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The forced ventilation analysis of panel block building pilot project

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The forced ventilation analysis of panel block building pilot project

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Abstract. The 21th century is characterized as a hectic age, which point out the inability of people to correctly understand and evaluate the physical parameter of the internal environment and microclimate. This misunderstanding often leads to the life endangerment in the way of carbon dioxide high levels and inappropriate living temperature. Latest technological development helps us to improve this situation by computational capabilities, which includes the possibility of measurement and collection data from long-term point of view. The contribution consists of long-term real-time measurement at panel block building pilot project in Brno, Czech Republic. The measurements are analysed and evaluated with respect to interior environment and microclimate requirements stated in Czech National Standards. The result comprise the proposals and simulations of internal microclimate, focusing on the carbon dioxide levels suggesting the most efficient forced ventilation unit operation, based on evaluation of measurement and simulations. The main asset is opportunity to regulate and optimize the forced ventilation units based on the simulation of the carbon dioxide level in the room, resulting in financial savings by proper regulation of the forced ventilation units and improving the microclimate of buildings.

1. Introduction

Low-carbon economy belongs to the main goals of European Union. The constant increasing of the requirements for the microclimate levels leads to the development of new technologies for its control and optimization. The contribute “*The forced ventilation analysis of the panel block pilot project*” point out the fact that in these days hectic age the people are not able to correctly evaluate the carbon dioxide levels and concentration. Therefore the long-term stay in such rooms leads to increased health risks and reduced working performance of individual residents, the main objective is to analyse selected panel block building room from temperature, relative humidity and carbon dioxide concentration point of view with the help of experimental measurements and the forced ventilation optimization based on computer simulation [4].

2. Carbon dioxide – measurement and concentration

The feeling of heavy and stifling air is often caused by carbon dioxide higher levels. Especially for air-tightly closed new building, where there is no automatic exchange of air and regular air exchanger is required. The concentration of carbon dioxide in poorly ventilated areas often exceeds 1 600 ppm (parts per million). In smaller and enclose, non-ventilated dormitories, the carbon dioxide level during the night may exceed 2500 ppm. According to these levels, it is not possible to rest during the sleep and in the morning rise with the sense freshness. The impact of carbon dioxide concentrations per living room inhabitant is shown in Figure 1[3].



CO CONCENTRATION IN AIR	INHALATION TIME AND SYMPTOMS
9 ppm	ASHRAE maximum allowable concentration for short exposure in a living area.
50 ppm	Maximum allowable concentration for continuous exposure in any 8-hour period.
200 ppm	Headache, tiredness, dizziness and nausea after 2 to 3 hours.
400 ppm	Frontal headache within 1 to 2 hours and life threatening after 3 hours. Maximum allowable amount (air-free) in flue gases.
800 ppm	Dizziness, nausea and convulsions within 45 minutes. Unconsciousness within 2 hours. Death within 2 to 3 hours.
1,600 ppm	Headache, dizziness and nausea within 20 minutes. Death within 1 hour.
3,200 ppm	Headache, dizziness and nausea within 5 to 10 minutes. Death within 30 minutes.
6,400 ppm	Headache, dizziness and nausea within 1 to 2 minutes. Death within 10 to 15 minutes.
12,800 ppm	Death within 1 to 3 minutes.

Figure 1. Carbon dioxide levels [3].

The main source of carbon dioxide in the interior is human breathing, where the concentration is although affected by cooking, the presence of animals (large dog release the same amount of carbon dioxide as adult human) and room plants. A sense of well-being is only possible with a sufficient oxygen supply. The concentration of carbon dioxide is measured in units ppm (parts per million), which express the number of carbon dioxide particles per one millions air particles.

According to statistical evaluations most people spend up to 90% of their day time in enclosed areas such as building interiors. Many times, the indoor air quality is worse than outdoor air quality. The evaluation of the air levels based on subjective feelings of cold, heat, exhaust air and odor gives us a signal to open windows and ventilation. An objective assessment of air quality is not enough. At present, it is becoming more and more popular to measure carbon dioxide concentration by data loggers [3].

3. Economic and technical attributes of the panel block building

The selected and afterwards analysed housing unit is located in panel block building situated in Brno, Nový Lískovec region on cadastral parcel with the area 434 m², 9 over ground floors and 32 housing units. The type of vertical structure is panel blocks. Figure 1 shows the location of pilot project and simplified selected housing unit floor plan.

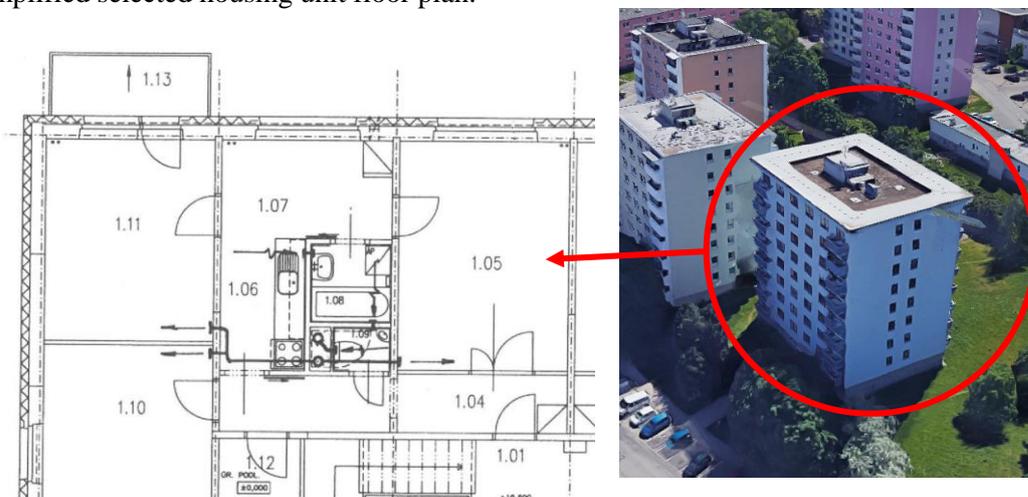


Figure 2. Location of selected housing unit with marked forced ventilation pipelines.

The residential unit is after a general reconstruction with the extra thermal insulation of the peripheral facades and the original wooden window replacement for the new triple-glass windows. The housing unit is inhabited by three persons, two of them aged 55-60 and one 28 years old. The time schedule of the inhabitants presence is show in Figure 2 [2].

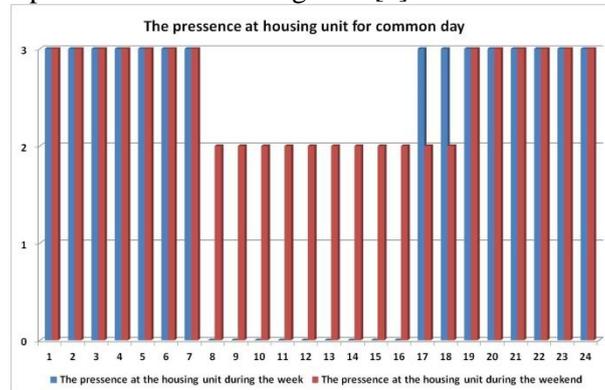


Figure 3. The presence at the housing unit.

The presence is based on individual interview with the inhabitants and is covering their common daily routine during the 24 hours, their presence. Based on the interview it is possible to state that inhabitants at the age 55-60 spend most of their time in unit by light physical activities, like watching television. The inhabitant at the age 28 spends most of its time in unit by working on computer.

4. The residential unit analysis

For the purpose of the residential unit analysis, there was chosen representative room, namely bed room based on which the analysis is divided into two parts, where the first part contains real-time measurements of relative humidity, carbon dioxide concentration in ppm units and indoor temperature provided by data loggers Comet. The second part contains the residential unit analysis and optimization of forced ventilation point of view [1].

4.1. The residential unit analysis – part one

The real-time measurement is based on data collection from four Comet sensors located in reference rooms of residential unit – two bed room, kitchen and living room. Following the statement in Chapter 4 as the reference room for the analysis was chosen the bedroom, where inhabitants aged 55-60 are sleeping.

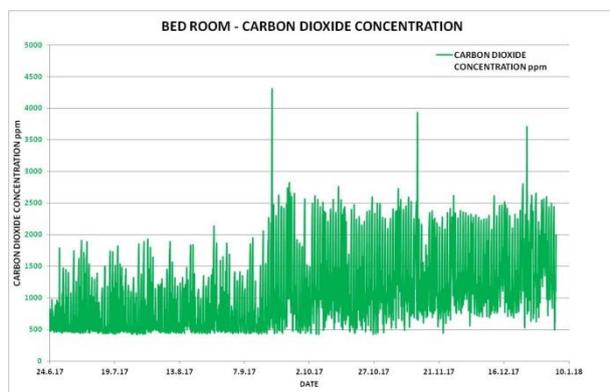


Figure 4. CO₂ concentration.

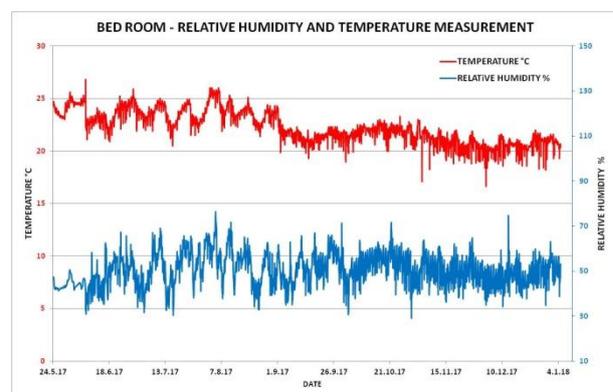


Figure 5. Temperature and relative humidity.

The highest temperature during the observed period was 26,8 °C, the lowest temperature was 16,7 °C and the average temperature 22,34 °C – shown at Figure 3 and Figure 4. Refers to the Czech National Standard – ČSN EN 12831 has the temperature at living spaces not overcome the boarder 20 °C for rooms such as bedroom due to health risks. During the measurement the temperature in in bedroom

overcome this border in 97,5 % of measured values, which from long-term point of view will leads to health problems. The data underlay the same proceedings as in article [3].

The highest relative humidity during the experimental measurement was 78,3 %, the lowest relative humidity was 29,2 % and the average relative humidity was 50,93 % - shown at Figure 3 and Figure 4. Refers to Czech National Standard – ČSN 060210, the relative humidity should be 60% due to health risks. During the experimental measurement was the relative humidity at the level 60 % for the 10 % of measured values which will from long-term point of view leads to health problems.

Based on provided experimental measurement it is possible to state, that the concentration of carbon dioxide at living area – bedroom was in intervals:

- < 1000 ppm 58,21 %
- 1000 – 2000 ppm 31,76 %
- 2000 – 5000 ppm 9,77 %

From health point of view 40% of measured values exceed border 1000 ppm, which resulted in concentration reduction, fatigue, approximately 10 % of measured values was in interval 2000 – 5000 ppm, which leads to headaches, fatigue and concentration reduction. Therefore, spending time in this room will from long-term point of view leads to health problems.

4.2. The residential unit analysis – part two

Based on experimental analysis for forced ventilation optimization was chosen as a reference day the Sunday 15.10.2017 at which measurement of the average carbon dioxide concentration values is shown in Figure 6. The physical activity during this day was set based in personal interview to the 150 W/m².

With respect to the boundary conditions and initial data for minimum carbon dioxide concentration 600 ppm – which refers to the average exterior carbon dioxide concentration, there was with help of MS Excel created carbon dioxide simulation during the reference day with the air exchange values 0,25; 0,5; 0,75; 1 h⁻¹. Figure 6,7,8,9 shows the graphical interpretation of carbon dioxide levels simulation, where after evaluation is possible to state the conclusion in form of recommendation for interior air exchanger value set to 0,25h⁻¹, due to the fact that by this value the concentration level will stabilize at the approximate value 600 ppm, which is from medical and economic point of view the most suitable technical solution.

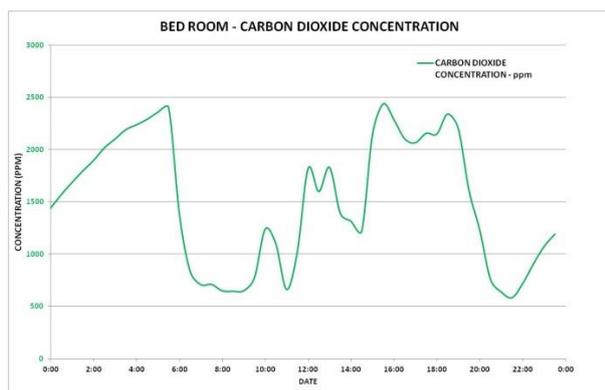


Figure 6. CO₂ concentration level.

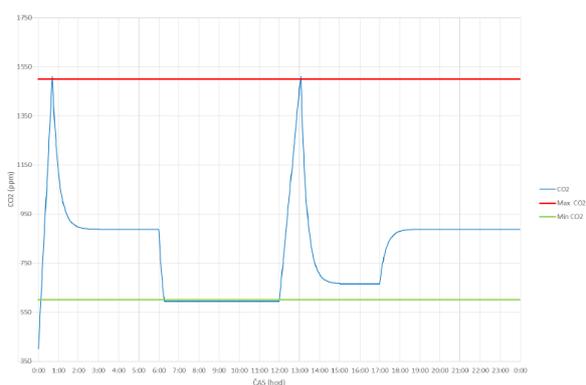


Figure 7. Air exchange: 0,25 h⁻¹.

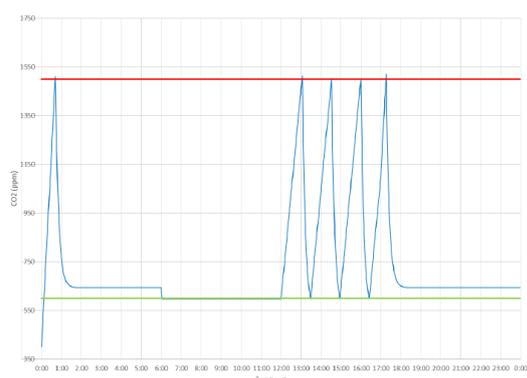


Figure 8. Air exchange: 0,5 h⁻¹.

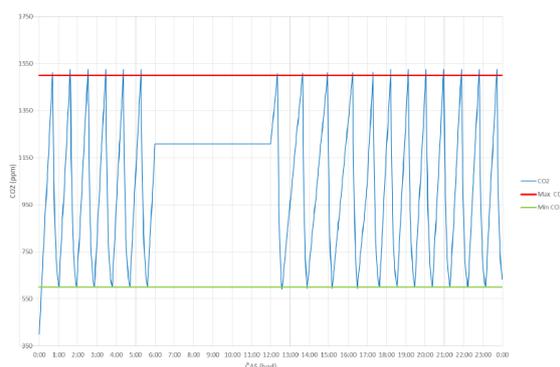


Figure 9. Air exchange: 0,75 h⁻¹.

4.3. The residential unit analysis – forced ventilation unit analysis

The forced ventilation unit at analysed panel block building is placed on roof top constructed by ATREA s.r.o. company with fabric name DUPLEX 2400 air condition unit with air recuperation. The composition consist of two ventilators AIRFLOW type 102GTL/4, recuperation heat exchanger hPs-K-B Duplex, two filters ATREA type G4 520 520 x 2050 mm, bypass, controlling and safety components. The air condition unit on the roof top is currently out of order due to the contamination of both filters with dust and other particles. After visual exploration it is possible to say that both recuperation heat exchanger and bypass are in good condition. The air handling unit is undamped, with construction connected directly to the roof construction. Air condition system is currently out of control due to swirl pad fully opened (Figure 10 and Figure 11).

Due the fact that air condition unit is out of order, the panel block building inhabitants were complying about the smell coming out of air distribution pipelines and solved this problem by connection their own supporting ventilator into the air condition system.

Winter operation is based on recuperation heat exchanger usage for partial incoming air heating with two ventilators operation. Summer operation is based on bypass usage and rejection of recuperation heat exchanger with one ventilator enhancing the outcoming air – the incoming air is naturally flowing.



Figure 10. Detailed filter photo.



Figure 11. Air unit overview.

5. Conclusion

Based on the experimental analysis elaborated during the time period from 24.05.2017 to 05.01.2018 it is possible to clearly see, that housing unit will not satisfy Czech National Standard ČSN EN 12 831 and ČSN 060210 in the values of temperature in more than 93 % and the values of relative humidity in more than 93,5 % of total time. The concentration of carbon dioxide in housing unit overcome the border 1000 ppm at which people will start suffer from health problems in more than 31,2 % of total time. To be able to resist this dissatisfaction and to avoid health problems caused by spending time in such as area, where the current state is inappropriate and insufficient it is necessary to design forced air

circulation respecting the economy, environmental and energy point of view. The article “The forced ventilation analysis of panel block building pilot project “provide complex analysis of reference room and gives recommendations about optimization of the forced ventilation unit presenting. The most important conclusion is that the ventilation unit is currently out of order due to the heavy dust sedimentation at filters and possible electric wires failure, where the recommendation is revitalization of current air condition unit, in the way of replacing damaged components and presenting the air exchange to the value specified in building simulations.

6. References

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