European Radon Solutions Database

Prepared by

: ERRICCA 2 *European Radon Research and Industry Collaboration Concerted Action*

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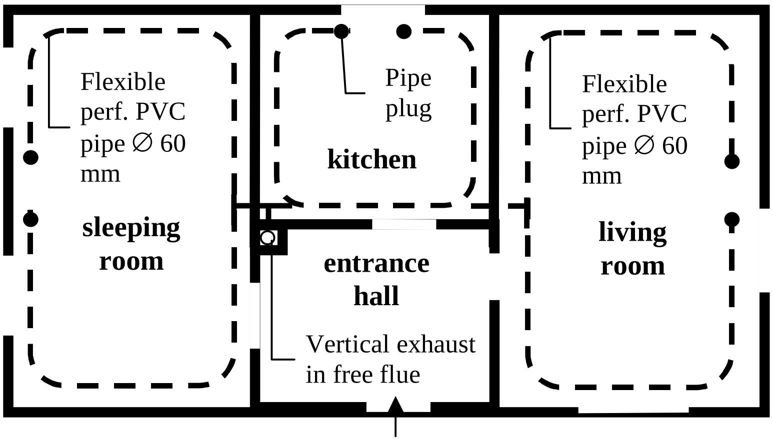
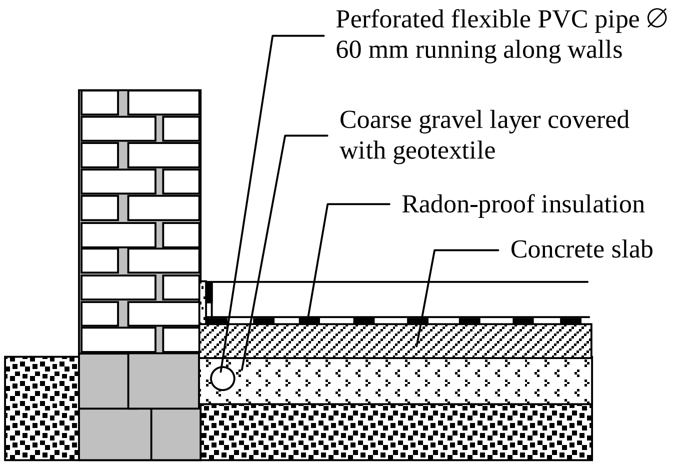
Existing Buildings

Generic Solution	Sheet N°	CZ/GS/07

Type	**RECONSTRUCTION OF FLOORS BASED ON INSTALLATION OF NEW RADON-PROOF INSULATION IN COMBINATION WITH SOIL DEPRESSURIZATION**
Country	**Czech Republic**

Illustration





Description

This solution is designed to lower the air pressure under the building and at the same time to increase the airtightness of the floors. The air pressure in the sub-floor region is lowered by means of a fan, which draws air from flexible perforated pipes. These pipes are laid in the drainage layer along walls in order to stop radon from entering the dwelling through the wall-floor joint or through vertical holes and pores within the wall. This layout of pipes decreases at the same time the humidity of the soil along walls and thus protects walls from becoming wet (if the insulation is not placed under walls). After installation of pipes the drainage layer is covered with concrete slab with geotextile underneath. Radon-proof insulation is applied when concrete has sufficient strength. Vertical exhaust pipe is usually used for the extraction of the soil air. The advantage of this solution is that the vertical exhaust pipe runs through the heated part of the house and thus it works partly as a passive system creating a slight underpressure in the subsoil without the help of a fan.

Radon-proof insulation

Only materials with measured radon diffusion coefficient can be used for radon-proof insulation. The thickness of insulation is calculated according to Czech Standard CSN 730601 from the following equations:

$$d \geq l.\mathrm{arcsinh}\frac{\alpha_1.l.\lambda.C_S}{E_{\lim}} \qquad \text{(m)}$$

$$E_{\lim} = \frac{C_{dif}.V.n}{A_f + A_w} \qquad \text{(Bq/m}^2\text{h)}$$

where C_S is the radon concentration in the soil gas (Bq/m^3), λ is the radon decay constant (0,00756 h^{-1}), d is the thickness of the radon-proof insulation (m), l is the radon diffusion length in the insulation $l = (D/\lambda)^{1/2}$ (m), D is the radon diffusion coefficient in the insulation (m^2/h), α_1 is the safety factor, that should eliminate the inaccuracies arising during the soil gas radon concentration measurements (for combination with soil ventilation α_1 = 1), V is the interior air volume (m^3), n is the air exchange rate (h^{-1}), A_f and A_w are the floor and the basement walls areas in direct contact with the soil (m^2) and C_{dif} is a fraction of indoor concentration caused by diffusion, i.e. C_{dif} is estimated to be 10% of the highest permissible radon concentration indoors (in the Czech Republic C_{dif} is equalled to 20 Bq/m^3 for new buildings and 40 Bq/m^3 for existing buildings).

Insulating materials must function effectively over their required service time. From this point of view the preference should be given to insulating materials with longer durability and higher resistance to ageing, i.e. suitable materials are PVC or PE foils and membranes based on plastomeric (APP modification) or elastomeric (SBS modification) bitumen. On the other hand membranes based on oxidised bitumen should not be applied, because their resistance to soil corrosion as well as to weathering is very low. As far as the reinforcing fabrics concerns only membranes with moisture resisting fabrics made of mineral, glass or synthetic fibres should be used, etc. Concerning application aspects, bonded sheets (fully adhered to the substrate) represent higher degree of protection compared to unbonded sheets, which rely on perfect joints to a far greater extent than do bonded membranes, because radon can travel in the air gap beneath the unbonded membranes to the untight places in the insulation. Complete insulating systems with extra components for external and internal corners, edges and pipe entries should be preferred to pure and simple insulating materials.

Fans

The most commonly used types of fans are in-line paddle-wheel fans with airtight casing or roof paddle-wheel fans. These fans should have a flow rate from 100 m^3/h to 200 m^3/h at a pressure difference from 250 Pa to 150 Pa and power consumption between 40 and 70 W. The power of fan is controlled by means of voltage regulator. To minimise negative effects (reduced underfloor temperatures and increased air exchange rate) the fan should be switched to intermittent mode with the frequency of operating periods depending on soil permeability, floor tightness and radon concentration in the soil.

Fans should be resistant to weathering and to moisture condensation inside pipes. To avoid disturbing noise effects the fan should be installed away from the occupied rooms.

Pipework

For suction of soil air flexible perforated PVC pipes with the diameter around 60 mm are used. Standard PVC-U pipes are convenient for main collecting pipes and vertical exhaust. The diameter of such pipes should correspond to the amount of air that is transported inside them. Main collecting horizontal pipes have the diameter from 60 to 110 mm and vertical exhaust pipes from 110 to 125 mm. To reduce visual impact vertical pipe can be inserted inside a free flue or can be boxed-in in the corner of a room. In flueways only flexible PVC, aluminium or rustless pipes are used. Due to the condensation inside pipes all pipes should be installed in a slight slope towards the perforated pipes so that water can escape (discharge) in the soil. Exhaust outlet should be located well away from windows, doors and other vents.

All pipe penetrations through floors should be carefully sealed by gun applied flexible acrylic or low modulus silicone sealants or by expanding polyurethane sealants.

When to use the system

This form of radon mitigation is convenient for houses with floors in bad condition (rotten timber floors, concrete slabs of poor quality, slabs with lots of cracks, etc.), where reconstruction of floors is necessary not only from radon point of view. The advantage of this solution is that it ensures perfect pressure distribution underneath floors due to layer of coarse gravel, at the same time solves damp and radon problems and provides houses with new floors. The system can be used in houses built on soils with very low permeability.

Pre-installation Diagnosis

To find source rooms (radon entry routes) and to prepare information for the effective design of the remedial measure, these parameters must be measured:

- Radon concentration in all habitable rooms performed at least by one weak measurements under conservative conditions (lower ventilation and good condition for radon entry into the house)
- Radon concentration in the soil gas under the house measured after removing of existing floors (the measuring depth is 0,8 m)
- Permeability of the soil under the house

Typical radon reductions achieved

The effectiveness of such systems varies between 70 and 90 %, which means that indoor radon concentration decreases to 30 % up to 10 % of the initial values. The effectiveness is mainly influenced by the fan power and by the air tightness of new floors.

Limitations

Among the disadvantages of this solution belong higher labour and time consumption, obstructions in the living space of the house and high installation costs. The system is not suitable for houses with basements or cellars and for houses, where:

- it is difficult to find a suitable route for the vertical exhaust pipe through the dwelling,
- the obstructions in the living space are not acceptable.

Common failure modes

The system can fail only in these situations:

- fan with inadequate pressure/flow rate characteristic is used,
- fan is damaged by condensed water,
- house owner switches off the system.

System enhancements

The intermittent operation of fans is recommended. The merits are: savings in operation costs, prolonged life of fans and reduced negative effects to subsoil (drying, freezing etc.). Operating periods of the fan should be adjusted according to continuous measurements of indoor radon concentration.

Numerical modelling is recommended for the optimisation of the design (fan power and layout of perforated pipes in dependence on the house substructure and soil characteristics). At this time three models are available: TLAK3D that solves pressure and air velocity fields in three dimensions, WIND2D solving temperature fields as a result of heat transfer caused by conduction and convection of soil air and RADON2D that calculates radon concentration fields in two dimensions.

Further Information

More detailed information can be found in the Czech Standard CSN 730601 “Protection of houses against radon from the soil”, in detailed guides published by State Office for Nuclear Safety and on website www.suro.cz. All these information are in Czech language.

Information in English:

- Jiránek. M, Hůlka J.: Applicability of Various Insulating Materials for Radon Barriers. In: The Science of the Total Environment 272 (2001), pp 79-84
- Jiránek. M, Hůlka J.: Radon Diffusion Coefficient in Radon-proof Membranes - Determination and Applicability for the Design of Radon Barriers. In: International Journal on Architectural Science, Vol 1, No. 4, pp 149-155, 2000

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