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METHODOLOGY OF THERMAL PERFORMANCE ASSESSMENT OF COMANDANTE FERRAZ ANTARCTIC BASE (BRAZIL)

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Abstract: *The studies on thermal comfort establish the conditions required to evaluate and form an idea concerning a thermal environment appropriate for activities and human occupancy, in addition to the institution of methods and principles for a detailed thermal analysis of an environment. The inhospitable climatic conditions in the Antarctic environment (low temperatures, high wind speeds, isolation and the need for conservation of the natural environment) demand a deep study of several fields comprising the environmental comfort of the buildings, since the observance of national and international regulations related to this subject means an additional connection with personal safety, as well as assuring the health and well-being of the users. The purpose of this research is to assess the level of thermal insulation efficiency of the envelopment of the Comandante Ferraz Brazilian Antarctic Base (EACF, acronym in Portuguese) by means of measurements of thermal comfort indices in pre-selected environments, using for this proper equipment in accordance with international standards. The results showed differences in temperature in evaluated environments and reflect inefficiency in the insulating material.*

Keywords: thermal comfort, thermal performance, architecture and climate, cold climate

Introduction

The American Society of Heating, Refrigerating and Air-Conditioning Engineers ASHRAE Standard 55 (2004) defines thermal comfort as a state of mind which expresses human satisfaction with the thermal environment. Thus, the studies of thermal comfort establish conditions required to assess and conceive a thermal environment appropriate for activities and human occupancy, in addition to the instituted methods and principles for a detailed thermal analysis of an environment.

The Comandante Ferraz Brazilian Antarctic Base (Lat = 62° 05’ S and Long = 58° 24’ W) in general has sandwich sealing with their external partitions made from corrugated steel and internal partitions with wood wainscoting and filled with isolating material like expanded polyurethane or glass wool according with the building area and time of construction.

In previous studies it was noted that from several refits and expansions, where some modules were attached to the former structure, the replacement of polyurethane for glass fibre as isolating material had occurred drastically reducing the inefficiency of the intended insulation. According to Alvarez (1995), this had occurred mainly through the accumulation of moisture inside the panels with concentration at the floor level, thus allowing the transfer of cold to the inside of the environments and differences in temperature of about 10 °C between the floor and ceiling.

This research is aimed firstly to identify the problems concerning the thermal comfort of the EACF by means of analysis of data from the internal air temperature of environments and the building characteristics in order to establish the level of efficiency of the envelopment of building. Secondly, considering that the cultural and psychological aspects interfere with feeling of feeling hot or cold, data related to the satisfaction of the users will be aggregated, furthermore with the expectancy of relating the data of envelopment with the energy consumption of the EACF.

This study refers to the results obtained from the measurements concerning the first stage of evaluation of the envelopment.

Materials and Methods

The verification of thermal behaviour of the EACF throughout the study was carried out following the parameters of performance established by international standardization, in that the indications for the levels of comfort to users provided basis to assess the building. With this, data of air humidity and temperature to proceed with the analysis of the research was obtained.

To obtain the data, measurements were undertaken in pre-selected environments for their features aiming at larger representations of several situations found at the EACF. For the selection of the environments, the criterion adopted was the condition of exposure to winds. Thus, for the collection of environmental variables the following environments were selected: cabin 1 (the most exposed) and cabin 9 (the least exposed).

The equipment used for performing the management of the environmental variables were in accordance with ISO 7726 (ISO, 1998), observing the minimal requirements for collection of data to evaluate the thermal comfort. Chart 1 shows the specifications of the thermo-hygrometer employed in the present research.

After selecting the environments, in each place the equipment placement points were determined, located in accordance with the ISO 7726 (ISO, 1998) recommendations, which for environmental variables predict measurement heights of 0.10, 0.60 and 1.70 m in relation to the floor. Thus, in February 2010, in each environment three pieces of equipment were placed which were predicted for working with data collection till the summer of 2010. Therefore, in this paper the analysis is be based on the two environments where the equipment is installed (Figure 1), and for testing the methodology the period analyzed is 1-30 June 2010, considering it to be a month with low external temperatures and, therefore, with higher demands of efficiency of the envelopment.

The information was collected using a specific software program (BoxCar Pro) that allows reading the data in form of tables and graphs with the recording taking place automatically every hour.

Results and Discussion

The data presented in Figures 2 and 3 show the differences in vertical temperature existing in the same environment, which indicates the condition of discomfort located, called the draught, which is the cooling or heating of a body part, caused by air speed and/or differences in temperature between floor and ceiling ISO 7730 (ISO, 2005). Note that in cabin 9 the difference in temperature, on average, was 9.2 °C between the lowest height and the highest height (Figure 2), whereas in the cabin 1 that difference was 7.1 °C, on average (Figure 3).

By comparing the temperatures in the two environments for the same height, is was noted that there were marked differences, as shown in the Figure 4 for measurements at the height of 0.10 m, while the mean difference equalled 5.5 °C.

Chart 1. Description of the main equipment used for in situ measurements.

VARIABLE	DESCRIPTION OF EQUIPMENT
Air temperature and relative humidity	HOBO U12 Temp/RH/2 External Channel Logger, manufactured by Onset Corporation. This equipment is 58 x 74 x 22 mm, and has sensors capable of recording and storing up to 430,000 records of data of air temperature and humidity.

Figure 1. Location of the thermo-hygrometers in the cabin 1 (a) and the cabin 9 (b).

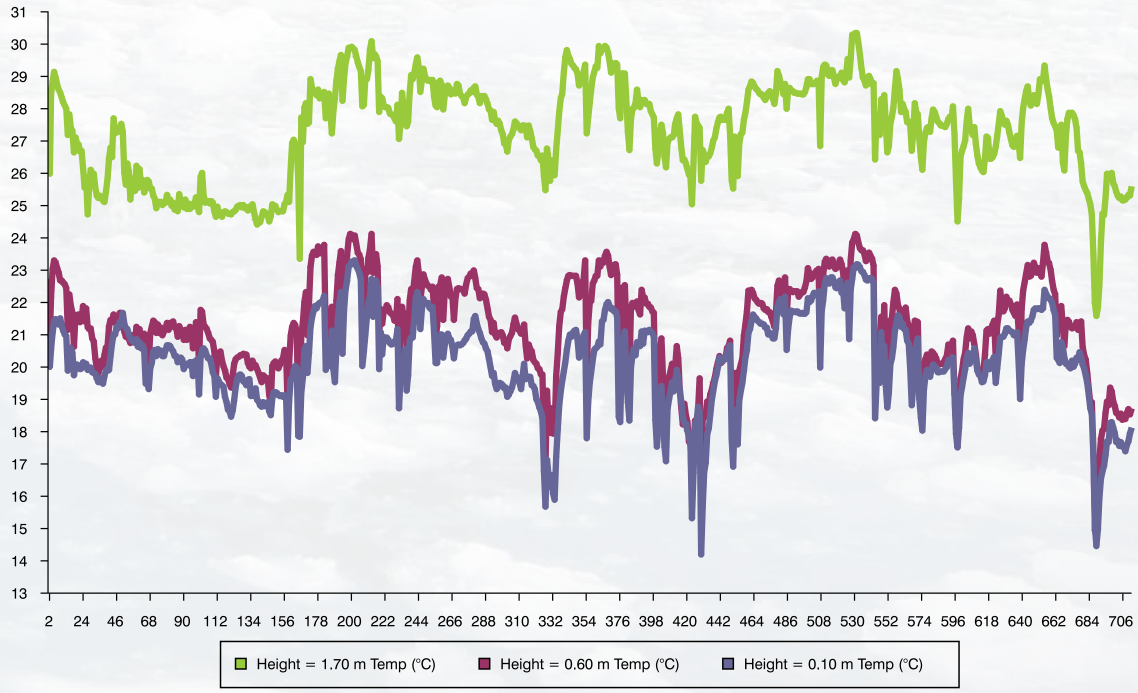

Figure 2. Air temperature measurements in the cabin 1 in three different heights.

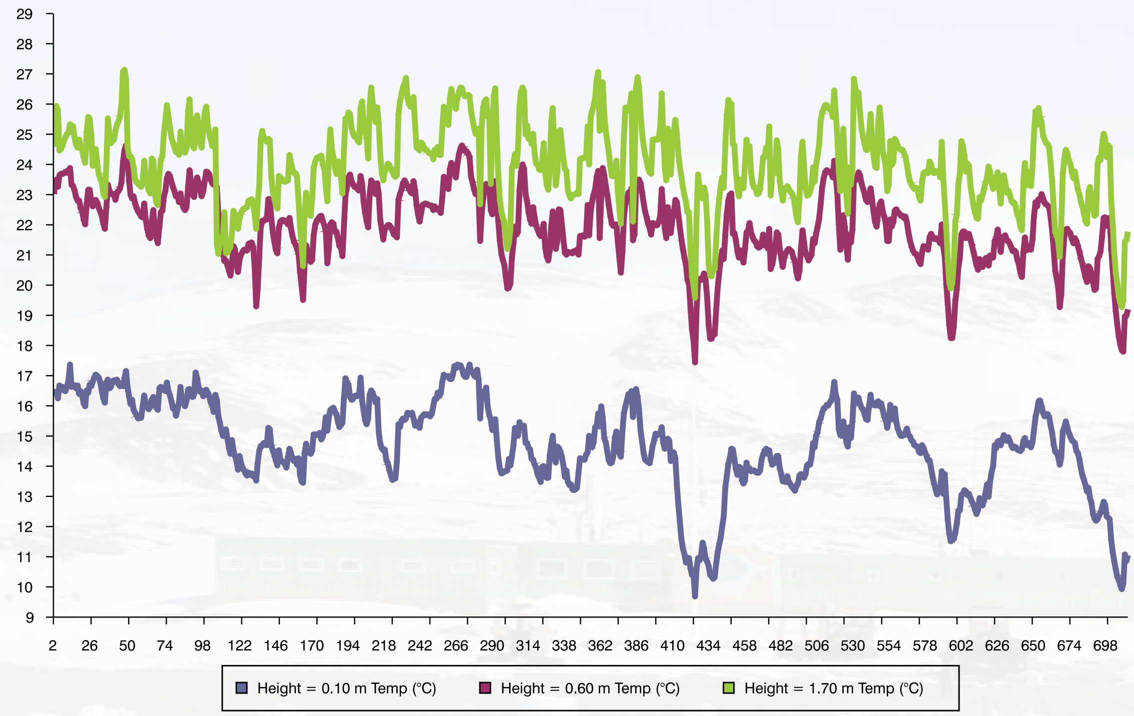

Figure 3. Air temperature measurements in the cabin 9 in three different heights.

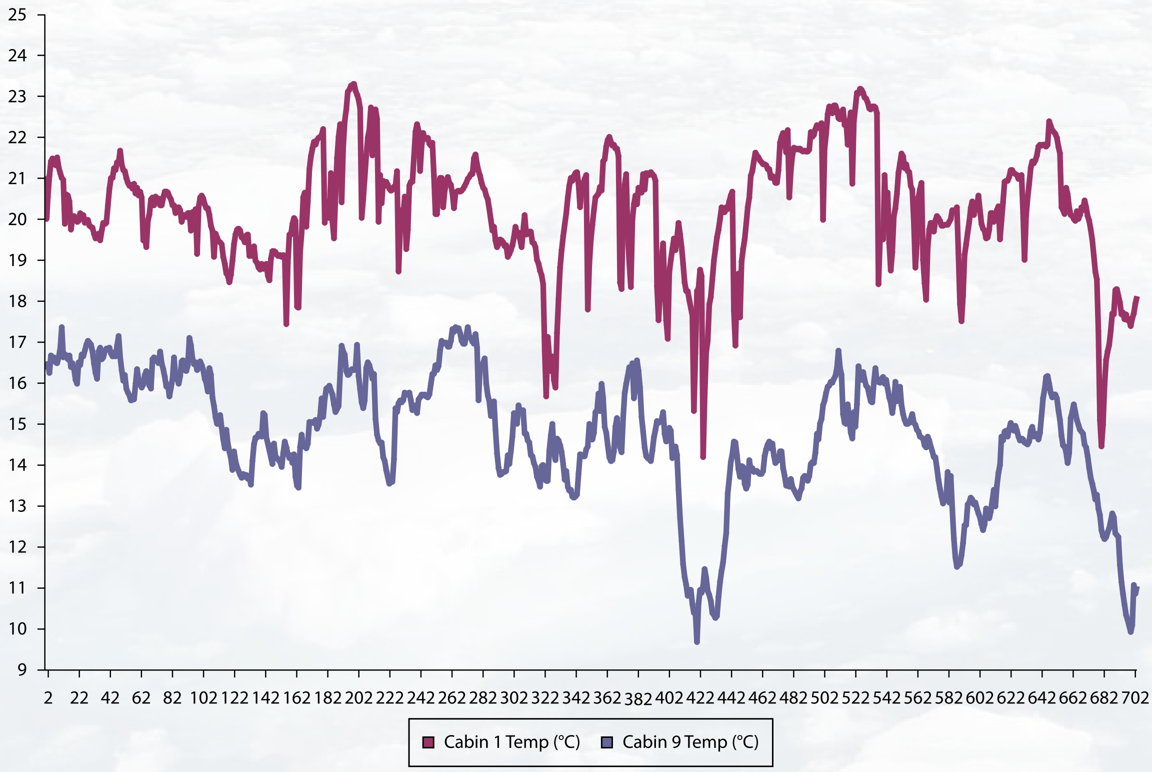

Figure 4. Temperature in the cabin 3 and 9 for the same height of 0.10 m.

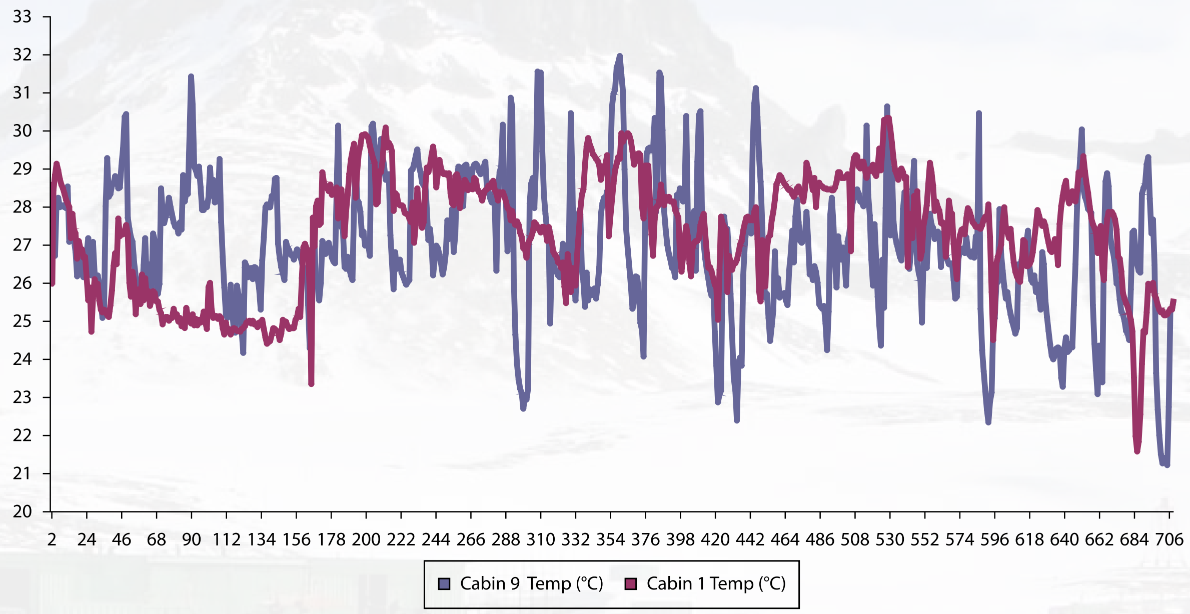

Figure 5. Temperatures in the cabin 1 and cabin 2 for the same height of 1.70 m.

For the height of 1.70 m, the differences were lower in the both cabins, since they reached 0.4 °C, on average (Figure 5). It was also noted that the temperatures in the cabin 9 ranged more than those in the cabin 1.

To evaluate the thermal comfort the knowledge of the environmental variables of namely, temperature, humidity, air velocity, and the mean radiant temperature, are needed. The respective characterizations for the environmental variables, measurement methods and instruments are described in the ISO 7726 (ISO, 1998). Although the information about the mean radiant temperature, humidity and internal air velocity had been collected, the results shown in the present paper do not consider those data since they are used for assessing thermal sensation defined in ISO 7730 (ISO, 2005) and are an integral part of a broader research. For the performance evaluation of envelopment the internal temperature data provided elements for a preliminary analysis.

Conclusions

In a preliminary analysis of data of the air temperature of the two studied environments, it was possible to conclude that:

- There was a local thermal discomfort due to the differences in temperature vertically, which proved the existence of draught;
- The difference in temperature of the floor in both the environments reflected inefficiency of the isolating material since the difficulty to maintain the heat was very likely due to transmission of cold to the inside of the environments. Considering the previous results reported by Alvarez (1995), it is believed that the inefficiency in the insulation may have due to the lack of thickness of the material associated with accumulation of humidity inside the panel;
- At higher heights the difference in temperature was lower, however disproportionate variation in temperatures were found, most likely due to changes in the characteristics of the envelopment, thus revealing the inefficiency of the insulating material and, therefore, the envelopment of the building.

For a complete analysis it is necessary to relate the data collected from inside the environment with the external temperatures, as well as to calculate the thermal comfort indices PMV (Predicted Mean Vote) and PPD (Predicted Percentage of Dissatisfied) proposed in ISO 7730 (ISO, 2005).

Acknowledgements

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