

Water Hazards & Your Building's Health

Still not convinced that moisture problems are real in today's buildings? Here are four soggy examples from an Iowa builder and consultant

by
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When windows show this much condensation, humidity levels are too high and should be corrected by eliminating moisture sources and increasing ventilation.

I grew up in the building business working for my father. With a degree in construction engineering from Iowa State, I started my own firm in 1974 and I've been specializing in energy-efficient structures for the last six years. In addition, I do some consulting—a chance to see where things have gone wrong in energy tight construction and why.

I'm seeing a lot of homes where moisture control was largely ignored. Moisture moves into and out of today's structures differently than it does in the ones our predecessors built. In our haste to reduce heat loss, we often don't realize the serious problems that can be created. Correcting these moisture-related problems in first-generation energy-efficient housing is big business in Canada today. Our errors here in the U.S. are just surfacing, and there's still a lot of confusion among consumers and builders alike as to what causes these problems, and the best way to avoid them.

Two to Tango

To have a moisture problem it takes two culprits, a source of excess moisture and a cold surface. Solving the problem is just as logical: Identify and remove (or reduce) the moisture source, and warm the cold surface.

Most homeowners recognize that taking a long, hot shower is contributing moisture to the house, but there are

lots of other sources that even many builders don't recognize. They include big contributors like firewood stored indoors, unvented gas ranges, and power humidifiers. It's amazing how many people don't equate the frost on their windows with the fact that their power humidifier has been running at full speed all winter!

But there are many other sources including cooking, laundering, cleaning, houseplants, and aquariums. And that doesn't include poorly-drained foundations, downspouts that are tied into footing tile, capillary action through basement floors and walls, and uncovered or loosely covered dirt crawlspaces. (A thousand square feet of uncovered earth in a crawlspace can generate as much moisture as five power humidifiers, even if the ground appears dry!)

The moisture can enter wall and ceiling cavities through a number of air-leakage points in conventional construction (see Figure 1). Once inside the cavities, there are many cold surfaces on which the moisture can condense.

Cold interior surfaces generally have fewer causes: wind blowing through the insulation (windwashing), or misplaced and missing insulation (see Figure 2). If indoor humidity is high, these cold spots will breed mold and mildew growth on the drywall or wallpaper.

Four With Serious Problems

In hopes of alerting builders who aren't up to speed on moisture control, here are four examples from my consulting work. If you're still building with yesterday's technology, you may see yourself or a client in one of the following situations.

Case number one. My client was an apartment developer in a Midwest college town. He owned six identical, three-story apartment buildings each with 30 units (see Figure 3). All had been built by the same builder using the same subcontractors. The three buildings that went up three years ago had no problems, but the other three, built last year, were a mess.

There was mold growing on ceilings, walls, and sash, and the windows showed heavy condensation. As far as the owner was concerned, the culprit was a loose-fit poly vapor retarder on the ceilings—the only difference he could identify between the newer and older buildings. (It's pretty common for old line builders to blame moisture problems on the presence or absence of poly in the ceiling.)

I found that all six buildings had a great deal of air leakage between units and between floors. The units with the highest moisture readings—50 to 70 percent relative humidity in February—were mainly third floor apartments, indicating a strong stack effect.

The older apartments without problems were occupied by young working singles. They didn't cook much and seldom used the shower more than once a day. The attic insulation above these units was blown fiberglass.

The new apartments with the problems were occupied by college students—two to three to a unit—who cooked at home and took several showers per day per unit. The range hoods in these units weren't ducted, and the bath exhaust fans weren't very effective. Aquariums were in style and every third unit had one.

The attics were insulated with blown-in cellulose, which forms a better air barrier than fiberglass. However, the insulating was poorly done since many of the infiltration stops (baffles) were improperly located flush with the inside of the wall (see Figure 4). This created a cold ceiling corner and defeated the purpose of using raised-heel "energy trusses."

Most of the bath exhaust ducting in these "problem apartments" was exposed and uninsulated, and large chunks of ice blocked many ducts. Several birds were nesting in the wall grilles of the lower level bath exhausts. The new buildings pressure-tested 25 percent tighter than the older ones—indicating that the builder and subcontractors had progressed somewhat on the learning curve of

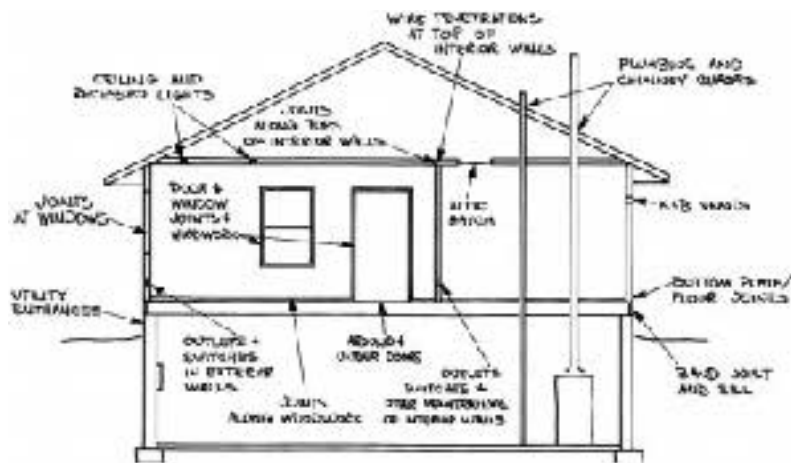


Figure 2. Insulation defects can cause cold spots on the interior surfaces of a home. Moist interior air can condense on these cold surfaces, causing mildew growth or rot.



obvious that the building was tight enough that it needed continuous ventilation in each unit. Sure enough, a survey of the occupants revealed that over half rated their apartments air quality fair to poor.

My recommendations included correcting the obvious insulation and bath venting problems, as well as ventilating all third floor units continuously with a 60 cfm roof-mounted exhaust fan. To reduce the stack effect, I suggested two American Aldes, humidity-controlled fresh-air inlets for each unit, and a time-delay switch on all bath exhaust fans that kept them running 15 minutes after the lights were switched off.

Case number two. This was a two-year-old ranch-style home with a partial basement and partial crawlspace. It had a full brick exterior, 2x6 walls, foam sheathing, Tyvek, low-e windows, a loose-fit vapor barrier, and a high-efficiency furnace. The nicest home in town, it was built by a conscientious builder using conventional building techniques.

The owner called me in because he was concerned about ceiling stains around the three bath exhaust fans, and heavy condensation on the high-performance glass. To the owner's dismay, the first place I went was the basement and crawlspace. "M problem is in the attic," he said.

After noting a loose-fitting vapor barrier on the crawlspace floor, I removed one of the fiberglass insulation batts at the band (rim) joist.

When the owner saw it was black with mold, he knew the attic was the least of his problems (see Figure 5).

The home pressure-tested at 21/2 air changes per hour a 50 pascals with a blower door; pretty tight for a conventional builder. At two air changes or better I usually recommend continuous ventilation. At three to four air changes per hour, intermittent ventilation is usually sufficient. But this home was carrying 60 to 70 percent relative humidity in January, and the bathroom exhaust fans were all ducted into the attic. In addition, the homeowners had a large collection of house plants and a large aquarium. I recommended central ventilation, a sealed poly ground cover in the crawlspace, an air barrier at the band joist, and exterior ducting for the bathroom exhaust fans.

As it turned out, we solved another problem at the same time. Out of curiosity, I did a radon test before we started. The home had a radon level of 32 picocuries per liter (pCi/l) on top of the moisture problem. With the central ventilation and the basement sealing, we were able to lower the radon level to an acceptable 4 pCi/l.

When we cut the hole through the wall to install the heat-exchanger's air intake, we noted that the wall cavity was also saturated with moisture. With the full brick veneer and the vinyl-clad windows, the owner might not have known there was a problem until the walls began to fall apart from rot in five to ten years.

Case number three. This home was

energy-efficient building. But they had neglected to account for moisture.

The exterior walls consisted of steel siding, gyp board sheathing, 6-inch batt insulation, a loose-fit vapor barrier, and 1/2-inch drywall. After seeing icicles forming on the siding, I was sure enough of what was happening in the walls that I cut a hole in the drywall from the inside of a third-floor unit and invited the owner to reach inside this exterior wall. He pulled out a handful of wet insulation.

An attic inspection showed that the stack effect had driven so much moisture up there that you could see the outline of the interior walls from above

where the insulation had become soaked and had settled. So much for loose-fit ceiling vapor barriers.

The real impact of the moisture generated by cooking and showering wasn't apparent until the early evening hours when everyone got back home and began showering and cooking in earnest. So I chose this time period to demonstrate to the owner how increasing the ventilation would solve the problem. Using the three existing 1,000-cfm attic exhaust fans, I opened the attic scuttles in the common hallways and stood back. Despite my 3,000 cfm ventilating effort, the moisture level rose 10 percent. It was

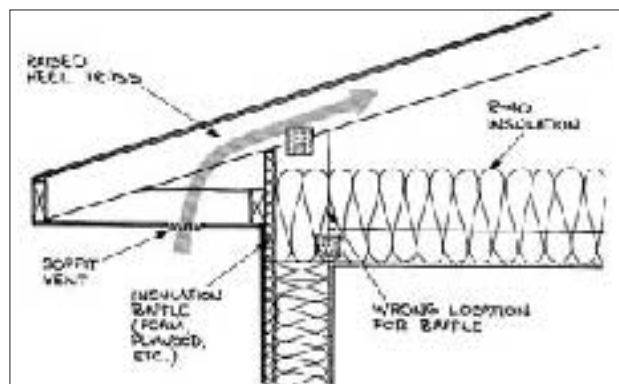


Figure 4. These insulation baffles (left) are ineffective since they are misplaced and damaged from heavy condensation. The baffles should be rigid and placed as shown (right) to keep wind from blowing under the insulation (windwashing), causing condensation, mold, and mildew at the ceiling corners.

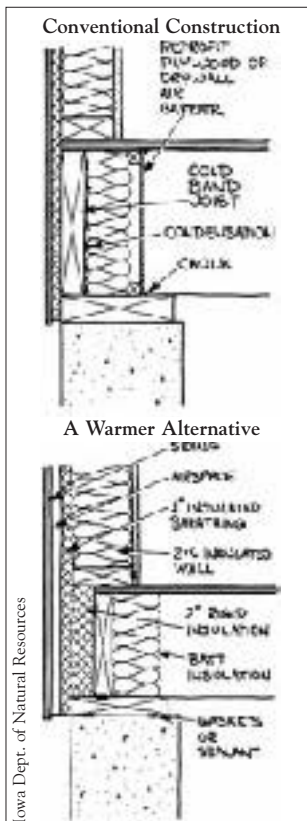


Figure 5. Conventional band or rim joists have cold interior surfaces that can condense moisture. The solution: Carefully retrofit airtight blocking between the joists (top) to keep moisture air out; or, in new construction, insulate the band joist on the exterior (bottom) to keep the band joist warm.

20 years old, but had 12 inches of cellulose insulation installed in the attic five years ago. The house had a gas range, lots of plants, no bath exhaust fan, and the kitchen exhaust hood had been blocked off to save energy.

After suffering a lot of condensation on their windows, the homeowners purchased some magnetic interior storm windows from a local window salesman. That worked for a couple years, but then they began getting condensation on the inside of the interior insulating windows. The relative humidity in the house was at 70 percent (see Table for recommended levels). This second jump in humidity was the result of a change often made in homes of this age: the installation of a new, high-efficiency furnace.

Ironically, each step the homeowners took to improve the efficiency of their home by tightening it up also generated more moisture, which then had

Recommended Levels of Relative Humidity

When the outside air temperature (in degrees Fahrenheit) is...	The inside relative humidity (at 70 degrees Fahrenheit) should be no more than...
Minus 20° or below	15 percent
Minus 20°—minus 10°	20 percent
Minus 10°—to Zero°	25 percent
Zero°—10°	30 percent
10°—20°	35 percent
20°—40°	40 percent

The author hands out this simple chart (developed by the University of Minnesota Engineering Laboratories) to his customers. He allows owners of superinsulated homes with low-e windows and good air barriers to exceed these values by five percent.

even fewer natural paths to follow out. To their credit, the home pressure-tested at 2.5 air changes per hour at 50 pascals, almost as tight as the new superinsulated structure I had just built on the same street. I recommended a central ventilation system.

Case number four. This homeowner replaced his old fuel oil furnace with a new high-efficiency gas model. The first spring after it was installed, the paint on the exterior of the 27-year-old house began to peel and the windows were heavy with condensation. The homeowner filed suit against the mechanical contractor and the furnace manufacturer. The owner was convinced that the new furnace was “pumping moisture” into his home



Figure 6. These sources of excess moisture—a shower without an exhaust fan, clothes drying in the basement, and a bathroom exhaust vented into the attic—are easy to fix if homeowner and builder are aware of the damage they can cause.

because he could see the water flowing out of the condensation line.

The insurance company hired me to sort out the facts and analyze the problem. I looked at a lot more than the furnace (see Figure 6). I found poor site drainage away from the foundation, a sagging and leaking rain gutter, a heavily used basement shower with no exhaust fan, a main-floor exhaust fan ducting into the attic, lots of house plants, a family with both a teenager and a baby (lots of showers and lots of laundry), and a clothesline full of wash hanging out to dry in the basement (they were proud of how much energy they saved by not using the dryer).

All of these moisture generating sources were in the home prior to the installation of the high efficiency furnace, and the homeowner admitted that “the house never did quite dry out in the winter.” But the conventional furnace flue was providing enough ventilation to partially relieve the problem. (A conventional furnace flue exhausts about 70 cfm continuously from a home, even when the furnace is not running).

A blower door test revealed that the house had 5.5 air changes per hour at 50 pascals pressure with the conventional furnace flue in place. The reading was 4.0 air changes at 50 pascals with the flue sealed. This difference in ventilation rates brought the relative humidity

up to 68 percent, which was the primary cause of the paint peeling and blistering. Contributing causes were wind-driven rain that penetrated the siding, and deteriorating putty around the windows.

In this case, I suggested improving the site grading, repairing gutters and downspouts, adding an exhaust fan for the basement bath, and cutting down the basement clothesline.

These suggestions should also bring the humidity down to a level where the house can dry out seasonally, eliminating the flywheel effect of increasing the moisture each year by building on the previous one. The house was already experiencing a moisture problem; the new furnace merely accelerated it, making it surface sooner. As is often the case, the “last guy in” got the blame.

There's some truth to the old saying: “They don't build ‘em the way that they used to.” In fact, homes today are built much better, but that means less margin for error. Proper moisture control, good air barriers, and adequate ventilation are the keys to houses that are more comfortable and durable as well as cleaner, quieter, and healthier to live in. ■

Bill Eich builds energy-efficient houses in Spirit Lake, Iowa. He combines the airtight drywall approach with specialized moisture control detailing, and central ventilation in all of his homes.