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Permeability as one of main parameters for radon risk classification of foundation soils

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Abstract. Permeability of soils and rocks for gasses is one of the main parameters for final radon risk classification of building sites. For the improvement of the method for radon risk classification it is recommended to complete in situ measurements of permeability and/or results derived from grain size analysis by an expert description of parameters of soils and rocks and their changes in vertical profile.

1 Introduction

The uniform method, that has been used for radon risk classification in Czech Republic since 1994, is based on the assessment of the soil-gas radon (^{222}Rn) concentration and of the permeability of soil and rock for gasses. Both parameters are evaluated in the vertical profile up to the level of assumed building foundations or to the level of assumed contact building – soil. Results of detailed radon surveys as well as results obtained from research studies, carried out in the period 1994–2000, indicated that the uniform method should be improved. A research dealing with this topic was performed by RADON v.o.s. in 2000–2002. The research was focused on the determination of soil permeability, not only because it is one of two main parameters for classification. There are many problems connected with the determination of soil permeability itself and some correspond to a variable understanding what this parameter describes or what it means in fact.

2 Methods and results

Due to the original method for classification it is possible to use direct in situ measurements of permeability (based on the soil gas withdrawal by means of low negative pressure) or particle size analyses (the permeability is derived very simply from the weight percentage of fine fraction in the soil sample). These data are completed with the description of changes in vertical profiles with respect to the expected foundation depth of the building. The main disadvantages are given by the fact that in case of particle size analyses other factors influencing the permeability (natural soil moisture, density, effective porosity etc) are not taken into consideration. Furthermore, one sample cannot describe a heterogeneous geological environment (horizontal and vertical changes, influence of human activity). In case of direct measurements the results are strongly dependent on small scale variations of the character of the soil and the equipment commonly used in Czech Republic does not enable to measure exactly in extremely low and/or high permeable soils (results vary in several orders of magnitude).

The research was divided into following sections:

- Comparison of approaches used in Czech Republic and in other countries for determination of permeability of soils and rocks for gasses.
- Advantages and disadvantages of methods and equipment for direct measurements, tests of prototypes.
- Spatial and seasonal variability and their impact on radon risk classification.
- Comparison of results of direct in situ permeability measurements and results derived from particle size analysis.
- The variability of permeability with respect to the variability of soil-gas radon concentration with depth.
- Minimal statistical sets of permeability values required for the evaluation.
- The final determination of permeability and the minimal content required for the soil profile descriptions.

At first a wide range of methods for soil-gas permeability determination in radon research has been considered for further investigation (mainly single probe measurements, dual

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probe measurements and derivation of permeability from other parameters – permeability for water, grain size analysis etc.). After comparison of advantages and disadvantages of the systems with respect not only to professional questions, but also to economical ones, three prototypes for direct measurements have been prepared. The main goal was to avoid or decrease the disadvantages of RADON JOK equipment (single probe system that is used in Czech Republic and that belongs to most widely used methods).

These prototypes and RADON JOK system were tested in various geological conditions. The tests confirmed the expected limitations of particular approaches. Single probe system was chosen for testing of temporal and spatial variability due to its simplicity and previous results. The measurements were performed at four reference areas with respect to various geological conditions each month during a one-year period. Permeability of soils and rocks for gasses was measured at 15 points, at two reference areas at two depths, 0.4 and 0.8 m, and at two reference areas at a depth of 0.8 m, i.e. at the same depth as soil gas samples are collected for radon concentration measurements. Other important parameters, mainly soil-gas radon concentration and soil moisture and/or the mass percentage of fractions, porosity and water saturation were determined, to be able to weigh correlations between different influencing factors.

In general, good correlations between the measured parameters were obtained at the areas with homogeneous and high permeable soils. On the other hand a correlation between radon concentration and permeability, as well as between permeability and soil moisture and other parameters were very weak at areas with medium or low permeable environment. This conclusion was valid even for the high permeable environment, when relatively high saturation of upper horizons occurred.

As for the statistical evaluation, it is possible to conclude that single values of permeability are substantially affected by small scale conditions of the measured soil volume, and that a large number of measurements should be required for evaluation.

These follow-up were completed by measurements of permeability and of soil-gas radon concentration in various vertical profiles with substantial changes in permeability, to be able to describe the influence of permeability changes on radon concentration with depth and to classify possible errors connected with the uniform depth for permeability measurements (with respect to the fact that the description of vertical profile to the foundation depth must be always known).

3 Conclusions

For the improvement of the method for radon risk classification it is recommended to evaluate all parameters and their changes in vertical profile from surface up to the level of assumed building foundations or to the level of assumed contact building – soil. It is necessary to describe as well as possible following parameters: permeability, grain size, soil moisture, saturation, effective porosity, porosity, density, compactness, thickness of Quarternary cover, weathering character of the bedrock, modification of soil layers by various antropogeneous activities. This description, which strongly depends on a personal experience, i.e. on expert, but subjective knowledge, should be completed either by a certain number of in situ permeability measurements, or by a description of a resistance during the soil gas sampling and by a grain size analysis of representative soil samples.

Some problems are connected not only with the permeability determination itself, but correspond to misunderstandings that sometimes occur. The permeability measured (or derived) in “green fields” during the investigation in an undisturbed environment is just the parameter that can be used for determination of radon potencial (“risk” point of view). But this permeability is not the same as the permeability of the environment at a future contact between the building and the soil. Therefore it cannot be used without correction for tasks solving the transfer of radon from soils into the buildings – transfer factor etc. (“transfer” point of view).

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