



Tool Training: Routers

**Repairing Broken
Load Paths**

Live-Edge Wood Floors

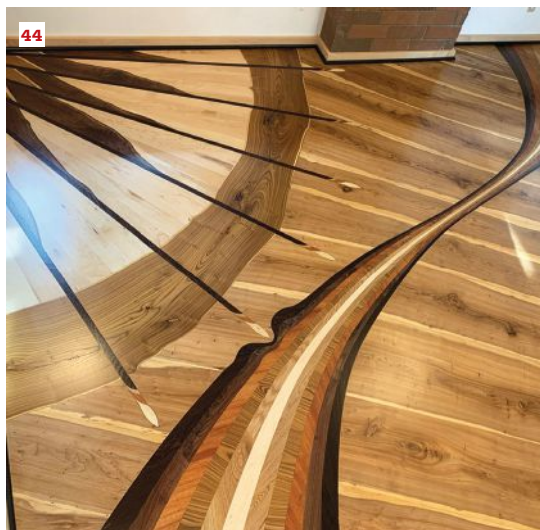
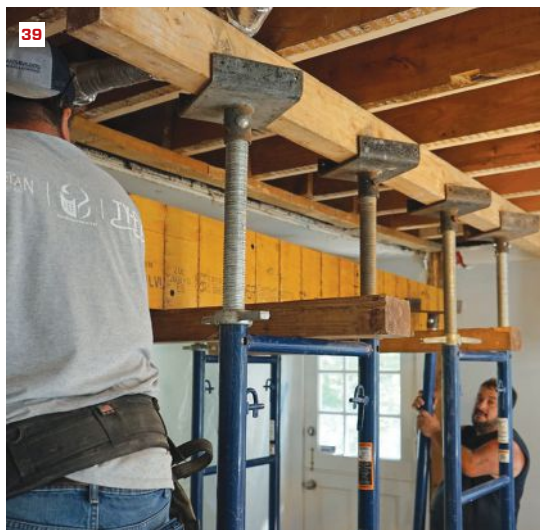
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On the cover: Tommie Mullaney profiles the edge of a mahogany slab—salvaged from Naples Botanical Garden after Hurricane Irma—for a live-edge table top in his Naples, Fla., shop. Photo by Tommie Mullaney. See the story on page 7.

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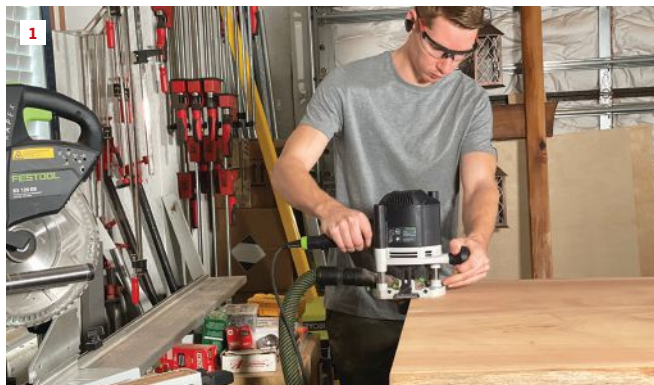
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BY TOMMIE MULLANEY



Whenever using a router, the author wears safety glasses and ear buds that also provide hearing protection **(1)**. Full-size and mid-size routers offer the most power and versatility, but compact routers—which come in both corded and cordless versions—are capable of most tasks **(2)**. The author's Festool routers can be fitted with a chip deflector accessory to improve dust collection **(3)**.

Choosing and Using Routers

Routers are essential tools in my woodworking shop, where I use them to add profiles to the edge of a board, cut dados and rabbets, and trim wood pieces to a precise size and shape. And on the jobsite, they can be workhorses for cutting out window and door openings in sheathing, pattern-cutting decorative rafter tails, and even duplicating stair stringers. As with other tools, however, routers can also cause a lot of damage to you or your workpiece if they are used improperly or unsafely. I've been using routers in my woodworking and trim carpentry business for several years, and in this article, I'll share some of what I know about this versatile tool, the bits that are used in them, and techniques for using them in a safe and controlled manner.

SAFETY FIRST

A router bit spins at speeds of up to 24,000 rpm, which guarantees that wood chips will fly, so eye protection is a must **(1)**. In addition to wood chips and (sometimes) bigger splinters and chunks, routing produces fine dust, so I always like to use dust extraction when I can or a mask when a router isn't equipped to collect dust. And routers are loud, so good hearing protection is important too. For me, Jabra Elite 65T Bluetooth ear buds provide a good combination of sound quality, durability, and noise reduction. Though they don't have an NRR (noise reduction rating) for OSHA certification, they have a snug fit that I find works better than regular ear plugs for blocking out unwanted sound.

The business end of a router—the bit that's spinning up to 24,000 rpm—is sharp but not as visible or obviously dangerous as a spinning saw blade; many tradespeople say because of this, a router is one of the most dangerous power tools. When handling a router, you need to be constantly aware of the cutter as well as what are known as wrap points, where loose-fitting clothing, chains, or loose jewelry poses an entanglement hazard. Avoid wearing these items. If you have long hair, you should always tie it back.

When operating a large router, use both hands to ensure you have full control. And when you are done with a cut, don't place the router on the workbench until the bit comes to a complete stop.



Trim routers with 1/4-inch spindles can only be used with router bits with 1/4-inch shanks; many mid-size and full-size routers come with both 1/4-inch and 1/2-inch collets and can use both 1/4- and 1/2-inch-shank bits (4). The author recommends purchasing bits as they are needed rather than in a boxed set, which might contain bits you'll never use (5). Some routers include a third collet size—8mm—to accommodate 8mm bits offered by some European manufacturers (6).

CHOOSING A ROUTER

Routers come in two basic sizes—those with 1/4-inch spindles and those with 1/2-inch spindles. Both sizes are fitted with collets that thread onto the spindle and clamp around the shank of a router bit. The router I use most often in my work is a compact trim router with a 1/4-inch spindle. With motors cranking out about 1 hp, trim routers can be operated safely with one hand and have ample power to complete most tasks, though the 1/4-inch collet limits bit size somewhat (2).

I use my trim router for smaller mortises and general template work because it's easy to control, which also makes it a perfect entry-level router. I like to use it with smaller bits, like a 1/8-inch-diameter round-over where I can just set the bit height and get to work.

Most mid-size routers can be used with either a 1/4- or 1/2-inch-diameter collet (some brands also include an 8mm collet with the tool). This versatility allows for a wider range of bit sizes—and can save money otherwise spent on duplicate bits with different shank sizes. Rated at 1.5 to 2.25 hp, these routers have plenty of power to turn the majority of router bits. They're common in woodworking shops and are a great, all-around choice. Whenever I tackle a large dado in a built-in, ease the edge of a table with a large, 3/4-inch-diameter round-over bit, or mount the router in a router table, a mid-size router is my go-to choice.

Many mid-size routers are available in combo kits that include both a fixed base and a plunge base. A plunge base offers full height adjustment similar to a fixed base, but it's usually easier to set and can be dialed in to thousandths of an inch. I commonly use a plunge router when I start a cut in the middle of a workpiece, such as when mortising a pocket door slab that has flush-mounted hardware. The plunge ability allows me to slowly and safely lower the spinning bit

into the material with the router base firmly planted on the work surface. Once the plunge cut has been made, a quick turn of a knob or lever locks the router height in place, and after the cut is finished, the bit can be easily retracted out of the material.

Most plunge routers have a lever mechanism to raise and lower the bit, but I prefer a twist knob, as on Festool routers. The knob gives me more control when locking or unlocking the base, and it can also be used as a handle for more control over the tool.

Depth-of-cut adjustment is similar on most newer plunge routers, with a micro-adjustment wheel and a depth stop turret that allows you to dial in three separate depths. The depth stop turret is underrated, but it's indispensable on certain projects, such as when you're installing modern pocket-door hardware that requires mortises with multiple depths. Not only does the turret save time, but it also reduces the chances of plunging to the wrong depth.

Some combo kits include a D-handle base, which some woodworkers prefer because it has a trigger-style on/off switch. None of my routers has this style base, though the pistol grip-style side-mounted handles on my Festools come close. I like that I don't have to take one of my hands off the tool to turn it on or off.

Fixed and plunge bases are typically available for full-size routers too, which have motor ratings of 3 to 3.25 hp. With the higher power comes much more weight; two hands are required at all times to operate these large machines, which are capable of spinning the largest router bits. While these machines are great for deeper cuts and larger bits, they are much harder to maneuver than compact and mid-size routers and can be difficult to use on small workpieces or narrow edges.

Cordless vs. cordless. Battery-powered tools are common on job-sites now, but is a cordless router a substitute for a corded one? While



Before cutting an edge profile with a router bit fitted with a bottom-mount bearing, the author sands the edge of the workpiece to ensure that the bearing has a smooth surface to follow (7). To ensure a snug fit when cutting dados in shelf supports, the author uses a slightly undersized straight cut router bit and guides the router with a Festool guide stop and track (8).

cutting the cord has advantages, any cordless router bigger than a trim router usually struggles to push larger bits, like a 3/4-inch dado bit or even a 2-inch-long flush trim bit. Batteries can drain fairly quickly, so several batteries are needed to make it through a typical workday. A cordless router shines, however, on a jobsite where power is scarce or not easily accessed.

On my cordless router, there is no power lock-out. To prevent the router from accidentally turning on when I'm removing the base or changing the bit, or if the battery dies while in the "on position," I always remove the battery first.

Dust collection. When I'm outside routing a round-over profile on a deck, I don't worry about dust collection. But routing inside a finished home—quite common for hardware installers—is a different matter. That is where dust collection is critical. Protecting a client's home is something you can never do too well, and part of that is keeping the home and your work area clean.

With the right router and accessories, you're not only keeping your client's home clean, you're also protecting your lungs from microscopic levels of dust. And whether you're working in a shop, in a home, or on a jobsite, removing sawdust at the source keeps your router bit cooler. Heat can lead to premature dulling of the cutter and cause burning marks on the wood.

But there's always a trade-off. Dust shrouds greatly improve sawdust collection, but they can distort the view of the bit, making it hard to see (3). Some routers have a small slide that allows you to open up the shroud for better viewing. Another handy feature for working in dimly-lit areas is built-in LED lighting, which most brands—with the exception of Festool—now seem to offer.

The best choice. Over the years, I have bought many routers, both corded and cordless, some with dust collection and some with-

out. When working in the shop or a finished home, I typically use the router with the best dust collection.

If dust collection isn't a priority for you, keep in mind that all of the routers mentioned will complete the same tasks, though some tasks will be easier with a larger motor (which also means more weight). If you're just starting out, consider a trim router. It's light and portable, with power that can be controlled. Trim routers are more forgiving than the bigger plunge routers and capable of completing most tasks in my line of work.

If you have some experience, a mid-size router is also a great choice. As mentioned, this size router gives you more bit choices with the option to choose between two shank sizes. Accessories like collets or dust collection shrouds are also much easier to find.

I recommend full-size routers for experienced woodworkers only. These tools are heavy and powerful, and if they're used incorrectly, things can go wrong quickly. Start small, and work your way up as you gain experience using a router.

BITS

Most router bits are available with 1/4-inch shanks, a size that fits most routers. Bits with a 1/2-inch-diameter shank are better able to withstand the stress and torque produced by the more powerful routers and can plunge deeper into material without the risk of the shank bending or snapping (4).

You don't need to spend a ton of money to get started. Buy router bits as you need them and avoid the large "bargain box" of router bits, as you will probably never use many of them. A variety of straight cut, round-over, and flush trim bits and a 45-degree chamfer bit will get you through most projects. If you find yourself using a particular router bit frequently, spend a little extra coin on the



To make duplicate table-top supports, the author first makes a pattern, using it to trace the support's outline on the workpiece, which he cuts out with a band saw. Then he uses double-sided tape to attach the pattern to the workpiece and finishes cutting it out with a flush trim bit with a top-mount bearing (9). After making the initial cut, the pattern can be removed from the stock and the cut can be completed using the same flush trim bit (10).

higher-end carbide versions. These higher-end bits will result in a better cut and last a lot longer (5, 6).

MAKING THE CUT

When you're installing or changing a bit, always unplug the router or remove the battery. This is a good time to inspect the bit for damage or visible dullness. When inserting the shank into the collet, don't bottom it out but leave a gap of about 1/4 inch between the end of the shank and the spindle as you tighten the collet nut. Some routers require two wrenches to loosen and tighten the collet, while Festool and many other manufacturers now equip their routers with some sort of spindle lock mechanism, which is a lot faster and easier to use.

Unless you are cutting a large workpiece such as a slab or table-top, make sure the material is secured to your workbench. Friction mats and bench dogs enhance holding ability.

For the safest operation, the router should be fed into the workpiece against the rotation of the bit. Going with the direction of the bit is called "climb cutting"; it's an easy way to lose control of your router and can be very dangerous. For example, if you're looking at your router from the top as the router base is sitting flat on the work surface, the bit rotates in a clockwise direction. If you are routing the face of a board or the outside of a frame, you should be routing from left to right in a counterclockwise direction. However, when the workpiece is between you and the router, such as when you're rabbeting a cabinet door frame for a panel, the router needs to move from right to left, so that the bit is always being pushed into the cut.

Never turn on the router with the bit making contact with the material—doing that can bend the shank of the bit or even the router itself. The same rule applies when finishing the cut: Make sure the bit has cleared the workpiece before you shut off the router,

then let the router bit come to a complete stop before you place the router on your workbench.

Profiles. Routing a profile on the edge of a board is an easy technique commonly used in both finish carpentry and furniture making. Examples include rounding over the front edge of a shelf or cutting a top profile on baseboard. To guide the cut and ensure that the profile is uniform throughout the entire workpiece, I prefer to use profile bits equipped with a bottom-mounted bearing. Before making the cut, I make sure the edge of the workpiece is smooth and free of bumps or voids—by running sandpaper along it, for instance—as the router bearing will follow this surface exactly. When removing a lot of stock or using large profile bits, take several passes, adjusting the height lower after each pass, to help prevent burn marks or tear out (7).

When a profiling bit reaches the end of the material, it can "fall off," which can distort the profile. To prevent this, add a scrap piece of wood, of the same thickness as the workpiece, at the end. While routing extra material is an easy method, it isn't always an option.

Dados and rabbets. Commonly used in cabinetry, furniture, and door making, these cuts are fantastic for making strong joints. I often use dados to support shelving, not only because they provide plenty of strength to support the weight of the shelf but also because locking the ends of the shelving into dados cut into the shelf supports helps prevent the wood from cupping.

To maximize strength, a dado joint requires a snug fit. For optimum strength, the width of a dado must be just a few thousandths of an inch greater than the mating piece. An easy way to achieve this result is by using dedicated cabinetry straight cut router bits called "undersized dado bits" (8).

A few other techniques and jigs can be used when making dado

or rabbet cuts, but my preferred method is using Festool's guide rail and guide stop (model 492601). I find this method to be very safe, as I can clamp the guide rail to the workpiece and keep a hand on the router and guide stop.

Template routing. Pattern templates are commonly used in furniture making to precisely replicate pieces without sacrificing production speed; they are a great alternative if you don't have access to a CNC machine. A template is typically made from scrap wood or MDF and then placed either over or under the workpiece. Then, with either a top- or bottom-bearing flush trim router bit, you can follow the template exactly, allowing you to make identical pieces (9, 10).

Templates are also great for mounting door hardware, especially when that entails mortising flush-mount pocket door pulls. The template helps me to accurately place the mortise, while it gives me fast and consistent results, along with less chance of making a mistake. On the jobsite (or in the shop), a door hinge template allows you to make precise shallow mortises for hinges on doors, as well as for locks. These kinds of templates have saved me hours of time (11, 12).

MAINTENANCE

I like to keep my routers running like well-oiled machines, literally. The router has a few moving parts, such as the spindle, and on the larger plunging routers, plunge tubes. A quick spray of white dry lube can keep these parts moving swiftly without sawdust sticking to them like it does to traditional oil lubricants (13). Any overspray can be easily wiped off with a rag once dry.

Router bits need a little more care than a quick shot of spray. With router bits, first inspect the cutter head for any damage or nicks; if the bit is not too damaged, it should be sharpened immediately. And just like other woodworking saw blades, router bits accumulate resin and pitch that significantly shorten their life and efficiency. This can be easily fixed with a quick soak in blade cleaner, followed by a brass brush. If your bits are clean, they cut more effectively, which translates to better results.

While the cleaning process removes pitch and resin, it also removes any beneficial oils that previously lubricated the tooling surface, so I restore those oils right after cleaning to prevent surface rust. For lubrication, I spray the sharpened and cleaned bit with a light coat of Blasters dry lube, rubbing it into the cutting surface with a paper towel.

Tommie Mullaney owns Mullaney Woodworks in Naples, Fla. You can visit his web page at mullaneywoodworks.com or follow him on Instagram @MullaneyWoodworks.



For cutting mortises for door hinges, the author uses a simple plywood template that he fastens to the workpiece with double-sided tape (11). The template is sized to fit the hinge template router bit, which typically has a short cutter-to-bearing distance since most hinges aren't very deep (12). An occasional spray with a dry lubricant will prevent the tubes on a plunge router from gathering sawdust and sticking (13).

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Q During winter, why do hot-water pipes freeze and burst more frequently than cold-water pipes?

A Foster Lyons, an engineer and building-science consultant, responds: The short answer is because hot-water pipes aren't attached to toilets, which help reduce the number of burst cold-water pipes. Here's why.

Water expands when it freezes, increasing in volume about 9% from its liquid state. That's why ice floats—it's less dense than liquid water. This increase in volume is the proximal cause of ruptured water pipes when they freeze but probably not for the reason you think. Expanding ice doesn't push against the pipe walls to cause the rupture; instead, it's high-pressure liquid water that does the damage.

Pipes that freeze are cooled from the outside in. The warmest location is always the liquid in the center of the pipe. As temperatures drop below freezing, the water starts freezing on the inner surface of the pipe in a slow process that allows plenty of time for liquid water molecules to get out of the way as their neighboring, recently frozen, solid molecules rearrange themselves into that 9% larger arrangement. This freezing progresses from the area near the pipe wall toward the center of the pipe—the opposite of tree ring growth but similar to plaque building up in our arteries.

If there are nearby nonfrozen areas, the last drops of liquid in the center are pushed to liquid areas on either side of the frozen area. When the pipe is frozen through and through, the pressure on the pipe walls exactly matches the pressure of the surrounding liquid outside the frozen zone. The water that is finally pushed out of the middle goes

toward either the water source (like the water main in the street or the hot-water heater) or the plumbing fixtures at the end of the line (like a sink or toilet).

The relocated water that goes toward the source doesn't cause much trouble. Usually there are plenty of places to relieve that pressure—a huge volume of water in a municipal system, a hot-water tank, or a well-system storage tank, for example. It's the relocated water that is pushed toward the end of the line that causes problems, and here is where bursts happen.

In a hot-water line, that relocated water has no place to go. At the end of every line is a valve, and—assuming you're not running the tap continuously—those valves are shut. Basically, as ice freezes in hot-water pipes, it pushes liquid water up against a dead end.

It is difficult to compress water. A 1-atmosphere increase in pressure results in only a 0.005% reduction in volume. Considered in reverse, the pressure skyrockets if you cram even the tiniest fraction of additional water into the same volume. That's what happens in those hot-water lines.

For a long time, scientists couldn't figure out how to build anything strong enough to measure the pressures that are generated by the expansion of a freezing water-ice mixture. They tried thick, brass containers and even cannons and artillery shells, but nothing could hold back the pressure generated by expanding ice, and, every so often, they accidentally blew up their concoctions and launched projectiles hundreds of feet. In comparison, the walls of copper pipe are about the strength of tissue paper as far as ice expansion is concerned.

Freezing ice can exert pressures up to 43,511.31 pounds of force per square inch (psi). Domestic water pipes are designed to withstand about 1,500 psi (³/₄-inch drawn copper)—depending on pipe size and manufacturing process—which is not even a road bump when you're on your way to 43,000 psi. Freezing water generates the sort of pressure that breaks mountains in half and is a death sentence for copper pipes that get caught between an ice blockage and a closed valve.

On the other hand, cold-water pipes have a relief valve—toilets. That's because toilets have a float valve—more properly called a ballcock—that is operated by pressure differences across the valve. When pressure builds up, the valve opens and releases some of the fluid, and the pressure is reduced. In toilets, this release pressure is controlled by the position of the air bladder. When the supply water pressure builds up in a cold-water pipe feeding a toilet, it pushes the air bladder down into the tank water and that allows just a little bit of water to pass through the valve, thereby releasing the supply pressure.



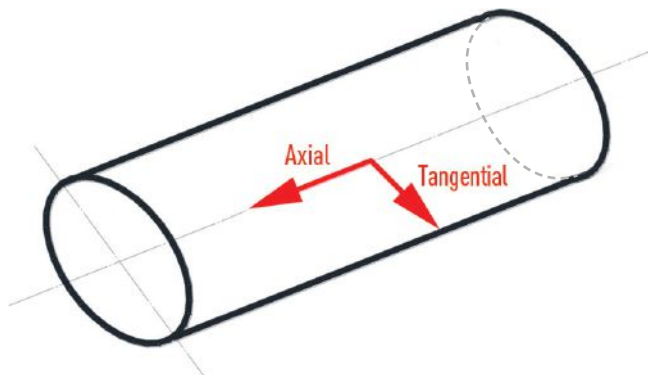
As water freezes in a water pipe and turns to ice, it expands and pressurizes the liquid water remaining in the pipe. Because water is difficult to compress, the pipe will burst if there is no other means for relieving the increased pressure.

As water continues to freeze along the length of the cold-water line toward the toilet, it keeps pushing liquid water through the float valve and the pressure never builds up in that supply line. It freezes, but never bursts, because the pressure in the line never exceeds the pressure setting of the float valve.

Of course, if there are two frozen locations in a cold-water line, the volume between those locations has nowhere to release its pressure, and the pipe will burst. That happens plenty. The same is true for hot-water lines.

Another interesting thing with freezing water: The water in the hot-water lines freezes faster. This is insanely counterintuitive but true. You can easily demonstrate this by pouring two equal cups of water, heating one of them up, and putting both cups into the freezer. Nine times out of 10, the heated cup will freeze first. This unsolved mystery of science is called the Mpemba effect, and nobody can fully explain (with proof) why it happens.

Water pipes burst in the same way as overcooked sausage—always along their length, not at their ends. Like the filling inside a sausage skin, water inside a copper pipe can cause only two stresses on the enclosure material: axial (which tends to change the length of a body) and tangential (where the direction of the deforming force is parallel to the cross-sectional area).



Tangential stress caused by internal pressure in a water pipe acts perpendicular to axial stress and tends to separate a pipe wall in a line parallel to the pipe's center line.

When you work through the math, you find that the axial stress is always half the tangential stress for any given internal fluid pressure. So, the sausage and the water pipe always burst along their length because that's where the greater stress exists.

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How Can Building Professionals Improve Training?

Success will likely come from robust in-house programs

BY CLAYTON DEKORNE

JLC recently ran an online survey to gauge how building professionals might improve skills training. The need is obvious. We have been hearing about the shortage of construction labor for more than a decade, and the problem only seems to have gotten worse. The labor shortfall has no doubt been fueled by the pandemic, but our industry's labor woes began well before this. Overcoming the shortfall will require more deliberate training and education programs, and our survey centered on the premise that more effective on-the-job training is a natural but largely understudied first place to focus industry efforts. Trades schools, educational reforms, manufacturer-based installer programs, trade shows and conferences, union apprenticeships, and self-guided education are all part of the equation. But we at JLC, guided by an informal collaboration with M.T. Copeland, a company dedicated to providing video-based skills training for the construction workforce, feel strongly that professional building and remodel-

ing firms, which are engaged in on-the-job training by necessity, have the greatest chance of moving the needle to close the skills gap. At the heart of this proposal, however, are some fundamental questions about how companies are structured, how they handle hiring and management, and how they can better afford to develop formal, structured training for production staff.

PART OF A BIGGER ISSUE

One respondent was disappointed that we pitched the survey as part of "solving the skilled trades gap" without asking about compensation. The respondent wrote, "The easiest sure-fire way to close the skilled trades gap is to both pay a good wage with good benefits and provide secure/steady work for tradespeople. Over time, this will both retain good people and attract new people into what can be a reasonable career path." This is a supremely important point but one that needs some unpacking; absolutely,



A good lead carpenter is the most effective teacher of building skills, bar none. But a company needs to account for the lead carpenter's loss of productivity—a detail that can frustrate lead carpenter and business owner alike when not addressed.

companies need to offer strong wages and benefits and (to add more) provide a compelling company culture and even offer flexible work hours to be competitive with other industries that are also trying to attract workers. However, we can't *just* look at pay and benefits as a solution. There is a finite number of people with skills to attract. It's a problem of demographics: Those most skilled will age out soon, if they haven't already. Ultimately, we have to solve the skills gap by bringing younger people onto the scene; that includes taking steps to expand the talent pool by attracting more women, Black people, Indigenous people, and people of color, all of whom are vastly underrepresented in the construction workforce relative to the population as a whole.

The aforementioned respondent invoked "a reasonable career path," and I agree that to accomplish this vital demographic shift, we need to give prospective workers a strong sense they are building a career, not just filling a job. Along with the prospect of building a rewarding career will come a vital sense of professionalism, which we need to support at every turn to elevate the social status of construction work; positive opinions about construction workers are painfully lacking in our culture. But at the heart of the quest for a more engaged workforce is the vital question: How will we impart the required skills to the next generation of carpenters?

THE HIRING PROCESS

Finding qualified help is the first step to building a skilled crew.

A common response to the question "What is your hiring process for new carpenters and other skilled tradespeople?" was that the "skilled" part is optional. As one respondent wrote: "At this point it's hard to be picky so I mostly look for someone with a good attitude and willingness to learn." Indeed, "attitude," "work ethic," "character," "personality," and "integrity" factored into a majority of responses as top qualifications for prospective hires. Some added "intelligence," "thoughtfulness," "ability to communicate,"

A company cannot begin to hire just when it has a vacancy but must always be searching for prospects.

and "eagerness to learn." As another respondent wrote: "Skills can be taught; attitude is hard to teach ... If they simply care about what they do, they will learn the skills because they *want to*, and they will produce a quality product because they *want to*, and they will show up to work every day because they *want to*."

Most respondents described a conventional hiring process that includes reviewing an applicant's resume and conducting a verbal interview followed by an on-site evaluation of the applicant. A few

Photo: Sara Lukaszewicz

First we went above.





Mike Guertin is one of the stand-out building skills instructors at JLC Live and Remodeling Show/Deck Expo. These educational events, now run by the international exhibitions company Informa Markets, have become a key element in many residential contractors' continuing education efforts. Even when most professional building and remodeling firms don't offer a formal, structured employee education program, respondents say that such yearly continuing education for crews offers an effective training option.

rely on word-of-mouth referrals to vet applicants. One respondent uses "social media to screen applicants." A number indicated that asking to see pictures of prior work (which may be part of the applicant's social media postings) is an effective way to gauge applicant skill, experience, and overall excitement with building.

Doug Howard of Remodelers Advantage urges that "hiring is not a single act, but a process ... to be effective in catapulting a company forward, the hiring process needs to start earlier and last longer than you might at first expect." Howard's perspective underpins a handful of respondents who indicated they deliberately extend hiring beyond the offer to include a "trial" or "evaluation" period. Different respondents expressed it differently, but there was a recurring suggestion that it takes time to evaluate skills. As one respondent elaborated: "I will put them with a crew and get feedback from the foremen. All people are apprehensive on a new job, and also, there are certain personality conflicts that arise at first. I give them a month. By then I know the score."

As to starting earlier, one respondent offered the practical suggestion of maintaining an online application to allow a company to always be collecting prospects to job postings. This strategy is consistent with an "always be hiring" strategy that some companies have been advocating in the current market, when so many firms have a backlog of work and demand has far outstripped most companies' ability to complete jobs. In this business climate, a company cannot begin to hire just when it has a vacancy but must always be searching for prospects.

STRUCTURED IN-HOUSE EDUCATION

When asked, "Does your company have a formal, structured training program for either new hires or existing crew members?"

90% of respondents responded, "No." But 25% of these indicated in one way or another that they should or would like to. More than half of responses (including some among those indicating "no") elaborated that "OTJ," or on-the-job, training (also expressed as "working alongside new hires" and "working closely with a lead carpenter" or with a "foreman") was the way they brought their crew up to speed on skills.

From the few respondents that indicated they ran some level of formal in-house training, here are some examples:

"For apprentice carpenters, we take them through the book *Modern Carpentry* [published by Goodheart-Wilcox; G-W partners with YouScience to correlate this textbook with a standards test]. At the end of the course, they take a test where they can receive a certificate. Lead carpenters are required to become Certified Lead Carpenters [via National Association of the Remodeling Industry (NARI)]. In addition, we train all new employees on key areas for our company, like setting a door, flashing windows and doors, and dust protection."

"We have a training agenda once every month usually on prints, specs, shop drawings, etc. The workforce dictates the year's training sessions on what they feel is most beneficial to their respective duties. We are a GC with laborers, carpenters, and concrete masons."

"Once a month we meet at the shop for a company-wide training session, usually an hour. Effectiveness is varied, but still beneficial. I'd say teaching the teachers is where we are missing the opportunity with monthly training."

"For new hires, we have several unlisted YouTube videos [made by the respondent's company and posted to its channel] that focus on different materials and techniques that are intended to bring a new person up to speed on baseline skills very quickly. We send

Photo: Andy Wornier

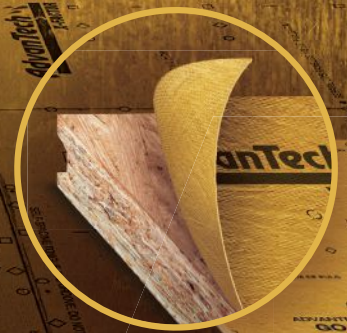
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One respondent noted, “A company always pays for training, even if it’s never a line item in the budget.” Indeed, mistakes and reduced productivity take their toll.

the link out to anyone who comes in for a tryout, so that the crew they are paired with isn’t saddled with having to maintain production while holding the new guy’s hand ... But there’s no substitute for hours and hours of actual practice. From that point, the company will pay for basic building science courses for anyone who’s interested (such as BPI Building Science Principles). We also have a company-wide meeting every Monday morning and frequently discuss a detail or technique that needs attention, and usually apply a building science concept to that so the crew develops ‘building as a system’ thinking.”

“As a GC, the work is varied. Being able to formalize the training would also allow us to assess skill set, which would help establish wages, instead of the current instinctual guess.”

While few companies are offering structured in-house programming to employees, a solid 75% lean on “continuing education” opportunities. Trade shows (including JLC Live, Remodeling Show, Deck Expo, and the International Builder’s Show) and training events organized at lumberyards are the most often cited.

One respondent added: “We believe all of our employees should

be pursuing some level of college education whether an associate degree or preferably beyond. Also specialty training in products and work protocols is considered critical. The formal education will (in our opinion) lead to a better grasp of why certain product installation requirements are important and not just ‘a case of over-design’ by the A/E team.”

“Creating a training program ourselves is going to be a long, slow process—hard to find the time for developing that. Having a trusted outside training program would be ideal.”

TRAINING CONTENT

It came as no surprise that almost all respondents think that “hands-on” or “in-person” training is the most effective method of instruction. This was often joined with “by far” or “no substitute” or the like. Still, there was a stronger vote for other formats than I expected. “Video” and “online” material tied with “books,” “textbooks,” and “magazines” for about 30% of responses mentioning these as viable supplements to reinforce training; few think of it as an alternative.

A handful of respondents indicated that online alternatives work especially well at the beginning of the training process or to train on specific products but are less effective for learning how to problem solve. The quality of the content, not just the format, also mattered to respondents, with many questioning the reliability of much of what can currently be found on YouTube and through search.

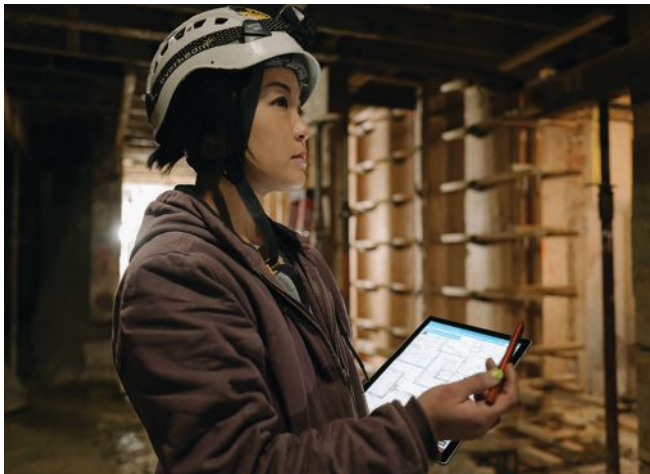
TRAINING BUDGET

As with formal in-house training, almost none of the respondents have a training budget, but about 16% of respondents indicated it would be a worthwhile overhead expense to add. A few who do budget for training offered varied advice: “Our budget is informal, but it would be about \$1,500 per employee in first year if they take full advantage of and are approved for the programs; probably about \$500 to \$750 each year after that.”

“We do have a small budget that we automatically add to every month (0.5% of revenue) for continuing education, subscriptions to trades media, etc.”

“Training and training budgets have to be built into the job costs and marked up as well.”

Paying for training may be inevitable. As one respondent noted: “A company always pays for training, even if it’s never a line item in the budget.” Indeed, mistakes and reduced productivity take their toll. Another echoed: “The industry is changing more rapidly than ever, and the customers and lawyers have made it clear there’s no room for ignorance.” To control costs and reduce risk, a deliberate spend on training could be the best course of action.



Elly Hart, a production manager on high-end multifamily developments, offers an in-depth course on reading commercial blueprints—one of many video-based training courses offered by M.T. Copeland. As courses like this come online, building professionals are discovering that high-quality video runs a close second to hands-on training and on-the-job experience. And for some technical skills that require a lot of study, video may be the place to start.

Photo courtesy M.T. Copeland

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BY CHRIS LAND

Leveling Up for Stone Countertops

Even for clients who are generally happy with their cabinetry, a common kitchen upgrade in my area is to change out an existing laminate countertop with one made from granite, quartz, marble, or some other natural or synthetic stone. The problem, though, is that stone countertops are much less forgiving of out-of-level cabinetry than laminate countertops are. The Marble Institute of America recommends the top surface of the cabinets be within $\frac{1}{8}$ inch (3mm) of flat and level across a distance of 10 feet (3 meters). If your clients currently have a laminate-type countertop, odds are that their cabinets don't meet this recommendation.

That's where I come in. For the past several years, I've specialized in prepping cabinetry for stone countertop installations for several big-box home centers in my area. To be profitable, I've had to develop a fast and accurate way of leveling existing out-of-level cabinetry for this popular upgrade.

Establishing a baseline level. The most efficient way to establish a level line for cabinets is with a self-leveling laser, though it is possible to do this with a spirit level if the level's accurate and long enough to span the longest run of cabinets. Trying to achieve a variation of $\frac{1}{8}$ inch or less over the total span of a set of cabinets just isn't possible using a short spirit level on top of each box, which might itself be level but still be out of plane with other cabinets (1).

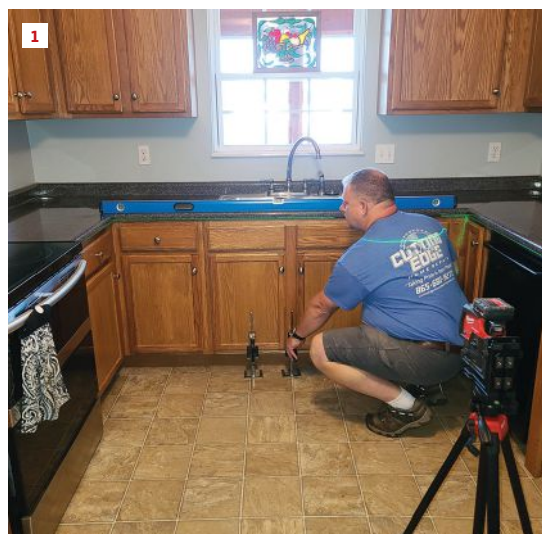
I schedule about four to five hours to prep the cabinets in an aver-

age-size kitchen. I start by carefully disassembling the sink so I can remove the countertop (2, 3). To properly level the cabinets, I need to be able to see both front to back and left to right of all the cabinet tops.

I position the laser where the beam will cover as much of the cabinetry as possible, and adjust it up or down as needed until I find the cabinet's high point (it's always easier to raise a cabinet than to lower it). If the beam doesn't reach all of the cabinets, I place painters' tape on the front of the cabinets and mark the laser line. Then I reposition the laser, align it with the reference elevation marked on the tape, and continue the process until I've determined the highest point of all of the cabinets; this is the level to which the rest of the cabinets must be raised prior to the stone countertop installation.

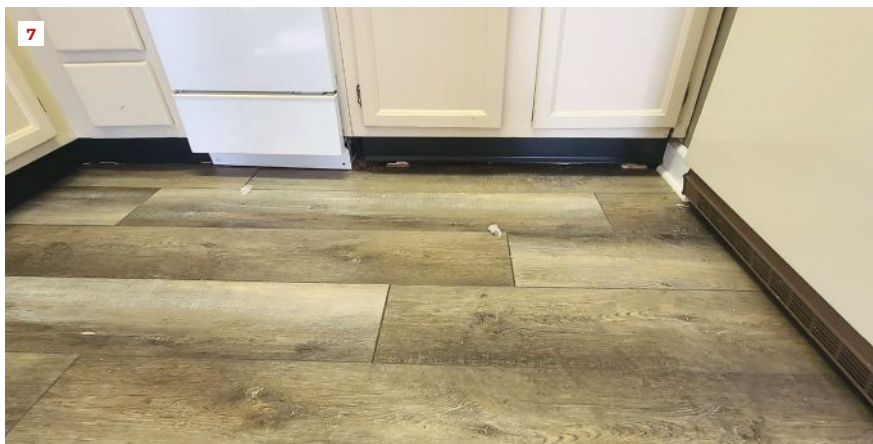
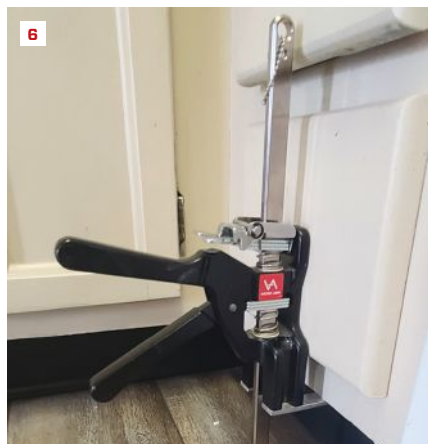
Evaluating the cabinets. I use both tapered composite shims and strips cut from hardboard, placing them as needed either underneath or on top of the cabinets (I don't use cedar shims, which can compress under the substantial weight of a stone countertop). The under-cabinet method allows the stone countertop and the top of the cabinet to be flush, but older site-built cabinets often cannot be raised from the bottom, in which case the shims must be placed on the top.

Shimming under the cabinets. I start by marking the laser line on the back wall with a pencil (4, 5). Sometimes during the leveling process, the laser can be obstructed by the front face of the cabinet, and the pencil mark makes for a good target that is easy



Assessing whether the existing cabinetry is within $\frac{1}{8}$ inch of level across 10 feet is part of measuring a kitchen for a new stone countertop (1). If shims will be required, the sink, dishwasher, and other plumbing and electrical fixtures must be disconnected (2). A right-angle drill is handy for disconnecting the countertop from the cabinets, and the cabinets from each other (3).

Photos by Chris Land



With the countertop removed, it's easier to see where the high and low points are and how far cabinets have to be lifted to the level line (4, 5). The author uses Viking Arm jacks to raise cabinets and hold them in position while he screws the backs to the wall and fits shims under the fronts (6). Shoe molding can be used to cover the gap between the finish floor and the toe kick (7).

to see. Next, I locate and remove all of the fasteners that were used during the cabinet installation. Normally, cabinets are screwed to the studs at the top rear of the cabinets, though sometimes installers place screws on the inside of the cabinets through the back panel. If the cabinets have been attached to each other from the sides, these fasteners will need to be removed as well. With face-frame cabinets, the fasteners are often located behind the door hinges. The front toe kicks also need to be removed from the cabinets.

While cabinets are often installed as one big assembly, it is easier to raise them as individual boxes. Trying to level the cabinets as an assembly can stress the frames and cause them to crack. Special consideration must also be taken when raising cabinets, such as sink cabinets, that have openings for plumbing or electrical. To provide clearance, I enlarge the openings as needed with a multi-tool. If the plumbing comes through the wall and the cabinet does not have a back, this step can be skipped.

To lift cabinets up to the level line, I use a pair of Viking Arm portable handheld jacks (see “Viking Arm Handheld Jack,” Jul/Aug/21), which have the ability to precisely raise or lower weights up to 330 pounds per jack (6). Once the back of the cabinet is lifted to the laser (or pencil) line, I screw it to the studs to maintain this elevation. Then I place tapered composite shims as needed under the cabinet until the front face is also aligned with the laser. The best result is to split the laser line across the front and back of the cabinet, where I can see the top half of the line across the back of the cabinet and the bottom half of the line across the face of the cabinet. This ensures that the cabinet is level front to back and left to right.

Once all the cabinets are aligned to the laser, I reattach them to each other with Wurth assembly screws, either through the face frames or the side panels. When I'm done, I check to make sure the laser line is still touching the tops of all the cabinets at both the front and rear and readjust as necessary. Finally, I mark and



Once the cabinets are leveled, the author temporarily reinstalls the old countertop in short sections so the kitchen can be used while the new countertop is fabricated (8). Custom and site-built cabinets often must be leveled at the top with hardboard shims (9). This typically leaves a gap between the countertop and the cabinets (10), which must be covered with trim (11).

trim the shims to length so they won't interfere with the toe kick when I reattach it (7). To keep the shims from shifting, I glue them to the floor, the cabinet, and each other with hot-melt adhesive or cyanoacrylate (CA) glue. If the shims create a gap between the toe kick and the flooring, I cover the gap with trim such as a shoe mold.

Shimming on top. I rip strips of 1/8-inch and 1/4-inch hardboard on a table saw to use as shims on the tops of cabinets (8). Depending on how far the cabinets are out of level, the shims may need to be layered to achieve the proper height. I start with the back, gluing and tacking the first layer to the tops of the cabinets with 23-gauge headless pins, then add layers as needed until the shims just touch the laser line (9).

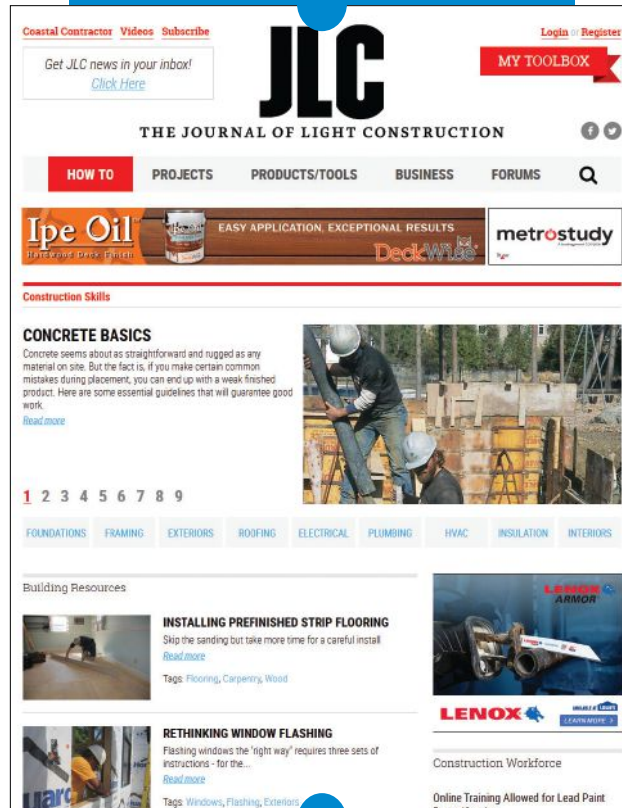
Along the fronts of the cabinets, I build the hardboard shim layers up so that the gap between the countertop and cabinets will be completely filled. Then I use a belt sander to level out the shims flush with the laser line. If the gap that I've filled with shim material to

level the cabinets is greater than 1/2 inch, I also completely cover the tops of the cabinets with a layer of 1/2-inch cabinet-grade plywood to act as a base for the stone. Finally, I check to be sure that none of the shim material sits proud of the front or side of the cabinet.

It will be a few weeks before the new countertops are ready, so I reinstall the old ones without screws, first cutting them into 4- or 5-foot-long sections to make them easier to handle. To make the kitchen functional, I reconnect the plumbing.

After the fabricators return to install the new stone countertop, there will often be a gap between the tops of cabinets and the countertop (10), which can be covered by a piece of trim (11). When determining what trim to use, I pay close attention to the tops of drawer and door clearances to make everything fit as it should.

Chris Land owns Cutting Edge Woodcraft in Greenback, Tenn. You can follow him on Instagram @cuttingedge.woodcraft.



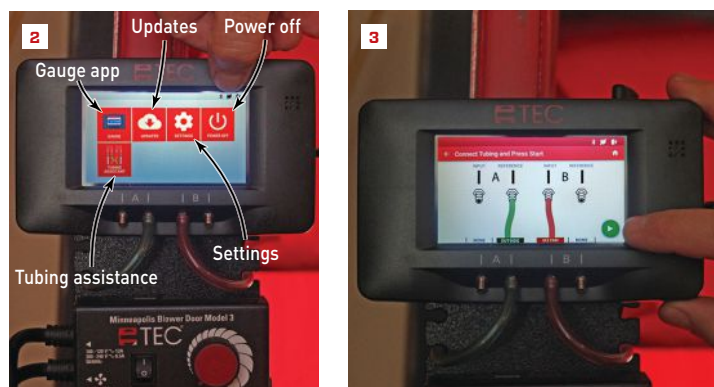
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BY JIM BRADLEY

Upgrading to a User-Friendly Manometer



The author switched from using his old workhorse DG-700 model (inset photo) to a DG-1000 (1), though he still uses the DG-700 for tests requiring multiple blower doors.



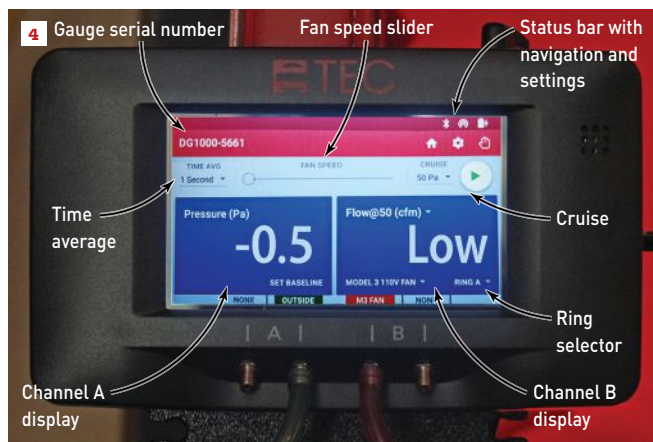
Large pictographs help users set up the manometer for testing. Here, the home screen shows the unit's five primary apps (2). Tests can be launched from either the gauge app or the tubing assistance app. Tubing assistance shows the user which pressure taps to hook the diagnostic tubing to, depending on the airflow-measuring task (3). The green arrow button is the "launch with current configuration" button, which takes the user to the gauge app.

I'm a BPI-certified home-performance contractor, Passive House-certified builder, and remodeler based in Vermont. Over the years, my home-performance consulting services have grown to include commissioning HRV/ERV units for Zehnder (making sure they're balanced appropriately after installation); helping contractors who aren't certified do air-leakage testing in new homes (in Vermont, where I work, the new 2020 Residential Building Energy Standards require all newly-built homes to be blower-door-tested for air leakage to certify a maximum building leakage of 3 ACH50); and performing home performance assessments/energy audits for clients over the past 16 years as an Efficiency Excellence Network contractor for Efficiency Vermont.

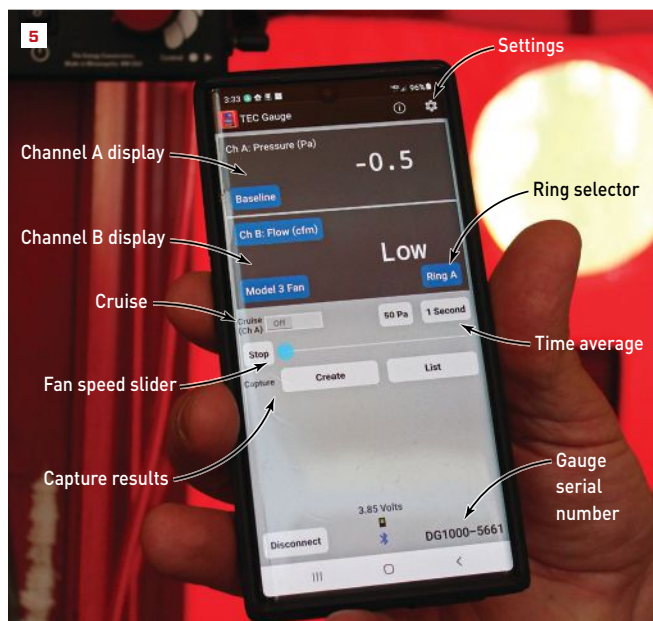
A year and a half ago, I upgraded to a TEC DG-1000 Pressure and Flow Gauge, manufactured by The Energy Conservatory, which helps calculate a home's ACH50 rate as well as other functions related to pressure and draft testing HVAC equipment. In that time, I've found the newer DG-1000 manometer much more intuitive than the old workhorse TEC DG-700 model I used for years (1). The new high-resolution touch screen graphically shows items such as what pressure taps to hook the diagnostic tubing to (depending on the airflow-measuring task) and boldly displays channel A (pressure) and channel B (CFM or pressure) numbers. TEC also has an app available that enables syncing a smartphone to the manometer, which allows users to operate the DG-1000 remotely from another part of the home or when running a second blower door set up within the structure—it's a big step up from the older model.

In this article, I'll highlight some tips and techniques I've discovered over the past 18 months while performing hundreds of blower-door tests (both depressurization and pressurization tests; see "Tracing Air Leaks With a Blower Door," Nov/Dec/20, for more information on pressurization tests using theatrical smoke) and regular combustion appliance zone or CAZ testing along with draft testing water heaters, furnaces, and boilers.

Updates and resources. Currently, I'm running software version 1.7.0 (35) on my DG-1000 (as shown in the photos). A significant advantage of the product is that The Energy Conservatory continually updates its software and app additions, improving the manometer's functionality. The company also provides excellent tech support, instructional manuals, and videos online, which help give



In addition to familiar channel A and channel B displays, the gauge app screen contains functions such as fan speed, time average, and cruise, which automatically starts the blower door fan running to achieve, in this case, ACH50. The unit's serial number is displayed in the upper left-hand corner, which is useful during calls for tech support or maintenance. The status bar contains navigation and settings (4).



The most substantial upgrade of the DG-1000 over the DG-700 is its connectivity to smartphones and tablets. TEC's gauge app allows users to operate the DG-1000 remotely and find, say, a leaky spot in the attic. Here, the gauge app screen appears on the author's smartphone (5). Once activated, the phone app overrides the unit's controls.

an overview on how to use the device (though the manuals aren't always entirely up to date with the latest software versions).

Due to limited space, I am only able to dive into some of the many features of the new DG-1000.

MORE INTUITIVE, BETTER GRAPHICS, INTEGRATED LIKE A SMARTPHONE

When the unit is powered up, its home screen has five primary apps: the gauge app, updates, settings, power on/off, and the newer tubing assistant, which was a software upgrade sometime after the product's original launch in 2017 (2).

The gauge app screen contains functions such as fan speed, time average, and cruise control mode, in addition to the all-important channel A and channel B displays (more on this below).

The settings screen contains screen brightness, gauge info (when last calibrated), auto time off, and the network configuration (ethernet, WiFi, micro USB). Here, users can create a network; for instance, a media mobile WiFi hot spot on a phone to have better connectivity than just Bluetooth or to avoid relying on the homeowner's WiFi.

Power on/off powers down the DG-1000. Alternatively, it can be powered down by pressing and holding the recessed power button on top of the unit for a few seconds (the DG-700's on/off button was not recessed and could be inadvertently switched on in its traveling case and drain the batteries, something that happened to me a number of times).

The tubing assistant is an invaluable tool for someone who is new to the industry or performs tests infrequently. Setup errors are common, and challenges with the diagnostic tubing setup are due largely to user unfamiliarity with the pressure tap orientation. Now, the tubing assistant tool acts as a tutor, walking users through the setup, whereas the DG 700 did not.

Attaching the tubing isn't always as simple as matching red and green tubes to the channel A and channel B taps. Variables such as test direction and gauge location influence how to set up the tubing. The tubing assistant tool guides the user through a series of pictograph prompts—test type (building tightness, duct tightness, and so on), test direction (pressurize or depressurize), gauge location (inside or out), test device (typically TEC's Model-3 fan)—eventually arriving at the "tubing connections" screen with a graphic representation of the correct setup. Once the tubing is set up, pressing the green arrow in the bottom right takes the user to the gauge app (3).

As an experienced user, I generally bypass the tubing assistant and begin with the gauge app screen. Occasionally, I'll use it to help set up tests I'm less familiar with, typically HVAC-related ones. Thus, for someone who branches out and expands their business to include additional types of testing, as I have, this tool will continue to pay dividends.

The gauge app is where it's at. Many of the manometer's functions can be accessed from the gauge interface app. Familiar channel A pressurization (measured in pascals) and channel B depressurization (in CFM, typically flow @CFM50 for testing homes) graphics are located here. Compared with the DG-700 screen, the

DG-1000's pressure and CFM display numbers are much larger and can be read—and photographed to confirm the blower test results—from farther away (4).

Within the display box on the right are channel B settings, airflow (CFM or pressure), blower-door fan type (typically TEC's Model-3 for testing house tightness), and ring size (Open Fan, A, B, C, and others). Ring openings decrease in diameter the further up the alphabet (an A-ring diameter is larger than a B-ring's and so on).

Ring selection. The DG-1000 is dynamic, but it's not intuitive enough to determine which ring size to use. Therefore, selecting the ring size is based on experience. For instance, if I'm running a test and I determine, "this seems like a pretty tight house, and they're trying to achieve high-performance construction or passive house," I might start with a C or a D ring. However, I may find out that the house is leakier than I thought when the manometer displays "low" on the channel B display window, which would then call for using ring A or B to accommodate for the leakier building. Should I need to change the ring size on the fan unit itself, I can easily update the selection on the DG-1000 gauge screen so they align. So, the gauge isn't a substitute for a trained technician, who can understand, "OK, I'm getting these readings and this is why."

With regard to ring size, one pitfall to be mindful of is the DG-1000 keeps the settings from the last time it was used. It doesn't zero out by default like the older DG-700 and DG-500 models did, for which a testing configuration needed to be set up every time the unit was powered on. I've had a few head-scratching moments due to not zeroing out the settings. (My initial baseline, test-in measurements didn't jibe with the test-out numbers I took after construction.) Thus, be aware of this; it'll save time scrambling around looking for photos for what ring was selected during a test and then having to go to a conversion chart to verify the numbers.

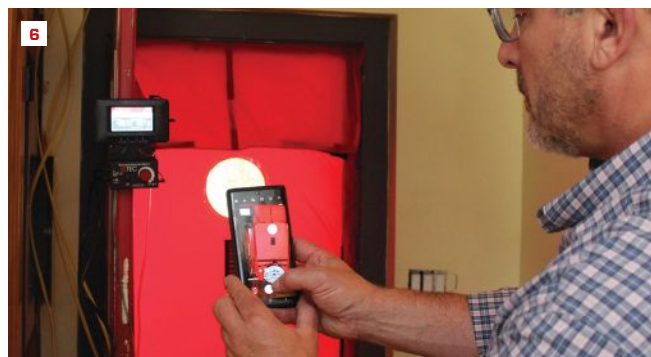
Connectivity. By using the available TEC Gauge app to sync a smartphone to the manometer, I can operate the DG-1000 remotely—when I might be in the basement or the attic while performing a screen capture to save the results of a test (5). The measurement can also be emailed from the app as an analog record of the same information (6, 7).

Running calcs. Under the Settings tab, users can calculate the area and volume of a structure by using the touch-screen calculator tool, though I don't usually use this; I do my own math later on.

Calibration. The unit's serial number is displayed in the upper left-hand corner of the gauge app, which is useful when I'm calling for tech support or maintenance (the newer DG-1000 needs to be calibrated every four years, whereas for the DG-700, it was every two years).

Costs. The Energy Conservatory (energyconservatory.com) lists the DG-1000 digital pressure and flow gauge for \$1,620. The unit comes with batteries, a charger, carrying case, and enough diagnostic tubing to get started. When bundled with a Minneapolis Blower Door System, it costs \$3,755.

Jim Bradley is a BPI-certified home-performance contractor, builder, and remodeler based in Vermont. He is currently a project developer and manager for Hayward Design Build in Colchester.



7 Label: Oct 9, 2021 3:39:07 PM

Ch A Value: -49.8 Pa (adj)
Baseline: -0.1 Pa
Ch B Value: 2028
Ch B Mode: Flow@50 (cfm)
Ch B Flow Units: cfm
Ch B Pressure: -127.6 Pa
Flow Device: Model 3 Fan
Flow Device Config: Ring A
Time Average: 5 Second
Area: 0.0 ft²
Volume: 0.0 ft³
Timestamp: Oct 9, 2021 3:39:07 PM
Gauge Serial Number: DG1000-5661
Gauge Calibration Date: May 1, 2020

Comment:
Smith res

In addition to the standard practice of taking a confirmation photo of the blower test results and the ring size used on the fan (6), the DG-1000 has a capture function that lets the user email a summary report of the test results (7).



The DG-1000 uses two lithium-ion rechargeable batteries with a 15-hour runtime (depending on WiFi use and screen brightness). Four strong neodymium magnets (shown here below the batteries) hold the unit to the metal gauge board (8).

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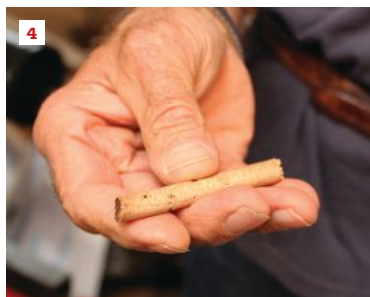


BY WILLIAM FLYNT

Dating Historic Structures



The author attaches a guide plate to the "waney edge" of a timber (inset), then takes a sample at each selected timber using a special coring bit (1).



Should the sample break during coring, the custom coring bit (2, 3) separates from the drive adapter to allow the core sample to be removed from the drill tube (4).

While serving as the architectural conservator for Historic Deerfield Inc. in Deerfield, Mass., I became proficient at dating structures via dendrochronology. In 2003, under the tutelage of Paul Krusic (at the time a dendrochronologist at the Tree-Ring Laboratory of the Columbia Climate School Lamont-Doherty Earth Observatory, based in Palisades, N.Y.), I learned the rudiments of dendrochronology as it pertains to the dating of historic structures (dendroarchaeology). Since then I've undertaken over 250 such studies of structures from the late-17th century to the late-19th century in all six New England states, as well as eastern New York state.

Dendrochronology, or the study of tree ring growth patterns, was initially developed in the 1920s by Andrew E. Douglass using long-lived ponderosa pines in the Southwest United States. An astronomer by training, Douglass was interested in historical sunspot activity and its relationship to earth's climate. He surmised that by looking at yearly growth ring sequences in long-lived trees growing in an arid environment where moisture is key, he might be able to ascertain yearly variations in climate attributable to sunspot activity. To extend the tree ring database back past the age of living trees, samples were taken from ancient roof poles located in Pueblo ruins; these samples turned out to eventually overlap the living tree data. Besides fulfilling his research needs, Douglass' work revealed the feasibility of dating archaeological structures.

In the 1980s, the advent of computer programs to collate the data and compile dated master chronologies enabled unknown samples to be compared to known masters with a high degree of accuracy. Also, regions once considered too variable climatically to provide reliable results—for instance the Northeast, where I work—were now in play. With improved data technology, dendrochronology is now used as a mainstream research tool for analyzing and establishing construction-timber felling dates throughout the world.

Species. In the Northeast, I have the best results dating oak, hemlock, and pitch pine because there are a number of robust regional databases for these species, thanks to the work of dendrochronologists from the Lamont-Doherty Tree-Ring Laboratory, the Oxford Dendrochronology Laboratory, the University of Arizona Laboratory of Tree-Ring Research, and my work. Occasionally, I deal with white pine, spruce, and chestnut,



The core samples are glued longitudinally into custom wood mounts and are sanded down using successively finer grit paper to a mirror-smooth finish. Here, recently cored spruce samples from a barn in Whately, Mass., are ready to be measured (5). This sample of pitch pine, which is a northern hard pine similar to southern yellow pine, displays contrasting growth rings (6).

though due to limited dated master availability and issues with climate sensitivity (seemingly in the case of white pine) and lack of old-growth living trees (in the case of chestnut), these species are more difficult to date. Spruce I tend to find in southern New England only if I'm studying a structure along the seacoast or near a major river valley where transport from regions farther north was enabled by waterways.

The true age of homes. "Historic" homes are generally not as old as people think. The hypothetical "This is my grandfather's ax. My father replaced the head, I replaced the handle, my daughter added tape to the handle. Is it still my grandfather's ax?" holds true for dating homes and other historic structures. It's not uncommon for people to go through deed records and trace a property back to say, 1721. The family that owned the property may have built a structure in 1721, added on to it in 1750, and in 1800, ripped off the original portion and replaced it with a new section. So, is this home 300 years old? No.

Here's another common scenario: A house built, say, in 1721, burns to the ground in 1740 and is replaced with a new house the following year. The family sells the property in 1780, and the deed records say the property was sold with the buildings "there on." The family owned the property the whole time, but there's no record that the house burned, so without careful study of the structure, the earlier date becomes associated with the present, later structure. If this research is put into print, it can become "fact" that is often repeated, further strengthening the erroneous information.

Prior to the 1980s, people researching historic homes did not have dendrochronology testing available as a research tool and had to rely on other, less sophisticated tools and methods to analyze a building's construction history. As a result, I often have to inform clients their homes are not quite as old as they think. This is not to say that some projects don't confirm a date that agrees with the existing research

on the building, as occasionally they do align. Once in a great while, the dendrochronology results reveal that a building was built earlier than previous research indicated, but this is rare.

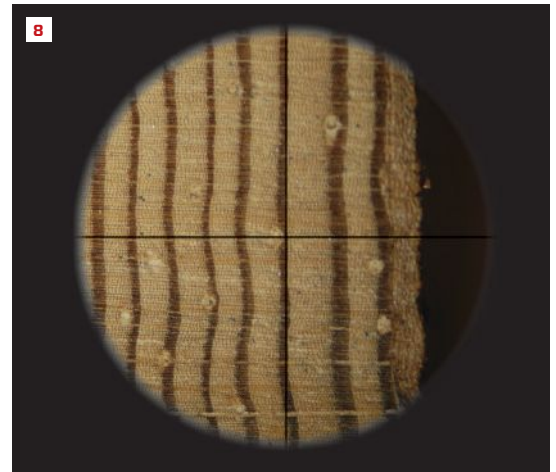
Sampling projects. When I enter a building, one of my first steps is to assess the structure and determine which timbers are most likely original to the structure and which retain a portion of the bark, or "waney" edge, a feature that must be present to establish with certainty the last year of growth. I'm not concerned about when the tree started growing, only the year it was felled.

In addition, there must be a sufficient number of rings in a sample to span several distinctive climactic variations that register as patterns of wide and narrow rings. Ideally, having 100 years of growth is best, but more often than not, samples will range from 60 to 100-plus years. Timbers with fewer than 50 growth rings cannot be used. For sampling, timber size isn't always indicative of success. I've drilled into large summer beams that have produced mere 60-ring samples and smaller studs that have yielded 100- to 110-ring samples. Thus, selecting likely candidates for sampling can be somewhat hit-or-miss.

Coring. I take a core sample at each selected timber. Typically, 10 to 20 core samples are needed per project for comparison and to allow for some not dating, for one reason or another.

After attaching a guide plate to the waney edge of a selected timber, I use a custom coring bit chucked into a cordless drill to obtain a $\frac{3}{8}$ -inch-diameter sample. My goal is to drill from the outside edge into the center of the timber perpendicular to the growth rings. As the center of the tree is not always in the center of the timber, it's not uncommon to drill a bit past the middle and a bit to one side or the other (which yields the semicircular growth rings shown in photo 6). This does not affect the results.

The custom coring bit doesn't readily expel sawdust, so I work slowly and repeatedly pull out and clear the drill bit flutes while



Each sample is placed under a stereo zoom binocular microscope on a sliding stage with a micro-adjustment knob calibrated to read to the nearest micron (7). Here, a pitch pine sample is viewed under a microscope fitted with crosshairs in one eyepiece; the waney edge is on the right (8).

coring. If the core stays intact throughout the drilling process, it is removed from the timber with the use of a thin metal rod with a sharp “L” tip that is slipped down the side of the core and twisted to cut through the base of the sample, which can then be removed. Should the sample break during coring, I simply separate the coring bit from the drive adapter and remove the cored sample from the drill tube. Coring samples run anywhere from 4 to 8 inches in length (or longer, in rare instances). When cores break during sampling, it is often possible to accurately reglue clean breaks without losing rings.

I label all the samples and enter them into a log book that notes the position of each sampled timber within the structure, its species, whether it has wane, and any other information pertinent to the sample.

Prepping samples. Back at home, I glue the core samples into custom wood mounts, longitudinally, as if you were looking down the tree in section view. The mounted samples are numbered (corresponding to the log book information) and then sanded down using successively finer grit paper with a bench top belt sander (150 grit) and hand sanding (220, 400, 600 grit) to create a mirror-smooth finish.

Measuring tree ring growth. I view all the samples using a low-power stereo zoom binocular microscope fitted with crosshairs in one eyepiece to ascertain and mark the number of rings per sample. This is followed by a visual review of all samples to determine if site-specific growth patterns can be picked out. Each sample is then placed under the microscope on a sliding stage calibrated to read to the nearest micron (.001mm), tied electronically to a computer. Measuring begins at the outer, or last year of growth ring, established as 1000, and proceeds to the center of the sample or first year of measure (the waney edge is assigned the number 1000, the

second-to-last ring is 999, and so on, down until the earliest ring in the sample is measured). Working with the measuring program J2X, I measure the width of each ring by moving the sliding stage with its rotating gear system and enter the width into a J2X computer file by clicking a start-stop button, similar to a mouse. Depending on the number of samples and the ring counts in them, measuring can take a couple of hours to more than a day.

Analysis. Now comes the interesting part—for me anyway. With the raw data in hand and using dendrochronology-specific software, I can compare the samples from each site to determine if all were cut more or less at the same time or within the span of several years or more. This creates what is known as a floating, or undated but aligned, chronology. The samples are also compared against one or more dated regional master chronologies of the same species to determine the exact year or years when the samples in question were felled. As strong samples are uncovered, they are added to a fledgling site master, and the raw data is run against the site master to see if additional samples align.

Example. Analysis can be complex and difficult to explain in a short article. To get a sense of what the results of a dendroarchaeology study look like, see the tables on page 36. The study shown was essentially a dendrochronological “home run”—because of how well all samples aligned among themselves as well as against dated masters—and was thus chosen for illustrative purposes. Not all studies are successful, though by my estimates, success is achieved approximately 85% of the time.

William Flynt served as the architectural conservator for Historic Deerfield Inc. for 40 years, retiring in 2019. Since 2003, he has conducted dendroarchaeology studies on over 250 structures in New England and eastern New York state.

Fisher House Samples Vs. a Regional Dated Hemlock Master Database

Samples. Sample 1 (OEF-01). Typically 10 to 20 samples are taken per project.

Last year of growth. The author sets the measuring program to start at 1000 and counts backward as each sample is measured from wane to center.

PART 8: DATE ADJUSTMENT FOR BEST MATCHES FOR COUNTED OR UNKNOWN

OEF-H VS NY-VT-MA HEMLOCK MASTER
50-YEAR SEGMENTS LAGGED 25 YEARS

SAMPLES	COUNTED SEGMENT	# 1 ADD CORR	# 2 ADD CORR	# 3 ADD CORR	# 4 ADD CORR	# 5 ADD CORR
OEF-01	895- 944	795 .40	990 .37			
OEF-01	920- 969	795 .64	745 .39			
OEF-01	945- 994	795 .66	660 .42			
OEF-01	951-1000	795 .65	686 .42			
OEF-02	898- 947	800 .53	1001 .39	1025 .37	968 .34	781 .33
OEF-02	923- 972	800 .58	986 .38	859 .36	750 .35	596 .33
OEF-02	948- 997	570 .42	800 .37	634 .37	724 .37	743 .34
OEF-02	951-1000	570 .37	688 .36	774 .35	850 .34	743 .32
OEF-03	903- 952	627 .42	799 .41			
OEF-03	928- 977	799 .58	664 .46			
OEF-03	951-1000	799 .65	742 .46			
OEF-04	882- 931	814 .40	926 .38			
OEF-04	907- 956	799 .52	600 .43			
OEF-04	932- 981	799 .55	971 .34			
OEF-04	951-1000	799 .52	633 .43			
OEF-05	888- 937	926 .35	711 .35	799 .35	978 .33	712 .32
OEF-05	913- 962	799 .67	544 .50	829 .41	1032 .38	570 .37
OEF-05	938- 987	799 .62	773 .42	600 .41	664 .37	843 .35
OEF-05	951-1000	799 .46	569 .44			
OEF-06	910- 959	595 .44	842 .43			
OEF-06	935- 984	799 .61	595 .47			
OEF-06	951-1000	799 .53	596 .39			
OEF-07	900- 949	799 .47	600 .37			
OEF-07	925- 974	799 .49	829 .38			
OEF-07	950- 999	799 .49	633 .42			
OEF-07	951-1000	799 .49	633 .40			
OEF-08	905- 954	799 .49	887 .39			
OEF-08	930- 979	799 .56	664 .45			

Second best data fit (column 2, and so on)

Best data fit (column 1).
Sample output when run against this dated hemlock master.

Year tree was felled.
Number added to every year of growth to determine ring calendar dates.
In this case, 799+1000 (last year of growth)=1799 (the year tree was felled).

Correlation coefficients represent how well each 50-year ring group fits with the dated hemlock master (.3281 is the threshold of significance; in this test, those associated with the "add" numbers 795, 799, and 800 are strong, around .50 and above).

Undated Floating Master of Fisher House Hemlock Samples

Floating masters reveal how each sample's last year of growth compares to the other samples within the group (represented here in column 1).

5-year offset is due, in part, to the fact that the outermost few rings were too indistinct to accurately measure.

PART 8: DATE ADJUSTMENT FOR BEST MATCHES FOR COUNTED OR UNKNOWN

OEF-H VS OEF-H ALIGNED
50-YEAR SEGMENTS LAGGED 25 YEARS

SAMPLES	COUNTED SEGMENT	# 1 ADD CORR	# 2 ADD CORR	# 3 ADD CORR	# 4 ADD CORR	# 5 ADD CORR
OEF-01	895- 944	-5 .82	53 .38	-24 .33	24 .29	34 .27
OEF-01	920- 969	-5 .85	24 .32			
OEF-01	945- 994	-5 .86	-63 .29			
OEF-01	951-1000	-5 .84	-50 .35			
OEF-02	898- 947	0 .76	29 .32			
OEF-02	923- 972	0 .84	14 .31			
OEF-02	948- 997	0 .82	-32 .32	-29 .31	-58 .28	-45 .22
OEF-02	951-1000	0 .80	-29 .32	-37 .28	-58 .25	-68 .25
OEF-03	903- 952	-1 .73	44 .42			
OEF-03	928- 977	-1 .79	-40 .36			
OEF-03	951-1000	-1 .83	-59 .37			
OEF-04	882- 931	-1 .82	14 .39			
OEF-04	907- 956	-1 .79	-24 .25			
OEF-04	932- 981	-1 .80	-40 .37			
OEF-04	951-1000	-1 .82	-23 .21			
OEF-05	888- 937	-1 .84	57 .38			
OEF-05	913- 962	-1 .90	28 .29			
OEF-05	938- 987	-1 .89	-14 .29			
OEF-05	951-1000	-1 .68	-15 .31			
OEF-06	910- 959	-1 .43	13 .33			
OEF-06	935- 984	-1 .80	13 .26			
OEF-06	951-1000	-1 .76	-78 .34			
OEF-07	900- 949	-1 .73	48 .38			
OEF-07	925- 974	-1 .78	-40 .27			
OEF-07	950- 999	-1 .81	-30 .35			
OEF-07	951-1000	-1 .80	-30 .35			
OEF-08	905- 954	-1 .82	44 .32			
OEF-08	930- 979	-1 .86	-40 .43			

Last year of growth for sample 2 (OEF-02) is represented by 0 in the first column.

This sample (and all others consistently exhibiting a -1 in the first column) have a last-year-of-growth ring one year earlier than samples such as OEF-02. Four other OEF samples (not shown in this partial summation) had a last year of growth of 0.

Correlation coefficients for 50-year ring groups within Fisher House hemlock samples were extremely high, ranging from .43 to .90 as shown in this partial project summation.

The Ephraim Fisher House, Orwell, Vt. (OEF). Of the 17 samples extracted from the Fisher House, 15 were hemlock and two were oak. The samples from both species of wood dated extremely well against master chronologies for those species, revealing a rather short period of tree felling to accumulate enough material to frame up the structure (as shown on the partial spreadsheet, "Fisher House Samples Vs. a Regional Dated Hemlock Master Database," above left). The felling began during the warmer months of 1800,

when some of the trees were still actively growing, and continued into the late fall and possibly the winter of 1800-1801, after the trees had ceased growing for the season. It is likely that the frame was raised in 1801, as framers preferred to work timbers green rather than dried.

What was remarkable about this study was the degree to which the samples aligned among themselves (see "Undated Floating Master of Fisher House Hemlock Samples," above right) and with the masters they were compared to, especially the

hemlock. The geographic distance between Orwell and the regions where the hemlock master samples were obtained is rather substantial. —W.F.



William Fyfe



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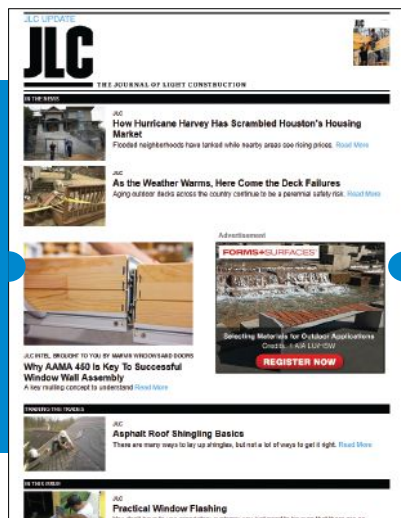
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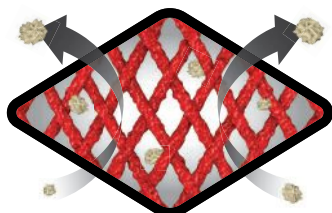
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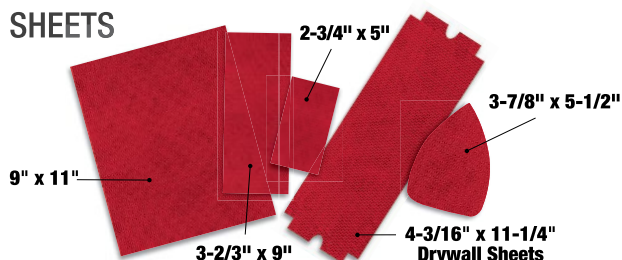
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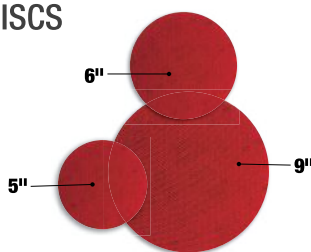
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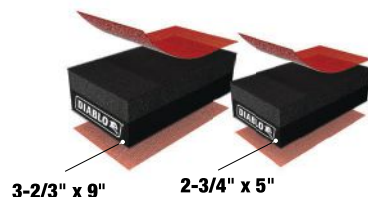
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STRUCTURE



A Study in Broken Load Paths Repairing the havoc wrought by sloppy prior work

BY JAKE LEWANDOWSKI

My family's company, Great Lake Builders, specializes in structural repairs in and around Chicago. Many of the homes we work on are similar to the one shown in this article: wood-frame buildings that have outlived their structural capacity. Some of these suffered damage from badly executed floor-plan changes or from mechanical contractors hacking up the structure to retrofit new systems. And many were underbuilt to begin with. This job suffered from all of the above.

LOAD-PATH ESSENTIALS

On this job, most of the structural problems could be traced back to breaks in the load path, which can be devastating to the integ-

rity of a building even if it doesn't collapse. The effects go beyond plaster or drywall cracks; they manifest in walls and floors that noticeably sag, in floors that bounce and squeak, and in doors that don't fit their openings and shake the walls when slammed.

Loads on a building must be supported by a complete load path that effectively transfers loads "from their point of origin through the load-resisting elements to the foundation," as it's described in Chapter 3 of the International Residential Code. In general, the load transfer needs to be continuous from roof through walls and headers, as well as floors, beams, and columns, to the foundation. Rafter and joists should align with studs, and all load-bearing walls and floor loads must be supported by foundation walls and footings

Photos by Jake Lewandowski



This flush beam in the second floor had no bearing on one end, only nails loaded in shear into a ledger **(1)**. The ledger was partly carried by cripple studs, but the header supporting these cripples had no support **(2)**. No joist hangers supported the joists carried by the flush beam **(3)**, and the end nails had pulled away as the beam, which was overloaded on one side, had rolled.



Plumbers over the century had done a good job of carving up floor joists **(4)**. The span and width of this undermount header **(5)** required a double LVL, but the remodelers who installed it to open up the room to the kitchen had used a double 2x12 instead.

or with beams supported by columns to footings. The alignment of structural members is the best way to effectively transfer gravity loads, but the loads are not all from gravity. Lateral loads and uplift forces require connections between members that are tight (wood-to-wood) and tied securely together with fasteners. In our repair work, we hardly ever toenail permanent connections; we rely exclusively on steel clips, corners, and straps fastened with structural screws.

On this job, we were called in to execute an engineer's design for reinforcing a number of key components in the load path. We addressed five critical areas of the structure:

1) Undersized floor joists on the second floor had sagged. In addition, an area of this framing below a second-floor bathroom had been severely chopped up by plumbers.

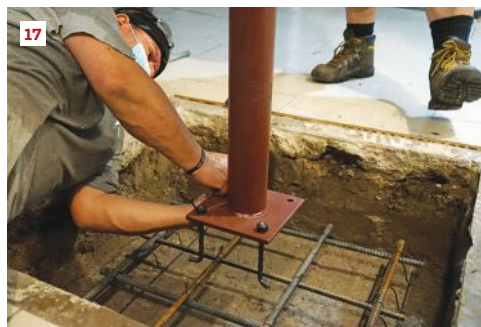
2) A flush beam in the second floor had no bearing at one end. It was simply toenailed into a ledger that was nailed to cripple studs, and the window header that picked up the loads on these cripples had no support



In this joist bay **(6)**, a new steel beam will be installed perpendicular to this basement girder. (It will span to another girder that runs parallel to it). The column supporting this girder had almost no footing **(7)**.



Ernesto Bonilla cuts flooring nails **(8)** so sister joists will fit tight to the existing ones. He and Toby Bonilla roll in sister joists **(9)**; a screw and hammer help pull the sisters flush to the bottom edge of the existing joists **(10)**. Blocking is key to stiffening the floor **(11)**. The studs in this critical wall section **(12)** had bowed and are reinforced before any jacking is done.

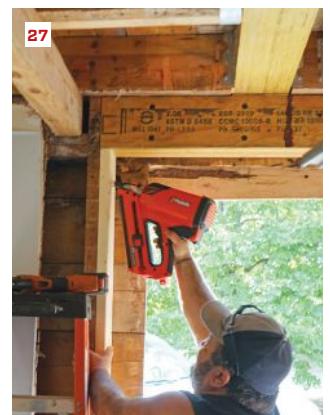
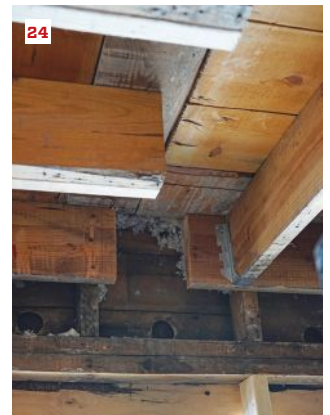


At the top of the wall section described above, the pencil line **(13)** shows the position of a laser before the beam is jacked into position in the basement **(14)**. When the beam is level, the wall has been raised more than an inch **(15)**. Steel shims are placed between the new beam and the old basement girders **(16)**. A new footing is prepped **(17)** and poured **(18)** for the new column.

UNDERMOUNT BEAM



FLUSH BEAM



Prior to removing the old undermount beam, the crew erects shoring on each side of the opening (19). The author joins two LVLs with structural screws and planes the top to flush up the two plies to get good bearing on both (20). The beam is lifted into place (21). It extends beyond the corner so the end column (22) bears directly on the new basement beam.

Toby and Ernesto erect shoring on one side of the old flush beam (23). After removing it, they cut through the ledger so the new flush beam will extend over the window (24). They use shoring to lift the beam into place (25). With the beam raised, the joists are secured with joist hangers (26), and a new LVL header is installed with full-length jacks (27).



At one end of the flush beam, the load path from beam to window header to full-height jacks is complete (28). At the other end, the flush beam has full bearing on a corner column (29) that bears directly on the new steel beam that spans the girders in the basement. To complete the job of reinforcing the floor system, the joists hacked up by plumbers are headed off (30, 31).

extending to the foundation. In addition, this beam was overloaded on one side and had rolled. The framing predated joist hangers, and the end nails securing the joists to this beam had pulled away.

3) An unsupported bearing wall was failing. It was carrying the other end of the flush beam, as well as a section of the underbuilt second floor, but it had no bearing in the first floor that transferred directly to the two steel girders in the basement.

4) An undermount header that had been retrofit to enlarge a door opening into the kitchen was undersized and unsupported. This beam was in line with the flush beam. For its span and depth, the engineer said it needed to be LVL, but the remodelers who installed it had used dimensional lumber, and one end column did not have bearing that transferred to the basement girders.

5) A steel column that supported one of the basement girders was failing because it had almost no footing.

FROM THE GROUND UP

As a rule, you want to approach a load-path repair by starting at the bottom and then lift the structure from a solid foundation. On this job, we began by excavating for the column footing in the basement. But before jacking, we first needed to sister the undersized floor joists in the second floor. We wanted to create a flat floor system so that when we started to lift the structure from the basement, the floor would rise uniformly and we would be able to accurately measure our progress. This would have been impossi-

ble with the extent to which the existing floor sagged.

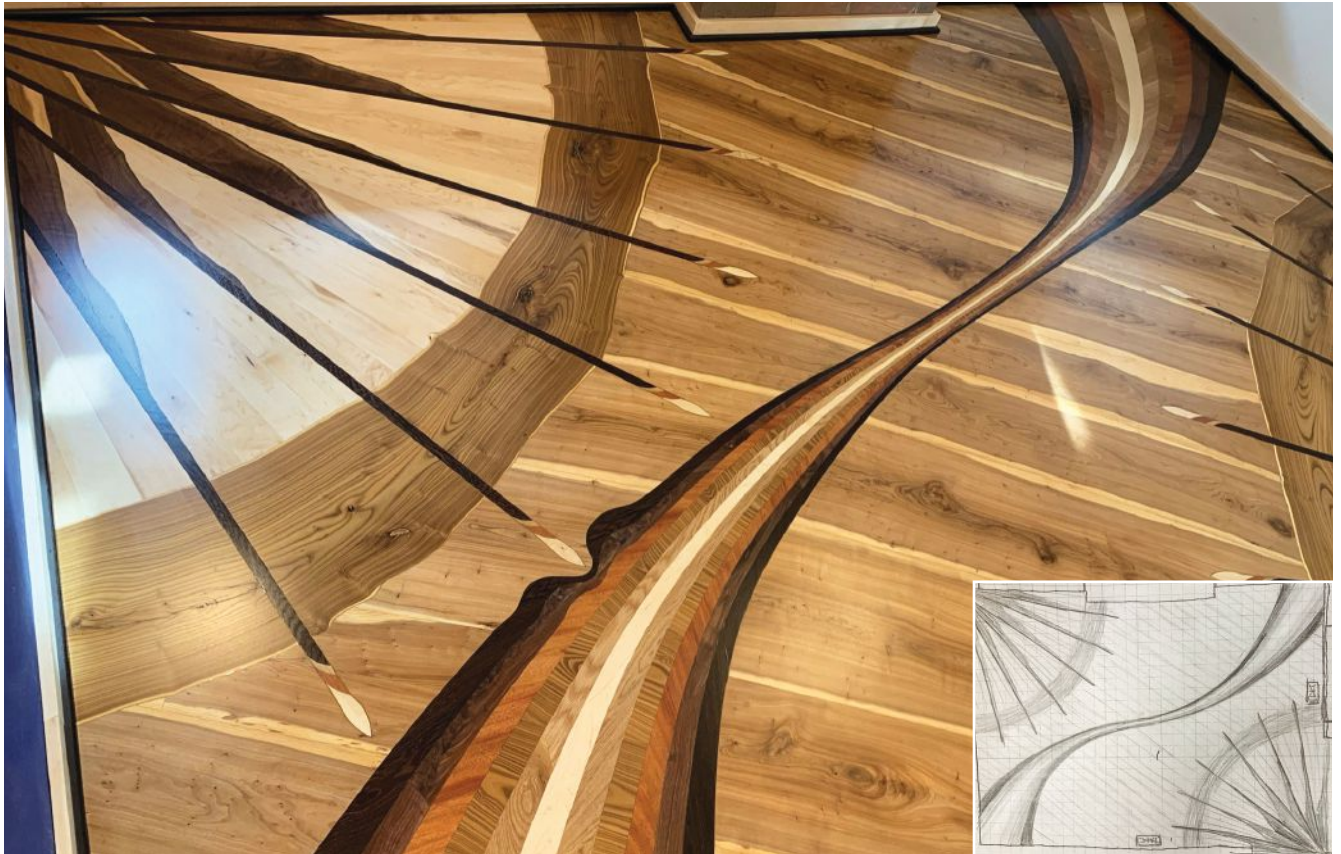
We also strengthened the unsupported bearing wall section mentioned above. The top and bottom wall plates had sagged at each stud, and the studs themselves were bowed. By reinforcing the wall with additional, plumb studs, we could reliably lift from below, knowing that everything would stay straight and the lifting force would be effectively transferred, raising the structure as a whole.

Before lifting, we installed a new steel beam spanning between the two existing basement girders. This new steel beam was positioned directly under the previously unsupported wall section; it would support the corner column at one end of the flush beam as well as the column at one end of the undermount beam. Jacking up this new beam to level straightened the wall plates and lifted the reinforced second floor as well.

Once the main floor elevation was established, we could install a new flush beam (four LVL plies) and new undermount beam (two LVL plies), as well as rebuild the floor where the plumbers had hacked it up. This required adding headers across joists to carry the loads around the plumbing so we could remove the cut-up joists. It was painstaking work, as it's difficult to screw off framing hardware in such tight spaces. Nevertheless, it's critical to follow through with tight joints and all holes in the hardware filled with screws.

Jake Lewandowski is a construction manager with his family's business, Great Lakes Builders (greatlakesbuildersinc.com) in Elk Grove Village, Ill.

INTERIORS



Installing Custom Wood Floors Make designs pop with live-edge inlays and multiple wood species

BY TOM OURADA

I don't install many floors with live-edge inlays and other custom features like the ones described in this article (the market for these unique wood floors is relatively small and select), but I would if I could. I like the process of working with clients to come up with a design and the technical challenge of executing it using various wood species that I've sourced myself.

I've been installing traditional hardwood and softwood floors for 15 years and began experimenting with these unique creations about nine years ago when my family was still walking on subflooring in our six-year-old home. A friend who had a mill was ambitious enough to help me slab some pine trees growing on my property, one of which was a "pistol butt," a tree growing out of and up a steep hill. The result-

ing 18-foot-long log was 26 inches wide with a 7-foot-tall curve—not to mention wet and heavy—but two days later, we had about 12 workable slabs. After they were dry, I used them to cover my home's subfloor with a design that won my first of six National Wood Flooring Association (NWFA) Floor of the Year awards. Certainly, my approach could be replicated on a less ambitious design, with similar results.

LOGGING AND MILLING

Over the years, I've accumulated equipment more suitable for a logging operation than for a flooring installer, including a 60-inch Alaskan saw—basically a frame that supports a large chain saw fitted with a 60-inch bar—and a couple of other semi-portable

Photos by Tom Ourada



The author constantly scouts for interesting trees from a number of sources. Sometimes he brings his portable Alaskan saw to mill a tree on-site (1), but more often he hauls the logs to his home (2) to mill them into nominal 1-inch-thick slabs with his band sawmill (3). The first slab cut reveals the log's grain pattern and color (4).

sawmills wide enough to handle the odd-shaped logs that I like to transform into flooring. I also have a small trolley and a crane to handle the logs once I've brought them back to my shop, and a small kiln to dry the planks after I've milled the logs.

Where I live near Spokane, Wash., hardwood trees are vastly outnumbered by ponderosa pine, Sitka spruce, Douglas fir, and other softwoods, so I'm always on the lookout for good hardwood candidates for my projects. I've salvaged a lot of trees scheduled for removal from city parks and often work with private landowners who have unwanted trees, bringing my tree-climbing gear (I'm also a rock-climbing enthusiast) and chain saws to carefully limb them and drop them to the ground without damaging them.

Of particular interest to me are trees with a nice curve or crotch, which produces the interesting shapes that I like to use in my designs. Anything with a C- or S-shape that can sit flat on the ground is a good candidate for flooring.

After I've sectioned the downed logs and hauled them back to the "log yard" behind my house, I try to mill them as soon as possible—it is easier to saw wet logs than dry ones and, in hardwood logs, results in less cracking or splits. Wet softwood logs tend to develop a fungus that creates a nice bluing effect but will also lead

to decay and softness if not checked in time by kiln-drying.

One lesson I've learned since I began milling custom flooring is that curved boards have to be cut thicker than straighter pieces to prevent "washboarding"—think wiggles on a lasagna noodle—when they are dried in the kiln. Of course, using pieces of different thicknesses makes getting the surface of the final floor in the same plane trickier than simply sanding the installed flooring smooth. Typically, I rough-saw boards to between $\frac{5}{8}$ inch to $1\frac{1}{2}$ inches thick, depending on their shape, species, and edge detail, before kiln-drying them to between 6% and 8% moisture content.

DESIGN AND LAYOUT

Before I design a floor, I like to meet with the clients in the room where the floor will be installed. In addition to getting a feel for their personalities and interests, I like to find out how the room will be used and what kind of furniture it will have. Drawing on both this discussion and my mental inventory of the pieces of wood that I have on hand, I sketch out three or four design ideas using paper and pencil. Usually, the final design meshes elements of these preliminary ideas that I've sketched out.

Once we've settled on a design, it's time to transcribe it to the

INSTALLING CUSTOM WOOD FLOORS



Working in his shop, the author uses a small band saw to cut wood pieces to fit the design (5) and cleans up the cuts with an oscillating benchtop belt sander (6). He creates the design in sections, starting with the big pieces (7). Smaller pieces are then cut to fit to complete the design (8). After one section is done, the author dismantles the pieces and starts working on the next section, repeating the process until the design is completed.



floor. The design is the big idea, but it's the wood that dictates how it is executed on the floor. I find that the wood pieces start designing themselves as I rearrange them according to their grain patterns and colors. I begin with the big pieces to balance the flow, tacking them in place using flat-head screws with small shanks that leave only tiny holes. Then I work in the small pieces.

I lay out the design on the floor of my shop, working in sections and varying the species to create contrasts and patterns. Russian olive is one of my favorites because of its color and grain, but it's tricky to work with because it's brittle and tends to crack. Wenge is a dark wood that I like to use to create contrasts, but I also sort of dread working with it because of its super-sharp splinters.

To cut out the desired shapes for a design, I primarily use a small 10-inch Rikon band saw, though I occasionally use a jigsaw too. I've tried using a scroll saw but abandoned it after breaking too many blades.

In the flooring community, one of the marks of a good installation is a tight fit, which is difficult to achieve with small pieces and complex shapes. For this type of work, it's critical to know the three sides of each line—inside, outside, and middle—and to pay close attention to where you are making the kerf. After I've cut out a piece, I check and re-check the fit, adjusting the cut as necessary until I'm satisfied (my goal is to use as little filler as possible). Then I

smooth out and back-bevel the cuts using an oscillating bench-style belt sander with the table tilted about 2 degrees.

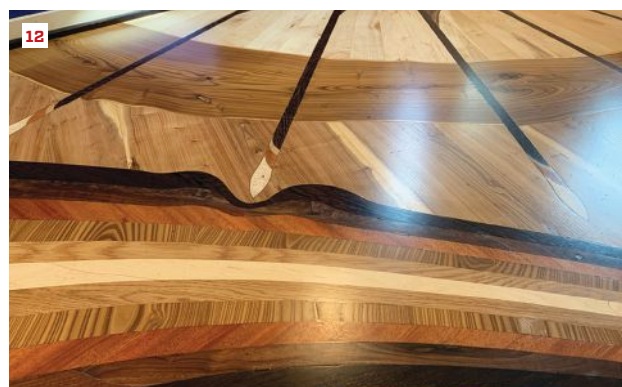
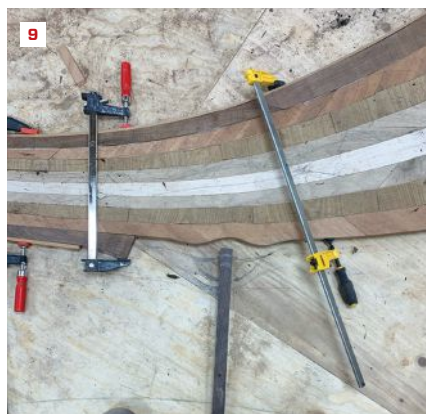
Along with a tight fit, flatness is a hallmark of a good floor installation. Because I'm working with flooring pieces of varying thickness, I need to do a lot of hand planing and sanding. I start by leveling out the high spots on the backs of the big pieces with a power planer to make them as flat as possible, checking them often with a straightedge before tacking them to the floor with screws. When pieces are less than 1/2 inch thick, I laminate them to 1/2-inch plywood backing before cutting them out.

Once I'm satisfied with the fit of the pieces on a section, I dismantle it and move on to the next section. Most of these floors are installed in homes that are far from where I live in eastern Washington, so after I'm done laying out the sections and cutting the pieces to fit, I pack everything up, load the floor and my installation tools into my van and work trailer, and haul it all to the jobsite for installation.

INSTALLATION

Unlike with blind-nailed strip flooring, which I install over a vapor retarder like Aquabar paper underlayment, these floors are glued directly to the subfloor with Bostik GreenForce adhesive, which also acts as a vapor retarder. First, I lay out all the pieces I precut in my shop, again screwing down the big pieces (using the

To create the swoosh pattern on this 12-by-17-foot dining room floor, the author laminated various species together, including maple, white oak, Russian olive, black walnut, and wenge (9). Those same species were used to create the radiating corner pieces (10, 11). After carefully leveling out the floor with a power planer and various sanding machines, he buffed the surface, then applied a sealer coat and two polyurethane finish coats; no stain was required to enhance the wood's grain and color (12).



same holes) and making adjustments as needed until everything fits tightly together. Since nothing ever goes back together exactly the way it fit in my shop, I bring along extra material and my tools so I can recut pieces as needed.

Then I pull up about a 4-by-8-foot section of the floor, spread Bostik adhesive on the backs of the pieces with the manufacturer-recommended notched trowel, and glue that section down. To hold small, pointy pieces flat to the floor while the adhesive cures, I pin them with special scored screws that are designed so that their heads will break off about 1/4 inch below the surface of the flooring (Squeak-No-More Pro Floor Repair Kit, squeakyfloor.com). Then I move on to the next section.

After the floor is glued down and has set overnight, I level out the high spots. I can't just jump onto the floor with my multi-head sander because of the mixture of relatively soft woods like poplar and hard woods like wenge or Japanese elm. So I start with a power planer to take down the high spots, checking the floor often with a straightedge. Then I go over the entire floor with a Clarke Super 7R edging machine fitted with a 16-grit open coat sanding disk. Next, I go over the floor with a Lagler Hummel 8-inch floor belt sander, beginning with a 40-grit belt, then switching to a 60-grit belt and changing the angle about 10 degrees. After that, the floor becomes more like a normal floor; I sand it with a Trio machine and finally,

prior to finishing, buff it out with a HydraSand multi-head sanding assembly fitted to my buffer for the highest grit recommended by the manufacturer of the stain or the sealer coat.

FINISHES

I'm not opposed to using water-based stains to add color to a design, such as a wildlife-themed floor featuring a portrait of a deer that I installed for a neighbor. But for the most part, I prefer to let the wood species speak for themselves as they acquire a patina over time. In my area, which experiences a wide range of humidity over the course of a year, I've found that oil-based finishes tend to work best.

I start by popping the grain by spritzing the floor lightly with water from a garden sprayer and spreading the droplets with a T-bar. After the floor has dried, I apply a Duraseal stain coat (if desired) and sealer coat, followed by two finish coats of Fabulon oil-based polyurethane satin finish. Before applying the final coat to the floor, I buff it with a maroon pad with three thin strips of 180-grit sandpaper attached to flatten any debris in the finish while prepping the dried finish for better adhesion of the final coat.

Tom Ourada owns Ourada Designs in Nine Mile Falls, Wash. You can follow him on Instagram: @OuradaDesigns.

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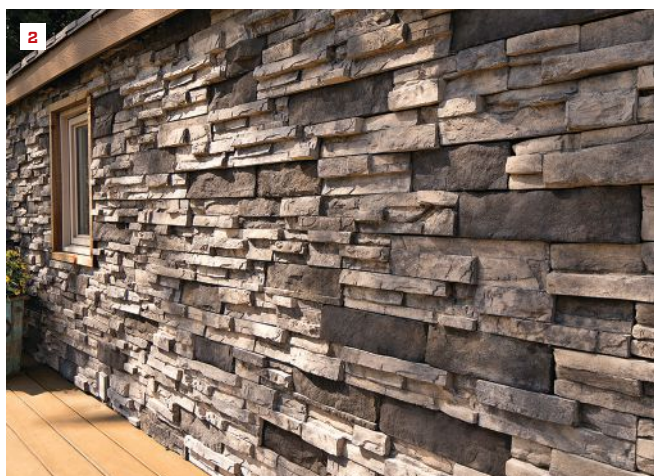
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BY VINCENT SALANDRO



1. Durable Steel Pergolas

Made with steel, Fortress Building Products' pergolas benefit from the material's modern aesthetic, low maintenance, weatherability, and resistance to fire, corrosion, twisting, insects, and rot. The pergolas can be configured in numerous custom setups—without specialized tools—in three style options, and then finished with composite boards. Pergolas include a 25-year limited warranty; pricing for one that measures 10 feet by 12 feet starts at \$1,500. fortressbp.com



2. Low-Maintenance Mortarless Stone Veneer

The stones in ClipStone Classic veneer from Cornerstone Building Brands are installed individually without mortar using an embedded self-spacing metal clip. These clips, which simply screw to sheathing or OSB, also hold the veneer off the wall to create a drainage plane and provide air circulation. According to the manufacturer, the stones have beveled sides to make them easier to position during installation, and once installed, the veneer requires no maintenance or sealing. The ClipStone line also includes a mortarless ColumnWrap and will be adding a large-format panel. Pricing is \$14 to \$15 per square foot. myclipstone.com



3. Hybrid Stain and Sealer

YellaWood Protector semi-transparent stain and sealer, an acrylic-oil hybrid that includes water repellents and UV inhibitors, can be used for wood decks, fences, siding, pergolas, gazebos, and outdoor furniture. The manufacturer recommends applying two thin coats. Protector comes in three shades as well as clear, in one- and five-gallon buckets. Pricing varies. yellawood.com



4. Coated Structural Fasteners

Intended for wood-to-wood connections in exterior structural applications with treated lumber components, Spax PowerLags T-Star Washer Head wood lag screws with HCR (high corrosion resistance) coating have a low-profile, large-diameter wafer head that the manufacturer claims provides additional surface area under the head for superior pull-down force. They require no predrilling and are available in 1/4-inch, 5/16-inch, and 3/8-inch diameters in lengths up to 10 inches. Pricing varies. spax.us

Products

5. Sturdy and Elegant Wood Cabinets

NorthPoint Cabinetry's two collections of all-wood cabinets have plywood cases reinforced with solid-wood corner blocks and include dovetail drawer boxes. The Essentials collection features cabinets with partial-overlay Shaker-style doors and slab-front drawers, while cabinets in the Premier collection feature upgrades like soft-close doors and drawers and full-overlay doors in a choice of two styles. Cabinets are available in various sizes and finishes, including a new slate finish. Pricing varies by project. hardwareresources.com/northpoint-cabinets



6. Multi-Slide Patio Doors

Weather Shield Contemporary Collection and Premium Series aluminum-clad wood multi-slide door systems are available either in stacked configurations or hidden inside a pocket wall, in options up to 57 feet wide and 12 feet tall. Panels move on a four-roller system, and the slide jambs incorporate glass-reinforced nylon endcaps to easily connect to sills using an interlocking dovetail joint. The Energy Star-compliant doors cost from \$8,000 to \$40,000. weathershield.com



7. Fiberglass Insulation

CertainTeed's InsulPure Fiberglass Building Insulation is fabricated with a fiberglass binder formula free of synthetics, additives, and coloring. Lightweight and easy to cut, InsulPure creates less dust during installation, promoting improved air quality and quicker jobsite cleanup. According to CertainTeed, the insulation has improved rigidity to help it stay in place between wall studs. The fire- and high-temperature-resistant product meets or exceeds all green building performance standards and is available in batts and rolls 3 1/2 to 15 inches thick and 15 to 24 inches wide. Contact CertainTeed for pricing. certainteed.com



8. Textured Wall Tiles

Island Stone's Ledger Panel and Ledger Corner textured wall tiles combine the aesthetic of split-face, tightly stacked stone cladding with an easy-to-install, large-format panel, according to the manufacturer. The tiles are suitable for interior walls, kitchen backsplashes, fireplace and shower walls, and exterior walls. The Ledger Corners come in two sizes that fit together at a right angle. The Ledger Panels measure 23 5/8 inches by 5 7/8 inches and are 5/8 inches thick. Contact a distributor for pricing. islandstone.com





9. Aesthetic Cabinet Pulls

Ormonde and Ulster Series cabinet pulls from Top Knobs are designed to be easy to grip. The Ormonde series (shown) incorporates bowed lines and beveled detailing, while the Ulster series features deep ridged contours. In the Ormonde series, knobs are 1³/₈ inches, and pulls range from 3³/₄ inches to 12 inches; in the Ulster series, knobs are 1¹/₄ inches, and pulls also range from 3³/₄ inches to 12 inches. Pricing for the two series ranges from about \$8.50 to \$170. topknobs.com



10. SmartSide Mounting Blocks

LP SmartSide Trim & Siding has introduced SmartSide J-Blocks (shown) and SmartSide Mini-Splits for mounting around a variety of exterior fixtures. Both are composed of primed engineered wood-strand substrate and feature a cedar-grain texture. The J-Blocks are 7.23 inches long, while the Mini-Splits are 6.75 inches long. Both products are 7.21 inches wide and 0.970 inch thick to provide durability and stability. Pricing for both products varies by region. lpcorp.com



11. Pourable High-Performance Flooring

Of the four new color palettes for Sherwin Williams' line of High Performance Flooring, three may be applied across the company's portfolio of seamless, resinous flooring systems while one applies only to terrazzo floors. Deco Flake System Colors combine multicolored vinyl chips with resin, Deco Quartz System Colors consist of quartz aggregate combined with resins, ResuFlor Topcoat Metallic System Colors combine resin with natural stone-mimicking pigments, and Terrazzo System Colors feature hues of marble, granite, and other aggregates. sherwin-williams.com



12. Durable Swinging Doors

Marvin's Ultimate Swinging French Door G2 is available in inswing and outswing configurations, and offered in heights up to 10 feet with four-panel configurations in widths up to 14 feet. Made with solid-wood interiors and extruded aluminum-clad exteriors with rot-resistant fiberglass sills, these doors can withstand even the harshest climates, says the manufacturer. For security, the doors have a multipoint locking system with concealed lock-status sensors that can connect to a smart home system to indicate when the door is closed and locked. marvin.com

Metabo HPT MultiVolt Framing Nailer

BY MIKE WHALEN

Over my 30-year career in the trades, I've used many different air-powered and cordless nail guns, so I was excited to try Metabo HPT's new 36-volt MultiVolt 3 1/2-inch cordless framer and see how it stacked up against the others. The first thing I noticed when I took the Metabo out of the box was the weight, which is almost 11 pounds with the battery installed in it. Though that's at the high end for battery-powered nailers, the tool felt balanced when I picked it up and held it for a little while. Pneumatic nailers are lighter, of course, and if they are coil-style instead of having a straight magazine like this one, they can sometimes feel lopsided when they are loaded with a full coil of nails. This nailer comes in both a round-head 21-degree version (model NR3690DR), which is the one we tested, and a clipped-head 30-degree version (model NR3690DC).

We were in the middle of framing a kitchen and had a triple LVL beam to install, so the timing was perfect to try out the tool. It took only eight minutes to bring the 36-volt battery up to a full charge, but with the MultiVolt system, we could have plugged the tool into an AC adapter and fired nails all day long, even with a discharged battery. The adapter doesn't come with the tool, though, so I appreciated having the four-bar battery life indicator on the back, which I checked from time to time to see how much charge was left. There is also a power button on the gun itself to turn it on and off, which could serve as both a safety and a power-saving feature. The gun will automatically turn off when it hasn't been fired for a half-hour, and there is a lock button on the side of the handle that was easy to switch to the unlock position when I was ready to use it.

The framer will take nails as small as 2 1/2 inches, but we were doing some wall and beam framing, so we used the bigger, 3 1/2-in. x 0.131-in. plastic strip nails, which we picked up at our local lumberyard. The magazine on this gun has a 37-nail capacity (the magazine on the clipped-head version accepts up to 47 paper-collated nails). The nails slide in on the left side of the gun; after pulling back the pressure slide, we were good to go.

I started out nailing 2x4 studs up and was impressed with the power the gun had. For this kind of work, the weight of the gun is an advantage, as it helps to minimize any bounce or push back from the pressure. Another advantage of a battery-powered nailer over a pneumatic is that there is no air blow-back. This is especially nice for inside work because

I don't end up having floor dust or ceiling insulation blown back in my face. The nail gun was easy to maneuver between a conventional stud layout, and it has the option for single fire or continued fire when the trigger is squeezed.

The biggest test was nailing up the three LVL members that we had to install for a structural beam. The nail gun had no problem sinking the 3 1/2-inch round-head nails flush every time. I was even able to consistently countersink the nails about 1/8 inch by adjusting the depth with the quick thread adjustment at the tip of the gun.

It's a pleasure to work in a smaller place without dragging a hose around or waiting for a compressor to catch up. We didn't have to wait for the motor to ramp up either and found that the ability to drive three nails per second was plenty fast enough for us.

According to Metabo, the included 2.5-Ah battery will drive 900 nails per charge. After a few weeks of using it inside to frame walls in a kitchen remodel and outside to frame a sunroom, it still has half a charge left.

The nailer comes with a pivoting belt hook and a nicely sized zippered storage bag, so we can easily take it along to our next framing job. Price: \$450. metabo-hpt.com

Mike Whalen is a project manager at DBS Remodel, a design-build residential remodeling company based in Poughkeepsie, N.Y.



Metabo HPT's MultiVolt cordless framing nailer has a brushless motor powered by a 36-volt battery (1). Both clipped-head and round-head versions are available; the author tested the round-head version (2).

Photos: Andalee Powers/courtesy DBS Remodel

Weigh In!

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

Flex 24-Volt SDS-Plus Rotary Hammer Drill

BY MARK CLEMENT

I have something of a love-hate relationship with rotary hammers. On the one hand, most tools in the pro category are well-designed and get jobs done that need doing. On the other hand, those jobs that require the jackhammer-like pulverization that rotary hammers are uniquely designed to dish out aren't my favorite. But after using the new Flex side-handle 1-inch SDS-Plus rotary/chipping hammer to break up a wire-mesh mud bed and a lot of tough circa-1950 ceramic tile during a kitchen remodel, free up a metric ton of plasterboard, drill holes in concrete for lags and shields, and remove trim, this rotary hammer has more than earned my appreciation because it makes those jobs easier. (Pro tip: A rotary hammer fitted with a 1 1/2-inch spade iron and set to chip-only mode makes for a fantastic 24-volt pry bar.)

With a 5.0-amp-hour battery, this powerful tool is built to work all day and then some, but perhaps its best feature is that it comes with a quick-change three-jaw Jacobs-style chuck. Pull a collar back, remove the SDS bit holder, swap in the chuck, and you suddenly own a low-speed, high-torque cordless drill that you can use to mix mortar, thinset for tile, concrete in a bucket for a plumbing penetration repair, or joint compound. It's also great for drilling big holes.

As a test, I tried sinking a number of 5/16-in. x 6-in. structural screws. While I do that regularly with the impact driver, everything gets hot after a while. In drill mode and fitted with the Jacobs-style chuck, the Flex rotary hammer ran cool and smooth.

The battery swaps out easily, both from the tool and from the charger (I have some cordless tools for which it's a micro-wrestling match to get the battery out or back in, a headache I don't want). I'm not beholden to any particular battery platform, and I work alone, so I don't mind having a few different chargers, but I recognize the extra cost. The tool performed beyond well, and it's at least two tools in one—whether that's worth the financial outlay for another battery platform depends on the other tools you have and the kind of work you do.

The rotary hammer comes with a zippered ballistic nylon tool bag, which does what it's designed to do but manages to be both too much and not enough at the same time. I have never—not once—zipped one closed in my whole life. Thus, I have reassigned it as a lunch box and keep the tool and bits in an old-school rigger's bag. Price: \$300. flexpowertools.com

Mark Clement is a carpenter, member of the JLC Live build team, and author of the novel The Carpenter's Notebook. Find him on Instagram @myfixituplife.



While the Flex FX1551A rotary hammer is designed for SDS-Plus bits, its brushless high-torque, low-speed (0-980 rpm) motor is ideal for driving large drill bits through thick material. Here, the author is drilling a pilot hole through wall framing with a ship auger bit as part of a window retrofit project (1). The battery-powered tool comes with an adjustable side handle, built-in LED lighting, and both an SDS-Plus bit holder and a 1/2-inch metal chuck (2).

Collomix AQiX Water Dosing Device

BY MATTHEW NAVEY

My father, John Carroll, and I specialize in small custom masonry projects and make our mortar in small batches. Adding just the right amount of water to the mix of sand and masonry cement—the key to producing a very good mortar with the right consistency—can be tricky, so recently we tested the Collomix AQiX Water Dosing Unit, a handheld battery-powered meter that connects to a hose, to see if it would help. Its buttons are reminiscent of a television remote: a pause and play button as its power button, plus and minus buttons for digitally scaling up and down the water you intend to let out, two memory preset buttons, and a function button. Being a German manufacturer, Collomix offers dosing in either liters or gallons. If you use gallons, as we did, the meter can be adjusted in tiny, hundredth-of-a-gallon increments.

Because the AQiX measures the water content precisely (the company claims that the device is accurate to 0.05 quart), the tool can be used to make higher-quality mortar or concrete. More importantly, it does this repeatedly; by putting in the same amount of water for every mix, you can have consistent quality. The trick is in the initial batches—finding the approximate amount of water for the result you want. I recommend using a hose with a splitter for this part; that way, you can attach the AQiX to one short length of hose and use the other hose for cleaning up and adding small amounts of water to the first few batches if they aren't right.

Our normal batch consists of 2 gallons of masonry cement (around a quarter of a bag) to 5 gallons of sand. With dry sand, we found that 1.2 gallons of water mixed into the sand and masonry cement made very good mortar, and with the AQiX, we were able to achieve the same result with every subsequent batch. (For a full bag of masonry cement, you'd need to set the dosing meter to about 4.5 gallons of water.) Because the water was precisely metered, it sped things up, too.

On a recent job, we mixed up 30 bags of concrete, using the AQiX to precisely meter out 2.6 gallons of water for every two bags of concrete. Not having to manually measure out the proper amount of water for each batch saved us a lot of time, allowing us to complete the pour in about two hours. Metering the exact amount of water all at once is much quicker and easier than gradually adding water to each batch until it reaches the proper consistency, especially in larger builds when we make many batches in a day. Price: about \$250 online. collomix.us

Matthew Navey is a mason, photographer, and carpenter's assistant working in Durham, N.C.



The Collomix AQiX delivers pre-selected dosing quantities from 0.3 to 99 quarts, in 0.1 quart increments. It connects to a garden hose with a standard 3/4-inch hose coupling (1) and has a battery-powered display (2). It comes with a metal bracket that can hook onto the mixing vessel (3).

Photos: Matthew Navey

DeWalt TStak and ToughSystem 2.0 Organizers

BY BARRETT SITES

When remodeling and doing home repairs, you never know what you're getting into or what you will need at the jobsite or at a client's house. And even when you have what you need, you might not be able to find it; I've searched my work van for fasteners or other supplies in vain, knowing that they were in there somewhere but being unable to locate them. It's frustrating to purchase a replacement only to find the item later when looking for something else. And it costs time: A trip to the local hardware or big-box store or lumberyard may take only 15 minutes, but those minutes quickly turn into an hour away from your project, not to mention the loss of momentum.

TStak. To solve this problem, I've recently been storing my fasteners, accessories, and tools in several DeWalt TStak storage boxes. The boxes are modular, so they can be stacked in different combinations, and they have latches, so they can be locked together. They can also be locked to a rolling mobile storage unit, a deep toolbox that has 7-inch wheels for going up stairs or over rough terrain and a retractable handle (also available in the TStak system is a cart and a luggage carrier-style trolley).

Some DeWalt tools, such as my DeWalt track saw, come with a TStak storage box; the boxes are available in different sizes to fit both small and large tools. For example, I keep my track saw in one TStak box and store an assortment of drill/drivers and batteries in another. The boxes come with plastic dividers, making it easy to customize them. DeWalt also sells foam inserts separately, and you

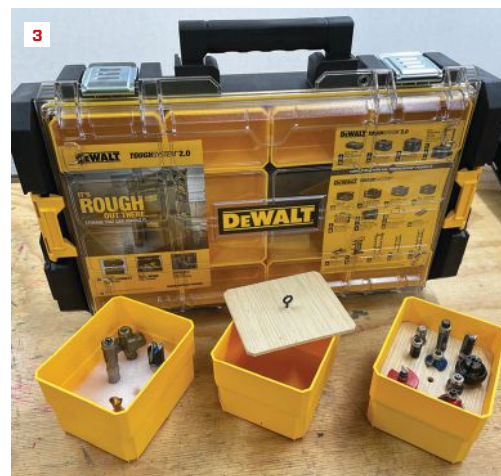
can find after-market solutions from other companies. In addition, I've used packaging foam, 1/4-inch plywood, and shop scraps to customize my boxes.

ToughSystem 2.0. I also acquired DeWalt's ToughSystem 2.0 DS100 organizer, which the company says is stronger and 20% bigger than the similar TStak box (and more expensive). The organizer has 12 removable cups—eight small cups and four larger ones—that lock into place with a water-sealing lid that gives the box an IP65 rating. It can be secured with a padlock and has new auto-connecting side latches that interlock with other ToughSystem toolboxes and with a workshop racking system. DeWalt also offers rack systems for standard-height trailers and vans and for Sprinter-style tall vans. The boxes have a rear center mount that allows them to be attached to the appliance cart-style DS Carrier.

ToughSystem 2.0 boxes are backward compatible with original ToughSystem boxes and range in size from 7 inches deep to almost a whopping 39 inches deep for the DS450 rolling toolbox. Along with various sizes and configurations of toolboxes, you can add a 27-quart cooler for drinks and lunch and a Bluetooth radio and charger to the system.

Though DeWalt does not have an adapter to connect the TStak and ToughSystem boxes together, I have found after-market connectors. dewalt.com

Barrett Sites is a remodeling contractor in Chambersburg, Pa.



DeWalt TStak storage boxes are available in various sizes and configurations and have side latches that allow them to be connected together as a unit. Here, several boxes are stacked on top of a wheeled storage box, which also has a handle (1). The organizer box has a clear lid and removable cups (2). ToughSystem 2.0 boxes are slightly larger and made with more robust materials but are based on the same concept. Both storage systems can be customized with foam inserts (3).

Photos: Barrett Sites

BY MARK LUZIO

American Chestnut

"A grove of chestnut trees is a better provider than a man—easier to have around, too." —Appalachian woman's oral history

Working in New England for over 40 years, I have dismantled and restored several houses that were around 250 years old. A necessary part of this work was demolition, which entailed my peeling though layers that were 100, 150, and 200 years old before getting to the original house. It's nasty work but comes with some reward when you discover small historical artifacts, however insignificant—a bit of old newspaper, a broken tool left in a wall, a coin or clay pipe, or even wood shavings that are the tell-tale sign of carpenters who once worked exclusively with hand tools. But for me, the best reward has been old wood I have been able to salvage, and some of the best of this has been American chestnut.

Once a common wood found in most East Coast and Appalachian houses and barns built before 1930, American chestnut is now rare because of a fungus that reached America from imported trees. The Bronx Botanical Garden was the first to report blisters that girdled the bark and killed trees at the Bronx Zoo in 1904. Over the next 40 years, from New England to the Carolinas, 4 billion trees were lost—fully 25% of the entire Eastern forest. As the American Chestnut Foundation put it: "The American chestnut tree survived all adversaries for 40 million years, then disappeared within 40."

Chestnut trees have been described as the redwoods of the East; some were the largest trees in the forest, growing to 5 or 6 feet in diameter, and some odd giants even measured up to 10 feet in diameter. The chestnut used to be a staple food for people and animals, and an important cash crop in the Blue Ridge and Great Smoky Mountains, until the tree disappeared at a most inopportune time, during the Great Depression. All rural people would have known this tree. Native Americans used its leaves and bark for medicinal tinctures. The high tannin content of the bark made it a cash crop to sell to leather tanneries.

Chestnut has a color and grain close to white oak but has the weight of pine. A good test to distinguish it from oak is to try scratching it with a fingernail; if it leaves a mark, it is probably chestnut. The wood was used in every part of a house or barn. It has strong natural resistance to rot, so it was often selected for sills and posts. It is light but strong, so it was also used for beams and especially rafters. But because it was so common and plentiful, it was used virtually everywhere else: as sheathing, interior wall panels, floorboards, and trim; it was even planed to 1/2-inch-thick dust boards between cupboard drawers and

rough sawn for lath. To quote a bit of Appalachian oral history: "I've seen it used for a cradle and a coffin."

I once found chestnut floorboards in the attic of a house I restored that had been built circa 1760. The width and tightly spaced growth rings put the age of the trees (likely cut within a mile of the house) at about 200 years, so they were probably saplings around 1560. Many years later, cutting joints on the last board from that attic, I thought, what a survivor—461 years now and hopefully another 100 or more in its new service life. While commissioned cabinet pieces make up most of my work now and I haven't done much demolition in the past few years, I still come across chestnut boards at architectural salvage yards. I look for boards with straight grain and widely spaced nail holes, looking to make the largest possible clear cuts. The thin strips are good for banding and picture frames, and the wider pieces for dovetailed boxes and drawers. Each little project becomes my respectful meditation on a once great tree.

Mark Luzio owns Post Pattern Woodworking, based in Brooklyn, Conn.



A dovetailed box made by the author from salvaged chestnut wood. The pull is inset with a 1902 half dollar from a time just before the blight.

Photo: Mark Luzio



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