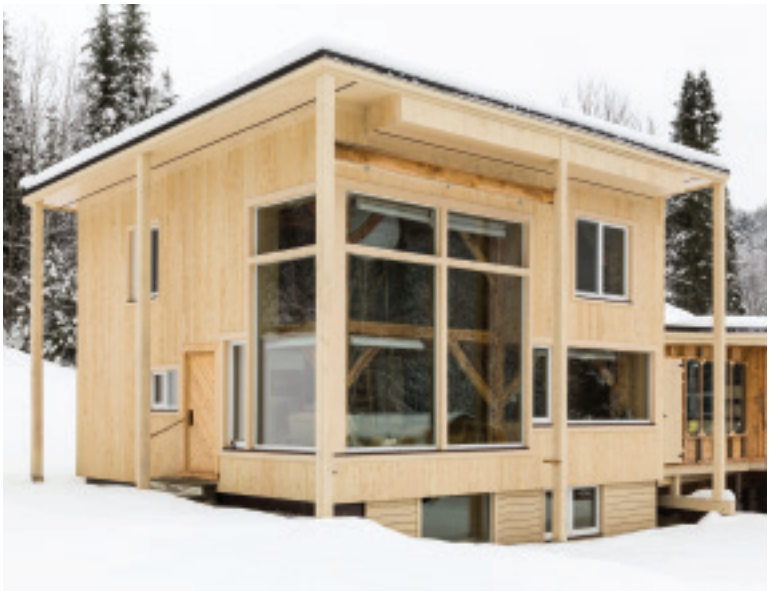
BY TED CUSHMAN

Unvented Flat Roofs: Theory Meets Practice

Advanced high-performance builders sometimes have to venture into uncharted waters, designing and building novel assemblies in the quest to create a cost-effective and durable airtight superinsulated envelope.

To help guide those first-of-their-kind designs, Passive House builders, in particular, typically rely on energy modeling tools. Depending on which flavor of Passive House the designer chooses for certification, he or she may select different tools. If the hope is to be certified for compliance through Europe-based Passive House International (PHI), designers have to use PHI's version of the Passive House Planning Package (PHPP), a complex spreadsheet developed in Germany. Designers pursuing certification through PHIUS, the U.S.-based Passive House offshoot, can use the PHIUS version of the PHPP for design calculations. But they also may use the new "WUFI Passive" modeling tool developed by Fraunhofer IBP, in Stuttgart, Germany. WUFI Passive includes a vapor-flow analysis capability drawn from Fraunhofer's industry-leading WUFI moisture modeling software; designers using PHI's version of PHPP often use a stand-alone version of WUFI to analyze particular components when they see a moisture-management concern.



Photos by Greg Whitchurch

The Whitchurch "in-law" annex in Vermont has an unvented flat roof that relies on a ProClima Intello variable-permeability membrane to limit moisture accumulation in winter and allow drying in summer.

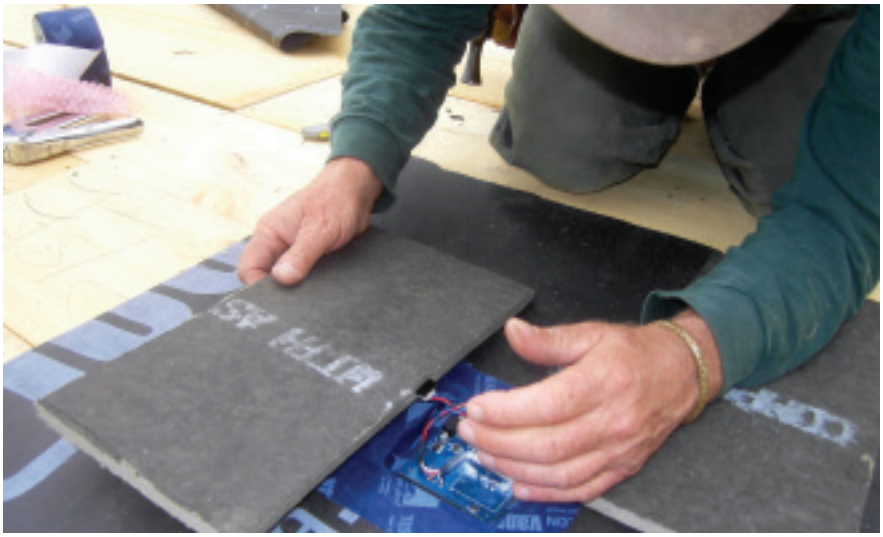
The Passive House world is full of opinions about which tools are best. But everyone agrees that the skill and experience of the designer or consultant matters as much as the power of the tool, or more. And no matter which flavor of Passive House designers may employ, there always seems to be some doubt about whether any computerized guesstimate is truly reliable when it comes to navigating the unknown. If you're building an assembly that has never been tried before—or never tried in your climate—how certain can you really be whether your ideas will work?

THE THEORY

In 2013, Montpelier Construction, a custom builder located in Montpelier, Vt., constructed a unique accessory dwelling unit that was pre-certified through PHIUS as a Passive House and that connected via a breezeway to an existing high-performance owner-built rural homestead.

One of the addition's unusual elements was an unvented low-slope roof system insulated with 22 inches of dense-blown cellulose and topped with black EPDM membrane roofing. With no way for moisture to escape upward, the roof's moisture-management concept relied on a "smart membrane" on its underside, just above the finish ceiling facing the conditioned space. In theory, the ProClima Intello membrane at the ceiling plane would limit vapor diffusion into the roof from below during winter, but permit downward drying by diffusion during summer. That roof has turned out to be something of a test case—for the materials and methods employed in its construction, and also for the planning and modeling tools employed in its design.

The choice of the unvented flat roof was driven by the homeowner, not the builder. Owner Greg Whitchurch is a long-time Vermont homesteader, a self-described "energy nerd" who majored in physics in college, and an owner-builder who has built two energy-efficient homes before. In planning this annex to house his elderly parents, Whitchurch had his own reasons for wanting a



Builder Chris Miksic, of Montpelier Construction, inserts a moisture sensor probe into the Homasote underlayment for the flat roof's EPDM membrane weather surface. Additional probes attached to long wires allow wood I-joist framing-member moisture content to be recorded using a Delmhorst moisture meter.

flat roof—not the least of which was to keep his wife's flower gardens from being buried by snow falling off a pitched roof in winter. And Whitchurch reasoned that venting the flat roof would be problematic—because with no pitch to speak of, there would be no "stack effect" air movement through the vents to carry moisture out of the assembly. "I didn't see venting as an automatic safe way to do it," he said.

After extensive research, Whitchurch had what he considered to be reasonable hope that his unvented flat roof would perform well. But experts on the pre-certification committee at PHIUS were not sure—and they agreed to pre-certify the Whitchurch project only after Whitchurch and Montpelier Construction partners Chris Miksic and Indigo Ruth-Davis took extraordinary measures to address their worries. Not only did the owner and builder supply PHIUS with WUFI modeling data—worked up by Floris Buisman, of 475 High Performance Building Supply, in New York City—they also commissioned an independent review by Charlotte, Vt., engineer Bill Root, an ASHRAE High-Performance Building Design Certified Professional. Root based his assessment on comparisons with similar designs carried out in a similar climate. Buisman and Root both concluded that the unvented roof should perform reliably.

Root, and PHIUS, also took into account the measures Miksic and Whitchurch took to verify the theory: They installed three different kinds of moisture and temperature sensors at key locations in the building assembly, and they've been monitoring the building to observe whether its performance met their expectations.

But that's not all. Whitchurch and Miksic also drew up a remediation and repair plan, in case the roof failed despite their predictions. Whitchurch said: "We figured it would cost us four grand to tear that EPDM off and put in a vent, and put it back down." So if the roof had failed—or even if it had started to move in the direction of failure, which the sensors would have detected early on—Montpelier Construction stood ready to fix the problem.

IN PRACTICE

But the roof hasn't failed yet. In fact, so far, Whitchurch's granny-annex roof is an

exemplary success: Any wintertime increase in lumber moisture content is more than balanced out by summertime drying, and the overall trend after almost two years of data collection is toward the dry direction. Like a well-built conventional attic, this roof is drying out over time.

Before anybody gets excited, however, let's be clear: Neither homeowner Greg Whitchurch nor builder Chris Miksic is inclined to draw any general conclusions about the reliability of WUFI modeling, or even about the appropriateness of the construction methods, based on the data from the Whitchurch house—at least not yet.

The data from the sensors on Whitchurch's roof are broadly consistent with WUFI's predictions for the roof. But would Whitchurch himself conclude that his roof's experience validates WUFI? "Oh, no," he said. "No matter what my outcomes are, I would never say that. Because it could be just chance." WUFI has limitations, Whitchurch said: "Like any other simulation, it can give you some information, and it can give some comparisons, but I don't think it gives absolute answers."

And builder Miksic said this roof has a number of specific details that, if changed, could alter the assembly's performance. For one thing, the small, 24-foot-square roof is vapor-open at the edges, with a permeable membrane on all four sides allowing vapor to escape into soffit vents. Second, during the summer, the dark EPDM roofing heats up in the sun, which helps to drive moisture through the smart membrane underside into the indoors. A white roof, a vegetated roof, or even shading from solar panels would change the roof's performance. A third factor is lumber choice: The roof is sheathed with solid-sawn pine, not with OSB or plywood, which are less vapor-permeable and more moisture-sensitive. "And there's a fourth, very important factor," said Miksic: "Quality of construction and airtightness. The vapor control layer, the Intello, is also the airtightness layer in this roof, and has to be meticulously air-sealed. You need a continuous vapor control layer and air barrier."

Ted Cushman is a senior editor at JLC.