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ANALYSIS OF THE VENTILATION AIR FLOW RATE FOR RENEWAL OF WINDOWS

Replacement of old wooden windows in a new plastic windows, in the old buildings, we achieve the massive reducing heat loss of the building. New windows are characterized by better tightness. The question is, how much more are reduce the uncontrolled ventilation. In the article is presented the experimental measurement indoor air quality in the room in two phases. In the first phase is in the room installed 55 year old wood window. In the second phase is in the same room installed new plastic window. From the experimental measurement indoor air quality is calculated intensity of ventilation – infiltration. These resultant intensity of ventilation are reciprocally compared. The aim of the article is to find, on the basis of the experimental measurements, the difference in volume flow of air in the room by infiltration, which caused by the replacement of the old wooden window with a new plastic window with insulating double glazing. According to the analysis, it can be stated that by replacing the old wooden window in the room with a new plastic window, the volume of air flow caused by the infiltration decreased by approximately 73 %. The total window heat loss was reduced by approximately 46 %.

Key words: window, ventilation, measurement, carbon dioxide, air flow rate.

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АНАЛІЗ ВИТРАТИ ВЕНТИЛЯЦІЙНОГО ПОВІТРЯНОГО ПОТОКУ ПРИ РЕСТАВРАЦІЇ ВІКОН

За рахунок заміни старих дерев’яних вікон на нові пластикові вікна в старих будинках ми досягаємо масового зниження тепловтрат у будівлі. Нові вікна характеризуються кращою герметичністю. Питання полягає в тому, наскільки є можливим зменшити неконтрольовану вентиляцію. В статті наведено експериментальні дослідження якості внутрішнього повітря в кімнаті, які проводилися в два етапи. На першому етапі в кімнаті було встановлене 55-річне старе дерев’яне вікно. На другому етапі, в тій самій кімнаті було встановлене нове пластикове вікно. З експериментальних вимірювань якості внутрішнього повітря є обчислена інтенсивність вентиляції – інфільтрація. Була взаємно порівняна результуюча інтенсивність вентиляції. Метою статті є знайти, на основі експериментальних вимірювань, різницю в об’ємі потоку повітря в кімнаті шляхом інфільтрації, що спричинюється заміною старого дерев’яного вікна на нове пластикове вікно з ізоляційним подвійним заскленням. Відповідно до аналізу, можна стверджувати, що, замінивши старе дерев'яне вікно в кімнаті новим пластиковим вікном, об'єм потоку повітря, викликаний інфільтрацією, зменшився приблизно на 73 %. Загальні втрати тепла у вікні зменшились приблизно на 46 %.

Ключові слова: вікно, вентиляція, вимірювання, вуглекислий газ, витрата повітря.

Introduction. In order to reduce heat loss in apartment buildings, the occupants of the flats will exchange original old wooden windows per new plastic windows. The new windows are generally

characterized by better thermal and technical properties. Characteristic for them is mainly better sealing, which prevents uncontrolled ventilation by infiltration. Replacement of original wooden windows per new double-glazed or triple-glazed double glazing windows mainly results in a reduction in heat losses of crossing through the window structure and by uncontrolled of ventilation (infiltration). Accordingly is generated worsen indoor air quality, which reduce the on performance and concentration of people [1]. The deficit of fresh air can cause a worsening of health. It is also possible to occur signs of fatigue and even it may cause disease [2]. In this paper is quantified drop in volume of air is due to better sealing of a new window.

Materials and Methods. For the purpose of determining the actual intensity of infiltration ventilation through the leakages building construction it was carried out experimentally measuring the concentration of carbon dioxide produced by the person. At the beginning of the measurement a person was in room. After two and a half hours a person left the room. Of the observed decrease the concentration of carbon dioxide was calculated ventilation rate due to infiltration. The said measurements were carried out in two stages. The first stage was carried out at an old wooden window and the second stage was carried out with a new plastic window mounted in the room.

Characteristic of the experimental space. The experimental space is located in a 5-storey building on the second floor. The internal volume of the space is 52.07 m^3. In the external wall is inserted one window with dimensions: height 1.75 m and width 1.13 m. The length of the window joints is 5.7 m.

The measuring devices. In the experimental space there was measured parameters of indoor air quality: indoor air temperature, indoor relative humidity and concentration of carbon dioxide. During the research, the following measuring devices were used in the selected space: temperature and relative humidity sensor: S3541 Thermo humidity sensor and carbon dioxide concentration sensor: C-AQ-0001R. The multifunctional TESTO 435 instrument with a carbon dioxide concentration sensor, relative humidity and air temperature was also used. First measurement was carried before renewal of building and second measurement was carried after renewal of building. Both of measurements were carried out in winter, but in the different years at the similar external weather.

Result and discussion. The experimental measurements were carried out in two stages. First measurement was carried before renewal of building and second measurement was carried after renewal of building. Both of measurements were carried out in winter, but in the different years at the similar external weather. In the first and second stages were measured: indoor air temperature, indoor relative humidity and indoor carbon dioxide concentration.

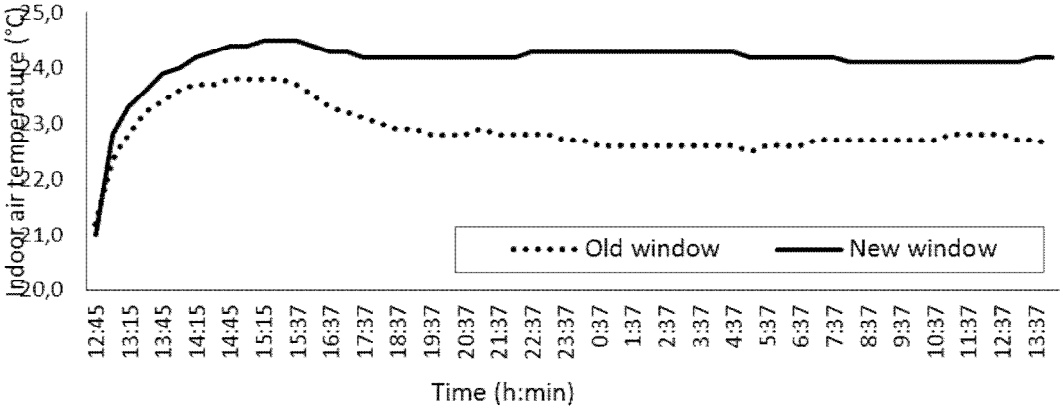

Fig. 1. The measured indoor air temperature

Also was were measured: outdoor air temperature, outdoor relative humidity, wind speed and outdoor carbon dioxide concentration.

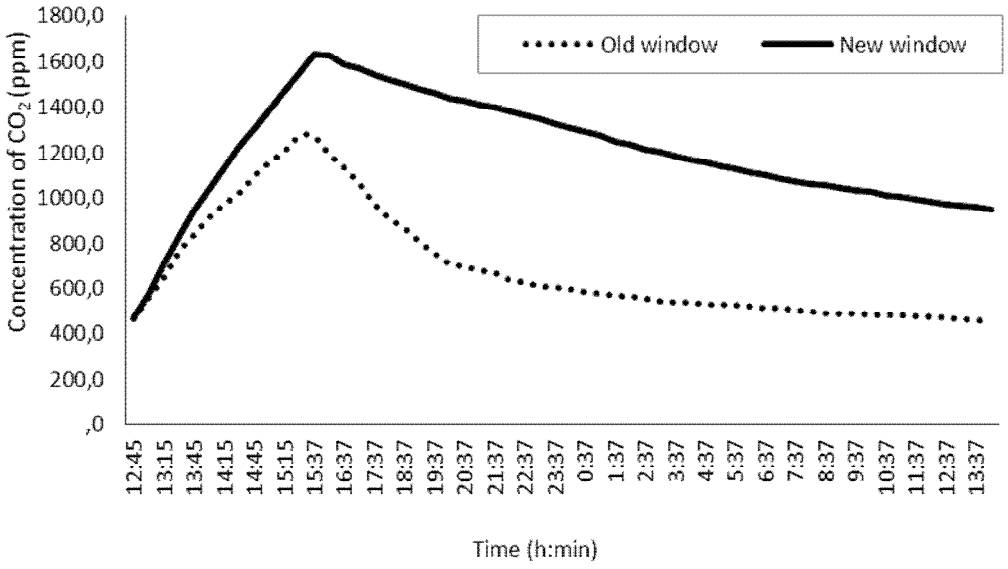

Fig. 2. The measured indoor concentration of carbon dioxide

During measurements it was outdoors carbon dioxide concentration of about 380 ppm. The average measured parameters of the outdoor air temperature and wind speed are documented in next table.

Table 1

The average parameters of the outdoor air

	Average outdoor air temperature (°C)	Average outdoor wind speed (m/s)
Old window	2.81	2.50
New window	4.52	1.89

An increasing concentration of carbon dioxide (Figure 2) was caused by the presence of a person. All the time, ventilation was provided only by infiltration in the room. When a person left the room, the concentration of carbon dioxide began to decline. As the concentration at the end of the measurement was different from the outdoor air concentration, the intensity of the ventilation by infiltration in the room was determined from decrease in carbon dioxide concentration [3,4].

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

where n – intensity of ventilation by infiltration (1/s); $C_{IDA,S}$ – concentration of carbon dioxide in the room at the start of the decrease (mg/m^3); $C_{IDA,E}$ – concentration of carbon dioxide in the room at the end of the decrease (mg/m^3); C_{SUP} – concentration of carbon dioxide in the outdoor air at time t (mg/m^3); t – duration of the decrease of carbon dioxide concentration (s).

The volume air flow is calculated from the determined ventilation intensity by infiltration and room volume:

$$q_V = 3{,}600 \cdot n \cdot V_M, \qquad (2)$$

where: q_V – the volume air flow (m^3/h); n – intensity of ventilation by infiltration (1/s); V_M – the volume of air in the room (m^3).

The calculated ventilation rate for the old window is 0.24 1/h and volumetric flow by infiltration is 11.10 m^3/h. For new window it is calculated ventilation rate 0.06 1/h and volumetric flow by infiltration is 2.94 m^3/h. Next was calculated total heat loss for window, which is for old window 155.26 W and for new window 84.54 W.

Conclusion. According to the analysis, it can be stated that by replacing the old wooden window in the room with a new plastic window, the volume of air flow caused by the infiltration decreased by approximately 73.52 %. The total window heat loss was reduced by approximately 45.55 %. Replacing the

old window with a new window will reduce the heat loss in the room and the intensity of ventilation by infiltration. Therefore, it is needs to take care of controlled ventilation in the room.

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