PROGRESS REPORT

Effects of Vegetation on Radon Transport Processes in Soil

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Outdoor Data

Radon concentrations in soil gas were measured on a weekly schedule. Samples were extracted through the tubes used for measuring pressure differentials at depths of 30, 100, 180 cm. Figure 1 shows the radon gas concentration near the structures for the time period November 1989 - August 1991. The sample uncertainty based on counting statistics is approximately equal to the dimensions of the circular symbols.

During the past year we have designed, built and calibrated an instrument to obtain in situ measurements of soil permeability. Figure 2 is a box plot representation of the measurements obtained to date. The horizontal line within the box represents the median value. The upper and lower dimensions of the box contain 25% of the data points less than and 25% of the data points greater than the median. The vertical lines represent the point that is within 1.5 times the interquartile range. The dots represent outliers.

These data indicate that there is no difference in the soil permeability near each structure. There is some indication of a change in permeability with depth, but more measurements are required to determine if the trend is statistically significant. The measurements are within the range of values obtained by Dr. A. Tanner using the USGS 3 packer probe.

Indoor Data

Improvements have been made in the blower door modification. The improved configuration has been installed on both structures. Measurements of the effective leakage area as a function of pressure differentials have been made for both structures.

The initial differences between houses were attributed to leaks and cracks at the entrance doors. The door seals were replaced and the results of the leakage area measurements for each structure are shown in Figure 3.

Experiments are underway to partition the radon entry rate into three components:

- a) Floor wall joint
- b) Concrete above ground level
- 3) Concrete below ground level

One structure has been equipped with a plastic barrier that effectively seals the floor wall joint; Figure 4. The integrity of this seal is checked periodically using the SF₆ monitoring system. Experiments can now be performed to make inter-house comparisons of radon entry with and without the seal.

Figure 5a shows the pressure difference between the soil (20 cm from the south wall, 100 cm deep) and the inside of the structure as a function of wind speed. Figure 5b shows the radon entry rate as a function of wind speed. The circles indicate that at low wind speed the floor-wall barrier reduces the radon entry rate by about 30%. The squares show the entry rate for wind speeds less than 1 m s⁻¹ when the house is pressurized to about 2 Pa using the blower door. This indicates that under calm conditions over 60% of the radon is entering by diffusion through the concrete. As the pressure difference between outside and inside the structure increases, the rate of change of entry is the same for both sealed and open floor wall joints. This implies that the resistance to forced flow entry of radon is the same for the floor-wall joint and concrete. More investigations are needed to confirm these preliminary results.

A set of radon accumulator plates have been constructed to determine the radon entry rate into the structures directly through the concrete. The accumulators are equipped with pressure sensors and regulators to insure that the pressure within the accumulator is the same as that inside the structure. Presently the radon passing into the accumulator is collected by charcoal containers that can integrate the radon for about four hours before becoming saturated. The dimensions of one accumulator was designed so that it measures the radon flux entering the structure from the concrete wall above ground level whereas the other accumulator determines the entry below ground level. Results from the first set of measurements are shown in Table 1.

Computer Modeling

The computer code, Rn3D, has been transferred to Colorado State University from Battelle Pacific Northwest Laboratories. The code to runs on a Sun Microsystem SPARC IV Workstation. A series of benchmark one dimensional problems have been used to understand input requirements and test the calculational algorithms. Figure 6 shows the results of a computation of radon concentrations in the concrete and underlying soil when the diffusion length in the concrete changes from 4-20 cm.

QUALITY ASSURANCE

We participated in the annual radon measurement intercomparison sponsored by the DOE Environmental Measurements Laboratory. The ratio of our determination of the test radon concentration reported by EML was 1.00 ± 0.07 .

SUMMARY

- A large component of radon entry cannot be explained by pressure differences between the soil and inside the structures.
- The persistence of this radon entry even when the house is pressurized by 1 Pa indicates that it must be due to molecular diffusion.
- The radon entry rate as measured by accumulators below ground level (soil + concrete) is roughly 2 times greater than that measured above ground level (concrete alone).
- The soil permeability is about 10^{-12} m^2 and does not change dramatically with depth down to 2 m.
- The diffusion component of radon entry is reduced by about 30% when the floor wall joint is sealed.
- The Rn3D model is operating on our computer system and is being modified to accommodate the geometrical configurations of the underground test structure.

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