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REQUIREMENT TO THE FRESH AIR IN THE CONGREGATION ROOM

We have more kinds of congregation rooms. When building of these spaces must to supervise, among other the requirements also the quality of the indoor air should be considered. In our article we are engaged analysis of ventilation in church of the 13th century. The aim is analyzing of produce of pollutant emissions from persons in the room. One of measurable the pollutant is carbon dioxide, which is produced by persons. Beside the respiration, the person produces other pollutants, such as odor and others. On the basis of experimental measurements the concentration of carbon dioxide produced by person, currently we know calculate how much air exchange is required for the room. The concentration of carbon dioxide has be smaller how 1,000 ppm and maximum up to 1,500 ppm. Already above the value of 1,000 ppm causes to decrease the concentration to perception for people. The aim of the paper is to determine the methodology for calculating the intensity of ventilation rate in the room. It is need to maintain the required air quality. Calculated ventilation rate should optimize investment and operating costs of ventilation equipment. In the work there is carried out analysis of calculation methods to determine the ventilation rate. It is processed the methodology for calculating the ventilation rate of room, there are used the measured values of concentrations of carbon dioxide. Values of concentrations of carbon dioxide and ventilation rate there are verified by experimental measurements. The methodology is selected for calculating ventilation rate applicable in to Slovakia.

Keywords: ventilation, concentration of carbon dioxide, mass flow rate, room.

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1. Characteristics of congregation room

The church in Gemersky Jablonec is the oldest in the micro region Medves, which is a valuable monument of the Romanesque architecture. There was a similar church in the neighbouring village Petrovce, which is already ruined. The churches have a similar disposition - longitudinal ship with quadrangular choir and a semicircular apse and a small tower on the western facade. Since the last century the church has moisture problems, despite the fact that it is on an elevated position [3].

Fig. 1. The analyzed church in Gemer´s Jablonec - Slovakia

Rys. 1. Analizowany kościół w Gemerskim Jabłońcu - Słowacja

In the construction of churches architects used different building materials. The already ruined church in Petrovce was built of bricks, while in Gemerský Jablonec just the foundation is made of bricks and above stone blocks were used. The walls were probably plastered [3].

Table 1. The number of persons in the church throughout week

Tabela 1. Liczba osób w kościele w ciągu tygodnia

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Morning	25	25	25	25	25	30	35
Lunch	35	35	35	25	35	35	35
Evening	15	15	15	25	15	25	20

The total volume of air in the church is 400 m^3 and total floor space is 140 m^2. The windows are traditional wooden type with single glazing. The door are also wooden. The length of the joints for windows and door is 20 m [3].

2. Analise of ventilation in the room

2.1. Air exchange by infiltration

The air exchange rate by infiltration is calculated for closed windows and door. The calculation [5] was performed from the next equation.

$$n = \frac{3\,600 \sum (i_{lv} \cdot l) \cdot B \cdot M}{V_b} \quad (1/h) \qquad (1)$$

where: i_{lv} - coefficient of length of the joints air permeability [$m^2/(s.Pa^{0,67})$]
l - length of the joints [m]
B - characteristic of building number [-]
M - characteristic of room number [-]
V_b - building volume [m^3]

Calculated ventilation rate from the infiltration is n = 0,00 1/h and n = 0,19 1/h.

2.2. Determination of carbon dioxide mass flow

During determining of mass flow of the carbon dioxide it is needed know production of carbon dioxide at person breathing. Composition of inhaled air is differing from composition of exhaled air. Exhaled air includes less oxygen, but more of carbon dioxide and water vapor [1, 2, 4].

During the whole lifetime of a building it is required a permanent exchange of air between inside and outside the building, in order to control the indoor relative humidity of air. If the moisture is not removed adequate by means of ventilation, it will penetrate into the walls, which will create in time mold and dampness [7].

In our study it is calculated mass flow for every person in a room. A young person exhaled approximately 7.6 mg of carbon dioxide per second, adult person exhaled approximately 10.15 mg of carbon dioxide per second and elderly person exhaled approximately 12.2 mg of carbon dioxide per second. The results are presented in Table 2.

Table 2. The production of mass flow in the room

Tabela 2. Masa przepływu wytworzona w pomieszczeniu

Number of persons [-]	Mass flow rate of carbon dioxide [mg/s]	Needed ventilation rate (for n=0.00 1/h) [1/h]	Needed ventilation rate (for n=0.19 1/h) [1/h]
15	159	1.33	1.20
20	213	1.78	1.70
25	266	2.22	2.20
30	318	2.65	2.60
35	377	3.14	3.20

2.3. Determination of needed ventilation rate

By using the Equation (2) according to STN EN 13 779 [6] we calculated the needed indoor air flow rate.

$$q_V = \frac{q_H}{C_{IDA} - C_{SUP}} \ [m^3/s] \tag{2}$$

where: q_V - air flow rate required for room ventilation, [m^3/s],
q_H - carbon dioxide emissions from the human source, [g/s],
C_{IDA} - carbon dioxide concentration in indoor air at time t, [g/m^3],
C_{SUP} - carbon dioxide concentration in supply air at time t, [g/m^3],

From the air flow rate it was calculated ventilation rate for a room. Results are documented in the Table 2.

2.4. Determination of concentration of carbon dioxide

The concentration over the value of 1,000 ppm is unacceptable because the result generates discomfort caused by emissions released from the breathing of the occupants. In order to determine the required ventilation rate, it can be used the theoretical calculation method which determines the volumetric airflow rate. In this case, it is used the carbon dioxide concentration, as determined by experimental measurements. The measurements were carried out in the church, during the winter time. The carbon dioxide concentration in the room is calculated according the Equation (3) [3].

$$C_{IDA} = C_{SUP} + \frac{q_H}{q_V} \cdot \left\{ 1 - \exp\left[\left(\frac{-q_V}{V_M} \right) \cdot t \right] \right\} \tag{3}$$

where: C_{IDA} - carbon dioxide concentration in indoor air at time t, [g/m^3],
C_{SUP} - carbon dioxide concentration in supply air at time t, [g/m^3],
q_H - carbon dioxide emissions from the human source, [g/s],

q_V - air flow rate required for room ventilation, [m^3/s],
V_M - room volume, [m^3],
t - time, [s].

Results of the existing course of concentration of carbon dioxide that was calculated from experimental measurement are documented in the next figure.

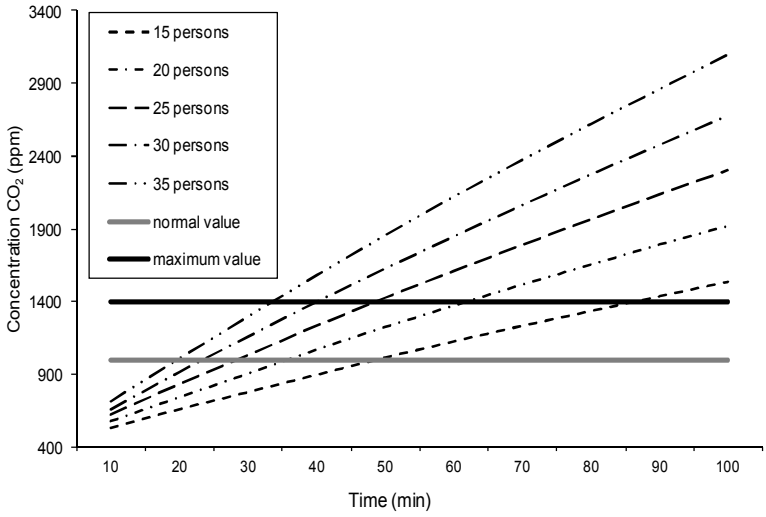

Fig. 2. The concentration of carbon dioxide
Rys. 2. Stężenie dwutlenku węgla

The calculated ventilation rate, based on the measured CO_2 concentration, is from n=0.19 1/h (room air volumes/h) to n=3.20 1/h (room air volumes/h).

3. Conclusion

From analyze we see that old building - church was constructed very good. For a church, the calculated ventilation rate based on the measured of carbon dioxide concentration is more accurately than according the standard STN EN 13 779 [6]. If there are only 10 people in the church there is no reason for mechanical ventilation. It is sufficient the ventilation by infiltration through the doors or windows gaps, even more as they are old. With the increasing of occupants inside the church it is necessity in more intensive ventilation - opening of door and windows.

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WYMOGI DLA ŚWIEŻEGO POWIETRZA WE WNĘTRZU KOŚCIOŁA

S t r e s z c z e n i e

Budowanych jest coraz więcej kościołów parafialnych. Wznosząc te obiekty należy przestrzegać wymogi dotyczące jakość powietrza wewnątrz nich. W artykule zajęto się analizą wentylacji w kościele z XIII wieku. Celem analizy była emisja zanieczyszczeń powodowana przez osoby będące w kościele. Jednym z mierzonych zanieczyszczeń był dwutlenek węgla wydychany przez osoby. Obok oddychania, osoba produkuje inne zanieczyszczenia, jak np. zapach. Na podstawie pomiarów doświadczalny poznano stężenie dwutlenku węgla wytwarzanego przez osobę, i jest znana konieczna objętość wymiany powietrza w kościele. Stężenie dwutlenku węgla powinna być mniejszym niż 1,000 ppm, a maksymalna do 1,500 ppm., ponieważ ponad wartością z 1,000 ppm skutkuje zmniejszenie koncentracji. Celem artykułu jest ustalenie metodologii dla obliczania intensywności wentylacji pomieszczenia, do uzyskania wymaganego stopnia czystości powietrza. Oszacowany wskaźnik wentylacji powinien optymalizować inwestycję i koszty eksploatacyjne wentylacji. Przedstawiono również analizę metod obliczania wskaźnika wentylacji dopasowanego do warunków obowiązujących na Słowacji.

Słowa kluczowe: wentylacja, stężenie dwutlenku węgla, współczynnik przepływu masowego kościół parafialny

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