paraíso has the highest temperature for January (Figure 4). The Station 03-Detention Tank is near from an urban void.

Fig. 3. Average monthly temperature.

Fig. 4. Temperature variation in relation to Station 01 - Camilópolis

Regarding relative humidity, the highest monthly averages were observed for Station 05-Vila Vitória until the month of July and the rest of the year for Station 04-Paraíso. Both present in the surroundings a small green area, which directly influences the increase of humidity. The lowest relative humidity was observed for Station 01-Camilópolis, already cited as the one with the largest area occupied by buildings impermeable surfaces (Figures 5 and 6).

Fig. 5. Average monthly relative humidity.

Fig. 6. Relative humidity variation in relation to Station 01 – Camilópolis.

Table 1 presents the weather stations and surrounds. It is possible to observe the nearby green areas, constructions areas and other impermeable surfaces in the surrounds.

Table 1. Weather stations and surrounds [7].

Station 01 – Camilópolis (Utinga)	Station 02 – Erasmo de Assunção

Station 03 – Tanque de Detenção	Station 04 – Paraíso

Station 05 - Vila Vitória	

3.1.2 Diurnal Cycle Average: Temperature and Relative Humidity

In terms of temperature of the diurnal cycle, the greatest differences were observed for Station 01-Camilópolis (Utinga), in the period from 11 to 17 hours, which presented the highest temperatures. The other stations showed very near temperatures (Figure 7). Station 03 – Tanque de Detenção stood out with slightly higher temperatures during the hours of dawn (0 to 6hrs). Station 05 - Vila Vitória stands out from 14hrs with lower temperatures (Figure 8).

Fig. 7. Diurnal cycle average relative humidity.

Fig. 8. Diurnal cycle average relative humidity: variation in relation to Station 01 – Camilópolis.

Regarding the relative humidity of the diurnal cycle, the highest values were observed for Station 04-Paraíso, followed by Station 05-Vila Vitória, both of them present a small green area in the surroundings, which influences the increase of humidity. The lowest relative humidity observed was again for Station 01-Camilópolis (Utinga) (Figures 9 and 10). The peaks of relative humidity in relation to Station 01-Camilópolis occur from 12 hours, reaching higher values at 15 hours.

Fig. 9. Diurnal cycle average temperature.

Fig. 10. Diurnal cycle average temperature: variation in relation to Station 01 – Camilópolis.

3.2. Bioclimatic Strategies for Santo André - SP

The following twelve graphs summarize the results of the average dry bulb temperature and competing relative humidity (Figure 11). Also shown on each monthly chart is a thick horizontal line, which indicates the comfort zone. In most of the months, the temperature is outside the comfort zone, mainly for the winter months (June and July). During summer, December and January, higher temperatures occur. The results also presents the dry bulb temperature with maximum between days, at 12 and 16 hours. The increase of dry bulb temperature is

accentuated from 8:00 a.m. and presents around two or three peaks in the afternoon, but the dew point temperature is relatively stable throughout the day.

Fig. 11. Average dry bulb temperature and relative humidity graphs for the Station 01-Camilópolis (Utinga) Santo André.

A psychrometric chart was obtained for the Station 01-Camilópolis (Utinga) (Figure 12). According to the Urban Master Plan, this area is an urban qualification zone. The psychrometric chart lists the temperature data (on the x-axis) with the relative humidity (on the y-axis). The application of the indicated design strategies allows achieving a certain degree of comfort. This list of project guidelines applies specifically to the climate whose climate file was analysed. According to the climate there are high temperatures in summer and lower temperatures in winter. Regarding adaptive comfort, the results indicate that without the use of active systems (using some energy source, such as air conditioning), the exclusive adoption of passive systems would only allow 32% of the thermal comfort conditions, being even more complex in the case of urban spaces, which are limited in terms of active strategies, which imply energy consumption and constant need for maintenance. The analysis performed by the program considers the Adaptive Comfort model, with naturally ventilated spaces, where the occupants can control the openings and their thermal response will depend in part on the outdoor climate. This model assumes that the occupants adapt their clothes to the thermal conditions and are sedentary (1.0 to 1.3 met). The comfort zone is defined in a range with temperatures of 19.9 to 27.8 °C and as shown in Figure 12, most temperatures are outside this range.

Fig. 12. Psychrometric chart for the Station 01-Camilópolis (Utinga) area, from Santo André with indicated strategies.

Based on the analysis of the weather data by the program, the strategies for the area near from Station 01

– Camilópolis (Utinga) of Santo André-SP were extracted from the results, some of which work for housing and some can also be applied to urban projects (Table 2).

Table 2. Bioclimatic Strategies for Santo André-SP.

Bioclimatic Strategies for Santo André-SP	
Strategy 17:	Use plant materials (bushes, trees, ivy-covered walls) especially on the west to minimize heat gain (if summer rains support native plant growth).
Strategy 32:	Minimize or eliminate west facing glazing to reduce summer and fall afternoon heat gain.
Strategy 33:	Long narrow building floorplan can help maximize cross ventilation in temperate and hot humid climates.
Strategy 34:	To capture natural ventilation, wind direction can be changed up to 45 degrees toward the building by exterior wingwalls and planting.
Strategy 35:	Good natural ventilation can reduce or eliminate air conditioning in warm weather, if windows are well shaded and oriented to prevailing breezes.
Strategy 36:	To facilitate cross ventilation, locate door and window openings on opposite sides of building with larger openings facing up-wind if possible.
Strategy 37:	Window overhangs (designed for this latitude) or operable sunshades (awnings that extend in summer) can reduce or eliminate air conditioning.
Strategy 42:	On hot days ceiling fans or indoor air motion can make it seem cooler by 5 degrees F (2.8C) or more, thus less air conditioning is needed.
Strategy 47:	Use open plan interiors to promote natural cross ventilation, or use louvered doors, or instead use jump ducts if privacy is required.
Strategy 49:	To produce stack ventilation, even when wind speeds are low, maximize vertical height between air inlet and outlet (open stairwells, two story spaces, roof monitors).
Strategy 53:	Shaded outdoor buffer zones (porch, patio, lanai) oriented to the prevailing breezes can extend living and working areas in warm weather.
Strategy 54:	Provide enough north glazing to balance daylighting and allow cross ventilation (about 5% of floor area).
Strategy 56:	Screened porches and patios can provide passive comfort cooling by ventilation in warm weather and can prevent insect problems.
Strategy 58:	This is one of the more comfortable climates, so shade to prevent overheating, open to breezes in summer, and use passive solar gain in winter.

3 Conclusions

For each microclimate it is necessary to consider the need to increase the surrounding vegetation, in order to decrease the high temperatures and the spaces between the buildings to better natural ventilation conditions.

It was also observed the need to analyse the particularities of each specific microclimate, in order to verify the influence of the characteristics of the surroundings in the same one, which implies in better precision in terms of building and urban design.

The microclimates found in the Santo André city present a need for natural ventilation strategies (cross ventilation) to reduce the energy consumption of air conditioning; correct positioning of glazed facades; use of overhangs; use of balconies and patios, among other strategies. Differences were observed between vegetated and extensive urban areas.

The climatic characterization of the Urban Qualification Zone (Station 01-Camilópolis area) of Santo André allowed to reach the proposed objectives, specifically: to elaborate the survey of bioclimatic (passive) strategies with potential of application in projects inserted in the climate; to verify its characteristics, which implies thermal discomfort and makes it difficult to adopt passive solutions and obtain the necessary characteristics for projects that imply better thermal comfort

This study can enabling architects and engineers to choose solutions appropriate to the climate of the Urban Qualification Zone of Santo André, during the process of designing of new interventions and revitalizing existing urban spaces.

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