RADON MITIGATION THROUGH RESIDENTIAL PRESSURIZATION CONTROL STRATEGY

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Abstract

A network of low-pressure differential transducers was installed in two research houses to measure pressure differences between outdoors and indoor zones. Measurements made during summer 1986 and winter 1986-87 under naturally varying outdoor conditions and during operation of a subslab airspace purge system rarely exceeded 4 pascals (Pa). Changes in pressure differentials exhibited an inverse relationship with the indoor/outdoor temperature difference. Indoor radon concentrations varied inversely with pressure differences between the basement and outdoors under summertime conditions. This relationship was less evident under wintertime conditions with heavy snow cover. During both seasons, indoor radon concentrations were reduced substantially during operation of a low flow purge system.

Introduction

Recent research results suggest that pressure-driven flow is an important mechanism of radon entry into residential dwellings.[1,2] Therefore, strategies that minimize pressure differences between basements and outdoors or that create positive pressure indoors may be valuable for radon mitigation. If indoor pressure modification proves to be a useful strategy, systems designed with low differential pressure sensors and pressure adjustment devices could be integrated in the future with control systems used in building ventilation and space conditioning.

Monitoring of pressure differences between outdoors and indoor zones was conducted at the GEOMET research houses in summer 1986 and the winter of 1986-87. Baseline measurements were made under a variety of meteorological conditions. The data were the basis for selecting pressure modification equipment and for developing the pressure control techniques to be used in future tests.

Radon concentrations at the GEOMET research houses are relatively low, typically below 150 Bq/m^3. Despite the low radon concentration, the houses proved an excellent site for the comparative measurement of building pressure differentials, indoor radon levels, and control technology performance. The houses have been well-characterized over the past 4 years and are heavily instrumented; measurements are made for over 100 indoor parameters in each house, outdoor meteorological parameters, and a variety of pollutants. Because the houses have identical designs and are unoccupied, comparative testing can be easily implemented under highly controlled conditions.

Experimental Setup

Under the sponsorship of the Electric Power Research Institute (EPRI), two nearly identical bilevel houses were constructed in 1982 on adjacent lots in a suburban area near Washington, D.C. The houses are designed with a living room, dining room, kitchen, and three bedrooms upstairs. The downstairs includes an unfinished living area/utility area beside an integral garage located beneath the upstairs bedrooms. Both houses are well-insulated and have the same orientation and wind exposure. One of the houses, termed the experimental house, was retrofitted after initial baseline monitoring, to achieve a 40 percent reduction in air leakage area. Average air exchange rates measured by tracer gas decay are approximately 24 percent lower in the experimental house than in the other house.[3]

A network of six low-pressure differential transducers (Setra Systems Model 261, Acton, Massachusetts, USA) was installed in each house to measure the following pressure differentials: (1) basement versus subslab airspace, (2) basement versus outdoors, (3) basement versus soil, (4) basement versus garage, (5) basement versus upstairs, and (6) upstairs versus outdoors. In the basement, the pressure sensor probe was located in the center of the living area. The upstairs pressure sensor was connected to a manifold with probes located in the center of each room to obtain the average pressure for the upstairs zone.

Radon was measured with a continuous alpha scintillation monitoring system with monitors for the upstairs and downstairs of each house and outdoors. Air exchange rates were measured continually by a tracer gas (SF_6) decay method. Meteorological data, including windspeed, wind direction, air temperature, soil temperature, and barometric pressure, were measured throughout the experimental period in addition to measurements of indoor temperatures in all rooms of each house.

The subslab purge system consists of a 0.1-m diameter duct connected to a hole that penetrates through the basement floor to the 0.1-m thick subslab aggregate layer. An exhaust fan located outside of the house at the end of the duct is controlled to operate at airflow rates of 70 to 110 m^3/hr.

Baseline Measurements

Pressure differentials (ΔP) were measured under a variety of meteorological conditions during the summer of 1986 and the winter of 1986-87 to determine their range and to assess their relationship to meteorological conditions and to the operation of the subslab purge system. During the monitoring periods, pressure differences rarely exceeded 4 Pa between any of the measurement zones. Pressure differences typically ranged from -3 Pa to +3 Pa. Representative measurements during August 1986 are depicted in Figure 1. Pressure differences between the basement and outdoors ranged from -2.8 to +0.6 Pa (average of -0.8 Pa). Also included in the figure are plots of temperature difference between indoors and outdoors (ΔT), windspeed, and radon concentration in the downstairs during the period. As shown in the figure, there was an inverse relationship between ΔT and ΔP (Pearson correlation coefficient of -0.6). Windspeed, however, was not as strongly correlated with ΔP (correlation coefficient of 0.3), except during selected periods.

Radon concentrations in the downstairs living area during the period varied from 24 to 154 Bq/m^3 (average of 79 Bq/m^3) and generally exhibited an inverse relationship with ΔP. Radon concentrations generally increased during periods when the magnitude of the negative pressure in the basement, relative to outdoors, increased. The correlation coefficient between changes in downstairs radon concentration and changes in ΔP, although relatively small in magnitude (-0.3), was statistically significant at the 0.05 level.

Under the wintertime conditions, with heavy snow cover, ΔP ranged from -4.5 Pa to -0.5 Pa and averaged -2.8 Pa for the basement/outdoor measurement. Radon concentrations during this period were lower than during the summer, did not vary as substantially, and were not clearly related to ΔP under the conditions that were encountered.

Subslab Purge Measurements

A subslab purge system was installed in the downstairs of the experimental house and operated during the summer and winter periods. Results of one summer test are depicted in Figure 2. Operation of the purge exhaust fan at 110 m^3/hr changed the pressure difference between the basement and the subslab airspace from -1 Pa to +3 Pa. Radon concentrations were reduced from an average of 74 Bq/m^3, prior to operation, to less than 15 Bq/m^3. During winter operation of the system at a flow rate of 70 m^3/hr, the basement/subslab ΔP was changed from -2.4 to +2.2 Pa and the radon concentration was reduced from 40 Bq/m^3 to 14 Bq/m^3. The indoor radon levels during operation of the purge system were near the lower limit of detection of the analytical system and may not be significantly different from zero.

Concluding Remarks

A low flow purge system altered the pressure difference between the subslab and the basement by 4 to 5 Pa while substantially reducing radon concentrations. Measurements at the research houses have confirmed that pressure differences between indoors and outdoors are typically less than ±4 Pa under natural conditions. The indoor-outdoor pressure differential exhibited an inverse relationship with the difference between indoor and outdoor temperatures. During one season (summer), there was also an inverse relationship between radon concentrations and the pressure differential between indoors and outdoors. Further analysis of the data is planned to develop relationships among indoor radon concentrations, ΔP, and other parameters that eventually could be used in pressurization mitigation strategies.

Acknowledgment

This research is funded by the Electric Power Research Institute (EPRI) under research project 2034-1. Dr. Powell Joyner is the EPRI project manager.

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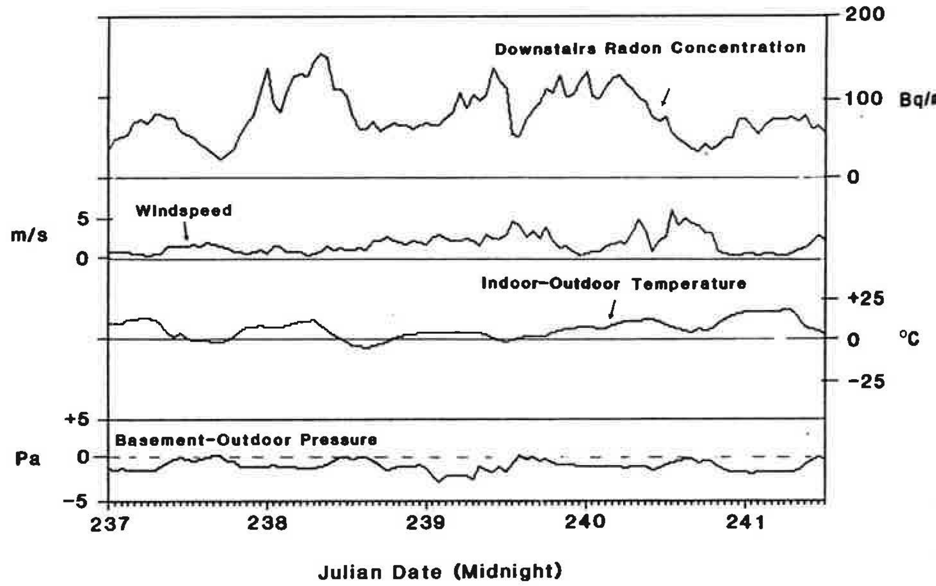

Figure 1: Windspeeds, ΔT, ΔP, and radon concentrations in the downstairs of the experimental research house in August 1986

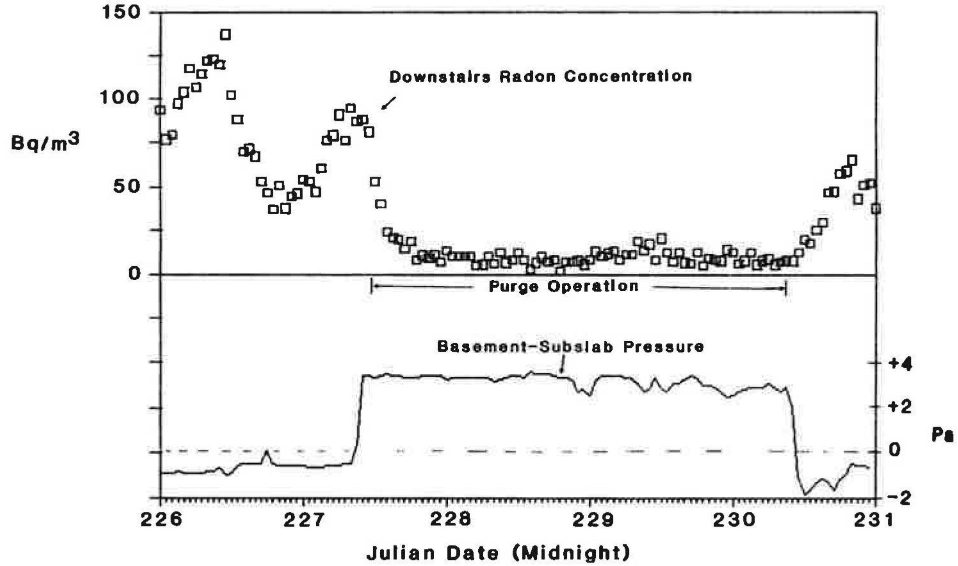

Figure 2: Radon concentrations and basement/subslab pressure differences during operation of the subslab purge system (August 1986)

RESOLVING THE RADON PROBLEM IN CLINTON, NEW JERSEY, HOUSES

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ABSTRACT

Significantly elevated radon concentrations were found in several adjacent houses in Clinton, New Jersey. The United States Environmental Protection Agency screened 56 of the houses and selected 10 for demonstration of radon reduction techniques. Each of the 10 houses received an intensive radon diagnostic evaluation before a house-specific radon reduction plan was developed. Before and after the plans were implemented, radon concentrations were determined by charcoal canisters and continuous radon monitors. A variety of sealing and sub-slab depressurization techniques were applied to the 10 houses. Radon concentrations were reduced by over 95% in all 10 houses. Five homeowners meetings were held to explain the radon reduction techniques being implemented and to answer questions of homeowners interested in applying similar radon reduction efforts to their houses.

Introduction

In March 1986, the New Jersey Department of Environmental Protection (DEP) reported to the United States Environmental Protection Agency (EPA) that significantly elevated radon concentrations had been measured in a single family dwelling in Clinton, New Jersey. Within 24 hours EPA's Air and Energy Engineering Research Laboratory (AEERL) personnel were in the house in Clinton where radon had been discovered. They were making measurements, diagnosing potential radon entry routes, and developing a radon reduction strategy for the house. Because the radon concentrations observed in this house far exceeded any residential radon measurements previously made in New Jersey, the New Jersey DEP conducted a general radon survey involving all interested Clinton homeowners. Charcoal canisters were distributed to the homeowners: the radon concentrations that were measured in 103 houses are summarized in Table 1. Due to the alarmingly high radon concentrations observed in many of the Clinton houses, the New Jersey DEP requested EPA's assistance in developing methods to reduce radon concentrations in the houses.

In April 1986, AEERL conducted screening visits in 56 homes in Clinton with the intent of selecting 10 homes where radon reduction techniques could be demonstrated. Evaluation criteria used in selecting the 10 houses included in the radon reduction project were: (1) the ability to identify and access the radon source in the house; (2) the ability to reduce radon concentrations with few potential complicating sources (e.g., fireplaces/chimneys); (3) elevated radon concentrations; (4) house sub-structures; (5) homeowner cooperation; (6) worker access to the house; (7) smokers in the house; (8) young children in the house; and (9) the time occupants spend in the house. Table 2 summarizes the