U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Technology Solutions for New and Existing Homes


Building America Case Study

# Field Testing an Unvented Roof with Asphalt Shingles in a Cold Climate

Bolingbrook, Illinois

## PROJECT INFORMATION

**Construction:** New construction

**Partners:**

K. Hovnanian Homes, *khov.com*

Building Science Corporation, *buildingscience.com*

**Climate Zone:** Cold (5A)

Building America U.S. Department of Energy

In cold climates, a common practice of the weatherization industry is to retrofit compact roof/ceiling assemblies (e.g., cathedral ceilings) with blown-in dense-pack cellulose. This technique minimizes the interior and exterior demolition required for retrofitting insulation compared to spray foam retrofits. However, a dense-packed compact roof assembly has high moisture and durability risks in cold climates (due to wintertime interior-sourced condensation). In addition, this assembly does not meet building codes. The development of new methods to retrofit dense-pack insulation into compact roof assemblies while controlling moisture risks could allow widespread application of this lower-cost technique without compromising building durability.

In this project, the U.S. Department of Energy Building America team Building Science Corporation devised an experiment to build and instrument unvented test roofs using air-permeable insulation (dense-pack cellulose and fiberglass) in a cold climate (Chicago, Illinois area, zone 5A) and to analyze the moisture effects over time. The team installed seven test bays in the attic over a garage; each test bay was an east-west pair of rafter bays. The test roofs included a code-compliant vented roof (vented air space above fiberglass insulation) and a dense-pack cellulose roof. Another of the dense-pack cellulose roofs used a diffusion vent detail—exterior gypsum board at the ridge, 50 perms wet cup—allowing diffusion drying while remaining an airtight assembly. The remaining four assemblies used a top vent detail that uses a polypropylene breather mesh between the sheathing and the asphalt shingles that creates an air space. The intent was to let interior moisture dry through the sheathing and be removed by ventilation from the air space. The four assemblies had fiberglass and cellulose insulation (two each), with or without interior gypsum board (two each). The interior was kept at 72°F and 50% relative humidity (RH) for all seven test bays; this high interior moisture loading was intended to stress the roofs to failure in these worst-case conditions.

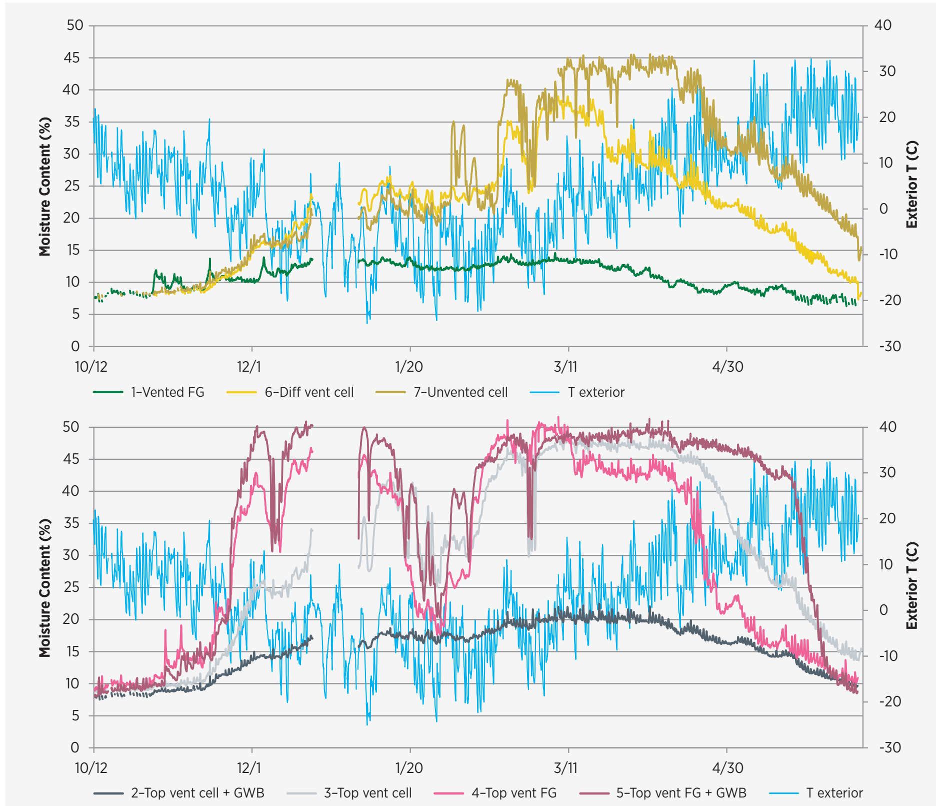
Results were collected from October 2013 through June 2014 to capture winter and spring conditions. The vented roof showed safe moisture conditions despite the severe moisture loading. All other roofs showed high moisture content especially at the ridge/peak, where moist air would concentrate. Rafter-framing moisture content (MC) is shown in the graphs on page 2; all unvented roofs showed long

## ROOF DISASSEMBLY

The roof was disassembled at the end of the experiment (top image) to correlate measurements with actual conditions. The unvented fiberglass batt roofs showed wet sheathing and mold growth (middle photo) although no structural failure. The cellulose roofs (bottom photo) exhibited only minor issues such as rusted fasteners, staining, and grain raise in sheathing. This difference was ascribed to three properties of cellulose: borate preservatives, airflow-retarding properties, and ability to safely store moisture.

For more information see the Building America report *Field Testing Unvented Roofs with Asphalt Shingles in Cold and Hot-Humid Climates* at buildingamerica.gov.

Image credit: All images were created by BSC.




Rafter-framing top moisture contents in experimental roofs

periods above 20% MC, with many hours in the 30%–40% MC range (high risk of fungal growth). Relative humidity and other sensors corroborated these high-risk moisture levels and showed evidence of condensation in many roofs. Sheathing MCs lower on the roof (near the eaves) were much lower (peaking at 20%–25% MC) compared to middle and upper sensors (some peaking at 40%+ MC).

The cellulose/diffusion vent roof showed peak MCs similar to the unvented roof; however, in the spring, the diffusion vent roof dried much more rapidly than the unvented roof. The top vent roofs also showed similar peaks to the unvented design, indicating that the drying available in the assembly (oriented strand board sheathing, ½-in. airspace) was insufficient to avoid failure. Assemblies with no interior gypsum board (cathedralized roofs) had higher moisture levels than roofs with gypsum board, which acts as an air barrier (with some vapor resistance). Analysis of the data using ASHRAE Standard 160 and other mold growth criteria showed that the roofs remained sufficiently wet into the spring (warmer weather) to run the risk of mold growth.

The team disassembled the roofs at the conclusion of the experiment and found that the fiberglass batt roofs had significant mold growth and staining, while the cellulose roofs showed only minor signs of damage (see sidebar). However, all roofs except the vented cathedral assembly experienced wood MC and RH levels high enough to constitute failure.



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