THERMAL COMFORT: CALCULATED PMV AND OCCUPANTS' OPINION

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ABSTRACT The vote of acceptance of the thermal conditions of a built space varies with the individual. The design of the space should consider the occupant's thermal comfort therefore the future users' opinion on thermal conditions. People's opinion regarding the acceptance of thermal circumstances of a room can be expressed by several indices the PMV the scale being the most used for this purpose. The objective of this paper is to report the results obtained in the comparison between values of calculated PMV and the users' answers for the acceptance of the thermal circumstances of a room not conditioned mechanically. The study confirms the variability of the individuals' opinions, the usefulness of an index that expresses a median opinion and it alerts for the care that should be taken in the interpretation of the data for its use in the design of spaces. The study was developed in the Universidade do Vale do Rio dos Sinos - UNISINOS being part of the activities of teaching of environmental comfort for undergraduate students in architecture.

1 Introduction

The minimum curriculum of the course of Architecture, in UNISINOS. was recently modified. The hourly loads and contents of some disciplines were altered. to carry out the directives of the Ministry of Education, Culture and Sports in Brazil. At the same time, to satisfy an expected demand, the Laboratory of Environmental Comfort (LACAM) was created. Initially, the LACAM should give support to the undergraduate course and future programs of professional specialisation. Secondly, it will provide services for the community in general, in the areas of thermal, acoustic, luminous comfort. Parallel with the creation of the LACAM the direction of research lines was to be established. This would then determine personnel training and acquisition of equipment for the laboratory. A work proposal was presented and approved in the line of "Thermal Comfort". The work had the objective of motivating undergraduate students for the need to investigate comfort conditions in the built environment, and to consolidate the activities of LACAM in the University. The work proposal was to investigate the concept of PMV and explore it as a form of understanding users' comfort in the built environment.

The present work summarises the teaching experience exploring the definition of PMV, with architecture students in the Universidade do Vale do Rio dos Sinos within the program of implementation of the Laboratory of Environmental Comfort.

2 Environment

The UNISINOS occupies an area of approximately 90 ha, in the county of São Leopoldo, at some 35 km distance from Porto Alegre, the capital of the southern state of Brazil.

Fig.1 Universidade do Vale do Rio dos Sinos

UNISINOS is about 40m above the sea level in the area of the Valley of Rio dos Sinos that is surrounded by hills of a medium height of 50m. In the summer temperature and humidity averages are a little high for comfort and the winter, although mild, can present very cold days when the wind is dry and blows from the West. This wind is known as Minuano.
The following Table 1 presents the climatic data for the region.

Table 1 Climatic data - São Leopoldo - latitude: 30.05°S, longitude: 51.20W

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
												TEMPERATURE (°C)
39.4	37.7	39.0	36.3	33.5	32.0	32.4	35.4	39.1	38.8	40.4	40.4	Extreme maximum
31.3	30.8	30.3	26.6	23.1	18.7	18.9	22.0	22.4	26.1	28.6	31.2	Mean maximum
24.9	24.4	23.6	20.5	16.9	14.1	13.4	15.5	16.7	19.9	22.1	24.4	Mean
20.1	19.9	19.1	16.2	12.9	10.3	9.5	10.9	12.4	15.3	17.0	19.2	Mean minimum
11.6	11.8	10.4	5.7	2.1	0	-0.6	-0.5	4.0	6.7	7.5	12.1	Extreme minimum
												RELATIVE HUMIDITY (%)
71	73	74	78	81	82	80	77	77	73	69	69	Mean
												RAIN FALL (mm)
172	113	88	134	83	163	160	132	154	163	118	110	Mean
109	83	66	87	63	109	113	57	110	81	50	60	24 –hour maximum
												DAYLIGHT (h)
210	213	210	209	183	159	140	188	199	186	226	272	
												SOLAR RADIATION (kWh/m² day)
6.013	5.478	4.629	3.733	2.756	2.314	2.338	2.826	3.838	4.792	5.664	6.048	Mean

2 Methodology

The project consisted of monitoring temperature and humidity in a classroom and circulation spaces of one of the typical blocks of the University. The classroom is one closed space without mechanical cooling or heating and the circulation space is covered with open sides. The monitoring was carried out for 6 days, when the hourly values of temperature and humidity were registered with remote sensors TYNETALK[1].

Figs.2 and 3 show the places where the sensors were installed. Inside of the classroom the sensors were hung 20cm below the ceiling, at the geometric centre of the room. In the circulation space the sensors were positioned on the top of a pillar in front of the classroom in a shaded place. In the afternoon and night of one day (31/8) 40 questionnaires were applied to identify the acceptance of the thermal atmosphere in the classroom. The questionnaire registered the activity (metabolic rate), the insulation level of the clothing and the students vote of thermal acceptance of in the classroom.

Fig.2 Circulation space at UNISINOS

Fig.3 Classroom at UNISINOS

3 Results

From the 40 questionnaires applied, 20 were in the afternoon (15:00 hours) and 20 at night (20:00 hours). The internal air temperature and relative humidity at 15:00 h were registered as 22.0°C and 54.8% respectively, while externally the air temperature and relative humidity were 23.0°C and 40.8%. At 20:00 h, the air temperature inside was 20.9°C and the relative

[1] TYNETALK – Orion Components Ltd., Chichester, UK.

humidity 59.5% and in the circulation space the registered air temperature was 15.6 °C and the relative humidity was 73.3%.

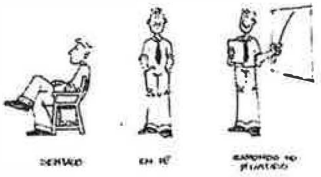


Fig.4 Questionnaire – Activity for the thermal environment

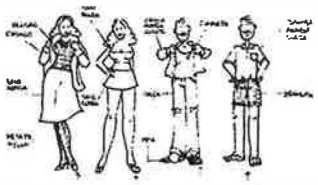


Fig.5 Questionnaire – Clothing

Fig.6 Questionnaire – Vote

For PMV calculations the software ANALYSES 1.5 was used. The software is based on Fanger's equation. The inputs are: air temperature, metabolic rate, level of insulation of the clothing, mean radiant temperature, relative air velocity and relative humidity. The air temperature and relative humidity data obtained in the monitoring were used. Clothing and metabolic rate were given by the questionnaire. The other parameters were assumed as follows: (1) the mean radiant temperature was considered equal to the air temperature and (2) the relative air speed was taken as 0,5 m/s.

Fig.7 (overpage) shows the graph of temperature and humidity monitored (classroom and circulation) in the period from 29/07 to 03/8 and Table 2 below presents tabulated answers of the acceptance of the thermal environment and values for the calculated PMV.

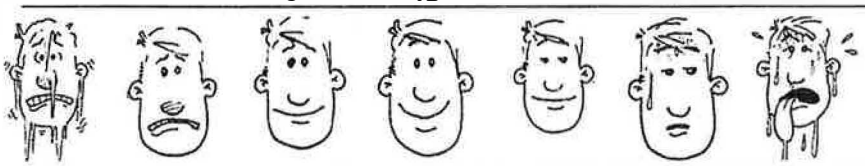
Table 2 Calculated PMV and occupants opinion on thermal environment - 15:00 h

#			5	9	5	1
Occupants opinion						
PMV ANALYSIS	-3	-2,9 to -2	-1,9 to -1	-0,9 to 0,9	1 to 1,9	2 to 2,9	3
#			7	12			

Table 2 above shows that 25% of the people answered that the atmosphere was cold comfortable against 35% calculated PMV. Following, 45% interviewee voted for a neutral condition against 60% calculated PMV. Finally, 35% of the occupants found the thermal environment comfortable hot and 5% hot.

The following Table 3 presents the results for calculated PMV and answers of occupants.

Table 3 Calculated PMV and occupants opinion on thermal environment - 20:00 h

#			3	12	4	1
Occupants opinion						
PMV ANALYSIS	-3	-2,9 to -2	-1,9 to -1	-0,9 to 0,9	1 to 1,9	2 to 2,9	3
#			10	10			

At night, as demonstrated in the table 3, 15% of the people answered that the environment was cold comfortable against 50% calculated PMV. While 50% voted for a neutral