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INDOOR RADON CONCENTRATIONS IN PUBLIC BUILDINGS

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Abstract

Indoor radon concentrations have been measured in a 13 year old two story concrete building of the University of Texas at Dallas. Variations of the radon concentration from the basement to the second floor in offices, classrooms, laboratories, storage rooms, corridors and other locations have been measured. Dependence of the above concentrations on the location and ventilation rates have been studied.

Introduction

High levels of indoor radon found in recent measurements, particularly in energy saving homes and buildings, caused serious concern in respect to their public health hazard. Radon diffuses out of the soil and ground water, specially in areas which have higher levels of uranium and radium, into the buildings and is entrapped in structural shells such as basements or other isolated and not well ventilated parts of the building. The radon gas builds up also in water pipes and outgasses to the air when the water is used. In addition to this radon is also emitted from building materials.

A large number of indoor radon measurements has been made in single family homes and other residential dwellings but very few studies were carried out in public buildings. The present paper summarizes the results of our measurements carried out in a university building housing research facilities and instruction in the natural sciences.

Experimental Method

Indoor radon concentrations have been measured in the Lloyd V. Berkner Hall of the University of Texas at Dallas for more than 8 months using Track Etch Type B radon detectors (1,2) manufactured by Terradex Corporation (Walnut Creek, California) which measure the total alpha activity of the air (radon and radon daughters). The university campus is located in Richardson, a suburb of Dallas, in the center of a large open area of more than 1000 acres (400 hectares). The Berkner Hall is a 13 year old two story contemporary concrete building located close to the west end of the campus and interconnected to the other buildings only by a second floor hanging corridor. The first and second floors of Berkner Hall used for research and teaching have a total surface area of about 74,000 sq ft (6,880 m^2) and a corresponding total volume of about 660,000 cu ft (18,480 m^3). The basement of the building has a total volume of about 302,000 cu ft (8,460 m^3) and consists of a large crawl space of 252,000 cu ft which has a dirt floor about 9 ft below ground level and an electric transformer room of 50,000 cu ft which has a concrete floor about 14 ft below ground level. The concentration of ^{238}U and ^{226}Ra in the surface soil around the building is about 0.8 pci/g, an unenhanced background level typical for the North Texas region.

The whole building is well ventilated and the first and second floors are airconditioned. The annual averages of air change rates, and the average fractions of outside and recirculated air in different parts of the building are shown in Table 1. Seasonal variations of the air change rates around these averages are less than 25%. The crawl space is ventilated through the transformer room. Outside air is sucked into the transformer room, exhausted into the crawl space and released from there into the outside atmosphere. This system is completely independent from the airconditioning system used for the first and second floors. It can be seen from Table 1 that the airconditioning system mixes the air by recirculation on both floors to a reasonable homogenity, and the outside air change averages to 1.1 per hour. The building is relatively well insulated thus wind increases this annual average by less than an estimated 10%. Air from restrooms and laboratory hoods is totally exhausted into the outside atmosphere.

Table 1. Ventilation of the building (annual averages).

Location	Air circulation (hr^{-1})	Outside air (%)	Recirculated air (%)	Air change (hr^{-1})
Crawl space	2.0	100 (through transformer room)	0	2.0
Transformer room	10.2	100	0	10.2
1st and 2nd floors	4.2	26	74	1.1

A total of 50 radon detectors has been located in typical offices, classrooms, laboratories, storage rooms, corridors and restrooms on the first and second floors, and in selected locations in the basement and transformer room of the building. This set of radon detectors was exposed for 3 months, and replaced every 3 months by a new set of 50 detectors in order to study seasonal variations.

Experimental Results

The major results of this study are the following:

(1) There is no significant difference between the radon levels measured at different locations on the first and second floors. This might be explained to a large extent by the relatively strong mixing of air by recirculation on both floors. There is no significant difference between the radon levels measured at different locations in the crawl space which are not separated from each other. According to this the average radon concentrations were calculated for the crawl space, transformer room, first and second floors for each set of measurements (Table 2).

Table 2. Average ^{222}Rn concentrations in pci/l.

Location	July-Sept., 1983	Oct.-Dec., 1983	Average over both sets
Crawl space	1.75 ± 0.22	2.39 ± 0.32	2.07 ± 0.20
Transformer room	0.51 ± 0.11	0.64 ± 0.11	0.58 ± 0.08
1st floor	0.22 ± 0.03	0.33 ± 0.03	0.28 ± 0.02
2nd floor	0.19 ± 0.02	0.30 ± 0.03	0.25 ± 0.02

(2) The decrease of radon levels from the basement to the first and second floors is in good agreement with the expectation and a large number of previous studies. The transformer room has a significantly lower radon level than the crawl space. This can be explained partly by the much stronger ventilation of the transformer room and by using outside air, whereas the crawl space is ventilated to a much lesser extent by the exhaust air of the transformer room (Table 1).

The other factor is the larger radon emanation rate from the soil into the unshielded crawl space than the emanation through and from the concrete floor and walls into the transformer room.

The radon levels measured on the first and second floors are not significantly different from each other which can be explained to a large extent by the strong mixing of air by recirculation, and by considering the soil as the major source of radon emanation (5).

(3) The radon levels measured on the first and second floors are relatively low as compared to the radon concentrations measured for comparable air change rates in residences (e.g. refs. (4,5)) and much lower than the indoor radon standards suggested by the U.S. EPA, the Union of Concerned Scientists, Sweden and Canada which vary between 2 and 3 pci/l. These relatively low radon levels can be attributed mainly to the low source magnitude, the strong ventilation of the basement and the relatively large building volume to basement surface ratio.

(4) There is a slight indication for an increase of radon levels in the second period of measurement. This might be caused to a large extent by the approximately 10% lower average air change rate on the first and second floors, and the approximately 24% lower average air change rates in the basement for the second period (3). This effect will be checked in subsequent measurements.

Conclusions

Radon levels in concrete public buildings built in areas of low ^{238}U concentration such as the Berkner Hall can be controlled by proper ventilation, particularly in under-surface areas below the building. Considering that people working in these public buildings spend in general not more than 40 hours per week, i.e. 24% of their time, the health effects of radon and radon daughter exposures related to these public buildings are in general small as compared to the potential health hazards due to radon exposures in residences.

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