# VENTILATION AND AIR INFILTRATION IN RELATION TO THE INDOOR AIR QUALITY AND ENERGY CONSUMPTION OF TYPICAL POLISH BUILDINGS

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## Abstract

The theoretical and experimental study of heat losses and energy consumption and its influence on the air quality in buildings has been undertaken by The Silesian Technical University since 1980. The heat consumption of buildings is influenced by the thermal insulation of buildings components, airtightness of these components and the types of ventilation systems. Simultaneously, the thermal comfort and also air quality is influenced by the modern building material and different types of buildings. The important results of investigations and the analyses of impact air infiltration and ventilation on both energy consumption and air quality in typical Polish buildings have been presented below.

## Introduction and scope of work

Fig. 1 illustrates the main directions of the experimental and theoretical study, which is based on the weather conditions, requirements for internal conditions, the building and types of ventilation and heating characterization. Heat consumption can be expressed as follows (Fig. 1):

$$Q(\tau)=f\{k_m, [a_m, \Delta p(\tau), c_g(\tau)] \text{ or } n(\tau), t_w(\tau), t_z(\tau), S, \varepsilon\} \quad (1)$$

The first aspect of this study concerns the measurements of all the factors in dependence (1) for existing buildings (are built prefabricated panels) with the natural and mechanical ventilation. These investigations have also given data to the question of minimum air ventilation rate (including air infiltration) that is necessary to achieve the desired air quality and possibilities of heat reduction.

In the second point of study to the usage of psychicomathematical model of air and heat flows in buildings. This problem is solved by the realization of air and heat flow balances in different models of buildings (the constructional elements and motive parameters of ventilation and heating systems have been taken into account).

The analysis of the large number of research works results have given data concerning the energy consumption for economic consideration and acceptable air quality and thermal comfort.

## The important results of measurements and analyses

The research work has been done in about two hundred buildings, that were built from prefabricated panels in the Silesia district of Poland (Fig. 2). The particular results have already been presented in literature (1, 2, 3, 4, 5). In this paper a short analysis of some results is presented in Table 1.

Table 1. Some results of measurements (in winter)

| Specification | | Buildings A | | Buildings B | |
|---|---|---|---|---|---|
| | | min/max | average | min/max | average |
| Air flow coefficient ($m^3$/mh) at 1 daPa | windows | 4.0/8.0 | 5.2 | 3.0/6.0 | 3.8 |
| | fl.-wall joint | 1.5/5.0 | 2.2 | 0.8/4.0 | 1.6 |
| | doors | 15.0/30.0 | 20.8 | 5.8/30.0 | 15.3 |
| The air change rate, ($h^{-1}$) | | 0.0/3.5 | 2.0 | 0.8/1.5 | 1.1 |
| Air temperature, ( °C) | | 13.2/28.7 | 19.5 | 17.4/24.0 | 18.8 |
| Air velocity, (m/s) | | 0.05/0.7 | 0.35 | 0.05/0.3 | 0.15 |
| Co-levels, (mg/$m^3$) | | 0.02/0.23 | 0.12 | - | - |

These results prove that there are accidental conditions, especially in blocks with the natural ventilation (buildings A). Characteristics for these results is the great value of standard deviation of all measuring factors. The CO-concentration has surpassed permitted one and the air velocity in the vicinity of windows has been greater than allowed one. The kinetic energy of the air infiltration is similar to the kinetic energy of convective flux of man's body (0.1÷0.2 mW/$m^3$). The air infiltration rates of external walls vary considerably with values of 2 $m^3$ to 3.5 $m^3$ per m sq. of the wall area at the pressure difference of 5 daPa. The average air flow coefficient is about 1.1÷1.4 W/$m^2$K and is similar to the average thermal transmittance of gross enclosure area. The ventilative heat losses (including air infiltration) is to 60 % of total heat losses.
In the blocks with mechanical ventilation (exhaust) the air flow is slightly influenced by the weather. In such cases both ventilation action and air quality are in accordance with required ones.
The ventilative heat losses equal 30÷50 % of total heat losses (about $50 \cdot 10^6$ KWh/year).

The results of calculations for physico-mathematical models of building provide a material for estimation of the air infiltration and heat losses reduction in existing and build in future blocks (4, 5). These results show that thermal insulation is good (according to the rules of new Polish Norms) the energy spent for heating the cold incoming fresh air amounts up to 60÷70 % of the total energy required for heating (for buildings B).

The important problem here is the necessary fresh air can be



The minimum air change rate must be between 0.5 $h^{-1}$ and 0.6 $h^{-1}$ but the natural ventilation gives no possibilities of the regulation of air flow in high rise buildings and the mechanical is necessary in these blocks.

## Conclusion

The possible energy reduction accomplished by heat losses limitation and air quality criteria are:

Increasing thermal insulation of buildings to the optimal heat transfer coefficient of gross enclosure area ($k_m$) lower or equal 1.0 W/$m^2$K (the energy saving is of $4 \cdot 10^6$ to $0.18 \cdot 10^6$ KWh/year for testing buildings).

Decreasing air leakage through external walls. The coefficient of permeability to air flow must be lower (or equal) 0.2 $m^3$/mh at 1 daPa. This value is an absolute maximum (the energy saving is $10 \div 11 \cdot 10^6$ KWh/year for examined blocks).

Supplying the necessary fresh air (minimum 15÷20 $m^3$/h per one person) in the controlled manner by using ventilation system (about 20÷40% reduction of real heat losses in testing blocks).

Applying waste heat recovery (about 65% reduction).

The total amount of energy saving is about 30÷60 % of recent energy consumption (Fig. 3 and Fig. 4), if there only is the increase of thermal insulation and decrease of air flows outside - inside (for one block that gives 7÷8 millions zlotys per year).

## References

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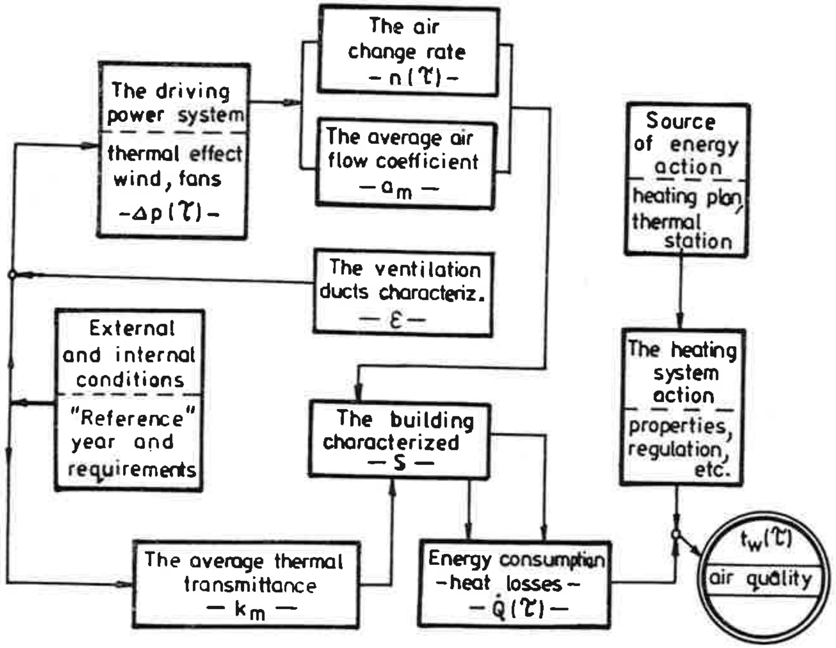


Fig. 1. Main ways of the measurements and analyses of heat demands and energy consumption buildings.



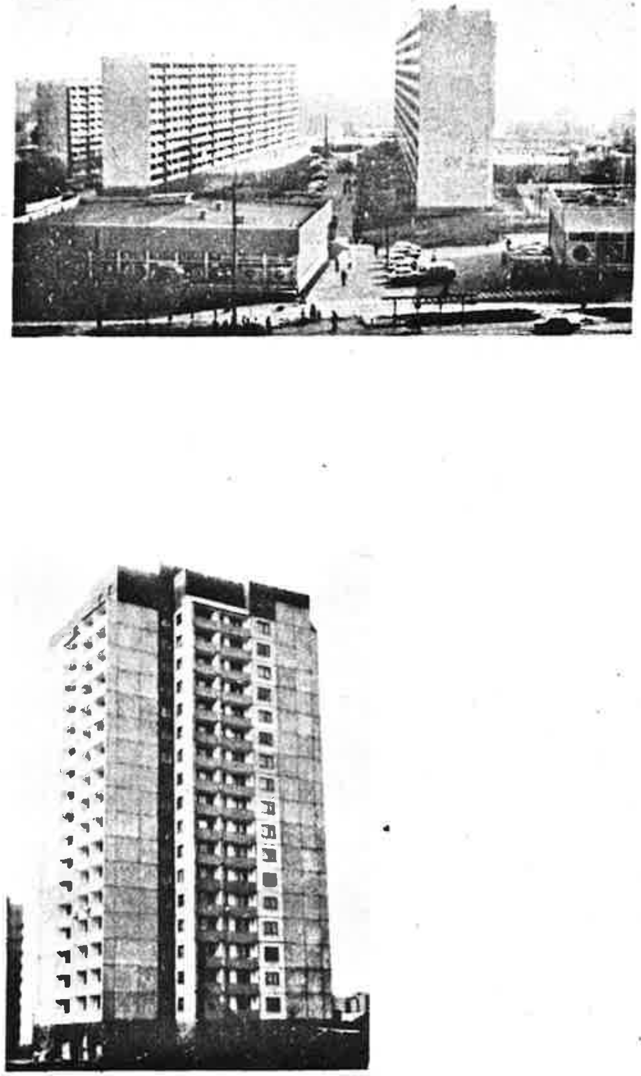

Fig. 2. Types of testing buildings (view).

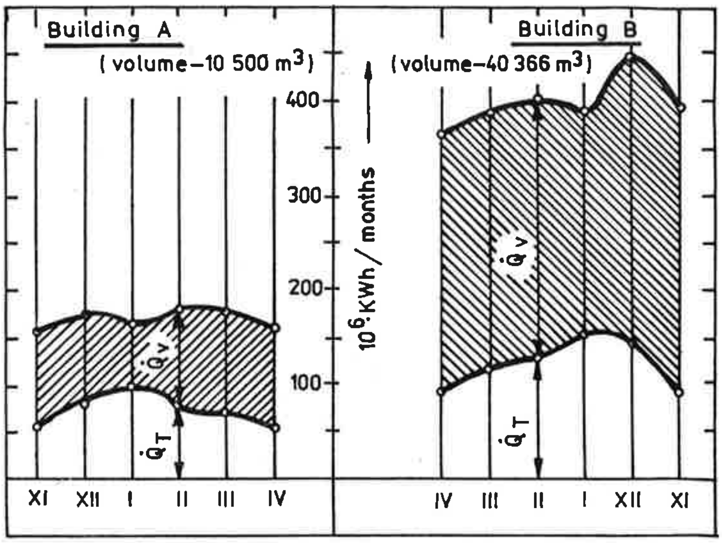


Fig. 3. Monthly heat demanded in existing buildings
$Q_T$ - Transmission heat loss
$Q_V$ - Ventilation heat loss (including air infiltration)

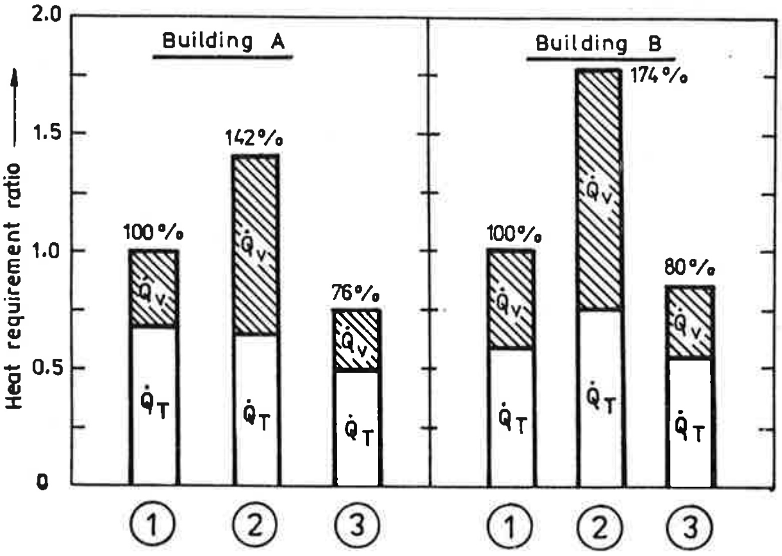


Fig. 4. Heat losses for different conditions.
1- Calculated according to the Polish Standards
2- From measurements
3- For economic consideration

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