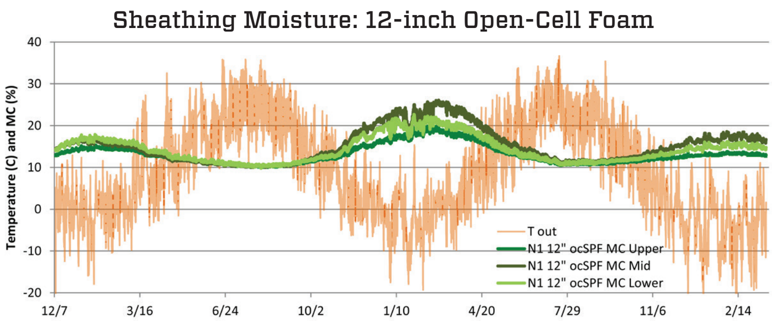
BY TED CUSHMAN

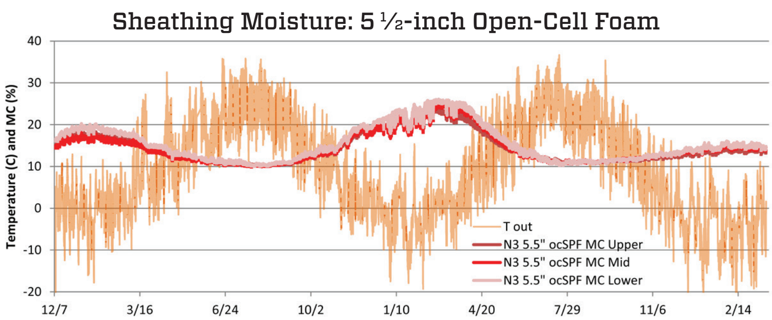
Studying Moisture in Fat Walls

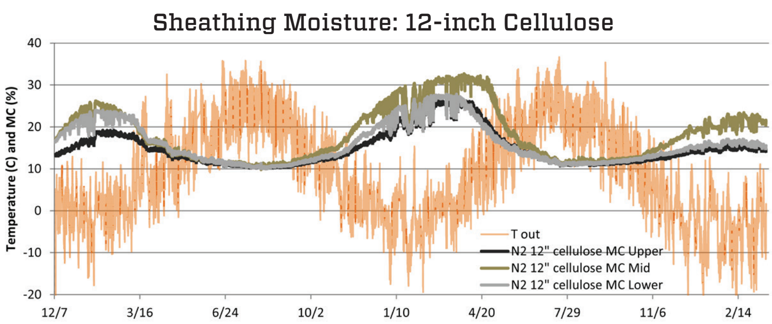
Double 2x4 stud walls insulated with dense-packed cellulose are about the simplest and cheapest super-insulated wall system you can build. But cellulose is vapor-permeable. So in cold climates, there's a risk that humidity inside the building will penetrate the wall, condense on the cold side of the sheathing, wet the wall, and support the growth of mold or rot.

With backing from the Department of Energy's Building America program, Kohta Ueno, a researcher with Building Science Corp., has been taking a closer look at that risk. Using test walls built into a real zero-energy house in Devens, Mass., as his laboratory, Ueno was able to compare the performance of a cellulose-insulated double wall against the behavior of the same wall insulated with two different thicknesses of low-density open-cell spray polyurethane foam (SPF).

So far, Ueno reports, the data show that the foam-insulated walls are less risky than the cellulose-insulated version. But given good control of indoor humidity conditions, and a good vapor retarder for the inside face of the wall, Ueno says that the cellulose-insulated wall could also function safely. Here's a closer look.







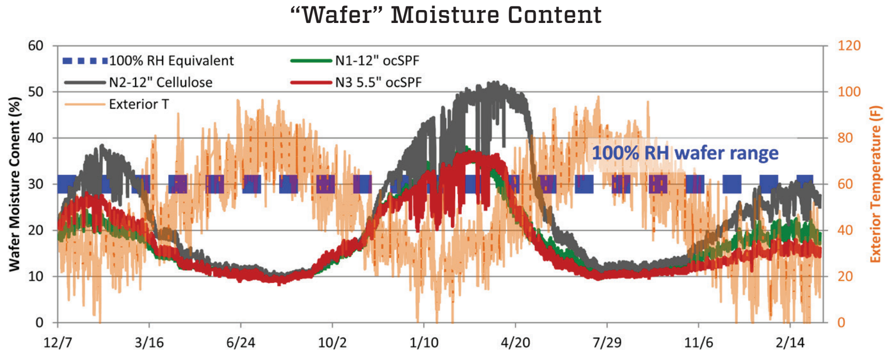
Source: Building Science Corp.

The builder, Carter Scott, of Transformations, in Townsend, Mass., was considering switching from his standard wall system—a double-stud assembly insulated with 12 inches of FoamLok open-cell spray polyurethane foam—to a dense-pack cellulose-insulated version of the same double-stud wall. To evaluate the pros and cons of the switch, Building Science Corp. set up three different test situations on the north and south walls of the Devens house. The base case was Scott's standard wall; the test cases were a wall section insulated with 12 inches of cellulose, and another section with just 5.5 inches of FoamLok. (The 5.5-inch version, Ueno says, was included in hopes of learning something about the performance of a more typical code-built wall.)

Ueno instrumented each test case with an array of sensors. For the past three winters, he has tracked interior and exterior temperature and relative humidity. He has also monitored the humidity within the wall cavities at three locations (near the inside face, near the outside face, and at the wall center). He kept track of the moisture content of the OSB sheathing by using pins driven into its inside face that allowed him to measure the electrical resistance of the OSB (the resistance decreases as the moisture content rises). And for a backup he also installed special sensors—thin pine wafers with attached electrodes—in the wall cavities near the outside wall face.

By now, Ueno has three winters' worth of data, and the information is starting to make sense. The charts at left tell the story of the walls' experiences in response to seasonal changes in indoor and outdoor conditions.

As chance would have it, conditions in the test house varied from winter to winter. In the first winter, the house was unoccupied, and humidity levels stayed low.



During the second winter, a family of four was living in the house—and coincidentally, the home's exhaust-only ventilation system was disabled. With minimal ventilation, humidity levels in the building hit 40% to 50% over the winter. "That's an unsafe level that we would never recommend," Ueno says, "but it gave us just the kind of conditions I might have included if I were designing a test hut to study this problem." By the third winter, the ventilation system had been repaired, so the data for that period reflect conditions created when the home is operating as intended.

As the charts show, all three walls experienced particularly high moisture levels during the second winter, when house humidity was uncontrolled. But the cellulose wall stands out as particularly wet: During late winter of 2012, the sheathing was above 30% moisture content for weeks.

The fourth, and most dramatic, chart (above) plots the data from the pine test wafers inside the wall cavities near the inside face of the sheathing. (Note: The temperature scale in this chart is degrees Fahrenheit, not Celsius as in the charts on the previous page.) During the winter that the home wasn't properly ventilated, the sensor readings surged to a level that indicates saturation and condensation—and the worst case was the cellulose-insulated assembly.

Ueno points out, however, that wet sheathing in the winter does not necessarily imply that there will be mold or rot. The walls got wet during winter—mostly during the season when it's too cold for mold to grow. And they dried to a safe 10% to 12% moisture content during the summer. The $64,000 question is, Ueno says, did the walls stay wet enough during the spring for the OSB to allow mold growth? The answer will come this summer when Ueno opens the wall and examines the three wall bays. But already he's learned how vital it is to control indoor humidity.

"When you're comparing things that will blow up walls," he says, "the interior relative humidity is at least as important, if not more important, than how cold it is getting outside."

Ueno predicts that the cellulose-insulated double wall would perform much better than these data show if the wall were equipped with a "smart" vapor retarder (such as CertainTeed MemBrain or ProClima Intello). Even a Kraft-paper vapor retarder on the inside face of the studs would help. All of those materials become more permeable as relative humidity increases, limiting a wall's wetting potential in winter while allowing some drying during summer.

Even with a good vapor-control strategy, Ueno warns that holes in the inside wall are always a concern, especially if they allow air movement. If there is an air leak into the wall from the inside, humid indoor air may condense in the wall cavity. That's when cellulose-insulated walls are most at risk. In that situation, exterior rigid foam insulation, applied outboard of the sheathing, can provide a significant advantage in protecting against condensation.

Ted Cushman is a regular contributer and former JLC senior editor based in Peaks Island, Maine.