PASSIVE STACKS IN A MULTIFAMILY HOUSING PROJECT

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ABSTRACT

The Summerfield multi-family, 1242 unit housing project that has been under construction since 1993 in Prince Georges County Maryland near Washington, DC suggests that passive stacks provides significant radon mitigation in multi-family construction. Random radon tests in these buildings indicate an average indoor ground floor concentration of 0.3 pCi/L with the stacks open, and 1.3 pCi/L with the stacks sealed. These buildings were built with post-tension slabs which should be more airtight than conventional floating slabs, and measurements show that the pressure field extension in these slabs in very good.

INTRODUCTION

In 1993, A. B. Craig of the EPA Office of Research and Development (EPA-ORD) was asked by Hunt Building Corporation to review the plans for passive stack radon control systems that were to be installed in the Summerfield multi-family housing project to be built in Prince Georges County, MD. Radon problems were anticipated because this project is located a few miles from an elementary school with elevated radon levels that had been studied by EPA-ORD. The Summerfield design calls for 1242 residences that are mostly slab on grade, two story, 7 residences per building, forced-air gas heating, and electric air conditioning. As of July 1995, the project is about 75% complete.

All floor slabs are 4 inch thick with a post-tension construction that does not have the perimeter crack of the typical floating slab construction. Each slab has a 4 inch diameter schedule 40 PVC passive stack that runs up through a 6 inch wall and out to a roof stack. The subslab aggregate is 4 inches of #67 stone, and there is a 6 mil polyethylene vapor barrier on top of the aggregate. The suction pit under the slab is a 4 foot square cavity in the aggregate with a steel cover supported by masonry blocks. Most slabs did not have bathtubs installed on them, and there were few significant penetrations in the slabs. There are no basements or sump pits in these buildings.

Since there was little previous experimental data on the post-tension slab and passive stacks, measurements of the subslab pressure field extension were made by the author with several fan sizes. This was done in order to make recommendations regarding fan sizing if radon problems were found in the buildings after construction, despite the passive stacks.

After the buildings were constructed, but before occupancy, short term radon tests were conducted in at least 10% of the units in order to determine if any indoor radon problems existed. Only ground floor units were tested. In addition, a few units were tested with the stacks sealed in order to determine if there was a potential radon problem at the site.

POST-TENSION SUBSLAB COMMUNICATION

Test Instrumentation

The subslab communication at Summerfield was tested with a stack tester that can measure both air flow and stack pressure. The instrument is driven by either a Fantech F175 200 watt fan that can draw up to 400 cfm and 2.5 inch water column (in. WC) pressure, a Fantech F100 48 watt fan that can draw up to 100 cfm and 1.0 in. WC pressure, or a "mini" 10 watt fan that can draw up to 20 cfm and 0.2 in. WC pressure. Subslab pressure is measured with a 2 in. WC Magnahelic pressure gauge, and flow is measured with a pitot traverse element connected to a 0.25 in. WC Magnahelic gauge calibrated in air flow units of 50 to 250 cfm. In addition, a micromanometer capable of measuring 0.001 in. WC was connected to the flow grid to all measurements down to 10 cfm. The stack tester was attached to the central stack on the slab, and test holes were drilled at the four corners of the slab. A digital electronic micromanometer capable of reading pressures from 0 to 2 in. WC with a resolution of 0.001 in. WC was used to measure the pressure field extension at a range of stack flow rates.

Building 1 Slab Description

On 11/04/93, the Summerfield slab for Tract #1, Building #1 was tested for subslab airflow communication with several possible mitigation fans to determine the minimum size fan acceptable for an ASD system. Several potential mitigation fans were tested and flow measurements down to 10 cfm were made. This post tension slab is 174 ft 10 in. long by 41 ft 6 in. wide. There are no control joints, expansion joints or other visible penetrations. There are a couple of hair-line cracks running width wise across the slab. Under the slab there is four inches of #67 stone that has been compacted mechanically. The soil beneath the aggregate is silty sand, type SM or ML. At the approximate center of the slab there is a 4 inch PVC stack pipe that connects to subslab suction pit in the aggregate layer. There are no subslab barriers to air flow under the slab.

Building 1 Measurements

Four 1/4 inch diameter test holes were drilled through the slab about 1 ft in from the corners of the slab, positioned to avoid the post tension rods. Pressure and flow measurements were made with three different types of fans:

Table 1. 11/4/93 Summerfield 1 Subslab Communication

Fan	Stack Pres	Stack Flow	NE Hole	SE Hole	NW Hole	SW Hole
F175	2.0 in. WC	42 cfm	1.60 in. WC	1.62 in. WC	1.75 in. WC	1.75 in. WC
F100	0.85 in. WC	35 cfm	0.66 in. WC	0.68 in. WC	0.75 in. WC	0.78 in. WC
Mini	0.16 in. WC	15 cfm	0.085 in. WC	0.091 in. WC	0.125 in. WC	0.128 in. WC

Before the subslab communication tests were made, a radon grab sample was taken at test hole A with a Pylon AB-5 monitor and pumped Lucas cell. The cell was pumped for 5 minutes at 1 liter per minute and sealed. After 16 hours the sealed cell showed an activity consistent with a subslab radon concentration of 1075 pCi/L. This is typical of the subslab levels that have been measured seen in houses and schools in this area with elevated indoor radon concentrations. However, this slab is so airtight that it may induce more elevated concentrations than the typical slabs found in this area.

Building 6 Slab Description

On 11/04/93, the Summerfield slab for Building #6 was tested for subslab airflow communication with several possible mitigation fans to determine the minimum size fan acceptable for an ASD system. This post tension slab is 50 ft long by 42 ft wide. It is the highest of a series of stepped slabs. There are no control joints, expansion joints or other visible penetrations. There are no visible cracks in this slab. This slab was poured directly on aggregate without a poly barrier in order to evaluate the effect of the poly on slab cracking. Under the slab there is four inches of #67 stone that has been compacted mechanically. The soil beneath the aggregate is silty sand, type SM or ML. At the approximate center of the slab there is a 4 inch diameter PVC stack pipe that connects to subslab suction pit in the aggregate layer. There are no subslab barriers to air flow under the slab.

Building 6 Measurements

Four 1/4 inch diameter test holes were drilled through the slab about 1 ft in from the corners of the slab, positioned to avoid the post tension rods. The drilling showed that the slab was about 5 inches thick. Pressure measurements were made with two fan types:

Table 2. Summerfield 6 Subslab Communication

Fan	Stack Pres	Stack Flow	NE Hole	SE Hole	NW Hole	SW Hole
F100	0.81 in. WC	27 cfm	0.66 in. WC	0.79 in. WC	0.05 in. WC	0.54 in. WC
Mini	2.0 in. WC	<10 cfm	0.13 in. WC	0.17 in. WC	0.012 in. WC	0.12 in. WC

Interpretation of Test Results

The measurements confirm that both slabs are very airtight, and that the aggregate layer provides excellent subslab communication. Only one test hole in the smaller slab that was poured without a poly barrier showed less than excellent communication, and even that test hole pressure indicated good radon mitigation with the mini fan. The post tension slab design appears to be much more air tight than the standard floating slab design, perhaps because there is no shrinkage gap around the perimeter of the slab. This slab is so tight that very low air flows produce high subslab pressures. Typical house slabs of 1500 sq ft area might require 50 cfm to produce 1.0 in. WC of stack suction, but 42 cfm in this 7250 sq ft slab produces 2 in. WC of stack suction. Furthermore, the pressure field extension is excellent because all but one test hole shows that approximately 75% of the pressure is transmitted to the edges of the slab.

The two tested Summerfield post-tension slabs were very airtight and it will require very little stack air flow for good subslab depressurization. Except for one test hole, the pressure field extension is excellent which indicates that the aggregate is air permeable and the soil beneath the aggregate is air tight. The one test hole that shows poor, but adequate communication appears to be due to concrete intrusion into the aggregate in the slab where there was no poly barrier. This slab should provide an excellent basis for either a passive stack radon control system or an active (fan driven) subslab depressurization radon control system.

RADON SCREENING TESTS

As Summerfield buildings were completed, radon screening tests were conducted in about 10% of the randomly selected units. Electret ion chamber radon measurement devices were used for these 2 to 5 day tests. Figure 1 shows a histogram of the 95 tests that have been conducted through July of 1995 with the passive stacks operating. The mean radon concentration with the passive stacks open is 0.3 pCi/L. Figure 2 shows a histogram of similar radon measurements made in 8 units where the passive stack had been sealed for about one week. The average radon concentration in these units is 1.3 pCi/L. The passive stacks appear to be effective in lowering radon concentrations in these buildings. Table 3 shows the stack sealed versus the stack open measurements. Note that the passive stack appears to provide consistent radon mitigation even at very low initial levels.

Table 3. Summerfield Radon With Stack Sealed And Stack Open

Stretford Way	6/2-5/95 test	6/15-19/95 Test
Bldg. Units	Stack Open	Stack Sealed
650-102	0.3 pCi/L	1.3 pCi/L
650-103	0.2 pCi/L	0.5 pCi/L
650-101	0.3 pCi/L	0.6 pCi/L
650-104	NA	1.4 pCi/L
620-103	0.0 pCi/L	0.5 pCi/L
620-102	NA	0.5 pCi/L
620-101	0.0 pCi/L	0.8 pCi/L
620-104	NA	3.3 pCi/L

SUMMARY

The Summerfield Project measurements suggest that passive stacks can provide significant radon mitigation in multi-family housing. The subslab pressure field extension measurements suggest that post-tension slabs are significantly tighter than floating slabs, as might be expected. Further radon measurements comparing the sealed stack to the open stack are needed to quantify the passive stack mitigation performance.

ACKNOWLEDGEMENTS

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FIGURES

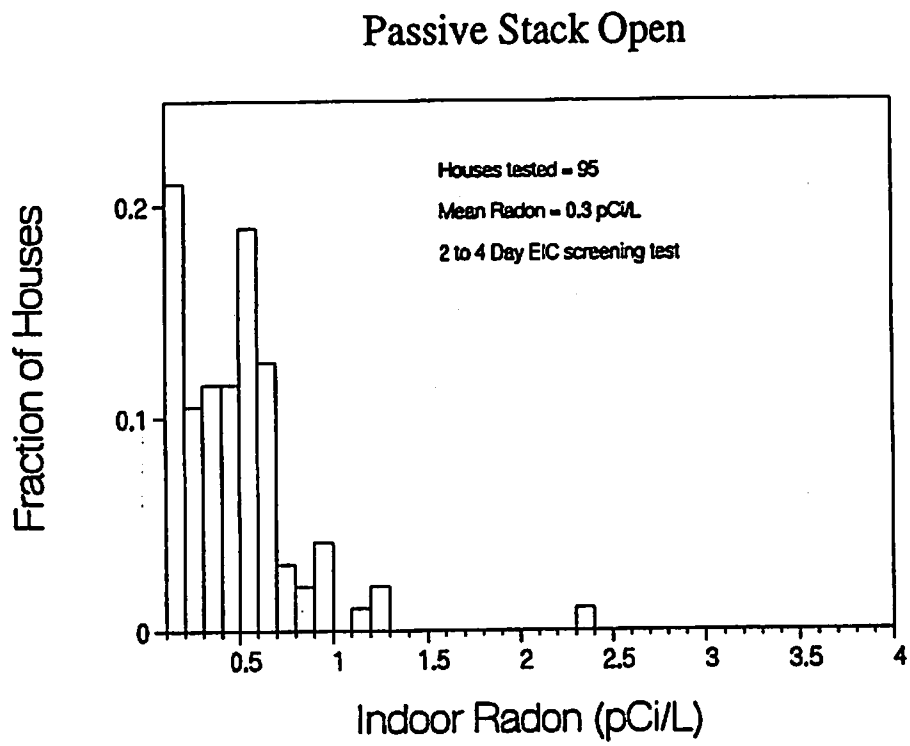

Figure - 1 Histogram of Radon Measurements with Passive Stack Open

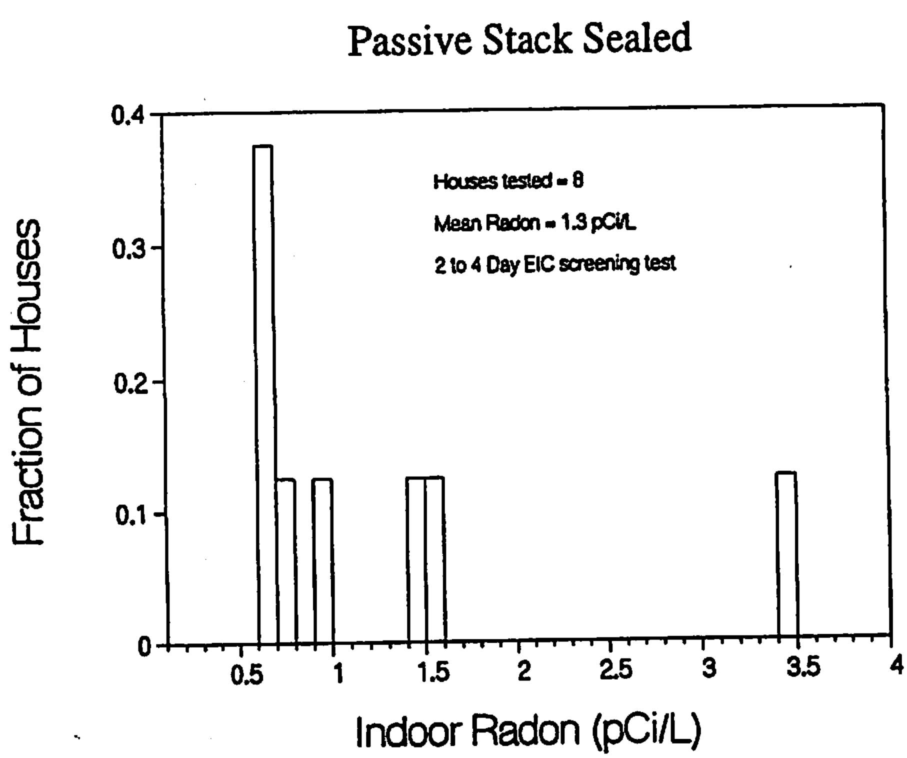

Figure - 2 Histogram of Radon Measurements with Passive Stack Sealed