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On the cover: Josh Meppen, president of Elevation Builders in East Greenbush, N.Y., vibrates concrete being placed for a curved interior staircase. See the story on page 37. Photo by Janette Meppen.

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THE JOURNAL OF LIGHT CONSTRUCTION (ISSN 1056-828X), Volume 41, Number 2, is published bimonthly by Zonda Media, 4000 MacArthur Blvd, Ste 400, Newport Beach, CA 92660-2543. 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. Copyright 2024 by Zonda Media. All rights reserved. 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 Newport Beach, CA., and at additional mailing offices. POSTMASTER: Send address changes to JLC, Box 3530 Northbrook IL 60065-3530.

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JLC welcomes letters and article submissions from our
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Note From the Editor

Dear Readers,

As we enter 2024, changes are afoot at JLC. The magazine remains strong after 41 years in print; the world of print publishing, however, has changed radically over that time with the growth of digital media. JLCOnline.com has emerged as a popular channel for digital content engagement, with almost 1 million page views per month from some 300,000 unique visitors. And while we will continue to print JLC, we are moving to a bimonthly schedule. Our weekly JLC Update email newsletter will continue to feature articles from the magazine but will now include more digital-only reports, webinars, and resources from JLCOnline.

Welcome architects. I want to take this opportunity to welcome new subscribers from our sister publication, *Architect*. As *Architect* has discontinued its print edition to focus on its burgeoning digital presence at Architectmagazine.com, we are excited to send you JLC for the balance of your subscription. We offer a wealth of building knowledge with expertise in building science and a commitment to helping all professionals build better.

If you have questions about your subscription, please contact customer service at jlc@omeda.com. I encourage all readers to reach out to me with your questions or comments. I will do my best to address any and all concerns.

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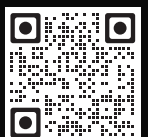
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BY CLAYTON DEKORNE

Model for the Future: A David vs. Goliath Story

In the ongoing search for a solution to the skilled labor shortage in the construction industry, there is no silver bullet, no guaranteed training solution that is going to lead construction employers out of the most troublesome of predicaments plaguing the industry at all levels. However, there are some glimmers of hope. The story of Rancho Cielo's stunning win at the Orange County Sustainability Decathlon in Costa Mesa, Calif., is one of those glimmers—perhaps even a beacon of inspiration—for all of us in the building trades, not least because this story brings us all one step closer to a model for practical, healthy, net-zero, and water-efficient homes.

On October 17, 2023, the Orange County Sustainability Decathlon announced that the team representing Rancho Cielo Construction Academy won the top prize in a sustainable home design and construction competition. Rancho Cielo was not only the smallest school with the fewest resources participating in the challenge, but it was also the only school that doesn't grant degrees. Rancho Cielo

bills itself as a comprehensive job-training program for students who are “underserved,” which it identifies as “low income, drug use, gang involvement, criminal background, truancy, school credit deficient, school dropouts, probation referral, homeless, on foster care.” All the other teams were from colleges and universities, including the University of California San Diego in collaboration with Zhejiang Normal University of China, University of California Irvine in collaboration with Orange Coast College, Cal Poly Pomona, and several Cal State programs.

MODEL TRAINING PROGRAM

The origin story of Rancho Cielo as an institution is itself inspirational. It was founded in Salinas, Calif., by John Phillips, a former Monterey County prosecutor and superior court judge, who (as he wrote in an essay that was picked up by *Time* magazine in 2015 from Zócalo Public Square, a nonprofit media syndicate) was beginning to question California's 1990's tough-on-crime



Rancho Cielo students begin framing one of four modules that will comprise Nexus 01, the prize-winning model home that was designed to have a zero-carbon footprint and operate off the grid using solar roofing and storage batteries.

Photo courtesy Bill Hayward/Hayward Lumber

stance, which restricted judicial discretion: “At work, I found myself having to decide if an 18-year-old kid would be sentenced to 46 years to life—or 52 years to life,” Phillips wrote. “Most of the young people who stood before me were men of color who, because of multiple factors, had never had the opportunities that are supposed to be afforded to all our kids in this great nation.”

Knowing there had to be a better way, Phillips explored the possibility of founding a school where kids could learn a trade and be given the opportunities they needed. Key to making this work was Phillips’ insistence that no kids would ever be sentenced to Rancho Cielo. “Judges could recommend Rancho Cielo, but we wanted this ranch to be considered an opportunity for success rather than a punishment.”

To make this happen, Phillips set his sights on a 100-acre parcel in Salinas, Calif., where the county was dumping surplus furniture and equipment in buildings that had once been part of the Natividad Boys’ Ranch, a defunct juvenile incarceration center. Transforming that very site was a fitting representation of the transformation of jurisprudence he felt certain was needed.

His first ventures to make this happen involved a board of directors composed entirely of elected officials who required a \$26,000 feasibility study. The study concluded that a transformation of the Natividad site would be impossible. Undeterred, Phillips recruited a new board made up of local business owners, including construction industry leaders who were willing to reconstruct the site along with youth volunteers.



Each module of the Nexus 01 home was designed and built to be lifted with a forklift and trucked to the site, then stacked and arranged, looking nothing like the usual “double-wide” modular (2-4). The layout of the 847-square-foot home features two convertible rooms, an upstairs loft, a vaulted living-room ceiling, a kitchen (designed with guidance from students in Rancho Cielo’s culinary arts program), and screened-in front porch. Henry Blueskin, Milgard windows, and Thermacork exterior insulation all helped the enclosure reach Passive House standards for air-sealing.

Photos courtesy Rancho Cielo



On site at the Orange County fairgrounds in Costa Mesa, Calif., students begin to install a Tesla Powerwall alongside two heat-pump water heaters. With support from Monterey-based Scudder Solar, the Powerwall was integral to the off-grid, net-zero strategy that helped Nexus 01 place first in the “sustainability and resilience” category of the competition (5). All of the students participating on the Rancho Cielo team were coached to know and present on every aspect of the Nexus 01 home, an approach that helped the team compete in the “communication and marketing” category. To aid this, the team provided a view into the behind-the-wall systems of the demonstration home, including the ERV and whole-house filtration (6) that were central to the home’s “health and comfort” strategy.

“I had no money, but we moved forward anyways, commencing work on the property in 2003,” Phillips wrote. “When I arrived at 7 a.m. on that first Saturday morning, 75 pickup trucks already covered the hills; 22 dump trucks from various trucking companies lined the road. It was a beautiful sight to see. We never looked back.”

Since 2000, the Rancho Cielo Youth Campus has served more than 1,000 out-of-school, 16-to-24-year-old students in programs ranging from auto mechanics to culinary arts, with the Construction Academy standing front and center in this year’s Orange County Sustainability Decathlon.

THE OCSD

The Orange County Sustainability Decathlon (OCSD) was formed in response to the California Legislature adopting the goal of being 100% reliant on renewable energy by 2045. The goal of the OCSD—adapted from the U.S. Department of Energy’s Solar Decathlon—is to challenge university teams from across the country to design and build model homes that address climate change and California’s housing needs.

The decathlon is organized around 10 contests that are scored independently, each worth 100 points. The team winning the most points takes top honors. Six of the contests—sustainability

and resilience, architecture and interior design, engineering and construction, communications and marketing (which evaluates the teams’ skills), market potential (which evaluates the model homes), and innovation—are judged by juries of industry professionals. Two contests—energy efficiency and water efficiency—are based on the home meeting a maximum 40 HERS and 40 HERS_{H2O}, respectively, with the lowest scores in each category winning the contest. The remaining two contests are “performance verifications,” for which the teams must meet health and comfort and lighting and appliance criteria by demonstrating that relevant home systems “function as intended and are installed and configured per the construction documentation.”

NEXUS 01

The Ranch Cielo model home, dubbed “Nexus 01,” won first place in five contests—sustainability and resilience, architecture and design, energy efficiency, health and comfort, and lighting and appliances—and second place in communications and marketing, engineering and construction, and innovation.

A few excerpts from the judges’ comments that capture the essence of how this project met the competition’s goals follow:

Sustainability and resilience. “Overall, extremely impressive and well-integrated building with great execution, attention

Photos courtesy: 5. Scudder Solar; 6. Rancho Cielo



Shown here (7) is the completed assembly of Rancho Cielo's Nexus 01 model home, which won the overall Orange County Solar Decathlon, at the Orange County fairgrounds, in Costa Mesa, Calif. (8).

to detail, research, and documentation. Inclusion of passive-house strategies, including airtightness, ERV, continuous insulation, and natural daylighting, makes it the strongest contender.”

Engineering and construction. “The thorough and thoughtful engineering and construction of this house make it applicable to any California climate. The engineering systems ensure a comfortable and healthy home.” A few of the key systems that stood out for judges included the energy performance of the building envelope and systems, the energy recovery ventilator, energy recovery from the shower drain, the solar hot-water system, and the Span panel, which provides “sophisticated electrical control for improved battery performance.”

Communications and marketing. “Each student understood every aspect of the project ... Did everything that was asked of them in a professional and timely way ... Mission is adopted and clearly communicated by everyone.”

The communications and marketing contest stood out for Bill Hayward, owner of Monterey-based Hayward Lumber and founder of Hayward's Healthy Homes (H3), as a particular point of pride for the Rancho Cielo team, not least because other teams he witnessed had student representatives who could speak well about the one or two aspects they had worked on, but did not have a grasp of all the details. “Understanding the house as a complete system is an essential knowledge we coached each student on throughout the design and construction. It's an essential knowledge for every designer and builder,” he urged.

In mentoring and guiding students through each phase of the project, Hayward was joined by a number of industry representa-

tives, including Pete Scudder of Scudder Solar and Scudder Roofing Co., and Thomas Rettenwender, principal of Carmel-based EcoLogic Architects, who all provided outsized support. However, in true “it takes a village” spirit, the Nexus 01 project received widespread community support from a host of local firms, including Don Chapin Co., Della-Mora Plumbing, Wheeler Flooring, Guardado's Landscape, Duke Kelso Construction, and Lopez House Movers, among others.

One of the standout guides on the project was instructor and former contractor Ed Bennett, said Mark Laliberte (known to the JLC community for his long-time contributions, most recently as a principal of Denver-based Construction Instruction), who also worked with students through the design and construction phases. “Ed is the guy that showed these students a way forward from the first day,” Laliberte observed. “Ed became the leader when they got there. He might not have been well-liked at first because he's the guy that told them, ‘If you wear your hoodies, you go home; if you write any gang sign on any tool, I'm going to find out who did it and you go home.’ He held them accountable. These are tough kids, but in the end, Ed was the guy they looked up to the most.”

Winning the OCSD appears to be just the first step in creating what Hayward contends is a “healthy home for all humanity.” Rancho Cielo Construction Academy and EcoLogic Architects have formed a partnership, Nexus Housing (nexushousing.org), which has designed a range of models that meet similar performance goals to those of the prototype Nexus 01 and is currently taking preorders.

Clayton DeKorne is chief editor of JLC.

Photos courtesy: 7. Orange County Solar Decathlon; 8. Rancho Cielo

My crew often has questions about nailing studs when we build walls. For starters, the code is specific about the number and size of nails for end-nailing wall plates to studs but doesn't specify the size of the studs. Do the same number of nails apply for 2x4 and 2x6 studs? How about for 2x8s in fat walls? Also, what's the correct angle for toenailing studs to plates? Is the goal to drive the nail through the center of the end of the stud or near the far corner?

A Don Dunkley, a former framing contractor and long-time JLC contributor responds: It's true, Table R602.3(1), which specifies the fastening schedules for wall construction in the International Residential Code, does not differentiate between 2x4 and 2x6 studs. Whenever I'm dealing with the code, I am careful to not assume anything beyond what is written. Since the stud size is not called out, the column "Number and Type of Fastener" implies both sizes of studs are included in the fastening schedule because they are not individually called out in the "Description of Building Elements" column. (For comparison, refer to Table R602.3(5) in the same code chapter, where it does differentiate between 2x4, 3x4, 2x5, and 2x6 for determining the height and spacing of wood studs. Here, the stud size is critical for lateral strength. Nails in stud-to-plate connections primarily resist against uplift and, frankly, they don't provide a great deal of resistance, particularly with nails into end grain. When uplift and shear resistance matter in high-wind and seismic zones, code looks to sheathing-to-framing connections and to hold-downs, tension ties, and other framing hardware. And jurisdictions in these zones mostly require engineered solutions that go beyond any prescriptive measures.)

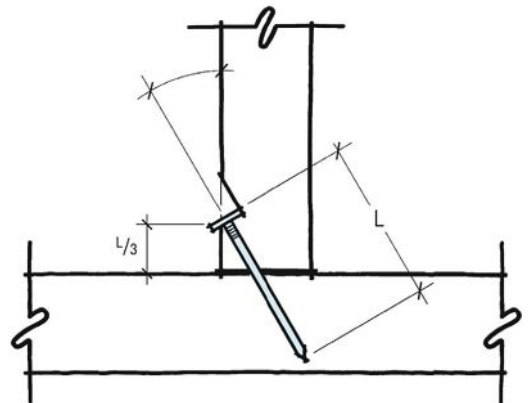
It's worth noting, a similar situation applies to the "Floor Joist" column for number and type of fastener, also

called out in Table R602.3(1). The nailing schedule shown is the same for all common-width joists, since no particular joist width is being defined or called out in the "Description of Building Elements" column. Here, as with studs, the table implies the number and size of the fasteners applies regardless of the size of the joist.

Concerning specialty walls, end-nailing into 2x8 and larger width studs isn't covered specifically so if your jurisdiction doesn't require stamped engineering details on the building plans for these, drive in a few extra nails as a best practices rule of thumb.

For the question on toenailing, a nail driven at an angle coming out the bottom of the stud close to its center will provide the strongest connection. This is what the American Wood Council tests to determine the strength of toenail connections in the National Design Specification. Nails that exit the far corner may not penetrate the plate deep enough to provide sufficient holding power.

My personal preference for toenails is hand-nailing with 8d sinkers (2 1/2-in. x 0.113-in.). I find they are the easiest to place and start for a roughly 45-degree exit at the center. (The angle would need to be steeper with a longer nail, as shown in the illustration, below). Practice makes perfect for speed and accuracy.



Proper toenailing. When toenailing, place the nail away from the end of the board at a distance that's equal to one-third the length of the nail. With a 2 1/2-inch nail (such as an 8d sinker), start 7/8 to 3/4 inch up from the end and drive it at around a 45-degree angle to exit the center of the stud section. A longer nail (as shown above) would be driven at a steeper angle to exit the center of the stud.

Illustration: Tim Healey

Q What is the difference between SEER, HSPF, and COP, and what should we be looking for when recommending heat pumps for whole-house heating and cooling? All the equipment installed on our jobs recently lists SEER2. What does this mean? Is it different from SEER?

A Connor Dillon, quality manager at the Building Science Institute, a firm offering training and quality control to home energy raters, responds: SEER, HSPF, and COP are three efficiency units used with HVAC equipment like air conditioners, air-source heat pumps, and ground-source (or geothermal) heat pumps. SEER represents the cooling efficiency of air conditioners and air-source heat pumps. HSPF represents the heating efficiency of air-source heat pumps, while COP is typically used for ground-source heat pumps in heating mode.

When you're assessing heat pumps to be installed, you need to know that the higher the number, the more efficient the system is. A 15 SEER, 9 HSPF air-source heat pump will perform better than a similarly sized system with 14 SEER and 8 HSPF. And all manufacturers are required to meet minimum efficiencies set for equipment by the federal government. This creates the "floor" of efficiency for HVAC equipment. And speaking of the federal government ...

At the beginning of 2023, two important updates were made by the Department of Energy:

First, the federal minimum efficiencies for split-system air conditioners and heat pumps were increased for the first time since 2015. The ratings vary by region, but broadly speaking, they were raised by 1 SEER and roughly 0.6 HSPF for all regions.

Second, the calculations for the efficiency units like SEER and HSPF were modified. This created a "new" unit of measurement, represented as SEER2 and HSPF2—COP was not affected by the new calculations. So the "old" SEER and HSPF calculations are now called SEER1 and HSPF1, respectively.

These new calculations typically lowered the number (but not relative efficiency) of HVAC equipment. Most 14 SEER1 systems are now calculated as 13.4 SEER2, for example. As you can imagine, this caused some confusion—in appearance, "lowering" the efficiency of a piece of equipment while simultaneously requiring that same system meet a higher minimum.

However, most manufacturers are now producing systems using the new efficiency calculation, while meeting the higher equivalent efficiency requirements. If you receive an Air-Conditioning, Heating, and Refrigeration Institute (AHRI) Certificate, you will likely find the SEER2 or HSPF2 label on it. The same principle mentioned above applies today—the higher the value, the more efficient the system is. SEER2 still covers cooling efficiencies and HSPF2 still does the same for heating efficiencies.

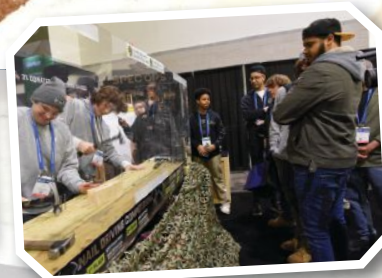
When making recommendations, you'll want to make sure the system meets any local or state requirements for minimum efficiency. Check with your local energy department. You'll also want to look into rebates. Some utilities, jurisdictions, and the Inflation Reduction Act include funding for system replacements. If you're pursuing a rebate, make sure the system you recommend meets those requirements.

One more thing: If you are working in a cold region, the Northeast Energy Efficiency Partnership (NEEP) hosts a cold-climate air-source heat pump (ccASHP) product list. If you are building or remodeling in a predominantly heating-dominated climate, you'll want to make sure the equipment you have installed is verified to operate correctly in the low temperatures the home will experience.

When assessing heat pumps to be installed, you need to know that the higher the number, the more efficient the system is. This holds true whether it's SEER, HSPF, or COP.

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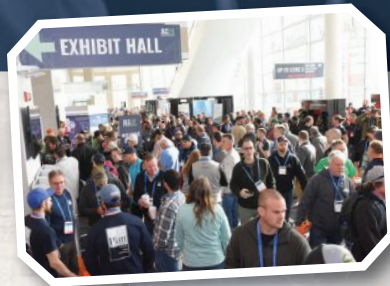
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Prefabricating a Frame-and-Panel Ceiling

BY GARY STRIEGLER

Early in my career, I chose to focus on custom homes and remodeling. Although this kind of work can sometimes be challenging, I like interacting with clients and adding custom details that make their house personal to them. Sometimes, those details come toward the end of the job.

For example, recently a client wanted to add a design element to a hallway ceiling that functioned as a transition between a two-story entry and a two-story living room. These rooms were trimmed with casing, baseboard, and ceiling details that I would describe as “transitional” Craftsman-style. She was hoping that the hallway ceiling would reflect some of these details without being too fussy.

By this point in the project, I had a good working relationship with my client, so we were able to come up with a plan for a flat panel ceiling detail with a center panel turned 45 degrees to the perimeter frame. As a final tweak to the design, we added a diagonal rail in each corner to mimic the look of the cabinet doors in the adjoining powder bathroom.

Layout. The roughly 8-by-8-foot ceiling was not quite square, measuring a few inches wider than it was deep. This was a factor that we had to take into account when planning the layout and making the miter cuts—which were not quite true 45-degree

cuts—at the corners for the ceiling panel. Because the hallway was relatively small, we decided that the best approach would be to pre-assemble the frame-and-panel ceiling and lift it into place.

I started by laying out the perimeter frame, sizing it about an inch smaller in each dimension than the ceiling; the gaps between the frame and the walls would be covered by a large cove molding after the paneled ceiling was installed. I made the stiles and rails 3½ inches wide out of 1x4 poplar and planned on overlapping one inch of the frame with the cove molding (1).

Frame assembly. I joined the outer frame together with pocket screws, then cut the center panel from ¾-inch-thick MDF to size to accommodate the base of a ceiling light fixture, which would be installed later.

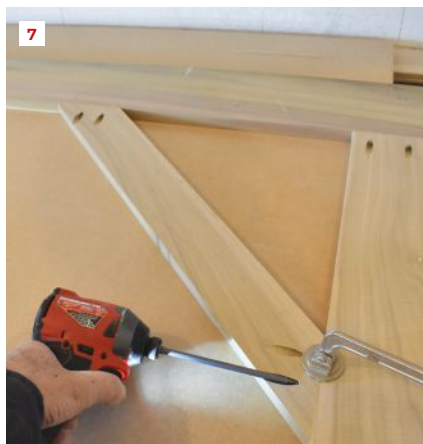
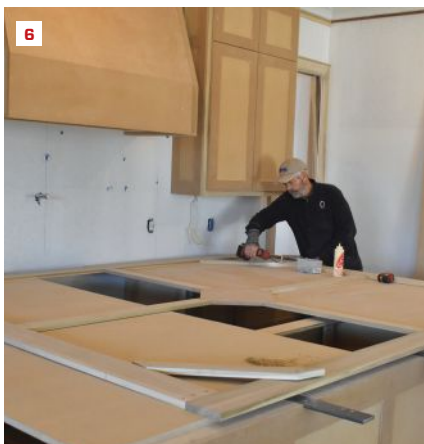
The design includes a pair of intermediate, 2½-inch-wide poplar rails that run from the center point of each outer frame piece and intersect on the diagonal with the corners of the center panel. Since the project was paint-grade and out of square by a small amount, I made the not-quite-45-degree miter cuts to fit the center panel, then added small filler pieces to each miter cut to complete the V-cut look.

For the joints between the intermediate rails and the center-panel corners, I used small, carefully placed, #0 biscuits because a pocket



The author assembled the approximately 8-by-8-foot frame from 1x4 poplar, using pocket screws to join the stiles and rails together (1). The frame was sized to leave a gap, which would later be covered by cove molding, between the frame and the walls. Small biscuits joined the 2½-inch-wide intermediate rails to the corners of the center MDF panel (2).

Photos by Gary Striegler



A short, headless pin driven into the glued and mitered biscuit joint helps to clamp the pieces together (3). A smaller filler piece completes the V-joint (4). After joining the intermediate rails to the center panel, the author fastened the assembly to the frame with pocket screws (5). He cut short diagonals and attached them at the corners with pocket screws (6, 7). Because he planned to rabbet the back of the frame for panels, he carefully located the pocket-screw holes so that the screws wouldn't land in the path of the rabbeting router bit (8).

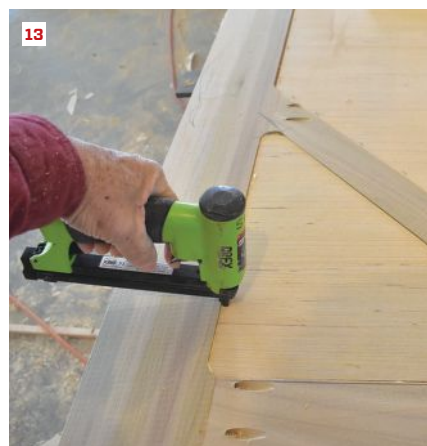
screw probably would have blown out the corner of the panel (2). To clamp the joint, I then drove a $5/8$ -inch headless pin into it (3). Finally, I added a filler piece with glue to finish the V-joint (4).

Keeping the panel centered was critical to maintain symmetry and align with the placement of the light fixture, so I double-checked the layout several times while I was adding the intermediate rails. I did this by fastening all four intermediate rails—which I had cut long—to the panel corners first, then adjusted the placement of the assembly on the frame until I was satisfied that the panel was centered. Next, I marked and cut the intermediate

rails to final length and fastened them to the frame with pocket screws (5). When drilling the pocket holes, I was careful to stay more than $1/2$ inch in from the edge of each joint in the frame piece so that the screws wouldn't be hit by my router bit as I cut the rabbets for the panels later.

Adding the short diagonal rails at the corners was the last step to finish the frame. I laid them out for equal distance from the corners. Since the frame was not a perfect square, I scribe-fit the cuts. Even at off angles, pocket screws make great, snug joints (6, 7, 8).

Panels. I could have simply stapled plywood to the back of the



The author used a router to cut 1/4-inch-deep-by-1/2-inch-wide rabbets in the back of the frame to accommodate the 1/4-inch plywood panels (9). When the corners were 90 degrees or greater, he simply clipped the panel corners to fit them into the rabbets (10). To fit the acute angles on the small, triangular corner panels, he used a belt sander to round over the corners (11, 12). The panels are held in place with glue and short wide-crown staples (13).

frame, which would have left a 3/4-inch step from the face of the frame to the plywood. But I knew from other projects that it looks a lot better to rabbet the plywood up into the back of the frame, leaving a 3/8-inch or 1/2-inch step. So I chose to cut a 1/4-inch-deep-by-1/2-inch-wide rabbet in the back of the frame with a Whiteside multi-rabbeting bit, using the smallest bearing in the set.

Getting a clean cut when making rabbets is important. If the wood tears out, it looks sloppy. I am comfortable with first making a light, counterclockwise “climb” cut, then removing the rest of the material with a normal clockwise cut (9). Another way to get a square corner is to set the router shallow for a first pass, then adjust the depth of cut. A third option is to set up two routers, make a shallow pass with the first one, and cut at full depth with the second.

I cut the panels from a couple of sheets of 1/4-inch sanded birch

plywood (10). The 1/2-inch width of the rabbet cuts allowed for a fair amount of forgiveness to cut the panels, but I did need to clip their corners to accommodate radius corners of the rabbet. That works well for 90-degree angles but not for the two acute angles at the corners of each triangular-shaped panel. I could have chiseled out a pocket for the plywood, but I tried using a belt sander to round the corners to fit. After a little practice, I decided this approach was much faster than the chisel option (11, 12).

After test-fitting all of the panels, I fastened them to the frame with glue and short, 1/2-inch-long staples. For this task, I like to use wider, 7/16-inch or 1/2-inch crown staples (the kind that you might use to put up plastic or a vapor barrier) rather than narrower, 3/8-inch crown staples, which tend to bury themselves halfway through the thin plywood panels. In addition, the wider crown staples have more holding power (13).



After installing the panels, the author flipped the assembly over and smoothed over the joints with a belt sander (14). A couple of 2x4 deadman supports propped up the ceiling while the crew first nailed and then screwed it through the drywall and into the framing (15). Cove molding covers the joint between the frame-and-panel ceiling and the walls (16). The painted ceiling in the transitional hallway complements the trim in the adjacent entryway and living room (17).

When all the panels were in place, I asked a couple of other carpenters on the job to carefully help me flip the assembly so I could sand the face (14) and carefully cut out the hole for the light box.

Installation. We had to move the ceiling assembly only a short distance to install it, positioning one man on each side to support it during the move. First, though, we carefully marked the locations of our ceiling joists to nail and screw into and made layout marks for the edges with a 2-inch gap all around to properly orient the assembly so that it didn't get misaligned.

Since I wanted to take pictures of the installation process, I cut a couple of temporary 2x4 support legs to length to act as a fourth pair of hands and help the other three guys until they could shoot enough nails to attach the assembly to the ceiling (15). It took a few minutes to double-check the layout and make sure we centered up perfectly on the electrical box for the light fixture, so

the 2x4 legs really came in handy. Afterward, we added trim-head screws at each fastener location for extra strength.

To finish up, we added the same cove-molding detail that we had used in the rest of the house (16). Our client was very happy with the result, especially after the paint crew had primed and painted the ceiling along with the trim work, and the electrician had wired up the ceiling fixture (17). The frame-and-panel detail creates a strong visual impression without being overly traditional in the most public area of the home.

Gary Striegler, a JLC contributing editor, owns Craftsman Builders, in Fayetteville, Ark. (craftsmanbuildersnwa.com), and teaches workshops at the Marc Adams School of Woodworking. Follow him on Instagram at @craftsmanbuilders. He will be presenting trim-carpentry building clinics on the show floor at JLC Live in Providence, R.I., March 2024.

Making Backer Boards for Drywall Butt Joints

BY AARON MILLER

Drywall butt joints, or what we call “drywall butts,” can be time-consuming to finish, and even if you feather out a wide area of joint compound, they can still cause humps in the final surface. To overcome those problems, we started using commercially available drywall backers, which are installed behind butt joints that are laid out to fall between studs or joists (over the cavity, not the framing member). Fastening the drywall to the backer board forces the joint inward, creating a slight depression along the joint that speeds up the finishing process tremendously. The only problem is, backer boards are not always readily available and can also be pricey. For those reasons, we began making our own.

We start with ripping $\frac{7}{16}$ -inch-thick sheets of OSB into $5\frac{1}{2}$ -inch widths. We prefer ripping 4x9 sheets, when they are available at our local lumberyard, because we can chop the OSB strips into 54-inch

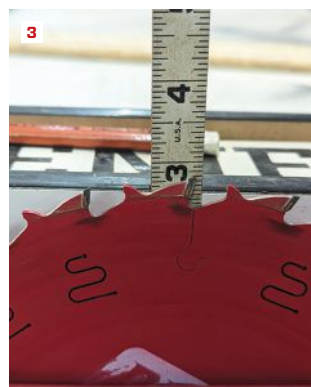
lengths without creating a lot of waste. This length is greater than the width of a sheet of drywall so that each end of the backer board can lap behind adjacent drywall panels, which helps strengthen and support the joint. If 4x8 sheets are our only option, we still cut the boards 54 inches long, and then piece together the leftovers into backer boards. This works well but takes longer. We also save scraps that are long enough, to add to our savings.

The photos that follow show our process of making drywall backer boards. It’s quite simple, and once we landed on this solution, it became a regular part of every job with new drywall.

Aaron Miller owns Millers Construction, based in Corning, Ark. He won the 2023 JLC Live “Next Live” Presenter contest and will return to the JLC Live Building Clinics this year. Follow him on Instagram at @millersconstruction.



Start by ripping a sheet of $\frac{7}{16}$ -inch OSB into $5\frac{1}{2}$ -inch widths (1). Set the fence to $\frac{1}{2}$ inch (2) and adjust the height of the saw blade to $2\frac{13}{16}$ inches (3). Next, set the bevel of the table saw to 3 degrees. It is important that the blade is tilting toward the fence. If everything is set correctly, the table saw should look like this (4).



Photos by Aaron Miller



Run one side of the ripped OSB through the saw (5). Then flip the board over and run it through the saw again (6). Feather boards help to hold the board straight and in position. The completed backer board has a recess a little over 1/4 inch deep (7).



With the backer board positioned between framing members (8), the butt end of a sheet of drywall is pulled in slightly, providing the perfect amount of recess for fast finishing (9).



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BY GREG WOLECK

Using a Daily Log to Streamline Production

As a **production consultant** with Remodelers Advantage, I speak with teams of project managers, lead carpenters, and site supervisors. Lately, a common theme has been that with the addition of new materials, energy codes, and specific sequencing of tasks, projects have become more complex, making it more crucial than ever to maintain a running record, or daily log, to effectively manage them. Keeping a daily log is an efficient way to record important details about the client, trade partners, and our own teams that can be used to improve the current project's closeout process and referenced on future projects to strengthen workflows and avoid repeating mistakes. It is also a means of communication between the client and builder; in some contractual situations, providing a daily log to the client is a requirement.

Everyone on the job must be involved in maintaining this record. If project managers and construction managers are unable to visit jobsites every day due to increasing workloads and labor shortages, the information recorded by trade partners in the daily log is critical data for the project management team and contributes to the post-project review process. Equally important, when trade partners are heavily involved in the work, it helps ensure accountability for their tasks.

A daily log can be as simple as a Word or Notes document. When using Word or Notes, we save the daily files to a "Logs" subfolder within a given job's main folder. Alternatively, a daily log can be part of project management software; it's a typical feature of Builder Trend, Co-Construct, BuildXact, and JobTread, to name a few. Even using a traditional paper form (see example, right) is sufficient, though this requires the extra step of scanning it so it can be emailed to all parties as needed. Regardless of the means, the following key items should be included in a daily log:

- **Basics.** Start with the project name, location, date, and contact phone numbers. Create a template with that information filled in so you don't need to re-enter it each time.
- **Weather.** Record a brief narrative about the weather for the day, especially if it impacted the work being performed.
- **On-site personnel.** Document the company names of trade partners, the number of people on site, and the specific work they performed. If trade partners are the only ones on site, they should fill out their own daily log. It is also important to record the names of your own team members present at the site, especially when self-performing work. This helps cross-check recorded hours with actual tasks performed. Additionally, documenting visits from the office, architect, or design team can be useful.

Daily Log	
Job: _____	Date: _____
Weather Conditions: _____	
Onsite (Trade Partners)*: _____	
Company name, number of persons, hours worked, tasks completed Onsite (Company Staff): _____	
*Name, hours worked, tasks completed Deliveries: _____	
Visitors*: _____	
Remember to document conversations with visitors to site including client Planning Ahead: _____	
What materials, staffing, equipment, information, will you need in the coming days Changes: _____	
*Are there any potential changes/change orders on the horizon	
Please return to Project Manager by 4:30 pm	

■ **Deliveries.** Record deliveries in case any damage to the client's or a neighboring property occurs. This information makes tracking dumpsters and reconciling bills for lumber deliveries easier.

■ **Visitors.** Keep track of neighbors, salespeople, inspectors, and unexpected homeowner visits to ensure an accurate record of conversations that may be relevant beyond the current scope of work.

■ **Issues.** Document issues such as rot repair or hidden conditions. Communicate them directly to clients and designers as well.

■ **Photographs.** Attach several photographs or even a short video. I believe in taking daily photographs that capture the project's location as well as close-up shots for detailed analysis. Using a 360-degree camera will ensure nothing important is missed.

There are few restrictions for what not to do. No detail is too small or insignificant to enter. However, remember that the daily log is a public document that can be accessed by all. Therefore, maintaining professionalism and confidentiality when logging data is paramount.

Properly maintained, the daily log in production teams' processes is a primary tool for fostering continuous improvement, which, after all, is essential to maintaining and growing a profitable company.

Greg Woleck, a production consultant for Remodelers Advantage, is a former production management consultant for Helm Construction Solutions, and a project manager and lead carpenter for residential and commercial contracting firms.

Queen of Zero: HVAC for a Tight House

As our team finalizes the details of the mechanical plan for the Queen of Zero house (the rebuild of a Queen Anne Victorian-style home in Maryland; see *JLC's Case Study 2024*, at jlconline.com), we are faced with the unique challenges of designing an optimal heating, cooling, and ventilation system for a tight, high-performance home.

MECHANICAL DESIGN CHALLENGES

Homes aspiring to a Zero Energy Ready (ZER) standard in climate zone 4A, such as the Queen of Zero, must achieve envelope airtightness of less than 2.25 ACH50 in 2024—in other words, the home's total volume of air will naturally ventilate less than twice per hour when subjected to 50 pascals of pressure through a blower-door test. (Under the ZER standard, the ACH50 requirement varies by climate zone.) Passive house standards require air-infiltration performance of 0.6 ACH50 or less. Mechanical systems to serve these types of high-performing homes present a range of design challenges and benefits:

- Airtightness combined with superior insulation and energy-efficient windows reduces the demand for mechanical heating and cooling throughout the space, allowing for smaller equipment.
- Tighter homes require more sophisticated ventilation systems to maintain optimal indoor air quality. Controlling humidity, removing contaminants from the air, keeping air balanced to avoid a negative-pressure situation, and circulating filtered fresh air throughout the home must all be addressed.
- While increasing the number of mechanical components to ensure comfort and wellness, a high-performing net zero home also works to minimize energy consumption and fossil fuels. Thus, the



Proposed front elevation of the Queen of Zero, in Maryland.

design should prioritize all-electric energy-saving strategies such as heat pumps and shorter duct runs (or ductless mini splits).

Furthermore, the industry currently lacks a robust workforce of HVAC professionals with the level of expertise, specificity, and accuracy needed to address the complexities of high-performance mechanical design. Take, for example, the ACCA Manual-J tool, which estimates heating and cooling loads based on building size, glazing, orientation, climate zone, airtightness, R-values, occupant preferences, and other factors. Municipal permitting offices are increasingly requiring Manual-J calculations to determine mechanical equipment sizing, but unfortunately, many reports are fudged.

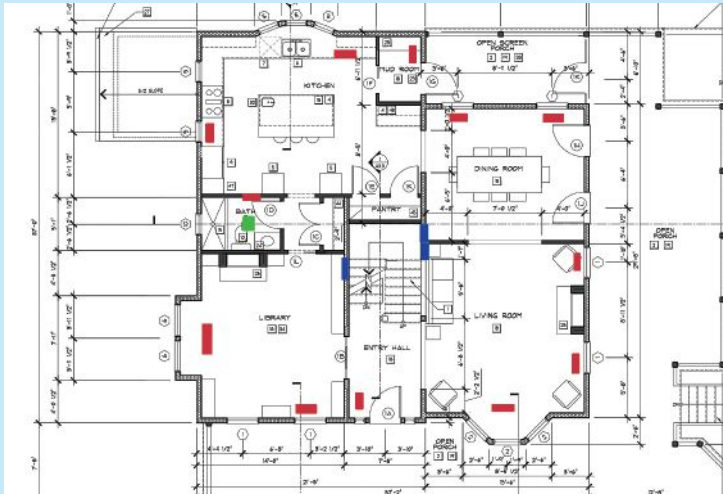
Building-science expert and author Allison Bailes explains, “A lot of HVAC contractors aren’t used to doing real design. They work

QUEEN OF ZERO MECHANICAL DESIGN

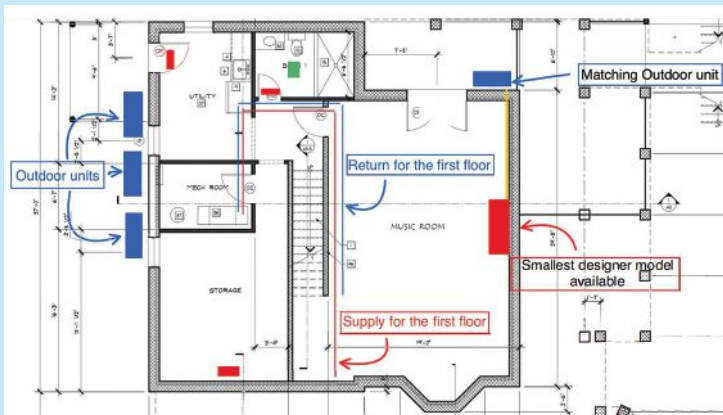
The floor plans in this article summarize the Queen of Zero mechanical plan, provided by HVAC contractor Ridgchi Appadoo of Thermal Plus in collaboration with mechanical designer Randy Sheppard of Green Gurus. The Manual-J calculations estimated a total demand of approximately 41,000 Btu/h of cooling design load (about 3.5 tons) for what is expected to be a tight, 4,600-square-foot house. To maximize comfort and energy use, the HVAC design was separated into four independent systems that totaled about 4.5 tons of cooling, assuming that the equipment’s variable speeds will compensate for any potential overage. This is dramatically different from the conventional average of 1 ton per 400 to 600 square feet of

living space, which would have resulted in at least 7.5 tons.

The mechanical design went through multiple iterations, as we incorporated new space designs and performance details. According to Appadoo, “Designing and building an HVAC system for a high-performing and tight home demands a great level of care. The intricacies lie in the seamless integration of the HVAC system within the home’s envelope. Even seemingly small details, such as ensuring that components like thermostats and humidistats can communicate effectively with the heating and cooling equipment, take on significant importance. Every aspect of the system, from ductwork layout to equipment selection and control strategies, must align with the home’s energy-efficient design.” —*N.T.*



The homeowner maintained a traditional Victorian layout for Queen of Zero's first floor, thereby segmenting the space into several distinct rooms, a layout not particularly conducive for ductless mini splits. Thus, the HVAC provider opted for a Mitsubishi Electric SVZ-KP18NA ducted air handler with a Mitsubishi Electric SUZ-KA18NAHZ heat pump. This variable-speed, 1.5-ton system will service half of the basement and the entire first floor. Housed in the basement mechanical room, the whole-house dehumidifier and energy recovery ventilator (ERV) will also be tied to this system.



The Queen of Zero basement includes a large (766 square feet) music room. To minimize sound transfer, the design utilizes a ductless mini split for heating, cooling, and dehumidifying the space. The HVAC provider specified a variable-speed, 32-SEER heat pump Mitsubishi Electric MSZ-FS06NA indoor unit coupled with the Mitsubishi Electric MUZ-FS06NAH outdoor unit with a minimum capacity of 1,700 Btu/h. The unit has a quiet setting at which the fan noise is barely audible at 19 dBA.

by rules of thumb, and if a building department says we need the Manual J, then they'll crank one out. But if they don't do this regularly and know what they're doing, a lot of times they'll manipulate the numbers until they come up with their desired load for the system."

Building-science experts readily admit that there is a lack of consensus on best practices in their industry, which continues to evolve through experimentation and new technologies. Home-performance expert and TV show host Corbett Lunsford, who produces educational videos on mechanical design, asserts that despite the evolution of the building-science field, "there's no manual on this," noting how each project should be tailored to a vast array of home-specific variables.

MECHANICAL DESIGN TIPS

In my work building high-performance homes, I find myself on a sort of reverse learning curve regarding mechanical design. The more I learn, the less I know as I continue to gain a deeper appreciation for the complexity of these systems. Yet, over the years, I have gathered some effective practices for builders to help smooth the process of designing an optimal mechanical system:

- **Understand the basics of mechanical design.** At a minimum, builders should be able to read and scrutinize the ACCA Manual J, D, and S reports, know the difference between load calculations and system sizing, understand the fundamentals of heat-pump technology (including methods for properly commissioning the equipment), and become familiar with the strategies for maintaining optimal indoor air quality. Many states and localities are now offering free training on high-performance mechanicals to support energy efficiency and electrification. It's worth checking with your state energy office.

- **Start the mechanical design process early.** So often, the consideration of equipment placements and duct runs is put off too late in the development of architectural drawings. As HVAC units have become more compact and more plentiful in homes, the layouts have also become more complex. Importantly, Bailes advises his clients, "Don't design the house with just a closet for an air handler because it's really difficult or practically impossible to get ducts in there installed and sealed properly." Also, designate appropriate space in the landscaping for heat pumps—preferably somewhat concealed but with room to "breathe" as per manufacturer requirements.

- **Recruit the best team.** I prefer to engage a third-party mechanical designer with expertise in high-performing homes to create the HVAC plan and then hand it off to my installer. Other builders prefer a design/build contract with the HVAC contractor. In most cases, a design/build HVAC contractor will be hiring a third-party mechanical engineer to draft the design documents.

Regardless of the contractual relationships, the builder, designer, and installer should all collaborate as a team throughout the process.

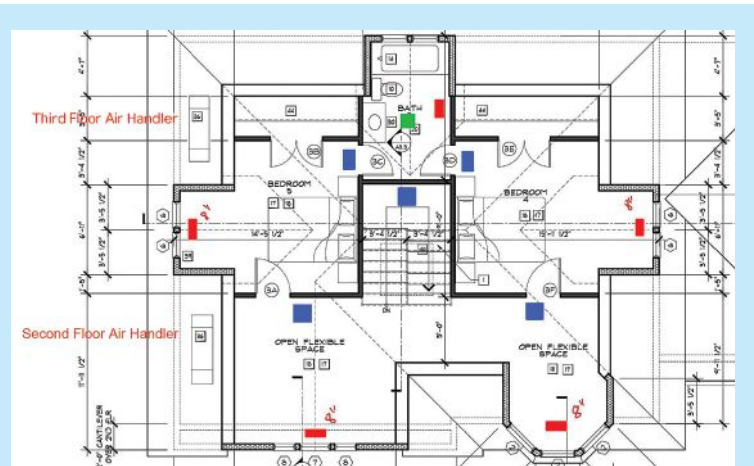
■ **Tailor the model to occupant behavior and comfort preferences.** Thermostat set points, fresh air circulation through open windows or doors, number of occupants, and use of various spaces throughout the day are all unique characteristics of families that should be incorporated into the mechanical design model. Lunsford explains that “every house is different mainly because every family is different. If you have people who are environmentally sensitive, they will have a very different experience of the same house because one person will get bothered and the other person won’t. They’ll cook differently. I always like to ask [homeowners], what kind of cooking do you do?” A family who cooks for eight hours a day will significantly impact the kitchen exhaust and negative air pressure in the home.

■ **Prioritize superior indoor air quality.** A common mistake in high-performance homes is to bring in unwanted humidity through a fresh-air ventilation system, such as an energy recovery ventilator (ERV). It’s also a common misconception that ERVs are sufficient to control indoor humidity across all climate zones. Thus, in addition to homeowner preferences, it is also critical to take into consideration the geography and climate of the home. For example, how does the ventilation system prevent outdoor contaminants, such as smog from wildfire smoke, from entering the home? In Lunsford’s TV series *Home Diagnosis*, he identifies five interrelated air-quality functions of the mechanical system: circulation, capture and filtration, humidity control, air dilution, and pressure relief.

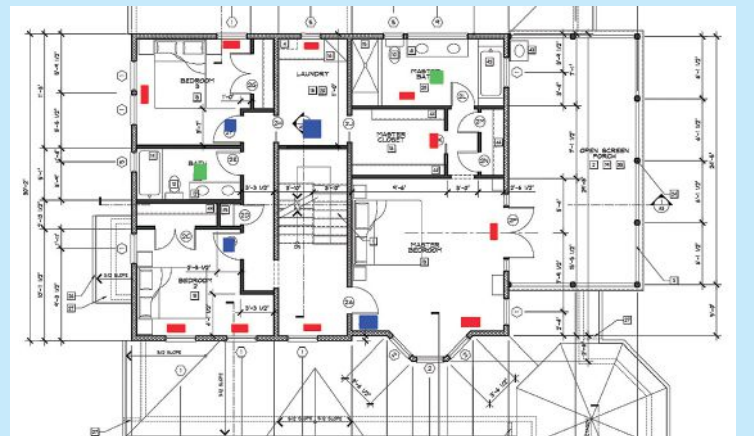
■ **Incorporate smart thermostats and monitoring support.** High-performance systems should include Wi-Fi capability to provide notifications for filter cleaning, filter replacements, and other maintenance-related issues. If feasible, the system should also include room sensors to monitor temperature and humidity. This data can be used to tweak the system over time, as needed.

Whenever we talk about mechanical design with the Queen of Zero homeowner, he reminds us that he’s a “fresh air guy” who likes to keep the windows open, which I’ll admit always gives me a tinge of heartburn. How will our very intentionally designed mechanical system, which includes a whole-house dehumidifier, perform with this frequent onslaught of unfiltered, unconditioned air “au naturel” in an area where average humidity is above 60% nine months of the year? The answer is: It’s a brave new world; we don’t really know.

Nicole Tysvaer is CEO of Symbi Homes, a residential builder and developer based in Bethesda, Md.



The Queen of Zero mechanical plan separates heating and cooling into four distinct zones: 1) 1.5-ton ducted air handler serving partial basement and first floor, 2) 1.5-ton ducted air handler serving second floor, 3) 1-ton ducted air handler serving third floor, and 4) 6,000 Btu/h ductless mini split serving the basement music room. This will allow the homeowner to make climate adjustments throughout the home based on comfort and usage, which will save on energy costs. In addition, Mitsubishi Electric’s Kumo App consolidates the controls for these multiple units into one program accessible on a smartphone.



The entire Queen of Zero structure will be insulated and integrated within the conditioned space of the building envelope. Therefore, the attic areas beyond the third-floor knee walls provide optimal space for HVAC equipment and ductwork. Two Mitsubishi Electric air handlers will be installed horizontally in these attics—one to service the second floor and one to service the third floor. Window seats in the dormers will provide space to conceal ductwork and install supply registers.

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Vapor Control in Walls With Continuous Insulation

The **International Residential Code** is supposed to provide clarity into how builders construct homes. In the IRC's own words, "The IRC was created to serve as a complete, comprehensive code regulating the construction of single-family houses, two-family houses (duplexes) and buildings consisting of three or more town-house units." Usually, the codes give us clear options on how we should build homes with the occupant's safety and health as our No. 1 priority. Codes also address energy efficiency and building durability. Sometimes though, the codes can be quite confusing. How we handle vapor retarders when using continuous insulation is one of those areas.

Let's begin with the energy code's required insulation values for walls in Table N1102.1.3 (R402.1.3), "Insulation Minimum R-values and Fenestration Requirements by Component," in Chapter 11 of the 2021 IRC. Here's a simplified version of this table, focusing on insulation requirements for wood-framed walls in all climate zones:

INSULATION MINIMUM R-VALUE	
Climate Zone	Wood-Framed Wall R-Value
0, 1, 2	13 or 0 & 10ci
3	20 or 13 & 10ci or 0 & 15ci
4 through 8 (including marine)	30 or 20 & 5ci or 13 & 10ci or 0 & 15ci

Climate zones 0 through 2 (0 is a new climate zone that does not exist in the continental U.S.; note, the IRC is an "international" building code) allow two options:

- R-13 cavity insulation only (2x4 wall insulated with R-13 batt insulation).
- R-10 continuous insulation (ci) only. For this option, the place for cavity insulation is set at "0."

Climate zone 3 offers three options:

- R-20 cavity insulation only (2x6 wall with R-20 batts).
- Cavity insulation and continuous insulation (2x4 wall with R-13 batts and R-10 ci).
- R-15 continuous insulation only.

Climate zones 4 through 8 (including marine zone 4) now all require one of four options:

- R-30 cavity insulation only. This could be a 2x6 wall insulated with spray foam or a 2x8 wall insulated with Rockwool or high-density fiberglass batts.
- Cavity insulation and continuous insulation (2x4 wall with R-13 batts and R-10 ci).
- Cavity insulation and continuous insulation (2x6 wall with R-20 batts and R-5 ci).
- R-15 continuous insulation only—something like Joe Lstiburek's "perfect wall."

Along with the insulation requirements above is also a reference in Chapter 11 to vapor retarders, in Section N1102.1.1 (R402.1.1), which reads: "Wall assemblies in the building thermal envelope shall comply with the vapor retarder requirements of section R702.7."

This sends us to Chapter 7, Wall Coverings, where we find information in Section 702.7 that defines the different classes of vapor retarders, explains where they are required, and provides details on how you can change the vapor retarder class when modifying the wall design to include continuous insulation and/or vented rainscreens. This is where confusion for some builders sets in. Before delving into that, however, we need a little more background on code definitions for vapor retarders.

What materials are used as vapor retarders? To answer this question, we first need to understand how vapor retarders are classified based on the ability of water vapor to move through the material. A "perm," or the "permeability" of a material, refers to the passage of one grain of water vapor through 1 square foot of material in 1 hour with a pressure differential between the cold and warm sides of the material at 1 inch of mercury. The higher the number, the more easily water vapor can diffuse through the material. Almost no water vapor moves through metal, whereas fibrous insulation is vapor open, and water vapor easily passes through it. A test used to verify a material's permeance is ASTM E96.

Table R702.7(1) (not shown in this article) classifies materials based on their permeability. It boils down to the following classifications:

- A Class I material has a perm rating of *less than or equal to 0.1*. Glass and metal are in this class, along with polyethylene sheeting.
- A Class II material has a perm rating *between 0.1 and 1*. Kraft-faced insulation, vapor-retarding paints, and most smart (responsive or variable) vapor retarders fall in this classification.

■ A Class III material has a perm rating *between 1.0 and 10.0*. Latex- or enamel-painted drywall is a Class III vapor retarder.

Any material more than 10 perms is considered vapor open. The classification of perm ratings needs to be understood before we can discuss the next table.

Where to use vapor retarders. Section R702.7 states that a vapor retarder is required on the interior side of all exterior wood-framed walls in climate zones 4 through 8, including marine 4. There are a few exceptions, however: Vapor retarders are not required on any below-grade or basement walls or in an assembly that is not damaged by moisture or frozen moisture. Some spray foam applications also satisfy the vapor-retarder requirement.

Table R702.7(2) (not shown here) describes where you can and cannot use a specific class of vapor retarder in a wall assembly. Class I and II vapor retarders should not be used in climate zones 1 and 2 (at least, not on the interior side of the wall). The reasoning has to do with vapor drive. The direction vapor moves in areas with higher outdoor heat (and humidity) is inward, toward the cooler and less-humid interior of the building. A low-permeance vapor retarder on the interior (this even includes some wallpaper) will trap this inward drive of moisture inside the wall, which may cause moisture-related problems.

A Class I vapor retarder should not be used in climate zones 3 and 4 (excluding marine 4). These areas can use a Class II or Class III vapor retarder. The remaining climate zones can use Class I or II vapor retarders, or a Class III in certain instances.

There are footnotes in Table R702.7(2) that pertain to Class I and II vapor retarders. The first of these (footnote a) states:

“Class I and II vapor retarders with vapor permeance greater than 1 perm when measured by ASTM E96 water method (Procedure B) shall be allowed on the interior side of any framed wall in all climate zones.”

This footnote is certainly confusing to a lot of builders: We just learned in Section 702.7(1) that Class I and II vapor retarders will be less than 1 perm, but footnote a tells us we are allowed to use a Class I or II vapor retarder that's more than 1 perm. This contradicts the definition. As it turns out, it comes down to the procedure for the ASTM E96 test, for which there are two different methods. Procedure A is the dry-cup test, which is the standard test for determining the permeability of vapor-retarder materials. Procedure B is the wet-cup test. A material tested under Procedure A can test under 1 perm, and that same material tested under Procedure B can test over 1 perm. These materials that can have two different perm ratings are the smart

(responsive or variable) vapor retarders. Why the code has chosen to describe these products by listing them as ASTM E96 Procedure A or B, which most builders are not familiar with, is beyond me. Maybe this will be changed in future code editions.

There are a couple of other footnotes to Table R702.7(2). We are permitted to use Class I and II vapor retarders in the climate zones marine 4 through 8, with a couple of qualifiers. If you are using a Class I interior vapor retarder in conjunction with a continuous exterior insulation product that is also considered a Class I vapor retarder, you'll need to provide the code officials with some sort

CONTINUOUS INSULATION WITH CLASS III VAPOR RETARDERS

Climate Zone	Class III Vapor Retarders Permitted for:
Marine 4	Continuous insulation with R-value > 2.5 over 2x4 wall
	Continuous insulation with R-value > 3.75 over 2x6 wall
5	Continuous insulation with R-value > 5 over 2x4 wall
	Continuous insulation with R-value > 7.5 over 2x6 wall
6	Continuous insulation with R-value > 7.5 over 2x4 wall
	Continuous insulation with R-value > 11.25 over 2x6 wall
7	Continuous insulation with R-value > 10 over 2x4 wall
	Continuous insulation with R-value > 15 over 2x6 wall
8	Continuous insulation with R-value > 12.5 over 2x4 wall
	Continuous insulation with R-value > 20 over 2x6 wall

Adapted with permission from Table R702.7(3) of the IRC. This table shows the requirements for insulation used to control moisture when using a Class III vapor retarder, such as poly, on the interior side of the wall. According to a footnote in the original table, the insulation materials used to satisfy this option (a Class III vapor retarder) contribute to but do not supersede the thermal envelope requirements of Chapter 11.

of engineering or analysis showing the design will not trap moisture between the two vapor retarders. In other words, you'll need approval (footnote b).

Another qualifier, footnote c, says, "where a Class II vapor retarder is used in combination with foam plastic insulation sheathing on the exterior side of framed walls, the continuous insulation shall comply with Table R702.7(4) and the Class II vapor retarder shall have a vapor permeance greater than 1 perm when measured by ASTM E96 water method (Procedure B)." Again, the ASTM E96 water method (Procedure B) refers to a "smart" vapor retarder. This footnote will eventually get us to Table R702.7(4), but first, let's look at Table R702.7(3), which covers Class III vapor retarders and when they can be used in marine zone 4 through zone 8.

Using Class III vapor retarders. A simplified version of Table R702.7(3) is shown on the opposite page. Here, we see when we can use continuous insulation to move from the required Class I or II vapor retarder to a Class III, painted drywall. (There are also options in the original table to add vented cladding, such as vinyl or brick veneer, to an assembly, but I am not going to cover vented cladding or vented rainscreens. In this article, we will just concentrate on continuous insulation.)

Table R702.7(3) in the IRC shows the conditions when a Class III vapor retarder is permitted. This table is creating more confusion by seeming to contradict the insulation requirements in Chapter 11 (Table R402.1.3). The table has lower continuous insulation R-value requirements than the table in Chapter 11 for climate zones marine 4 through 6. Why? It states this in a footnote: "The requirements in this table apply only to insulation used to control moisture in order to permit the use of Class III vapor retarders. The insulation materials used to satisfy this option also contribute to but do not supersede the thermal envelope requirements of Chapter 11."

As an example, in climate zone 5, you can use R-5 continuous insulation in a 2x4 framed wall to control moisture if you use a Class III vapor retarder, but per Chapter 11 (Table 402.1.3), R-10 is the minimum R-value of continuous insulation for a wall with R-13 cavity insulation. (The table also bounces back and forth between listing a 2x4 or 2x6 wall, then moving to R-13 and R-20 cavity insulation, causing more confusion.)

Using Class II vapor retarders. The last table in the vapor retarder section (Table R702.7(4), above right) is another table that does not line up with the insulation requirements of Chapter 11.

Table R702.7(2), which told us where we can use different vapor retarders, has already shown us we are allowed to use a Class I or II vapor retarder in climate zones marine 4 through 8, and a Class II retarder in

CONTINUOUS INSULATION WITH CLASS II VAPOR RETARDERS

Climate Zone	Class II Vapor Retarders Permitted for:
3	Continuous insulation with R-value > 2
4, 5, and 6	Continuous insulation with R-value > 3 over 2x4 wall Continuous insulation with R-value > 5 over 2x6 wall
7	Continuous insulation with R-value > 5 over 2x4 wall Continuous insulation with R-value > 7.5 over 2x6 wall
8	Continuous insulation with R-value > 7.5 over 2x4 wall Continuous insulation with R-value > 10 over 2x6 wall

Adapted with permission from IRC Table R702.7(4). This table shows the requirements for insulation used to control moisture when using a Class II vapor retarder. Once again, a footnote in the original table states that the insulation materials used to satisfy the option of a Class II vapor retarder contribute to but do not supersede the insulation requirements of Chapter 11.

zones 3 and 4. The table above now lets us know we can use less R-value in conjunction with a Class II vapor retarder, but according to the Chapter 11 insulation requirements, we are *not* allowed to use less R-value than Chapter 11 requires. There's probably some reasoning behind the contradictions of the previous two tables with the energy code R-value requirements, but why confuse most builders with this information? In the building code, insulation requirements trump condensation risk when it comes to continuous insulation. It would be simpler if the insulation requirements and vapor-retarder tables agreed with one another.

We will have to wait and see if the 2024 IRC simplifies vapor-retarder requirements with the energy code. Until then, I hope this article has helped you better understand how to navigate the insulation requirements and rules for using vapor retarders.

Randy Williams is a builder and energy auditor in northern Minnesota. Follow him on Instagram @northernbuiltpro and his blog at northernbuilt.pro.

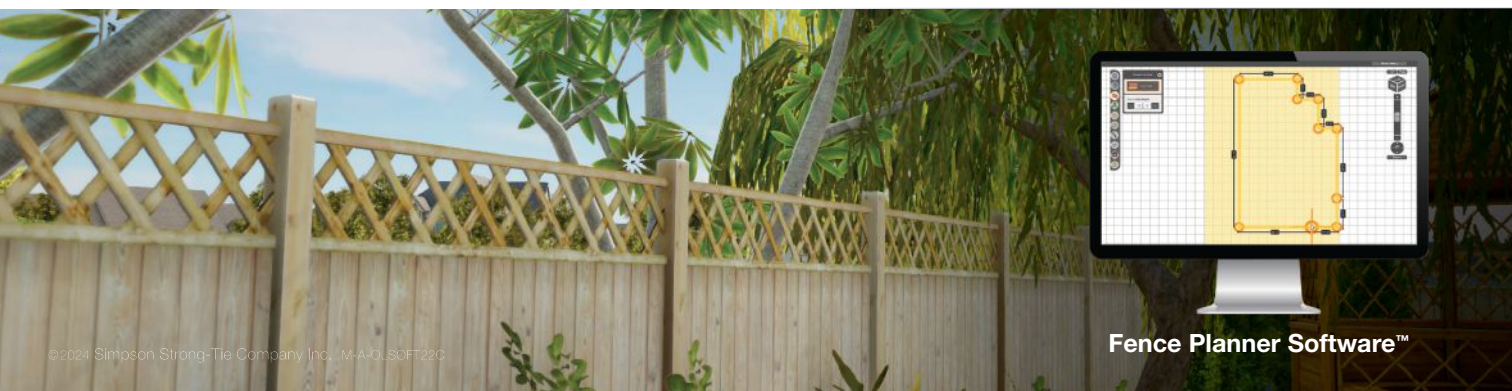
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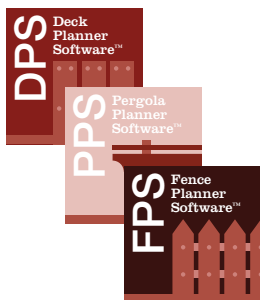
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FOUNDATIONS



Concrete Slab Over Living Space Locating the garage on the main level requires sturdy framing and waterproofing details

BY TIM UHLER

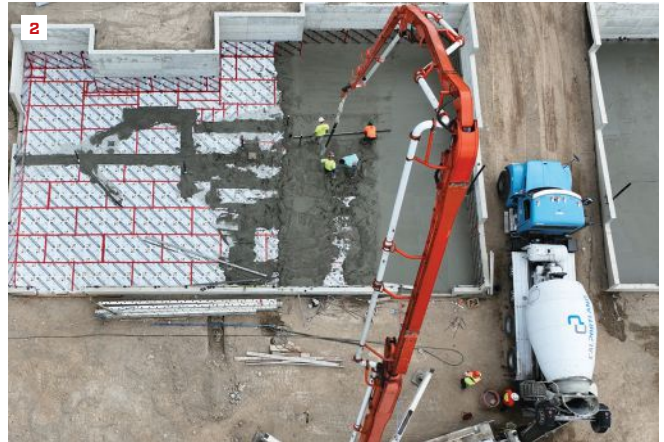
We recently framed a house on a sloped site with a walk-out basement and a garage on the main level. Instead of leaving the area underneath the garage unexcavated and pouring a slab on grade, we decided to take advantage of this real estate and create a roughly 24-by-24-foot living space below the garage slab. In this article, I'll describe the approach we took; keep in mind, we self-perform all of our framing and foundation work.

Engineering considerations. The slab and supporting structure needed to be able to support the weight of the materials and vehicles, but that's not all. The footings and foundation also would need to resist soil lateral loads on the 10-foot-tall foundation walls.

Floor design. We had already planned on using Roseburg I-joists for the home's floor system, and our engineer was able to modify his design to support the slab using 11⁷/₈-inch I-joists 12 inches on-center that sat in joist hangers attached to a 5¹/₄-by-11⁷/₈-inch RigidLam LVL located midspan. This LVL was then supported at each end by a 6x6 column with an expanded footing and by one column in the center of the room below the garage on a 36-by-36-by-12-inch footing. The subfloor itself is 3/4-inch AdvanTech. While we would have loved to eliminate the center column, the depth of the beam needed to provide an unsupported span would have presented headroom issues.

We framed this floor so that it was lower than the main-level

CONCRETE SLAB OVER LIVING SPACE



Shown here are the expanded footings for the columns and bearing walls that will support the framing underneath the garage slab, and the steel reinforcement for the 10-foot-high foundation wall (1). Foam insulation was installed underneath most of the basement slab except over the footings that support point loads (2). A 5 1/4-inch-by-11 7/8-inch flush beam that bears on midspan and end-span columns was installed to support loads from the slab and two cars (3). The crew then hung 11 7/8-inch I-joists from the beam 12 inches on-center (4). Note that the entire subslab floor system is dropped below the main-level floor system to accommodate the thickness of the garage slab.

floor by 6 inches so that the top of the slab could be roughly even with the entry into the house. We chose 6 inches so we could slope from that height to 4 inches in the front at the garage door opening for positive drainage away from the garage. Because the structural design was more than sufficient for the load, there was no reason to specify lightweight concrete.

The I-joists that support the slab are supported by 2x6 walls with studs spaced 12 inches on-center. Because the rear and side walls are shear walls and are anchored to footings, we sheathed them with 7/16-inch sheathing.

Foundation wall design. Across the front of the house, the foundation walls are 10 feet high and therefore have special reinforcing requirements (rebar), along with a footing design that sup-

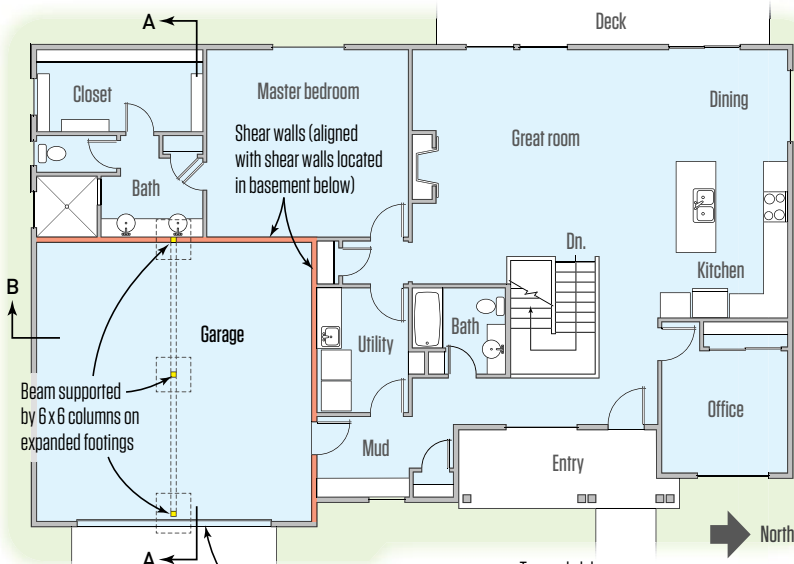
ports not only these walls but also the walls we needed to build under the floor joists around the inside of the basement (1, 2).

While the design featured 10-foot-tall basement walls, the top of the floor system needed to be flush with the top of the mudsill. This means that there is no rim joist along the front of the house; instead, to minimize the height coming into the house, there is only the top of the foundation wall. To execute this design, we had to frame bearing walls along the inside of the house's foundation walls to support the floor system (3, 4).

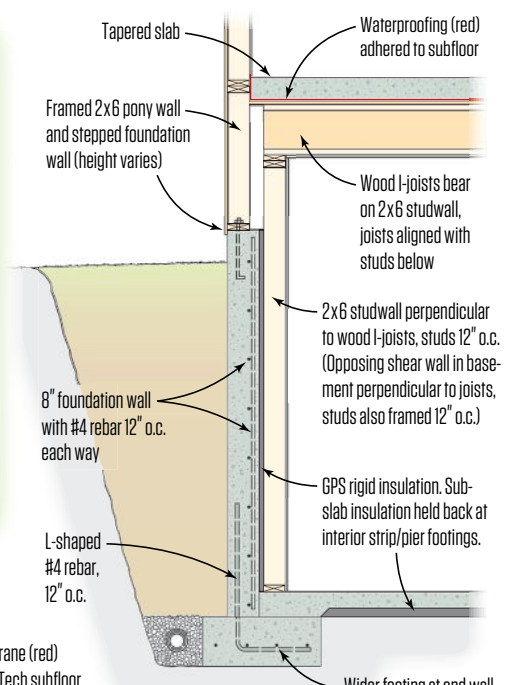
The exterior walls above are bearing on the stem walls. This affected the footing design. The footings are 2 feet wide by 1 foot deep with three #4 rebar running the length of the footing. The footing is slightly biased toward the inside of the house to support

Concrete Slab Over Living Space Details

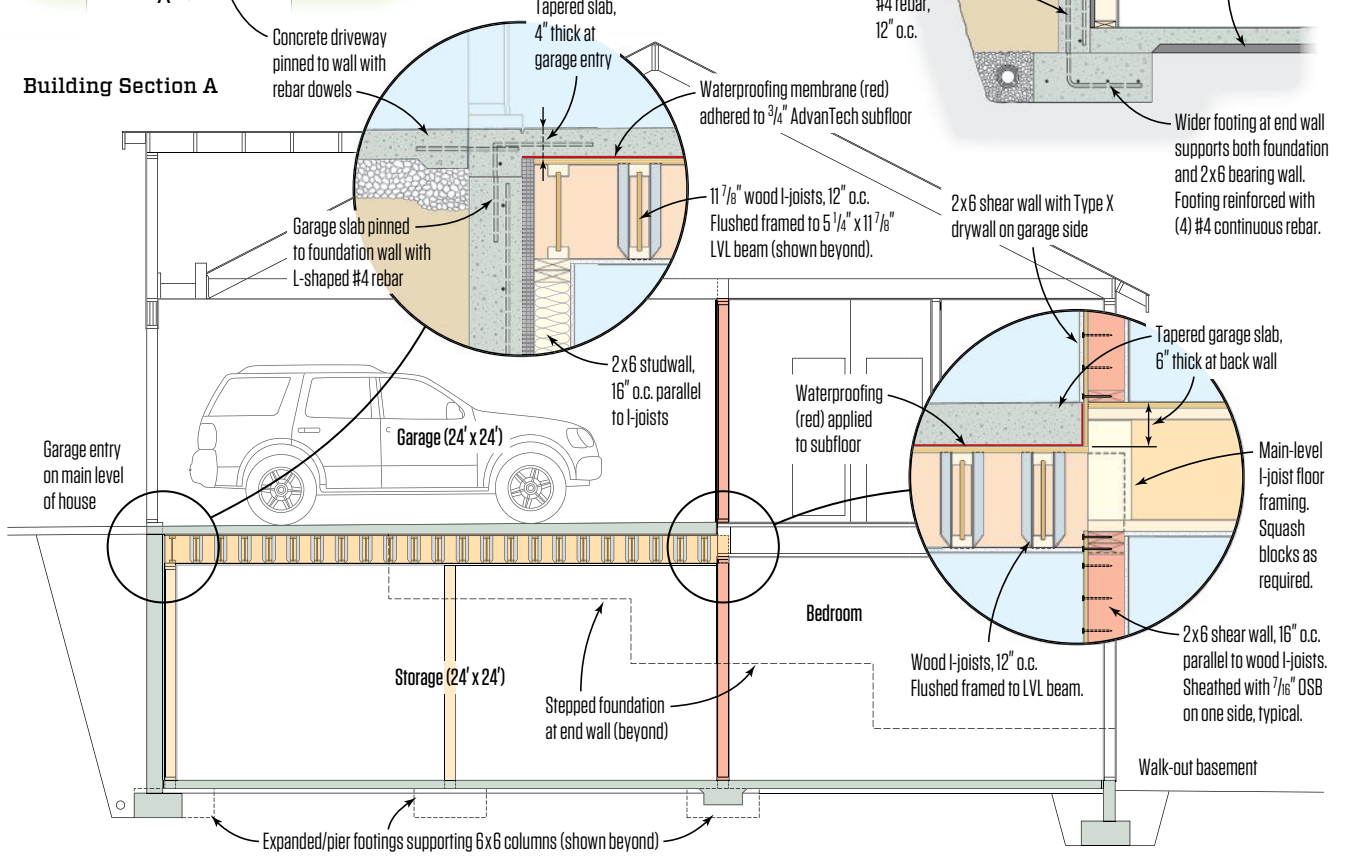
Main Floor Plan



Section B—End Wall



Building Section A



The engineered design for the main-level garage slab includes robust structural details to resist both vertical and lateral loads and a vapor-permeable membrane between the slab and subfloor sheathing. Shear walls are also part of the design.

CONCRETE SLAB OVER LIVING SPACE



The center column was needed to allow the rest of the ceiling below the slab to be flush-framed (5). Here, a worker is installing one of the main-level I-joists above the walk-out portion of the basement at the back of the house (6). The subfloor sheathing at the garage entry (see white arrow) will be cut back to allow the slab to be pinned to the foundation wall (7). The shear walls on the main level were framed so that they are aligned with the shear walls underneath the garage slab (8).

the basement slab and framed walls. On the north/south walls, running parallel to the joists, the footings are 2 feet 6 inches by 12 inches deep with four #4 rebar, again biased toward the interior 1 foot 3 inches. That had mostly to do with the joists running parallel to the foundation wall (5-8).

Slab prep. This isn't the first time we've installed a garage slab over wood framing. I remember a few projects that we completed in the early 1990s with a similar detail, mainly because I had to tediously hand-nail joist hangers for tightly spaced 2x12 joists. On this job, we spent considerable effort raking debris out of the joints in the subfloor sheathing and then cleaning off the dust with a leaf blower (9).

To protect the AdvanTech subfloor from the concrete slab on top

of it, we used a highly vapor-permeable roofing underlayment called SlopeShield Plus SA (vaprosshield.com), designed for mass-timber floor and roof decks. Similar to an ice-and-water-barrier product but vapor open (30 perms), SlopeShield is designed to block bulk-water intrusion but allow long-term drying of a roof or subfloor assembly through vapor diffusion.

SlopeShield measures 20 mils thick and comes in 59-inch-wide-by-102-foot-long rolls. It has a release film backing, and my brother and I were able to install it quickly. There is no need for a primer, and the pressure-sensitive adhesive allowed us to reposition the membrane as needed as we rolled it out and pulled off the release film. As recommended, we used a 100-pound vinyl-flooring roller (that



Before rolling out the subslab membrane, the author raked out the sheathing joints and blew the dust off the subfloor (9). A heavy flooring roller was used to help adhere the SlopeShield Plus SA underlayment to the subfloor (10). The 4,000-psi concrete for the slab was placed without rebar (11). Contraction joints were strategically located, including over the joint where the slab thickness transitions from 10 inches over the concrete stem wall to 4 inches where the rest of the slab is supported by the wood subfloor (12). The slab was given a steel trowel finish and tapers away from the entry into the house for a smooth transition (13).

our flooring contractor let us borrow) to roll out the product; once we did, the membrane was permanently stuck to the subfloor. The roller is definitely a “must use” with this product (10).

Concrete. No special prep was required for placing the concrete because the floor is flat and designed for the load. We use a 4,000-psi concrete mix, which we’ve confirmed with third-party testing at least twice over the years (11).

We elected to go without rebar because it doesn’t prevent cracking, and the underlying structure isn’t going to be moving. Since all concrete eventually cracks, we discussed the locations of the contraction joints with our flatwork subcontractor to make sure any cracking that does occur looks intentional. It’s important to break

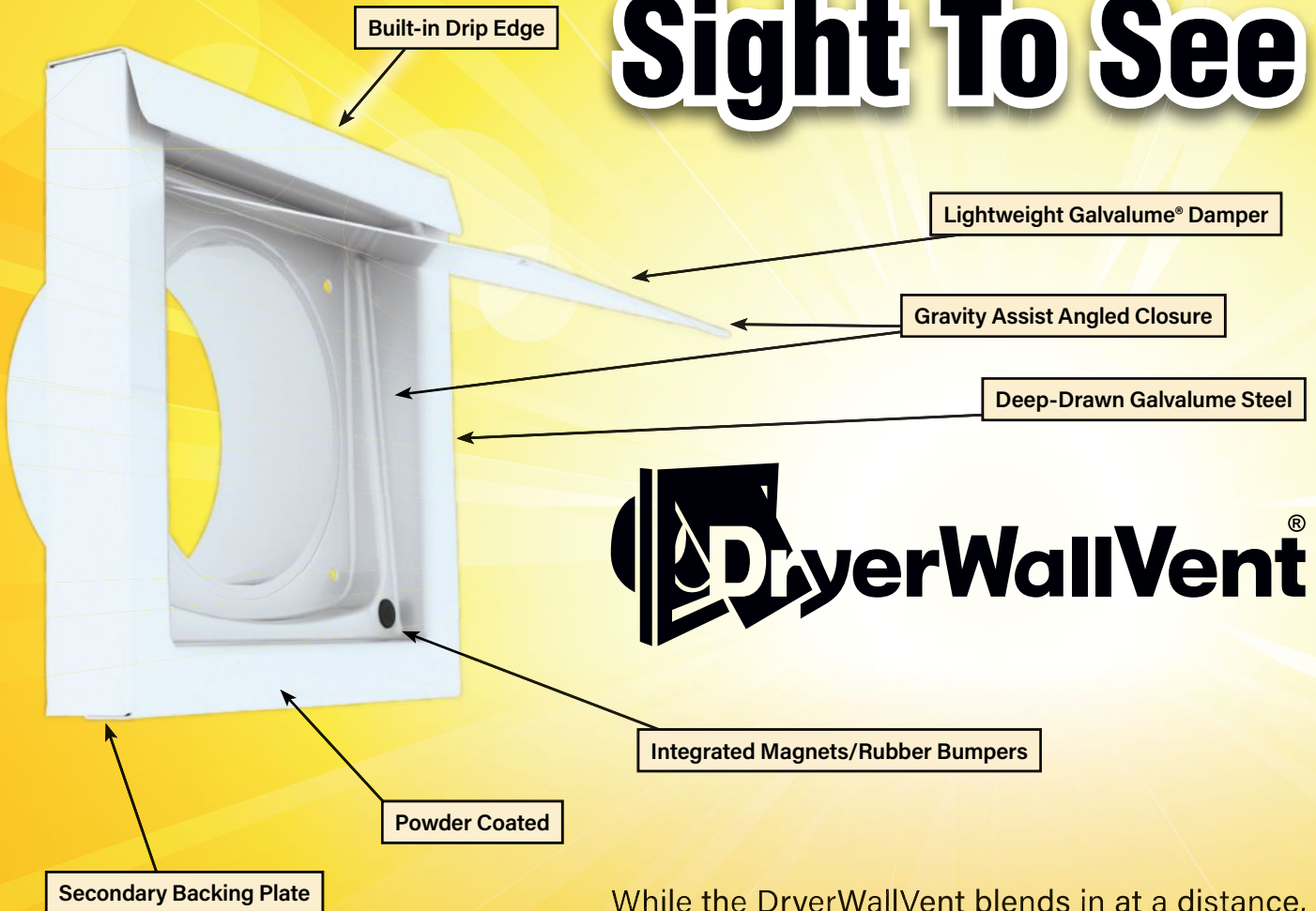
up the area with enough joints to prevent unintentional cracking elsewhere. He does an outstanding job tooling in the joints (12).

The slab tapers from 6 inches thick at the back wall to 4 inches thick at the garage door opening for drainage (there is no center drain). For a flush, wheelchair-accessible transition, we created a slight taper in the slab between the garage slab and the entry from the garage into the house (13).

Tim Uhler is a lead carpenter for Pioneer Builders in Port Orchard, Wash. He is a contributing editor to JLC and Tools of the Trade. Follow him on Instagram at @awesomeframers, subscribe to his YouTube channel, or visit his website: awesomeframers.com.

Upon Closer Inspection Excellence Stands Out

Sight To See

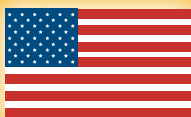


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INTERIORS



Building a Curved Concrete Staircase

This unique architectural feature began with careful formwork

BY JOSH MEPPEN

When it came time to build a “forever” home for my family, I drew on the experience gained over my 15-year career as a project manager for several commercial general contractors and later as the owner of a subcontracting company that erects large-scale, wood-framed buildings for hotels and apartment complexes. For example, in lieu of a traditional wood-framed floor system, I designed our home to have a podium concrete-slab floor system on the main level supported by structural steel and metal “B” Deck over a walk-out basement, a construction technique that we often use on commercial structures.

When we started this project, our kids were in their early teenage years, and we wanted a solid floor system to help reduce the impact sound they made when they were running throughout the house.

This structural feature—more typical of commercial construction—allowed us to be creative with the design of the stair system to the ground-level floor where the kids’ bedrooms would be located. We wanted the stairs to feel like an appealing feature of the house, and not be just a door to the basement. The challenge was that the open staircase we had in mind was designed on a radius; subcontracting it out was beyond our budget.

Photos by Janette Meppen

BUILDING A CURVED CONCRETE STAIRCASE



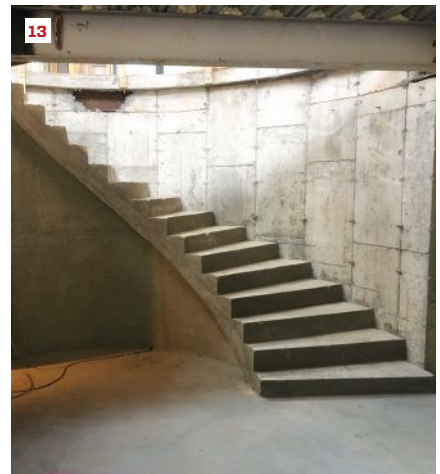
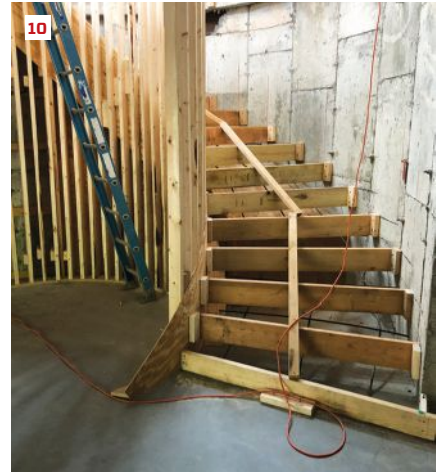
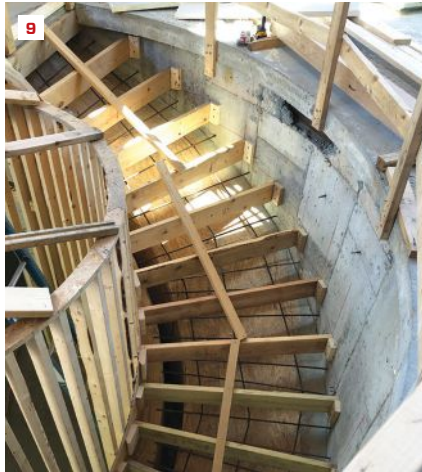
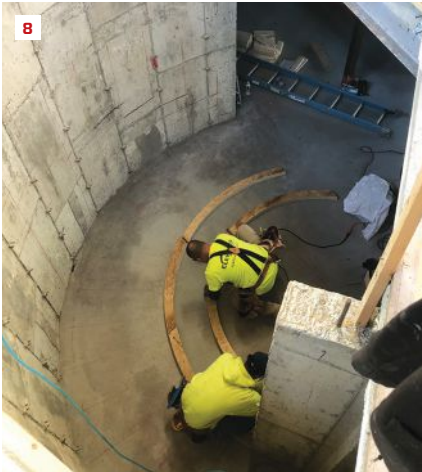
The staircase is supported by a 12-inch-thick footing (1) and enclosed within an 8-inch-thick-by-18-foot-diameter semi-circular poured concrete wall (2). Beveled 2-by strips fill the gaps between the forms on the outside wall (3). Steps formed at the top of the wall (4) allow the steel beams (5) that support the B-deck substrate (6) for the structural first-floor concrete slab (7) to “fly over” the staircase wall without bearing on it.

Having experience building radius walls with bar-and-latch-type concrete forms (advanceconcreteform.com), I knew we could build the stairs more economically out of concrete using in-house carpentry labor. This became the basis of our stair design: a concrete staircase with bluestone treads and natural stone risers. As an added benefit, the area below the stairs would also act as a safe room.

FOOTING AND FORMS

Our first step was to form and place a 1-foot-thick footing below the entire stair system to support the estimated 61,800 pounds of the assembly (1). After the concrete cured, we started forming the full-height curved walls for the staircase, which has a 4-foot 4³/₄-inch inside radius and an 8-foot 6³/₄-inch outside radius.

Forming the walls. We positioned the forms for 8-inch-thick walls following layout lines that we had marked on the footing, using two ties (instead of the normal one) per latch. As we installed the forms, we were able to latch the inner wall forms together, but we left the outer wall forms unlatched. Then we divided the number of gaps in the outer forms by the combined width of all the gaps. This provided us with a consistent dimension for our wood filler strips, which we ripped out of 2-by material, beveling the cuts to a 10-degree angle for a tight fit between forms. As we inserted the filler strips, we used 1/2-inch clips instead of latches to join the forms together, with two clips in place of each latch. Then we installed blocking bridges over the wood strips to hold the panels together (2, 3).



Workers fastened base plates (8) for the two partitions needed to form the stem wall that will support the stairs (9). A third, full-height partition was also built to help form the stair treads, which will cantilever over the stem wall (10). The 4,000-pound, small-stone concrete mix was vibrated carefully during the pour (11). A “safe room” was created under the stairs (12) after the formwork was stripped (13).

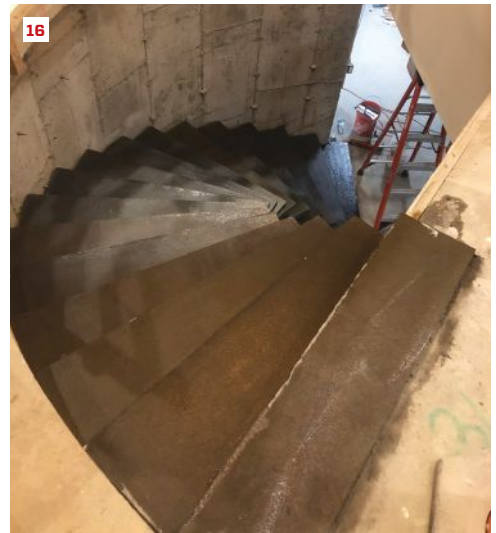
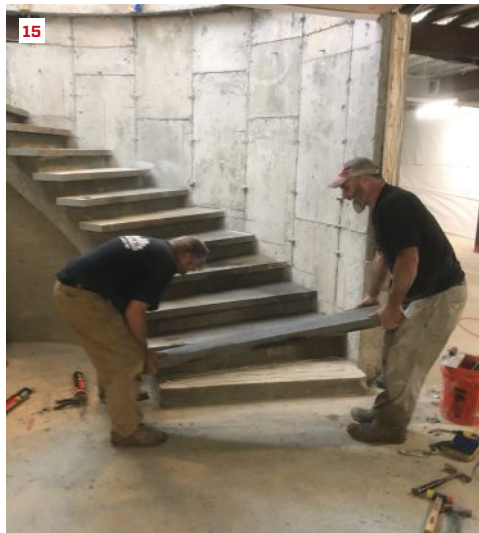
At the top of the radius wall, we formed steps, which were needed so that the structural steel supporting the floor system would “fly over” this wall (4, 5). The radius wall was designed to carry the load of the stairs only and not of the floor above. In podium construction, all of the house loads are carried by the first-floor slab over the Type B metal deck supported by structural steel, which transfers those loads to steel columns and the perimeter foundation walls (6).

Forming the stair opening. Once the structural steel and Type B metal deck structural substrate were assembled, we needed to create the stair opening, which would cantilever past the vertical plane of the large radius wall and the steel. For this, we infilled and formed the opening with temporary partition walls, wood joists, and plywood. Then we placed the concrete for the structural slab floor (7).

Radius stem walls. Next, we formed the radius stem wall on the open side of the stairwell along with the stair steps in preparation for a monolithic concrete placement. The layout needed to comply with a couple of IRC sections for winder treads; one is R311.7.4 Walkline, which states: “The walkline across the winder treads shall be concentrated to the curved direction of travel through the turn and located 12 inches from the side where the winders are narrower.” The other relevant code section is R311.7.5.2.1 Winder Treads, which states: “Winder treads shall have a depth of not less than 10 inches measured between the vertical planes of the foremost project of adjacent treads at the intersections with the walkline.”

Once we had determined the layout, we snapped lines on the floor and also vertically on the concrete walls so that the layout

BUILDING A CURVED CONCRETE STAIRCASE



After cutting the rectangular, 2-inch-thick bluestone treads to fit, workers installed them from the top down (14), setting them with landscape adhesive (15). The top tread fit in a notch cast into the landing of the first-floor structural slab so that it would be flush with the porcelain-tile finish floor. All the treads were treated with a stone impregnator and sealer (16).

would stay true when we were ready to form the steps against the full-height wall. We cut the baseplates and top plates out of 1-inch-thick AdvanTech sheathing and fastened the baseplates to the concrete floor with Tapcons (8).

We built three temporary partition walls to act as forms for the treads and for the stem wall that would terminate below the concrete mass for the stair system itself. We constructed the innermost wall full height to allow for the narrowest part of the stair treads to be cantilevered over the stem wall so that the stone façade in the lower floor level would have a termination point. Then we built the two partitions for the stem wall, with 2x4 studs located 6 inches on-center (9).

To sheathe the partition walls to make the forms, we first applied 1/2-inch plywood to the inner face of the small inner partition below the stairs. Then we temporarily removed the system off the bottom plate so that we could sheathe the inner face of the other partition wall and wrap the full-height wall with plywood. Then we dropped the small partition back into position.

We transferred the locations of our tread ends to the vertical walls and formed the underside of the stair system 8 inches below the bottom of the tread forms. We anchored the tread forms to the partitions and the concrete wall, applied form release to all surfaces, and then drilled and epoxied #5 rebar into the full-height concrete walls (10).

PLACING THE CONCRETE

When laying out the forms, we paid close attention to IRC Section R311.7.5.1, which notes that “the greatest riser height with-

in any flight of stairs shall not exceed the smallest by more than 3/8 inch.” Knowing this, we had to be as accurate as possible with the placing and finishing of the concrete.

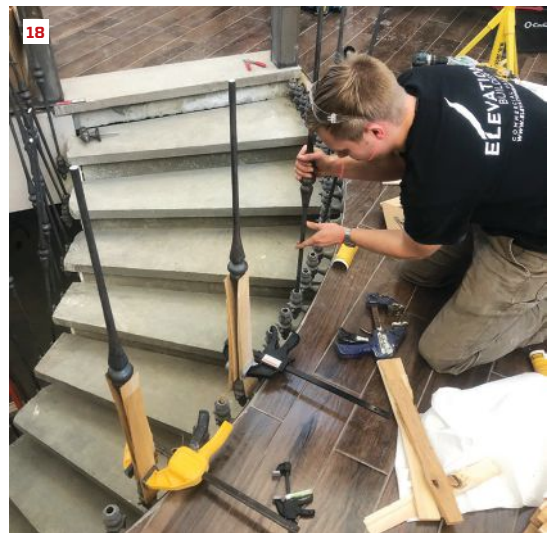
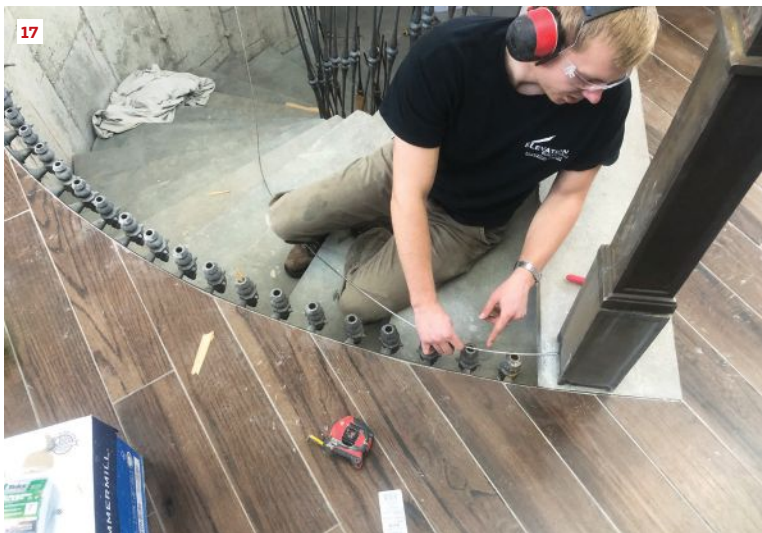
We ordered a 4,000-pound, small-stone concrete mix with a 5-inch slump for the pour. To eliminate voids, we carefully and thoroughly vibrated the poured concrete, starting at the bottom and working our way up as we placed it. In all, the stairs and pony wall took about 4 1/2 yards of concrete (11, 12).

The next morning, we removed the risers before the formwork had a chance to swell and become very difficult to remove. Then we waited another day to strip the temporary walls (13).

FINISH TREADS

We purchased 2-inch-by-18-inch-by-6-foot thermal bluestone treads (Ghent Wood Products, ghentwoodproducts.com) and used a demo saw guided by a straight 2x8 to cut them to size. Because we would be facing the risers and walls with natural stone, we had generous tolerances for making these cuts.

We set the treads with landscaping adhesive, using a laser level for reference and placing plastic shims as needed to ensure the treads were within tolerance. We began with the uppermost tread, for which we had formed a recess notch in the upper floor slab (14). This allowed us to set the tread so that it would be flush with the porcelain-plank-tile finish floor. Then we worked our way down, chipping away the occasional glob of concrete “snot” as needed. After the treads were placed, we sealed them with Miracle Sealants 511 Impregnator Sealer, followed by Behr Wet-Look Sealer (15, 16).



After the baluster brackets were set in place with epoxy and threaded rod, project manager Bryson Gibson used a length of 1/8-inch-diameter wire cable to record the length of the wire-cable handrail and baluster layout (17). Gibson then set up a laser level to establish the tops of the balusters, which were set with epoxy in their brackets and then clamped in place (18) to prep for installation of the wire-cable handrail.

BALUSTRADE

We anchored Azek trim boards to the edge of the stair opening in the upper slab and the stringer of the open side of the stairwell with Tapcons, then patched the holes with Bondo. We didn't need to use heat blankets on this project to make the Azek more pliable but would recommend them if it needed to be bent to a tighter radius.

I had spent many months grappling with the question of how to build a baluster and railing system for a lower cost after receiving quotes in the neighborhood of \$25,000 for a traditional wood railing system. But then I remembered a house that I had grown up in that my father had built that had a steel cable for a railing system. After some online research, I found Westech Rigging (now known as Bishop Lifting, lifting.com), which carries the perfect cable rail for this application: 1 1/4-inch-diameter swaged wire rope with a smooth edge, commonly used in the logging industry.

More research to find all the other components, such as newel posts, balusters, and baluster brackets, led me to DJA Imports (djaimports.com). The biggest challenge was figuring out if we were going to anchor the balusters directly into the porcelain tile and bluestone or use some other method. After searching DJA's website and grappling with this step, we landed on cast-iron side-mount baluster brackets with a 3/8-inch-diameter female thread on the back of the flange for attachment into the stringers and upper landing. For the newel posts, we used a two-piece cast-iron product, also from DJA. For the balusters, we found wrought iron, 9/16-inch-diameter round pickets on clearance at DJA for \$8.03 per piece.

Assembly. When we installed the newel posts, we had to take care that they were on the correct plane so that the side-mount

brackets and cable handrail would land in the center of the newel posts. Knowing that welding cast iron is difficult, we decided to join the two components of the posts together with epoxy, then fill the posts with concrete and two pieces of #4 rebar. With the rebar protruding out of the bottom, we let them cure upside down. We then drilled holes into the bluestone and concrete slab to accept the rebar, and set the posts with DeWalt AC100+ Gold Quik-Shot two-part acrylic epoxy adhesive.

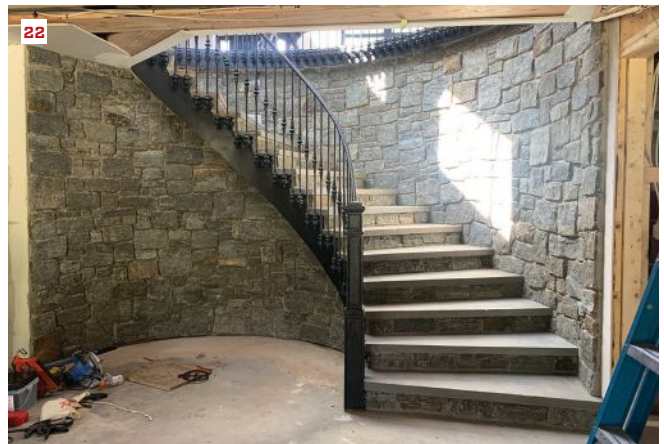
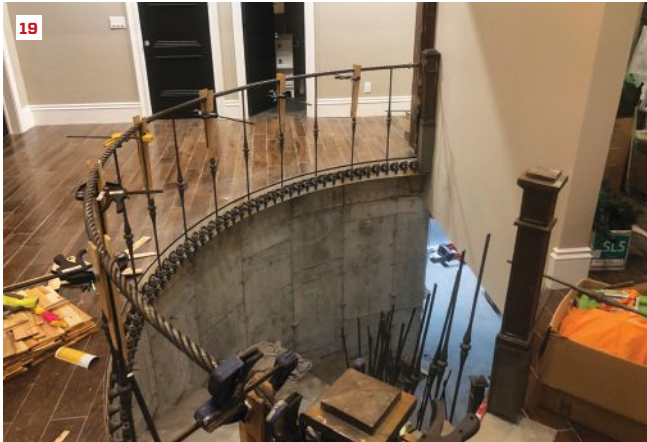
The next step was to lay out and install the side-mount brackets. For the upper landing, we used a laser to mark out a horizontal line and marked every 4 inches on-center. We then drilled 3/8-inch-diameter holes through the Azek and concrete for 3/8-inch-diameter-by-6-inch lengths of threaded rod. We assembled the threaded rod into the back of the side-mount flanges, injected the drilled holes with DeWalt epoxy, and inserted the side-mount brackets into the holes, using a laser to ensure that the brackets were plumb.

Handrail. To make sure we cut the wire rope to the correct length, we first used a 1/8-inch-diameter wire cable as a template, laying it across the brackets and holding it in place with clamps. We marked the centers of the brackets on the cable so that the marks could be transferred to the wire rope (17, 18).

Knowing that steel can't be welded to cast iron, we planned to attach the wire rope to the newel posts by cutting it 3 inches longer on each end and then cutting back 3 inches of the outer core at the ends, leaving the center core of the wire cable intact. Then we could insert the center core into a hole drilled into the concrete-filled cast-iron newel post.

Logger's cable/wire rope is manufactured and shipped with

BUILDING A CURVED CONCRETE STAIRCASE



The stripped ends of the wire-cable handrail were inserted into epoxy-filled holes in the newel posts, and held in place with clamps on top of the balusters (19). Then the remaining balusters were installed, with the ends of the balusters welded to the handrail (20). The balustrade was primed and finished with two coats of acrylic coating (21), while natural stone veneer was applied to the risers and walls (22).

grease, which must be removed before installation. While we hand-sprayed the rope repeatedly with mineral spirits and wiped it down, it would have been better if we had soaked the cable to remove the grease inside the core. We discovered this problem later when welding the balusters to the rope, which resulted in small puddles of melted grease.

Balusters. The cast-iron side-mount brackets had some variation in the baluster pockets. On the upper landing, we set up a laser to the correct height of where the bottom of the wire-rope handrail would be located and measured, numbered, and cut each baluster to its correct height. After injecting the newel posts with epoxy, we inserted the ends of the wire rope into them. We supported the heavy cable at the proper height by placing a baluster every 2 feet or so, clamping the balusters to the wire rope and securing their bottom ends into the side-mount brackets using epoxy (19).

We followed the same procedure when installing the handrail on the stairs, though we also had to twist the rope to make the curve up from the lower newel to the upper one. Then we welded the balusters to the wire rope, following the lines that we had marked with the help of our 1/8-inch-diameter template (20).

After cleaning up the welds with an abrasive flap disk mounted in an angle grinder, we applied a thin epoxy overcoat by hand. Then we primed and painted the railing system. Instead of spraying the finish on, we used a sock to apply one coat of Sherwin-Williams Pro-Cryl-Universal acrylic primer, and two finish coats of its DTM Acrylic Coating in semi-gloss black (21).

Finally, we applied natural, 1 1/2-inch-thick stone veneer from Chippewa Stone (chippewastone.com) to the risers and walls (22).

Josh Meppen owns Elevation Builders in East Greenbush, N.Y.



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The 2023 JLC Editorial Index contains listings for feature articles, selected departments, product reviews, and tool reviews. References are listed by topic rather than by article title. The following codes are used to help you find information:

* — In-depth coverage

L — Letters

Q — Question and Answer

P — Product information

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BY VINCENT SALANDRO



1. Bathroom Vanity Collections

Hardware Resources added three new collections to its Jeffrey Alexander Vanity line. Vanities in the Dashwood collection (pictured) sport a mid-century modern design with straight lines and tapered legs; Pascal vanities have a square metal frame with an open bottom shelf; and Jubilee vanities celebrate minimalism with clean lines and Gola-style hardware hidden by the door or drawer front. Each collection is available in a range of finishes in 24-, 30-, 36-, 42-, and 48-inch single-bowl models and a 60-inch double-bowl model. hardwareresources.com



2. High-Performance Composite Roof Tiles

Brava composite roof tiles, available in cedar shake, slate tile, and Spanish barrel tile, are fabricated with UV protection to prevent degradation, according to the manufacturer. The tiles—approved for use on buildings in Miami-Dade County—carry a Class 4 impact rating and are tested and approved to withstand wind speeds of 188 miles per hour with nails and up to 211 miles per hour with high-wind, screw installation. bravarooftile.com



3. Noise-Reducing Jobsite Earmuffs

With a noise reduction rating of 23, Situational Awareness Bluetooth Earmuffs from Klein Tools are ideal for loud jobsites. According to Klein Tools, users can still safely listen to their surrounding environment to be aware of potential hazards and to communicate with co-workers, and a noise-canceling microphone eliminates background sounds for clear calls. The headphones retail for \$100. kleintools.com



4. Stand-Up Screw Fastener

Users can drive large structural screws while remaining in a standing position with the Timber Drive Structural Screw Fastening system. Suited for building decks, docks, piers, flooring, and other jobs that require repetitive fastening, the tool can be used with corded or cordless motors to drive structural screws in a variety of sizes, thread types, and head styles. The nosepiece can be configured either with a nose plate for face-fastening or with a precision-placement tip for fastening metal connectors to wood. strongtie.com

Products

5. Large-Format Paver Tiles

Aspire Pavers (formerly Azek Pavers) has introduced a larger, 16-by-16-inch size, which can cover an area more quickly, reducing labor requirements. Fabricated with post-consumer recycled materials, including recycled scrap tire rubber and plastics, the pavers interlock with four mounting grids and add design options to a lineup that also offers 4-by-4-, 4-by-8-, and 8-by-8-inch sizes. Among the available colors are more conventional options like ivory, charcoal, obsidian, and terra cotta, as well as a few brighter colors like deep-sea blue and moss green. aspirepavers.com

6. Recyclable Work Tarp

Recyclable tarps and drop cloths made from a low-carbon coated fabric are Renegade Plastics' alternative to common polyethylene tarps. Free from lead, phthalates, dioxins, PFAs, and heavy metals, the industrial-strength polypropylene-based tarps provide maximum UV stability, according to the manufacturer, and can be used in a variety of applications, including renovation projects. Multiple sizes are available, including 6 by 8 feet, 8 by 10 feet, 9 by 12 feet, 10 by 10 feet, and 12 by 20 feet. renegadeplastics.com

7. Wi-Fi-Enabled Smart Outlet

Leviton's SmartlockPro Smart Ground-Fault Circuit Interrupter (GFCI) Outlet sends users notifications via the My Leviton app when the GFCI trips. The smart outlet, which has an optional audible alarm, can be combined with other My Leviton-enabled devices to build a whole-home smart solution. The device prevents reset if the GFCI is not wired or operating correctly, while tamper-resistant shutters help to prevent the accidental insertion of objects. A 15-amp outlet costs \$45 on Leviton's website. leviton.com

8. Handcrafted Glass Tiles

Lunada Bay Tile's Haisen Collection is handcrafted by melding streams of colored glass. Available in a variety of patterns, colors, shapes, and finishes, tiles are made from 70% post-consumer recycled glass and are mounted on paper. The tiles are suitable for many applications, including interior walls, backsplashes, fireplace and cooktop surrounds, shower walls, exterior walls, pool features, and shower floors. lunadabaytile.com



9



9. Wood and Composite Deck Screws

Grip-Rite has introduced a couple of exterior screws, both of which feature PrimeGuard Nano Coating to help resist corrosion from exposure to weather. DeckForce exterior wood screws, designed for fastening wood decks and fences, have a T-17 auto-pilot tip, dual-action auger threads, a diamond-file shank, and a wedge-lock head. DeckForce exterior composite screws, for composite and PVC decking, have aggressive saw teeth, a T-17 saw tip, clear-out threads, and an undercut head to prevent bulging. The screws are available in limited distribution at Lowe's. grip-rite.com

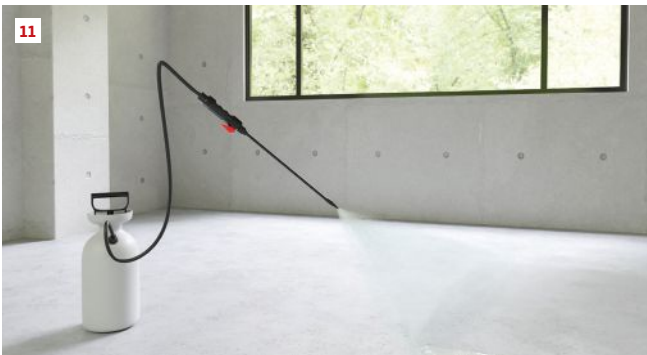
10



10. Exterior PVC Panels

Extending the brand's interior Slatpanel series, The Wood Veneer Hub launched exterior panel offerings. The composite PVC panels—available in oak, walnut, gray, and black—feature a 3D wood grain to mimic natural wood. According to the manufacturer, the tongue-and-groove panels cut easily to size, keep fasteners hidden, and sport a waterproof, polymer coating that promises low maintenance. thewoodvenerhub.com

11



11. Concrete Vapor Spray

Protecto Seal Vapor Block is a spray-applied permanent sealer formulated to penetrate concrete surfaces. The manufacturer claims that the sealer seeps approximately 1 inch below the concrete surface, allowing for surface repairs to occur after application without impacting the integrity of the seal, as well as protecting against through-slab moisture vapor emissions to provide a suitable substrate for Protecto Wrap's Flooring Underlayments. protectowrap.com

12



12. Self-Adhering Waterproofing Membrane

Tarco's LeakBarrier BG700 modified bituminous membrane has a nominal thickness of 60 mils (1.5mm) with two layers of waterproofing: an SBS-modified bituminous layer and a high-strength, cross-laminated, high-density polyethylene film layer. The membrane is suitable for below-grade waterproofing applications and for use under siding, wall flashing, or exterior plaster, as long as it is protected from prolonged exposure to UV. According to the manufacturer, the self-adhering, self-sealing membrane adheres well to a variety of materials. tarcoroofing.com

Two-in-One Worktable

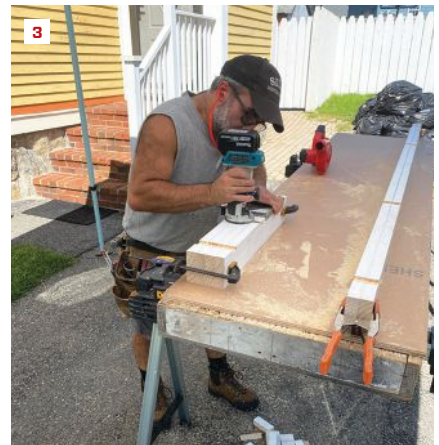
BY EMANUEL SILVA

One of my most useful jobsite tools is the easy-to-build worktable shown in this article. I've made several variations on the basic design over the years as I've fine-tuned its features. For example, my first worktables were simple frames, some with plywood tops and some without; a top skin provides a useful work surface, but it's easier to make rips and cross-cuts on an open frame without damaging it. My current model incorporates both features and can be flipped to either side depending on the task at hand.

When I built this latest version, I used a track saw to rip a sheet of 1/2-inch MDO in half, making it possible to assemble two 24-inch-wide tables at the same time (1). At around \$80 per sheet, primed MDO isn't the least expensive table-top option, but it's rugged and

stands up well to weather. I usually cut a few inches off the ends of the ripped panels to make the tables a little shorter than 8 feet so that they will fit more easily in the back of my box truck.

Frame. I made the frames out of three 16-foot lengths of primed 5/4x4 stock, cutting all of the pieces for both tables to length at the same time. Before assembling the frames, I clamped the four long stiles (two for each table) and eight shorter rails (two end rails and two intermediate rails per table) together (2) and laid out the locations for approximately 1 1/2-inch-wide slots in the edges of the stiles and rails. By simply aligning my cut line with the slots, I can make cuts either along or across the frame without making saw kerfs in it. Of course, eventually the edges of the frame will be riddled with



Photos by Emanuel Silva

Weigh In!

Want to test a new tool or share a tool-related testimonial, gripe, or technique? Contact us at jlctools@zondahome.com.

saw kerfs, but as long as they aren't too deep, they won't affect the frame's integrity.

I used a router with a straight bit to make the slots 1/2 inch deep, first scoring the layout lines with a utility knife to prevent blowing out the edges of the 5/4 stock (3).

You could fasten the frame together with toe screws, but I prefer to use exterior-grade pocket screws because I think they make a stronger connection. Probably a pair of screws at each joint is adequate, but I added a third one for a little extra strength. I didn't bother using glue, but you could. I used a Kreg portable pocket-hole jig to make the holes, for both the stile-to-rail connections and the connections between the frame and the MDO top skin (4, 5).

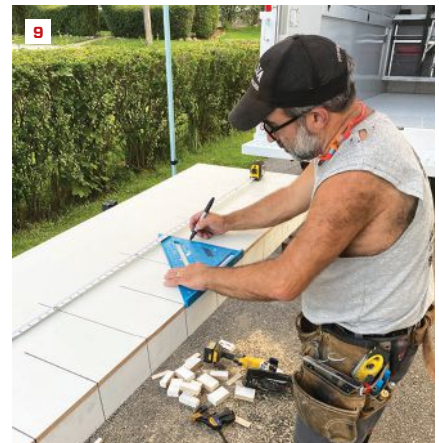
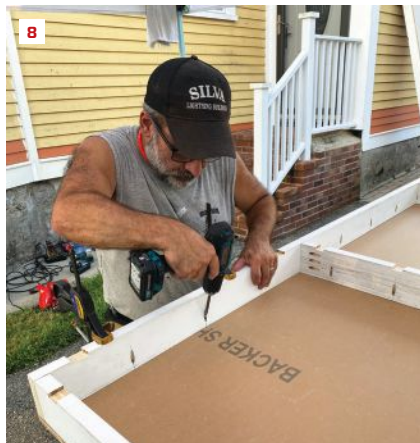
Top skin. After I assembled the frame with 1 1/2-inch-long, exterior-grade, coarse-thread Kreg screws (6, 7), I placed it on top of the MDO skin so that the edges were aligned. I used shorter, 3/4-inch-long pan-head screws to fasten the frame and top skin together (8).

The shorter screws are needed to avoid penetrating through the 1/2-inch-thick sheet stock, and require a Kreg Micro-Pocket drill guide for drilling the pocket holes.

Then I flipped the table over and marked layout lines on the top skin with a Sharpie permanent marker every 6 inches on-center. On the 1-foot intervals, I extended the lines the full height of my layout square; in between, I drew the lines only 6 inches long. I also extended the lines onto the sides of the table, making it possible to read them even when the table is covered (9, 10).

For about \$200 in materials and a couple of hours of labor, I built two tables that will stand up for years to daily use and abuse on the jobsite—a pretty good investment (11, 12).

Emanuel Silva, a JLC contributing editor, owns Silva Lightning Builders in North Andover, Mass. Contact him at silvalightningbuilders@gmail.com or follow him on Instagram at [@emanuel.a.silva1996](https://www.instagram.com/emanuel.a.silva1996).



Georgia Boot Carbo-Tec LT Work Boots

BY MARK CLEMENT

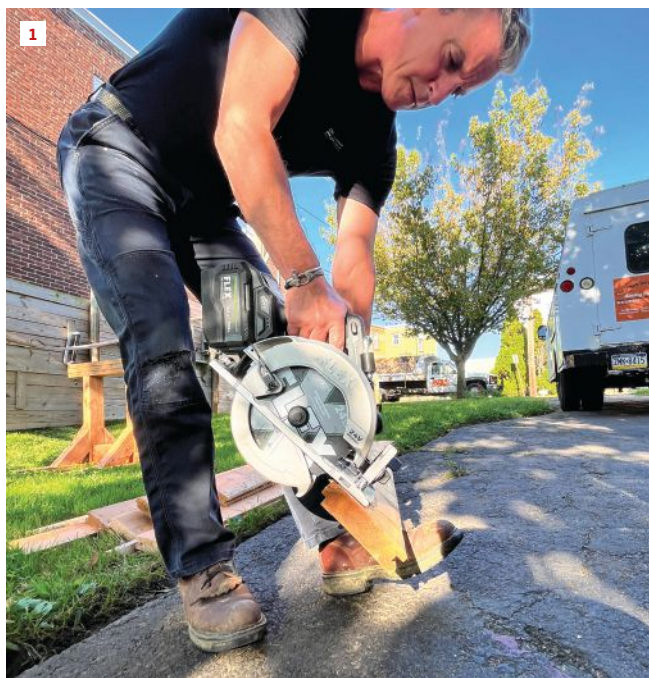
It has taken the lion's share of my career as a deck builder and remodeling contractor to land on a boot style—and price point—that works for me. The combination of features I like is simple: full-grain-leather uppers, rugged sole, 8-inch height, and an unreinforced toe box. (I get the importance of the reinforcement, but a toe that doesn't flex creates as many problems for me as it solves.)

Because I am equally likely to be using a finish nailer as I am a shovel, chain saw, or tractor, I need boots that can go everywhere and support my skeleton along the way. After months of wearing Georgia Boot's Carbo-Tec LT waterproof lacer farm and ranch boots, I can say they are super-comfortable. Unlike the soles on some other leather boots, these have a give to them without being lame. Tough thread binds the outsoles to the uppers, and as much as I like a knobby tire tread, this tread is more two-dimensional and doesn't hold mud like other boots (1, 2).

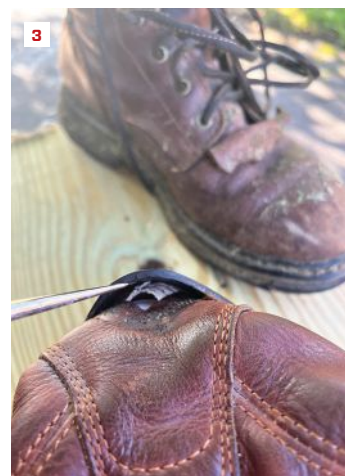
I found these boots to be fully supportive—something I can feel (and appreciate) during and at the end of the day. As an amateur doctor, I lay the blame for lots of aches and pains not on age (yet) but on boots that have overstayed their welcome; boots don't need to be torn up to be used up. And the manufacturer's waterproof/breathable claim is legit. I plod through a lot of puddles and wet grass, and my feet stay dry, the boots don't smell, and my feet aren't wrinkled at the end of the day.

The Carbo-Tec has a hard rubber heel, part of the boot's heel-stabilizing feature. After a hundred miles or more of work, this intersection of materials is where my boots are beginning to show signs of failure (3). That said, all boots wear out, whether developing holes or becoming less supportive (while leather boots don't delaminate like hikers, they do stretch over time and the foot can slosh around a little in there; a problem for the way my body works, possibly not for others). Even so, I'm happy to give Georgia Boot Carbo-Tecs a high grade. They come in medium and wide versions and in pull-on and steel-toe variations too. They have done all the things I need my boots to do, at a price point (\$190) that is pretty awesome for the amount of boot you get. georgiaboot.com

Mark Clement is a deck builder and remodeler in Ambler, Pa. He's the author of The Carpenter's Notebook. Follow him on Instagram at @myfixituplife.



Georgia Boot's Carbo-Tec LT soft-toe, 8-inch work boots are waterproof with full-grain-leather uppers, dual-density, slip-resistant outsoles, and removable polyurethane foam insoles (1, 2). After a few months of hard wear, the author discovered that the rubber heel counter was starting to separate from the leather upper on one of the boots (3).



Photos: Mark Clement

Milwaukee M18 Transfer Pump

BY JAKE LEWANDOWSKI

It's not every day that I need to drain the water from a hole or two, but it definitely happens more times than I am prepared for and lately seems to be a more regular occurrence than usual. In the past, we have used full-blown, heavy-duty electric trash pumps that are hooked up to large-diameter hoses, similar to fire hoses. And for minor water events, a shop vacuum with the air filter removed has generally been fine. Both options worked, but what I really wanted was something small, portable, and—preferably—cordless to add to our core tools.

What I landed on was the Milwaukee M18 (model 2771-20) transfer pump. It isn't a new tool; in fact, I think it's one of the first cordless transfer pumps to come to market. It weighs just under 8 pounds without a battery and has a small footprint, measuring about 13 inches long, so it doesn't take up much space in our job box. Milwaukee states that the nonsubmersible pump's maximum flow rate is 8 gallons per minute and, with an XC5.0 battery, you can expect to pump as much as 240 gallons of water at a rate of 480 gallons per hour on a single battery charge, which seems to be just about right based on our experience. According to Milwaukee, the pump is not designed to be used with flammable fluids such as fuel oil or gasoline; in fact, using it to pump anything other than clear water—think water tanks and hot water heaters—will void the warranty.

One thing I didn't know about and wasn't expecting was a recommendation in the product manual calling

for a 6-foot length of heavy-duty, $\frac{3}{4}$ -inch-diameter hose on the inlet side, while the vast majority of garden-type hoses are considered medium duty and $\frac{5}{8}$ inch in diameter. The concern about using a lighter-duty and more-restrictive hose is the possibility that the pump's suction will cause the hose to collapse. The pump's outlet is also a $\frac{3}{4}$ -inch-diameter brass fitting **(1)**.

To use this pump on our jobsites, we upfit the inlet hose with a filter made from a length of drilled-out PVC pipe with a cap and a PVC hose fitting. We covered the pipe with a laundry lint-trap filter purchased at a big box store **(2)** and wrapped the assembly in filter fabric to prevent stones and debris from clogging up and possibly damaging the pump's replaceable impeller.

We paid full price for this tool, and because it has proven to be so useful, we would buy it again if ours somehow disappeared from the jobsite. With 18 feet of lift (the ability to pull up water that is below the pump) and 75 feet of head height (the ability to raise water vertically above the pump), this self-priming unit has plenty of power to pump water up from a basement footing and away from a building to an alley or ditch. And for its size and weight, it does this much more quickly than I would have expected. \$230 (tool only). milwaukeeetool.com

Jake Lewandowski is a construction manager with his family's business, Great Lakes Builders, based in Chicago, and a contributing editor to JLC.



Milwaukee's cordless M18 transfer pump can move as much as 240 gallons of water on a single charge **(1)**. To protect the pump's impeller, the author assembled an in-line filter out of a length of PVC pipe covered with a laundry lint-trap filter **(2)** and wrapped with filter fabric.

Photos: Jake Lewandowski

BY TOM O'BRIEN

Restoring Box-Head Windows

I've repaired countless antique double-hung windows and pocket doors over the decades but had never laid eyes on a pocket window until a few months ago, when I was hired to tune up the windows in an early 20th-century Dutch colonial. Those in the main part of the house were the typical double-hung variety that simply required smoothing and waxing friction surfaces, lubricating pulleys, and restringing a few sash weights to enable them to operate with the touch of a finger.

The porch was a different story. It was enclosed by a dozen double-hung windows that looked exactly like the others ... until I lifted one of the few operable sashes and watched it disappear completely into the wall above (1). Back when all 12 of these units worked properly, this ingenious design would have empowered the homeowners to transform their porch from indoor to outdoor space—or vice versa—within a minute. And what's more: If uninvited pests flew in to spoil the party, drop-down insect screens (permanently housed in each overhead compartment) could have been deployed just as quickly (2).

This three-in-one window transformer was the brainchild of Edmund H. Lunken, a manufacturer from Cincinnati. Although Lunken never claimed to have invented the pocket (or box-head) window concept, he was awarded numerous patents for his innovations, such as the skinny, two-piece nested screen and thinner, steel-reinforced sashes that afforded space for the screens without requiring thicker walls. He also patented an effective means of weatherstripping the upper sash and lower screen to seal the pocket from air infiltration.

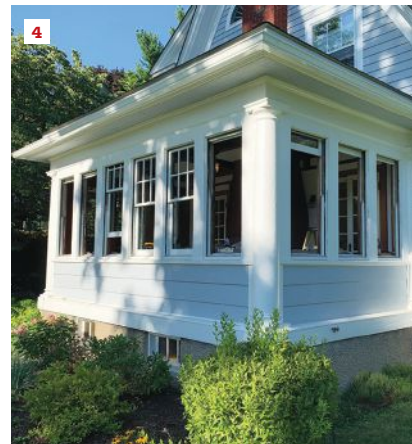
These patents were issued between 1916 and 1918; by 1920, the finished products were advertised for sale (3), and when these state-

of-the-art showpieces were installed on a certain porch in Western Connecticut, they must have been the talk of the town. Sadly, by the time I arrived in the summer of 2023, only 11 out of 48 cords were intact and those were as stiff and faded as the broken ones. It was plain to see that these magnificent 100-year-old windows had fallen into disuse simply because nobody knew how to restring them.

Much like so many of Frank Lloyd Wright's masterpieces that didn't age well, Edmund Lunken's invention was both ingenious and a nightmare to maintain. The poor soul sent in to replace the first broken sash cord—decades after the windows were installed and long after the owner's manual had disappeared—would have encountered three stiff challenges: no access panel cut into the frame; a permanently fixed metal parting bead that did not allow removal of the "upper" sash from inside; and pulleys mounted high up inside the pocket and difficult to access.

Fortunately, I discovered that Lunken had left a trail of breadcrumbs, in the form of brass screws—some of them decorative—to identify particular stops and other components that were designed for disassembly. I ultimately had to remove a total of nine pieces before I was able to get my hands on the first of many pairs of unstrung cast-iron weights. It was also my good fortune to have arms long enough for my fingers to touch the pulleys at the top of the pocket. With practice, I was able to coax a fishing sinker, with a new cord attached, over the pulley and down to the sash weight. After 48 successful restringings, plus the standard tuneup work, all 24 of Lunken's sashes go up, down, or out of sight with the greatest of ease (4).

Tom O'Brien is a carpenter and freelance writer in New Milford, Conn.



Photos by Tom O'Brien



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