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INDOOR AIR QUALITY IN COMPUTER LABS

Abstract
The article presents the results of indoor air quality measurements in three university computer labs. In the spaces concerned natural ventilation system has been applied. The obtained results indicate a very low air quality in this type of room.

Keywords: building physics, ventilation, air exchange, indoor air quality, CO_2 concentration

1. Introduction

The university buildings are objects even several decades old. Only a small percentage of those buildings located in Poland is equipped with a mechanical ventilation system with adjustable microclimate parameters. The standard solution in such buildings is a system of natural ventilation.

The poor financial situation of universities meant that managers are looking for solutions that reduce operating costs. The heating is one of the main items in the cost of building maintenance. Most simple and most effective solution to this problem is to increase the thermal insulation of the building envelope. Carrying out some modernization work without the organization of the air exchange has a negative effect on the microclimate inside these objects [1, 2, 3]. In the article the problem of what was contacted while conducting research on the microclimate in the university computer labs subjected to thermal modernization is presented.

The [4] sets out general requirements for ventilation. The standards [5, 6] are given, inter alia acceptable tightness of opening windows. These data is very important for new buildings, but also renovated and modernized. Usually thermomodernization works are very complex and include works from several areas of the building. In accordance with applicable regulations [7] some work can be carried out without the need for facility owners or license agreements. The requirements contained in the provisions [5] apply to new facilities, which results from the application of the standard.

Equipment in the tested rooms is characteristic. More than a dozen computers in a small laboratory also has a large impact on the parameters of the microclimate. The result is usually disturbances in the operation of natural ventilation and the deterioration of the internal microclimate.

2. Carbon dioxide as the indicator of air quality

The relationship between the quantity of ventilating air and the concentration of carbon dioxide inside rooms has for years been recognized and applied as criterion of air quality valuation. The frequent occurrence of carbon dioxide in typical conditions is not dangerous. This non – toxic gas can only cause the feeling of smaller or larger air stuffiness. One usually observes the growth of CO_2 concentration in the air coming from external and internal sources in closed rooms. First of all, it penetrates to the room from the outside by means of air infiltration through untightness in the lining of the building. The growing degree of industrialization causes that the level of carbon dioxide concentration in the atmosphere constantly grows. At present its value hesitates between 400 – 600 ppm. Alive organisms and gas devices are the source of carbon dioxide inside the rooms. Its concentration depends on organism activity and my vary for individual people due to their diet, the mass of the body and the condition of the whole organism. It is obvious that the concentration of carbon dioxide depends on the number of people inside the room, not sufficient air exchange (the fall of the content of oxygen in the air) and intensification of combustion processes in the room (e.g.: smoking tobacco, preparing meals). That is why, carbon dioxide was chosen for the qualification of the microclimate quality inside considered flats.

The boarder value of carbon dioxide concentration for which the lack of harmful working bets on the man 8500 ppm according to Hodgson. The present standards for the internal air assume the admissible level of carbon dioxide concentration on the level of 1000 ppm. This coefficient was proposed by Max von Pettenkofer in the nineteenth century [8].

Table 1. The influence of carbon dioxide on human organisms [9]

No.	Concentration of CO_2 in the air, ppm	The symptoms
1.	300 ÷ 450	Dry external air
2.	1000	Basis for the qualification of most standards concerning the quantity of ventilating air for a single person
3.	1550 ÷ 500	The growing feeling of stuffiness
4.	5000	Limitations concerning working posts
5.	7000 ÷ 10000	The growth of breathing capacity
6.	15000	The appearance of metabolical stress
7.	20000	The increased frequency of breathing and headaches
8.	40000 ÷ 52000	CO_2 concentration in the air breathing out from the lungs
10.	60000 ÷ 80000	The possibility of partial paralysis
11.	> 80000	Losing of consciousness in a few minutes

Table 2. Emission of carbon dioxide for different levels of activity [9]

A type of activity	Emission of CO_2, dm^3/h
Dream (motionless recumbent position)	10 ÷ 12
Sitting position (without doing any work)	12 ÷ 15
Sitting posture – easy office works	18 ÷ 25
Doing work of average difficulty	32 ÷ 44
Doing hard work	>55

The applicable Polish regulations do not specify maximum concentration of carbon dioxide in the premises of residential and public buildings. However, in standard [9] categories of indoor air according to the concentration of CO_2 are defined (Table 3).

Current standards for indoor air quality indicate an acceptable level of CO_2 concentration. It equals 1000 ppm [11, 12]. It is a minimum hygienic requirement. In the standard [10] this value corresponds to moderate indoor air quality. The author concluded that value as the maximum recommended.

Table 3. Classification indoor air quality for rooms with low emission of pollutants and non-smoking by [10]

Category	Description of indoor air quality	Increase of CO_2 concentration in relation to the outside air, ppm	The volume flow of outside air, m^3/h
IDA 1	High	< 400	< 54
IDA 2	Average	400 ÷ 600	36 ÷ 54
IDA 3	Moderate	600 ÷ 1000	22 ÷ 36
IDA 4	Low	> 1000	> 22

3. The subject of research

The testes were conducted in 5–storey buildings constructed in masonry technology. External walls were insulated with 15 cm thick foamed polystyrene with thin coat render. Roofs and roof spaces were insulated with 20 cm mineral wool. The buildings had ducted ventilation systems. The researches were performed in the period between October 2014 and February 2015 at the outside air temperature of –12°C÷+10°C and relative humidity in the range of 45%÷96%. Carbon dioxide concentration in atmospheric air was 470÷730 ppm by volume. Wind velocity reached the values from 0.00 to 6.10 m/s.

During the measurements registration of basic microclimate factors were carried out: the concentration of CO_2, temperature and relative humidity. The parameters were measured for three months in a two-week period at an interval of 30 minutes. Three series of measurements for each computer lab were done. Daily averages values of the external air in the course of the study are presented in Table 4.

Table 4. The average daily value of external air parameters during the measurement

Parameter	October	December	February
Temperature [°C]	8 ÷21	0 ÷ 9	– 2 ÷ 7
Relative humidity [%]	58 ÷ 92	70 ÷ 96	73 ÷ 86
Atmospheric pressure [hPa]	1002 ÷ 1026	998 ÷ 1029	1005 ÷ 1023
CO_2 concentration	403 ÷ 416	429 ÷ 441	460 ÷ 486

4. Results of measurements

In all labs the variation of microclimate parameters were made according to the same scheme. The values of the measured parameters (CO_2 concentration, internal temperature and relative humidity) have been rising since the start activities and soon reached maximum values. After complete leaving the premises, these values decreased slowly again to the minimum value (Fig. 1).

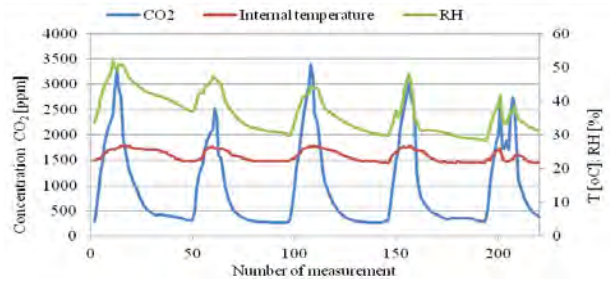

Fig. 1. Weekly diagram of indoor air parameters for a series of measurements in the selected computer labs

In all the surveyed laboratories the indoor temperature has exceeded temperature of thermal comfort. The maximum temperature was in the laboratory No. 3 and amounted to 32.7°C. It should be noted that it was during a sunny day in a room on the southern side. In other cases, the maximum temperatures were in the range of 29.6°C to 32.7°C. Temperatures lower than 20°C were reported rarely while using the computer labs. It was only after extensive and long term (over 30 minutes) weathering. The lowest values of the internal temperature were recorded at night or in the morning and they ranged from 19.6°C to 21.5°C. Minimum and maximum values for individual labs are shown in Figures 2-4.

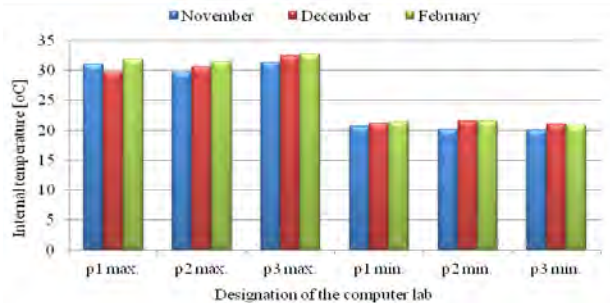

Fig. 2. The minimum and maximum values of the internal temperature in the computer labs

When the computer labs were used relative humidity were between 30.4% to 36.5% (Fig. 3). They were lower than the recommended 40%. When labs were being used relatively large and fast increases in relative humidity were reported. However, they did not exceed the maximum allowable values for thermal comfort, recommended in [13].

The lowest values of CO_2 concentration were recorded at night or early in the morning. They ranged from 474 ppm to 526 ppm. The values do not exceed the recommended 1000 ppm. During the day the CO_2 concentration increased rapidly to the maximum. Maximum values exceed even 3000 ppm. The characteristic small declines in the value of the carbon dioxide concentration during the day (Fig. 4) is the result of short rooms weathering. It did not have a major impact on improving the indoor air quality. It improved the internal air quality only for a moment (Fig. 1).

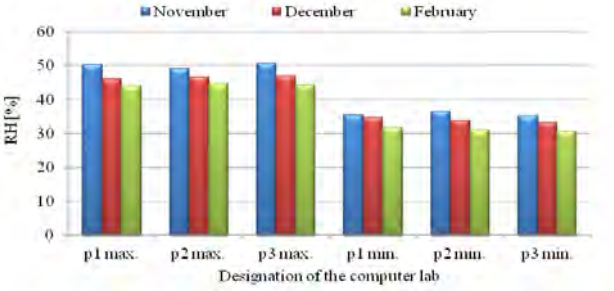

Fig. 3. The minimum and maximum values of the relative humidity in the computer labs

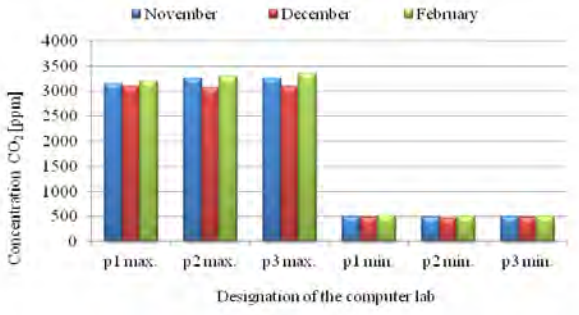

Fig. 4. The minimum and maximum values of CO_2 concentration in the computer labs

5. Summary

Conducted research indicates that indoor air quality in the studied computer labs is very low. All IAQ parameters do not meet the current standard requirements. The values of CO_2 concentration exceed and even triple the maximum recommended values. Even though the reported levels were temporary, they occurred at all times using the labs were in use. The measurement results qualify all test computer laboratories to the IDA 4 category of air quality according to EN 13779: 2008. It is the result of a low capacity of natural ventilation during spacesą use. It is also the result of the inability to control the ventilation system (increased efficiency over time).

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Jakość powietrza wewnętrznego w pracowniach komputerowych

1. Wstęp

Budynki, w których mieszczą się uczelnie wyższe to obiekty nawet kilkudziesięcioletnie, wyposażone w system wentylacji grawitacyjnej. Tylko niektóre posiadają wentylację mechaniczną. W artykule przedstawiono wyniki badań typowych parametrów opisujących mikroklimat w laboratoriach komputerowych obiektów poddanych termomodernizacji.

2. Poziom CO_2 jako wskaźnik jakości powietrza

Zależność między jakością powietrza wentylacyjnego a stężeniem dwutlenku węgla w pomieszczeniach od lat stanowiła kryterium oceny jakości powietrza. Generalnie w typowych warunkach stężenie tego gazu nie stanowi niebezpieczeństwa. Jest on nietoksyczny i może prowadzić do uczucia większej bądź mniejszej duszności. W zamkniętych pomieszczeniach obserwuje się wzrost jego stężenia zarówno ze źródeł zewnętrznych, jak i wewnętrznych.

3. Przedmiot badań

Badaniom poddano laboratoria komputerowe w budynku uczelni wyższej o konstrukcji tradycyjnej. Występujące w takich obiektach pracownie komputerowe charakteryzują się dość specyficznym mikroklimatem. Wynika to głównie z niewłaściwej organizacji wymiany powietrza, ale również ma to związek z wyposażeniem takich pracowni. Badania obejmowały pomiary stężenia dwutlenku węgla, temperatury wewnętrznej i wilgotności względnej.

4. Wyniki badań

We wszystkich analizowanych pomieszczeniach przebieg zmienności parametrów mikroklimatu odbywał się według tego samego schematu. Wartości mierzonych parametrów wzrastały od momentu rozpoczęcia zajęć i w krótkim czasie osiągały wartości maksymalne. Po całkowitym opuszczeniu pomieszczeń wartości te powoli spadały, aby uzyskać ponownie wartości minimalne. Najniższe wartości stężenia dwutlenku węgla odnotowano w nocy i wynosiły one od 474 ppm do 526 ppm. W trakcie użytkowania pomieszczeń stężenie CO_2 wzrastało szybko do wartości maksymalnych. Maksymalne wartości przekraczały nawet 3000 ppm.

5. Podsumowanie

Przeprowadzone badania wskazują, że jakość powietrza wewnętrznego w badanych pracowniach komputerowych jest bardzo niska. Wszystkie mierzone parametry IAQ nie spełniają aktualnych wymagań normowych. Zmierzone wartości stężenia

CO_2 przekraczały nawet trzykrotnie maksymalne wartości zalecane. Pomimo że odnotowane wartości przekroczeń miały charakter chwilowy, to jednak występowały one przez cały okres użytkowania pomieszczeń. Wyniki pomiarów kwalifikują wszystkie badane sale do kategorii IDA 4 jakości powietrza wg PN-EN 13779:2008. Jest to wynikiem niewystarczającej wydajności zastosowanej wentylacji grawitacyjnej w czasie użytkowania pomieszczeń. Wynika to również z braku możliwości sterowania systemem wentylacji (okresowego zwiększenia wydajności).