THERMAL COMFORT IN ALGERIA PRELIMINARY RESULTS OF A FIELD STUDY

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ABSTRACT

A field survey on thermal comfort in Algeria has never been previously attempted, and for this reason the present study was conducted. The present paper will present a field study of thermal comfort in Algeria. A thermal comfort survey has been held among 160 persons in 4 towns of Algeria representing three different climatic regions. The survey has been carried out in two different types of buildings: Domestic buildings and Office buildings. Subjective data were collected from 160 people by the use of questionnaires. The survey has been held in two different times of the year; during the hottest months and during the coldest months. There were no criteria in choosing the subjects, we randomly chosen the subjects except in some office buildings in a certain town where we had to rely on our connections for security reasons. The main aim of this project is improving indoor air temperatures in habitations and office buildings and to establish new thermal standards for habitation and office buildings via the votes of the selected subjects. Some preliminary analysis of the data is presented.

KEYWORDS

Thermal comfort, field study, indoor air temperature, comfort temperature.

INTRODUCTION

The tradition of designing with climate to achieve comfort and reduce energy use within buildings is not confined to the provision of warmth. In many climates the problem that faces the architect is to cool spaces in order to achieve comfortable conditions as well as saving energy. In fact, climate has a major effect on building performance and energy consumption. The process of identifying, understanding and controlling climatic influences in the building is perhaps the most critical art of building design. The objectives of climatic design include:

- The reduction of the energy cost of a building
- The use of “natural energy" instead of mechanical system and power
- The provision of a comfortable and healthy environment for people

A building may be considered as a climate modifier, which shields the indoor environment from the external climate. Before designing a building in a particular place, the changes of weather from season to season (i.e. the climate) must be well understood so that the building can be built to shelter people all the year round. To assess the climate in a certain location, one must study the climatic data and, use them to evaluate design options and determine design strategies. The amount of energy use in a building is direct result of the climate, the building's use and the building's form. One of the many requirements of good building is the provision of an acceptable thermal environment for the user. As living and working conditions have improved there has been a general rise in internal temperatures in winter, and more recently, a growth in the use of air conditioning to restrict temperatures in summer. Whether our concern is with winter or summer temperatures, or with year-round energy consumption, designers must have methods of relating temperatures and energy requirements to the building design, taking account of the needs and behaviour of the user and the prevailing climate.

OVERVIEW OF THERMAL COMFORT

Today, creating a thermally comfortable environment is still one of the most important parameters to be considered when designing buildings. Before examining thermal comfort it is necessary to define it so that it is known what is being measured. The semantic of comfort is important, since various scales of thermal sensation [1], acceptability, preference and satisfaction have all been used in studies, but do not necessarily have the same meaning. Fanger's [2] PMV is based on the ASHRAE thermal sensation scale, therefore it may not necessarily relate directly to thermal comfort. Comfort may be defined at different levels; rather than using perception (reported by subjective rating) it may be possible to define it in terms of physiology, or its effects (eg productivity), or by using instrumentation such as the artificial skin or thermal manikins. Thermal comfort can be achieved by many different combinations of the physical variables and therefore also by the use of many fundamentally different technical systems. The positive or negative effect of one parameter on comfort may be enhanced or counterbalanced by the change of another parameter. There are six major factors that determine thermal comfort:

Environmental: Air temperature (dry bulb temperature or DBT), Humidity (relative humidity RH), Air movement (velocity v in m/s) and Radiation (Mean radiant temperature MRT).
Individual: Activity and Clothing

A field survey consists of a range of techniques designed to collect information. The purpose of thermal measurements is to determine the degree of thermal comfort for those persons who are to occupy the particular locality. Fields studies provide practical data, and can give an accurate estimate of thermal environment liked by particular people in a particular building at a particular time. There are two principal locations where thermal comfort surveys may be conducted: the places where people live and the places where people work. It tends to be more difficult to organise an extensive study in private homes than in work places. This is due to the natural reservation of the occupants about any intrusion into their private lives.
Thermal comfort surveys have been carried out in a many regions of the world involving measurements. In Pakistan data have been collected from many subjects and have been analysed to obtain estimates of the temperature which subjects find comfortable. This project was carried out with the co-operation of the ENERCON agency of the Pakistan Government by a team from Oxford Brookes University [3] to see what temperatures people find comfortable in real conditions. A similar survey to the one described has been taken in Tunisia and others are projected in Sri Lanka, Iran [4], Indonesia, Egypt and Zambia [5]. The Tunisian researchers from the school of engineering (ENIT) have carried out a similar field study among 200 subjects in five towns of Tunisia [6]. Similar work has been done in Libya (Ghadames) [7] in the summer seasons 1997 and 1998, where 30 old naturally buildings have been monitored resulting in 135 sets of data. The results from this study suggest that, to assess thermal comfort in such environments, the Adaptive model is valid for predicting the thermal comfort, while ISO 7730 [8] (1995) is less successful, without modification.

THERMAL COMFORT IN ALGERIA

The climate of Algeria is divided into three types, (1.) a Mediterranean in the north with dry hot summers and mild wet winters with rainfall increasing from west to east this region is

represented by the capital city of Algiers. The average temperature ranges in Algiers are from 9 to 15 degrees Celsius in January to 22 to 29 degrees Celsius in August. (2.) A continental climate in the high plateau regions with higher daily temperatures while rainfall is patchy falling mainly within a short period. The main cities in this region are Setif and Djelfa. The High Plateau is mostly a barren wasteland. The climate in the Tell Atlas region is also temperate but cooler due to the altitudes, with increased rainfall. The climate of the High Plateau is arid with irregular and low precipitation, measuring 200-400mm (8-16in) per year. The Sahara Desert is arid with extremely low annual precipitation, measuring less than 130mm (5in) per year. . (3.) A true desert climate in the Sahara with erratic and spasmodic rainfall. A hot, dry sirocco wind blowing north from the Sahara during the summer season, brings blinding sand and dust storms to the coastal region.
The Sahara Desert occupies about 85% of Algeria which is almost completely uninhabited. It is mostly an arid flatland. Timimoun and Tamaneraset and Ouargla represent the main areas of the Algerian desert. The climate is hot and dry; some areas may not see any rainfall for as much as 20 years at a time.
In Algeria improving thermal comfort is in its infancy, a field study has not previously been attempted in Algeria. The ministry of energy is working actually hard to set up new thermal regulations for buildings and dwellings. In Algeria, energy consumption has risen from (7091 in 1975 to 34338 in 1997) in (thousands metric tons of oil equivalent). And the electricity production soared from (5212 to 21489 million kwh) during the period (1978-1997) where the electricity production comes mainly from fossil fuels 98.91% (1996). Thermal regulations for dwellings for the North Africa countries are being prepared by the Tunisian energy agency. As a result, a thermal comfort survey in Algeria is indispensable to achieve the objectives.

Thermal comfort surveys

Thermal comfort surveys have been held among 160 subjects in 4 towns of Algeria representing three different climatic regions, during two different seasons (summer- winter). 80 subjects were questioned in their working area, and the other eighty people at their houses. None of the surveyed dwellings were systematically heated or cooled, and the indoor temperature was fluctuating. During the survey we tried to have an equal number of males and females and also a wide range of age in order to get a varied vote. The instrumentation, which has been used to measure the physical parameters, will be described in the presentation. The subjects were questioned about their thermal sensations and preference, the clothing they were wearing, their activity during the last thirty minutes, the air quality, the air movement and some alternative questions concerning the controls use. At the same time environmental variables were measured: air temperature, relative humidity, absolute humidity, air velocity, and globe temperature as well as outside temperature and outside relative humidity. Because the aim was to obtain a typical reaction to conditions, during the whole survey we made sure to obtain the typical people reaction to conditions. People were asked to carry out their usual activities and we insisted on not interfering their way of clothing and activities. Hence the response of the subjects was considered as typical. The aim of this survey is to establish new thermal standards for habitation and office buildings via the votes of the selected subjects. The interest was generally to find a temperature or range of temperatures and other environmental variables that people in their localities would consider neutral. One natural constraint we have found when surveying the dwellings is that during the day the occupants will be mostly female. Whereas, in the building offices we managed to match sexes with job descriptions or positions. The measurements of environmental parameters were used to calculate the neutral temperature of the subjects. Data from the questionnaires were used to determine the actual mean vote.

RESULTS AND DISCUSSION

In the following analyses we use indoor air temperature (Ta) as the measure of internal temperature. Mean indoor temperature was very consistent between cities in both seasons. The air-velocity was fairly uniform in all cities within the two different seasons. The comfort vote (C) of the subjects was determined from the questionnaire. The neutral temperature of the subjects has been calculated using the environmental parameters measured during the survey.

Table 1. Linear regressions of AMV on IAT for all the buildings

Location	number of Buildings	Values for *a*	Values for *b*	Correlation coefficient *r*
Algiers	40	0.15	- 0.17	0.52
Djelfa	40	0.04	2.37	0.24
Setif	40	0.12	0.75	0.55
Timimoun	40	0.11	0.56	0.56
All	160	0.09	1.29	0.42

Table (1) shows the results of linear regression in the form: $C = aT_a + b$
(1)

From table 1 we remarked that the more we move to the south the greater is people's resistance to the heat. Also in Algiers the minimum vote was for (slightly cold) for a temperature range between 16 and 30 ^oC. Whereas, in Timimoun they voted (cold) for the same temperature range. In Algiers the subjects voted 4 (neutral) when the temperature ranged between 16^{o}C and 21^{o}C in the winter and between 26^{o}C and 28^{o}C in the summer. However, in Djelfa the vote was between 17^{o}C and 25^{o}C in wintertime and between 27^{o}C and 32^{o}C in summertime where one subject vote 4 for an internal temperature of 38^{o}C due to the high air velocity.

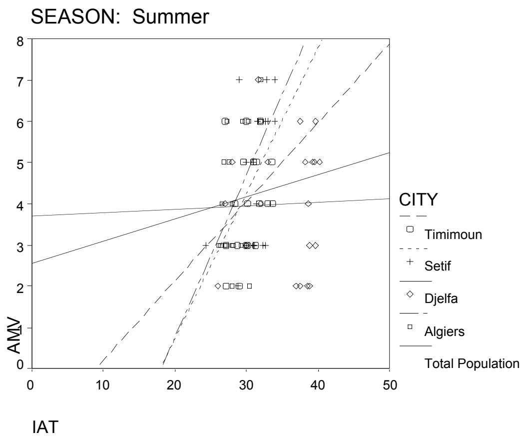

Figure 1 : AMV versus indoor air temperature in all buildings in summer

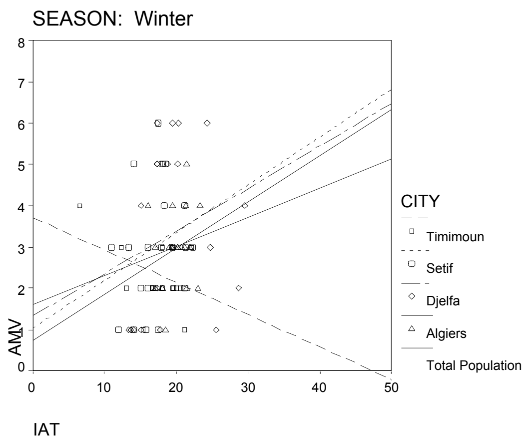

Figure 2 : AMV versus indoor air in all buildings in winter

The relationship between (C) and the indoor air temperature for all the buildings in each city in the two different seasons are shown in figure 1 and figure 2.

Linear regression gives, the buildings in:

Algiers (r = 0.52):	$C = 0.15(T_a) - 0.17$	(2)
Djelfa (r = 0.24):	$C = 0.04(T_a) + 2.37$	(3)
Setif (r = 0.55):	$C = 0.12(T_a) + 0.75$	(4)
Timimoun (r = 0.56):	$C = 0.09(T_a) + 1.27$	(5)

To calculate comfort temperatures by using equation (1) for example when (C) has a value of 4, T_a from the equation becomes the neutral temperature and values of a and b can be found from table (1). In this case:

Location	Summer		Winter	
Algiers	$t_n = 28.3$	^oC	$t_n = 21.9$	^oC
Djelfa	$t_n = 35.5$	^oC	$t_n = 20.5$	^oC
Setif	$t_n = 29.8$	^oC	$t_n = 19$	^oC
Timimoun	$t_n = 30$	^oC	$t_n = 21.1$	^oC

Comfort temperatures vary from season to season. The difference between comfort temperatures summer and winter is 6.4 ^oC in Algiers, around 10.8 ^oC in Setif and 8.9 ^oC in Timimoun. However; in Djelfa we recorded the highest comfort temperature difference with 15 ^oC . This is can be explained by changes in clothing between the two seasons as shown in Figure 3. Figure 4 shows air-velocity versus the mean indoor air temperature. On average people changed their clothing insulation by 0.53 clo units in Algiers and Setif, 0.44 clo in Djelfa, and 0.49 clo in Timimoun. According to figures from Humphreys [9] a change in clothing insulation of 0.5 clo implies a change of comfort temperature of 3.5-4 ^oC. About 1 or 2 ^oC of the remaining differences is accounted for by the change of mean air-velocity. Other effects such as activity skin moisture have to be considered.

These comfort findings are presented as neutral temperature of each subject. In previous studies the neutral temperature was related to the mean indoor air temperature, (T_a). We followed the same approach in the present study, where the neutral temperature t_n is considered as the indoor air temperature (IAT) when the actual mean vote (AMV) has a value of 4.

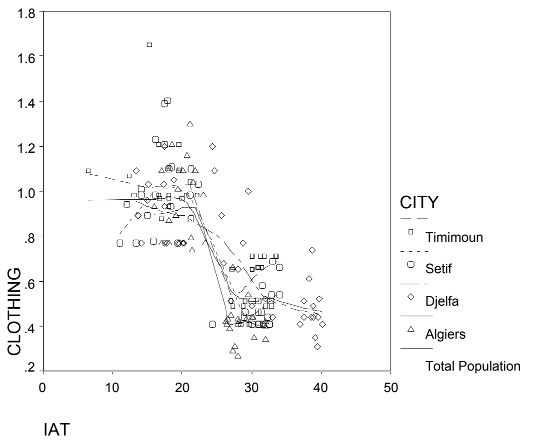

Figure 3 : Clothing versus indoor air temperature

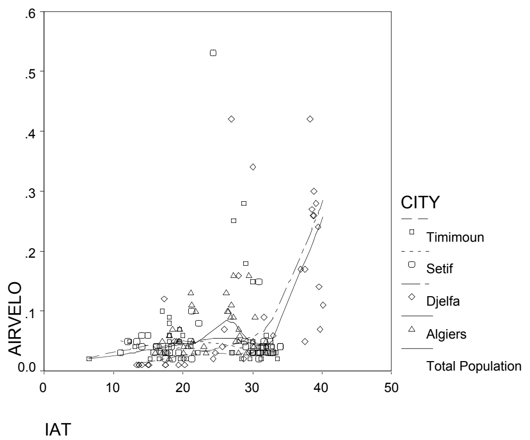

Figure 4 : Air-velocity versus indoor air temperature

CONCLUSION

A thermal comfort field study can give an accurate estimate of the thermal environment liked by particular people in a particular building at a particular time. Thermal comfort study in Algeria showed that people have different comfortable condition depending on the climate they live in. The sensation of comfort expressed by the subjects depends on all parameters, which define the comfort (Temperature, humidity, air-velocity, clothing, activity…). We correlated the sensation with the indoor air temperature to find the comfort temperature, usually; this has not a great influence on the results because all the parameters are equally effective on the all the subjects. This is our case because all the subjects were questioned at their work place or at home. As a result, the only parameters varying from subject to another. The clothing rate played a very significant role concerning the thermal sensation vote of the subjects where people used the clothing as an adaptive measure. However, during the summer the subjects were seeking more comfortable environment by moving from one space to another within the building.

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