Cathedral Ceiling Solutions

Five contractors describe the sloped ceiling details that work best for them

Few components in low-energy homes produce more diverse approaches — and more disagreement — than cathedral ceilings. The reason is simple: Trying to satisfy the insulation and ventilation requirements in such a tight space is a real challenge.

It's often impossible to fit the required amount of insulation into the depth provided by a 12-inch rafter. A common solution for an R-40 ceiling is to use fiberglass batts between the rafters and then nail an inch of rigid insulation underneath the rafters. The seams of the foamboard can be taped so that it doubles as a vapor barrier. An alternative is to use deeper (but more expensive) engineered beams such as I-joists or trusses and avoid the use of foam insulation.

Another problem is providing adequate roof ventilation. Most roofs are designed to have an eaves-to-ridge flow of air. These are called cold roofs because they keep the underside of the sheathing cold in winter. In a heating climate, the flow of cold air under the sheathing discourages interior moisture buildup and ice damming. In a cooling climate, ventilation relieves heat buildup.

To complicate matters, not all builders and researchers agree that ventilation space above the insulation is necessary in heating climates. Cathedral ceilings that aren't ventilated are referred to as hot roofs, and typically rely on a well-sealed air and vapor barrier to keep moisture out of the roof. Solid foam roof systems, such as stress-skin panels, are a type of hot roof.

Thoroughly confused? Because so many builders feel caught in the crossfire of these debates, we asked five experienced, energy-conscious builders and designers from different locales to show us how they detail cathedral ceilings, and to point out why they settled on these designs.

—JLC

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Packing R-38 into 2x12 Rafters

by John Raabe
Langley, Washington

Here in the Pacific Northwest, new energy codes require all builders to meet high insulation levels and use progressive building techniques. For cathedral ceilings, this means insulation levels of R-38 to R-40.

Cathedral ceilings in this area are most often built with 2x12 rafters on 24-inch centers. Only a few years ago, insulating to R-38 with these rafters meant an additional layer of foam insulation or some extra framing. However, there are now two ways to achieve R-38 to R-40, keep the code-required 1-inch air space above the insulation, and still use standard framing.

The one I like best is using Ark-Seal's "Blown-in-Batt-System," or BIBS (Ark-Seal International Inc., 2185 S. Jason St., Denver, CO 80223; 800/525-8992), as shown in the drawing. This proprietary process uses chopped fiberglass in combination with a latex binder that coats the fibers and hardens to form a fluffy, semi-rigid mass. It is blown into the cavity through a hose, and is retained by mesh netting that is stapled to the framing.

This insulation does not settle, and completely fills small voids and gaps that can degrade the insulation value of fiberglass batts. The material is well documented at R-4 per inch, and a simple two-coat PVA primer on the drywall can be used as the vapor barrier. The system is fast, but it is somewhat more expensive than using fiberglass batts because it requires a special insulation contractor.

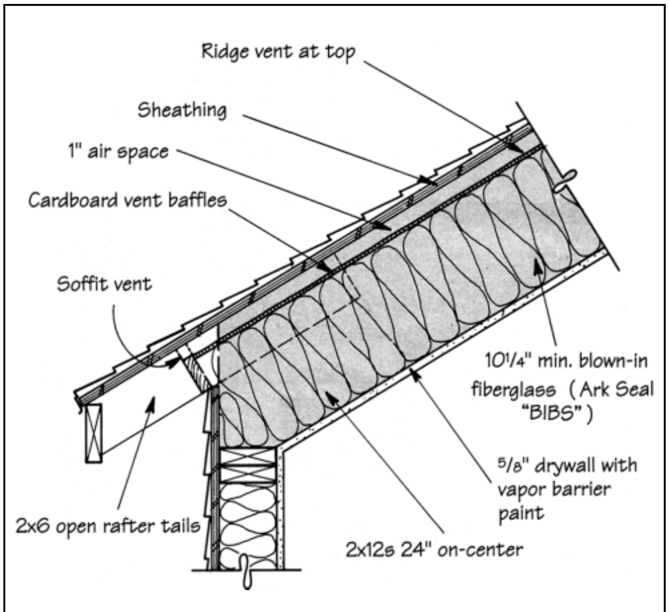
Batt manufacturers are meeting this challenge with products of their own. Manville Corporation (Box 5108, Denver, CO 80217; 303/978-4900) is beginning to market a high-density 5-inch batt. This certified R-19 batt can be doubled up in the rafter cavity to yield an R-38 roof with over an inch of vent space above. Both Owens-Corning Fiberglass (Fiberglas Tower, Toledo, OH 43659; 419/248-8000) and Certainteed Corporation (Box 860, Valley Forge, PA 19482; 215/341-7000), the other big batt manufacturers, are hard at work on high-density, 10-inch (R-38) batts for this same application.

These batts should be installed with a 6-mil poly vapor barrier underneath to provide support as well as to control moisture and air leakage.

Although I include ventilation in the cathedral ceilings I design, there is some interesting evidence that in moist climates, venting above the insulation actually increases the moisture content of the roof cavity. In some situations, it may be better to completely fill the rafter space than to ventilate the cavity. To do this successfully, you need a complete vapor barrier and no air leakage into that cavity. This means no recessed lights or other hard-to-seal openings in the cathedral ceilings.

My own suspicion is that the moisture issue will turn out to be relatively climate specific, and that roof ventilation will become more subject to review by the local inspector than it is now. For most of us, the real world dictates that it's easier to ventilate than it is to debate the point for each home and with every new building official.

John Raabe heads up Cooperative Design in Langley, Wash., and is a co-author of Superinsulated Design and Construction *(Van Nostrand Reinhold, 1987).*



Type: 2x12 rafters with blown-in fiberglass (BIBS)
Designer: John Raabe; Langley, Wash.
R-Value: 38-40
Pros: Achieves high R-value with standard framing. Installation is fast. No settling of insulation.
Cons: Somewhat more expensive than batt insulation.

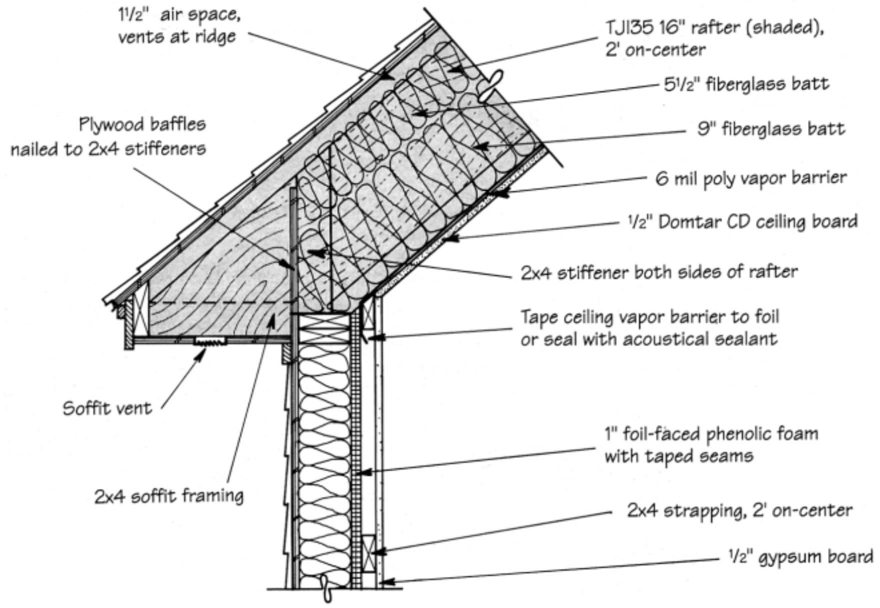
R-50 With Wood-Web I-Beams

by Chuck Silver
New Paltz, New York

I've experimented with several different ways to design an R-45 to R-50 cathedral ceiling — installing rigid insulation beneath 2x12 rafters, filling the rafters with fiberglass and using an air barrier and furring strips on top to get ventilation, and using open-web, parallel-chord trusses. None of these, however, is as easy, efficient, or cost-effective for me as using 16-inch-deep (or deeper) wood-web I-beams.

There are a lot of advantages to I-beam rafters:

- They are very light, perfectly straight, and available in any length up to 60 feet.
- They come in a large range of depths to accommodate any insulation thickness.
- They offer minimal interruption to the insulation (a 1/2-inch plywood web every 2 feet).
- They eliminate the need for rigid insulation on the bottom of the rafters, giving you a superior fastening surface for the drywall.
- They have terrific span capabilities. This can sometimes mean the elimination of bearing walls which can help offset the additional expense of I-beams over solid-sawn rafters.



Type: 16-inch wood I-beams, fiberglass batts
Designer: Chuck Silver; New Paltz, N.Y.
R-Value: 45-50
Pros: Wood I-beams are stable, straight, and offer plenty of room for insulation and ventilation. No foam is needed.
Cons: I-beams are costly and require special detailing at bearing points.

I use 16-inch TJIs (Trus-Joist Co., 9777 W. Chinden Blvd., Boise, ID 83714; 800/338-0515) on 24-inch centers for an R-50 ceiling. A structural ridge beam is typically necessary. Wood I-beams also require 2x4 vertical stiffeners between rafters where they bear on exterior walls. We use the stiffeners as nailers for plywood baffles, which provide bracing, as well as directing ventilation air from the soffit up over the fiberglass. The baffles prevent cold air from penetrating the edge of the batts and chilling the ceiling corners.

However, when I use cedar shingles, as shown in the drawing, I don't include soffit-to-ridge ventilation. My reasoning is this: The primary difference between walls and roofs, besides orientation, is that roofs typically have an impermeable membrane attached to them, which makes it important to vent. This isn't true of cedar shingles on spaced sheathing, so I don't vent. I've never had any problems with this design.

With wood I-beam rafters you do have to use full-width (24-inch) insulation. I use 5 1/2-inch and 9-inch fiberglass for a 16-inch rafter, which still leaves 1 1/2 inches of air channel for ventilation, when required. I carefully install a continuous, 6-mil poly vapor barrier, and then finish with Domtar Gypsum's CD Ceiling Board (PO Box 543, Ann Arbor, MI 48106; 800/366-8274). This is a 1/2-inch drywall that has the rigidity of a typical 5/8-inch gypboard, and works very well on 24-inch centers.

Chuck Silver is president of Solaplexus, a design and consulting firm in New Paltz, N.Y.

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Scissor Trusses Keep It Simple

by William J. Baldwin
Johnston, Rhode Island

We're residential developers with a strong interest in energy-efficiency because of what it offers to the client. The roof system is just one of many integral parts of this package, and like the whole, must be simple in design, easy to install, cost-efficient, and durable.

We typically use simple, wood scissor trusses with raised heels. Since the trusses stand "on edge" like a wall stud and are placed 24 inches on-center, there is only a small percentage of thermal short-circuiting through the truss chord members. Still, we are very careful about fitting the fiberglass batts within the truss bays, making sure all the voids are filled and the insulation is fully expanded.

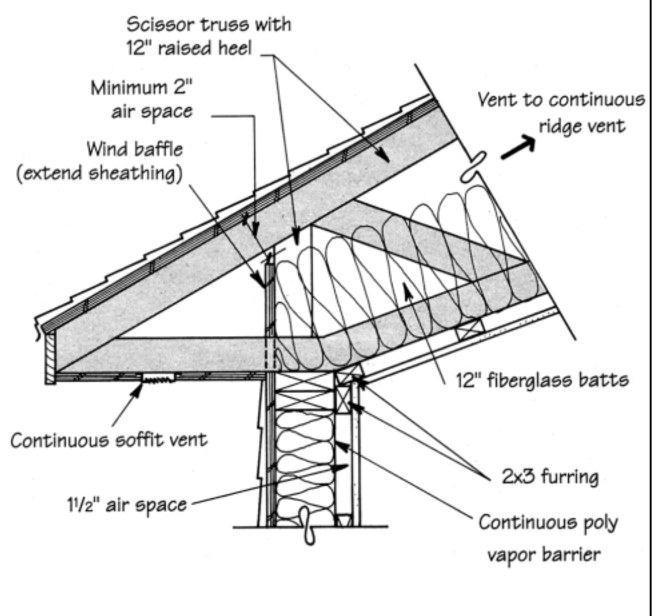
We extend the exterior sheathing up the wall to the top point of the insulation to direct air brought in by the soffit vents above the insulation. You can substitute cardboard wind baffles if you like.

We also take a lot of care with the vapor barrier. It should be continuous and overlapped, and sealed at all joints and stack pipe penetrations. On top of the vapor barrier we nail strapping — utility-grade 2x3 furring strips — on 24-inch centers to the underside of the bottom chords. This 1½-inch space allows ample room for all electrical wiring and ceiling light boxes. If clients ask for recessed (can) lights, we explain the obvious advantages of substituting track lights.

A lot of what makes this system work is that it's straightforward. This allows us to expect high quality workmanship and provide proper supervision. We do a lot of training, with both employees and subcontractors, and we include the "whys" as well as the "hows." This saves countless hours of work-site time and energy, particularly in the volume we build — over 15 houses per year.

We also feel strongly that energy-efficient features should be cost-effective. We like to be able to point to the direct relationship between increased building costs and energy savings.

Bill Baldwin is president of the Baldwin Corporation, a residential development company in Johnston, R.I.



Type: Scissor trusses with raised heels, fiberglass batts.
Builder: William Baldwin; Johnston, R.I.
R-Value: 40
Pros: Simple detailing is cost-effective. Raised heels ensure full insulation at eaves.
Cons: Batts must be carefully fitted to minimize short-circuiting at truss chords.

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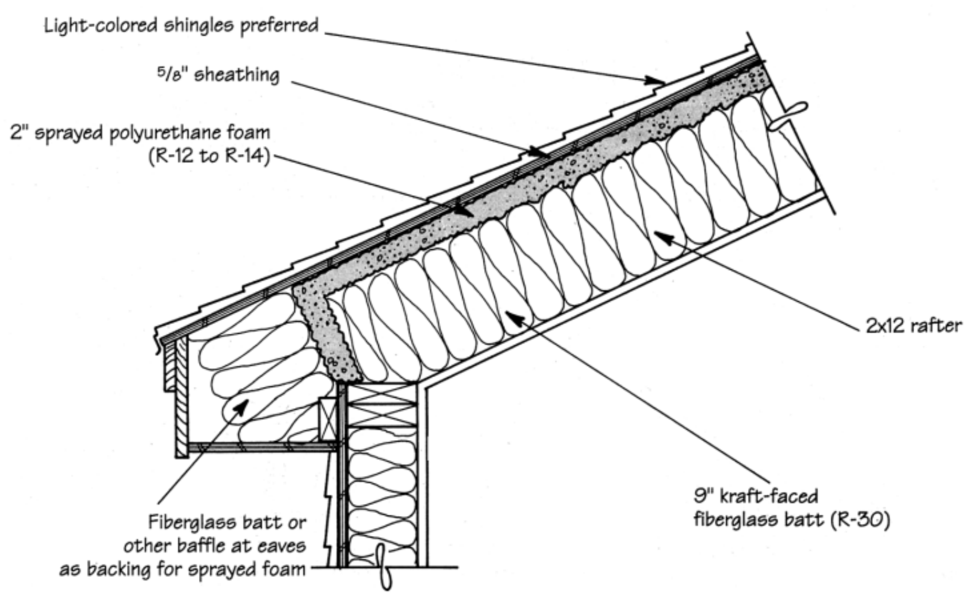
A "Hot" Roof for a Cold Climate

by Paul Bourke
Leverett, Massachusetts

I have used this "hot roof" detail on my last eight homes, and I couldn't be more pleased with its performance and simplicity. Among other things, it

- allows for higher insulation levels in the same size rafter cavity;
- eliminates the costs of installing soffit and ridge vents, and insulation baffles;
- doesn't require venting for those almost impossible-to-vent rafter bays created by hips, valleys, gambrel roofs, and skylights; and
- raises the temperature of the condensing surface on the underside of the roof sheathing, reducing the risk of condensation problems.

However, "hot roofs" are not widely accepted, particularly among code officials. When I run into resistance, I often add a detail drawing signed by a local architect or engineer, or hand the official a copy of "Hot Roofs and Cold Roofs," an article from the May 1986 edition of the newsletter *Energy Design Update*. I also point out that stress-skin panels, which are widely accepted in commercial and residential work around here, operate on this same principle.



Type: Hot roof using fiberglass and spray urethane
Builder: Paul Bourke; Leverett, Mass.
R-Value: 45 plus
Pros: No venting needed, which simplifies complex roofs with hips, valleys, skylights, etc. If properly designed, condensation should not be a problem.
Cons: Not accepted by some code officials. Ice damming an issue in high-snow areas. CFC concerns.

Code officials and others have three primary concerns: ice damming, shingle deterioration, and moisture buildup in the cavity. I have not had problems with any of these.

The ice damming question is directly related to the level of insulation used (higher levels reduce the problem), the care taken with the foam, and the average depth of snow on the roof. My roofs are typically R-45 (2 inches of sprayed urethane foam and 9 inches of fiberglass). I have a very good foam sub, and I limit this design to roofs of at least a 4/12 pitch, which keeps the snow depth to less than 13 inches.

As for shingle life, venting an attic or ceiling will cool down the roof surface only a few degrees. The more important step is to use light colored shingles, which reflect more sunlight and stay significantly cooler.

Condensation is not a problem for a couple of reasons. First, very little moisture gets into the ceiling due to the vapor retarder on the warm side and the near-perfect air barrier (the foam) on the outside. Second, any water vapor that does leak into the cavity is unlikely to condense since the underside of the foam where condensation would occur is relatively warm.

To insulate the roof, I bring in my foam sub once I have the 5/8-inch sheathing on, and all plumbing vents, electrical, ductwork, etc., are in place. The 2 inches of foam is sprayed on the *underside* of the sheathing. The foam does two things: It seals the roof system, making it virtually airtight, and it adds R-12 to R-14 to the cavity.

Next I install 9-inch kraft-faced fiberglass batts. These need to be stapled tightly to the rafters. The paper facing meets my code for a vapor retarder on the warm side of the ceiling, but you can also use a poly barrier or vapor retarding paint on the drywall if you choose.

Increasing the thickness of foam, and decreasing the amount of fiberglass below it, will raise the R-value of the system. But with foam-in-place polyurethane coming in at \$.50 to \$1.00 per board foot, you need to use it wisely.

The only concern I have with this system is that the blowing agent for polyurethane foam currently contains CFCs. However, a new formulation using H-CFC-141B is now available for residential use. This is only 5% as harmful to the Earth's ozone layer as CFCs. And that number can be further reduced by using it in conjunction with a 35% water-blown system, which will be available soon. A 100% water-blown system with no CFCs will be available within one to two years.

Paul Bourke, of Bourke Builders, designs and builds energy-conscious homes in Leverett, Mass.

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Holding the Heat Out

by Lawrence Maxwell
Cape Canaveral, Florida

In a hot climate, heat gain through the roof of a cathedral ceiling to the living space below is a primary concern. The first step in blocking the heat is to choose the roofing material and its color wisely.

The ideal roofing in our hot southeast climate is concrete or clay tile. These materials work very well at reducing heat gain because of their mass and the fact that they sit on battens. The mass lets the tiles absorb and store the heat (the lag effect) and the battens allow the heat to escape through ventilation.

> The lighter the roof color, the more heat the surface reflects. White is best.

If the budget can't afford tiles, asphalt/fiberglass shingles are okay, but it's important to stay with very light colors; white is best. The principle is simple: The lighter the color, the more heat the surface reflects.

Cathedral ceilings in hot climates also need to be ventilated to discourage heat gain. This requires continuous soffit and ridge vents, and a *minimum* of 2 inches between the top of the insulation and the underside of the radiant barrier.

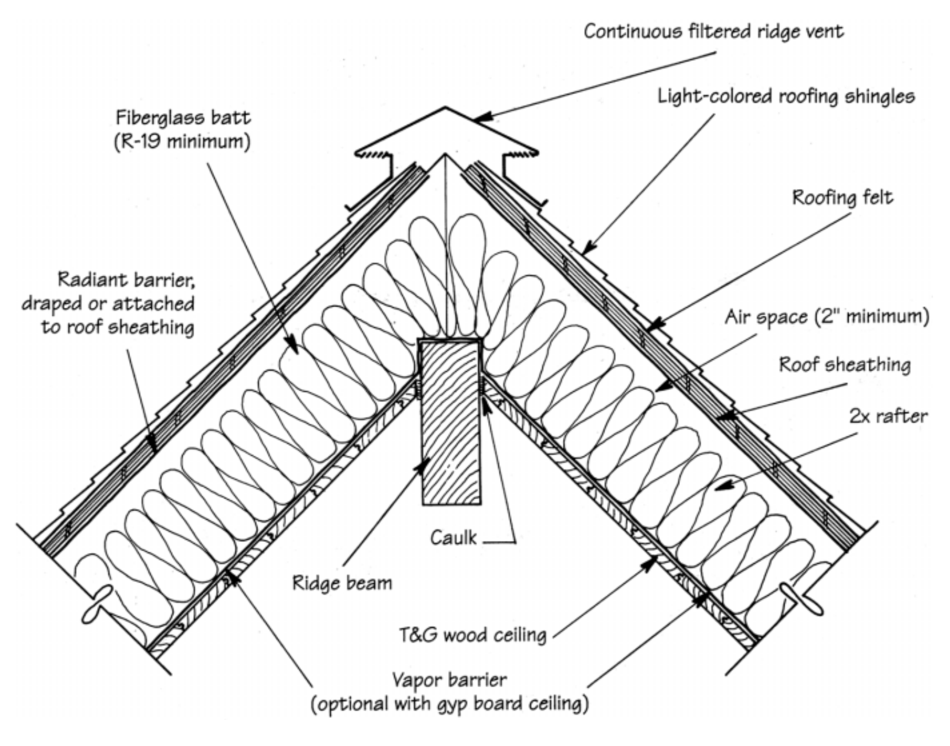
This barrier is important in hot climates, since as much as 90% of the heat transfer from the roof deck to the ceiling drywall is by *radiant energy transfer*.

There are two common methods of radiant barrier installation; both require that the "shiny side" go face down (toward the living space). The first method is draping the radiant barrier over the tops of the rafters. The second, which requires a good deal less work, is to fasten it directly to the plywood prior to sheathing the roof. A perforated radiant barrier is best for this second method.

Installing the insulation is pretty straightforward, although you should place it carefully, and fasten it to the ridge beam so it doesn't slip downhill over time and leave an uninsulated space at the peak.

If you are using drywall as a ceiling finish, a vapor barrier is optional in this climate. However, if you're nailing a tongue-and-groove wood ceiling directly to the underside of the rafters, you should first place a vapor barrier to control the infiltration and exfiltration of air through the joints between boards. Make sure the vapor barrier is continuous under the ridge beam, and use backer rod and caulk between the topmost board and the ridge beam. ■

Larry Maxwell is the senior research architect with the Florida Solar Energy Center in Cape Canaveral.



Type: Radiant barrier with fiberglass batts (for hot climate)
Designer: Lawrence Maxwell; Cape Canaveral, Fla.
R-Value: R-19 plus
Pros: Combined with concrete, clay, or white asphalt shingles, radiant barrier effectively blocks heat gain.
Cons: Draping radiant barrier over rafters can be tricky. (Option is to fasten to sheathing before installation.)