A Rotting Timber Frame

Foam sheathing, too much moisture, and a broken vapor barrier almost spelled disaster for a four-year-old timber-frame house in southern Vermont.

by Steven Bliss

"If you don't put in a vapor barrier, your house is going to rot away." You've heard this many times, but it's not so simple.

Thousands of insulated houses with no vapor barrier (or a lousy vapor barrier such as kraft paper) have *not* rotted away. Furthermore, sticking a sheet of poly in the wall is no guarantee against problems. Take the rotting timber-frame house that I visited in southern Vermont last November...

The 1,800-square-foot, 1-1/2-story Cape is four years old. The walls are framed with 8x8 timbers, which are exposed on the interior of the house. Between the 8x8s the builder framed-in with 2x4s to provide nailing and a place for fiberglass insulation. The frame was sheathed with one-inch boards, then wrapped with one-inch-thick, foil-faced isocyanurate, which was taped and caulked. Clapboard siding was installed over kraft paper (see diagram).

Rotting Beams

The owner discovered the problem when a renovation contractor opened up the south side of the house in order to add a sunspace. He found extensive decay in and around the timbers. The rot occurred on the outer face of the timbers-up to two inches deep in some sections—and in the sheathing and 2x4s wherever they touched the timbers.

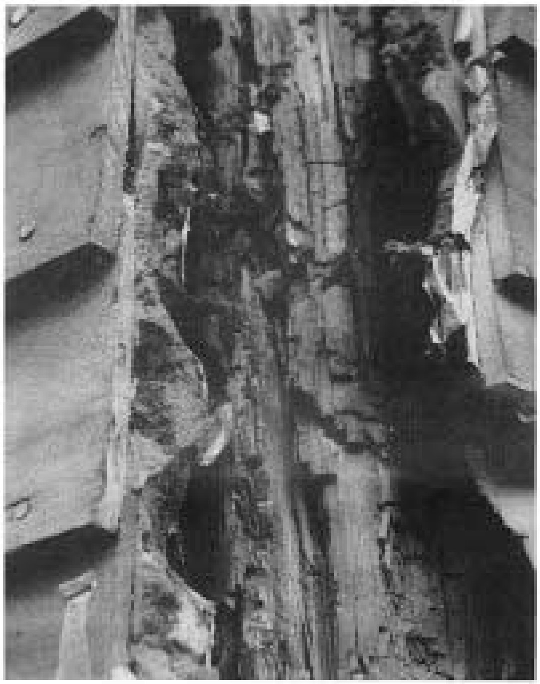
To learn more, the owner cut out sections of siding and sheathing on all sides of the house and found decayed wood on the north, south, and west. Only one hole was cut on the east side, and showed only minor damage.

There was decay on nearly all the beams looked at—high and low, on vertical posts, and on horizontal beams. Rot also occurred in the 2x4s that were directly nailed to the beams, and in the 1x pine sheathing where it touched the beams. No decay was found in the wall sections between the beams, or elsewhere—although a thorough search was not made of all areas.

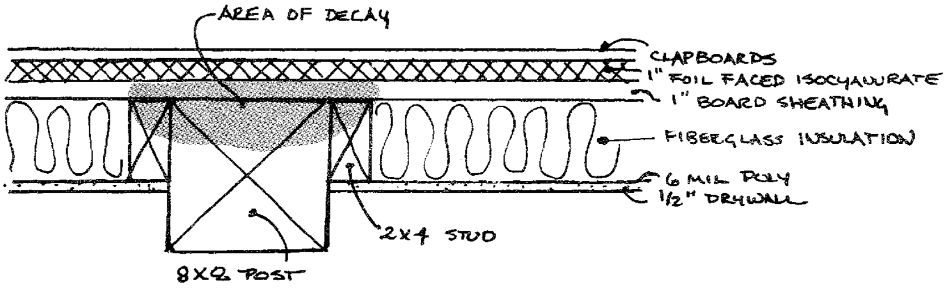
Looking Further

When I visited the house in November, I looked for evidence of high moisture levels. It was a sunny day in the 40s—too warm for condensation to form on the windows. But all the second-floor windows—and most on the first floor—were badly stained from pooling condensation.

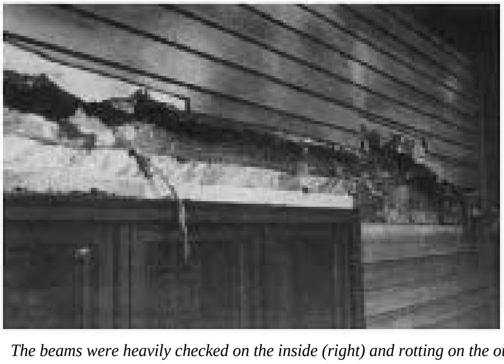
The owner confirmed that condensation covered most of the windows for most of the winter. The sources of moisture were many. For the first two years, the house had a wet basement each spring. (This was finally cured by regrading around the foundation.) There were no bathroom or kitchen fans, and the dryer vented indoors. The

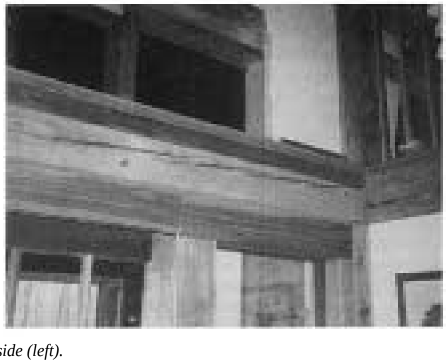


The west face of the house (above) was cut open in four spots, all revealing severe decay of the timber frame and adjoining wood. The southwest comer (below left) and center holes (below right) are shown close up.



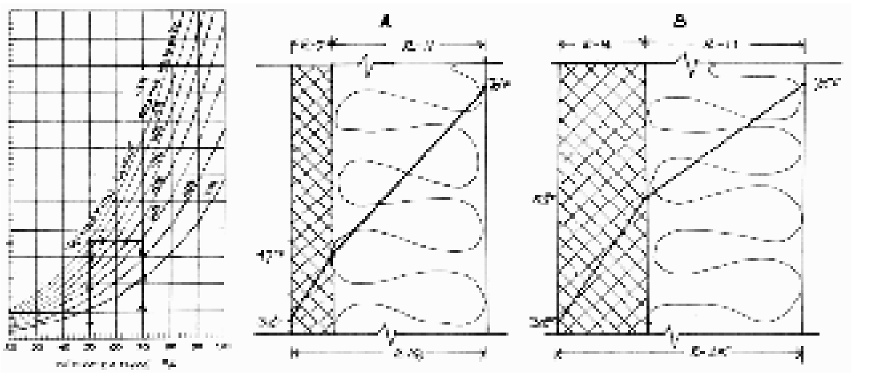
Decay was concentrated on the outer portion of the timbers and the nearby sheathing and studs, as shown in the darkened area.





The beams were heavily checked on the inside (right) and rotting on the outside (left).

Why Two Inches of Foam Are Better Than One



To find the dew point for any temperature and relative humidity: Start with the temperature, move up to the current relative-humidity line. Move left to the saturation curve and down to find the dew point, as shown.

Insulating foam sheathing is becoming fairly common in cold climates. But in most cases, it violates the rule of thumb that the exterior of a building should be five to ten times more permeable than the interior. This is particularly true with foil-faced sheathings.

Some people argue that it's all right to use insulating sheathing, because it warms up the wall cavity enough to prevent condensation problems. This is supported by tests (based on 40 percent relative humidity indoors) done at the U.S. Forest Products Laboratory in Madison, Wisc.

How can you gauge this for yourself? First, you need to calculate the dew point of the interior air during the winter. To be conservative, assume an indoor relative humidity of 50 percent at 70°F. That gives you a dew point of about 50°F, according to the chart.

Next, calculate how cold it must be outside before the inside surface of the sheathing will fall below the dew point. The inside surface of the sheathing is where condensation is most likely to occur.

You can calculate the temperature at any point in the wall if you know the total R-value inside and outside that point. The temperature rise through the wall and the R-values are in direct proportion.

For example, in Wall A, when it's 32°F outside, the temperature at the sheathing surface is 7/18 of the way from 32 to 70, or 47°F, which is *below* the dew point of the interior air. In Wall B, with two inches of foam, the temperature at the sheathing surface is 53°F—safely *above* the dew point.

Since the average winter temperature in most of central and northern New England is at or below 32°F, Wall A appears risky unless you use one of the more permeable rigid insulations (headboard or rigid fiberglass), or have a perfect air/vapor barrier. That's not a bet I'd like to make. ■

—S.B.

house is heated mostly by a wood-fired furnace in the basement, which tends to keep the basement warm and drive any moisture upstairs. To this day, the basement houses wet firewood.

Up in the attic, the owner and I found black mold covering the underside of the sheathing on the north side. The wood felt wet.

What let moisture *into* the attic were eight recessed lights, along with the usual wiring, plumbing, and framing holes. The attic was vented with two large gable-end vents and small, round, plug-type soffit vents. Judging by the mold, however, the vents could not handle the excessive moisture load.

Surprisingly, the home's interior had no musty smell, and no obvious signs of water damage other than on the window sash. All the damage was "safely" hidden from view.

The Diagnosis

So what caused the problem? In short, a combination of green wood, a moist house, a cold-side vapor barrier, and a cold climate. The timber-frame, built of 8x8 hemlock beams, had been assembled green in the fall and closed in in the spring. Since wood does not dry well in the cold, it was probably still quite wet when wrapped in foam the following spring. The water in the green wood gave the decay fungi a head start the first year.

Why didn't the beams dry toward the inside of the house over the summer? They did—at least near the inside faces, which became severely checked. But when winter came, the high moisture levels in the house drove the moisture back into the beams toward the sheathing, where it condensed.

The large gaps in the 8x8s provided an easy path for moisture into the wood, which is quite permeable anyway. Moisture could also penetrate the wall along the sides of the beams. Other interruptions in the vapor barrier—at floors, ceilings, and electrical outlets—let more moisture into the wall cavities. The inside face of the foam was below the dew point of the moist interior air throughout much of the winter (see sidebar).

The exposed inside sections of the beams dried, but the wet outer sections festered. Enough water got into the wood each winter so that warm spring temperatures caused decay before the wood could dry out. The foam kept the wood from drying outward, and kept the sun from drying the wood inward. By midsummer, perhaps, the wood fell below saturation levels, stifling decay growth. But the next winter the cycle would repeat.

The Treatment

To prevent further deterioration, the wood must be kept dry. A building consultant, Bill Lotz, recommended a three-pronged approach:

1. Keep household moisture levels down by adding fans and venting the dryer outdoors.
2. Seal the checking in the beams and the gaps around the beams with caulking. Then seal the beams with a clear finish.
3. Replace the foil-faced sheathing at the beams with beadboard to allow some drying at these points.

It is possible that just reducing the moisture level would do the trick. In fact, most of the damage may have occurred in the first two years when household and wood moisture levels were highest. But several layers of defense is the best approach.

Conclusions

Up to a point, wood-frame houses are forgiving; they can safely store winter condensation and get rid of it in the spring. But if you push things too far. watch out.

This house violated too many rules. It combined too much moisture with too little ventilation, too cold a condensing surface, and too few opportunities for the wood to dry out. The moisture balance was tipped the wrong way, and the consequences were severe.

But how far is too far? What precautions should you take?

If you like to live dangerously, you—or an engineer—can make an educated guess about how wet a given wall system will get in a given climate, and how fast it will dry. But there are always unknowns.

To play it safe and allow for a margin of error, you should design for dry wall and ceiling cavities. Keep in mind that:

1. You can't control how a home owner will run a house, but you can reduce the likelihood of high moisture levels. At a minimum, install kitchen and bath fans, continuous soffit and ridge vents, and build a dry foundation. Inform the customers that if they have condensation all winter long on double-glazed windows, they need to reduce moisture levels.
2. A vapor barrier with gaping holes (like the beams and recessed lights) is no barrier at ail. To keep moisture out of the walls and ceiling, seal all significant seams and holes in the air/vapor barrier. If you use recessed lights, put them in a dropped ceiling or use IC-type units.
3. In cold climates, keep the exterior of the wall more permeable than the interior, or keep the sheathing temperature warm enough that condensation there is rare. In practice, this means don't use foil-faced exterior insulation at all, or use a lot of it-at least two inches. Better yet, put it on the inside.
4. And for remodelers: Don't weatherize a house without solving moisture problems first. ■

Steven Bliss is editor of New England Builder.