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Project Summary

Engineering Design Criteria for Sub-Slab Depressurization Systems in Low-Permeability Soils

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Engineering design criteria for the successful design, installation, and operation of sub-slab depressurization systems have been developed based on radon (Rn) mitigation experience on fourteen slab-on-grade houses in south-central Florida. The Florida houses are characterized as hard to mitigate houses because of low sub-slab permeabilities. Premitigation indoor concentrations ranged from 10 to 100 pCi/L. Mitigation experience and results have been combined into tables and graphs that can be used to determine recommended numbers and placement criteria for suction holes. Fan and exhaust pipe size selection is assisted by other tabulated and derived information. Guidance for installation of the sub-slab system to enhance the system's operation and effectiveness is also provided. This guidance is being reported in the form of a design manual for use by mitigators when they are dealing with houses similar to these.

This Project Summary was developed by EPA's Air and Energy Engineering Research Laboratory, Research Triangle Park, NC, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

Sub-slab depressurization (SSD) is generally the most common and most effective radon (Rn) mitigation strategy employed in basement and slab-on-grade houses. In many areas of the country, the standard building practice is to place a layer (often 4 in. [100 mm] or so) of coarse gravel directly beneath a vapor barrier before pouring the slab. When this has been done, an SSD system is usually quite effective because of the good permeability and communications afforded by the gravel layer. However, many older houses were built before using gravel became a common practice, and in some areas of the country gravel is not readily available. In these houses the slabs are poured over either the native soil or a fill soil that has been compacted to some degree to prevent settling away from the slab once the concrete has hardened. Most of the time such a soil fill has much lower permeability to air flow than does gravel. In such instances an SSD system will not operate as effectively as it would over a coarse aggregate bed. Since much of the literature about SSD systems addresses slabs poured over gravel, guidance in the installation of SSD systems over low permeability soils has generally been lacking. Some researchers have reported cases of low permeability beneath the slabs and have either made somegeneric observations about the average slab area affected by given suction holes or offered unique remedies found to work in specific houses. However, no uniform guidance document exists that uniquely addresses design and installation strategies for solving this problem.

In 1987, the Radon Mitigation Branch (RMB) of the U.S. Environmental Protection Agency's Air and Energy Engineering Research Laboratory (AEERL), Research Triangle Park, North

Carolina, initiated a regional demonstration of radon mitigation in slab-on-grade houses in the phosphate mining area of Polk County, Florida. South Central Florida is one area in the U.S. where coarse gravel is not readily available. The customary building practice is to prepare a base of compacted fill soil, overlay it with a vapor barrier, and then pour the slab.

From December 1987 to September 1989, 14 single-story slab-on-grade houses with living areas of about 1300-2600 ft^2 (120-240 m^2) and initial indoor radon concentrations of 10-100 pCi/L (400-4,000 Bq/m^3) were mitigated with SSD systems. The systems ranged from central- and perimeter-located single suction hole systems to up to four central and/or five perimeter suction holes, with a variety of combinations. Suction pits ranged from no pits, to pits up to 12-15 gal. (0.05-0.06 m^3) in size. Different sizes of fans and pipes were installed. Suction holes were drilled through the slab from inside the house, and horizontally through stem walls under the slab from outside the living shell. Fans were located in attics and outside the houses.

This design guide is an outgrowth of the results that have been measured in these houses over the last two years. This document has several purposes. It may be used by mitigators to aid them in the design and installation of SSD radon mitigation systems. Since radon mitigation is a relatively new industry, in some areas where this document may be used it may also provide a reference to supplies, equipment, and sources useful in the mitigation field. Because this document reports some lessons learned during the demonstration and research conducted in these 14 houses, another purpose is to alert mitigators to potential pitfalls and problems in installations, often discovered too late by experience.

Scope

Every house is a unique structure. There are many variables, from geological or physical characteristics, to construction features, to operational house dynamics, to seasonal environmental factors, to home owner inputs that may affect the potential for radon's entry into that structure. Fourteen houses is not an adequate sampling to predict all possible problems or situations. It is hoped, however, that the guidance offered here helps the mitigator get started in the right direction and helps the user structure the planning and installing process in a proper framework. Situations will occur where the information provided in this document will not be applicable or adequate. For some houses, SSD is not the preferred, or even a recommended, mitigation option. For instance, if there are major unsealed openings in the slab or extensive cracking whereby the sub-slab space is in direct communication with the indoor space, then sealing the known openings may be sufficient to reduce the indoor radon concentrations. Having unblocked openings between the two spaces not only allows soil gas entry, but also provides leaks whereby the pressure field of an SSD system may be truncated. Professional judgment is still the most important element in the design and installation of radon mitigation systems.

Research is also continuing relevant to design criteria for sub-slab mitigation systems in the same (and other) areas of Florida, across the U.S. and in other parts of the world. The University of Florida, in particular, is contributing much complimentary research to houses in a different part of the state. Other local mitigators who have worked through problems and situations unique to their areas and/or building practices are also good potential sources of information on possible changes or permutations in these guidelines. Two years is too short a time frame, considering the life of a house, to be able to state definitely that these guidelines will be the final word in SSD systems in low-permeability soils. Because radon mitigation is a field growing in breadth and application, readers are encouraged to seek additional information. EPA Regional Offices and appropriate state and local agencies should be good sources of the latest information or of suggestions for how to obtain such information.

This report includes a description of background information necessary or useful to know before installing a system, keys to the selection of good suction hole locations, fans and pipe sizes, installation suggestions for suction holes, piping, fans, and exhausts, and recommendations of system indicators and labeling. A section on commercial equipment is included to help identify potential sources of supply for products that may be unfamiliar or unavailable to the reader.

Background Information

Before a mitigator or homeowner starts to design a radon mitigation system, it should be established that indoor radon is a problem. With all of the publicity that radon has received from often-times less-than-informed sources, home owners may be acting or reacting without knowing the seriousness or even the certainty of their problem. It is reason[illegible] and ethical for a mitigator[illegible] communicate to the homeowner [illegible] recommended EPA protocols for screening and follow-up measurements. Several EPA publications present guidance for making reproducible measurements of radon concentrations in residences, including recommendations for using the results to make well-informed decisions about the need for additional measurements or remedial action.

Once it is determined that the house in fact does have elevated radon concentrations, before any other action is taken, certain basic house information needs to be obtained. Many of the items useful to investigate are given and discussed and appropriate forms are suggested for use, including house summary information, radon entry point determination, house differential pressure readings, and sub-slab communication and permeability measurements.

Sub-Slab Depressurization Design Process

Once the decision has been made to install an SSD system for radon mitigation, the first and most critic[illegible] question to answer is how many suc[illegible] holes will be needed to remedy [illegible] problem and where to put them. If th[illegible] house has more than one slab separated by footings or a foundation wall, then for determining the number of suction holes, each slab is treated separately. The following process should be conducted for each separate slab area. The single most useful diagnostic tool to use as input in this determination is the sub-slab pressure field extension measurement. The mitigator should have obtained a reasonable feel for types of communication present under the slab. Based on the results of this test and a figure presented in this report, the mitigator is instructed how to approximate the coverage area of a suction hole. When this information is combined with the slab area and geometrical considerations, the number and placement of the suction holes can be determined. After considering how moisture variation and other factors may adversely affect the ability to move gas through the soil, this document recommends that a mitigator be conservative in estimating system performance when designing the system.

Actually placing the suction holes i[illegible] very dependent on the structural feat[illegible] of the house. Some guidance is given in \ report for unfinished and finished ements and for slab-on-grade houses ..n adequate access to all slab areas from interior placements of suction holes and those without. Installation guidance and tips for drilling the holes, excavating the pits, and finishing the installation are provided for several commonly installed systems.

While the pressure field extension measurements of the sub-slab communications diagnostic give information useful for suction hole placements,the pressure and flow measurements indicate sub-slab flow characteristics. Fan performance curves indicate ranges of pressures and flows where the fans are effective. The report illustrates and describes how to interpret the sub-slab flow curves and fan curves to estimate the potential effectiveness of various fans on sample types of fill. The influence of other factors such as fan durability, costs, noise, and installation features of various fans is also discussed from the perspective of fan selection.

Generally most mitigators use PVC pipe when installing SSD systems. It is lightweight, easy to cut and handle, convenient for fittings and accessories, strong in its glueing characteristics, noncorrosive, and smooth so as to offer low resistance to air movement. For permeable sub-slab environments conducive to high volumes of air flow, 4-in. (100 mm) PVC piping is generally used. For the low flows resulting from the low-permeability soils addressed in this document, 2-in. (50 mm) or larger PVC piping is usually adequate. The smaller piping has the added advantages of being lighter and easier to handle, less obtrusive to the homeowner and easier to conceal if desired, and usually less expensive for the piping, fittings, and accessories. Therefore, an important determination is what size of pipe is the best to use for the given mitigation project.

A figure is provided to help the mitigator estimate the size of pipe to select for a house dependent on the projected flow in the system and the approximate length of pipe to be used. A sample house is used with appropriate numbers provided so that the reader can experience the use of the figure. Descriptions of how to calculate friction loss for both the pipe and connectors are given with the help of a table and a realistic example. Other factors to consider in the process of pipe selection are indicated.

Some generic guidelines for the proper design and installation of the piping and for the fan placement are given for several types of mitigation systems. Additional installation tips from experienced contractors are passed along to the reader as well. For houses requiring roof penetrations, a section containing guidance and suggestions is also provided.

Finally, the successful installation of a mitigation system should not be considered complete unless some sort of system monitoring and labeling is provided for the benefit of the current and future home owners and others who may be working with or around the system. Some of the available options for accomplishing these aspects of the process are included.

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The complete report, entitled "Engineering Design Criteria for Sub-Slab Depressurization Systems in Low Permeability Soils," (Order No. PB 90-257 767/AS; Cost: $17.00, subject to change) will be available only from:
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