1988-46

OVERVIEW OF RADON-RESISTANT NEW CONSTRUCTION

by: Terry Brennan
Camroden Associates
Rome, NY 13440

Michael C. Osborne
U.S. EPA, AEERL
Research Triangle Park, NC 27711

ABSTRACT

It has been estimated that between 5 and 15% of the existing United States housing stock has elevated indoor radon levels. The United States Environmental Protection Agency (U.S. EPA), United States Department of Energy (U.S. DOE), and numerous other privately and publicly funded researchers have developed and tested control techniques that can be retrofitted into these buildings. However, new single and multi-family homes are being constructed in the United States at a rate of almost 1.2 million per year, or slightly more than 1% of existing housing stock. Care should be taken to ensure that new buildings are constructed to discourage the entry of radon, and there should be easier accessibility to remediate, if a problem does arise. This is especially true of houses being built in areas where indoor radon is known to present problems.

This paper has been reviewed in accordance with the U.S. EPA's peer and administrative review policies and approved for presentation and publication.

INTRODUCTION

This paper is an overview of current ideas on constructing radon-resistant houses. Because there is no way to determine radon levels before houses are built, the major difficulty with such an effort is that there are very little experimental data from which to draw. At present, a few radon-resistant new construction research projects are underway in various locations across the country. The largest is the project being conducted by the National Association of Home Builders (NAHB) National Research Center (NRC), the New Jersey Department of Community Affairs, the New Jersey Builders Association, the U.S. EPA, and the New Jersey Central Power and Light Company. Two others are also being conducted by home building firms: one is in conjunction with NAHB, and the other is with EPA. Another is a modest effort being conducted in New York by W. S. Fleming for the New York State Energy Research and Development Authority (NYSERDA) and U.S. EPA. In addition, the Radon Information Clearinghouse for the home building industry, operated by the NAHB NRC and funded by the U.S. EPA provides technical support to builders.

Because of the difficulty of acquiring field data, most ideas for radon protection in new construction are based on what has been learned from studies of existing houses and gedankenexperiments (experiments carried out by proposing a hypothesis in thought only). For example, although there are no extensive field data to prove it, it is hypothesized that, if an airtight barrier could be placed between the foundation and the earth, no radon could enter from the soil. The problem is that it is much easier to <u>draw</u> an airtight barrier than it is to <u>install</u> one.

This paper will briefly illuminate the following topics in radon-resistant new construction:

Site Evaluation
Preventing Radon Entry
Building-In a Solution
Adoption of Radon-Resistant New Construction Techniques

SITE EVALUATION

It has been estimated that between 5 and 15% of the existing United States housing stock has elevated indoor radon levels (1); however, being able to predict whether a site will have a radon problem before a house is built is extremely difficult. Attempts have been made to use the following measurement types as predictors:

- Soil Radon Concentrations
- Soil Permeability
- Soil Radium Concentrations

Unfortunately, no strong correlations between simple, inexpensive measurements and indoor concentrations have been made. Recently, better predictions have become possible by combining concentrations and permeabilities. These results were presented earlier in this conference (2,3).

PREVENTING RADON ENTRY

There are two fundamental approaches to radon protection for new construction: (1) preventing entry by using physical barriers and/or reducing the driving forces, and (2) building-in a solution.

As stated earlier, if an airtight barrier could be extended between the soil/bedrock and the foundation, thus reducing radon entry to diffusion through a solid, then little radon would enter the building from the soil. The ideal barrier would be easy to install, last a long time without developing leaks, and be able to seal around penetrations.

A significant contribution to sealing is provided by the foundation materials themselves. Solid concrete provides a good air barrier as long as it does not crack. On the other hand, uncoated concrete block walls have significant air leakage through them even when care has been made to fill and strike the mortar joints cleanly. The problems with using the foundation materials as the barrier are the penetrations, joints, and cracks that may develop. There are situations where a small leakage area in the foundation and tiny pressure differentials can result in elevated radon concentrations. Walls and slabs should be constructed to meet structural codes to reduce the risk of cracking. Plastic additives can limit shrinkage cracks by making concrete easy to work while using a reduced amount of water.

Dampproofing coatings and membranes that are normally installed for moisture control also go a long way toward preventing soil air entry. Coatings are usually either cementitious or organic. Simple parget coats that contain plastic binders stick well and have some flexibility. Because of their greater elasticity, asphalt coatings are often used over parget coats to span cracks. Sometimes plastic membranes are used as dampproofing on the exterior of foundations and under concrete floor slabs. On walls, polyethylene film is sometimes stretched across the wet asphalt coating. Under slabs a polyethylene vapor barrier is frequently used. Although these films are punctured during typical installation, they may have good value in spanning cracks that develop in walls or floors. Other membranes that are used for dampproofing are composed of polyvinylchloride (PVC), cross-laminated polyethylene, EPDM™, and neoprene. The heavier membranes are usually found only in underground houses or commercial construction.

Interior paint or stucco finishes can also be used to limit the amount of soil air entry. The amount of benefit seems to vary with type of paint, time after coating, and number of coats. Laboratory specimens have been used to measure airflow through concrete block walls with various configurations of coatings. Leakage through block walls can be greatly reduced by coatings. The EPA poster paper on the "Radon Wall Coatings Test Facility," presented yesterday at this meeting, clearly demonstrated the potential effectiveness of coatings, although some coatings, such as latex paints, may require three or more coats to provide an adequate seal.

Cracks and penetrations can be sealed using caulks and occasionally plastic foams. The major cracks in foundations that appear at the time of construction are the perimeter crack at slab edges and the cracks at control joints. Both of these can be treated with a zip-top expansion material which easily leaves a channel that a pourable urethane caulk can seal.

Penetrations can be sealed using canned foam or backer rods with caulks. Sump holes should be sealed with a gasketed, removable cover. French drains or perimeter canals are difficult to deal with in new construction. Alternate drainage methods that allow floors to be sealed to walls (e.g., exterior curtain wall drainage) should be considered. Floor drains should have water traps and/or be composed of sealed solid pipe.

A fundamentally different approach to preventing soil air entry is to reduce the air pressure differentials between the basement air and the soil air. It has been theorized that providing a curtain of air that is vented to the outdoor air around a foundation would prevent soil air entry. The dynamics are visualized as being similar to having a hole in a drinking straw. Passive vents would also allow radon to escape by concentration gradient-driven molecular diffusion. Pressure differentials between the air curtain and the outdoor air would cause outdoor air to pass through the vents, lowering the radon concentration in the air curtain. An air curtain could be made using a number of commercially available drainage products (Figure 1). This method is completely untried, and there are no data on which to judge its merits.

BUILDING-IN A SOLUTION

When conditions allow, the most effective method of controlling radon in existing houses is sub-slab soil depressurization. This technique transfers easily to new construction in many situations because it is well suited to drainage systems and inclusion of these is a recommended practice in many areas of the country. All that is involved is to place a layer of permeable aggregate beneath the slab and seal the air in the layer away from the basement air (e.g., no French drains or open sumps) and outside air (reverse flow valves on any drains to daylight). This permeable layer can be composed of #2 stone (as graded by DOT). In areas where stone is not readily available, sand and strips of drainage mat could be tried. Such systems become even more effective if perforated pipe is placed around the interior perimeter of the footing. Some builders who do this bring risers into the basement from the pipe and cap them. This approach is not recommended, since there is no way to prevent an occupant from unwittingly opening this cap at some later time. It would be much better in a new house to run the riser straight through a plumbing chase and vent it out through the roof like a plumbing stack. This provides passive venting, reduces the risk that the vent will be opened to the house air, and makes powering the system at a later time very simple. Many of the sealing methods described earlier would improve the effectiveness of a built-in sub-slab system.

Another type of built-in approach is to plan the ventilation as one system and not as a number of independent systems. Two operating principles help to control radon in this case:

- o Dilution by Introducing Outside Air
- o Reduction of Indoor/Outdoor Pressure Differentials

All of the mechanical devices (as well as stack effect) exhaust air from the building. This increases the entry rate of soil air and outside air. Depending on the soil air radon concentration, the flow rate of soil air and the flow rate of outdoor air will have different effects on the indoor radon concentration.

By supplying air from above grade to the building, the pressure differentials will be reduced, thus lowering soil air entry. Moreover, outdoor air will be introduced, diluting the indoor radon concentrations.

A number of approaches could be taken to do this. Combustion equipment is available that has dedicated outside air supplies. This is often a code item for fireplaces. When this is done, the entire combustion process is isolated from the house air. This has the additional, and perhaps more important, advantage of reducing the risk of downdrafting and spillage. Any makeup air supplied to combustion devices should be in compliance with mechanical codes and manufacturers' recommendations. For air exhaust fans (bath, laundry, and kitchen fans and driers), it is best to supply air to the living space, not directly to the device, as can sometimes be accomplished with combustion devices.

Some manufacturers are supplying passive air inlets that increase the above grade leakage area as the building is depressurized by exhaust devices. This allows more outdoor air in and reduces, but does not eliminate, pressure differentials. These inlets can be placed directly through walls or can be ducted to the cold air return of a warm air distribution system. Care must be taken with the "through the wall" approach to avoid cold drafts that might make people uncomfortable or freeze water pipes. A few manufacturers have engineered central exhaust/passive supply systems for the whole house.

Another approach to supplying makeup air to houses is to use heat recovery ventilation. This method consists of fan-powered air exhaust and supply, a distribution system, and an air-to-air heat exchanger. This method has been studied for several years in the low energy use housing field. A number of manufacturers supply a good selection of components for installing them, but successful applications require careful planning and installation. Such systems have the advantage of a long track record compared to other ventilation methods.

Ventilation systems in residences should be planned to provide enough outside air to meet the ASHRAE guidance of 0.35 air changes per hour (ACH) (4). This guide can also be met by using acceptable air flow rates per person for different types of rooms. Air exchanges of 0.35 ACH can only be effective in houses that have low radon source strengths. It is unknown how much effect lowering the pressure differentials by supplying outdoor air can have on radon entry.

ADOPTION OF RADON-RESISTANT NEW CONSTRUCTION TECHNIQUES

How widely a recommended practice becomes adopted depends on at least three factors. First, there must be a reason to adopt it. Second, it must interface with a large body of existing building codes. Third, builders must learn to apply the techniques properly.

Reasons for adopting radon-resistant construction practices include public health and liability. This does not mean that such a practice will be widely adopted. Probably only about 10% of the United States' housing stock has elevated radon levels. This means that many new houses will not have radon problems using current building practice. It is likely that a radon-resistant construction practice will gain acceptance and use only in areas that have problems. Just as there are very few water drainage systems found around foundations in desert communities, radon protection techniques will see little use in areas where radon has not been found to be a problem. In the Northeast, with over 100 in. of rain per year, drainage detailing is used extensively although perhaps not frequently enough.

There are three major model building codes, thousands of code jurisdictions, and tens of thousands of building inspectors, fire marshals, and insurance inspectors. It is important that an emerging building technology fit into existing codes smoothly. Nothing should be recommended that violates existing codes. Unfortunately, there is disagreement within the three major model codes pertaining to drainage systems and termite caps.

Getting the word out to builders concerning proper installation techniques can be very difficult. Builders would like to build things in the best way: however, the industry is very fragmented, consisting of a large number of small builders and a small number of large builders. Many of these builders do not belong to trade associations and are hard to reach with new information. Compounding this problem is the amount of construction information that is distributed informally by magazines, newspapers, lumberyards, and related trades.

CONCLUSION

Techniques to control the entry or level of radon in new houses have been hypothesized. It is not easy to demonstrate their effectiveness in the field; however, one method that has the highest chance of success is building in a sub-slab depressurization system. It is probably cheaper and easier to protect a new house with sub-slab depressurization than it is to do enough site testing to evaluate the risk of having a problem.

REFERENCES

1. Nero, T. Hazards of Indoor Air Pollution. Sci. Am. 46(5):258, 1988.

2. Sextro, R. "Soil Permeability and Radon Gas Concentration Measurements and a Technique for Predicting the Radon Source Potential of Soil." Presented at the EPA Symposium on Radon and Radon Reduction Technology, Denver, Colorado. October 17-21, 1988.

3. Peake, T. "The Influence of Foundation Type and Regional Geology on Indoor Radon Concentrations." Presented at the EPA Symposium on Radon and Radon Reduction Technology. Denver, Colorado. October 17-21, 1988.

4. "Ventilation for Acceptable Indoor Air Quality." American Society of Heating, Refrigerating, and Air-Conditioning Engineers. report 62-1967, 1967.

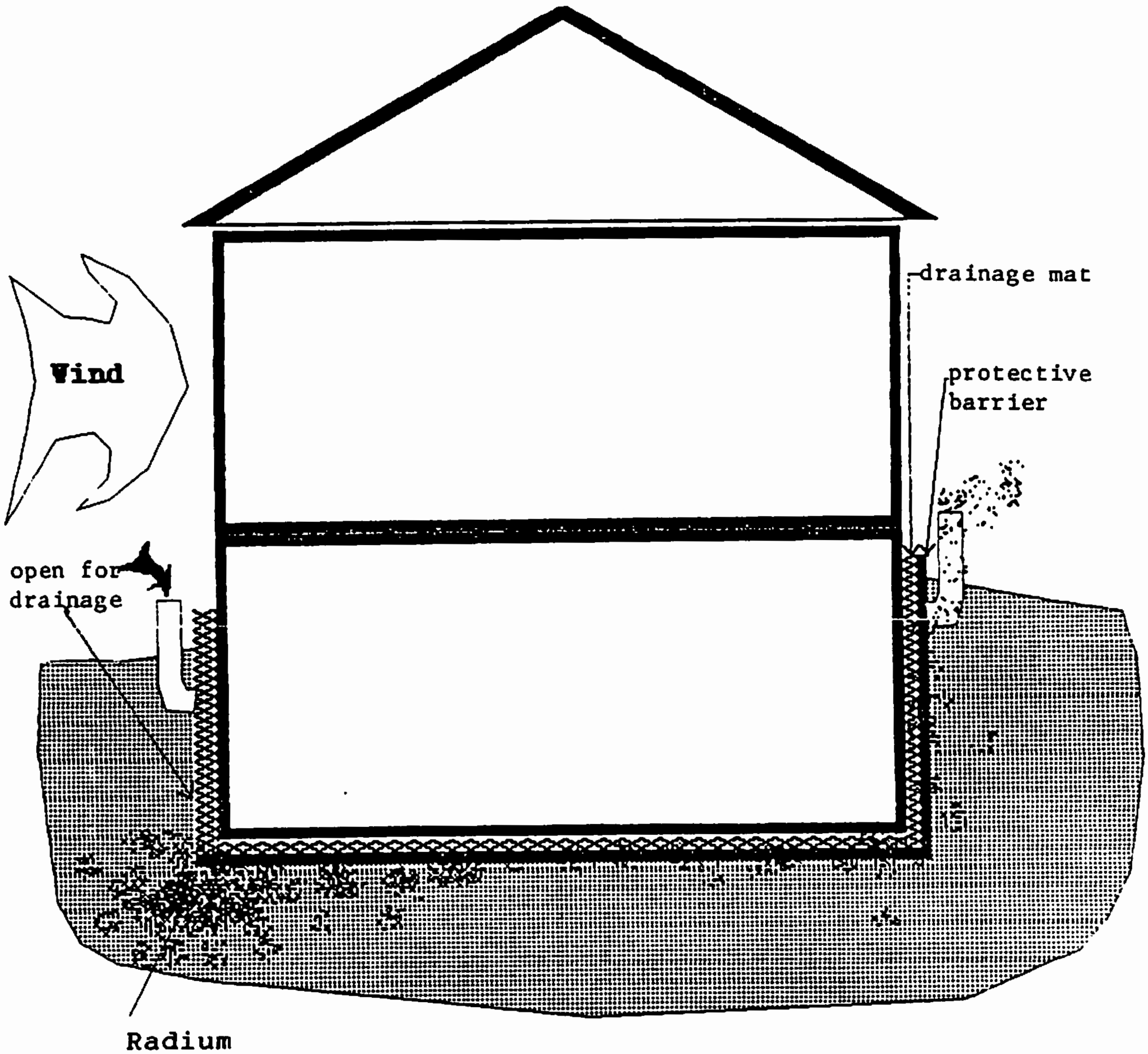

Figure 1. A drainage mat would create an air curtain around a foundation.