Thermal comfort in urban spaces: The case of very warm and dry climate

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ABSTRACT

Most of studies on thermal comfort have been done considering the environmental conditions of the interior of the buildings, but for outdoor spaces the way to consider the sensation of thermal comfort it is not completely defined.

A direct application of indoor comfort criteria for outdoor spaces is not appropriate because the variation of the climatic parameters is greater and faster than indoors. Due to seasonal variations, the acclimatization of the people to the local climate, influences enormously their appreciation of thermal comfort.

A field study has been carried on at the city of Hermosillo, in the Desert of Sonora, Mexico, where the climatic conditions during the summer are very warm and dry. It has been found that conditions that most of the local inhabitants consider comfortable, are almost unbearable for people adapted to temperate climates. This work shows the first results of the study.

1. INTRODUCTION

The microclimates into a city change from one small area to another. For this reason, in order to control the microclimates, it is necessary to know and determine which of these factors can be manipulated to create spaces that are more pleasant for humans and to achieve better conditions for a sustainable environment. This is also important for encouraging reductions in energy requirements and for diminishing the environmental impact of buildings (Ochoa and Roset, 2000; Ochoa et al., 2001; Sánchez et al., 2004). Therefore, town planners, landscape architects and architects should pay attention in the climatic consequences of their projects and the solution of possible problems

However, when an outdoor space has to be planned, usually the thermal comfort requirements of the users, nor the energy effects on adjacent buildings, are not considered in a quantitative way. Generally, the designer brings in to play his/her intuition to resolve this problem. There are some main reasons for this attitude:

1. Designers should acquire knowledge pertaining to a series of fields as diverse than climatology, botany and geography; however, this knowledge is not always expressed in a language that they can adequately apply in their work.
2. Since exterior spaces are normally not artificially cooled or heated, there is no extra energy consumption directly related with the outdoor thermal comfort. So developers of design tools and software have centered their efforts in thermal design and efficient use of energy in building indoors, banishing the landscape microclimatic design.
3. Furthermore there is a lack of standards and regulations for outdoors, like the existing ones for buildings, for example the ISO 7730 (1994) or norms fixed by the ASHRAE. (1992).

The scope of this study is to find local outdoor comfort parameters, considering the specific conditions of desert climate, looking for comprehensive relationships between human outdoor comfort sensation and most relevant microclimate parameters in the urban environment. This study has been developed through field surveys of comfort sensation and simultaneous measurement of main climatic parameters.

Comfort Outdoors Vs. Indoors

A direct application of indoor comfort criteria for outdoor spaces is not suitable; the variation of the climatic parameters is greater and faster than indoors due to daily and seasonal variations. Changes in microclimatic conditions also occur, if the subject is moving.

The acclimatization of the people to the local climate influences enormously in their appreciation of thermal comfort. It does not include only adaptation to the local climate through changes in activities and clothing, but also increased tolerance to climatic extremes.

Another factor is the comfort expectative of people that are habituated to have more control of the environment indoors than outdoors.

2. LOCAL CLIMATE

The local climate is characterized by high solar radiation levels, clear skies and daily high temperature swings the whole year. Summer season is very warm, with minimum air temperatures of 25-30°C and maximum about 40-44°C. Air temperatures can reach in extreme cases up to 50°C. Relative humidity oscillates between 50 and 15%. Summer wind is usually warm and dusty, so it does not help for passive cooling or for get better outdoors thermal comfort. Ground surface temperature may reach up to 70°C.

The hot season extends during 5 or 6 months per year and it is necessary the use of air conditioning inside buildings the whole day.

However, winters are comfortable, with minimum temperatures of 0-7°C and maximum between 25 and 30°C.

Local people have adapted their way of life to these circumstances: the siesta during the afternoon hours is very common and in general the necessary physical activities and movements such as walking, are done very slowly. People wear long-sleeved thick shirt, cotton underwear, hat and boots during summer season as a radiation shield.

3. METHODOLOGY

A research based on a field technique was adopted for this study because of the variability of exterior climate conditions and site spatial configuration, instead of a climatic chamber that is appropriated for indoor comfort studies,

The study was conducted in two seasons, spring and summer. For spring, March was selected, because of its mild-harmless climate. But for summer, the surveys has been applied in August, one of the hardest month of the season, with temperature ranges from 20-42°C, about 1000W/m^2 of horizontal solar radiation, and low relative humidity (40-15%).

Fieldwork

The objective of the fieldwork was to identify the comfort sensation in the context of the dynamic outdoor climate conditions for different urban situations. A survey was applied to people walking or resting in five different sites in the university campus. Simultaneously measurements of main microclimate parameters were taken.

The survey included two basic questions about comfort sensation and comfort preferences of the subject, notes about clothing, activity, sex, complexion and age of the inquired people were taken.

At the same time, measurements of air temperature, relative humidity, wind speed, surface temperatures of the surroundings were recorded.

All measurements and surveys, have been carried out by undergraduate students of the Architecture Department, that have been trained for field work. The sample was 90 surveys for summer and 95 for spring.

The instruments utilized to measure the environmental parameters were a handheld digital thermo-hygrometer with anemometer (Fig. 1), and an infrared thermometer for surface temperatures (Fig. 2). Incident solar global radiation was taken from the weather station of the Energy and Environment Lab of Architecture (Fig. 3).

4. EXPERIMENTAL RESULTS

It was procured that the conditions for both surveys were similar; 51 % of people was men and 49% women, in its majority (91%) they were seated reading, talking or resting and (9%) walking slowly. Respect to the age, 83% are between 18-25 years old, 6.5% between are 26-35 years old and 10.5% are between 36- years old.

Figure 1: Thermo-hygrometer with anemometer.

Figure 2: Infrared thermometer used for surface temperatures measurements.

Figure 3: Piranometer utilized for measurements of solar radiation.

4.1 Spring Survey

The most relevant effects corresponded to air temperature and the wind speed, in Figure 4 it can be appreciated that the temperature preferred by most of people (75-89%) was between 24 and 38°C, descending to 30% from 32-34°C.

Concerning to the wind, in Figure 5 it can be appreciated that while wind speed increases there are also increments on the percentage of comfortable people, obtaining 48% for 0-1 m/s and 100% for speeds between 3-5 m/s.

The relative humidity seems not to affect much the comfort sensation outdoors, nevertheless winter and the spring are dry seasons, with humidity relative lower than 15%, for these conditions the comfort sensation was of 45%, whereas for more humid conditions, from 20 to 35%, the preference was of superior to 70% (Fig. 6).

The radiant temperature is not a problem at this time of the year, the measurements indicated that it always was lower than air temperature; comfort sensation was between 50 and 83% (Fig. 7).

4.2 Summer Survey

For summer the conditions changed greatly, since the temperatures oscillated in a rank of 34 to 40°C during the time when the surveys were

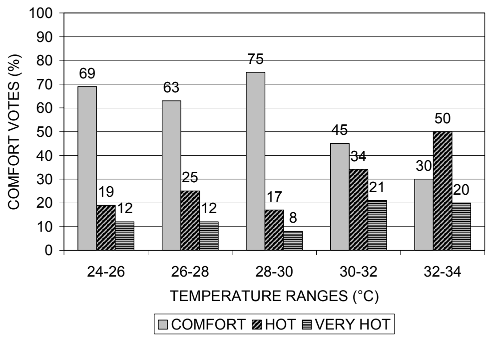

Figure 4: Air temperature surveyed vs. preferences in spring.

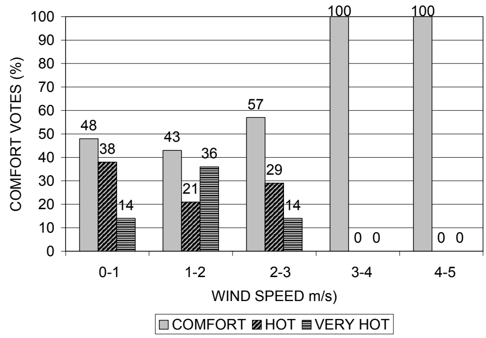

Figure 5: Wind speed surveyed vs. preferences in spring.

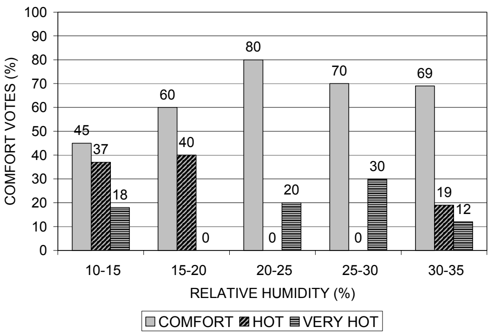

Figure 6: Relative Humidity vs. surveyed preferences in spring.

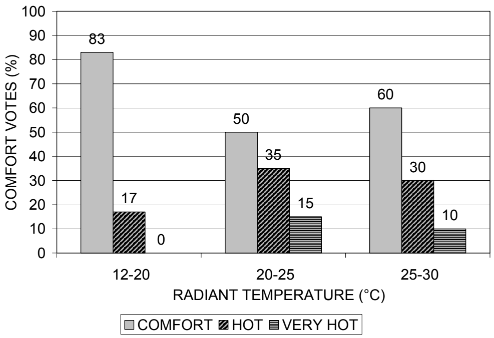

Figure 7: Radian temperature vs. comfort votes surveyed in spring.

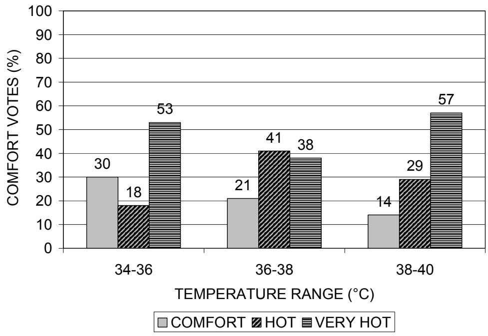

Figure 8: Air temperature vs. surveyed preferences in summer.

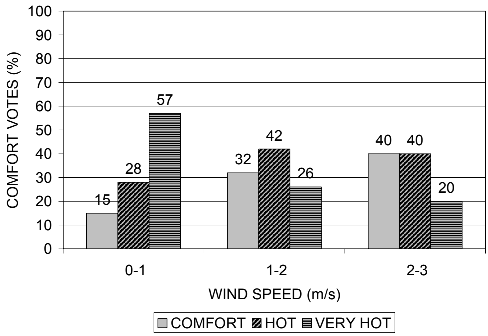

Figure 9: Wind speed vs. surveyed preferences in summer.

carried out, the wind speed was also lower (0-3 m/s) and relative humidity was higher (30-50 %). Due to the high solar radiation, with maximum values between 895-965 W/m2 during the surveys period, the radiating temperature also increased considerably.

Nevertheless, the way in which elements of the climate affect the comfort sensation of the surveyed people did not had great variations.

As it can be observed in Figure 8, while the temperature increases, the percentage of people who feels comfortable diminishes, being the most unfavorable rank from 38 to 40°C.

In Figure 9 it is possible to observe that with the increase of wind speed also increases the comfort sensation, however, higher wind speeds do not agree with higher temperatures, therefore cannot be affirmed that always high wind speeds are more comfortable.

The comfort sensation does not vary too much when the relative humidity is between 30 and 45%, nevertheless with humidity greater to 45%, the percentage of people feeling very hot was 100% (Fig. 10).

Unlike the spring, in the summer the radiant temperature plays an important role; since it is associated with the intensity of solar radiation and air temperature, both parameters have elevated values in the summer. In Figure 11 it is observed that while temperatures of 25-30°C are acceptable for 57% of the sample, for surface temperatures higher to 40°C are very hot for 80% of the people.

5. CONCLUSIONS

As preliminary results of this study, it is possible to affirm that there is a certain level of seasonal acclimatization, taking into account that the temperature average that people has voted as comfortable for spring was of 28.7°C and for summer of 36.2°C.

In both seasons for higher wind speed, better comfort sensations are registered, nevertheless during the summer, but when strong winds and higher temperatures agreed, the comfort sensa-

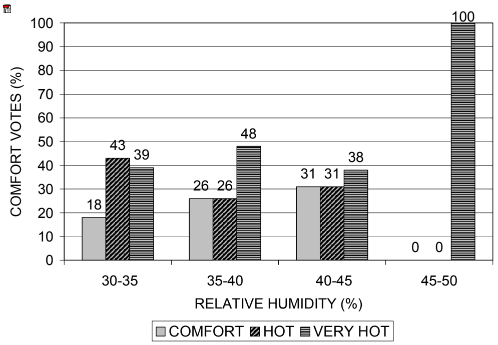

Figure 10: Relative Humidity vs. surveyed preferences in summer.

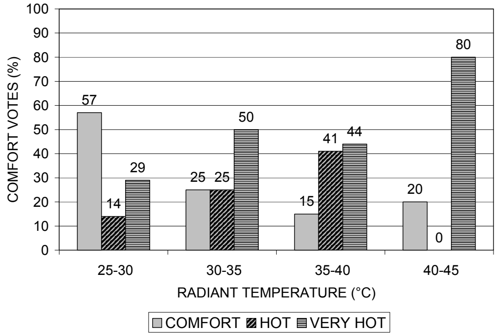

Figure 11: Radiant temperature vs. comfort votes surveyed in summer.

tion changes from comfortable to very hot.

These are preliminary results of the study. As future development, the sample is planned to be extend to a greater number of people. Data during other daytimes will be measured, for example in the morning, noon, evening and night, to have the opportunity to analyze, for example, what happens when there is no solar radiation.

Also is planned to increase the sites of study, to finally be able to generate a model applicable to most of the cases of the region.

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