USE OF SEALED MEMBRANE SYSTEMS IN CONJUNCTION WITH PASSIVELY VENTED CRAWL SPACES IN HOMES IN COLD CLIMATES

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ABSTRACT

Reasonable reductions in radon entry on residential dwellings may be achieved by installing polyethylene membranes on earthen floor areas and sealing it to the foundation walls with passive relief. In some cases, passive relief routed to the outside, without the use of a depressurization fan can effectively vent radon collected beneath the plastic. Guidance for application of this technique are discussed.

INTRODUCTION

Active sub-membrane depressurization is a common method for reducing radon in homes. This common technique employs a high density polyethylene sheeting that is sealed to the foundation walls of the crawl space. A fan is incorporated into the active sub-membrane depressurization system which collects the soil gas from beneath the plastic and vents it to a safe location above the home. This approach is often used in cold climates where more simple crawl space ventilation is not practical due to the potential for freezing damage to plumbing often found in these crawl spaces.

Recently a great deal of research has focused on passively vented systems for use in new home construction[1]. This app.oach insures that a means for good pressure field extension beneath a slab is incorporated in the construction of the home (typically 3/4 inch rock or perforated piping beneath slab). A 4 inch vent is then routed through the home to the outside to allow for the passive relief of the soil gas from beneath the foundation of the home. This approach is enhanced by extensive floor to wall joint sealing and by routing the vent piping through the interior of the house to increase thermal stack effects on the vent pipe.

[1] Proposed Model Standards and techniques For Control of Radon in New Buildings, Environmental Protection Agency, US Federal Register, Vol. 58, No. 68, Monday, April 12, 1993

The method investigated by this paper combines certain elements of the approaches utilized by both a standard active sub-membrane depressurization system and passive systems proposed in new home construction but applied to the remediation of existing homes. That is, a polyethylene sheet laid upon the earthen floor of a crawl space and sealed to the foundation walls, simulates the concrete slab and the caulking of it at the floor-wall joints as suggested in the new home constructions techniques. Furthermore if a perforated pipe is laid beneath the plastic and extended via non-perforated pipe to the outside, or if the plastic barrier is extended above a crawl space vent a passive relief for the trapped soil gases can be achieved.

This paper investigates the applicability of this method as a stand alone technique or one that can represent an initial step in a phased approach for the full installation of an active soil depressurization system.

Methodology

The buildings that were studied are homes which were mitigated as part of the normal course of business by two radon mitigation firms. Because they were mitigated within the framework of a normal contractor client relationship, exhaustive data could not always be extracted. In some cases the post-mitigation testing was performed by third parties who often only reported back to the contractor that the results were sufficiently below 4 pCi/L to allow for the house to be sold.

The homes used in this survey are located in the vicinity of Fort Collins, Colorado. These homes are wood frame homes constructed on poured concrete foundations that penetrate the grade a minimum of three feet due to frost constraints of the local building codes. The homes were constructed on two basic soil types: clay or decomposed granite. Detailed descriptions are provided in Table 1.

The application of the passive sub-membrane approach was performed by laying a high density, 4 mil, cross-laminated polyethylene sheet completely on the crawl space earthen floor. The seams were overlapped a minimum of 12 inches and sealed with a 3/8 inch bead of polyurethane caulk between the overlaps. The edges of the plastic were sealed to the foundation walls by running a continuous bead of polyurethane caulk along the side of the wall after the wall had been wire brushed. The plastic was the laid up on the wall a minimum of 12 inches and pressed into the caulking. Duct tape was used to secure the edges and seams until the caulk fully cured.

The passive relief of the area beneath plastic sheeting was accomplished in either of the two following methods. In either venting method, provisions were made to allow for the installation of an active depressurization fan, should post passive mitigation testing prove the reduction to be insufficient.

Venting Method A: A three inch perforate pipe was laid between the plastic sheet and the soil and run the length of the crawl space. A 4 inch PVC pipe was routed above the plastic sheeting to the outside with an exit at the rim joist. The other end of the PVC pipe penetrated the plastic and was connected to the perforated pipe beneath the plastic.

Venting Method B: Additional crawl space vents were added through the rim joists to the crawl space area. In these locations the plastic was brought up above the crawl space vents when it was sealed to the walls. This allowed for the passive relief to be accomplished without the use of any piping systems.

Results - Table 1

House #	Cat.	Soil Type	Pre-Mit. Rn (pCi/L)	Was Passive Vent Successful?	Area of Crawl Space (sq. feet)	Basement Slab-on-Grade Area (sq. feet)	Type of Passive Venting Method Employed	System Activated with fan? If so to what Rn level?
1	A	G	House > 4.0 (owner test) Crawl-203	YES 0.5 in house 6.1 in Crawl	960	None	B 2 added to 2 existing	
2	A	C	House-12.5	YES 1.2 in house	952	None	B 3 added to 0 existing	
3	C	C	House-10.3 Crawl-19.1	NO House-9.11	2100 L shaped	250	B 2 added	YES House-1.3
4	B	G	House-60	NO House-47.0	400	2100	B 1 added	YES House-1.7
5	C	C	House-5.8	NO House-5.1	600	550	B 1 added	YES House-2.4
6	B	C	House-13.3	YES < 4.0	1536	1624 Thorough Sealing	A	
7	C	C	House-7.0	NO	176	720 No Sealing	A	YES w SSD < 4.0
8	C	C	House-7.9	NO	580	528 & Sump	A	YES w SSD 1.0
9	C	C	House-8.0	NO	240	832 No Sealing	A	YES w SSD 3.6
10	C	C	House 8.0	NO	636	900 No Sealing	A	YES w SSD < 4.0
11	B	C	House-7.0	YES House-2.7	440	728 Thorough Sealing	A	
12	B	C	House-7.9	YES <4.0	392	968 Thorough Sealing	A	
13	C	C	House-6.4	NO	252	900 No Sealing	A	YES w SSD < 4.0
14	C	C	House-9.3	NO	400	416 No Sealing	A	YES w SSD 0.7

Notes: C= Clay, G = decomposed Granite; SSD = Sub-Slab Depressurization in adjacent basement connected to Active Sub-Membrane Depressurization system. All homes mitigated at time of re-sale except for #10.

Category Classification:

- A= Houses completely over crawl space with no slab-on-grade or basement areas
- B= Houses with adjacent unfinished basements where thorough floor to wall joint and control joint sealing could be accomplished
- C= Houses with adjacent finished basements or slab-on-grade areas where thorough floor to wall joint sealing could not be accomplished

DISCUSSION OF RESULTS

The following discussion references the data in Table 1. It should be noted that post-mitigation results were not definitively known in all cases due to the fact that the short-term follow-up testing was performed by agents of third party firms. Successful mitigation to below 4 pCi/L was based upon notification to homeowner by the third party that the radon concentrations were sufficiently below 4 pCi/L to allow for the completion of the real estate transaction. The data can be broken down into three categories as discussed below:

Category A - Homes constructed completely over earthen crawl space style foundations. Houses #1 and #2.

Both of these homes were constructed with poured concrete foundation walls as opposed hollow block or wood. The membrane installed in the crawl space area the passive ventilation approach was a high density cross linked polyethylene sheeting material. The sheeting was sealed to the inner surface of the foundation walls with a polyurethane caulk. All sheeting seams as well as penetrations through the plastic for plumbing and pier supports were sealed with polyurethane caulk. In both cases the method of venting was to either add one or more crawl space vent to the rim joist to allow for passive venting method B to be utilized. In these two cases the plastic sheeting was secured to the foundation at the location of the vent in such a manner to have the vent be below the plastic sheeting. This allowed for the flow through of air beneath the plastic sheeting.

Although a large enough population does not exist for a complete statistical assessment of this group, it would appear that where crawl spaces are completely above earthen crawl spaces that passive venting from beneath a well sealed membrane may be sufficient.

Category B: Homes constructed with a combination crawl space and adjacent unfinished basement area. Homes #4, #6, #11, and #12.

These three homes were constructed with foundations consisting of earthen crawl spaces and basements. All foundation walls were poured concrete. The basements were adjacent to the crawl spaces as is typical with split level construction. The membrane installed in the crawl space area was a high density cross linked polyethylene sheeting material. The sheeting was sealed to the inner surface of the foundation walls with a polyurethane caulk. All sheeting seams as well as penetrations through the plastic for plumbing and pier supports were sealed with polyurethane caulk. The method for venting the area between the plastic sheeting and the soil was to run a length of perforated pipe the length of the crawl space which transitioned to solid Sch. 40 PVC pipe beneath the plastic at the point of the vent exiting the plastic sheeting. This PVC pipe was then routed through the rim joist where it was open to the atmosphere near the exterior grade. Note that this venting near grade is not at odds to the US EPA's Interim Mitigation Standards since the system is not activated.[2] The point where the pipe exited the home was judiciously chosen such that if the passive ventilation did not prove successful, the pipe could be extended, and a fan with additional exhaust piping could be added to fully activate the sub-membrane system.

These three homes also had unfinished basements without sumps. This allowed the contractor to access all floor-to-wall joints, control joints, plumbing penetrations, and stress cracks for thorough caulking and sealing. The passive ventilation of the area beneath the plastic in the crawl space appeared to

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[2]Radon Contractor Proficiency Program Interim Radon Mitigation Standards, December 15, 1991.

be successful in these three of the 4 cases. House #4 did work successfully perhaps due to the large proportionate area of the basement compared to the size of the crawl space and the fact that only moderate sealing was able to be performed economically.

Category C: Homes constructed with a combination crawl space and adjacent finished basement area. Homes #3, #5, #7, #8 ,#9, #10, #13, #14

These homes were constructed with foundations consisting of earthen crawl spaces and basements. All foundation walls were poured concrete. The basements were adjacent to the crawl spaces as is typical with split level construction. The membrane installed in the crawl space area was a high density cross linked polyethylene sheeting material. The sheeting was sealed to the inner surface of the foundation walls with a polyurethane caulk. All sheeting seams as well as penetrations through the plastic for plumbing and pier supports were sealed with polyurethane caulk. The method for venting the area between the plastic sheeting and the soil was to run a length of perforated pipe the length of the crawl space which transitioned to solid Sch. 40 PVC pipe beneath the plastic at the point of the vent exiting the plastic sheeting. This PVC pipe was then routed through the rim joist where it was open to the atmosphere. The point where the pipe exited the home was judiciously chosen such that if the passive ventilation did not prove successful, the pipe could be extended, and a fan with additional exhaust piping could be added to fully activate the sub-membrane system.

The distinction between this category and category B was the accessibility of radon entry points in the basement. These homes had finished basements or slab-on-grade areas where floor-to-wall joints could not be reasonably accessed for thorough sealing. The existence of large floor-to-wall joints behind furred out walls presented large entry points that could not be compensated for by the work performed in the crawl space area.

Conclusions and Recommendations

The potential for the success in passively venting from beneath a plastic sheeting sealed to the foundation wall in homes with crawl spaces would appear to be:

- Most successful if the house is constructed completely over a crawl space foundation
- Moderately successful if the house is constructed over both crawl space and basement where thorough sealing of the basement entry points can be achieved, and the basement area is not significantly larger than the crawl space area.
- Not successful if the house is constructed over both crawl space and basement where the basement is finished and thorough sealing of the basement entry points cannot be achieved

The authors recognize the small number of data points presented herein do not warrant definitive conclusions. Additionally, they recognize that long-term follow-up of these homes is also necessary to determine the seasonal effectiveness of these homes as well as their long-term durability However, given the premise that the passive venting from beneath a membrane space does not preclude the ability to complete the fully active sub-membrane system and that sealing the membrane can enhance system performance[3], the

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M. Messing, B. Henschel,[3]Radon Mitigation Experience In Houses With Basements And Adjoining Crawl Spaces, EPA/600/9-90/005d, January 1990.

use of a sealed membrane with passive ventilation presents a reasonable first step in a phased mitigation approach.

The authors recommend that further study be done on this approach to better define guidances of application in order to provide a better confidence level in performance prediction. Additional improvements to the system that should be studied would be the benefit of interior rather than exterior vented passive vent stacks as recommended by the EPA Model Building Standards.