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WIND ACTION ON THE BUILDING FACADE AND ITS INFLUENCE ON VENTILATION HEAT LOSSES

Важливим фактором, що впливає на клімат у приміщенні і споживання енергії в будівлях, є обмін повітря. Метод кореляції використовують переважно для стаціонарних зовнішніх кліматичних умов, зазначених у стандартах, враховуючи постійне значення кратності повітрообміну n_N ³ 0,5 1/год, яка задається в STN.

Значно впливає на фільтрацію повітря і споживання енергії загальний тиск повітря Δp_c, який створюється під впливом різниці температури Δp_q та вітрового навантаження Δp_v. Різниця тиску повітря створюється на межі внутрішнього та зовнішнього середовища. З зовнішнього боку вітер діє на будівлю з певною силою, вираженою зовнішніми аеродинамічними коефіцієнтами C_{PE}. Фасад показує певну ступінь проникності повітря, що викликає зміни взаємодії зовнішнього і внутрішнього тиску. Тому ми повинні також враховувати розмір і значення коефіцієнта внутрішнього тиску, який діє на іншому боці поверхні.

Розглянуто проблему нестаціонарних процесів, у результаті яких виникають коливання повітрообміну і вентиляційних тепловтрат, використовуючи точні аеродинамічні коефіцієнти, які застосовуються в методах моделювання. Проаналізовано та кількісно визначено результати для вибраних факторів, а саме прокладання, пропорції і розмір конструкцій фасаду, що відкриваються, для конкретного типу будівлі пропорційно до їх площі та висоти.

Ключові слова: фільтрація повітря, вентиляційні тепловтрати, кратність повітрообміну, різниця тисків.

A significant factor affecting of indoor climate and energy consumption in buildings is the air exchange rate. In correlation method is used mostly stationary outdoor climatic conditions specified in the standards - considering the constant value of the air exchange rate of n_N ³ 0.5 1/h, which is set in STN.

Great influence for air filtration and energy consumption has the total air pressure difference Δp_c - creationed from influence of pressure difference from temperatures Δp_q and the wind Δp_v. The air pressure difference is created at the interface between the internal and external environment. In real environment is the interface formed by buildings and their façade. From outside act the wind on the building the power expressed by external aerodynamic coefficients C_{pe}. Facade shows a certain degree of the air permeability, which causes the interaction changes of external and internal pressure. Therefore we must also consider the size and dimension of the internal pressure coefficient C_{pi}, acting on the other side of the surface.

The paper is focused on the issue of non-stationary processes, causing a large variability of the air exchange rate and ventilation heat losses, with an emphasis on accurate aerodynamic coefficients used in the simulation methods. In the article were analyzed and quantified the results for selected factors – the layout, the proportion and size of the opening constructions in the façade - for the particular type of buildings in terms of space and height proportionality.

Key words: air filtration, ventilation heat losses, air exchange rate, pressure difference.

Introduction. One of the key tasks in the process of building construction design is the minimization of heat and energy and to create optimal environment which provides protection from negative climate externalities and creates suitable microclimate of the internal spaces.

When evaluating the buildings in terms of energy efficiency is an important component analysis of the air flow in a building which influences: decrease (increase) in energy use for heating, sizing of the heating system, hygienic comfort, studying the movement of smoke. Great influence for air filtration and energy consumption has the air exchange rate, which affects the total air pressure difference Δp_C. Total air pressure difference Δp_C is dependent on many factors. Of these factors is in this paper analyzed in mainly the impact of the layout, the proportion and size of the opening constructions in the façade.

Analysis of air exchange rate. The value of air exchange rate as set by the norm $n_N \geq 0,5$ 1/h does not correspond with real values of air exchange. More accurate analysis can be done with the use of simulation method which tolerate the dynamics of buildings under various external climate influences in short time intervals**.**

Air exchange rate can be expressed:

$$n = 3600.\frac{V_{\inf}}{V_m} = 3600.\frac{\left[\Sigma\left(i_{l,v}.l\right).\Delta pc^m\right]}{V_m} \quad (1)$$

The air exchange rate is very variable and depends mainly on the total air pressure difference and many factors – the outside air temperature, wind speed and wind direction, layout and size of the openings in the peripheral wall structures.

In determining of the values of the air exchange rate is the most difficult quantifiable value of the total air pressure difference Δp_C, especially the differential pressure of the wind Δp_V – expressed:

$$\Delta p_C = \Delta p_\theta + \Delta p_v = \pm h.g.\left(r_e - r_i\right) + C_p \frac{v^2.r_e}{2} \quad (2)$$

Building envelope, in particular a roof and façade, are in the attic and corner exposed to extreme loads from the effects of wind. Great influence on the values of this loads has the air permeability of the façade – which causes the interaction changes of external and internal pressure and it is therefore necessary to know not only the value of the aerodynamic coefficient of external pressure, but also the internal pressure and internal aerodynamic coefficient C_{pi}.The value of aerodynamic coefficient of internal pressure C_{pi} is based on the assumption of the same volume of infiltrated and exfiltrated air in the building and on the theory of air permeability of the external walls. Based on these assumptions, it is possible on some simplified buildings to quantify the internal aerodynamic coefficient C_{pi} according to studies [2] as a function of the opening ratio ***a*** for each wind direction, expressed:

$$C_{pi} = f\left(a\right) \qquad a = \frac{A_{(+)}}{A_{(-)}} \quad (3)$$

Basic classification of the reference building and the values of external and internal aerodynamic coefficients for the reference room oriented to windward and the side wall, with wind direction 360^0 (on the long side of the building) and 90^0 (on the short side of the building), for different ratio of openings on each side of the building envelope are given in Table 1.

Table 1

Values of external and internal aerodynamic coefficients for different ratio of openings

	Wind direction on the long side - 360^0			Wind direction on the short side - 90^0		
	C_{pe}	C_{pi}		C_{pe}	C_{pi}	
		2:1	3:1		2:1	3:1
Windward wall	+0.7	-0.2	-0.15	+0.8	-0.6	-0.8
Lateral wall	-0.5	-0.2	-0.15	-0.5	-0.6	-0.8

Analysis of ventilation heat losses. Ventilation heat losses depends primarily on the air exchange rate. In computational methods is considered a constant value of the air exchange rate $n_N \geq 0.5$ 1/h, which is set in the STN.

Ventilation heat losses are in addition to the air permeability also influenced by external climatic factors, which are highly variable. More accurate analysis and calculations can be done with the use of simulation method which tolerate the dynamics of buildings under various external climate influences in short time intervals.

Ventilation heat loss of the room Φ_v can be expressed as:

$$f_v = 1200.\Sigma\left(i_{l,v}.l\right).\Delta pc^m.\left(q_{ai} - q_e\right) \tag{4}$$

$$f_v = 0,33.n.V_m.\left(q_{ai} - q_e\right) \tag{5}$$

Quantifikation of air exchange rate and ventilation heat losses. Quantifikation of air exchange rate and ventilation heat losses indicated graphically in figure 1 and 2 were processed for selected day – 17 January 2016 in Košice, for reference room with a volume of 53 m^3, $i_{l,v}$=0,4.10^{-4} m^3/(m.s.Pa^{0,67}) and the joint length of 14 m, indoor air temperature +20 °C. Outdoor air temperature θ_e was from -4 to -6 °C. Reference room was oriented alternative at windward and side wall.

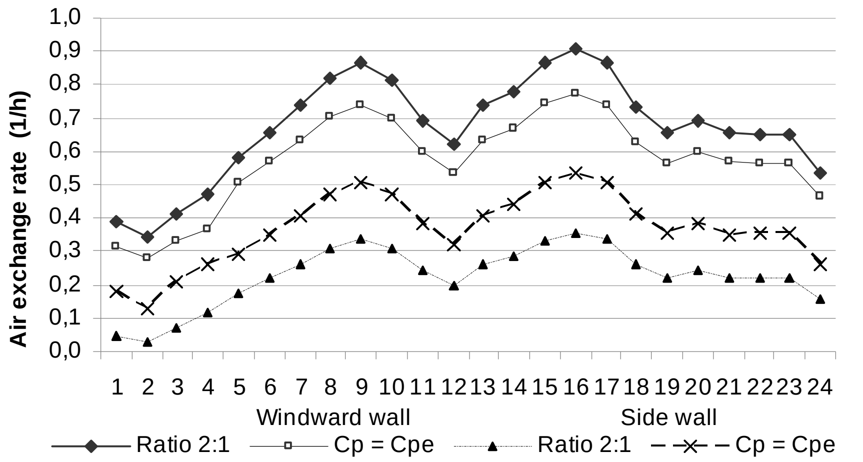

Fig. 1. Comparison of the air exchange rate for the selected day - 17 January 2016 in Kosice with considering and without considering the influence of openings – open terrain

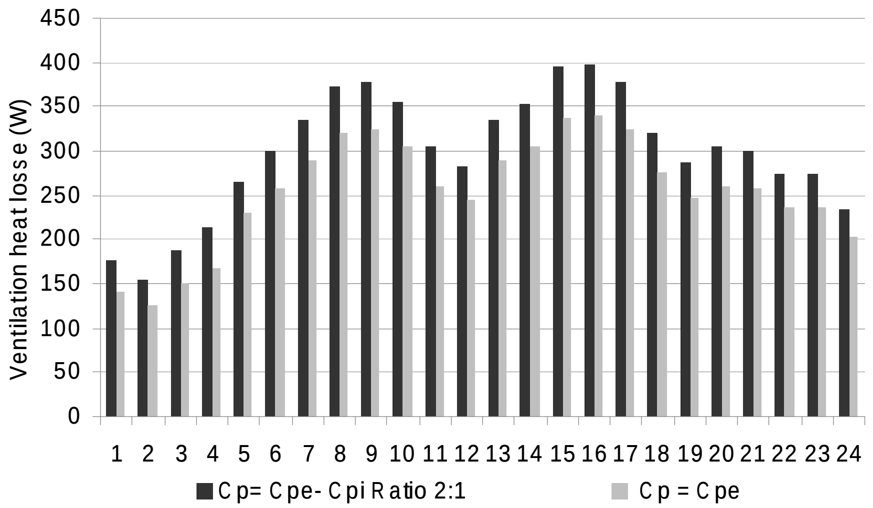

Fig. 2. Comparison of the ventilation heat losses for the selected day - 17 January 2016 in Kosice with considering and without considering the influence of openings – open terrain

Values are given for reference building:

– a simplified, middle building – rectangular shape, the plate type building,
– different wind direction (360^0),
– with considering (C_p=C_{pe}-C_{pi}) and without considering (C_p=C_{pe}) the impact of openings,
– ratio of openings on each side of the building facade (2:1, 3:1),
– in open terrain 10 m height above the ground.

In Fig. 3 is a comparison of ventilation heat loss at 17 January 2016 for maximum wind speed v=13.4 m/s. The values are compared without considering of the impact of openings $C_p = C_{pe}$ and with the considering of the impact of openings $C_p = C_{pe}$-C_{pi}, with a ratio of 2:1 and 3:1.

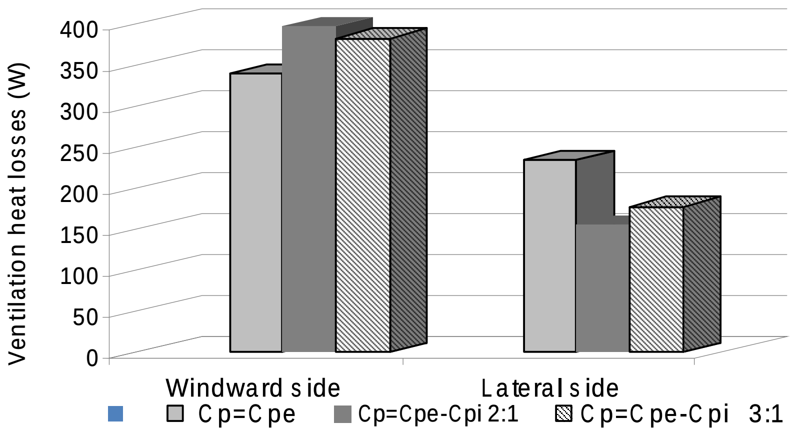

Fig. 3. Comparison of th e ventilation heat losses, with considering and without considering the impact of openings windward and side wall – open terrain

As shown in Figure3, higher proportion of openings on the windward side increases the effect of these holes and therefore reduces the air exchange rate and ventilation heat losses. On the lateral sides – where wind uplift - is the opposite phenomenon.

Conclusion. The exact results of the air change rate and ventilation heat loss show that besides the basic aerodynamic quantification, which reflects only the wind impact from the outside of a building (a direction, wind speed, ground-plan shape), acceptance of the air permeability of the building facade affecting the pressure conditions in the interior, plays an important role.

Especially when determining the wind load are often forgotten to take account the action of the internal pressure, that may be significant contribution to the total design of load, depending on the geometrical shape of the building, size and location of the openings and the many other aerodynamic factors. Neglect of the effect of internal pressure to a total load of buildings may result increased values of suction on the leeward sides, and vice versa. It may cause undesirable of energy losses from air filtration and change of ventilation heat losses.

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