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VENTILATION IN FLAT

The paper focuses on the natural ventilation research of space through windows. The various ventilation strategies were examined in relation to the number of open windows and ventilation geometry ergo air flow distribution. The numbers of chosen air flow distributions in space are 2. The first air distribution flow presents a simple ventilation distribution with one open window and the second is cross ventilation by 2 windows on opposite sides of the building envelope. The measurements were performed for the purpose of monitoring of carbon dioxide (CO_2) concentration decreasing, which is on value level over 1200 ppm, to value level of 500 ppm up to 530ppm in relation to speed of decline, thus a time duration of ventilation. The level of CO_2 concentration exceeding the value 1200 ppm represents values, which do not meet Code requirements of European standards STN EN 15251 and STN EN 13779. The considered CO_2 concentrations of 500 ppm up to 530 ppm meet first category of European standards STN 15251 and also represent values at about 100 ppm above background outside CO_2 concentration. The measurements were performed by using of Testo 435 instrument and took 4 days. The aim of the measurements was to determine the simple but effective strategy of ventilation for the operation of the apartment space and to achieve the Code values of CO_2 concentration and thus for the purpose the indoor air quality improving.

Key words: air ventilation rate, carbon dioxide (CO_2), indoor air quality, IAQ.

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ВЕНТИЛЯЦІЯ В КВАРТИРІ

Стаття фокусується на дослідженнях природної вентиляції через вікна. Розглянуто різні стратегії вентиляції щодо кількості відкритих вікон та геометрії вентиляції. Число вибраних розподілів потоку повітря в просторі становить 2. Перший потік повітряного розподілу – це простий вентиляційний розподіл з одним відкритим вікном, а другий – перехресною вентиляцією на 2 вікна на протилежних сторонах корпусу. Вимірювання проводили з метою моніторингу зменшення концентрації двоокису вуглецю (CO_2), що на рівні значення більше ніж 1200 ppm до значення 500 ppm до 530 ppm відносно швидкості занепаду, таким чином, тривалість часу вентиляції. Рівень концентрації CO_2, що перевищує значення 1200 ppm, відповідає значенням, які не відповідають вимогам європейських стандартів STN EN 15251 та STN EN 13779. Розглянута концентрація CO_2 від 500 ppm до 530 ppm відповідає першій категорії європейських стандартів STN 15251, а також становить приблизно 100ppm над фоном поза концентрацією CO_2. Вимірювання проводили за допомогою приладу Testo 435 та тривали 4 дні. Метою вимірювань було визначення простої, але ефективної стратегії вентиляції для експлуатації квартирного простору з метою поліпшення якості повітря у приміщенні.

Ключові слова: кратність повітрообміну повітря, двоокис вуглецю (CO2), якість повітря в приміщенні, IAQ.

Introduction The carbon dioxide (CO_2) is a major component of air in relation to indoor air quality. The quantity of carbon dioxide in the air is variable, but mainly in indoor spaces with people (space users), that are the source by their breathing process. The content by volume ingredients in the air is about 0,03 %. The concentration of carbon dioxide is generally influenced by ventilation. Most apartment buildings in Slovakia have not implemented mechanical ventilation. Residential buildings are limited only to the infiltration of natural ventilation through window openings. Such a method of natural ventilation (uncontrolled ventilation) obviously does not provide sufficient air exchange rate [1–4]. On the other side, it represents a significant initial investment savings to controlled ventilation. Of course, the energy costs to operation are only those that are related to the infiltration of heat loss in the given space. The answer is a strategy of modern, compact heat recovery and ventilation systems. This type respectively ventilation strategy, but also for heating purposes is nothing new. It used for years in commercial office buildings, where for this thing the financial space is created. Also it is not news that considerably saves operating costs for ventilation and heating with a strong return of costs [5]. The studies show, that when in the rooms increases concentration of CO_2 over the value of 1000 ppm, then approximately 20 % persons feel discomfort. Discomfort is caused by emissions coming from breathing and perspiration persons. In order to determine the required ventilation rate can be used theoretical knowledge for calculation determining the air volumetric flow [6–10].

Objectives of research This case, the experimental measurements were performed in order to quantification of gaseous pollutants – CO_2. Measurements were carried out in the heating period (winter) in apartment flat in one room during 3 days. From measured data concentration of CO_2 is possible calculated the required air flow and consequently ventilation rate. Ventilation rate must provide hygiene regulations.

Research conditions Type of measurement room is bedroom in apartment building. The room is located on the 6th floor in the 8 storey building. The size parameters of room are mentioned in Table 1.

Table 1

The room dimensions

Room dimensions				
Width, (m)	Length, (m)	Height, (m)	Room area (m^2)	Room volume, (m^3)
2.78	4.65	2.8	12.9	36.2

During the 3 day of measurements were three persons (occupant) in apartment in common operation mode. There were two adult persons and one 2-month child. The geometry of room and location in the frame of apartment are presented in Figure 1. The measurements were performed at 3 research alternatives – 1 continuous measurement during 3 days, but where during the 3 days the 3 ventilation modes were realized (3 modes). The schemes of ventilation modes in apartment are illustrated in Figure 2 and Figure 3.

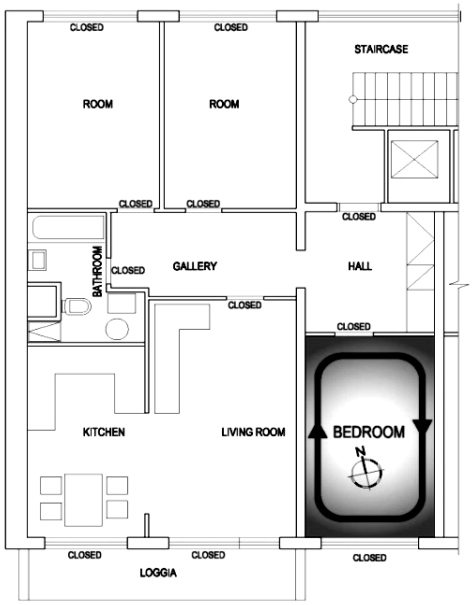

Fig. 1. The geometry of apartment and room location in the frame of apartment

Ventilation Mode 1: The first day was realized measurement, which began at 8:00 in the morning. The measurement runs during standard daily operation cycle of young family with a small child, who slept in the measurement room. At the time of ventilation was room empty. The room ventilation was realized only by opening of windows – wide open. The time of window opening was 45 minutes in the morning (8:30–9:15) and window opening was 45 minute in the evening (20:55–21:40). The door to the room was closed, as well as all the other doors and windows in the apartment, Figure 2.

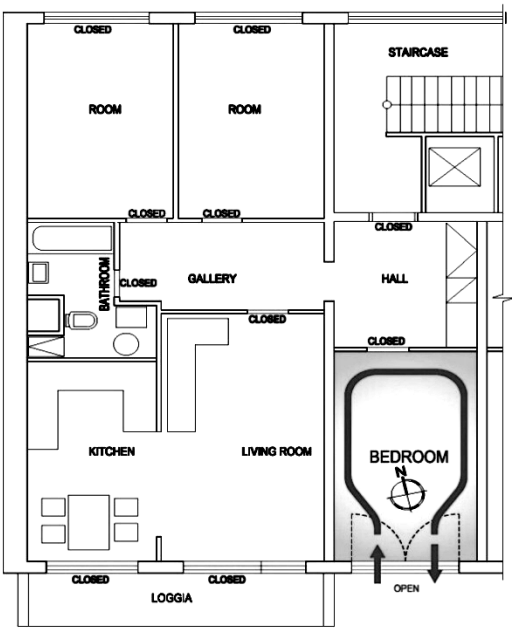

Fig. 2. The scheme of ventilation – mode 1

Ventilation Mode 2: The second day measurement continues permanently from first day. The measurement runs during standard daily operation cycle of young family with a small child, who slept in the measurement room. At the time of ventilation was room empty. The room ventilation was realized only by opening of windows – wide open. The time of window opening was 30 minutes in the morning (9:20–9:50) and window opening was 10 minutes during afternoon (13:25–13:35). The door to the room was open and also window on north side of apartment was open – cross ventilation, Fig. 3.

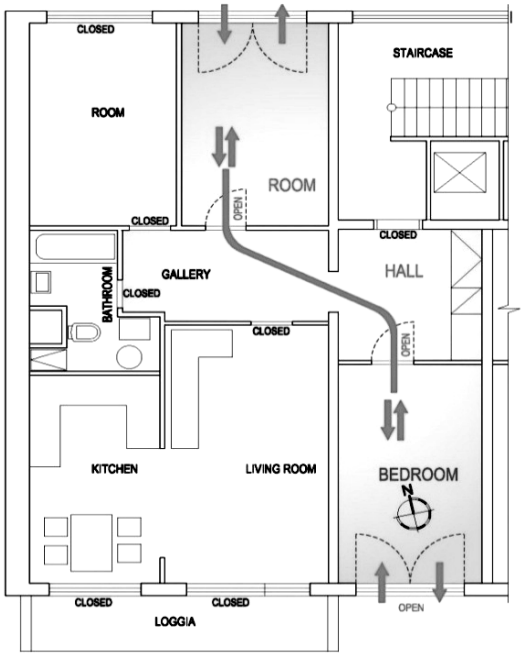

Fig. 3. The scheme of ventilation – mode 2

Ventilation Mode 3: The third day measurement continues permanently from second day. The measurement runs during standard daily operation cycle similar to day 1 and 2. At the time of ventilation was room empty. The room ventilation was realized only by opening of windows – wide open. The time of window opening was 15 minutes in the morning (8:00–8:15). The door to the room was open and also window on north side of apartment was open – cross ventilation, Figure 3. The ventilation mode 3 is similar to mode 2, but distinction is only in time of window opening (mode 2 – 45minutes, mode 3 – 15 minutes).

Results. The results of all 3 modes of ventilation are presented in Figure 4 (graph). From the results of measurements of all 3 modes it is evident, that CO_2 concentration in the night is still increasing at a maximum, whereas at night the room is fully occupied and ventilated only by infiltration through the window gaps, thus the window is of course closed. Time ventilation by open window 45 minutes respectively 30 minutes was not random.

In mode 1: It was time 45 minutes, when we reached almost outdoor background concentration 450 up to 500ppm. To reach real outdoor background concentrations 390 up to 400 ppm was according to given the operational requirements of families with a small child in time but also with regard to temperature stability, unreal (already very low temperature in the room). Subsequently, the concentration of CO_2 has increasing to value 2200 ppm during the day. By ventilation of room in the evening, we have decreased the CO_2 concentration to 500 ppm again, even though the concentration at night increase to its maximum values up to 2600ppm, which are really unfavorable values in relation to air quality, but also in relation to current valid Standards STN EN 15251, STN EN 13779, as well as other national regulations and directives [11], [12].

In mode 2: It was time 30 minutes, when we reached almost outdoor background concentration 450 up to 500 ppm. The distinction is in time, when in mode 2 was value reached already in 30 minutes, instead of 45 minutes as in mode 1. In afternoon was realized also fast cross ventilation which takes 10 minutes. Total time of ventilation in mode 2 was together 45 minutes as in mode 1. At evening was not realized cross ventilation as in mode 1. Instead of this, it was not possible to reach lower CO_2 concentration at night in mode 2, when was room fully occupied as in mode 1.

In mode 3 – similar to mode 2: By cross ventilation for 15 minutes in morning, only background CO_2 concentration at value 650ppm was achieved and subsequently CO_2 concentration goes sharply up.

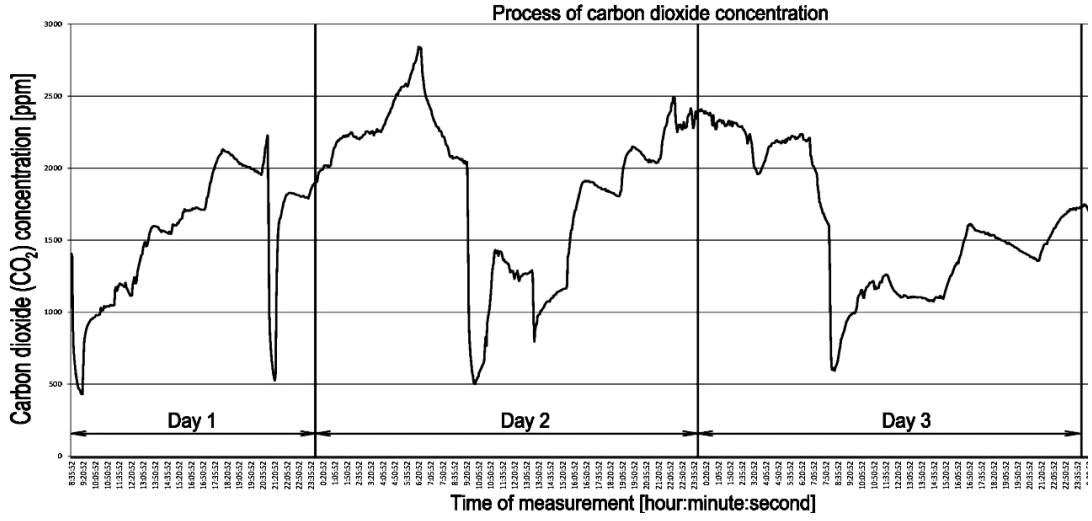

Fig. 4. The carbon dioxide concentration process during 3 days.
(1 day/Mode 1 2 day/ Mode 2 3 day/Mode 3)

Conclusion. From this initial study and measurements mentioned, that time ventilation, process ventilation and ventilation rate influence not only on the level of CO_2 concentration but also to fact, how fast we know to achieve background concentration. Thus, it has also an impact on the final energy balance of given room.

We ventilation strategy influences the future development of the concentration over time and thus the indoor air quality. The results have shown that the mode 2 is slightly better ventilation strategy as mode 1. Night concentrations were moderate. Mode 2 is not taken to the comparison, because it represents short shock ventilation and from point of view starting background concentration, there are not similar conditions of total time duration of ventilation.

Further research will deal with dependence of the CO_2 concentration decreasing over time, but also on indoor air temperature in room.

1. Kapalo Peter, Pauliková Alena, Muntea Cornel, Domniţa Florin: Evaluation of ventilated rooms. In: Ştiinta modernâ şi energia: Producerea, transportul şi utilizarea energiei. 2. Kapalo Peter, Pauliková Alena: Vplyv vetrania na kvalitu vnútorného prostredia v nízkoenergetických stavbách-2012. In: Drevostavby a ekologické bývanie: Vedecká konferencia s medzinárodnou účasťou: Zborník príspevkov: Zvolen, 2012, s. 1–7. ISBN 978-80228-2356-2. 3. Persily, A.: What we think we know about ventilation? In: Proceeding of the 10th International Conference on Indoor Air Quality and Climate "Indoor Air 2005", Beijing, China 2005, P. P24–P39. 4. Luo, Q., Tang, G., Huang, W.: Ventilation strategies to improve air quality. In: Proceeding of the 10th International Conference on Indoor Air Quality and Climate. Indoor Air 2005, Beijing – China, p. 3313–3317. 5. P. Horbaj, P. Tauš, N. Jasminská, T. Brestovič: Niekoľko poznámok k energetickej situácii na Slovensku. In: 27. Setkání kateder mechaniky tekutin a termomechaniky-Plzeň: ZČU, 2008 6 p. – ISBN 9788070436660. 6. Edgar Voigt, Jens Pelikan: CO_2-Measurement during Ventilation. Dräger Medizintechnik GmbH, Lübeck. ISBN 3-926762-38-1. 7. Gebauer, G., Rubínová, O., Horká, H.: Ventilation. ERA group, Brno 2005, ISBN 80-7366-027-X. 8. Analysis of Environmental Aspects in High Energy Performance Family House – Case Study / Silvia Vilčeková. – 2013. In: Chemical Engineering Transactions. Vol. 35 (2013), P. 385–390. – ISSN 1974-9791. 9. Hirš, J., Gebauer, G.: Ventilation in the examples, VUT in Brno, 2006, ISBN 80-7204-486-9. 10. Persily, A.: Evaluating building IAQ and ventilation with indoor carbon dioxide. Transactions American society of heating refrigerating and air conditioning engineers, 1997, p. 193-204, ASHRAE. 11. STN EN 15251:2007 Indoor environmental input parameters for design and assessment of energy performance of buildings addressing indoor air quality, thermal environment, lighting and acoustics. 12. STN EN 13779:2007 Ventilation in non-residential buildings. General requirements for ventilation and air conditioning equipments.