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On the cover: Tom Meehan, a tile specialist from Harwich, Mass., wipes the last of the grout haze from a glass-tile shower wall with a decorative wave. Read about the nuances of working with all types of glass tile on page 49. Photo by Gil Potts.

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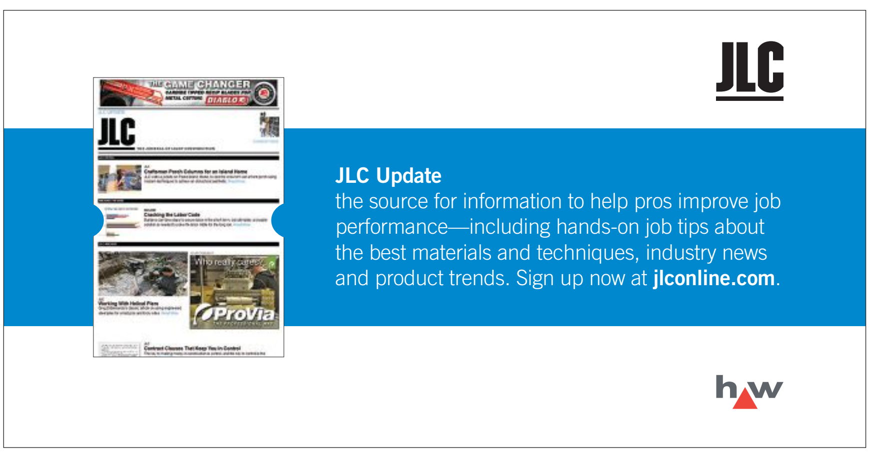

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BY GREG BURNET

Cutting Common Rafters

Getting back to basics in order to lay a solid foundation for the next generation of builders, *JLC* is launching a new fundamentals series for *Training the Trades*. We will focus on many of the skills a well-rounded carpenter should acquire during his or her first year on the job; the goal is to provide a primer for people wishing to enter the industry as well as a refresher for veterans and a tool for business managers to use when training employees.

We'll cover both frame and finish skills—from laying out and cutting common framing members to hanging doors and running trim. We'll talk about the technical aspects of each element, and we'll discuss basic terminology, which is crucial to concise and effective on-the-job communication.

In this first installment, we explain the process of laying out and cutting a common rafter. There are several approaches to laying out rafters, but I'll cover the most efficient method that I've found, which uses a Construction Master calculator and a layout square. The only other tools you'll need are a tape measure and a sharp pencil.

COMMON RAFTER LENGTH

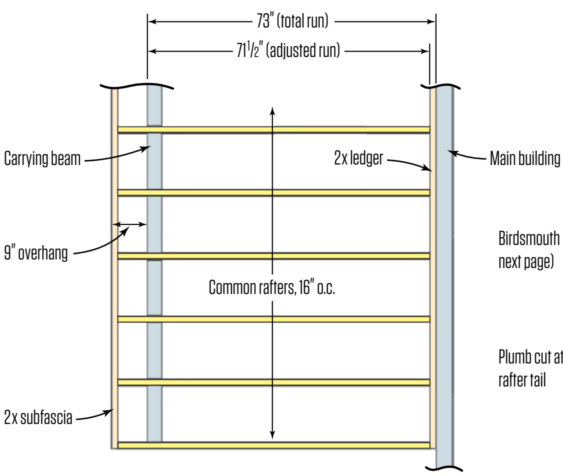
To lay out a rafter, you need to know the roof slope and calculate the rafter run.

Roof slope is the incline of the roof, expressed as a ratio of the number of inches of rise (vertical travel) for every foot of run (horizontal travel). In our example, we have a 7:12 roof—7 inches of rise for every foot of run. On construction calculators, slope is often called "pitch."

Rafter run is the horizontal distance the rafter travels. On a full gable roof, this is equal to half the building width minus *half* the ridge thickness. On a shed roof (see illustration, below), rafter run is the distance from a ledger on the main building to the outside of an addition wall or porch carrying beam. We need to adjust the total run (73 inches in our example) by subtracting 1 1/2 inches, the *full* width of the ledger (adjusted run = 71 1/2 inches).

The calculation sequence to find rafter length on a Construction Master is shown below. Note that rafter length is measured from the tip of a plumb cut at the top end of the rafter to the building line (shown as a dotted red line in the section/elevation below). Rafter length does not include the rafter overhang.

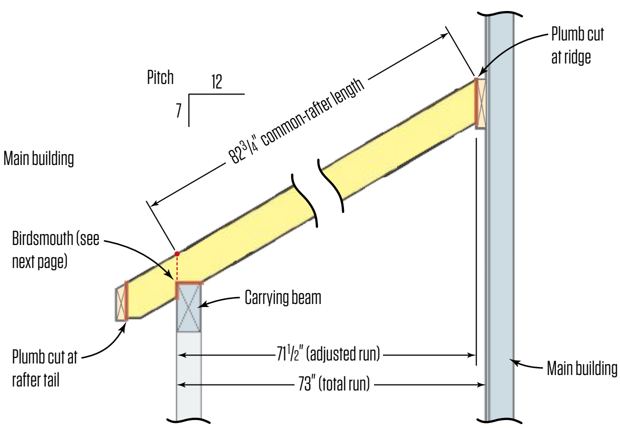
Roof Plan



Determine Adjusted Run

73" (total run) – 1 1/2" (ledger thickness) = 71 1/2" (adjusted run)

Section/Elevation

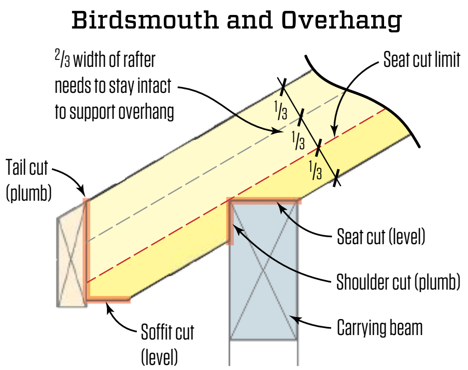


Calculate the Rafter Length

On the Construction Master, punch in the following sequence:

71 [Inch] 1 [/] 2 [Run] 7 [Inch] [Pitch] [Diag] = 82 3/4"

Photos by Sue Burnet / Illustrations by Tim Healey



Rafter stock. I start by selecting material that's as straight and free of twists as possible. Even good lumber usually has a bit of a crown, so I sight down the edge of the material **(1)**, and place a mark pointing to the edge where the crown faces up. We will install the rafters with crowns facing up, so I place that side towards me on a bench or sawhorses.

Plumb cut. Next, I mark a plumb cut on the end of the rafter that will butt the ridge or ledger board. To do this, I line up a Swanson Speed Square on the top edge of the rafter and pivot it until the appropriate slope mark ("7" on the square's "Common" scale for a 7:12 roof) lines up with the board's edge **(2)**. Using a sharp pencil, I strike a line across the face of the material, and I use a circular saw with a good blade to cut to the line.

Rafter length. I can now hook a tape measure on the long point of this plumb cut **(3)** and measure for the length of the rafter. In this case, it's 82 3/4 inches. **(4)**.

Birdsmouth. Place a square at the 82 3/4-inch mark, and draw another plumb line, parallel to the top cut **(5)**. This line represents the shoulder of the birdsmouth.

Birdsmouth depth. Whenever a roof has an overhang, you don't want to cut too deep a birdsmouth. As a general rule, you want to leave roughly two-thirds of the width of the rafter stock intact to support the overhang (see illustration, top left). In this case, we have 2x6 rafter stock, so we want to leave roughly 3 5/8 inches (it doesn't need to be exact). This is measured square to the board, not along the plumb line.

Seat cut. Set the flange of the square on the plumb line that marks the birdsmouth shoulder, and slide this flange to the approximate depth of your seat cut (following the 2/3 rule). In this case, the width of the carrying beam we are bearing on is 3 1/2 inches, and that's close to what we end up with for the length of the seat cut **(6)**. But the birdsmouth doesn't need to have full bearing. On a steeper roof, it will be shorter; on a shallower roof, the seat cut will be longer. The birdsmouth (identified in the photo with hatch marks) can be cut now **(7)**, but I usually wait until I have laid out the tail cuts.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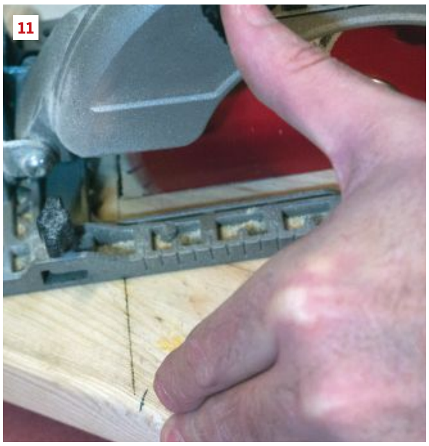
11


12


13


14


15

Tail cut. In our example, the roof has a 9-inch overhang as measured on a level plane from the building (see Roof Plan, page 13). I lay this out by measuring horizontally across the rafter **(8)** from the birdsmouth shoulder. (It's not shown, but you may want to use a square to make sure you are pulling the tape square to the birdsmouth shoulder.) I mark a plumb line here using the layout square, the same way I did for the top cut and for the shoulder of the birdsmouth.

Boxed eaves. If we had open eaves, I would cut the rafter ends plumb on this line. In our case, however, we will have boxed eaves, and the ends of the rafter will be tied together with a 2x6 subfascia. So using a scrap of 2-by material, I just draw a line $1\frac{1}{2}$ inches back from the plumb line **(9)**. In the photo, I have used black hatch marks to note where the subfascia will land relative to my rafter **(10)**. I can now make this plumb cut, chopping off the hatch marks.

Cutting the birdsmouth. With the saw out, I also cut the birdsmouth. The birdsmouth is a stopped cut, or notch. It's important not to overcut the lines, as doing so can weaken the rafter. When using a circular saw, stop the cuts right at the intersecting marks of the plumb and seat lines **(11)** and finish the cuts with a hand saw or jigsaw.

Soffit cut. The plumb cut at the end of the rafter is longer than the 2x6 subfascia is wide. Therefore, I want to cut off the long point of this plumb cut so it doesn't protrude below the subfascia or interfere with the soffit material. The simplest way to do this is to hold a scrap of the subfascia material in position **(12)** and mark the bottom edge. I also deduct another $\frac{1}{4}$ to $\frac{1}{2}$ inch to be sure that none of the tails will extend into the finished soffit, and I strike a mark **(13)**. To make the soffit cut, I hold my square on the plumb cut, and mark a "level" line square to the plumb cut **(14)**. The final tail cut is made along that line **(15)**, and the resulting rafter can be used as a pattern to lay out all the other common rafters.

Sue and Greg Burnet are co-owners of Toolbelt Productions (toolbeltproductions.com), an education and training firm for the building industry.


YOU'VE HEARD OF INTERIOR
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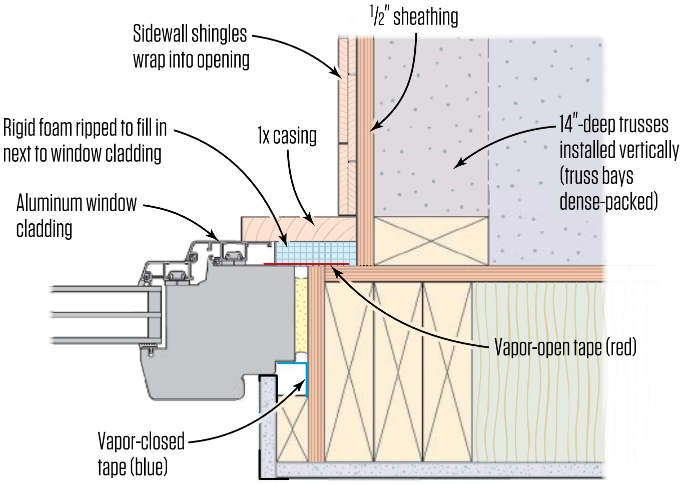
Q How was the exterior window trim handled on the Passive House featured in "Building a Passive House for the First Time" (Jul/14)?

A Farley Pedler, the article's author and a home builder from Tisbury, Martha's Vineyard, Mass., responds: Because the wall construction differed on the upper and lower sections of the house, we used two approaches for applying the exterior window trim.

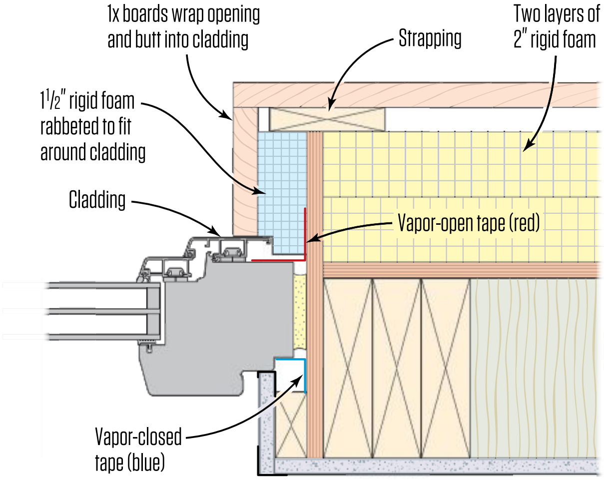
The core structure for the house was 2x6 balloon-framing with a skin of 1/2-inch Zip System sheathing. We used European-style aluminum-clad windows on which the cladding is spaced off the frame by approximately 5/8 inch. On both levels, we installed the windows with the wood frame in plane with the outside of the sheathing.

On the lower level, we built a superinsulated wall by attaching 14-inch-deep trusses over the sheathing and fastening them to the framing behind. This created a deep window well (also clad in sheathing) around each opening. The framing stepped the openings in a few inches on all sides, which allowed us to use more traditional-looking flat casing. After sealing the window frames to the sheathing with vapor-open flashing tape, we had to fill the space created by the aluminum cladding sitting proud of the sheathing. We inserted a layer of rigid foam ripped to a 5/8-inch

Lower-Level Jamb Casing



Upper-Level Jamb Casing



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thickness, which added a layer of insulation over the frame while padding out the wall to keep the casing flat. We finished the opening by returning the side-wall shingles into the opening and butting them against the trim.

The upper windows were much easier. These walls had a double layer of rigid insulation over the wall sheathing, and a layer of sheathing to box in each window opening. After the windows were installed and sealed to the opening, we installed 1 1/2-inch rigid foam that acted essentially as an exterior extension jamb. Because the space between the cladding and the window buck was only an inch wide, we rabbeted the foam so that it could slip past the cladding and be in contact with the window frame. The siding on that level consisted of horizontal 1x4 yellow-cedar boards attached to vertical furring strips over the rigid foam. Instead of casing each window, we simply returned the siding into each opening and let it terminate on the window cladding. Because of the built-up insulation, we attached the siding returns with 3 1/2-inch nails.

Q Precut studs obviously save labor and material, but how was their length determined?

A **West Coast**: Tim Uhler, lead framer for Pioneer Builders in Port Orchard, Wash., responds: Here, precut studs for 8-foot walls are 92 5/8 inches, which makes the overall height of the wall framing roughly 97 1/4 inches with three plates (two top and one bottom). I've always been told that this stud length was meant to accommodate 5/8-inch drywall on the ceiling. You could butt two 4-foot-wide sheets up against the lid and still keep the drywall about 1/2 inch off the floor. The bottom edge of the drywall would roughly split the bottom plate. But even with the stronger, lighter 1/2-inch drywall, the bottom edge still has plenty of nailing on the bottom plate.

With 9-foot ceilings, the precuts are 104 5/8 inches, which gives us an overall height of 109 1/4 inches. (In my experience, the precut studs for 9-foot ceilings always seem to come a hair long for some reason). In this case, we butt two 54-inch-wide sheets of drywall against the ceiling, which gives us the same clearance at the bottom. Beyond that, the precuts do save us and the drywall installers a significant amount of time and energy.

A **East Coast:** John Spier, owner of Spier Construction, a building and remodeling company on Block Island, R.I., responds: In my opinion, the best thing about precuts is they come off the pile in a usable (and reliable) length (92 5/8 inches), and you don't have to take time to cut them all to length. Whereas if you buy a stack of so-called 8-foot lumber, the lengths always seem to vary a bit and you have to cut every one to length.

If you strap your ceilings, as many East Coast carpenters do (see "Strapping Ceilings," Sep/14), while using standard precut studs, you usually have to rip a bit off the edge of one of the sheets of drywall before putting it on the wall. This obviously defeats the purpose of the precuts but is still better than cutting a couple of inches off every stud in the house. One way around that problem is to add a third top plate layer made from rips of subfloor sheathing that are wider than the wall plates. The extra width becomes the perimeter strapping, and the precuts can work as they're supposed to. (This perimeter detail also becomes a good place to transition an air barrier from the outside of the walls to the interior of the ceiling.)

I've heard carpenters from other parts of the country mention different precut stud lengths; for example, 93 inches (in parts of the South) or 92 1/4 (in parts of California). There must be local reasons why this makes sense. Anyone know?


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Photos by Mark Pollard/Thompson Johnson Woodworks

Roof Framing Challenge

BY TED CUSHMAN

Last fall, *JLC* went to the jobsite on Peaks Island where lead carpenter Mark Pollard and the crew of Thompson Johnson Woodworks were building the foundation for one of the company's most challenging jobs to date: an architect-designed custom home with enough odd angles to puzzle Pythagorus (see "Customizing an ICF Foundation," Nov/16).

Unique as it was, that foundation has not been the toughest problem this custom project has thrown at the Thompson Johnson team. Wall framing, involving a wood I-joist buildout for superinsulation as well as a two-story corner window, brought its own head-scratchers. And then came the roof (the topic of this story).

To make the most of a gently sloping clearing that borders on woods, Portland architects Kaplan and Thompson devised a highly original form. The largest element in the house (shown during framing) is a long parallelogram-shaped main room with a two-story vaulted space at the downhill end **(1)**. This long room has a monopitch shed roof, with one major wrinkle: Rising up at one corner of the roof is the upper portion of a tall, two-story corner window wall, which, for lack of a better term, the construction crew is calling "a dormer." But this is no ordinary doghouse dormer. It's really more of a boxy shaft that thrusts through the main shed roof, and it's topped with its own shed roof that pitches on two axes, forming a shallow valley with the main roof **(2)**.

Visualizing the shape. The custom-designed windows specified for this end of the house aren't square at the top, but instead have one corner higher than the other. And at the wall-to-ceiling joint, says Pollard, the plans call for no window casing: "The drywall on the ceiling just dies right into the top of that window, without any step-down." So Pollard took his layout for the roof assembly from the shop drawings for the upper corner windows. "I just drew a full-scale drawing on the subfloor," he says. Then he framed a skeleton shape with 2x4s **(3)** to guide

The crew set pie-shaped pieces of Zip System sheathing in place on the skeleton outline of the window-wall structure **(4)**. The valley rafter, downsized to a 12-inch height to allow for insulation above it, had to be shaved at the ends to allow for its out-of-square and out-of-level orientation with respect to the common rafter supporting it at the uphill end, and the wall header supporting it at the downhill end **(5, 6, 7)**.

the placement of massive LVL headers to support the roof frame. This skeleton outline would also determine the plane of the vaulted room's ceiling.

BEAMS AND A FLUSH CEILING

This custom home is aiming for Passive House energy performance, and for health reasons, the clients also need indoor relative humidity maintained at 50% year-round. For airtightness and calibrated vapor control, the designers opted to sheathe the underside of the ceiling with Huber Zip System sheathing (with the membrane side facing down) and tape the seams with Zip tape. So once the 2x4 skeleton of the room was in place, Pollard went ahead and installed Zip System panels around the perimeter of the shape (see photos, above). The panels defined the plane of the ceiling, even before the perimeter beams and low-slope I-joist roof rafters were installed.

If the pie shapes of the panels and the zig-zag pattern they form look peculiar, it's because the crew laid out and cut the panel shapes in anticipation of the roof framing that would follow. Says Pollard: "Those pieces of Zip panel were cut that way so that they would be square to the rafters, so that eventually when we were all done framing the roof, we could go back, and we would not have to cut weird polygon shapes to infill the rest of the Zip on the ceiling. The edges are cut to fall out at the midline of the rafters when the rafters are placed."

Next the crew had to set structural beams around the perimeter of the room, forming a sort of hybrid between a window header and a structural rim joist—but intended to support not floor joists but low-slope I-joist rafters. They also needed to set a structural valley rafter at the intersection between the main building's shed roof and the counter-sloping roof of the window-wall room. For

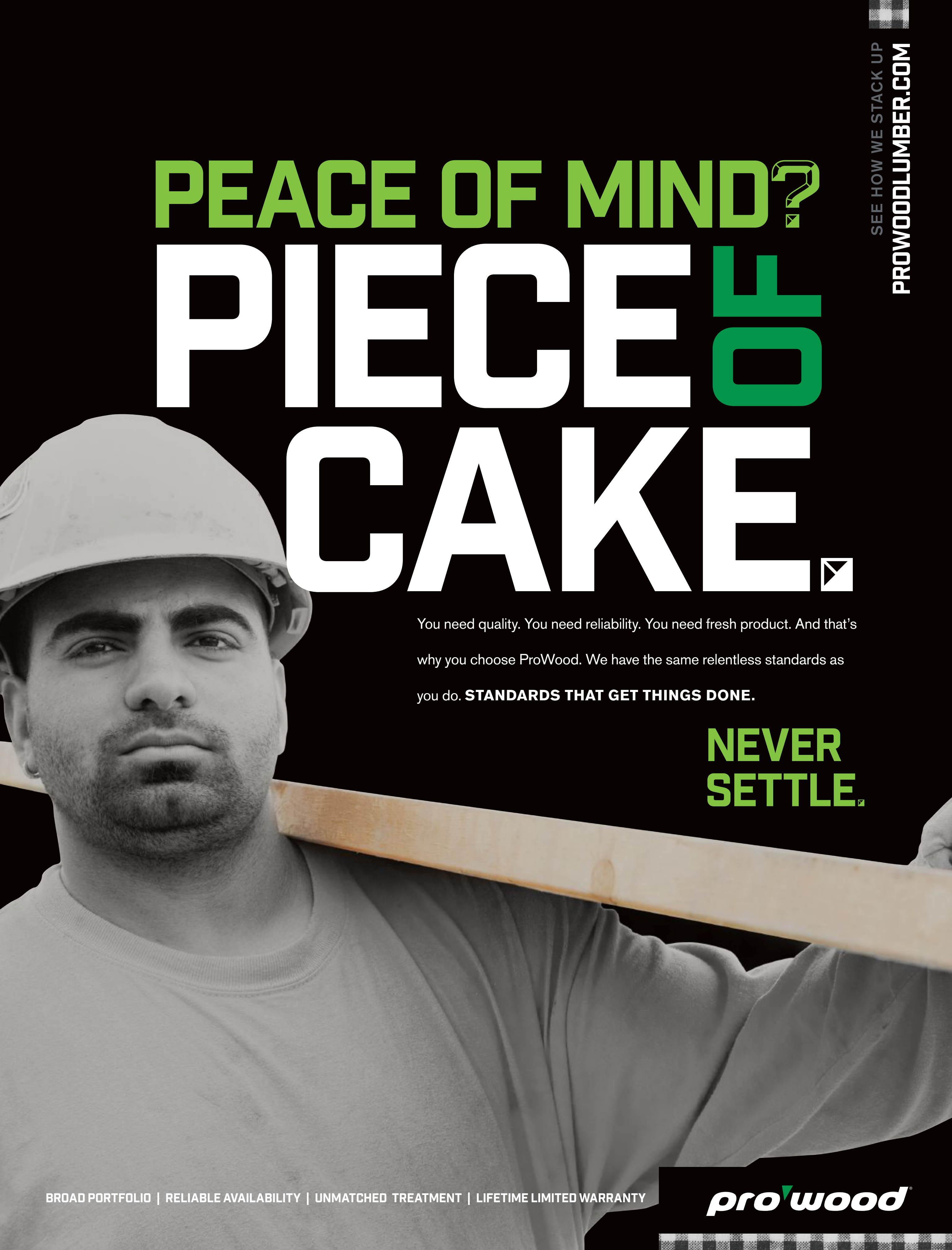
The LVL rafters for the low-slope roof system were set out of square to the beams that they tied into, requiring the use of "slopeable, skewable" structural connectors **(8, 9)**. The bottom shoe of these hangers can pivot up and down, while the ears on the sides can be bent from side to side. Where the I-joist rafters meet the doubled-up LVL valley rafter, the I-joists stand about 4 inches proud, leaving space for insulation above the valley member to reduce the risk of melting snow and formation of ice in winter **(10, 11)**.

this valley rafter, Pollard explains, Portland engineers Casco Bay Engineering originally specified a single 16-inch-deep LVL. At the uphill end of the valley, the original plan was to tie the valley rafter into a doubled-up 16-inch LVL common rafter.

"But we were concerned about thermal bridging at the valley," says Pollard, "and the potential for ice to form there in the wintertime when there's a lot of snow on the roof. So we asked the engineer to downsize the valley rafter, as well as the common rafter that it ties into at the uphill end." The revised solution was a double 12-inch LVL valley rafter and a double 14-inch common rafter. The 16-inch I-joist jack rafters would sit proud of the valley beam by 4 inches, leaving room for blown cellulose insulation between the beam and the skin of the roof.

Connecting the valley rafter to its support beams at either end, and connecting the I-joist jack rafters to the wall header beams and the valley beam, posed a hardware problem: None of the connections were at right angles. For the I-joist rafters, however, there turned out to be an off-the-shelf solution. "It's a Simpson Strong-Tie product called the LSSUH310—a 'slopeable, skewable' hanger," says Pollard. "It has a bottom shoe that can pivot up and down for your roof slope, and two big wings on either side, where it gets nailed to the carrying beam, that you can bend in order to skew the rafter from side to side." To connect the hangers to the beams, the crew used positive-placement gun nails—$1\frac{1}{2}$-inch nails for fastening to single LVL timbers, and 3-inch nails where doubled-up LVLs provided enough meat for the longer nails.

There was no comparable piece of hardware for the valley rafter, however—and it, too, had to connect at out-of-square angles to the LVLs supporting its ends. So the crew had to shave and bevel the rafter's ends (see photos, page 24) to fit into a conventional hanger.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With the roof framing complete, the crew constructed a vented roof assembly. Vapor-open, water-resistive VaproShield SlopeShield roof membrane was attached to the rafters **(12)**, and 2x4 furring laid on top of that. Then the crew sheathed over the furring with Zip System roof sheathing **(13)**, sealing the seams with Zip tape and protecting the valley with Grace Ice & Water Shield **(14)**. The 16-inch I-joist rafter cavities would later be filled with dense-blown cellulose insulation.

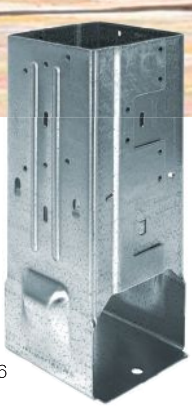
CONSTRUCTING THE VENTED ROOF

A unique, low-pitch cathedralized roof wouldn't be complete without an extra building-science challenge thrown in, and this building supplies one: As we mentioned, the home's mechanical systems are designed to maintain interior relative humidity at a constant 50% because of the owners' health requirements. So the superinsulated walls and ceilings have to be able to handle this condition, year round.

The team got a thumbs-up from Portland mechanical engineer and Passive House consultant Sonia Barrantes for a cold-roof assembly with plywood sheathing on the rafters, 2x4 sleepers to create an air channel, and another layer of plywood for the roof deck. But in the end, they opted for a more vapor-open solution. They stretched VaproShield's SlopeShield membrane (vaproshield.com) over the rafters, and nailed 2x4s through the membrane to create a venting space. Then they installed Zip System roof sheathing over the furring, sealing the seams with Zip tape and protecting the valley with Grace Ice & Water Shield.

Like other high-performance weather-barrier products on the market, VaproShield membranes are highly vapor-open. "But my big reason to prefer VaproShield was its Integrated Tape system," says Pollard. "At the bottom of each roll of fabric, there's tape on the back, and at the top, the tape is on the face. So as you shingle-lap the courses, you pull off the cellophane on the strips of tape, and the two faces bond together tenaciously—as opposed to other systems where you have to face-tape over the laps. I mean, those other systems have worked forever, and you know they're going to work, but to me it just seems wrong to reverse-lap tape."

Ted Cushman is a senior editor at JLC*.*



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Decorative Beams for a Craftsman-Style Arbor

BY CREGG SWEENEY

Our crew was recently asked to build an arbor for a Craftsman-style house we were building on Cape Cod. The arbor created a covered connection between a greenhouse and a garage in a T-layout **(1)**. The framework for the arbor was pretty simple: Horizontal 4x10 (actual) red-cedar beams notched into pressure-treated posts to form the "T." (The posts later received a cedar veneer.) On top of the beams, we built 16 cross beams, also made from 4-inch-wide red cedar. Each cross beam had a gently sloped top surface and an arch below. Horizontal "wings" extended from the ends of each beam to overhang the support beams by about 18 inches at each end. Angled notches at the ends of the wings completed the detail.

The two sections of the T were different widths, so the cross beams had to be two different sizes to span between the horizontal members. Our challenge was to come up with a way to cut multiple beams so that all the beams within each section would be exactly the same. In the name of production, the cutting process had to go fairly quickly while leaving as smooth a surface as possible to minimize sanding.

GLUE-UP MAKES DEEPER STOCK

For the longer cross beams, the total vertical height was just under 20 inches. Because stock that size is hard to get, as well as being expensive, and because we would end up removing a fair amount of wood to make each cross beam, we opted to create stock for each beam by laminating a small section of 4x4 and two short sections of 4x6 to a longer piece of 4x10 **(2)**.

The 4x4 piece was centered on the top of the 4x10 to give us stock for the peak of the beam. For the extra stock needed at the ends of the beam for the bottom part of the arch and the horizontal wings, we placed the 4x6 pieces about 18 inches from the center, one on each side. When the cross beams were installed, the lower faces of the 4x6s would rest on the horizontal arbor beams.

To align the pieces and help strengthen the cross section, we pinned the laminations with strategically placed dominoes. We laid out and marked the positions of the dominoes so they wouldn't be exposed when we cut out the beam. We used waterproof Gorilla glue for the glue-up, and with the dominoes aligning the faces of the boards, we only needed to clamp them in one direction.

DUAL-PURPOSE TEMPLATES

After letting the glue cure properly, one of the crew removed the excess dried glue and sanded the faces of the blanks. When they were ready, we set them on blocks on a large worktable.

We'd made two MDO templates—one for each size of cross beam—working directly from the dimensions on the architect's

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Photos by Roe Osborn

On a Craftsman-style home on Cape Cod, arched, red-cedar cross beams support a glass covering for this arbor **(1)**. To make the arbor beams, the crew laminates multiple layers of 4-inch-thick cedar together. Two pieces of 4-by-6-inch cedar glue to the bottom side of a 4x10, while a short 4x4 clamps to the top **(2)**. Dominoes align the pieces during the glue-up.

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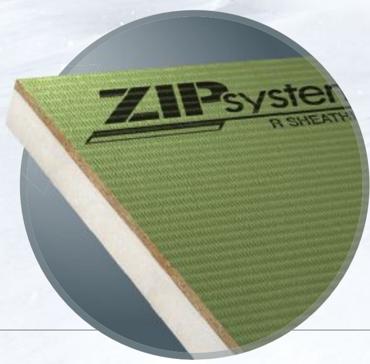

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FROM THE CREATORS OF AdvanTech

A crew member traces a line 1/4 inch outside the template with a spacer **(3)** and then cuts along the line with a circular saw. A jigsaw finishes the cut and rough-cuts the arch **(4)**. A router with a top-bearing flush-trim bit follows the template for the first finish cut **(5)**. The beam is flipped over and an up-cut spiral bit rides on the first surface to finish the cut **(6)**.


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blueprints. The templates served two purposes: First we used them to lay out for the rough cutting, and then later they became router-bit guides for our initial finished cut.

To lay out for the rough cut, we centered the template on the blank with the bottom edge of the template lined up with the bottom edge of the blank and clamped them together. We indexed the template to the blank so that we could reposition it after the rough cut. To mark out for the rough cut, we placed a small, 1/4-inch-thick block of wood against the template and drew a pencil line outside the block **(3)**. When we'd marked the edges of the beam that needed to be cut, we removed the template and set it aside.

We rough-cut the straight lines of each beam with a 10 1/4-inch wormdrive saw. Unfortunately, the blade did not cut all the way through the true 4-inch-thick lumber, so we finished the cut with a jigsaw equipped with an aggressive 6-inch blade. We used the same jigsaw to cut the arch **(4)**. Admittedly, a jigsaw does not leave a precision cut, but for this step, our cuts were still 1/4 inch outside the finished surface of the beam.

TWO-STEP ROUTING

With the rough-cutting done, we re-clamped the template to the beam and worktable, taking care to position the template on the beam exactly where it had been before. For the first router pass, we mounted a top-bearing flush-trim bit in a fixed-base router. With the router-bit bearing riding against the template, we cut back the edges of the beam, moving the clamps as necessary to complete the pass **(5)**. Whenever you're routing in this manner, it's always important to push the router against the rotation of the bit so that it cuts into the work without tearing out.

The 3/4-inch-diameter bit was removing only about 1/4 inch of material, so it wasn't over-taxed and stayed sharp for a longer period of time. As soon as we noticed the bit cutting more slowly than normal, we stopped and changed it, usually after cutting three or four beams. The result was a glass-smooth surface that would be easy to sand. But more importantly, we needed that smooth surface to guide our second pass with the router.

We removed the template and flipped the beam over before making the second pass with the router. This time, we used an industrial-grade up-cutting spiral bit with a double bearing on the *bottom* of the bit. With the bearings following the surface from the first pass, the bit cut perfectly flush with that surface **(6)**. The up-cutting action of the bit minimized the chances of tear-out, and again we carefully monitored the sharpness of the bit, changing it before it could start burning the wood. When the routing was finished, each beam received a thorough sanding.

To locate the holes for the attachment screws, a crew member places a small template on the bottom of the beam **(7)** before carefully drilling the holes **(8)**. Crew members center each cross beam on the horizontal beams **(9)**, and then drive the structural screws while keeping the beams square to the top surface of the carrying beams below **(10)**.

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ATTACHMENT STRATEGIES

As nice as these beams looked, they also had to be functional, tying together the arbor structure. The cross beams attached to the linear support beams (that formed the T) in two different ways. At all four ends of the T, as well as at the intersection points of the T and at intermediate points along the longer, narrower section, we bolted the cross beams to galvanized threaded rod epoxied into the posts. Structural screws secured all of the other beams in place. Both strategies required accurate placement of the holes to keep the cross beams aligned properly and fastened securely to the support beams below.

To locate the holes for the through-bolts, we set each beam in place, centered it, and scribed the bolt positions onto the beam. To drill the holes, we started with a Forstner bit that made a large, flat-bottom hole for the nut and washer on the top side of the beam, and a clearance hole on the bottom of the beam for the nut already threaded onto the bolt. We connected the top and bottom holes with a spade bit slightly larger than the bolt diameter to give us a little wiggle room for positioning the beams. After slipping the beam into place, it was just a matter of measuring the overhangs for an exact placement before tightening the nuts.

We used a different approach for the structural screws that attached the other beams. On the bottom edges of each beam, we measured in the distance from the beginning of the arch to the horizontal beam (about 2 inches), and then set a small template in place that located the screw positions **(7)**.

We drilled guide holes at every screw position, then drilled a hole through from the bottom of the beam to the top while keeping the bit as square to the beam as possible **(8)**. As with the through-bolts, the bit we used was slightly larger than the thread diameter of the structural screws. After drilling all the way through, we flipped the beam over and chased the holes with a 1-inch Forstner bit, for a flat-bottomed hole for the screw heads to bear on.

After setting the beams in place, we again centered them side to side over the horizontal beams **(9)**. Because the screws fell on the sides, not in the center, of the cross beams, we took special care to keep the beams vertically square to the beams below as we torqued the screws with impact drivers **(10)**.

To complete the installation, we cut wooden plugs and glued them into the holes above each fastener. After cutting the plugs flush, the beams were ready to support the glass covering that would provide protection for people walking below.

Cregg Sweeney owns Cregg Sweeney Artisan Builders, a building and remodeling company in Orleans, Mass. (csartisanbuilders.com).

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BY TED CUSHMAN

Heat Pump Water Heaters

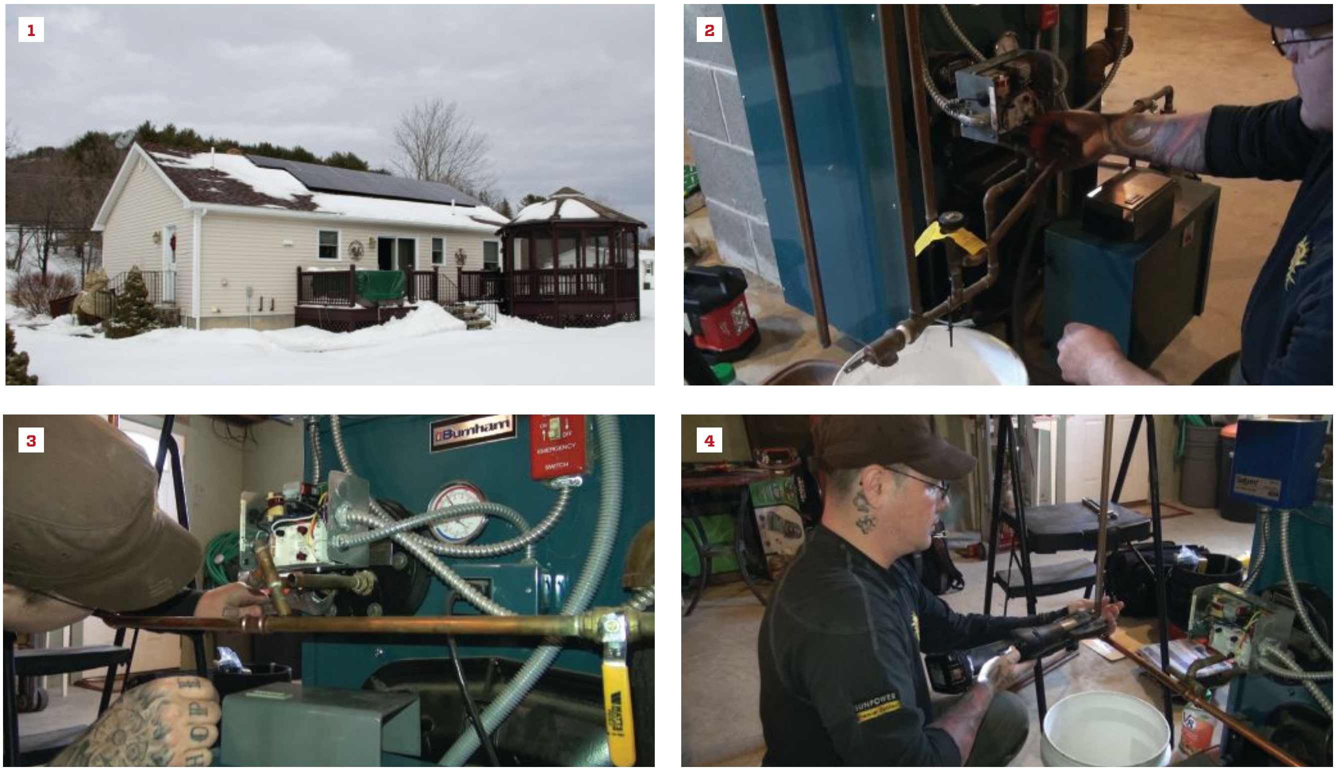
Photos by Ted Cushman

Heating domestic water accounts for more than 15% of a typical American household's energy consumption, according to Department of Energy statistics. And while home-heating-and-cooling energy consumption has declined in recent decades as a result of improved construction methods and gains in equipment efficiency, water-heating energy use has stayed flat, or even increased slightly. So water heating is one of the big remaining slices of the home energy pie for which advancing technology offers an opportunity to shave consumption.

Heat-pump water heaters are two to three times more efficient than conventional electric resistance water heaters at turning electricity into heat. And depending on the source of the electricity, they can be the lowest-cost way to heat domestic water over the lifetime of the equipment. Heat pumps are a complicated technology, and the up-front cost of a heat-pump water heater is many times the price tag of a basic electric resistance water heater. But some of that cost is offset by rebates in many areas, and heat-pump water heaters are continuing to make inroads in the market. In February, *JLC* went on site with master plumber Dan Leonard from ReVision Energy in Maine to learn more about heat-pump water heaters.

Brandon Bernard, a system design specialist for ReVision Energy, ticks off three reasons customers may approach him about a heat-pump water heater. The top reason is just that their existing equipment—an electric resistance water heater, a gas water heater, or a tankless coil in the oil heating boiler—needs to be replaced. Second on the list is energy cost: The customer is spending too much money to heat water year-round (typically with fuel oil) and wants to pay less. Finally, some customers are concerned about the environment and want to reduce their fossil-fuel use and carbon emissions.

Going solar. In the last case (where the customer wants to switch to clean energy), ReVision can offer a package of photovoltaic panels, mini-split heat pumps for house heat, and a heat-pump water heater for domestic hot water. Pairing heat pumps with PV pencils out as the solution with the lowest lifetime operating cost, especially if the long-run price of fossil fuels rises, says Bernard: "You pay for the panels, and they put out free power for 40 years." But the practicality of that approach



PV panels on this small house **(1)** are sized to carry much of the home's annual load, including heat and hot water. ReVision Energy master plumber Dan Leonard cuts a water line serving the existing boiler **(2)**, tightens down the plate on the tankless coil so the gasket won't leak **(3)**, and patches in the water line for topping up the boiler's hydronic loops using a solderless compression fitting **(4)**.

depends on the household's total water needs. For high-volume hot-water users, like large families with young athletes to raise, or homes with jetted tubs, thermal water-heating panels with a fossil-fuel backup offer output that a heat-pump water heater can't match. But the heat-pump water heater is a good fit for families who might expect to use less than 100 gallons in a morning or evening, like the retirees in the house shown above; ReVision calculated a five-year or six-year payback for these PV panels coupled to heat pumps for heat and hot water.

Getting off oil. Unlike most of the United States, where oil barely figures in the home-heating fuel mix, about 25% of the heating energy in the Northeast is oil. Maine is the extreme example: 64% of Maine households heat with oil. In many of those homes, a tankless coil in the oil boiler heats the domestic water. That's a very inefficient method of heating water, not least because it requires a boiler that's sized to provide ample heat in the dead of a Maine winter to stay hot all summer long just to keep water ready for the occasional shower or dishwashing session.

The job shown on this page is a classic example of the best case for a heat-pump swap-out: The tankless coil in a boiler is being disconnected and decommissioned, allowing the boiler to run less in winter and to shut down altogether as soon as the weather moderates enough to allow the air-source heat pumps to handle the home's full heating load. The boiler is being "unloaded" except when it's needed to heat the home during the coldest hours of winter (the continuous-run scenario when the boiler operates at its highest efficiency)—and photovoltaics will supply the juice.

The heat-pump water heater being installed here is a top-of-the-line Stiebel Eltron Accelera "E" unit, ReVision Energy's go-to choice. It comes with a 10-year guarantee and uses a low-voltage direct-current circuit, rather than a sacrificial anode, for corrosion protection. ReVision Energy's Brandon Bernard speaks highly of the equipment, but he acknowledges that heat-pump water heaters have limitations and aren't right for every situation. The units work by pulling heat out of the room air where they're located, so they need at least 800 cubic feet of space around them—and when they're operating, they can cool that surrounding space by as much as 5°F to 10°F. The heat-pump motors are noisy (although not as loud as a typical high-mass oil boiler). And the coils collect condensate that has to be drained somewhere—but the upside, at least for basement locations, is that the units dehumidify the space whenever they're running.

Ted Cushman is a senior editor at JLC.

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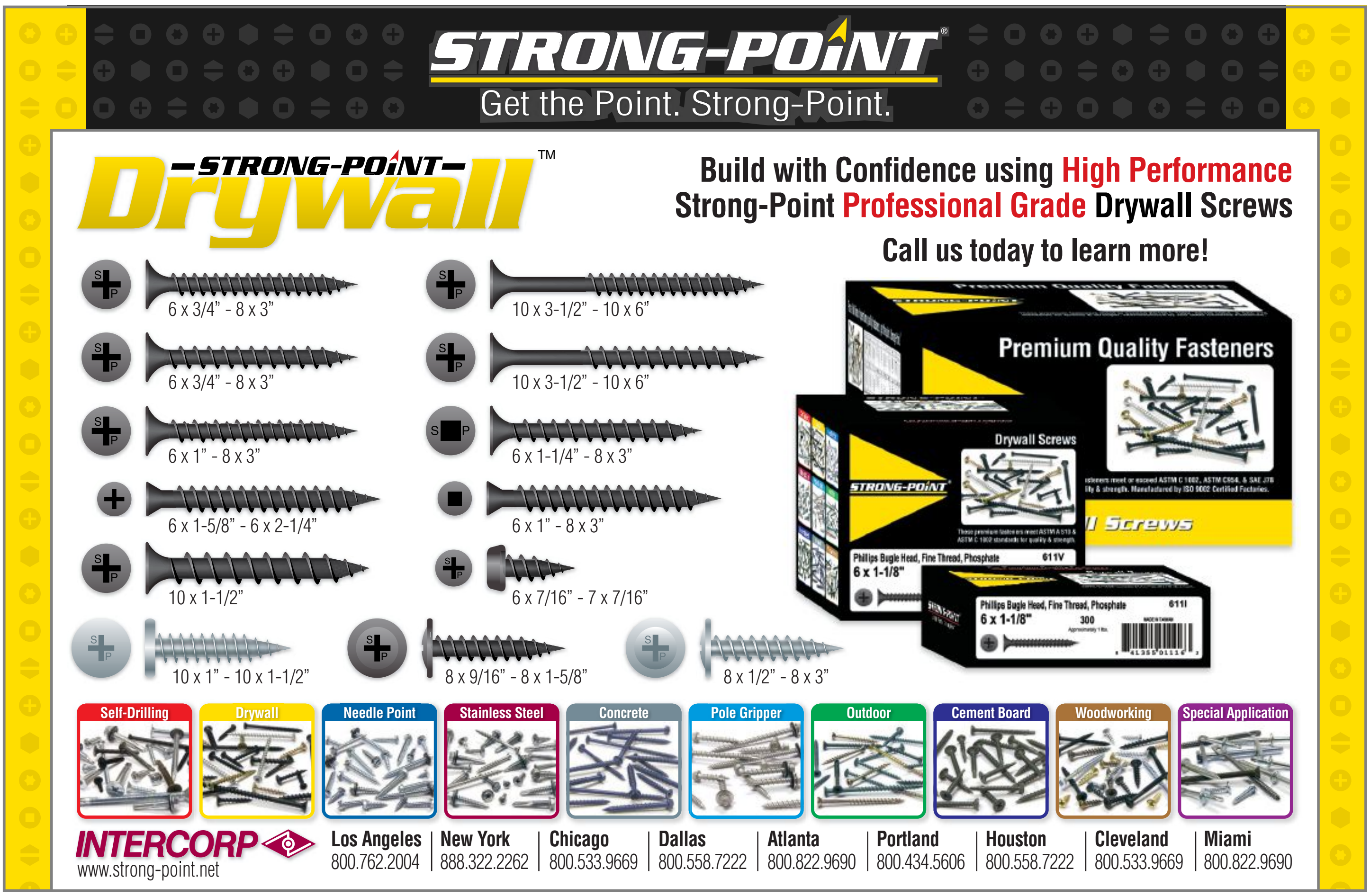
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Photos by Matt Risinger

Pier-and-Beam Foundations

For problem soils, there's no better foundation type, but you better get the details right

BY MATT RISINGER

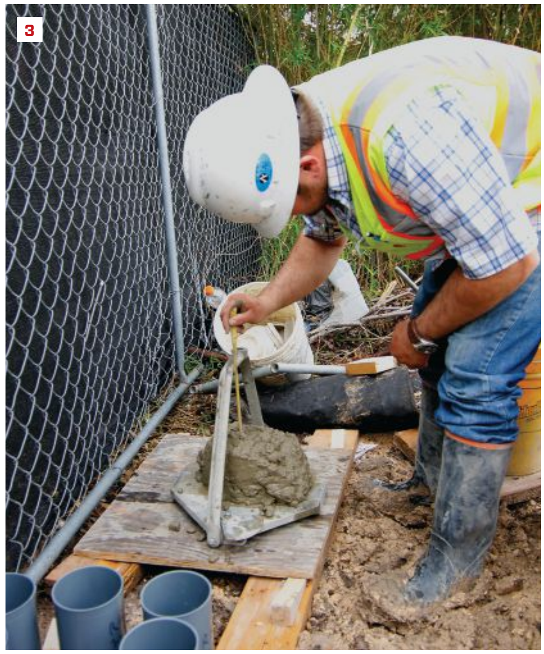
If you are building a new house, one of the most important decisions is always what type of foundation to use. If you get the foundation right, you have a fighting chance of building a good house. On the other hand, with a bad foundation, no matter what you do in the build, you will have problems with the house.

Here in the South, we usually build slab-on-grade. We don't have a frostline, so code does not require that we dig down several feet. It isn't like the Northeast and the snowbelt states, where once you are digging below the frostline, it makes sense to dig out the entire footprint to gain usable space below grade. However, when we build on problem soils—and we have plenty—we have to use pier-and-beam foundations. In this article, I cover two examples I've built recently—one with concrete piers for a SIPs home on a lot with clay soils and one with steel piles for a house on the shores of Lake Austin, where the water table was only a few feet below grade.

These days, lots are scarce just about everywhere, and builders in all regions find themselves building on land they might not have even considered 20 years ago. The two foundations I describe in this article were both built near Austin, Texas, but they are foundation types that could work in any region, provided you are working with a geotechnical engineer to evaluate the specific local site conditions.

CLAY SOILS

Texas is full of building sites with high clay content, so we often work closely with a geotechnical engineer at the start of a project.



On our recent SIPs house, we had only a foot or two of good top soil; underneath that, the engineer's soil test showed a high clay content in the soil, extending all the way down to bedrock at about 20 feet.

The problem with clay is that it expands dramatically when it gets wet and then shrinks back just as far when it dries out. If we were to build a typical slab-on-grade foundation on clay, the house would experience a lot of uneven movement. It would pitch around, in slow motion, like a boat on rough water. This, of course, could cause windows and doors to stick, and stucco, siding, and drywall to crack.

But it can get much worse than that. Many clays are highly attractive to water, and when they expand, they do so with considerable force—enough to crack concrete footings and foundations.

Of all the soil types, clay (as well as sandy clay, silty clay, and clayey silt—all soils that vary in the amount of clay content) has the lowest bearing capacity (only around 1,500 psf, compared with rocky and gravely soils, which have a bearing capacity around 3,000 psf, or bedrock, at 12,000 psf). Clay is just not the stuff you want to build on. Therefore, the only real option for our SIPs house was to sink piers all the way through it, to support the house on bedrock. In effect, we were building something like a beach house up on stilts; though the clay was there, we were not depending on it in any way to support the house.

CONCRETE PIERS

To place the piers, we worked with a drilling company to bore through the clay **(1)**. I have built homes with piers drilled up

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to about 40 feet deep. Often, the drilling rig will bore not only through the clay but also into the bedrock—up to about 4 feet—to securely anchor each pier to the rock.

Rebar cages. The foundation crew wired up long rebar cages that extended the entire length of the boring (see photo, page 41). Once a few holes were drilled, the crew lifted the cages with the drilling rig to lower them into the holes. The holes provided the form for the concrete, and we didn't want them filling up with dirt, so the foundation crew installed the cages and poured all the holes they could drill in a day **(2)**.

When pouring the concrete here, we needed a fairly loose mix so it would pour easily through the rebar cages without creating voids. We did not want to just water down the mix, though, but instead used a rich mix, carefully controlling the slump. The engineer was kept busy throughout the process, periodically evaluating each truckload of concrete **(3)**.

CARTON FORMS

Even though the piers extended from the slab to bedrock, the clay soil could still expand upwards and crack the slab. So on this house, we isolated the slab from the soil using carton forms **(4)**. In effect, these created a sub-slab cardboard box that provided enough strength to support the slab and the grade beams during the pour. The carton forms were covered with a durable, 15-mil poly, and the rebar was wired tightly, with plenty of stand-offs to keep the reinforcing in the midsection of slab **(5)**. Once 4-inch mesh was laid on top of this, the concrete crew was able to work off the reinforcing layer during the pour without falling through the carton forms.


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Once the concrete cured, the rebar in the slab and in the grade-beams created a self-supporting structure. The forms may crush over time, but the soil pressure will not be able to exert any significant force against the concrete.

Grade beams. The grade beams were poured at the same time as the slab, so all the concrete and reinforcing was integral. The rebar running through the beams interlocked with the slab reinforcing and with the pier reinforcing **(6)**.

Perimeter beams. Around the outside of the foundation, we formed a perimeter beam that both supported the slab edges and acted as a stem wall, rising above the slab floor to create a crawlspace **(7)**. (We will insulate and condition the crawlspace to be inside the building's thermal envelope.) This gave us access to all the utilities under the house, by sleeving through the perimeter beam **(8)**.

Termite control. Termites are a given with every foundation we build. In this region, they are often dealt with by pouring chemicals around the foundation, but chemicals inevitably leach away and become ineffective. They also create a health hazard in local waterways, so I prefer Termimesh—a tight-woven stainless steel mesh.

On this build, we had a couple of concrete posts on footings that we formed up and poured before the slab. The posts were needed structurally to support the floor girder, but it created a cold joint in the concrete that needed to be protected with Termimesh **(9)**. While Termimesh does a great job of sealing the smallest gaps where termites would otherwise squeeze through, remember that Termimesh is not a substitute for yearly inspections. An inspector still needs to come around each year to inspect the inside and outside of the crawlspace.

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STEEL PILES

The house on Lake Austin sits on a flat lot, right by the water. Lake Austin is a man-made, constant-level lake, so we didn't have to worry about a rising and falling water level, but the downside of this property was that the water table was only a few feet below grade.

The geotechnical engineer took a core sample all the way down to bedrock, which was just a bit over 50 feet deep. He found good soil for the first couple of feet and then soupy soil all the way down to bedrock. For this condition, a structural engineer recommended steel piles, and he designed the piles to lay out in a very specific grid pattern to support grade beams, so the house, in effect, would float above the soupy mess below.

Sinking piles. The first step to installing the steel piles was to drill holes about 10 feet deep, using a rig with a much smaller diameter bore than we needed for the pier holes on the SIPs house **(10)**. This provided the holes for driving each pile.

The steel piles, which are made of 3/8-inch steel, 8 inches in diameter, come in 30 foot lengths. Before we drove them, we welded a steel cap on the bottom end **(11)** so they would not fill up with water or mud. We wanted to keep that column free, so we could fill it later with both rebar and concrete.

We dropped the pile into our drilled hole with the forklift, and it was able to push the pile down the first 35 feet or so. The soupy soil offered very little resistance to pressure from the hydraulic lift. All we had to do was press with the forklift **(12)**.

With bedrock over 50 feet down, we needed to combine pile sections. Once that first length was just a few feet out of the ground, we brought over a new section with the forklift and welded it on

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before we continued **(13)**. Once we reached that last 5 feet or so, the forklift was no longer effective, and we needed a pile driver. We used a crane-supported pile driver, driving that final distance until the pile came to "refusal."

The steel of the pile was structural and did not require reinforcing steel for the entire length. We did install rebar hooks at the top **(14)**, however, so we could tie each pile into the grade beams.

FORMING THE SLAB

After the pile was in place to support both the house and the hardscaping, we brought in a concrete crew to form up the slab. They placed and compacted a gravel mix and formed trenches in this sub-slab surface to define the network of grade beams that would support the house.

On this project, we used 15-mil Stego Wrap, which has become my go-to vapor retarder for below-grade work **(15)**. Because many of my projects have wood floors and other interior woodwork, I am always extremely careful to limit the amount of moisture that can wick up through a porous concrete slab. Stego provides a super-durable seam tape **(16)**, as well as a compatible mastic, which we used in addition to the tape to seal all the slab penetrations **(17)**.

Reinforcing. The rebar was a big part of the job, as it was critical to the strength of the entire foundation. Reinforcing for the grade beams was put in first, formed in sleeves and interlaced with the piles **(18)**. Over the grade-beam steel, we laid out a precise gridwork, following the structural engineer's design. This gridwork needed to be well supported on chairs so it would end up in the midsection of the 5-inch slab, and it needed to be tightly wired so

it would stay in place during the pour. Added reinforcing was required where column bases were integrated into the slab at specific beam intersections **(19)**.

The drone shot **(20)** shows the extent of the foundation for the house and the hardscaping.

POURING THE FOUNDATION

Just before starting the pour, we installed Termimesh with stainless-steel pipe clamps around all of the penetrations through the slab. The mesh was held 2 to 3 inches up from the sub-slab vapor retarder and was embedded in the concrete to create a physical barrier when the concrete dried and shrank back slightly from the pipes and sleeves (termites can squeeze through a gap as small as 1/32 inch). With the house being so close to the lake, Termimesh was the only solution possible for discouraging termites, as any chemicals were strictly prohibited.

When you're pouring a foundation with this much reinforcing steel, it's critical for an engineer to be on site to evaluate the mix and for the foundation crew to vibrate the concrete—particularly in the grade beams **(21)**—to ensure that it is well consolidated, without voids.

On this site, so near to the lake, it was also especially important that the concrete drivers follow strict protocol, using wash-out basins when it came time to clean out the trucks.

Matt Risinger is the principal of Risinger & Company, based in Austin, Texas. Be sure to check out his YouTube channel, as well as his blog at www.risinger.com.

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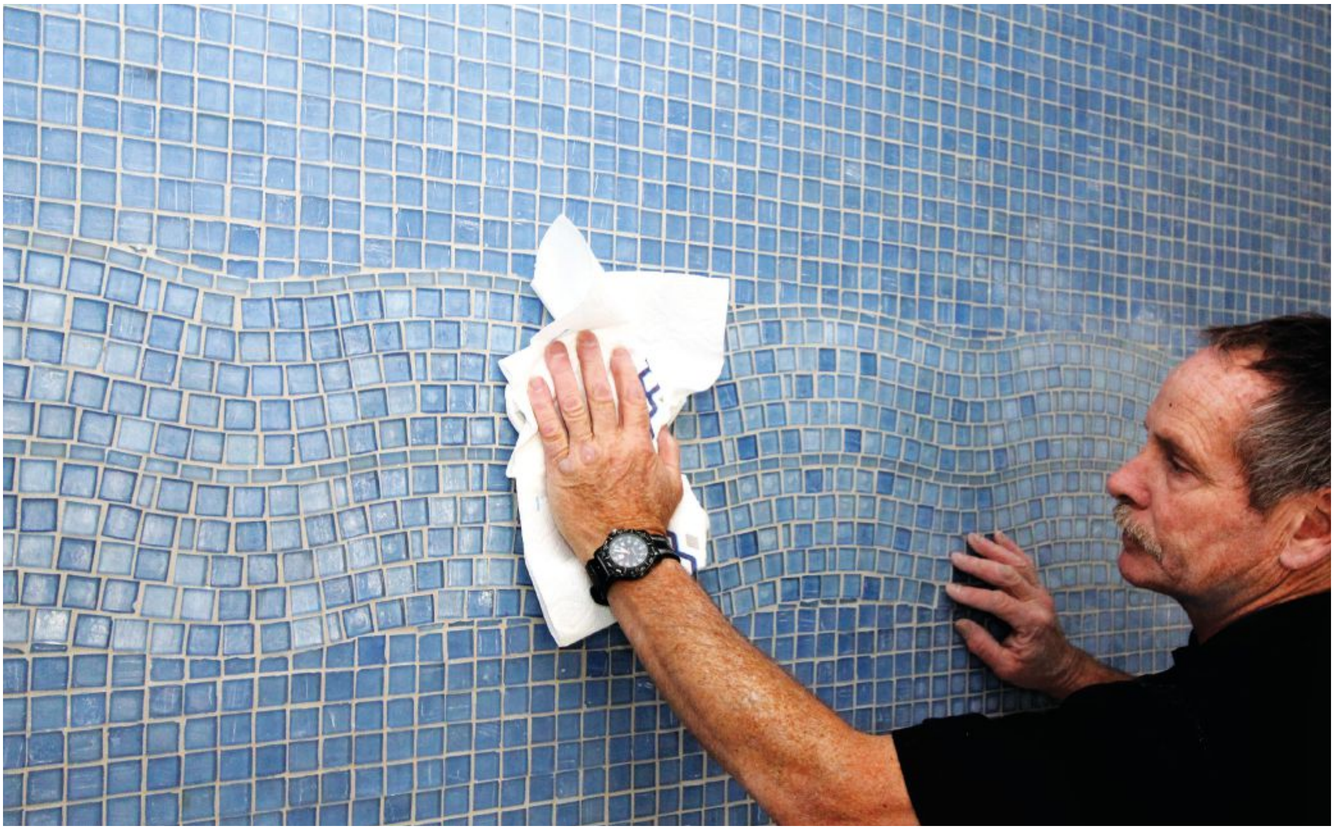

Photo: Gil Potts

Working With Glass Tile

Getting the most from this amazing material

BY TOM MEEHAN

There is an old saying: Fools rush in where angels fear to tread. In other words, an inexperienced person often jumps into situations that a wiser, more experienced person might avoid or at least approach more cautiously. This concept is fitting for the tile industry—especially when it comes to glass tile. While glass is probably the fastest-growing segment of the tile market, it is also probably the least understood when it comes to using the right materials and techniques to create a long-lasting installation. However, with a little familiarity and a good grasp of the nuances of this amazing material, your chances of success can be greatly improved.

Glass tile has been around for millennia, and over the last hundred or so years, it has been mass produced for installation in homes. Twenty-five years ago, most of glass-tile installations that I did with my dad were straightforward, paper-faced 1x1 mosaics. And while that type of glass tile is still available, today glass tile is made in a staggering assortment of styles, colors, and sizes—each with its own specific requirements. The result is an explosion of creative and beautiful installations that could not have been conceived of just a short while ago.

I do hundreds of tile installations every year and a lot of them incorporate glass tile, used either as an accent or for all the tile in the project. I've worked with many varieties of glass tile, but even so, when I come across a new type or a different manufacturer for the first time, I always do my homework beforehand to make sure that the installation will be successful and that my clients will be happy with the end results.

Tom Meehan, co-author of Working with Tile*, is a second-generation tile installer who lives and works in Harwich, Mass.*

START WITH THE RIGHT THINSET

In the February 2017 issue of *JLC*, I answered a question about when to use latex-modified thinset mortar for installing tile. Choosing the proper thinset is never more important than with glass tile. Because of the resiliency of glass (its inability to absorb moisture) and because of the different configurations of glass tile, manufacturers usually require a specific glass-tile mortar for their particular tile **(1)**. To ensure good adhesion and to maintain the warranty for the tile, always follow the tile manufacturer's recommendations. If no specific glass-tile mortar is called for, check with the thinset manufacturer before using its product to be sure there are no issues.

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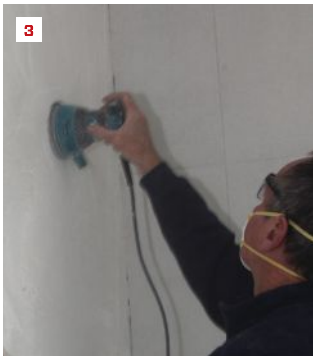
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PREPPING THE WALLS FOR GOOD ADHESION

Wall prep for a glass-tile installation begins with a coating of a liquid stress-crack membrane (the dark area in the photo), such as Hydro Ban **(2)**. Tile can slip when installed on the membrane, so I add a skim coat of glass-tile mortar or latex-modified mortar. Then I sand down any high spots before proceeding with the installation **(3)**.

INSTALLING PAPER-FACED TRANSLUCENT MOSAICS

Sheets of small mosaics mounted on a paper face are one of the most common forms of glass tile. The tile is usually translucent, with no type of back layer applied. For this accent wall, the layout started with a vertical line in the center of the wall.

To complete the initial layout, set a level on the shower floor and measure up the distance of two full sheets of mosaics from the top of the level **(4)**. A tile baseboard will fill in the space below the mosaic tiles after they are installed.

Using the flat edge of a trowel, coat the entire layout surface with glass-tile mortar before combing it with a 3/16-inch square-notched trowel **(5)**. A 3/16-inch V-notched trowel would also work for this step. After combing the surface evenly, knock down the ridges left from the trowel using a flat-bladed taping knife **(6)**.


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Photos: Roe Osborn

INSTALLING PAPER-FACED TRANSLUCENT MOSAICS (CONTINUED)

Knocking down the ridges made by the notched trowel ensures nearly 100% surface-area adhesion, which is crucial for most types of glass tile. Starting at the horizontal layout line, press sheets of the mosaic tile into the mortar, applying pressure to all parts of each sheet for good adhesion **(7)**.

Sheets of mosaic glass tiles are often uneven or out of square, so after each section is pressed into the wet thinset, place a straightedge (in this case, a level) on the top edge of the tiles to make sure that they are aligned. If any tiles need adjusting, slit the paper with a razor knife **(8)** and then either push the misaligned tiles up by hand or insert a flat-bladed taping knife into the slit to slide the row of tiles in unison. If the discrepancy is more than 1/16 inch, slit more than one row and spread the adjustment out evenly.

After lining up the top edge of a section, lay out the next section of tiles. In this case, the layout extended up to the edge of a decorative band, so the layout line landed two complete sheet courses plus four rows of mosaics above the finished courses below.

Spread the glass-tile mortar up to the line as before, combing it with a notched trowel and then knocking the ridges flat. Then press the next courses into the thinset **(9)**. Note that staggering the seams of the sheets is not necessary but can be done. After each section is placed, go over it with a rubber grout float, gently tapping it flat against the tiles to completely embed them into the thinset **(10)**.

When the mortar starts to set (15 to 20 minutes after the initial installation), dampen, but do not drench, the paper face with a wrung-out sponge **(11)**. Wait one to two minutes for the water to dissolve the glue, then peel off the paper. Peeling technique is critical. Start at one corner and slowly pull off the paper diagonally, keeping your hands close to the wall **(12)**. Expect some tiles to come off with the paper. Butter the backs of those tiles and push them back into place.


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Photos: Roe Osborn

INSTALLING MESH-BACKED OPAQUE MOSAICS

The description "opaque" is a bit misleading for this type of glass tile. The tile itself is transparent—it's the applied coating on the back of the tile that's opaque. That coating also gives the tile its color.

The tile shown below comes in sets of eight vertical tile sheets; the bottom sheet of each set contains the most dark tiles while the top sheet has the most light ones. The color gradates slowly and randomly from dark to light from the bottom of the wall to the top, so it's important to keep the numbered sheets in order during the installation.

Because the adjacent wall had the same tile, layout for this wall could be taken directly from the installed tile. The top of the third sheet from the bottom was used as the first layout line **(13)**.

Apply the glass-tile mortar up to the layout line, spreading a thin layer and combing it with a 3/16-inch square-notch trowel. Because of the opaque backing and small size of the tile, I didn't knock down the ridges, although doing so is fine.

Instead of paper, a lightweight plastic mesh holds these sheets together **(14)**. Press each sheet into the thinset and move it side to side slightly to adhere it to the surface of the wall. As with paper-faced tile, check to be sure that the top edge of the tile is in a straight line **(15)**. When all the tile for a section is finished, go over the entire surface, tapping with a rubber trowel **(16)**. This maximizes adhesion and helps to eliminate lippage where some tiles stick out farther than others.

To avoid cutting tiny glass slivers to fill in along a corner, adjust the tile spacing instead. First slice through the mesh backing with a razor knife **(17)**. Then slide a row (or rows) of tiles over with a flat taping knife until an acceptable grout space is left along the corner **(18)**. By slitting and adjusting several rows in this manner, it's possible to make up for gaps as wide as 3/16 inch.


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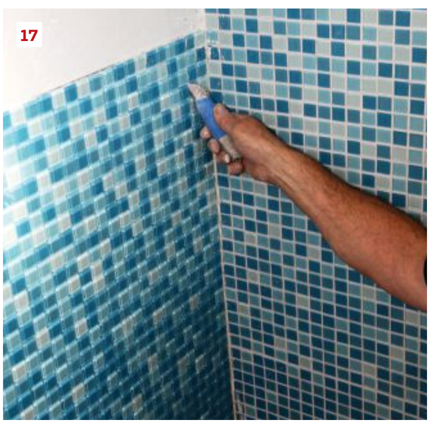
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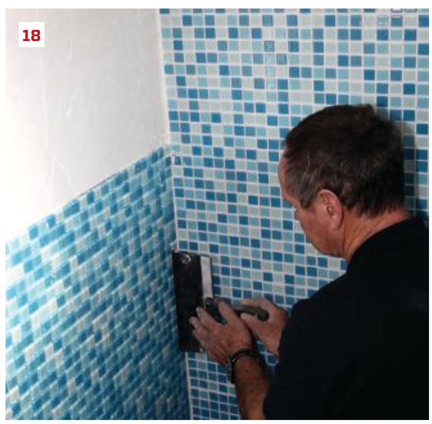
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Photos: Roe Osborn

CUTTING MOSAICS

The best way to cut glass mosaic tile is with a wet saw. But using a glass-tile cutting blade is a must. These specialty blades can cost twice as much as a standard wet-saw blade but will give you the smoothest cuts.

To support both sides of the cut and hold the tiles stationary, a site-built cutting jig can be helpful **(19)**. Cut a saw kerf about two-thirds of the way through a porcelain tile. Use a factory corner from another tile to hold the mosaics parallel to the blade at the desired width. Hold the mosaics stationary with a second tile.

Tip: Don't try to cut too many mosaic tiles at once. Cutting tile for a ceiling strip, for instance, is best done a few tiles at a time **(20)**.

WORKING WITH LARGE-FORMAT GLASS TILE

When porcelain or ceramic tile is discussed, the term "large format" indicates tile that has one dimension of at least 15 inches. But with glass, because of its fragile nature, any tile with a dimension of 3 inches or more is considered large format. The tile for this shower project measured 3 inches by 12 inches and was installed in subway-tile fashion. A decorative band of smaller glass tile that mimicked green marble wrapped around the shower at chest height. The band's location was determined by the layout of the tile below.

A story pole is the quickest way to check a layout. To make a story pole, line up and trace the edges of the tiles on a thin, straight piece of wood, leaving space for the desired grout line between the tiles. Set the bottom of the story pole at the starting point of the layout (a level straightedge) and mark the bottom position of the decorative band to break on a whole tile layout **(21)**. Then set a sheet of the band tile in place and mark the top and bottom of the band **(22)**.

Next check the distance from the band to the ceiling to be sure that the tiles along the ceiling will be close to the width of a full tile. Narrow slivers are undesirable from a visual standpoint as well as being problematic to cut and install. Before finalizing the layout, check the ceiling to make sure that it's close to being level and that there aren't any major discrepancies on the adjacent wall.

Photos: Roe Osborn

LARGE-FORMAT GLASS TILE (CONTINUED)

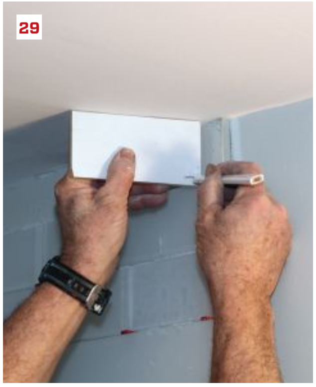
This large-format glass has a translucent applied backing, so any voids left in the mortar might show through as shadows after the mortar has set up. For this tile, spread an even layer of glass-tile mortar on the wall and comb it with a 1/4-inch square-notch trowel. As before, knock down the ridges with a taping knife **(23)**. Butter the back of each tile with a thin layer of mortar **(24)**, then press the tile into place, sliding it side to side slightly to embed it fully **(25)**. The mortar on the back of the tile helps to fill any small voids in the mortar layer.

Only spread mortar for the number of courses you can install comfortably without the mortar beginning to set up. After setting the tile on a couple of courses, wipe off any excess mortar with a sponge, then insert tapered spacers to separate the tiles and leave the proper grout joint **(26)**.

CUTTING LARGE-FORMAT GLASS TILE

Though not suited to glass mosaics, a score-and-snap tile cutter works well for cutting many large-format glass tiles **(27)**. For a subway-tile format, it's efficient and convenient to set up the cutter next to the shower for cutting the half tiles that begin every other course and for cutting the tiles at the inside corners. A wet saw equipped with a glass-cutting blade also does a great job of cutting tile without chipping the applied backing **(28)**.

Photos: Roe Osborn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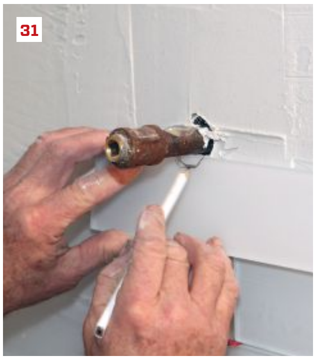
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Photos: Roe Osborn

OTHER CUTS IN LARGE-FORMAT TILE

The layout of the large-format glass tile in this shower left a partial-width tile at the ceiling. That width varied slightly because the ceiling was slightly out of level. To cut each tile to the proper width, place the tile against the ceiling in the area where it's to be installed, and mark the amount that needs to be removed **(29)**.

The best, and maybe the only, way to make a clean and straight cut down the length of a large-format glass tile is to use a wet saw equipped with a specialized glass-cutting blade. These blades have finer and more numerous diamonds and make a smooth cut through the glass and any backing without chipping or tear-out that can be visible once the tile is installed. After marking the width of the tile, carefully cut with the specialized blade. Thin rips in large-format glass tile such as this become fairly routine **(30)**.

CUTOUTS FOR PLUMBING

To make plumbing cuts for the shower controls and for the piping that supplies the shower head, the process is similar to that with ceramic or porcelain. The difference is that extra care must be taken so that the glass breaks out evenly without the applied coating chipping out beyond the cut. These cuts don't have to be a perfect scribe to the pipe, but don't assume that the plumbing flange will hide a bad cut.

When the cut falls on a seam between tiles, set the tile roughly in position and mark out the cut **(31)**. At the wet saw, make several cuts to the cut lines **(32)**. Using glass-tile nippers, carefully break out the glass over to the line, "nibbling" a little at a time until the cut is big enough for the pipe **(33)**. Then back-butter the tile and set it in place **(34)**.

If the pipe falls in the middle of a tile, drill the hole with a hollow-core diamond-coated bit with a water feed **(35)**. Be sure to do the drilling on a solid surface that supports the tile evenly, and cut the hole slowly and carefully, letting the weight of the drill apply the pressure for the cut.

BUILD-OUT FOR THINNER-PROFILE TILE

When a decorative band is used on a glass-tile project, the tile for the band is often thinner than the field tile. The best strategy for building out the band is applying either 1/4-inch backerboard or a layer of membrane, depending on the amount of build-out needed. For a band like this one, comb out an even layer of mortar over the band area **(36)**. Embed a piece of thick membrane (Kerdi was used here), smoothing the membrane with a taping knife **(37)**. Apply a layer of glass-tile mortar over the membrane, comb it out with a notched trowel, and knock down the ridges with a taping knife **(38)**. Press the band tile into place **(39)** and tap it with a rubber trowel to embed it completely in the mortar **(40)**. When the mortar has had 15 to 20 minutes to set up, dampen and remove the paper as with paper-faced glass mosaics.


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GROUTING GLASS

Grouting glass tile is much like grouting other tile, with no special materials required. However, because of the resilient (non–moisture absorbing) nature of glass, use a grout mixture that is much stiffer, with less water than usual **(41)**. Float the grout with a rubber trowel, using diagonal strokes to fill the grout joints completely. Remove excess grout with a clean sponge **(42)**, and wipe off the grout haze with a terry-cloth towel after it dries.

Photos: 36–40, Roe Osborn; 41 & 42, Gil Potts

Fixing the Bonus Room

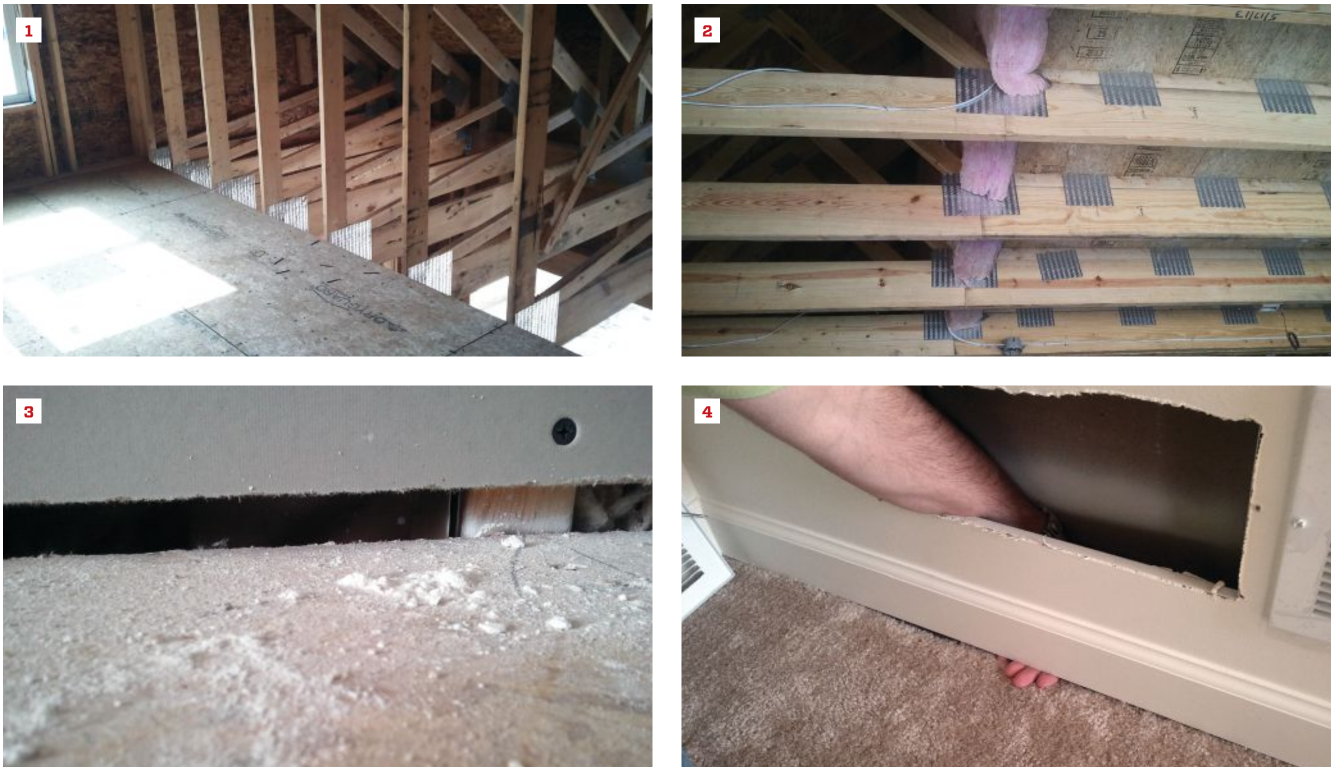
A room over the garage shouldn't always be a warranty issue

BY MATT BOWERS

I'm a HERS rater and project manager for Airtight Services, a home-performance contractor in upstate New York. In the photo above, one of our carpenters is cutting open the gable-end wall over a garage on a brand-new house. He's starting one of the jobs that have become part of our bread and butter: an energy upgrade performed as warranty service for a home builder on a cold, leaky "bonus room" over the garage.

In our area, bonus rooms have been a common feature of new construction since the 1970s. That's because builders here have optimized their plans to fit more houses on a development, and one way they create inexpensive square footage is to build a second-story room over an attached garage, framing the roof and the bonus room in one quick step using an attic truss. The bottom chords of the trusses form the garage ceiling as well as the bonus-room floor. Vertical webs of the trusses form the sidewalls of the room.

It's a frugal way to build what could be usable space, but the result is often uncomfortable space. Time after time, we are called because a homeowner has just moved into a house, and the room over the garage is 20°F colder than the rest of the house in the winter—the main house is a cozy 68°F, but the bonus room is in the 40s or 50s. We find this condition not only in older homes built under obsolete codes, but in brand-new houses built to comply with the 2009 International Energy Conservation Code (IECC) and even in homes built under the recently adopted 2015 IECC. The example shown in this story—a typical case—is warranty work on a new house built to comply with the 2009 energy code.



To construct a typical bonus room, the builder first installs OSB subflooring on the truss chord **(1)**, then insulates the vertical sidewall truss webs with kraft-faced fiberglass batts **(2)**, stapling the facing to the sides of the 2x4 webs. Next, the builder applies drywall to the room walls—leaving space below the drywall **(3)** for the carpet installers to attach a tack strip. After carpet and trim are in place, a huge air gap remains at the base of the wall **(4)**, communicating with the cold vented attic.

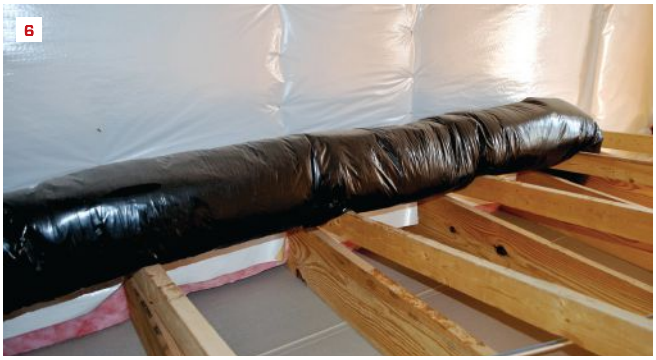
Now that the 2015 IECC has been adopted in New York, rooms like this one are likely to cause new homes to flunk the building envelope airtightness standard. New York's new energy code requires homes to achieve no more than 3 air changes per hour at 50 pascals of pressure (3 ACH50) during blower-door testing.

The photos above show a typical bonus room at various stages of construction. Because the framing is basically a set of trusses, there is no wall plate at the bottom of the wall. As a result, there's a gap—typically a big gap—at the bottom of the wall. This allows air to leak freely into the room from the space behind the wall, which is connected to the outdoors via the roof eave soffit vents.

Bonus rooms have big leaks. In pressure diagnostics, if I close the door to a bonus room and isolate it, I often measure a 20- to 25-pascal difference between the bonus room and the main house—and you can feel the air pouring in under the door.

To make matters worse, the typical forced-air heat for a room like this tends to underperform. The ducts serving the room typically are insulated to only R-4.2 and run the 24-foot length of the garage through unheated space and then back to the furnace in the basement—often the longest duct run in the house. The thermostat is generally located in the family room on the first floor. So, controlled by calls for heat from the warm inside of the house, the furnace would struggle to heat the bonus room adequately even if the bonus room weren't leaky, poorly insulated, and exposed on five sides to outdoor temperatures.

Bonus-room conditions can get extreme. We've walked into older bonus rooms, built in the 1970s or 1980s, with built-in dresser cabinets added to the knee wall, projecting into the cold space. One occupant's main complaint was frosty underwear on winter mornings. Homeowners in these situations aren't focused on their heating and cooling bills. They don't care what it costs, or how much they will save; they just want to be comfortable.



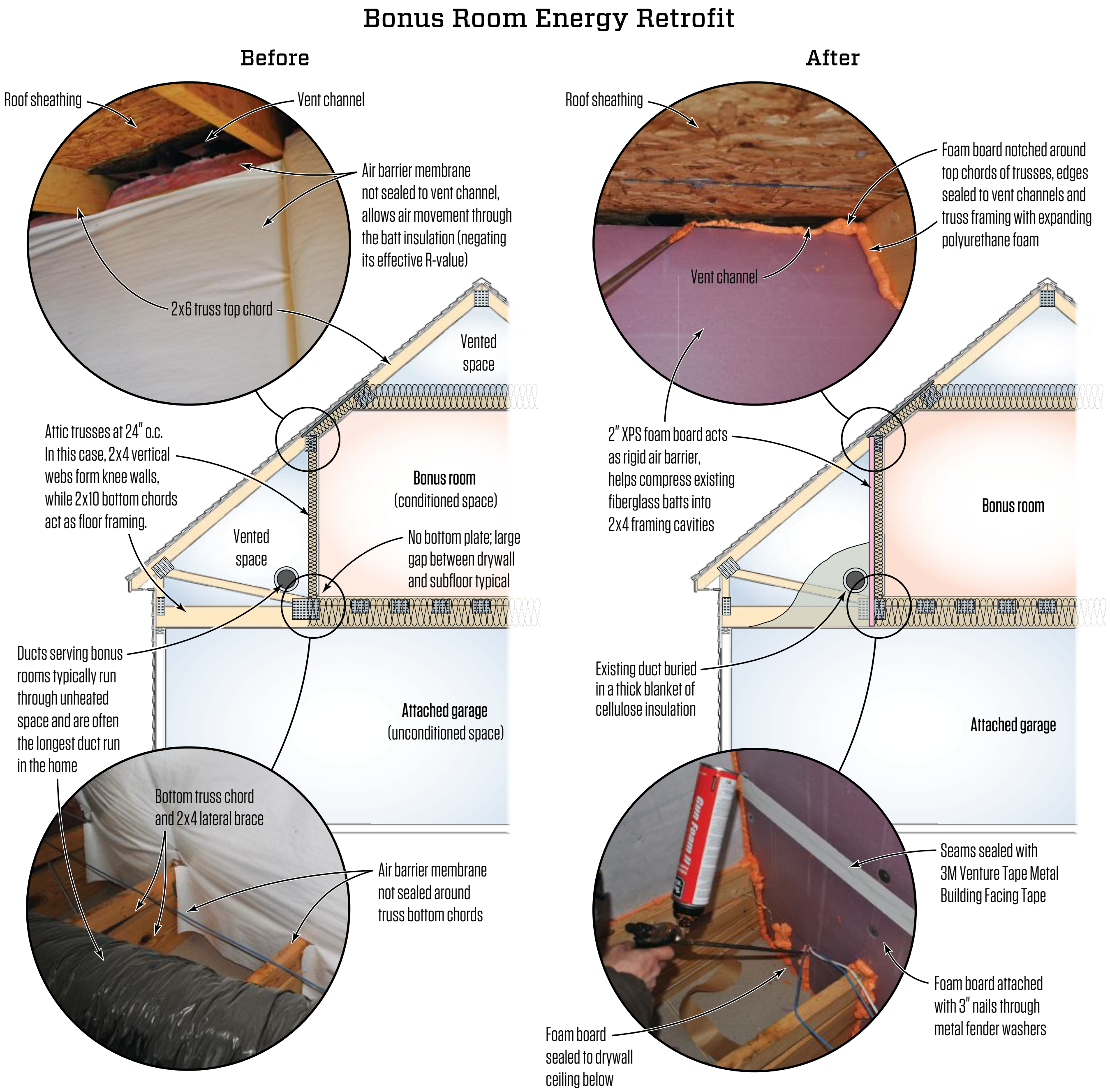
Working from outside, a carpenter cuts into unheated space above the garage next to the bonus room **(5)**. Under the low roof, he finds the back of the bonus-room wall **(6)**, with a plastic air barrier stapled to the wall over the fiberglass insulation (but not sealed at the top or the bottom). With the plastic removed, the R-19 batts bulge out beyond the 2x4 framing **(7)**. Where the wall meets the floor, nothing blocks air from flowing through fiberglass batts installed under the subfloor **(8)**.

CUTTING IN

Before we start a job like this, I look in the bonus room to make sure that there aren't valuable things hanging on the walls. We are going to be nailing up an air barrier from the other side and don't want to knock anything off the wall. I also find out where the duct registers are, so that we'll have an idea of what to expect when we open up the space behind the wall. And finally, I like to double-check the room dimensions to make sure that when we cut open the gable end of the house, we won't cut into the occupied space. I take a measurement from the window to the knee wall inside the room, and then we measure off the same window when we choose a place to cut open the gable end.

Gaining entry through the gable end is the simplest approach. We could cut through the drywall from inside the room, or we could go in through the ceiling of the garage, but then it would be hard to patch up the holes we would make. Vinyl siding just unzips; then you take a couple of nails out and peel back the housewrap, cut out a piece of sheathing, and climb in. On the way out (see photos, page 64), you replace the sheathing, tape up the housewrap, rehang the vinyl, and move along.

What we found in the space behind the bonus-room knee wall in this house is typical (see photos, above). The white plastic air barrier is not sealed at the bottom or the top. With the plastic sheeting removed, the R-19 fiberglass insulation bulges out from the 2x4 wall framing cavities. When I fold back that kraft-faced wall insulation at the bottom, we see the condition under the floor: two insulation batts stuffed up into the truss bays from below, with the lowermost batt's kraft facing stapled to the truss sides to hold the insulation in place. And it's a little hard to see in these photos, but the joint between the subfloor and the drywall is open half an inch, as in photo 3 on the facing page—and there's daylight between the baseboard and the carpet.



As originally built (above left), the bonus room's air barrier allowed free airflow through the fiberglass insulation under the floor and in the walls. The author's repair (above right) created a rigid air barrier that air-sealed the living space, protected the floor and wall insulation from air infiltration, and boosted the wall system's nominal insulation value from R-19 to R-24.

Above, carpenters notch and fit 2-inch XPS insulation board over the wall studs, fastening the board with nails and washers as they compress the R-19 batts into the wall framing cavities **(9)**. They cover the whole wall with 2-inch (R-10) XPS, notching around the upper truss chords at the top of the wall **(10)**. They seal the foam board to the framing with gun foam, sealing duct penetrations at the same time **(11)**. Finally, they tape the seams between sheets of foam board to perfect the airtight seal **(12)**.

CREATING AN AIR BARRIER

On the left side of the illustration on the facing page, you can see the deficiencies that made this room so uncomfortable; on the right are the repairs that our crew made. When the original plastic air barrier membrane was installed, somebody took time to notch it out around the bottom chords of the trusses—but it was never sealed. Our goal was to seal our air barrier all the way around the truss chords and seal it to the drywall underneath.

Fabric wraps are difficult to work with, so we like to use a beefy rigid air barrier material here. For this job, we used 2-inch XPS foam, which adds R-value and is stiff enough to compress the existing R-19 batts into the 2x4 wall cavities (note: some jurisdictions may require a fire-rated material such as Dow Thermax at this location).

We notched the XPS out carefully to fit around the trusses, making sure the board contacted the drywall at the bottom of the truss cavity, and attached the boards with 3-inch nails and washers, which we have found give a better positive attachment than ordinary cap nails.

Compressing the R-19 batts into the 2x4 cavity gives an effective R-value of R-14; in new construction, a high-density R-15 batt would cost less and perform better. But with the XPS, our retrofit still achieves a nominal R-24. And by abating the convection and thermal bridging that had reduced the effectiveness of the original R-19 batts, our upgrade substantially boosts the wall's performance.

At the top of the wall, the existing air barrier membrane was never sealed to the vent channel installed under the roof sheathing—again, exposing the fiberglass to wind-washing. So when we notch the foam board around the top chords of the trusses, we seal the edges to the vent channel as well as to the trusses.

Finally, we seal the seams between the pieces of foam board using 3M Venture Tape Metal Building Facing Tape, which clings tenaciously and is much cheaper than some specialty tapes.

With the new foam-board air barrier in place and sealed with gun foam and tape, the crew augments the insulation wrap on the flexible heating duct with an additional 10-inch blanket of blown cellulose **(13, 14)**. Then the carpenters nail the cut-out section of wall sheathing back in place, and reattach the housewrap and seal the seams with tape **(15)**. Finally, they replace the vinyl siding **(16)**, leaving no visible trace that any repair ever happened.

A BLANKET FOR THE DUCTWORK

As I mentioned earlier, the ductwork for a bonus room tends to be the longest duct run in the home, and it's usually only insulated to R-4.2. The airflow in the ducts suffers from friction losses, and the air loses heat to the cold attic space as it makes its way to the room. So after we seal up the insulated air barrier for the bonus-room knee wall, we install a thick blanket of cellulose insulation around the duct. This helps keep the supply air coming into the room nice and warm. We put about 10 inches of insulation on all sides of the duct—including below it—for a good R-30 to R-40.

With that done, all we have to do is go back out through the hole in the wall, nail the OSB sheathing back in place, staple the housewrap back onto the wall, and tape the housewrap seams. Then we reattach the vinyl siding, and we're done. It's a one-day job; start to finish, the whole job typically takes about three hours for each side of the room.

So how could a builder avoid this callback? Well, the big problem is the air barrier, and the major flaw is the floor-to-wall joint. So when the subfloor and the drywall are both installed, but before trim or carpet are installed, one good step would be to air-seal that joint with a can of gun foam—or better yet, with tape. Blocking nailed between the trusses behind the drywall at the wall base, to make up for the missing wall plate, would also help.

If you are hoping to meet an above-code standard or to surpass code-required insulation and airtightness levels in this relatively vulnerable room, there's another option: Specify a truss with a shorter knee wall, and frame a whole separate wall inboard of that for your room. That way, you'll have room for more insulation than an R-19 batt.

Certified Passive House Consultant and HERS rater Matt Bowers works for Airtight Services, in Marion, N.Y.

Products

BY LAUREN SHANESY

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1. Easy-to-Install Rafter Hanger
Simpson Strong-Tie is making roof framing easier with the LSSJ field-adjustable jack-rafter hanger, which has a hinged seat that adjusts to typical rafter slopes and connects rafters to hip or valley beams. The gripper seat frees up a hand for the installer at the time of attachment, and the hanger attaches to the open side of the jack rafter for easier fastener placement. The LSSJ is sold in two versions and is available in three sizes. Pricing varies. strongtie.com/lssj

2. High-Performance and Sustainable Siding
Boral TruExterior's 8- and 10-inch Bevel Siding is made from 70% recycled content and a blend of polymers and fly ash. The material offers reduced expansion and contraction and resists warping, cracking, and splitting. In the field, the siding requires no sealing of ends or cuts and installs with standard woodworking tools. The bevel profile resembles wood, with a true taper and deep shadow lines. Pricing varies by size from $3 to $4.50 per square foot. boraltruexterior.com

3. The First Auto-Calibrated Level
Ready to measure as soon as they're powered on, the e105 Series True Blue Digital Box Levels from Empire Level are the first auto-calibrated digital levels on the market. The levels, which are available in magnetic and nonmagnetic models, have seven measuring display modes, an audio indicator that outputs a continuous tone when in level, a hold function that allows the user to lock measurements, a top-read digital display, and a tilt indicator. The levels range in price from $100 to $200, depending on the model. empirelevel.com/digital-levels

4. A New Type of Flooring Material
Armstrong Flooring has released a new flooring material that it says is waterproof and dent-proof. Pryzm is constructed from a thermal plastic core and a cork pad with a durable AC4 commercial-grade layer on top to protect from scratches, spills, stains, fading, scrapes, and dents caused by the weight of appliances. The planks lock together for easy installation and require no acclimation time, and they come in 48-inch lengths, allowing for installation in large areas without the need for transition strips. The flooring costs approximately $5 to $6 per square foot. armstrongflooring.com

5. A Smart Touch-Screen Thermostat

The new Champion touch-screen residential thermostat from Johnson Controls is a smart system that communicates with both conventional and connected Champion HVAC systems. Homeowners can control the system through the touch-screen hub or on a smartphone app. A quick-heat and quick-cool feature for short-term, high-capacity heating or cooling helps the system reach set points more quickly and is optimized to provide Energy Star Most Efficient performance. When maintenance is required, the thermostat sends alerts to the homeowner and can also connect homeowners directly with contractors through the app. Pricing is currently unavailable. championhomecomfort.com/lxseries

6. Air Sealant for the Smallest Gaps

Tytan Fill All insulating foam sealant from Selena USA fills both small and large gaps—from 1/4 inch to 3 inches—eliminating the need to have multiple gap-specific products on hand. The sealant has less shrinkage than other products, offers a higher yield, and keeps its seal regardless of temperature, climate, and construction changes, according to the company. It may be cut after 60 minutes, cures in six hours, and is fully cured in 24 hours. A 12-ounce can is priced at $5. tytan.com

7. A Shower With Increased Accessibility

Bestbath's 60-inch-by-60-inch universal design shower provides increased accessibility for users who have less mobility. The multipiece shower installs with Bestbath's new SpringClip wall system, which the company says offers faster and easier installation. The 90-degree corners create a watertight connection, and the wood-backed walls allow grab bars to be installed at a later date. The shower is available in eight configurations, including a two-wall corner shower. Price is $4,300. bestbath.com

8. A Wi-Fi-Enabled Smoke and CO Alarm

The Onelink by First Alert from BRK Brands is a two-in-one alarm system equipped with both photoelectric and electrochemical sensors to detect smoke and carbon monoxide. The smart system can alert homeowners via a smartphone app as well as with an audible voice alarm, and it can contact help directly through the app when an alarm notification is received. It's also compatible with non-Wi-Fi interconnected hardwired alarms. Pricing is unavailable. brkelectronics.com

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9. A Kitchen Range Hood for Small Spaces
Part of a new line of appliances designed for small kitchens, the 24-inch Slanted Chimney Vent from Haier is a high-powered kitchen range hood with a small footprint. The vent features a 450-cfm motor with four speeds and a recirculating option to remove smoke and grease. The three-layer grease filter can be easily removed and is washable. The hood also has two halogen lamps and electronic touch controls. It comes in a black glass finish and retails for $600. haieramerica.com

10. A Push-to-Connect PEX Plumbing System
SharkBite Plumbing has introduced a PEX pipe plumbing system that's designed to fit a variety of fittings, PEX pipe, outlet boxes, valves, and other accessories without the need for special tools, reducing installation time. The EvoPEX pieces are made from Acudel high-performance polymer and feature a green visual indicator to ensure that the fitting is properly connected. The system is safe to use on pipes with drinking water. Pricing varies. sharkbite.com

11. Revamped Cement-Board Screws
ITW Buildex has updated its Backer-On and Rock-On cement-board screws with a new serrated head for flush seating, even at angles, and for eliminating mushrooming and reducing board blowout, according to the manufacturer. With serrated thread forms, these new screws need less torque, for faster installation and increased holding power. The screws also feature T-25 star drive with "Stik-fit," which the company says allows for one-handed operation with no wear on the bit. The screws are coated in a corrosion-resistant finish. Pricing ranges from approximately $7 to $26, depending on screw size and quantity. itwbuildex.com

12. A Heavy-Duty Drainable Housewrap
Typar's Drainable Wrap has an integrated drainage plane that uses a layer of multidirectional polypropylene fibers to divert water from exterior wall cavities and drain it away from the assembly, allowing the system to divert more bulk water than traditional housewraps, according to the company. The wrap protects against damage, such as mold and rot, caused by trapped water and meets current code requirements per ASTM E2273. The integrated system reduces labor, because it can be installed without strips and extra pieces. Pricing varies. typar.com

BY CHRIS ERMIDES

A Dustless Dry-Cutting Tile Saw

Waterless cutting. It looks like a traditional tile saw, without the mess. The sliding table accommodates 24-inch-long tile, and has a built-in extension arm that pulls out to the right for holding wider tiles. At this time, the saw does not bevel. Saw and stand sold separately.

At the World of Concrete show recently, I walked by iQ Power Tools just as one of its representatives was cutting tile—inside, on a carpeted surface, without a dust mask or hose hookup, on a full-sized tile saw. We've covered some of iQ's products in the past, including a dust-free masonry chop saw and a dust-collecting cut-off saw; the brand was blue and yellow back then. Now it's orange and gray—almost the same color scheme as Husqvarna, which is why it initially caught my eye.

The new saw (iQTS244), released in February, is completely dustless thanks to an integral vacuum that includes a multi-stage cyclonic filtration system and dust collection tray. It requires a specialized 10-inch blade, which is included, that cuts porcelain, marble, granite, ceramic, and stone. According to the manufacturer, blade life is similar to what you would expect from a good-quality wet-cutting blade.

HOW THE DUST COLLECTION WORKS

Dust is pulled through a slot beneath the cut, then captured first by the cyclonic filtration system, which sits just below the saw's sled, while the rest falls into a tray that sits under the saw (see photo, page 70). After about 500 lineal feet of cutting, you spin the filter, which shakes the captured dust and dumps it onto the tray. Pull the tray out, empty it, and reinstall it, and you're ready to continue. A replacement filter runs about $90 and is expected to last up to one year with daily use. The built-in vacuum serves two functions: It cools the blade throughout the cut, and it removes debris from the kerf so the blade isn't grinding that material.

The saw has a 24-inch cutting capacity at 90 degrees. A proprietary, specially shaped arbor holds the blade—presumably ensuring you won't use a wet-saw blade, which would render the integral dust collection system virtually useless. The specialized blades are designed to stay cool while dry-cutting—a technology that iQ Power Tools has used in its other masonry saws. A replacement blade will run you $100. Currently, the saw will not bevel, but the manufacturer says a bevel-cutting attachment will be available later this year.

The saw (with one blade) sells for $1,590. It has a 10-foot cord, two wheels, and a handle built into the

The filtration system sits just below the iQTS244 tile saw's sled.

cage-design of the main housing so it can be moved around like a piece of large luggage. A folding stand sells separately for $150.

It's a hefty price tag—but the manufacturer is banking on the saw's convenience. You can use it inside and not worry about tarps, water, and slurry, and you never have to deal with a clogged pump or emptying and cleaning a reservoir. If you do a lot of tile work, it might be worth a closer look—especially if you often work on second-floor bathrooms and have to set up your saw outside. The time you'll save not walking up and down the stairs alone could be worth the money. iqpowertools.com

Flir Upgrades Two IR Cameras for Remodelers

Flir recently introduced several new thermal imaging cameras, two of which are new generations of previous models.

The new C3 (see photo, bottom right) looks like and functions similarly to the C2, which Doug Horgan reviewed for *JLC* (see "New Infrared Options for Remodelers," Jun/15). Like its predecessor, the C3 is a pocket-sized, touch-screen unit that combines a visual camera with an IR imager. Both have a thermal resolution of 80x60 and let you save infrared and visual images at the same time. These cameras also have a function that Flir calls "MSX" overlay—a view that combines the IR image with faint lines outlining objects and patterns from the visual image. According to Horgan, the MSX image provides a clear representation of the captured area, along with the thermal information you need. The C3 has other functions as well, like Wi-Fi connectivity through the Flir Tools App—letting you mirror whatever you're capturing onto your phone or tablet—and the ability to locate the lowest or highest temperature within a chosen area on the screen. The C3 sells for $700; the C2 is now available for $500.

If neither of those options is in your budget, you might consider the third-generation FlirOne—also available in a new Pro model. Like the C2 and C3, both FlirOne models provide visual and IR images along with the MSX overlay. Both options also have a new adjustable-height connector, which is meant to adapt the fit for most phone and tablet cases on the market. The visual image output resolution for both cameras is 1440x1080. The standard FlirOne has a thermal resolution of 80x60 and will cost $200. The FlirOne Pro has a thermal resolution of 160x120 and will cost $400. flir.com

Chris Ermides is a senior editor at JLC.

IR camera upgrades. The FlirOne (left) and FlirOne Pro feature an adjustable-height connector to adapt to most phone and tablet cases. The Pro has better thermal resolution than the standard version. The C3 (below) has many of the same features as the C2, as well as Wi-Fi connectivity and more customizable options.

Product Literature / Classifieds

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BY TED CUSHMAN

Learning by Doing

Yestermorrow Design/Build School, located in rural Waitsfield, Vt., is many things to many people. The organization is perhaps best known as a place for handy owner-builders to pick up the trade skills and design methods they need to craft their own personalized homes or additions. It also has a reputation as a reality check for architecture students, where they can get their hands dirty on a real construction project and learn how to tether their imaginations to an actual jobsite that's constrained by the hard truths of real materials and labor.

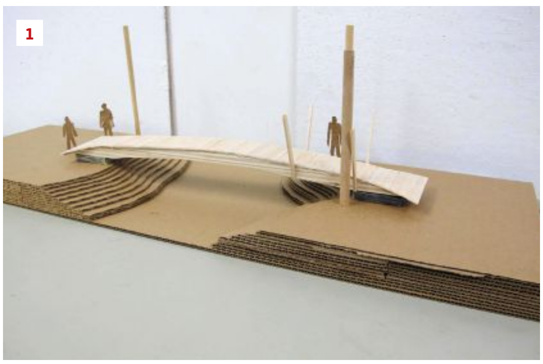
But you might not think of Yestermorrow as a place where an experienced contractor or tradesperson can take a few days to hone his skills and broaden his capabilities. However, that's exactly what the school is to Mike Horgan (horgandesignbuild.com), a builder and remodeler based on Cape Cod in Massachusetts.

Horgan has spent years running a busy company. When the opportunity arises, he told *JLC* recently, he'll gladly take a trip up to Yestermorrow between jobs for a design-build exercise that's part fun and part learning—like the arched footbridge over a brook pictured on this page.

In an email, Horgan told *JLC*: "My buddy Ryan Adanalian is an architect working for Board and Vellum out in Seattle. We got to be friends when we did a timber-framing workshop at Yestermorrow a few years earlier. Ryan emailed me out of the blue one day and said he was going to take a vacation and hit Yestermorrow for a little workshop, and that I should cruise up and do it too.

"It turned out to be a community design-build workshop with Steve Badanes and the Jersey Devils. I am a huge fan of those guys. So I cruised up to Vermont, hung out with the Devils day and night for two weeks straight, and learned everything I could possibly glean from them over that time period. We designed in the studio and built that bridge largely in the parking lot. We did the install, and then the next day they were having a party to commemorate it ... but I had to get home, because I had a foundation to pour.

"It was intense. It's a design-build challenge; you don't have any idea of what you're doing until you arrive the first day, visit the site that's been donated, and immediately begin the charrette. You stay up day and night non-stop for two weeks, designing and then building. I love it."



(1) A conceptual model from the charrette; (2) Truss-wrestling exercise; (3) The finished project graces a Vermont meadow and woods.

Photos by Mike Horgan and Ryan Adanalian

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