TECHNICAL TRANSACTIONS | CZASOPISMO TECHNICZNE
CIVIL ENGINEERING | BUDOWNICTWO

5-B/2014

ANNA DUDZIŃSKA*

THE ATTEMPT OF EVALUATION OF THERMAL COMFORT CLASS IN A PASSIVE SCHOOL BUILDING ON THE BASIS OF SHORT-TERM IN SITU RESEARCH IN CONTEXT OF PN-EN 15251 STANDARD

PRÓBA WYZNACZENIA KLASY KOMFORTU CIEPLNEGO W PASYWNEJ SZKOLE NA PODSTAWIE KRÓTKOTERMINOWYCH BADAŃ IN SITU W ODNIESIENIU DO STANDARDÓW NORMY PN-EN 15251

Abstract

In this paper, the classification of thermal conditions within a passive school building in Budzów in a narrow time spectrum, in accordance with PN- EN 15251 standard requirements is presented. Results of the short-term initial measurements made within the school building are shown. On their basis, a preliminary evaluation of the environment category was performed.

Keywords: thermal comfort class, PMV, PPD, DR, PD

Streszczenie

W artykule zamieszczono informacje na temat warunków termicznych w wąskim przedziale czasowym wewnątrz pasywnej szkoły w Budzowie w odniesieniu do wymagań normy PN-EN 15251. Przedstawiono wyniki krótkotrwałych, próbnych pomiarów prowadzonych w tym obiekcie i na tej podstawie dokonano wstępnej oceny katergorii środowiska.

Słowa kluczowe: klasa komforut cieplnego, PMV, PPD, DR, PD

* M.Sc. Eng. Anna Dudzińska, Institute of Materials and Building Structures, Faculty of Civil Engineering, Cracow University of Technology.

1. Introduction

After Polish accession to the European Union, it was necessary to implement the 2002/91/EC Directive of the European Parliament and the European Council dated 16th December 2002. Concerning the energetic effectiveness of buildings. Its main goal is to stimulate the economy in EU member countries to create buildings characterized with the lowest possible energy demands, as well as, respective indoor microclimate and profitability of the investment. According to the Directive's requirements, all newly erected or rented buildings are to be certified. Energetic quality certificates need to account for the heat capacity, cooling system and passive heating, thermal bridges, anti-solar protection, heating systems and electricity systems powered by renewable energy sources, as well as, indoor climate conditions.

Classification of the building in context of the thermal comfort is performed in accordance with the PN-EN 15251 standard [1]. Analysis should be carried out exclusively for closed environments in the period of their highest thermal effort. It is suggested that the measurement period was several days long. However, for the preliminary analysis of the indoor conditons purposes, a several hours long period with high outdoor air temperatures was selected. Preliminary in situ tests of such type enable us to evaluate the indoor environment. In case of disadvantageous results (bad indoor conditons), these tests will be the basis for the further thorough thermal analysis for longer time periods.

2. Assumptions of PN-EN 15251

PN-EN 15251 [1] classifies objects into the respective thermal comfort classes on the basis of assumed requirement level. In this document, three environment categories are distinguished:

- Category A – rooms fulfilling high requirements. It is recommended for rooms in which sensitive and weak people live. E. g. small children, disabled or ill people.
- Category B – rooms fulfilling medium requirements (normal requirements). This category is designed for new and modernized buildings.
- Category C – rooms fulfilling moderate requirements. It is designed for building used at the acceptable level [2].

The above classes allow to decide, into which group the existing or planned building should be classified. They determine criteria for their respective level. Several factors affect the thermal comfort evaluation:

- Air temperture and spatial distribution of temperature within the room,
- Temperature of the surrounding space,
- Air moisture,
- Air velocity.

The analysis of the above parameters in each room decides on the whole building's thermal comfort class.

Coefficients PMV, PPD, DR and PD (computed in accordance with PN-EN ISO 7730:2006 [3]) are used in the evaluation of the thermal environment conditions. PMV coefficient (Predictive Mean Vote) determines the predicted mean vote according to the 7-grade psychophysical scale of thermal feeling – from +3 (hot) to –3 (cold). PPD coefficient (Predicted Percentage of Dissatisfied) determines the predicted percentage of people, who would be dissatisfied with the thermal comfort within the room. The aforementioned coefficients determine the thermal comfort with reference to the whole body. Human can feel the so-called "local discomfort", which is related to different factors. Percentage of people dissatisfied with the air velocity within the room (draught) is specified into DR (Draught Rating) coefficient. Local thermal feeling related to either too cold or too hot floor due to the height and the asymmetry of the heat radiation is accounted for in PD coefficient.

Table 1

Recommeded values of the thermal comfort coefficients for respective room classes [1]

Room category	Thermal feeling of the whole body		Local discomfort			
			PD [%]			
	PMV	PPD [%]	DR [%]	Vertical air temperature difference [%]	Hotter or colder floor [%]	Asymmetry of the heat radiation [%]
A	–0.2 < PMV < +0.2	< 6	< 15	< 3	< 10	< 5
B	–0.5 < PMV < +0.5	< 10	< 20	< 5	< 10	< 5
C	–0.7 < PMV < +0.7	< 15	< 25	< 10	< 15	< 10

The classification is performed on the basis of design data, measurements and numerical simulations. Representative rooms in a building are analysed.

3. The first passive school building in Poland

The first passive school building was erected in Bremen-Sebaldsbruck (Germany) in 2001. Eleven years later, a similar structure – characterized by great energy savings – was built in Poland. This school, located in Budzów (Lower Silesia), is heated with the special devices using the energy produced by students as well.

Fig. 1. The passive school building in Budzow

The school building is characterized by great tightness. Thus, the energy recovery ventilation is used to recover the generated heat. Thermal transmittance coefficients for walls are equal to about 0.1 W/m^{2}K, whereas they are equal to 0.8 W/m^{2}K for windows, and the energy demand for heating purposes equals to about 15 kWh/m^{2}year [4].

Measurements were made on the 17th of June at about midday (from 10 a.m. to 1 p.m.). In a representative classroom (located at the east side of the building), there were 30 students and a teacher.

The calibration of activity, metabolism and cloth coefficients was made. Students' activity in a siting position is rather small. Thus, the value of the generated energy was assumed as 1.591 met. Clo value for the light clothes was set as 0.5 accounting for the thermal resistance coefficients.

4. Results

The values of PMV and PPD for the analysed school classroom are presnted in Fig. 2. Predicted Percentage of Dissatisfied equals about 17%.

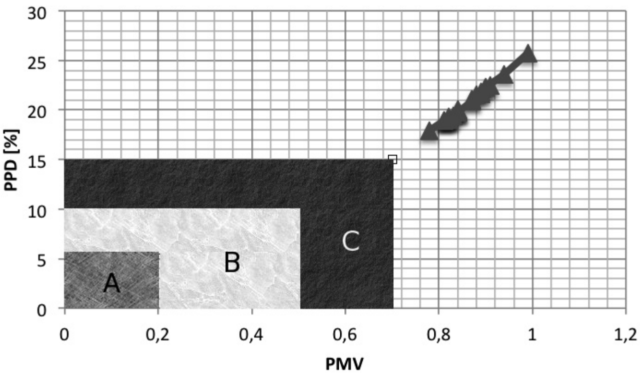

Fig. 2. Values of PMV and PPD coefficients

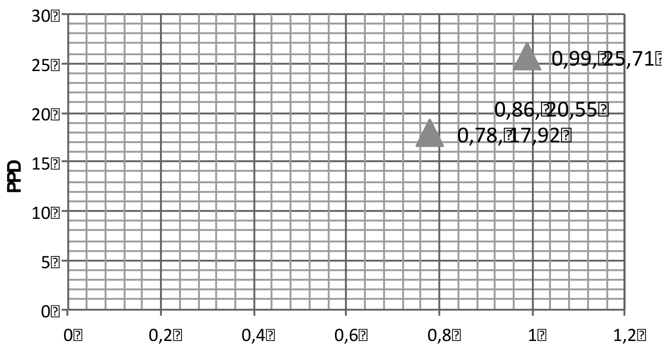

Fig. 3. Minimum,medium and maximum values of PMV and PPD coefficients

The value of DR coefficient for the whole measurement period is equal to 0. It was evaluated according to the following formula:

$$DR = (34 - t_{a,l})\cdot(v_{a,l} - 0.05)^{0.62}\cdot (0.37\cdot v_{a,l}\cdot T_u + 3.14),$$

where:

$t_{a,l}$ – air temperature at the point [°C];
$v_{a,l}$ – mean air velocity at the point [m/s], $v_{a,l} < 0.5$ – we assume that $v_{a,l} = 0.5$;
T_u – turbulence intensivity at the point ranging from 10% to 60% (value of 40% was assumed) [3].

PD coefficient, the indicator of the local discomfort due to the differences in vertical temperature distribution, too cold or too hot floor and the asymmetry of heat radiation, was not measured beacause of the gauge limitations.

Table 2

Values of the evaluated thermal comfort coefficients

Thermal feeling of the whole body		Local discomfort			
		PD [%]			
PMV (medium)	PPD (medium) [%]	DR [%]	Vertical air temperature difference [%]	Hotter or colder floor [%]	Asymmetry of the heat radiation [%]
0.86	20.55	0	No data	No data	No data

5. Conclusions

On the basis of results of measurements one can conclude that:

- Mean value of PMV coefficient is equal to 0,86. It means that, according to PN-EN 15251 [1], it does not match for any of the presented environment categories.
- The evaluated values of the predicted mean vote denote a "hot" microclimate within the school classroom, according to Fanger criterion [5]. It should be noticed that the masurements were not made in the period of maximum outdoor temperature. It can be predicted that temperature increase would result into further deterioration of thermal comfort within the classroom.
- Over 20% students having classes in the analysed school classrom are not satisfied with its thermal conditions. It is reflected by the mean value of PPD coefficients (20.55).
- Local discomfort coefficient (*DR*), determinig the percentage of users sensitive to the air motion of high velocity, equals 0 for the whole analysis period. It comes from the low air velocities ($v_a < 0.05$) ranging from 0.00 to 0.03 m/s.
- The percentage of users dissatisfied with the differences in vertical temperature distribution, too hot/cold floor or the asymmetry of heat radiation was not evaluated. It was due to the gauge limitations, which are able to measure the temperature at only one height. The preliminary analysis of the environment category within the school does not allow us to classify the object into any of the thermal comfort classes specified in PN-EN 15-251. Due

to the incomplete measurements set, limited range and time period of the analysis, the full description of the thermal conditions is not provided. Future research effort is to analyse the microclimate in a period of low outdoor temperatures using a gauge equipped with three probes located at different elevations. It will provide a reliable building evaluation.

Due to the incomplete set of results (limited range and measurement period), one obtains only the temporary overview of environment conditions. However, the possibility of uncomfortable thermal situation can be observed, which may affect the performance of the human body. It should be verified if the functioning of the object beside the thermal comfort range exceeds 10% of the whole year, which is the obligatory limitation. Thus, futher microclimate measurements are planned for several days periods with the maximum outdoor air temperatures, as well as, the statistical analysis. They will enable more reliable building evaluation, including its categorization.

References

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