Influence of window constructions on the creation of the working environment of buildings in the warm season

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Abstract. The contribution is devoted to the needs of thermal and humid microclimate and aspects that affect a specific administrative character, i.e. in the work environment. It describes the measurement methods, measurement results and derives corresponding sub-plants for the warm climatic conditions of the year in the area of thermal comfort, determined on the basis of measurements in the selected office room.

1. Introduction
In this article we focus on the comparison of the heat-humidity microclimate in terms of its quality and the factors that affect it in summer and winter. We chose a room - an office in the Research Center UNIZA building, which is oriented to the west. The instruments used measured the physical components of the indoor environment, the effect of solar radiation through window structures and the temperature of the air from the cooling ceiling. Furthermore, the article will describe the measurement methods, the instrumentation used, and the resulting partial conclusions for the warm (summer) climatic period of the year.

2. Description of the building and the room to be evaluated
The subject of the evaluation is the building of the RC UNIZA, which was purposefully designed and built in an energy-passive standard (energy gains from the building, its environmental technology equipment and renewable energy sources should prevail over the energy losses related to its year-round operation) and managed by intelligent operations (central computer control system). It is described in more detail in the publication [1]. The building and its technical, technological and laboratory equipment are used not only for the purposes of administration and research workplaces, but also for experimental research focused on the design and operation of buildings with the lowest possible energy consumption for the workplaces of the three UNIZA faculties. Its general description and technical support can be found in [1], a brief description is given in [2]. The room we chose as the measuring point is located on the 2nd floor and is oriented to the west (figure 1).
3. Indoor environment conditions in administrative buildings

The quality of the indoor environment in the working spaces of office buildings is required by the relevant legislation in most countries of the world. In Slovakia it is Act no. 355/2007 Coll. [3], which states that the indoor environment of buildings must meet the requirements for thermal-humidity microclimate, ventilation, heating, lighting, glare and other types of optical radiation. Persons who operate buildings for the public, whether natural or legal persons, are obliged by law to ensure the quality of indoor air in the building to avoid the risk of chemical, physical, biological and other harmful factors. More specific requirements for the indoor thermal-humidity microclimate are further discussed in the Decree of the Ministry of Health of the Slovak Republic no. 259/2008 Coll. [4]. Factors that can also affect the indoor microclimate are the production of heat by the body, the production of heat by devices and the clothes that people wear. Administrative work is included in activity class 1a (table 1) and the total thermal resistance of the garment is considered for standard clothing $R_{cl} = 1.0$ duty. Optimal and permissible conditions of the thermal-humidity microclimate in the offices for the warm period of the year are given in table 2.

**Table 1.** Class of employment in offices according to [4]

| Activity class | Total energy expenditure $q_M$ [W/m²] | $q_M$ [met] | Examples of activities |
|----------------|---------------------------------------|------------|-----------------------|
| 1a             | 66 - 80                               | 1.13 – 1.38| Activity of a sitting room with minimal physical activity (administrative work, activity in classrooms); sitting activity associated with easy manual work of hands and arms (typing, working with a PC, simple sewing, laboratory work, assembling or sorting small light objects). |
4. Description of measurements of thermal-humidity microclimate parameters

The measurement methodology and measuring instruments used were the same as in the cold period of the year [2] focused on monitoring the objective parameters characterizing the quality of the heat-humidity microclimate. A ConfortSense instrument with stationary and flexible probes (figure 2 on the left) placed on racks in the middle of the room at different height levels and on the windowsill [5] was used to measure indoor air temperature, operating temperature, relative indoor humidity and indoor humidity. The air velocity was measured using stationary probes placed on a stand. The measured values were recorded at five minute intervals. At the same time, measurements of solar radiation intensity immediately after glazing were performed using a pyranometer (figure 2 on the right) and internal surface temperatures using thermocouples placed on the window (identical to [2]). All probes were connected to the measuring station in a time step of five minutes, followed by entering the measured values into a computer. Measurements have been taking place since January 2018.

5. Measurement results

For the purposes of the paper, a section of one week with the highest temperatures in June 2019 with the range of outdoor air temperature measured just before the facade from 12.1 to 45.6 °C (average temperature 25.3 °C) is selected. Figure 3 shows, in addition to the outside air temperature, the indoor air temperature profiles together with the intensity of solar radiation, measured just in front of the façade in the vertical plane above the window under consideration and behind the window at the center of the windowsill in a horizontal position. The intensity of global solar radiation reached the maximum value of 743.9 W/m² in the summer on a clear sunny day, with an average value during measurements of 140.8 W/m². In the interior and due to the position of the pyranometer, it ranged only in the range from

| Washing class | Operative temperature $\theta_0$ [°C] | Permissible air velocity $v_a$ [m/s] | Permissible relative air humidity $\varphi$ [%] |
|---------------|---------------------------------|----------------------------------|-----------------------------------------------|
| 1a            | 23 - 27                         | 20 - 28                          | $\leq 0.25$                                   | 30 - 70                                      |

Table 2. Optimal and permissible conditions of the thermal-humidity microclimate for the cold season of the year [4].
0 to 94.6 W/m². The indoor air temperature, measured in the middle of the room, was in the range of the requirements of the optimal microclimate, even though the blinds were pulled off during the measurement. This was mainly due to the favorable effect of ceiling cooling from ground collectors.

**Figure 3.** Temperature and intensity of solar radiation in front of the facade and behind the window in summer.

Figure 4 shows the intensity of sunlight and the movement of the sun across the sky in summer and the recorded temperature behind the window on the probes located on the windowsill (probe 1 - the left edge, probe 2 - the center, probe 3 - the right edge of the window). The monitored temperatures during the measurements were usually below the values of the air temperature in the middle of the room. This was influenced by their location under window friezes with partial shading.

**Figure 4.** Temperature courses in the measured room in summer.
Figure 5 shows the temperature profiles from sensors located on the inside of the window structure in the summer. The lowest temperature was recorded from sensor 105 (horizontal cross-section between the sash), namely a temperature of 19.5 °C and, conversely, the highest temperature was measured by sensor 107 (lower right corner of the glazing), namely a temperature of 47.4 °C. At this measuring point, the temperature of the inner surface of the glazing was regularly higher than the temperature of the outside air at the peaks.

![Temperature Profiles](image)

**Figure 5.** Course of temperatures on the inner surfaces of the window construction in summer.

Figure 6 shows the course of the air flow rate in the room. The figure shows that the values do not exceed the permitted standard values, even if the outside air temperature was higher than 30 °C.

![Air Flow Rate](image)

**Figure 6** The course of air velocity in summer
6. Conclusions
The combination of the construction solution with the technological equipment on the building of the Research Center of the University of Žilina is to ensure the conditions of the indoor microclimate so that they meet the current standard requirements. Measurements that have taken place and are still taking place in the winter and summer period, we verify whether the indoor environment is not affected. In the winter, we focus on whether the underfloor heating system and its connection to geothermal wells in the underground is sufficient and whether it is not necessary to connect a secondary heating source. In the summer, we focus on whether the interior of the monitored room overheats in terms of surface temperatures and heat radiation to the environment. These measured values are then used for further evaluations needed to determine the indoor microclimate. The measured and evaluated quantities were in the optimal values during the evaluation, even though the shading element (exterior blinds) was completely pulled out. Optimum values have also been achieved due to the good orientation of the room (west) and the efficient cooling ceiling system which is connected to the ground collectors.

The evaluation of measurements and their analysis is currently ongoing and the positions of exterior blinds are also being varied. Subsequently, these variants will be evaluated for the shading efficiency of exterior blinds in different positions.

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