Turning an Outbuilding Into an Office

by Paul Huijing

Before tightening a structure, make sure you have a strategy to deal with moisture buildup

A new client contacted me about a small timber-frame barn he wanted to use as a home office. His plan was to maintain the look of the barn both inside and out but improve its comfort and energy efficiency.

Although well-built, the structure was never intended for use as heated space. The vertical ship-lapped barn-board siding also served as the interior finish material, and there was no insulation in the ceiling. Knotholes and gaps between the boards meant there was lots of air infiltration. When he called me, the client had been using a large wood stove to heat the space, but on freezing-cold days the interior temperature wouldn't climb above 50°F.

Planning for Insulation

Because the building was a timber frame, there were no stud cavities to insulate. I could either fit rigid insulation between the posts and beams — which would be time-consuming and still leave conductive heat loss at all the heavy members — or insulate on the outside, which made far more sense. Air-sealing from the outside would be easier and more effective, and I would reduce thermal conduction through the frame.

One challenge was that the building had no roof overhangs, so I'd have to come up with a detail to accommodate the thicker exterior walls that would result from adding rigid foam. Insulating the roof from the outside would unfortunately mean removing the existing roof shingles, which were still in good condition.

Code. Because the barn is not heated all the time, the Massachusetts energy code did not apply to the project. We still wanted to install a healthy amount of insulation, but the owner decided it was not worth the cost to super-insulate the building. I proposed using 2 inches of polyisocyanurate on the walls, giving an aged R-value of about 12. This compares favorably with the effective R-14 that you get with a typical insulated 2x6 wall once

Figure 1. To accommodate the extra thickness of the exterior wall insulation, the author extended the roof overhangs with dimension lumber (above left and above). Doubled 2x4s along the edge of the rake (left) will capture the double layer of 1½-inch foam board to be installed on the roof. Note the spray foam used to seal gaps in the roof sheathing.

you count conductive losses through the studs. On the roof, I would use 3 inches of polyisocyanurate, for a continuous R-value of about 18.

Crawlspace Concerns

The barn was built on a practically inaccessible vented crawlspace foundation; the floor joists were less than a foot above the ground. I created an access through the framed floor to examine — and determine how to insulate — the space. I discovered that kraft-faced R-19 fiberglass batts had been stapled to the top of the joists. The paper facing had deteriorated, allowing some of the insulation to sag. The dirt floor had been covered with a layer of poly.

The floor joists showed no evidence of mold in the area I inspected. But I was immediately concerned that if I sealed and insulated the leaky barn and crawlspace, the moisture level under the floor

Figure 2. The crew sealed the original roof sheathing with flashing tape (above left), then installed two layers of rigid foam, staggering the seams (above) and taping the joints in the top layer (far left). A new layer of roof sheathing was installed over 2x4 battens, with gaps at the top for ridge venting (left).

would increase and mold might grow.

Given the limited clearance below the joists, I couldn't see a practical way to increase the floor insulation without removing the flooring, which was not in the budget. I was able to locate a company called Neutocrete Systems (neutocrete.com) that insulates dirt crawlspaces with a cementitious slurry containing vermiculite. The slurry, which has an R-value of 2.5 per inch, is sprayed a few inches thick across the floor and up the side of the crawlspace to meet the floor framing. As it cures (a three-month process), it forms an airtight, moisture-resistant barrier that can reduce moisture transmission from the ground. The company quoted a price of around $6,500 for the 600-square-foot building. The client decided to wait and see how the crawlspace would react to the barn insulation changes before committing to the expense.

Insulating the Roof

We started by stripping the shingles and sealing the existing roof sheathing seams with Huber Zip System tape (huberwood.com). Next we built out the roof overhangs, extending a 2x10 over the rake, supported by a continuous 2-by block underneath (**see Figure 1, previous page**). Along the eaves, we simply extended the 2x4 sleepers and added soffit blocks below.

We then added two layers of rigid foam insulation (**Figure 2, previous page**), 2x4 sleepers, and a new layer of roof sheathing, using the technique described by Dan Perkins in the article "Retrofitting an Insulated Cold Roof" (11/08).

Figure 3. After installing a layer of 3/4-inch plywood over the existing barnboard, the author sealed the critical wall-to-roof juncture with flashing tape, spray foam, and a rubber gasket (above left). A 2x4 ledger at the base of the wall (above) temporarily supported the double layer of 1-inch rigid foam, which was lapped at the corners (left), carefully cut in at the soffit, and sealed to framing members with spray foam (below).

Insulating the Walls

We first applied a layer of 3/4-inch plywood to the barnboard to serve as a nail base. We had to be careful not to allow nails or screws to penetrate the interior of the barnboard and mar the interior finish. After calculating the combined load of the insulation, furring, windows, and siding, we drove 15 Headlok screws (fastenmaster.com) per sheet into the barn's timber frame. We also taped the plywood seams to provide a good air barrier.

To create a durable and flexible seal where the wall meets the roof, we stapled a rubber gasket at the junction of wall and roof (**Figure 3**). We also sealed gaps and joints between framing members with peel-and-stick membrane and spray foam, making an effort to be as meticulous as possible.

Then across the bottom we attached a 2x4 pressure-treated ledger, screwing through the plywood and barnboard into the rim joist. This ledger supported the two layers of 1-inch polyisocyanurate insulation, which we temporarily secured with roofing nails, staggering and taping the seams as we went. The outer layer of foam would serve as the drainage plane. We used spray foam wherever the rigid insulation met framing, and carefully cut in the joints around the soffit members.

Siding

We next installed 2x4 furring, to better secure the foam board and provide an air space behind the siding (**Figure 4**). The 2x4s rested directly on the ledger at the base of the wall, and I decided not to worry about supplying a vent channel. I discussed this with Paul Eldrenkamp, a Boston-area remodeler and speaker at *JLC* Live. Paul had had the opportunity to disassemble unvented siding applications when doing additions and remodels to homes he had worked on previously, and he'd found that the unvented rain-screen wall assemblies were performing well. I was confident that the large air space provided by the 2x4 furring would allow any moisture to evaporate and escape through cracks between cladding members.

Fiber-cement cladding. To match the look of the vertical barnboard, I investigated using HardiePlank lap siding butted together in a vertical position. Because this was a nontraditional installation, however, it wouldn't be warrantied, so instead we decided to use HardiePanel with applied battens. The 4x8-foot HardiePanels would be applied vertically with battens every 12 inches to cover the seams and most of the nails.

Furring. We secured the 2x4 furring members with Headlok screws, again being careful not to penetrate the interior barnboard.

I was concerned about the number of screws that should be used to secure the furring strips. There was some disagreement among the structural engineers I spoke with; the screws are holding either a cantilevered or shear load, depending on your view of the assembly. Finally, we settled on a maximum 16-inch on-center spacing. We tested the assembly with the weight of a couple of carpenters and it didn't budge.

For rain-screen applications, James Hardie actually requires 1$\frac{11}{16}$-inch-thick furring members, with fasteners placed every 16 inches to meet wind-load requirements. We modified the company's recommendations only slightly by reducing the furring thickness to 1½ inches, but increased the nailing of the panels to 12 inches on-center, using stainless steel ring-shank coil nails.

HardiePanels come in 8-foot and 10-foot lengths; we ordered appropriate sizes so as to reduce the number of seams. We used Z-flashing at horizontal seams and cov-

Figure 4. Once the joints in the outer layer of rigid foam had been taped, the crew installed vertical 2x4s on 16-inch centers (top left), then set the windows, flashing them to the plane of the furring members. Site-bent flashing taped to the foil-faced foam protects the window heads (top right). HardiePanels were nailed to the furring and Z-flashed at horizontal joints (above left). Rough-textured Miratec was used for trim (above right).

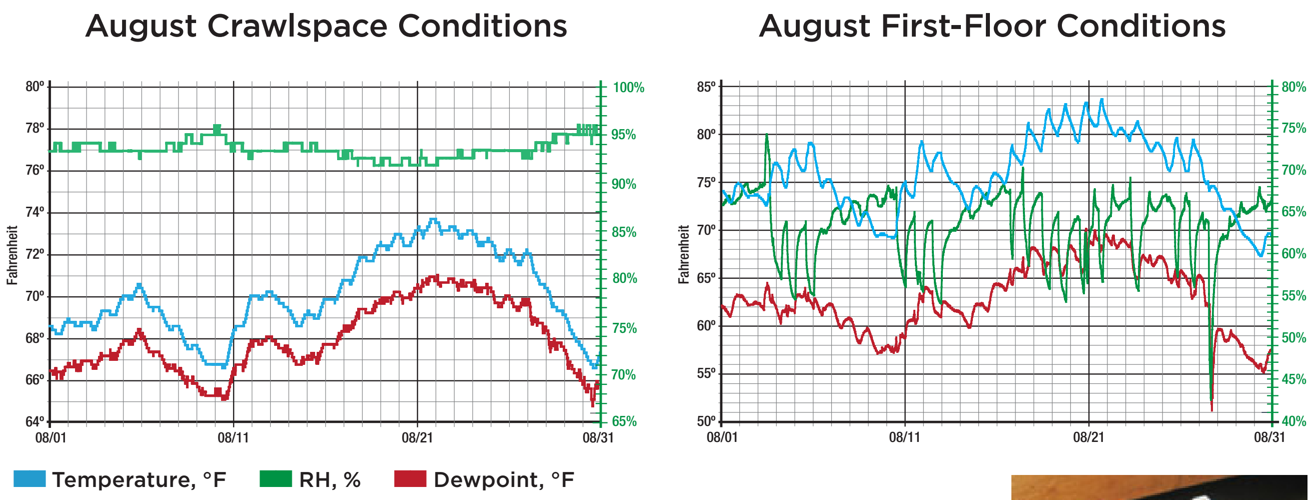

Figure 5. Readouts from Hobo data loggers placed in the building (photo, right) indicated high humidity in the crawlspace (above left), with air temperatures only slightly higher than dewpoint temperatures, creating a risk of condensation. Upstairs humidity was also high — typical for an unconditioned building in the summertime — but the average temperature stayed well above dewpoint (above right).

ered vertical seams with 2-inch Miratec wood-plastic composite battens (miratectrim.com). Most of the fasteners ended up being covered by the battens.

Windows

We installed the new Pella windows in the plane of the furring members, first lining the rough openings with Jamsill pan flashings (jamsill.com), then taping the window flanges to furring around the window opening. A three-piece site-bent flashing with corner pieces protects the window head.

On the inside, pine extension jambs covered the exposed foam layers, and we sealed the gaps with spray foam and added a small pine casing.

Interior Moisture

After sealing the building, we knew that interior moisture was a concern, so we installed a small Panasonic Whisper-Comfort energy-recovery ventilator to provide fresh air in the winter (panasonic.com). An exhaust fan on a timer was installed on the high ceiling of the loft for summer ventilation.

To keep an eye on possible moisture buildup, I placed HOBO U10-003 data loggers (onsetcomp.com) in the crawlspace, first-floor, and loft areas of the barn. The loggers, which cost $81 each, record temperature and relative humidity and are configured and downloaded with a companion software, which costs an additional $99.

I set the loggers to record data at 10-minute intervals from April to September 2009 (**Figure 5**). After retrieving the loggers and downloading the data into my computer, I could see the expected seasonal swings, with temperatures rising in the summer and starting to fall in September. What had me concerned, though, was the high relative humidity in the crawlspace and the 2- or 3-degree difference between the air temperature and the dewpoint temperature. This difference means that as the temperature cycles, if the framing is slightly below the air temperature, moisture will condense on the surface and promote mold growth. Even without condensation, the high humidity alone might support mold, since mold will grow in a wide range of temperatures above freezing.

Relative humidity upstairs was more variable but lower overall. The variability probably resulted from occupant behavior, like windows being opened as the building was used. The RH was frequently 60 percent or higher, but the minimum 10°F difference between the air temperature and dewpoint reduced the potential for condensation.

Based on the humidity data, I recommended that the client run a dehumidifier and consider sealing the crawlspace in the future. Once the crawlspace is clean and dry, it can be safely incorporated into the conditioned space of the building.

In Hindsight

Because the crawlspace was inaccessible, I wasn't able to upgrade the insulation below the floor. Although we did a thorough job of air-sealing the upper part of the building, I wish I had treated the rim-joist area differently. Instead of simply covering up the barnboard at the base of the wall with the plywood nail base, I should have cut the boards off where they overlap the rim joist, then replaced the bottom section with a horizontal board properly sealed with caulk and spray foam. This would have prevented air leakage through the gaps between the individual barnboards, which are open to the atmosphere at the bottom.

Paul Huijing *owns Paul Huijing, Inc., Construction & Engineering in Wilbraham, Mass.*