THERMAL EVALUATION OF CONSTRUTIVE MODEL MANUFACTURED IN LIGHTWEIGHT CONCRETE

Hyram D. de Andrade
Universidade Federal do Rio Grande do Norte
Núcleo de Tecnologia Industrial
Laboratório de Transferência de Calor
Campus Universitário
59072-970 – Natal RN
hyramdionisio@yahoo.com.br

Luciano A. C. Bezerra
Universidade Federal do Rio Grande do Norte
Núcleo de Tecnologia Industrial
Laboratório de Transferência de Calor
Campus Universitário
59072-970 – Natal RN
landre@dem.ufrn.br

George S. Marinho
Universidade Federal do Rio Grande do Norte
Núcleo de Tecnologia Industrial
Laboratório de Transferência de Calor
Campus Universitário
59072-970 – Natal RN
gmarinho@ct.ufrn.br

Abstract. *To analyze the thermal behavior of lightweight concrete blocks, two models (test cells) were built with the same dimensions, one of them with cement blocks, and the other with lightweight concrete blocks (blocks with sandwich section constituted by three layers: cement + sand + EPS / plate of EPS / cement + sand + EPS). Each test cell had external dimensions of 1,80 m of height, 1,80 m of length and 1,60 m of width and they were mounted in open field (to outdoor tests), without obstacles to the wind nor to the sun. Sensors of temperature were fixed in the external faces eastward and westward directions, in the internal face of the East wall and inside the cells. A data acquisition system was used to register the temperature of the cells during ten days. Data of thermal properties of samples of the lightweight concrete blocks were collected and used to support the analysis of the results of the experiments with the test cells. The analysis of the temperature profiles allowed us to evaluate the thermal performance of the two construction types comparatively.*

Keywords: *lightweight concrete, energy efficiency, thermal behavior.*

1. Introduction

Nowadays the electric energy consumption in Brazilian constructions is very high. Approximately 42% of the consumed electric power in Brazil is destined to constructions (LAMBERTS, 1997). The same author affirms that it is possible to reduce in up to 50% the energy consumption in new constructions, just harnessing the environmental comfort to the smallest energy consumption, since a part of this cost is destined to that end.

Responsible for great electric energy consumption, added to the increase of the urban population, the constructions become a problem when we consider the thermal conditions of the habitability. Thermally well conceived a building allows significant consumption economy, mainly in instants of energy crisis. This takes to suppose that it is the building the responsible for the treatment of the subject starting from the knowledge and use of the technique to project, orientation, materials and devices being that the planner should satisfy those demands with the resources that he disposes.

In the search for solutions of construction projects, aiming alternatives to energy conservation, a significant increase was verified in the use of thermal insulating materials applied to the constructive systems in the last decades. Recently Bezerra and Marinho (2003a, 2003b) realized study about the thermal behavior of Lightweight Concrete Blocks (LCB) in laboratory using artificial source of heat. This construct system was compared with conventional materials such as ceramic blocks and concrete blocks. According to the authors both conventional systems showed up less efficient then LCB to provide thermal isolation.

Al-Jabri *et al.* (2004) also research about massive concrete blocks made with lightweight aggregates, in this case vermiculite and polystyrene beads. Moreover, hollowed concrete blocks manufactured with polystyrene beads were produced. The authors noted that the hollowed blocks showed the best results when they were compared with the other two sort of block.

In this research the results attest the viability of the use of expanded polystyrene (EPS) for the reduction of the transfer rate through the opaque closings. In other words being used appropriate materials, the flow of heat proceeding from the solar radiation through the closings can be reduced, besides avoid environmental problems due to the generation of EPS residues.

2. Methodology

The research was accomplished in four different stages: construction of the test cells, assembly of the system of temperature measurement, measurement of the temperatures and analysis of the thermal behavior of the cells.

2.1. Construction of the test cells

The test cells consist of two cabins with identical geometry; one with cement blocks, and other with lightweight concrete blocks (blocks with sandwich section constituted by three layers: cement + sand +EPS / plate of EPS / cement + sand +EPS, fig. 1).

Figure 1. Lightweight concrete block

These cabins had, each one, external dimensions of 1,80m of height, 1,80m of length and 1,60m of width and they were mounted in open field, without obstacles to the wind nor in the sun and raised on concrete base and using mortar of nesting in cement and sand in the mix proporcion 1:3. As covering was used plates of EPS with 0,10m of thickness glue to a coated compensated naval panel in the superior part with blades in PVC for the protection against the bad weather (fig. 2).

Figure 2. Test cells

2.2. Assembly of the Measurement System

For the assembly of the system of temperature measurement the following material elements were used: data acquisition system (DAS) - composed by computer equipped with plate of data acquisition and thermocouple type T (copper-constantan).

DAS was set up third cabin, halfway of the test cells, and the termopares inserted in flexible eletrodutos embedded 0,40m of the surface of the land. The thermocouple in each cell were in number of four and they were located respectively: externally in the center of the wall directed toward the east, internally in the center of the wall directed toward the east, internally in the center of the volume of the cabin and externally in the center of the wall directed toward the west of the cell. The temperature sensor installed in the center of the cabin was protected by a small aluminum foil wrapper, to reduce the influence of convective internal currents.

It was accomplished in 10 days with data collected in intervals of five minutes, generating a total of 240 uninterrupted hours of measurement in such a way during the day as the night. In all the measurement process the interference of gusts of winds as well as the occasional rain possibility was disrespected, because the purpose was to study the performance in a typical situation of use in a no controlled atmosphere.

2.3. Analysis of the Thermal Performance

The thermal performance was evaluated through the comparative analysis of the temperature profiles drawn for the two cells monitored during the period of 10 days.

3. Results and Analysis

This work corresponds to the initial stage of the project *"Rede de Pesquisa em Eficiência Energética de Sistemas Construtivos"*, sponsored by FINEP and CNPq. Therefore, the climatic variables that would influence directly on the test cells have not been considerate quantitatively, yet. To evaluate comparatively the thermal behavior of the test cells, we consider the temperature profiles of each wall during 10 days. In fig. 3 to 6, we adopted the following convention:

CCBextE: temperature in the external face of the wall of the cell, constructed in cement + sand block, directed toward east;
CCBintE: temperature in the internal face of the wall of the cell, constructed in cement + sand block, directed toward east;
CCBcent: temperature in the center of the internal volume of the test cell built in cement + sand block;
CCBextW: temperature in the external face of the wall of the cell, constructed in cement + sand block, directed toward west;
LCBextE: temperature in the external face of the wall of the cell, constructed in lightweight concrete block, directed toward east;
LCBintE: temperature in the internal face of the wall of the cell, constructed in lightweight concrete block, directed toward east;
LCBcent: temperature in the center of the internal volume of the test cell built in lightweight concrete block;
LCBextW: temperature in the external face of the wall of the cell, constructed in lightweight concrete block, directed toward west;

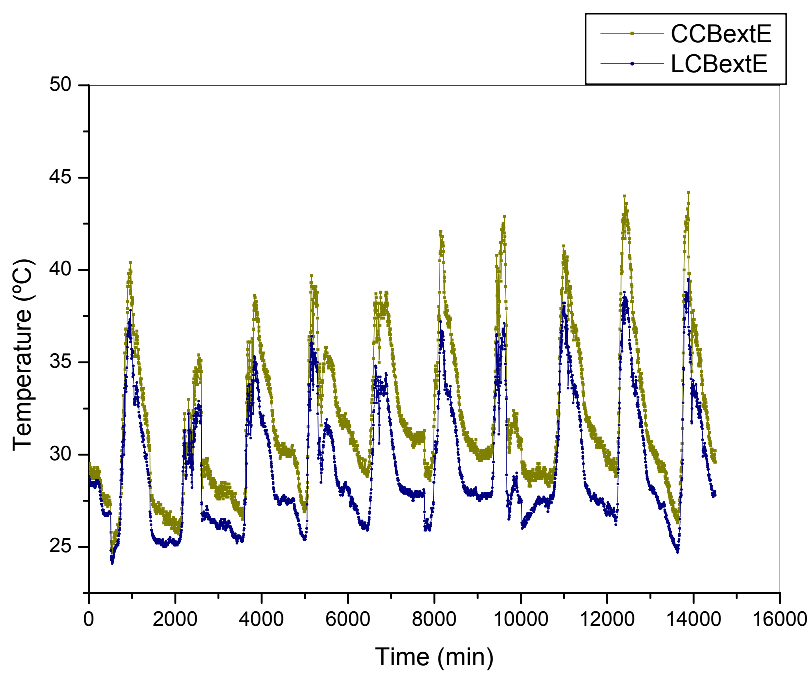

Figure 3. External surface (east)

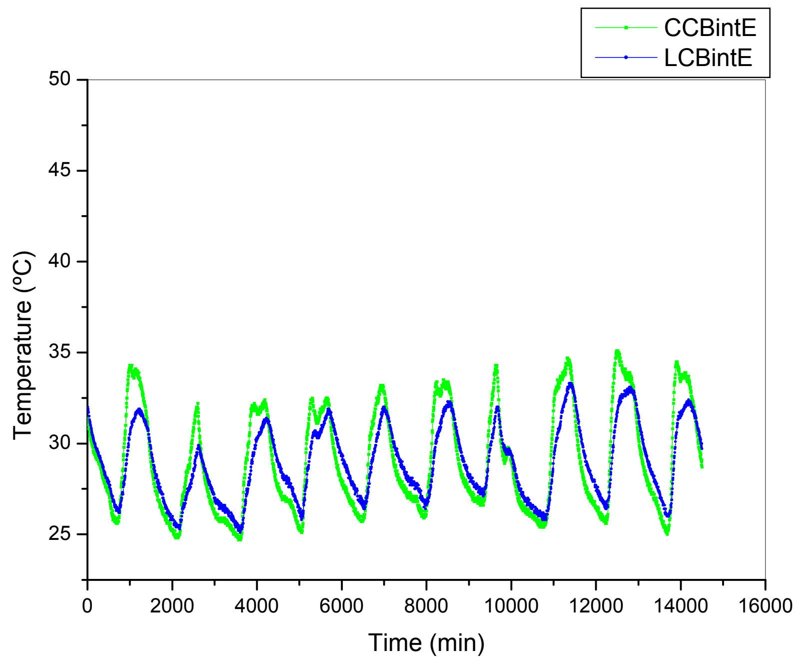

Figure 4. Internal surface (east)

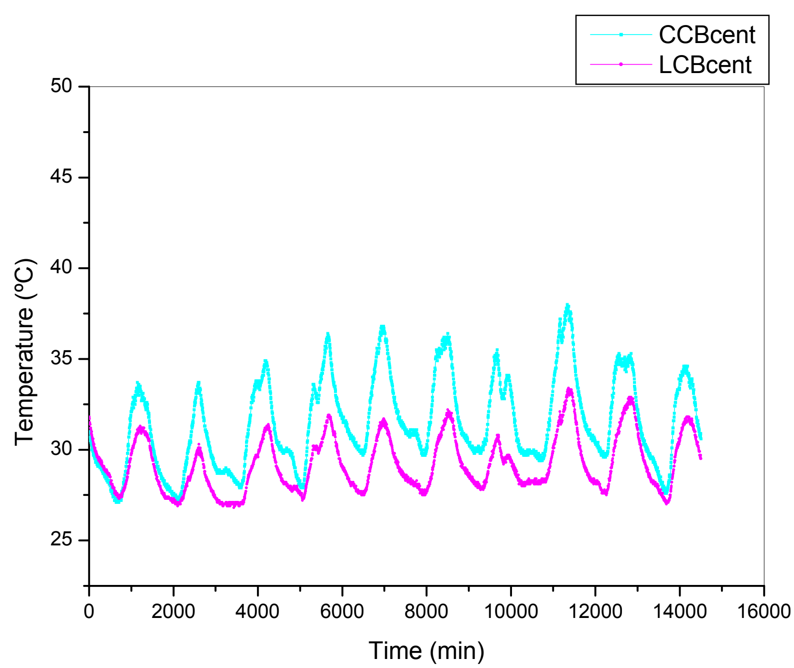

Figure 5. Central point of the test cell

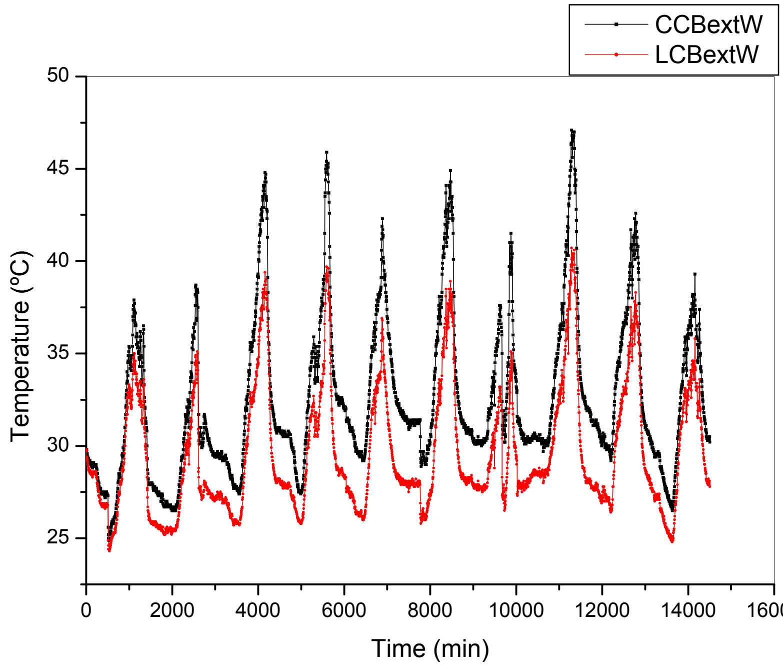

Figure 6. External surface (west)

It was observed a similar behavior of the temperature profiles along the days for both kinds of test cells – Light Concrete Blocks (LCB) and Conventional Concrete Blocks (CCB). Considering that they were submitted to the same environmental conditions, that behavior was indeed expected.

As it can be observed in fig. 3, the walls of the LCB test cell presented a larger thermal retard when compared with the walls of the CCB cell. This property provokes the displacement of the picks of the maximum temperatures in LCB cell in relation to the picks of the maximum temperatures presented by the CCB cell. One still perceives that the maximum peaks of temperature in the LCB present greater uniformity of increasing and decreasing.

An average gradient was determined between the peaks of maximum temperature in both test cells. It was verified that the maximum temperature observed inside the LCB test cell was 3,75ºC inferior when compared with the average of the temperature inside the CCB cell.

4. Conclusions

In all of the analyzed profiles was verified that the temperatures associated to the LCB were inferior the temperatures measured in CCB.

The use of the lightweight concrete as a constructive element has been shown technically viable, providing significant decrease in the costs with thermal isolation when compared with conventional material. This fact contributed to join value to the product and to diversify its application, besides making available an alternative to the economy of energy used to the acclimatization of the dwelling spaces without the need of great expenses for acquisition and installation of equipments.

The adopted methodology was appropriate to the analyses of the thermal behavior of the alternative constructive elements as well as it made possible the progress of the researches linked to the Project. This stage was necessary to assure the next step of the Project – the quantitative analysis of the thermal behavior of the test cells. This will allow the establishment of a database to improve the knowledge of the complex relationship between the construction and the environment, when the thermal comfort is aimed simultaneously with the energy efficiency.

5. Acknowledgements

The authors are also grateful to the CNPq, CAPES, FINEP by sponsorship either *Núcleo de Tecnologia Industrial-UFRN* by support.

6. References

Bezerra, L. A. C., Oliveira, M. F. M., Marinho G. S. "Reaproveitamento de resíduo de eps como agregado de bloco construtivo", Inter American Conference on Non-Conventional Materials and Technologies in the Eco-Construction and Infrastructure - J. Pessoa, Nov., 13-16th 2003a.

Bezerra, L.A.C., Marinho, G. S., 2003b, "Análise do Desempenho Térmico de Sistemas Construtivos de Concreto com EPS como Agregado Graúdo", Dissertação/Mestrado, Natal, Brasil, 50 p.

Al-Jabri, K.S., Hago, A.W., Al-Nuaimi, A.S. and Al-Saidy, A.H., 2004, "Concrete Blocks for Thermal Insulation in Hot Climate", Ed. P.W., São Paulo, Brasil.

Lamberts, R., Dutra, L. and Pereira, F.O.R.,1997, "Eficiência Energética na Arquitetura", Ed. P.W. São Paulo, Brasil, 192p.

6. Responsibility notice

The authors are the only responsible for the printed material included in this paper.