RADON PROTECTIVE AND REMEDIAL MEASURES IN THE CZECH REPUBLIC

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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:

- **ČSN 73 0601** Protection of buildings against radon from the soil, 1995, 2000, 2006
- **ČSN 73 0602** Protection of buildings against radon and gamma radiation from building materials, 2000, 2006

PROTECTION OF NEW BUILDINGS

The type and the degree of protection depends on the **“radon index”** 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: • **sub-slab depressurization** • **air gaps ventilation**

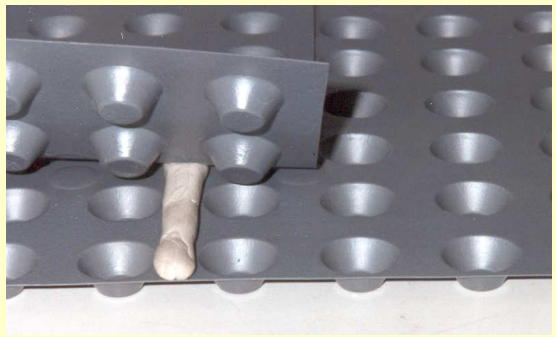
Radon-proof insulation

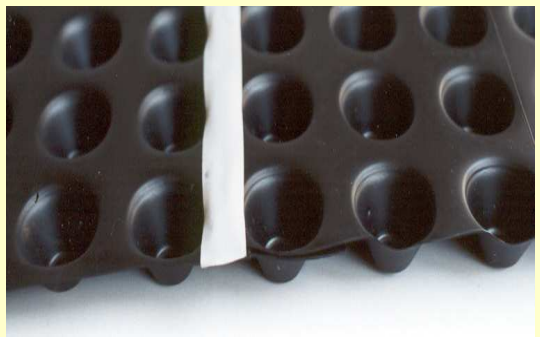
Radon-proof insulation is selected from standard waterproofing materials.

- **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.)

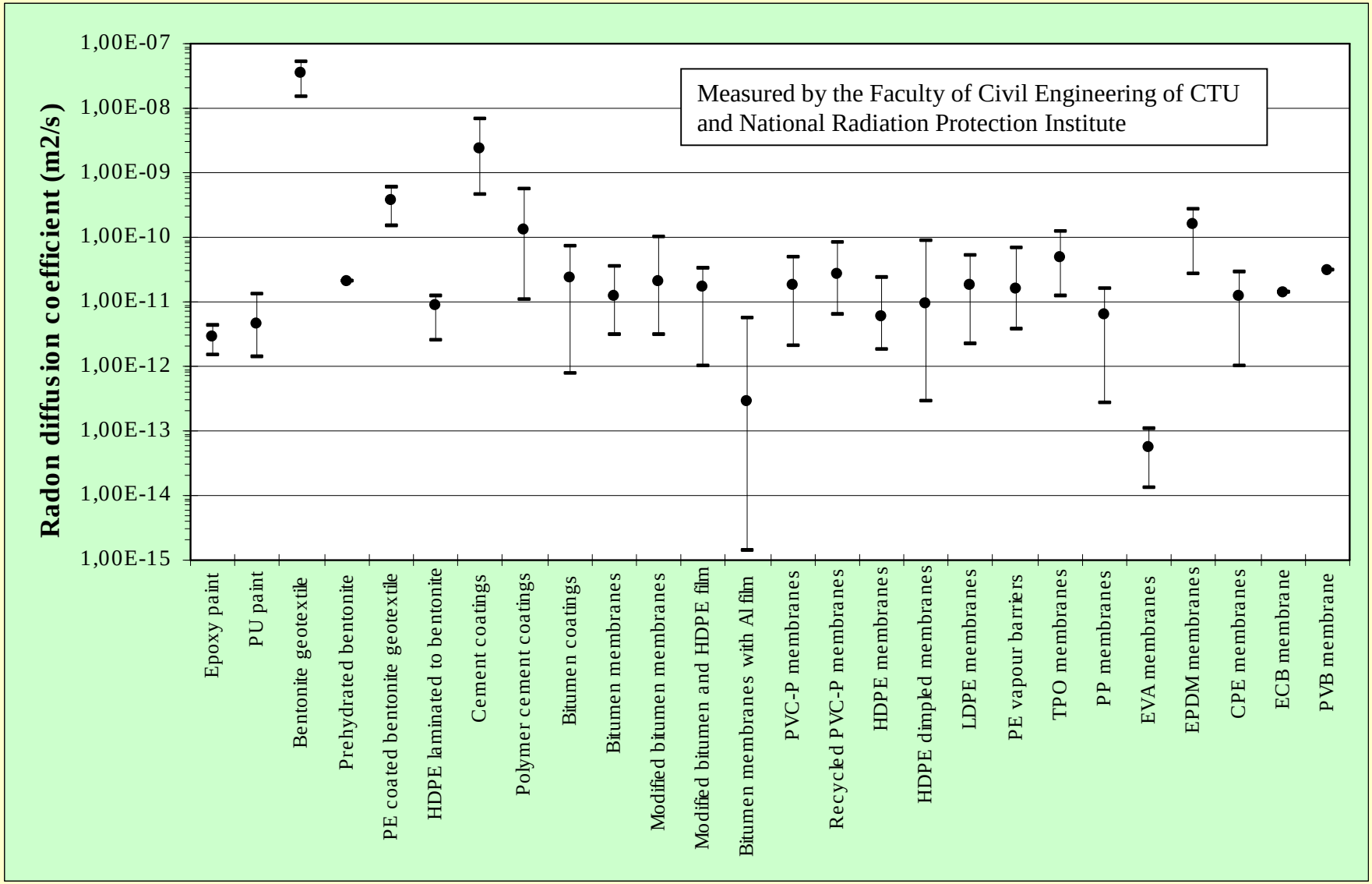




Determination of the Rn diffusion coefficient

- 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
- Up to now more than 360 materials obtained throughout Europe have been tested
- The tests of radon diffusion coefficient are required by the Czech technical standard ČSN 73 0601 „Protection of buildings against radon from the soil“

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 …radon concentration in the soil gas (Bq/m^3)
λ …..radon decay constant (0,00756 h^{-1})
d …..thickness of the membrane (m)
l ….. radon diffusion length in the membrane $l = (D/\lambda)^{1/2}$ (m)
D …. radon diffusion coefficient in the membrane (m^2/h)
α_1 …safety factor
$A_f A_w$ .floor and wall areas in contact with the soil (m^2)
n……ventilation rate (h^{-1})
C_{dif}…fraction of reference level caused by diffusion (Bq/m^3)

Combined systems

Radon-proof insulation in combination with:

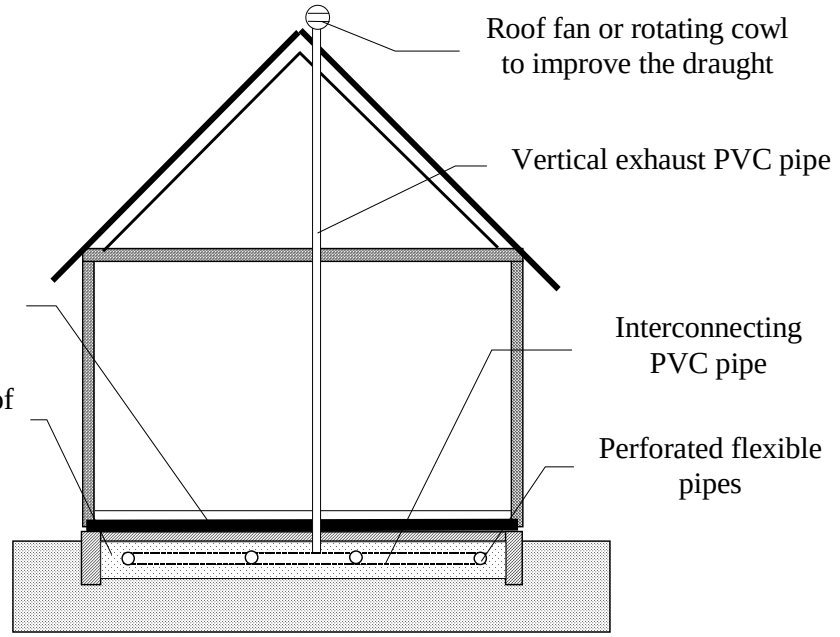
- sub-slab depressurization (ventilation)
- air gaps depressurization (ventilation)

Application

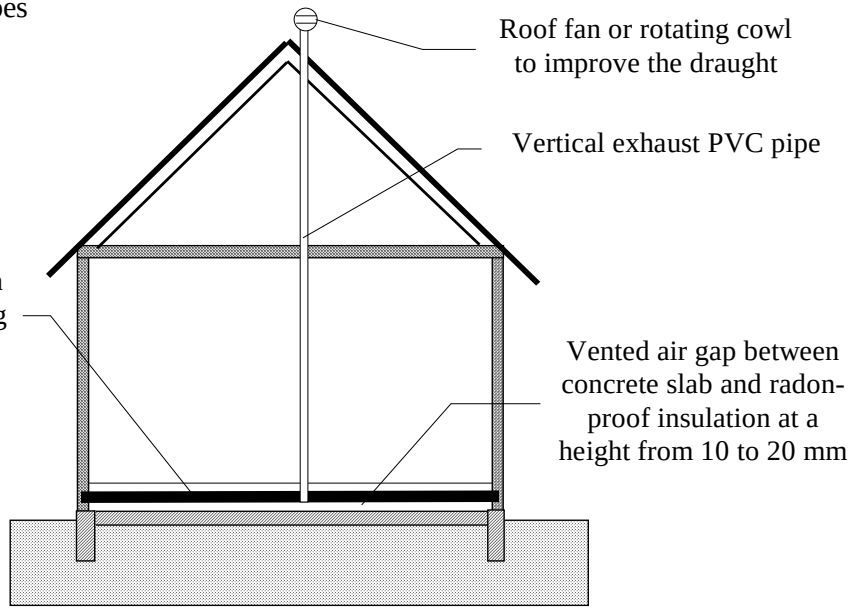
- Soil gas radon concentration exceeds:
  - 60 kBq/m^3 in highly permeable soils,
  - 140 kBq/m^3 in soils with medium permeability,
  - 200 kBq/m^3 in soils with low permeability.
- Highly permeable gravel layer is placed under the house
- Heated floor rests on the soil

Combined systems

Radon-proof insulation + sub-slab ventilation

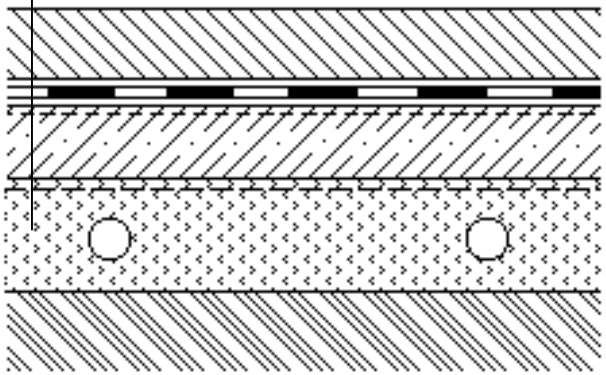


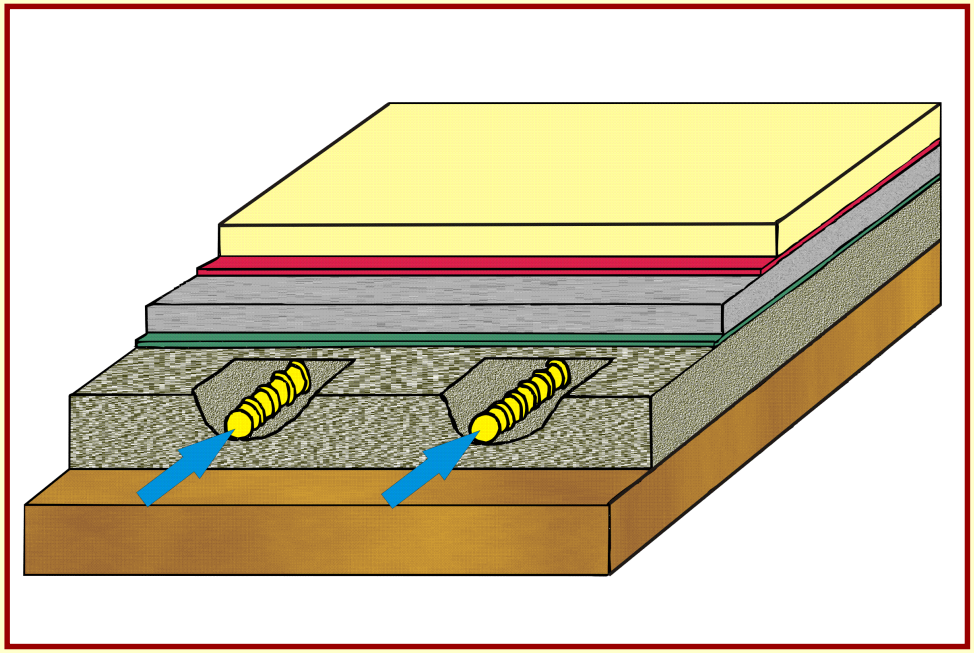
Radon-proof insulation + air gaps ventilation



Sub-slab ventilation

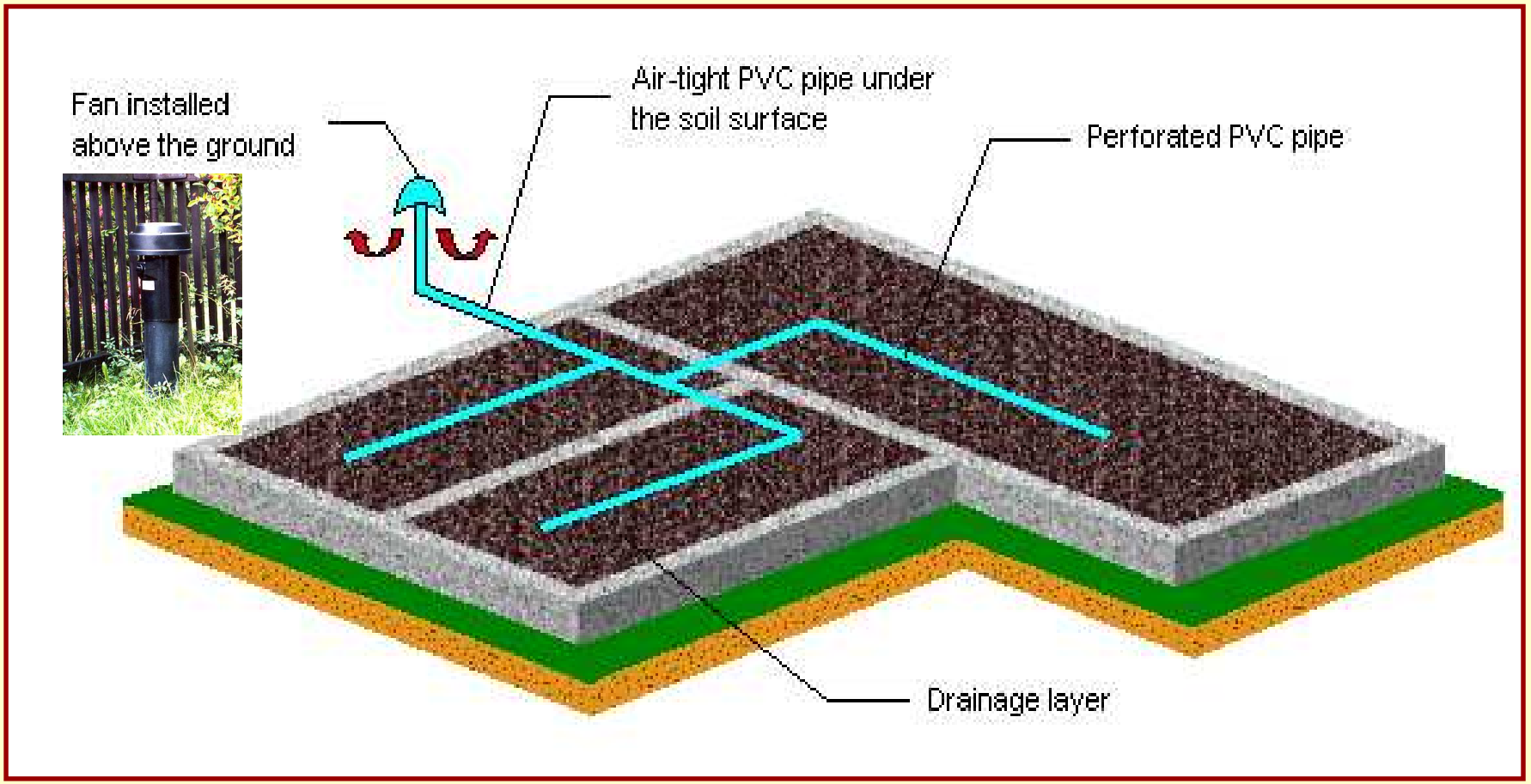
- Floor layers
- Radon-proof membrane
- Bonding primer or geotextile
- Blinding concrete
- Geotextile
- Coarse gravel with perforated pipes
- Subsoil





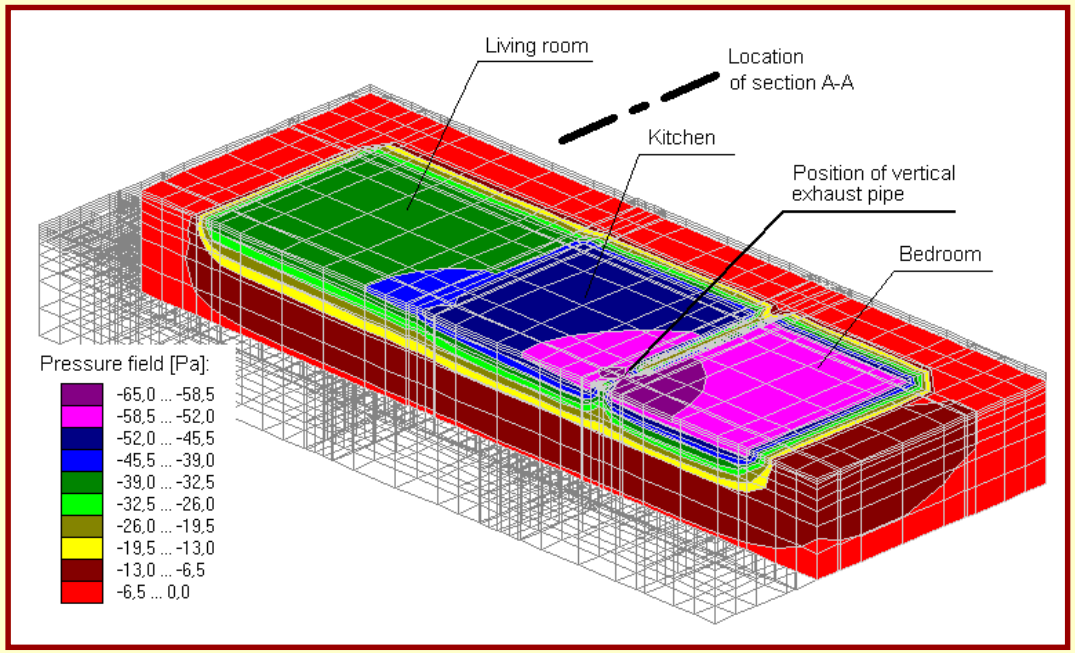
Geometry of sub-slab ventilation systems

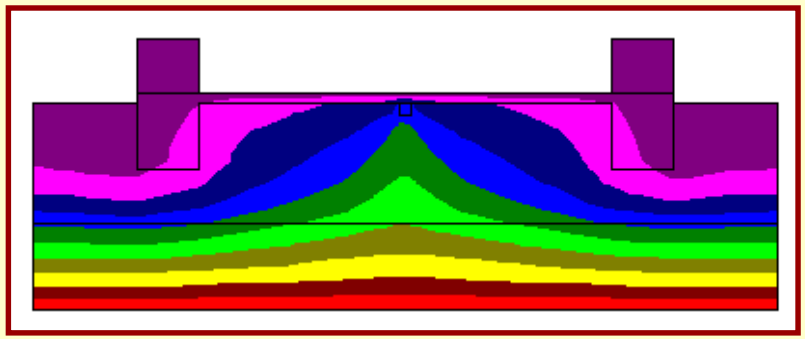
Geometry of sub-slab ventilation systems

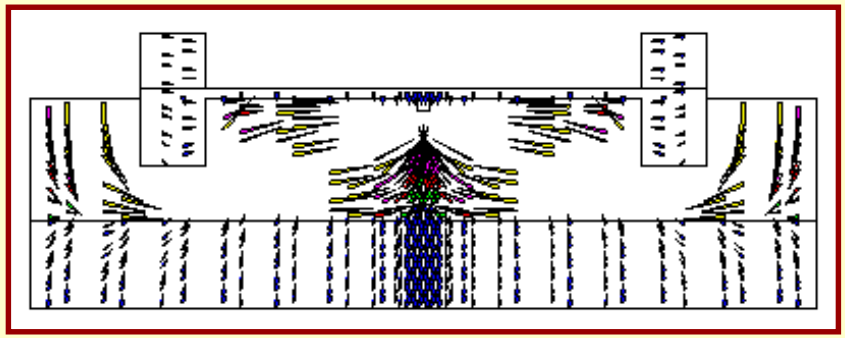


Simulation of sub-slab ventilation systems behaviour

Optimisation of a sub-slab ventilation

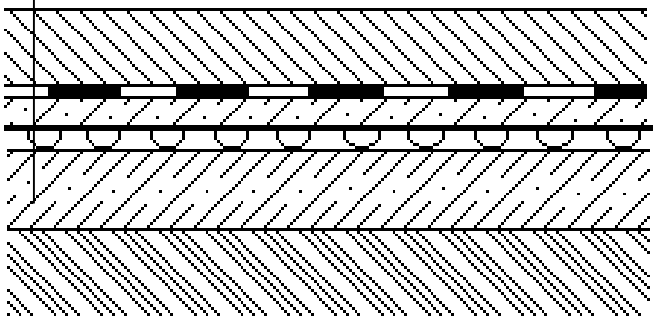


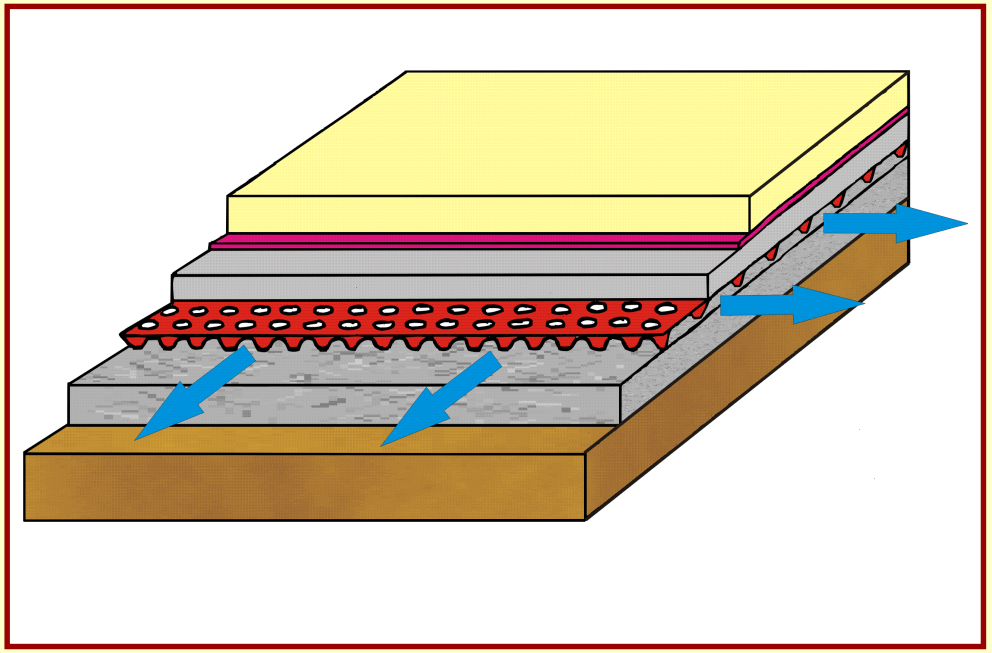




Floor air gaps ventilation

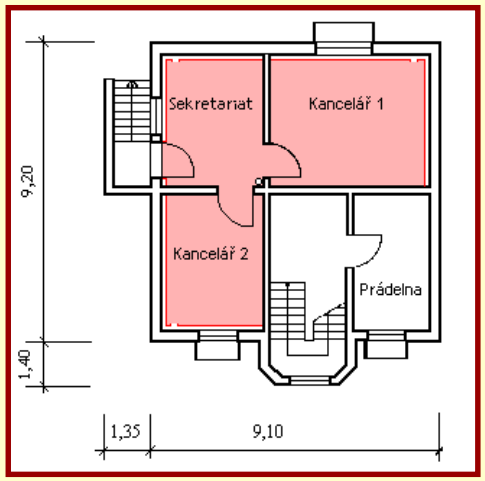
- Floor layers
- Radon-proof membrane
- Cement screed
- Plastic membrane with dimples
- Blinding concrete
- Subsoil

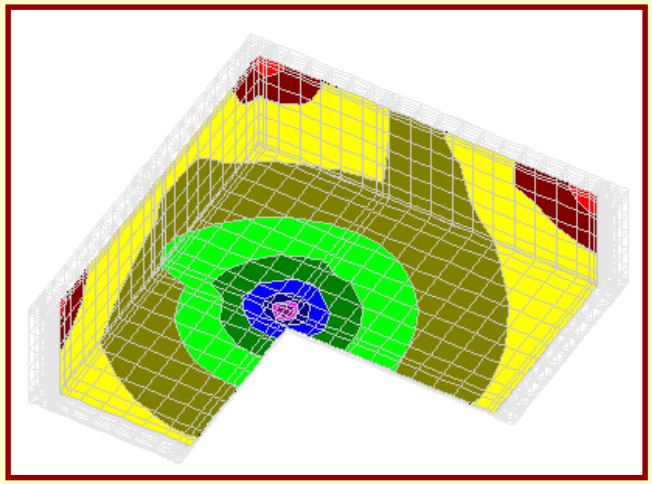


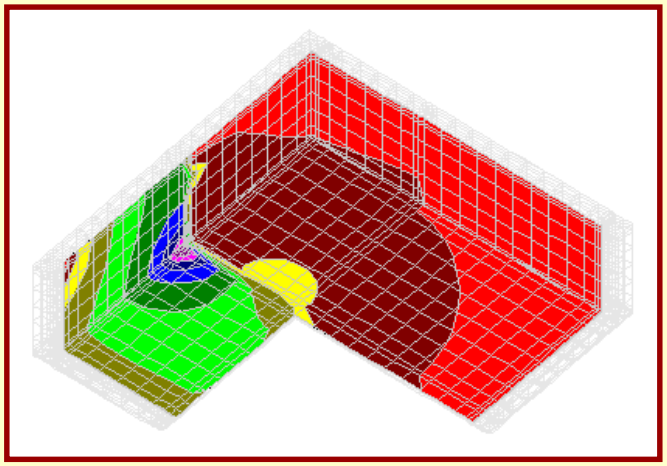


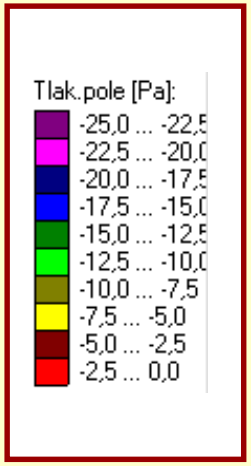
Simulation of an air gap ventilation behaviour

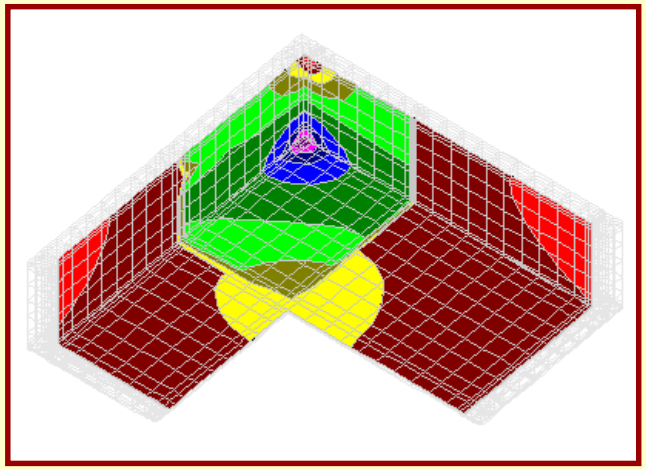
Optimisation of an air gap ventilation











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 radon entry routes** (cracks, pipe penetrations, etc.)
- **improving the cellar – outdoor ventilation**,
- **preventing the air movement** from the cellar into the first floor,
- **exceeding the** indoor – outdoor **ventilation**,
- creating a slight **overpressure within the building.**

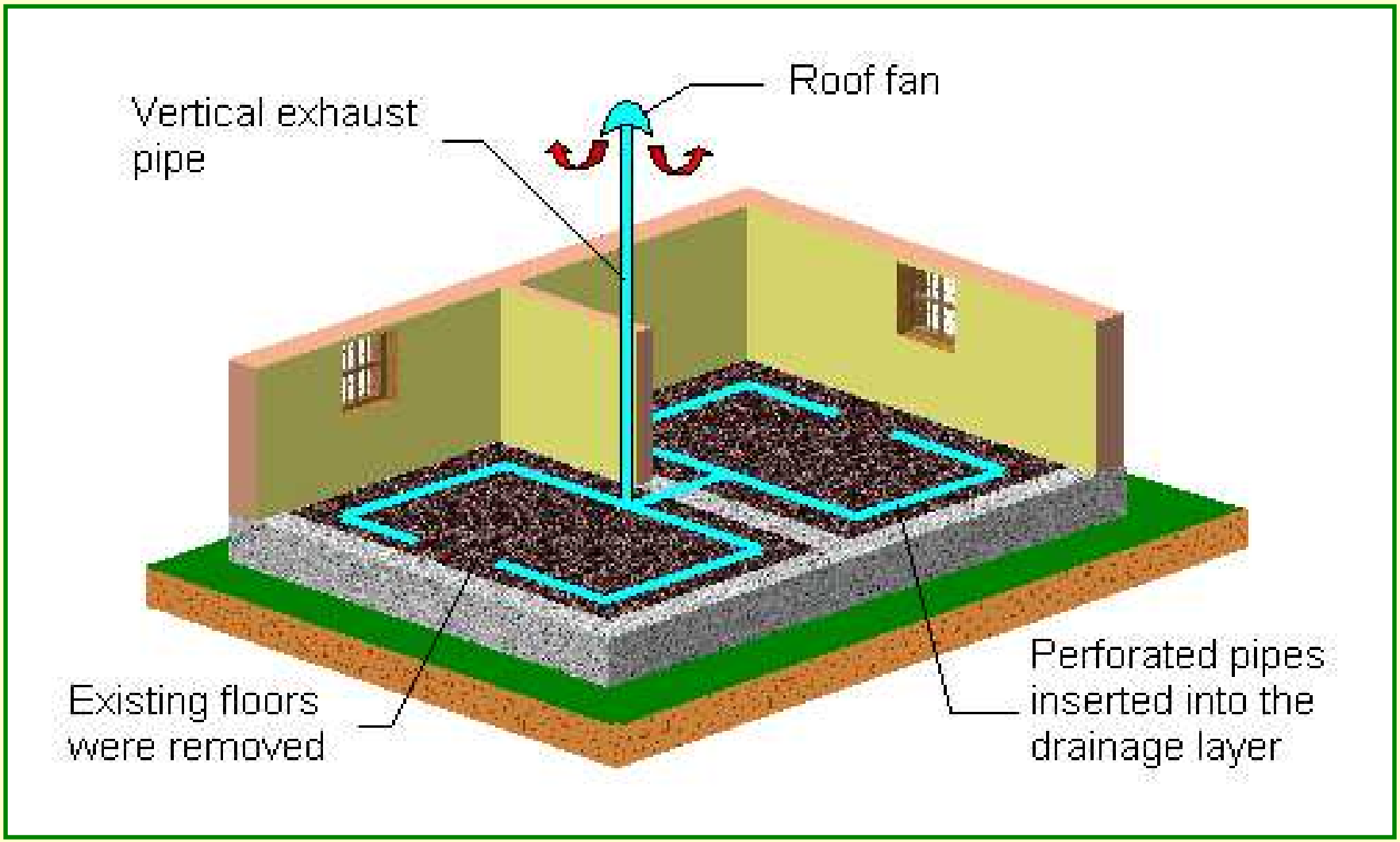
Indoor radon concentration > 600 Bq/m^3 – more effective methods

- The most effective solution is the installation of a **sub-slab depressurization** system. The preference should be given to systems that can be installed without the reconstruction of floors
- In houses with damp walls and floors - replacement of existing floors by new ones in which the **radon-proof insulation** is combined **with the soil ventilation** system **or with ventilated air gaps**
- In houses, where radon problem is caused by radon from building materials – installation of **mechanical supply and exhaust air ventilation** creating a slight overpressure in the living rooms

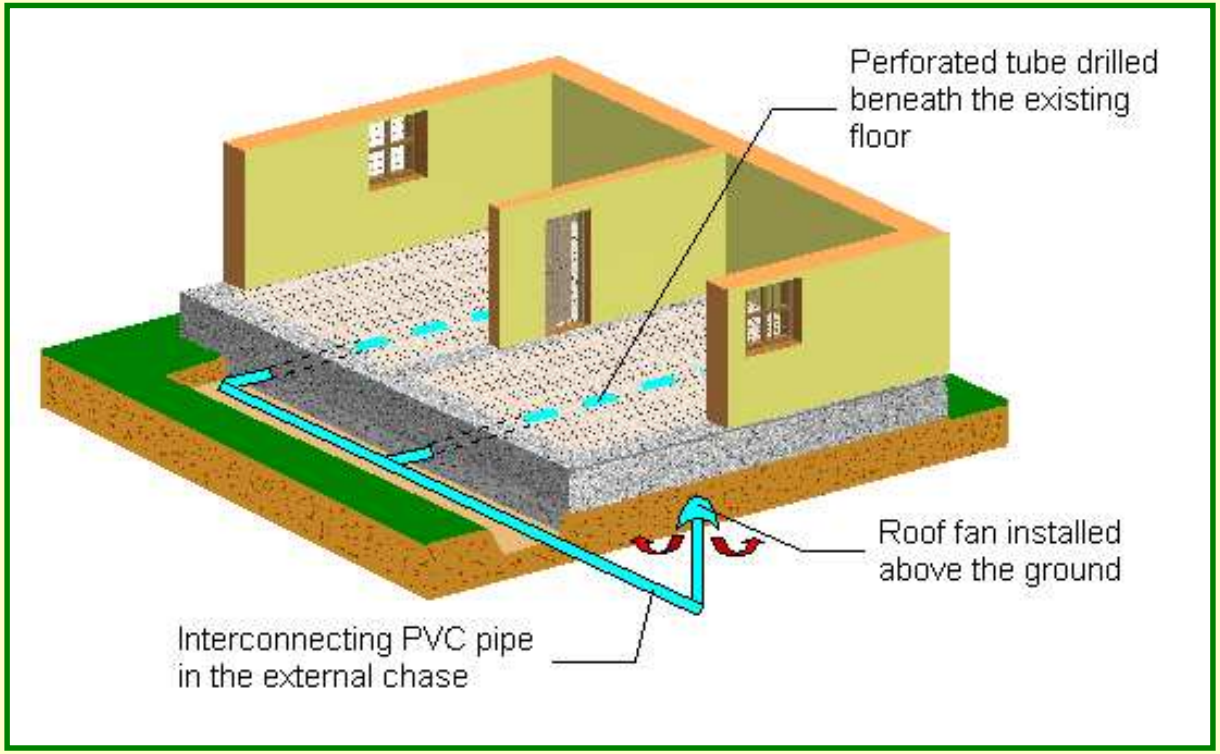
Forms of sub-slab depressurization systems suitable for existing buildings

- **Perforated tubes** drilled beneath existing floors without their damage
- **Network of flexible perforated pipes** inserted into the drainage layer
- **Radon sumps** – not so common

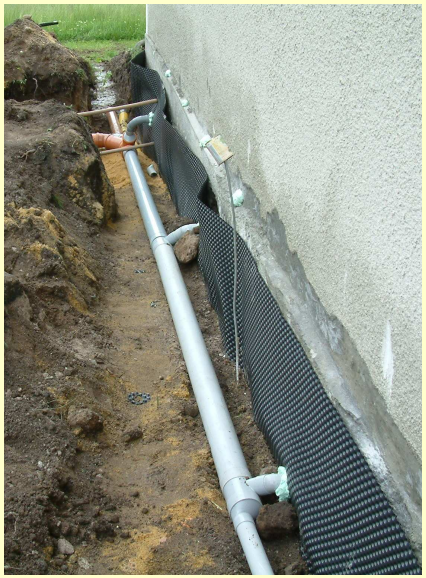
Network of flexible perforated pipes inserted into the drainage layer

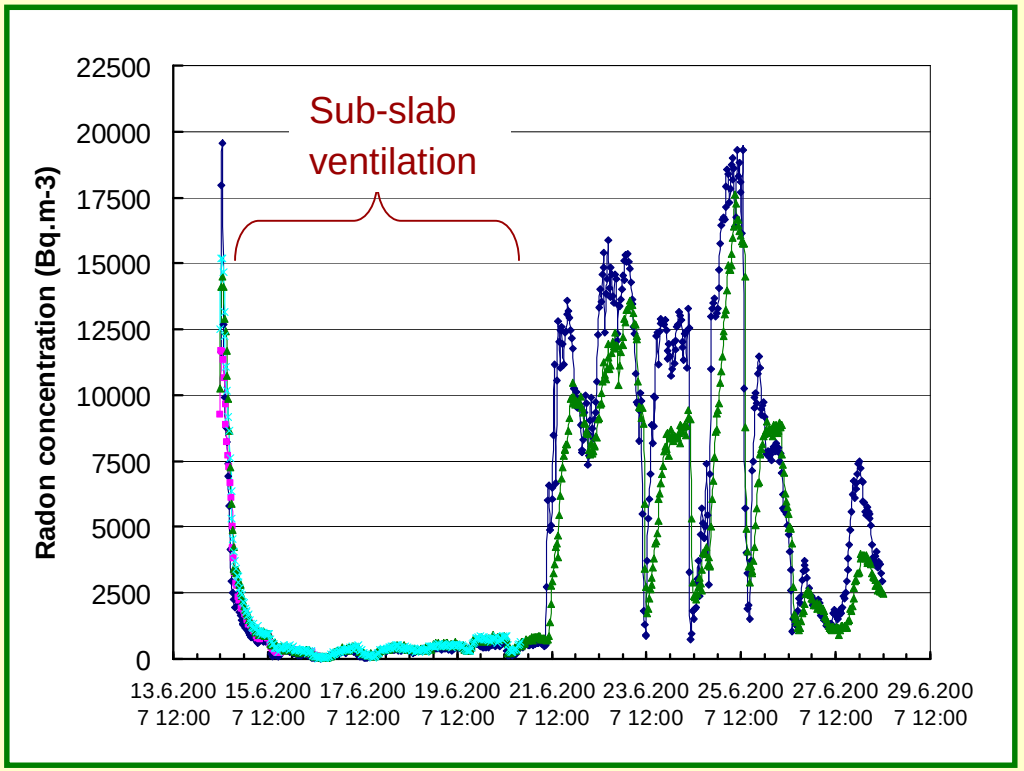


Perforated tubes drilled from the external trench



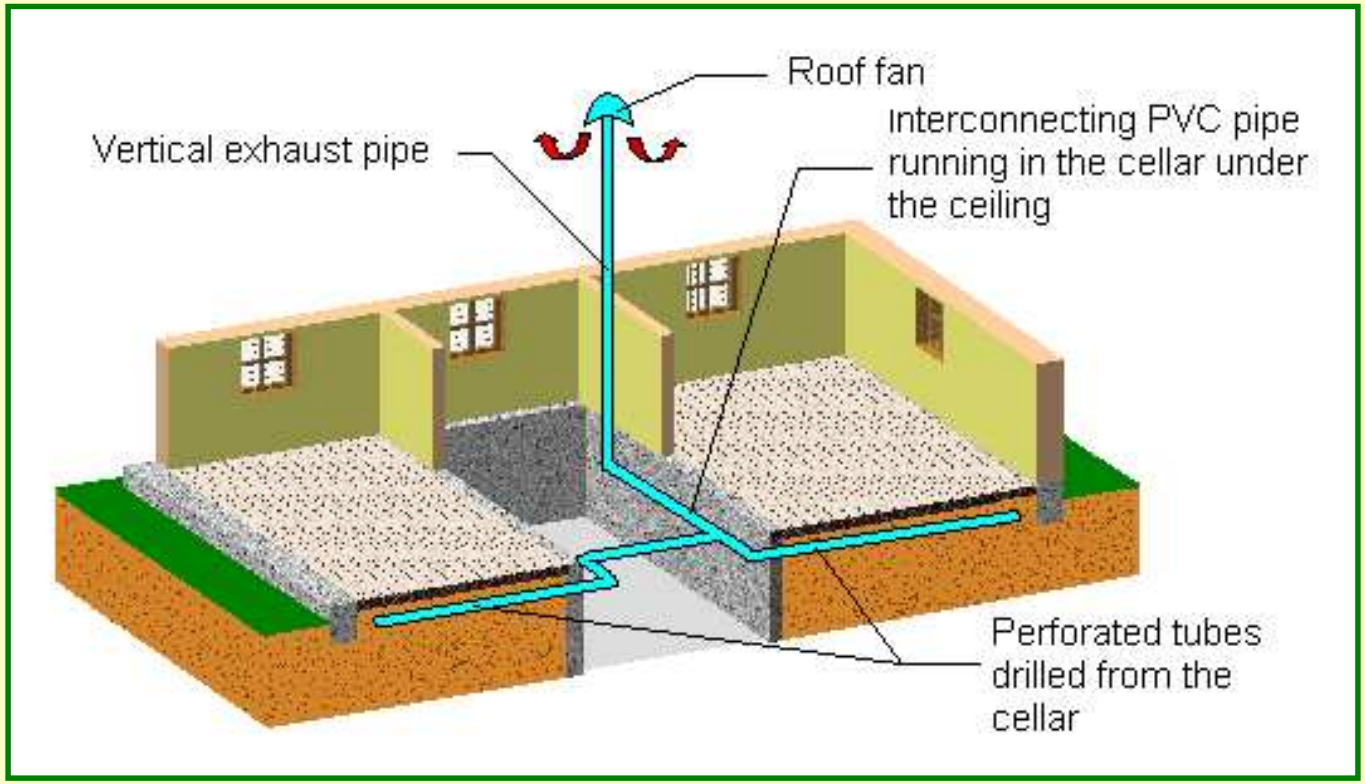
Example of application



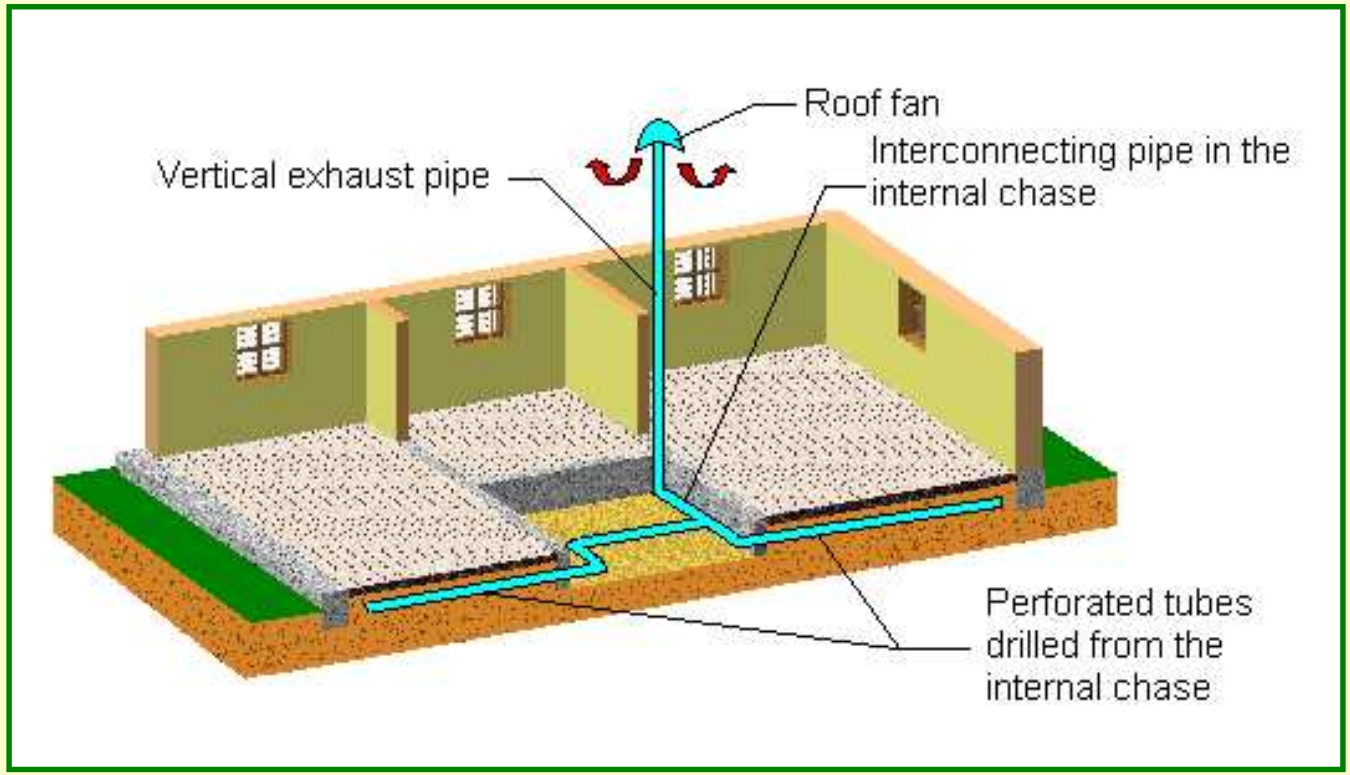


Mean indoor radon concentration after remediation 281 Bq/m^3.

Perforated tubes drilled from the cellar

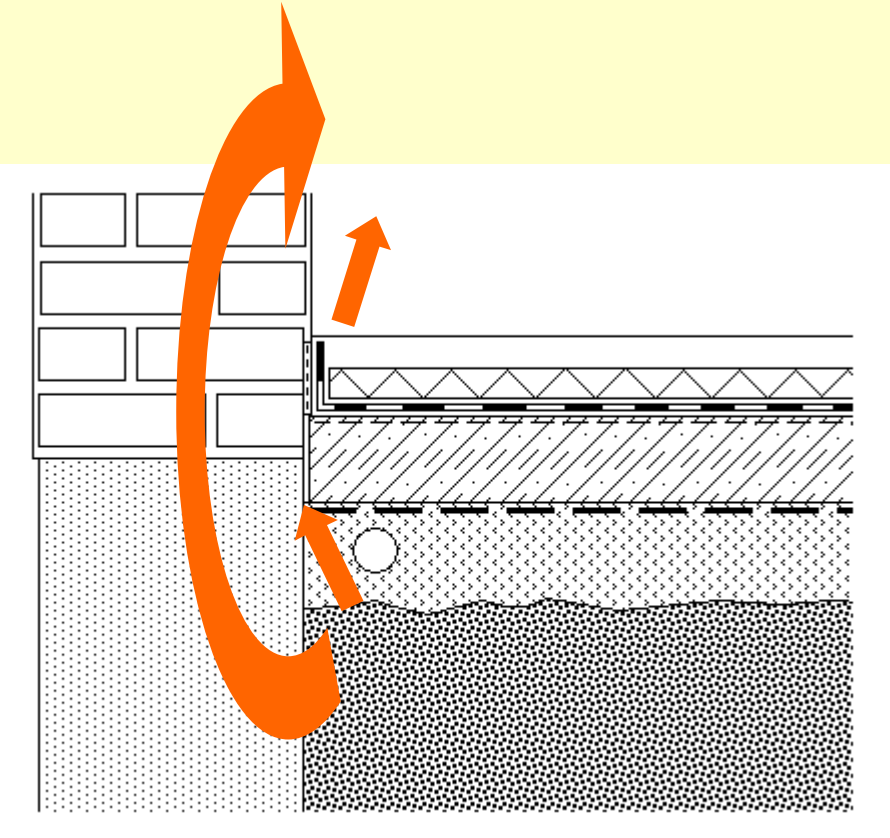


Perforated tubes drilled from the internal pit



Additionally applied radon-proof insulation

In existing houses not so effective (less then 50 %), because it usually cannot be applied under the walls and thus radon can be still transported through wall-floor joints. Therefore combination with a soil ventilation system is recommended.



THANK YOU FOR YOUR ATTENTION