Observing Mother Nature: Moisture in Buildings in the Southeastern U.S.

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In this article, we present a rogues' gallery of moisture problems. Rather than exploring any one moisture diagnosis in great detail, we believe you will be more interested in this tour of the variety of moisture problems we have encountered. These problems can be traced back to moisture behaving naturally and to members of the building profession who either do not believe in or fail to consider the principles of physics, chemistry, and biology. Of course, that task became more important when society opted for indoor plumbing and air conditioning and decided that building on high, open piers was not pretty enough for "modern houses".

In any problem investigation, it is important to identify when and where the moisture is following its natural rules of behavior. Does the problem occur in summer or winter, inside or outside, or some combination of these? Here in the Southeast, we are especially interested in moisture because it is everywhere. Our humid climate poses special challenges in cooling and heating. While moisture is *essential* for life, it can spell *death* for a building!

Moisture in Attics

Moisture on ducts in the attic causes many problems. Insulated ducts in the attic have a vapor barrier on the exterior of the insulation. However, if this vapor barrier is also covered with standard attic insulation, the exterior surface of the vapor barrier can be cooled to the dew point of the water vapor that is in the attic insulation, resulting in condensation. This is a problem we are often asked to explain.

We were summoned, in another case, to an office building where rain had formed on the ceiling tiles and had begun dripping on the desks of the office workers. The building's roof had recently been resurfaced. Our inquiry revealed that the building's owner had always wanted to have the roof deck insulated. So when the 17-year-old roof was replaced, the two inches of foam board were added to the roof deck. The metal ducting for the air conditioning system was in the vented attic, as it always had been. But without the heat from the roof, the metal ducting was now cool enough to reach the dew point of the outside air that traveled through the attic. The condensation forming on the ducts was dripping down onto the T-bar and ceiling-tile surface below, and then on to employees' desks.

Because winter snow and ice are infrequent visitors in this region, conditions for ice dams lurk everywhere. During our rare bouts of snow and cold, many of our buildings grow world-record ice dams and icicles. These often serve as telltale signs of heat loss that has otherwise remained undetected. However, an observant diagnostician can learn to read the signs of things to come before a winter storm hits, simply by reading roofs on frosty mornings.

Moisture in Floor Cavities

Rain was falling from the center of the downstairs living room ceiling when we responded to a call at an apartment complex. In general, the contractors had followed our recommendations for energy efficiency as they remodeled the apartments. Unfortunately, they chose to disregard our recommendation to seal the second story floor cavity from outside air at the band joist. And because the air conditioning ducts were inside the floor cavity, they had decided that they could simply forgo insulating the boots. Knowing that, you can guess the result! There was an airflow path that routed outside air through the non-compartmentalized floor cavity, past the metal boot, and on out through the attic. Air paused long enough at the boot to form condensate that was now dripping into the living room.

In another investigation, the sheetrock ceiling in a downstairs hall became saturated and fell. This situation occurred after an energy-efficiency HVAC contractor had sealed off a big hole in a return duct. An airflow path, fueled by a powered attic ventilator, made its way past the metal supply duct that was located in the floor cavity. When the contractor sealed the hole in the return duct, the loss of hot air crossing the A/C coil caused the temperature of the air traveling through the supply duct to drop. As a result, the metal reached the dew point of the outside air that had always been there. When the resulting water saturated the sheetrock ceiling, it merely followed the laws of nature and fell to the floor.

Moisture Inside the House

Water running down the inside surface of the windows and rampant mold growth prompted another call. A family of four lived in a very tight house that had no ventilation strategies, even though they needed air exchange in winter to remove excess internal moisture vapor load. During the summer, their moisture problems stemmed from the slab-on-grade house being located in a cool, moist climate and having no air conditioning. Water vapor in the air was condensing on the slab and saturating the rugs and cardboard boxes sitting on it, especially under beds.

People continue to use lung-filtered, house-vented (more commonly called vent free) heaters. The common practice is to simply use them, rather than using them according to restrictive, engineered plans. The result is walls covered with mold and water collecting in ponds under furniture in rooms away from the heat source—an extremely unhealthy situation for inhabitants.

Moisture Inside the Walls

There are waivers in the building code that allow for buildings on the coast to opt out of installing a vapor retarder on the wall prior to hanging the sheetrock. It is even more important that the vapor retarder installed at coastal locations not be poly, as proven by one of our investigations. The south-facing wall of the building has water pouring out of the electrical outlets, except for one portion of that wall. As it turned out, the contractor had used kraft-faced batts, rather than poly, in that particular area. The wall configuration was acting as a moisture reservoir. The sun was driving vapor into the walls and the poly slowed it down enough that dew point was reached. The water that formed was simply running down the poly and out of the outlets.

Hardwood Floors Plagued by Moisture

Cupping, bucking, rippling, and waving hardwood flooring is a common complaint. We often find that code compliant, vented crawlspace construction along with typical floor insulation installation results in the wood absorbing moisture and expanding. Such was the case for a builder who normally builds on open piers at the coast. He elected to build his own home, which he hoped to use as a showcase for prospective customers, on a code-compliant crawlspace. But the undulating hardwood floor that resulted in his home was not something he wanted to share. If vapor could flow freely through the hardwood, then there might not be a problem. But where is the major vapor retarder located on hardwood flooring? It is on the top surface finish. So when vapor enters from below, it really slows down as it hits the bottom side of the finish, and then accumulates in the flooring. The solution is to remove the moisture source; use dry, thermally improved, crawlspace construction.

Vented Crawlspaces Wreak Havoc

During a *Dry, Thermally Improved, Crawlspace Construction* presentation, a builder attending the session raised his hand and said, "So what you are saying is that until we build crawlspaces that do not have 8 inches of water in them, we don't need to worry about the moist air entering the crawlspace through the foundation vents". Many parts of the code that address crawlspace construction are useful in preventing or reducing the moisture load on the crawlspace. However, the specifications regarding foundation vents can result in moisture loading during our humid summers. Such unanticipated moisture loading has proven to be the culprit in a multitude of moisture-related building failure problems.

Advanced Energy is currently involved in a research project to compare traditionally constructed, code-compliant crawlspaces that use foundation vents to dry, thermally improved, crawlspaces. See Figure 18 for a comparison of relative humidity in vented versus dry crawlspaces.

Remember: An increase in the rate of vapor flow into a space or material and a decrease in the rate of vapor flow out of the space or material will often result in a moisture problem. (The imbalance in the relative rates of flow is the culprit!)

Moisture on the Outside

We are periodically asked about condensation on the outside of windows during the summer. This is commonly caused by the supply airflow blowing on the window glass and chilling it until the outside surface reaches dew point of the outside air.

Some people are suspicious that moisture on the siding of a house is an indicator of a moisture problem inside the house. It is just a good example of how Mother Nature interacts with buildings. Mold will grow on the surface of vinyl siding, especially on the north side of a house. Just wash the mold off.

Rotting siding is, however, a real problem. Unfortunately, siding products are sometimes installed in such a way that their drying potential is reduced and their wetting potential is increased. Under those conditions, the siding can actually begin to rot.

Flashing Details and Drainage Planes Matter

Yes gravity works for you or against you here in the Southeast, too. You can harness it for your benefit or ignore it and let the building be damaged by it during moisture events. Attention to roof and window flashing details is important. In this region, the most important function of properly installed building papers, such as felts and tyveck, is not as an air retarder but for their drainage plane function.

Ducts, Duct Air Leakage, and Building Pressures

So many stories; so little time. Yes, those ducts, duct air leakage, and building pressures that are not addressed will cause water and water vapor to be driven to all the places in the structure that you do not want it to go. And the results will be bad.

Determining Moisture Content is No Simple Matter

So you took a *moisture content* reading with that moisture meter that you have there in your hand? Most likely, you did not! You probably only took a moisture meter reading. Determining what the moisture content of a material requires some additional work. Once you have properly applied the moisture meter to the material, you read the number in the display. For example, some meters say to stick the pins into the wood with the grain. Once you read the number from the meter, it often needs to be converted using formulas for temperature and the wood species. Determining moisture content is even more difficult with manmade materials, such as OSB, because there are no conversion formulas available. Other issues to consider in determining moisture content are sample size, sample locations, and time of day. And you must use the proper meter type—pin or surface. (Homeowners will not want you to use a pin type meter on their hardwood floors!)

Condensation and Mold as Diagnostic Aids

The occurrence of condensation and mold does have one bright side. Both are useful and convenient tools in diagnostic logic. When they are present, the diagnostician can use them as a tracer to better understand the building science dynamics that are taking place. And it is equally instructive to observe where the condensation and mold are *not* occurring.

An area where condensation and mold are occurring is often referred to as a *microclimate*. This perspective is a useful concept in the investigation of moisture problems. Sometimes several different microclimates are present in a single problem house, and each different microclimate can produce very different results.

Summary

As you can see from this quick tour of our rogues' gallery, moisture issues in the Southeast are vast and varied. Further complicating many situations is the fact that several factors often work in concert. Solving such challenges is personally rewarding for the diagnostician. More importantly, the solutions can be vital to the survival of the structure, the health of the occupants, and the profitability of the construction industry as moisture resistant practices are understood and eventually become standard practice.

For more details on these types of diagnostics, Advanced Energy periodically offers a variety of courses covering "Moisture Diagnostics", "Diagnostic Equipment", and "Building Diagnostics". See www.advancedenergy.org for more information on the courses and schedules.

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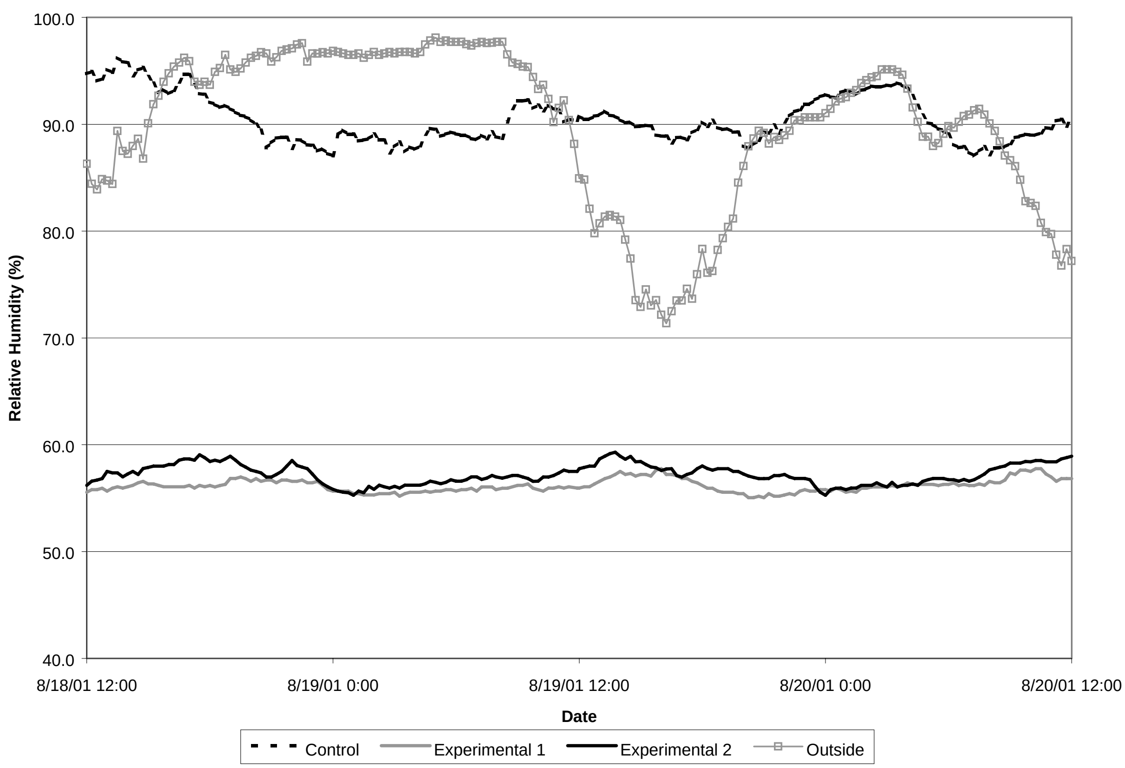

Figure 18: Relative humidity in control [vented] and experimental [dry] crawlspaces and outside for two-day period in August 2001