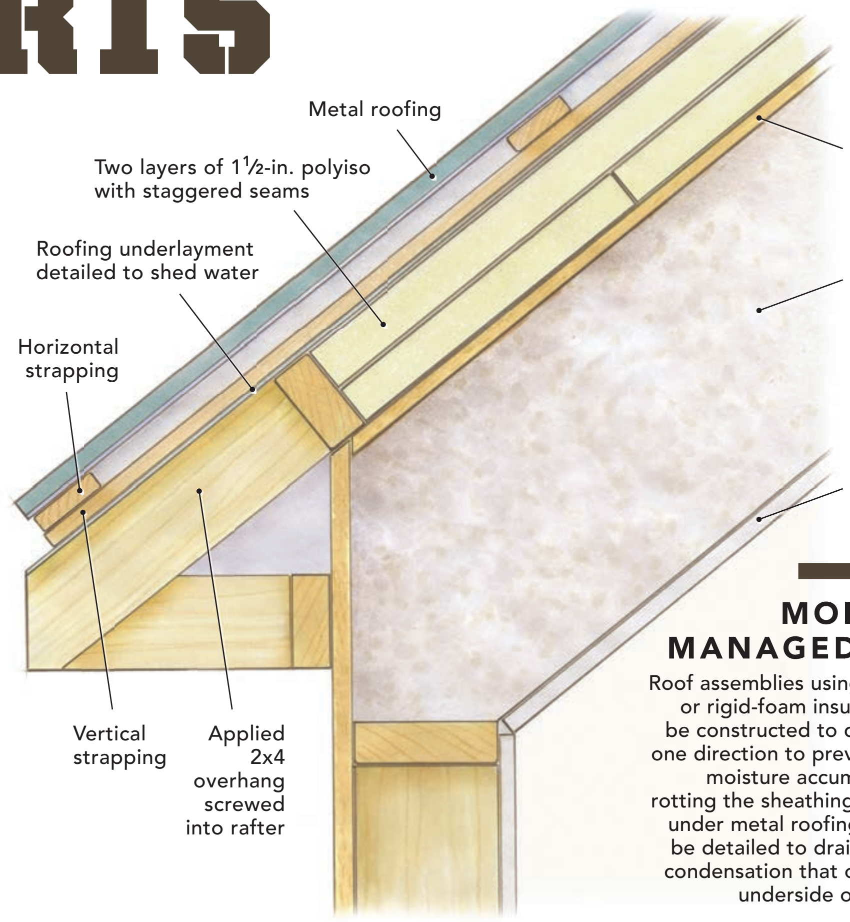
Ask the EXPERTS

YOUR QUESTIONS // PRO ANSWERS



MOISTURE-MANAGED ROOF

Roof assemblies using spray foam or rigid-foam insulation should be constructed to dry in at least one direction to prevent seasonal moisture accumulation from rotting the sheathing. Assemblies under metal roofing should also be detailed to drain water from condensation that occurs on the underside of the roofing.

Exterior insulation for a cathedral ceiling

I'm designing a Pretty Good House (I have the book) in climate zone 4A, and the upper floor will have a cathedral ceiling. Everything I've read has stated that if you use closed-cell foam underneath the sheathing, don't put any exterior insulation on the other side of it so that the assembly can dry in at least one direction. If everything outboard of the sheathing (Zip in my case) is vapor-permeable (GPS insulation, furring strips, and metal roofing), wouldn't that allow the sheathing to dry out?

—DEREK
Brentwood, Tenn.

Michael Maines, residential designer and coauthor of Pretty Good House, *replies:* Because your assembly is not a typical one, we could use a hygrothermal model to test how it will work, but I think an understanding of vapor control and building codes works as well. Despite common assumptions, closed-cell foam is not completely impervious to water vapor; it's typically around one perm at 1 in. thick. Even at 3 in. some moisture will pass through the foam via diffusion during the heating season and accumulate in the sheathing. Additional moisture will be carried by air leaks at the perimeter and where foam has pulled away from the framing.

Both plywood and OSB sheathing are somewhat vapor-open. If they can dry readily to the exterior, it's not a problem. However, if the exterior side of the sheathing is vapor-closed, as with many self-adhering membranes, or with exterior insulation that limits vapor movement, you could end up with rotten sheathing.

With enough exterior insulation relative to the interior R-value, the sheathing will remain warm enough during the heating season to limit condensation. In your climate zone, the exterior insulation layer should be at least 30% of the total roof R-value. Provided interior humidity is kept at normal levels, you should not have enough moisture accumulation for problems.

The 2018 IRC requires R-49 in roofs and ceilings and R-15 exterior insulation for unvented roofs of this type in climate zone 4, so you need at least 3¼ in. of GPS (at R-4.7 per in.) and no more than R-34 or about 6 in. of closed-cell foam on the interior. Additional insulation on the inside will keep the sheathing colder during the heating season and make it wetter. Despite advertised values, all closed-cell foam degrades to about R-5.6 per in. as the blowing agent dissipates, so I use this more conservative number in dew-point calculations.

With one layer of 1-in. vertical furring strips and one layer of 1-in. horizontal furring strips, you could have a code-compliant vented roof with any thickness of exterior GPS. But at 3¼ in. thick it's less than 1 perm, which would restrict outward drying enough to risk rotting your sheathing. At 1 in., GPS is around 2.5 perms, which is about as vapor-open as damp OSB and so reasonably safe to use, but it would add less than R-5 continuous insulation—probably not worth the extra effort on a roof.

Air conditioning is used in your area almost as much as heating. In the summer, when the air conditioning is running, vapor moves from exterior to interior, passing through the GPS and into the sheathing, where it will be slowed to a crawl by the closed-cell foam on the inside. To prevent moisture accumulation in the sheathing,

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Drawing: Dan Thornton

I would be more comfortable with a less-permeable exterior insulation such as polyiso to slow vapor drive toward the inside during the summer. Its higher R-value and lower perm rating than GPS will control water vapor better than GPS during both heating and cooling seasons. With polyiso on the exterior, I would put a fibrous insulation inside, which costs less and has lower carbon emissions than foam.

One final consideration is bulk water from condensation. On cool, clear nights, metal roofing can be below the air temperature due to night sky radiation, making it a condensing surface. Choose a good-quality, waterproof underlayment over the exterior insulation and detail it to drain water that accumulates on the underside of the roofing.

Envelope or enclosure?

Is there a difference between the terms "building envelope" and "building enclosure"? They seem to be used interchangeably in the building community, but do they mean the same thing?

—SAMANTHA MAVER
Trumbull, Conn.

Kohta Ueno, principal engineer at Building Science Corp., replies: "Building envelope" and "building enclosure" are currently used synonymously, but "building enclosure" is the more up-to-date term. Both describe the part of the building (above grade or below grade) that physically separates the interior environment from the exterior environment. Therefore, walls, roofs, foundations, floor assemblies, and glazing typically make up the building enclosure.

The terminology "building enclosure" comes from Eric Burnett, a professor who has educated and influenced an entire generation of building scientists in North America, including both of my mentors, Joe Lstiburek and John Straube. Professor Burnett is a stickler for exactness; one of his points is that historically, "building envelope" has not included the below-grade enclosure, which definitely separates interior from exterior. His common refrain is, "You put letters in an envelope, and you put people in an enclosure."

I can't say that I completely understand the semantics, but out of deference to "Dr. B." (who has thought far more about this topic), I always use "building enclosure" … although I still understand "building envelope." Also, many of the technical bodies such as ASHRAE and the Building Enclosure Councils have switched to "building enclosure." The takeaway: Use "building enclosure" if you want to sit at the big kids' table.

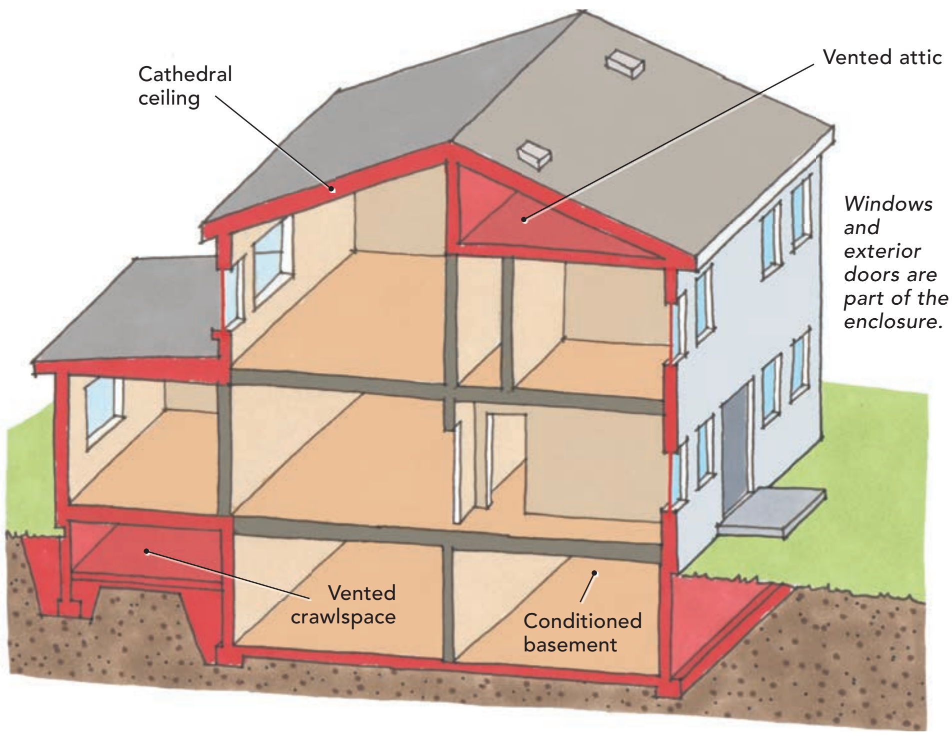
On modern houses built to code, the building enclosure will include four principal control layers: a water control layer, an air control layer, a vapor control layer, and a thermal control layer. These jobs can be split up among multiple materials, or be combined in one.

The International Residential Code, in the section on energy efficiency, uses the term "building thermal envelope," which refers to the location of the thermal control (insulation) layer. Therefore, the thermal envelope may be within the boundary of the building enclosure—for example, imagine a ventilated attic, where insulation is at the floor of the attic space. Taped drywall with air-sealed penetrations on the ceiling provides air and vapor control, preventing air and vapor leakage from conditioned space to the ventilated attic. Loose-fill insulation on top of the drywall provides thermal control. The ventilated air space of the attic also provides vapor control: interior-to-exterior moisture leakage into the attic is "ventilated away" before condensing on cold surfaces. And lastly, water control is provided by the shingles and underlayment on the roof sheathing.

When combined, the four control layers make up the building enclosure—so while some control layers are at the ceiling, the entire ventilated attic space is part of the building enclosure.

AN ENCLOSURE NEEDS FOUR LAYERS

The building enclosure (in red) is an assembly of materials that separates the indoors from out. The control layers that make up the enclosure may be close together, as is common in walls, cathedral ceilings, and conditioned basements. By contrast, a vented attic may have the layers more separate, with water control on the roof, air and thermal control at the ceiling, and vapor controlled by the ceiling assembly and ventilation. The attic space is nonetheless part of the enclosure.



Drawing: Martha Garstang Hill, adapted from John Straube