Building America Case Study

Field Testing an Unvented Roof with Fibrous Insulation and Tiles

Orlando, Florida

PROJECT INFORMATION

Construction: New construction

Partners:

Building Science Corporation, *buildingscience.com*

David Weekley Homes, *davidweekleyhomes.com*

Climate Zone: Hot-humid (2A)

Building America U.S. Department of Energy

A measure that has an established presence in Florida markets is the use of unvented roofs (also known as "cathedralized" attics), which include polyurethane spray foam at the underside of the roof deck. This method moves the heating, ventilating, and air-conditioning equipment and ductwork within the conditioned space, and it improves airtightness in practice (by shifting the air barrier from the ceiling to the roofline). However, some builders have become wary of using spray foam because of liability concerns about indoor air-quality issues. Unfortunately, unvented roofs using only fibrous insulation (cellulose or fiberglass) have been demonstrated to be at risk of moisture issues in zone 2A climates with condensation and accumulation at the ridge.

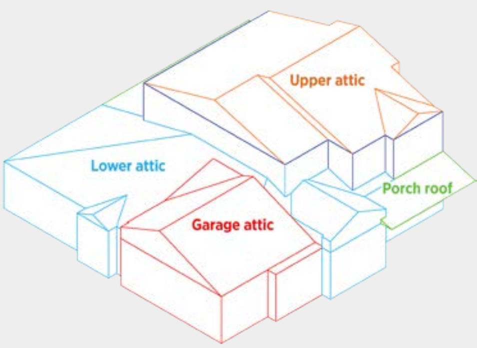
This research by the U.S. Department of Energy's Building America research team Building Science Corporation is a test implementation of an unvented tile roof assembly in a hot-humid climate (Orlando, Florida; zone 2A), insulated with air-permeable insulation (netted and blown fiberglass). Given the localized moisture accumulation and failures seen in previous work, the team theorized that a "diffusion vent" (water vapor open but air barrier "closed") at the highest points in the roof assembly might allow for the wintertime release of moisture to safe levels. The diffusion vent is an open slot at the ridge and hips that is covered with a water-resistant but vapor-open (500+ perm) air-barrier membrane. As a control comparison, one section of the roof was constructed as a typical unvented roof (with a self-adhered membrane at the ridge).

Instrumentation was installed to capture a variety of orientations and roof conditions, including multiple roof ridges (both diffusion vent and unvented), hips, and roof-wall interfaces. Measurements included temperature and relative humidity (RH), wood moisture content (sheathing), and a wood "wafer" sensor intended as an RH surrogate and condensation indicator. Instrumentation was completed in November 2014, the house was largely completed by February 2015, and it was occupied by homeowners in May 2015.

Airtightness Testing

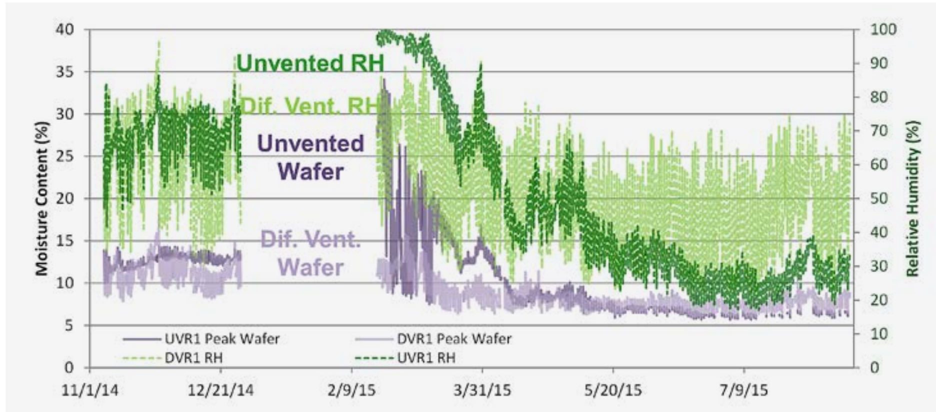
Overall house air leakage was higher (7.6 air changes per hour at 50 Pa) than 2012 International Energy Conservation Code targets (5 ACH 50). The air leakage of the unvented attic zones was measured using nulled (multifan) testing. Air leakage was high in the lower (over the first floor) attic. There was significant leakage from the lower attic to the exterior (196-ft^2 EqLA/leakage area). In comparison, the upper attic had 35-ft^2 EqLA to the exterior (much tighter), and the conditioned space (first and second floors) had 311-ft^2 EqLA.

These results indicate that complicated details and roof-wall intersections (per the lower attic) can result in air leakage. In addition, the self-adhered roof membrane had less-than-ideal adhesion on the vertical oriented strand board wall surfaces. This is not an issue for rain control, but it resulted in some air-barrier failures at the roof-wall connection. However, the roof and the diffusion vent ridge detail were not significant sources of air leakage.



For more information see the Building America report *Field Testing of an Unvented Roof with Fibrous Insulation and Tiles* at *buildingamerica.gov*.

Image credit: All images were created by the Building Science Corporation team.



Comparison of unvented to diffusion vent ridge wafer MC and RH

The data collected to date (during 9 months, capturing winter through summer) indicate that the diffusion vent roof shows greater moisture safety than the conventional, unvented roof design. The unvented roof had extended periods (during cold winter months) of 95%–100% RH, and wafer measurements indicating possible condensation. The high moisture levels were concentrated at the roof ridge, which is consistent with previous field experience. In contrast, the diffusion vent roofs had drier conditions, with most peak moisture content (MC) (sheathing) below 20%.

These trends are captured in the plot above, which compares unvented to diffusion vent ridge conditions. These two roofs are directly adjacent to each other, on the same ridge. The plot includes the MC of the ridge wafer sensor (left axis) and the RH at the ridge (right axis).

In the spring, as outdoor temperatures warmed, all roofs dried well into the safe range.The unvented roof dried rapidly, consistent with a vapor-impermeable exterior layer and a strong temperature gradient (which drives moisture downward). The diffusion vent roof also showed a drying pattern during the spring, but RH remained slightly higher (but in the safe range), because the diffusion vent allowed vapor communication with the exterior.

Some roof-wall interfaces showed moderately high MCs; this might be because of moisture accumulation at the highest point in the lower attic and/or shading of the roof by the adjacent second story.

Monitoring will continue at least through spring 2016 (another winter and spring). The interior moisture levels during winter 2015–2016 may clarify the risks of unvented roofs compared to the diffusion vent detail. Winter 2014–2015 had high interior moisture levels because of the drying of construction moisture. With occupied conditions, interior moisture will be generated; however, the cooling system will be operated through summer 2015, resulting in dehumidification and on occupancy, behavior, and ventilation rates.

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