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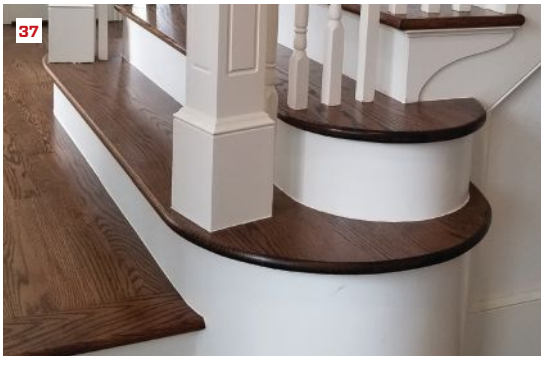

On the cover: Joe Rosipal, of Air Rite by Design in Austin, Texas, checks the operation of a Mitsubishi variable-refrigerant-flow heat-pump compressor. See the story on page 25. Photo by Ted Cushman.

FEATURES

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BY CLAYTON DEKORNE

Heat Transfer Through Buildings

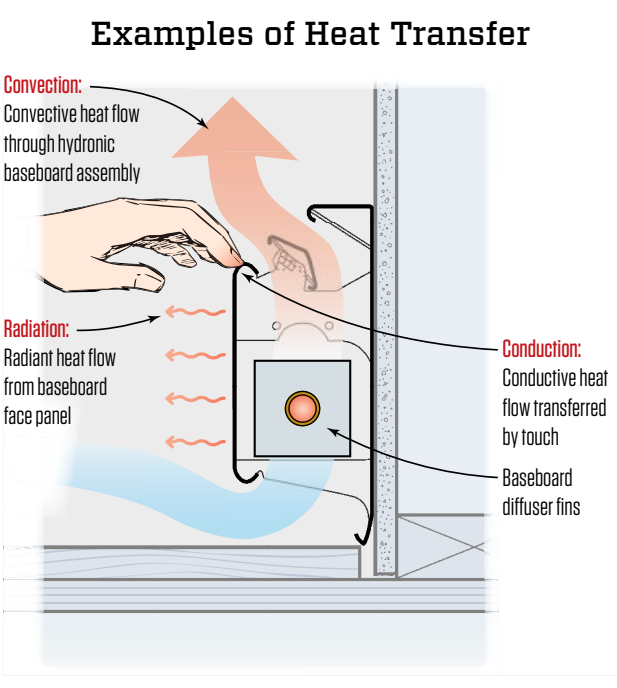
On average, more than half of the total annual energy used by households goes to space heating and air conditioning. About 27% goes to water heating, lighting, and refrigeration combined and the remaining 21% to everything else—from washers and dryers to cellphone chargers, computers, and all the other devices we use in a home.

The amount of energy that's consumed for heating and cooling homes varies significantly by geographic location, house size, construction type, and the equipment and fuels used. But the majority percentage of household energy that is used on heating and cooling speaks loud and clear to the importance of understanding how heat moves through buildings. The mechanisms of heat flow not only influence the heating and cooling systems we install but also inform how we build the "thermal separation" between indoors and outdoors.

ESSENTIAL CONCEPTS

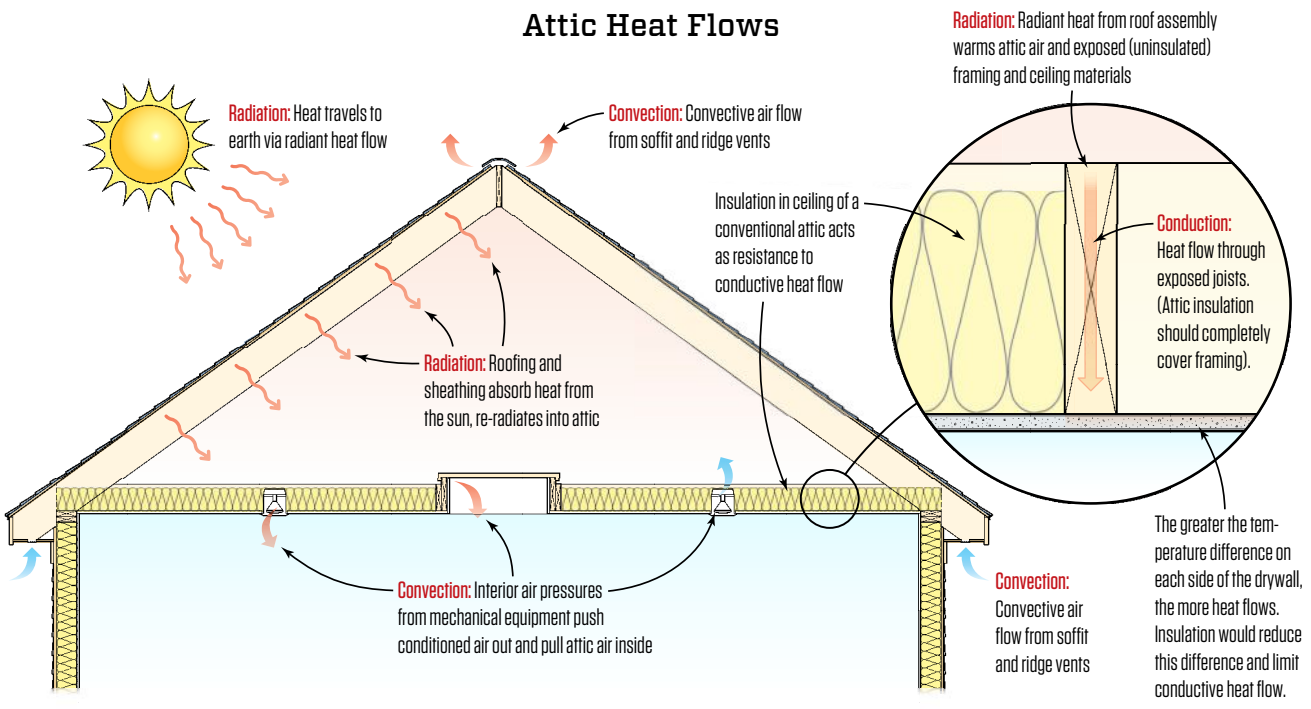
Regardless of the climate or the home, heat always behaves in predictable ways, and these are useful for understanding how heat moves through structures. When evaluating the energy efficiency of any structure, keep the following essential concepts in mind:

- Heat always moves from warmer areas to colder areas. In winter, we heat the interior of a home, so the direction of heat flow is from inside to outside. In summer when it's hotter outdoors, the direction is reversed.
- The greater the temperature difference, the faster heat



Heat flows from warm to cold. In a framed wall assembly, cavity insulation limits conductive heat flow, but the studs themselves can also transfer heat through the assembly unless continuous insulation, such as rigid foam, is installed (above left). A fin-tube radiator (above right) transfers little heat by radiation. It mostly moves heat by convection (air flowing through the diffuser fins) and by conduction (heat moving across the pipe wall and into the aluminum fins).

Photo by Ted Cushman; illustrations by Tim Healey



All three heat transfer methods are illustrated in this attic section. Roofing materials absorb radiant energy from the sun. As those materials heat up, they re-radiate heat into the attic, warming the attic air and exposed framing. Insulation limits heat flow by conduction across the ceiling; the more insulation, the more resistance to conductive heat flow. Convection helps cool the attic by moving air through soffit and ridge vents, while interior air pressures move air through holes in the ceiling.

flows. If it's 70°F inside and 75°F outside, there's not much energy moving through the enclosure, and the difference is not very noticeable. But, if it's 70°F inside and 0°F outside, there is a lot of heat flow, and the difference is immediately noticeable. (Note: Heat flow has a big impact on comfort; that is, how we feel about the heat or the lack of it.)

- Air contains moisture vapor. The warmer the air is, the more moisture it can hold. If the air cools sufficiently to cause the moisture in the air to condense on a surface in the home, it can have a huge impact on building durability. (The mechanics of moisture flow is a whole series of lessons in itself. Stay tuned.)

HEAT VS. TEMPERATURE

Heat is not the same as temperature. Heat is kinetic energy; temperature is a measurement of how intense that kinetic energy is. To illustrate this, think of two containers of water—one containing 10 gallons and one containing 1 gallon. The water in both containers is 50°F. Although they are the same temperature, the larger container holds 10 times more heat than the smaller one. The larger container has more thermal mass and therefore has more heat capacity.

HEAT TRANSFER

Heat moves through building assemblies primarily in three ways: by conduction, by convection, and by radiation.

Conduction is the movement of heat energy directly through solid materials from molecule to molecule. The movement of the material plays no role in the transfer of heat.

Building materials conduct energy at different rates. Metals, such as copper and steel, for example, have high conductivity, meaning heat energy moves through them at a very efficient rate. Fiberglass batts and rigid foam, on the other hand, have low conductivity. Materials that are poor conductors serve as insulators when they are placed between more-conductive materials in an assembly such as a wall or a roof. The flow of heat through an assembly of materials is slowed down appreciably by insulating materials. Wood is somewhere in the middle for conductivity. It's not a good insulator unless it is shredded and has lots of air pockets between the wood fibers. (The secret behind most insulation is air

TABLE R402.1.2
WALL INSULATION REQUIREMENTS

CLIMATE ZONE	WOOD FRAME WALL R-VALUE
1	13
2	13
3	20 or 13+5
4 except Marine	20 or 13+5
5 and Marine 4	20 or 13+5
6	20+5 or 13+5
7 and 8	20+5 or 13+5

In this selection from the energy code, we can think of different climate zones as representing varying temperature differences. In colder climates (zones 4 and above), the temperature differences in winter between indoors and outdoors are greater, so conductive heat flows at a greater rate through building assemblies. To limit this heat flow, more insulation is needed. Note that the "+5" R-values indicate continuous insulation that insulates against heat flowing across wall studs, while the other numbers indicate cavity-insulation R-values.

pockets that disrupt the conductive heat flow through a material.)

The rate of conductive heat flow is measured as U-value, and resistance to heat flow is measured by its reciprocal, R-value.

U-value = rate of heat transfer

R-value = resistance to heat transfer

The lower a given material's U-value, the less conductive it is. The higher the U-value of a material, the more conductive it is.

Convection is the flow of heat within a fluid, with warmer fluids rising and colder fluids falling. In homes, this fluid is air; in the ocean or a boiler, it's water.

In air, convection is often called the "stack effect." As air warms, the molecules move farther apart, and the air becomes more buoyant, floating upwards. As that air rises, cold air is pulled from below to replace it (for more, see "Air Barrier Basics," Jan/19). In a boiler or heat pump, warmed water circulates in a similar way, and piping systems can be designed to use this "thermosiphon" to circulate water.

When we account for convective air flows in buildings, we look at the following variables:

- Difference in temperature (ΔT): As with all methods of heat transfer, a difference in temperature from one area to the other is a necessary condition for heat to flow.
- Time (t): Length of time the air movement occurs.
- Volume of air (V): The volume of air within a home can be measured by multiplying the length, width, and height of interior space. The volume of air in a home remains constant, although the air itself changes.
- Air changes per hour (AC/hr): The rate of air movement is measured as air changes. The "change" is the movement into and out of a defined space, such as the volume of air in a room (the amount used to balance air flow in an HVAC system), or in a whole house (the amount used to measure house leakage).

Radiation is the movement of heat through space (not air) as electromagnetic waves. The sun's energy reaches earth by radiation. Radiation is not affected by the air. The sun and a campfire both emit radiant heat, even when the wind is blowing. Radiant heat moves at the speed of light without heating the space between the radiant source (often called a "radiant body," be it the sun, or a heated slab, or a thick mass of asphaltic roofing and wood sheathing) and the surface of another object.

To be warmed by a radiant heat source, the surface needs to be in the line of sight of the heat source. This is why shading works. We can put an overhang or an awning between the sun and a window to reduce radiant heat flow. In that case, the sun warms the overhang or the awning when the energy is absorbed into those materials.

Instead of being absorbed into the materials, radiant heat can also reflect off white or shiny surfaces. During the summer, heat absorbed through roofs and through windows are the two main sources of heat gain in homes. To control this heat gain, many windows include a very thin metal coating on one surface to reflect radiant heat. And on roofs, we can use light-colored roofing to reflect heat, or we can install a radiant barrier—a layer of foil on the sheathing facing into the attic.

Radiant energy is a principal heat source in hydronic heating systems. Both hot-water and steam systems depend on "heat emitters." Though more commonly known as radiators, most do not transfer heat by radiation alone. The majority of heat produced by a finned-tube baseboard is convective heat flow: Cooler air enters the bottom of the baseboard enclosure and is warmed as the air moves through the fins, and then warmer air rises out the top. By contrast, most of the heat produced by radiant floors and the heavy cast-iron Euro-style radiant baseboard is radiant heat, though some convection currents are also created as the air around them is heated and rises.

Clayton DeKorne is chief editor of JLC.

For a more detailed discussion of these building-science principles, go to **jlconline.com/training-the-trades/heat-transfer-through-buildings**.

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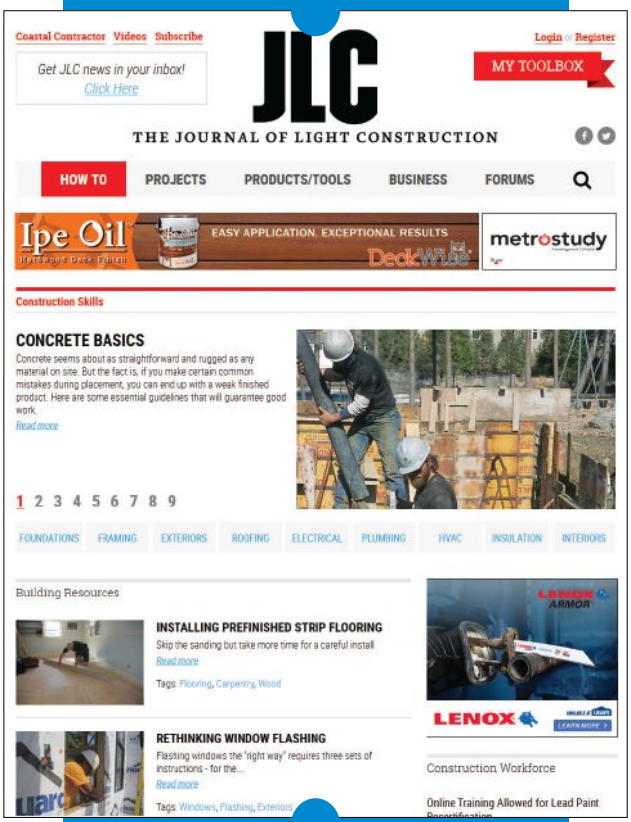

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Q I need to insulate the cathedral ceiling of a large building, which is located in western Virginia (climate zone 4) with hot summers and cold and snowy winters. The insulation contractor recommends insulating the rafters with a 1-inch layer of closed-cell foam, followed by fiberglass batts. Is this "flash and batt" system a good choice in my climate? Do I need to worry about condensation?

A Peter Yost, vice president of building performance for BuildingGreen in Brattleboro, Vt., responds: Flash-and-batt systems are hybrids that use more than one type of insulation—an air-impermeable outer layer and then an inner layer. But before discussing the flash-and-batt system, we first need to understand that in any building that is being heated or cooled, warmer, more-moisture-laden air can result in condensation if that air hits a surface with a temperature that is at or below dew point. When this happens inside a building assembly, we call that surface the first condensing surface.

If you are cooling a house in the summer, the warmer, more-moisture-laden air is outside and the colder, dryer air is inside. If that outside air leaks into the house, the first condensing surface that the air hits is typically the reverse side of the gypsum wallboard. If you are heating a house in the winter, the warmer, more moist air is inside, and the colder, dryer air is outside. So if inside air leaks out of the house, the first condensing surface that the air hits is usually the interior-facing side of your structural sheathing. The longer you need to cool or heat your home, and the hotter or colder the climate is outside, and the more moist or dry the air is either inside or outside a home, the greater the chance is for condensation to occur.

There are many ways to prevent condensation from occurring inside building assemblies (called "interstitial condensation"). The first way is air-sealing. Much more moisture as vapor moves through walls by air leakage than by diffusion. If you don't air-seal to control interstitial condensation, don't even bother trying to manage condensation with the other ways listed below.

The next way is warming the first condensing surface so it is less likely to be at or below dew point temperature. You can also try to manage inside moisture

MINIMUM AIR-IMPERMEABLE SPF INSULATION FOR HYBRID INSULATION SYSTEMS USED IN UNVENTED ATTICS AND CATHEDRALIZED CEILINGS

(Based on 2009 IRC Section R806.4 or 2012 IRC Section R806.5)

IECC Climate Zone	Minimum R-Value from SPF	Total Insulation R-Value / SPF R-Value % Ratio (2009 IRC)	Total Insulation R-Value* / SPF R-Value % Ratio (2012 IRC)
4C (Marine)	R-10	R38 / 26%	R49 / 20%
4A, 4B	R-15	R38 / 39%	R49 / 31%
5	R-20	R38 / 53%	R49 / 41%
6	R-25	R49 / 51%	R49 / 51%
7	R-30	R49 / 61%	R49 / 61%

*When more total R-Value than required in the 2009 or 2012 IECC is utilized, a higher R-Value for the SPF is required than that listed in Table 2. Use the minimum percentage as indicated to the right to determine the SPF R-Value.

To control condensation in hybrid roof assemblies, the code sets minimum R-values for the air-impermeable layer (column 2) and its percentage of the total R-value of the system (columns 3 and 4). R-value requirements have not increased since the 2012 code. While this table addresses the R-value of SPF, the R-value percentages also work for rigid-foam insulation installed above the roof sheathing.

when you are heating (you can't really do the reverse when you are cooling). Finally, you can retard the moisture moving by vapor diffusion into the assembly.

So what does any of this have to do with flash-and-batt insulating systems? We know that vapor moves readily through air-permeable insulations such as fiberglass batts. To keep that vapor from condensing in your wall or roof assembly, a flash-and-batt system is one way to warm the first condensing surface with air-impermeable insulation. There are other ways to accomplish this: Continuous rigid insulation on the exterior of the structural sheathing warms the sheathing and, if the insulation is thick enough, can prevent condensation on the first condensing surface. A flash-and-batt system uses air-impermeable insulation, such as closed-cell spray foam in the building cavities (joist or stud bays) installed against the inside of the structural sheathing. This strategy does not make the structural sheathing warmer, but it does move the first condensing surface to the inside face of the spray foam, and if this layer of insulation is thick enough, it will prevent condensation on that new surface.

The bottom line is that the R-value of the outer air-impermeable layer of insulation needs to be great enough to keep that first condensing surface above dew point. The colder the climate, the greater the R-value needs to be in that air-impermeable layer. For determining the thickness of the air-impermeable layer in a flash-and-batt system (also called flash-and-fill), there is guidance from both the most recent energy codes as well as the Spray Polyurethane Foam Alliance (SPFA). The table on the previous page shows how much R-value the foam layer should provide to a flash-and-batt insulation system, both as a minimum R-value and as a percentage of the total.

Using that SPFA table, let's look at our example in western Virginia (climate zone 4A). Virginia has adopted IRC 2015, but with some amendments. One of those amendments keeps the climate zone 4 ceiling-insulation minimum total value at R-38, the 2009 IRC level. For the building in the question to comply with both the building code and SPFA guidance, the spray-foam "flash" layer would need to equal an R-value of 15 (column 2), which represents 39% of the 2009-required total minimum ceiling R-value of 38 (column 3). If the R-value of closed-cell spray foam is 6.5 per inch, then 2 1/3 inches of spray foam would be the minimum requirement to meet the Virginia code.

If you decided to go beyond code for total ceiling R-value, let's say to R-60, then use the ratios shown in the fourth column. (While these ratios reflect the amount of spray foam needed to control condensation in a flash-and-batt system that meets the higher 2012 insulation requirements, they are safe to use for higher-R assemblies as well). That is, the flash layer needs to be 31% of the total insulation R-value, which means R-18.6. To achieve that R-value with spray foam, the layer would need to be 2.9 inches thick.

The SPFA provides two reference documents for guidance with hybrid insulation systems, one for warm climates (zones 1–3) and one for cold climates (zones 4–7). Both of these documents can be downloaded from the SPFA website, sprayfoam.org.

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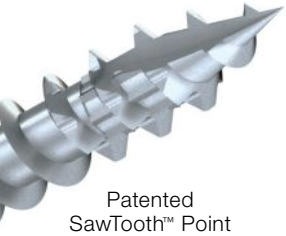

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Reinforcing A Weak Foundation

BY JAKE LEWANDOWSKI

In my article, "A Partial Foundation Retrofit" (Jun/19), I mentioned two locations that needed attention in this client's foundation. In that article, I focused on where the existing foundation had lost all structural integrity and needed to be completely replaced. Here, I address the second location, where the engineer deemed that the existing foundation—though weak—would just require reinforcing.

The solution was pouring what we call a "bench wall," which is basically a reinforced retaining wall poured against and tied into the original foundation wall. Before starting, we checked an area where the slab had broken and discovered that there was no footing under the original wall. The engineer's answer was to excavate under the original foundation in alternating 2-foot sections, supporting the old wall while allowing the new concrete footing to extend into the voids under the wall.

Once the bench wall was poured on top of the new footing, we framed a tight-fitting 2x4 wall between the floor joists and the top of the concrete. This wall helped support the exterior wall load and the floor load, and it also helped the newly poured wall resist buckling horizontally.

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

This area of the existing foundation was weak but still structurally sound **(1)**. In their investigation, the crew discovered that there was no footing under the original foundation **(2)** and turned to an engineer for a solution.

The crew cut the slab and dug a footing trench 1 foot wide and 1 foot deep **(3)**. Under the wall, they dug 2-foot-wide voids 2 feet apart that would be filled with concrete as part of the new footing. A special tool bends rebar into the needed shapes **(4)**.

Photos by Jake Lewandowski


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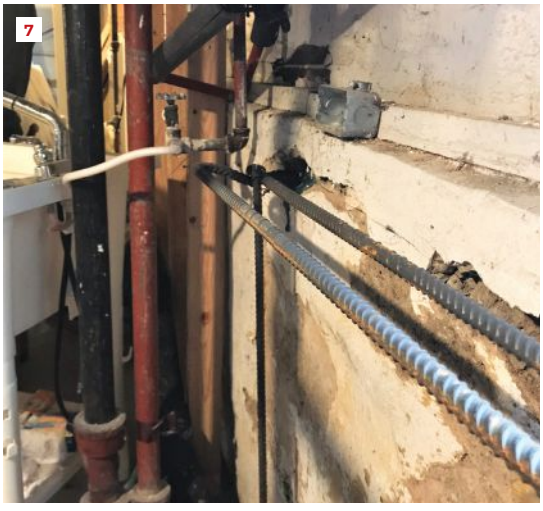
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Rebar was essential for tying the new bench wall to the existing foundation. A crew member started by drilling holes at the top of the adjacent foundation walls **(5)**, then used high-strength epoxy to attach two lengths of rebar at one end of the wall **(6)**. Short lengths of rebar drilled and epoxied into the foundation wall provide support for the rebar along its length. At the other end, the rebar was bent and epoxied into the existing wall **(7)**. The ends of the vertical and horizontal lengths were tied together for the pour. In the footing trench, lengths of rebar were set on chairs pinned to the base of the footing **(8)**. One of the 2-foot voids dug out under the existing foundation every 2 feet is visible in the foreground. The concrete for the footing extended into these holes to support the existing wall. The crew mixed and poured concrete for the footing from bags, troweling the top for a smooth surface **(9)**.


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13

A keyway cast into the footing helped to lock the bench wall in place **(10)**, while a laser line was used to guide placement of the form. After scribing the form plywood to the adjacent wall **(11)**, the crew built a frame for the form. A 2x4 anchored to the slab held the bottom of the form in place **(12)**. To ensure that the form didn't move or bow out during the pour, the crew attached a horizontal strongback across the middle **(13)**. Diagonal 2-bys braced back to the floor provided additional support. After placing the concrete and allowing it to set for a few days, the crew stripped the form and framed a 2x4 wall tight between the bench wall and the joists above **(14)**. In addition to the wall helping support the floor and exterior wall loads, pressure on the wall added to the lateral stability of the bench wall.


14

Restoring a Gothic Porch

BY MARC BRAHANEY

I own and operate Lasley Brahaney Architecture and Construction. We specialize in custom design-build residential projects in and around Princeton, N.J. In late 2017, I began work on a major addition and exterior restoration project on my own home, a Gothic Revival built in the 1870s. The house definitely has a bit of character to it and is recognized as a landmark property in the Township where I live. Part of the project's scope was to restore the home's front entry porch to its original design (the previous owners had removed roughly half the porch because it had deteriorated, reducing it from two bays wide down to one).

Factory-milled Boral. From the outset, I knew replicating the porch's original moldings and trim would be a challenge; some of the Gothic-inspired shapes I needed were fairly large and chunky. Reproducing them from rot-resistant wood (plastic products were not an option) would be difficult and expensive, so I reached out to Keith Coleman of Duration Moulding & Millwork (durationmillwork.com). Duration specializes in milling exterior trim and siding from Boral stock (a poly-ash material resistant to both moisture and termites). In addition to milling common trim and siding profiles, Duration can fabricate large custom shapes out of laminated pieces of Boral stock at its facility in nearby Hamilton, N.J. After speaking with Keith, I concluded that milled Boral would be the best product to use, both for durability and to match the home's unique trim work.

Shop drawings. During demolition, our crew discovered vestiges of the porch's original dimensions and layout. I was able to design the new porch from these leftover signs, returning it to its original two-bay width and making it a little deeper (measured out from the house) to give it a more generous feel. I sent Duration

Photos by Lasley Brahaney Architecture + Construction

The author rebuilt the Gothic-style porch as part of a major addition and exterior restoration project **(1)**. A new factory-milled pilaster was installed a couple of feet beyond the previous pilaster location (due to the widening of the porch) **(2)**. The pilasters, columns, crown molding, trim stock, and brackets were all made from Boral (supplied by Duration) **(3)**. The only non-Boral material used was the beadboard ceiling.

detailed design drawings along with one of the salvaged posts to use as a template to help make the new columns and pilasters. Within a few days, the company provided shop drawings of the new replacement pieces, which I reviewed and approved.

In the interim, we conventionally framed the porch deck and installed 5/4x4 T&G Douglas fir decking, which we painted later. The roof, which would be covered with new flat-seam copper, was framed to provide sloped contours pitched towards two downspouts at the roof's edge (a raised curb maintained a level height around the roof's perimeter). We temporarily braced and supported the roof and waited for our new moldings and trim to arrive on site.

Rot-resistant components. The columns furnished by Duration were comprised of a center pressure-treated post wrapped with Boral trim. At the factory, they were made in components: the trimmed-out portions (these came with three sides assembled and a separate fourth side); the column plinths (which wrapped the finished Boral columns at the base); and the PT posts. On site, our carpenters easily installed the posts and Boral pieces, securing them with Loctite PL Premium adhesive and stainless steel trim screws (countersinking them and applying an approved filler). Sealant was applied at all joints between components. The pilasters were installed similarly, though the Boral trim wrapped 2-by PT stock.

With the columns and pilasters in place, our crew trimmed out the beams and fascia with the milled Boral, securing it similarly to the columns. Then they installed the decorative brackets with larger screws.

As far as finishes, the only non-Boral materials used were the beadboard ceiling and fir decking. Looking at value engineering over the long haul, I believe the milled Boral was the most economical choice. I'm counting on it to hold up better than wood under the intense weather and sun exposure the porch will experience.

Marc Brahaney is a licensed architect and president of Lasley Brahaney Architecture + Construction in Princeton, N.J.

At the fascia, Boral crown molding and dentil trim from Duration covered a raised perimeter curb needed for roof drainage **(4)**. Elsewhere on the home, new window sills and highly decorative trim for box gutters were also made from milled Boral. Finishing up, the porch trim is to be painted white, nicely offsetting the home's light yellow stucco cladding and the dark green (almost black) shutters **(5)**.


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EDITED BY CLAYTON DEKORNE

Three Perspectives on Getting Change Orders Right

Adobe Stock/jumlongch

Change orders are one of the business processes that many builders and remodelers feel most uncertain about. Part of the reason might be that we want to do right by the client and have already started to have a good working relationship with them, so we may be reluctant to rock that boat. So many clients these days are poised to be critical of contractors, having heard from friends or family members that contractors are notorious for low-balling the price and then ratcheting up the cost through changes. Does that matter? It might to the contractor-client relationship, but it probably doesn't matter from a business perspective. A change is a change, and if that change originated with the client, you deserve to be paid for it.

Here are three perspectives from leading building-business advisors Leslie Shiner and Melanie Hodgdon, Tim Faller, and Judith Miller that might help you think a little differently about change orders and help you create a straightforward system that can be integrated easily into your existing business systems.

Create an easy-to-use additional work authorization (AWA) form that your crew can use in the field. It doesn't need to be a complicated form. It should include the date and name of the job, a description of the situation and possible solution, and a place for employee and client signatures.

FORM IS FUNCTION

Leslie Shiner, owner of The Shiner Group, and Melanie Hodgdon, president of Business Systems Management, are co-authors of A Simple Guide to Turning a Profit as a Contractor *and provide management consulting for contractors. They emphasize the importance of having a change-order form that gets things down in writing and moves the relevant details along to the correct party.*

A poor change-order process is one of the biggest sources of lost profits for contractors, and it can also be a source of misunderstanding and resentment on the part of customers.

To clients, moving a window 3 inches to the left or choosing a different tile color after the tile has been ordered doesn't seem like a big deal. But these kinds of changes can wreak havoc on your job schedule and can cost significant time.

Have a change-order policy clearly written in the contract and go over that section orally with your customers before they sign. Include in your sales documentation a sample change-order form. Preparing clients for the possibility (and probability) of change orders goes a long way toward getting approval for increases in the contract price as well as maintaining client satisfaction.

Watch the field employee-customer relationship. Perhaps the crew does small favors without proper authorization or notification. These favors may not produce additional materials costs, but they can easily put you over your budgeted hours. Make it clear to the crew that they work for the company not for the customer. Provide production workers with the scope of work and an hours budget so they can distinguish between tasks that are and aren't included in the contract price.

Create an easy-to-use additional work authorization (AWA) form that your crew can use in the field. It doesn't need to be a complicated form. It should include the date and name of the job, information

such as a description of the situation and possible solution, and a place for employee and client signatures.

The form need not include pricing; that can be done in the office. Make copies for client, field, and office. Be sure to include a sentence that says something like "An additional work authorization can and usually does increase the time and cost for the contract."

A scripted conversation during the initial client meeting about change-order management includes a discussion of the three types of change orders—client modifications to the original scope of work, required code upgrades, and unforeseen circumstances—plus projections (based on historical data) of how change orders might affect the final cost.

CHANGE-ORDER KING

Judith Miller, a Seattle-based construction business consultant and trainer, and a facilitator for Remodelers Advantage, shares a system used successfully by one of her clients.

I often run into questions about change orders with the clients I advise. They don't have a change-order process and that sparks scenarios that stress the client-contractor relationship. It usually begins with a client phone call that goes something like this: "You're nearly 30% over our original budget. What are you going to do about it?"

In some companies, a call like that would set off a string of events, beginning with the client refusing to pay future invoices and possibly leading to the ultimate calamity, a lawsuit. Both sides lose.

What can you to avoid this? A company I recently visited with has a solution dubbed the "Change Order King." This is not a person but rather a system for managing the inevitable changes to the scope of work that each change involves. The Change Order King works every time it is fully implemented.

The system consists of the following:

- **A scripted conversation** during the initial client meeting about change-order management includes a discussion of the three types of change orders—client modifications to the original scope of work; required code upgrades; and unforeseen circumstances—as well as projections (based on historical data) of how change orders might affect the final cost.
- **A clear scope of work** is created along with a final estimate with all owner selections made (no allowances).
- **A contract** reiterates the definitions of the three types of change orders and spells out exactly how each will be handled.
- **A checklist** is used for writing up change orders, securing client signatures (written approvals are required), and accepting payment in advance.
- **Contract billings** reflect total changes to the contract by each of the three change-order types, as well as a revised contract price.

The company rarely had to fall back on this documentation, but when it did, the system came in handy.

In the case of a call similar to the one mentioned above, the company owners spent a couple of hours pulling together copies of all the signed change orders and totaling them by type, then personally presented the reconciliation to the client at the end of the same day. After reviewing the documentation and talking with the company owner about her decisions to modify the original scope, the client said, "You're right, this makes sense. Now I can see where the money has gone. Let's keep going."

This is a true story. If it's not your story, set up the Change Order King and take control of change orders. You'll be glad you did.

CHANGE ORDERS IN CONTEXT

Tim Faller, a senior consultant and the "Master of Production" for Remodelers Advantage, points out positive and negative aspects of a change-order system that you will want to consider when you are setting one up. In addition, he highlights the importance of putting a price on the disruption caused by change orders.

Adobe Stock/ungvar

Dealing with change orders requires putting a system in place that will prevent you from losing money on additional work. It may help to push some of the responsibility to the field manager by asking him to estimate the additional work and present the change order to the client. Here are some pros and cons to consider with this option.

Pros

The positives of implementing a formal change-order system are obvious, but have some nuance.

Capturing payment. Often the small changes on a job aren't captured because field staff complete the work without a paper trail and estimate just to keep the process flowing. If you encourage your field manager to stop for an hour to write up a change and have the client sign it, you're more likely to get paid for both small and large changes.

Smoother work flow. At any given time, office personnel are working to get more jobs into production. Rather than have them stop and focus on an existing job, the production team can complete the changes. This prevents a log jam in the flow and the production manager or salesperson can concentrate on new sales.

Accuracy. On-site field managers and lead carpenters are more familiar with the full circumstances of the change order and all the phases of the project the change will affect. Ultimately, they are the right people to set it in action, but, as noted below, it may take some training before they are the right ones to price it.

Cons

Setting up a change-order system does have some negative aspects that you should keep in mind.

Sales slack. If the sales and design teams know that the field will handle change orders, they may slack off on preparing a job for production. A "complete package" still needs to be delivered to production.

Increased paperwork. Most lead carpenters are more interested in the work and don't always appreciate more paperwork. It could take their time and attention away from the main job.

Inaccuracy. Despite "accuracy" listed in the pros column, the flip side is that if not trained properly, lead carpenters might be too optimistic for the estimated time it will take for them to complete the change.

An important part of any system you put in place is making sure your team understands it and has the guidance they need for setting prices or for asking for help. If they don't have the expertise, don't give them the reins for the full change-order document. Just have them to fill out an AWA form like the one Leslie and Melanie mention above, and put the price-setting part on the staff—but share those prices with the lead carpenter so he or she begins to develop the understanding to set prices on changes in the future.

Disruption Days

Putting control in the hands of the field manager provides a path to a basic system. But often the problem is convincing yourself it's worth doing. Consider this: The impact of not implementing a change-order system goes beyond just the money lost on what it takes to add the change to the existing scope of work. What's often missing in the calculation of the total loss is the cost of what I call "Disruption Days." These are the days not associated with any labor costs but that hit the job because of disruption created by the change order. This is especially critical in the current moment—everyone is busy and we can't just reschedule trades or material deliveries for the lost time of the labor. The job could slow down by a week or more for one day of changes.

Try thinking in terms of overhead per day, per job. If overhead in a company is $500,000 in real dollars for the year with four jobs going at a time, then overhead per day per job is $500.

That means for every day of a job, you're spending $500 of overhead. When you calculate a change-order price, the days included in the labor numbers have an overhead amount attached to them automatically, but the Disruption Days do not.

To add insult to injury, by extending the job extra days not associated with labor costs and revenue, you end up pushing the start of other projects out and losing the "opportunity profit" of another job. So some consideration must be given to adding this extra overhead into the sale price of a change order.

What's often missing in the calculation is the cost of what I call "Disruption Days." These are the days not associated with any labor costs, but which hit the job because of the disruption created by the change order.

As an example, let's use that same company. It projects $2 million in revenue for the year, making the overhead 25% of revenue. Assume there are 250 working days in the year, which means the company needs to produce $8,000 per day to hit the revenue target. If a few jobs extend past the completion dates, and the company does not compensate for the extension by marking up labor, the company won't be able to produce the desired $2 million. Assume this happens to the tune of 30 days'—or $240,000 (8,000 x 30)—worth of work that can't be produced. That leaves the company at $1,760,000 for the year, short of its goal. The 28.4% overhead is robbing net profit of roughly 3.4%.

Some of you are thinking, "I can't just add $500-per-day extra to every change order!" You're probably right. But the costs are real. So to avoid losing money, calculate overhead per day per job. Write down on each change order the number of Disruption Days. See if you can add that money back in. If you can't add it all in, add something for those lost days. And if nothing else, you'll be aware of what each change really costs you.

BY TED CUSHMAN

'Embodied Carbon'—What's Up With That?

Different people have different motivations for caring about the energy performance of buildings. For some, it's a matter of economizing: What's the most cost-effective way to create a home that will be cheap to operate? But others in the building and remodeling community have a planet-saving agenda: They're interested in doing whatever they can to reduce, prevent, or perhaps even reverse the pollution of the atmosphere by gases that induce global warming and threaten catastrophic changes in the earth's ecosystem.

If you're in the second group, you'll be interested in a movement that is rapidly gaining ground among some in the industry: the movement toward considering not just the carbon or other global warming gases that a building will emit in its useful lifetime, but also the carbon that is emitted in the construction of that building—what's known as "embodied carbon." It turns out that in the short run—that is, in the next few decades—the CO_2 and other global warming gases that are released into the atmosphere in the extraction and manufacture of the materials that go into a typical house dwarf that house's carbon footprint in operation.

But when it comes to embodied carbon, all houses are not the same. It's possible to build a house in a way that minimizes the carbon released in the process. More than that: It's possible to build a house in a way that actually removes carbon from the atmosphere and stores it, long-term, in the components of the structure itself. Houses, to put it in simple terms, can fight global warming—not just in their operation, but also in their creation. By using appropriate materials and methods, homebuilders can participate, right now, in what's being called "carbon drawdown." Homes can be "carbon sinks."

That's important because climate change is not just a long-term threat. It's a crisis that will have major impacts in our own lifetime and will become even more severe in our children's lifetimes. If your house has low emissions in a hundred years, but releases high emissions while you're building it this year, the bad part comes now, and the good part comes too late to help. So if you want to take action to confront climate change, you have to take action that's effective in the short term—ideally, action that's effective right away.

At $303 per square foot, this 1,650-square-foot Middlesex, Vt., off-grid, foam-free house sequesters 600 kilograms of CO_2.

That was the message heard by builders who attended the keynote session at the New England Sustainable Energy Association's recent Building Energy conference in Boston, Mass. Jacob Racusin and Ace McArleton, of New Frameworks (Burlington, Vt.), and Chris Magwood, of the Endeavour Centre (Peterborough, Ont.), took a comprehensive look at the issues involved. They started with the goal to "drastically reduce our building carbon emissions within a decade."

If you want to build a house that's a carbon sink, you want to stay away from materials with a high "global warming potential" and focus on materials that are effective carbon sinks. That means minimizing things like concrete and plastic foam and focusing on things like wood, cellulose insulation, and other materials that are derived from plants.

Of course, nothing is ever that simple. Analyzing the global warming impact of

Photos courtesy New Frameworks, Endeavour Centre

a construction material's production is complicated and subtle. It can be hard to get good information on materials such as lumber or stone to determine whether they're being produced in a way that adds a lot of carbon to the atmosphere, or not. Even a seemingly green material like straw bales might come from a local organic co-op, or might be transported long distances from an industrial farm.

One way to research materials is to look for an Environmental Product Declaration, or "EPD." "A company will hire a third party to do an EPD," explained Chris Magwood, "and they review all the energy and material inputs and outputs of somebody's entire process and come up with a bunch of figures. The one that we're looking at for this study is the Global Warming Potential (GWP)."

Using EPDs and similar sources to categorize materials, Magwood and Racusin modeled two simple buildings—a single-family dwelling and an eight-unit multifamily building—to analyze how using different materials would affect the structure's greenhouse-gas profile. They found a drastic difference between buildings that used the most carbon-intensive materials and the versions that used materials with lower global warming potential. Just by selecting off-the-shelf materials with low carbon footprints that are available at any home center, they found, it was possible to sharply reduce the building's global warming impact.

Built by Chris Magwood's Endeavour Centre in Clarksburg, Ont., this 1,100-square-foot zero-energy house cost $254 per square foot and stores 24 tons of CO_2.

Said Chris Magwood in an email to *JLC*: "It's a pretty typical set of materials, with cellulose wall and roof insulation and wood fiberboard exterior continuous insulation being the two key carbon-storing substitutions. I've also included some wood flooring and some wood interior walls and exterior cladding."

By selecting less readily available materials that are the most effective carbon sinks (such as straw insulation), it was even possible to construct the building so that it decreased atmospheric carbon just by being built. Scaled up across the entire building industry, the numbers pencil out to mean that in theory, by holding themselves to the smallest carbon footprint possible, builders could remove as much carbon from the atmosphere as is produced by dozens of coal-burning power plants.

The researchers modeled two versions of each building: one that complied with current energy code, and a second, "high performance" version designed to use less energy in operation. When you combine an analysis of the carbon impact of constructing the building with the carbon impact of operating the building for 30 years, the results are striking: The code-compliant building built with carbon-intensive materials added tons of greenhouse gases to the atmosphere by 2051, whereas the advanced building constructed with carbon-sink materials reduced atmospheric carbon over 30 years. Said McArleton, "This is a really important thing for all of us to note: that instead of getting to do less harm, we get to consider that we could do really, really good."

The flip side is also interesting. Over a 30-year period, the numbers show, a high-performance building constructed with materials that have a high carbon footprint releases more emissions than a basic code-compliant building built with less carbon-intensive materials. "This is a big deal," said Racusin. "We cannot just chase energy reduction and expect that we are doing good by the climate." And Racusin noted, "It is also possible to build a net-zero embodied-carbon building using off-the-shelf code-compliant materials. That was encouraging for us. Using actual wood. Using cellulose insulation. Using fiberboard products. We can all access those materials and you can build a net-zero embodied-carbon building tomorrow using those materials."

Ted Cushman is a senior editor at JLC.

JLC INTEL

GRANULAR VS. SMOOTH: WHY THE ROOFING UNDERLAYMENT YOU PICK MATTERS

There are many self-adhered underlayment product choices available to contractors. While self-adhered roofing underlayments are designed to prevent water from leaking through the roof, not all are created equal.

There are significant differences in performance depending on how the product is constructed. An important consideration that contractors should keep in mind when selecting a self-adhered roofing underlayment is whether to choose a product that is granular or smooth.

GRANULAR UNDERLAYMENTS

Granular self-adhered underlayments have a sand-like surface. They are heavy, with a thickness ranging from 40–60 mils. This type of underlayment has grown in popularity, as it is perceived that they are slip resistant. They are generally sold at a lower price.

Many contractors and roofers are comfortable with the granular underlayment, because they work with asphalt shingles all the time. They like the thickness, believing that it makes it easier to install, and that "thicker is always better."

SMOOTH UNDERLAYMENTS

Smooth self-adhered underlayments are also often referred to as film surface underlayments. Their smooth surface provides benefits when it comes to waterproofing a roof. They seal aggressively to roof decks and seal around roof fasteners to prevent leaks and create a watertight bond.

Smooth surface underlayments have multiple levels of performance to choose from. For example, some fully-adhered roofing underlayments have a thick layer of aggressive adhesive, offering the ultimate level of protection. Fully-adhered membranes are designed to perform in severe alpine and coastal environments. Other smooth surface roofing underlayments have a thinner, less aggressive adhesive layer. Smooth surface underlayment products from GCP Applied Technologies, such as Ice & Water Shield and Select are good examples of both styles. They deliver the protection, economy and ease of installation typical of granular membranes, with these advantages:

- Lighter weight for easier installation
- Watertight laps can be easily formed due to the smooth film surface
- No granules that can become loose
- No oil tracking on the roof covering on a hot day.

Roofing underlayments aren't created equal. Ask yourself the following questions as you consider your underlayment options:

- What level of protection does the job require?
- What surface is ideal for application and securing overlaps?
- What is safest for my crew?
- What would the homeowners prefer for re-roofing in the future?

Cheaper isn't better if it costs you your reputation and fails to deliver homeowner performance.

To learn more about roofing underlayment, visit:
www.gcpat.com

Photos courtesy of Matt Risinger and Air Rite By Design

State of the Art HVAC

There's more to HVAC than heating and cooling

BY KRISTOF IRWIN

Americans live most of their lives immersed in a fishbowl of air of their own making. The qualities of this air are readily controllable and impact health, comfort, and well-being. Alas, being invisible, air gets less attention than the building enclosure; but it's no less important to understand or to do well.

I'm the principal of Positive Energy, a full-service building-science consulting firm based in Austin, Texas. Among the services we provide to architects and builders are heating and cooling system design, building pressure testing, duct pressure testing, system commissioning, and duct-flow balancing and verification.

We serve a high-end custom-home market where clients are willing and able to spend the money to get an HVAC system whose quality matches the quality of the rest of the building. In an industry where the lowest common denominator often controls, we are focused on providing top-quality solutions for our clients. In this story, I'll talk about the principles and practices that guide our designs for state-of-the-art HVAC systems.

HEATING AND COOLING EQUIPMENT

These days, we prefer to specify VRF equipment, which represents the future of the HVAC industry. VRF stands for "variable refrigerant flow," and modern VRF equipment offers advantages in at least three areas: efficiency, occupant comfort, and zoning capability.

In the old days, air-conditioner or heat-pump compressors had two modes of delivering power: either full on or off. More recently, dual-stage and unloading compressors have come into the market

Gilbert Rosipal of Air Rite By Design of Austin, Texas, wires up a Mitsubishi variable refrigerant flow (VRF) outdoor unit. Controls in the compressor allow the system to ramp its power up and down gradually, dialing back to as low as 15% of full capacity when appropriate to address "part-load" conditions.

that add a second option at either 50% or 65% of full capacity. VRF is a generation ahead of that dual-stage equipment. What VRF supplies is the ability to continuously vary the capacity of the machine. The goal is to vary the rate of heating or cooling to match the rate of heat leaking out or in through the building enclosure.

I use a car analogy to explain the difference. Suppose you hop into your truck to go somewhere, and the rules are, you have to floor the accelerator all the time, and you control the speed of the truck by turning the ignition key on and off. That's standard single-stage equipment. With VRF, you now have a gas pedal: You can smoothly vary the power output of the engine depending on how fast you need the vehicle to go. A 4-ton VRF compressor like the Mitsubishi City Multi can smoothly vary its power from 48,000 Btu/hour all the way down to 15% of that, or anywhere in between.

That capability in the VRF equipment allows it to efficiently manage what we call "part-load" conditions, when standard equipment suffers from the problem of over-sizing. ACCA Manual J is the industry standard manual for sizing HVAC equipment. Manual J is often referred to as a load calculation. A word is missing there, however: It's actually a *peak*-load calculation. The Manual J load is representative of the peak heating and cooling loads you're going to see in your climate zone for 1% of the hours throughout the year. Designers size their equipment to handle the peak load, but the vast majority of the time, your building will not see loads that high. It will see loads at part-load conditions, when one-stage equipment runs in a less efficient stop-and-start mode that causes more wear and tear on components. VRF equipment, with its ability to match power to the load, is able to meet part-load conditions more efficiently.

Another reason a VRF heat-pump compressor is more efficient than a standard compressor is in the design of the compressor motor. The electronically commutated (ECM) motors in these units are driven by an inverter, which has the capability of adjusting not just the frequency of the current being delivered to that motor, but also the voltage. By playing with those two parameters in concert, the motor achieves the highest power factor possible at any given speed and any given load that the motor is under. This improves the Energy Efficiency Ratio (EER) of the equipment (which expresses how many Btu of heat are moved for every watt of energy you purchase). Simply put, you're getting more heating or cooling per watt out of the VRF equipment at any speed. We're getting more mechanical work than we were with the previous generation of equipment, for the same amount of power. So even at peak load, a 4-ton VRF system with an inverter drive runs much more efficiently than a 4-ton single-stage or dual-stage system sitting next to it.

The author examines a Mitsubishi PFFY compact air handler. This small unit is useful for handling the heating and cooling requirements of peripheral zones in a building and can be one of multiple air-handling units connected to the same outdoor VRF compressor.

You can think of this in terms of the amps required to start and run the compressor motor. A standard single-stage 4-ton unit will take about 100 amps of power to get started and then will run at about 40 amps continuously once it gets going. A 4-ton Mitsubishi City Multi will start out at about 2 amps, then it will ramp up slowly if necessary to meet the demand, up to about 24 or 26 amps. When the temperature in the space approaches the set point, the VRF unit will slowly reduce power and creep up to the set point, and, guided by its software, will then run just hard enough to maintain the temperature at exactly that set point. Traditional equipment will overshoot the set point, shut off, and then wait until the temperature rises above the set point again before it starts up again.

In practice, the lower amp draw combined with the precise control of the VRF unit adds up to a savings of 20% to 40% in energy consumption. And because with a properly functioning controller, the unit maintains a rock-steady set point, it also provides better comfort, without swings in temperature.

AIR HANDLERS AND ZONING

The outdoor compressor is linked to indoor units by refrigerant lines. Depending on the size and model, a VRF compressor can handle anywhere from several indoor units up to dozens of units (in the case of big commercial equipment running on three-phase power). The homes we're designing for typically have single-phase power, so we're restricted to the equipment that can run on single-phase. We typically call for one or more Mitsubishi City Multi S-Series compressors, rated at 3, 4, or 5 tons, each of which can serve eight independently controllable indoor units.

The indoor units could be anything from wall-mounted units or ceiling cassettes to variable-speed vertical or horizontal air handlers (commonly known as "multi-position") much like the form factor of air handlers for a traditional system. Our clientele has not embraced the visible wall-mounted units, so we typically specify one or more Mitsubishi multi-position air handlers and conventional ductwork. This form factor also leverages our ability to impact architectural decisions early in the design process.

When it comes to zoning and duct design, there have to be conversations with the owners and the architect. Many in the industry, particularly residential, have grown accustomed to a process based only on an installation and not on any planning during the design stage. Architects don't always consider the air distribution system when they're drawing house plans, but they should; that's like working a Sudoku puzzle but only looking at the columns and not the rows. Not leaving room for the "lungs of the building" is

An installer for Air Rite By Design of Austin, Texas, assembles metal ductwork on a jobsite. Positive Energy specifies metal duct for all installations because of its durability and for sanitary reasons. Once installed, the ductwork is buried inside permanent building assemblies and is difficult and expensive to access or replace, so durability is a key aspect of quality.

not really a full design. By "room," I mean two things: both room in the design process, and room within the architectural and framing designs. I want architects to be thinking about the air distribution system early enough in the process that the ductwork can be allowed for. The simple concept of an integrated process, one that aligns architectural, structural, and mechanical designs, is catching on strongly because it's simple, it's effective, and it improves outcomes.

As for zoning, that requires a conversation with the customers on how they plan to live in the space as well as an analysis of the building. We zone the building by load profile and use profile. Load profile means, for example: "This room is facing east. That room is facing west. This room's on the first floor with very little exterior load and glazing. This room's on the third floor." So those are different load profiles.

You can also zone based on use profile: "This is the bedroom; it's not occupied during the day. This is the central core. It's rarely occupied at night." Those will be different zones. "These two rooms are occupied by a teenage daughter and an 8-year-old son. They're not going to want things the same, so give each their own control."

In the case of the east and west sides of the building, we may choose to give each zone its own outdoor compressor. That way, during a season with chilly nights and warm days, if the sun starts to overheat the east side in the morning while the west side is still cool enough to need heating, we can handle both needs at once.

But most zones aren't going to have opposite needs, so multiple zones can usually be run off the same compressor using refrigerant lines and controls. In that case, we give each zone a dedicated air handler and air distribution system that serves that area. Because we can have multiple air handlers served by the same outdoor system, VRF gives us the flexibility to do that and keep the initial cost down. This also minimizes the footprint necessary for all the equipment.

Sometimes, we have a situation where the zones are too small even for the smallest air handler. In that case, we do "air-side zoning"—we zone the areas using dampers and controls in the duct system served by a single air handler. And occasionally, there's a point load, such as a laundry room or a garage, that is best handled by a wall-mounted unit.

DUCT SYSTEMS

Duct-board box plenums and flex-duct supply lines are typical in our market. We don't do things that way; we specify metal duct for all our designs. Here's our reasoning: People put a lot of effort into

An installer for Air Rite By Design tapes insulation on a duct. Even though the ducts are within the conditioned envelope, they still must be insulated. At right is a multi-position air handler for a variable refrigerant flow (VRF) system. The air handler is suspended from the roof framing with threaded rod and vibration-damping couplings.

constructing a durable, functional building enclosure. You have one chance to get it right, and then it's inconvenient to fix it forever. The ductwork is the same way: It's a durable, functional, passive assembly; you have one good chance to get it right, and then it's inconvenient to fix it forever. Air distribution systems matter for the life of the home. It only makes sense to do it right when you have the chance.

Metal duct is appropriate for that situation. Metal is a durable material. It will last the life of the home, if attached well and done well. And it's a recyclable material, so at the end of its life cycle, there is something we can do with it.

Metal has a natural galvanic action that retards the growth of mold, bacteria, viruses, and protozoa. With air quality in mind, we always aim for fiber-free air distribution systems. The nooks and crannies of duct board and the turbulence created by flex duct spiral pressure liners do not help keep distribution systems clean. ("Clean" is another way of saying free of food, or substrates on which to grow unhealthy indoor microbiomes.)

This is perhaps the key consideration: An air distribution system moves tens of thousands of pounds of air every day. It will do so with either a lot of friction, very little friction, or somewhere in between. Using low-friction metal distribution systems based on the principles of fluid mechanics is analogous to having the right amount of air in your tires. Rolling resistance resists motion. So does friction in duct systems.

FILTRATION

Why filter the air in a home? It's just dust, right? Oh, if only it were "just dust"—bits of leaves or soil, or even gross things like skin flakes. But dust is like a candy-coated M&M, and the candy coating is things like chemical pollutants and biotoxins. You breathe those things in with the dust, and if the particles are small enough, they can lodge in your lungs. The best way to keep from being exposed to those toxins is to filter the air, with at least a MERV-13 filter integrated with the air handler.

The MERV-8 filters that many installers put in are touted as being 99% effective at catching dust. But all they catch is larger dust that your bronchial cilia are capable of catching and expelling from your system. MERV-8 filters are there only to keep the air conditioner coil from fouling. They're not there to protect the health of the people in the building. ASHRAE has recommended MERV-13 as a minimum since 2015. Based on our expertise in indoor air quality, and to conform with ASHRAE standards, we specify MERV-13 filtration at a minimum; this captures most of the smaller particles that your

Under humid atmospheric conditions when temperatures are moderate, air conditioning systems by themselves can't effectively control indoor humidity. Here, an Ultra Aire dehumidifier is ducted into the air distribution system of a central heating and cooling system. The dehumidifier independently manages humidity, responding to its own controls.

bronchial tubes won't catch and clear. If the clients are sensitive, we may go up to MERV-16 or even to a whole-house HEPA filter.

FRESH AIR AND DEHUMIDIFICATION

Humidity control is important for occupant comfort and for building health. If you maintain the air relative humidity (RH) in an acceptable range of 35% to 55% (or 50% to 55% in hot, humid climates), the occupant's thermal comfort will be satisfied over an expanded range of sensible temperatures. That can make up for situations like an overheated sunroom: If I keep it dry, I am able to evaporate moisture off the occupants' skin, which is part of cooling.

Controlling moisture also helps maintain the stability of trim or of musical instruments in the house.

But most importantly, dry air is critical for the health of human occupants of the building, because humid air supports the growth of all the organisms in the "microbiome" of the home. Fungi, bacteria, and other organisms battle for supremacy in a humid environment, and they release biotoxins that cause human health problems. If we keep the air dry, we take away a major factor in that health threat.

And as the energy code evolves, it's increasing the need to independently manage humidity. Tighter building enclosures, more insulation, and better windows are reducing the sensible load in the house. That means air conditioners—which are the only dehumidification equipment in most houses—are running less often. And if the air conditioner is not running, you're not removing humidity. Meanwhile, required fresh-air ventilation is bringing moisture into the home during much of the season.

So for our clients, we always specify a dedicated dehumidifier with its own controls. Typically, that is an Ultra Aire unit, because we have a good relationship with Ultra Aire, we have the ability to access its technical teams, and we have a solid track record with its product. We pull air from the conditioned space into the dehumidifier, and send it to the supply-air distribution system. We also use a dedicated damper-controlled ventilation port on the dehumidifier unit to draw in fresh air and distribute it using the heating and cooling air distribution system. (Note that this system needs to be designed to account for the additional volume of dehumidified air.)

The dehumidifier runs in response to relative humidity in the house. It doesn't run only when the air conditioner or heat is running. But it doesn't require the air handler to be running—the fan in the dehumidifier unit is sufficient to move the dry air where it needs to go.

Kristof Irwin is the principal of Positive Energy, a building science firm based in Austin, Texas (www.positiveenergy.pro).

Air-Sealing the Garage Wall

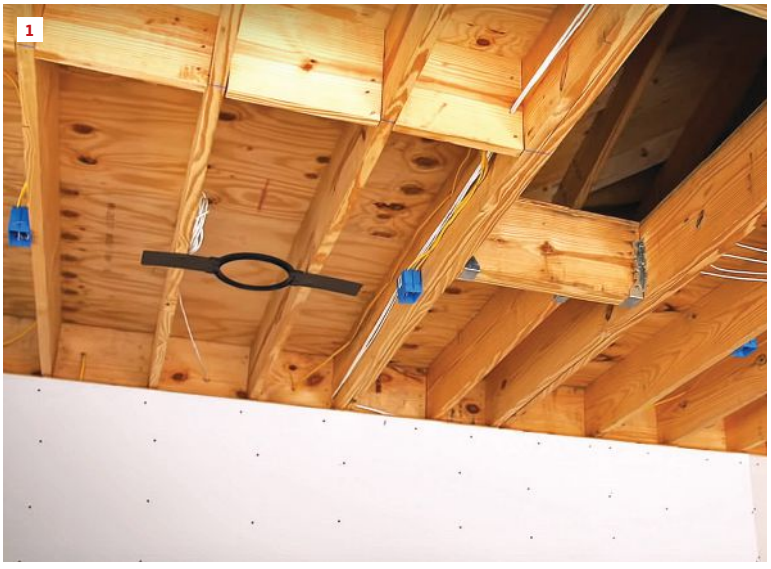
Energy is not the only reason to get this right

BY MATT RISINGER

Most attached garages are unconditioned and effectively "outside," so the wall between an attached garage and living space is part of a home's thermal enclosure. The energy performance of the homes I build is important to me, but it turns out there are other important reasons for focusing my air-sealing efforts on the garage wall. For one, it's an important fire barrier. According to the U.S. Fire Administration, around 7,000 residential fires start each year in the attached garages of one- and two-family homes, and the majority of these fires spread further and caused more damage than other residential fires, largely because of all the fuels—flammable liquids, paints, chemicals, ammunition, recyclables, and other items—stored in garages. This array of fuels also hints at the toxic cocktail of fumes from vehicles, lawn equipment, and all those chemicals that may be getting sucked into the house and creating terrible indoor air quality.

The most common and noxious of these gases is carbon monoxide (CO), which in the best of cases is released for only a moment when a car drives in or starts up. In the worst cases, however, the release of CO into the garage can be a sustained event that turns fatal. A report last year in *The New York Times*, "Deadly Convenience: Keyless Cars and Their Carbon Monoxide Toll," examined cases of car owners leaving their cars running because the drivers didn't know the cars were still running after they were parked. The CO buildup

Photos: Risinger & Co.



In a typical one-story garage attached to a two-story home, the roof ties into the second-floor walls; in this case, into the knee walls of a much larger attic area. Below the rim joist, the author's crew hangs drywall on the garage side of the wall, ahead of the drywall crew that will install drywall in the rest of the house **(1)**. This allows him to begin air-sealing penetrations, such as packing electrical boxes with a two-part, closed-cell spray foam **(2)**.

in garages leaked into the homes, tragically resulting in the deaths of occupants. For builders, all these issues—energy performance, fire safety, and indoor air quality—serve as so many wake-up calls, signaling what's at stake if we don't air-seal the garage wall.

COMPLETE SEPARATION

In the photos in this article, we show a typical one-story garage attached to a two-story house. To create a tight, thermal barrier, my crew starts by hanging drywall on this wall after framing. This happens before the drywall subs come and hang all the drywall in the rest of the house. Most of the time, our exterior wall framing is 2x6. (Yes, the garage wall is an exterior wall; it's the thermal boundary between inside and outside the home.)

Installing this drywall ahead of time allows us to take care of two critical details: penetrations and the roof bypass.

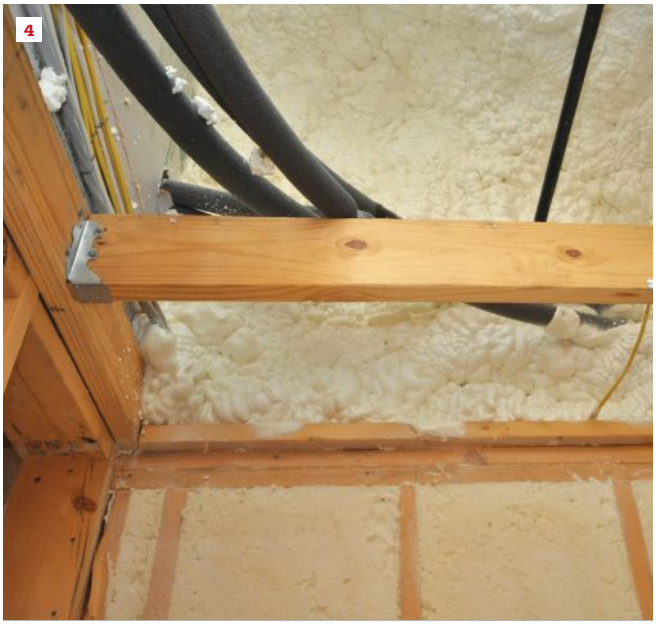
Penetrations. We install a two-part, closed-cell spray foam around any electrical boxes or other wall penetrations to create a tight air seal. In most residential garages, it is not practical to avoid outlets or lights on the garage wall; they serve a practical purpose for homeowners, and eliminating them is really not an option. But because we need to have these penetrations, we need to be certain they don't leak.

Roof bypass. This detail is perhaps more important because it represents such a big air bypass. We seal the garage wall all the way up to the roofline. This means we extend the drywall to the rim joist, and, above the ceiling line in the garage, we sheathe to the roofline with 1/2-inch plywood or another sheet good. (This is one good place for Thermoply, which I would not ordinarily use as an exterior sheathing, but in this case is used solely as a backer for the insulation; the smooth surface adheres well to tape at the seams for a good air seal.) Without this added sheathing, the wall above the ceiling is completely connected to the second story of the home. It's best to do this at the framing stage, before the mechanicals are installed. But we've also followed on the mechanical installations by sealing any wiring and other penetrations that run inside the garage wall.

On the house shown in these photos, we insulated the walls with Rockwool and with open-cell foam. While we need closed-cell foam to air-seal large and direct penetrations, we get a pretty good seal with open-cell foam in the wall cavities, as long as we apply it at least 4 inches thick. On the wall above the rim joist to the garage roofline, the insulation contractor will spray the sheathing with 6 inches of closed-cell foam so we get a good air seal and thermal barrier.

SILL SEAL

With a new home, we like to have the garage slab poured integrally with the rest of a structural slab for the house. But in existing homes we are renovating, it's not uncommon to have the garage slab butting the main house foundation, whether that foundation is a structural slab, a stem-wall foundation, or a full basement.



The garage-wall cavities are insulated with an open-cell spray foam. If installed to a depth of at least 4 inches, an open-cell foam provides a decent air seal to close off small cracks and gaps in the stud bays. Notice that the author frames with a California corner, so wall corners can be filled with insulation **(3)**. The rim-joist area and the wall above the rim joist are insulated to the roofline of the attached garage with 6 inches of closed-cell foam **(4)**. This not only insulates the wall but also seals all penetrations.

And whether there is a step up to the house from the garage slab or not, in all cases, we have a critical air seal to make between the concrete and the bottom sill of the garage wall.

For sealing the slab-to-wall transition, the easiest method is to simply lay a fat bead of caulk in the gap created by the foam sill seal between the foundation and the framing. A top choice is a single-component, nonhardening synthetic rubber, such as Tremco's Acoustical Curtainwall Sealant (what has been commonly dubbed "black death" in the field). This material stays flexible for an incredibly long time. But an exterior silicone formulation for concrete or a high-quality polyurethane sealant can also work for this application. In any case, I prefer sealants that come in sausage packs and that can be applied with a professional-grade gun. A sausage gun is so much easier to control and much less tiring to use than a skeleton gun.

If there's a step up from the garage and the concrete-to-wood connection is on the vertical plane of the wall, I prefer to use a fluid-applied sealant, such as Prosoco's R-Guard Joint & Seam Filler. Or I use Blue Barrier, which is a bit thicker than R-Guard and fills gaps up to 3/4 inch. I do this before installing the drywall, and then we run the drywall past the sill plate to cover the joint and create a gasket effect. (We use the same material on the exterior walls for sealing the concrete-to-wood connection at the sill, usually after the walls have been sheathed. In this case, we will often run a temporary line of tape on the concrete so we get a clean line with the sealant that we can cover with the siding.)

The Prosoco product line evolved from material developed in Japan for installing windshields; the material is both adhesive and waterproof, and it sticks on just about any surface. These materials are moisture-curing compounds, so they bond directly to damp or dry surfaces, even green concrete, with no primer needed, and cure under a variety of weather conditions. Low temperatures and dry conditions will slow down the drying time, while high temperatures and high humidity or wet conditions will accelerate curing. But the bond will only improve over time, which strongly appeals to me. I also like that this material bonds without primer. In most

Thermoply is not a sheathing the author ordinarily uses for structural framing, but it proves to be an excellent backer for air-sealing above the rim joist to the roofline **(5, 6)**. The reverse side of this sheathing was later insulated with 6 inches of closed-cell foam. Seal along the base of the wall between the concrete and the bottom plate with more than the standard foam sill seal. A siliconized acrylic caulk formulated for concrete **(7)** or a good-quality polyurethane sealant **(8)** works as a sealant here.

other cases, there are almost always issues with sealing to concrete. Form oils, wax, concrete additives, and especially moisture all can affect the bond, and I always feel reserved about the long-term viability of an adhesive bond. These fluid-applied options form a "rubber barrier" at the base of the wall and do an excellent job at stopping airflow.

BONUS COVERAGE

The issues surrounding air-sealing are much more involved if the house has a "bonus room" over the garage. In my market, we don't do those much, but they are popular in the production market, and they are often done very poorly. For information on this, see the article "Fixing the Bonus Room" by Matt Bowers (Mar/17), a home-performance contractor in upstate New York who has made a steady business of solving the comfort problems associated with living space over the garage. It's worth keeping in mind that while the air leakage into these above-garage rooms during a cold, New York winter can render these rooms nearly uninhabitable, the problems don't stop there. They are also potential indoor air-quality nightmares.

Matt Risinger owns Risinger & Company, a design-build firm in Austin, Texas. Follow his Build Show episodes on YouTube and on Instagram @risingerbuild.

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Custom-Built Radiused Starter Steps

Scribing and cutting to curves adds to the challenge

BY GARY STRIEGLER

Most of the homes I build have standard stairways with wooden treads that fit between two walls or that have mitered returns and a skirt board on one end. But on a recent project, the staircase in the plans was far from standard. The main stairway featured a double starter step (open-ended treads with radiused ends). Then the stairs stepped down to a lower level with a single tread that fit against the curved riser of the starter steps.

The framer did a great job building a solid support structure for the steps. He created each radius with lengths of 2-by material of various widths installed on end, and then he crafted the rough treads from 3/4-inch OSB subfloor. The resulting frame provided a good, sturdy platform for the steps as well as plenty of fastening surfaces for the curved risers.

STAIR-BLANK GLUE-UPS

In a perfect world, you could open a catalog and order starter steps that were the right length with the right overhang and that had the right inside and outside radii, but last time I checked, this carpenter's world wasn't perfect. The good news is that I enjoy the challenge of custom work like making these treads, and the eye-catching results help cement my reputation as a truly custom builder.

To make these stair treads, I needed to glue up three custom blanks. I made the two starter steps from three 4 1/2-inch-wide

Photos by Gary Striegler

For the step blanks, the author glued up oak strips, alternating the growth rings up and down between pieces **(1)**. He added a piece for the final width of the bottom step **(2)**. The upper step was not as wide **(3)**, and he planed the blank in one shot **(4)**. The last blank consisted of 3/4-inch oak strips with a 5/4-inch bullnose strip **(5)**. Finally, the blanks were rough sanded **(6)**.

rippings of 5/4 oak **(1)**. To give the tread blanks more stability, I alternated the orientation (up and down) of the growth rings of each board. After clamping the straight-section boards together at the exact finished depth that I needed, I added shorter pieces of board to the ends for crafting the radiused returns.

For wide, flat glue-ups, I have a small arsenal of Bessey pipe clamps that I like to use. These clamps have "feet" on each end that keep them from rolling over, allowing me to align multiple boards for a wide glue-up. Alternating clamps above and below the boards that I'm gluing up keeps the assembly flat while the glue is curing. These wide glue-ups require a lot of clamping pressure, and the handles on these pipe clamps make it easy to dial up the pressure for tight joints.

The next step was running the glued-up blanks through a Woodmaster planer. The final width of the lower starter step was larger than the 24-inch planer could handle, so I glued up that blank at just under 24 inches. Then after I'd planed the blank to the 1-inch thickness I needed, I added an extra piece to each side to achieve the required finished width. I attached the add-on pieces using glue and dominoes **(2)**. The blank for the upper starter didn't need to be as wide **(3)**; I was able to feed its entire width through the planer, and I didn't have to add pieces to it afterward **(4)**.

The glue-up strategy had to be a little different for the step down to the lower level. The way that step was framed, the height of the rough step dictated that I had to use 3/4-inch-thick stock

The author set the lower blank atop the upper riser to scribe the inside radius **(7)**. After cutting the inside radius with a jigsaw **(8)**, he set the blank in position on top of the lower riser and scribed that radius **(9)**. To project the scribe line to the desired overhang, he followed the line with a 2 1/4-inch block of wood **(10)** and then cut the outside radius to that line.

for the tread (probably with the idea that the finished step could be made from oak flooring). For this step, I glued together three strips of 3/4-inch-thick stock with a strip of 5/4 stock on one edge for the bullnose **(5)**, which would keep the appearance of the treads consistent.

Because of that piece of 5/4 stock, however, there was no easy way to run the blank through the thickness planer. With very little thickness to spare, I flattened the blank with a belt sander. To flatten out a glued-up surface with a belt sander, I first sand 90 degrees to the glue joints until the surface is flat. Then I sand with the joints to remove cross-grain marks. I've found that when I start out sanding with the grain (parallel to the glue joints), it's far too easy to end up with grooves or ruts in the surface. Once I had the last blank belt-sanded flat, I went over all three of the stair blanks with a random orbital sander **(6)**, and they were ready to take to the jobsite.

DOUBLE RADIUS FOR THE LOWER STEP

Because the upper starter step overlapped some of the same curved footprint as the lower step, I needed to cut and install the lower tread first. The lower starter step had two curves cut into each end: an inside radius that wrapped around the curved riser above and an outside radius that extended over the curved riser below. Before scribing the inside radius, I measured out from the

The author measured and cut the upper blank to fit around the skirt boards before scribing the radius **(11)**. After projecting the edge of the radius out 2 1/4 inches as with the lower step, he cut the curve with a jigsaw **(12)**. For both steps, he used a belt sander to smooth out the curves **(13)** and then routed a bullnose into the edges using a round-over bit **(14)**.

center and notched both of the side "ears" so they would slide over the skirt boards.

I set the blank for the lower step in position on top of the upper radiused riser, propping up the leading edge of the step to keep it level **(7)**. Reaching under the blank, I scribed the inside radius by following the edge of the rough tread. Then I flipped the blank over and cut to the scribe line with a jigsaw **(8)**. When that cut was finished, I slipped the blank down around the upper radius onto the lower radiused riser. I reached underneath and followed the edge of the rough tread to scribe the radius of the lower riser **(9)**.

The finished tread needed to sit 2 1/4 inches proud of the rough tread (1 1/2 inches for the overhang and 3/4 inches for the riser that I would add later). Using a 2 1/4-inch-wide block, I extended the cut line out from the scribed line **(10)**, and then cut the radius with a jigsaw. My jigsaw work was close, but I had to touch up the outside curve with a belt sander. After sanding, I finished the edge with a 1/2-inch round-over bit set slightly shallow in the router to create close to a full bullnose on the edge.

ONLY ONE CURVE FOR THE UPPER STEP

The upper starter step returned to the skirt board, so it required scribing for only the outside radius. Measuring out from the center, I cut the inside edges of the ears to fit around the skirt boards. I'd made the main part of the tread the right depth to create the

Sanding the rough treads prepared them for the finish step installation **(15)**. After applying adhesive to the rough step **(16)**, the author set the finished lower step in place **(17)**. He plotted out the exact fastener locations with a framing square **(18)** and then drilled straight-sided holes **(19)** for the finish-head screws **(20)**. The floor finishers later filled the holes and stained the steps.

same 2 1/4-inch overhang, so I slid it into place with the back edge up against the next riser. As before, I scribed the curved riser on the underside of the tread **(11)**.

I used the same 2 1/4-inch block that I'd used on the lower tread to mark the projected radius at the required distance. Then I cut to the line with a jigsaw **(12)**. After fairing the curve with a belt sander **(13)**, I routed a bullnose into the edge of the tread **(14)**.

GLUE AND SCREW THE STARTERS

When both starter treads were ready, I sanded the rough treads to clean them up before finish treads went in **(15)**. Starting with the lower one, I put down a healthy amount of construction adhesive on the rough tread **(16)**. With the help of another crew member, I carefully slipped the tread down around the upper curved riser and pressed it into the adhesive **(17)**.

For a highly visible finished area such as a staircase, I like the screw layout to be consistent, so I used a framing square to mark the exact screw positions **(18)**. Plotting the location of the screw holes with a square takes a little more time, but the careful layout is worth the effort.

To attach the finish treads, I opted for 2 1/4-inch trim-head screws. The straight sections of the starter treads were 52 inches wide, and I used four pairs of screws to fasten each one. After drilling straight holes at each screw location **(19)**, I drove the finish-head screws to

After applying a liberal amount of construction adhesive to the rough tread **(21)**, the author set the finished upper tread into place **(22)**. As before he plotted out the exact fastener location with a framing square **(23)**. He then drilled and drove finish-head screws at each location **(24)**. Each starter step was held in place with four pairs of screws.

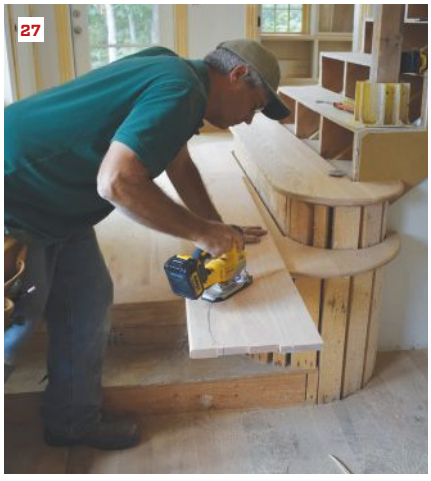
secure the lower tread **(20)**. The upper starter tread came next, with a generous amount of construction adhesive applied to the rough tread **(21)**. I was able to slip this tread into place without help **(22)**. As with the lower tread, I laid out the fastener positions **(23)**, then drilled and drove the screws to secure the tread **(24)**.

I should mention that these treads were to be lightly stained and polyurethaned to match the wood floors in the rest of the house. In instances like this, I find that the way to make the fasteners least visible is by driving the finish-head screws into straight holes (with no countersink). The floor finishers then typically fill the holes with a stain-compatible filler before sanding, staining, and finishing the treads.

TEMPLATE FOR THE STEP DOWN

As mentioned earlier, there was a single step down to a lower level that was below and at a right angle to the double starter steps. The end of that step fit against the curved riser that extended down from the lower starter step. I'd invested a lot of energy in making the blank for this step, so to make sure that I cut it right the first time, I made a template out of 1/4-inch plywood. To scribe the curve of the riser, I used a large pair of dividers and then cut to the line with a jigsaw. I fine-tuned the template until it fit almost perfectly to the curve **(25)**.

I had decided that the best look would be for the lower tread to extend to the middle of the tall curved riser. So with the template



For the step down to the lower level, the author templated the curve out of 1/4-inch plywood **(25)**. After positioning the template on the blank and plotting the curve **(26)**, he cut the curve with a jigsaw **(27)**. He routed a bullnose where the step returned to the riser **(28)**, and he bedded the finished tread in adhesive **(29)**. Finish-head screws completed the installation **(30)**.

in place, I measured over to that point on the riser from a position marked on the template and recorded the measurement. I also measured over to the opposite corner so that I could place the template precisely on the blank **(26)**.

After cutting the curve with a jigsaw **(27)**, I routed a bullnose into the edge of the tread, including the end where it returned to the curved riser **(28)**. As with the starter treads above, I bedded this tread in a layer of construction adhesive **(29)**, and then drilled and drove fasteners to attach the tread **(30)**.

To craft the paint-grade curved risers, I used multiple layers of 1/8-inch-thick untempered Masonite that bent easily to the curve. I spliced the straight sections of the risers into the curves, blending them together with a little Bondo filler that looked seamless when the painters had finished.

In more than 45 years as a trim carpenter, I'd never done a staircase like this, but I'm sure glad that I got to tackle this one. I was able to use many skills that I'd learned in the past—and take those skills a little bit further. I always enjoy having my skills as a craftsman challenged, but by the time I finished this one, I was hoping for a nice standard straight run of stairs next time around.

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

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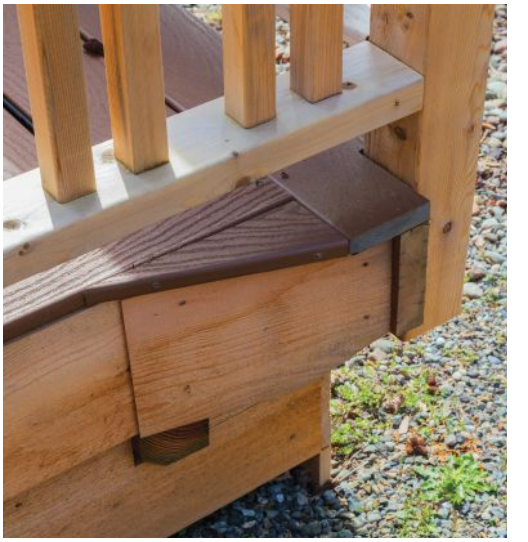

PHOTOS OF POST DETAIL BY GARY PENISTON

Single Corner-Post Detail for Fascia-Mounted Guard Posts

by Gary Peniston

I usually bolt guard posts to the outside face of the rim joist to maximize a deck's usable square footage. This presents a problem at corners, though, where there is no place to fasten the post. Most builders solve the problem by installing double-post corners, which I think look clunky. Instead, I extend the rim joist beyond where it intersects with the end joist, so that I can place the single corner post where it needs to go. Then I reinforce the connection with metal hardware (photo, above left).

In my area, Simpson Strong-Tie DTT2 tension ties (or the equivalent) are required to connect all rail posts to the deck framing. In this application, the DTT2 on the corner post strengthens the post in one direction at the base, while the top rail—which locks the assembly together with the other guard posts—strengthens it from side to side at the top.

Because this leaves a big piece of hardware exposed for all to see, I run the outermost course of decking beyond the last joist, so that it extends to the outer edge of the corner post. Then I cut a triangular-shaped piece of infill decking to fill in the corner (photo, above right). Finally, I cut a tapered section of fascia that boxes in the metal hardware and conceals it from view. ❖

Gary Peniston is a builder in Gig Harbor, Wash.

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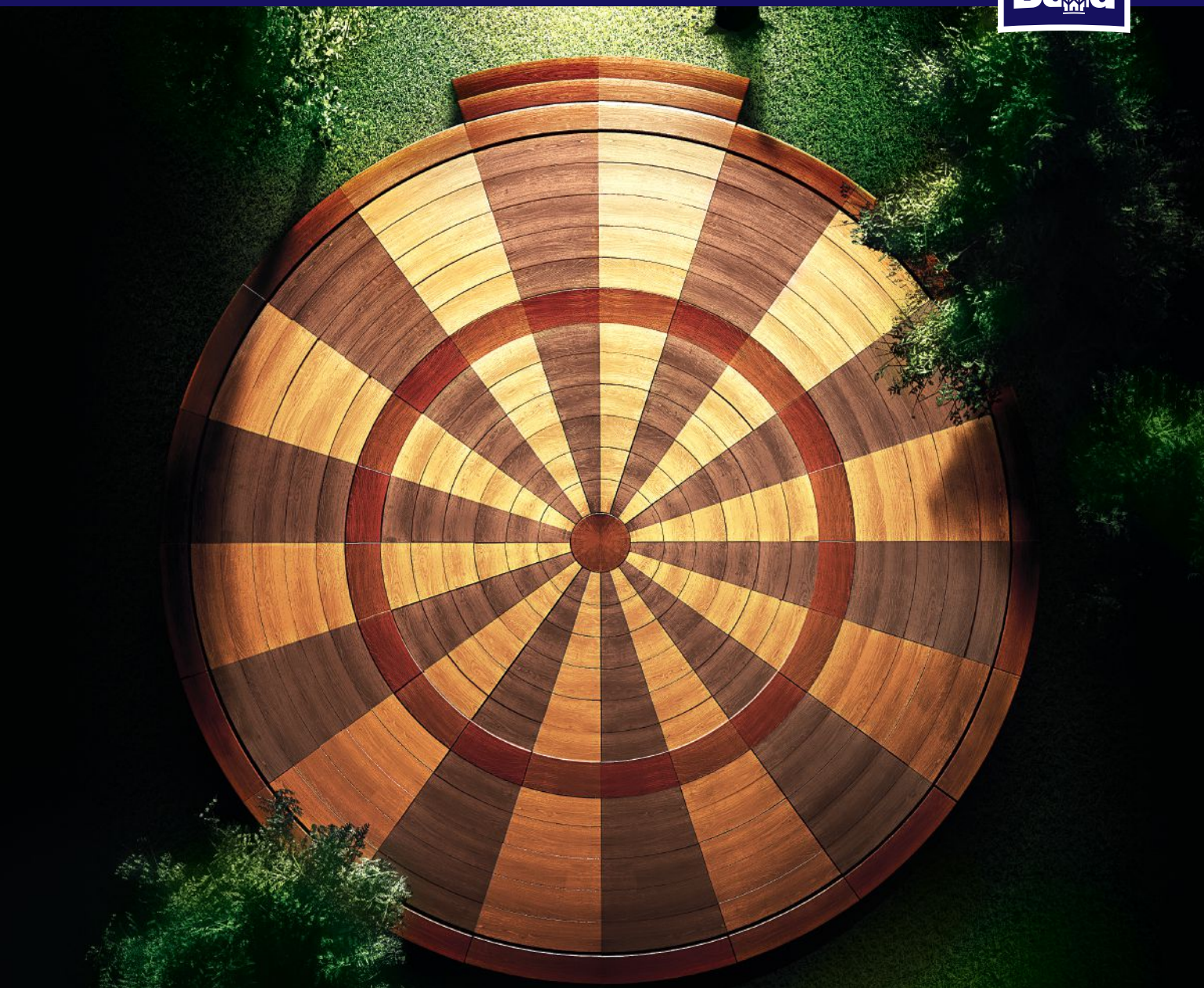

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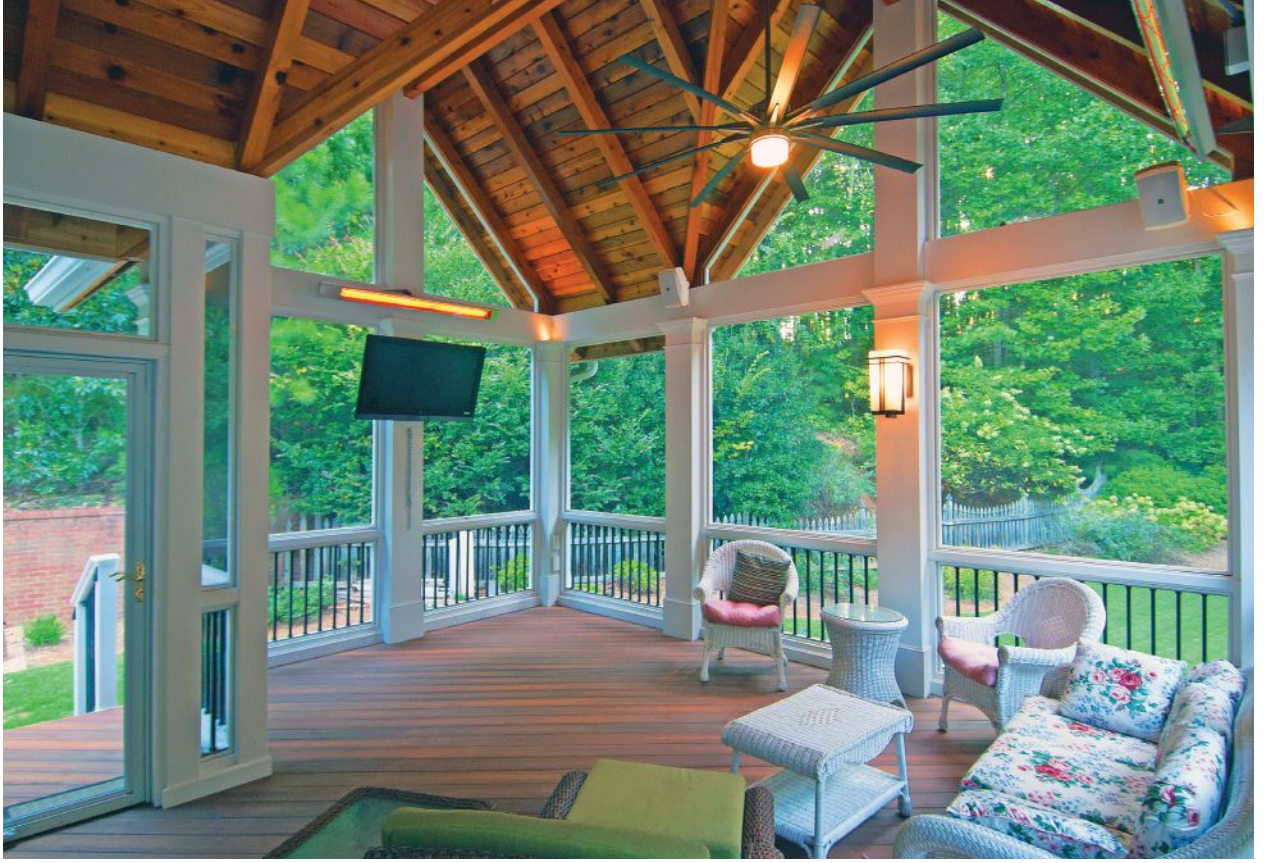

Designing Screened Porches

Give the porch a practical floor plan, and make it look like an extension of the house

by Bobby Parks

My approach to designing a screened porch is the same as my approach to designing a deck: The goal is to create an attractive space with a functional layout that blends in architecturally with the existing home. Even though screened porches are typically located at the back or side of the house, I think that they should still look like part of the original plan, not an "add on."

Like a deck, the porch should be designed with travel routes in mind so that people can navigate easily from the house to outside without disrupting the porch's living areas. I also take into consideration the home's existing windows and doors, which dictate where the porch walls can intersect with the house, and where columns that support wall return beams near the house can be located. Upper-level windows play a role in potential roof options and roof pitches for the porch, while the home's existing roof pitches and types play into what will or won't look like part of an original plan.

Site Assessment

When there is an existing deck, the usual assumption is that this is where the new screen porch should be located. But as I assess a site, I try to get an overall sense of where the outdoor room would best fit. I also consider practical details, such as where the new porch roof can tie into the existing structure.

Even though the homeowners may believe that they know where the screen porch should go, my job is to determine where the best location actually is. I've gotten many jobs because I came up with a different option and location from what other bidders proposed.

Because most clients want to dine out on their new porch, I always try to capture a breakfast-nook or dining room entry door in the design. It's better to carry food and drinks directly from the kitchen to the dining table, rather than take a roundabout route through the living room. Even better are French doors that open out onto the porch area, a great look that allows for a seamless entry and true extension into another living space. Sometimes, it's possible to provide access to the porch from both dining and living rooms by "capturing" one or both doors with a porch roof offset (**Figure 1**).

PHOTOS BY BOBBY PARKS

In 90% of my builds, I designed the porch to be wider than its projection out from the house. This makes it easier to divide the area into zones and arrange furniture. There's a structural advantage too, as this configuration has more inherent lateral stability than a structure that projects out farther than its width.

The minimum suggested projection is 12 feet, though 14 feet or more is preferred (I can't recall anyone complaining about their project being too big). To create a truly functional sitting and dining space, I recommend a 20-foot porch width. If more than 20 feet is available, the space can be divided into two zones, providing plenty of room for both sitting and dining furniture. If less than 20 feet is available, a single zone for sitting or dining could work in the smaller space.

Figure 1. Try to locate the porch door away from seating areas, preferably on a side wall rather than an end wall. Sometimes the door can be located in an offset extension outside the main porch area.

Door Location and Travel Routes

As a general rule, I like to plan a porch so that people can exit from the house, then turn left or right to travel to a screen door that is located close to the house. This avoids encroaching on the outside perimeter of the porch, where furniture can be located without worrying about traffic through the furnished area. It's also easier to integrate a screen door into the design when it's located on a side wall than it is when it's located on an end wall, especially on a gable porch.

Every rule has an exception, of course, and some homeowners prefer to locate furniture near a house wall, facing out. In this case, it makes sense to move the screen door out away from the house, though trimming it so that it doesn't stick out as an oddity can be a challenge.

Vertical Structures

Undersized vertical supports result in a spindly look on any porch, so I typically wrap support posts at the outer corners and back at the returns against the house with PVC trim. Wrapped columns are also usually located directly under the ridge beam (when the porch has a gable roof) and occasionally to break up side wall spans (**Figure 2**).

On many screened porches, you'll see 4x4 posts located on 3-foot centers to provide frames for the screen panels. But to provide an unimpeded view from inside

Figure 2. One way to blend a screen porch into the overall design of the home is to incorporate either front (above left) or side (above right) offsets into the design. Note too the use of fewer vertical supports, which opens up the view from inside the porch.

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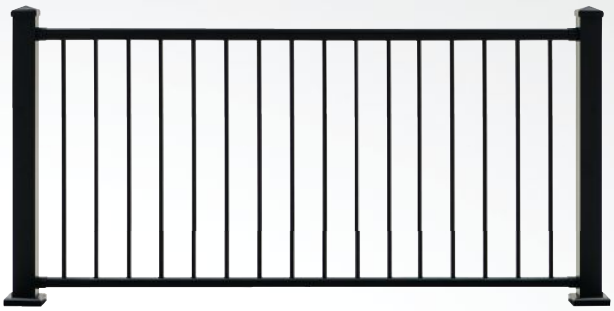

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Figure 3. An open-style knee wall fitted with balusters (A) offers enhanced views and ventilation, while a solid knee wall (B) offers more weather protection and trim options. When upper-story windows create a clearance problem, either a low-slope gable roof (C) or a low-slope shed roof (D) is a good design solution.

the porch, I prefer to use larger—but fewer—vertical members. To make sure they are capable of supporting the loads from the longer spans, these columns are typically framed with 6x6s rather than 4x4s, and finished with PVC wraps.

Knee Walls and Railings

On a screened porch, I prefer knee walls rather than railings, typically building them with vertical or horizontal aluminum balusters or solid PVC panels. Baluster-style knee walls provide a better view for those who are seated and better airflow compared with solid panel options. On the other hand, solid panels offer more trim detail alternatives and can be designed to look like wainscoating or frame-and-panel trim (**Figure 3**).

Many PVC manufacturers offer 4x8 panels that are perfect for building knee walls. Unlike traditional materials such as cedar or pine, which can stain, bleed tannins, and sometimes rot, PVC doesn't wick moisture, making it a great option for porch applications.

Roof Types

Roof types are determined by the style of the existing roof, by what can be practically tied into the home's structure, and by the budget. For example, if the home has a 12/12 pitch gable roof, I avoid putting a low-slope gable roof on the porch. In this case, a shed roof might be a better design option, especially if the budget is tight. That's because a 12/12 roof and ceiling will cost significantly more than a low-slope or shed roof.

Low-slope roofs can be challenging too. For example, if you try to tie in to an existing 5/12 pitch roof with a shed roof, you would end up "chasing the slope" with your porch rafters, potentially building more roof over an existing one than over the porch area. On the other hand, tying a shed roof into a wall is relatively simple and economical.

Sometimes both a shed roof and a gable roof can be incorporated into the design. Regardless, most of the time, the roof type won't limit the floor footprint or size options for the porch, though if you're trying to match another pitch, keep in mind that a wider footprint can lessen the slope compared with a narrower one.

When tying in the new roof, existing overhangs will have to be addressed and (usually) modified, whether it's a soffit underneath rafter tails, or a second-floor




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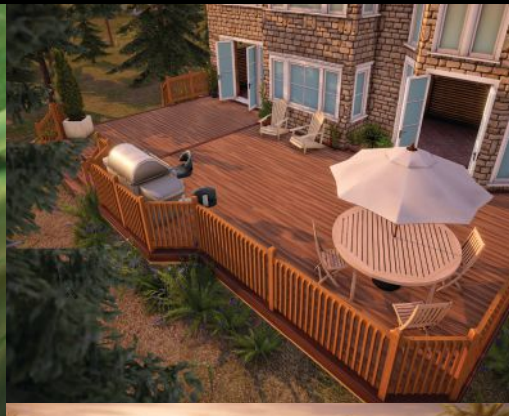


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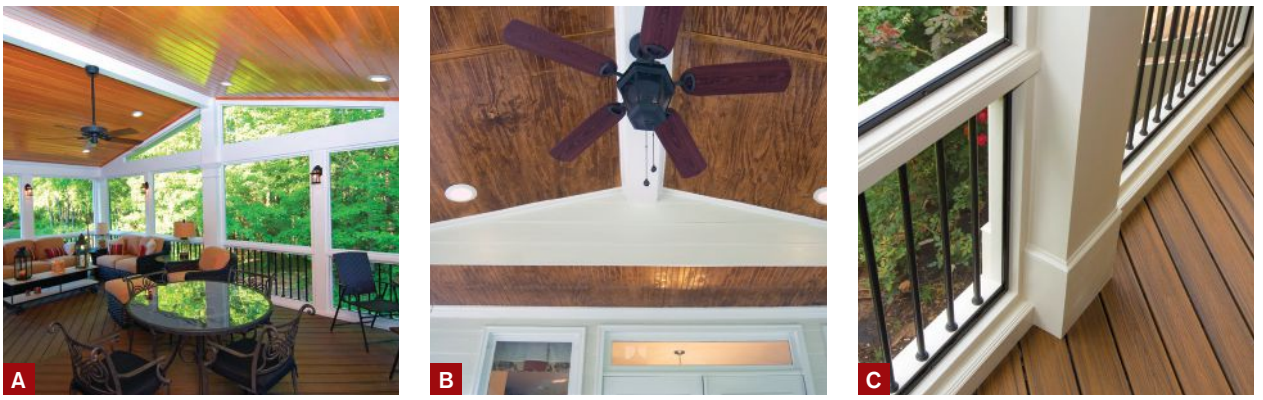


Figure 4. When planning ceiling finishes, keep in mind how light fixtures and ceiling fans may affect the design (A). It may be necessary to incorporate structural features of the existing house, such as this second-floor cantilever, into the porch ceiling (B). Shown here is the author's standard sill plate, chair rail, and column detail, all executed with PVC trim (C).

cantilevered soffit under a framed floor system. For example, if you were on a new porch and looked up to see fascia and soffit that was part of the original house, that would be a tip-off that the porch was not an original part of the house. Cornice overhangs, which are typically nonstructural, can be removed and reworked with siding or trim, while second-floor cantilevered floor structures can be modified by simply resurfacing the soffit area to match the porch ceiling material.

Interior Finishes

Regardless of the roof type, the key to interior ceiling design is to maintain balance with whatever you use to finish the ceiling. If the rafters are exposed or if there will be a beadboard treatment, determine in advance where lighting fixtures and ceiling fans will located so that the panels and breaks are oriented properly. It's also a good idea to check existing electrical panel capacities to make sure there's room for expansion before pricing and contracting a project (**Figure 4**).

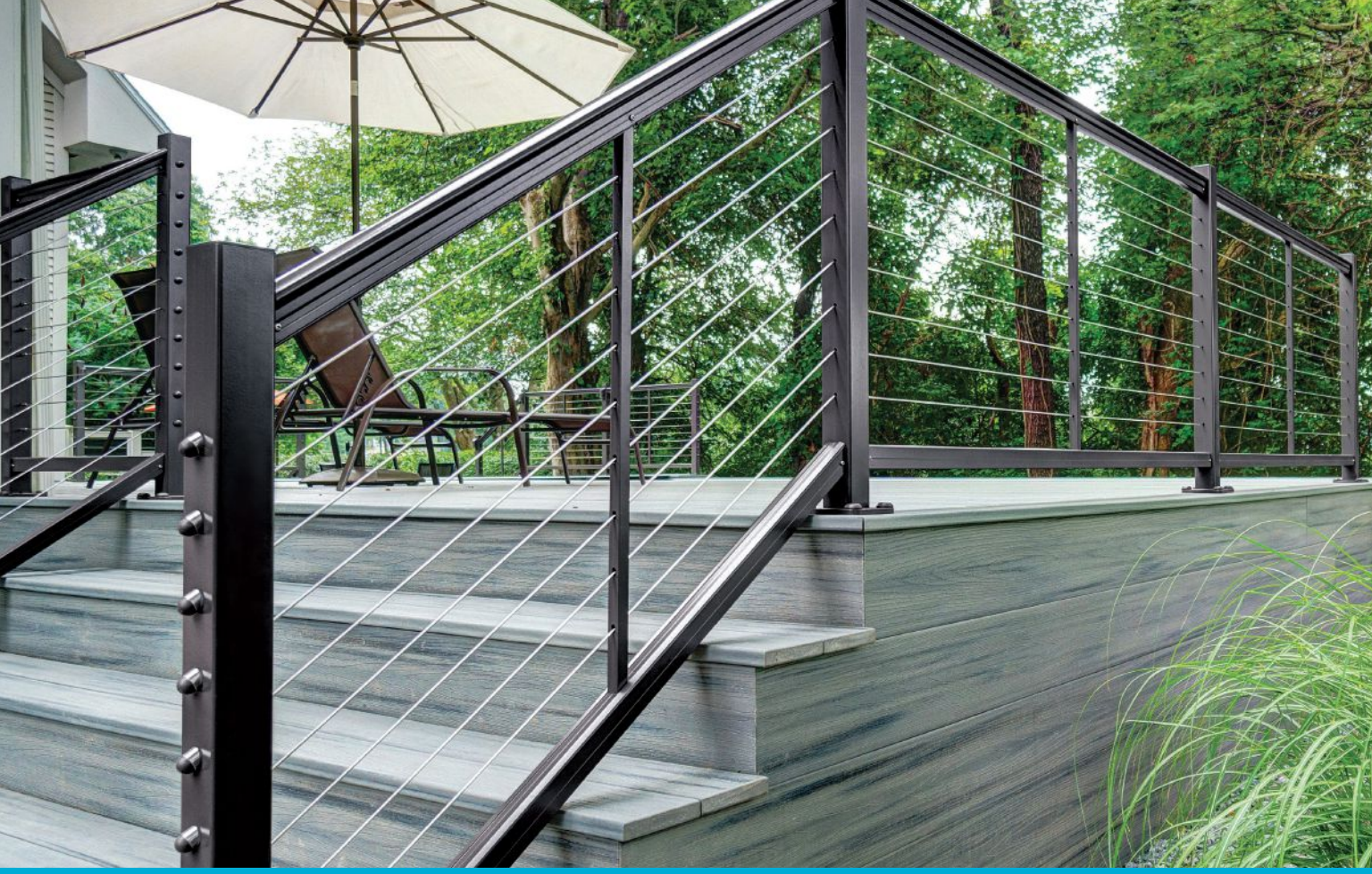
Popular ceiling finishes include cedar with exposed rafters, beadboard underneath rafters, and even cypress. In addition to these traditional materials, homeowners can now choose from newer products, such as Versatex's Canvas series PVC boards, a traditional-looking T&G profile with a natural-looking woodgrain laminate finish.

Finally, don't forget the trim details, which all work together to give any porch that custom look. These include trimmed-out sill plates and bottom outer band, wrapped wall beams, chair rail, wrapped columns, and ridge beam. And while this is custom work, over time these details became standard practice for my company. We learned how to build them efficiently and price them so that we were competitive with other builders while remaining profitable. Building these types of jobs separated us from the porch builders who kept it standard and simple. Although markets vary, virtually all markets have customers that will pay for these types of jobs. ❖

Bobby Parks, a nationally recognized deck, porch, patio, and remodeling contractor, owns BP Consulting and Design LLC and is a contributing editor for Professional Deck Builder.

Screen Options

Like most contractors, I used a local fabricator to produce my screen panels (see "Screen Options for Porches," Jul/Aug 2015). These typically have extruded powder-coated aluminum frames fitted with fiberglass or polyester screening. Other options include purchasing frame stock and assembling the panels on site or installing a base-and-cap-type system (shown here is the ScreenEze system). Motorized retractable screens are an interesting—but more expensive—alternative; these disappear entirely, so that the porch can be left open or closed off when mosquitos and other flying creatures become a problem. Regardless of the system, I recommend high-visibility screening, such as Phifer's BetterVue or UltraVue products, which allow more light and air into the room. *—B.P.*



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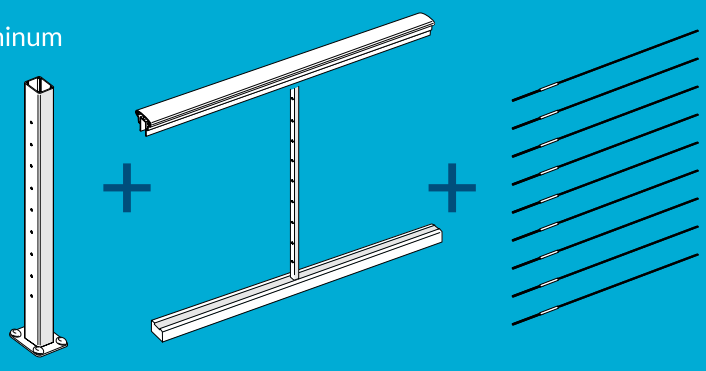

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PHOTOS BY BRUCE BARKER

Common Deck Defects

Here's a look at the framing and flashing details that contractors keep getting wrong

by Bruce Barker

As a home inspector, I examine decks almost every day. Usually, I do this as part of a home inspection following the American Society of Home Inspectors' Standard of Practice for Home Inspections (ASHI SoP). But as more inspectors become specifically trained in ASHI's new Deck Inspection Standard of Practice, I expect to more frequently see deck inspections that are performed independently from a home inspection.

Most decks that I inspect have multiple defects, some of which present serious safety risks. This isn't a surprise on an older deck, but I've also found serious problems on recently built decks. Because I've already examined deck stair defects in a previous article (see "Common Deck Stair Defects," Nov/Dec 2016), I'll focus here on deck framing and flashing defects.

Contrary to what some contractors may believe, home inspectors would rather not find defects during an inspection. Defects cause problems for everyone: the builder, who faces callbacks and the risk of being sued because of a deck failure; the homeowner, who has a potentially unsafe deck; and the inspector, who is faced with writing up a lengthy report.

I don't consider a "defect" simply a failure to comply with the building code. Rather, I consider it a failure to follow current best practices as presented in the American Wood Council's *Prescriptive Residential Wood Deck Construction Guide*, or DCA 6-15. Building codes are the minimum standard; they are not the standard for contractors who build quality decks. Remember, too, that the building official is not responsible for ensuring that a deck is safe, or even that it complies with local building code. You, the contractor, are fully responsible for both of these. A deck that passes local code inspection may still be unsafe; therefore, I consider DCA 6-15 to be the standard to which all decks should be built, regardless of what might be allowed by a code official.

Deck Ledger Attachment

Most of the decks I inspect are supported on one end by a ledger attached

Figure 1. Older decks frequently have ledgers that have been nailed rather than screwed or bolted to the house (A), but the author sometimes finds this problem on recently built decks too (B). Note the nailed double-ledger connection, which is in the process of separating, in photo (C).

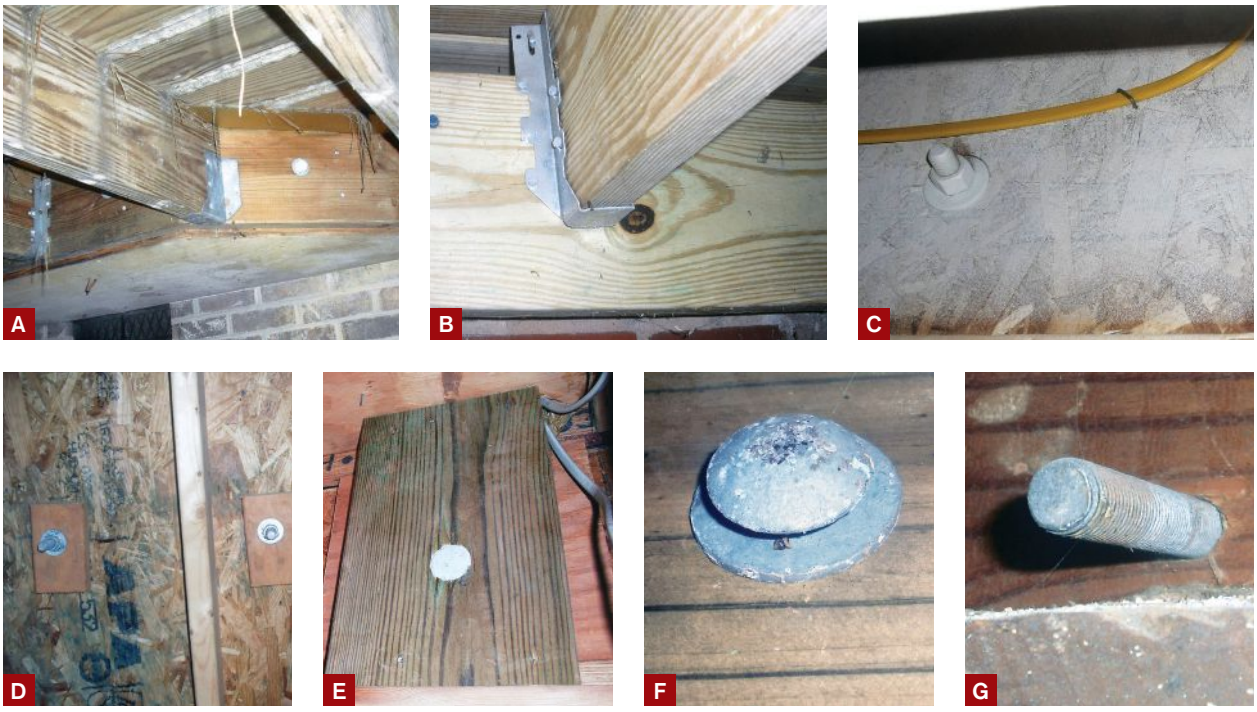

Figure 2. Ledgers shouldn't be fastened to a cantilevered projection (A), to brick veneer (especially with masonry screws) (B), to the web of an I-joist rim board (C), or to OSB sheathing (D). This ledger, on a year-old deck, was fastened to an I-joist rim board with carriage bolts; neither the fasteners nor the method are allowed by code, despite the blocking (E). Adding a washer to a carriage bolt doesn't make the connection code compliant (F), but it's better than forgetting the nut and washer (G). Also note that this bolt is too close to the edge of the rim joist and could cause it to split.

to the building. These ledgers are subject to vertical loads (gravity) that try to pull the deck down from the building, and horizontal—or lateral—loads that try to pull the deck away from the building. The requirement that the deck ledger be positively anchored to the building to resist both loads or that the deck be freestanding has been in the code for many years (R507.8 in the 2018 International Residential Code), but—based on what I've seen—this requirement is still not well understood, and it is still not widely enforced.

For example, surprisingly, I still

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Figure 3. White rust is already forming on this joist hanger, which is only approved for interior use (A). Metal-roofing screws aren't approved joist-hanger fasteners (B), nor are roofing nails (C); all of the holes in metal hardware should be filled with approved hanger nails or structural screws, and the hanger flanges should fit snugly against the joist (D). Metal hardware shouldn't be field-modified; with its seat removed, this hanger provides minimal joist support (E).

find ledgers that have been nailed to the framing, which is prohibited by both DCA 6-15 and the IRC (**Figure 1**). When I do, I complete my inspection, then explain the risks to my clients and advise them (and their real estate agent) not to walk on the deck until it is properly attached to the house. In my report, I highlight this defect in red ink to emphasize the importance of this finding and recommendation.

Reactions vary. A few people—usually the agents—believe I'm being overly cautious. On the other hand, most clients seem to appreciate my concern for their safety.

Even when bolts or screws are used to attach the deck ledger to the building, many of these deck ledgers are improperly installed. I've seen plenty of creative—but incorrect—ways to attach a deck ledger to a building. I've discovered ledgers that have been bolted to masonry walls, to OSB sheathing, and even to the web of an I-joist rim board (**Figure 2**).

Another problem is ledgers that are attached to cantilevers. Because cantilevers aren't typically designed to support the loads from a deck, both the IRC and DCA 6 require that the band joist supporting the deck ledger be fully bearing on the structure, effectively prohibiting attachment of a deck ledger to a cantilever.

One of the key details I'm looking for during an inspection is that the deck ledger is solidly attached to a dimensional-lumber band joist or to a 1-inch-thick (or greater) engineered rim board. I also pay close attention to the fasteners, since the primary job of the bolts or screws is to resist the vertical loads imposed on the deck ledger. These fasteners should comply with the requirements in the IRC and meet DCA 6-15 guidelines.

While the bolt and screw rules in the IRC and DCA 6-15 are based on the use of $\frac{1}{2}$-inch-diameter galvanized machine bolts or lag screws, builders sometimes use smaller-diameter fasteners, such as LedgerLoks or Simpson Strong-Tie SDWS and SDWH fasteners. These structural screws need to be installed according to the manufacturer's instructions. You can't simply substitute them one-for-one with


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Figure 4. The white rust on this ledger bolt indicates that it is still safe but is nearing the end of its service life (A). The extensive red rust on these bolts indicates that the hardware should be replaced immediately (B). Water intrusion is causing wood rot and the red rust on this lag bolt; the connection is likely weakened (C).

the ½-inch-diameter fasteners spelled out in the code. And while larger-diameter fasteners may be used, the location details change (more distance is required from the edges of the ledger).

Whether or not bolts or screws will provide the necessary lateral load resistance requires a structural analysis of the specific deck. It's a lot easier—and less expensive—to follow one of the prescriptive methods spelled out in the IRC and in DCA 6-15. At around $35 for a set of four SST DTT1Z (or similar) connectors and the necessary fasteners, easy-to-install tension ties are a low-cost way to help ensure full compliance with the lateral-load provisions in the IRC and conform with DCA 6-15.

Joist Hangers and Fasteners

I often find problems with joist hangers and other metal hardware. Sometimes the deck builder has used hangers intended for interior use, when he or she should have used G185 (minimum) galvanized hangers, or even stainless steel hangers in coastal areas. One way to verify that a Simpson Strong-Tie joist hanger is suitable for use on a deck is to look for a Z (galvanized) or an SS (stainless steel) at the end of the model number (**Figure 3**).

It's not unusual to see joist hangers fastened to the framing with roofing nails or drywall screws. Hardware manufacturers typically specify the type and size of fasteners that must be used with their products; in general, screws—except those specifically allowed by the manufacturer—should not be installed, nor should you mix metals.

Curiously, I often find hangers installed with just two or three fasteners. In almost all cases, joist hangers should have a manufacturer-specified fastener in every round and oblong hole.

I often find field-modified hardware too, but in most cases, joist hangers and other hardware should not be bent unless the manufacturer allows bending. Even then, the hardware should be bent only once to the required position.

One of the most important things I look for when inspecting a deck or balcony is white or red rust. White rust appears on metal hardware as white stains, indicating that the protective zinc coating (galvanization) is deteriorating. While white rust indicates that hardware is nearing the end of its service life and should be monitored regularly, significant red rust indicates that the component has reached the end of its service life and should be replaced (**Figure 4**).

Deck Flashing

It won't matter how well a deck ledger is attached to a building if the band joist or rim board it's attached to is water-damaged. The bolts or screws may withdraw from water-damaged wood, and if this occurs, the deck will collapse. Even though flashing details are not spelled out in the IRC, properly installed deck flashing is essential for the long-term structural integrity of a deck (**Figure 5**).

Properly installed flashing is also essential for the long-term performance of the building. Water damages building components and provides moisture that is necessary for fungal (mold) growth. Mold claims can be very costly to deal with. Properly installed deck flashing is, therefore, essential on several levels.

When I inspect a deck, I look for deck flashing that is integrated into the wall drainage system and into the flashing for wall penetrations, such as doors, that open on to the deck. The objective is to direct water away from vulnerable wood and away from entry points into the building, but builders often get the details wrong, with serious—and sometimes catastrophic—consequences. Seemingly minor flashing errors can admit a lot of water into a wall assembly.

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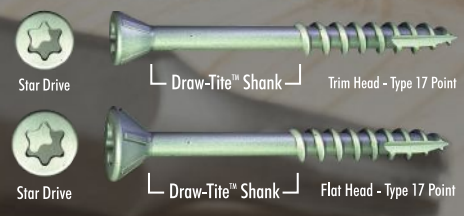

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Figure 5. The sheathing and band joists on these homes (A, B) are in rough shape, thanks to moisture intrusion from their decks, and require replacement. Improperly installed ledger flashing on a one-year-old deck was the cause of this water damage (C). Flashing is often improperly installed underneath door thresholds (D) and where ledgers intersect with other building components, such as a roof (E). During a new-home inspection, the author discovered flashing that hadn't been integrated with the water-resistive barrier underneath the home's siding (F).

Cantilevered Balconies

During a home inspection, I pay particular attention to cantilevered balconies and their flashing details, since failure to install proper flashing and ventilation where cantilevered balcony joists penetrate the building wall can contribute to catastrophic balcony failure. This is what caused a balcony to collapse on an apartment complex in Berkeley, Calif., in June 2015, resulting in the deaths of six students.

Cantilevered balconies are vulnerable to deterioration and failure, especially if they are covered on both the top and bottom. The framing that supports these top- and bottom-covered balconies can get wet and can stay wet. There is usually no ventilation of these balconies to help the framing dry. This constant wetness hastens deterioration. In addition, these balconies cannot be visually inspected without destructive measures. Deterioration can go on for years until failure occurs.

To head off these problems, I recommend that existing wood balconies that are enclosed be retrofitted with ventilation and inspection openings. These features should also be incorporated into new cantilevered balconies built with wood, along with some version of the flashing details developed by California architect Patrick Burger, which you can find in the *PDB* article "A Path to Safer Balconies" (Mar/Apr 2016), at deckmagazine.com. —*B.B.*

Deck Inspections

If you're not doing this already, you should recommend or offer an annual deck and balcony inspection to your clients. This is especially important if the home is near a large body of water or is a rental property. Regular inspections are important to spot visible indications of unsafe conditions and potential failure. A visual inspection is usually adequate for the annual inspection of newer residential decks and balconies. A comprehensive inspection based on the ASHI Auxiliary Standard of Professional Practice for Residential Deck Inspections is better for older decks and balconies, those near water, and those at a rental property. ❖

Bruce Barker is a licensed contractor and certified ICC inspector. He owns Dream Home Consultants, in Cary, N.C.

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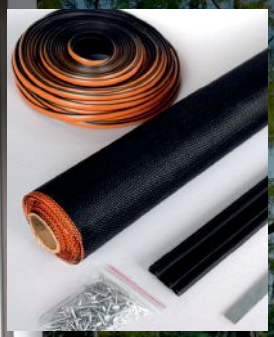

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Installing a Deck Ledger

Part 1. Use the right fasteners and space them correctly when attaching the deck ledger to the house framing

by Mike Guertin

[Editor's note: This three-part series goes beyond code to offer a best-practices guide to deck ledger installation. In part one, we'll take a close look at attachment details; later, we'll cover moisture protection and lateral-load anchors.]

Deck ledgers are the odd duck of residential construction. Most gravity loads in platform framing rely on stacking building elements, such as joists and rafters on mudsills and plates, beams on posts, headers on jacks, and so on. Instead of stacking the load, however, deck ledgers rely on bolts or screws to transfer the live and dead loads of the deck into the frame of the house. Because of this, fasteners must be positioned accurately along the ledger and into the house rim joist at the spacing required by the building code or the fastener manufacturer's instructions. Incorrectly positioned fasteners can split the ledger or the rim joist, and if the spacing isn't matched to the joist span, there may not be enough fasteners to support the loads on the deck.

Approved Fasteners

The International Residential Code lists two fasteners for directly attaching ledgers to a house: ½-inch-diameter hot-dip-galvanized hex-head machine bolts and ½-inch-diameter hot-dip-galvanized lag screws. Note that "carriage," or "cap head," bolts are not listed (**Figure 1**). The IRC also provides a table (R507.9.1.3(1)) for the spacing of the fasteners (**Figure 2**).

The bolts or lags must be placed along the ledger in two rows—one row along the top and one along the bottom—with the fasteners staggered between the two rows at the spacing indicated by the IRC table. For example, on a deck with a joist span of 15 feet, the lag screws are spaced 11 inches apart. To start the pattern, the first lag is placed on the bottom row approximately 3 inches in from the end of the ledger, and the next lag is located on the top row 11 inches from the first one. The next lag goes on the bottom row another 11 inches over, and the pattern repeats until the other end of the ledger is reached (**Figure 3**).

Eventually, there will be conflict between a fastener head and a joist position (or the flange of a hanger supporting a

PHOTOS BY MIKE GUERTIN

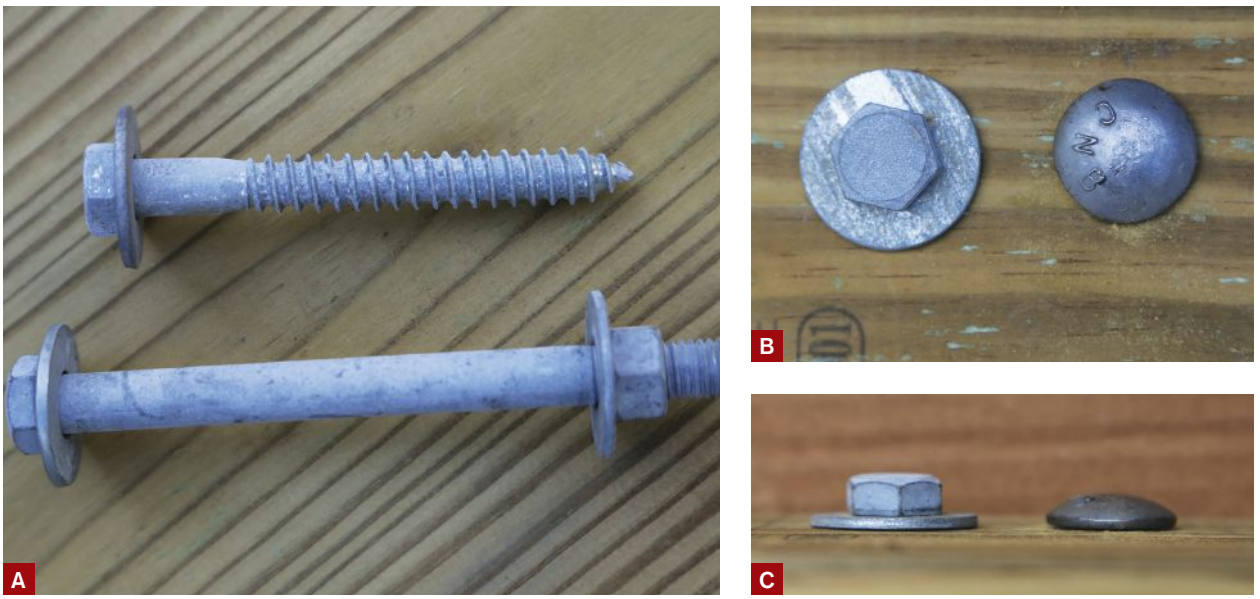

Figure 1. Hex-head 1/2-inch hot-dipped galvanized bolts and 1/2-inch lag screws with standard cut washers (A) are the only two fastener options listed in the IRC for attaching deck ledgers. Carriage (cap head) bolts are not permitted fasteners. The cap-type head has 30% less surface area than a 1/2-inch bolt washer (B) and is thinner than a hex-head bolt (C).

joist). When this occurs, you are allowed to shift the fastener to the left or right up to 3 inches to avoid the conflict. Don't be tempted to countersink a fastener head so that it is flush with the ledger surface—this is not permitted. Even when a fastener is shifted left or right, the spacing pattern of the remaining fasteners continues from the original layout point.

Layout

To make sure the connection between the deck and house framing is structurally sound, the IRC spells out the orientation of the top and bottom fastener rows in the ledger and the house rim joist (**Figure 4**). Each one is simple on its own to understand, but when you combine the two and try to set the position of the ledger and maintain the minimum and maximum spacing of the two rows of fasteners, it can feel like a game of three-dimensional chess.

The limitations of the fastener row placement limit the level of the deck in relation to the inside floor level in the house. The deck's elevation will also be influenced by the size of the house rim joist and the deck ledger (**Figure 5**).

There are installation requirements for bolts and lag screws that aren't specifically noted in the IRC, but are instead found in the *Wood Frame Construction Manual* and the *National Design Specification for Wood Construction*—the core documents that the framing section of the IRC is based on. For example, 1/2-inch-diameter bolts and 1/2-inch-diameter lag screws must be installed with 1/2-inch washers that are 1 3/8 inches in diameter with a 9/16-inch-diameter hole. Bolts will require clearance holes drilled through the ledger, wall sheathing, and house rim joist that are at least 1/32 inch larger than the bolt itself (17/32-inch diameter) but no more than 1/16 inch larger (9/16-inch diameter), a rather narrow range for the hole diameter.

A lag screw also requires a clearance

TABLE R507.9.1.3(1)
DECK LEDGER CONNECTION TO BAND JOIST[a, b]
(Deck live load = 40 psf, deck dead load = 10 psf, snow load ≤ 40 psf)

CONNECTION DETAILS	JOIST SPAN						
	6' and less	6'1" to 8'	8'1" to 10'	10'1" to 12'	12'1" to 14'	14'1" to 16'	16'1" to 18'
	On-center spacing of fasteners						
1/2-inch diameter lag screw with 1/2-inch maximum sheathing[c, d]	30	23	18	15	13	11	10
1/2-inch diameter bolt with 1/2-inch maximum sheathing[d]	36	36	34	29	24	21	19
1/2-inch diameter bolt with 1-inch maximum sheathing[e]	36	36	29	24	21	18	16

For SI: 1 inch = 25.4 mm, 1 foot = 304.8 mm, 1 pound per square foot = 0.0479 kPa.
a. Ledgers shall be flashed in accordance with Section R703.4 to prevent water from contacting the house band joist.
b. Snow load shall not be assumed to act concurrently with live load.
c. The tip of the lag screw shall fully extend beyond the inside face of the band joist.
d. Sheathing shall be wood structural panel or solid sawn lumber.
e. Sheathing shall be permitted to be wood structural panel, gypsum board, fiberboard, lumber or foam sheathing. Up to 1/2-inch thickness of stacked washers shall be permitted to substitute for up to 1/2 inch of allowable sheathing thickness where combined with wood structural panel or lumber sheathing.

Figure 2. To determine fastener layout on a ledger, identify the joist span (listed in 2-foot increments) and the type of fastener. The joist span is measured from the center of the joist hanger at the ledger to the center of the beam the joists rest on and doesn't include any cantilever overhangs past the beam.

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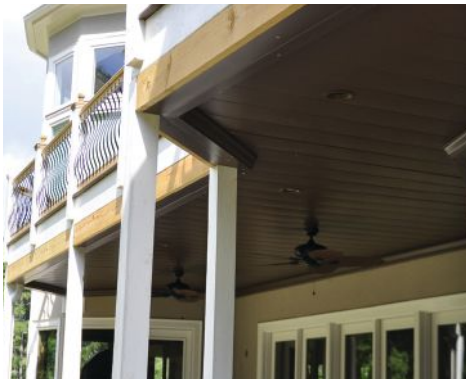

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Figure 3. Fasteners are laid out on the ledger in two rows, starting approximately 3 inches in from one end, with the on-center spacing from the code table staggered in a "W" pattern between the two rows. Since bolt and lag heads can't be countersunk into the ledger, the fastener can be moved left or right up to 3 inches to avoid conflicting with joist location or the hanger flange, provided the rest of the fasteners remain on the same layout.

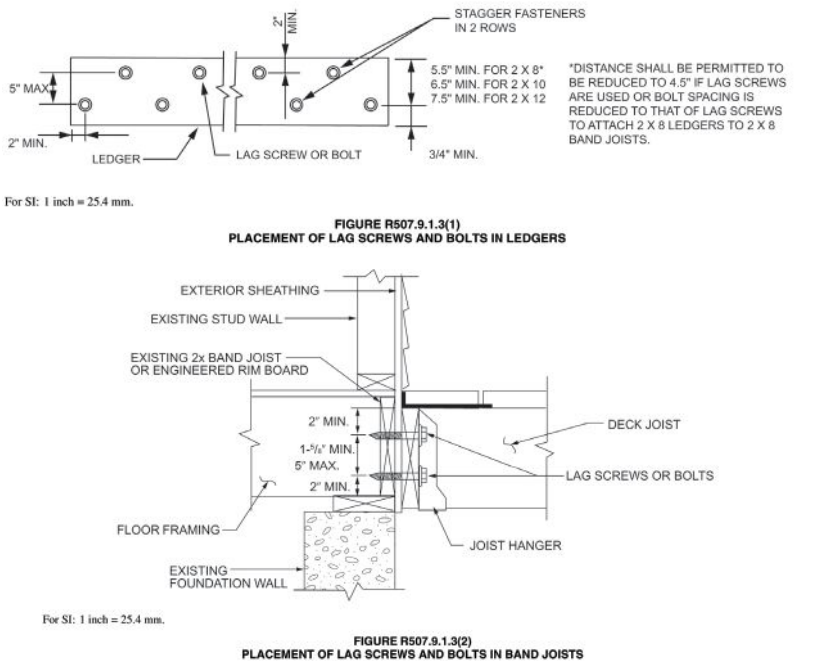

Figure 4. The IRC clearly spells out where the 1/2-inch-diameter lags or bolts should be located in both the ledger (top) and the rim joist (bottom).

hole through the ledger (in the same size range as for a 1/2-inch-diameter bolt), plus a smaller pilot hole through the house rim joist and wall sheathing. The pilot hole should be the same diameter as the root of the screw portion of the lag, generally 5/16-inch diameter (**Figure 6**).

Bolts must penetrate through to the inside of the rim joist far enough to accommodate a washer and allow a nut to fully engage the threads. Lag screws must penetrate through the rim joist by the length of the tapered portion at the end, typically about 5/16 inch to 3/8 inch. Bolts and lags must be tightened enough to draw the ledger and rim joist firmly together, but not so tight that the washers compress the wood on either side.

Whether you use bolts or lag screws, there must be access to the inside of the rim joist in the house for the building inspector to evaluate the ledger attachment. Some builders believe that using lag screws allows them to avoid cutting into a finished ceiling, since no washers and nuts have to be installed. But when inspectors can't verify the rim-joist material, view the edge distance of the fasteners on the inside of the rim joist, or check the penetration of the fasteners, they can't conclude that the deck will be adequately supported by the ledger. In that case, the deck will have to be designed and built to be completely self-supporting.

Structural Screws

Instead of 1/2-inch-diameter bolts or 1/2-inch-diameter lag screws, many deck builders now use proprietary structural screws for attaching deck ledgers. For

Figure 5. Applying the code figures when fastening a ledger can be confusing. The fastener locations through the ledger and through the rim joist differ, so you have to match the zones to ensure that the wood doesn't split and that you provide enough support for the deck.

Figure 6. Clearance holes for 1/2-inch lag screws and bolts have a narrow range: 17/32 to 9/16 inch. A 1/2-inch drill bit is too small, and a 5/8-inch bit is too large (A). A pilot (lead) hole through a rim joist should be about 5/16 inch for lags (B, C).

those to be an acceptable alternative to lag screws and through bolts, manufacturers must have their screws tested and obtain third-party evaluation reports that can be presented to a building department. It is up to the local building official to accept or reject the use of these screws, so always check with the building department before using them (**Figure 7**).

These structural screws have a smaller (about 1/4 inch) diameter than code-specified bolts and lag screws, so they don't require pilot or clearance holes, resulting in faster installation and less labor. They're coated for exterior use and compatible with the latest types of pressure-treated lumber, and have head styles with integral washers (hex and flat/flush). They typically offer a wider installation range on ledgers and rim boards, with live load capacities that are greater than 40 psf. Most can be used with a variety of engineered rim boards.

When using structural screws, follow the manufacturer's instructions and building code reports, rather than the tables in the IRC. Most manufacturers

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Figure 7. Proprietary structural screws don't require predrilled holes and have a wider positioning range through the ledger, rim joist, and even the mudsill or wall plate. Pictured (from left to right): 1. Mitek WSW Pro Series washer head and hex head exterior screws; 2. Simpson Strong-Tie SDWH HDG (short and long) screws, coated SDWS, and coated SDWH Timber-Hex screws; 3. FastenMaster LedgerLok (long and short) screws; 4. GRK RSS (short and long) screws

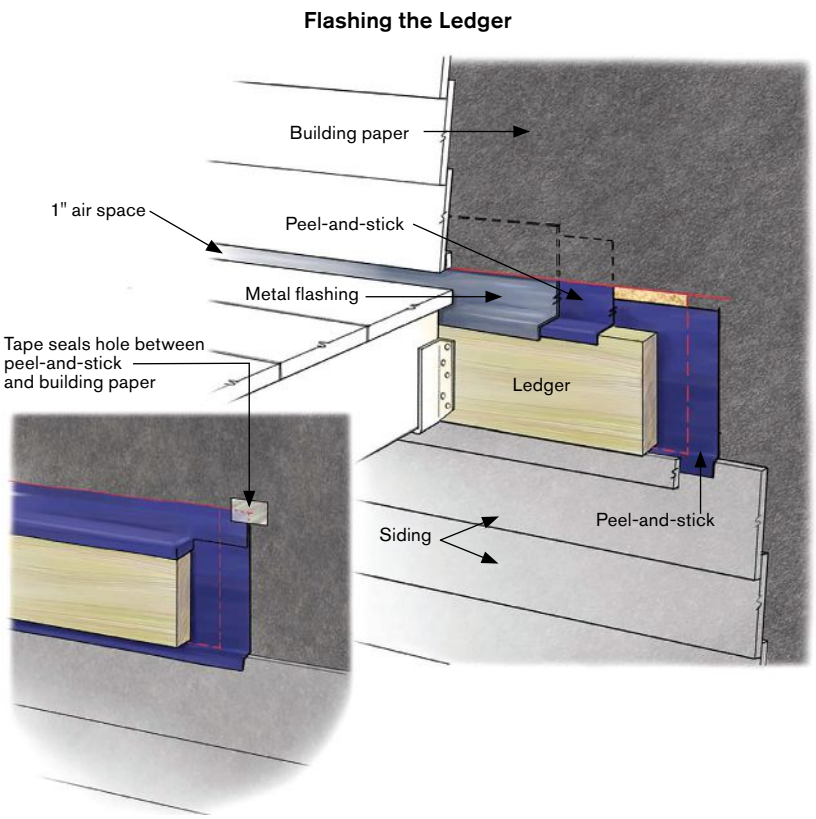

Figure 8. The IRC requires ledger flashing (per R703.4) but doesn't provide any details. Here is the general approach followed by the author.

provide deck-ledger spacing tables that follow the IRC fastener-table format, with joist spans in columns and different rim-joist materials and live loads in rows. However, the proprietary screw spacing will generally be closer for a given span than the code table for ½-inch-diameter bolts or lag screws, so you do need to refer to the manufacturer's information. Each table is unique to each manufacturers' screws, so you can't substitute the instructions of one company for the screws of another.

While the spacing may be different, some of the same installation provisions for the code-specified fasteners apply to structural screws. For example, you can't countersink screws, and you can relocate a screw that interferes with a joist or hanger position by up to 3 inches to the left or to the right. You'll still need to provide access to the inside of the rim joist for the code inspector to verify that the screws are adequately engaged (refer to the instructions for how far the screw tips must penetrate the rim). One benefit to using structural screws is that some manufacturers permit the screws to be installed into the mudsill or top plate of a wall, not just into the rim joist. That widens the range of heights you can position a ledger at so the deck can be set a full step down from the inside of the house, if desired.

Next Steps

Ledger installation takes planning and precise execution to ensure a safe deck, and it shouldn't be rushed. When installed properly, a deck ledger will handle the design loads for many years to come. The next step is to protect the ledger and the wall that it is connected to from water damage (**Figure 8**). I'll cover that in detail in the next installment of this three-part series. ❖

Mike Guertin is a builder and remodeler in East Greenwich, R.I., and frequent presenter at JLC Live and DeckExpo.

ILLUSTRATION BY CHUCK LOCKHART

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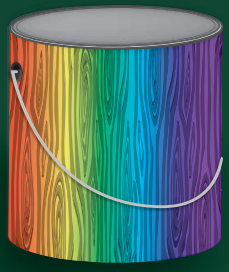

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Kebony Backyard

by Andrew Wormer

When a young Canadian family enlisted Yuill McGregor and his team at North on Sixty, a Toronto-based design/build firm, to help re-imagine their urban backyard, their goal was to channel the feeling of spending time in a northern cottage. To create the family's oasis, McGregor incorporated a number of features into the design, including a gunite pool, a Scandinavian-style sauna, and a compact outdoor kitchen.

But the foundation of the space is the expansive grade-level deck that surrounds the pool, which is clad with Kebony decking. The Kebony modification process is used almost exclusively with softwood lumber—in this case, southern yellow pine—and involves impregnating the wood with preservatives and bio-based furfuryl alcohol. Then the wood is heated, which evacuates the alcohol and polymerizes the other elements in the cell walls to make the wood denser, more stable, and less hygroscopic. McGregor says that the modified wood won't splinter and stays relatively cool in the hot summer sun—good attributes for use around a pool. ❖

The original exterior (inset) was updated with a new terrace door and the addition of a sandblasted tempered-glass roof to shelter the outdoor dining and living areas.

Across the courtyard, a pavilion containing a sauna was built to replace the original privacy fence (inset). Solar collectors on the pavilion roof provide hot water for the pool.

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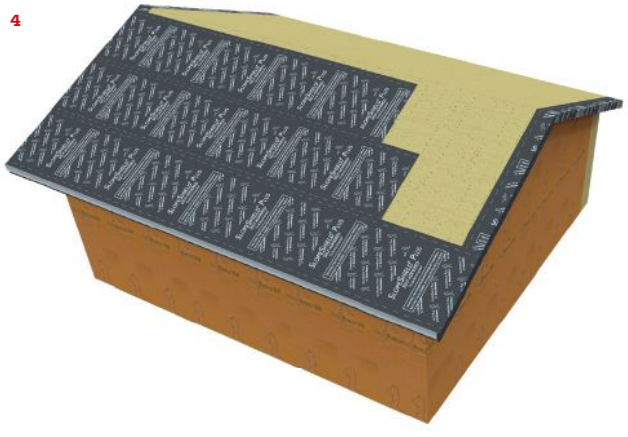

1. Luxurious Laminate

Formica Corp.'s new laminate countertop offerings in its Living Impressions Collection take inspiration from stones and woodgrains around the globe, from Nero Marquina's black base with white veining to Neapolitan stone's (pictured) blend of whites and grays. In all, the collection has six new 180fx patterns using the company's true-to-scale scanning technology and six new Formica patterns. Two finishes, SatinTouch and Pure Grain, and two edge profiles, Waterfall and Double Radius, were also added. Contact a distributor for pricing. formica.com

2. Voice-Enabled Lock

The upgraded Lockly Secure Pro smart lock features integrated unlocking options including a new voice control through a virtual assistant. Using their voice or an app, users can lock, unlock, and check the status of their doors through Amazon Alexa or Google Assistant. The Secure locks are available in satin nickel and Venetian bronze finishes and deadbolt or latch hardware configurations. The lock operates on AA batteries, supported by a backup battery. Pricing starts at $300. lockly.com

3. Built-in Blinds

Hy-Lite's newest fixed window model, the Vari-Lite, incorporates a set of blinds between two panes of glass. The window is a standard 4'-0" x 4'-0" size and is AAMA certified to DP 100. Fingertip controls on the side of the frame raise, lower, or tilt the blinds. The Vari-Lite window is available in four standard frame colors. Pricing starts at $750 with a new-construction frame and $825 with a retrofit frame. hy-lite.com

4. Vapor-Permeable Underlayment

VaproShield has announced it has a new roofing underlayment, SlopeShield Plus Self-Adhered. The water-resistive and vapor-permeable roofing underlayment is made of spun-bond polyester with a polymer composite coating. The manufacturer says it quiets the "concussion effect" of heavy rain and foot traffic during construction. The underlayment is compatible with metal roofing, slate or clay tile with batten or counter-batten substructures, and cedar shingles or shakes with VaproShield's VaproMat. It's designed for use on sloped roofs of 2:12 or greater pitch. Contact a local distributor for pricing. vaproshield.com

5. Vinyl Privacy Fence
CertainTeed's Bufftech Brookline vinyl fence offers homeowners a durable, contemporary privacy fence with steel reinforcement for added support. The fence itself is manufactured from premium-quality PVC and will not rot, warp, split, or splinter, says the company. Brookline is available in three solid colors and four multi-chromatic color blends, in either a smooth or a woodgrain texture. Contact a local distributor for pricing. certainteed.com

6. Brick-Veneer Connector
Simpson Strong-Tie's BVLZ brick-veneer ledger connector kit provides a code-compliant solution for attaching decks to wood-framed homes that have a brick- or masonry-veneer exterior covering. Fabricated from 12-gauge steel with a ZMAX galvanized coating, the bracket design includes two tension screws that pass through the mortar into the structural framing, allowing the compression strut to transfer forces from the ledger plate to the rim joist. Pricing for a 4-pack kit ranges from $130 to $150, while pricing for a 1-pack kit runs about $35 to $40. strongtie.com

7. Easy Gate Latch
Designed for ease of installation, the LokkLatch 3 Plus medium-security gate latch features a locking mechanism that is accessible from both sides of the gate. Made of a UV-stabilized polymer with stainless steel components, the gate latch requires only a single hole through the post. Once installed, the latch is easily adjusted both vertically and horizontally for proper gate-to-latch alignment, according to the manufacturer. It's available in black or white and in keyed-alike and keyed-different versions. Pricing ranges from $56 to $62. ddtechglobal.com

8. Smooth-Finish Paint
Sherwin-Williams' Supreme High Build interior latex is designed to allow large-scale builders to achieve consistent performance with optimal productivity. Compared with standard interior coatings, the paint requires less labor to deliver a smooth, uniform finish, and its ease of application reduces fatigue, says the manufacturer. It has better washability, scrubability, and hide compared with basic builder paints, according to the company. High Build interior latex is offered in a flat sheen, which diminishes minor flaws, as well as in eggshell and semi-gloss. Contact a local distributor for pricing. sherwin-williams.com


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9. Mechanical Earth Drill

Drilling equipment company Little Beaver offers mechanical earth drills that are ideal for a variety of industries, including fence installers and building contractors. The drills feature a steel torque tube that allows operators to use large-diameter augers without fear of kickback. In addition, its compact design allows access to areas unreachable by skid steer–mounted augers and provides a 360-rpm operating speed for cleaner holes. The tool is available with either a 5.5- or 8-horsepower engine and is mounted on 8- or 10-inch semi-pneumatic tires. Pricing averages around $2,500. littlebeaver.com

10. Wireless Fan Control

The latest addition to Lutron Electronics' Caséta smart lighting system is the Caséta by Lutron Fan Speed Control, which allows owners to wirelessly control their ceiling fans from anywhere inside their home. The fan speed control and its smart connections are compatible with most ceiling fans and allow users to adjust to four speeds and designate a favorite setting. The console is easy to install, according to the manufacturer, and does not require the use of a canopy module. It is available in four finishes. Pricing starts at $80. lutron.com

11. Camouflaged Exterior Vent

The newly patented Hide-A-Vent was designed to blend into a home's siding to camouflage exterior vents. Its customizable cover can be installed to any section of siding, including clapboard, shingles, and vinyl. Models come in two sizes: Model A disguises dryer vents and bathroom ceiling fans with a 4-inch round opening, and Model B fits microwave hoods and most residential kitchen hoods with its 3.25-inch-by-10.25-inch rectangular opening. Pricing ranges from $40 to $45. hideavent.com

12. Combi-Steam Wall Oven

Miele's Generation 6000 combi-steam wall ovens offer the form and function of a steam oven with a wide variety of standard cooking modes. The ovens are equipped with Miele's MultiSteam technology, which uses six to eight steam inlets to facilitate even steam distribution and quick heat-up times. Other operating modes include sous-vide, broiling, reheating, standard convection baking, and combination cooking. The combi-steam ovens are available in a total of 19 models and configurations, with two cavity sizes and a brilliant-white, clean-touch-steel, or obsidian-black finish. Pricing starts at $4,150. mieleusa.com

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Four-Speed Impact Driver

BY BEN BOGIE

Over time, I've watched impact drivers slowly filter in to what was a drill/driver world only. Early impacts were novelties on most jobsites. Soon, however, their power, speed, and efficiency started knocking drill/drivers (corded and cordless) back into the tool trailer. In lockstep, construction screws have also evolved and required more power to drive them. Tool manufacturers have done their part, delivering increasingly powerful tools. As a result, the category entered what I'd call a musclebound phase: high-umph tools that can bomb in fasteners at blistering speeds. But what about areas requiring more control and finesse?

For the work I've encountered in recent years—everything for new construction and remodeling from form work to custom stain-grade millwork to a steel-clad custom home—I've found myself reaching for smaller-capacity drill/drivers or screwdrivers for installing trim screws or hardware where the burly impact could result in overdrives or cammed-out screw holes or stripped heads. The impacts were too powerful and fast and risked damaging the more delicate assemblies, namely cabinet face-frame connections, interior trim assemblies, and door and window hardware.

Well, that's over now with this Makita impact driver.

FOUR-SPEED VERSATILITY

On the surface, the Makita XDT12Z four-speed impact driver is a standard 1/4-inch hex drive built on Makita's full-size 18-volt battery platform. Its brushless motor delivers up to 1,550-inch-pounds of torque in a surprisingly compact shell. The real genius here, however, is Quickshift. This feature—which I use all the time—takes advantage of the brushless motor's control circuitry to provide a 4-speed "transmission," so to speak, and has a couple of other nifty tricks up its sleeve.

The base of the tool has a small LED panel with three buttons. One LED bar shows battery charge level. The other displays the speed/power selection as well as what's called T Mode. We'll get to T Mode in a minute. Pressing the power-adjustment button cycles you through the levels. For driving larger screws, like #10x3, in framing applications or structural screws for roof framing or deck ledgers or connections requiring maximum demand, Level 4 is the sweet spot. The driver delivers blistering speed and great torque, handling all but the largest structural fasteners you're likely to encounter.

Still, it's a 1/4-inch drive, so it does have an upper limit (which I don't often reach). For reference, old-school 1/2-by-6-inch lags and 3/8-by-7 1/4-inch construction screws into white oak are beyond the tool's scope. Really, it's beyond the scope of the category. For these applications, you're better served with a 3/8- or 1/2-inch impact wrench.

For the most part, the Makita has the guts for the big stuff I need it for, but that's not all I do. Finer work is where this little giant begins to sing. I use a lot of trim screws, ranging from 1 1/4 inches to 5 inches. I also use cap-head screws and stainless steel exterior screws, and I want those screws to go in precisely and be set uniformly. On interior trim, I want the screw set deep enough to accept filler but not so deep that it deforms the surrounding material or risks cracking. In exterior trim where the fasteners will be left exposed, I want to be able to set all of them to a uniform depth for aesthetics, as we often do on removable screen panels and face-screwed decking.

On Level 2, the driver sends 3-inch trim screws nicely into poplar, Boral, pine, cedar, maple, and PVC. On this setting, the tool's reaction torque at startup—which can result in parts shifting if the tool twists too much—disappears. Then, as the screw is just about set where I want it, I can let off the trigger and deliver a slow, methodical finish. This perfectly snugs parts up and enables me to set the heads at just the right depth—repeatedly.

For tasks like installing brass door hardware—expensive, soft

The Makita XDT12Z is compact, powerful, and versatile. Its Quickshift control panel makes this a go-to tool in all phases, from trim screws to cabinet doors to structural screws.

Photo: Ben Bogie

metal where screws are easily damaged—I used to use a ratcheting screwdriver. Not anymore. I can dial the Makita down to Level 1 and install delicate finish hardware efficiently without concern.

Now for the nifty tricks up the Quickshift sleeve.

T MODE AND AUTO START

On the LED bar, there's an additional "T" for self-tapper mode. If you've ever installed self-tapping sheet-metal screws, you know they require a high-speed start followed by a quick trigger release to set the screw without camming out the hole. I've done it plenty of times. In T Mode, there's no guesswork or wasted time.

T Mode starts the driver at maximum rpm to pilot the hole. Then it senses the resistance change as the screw tip pierces the steel and quickly drops the rpm for cam-out-free fastening. No longer do you need cat-like reflexes for multiple trigger pulls in a single, tiny fastener.

And while T Mode works well, there's at least one limitation. It doesn't function that well on thinner-gauge sheet metal (less than 30 gauge or aluminum). It doesn't seem to slow down fast enough to avoid stripping. In medium- to heavy-gauge ductwork, I found the driver is sensitive enough to throttle back before camming the hole. In heavier-gauge metal—like the thousands of square feet of architectural metal siding and trim on a recent job—it performed reliably. For this heavier-gauge steel, I drove more than 3,500 1 1/2-inch gasketed screws. In T Mode, it was an absolute dream. Pull the trigger, the screw screams as it pilots a hole. Then, abraca-brushless-dabra, the tool downshifts as the fastener threads into the sheathing, finally slowing down to a nice, steady speed, enabling me to accurately set the gaskets.

Then there's Auto Start. This feature is essentially the opposite of T Mode and is intended for large—longer than 3 inches or with a 5/16-inch or better diameter—structural screws. Pull the trigger, the unit starts spinning slowly. This allows you to accurately guide the start path of long fasteners—which can be somewhat unruly at the tool's maximum 3,800 rpm. As the fastener threads, the tool's electronics sense increased resistance and deliver power and speed to match. This sends fasteners quickly to their final resting place while you move on to the next ones in line.

BOTTOM LINE

Hands down, this is my go-to driver. Of all the options we have in the tool trailer or in the shop, it's the one I reach for at the start of my day and it's always within arm's reach. The power, compact size, and ergonomics alone are enough to put it at the top of my list. Add its serious versatility, and it's a real darling.

I haven't had the tool long, so I can't speak to its durability. However, I did own an early model released only in Japan. For more than three years, that has been absolutely punished with no ill effects. I have little doubt this newer one will perform just as well. The XDT12Z costs $180 (tool only); a two-pack battery kit costs $160.

Ben Bogie is a second-generation builder working as a lead carpenter for Kolbert Building, in Portland, Maine, and a presenter at JLC Live. He specializes in building science, low-energy designs, and high-end custom finishes.

Driver Extension for Structural Screws

BY TIM UHLER

If you've used an auto-feed screw-gun extension, you'll find that the Simpson Strong-Tie Quik Stik is the same idea, just upside down for overhead use. And it drives 6-inch structural screws into top plates, and works for trusses and rafters.

As hardware requirements increase with each code cycle, manufacturers are providing alternatives that speed up installation and still meet code. So, if I can use a structural screw instead of straps and nails, I'll choose that every time. Structural screws install quickly, require few tools, and hold fast. Using a Quik Stik to install them, I found, reduced the number of trips up and down the ladder, and increased not just installation efficiency but also time and effort savings throughout the supply chain. Here's what I mean.

BENEFITS

First, structural screws install twice as fast as an H1 or H2.5a hurricane clip and here the Quik Stik showed up for work, enabling

The Quik Stik is designed to drive Simpson's bright orange SDWC Truss Screw in a variety of positions along the double top plate to accommodate different truss and rafter positions as they relate to the studs below.

Photos on this and facing page: Tim Uhler

Quik Stik's 1/4-inch hex drive chucks into your impact driver or cordless drill.

us to make reliable and fast connections in various plate and rafter configurations.

Because it requires just a 1/4-inch hex impact driver, which we all have (I used the first-generation Bosch Freak with no problems), I don't have to drag out hoses, nailers, boxes of nails, and so on. That's time and effort saved.

The screw this tool is designed for is the fully threaded 5 3/4-inch Strong-Drive SDWC. It has what I call a "cap-style head" that countersinks into the plate and won't affect finishes by remaining proud of the plate after installation. Bright orange, it's easy to spot for inspection—or just to see if you missed one. Simpson also has a 4 1/4-inch screw for other connections.

Safety and efficiency. A safe jobsite is based on the "hierarchy of controls." While this may sound like the title of a spy movie, it basically means that whenever possible, we seek to eliminate a hazard. If we can't do that, we try to replace that hazard by doing something differently. Falling from heights and falling off ladders account for a high percentage of injuries, and using a Quik Stik sidesteps those hazards by enabling us to make connections without leaving the floor or climbing outside the building. Quik Stik either eliminates or reduces the need for ladder work for fastening roof framing to top plates. That's a big deal.

This also further streamlines the workload: There are no ladders to unlock, take out, move 500 times, put away, chain back up, trip over, or fall from.

Details. The bit holder is at the end of the extension arm, of course. The arm has angle guides, a detachable bubble level, centerline guides, and positioning prongs. Read the manual to see how to use each of these for proper screw placement. The fasteners rely on being driven at proper angles to meet the specified loading tables. We found various connections were quick to make with the Quik Stik guides. It was easy to install to about 10 feet without ladders. Again, that's a huge time savings for us.

Codes. Some municipalities may not be familiar with screwing rather than strapping and nailing roof framing. To streamline this potential hiccup, we added a detail to our blueprints that includes the catalog pages from the fastener manufacturer. This way, it's stamped when the inspector comes out, and there are (ideally) no surprises. And if the detail is new to the inspector, it starts a dialog early in the process.

Cost. I found the kit online for $170. This price includes a carrying case for easy storage.

To me, this is one of those "no brainer" products. It's inexpensive, and improves productivity and promotes safety without any hassle. And, structural screws are also slightly less expensive than clips and nails, and who doesn't like that?

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 @awesomeframers.*

Classifieds

July Advertising Index

*Advertising appears in regional editions

BY ELIOT LOTHROP

Salvaging a Hero's Home

Last summer, I joined a team of local design professionals and volunteers tasked with salvaging and relocating a historic home in Milton, Vt. The small, unassuming farmhouse (built circa 1840) was once owned by Civil War hero and Vermont native George Jerrison Stannard **(1)**.

Stannard, a general in the Union army, is renowned for helping to blunt Pickett's Charge at the battle of Gettysburg. On July 3, 1863, he ordered a series of pivot maneuvers and provided withering flanking fire to repulse the Confederate assault. Later in the war, he was wounded and had his right arm amputated. He resigned from the Army in 1866 and purchased the Milton farmhouse. Stannard later moved to Washington, D.C., where he lived until his death in 1886.

Documenting, dismantling, and storing. Despite years of neglect, much of the home was worth preserving. Starting last April, we began the process of salvaging as much of the original house as possible, which was tricky given that it had been heavily remodeled twice, once in the 1890s and again in the 1930s. We tagged all the timber framing with coded "hand-punched" tin discs **(2)**, nailing them to beams, posts, studs, and rafters (we later documented their locations on a set of drawings). Then, with the help of a telehandler and personnel lift, we started dismantling the building **(3)**.

The home's wide board sheathing was salvageable **(4)**. The doors and windows, though not all original, were also saved. The discovery of a buried casing from an original fan light and visible ghost lines of original bed molding trim were pleasant surprises **(5)**.

The salvaged pieces have been stored and are waiting to be incorporated into the home's restoration on a new site. Visit generalstannardhouse.org for more information about the project.

Eliot Lothrop operates Building Heritage, specializing in historic preservation and timber-frame restoration, in Huntington, Vt.


1


2

3

4


5

Photos: 1, courtesy Milton Historical Society; 2–5, Tim Healey

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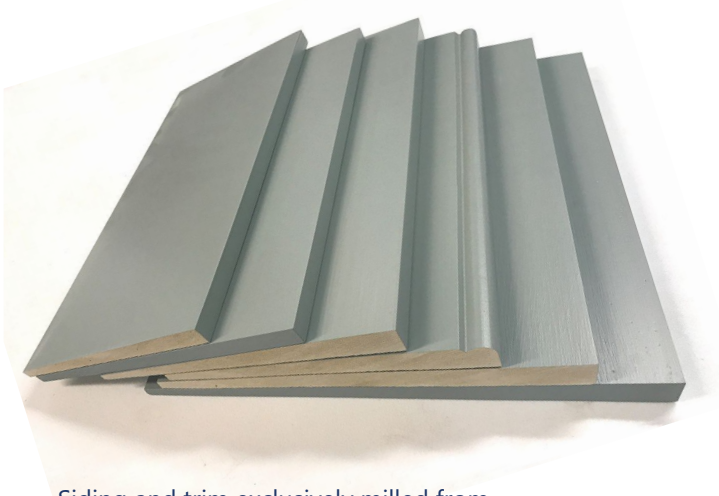

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