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On the cover: Tim Uhler (operating the forklift) and Kyle Davis set a balloon-framed wall in place for a house under construction on the Olympic Peninsula in Washington. See the story on page 29. Photo by Tim Uhler.

FEATURES

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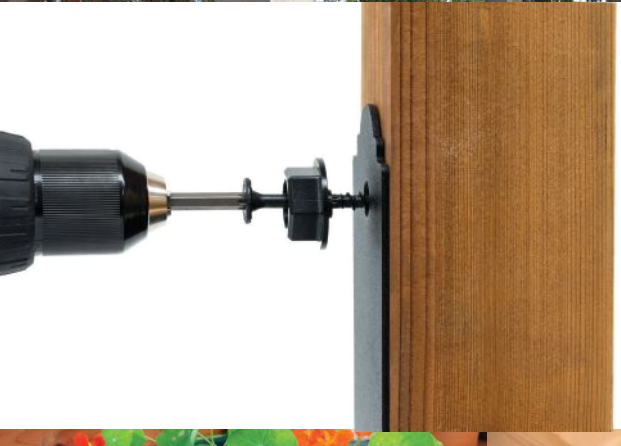

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Q Is it okay to use epoxy grout with natural stone pebbles for a tile shower floor? Are there any special considerations when using either epoxy or a cement-based grout with natural stone, which is (presumably) unsealed and possibly porous?

A *Tom Meehan, a second-generation tile installer in Harwich, Mass., and author of* Working with Tile, *responds:* There is an art to grouting natural stone pebbles, but it is not difficult in any way if you know your product and the materials needed to perform this task. First of all, there are two types of natural stone tile: Flat stones, which have been cut to a consistent thickness, and irregular raised pebbles, which vary considerably in both size and thickness. Raised pebbles used to be popular, but the highs and lows created by the rounded stones can block water drainage, which becomes a maintenance issue requiring more frequent cleaning. That is why flat stones are now used about 90% of the time in my area. Even with them, I increase the pitch of the shower floor slightly to a little more than 1/4 inch per foot to help avoid drainage problems.

Photo by Tom Meehan

Irregular stone pebbles add a natural design element to a tiled shower but should be installed over a base with more pitch than normal to allow for better drainage.

Regardless of the type of natural stone you are using, the pebbles should be thoroughly cleaned and sealed prior to being grouted. After setting the stone in thinset mortar, I inspect the joints carefully and clean them up with a utility knife so that the dry thinset is at least 1/8 inch below the surface of the stone tiles. Then I go over the joints with a damp sponge, rinsing the sponge frequently in a clean bucket of water. I'm careful not to use too much water and flood the joints, since they must be thoroughly dry prior to grouting; any water that accumulates in them will weaken the grout.

When the stone pebbles are dry, I seal them with Miracle Sealants 511 impregnator sealer, applying a thin coat with a foam brush or equal applicator. If the stones are very porous, I'll add a quick second coat, which will make the stones appear darker at first. I tell my clients not to worry, though; after the sealer dries, the pebbles will once again have that dry, natural stone look.

When it comes to grouting, keep in mind that some joints will be as wide as 1/4 inch, with some pebbles much thicker than others (which is part of the desired look). While you could use epoxy grout with pebbles, I typically use it only in areas that need to be chemically resistant to bacteria, like food processing areas or—in some cases—steam showers. I find that the strict time frame required to work successfully with epoxy grouts can be counterproductive and prefer to use traditional cement-based grouts for most applications.

For irregular natural stone, I recommend using a good, sanded, high-performance grout, such as Tec Power Grout, Laticrete Permacolor Grout, and Mapei Keracolor Grout. These grouts are easier to work with than epoxy grout for this application and have additives that make them stronger than regular grout, with more consistent color and mildew resistance.

When using these grouts, be sure to closely follow the manufacturer's mixing and application instructions. For example, avoid using too much water while cleaning the grout residue off the surface of the stones, because it will not only weaken the grout but will also wash out some of the color. I work from a couple of buckets of water, one with clean water for washing and one for rinsing out my sponge on the second wash.

At the end of the job, I apply another light coat of sealer over the entire floor, which helps protect both the stone and the grout.

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Replacing a Tub With a More Accessible Shower

BY JOHN CARROLL

Ten years ago, my brother Rick was diagnosed with Parkinson's disease. One of the strongest and hardest-working men I've ever known, he is now unsteady on his feet and uses a walker to get around. These days, he shows a different kind of strength as he stoically confronts the daily challenges of this debilitating disease.

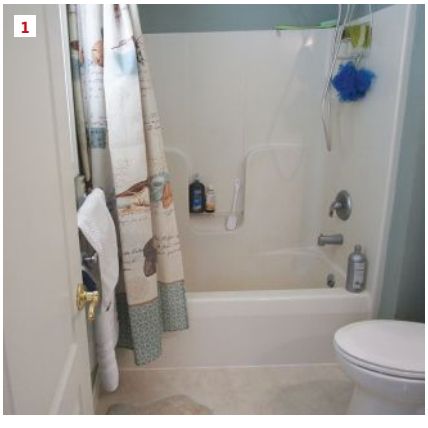
He doesn't ask for much, but his fondest desire is to continue living in his house. His seven siblings, three children, a niece, and a nephew have all pitched in to help him do just that. With the help of my son Matt, my contribution was to make his bathroom safer and easier to use.

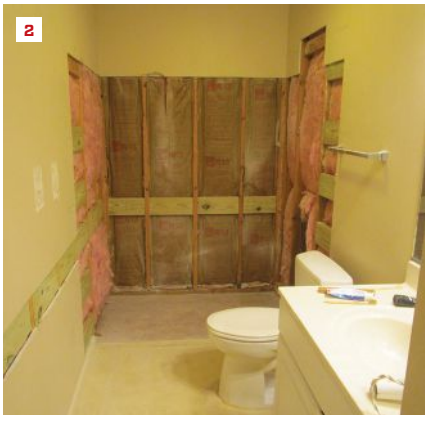
Budget limits the scope of work. We had a limited budget, which meant we couldn't rearrange or expand the bathroom. Our main focus was removing the tub and installing a shower without changing the sink, vanity, toilet, or floor covering. Our other focus was providing secure grab bars throughout the bathroom.

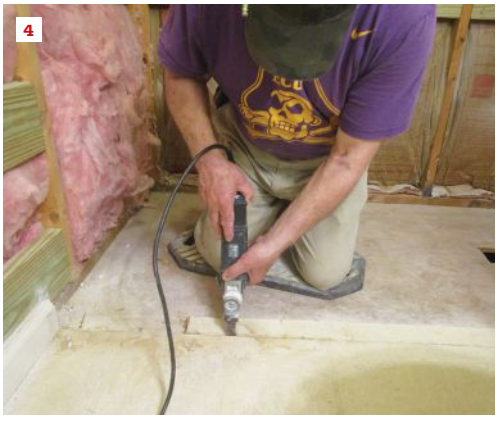
Because we limited the scope of the job, we were able to upgrade from the basic builder-grade fiberglass tub **(1)** to a tile shower. In addition to improving the look of the shower, using tile allowed us to build in the accessible features that we wanted.

After removing the plumbing fixtures, I cut the tub into manageable pieces using a 4½-inch angle grinder fitted with a diamond blade, and hauled the fiberglass scraps out of the house. Then, to gain access to the framing for blocking, I cut the drywall back one stud beyond the space we planned for the shower **(2)**.

With the framing exposed, I began to install blocking. This blocking would provide not only anchorage for the edges of drywall and

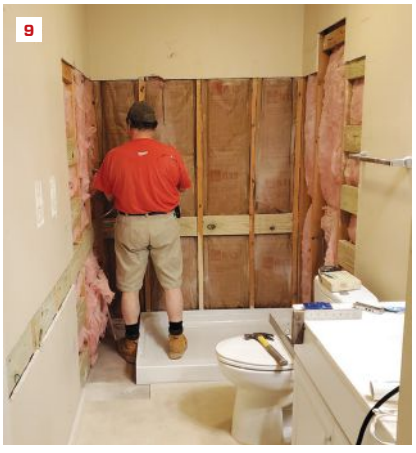






Photos by Matthew Navey

After removing the existing fiberglass tub **(1)**, the author cut back drywall and installed blocking for new grab bars **(2)**. Using the new shower base as a pattern **(3)**, he marked where the flooring and underlayment needed to be cut back **(4)** and where a hole for the shower drain needed to be drilled **(5)**.



Before installing backer board, the author checked the wall framing **(6)** and planed any bowed studs so that the wall would be flat **(7)**. Clips hold the shower base in place **(8)**. A new bench seat will be installed in the gap between the shower base and the wall **(9)**.

tile backer boards but also solid attachment points for mounting grab bars and plumbing fittings. I also added blocking where we planned to attach a short wall and a bench at the end of the shower.

Shower base. For the shower floor, we chose Sterling's Guard+ 34-inch-by-48-inch Vikrell base (sterlingplumbing.com), which was much faster and easier to install than a tile floor. The installation of the drain, in particular, was greatly simplified; in this case, the house was built on a crawlspace foundation rather than a slab, which allowed us to easily move the drain line. We also routed the supply line for the handheld shower from the shower valve diverter to the opposite wall (i.e., the wall behind the bench) under the floor. This was a better option than running it through the exterior wall, where—though it was insulated—there would be a greater risk of freezing. Also, any problems in the line would be much easier to fix under the floor than they would be in a wall covered in tile.

I used the base itself to lay out the cuts for the drain and the vinyl flooring and underlayment, since the tub was 30 inches wide and the shower base was 34 inches wide **(3)**. I also had to cut an additional 7 inches or so where I would build the short wall at the end of the shower. After I cut the floor covering **(4)** and the hole for the drain **(5)**, I checked the wall framing with a level to make sure the studs were straight **(6)**. Before installing the shower base, I planed off the bow from a few studs **(7)**, then used roofing nails to attach the clips that held the base in place **(8, 9)**.

Framing the wall and bench. Like bathrooms in many middle-class houses, this one was 60 inches wide, while the Vikrell shower base was 48 inches long, which left 12 inches between the shower base and the wall. In this area, I framed a short wall and a bench, both of which I later covered with tile. The 16-inch-long wall runs a few inches past the end of the base.

I made the bench 12 inches deep and ended it at the edge of the shower base. In use, the 4-inch overlap of the new wall allows the shower curtain to run 4 inches behind the wall, which helps keep water inside the shower enclosure.

I built the wall the same height, 75 inches, as the rest of the tile enclosure because we wanted steam from the shower to flow over it. Since it would be covered in tile, this wall had to be rigid. Rather than extending a post to the ceiling, which we thought would look odd, I used some unconventional framing to hold the wall rigidly in place. After screwing 2x6 blocks 12 inches on-center in the adjoining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To make the short, 3/4-height wall that partially encloses the shower bench, the author framed it with 2x6s tied with plenty of blocking to the existing framing **(10)**, and covered both sides with 5/8-inch plywood **(11)**. A diverter valve supplies water to either the showerhead **(12)** or a handheld shower over the bench seat **(13)**.


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wall, I attached 2x6 pieces horizontally **(10)**. Next, I screwed a pair of vertical 2x6s to the ends of these blocks and then covered both sides of the wall with 5/8-inch plywood. Tying in the bench, which itself was built like a tank, made this little wall rock solid **(11)**.

On the wall above the bench, I framed a niche, which consisted of two 2x4s screwed horizontally in the bay between two of the studs and one 2x4 installed vertically to make it 12 inches square. As a result, the niche is not perfectly centered on the wall, but centering it would have involved reframing the entire wall and considerable drywall repair.

Plumbing. For the water supply, we used a diverter valve (Kohler K-11 748-K) that allows the bather to switch from the standard overhead shower to a handheld shower mounted beside the bench **(12)**. The maximum temperature of the water that flows through this valve can be adjusted, a great feature for people like my brother, whose hands don't work as well as they used to, because it prevents them from being scalded. We adjusted the maximum temperature to 120°F.

Tile backer board. After testing the plumbing lines for leaks, I installed Permabase, a cement-based tile backer board, on the walls and the bench. Then, following the manufacturer's directions, I covered the seams using modified thinset and 2-inch alkali-resistant mesh tape. I also covered the screws with the thinset. This process is similar to taping drywall, and I used my 6-inch taping knife to apply the thinset and embed the tape **(13)**.

When I framed the niche, I laid it out so that the back could be covered by a single piece of the 12-inch-wide gray tile that we planned to use on the project. When I installed the backer board, I used construction adhesive to attach a piece to the back of the drywall for the bedroom that adjoined the bathroom. After installing the back piece, I installed pieces on the top, bottom, and two sides of the niche. Then, I taped the niche with thinset and mesh tape while I was taping the rest of the shower.

Waterproofing membrane. We chose Mapei Mapelastic AquaDefense liquid-applied membrane to waterproof the shower. This membrane is easy to install; you just paint it on with a roller or brush. The key thing to remember is that it's water-soluble, so it's essential to apply it to a dry surface. I let the thinset dry overnight before applying the first coat of Aqua Defense, then let that coat dry overnight before I applied the second coat **(14)**.

Tile. We chose a fairly inexpensive 4-inch-by-12-inch tile and

The author coated the tile backer board with a liquid-applied waterproofing membrane **(14)**, then installed 4-inch-by-12-inch tile in a subway pattern **(15)**. Tile colors were chosen for high visibility **(16)**, while the new grab bars make all areas of the 5-foot-wide bathroom safer and more accessible **(17)**.

ran it in an offset, subway-tile pattern. The tile was white with gray streaks, which made it look like marble. For the border, we used gray tile, which brought out the gray streaks in the field tile, and we used a matching gray grout. We chose the same gray tile for the bench and the niche at the end of the shower. Although we certainly wanted my brother's shower to look nice, our decision to use these colors was also driven by a desire to maximize visibility. The largely white tile reflects light well and the gray grab bars and bench stand out visually, making getting into and using the shower easier and safer **(15)**.

To simplify things, I stayed in the Mapei system, using its polymer-enriched thinset mortar to install the tile. I spread a fairly thick coat of the thinset on the wall before combing it with a 1/4-inch-by-1/4-inch notched trowel. Then I back-buttered each tile before setting it in place.

I also used Mapei's Keracolor unsanded grout to fill the joints. Finally, I used matching Mapesil acetic silicone sealant, which color-matched the grout perfectly, at the inside corners and the joint between the tile and the shower base **(16)**.

Grab bars. When I installed the blocking, I was careful to note its locations on the walls before hanging the drywall. I also made crude, dimensioned sketches of those locations in a notebook. When I installed the grab bars at the end of the job, I was glad to have these records, especially for the walls covered with tile.

Per ADA recommendations, we installed the horizontal grab bars at 34 inches off the floor. We also installed vertical grab bars on both sides of the entry into the shower. Two of the grab bars have also proven to be helpful for using the toilet, which is next to the shower **(17)**.

This bathroom doesn't come close to meeting the ADA requirements for accessibility, which are written mainly for people in wheelchairs who are using public accommodations. While this bathroom is not accessible for an unaccompanied person in a wheelchair, it is much more accessible than it was before. My brother has been using it for a year and a half now and has told me that the modifications we made have worked extremely well. He particularly likes being able to bathe while seated using the handheld shower.

John Carroll, author of Working Alone, is a builder who lives and works in Durham, N.C.

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Running a Bath Fan Exhaust Through Metal Roofing

BY AARON MIILLER

There are many ways to properly ventilate a bathroom exhaust fan, and plenty of options available to run the exhaust through a shingle roof or directly through a wall. However, I rarely see one installed through an exposed-fastener metal roof, so I have had to devise a way to do this efficiently.

For a bathroom on the interior of a floor plan, running the duct through the attic and out the roof is often the most direct, if not the only, option. While a gable-end wall may sometimes be an option, we have had customers balk at this when it was practical. More often, it is not practical. For a typical 50-cfm bath fan, code limits the length of 4-inch exhaust ducts to a straight run of 56 feet *or the equivalent*. The termination equals 30 feet, and each 90-degree elbow is equal to 15 feet, so you're often not left with very much distance. This is the reason I typically opt to go out the roof, and since many of the homes we work on have exposed-fastener metal roofing, this method has proven to work time and time again for us. The following photos and captions explain how we do it.

Aaron Miiller owns Miiller Construction, based in Corning, Ark. Follow him on Instagram: @miillerconstruction.

Suppliers often recommend zip ties for securing ducts to fan housings **(1)**, but that is not enough. The author uses insulated flex duct and first secures the inner plastic sleeve with a high-quality foil tape **(2)**. Then, he pulls up the insulation and secures it with the zip tie **(3)**.

It's usually easier to secure the duct to the fan first and then install the fan in the ceiling **(4)**. Note: Using insulated duct is important to help prevent condensation from forming inside the duct, where it may collect or drip into a room through the fan body.

Once the fan is installed, the author strategically cuts a hole as close to a framing member as possible. This member will provide support for the vent pipe. Temporarily using pipe strap, he attaches a short length of 3-inch PVC pipe to the rafter next to the hole **(5)**.

Photos by Aaron Miller

To further help prevent condensation, the author installs a secondary damper near the outlet, using this type of PVC backdraft damper **(6)**, which is available online for around $10. He can find the damper only in a 4-inch diameter, so he tapes it to a 3-inch PVC coupler **(7)**; then, making sure the damper is closed, he glues the damper assembly to the short PVC pipe on the rafter **(8)**, making sure that the damper is in the appropriate closed position.

After cutting the duct to length, the author tapes its interior sleeve around the damper assembly **(9, 10)**. The insulation jacket is cut longer than the inner sleeve to allow the insulation to be pulled over the short PVC pipe, insulating it up to the roofline. To secure the insulation, he backs out the screws on the pipe strap, pulls up the insulation, and after a final check outside to make sure the pipe is plumb and straight, he reattaches the pipe strapping permanently **(11)**.


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On the outside, the result is a common and easy pipe penetration through the exposed-fastener metal roof **(12)**. The author then installs a flexible boot (this one is made by Oatey), which has a soft aluminum and lead edge made to conform to the panel ribs **(13)**. (For more on the installation of this type of boot, see the author's article "Reroofing With Exposed-Fastener Metal Panels," Sep/20.)

The final steps address two concerns: vermin and water entering the exhaust pipe. To combat vermin, the author uses a PVC mesh insert **(14)**, which he buys online for around $9. To prevent water from entering the exhaust pipe, he connects two 90-degree elbows together and attaches them to the exposed PVC stack **(15)**. He keeps the outlets high enough to prevent snow from blocking them. In areas with more snowfall, they can be made higher, though in practice, the exhaust typically melts snow away from most roof vents before it can cause problems.


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BY DAVID GERSTEL

The Employee-Centered Company and Your Financial Freedom

Half a dozen years into my career, an older and wiser builder showed me that if I put my mind to it, I could rapidly make my way to financial independence. Work would then be a choice, not a necessity. I'd rise every day free to do what I liked, unfettered by monetary necessity.

That sounded good to me. I went for it. Likely my thinking and strategizing was not quite so clear in my mind as I see it in retrospect. But I did know that I wanted to stay in construction. I liked the work, from bidding and estimating to orchestrating the trades and driving nails at a jobsite. I liked the camaraderie among workers and builders and felt valued when clients referred my company to their friends.

I could also see, however, that construction is, financially speaking, a marginal business. Failure rates are massive; consistent profits are hard to come by. I concluded that building a company with the intention of eventually selling it was not my best path to financial freedom. There was not likely to be a robust market for not-so-good businesses like construction companies. (Generally speaking, I was right. As I explain in my new book, *Building Freedom, A Construction Pro's Path to Financial Independence*, selling a construction company is likely to be difficult but not likely to be lucrative.)

Instead of conceiving of it as an eventually marketable commodity, I viewed my construction company as a money pump. If run properly, it could pump out enough cash to provide me with adequate pay, reward my employees generously, build up capital reserves, and provide funds for the investments that would set me free.

SMART FRUGALITY

My design for that company rested on two principles, both expressions of frugality. First, it was lean. And I mean really lean. I hope to go into the particulars in a future article. For now, it is enough to say that no overhead cost was incurred that was not essential to support high-quality production at jobsites—and that "lean" does not even imply "mean." Worthwhile frugality is about caring, careful, efficient, and effective use of resources. It is not miserliness.

The second principle emphasized creation of an "employee centered" company. Employees are a construction company's most precious resources. Investing in them is smart frugality.

A fellow builder, Sam I call him in *Building Freedom*, underscored the two principles with his tart observations of a construction company that was attempting to recruit him for a management position. When he arrived, the CEO toured him through what Sam describes as the company's "Taj Mahal" facilities: An expansive warehouse. A large office building featuring post-and-beam construction. A dozen rooms for staff, meetings, and product displays. To Sam, it all looked like a lot of questionable overhead.

After the tour of the facility, Sam was handed over to the company's project manager and taken out to jobsites. There he got an impression not of lavish spending but of stinginess. The PM himself, Sam learned, was a self-taught carpenter with thin knowledge of construction. None of the guys on his crews had enough time in the trades to qualify as journeymen. The PM complained to Sam about the endless mistakes his inexperienced crews were making. But Sam saw that they were working from plans that were woefully shy on the details needed for construction.

Sam came away from his visit disappointed in the company and its allocation of resources. He shares my view that a construction company is not a creature with an exoskeleton. It does not derive its strength from a trophy office and the like. Its strength is internal, coming from the motivation and capability of its workers. What Sam had been toured through, however, was a company with an elaborate shell and weak muscles.

Frugality, Not Miserliness

Frugality becomes foolish miserliness when it is misapplied in the management of a construction company. Running lean, eliminating nonessential cost, wasted motion, and expensive trappings which produce marginal if any benefit is frugality. Squeezing employees, chiseling trade partners, and cutting corners on quality is mere miserliness. Stinginess with employees contributes to turnover, which can be brutally expensive. Squeeze your trade partners, and they will move on and spread the word, "stay away from this guy." Cut corners and you will experience building failure, which impairs reputation and imposes severe dollar costs.
—Building Freedom, A Construction Pro's Path to Financial Independence

I know from responses to my past articles that my pro-worker principles, like my advocacy of transparency, may irritate some readers. They view such ideas as inappropriate for our industry and worse. I respect and have considered their perspectives. At the same time, I think it's worth noting that the founders of iconic corporations like L.L. Bean, Hewlett Packard, and Costco, as well as many highly regarded builders, chose to create employee-centered operations. They saw the benefits to their companies and to themselves. My own preference for employee-centered does arise from a belief that workers deserve a generous share of the rewards that accrue to the company that their work sustains. But it is equally based on self-interest. I understand that an owner benefits by embracing employee-centered practices. I want those benefits.

EMPLOYEE-CENTERED PRACTICES

Before reviewing the benefits to owners, let's take a look at a few of the practices embraced by employee-centered companies. They are of two basic types. Those at the surface involve time and money. An employee-centered company aims to provide its employees with a compensation package at or near the top end for its local market. It provides good wages and as full a complement of benefits, from medical insurance through paid vacation days, as it can manage.

In the employee-centered company, pay for the employees at times takes precedence over pay for the owner. During the brutal recession that set in around 2007, two companies I know well were having such a hard time winning bids they had to offer their employees a tough choice: Take a substantial pay cut. Or have no work at all. But before offering that choice, the owners sharply reduced their own pay—at one of the companies, to zero.

In my own company, good pay was supplemented by profit sharing. The profit shares were substantial. They amounted to 15% of the top-of-market wages my employees earned.

An owner benefits by embracing employee-centered practices. I want those benefits.

An additional benefit that I emphasize is operation of safe work sites. Employee-centered companies steadily invest money and time in the safety of their people. At their work sites, you see steel scaffolding, not shaky staging assembled from leftover framing lumber. You see sturdy pro-grade ladders, not those flimsy contraptions from the local hardware store that caters to homeowners. The sites are swept up, not littered with tripping hazards. Though required by law, safety is largely ignored on many jobsites. Workers suffer horrible injuries. Maintaining safety takes time. And it costs money. Abiding by and even exceeding the legal requirements for safety is a benefit companies too often deny their employees.

An unusual benefit that I favor has to do with time. It ranks with maximal profit-sharing as the employee-centered practice that provides the greatest mutual value to employees and owners. That practice is use of the four-day workweek—namely four days of work followed by three days off. My employees worked for nine and one-half hours each day during four days of the week, typically Monday through Thursday. Then they were off Friday through Sunday. Our 4/3 week was flexible. If they liked, a crew could work Monday through Thursday one week and Tuesday through Friday the next. Thereby, they could open up a four-day window of free time for themselves.

Underlying all these concrete benefits, from good pay through the 4/3 week, is a less tangible but crucial benefit: respect. Good pay says to an employee, "You are valued." Poor pay is demeaning. It says, "You are not worth much to me."

Likewise, investment in safety expresses respect—especially if presented as such: "You guys are essential. We can't have you unable to work. We need to do all that we can to prevent injuries."

The 4/3 week emphatically expresses respect. It recognizes that employees have responsibilities and pleasures beyond their jobs and that you have cleared as much space for that as you can. (Do the math, and you will see that with the 4/3, work occurs during less than one-half of the hours in a week).

It should go almost without saying that at the company that emphasizes respect for employees, disrespect is not allowed. No sneering put-downs of apprentices when they make mistakes but instead helpful instruction on doing the task properly. No demeaning remarks about personality traits. Absolutely no stupid racist, misogynistic, or similar slurs. (None of which precludes playful bantering between workers who have long known one another and enjoy camaraderie at the jobsite.)

BUSINESS COSTS AND BENEFITS

At the employee-centered company, an old business adage has been set aside. It's no longer "customers come first" and "the customer is always right." Customers are served with great consideration, of course. But it is the employees who come first. In fact, if there is a conflict between a customer making an unfair demand of an employee (or trade partner) who is doing the right thing, you back your people.

That can inflict short-term cost. During my career on a few occasions, I pushed back hard against clients demanding way too much of my trade partners and project leads. Though we did great work for those clients, they never recommended us to anyone (which makes them nearly unique among our clients). But the

Co-workers, Not Underlings

During a severe recession, I visited with the owner of one of the most employee-centered construction companies I have encountered. (Strikingly, the company's website features photos of every one of its 80 employees, not only those of the top managers.) "How's business?" I asked the owner. "We're scrambling to keep things going," he said. "We are resilient. We will get through this." Notice the use of "we." The employees had the owner's back. He had theirs. Together they fought through the recession and thrived during the succeeding boom.

investment in the employees and trade partners paid off. They stayed with our company for many years, producing great work and helping to win many referrals to good projects. Had I stuffed the clients' demands down their throats, I would have soured our relationship. They may have moved on. Top-notch tradespeople can pick and choose who they will work with.

For an owner who structures and maintains an employee-centered company, the rewards can be tremendous. Your employees become proprietors. They think of the company as their company, too, because it is. I felt I'd made progress toward creating an employee-centered company when my crew began referring to it as "our company."

When it is their company, employees take good care of it—especially of its second most valuable asset, its clients. The clients become, in response, the company's sales force. In our case, they gave us so many strong recommendations that we had to do no other marketing. None. And that was a substantial frugality that enhanced the availability of cash for profit-sharing and freedom-granting investments.

In the employee-centered company, turnover can virtually disappear. Along with it, huge costs disappear: Time spent finding and interviewing possible new employees. Training of new employees. Integrating them with established crew. Correcting the damage when you hire the wrong new person.

In my own company, turnover was virtually nonexistent. No key person ever left voluntarily. That is not attributable to my personality. No one has ever accused me of being a particularly nice guy. I'm not. Though I steadily encouraged my employees and expressed appreciation for their work, I am assertive and demanding. I tried to give a lot but also expected a lot. I ran a tight ship. To my way of thinking, that's part and parcel of running an employee-centered company. If you don't, the company fails. And then the employees lose their jobs.

My way of doing things is not everyone's cup of tea, but for me, running an employee-centered company worked. My employees stayed because of our company culture. For the respect our practices manifested. For the good pay and safe work sites. Because of the profit-sharing. And for the 4/3 week that made room in their lives for their priorities beyond exercise of their craft.

The 4/3 week produced benefits for my company as well as for the employees. It saved money since jobs had to be set up and closed down 20% less of the time than with a standard 5/2 week. Having projects under construction four rather than five days a week reduced pressure on me. It reduced pressure on clients when we were working at their homes and, thereby, enhanced their desire to recommend us.

It is probably too much to say, as I have heard said of another employee-centered construction company, that my employees and I were a "band of brothers." But it has been gratifying to me that I still regularly hear from former employees. Just the other day I got a note from one who wanted to thank not just me but all our co-workers for teaching him how to build and run a construction operation. He is now doing well with his own business on the northwest coast.

Such appreciation means as much to me as my financial freedom. Both rewards were generated by our employee-centered principles. That's the secret sauce, along with frugality. If I run a line from my beginnings in construction as a carpenter to my financial freedom, it runs straight through the employee-centered practices I have described here. Not that I got things right all the time. Far from it. Running an employee-centered company is kind of like parenting. Though in other kinds of tests you can score 100 out of 100 possible points, the highest score anyone has ever gotten at construction company management, as at parenting, is probably around 70. But that performance, it turns out, is okay. It delivers a lot to your co-workers and your clients. And it can deliver a great deal to you, including eventually the great privilege of enjoying financial freedom.

David Gerstel is a veteran builder and the author of several books on construction company management including his most recent one, Building Freedom: A Construction Pro's Path to Financial Independence.

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BY RANDY WILLIAMS

An Introduction to Zonal Pressure Diagnostics

During a ZPD test of attic pressure with respect to the living space, a manometer that shows this zone at a pressure near 50 pascals **(1)** indicates that the ceiling air barrier is nearly perfect, because the attic is at the same pressure as the outside. However, if the zone pressure reads near zero **(2)**, the attic zone is completely connected to both outside and inside.

Photos by Randy Williams

Zonal pressure diagnostics, or ZPD, is a testing method used to compare pressure differences between spaces, or "zones," in a building. These zones may be areas like attics or crawlspaces that are already separated from the main living space, or areas that we can isolate from the rest of the house to gather information. Detecting pressure differences between zones helps us evaluate the effectiveness of the air barrier between the zone and the conditioned area of the home and decide whether to focus our air-sealing attention on that zone. Two ZPD tests are performed using a blower door: simple and advanced. A third ZPD test uses the fan from a forced-air heating system instead of a blower door to determine if the supply and return ducts are balanced in the room being tested. I will discuss all three types of testing in this article.

SIMPLE ZPD TESTING

As an example of how a simple ZPD test might work, let's say we are blower-door testing a home and find it has a high rate of air (measured in cubic feet per minute, or cfm) moving across the fan during the test. This suggests that the home may benefit from air-sealing. A hunch tells us that the ceiling of the home is the issue. The ceiling drywall in this home is the air barrier; above the ceiling is an unconditioned and vented attic that should be completely outside the conditioned space of the home. To determine if this is the case, we operate the blower door at a negative or positive 50 pascals of pressure with reference to the outside. All the spaces outside the conditioned space of the home should be at 50 pascals of pressure (either positive or negative, depending on if the test is pressurized or depressurized) with reference to the home. If 50 pascals is measured between the home and the attic space, we have a perfect ceiling air barrier—exactly what we are looking for.

However, if we test the pressure of the attic space with reference to inside the home and find it is at 25 pascals, we can surmise the attic space is connected to both the home and outside and that the size of the holes between

the outside and the vented attic is equal to the size of the holes between the home and the attic. We don't how many holes, and we don't know their exact locations; we just know that the holes between the attic and the home and those between the attic and the outside are equal in area. If the attic space is at 0 pascals, there is no separation between the outside and the home; the attic is completely connected to both the outside and the inside.

Our example is an attic, but this sort of simple ZPD test is commonly used to test other house zones, including attached garages, the "attic" spaces behind knee walls, unconditioned crawlspaces, sunrooms, and other spaces connected to the home that should be outside the thermal and air boundaries.

While we don't know the exact number and size of the holes in the air barrier we found with our simple ZPD test, we can deduce something about the *relative* size of the holes, as described in the chart below.

RATIO OF PRESSURES TO LEAKAGE

Zone Pressures (in pascals)		Relative Size of Leaks	
Zone to House	Zone to Outside	Zone to House	Zone to Outside
12	38	2	1
25	25	1	1
37	13	½	1
41	9	⅓	1
45	5	¼	1
48	2	⅛	1
49	1	1/13	1

Source: Michael Blasnik and Jim Fitzgerald

In the chart above, the test is reading the zone to the outside compared to the zone to the house. The pascal reading on the manometer indicates a ratio of leakage. If the zone-to-house reading is 12 pascals, we can deduce that the cumulative holes in the air barrier are twice the size of the holes between the attic and the outside. If the zone-to-house reading is 37, the cumulative holes in the air barrier are half the size of the holes between the attic and outside. As long as the blower door test uses 50 pascals as the test pressure, the zone-to-house plus the zone-to-outside pressure readings will always equal 50.

This simple ZPD test is telling us only hole-size ratios, not how big the holes are. However, it is possible to roughly estimate the size of the holes between the outside and the attic by measuring the actual ventilation openings, then multiplying by the ratio. But these measurements won't account for unseen holes in the gable ends or roof sheathing. We would need more advanced ZPD testing to evaluate those.

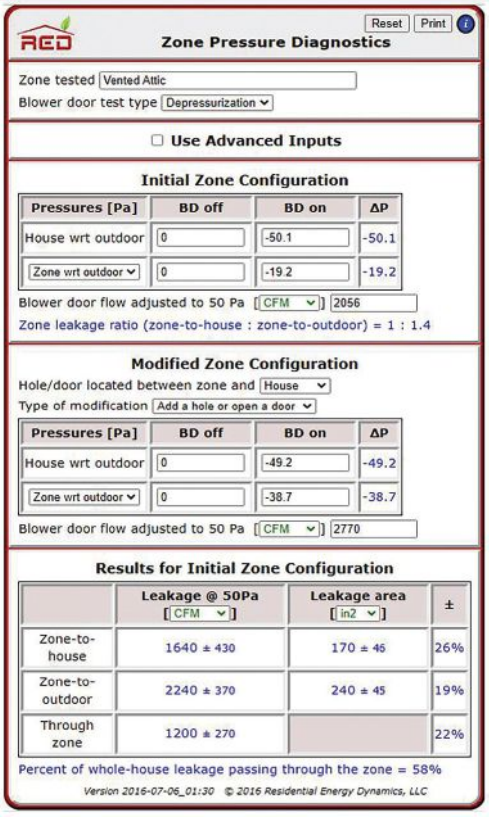
Another simple ZPD test compares rooms that should be completely inside the building or air barrier with regard to an adjacent inside space. As an example, we could compare the pressure in a bedroom with the pressure in the hallway outside of it. For this test to work, we need to be able to isolate the two spaces from each other; usually that only requires closing a door. Ordinarily when conducting a blower door test, we keep all the doors open, so all rooms and areas inside the air barrier are connected with the blower door. When performing this ZPD test, however, we close a door to one of the spaces and measure the pressure difference between inside and outside that closed space.

Because the spaces are completely inside the air barrier, the pressures between the spaces should be the same—that is, the manometer should read 0 pascals. If the manometer reads any other number, we suspect that we have some type of connection in the closed-off space with the outside. This connection could be through an outside wall, an attic, the ceiling of the space, or the floor. But we could also be pulling air from other spaces, such as an adjacent room that has its own air leaks to the outside, or through any ductwork in the room. Because there is a possibility of pulling air from adjacent rooms or ducts, room-by-room testing can be unreliable; a reading on the manometer only suggests there is a potential air leak, which is a starting point for finding that leak. But further testing will be needed to confirm the location and amount of leakage.

ADVANCED ZPD TESTING

Advanced ZPD testing yields much more information. This test, also known as "add a hole," can estimate the amount of air leakage (measured in cfm) between two spaces that are supposed to be completely separated from each other. To conduct this test, we first perform a standard blower door test and register the test pressure both in pascals and cfm rate. During this first blower door test, we also measure the pascal reading between the attic and the home with the attic hatch closed. After attaining those values, we perform a second blower door test with the attic hatch open (hence, "adding a hole"), recording the new number of cfm along with the pascals of pressure in both the attic and the home.

Here's an example: Let's say the blower-door pressure



Zone Pressure Diagnostics

Reset Print

Zone tested: Vented Attic

Blower door test type: Depressurization

Use Advanced Inputs

Initial Zone Configuration

Pressures [Pa]	BD off	BD on	ΔP
House wrt outdoor	0	-50.1	-50.1
Zone wrt outdoor	0	-19.2	-19.2

Blower door flow adjusted to 50 Pa [CFM] 2056

Zone leakage ratio (zone-to-house : zone-to-outdoor) = 1 : 1.4

Modified Zone Configuration

Hole/door located between zone and House

Type of modification: Add a hole or open a door

Pressures [Pa]	BD off	BD on	ΔP
House wrt outdoor	0	-49.2	-49.2
Zone wrt outdoor	0	-38.7	-38.7

Blower door flow adjusted to 50 Pa [CFM] 2770

Results for Initial Zone Configuration

	Leakage @ 50Pa [CFM]	Leakage area [in2]	±
Zone-to-house	1640 ± 430	170 ± 46	26%
Zone-to-outdoor	2240 ± 370	240 ± 45	19%
Through zone	1200 ± 270		22%

Percent of whole-house leakage passing through the zone = 58%

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Test results on this ZPD app indicate that there are 170 +/- 46 square inches of leakage between the outside and the vented attic space. Between the attic and the home, there are 240 +/- 45 square inches. The results also show that about 1,200 cfm of air is leaking through the ceiling. With the home at a total leakage rate of 2,056 cfm, 58% of this total leakage is between the unconditioned, vented attic and the indoor living space of the home. Air-sealing the attic would be the clear recommendation.

of the home with reference to the outside is 50.1 pascals. The unconditioned and vented attic space with reference to inside the home reads 19.2 pascals on the manometer. The total leakage of air through the blower door is 2,056 CFM50. These readings are taken with the attic hatch sealed.

The next step is to retest the home with the attic hatch open. In our example home, the manometer now reads 49.2 pascals for the home with reference to the outside. The reading in the attic with the hatch open is 38.7 pascals and the total airflow through the fan is 2,770 cfm. For the best accuracy, be sure to baseline the manometer before each test.

To simplify the calculation required, I like to use Residential Energy Dynamics' Zonal Pressure Diagnostics tool (redcalc.com). An example of the results it displays is shown at left.

This advanced ZPD test method would be the same for testing any other zone or space that should be outside the air and thermal boundary, as long as there is an opportunity to open the spaces to each other. This advanced ZPD test is not possible if there is no access between the spaces.

HVAC ZPD TESTING

The third type of ZPD testing does not use a blower door to induce a pressure difference. Instead, it uses forced-air heating or cooling equipment. This test is used to find out if the room's pressure ends up positive or negative depending on whether the supply and return ductwork is properly balanced.

As an example, consider the house we started with: We first check with the blower if there is any pressure difference between a bedroom and a hallway outside it, without the forced-air system in operation. We throw a manometer tube on the floor across the door opening and close that door. If the HVAC supply and return are equal, the manometer will read 0 pascals, indicating a balanced system. If the manometer shows anything else, we will want to determine the cause. It may be windy or some other ventilation system may be in operation, such as a balanced ventilation system like an ERV/HRV. If we are at (or very close to) 0 pascals, we can now start the forced-air system. If a negative pressure is produced, we know we have more return than supply. If a positive pressure is present, that means more supply than return. If any reading is greater than +/-3 pascals, we may want to suggest balancing the system.

ZPD testing is one of many tools in an energy auditor's or building diagnostic practitioner's toolbox. When used correctly, the information provided can help to identify and quantify air-sealing goals. It may also suggest if forced-air heating and cooling systems are operating correctly. Testing equipment and third-party software and apps, such as the RED Zonal Pressure Diagnostics tool mentioned earlier can simplify the complex calculations needed to estimate test results. The Energy Conservatory (energyconservatory.com) and Retrotec (retrotec.com) both have excellent YouTube channels with useful video training on ZPD.

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

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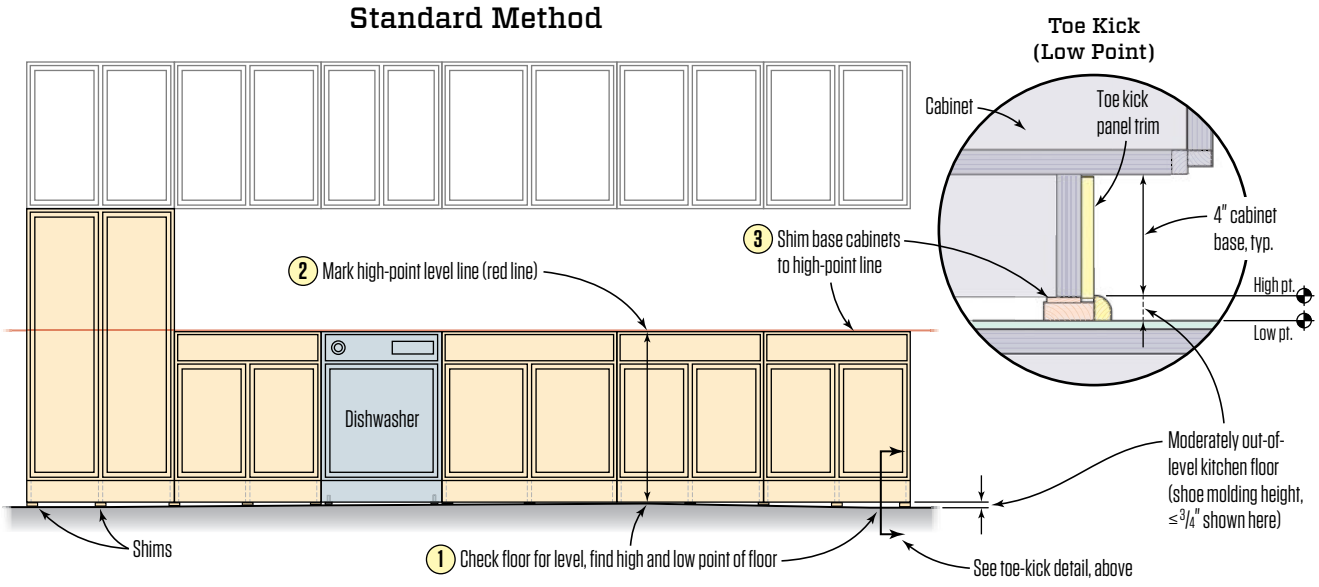
ADVANCED Building Products Inc.

BY DOUG HORGAN

Installing Base Cabinets in Out-of-Level Kitchens



When kitchen floors are reasonably level, shimming cabinets up to match the high point is simple and quick. Under-counter appliances and full-height cabinets normally fit just fine.

All kitchens are out of level, with irregularities that need to be adjusted for during a cabinet installation. However, once a floor is off more than maybe 3/4 inch, the decisions get more interesting. Here are some methods we've used to achieve good results when working with the less-than-level floors common in our remodeling work.

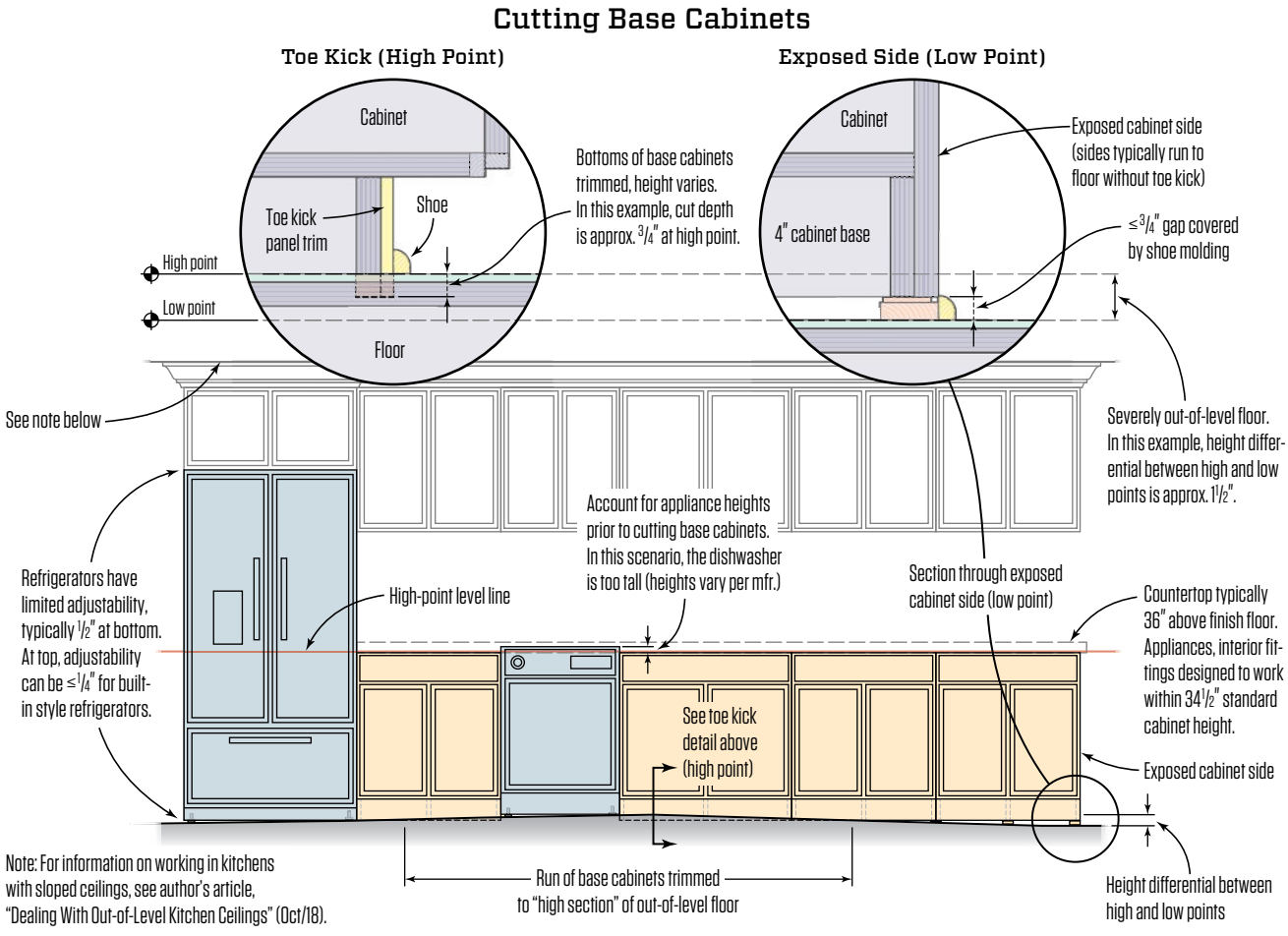
Standard method. The easiest and most common method for installing base cabinets is to find the high spot in the kitchen and shim all the cabinets to that. We usually treat each run of cabinets separately, rather than trying to level up cabinets that aren't connected; there's less adjustment that way, and a slight difference across a kitchen isn't normally noticeable.

Cabinets usually have vertical toe-kick trim that can be scribed to an uneven floor to cover any gaps. Shoe molding can also be used to cover a small gap. Either method is easy and quick and leaves enough vertical room for standard under-cabinet appliances.

Cut some cabinets. Sometimes, shimming all the cabinets would create an unacceptable gap somewhere. For example, the low point could be so much lower that the gap is too high for shoe molding to hide. Cabinet sides usually don't have separate toe-kick trim, so making them look good can be hard if a gap is big. And lately, many cabinets have "furniture base" decorative elements that run to the floor and do not gracefully lend themselves to trimming out the bottom. For example, decorative legs with round profiles in the 2-to-5-inch-diameter range wouldn't look right with a curved shoe molding, to say nothing of time to execute such a solution. Similarly, some decorative toe kicks have angled shapes that don't look good if trim is

Decorative legs can be hard to adjust for floor heights. Adding shoe molding to a round post like this would be time-consuming. Other styles can't be trimmed without noticeably affecting the shape.

Photo by Doug Horgan; illustrations by Tim Healey



If the amount the floor is out of level is more than the height of shoe molding (typically about 3/4 inch), we usually trim the bottoms off some cabinets at the high point of the floor. It's important to verify the appliances will fit. Cutting more than 1/2 inch can lead to trouble when appliances are changed out later, even if the model being replaced fit fine.

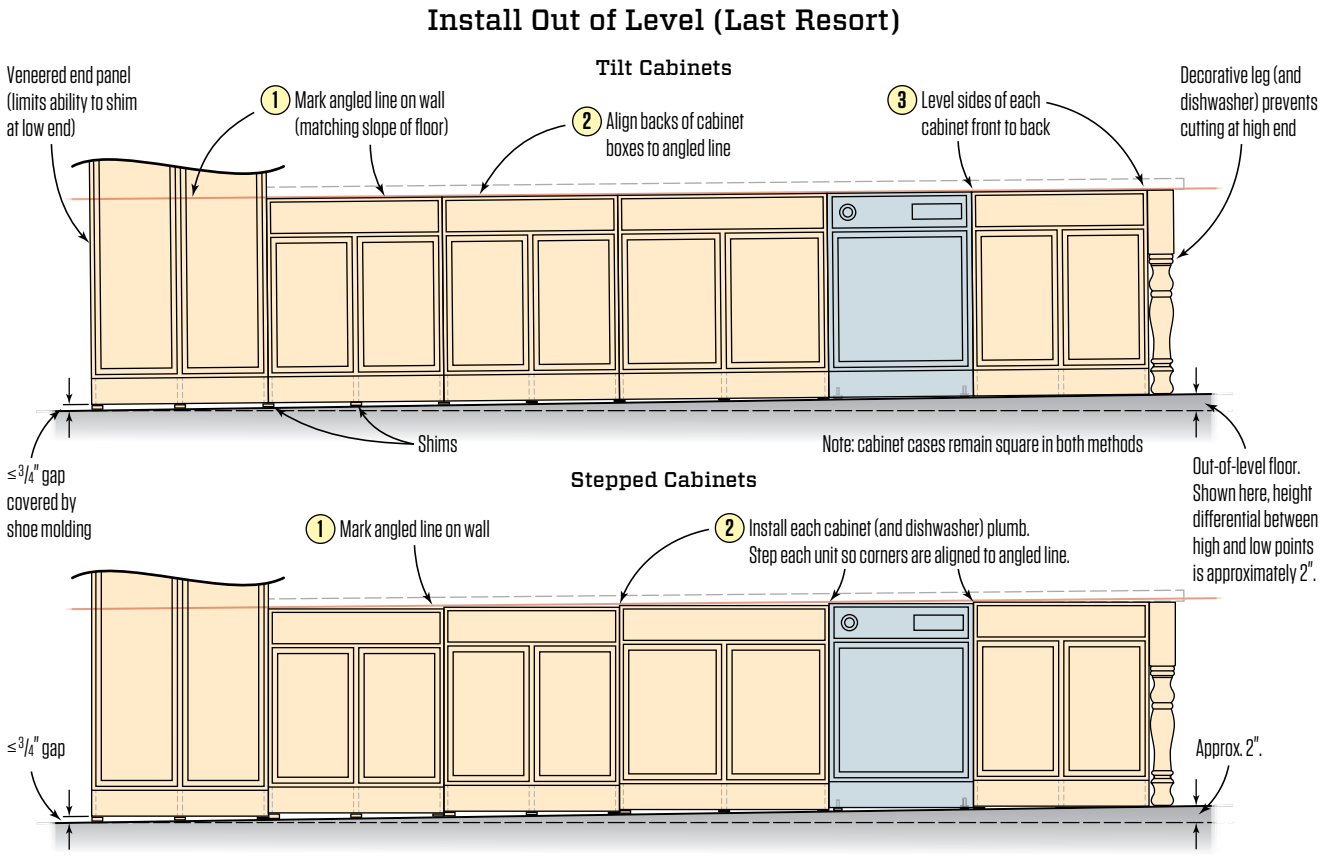
installed around them. In these cases, we often trim the bottoms off the cabinets at the highest point in the run, so the decorative parts can land on the floor. Sometimes, we even cut off the bottom of the furniture legs on part of the run; though not ideal, it looks better than adding shoe molding. If the high point is at the back of the cabinets (as it often is), we may not need to modify the fronts much at all.

Be careful with appliance spaces, though. Standard undercounter spaces are 34 1/2 inches tall, and when we cut cabinets, the available space gets smaller. Different appliance models can require different heights. The first kitchen I ever installed had a dishwasher that required 34 3/8 inches of vertical space, and when I installed the cabinets at 34 1/8 inches, it was a heartbreaker.

Another complication involves cabinetry that runs from floor to ceiling. Some trims, such as smaller crown or modern "reglet" reveals, don't allow much vertical adjustment at the top. Cabinets can be trimmed or shimmed only so much below before we create a new issue above.

Install cabinets out of level. Let me say two things: First, this is something we do only when we have no other options. It's more work, it introduces all kinds of complications to the install, and it's easy to make mistakes. You forget how much you rely on level and plumb until you attempt to work without them.

Second, apologies if it just feels wrong to you. Yes, deliberately installing things out of level should be questioned, and alternatives should be found when possible. As remodelers of structures both recent and very old, however, we often find ourselves stuck with a building that is quite out of level and, for various reasons, can't be brought to level. An example is a kitchen with a floor we're not modifying at one end and an exterior door at the other end, in a historical building whose exterior isn't permitted for modifications.



When forced to go out of level, we use one of two methods: One is to tilt all the boxes out of level as we go along; the second is to install each box plumb but step the units so the top corners are in a straight line that slopes up or down as needed.

We likely can't add more than maybe 3/4 inch to either end of this hypothetical kitchen without changing the door (not allowed) or introducing a major step up or down at the existing floor (not desired by the clients). That's before considering the expense of extensive leveling, which varies with materials and techniques but may not be worth it to the people writing the checks.

The first time I presented on this topic at JLC Live New England, I warily paused to check in with the carpenters in the room. That day, they were mostly from New England (where there are a lot of old, very out-of-level buildings) and all had used "out of level" installation techniques. So, depending on your common building stock, you may be used to the concept. If not, carry on installing level until you are stuck, and then fall back on this technique.

How to install out of level. We've found two basic approaches. The first is to tilt all the boxes out of level as you go along. The second is to install each box plumb but drop each one a little bit so the top corners are in a straight line that slopes up or down as needed.

I tend to prefer the first method. I strike a line on the wall at the angle needed, and run the backs of the cabinets to it, then level each side separately and watch the door reveals to be sure the cabinet face is square. As mentioned, it's easy to make mistakes. The front of a cabinet can easily be 1/32 inch or even 1/16 inch different from the back, and we can't easily check with our normal levels because the cabinet is supposed to be tilted so the level won't read right anyway.

I am lucky to work with Abidan Munoz, a fantastic carpenter who showed me the second method. He strikes his out-of-level line on the wall but installs each box plumb and square with the high corner touching the line. Adjacent cabinets don't line up perfectly, but this can be finessed with a bead of caulk under the countertop, or with a belt sander. Either way, you can get out of a lot of trouble with this technique. I've seen Abidan use it on a 14-foot run that was about 1 5/8 inches out of level, with floor-to-ceiling cabinets at each end, furniture bases, and a crown that was difficult to adapt to height differences. He made up half the difference in the crown, and the rest in the boxes.

Doug Horgan is vice president of best practices at BOWA, a design/build remodeling company in McLean and Middleburg, Va.

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A Modern Approach to Balloon Framing

How a short-handed crew builds full-height walls on the flat and lifts them into place

BY TIM UHLER

We recently framed a three-story house with a gable on the tall side, our third time building this particular design. The first two times, we used conventional platform framing because the ground was too wet with too much slope to safely use a forklift to lift the walls in place. But on this project, the site was firm and dry, with plenty of maneuvering room, and because we were down to a two-man crew, we wanted to balloon frame the walls to keep the project moving along. In this article, I'll explain in more detail how we balloon frame walls and what some of the benefits and drawbacks of this approach are.

Basically, balloon framing means using long studs to frame continuously from the bottom plates of the first floor to the top plates of the top floor. This is oversimplified, of course, but in general, we typically try to balloon frame the tall walls in great rooms, entries, and stairwells. Contrast this with platform framing, in which walls that stop at ceiling height are framed on top of each floor.

Balloon framing is not new; in fact, many homes built in North America before the 1950s were balloon framed. Because they typically were framed without blocking for fire separation between the walls and the floors, these homes are at greater risk from fire. *[Editor: "fire stops" were addressed in the model Uniform Building Code (UBC) when it was first published in 1927, but adoption of that code was sporadic at first and limited to mostly western states.]* As I'll explain in more detail below, fire blocking is an essential part of our modern balloon framing process.

WHY BALLOON FRAME?

One of the fundamental principles that guide our jobsite decision-making is safety; specifically, limiting the need to work at

Photos by Tim Uhler

To stiffen a balloon-framed wall for lifting, the author doubles up the 2x6 king studs on either side of openings **(1)**. The 2x6 blocking installed on the flat will support panel edges **(2)**, while solid 4x6s are used for both panel edge support and fire blocking where needed **(3)**. Fully framed from the bottom plate to the gable, this wall is ready for sheathing **(4)**.

height. This can't always be avoided, but whenever we work with tall walls and gables, we try to balloon frame them as a way to reduce our exposure to height.

But we don't stop there; we also typically install trim and siding on most of the walls we frame before lifting them into place, whether they are platform or balloon framed. It saves time and labor when we can work on a stable surface like a floor versus doing the same work up high. Balloon framing also reduces duplicate steps like laying first-floor wall plates, then second-floor plates when they are the same length anyway. There's also less shrinkage of the framing, which results in less drywall cracking.

While there are benefits to balloon framing, there are challenges when framing tall walls versus shorter walls. The most obvious one is that we'll still have some work to do at height. We'll need to safely connect the walls at the top when they are 18 feet tall, not to mention lift them to begin with. Floor framing and fire blocking call for different approaches, too.

Required equipment. We have two forklifts, either of which can be fitted with our extended-reach truss jib. Rated with a lifting capacity that is far more than our walls weigh, the forklift-mounted truss jib is the key to making balloon framing possible for our crew, though when site conditions prohibit the use of a forklift, we sometimes hire a crane for the lift. Along with owning this equipment, we are forklift- and rigging-certified.

With conventional platform-framed walls, overlapping plates are typically used to tie walls together. When balloon framing, we connect the walls with straps at the top plates, working from a manlift basket. This simplifies layout and framing and makes fitting them together up high much easier.

WALL FRAMING

On this project, we ordered 20-foot 2x6 Doug fir studs to frame the 18-foot-high walls, saving the 2-foot offcuts for use as blocking. We cut the top and bottom plates and marked their 24-inch-on-center layout at the same time. When there are king studs on either side of an opening, we double the framing to stiffen up the walls for the lift. When double-studding, opposing the crown helps to straighten the studs; to keep them from bowing, we snapped layout lines after squaring up the wall and tacked the studs to these lines prior to blocking and sheathing.

Sheathing is installed from the top plate down, leaving the framing exposed at the bottom of the wall **(5)**. The 4x8 panels are aligned vertically and nailed to the framing 6 inches on-center **(6)**. The author uses a router to cut out window and door openings **(7)**. Where required for seismic reinforcement, the author installs continuous strapping above and below openings **(8)**.

We used 1 3/4-by-9 1/2-inch LVLs with 2x6 top and bottom plates to build our headers, exactly as we would for a platform-framed wall. At the corners, we used a two-stud California corner to supply backing for drywall.

Blocking. As mentioned above, a major drawback of balloon framing in the past was the lack of fire blocking. Platform framing naturally provides separation at the top plates between the walls and the floor system. The subfloor and bottom plate of the wall above also keep the floor separate from upper-floor walls.

To prevent fire from spreading in cavities that run the full height of the wall, we need to block a minimum of every 10 feet vertically and at all ceilings or floors, per code. I like to lay out the blocking working down from the top plates the length of the wall sheathing.

Since the upper floor on this project had 8-foot ceilings, I installed 4x6 blocking 8 feet down from the top of the double top plate, with the blocking centered on the mark. This aligned the fire blocking with the floor sheathing, while also providing edge blocking for the wall sheathing for lateral loads (hanging the sheathing vertically saves blocking). The use of 4x6 stock for this blocking also helped to stiffen the wall during the lift.

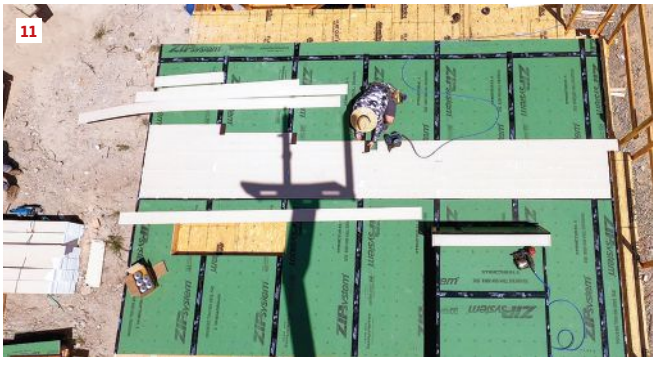
Once the first row of fire blocking was installed, I measured down another 8 feet for 2x6 panel edge blocking, which we installed on the flat to allow for insulation. This blocking is needed to meet seismic requirements that the perimeters of the sheathing panels be supported with full 6-inch-on-center nailing.

We also need to install 4x6 blocking wherever strapping is spec'ed; for example, for force transfer around openings, where windows interrupt load path. Here, where we are basically punching a bunch of big holes in shear walls, continuous strapping will need to be installed over the sheathing to seismically reinforce the wall.

Sheathing. To get better unit pricing and better manage waste, I prefer to order all 4x8 Zip System sheathing, rather than opting for longer panels (which I also think are a little less stable). Installing the sheathing from the top down with the panels oriented vertically allows the bottom sheet—which we install after lifting the wall into place—to span the bottom plate and connect down to the mudsill. This also provides for easy access for installing tie-downs and other hardware.

Because we had already installed panel edge blocking, we installed the sheathing railroad style instead of staggering it (staggered sheathing isn't required by code). With the framing at 24 inches o.c. (rather than 16 inches o.c.), we nailed off the sheathing 6 inches o.c. (instead of 12 inches o.c.) in the field, as well as along the panel edges.

After cutting out window openings and taping all of the seams,



Details such as this bump-out **(9)** and soffit **(10)** are easier to build while the wall is flat on the ground. Windows and siding can also be installed before the wall is lifted into position **(11)**, as well as gable rake trim **(12)**.

we installed continuous strapping over the sheathing where spec'ed in the plans for force transfer around openings. To keep the strapping straight, I like to first snap a line, then nail the strapping to the sheathing with 2 1/2-in. x 0.162 positive-placement nails every 6 inches or so while following the line, so that the strapping lies flat to the sheathing with no bubbles. After cutting the strapping to length, I go back and nail off every hole in it.

Siding and trim. Inspectors in the municipality where we build circle the walls they want to inspect for shear nailing, and these are always walls with hardware like straps or hold-downs. The rest are fair game, so before we lift a wall into place, we go ahead and install the siding, which in this case—as on most of our projects—was LP SmartSide.

I figure layout from the mudsill and transfer that to the wall, and then we snap lines for each course. Per the instructions for Zip System, I tape (using Zip tape) the side of the wall sheathing to the side of the end stud. Then I snap a vertical line 1 inch in from the edge of the wall so that when the next wall is installed, I can wrap the tape from that wall to the wall being sided. This is also where we align the ends of the siding, which we later cover with overlay corner boards, once all of the walls are installed.

Installing windows with the walls flat on the deck is easy (I first learned how to do this in the early 1990s and show how to do this on my YouTube channel). Installing window trim and drip-cap flashing is much easier at this point than later, off ladders or scaffolding. Since we are using Zip System, the flashing details are simple.

One negative to siding on the ground is that we work bending over. While that is a fair concern, we do this only a few days out of the month a few times a year and it's worth it. We trade off as much as possible so one person isn't doing all the work bent over, and since we save so much time, we tend to take a few more rest breaks. Often, it takes less than an hour to side the wall. For example, it took us less than two hours to install 100 pieces of SmartSide on the big wall shown here (see photo 11, above).

Later, when the walls are up and we finish the siding, we'll just work up to the last course that we had installed before lifting and tuck the last pieces underneath and face-nail them. I like to use Big Stretch sealant on the face nails, which we touch up with paint later.

Closed soffits are easy to install when the wall is flat; they just need to be finished off when we install corner boards. I draw out the overhang to determine the exact location of the subfascia, then nail a 2x6 ledger to the wall and a 2x6 subfascia to LP SmartSide 16-inch-wide vented soffit to create the soffit assembly, with blocking on approximate 4-foot centers spaced so that the blocking won't interfere with the rafters. Another benefit to installing the soffit on the flat is that it acts as a strongback during the lift.

On this long wall, the soffit acts as a strongback during the lift **(13)**, while toenails through the plate prevent the wall from sliding on the deck while it's raised **(14)**. The toenails are removed once the wall is vertical and up off the deck **(15)**. Screwed to the wall and floor framing with structural screws, 2x6 braces hold the wall in position after the bottom plate has been screwed to the deck, also with structural screws **(16)**. As each wall is raised and installed, it acts to brace the adjacent wall **(17)**. Once the walls are in place, metal strapping installed from a manlift basket is used to connect the top plates together **(18)**.

LIFTING AND BRACING

To prep for the lift, we fasten specifically engineered and fabricated brackets to the top of the wall. In addition to following the fastening schedule required for the brackets, I've started adding SST SDWS screws through the plate to the studs on either side of the pick point for a little extra reinforcement.

Wind is always a factor when setting walls; we can't lift when it is too windy. To keep the wall section from sliding around while we hoist it up off the deck, we toenail the bottom plate to the deck prior to the lift. Then, once the wall is vertical and suspended, we pause to remove these toenails from the plate.

Lifting walls is dangerous, and we work slowly and carefully as one of us operates the forklift and manipulates the boom while the other signals the forklift operator and helps guide the wall into

The floor system is hung from ledger boards that are fastened to the wall framing with structural screws **(19, 20)**. To help flatten the walls, the author temporarily screws an I-joist to the studs to pull them into plane while he installs the ledger boards **(21)**. After the floor system is in place, construction can proceed conventionally **(22)**.

position. We locate one corner first, and then fasten it to the layout line snapped on the deck with SST SDWS structural screws, which can be removed if the wall position has to be readjusted later. Then we ease the rest of the wall into position so that the plate is just shy of the line, and fasten it to the deck with more structural screws.

Once the wall is in place but still supported by the lifting straps, we brace it with 20-foot 2x6 braces fastened to the framing with 6-inch structural screws. We plan the order that we frame the walls so that there is room on the deck to build them and so that we can tie adjacent walls together as we raise them. They are basically giant sails, so we brace them with long structural screws driven into the framing rather than with cleats and nails, and we tie them together with strapping across the top plates. Then we move on to the next wall.

FLOOR FRAMING

Once the walls are in place, we frame the floor system similar to how we would a deck, starting with a ledger that is fastened to the wall framing. Remember, the ledger is supporting only floor loads, not roof loads, so this approach provides plenty of strength. The ledger also acts as fire blocking that separates the floor system from the wall cavity.

To help position the ledger, we cut a 2-by to the height of the back wall plate (109 1/8 inches on this project) and used the 2-by to mark that elevation at all of the corners. Then we worked around the walls, tacking the ledger in place with nails and then fastening it to the 2x6 studs using 5-inch-long Simpson Strong-Tie SDWS timber screws. These screws are designed for deck ledgers, and our engineer specifies the spacing. We always use more than spec'ed because we use the ledger to help pull the studs into plane.

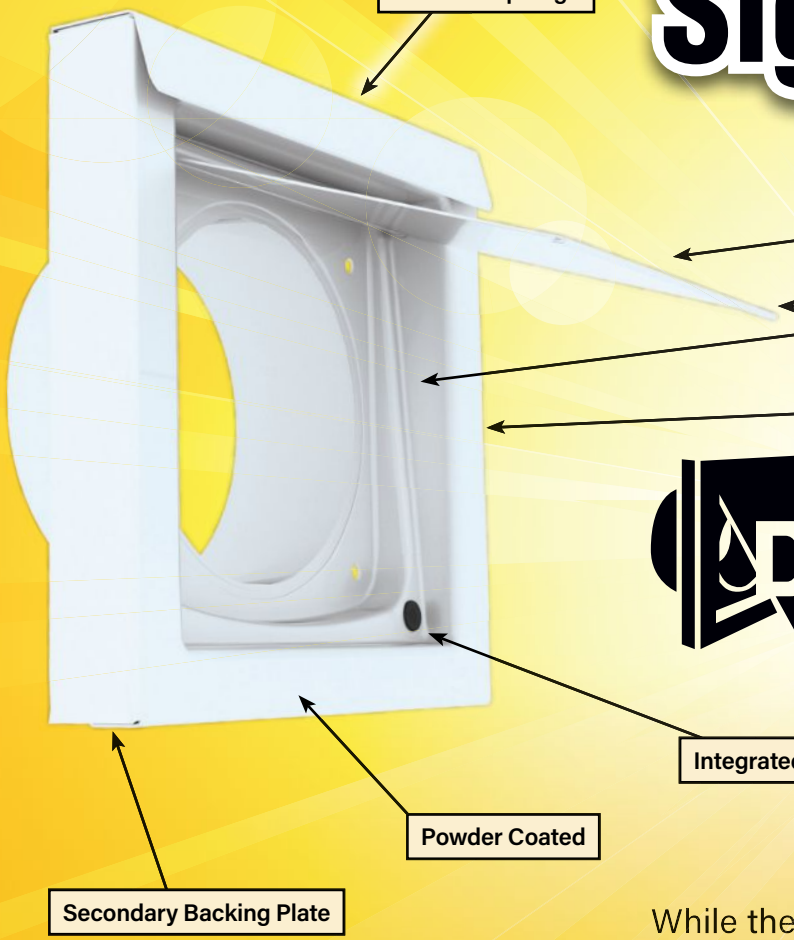
To flatten the wall until the floor is sheathed, we screw an I-joist on edge to the studs just below the ledger. Our order of operation is to install the ledger and then the I-joist "strongback" before bracing the walls plumb and straight. We find that we need fewer braces using this method.

Then we are ready to start installing floor joists. We typically toenail them into place and add hangers later, unless there is an intermediate beam. In that case, I like to install the hangers before lifting the beam into place.

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

Upon Closer Inspection Excellence Stands Out

Sight To See



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Deep Energy Retrofit
Part 1: Air-sealing

BY PHILIP ARMAND

"And one more thing, Phil ..."—the building inspector, who is a khaki-colored trench coat away from being a clone of my favorite TV super-sleuth, has a habit of dropping a request bomb as he heads toward the exit—"... You need to get a HERS rating for this renovation. Have a nice afternoon." I am stunned. A HERS rating on a partial renovation of a poorly maintained wreck of a house? I take a breath, look around, and feel a giddiness begin to stir inside.

HERS stands for Home Energy Rating System, a nationally recognized system for rating the energy efficiency of a home. The only way to pass is to meet standards that are dramatically more stringent than this 1977 colonial would ever meet. In my area, this rating is not required for renovations—except at the discretion of the building inspector. In a typical renovation where a sizable portion of the house is untouched (about 20% of the interior was not gutted on this home), the chance of meeting the HERS standard is near zero. R-values of existing insulation are incalculable, and the required blower-door test would reveal dramatic breaches in the air barrier. This colonial was a sieve—not a premium, fine-mesh sieve, but a hole-ridden shell; critters and creepy-crawlers had set up shop in the attic, basement, crawlspace, and wall cavities.

However, this was not a typical renovation. Part of the budget had been directed at a deep energy retrofit. We were contracted to move insulation from ceiling joists to roof rafters and add a sweater of continuous exterior insulation with high-performance windows and doors and extended eaves. The job also included ventilation systems, pressure-balanced rainscreens, air-sealing, air-sealing, and more air-sealing. My growing giddiness at the inspector's request came from being able to justify the cost of a blower-door test; I was itching to confirm how well we had sealed this 1977, hilltop sieve.

All the extensive and expensive details that a deep energy retrofit entailed were easily sold to my clients partway through the renovation. After discovering extensive rot, thriving infestations of bugs and four-legged critters, and massive insulation voids in the building

Photos by Philip Armand

envelope, we had a meeting. The husband, an accountant who understands return on investment, saw the value of the work I proposed. His wife agreed, focusing on the immediate and permanent eviction of all uninvited four- (and more-) legged tenants. I did my best deadpan nod at my new directive and walked off, seemingly cool and collected while my internal building-science nerd did a happy dance and rubbed his hands together, with a stupid smile plastered across his face. We were ready to tackle an amazing challenge.

LIST OF PRIORITIES

I usually approach a deep energy retrofit using the following order of priorities (not of process) that I establish with clients to decide where to allocate funds until we run out of budget:

1. Air-sealing
2. High-performance insulation
3. High-performance doors and windows
4. Thermal decoupling
5. Recovery ventilation
6. Efficient heating and cooling distribution and equipment

I aim to execute each of these impeccably, but since open-wallet clients don't seem to have my phone number yet, I pick my battles. Air-sealing is always nonnegotiable, and that's where I'll start for this article. Later in this series, I will cover the negotiable items and share more about the order of priorities, as well as what I have discovered gives the best bang for the buck.

In theory, air-sealing is quite simple: Keep the air in and out of your building. In practice, you have irregular-shaped geometry at a large scale, with a wide variety of penetrations: outlets and other wires, plumbing, vents, windows, doors, chimneys, access hatches, random holes made by negligence or beast, and the gap under the sill plate that is often as accessible as a popcorn hull between molars. In the field, the tools, materials, and methods are mostly simple to use; the tricky part comes in maintaining a high degree of impeccability and exercising patience.

AIR-SEALING TOOLS

The tools we always depend on for air-sealing work include:

- **Good caulking gun,** preferably one with an adjustable thrust ratio. The 24:1 to 12:1 settings are great for acoustical sealants that are very thick and heavy, while the lower setting of 12:1 is great for nearly any caulking job.
- **20-ounce sausage gun.** We also use a 12:1-thrust-ratio caulk gun that takes large caulk sausages. Many professional sealants are sold in this format. Buy several extra tips as they may dry out between uses and need to be replaced.
- **Caulk sealing caps.** Basically, a latex glove for your caulk tip. These make it easy to switch from one sealant to the next, while keeping sealants fresh the next time they're needed.
- **Putty knives and scrapers.** I like plastic body filler spreaders and a variety of metal putty knives. The most common sizes of putty knives we use are 1 inch and 1 1/2 inches wide, though occasionally we pull out the 3-inch.
- **Spray-foam sealant gun.** A pro gun allows you to buy the pro-sized cans and not worry about the product drying up by the end of the day. I recommend buying a stock of plastic gun tips; they protect the gun and allow easy access to small gaps and cracks. Foam-gun cleaner is available in the same format as the foam; keep the gun clean between uses, and it will last for several jobs.
- **Tape roller.** Pressure-sensitive tapes and peel-and-stick weather resistive barriers have revolutionized the industry. Having a set of small to large rollers is a must.
- **Rubber gloves and eye protection.** On two occasions—once when a spray-foam can exploded and once when cleaner shot onto my assistant's face—severe eye damage was averted by eye protection. In the case of the cleaner, the caustic material destroyed his plastic eyeglass lenses immediately. It was a good reminder to always proceed with caution.

AIR-SEALING MATERIALS

We regularly lean on a cornucopia of reliable materials, including:

- **Liquid sealants and foam sealants.** On this project, we used six products: On exterior nail holes, between sheet goods, and at wall-to-masonry transitions, we used Zip Liquid Flash, mostly in the 20-ounce sausage format. Around windows and doors, we used Henry Moistop Sealant (also available in the 20-ounce format). On framing penetrations like rafter tails and on interior framing bays and voids, Sashco Big Stretch and Dap Extreme Stretch did the job. For interior pipe and electrical penetrations, we used 3M Fire Barrier Sealant. Under sill plates on newly framed or repaired areas, we used Auralex StopGap Acoustical Sealant. We also leaned on low- and high-expansion foam sealants to fill large gaps before applying a waterproof seal.
- **Henry Blueskin** VP 100 Self-Adhered Water Resistive Air Barrier Membrane. We used VP100, as it is waterproof and vapor open; much of the home needed to dry to the outside as tile, wallpaper, and millwork covered large portions of the interior. A peel-and-stick WRB, like Henry Blueskin, was ideal for steadfastly bonding irregular surfaces that the old house shell presented, where a staple-up WRB would be sloppy and hard to detail. Another desirable aspect of the Blueskin is the fact that fasteners self-seal when penetrating it. Our rainscreen install did not compromise the air/water-sealing strength of Henry Blueskin. Local availability was another factor: Henry products are a system with components like primer, caulk, and sealing tapes. Being able to dip into local stock is important.
- **Weather-barrier tapes** including Henry Weather Barrier, Vycor Plus, Zip Tape, and DuPont FlexWrap NF. We found that all these tapes adhered extremely well to the Henry Blueskin. We stayed with Zip Tape on the areas with Zip Sheathing, except the window sill pan—there we used a piece of clapboard siding to induce a slight pitch, over which we used Dupont FlexWrap NF. This is my go-to sill product, and it adhered extremely well to both the Zip and the Henry Blueskin. FlexWrap stays slightly wrinkled, allowing drainage channels under the lower flange of doors and windows.

The photos and captions that follow highlight the critical steps of bringing this home from a leaky sieve to 1.2 ACH50 (code is 3 ACH50). The HERS inspector had never seen a home without an envelope of spray foam do so well. Though I wish we had done a blower door test on the front end of the project and knew the extent of the improvement, it's great that the inspector gave us the imperative to test out, verifying that we had a tight shell in which to build the rest of the systems for this deep energy retrofit.

Philip Armand is a general contractor on Long Island in New York.

We sealed the connection to the sill plate with a site-bent flashing. We added a generous bead of Henry Moistop Sealant to the bottom edge of the sheathing, then set the flashing into that. We topped it all with tape and then Henry Blueskin peel-and-stick WRB **(1)**.

This home had two major renovations in its 46-year existence. We used different approaches to match different circumstances. In this area, a large overhang resulted from adding R-16 to the exterior (the interior of this area remained intact); we air-sealed the overhang with a site-bent flashing and Zip Liquid Flash caulking. Zip Flashing Tape seals the top edge of the flashing and the Zip areas **(2)**.

To maintain a vapor-open ceiling on the cathedral interior, we used Henry Blueskin on the roof, then built a vented overroof. This allows vapor to migrate out and through the structure. We meticulously sealed the existing rafter tails with Henry Moistop Sealant after the WRB was rolled out. We used Henry Blueskin VP100 in these areas, as it is waterproof (this area was left in the rain for several days with no issues) while remaining vapor open. This product is not easy to use; however, the benefits outweigh the steep learning curve **(3)**.

The overroof sits on 2x3 sleepers **(4)** (see also **8**). Air washes into the soffit and behind the siding. A 2x3 rainscreen was added later.

A peek under the Zip sheathing reveals a double layer of 2-inch-thick Rockwool Comfortboard 80, for a total of R-16 **(5)**. We used this strategy in areas we did not have access to from the interior. We used foam sealant in any gaps between the Comfortboards to eliminate interstitial convection within the cavity insulation.

In areas where we did have access from inside, we insulated and air-sealed the rim-joist sill first with Sashco Big Stretch to seal all connections to the sill plate and rim joist. Prior to spray-foaming, we added 2-inch blocks of Rockwool Comfortboard over the rim joist. This vapor-open buffer zone allows moisture to dissipate into neighboring materials and dry into the building **(6)**.

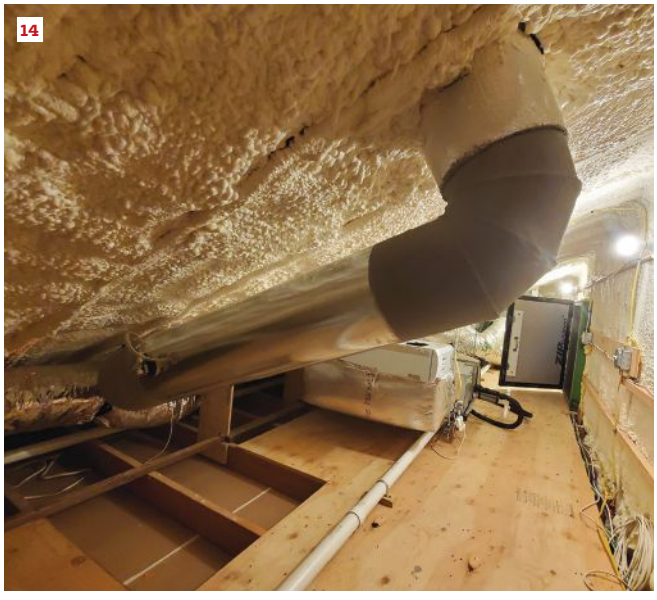
At the bottom of this image **(7)**, a blue Quickflash panel is visible. We detailed most of our electrical, HVAC, and water penetrations with gaskets like Quickflash.

For optimal water and air detailing, we apply Zip Liquid Flash over all nail holes, loose tape, or scratches in the green Zip WRB. In this area, we built the soffit over the Zip R-3 **(8)**. The sheathing connects to the air-sealing layer that travels 1 inch below the roof sheathing. This allows an overroof for airflow.

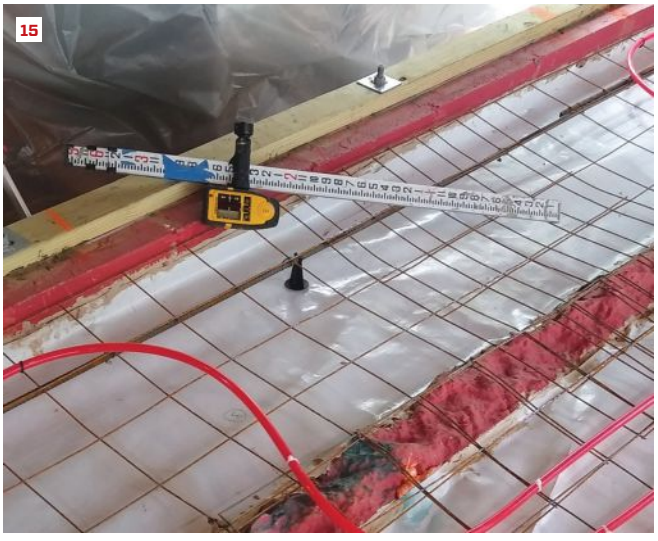
On this bedroom wall, which extends to the kitchen below, we used CertainTeed's MemBrain, a material that allows water vapor to pass through when humidity levels are high while stopping airflow **(9)**. The membrane worked well to reduce the amount of cooking odors that permeated into the bedroom.

Air-sealing is not relegated to one phase of construction. Throughout the entire build, we continually seal anywhere air can penetrate or convect, as seen in this interior plumbing wall after the shell was sealed **(10)**. Reducing air movement in walls is also important for improving fire safety, deadening sound (sound travels through air), and reducing unwanted moisture movement. In this case, these walls will be tiled on both sides.

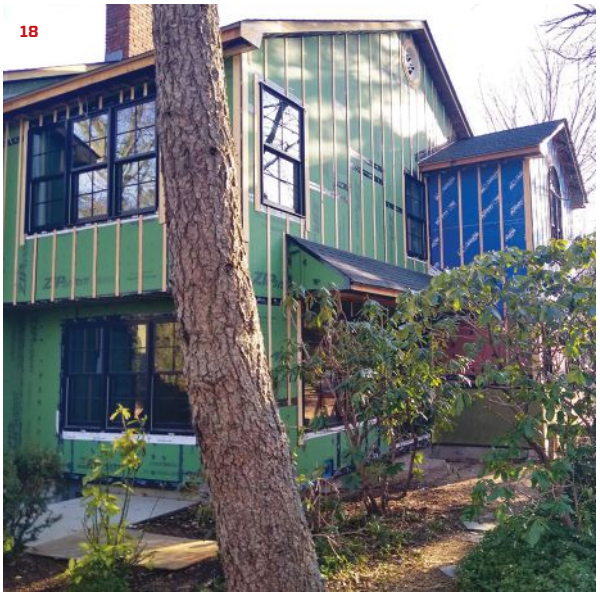
Access hatches from the exterior into a crawlspace **(11)** and from the interior into a knee-wall attic area **(12, 13)** are often leaky. For each one, we took care to build insulated access hatches with Zip System sheathing and foam-rubber gaskets.



There are three separate attics with three separate access points. This one was the smallest **(14)**. The air-barrier here consists of 1 1/2-inch XPS foam that we cut into the rafter bays to create a 1-inch ventilation space below the roof sheathing. We do not rely on the closed-cell foam as a singular air barrier.

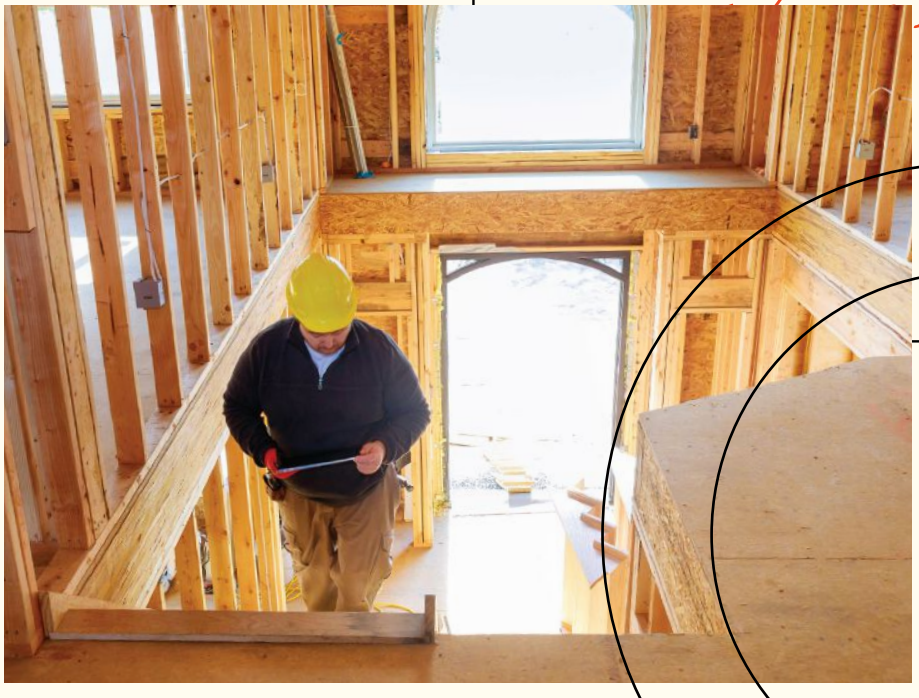


We used the trick of drawing a line around the structure on plan sections to see where the discontinuities of the control layers were (see "Air Barrier Basics," by Steve Bazcek, Jan/19). In this area, we had to remove an existing slab to create continuity from slab to foundation to sill. The vapor-barrier is sealed to the foundation where a liquid-applied barrier continues to the sill plate. The sill plate is gasketed and caulk-sealed to the foundation **(15)**.



We added a small roof over a sliding door, and to avoid penetrating the exterior shell with framing to support this projection, I had brackets fabricated that we bolted through the header **(16, 17)**. Small holes for the bolts are much easier to seal than large framing components. And even though steel conducts heat better than framing lumber, this approach still minimizes thermal bridging **(18)**.

JLC



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Sprucing Up a Cape With a Front Porch

By Mike Whalen

PHOTOS BY DBS REMODEL AND TIM HEALEY

Figure 1. A new porch enhances the curb appeal of a homeowner's mid-1950s Cape while offering the family a better transition to the outside (A). Originally, a masonry stoop with wrought-iron railings (typical of Capes in the Northeast) led up to the little-used main entry door, the focal point of the home's prerenovation front façade (B).

Last fall, my company, DBS Remodel, completed extensive renovation work on a Cape-style home located in Millbrook, N.Y. Our job scope included remodeling the home's two existing full baths, and adding a full bath in the master bedroom and a half-bath off a second-floor bedroom. The existing kitchen was taken down to the studs and redesigned to have an open floor plan to improve maneuverability and flow. On the exterior, we tore off the existing roof and ran new asphalt shingles over ice barrier membrane to guard against ice damming and re-sided the home with vinyl clapboard siding.

During the project's design phase, the homeowner asked if we could improve upon the home's bland front façade; its east-facing elevation had a seldom-used front door with a masonry stoop leading up to it. We suggested adding a front porch, which would enhance the home's curb appeal and allow her family to take advantage of the property's spacious front yard. (The homeowner had four children—the oldest of whom were teenage triplets—and the new porch would provide a place to hang out and connect to the outdoors.) She liked the idea, so we designed the porch to be large enough to fit four rocking chairs (and two side tables) while being careful not to overwhelm the proportions of the Cape's front façade. To avoid an existing bay window, we offset the porch to one side **(Figure 1)**.

Foundation Prep

Starting out, we removed a few small trees and shrubs from the front foundation to make room for the new 7-foot-by-18-foot porch. Next, we marked the layout for the three concrete piers needed

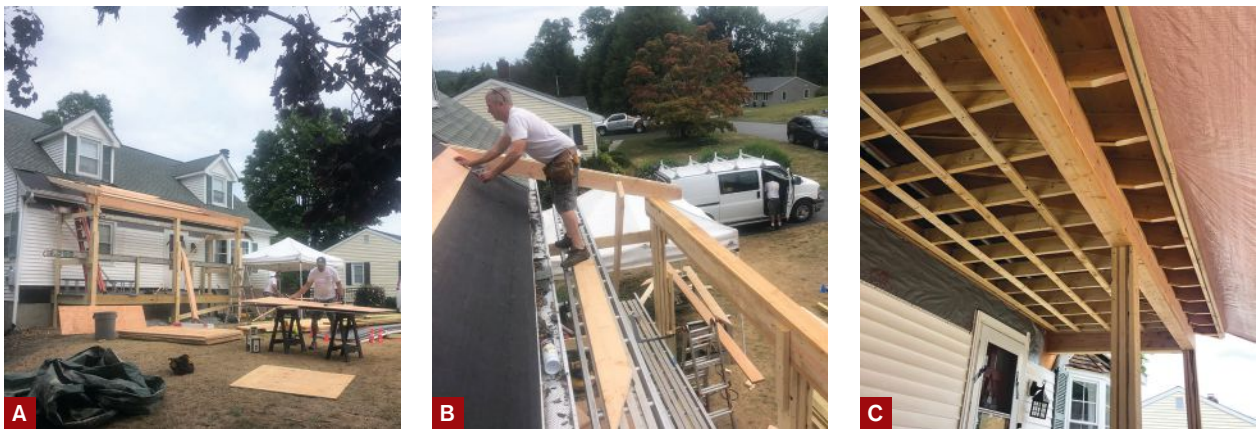

Figure 2. Crew members framed the new 7-foot-by-18-foot porch (A), tying it to the main roof (B). The upper porch was framed with site-built "laminated" 6x6 posts supporting a triple 2x10 girder, 2x8 rafters, and 2x6 ceiling joists (C).

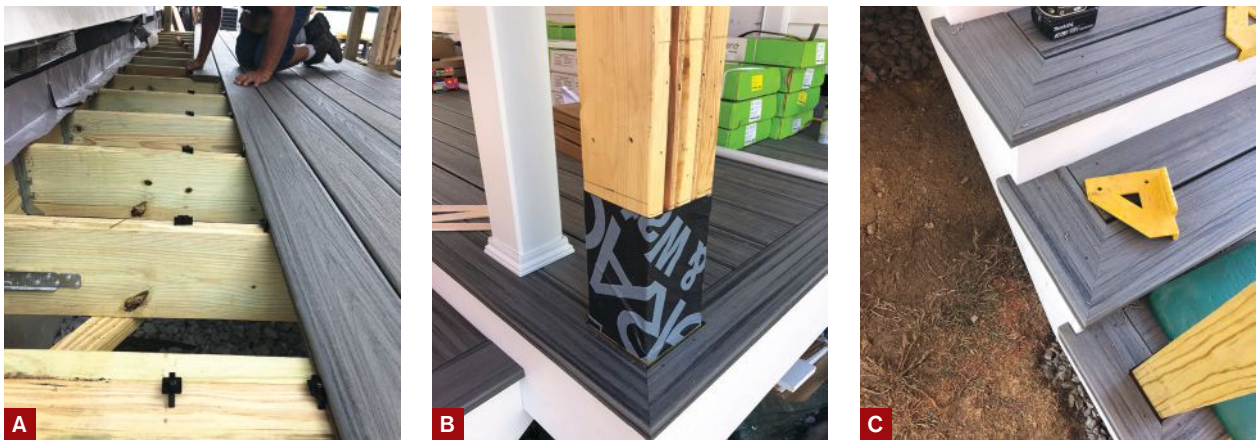

Figure 3. Hidden fasteners were used to install the Trex porch decking (A), while color-matched trim-head screws were used to fasten the picture-framed perimeter edge boards (B) and stair treads (C) to the framing.

to support the porch and broke up the existing block and poured concrete stairs, using some of the pieces to fill the void left by its removal. To provide drainage and a measure of protection against rodents burrowing under the porch, we covered the ground with landscape fabric topped off with 1 1/2-inch crushed stone.

After digging 4-foot-deep holes for our footings, we set our three 14-inch-diameter forms. After the town inspection, we filled the forms with concrete and began laying out the rough framing.

Framing the Porch

The original stoop had 8-inch-plus-high risers, making the steps hard to climb, so we redesigned the stair layout to include an additional riser. This resulted in more comfortable stairs with 7 1/4-inch-high risers, along with a 4-inch step down from the door threshold to the porch decking. Typically, we like to install the 2-by ledger 4 to 7 inches below the entry door to help prevent any issues with drifting snow and wind-driven rain.

We removed a few bottom courses of the existing siding, snapped a level line to field-verify the stair layout, and inspected the house framing to make sure that it was structurally sufficient to hold the new ledger. We removed a section of the existing 2x8 rim joist where we found some rot and confirmed the layout of the existing floor joists (we also checked for any electric or plumbing that might have been in the way).

After replacing the rotted section of rim board and sheathing, we ran a 2-foot-wide-by-20-foot-long piece of peel-and-stick membrane from the bottom of the sheathing up the wall, then secured the new pressure-treated 2x10 ledger board with 4-inch Ledger-Lok screws 6 inches on-center in a staggered pattern, top and bottom.

At the three footings, we installed 6x6 adjustable post base anchors for the new pressure-treated posts to sit on. We transferred the elevations from the ledger board using a transit, then began to build

A

B

Figure 4. The deck's three site-built "laminated" 6x6 rough posts were finished with PermaSnap composite column wraps. Here, the 1/2-inch-thick white composite trim is temporary taped while its adhesive cures (A). A Trex composite guardrail system encloses the completed porch (B).

the flush-framed deck, which consisted of a double pressure-treated 2x10 flush girder and pressure-treated 2x8 floor framing at 16 inches on-center. To prevent lateral movement, we installed Simpson DTT1Z deck tension ties every 4 feet and 1 foot in from each end of the porch deck framing. We secured them with 3/8-inch-diameter lag screws, which we embedded 3 inches into the existing mudsill.

We framed the porch with three site-built "laminated" 6x6 posts, which supported an upper girder. Because we planned to wrap the rough columns with a white composite trim, we assembled the posts out of three spruce 2x6 studs with a layer of 1/2-inch CDX plywood glued and nailed between each stud. We've found these laminated rough posts guard against any twisting over time, something we've seen with longer length pressure-treated SYP 6x6s.

With the posts up, we installed a triple 2x8 header, then 16-inch-on-center 2x8 rafters and 2x6 ceiling joists. We applied ice barrier membrane over the 1/2-inch CDX plywood roof sheathing, then moved on to decking and exterior trim. Later, we shingled the porch with GAF Timberline charcoal laminated shingles, matching the main roof **(Figure 2)**.

Finishing Up

We flashed the top of the ledger with lengths of 12-inch-wide YorkShield copper flashing bent into an L-shape, then wrapped the bottoms of the laminated 6x6 posts with peel and stick to guard against moisture damage. Next, we installed Trex Transcend island-mist decking, which we fastened to the framing with the company's hidden fastener system. The Transcend had a nice finish look and was a big time saver as far as the installation time was concerned, though we did end up using some color-match trim-head screws to fasten the perimeter edge board and the stair treads **(Figure 3)**.

We wrapped the posts with PermaSnap Wrap and Snap Columns, a 1/2-inch-thick white composite trim that folds around the posts and is joined with adhesive (hbgcolumns.com). For the railings, we used the Trex guardrail system; we matched white newel posts to the support post columns and installed black handrails and balusters per the homeowner's request. All exposed pressure-treated framing was trimmed out with 1-by Azek exterior composite boards fastened with trim-head screws and white composite plugs.

Finishing up, we used a solid triple 4-inch vinyl soffit (gpvinylsiding.com) for the porch ceiling and installed a ceiling fan to help with airflow on the hotter days of summer **(Figure 4)**. To complete the welcoming front porch on the homeowner's renewed Cape Cod–style home, we laid a hardscape walk (unilock.com) from the driveway to the stairs. ❖

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

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Right-Sizing Deck Joists

Making sense of the 'Maximum Deck Joist Span' table in the 2021 IRC

by Mike Guertin

I used to size deck joists and beams by what I guessed would pass muster with the local building official. After submitting my deck plans, I'd keep my fingers crossed that they'd be approved, hedging my bets by sizing the joists larger than I guessed they'd need to be and reducing beam spans by placing footings closer together. Because my framing plans were rarely questioned, I figured I was doing something right.

But during a discussion about deck framing with a building official, I realized that he ran into the same challenge. Without tables for deck framing in the code, he didn't have a simple resource to determine whether I and other deck builders sized joists and beams properly. One solution, of course, would have been to require an engineer to design the framing, but thankfully most officials were reluctant to add that expense to our jobs. When I asked one official how he determined whether a joist could span the designed distance, he said he used floor-joist tables intended for interior floor framing. But those tables don't have wet service or incising factors applied, so they aren't applicable for deck design.

First Code Appearance

Both deck builders and code officials were happy when deck joist- and beam-span tables were introduced in the 2015 International Residential Code. These tables gave deck builders a way to select joist and beam sizes to satisfy their designs and the code, and they gave building officials a needed resource for evaluating deck frame designs during plan review. I started using them regularly when planning frames for deck designs, but as with any new tool you become infatuated with the first few times you use it, it wasn't long before I realized the tables' shortcomings and limitations.

Even though the old joist-span table wasn't ideal, I was still fortunate to be able to use it—not all deck builders could. The 2015 table was designed for a 10-pound-per-square-foot (psf) dead load and 40-psf live load, and because I work in an area with a snow load less than 40 psf, I could apply the table; deck builders in areas with snow loads greater than 40 psf weren't so fortunate. They would have to do a deep dive into the

Navigating the Deck Joist Span Table in the 2021 IRC

Example: Project built in a 30-psf ground snow load area with southern pine joists. Default to the major 40-psf live load row, then narrow further to the southern pine sub-row (leaving only four joist size rows).

TABLE R507.6
MAXIMUM DECK JOIST SPANS

LOAD[a] (psf)	JOIST SPECIES[b]	JOIST SIZE	ALLOWABLE JOIST SPAN[b, c] (feet-inches)			MAXIMUM CANTILEVER[d,f] (feet-inches)							
			Joist spacing (inches)			Joist back span[g] (feet)							
			12	16	24	4	6	8	10	12	14	16	18
40 live load	Southern pine	2×6	9-11	9-0	7-7	1-0	1-6	1-5	NP	NP	NP	NP	NP
		2×8	13-1	11-10	9-8	1-0	1-6	2-0	2-6	2-3	NP	NP	NP
		2×10	16-2	14-0	11-5	1-0	1-6	2-0	2-6	3-0	3-4	3-4	NP
		2×12	18-0	16-6	13-6	1-0	1-6	2-0	2-6	3-0	3-6	4-0	4-1
	Douglas fir-larch[e] Hem-fir[e] Spruce-pine-fir[e]	2×6	9-6	8-4	6-10	1-0	1-6	1-4	NP	N			
		2×8	12-6	11-1	9-1	1-0	1-6	2-0	2-3	2			
		2×10	15-8	13-7	11-1	1-0	1-6	2-0	2-6	3			
		2×12	18-0	15-9	12-10	1-0	1-6	2-0	2-6	3			
	Redwood[f] Western cedars[f] Ponderosa pine[f] Red pine[f]	2×6	8-10	8-0	6-10	1-0	1-4	1-1	NP	N			
		2×8	11-8	10-7	8-8	1-0	1-6	2-0	1-11	NP	NP	NP	NP
		2×10	14-11	13-0	10-7	1-0	1-6	2-0	2-6	3-0	2-9	NP	NP
		2×12	17-5	15-1	12-4	1-0	1-6	2-0	2-6	3-0	3-6	3-8	NP
50 ground snow load	Southern pine	2×6	9-2	8-4	7-4	1-0	1-6	1-5	NP	NP	NP	NP	NP
		2×8	12-1	11-0	9-5	1-0	1-6	2-0	2-5	2-3	NP	NP	NP
		2×10	15-5	13-9	11-3	1-0	1-6	2-0	2-6	3-0	3-1	NP	NP

Rows omitted for space considerations

Table now includes joist spans for areas with 50-, 60-, and 70-psf snow loads.

70 ground snow load	Southern pine	2×6	8-3	7-6	6-5	1-0	1-6	1-5	NP	NP	NP	NP	NP
		2×8	10-10	9-10	8-2	1-0	1-6	2-0	2-2	NP	NP	NP	NP
		2×10	13-9	11-11	9-9	1-0	1-6	2-0	2-6	2-9	NP	NP	NP
		2×12	16-2	14-0	11-5	1-0	1-6	2-0	2-6	3-0	3-5	3-5	NP
	Douglas fir-larch[e] Hem-fir[e] Spruce-pine-fir[e]	2×6	7-11	7-1	5-9	1-0	1-6	NP	NP	NP	NP	NP	NP
		2×8	10-5	9-5	7-8	1-0	1-6	2-0	2-1	NP	NP	NP	NP
		2×10	13-3	11-6	9-5	1-0	1-6	2-0	2-6	2-8	NP	NP	NP
		2×12	15-5	13-4	10-11	1-0	1-6	2-0	2-6	3-0	3-3	NP	NP
	Redwood[f] Western cedars[f] Ponderosa pine[f] Red pine[f]	2×6	7-4	6-8	5-10	1-0	1-4	NP	NP	NP	NP	NP	NP
		2×8	9-8	8-10	7-4	1-0	1-6	1-11	NP	NP	NP	NP	NP
		2×10	12-4	11-0	9-0	1-0	1-6	2-0	2-6	2-6	NP	NP	NP
		2×12	14-9	12-9	10-5	1-0	1-6	2-0	2-6	3-0	3-0	NP	NP

"Maximum Cantilever" column is divided into eight sub-columns by "Joist Back Span" in 2-foot increments from 4'-0" to 18'-0" deck depth.

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square foot = 0.0479 kPa, 1 pound = 0.454 kg.
NP = Not Permitted.
a. Dead load = 10 psf. Snow load not assumed to be concurrent with live load.
b. No. 2 grade, wet service factor included.
c. $L/\Delta = 360$ at main span.
d. $L/\Delta = 180$ at cantilever with a 220-pound point load applied to end.
e. Includes incising factor.
f. Incising factor not included.
g. Interpolation allowed. Extrapolation is not allowed.

Permits interpolation between joist lengths listed in tables (see "Interpolating Maximum Cantilever," page 13)

Figure 1. The major difference between the deck-joist-span table in the 2021 edition of the IRC (Table R507.6) and earlier versions of the table is that it allows joists to be sized for 50-, 60-, and 70-psf ground snow loads. In addition, it is now a little easier to calculate the maximum cantilever allowed for each joist according to species, size, and spacing.

AWC's *Wood Frame Construction Manual* and spend some time crunching numbers or hire an engineer to determine framing member sizes. Another shortcoming of the table was the odd, two-step process to determine cantilever distances that left users scratching their heads.

The joist-span table updated in the 2018 IRC simplifies cantilever spans a little. Even bigger changes came in the 2021 IRC, which expands the joist-span table to include 50-, 60-, and 70-psf snow loads, permits us to interpolate between lengths listed in the tables, and makes the cantilever section in the joist-span table a little simpler to apply.

In this article, I'll explain how to navigate the updated deck-joist-span table (R507.6), how joist spans and cantilevers are measured, and how I select joists for a deck design. I'll also introduce how to interpolate the maximum cantilever when the joist back span falls between two columns on the table. Later, in an upcoming article, I'll discuss how to size a beam using the 2021 IRC beam-span tables.

Reading the Joist Table

There are two field sections in Table R507.6 "Maximum Deck Joist Spans"—the "Allowable Joist Span" column and the "Maximum Cantilever" column (**Figure 1**). The lengths listed in the field for each section are controlled by four factors: load, wood species, nominal joist size, and either on-center joist spacing (for joist span) or joist span (for cantilever).

The joist-span column is divided into three sub-columns by joist spacing: 12, 16, and 24 inches on-center (o.c.). The maximum cantilever column is divided into eight sub-columns by "Joist back span" (that is, joist span) in 2-foot increments from 4 feet to 18 feet.

The other factors are oriented into rows. The four major rows are based on the live and snow loads in psf—40 live and 50, 60, and 70 snow.

Each major load row is further divided into three wood species groups: southern pine; Doug fir-larch/hem-fir/spf; and redwood/western cedars/ponderosa pine/red pine. And those sub-rows are each divided again by joist size: 2x6, 2x8, 2x10, 2x12.

Though the table looks large and intimidating, you only have to focus on a small portion. Let's say you're building in a 30-psf ground-snow-load area with southern pine joists. You'll default to the major 40-psf live-load row and then narrow further to the southern pine sub-row. That leaves only the four joist-size rows.

Measuring Joist Span

Before you can apply the table, you need to know how the deck joist span is measured. Figure R507.6 "Typical Deck Joist Spans" includes four illustrations depicting the joist-span measurement points for two decks attached to a wall by a ledger—one with a flush rim beam and one with joists cantilevering over a dropped beam—and two free-standing decks—one with flush beams and one with cantilevers. The important thing to note is that the joist span is measured from the center of the joist bearing at each end. Some people confuse "joist span" with "deck depth" (the distance from exterior wall surface to the outside of the rim joist).

If the deck is framed from a ledger to a

Live Load, Snow Load, and Dead Load

The dead load assumed in all the Section R507 Deck tables is 10 psf. Dead load is the weight of all the materials—like posts, beams, joists, decking, and railing—used to build the deck. I've measured the weight of some decks I've built and the dead loads ranged from 5 psf when we're using wood decking to 7 psf when decking with a heavy composite. So the 10-psf dead load assumed in the table is fairly conservative. But 10 psf would not apply to extra-heavy decking types like concrete decking planks or concrete pavers, so you wouldn't be able to size a joist or beam using the code tables.

Live load comprises people and stuff that inhabit the deck. Live load would include portable things like tables, chairs, coolers, umbrellas, and entertainment equipment you can carry on and off a deck. It would not include a hot tub or built-in outdoor kitchen with a stone top or masonry-clad fireplace. Heavy, permanent equipment requires a load calculation and heavy-duty framing and larger footings that the code tables don't factor for.

Ground snow load (snow load) is the weight of snow typical for a region. You can find the ground snow load for an area in which you're building a deck in Table 301.2 that is filled out by a local building department and by checking figures R301.2(3) and R301.2(4) in the IRC.

Footnote "a" in Table R507.6 states, "Snow load not assumed to be concurrent with live load." This means you don't add snow load to live load; instead, you apply whichever is greater for your area. The live load default for residential construction is 40 psf, so that's the minimum load. If you build in an area with a snow load less than 40 psf, then you would use the 40-psf major row. If you build in a 50-, 60-, or 70-psf snow load area, then you would apply the applicable row. If you're in an area with a snow load greater than 70 psf, then you'll probably need an engineer to size your joists and beams. —*M.G.*

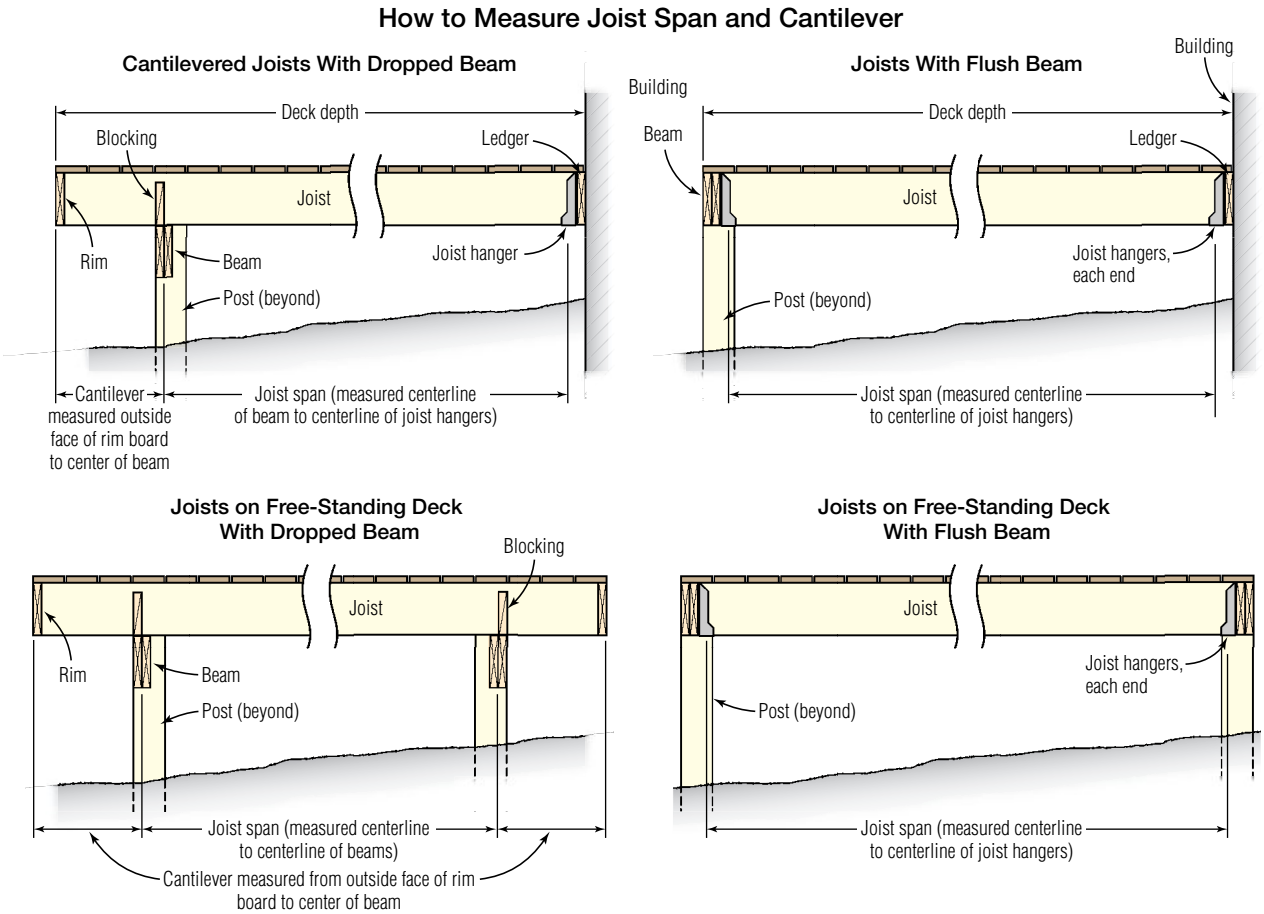

Figure 2. The depth of a deck depends on joist span, cantilever (if any), and other considerations that can add as much as 6 1/2 inches. The illustrations above (adapted from Figure 507.6 in the 2021 IRC) show where measurements for joist span and cantilever begin and end, and how to account for ledgers, rim beams, and hardware when sizing joists.

flush rim beam at the outside, then the span measurement is taken from the center of the joist hanger at the ledger end and the center of the joist hanger at the beam end. Many joist hangers used on decks have a 2-inch-deep saddle that the joists rest on. So a deck with a two-ply flush beam at one end and a single-ply ledger at the house end essentially "gains" 4 inches of deck depth at the outside end and 2 1/2 inches at the inside end—a total of 6 1/2 inches. This may seem like an insignificant distance, but using deck depth instead of joist span may lead you to look down the wrong joist-span column and size the beam with shorter spans than necessary (more about beam sizing in a follow-up article).

On decks where the joists cantilever over a dropped beam, the span measurement is taken from the center of the joist hanger at the ledger end to the center of the beam. The cantilever portion of the joist is not counted as joist span. The depth of a deck with cantilever joists can be several feet greater than the joist span due to the cantilever portion (**Figure 2**).

Measuring Joist Cantilever

The cantilever is measured from the center of the beam to the outside edge of the cantilever, but where that point is can be confusing. The code figure depicts only one of several possible details: the measurement point at the outside face of the rim board—which is also where the figure depicts the edge of the last deck board. If the deck board overhangs past the rim board, then should that projecting edge of decking be the measurement point for cantilever span? What if a fascia board is installed over the rim board and then the decking overhangs the fascia?

In practice, someone could stand on a decking board at its outer edge and thereby put a load that carries back to the deck joists. I would err on the side of being conservative here and measure the cantilever to the outer edge of the decking and not just to the face of the rim board.

We're only talking about an inch or

Selecting Joists for a Deck Design

TABLE R507.6 MAXIMUM DECK JOIST SPANS

LOAD[a] (psf)	JOIST SPECIES[b]	JOIST SIZE	ALLOWABLE JOIST SPAN[b, c] (feet-inches) Joist spacing (inches) 12	16	24	MAXIMUM CANTILEVER[d,f] (feet-inches) Joist back span[g] (feet)
40 live load	Southern pine	2 × 6	9-11	9-0	7-7	
		2 × 8	13-1	11-10	9-8	
		2 × 10	16-2	14-0	11-5	
		2 × 12	18-0	16-6	13-6	
	Douglas fir-larch[e] Hem-fir[e] Spruce-pine-fir[e]	2 × 6	9-6	8-4	6-10	
		2 × 8	12-6	11-1	9-1	
		2 × 10	15-8	13-7	11-1	

Example: A flush-framed deck with a double rim beam, an outside dimension of 13'-6", southern pine, and a 40-psf live load. (The deck design also calls for synthetic decking laid diagonally.) Go to 40-psf southern pine row, choose closest allowable spans; in this case, 13'-1" for southern pine 2x8s at 12" o.c.

Table R507.6 excerpted from the 2021 International Residential Code; Copyright 2021 Washington, D.C.: International Code Council. Reproduced with permission. All rights reserved. www.ICCSAFE.org.

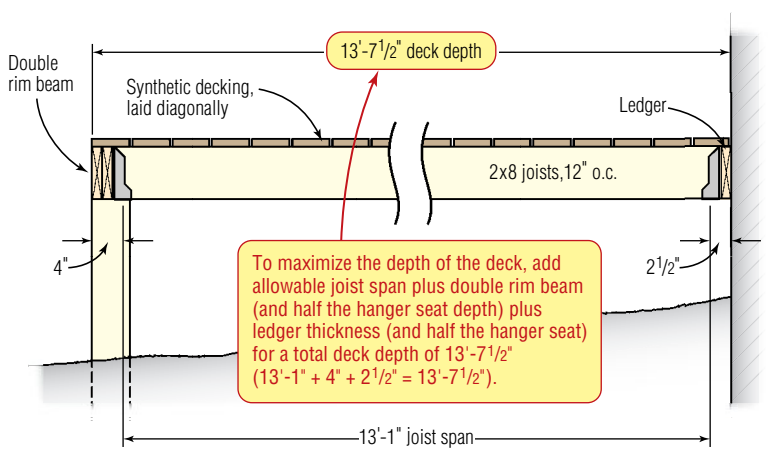

Figure 3. In this example, a deck with a flush double rim-beam with an outside dimension of 13 feet 6 inches and synthetic decking laid diagonally, choose the 12-inch-o.c. joist-spacing column. From the table, find the closest allowable span: 13 feet 1 inch (2x8s at 12 inches o.c.) under the 40-psf southern pine row. Adding 4 inches (to account for the double rim beam and half the width of a joist hanger) and 2 1/2 inches (to account for the ledger and half the width of a joist hanger) to the 13-foot-1-inch joist span yields a 13-foot-7 1/2-inch maximum deck depth.

two between a fascia board and decking overhang, but sometimes that may be just the distance you need to start and end with full deck boards at the outside and along the wall. It may be worth checking with your local building department to see if it counts the overhanging decking as part of the cantilever span.

Applying the Table

There are several ways you can approach using the joist table. The inside-out approach starts with a predetermined measurement on a deck plan that you match to lengths listed in the field cells of the table. There's rarely a perfect match but you can choose lengths that are a little greater than the design measurement, then follow rows and columns outward to see what joist-size and spacing options there are to select from.

Inside-out example: Shown in Figure 3 is a flush double rim-beam deck with an outside dimension of 13 feet 6 inches. Knowing that the measurement points are the centers of the joist hangers, we can count on 6 1/2 inches of deck depth that's not counted in the joist span (3-inch beam, 1 inch to center of each joist hanger, and 1 1/2-inch ledger), so the actual joist span is 13 feet 1/2 inch. From the table in the 40-psf southern pine row, the closest allowable spans are: 13 feet 1 inch (2x8s at 12 inches o.c.), 14 feet (2x10s at 16 inches o.c.), and 13 feet 6 inches (2x12s at 24 inches o.c.).

There are other factors that may lead you to select one joist size over another. If you're using synthetic decking laid diagonally, the manufacturer may require 12-inch-o.c. joist spacing, so 2x8s would make the most sense. Cost is another factor; it may be more cost-effective to use 2x12s at 24 inches o.c. if using 2x6 PT decking—which can easily span over joists set at 24 inches o.c.—rather than 2x10s at 16 inches o.c. or 2x8s at 12 inches o.c.

Outside-in example: You can also work from the outside in. Select the joist size and spacing you think will work, then check the joist span length in the field cell to see if your choice meets the joist span of the design. For example, your plan is to use southern pine 2x8s at 12 inches o.c. to span 12 feet for the deck design. Reading down the 12-inch-o.c. joist-spacing column to the matching 2x8 row, you'll find that the allowable joist span is 13 feet 1 inch, so you're good to go. This method doesn't lend itself to maximizing joist span but rather just affirms that a joist species, size, and span won't exceed the maximum distance listed in the field cell.

Organic approach. Or, you can work organically while you're designing a deck plan by checking joist spans and cantilever lengths in the table and adjusting the design to get the most span out of a joist and cantilever.

When using the organic approach, I may have a target deck depth of 13 feet 6 inches and plan to use southern pine 2x10s at 16 inches o.c. 2x10s can span 14 feet, which meets my deck-depth criteria. But reconsidering the deck depth, I could change the design to use the full

14-foot allowable joist span and build a larger deck that's 14 feet 6 inches deep, for the cost of a few more deck boards. Since I usually use PT southern pine lumber, I've almost memorized that small portion of the span table so I can make quick assessments of joist size and spacing when doodling out a rough deck design.

Adding a Cantilever

The 2018 IRC version of the joist table requires a two-step procedure to verify the maximum distance of a joist cantilever over a dropped beam. You have to calculate one-quarter of the back span of the joist (L/4) and compare it to the results from the maximum-cantilever columns in the table. Whichever is less prevails.

The 2021 IRC simplifies the process to a single step: looking at the distance in a table cell. Once you've selected a joist size and know the joist span between the center of the beam and the center of the joist hanger at the ledger, you read down the corresponding joist-back-span column.

For example (following the 40-psf live-load table section), if you're installing southern pine 2x10s at 16 inches o.c. with a 14-foot joist span (the maximum allowable), follow the 14-foot joist-back-span column down to the 2x10 row and read the entry: 3 feet 4 inches (**Figure 4**).

If you want to maximize the depth of the deck, you can add the allowable joist span and maximum cantilever measurements together, in addition to the ledger thickness and half the hanger seat depth at the house side of the deck. So, the maximum total deck depth would be 17 feet 6 1/2-inches from the face of the wall where the ledger is mounted to the edge of the decking when using 2x10s at 16 inches o.c. (14 feet + 3 feet 4 inches + 2 1/2 inches = 17 feet 6 1/2 inches).

You don't have to use the entire cantilever distance allowed, but it is available.

Interpolation

Say your design calls for a deck depth of 14 feet 6 inches, just out of reach for 2x10s at 24 inches o.c. According to Table R507.6, the allowable joist span for a 2x10 would be 11 feet 5 inches, with a maximum cantilever (taken from the "10" joist-back-span column) of 2 feet 6 inches, for a total span of 13 feet 11 inches. Even adding 2 1/2 inches for the ledger and half the hanger seat, the total maximum deck depth is 14 feet 1 1/2 inches. To frame the deck, you could change the joist spacing from 24 to 16 inches o.c. with a joist span of up to 14 feet plus a cantilever to total 14 feet 6 inches. Or you could change the joists to 2x12s at 24 inches o.c. with a joist span up to 13 feet 6 inches plus a cantilever to total 14 feet 6 inches. Or you can interpolate (see Footnote "g" at the bottom of Table R507.6).

Essentially, interpolation means calculating the measurements for cantilevers (in this case) that fall between the 2-foot increments of the joist-back-span columns. For example, a simple interpolation would be a joist-back-span measurement that falls precisely halfway between two columns—say 11 feet, falling

Selecting Maximum Allowable Cantilever

TABLE R507.6 MAXIMUM DEPTH JOIST SPANS

LOAD[a] (psf)	JOIST SPECIES[b]	JOIST SIZE	ALLOWABLE JOIST SPAN[b, c] (feet-inches) Joist spacing (inches) 12	16	24	MAXIMUM CANTILEVER[d, f] (feet-inches) Joist back span[g] (feet) 4	6	8	10	12	14	16	18
40 live load	Southern pine	2 x 6	9-11	9-0	7-7	1-0	1-6	1-5	NP	NP	NP	NP	NP
		2 x 8	13-1	11-10	9-8	1-0	1-6	2-0	2-6	2-3	NP	NP	NP
		2 x 10	16-2	14-0	11-5	1-0	1-6	2-0	2-6	3-0	3-4	3-4	NP
		2 x 12	18-0	16-6	13-6	1-0	1-6	2-0	2-6	3-[illegible]	3-6	4-0	4-1
	Douglas fir-larch[e]	2 x 6	9-6	8-4	6-10	1-0	1-6	1-4	NP	NP	NP	NP	NP
	Hem-[illegible]	2 x 8	12-6	11-1	9-1	1-0	1-6	2-0	2-3	2-0	NP	NP	NP
	Spruc[illegible]												P
													11

Example: To determine the "maximum cantilever" for southern pine 2x10s at 16" o.c. with a 14'-0" maximum allowable joist span and a 40-psf live load, follow the 14'-0" "joist back span" column down to the 2x10 row, find 3'-4".

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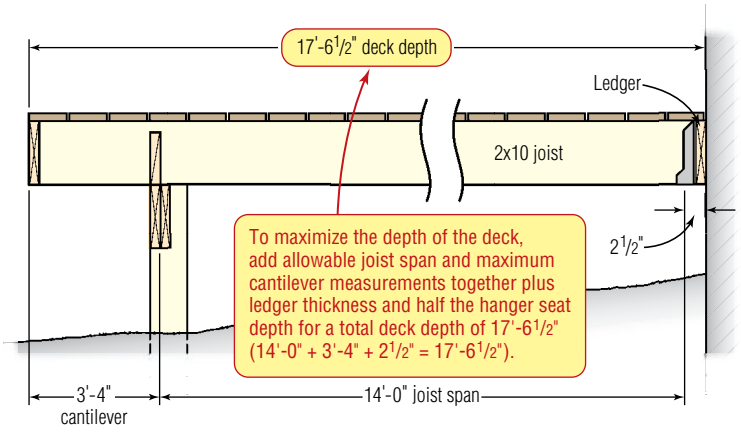
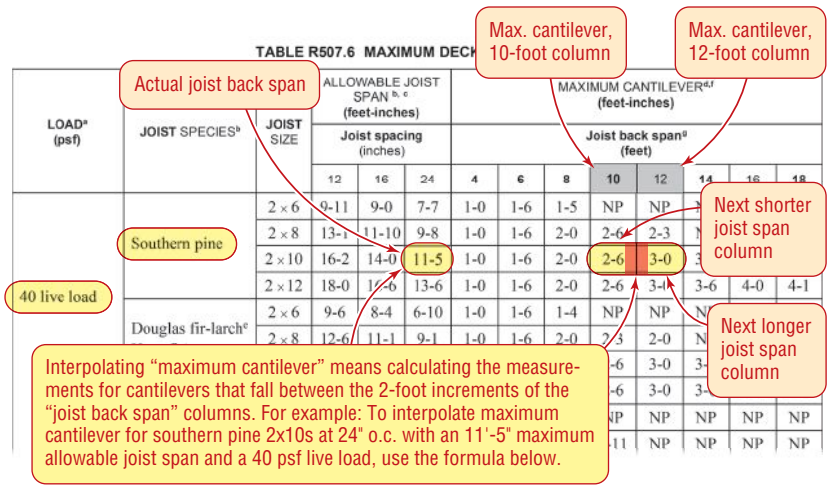


Figure 4. To determine the maximum cantilever for southern pine 2x10s at 16 inches on-center with a 14-foot joist span (the maximum allowable) and a 40-psf live load, follow the 14-foot "Joist back span" column down to the 2x10 row and read the entry—3 feet 4 inches. To maximize the depth of the deck, add the allowable joist span and maximum cantilever measurements together plus the ledger thickness and half the hanger seat depth at the house side of the deck for a total deck depth of 17 feet 6 1/2 inches.

Interpolating Maximum Cantilever



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Interpolation Formula

$$\text{Interpolated cantilever} = \text{Max. cantilever, 10-foot column (2'-6")} + \left(\text{Actual joist back span (11'-5")} - \text{Next shorter joist span column (10'-0")}\right) \times \frac{\left(\text{Max. cantilever, 12-foot column (3'-0")} - \text{Max. cantilever, 10-foot column (2'-6")}\right)}{\left(\text{Next longer joist span column (12'-0")} - \text{Next shorter joist span column (10'-0")}\right)}$$

$$\text{Interpolated cantilever} = 2'\text{-}6" + (11'\text{-}5" - 10'\text{-}0") \times \frac{(3'\text{-}0" - 2'\text{-}6")}{(12'\text{-}0" - 10'\text{-}0")}$$

$$2'\text{-}6" + (1'\text{-}5") \times \frac{(6")}{(24")} = 2'\text{-}6" + (1'\text{-}5") \times (.25") = 2'\text{-}6" + 4\tfrac{1}{4}" = 2'\text{-}10\tfrac{1}{4}"$$

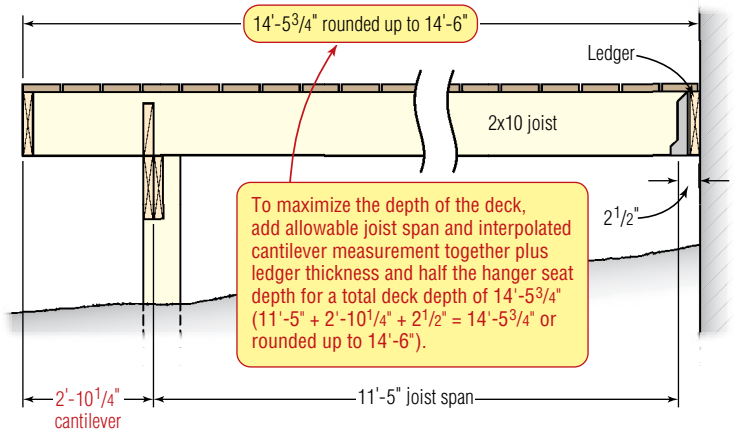

Figure 5. Footnote "g" in Table R507.6 allows for the interpolation of cantilevers that fall between the spans listed in the table, following the process outlined above. Solving for y following the formula above yields 2 feet 10 1/4 inches (the interpolated cantilever), which is then added to the joist back span listed in the table (11 feet 5 inches), plus ledger and half the joist hanger seat (2 1/2 inches) for a maximum deck depth of 14 feet 5 3/4 inches, rounded to 14 feet 6 inches.

between the 10- and 12-foot columns. In this example of 2x10s at 24 inches o.c., the interpolation is easy. The maximum cantilever in the 10-foot column is 2 feet 6 inches and the cantilever in the 12-foot column is 3 feet. Halfway between 2 feet 6 inches and 3 feet is 2 feet 9 inches.

When the actual joist back span is not a simple fraction—like one-half or one-quarter the distance between two columns—the process of interpolation requires a formula. Since the 11-foot-5-inch span is much closer to the 12-foot joist-back-span column that has a 3-foot maximum cantilever, you can eke out a few more inches of cantilever by solving the math formula for linear interpolation. It looks scary, but it's just a simple math and order-of-operations problem (**Figure 5**).

Solving for y in this example, the interpolated maximum cantilever for a joist with an 11-foot-5-inch back span equals 2 feet 10 1/4 inches. Total up the joist span (11 feet 5 inches) + cantilever (2 feet 10 1/4 inches) + ledger and half hanger seat (2 1/2 inches) = 14 feet 5 3/4 inches, rounded to 14 feet 6 inches. Yes, you can round up or down as needed so you don't have fractional results. Even the values in the table are rounded to keep it simple.

Okay, I'm splitting hairs here with interpolation and adding back the ledger and half the hanger seat distance to stretch as much deck depth out of the code table as possible. Most deck builders would probably upsize the joists or reduce the joist spacing and add the extra lumber cost into the job price. And I wouldn't fault anyone for doing that. But there are times where a board stretcher comes in handy, and that is exactly what Table R507.6 and Figure R507.6 have tucked inside.

In a future article about sizing deck beams, I'll use another addition to the 2021 IRC akin to interpolation to get the most out of beam spans and reduce the number of footings in the process. ❖

Mike Guertin is a builder and remodeler in East Greenwich, R.I., and a frequent presenter at JLC Live and DeckExpo. You can follow him on Instagram: @mike_guertin.

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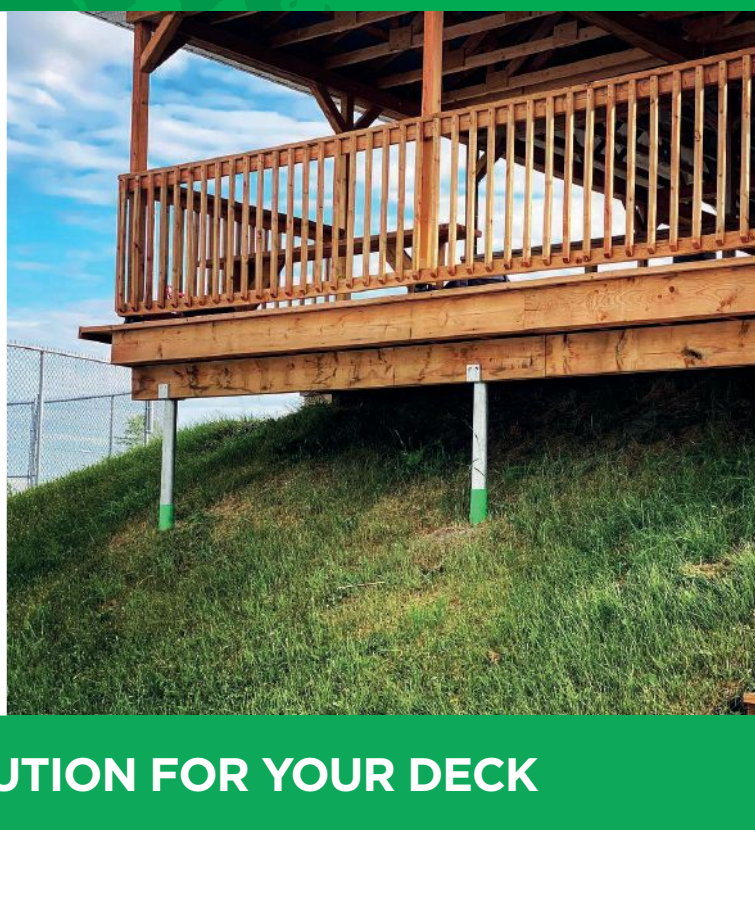

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Hardscaping a Backyard

You already have most of the skills needed to pour concrete slabs and build patios and retaining walls

by Matthew Breyer

Over the past few years, my company has been aggressively adding hardscape features such as patios and retaining walls to our deck projects. This is partly in response to our clients' expectations, which have been influenced by what they've seen done by their neighbors or on YouTube and TV, and partly due to the rolling hills of our area and the need to get creative with maximizing backyard spaces. Not only has this kept us busy, especially during the early stages of the COVID-19-related shutdown as we were deemed to be an "essential service," but it has also added a growing repertoire of tools and building techniques to our formerly deck-centric construction company.

The project featured in this article offers up a good example of our approach. Our client's home, which sits at the back corner of a development, has a yard that slopes in every direction. While that is fine for letting the dog run around, it's not so great when there isn't anywhere level to set a few chairs for family time or social events.

The core of our design was an elevated deck on the back of the house that would provide usable living space easily accessed from the main level via a 6-foot sliding door. But the home also had a fully finished walk-out basement with another 6-foot slider leading to the backyard, so we designed an outdoor living space that would allow our clients to entertain on multiple levels with maximum accessibility and functionality. Incorporating hardscaping elements into the design ensured that our clients' needs would be met and that the elements would work together cohesively, not just during the construction phase, but long-term as well.

Site Work

On a project like this, erosion and sediment (E&S) controls are typically dictated by local township regulations. E&S regs, in both their interpretation and engineering/paperwork requirements, depend on the municipality, ground-coverage rules, and overall project size. Generally, over the course of 50 to 100 projects a year, we may have two or three that require outside engineering or E&S documents, and maybe five to 10 more

PHOTOS BY MATTHEW BREYER

that can be handled by a discussion with the building code official or a clarifying in-house drawing while applying for the building permit.

The first stage was to clear out all of the unneeded dirt, or spoils, from the work area (**Figure 1**). Though when we quickly glance at a backyard to assess a job, it typically doesn't look like much dirt will need to be moved, we've learned that it's worth taking measurements and running a few calculations on larger projects. This one generated about six tri-axle dump-truck loads, or about 90 cubic yards of "junk dirt," of which we retained about two loads on site to help reshape the yard around the new spaces.

The junk dirt created some logistical concerns because it needed to be stockpiled outside the work area without risking runoff into a protected reserve and without blocking access from the driveway to the jobsite. In addition, as specified in the E&S drawing for this project, we had to install a silt fence.

Once the area was cleared, we used a Kubota KX040 mini-excavator to dig a 4-by-4-foot footing for the deck post that would support the corner of the deck. While there is a second support post, it is integrated into the front framed wall of an under-deck storage room that was part of the project, and we incorporated the below-grade footing for that post into the footings for that wall.

The soil on site was primarily a mix of rock and clay, which meant that we were able to dig a simple rectangular hole into the hillside for the storage room. To protect workers in other types of soils and deeper excavation depths, we often have to step back the excavation a couple of feet for every 4 to 6 feet of dig depth to prevent the sides of the excavation from collapsing.

Figure 1. The author uses a bulldozer, a skid steer, and a small tractor for general site work, as well as a Kubota KX040 compact excavator (A). After the site was leveled, the excavator was used to dig for footings for the deck and storage-room walls, and for the sitting walls at the corners of the patio (B).

Concrete

Most of our jobs don't require a lot of concrete; for example, a typical 12x12 patio slab requires only about 2 yards of concrete. While that's too much to mix by hand, to avoid short load fees we generally order from metered concrete service providers that mix up exactly what we need on site, rather than ordering by the yard from a ready-mix plant. This eliminates most of the clean-out waste on site and makes ordering more accurate and efficient, since there are no wasted overages.

On this project, we ordered 6 yards of concrete to pour the deck footing, the storage-room wall footings, and the footings for two sitting walls on the patio all at the same time. Because the concrete company shipped us a "stump," which was left over from a prior government-building pour, this concrete had a pink color. While this was acceptable for the buried footers, it showed up "hot" and set up almost immediately once placed in the trenches, requiring substantial effort to get it to properly fill the forms.

Per the engineered plans for the storage-room footings and block walls, vertical and horizontal rebar reinforces the footing and wall, as well as the connection between the wall and the slab floor. As we laid up the block work for the storage-room wall—which acts as a retaining wall—to bring it up past grade, we carefully backfilled with clean, crushed stone. On the exterior, the crushed stone around the footing drain and between the block wall and the dirt facilitates drainage and limits freeze/thaw pressure against the blockwork. On the interior, we used the crushed stone to provide a sub-base for the concrete slab floor.

After we built the block walls, we filled the cores with concrete at the same time we poured the interior floor slab for the storage room (**Figure 2**).

Deck

The storage-room walls needed to be completed before we could finish framing the deck. Because we weren't subcontracting either aspect of the job, we were able to partially build the deck's frame as the block walls were being built. In addition, having our excavation equipment on site allowed us to easily lift the deck's heavy engineered laminated beam into position, with one end supported by the block wall. This in turn allowed us to quickly finalize the deck frame shortly

Figure 2. Shown here is the formwork for the footings (A) that support the engineered block retaining wall (B) built to partially enclose a dry storage area underneath the deck. After the retaining wall was built, the author's Kubota SSV65 skid loader was used to lift the heavy deck beam into position (C). The storage room has a concrete slab floor (D).

after the block walls were finished, which helped move our project schedule along.

After we framed the deck, we installed an EPDM rubber under-deck drainage system to protect both the storage room and the open-air living space below the deck. For spaces that are sealed, such as the storage room, it's essential to water-test the drainage membrane and provide good ventilation.

Patio

Because of the overall size of the patio and the slope of the yard, we opted to partially build the outside sitting walls at the corners of the patio prior to finalizing the patio elevation and installing the pavers. This allowed us to adjust the wall heights as needed for uniform and consistent seating. While this approach required more patio protection in the form of drop cloths to limit mortar and foot-traffic dirt and added post-project cleanup, such as a heavy scrubbing of the masonry dust that is inevitable on a project like this, these extra efforts kept us from having to redo any work.

Visually, our goal was to have the sitting walls to appear parallel with the patio (which has a slight slope away from the house for drainage), but the walls also need to appear level from the outside as well. For L-shaped walls that extend around corners (as the ones on both sides of this patio do), this requires a little fudging both during the patio installation and while establishing the wall heights; a 12-foot-long sitting wall next to a patio with a ¼-inch-per-foot slope would generate a 3-inch seat-height difference, which is noticeable.

Generally, we can absorb an inch of height difference in a sitting wall over 10 to 12 feet of length, as long as we stay between 16 to 18 inches in height—any higher or lower, and we've found that people will notice the difference when they sit down. We can also adjust the patio grade

Figure 3. The sitting walls at the corners of the cast-stone-paver patio are supported by full below-frostline footings (A), which prevent heaves and cracks and stabilize the edges of the patio (B). The block walls are finished with manufactured stone veneer (C), and capped with manufactured pavers that match the edging around the sunken fire pit (D).

so the patio stops pitching out toward the yard, and is installed level along the wall, and then pitches toward the center of the patio, before pitching back to the front yard edge. Basically, it's a multipitched patio that still drains, rather than a flat, single-slope patio.

The block sitting walls are supported by poured concrete footings below frostline and finished with manufactured stone veneer. The walls are capped with manufactured pavers that match the step edge and cap used along the sunken fire-pit area. For the patio, we used oversized Cambridge cast-stone bluestone-blend pavers in a three-piece pattern.

We installed a built-in fire pit using natural stone that our clients had selected from a local quarry. To provide access from the patio area in front of the storage room to the side yard, we installed stone steps using manufactured stone treads. These steps also help to retain the hillside and let us adjust the ground height between the deck and the steps, and then from the steps out to the yard, for a more natural look.

The final grading around a project like this is extremely important. Bringing the dirt up high enough to properly support the patio and walls while gently grading it away from the project helps to divert rainwater away. Having extra dirt on site allowed us to finesse the grading; once we were finished, we removed one final load of spoils and debris.

Finally, we raked out the site, first by machine and then by hand, adding top-dressing soil as needed. To prevent the newly seeded dirt from washing away in heavy rain, we used a mixture of straw bales broken down and spread by hand, finely-chopped straw with a tackifier added to keep it from blowing away, and rolls of straw netting. ❖

Matthew Breyer is president of Breyer Construction and Landscape, in Reading, Pa.

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A


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C


D


E

Orange County Lanai

by Michael Walter

Last year, to prep for a major backyard living project **(A)**, I installed a wide La Cantina five-panel hinged door that opened onto an existing concrete patio behind my client's home. While we had the wall opened up to beef up the framing seismically with Simpson Strong-Tie Strong-Wall shear wall panels and a 20-inch-high PSL header **(B)**, we upgraded the electric to provide controls and wiring for a planned patio cover and a new 1,000-square-foot deck. Recently, I returned with my crew to finish up the project, located in the hills of California's northern Orange County.

We started by removing the existing deck and breaking up the concrete patio. Then, after building the forms for new engineered footings to support the patio cover, we brought in a subcontractor to monolithically pour the footings and a new stamped and colored concrete patio.

We anchored a pair of 6x6 posts to the footings with seismic brackets, then lifted a big PSL beam into position on top of the posts. After connecting the beam to the posts with more seismic hardware, we hung the patio cover's 2x8 rafters and 2x6 ceiling joists, then sheathed and shingled the roof **(C)**.

While the stucco contractor stapled up lath and started applying colored stucco with a Spanish texture to the patio cover **(D)**, we began framing the new deck, which is elevated a couple of steps above the level of the patio **(E)**. Finished with Trex Transcend tiki torch decking with a lava rock border and a matching Trex railing, the new deck provides the homeowners with a better view of the nearby Santa Ana Mountains when they are snowcapped in the winter.

To illuminate the steps for both safety and as a design element, we installed a series of recessed lights in the risers. These are part of the package of 57 Trex step and cap low-voltage lights that illuminate the deck and railing. ❖

Michael Walter owns MLW Construction, in Anaheim Hills, Calif.

PHOTOS BY MICHAEL WALTER

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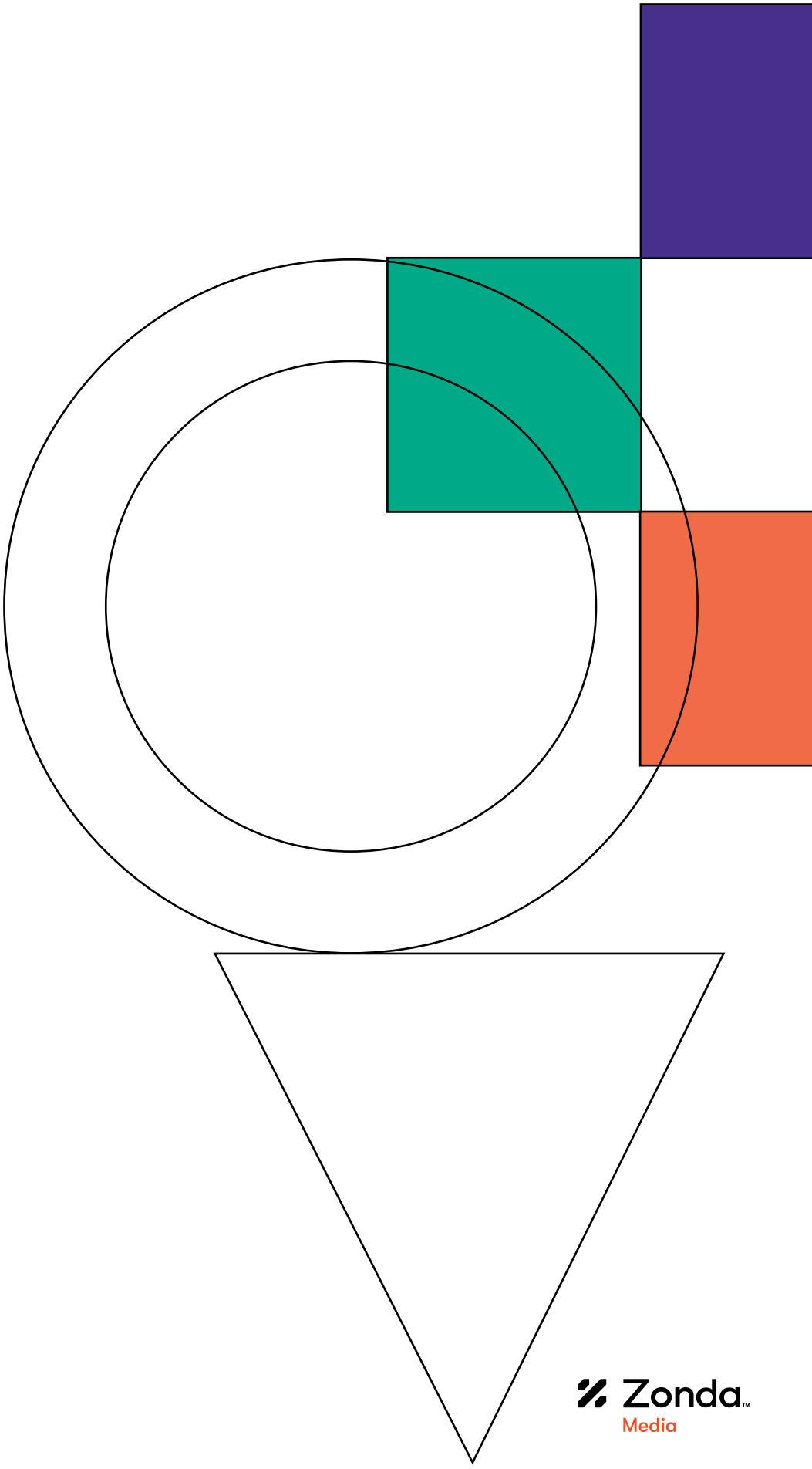

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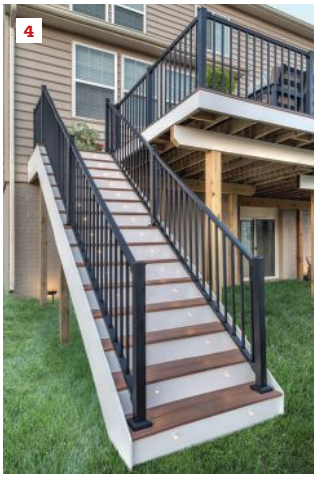


1. Heat-Treated Wood
Tantimber ThermoWood products are thermally modified with no chemical treatment. With reported properties including durability against decay, reduced equilibrium moisture content, reduced thermal conductivity, and reduced bending strength, the material is suitable for decking, siding, louvers, ceilings, soffits, pergolas, and decorative wall coverings, inside and out. Available wood species include ash, pine, poplar, and iroko; not all products are available in all species. gwoodpro.com

2. Powder-Coated Aluminum Lattice
Aluminum lattice panels from Permalatt Products can be used for pergolas, patio rooms, skirting for decks, enclosures for HVAC systems, and patio covers. Welded together with welds hidden from view, vertical and horizontal $1\frac{1}{4}$-inch-by-$\frac{1}{4}$-inch hollow-core slats cross to form a 2-inch-square lattice pattern. Panels are available in nine powder-coated colors—including brown hues, black, gray, and bronze in addition to white—in satin and fine-textured finishes. A 4-foot-by-8-foot panel costs between $367 and $385. permalatt.com

3. Soft-Close Adapters for Cabinet Doors
UniSoft soft-close adapters from Grass America can be mounted on the upper corner of a new cabinet or as a retrofit. Wide-ranging applications include all types of door overlays for face-frame cabinets, and full-overlay doors for frameless cabinets. Adapters can be manually adjusted to achieve a desired closing speed; the damper is concealed in a brushed nickel casing, allowing it to blend with a hinge finish, according to the manufacturer. A package of 10 adapters retails for around $30. grassusa.com

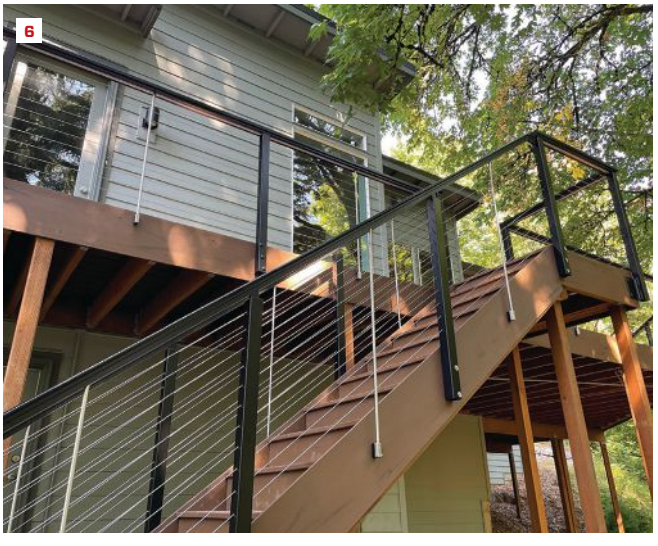
4. Assembled Stair Rail Panels
Trex has added preassembled aluminum stair rail panels to its Trex Signature portfolio as a time- and labor-saving option. Panels are offered in charcoal black with square balusters to match the manufacturer's preassembled Trex Signature horizontal railing panels and are available in 6-foot and 8-foot lengths and 36-inch and 42-inch heights. Posts and hardware are sold separately. trex.com

5. Lower-Carbon-Footprint Framing

The BamCore Prime Wall is a nearly hollow wall system for commercial and residential low-rise construction. According to the manufacturer, Prime Wall's high-performance design eliminates the need for 90% of studs, headers, posts, OSB, and drywall. The engineered bamboo panels are custom-fabricated for each job using 3D BIM technology, and MEPI maps can be printed on the panels to indicate rough-in lines. Walls can be filled with any type of blown-in insulation. bamcore.com

6. Low-Profile Cable-Rail Pickets

Used with CableRail infill where posts are spaced more than 3 feet apart, Stainless Steel Intermediate Pickets for DesignRail are a low-profile alternative to square, powder-coated pickets. Available in 36-inch-level, 42-inch-level, and universal stair configurations, the 5/8-inch-diameter 316-stainless-steel tubes are predrilled every 3 inches for 1/8-inch-diameter cable and can be trimmed in the field. Hardware is included. feeneyinc.com

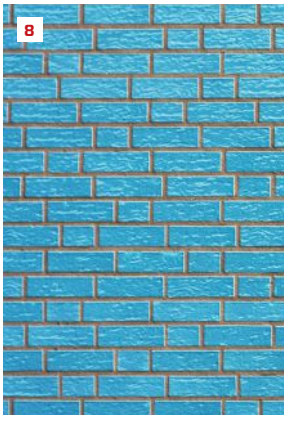


7. GuardDog Exterior Wood Screws

FastenMaster's enhanced GuardDog exterior wood screw has a Torx ttap drive system, a type-17 auger point for quick cutting into the wood surface, and cutting nibs under the head. The screws can be used for pressure-treated decks, railings, and stair stringers and are approved for use with treatments such as ACQ and CA-B and in acidic woods such as cedar and redwood. The fasteners are available in lengths ranging from 1 5/8 inches to 3 1/2 inches and in quantities up to 1,750-piece buckets. A 75-piece box retails for around $10. fastenmaster.com

8. Color-Matching Mortar Base

MVIS Premium Pointing Mortar Base from Laticrete can be used for a variety of exterior and interior projects, including glazed thin brick, glazed block, porcelain pavers, and hardscapes, with joints up to 1/2 inch wide. Color is added via a dispersible dry pigment pack, which is available in 40 standard color options. According to the manufacturer, fiber reinforcement in the mortar resists cracking and powdering, and Microban antimicrobial technology resists the growth of mold and mildew. A 50-pound bag retails for $28. Custom color matching is also available. laticrete.com



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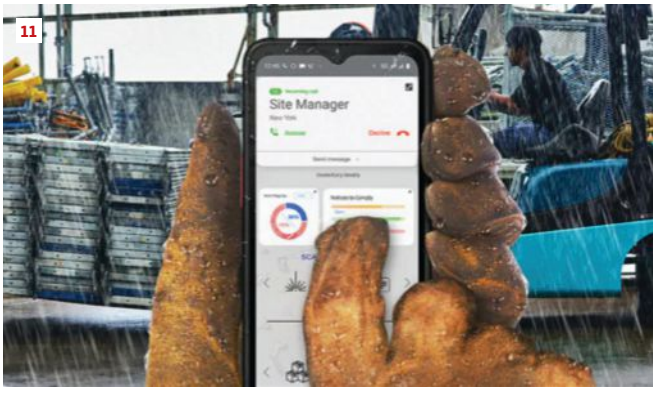


12

9. Narrow-Body Ceiling Cassette
Compatible with Mitsubishi Electric Trane HVAC multi-zone outdoor mini-split systems, the EZ Fit MLZ-06 Recessed Ceiling Cassette is sized to fit between joists for flush-mounting to the ceiling in either new construction or retrofit projects. Airflow can be adjusted for a low or high ceiling, and air direction can be adjusted with automatic vane control. The unit has a 6,000 Btu/h capacity. mitsubishicomfort.com

10. Drywall Backer
Buttboard Drywall Backer from Trim-Tex installs behind butt joints in drywall between studs, helping to hide the joints and simplify panel layout on walls and ceilings. As the backer is screwed to each sheet of drywall, it pulls back on the edge, creating a tapered seam that the manufacturer says requires less joint compound to finish. Made from formaldehyde-free premium density OSB board, the backer works with metal and wood framing without the need for special tools. A case of 12 48-inch backers retails for $155. trim-tex.com

11. Jobsite Phone
The Samsung Galaxy XCover6 Pro phone features a military-grade rating for shock, vibration, dust, sand, and drops on concrete up to 1.5 meters, as well as an IP 68 rating for water spray and complete submersion. The phone's moisture-resistant screen is responsive to wet gloves, and the battery is replaceable. The phone is CBRS-ready and works with wireless data networks 5G and Wi-Fi 6E to ensure high-speed connectivity on the site. The phone retails for $600. samsung.com

12. Liquid-Applied Flashing Sealant
LP WeatherLogic Seam & Flashing Sealant is a liquid-applied flashing material certified to AAMA 714-19 and is the only liquid-applied sealant approved to seal the panel joints between LP WeatherLogic panels. The sealant can also be used to flash window and door openings, material transitions, and penetrations of any shape (gaps wider than 1/8 inch should be filled with backer rod). Surfaces must be clean and dry before application. The VOC-compliant sealant has a 10- to 15-minute tooling time and a 110-minute surface tack time, and can fully cure in 24 hours, depending on conditions. lpcorp.com

Cut Above the Rest

BY JAKE LEWANDOWSKI

In my company, Great Lakes Builders, we were early adopters of the SawStop safety system and bought one of JSS Job Site Saws as soon as they became available. Like most small businesses, we strive to make our workplace as safe as we can. Having a safe table saw—one that shuts down the instant the blade comes in contact with skin—certainly helps lower the risk of injuries.

Frequently, however, we work in areas with tight access, and my crew had been after me to buy a compact table saw. A smaller saw unquestionably has a place on the jobsite; being light and easy enough for one person to maneuver offers a clear advantage. I had dragged my feet on this request, but when SawStop recently released the CTS Compact Table Saw, I jumped at buying it.

The SawStop CTS is a premium offering with a price to match: $900 at the time of publication. The safety advantage alone is worth this high price tag to us, but I was pleased to find the build quality to be quite good compared with other compact models on the market.

PROS

Here are some of the quality features on the CTS that we like a lot:

- The saw runs a 10-inch blade, compared with the 8 1/4-inch blades found on many other compact saws.
- A rack-and-pinion mechanism holds the fence square to the blade. This has proved reliable and looks like it will stay that way for the life of the saw.
- The fence has what SawStop calls a "high and low face," which means the fence includes a "low face" spacer that separates the material you are cutting from the "high face" (main body) of the fence, allowing for more room for your hand or a push stick between the blade and the fence. This also helps reduce the chances of material binding between the blade and the fence.
- SawStop offers a well-thought-out folding stand for the CTS. This retails for an additional $130, and I would recommend buying one. The simple quick-release connectors (one at the front, one at the back) that secure the saw housing to this stand make for an especially easy setup and breakdown.
- Dust collection appears to be better than on any other compact saw we have run in the past. The port pulls air and dust from directly below the blade—a vast improvement over a port coming out the back of the housing.
- The motor easily handled cutting 2-by SPF and Doug-fir stock, along with ripping 3/4-inch CDX and OSB sheet material. Run-out from the direct-drive motor seems to be nonexistent.

While SawStop's CTS **(1)** is more expensive than any other compact table saw, the blade-stopping safety advantage is worth the high price tag, says the author. He likes the fence's rack-and-pinion mechanism **(2)**, which, he reports, reliably holds the fence square to the blade. Deactivating the brake cartridge is required when cutting wet material, such as pressure-treated lumber. But to do this requires turning the bypass switch (below the red button to the right of the main power switch) while pulling the red paddle button out **(3)**. The author would prefer a simple on-off switch for the safety system.

Photos: Jake Lewandowski

LIMITATIONS

Other than the obvious limitations that come with using a compact table saw, regardless of brand, these are a few things to consider:

- The CTS currently only comes with a cord, which isn't an issue if you're like me and regularly run a vacuum on your tools. We have to run an extension cord for the vac anyway and can simply plug the saw into the automatic-on switch on the vac.
- The CTS is not designed to run a dado blade. This isn't a huge deal but is worth a mention. For us, the JSS model does allow for an 8-inch stacked dado blade, so for the few times we might need this, we're covered.
- The saw has a side handle and is designed to be carried like a briefcase (with a safe way to lock the fence in position under the table for storage). We tried transporting the saw this way, but getting the saw in and out of the truck and on and off the stand was awkward. We found it much more natural to lift it from the tabletop. This is not so much a limitation as it is a comment on a feature that isn't of much help.
- The CTS uses a new version of the SawStop brake cartridge (TSBC-10R3). If you're already part of the SawStop family, this cartridge is compatible with the rest of the table saws in the SawStop lineup. However, any older cartridges you might have on hand may not fit.

CONS

Only one minor thing bugged me: You need to deactivate the SawStop safety brake to cut wet lumber. That in itself is not the problem; it's that putting the saw in this bypass mode requires two hands (see photo 3, facing page). As an employer, I found this problematic because the guys were putting the wood on the ground to deactivate the safety system. Or even worse, they were deactivating the saw and then walking away from the saw while it was running to grab the material they needed to cut.

I would prefer a simple on-off switch. The onboard warning lights on the saw make it clear that the brake system is deactivated, so you're not likely to forget you turned it off. And when the saw is switched off, it automatically returns with the brake system activated.

One accessory I would like to see in the future is an outfeed table that can be clipped to the back of the saw table. This is needed on any compact table saw, because with a limited table area for holding material, large stock can fall out of balance and bind the blade, causing a kickback. For a saw like the CTS, which is designed to improve user safety, a smart outfeed system would be a natural improvement.

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

Photos: Martin Gutierrez

Milwaukee M18 Fuel Cordless Wet/Dry Vacuum

BY IAN SCHWANDT

Like many medium-sized remodeling companies, TDS Custom Construction performs varied scopes of work that require our tradespeople to be organized and nimble and—above all—to keep a clean jobsite. That makes vacuums and their filter assemblies an important part of our work, but not just for keeping our client's homes clean; when used with HEPA filtration under our state's Lead Safe guidelines, they also keep occupants and workers safe. We recently added the Milwaukee M18 Fuel 12-gallon cordless wet/dry vacuum to our stable as an option to help our M18-battery-powered

The Milwaukee M18 Fuel cordless wet/dry vacuum is powered by a dual-battery motor head that can be fitted to a 12-gallon tank **(1)** or to smaller and more portable 6-gallon **(2)** or 9-gallon tanks. The 0930-22HD kit includes the 12-gallon tank and matching cart with a handle, along with a hose, extension tubes, a filter, and other accessories.

carpenters maximize their existing tool kit and improve efficiency.

The 0930-22HD kit, which retails for $800, came with a dual-battery motor head, two 12-Ah M18 batteries ($500 retail value by themselves), a dual-bay rapid charger, a high-efficiency filter, the premium 12-gallon vacuum tank and matching cart with handle, and 9 feet of hose with two extensions, a crevice tool, and a floor utility nozzle. The motor head is powered by a brushless motor and produces 109 cfm and 77 inches of suction. It's part of a modular system that includes 6- and 9-gallon canisters, as well as the 12-gallon canister fitted to our cart. Other components in the system include the company's HEPA, high-efficiency, and wet-use filter cartridges. We also tested several of Milwaukee's optional attachments, such as the Air-Tip dust collector, low-profile pivoting brush, and flexible crevice and magnet utility nozzles.

Power. The Milwaukee 0930-22HD is a true shop vacuum in that it is not specifically designed for attachment to power tools for use as a dust extractor. Compared with the other corded shop vacuums that we own, the Milwaukee performs well in terms of suction, though we noticed some loss of power when attempting to vacuum larger debris as the battery charge dropped. Milwaukee advertises the runtime for two 12-Ah batteries as 49 minutes for light debris and 34 minutes for heavy debris. For our typical remodeling work and our start-of-the-year shop cleanup, the vacuum performed closer to the 49-minute advertised runtime.

We also tested the dual-battery motor head on the smaller, 6-gallon tank, which, when used without the cart, reduces the vacuum to a portable unit that lends itself well to punch-list work. Milwaukee also offers a single-battery M18 motor head, which we didn't test, and says that it plans to release a 120-volt AC motor head that will work with all parts of this system.

Dust collection. The large, 2 1/2-inch-diameter hose performed well without clogging in post-demo cleanup, and the Air-Tip dust collector attachment was a favorite among our team. This attachment uses the suction created by the vacuum to stick to a wall underneath the work area where dust is being created. Whether used for dust collection for cutting plaster with a multi-tool or drilling pilot holes for handrail brackets, this attachment has proven to be valuable in keeping finished interiors clean.

We found the filter cartridges to be easy to remove and clean out using either an air hose or the tried-and-true method of banging the filter on the side of a dumpster. Milwaukee does offer removable bags in sizes that match the tanks, but we have yet to source them locally.

At $800 for the kit, this vacuum is not targeted toward everyone; rather, this offering from Milwaukee seems to be targeted toward the professional remodeler who is already heavily invested in Milwaukee's M18 ecosystem and values getting two 12-Ah batteries with a tool. If this sounds like you or one of your tradespeople, then this vacuum deserves a look based on its versatility and the wide range of accessories and options that Milwaukee has built into its wet/dry vacuum system.

Ian Schwandt is production manager for TDS Custom Construction in Madison, Wis.

Crew members used several optional Air-Tip vacuum accessories that are available from Milwaukee, including a magnetic utility nozzle and a corner brush **(3)**. When making cuts or drilling holes in walls, they found that the Air-Tip dust-collector attachment **(4)** was effective at scooping up debris.

Photos: Martin Gutierrez

BY CLAYTON DEKORNE

A Clear-Eyed View of Building Tech

With an astute perspective on the construction industry, Belinda Carr's engaging YouTube channel, "Your Unbiased Guide to Building Products and Tech" (youtube.com/@BelindaCarr), tackles tough questions about new building materials, products, technology, and design methods. Ms. Carr is refreshingly sane, wonderfully skeptical, and fearless in her quest to get to the bottom of what works to advance the promises of sustainable architecture. She is a master at exposing fallacies that are all too common in the media and marketing hype surrounding building technology.

An architect by training, she sits squarely in the camp of building professionals who focus on a holistic view of the AEC (architecture, engineering, and construction) landscape, and her videos inspire the feeling that everyone in the industry should be rowing in the same direction.

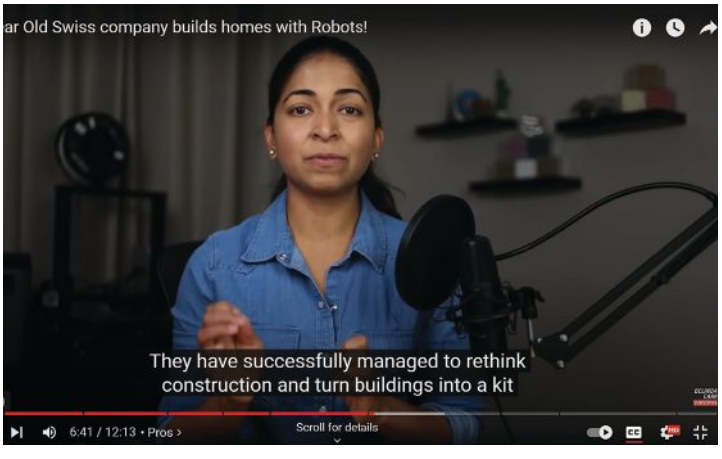
Her specialty is myth busting. She deftly articulates many of my qualms: Her video "The Hypocrisy of Being Green" should be required watching not just for every budding building professional, but for every prospective marketing and communications employee serving anyone exhibiting at any home show. It's ostensibly a critique of the LEED design standard, but purposefully she makes it so much more. "It's not the word 'green' itself that's troubling," she says. "We can replace it with anything else, like 'ecofriendly,' 'clean,' 'energy-saving,' 'environmentally safe,' 'ecological,' etc. It's the idea that if you tick certain boxes you've done your part in saving the planet, when in fact, you might be doing more harm than good."

Carr has gotten the most views for her exposés on shipping containers as a building solution,"7 Reasons Why Shipping Container Homes are a Scam," and 3D-printed homes, "Exposing 5 Lies About 3D Printed Concrete Homes." Of the latter, she explains, "I do not think the technology is a gimmick, but I despise the sensationalist coverage, misleading claims, and overpromises. They generate a lot of buzz and probably help to fund startups, but I think the lies cheapen the value."

She brings home the point about startups especially poignantly on her video "The Rise and Fall of Katerra | WeWork 2.0," in which she examines the failure of that massively funded off-site building company and asks what can we learn. Her answer begins: "For starters, we have to be cautious of outsiders, particularly from the tech industry, who have grandiose ambitions to 'fix' AEC ..." She goes on to explain that tech companies that believe they can easily "disrupt" construction by dumbing it down are doomed to fail. "Their hypergrowth strategy is employed by social media and software companies, but it doesn't work in complicated, slower-moving industries like real estate and construction," she contends.

Carr is not negative, just realistic and maybe even hopeful. The industry needs solutions for real problems, such as poor productivity, shortages of skilled labor, and slow progress on improving building performance on a majority of buildings. Finding realistic solutions for such problems seems to drive her critical viewpoints. "I think professionals who respect and understand the complexities of AEC will be the ones to initiate change," she urges.

One hopeful change-maker she reports on is Renggli, a Swiss modular home builder. Her review is inspiringly positive, but Carr doesn't have to go all the way to Switzerland to find similar examples. Companies like Unity Homes by Tedd Benson in New Hampshire and Plant Prefab by Steve Glenn in California show the enormous potential of building high-quality, ultraefficient prefab homes. Will such solutions render stick building obsolete? Not for a long while yet. Off-site construction methods (including modular, prefab, and panelization) account for only 2.4% of the 970,000 new homes constructed in 2021, according to U.S. census figures. Off-site building techniques make sense only in dense housing markets where the cost to build a state-of-the-art house factory can be rationalized across a short distance. But the U.S. is an immense country. Switzerland is about half the size of Maine. Sixteen Switzerlands would fit in Texas. The cost (and carbon) of transporting massive building components over long distances begs the question: How many factories do we need to build before we "fix" construction across the entire U.S.? Real answers, Carr helps me realize, are not going to be found solely from tech solutions.



Belinda Carr specializes in video critiques of overhyped building solutions. She also points to some that hold real promise.

Photo via YouTube https://www.youtube.com/@BelindaCarr

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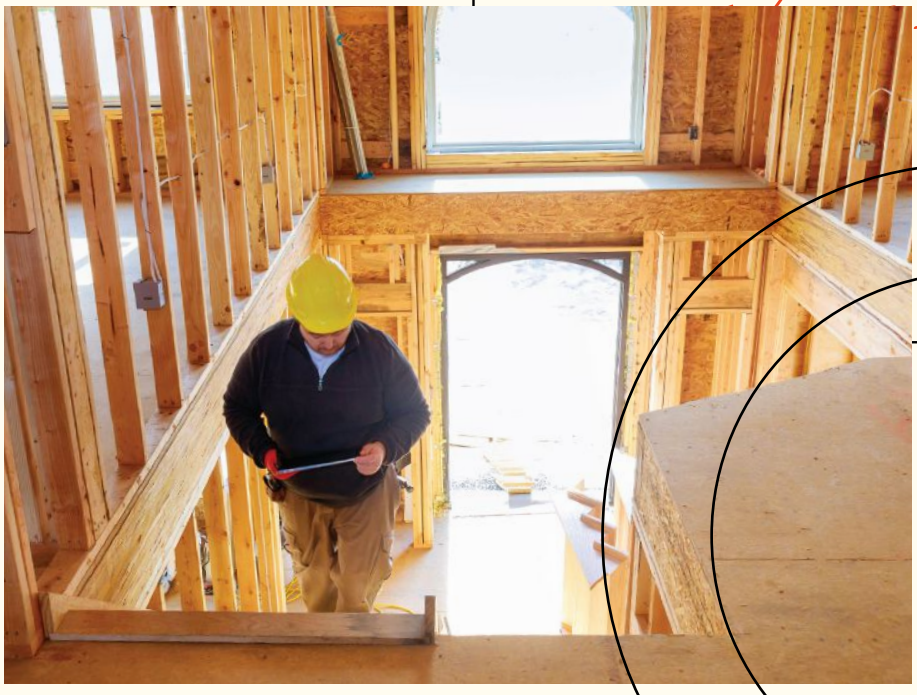

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