

Airtightness of multifamily residential buildings in Czech Republic

Theory vs. reality

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Introduction

Single-family houses



- long experience with:
 - airtightness testing
 - airtight construction
- technical solutions exist
- good results achieved

Residential buildings



- limited experience
- good airtightness expected
- ↓
- know-how from single-family houses
- favourable A_E/V

!!!

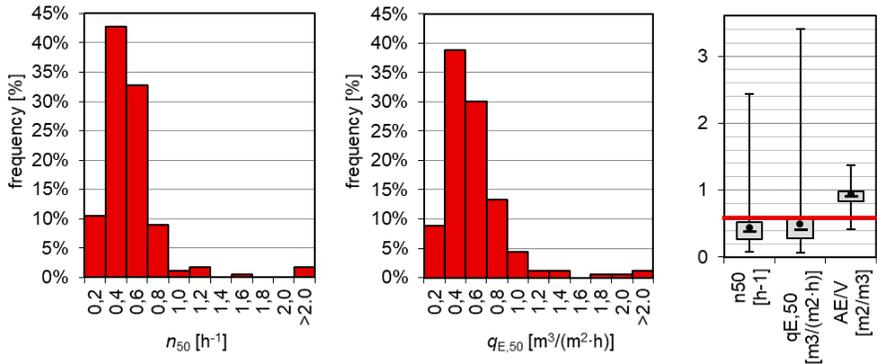
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Reality

Single-family passive houses

- database A.BD_CZ
- 180 buildings
- measured between 2010 and 2024



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Theoretical expectations...

Building size effect

$$n_{50} = \frac{A_E}{V} \cdot q_{E50}$$



$A_E/V = 1.0 \text{ m}^2/\text{m}^3$
 $q_{E50} = 0.6 \text{ m}^3/(\text{h}\cdot\text{m}^2)$
 $n_{50} = 0.6 \text{ h}^{-1}$



$A_E/V = 0.56 \text{ m}^2/\text{m}^3$
 $q_{E50} = 0.6 \text{ m}^3/(\text{h}\cdot\text{m}^2)$
 $n_{50} = 0.34 \text{ h}^{-1}$



$A_E/V = 0.18 \text{ m}^2/\text{m}^3$
 $q_{E50} = 0.6 \text{ m}^3/(\text{h}\cdot\text{m}^2)$
 $n_{50} = 0.11 \text{ h}^{-1}$

- good airtightness in large buildings? → easy...!

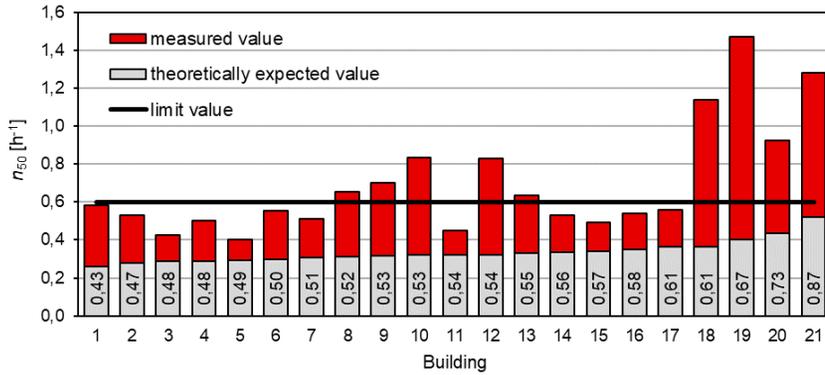
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Reality

Multifamily residential passive houses

- database A.BD_CZ
- 21 buildings
- measured between 2022 and 2024

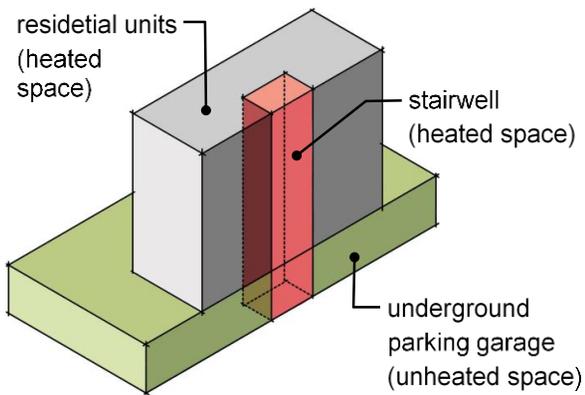


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Reality

Multifamily residential passive houses



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Leakage detection

Method

- anemometer, $\Delta p \approx -50$ Pa



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Leakage detection

Results – common areas

Leakage path detected	Loc.	Occ.
Doors to adjacent underground unheated spaces	C	11
Smoke exhaust vents in the stairwell	C	2
Ventilation equipment or opening for the elevator shaft	C	10
Penetrations of large ventilation ducts from common areas to adjacent underground unheated spaces	C	6
Service penetrations from common areas to adjacent underground unheated spaces	C	7
Service penetrations from common areas to roof	C	3
Roof access hatch	C	4
Entrance door (functional joint)	C	6
Unrendered masonry walls between common areas and adjacent unheated spaces	C	2

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Leakage detection

Results – residential units

Leakage path detected	Loc.	Occ.
Penetrations from installation shafts inside residential units to roof and adjacent underground unheated spaces	R	8
Junction between external wall and ceiling slab	R	2
Window-to-wall junction	R	4
Electrical boxes in external wall	R	2
Other penetrations through the internal plaster layer	R	4

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Leakage paths - common areas

Causes

- design proces - airtightness is not addressed
- construction proces - solutions based on experience with single-family house construction
- **leakage paths in common areas – not present in single-family houses**



Leakage path detected	Loc.	Occ.
Doors to adjacent underground unheated spaces	C	11
Smoke exhaust vents in the stairwell	C	2
Ventilation equipment or opening for the elevator shaft	C	10
Penetrations of large ventilation ducts to unheated spaces	C	6
Service penetrations to adjacent unheated spaces	C	7
Service penetrations from common areas to roof	C	3
Roof access hatch	C	4
Entrance door (functional joint)	C	6
Unrendered masonry walls to adjacent unheated spaces	C	2
Penetrations from install. shafts to roof and unheated spaces	R	8
Junction between external wall and ceiling slab	R	2
Window-to-wall junction	R	4
Electrical boxes in external wall	R	2
Other penetrations through the internal plaster layer	R	4

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Leakage paths - common areas

Method – reductive sealing

- 2 successive building airtightness tests:
 - with a leakage path unsealed $q_{50,u}$ [m³/h]
 - with a leakage path sealed $q_{50,s}$ [m³/h]
- airtightness of the leakage path $q_{50} = q_{50,u} - q_{50,s}$ [m³/h]
- uncertainty!



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Leakage paths - common areas

Results

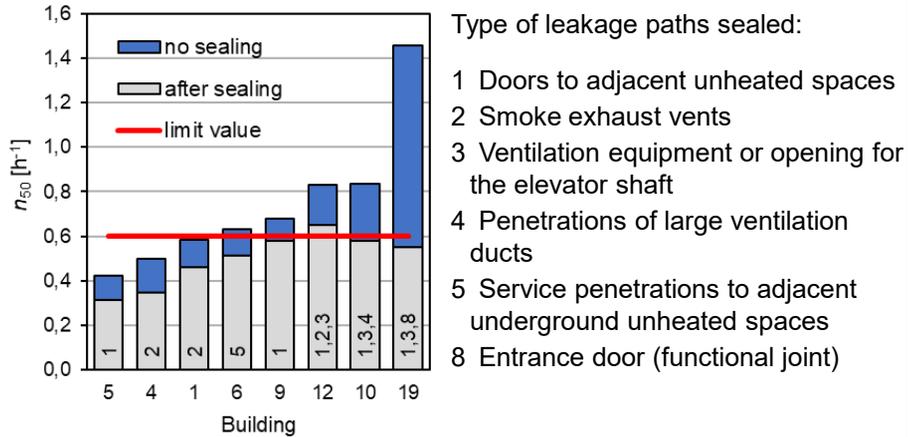
Leakage path	Air leakage rate q_{50} [m ³ /h]
Door to adjacent underground unheated spaces	250 ±90
Smoke exhaust vent - with self-closing louvres	1 400 ±900
Smoke exhaust vent - mechanical exhaust equipment	300 ±300
Elevator shaft ventilation system - mechanical exhaust equipment	200 ±200
Elevator shaft ventilation system – simple ductwork (natural ventilation)	600 ±200
Penetration of large ventilation ducts from common areas to adjacent underground unheated spaces	700 ±200
Service penetration from common areas to adjacent underground unheated spaces	500 ±300

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Leakage paths - common areas

Contribution to the total air leakage



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Conclusions

A lesson learned

- identified issues could have been resolved in design phase
- different building types → different airtightness issues !
- proven solutions from one building typology cannot be directly applied to another without critical adaptation !!!

Progress needed

- improved technical solutions (details elements, equipment)
- raising awareness (designers)
- design methods, guidelines, tools
- identification of potential risks → airtightness strategy (airtightness concept)
- requirements on airtightness-related information in the building design documentation

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Thank you for your attention

Questions?

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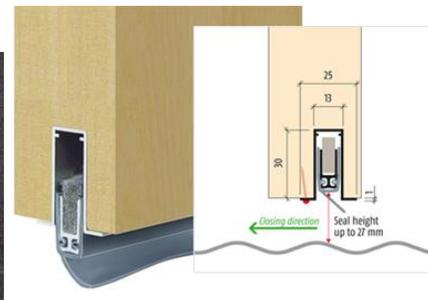


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Leakage paths - common areas

Doors to adjacent underground unheated spaces

- $q_{50} = 250 \pm 90 \text{ m}^3/\text{h}$



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Leakage paths - common areas

Smoke exhaust vents - with self-closing louvres

- $q_{50} = 1\,400 \pm 900 \text{ m}^3/\text{h}$



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Leakage paths - common areas

Smoke exhaust vents - mechanical exhaust equip.

- $q_{50} = 300 \pm 300 \text{ m}^3/\text{h}$



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Leakage paths - common areas

Elevator shaft ventilation - mechanical exhaust

- $q_{50} = 200 \pm 200 \text{ m}^3/\text{h}$



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Leakage paths - common areas

Elevator shaft ventilation – simple ductwork

- $q_{50} = 600 \pm 200 \text{ m}^3/\text{h}$



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Leakage paths - q_{50} estimation

Penetrations – large rectangular ducts

- $q_{50} = 700 \pm 200 \text{ m}^3/\text{h}$



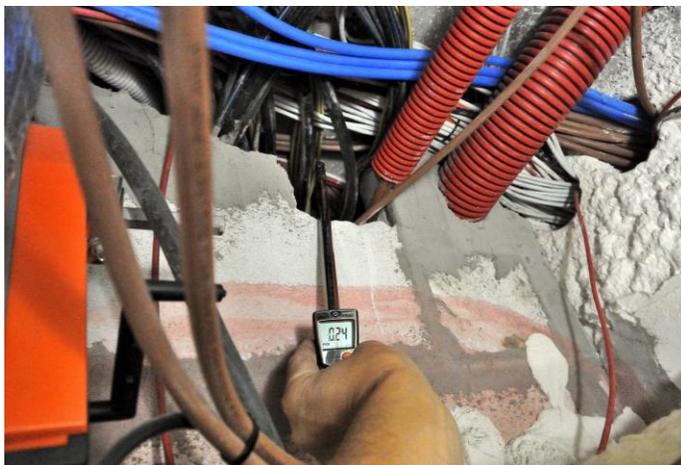
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Leakage paths - common areas

Penetrations – service penetrations

- $q_{50} = 500 \pm 300 \text{ m}^3/\text{h}$



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