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Get the timber-frame look for less with this smart framing approach p. 36

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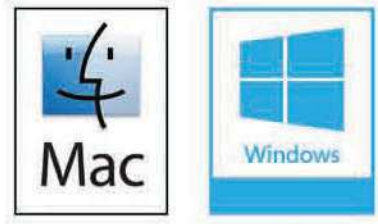

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TOP CORDLESS SAWS

People can't keep their hands off it. Should we tell them it's a touchless faucet?

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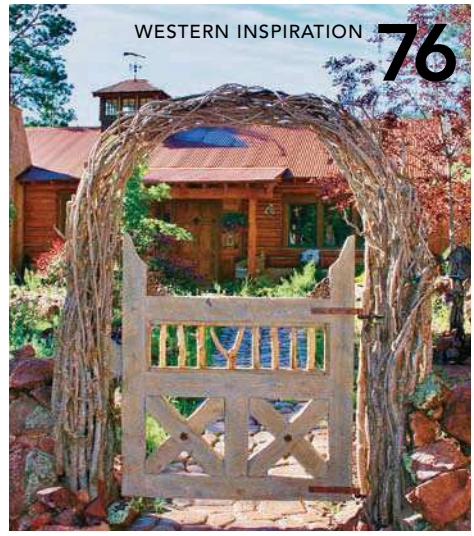

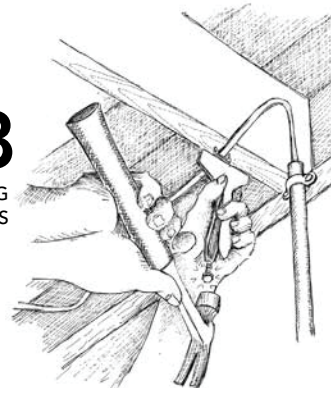

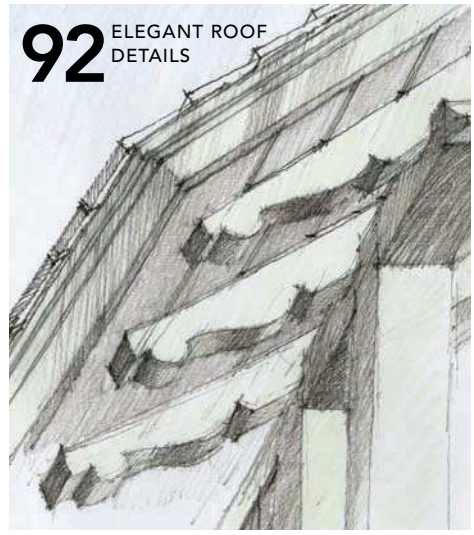

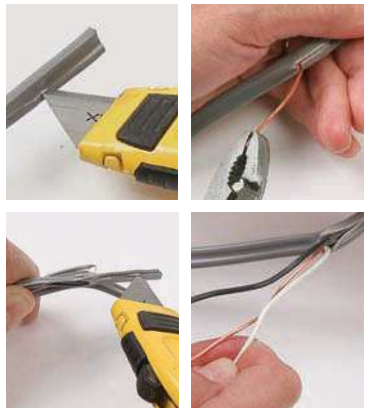

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Inspiration for hands-on living®

ON THE COVER: Custom builder Sam Koerber has developed a method for integrating structural solid-sawn timbers into an otherwise conventional stick-frame house. Photo by Justin Fink.

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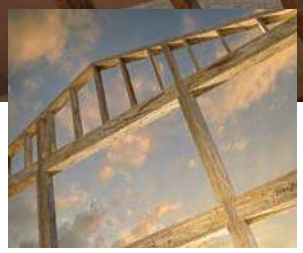

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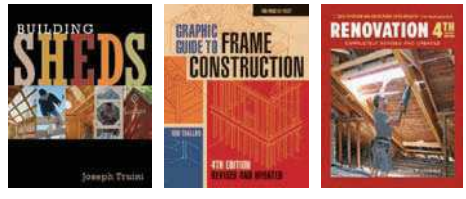

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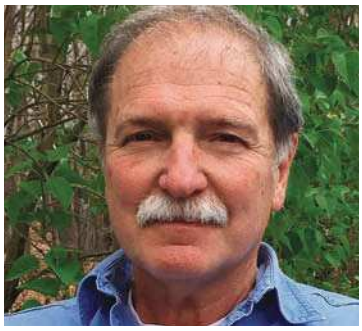

GREG SOPER (“Rolling Barn-style Doors,” pp. 52-53) graduated from Middlebury College in 1974 with no plans for a career but with a lifelong interest in making things. After working at a small cabinet shop for two years, he and a coworker started a renovation company in Belmont, Mass. After moving to North Yarmouth, Maine, in 1989, he hung up his nail apron and instead focused on building high-end cabinetry for custom home builders in the Portland area.

DAVID FRANE (“18v Recip Saws,” pp. 49-51) has built boats and worked as a finish carpenter, furniture maker, site foreman, and millwork-shop superintendent. In recent years, he has been an editor at tool and construction magazines. He currently writes from his home in Alamo, Calif., but he looks for any excuse to escape from the office to wander the aisles of tool stores, use woodworking machinery, and repair things with duct tape and baling wire.

JAMES GLASS is a general contractor from Blacksburg, Va. His work includes custom concrete countertops, custom fixtures, and high-quality, energy-efficient renovations. James is keenly interested in elegant solutions for mechanical systems that are often hastily installed, so he has developed better installation techniques for structured media, electrical, and plumbing systems. One such system for a plumbing manifold can be found on pp. 42-43.

During childhood, **JOE FILANOWSKI JR.** (“Custom Curves,” pp. 44-48) began making things with wood scraps his father produced while carving decoy ducks. Years later, with training from a vocational-technical school in his hometown of Milford, Conn., he began work as a carpenter. After spending over a decade in the field, Joe was ready to start his own business, so he teamed up with one of his grammar-school friends to establish J&J Custom Builders.

write an article

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letters

READER FEEDBACK

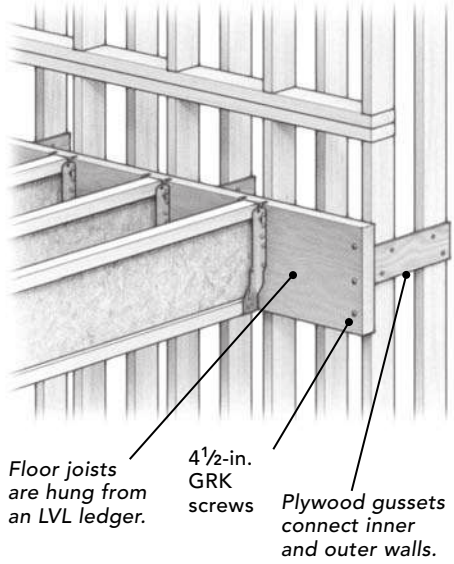
IN THE SPOTLIGHT

Balloon framing reconsidered

In "Bringing Back Balloon-Frame Construction" (*FHB* #260), Paul Biebel is quite right when he says that "continuous eave-wall studs eliminate the structural hinge point of short upper-story stud walls, offering better resistance against outward force of the roof rafters above." What he fails to mention is that part of this resistance is attributable to the floor joists, which act as rafter ties. The use of a ledger to carry the floor joists as detailed is a questionable technique. I'm sure he has had an engineer sign off on his approach, but I believe that joists should be installed only between eave walls and that if a ledger is used, there needs to be a robust connection between the joists and the stud walls—that is, fasteners and hardware more substantial than just framing nails.

—STEVEN ALBERNAZ
via email

Author Paul Biebel replies: I agree with you, Steven. My preference is to run joists perpendicular to trusses and rafters, but the owner of the home in the article requested an open plan that required us to build the floor assembly as we did. Perhaps these details weren't clear in the article, but we take several steps to reinforce the ledger attachment. We install a plywood gusset to studs at equal intervals to connect the two walls together behind the ledger. Then we fasten the ledger to each stud with three 4½-in. GRK screws instead of framing nails. When required, we also sometimes use a hurricane tie that attaches to the plywood gusset and the ledger. Once the subfloor is glued and screwed down, it also contributes to the strength of the entire assembly.



Drawing: Christopher Mills

What about the weeds?

I enjoyed reading your article "Long-lasting Gravel Driveways" in the June/July issue (*FHB* #260), but it totally omitted methods of preventing weeds from coming up through the base layer and growing in the dirt, dust, and decaying leaves that accumulate on top of the gravel.

In my case, water runoff from the driveway flows down to the well house, so I can't use a ground sterilizer chemical on the driveway without poisoning myself.

—CLAYTON CHINN
via email

Author David Crosby replies: This is a first-rate illustration of how all of our decisions in the built environment are connected, and kudos to you for recognizing the importance of

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—ROB YAGID
editor

managing runoff and the dangers of herbicides.

Aggregate base course (ABC) by itself doesn't work very well as a growth medium, but if weeds are a concern, a layer of geotextile under the ABC helps to minimize the growth of plants from the underlying soil. If regular cleaning of dirt, dust, debris, leaves, and other accumulations from the driveway surface is necessary, then paving should be considered as an alternative.

Regarding the issue of runoff and the well house, consider installing some modest retention strategies for the surface flow between the driveway and the well house. Not only are herbicides dangerous in certain concentrations, but so are many of the other chemicals that run off a driveway.

Deck-stair details

My very first issue of *Fine Homebuilding* was #81 (April/May 1993). Since then, many issues have outlined methods to build exterior structures that last. Three such methods are minimizing wood-to-wood contact that can trap moisture, painting or treating all six sides of wood elements, and ventilating adequately.

So I was surprised to see the article "Stronger, Smarter Deck Stairs" in the April/May issue (*FHB* #258), which didn't address any of these details. In my opinion, all three principles are always critical. The article totally ignores two of the three, and the recommended ventilation strategy seems inadequate. To me, the article suggests speed of construction, rather than durability, as its focus.

—MARK LEJA
via email

Minisplit aesthetics

I just read your recent article on installing a minisplit heat pump (*FHB* #258) with great interest. I have an older home (1949) with an old gas wall furnace. This works fine for now, but we are planning on remodeling and expanding the house. The old furnace will not do the job, and I find these ductless minisplit heat pumps to be intriguing except for one issue: They are a bit ugly to look at. Are there any minisplit mounting options that are more visually appealing?

—DOUG LA PORTE
San Jose, Calif.

Senior editor Andy Engel replies: There is no elegant way of completely concealing the head of a ductless minisplit without impacting the manufacturer's installation requirements and the unit's performance. There are, however, ducted versions of minisplits that could be a solution for you in such an extensive remodel. Such systems are far less visually intrusive than their ductless counterparts.

Spray carefully. *If you're working around surfaces to be finished, silicone-based lubricant isn't the best option.*

Prevent failed finishes

The comparison of spray lubricants in the June/July issue (*FHB* #260, p. 26) failed to point out a critical flaw with silicone-based sprays. Readers should know that silicone-based lubricants can easily contaminate surfaces and compromise the adhesion of a finish to that surface, making finishing or refinishing work a nightmare. So spray carefully, or choose an alternative lubricant to use around work that is to be finished.

—ERIC JOHNSEN
via email

Email your own letter to us at FH@taunton.com.

Photo: Patrick McCombe

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tips&techniques

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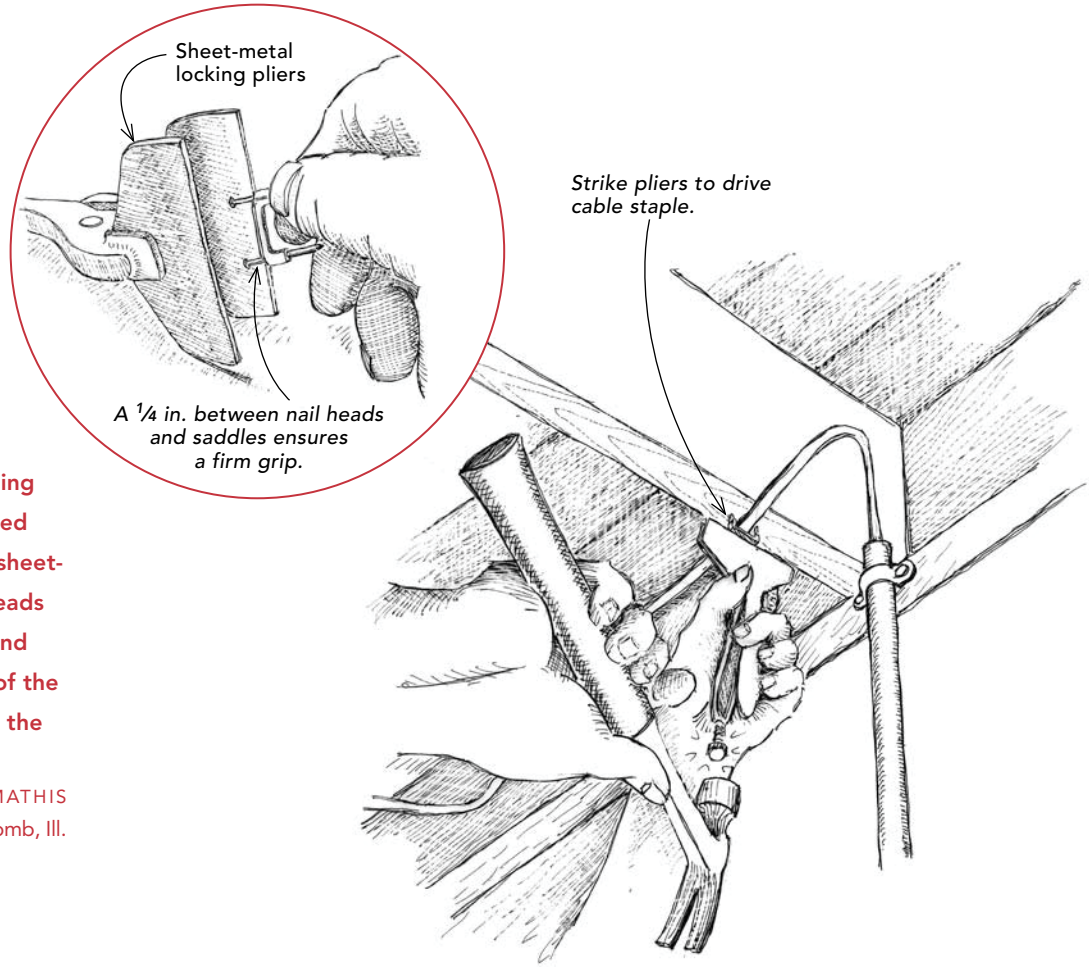
Starting a staple in a tough place

Insulated cable staples can be hard to start. Or maybe it's because you're trying to hold a staple and swing a hammer without hitting a finger. Recently, I was wishing for a staple holder, and then I realized that I had one right on the job: my sheet-metal locking pliers. I backed the heads of the staple nails out about ¼ in. and clamped the nail heads in the jaws of the pliers. This made it easy to straddle the wire and start the staple.

—DON MATHIS
Macomb, Ill.



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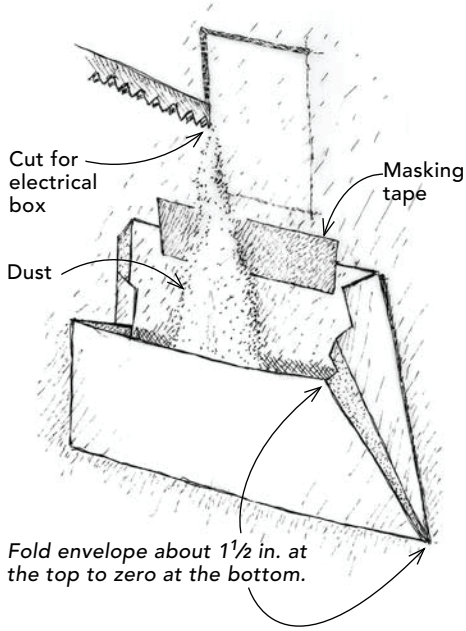

Drywall without the dust

Need to drill a hole in existing drywall or to cut an opening for an electrical box? Eliminate dust cleanup altogether by taking a business envelope, folding a dart in each end so that the envelope stays open, and using some masking tape to stick the envelope to the wall just below where you'll be cutting (drawing left). Any drywall dust that's generated during drilling or cutting falls into the open envelope.

—BERNIE VAN WORMER
LaPorte, Ind.

Five-chisel storage

For storing the few sharp chisels I need to carry in my tool bag, I find that an old leather winter glove works great. It also works well for small saws or specialty cutting tools.

—CONNOR WARNECK
Royal Oak, Mich.

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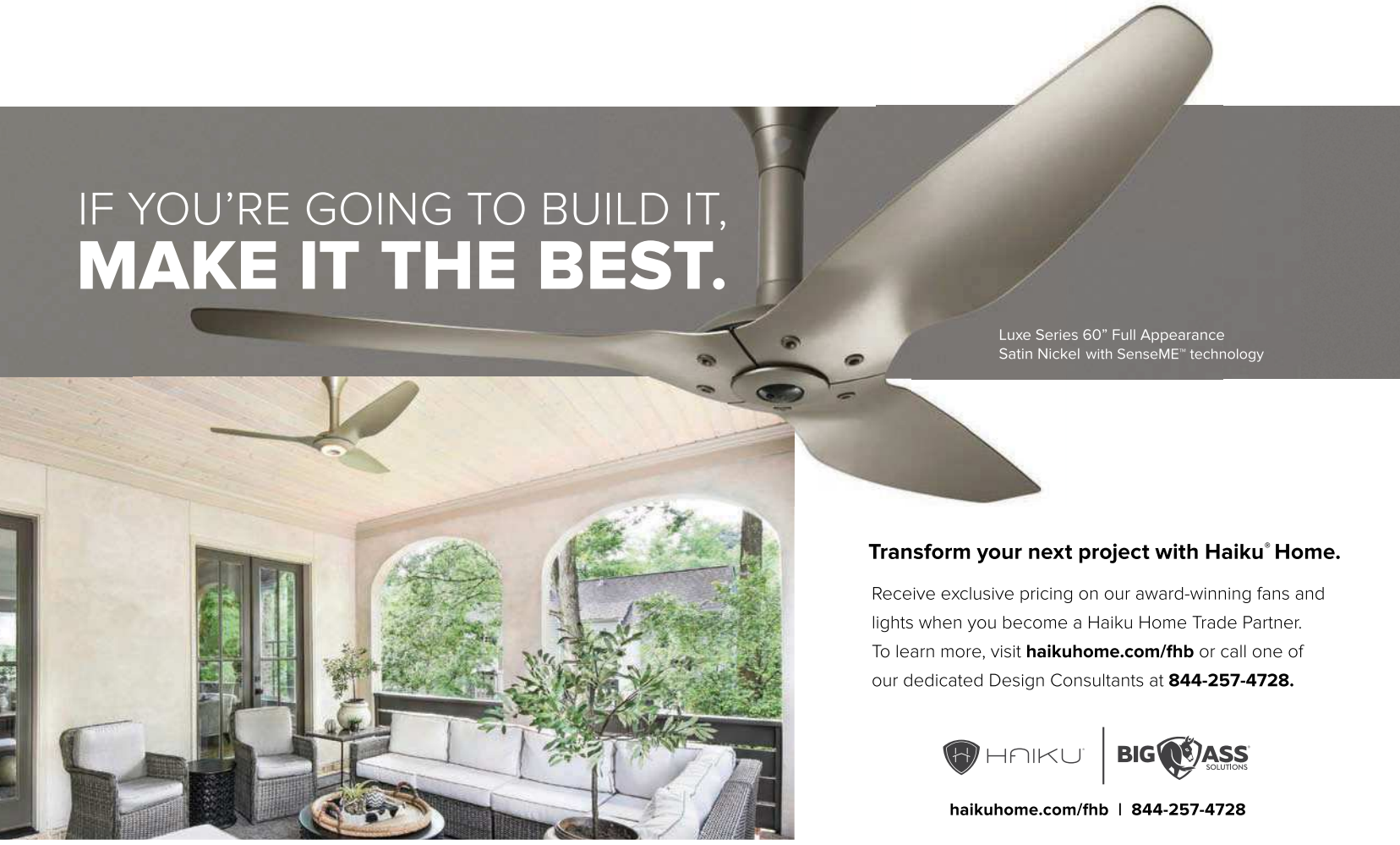

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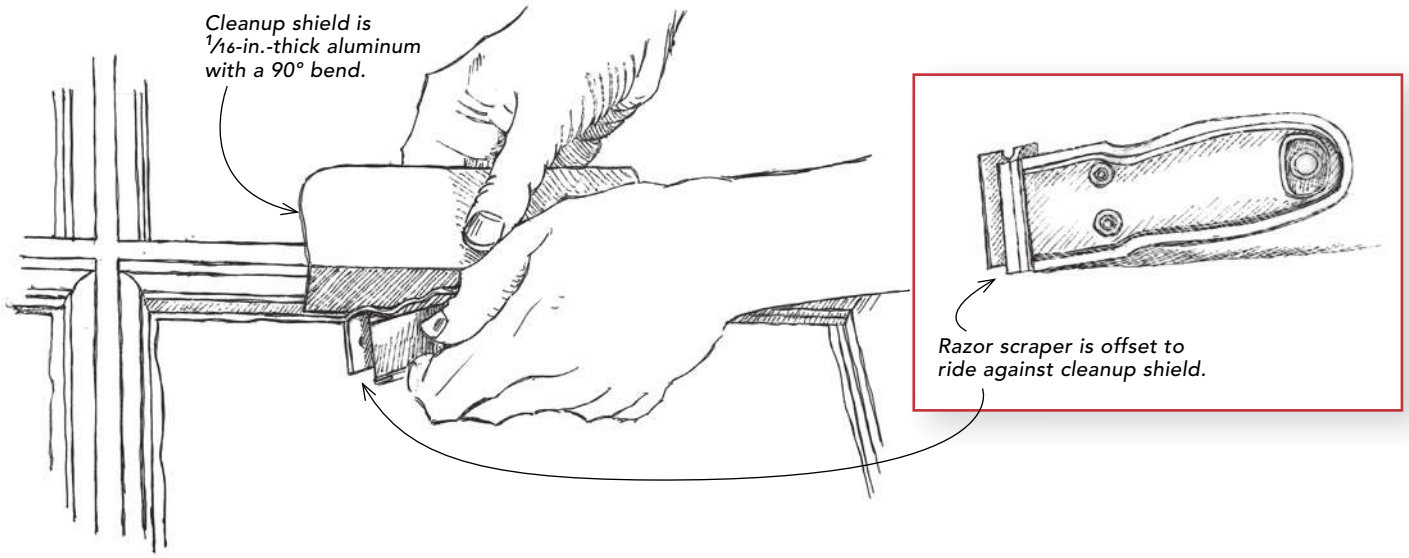
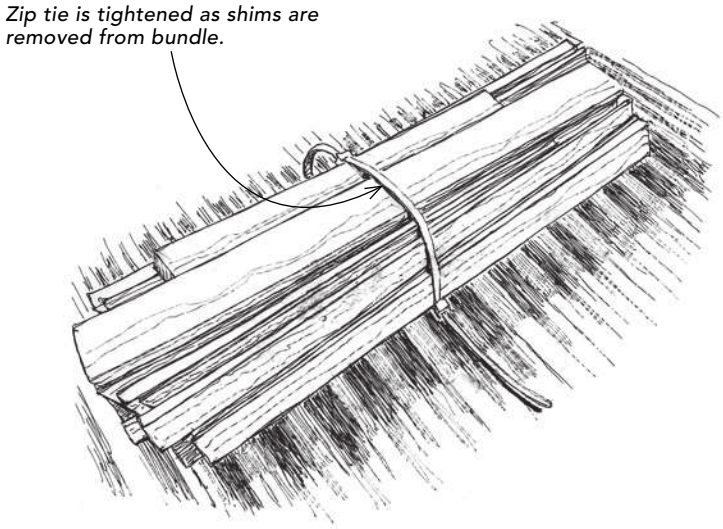


Painting doors with windows

Many manufacturers of wooden doors ask that the finish paint lap 1/16 in. onto any glass surfaces exposed to weather. This prevents moisture from penetrating the joint between glass and wood. Painters can do this all day, but not me, so I made a cleanup shield from a scrap of aluminum 1/16 in. thick. I painted generously onto the glass and let the paint dry. Then, as shown in the drawing above, I held the shield against the wood and used a razor scraper to remove the excess paint, leaving a clean 1/16-in. layer of paint along the glass.

—BILL HOUGHTON
Sebastopol, Calif.



Cleaning glass without lint

To clean a window or mirror without leaving a trail of lint behind, keep the rag moving in a smooth circular motion, not back and forth. Changing direction is what breaks off the tiny fibers that become lint. Even starting and stopping creates lint. See this for yourself by squirting a small spot with cleaner, then scrubbing it back and forth with a paper towel. You'll soon see a little pile of lint right where you changed direction.

It doesn't matter whether you use paper towels, cloth towels, or old T-shirts. (I like to use paper towels and to add a single dry sheet to the wad as necessary.) Just keep moving in smooth circles, always in the same direction. Forget about expensive window-cleaning solutions; a quarter-cup of white vinegar in a quart spray bottle full of clean water works better than anything I have found. To avoid streaks, clean a small area with the damp towel, then polish it with a dry one before the streaks have a chance to dry on their own.

—GARY WILLIAMS
Campo, Calif.

Neatly bundled shims

As shown in the drawing at left, I keep shims neatly bundled by using long zip ties. As I take out shims, I tighten the zip tie to keep the bundle nice and snug.

—DANTE RAMARUI
Rockville, Md.

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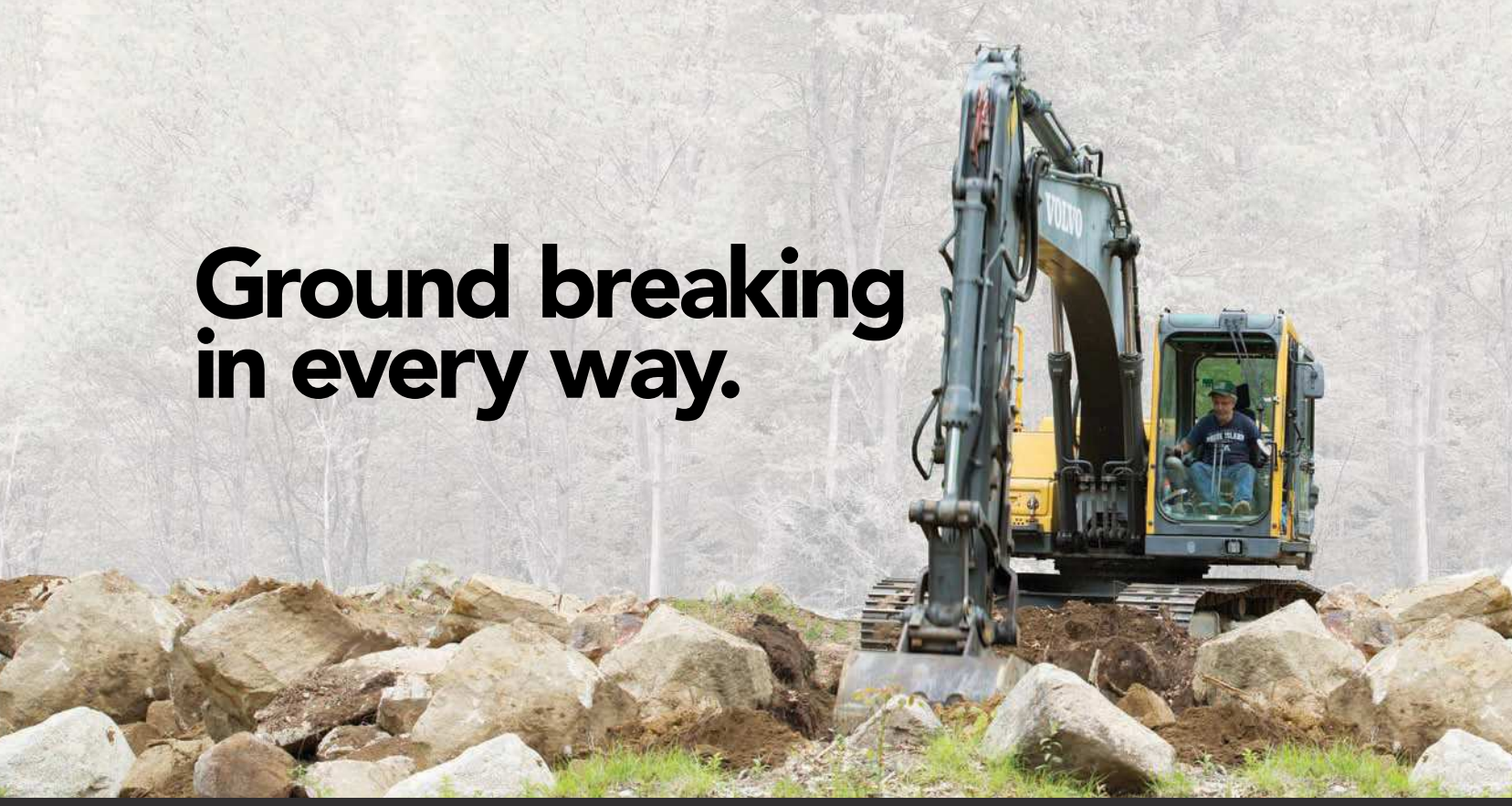

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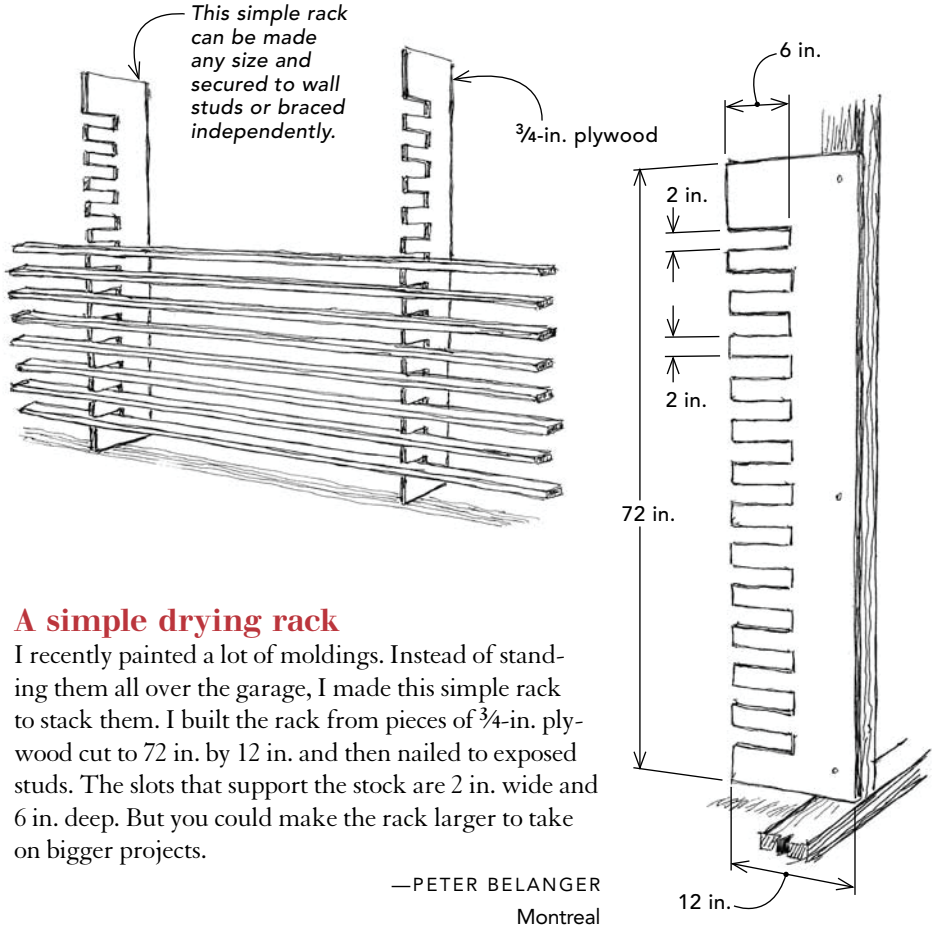


A simple drying rack

I recently painted a lot of moldings. Instead of standing them all over the garage, I made this simple rack to stack them. I built the rack from pieces of ¾-in. plywood cut to 72 in. by 12 in. and then nailed to exposed studs. The slots that support the stock are 2 in. wide and 6 in. deep. But you could make the rack larger to take on bigger projects.

—PETER BELANGER
Montreal

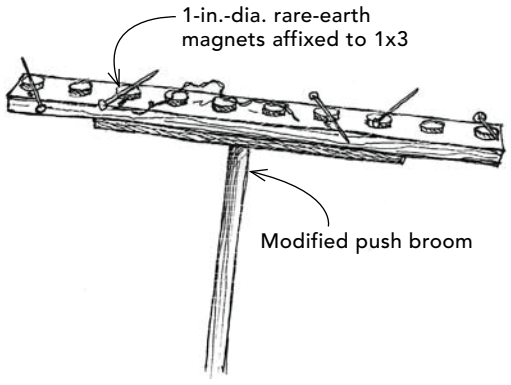
ISSUE 180 // 2006

TIP FROM THE ARCHIVES

Magnetic broom

If you've ever had to pick up the nails littering the ground after tearing off an old roof or to snag the bits of metal that can accumulate on a job site, this broom is for you. As shown in the drawing, I modified a defunct push broom by affixing a 1x3 to the broom's head. To this 1x3, I attached 10 1-in.-dia. rare-earth magnets (leevalley.com). These magnets are astonishingly strong; each one can lift a 30-lb. block of steel. The magnets fit into steel cups (also available from Lee Valley) that are screwed to the 1x3.

—MIKE NATHAN
Hailey, Idaho



STEEL SPECIALIST

I build custom decks in Colorado. Because of a steady decrease in lumber quality and the devastating effects to wood caused by the state's dry, sunny weather, I decided to switch to light-gauge steel deck framing in 2009. With that change came the challenge of cutting the 12-ga. to 16-ga. framing material. At first, I made cuts with abrasive blades mounted in a worm-drive circular saw, but this type of blade wears down quickly. I then switched to Diablo Steel Demon sawblades, which last longer and cut more efficiently. Unfortunately, the flying metal chips went everywhere. In addition to safety glasses, I had to start wearing a face shield and welding sleeves (for keeping the hot, sharp, metal shrapnel off my arms).

Skilsaw has released a promising solution to cutting steel on the job site, and I had the opportunity to try one on several of my steel-framed decks. Dubbed the Outlaw ($169), this worm-drive saw comes equipped with an 8¼-in. Diablo Steel Demon blade and a metal guard that fully encloses the upper part of the blade and that is easy to remove and to empty (you will be surprised at how much debris it collects). The oversize guard somewhat obstructs the view of the blade's path, but a glass window in the guard and good markings on the saw's baseplate make it easy enough to follow a line. I especially like how you can easily retract the lower guard from the top handle to prevent the guard from hanging up on thinner material.

The saw's maximum depth of cut is 2¾ in., and adjustments are quick and easy to make. One downside is that this saw doesn't have a bevel adjustment. A lot of people don't think a bevel adjustment is necessary for cutting metal, but I use the feature when cutting the ends of joists that meet the band joist at an angle other than 90°, such as on clipped corners of a deck.

Overall, I like this saw very much. The handle is comfortable, and all adjustments and controls are well laid out. The saw is a little heavy (13½ lb.), but it wasn't overly tiring to use. It has good power and appears to be durable, having taken a 3-ft. fall from the shelf in my tool trailer with no ill effects. Perhaps the greatest thing about this saw is that I no longer have to wear a face shield or welding sleeves when I cut steel.

Robert Shaw, a framer and deck builder in Colorado Springs, Colo.

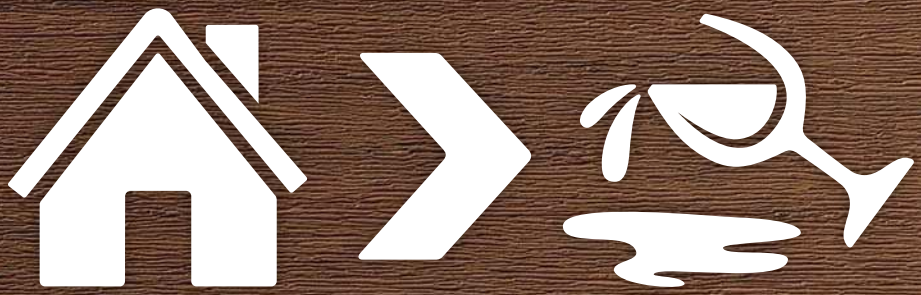
WRB sheathing

Similar to Huber's well-known Zip System sheathing, Georgia-Pacific's new Force Field OSB sheathing has a waterproof overlay that works in combination with a pressure-sensitive tape. Used together, the tape and overlay create an ASTM-approved air and water barrier. Georgia-Pacific's website lists 8-ft., 9-ft., and 10-ft. panels. The company is rolling out the product first in the Southeast, closer to its manufacturing plant in Allendale, S.C. In that region, ForceField 8-ft. panels are selling for $4.50 to $5 more per sheet than the company's regular 7/16-in.-thick, 8-ft. OSB panels.

Patrick McCombe, associate editor

Photos: courtesy of the manufacturers

ALLOY ARMOUR TECHNOLOGY



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Deck shown in Vintage Mahogany

Totable dust collector

If a wheeled dust collector isn't quite portable enough for you, check out the new Festool CT SYS. This ultracompact vacuum is the same size as a medium-size Systainer, with a smaller Systainer on top that carries the hose and accessories. (Systainer is Festool's system of stackable storage boxes.) You can sling this 15-lb. vac over your shoulder with an attached strap, freeing your hands for other tools. Despite its small size, it's not short on features, such as full HEPA filtration, high-efficiency dust bags, and tool-triggered operation. The 67-db. CT SYS sells for $375. A five-pack of replacement bags sells for $20.

P.M.

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LESS-MESS PLASTER PATCH

My standard fix for plaster cracks is to carve out the damage, fill the gap with setting-type joint compound, tape it, add topcoats of compound, and sand. This method is effective, but removing the damaged plaster and then sanding the new compound creates a lot of dust. The Krack Kote patching system from Abatron promises to be permanent and completely dust free. Since I've been using Abatron's wood-repair products for over 20 years, I was eager to give this new product a try.

The package consists of three components: a tub of emulsion, which has the consistency of thick paint; a roll of 2-in.-wide fabric; and a 5-in.-long spreader, which is really just a piece of a venetian-blind slat. I tested the system on a bunch of hairline cracks in my house (a 1903 Queen Anne Victorian) that I've been meaning to get around to fixing for years.

For cracks that are ⅛ in. wide or less, the only prep work is to make sure the wall or ceiling surface is clean. After I did that, I cut the fabric strips to length. Then I applied the emulsion with a 2-in. paintbrush, coating the plaster on both sides of the crack and allowing a ridge to build up over the crack to ensure that I would know exactly where to place the fabric. Pressing the fabric into the emulsion was straightforward. Wiping it down was anything but.

My standard practice with drywall finishing and plaster patching is to tool the compound relatively smooth, let it dry, then sponge or sand it to match the surrounding surface. That doesn't work here. The acrylic emulsion is not water-soluble when dry (and thus can't be sponged), and it just gums up the paper if you try to sand it.

My first few attempts at wiping the patch perfectly smooth were pathetic. I was ready to blame my failure on the absurd little spreader that the manufacturer provided, but switching to a taping knife wasn't any better.

Nobody ever accused me of having a steady hand, but after much trial and error, I did get better. What worked for me was to hold the spreader at a low angle; to apply light, consistent pressure; and to wipe from one end to the other without stopping. I also used a rag to wipe the spreader clean between passes (as if it were a window squeegee), and I replaced the spreader as needed.

Abatron suggests that two coats should be sufficient to achieve a satisfactory finish. It took me three, with the third one thinned by a few drops of water. I'm sure that a skilled painter or drywall finisher would have nailed the process in no time.

There are plenty of cracks left in my house, so I'll keep practicing with this material. I might not use it on large-scale renovations, but it seems like a great option for jobs where dust is a deal breaker, especially if lead paint is involved.

Tom O'Brien, a restoration carpenter in New Milford, Conn.

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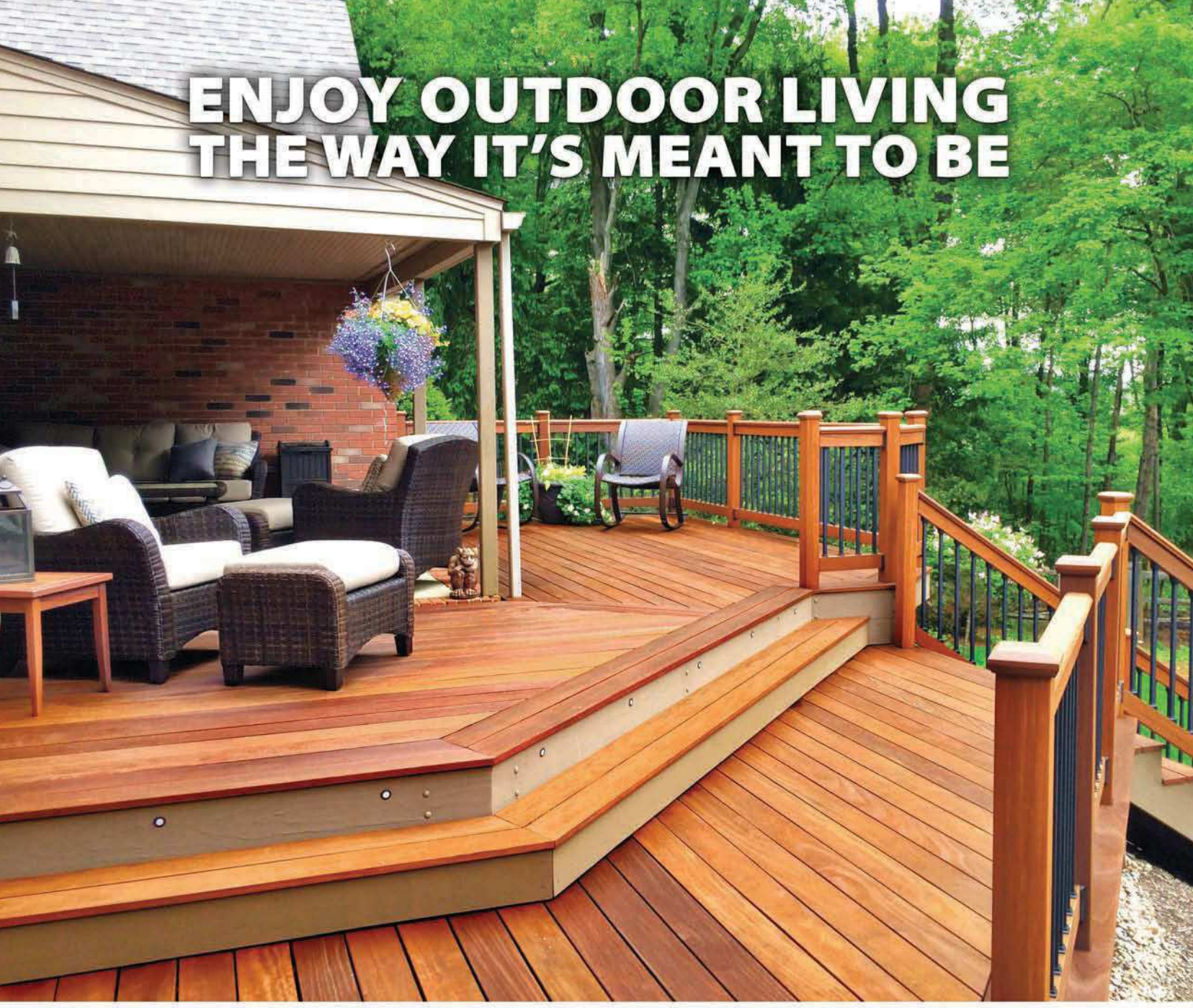
As the name implies, Sashco's Big Stretch is more elastic than any other caulk I have ever used. This quality makes it great for bridging gaps that experience seasonal movement. It's available clear and in 12 colors, and it can be used both indoors and out. It's easy to tool, cleans up with soap and water, and remains stable for up to 10 freeze/thaw cycles. The only downside I've discovered is that it takes longer to dry than other sealants. You have to wait a minimum of four hours before doing exterior painting and from 24 to 48 hours before doing interior painting.

P.M.

Dust-free foam cutting

The CenterFire sawblade from Bullet Tools is specifically made for cutting EPS, XPS, and polyiso foam insulation. Sure, you can cut foam with nearly any sawblade, but the toothless, knifelike rim of the CenterFire blade means that there's no foam dust coating the ground or clinging to your skin and clothes. Managing editor Justin Fink tried the 7¼-in. version during a recent basement remodel and gave it an enthusiastic thumbs-up. The 7¼-in. blade sells for $60, and the 10-in. version goes for $90.

P.M.



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CONTINUED

QUIET DRIVER

As a remodeling contractor who specializes in finish carpentry, bathrooms, and kitchens, I use an impact driver every day for a wide variety of tasks. About the only downside to these tools is noise, so when I was offered a chance to try Ridgid's new pulse driver (model R86036K; $199), which promises to be 50% quieter than a traditional impact driver, I jumped at the opportunity.

At this point you're probably asking, "What's a pulse driver?" A pulse driver is similar to an impact driver, but instead of using a rotating hammer and anvil to create the impacting action, it uses a fluid-filled coupling. The big advantage is that it's half as loud as a conventional impact driver, making it less damaging to your hearing and less annoying to coworkers and clients.

I used this driver for hanging cabinets and for installing drywall, plywood subfloors, and concrete tile backerboard. I threw any and all of my daily remodeling tasks at this driver, and it performed well. As a run-time test, I tried to drive as many 5¼-in. GRK RSS screws as I could before the battery was spent. With a 2-Ah battery, I was able to drive 40 screws, or 20 screws per amp hour. For comparison, the impact drivers in *Fine Homebuilding*'s recent head-to-head test of two-tool cordless kits (*FHB* #256) drove between 20 and 31 screws per amp hour.

I found the driver's grip to be comfortable in my hand, but the tool itself is bulky and pretty heavy—a little over 4 lb. with a 2-Ah battery. As other manufacturers continue to reduce the size of their tools, I think Ridgid took a step in the wrong direction with this tool. It's likely that there are mechanical reasons why a pulse driver needs to be larger, but this one seems heavy and cumbersome. The noise reduction is noticeable and appreciated, but it's not enough of a bonus for me to want to replace my current impact driver with a larger and heavier alternative.

Tyler Grace, a remodeler in Haddon Heights, N.J., and a Fine Homebuilding *brand ambassador*

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CONTINUED

HYBRID HOSE

Senco's new hybrid-polymer air hose is the best of both worlds. It has the flexibility of rubber without the weight, and the lightness and durability of PVC without the ankle-grabbing coils. This hose is 40% lighter than an all-rubber hose, and it's flexible down to –40°F. By comparison, rubber hoses lose their flexibility at –20°F, and PVC hoses are almost unusable once the temperature gets below freezing. A few hours in the freezer proved that the new hose is almost as flexible at 0°F as it is at 70°F.

However, it's the nonmarring quality of the hose's outermost layer, rather than its cold-weather flexibility, that impressed me most. Although I dragged it over white base trim, no marks were left and no touch-ups were required, an improvement over rubber hoses. The hose doesn't kink, and it lies flat with no coil memory, so it's much less likely to trip you up than a comparable PVC hose.

Even if the hose material weren't so good, the ends of the hose would still be noteworthy. They have compression-type fittings that attach without clamps. With a pair of crescent wrenches or pliers, you can remove the hose end, cut off a damaged section of hose, and reattach the fittings in a few minutes.

Overall, I found Senco's new hose (model PC1321, $36 for 50 ft.) to be surprisingly feature-rich for something as simple as an air hose. It's a bit pricier than some of the hoses on the market, but as a remodeler who does lots of finish work in higher-end homes, I'd buy this hose in a minute.

Steven Smith, a remodeler in Seattle

Repairable ends. *When Senco's hybrid air hose gets damaged, you can remove the hose end with a pair of wrenches and then reinstall it on the undamaged section of hose.*

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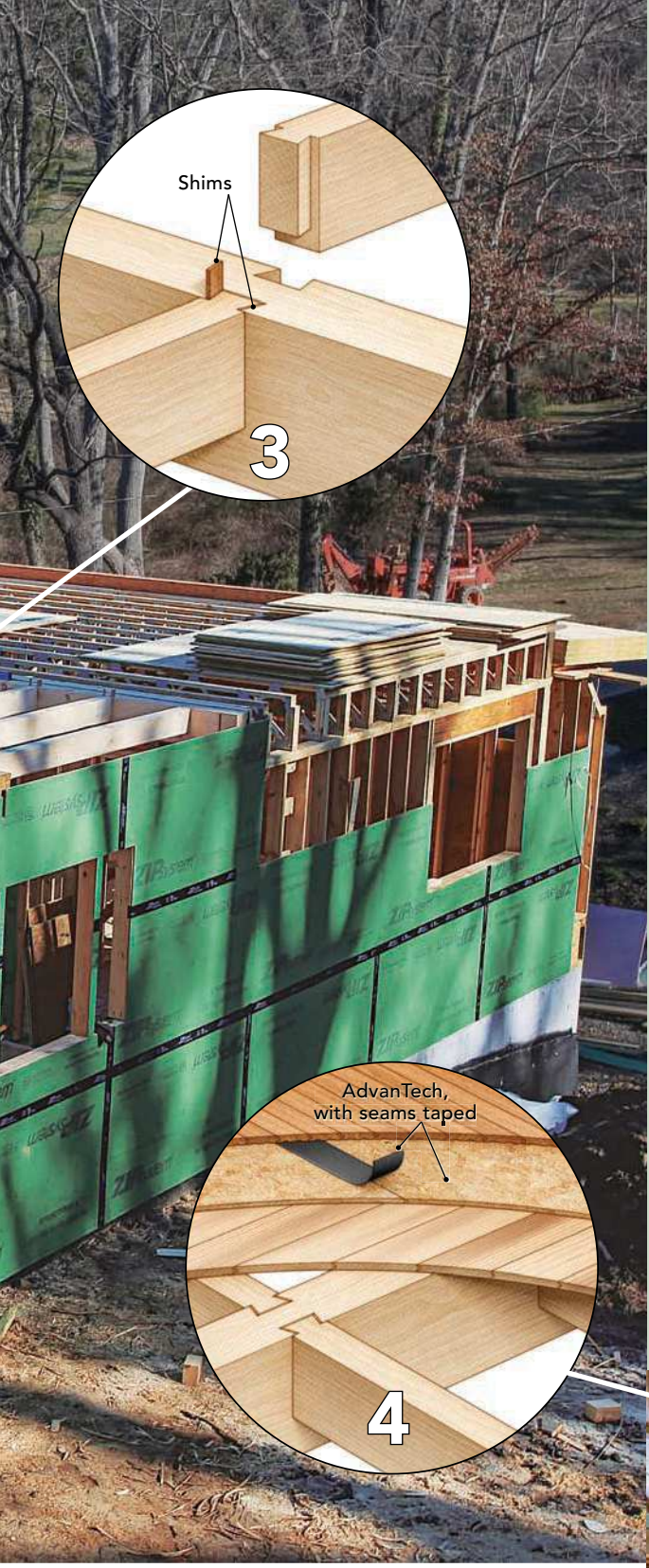
FROM THE CREATORS OF AdvanTech

Build a Hybrid Timber-Frame

Incorporate the beauty of structural timbers into a stick-frame house

Photo this page: Justin Fink. Photo facing page: deborahscannellphotography.com, courtesy of the author. Drawings: Christopher Mills.



1 Beam in wall If a beam lands in a pocket below the top plate of a wall—a common situation in 1½-story frames—it's helpful to notch the studs along that wall so that an inset 2x cleat can be added for nailing the tongue-and-groove subfloor planks.

2 Beam on top plate As with other structural beams, timber beams landing on a stud wall must be supported by posts. But because timbers vary, it's often necessary to remove material from the bottom of a beam where it bears on the wall plate in order to keep the floor above level.

3 Dovetailed mortises To avoid visible fasteners, joists connect to beams with dovetailed tenons that fit into slightly oversize mortises. Hardwood shims are driven along each cheek of the loose-fitting tenons, drawing the pieces together.

4 Planks complete the look A layer of tongue-and-groove planks installed over the joists and beams mimics traditional board sheathing, and a layer of AdvanTech subfloor with Zip System tape protects the installation from the weather until the house is dried in.

Floor

BY SAM KOERBER

When I built my first house at the age of 19, I wanted it to be cheap but interesting. My dad suggested using doubled-up 2x10s for the floor joists, skinning them along the bottom edge with 1x4s to hide the seam, and capping them with tongue-and-groove planks. It amounted to a budget version of a real timber-frame floor, but it worked, and living in that house caused the look of exposed structural timbers to seep into my design psyche and become an essential part of my style.

It was only after building a few more houses with this technique that I realized my doubled joists weren't much cheaper than real timbers, and that although the look was OK, it still wasn't what I really wanted. I had seen other builders apply solid, nonstructural timbers to finished drywall ceilings, but that seemed way too much work for what, to me, wasn't authentic.

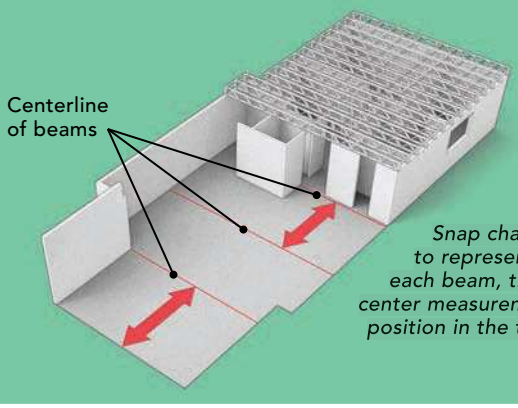
So when the next opportunity came along, I went with a hybrid approach that I still use today: a conventional stick-built house that incorporates real structural timbers and traditional joinery, completed mostly with common carpentry tools. This represents an authentic and sparing taste of the timber-frame aesthetic.

Timbers can mix with 2xs

My usual approach is to frame one part of the main-level ceiling in timbers, and then use dimensional or engineered lumber elsewhere in the house. In order to make this work, the needs of each room must be coordinated with the realities of having exposed timbers, because you're surrendering the drywall-covered joist bays that are used to hide mechanicals. Upstairs bathrooms need to be located so that waste lines are not visible from below. Similarly, if you

SEQUENCE FOR A SNUG FIT

To maximize efficiency, we cut as many joists as possible before anything is lifted into position. To do this, we mark beam positions on the subfloor and take measurements to create a joist cutlist. This floor breaks down into three sections, but only the two outer sections are cut ahead of time, leaving the center joists to be measured once the beams are set in place.



Snap chalklines on the floor to represent the centerline of each beam, then take center-to-center measurements for each joist position in the two outer sections.

MORTISES FOR THE BEAMS

The beams are set atop timbers that span pairs of stout sawhorses 20 in. tall, which is a comfortable working height. This allows the beams to be rolled as necessary as mortises are roughed out on both sides.

Kerfs on a bevel. *Working with two saws—one that bevels left and one that bevels right—a pair of carpenters can work their way quickly down the length of a beam, establishing the shape of each mortise.*

Chisel to the lines. *Although any wide chisel can get the job done, the extra length of a large timber-framing chisel makes it the ideal tool for removing the bulk of the kerfed waste.*

A square seat. *To ensure that the joists bear solidly on the bottom of each mortise without the need for tapered shims, check the bottom for square against the side of the beam.*

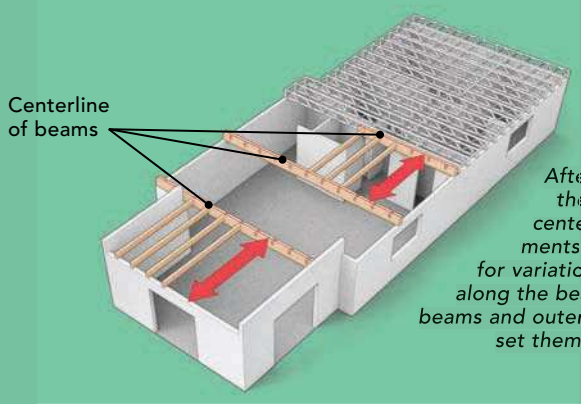
want recessed lighting in the kitchen, it makes more sense to finish this area with conventional drywall.

You also need to think about beam and joist spans, and about whether you want to (or can) get away without posts. In most cases, posts are necessary, and they can reinforce the timber-frame look. The clients for the house shown here wanted a clear-span look, so we eliminated posts by supporting the beams with a trusslike setup connected to the roof framing above. Whether or not posts are used, beams and joists should be sized by an architect or engineer.

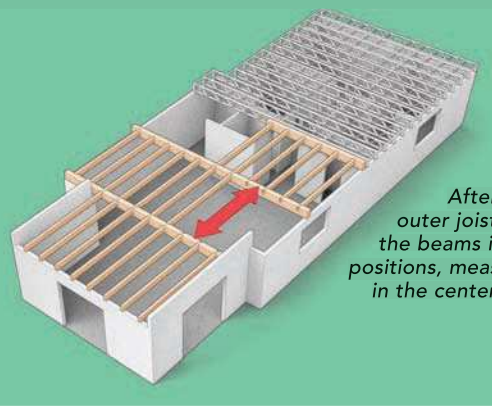
When the plans are finalized, they become your cutlist for ordering the timbers from a sawyer. I typically order posts and joists one or two feet longer than needed to allow enough room for the tenons to be cut, and I get a couple of extra joists in case I make a mistake during layout and assembly. For beams, I order only what I need, and I have them cut to exact length if possible.

Although I've used poplar and oak in previous timber-framing projects, my favorite wood is white pine. It's straight, has the lowest shrinkage ratio of any species, works easily with both power tools

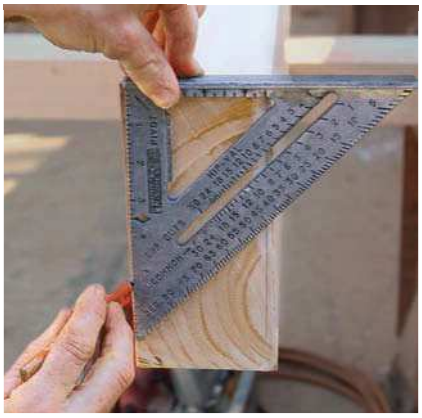
Photos this page and facing page: Justin Fink



After adjusting the center-to-center measurements to account for variations in width along the beam, cut the beams and outer joists, and set them into place.



After securing the outer joists and locking the beams into their final positions, measure the joists in the center section for a perfect fit.



Square it off the top. *Working from the center of the joist end, measure an equal distance to each side, then square down the height of the beam mortises. Connect the dots to mark the bottom of the tenon.*

Up and down. *Set the circular saw to a 15° bevel and a 2-in. depth of cut, then make a pair of cuts along the marked lines—down one side and then up the other—to shape the dovetailed sides of the tenon.*

Remove the waste. *After scribing a line around the outside of the joist, cut away the waste to leave the finished tenon.*

TENONS FOR THE JOISTS

Depending on their position in the layout, joists bear directly on a plate or connect to a beam with a dovetail tenon on each end, or they connect with a tenon on one end and a square cut on the other. The top of each joist needs to sit flush and square to the beams in order to adequately support the floor sheathing above, so the layout always references from the top face.

and hand tools, and looks beautiful when finished with either linseed oil or stain.

Fresh-cut, so-called green lumber is the norm in timber framing, but depending on the sawyer, it may be possible to pay extra to have the wood partially kiln dried. I use the word *partially* because I've found that even kiln-dried timbers still have a relatively high moisture content. So while they may be slightly lighter in weight, and joints may stay a little tighter because there's going to be a bit less shrinkage after installation, I don't bother paying the extra for kiln-dried timbers. It's best to go into this project with an understanding that no matter what you do, the timbers will be heavy, and they will shrink and move as they dry. That's where technique comes into play.

Framing for finish

Because this hybrid approach is essentially structural framing that doubles as finish carpentry, you need to think like both a framer and a finish carpenter. The most challenging parts of the job are strategizing, moving the material efficiently, and designing and executing the

DRESS, SAND, AND INSTALL

To give the timbers a hand-dressed look, we ease all the edges, do a rough sanding to remove any layout marks, and treat all cuts with a wax sealer such as Green Wood End Sealer ($16, rockler.com) before lifting each piece into place. A final sanding is usually necessary but will come after the wood has dried to a lower moisture content.

Remove the crown. *Snap a chalkline along one side of each timber (held down 1 in. from each end) so that any major deviation from the 1-in. benchmark can be shaved off with a power planer (top).*

Ease the edges. *Holding it nearly flat, pull a sharp drawknife down the length of each timber to ease the edges and disguise imperfections.*

Rough sanding. *Use a high-speed sander with 40-grit paper to clean up the rough-hewn results of the drawknife work and to remove layout marks.*

installation to take into account all the other parts of the house that will be built along with the floor. Because the framing will all be visible, you have to lay out and cut the various joints with care so that they result in a finished look.

All of the timber-frame joints I use have a functional purpose. The mortise-and-tenon joints used at post-and-beam connections keep the post in line with the beam even as both members shrink and twist. The dovetail tenon joints for the joists and the beam allow the top of the beam to be flush with the top of the joists, and the shims pull it tight to counteract some of the shrinkage that occurs as the pieces dry.

I've developed a workflow that allows me to cut all the necessary joints with common carpentry tools. In addition to the usual bevel-left and bevel-right 7¼-in. circular saws, power planer, and high-speed sander, I use a 2-in. timber-framing chisel, a wooden mallet, and a drawknife, which is great for dressing the edges of the timbers. You may find that a 10-in. or even 16-in. circular saw, a chain mortiser, and a wide beam planer such as the Makita KP312 are all helpful also.

Big-timber logistics

Being efficient in how you move the timbers is crucial. It's best to arrange the timber delivery when an excavator is on-site for backfilling and grading. The excavator can pick up the bundle with a couple of straps and then place it on the main floor. If the walls are up, I might work on the joists outside the house and then carry them in for installation. The beams are usually too heavy to carry easily, so if I can't have them dropped inside, I at least have them placed so that

Photos this page and facing page: Justin Fink

Easy lifting. *A wheeled material lift, available from rental yards for about $60 a day, makes quick work of lifting the beams and joists into position.*

Shims for the tenons. *Untapered oak shims draw the shoulders of the joists tight against the beam face, locking the joists into place.*

Screws for the plates. *With the drywall groove aligned to the interior face of the stud wall, a single structural screw (TimberLoks were used here) driven through the top of its end secures the joist to the top plate below. Because the lumber is wet, no pilot hole is needed.*

they lean into a doorway. This way, we can maneuver the beams into the house on rollers made from offcuts of PVC pipe and then lift them onto sawhorses one end at a time so that they can be worked more comfortably.

For working on the timbers, I like to have four 20-in.-tall pony-style sawhorses. I set them up in pairs—ideally over a well-supported section of the subfloor framing—and set one of the timbers across each pair in order to give me a surface for stacking the rest of the pile. This setup allows several guys to be working on the timbers at the same time, and it provides room to roll the timbers as necessary.

To raise the finished pieces on this job, I rented a material lift for about $60 a day. The lift is rated at 750 lb. and is the perfect tool for lifting, maneuvering, and setting timbers from a subfloor deck. If there is a strong anchor point overhead—either part of the house frame or a temporary rig—a chain hoist also can be used.

We try to put up the timbers during a stint of dry weather, then we install the tongue-and-groove planks, followed by a layer of ¾-in. AdvanTech sheathing. If noise is a concern, we install a layer of ½-in. Homasote atop the tongue-and-groove planks and then add the sheathing. AdvanTech is not intended to be waterproof, but sealing the seams with Zip System tape goes a long way toward preventing water from seeping through during construction. This last detail protects the beams from water stains that develop from rain and snow that fall during construction, saving a lot of sanding in the end. □

Sam Koerber is a custom builder in Asheville, N.C.

Build Your Own PEX Manifold

A homemade array of tubing and fittings can rival brand-name water-distribution panels

BY JAMES GLASS

Think of a PEX manifold as the plumbing equivalent of a main electrical panel. It's the central distribution hub for all of the water running to your household fixtures.

The concept is that each fixture or group of fixtures in the house has its own water supply line stemming from this central point, a configuration known as a home-run setup. Tubing can be color-coded to indicate cold-water lines (blue) or hot-water lines (red) and then labeled with their destination. This allows homeowners to quickly locate and shut off water to a certain area of the house for maintenance, for remodeling, or in an emergency.

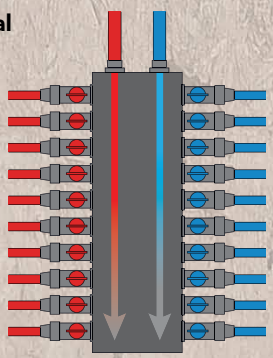
You can buy a brand-name PEX manifold, which comes labeled for cold-water and hot-water lines, but these versions have some drawbacks in their design and function. I prefer to make a pair of homemade manifolds—one hot and one cold—from off-the-shelf parts. Not only can making your own manifold save some money and let you use high-quality parts, but it allows you to customize the setup to suit your needs, and to reconfigure or repair the manifold as needed.

James Glass is a general contractor in Blacksburg, Va.

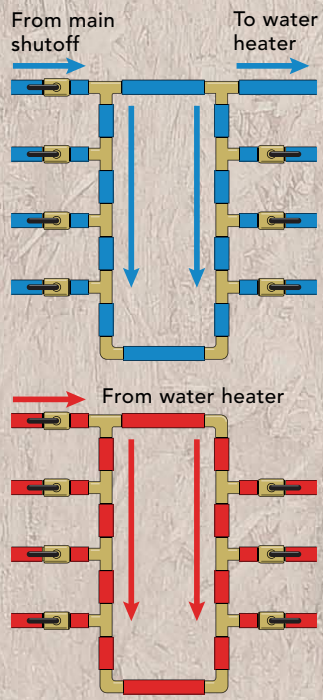
SIX BENEFITS AT A GLANCE

BALANCED WATER PRESSURE

Compared to a typical manifold, where the branch lines all stem from a single linear chamber, a custom manifold can be fed from two directions, offering more stable water pressure if the toilet is flushed, the shower is running, or the washing machine is starting a rinse cycle.



Conventional Last branch line in series gets less water if other lines demand water first.

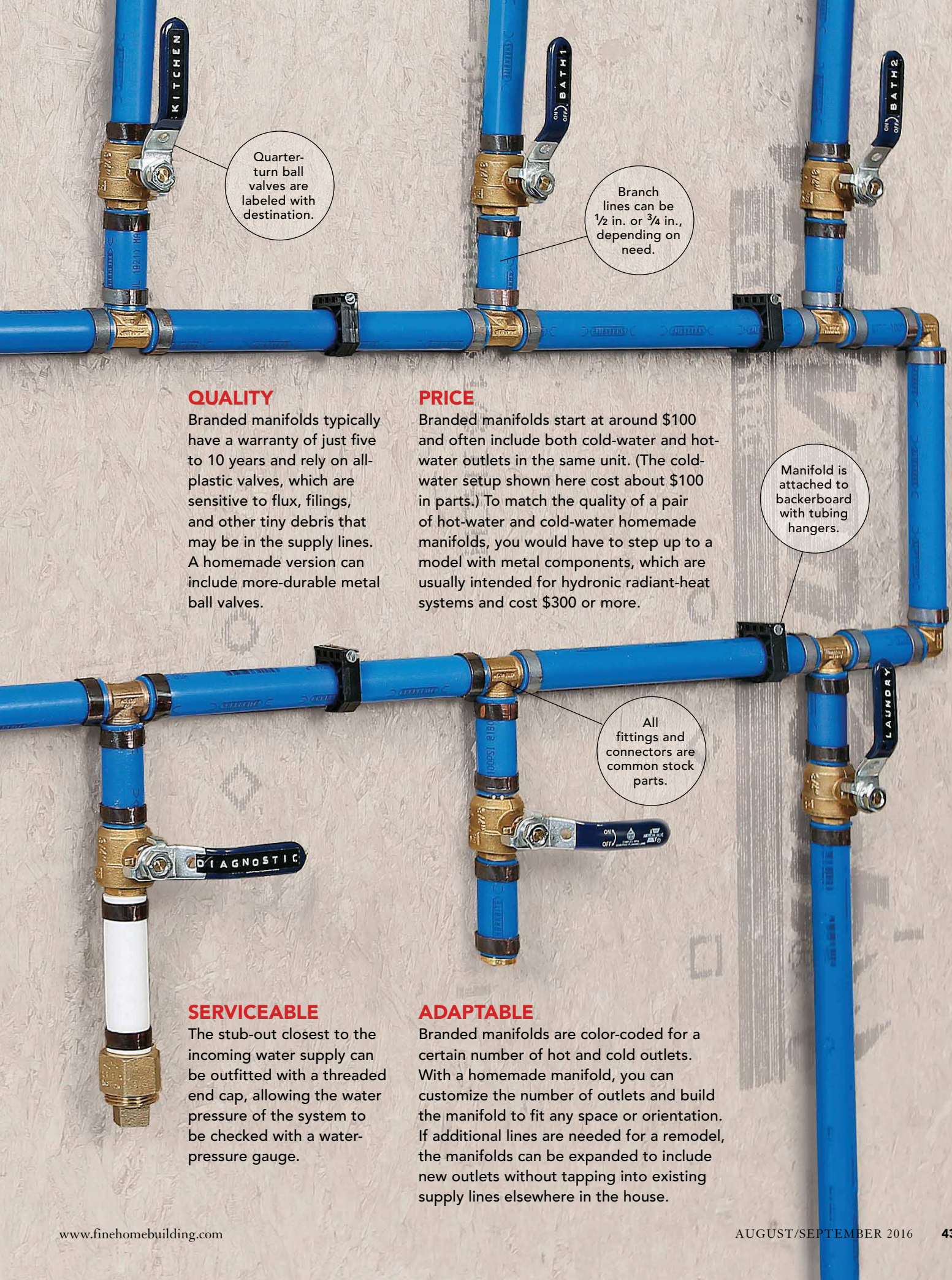


Custom Water flows into manifold from two directions, balancing pressure.

REPAIRABLE

The system is made from off-the-shelf tubing, valves, and PEX connections of your choosing, so it can just as easily be repaired with off-the-shelf components, too. If a manufactured manifold fails, you have to disconnect and replace the entire unit.

Photo: Rodney Diaz. Drawings: Patrick Welsh.



QUALITY

Branded manifolds typically have a warranty of just five to 10 years and rely on all-plastic valves, which are sensitive to flux, filings, and other tiny debris that may be in the supply lines. A homemade version can include more-durable metal ball valves.

PRICE

Branded manifolds start at around $100 and often include both cold-water and hot-water outlets in the same unit. (The cold-water setup shown here cost about $100 in parts.) To match the quality of a pair of hot-water and cold-water homemade manifolds, you would have to step up to a model with metal components, which are usually intended for hydronic radiant-heat systems and cost $300 or more.

SERVICEABLE

The stub-out closest to the incoming water supply can be outfitted with a threaded end cap, allowing the water pressure of the system to be checked with a water-pressure gauge.

ADAPTABLE

Branded manifolds are color-coded for a certain number of hot and cold outlets. With a homemade manifold, you can customize the number of outlets and build the manifold to fit any space or orientation. If additional lines are needed for a remodel, the manifolds can be expanded to include new outlets without tapping into existing supply lines elsewhere in the house.

Custom

Save time and money by bending PVC trim with a site-made oven

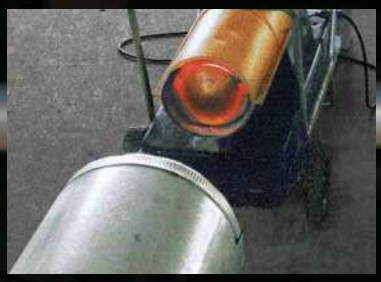
BY JOE FILANOWSKI JR.

My business partner, John Costantini, and I have been building custom homes for over 25 years, and timing has always been essential when it comes to coordinating our numerous subcontractors. About eight years ago, we were working on a job that called for exterior PVC trim with significant bends around a turret. Manufacturers can bend trim by warming it in a PVC thermoforming oven, but that would have required at least four to six weeks lead time, and we were on a tight schedule. Custom bending is also expensive; it would have cost $2200 for the 20 ft. of trim we needed to be shaped. There are special thermoforming blankets for trim that allow you to do the bending work on-site, but they cost over a thousand dollars—a difficult expense to justify unless you plan to use the blanket regularly. Another downside is that the largest blanket sold is only 10 ft. long and 5 in. wide. While renting might be an option, availability is limited, and rental costs are high. We devised our own technique for bending trim in order to meet our deadline, and it worked so well that now it's our go-to method.

Joe Filankowski Jr. is a co-owner of J&J Custom Builders in Milford, Conn. Photos by Aaron Fagan.

Curves

IMPROV OVEN



Our oven is simply a Master torpedo heater (155,000 Btu) aimed into lengths of 14-in.-dia. metal HVAC duct propped up on concrete blocks. Scrap stone or brick can be used to keep the duct from rolling. Inside the duct, lengths of fiber-cement siding are suspended by 24-in. wire batt supports running through the diameter at regular intervals. A piece of plywood at the opposite end of the duct confines the heat.

TEMPLATING AND PREP

An advantage of templating and bending on-site is that the contour is taken directly from where it will be installed, and if there is any unforeseen error, you can simply modify it and try again without the added time and expense such a mistake would cost by going through a manufacturer.

Storyboarding. *After tracing the contour from where the trim will be installed, the plywood template is cut and then screwed to the subfloor.*

Block party. *Predrilled 2x4 blocks are screwed to the subfloor at regular intervals to match the curvature along the edges of the plywood template.*

Molding mold. *The original plywood template is removed, and plywood strips that match the height of the cove molding to be bent are fastened to the 2x4 blocking.*

Plenty of room. *After the surrounding area is cleared, drivers are set within reach, and 2x4 blocks loaded with screws are staged for bracing the cove once it's in place.*

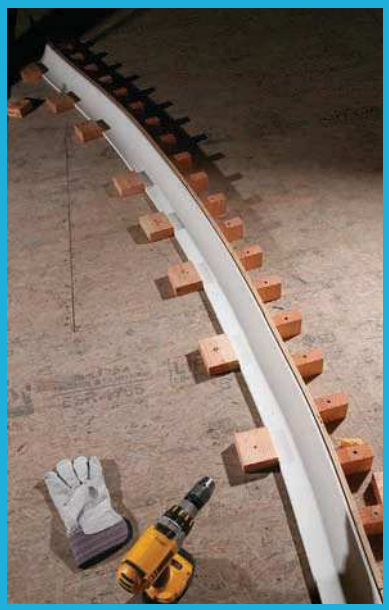
Load when ready. *The oven is preheated for about five minutes before loading the trim. Depending on the outside temperature, it can take 30 minutes to an hour to get the trim up to a bendable temperature.*

THE BIG BEND

The trim will remain at a pliable temperature for less than 30 seconds after it comes out of the oven, so it's critical to have the template staged and to have extra hands for securing the trim in place.

Learning curve. *A few pokes and lifts with a stick show if the trim is noodlelike enough to bend. Of the various types of PVC trim, the more-open cellular varieties, like the Kleer pictured here, tend to bend the easiest.*

Assembly line. *The team sets the trim on the subfloor, pushes it tight against the form, and secures it with regularly distributed blocks.*



Rest after baking. *Even though the trim hardens in less than 30 seconds, it's given 10 minutes to cool thoroughly in the form before being removed for installation.*

Tool Test

18v Recip Saws

These tools combine **corded performance** with **cordless convenience**

BY DAVID FRANE

The advantages of cordless reciprocating saws are obvious. Cordless saws allow you to make cuts with less setup, and they free you from the weight and hassle of extension cords. It's been a while since I bought a new cordless recip saw, so I was eager to test eight of the most popular 18v Li-ion models.

Although some of the saws I tested are available in kits that include a battery and a charger, many are sold only as bare tools. For the sake of testing, I asked each manufacturer to provide the highest amp-hour battery it currently offers. Before each test, I put fully charged batteries and new blades into the tools: Lenox Gold Power Arc blades for wood and Diablo Steel Demon carbide-tipped blades for metal.

Top picks

The Milwaukee saw is my choice for best overall. It's comfortable to use, cuts faster, and has a longer run-time than every other model. The Ridgid is nearly as comfortable and came in a close second in cutting speed. At about $60 less than the Milwaukee (bare tool), it's an easy pick for best value.

David Frane is a carpenter and freelance writer in Alamo, Calif. Photos by the author.

MILWAUKEE M18 FUEL SAWZALL 2720

$179 (bare tool); $299 with one 4.0-Ah battery and a charger; $129 for one 5.0-Ah battery

This saw cuts about as fast as corded models and faster than the other tools tested—in most cases, by a significant margin. The only tool with a brushless motor, this saw made more cuts per charge with a 5.0-Ah battery than saws equipped with higher-rated batteries, and it made more cuts per amp hour than any other saw tested. Features include an LED light and a handy folding rafter hook. The blade clamp and adjustable shoe are both controlled by levers. The only bad thing I can say about this saw is that it's the heaviest tool in the test (9.1 lb.). It's available as a bare tool and in a kit with one or two 4.0-Ah batteries.

RIDGID GEN5X R8642

$119 (bare tool); $499 for a five-tool combo kit with two 4.0-Ah batteries and a charger; $119 for a 5.0-Ah battery

The Gen5X recip saw was surprisingly fast, cutting 2x12s and black pipe faster than all but the Milwaukee. The run-time was average, but the saw cut smoothly and with minimal vibration. Features include a ring-style blade clamp, an adjustable shoe, and an LED activated by the trigger or a separate switch below. It's the only model with two cutting modes: straight and orbital. I wouldn't let this sway my decision; orbital action greatly increases vibration. Most companies dropped this feature long ago, when wood-cutting blades designed to mimic orbital action rendered it unnecessary. This is a very nice saw; perhaps the only downside is the limited number of tools in Ridgid's cordless system.

SPECS VS. REAL-WORLD PERFOMANCE

Most saws have a 1⅛-in. stroke and produce around 3000 strokes per minute, so their performance should be nearly equal. Yet testing reveals that their cutting speeds vary greatly.

SPEED TEST

With the material mounted in a sturdy stand and a weight hung from the front of each saw (10 lb. for metal; 20 lb. for wood), I made 12 cuts in a Douglas-fir 2x12 and in ¾-in. black pipe to test cutting speed. After throwing out the two fastest and the two slowest times, I averaged the remaining eight times.

RUN-TIME TEST

To determine run-time for each saw, I used the same test rig to make as many cuts in a Douglas-fir 2x12 as possible. To prevent overheating, I switched blades after every five cuts. Because batteries vary, I divided the number of cuts by the respective battery's amp-hour rating. All of these saws are 18v except for the Hilti, which is 21.6v.

Manufacturer	SPEED TEST (in seconds)		RUN-TIME TEST		
	2x12 Douglas fir	¾-in. black pipe	Total cuts	Ah of battery	Cuts per Ah
Bosch CRS180	12.8	8.6	29	6	4.8
DeWalt DCS380	11.9	7.5	27	5	5.4
Hilti WSR 18-A	14.4	17.2	36	5.2	6.9
Hitachi CR18DGLP4	15.7	10.3	13	3	4.3
Makita XRJ03	14.5	9.6	18	5	3.6
Metabo ASE 18 LTX	13.4	12.4	28	5.5	5.1
Milwaukee M18 Fuel 2720	8.8	5.3	38	5	7.6
Ridgid Gen5X R8642	10.4	6.7	27	5	5.4

BOSCH CRS180

$119 (bare tool); $177 with one 4.0-Ah battery and a charger; $129 for one 6.0-Ah battery

Lighter than average, this saw has good power but vibrates during heavy cutting. The housing tapers heavily in front and is easy to grip, and a lever above the handle locks the trigger and selects either high or low speed. The blade clamp is better than average; spent blades are ejected with the twist of a ring, and the clamp remains open until a new blade is inserted. The saw is available in combo kits, as a one-battery (4.0 Ah) kit in a bag, or as a bare tool with or without a carrying case.

HILTI WSR 18-A

$209 (bare tool); $489 with two 5.2-Ah batteries and a charger

Hilti's battery packs contain two extra cells, boosting their power to 21.6v. Despite its higher voltage batteries, this tool is a slower-than-average cutter and tends to vibrate during heavy cutting. It has an AVR (Active Vibration Reduction) shoe that allows it to flex in and out while the saw is cutting. I found that it actually increased vibration to the point where the saw was unpleasant to use, especially for cutting metal. The tool is available bare and in a two-battery kit.

MAKITA XRJ03

$119 (bare tool); $129 for one 5.0-Ah battery; $99 for charger

The Makita's shoe adjusts with the push of a button, and the saw has a superior blade clamp that ejects hot blades and remains open until a fresh blade is loaded. Weight and cutting speed are about average. Run-time per amp hour is the lowest of the saws tested, though this could be offset by Makita's charging time (45 min. for a 5-Ah pack). The tool cuts smoothly and is comfortable to use. The XRJ03 is Makita's lightest full-size recip saw and is available as a bare tool and in combo kits.

DEWALT DCS380

$119 (bare tool); $259 with one 3.0-Ah battery and a charger

The best thing about this saw is how little it weighs (6.6 lb.). The worst thing is that it vibrates at all speeds. The saw is fine for intermittent use, but it's uncomfortable for long bouts of heavy cutting. Features include a shoe that adjusts with the push of a button, a lever-activated blade clamp, and a unique four-way blade holder that allows you to install blades with the teeth facing up, down, left, or right. The saw is available in combo kits, as a bare tool, and in a kit with a 3.0-Ah battery.

HITACHI CR18DGLP4

$89 (bare tool); $97 for two 3.0-Ah batteries; $97 for one 5.0-Ah battery; $39 for charger

This saw was tested with 3.0-Ah batteries because the anticipated 5.0-Ah packs were not yet available. Smaller and lighter than most other saws, the Hitachi is pleasant to handle because it vibrates less than expected for a tool of its weight. However, it cuts about half as fast as the Milwaukee and employs an aggravating safety switch that requires you to hit a button before every cut. I much prefer the sliding on/off lock found on most other saws. The Hitachi is sold as a bare tool only.

METABO ASE 18 LTX

$210 (bare tool); $95 for one 5.5-Ah battery; $169 for one 6.2-Ah battery; $57 for charger

Sold as a bare tool only, the Metabo is the second-heaviest saw tested. It cuts smoothly and with little vibration. Features include a lever-activated clamp and an adjustable shoe that requires a hex wrench, which stores in the handle. The biggest downside is the automatic safety on the trigger, which requires you to shift your grip to hit the button before every cut. Cutting speed is about average in wood and slower than average in metal. Run-time is about average.

Rolling

Simple joinery supports

BY GREG SOPER

On a recent job where I was building and installing new kitchen cabinets, the homeowners asked if I also could design and build doors for their walk-in pantry. They wanted to incorporate a barn-style window into each door, but the rest was left up to me. I decided to use divided-lite pine cellar-window sashes ($50, brosco.com) set into shopmade poplar door frames. The frames would be skinned with poplar boards designed to look like a clean version of traditional tongue-and-groove planks. Finished off with a custom shade of green paint and hung on industrial-inspired barn-door hardware (rusticahardware.com), the finished product creates a visual pop against the other wood tones and surfaces of the kitchen.

Greg Soper owns North Yarmouth Woodworks in North Yarmouth, Maine.

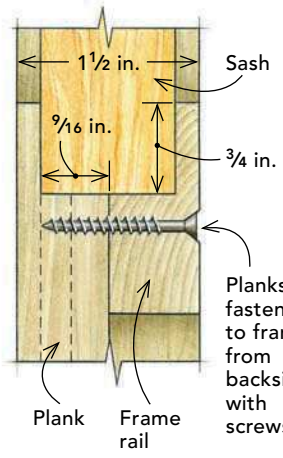
Photos: Steve Fuller. Drawings: Don Mannes.

Barn-style Doors

inexpensive windows to yield jaw-dropping interior doors

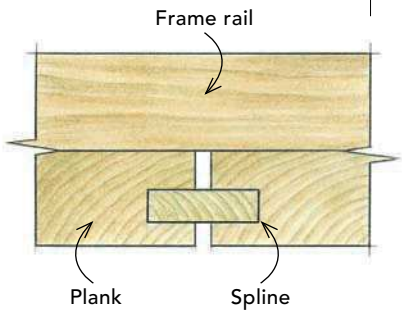
Locating the window

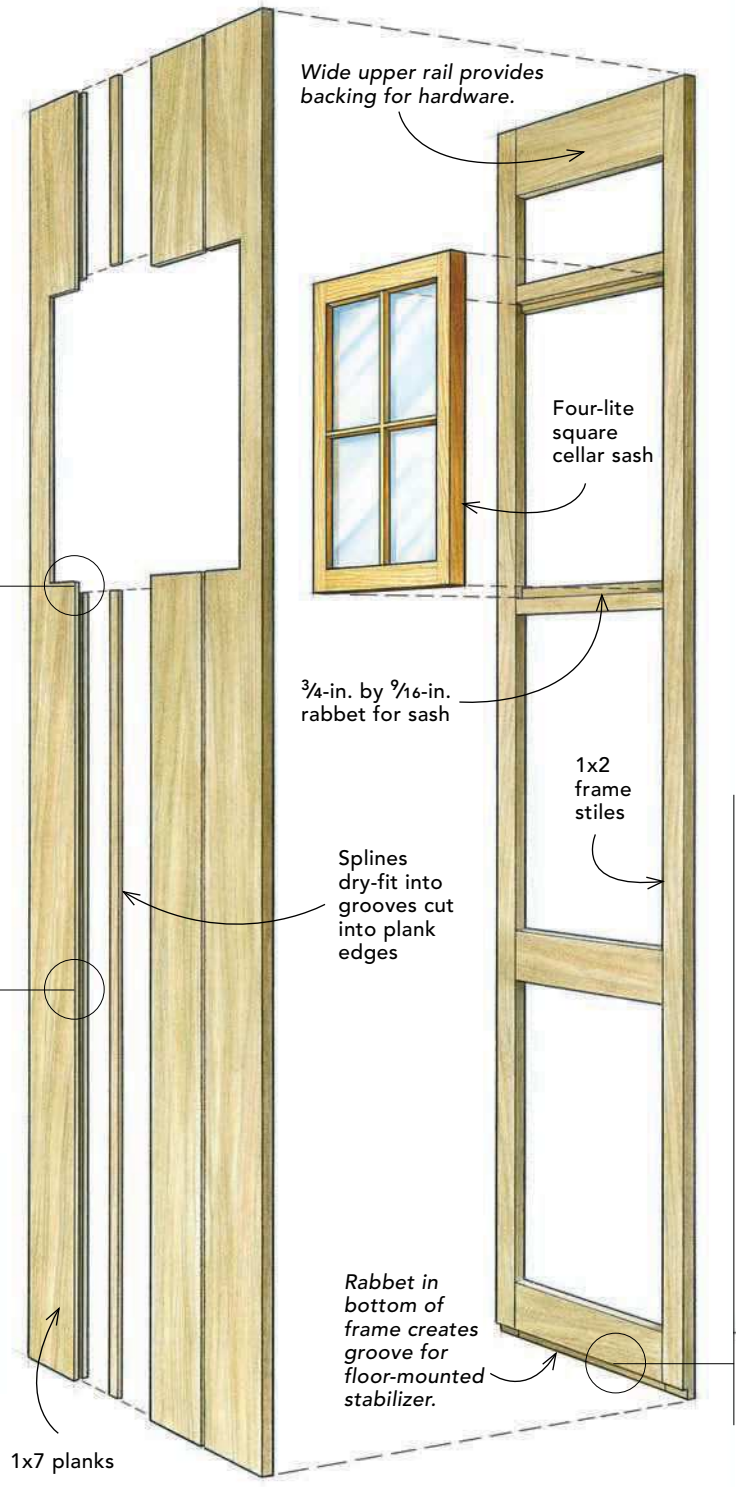
After cutting all the pieces and temporarily clamping the door together, lay the window atop the door, and trace its position. Make the cutout ¾ in. inside of these traced lines, then rabbet the edges to receive the sash.

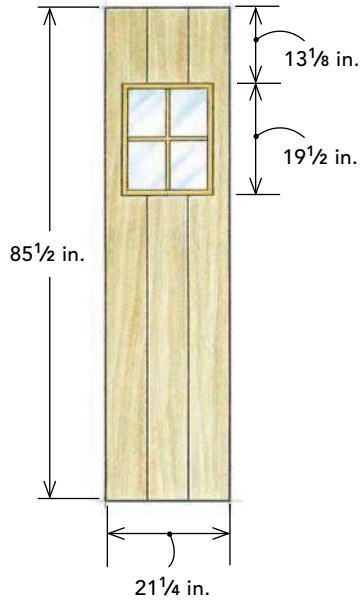


Spacing the planks

Cut dadoes ¼ in. wide and about ⅜ in. deep into the sides of each plank. Fill them with ⅞-in.-wide dry-fit splines to space the planks apart about ⅛ in.

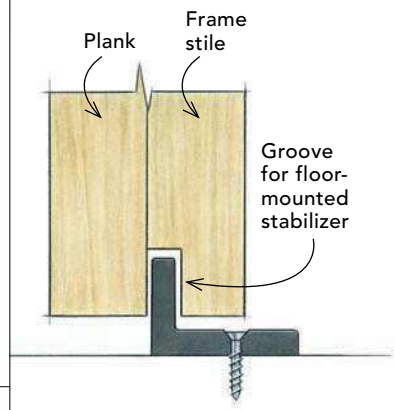






Guiding the door

To keep the hanging door from swinging, apply the planks over the rabbeted frame to create a groove for the floor-mounted stabilizer.



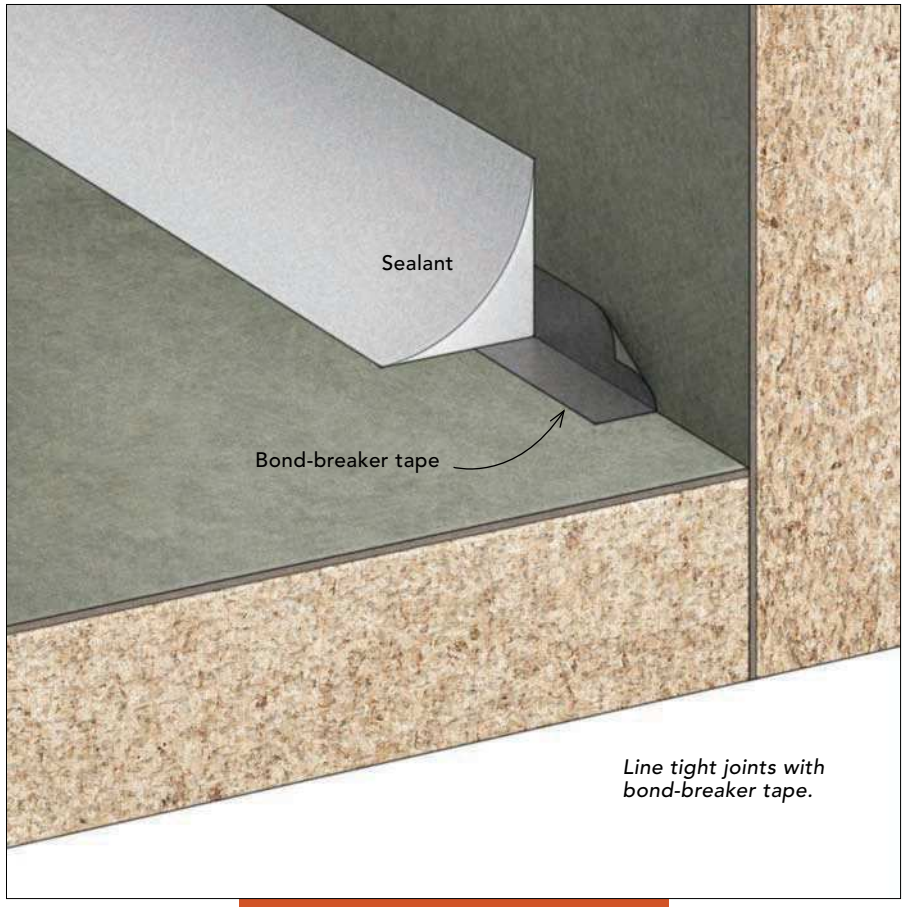
Caulk This Way

Joint design and prep may matter even more than choosing the right product

BY ANDY ENGEL

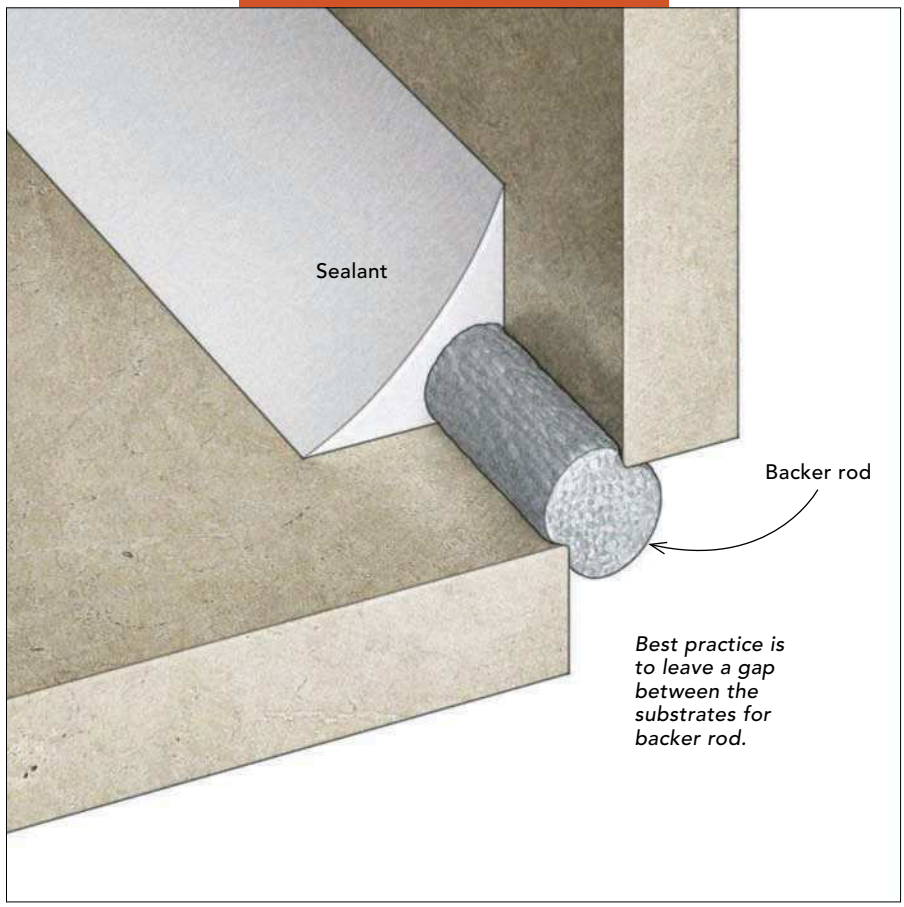
After researching and writing this article, I had an epiphany: In 35 years of doing and writing about residential construction, I have never seen a caulk joint executed properly. Most residential caulk joints I've seen have failed or are likely to. Builders, including myself, barely know which caulk or sealant to use where, and hardly anyone in residential construction knows how to execute a proper joint by considering crack width and depth and the use of backer rod or bond-breaker tape. There is a lot to know.

The first thing to know is that building components move. Builders don't like to acknowledge this. That may be because it feels like a reflection on their work, or because it introduces complexities in material choices and procedures they'd rather avoid, or just because it never occurred to them. Movement happens mostly because of changes in temperature and humidity. We see the results in gaps between materials. In some instances, such as with interior trim, this is only an aesthetic issue. But in other cases—the corners of a shower, the gaps around a window, expansion joints in concrete—such spaces can lead to



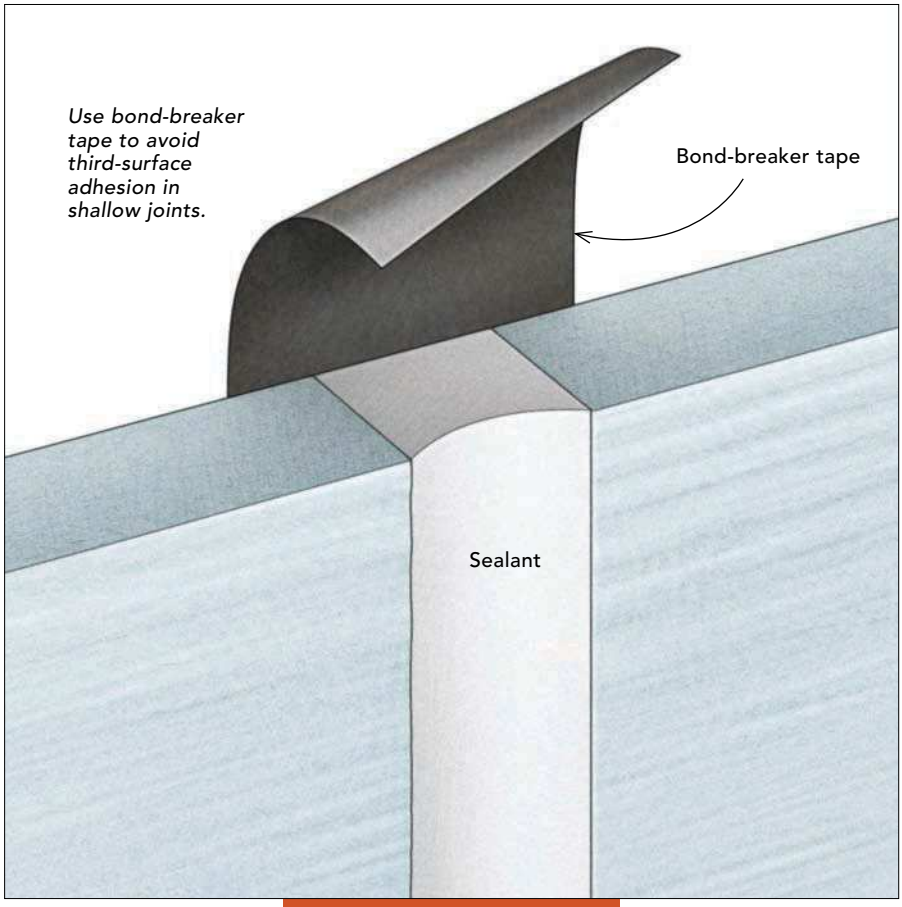
Line tight joints with bond-breaker tape.

CORNER JOINTS

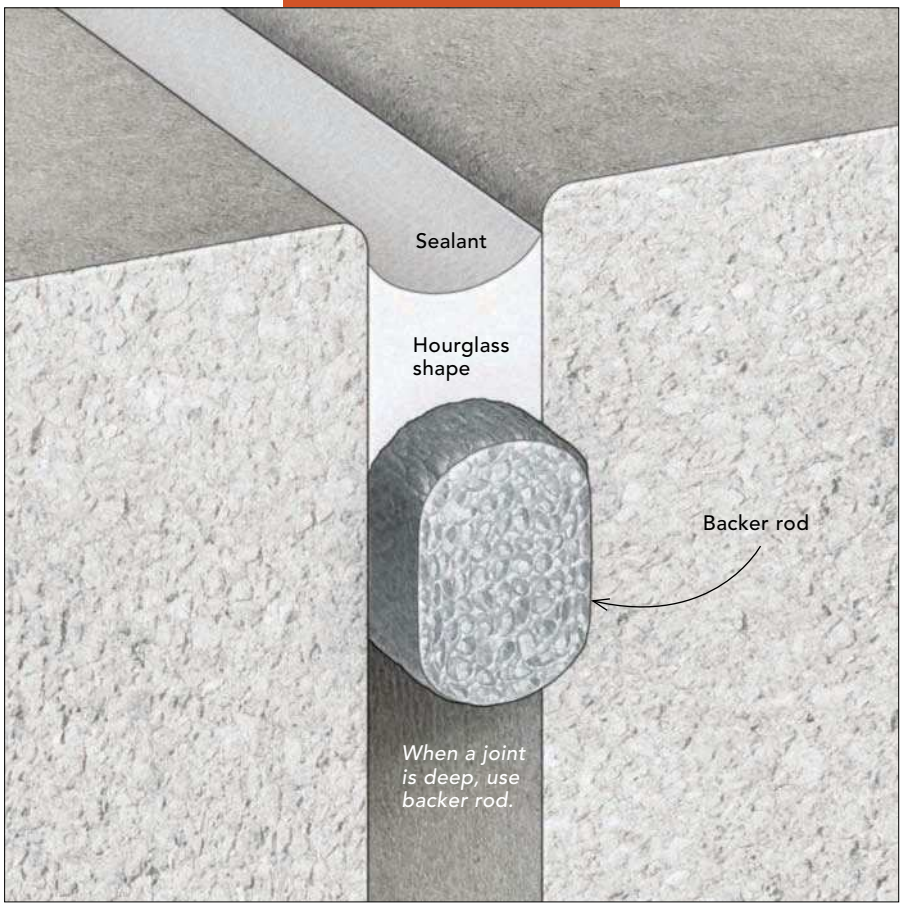


Best practice is to leave a gap between the substrates for backer rod.

Drawings: Christopher Mills



FLAT JOINTS



DESIGNING JOINTS

According to Sika, a major sealant manufacturer, proper joint design and preparation eliminates 95% of callbacks for sealant failure. ASTM C920 covers joint design, including the required sealant depth where it meets the substrate, which depends on both the width of the joint and whether the surface is porous or not. Porous surfaces are found on materials such as concrete, masonry, fiber-cement siding, and raw wood. Examples of nonporous surfaces include aluminum, steel, glass, tile, painted wood, and plastics. There are three golden rules of sealant joints: They must be at least ¼ in. wide, surfaces must be clean, and the sealant must adhere only to two surfaces. Bond-breaker tape and backer rod are used to prevent the sealant from adhering to the back of the joint.

WIDTH-TO-DEPTH RATIOS

Joint width	Sealant depth
Porous substrates	
¼ in. to ½ in.	Equal to the joint width
½ in. to 1 in.	Half the joint width
Nonporous substrates	
¼ in. to ½ in.	¼ in.
½ in. to 1 in.	Half the joint width, maximum ⅜ in.

Control your sealant

While backer rod is readily available from home centers and hardware stores, bond-breaker tape is easier to find online.

crlaurence.com
nationalsealantproducts.com
sealantengineering.com

SEALANT PROPERTIES

No sealant does everything well. The trick is choosing the sealant that meets the requirements of the job and works for the conditions at hand. The properties discussed here are general, and some specific products within the category may perform better or worse than what's typical.

ACRYLIC/LATEX

Often the least expensive choice, these water-based caulks cure by evaporation. Consequently, they can shrink by a quarter to a third of their volume before they're fully cured. They hold paint well and usually can be painted within four hours. Most aren't as flexible as many other sealants, but they're a good choice for filling small gaps between interior-trim pieces.

BUTYL/RUBBER

The original modern sealant, butyl dates from the 1920s. It cures through the evaporation of organic solvents, shrinking a quarter to a third in the process. Butyl is sticky and can be harder to tool than other sealants, but it can be used in freezing weather. Best used outdoors because of its odor before curing, butyl is less common in residential construction than other sealants.

POLYETHER/SILICONE

So-called STPE (silyl-terminated polyether) sealants are similar to and sometimes superior to polyurethanes. Relatively new to the U.S. market, STPEs have been used in Japan for decades. Based on polypropylene glycol, they cure by reacting with water. The cure rate is much faster than that of polyurethanes, and STPEs can be painted sooner. They can be used on damp surfaces and in below-freezing temperatures, making them a good choice for outdoor use.

TYPE OF SEALANT	Acrylic/latex	Butyl/rubber	Hybrid polyether/silicone (STPE)
WORKING TEMPERATURE	40°F to 120°F	20°F to 100°F	0°F to 120°F
CURING METHOD	Water evaporation	Solvent evaporation	Reaction with water
TIME BEFORE PAINTING	2 to 4 hours	7 to 14 days	1 to 2 hours
MOVEMENT RANGE	12.5% to 25%	12.5% to 25%	25% to 50% typical, up to +100%/–50%
BEST FOR	Aluminum, concrete, fiber cement, masonry, vinyl, wood	Aluminum, concrete, fiber cement, masonry, steel, vinyl, wood	Aluminum, concrete, fiber cement, many plastics, masonry, steel, vinyl, wood
AVOID	Steel	N/A	N/A

serious effects by allowing unwanted air or water to enter. The solution isn't necessarily to make tighter joints, but rather to design the joints for the realities of the environment and the material, and then to install a good sealant properly.

I'm not arguing against good workmanship. The best caulk ever made still can't make a badly executed interior-trim joint look good, for example. But good workmanship sometimes means leaving a gap that's sized to allow a proper caulk joint. Many materials move so much with changes in temperature and humidity that no joint will stay tight, and so a flexible sealant is exactly the ticket. In fact, the manufacturers of building materials such as PVC trim, fiber-cement or wood-composite sidings, and vinyl windows actually specify gaps at joints to allow for movement and caulking. Good caulking is good workmanship, but maybe because caulking a joint feels like punting on quality—something done when a person lacks the skill or care to fit materials tightly—it gets short shrift. It's often not even clear whose job it is. The painter's? The carpenter's?

In commercial and institutional construction, caulk joints are expected to last for 10 to 20 years. In fact, the materials aren't even called caulks, but rather sealants. Joint design and sealant choice are handled by the designer (based on ASTM C1193), and the work is done by a specialty contractor. Mock-ups of building assemblies are made on-site so that the specified sealants can be tested for effectiveness with samples of the materials that will be used.

POLYURETHANE
Although urethane cures by reacting with moisture, it shouldn't be applied to wet surfaces or when rain is in the immediate forecast. An excess amount of water can cause a reaction that releases an undesirable amount of CO_2, which can cause the sealant to froth and compromise its ultimate strength. Although hard to tool, polyurethane sealants are paintable, long lasting, and abrasion resistant.

POLYURETHANE/SILICONE
These SPUR (silyl-terminated polyurethane) hybrids have characteristics similar to STPEs. Like STPEs, SPURs rely on groups of a long-chain polymer (in this case, polyurethane) for the backbone of the sealant, and groups of a second polymer (silyl or silane) for the ends. The long-chain polymer provides both elasticity and cohesive strength, while the silyl endcaps provide adhesion.

SILICONE
Early versions of silicone caulk had a so-called acid cure and released a vinegar smell. Modern silicone cures by reacting with moisture and gives off very little odor. Silicone bonds at a molecular level with glass, making it a good choice for frameless shower doors and tile. It doesn't take paint, and not even silicone sticks to where silicone has been used before, so recaulking usually requires mechanically removing some of the previous substrate.

Polyurethane	Hybrid polyurethane/silicone (SPUR)	Silicone
32°F to 100°F	41°F to 104°F	20°F to 120°F
Reaction with water	Reaction with water	Reaction with water
Up to 7 days	1 to 2 hours	Never
25% to 50% typical, up to +100%/–50%	25% to 50% typical, up to +100%/–50%	25% to 50% typical, up to +100%/–50%
Concrete, masonry, metal, stone, vinyl, wood	Aluminum, concrete, fiber cement, many plastics, masonry, steel, vinyl, wood	Aluminum, ceramic, enamel, glass, nonporous surfaces, plastics
N/A	N/A	Concrete and masonry, steel

There's usually no downside to using a more elastic caulk except that it will cost a little more. Given the small amount of caulks and sealants most projects require, spending a few bucks more on higher-quality products makes good sense.

Meanwhile, many of us in residential construction don't even know which of dozens of products to use. The marketing doesn't help; the caulk and sealant aisle is as confusing as a Marrakesh bazaar. Knowledge is the only defense. Caulks and sealants fall into just a handful of categories, and all of them are gauged by ASTM C920.

Caulks and sealants are meant to keep out air and water over the long term. To do these things, a product must balance elasticity, strength (cohesion), and adhesion—that is, it must stretch in response to material shrinkage without tearing or detaching from its substrate. It must compress when the material around it expands, and return to its original shape when the material contracts. Other important characteristics to consider when choosing a product include UV resistance, durability, paintability, and workability. Also, chemicals from a caulk or sealant might stain some surfaces, such as marble.

Understanding performance criteria

ASTM C920 provides a uniform platform for comparing sealants and is often specified on construction documents for commercial buildings. Some products provide C920 data on the tube, while for others, you have to go to the manufacturer's website. C920 incorporates 10 tests and multiple classifications, but the most important consideration is elasticity. Class 12.5 sealants can stretch and compress 12.5%, whereas Class 50 sealants can stretch and compress 50%. There are even Class 100/50 sealants that stretch 100% and compress 50%. This,

Polyurethane safety

Although health problems are more common among spray-foam installers and other workers with high exposures, anyone using a urethane-based product may be at risk. Isocyanates, the building blocks of all urethanes, are the reason. Isocyanates are chemicals that polymerize by binding with OH molecule groups such as are found in water and many organic solvents. Depending on other components, this polymerization forms a variety of useful end products such as paints, wood finishes, glues, insulating foams, and sealants.

According to Christopher Weis of the National Institute of Environmental Health Sciences, "Contact with uncured isocyanates by breathing or through the skin can sensitize workers or family members. Once someone is sensitized, future exposures can cause severe asthma and skin problems." Asthma isn't just an inconvenience. People have died from isocyanate-induced asthma attacks.

But the news isn't all bad. The California Department of Public Health says, "Fully-cured polyurethanes are non-toxic, unless they are heated. Polyurethane materials give off isocyanates and other toxic substances when they are burned or abraded."

Be cautious with any polyurethane product. While activities such as spray-foam application call for a Tyvek suit, rubber gloves, and a full-face supplied-air respirator, NIOSH standards allow a regular organic-vapor cartridge-type respirator to be used for operations of a short duration. Good ventilation is also recommended, as is avoiding skin contact by wearing nitrile or neoprene gloves.

Stay safe. *Use a respirator and plastic gloves to minimize isocyanate exposure.*

by the way, is a loose way to distinguish between the terms *caulk* and *sealant*. Your local hardware store or home center sells products labeled both ways, but caulks are less flexible than sealants and may have an elasticity factor of less than the 12.5% minimum required to meet C920.

For most exterior uses, Class 25 sealants are sufficient, while for interior use, Class 12.5 might do. Not all caulks comply with C920, but one that doesn't might still perform just fine in filling trim joints so that paint will look good. With interior trim, the most important attributes are fast drying times, ease of application, and paintability. Still, there's usually no downside to using a more elastic caulk except that it costs a little more. But given the small amount of caulks and sealants most projects require, spending a few bucks more on higher-quality products makes good sense.

Some caulks or sealants claim to "meet the performance standards of ASTM C920." That's not the same as complying with ASTM C920, but it may not mean that the caulk is inferior. Often, such caulks are solvent based and shrink more during their cure than the standard allows. It's more important to know the elasticity.

One type of sealant not intended to keep out air and water or to make trim joints look good is acoustical sealant. Its purpose is to keep out sound, although it's often used in energy-efficiency applications such as sealing wall plates to subfloors and plastic vapor barriers to crawlspace foundations. Acoustical sealant never hardens, so it accommodates movement well. It remains sticky and is only used where it's unlikely to be encountered once construction is complete.

Joint size and backer rod

For a sealant to stretch and rebound and to remain adhered to the substrate, there must be enough of it in place. In general, sealants require a gap of at least ¼ in. In fact, ASTM C1193, the standard that governs sealant-joint design, states, "Under no circumstances should a liquid applied sealant [a technical term that includes caulks in a tube] be applied in a joint opening that is less than 6mm (0.25 in.) wide." The standard is concerned with joints that must be weathertight, so this doesn't apply to caulked joints along interior trim, for example. The same standard also provides depth-to-width ratios for sealant application, which are crucial to a durable joint.

Sealants are also meant to adhere to two substrates, stretching and compressing as they move. If you introduce a third surface, such as the material underlying the two substrates, adhesion to that third surface can interfere with the sealant's ability to stretch, and it may crack or detach from the surrounding materials.

Clearly, it's important to manage the depth of the sealant application. That's where backer rod and bond-breaker tape come in. Backer rod is made from open-cell or closed-cell foam and is available in diameters from ¼ in. to 6 in. Curiously, it's often stocked alongside weatherstripping products rather than caulks. Backer rod should be sized so that it's 30% to 50% wider than the joint. It pressure-fits into the joint to create a space based on what's required to achieve the correct sealant depth. It's also available in triangular shapes for corner joints where there is no space between the two substrates. Backer rod is very flexible, and sealants don't tend to stick to it, so it doesn't create third-surface adhesion problems. With proper tooling of the face of the sealant using a plastic spoon, Popsicle stick, or your finger, backer rod helps to form the sealant into an hourglass shape that optimizes both the elastic and the adhesive qualities of sealants.

Add paint to the caulk tube. *Measure out the specified amount of paint with the supplied syringe, then cap and shake.*

Add activator to the tube and shake. *The activator causes the caulk, which is very liquid until now, to thicken.*

Caulk neatly. *After allowing 30 minutes for the activator to thicken the caulk to a normal consistency, fill the joint.*

Color-matched caulks

Responding to the increasing popularity of factory-painted siding and trim, some manufacturers of caulks and sealants make products in hundreds of colors to match the palettes offered by siding manufacturers. In most cases, these products are purchased from the siding supplier.

Two companies, Red Devil and Sashco, offer tintable caulks. Simply add the specified amount of the paint you're matching to the special caulk tube, shake it like Elvis after a triple espresso, and caulk away. You can even match faded paint by taking a sample to a paint store and requesting a small quantity of color-matched paint.

Color-matched sealants can be a boon when you're caulking materials with high coefficients of expansion. In some cases, although you can easily find a sealant that will handle the movement, no paint is that flexible. The paint will crack and reveal the caulk below. By using a color-matched sealant, the problem goes away.

Although backer rod made of closed-cell foam has few drawbacks and is the type commonly found in retail outlets, backer rod made of open-cell foam can be helpful with moisture-cure sealants such as STPE, polyurethane, and silicone. In dry climates, or in cases when you want a faster cure, open-cell backer rod may allow moisture to reach the back side of the sealant to accelerate a full cure. It's also more malleable than closed-cell backer rod, making it a better choice for irregular joints. That said, ASTM C920 advocates caution when using the open-cell product in horizontal applications because it can wick and retain water.

Bond-breaker tape is harder to find than backer rod; I could only buy it online. In joints too shallow to accommodate backer rod, bond-breaker tape applied to the rear or bottom substrate prevents three-sided adhesion. Inside corners are another application, and ¼-in. bond-breaker tape allows very shallow fillets of sealant.

Surface prep is crucial

It doesn't matter which caulk or sealant you use or how much money you spend on it; if you apply it to a dirty, loose, wet, or contaminated surface, it won't adhere. For example, any building material that spent time in a lumberyard warehouse is likely to be contaminated with oily soot from diesel trucks and forklifts. The prep varies with the surface. Wood should be fresh and clean. A light sanding followed by vacuuming or blowing off the dust with compressed air should be sufficient. Painted wood, plastic (such as PVC trim or vinyl windows), and aluminum trim or window cladding need a dusting (microfiber cloth does a great job) and should then be wiped down with a solvent such as MEK, acetone, or mineral spirits. Test the solvent on a small area to be sure it doesn't damage the substrate. Wipe the surface with a solvent-saturated rag, then follow up with a clean, dry rag before the solvent evaporates. Change the rags frequently. Old caulk joints, masonry, and concrete might require scraping, grinding, wire brushing, and a blast of compressed air. Leave no loose material.

Silicone leaves a residue that not even silicone will stick to. Mechanical cleaning such as sanding or wire brushing is usually required, although Sashco's Charis Babcock reports success in removing silicone with McKanica Silicone Caulk Remover (mckanica.com).

Site conditions matter as much as prep. Many sealants specify a minimum application temperature of 40°F. There are several reasons for this, but perhaps the most important is simply that the surface-wetting characteristics of most substances decrease at colder temperatures. Simply put, most sealants don't stick well to cold surfaces. Additionally, many sealants don't flow well from the tube when they're cold, and inconsistent application can create voids that weaken the bond. Finally, cold temperatures can slow curing, exposing the soft sealant joint to damage. That said, there are some sealants whose manufacturers allow application in cold or wet conditions, but no one claims these conditions are optimal. If possible, wait for a nice day. □

Andy Engel is a senior editor. Photos by Rodney Diaz.

Balanced Balusters

Simple calculations make for a much more accurate spacing method

BY MICHAEL MAINES

There are countless methods people swear by for laying out balusters. Many of them take a great deal of time and, in the end, are not very precise. I use a method that gives me a precise layout on the first try, on both simple and complicated railing designs.

The symmetrical balustrade pictured here was designed by the architecture firm Albert, Righter & Tittmann and built by Fine Lines Construction. A project of this scope illustrates the importance of being able to accurately determine the spacing and number of balusters.

Michael Maines (michaelmaines.com) is a residential designer and former carpenter in Palermo, Maine.

BASIC BALUSTER EQUATION: A ÷ (A ÷ B) = C

By adding the width of a baluster or group of balusters to the length between newels, this simple equation calculates the number of balusters or groups and the centerline measurement needed for your layout.

SINGLE The length between newels plus the width of one baluster is A. B is the width of one baluster added to a code-compliant baluster space. Divide A by B. Round the quotient up if the baluster space is equal to the code maximum; you can round the quotient up or down if the space is less than the code maximum. The rounded quotient is the number of balusters needed, including the phantom one. Now divide A by the rounded quotient to calculate C, the centerline spacing used for layout. Note that the first centerline will be less one-half the width of a baluster. **Example:** 50 ÷ (50 ÷ 6 = 8.3 [rounded up to 9]) = 5.5.

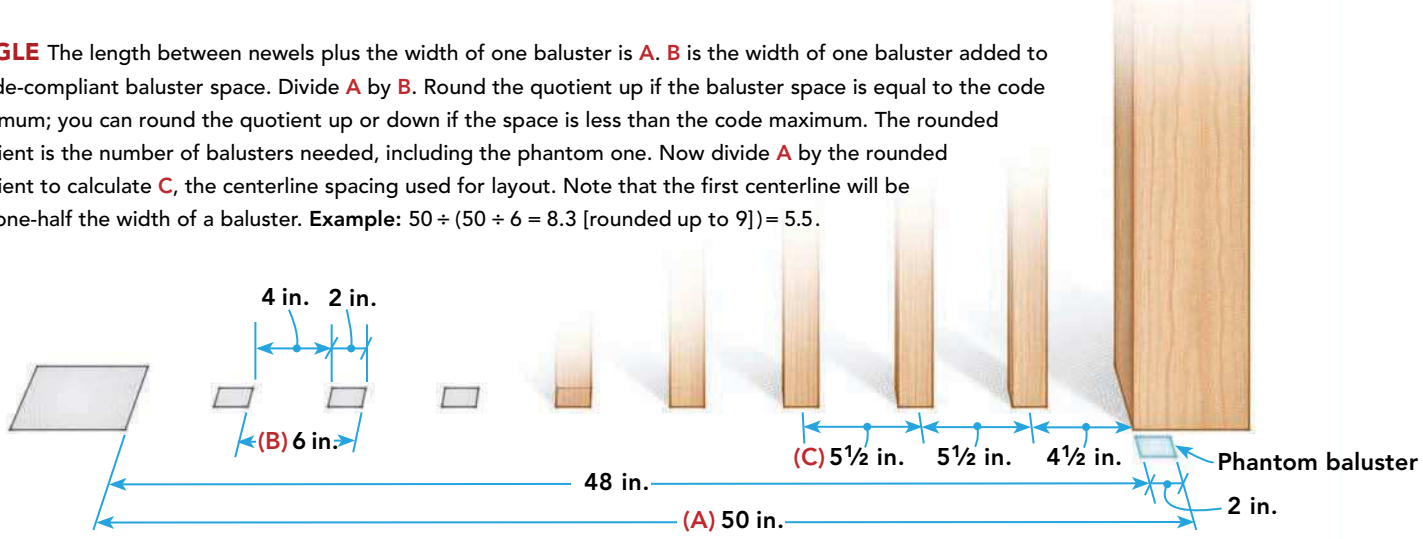
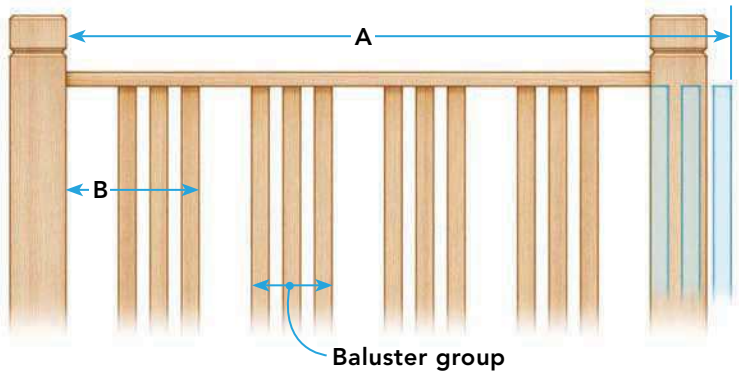
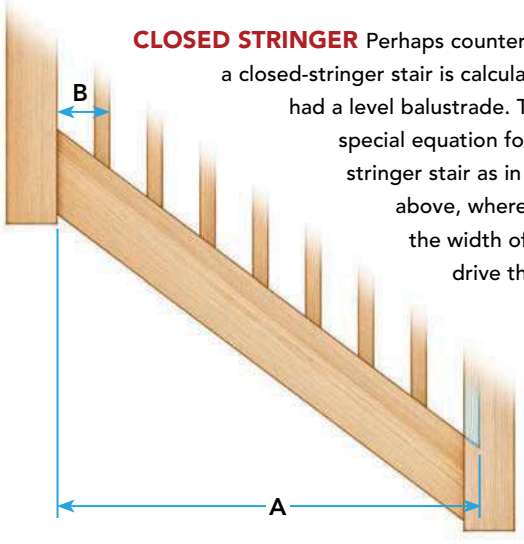


Photo: courtesy of Fine Lines Construction. Drawings: Christopher Mills.

CODE NOTE
The largest space allowed between balusters is usually 4 in. on level rails and 4⅜ in. on stairs. For turned newels and balusters, measure the widest space.



GROUPED The same math works for grouped balusters, but B is the width of the group added to a code-compliant space. The first layout mark is the centerline dimension less one-half the width of the group.

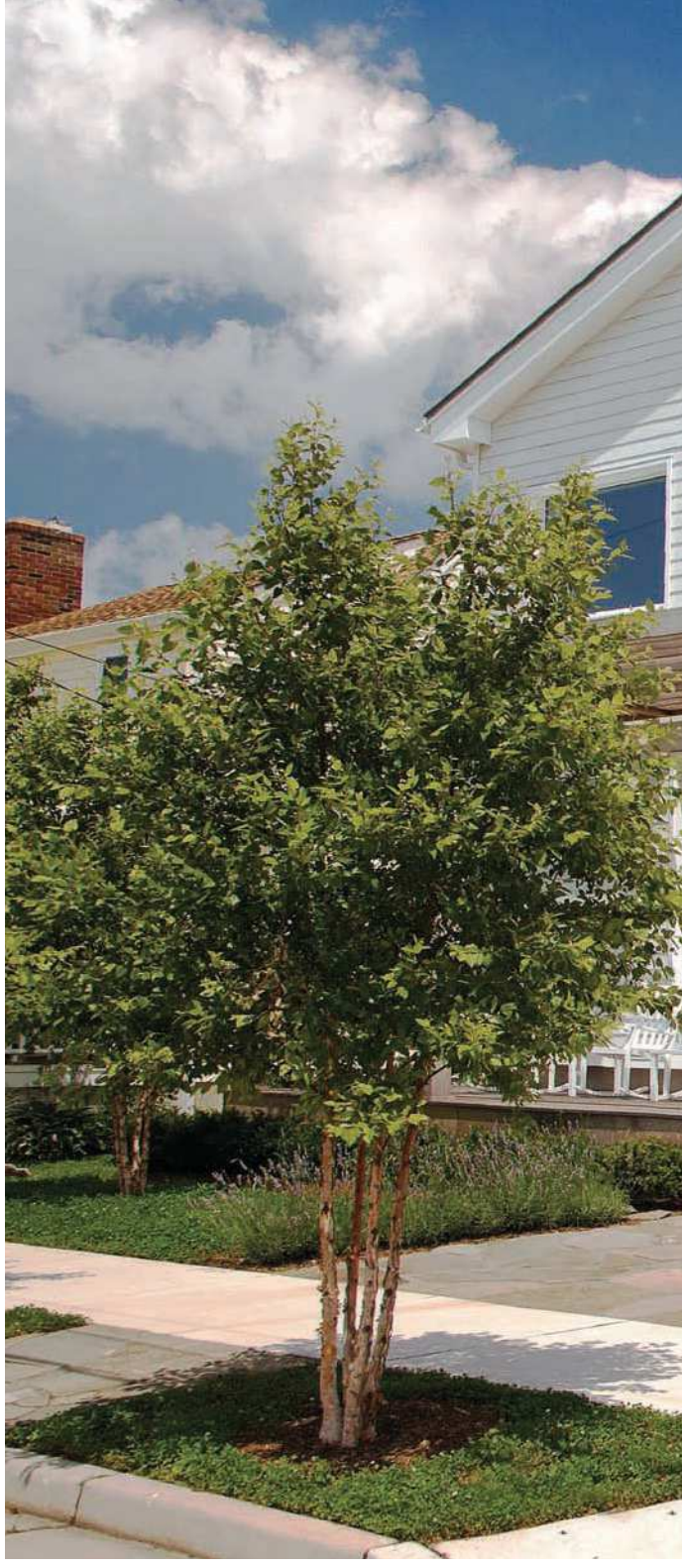


CLOSED STRINGER Perhaps counterintuitively, a closed-stringer stair is calculated as if it had a level balustrade. There is no special equation for an open-stringer stair as in the photo above, where code and the width of the tread drive the baluster position.

Better Than

This practical and healthy home confronts the challenges of location, extreme weather, climate change, and the looming clean-water crisis with noteworthy simplicity

BY BRIAN PONTOLILO



According to the National Centers for Environmental Information, 2015 was the warmest year since 1880, the year when global temperatures began to be recorded. But climate change is fickle, and during the winter of 2015, many in the northeastern United States were muttering the new cliche, "So much for global warming!" Instead of experiencing the warm winter much of the western United States was having, the northeastern states were bundling up against the polar vortex, the extremely cold pocket of air that typically hovers above the Arctic but occasionally reaches deeper into North America.

That winter, Margate, N.J., had its third-coldest February since 1895. Frigid temperatures caused Kirsten and Joe Levin's heat pump to fail. "I don't remember how long it was before we realized the heat wasn't working," says Kirsten, "but it took a while." Once they figured out that the temperature in their new house had dropped a few degrees, Kirsten plugged in a pair of small electric space heaters that she had used to help heat the uninsulated cottage that formerly occupied the property. "We were fine," she says. "It's amazing how well the new house holds heat."

It's said that a certified Passive House can be heated with a couple of hair dryers, but Kirsten and Joe's home is not a Passive House. It is certified by the New Jersey Climate Choice Home program, which means that it meets New Jersey Energy Star requirements. But for the team at ZeroEnergy Design (ZED) responsible for designing it, such certifications are a means to financial incentives—namely, rebates—not a goal in and of themselves or necessarily a performance standard.

Architect Stephanie Horowitz, engineer Jordan Goldman, and business-development director Adam Prince started ZED with a simple commitment: to design houses and other buildings that use 50% less energy than those built to code. Yet Kirsten and Joe's home has much more to offer than a tight, well-insulated envelope: It fits well into its eclectic neighborhood, it is sited to maximize opportunities for light and outdoor space, it conserves water, it is designed and built to stand up to coastal storms and flooding, it has finish materials and mechanical systems that support its owners' physical health,

A PERFECT FIT

Surrounded by a variety of mostly traditional home styles, this barn-inspired exterior blends right in. The front porch splits the elevation and softens the transition from grade to the raised first floor. A wood trellis wraps the house to shade both the front porch and the south-facing first-floor windows.

Average

A CLEAN KITCHEN
The kitchen appliances are energy and water efficient. The range hood and no-VOC, easy-to-clean surfaces keep indoor-air quality high. The modern style is sparse and crisp, and the European tilt/turn windows let in ample light and the ocean breeze.

COOKTOP AND OVEN
Thermador 30-in. Masterpiece Series

RANGE HOOD
Best Eclisse with recirculation kit

DISHWASHER
Thermador 24-in. panel-ready Topaz

KITCHEN LIGHTING
LED track lighting

REFRIGERATOR
Thermador 30-in. custom two-door with bottom freezer

KITCHEN COUNTERS
Stainless steel

and it has a floor plan that supports the family's lifestyle.

With four bedrooms and three baths in 2600 sq. ft., this home is similar to the average new American home described by the U.S. Census Bureau and the National Association of Home Builders. A look at the construction methods used to build this house shows that it is within reach of most experienced builders. But it is hardly average.

A house within reach

American houses consumed about 18,946 trillion Btus of energy in 2015, making them the third-largest user, following industry and transportation, according to the U.S. Energy Information Administration.

It's not clear how much our homes contribute to greenhouse-gas emissions and to climate change. The most recent data available from the Department of Energy is from 2009-2010. Outdated as it is, this data indicates that residential buildings contribute around 20% of total U.S. greenhouse-gas emissions. This includes fossil fuels used on-site (e.g., natural gas for cooking and heating) as well as electricity.

Speaking about the work of ZED, Stephanie is quick to proclaim, "Energy motivates us!" She and Jordan describe their approach to energy efficiency as a three-step process. First, design and build the house to conserve as much energy as possible. The building envelope—foundation, floors, walls, and roof—is the main focus here. Second, design and install the most-efficient mechanical systems needed to heat and cool the house and to maintain fresh and healthy indoor-air quality. Finally, add renewables. With photovoltaic (PV) costs currently as low as $3 per watt installed after incentives, Jordan advises clients to add all the PV they can afford.

At Jordan's recommendation, Kirsten and Joe installed a 5kw PV system on their home, which qualified them for a state rebate. Between conservation measures and renewables, this home is using about 73% less energy than the average code-built home. That puts net-zero energy easily within reach should Kirsten and Joe decide at any point to make an additional investment in PV.

Durability is in the details

On the day of a full moon in October 2012, Superstorm Sandy struck the New Jersey shore. Nearly 350,000 homes were damaged or destroyed by the severe wind and by the state's second-highest recorded floods. In Margate, an island town within the bull's-eye of Sandy's landfall, the foundation for Kirsten and Joe's home recently had been poured. This home, like many others across the country, is in a risky area to build.

For extra flood protection, Stephanie and Jordan raised the foundation 4 ft. above grade, a foot higher than the building department required at the time. Going higher would have made it difficult to fit the two-story home into the neighborhood's overall height limitation for buildings. The raised foundation allows water to flood beneath the house and to drain via water vents. It's detailed as an unconditioned crawlspace.

The first floor is framed with I-joists and is air-sealed and insulated with a combination of rigid foam and water-based spray foam. The 2x6 stick-frame walls are filled with dense-pack cellulose. The roof is framed with 12-in. I-joists, also filled with cellulose. ZIP System sheathing provides the air barrier for most of the building.

The entire exterior—walls and roof—is covered with 4 in. of rigid polyisocyanurate foam. To Jordan, this approach to insulating the envelope is about durability as well as efficiency. "Exterior insulation keeps the wood framing warm and dry over the life of the house," he says. "If moisture gets into the wall cavity, it can dry to the inside because there is no interior vapor barrier."

Though some American manufacturers now offer triple-glazed, high-performance windows, ZED prefers European products—in this case, from Schüco (schueco.com). Jordan says that they are more cost-effective than the domestic offerings and have a modern style that many homeowners are looking for. Beyond thermal performance, these windows provide thermal comfort by keeping the mean radiant temperature, or the average temperature of all interior surfaces, consistent. Because they are not available in impact-resistant glass, the house has a fabric shutter system that can be deployed when strong winds are imminent.

Detailing the envelope and installing the windows were the trickiest parts of the project for Chris Alexander, the builder, who had not put up a high-performance house before this. "We had a lot of meetings and 60-something pages of plans," he says. "We usually have eight." About the permitting and inspection process, Chris reports, "The building inspector was thrilled that a house like this was being built around here."

Everything is inextricably linked

Not only does it make sense to use electric mechanicals and appliances in a home that produces electricity on its roof, but burning fossil fuels on-site is contrary to another of ZED's ethics: to provide healthy indoor air for clients. Combustion appliances are on the EPA's list of indoor pollutants, and a significant factor in poor indoor-air quality, according to the agency, is inadequate ventilation.

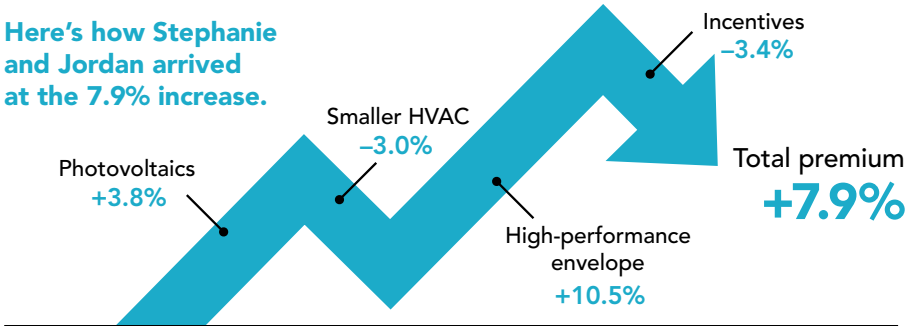
"It's all inextricably linked," says Stephanie. "When you address air infiltration, for example, you're addressing energy efficiency, thermal comfort, and indoor-air quality." In this case, ZED's approach to airflow was to build an extremely tight house (0.47 ACH50) and to provide plenty of fresh air with a Venmar energy-recovery ventilator and a balanced ventilation system. Fresh air is continuously supplied to bedrooms and living spaces. Stale air is continually exhausted from the kitchen and baths, each of which has a boost switch to make sure that enough air is being exhausted when the rooms are in use.

Electric heating and cooling are supplied by a Mitsubishi minisplit heat pump. The house has a heat-pump water heater and an induction cooktop as well. The electric

How much does a better home cost?

The answer, say Stephanie Horowitz and Jordan Goldman of ZeroEnergy Design (ZED), is typically about 5% to 8% more than a similarly finished code-built house. The home featured here cost $275 per sq. ft. of conditioned space, a premium of about 7.9%. This house is on the higher end of the price-increase continuum for a few reasons: It doesn't have the inexpensive space of a basement to lower the cost per square foot, and it's a bit smaller than the average new house. (All else being equal, larger houses have a lower cost per square foot.) A larger, fancier house with a basement typically will be at the 5% end of the range, sometimes even lower. Also, the budget for a high-performance house is allocated differently from that of a more average house. For example, more money is spent on the building envelope, which here includes European windows and doors. The result of such spending is that the house requires a much smaller heating and cooling system.

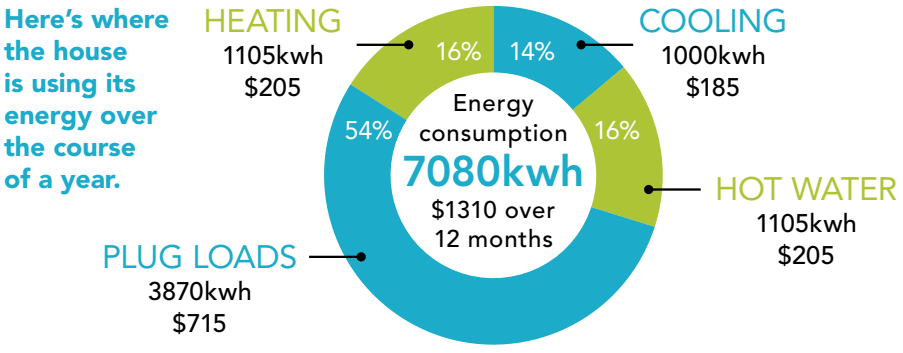
Here's how Stephanie and Jordan arrived at the 7.9% increase.



There is a return on investment in the form of significantly lower utility bills. The ZED team estimates a payback period of nine to 14 years, depending on future energy costs. Yet Stephanie says, "We do not try to justify the improvements we make, relative to code construction, on an economic basis. There are too many benefits that cannot be monetized, such as thermal comfort, altruism, resilience, durability, and sound attenuation."

Over the last 12 months, this house used $1310 worth of electricity (7080kwh). By Jordan's calculations, a code-compliant house would have used $4800 worth of gas and electricity (assuming gas heat and hot water for the code-built house). So this house operated with a 73% reduction in utility bills, almost $3500 in annual savings.

Here's where the house is using its energy over the course of a year.



A MODERN INTERIOR

The interior is clean and uncluttered, with purposefully designed built-in storage. Large windows offer views and daylight, and shades provide privacy when needed. The white-oak flooring from Vermont Plank Flooring brings warmth to the otherwise bright, white interior.

mechanicals and appliances don't introduce any pollutants to the house, nor do any of the zero-VOC adhesives, surfaces, finishes, and furniture. These efforts earned the EPA's Indoor AirPLUS certification for the house.

Just as the systems of a house are inseparable, so are our national infrastructure and resources. The looming water crisis and what we can do about it in our homes is a fitting example. According to the U.S. Geological Survey, the average family of four uses between 320 gal. and 400 gal. of water a day in their home. Production of electricity, however, is the largest consumer of freshwater worldwide. Kirsten and Joe's home conserves water first by producing its own electricity. But it also collects rainwater from the roof for landscape irrigation and has only water-efficient fixtures and appliances inside.

Average size but hardly average

Kirsten and Joe had been living in an uninsulated, split-level "money pit" on this property before they found ZED and decided to build a new home. Though they could have put a bigger house on the property, they were committed to building only what they needed. Kirsten had kept an idea file and knew she would like a "modern barn" aesthetic outside with a modern interior.

The home's orientation along the northern side of the lot maximizes solar gain during the winter, and the driveway acts as a buffer between Kirsten and Joe's home and a neighboring home. Cost-saving is inherent to the home's simple shape. Splitting the elevation between grade and the first floor with the deck minimizes the visual impact of raising the house and means no handrail is needed. The planters and trellis add a clean modern edge. In a neighborhood with no prevailing architectural style, the exterior is unlikely to offend anyone's design sensibilities.

Stephanie's challenge was to design an interior that reflects the way Kirsten, Joe, and

Floor-plan drawings: Martha Garstang Hill

FIT FOR A FAMILY

Open plans have been the trend for many years. But too open is sometimes too much. Here, the entry is separated from the living areas and designed for function, as it serves as the family's main path into the house. While the kitchen and living room are open to one another, a multipurpose room on the first floor has pocket doors that can be closed for privacy.

SPECS

Bedrooms: 4, plus multipurpose room

Bathrooms: 3

Size: 2600 sq. ft.

Cost: $275 per sq. ft.

Walls: R-44

Roof: R-68

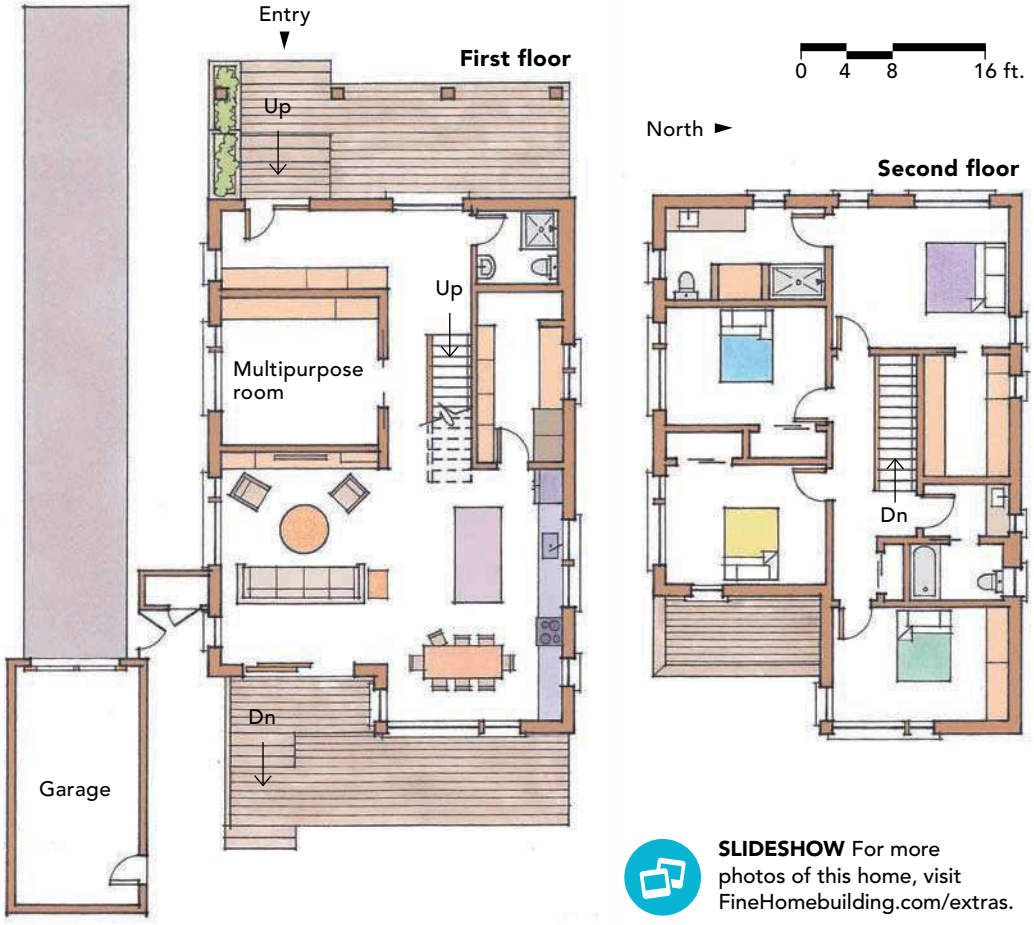
Windows: U-factor, 0.13 SHGC, 0.35

Completed: 2013

Location: Margate, N.J.

Architect: ZeroEnergy Design, zeroenergy.com

Builder: Chris Alexander, C. Alexander Building & Maintenance Co., calexanderllc.com



SLIDESHOW For more photos of this home, visit FineHomebuilding.com/extras.

their three children would live in the house. The front entry, for example, was an important consideration in a home near the beach with street parking. Instead of opening into the great room or to a long view, which is so common today, the front entry opens to a bench and built-in storage cabinets. A full bathroom is only steps away.

The inside of the house is clean and modern. There is minimal trim, the stairs are open and sparse, the finishes are light in color, and generous storage keeps each room uncluttered. Natural-wood was used for the floors and stairs, as well as an accent in the kitchen cabinetry. And plenty of sunlight warms the home literally and in that blissful-Sunday-morning way.

Since the house was built, Margate has adopted the 2015 International Residential Code (IRC). In terms of energy performance and indoor-air quality, this home still far exceeds it. In the wake of Superstorm Sandy, some resiliency provisions, such as the height to which a home must be elevated above grade, have been increased by the township.

Yet legislation is unlikely to be the force that makes a significant impact on how we build. The International Code Council (ICC) updates the nation's most commonly used residential codes every three years, but the updates are rarely adopted. For example, only two states have adopted the 2015 code, and many have yet to adopt the 2012 code. California has an ambitious goal that all new homes built in the state will achieve net-zero energy use by 2020, but critics fear that simply adding renewable energy to average houses misses the most important aspect of high-performance homes: conservation.

With the dire forecast of climate change and more severe weather patterns predicted for the future, the likelihood of continued unpredictable fuel prices, and the knowledge and technology to build smarter and better than average, it's time to demand more of our homes. It's time to build more houses like this—houses that prove how easy it is to outperform the average. □

Brian Pontolilo is design editor. Photos by Eric Roth (ericrothphoto.com).

PRO HOME

Elevating the Standard of Building

Photo: Brian McAward

FOLLOW THE BUILD

Beginning with *FHB* #260, we've been exploring the theory and logic behind our demonstration home. Be sure to visit FineHomebuilding.com/prohome regularly to watch the construction of the house unfold and to hear expert insights straight from the design-and-build team.

WATCH our multi-part video series highlighting every important step of the project.

GET UPDATES on the build and special events by following us, our project partners, and #proHOME on social media.

An ICF foundation, advanced-framing techniques, and engineered lumber form the base of this high-performance home

BY SEAN GROOM

Building a net-zero house calls for planning and appropriate material choices. It also requires craftsmanship—not just in the trim carpentry but also in the foundation and framing. The details buried in the ProHOME's foundation, floor, walls, and roof are developed with insulation and air-sealing in mind, reducing the heating and cooling loads enough so that they can be offset with renewable energy.

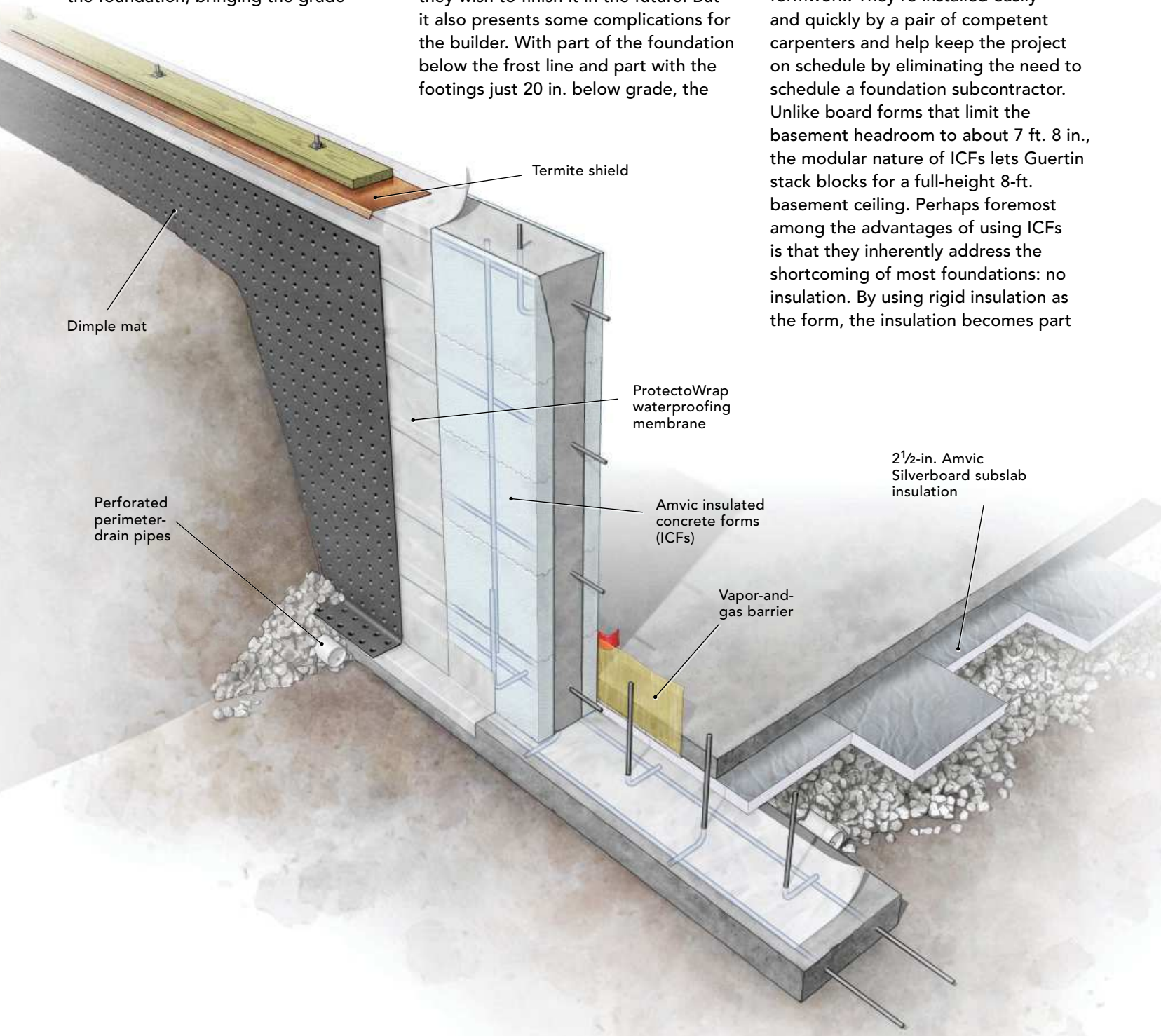
Designer Michael Maines and builder Mike Guertin have exchanged countless emails and phone calls debating framing details, material compatibility, constructability issues, and aesthetic concerns. Recurrent themes have included eliminating redundant framing lumber and maximizing the amount of insulation in each assembly without adding excessive costs or construction time to the project.

Sean Groom is a contributing editor.

A FOUNDATION LIKE A COOLER

Due to the slope of the lot and site work that took place before Guertin purchased it, he only had to dig down 18 in. for the conventionally formed footings. After the foundation is poured, he will truck in dirt to backfill the north and west sides of the foundation, bringing the grade to full height along the foundation walls. The south- and east-facing walls will remain exposed and create a walkout basement. This will offer the homeowners direct access between the yard and the basement and more flexible use of the basement should they wish to finish it in the future. But it also presents some complications for the builder. With part of the foundation below the frost line and part with the footings just 20 in. below grade, the foundation is a hybrid of a traditional frost-protected foundation and a frost-protected shallow foundation.

Guertin has chosen to use insulated concrete forms (ICFs) for the foundation walls. Among the reasons he likes ICFs is that they don't require separate formwork. They're installed easily and quickly by a pair of competent carpenters and help keep the project on schedule by eliminating the need to schedule a foundation subcontractor. Unlike board forms that limit the basement headroom to about 7 ft. 8 in., the modular nature of ICFs lets Guertin stack blocks for a full-height 8-ft. basement ceiling. Perhaps foremost among the advantages of using ICFs is that they inherently address the shortcoming of most foundations: no insulation. By using rigid insulation as the form, the insulation becomes part



Drawings: John Hartman

of the wall, and there are no forms for Guertin to strip off after the pour. Many ICFs provide an R-value of about R-20. The Amvic 3.30 blocks chosen for the ProHOME have thicker foam than most and provide R-30 insulation and a 6-in.-wide concrete core. Even with this integrated insulation, the exterior of the footings and below-grade portions of walls on the walkout sides of the basement require an additional 2½ in. of rigid EPS to circumvent heat loss.

While ICFs use less concrete, they require more steel than conventional foundations, with horizontal and vertical rebar at 24 in. and 16 in. on center, respectively. Even with the rebar, the engineer on this project was concerned about the soil pressure from the north and west sides without backfill on the other sides. His concern related to potential hingepoints, weaknesses at connections of different assemblies—in this case, at the junctions of wood and ICF walls. The original plan was to stick-frame the walkout portions of the basement to "future proof" the basement by providing flexibility for window arrangements and door locations. To allay the engineer's concerns, however, the plan was modified to use ICF construction everywhere in the foundation except for a small area around the windows on the south side.

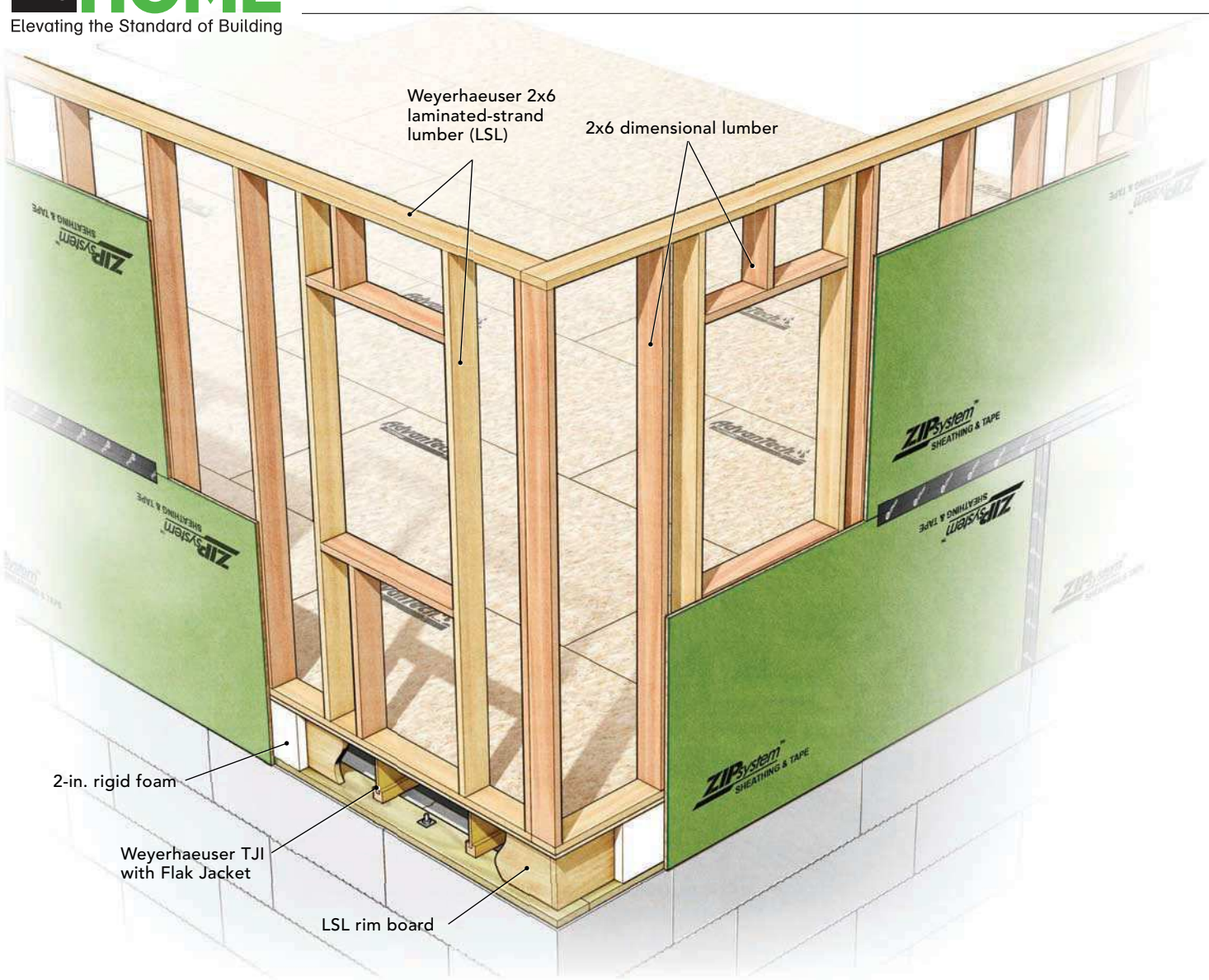
ICFs require special treatment on both the exterior and the interior because of their foam faces. Inside, code requires that a thermal barrier or ignition barrier be installed over the foam. Here, it will be CertainTeed drywall. On the exterior, Guertin will use a belt-and-suspenders approach to protect the foam. First, he will cover it from the top of the ICF down over the footings with ProtectoWrap's Protecto Universal Primer-Free Membrane, which serves as an ICF waterproofing membrane. Next, he will install a dimple mat. This sheet provides drainage space, eliminating hydrostatic pressure, and serves to protect the waterproofing membrane from damage during backfilling.

Slab details for a continuous vapor barrier

In a high-performance house, Joe Lstiburek of Building Science Corporation recommends insulating basements north of the Mason-Dixon Line with R-10 subslab insulation and R-20 foundation insulation. The ProHOME's ICFs exceed his basement guideline. To insulate the 4-in.-thick concrete slab, Guertin is using 2½ in. of EPS rigid foam, which provides R-12.5. The Amvic Silverboard under the slab has a polypropylene lamination on both sides that improves durability in this application. A 6-mil poly vapor-and-gas barrier goes over the foam. All seams are taped, and the ends of the poly sheets turn up the ICFs and are taped as well.

It's important that the insulation and vapor barriers be continuous, so slab penetrations have to be considered carefully. The footings beneath the basement columns aren't continuous with the slab. By forming the top of the footings 2½ in. below the bottom edge of the slab, there is room to continue the subslab foam over the footings and to tape the vapor barrier to the columns.

A good gravel base ensures that the slab performs as intended. The insulation rests on 4 in. of compacted ¾-in. crushed stone. This base serves several functions: It's easy to level, it's a capillary break, and it provides a space for water and soil gases such as radon to move horizontally and to collect in the perforated perimeter-drain pipe. The perimeter drain carries water to daylight well past the house through a sloped drain. A vertical riser from the perimeter-drain loop passes through the slab in the northwest corner of the house and terminates through the roof. The stack effect within the riser induces a slight negative pressure in the perimeter-drain loop. In his region, Guertin has found that a passive vent and a subslab plastic vapor barrier generally control radon levels in the house. If radon levels rise to the EPA's action level (more than 4 picocuries per liter), adding a continuously running mechanical fan in the riser should correct the problem.



AN ENGINEERED FLOOR THAT TAKES WOOD OUT OF THE WALLS

The ProHOME framing package is a mix of engineered and dimensional lumber. The goal was to reduce the amount of framing lumber in order to improve thermal performance and to save on resources and construction time.

The basement is a key part of the house's flexible nature. This unfinished space can be used to address the occupants' future needs. Because it's unfinished, the engineered first-floor framing system will be exposed. Here it made sense to use TJIs with Flak Jacket by Weyerhaeuser to provide the fire protection for floors required by section R501.3 (2012) and section R302.13 (2015) of the International Residential Code. The Flak Jacket coating is engineered to provide up to an hour of burn protection without adding a gypsum or mineral-wool barrier.

The second-floor framing is also TJIs, but without Flak Jacket. Both first and second floors have a 1¼-in. by 11⅞-in. LSL rim board as a continuous rim joist that functions as the primary in-floor header for openings in the load-bearing walls. In many cases, this eliminates the need for additional headers. For wide openings—ganged windows and double doors, for instance—a flush LVL header is nailed to the inside of the rim board. This approach saves lumber and is faster to frame. To improve thermal performance along the rim joist, Guertin places the rim board 2 in. inboard of the outside edge of the mudsill and top plate. This creates space for 2 in. of rigid insulation behind the sheathing and still leaves room for the 1¾-in. LVL flush header where it's needed. Combined with the 2 in. of rigid insulation outside the sheathing, there's R-18 at the rim joist before any insulation is added on the inside of the rim board—a traditionally weak thermal spot.

Guertin chose Huber's ¾-in. tongue-and-groove AdvanTech subfloor because he has found that it spans the 24-in.-on-center floor joists better than commodity OSB panels. Gluing the panels to the TJIs with a polyurethane foam adhesive makes a stronger floor assembly.

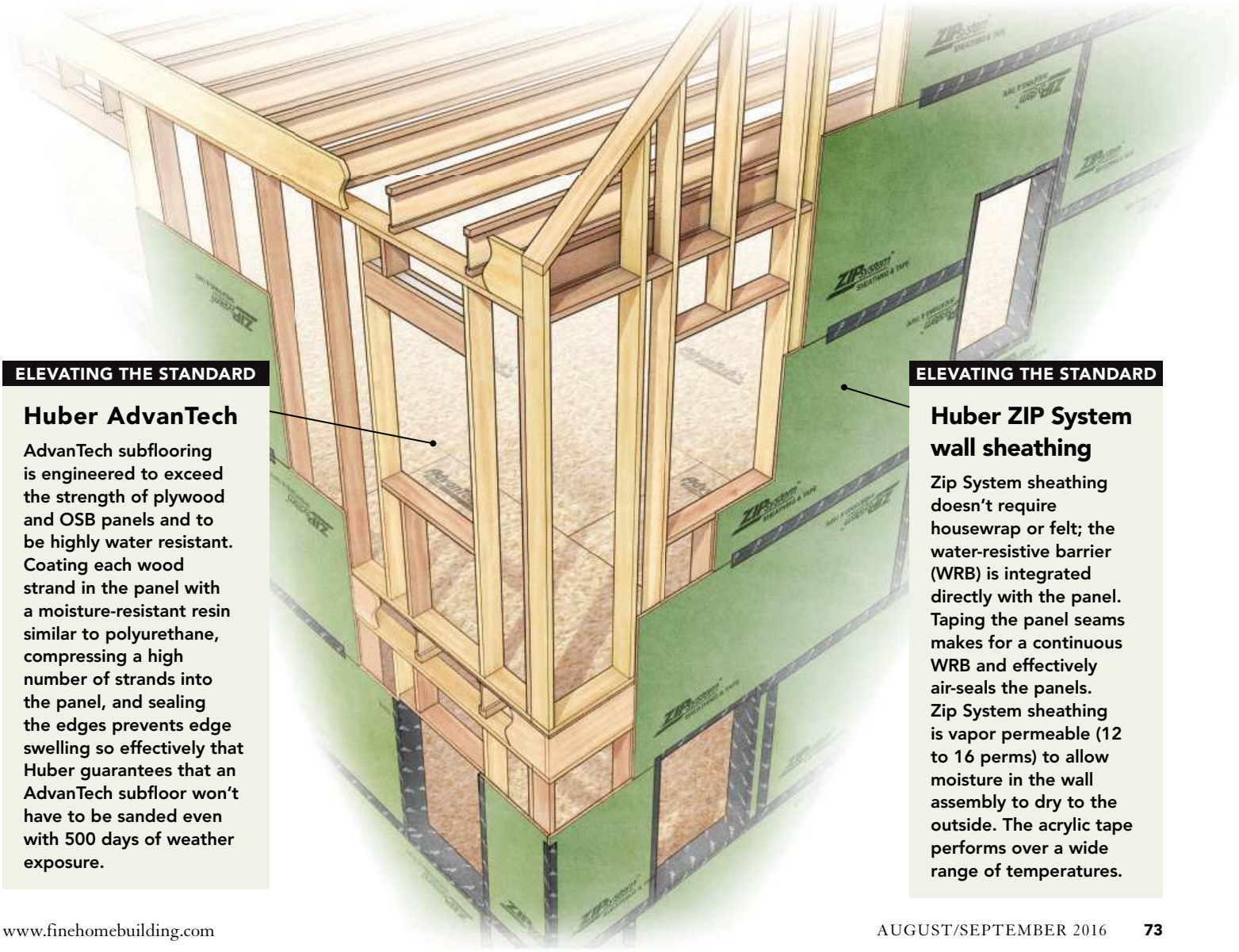
BUILDING LEAN, STRONG WALLS

In their attempt to reduce the amount of wood in the walls and increase the amount of insulation, Guertin and Maines adopted advanced-framing techniques. Spacing the studs and joists 24 in. on center to align loads through the wall and floor assemblies eliminated the need for a double top plate as well as jack studs at rough openings.

Most of the studs are standard 2x6s, but Guertin is using laminated strand lumber (LSL) studs in several places to take advantage of their dead-straight characteristics and their availability in longer lengths than solid-sawn lumber. All of the king studs in the walls are LSLs because the lack of any twist or crown speeds up window and door installations and improves flashing and air-sealing. Guertin will also frame the west kitchen wall with LSLs. Straighter walls with few dips and humps will speed up cabinet installation.

Because the walls have single top plates, all wall plates are LSLs, which allow most walls to have a continuous plate without the need for splices. (Weyerhaeuser's 2x4 and 2x6 TimberStrand LSLs are available in lengths up to 24 ft. in New England.)

As the primary air barrier, the wall sheathing is an important component of the ProHOME. With Zip System sheathing, the walls are dried in and much of the air-sealing work is done when the walls are stood up. The walls will be detailed with exterior insulation and a rain screen. Rather than run exterior insulation all the way up the gable ends to the rake subfascia, Guertin will terminate it at the level of the attic insulation and fur out the siding with ripped 2x stock toenailed to the studs. This technique is easy and fast when working on a second-floor deck and saves rigid foam for the areas where it's needed.



ELEVATING THE STANDARD

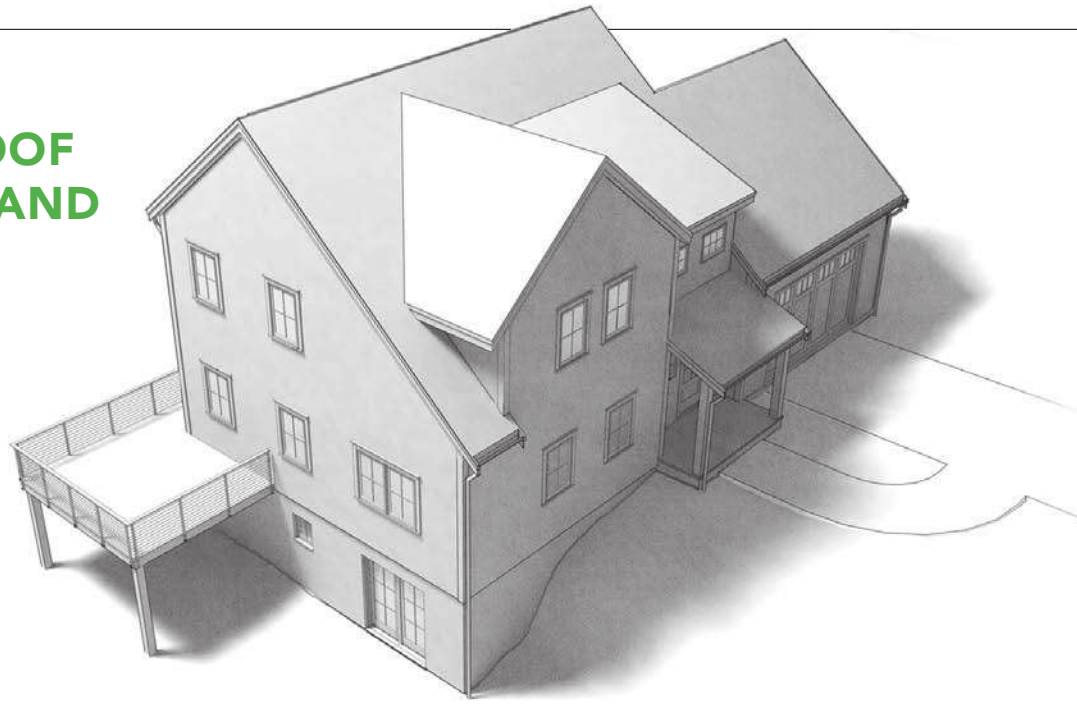
Huber AdvanTech

AdvanTech subflooring is engineered to exceed the strength of plywood and OSB panels and to be highly water resistant. Coating each wood strand in the panel with a moisture-resistant resin similar to polyurethane, compressing a high number of strands into the panel, and sealing the edges prevents edge swelling so effectively that Huber guarantees that an AdvanTech subfloor won't have to be sanded even with 500 days of weather exposure.

ELEVATING THE STANDARD

Huber ZIP System wall sheathing

Zip System sheathing doesn't require housewrap or felt; the water-resistive barrier (WRB) is integrated directly with the panel. Taping the panel seams makes for a continuous WRB and effectively air-seals the panels. Zip System sheathing is vapor permeable (12 to 16 perms) to allow moisture in the wall assembly to dry to the outside. The acrylic tape performs over a wide range of temperatures.



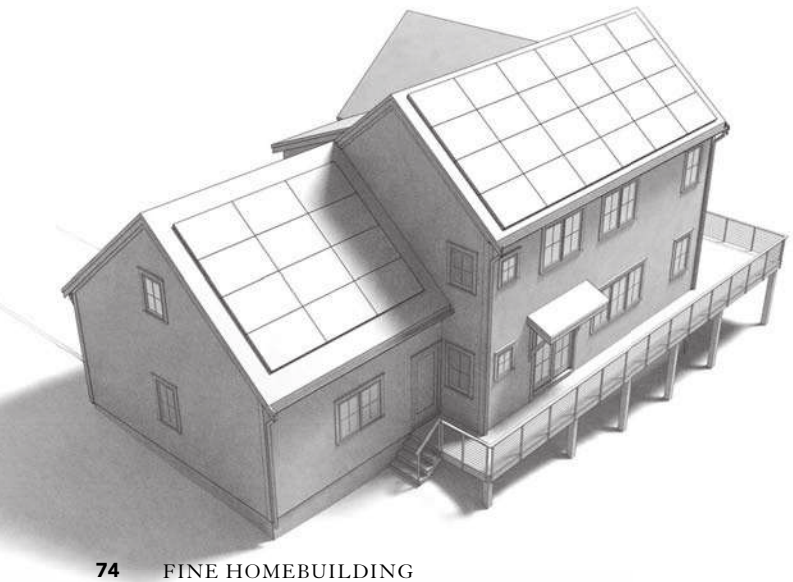
AN INTERESTING ROOF ADDS COMPLEXITY AND TIME TO THE BUILD

Visually, the ProHOME's dormered roofline defines the house. The large gable dormer creates the space for the large master bathroom, while the shed dormer accommodates the other full bath and the laundry room. The low eaves across the front of the house create a horizontal emphasis, reducing the scale of the house and creating a comfortable entry. Maines used the combination of dormer styles to evoke several architectural styles—Victorian, farmhouse, and the venerable Cape—that figure prominently in the local housing stock.

For all its design elegance, however, the roof will be an epic framing job. Guertin figures the second-floor ceiling and roof will take about two-thirds of the framing time for the entire house. The two dormers, each with a different roof pitch, create an irregular valley and add complexity to the framing. Using TJIs for the ceiling joists and rafters takes more time; they are more cumbersome to cut than dimensional lumber, and both the joist and the rafter webs have to be padded out at the eaves so that these offset framing members can be screwed together. Despite the added steps, TJIs have some distinct advantages: They are straight and don't shrink, twist, or crack—and they're light, an advantage any carpenter will appreciate.

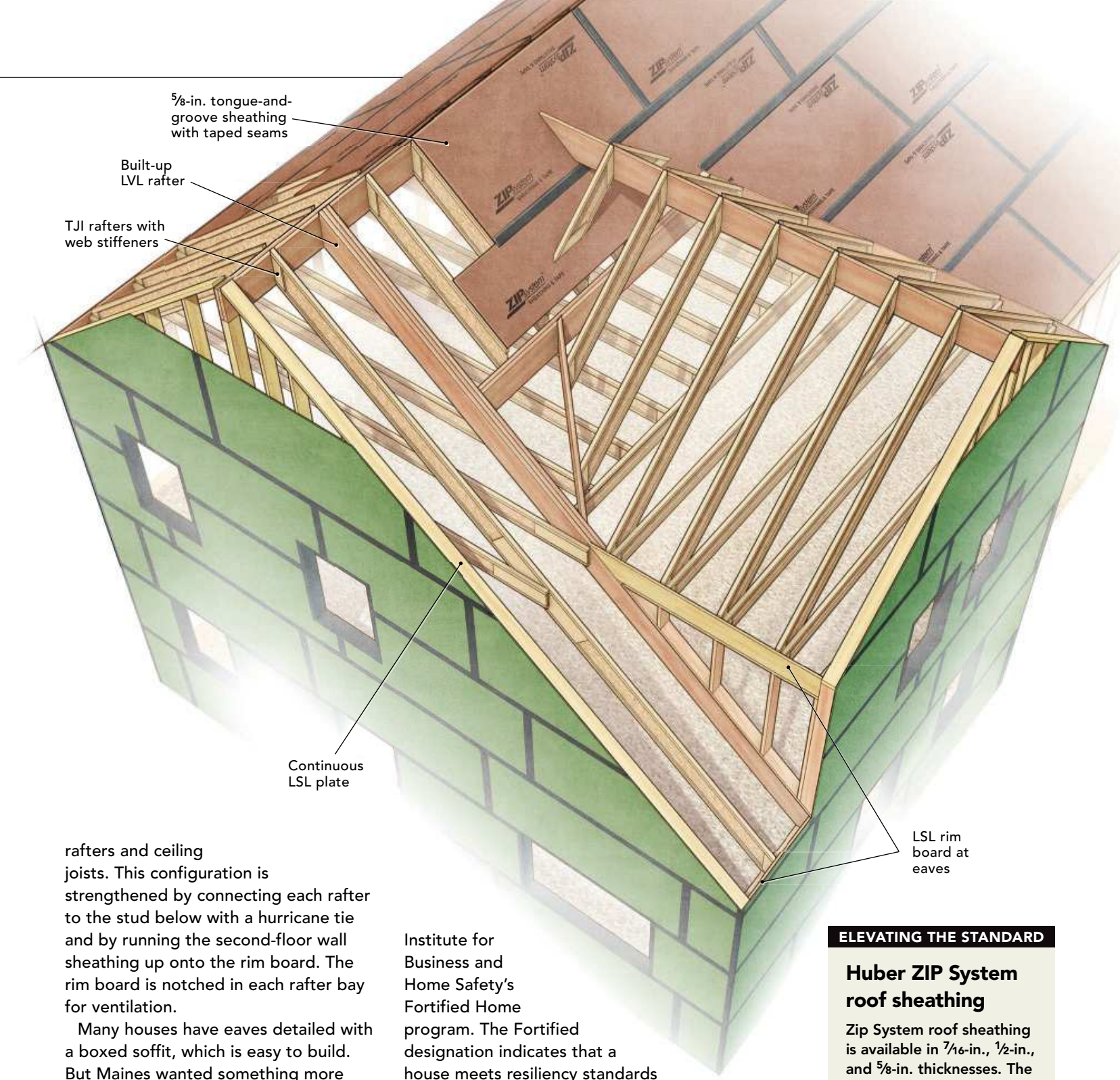
With a vented roof assembly and a deep blanket of blown-in insulation, insulation baffles are necessary to maintain an airspace along the eaves and at the shed dormer roof. The underside of the I-joists' top flange is a convenient place for Guertin to fasten insulation baffles that he'll make from rigid polyisocyanurate insulation. This ensures a clear air path between the continuous Cor-A-Vent soffit and ridge vents. And because of their thin OSB webs, TJIs also have limited thermal bridging compared to dimensional lumber, so they improve thermal performance along the eaves where thermal bridging could occur.

Instead of installing blocking between the rafters at the eaves, a continuous LSL rim board runs along the outer edge of the top plate and braces the



MAXIMIZING SOLAR PRODUCTION

An important part of the roof plan is the photovoltaic panels. While there are no structural concerns for adding a PV array to this roof system, Maines took several steps to optimize the roof for an array. With a two-story eave on one side and a one-story eave on the other, the house is essentially a saltbox. Orienting the two-story facade with the unbroken roof plane to the rear for southern exposure was important to accommodate the 12kw array needed for net zero. Consolidating all of the plumbing into a single vent stack maximized the usable area. While a steep roof was desirable for aesthetic reasons, the 10-in-12 roof pitch—between the ideals for summer and winter—was chosen to maximize production over the course of the year.



rafters and ceiling joists. This configuration is strengthened by connecting each rafter to the stud below with a hurricane tie and by running the second-floor wall sheathing up onto the rim board. The rim board is notched in each rafter bay for ventilation.

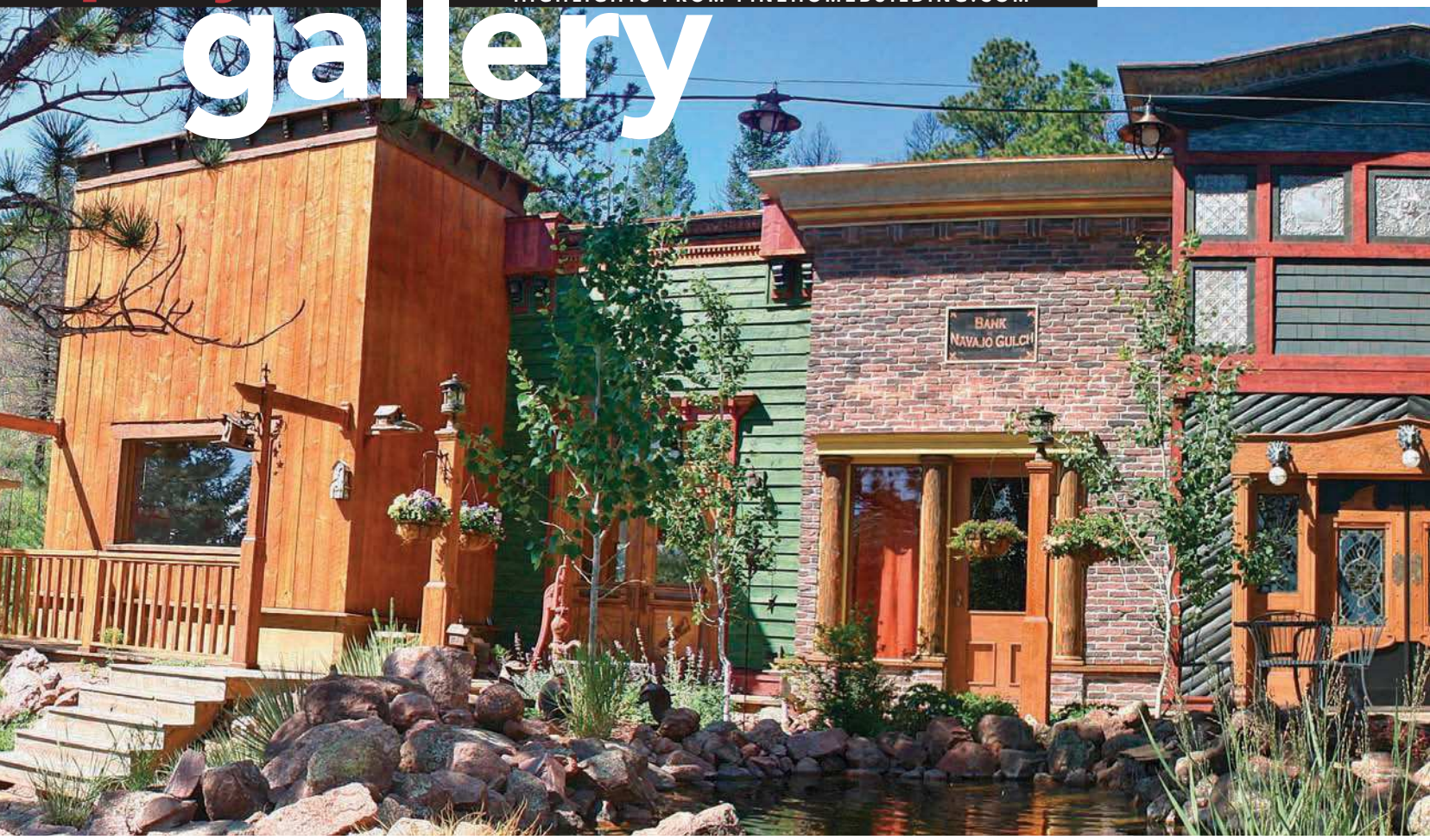
Many houses have eaves detailed with a boxed soffit, which is easy to build. But Maines wanted something more appealing. His choice was a traditional-looking sloped soffit that he believes subtly draws attention to the roof plane. Borrowing an assembly method from Passive Houses, he designed the soffit to be built ladder-style and screwed onto the wall through the rain-screen strapping and exterior foam.

The Zip System roof sheathing is an important part of Guertin's plan to enroll the ProHOME in the Insurance Institute for Business and Home Safety's Fortified Home program. The Fortified designation indicates that a house meets resiliency standards designed to limit damage from natural events such as hurricanes. The program requires the type of integrated WRB and taped seams on the roof that Zip provides, because felt paper and synthetic underlayment can be damaged when storms blow off shingles. As with the walls, the taped seams get the house dried in quickly and eliminate the need to apply rolls of material on the roof.

ELEVATING THE STANDARD

Huber ZIP System roof sheathing

Zip System roof sheathing is available in 7⁄16-in., 1⁄2-in., and 5⁄8-in. thicknesses. The 5⁄8-in. tongue-and-groove version on the ProHOME has the greatest span capability—up to 40 in. for rafters and trusses. The Zip System tape used on wall and roof sheathing is applied to panel edges and then adhered with the help of a J-roller to ensure a tenacious bond and to help dry in the roof.



Fine town-building

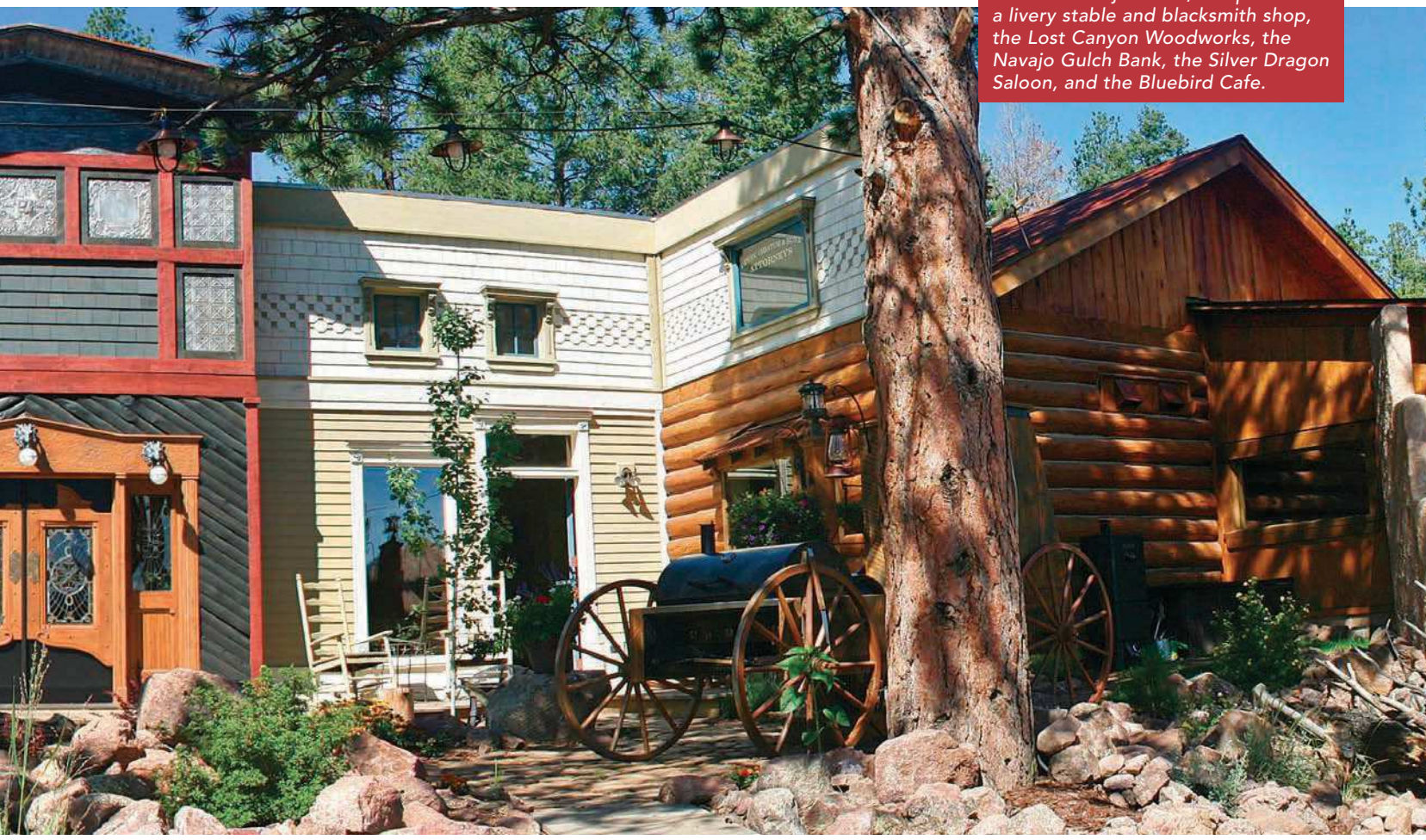
One of the first submissions to our 2016 HOUSES awards was this panoramic view of an Old West town submitted by Caroline and Dave Nelson, who also submitted a photo of a log cabin. Looking at the photos, we thought the cabin must be situated near some quaint Old West tourist town. It turns out that this Old West town is not just near the Nelsons' house—it is the Nelsons' house.

Since 1978 Caroline and Dave have been partners in life and in business. Through their custom architectural-woodworking firm, Lost Canyon Woodworks, they have designed and built many one-of-a-kind items for their clients. After 35 years of fulfilling others' desires for fanciful woodworking creations, they decided to fulfill their own dream and designed this 3448-sq.-ft. house and workshop on 14 mountaintop acres with an incredible view of Pike's Peak.

Requiring only minimal assistance with some of the framing, drywall, and setting of the rocks for the courtyard's pond, the Nelsons built the house themselves. The living area is approximately 1850 sq. ft., with a studio and shop taking up the rest of the square footage. The post-and-beam house is set on a concrete slab with radiant-floor heat. Locally sourced materials such as hand-peeled half logs were used inside and out. Photovoltaic panels provide almost all the electricity needed thoughout the year. Solar-thermal collectors tie into the in-floor heating system. Two 120-gal. insulated storage tanks provide all the domestic hot water and a portion of the heat in the winter.

Cozy cabin. *The roof is heavy-gauge corrugated steel with a beautiful rusty patina. The gate is rough-sawn beetle-kill-pine; the arbor is scrub oak and willow.*

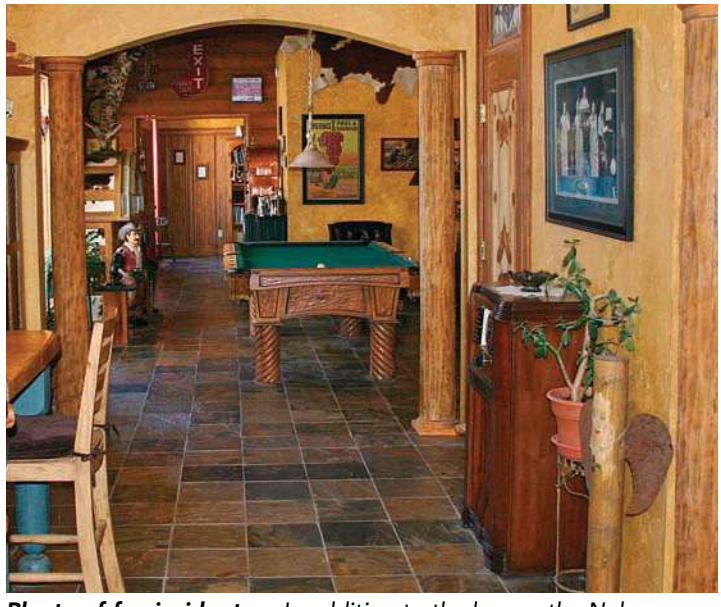
Time travel. *Entering the courtyard transports visitors back in time to the town of Navajo Gulch, complete with a livery stable and blacksmith shop, the Lost Canyon Woodworks, the Navajo Gulch Bank, the Silver Dragon Saloon, and the Bluebird Cafe.*



Design and construction Caroline and Dave Nelson, Florissant, Colo.; lostcanyonwoodworks.com

Woodcarving Charles Hensley, Manitou Springs, Colo.; charleshensleywoodcarving.com **Photographs** courtesy of Caroline and Dave Nelson

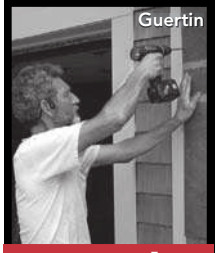
Well-done dinners. *The Nelsons designed and built a "chuck wagon" to house their gas and charcoal grills. The courtyard patio is stamped concrete in a fieldstone design. The view of Pike's Peak enhances the enjoyment of al fresco dining.*



Plenty of fun inside, too. *In addition to the house, the Nelsons also built the jukebox and the billiard table. The door next to the jukebox is one of 13 custom interior doors the couple designed and built.*

ask the experts

YOUR QUESTIONS—PRO ANSWERS



experts

Brian Walo is a licensed electrician in Mount Pleasant, S.C. He has written numerous articles on electrical work for *Fine Homebuilding*.

Editorial adviser **Mike Guertin** is a builder and remodeler who has written over 100 articles for *Fine Homebuilding* and appeared in dozens of videos.

Need help?

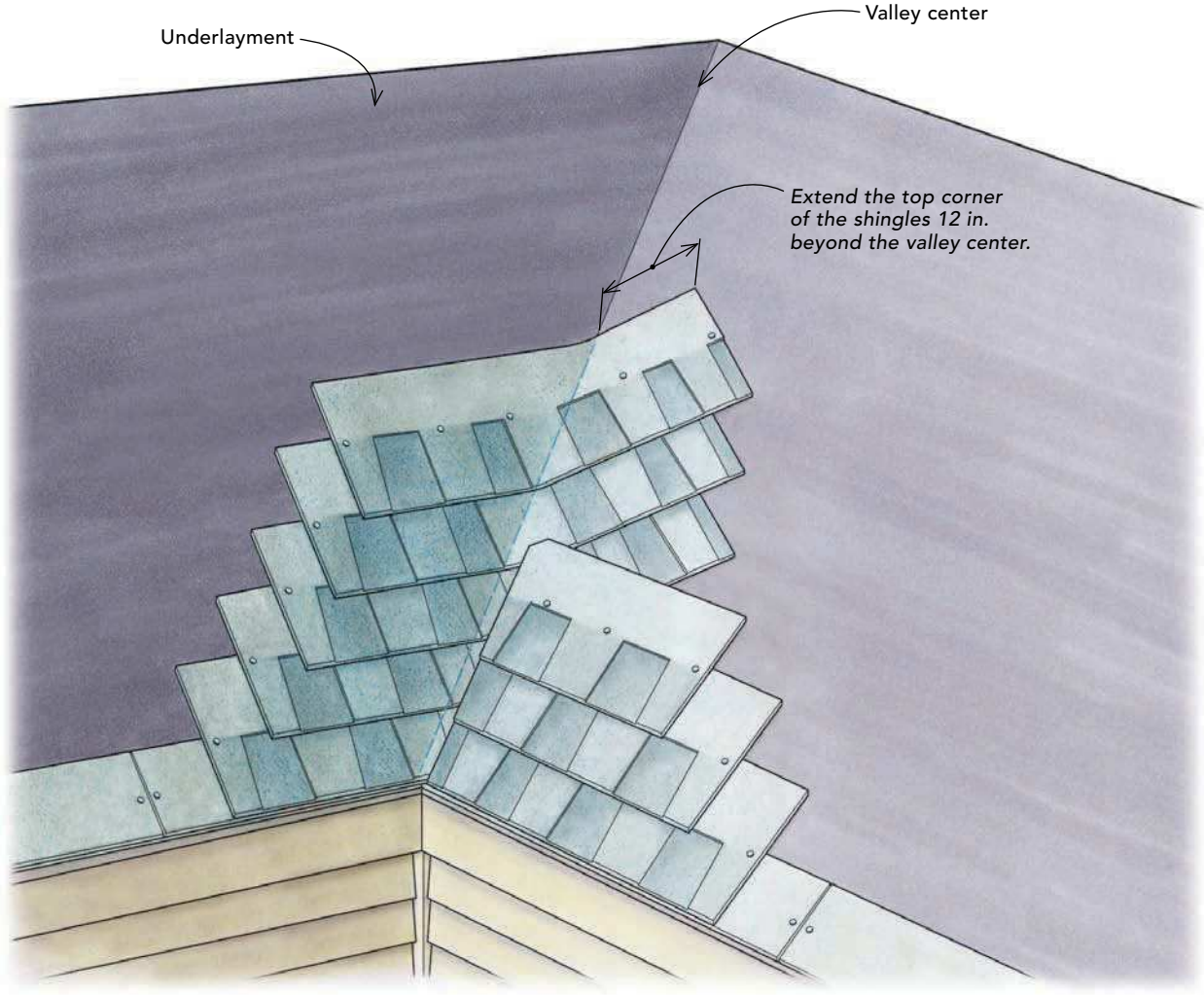
Get answers you can trust from the experienced pros at *FHB*. Email your question to Experts@FineHomebuilding.com.

Shingling a valley

I'm covering a closed-cut valley with laminated shingles, and the instructions say to extend the ends of the shingles at least 12 in. onto the adjoining roof. Where is the 12 in. measured from on the shingle? If I measure at the bottom edge, then only 8 in. of the top edge extends onto the adjoining roof.

—PATRICK CROFTS
Dublin, Calif.

Mike Guertin: Because of the angle of the valley in relation to the horizontal line of the shingles and square shingle ends, it isn't obvious where you should measure the 12-in. point from. Is it the bottom corner, the top corner, or the nail line to the centerline of the valley? I checked the American Roofing Manufacturers Association's *Residential Asphalt Roofing Manual* as well as the installation instructions from several shingle makers, but none specify in words or drawings where to measure from. I called two shingle manufacturers and stumped the customer-service representatives. The companies responded after checking with their technical people, and the answer in both cases was to measure the 12 in. at the top corner of the shingle. One company rep noted that the 12 in. along the top edge is a general target and doesn't have to be perfect to satisfy the warranty.



Photos: *FHB* staff. Drawing: Dan Thornton.

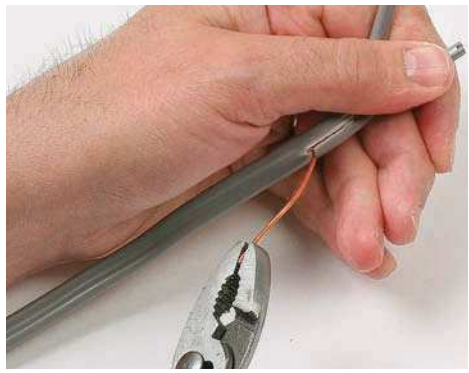
Stripping UF-B cable

Stripping the jacket off regular interior-use NM electrical cable is pretty easy to do, but doing it to outdoor UF-B cable is difficult. The conductors within UF-B cable are encased individually within the plastic jacket. I've found it next to impossible to carve off the jacket without damaging the individual conductors inside. Is there a trick to getting the jacket off UF-B cable without harming the plastic on the wires inside?

—MARC PREST
Newington, Conn.

Brian Walo: UF-B is always a hassle, but here's how to deal with it: Cut about 2 in. along the concave center of the cable with a utility knife. With pliers, pull out the bare ground wire in the center, using it like a rip cord to split the jacket as far as needed. Score the jacket inside the grooves left by the ground wire where the hot and neutral conductors are encased. Finally, pull the conductors out the same way you did with the ground wire, and cut off the portion of the jacket you no longer need.

Cut down the UF-B cable's concave center.



Pull out the center ground wire with pliers.

Score the inside of the jacket.

Pull the conductors out from the jacket.

Algae roof stains

While reshingling a roof five years ago, I installed zinc strips under the cap shingles to prevent algae staining on the roof surface. I left the bottom edge of the zinc exposed 2 in. Now algae stains are appearing in the middle of the roof. Was I sold a bogus solution, or did I install the strips incorrectly?

—JACK SOMMERS
Ithaca, N.Y.

M.G.: The solution is not bogus. When rainwater runs over the surface of the strips, zinc ions are released that wash over the surface of the roof and kill algae. The problem is that while the zinc strips you installed under the cap are probably keeping algae from forming in the top few feet of the roof, by the time the water reaches the middle of the roof, it is so diluted that it no longer contains enough zinc to stop the algae growth. You need to install additional zinc strips at intervals up the roof. A lot of factors impact how to space the strips: humidity, rainfall amounts, age of the roof, roof slope, width of the strips, and algae resistance built into the shingles. I've never seen a formula for spacing zinc strips. One manufacturer recommends strips every 6 ft. Another suggests strips every 3 ft.

Ideally, the strips should be installed at the time the shingles are installed. They are nailed along the nail line on the shingle course so that the overlying shingles cover the nails. Since the zinc strips may cover the self-sealing strips on the shingles, you may need to apply dabs of roof cement to ensure that the overlying shingle course is sealed to the one beneath.

If the roof already has algae stains, you can add zinc strips to kill the algae, but it will take time for the rain and zinc to work. You can accelerate the cleaning process by spraying the roof with an algae cleaner.

Moldy cabinets

After moving into a 1920s Craftsman-style house, I suspected there were leaks in the roof because mold appeared on the walls inside some of the kitchen cabinets each winter. I had the asphalt roofing shingles replaced with a cedar-shingle roof. The new roof seemed fine until midwinter, when mold appeared in the kitchen cabinets again. The roofer went in the attic and found no evidence of water leaking in. He also said he put a peel-and-stick membrane on the bottom edge of the roof. There are wide overhangs on the roof, so I don't think water is leaking in through the walls. What can be causing the mold if it's not from roof leaks?

—PATRICK KENSINGTON
Seattle

M.G.: The cabinets in a house from that period were probably built in place rather than installed as separate cabinet boxes. When you look inside the cabinets, you may be looking at the painted plaster on the wall surface, which would show permanent water stains if there were a leak.

Photos: Dan Thornton

Because you noted mold but no water stains, my guess is that there is a humidity problem inside the house and that the mold is due to condensation rather than a water leak. There may be no insulation in the walls, or blown-in insulation may have settled over the years, leaving voids near the tops of the stud cavities. In either case, the plaster on the exterior-wall surface is cold in winter. Moist air inside the house can condense on the cold surface and lead to mold. You're more likely to see mold inside the cabinet because the cabinet doors reduce warm-air circulation inside the cabinet. It's probably slightly colder on the exterior walls inside the cabinets than on the rest of the exterior walls inside the house.

Test the relative-humidity level inside the cabinets on a winter day. You'll likely find that the moisture level is higher than 50%. You'll need to track down the moisture source and address it. It could be that moisture from the basement is migrating into the living space, or the problem could be moisture generated by activities such as showering, cooking, and cleaning. Ventilation likely will be part of the solution. This could include exhaust fans inside the bathrooms and over the cooktop, as well as whole-house ventilation.

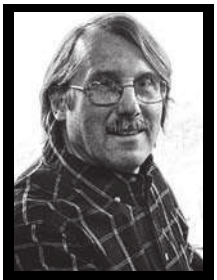
Identifying electrical circuits

The circuits on the electrical panel in my house aren't marked on the panel cover. Is there an easy way to pinpoint which circuit handles which loads, or do I have to go on a hunting expedition?

—HEATHER COPE
Houston

B.W.: Circuit tracers exist, but due to their high cost (about $1000), I just check outlets and workboxes to see which breaker controls power to them. Most outlets and lights are grouped geographically or by function. Lighting is often run on 15-amp breakers, with outlets on 20-amp breakers (especially with arc-fault outlets needing to be separated from lighting). Bathroom outlets are usually on one circuit for cost-effective GFCI protection. Tone generators that can trace the wiring within walls are $60 to $300, but they can be finicky and are more useful for locating individual runs of wiring than whole circuits.

BY MARTIN HOLLADAY



"Musings of an Energy Nerd" showcases the best of Martin Holladay's weekly blog at GreenBuilding Advisor.com, where he provides common-sense advice about energy issues to residential designers and builders. Because his data-driven conclusions usually fall between the extremes of minimum code compliance and adherence to the Passive House standard, they are often controversial.

Green Building Advisor

Green Building Advisor is for designers, engineers, builders, and homeowners who craft energy-efficient and environmentally responsible homes.

Plan ahead to save energy

It's not unusual for a designer, builder, or homeowner to post a question on Green Building Advisor like the following: "We just finished framing, installing windows, and roofing. What's the best way to insulate?"

My usual reaction is "Really? You're asking now?"

Leaving these decisions to the last minute limits your options. The most common approach to insulating a home in much of the United States is to fill the stud bays with fiberglass batts and, once the ceiling drywall is installed, to unroll more fiberglass insulation in the attic—a simple approach that doesn't work very well. To build a house that performs at a high level, your insulation strategy must be part of the design process.

Choose wall insulation before installing windows

Why would anyone leave decisions about insulation to the last minute? Some builders think, "We'll either fill the stud bays with fiberglass batts, or, if the homeowner wants to pay for an upgrade, we'll just use spray foam." The trouble with this approach is that a wall with insulation only between the studs still has a lot of thermal bridging through the framing.

If you care about this thermal bridging—and you should, because thermal bridging through studs reduces the whole-wall R-value considerably—you need to include exterior rigid foam or exterior mineral wool, or to frame a double-stud wall. Once the windows are in, it's usually too late to install rigid foam or mineral wool on the exterior side of the wall sheathing, and it's certainly too late to think about a double-stud wall. This decision has to be made at the design stage, before the walls are framed.

Roof insulation needs planning, too

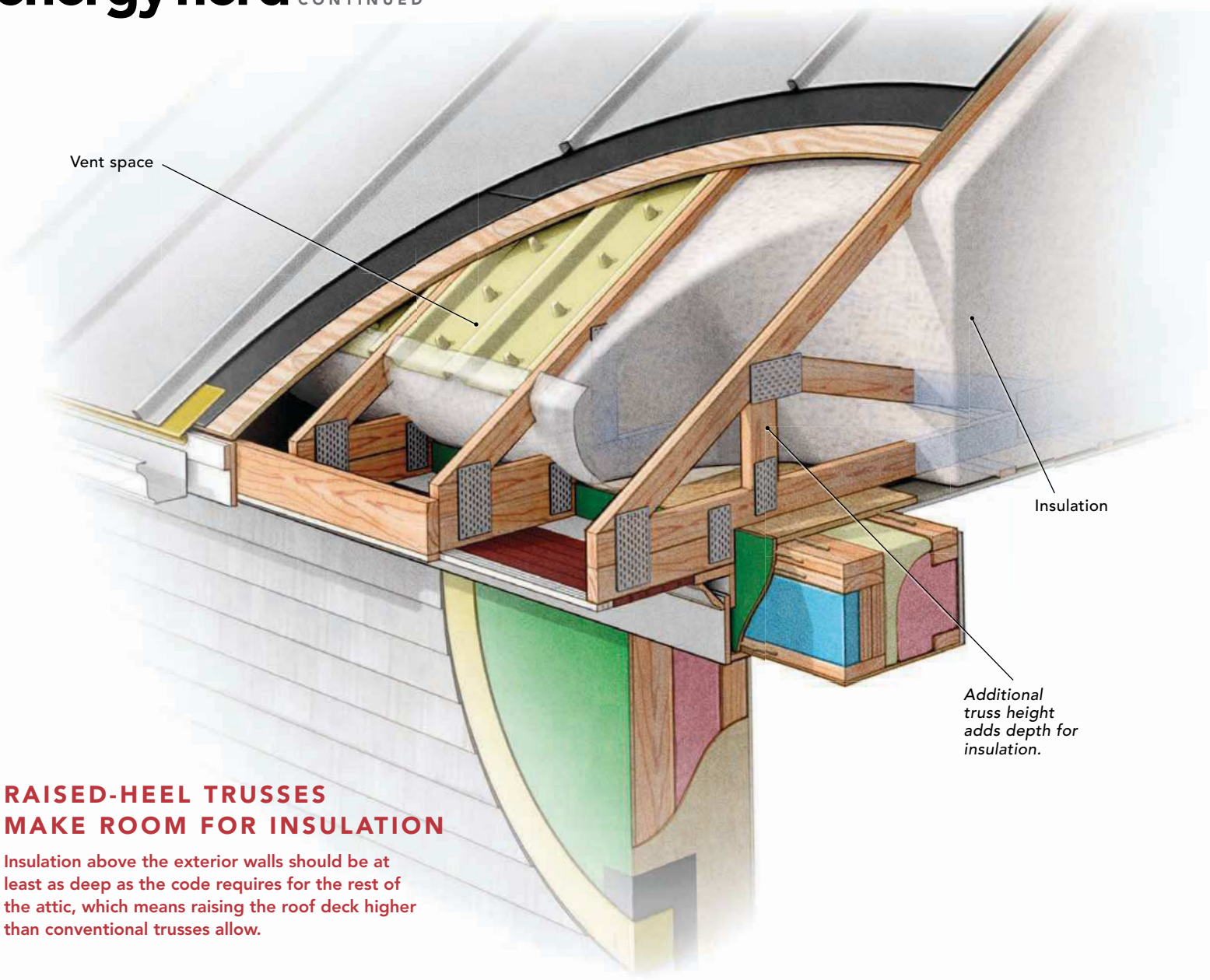
Once the roof trusses have been installed, it's too late to order raised-heel trusses, which are needed to make sure there's room at the perimeter of the attic to install enough insulation between the top plates of the exterior walls and the roof sheathing. Why would anyone who is planning a vented, unconditioned attic forget to order raised-heel trusses? I don't know. But it happens all the time.

Properly insulating cathedral ceilings also takes planning. Green Building Advisor regularly

EXTERIOR FOAM KEEPS YOUR STUDS WARM

Exterior foam reduces thermal bridging, but it also requires planning the details for attaching and flashing doors and windows.

Photo: courtesy of Karyn Patno.
Drawing: Bob LaPointe.



RAISED-HEEL TRUSSES MAKE ROOM FOR INSULATION

Insulation above the exterior walls should be at least as deep as the code requires for the rest of the attic, which means raising the roof deck higher than conventional trusses allow.

receives questions from readers with poorly performing cathedral ceilings. Problems include high energy bills, temperature stratification, and ice dams. In almost all cases, the best solution includes installing exterior rigid foam. On an existing house, especially one with skylights, this is very expensive work. On a new house, the work is much simpler and cheaper, but you have to plan ahead. If you wait until the shingles are on, you're too late.

Of course, it's possible to insulate a cathedral ceiling without using any exterior rigid foam. But to install enough interior insulation to meet even minimum code requirements, you may have to lower the ceiling—and a lot of homeowners don't want to do that.

Designers often punt on the mechanical room

Insulation problems aren't the only consequences of failing to plan. Another is failing to make the mechanical room big enough. How often do residential designers do a good job of designing a mechanical room? In my experience, less than half the time.

Mechanical equipment for a typical house may include a furnace, an air handler, or a boiler, plus a water heater, a water pump, a pressure tank, and a water softener. Higher-performance houses also may have a heat-recovery ventilator (HRV) or an energy-recovery ventilator (ERV), along with associated ductwork.

Some of these appliances have access panels, so the designer of a mechanical room has to provide enough space for service personnel to get to those panels. The manufacturer of each appliance specifies how much access is needed for proper servicing of the equipment. Failure to follow the manufacturer's installation instructions is a code violation.

What happens when these issues are left to the last minute? There's no obvious place for some critical piece of equipment. It's only then that the builder posts a ques-

Drawing: John Hartman

tion: "We've decided to install an HRV, but we're not sure where to put it. Can we install an HRV in the garage or the attic?"

Oh, yeah—the ducts

Sometimes a designer or an owner-builder does a good job of designing the mechanical room. There's plenty of space for the furnace, the HRV, the water heater, and the rest of the equipment. However, no one has thought about how to run the ducts, and everyone now realizes that there is a major beam in the way. Or maybe the designer thought about the supply-air system but then forgot about the need to install return-air ducts.

Suddenly, everyone is discussing trade-offs: What's worse—adding a soffit in the living space to hide the ducts, or installing an imperfect duct system?

If you're trying to save energy, oversize ducts are always preferable to undersize ducts, which means that contractors can't just squeeze a duct into a cramped space at the last minute.

Hire a gray-haired designer

If you are an owner-builder, you will probably make some mistakes—even if you've read this article. (They'll just be different mistakes from the ones mentioned here.) If you hire an architect or a residential designer, ideally one with gray hair, you won't regret the decision.

That said, even if you hire a designer with years of experience, you still may encounter problems. Some designers care more about aesthetics than they do about building science. Your goal is to find one with a foot in both worlds.

In the worst case, the chosen designer has spent decades working in a region of the country where designers, builders, and homeowners rarely pay much attention to energy efficiency or green building. Once the house is designed and construction has started, the homeowners discover Green Building Advisor. Now they're running to the architect every week with new requests—for example, "We've decided that we need an HRV. Can you add that to the plan?"

Sometimes changes can be made. At other times, it's too late. All the homeowners can do then is post a new comment on Green Building Advisor: "I wish I had discovered your website three months ago."

BY ANDY ENGEL

Make a head flashing

Every window and door needs head flashing, and bending metal for these simple flashings is a gateway to the skills needed to make other wall and roof flashings. You probably already have the necessary cutting tools: a square, a utility knife, and snips. You also need hand benders and a brake (often called a siding brake or an aluminum brake).

The metal flashing used for this project is often called coil stock. It is sold in rolls in a variety of lengths, widths, thicknesses, and metals. Aluminum flashing—either bare (mill finish) or painted—is most common, followed by copper and galvanized steel. Lead-coated copper is also available and should be used when copper is placed below exposed cedar because tannins leaching from cedar corrode copper. Aluminum's thickness is measured in thousandths of an inch, with

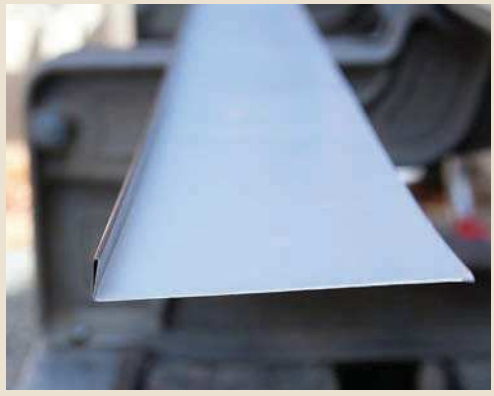
STEP BY STEP

1 Cut to width. *Mark the width at both ends of the metal. Insert the metal in the brake so that the marks align with the edge of the jaws, then pull down on the top handle to clamp the metal. Score it with a sharp knife. Pull up the bottom handle to bend and break the metal along the score.*

2 Bend the hem. *Mark the width of the hem (⅜ in.) at each end of the metal. With the inside face up, insert the metal ⅜ in. into the jaws, and tighten down the clamp. Raise the lower handle of the brake as far as it will go to make this bend.*

3 Crimp the hem. *Insert the bent edge into the jaws, and use the clamping action of the brake to pinch the hem closed.*

STEP BY STEP

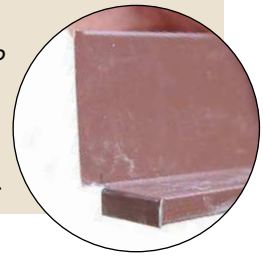


4 ***Bend the overhang.*** *Put the hemmed edge in the jaws with the inside face up. Align the edge with the jaws, then clamp it and bend it a little past 90°. Once bent, the metal will relax a few degrees.*

6 ***Cut the ends.*** *Use snips to cut ⅜ in. along the back bend. In the front, snip out a ⅜-in. square at the end of the hem.*

5 ***Bend the upturned leg.*** *Mark the width of the casing or jamb on the outside face. Keep that face up, align the jaws with the mark representing the back of the window, then clamp and bend.*

7 ***Bend the ends.*** *Grab the end flap with hand benders, keeping the sides of the jaws even with the inside of the hem, and fold it over.*



Bending and cutting tools

Siding or aluminum brakes come in lengths from 4 ft. to 10½ ft. Brakes cost $1000 and up, but they can be rented for around $60 a day. Accessories are available to aid in cutting and rolling out coil stock. Hand benders cost around $20. Some models have replaceable jaws of various lengths so that they can be adapted to the job at hand. Snips come in a variety of forms. The ones shown here are common straight-cut aviation snips. Left- and right-cutting snips are also available to ease curved cuts. Snips cost about $15.

Bottom photos, this page: left, courtesy of Van Mark Products; center and right, Dan Thornton

0.019 in. and 0.024 in. being common. Heavier aluminum with thicknesses of 0.027 in. and up is often referred to as gutter coil, because it's also used to form seamless gutters. Copper's thickness is measured by weight, with 16 oz. per sq. ft. being typical. Galvanized steel is measured by gauge, with smaller numbers corresponding to thicker material.

Thicker flashing material is more durable and more resistant to buckling from thermal expansion than thinner material; however, it also is more expensive and more difficult to bend. Siding brakes typically can bend aluminum up to 0.027 in. thick, copper up to 16 oz. or 24 oz., and galvanized steel up to 26 ga. or 28 ga.

The first step in bending metal flashing is measuring what you want to flash. To find the width of the metal needed in the case of a head flashing, I measure how far the jamb or casing protrudes from the wall sheathing. To that, I add ⅛ in. because the bend will consume some material width. The wall leg should extend at least 2 in. up the wall. Finally, I add something for the leg that turns down over the face of the casing or jamb. I like to extend that about ⅜ in. down, but because I hem that edge, I allow a total of ¾ in.

Hemming is when the edge of a piece of flashing is bent back on itself and flattened. This creates a straight edge that's less likely to wrinkle. Additionally, cut edges of sheet metal are surprisingly sharp. Hemming folds the cut edge behind the face of the flashing and places the dull, folded edge out where people are most likely to be. To find the length of the metal, add 1 in. (to allow for each end to be folded) to the width of the jamb or casing. Cutting metal to length is simple. Use snips, or score the material with a sharp utility knife guided by a square, then bend along the score until it breaks.

Andy Engel is a senior editor. Technical advice was provided by Tom Struble, a siding contractor in West Milford, N.J. Photos by Rodney Diaz, except where noted.

BY MARK HUTKER

Exposed rafter tails

As an architect, I love the authenticity of exposed structural elements like rafter tails. They celebrate the hand of the craftsmen who built the home and allow the true nature of the home's construction to be celebrated in its aesthetic.

The roof rafters on many houses extend beyond the top wall plate to create overhangs at the eave (so-called lookouts create overhangs at the rake). These roof overhangs direct water away from the walls and the foundation, shelter entry doors, and shade windows from high summer sun. Sometimes the projecting portions of the rafters—the rafter tails—are cut plumb and level to be boxed in with a soffit and fascia or more ornamental trim. At other times, the rafter tails are left exposed.

Early examples of exposed rafter tails likely occurred for reasons of efficiency and economy, as simple plumb-cut rafter tails successfully created an overhang with no extra effort, material, or expense. Exposed rafter tails also offered the possibility of function. By cutting simple notches into the rafter tails, for example, you could create an opportunity to rest gutters directly within

BEAUTIFUL BUT WRONG

If you're designing a home or addition with applied rafter tails, the design principles should mimic those of the real thing. For example, historically, rafters were cut from true 2-in. boards. If you use today's dimensional 2x lumber for a traditionally styled house, the detail will not appear authentic. Most important, though, the applied rafter tails should appear to be an extension of actual rafters; their exterior placement should have integrity with where they would actually align. One common mistake is wrapping them around a corner, which is not how the house is framed. Another is installing the rafter tails horizontally rather than in plane with the roof.

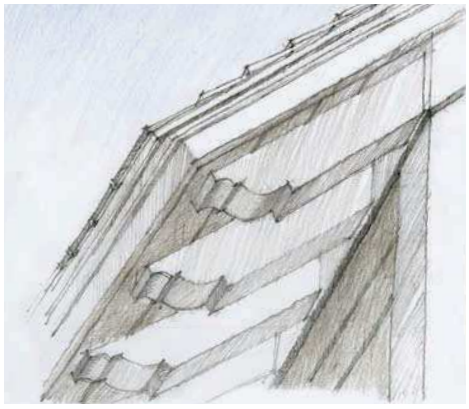
1. *Dimensional 2x lumber would not have been used on a home of this vintage.*
2. *Rafter tails should have the same pitch as the roof.*
3. *Rafters don't turn corners.*

RAFTER TAILS DESIGNED RIGHT

The most basic traditional rafter tail has a simple plumb cut at the end of true 2x lumber, with the benefit of offering a robust surface for attaching a gutter.

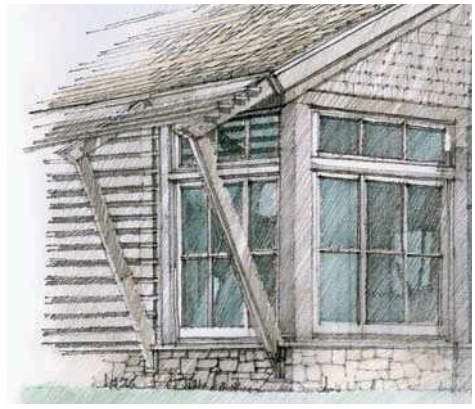
Rafter tails cut from true 2x material also can have a tapered bottom edge, which adds a subtle suggestion of the craftsman's hand and a more modern appearance to the house.

Landing on a purlin that extends beyond the gable wall to carry the roof overhang, these cottage-style rafter tails are based on the Italianate style and are cut from lumber at least 2 in. thick.



Fitting on a Victorian or Georgian home, this rafter-tail profile would traditionally have been cut in hand-hewn rafters, possibly as thick as 3 in.

These Arts and Crafts–style rafter tails are drawn from the traditional style of the early 1900s and seem to be reaching out to grab the integral gutter.

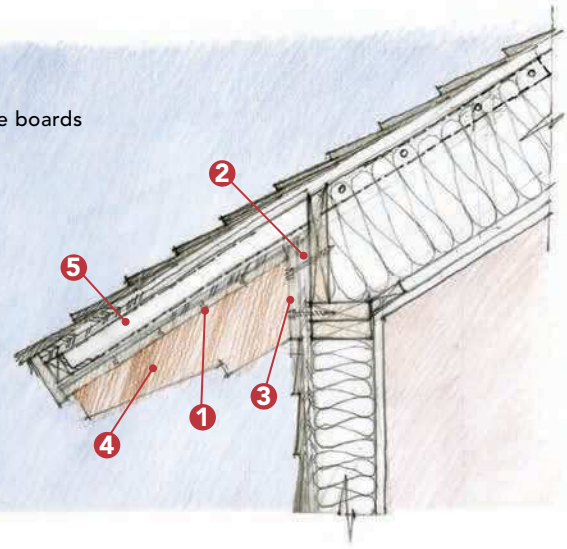


On this modern house, the extralong rafter tails are given a new function: to create a sunscreen for shading the floor-to-ceiling windows underneath.

ENERGY-SMART RAFTER TAILS ARE NOT CONTINUOUS

A more thermally efficient approach to rafter tails is to end the roof rafters at the top plate and add a rafter-tail assembly at the eave. The assembly of rafter tails and tongue-and-groove boards that create the appearance of sheathing from below can be built on the ground and installed as one piece or in sections. In this detail, wood struts extend from the top of the assembly into the roof, where they are sistered to the roof rafters to support the overhang.

1. Tongue-and-groove boards
2. Construction lags
3. Frieze board
4. Rafter tail
5. Strut



the roof structure, an elegant solution before modern gutters became available.

Aesthetically, exposed rafter tails created a pleasing and unfussy character, highlighting the beauty, rhythm, and order inherent in the building's structural form itself. Beyond that, exposed rafter tails provided opportunities for designers and carpenters to demonstrate their skills by adding corbels and also mitered, scalloped, or beveled details. With the increase in popularity of exposed rafter tails, different styles and shapes came to characterize traditional home styles such as Craftsman, West Indies, Italianate, and Carpenter Gothic.

Exposed rafter tails have evolved as a signature element of our firm's work. They complement not only traditional-style homes but also some of the more contemporary homes we design. They offer opportunities for interesting and distinctive detail, while providing real functional value.

Unfortunately, true continuous rafter tails create a thermal bridge and an energy penalty because they puncture the building envelope. For this reason, and because we now have manufactured trusses and alternative framing options, it's more common in current construction for roof rafters to terminate at exterior walls. In these cases, rafter tails can still be used in an ornamental capacity, attached to the exterior frieze board beneath the eaves. This provides an opportunity to create style and add character, while maintaining the roof overhang to shelter and protect the home.

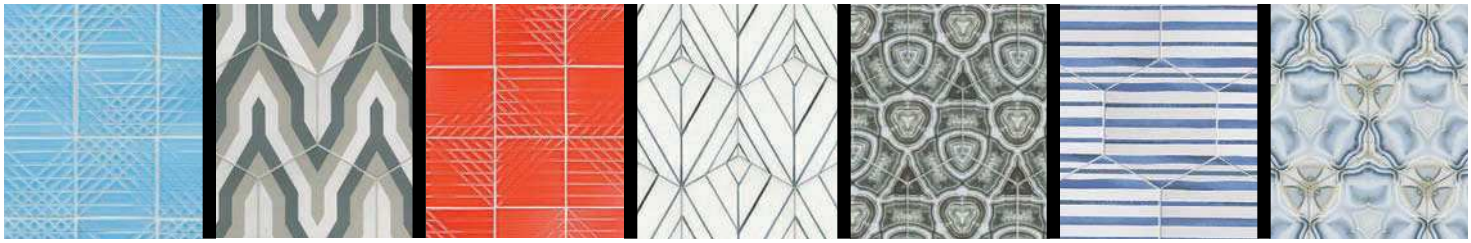
Whether you are designing a home with true continuous rafters or applied rafter tails, it's important to get the proportions and details right. On traditional-style homes, for example, avoid today's dimensional 2x lumber, which was not available when most early American architectural styles were emerging and will likely look undersize and out of proportion. On modern homes, stay true to structural integrity, and look for opportunities to add function.

Here are some common mistakes to avoid, some inspiring examples of how to get rafter tails right, and a look at the construction details of an applied energy-smart rafter tail.

Mark Hutker, FAIA, is principal and founder of Hutker Architects (hutkerarchitects.com), which has been designing homes in New England for more than 30 years. Illustrations by Matt Schiffer of Hutker Architects.

tailgate

INTERVIEW BY AARON FAGAN



LINDSAY MEACHAM, Tilemaker This owner of Red Rock Tileworks in Nashville, Tenn., designs and manufactures environmentally friendly lines of handmade and custom tile.

At what point did you discover your passion for tilemaking?

My parents are both architects, and they instilled in me an appreciation for good design early on and have always encouraged me artistically. My first experience with clay was in an after-school class in third grade. After that, it was difficult to keep me out of the mud. My ceramics professor in college had us do a tile project, and it was at that moment when I realized I could connect my passion for clay and design with a career.

Are you driven by tradition, breaking from tradition, or both?

I'm inspired by tradition and feel that we offer some timeless designs that will never fade. When I first started making tile, this was really important to me because I wanted to be a part of history and lasting architecture. As I have evolved as an artist, I find myself looking more forward than backward. I reference different design movements but am much more comfortable putting my own stamp on them.

What inspires your handmade tiles?

I'm inspired by various cultures and traditions, but I like to add my own contemporary twist. Whether it's the bright colors of spices in a Moroccan market or the gestural motions in graffiti on a subway wall, I always have my eyes peeled for new shapes and color combinations.

I just launched two new collections: Verge and Linea. Verge is rooted with natural elements but has a psychedelic twist. I photographed agate—a variety of quartz—and broke up the images like a kaleidoscope. I also played with watercolor and mimicked the veining of large Amazonian leaves. Linea is a very simple collection, and it reflects my love and respect for the simplicity and directness of midcentury-modern design. The lines of the tile can create more complex shapes depending on how they are installed. I present the tile in bright candy-like colors, but they are available in any of our 62 glazes.

What is your creative process?

For each collection, my process changes and is quite spontaneous. Sometimes I sketch while I'm having lunch; at other times, I pour my brain power into geometry and perfection through graphic-design software. After I have a preliminary drawing, I carve in clay, plaster, wax—whatever suits the look. The designs evolve in this three-dimensional phase, as I start to understand how the glaze will play on the raised and lowered relief of the tile. Some designs just don't translate from paper to clay.

Once I'm happy with the single tile, I make a master tile and a mold. I may decide to make slight changes if I foresee glaze issues, but for the most part, I've learned from my early tile-making mistakes and am purposeful with my prototyping.

Have you developed custom designs?

Yes. Typically our commercial clients come to us for custom tile, and it's so much fun! Each client has specific ideas, but we try to offer insight into our medium in ways they may not have considered. Architects and designers sometimes share Pinterest folders, image files, or even CAD drawings of what they want. We then quote the project and get carving. Handmade tile has natural variation, so we try to emphasize this during the process. It's part of what makes handmade tile so beautiful.

What are the advantages of boutique tile manufacturing?

Flexibility, response time, and uniqueness. Unlike those in mass-production factories, our molds are relatively inexpensive to make. If I see a trend or have a client who wants a specific look, I can make the tile in a matter of weeks. Imported tiles may be less expensive, but the time from concept to market can take months if not years. We can react quickly, and we can also craft for discerning clientele. Because we produce smaller runs, we can tailor to specific looks. Larger factories need to appeal to larger audiences, and this can sometimes water down the design.

Your operation is very conscious of the environment.

Ceramics is naturally a green process, and we take advantage of every green process we can. We do not deal with any toxic or harmful materials, and we make every effort to recycle where possible. We recycle all of our wastewater, scrap clay, paper, and other materials. It's nice to know that we can make something beautiful and not hurt this beautiful earth at the same time.

For the complete interview, visit FineHomebuilding.com/extras.

Photos: Kate Holl, courtesy of Red Rock Tileworks

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Dragon's den

This whimsical playhouse was conceived and built by artist, woodworker, and carpenter Chris Axling. Axling built his first playhouse after taking on his most important job: stay-at-home father for three-year-old Josephine. Not only was his daughter enchanted with the little house, but his friends and family were, too. With their encouragement, Axling started his business, Magical Playhouses.

Axling created the dragon playhouse for the 2015 Bellevue Arts Museum's annual fair. He designed the swooping line of the shake roof to look like a dragon's wings frozen in a downbeat. The swoop of the roof is echoed by cedar sidewall shingles. Unable to find real dragon horns on eBay, Axling added the next best thing to the hand-carved cedar dragon head: genuine Texas longhorns. The stained glass in the three arch-topped upper windows was done by Axling's wife, Sarah. Inside the playhouse are custom built-in bookcases and cabinets, a window seat with a pull-out step, and a secret compartment in the floor.

Axling's playhouses use the same construction practices employed on many well-built homes: Douglas-fir 2x4s, plywood sheathing, R-13 insulation, and electrical wiring. The dragon playhouse has a Broan wall heater (wired with a safety shutoff switch 52 in. off the floor) and double-paned windows tempered for safety. Axling also builds treehouses, potting sheds, and custom woodworking pieces to the same high standards.

—Maureen Friedman

DESIGN AND CONSTRUCTION Chris Axling, Magical Playhouses, Port Townsend, Wash.; magicalplayhouses.com

PHOTOGRAPHS courtesy of Magical Playhouses

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