PRELIMINARY FIELD DATA ON THE UTILIZATION OF AN ELECTROMAGNETIC SHIELD TO REDUCE INDOOR RADON GAS ENTRY

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ABSTRACT

This paper presents preliminary data on the utilization of an electromagnetic shield system to reduce indoor radon gas entry. The test site is a Franklin, Wisconsin house that has exhibited moisture and radon problems in the basement. A prototype system that utilizes electromagnetic waves to dewater the basement is being tested for effectiveness in reducing indoor radon gas entry. The non-invasive electromagnetic shield system consists of a patented power supply, an antenna located in one of the foundation walls, and a soil potential spear which receives a modulated, timed and mixed frequency from the control device. An advanced measurement system with state-of-the-art instrumentation is being used to monitor environmental conditions, concrete humidity levels, and indoor radon gas concentrations. Details of the electromagnetic shield system, the experimental setup, and the preliminary data are described.

INTRODUCTION

A *cutting*-edge method to prevent radon gas transport through concrete was introduced by Nam and Renken (1998) and Renken and Nam (2001). These laboratory experiments utilized an electro-osmotic pulsing system (EOPS) to reduce the diffusion transport of radon soil gas through an intact concrete sample. The concrete contained several embedded electrodes that were connected to a pulsating power supply and an external copper bar cathode. The experimental results showed as much as a 93% reduction in the radon soil gas diffusion coefficient through the concrete slab when the EOPS was in operation. More recently, an electromagnetic shield system to retard radon gas transport via moisture movement was introduced by Daoud and Renken (2001). They presented data on laboratory experiments that utilized electromagnetic waves to reduce the diffusion of radon gas through a fracture-free concrete sample. The experimental results showed an approximate 130% reduction in the radon gas diffusion coefficient through the concrete when the electromagnetic shield system is in operation.

The objective of our current research is to field-test an electromagnetic shield system at a Wisconsin detached house that has exhibited moisture and radon problems in the basement. A prototype electromagnetic shield system has been installed in a residential home in Franklin, Wisconsin. A PC-data acquisition system (PC-DAS) has been setup to measure characteristics of the electromagnetic shield system effectiveness (concrete humidity, indoor radon concentration, foundation temperature, and pressure differences between the surrounding soil and the basement) and the environmental conditions (barometric pressure, temperature, humidity, wind speed and direction, solar radiation flux, and precipitation) that influence the performance of this innovative system.

DESCRIPTION OF EXPERIMENTAL SITE

The experimental test site is located in Franklin, Wisconsin (15 miles south of Milwaukee). The house is a 10-year old conventional single floor ranch style over a full basement measuring 2,100 square feet. It is slightly shielded by neighboring houses on both sides, open in front and surrounded by trees and a small creek in the back. The basement is adequately sealed from the upstairs living area by a tight plywood sub-floor, and consists of a poured concrete slab floor, hollow-block walls, one sump well, and two tightly sealed windows. The house has air-conditioning system and a high-efficiency furnace. Figure 1 presents a photo of the test site.

The soil surrounding the house is New Berlin glacial till associated with one of the early Wisconsinan Stage glacial advances across southeastern Wisconsin. The till is geologically described as gravelly sandy loam till (Schneider, 1983). From a geotechnical engineering perspective, the glacial till is typically clayey silty fine to coarse sand with some fine to coarse gravel and frequent cobbles and boulders. The till has low plasticity (Unified Soil Classification symbol of CL-ML), but generally has a high enough clay content to provide sufficient standup time in excavations such as those for house basements to allow for construction of basement walls and footings.

DESCRIPTION OF ELECTROMAGNETIC SHIELD SYSTEM

The electromagnetic shield system utilized in this investigation is identical to the one utilized by Daoud and Renken (2001). It consists of a self-monitoring power supply, a ground connection spear, and a frequency-stimulating antenna (Fig. 2). The antenna is embedded into the basement wall along with a concrete humidity sensor while the spear is placed in the soil adjacent to the exterior of the concrete slab as shown in Fig. 2. The antenna and the spear are connected to the controlling device that is mounted on the concrete wall. The power supply sends a modulated, timed, and varying frequency to the antenna to produce an applied electromagnetic field. This alternating field with wavelength of 2,000 m operates at a frequency of 141 kHz with an output of 26 mW. The electromagnetic waves interact with the water molecules within the damp walls and the floor (higher frequencies typically produce more intensive interactions). Due to their dipole character, water molecules present in the concrete that is exposed to these electromagnetic waves, try to orient according to the magnetic field. A larger accumulation of molecules generates a greater phase difference between the magnetic field and the orientation of the molecules. This slip between the magnetic field and the induced field, produced by the orientation of molecules, generates a counter-electromotive force, which is oriented exactly opposite of the generating field, away from the antenna.

By stimulating the saturated concrete with this frequency, a current condition is developed which results in a lowering of the potential line. By lowering the zero potential line, the voltage field changes and the water ions present are forced to change direction and move quickly out of the field. This electromagnetic field influences the fluid flow through concrete and forces it to change its direction. The motion is greatly affected by the humidity as well as the salts in the concrete and soil that generate a negative charge within the damp concrete wall and the surrounding soil.

As the external electromagnetic field is induced and due to the water molecules electric dipole behavior (Halliday et al., 1997), the water molecules and the salts are forced to leave this field dragging any adjacent gases (e.g., radon gas) away from the indoor environment (antenna) to the exterior ground connection spear.

DESCRIPTION OF INSTRUMENTATION

We have installed a multitude of sensors and transducers to measure the environmental conditions as well as the electromagnetic shield system's performance. Figure 3 is a schematic of the instrumentation that is installed in the basement of the test site. More specifically, sensitive relative humidity/temperature sensors are installed in the four basement walls (North, South, East, and West) as well as the basement floor (Slab) to measure moisture and temperature conditions in the concrete foundation. An additional relative humidity/temperature sensor measures the ambient moisture and temperature conditions. Very accurate and sensitive differential pressure transducers are used to measure the pressure difference between the surrounding soils and the basement. Soil pressure probes are constructed from 1 ¼" diameter well points fitted with ¼" copper refrigeration tubing, a compression fitting, and ¼" polyethylene tubing. The well points are placed 3' deep into the ground at four locations around the perimeter of the house (North, South, East, and West). Differential pressure between the ambient basement conditions and below the concrete slab is also being measured as shown in Fig. 4. Calibrated continuous radon monitors measure radon gas concentrations in the basement. These monitors utilize a scintillation cell and a photomultiplier tube to count the number of alpha emissions given-off by the radon gas present.

Meteorological conditions at the test site are also being monitored. Outdoor barometric pressure, air temperature, and relative humidity are measured using accurate transducers. A tipping bucket rain gauge is installed in the backyard of the house to measure precipitation. A thermostatically controlled heater mounted on the unit prevents it from freezing and allows snowfall to be measured as well as rain. In-line wind speed and direction transducers as well as a solar radiation flux sensor are mounted on a 25' pole. A commercial dual output DC bench power supply is used to excite the sensors and transducers.

Raw data measurements by the sensors, transducers, and radon monitors are collected by a modern PC-data acquisition system (Fig. 5). The PC is a 1.2 GHZ, 256 MB RAM, 30 GB hard drive notebook that contains a CD-RW drive. The data acquisition unit is a three-slot mainframe with internal 6½ digit DMM. We employ two multifunction module counter/totalizer cards and one 40 channel single-ended multiplexer card. Windows-based icon-driven data acquisition software is used to control the data collection process. Readings are taken at 15-minute intervals and are stored on the hard drive of the notebook. Excursions to the test site are taken once a month to download the raw data onto a CD-RW and to check on equipment performance.

DISCUSSION OF RESULTS

Initial measurements revealed an average radon gas concentration in the basement of the test site of ~ 8.2 pCi/L. These measurements were taken during the spring of 2001. The installation of the electromagnetic shield system and the experimental measurement system was completed on June 15, 2002. Therefore, the following data represents preliminary results only. This paper is based on our collected data for the period of June 15, 2002 to August 19, 2002.

Figure 6 presents the average radon concentration in the basement for the test period. Here, we see the radon gas readings ranging between 3 and 27 pCi/L with an average of 10 pCi/L. The data shows that the electromagnetic shield system has not started to reduce indoor radon gas entry rate at this stage of experimentation. The authors believe the electromagnetic field has not yet been fully established around the envelope of the test site. This is verified by Fig. 7, which presents the measured humidity in the concrete walls (North, South, East, and West) and the basement floor (Slab). As shown, the humidity level has dropped noticeably in the North wall and the floor (Slab) as compared to the other three walls. The North wall contains the embedded ferrite antenna, while the slab has the ground connection spear. This suggests that the electromagnetic waves have not permeated the entire concrete foundation because of insufficient time for electromagnetic field development. The authors plan on providing additional testing time and utilizing more antennas to increase field strength. The German manufacturer of the system has recently introduced a more powerful unit that can utilize four antennas to reduce remedial action time. This new unit is being shipped for our testing.

Precipitation events during the period of June 15, 2002 to August 19, 2002 are plotted in Fig. 8. As expected, we see the basement radon concentrations increase (Fig. 6) after each precipitation occurrence. This increase is observed with a delay of approximately five hours between the initial rise in radon concentration and the onset of precipitation. Similar patterns are observed in the humidity levels of the South, East, and West walls of the basement as shown in Fig. 7. The North wall and the floor appear to be unaffected by precipitation due to the embedded antenna and ground spear.

Figure 9 displays the differential pressure measurements of the soil with respect to the basement for the same time period. The pressure differences across the basement walls ranged mostly between 0 and 2 Pa (higher in the soil than that of the basement) and are attributed to hydrostatic pressure. For this same period, the concrete temperatures were steady and ranged between 16° and 23°C as compared to the variable outdoor atmospheric temperatures, which ranged between 10° and 34°C as shown in Fig. 10. It should be noted that the missing data points observed on the above referenced figures are due to power outages at the test site during this test period.

CONCLUSION AND RECOMMENDATIONS

This paper has presented preliminary field data on the effectiveness of an innovative system to retard indoor radon gas entry while reducing moisture levels in the basement. Initial data shows that the electromagnetic shield system has not yet started to reduce the indoor radon levels at this early stage of testing. The data does show a significant decrease in the humidity level of one basement wall and the slab as compared to the others. This basement wall and the slab contain the embedded antenna and ground-connecting spear, respectively. The authors conclude that more testing time is needed for the electromagnetic field to diffuse throughout the basement foundation. In addition, the system may need more electromagnetic field strength. Future tests will employ a new more powerful electromagnetic shield system.

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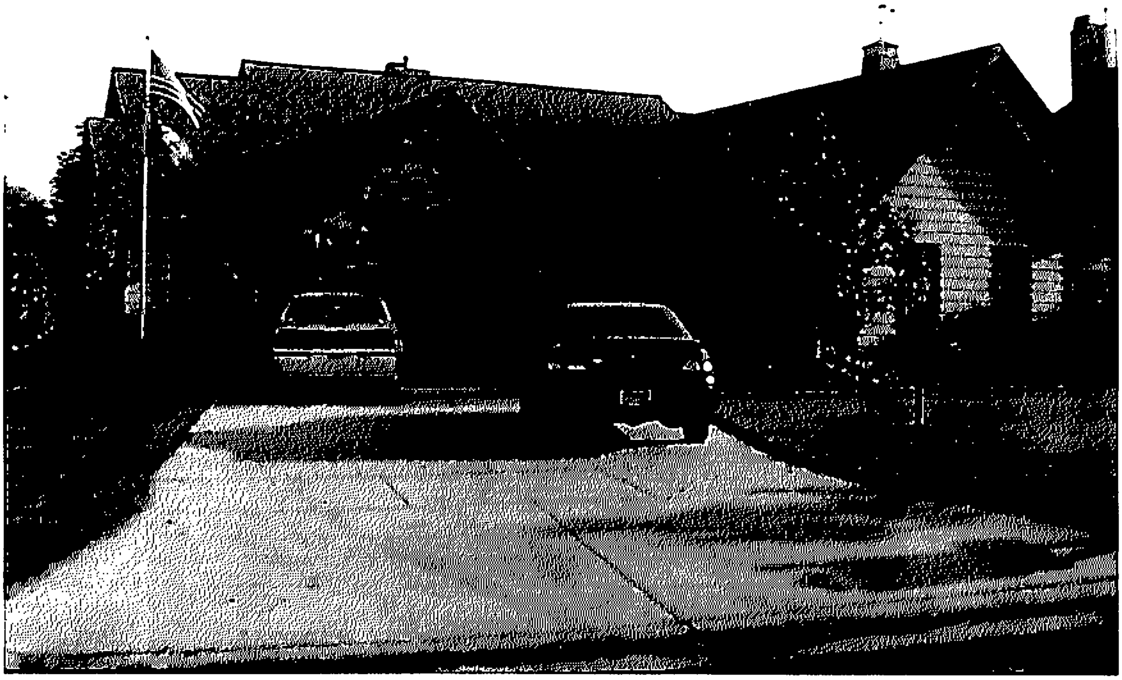

Fig. 1. Photo of Franklin, Wisconsin test site house.

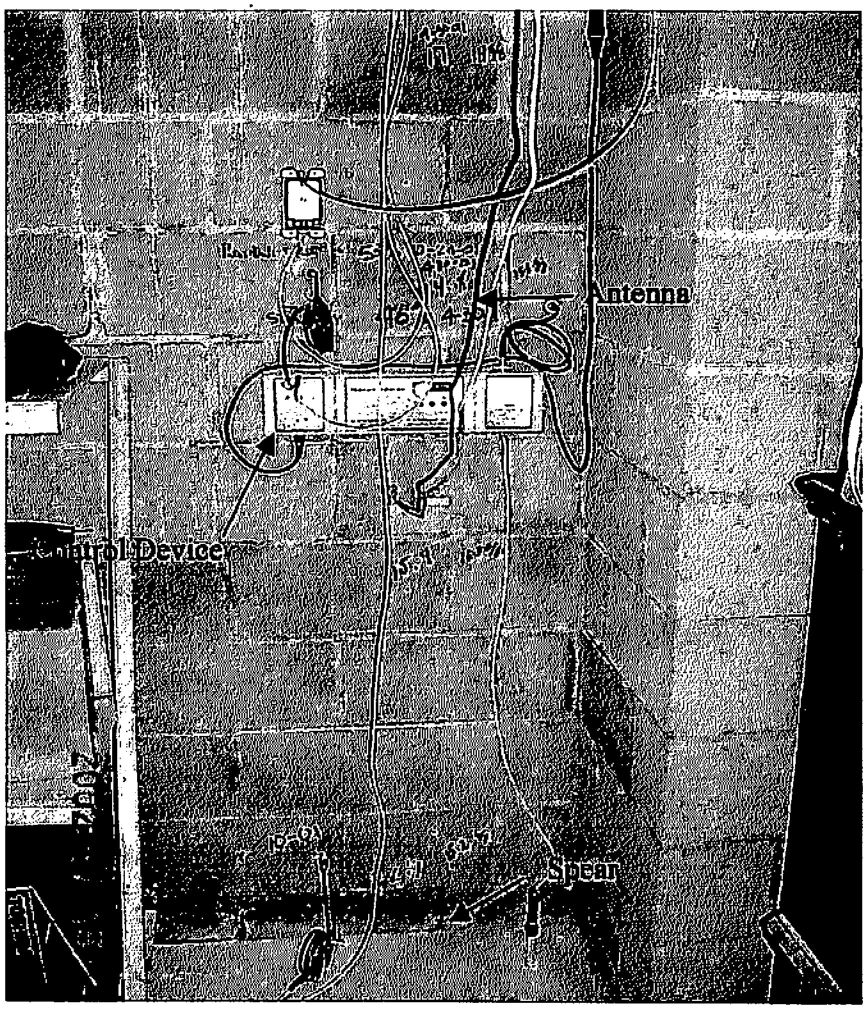

Fig. 2. Photo of electromagnetic shield system.

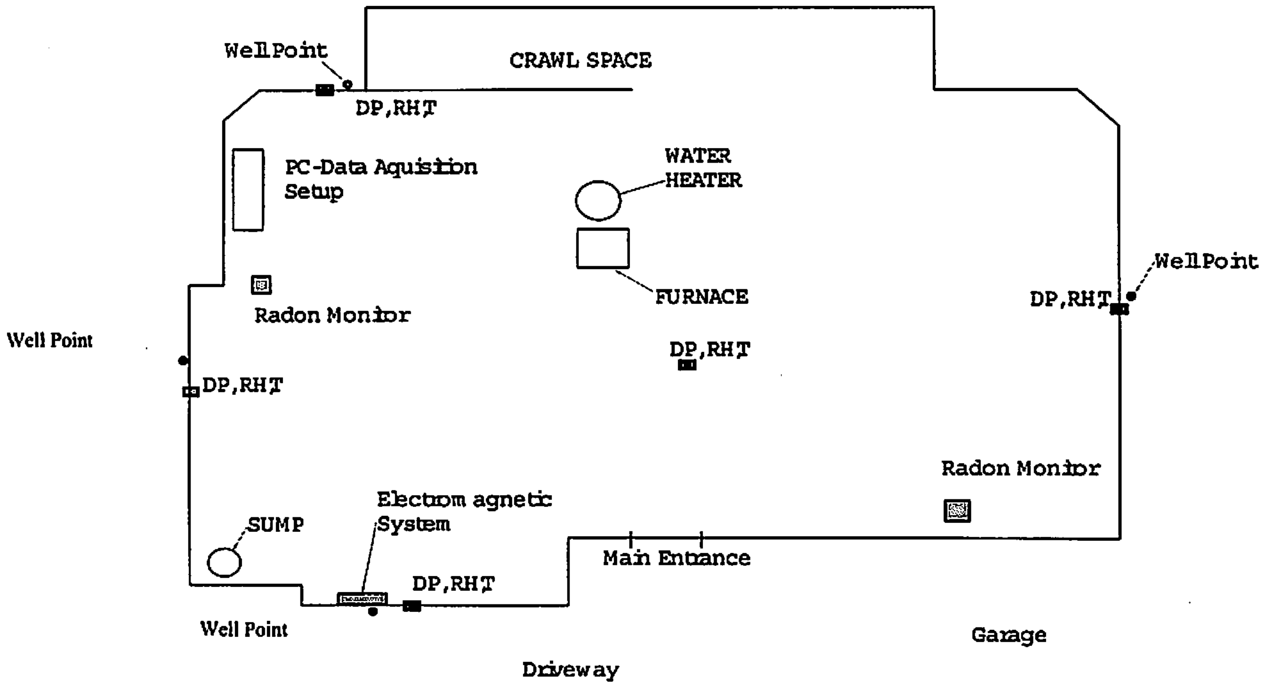

Fig. 3. Schematic of instrumentation locations in the basement of the test site.

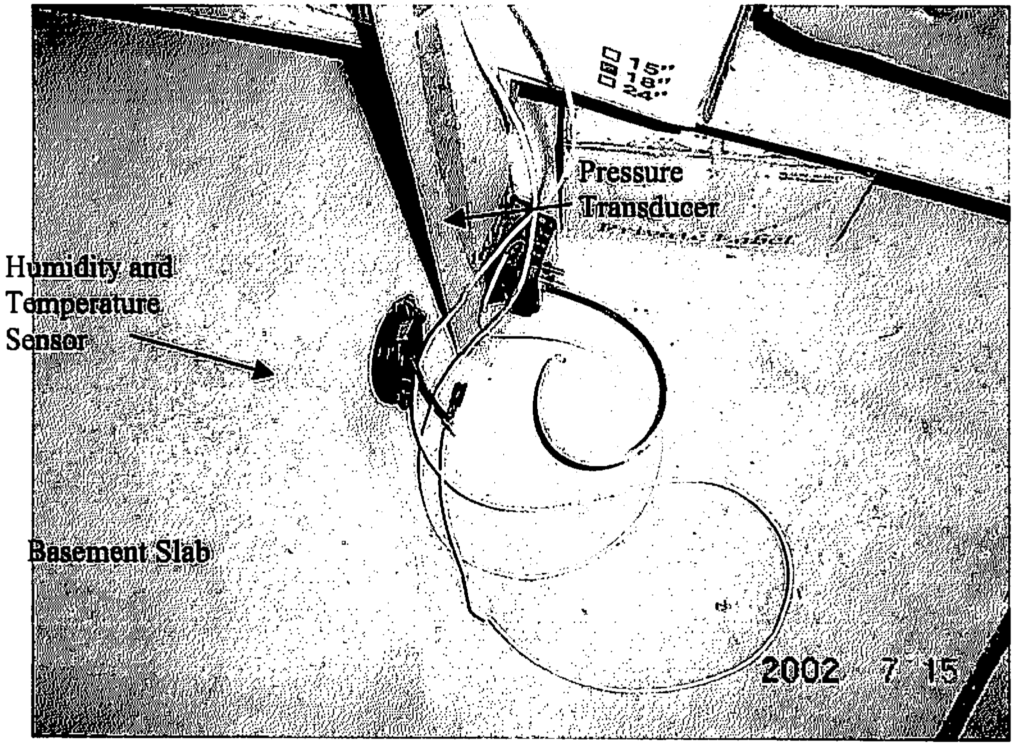

Fig. 4. Photo of basement slab humidity, temperature, and differential pressure transducers.

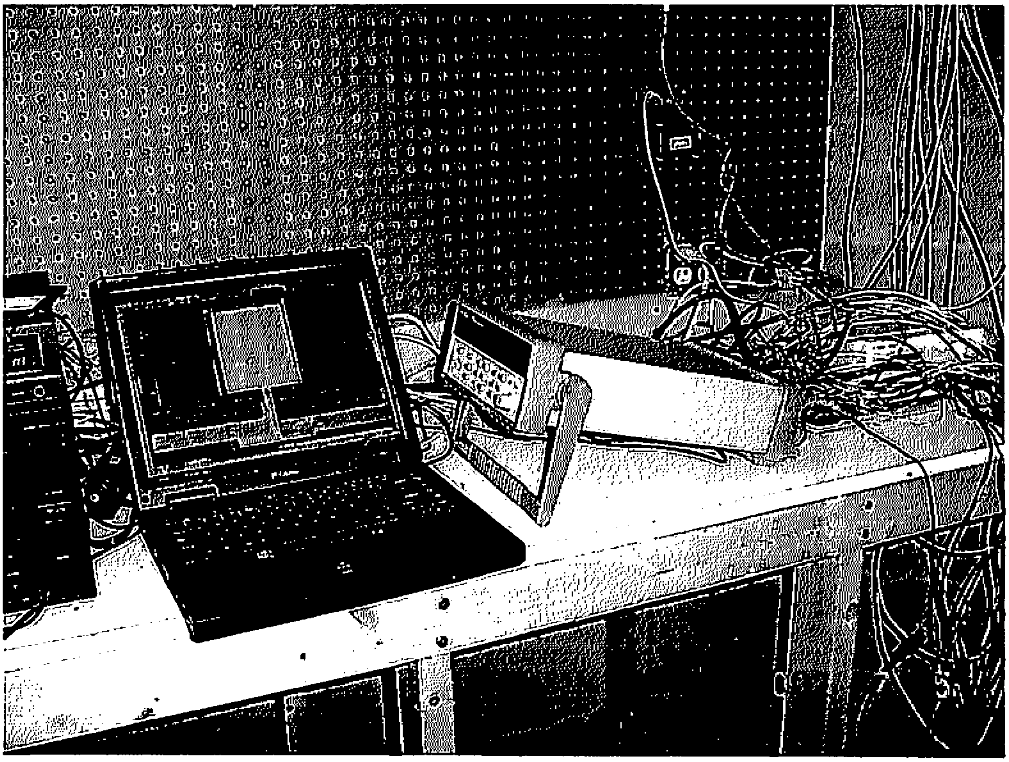

Fig. 5. Photo of PC-data acquisition system with instrumentation hook-up.

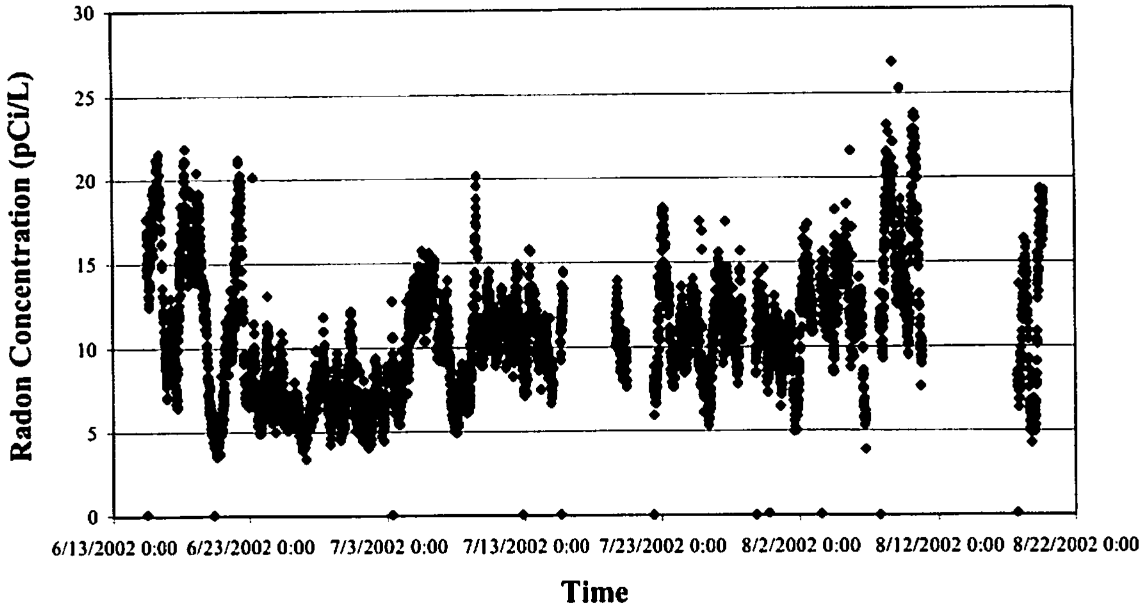

Fig. 6. Basement radon gas concentrations for the test period of June 15, 2002 – August 19, 2002.

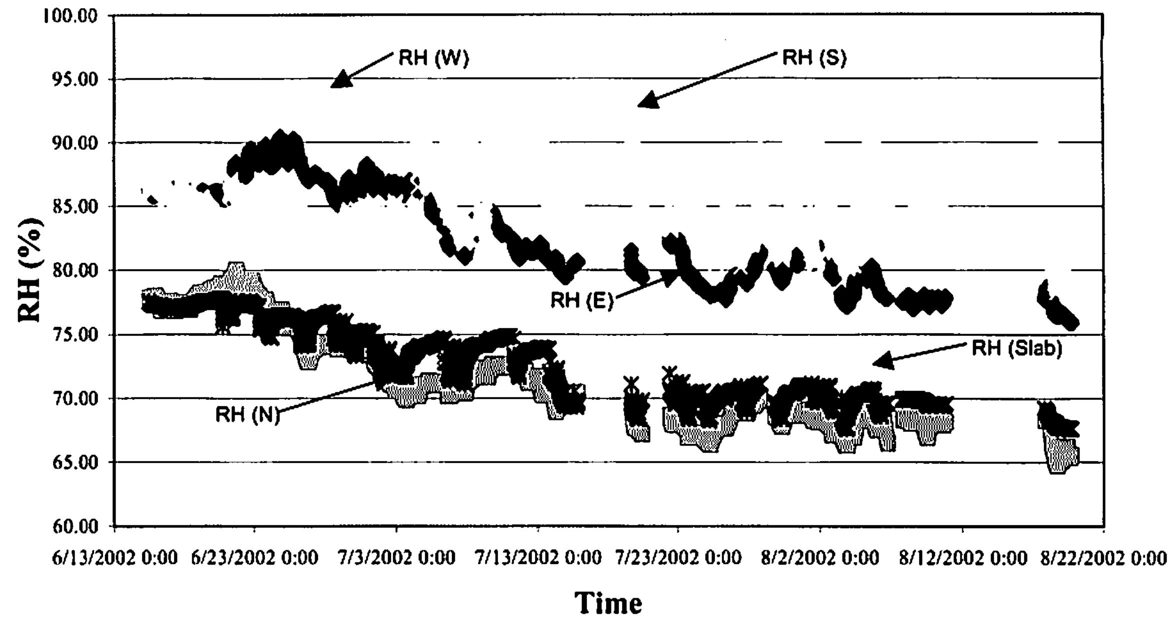

Fig. 7. Relative humidity levels in the basement walls and concrete slab for the test period of June 15, 2002 – August 19, 2002.

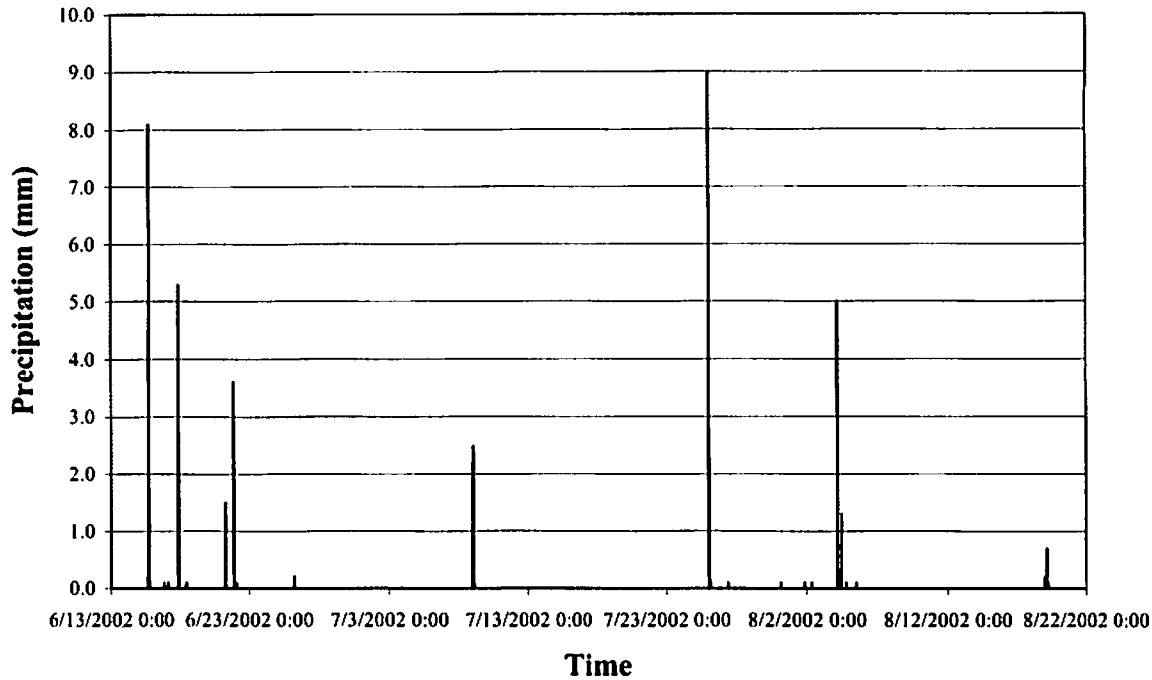

Fig. 8. Precipitation events at the test site for the test period of June 15, 2002 – August 19, 2002.

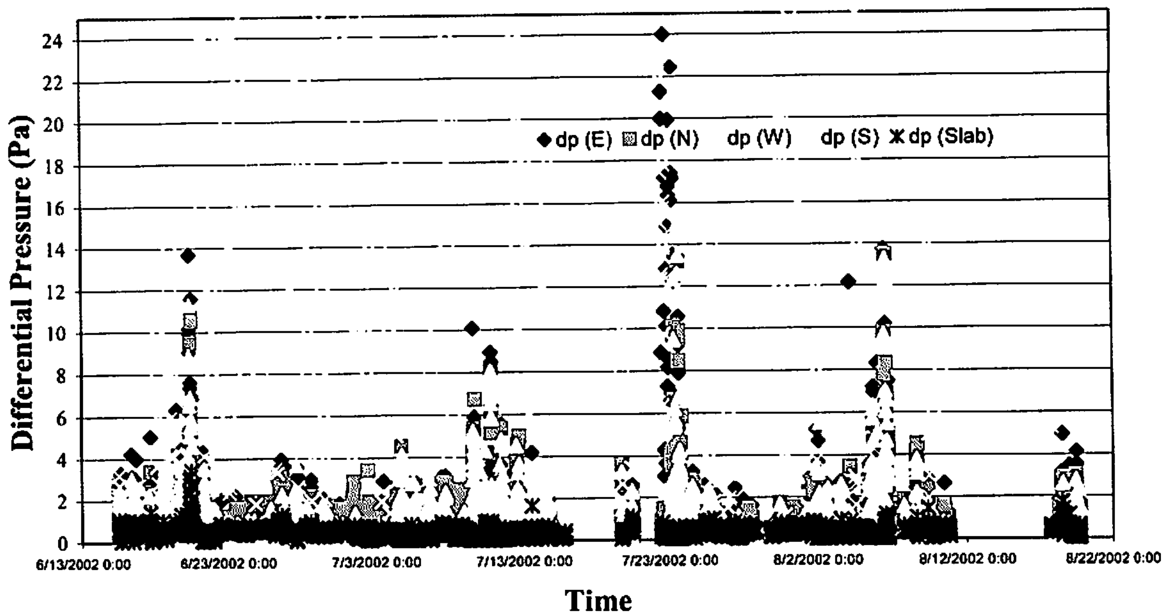

Fig. 9. Differential pressure readings across the basement walls and concrete slab for the test period of June 15, 2002 – August 19, 2002.

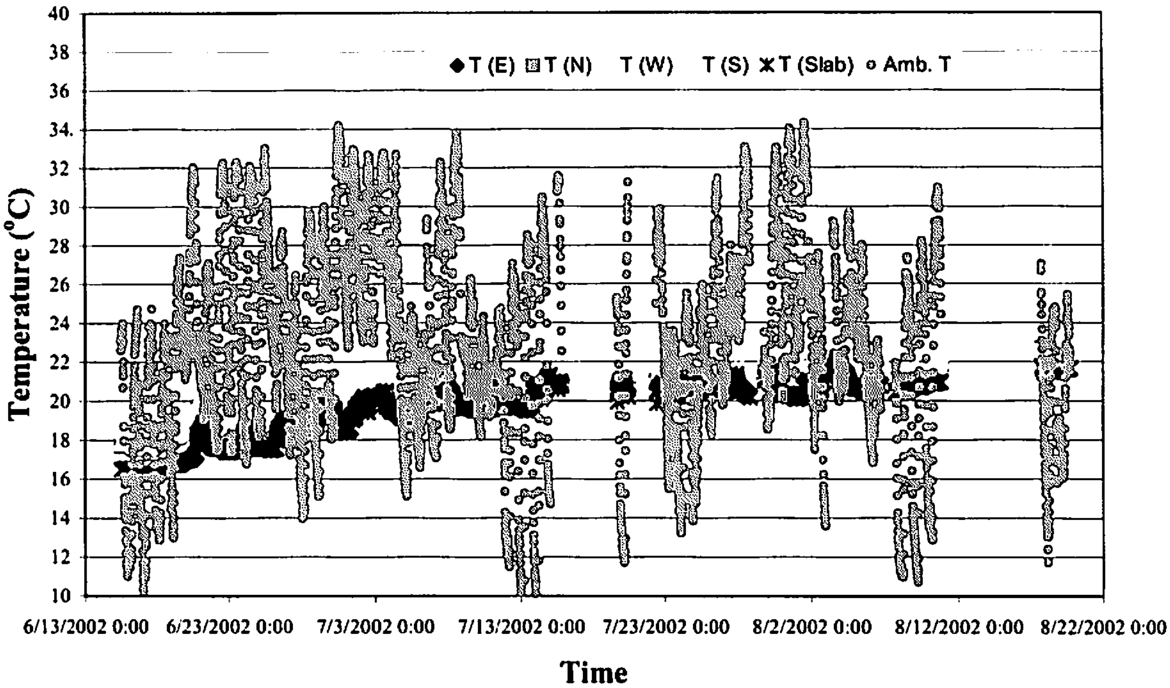

Fig. 10. Comparison between ambient air, basement wall, and concrete slab temperatures for the test period of June 15, 2002 – August 19, 2002.