Indoor climate influence related human performance. Case Study

Influenta climatului interior asupra performantei umane. Studiu de caz

Cristian Pacurar [1], Adriana Tokar [1], Marius Adam[1]

[1] Politehnica University of Timisoara, Romania
Traian Lalescu 2, Timisoara 300223, Romania
E-mail: cristian.pacurar@upt.ro, adriana.tokar@upt.ro , marius.adam@upt.ro

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Abstract. *The indoor air quality is one of the main factors that influence the thermal confort and, consenquently, the human performance inside buildings. Throughout the years, a lot of studies described the relation between the climate confort and the performance .This study follows the thermal sensations of students in a seminar room during the summer and winter periods and presents the results between them.*

Key words: thermal comfort, productivity, performance, PMV, PPD, environmental comfort, indoor environment1. Introduction

1. Introduction

Currently people spend up to 87% of their time in indoor environments, be it in residential, academic or commercial buildings, and another 6% in their vehicles, and thus are continually being exposed to the indoor environment [1]. According to Wong et al. (2007) [2], the acceptance of an environment by its occupants depends on environmental parameters, namely thermal comfort, indoor air quality (IAQ), sound and visual comfort, which are identified to determine indoor environmental quality.

This study focuses mainly on education because children spend 30% of their time in schools and educational activity has major repercussions on the future development of young people [3]. Indoor Environmental Quality (IEQ) includes factors such as indoor air quality, thermal comfort, acoustic comfort and visual comfort. It is very important to study these factors, because people spend very long time inside buildings [4]. Besides this to provide comfort to its occupants, buildings should have low energy consumption and concern with sustainability [5].

In many studies it has been proven that poor IEQ may cause diseases, negatively affecting the worker's well-being and reduce its productivity [6]. The thermal environment is one of the main factors that influence thermal comfort and the productivity of occupants inside buildings. It was noted that there was a large number of publications in the last years related of the importance of the IAQ in people's quality of life. Air temperature is a commonly used indicator in thermal environment in IEQ and in performance research [6]. Many studies held in the last decades have reported the connection between air temperature and the performance of its occupants [7]. The physical effects obtained in the thermal environment may vary and may affect the performance of workers, affecting their productivity.

In the case of an academic environment the performance and the productivity can be measured using different methods. There are many factors who can affect the productivity and it can be mentioned environmental, organizational, social and personal factors. It is a limit to the studies which determine mathematical models and relations between productivity and physical factors of the indoor environment, such as thermal comfort, visual comfort, acoustic comfort and air quality. Very many years the aspects of IEQ were analyzed separately and there are other factors that should be considered, such as multisensory interactions [5]. Occupant's productivity could be measured: physiologically, objectively or subjectively. Physiological measurements mean to monitor the indicators of the nervous system, the cardiovascular system, the respiratory system and biochemistry. In subjective assessment, occupants' feedback on changes in the physical environment can be gathered by means of field research (interviews and questionnaire) and objective assessments (calculations and metrics) [8].

2. Content of the paper

The study highlights the possible links between the learning activity of students in their classes and specific parameters of indoor climate. More exactly, based on tests of attention, the study is trying to determine approximate values for efficiency of a person at a certain period of time. Knowing the indoor climatic parameters (measurements were performed earlier), and based on the correlation relationship, the dependency that exists between a person's efficiency and the climatic conditions will be highlighted. Measurements were made in cold period at indoor temperature values ranged between (22 ÷ 28) ±0.8°C and in hot period at temperature values between (16 ÷ 22) ±0.8°C. The average humidity was 50±10 % and the air speed of approx. 0.22 m/s. The seminar room was without mechanical ventilation, with central heating and SPLIT air conditioning cooling. The study described in this article was realized based on several series of measurements for the following climatic parameters: indoor temperature, air velocity and relative humidity [9]

The measurements were made with a device (type meter Testo 350) connected to a sensor which has the following characteristics: temperature (range: +20…70 °C, accuracy: ±0,4°C), air velocity (range: 0…10 m/s, accuracy: ±0,03m/s), humidity (range: 0…+100 %, accuracy: ±2%RH), CO_2 probe measures (range 0 …10000 ppm CO_2, accuracy: ±50 ppm CO_2). At the beginning and end of each measurement session, participants were asked to fill out a questionnaire for determining the IAQ sensation. To determine the PMV and PPD comfort indices according to the Fanger model, the activity of the occupants was estimated to be 1.2 met (69.84 W/m^2), and the thermal resistance of the clothing was 0.5 clo in summer and 1 clo in winter.

In the study is presented a comparation between representatives' relations for relative performance in order to analyze the best option to be used in the futures studies. For the study are used the below relations related to relative performance (RP) with indoor temperature (T_i) and relative humidity (RH_i) .

Koehn, E. and Brown, G. presents relative performance (RP) with indoor temperature ($T_{i)}$ (^{0}F) and relative humidity (RH_i) differentiated used in cold climate (equation (1.1)) and in hot climate (equation (1.2)).

$$RP = 0{,}0144 \cdot T_i - 0{,}00313 \cdot RH_i - 0{,}000107 \cdot T_i^2 - 0{,}000029 \cdot RH_i^2 - 0{,}0000357 \cdot (T_i \cdot RH_i) + 0647 \quad (1.1)$$

$$RP = 0{,}0517 \cdot T_i + 0{,}0173 \cdot RH_i - 0{,}00032 \cdot T_i^2 - 0{,}000985 \cdot RH_i^2 - 0{,}0000911 \cdot RH_i - 1459 \quad (1.2)$$

Relative performance (RP) could be represented with another formula for the both type of climate performance is related in equation (2) and is in dependence only with indoor temperature (Ti) (^{0}C)

$$RP = 0{,}1647524 \cdot T_i - 0{,}0058274 \cdot T_i^2 + 0{,}0000623 \cdot T_i^3 - 0{,}4685328 \quad (2)$$

Thomas, H.R. and Yakoumis, I. presents relative performance (RP) in dependence with indoor temperature ($T_{i)}$ (^{0}F) and relative humidity (RH_i) in equation (3).

$$RP = \frac{1}{9{,}448 + 0{,}0518 \cdot T_i - 0{,}2{,}819 \cdot \ln(T_i) + 3{,}89 \cdot 10^{-37} \cdot e^{RH_i}} \quad (3)$$

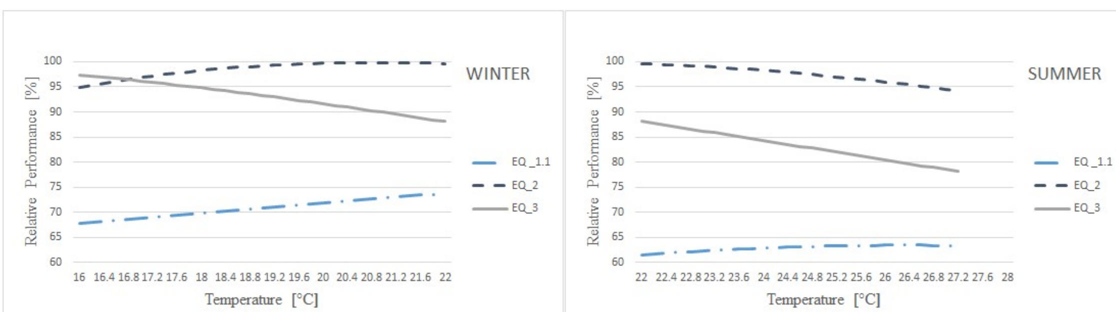

Fig. 1. Relative performance depending on the indoor temperature and relative humidity

Based on these equations, the final model resulting from the superimposition of the relative performance results depending on the season, indoor temperature and relative humidity are shown in the graph above. Most of the research studies in this area agree on the premise that indoor temperature and relative humidity have a very influential effect on people' productivity.

Conclusions

This study provides new insights into the indoor environment that maximizes the productivity of those who occupies a certain space and thermal satisfaction. Thermal comfort evaluation becomes even more relevant when the aim is to maximize performance/productivity, which occurs in a lot of domains. It is necessary to ascertain how environmental variables (air temperature, average radiant temperature, air velocity and relative air humidity) and people (metabolism and clothing) influence thermal comfort and productivity.

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