TECHNICAL TRANSACTIONS | **CZASOPISMO TECHNICZNE**
CIVIL ENGINEERING | BUDOWNICTWO
5-B/2014

KATARZYNA NOWAK-DZIESZKO, MAŁGORZATA ROJEWSKA-WARCHAŁ*

MEASUREMENTS OF THE THERMAL COMFORT IN THE W70 PANEL BUILDING

POMIARY KOMFORTU CIEPLNEGO W BUDYNKU WIELKOPŁYTOWYM W SYSTEMIE W70

Abstract

It is estimated that about 4 million flats in Poland are made of prefabricated elements in different systems. Moreover, at present more than 10 million Poles live in system buildings. Despite the commonness of those buildings the analyses of the microclimate of the interior space are very rare. The paper presents the results of the thermal comfort measurements conducted in different flats of multi-family panel building made in W70 system. It appears there is a problem with the overheating effect during the summer months in all parts of the building.

Keywords: panel building, W70 system, thermal comfort measurements, PMV (Predicted Mean Vote), PPD (Predicted Percentage of Dissatisfied)

Streszczenie

Szacuje się, że w Polsce około 4 milionów mieszkań wykonanych jest w technologi wielkiej płyty w różnych systemach. Co więcej, obecnie ponad 10 milionów Polaków mieszka w budynkach systemowych. Pomimo powszechności tychże budynków analizy mikroklimatu wnętrz jest bardzo rzadkie. W artykule przedstawiono wyniki pomiarów komfortu cieplnego przeprowadzonych w różnych mieszkaniach wielorodzinnego budynku wzniesionego w systemie W70. Okazuje się, że we wszystkich analizowanych mieszkaniach występuje problem przegrzania w miesiącach letnich.

Słowa kluczowe: budynek wielkopłytowy, system W70, pomiary komfortu cieplnego, PMV (Predicted Mean Vote), PPD (Predicted Percentage of Dissatisfied)

* M.Sc. Eng. Katarzyna Nowak-Dzieszko, M.Sc. Eng. Małgorzata Rojewska-Warchał, Institute of Materials and Building Structures, Faculty of Civil Engineering, Cracow University of Technology.

1. Prefabricated panel buildings

In the fifties of the twentieth century the erection of panel system buildings began in Poland. For the several dozen years about 4 millions flats have been adjusted to use. At present more than 10 million Poles live in system buildings. It makes the problems connected with the proper usage and thermal insulation very important and common. The thermal insulation of those buildings is low and the seasonal heating energy demand is usually 50% higher than the national requirements [1]. The most important aspect is the improvement of the building energy certificate of those buildings. It is connected with the thermal modernization of the building envelope and change of windows.

Unfortunately at the stage of considering and designing the thermal modernization no-one takes into account the thermal comfort and overheating issues in summer which seem to be very important from the occupants' point of view.

The W70 System is the "opened" system used for the erection of multi-family buildings, in which, contrary to the "closed" system, all construction walls within the flats were eliminated. It allowed the changes of the partition wall pattern and at the same time enabled designing of flats with different areas and room arrangements. It is estimated that about 15% of all system buildings were erected this way.

2. Thermal comfort

Thermal comfort is related to the thermal balance of the body which is affected by different parameters: personal and environmental. The microclimate of the interior space is the combined effect of the design process, erection and the utilization of particular rooms. Thermal comfort is affected by human activity, clothing insulation and the environmental parameters such as air temperature, average radiation temperature, air flow speed and relative humidity. The evaluation of thermal comfort is based on the PMV (Predicted Mean Vote) and PPD (Predicted Percentage of Dissatisfied) indices.

The international standard PN-EN ISO 7730 "Ergonomics of the thermal environment. Analytical determination and interpretation of thermal comfort using calculation of the PMV and PPD indices and local thermal comfort criteria" [4] uses Fanger's method to estimate thermal comfort.

The Fanger's PMV method combines the following environmental features: air temperature, air velocity, mean radiant temperature and relative humidity and two personal variables: clothing insulation and activity level into the index that can be used to predict the average thermal sensation of a large group of people. The thermal sensation 7-level scale with values between –3 and 3 describes the thermal sensation between "hot" and "cold".

In this model, all major modes of energy losses from the human body are taken into account and the person is assumed to be at the steady state condition.

3. Flats analyzed

The aim of the field measurements was to analyze the thermal comfort in the particular parts of the W70 panel dwelling building, built in 1974 (Fig. 1). The tests were conducted using the digital thermal comfort measurement device (Babuc), Fig. 2 Infogap program to analyze test data.

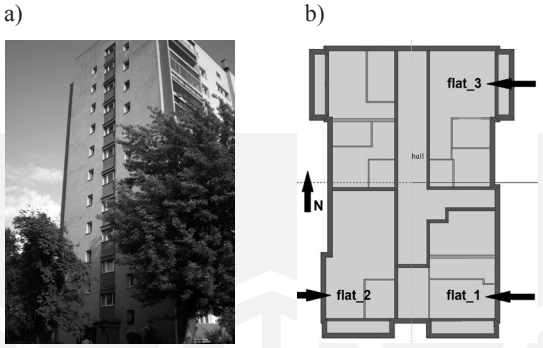

Fig. 1a) South elevation of the analyzed building,
b) location of flats at building floor

Fig. 2. BABUC – device used to measure thermal comfort

Building plan area 21.5 × 13.2 m; usage building area – 2279 m^2, 25 m high with 11 levels. Basement below the entire building, flat roof.

Building with the natural ventilation, central heating system with convection heaters.

Communication area located in the center part of each building level. Four flats at every story located in the corners of the building.

The field tests were conducted in three flats at different levels and with different window orientation:

1) Flat number 1 – ground floor, South-East orientation,
2) Flat number 2 – fifth floor, South-West orientation,
3) Flat number 3 – seventh floor, North-East orientation.

Exterior walls made of prefabricated panels in W70 system, insulated with 10 cm of styrofoam with plasters at both sides: $U = 0.25$ [W/m^{2}K], double glazing windows: $U = 1.7$ [W/m^{2}K].

4. Test results

The main aim of the field tests was to analyze the microclimate conditions of the particular flats at different elevations during summer. Measurements allowed to determine the internal operative temperatures, and therefore – based on the measurement data – calculate the values of PMV index and PPD index.

The measurements were conducted in three days between 29th July and 31st July, for 24 hours in every flat referenced above, starting at seventh floor, next of the fifth floor and finally at ground floor. In each case the measuring device was located in the living room where the percentage of glazing at exterior walls is the highest.

The average external temperatures during those days were even above 30°C and were measured continuously, the results are presented in Fig. 3. The electronic device used for temperature measurements was located at the balcony of each flat.

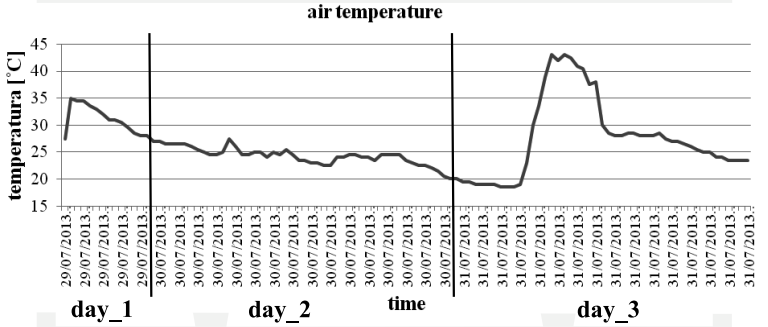

Fig. 3. External temperature between 29th and 31st July in Cracow

In all dwellings the operative temperature in the analyzed period of time is considerably higher than 25°C. The daily maximum interior operative temperature is 29.17°C. Those negative flat conditions continue for the entire day and do not change significantly at night. The flats can be cooled down during the night through the open windows. However, in case of such high external temperatures, it doesn't change the operative temperature much. All data are presented in Fig. 4.

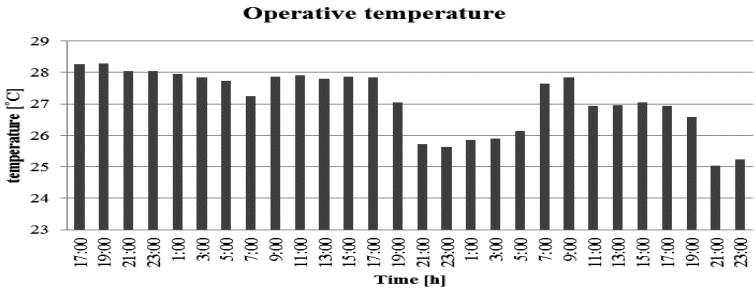

Fig. 4. Internal operative temperatures between 29th and 31st July in the analyzed flats

The thermal comfort conditions are closely related with the human activity and clothing insulation. The parameter *clo* = 0.5 describing clothing insulation, based on standard [3], was assumed in the calculations of PMV index. Regarding human activity, two cases were calculated: first one for a person having a rest and the second one for a person doing the cleaning.

Figure 5 presents the PMV values with the assumption that flat users have a rest. For most of the time the PMV value is between –0.5 and 0.5, for the rest of the time it's higher than 0.5 but not more than 1.

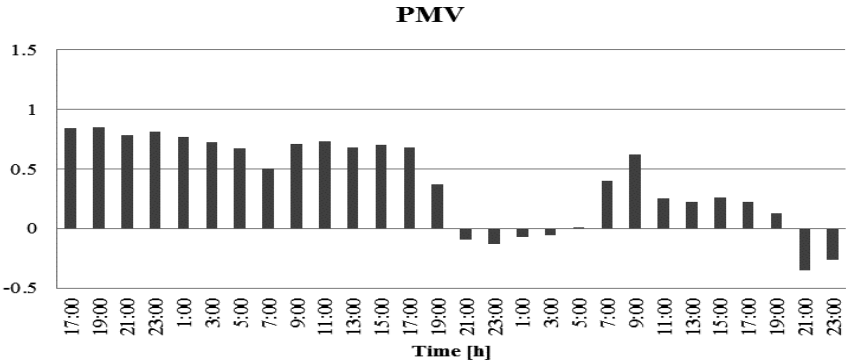

Fig. 5. PMV index – users having a rest

The results are much different when we assume different activity level of people staying inside the flats. Figure 6 presents the results. The PMV values are much higher than 1.5 almost for the entire period of time. Those are not comfortable conditions for users.

The predicted percentage of dissatisfied, described by PPD index in the analyzed period of time is between 50% and 80% (Fig. 7).

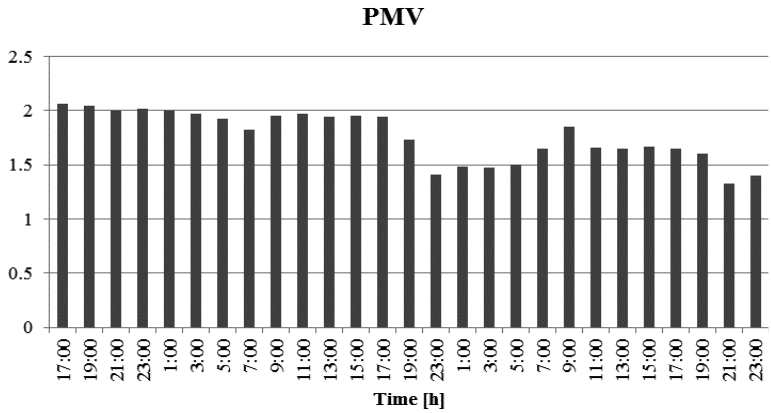

Fig. 6. PMV index – users cleaning the room

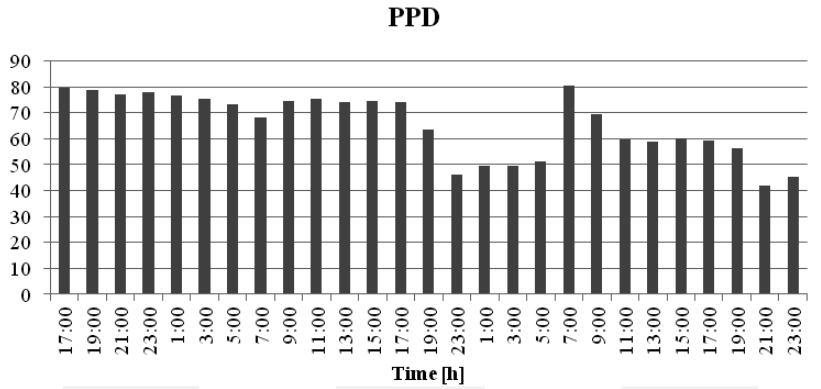

Fig. 7. PPD index – users cleaning the room

5. Conclusions

The results of conducted analysis show that the overheating problem in summer occurs in all flats of the panel building. Windows in the prefabricated panel buildings in most cases are poorly shaded from solar radiation. Glazing is the source of the excessive heat gains and results in overheating of the dwellings. The microclimate conditions in all flats are very uncomfortable and the parameters describing thermal comfort exceed the acceptable values. The operative temperatures are much higher than 25°C and the PMV values for most of the time are between 1.5 and 2 and the percentage of dissatisfied people for all the time is higher than 50%.

In case of all flats the internal or external shadings should be used to improve the microclimate conditions and reduce the internal operative temperatures.

References

[1] Rozporządzenie Ministra Infrastruktury w sprawie warunków technicznych, jakim powinny odpowiadać budynki i ich usytuowanie z dnia 12 kwietnia 2002.

[2] Ostańska A., *Wpływ dotychczasowych termomodernizacji budynków mieszkalnych na oszczędność energii i planowanie programów rewitalizacji na przykładzie jednego z lubelskich osiedli* Budownictwo i Architektura 7, 2010, 89-103.

[3] PN-EN ISO 7730 Ergonomics of the thermal environment. Analytical determination and interpretation of thermal comfort using calculation of the PMV and PPD indices and local thermal comfort criteria.

[4] Nowak K., *Modernizacja budynków a komfort cieplny pomieszczeń*, Energia i Budynek, 11 (54), 2011.

[5] Dębowski J., *Cała prawda o budynkach wielkopłytowych*, Przegląd budowlany 9/2012.