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Comparison of the Intensity of Ventilation at Windows Exchange in the Room - Case Study

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Abstract

Doing the replacement of old wooden windows in a new plastic windows, in the old buildings, we get the great reducing of the building heat loss. Simpler maintenance and attendance of window is the next advantage. New windows are characterized by better tightness. The aim of the article is determination due to the performed experimental measurements, how much more are reduce the uncontrolled ventilation that is caused of the infiltration windows. In the article there is presented the experimental measurement of indoor air quality in the room in two phases. In the first phase there is the room installed by 55 year old wood window. In the second phase there is the same room installed by new plastic window. Due to the experimental measurement of indoor air quality it is calculated intensity of ventilation - infiltration. These results of ventilation intensity are reciprocally compared.

Key words: window, room, measurement, carbon dioxide, infiltration

1 Introduction

Replacement of windows is an integral part of building renovation. Exchange of old wooden windows double glazing on of new plastic windows, which have insulation double glazing, those can reduce heat loss up to 50 %. When we use triple insulating glasses, then is possible to reduce heat loss about 65 % to 75 %. Due to used seals, we can remove air filtration through the window joints, as well as improve acoustic performance up to 40 % [1].
For specific operating conditions the reduction of infiltration may cause the bad indoor air in room much earlier, than we used to. It must therefore be regime change ventilated room, which requires creating the new habits for room users.
Bad indoor air quality can reduce the performance of office work by 6 – 9 %. Also the little air temperatures increasing have a negative effect on office work performance. The noise in offices above 55 dB(A) has negative effects on the performance of complex office. The

worsening indoor air parameters have the negative effects on performance and concentration that causes the reduction in the performance of office work [2, 3].
The deficit of fresh air can cause a decreasing of professional performance on account the diminution attention of employees. It is also possible to occur signs of fatigue and even it may cause disease [4].
The aim of the article is also to obtain values of carbon dioxide production for people in office room. The data obtained can be useful in designing of the ventilation systems in office buildings.

2 Materials and Methods

For the determining of the actual intensity of ventilation by infiltration through the leakages building construction it was carried out experimentally measuring of carbon dioxide concentration in the room. At the beginning of the measurement a person was in room, which produced the carbon dioxide. Then a person left the room and therefore the concentration decreased in the room caused the dilution of indoor air, which is caused by the infiltration through the leakages of the building structure. Due to the values recorded decreasing of the carbon dioxide concentration it was calculated ventilation rate due to infiltration. The said measurements were carried out in two stages. The first stage of measurement was carried out with an old wooden window and the second stage was carried out with a new plastic window mounted in the room.

2.1 Characteristic of the experimental room

Experimental room was selected as office (Figure 1), which is located on the second floor in the five stored building located in Kosice, Slovakia (Figure 2). During the experimental measurement in the selected room it was occupied by one adult person. The sizes of the office, where the experimental measurements were carried out, are: length: 5.63 m, width: 3.40 m and height: 2.72 m. The window has the following dimensions: height: 1.75 m and width: 1.10 m. The volume of the room is 52 m^3, the floor area is 19.14 m^2 and the length of the window joints is 5.7 m.

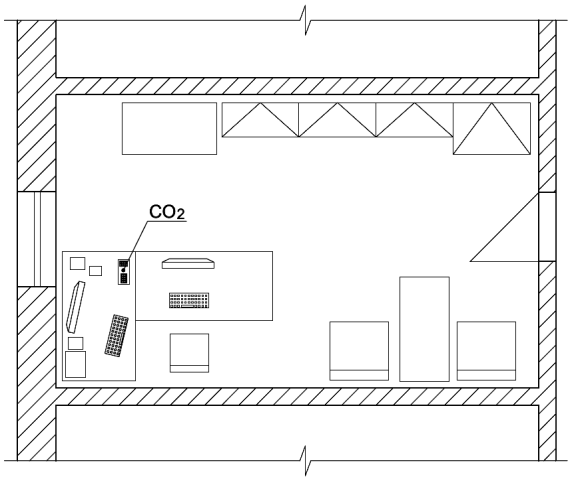

Figure 1: Ground plan of office

Figure 2: View of the building

Window of office is oriented to the north. In the city mostly north wind blows. During measuring the wind velocity was 4.6 m/s.

2.2 The measuring instruments

In the room there was measured several parameters of indoor air quality: air temperature, relative humidity, concentration of carbon dioxide. Measurements were carried out in winter. The concentration of carbon dioxide was measured by device C-AQ-001R. The measuring range of this device is from 0 ppm to 5,000 ppm. Its sensitivity is 1 ppm. Air temperature and relative humidity was measured by thermo-hygrometer S3541. Temperatures from -30°C to +70°C were measured with sensitivity 0.1°C. The accuracy of relative air humidity measurements is ±2.5 % RH in a range from 5 % to 95 %. The sensitivity of the device is 0.1 % RH. The devices were placed close to the center of the occupied area in height of 0.8 m to 1 m. This approach is agreed with the results published by [5].

3 Result and discussion

The experimental measurements were carried out in two stages. The first stage was carried out for an old wooden window and the second stage was carried for a new plastic window mounted in the room. The second stage was realized about one year later, than the first stage.

3.1 Measuring parameters of indoor air – the first stage

The measured parameters of indoor air were: air temperature, relative humidity and carbon dioxide concentration. Measurement was carried out in winter. In order to perform according to the measured data, the most accurate comparison, it is essential to ensure the measurement stable boundary conditions. In addition to the measured indoor air parameters they were determined the parameters of outside air: the temperature of the exterior air and wind velocity. During measurements outdoors carbon dioxide concentration was about 380 ppm. The above data affected the size of the intensity of ventilation - infiltration.
The measured parameters of the outdoor air are documented in Table 1 and the measured parameters of indoor air are documented in Figure 3.

Table 1: The measured parameters of outside air – the first stage

Time (h:min)	Temperature (°C)	Wind velocity (m/s)		Time (h:min)	Temperature (°C)	Wind velocity (m/s)
12:45	7	2.1		1:00	1	1.5
13:00	7	3.1		2:00	0	0.0
14:00	8	4.6		3:00	-1	2.6
15:00	7	4.1		4:00	-1	2.6
16:00	6	4.6		5:00	-1	0.5
17:00	4	4.6		6:00	0	1.5
18:00	2	4.1		7:00	-1	0.5
19:00	2	4.6		8:00	-1	0.5
20:00	2	2.6		9:00	3	1.5
21:00	1	1.5		10:00	4	2.6
22:00	2	2.6		11:00	5	2.6
23:00	1	0.0		12:00	6	1.5
24:00	2	3.1		13:00	7	3.1

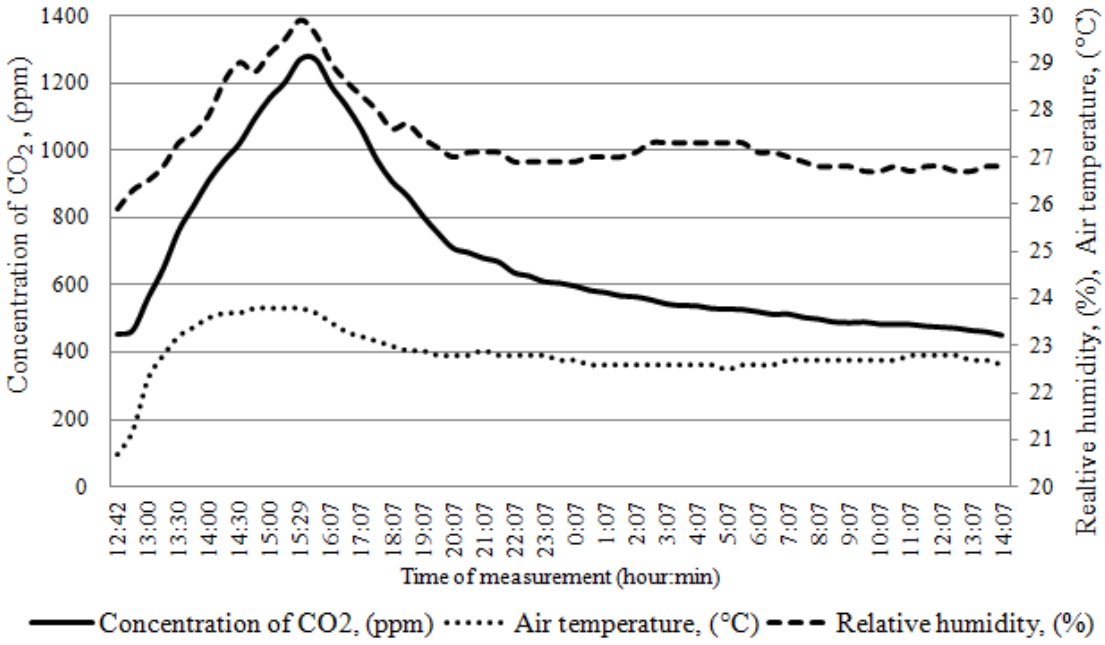

Figure 3: The measured parameters of indoor air – the first stage

Figure 3 shows that the course of increasing and decreasing the carbon dioxide concentration is similar then relative humidity. The mean, minimum and maximum values of CO_2 concentrations were 725 ppm, 454 ppm and 1,273 ppm, respectively.

3.2 Measuring parameters of indoor air – the second stage

And in the second stage, after replacing the old wooden windows during the new windows, there were measured in indoor air parameters: air temperature, relative humidity and carbon dioxide concentration. This measurement also was carried out in winter, but one year later. The measured parameters of the outdoor air are documented in Table 2. Wind velocity was not recorded. The measured parameters of indoor air are documented in Figure 4.

Table 2: The measured parameters of outside air – the second stage

Time (h:min)	Temperature (°C)		Time (h:min)	Temperature (°C)
11:30	0.6		21:00	-0.6
12:00	0.8		22:00	-0.5
13:00	0.6		23:00	-0.3
14:00	0.4		0:00	-0.3
15:00	0.5		1:00	-0.4
16:00	0.4		2:00	-0.4
17:00	0.4		3:00	-0.5
18:00	-0.2		4:00	-0.4
19:00	-0.5		5:00	0.0
20:00	-0.5		6:00	0.0

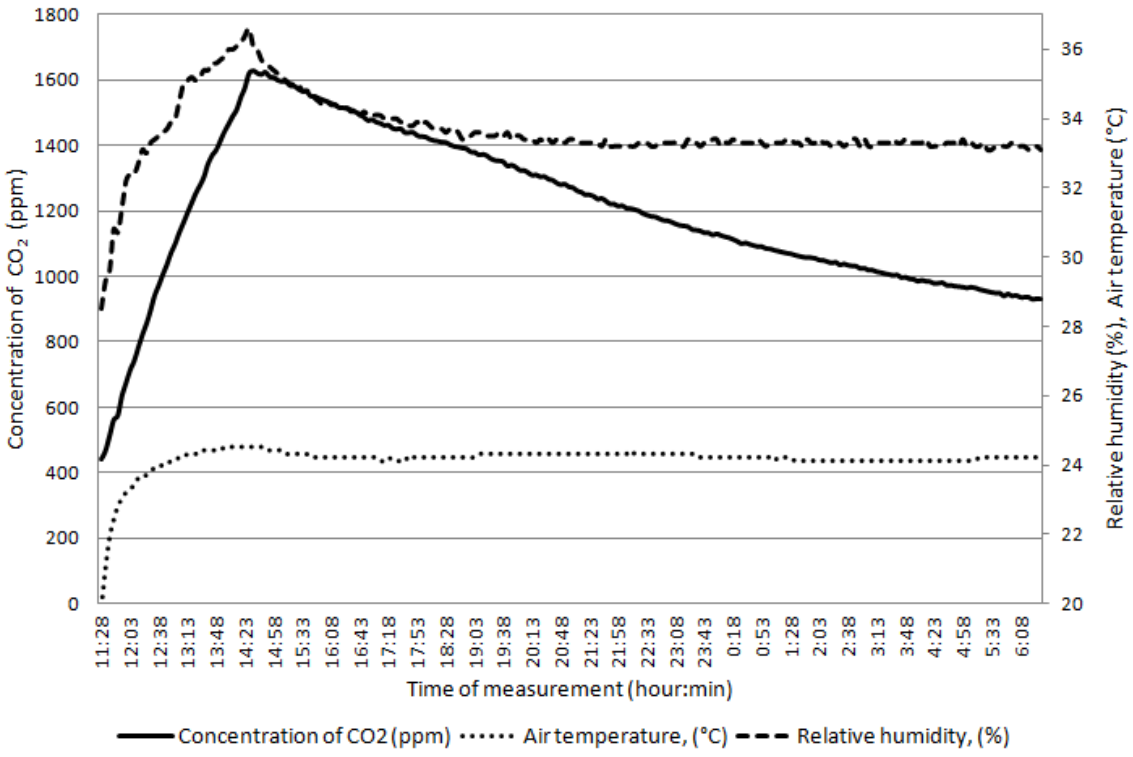

Figure 4: The measured parameters of indoor air – the second stage

Figure 4 also shows that the course of increasing and decreasing the carbon dioxide concentration is similar then relative humidity. The mean, minimum and maximum values of CO_2 concentrations were 1,199 ppm, 443 ppm and 1,630 ppm, respectively. Study [3] presents results of monitoring of CO_2 concentrations carried out in two office rooms on the 1st floor of office building located in city of Kosice. Experimental measurements were conducted for three days; each day for 6 hours during operation of building. In office 1 the maximum concentration of CO_2 reached value of 1,060 ppm and mean value was 886 ppm. In office 2 the maximum concentration of CO_2 reached value of 976 ppm and average value was 806 ppm. It can be stated that results of CO_2 concentrations are comparable. Another study [6] confirmed similar level of CO_2 concentration determined in open spaces as well as enclosed spaces. In experimental open space office the maximum concentration of carbon dioxide reached value of 998 ppm and average value was 997 ppm. In enclosed office the maximum concentration of carbon dioxide reached values of 823 ppm and average value was 673 ppm, respectively. Multifunctional 5 floor-building in city of Kosice, representing an office and salesroom workplace was selected for the research in study [7]. The investigated office room can be described as closed and shared with other users. At the time of measurements there were new furnishings and several equipment such as personal computers, copiers and printers. Administrative sedentary work was performed by 7 employees in the evaluating area of workplace. The minimum measured CO_2 concentration was 972 ppm, maximum 2,224 ppm and mean value of 1,546 ppm. Results of CO_2 concentrations respond to our results taking into account number of occupants.

3.3 Calculation of infiltration

The indoor concentration of carbon dioxide at the end of measurement differed from the concentration of carbon dioxide of outdoor air. The ventilation rate caused by the infiltration can be calculated from the function of carbon dioxide concentration that is decreasing depending on time [8, 9]. For the calculation we use the measured values of carbon dioxide concentration. The infiltration can be expressed as:

$$n = \frac{1}{t} \cdot \frac{C_{IDA,S} - C_{SUP}}{C_{IDA,E} - C_{SUP}} \quad (1/s) \qquad (1)$$

Where: n – ventilation rate caused by infiltration (s^{-1}); t – time of carbon dioxide concentration decrease (s); $C_{IDA,S}$ – carbon dioxide concentration at the beginning of its decrease (mg/m^3); $C_{IDA,E}$ – carbon dioxide concentration at the end of its decrease (mg/m^3); C_{SUP} – outdoor carbon dioxide concentration (mg/m^3).

The calculated ventilation rate for the first stage is 0.21 1/h and volumetric air flow rate from infiltration is 11.13 m^3/h. For the second stage ventilation rate is 0.06 1/h and volumetric air flow rate from infiltration is 2.96 m^3/h. Reduction of infiltration is 3.76 multiple. The calculated production carbon dioxide from person in office room is 13 mg/s.

4 Conclusion

From experimental measurements it can be concluded, that during the stay of one person in the room with new plastic window there was an increasing of carbon dioxide concentration of 33 % higher, than in the case, when in the room with old wooden double window. When the person left the room, concentration of carbon dioxide started to decrease. When the room has new plastic windows, decreasing of carbon dioxide concentration was about 27 % less in an empty room, than in empty room with old wooden window. Calculated reduction of infiltration is 3.76 multiple.

Acknowledgements

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