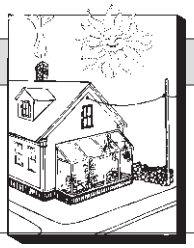
Hot Debate Over Hot Roofs



by J.D. Ned Nisson

For the past year I've been conducting an informal survey about "hot roofs" — unvented cathedral ceilings in which the rafter cavities are packed full with insulation. Who is building them and why? When do problems occur and why?

From Anchorage to Atlanta, the responses have been remarkably consistent. Hot roof fans claim there will never be problems as long as the entire rafter cavity is packed full with insulation and protected against moisture intrusion. Most use blown-in insulation rather than batts. One such system, Ark-Seal's Blow-In-Blanket (BIB), is particularly popular with hot roof advocates (see Figure 1).

On the other side are the more conservative contractors who insist that without ventilation, a cathedral ceiling will suffer ice damming in cold climates, shingle damage in warm climates, and moisture problems almost anywhere. Building inspectors invariably fall in the latter group, citing stories about rotted sheathing over unventilated roofs. (Some codes allow unventilated roofs at the inspector's discretion.)

Roof ventilation can be confusing, but by examining exactly why it is usually necessary, we can see when it can be eliminated from cathedral ceilings without creating problems.

Not Just a Slanting Wall

If walls don't need ventilation, then why should roofs? To make the point more graphic, draw a sketch of an exterior wall section. Is the wall ventilated? Of course not. Now rotate the drawing 45 degrees and, presto, it's an insulated cathedral ceiling. Since it's the same component, why should it now need ventilation simply because it is tilted? I've seen lecturers use this technique to convince whole rooms full of builders that cathedral ceilings shouldn't need ventilation any more than vertical walls.

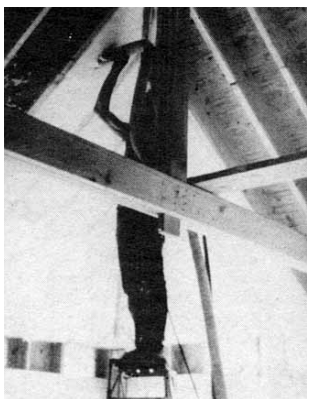


Figure 1. *Using Ark-Seal's "Blow-In-Blanket" system, a contractor pumps loose-fill fiberglass, with a little water and adhesive, into a rafter cavity covered with nylon netting. Here, the cavity is blown full with no air space above the insulation, creating an unvented "hot roof."*

While convincing, this demonstration is flawed in that it overlooks several fundamental differences between walls and roofs, such as snow loading, sun exposure and, perhaps most important, air leakage from the occupied space below.

Why Ventilate Ceilings?

Ventilation in insulated roofs (see Figure 2) performs three functions:

1. Prevents ice damming in winter. Ice damming can occur whenever the roof surface temperature is above freezing over the building while it is below freezing at the eaves (overhangs). Melted snow flows down to the eaves where it freezes into ice and backs up under the shingles. Ventilation reduces the potential for ice damming by cooling the roof sheathing.

2. Removes water vapor. Roofs are more susceptible to moisture problems than walls because warm indoor air tends to rise and carry water vapor upward into rafter cavities. Also, roof shingles create a more effective exterior vapor retarder than do most wall siding systems. Therefore, roofs are more subject to moisture problems than walls.

Ventilation helps provide an escape route for trapped moisture. An important point that is often overlooked is that vent chutes in cathedral ceilings must be vapor permeable to allow moisture relief. Some plastic vent chutes are not permeable and should be perforated by the contractor on site.

3. Carries away excess heat in summer. This is an uncertain benefit. Theoretically, roof ventilation cools the roof and insulation surfaces, thus prolonging shingle life as well as reducing heat gain in the conditioned space.

However, preliminary research data from the University of Illinois show that roof ventilation has remarkably little effect on shingle temperature. The Illinois research is supported by experiments at the Florida Solar Energy Center (FSEC) which showed only a few degrees difference in shingle temperature between vented and unvented roofs. The FSEC research found that shingle color has a much more pronounced effect on shingle temperature than does ventilation.

While ventilation has little effect on shingle temperature, it should cut heat gain *through* the roof, and cut cooling costs in warm climates, according to FSEC. This effect, however, is not well-documented.

Why Build a Hot Roof?

There are three practical advantages to building a roof without ventilation: higher R-value, lower cost, and improved appearance. Packing the entire rafter cavity with insulation instead of leaving a 2-inch air space adds about R-5 or R-6 to the assembly. Eliminating vent chutes, soffit vents and ridge vents could save a few hundred dollars on an average 1,500-square-foot house. Finally, the roof line looks somewhat cleaner without a ridge vent.

Hot Roof Tips

The key to successful hot roof design is to eliminate the need for ventilation by finding other ways to protect against ice damming, moisture condensation, and overheating (see Figure 3).

Protection against ice damming. Ice damming can be controlled to a certain extent by installing high R-value roof insulation, which keeps the roof surface cold. The problem is that, as snow builds up on a roof, it acts as insulation (about R-1 per

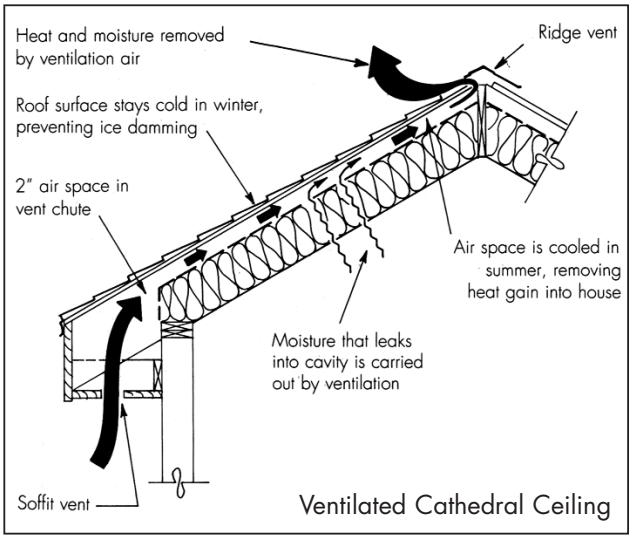


Figure 2. *In a vented cathedral ceiling, air flow carries heat out of the roof assembly, preventing ice damming in winter and overheating in summer. It also removes any moisture that penetrates the rafter cavity. Typically the ventilation air space is maintained by plastic "vent chutes," which should be perforated to allow moisture laden air through.*

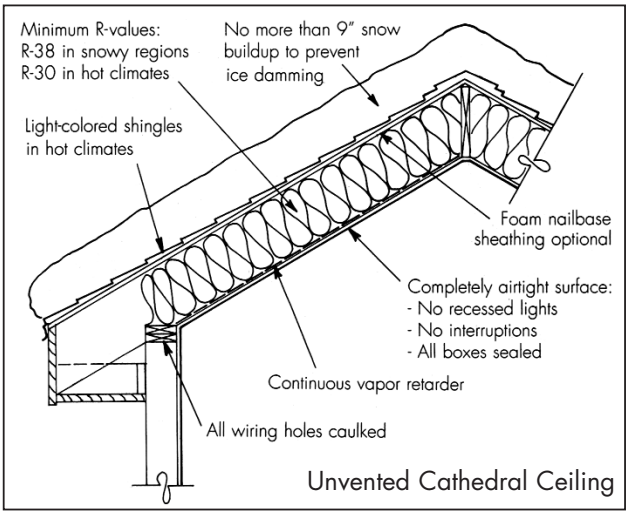


Figure 3. *To avoid problems, an unvented cathedral ceiling must have high R-value to protect against ice damming in winter and overheating in summer. It also needs a perfect air barrier and an effective vapor retarder to limit moisture accumulation.*

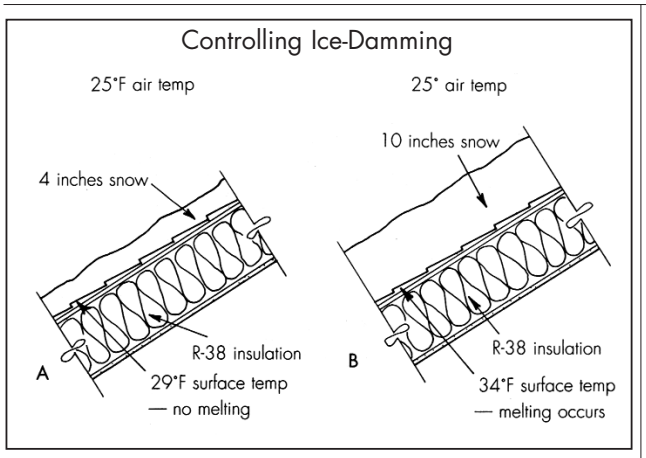


Figure 4. *High R-value helps protect hot roofs from ice damming by keeping the roof surface cool. For example, the surface of an R-38 roof with 4 inches of snow stays below freezing even when outdoor temperatures rise to 25°F (A). But with 10 inches of snow, the roof will be above freezing and subject to ice damming (B). For this reason, unvented roofs are not recommended in heavy snow areas.*

inch), and tends to warm the roof surface (see Figure 4).

In regions where snow accumulation on roofs rarely exceeds 8 or 9 inches, R-38 roof insulation is sufficient to prevent ice damming at any outdoor temperature. Where thicker snow buildup is common, more insulation would be necessary, but probably not practical. For example, in Fairbanks, Alaska, the combination of high snowfall and very low winter winds often piles snow over two feet high on roofs. It's no surprise that hot roofs are never built in Fairbanks, although they are common in other parts of Alaska.

Protection against moisture condensation. An unvented roof is much less forgiving than a vented roof or a conventional insulated attic. With a vented roof, if the vapor barrier is flawed, or if there is air leakage through the ceiling, you *might* have moisture problems. With an unvented cathedral ceiling, however, you are almost guaranteed to have moisture problems in cold climates unless the air and vapor barriers are meticulously installed.

The interior surface of the ceiling should be absolutely airtight: no recessed lights and no electric boxes unless completely sealed. You must also seal all wiring holes in wall top plates — both exterior walls and partitions — and any joints where interior partitions intersect the ceiling. The ceiling surface must also include a vapor retarder (such as oil-base paint, poly, or kraft paper) to prevent vapor diffusion through the drywall.

A builder in Illinois built an unvented cathedral ceiling (his first and last) with Kraft-faced batts and tongue-and-groove cedar paneling as the interior finish. Kraft facing is an okay vapor retarder, but narrow cedar paneling is a lousy air barrier, particularly after it dries and shrinks.

During the first winter, air leakage carried water vapor up into the unvented rafter cavity where it condensed, wetted the insulation and dripped back down through the joints in the cedar panelling. Had the roof been ventilated, the problem might have occurred anyway (if the humidity were high enough), but with an unvented ceiling, the lack of good air barrier spelled disaster. The problem was fixed by removing the cedar paneling, installing a poly air barrier, and reinstalling the paneling.

An experiment conducted by William Rose at the University of Illinois tested an opposite situation. An unvented test ceiling was built with a perfect air barrier (well-sealed drywall with two coats latex paint), but no vapor retarder. During the first winter, moisture diffused through the ceiling drywall, creating frost buildup on the sheathing. Interestingly, an identical test ceiling with ventilation had no moisture accumulation, proving that a ventilated roof can forgive mistakes such as a missing vapor retarder.

Overheat protection. This is a judgment call. As far as we know, unventilated roofs should not suffer significant reduction in shingle life. On the other hand, they may suffer significantly increased heat gain to the building. To compensate for the loss of ventilation, unventilated roofs in hot climates should have light-colored shingles and relatively high R-value (R-30 or better).

If It Were My House

I would not hesitate to build an unventilated cathedral ceiling in my own house. I'd have enough R-value to prevent ice damming; I'm not worried about overheating; and I'd personally make sure that the ceiling had a good air barrier and vapor retarder. But frankly, I hesitate recommending it to clients unless I'm absolutely assured of impeccable quality control. In my opinion, roof ventilation is cheap insurance against expensive callback problems. Why gamble? ■

J.D. Ned Nisson is president of Energy Design Associates Inc., a New York City-based building systems consulting firm, and editor of Energy Design Update *of Arlington, Mass., a monthly technical newsletter on energy-efficient building design and construction.*