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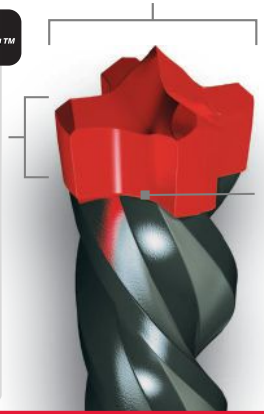

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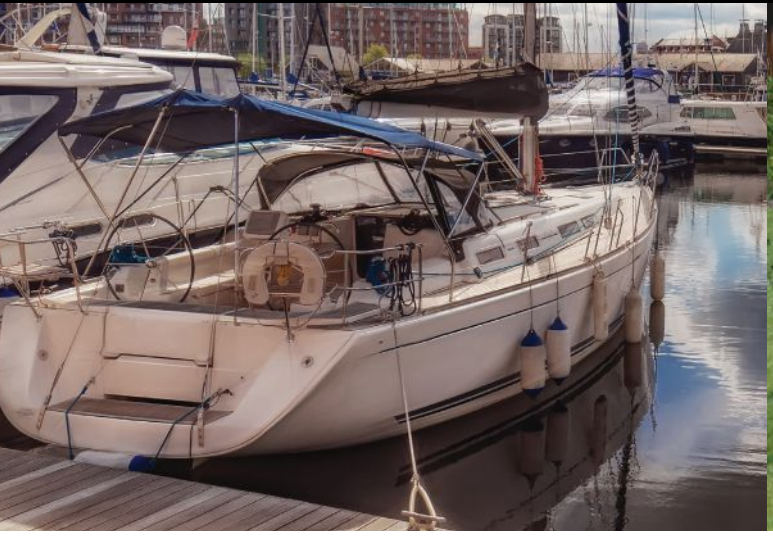

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On the cover: Gary Striegler lays out the balusters for a renovated stair railing on a house in Johnson, Ark. See the story on page 15. Photo courtesy Craftsman Builders.

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THE JOURNAL OF LIGHT CONSTRUCTION (ISSN 1056-828X), Volume 38, Number 11, is published 10 times per year (January, February, March, April, May, June, July/August, September, October, November/December) by Hanley Wood, 1152 15th St. NW, Suite 750, Washington, DC 20005. Annual subscription rate for qualified readers in the construction trades: $39.95; nonqualified annual subscription rate: $59.95. Frequency of all magazines subject to change without notice. Double issues may be published, which count as 2 issues. Publisher reserves the right to determine recipient qualification. Canada Post Registration #40612608/G.S.T. number: R-120931738. Canadian return address: IMEX, PO Box 25542, London, ON N6C 6B2. Periodicals postage paid at Washington, DC, and at additional mailing offices. POSTMASTER: Send address changes to JLC, Box 3530 Northbrook IL 60065-3530.

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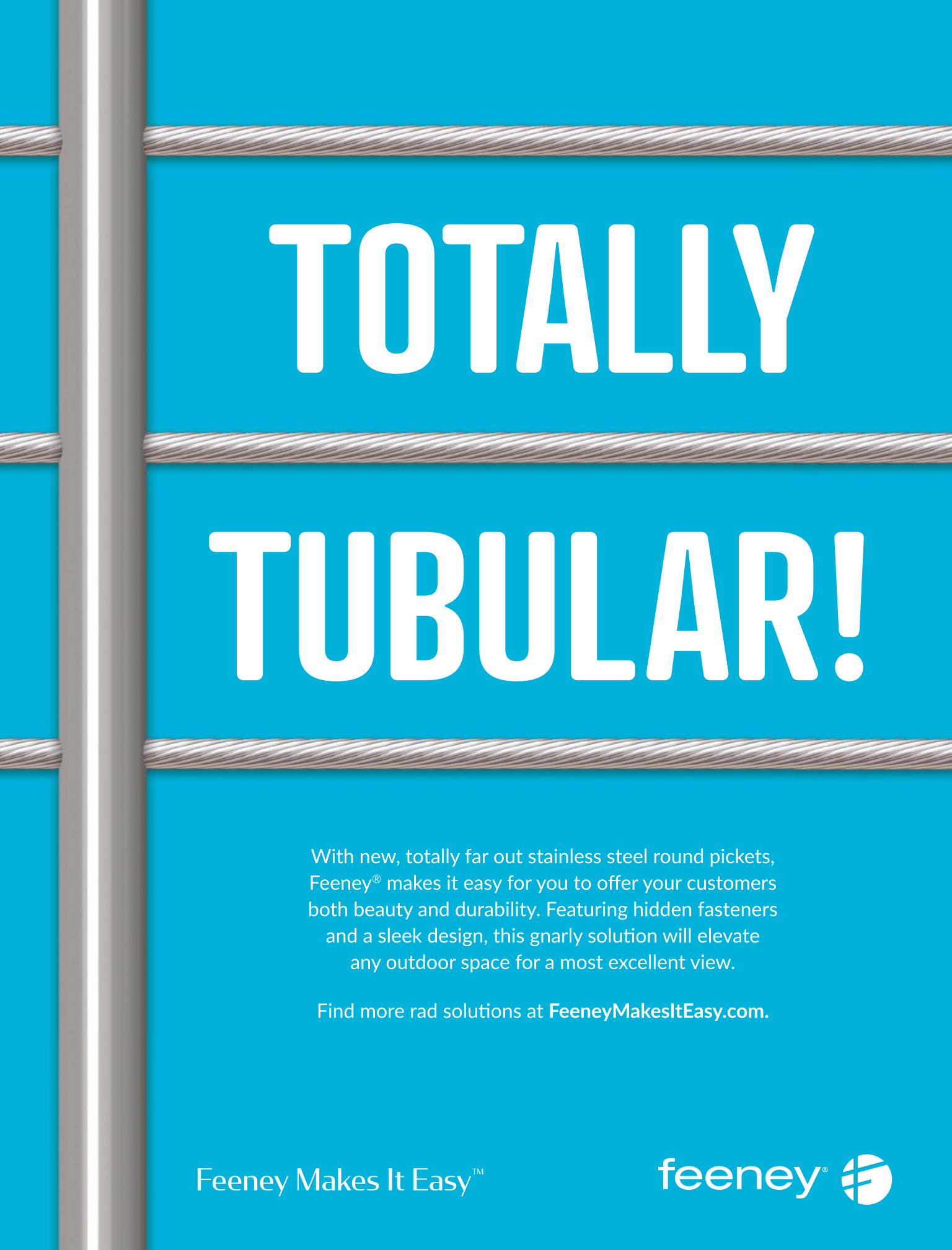
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DEFLECTION CAUSES SQUEAKY FLOORS. HERE'S HOW TO STOP IT.

A stiff, composite action subflooring assembly is the unsung hero of quiet floors.

In engineering, deflection refers to how much a structural element will bend from its original positioning when a load is applied to the element. More specifically, for home subfloors, it indicates how much bounce or sag the floor endures under the weight of people or furniture. That movement can result in squeaks and, with too much movement, could eventually cause damage to certain types of floor finishes.

Why Reducing Deflection Is Important

Floor squeaks are often cited as a major source of callbacks for builders, negatively impacting both their schedules and budgets. Mike Pyle, an engineer and the director of technical services at Huber Engineered Woods, advises builders to consider the subfloor assembly of the home as highly important.

"There is no easy way to swap a subfloor out," Pyle said. "You can upgrade lighting, plumbing and finish flooring down the line, but you get one chance during construction to get your subflooring right."

Poor subfloor performance, marked by more movement and squeaks, may be felt right away during construction or later by the homeowners. To minimize deflection in the floor, aim to build a stiffer subfloor assembly.

How to Increase Subfloor Stiffness and Decrease Deflection

A stiff subfloor assembly decreases deflection and can help minimize the possibility of future squeaks. Consider these three subfloor material selections for a stiffer subfloor:

1. Choose high-quality subflooring panels. Subflooring panels, placed on top of the framing, vary in quality and performance. A commodity OSB or plywood product, for example, may

> **"You can upgrade lighting, plumbing and finish flooring down the line, but you get one chance during construction to get your subflooring right."**
>
> Mike Pyle, Engineer and Director of Technical Services
> Huber Engineered Woods

be more vulnerable to moisture damage in wet climates than a premium product. This moisture damage could cause panel edges to swell, creating an uneven surface that holds the potential for deflection — and additional time on the schedule for sanding — down the line. Conversely, the increased wood density, tongue and groove engineering, and moisture-resistant resins in a premium product all work together to increase the strength and stiffness of the panel, giving overall floor stiffness a helpful boost.

2. Bond panels and joists with subfloor adhesive. Another major component of a stiff subfloor is applying glue, also known as subfloor adhesive, between the subflooring panels and the joists. According to Pyle, glue is what takes your subfloor from separate, manually joined parts to one solid (and therefore stiffer) assembly. The subfloor adhesive fills in the gaps from natural variations in the wood products and bonds the subflooring panel to the truss or joist. The phenomenon of making the joist and subfloor act as one piece is known as composite action.

3. Use subfloor fasteners for maximum stiffness. Builders can choose from nails, screws or certain proprietary type fasteners to fasten the subfloor panel to the joist. Common nails with a basic head and smooth shank should be avoided to minimize the chance of squeaks.

Is Your Floor Built to Last?

For homeowners and builders alike, it can be tempting to deprioritize subflooring materials because, after construction, you don't see the subfloor assembly. According to Pyle, that line of thinking is a mistake because, while it is invisible, the subfloor is extremely functional and cannot be easily traded out later. Although we don't think about it, subfloor panels get used every day for the life of the structure.

Especially if the home has premium finishes, such as hardwood floors or porcelain tile, the subfloor below impacts how well the (often expensive) finished floor performs and whether it's subjected to unwanted movement.

"The subfloor is the unsung hero."

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"A SIMPLE VENTILATION STRATEGY" (JUN/20)

I enjoyed Bryan Uhler's article about combining continuous with intermittent ventilation, but I have some questions:

1) How is the ERV supply air distributed? What about the ERV return? Is that pulled from a single central location?

2) You have a 400-cfm range hood with no dedicated makeup air. It seems this flow rate could depressurize the house somewhat while the range hood fan is running. Can this cause reverse flow through the ERV return (exhaust) path, in effect turning it into a temporary makeup air source? Is there some level of whole-house airtightness where you would need to provide makeup air for the range hood?

3) Would you use the same system in a house with combustion appliances? What about a gas range? —*Don Christensen, Aurora, Colo.*

Author Bryan Uhler responds: I'll address your questions in order:

1) The supply air from the ERV is distributed by ducting into the return duct of one of the ducted Daikin mini-split units. (There are two of these ducted mini-splits and two ductless units that provide heating, cooling, and dehumidification for the house.) We keep the duct runs for the ducted units very short and internally pressure test these ducts, so we know they are very tight.

2) The 2015 Washington State Mechanical Code, section 505.2 "Makeup Air Required," requires makeup air when the exhaust hood system exceeds 400 cfm. Since we are at 400 cfm, makeup air is not a code requirement. Even so, I had reached out to Panasonic regarding your very question about the possibility of the ERV becoming a source of makeup air. The short answer is that there is no proof that reverse flow through the ERV return would occur. In theory, some makeup air could be drawn in through the supply side of the ERV; the roof vent connected to the supply-air side is open with a bug screen. It isn't likely to come in through the exhaust side, because the roof vent has a flapper on it that opens only when air is being exhausted. But in a real-world application, this home will have around 40,000 cubic feet of air. At a ratio of 40,000:400, or 100:1, I don't think reverse flow is a huge concern, and I think that the location of the ERV in relation to the exhaust fan makes it unlikely that makeup air will come from the ERV. The ERV can be set to positively pressurize the house, and that is how we set it up. We air-seal with Aerobarrier, and I anticipate that we'll end up between 1 and 2 ACH50.

3) This house does have combustion appliances, and I'm not concerned about backdrafting. While heating and cooling is provided by the two mini-split units and water is heated by a heat pump water heater, there is a natural-gas fireplace that is direct vented. The cooktop is natural gas and the oven is electric. I live in a home with almost the exact same types of appliances. My wife does a lot of cooking, yet the amount of natural gas that is consumed is minuscule, and combustion fumes are easily exhausted by the hood. What actually affects air quality the most is using a toaster and waffle iron. We could turn on the vent hood to help clear the air when using these appliances, but like most people, we don't.

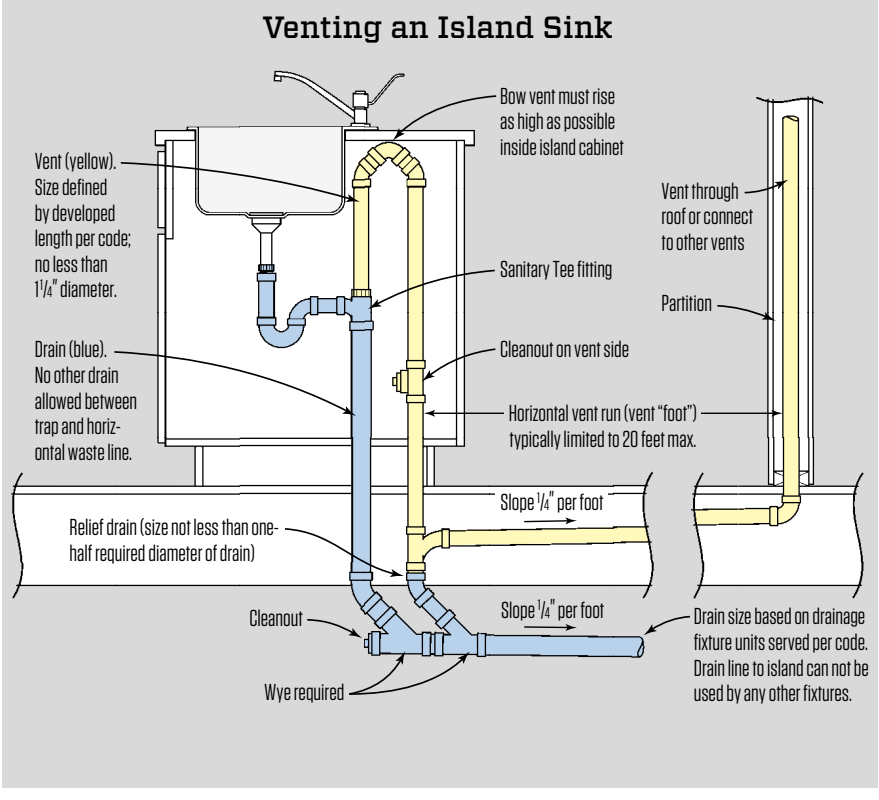

Illustration: Tim Healey

"ROUGHING-IN KITCHENS" (JUN/20)

The illustration of the island loop vent (on page 39 of the June 2020 issue) is wrong. The drain side transition from vertical to horizontal should "sweep," with a 45 into a T-Y fitting for the cleanout, similar to what you show for the vertical-vent-to-horizontal-drain transition. The vent side also needs a cleanout according to IRC 3112.3, and it should also be noted that the drain line to the island can't be used by any other fixtures. —*Karl Knudson, Falls Church, Va.*

The editors respond: Thank you for alerting us to the error. This was *JLC*'s error alone (it did not stem from the author), and we have updated the online illustration with the version at left.

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Stair Rail Facelift

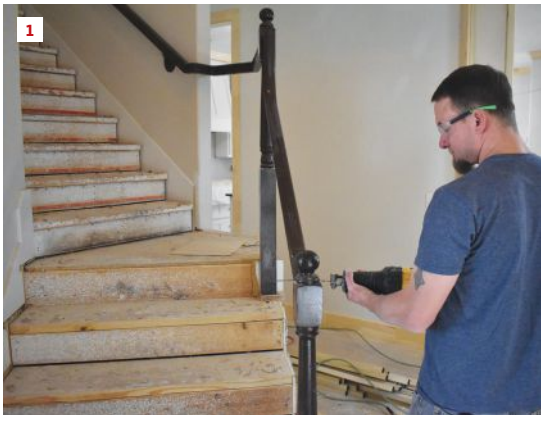
BY GARY STRIEGLER

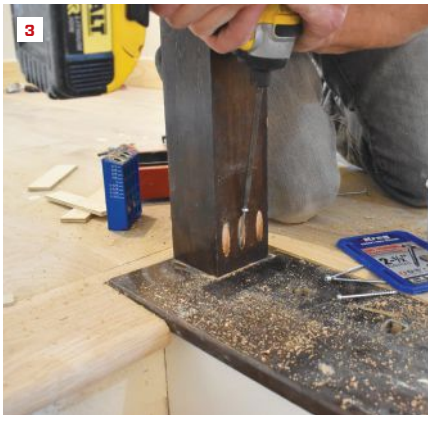
Referrals make up most of my business these days, with a recent insurance job offering a great example of how the process works. The client had experienced a small fire in his home resulting in lots of water damage, and I had been recommended to him by both of his business partners to tackle repairs. No one wants to have their lives disrupted by unanticipated repair work in their home, but in this case, the clients looked at the fire as an opportunity to make some changes.

New floor coverings and paint colors don't take a lot of planning, but the clients decided they also wanted to make major changes to their entry staircase. The railing was serviceable but dated, with iron balusters and dark oak ball-top newel posts, and they wanted to replace it with a more contemporary-looking railing without busting the budget. They liked pictures I shared of painted staircases with square wood balusters and simple newel posts. The replacement stair parts were pricey, so I decided to buy lumber and make our own.

Most of the work was on the long upper balcony, but there was also some on a short run of open stairs at the entry and on an intermediate landing.

Removing the old stair. It only took a couple of hours to demo the staircase using a reciprocating saw and a hammer, but we were careful to leave the newel posts in place. My plan was to sleeve the turned oak posts to transform them into contemporary





Workers removed the old rails and balusters, but left the turned newel posts in place **(1)**, reinforcing them with pocket screws **(2, 3)**. The landing newel post had to be relocated, so the author reinforced the connection with construction adhesive **(4)** and structural screws driven through the base of the newel post into the framing **(5)**.

Photos courtesy Craftsman Builders

The crew used spacer blocks when clamping the sleeves to ensure they would fit over the old newels **(6)**. A router with a flush trim bit was used to clean up the glue joints **(7)**, while a 45-degree chamfer bit was used to profile the sleeve corners **(8)**. The sleeves fit snugly over the old newel posts **(9)**. Post caps were glued and pocket-screwed together **(10)**.

square posts, so we sliced off the top of each newel post.

The posts were sound, but a few of them needed shoring up. I drilled pocket holes and used long Kreg screws to tighten them up. One notched newel post had to be removed and reset so we could remove the damaged riser behind it.

Making the posts. The newel posts were going to be painted, so we made the sleeves out of Trupan, a high-grade MDF. As we carefully glued and clamped up each sleeve, we used spacers about 1/16 inch bigger than the oak newel posts to create a snug fit while ensuring that the sleeves would slide down over the posts.

After the glue cured and we removed the clamps, we cleaned up the joints using a router with a flush trim bit, then sanded everything smooth. I always build projects like these sleeves oversized, then trim them to exact length later. Finally, we chamfered the corners of the sleeves with a compact router, clamping stop blocks to the assembly to make sure the chamfers were consistent. That added just a little detail and eliminated the sharp edges.

We made the post caps out of poplar. To avoid showing end grain, which is always a little rough and just won't take paint or stain the same as edge grain, we made the post caps out of four mitered pieces, which we pocket-screwed and glued together.

As it turned out, the old oak posts weren't exactly straight and varied in size a little, so our sleeves barely slid in place over them even with the extra 1/16 inch of width that we'd added to their design. With this snug fit, it probably wasn't necessary, but we did shoot a few 18-gauge brads into each sleeve to hold it in place.

Hand rail. The rail was more of a challenge. Square balusters require a plowed dado on the bottom of the rail to house the top of each baluster, so the rail had to measure a minimum of 1 5/8 inches wide on the bottom face in order to accommodate the 1 1/4-inch-square balusters. The rail was going to be finished with stain, but to avoid the strong grain pattern of oak, we decided to use poplar instead.

There are certain standards a handrail must meet to be considered grippable, so if you decide to make your own rail, make sure you consult with a building inspector first. I made the two profiled

The author milled the poplar handrails in two pieces, then joined them using glue, Festool dominoes, and plenty of clamps **(11, 12)**. A table saw fitted with a dado head was used to cut the baluster channel in the underside of the rails **(13)**. For a precise fit between the stair newels, the author lay the stair rails across the treads to mark their length **(14)**. After checking the fit, a worker drills holes for the pocket screws that will be used to fasten the rails to the posts **(15)**.

rail sides on a Woodmaster molder out of the straightest 6/4 poplar I could find. Then, to make a code-approved graspable rail profile that is 2 5/8 inches wide at the widest point and 2 1/8 inches wide along the bottom edge, I glued and clamped the two halves together, using Festool dominoes for alignment. After one of the more patient members of my team scraped and hand-sanded the rail blanks, we finished up by making two passes on a table saw fitted with a dado head to prep the rail bottom.

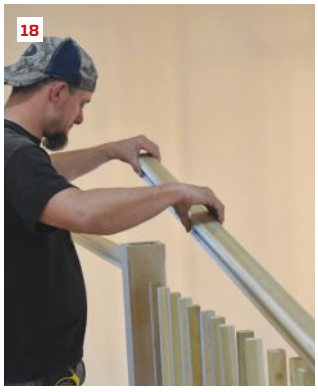
After precisely measuring and cutting each rail section to length, we drilled pairs of pocket screw holes in the end of each rail piece to prep them for installation.

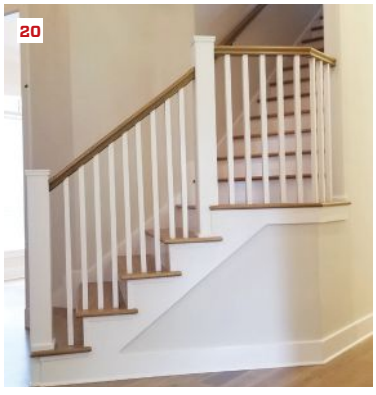
Balusters. I made the 1 1/4-inch-square balusters from clear 6/4 poplar that we ripped to width. We then ran the stock through a planer with sharp knives, hitting all four faces to clean them up. We ran the material full-length, then cut the balusters to length, making sure to trim off any snipe at the ends.

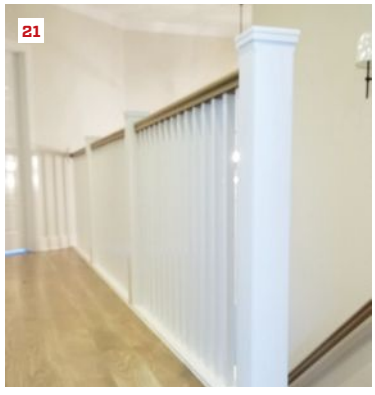
Using dowel screws (bolts with wood threads on each end) is the best way I know of to attach balusters. Instead of trying to fill the old baluster holes, we added a new piece of poplar over the flooring between the newel posts, first laying down a bead of construction adhesive before nailing the poplar in place.

Code calls for balusters to be evenly spaced such that a 4-inch-diameter ball can't fit between them. To lay the balusters out, I start with a center mark between newel posts, then decide if it is better to place the baluster in the center of the run or 2 inches off-center, so that the space between the first and last baluster and the adjacent newel posts are equal.

Using a combination square as a marking gauge, I located and







A special driver bit was used to install dowel screws **(16)**, while a cup-shaped drilling guide helped center the holes in the balusters **(17)**. After twisting the balusters down onto the dowel screws, a worker fits the railing **(18)**, then installs fillets to lock the balusters in place **(19)**. The posts and balusters were painted, while the rails were stained to match the stair treads **(20, 21)**.

drilled 1/4-inch-diameter pilot holes, then drove the dowel screws in place (a driver bit is available from most stair parts companies). To drill the pilot holes in the end of the balusters, we used a special cup that has a drilling guide (also available from stair parts companies). The hardest part of the whole job is twisting the balusters in place onto the dowel screws; it makes for a real forearm workout.

On the angled landing and the open stairs, I used a laser to locate and mark the rail centerline. To make sure I didn't exceed the allowed maximum spacing, I placed a couple of baluster cutoffs on the centerline and spaced them an equal distance from the diagonal joint. Then I pulled my layout in both directions from those two cutoffs.

Assembly. It took some time to work the rail pieces into place on top of the snug-fitting balusters. Then, with the rail in position, there wasn't any way to use a drill to drive the long pocket screws that fasten the rail to the newel posts; each one had to be hand-driven using a small ratcheting driver.

After plumbing up the first baluster in a run, we held it in place with a poplar fillet cut to the length of our baluster spacing and installed in the rail dado. As we installed the fillets, we occasionally checked the balusters for plumb to make sure they were remaining on the layout.

We waited until the end to add the post caps and a small molding under the caps. I'm not sure if this is an approved connection, but I am sure that between the pocket screws and the balusters bolted in place, the rail meets the building code's 200-pound load requirement for a railing.

To mark and cut the rail sections for the open stairs, I simply set a section of rail on top of the steps and marked angles. Basically, if the cuts and length are right sitting on the treads, they will fit just as well when raised up 32 inches.

From start to finish, the restoration project took more than two months. If you asked the clients, they wouldn't have chosen the disruption in their lives, but I think they would agree that the result was worth the wear and tear.

Gary Striegler, a JLC contributing editor, owns Craftsman Builders (craftsmanbuildersnwa.com), in Fayetteville, Ark., and teaches workshops at the Marc Adams School of Woodworking. Follow him on Instagram: @craftsmanbuilders.

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Selecting Caulk

BY BILL ROBINSON

We have come a long way from tar and oakum for patching leaks. Now there are caulks and sealants with chemistry that makes them stick to other materials, stretch to as much as 100% of the installed width, and last more than just a couple of years. That said, I advise thinking of caulk joints as temporary at best. They will always need periodic inspection. Even if they last many years, the service life of even a high-quality caulk is significantly shorter than the service life of the materials they are sealing.

There are a wide range of chemistries used in caulks, adhesives, and sealants. This article covers the ones I have found to be the most common in residential and light-commercial construction. We in the residential construction industry have not kept up well with the advances in chemistry, and while I try to stay informed on this topic, I am aware that the landscape is constantly changing.

In particular, it is time to adjust to the 21st century of high-performing caulks and sealants by getting into the habit of checking the manufacturers' tech sheets. I work with five different types of caulk—water-based, solvent-based, polyurethane, silicone, and modified polymers. This last category mostly includes silane modified polymers and other chemical hybrids that have emerged in the last decade; they are typically proprietary formulations but have some common characteristics that allow us to group them together. Each of these types has a purpose, and rather than looking for a one-size-fits-all caulk, I suggest you identify the things you use caulk for, select the appropriate caulk for each use, and then make sure it is used as intended.

Water-based caulks typically clean up with water and cure on evaporation. Anything that cures on evaporation will shrink. Most water-based caulks are 40% to 60% solids (with some exceptions). When the caulk cures, it shrinks to the percentage of solids in the mix. Sometimes it is difficult to tell from the label what the chemistry is, but a clear "tell" of a water-based caulk is a warning on the tube to keep it from freezing. Another is marketing language that says something like "easy water cleanup." Be aware that an acrylic or latex caulk that has been "siliconized" is still a water-based caulk that will shrink. I would not use such caulk on the exterior of a building. I like water-based caulks for covering up joints in trim on the interior. For anything else, I steer clear of them.

Solvent-based caulks. The solvent is typically mineral spirits and, similar to a water-based caulk, a solvent-based caulk cures on evaporation of the solvent. That means it will shrink, though typically a little less than water-based formulations.

Solvent-based caulks are typically 60% to 80% solids and will shrink to 60% to 80% of their original dimension. They are typically very sticky and therefore adhere well to substrates. In official terms, they typically have good *cohesion* (meaning the material sticks well to itself) and *adhesion* (meaning it sticks well to a properly prepared substrate).

The primary consideration for a solvent-based caulk is that the curing process will off-gas some solvent material, which means high VOCs and a short-term hazard to indoor air quality. I steer clear of them for interior use, but these caulks are very good outside and typically come in several colors. I like to use them when I need a color-matched caulk for siding.

Polyurethane caulks cure on exposure to the moisture in the air. Since they do not cure by evaporation like water- and solvent-based caulks, they do not shrink when they cure. They are nearly 100% solids—you get what you squeeze out of the tube. Based on what I hear from a wide range of exterior contractors, polyurethanes are typically the preferred caulk for exterior use. The downside of polyurethanes is they do not stand up well to UV light and have to be replaced after a few years of exposure to the sun.

Silicone caulks. I am talking about pure silicone sealant, not a "siliconized" formulation. Pure silicone is a nearly 100% solids material that cures on exposure to the moisture in the air. It does not "dry," and that means it does not shrink. Mistakenly, many people believe silicone is the go-to sealant for *all* applications and make a lot of assumptions about what silicone caulk can do.

Photo: Ted Cushman

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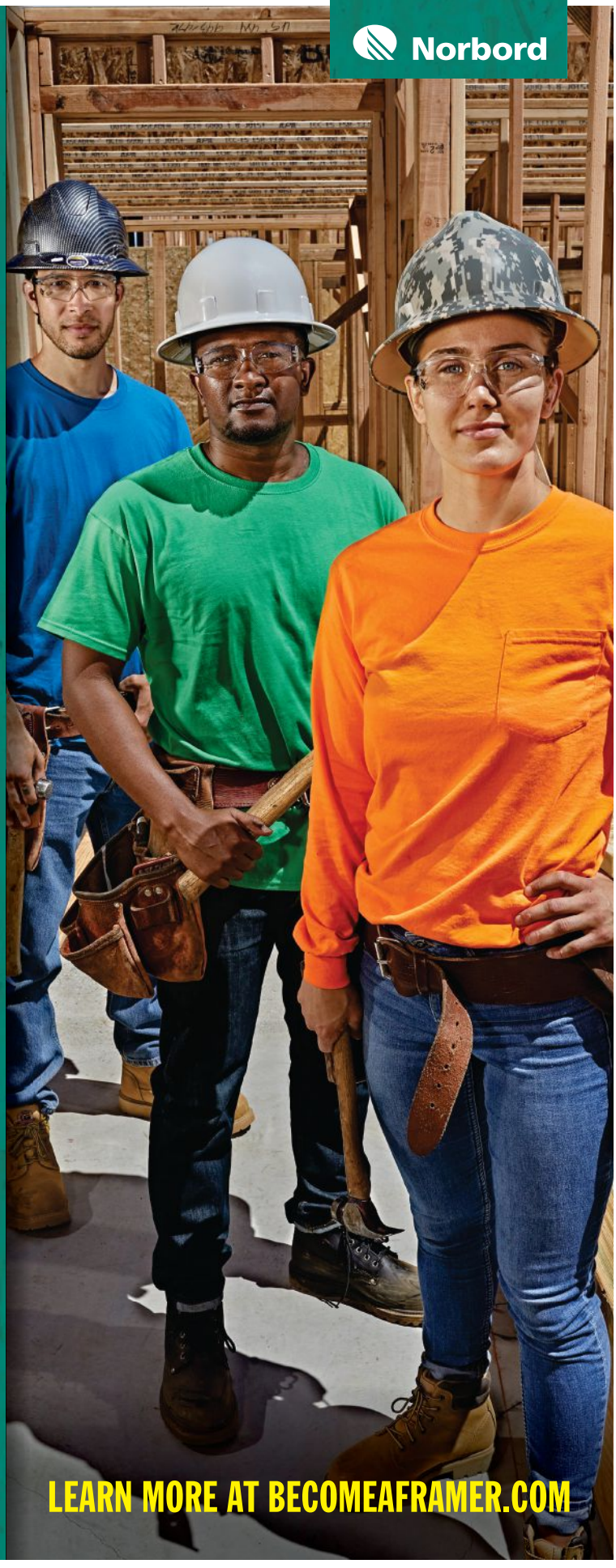

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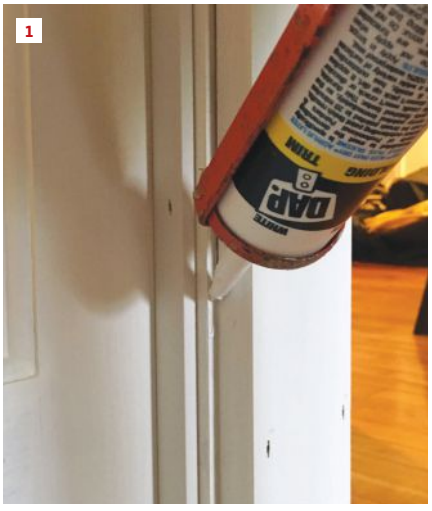

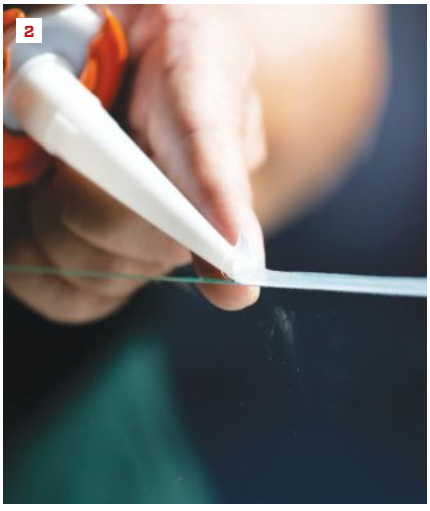

Acrylic caulks, even ones "with silicone," will shrink when they cure, and are best suited for interior uses **(1)**. A true silicone doesn't shrink much and works best for sealing nonporous materials, such as glass and tile **(2)**; it's often a good choice for wet-area applications. For exterior applications, the author prefers advanced polymers, such as this one from Henry Company **(3)**.

Not all formulations are equal. There are two basic types of silicone caulk—acetoxy and oxime. The acetoxy formulation is what you will usually find on the shelves at lumberyards and big box stores. These caulks release acetic acid when curing, giving off a vinegar smell that can be an irritant to some people. Clear, 100% acetoxy formulations are unpaintable; the paint does not adhere to them and separates from the caulk. The biggest problem with acetoxy silicones, though, is they can cause corrosion of some materials. This was a bigger problem in the past, when silicone sealant technology was new and there was too much "free acid" in a lot of formulations. But even now, with mature product lines, adhesion and corrosion can be problems on acrylic, PVC, ABS, galvanized steel, and brass, depending on the product line.

Oxime formulations are "neutral cure"—meaning they release pH-neutral substances that are noncorrosive—and are specified by many material manufacturers to avoid the possibility of corrosion.

Silicones bond well to nonporous substrates like tile, glass, and most metals but don't work as well on porous materials like stone, masonry, and unpainted wood. They work well for wet areas, like baths and kitchens. I also use neutral-cure silicone to apply silicone bulb as weatherstripping on door astragals. In commercial applications, silicone is the go-to product for structural glazing.

Advanced polymers include caulks labeled MS (modified silicone) polymer, STPE (silyl terminated polyether), or a "hybrid." They are nearly 100% solids—so they do not shrink—they cure on exposure to moisture in the air, and they have great adhesion, cohesion, expansion, and durability. Many of the newer liquid flashing products fit into this category.

These are my preferred caulks for almost all exterior applications: They are usually easy to work with because they are typically more viscous (thicker), but you need to use a good caulk gun that has a higher thrust ratio (meaning the plunger moves a short distance for each full pump of the trigger). Some tend to skin over quickly, a property that is useful to me when I work in a light rain, because I don't need to worry about the caulk diluting before it cures. Since we are covering a wide range of sealant materials in this category, it is wise to confirm in the tech sheets available on the manufacturer's website that the sealant has the particular properties you want. (If the manufacturer is being cagey about revealing the material, check the MSDS, where manufacturers have to identify the ingredients.)

The organization of caulk types in this article is based on my experience. In particular, several years ago I worked on an EIFS (exterior insulation and finish system) project in California. After beginning the project, we learned that the window manufacturer would not warranty its product when installed with residential EIFS. But we were already underway: The windows had been purchased and we had to make it work. To learn more about EIFS applications, I met with a waterproofer who was well-versed in commercial work, especially EIFS installations, and it was an amazing "aha" moment for me when he said he was not familiar with water- or solvent-based caulks in his usual work. This surprised me, because in our residential world, for the most part, contractors favor a certain water- or solvent-based caulk, either because of the easy cleanup (for water-based) or for the variety of colors (for solvent-based). At the waterproofer's suggestion, we selected a neutral-cure silicone for our EIFS project, and we were able to get a warranty from the window manufacturer once we disclosed our application details.

That job put me on a track to learn more about caulks and sealants (as well as adhesives and tapes—other everyday products in our world of construction for which some understanding of chemistry is helpful). In particular, that job gave me an appreciation for how important the right sealant is for each job. Different product

Photos: 1, Ola DeKorne; 2, Adobe Stock; 3, Gene Summy

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SELECTING CAULK

Type	Cure	Solids	Suggested use	Certification
Water-based	Evap.	40–60%	Interior trim	ASTM C834 - 17 Standard Specification for Latex Sealants
Solvent-based	Evap.	60–80%	Exterior siding, trim	ASTM C-920
Polyurethane	Moisture	~100%	Exterior (but protect from UV)	ASTM C-920
Silicone	Moisture	~100%	Wet areas, nonporous materials	ASTM C-920
MS polymers	Moisture	~100%	All exterior work	ASTM C-920

The ASTM certifications are an easy specification to look for on the label. The author suggests that any product that has *not* gone through the testing and certification process may not be the best choice for quality work.

manufacturers can be picky about what they will and won't accept. In the commercial construction world, this is much more controlled. In residential work, there are fewer controls and a lot of assumptions are made. It's worth pushing for tighter specs on the sealants you use. Don't just grab any caulk off the shelf if you are concerned for performance and longer durability. As a general rule, on any exterior, weather-sensitive application, we should be using high-solids-content caulks with good adhesion and cohesion. It's also important to define the properties you want, as the brands and the chemical formulations change over time.

I've discussed my preferred caulks here, but you might have your own preferences or know of brands I have not used. Once you find what works, of course, share what you learn with your crew and trade partners, provide them training, and above all, push them to use best practices for installing caulks and sealants (which is the subject of a different article).

Bill Robinson is a New Orleans–based contractor who focuses on solving building envelope and hot/humid-climate performance issues. He is a frequent presenter at JLC Live. Follow him on Instagram: @bandannabil.

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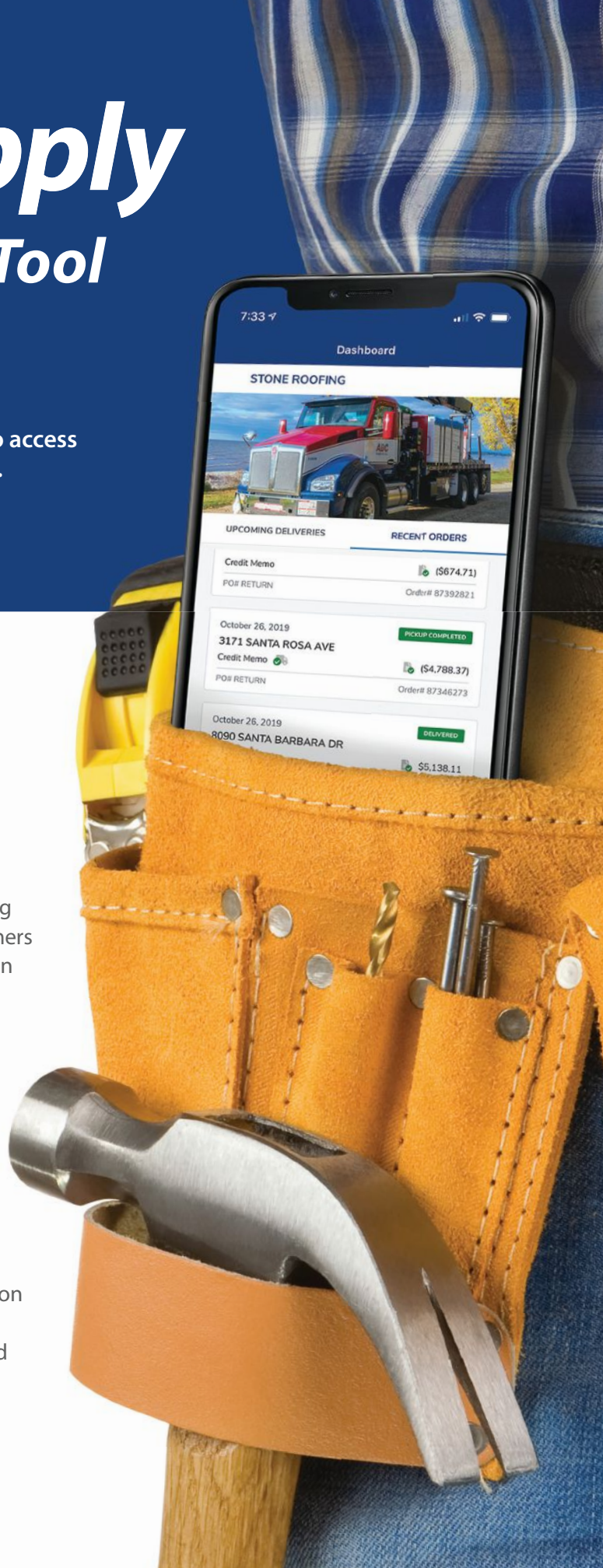

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BY MELANIE HODGDON

Rethinking Your Company's P&L

Whether due to a mandate by their state or a sense of respect for human over business health, an enormous number of contractors cut back activity somewhere along a zero to 100% continuum during the coronavirus outbreak. As of this writing, nearly every state has "opened up" to some extent, though the criteria and terms vary enormously.

Throughout this pandemic experience, many contractors have been torn between loyalty to their employees (keep everybody on for as long as possible) and a survival urge (eliminate every possible financial drain and hope for the best). Many of you took advantage of the Paycheck Protection Plan (PPP) or Economic Injury Disaster Loan (EIDL) loans; drew on lines of credit (for which you hopefully applied during times of plenty, when your company was a good candidate); dived into the savings that well-established, profitable companies have tucked away; or as a last resort, drew against credit card accounts.

Unexpected or expanded debt, even when a portion may be "forgiven," can weigh heavily on business owners. And, because debt is handled on the balance sheet (as current or long-term liabilities), there is a strong "out of sight, out of mind" inclination that we all indulge in. But this inclination could lead your business to fail if you don't plan for debt reduction—especially if debt is something you're not used to.

WHAT ARE A CONTRACTOR'S "NECESSITIES"?

An article I read recently on personal finances in the age of COVID-19 recommended thinking in terms of absolute necessities. For individuals, this means food and medication. Everything else, the article suggested, may have to be put on the back burner.

For a business, things are a little different. Overhead is certainly one of the necessities. For example:

- If you don't pay your power bill, your office shuts down.
- If you have umbrella, liability, or contents insurance, failure to pay could make your business vulnerable.
- If you don't pay your office rent or mortgage ... well, there may be some allowance for that. Many states have a temporary moratorium on evictions. The original CARES Act allowed for mortgage forbearance or payment deferrals, and a temporary moratorium on evictions and late fees. That has since expired but may be extended (as of this writing, it is held up in Congress). Rules vary by state, and you are responsible for determining what rules and deadlines apply to you, but there is a clear risk to the business if you forego this obligation.

There are other necessities in terms of projects:

- You must be able to acquire materials. Rules governing acquisition and delivery may vary from supplier to supplier, so be sure to investigate. Best practices recommend that you pay with your customer's money by getting deposits at signing, front loading your payment schedule (contract jobs), and subscribing to BEBO (bill early; bill often). If you aren't getting up-front deposits (including on T&M work), then you're draining your precious cash when you don't need to and can least afford it.
- You must be able to incorporate trade contractors into the project workflow while still adhering to COVID-19 recommendations. Many prospective customers are deeply concerned about the prospect of allowing strangers onto their property, so stating and adhering to guidelines may differentiate you from other contractors while increasing the safety of your team. As with materials, you should always be paying subs using the customer's money, so projects should not cause any negative impact on cash flow.
- If you don't sub out all labor, then you must maintain a field crew. If you have successfully received a PPP Loan, good for you. However,

GAAP Compliant P&L

	Ordinary Income/Expense	Margins	
Income	$1,000		
Cost of Goods Sold	$710		"Above the line"
Gross Profit	$290	29.0%	
Expense (overhead)	$245		"Below the line"
Net Ordinary Income	$45	4.5%	
Other Income/Expense			
Other Income	$5		
Other Expenses			
Xxxxx	$3		
Net Other Income	$2	0.2%	
Net Income	$47	4.7%	

Above is an example of a GAAP-compliant P&L. Notice that *Net Ordinary Income* is 4.5% and *Net Income* is 4.7%.

you will have to negotiate the complex rules of forgiveness (still in flux as of this writing) to be sure that you will be able to write off all that you think you can. You can't assume that 100% of that $58,000 loan is forgivable—it may or may not be.

■ As with subs, your crew will need to adhere to health recommendations (and be prepared for "suggestions" to become "requirements" based on the status of the pandemic from week to week) and this will mean reduced efficiency. Remember when you had to adjust to RRP requirements (or stop taking work on any pre-1978 projects) in terms of estimating costs and completion time? Working through the pandemic will decrease efficiency and increase project time even more.

■ If you priced out a job and then were forced to delay the start date or suspend work, bear in mind that the job may now cost more than you originally planned for. There may not be any practical way to recoup this (certainly, keeping tight control of tasks performed within the written scope of work and rigorously tracking and charging for change orders will be particularly critical now), but be aware that you may need to revisit pricing on jobs for which contracts haven't yet been finalized.

And there are necessary obligations in terms of investment and prior debt reduction:

■ This is probably not the time to go out and buy a new truck! This is the time to be as conservative as possible. In all likelihood, you will need every bit of "spare" cash, particularly because nobody can predict how the pandemic will evolve or how many waves of the virus we may eventually endure.

■ If you can negotiate delayed or reduced payments while you ramp up, give it a shot. It never hurts to ask, and if your prior payment history is exemplary, you may be able to hang onto cash during the challenging transitional period between reduced or nonexistent work and a resumption of your income stream. Recognize that this income stream may well be reduced for some time to come, and bear in mind that many companies that looked profitable on paper bellied up because they ran out of cash.

What should you do as a business owner to face these necessities?

Management P&L (A)

	Ordinary Income/Expense	Margins	
Income	$1,000		
Cost of Goods Sold	$710		"Above the line"
Gross Profit	$290	29.0%	
Expense (overhead)	$245		"Below the line"
Net Ordinary Income	$45	4.5%	
Other Income/Expense			
Other Income	$5		
Other Expenses			
Loan A payment	$1		
Loan B payment	$2		
Loan C payment	$2		
Loan D payment	$3		
Xxxxx	$3		
Net Other Income	$(6)	-0.6%	
Net Income	$39	3.9%	

On version "A" of a sample management P&L, loan payment accounts (to populate your budget) have been added as *Other Expense* type accounts. Notice that *Net Ordinary Income* is still 4.5%, but *Net Income* has dropped to 3.9%. Remember to adjust these costs back to the balance sheet for tax preparation purposes.

BUDGET CONSIDERATIONS

If you based your budget only on accounts that are included within your profit and loss (P&L) or income statement (income, cost of goods sold, and expenses), you may be ignoring the need to start budgeting for paying down debt incurred because of the pandemic. Although it does not adhere to GAAP (Generally Accepted Accounting Principles), you may want to consider adding accounts for loan payments as if they were *Other Expenses* (a category of account within your chart of accounts that falls below *Net Ordinary Income* on your P&L) in order to include them on your budget (see "Management P&L (A)," above). Or you may even wish to include them as expense-type accounts in order to have their projected costs included in overhead (see "Management P&L (B)," opposite page). Such "non-GAAP-compliant" P&Ls are known as "management P&Ls" and are perfectly legitimate, useful tools for analysis. Be aware that for tax preparation purposes, accounts that belong on the balance sheet must undergo adjustments, but throughout the year, you will be able to get useful numbers for the analysis of business health and for pricing.

PRICING CONSIDERATIONS

Since overhead is the basis of pricing your jobs, increasing overhead to account for debt reduction can help you price upcoming jobs more realistically. Notice that when debt payments are included, your bottom line is reduced. In terms of accounting, this is "wrong" since loan payments are not costs. However, this information becomes extremely important when you're considering cash requirements, especially since the only way to increase cash (other than by adding to debt) is to increase project profitability.

SCHEDULING CONSIDERATIONS

If productivity is expected to drop, then you will not be able to produce as many jobs in the same time period. During that same time period, your overhead will continue to march on. Therefore, you must find ways to reduce overhead or increase the efficiency of production, or consider raising your prices when you sell work. Is it realistic to assume that your crew will be able to produce faster while still adhering to safety guidelines? If not, and you can plan

Management P&L (B)

	Ordinary Income/Expense	Margins	
Income	$1,000		
Cost of Goods Sold	$710		"Above the line"
Gross Profit	$290	29.0%	
Expense (overhead)	$245		"Below the line"
Loan A payment	$1		
Loan B payment	$2		
Loan C payment	$2		
Loan D payment	$3		
Total Expense	$253		
Net Ordinary Income	$37	3.7%	
Other Income/Expense			
Other Income	$5		
Other Expenses			
Xxxxx	$3		
Net Other Income	$2	0.2%	
Net Income	$39	3.9%	

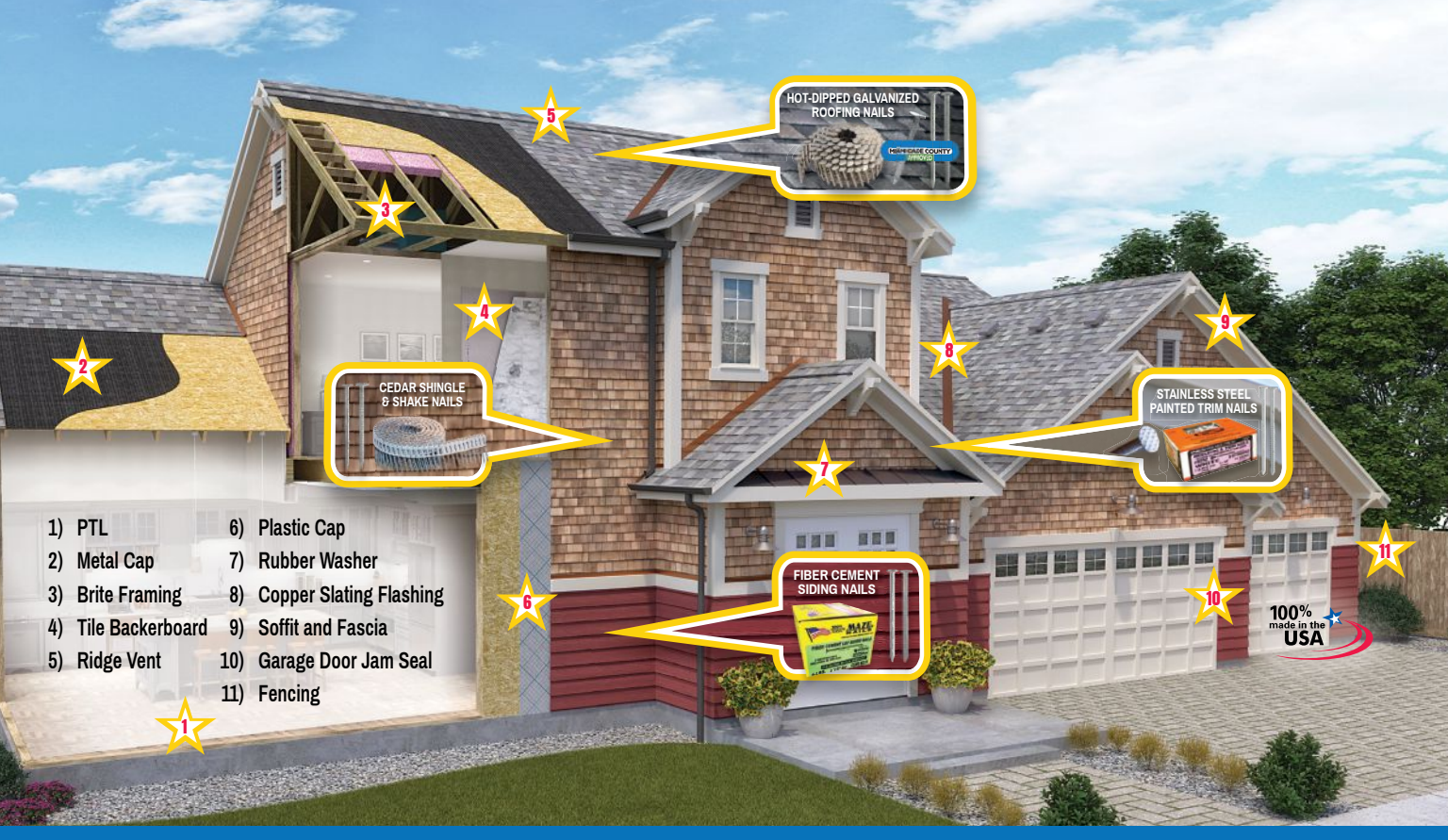
to complete only 80% of the projects you normally would, then project how much more profit you will need to squeeze out of each of them in order to cover overhead plus debt reduction.

FINAL THOUGHTS

The pandemic has thrown a devastating curve ball at the construction industry, and there is no way to predict when or the degree to which things will return to "normal." The best thing contractors can do is to stick to the basics: Understand your costs, monitor your job costs, don't over-extend, keep overhead to the absolute minimum, be prepared to downsize your labor force if sales don't support the status quo, and hang onto your cash like it's a lifeline, because it may well be.

Melanie Hodgdon, president of Business Systems Management, provides management consulting and coaching for contractors. She co-authored A Simple Guide to Turning a Profit as a Contractor, *with Leslie Shiner.*

On version "B" of our management P&L, the loan payment accounts were added to overhead expenses. This increases total overhead from $245 to $253 and reduces *Net Ordinary Income*. Since you will base your pricing strategy on overhead, this change should force you to increase your markup to compensate. Remember to adjust these costs back to the balance sheet for tax preparation purposes.



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BY CLAYTON DEKORNE

Blue stain **(1)** is caused by a fungus that lives in the sapwood of trees. It discolors the wood but is not rot and does not have any effect on the strength of the wood. In North America, the two most common types of true rot are "cubic brown rot" **(2)**, which attacks the cellulose component of wood, and "white rot" **(3)**, which feeds on the lignin that binds wood cells together.

A Builder's Guide to Wood Rot

Wood rot is caused by several kinds of fungi, but not all fungus that lives on wood causes rot. Mold, for example, is one type of fungus that can live on the surface of wood—and should be dealt with when present (see "Mold on Lumber," page 32)—but has no effect on the strength of the wood.

Similarly, blue stain is caused by microscopic fungi that commonly infect the sapwood of living trees; the fungi remain in the wood when the tree is milled into lumber, but cause no loss in strength. Decay fungi, on the other hand, break down the cellular structure of wood, which does cause a loss of strength.

THE MECHANICS OF ROT

There are a number of different types of decay fungi, all of which rot wood by secreting enzymes or producing chemical reactions that break down the wood's cell walls. Decay becomes apparent when the wood changes color, becoming either darker or lighter than surrounding wood. As decay advances, the wood develops checks and cracks in the discolored area and becomes obviously softer or more brittle than solid wood.

Rot fungi are living organisms that need four things to survive: food (wood); favorable temperatures (above 32°F to around 100°F), water, and oxygen. If wood is rotting, you can stop the rot process by eliminating one of these four things.

Generally, the most effective approach to combating rot is to keep the wood dry. New wood needs to be at around 28% moisture content before decay fungus can grab hold and start growing. That's very wet, close to saturation in most woods, but it doesn't mean the whole board needs to be completely soaked. A board that remains wet on one side and is continuously exposed to a high moisture content can begin to rot. As the rot advances and breaks down the wet

Photos: 1, Steve Easley; 2, Kyle Diamond; 3, Robert Mignogna


4


5

Both white and brown rot can grow in the same piece of wood—in this case **(4)**, the sheathing around a poorly flashed cupola. Rotten wood is often found in a dry condition **(5)** and so is called "dry rot." But the wood had to have once been wet for the decay to occur. In this case—an old wood gutter—the wood had ample opportunity to get wet.

MOLD ON LUMBER

Mold growth on lumber has no structural effect on the wood. Unlike rot fungi, mold fungi grow only on the surface of lumber and do not have roots that grow deep into the lumber. When you find mold on lumber in the lumberyard or after storing lumber on site (black is most common, but it can also be green, pink, or orange, among other colors), it should be avoided or cleaned off.

Typically, mold on lumber is an indication of high moisture levels in the wood, and the lumber needs to be dried to a moisture content below 22% before using it to frame a wall. (Dry below 19% before closing it in; some folks will even say below 12% before hanging drywall if they are concerned about interior wood joints staying tight.) The mold stain may remain on the surface of lumber after the wood is dry, and once encased in the wall is unlikely to be a problem ... except that it can be. There is limited research that "hidden" mold can increase the number of mold spores in the indoor air, but mold is one of those hair-trigger issues that is best to avoid if you can. If owners are walking the site and see mold on lumber, it will raise concerns, and concern easily escalates into fear and litigation. To avoid all that, it's best to not select it at the lumberyard to begin with. If it's delivered and can't be returned, or is discovered after it's on site, it's best to clean off the mold before building with it.

To clean mold from the surface of lumber, scrub with water and detergent, then rinse and wet vacuum the surface. The individuals doing this work should wear gloves, eye protection, and NIOSH-approved respirators. Do not use bleach. Bleach may remove the mold stain, but it won't remove mold spores and is a lung and skin irritant. Using bleach only unnecessarily exposes workers to a hazard. Detergent will do as well to remove the stain, and what will really get rid of mold spores is vigorous scrubbing, rinsing, and vacuuming. If the mold is caused by a flood contaminated with black water, use an EPA-registered disinfectant. These tend to have fewer adverse effects on workers than bleach, but you still need to follow safety guidelines for protecting workers. —*C.D.K.*

Photos: 4, Isaias Antonio-Santos; 5, Kyle Diamond

Leaving rotted wood in place is often a judgment call. If the leaks above this fascia were solved and the moisture problem eradicated, would you leave these old rafter ends in place? It's a tough decision, but if new outriggers to support the fascia and soffit are put in place, the rotted beam ends could remain without the complete demolition and rebuilding of the eaves.

side of the board, more of the board will be exposed to that high moisture content, and eventually it will rot through.

Wood that has begun to rot but is still solid can be salvaged, however. Wood that has started to rot will stabilize once it has dried. The fungus goes dormant below a moisture content of about 22%, and as long as the moisture content is maintained below this level, the wood will not continue to rot. But the decay fungus can reactivate and begin growing when the moisture content again rises above 22%.

TYPES OF ROT

In general terms, the two most common types of wood-eating fungus in North America are "white rot" and "cubic brown rot." White rot eats the lignin, leaving the cellulose and covering the wood surface with a white mat of fungal fibers. Cubic brown rot eats the cellulose component of wood, leaving the darker brown lignin component, which shrinks into characteristic blocky formations.

Rot is known by a lot of names, not all of which necessarily correspond to a specific fungus species. These are some of the common terms:

Dry rot is a term loosely applied to any dry, crumbly rot, and especially when, in an advanced stage, the rot can be crushed easily to a dry powder. The term is a misnomer for any decay, though, since all fungi require considerable moisture for growth.

Heart rot is any rot confined to the heartwood. This type of rot, specific to certain species of fungi, generally originates in the living tree and rarely makes its way to the jobsite. However, it's not uncommon to discover boards in the lumberyard that slipped through the grading process with rotten hearts.

Soft rot is a special type of decay developing under very wet conditions in the outer wood layers. It is caused by cellulose-destroying microfungi that attack the secondary cell walls and not the intercellular layer. This sort of rot is found in old commercial cooling towers and in boat timbers at the water line—where, despite the nearly submerged conditions, the fungi still have access to oxygen, a necessary ingredient. Soft rot is not possible, however, in trees that have been submerged completely in rivers or swamps and then are brought up, dried, and milled into usable lumber. Under such fully submerged conditions, fungi spores in the wood are not able to develop without oxygen, and the wood, though soaked, is preserved. Sometimes, anaerobic bacteria help the preservation by breaking down some of the gummier parts of the tree, creating a

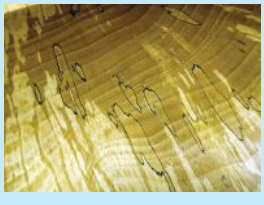
In cases of advanced decay **(7)**, there is little question that the rotted structure needs to be completely replaced with new framing. But not all wood destruction is caused by rot. Water seeping through brick got things started here **(8)**, and you can see where white rot lingers on the surface of this rim joist. But the ultimate destruction of this framing came from termites.

wood that is actually stronger than it might have been if the tree had been harvested on dry land in the first place.

Not all deteriorated wood is rot, though. Termite damage often looks exactly like "dry rot." And in many cases, the scent of rot may be what drew the termites. But termites usually are a lot quicker than fungi at destroying the structural integrity of wood.

SPALTED WOOD

Spalting is caused by certain types of white-rot fungi growing in wood (primarily hardwoods such as maple, birch, and beech). The fungi create "zone lines" in the wood where territories of competing fungi meet. Though usually used for decorative woodwork and furniture (live-edge tables and shelves are currently in vogue), spalted wood is occasionally used for interior trim, as well. According to the Forest Products Laboratory, once the wood is harvested, the fungi die and remain in stasis without further growth or compromise to the wood. (It is also possible to induce spalting in harvested wood; see the Forest Products Laboratory's technical bulletin "Producing Spalted Wood.") —*C.D.K.*



INCIPIENT VS. ADVANCED DECAY

Early-stage decay that has not advanced far enough to soften or otherwise perceptibly impair the hardness of wood is known as "incipient decay." It is usually accompanied by a slight discoloration of the wood, and the big question that carpenters often face when working on existing structures is whether it is OK to build onto slightly decayed framing. As long as the wood is solid and is kept dry, wood that is slightly discolored by decay fungus is OK to leave in place. Before sistering new framing to the old wood, treat the existing lumber with liberal doses of a copper-based wood preservative, such as QNap, or spray with a borate-based preservative, such as Bora-Care.

Wood in an advanced stage of decay, in which the attack has caused the wood fibers to become friable or has split the wood into sections, is essentially worthless. As much of this destroyed wood as possible should be replaced.

Inevitably, it may make sense to leave some damaged wood in place. For example, floor joists that have rotted at the ends near the sills may be inaccessible to remove. If reinforced with sistered joists and a new rim joist or blocking, the rotted ends can remain. The ends of the rafters shown in photo **(6)** are another case in point. As long as no structure depends on the deteriorated wood for support, and the wood is kept dry, they should be OK.

Clay DeKorne is chief editor of JLC.

Photos: 7, Isaias Antonio-Santos; 8, Robert Mignogna; sidebar, Bernhard Hofmann

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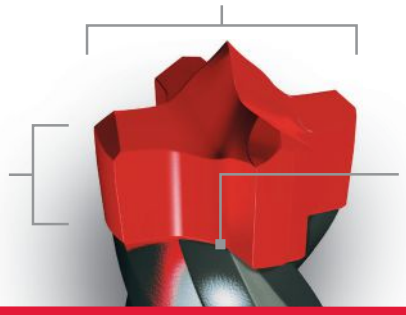

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Photos by Rick Mills

High-Performance Crawlspace Foundations

A concrete slab improves the performance of an unvented crawlspace, but you still need to air-seal and insulate it right

BY RICK MILLS

Crawlspace foundations typically follow regional building practices. Although they can be found in most parts of the country, there are regions—like ours—where they are the go-to foundation choice. Here in the Southeast where we work, you will typically find either slab-on-grade construction or pier-and-beam foundations built with CMUs. Basements are rare in our area because water-table levels are typically high, and the reduced height of a crawlspace compared with the height of a full basement is one way to assist in proper water management.

However, crawlspaces have a well-earned reputation for being problematic. Due to their typical lack of accessibility, most are neglected and become damp, dark, mold- and mildew-prone environments that homeowners tend to ignore … that is, until they have a problem.

VENTED VS. UNVENTED

Traditionally, crawlspaces are built as vented assemblies, with foundation vents sized according to IRC guidelines and installed in the stem walls to allow unconditioned air to flow freely underneath the floor framing. These vents can be closed in the winter to keep winds from blowing cold air through them and left open in summer to allow for some airflow, in the belief that this will help maintain appropriate humidity levels and dry out

Spraying the underside of this concrete porch floor with foam insulation is a necessary step in turning the crawlspace beneath into conditioned space **(1)**. With a slab over the crawlspace's vapor barrier and with lighting and dehumidification, the space is easier for the homeowner to maintain **(2)**.

A worker preps the interior of a CMU wall to accept a layer of rigid foam by grinding off mortar drops and other irregularities **(3)**. Installing drains prior to placing the vapor barrier and pouring the slab helps avoid trapping water underneath the house **(4)**.

the space. To keep water from freely flowing through the masonry walls, many vented crawlspaces are partially filled with sand to a level higher than the outside grade.

When it became clear that these construction methods don't help much with moisture control, the building code in Virginia where we work (which is modeled on the IRC) began requiring an approved Class I polyethylene vapor retarder placed over the bare ground to reduce moisture migration from the ground into the air of the crawlspace. Of course, this approach doesn't account for the humidity level of the outside air freely flowing through the vents; in addition, most plastic vapor retarders aren't installed very carefully anyway. It's common to find large gaps in the plastic sheeting around piers, at lap joints, and along the perimeter walls of the crawlspace. And by the time construction is completed and multiple trades have crawled and worked over the vapor barrier, it's likely to be wrinkled, littered with debris, and compromised with several tears and holes exposing the ground that was initially intended to be covered.

Fortunately, improved vapor barriers with greater durability are now available, with woven fiber reinforcing as well as higher mil thickness options. But our understanding of building science has also improved, and now the IRC no longer requires ventilation openings in the foundation, as long as the subfloor area is treated as part of the structure's conditioned space. Altering a vented crawlspace to an unvented assembly is the first step to conditioning the crawlspace, while proper air-sealing and insulation complete the effort. The crawlspace can then be conditioned (like the spaces of the house above) with supply air from the house HVAC system. To help sell our clients on this process, we explain that the superior

A crew member preps the perimeter of the crawlspace for a continuous 2-foot-wide layer of 2-inch XPS foam **(5)**. Then 6-inch-wide XPS strips are fastened to the walls, with the top edge of the foam aligned with chalk lines marking the top of the slab **(6, 7)**. After the drains and perimeter foam are in place, the sand base is raked smooth in preparation for the vapor barrier underneath the slab **(8)**.

crawlspace environment translates to durability, higher performance, and an overall healthier home environment.

CONCRETE SLAB FLOOR

To mitigate the concerns of some of our clients who have had bad experiences with crawlspaces, our company has been offering the option of finishing crawlspaces with concrete slab floors. The slabs are fitted with floor drains piped to daylight, and a sump pump to provide backup should a floor drain fail. In addition, the drains can pull double duty if a pipe were ever to break in the crawlspace, giving the water a way out and preventing the space from flooding. To prevent pest infiltration and unwanted airflow into the crawlspace, we fit the drain lines with check valves.

After the house is dried in, we also install evenly spaced lighting throughout the crawlspace. Proper lighting seems to help prevent the abandonment of the space and fosters a higher willingness to enter it, thereby minimizing much of the neglect experienced by a typical crawlspace.

Finally, we also like to include a dedicated dehumidifier in this upgraded package. While conditioned supply air will bring the temperature in the crawlspace in the summer down to reasonable levels, humidity levels still remain quite high and could potentially promote some mold growth. With a dedicated dehumidifier, this risk is drastically reduced, if not eliminated **(1, 2)**.

DRAIN DESIGN

When you are incorporating a new design element into a project, the law of unintended consequences has to be considered. With

After compacting the sand base **(9)**, workers install the Stego Wrap vapor barrier **(10)**, carefully cutting and folding it to fit around corners and piers. OSB strips fastened over the membrane to the CMU walls hold it in place until the slab is poured **(11)**. Pipe openings in the membrane are sealed with black Stego mastic **(11)**, while seams and edges are sealed with red Stego tape, which is also used to protect the linear drain openings during the pour **(12)**.

a concrete slab in the crawlspace, you are essentially creating a bathtub underneath the house, and so a plan for multiple drain locations in the slab becomes a requirement **(3, 4)**.

Planning for drains happens early in the project. We start by evaluating the pier layout, overall foundation design, and the site plan to determine the proper path for piping and water runoff from the crawlspace. Working closely with our civil engineer, we determine the best location for the drain piping outlet (on small projects) or outlets (on large projects). We also consult with our plumber, who can offer practical experience as we develop our plan for drain locations and exit points from the house. In certain localities, it may be necessary to tie this into the main waste line, in which case a check valve would also be required to prevent backflow of sewer gases.

Immediately after concrete footings have been placed, we focus on drain installation. Depending on how much dirt is excavated, it can make sense to come in with a skid steer and scrape off the high areas, but before that step can happen, a grade for the drains needs to be set. Again, we work closely with our plumber and concrete contractor to help set grade for the drains and high points out from the drains. You don't need to create a steep slope, just enough to get the water moving; we usually don't specify more than 1/8 inch of fall per foot.

On a typical drain layout, we try to place one drain between each row of piers (depending on the size of the house's footprint), using the piers as the high point. But like most details on custom homes, every layout is unique. For example, on a recent project, our plumber suggested using the existing natural slope of the site and sloping the slab from one end of the house to the other, with a large linear drain installed at the low end. This saved us from having to bring in a lot of fill and relevel the space.

Once all trades involved approve the drain locations, we grade off the house footprint down to around 6 to 8 inches below the top of the concrete slab, thus allowing for 2 to 4 inches fill sand to be brought in later. While this grading tends to cause some cave-ins


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On a large project, the crawlspace slab is typically poured in sections **(13)**; visible around the base of the piers is black 1/2-inch-thick Nomaflex expansion joint material. Because the slab isn't structural, there is no need for rebar **(14)** or extra-strength concrete, though the author typically specs fiber reinforcement. A small slab can be fitted with a single drain, while a large crawlspace requires several drains, with each slab section sloped toward a drain **(15)**. Control joints sawn into the slab control cracking, while the author organizes penetrations through the wall by marking them with paint colors that correspond to the local DigSafe code (blue for water, green for sewers and drain lines, red for electrical, yellow for gas lines, and so on) **(16)**.

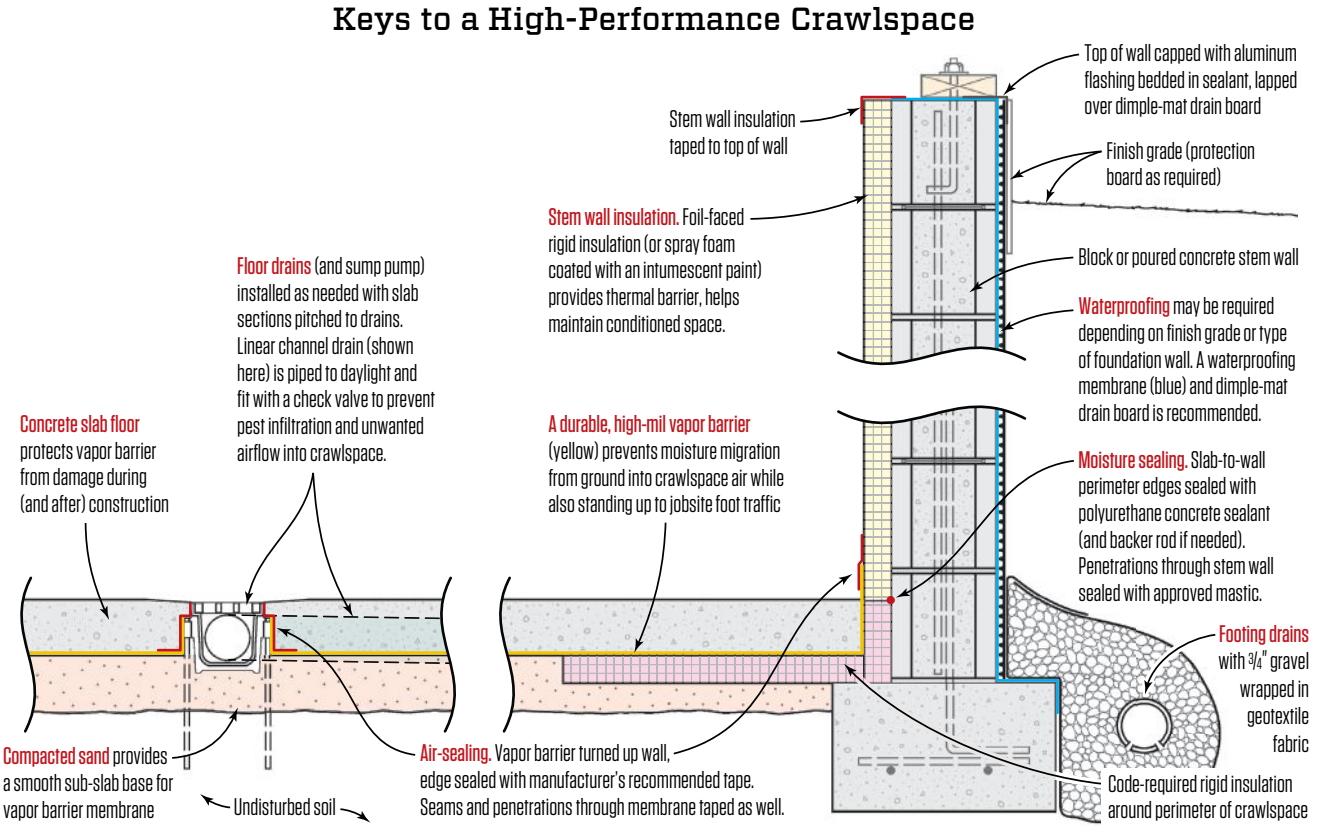
and footings to be covered in sand, the extra step of cleaning off the footings is well worth it compared with trying to remove excess material working around all the CMU piers and walls after they are installed.

Working from our plan, I then use spray paint to mark the exit locations for drainpipes on the ground and on the footing. I make sure to provide schedule 40 pressure-rated pipe as a "sleeve" through the block wall, sizing the pipe one size up from the actual 3- or 4-inch-diameter drainpipe (depending on how many drains have converged on that particular exit point). The benefit of this is two-fold. First, the sleeve provides a clean pathway through the block wall, so that a tradesperson won't need to come along later and use a large maul or hammer drill to create the opening, leaving a jagged hole in their wake. Second, if any weight was ever to settle over the pipe, the sleeve provides some protection to the smaller pipe to prevent crushing or cracking from occurring.

When all the CMU stem walls and piers have been laid up, it's time to knock down any remaining high spots in whatever spoils were left from excavation and start snapping chalk lines. Once the perimeter top-of-slab lines are marked, I transfer the marks onto the piers.

VAPOR BARRIER

Per code, conditioned and unvented crawlspaces require insulation. So before pouring the slab, we install a continuous 2-foot-wide layer of 2-inch XPS foam around the perimeter of the building. We start by spreading the sand evenly so that it comes up to 3 or 4 inches below our marks for the finish slab elevation, then tamp the sand with a plate compactor. Next, we use a concrete rake to excavate a 2-foot-wide-by-2-inch-deep trench in the sand along the perimeter walls **(5)**.



The conditioned crawlspace details used by the author's company were developed in conjunction with architect Steve Baczek and include a slab floor over a well-sealed vapor barrier. To prevent water accumulation, the slab is fitted with floor drains.

Using a track saw, we rip some of the sheets of XPS foam into 6-inch-wide strips, which we attach to the foundation walls at our grade marks with Poly Wall Quick Grip adhesive and a powder-actuated nailer shooting 3-inch nails through attached washers. This will allow for a full 4-inch depth for the slab after the 2-inch-thick horizontal sheets of XPS foam are butted up against the 6-inch-wide rippings **(6–8)**.

After we rake the sand smooth and level it out **(9)**, it's time to install the vapor barrier. Our first choice is Stego Wrap's 15-mil below-slab product, which we've found stands up extremely well to jobsite foot traffic **(10)**. It's a little difficult to fold this stiff membrane up the wall and around corners, but we've came up with a solution that works fairly well. After laying out the vapor barrier, we nail 3-inch-wide strips of 1/2-inch OSB plywood to the stem wall on top of the 6-inch-wide vertical strips of foam, sandwiching the vapor barrier down tight to the foam. This step ensures that the membrane lays up against the foundation wall and out of way, leaving the concrete crew with a clean screed surface **(11)**.

On the corners, it takes a little bit of skill to master the best folding techniques (it's a little like wrapping a present). Fortunately, Stego makes a very sticky red tape that works great for sealing up folds, taping lap joints, and taping to itself as needed **(12)**.

After the vapor barrier is down, we use 4-inch-wide strips of 1/2-inch-thick Nomaflex (a polypropylene expansion joint material that we get from our concrete supplier) to make expansion joints around the base of the piers, which also helps to lock in the membrane flaps during the pour. We tack the strips together with 3/4-inch-long nails, then wrap the corners with Stego Wrap tape.

Finally, once the vapor barrier is installed and detailed, we go around and make sure all of the penetrations through the membrane and stem wall are sealed either with tape or with Stego Mastic, which is made for sealing around pipes. We also tape off the drain openings in preparation for the slab pour **(13–16)**.

INSULATION

After the slab concrete has been placed and allowed enough time to cure, we can move on to framing; once the house is dried in, we wrap up the final steps of insulating the crawlspace walls.

First, we remove the 1/2-inch OSB strips and trim away any excess Stego wrap that extends too far above the concrete slab. Next,

On this project, the CMU walls were sprayed with Poly Wall Home Stretch liquid waterproofing membrane **(17)**, then covered with Arroyo dimple-mat drain board glued to the walls with Quick Grip spray adhesive **(18, 19, 20)**. The tops of the walls are capped with aluminum flashing bedded in sealant **(21)**, while masonry shelves are flashed with Home Stretch detail tape.

we seal the foam-to-wall connection with a polyurethane concrete sealant (backer rod may be required) or spray foam to prevent the possibility of moisture coming up between the membrane and the CMU walls later. Then we insulate the stem walls with 2-inch-thick Thermax polyisocyanurate foam board with a foil facing, which eliminates the need for a thermal ignition barrier, or we have a spray foam contractor come in and coat the CMU walls to the desired R-value. When insulating with spray foam, make sure to confirm that your insulation contractor includes coating the foam with an intumescent (or fire-resistant) paint in their bid.

Depending on the outside grade on a project, we may also include waterproofing for the exterior walls. We like to use Poly Wall's below-grade waterproofing system, a two-part system that uses its Home Stretch liquid-applied waterproofing membrane and Arroyo Drain Board **(17–21)**.

After we're done, our clients are assured of a superior crawlspace environment that will provide them with durability, higher performance, and an overall healthier home environment.

Rick Mills is a senior project manager for Jackson Andrews Building + Design, in Virginia Beach, Va. Follow him on Instagram: @rick.jackson andrewsbuilding.

Reroofing With Exposed-Fastener Metal Panels

A premium roof that's less expensive than laminated shingles

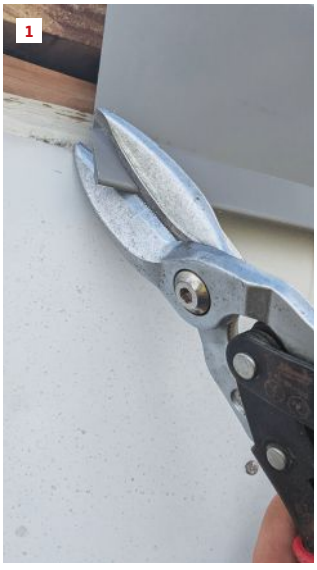
BY AARON MIILLER

Our company, Miiller Construction, installs a lot of exposed-fastener metal roofs. Most of these are reroofs on homes, which we typically install over existing asphalt shingles. All of the commercially available metal roofing we can buy in our area is warranted for contact with asphalt, but we prefer to install 3 1/2-inch wood strapping first, securing it through the shingles to the sheathing with ring-shank nails. This gives us a firm base for the screws that hold down the roofing. Many of the older roofs in our area are decked with board sheathing. With a nail gun, it's obvious when you miss a solid board, and you can just fire in another nail. But if you are screwing the roofing directly to the shingles and hit a dead space, you need to back the screw out and fill the hole with a grommeted stitch screw. All the extra holes in the metal makes for more risk than we care to take on. It also takes longer.

On the majority of roofs, we install 29-gauge panels, which are less expensive than heavier, 26-gauge panels. We explain to customers that the heavier-gauge material will withstand hail better, but most still opt for lighter-gauge material because of the cost. We can actually install 29-gauge metal (strapping, screws, and 29-gauge trims included) for less than we can install a good architectural shingle roof with a similar lifespan. Even at the lower cost, most of our clients see a metal roof as an upgrade over shingles. (We do price out heavier-gauge trims as an option, disclosing to customers that the lighter-gauge trim can oil-can easily, but most clients still go with the less expensive package.) The photos that follow here detail the key steps from a couple of roofing jobs that show our methods for a fast, quality installation.

Aaron Miiller owns Miiller Construction, based in Corning, Ark.

Photos by Aaron Miiller



We start by ripping off the overhanging edge of the shingles with a hooked knife and remove any existing metal drip edge so we can install our eaves trim. We attach this trim by hand with roofing nails. On most homes, the eaves are longer than one trim piece, so we need to splice the trim. For this, we cut a little diagonal on the drip leg **(1)**, and take a utility knife and open up the hem a little bit on the joining piece **(2)**. This allows the diagonal cut to slip into that open hem **(3)**. If you don't do this, the overlapping piece will stick out and may open up as wind catches that lip and bends the trim.

On a house, we normally install lath every 2 feet. More is not needed; there's no reason to drill extra holes through the roofing panels. But it's key that you know where your holes go. We measure the distance to the center of each lath and write those numbers down **(4)**. We can then transfer these numbers to the panel **(5)**. We clamp the marked panel to a stack of panels (enough for the run) to hold them together and drill all the holes all the way through with an 1/8-inch bit **(6)**. This way, all the holes are in exactly the same position on all the panels so we end up with a nice, straight line of fasteners.

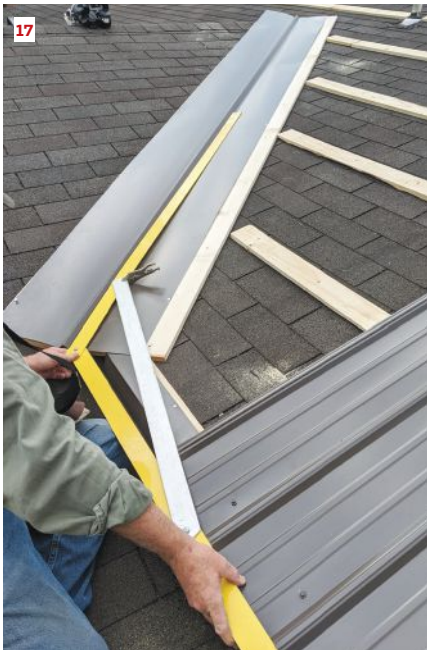
Existing roofs are rarely square, so we use a method for positioning panels that focuses on getting the overhanging edge straight; if the gable edge is off, it will be covered with trim. We start by measuring any distance that allows for the roofing to overhang the eaves trim by 1½ inches and lands on the drip edge—in this case, we chose 4 inches **(7)**. We mark the same distance on the far end of the roof and pop a chalk line **(8)**. I mark the same distance (4 inches) on both sides of each roofing panel **(9)** and use the marks to align the panel on the chalk line **(10)**. As a result, we don't spend a lot of time trying to microadjust each panel to align with the roof, and we end up with a consistent overhang along the front fascia.

We place screw holes in the center of the pan, just to the right of the rib, and use 1-inch roofing screws to secure the panels **(11)**. Ridge cap is secured to the ribs of roofing panels with stitch screws for a metal-to-metal connection. Typically, we complete the roof in sections **(12)** so we don't have to move ladders around the house multiple times and continually walk back and forth to one work station.

After the roofing panels are installed, we cover the gable edge with rake trim. To find the plumb cut for the trim at the peak, we use a sliding bevel square **(13, 14)**; it's a simple, old-school tool, but it works well.

We start installing the trim from the bottom and work our way up **(15)**, just as we do with the roofing panels, so that the lap drains water away with gravity.


16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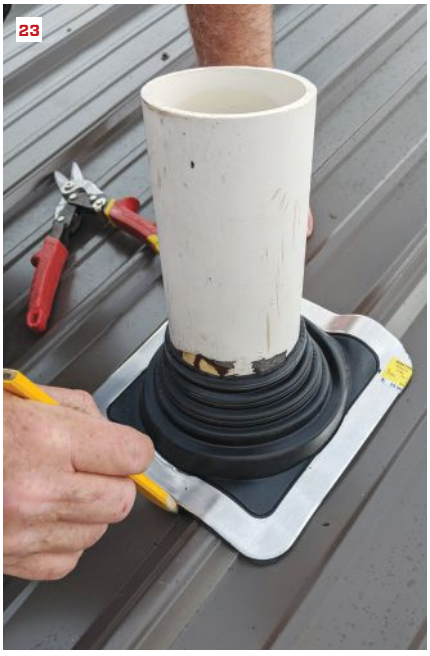
21

At valleys, we start with 1x12 decking boards so the metal W-valley has continuous support **(16)**. On existing homes, it's often hard to be precise with the math (where you measure to is often a guess in a woven shingle valley), so we developed a method to measure the angle of the metal panels. We made the angle gauge using 3-foot aluminum rulers (the yellow ones are made by Swanson) that we joined with swivel screws. We lay this in the valley and hold the angle with vice grips **(17)**, which makes it easy to transfer the exact angle to the roofing panel. All cuts we make with a nibbler **(18)**. The marking is fast enough we do it for each panel, working up the valley **(19, 20)**, so we end up with straight, parallel lines **(21)**.



We rough-cut the metal panel around plumbing vents using a metal blade in a jigsaw and rely on a boot to seal the penetration **(22)**. After trimming the rubber to fit the vent, we dry-fit the boot and mark the perimeter **(23)** so we know where to apply a continuous bead of a solvent-based rubber sealant. (We use a sealant by Sashco; a sealant that stays flexible is critical for metal roofing, which moves a lot with changes in temperature.) Don't remove the boot after marking; just lift it up to apply the sealant **(24)**. It's great when the vents fall in the center of the pan **(26)**, but this doesn't always happen. The boot (this one is made by Oatey) has a soft aluminum and lead edge that is made to conform to the panel ribs. When securing over a rib, we typically place the screws at an angle so they suck the metal edge into the indents of the rib profile **(25)**.

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ELECTRICAL CORDS CAN BE SUCH A DRAG.

Reducing Drywall Callbacks

Most drywall problems are caused by structural movement that is under a builder's control

BY STEVE EASLEY

Photos by Steve Easley; illustrations by Tim Healey

As a consultant to the home building industry, I help builders identify and correct construction problems that can cause defects or costly callbacks. One of the more common areas where callbacks are a concern is drywall. Nail pops, cracking, and ridging in their walls and ceilings are the kinds of things that homeowners notice and complain about, and some builders are plagued with those sorts of callbacks.

Most cosmetic issues with drywall are caused by movement:

- Structural movement related to framing (due to inadequate engineering or poor framing techniques)
- Thermal movement related to installation conditions (expansion and contraction of materials due to temperature differences)
- Hygrometric movement related to finishing conditions (movement due to elevated moisture content of framing lumber and drywall)

All of these issues are under the builder's control, at least to some extent. So with an understanding of the source of the problem, builders can prevent, or at least reduce, those callbacks. Here's a look at where some of the most common drywall problems begin.

WALL BRACING

Some production builders are so focused on cost that they reduce the structural wood panel sheathing on their buildings to the

When installing drywall on a frame with a post that carries a heavy point load like a structural ridge **(1)** or a girder **(2)**, be sure not to place the butt joints over the posts. Instead, position drywall sheets to span over those posts.

Positioning panels requires some judgment. The position here shows a good compromise that effectively spans the structural elements and avoids joints near window corners.

bare minimum required by code. The result is a structure that is less stiff than if the builders had fully sheathed the entire exterior of the building.

A partially sheathed building, such as the one shown in the photo on page 51, may not fall down, but it does flex more than a fully sheathed building under wind loads. That can cause the drywall to crack. Fully sheathed buildings are stiffer, and they have fewer drywall problems.

LOADING THE BUILDING

It's important to have the major structural loads in place before drywall is applied. For example, roof shingles should be installed, or at least evenly loaded on the roof, before applying wallboard. Large, heavy items such as bathtubs should be in place before drywall is applied. If there's heating and cooling equipment installed in the attic, that should also be in place before drywall is finished.

LOAD PATHS

Drywall joints on built-up posts that carry heavy point loads are prone to cracking **(1, 2)**. Instead of breaking the butt joint on a column, break the drywall joint elsewhere on the wall. At left **(3)** is a good example of a sheet of wallboard placed so that it spans a carrying post. The joint here will also be located well away from the corners of the window rough opening (see discussion, below).

TALL WALLS

In modern homes, it's common to find open two-story spaces such as foyers. Rather than balloon-frame these tall walls, it's typical to use a floor joist between the upper and lower wall frames. If you frame a tall wall this way, it's better to use an engineered lumber joist. Solid wood shrinks most in the cross-grain direction, and a sawn lumber joist at this location can shrink a half-inch, creating crushing at the joint. With wood I-joists, shrinkage is minimal in all dimensions, and crushing is less likely.

WINDOW AND DOOR OPENINGS

Walls experience a lot of stress at the corners of window and door openings. For that reason, industry standards recommend locating

drywall joints at least 12 inches away from the corners of any rough opening (see Drywall Joints at Openings, below right). In the photo at right **(4)**, you can see how the drywall joint that's just a few inches from the corner has cracked.

WALL-TO-CEILING JOINTS

Cracks often occur at the corners where walls meet ceilings. This is caused by lumber shrinkage and a rigid attachment of the drywall to the framing at the corners. Industry guidelines recommend that instead of fastening the drywall to the wall plates, builders hold the fasteners back 7 inches on the ceiling and 8 inches on the wall to allow the drywall to float in the corners (see Wall-to-Ceiling Joints, page 54). In cases where the ceiling framing is parallel to the wall, the guidelines recommend installing blocking as needed between the nearest ceiling member and the wall—rather than using a nailer fastened on top of the wall plate—so that fasteners can be placed at the recommended distance from the wall.

It's wise to avoid using small strips of drywall next to a corner **(7)**, because it doesn't allow you to fasten far enough from the corner to allow the drywall to flex; good integrative design would have been helpful in this case. Builders should have a conversation with their designers about dimensioning rooms so that full sheets of material will fit the space.

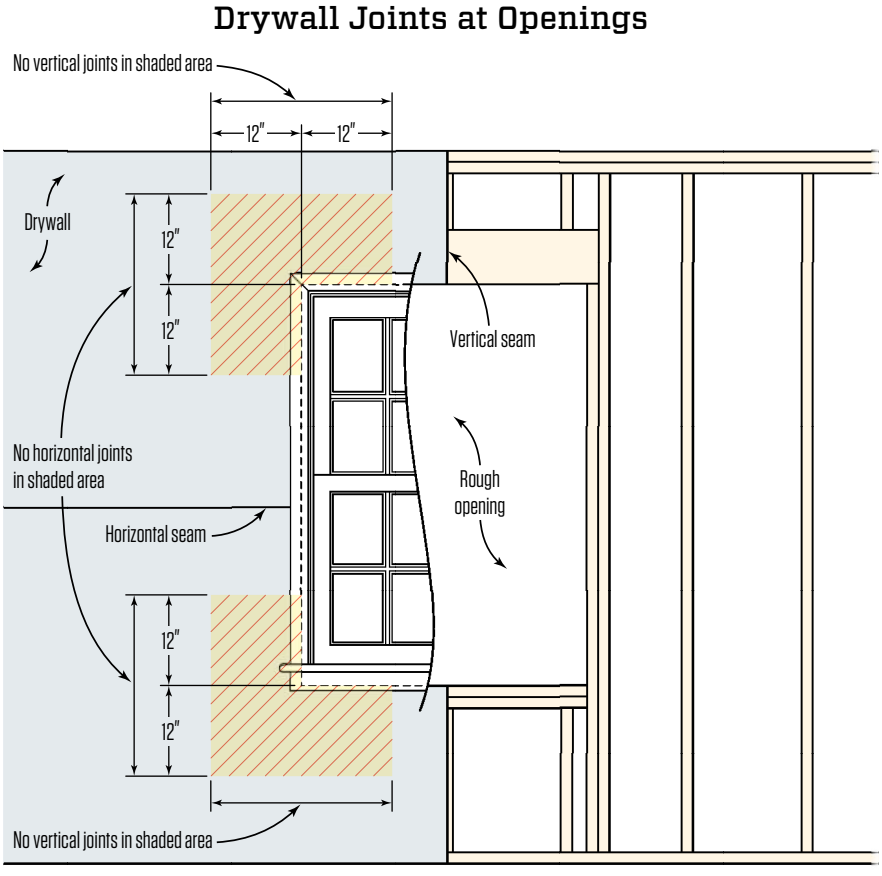
LONG SPANS

Modern buildings often have wide rooms with long ceiling spans. In those cases, drywall ridging or cracking near the center of the room is a typical callback. I recommend that builders consider using resilient channel in those large rooms, or anywhere that a long span and a short span occur next to one another. Resilient channel takes up the stresses of differential movement in adjacent members and allows the framing to flex without transmitting stress to the drywall.

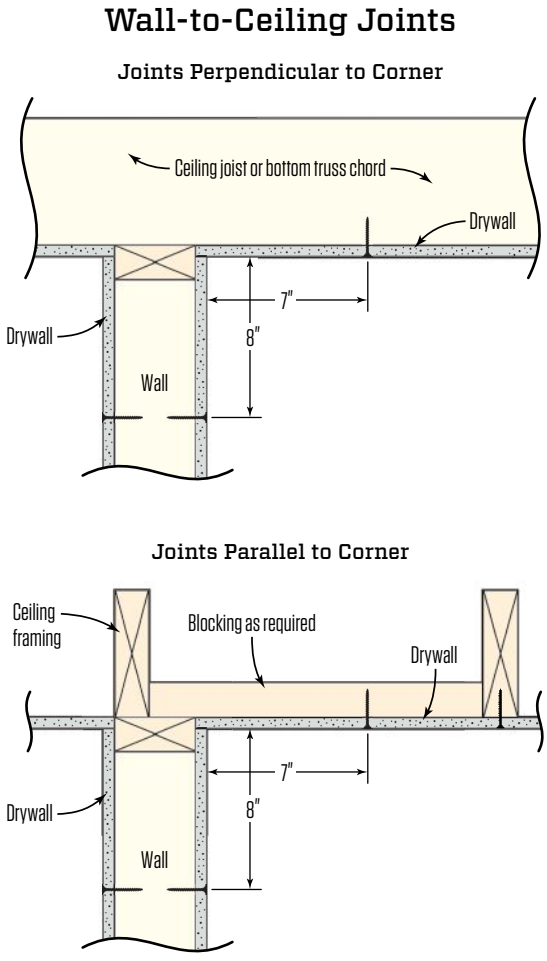
BELLY BANDS

In higher-end homes, 9- or 10-foot wall heights are common. In that case, 4-foot

Panel joints placed too near window and door corners will tend to crack as the lumber in the header and other framing around the openings shrinks.



To avoid panel-joint cracks near window and door corners, keep seams and butt joints at least 12 inches from the corners of rough openings.



When drywall panels are rigidly fastened into the corner of the wall-to-ceiling intersection, cracks often develop when the floor or ceiling framing shrinks. To avoid such cracks, place drywall fasteners as shown in the illustrations above. This means that you should avoid installing nailers for the ceiling panels along the walls **(5)**. Instead, install blocking **(6)** perpendicular to the wall. This allows the fasteners of ceiling panels to be held back about 7 inches from the corner.

drywall sheets don't break evenly at the top and bottom of walls: A rip is required to completely cover the wall. Some installers will place one sheet all the way to the wall top, place one sheet all the way to the bottom, and cut the rip to fit the middle, creating what's known as a "belly band." But that's not good practice, because it requires butting a ripped edge to a tapered edge, creating a bump halfway up the finished wall. Instead, place the rip at the bottom of the wall. This allows you to make all the joints with tapered edges on both sides.

Photo **(8)** on the opposite page shows ridging of a horizontal joint at mid-wall height. This could have been caused by lumber shrinkage due to the use of wet lumber, or it could be an example of ridging caused by butting a ripped edge to a tapered edge. Both conditions are preventable, either by keeping the lumber dry or by making sure to butt tapered edges together.

APPLICATION CONDITIONS

Gypsum wallboard, like other construction materials, is sensitive to temperature and moisture. For good results, it's important to control the environmental conditions where drywall is installed and finished. Temperatures in the building should be 40°F or warmer for hanging drywall, and 50°F or warmer for adhesive application, as well as for taping and finishing. After the drywall is installed, maintain temperatures at 50°F or warmer.

Temperature and humidity affect the time that it takes for a coat of drywall mud to dry. If you're at freezing temperatures and the relative humidity (RH) is at around 50%, it will take about four days for the mud to cure. At the same RH and a warm, 70°F, it will take about 27 hours.

Some builders use portable "salamander" heaters for temporary heat, but it's important to realize that whether it's propane

Avoid small strips of drywall at ceiling corners **(7)**. This problem should be solved during design. (Room dimensions based on 2-foot intervals work well.) Ridging of a horizontal drywall joint **(8)** may be caused by excessively wet lumber shrinking, or may appear from butting a tapered edge to a cut edge. Both conditions should be avoided.

Don't use portable combustion heaters in winter if you want to dry the interior. Combustion heaters release water into the air. Instead, use dry heat, such as this portable heat exchanger. For drying, apply heat and air flow evenly throughout the building.

combustion or another fuel like kerosene, combustion releases water as a byproduct. A propane heater releases 7.8 pounds of water for every gallon of propane burned and significantly increases the relative humidity in the building.

Sometimes, builders will install drywall on the ceiling under the attic, then immediately come back and start taping and finishing. But it's important to insulate the ceiling as soon as drywall is installed. If you don't insulate before taping, there can be a big temperature gradient across the drywall between the conditioned space and the unconditioned attic, which is an invitation for trouble.

Condition of framing materials can have a huge impact on callbacks. If lumber is stored on the jobsite and is not protected from the elements, elevated moisture content can result in excessive shrinkage if the drywall is installed before the lumber has had time to dry out. I never like to see framing lumber above 13% to 14% moisture content.

Home moisture levels are a wild card. Many times, homeowners have elevated levels of moisture in the home due to perceived comfort and lifestyle. Always bring a digital hygrometer and measure the relative humidity of the occupied spaces to see if the issues are caused by the homeowner over-humidifying the home. For example, I visited one callback where the homeowner who was experiencing drywall issues had a 500-gallon aquarium in the living room. If you spot condensation on low-E windows under moderate outdoor temperatures, that's a hint that the home is over-humidified.

LOW-VOC ADHESIVES AND SCREW POPS

A few years ago, the drywall industry received a rash of complaints relating to nail pops and "screw buttons" (bumps or protrusions forming over the heads of screws in finished drywall). USG undertook a field and laboratory study of the situation and traced the problem to the use of low-VOC adhesives. The results of the investigation are published in a white paper, "USG Fastener-Related Drywall Installation Issues and Recommendations."

USG determined that water-based low-VOC adhesives were shrinking as they dried, pulling the drywall closer to the framing members and causing bumps to form at screw locations. To address the problem, USG offered two recommendations: Either give the adhesive time to dry, then go back and reset drywall screws to make sure they don't protrude above the paper face of the wallboard; or just stop using low-VOC adhesives.

Steve Easley is principal of Steve Easley Associates, a building-science consulting firm based in Scottsdale, Ariz.

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PHOTO BY TIM HEALEY

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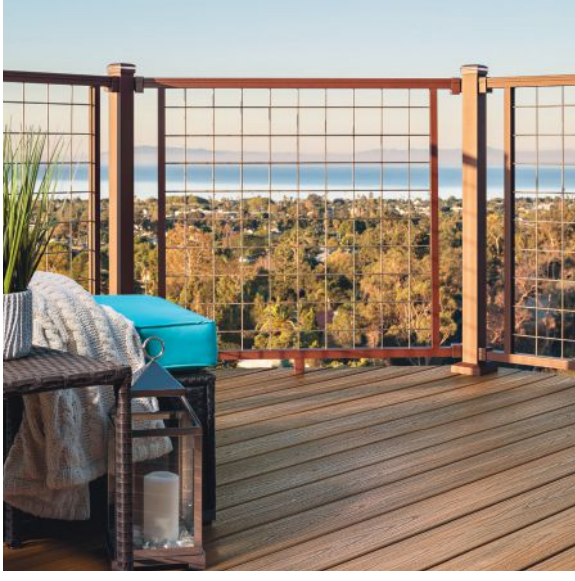

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Engineering What's Next in Outdoor Living®

Grain Silo Pergola

by Dave Settlemyer

When his children were young, my client's home featured an above-ground swimming pool. But eventually the kids grew up, and with the children and pool long gone, he was looking for a way to utilize the level, circular area where it once stood. Traveling down back roads during his daily commute to and from work, he passed a farm that had three grain silos on a busy corner lot, one of which had been hit by a car as the result of a traffic accident at the intersection. He daydreamed about someday removing the damaged area and creating a large opening or doorway in the round silo, which was otherwise intact and undamaged. Putting two and two together, he wondered if the modified silo would fit somehow in the space vacated by the pool.

After passing by the silo for several years, he finally stopped in one day and spoke to the owner of the property, an older woman who told him that the silos were used primarily to store junk. She was willing to sell him the damaged silo for $300, as long as he could figure out a way to move it. His concept for his backyard was slowly taking shape, but he had no idea how to pull it off or what to actually do with the silo, which is when he contacted me.

Recycled Materials

The basic plan that we first discussed involved repurposing the conical silo roof as a pergola or patio cover. But we identified several issues on the site that needed addressing, including drainage and grading problems and a dilapidated and undersized builder's-grade deck that he wanted to replace.

Taking the raw steel of the silo for inspiration as my plan took shape, I created a theme of steel and concrete with usable patio space and an outdoor kitchen. Instead of using just the top of the silo, we would use every part of it that wasn't damaged. I suggested using pavers rather than pouring a concrete patio, as slabs typically crack within a few short years in this area of Colorado.

There are always budget restrictions on any project, but this project seemed to take the word "thrift" to another level, as we were able to find a majority of the materials free or discounted. In addition to the inexpensive reclaimed silo, the homeowners found overstock pavers that had been discounted 50%. We crafted a fire pit from a broken piece of concrete culvert pipe left over from one of my previous projects earlier in the year,

PHOTOS BY DAVE SETTLEMYER

Figure 1. The barren backyard once had a small deck and an above-ground pool, which had long since been retired (A). The outdoor environment that the author designed featured a paver patio (B) and a new, larger deck. A pair of semi-circular concrete pads (C) mark the location of the grain silo pergola, the centerpiece of the project.

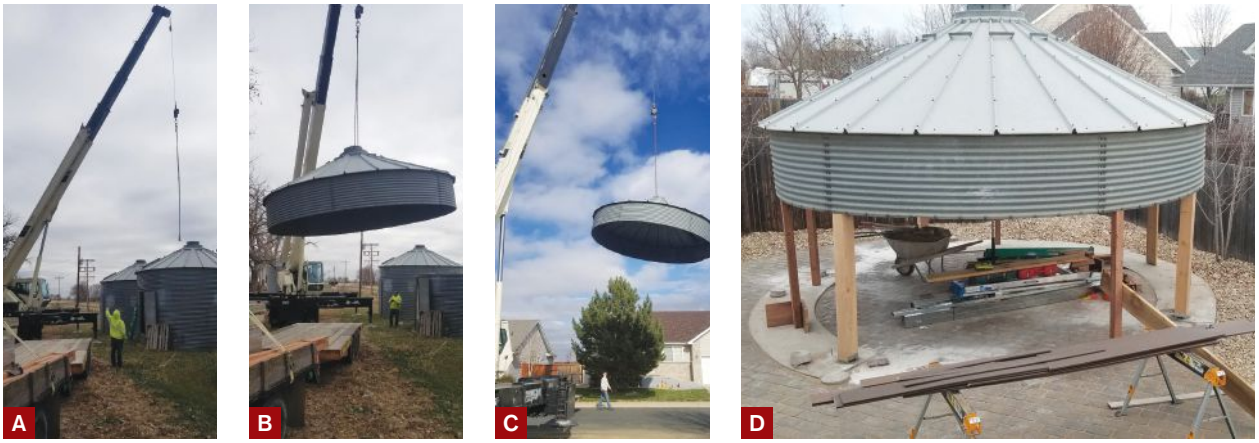

Figure 2. After most of the bolts holding the grain silo sections together were removed, a crane lifted the roof and upper section from the rest of the structure (A) and set it onto a flatbed trailer (B). At the client's home, the silo roof was hoisted over the house (C) and set gently onto temporary 4x4 posts. Later, permanent 6x6 posts were installed (D).

and to face the steel-framed kitchen cabinetry, we used old fence pickets from the demolition of another project.

The homeowner's association unbelievably had no problem with our plan, and all the neighbors were excited to see the project evolve. It was presented to the building department as a pergola, which allowed us to place the structure up to the 5-foot accessory building and utility property setbacks. Everything really fell into place on this project.

Site Work

To prep the site, we graded and shaped the yard to accommodate additional xeriscape landscaping (**Figure 1**). Next, we cleared the patio base and drilled the support caissons for the silo post anchors. Because I planned to build the silo's kitchen cabinetry on site using steel framing supported by a concrete base, we poured a pair of semi-circular slabs prior to installing the paver patio. The slabs also outlined the silo's location and gave us an opportunity to work around it before it arrived. This way, we were able to complete all the remaining landscaping and deck work, leaving the silo installation as the final phase of the project.

Moving the Silo

We hired a local crane company to help us move the silo, so it didn't have to be completely disassembled into individual panels (**Figure 2**). To prep for the move, we removed almost all the screws holding it

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together at the top band of corrugated steel, leaving four screws to hold it up until the crane was ready to lift it off the base.

After removing the cap on top of the silo, we lowered the crane rigging down into the center and strapped an old tractor tire to the rigging. The crane operator lifted the rigging enough to take the weight off the structure so that we could remove the last four screws, then lifted the top section away from the base and placed it on a flatbed trailer.

We strapped the silo to the trailer and moved it two miles down the middle of a gravel road, through the back entrance to the owner's housing development, and up to the curb in front of the owner's house. There, the crane set up a second rigging and lifted the silo off the trailer, over the house, and into the backyard.

To finish up the crane work more efficiently, we lowered the silo onto temporary 4x4 support posts, positioning the silo high so that we could then lower it onto its permanent 6x6 posts later, without the crane. There the silo sat for about a week while we made adjustments to our caisson layout (it turned out the silo wasn't a perfect circle, thanks to the car accident that had damaged it, and so we had to move a couple of piers) and installed the permanent posts. While the silo was perched up high, we prayed for calm weather and no wind every day.

Finally, it was time to lower the silo to its final resting place. It was a Sunday, and I was alone, so I used a jack to slightly lift one side while I unscrewed one of the temporary 4x4 posts. But as I lowered it, the whole thing tipped toward me. I was able to catch it and keep it from toppling to the ground, but the owner wasn't home and I couldn't let it go or it would all fall. (Keep in mind, it was barely connected to a few unsecured 4x4s.) I couldn't reach posts to resecure it, but I had my phone in my pocket and I was able to call one of my employees to come and help me. But he lived more than 30 minutes away, so I had to hold the silo until he arrived about 45 minutes later.

He was just in time. Though the silo was primarily stabilized by the remaining temporary supports, acting as the final support post began to wear on me. Lowering the silo was much more of a task than I had originally thought. There really wasn't an effective way to detach the temp posts, lower it, and reconnect it to the permanent supports without it tipping down on one side while rising up on the other. We had to work in a circular fashion around the perimeter of the silo where we were able to use a floor jack to brace each post location, making the silo easier to lower. We finally got it to the right elevation and connected to the new 6x6 support posts.

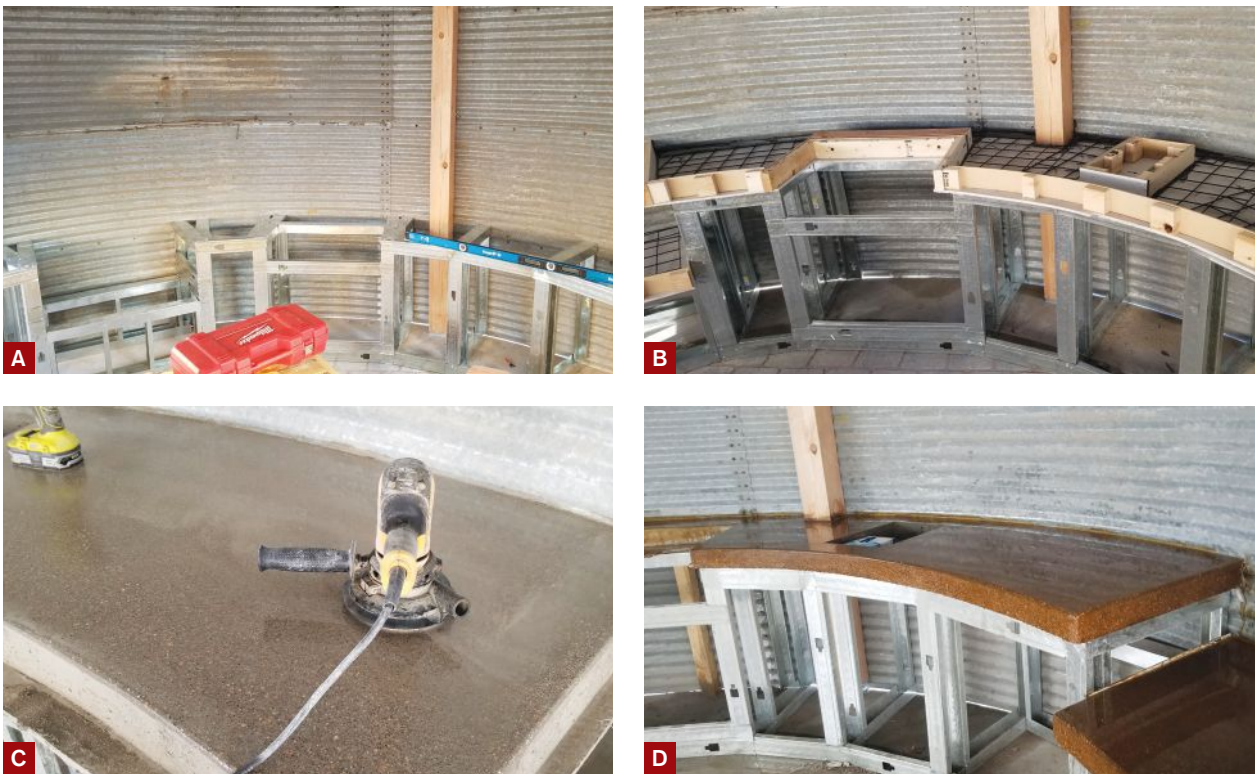

Figure 3. The author framed the kitchen cabinetry with light-gauge steel (A), then used cement board to form the base of the countertops, and smooth MDO plywood screwed to blocking to form the sides (B). Once the concrete cured and the forms were removed, the tops were polished smooth (C), then acid-stained and sealed with epoxy (D).

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Figure 4. Reclaimed random-width fence pickets face the kitchen cabinetry (A), which wraps around the inside of the silo pergola. In the midst of a Colorado Front Range subdivision, the steel structure is a friendly reminder of the area's agricultural roots (B).

Finishing Up

We spent the next week disassembling the remaining sections of the silo for reuse, and building the framework for the outdoor kitchen. We had enough undamaged sections to reconstruct a back wall for the kitchen and give it an enclosed feeling, but we lacked enough undamaged pieces to enclose the whole thing. Instead, we left a large portion of the structure open on two sides, which added to the functionality and open-air feeling. To increase the functional seating, we added a knee wall capped with a bar top to the side of the pergola opposite the kitchen.

We used light-gauge galvanized steel studs to frame the kitchen cabinets (**Figure 3**). We chose steel framing because in addition to being perfectly straight and rot-resistant, it is non-combustible, an important consideration in an outdoor kitchen with an insert grille planned for installation in the countertop. Finally, we needed the steel framing to support the weight of all the concrete that we were planning to pour to form countertops.

We chose concrete as the medium for all the countertop work because it was the most adaptable material for the curvature of the pergola. We have a lot of experience with cast concrete and have developed a few techniques that we were able to incorporate into this project. For example, we used Hardibacker cement board as the base for our formwork, because it's strong and easy to secure to the framework with screws, and we don't have to worry about having to remove it after the concrete has been cast in place.

Also, we no longer reinforce our slabs with #4 steel rebar, but instead use what we call hog wire, a 10-gauge welded wire fabric with a rubberized coating. We've found that this material provides plenty of reinforcement, but the wire gauge is small enough to allow the aggregate in the concrete to flow easily around it. When using rebar, we've found that the jittering process used to settle the concrete into the forms leaves aggregate stacked on top of the rebar, creating visible lines on the slab surface showing where all the rebar was located.

We started the project in the late fall, which in Colorado means that we experienced several snowstorms and freezing temperatures—in any other application, the weather would have meant long delays waiting for the right window of opportunity. Fortunately, on this project, we were able to close off all the openings with plastic sheeting, allowing us to keep a heater going inside while we poured the concrete and let it cure in 65°F heat for a week.

We polished the slabs to an 800-grit glass finish, stained them with a mix of amber and ebony acid stain, and sealed them with a two-part exterior-grade UV-resistant epoxy. All the elevations were cast in place, creating multiple levels of countertop. These allowed for flexibility with the placement of components such as a smoke box, grill, wash tub/ice bin, and refrigerator. We left several areas open under the counters in order to have versatility in placement of access doors and a balanced feel.

We faced the cabinets with multiple sizes of reclaimed 3-, 4-, and 6-inch-wide fence pickets, installing them vertically in order to match the pergola's circular shape more accurately (**Figure 4**). ❖

Dave Settlemyer owns LS Underground in Longmont, Colo.

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Pinning a Deck to Ledge

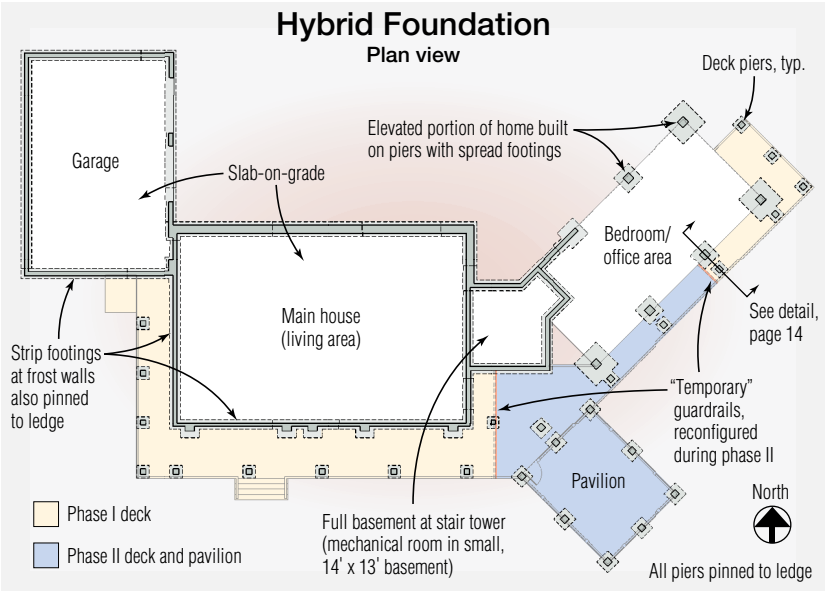
On a steep and rocky site, tall piers were the key to adding outdoor living space to a new lakefront home

by Jim Bradley

PHOTOS AND ILLUSTRATIONS BY TIM HEALEY

In the summer of 2017, the company I work for, Hayward Design Build, broke ground on a new high-performance home on the shore of Lake Champlain in northern Vermont. The 2.5-acre, mostly wooded site was located on the tip of a small peninsula and featured a rock outcropping that dropped off steeply to the water's edge some 70 feet below. The homeowners wanted their new home to blend into the landscape while also taking advantage of the property's stunning 230-degree lake views. With the help of architect David Pill of Pill-Maharam Architects in Shelburne, Vt., they designed a sleek minimalist-style structure and sited it on the point's rocky bluff.

Because of the sloping ledge, the home's foundations needed to be a mix of slab-on-grade and pier construction. The living areas in the main part of the home would be supported by a slab-on-grade, while the bedroom-office wing (which doglegged 45 degrees from the main structure) would be "floated" on concrete piers. An important part of the design was a wrap-around deck running the full length of the home's southern elevation and along portions of the east and



Built on a rocky bluff, the home's foundation was a mix of slab-on-grade and pier construction. A wrap-around deck and screened porch (or "pavilion") were also supported by piers. The project's two phases spanned three years.

Figure 1. The bedroom-office wing was "floated" on the piers. Here, the deck was being framed on the home's elevated southeast corner (A). The larger deck off the main living area was close to grade and supported by shorter piers (B).

west elevations, which would also be built on piers (see Hybrid Foundation, left). Although the home's aesthetic was simple, building the complicated, near Passive House–level structure and expansive deck areas proved otherwise.

Pinning to Ledge

During the project's design phase, a geotechnical engineer inspected the geology of the proposed house placement and adjacent areas and consulted with the structural engineer. They concluded the rock outcrop was ledge (as opposed to large, fragmented boulders), but that it was fractured and could become unstable if it were site-blasted to make way for full-depth foundations. This brittleness of the bedrock necessitated the "half slab-on-grade, half pier" foundation solution.

In lieu of blasting, we brought in an excavator with a hydraulic breaker hammer to chip out ledge for the footings. The excavator carved trenching for strip footings out of the rock where frost walls were needed in the slab-on-grade areas, and hammered out holes for individual footings at pier locations in the bedroom wing and deck areas. Larger holes were made for spread footings at piers supporting the "floating" house.

Dowels. To pin the footings to ledge, L-shaped dowels were embedded 12 to 18 inches—depending on the footing size—into the rock and set with Hilti HY200 adhesive. After drilling the holes, we blew them clean with compressed air and then set the dowels. At the frost walls, we pinned the strip footings to rock with rebar dowels in a staggered pattern and installed dowels at each of the large spread footings and smaller deck footings. The size and number of dowels varied depended on the footing size.

Working concurrently on the slab-on-grade and piers, the foundation crew poured the footings and frost walls, then assembled the heavy rebar reinforcement for the piers. To level the irregular rock surface for the slab-on-grade portion of

Note: See your Fiberon seller or visit www.fiberondecking.com for details on limited warranties and exclusions.
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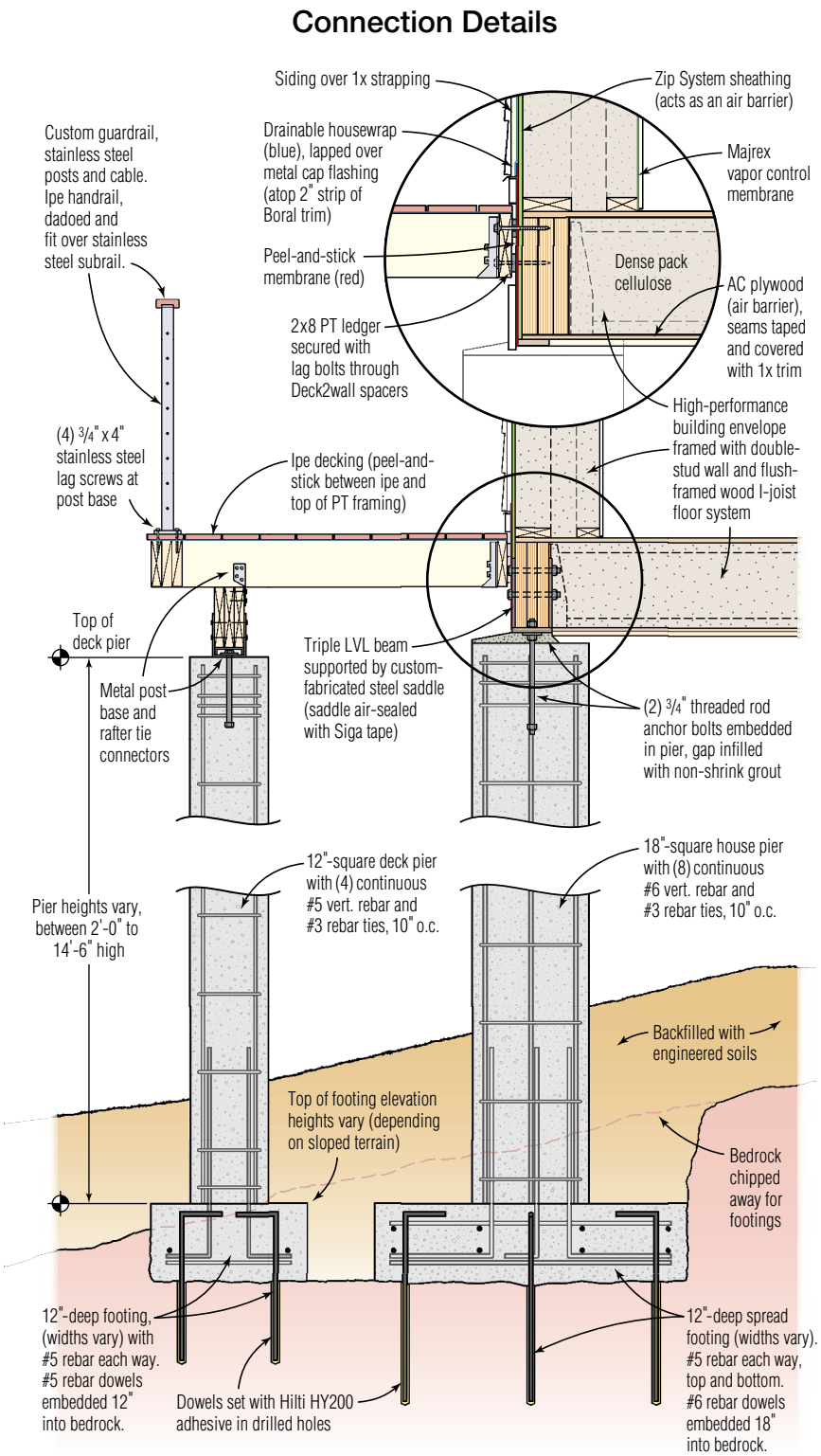

Taken through the bedroom wing, the section drawing shows the footings for the heavily reinforced piers pinned to the ledge with L-shaped dowels. Dowel size, number, and depth varied depending on footing size.

the home's foundation system (a 4-inch radiant slab in the home's conditioned space with 8 inches of sub-slab EPS insulation), we trucked in gravel and fully compacted it.

Piers. The larger, 18-inch-square house piers were heavily reinforced with continuous #6 vertical rebar, while the 12-inch-square deck piers were reinforced with continuous #5 rebar. Depending on the sloping topography, the height of the piers ranged anywhere from 2 to 14 ½ feet (see Connection Details, left).

After the piers were poured, the site was backfilled with engineered soils.

Prepping for a Pavilion

Included in the foundation work was the installation of eight piers for a stand-alone, screened-in porch (or "pavilion") located in the middle of the home's south elevation. The pavilion was in the initial job scope, but due to budgetary issues, it was deferred to a future Phase II. As a result, the middle portion of the wrap-around deck was left unbuilt for a year and a half while the homeowners contemplated whether to build it. In the interim, the deck section adjacent to the bedroom wing and the one at the main house were treated as two separate decks, with code-approved guardrails. *[Note: The pavilion and middle deck section were completed this summer. See Figure 6, page 20, and* Day's End*, page 28.]*

Framing Decks, High and Low

We began installing the deck at the higher, southeast corner of the home, where the bedroom wing's elevated first-floor 14-inch-deep wood I-joists were flush-framed to triple LVL rim beams (**Figure 1**). The built-up LVLs ran around the perimeter of the floor system and were connected to the piers with custom-fabricated steel saddle connectors (see Connection Details, left). These LVL rim beams provided plenty of "meat" for the threads of the lag bolts we used to secure the deck ledgers.

Prior to installing the 2x8 PT ledgers,

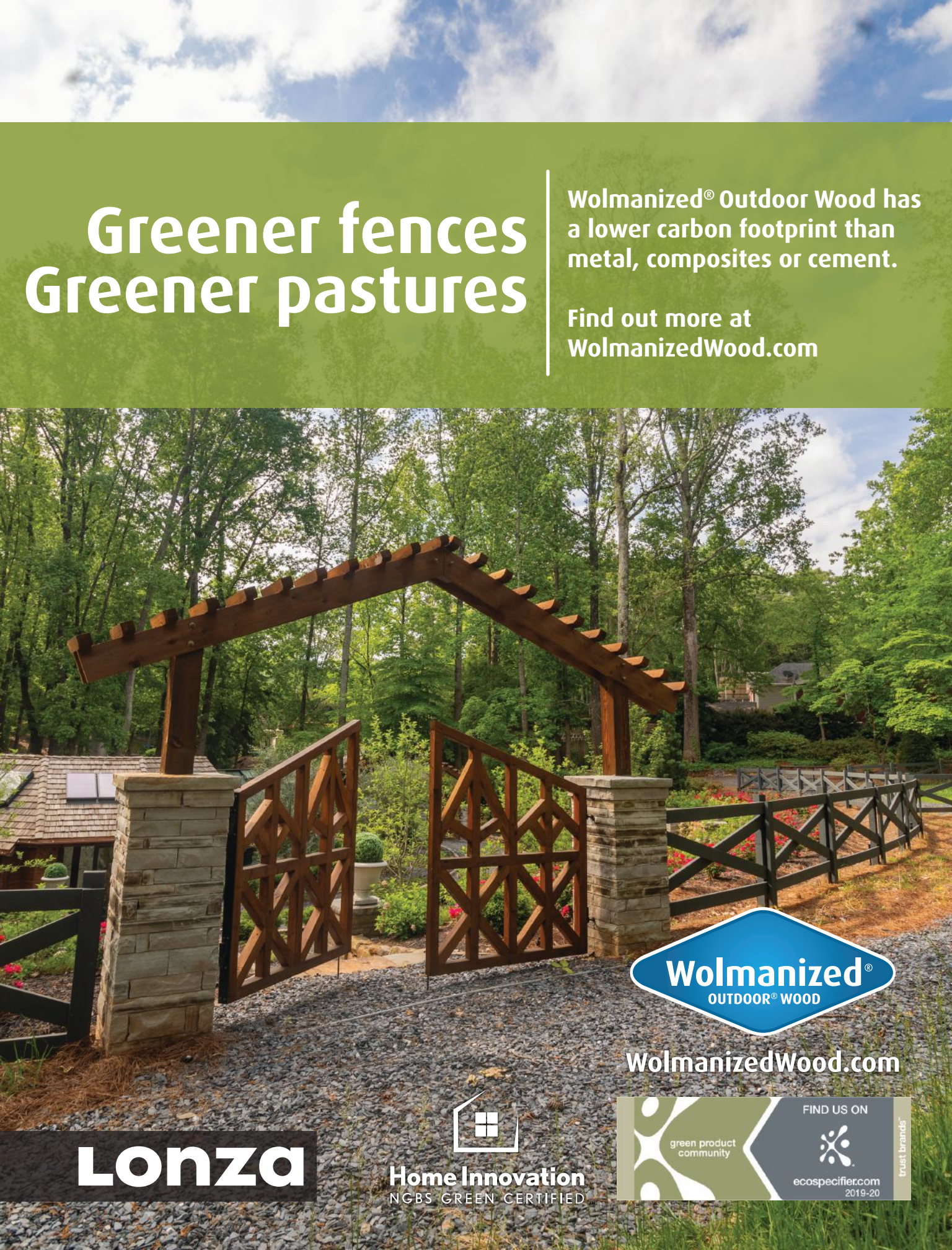
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Figure 2. Ledgers were lag-bolted through spacers to the elevated floor's triple LVL rim beams spanning the piers (A). Fentrim flashing tape was used for both water- and air-sealing. Here, it air-seals a deck beam pocketed into a wall (B).

Figure 3. In the slab-on-grade areas, the wider grade-level deck section was framed with beefier 2-by stock (A). Threaded rod set in adhesive attached the ledgers to the top of the frost walls (B). Peel-and-stick capped the 2-by stock.

we installed Fentrim 430 Grey flashing tape (sigatapes.com), starting a couple of inches above the ledger and running to the bottom of the wall. Fentrim is a semi-permeable flashing tape that offers effective protection from air leakage and water penetration. I've found that the peel-and-stick tape hugs the shafts of the fasteners well during installation.

Deck connections. We secured the 2x8 PT ledgers for the narrow decks in the elevated southeast corner with lag bolts driven through ½-inch-thick polypropylene Deck2wall spacers (deck2wallspacer.com). These spacers stand the ledger off the framed wall to protect it long-term from water and debris (**Figure 2**).

At the outer deck, a triple PT 2x10 beam spans between the deck piers. We connected the built-up beams to the piers with metal post-base anchors with 1-inch standoffs to help prevent rotting. 2x8 PT joists cantilever over the carrying beams and attach to the beam with rafter tie connectors. At the ledger, the joists are flush-framed and attached with joist hangers.

Down low. We framed the wider grade-level deck along the south and west elevations similarly, though it required beefier 2x10 joists with a triple 2x12 carrying beam for the longer spans. At the top of the frost walls, we attached the deck ledger to the concrete with ½-inch threaded rods set with Hilti HY200 adhesive, again using Deck2wall spacers to stand the ledger off the frost wall (**Figure 3**).

Finishing Off the Deck

With the two deck sections framed, we began to install the ipe decking on the "high" deck. First, we applied strips of peel-and-stick flashing to the top of the framing members to help extend the lifespan of the PT wood. It's a little bit of a belt-and-suspenders assembly, but ipe lasts longer than pressure treated wood, so we deemed it worth the effort.

Cutting. Due to the site's steep topography and the height of the deck off grade,

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Figure 4. The ipe decking was installed on the elevated deck area first (A). Cut ends were sealed (B) and the decking was predrilled for stainless steel trim screws (C). A couple of 8d nails helped uniformly gap the boards (D).

Figure 5. The south elevation was 80% glass. Large high-performance European-style lift-and-slide glass doors set in a steel moment frame (left exposed as an architectural feature) opened onto the ipe deck.

we set up our cutting station on level ground at the north-facing front of the house. Unfortunately, this was a long hike back and forth through the length of the house for our cut guy, which added time to the job. Immediately after the decking was sawn and prior to lugging it to the install area, we sealed the cut ends of the ipe with Ipe Seal (deckwise.com).

Fastening. We face-fastened the ipe to the framing with 2 ½-inch-long stainless steel coated trim screws (fastenmaster.com), which were color matched to the ipe. After running a perimeter band of decking, we started applying the field boards, working from the outer edge towards the house (**Figures 4, 5**).

Because of the visible fastener pattern, we predrilled holes and carefully aligned them using a layout square, placing two screws at each joist. To uniformly gap the 1x6 boards, we temporarily tacked a couple of 8d nails into the framing at each course, then set the deck screws with an impact driver. Then we removed the temporary spacer nails, repeating the process until we reached the exterior wall.

Deck to wall. Where the decking meets the exterior wall, we installed a 2-inch-wide strip of Boral trim with metal cap flashing. The cap's vertical leg runs up the Zip sheathing and is taped off with Zip System flashing tape, while its prominent 45-degree kickout directs water away from the deck-to-wall juncture.

The home is clad with a mix of fiber-cement and Galvalume siding. For an extra layer of water protection, we installed Hydrogap drainable housewrap over the Zip System sheathing in preparation for the home's rainscreen siding (1-by strapping was installed over the Hydrogap). The drainable housewrap laps over the cap flashing's vertical leg.

Guardrails. One of the last tasks of the project was to install guardrails on the two deck sections. Like most people who have invested in homes with spectacular views, our clients wanted their views, of Lake Champlain, to be as

Figure 6. A custom-built guardrail with cable railing was installed (A). The deck was temporarily treated as two separate decks with code-approved guardrails (B, C). Guardrails and decking were reconfigured during the pavilion work (D).

unobstructed as possible. They didn't want to sit in their chairs—whether on the deck or on the inside—staring at a railing and an array of balusters. So, we installed a custom-built guardrail system with stainless steel posts and cable railing.

We used 1½-inch-thick ipe stock for the cap rail, which we dadoed to fit over a stainless steel subrail. Local town code allows for 36-inch-high guardrails, which helped keep the rail out of view lines. The posts were set with stainless steel lag bolts set into solid framing (**Figure 6**).

Because we ended up building the pavilion and middle portion of the deck connecting the two decks a year and a half after the house was completed, we needed to reconfigure the guardrails and change the orientation of the decking in some locations to avoid a patchwork look. We reused as much of the expansive rail system as we could but had to install a few new sections. Last, we pressure-washed the older decking, which brought a lot of the color back, then sealed it to match the new. There was slight difference between the two, but I think the ipe is going to weather evenly over time. ❖

Jim Bradley is a BPI-certified home-performance contractor, builder, and remodeler based in Vermont.

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Double-Decker Deck

With an outdoor kitchen above and a three-season screened porch below, this elevated deck makes the most of a compact footprint

by Pete Ciaraldi

When the clients on this project first contacted us, they were interested in replacing their old, elevated pressure treated deck with one that would allow them to optimize the use of their yard and beautifully finished basement. One design goal was to have a small outdoor kitchen on the upper level for al fresco dining when the weather was nice, and a dry, weathertight space below the deck for dining and entertaining when the weather turned too hot, too cool, or too wet.

The clients were also looking for some flexibility. For example, one option we discussed was a roof over the second level, which would require beefier footings and framing. They also expected to expand their outdoor living options at some point with the addition of an inground pool and so wanted a staircase that projected out from the deck, with dry storage underneath.

Steel Framing

Like most of our projects, this deck is supported by helical piles. After we deconstructed the original deck, our GoliathTech sub installed the piers according to our layout (**Figure 1**).

In the area where we work, the company's 1⅞-inch-diameter helical piles are OK for most residential work, but we typically specify 2⅜-inch-diameter piles, which have about an 8,000-pound bearing capacity. On this project, however, because the clients expressed an interest in adding a roof to the deck and because of the added weight of the outdoor kitchen, we offered them an upgrade to 2⅞-inch-diameter piles, which have a bearing capacity of about 13,725 pounds. They decided that the small cost increase for the larger piles was worth the upgrade.

Later, after we had reframed the new deck, we removed the old concrete piers. Typically, we pull old piers out of the ground with an excavator, but when we can't remove them for some reason (such as limited site access), we break them off below grade and bury them.

We used Trex Elevations light-gauge steel components to frame the deck. This is our preferred substructure system, due to the consistency of materials and the greater span capabilities of steel framing.

PHOTOS COURTESY PROFESSIONAL BUILDING SERVICES

Figure 1. In the first phase of the project, workers removed the existing deck and installed new helical piles (A). The new deck was framed with Trex Elevations light-gauge steel, supported by 6x6 PT posts that bear on the helical piles (B). On the right-hand outside corner of the deck, the framing has been clipped at a 45-degree angle to accommodate the stairs leading to the upper level.

Figure 2. To keep the area below the deck dry, workers installed a Trex RainEscape under-deck drainage system (A). Extra courses of waterproofing tape underneath divider boards and over the blocking needed for the octagonal inlay protect the troughs from damage (B). After the drainage system passed water-testing, Trex decking was installed using hidden fasteners (C).

We supported the steel framing with 6x6 PT posts that bear on the helical piles.

Because of the added weight of the outdoor kitchen components and the furniture that the clients planned to use on the deck, we doubled up the single Elevations 2x8 galvanized steel box beam that we would have normally used to support the joists on a deck this size. This upgrade also gives the clients future design flexibility in case they decide to add a roof or other enhancements to the upper deck.

We clamped and bolted the two box beams together, then fastened them to the wood framing with pairs of Simpson Strong-Tie AC6 post cap connectors and coated structural screws.

Waterproofing

To create the dry space underneath the deck, we installed a Trex RainEscape system, which consists of proprietary downspouts, 20-mil trough material, and compatible flashings, single and double-sided tapes, and sealant. We always install the troughs to have the maximum amount of fall from one end of the joists to the other, which increases the velocity of the water flow and helps keep the troughs clear of organic debris (**Figure 2**).

Wherever we know we are going to have additional fastening, such as where there will be a decking pattern or an inlay, we install plenty of sealing tape to ensure there is a great seal between the frame and deck boards. In this case, we applied the tape where we would install the

Figure 3. Workers determined the position and elevation of the stair landing with the help of a stringer for the upper flight of stairs (A). The landing was framed with steel and supported by helical piles (B). Steps lead up to the landing from all three sides (C). RainEscape troughs were fastened to the stair stringers so the underside of the stair could be finished with beadboard (D).

blocking and divider boards used to create the deck's octagonal center inlay and diagonal decking pattern. Afterwards, we carefully water-tested the installation; we need to make sure the drainage system is 100% watertight every time.

After we ran the low-voltage wiring for the deck lighting system and were satisfied that we hadn't pierced the waterproofing troughs, we installed the Trex decking and composite railing. We bolted 4x4 guard posts to the steel framing prior to installing the decking, then finished the posts with composite post sleeves. To complete the low-maintenance rail system, we installed contrasting composite rails and round aluminum balusters.

Finally, we trimmed out the perimeter of the deck with PVC fascia material and installed the outdoor kitchen cabinets, along with a granite countertop. The original slider leading out onto the deck had significant rot damage, so we replaced it with a new French door sized to fit in the original rough opening.

Stairs

The distinctive stair design was driven by the homeowners' request to be able access the stair landing from three sides to accommodate future plans for their backyard, including a possible inground pool. Because of the way the staircase extends out from the corner of the deck and into the yard, it is clearly visible from multiple directions, including from inside and outside the house and from within the enclosed area underneath the deck. To give the assembly a finished look, we wrapped the stringers with PVC trim and installed a "ceiling" on the underside of the staircase (**Figure 3**).

We framed the landing like a mini deck, supporting the four corners of the steel-framed platform with helical piles. To make sure the landing was at the correct elevation, we waited to install the piles for it until the main deck was framed and we could establish an accurate TOD (top of deck) elevation for determining the precise rise and run of the stairs.

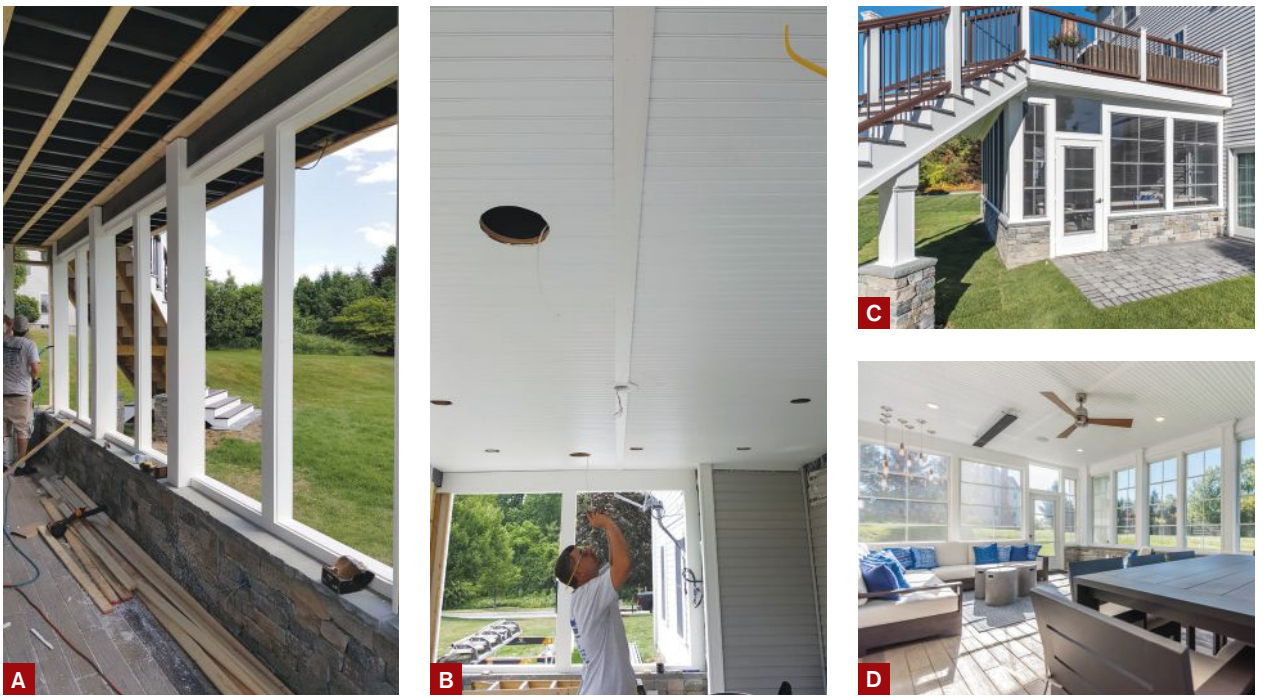


Figure 4. Under the deck, the crew poured a concrete slab floor, built CMU knee walls finished with stone veneer, and framed the window openings (A). PVC was used to prep the openings for the prefabricated aluminum screen windows and to finish the ceiling (B). A small paver patio links the new three-season porch with the walkout basement (C), while the concrete slab floor within the enclosed porch was tiled with porcelain pavers with the look of a wood floor (D).

Because the underside of the stairs would be clad with PVC beadboard trim, the same material used to finish the ceiling underneath the deck, we also needed to fasten under-deck drainage troughs to the bottoms of the stringers before installing the trim. These don't empty into downspouts, but just divert water down and away from the back of the ceiling material. After installing the troughs, we strapped the stringers and nailed up the beadboard.

On many projects, we then close in the area underneath the stairs for useful storage, but in this case the area remains open and highly visible, which is why we trimmed out the midspan support with the same trim detail used on the three-season room under the deck.

Finishes

The clients wanted the new three-season porch underneath the deck to feel completely separate from their indoor spaces, so there's no direct access to that area from inside the home. To provide a solid subfloor and base for the screen porch's knee walls, we poured a concrete slab with a thickened perimeter. Then we laid up the CMU knee walls, which are clad with natural stone veneer finished with a bluestone cap (**Figure 4**).

The porch slab is finished with porcelain pavers with a wood-grain texture. Outside the porch, a small stone paver patio that the homeowner installed provides a solid walkway from the screened porch to the French doors leading to the basement.

After strapping the joists for the beadboard ceiling, we framed the window and door openings with PT 2x4s and trimmed them with PVC. While we were working on the deck design, the clients had been researching screening options for their new space. They settled on EZ-Screen porch windows, which are multi-track aluminum frames fitted both with sliding screens and with aluminum-framed 10-mil vinyl panels. They ordered the windows early on in the project, and they were delivered to the site preassembled. One of the benefits of using this company was that only a few weeks of lead time were required, instead of a couple of months for similar products from other manufacturers, which helped keep our schedule on track.

After we installed the screen window panels and door, we finished trimming out the room. Finally, we reinstalled the vinyl siding that had been removed to install the deck ledger and tie the new double-decker deck to the house. ❖

Pete Ciaraldi owns Professional Building Services, a remodeling company specializing in decks and siding in Salem, N.H.


A


B


C


D

A Pavilion Perched High on a Ledge

by Tim Healey

When Hayward Design Build recently finished work on a screened-in pavilion located on a bluff overlooking Vermont's Lake Champlain, it marked the end of a multi-year project building a high-performance home on a steep, rocky site (see "Pinning a Deck to Ledge," page 11). Designed by the company in conjunction with the clients and their architect, the 16-by-20-foot free-standing building provides shelter and a bug-free environment for lake gazing and small get-togethers (**A**).

The pavilion is supported by 8x8 PT posts bearing on concrete piers attached to ledge; to prevent racking, the posts are reinforced with steel-rod X-bracing. The floor is framed with 2x12 PT stock, while 6x6 corner and midspan posts were installed to hold up the pavilion's low-slope roof, which is covered with a fully adhered TPO membrane.

For the decking, workers ran a couple of 1x6 ipe boards around the deck's perimeter, then infilled the floor area (more of a traditional wood floor than a deck) with 1x4 T&G ipe to avoid insect-penetrating gaps. Around the perimeter of the floor, a strip of perforated linear drain was let in under the screened openings for drainage (**B**). According to project manager Jim Bradley, the goal was to allow any wind-driven rain blown through the screening to drain out at the edge, though the clients were on board with occasionally having to break out a squeegee after strong rainstorms.

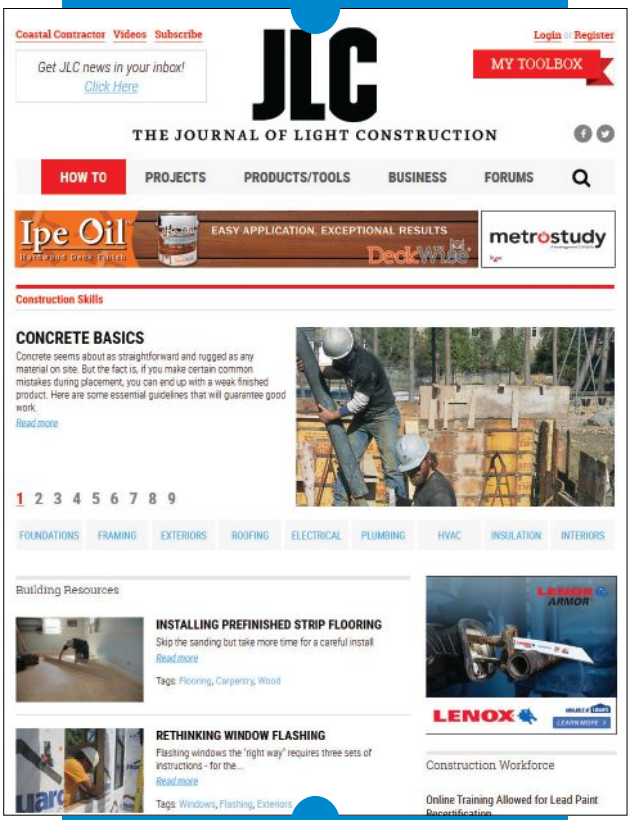
At the walls, 1/4-inch tempered glass panels were run up to a 2x4 ipe mullion 36 inches off the deck (matching the adjacent deck guardrail height). The panels were then set in the openings with site-ripped 5/8-inch-square ipe stops (**C**). Above the mullions, workers installed heavy-duty bronze metal screening in custom frames, again setting the frames in the openings with ipe stops (**D**). For the entry, the company special-ordered a Larson screen door and refitted it with the heavy-duty bronze screening.

The space was wired for lighting, a ceiling fan, and sound. Then Bradley and his crew installed trim, finishing the ceiling and area above the screen openings with T&G western red cedar. ❖

Tim Healey is a senior editor at JLC.

PHOTOS BY JIM BRADLEY AND TIM HEALEY

JLC



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BY VINCENT SALANDRO

1. Low-Maintenance Composite Cladding
Alside says the Ascend Composite Cladding system is designed to deliver a simpler installation process and lower cost to professionals. According to the manufacturer, the product comes in 20 fade-resistant colors and joins with a self-aligning stack lock that requires no specialized tools to install. The cladding is made with a glass-reinforced polymer and graphite-infused polystyrene, which provides a Class A Fire Rating. Ascend is reportedly priced to provide a lower total installed cost than competitive products. ascendcompositecladding.com

2. Acrylic Urethane Paint Sealant
Dap's Power Point 300 line of acrylic urethane elastomeric sealants reportedly offers strong multi-surface adhesion and stretches up to 600%, allowing it to seal gaps up to 3 inches wide. Power Point 300 has a two-hour paint ready time, and it reportedly won't shine through, dull, or discolor paint. It's available in 14 colors. Pricing ranges from $4.50 to $5. dap.com

3. Smooth Finish Trim
LP SmartSide Trim is an engineered-wood material that is available in widths from 1.5 to 11.2 inches and in lengths up to 16 feet. It's backed by an industry-leading 5/50-year limited warranty that LP says covers replacement cost of labor and materials for first five years, and cost of materials thereafter. Like the siding, the trim is reportedly protected against weather impacts, freeze/thaw cycles, high humidity, and fungal decay by LP's SmartGuard manufacturing process. Pricing varies by region. lpcorp.com

4. Flexible Deck Board
The Kebony Deck Board accommodates four varieties of fasteners to provide easy and quick installation, according to Kebony. Deck boards come with a 30-year warranty against rot with no maintenance and a 50- to 75-year expected lifespan. When left unfinished, the decking evenly fades to a silver-gray patina. The re-engineered profile is compatible with the Step-Clip for Kebony, hidden fastener clips, the Pro Plug System with Kebony wood plugs, and stainless steel screws. Pricing starts at $11.50 per square foot. us.kebony.com

5. LED Deck Underlighting
Trex Co.'s Trex RainEscape Soffit Light is a directional LED downlight that installs into the ceiling below a deck drainage system on an elevated deck. The fixtures feature CREE long-life LEDs that use 75% less energy than standard can lights, according to Trex. Made for outdoor use, the components are reportedly durable and designed to stand up to years of exposure to extreme elements. Each soffit light comes with two steel spring tension clips that reportedly hold the fixture securely on any type of soffit material. Optional timer and remote-control dimmer are sold separately. Pricing starts at about $80 per fixture. trex.com

6. Novel Steel Railing System
DuraLife Concord Steel Railing includes prewelded, fully assembled panels and posts with pre-attached brackets and comes in 6-, 8-, and 10-foot level rail kit lengths and 6- and 8-foot stair rail kit lengths. The railing is available in matte black and hammered bronze finishes and a variety of configurations, and the system can be enhanced with a complete line of steel accessories. Pricing varies by location. duralifedecking.com

7. Advanced Polymer Adhesive and Sealant
Titebond's Ultimate PVC Trim Adhesive and Sealant is an advanced polymer formulation that can reportedly bond to most building materials, including wood, masonry, aluminum, and vinyl. Titebond says the sealant's increased flexibility enables the product to function with 50% joint movement capability. The sealant can be installed in weather conditions as low as 0°F to provide a durable bond and weathertight seal, according to Titebond, and it gives contractors 10 to 20 minutes to adhere the PVC components. VOC content is 9g/L. It's available in 10.1-ounce cartridges; pricing starts at $5.50 per cartridge. titebond.com

8. Double-Course Panel Siding
CertainTeed's Double 7-inch 3G Straight Edge Perfection Shingles are composite wood and feature slanted, tapered gaps, a high-definition texture, and an offset corner to replicate a woven appearance. CertainTeed claims the double-course panel provides increased coverage and requires fewer fasteners than single-course siding. The shingles include hidden drainage holes, friction dots, reverse texture backing, and a built-in spacing indicator. Pricing starts at $450 per square. certainteed.com

9. Reciprocating Saw Blades
L.S. Starrett's 3X Power series of Bi-Metal Reciprocating Saw Blades are reportedly highly resistant to breakage, have a reinforced shank, and are engineered for use on corded and cordless saws. The series includes blades for cutting wood, metal, multiple materials, and heavy-duty materials. The manufacturer claims these blades can make more cuts than competitive blades. The line's King Cut 3X Heavy-Duty blades feature heat-treated teeth with a pitch set designed to slice through any material, according to Starrett. starrett.com

10. Preassembled Aluminum Railing System
Deckorators ALX Contemporary preassembled heavy-gauge aluminum railing panels are welded to maximize rigidity and strength, according to the manufacturer. The system comes in 36- and 42-inch heights and 6- and 8-foot on-center lengths when installed between 2 1/2-inch posts. The 2 1/2-inch post kits include one-piece post trim and a leveling plate. Available in four powder-coated colors, the railing has a rectangular top rail profile and square balusters. Price for Deckorators ALX Contemporary preassembled railing averages $50 to $55 per linear foot. deckorators.com

11. Single-Hand Skimming Blade
Advance Equipment's Radius Skimming Blade drywall tool can reportedly be used with a single hand for a natural drywall finishing feel. The blade is shaped to hold mud, making it ideal for skimming patchwork or achieving a Level-5 drywall finish, according to the manufacturer. Advance Equipment says that with its offset blade and radius corners, the thin and flexible skimming blade is ideal for smoothing and for using behind finishing boxes for less sanding. The stainless steel Radius Skimming Blade is 3 1/2 inches in depth and is available in 10-, 12-, 14-, and 16-inch lengths. advance-equipment.com

12. Low-Profile LED Luminaires
The NULS LED Linear low-profile 120V luminaires from Nora Lighting feature a frosted lens that makes them ideal for task lighting. The luminaires are 1 3/8 inches deep and are offered in four lengths and three color temperatures, from 2700K to 4000K, with a color rating index above 80. According to Nora Lighting, the fixtures can be linked together seamlessly and can be hardwired into a junction box (sold separately). Contact a local distributor for pricing. noralighting.com

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A Working Professional's Personal AC Unit

BY TOM O'BRIEN

It always seems that whenever a heat wave sets in, I find myself atop an asphalt roof or inside an attic. Luckily, the last time the mercury approached triple digits, I had an Isotherm Cool Vest at my disposal.

Made from flame-retardant cotton, this product has polyester sleeves inside the front and back into which two large cooling packs are inserted and secured with Velcro. The standard model comes in Walmart blue, but the vest is also available in a bright yellow version that meets ANSI/ISEA Class 2 High-Visibility requirements.

Sizes range from small to extra large. The one I used was M/L, but Velcro adjustments at six different points led me to believe that it could be made to fit almost anyone.

According to the manufacturer's instructions, the cooling packs can be energized before use by placing them flat in a freezer or refrigerator for a few hours, or by immersing them in ice water for 20 minutes. They're ready to get to work when the clear liquid in each compartment has congealed into a white solid.

Although I feared that the experience of putting on the vest would be like taking the ice bucket challenge, what I felt was more of a cool breeze than an icy blast. Bullard, the manufacturer, explains that its cooling-pack inserts feature a phase-change technology that maintains a consistent 55°F for up to four hours, depending on the job conditions. I was working in a sweltering attic when I put it to the test, and it was easily two hours before I noticed sweat dripping down the back of my neck.

The first time I tested the manufacturer's claim that an exhausted pack is fully revived after only 20 minutes in ice water, I nonchalantly tossed both packs in the cooler. When the timer went off, I discovered that the fully submerged pack was solid, but the one I'd left floating on top was semi-liquid.

Photos: Tom O'Brien

Isotherm's cool vest is equipped with controlled-release phase-change cooling packs (not ice or gel packs) that are designed to maintain a consistent 55°F temperature for as long as four hours. The packs can be recharged in a cooler of ice water (right).

If you're planning to take advantage of a lunch break to recharge these batteries, pour extra ice over the top, or weigh them down.

When I had to put on a toolbelt, I was relieved to find that the vest did not get in the way. The 6-pound weight of the garment was not a bother, but the bulkiness was. When the cooling packs were fully charged, they were as stiff as concrete. But within a half-hour, they softened up to become more flexible and form fitting. Compared with being hot, miserable, and unproductive for hours, a few minutes of discomfort was a bargain.

Isotherm can be purchased online for about $220. Extra cooling packs are also available. bullard.com *—Tom O'Brien is a freelance writer and a restoration carpenter in New Milford, Conn.*

A Pair of Tough Cordless Routers

BY TIM UHLER

Over the past five years or so, we have been steadily marching towards a cordless jobsite. Until recently, the only tools that we still rolled out a cord for were beam saws and the routers we use to cut the sheathing out of all our window and door openings and along the top of rake walls. Last year, to get closer to our battery-powered goal, we added DeWalt's DCW600B 20V Max cordless router and then Milwaukee's 2723-20 M18 Fuel router to our tool inventory.

I first made the switch from using a saw to cut out door and window openings to using a big 3 1/4-hp router in 2001, after seeing another framing crew using this method on their jobsite and noting how efficient it was. The openings were perfectly trimmed, and the work went more quickly and safely. With a flush-cutting bit chucked in the router, there was virtually zero measuring or marking, and the cutouts were also perfectly straight, making it easier to use them elsewhere. What's not to like?

DeWalt's DCW600B 20V Max compact router has a soft-start brushless motor controlled by a variable-speed dial that spins router bits with 1/4-inch-diameter shafts from 16,000 to 25,500 rpm. When it's time to stop, it has an electronic brake that works very well. I like the depth-adjustment ring, which is easy to use, and the dual LEDs, which light up the work surface.

While the router runs great on a 20V battery, I prefer to use it with a Flexvolt battery. To cut 7/16-inch Zip Sheathing, I use a 1/4-inch-diameter spiral-cutting bit, and it does such an outstanding job, I don't miss our old 3 1/4-hp workhorse at all.

Milwaukee's 2723-20 M18 compact router also has a brushless motor that spins 1/4-inch-shaft bits, but from 10,000 to 31,000 rpm. For precise adjustments, it has a "micro-adjustment dial," and to simplify bit changes, the spindle lock is tool-free. The bit stops almost instantly, and the LEDs light up the work surface well. This compact router is compatible with offset and plunge bases, which are sold separately.

I had no trouble powering this router with a 5.0-Ah M18 Fuel battery, but—as with the DeWalt—I prefer to use bigger, 9-Ah batteries. And though the compact router felt like a toy out of the box, it had no trouble at all cutting through 7/16-inch-thick Zip Sheathing.

Bottom line. After using both routers for several months, not once have I wished I had a larger corded router on our framing sites. These two models are lightweight and easy to handle, yet have all the power I need. We've been using them for a year, and haven't burned one up yet. A production framer from Ontario emailed me last week saying they've run the DeWalt hard for a year, too, and it's still going strong.

Milwaukee's M18 Fuel and DeWalt's DCW600B routers have the power and speed the author needs for sheathing cutouts.

Photo: Tim Uhler

It helps to have a good 1/4-inch-diameter spiral-shank flush-cutting bit. We use a Whiteside bit and get about three houses out of one bit, which includes not only cutting out all the window and door openings, but also cutting the sheathing off along the top plates on the rake walls, which we build on the ground before lifting them in place. To see which router cuts faster, we've informally "raced" the two machines, and while the Milwaukee might have a slight edge over the DeWalt thanks to its 31,000-rpm motor, I can't say one is better than the other. Both cost around $300 with one battery. *—Tim Uhler is a lead carpenter for Pioneer Builders in Port Orchard, Wash.*

Heavy Lift: Milwaukee M18 Fuel Framing Nailer

Milwaukee recently introduced its M18 battery-powered 30-degree framing nailer, which is similar in basic design to the Metabo HPT (formerly Hitachi) hoseless framing nailer that I reviewed a couple of years ago ("Hitachi Cordless Framing Nailer," Apr/18). I have reviewed a number of other hoseless guns from Paslode, Bostitch, and DeWalt, so I have a pretty good feel for this type of tool and was eager to try Milwaukee's new offering.

CORDLESS DOESN'T MEAN COMPROMISE

First off, this gun is fast. Milwaukee says it shoots three nails—either clipped or full round—per second. I was unable to test that because I'm too slow with a stopwatch, but there is no lag when pulling the trigger. The gun toenails very well and is a dream to use when toenailing into LSL rim board. The dial-type depth of adjustment works well, but I wouldn't use the gun for shear nailing, where it's critical not to over-drive nails. The gun is so powerful that it was hard to get a consistent depth.

The battery-powered nail gun has two hooks, one for hanging it from a rafter and one for hanging it from a belt. There's a switch just above the battery that is used to set the gun to shoot sequentially, one nail at a time, or to bump fire.

This battery-powered nail gun has two hooks, one for hanging it from a rafter and one for hanging it from a belt. There's a switch just above the battery that is used to set the "mode" to shoot one nail at a time, or bump fire.

I like that the gun has two hooks. The belt hook is on the left side of the gun, and a second, larger hook that fits over framing material is on the right side.

PERSONAL LIMIT

Now let's get down to it. Despite all the great features and performance, I can't recommend this gun, because it is too heavy for me. It is heavier than our old Hitachi NV83A2 framing nailer with a full coil of framing nails. It is also jarring to my wrist when I'm shooting nails, to the point where my joints are sore the next day—which has never happened to me in 25 years on the jobsite. I'm 42 years old and can't afford to use a tool that has this effect on my body.

To make sure I wasn't overestimating the tool's heft, I weighed all the nailing guns I have worked with over the last few years, each loaded to full capacity with 3-in. x .131-in. framing nails. The new Milwaukee weighs just under 12 pounds (11 lb. 13.8 oz.) with the battery and one stick of nails. In comparison, my old Hitachi nailer weighs 11 lb. 6 oz. with one full coil, while the Makita stick nailer I reviewed last year weighs 9 lb. 14 oz. with two sticks. Granted, a pneumatic nailer has a hose that limits some motions, but at most it adds just under a pound, unless you are on a ladder and holding up a long length of hose. Most of the time, the hose is a non-issue. Cordless nailers tend to be heavier than pneumatic nailers because of the battery. But of all the cordless framing nailers I've used so far, the Milwaukee is the heaviest yet.

Still, this is a great gun that does its job very well. It has plenty of power and doesn't have any cycling time or an extra fuel cartridge like some other battery-powered nailers; adding the longer magazine (for an extra $80) makes going hoseless more reality than a dream. So, if you think the weight won't be an issue, then I think you'll be satisfied with the gun. Just check in with me in five years and let me know how your arm is feeling. You can find the gun online for $350. milwaukeetool.com. —*T.U.*

Photos: left, Kyle Davis; right, Tim Uhler

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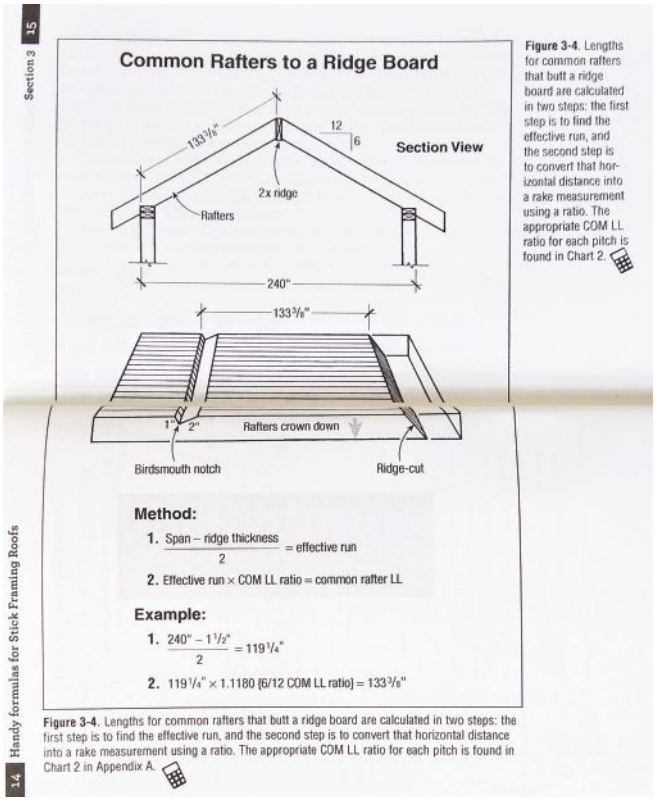

Figure 3-4. Lengths for common rafters that butt a ridge board are calculated in two steps: the first step is to find the effective run, and the second step is to convert that horizontal distance into a rake measurement using a ratio. The appropriate COM LL ratio for each pitch is found in Chart 2 in Appendix A.

Handy Formulas for Stick Framing Roofs

Storied roof framer Will Holladay has come out with a new roof framing guide—*Handy Formulas for Stick Framing Roofs.* Think of it as the CliffsNotes version of Holladay's first book, *A Roof Cutter's Secrets to Framing the Custom Home.* Holladay pulled out the illustrations from this famed roof-cutting manual and organized them with sample calculations into a pocket-sized book to make them easy to access on the jobsite.

This is not exactly a book for beginners. At the very least, you need to be well-versed in the methods that Holladay details in *A Roof Cutter's Secrets.* Chief among these is the concept of the line length ratio: To lay out the ridge cut and birdsmouth of a common rafter, for example, Holladay determines the rafter's line length (LL), which equals the length from the ridge cut to the heel cut of the birdsmouth. This length is measured along the bottom edge of the rafter. For a straight gable rafter, the run is equal to the actual rafter run multiplied by the common LL ratio for a specific pitch. Most people are used to using a theoretical rafter run. To find the actual rafter run, he subtracts the thickness of the ridge from the span of the building and divides by two (see sample at left). The common LL ratio is, in trigonometric terms, the secant of the roof pitch angle, and rather than using rafter tables or running through the Pythagorean theorem, Will uses it to figure all roofs.

Another key concept is the roof rise ratio, which, in trigonometric terms, is the tangent of the roof pitch angle. It's essential to Holladay's method whenever he needs to find the rise. (For example, finding the overhangs for intersecting roofs with unequal pitches or resolving the intersections of different width rafters). Like the LL, he figures RR ratios out for a range of roof pitches beforehand and includes these in tables early in the book.

Throughout the book, Holladay includes, in addition to his method equations, the relevant key strokes for the Construction Master Pro calculator on an adjacent page. True to the title, this makes for an especially handy resource if you aren't doing the calculations every day and need a ready reminder.

The more cut-up and complex the roof, the more you will want to pore over the illustrations and notes in this guide. It's all here, if you know how to apply it. I just wish it were an app on my phone rather than a book.

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