RADON PREVENTIVE AND REMEDIAL MEASURES IN THE CZECH REPUBLIC

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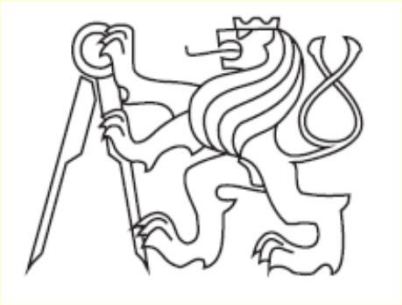

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Documentation supporting the design

Principles of designing and application of various types of radon reduction techniques are presented in the following standards:

- **ĻSN 73 0601** Protection of buildings against radon from the soil, 1995, 2000, 2006
- **ĻSN 73 0602** Protection of buildings against radon and gamma radiation from building materials, 2000, 2006
- **Radon ï Building Context** ï detailed manual for building professionals

PRINCIPLES OF PROTECTION

The type and the degree of protection depends on the **ñradon indexò** of the building site (low, medium, high).

Radon index	Principle of protection
Low	No special protection is required.
Medium	The basic measure is a **radon-proof insulation.**
High	Radon-proof insulation is usually combined with: Å**sub-slab depressurization** Å**air gaps ventilation** Å**mechanical ventilation of indoor air**

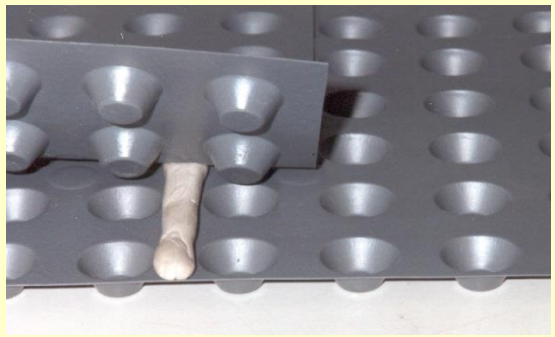
Radon-proof insulation

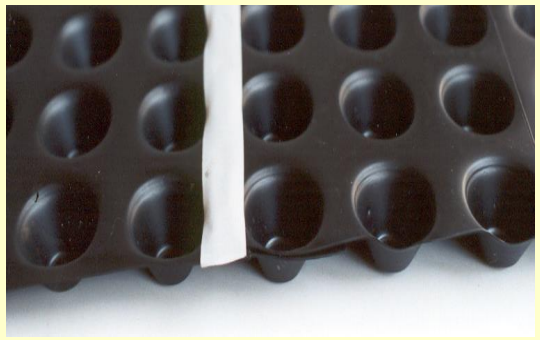
Radon-proof insulation is selected from standard waterproofing materials.

- **radon diffusion coefficient** of the insulation must be measured
- **durability** must correspond to the lifetime of the building

Prohibited materials

Bitumen membranes with Al foil and plastic membranes with dimples (Delta, Platon, Tefond, etc.)

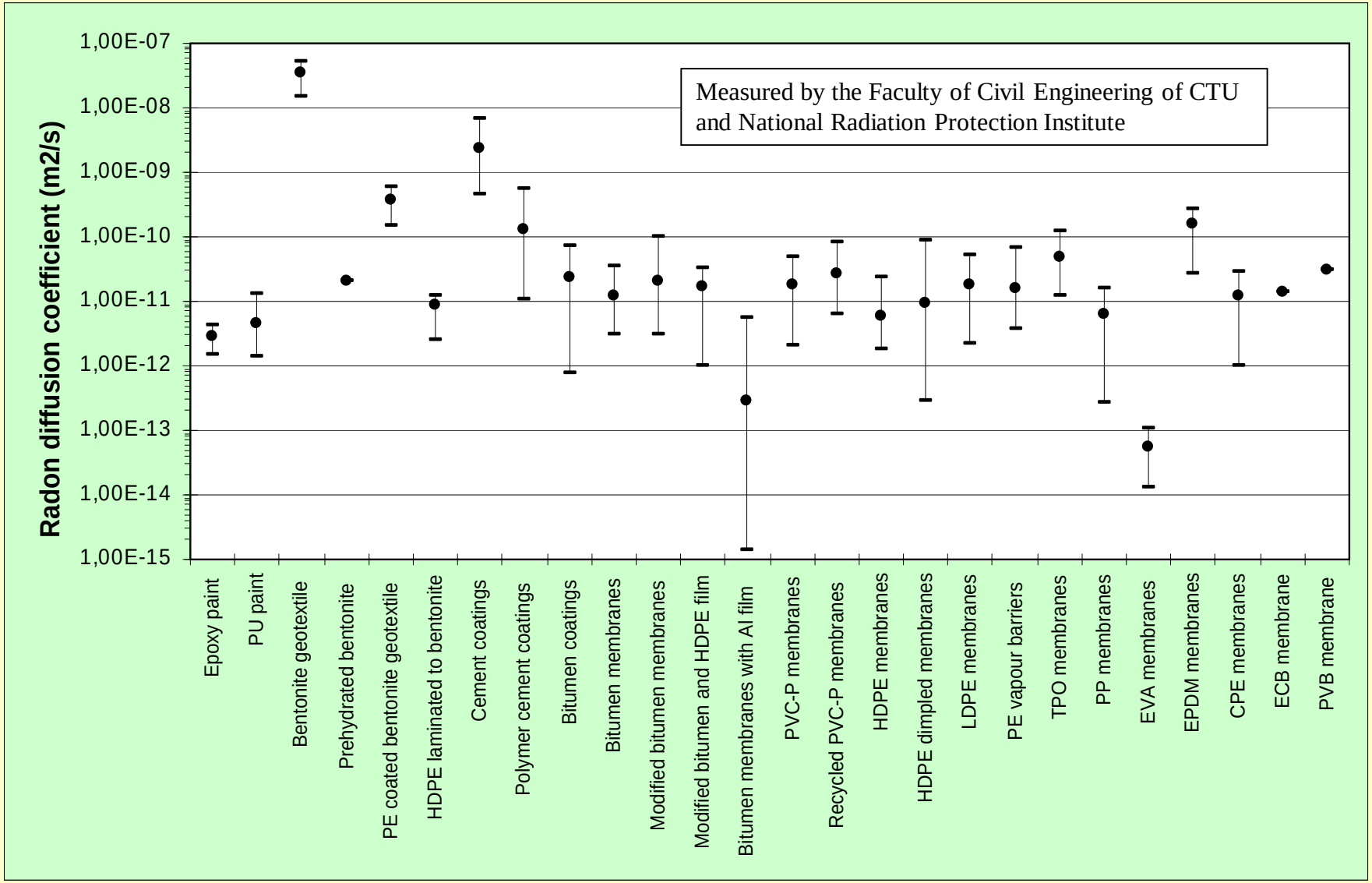




Determination of the Rn diffusion coefficient

- Systematic testing started in 1995 according to the method developed by the Faculty of Civil Engineering in cooperation with the National Radiation Protection Institute
- The Czech test method is accredited by the Czech Accreditation Institute and satisfy requirements of ISO/DIS 11665-10
- Up to now nearly 500 materials obtained throughout Europe have been tested

Summary of radon diffusion coefficient measurements



Application of the radon diffusion coefficient for the design of radon barriers

1. Limit for the maximal value of D

Applied for example in Ireland (max D = 12.10^{-12} m^2/s)

2. Limit for the minimal thickness of the membrane

Applied for example in Germany ($d \geq 3l$)

3. Calculation of the membrane thickness in dependence on the soil and building characteristics

Applied for example in Czech Republic

Thickness of the radon-proof insulation

$$d \geq l.\operatorname{arcsinh} \frac{\alpha_1.l.\lambda.C_S.(A_f + A_w)}{C_{dif}.n.V}$$

C_s é radon concentration in the soil gas (Bq/m^3)

λ é ..radon decay constant (0,00756 h^{-1})

d é ..thickness of the membrane (m)

l é .. radon diffusion length in the membrane $l = (D/\lambda)^{1/2}$ (m)

D é . radon diffusion coefficient in the membrane (m^2/h)

α_1 é safety factor

$A_f A_w$ .floor and wall areas in contact with the soil (m^2)

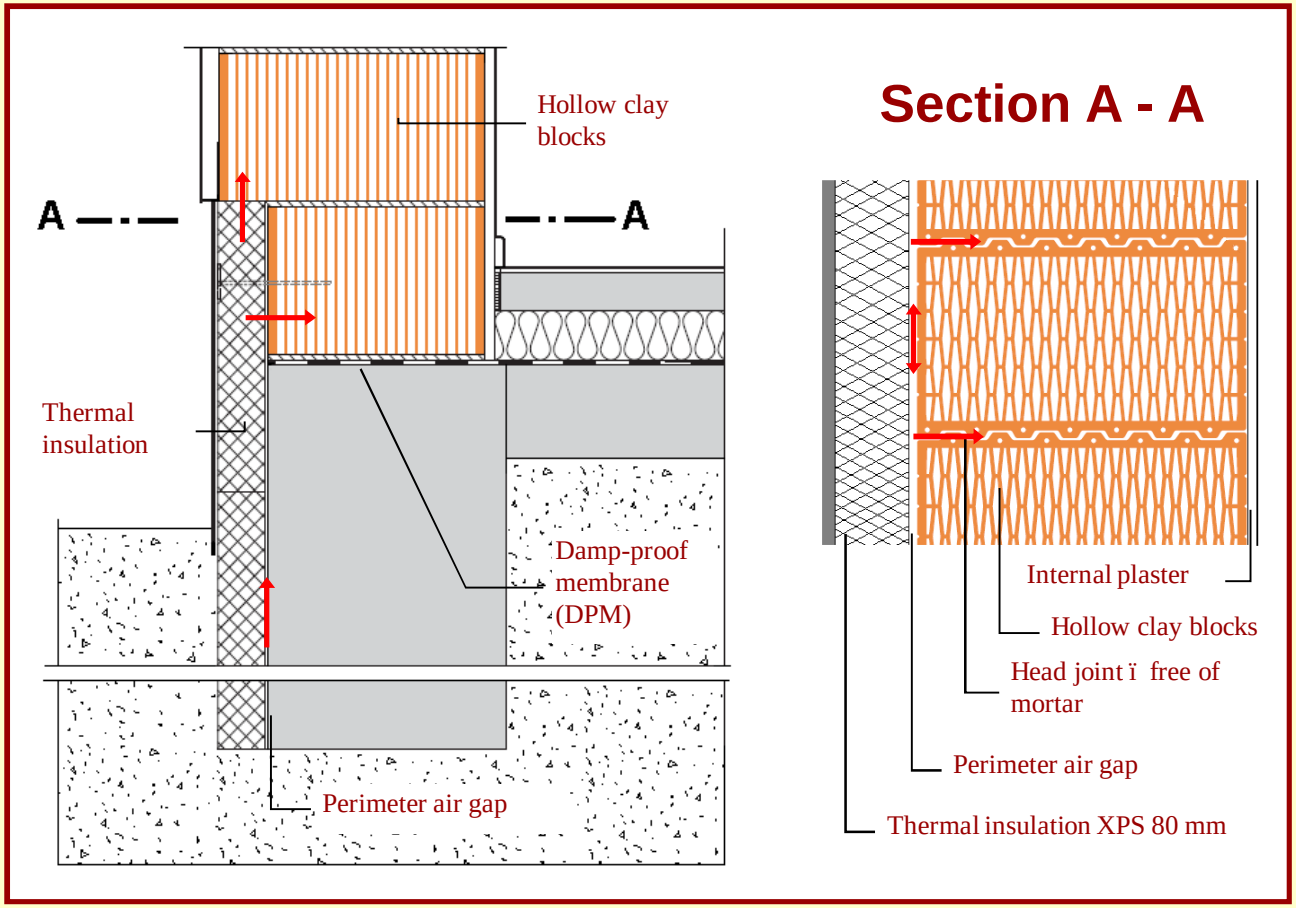
né é ventilation rate (h^{-1})

C_{dif}é fraction of reference level caused by diffusion (Bq/m^3)

Thermal protection X radon protection

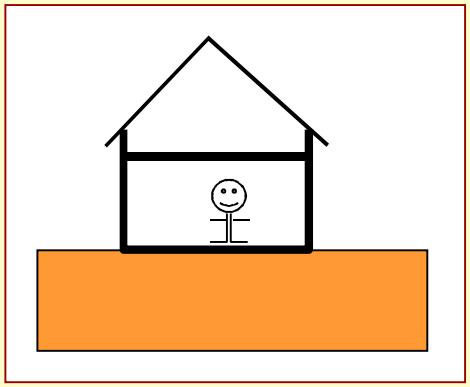
Radon-proof insulation must prevent radon from penetrating through an air gap between perimeter thermal insulation and foundations

Elimination of thermal bridges should not result in radon bridges



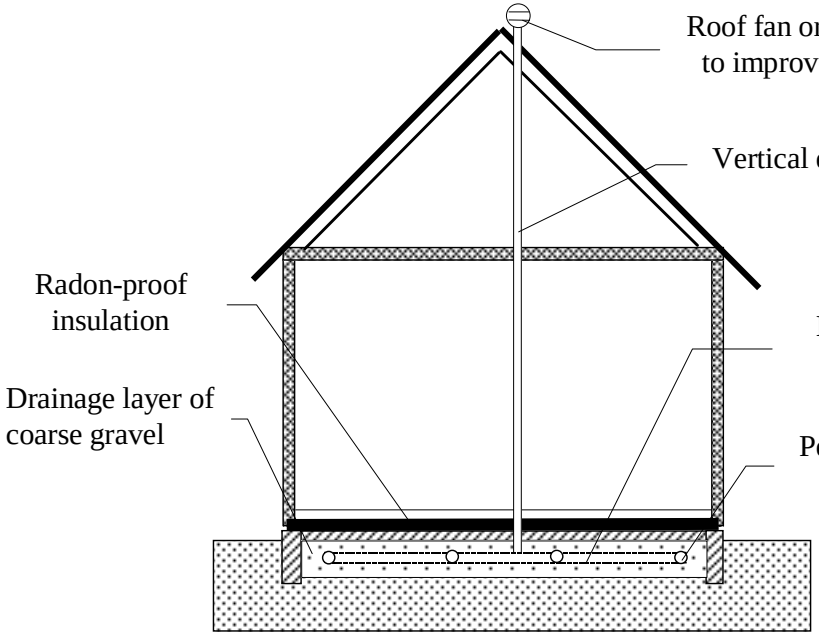
Combined systems

Combined systems are applied in houses with habitable rooms on the floors in direct contact with the soil, when:



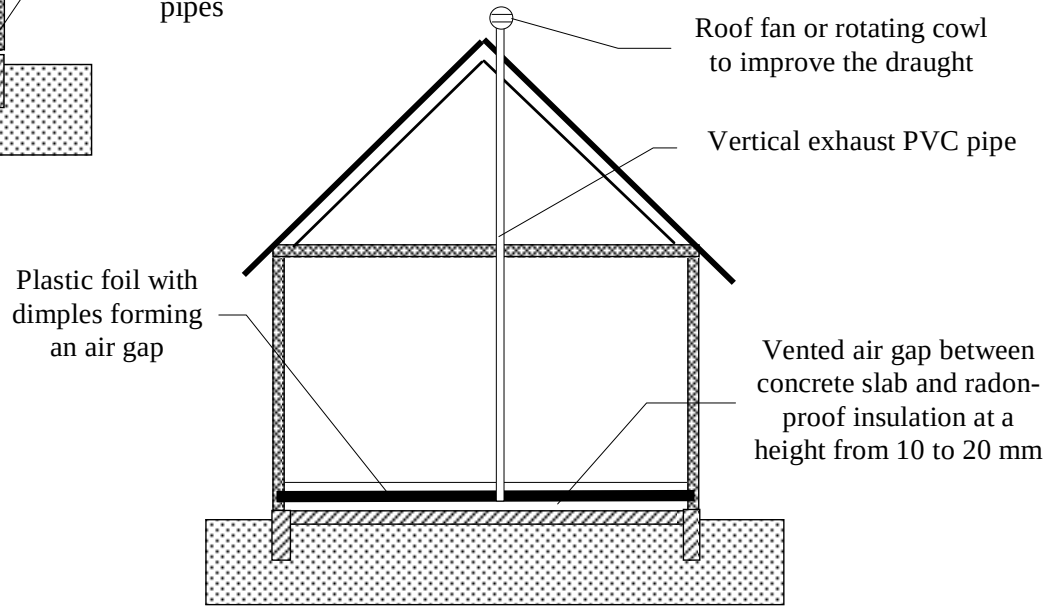
- Highly permeable gravel layer is placed under the house
- Floors resting on the soil are equipped with under-floor heating
- Radon index of foundation soils is high

Combined systems



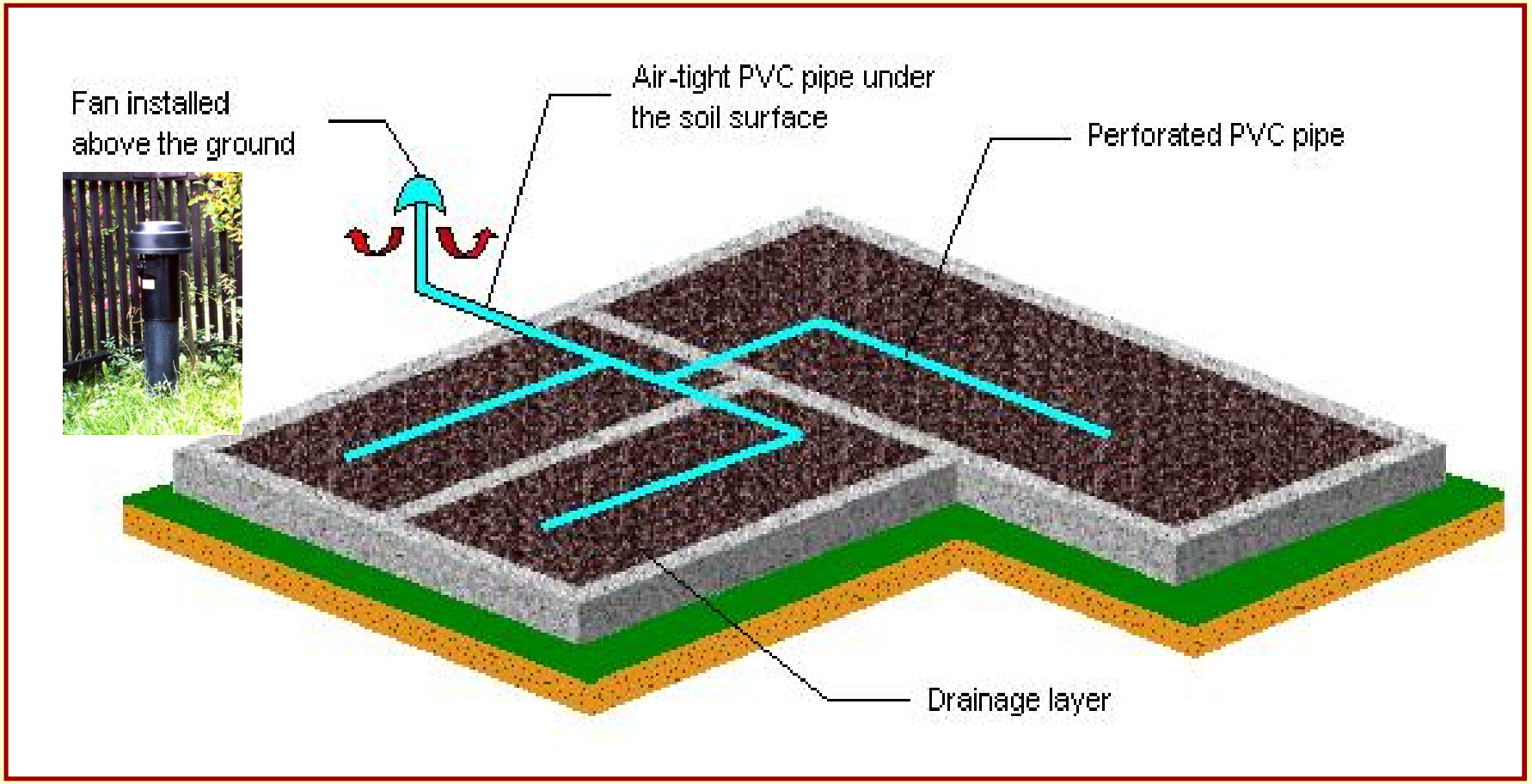
Radon-proof insulation + sub-slab ventilation

Radon-proof insulation + air gaps ventilation



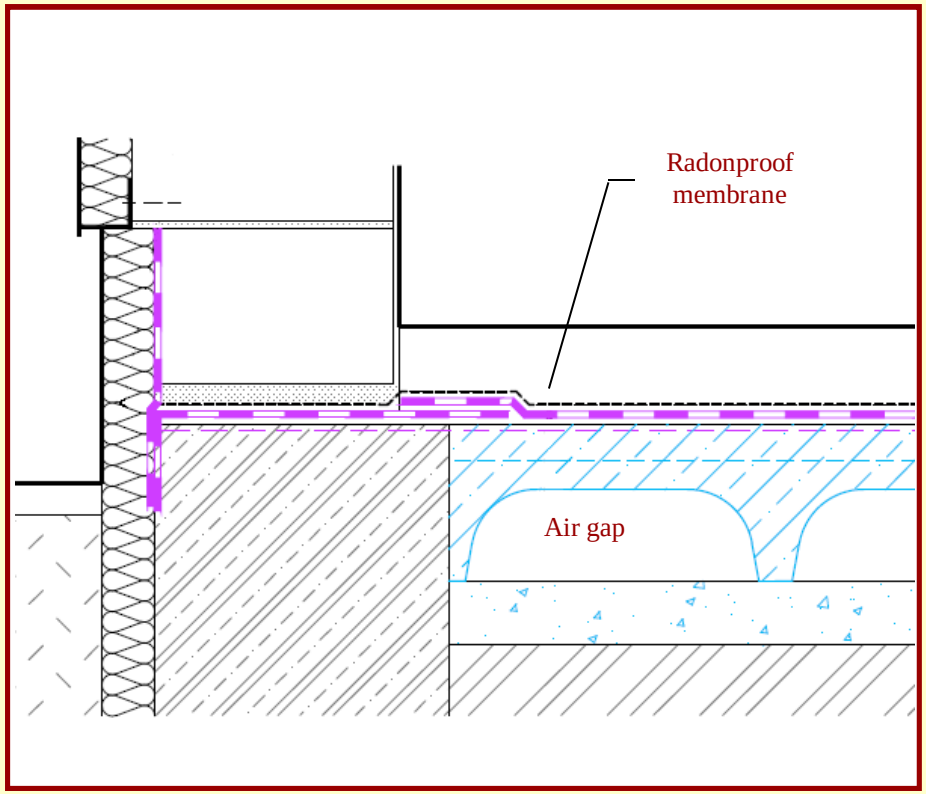
Sub-slab ventilation systems

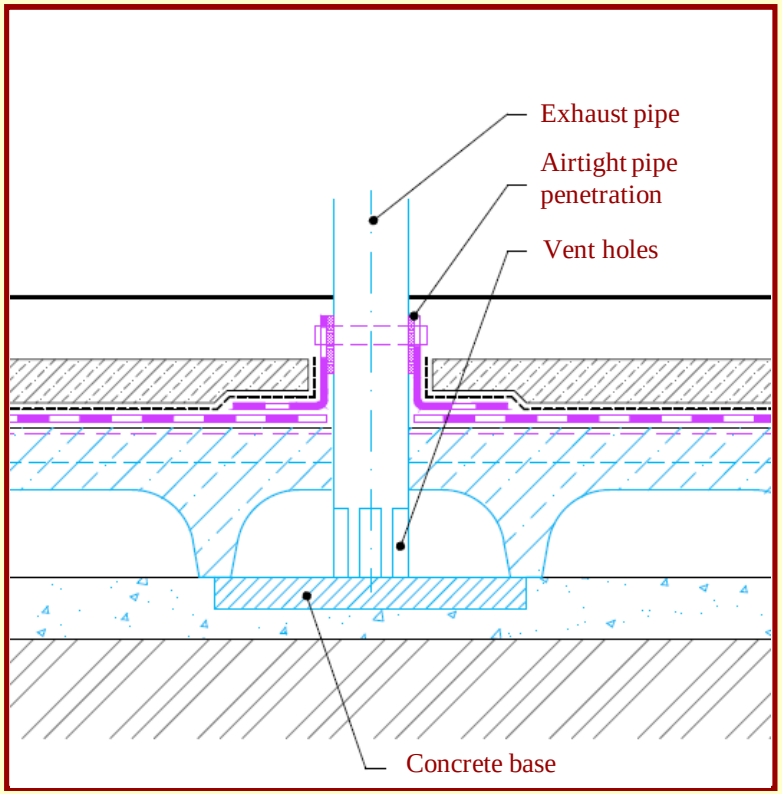
Geometry of sub-slab ventilation systems



Floor air gaps ventilation

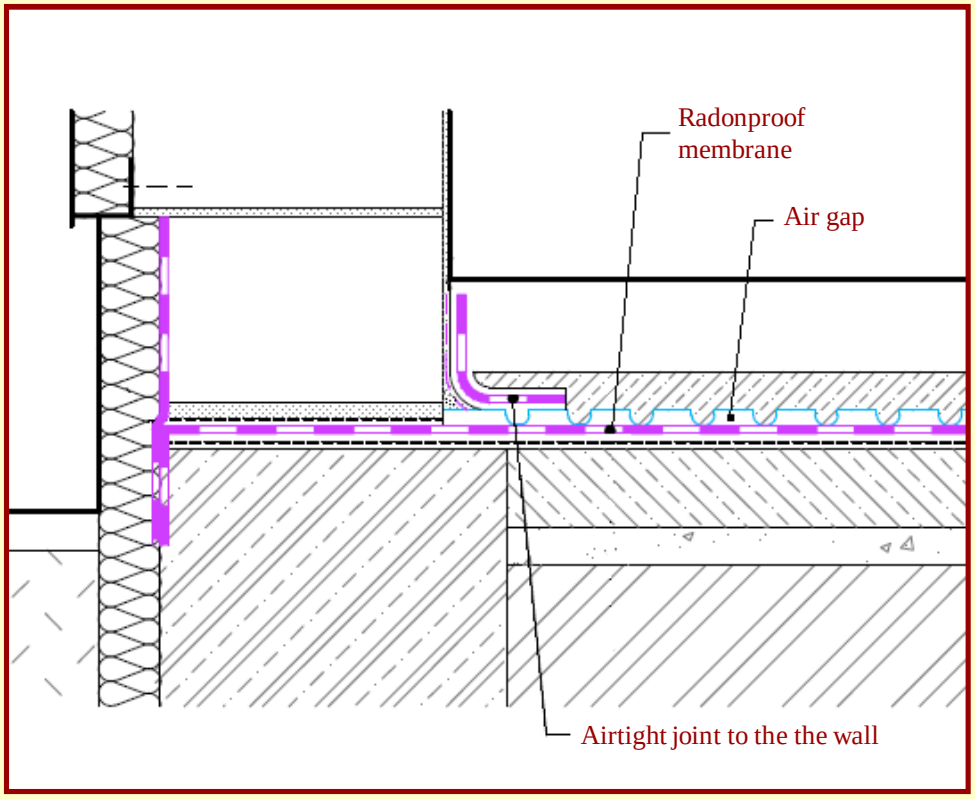
An air gap below the radon-proof membrane

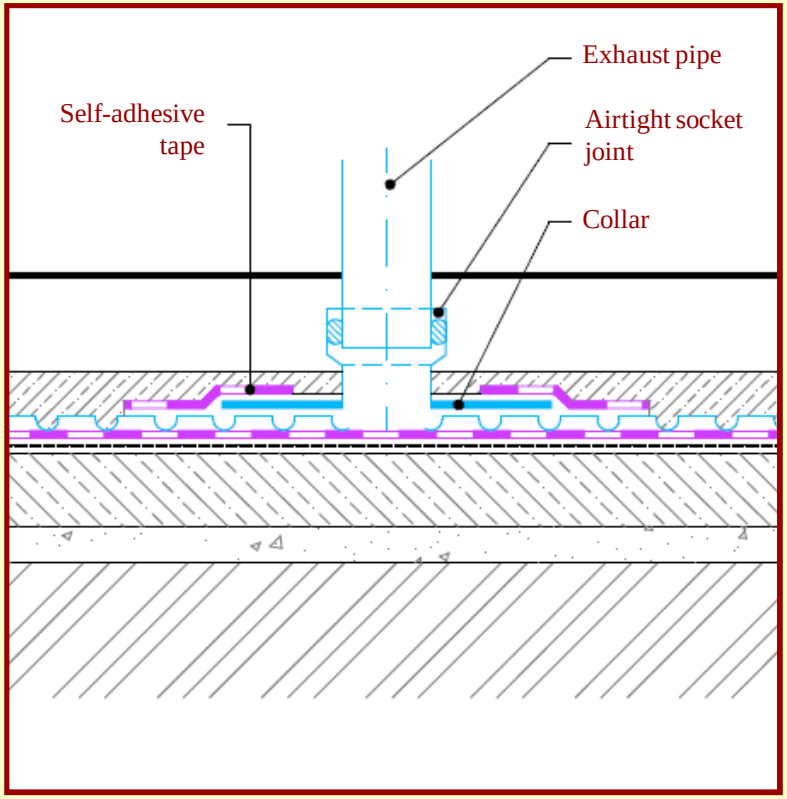




Floor air gaps ventilation

An air gap above the radon-proof membrane





REMEDIATION OF EXISTING BUILDINGS

The type and the degree of remedial works depend on the **level of indoor radon concentration** and results of **diagnostic measurements** performed in the building.

Indoor radon concentration < 600 Bq/m^3

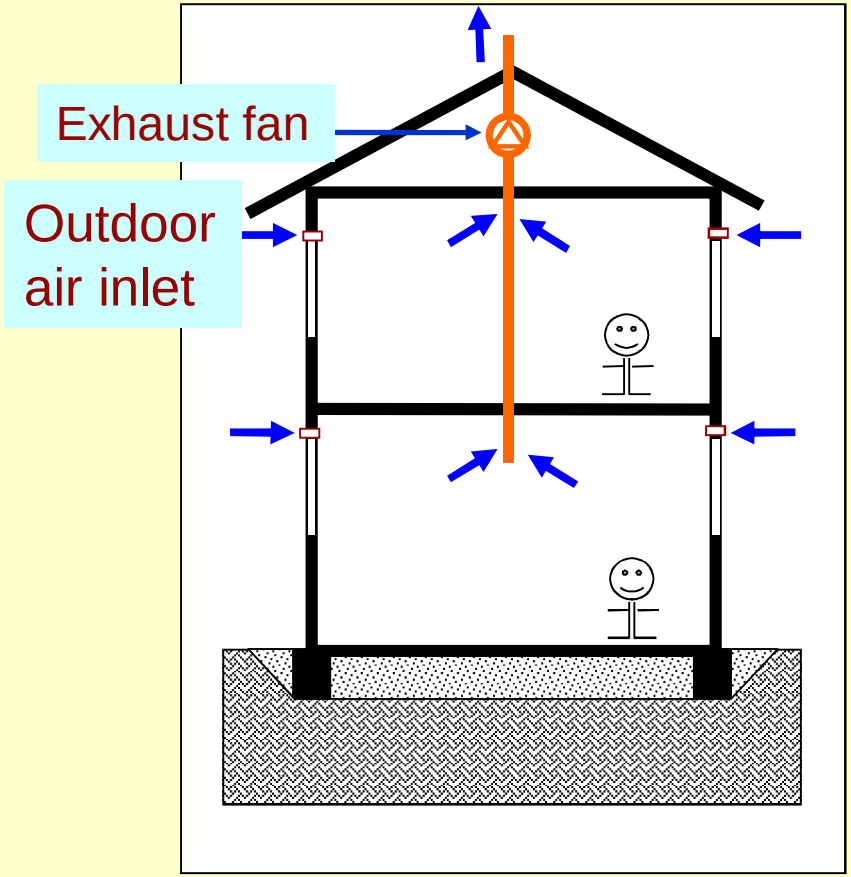
Simple methods (sealing of entry routes, improving ventilation, etc.)

Indoor radon concentration > 600 Bq/m^3

More effective methods (sub-slab depressurization, replacement of existing floors, mechanical supply and exhaust air ventilation)

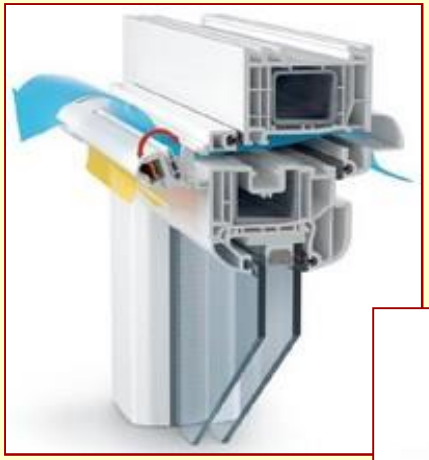
Improving ventilation

- Natural ventilation supported by outdoor air inlets
- Mechanical exhaust air ventilation with outdoor air inlets

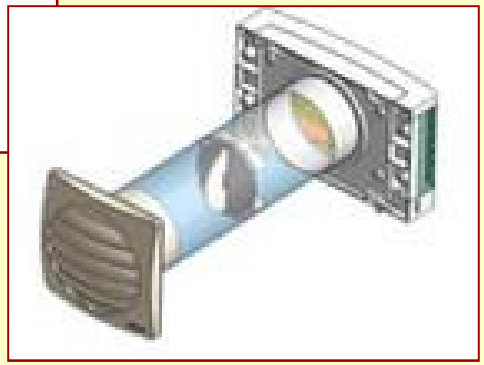


Types of outdoor air inlets

Window registers



Wall registers



Improving ventilation

Mechanical supply and exhaust air ventilation - local ventilation units with heat recovery

Typical characteristics:

Power: 4 ï 25 W

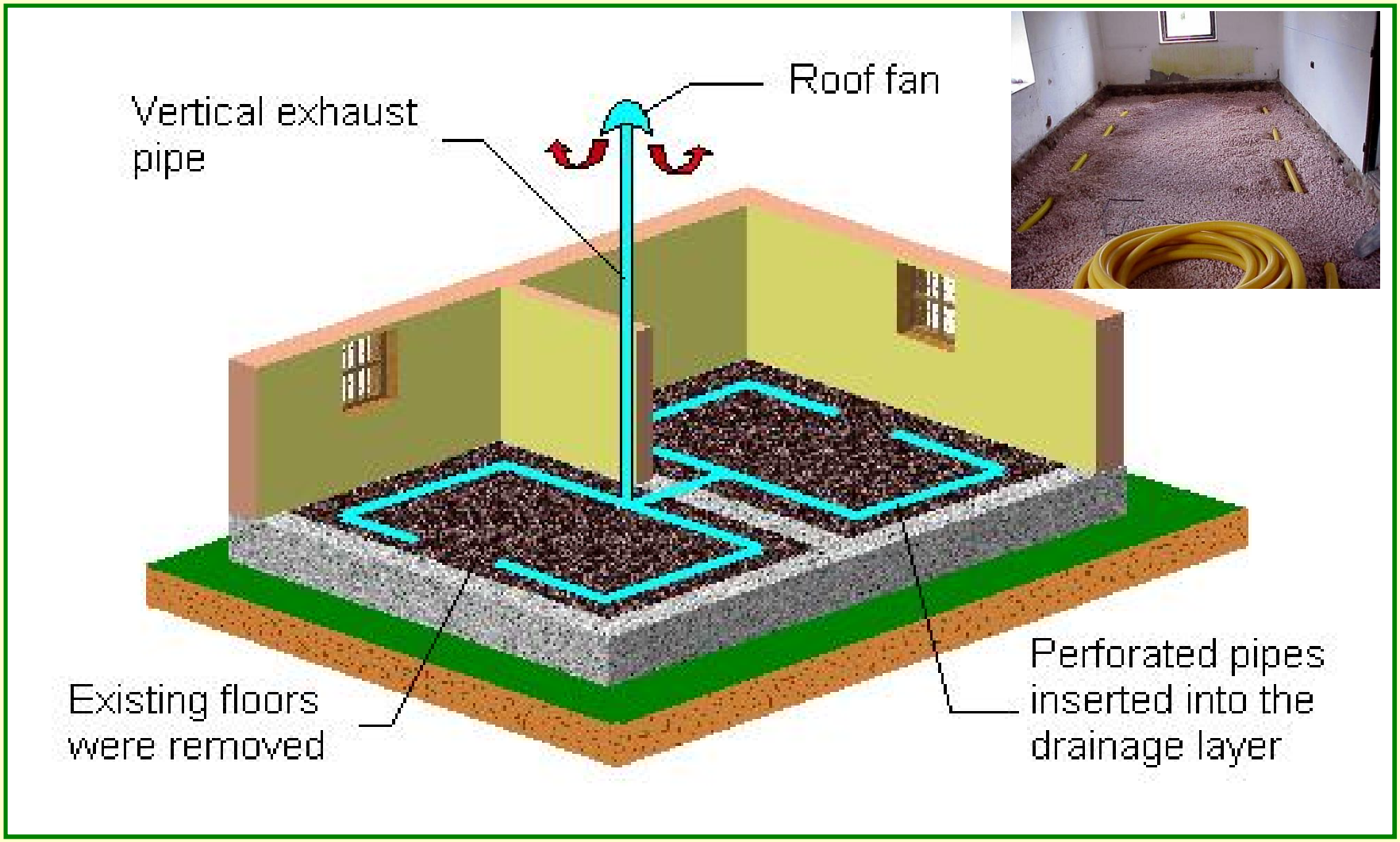
Air flow: 15 ï 60 m^3/h

Noise level: 17 ï 49 dB(A)

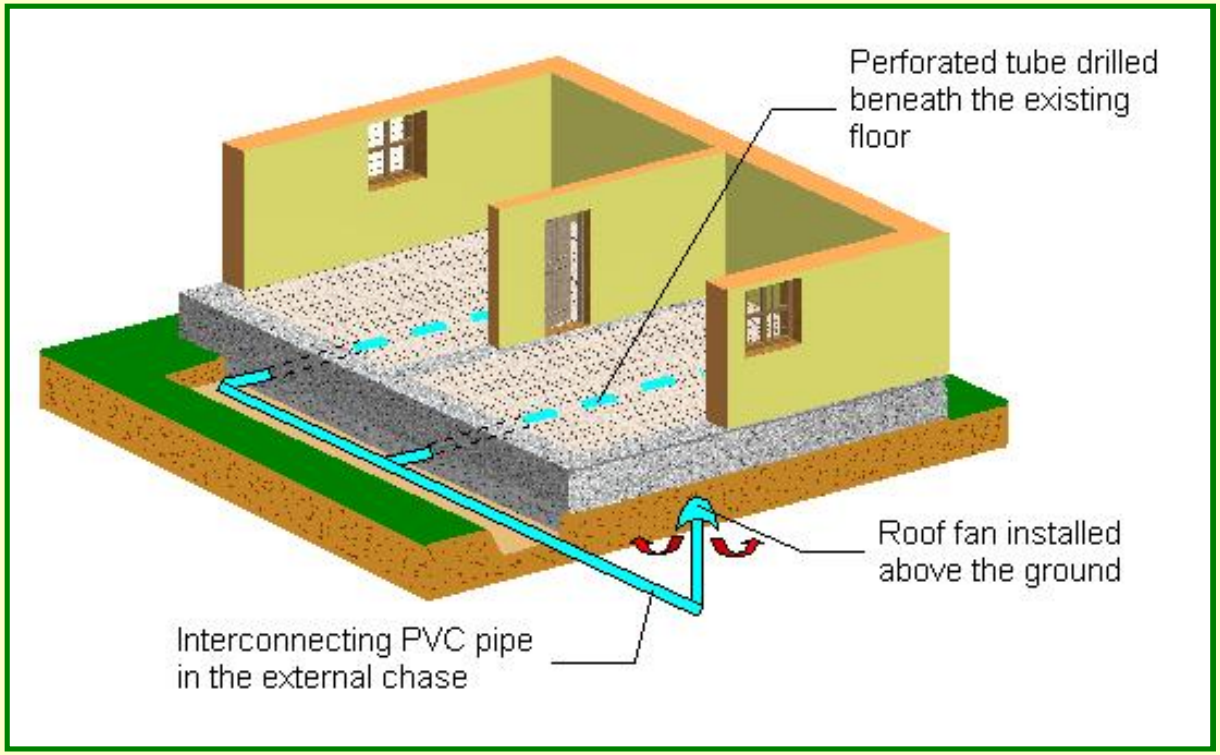
Efficiency of heat recovery: < 75 %

Intended for application in particular rooms with the floor area < 45 m^2.

Network of flexible perforated pipes inserted into the drainage layer



Perforated tubes drilled from the external trench

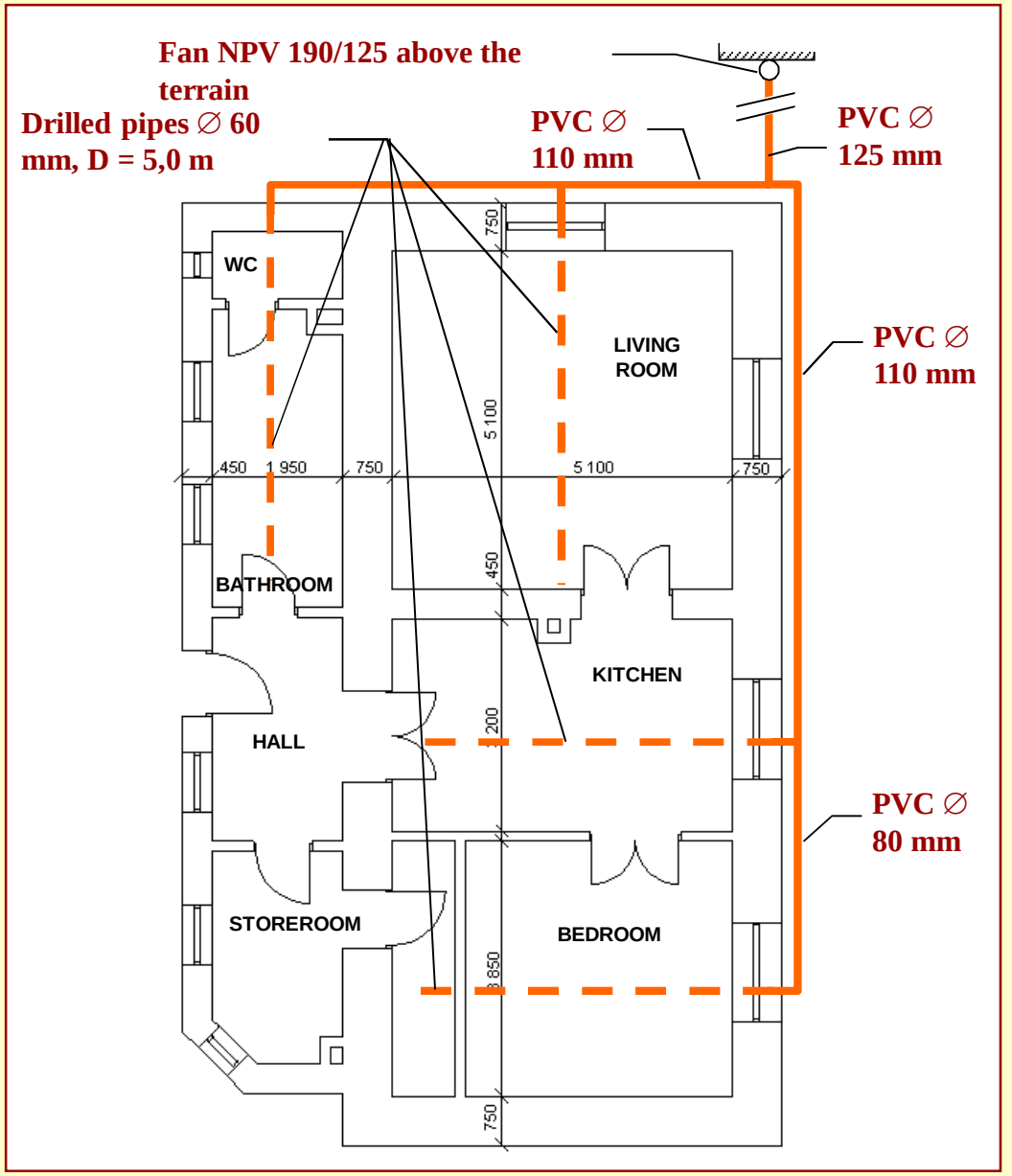


Example of application

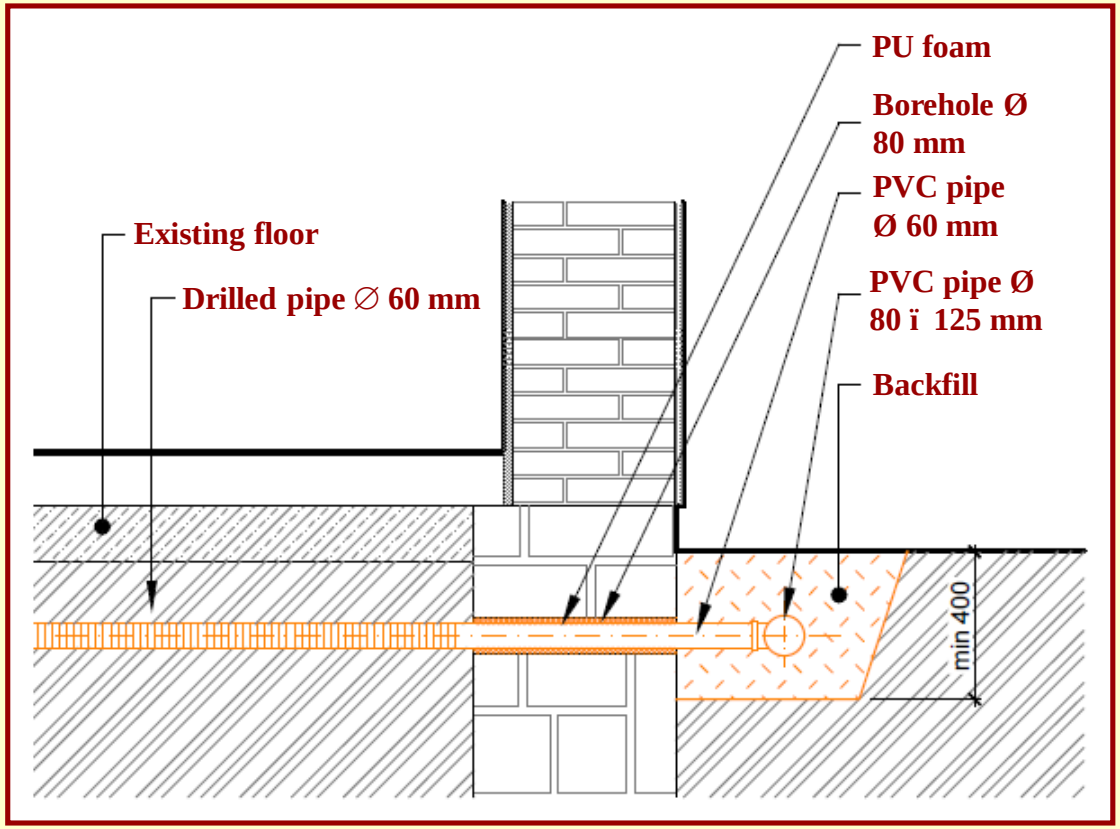
Single family house

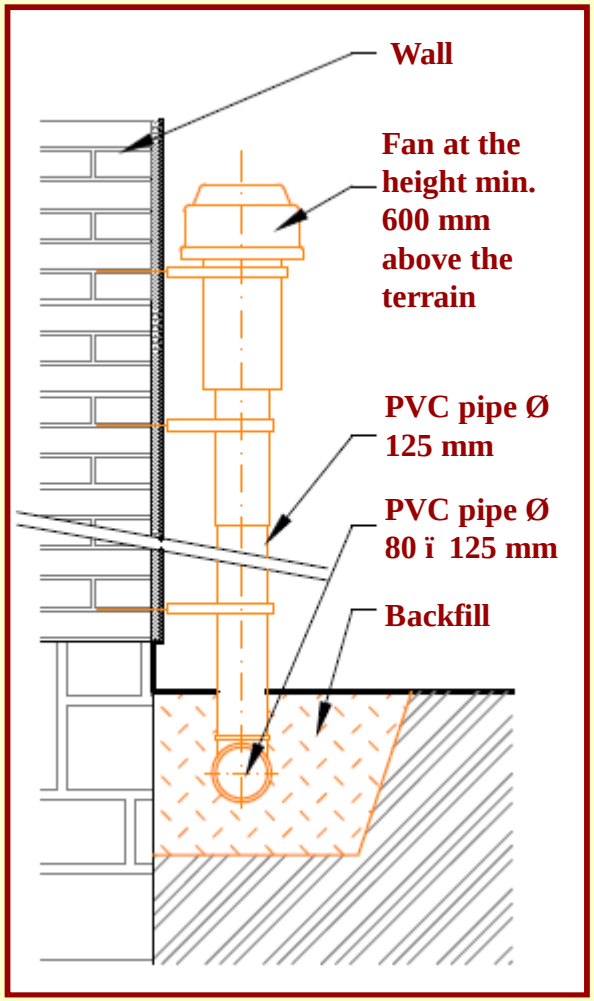
Indoor radon concentration before mitigation:

1 145 Bq/m³



Details of remedial measures





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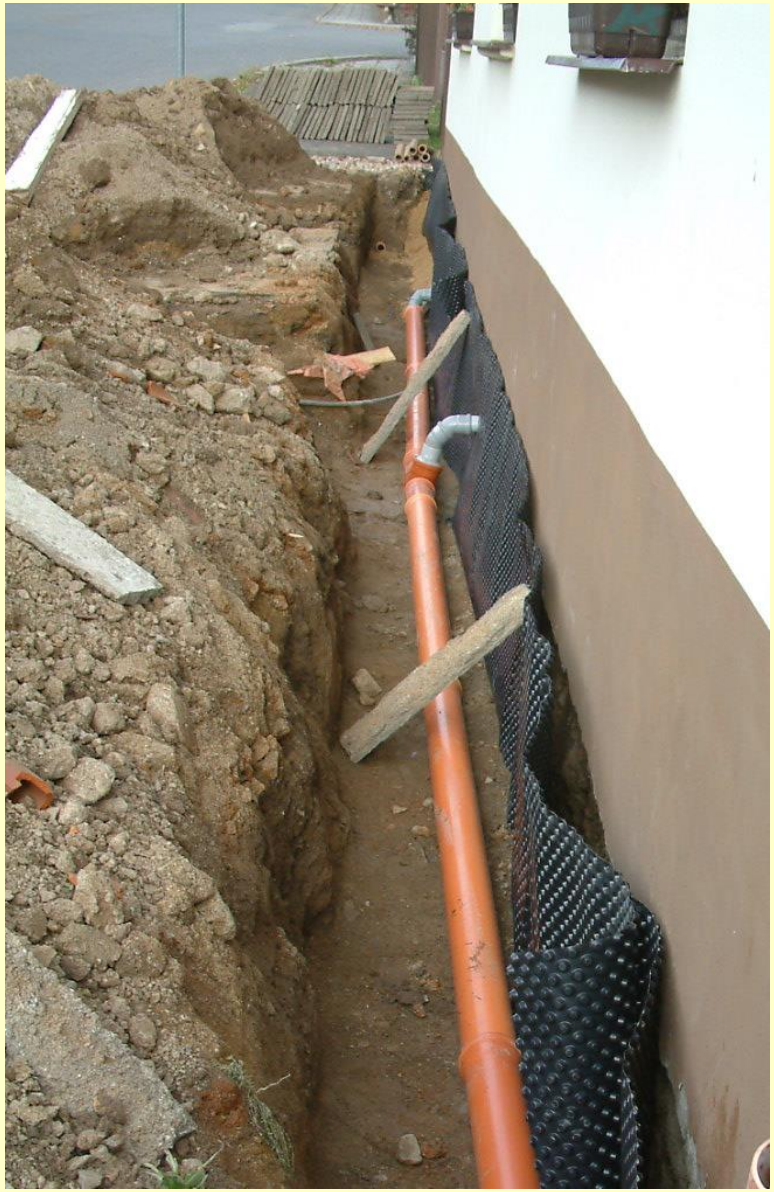
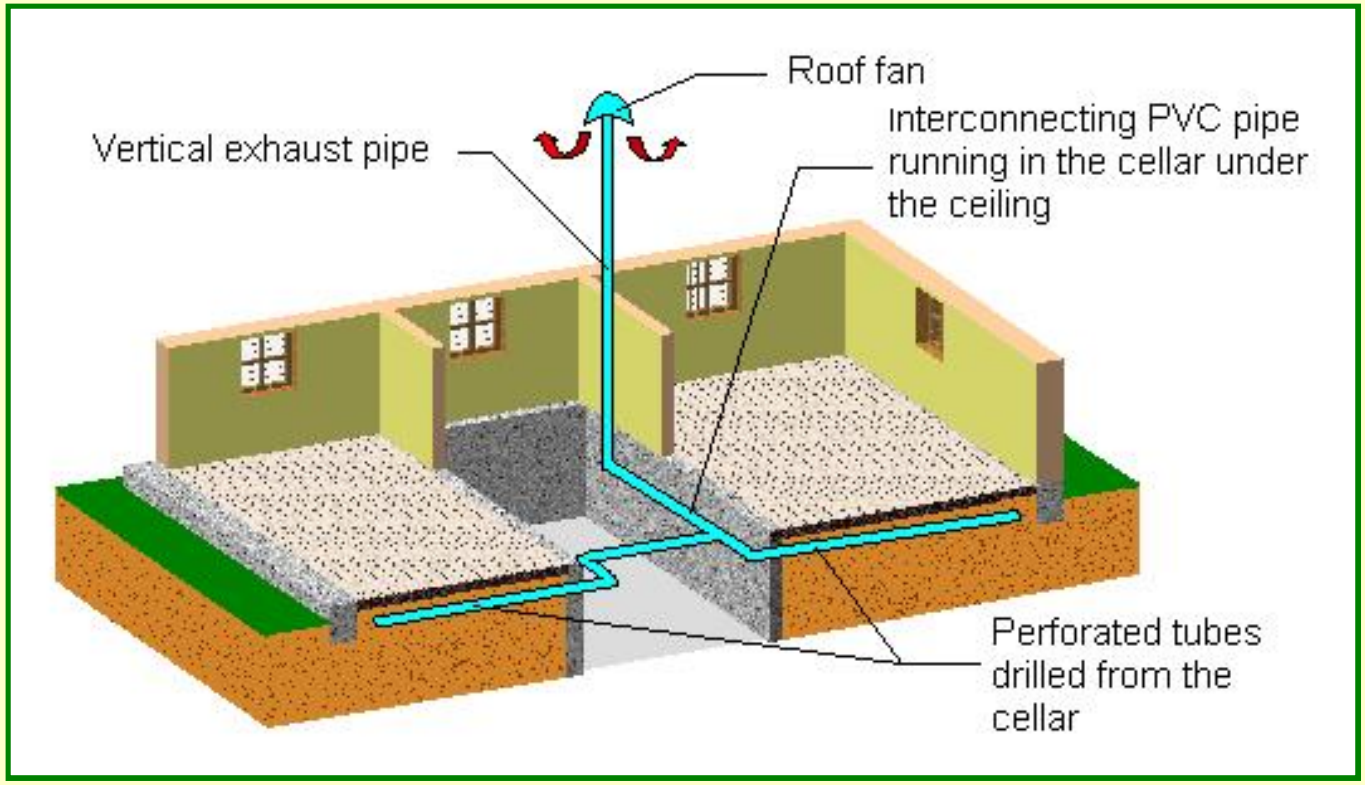


Indoor radon concentration after remediation

During active ventilation indoor radon concentration decreased to the mean value 152 Bq/m^3.

Perforated tubes drilled from the cellar

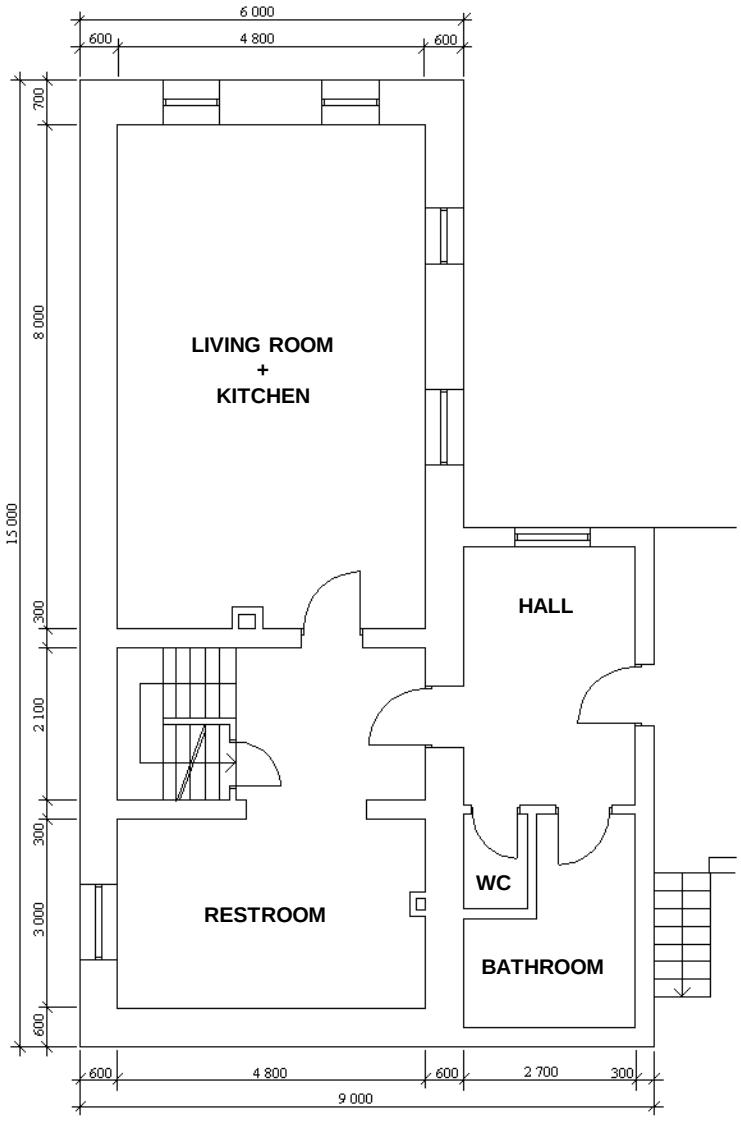


Example of application

Single family house

Indoor radon concentration before mitigation:

3 240 Bq/m³



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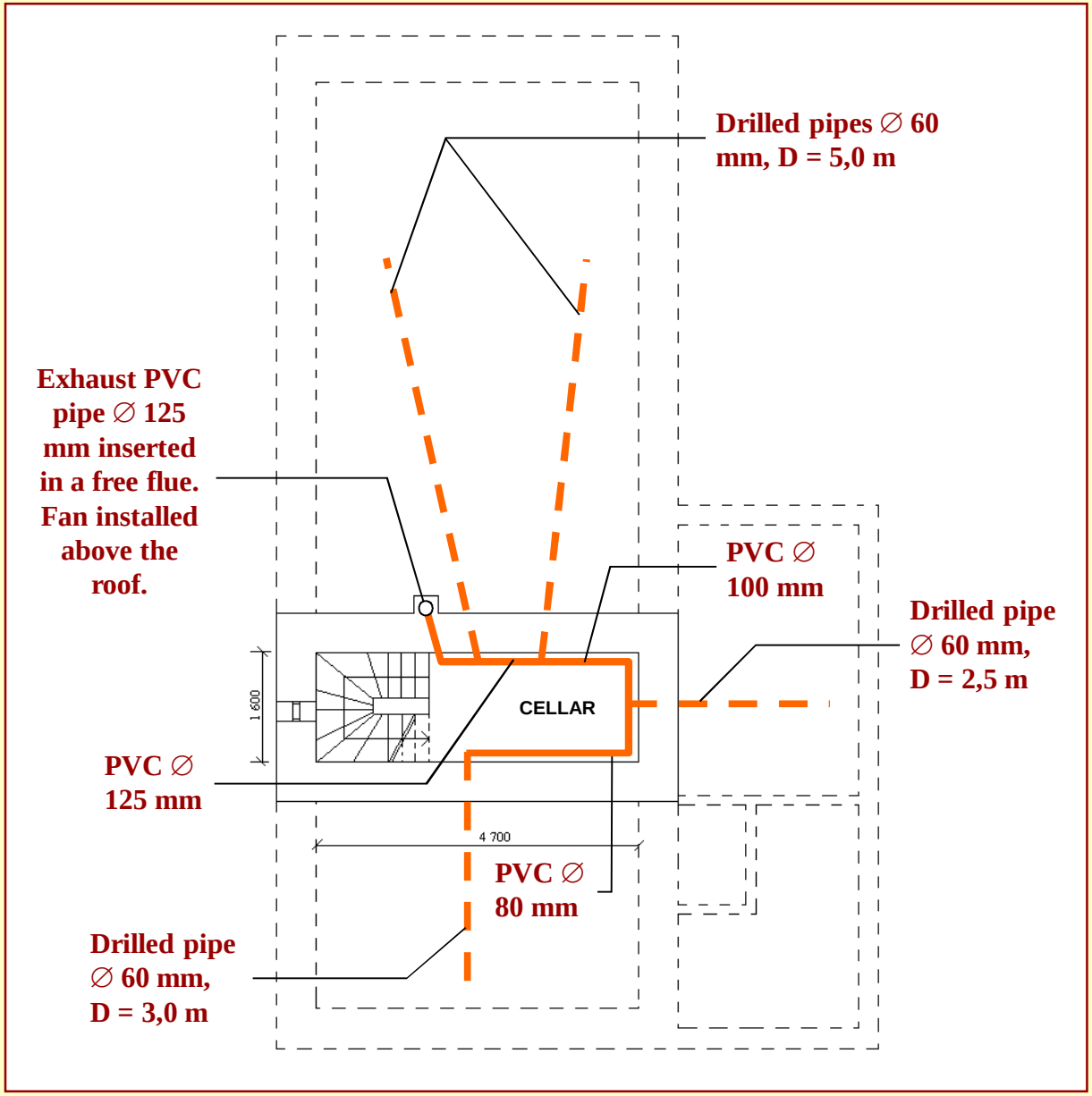

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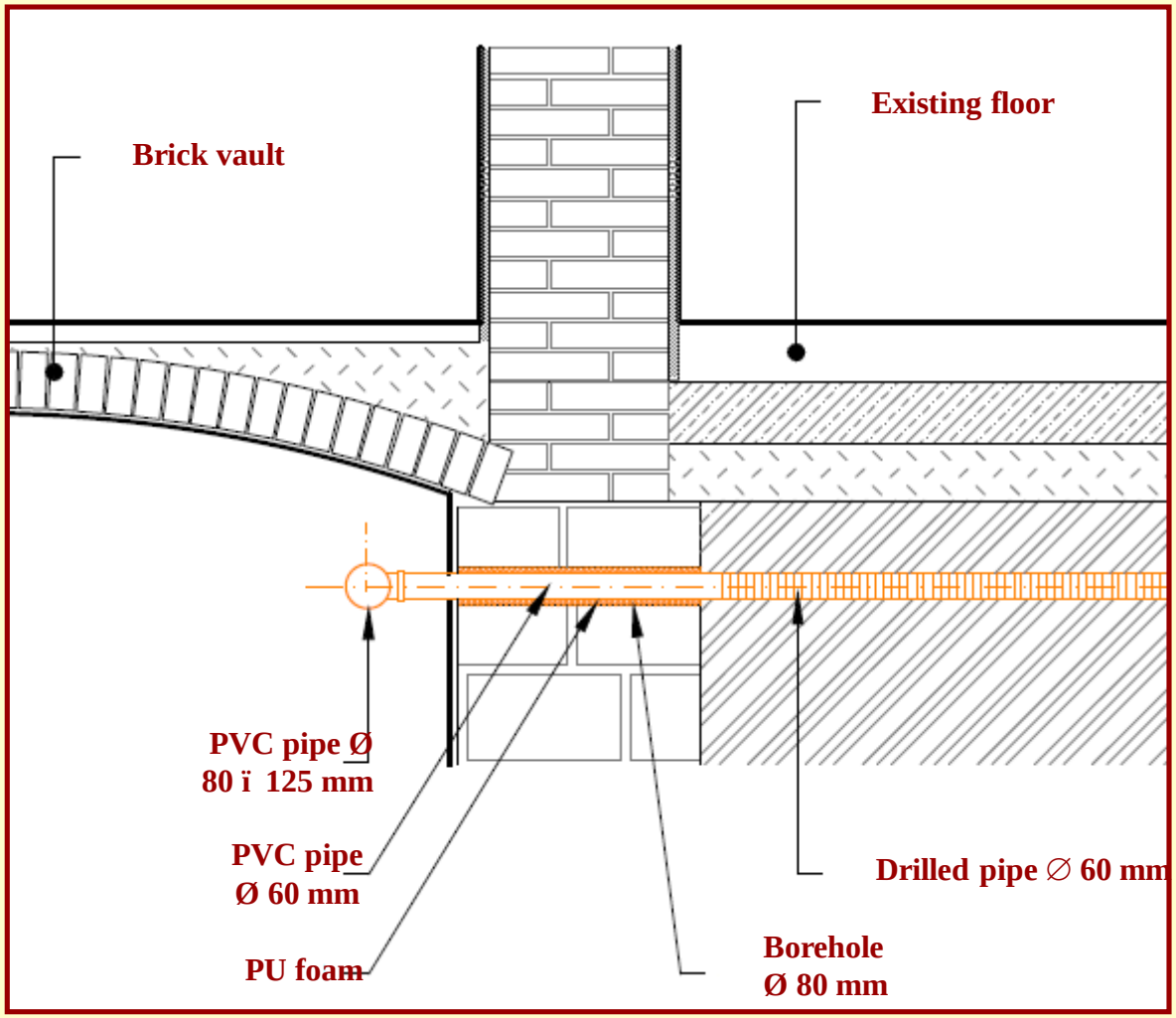

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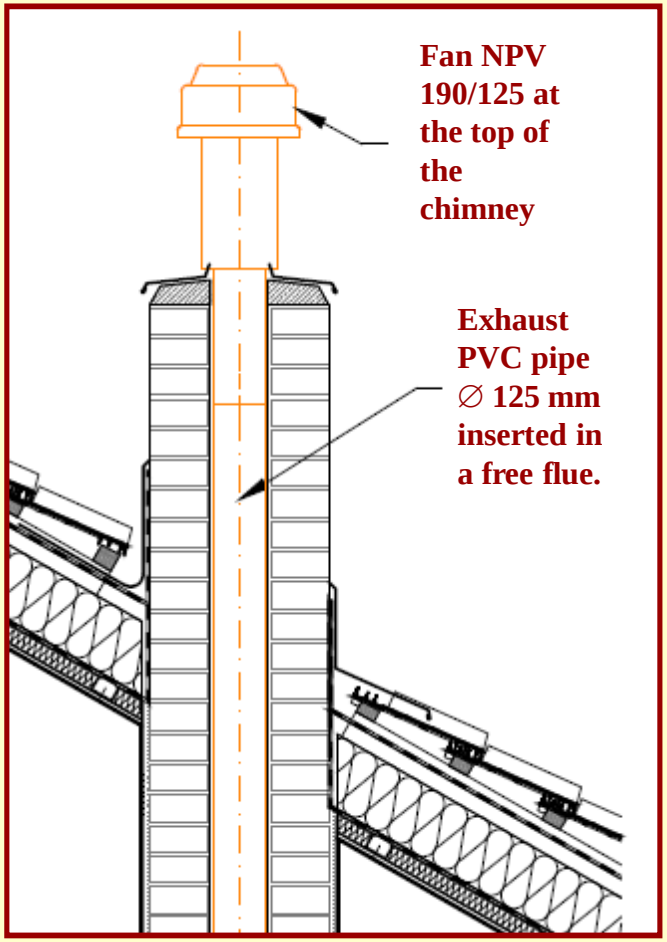
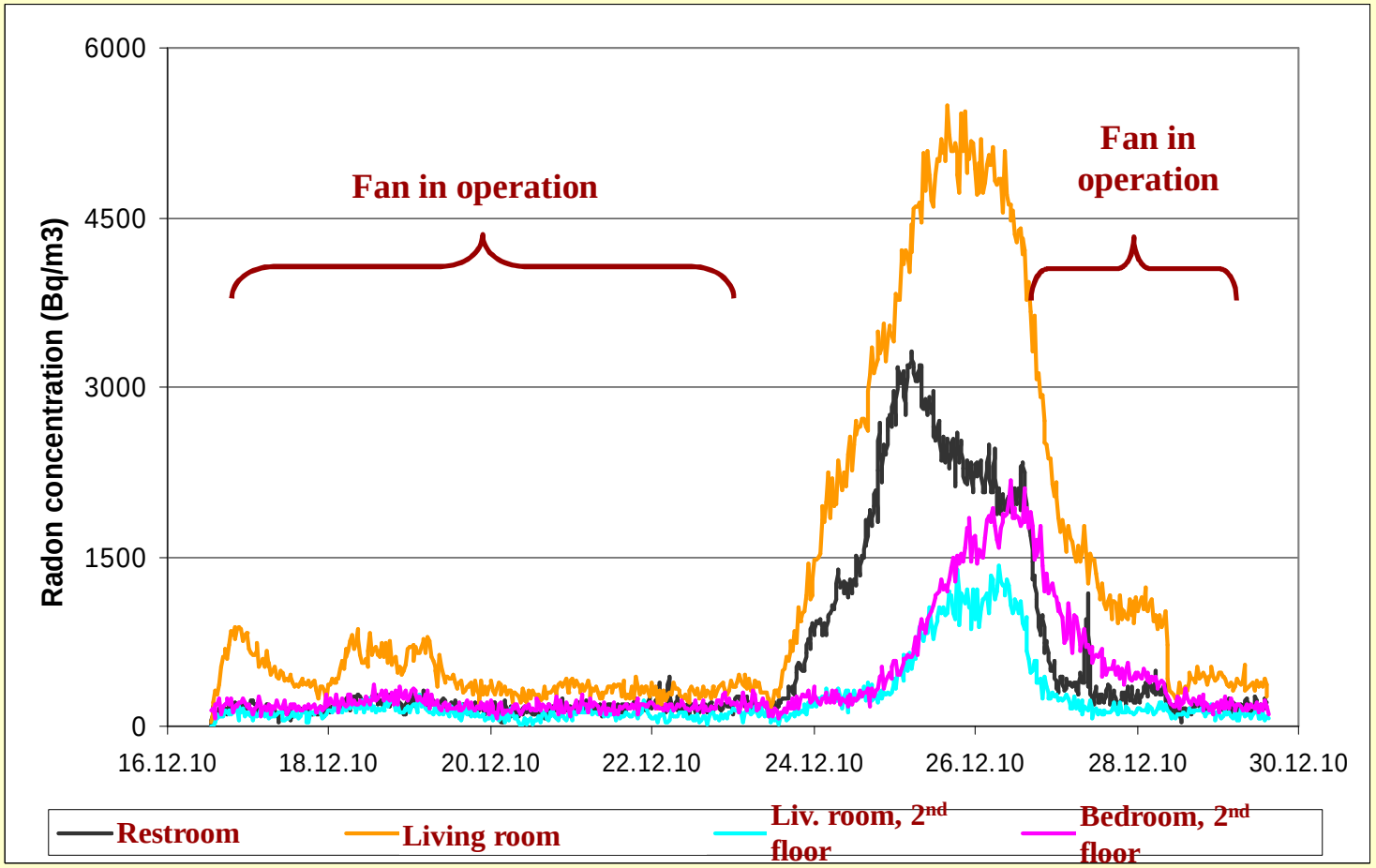
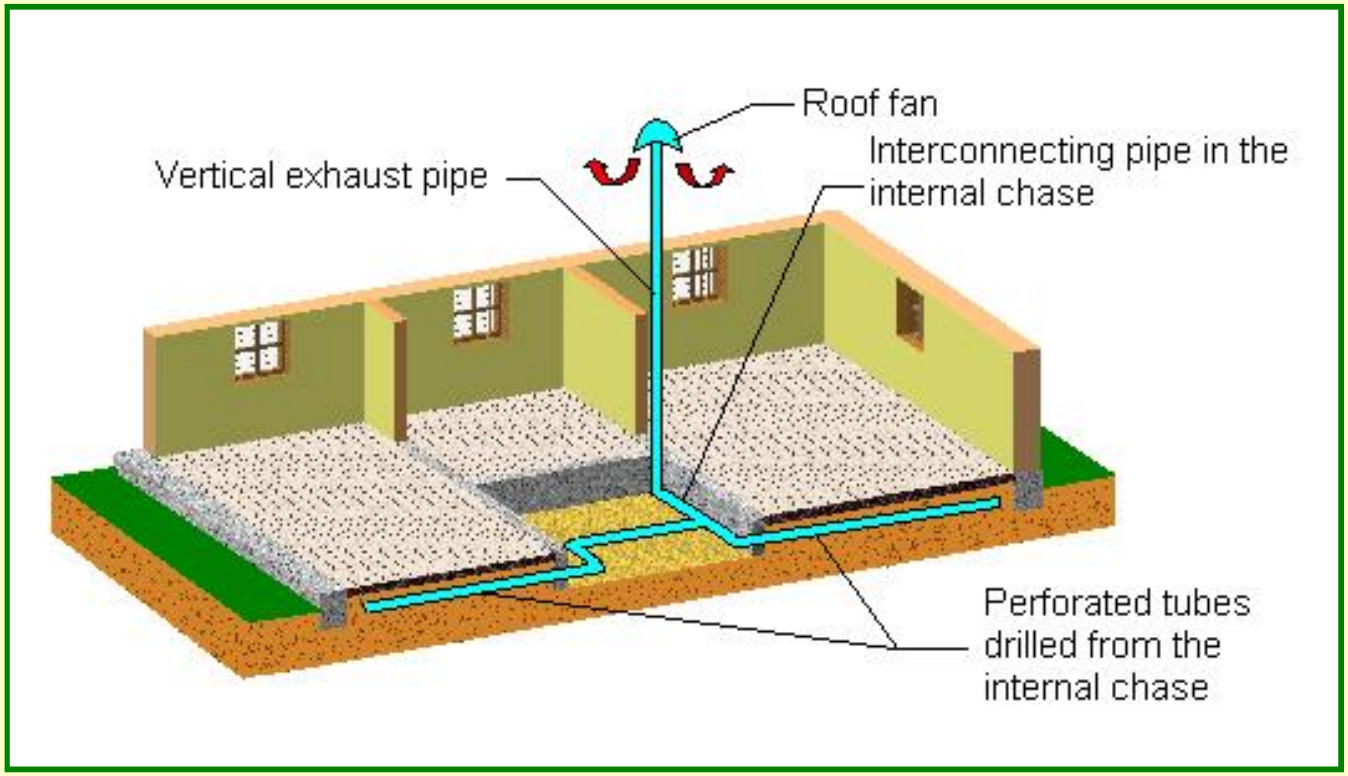


Indoor radon concentration after remediation

During active ventilation indoor radon concentration decreased to the mean value 223 Bq/m³.



Perforated tubes drilled from the internal pit



THANK YOU FOR YOUR ATTENTION