Indoor Environment of Buildings – Quality and Basic Ventilation Air Parameters: Part II

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Abstract**—** *A series of articles focused on the indoor environment of buildings. Articles discuss the importance of a quality indoor environment and the implementation of the measurement of the parameters of the outgoing air from the indoor environment in the ventilation shaft of a panel house. The content of the second article is the determination of the procedure for measuring the speed, temperature and humidity of the air flowing through the ventilation shaft at the exit from the air duct of the selected panel house.*

Keywords**—** ***Air Flow Rate, Air Temperature, Measurement of Air Parameters, Relative Air Humidity, Ventilation Shaft.***

I. INTRODUCTION

Following the article Part I., the second article is devoted to the monitoring of the internal environment of living spaces. Article Part II. maps the procedure of measuring the ventilation air parameters of living spaces, specifically an 8-storey panel house in Slovakia. The methodology for measuring the quantity and parameters of the ventilation air in the selected panel house consists of several points (Fig. 1):

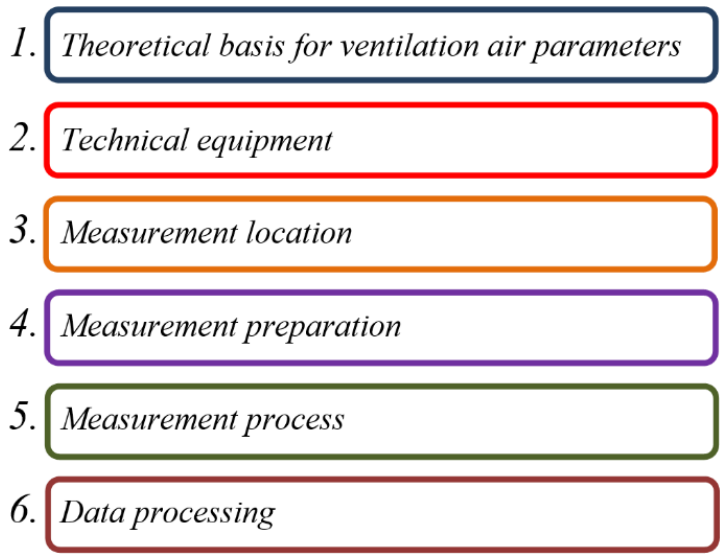


FIGURE 1: The methodology for measuring the quantity and parameters of the ventilation air

II. THEORETICAL BASIS FOR VENTILATION AIR PARAMETERS

The theoretical basis for ventilation air parameters was described in the first article Indoor Environment of Buildings – Quality and Basic Ventilation Air Parameters, Part I.. To determine the quantity of air that leaves the air duct, it is necessary to measure the following air parameters at the outlet of the air duct:

a) air flow velocity,

b) air temperature,

c) air humidity.

III. TECHNICAL EQUIPMENT

The measurement of the air parameters was performed using the measuring and recording devices shown in Table 1.

TABLE 1

TECHNICAL EQUIPMENT[1]

Type of measuring equipment	Producer	Measured parameter
Propeller probe FV A915-S140 	AHLBORN	Air velocity in the air duct
Combined temperature and humidity sensor FH A646 	AHLBORN	Air temperature in the duct
		Relative air humidity in the duct
Data logger ALMEMO 2390-8 	AHLBORN	Recording of measured data

IV. MEASUREMENT LOCATION

An apartment building of type T 08B KE (Fig. 2) located in Slovakia at an altitude of 206 m above sea level was chosen for the measurement of ventilation air parameters in the ventilation shaft of the panel house.

FIGURE 2: Schematic illustration of terraced panel house type T 08 B KE[2]

The selected panel house is a terraced building with 8 residential floors. Each floor of the subject panel house (Fig. 3) consists of two 3-room and one 1-room apartment. Each of the apartments has its own installation shaft, which includes an air duct – one pipe is common to 8 apartments [2].

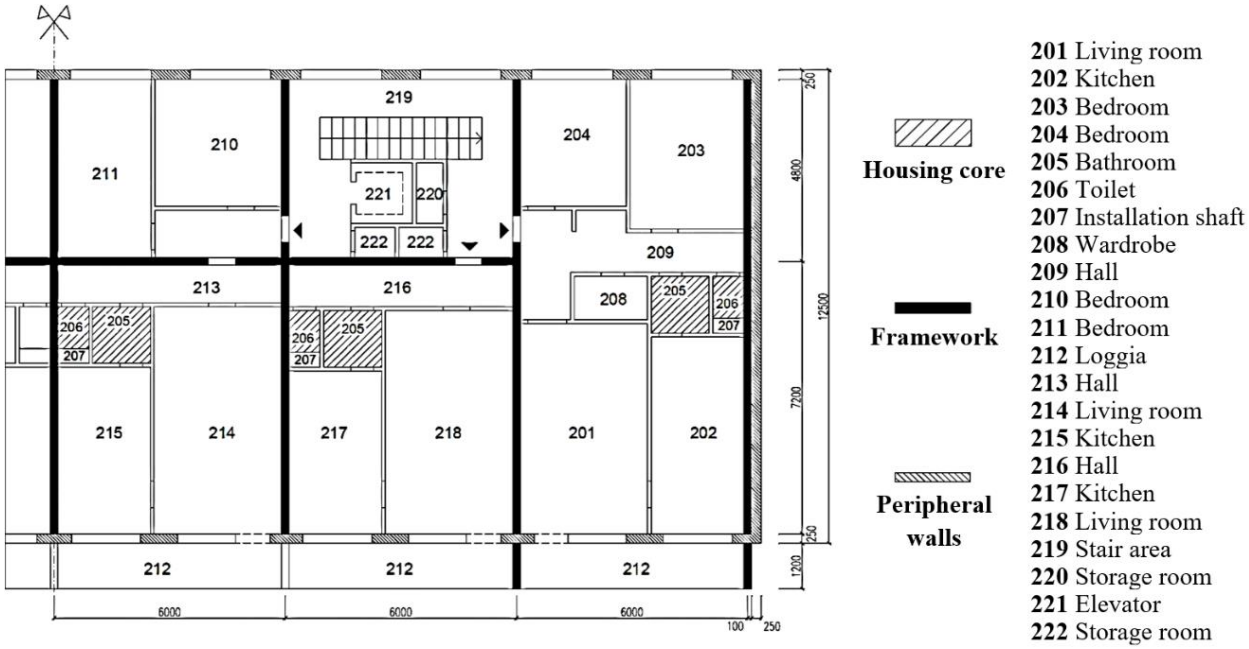


FIGURE 3: Typical floor of the panel house type T 08B KE [2]

The selected air duct is used to ventilate 3-room apartments, which are mostly inhabited by four people. The duct opens into the damping chamber, the ventilation air from the ventilation duct is removed through a vent duct cup (Table 2). Originally, the air outlet was ensured by a fan, currently the fan is not functional, or it is shut down.

TABLE 2
TERMINATION OF THE AIR DUCT

	**1**	*Vent duct cup with installed fan:* - diameter of the cup: d = 720 mm
	2	*Damping chamber:* - the space into which the ventilation duct opens, - chamber dimensions (width / length / height): W / L / H = 900 mm / 1300 mm / 400 mm
	3	*Ventilation of the air duct*

V. MEASUREMENT PREPARATION

Before installing the measuring apparatus for continuous measurement, it was necessary to obtain the overall profile of the air flow of the duct by control measurement. Nine measuring points were chosen for the square ventilation duct with dimensions of 225 x 250 mm (Fig. 4). The flow profile was obtained by control measurement. A median was created from the measured parameters.

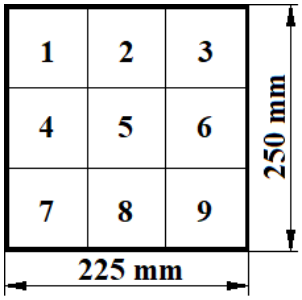


FIGURE 4: Air duct cross-section with 9 measuring points

The measuring probes (Fig. 5) were placed in point 2 to ensure the stability of the support grid with probes installed on the duct outlet. The measured results were subsequently modified by calculation coefficients, which were created by evaluating the ratio of the mean values of individual parameters to the parameter values from point 2.

FIGURE 5: Installation of measuring equipment

VI. MEASUREMENT PROCESS

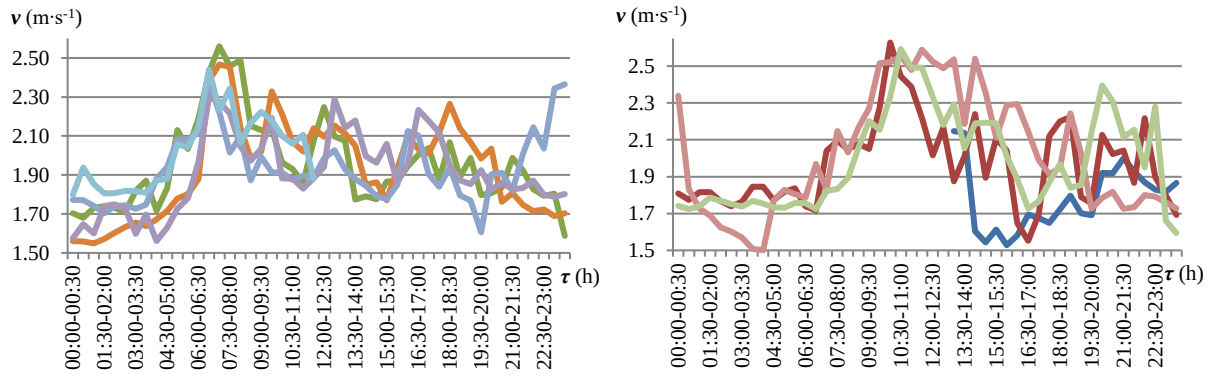
The measurement took place nine days during the heating season continuously. One measurement interruption was recorded during the measurement. It was necessary to replace the batteries in data logger Almemo 2390-8. After the measurement, the measured data was downloaded to the computer for subsequent processing.

VII. DATA PROCESSING

The measured data were transferred to the spreadsheet editor MS Office EXCEL and then processed. Measured air parameters at the outlet of the ventilation duct:

7.1 Air flow rate

The flow rate of the outgoing air is shown by graphs with values processed in half-hour intervals. The air flow during the 4 working days of the week (Fig. 6a) is relatively stable. The outgoing air reached a velocity between 1.5 and 2.6 meters per second. From the course of air flow velocities, it is possible to deduce approximately when residents get up, that is, when they use the bathroom to a greater extent, etc.



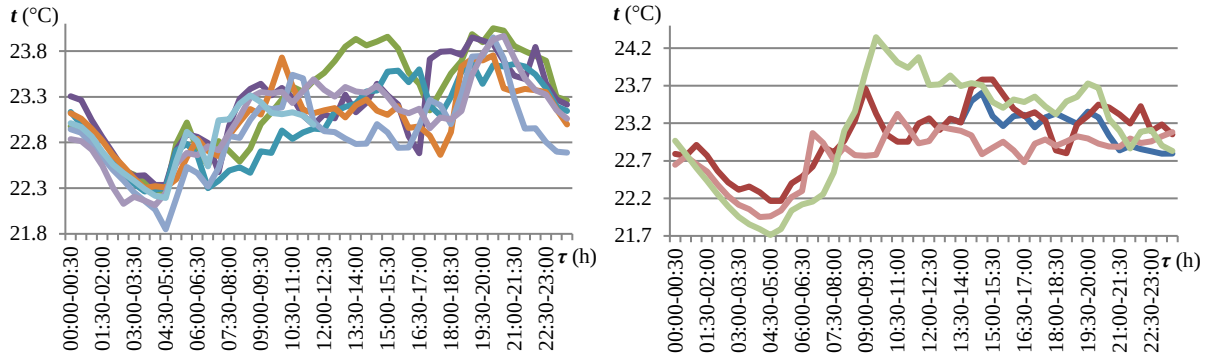
a. working days ***b. weekends***

FIGURE 6: The air flow rate in monitored period

As for the weekend ventilation air flow profile, the following graph (Fig. 6b) shows that most residents are at home and engaged in various activities (cooking, cleaning). The later time of getting up and therefore using the bathroom and toilet is also evident. The outgoing air reached a velocity between 1.5 and 2.6 meters per second during the weekends. Compared to the working days of the monitored period, the maximum flow velocity values were recorded later, approximately between 10:00 a.m. to 12:00 p.m.

7.2 Ventilation air temperature

An overview of the ventilation air temperatures at the outlet of the ventilation duct is shown in the following graphs (Fig. 7).



a. working days *b. weekends*

FIGURE 7: Ventilation air temperatures in monitored period

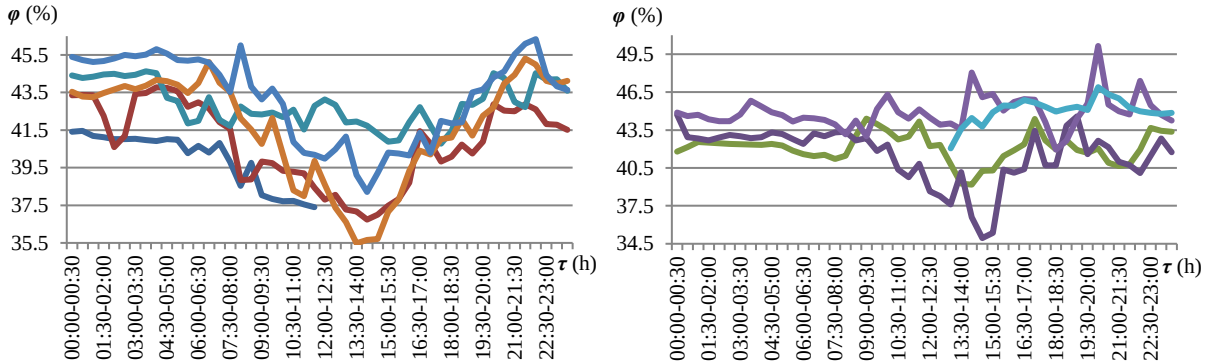
During working days, the temperature of the ventilation air reached a maximum of 24 °C, the minimum temperature was 21.8 °C. At approximately the same time, the probes recorded an increase in temperature and air flow speed.

The dependence of temperature and flow speed was also confirmed when comparing the graphs of the observed weekend period. The temperature range during the weekends was between 21.7 °C and 24.3 °C.

7.3 Relative air humidity

The humidity of the air developed depending on the temperature and the speed of the air flow in the duct. Relative air humidity reached a maximum of 50 %, its minimum was 35 %. The largest dispersion of values in the monitored period was recorded between 8:30 a.m. to 2:30 p.m.

The course of the relative humidity values in Fig. 8a indicates that after the evening hygiene of the residents, the bathrooms are gradually ventilated. A decrease in relative humidity values is recorded until approximately 3:00 p.m., which indicates the approximate time of arrival of residents from work, school, etc.



a. working days *b. weekends*

FIGURE 8: Relative air humidity

For a complete analysis of the development of relative humidity, a graph for weekend days is also presented (Figure 8b). Relative humidity values show a stable trend from midnight to approximately 10:00 a.m. with relative humidity values ranging from 41.2% to 45.8%. It can be assumed that residents get up around 10:00 a.m. on weekends.

VIII. CONCLUSION

The results of the measurements capture the basic parameters of the indoor air. Based on the results of the measurements, it is necessary to evaluate with further analyzes whether the air circulation is sufficient to ensure a healthy internal environment of the building with a subsequent proposal of solutions on how to achieve and maintain a healthy internal environment without increasing costs in connection with the need for increased ventilation. We plan to process these data for the calculation of heat losses through ventilation.

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