RECONNAISSANCE TECHNIQUE FOR RADON RISK CLASSIFICATION OF FOUNDATION SOILS

Martin Neznal, Matěj Neznal, J. Šmarda

RADON corp.
Za koncem 1380, 28922 Lysá nad Labem
CZECHOSLOVAKIA

ABSTRACT

Infiltration of radon from the ground is usually the primary source of indoor radon pollution. A uniform method for radon risk classification of foundation soils based on soil-gas radon concentration measurements and on the determination of soil porosity, permeability and structure was proposed in 1990. Results of assessment of some areas in Czechoslovakia, containing more than 5 000 radon concentration measurements, demonstrate the utility of the technique and confirm the link between geology and radon potential of the soil.

INTRODUCTION

The Czech Republic /CR/, the western part of Czechoslovakia, is situated mostly on the eastern end of the Central European Platform with a higher than normal content of uranium in rocks. These geological conditions cause higher risk of radon penetration into buildings from the ground. Since the acceptance of the Decree of the Ministry of Health of the CR concerning the Requirements for Limiting the Irradiation from Radon and Other Natural Radionuclides /1/ in 1991, the delailed radon measurements are obligatory for all areas of urban planning.

RADON corporation, a private radon monitoring firm, was established in 1990. During one year it has realised a radon survey at about 70 areas of different size /from 400 to 200 000 sq.m./, especially in Prague and in Northern Bohemia but also in other regions of the CR. Some results of this work, containing more than 5 000 radon concentration measurements, are presented in this paper.

RADON RISK CLASSIFICATION OF FOUNDATION SOILS

The uniform method for radon risk classification of foundation soils, proposed by Geological Survey Prague in cooperation with the Ministry of Health of the CR and other authorities /2/, is based on soil-gas radon concentration measurements at each measured point of the area investigated /grid 10 x 10 m/ and on permeability classification of foundation soils, which respect the Czechoslovak National Standard 731001 /three groups of foundation soils - low, medium and high permeability soil classes - see Table 1/. The other parameters including vertical and horizontal changes in soil and rock profile are also taken into consideration /geological description and laboratory analysis - the documentation of 4 - 6 drillings for each 10 000 sq. m. of the area/. In practice, the radon classification is usually done in connection with the engineering geological investigation.

Table 1 - Radon risk classification of foundation soils

classification of risk /categories/	radon concentration /222-Rn/ in the soil gas /kBq.m-3/		
	low	medium	high
	soil permeability		
low risk area	$\leq$30	$\leq$20	$\leq$10
medium risk area	30 - 100	20 - 70	10 - 30
high risk area	$\geq$100	$\geq$70	$\geq$30

Note : A special category of extremely high risk has been established for anomalies more than ten times higher than those at the high risk areas.

SOIL-GAS RADON CONCENTRATION MEASUREMENTS

The soil-gas sample collection method has been described recently /3/, similar sampling technique was used by Reimer /4/. The sampling system consists of a small-diameter hollow probe pounded into the ground to a depth of 0,60 - 0,80 m . Samples of about 100 cm3 are collected by a syringe and introduced into evacuated Lucas cells. The cells are transported into the laboratory and counting begins usually from 5 to 15 hours after injection. The radon concentration is determined with analytical sensitivity of about 0,3 kBq.m-3.

Both the method and its calibration have been verified in the Reference laboratory /Ministry of Health of the CR/. In September 1991 RADON corporation took part in the international intercomparison and intercalibration excercise /Badgastein, Austria/.

SURVEY RESULTS

It is known, that soil characteristics do vary over a small area, both large scale and the small scale parameters have to be considered. The first effort is to gather general data appropriate for radon assessment on the large scale - lithology, soil and bedrock structure, structural geo - mechanical deformation of rocks. The second approach is to investigate factors influencing the production and migration of radon in soils. In brief, it is necessary to determine local soil conditions - in particular the permeability and changes in the soil profile.

Experiences based on the large number of survey data are shown in the following summary.

1. It is possible to collect a large number of samples in a short time period. Sample collection must be made very carefully. Perfect sealing of all parts of the equipment is especially important. There are no problems with sample collection even when very high soil-moisture contents or fine clays are encountered. Some difficulties may appear when the sampling depth is below the ground water level.

2. Tectonic zones determine the potential for more serious radon problems to exist. Measurements in some regions in the north-western part of Bohemia confirmed this fact. Values of soil-gas radon concentration observed in the area situated on a tectonic zone /Hrob area/, where longitudinal and transverse faults form a fault belt /called Krušnohorský/, were about four times higher than those in the near-by areas with similar geological conditions /Litvínov and Dubí areas/ . Average soil-gas radon concentration in the Hrob area was 300 kBq . m-3 /standard deviation 261 kBq . m-3; number of samples 36/, while in the Litvínov area it was 69,7 kBq . m-3 /27,8 kBq . m-3; 36/ and in the Dubí area 84,9 kBq . m-3 /34,1 kBq . m-3; 36/. Similar results were obtained in Chaby, Prague, where RADON corporation had realised a detailed radon survey for the projected housing estate /3/ - about 1 700 soil-gas radon concentration measurements.

3. Radon risk mapping on large scales is first of all based on the evaluation of bedrock. In many measured areas,soil-gas radon concentrations really correspond to the expected radon potential of bedrock with different stratigraphical and petrographical character /3/. On the other hand, some results of detailed in situ measurements / for example at the locality north of Prague/ illustrate the significant role of various soil layers. Two reference areas /Veltěž, Ďáblice/ are situated in the Tertiary /Pliocene/ sandy gravel fluvial and lacustrine sediments. Owing to the granite pebble content in these sediments, higher radon concentrations were assumed. In the Ďáblice area, loess eolian deposits /average thickness of about 5 m/ cover underlying fluvial and lacustrine sediments. Homogenous and relatively less permeable loess and loess loam cause homogenous and relatively not so high soil-gas radon concentrations ranging from 29,5 to 58,4 kBq . m-3 /average value 41,8 kBq . m-3; standard deviation 7,2 kBq . m-3;number of samples 36/. Different situation was found in the second area /Veltěž/, where the thickness of loess eolian deposits varies from 0 to 1m. Soil-gas samples were thus collected in the layer of high permeable sandy gravel sediments. Presence of overlying less permeable layer at majority of the measuring points resulted in higher radon concentrations /with the highest value 158 kBq . m-3/and in inhomogenous distribution /average value 78,4 kBq . m-3; standard deviation 45,4 kBq . . m-3; number of samples 36/. These results confirm the important role of air permeability of soils. The permeabilities have much larger range than the values for other parameters and local diferences in them may be very significant in determining radon infiltration risk /5/.

4. Radon risk classification of foundation soils may be difficult in areas,where excavations or other human interventions occurred in the past, because of frequently observed anomalies.

5. Investigations concerning seasonal and meteorological variations of soil-gas radon concentrations have not been finished yet. Because it is evident that these variations differ in different geological conditions, further data are needed.

CONCLUSIONS

The applications presented in this paper demonstrate how geology /including lithology, structure and soil permeability/ and soil-gas radon measurements can be combined in a reconnaissance of the radon infiltration risk from the ground. Survey results improve understanding of factors controlling the radon generation and migration pathways. It is possible to divide the areas reserved for building activities into different groups of potential risk. When the locations of building areas or separate houses are known, the radon risk prevention technology for buildings can be chosen and proposed.

REFERENCES

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