Air Conditions Mod in Building during Local Fire

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Abstract. The statement of the problem of the air condition of a building in case of a local fire in a room differs from the traditional form of recording the excess pressures at each considered point of the external or internal environment. In this paper, an example of calculating the air regime of a seven-story residential building in case of a fire in an apartment hall is considered.

1. Introduction

The traditional method for calculating the air condition of buildings with the same room air temperature (hereinafter "method 1") [1-4] involves subtracting the excess gravity pressure of the internal air at each horizontal level from the excess pressure of the outside air. This difference is the external boundary condition for the calculation of the air condition of the building. Due to the removal of the gravity component of the pressure in the internal air outside the building, a constant air pressure was achieved in each room along its height.

The main difference between setting the problem of the air mode of a building with different room air temperatures ("method 2") is to set its own excess pressures at each point. When calculating by "method 2", the removal of the gravitational component of the internal air is impossible, since the temperature of the internal air in different rooms can be different. As an example, Fig. 1 shows the distribution of pressures along the height of a seven-story residential building with the same room temperature, equal to tint = 20 °C, at an outside air temperature text = -28 °C and no wind.
The gravitational pressure of the internal air must be determined taking into account the different air density at the overlying points [5]. Since different rooms are connected with the atmosphere by different vertical aerodynamic paths, the gravitational overpressure on one horizontal level can be different. Moving along aerodynamic connections, air with different temperatures mixes, and thus the distribution of temperature and pressure across the building is formed.

The process of calculating the air condition of a building is iterative with a set of interacting variables: temperature, pressure and airflow in various elements of the building and ventilation network, aerodynamic resistance of tee ventilation systems, depending on the air flow ratio. Therefore, it is necessary to use various auxiliary measures to improve the convergence of the calculation process.

2. Objective of article and research

The purpose of this paper is to demonstrate the feasibility of applying the proposed "method 2" in the practice of smoke removal in a fire in multi-storey buildings, for example, to detect the difference in pressures on closed doors or to verify the correct directions of smoke and supply air at the selected smoke removal and external airflow.

The calculation of the air regime of the seven-story apartment house was carried out, in which an apartment in the apartment on the lower standard second floor is in a fire. The building of seven floors is taken as a debug option.

Suppose that when a fire in the apartment is allocated 12800 kg/h of smoke with a temperature of 400 °C. Through the smoke exhaust valve, which is located in the common housing hall, 12800 kg/h is also removed. Equal costs (combustion products and smoke-air mixture through the valve) are chosen to determine the path of smoke propagation with equal or insufficient extraction through the smoke exhaust valve.

In the staircase of the second type, 12160 kg/h of air is fed, the temperature of which, according to [6], is taken as the average between the external text = -28 °C (out) and the inner tint = 20 °C (in
rooms), that is equal to \( t_s = -4 ^\circ C \) (supply air). The doors to the evacuation of people from the burning apartment are open. Thus, the doors of the apartment itself, the apartment hall, the stairwell on the floor of the fire and on the ground floor are open, as well as the entrance doors to the building. All other doors of the house are closed. The calculated floor plan is shown in Fig. 2.

![Figure 2](image)

**Figure 2.** The calculated plan of the 2nd floor with the directions of air flows and temperature.

![Figure 3](image)

**Figure 3.** Dependence of the temperature of the exhaust air in the tee (a) and the sum of the costs (b) of air in the apartment.

Through the exhaust grilles of natural ventilation systems from the height of the building:

- ▬ ♦ ▬ BE-1 - a system of natural ventilation in an apartment without a fire;
- ▬ ■ ▬ BE-3 - natural ventilation system in an apartment with a fire center

The calculation is carried out in the mode of steady fire with closed dense apartment doors (except for the apartment with a fire) and open doors on the way of evacuation. The fire is located in the
corridor of a one-sided two-room apartment. In the calculation, doors with an air permeability resistance were adopted with a pressure difference $\Delta p = 10$ Pa, equal to: $0.16 \text{ m}^2/\text{h}$ in a staircase, $0.16 \text{ m}^2/\text{h}$ in a hall of a lobby, $0.3 \text{ m}^2/\text{kg}$ in a flat/kg. Pressure differences in closed stairwell doors, entrances to apartments and pre-apartment halls prior to a fire are given in Table 1. According to the norms [8-10], the difference in pressure on both sides of the door on evacuation routes during a fire should not exceed 150 Pa. This important point, unfortunately, is difficult to calculate with a manual account.

In the practice of calculating smoke removal systems and supports in buildings with staircases of the 2nd type, it is noted that it is difficult to keep the difference in pressure on the doors within the limits of the norm, which was confirmed by calculations in the computer program. The large difference in pressure on the doors is explained by the fact that the evolved smoke consumption is compensated by the exhaust through the smoke exhaust valve, and the supply of fresh air supplied to the stairwell is not compensated for and creates an increased pressure on the way of its spread. But in fact a fire, especially in the beginning, may not reach the calculated power, and then a part of the fresh air will escape through the smoke exhaust valve, which will sharply affect the pressure value. In addition, at such significant pressures, air permeability of walls begins to play a role, which was not taken into account here. And one more factor: in the seven-story buildings neither a smoke exhaust system nor staircases of the second type are envisaged. With included smoke removal systems and external air inflow in a seven-story building, the pressures created by the support in the stairwell of the 2nd type are too large. In high-rise buildings, the pressure, of course, will be less, since the same air flow will spread over a larger number of floors. Therefore, the values of the difference in pressure on the doors presented in Table 1 can be regarded as an idealized case.

| Table 1. Pressure drop on both sides of the closed doorway before the fire, Pa. |
|---------------------------------|-----------------|-----------------|
| The type of doorway              | Before the fire | During the fire |
| Stairwell                       | +1,2…−5,2*     | up +3000        |
| Entrance to the apartment        | +11,9…−6,9     | 0…−1800         |
| Apartment hall                   | 0…−8,8         | up −3000        |

3. Conclusions

Based on the results of calculations, we can draw conclusions:

The fire in the building significantly changes the pattern of airflow distribution in the building. The greatest impact is on the fire ventilation.

1. The absence of a smoke removal system leads to a rapid spread of heated air and smoke through the building (it can be judged by the cost of hot air), which leaves little time for evacuation of people (in a seven-story building, the smoke removal system is not arranged).

2. The system of natural ventilation, located in the immediate vicinity of the fire, partly takes on the function of smoke removal and passes through its barrel air with a sufficiently high temperature, despite the associated mixing with air from higher floors.

3. The existing special automatic system for temporarily reducing the pressure in the staircase, allowing to open the door to a staircase or hall, may not be sufficient, as increased pressure differences are observed not only on these doors, but also at the exits from the apartments.

4. The temperature values obtained in different parts of the building can be relied on only conditionally, since the calculation did not take into account the thermal conductivity and heat capacity of the enclosing structures and the posterior separation of air flow on the floor in height.

5. The developed program for calculating the air conditions of buildings with different room temperatures can be useful for calculating the difference in pressure on the doors, checking the location of the smoke valves and other aspects of fire protection.
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