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Sustainable Buildings – Thermal Sensations Case Study

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Abstract. Currently, thermal comfort is becoming one of the most important aspects of human life. It is related to the time people spend in a closed environment. That is why it is so important to study this issue in terms of their actual thermal sensations, in order to better understand and clarify the scope of the relevant parameters, in particular by looking for such data for buildings built with a view to sustainable development. They are to meet all standards, ensuring thermal comfort for people staying in them. The article discusses thermal sensations, thermal preferences, and humidity for the group aged 21-25 in the winter in the Energis building belonging to the Kielce University of Technology. The methods that were used for this purpose include an environmental measure that takes microclimate parameters and questionnaires assessing the conditions in the room under study.

Introduction

Modern, sustainable construction encourages designers to provide the highest-quality internal conditions in a closed space so that everyone can feel comfortable in it. Thermal comfort depends on many factors, such as air temperature, clothing, airflow speed, carbon dioxide level, relative humidity, etc. can cause fatigue and weariness. Therefore, it is so important that intelligent buildings can provide the greatest possible comfort for working and learning people. Taking into account the above factors, an analysis of the available literature was carried out, in which not much research related to modern buildings of an educational nature was found, but many studies related to buildings being trained in various climate zones. An example of such research is the research [1, 2] carried out in China, which in the first case showed that students prefer cooler temperatures, with the selected temperature range from about 21ºC to about 27ºC, while in the second case, 90% of people believed that they felt thermal comfort. The intelligent building, which was examined by the authors [3, 4], provided information in both cases that it meets the thermal expectations of people because the conditions that prevailed at that time were closest to their expectations of comfort. Other interesting studies concern thermal comfort in tropical climates like Australia [5] where the temperature range, according to the respondents, was from 19ºC to 26ºC, Malaysia and Japan [6] where the best temperature was about 25ºC-26ºC degrees, and Bangladesh [7] in which students identified the temperature of 27ºC as the most neutral in their climate zone. As mentioned earlier thermal comfort depends on many factors including also individual preferences, medical treatment as well as heat transfer issues [8-11]. A thorough theoretical analysis of the heat distribution would be very complex [12-14] and would require either time-consuming FEM modeling or the use of semi-empirical methods [15-17].

The main purpose of the study was to learn about the thermal sensations of the group in order to check whether the intelligent building meets the thermal expectations of people in the winter.

Methodology

The study was conducted in the winter in the Energis building at the Kielce University of Technology. The Energis building was created with sustainable development in mind, so as to be self-sufficient in energy, using renewable energy sources, such as heat pumps, photovoltaic and solar panels, and windmills. In addition, the building has a BMS (Building Manager System) system programmed, the main assumption of which is to control microclimate parameters in lecture halls or employees' rooms, additionally it provides control of lighting inside the building and electricity yield and its further use to power teaching devices. Energis is shown in Fig. 1.

Fig. 1. *Energis building, Kielce University of Technology.*

The study was performed using a microclimate meter that collected data from the internal parameters of the room and questionnaires, which were completed by the study group. First, the meter was placed in the central part of the room. After approximately 15 minutes, the results were written down. Secondly, the questionnaires were distributed and completed by the respondents. The task of the students was to assess thermal sensations, and moisture, and determine their well-being and productivity on the basis of the questions contained in the questionnaire. 20 people aged 21 to 25 participated in the study. After the analysis, 4 questionnaires were rejected because these people felt sick and could not be taken into account in the further evaluation of the results. Men accounted for 62.5% and women accounted for 37.5% of the studied group. The lecture hall is presented in Fig. 2.

Fig. 2. *Lecture hall in Energis building.*

Results

The conditions that prevailed during the performed test were:

- air and black ball temperatures: 23.8 [°C] and 23.5 [°C];

- relative humidity and air speed 25.51 [%] and 0.08 [m/s];
- light intensity and CO_2 concentration: 475.7 [lx] and 719 [ppm].

The obtained parameters are within the applicable ranges for closed rooms. The responses of the respondents are shown in the next figures. Fig. 3 shows the real thermal sensations of people.

No person has identified room conditions as cool or cold. Definitely 43.75% of people considered the conditions in the room as comfortable and as negative – 31.25%. On the other hand, 25% of people declared that the room was too warm. The chart below presents the acceptability of temperature by the participants of the study.

Half of the group consider the prevailing temperature as comfortable, and the other half that it is acceptable. It means that all the people who were participating in the current study expressed positive ideas about the indoor microclimate. No one complained about the conditions in the room, which is quite strange, because a quarter of the population there said that it was too hot (Fig. 3), but none expressed any complaints about it regarding the acceptability of the environment they were in.

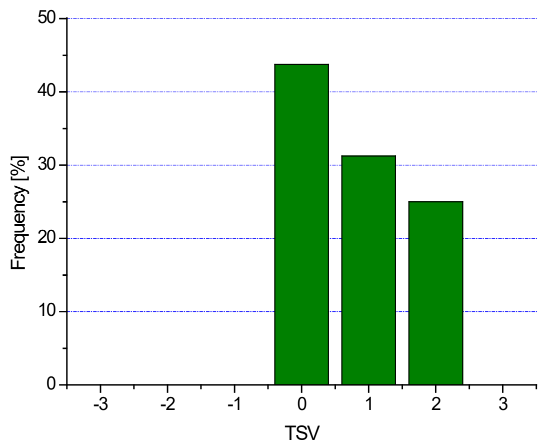

Fig. 3. *Thermal sensation of respondents (TSV): -3 – too cold, -2 – too cool, -1 – pleasantly cool, 0 – comfortable, 1 – pleasantly warm, 2 – too warm, 3 – too hot.*

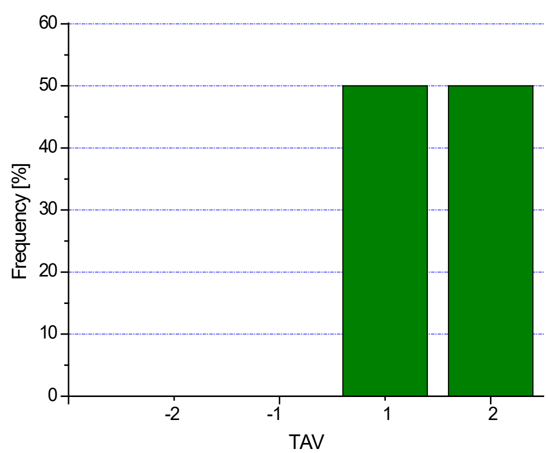

Fig. 4. *Temperature accepted by the respondents (TAV): -2 – definitely unpleasant,, -1 – unpleasant, 1 – acceptable 2 – comfortable.*

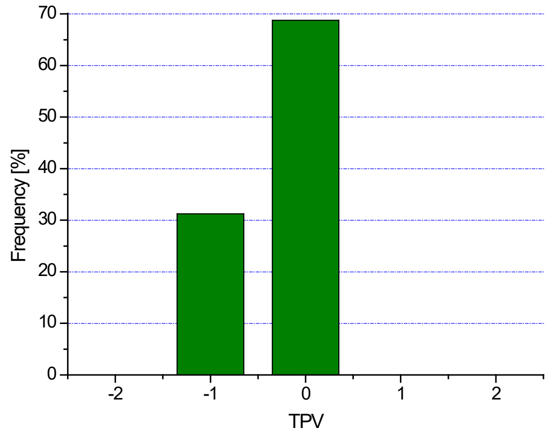

Fig. 5. *Thermal preferences vote (TPV):*
-2 – definitely cooler, -1 – cooler, 0 – no change, 1 – warmer, 2-definitely warmer.

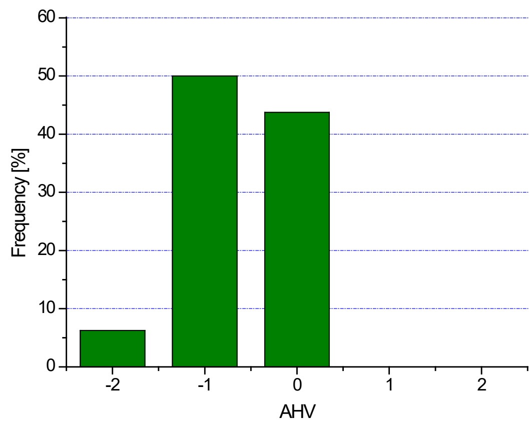

Fig. 6. *Assessment of humidity vote (AHV):*
-2 – too dry, -1 – quite dry, 0 – pleasantly, 1 – quite humid, 2 – too humid.

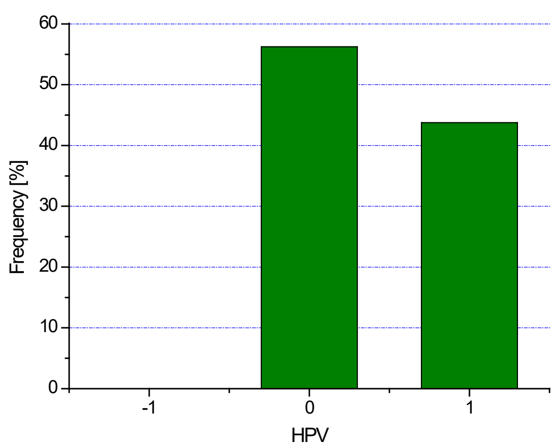

Fig. 7. *Humidity preferences vote (HPV):*
-1 – more dry, 0 – no change, 1 – more humid.

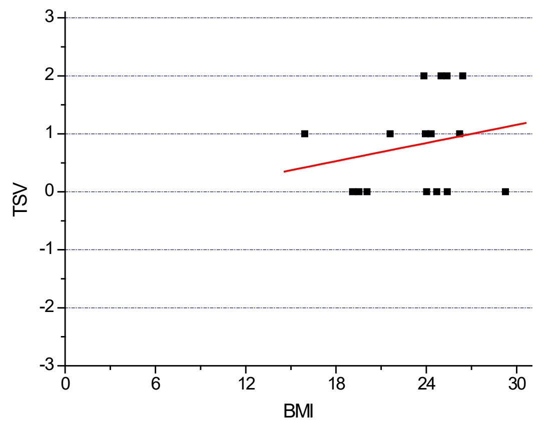

Fig. 8. *The relationship between the BMI index and the TSV.*

The next question in the questionnaire dealt with another important issue – Fig. 5 shows people's heat preferences, i.e. what temperature would be better, warmer, or cooler. It turned out that 68.75% of people would leave the temperature unchanged, while 31.25% would like it to be cooler. Fig. 6 below shows the assessment of humidity in the lecture hall.

An overall estimate shows that around 56.25% of people in the room are too dry or too dry. Contrary to 43.75% who rated the humidity as pleasant. The purpose of Fig. 7 is to show the willingness to change the humidity in the lecture hall, where the test took place, to a more humid or drier one.

According to the respondents, the humidity could remain unchanged at 56.25%. Changes in humidity to the more humid one were expressed by 43.75% of people. Fig. 8 below shows the relationship between the BMI and Thermal Sensation Vote (TSV).

Summary

The surveyed group was 75% satisfied with temperature – only ca. 31% would prefer it to be cooler. The humidity was judged as quite dry or too dry, so it could be wetter in the room. The sustainable building met people's expectations during the test, except for relative humidity which could be higher.

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