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AIR VELOCITY MEASUREMENTS IN THE OFFICES OF THE FACULTY OF ENGINEERING

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Abstract

During renovations in various areas of the Engineering Faculty, fan coil and split air conditioning units have been installed. These devices have significantly improved the indoor environment quality during the summer season. However, if the indoor units are not properly positioned, they can exert several negative effects on the comfort of occupants and the quality of the indoor environment. Furthermore, improperly selected indoor units can increase installation and operational costs.

As a conclusion we can say that a correctly positioned and selected air conditioning unit can help maintain optimal indoor environmental conditions, while improperly chosen or positioned equipment can adversely affect occupants' comfort and increase operational costs.

Keywords*: air velocity measurement, Testo 400, comfort.*

1. Introduction

People spends 80…90% of their lives in closed spaces. In order to be in a pleasant atmosphere in a building, we require comfort. However, humans make use of more and more glazed surfaces, which causes an increase in summer heat load on one side and, as a consequence, the drastically increase of cooling load on the other side. [1] The glazed building envelope is becoming an important component of contemporary architecture. Glass allows natural light, offers a visual communication with the outdoors, reduces structural load and enhances the aesthetic appearance of buildings. With the many benefits that glazing offers the occupants and the designers, it is not free of problems if it is not properly selected. The building envelope and its glazed fenestration represents a major source of unwanted heat, solar gain and thermal discomfort. Moreover, glazed curtain walls cause glare problems and increase the energy consumption required for cooling systems due to the high internal air temperature. This has resulted in a complete reliance on mechanical means to manipulate the indoor temperature and finally to achieve the thermal comfort at high energy consumption [2]. Hungary has a continental climate, with hot summers and low overall humidity levels but frequent rain showers and mildly cold snowy winters. Average annual temperature is 9.7°C. Temperature extremes are about 42°C in the summer and −29°C in the winter. (Wikipedia) Since July is the hottest summer month in Hungary I analyzed the interior temperature fluctuation during a specific day of this month in different rooms of a building. [1] Internal temperature in detached buildings varies during the day depending on the external temperature, orientation of the facades, glazed area and thermophysical properties of the opaque building elements. [3] The natural ventilation helps to temper the building structure, which greatly reduces the risk of overheating in the building during the summer period.

In summer the natural ventilation is through windows, which highly depends on prevailing winds and on the temperature difference caused by sunshining, on different parts of the building, so we cannot regulate the quantity of the entering air. [4]

The eastern-facing facade of the Faculty of Engineering has been renovated, and over the years, several expansions have been made to the complex. I had the opportunity to record the internal air velocity in various rooms during the summer period.

2.Introduction of the building

The University of Debrecen, Faculty of Engineering's building can be found in Ótemető street, 2-4, Debrecen. (**Fig. 1**, **Fig. 2**) The building complex includes, the educational part, the workshops, the laboratories and the college with 270 living accommodations. In the educational part of the building is placed the Faculty's restaurant served by a 500-dose cuisine. The educational building has five floors (Ground floor + 4 floors), but the third and the fourth level floor space differs from the other levels. **[1]**

Floor plan of the third-floor offices and split air conditioners installed after the building's HVAC renovation. (**Fig. 3**)

On the third floor of the old wing, there are 9 offices with different layouts, as illustrated in **Fig. 4.**

During summer months, Dr. Csáky Imre and Dr. Kalmár Ferenc presented thermal imaging in their article "Indoor temperature monitoring in east orientation offices," revealing surface temperatures (up to 49.3 °C) contributing to high air temperatures within the offices. (**Fig. 5**, **Fig. 6**) **[5]**

The office air temperature reached its peak between 10-11 am, as high as 37 °C. (Measurements ranged from 31-37 °C during a summer day.) **[5]**

In those spacious offices, where artificial ventilation is not feasible, alternative measures need to be taken during operating hours. Therefore, the building management implemented the following measures: Split air conditioners were installed in the rooms of the old wing. In the renovated wing, fan coil units were installed. In those areas where neither split air conditioners nor fan coil units were installed, desk and tower fans are used by occupants during the summer months.

According to the MSZ CR 1752:2000 standard, in large office spaces, the average air velocity in the occupancy zone is 0.18 m/s for comfort category A, 0.22 m/s for comfort category B, and 0.25 m/s for comfort category C. **[6]**

Fig. 1. *Satellite image of the Faculty of Engineering. (Google Maps)*

Fig. 2. *Eastern wing of the Faculty of Engineering.*

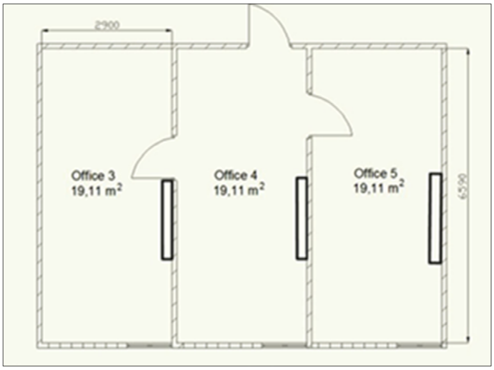

Fig. 3. *Office floor plan with split air conditioners.***[1]**

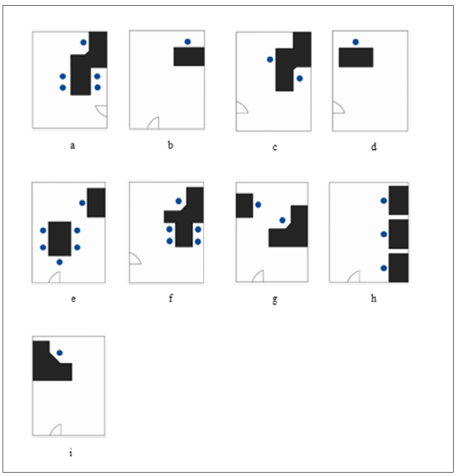

Fig. 4. *Office layouts at the Faculty of Engineering.*

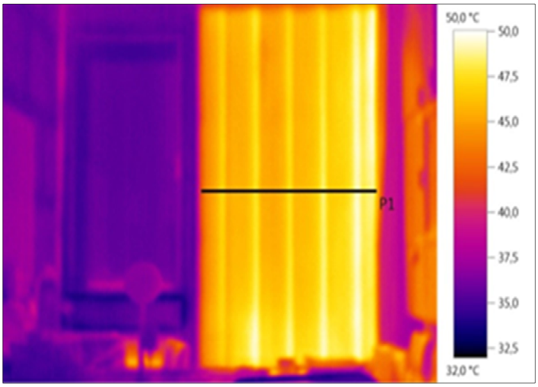

Fig. 5. *Thermal image* [5]

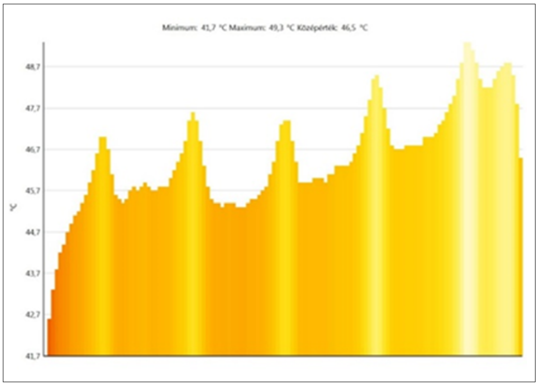

Fig. 6. *Temperature distribution.* [5]

3. Introducing the Measurement Instrument

During my measurements, I used the Testo 400 climate and air conditioning measuring instrument and Testo turbulence probe. (Fig. 7, Fig. 8)) The air velocity experienced indoors has an impact on thermal comfort. Turbulence intensity is expressed as a percentage and calculated based on the average air velocity and air temperature prevailing in the room. Turbulence intensity reflects the temperature fluctuations occurring within the indoor space and the intensity of air movement. There is a direct correlation between air temperature and measured turbulence intensity. [7] The climate and air conditioning measuring instrument, with its built-in measurement assistant, provides optimal support for conducting air velocity and thermal comfort measurements according to standards, as well as for examining and adjusting ventilation and air conditioning systems. [8]

The Testo turbulence probe can measure independent of direction and simultaneously calculate turbulence intensity and draft risk according to EN ISO 7730 / ASHRAE standards. To ensure precise measurement results, it compensates for air density using built-in absolute pressure measurement. Draft restricts comfort and is the most common cause of indoor air-related complaints. The probe is ideally suited for determining turbulence intensity and draft risk typical in workplaces. Turbulence intensity corresponds to the degree of fluctuation in air velocity over time. It is necessary for determining draft risk. [9] The climate and air conditioning measuring instrument provides optimal support for conducting air velocity and thermal comfort measurements according to standards, as well as for examining and adjusting ventilation and air conditioning systems, with its built-in measurement assistant features a high-precision, location-independent, built-in differential pressure sensor. It can meas-

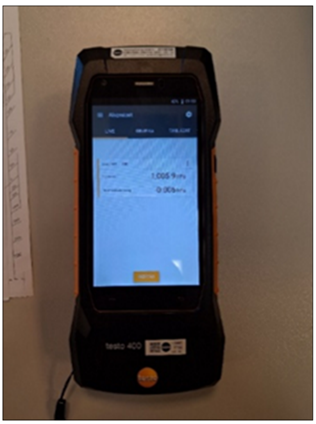

Fig. 7. *Testo 400*

Fig. 8. *Testo turbulence probe*

ure all IAQ parameters: air velocity, temperature, humidity, pressure, illumination, radiant heat, turbulence intensity, CO_2 and CO. [10] Among these, I examined air velocity, temperature, turbulence intensity, and draft ratio during my measurements.

4. Measurement

I performed my measurements at two locations: in actual offices and in the laboratory. In the offices, I carried out measurements with split air conditioners and fan coils. In the Air Conditioning and Air Ventilation Laboratory, measurements were carried out by using fans to simulate office spaces. Laboratory measurements were necessary because the walls are painted black to make smoke from the fans clearly visible. Smoke was used to demonstrate how the outgoing air arrives at the point of interest. (Fig. 14 and 16)

4.1. Measurements with split air conditioners

I performed my measurements at five points in the office depicted in **Fig. 9** (magnified view of **Fig. 4/a**), at two specificheights: 1.7m and 1.1m. These correspond to the standing person's head height and the seated person's neck height, respectively. I chose point 5 as the specific location since it is where the desk computer is located, and where occupants spend most of their time.

I designated Position 2 as the most unfavorable location since it has the highest air velocity, which even on the lowest setting exceeds the comfort criteria by more than twice. I organized the measured results into a table, where it is evident that the air velocity does not correspond to the comfort categories. (**Table 1.**)

The offices are equipped with Midea split-type air conditioners. Their cooling capacity is 4982 W, and their heating capacity is 5275 W. The maximum operating pressure under suction is 1.5 MPa, and under pressure is 4.2 MPa. The nominal power consumption is 2200 W. (**Fig. 10**)

4.2. Measurements with tower fans

I performed measurements in the climate and air conditioning laboratory, where I set up the room to simulate the office layout. I examined a section of the offices where one person is seated at a desk and adjusts the fan according to their own preferences. (**Fig. 4**/b, d, g)

Fig. 11 illustrates the position of the equipment relative to the individual. According to standards for comfort measurements, it is necessary to measure at four heights: 1.7m for standing height; 1.1m for seated individual's neck height; 0.6m for seated individual's waist; and 0.1m for ankle height. I did not include the results measured at 0.6m and 0.1m heights, as they are below the work surface and thus not affected by the airflow generated by the fan. The fan was in a fixed position, and I performed measurements at three different power levels (**Fig. 12**, **Fig. 13**).

Table 1. *Measurement results of Room 302*

Position	Height (m)	Air velocities at different settings (m/s)		
		Erős	Közepes	Gyenge
1.	1.7	0.58	0.24	0.11
	1.1	0.31	0.17	0.08
2.	1.7	0.61	0.46	0.45
	1.1	0.5	0.4	0.39
3.	1.7	0.3	0.1	0.08
	1.1	0.17	0.11	0.03
4.	1.7	0.32	0.24	0.07
	1.1	0.31	0.19	0.04
5.	1.7	0.08	0.04	0.03
	1.1	0.09	0.06	0.03

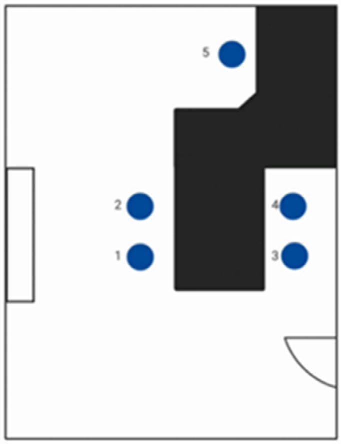

Fig. 9. *Room 302 at the Faculty of Engineering.*

Fig. 10. *Midea split air conditioner*

I recorded my measurement results in **Table 2.** I highlighted air velocities (v) exceeding the comfort criterion in red. It is evident that even at level 1, the air velocity at the distinguished point is many times higher than the allowed limit. Furthermore, I measured turbulence intensity (Tu), draft ratio (DR), and temperature (t).

4.3. Measurements with desk fan

The procedure and setup for the measurements were the same as those carried out with the tower fan. The measurement setup is shown in **Fig. 14** while the smoked condition is illustrated in **Fig. 15**.

The measurement results were similar to those obtained with the tower fan. The results that do not meet the comfort criteria are highlighted in red in the table. (**Table 3**).

During the summer season, in rooms where there is no split air conditioner or fan coil, and the temperature exceeds 28▯, higher air velocity is appreciated by people and improves comfort. These offices, which only have fans, are used only briefly during the summer season. In the long term, rooms equipped with fan coils or split air conditioners are preferred. Each person can adjust the desk fans according to their own preferences, thus improving their personal comfort. The position and angle of the fan's head are adjustable, so I was not able to examine every option. Increasing the fan's speed depends on the internal air velocity.

Fig. 11. *Placement of the fan and the person*

Table 2. *Measurement results of the tower fan*

Fan speed	h (m)	Tu (%)	DR (%)	v (m/s)	t (°C)
1.	1.7	63	0	0.04	23.7
	1.1	7	84	1.26	22.3
2.	1.7	51	0	0.04	23.4
	1.1	7	100	1.57	21.9
3.	1.7	56	0	0.05	23.1
	1.1	7	100	1.78	26.1

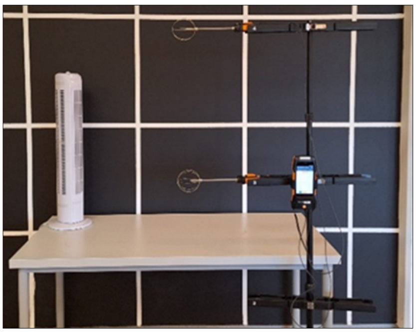

Fig. 12. *Tower fan measurement.*

Fig. 14. *Desk fan measurement.*

Fig. 13. *Smoke test of the tower fan.*

Fig. 15. *Smoke test of the desk fan.*

4.4. Measurements with fan coil

I performed measurements using the SABIANA CARISMA fan coil. Its cooling capacity is 2.87 kW, and its heating capacity is 3.56 kW. [11] (Fig. 16)

During the measurements with the fan coil, I measured at 3 points. Point 1 was directly above the fan coil (most unfavorable location), point 2 was where one person was seated at the office desk, and point 3 (specific point) was where two people were seated at the desk, and I considered the position of the person closer to the fan coil during my measurements. (Fig. 17).

The most unfavorable location is near the fan coil, where high air velocities have been recorded. At the distinguished point, however, the air velocity has exceeded the comfort criteria compared to position two (Table 4).

5. Conclusions

I carried out comprehensive measurements during the summer period to demonstrate air velocities in areas where people typically spend most of their time in offices at specific heights. The results indicate the need to pay attention to the proper placement of workstations. I examined and confirmed the application possibilities of equipment in offices with different layouts through both field and laboratory measurements. After outlining the research methodology, I performed measurements in the offices. The offices of the Engineering Faculty provided me with fan coils, fans, and air conditioning units for my measurements. During the measurements, I used calibrated Testo instruments to measure indoor air velocity, turbulence intensity, draft ratio, and temperature. In the future, my goal is to explore the potential of natural ventilation during the summer season to understand the air velocities that develop in the occupancy zone.

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Table 3. *Measurement results of the desk fan*

Fan speed	h (m)	Tu (%)	DR (%)	v (m/s)	t (°C)
1.	1.7	51	0	0.05	23.7
	1.1	12	100	1.36	22.7
2.	1.7	57	3	0.06	23.7
	1.1	19	100	1.47	22.7
3.	1.7	66	6	0.08	23.6
	1.1	27	100	1.72	22.8

Table 4. *Measurement results of the fan coil*

Position	h (m)	Tu (%)	DR (%)	v (m/s)	t (°C)
1.	1.7	31	100	0.76	20.8
	1.1	10	100	1.24	20.8
2.	1.7	46	7	0.08	21.3
	1.1	71	0	0.04	21.2
3.	1.7	44	25	0.21	22
	1.1	32	7	0.11	21.6

Fig. 16. *Fan coil.*

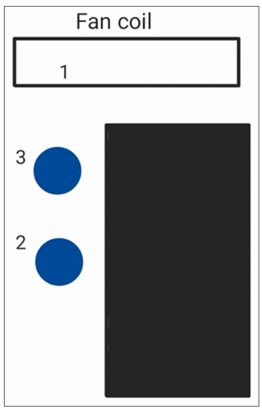

Fig. 17. *Simulated office.*

References

[1] Csáki E.: *Influence of Transparent Surfaces on Summer Thermal Comfort in Buildings.* Proceedings of 16th Building Services, Mechanical and Building Industry Days, Debrecen, Hungary, 2010.)

[2] Nedhal A., Sharifah F., Adel A.: *The Effect of Orientaion and Glazed Area to the Indoor Air Temperature in Unventilated Building Sin Hot-Humid Climate.* The 3rd International Conference on Built Environment in Developing Countries, Universiti Sains Malaysia, 424–433.

[3] Kalmár F., Csiha A.: *Interrelation between Glazed Surfaces, Building Structure and Thermal Comfort.* The 23rd Conference on Passive and Low Energy Architecture, Geneva, Switzerland, 6-8 September 2006.

[4] Recknagel, Sprenger, Schramek: *Fűtés és klíma technika 2000*. Dialóóg-Campus kiadó, Budapest–Pécs 2000.

[5] Csáky I., Kalmár F.: *Indoor Temperature Monitoring in East Orientation Offices* . In: Proceedings of Denzero International Conference: Sustainable energy by optmal integration of renewable energy sources, Debrecen, 2014. 155–164.

[6] MSZ CR 1752:2000; Épületek szellőztetése. Épületek belső környezetének tervezési alapjai; Magyar Szabványügyi Testület

[7] https://www.testo.com/hu-HU/komforterzet-meres/turbulencia-fok/c/applications_building_construction_comfort_level_turbulence_degree (2023.08.23.)

[8] https://www.testo.com/hu-HU/testo-400/p/0560-0400 (2023.09.27.)

[9] https://www.testo.com/hu-HU/turbulencia-fok-szonda/p/0628-0152 (2023.09.27.)

[10] https://www.testo.com/hu-HU/testo-400/p/0560-0400 (2023.10.01.)

[11] https://climamarket.com/products/fan-coil-sabiana-carisma-crc-mv-33-kw-2-92-2-39 (2024.02.17.)