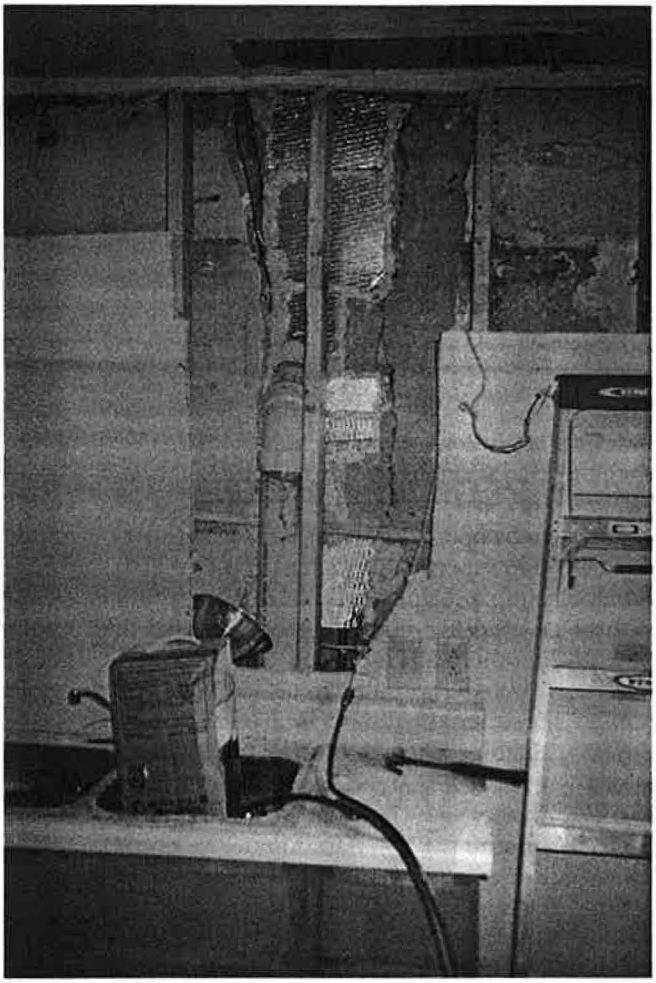
Today's Weather: Rain in the Living Room!

by Bruce Davis

Last summer, the Applied Building Science Center received a call to investigate a North Carolina multifamily residence where it was raining inside the apartment. This home serves as an example of the need for good air sealing and a whole-building approach. While the apartment ended up gutted, its lessons may save other building owners from a similar fate.

The 20-year-old building is a set of six two-story attached apartments, in which each unit has its own front and back door. It has a slab-on-grade foundation, with 4-inch cement block common walls that are open from the slab to the attic. Front and rear walls are also four-inch block, with a brick facade separated from the blocks by a finger space. Inside the masonry walls, nonbearing interior walls are framed with wood. The ground story floor is elevated to provide space for plumbing, ducts, and electric runs, and the second-story floor is supported by I-beams held up by the masonry walls.



ROBB FLYNN, COURTESY OF ABC

After the new cabinets were taken off the wall, we began to tear into the wall to seal the open air passages. This cutaway revealed leakage paths to the outside, into the next apartment, and into the attic and the floor cavity. The base cabinets had to be removed as well. To make matters worse, this was only one of six such areas that had to be torn open because of similar unsealed air passages. The construction supervisor in charge of the remodeling project began to dread getting our calls, because with each call another wall had to go.

We had been to this site before to advise the building owner on how to provide the residents with better comfort and energy efficiency. He chose to use forced-air cooling from an Insider, a heat pump that requires no outside unit. Good contractors had installed the equipment and the duct system. A recommended air sealing procedure was planned but overlooked in completing this unit. Rushing through the remodeling, he created a beautiful apartment as a pilot, with modern decor, good-looking kitchen and bathroom cabinets, and attractively painted walls and ceilings. The apartment was ready for occupancy, and he was ready to move renters in right on schedule.

Then came the rain in the living room. Water dripped out of the living room ceiling supply register onto the floor. By the time we arrived, the ceiling "drywall" was sopping wet. Before we could stop the rain, we had to knock holes in the walls, take down new cabinets, and rip out the ceilings. For the owner, it was a stark example of "pay now—or pay later." By neglecting the air sealing during the remodel, he created problems that cost him more time and money to repair.

We looked around for the cause of the problem. Using my memory and photos taken while the heat pump was being installed, we were able to find several significant air leaks in the envelope, such as where the back porch roof joined the house. In the mechanical closet, we found an 18-inch x 1-inch gap from the ceiling, opening directly into the attic, and another gap around the ducts into the floor. The heat pump is designed to bring return air through a grille in the closet door, but because of the leaks, it was drawing in attic and floor air as well.

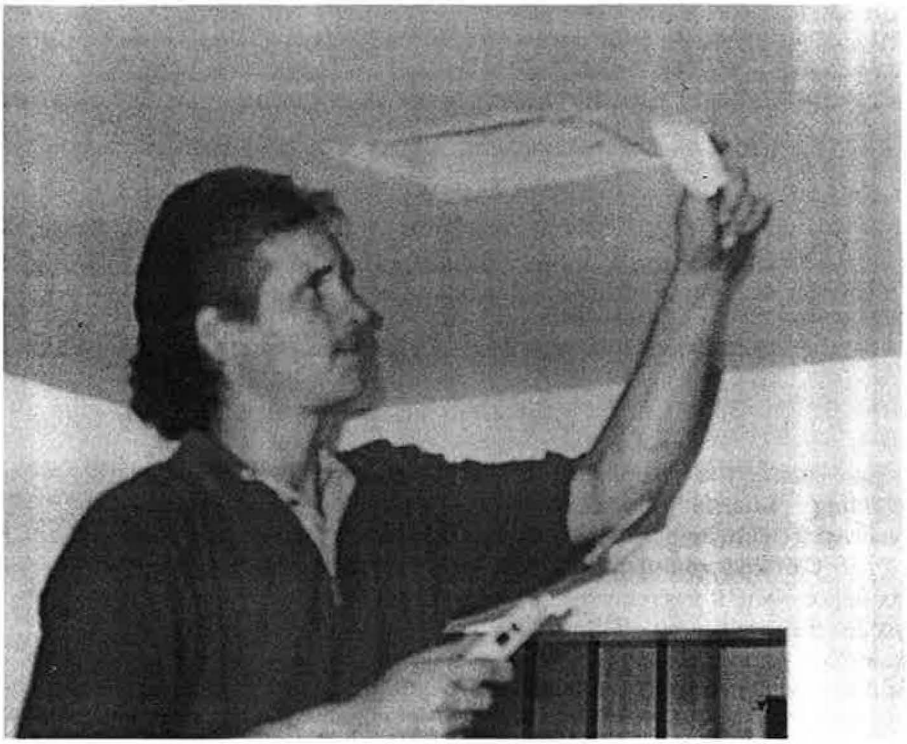
To find more leaks, we used an infrared scanner. We depressurized the house while scanning the walls, floor, and ceilings. Since the air conditioning

had been on all night and it was hot outside, the scanner showed hot air feeding into the house. When we used the infrared scanner on the area where the rain was falling, it looked like a cold spot, but it was something worse—several square feet of wet drywall. From all these examinations, we determined that although the air seal of the inner building surface was leaky, it was built more or less according to common practice. The problem was that the internal building cavities had wide open air passages to the outside. This allowed warm, moist outside air to move through structural framing passages.

Cavities that open to the outdoors are detrimental in any house. What made this house's cavity problems disastrous were the dropped ceilings throughout the unit. These ceilings joined all the joist cavities, so a leak for one cavity was a leak for all. And there were leaks—I beams broke through each side of the block party wall; other holes opened to the finger space behind the brick facade.

Similarly, a portion of the party walls were made of wood framing over cement blocks. A 4-inch plumbing stack rose from the slab-on-grade up through the block wall to the roof, servicing bathroom plumbing from both floors of two adjoining apartments, and providing a vent stack. By breaking through the block wall in so many places, this stack connected the attic, the inside of the framed walls, the inside of the floor cavities, and even the next apartment, into one big leakage system. We could look into the plumbing penetrations and see the floor cavity of the next apartment.

The rain coming from the living room supply register was apparently caused by outside humid air moving through the dropped ceiling and condensing on exposed metal in the register boot. But because the house was leaky in so many places, sealing a leak or two wasn't enough. We started air sealing in the attic and continued to run the blower door. Every time we sealed one leak, our smoke just changed direction, leading us to another big opening. It was shocking enough for the owner when we announced we would have to cut holes in his newly remodeled ceiling. But we kept finding more leaks. Smoke went



ROBB FLYNN, COURTESY OF AEC

Jeff Tooley from the North Carolina Alternative Energy Corporation cuts sheet rock around the supply register boot, where water was dripping into the living room.

behind the new kitchen cabinets, so they had to go. With the cabinets gone, we tore into the wall. Six areas in all had to be opened and sealed. The construction supervisor in charge of the remodeling project began to dread getting our calls, because with each call, another wall had to go.

As we continued to test and seal the building, we found one error in the duct installation—the outside air loop wasn't sealed to the outside. The Insider uses 700–1,500 cubic feet per minute (CFM) of outdoor air as a heat source or heat sink, pulling it (theoretically) from outside and blowing it back out. In this case, some of the air was coming from the floor, depressurizing the floor cavity and exacerbating infiltration through various holes and the plumbing stack. Like many of the problems in this house, a poorly sealed duct would not have been a big deal in itself. But a critical mass of errors led to rain.

By the time we had the house reasonably well tightened up, the remodel was ruined. However, the relative humidity in the cavities was much lower, the heat pump was working fine, and the rain had stopped. More importantly, the owner is now remodeling another several dozen other units in the complex. As he has heat pumps installed, he will have this lesson in mind, and he will remember to have the homes sealed. During this experience, the owner has even sent some of his maintenance staff through the two-week Duct Diagnostics and Repair training course at the Applied Building Science Center.

We have to replace the old way of looking at problem solving. We used to view it as "making repairs." We now know the guidelines, the specifications, and the construction details that allow us to do the job right the first time. Air sealing, insulation, framing details, duct sealing and design, HVAC sizing, moisture issues, ventilation systems, and other indoor air quality issues must be considered as parts of the whole, not in isolation one from another. Until then, we'll continue to see homes and buildings where it may be bad luck to open an umbrella inside, but it's the only way to stay dry.

Bruce Davis is a senior building science consultant at Alternative Energy Corporation's Applied Building Science Center in Raleigh, North Carolina.