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BUILDING RADON MITIGATION INTO INACCESSIBLE CRAWLSPACE NEW RESIDENTIAL CONSTRUCTION

by

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ABSTRACT Specifications for new residential housing units for base personnel at Ellsworth Air Force Base, Rapid City, SD, called for demonstrated radon levels below 4 picocuries per liter (pCi/L) before they would be accepted by the Air Force. Hunt Building Corporation decided that it would be cheaper to build radon control systems into all the units than to have to retrofit some later. The Radon Mitigation Branch of EPA's Air and Energy Engineering Reasearch Laboratory assisted during the design and installation of the active soil depressurization (ASD) systems and followup measurements. The buildings utilized below grade wood floor construction over an inaccessible crawlspace because of the highly expansive soils. The initial installations demonstrated the need for complete sealing of the floor system. An effective quality control scheme was instituted which tested the negative pressure field established under every building and required additional sealing until each corner of the floor was under at least 2.5 pascals (Pa). Early data indicate that moderate levels of radon (100 pCi/L) exist in the crawlspace when the mitigation fan is off for several days and virtually none when it is on. Results from several buildings are presented.

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

BACKGROUND

A major housing project which will be leased by the Air Force at Ellsworth Air Force Base, Rapid City, SD, is being built by the Hunt Building Corporation. The housing project has 828 residential units in 251 buildings, consisting of singles,

duplexes, and quadruplexes. The area where the houses are being built is known to be radon-prone. The Air Force had tested 30 of their 2500 houses and found about 60% of them above 4 pCi/L. As a result of this high radon incidence, the Air Force's initial Request for Proposal (RFP) contained a radon performance clause requiring the builder to test the houses before occupancy to guarantee that they were below 4 pCi/L. A unit testing below 4 pCi/L is accepted by the Air Force for occupancy and a 1-year alpha track test is commenced. If radon levels in the living area test below 4 pCi/L for the first year, then Hunt has met its performance requirement and no longer has any responsibility. If the house initially tests above 4 pCi/L, then Hunt must bring the level below 4 pCi/L before occupancy. When the 1 year test increases above 4 pCi/L, then the Air Force will stop payment until the level has been brought below 4 pCi/L.

With limited radon control experience, Hunt Building Corporation contacted EPA to seek advice on the best way to construct these multifamily housing units to ensure radon levels of below 4 pCi/L or to mitigate them to this level if they are found to contain higher levels when tested. The decision was made by Hunt to install a radon mitigation system in all units since retrofit into an inaccessible crawlspace would be very difficult and potentially expensive.

MITIGATION SYSTEM DESIGN

Most of the units are two-story quadruplexes with the lower level built approximately 3 ft (1 m) below grade (Figure 1). The

individual units are separated by a double wall for sound deadening, but no firewall. Because the units are built on expansive soils the Air Force is requiring that the lower floors be treated plywood over joists with a crawlspace below. The units are built with a 6 in. (15 cm) crawlspace between the bottom of the joists and the clay under the units. The building site is being excavated to a depth of 5 ft (1.5 m) and backfilled with compacted glacial aggregate in an effort to stabilize the ground and minimize movement. This is moraine till which is quarried on site consisting of a moraine stone with a great deal of fine sand and some soil in it.

After reviewing the various techniques which AEERL has tested on the mitigation of radon in crawlspace houses, it was recommended that the most cost-effective way to mitigate the house with a high level of assurance of lowering levels to below 4 pCi/L was to use either suction under a polyethylene sheet in the crawlspace or suction on the crawlspace itself. It was decided that there was an excellent chance of making suction on the crawlspace satisfactory by doing a thorough job of sealing the plywood subfloor. The plywood is tongue and groove along the 8 ft (2.4 m) edge and all 4 ft (1.2 m) edges are on joists. The plywood is screwed to the joists. No outside vents are in the crawlspace, and every effort is made to make the crawlspace as airtight as possible. Moisture should be controlled by the active mitigation system. The joint between the floor and the concrete wall is sealed with polyurethane caulk. Any cuts through the polyethylene and plywood for pipes are carefully sealed around the pipe with polyurethane foam. Hunt has built a box in the

joists under the bathtub so the bathtub trap does not penetrate into the crawlspace and provide a possible radon entry route.

One suction pipe per unit is used. This 6 in. pipe, in the wall between the two middle units of each quadruplex, extends straight up to the fan in the attic and exits the roof immediately above.

TESTING FIRST UNITS

Since the building season is short in South Dakota, testing began as soon as the first crawlspace floor was installed. AEERL sent a team to Ellsworth Air Force Base to install a temporary fan on the system and to measure pressure reduction at the various points of the crawlspace below the plywood floor. When negative pressures can be achieved throughout the crawlspace as measured in all four of the corners, the greatest distances from the suction point, then no soil gas should be sucked into the house. A 6 in. pipe was installed through the deck of a quadruplex at the intersection of the central "party" wall and the central beam which ran the full length of the unit. An axial aligned centrifugal fan was mounted on the pipe with power provided through a speed controller. An electronic manometer measured the pressure under the deck at several locations. Once a few small leaks had been sealed, at least -0.010 in. WC (-2.5 Pa) was obtained at each corner of the building and more than 1.0 in. WC (248.8 Pa) fan suction was recorded.

A duplex was the second unit tested. No perimeter or penetration sealing had been done so this provided an excellent opportunity to test the effect the extra sealing had on the suction obtained. No suction was detected at the corners and only

0.2 in. WC (49.8 Pa) of fan suction was measured which was the pressure drop through the floor opening. The fan suction was monitored while the sealing crew proceeded to close the openings. Little change was noticed until most of the wall joint and the pipe penetrations were closed. As the final openings were closed, dramatic increases in the fan suction were seen. The installation crew understood the need for carefully sealing all openings as a result of this test. This effort also provided the basis for the strict quality control and quality assurance program instituted by Hunt.

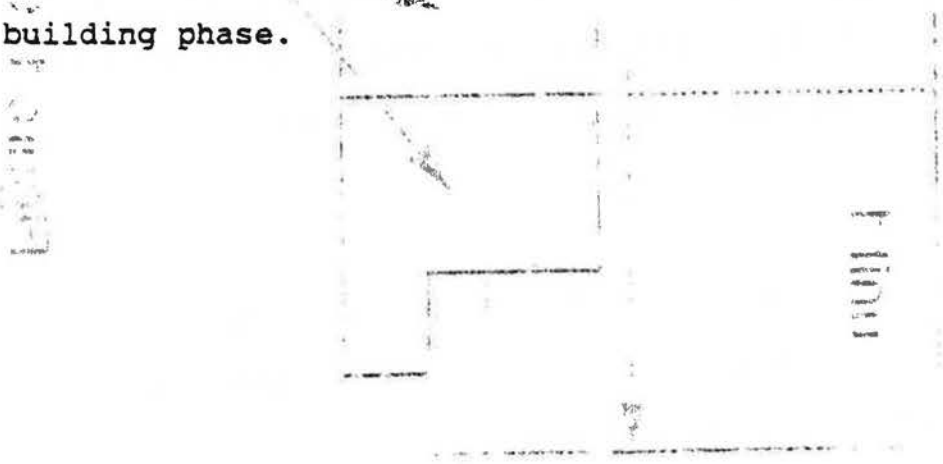
Every deck was tested when it was sealed and all plumbing activity was finished. A separate crew performed the tests and repaired breaks in the seal. A temporary fan depressurized the crawlspace and the sub-floor suction was measured. Any unit that failed to draw at least 0.010 in. WC in the corners was checked for leaks and resealed before additional construction activities were allowed to proceed. All buildings completed so far have exceeded the requirements when the seal was completed and a 6 in. fan installed. It may be possible to reduce the power consumption further by adding a speed control to the fans.

RESULTS

As the first units were finished, an AB-5 Pylon radon monitor was used to check for radon in three units: a finished one with an operating mitigation system, a unit with a finished floor which had been sealed for 1 week, and a third with a just-completed floor without final sealing. No radon was found under the floor in the finished unit nor in the mitigation system duct.

Likewise, the completed but not sealed unit had no measurable radon in the crawlspace. The crawlspace under the sealed floor did yield levels of 100 pCi/L. This is a moderate source strength, but could be enough to elevate unmitigated units above the EPA action level of 4 pCi/L because the shell of each house is very tight and low dilution could be expected.

Acceptance testing of the first 130 unit section yielded levels between 0.8 and 2.4 pCi/L except for a single unit which had a carbon cannister reading of 16.0 pCi/L. A check of the system in this house found that the circuit breaker had been turned off; consequently, the reading was really an indication of the level that could have been expected if no mitigation system had been installed. A retest with the fan operating showed the levels reduced to 2.5 pCi/L. This fan inoperation showed that the effort and commitment of Hunt to install the mitigation systems and insist on an effective quality assurance program was well worth the investment. Retrofitting mitigation systems into these units would have been much more costly than doing it during the building phase.



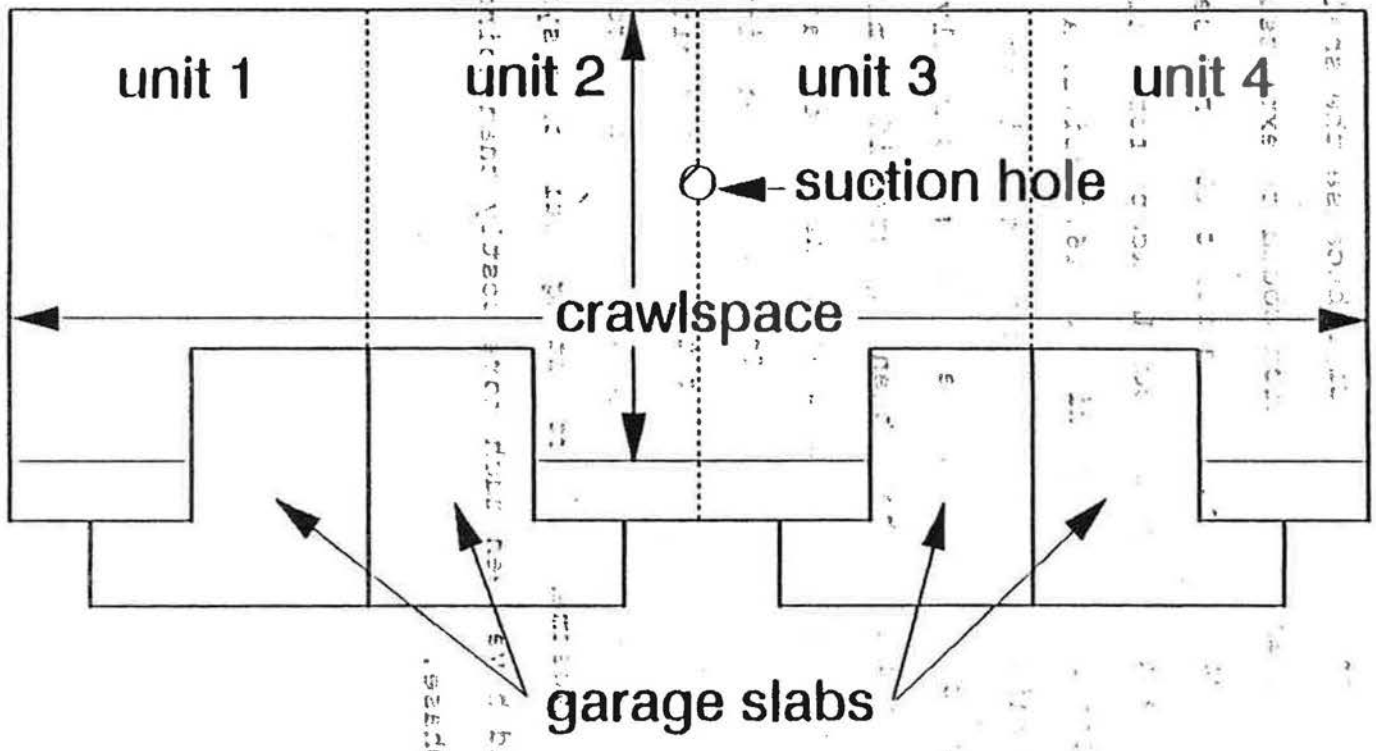


Figure 1: Quadruplex foundation plan