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# Adventures in **RADON** & **Moisture Mitigation**

photos by Elizabeth Grant

BY ELIZABETH GRANT

**M**y recent attendance at a Building Science Fundamentals seminar given by Joe Lstiburek and John Straube has motivated me to tell the story of my own basement. I am an architect, a professed defender of the health, safety, and welfare of society, and yet I essentially, and avoidably, poisoned myself and my family for six years due to my insufficient understanding and awareness of airflow patterns and moisture migration in my home. I tell this story in a sincere bid to help other homeowners avoid the same fate, and because it has the elements of a good Greek tragedy, like hamartia and hubris. Since I live in the South, it also has the elements of a good country song: dogs, a truck, and a baby for good measure.

First, a little bit about my house. It is what realtors call a raised ranch, built in 1959, owned by about seven other people before my husband and I bought it in 2000 for a very reasonable price. Its only real claim to fame is that it was owned at one time by an offensive lineman for the New York Giants. It has two floors of approximately 1,000 square feet each, with the lower being a walk-out basement containing a bedroom, a bathroom, a good-sized family room, and some other semifinished spaces.

The foundation is 12-inch-thick concrete masonry units (CMUs), presumably bearing on spread footings, with a concrete slab within. The foundation wall interior looks like it has been parged, then covered directly with polyethylene, then furred out with wood 1 x 2s, and then covered with gypsum wallboard in the finished spaces. In the semifinished spaces, the polyethylene and furring are exposed; it looks like someone tore down wood paneling that had been put up by someone else. I believe the sheet of polyethylene was originally installed in an earnest but misguided attempt to block moisture coming inward through the CMU walls and parging. As for the exterior, the odds of there being adequate dampproofing or perimeter drainage at the footings are slim, since neither of our investigative Chihuahuas has found outlets for these in the yard yet.

## Drunk Roofers or Radon?

When buying this house, I decided I could live with what I could see in the basement, but I was more concerned with what I could not see. I insisted that the seller do a radon test. The odds of there being radon in this house, with its various “cosmetic” cracks in the foundation wall, a floor drain in the laundry room (which doesn’t actually work but makes me look like a smart person with a floor drain in her laundry room), and the general quality of construction (I believe the euphemism used in infiltration calculations is “loose”), are close to 100%. One only need drive around my neighborhood to see multiple examples of downspouts pointing upward, some of them connected to exhaust fans.

Either we have very drunk roofers here, or we have radon. I have since verified that we are in fact in EPA’s Zone 1, that is, a high radon potential area. These “upspouts” and fans are telltale signs of houses where people discover radon and need to do a retrofit to depressurize the area under their slabs, and would rather have the retrofit on the outside of the house than on the inside.

The seller grudgingly agreed to do the test, we called out the guy with the magic tricorder (let’s call him Radon George), and after a couple of days, presto, we knew we had radon, about 5.3 picocuries per liter, (pCi/L), just over EPA’s action level of 4 pCi/L. The seller was annoyed, but per our sales contract, Radon George came out and installed a \$900 radon abatement system. Radon George drilled a hole in the slab, ran a PVC pipe from that hole up the wall of the laundry room, up through the closet of my daughter’s bedroom (we didn’t have the daughter yet, so of course sacrificed her future happiness and closet space so we wouldn’t have to have that ugly plastic pipe in our own closet), up through the attic where it attached to an exhaust fan, and up and out through the shingled roof, with (I hope) an appropriate flashing detail for good measure.

Radon George then installed a manometer in the pipe in the basement. I thought this was cool because it had a visual indicator filled with pink liquid, and because as an architect I'm easily impressed by anything with a name like "manometer."

Radon George left the magic tricorder in the family room again, and the numbers came back better enough, at 2.9 pCi/L, to buy the house, and forget about the whole thing for years. I could now walk into my laundry room with consummate satisfaction, glance smugly at my floor drain and my manometer, and wash clothes with the same joy usually experienced only by housewives on Snuggle commercials.

### A Little Moisture Problem

Fast-forward to 2005. My husband and I were in the process of adopting our daughter. I was furiously nesting by painting the interior of the house, and I decided, as the wait dragged on and I ran out of rooms to paint, to convert my Southern basement family room into a Scandinavian loft. I popped down to the local big box store and had them sell me a big load of beautiful blonde laminate flooring. Yes, I realize this was crazy.

So a nice married couple in their fifties came to my house and, with a work ethic that put mine to shame, scraped off the Berber carpeting that had been glued with some tenacious mastic to the concrete floor slab. Of course, this was going on, as all good home improvement should, in August. In the process, they informed me that I had "a little moisture problem." Of course, I already knew I had a little moisture problem, manifested by mold in a corner of the foundation wall in the basement, right where the foundation wall did its one architectural jog to relieve my house from being a perfect rectangle. The previous owners had already built a closet at this intersection, which made it more difficult to dry, but also cleverly hid the problem. So I was not surprised that there was some moisture under the carpet near the foundation wall when the carpet was removed. But I still wanted my underground Scandinavian loft for my new daughter, so I pressed on.

To get the Scandinavian loft, I had to deal with the moisture problem, so my next step was to contact a company that deals with this variety of unpleasantness; that can promise you the dry basement of your dreams if you are willing to dig up portions of your floor. Some guys came out and demolished the 2 feet of slab adjacent to the foundation wall, put in a drain attached to a new



Signs of drunk roofers or radon mitigation systems?



Radon remediation installation in my house in 2000. Left to right, a PVC pipe runs from the hole in the slab to the ceiling of the basement, up through the floor and ceiling of my daughter's closet, into the attic where it attaches to an exhaust fan, and up and out through the roof.

sump pump they buried in the floor of the storage room adjacent to the family room, filled the trench with gravel, and installed a flashing detail to ensure that any moisture seeping through the foundation wall would be guided into this trench rather than onto the surface of the slab—that is, the underside of my beautiful blonde laminate flooring. (See Figure 1.)

They then poured a new slab, and after it cured, the kind fifty-something couple with the superior work ethic came back to install the laminate flooring. They told me it wouldn't be warranted now, but they laid down a sheet of polyethylene and went to town anyway. When they were done, it looked good. The daughter showed up a few weeks later, and I became too preoccupied to tear up any more of the house or worry about my little moisture problem.

## Before and After Moisture Abatement Work

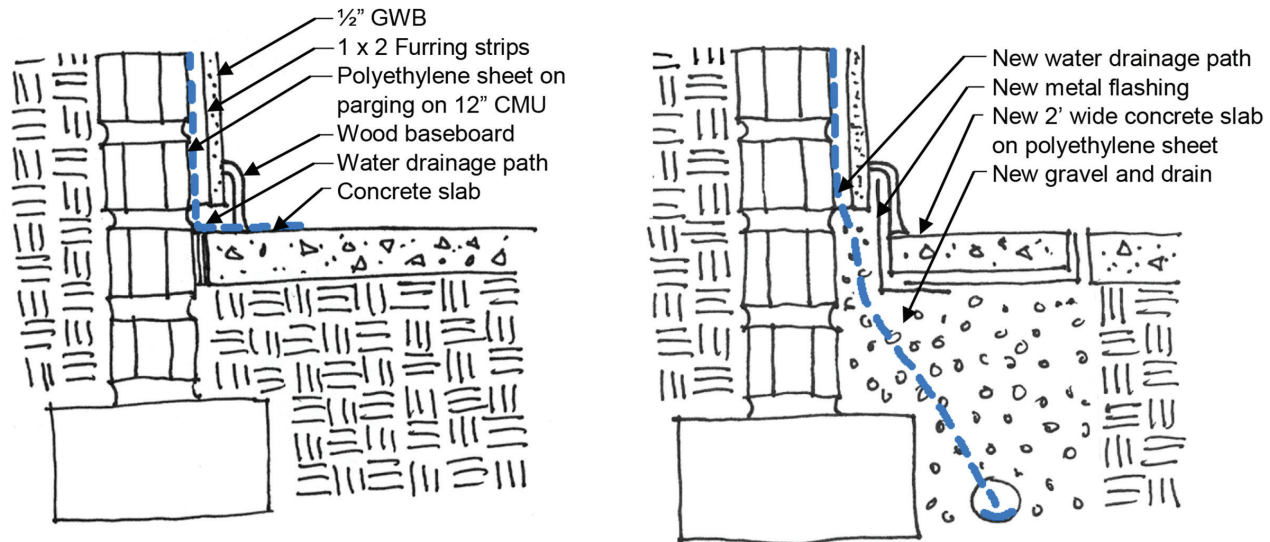


Figure 1. My best guess concerning the construction of my floor slab and foundation wall before, left, and after, right, the moisture abatement work.

### The Return of Radon George

That is, until I got a faculty appointment at the land grant university in my town and started teaching environmental building systems to architecture students in the fall of 2009. This course involves a brief discussion of air quality, and given all the aforementioned wonky upspouts in our town, we traditionally include a test for radon, because invariably some of the students live in grotty basement apartments teeming with it and have no idea. It makes for good theater when we plot the results in class. So of course, being the dedicated academician that I am, I also tested my own house with the mail-in kit the students were using, confident though I was in the pink water column still happily elevated in my laundry room. My results came back as 4.0 pCi/L, right on the cusp of doing something about it. But since I'd already done something about it, I mumbled something about "seasonal variation" and "differing test sensitivities" and promptly forgot about it. Until I tested again for the same course, two years later, just to see. This time, it came back at 4.7 pCi/L. So I became a little nervous at this point. After all, this was 2011, and my family had spent a lot of time watching TV and playing with old Star Wars figurines and My Little Ponies in that basement. So I dragged my feet, but finally asked Radon George to come over and see what was going on in early 2012.

So Radon George came out, scratched his head, and following an age-old treatment protocol for what doctors like to call idiopathic problems—that is, problems where doctors are idiots and don't know what's causing the problem, Radon George installed a stronger fan, thinking that perhaps my existing fan was getting old. He put the old fan in his truck. It was a reasonable hypothesis, but when we tested the basement with the magic tricorder, the reading was worse, at 6.6 pCi/L. So then Radon George came back out and performed a test that Drs. Lstiburek

and Straube introduced at our seminar, called "walking around and looking at stuff." Since radon is odorless and colorless, all Radon George could rely on were his brains and his eyes to help him identify the enormous gaping hole in the slab which was the sump pump, and the associated skinny but extremely long gaping hole which was the space behind the flashing leading to the new gravel pit along the new slab perimeter.

Radon George was apparently not an adherent of another approach we learned in Building Science Fundamentals, namely, "even though you know what categorically stupid thing is causing the problem, drag it out and do some more tests so you can prove it to your client and justify your fee." Radon George told me all about the gaping holes, and said he could solve the problem by plugging them up. But just to satisfy any lingering doubts I may have had, he left his magic tricorder with me yet again, this time in the storage room containing the sump pump. I watched in abject horror as the numbers climbed to 16.2 pCi/L by the next morning. This was of particular concern because the TV is on the opposite side of the wall of the storage room, and there are many holes punched through that wall for various electronics. So my earlier readings, taken on the other side of the family room, were likely artificially low.

Of course, I humbly reported this to Radon George, and Radon George, being a kind fellow, did not call me an idiot, but quickly and calmly got the can of spray foam out of his truck, sealed up the exposed portions of the flashing angle, and sealed up the perimeter of the sump pump lid (probably not an issue since it has never run, ever, but I suppose I should open it up every year anyway to check it and reseal it). Based on the logic that it would be cheaper and easier to create suction pressure on that gravel trench than to rip off the baseboards again and try to seal the flashing along the finished walls, he installed



Second radon remediation installation in my house in 2012. On the right, a PVC pipe is installed through the sump pump lid, and on the left, it penetrates the foundation wall and is connected to an exhaust fan named R2D2. Spray foam was injected behind the perimeter drainage angle to close the air gap. The adhesive lines on the wood furring strips are likely left over from when one of the seven previous owners tore down wood paneling installed by an earlier previous owner.


another gorgeous PVC pipe through the lid of the sump pump. This led to, you guessed it, another hole through the house, this time through the back, exposed portion of the foundation wall to another exhaust fan sitting in the backyard. And, wonder of wonders, he happened to have just the right size exhaust fan in his truck! The irony of this was not lost on me, but I was eager to save a few bucks, and I figured if it still sucked, it still worked, at least for a while. We've nicknamed him R2D2, and he's actually not that bad looking when you consider the state of my ancient condensing unit right next to him.

After this procedure, which took all of about an hour and a half, Radon George made some pretty impressive claims about how quickly my radon problem would resolve itself, and left his magic tricorder in my custody for a few days so I could see for myself. So every hour or so, I would go downstairs, press the AVG button, and yell, "Hey, honey, I'm not killing you anymore, it's down to 1.7!" It finally stabilized at 0.7 pCi/L in the storage room after 18 hours, so I moved it to the family room, and got an average reading of 0.4 pCi/L after 12 more hours.

Apparently all's well that ends well. The moisture problem is no worse than it has been historically, even though Radon George interrupted the drainage path created by the basement fixer guys in places by injecting foam in its way. Fortunately the dehumidifier and, more likely, the persistent negative pressure caused by the exhaust fan, seem to be dealing with this moisture in the unfinished spaces, and we didn't mess up the pathway in the finished spaces.

I recently did another of the mail-in radon tests with the students, and the results came back at 0.3 pCi/L. Hunky dory. But for

this effect. It is amply discussed in EPA's publication *Building Radon Out: A Step-by-Step Guide on How to Build Radon-Resistant Homes*, but I did not read this at the time, as I was not building a home. Radon should be tested every few years no matter what, just to guard against shortsightedness when people inevitably poke new and different holes in their houses and ignore the consequences.

As for the moisture problem, I'm not sure if it is caused by soil moisture migrating through the wall or by interior moisture condensing on the slab and the foundation wall when their surfaces fall below the dew point temperature during some portions of the year. Probably a little of both. Did we need the interior drain and sump pump after all? Maybe. I live on the side of a hill, and though I've taken steps over the years to improve exterior drainage, I consider the interior drainage trench and sump to be something of an insurance policy. Now that they're negatively pressurized, I like to think they're even more effective, though I realize this constant suction could have some minor thermal consequences. One of these days, I'll go back and redo the basement walls right with some foam that can breathe, and I'll put down a reasonable floor finish that can either pressure-equalize or breathe. I got some ideas from Joe Lstiburek's "Concrete Floor Problems." Or, better yet, I'll tear the whole house down and start over. Until then, I will run my dehumidifier and hope that my faithful R2D2 is enough to keep me out of trouble. 

Elizabeth Grant is an assistant professor at the School of Architecture + Design at Virginia Tech. She teaches courses in environmental design research, environmental building systems, and architectural systems integration.

#### >> learn more

U.S. EPA. *Building Radon Out: A Step-by-Step Guide on How to Build Radon-Resistant Homes*, EPA/402-K-01-002. Washington, DC, 2001.

Lstiburek, J. "Concrete Floor Problems." *ASHRAE Journal* 50, no. 1 (2008): 28-32.



## AMANDA HATHERLY

“Training in the 21st Century: From Sage on the Stage to Guide on the Side” — p. 6

Plenty of new techniques for becoming a more effective trainer in the 21st century are discussed in Hatherly’s article this month, but there are some techniques that can be prioritized. If you’re a trainer who is going to choose just one new tool to incorporate into your lessons, Hatherly recommends video. “Being able to record quick videos with either screen capture software like Jing or Camtasia, or using a smartphone to record in the field, is a wonderful skill to have.”

**What you didn’t know about her:** “I wrote most of this month’s article while walking on a treadmill desk—I probably walked about 6 miles.”



## ELIZABETH GRANT

“Adventures in Radon and Moisture Mitigation” — p. 20

Grant’s article delves into her personal experience with radon. “Even after teaching air quality concepts to architecture students, I really hadn’t considered the consequences of installing the drainage system in my own house,” she says. She hopes that her experience encourages all building professionals to think more holistically when changing conditions at the building slab and foundation walls, especially where radon is prevalent.

**What you didn’t know about her:** “I am trying, through my teaching and research, to expose this generation of architects to the importance of mastering basic building science concepts.”



## HESHMAT AGLAN

“Impact of Oil-Contaminated Floodwater on Building Materials” — p. 26

If there’s one takeaway from Aglan’s article, it’s that not all building materials can be effectively cleaned after a flood. “Restoration of drywall, for example, may not be advisable, and instead it should be replaced, especially after extended water exposure,” he says. While writing his article, Aglan also came across something of a surprise: that floodproofing is a misnomer. When there’s a flood, “the water will find its way into a building envelope, regardless of how much sealing and floodproofing has been done,” he says.

**What you didn’t know about him:** “I enjoy spending time outdoors and am an avid deer hunter.”



## THERESA GILBRIDE

“DOE’s Zero Energy Ready Home Case Study—It’s All in the (Envelope) Details” — Online

You’ll learn a lot about DOE’s Zero Energy Ready Home (ZERH) in this month’s online-only article from Gilbride, but there are some basics you may not know. For example, did you know that the ZERH program is free to builders? Aside from any fee charged by the HERS Rater, it’s completely free. It’s also nationally recognized and ties together many programs builders are already complying with.

**What you didn’t know about her:** “When I was kid I organized a neighborhood fundraiser to buy building supplies for the best fort in town. It was an A-frame with skylights.”

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