ANALYSIS OF THE MICROCLIMATE OF SÃO CRISTÓVÃO AND ITS INFLUENCE IN HEATING SYSTEMS, VENTILATING AND AIR CONDITIONING (HVAC)

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1 Introduction

The metropolitan region of Rio de Janeiro has a high population density and a very high degree of industrialization, and as a consequence a large concentration of pollutant emissions and heat sources. Its topographic and atmospheric peculiarities directly affect the dispersion of air pollutants and heat. Furthermore, the land use characteristics of the region with a high percentage of areas covered with asphalt and concrete are able to convert and store solar radiation into a greater extent than rural areas, promoting the onset of a horizontal temperature gradient phenomenon known as the urban heat island [1].

This manuscript aims to investigate the influence of urban microclimate on air conditioning designs through using climatic data from the closest meteorological station instead of those recommended by the Brazilian air conditioning design standard ABNT NBR16401. For the city of Rio de Janeiro, this standard provides climatic data from Antônio Carlos Jobim International and Santos Dumont Airports. Both are located next to the sea, so it can be supposed that they are less impacted by the urban heating.

2 Materials and Methods

The building has an area of 120m² and it is internally divided into administrative room, reception, security room, circulation area, information technology room, dining room and bathrooms. It is placed in the Sao Cristovao neighborhood, and for this investigation, strategically located where there is a meteorological station. Sao Cristovao is far respectively, 6 km and 10 km, from the Santos Dumont and Antonio Carlos Jobim airports. These distances were approximately measured through straight lines using a specific tool available in the Google Maps. For any place in the Rio de Janeiro city, there is no indication in the NBR 16401 about what climatic data must be chosen. It is well known that air conditioning designers adopt the highest temperature data.

The São Cristóvão meteorological station belongs to the Fundação Instituto de Geotécnica (Geo-Rio), within the Rio de Janeiro's City Hall, a department created for monitoring the rainfall in order to warn the population about risks of slope slips. It is located at the latitude of -22.896667, the longitude of -43.221667 and an elevation of 25 meters, on the top of the Geo-Rio building. This station measures and records temperature, humidity, pressure, rainfall and wind speed at 15 minutes intervals. It has supplied access to download data since 2002, but the period used here is from 2003 to 2015 [2].

São Cristóvão climatic data must be processed following a methodology defined by ASHRAE (2013) in order to generate a climatic data table similar to those available in the NBR 16401. It requires an extensive database obtained by direct measurement of several variables, hourly, over a period of at least eight. Among the data required is the design temperature, which for conventional cooling designs is the dry bulb temperature (DBT). This is achieved by arranging the data stored in the measurement frequency vectors, and calculating the temperature which is only equaled or exceeded by a specific percentage of the total number of times of the year. The percentages correspond to desired frequency levels. The coincident wet bulb temperature (CWBT) is obtained by arranging the stored data in frequency matrices by averaging the wet bulb temperatures that occur along with the calculated DBT [3].

The dry bulb temperature, dew point (DPT) and wet bulb temperature and wind speed corresponding to different annual percentage representing the value that is exceeded on average by the percentage indicated the total number of hours per year (8760h). The 0.4%, 1.0% and 2.0% are exceeded, on average, 35h, 88h, 175h per year, respectively, for the record period [3].

Meteorological data sets used for the calculations may contain missing values. Gaps up to 6 hours were filled by linear interpolation to provide the most complete possible time series. When the data at the right time are lacking, they can be replaced by data up to 0.5 hours before or after, when available [3].

Some months were also eliminated during the additional quality control checks. The dry bulb temperature of a station will only be used for design calculation if there was data from at least eight months that met the quality control and selection criteria from the registration period for each month of the year [3].

Microsoft Excel was used for data processing. Downloaded climatic data are formatted with columns corresponding to climatic variables and lines to time. Only DBT, relative humidity and pressure columns were maintained, all other columns were deleted. Then, the lines corresponding to fifteen, thirty and forty five minutes were also eliminated. The lacking of DBT data was searched, and when found, data were fulfilled with the closest available, within a thirty minute interval. So, DBT data were arranged in ascending order to find the DBTs that correspond to the frequency levels of 0.4%, 1.0% and 2.0%. Finally, the coincident relative humidity and pressure values were determined as the average ones. CWBT and DPT were read in a psychrometric chart.

3 Results

The DBT for São Cristóvão was approximately a mean value between the others, accomplishing its geographical location. On the other hand, both CWBT and DBT for São Cristóvão were the lowest for all frequency levels. This was expected since São Cristóvão is more far from the sea than other stations.

After defined the entry temperatures, thermal load calculations were made in order to evaluate their influence on the air conditioning design. Table 1 shows the thermal loads corresponding to the three places at the three frequency levels, with a vertical bar representation illustrated in Figure 6. The Antônio Carlos Jobim airport had the highest thermal load at all frequency levels. The thermal loads for São Cristóvão and Santos Dumont airport are very close at the frequency levels of 0.4% and 1.0%.

Thermal Load	**0.40%**	**1.00%**	**2.00%**
Antônio Jobim	40.4kW	38.6kW	37.5kW
Santos Dumont	38.1kW	36.5kW	35.7kW
São Cristóvão	37.9kW	36.3kW	34.7kW

Table 1. Thermal Load

4 Conclusions

The DBTs calculated for São Cristóvão have confirmed that there is an increasing temperature gradient from the south to the north in the study region. Since São Cristóvão is a neighborhood where buildings up to 2 floors are predominant, the elevation of its meteorological station has contributed to a negligible urban heating perception.

Although the DBT for São Cristóvão is midway between the others, the thermal load for São Cristóvão was the lowest. This can be justified due to its lower air humidity.

The variations of the thermal loads among the sites chosen are around 6% for the studied construction, which does not significantly interfere in the selection of the air conditioning equipment. At first the size of the building should be higher for that percentage has a significant impact on thermal load calculation.

References

[1] R. B. Stull. *An Introduction to Boundary Layer Meteorology*. Kluwer Academic Publishers, 1993.

[2] Sistema de Alerta Rio da Prefeitura do Rio de Janeiro, ALERTA RIO, *http://alertario.rio.rj.gov.br/,* Rio de Janeiro - RJ, 2016.

[3] American Society of Heating, Refrigerating, and Air-Conditioning Engineers. *Climatic Design Information*. Handbook Fundamentals, ASHRAE, Atlanta - GA, 2013.