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IMPACT OF AERODYNAMIC QUANTIFICATION ON RELATIVE AIR HUMIDITY AND VENTILATION HEAT LOSSES

Annotation: *Adequate air exchanges relieve the internal environment of various pollutants and affect the moisture regime of the indoor environment. The air exchange rate undersizing causing changes in moisture conditions, up to the limit of hygienic requirements with subsequent adverse hygienic defects and the formation of mold. The paper deals with the aerodynamic quantification of buildings and his impact on relative air humidity and ventilation heat losses and compares the calculated values with values measured in the selected room.*

Keywords: relative air humidity, moisture regime, ventilation heat losses, aerodynamic quantification

Introduction. Indoor moisture regime, which means keeping the indoor relative humidity (RH) at correct levels, is very important for whole building performance in terms of indoor air quality (IAQ), energy performance and durability of the building. Room humidity - which means keeping the relative humidity (RH) at the correct levels, is very important for the overall performance of buildings in terms of indoor air quality (IAQ), energy efficiency and building durability. In building is the key to maintain the relative humidity at a comfortable range—low enough to be comfortable but high enough to avoid problems associated with very dry air.

Relative air humidity and ventilation heat losses. The relative air humidity is an important parameter that affects the quality of the indoor environment. When the relative humidity is low - $\varphi i = 35\%$, the air is more ionized and increasing irritate the respiratory system and create the conditions for respiratory diseases.

When the relative humidity is high, evaporation of water is slow. Condensation can occur on surfaces, leading to problems with mold, corrosion, decay, and other moisture-related deterioration. Condensation can pose a safety hygienic risk as it can promote the growth of mold. For the comfort of housing are values of relative humidity of air in the residential spaces recommended 35 - 60 %, in the living spaces the pleasant relative air humidity is 40% – 50 %.

The relative air humidity can be determined from the partial pressure of water vapor in the indoor air, for which holds:

$$p_{di} = p_{de} + 462.\ G.\ T_i / n.V_m \qquad (1)$$

where: p_{di}, p_{de} - partial pressure of vapor in the internal /external air; 462 - gas constant for water vapor; Ti - temperature; G - water vapor produced

An important parameter in equation (1) is the air exchange rate – n. The intensity of air exchange significantly influences the heat losses of buildings – the natural unregulated ventilation, as well as the micro climate of the building interior. Currently, in order to reduce consumption of heat and energy with radical reduction of air filtration occur the undersizing of the air exchange rate. This trend makes in the rooms begining to creates undesirable defects - mold, wetting.

Air exchange rate and ventilation heat losses can be expressed:

$$n = 3600.\frac{V_{\inf}}{V_m} = 3600.\frac{\left[\Sigma\left(i_{l,v}.l\right).\Delta pc^m\right]}{V_m} \qquad (2)$$

$$\Phi_v = 0{,}33.\ n.V_m.\ (\theta_{ai} - \theta_e) \qquad (3)$$

$V_{\inf}$, V_m – volume of infiltrated air in the room with natural airflow,m^3; $i_{l,v}$ - gap permeability coefficient, $m^3/(m.s.Pa^{0,67})$; l - length of the gap, m; Δp_C - total air pressure difference, Pa

Aerodynamic quantification. Aerodynamic quantification takes into consideration the complex wind effects and particular building‘s parameters and we have to know:

- outdoor climatic parameters - wind speed and wind direction, outside air density,

- aerodynamic parameters of the building - overall aerodynamic coefficient consisting of the external and internal aerodynamic coefficients $C_p = C_{pe} - C_{pi}$ (-)

External wind pressure (suction) is expressed in external aerodynamic coefficient C_{pe} (-), depending mainly on the geometric shape of the building and wind direction. Several researchers conducted a series of measurements in the wind tunnels on the models of rectangular shape and investigated the impact of aspect ratio on the external aerodynamic coefficient [1].

Values of this pressure coefficient for simple buildings in respect only strong winds - with a rectangular ground plan and vertical exterior walls are: C_{pe}= +0.7 to 0.8 on the windward side and C_{pe}= - 0.1 to - 0.5 on the leeward and lateral side [2,]. However, if the external aerodynamic coefficient unevenly, extreme value is significantly different from the average and at windward may be a difference of up to 50%.

Façade shows a certain degree of the air permeability, which causes the changes of external and internal pressure. Therefore, when dealing with the wind impact, we must consider the size and dimension of the internal pressure coefficient C_{pi} which acts on the other side of the surface.

For simple buildings is the internal pressure coefficient C_{pi} a function of the *h*/*b* and the ratio of the openings for each wind direction expressed as a function:

$$C_{pi} = f(a) = f\left(\frac{A_{(+)}}{A_{(-)}}\right) \tag{4}$$

where a = the ratio of openings; $A_{(+)}$ = real surface of the openings on the windward wall of a building; $A_{(-)}$ = real surface of the openings on the leeward and lateral sides of a building.

Values a shall be determined for the different wind directions, variable size and layout of the openings and subsequently C_{pi} can be determined utilizing the graphical C_{pi}=f(a) [2].

Internal and external pressures shall be considered to act at the same time.

Measurement and calculation of relative air humidity and ventilation heat losses in the reference building. The reference building is a high-rise apartment building with 12 + 1 floor, with a total height 35.1 m and rectangular ground plan, with 2 gable walls, situated in the Košice - North. The reference room is on 2nd NP, with orientation NW. Room dimensions are 4 x 3.55 x 2.6 m. The windows are plastic, with an isolation binocular, with a coefficient of permeability i_{lv} = 0.4 $m^3/(m.s.Pa^{0,67})$ and with a length of joints l =13.4 m.

Internal climate parameters - indoor air temperature, internal air flow speed, internal air pressure and relative air humidity was measured on 17.3.2018 using TESTO 435. External parameters affecting the air exchange rate and consequent relative air humidity and ventilation heat losses - outdoor air temperature θ_e was from -10 to -14°C and wind speed 5.7 – 14.9 m/s, wind direction NW – 337.5^0 . Values of wind speed 5.7 – 14.9 m/s measured in open terrain were reduced by

$$v_Z = k.v_{10,\,MET} \quad (m/s) \tag{4}$$

where: $v_{10,MET}$ -wind speed measured at hydro-meteorological stations at 10 m height; k - coefficient indicating the impact of urban buildings and the height above the ground

Measurement and calculation of relative air humidity and ventilation heat losses values indicated graphically in Figure 1 and Table 1 were processed for particular day – 17 Marc 2018 in the reference room with the moisture load of 100 g /h.

The values were calculated without considering the influence of the holes - $C_p = C_{pe}$, and with considering the effect of the holes $C_p = C_{pe} - C_{pi}$ – for building with 2 gable walls.

Table 1: Values of aerodynamic coefficients

Wind direction	$C_p = C_{pe}$	C_{pi} - building with gable walls
NW – 337.5^0	+ 0.525	+0.2

Table 2: Comparison of the ventilation heat losses - Φv (W)

	Φv- for n -STN	Φv - for 2 gable walls	Φv for $C_p=C_{pe}$
at 16.00	234,4	239	304
at 19.00	241	284	366

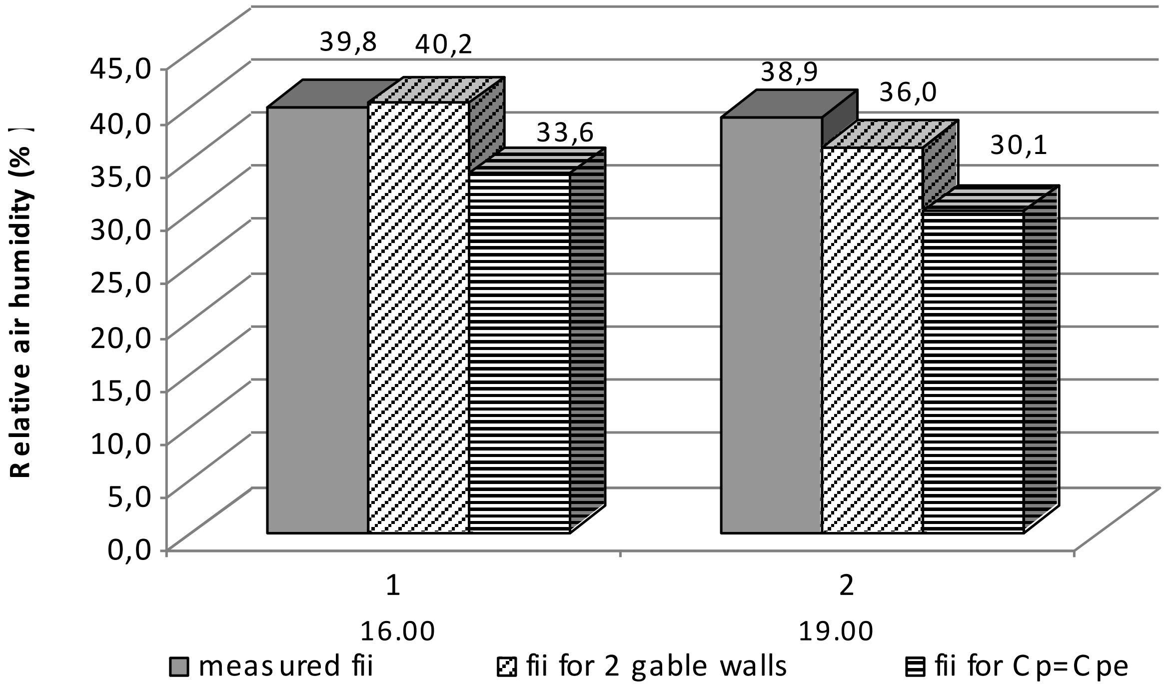

Figure 1: Comparison of the relative air humidity –terrain in the city

As shown in Figure 1 calculated value of relative humidity with considering the effect of the openings, i.e the total aerodynamic coefficient $C_p = C_{pe}- C_{pi}$ are comparable to the measured values, but value without considering the effect of the openings - $C_p = C_{pe}$ is substantially lower. The results shows, that acceptance of the air permeability of the building facade affecting the pressure conditions in the interior, plays an important role.

Conclusion. The measured and calculated results of the relative air humidity show the importance of accepting the air permeability of the building envelope structures. Calculated relative humidity values with considering the effect of the openings, i. the total aerodynamic coefficient $C_p = C_{pe} - C_{pi}$ are comparable to the measured values. Neglecting the effect of internal pressure to a total load of buildings may result they are undesirable ventilation energy losses and moisture regime change in room.

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Анотація:

Адекватні повітряні обміни полегшують внутрішнє середовище різних забруднювачів і впливають на вологість середовища в приміщенні. Підвищення обмінного курсу повітря призводить до змін умов вологості, до межі гігієнічних вимог з наступними несприятливими гігієнічними дефектами та формуванням цвілі. Робота присвячена аеродинамічному кількісному вимірюванню будівель та його впливу на курс повітря та відносну вологість повітря та порівнює розрахункові значення з значеннями, виміряними у вибраній кімнаті.

Ключові слова: відносна вологість повітря, режим вологості, втрати теплової вентиляції, аеродинамічне кількісне визначення

Аннотация:

Адекватные воздушные обмены облегчают внутреннюю среду различных загрязняющих веществ и влияют на режим влажности в помещении. Скорость изменения обменного курса воздуха вызывает изменения в условиях влажности, вплоть до предела гигиенических требований с последующими неблагоприятными гигиеническими дефектами и образованием плесени. В статье рассматривается аэродинамическая количественная оценка зданий и его влияние на относительную влажность воздуха и потери тепла в помещении и сравниваются вычисленные значения со значениями, измеренными в выбранной комнате.

Ключевые слова: относительная влажность воздуха, режим влажности, потери тепла при вентиляции, аэродинамическая количественная оценка