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Indoor climate in contemporary buildings

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Summary

Microclimate in contemporary residential buildings is nonconforming, because packaging constructions are too tight. In the aspect of presence of people is the most important thermal-moisture microclimate.

To guarantee optimal temperature in an interior can be quite simple, but to achieve optimal relative humidity can be problematic. But mildew emerges from higher relative humidity. It is important to guarantee sufficiency of ventilation air in the rooms, especially in winter period. Winter is the highest-risk period for increasing the relative humidity and following arise of the mildew.

This entry is comparing results of intensity of natural ventilation in various types of contemporary buildings.

KEYWORDS: indoor climate, contemporary buildings, relative humidity, natural ventilation, exfiltration, infiltration

1. INTRODUCTION

This entry intends to verify the authenticity methodology of computation of buildings ventilation. It especially determines more accurately interdependence parameters of leakage window chink of ventilated room size in the case of meeting existing hygienic requirements and conditions for protecting engineering construction (such requirement is for example moisture outlet).

At computations air change rate was not taken into account effect of under pressure ventilation bathroom and toilet to other rooms. Considering limited range of this article it is impossible to describe all the computations, which we have made. To make the computations more understandable I added a table to the last part of each of them.

Below in the text I am using a help term „diagonally ventilated flat“. Diagonally ventilated flat is a flat, which windows are situated on the opposite sides of building facades. On the contrary not diagonally ventilated flat has windows only on one facade.

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As basis of computations all three examples of natural ventilated rooms are taken into account flat 3+1. Disposition of this flat in a panel house has total volume of all the rooms 160m3.

2. VENTILATION IN CONTEMPORARY BUILDINGS

2.1. Problems of heat consumption for ventilation

Almost 4 million people in the Czech Republic live in panel houses. Majority of older panel houses are not corresponding to the standard ČSN 73 05 40 (thermal buildings protection) nowadays. Expensive reconstructions of panel building are passing through – heat cladding facades, changing original wooden windows to plastic, glazzing loggia as well. We are packing flats to save money for energy.

But how big is the importance of these changes to the flat natural ventilation? Well, all the buildings are so tight now that the infiltration rate is so minimal – the air supply by the chink in construction’s blocking.

Nevertheless each household is producing moisture – by evaporating from the flowers, by cooking, by bathing etc. As far as the draining away of this moisture is not solved, due to it can be inception of moisture and degradation of engineering construction (rot). There is only one possible solution how to reduce relative humidity. It is ventilation, which at the same time ventilates others injurants from the interior (CO2, formaldehyde etc.) and ensures the supply fresh air into the flat.

Is it possible to count only on infiltration by window chink in so tight objects?

Does not mean heat cladding facade, new tighter windows, possibly glazed loggia periodical opening the windows for ventilation, so that to ventilate the room actually?

Will not be necessary to wake up each 1,5 hour and perfectly air all the room?

In this entry author presents how much energy do we use up for prescribed necessary hygienic need on air change rate in the room. How does differ from each other the heat consumption for ventilation by infiltration, exfiltration or standard 0,5times air change rate per hour for definite flat in the panel house?

2.2. Ventilation by wind with its different speed during the year – INFILTRATION

The main part of the wind effect ventilation in the flat takes not only the wind speed, but the flat position too. We consider a wind speed in variants of 2,5m/s; 5m/s; 10m/s.

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The air change rate in the flat grows according to the velocity of wind. Flats in the ground floor of the buildings are mildly ventilated by wind in comparison with the flats in the upper floors, which are ventilated intensively.

It is valid the rule of wind influence to the buildings. Wind speed is increasing with the building height. And that is why the flat in the eight floor is more ventilated then the flat situated in the first above-ground floor.

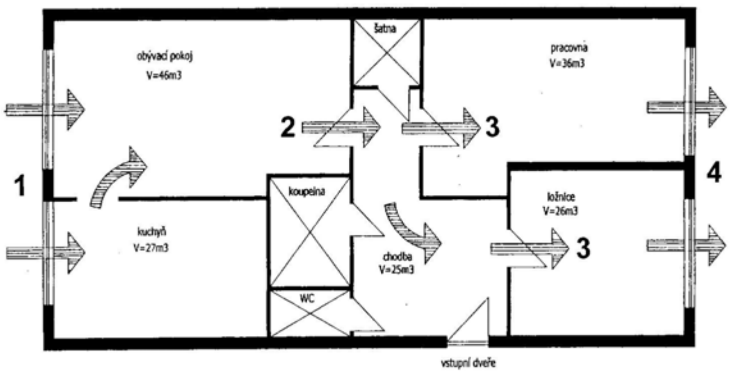

Figure 1. Ground plan of the flat – wind effect ventilation - INFILTRATION

Of course we consider flat position in the computations. We choose different coefficient leakage window chink and variants closed or opened interior doors in the flat in computations as well.

2.3. Ventilation by static pressure effect in the stair's shaft – EXFILTRATION

Lower flats are intensively ventilated, namely at not tight openings and chinks in the upper part of stair's shaft. When the inner stair's shaft is connected through the flats on exterior the ventilating air from the lower flats can get into the upper flats namely when

- Entry flat's door is not tight
- Lower flat's windows are not tight or opened

For ventilation by static pressure effect in the stair's shaft is important that

- Upper flats are practically not ventilated from the exterior. But air is pressed from lower flats to upper flats through the stair's shaft (by inner stair's shaft).
- On the contrary lower flats are intensively ventilated by exterior air, the air is sucked up to them under pressure through the stair's shaft.

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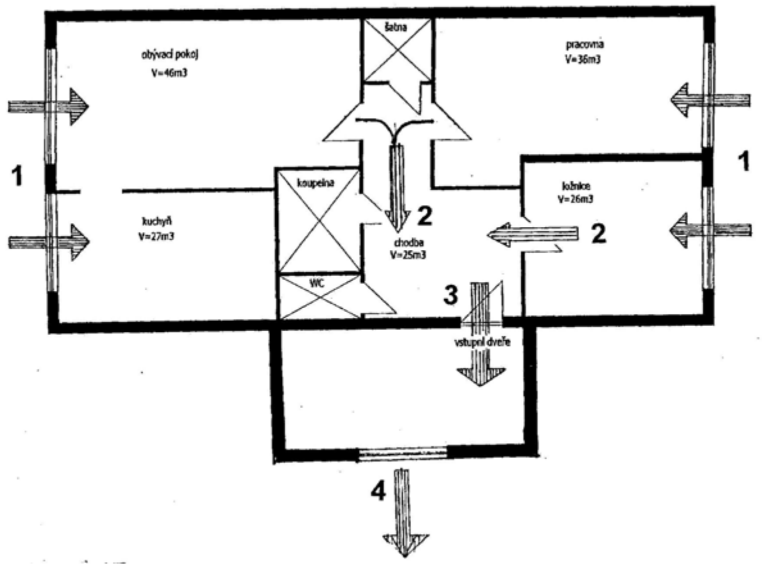

Figure 2. Ground plan of the flat – ventilation by static pressure effect in the stair's shaft - EXFILTRATION

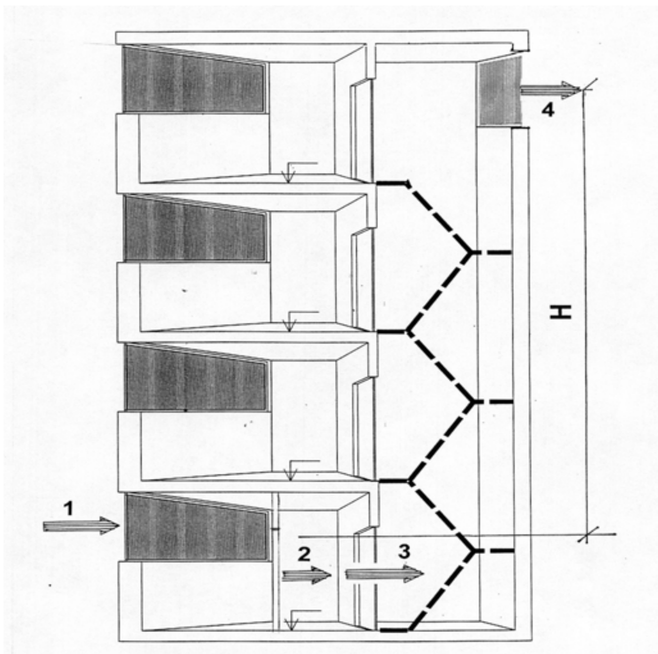

Figure 3. Section across the building – ventilation by static pressure effect in the stair's shaft - EXFILTRATION

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2.4. Ventilation by combination of wind effect and stair's shaft effect

Combination of wind effect and stair's shaft effect compensates fair extremes in upper and lower flats (we do not include this combination in computations)

- Low – small wind effect and up – meaningful stair's shaft effect.
- Up – meaningful wind effect and low – small stair's shaft effect (under pressure against to excess pressure from the wind).

2.5. Ventilation by standard 0,5times air change rate per hour

Hygienic requirement for ventilation by standard 0,5times air change rate per hour lets

- By relatively small total volume of the room and small length window's chink, for example in panel building bigger infiltration coefficient i_{LV} (classic value coefficient leakage for original wooden windows is 1,4*10-4 m-2 s-1 Pa-n). From the energetic point of view in panel buildings is not necessary to plant tight windows.
- By relative large total volume of the room in old buildings (high room's headroom) and large length window's chink could be smaller infiltration coefficient i_{LV} (tightly windows).

3. AIR CHANGE RATE – COMPUTATIONS

End computation conditions: we consider a flat with a total volume of 160 m3 (area with 64m2 and height of 2,5m).

Rooms are ventilated by natural infiltration or exfiltration effect. MS Excel makes all the computations.

Entry value, inter computations and results are elaborated in well-arranged tables with particular descriptions of quantities, formulas and at the end comparing end values with standard values.

4. HEAT CONSUMPTION FOR VENTILATION - COMPUTATIONS

Computations about heat consumption for ventilation are elaborated in three variants air change rate in the flat.

4.1. Heat consumption for ventilation by wind effect – INFILTRATION

When wind speed is higher, than heat consumption need is higher too, we have higher heat consumption to secure the loss during the ventilation.

With the wind speed of 10m/s is used up to 47% heat consumption quantity from total heat quantity.

Table 1. Ventilation by wind effect force with different wind speed during the year

	wind speed	percentage share	hour number	exterior temperature	interior temperature	ventilation air volume	(t_i-t_e)*0,36	power	heat quantity
	c	x	h	t_{em}	t_i	Vv		Q	Q_c
	m/s	%	h	(°C)	(°C)	m^3/h		W	kWh
1	2,5	30	1800	4	20	20,36	5,76	117,27	211,09
2	5	15	900	4	20	81,46	5,76	469,21	422,29
3	10	5	300	4	20	325,84	5,76	1876,84	563,05
		50% =	3000 hours from 6000 hours in heating period						1196,43

4.2. Heat consumption for ventilation by static pressure effect in the stair's shaft – EXFILTRATION

- To secure the loss during the ventilation is needed the biggest heat quantity, when the exterior temperature is -2,2 °C. It is 55 %.
- At the same time this maximum is raised by the fact that the temperature of -2,2 °C secures 118 days from 240 days in heating period.
- It is 50% of days in the heating period.

Table 2. Ventilation by static pressure effect in the stair´s shaft

interior air density	exterior temperature	day number	$(273+t_e)$	$\frac{273}{(273+t_e)}$	$\frac{1{,}293 \cdot 273}{(273+t_e)}$	shaft´s high	$(\rho_e-\rho i)$	static pressure	ventilation air volume	power	heat quantity
ρ_i(20°C)	t	x			ρ_e(při x°C)	H		p_H	Vv	Q	Q_c
kg/m^3	(°C)				kg/m^3	m		Pa	m^3/h	W	kWh
1,205	-15	6	258	1,058	1,368	15	0,163	24,476	31,53	397,28	57,21
1,205	-9,4	19	263,6	1,036	1,339	15	0,134	20,116	25,77	272,75	124,37
1,205	-2,2	118	270,8	1,008	1,304	15	0,099	14,776	18,84	150,57	426,41
1,205	1,8	52	274,8	0,993	1,285	15	0,080	11,930	15,19	99,52	124,21
1,205	7,4	37	280,4	0,974	1,259	15	0,054	8,081	10,19	46,22	41,04
1,205	11,2	18	284,2	0,961	1,242	15	0,037	5,557	7,11	22,52	9,73
	day sum =	**250**							total heat quantity	Q_{SUMA} =	782,98

4.3. Heat consumption for ventilation by standard 0,5times air change rate per hour

- Results are percently agreeing with example 4.2
- To secure the loss during the ventilation is needed the biggest heat quantity, when the exterior temperature is -2,2 °C. It is 54 %.
- At the same time this maximum is raised by the fact that the temperature of -2,2 °C secures 118 days from 240 days in heating period.

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- It is 50% of days in the heating period.

Table 3. Ventilation by standard 0,5times air change rate per hour

exterior temperature	day number	interior temperature	air change rate	flat volume	ventilation air volume	$n*V_v*0,36$	temperature difference	power	heat quantity
t	**x**	**t_i**	**n**	**V**	**Vv**		**t_i-t_e**	**Q**	**Q_c**
(°C)		(°C)	h^{-1}	m^3	m^3/h		(°C)	W	kWh
-15	6	20	0,5	160	80	28,8	35	1008,00	145,15
-9,4	19	20	0,5	160	80	28,8	29,4	846,72	386,10
-2,2	118	20	0,5	160	80	28,8	22,2	639,36	1810,67
1,8	52	20	0,5	160	80	28,8	18,2	524,16	654,15
7,4	37	20	0,5	160	80	28,8	12,6	362,88	322,24
11,2	18	20	0,5	160	80	28,8	8,8	253,44	109,49
day sum =	**250**							total heat quantity **Q_{SUMA} =**	3427,80

5. CONCLUSIONS

- The highest heat consumption provides ventilation by standard 0,5 times air change rate per hour
- At the same time maximal heat quantity is value, which is needed for perfect flat airing, it means to hold the norm standard 0,5 times air change rate per hour
- Airing by INFILTRATION, with the same entry conditions, air change rate is only 0,175 times per hour
- Airing by EXFILTRATION, the flat is ventilating only 0,115 times

Table 4. Results comparing – computations heat consumption for ventilation

	heat quantity	percentage share heat quantity	air change rate
	Q_c		**n**
	kWh		h^{-1}
INFILTRATION	1196	35%	0,175
EXFILTRATION	783	23%	0,115
n = 0,5per hour	3428	100%	0,5
	maximum		

After comparing the results of total heat consumption we are satisfied that maximal heat quantity (that is 55% from total heat consumption) is important to supply when the exterior temperature is -2,2 °C.

This percentage share completely corresponds with percentage share day number during heating period while different exterior temperatures. Day number during heating period while exterior temperature is -2,2 °C, it is to 50%. And it is the same in the case of stair's shift effect and standard 0,5times air change rate per hour too. In both cases is used about 55% from total heat consumption.

We are satisfied that room's ventilation by standard 0,5times air change rate per hour is the most energetic expensive.

Total heat consumption for ventilation by standard 0,5 times air change rate per hour is 100%. This energy cost we could theoretically decrease by calculated heating loss by infiltration (35%) and exfiltration (23%). We can decrease total heat quantity by heat quantity from wind effect (infiltration) and stair's shaft effect (exfiltration). Percentage share 58% (35% + 23%) is more than a half needed heat quantity. This result we cannot neglect.

Total air change rate can we compute by this equation (1). Air change rate 0,79times per hour in this case is much more than hygienic requirement presents.

$$n_{0,5} + n_{INFIL.} + n_{EXFIL.} = n_{TOTAL}\ [h^{-1}] \qquad (1)$$

$$0{,}5\ h^{-1} + 0{,}175\ h^{-1} + 0{,}115\ h^{-1} = 0{,}79\ h^{-1}$$

Because natural ventilation is passing through all the time in parallel with controlled standard 0,5 times air change rate per hour. If we do not accept natural ventilation, the room will be ventilated more than hygienic minimum.

Controlled standard 0,5 times air change rate per hour is the most energy consuming. We can decrease total heat quantity by heat quantity from wind effect (infiltration) and stair's shaft effect (exfiltration). It is computed in second equation (2).

$$Qn_{0,5} - Qn_{INFIL.} - Qn_{EXFIL.} = Qn_{TOTAL}\ [kWh^{-1}] \qquad (2)$$

$$100\% - 35\% - 23\% = 42\%$$

We are satisfied that total heat quantity can bee decreased more than to half.

Acknowledgements

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