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Experimental Study of Thermal Comfort in Arid Zones (South West of Algeria)

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Abstract

In this work, we carry on an experimental study and comparison of thermal comfort of a prototype with and without moisture in an arid area as Bechar. To get to carry out this study we begin with the cooling thermal loads in order to have in the first the power conditioning that must be installed in the prototype and also the inside blowing rate. We compared the results obtained for the same day with the same conditions. We build a box for the macroclimate inside this latter we invented a whole system for controlling the temperature. The temperature is measured by ENERGARID lab weather station and injected as a function in the control system to ensure the required climate inside the box (summer climate). For the microclimate, we choose the frozen water system for air conditioning to ensure thermal comfort inside prototype. After the first experiment (without humidity), we added a humidifier inside, and we compared the results of temperature and humidity. We have obtained very good results, which allow us to clearly defined the concept of thermal comfort especially in arid zones where the relative humidity in the summer time does not exceed 14%.

Keywords: Thermal comfort; Temperature; Humidity; comfort zone; Building.

INTRODUCTION

With the current needs of energy-saving and controlling the environmental impact of the building, some doubts arise about the definition of thermal comfort, how to create it and maintain comfort conditions. In situ studies of thermal comfort have found an overestimation of perceived discomfort level compared to that provided by these standards, especially in air-conditioned buildings during hot weather. These studies were used to put the bases of an adaptive approach, which characterizes the thermal comfort through adaptive interactions between the occupant and the environment. The use of standards can lead to systemic use of air conditioning, while the adaptive approach ensures thermal comfort with energy consumption more modest. What differentiates the situation where modern architecture at the energy problem, the architecture of any epoch is not only the reduction in the availability of energy resources but rather the requirement for thermal comfort become mass only since the nineteenth (19th) century [1]. Recent years is an important period for the development of thermal comfort in buildings, during which some brakes and other obstacles to the extension of comfort will be removed, allowing it to become a challenge, both economically and socially.

The development of technology has played a very important role to improve comfort. This period is characterized by the growth and development of machinery thermal [2]. Currently, thermal comfort is a request acknowledged and justified in buildings because of its impact on the quality of indoor environments, the health and productivity of the occupant through three quarters of their time indoors. This request is supported by standards and regulations RTD [3] (Regulatory Technical Documents) that ensure the compliance of the indoor thermal comfort requirements. However, research environments uniform internal heat and comfortable to standards, throughout the year, without taking into account the peculiarities of climate, site, building is accompanied by an increase in climate systems, resulting in high energy consumption, fossil essentially exhaustible and polluting. Ambient temperature and humidity with respect to partial water vapor pressure are the boundary conditions always affecting both sides of the building envelope. The climate-dependent exterior conditions may show large diurnal and seasonal variations. Therefore, at least hourly data are required for detailed building simulations, though monthly data may suffice in case simple calculation methods are applicable. ASHRAE for example, provides such meteorological data sets, including temperature and relative humidity, for many locations worldwide [4]. These data sets usually represent average meteorological years based on long-term observations at specific locations. However, data of more extreme climate conditions may be important to assess the risks of moisture damage. Therefore, Sanders [5] proposed using data of the coldest or warmest year in 10 years for hygrothermal analysis, instead of data from an average year. This method analyzes the data with respect to their effect on moisture behavior of typical building assemblies. The more severe datasets increase the safety of risk prediction for the service life of building envelope components, but they are less suitable for analyzing the long-term behavior (performance over several years) of constructions because the probability of a sequence of severe years is very low. Also, note that the temperature at the building site may differ from the meteorological reference data when the site's altitude differs from that of the station recording the data. The microclimate around the building may result in an additional temperature shift that depends on the season [6]. The Indoor climate conditions depend on the purpose and occupation of the building. For most commercial constructions, temperature and humidity are controlled by HVAC systems with usually well-defined set points. Indoor humidity conditions in residential buildings, however, are influenced by the outdoor climate and by occupant behavior. Moisture release in an average household is highly variable. According to Sanders [7] it may range from 3 to 20 kg/day, with an average of approximately 8 kg/day. This moisture must be removed by ventilation or air conditioning, But this is not the case in arid area were relative moisture is less than 14% [8]. In this later, we need binding to add humidity in indoor air using a different HVAC system. However, in dry areas as south of Algeria, were the humidity is in lower values in the summer time; the only system used is split HVAC system .We focus in this work the analytical aspect of thermal comfort in addition an experience, which together provides a holistic view of thermal comfort in buildings. Since the problem under consideration is still valid and saw the work presented by Xiaoshu read, 2001 [9], those carried out by Chien Hung Chi Nan Lin and Liao [10] M. Bensafi et al [11] the work is the study of the thermal comfort of an office in the region of Bechar and as the study by N. fezzioui et al [12] a comparative study between two regions in southern Algeria (quantitative study), Bechar and Tamanrasset, and that presented by N. el Gharbi and A. Benzaoui [13], their goal is to provide optimal conditions (temperature distribution, humidity and air flow mode), for an operating room. All these works focus on the distribution of temperature and humidity inside buildings, without taking into account the climatic data of the region, and the air conditioning system used. Our work erected in the thermal comfort in all consider the two main factors (temperature and humidity).

DESCRIPTION OF THE PROBLEM

We would compare a thermal comfort inside to the prototype, first of all, we build a box where we add a heat system inside, and we build another small prototype for the microclimate; this later is placed inside the big box. The different experience organs are bellow.

Macroclimate

In this part, we construct a plaster plate box with $1 \times 1 \times 1.2\,m$ in dimensions. The choice of the box of the building material is't done randomly; by against the thermo physical properties are among the factors that allow us to choose the plasterboard. The figures below represent the box that we put in the microclimate prototype.

Figure 1 In the left the macroclimate box, in the right the prototype microclimate.

The temperature inside varies with time in a curve of a summer day as August 8, the temperature values recorded by ENERGARID lab weather station. By the polynomial method, we found the temperature polynomial function that changes in function of time for the considered day. The equation below present the temperature polynomial:

$$T(\mathrm{t}) = 0.0007t^4 - 0.0406t^3 + 0.7549t^2 - 4.1464t + 38.4624$$

After getting the temperature polynomial, this latter was injected in a microcontroller to control a device (homemade), which ensured the temperature desired in the housing for the macroclimate. The figure below shows the change in temperature over time in the box compared with the values pick up by the ENERGARID laboratory weather station.

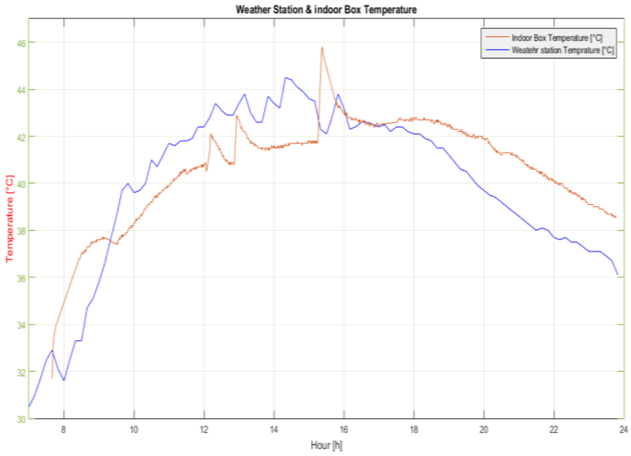

Figure 2 The both temperature: raised by the weather station and inside of the box

Microclimate

For microclimate, we built a plasterboard prototype, size of $30\times30\times50cm$ for raison that the scale will be 1/10. Moreover, and with a homemade software (developed in Delphi) we conducted a thermal load to determine the cooling power that will be installed on the inside of the prototype.

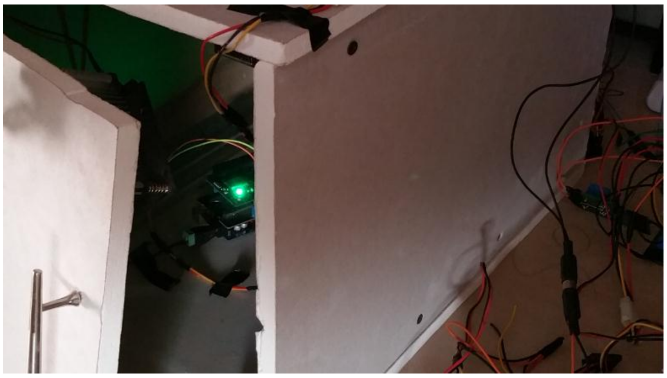

Figure 3 The prototype with the sensors and the microcontroller within

THERMAL LOADS:

We have developed a software for the thermal loads that was based on the RTD, the figure below present the software and the cooling and heating loads.

Composants
Zone Climatique: I0m zone=D1
Parois: Plancher Bas
Nom: Plancher Bas_0
Longeur: 0,5
Largeur: 0,3
Contact: L'extérieur
Orientation: O
Type: Logement Individuel
Fenêtre/Porte
☐ Porte , Fenêtre
Nom:
Matériaux: Métal / Bois
Longeur: 0
Largeur: 0

Les Composants :	S= L x H m²	Orientation	Contact Avec	Type	La Puissance frd W	La Puissance chd
Mur_0	0,09	N	L'extérieur	Mur	1,16676	0,126
Mur_1	0,09	S	L'extérieur	Mur	1,44648	0,126
Mur_2	0,15	E	L'extérieur	Mur	2,2029	0,21
Mur_3	0,15	O	L'extérieur	Mur	2,8035	0,21
Plancher Haut_1	0,15	O	L'extérieur	Plancher Haut	3,73065	0,36
Plancher Bas_0	0,15	O	L'extérieur	Plancher Bas	3,73065	0,51

La Puissance = 15,08094 W
La Puissance = 1,542 W
14:18:33 28/09/2016

Figure 4. Software to Calculate Thermal loads.

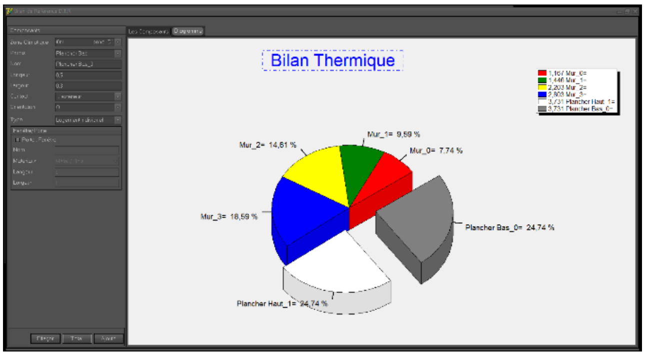

Figure 5 The percent of heat load for each wall.

BLOWING RATE:

After obtaining the cooling capacity, we have calculated the blowing rate (with the speed of comfort). We built a cooling unit inside that; this latter contains a heat exchanger and a fan. As the figure shows.

Figure 6. The heat exchanger with fan.

AIR CONDITIONING SYSTEM USED:

To ensure thermal comfort in the prototype we choose frozen water air conditioning system, that it used the water as a refrigerant fluid, where it circulates through a mini pump, in a closed circuit as figure below shows. The whole system is controlled by a programmable microcontroller and digital sensors of temperature and humidity.

Figure 7 Piping for Air conditioning system

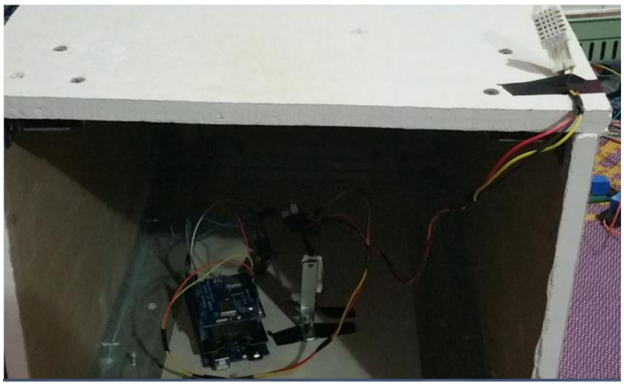

Figure 8 Temperature and humidity sensors inside and outside of the prototype.

The figure below represents the electronic interface that controls the entire air conditioning system, including the control of starting and stopping of the pump and the fan according to the inside prototype temperature.

Two sensors of temperature and humidity (DHT22) is placed inside and outside prototype for the measurements. We have added a device to the entire microcontroller (SD shield) for recording data in a min SD memory card as the values for temperature and humidity over time. To ensure that the system works well in conditions and to avoid technical problems, we added a wireless device and we created a local website server where the results will be displayed in real time.

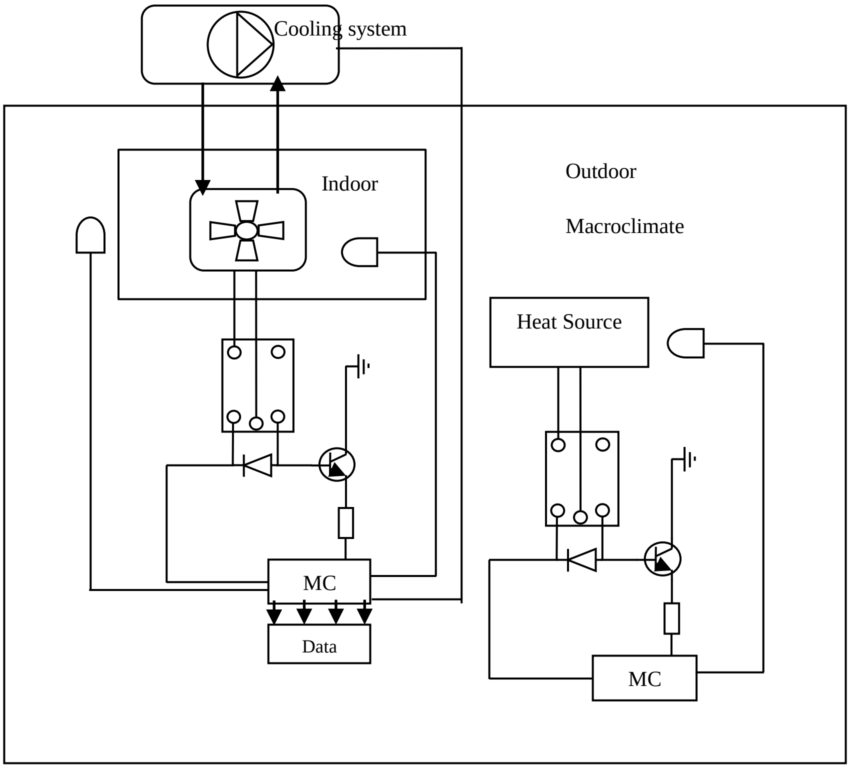

Figure 9. A preventative scheme of control system

The figure above shows the website page and sever the results. For assured that our system works very well and does not have problems.

DESCRIPTION OF THE EXPERIMENTS

In the first case, we have launched at the same time:

- The macroclimate system that ensured the temperature of the day considered
- The air conditioning system with data recording.

In this case, we used the known and widely used air conditioning system as split system.

In the second case, we have launched the experiment again, but this time we added a device inside the prototype. The device is a humidifier that it added the moisture in the air of the prototype.

RESULTS AND DISCUSSION:

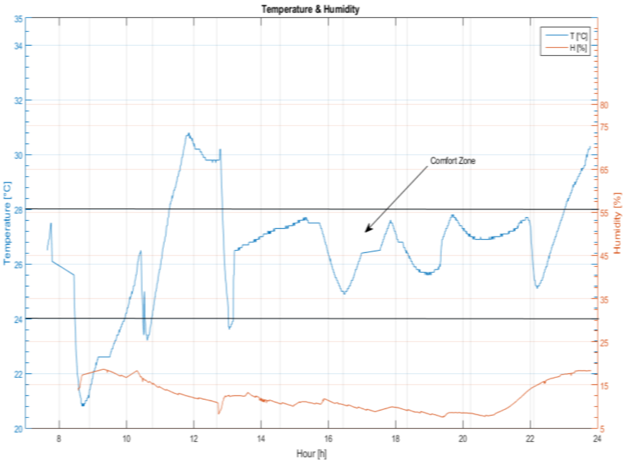

Figure 10 The temperature and humidity inside the prototype.

The definition of thermal comfort does not limited at only the temperature; humidity plays a very important role for the human being comfort inside the building, and exclusively in arid regions like the Sahara case the southwest Algeria as Bechar, or humidity does not exceed 14% for the summer season. The figure shows all of the temperature and humidity within local raised by the microcontroller for the completely sunshine duration. The two lines in the graph limit the thermal comfort area. The temperature values varies within the comfort zone by against the moisture curve varies outside the comfort zone. Which allow us to say that the two factors do not satisfying the needs of the human thermal comfort.

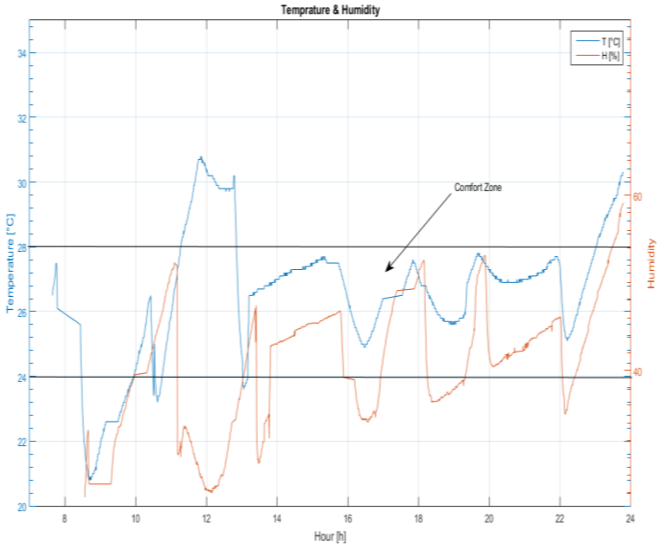

Figure 11 The temperature and humidity for the second case.

In the second case, we added a humidifier inside the studied local. We note that the temperature and humidity curves varies within the comfort zone. That allow us to announce that the human feel comfortable.

CONCLUSION

In the present work, we conducted an experimental study of thermal comfort in an arid area as Bechar. We build a box with plasterboard for the macroclimate, in which we build a whole control system provided a climate similar to Aug. 8, as the figure in top shows. After we build a prototype for the microclimate. We conducted a heat balance through software that we developed to determine the cooling capacity that to be installed inside and determined the power of fan and blower speed. The air conditioning system used is controlled by an electronic system that we have manufactured. We studied two cases in the first we used the air conditioning that is widely known in the area. In the second case, we put a humidifier inside for added moisture to the prototype air, and we added a microcontroller for data acquisition.

The results obtained are in the form of the temperature and humidity curves that are limited by two lines who define the thermal comfort zone. The results obtained allow us to fully understand the concept of comfort for humans inside the building. In the arid and Saharan area, people used the split system, which gives us a cold dry air. It effect directly on the health of humans in these areas. When the person gets up in the morning feeling a dry throat, tired and sometimes with back pain. which indicate the lack of moisture in the air inside the building.

REFERENCES

[1] M. BENSAFI and B. DRAOUI, " Etude et Simulation du Confort Thermique d'un Local dans la Région de Béchar" Thése de Magister, 2012 P10-15, Tahri Mohamed University of Bechar.

[2] 'Regulatory Technical Documents, cooling charges', National Centre for Studies and Research Integrated Building, Algeria.

[3] ASHREA Fundamentals 2013 SI edition 'Heat, Air, And Moisture Control In Building Assemblies Fundamentals'.

[4] Sanders, C. 1996. Environmental conditions. IEA Annex 24 Report, vol. 2, Catholic University–Leuven, Belgium.

[5] ASHREA Fundamentals 2013 SI edition 'Indoor Environmental Quality, Thermal comfort section'.

[6] Sanders, C. 1996. Environmental conditions. IEA Annex 24 Report, vol. 2, Catholic University–Leuven, Belgium.

[7] Laboratory of energy in arid areas (ENERGARID) weather Station Data.

[8] Xiaoshu Lu, "Estimation of indoor moisture generation rate from measurement in Buildings", Laboratory of Structural Engineering and Building Physics, Helsinki University of Technology, Building and Environment 38 (2003) 665-675.

[9] Chien Nan Lin et Chi Hung Liao, "Analysis of Temperature and Velocity Field in Air Conditioned Room", Dept. Mechanical Engineering far East university Tainan, Taiwan, 2010 International Symposium on Computer, Communication, Control and Automation.

[10] M. BENSAFI and B. DRAOUI, " Etude et Simulation du Confort Thermique d'un Local dans la Région de Béchar" Thése de Magister, 2012, P110-120 Tahri Mohamed University of Bechar.

[11] N. Fezzioui et al, "influence des caractéristiques dynamique de l'enveloppe d'un bâtiment sur le confort thermique au sud Algérien", université de Béchar, Revue des Energie Renouvelables Vol. 11 N° 1 (2008) 25-34

[12] Najla EL GHARBI ET Ahmed BENZAOUI, " transfert de Chaleur et de Masse dans une Salle d’Opérations conditionnée. Comparaison Entre Deux Modes de Soufflage". Université des Science de la Technologie Houri Boumediene, Faculté de physique, laboratoire de thermodynamique et de système énergétiques, 13èmes journées internationales de thermique, 2007.