Study on the Comfort Microclimate at the Educational Building in Research Laboratories

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Abstract. The article presents some conclusions on the comfort microclimate at educational buildings, by monitoring the temperature during the summer. The laboratories are located in two buildings, which differ from the point of view of the construction and building envelope, different positions, from the cardinal point of view, and therefore with considerable differences of solar inputs, but having the same type of glazed elements in terms of technical characteristics. The values of the interior temperatures were recorded in the two laboratories. The conclusions of the study are important in the context in which, for occupants, the resulting thermal discomfort can be reduced by implementing shading, proper ventilation / cooling measures, measures that can mitigate the negative effects brought by solar intakes.

Keywords: comfort microclimate · temperature · humidity · discomfort

1 Introduction

Thermal comfort is affected by conduction, convection, radiation processes and evaporation heat loss.

The microclimatic parameters of the working environment are also known as parameters of thermal humidity. They are determined by temperature, relative humidity and air currents. These physical amounts define comfort or discomfort.

The impact of climatic disturbances on buildings cannot be ignored, manifesting itself both structurally and directly. They affect the behaviour of users, insofar as an adequate quality of the indoor environment (air quality, thermal comfort, acoustic comfort, etc.) could be ensured. This impact on the behaviour of building users is manifested in particular by the increase in thermal discomfort in summer and, therefore, the difficulty of achieving comfort conditions without additional energy consumption.

Thermal comfort is analyzed by the predicted average vote (PMV), the percentage of dissatisfaction (PPD) and the operative temperature.

The range of values for PMV = - 0.2… + 0.7 is divided into 7 classes. The analysis must also take into account the other criteria (PPD, air currents, vertical gradients,

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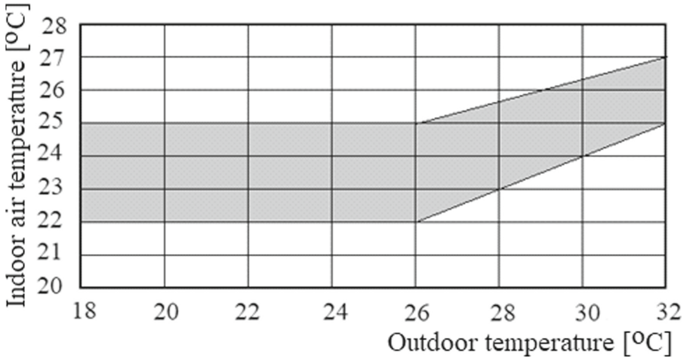

Fig. 1. Permissible comfort zone depending on indoor air temperature.

temperature asymmetry, floor temperature). The overall comfort indicator is calculated as a weighted average [5].

2 Analyzed Parameters

Indoor air temperature is the most common indicator of thermal comfort. It is defined as the air temperature around the human body, at a distance from the radiation of heat sources. Even very small variations in this temperature are immediately noticed by the human body. This temperature is considered as an average value and must be taken into account in each analysed case. The energy consumption for heating and cooling is calculated. Depending on its value, the indoor air temperature must be higher in rooms where people are resting or performing light work, and must be lower where the activity is more intense [1] (Fig. 1).

The relative humidity of the indoor air is defined as the ratio between the partial pressure of water vapor and the saturation pressure at a certain temperature and pressure. The relative humidity of the indoor air influences the heat exchange of the human body with the environment by evaporating sweat to the surface of the skin. At low indoor air temperatures, the heat dissipation by evaporation is lower, so the relative humidity of the indoor air has a lesser influence. At higher air temperatures and intense physical activity, the increase in relative humidity has a great influence on the heat exchange between human body and the environment [1].

In standards and normatives are presented combined influences of thermal comfort factors. Figure 2 shows the combined influence of indoor air temperature and relative humidity.

Interior comfort is defined by thermal comfort parameters (Table 1).

- PMV index (predicted average vote);
- PPD index (predictably dissatisfied percentage)

Sample Heading (Third Level). Only two levels of headings should be numbered. Lower level headings remain unnumbered; they are formatted as run-in headings.

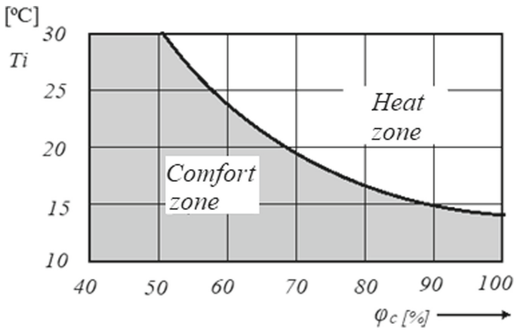

Fig. 2. Influence of the environmental comfort factors: indoor air temperature and relative humidity.

Table 1. Classes of interior thermal comfort.

Comfort class	The overall thermal balance of the body		Additional local discomfort			Asymmetry of radiant temperature [°C]
	PPD	PMV	Air currents	Vertical temperature gradients	Ground temperature	
A (high)	< 6%	-0.2 ÷ + 0.2	< 15%	< 3%	< 10%	< 5
B (medium)	< 10%	-0.5 ÷ + 0.5	< 20%	< 5%	< 10%	< 5
C (low)	< 15%	-0.7 ÷ + 0.7	< 25%	< 10%	< 15%	< 10

Sample Heading (Forth Level). The contribution should contain no more than four levels of headings. The following Table 1 gives a summary of all heading levels.

Legal standard no. 1425/2006 for the approval of the Methodological Norms for the application of the provisions of the Law on safety and health at work no. 319/2006, in Chapter 4 provides that at the workplace (offices, control rooms, rooms with video-terminals, social-cultural rooms, etc.) where carrying out the professional activity requires thermal comfort, the following conditions must be ensured:

During summer:

- operating temperature between 23 - 26 °C;
- vertical difference in air temperature values at 1,1 m and 0,1 m above the ground (head and ankle level) less than 3 °C;
- relative air humidity between 30 - 70%;
- average speed of air currents between 0.1 - 0.3 m/s. [2]

Table 2. Average sunshine durations [hours/month] [4]

Location	Ianuarie January	Mai May	Iulie July	Septembrie September
Bacău	67	213	262	195
Galaţi	76	250	307	230
Constanţa	78	254	330	243
Ploieşti	82	231	281	215
Craiova	64	252	310	208
Cluj	83	219	236	201

The average durations of sunshine, determined by statistical processing of meteorological data, differ depending on the locality and the month of the year. In the following table there are the average durations of sunshine, in hours per month, for some localities in Romania [4] (Table 2).

3 Methodology. Experimental Results

Temperature and humidity measurements were made, the sensors being placed as follows:

- in the BL26 laboratory room, located in the BL26 laboratory block, construction made in the 80's, made of concrete frames with BCA masonry. There are windows only on the western side with double-glazed windows and PVC joinery in the ba143 laboratory room, located in the building of the Faculty of Mechanics, made of brick masonry between 1898–1901.
- room BA 143 has windows on both the western and eastern walls, so apart from a short period during lunch, it is exposed to solar radiation all day long.
- external sensor located on the west façade of the building, outside the room BA143.

Temperatures and humidity values were monitored for two months (July and August 2021), daily, over 24 h (Fig. 3). The measurements were recorded using video surveillance cameras mounted in front of the measuring devices, at the following hours: 1, 2, 4, 5, 7, 8, 10, 11, 13, 14, 16, 17, 19, 20, 22 and 23, For the other hours when no measurements were recorded, the values were approximated by interpolation (Fig. 4).

To be noted that during this period the rooms were not ventilated, this fact also explaining a certain inertia of the temperature and humidity values, especially since the two buildings have polystyrene thermal insulation (Fig. 5).

Fig. 3. Aerial view of the Faculty of Mechanics. In red are marked the areas in the Western part of the buildings where BA 143 and Bl 26 laboratories are located (source Google Maps)

Fig. 4. External view of the BA143 laboratory – up the east side, down the west side

Fig. 5. External view of the building where the BL26 laboratory is located, west orientation

4 Devices Used for Measurements

The measurements were made using a wireless thermometer/hygrometer with external sensor with the following characteristics:

Indoor temperature:	-5 to + 50 °C
Max. Number of sensors:	3
Indoor humidity resolution:	1%
Indoor temperature resolution:	0,1 °C
Sensor dimensions:	55 x 103 x 30 mm
Base station dimensions:	110 x 125 x 30 mm
Outdoor humidity:	20 to 95%
Indoor humidity:	20 to 95%
Radio frequency:	433 MHz
Maximum range:	20 to 30 m
Outside temperature resolution:	0,1 °C
Humidity resolution	1%
Outdoor temperature:	-20 to + 60 °C
Sensor power supply:	2 AA batteries (LR6)
Station power:	2 AA batteries (LR6)
Transmission type:	radio

4.1 Hygrometer Thermometer

Fig. 6. Images recorded in room BA143. The hygrometer thermometer indicates the temperature and humidity outside the building (west side), at the top right, and at the bottom measurements in room BA143.

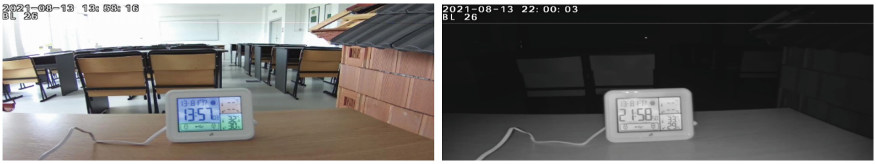

Fig. 7. Images of the room BL 26

5 Recorded Results

As an example, measurements were processed from 31.07.2021, considered a day with temperatures and humidifies that do not leave the average zone for a summer day (Fig. 6) (Table 3).

By monitoring the comfort parameters in the two laboratries, the following values have been recorded that can represent a reference basis for the adoption of measures to eliminate the thermal discomfort: (Fig. 7).

Large variations in temperature and humidity recorded by the outer sensor placed on the western façade of the BA143 laboratory (Fig. 8). Due to the fact that in the 14–17 h interval, when the sun's rays fall directly on the façade, the sensor frequently recorded temperatures above 50 °C, even 63.3 °C in 9.08 (humidity 20%), while inside there were 35 °C (30% humidity) (BA143), respectively 32.5 °C (29% humidity) (BL26) (Fig. 9).

Table 3. Temperature values measured on 31.07.2021 [°C]

	WEST external sensor	**Room BA 143**	**Room BL 26**
hour	**Recorded temperature [°C]**	**Indoor temperature [°C]**	**Indoor temperature [°C]**
1	26.1	33.9	32.3
2	25.3	33.9	32.1
3	24.4	33.5	31.95
4	23.5	33.1	31.8
5	22	33.3	31.7
6	21.35	33.4	31.35
7	20.7	33.5	31
8	22.2	33.4	31.5
9	25.45	33.95	31.55
10	28.7	34.5	31.6
11	31.1	35	31.7
12	32.8	35	31.85
13	34.5	35	32

(*continued*)

Table 3. (*continued*)

	WEST external sensor	Room BA 143	Room BL 26
14	36	34.9	32.1
15	49.65	34.95	32.3
16	63.3	35	32.5
17	59.5	35.3	33.1
18	49.9	35.2	33.45
19	40.3	35.1	33.8
20	36.6	34.8	33.9
21	34.05	34.6	33.5
22	31.5	34.4	33.1
23	29	34.3	32.8
24	29	34.3	32.8
Average	33.20	34.35	32.32

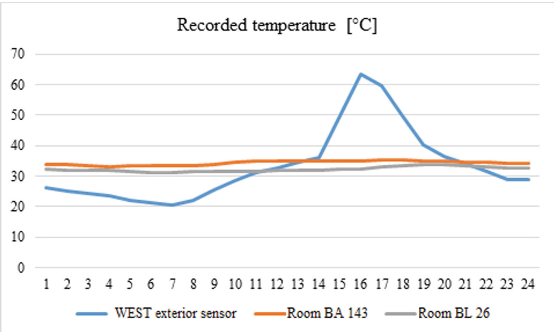

Fig. 8. Temperatures recorded on 31.07.2021

The humidity values recorded inside were kept approximately constant, with variations of a maximum of 5%, on days when the outside humidity recorded humidity variations up to 50%. The largest variations in humidity were recorded in room BL26 (Table 4).

In room BA143, higher humidity values were recorded compared to those recorded in room BL26. In room BA 143, higher temperature values were recorded than those recorded in room BL26. In terms of humidity, the values recorded throughout the monitoring period in the two rooms were generally in the lower comfort zone (30 -70%), in room BL26, with periods when the humidity was 1–2% below the comfort limit.

Table 4. Humidity values recorded on 31.07.2021 [%]

	WEST external sensor	Room BA 143	Room BL 26
hour	Recorded temperature [°C]	Indoor temperature [°C]	Indoor temperature [°C]
1	23	31	29
2	27	31	29
3	30.5	31	29
4	34	31	29
5	40	31	29
6	44.5	31	29
7	49	31	29
8	50	31	29
9	46.5	30.5	29
10	43	30	29
11	39	30	29
12	32.5	30	29
13	26	30	29
14	23	30	29
15	21.5	30	29
16	20	30	29
17	20	30	28
18	20	30	28
19	20	30	28
20	20	30	28
21	20	30.5	28.5
22	20	31	29
23	20	31	29
24	20	31	29
Average	29.56	30.50	28.81

In room BA143 there was a monthly maximum of 34.6 °C and a minimum of 31 °C, and a maximum humidity of 45% and a minimum of 27%, while in room BL26 a maximum temperature of 32 °C and a minimum of 27 °C were measured, as well as a maximum humidity of 44% and a minimum of 32%.

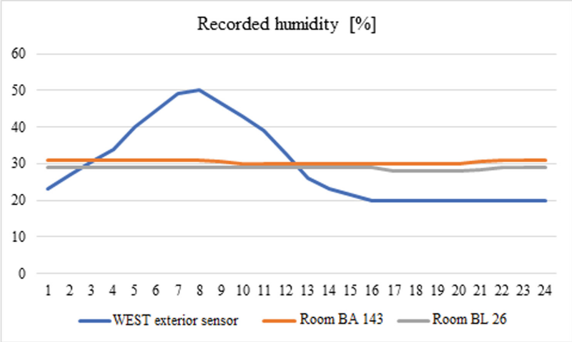

Fig. 9. Humidities recorded on 31.07.2021

6 Conclusions

The main role of a building is to provide the occupants with a healthy, pleasant and comfortable environment, as little as possible dependent on outdoor conditions, especially weather and acoustic conditions.

The paper presents the time evolution of two physical parameters characterizing the indoor environment quality (indoor temperature and humidity).

The monitoring the comfort parameters reveals the following: or the BA143 laboratory, the variation in indoor temperature in July was 3.6 °C, and the variation in indoor humidity was 18%. These values are due to the fact that between 14–17 o'clock the sun's rays fall successively on both glazed surfaces from the east and west.

For laboratory BL26, the temperature variation was 5 °C and the variation in indoor humidity was 12%.

From the point of view of humidity, the values recorded in the two rooms were generally in the lower area of the comfort limit (30 - 70%), in the BL26 room, registering periods when the humidity was 1–2% below the comfort limit.

The average variation in the temperature values recorded by the outside sensor was 41 °C and the outside humidity recorded a total variation from 64%. In the afternoon the sun's rays fall directly onto the façade where the sensor was mounted.

To improve the comfort microclimate in summer, natural shading systems can be used (for both laboratories) - planting trees that will reduce the energy requirement for air conditioning – solution for BA143. Their location must be near the facades. At the same time, it is necessary to report these effects both in the vegetation phase and in the cold period of the year, when these shading elements can reduce the use of solar intake.

If a western façade shading solution were used to lower the temperature, the comfort microclimate would improve significantly. Shading devices can be used - devices placed inside or outside glazing that can control solar intake directly or indirectly – solution for both laboratories. These systems are aesthetically acceptable and are not expensive. Reflective shading devices, interior drapes, special glazing, sun visors are recommended to be used. Devices with moving parts are preferable, but, being placed on the outside, they will be subject to corrosion. The dynamic tire has the effect of both reducing the discomfort of the occupants and reducing the energy consumed at air conditioning.

For both locations it is recommended to be also used intelligent blind systems or shutters with radiation sensors made of photoelectric or photovoltaic materials that bring their contribution in both directions (to reduce thermal discomfort, but also to increase energy efficiency). This study and methodology can be used also in office buildings in order to reduce the discomfort of the occupancies and for improve the energy efficiency through reducing cooling energy consumption during summer season. Cooling systems use a lot of energy and using solutions proposed in this study, result a way of reducing their energy use while maintaining good conditions for occupants.

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