Deflector role in formation of apartment air exchange of the multistorey building

Kaminat Agakhanova*

Moscow State University of Civil Engineering, Yaroslavskoe shosse, 26, Moscow, 129337, Russia

Abstract. The purpose of this article is to identify capability of deflectors to raise air consumption over an expense, formed in system with a hood, and assessment of efficiency of this unit for application in the nineteen-floor residential building in the conditions of Moscow. This research is performed with the help of a calculation method on the electronic computer in the Matlab programming language. In the research we perform multiple calculations of the air mode of the residential building. The object of the research is a section of the nineteen-floor residential building. In the building the natural system of supply and exhaust ventilation is designed, which comes to an end, in the first case, with a hood, in the second –with the deflector TsAGI. Calculations were carried out in parameters of external air of winds of various directions in January. The results of calculations show whether installation of the deflector in the system of natural ventilation exceeds an air consumption over an expense, formed in system with a hood. On the basis of the received results recommendations about improvement of air exchange of apartments of the multistorey building are made.

1 Introduction

On the one hand, everyone knows that on the top floors the most part of time standard air exchange isn't provided. At the same time on the first floors the most part of the cold period of a year the surplus of an expense is observed. Deflectors are used to increase consumption of ventilating air on the top floors. It is known that the deflector strengthens a suction from a ventilating duct at the expense of a wind pressure.

2 Results of calculation

For identification of a possibility of deflectors to raise air consumption over an expense, formed in system with a hood, it is necessary to calculate the air mode of the residential building. It was performed by a calculation method. The calculation procedure is presented in [1].

As an object of a research, the section of the nineteen-floor residential building with the lift hall, apartments, a corridor in which there are doors of apartments and the lift hall, and a

* Corresponding author: kaminat29@mail.ru

smoke-free ladder N1 (figure 1) is accepted. The smoke-free ladder H1 is separated from the common part of the building, you can get there from the floor through an external part of the section along open corridors. Residential floors are from the 2nd to the 19th floors inclusive. Over the last residential floor there is a service attic that is not heated. On each residential floor (from the 2nd to the 19th floor) there are three apartments: two 2-roomed: one of them is with bidirectional orientation (apartment 1), and the other is one-directional (apartment 2); one 3-roomed apartment is with the windows on two opposite facades (apartment 3). In the section it is designed the lift hall with passenger elevators from which on each floor there is an exit to an evacuation smoke-free ladder and to an intercourse corridor. On each floor the doors of all three apartments and the ladder and lift hall come into contact with the mentioned above common corridor.

Section 1

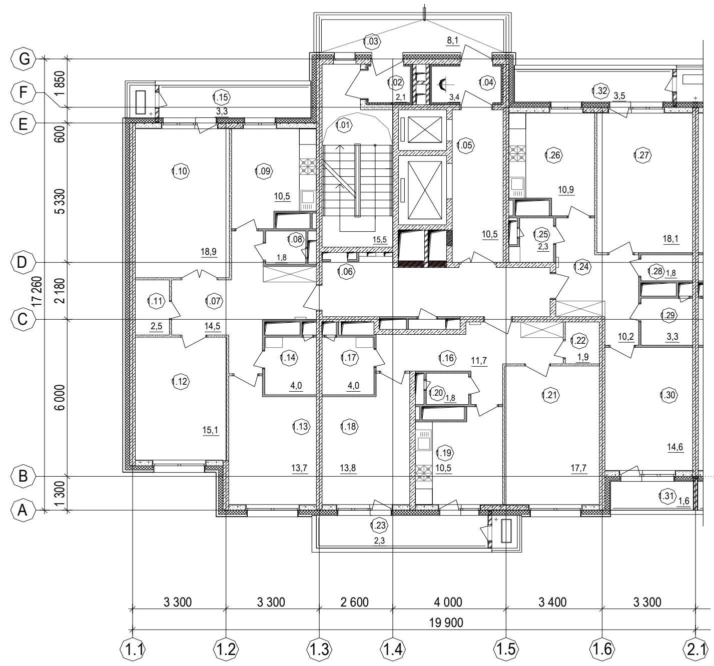

Fig. 1. Plan of the standard floor of a section of the nineteen-floor house.

In the research we consider the natural system of a supply and exhaust ventilation in premises which is performed according to [2, 3, 4, 5, 6]. Air flow to premises is carried out through a rotary and folding shutter of a window or through the leakages of closed windows, and removal is done via individual exhaust ducts from each exhaust device – an exhaust grid (figure 2). Two last floors are ventilated with household fans. Removal of air is provided from kitchens, bathrooms and bathroom units in volume of [3]:

– from a kitchen - 60 m^3/h;

– from a bathroom – 25 m^3/h;

– from bathroom units – 25 m^3/h.

The consumption of fresh air has to compensate an expense of the removed air by opening windows at least in one room or a kitchen.

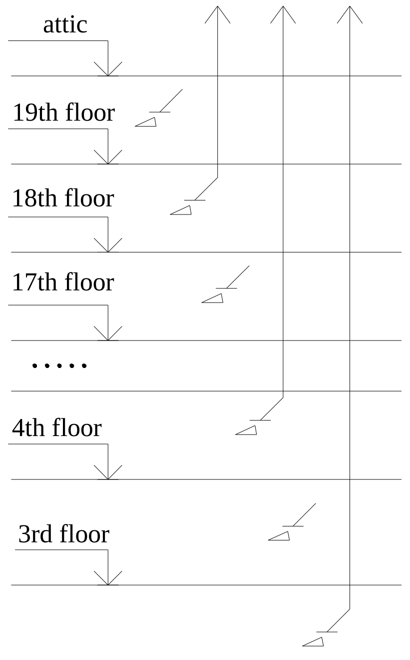

Fig. 2. The scheme of the ventilation system with individual exhaust ducts from each exhaust device.

Currently, one of the ways to improve the work of natural ventilation system is to use deflectors [3, 7]. Therefore in the research we performed multiple calculations of the air mode in the section of the nineteen-floor residential building in which ventilation systems come to an end in the first option with the hood, in the second - with the deflector.

Deflectors are recommended to be installed in exhaust shafts of rooms with insignificant excess of heat. The deflector transforms energy of a stream of the rushing wind into depression at the entrance of the shaft that strengthens an extract from rooms [8, 9]. In the research the deflector TsAGI (figure 3a) is accepted [10]. The depression created by the deflector depends on the speed of wind of v_w and is determined by the graph (figure 3b).

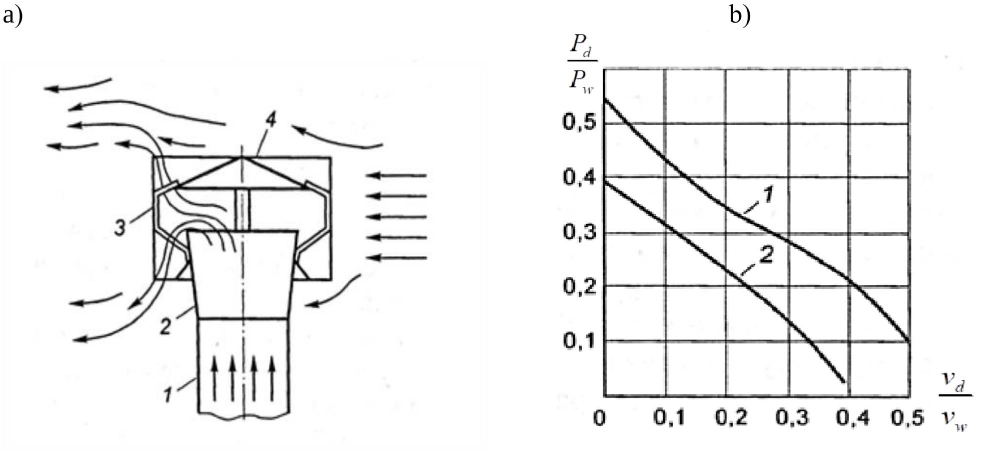

Fig. 3. The deflector TsAGI and the graph for its selection: a) scheme of the deflector TsAGI: 1 – the exhaust shaft, 2 – the deflector frame, 3 – a windbreaker, 4 – a hood; b) the graph to determine the depression created by the deflector: 1 – for the deflector of circular cross-section, 2 – for the deflector of .square cross-section.

Knowing wind speed, we determine speed in a deflector branch pipe:

$$v_d = (0,2 \div 0,4) v_w \tag{2.1}$$

v_w – speed of wind, m/s.

Taking into account the ratio between the depression created in the deflector by the P_d, Pa, and the high-speed wind pressure, P_w, Pa, (figure 3b) we calculate the value of the depression created by the deflector, Pa:

$$P_d = \frac{P_d}{P_w} \cdot \frac{v^2}{2} \rho \tag{2.2}$$

P_d – the depression created in the deflector by wind, Pa;
P_w – high-speed wind pressure, Pa;
ρ – density of internal air, m^3/kg.

Calculation of the air regime performed with the help of a calculation method on the electronic computer in the Matlab programming language for January, as for the most adverse month under the terms of operation of buildings. Parameters of external air of winds of various directions and their repeatability for Moscow are presented in the table 1 [11].

Table 1. Air temperature, average for January, ^0C, repeatability, %, and speed, m/s, winds of various directions for Moscow.

Populated area	Unit of measurement	Wind Direction								
		N	NE	E	SE	S	SW	W	NW	Dead Calm
Moscow	^0C	-13,3	-15,7	-11	-5,1	-4,1	-4	-5,5	-8,9	-7,5
	%	8	4	6	12	18	24	18	10	7
	m/s	4,6	4	4,6	4,4	4,5	5,4	3,7	3,6	0

In Figures 4-7 results of calculation of the air mode of the first and second apartments of a nineteen-floor house are presented, in each of which one rotary and folding shutter of a window of the living room is open or windows are closed. Calculations are carried out for various parameters of external air (table 1) for the following options:

1. ventilation systems come to an end with a hood, windows are completely closed;
2. ventilation systems come to an end with a hood, one rotary and folding shutter of a window of the living room is open;
3. ventilation systems come to an end with the deflector, windows are completely closed;
4. ventilation systems come to an end with the deflector, one rotary and folding shutter of a window of the living room is open.

The received results of expenses of air are compared to standard values.

https://doi.org/10.1051/matecconf/201825103044

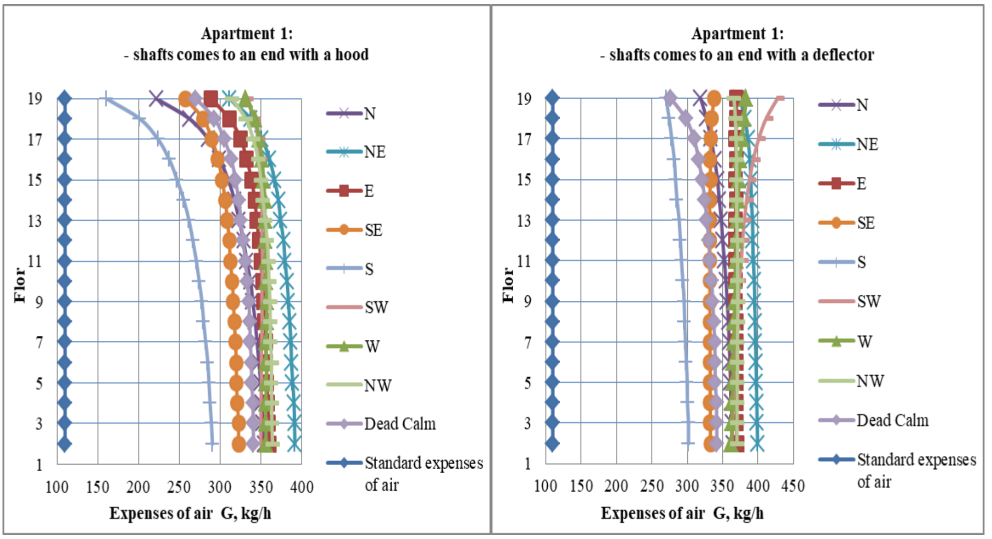

Fig. 4. The graph of expenses of air to the apartment 1 with an open rotary and folding shutter of a window for various parameters of winds of various directions.

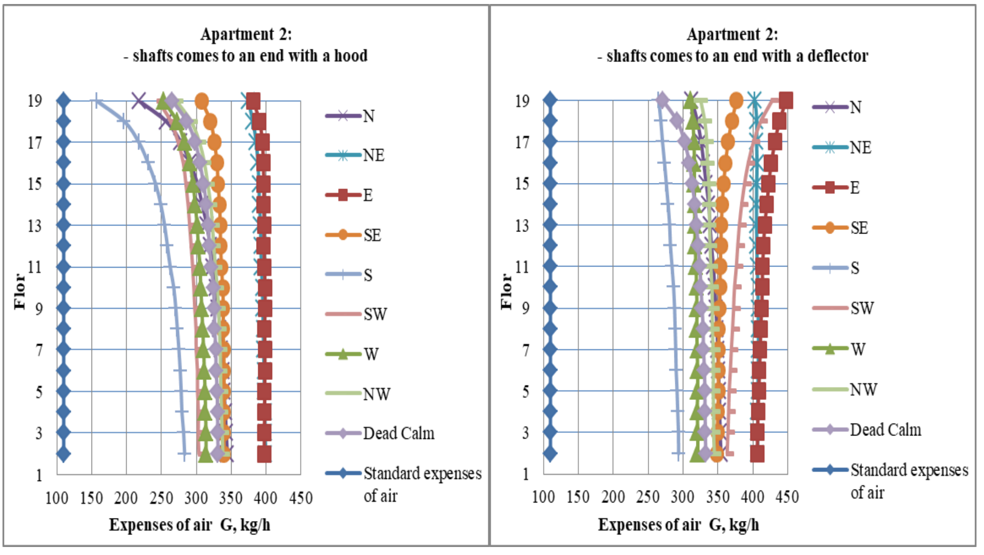

Fig. 5. The graph of expenses of air to the apartment 2 with an open rotary and folding shutter of a window for various parameters of winds of various directions.

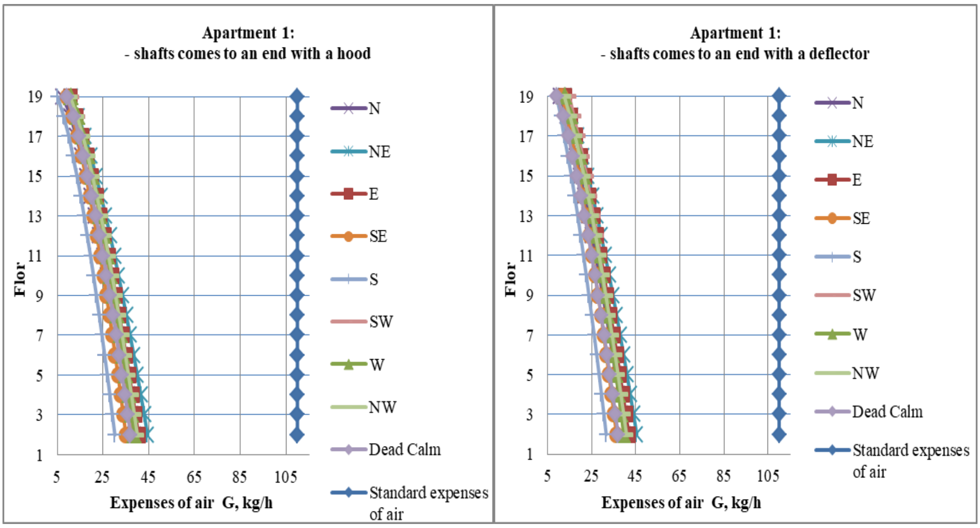

Fig. 6. The graph of expenses of air to the apartment 1 with the closed windows in apartments for various parameters of winds of various directions.

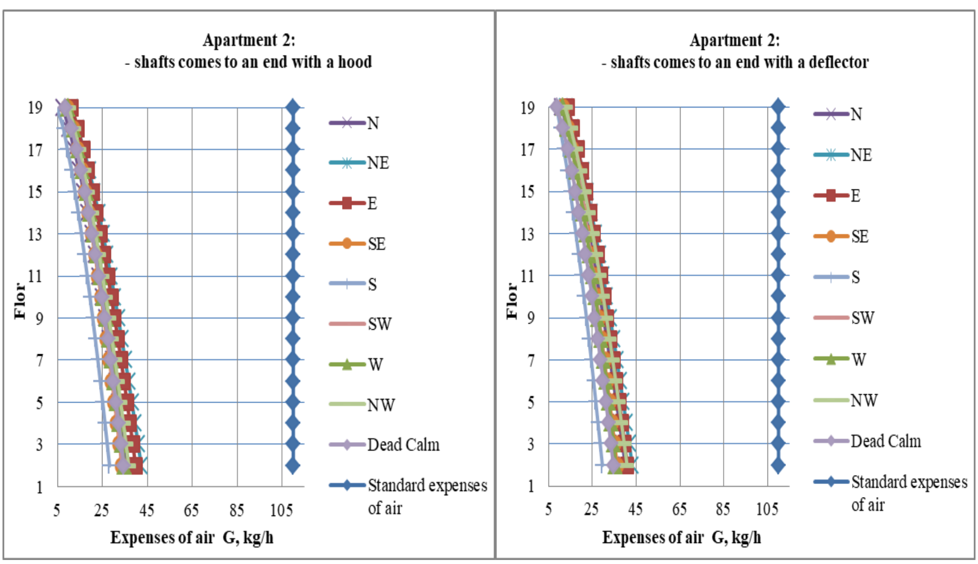

Fig. 7. The graph of expenses of air to the apartment 2 with the closed windows in apartments for various parameters of winds of various directions.

3 Conclusions

The analysis of the received results shows that installation of the deflector slightly increases consumption of the removed air in comparison with an expense by the entrance of the air shaft of the natural exhaust ventilation system, formed in system with a hood. When one rotary and folding shutter of a window of the living room is open the surplus of an expense is observed, windows are completely closed - the lack of flow. Air exchange of apartments does not correspond to standard data. It is possible to regulate air exchange by opening and closing of window leaves. In apartments where there is a surplus, it is possible to leave an opening or to air from time to time.

References

1. K.M. Agakhanova, Calculation of Air Regime of a Residential Building with Individual Exhaust Ducts, XXI International Scientific Conference on Advanced in Civil Engineering "Construction - The Formation of Living Environment" (FORM 2018), IOP Conference Series: Materials Science and Engineering, Volume 365, 2018.
2. SP 60.13330.2016. Heating, Ventilation and Air Conditioning. Updated revision of Regulations 41-01-2003 (Department of Architecture, Construction and Urban Policy, Moscow, 2016)
3. SP 54.13330.2016. Multicompartment Residential Buildings. Updated Revision of Regulations 31-01-2003 (Department of Town-Planning Activity and Architecture of the Ministry of Construction and Housing and Communal Services of the Russian Federation (Minstroy of Russia), Moscow, 2016)
4. STO NP «AVOK» 2.1-2008. Residential and Public Buildings. Air Exchange Rates (NP «AVOK», Moscow, 2008)
5. TO-06-17640. Manual on the Design Concepts of Ventilation System and Smoke Ventilation in Residential, Public Buildings and Parking Area: Examples of Diagrams and Solutions. Fire-resistant Ducts. Fire Dampers and Smoke Flaps (OJSC «Mosproject», Moscow, 2007)
6. R NP «AVOK» 5.2-2012. Technical Advice on Air Renewal in Apartments of Residential Buildings (NP «AVOK», Moscow, 2012)
7. V.P. Kharitonova, Natural Ventilation with Inducement, AVOK, No. 3, 2006
8. V.G. Zalesskiy, Deflectors and Their Application for Ventilation of Residential Premises (Moscow, 1970)
9. K.A. Ushakov, Atlas of Fans and Deflectors, (Central Aero-hydrodynamic Institute N.E. Zhukovsky, Moscow, 1934)
10. E.I. Tertichnik, Ventilation (Stroyizdat, Moscow, 2015)
11. A.I. Kruglova, Climate and Building Envelope (ASV, Moscow, 1970)