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On the cover: A carpenter strips the forms on the first-floor of a house near Seattle, where seismic codes demand significant amounts of steel in both the foundation and framing. See the story on page 51. Photo by Tim Uhler.

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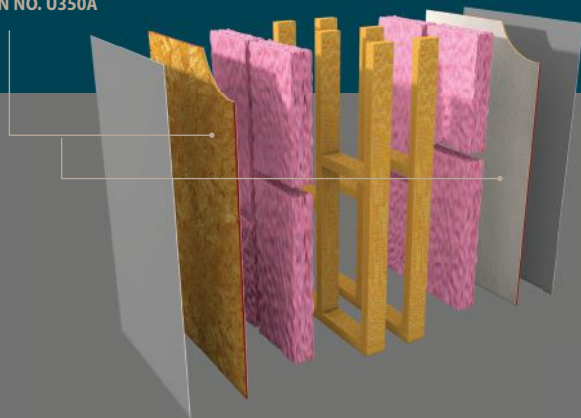
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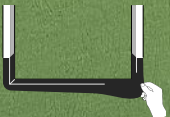
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Reader Feedback

The following excerpts are taken from comments in response to the JLC articles referenced.

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Letters

“ATTACHING FLOOR FRAMING TO SIPS,” BY BILL CHALEFF (Q&A, JUN/16)

Hands On Engineer (online, 7/31/16): No squash block inside the SIP wall to resist the compressive forces from the SIP screws that hold the ledger? Wow. No adhesive to bond the ledger to the inner skin? This sure looks like an attachment that might be regrettable in the future:

1. You are relying solely on shear strength of the fasteners rather than designing a clamping-type joint to connect facing surfaces.

2. You are loading the inner OSB skin in compression, such that it would surely buckle if not for the bond to the foam core. How much do you trust that bond, and how much does the introduction of these buckling forces tend to degrade that inter-panel bond? If this were my home, I certainly would feel better if the second floor had actual bearing on something substantial. I like the concept of SIPs, but structurally this is a bridge too far.

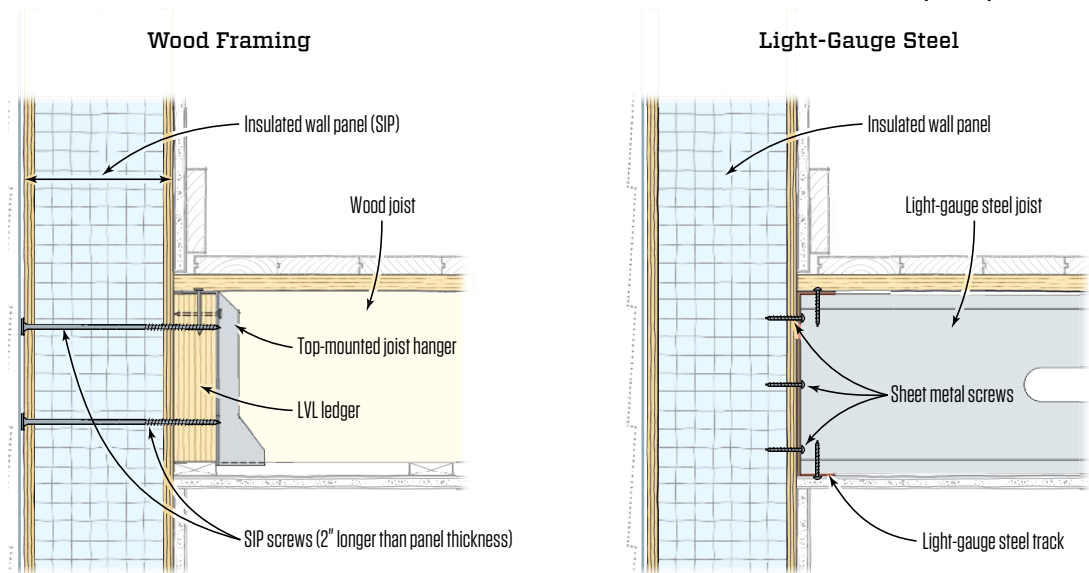
Bill Chaleff responds: My first SIP building was completed in 1986 and is celebrating its 30th anni-

versary by stubbornly refusing to fall down. In that particular building, we used the light-gauge-steel framing detail (see illustration, below) shown in the June Q&A.

In answer to your first question, no compression blocking is required to supplement the low compression resistance of the foam core because the horizontal vector component of the load is extremely low. In fact, if there is any danger of the SIP screws drawing the two skins closer and compressing the SIP, it would be created by extreme and deliberate over-tightening of the screws. The detail is similar in this effect to the standard SIP roof-to-wall connection (see “SIPs Construction Details,” at sips.org). The industry hasn’t yet seen any problems develop with this detail.

With respect to the load-carrying capability of the detail, yes, we are relying solely on the SIP screws in shear and on the OSB inner skin at the screw hole not to fail in compression. When the loads are calculated—for most buildings, this joint won’t exceed 500 PLF down force—it may be readily seen that the SIP screws and OSB are

Floor Attachment to Structural Insulated Panel (SIP)



Two ways to attach floor joists to structural insulated panel (SIP) walls. Wood joists should be attached to the wall with top-mounted hangers on an LVL ledger. Light-gauge steel joists can be attached to a metal track screwed into the inner skin of the SIP alone.

Illustration: Tim Healey

loaded well below their respective shear and compression capacities.

This can be most easily seen from examining the illustration (on the previous page) of the light-gauge-steel detail, in which no fasteners continue through from inner to outer skin. Clearly, the entire load is handled by the inner skin only. While there may be some lateral loads created by wind, which might threaten to exceed the withdrawal resistance of the screws, in practical applications with “normal” building geometries, these limits are in no danger of being reached with safety factors of 5 to 10 times failure mode. This is far greater than the common safety factor of 3 utilized by most structural calculations.

One interesting point in your comments is central to how SIPs work: The foam core keeps the skins from buckling, and therefore their ability to resist axial loading may be seen as decreasing their effective height, which is known as the “slenderness ratio” of l/r – length (or in this case, height) over least radius of gyration of the section. Yes, we are entirely reliant upon the adhesive that holds the entire assembly together. Do I fear for the integrity of the structure? More than 50 years of standing SIP structures tell us not to.

I might also mention that most of the commercial aircraft we fly in relies on construction adhesive to hold critical components together with no mechanical fastener back-up.

I must also note the following:

- SIPA has not officially endorsed this detail, although they also

have not forbidden it. Engineers at NTA—SIPA’s official engineering firm, which developed the organization’s Code Listings and Engineering and Design Manuals—have seen this detail and told me they see nothing wrong with it. This detail is “load-specific” and not to be used in a “prescriptive” application, only an engineered one. That is to say, the loads have been calculated and the design checked by calculation.

- We do specify the use of structural adhesives between the wood ledger or steel track and the OSB surface, but only to insure good surface mating. We discount their adhesive value by 100%, as field conditions (icing, sawdust, improper application) may render the adhesive useless. The mechanical properties of the screws and the OSB may be relied upon as they are mass-produced under rigidly controlled factory conditions.

- Finally, we do specify—and this was left out of the illustration—that should the SIP screw protrude ever so slightly (say, $1/4$ inch) past the inner skin of the ledger, it must be covered with spray foam to prevent condensation occurring. This condensation might drip onto the ceiling below and eventually show a stain, or—over a very long time, well past the service life of the building—rust the screw.

In closing, I would like to state that we have more than 50 of these buildings standing, some as old as 30 years, and none have indicated the possibility of failure due to this detail, and many more are on the drawing board.

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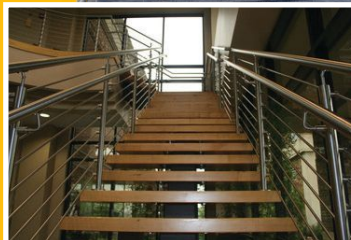
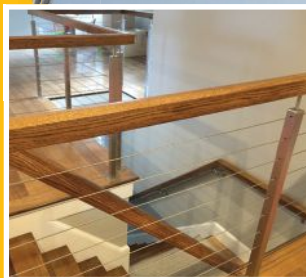
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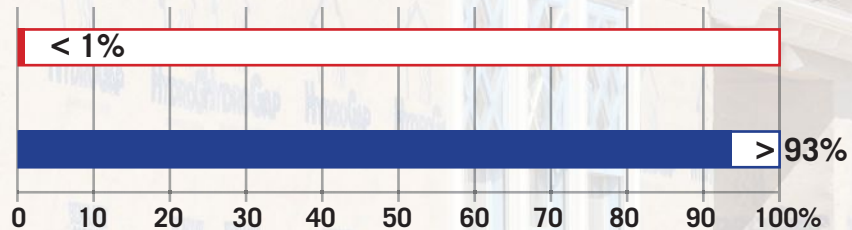
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NESEA Building Energy Bottom Lines

I have started working with a peer network that's an offshoot of my favorite builder's organization, Northeast Sustainable Energy Association (NESEA). One focus of this new networking group, dubbed Bottom Lines, is helping insure the future of our industry. The group operates much like other business networks: Members gather at one business at a time and delve deeply into finances, personnel, practices, and the like to identify areas of strength and weakness, and help the owner (or owners) develop a plan for improvement.

FOCUS ON PEOPLE

A unique aspect of this group is our focus on people. The question of *why* we stay in business is not typically asked at business training meetings such as these. But the way employees feel about a company can have a direct impact on the financial bottom line—happy crewmembers are more productive, do better work, and are apt to stay with a company longer. So this group asks the tough questions: Are the employees treated well? Are they paid at a level that allows them to live a good life? Are they provided with opportunities for growth and rewarding work?

The organizers of this group have thought long and hard about what makes their own businesses work and what the building industry in general needs. Each one

facilitates a Bottom Lines group of 10 or more companies. When I signed up, I didn't know what to expect. But I was attracted to the idea of mutual support and had tremendous respect for the group leaders.

My group, headed up by Paul Eldrenkamp (his company, Byggmeister, is also a member), has met at four different companies so far. I played host at the most recent meeting, and I'm still absorbing the things we discussed. I had been going through a rough patch in my business, and our meeting helped clarify some of the problems and opportunities I was facing. But the "people" part of this meeting was clearly the most important.

I had a difficult personnel situation with a long-term employee who was having trouble moving into a more supervisory role. His reluctance had alienated some promising crewmembers who had taken me a long time to recruit and hire. I was torn between loyalty and reality and wasn't sure what direction to take.

The meeting happened over two days. The first morning was spent in a roundtable check-in, sharing current issues and getting feedback and giving updates on past problems we've discussed. In the afternoon, we prepped for the deep dive into the host company—mine. The next day, we broke into groups of four for a series of interviews with people associated with my business, including an ex-employee now working on his own, a recent client, and my lumber salesman of two decades. After that, I was interviewed along with my three crewmembers—all individually.

The group then convened without me for a while, before inviting me back in. In the end, I got mixed messages about how to solve my situation. Some said to let the problem employee go immediately, while others said to define his role and see what happens.

TAKING ACTION

Since the meeting, I made the painful but necessary choice to let that person go. I may have come to that conclusion on my own over time, but it would have been a longer and messier process, and I wouldn't have felt the same clarity I got from discussing it with a group of peers I have come to trust and respect. As difficult as the decision was, it immediately had a positive impact on my business.

Another employee-related topic we've discussed



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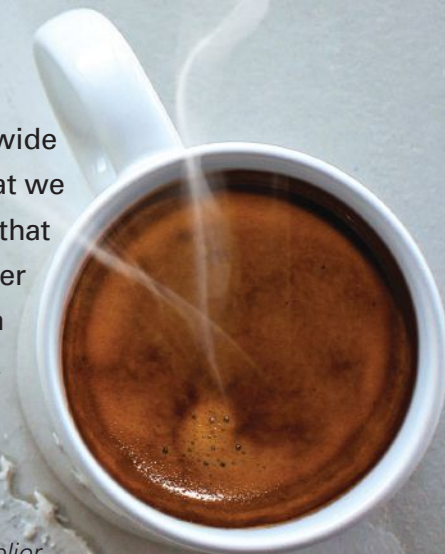


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Training the Trades

is wages. Using an online calculation tool (livingwage.mit.edu) developed by Dr. Amy Glasmeier of MIT, we looked at cost-of-living data from around the Northeast to see if our wages sustained our employees. For my area (Portland, Maine), a living wage varies from \$11 an hour for a single adult to \$24.50 an hour for an adult supporting a spouse and two children. I was pleased to learn I was paying wages that were significantly higher than the levels that my various employees happened to be at in their lives—and I offered significant benefits on top of that.

The Bottom Lines group is also working on lead-carpenter training, which should make a huge difference in companies' ability to advance employees and to recruit new ones. Recently, a group of lead field employees from companies around New England spent several days at Yestermorrow, in Vermont, laying the groundwork for what should be included in the training.

Though we all have different businesses and operate in different localities, we share many common issues. Finding and keeping new talent is an issue we all struggle with, and one that is always discussed at our meetings. As one member of my group, Steve Greenberg, of Steveworks, in Newton, Mass., says, "In our smaller groups, we are able to help each other solve our hiring difficulties and learn from each other about our 'people' policies. This has been of critical importance of late, as it's one of the major factors limiting company growth."

We have shared strategies—those that work and those that don't—and given each other advice on what to do about key or problematic personnel. Many of us have brought at least some of our team to the network meetings—interviewing employees is a critical piece of the site visits to each other's businesses.

While we can't magically create a supply of skilled workers, we can discuss how to attract those who are available and nurture growth in them. We are planning another summit this fall, and I'll be leading a workshop on finding the next generation of tradespeople, which continues to be a major issue under discussion.

Dan Kolbert is a building contractor in Portland, Maine. For more information about Bottom Lines, visit nesea.org/buildingenergy-bottom-lines.

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*Source: Dodge Data & Analytics 2015 SmartMarket Report - Green and Healthier Homes: Engaging Consumers of all Ages in Sustainable Living



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Q How do wastewater heat recovery systems work, and are they practical to install in a new home?

A Steven Baczek, a residential architect from Reading, Mass., who specializes in designing durable, low-energy homes, responds: Whenever we shower, we infuse water with energy to heat it, use it for about two seconds, and then send that warm water—and all that energy—literally right down the drain. It is estimated that somewhere between 80% and 90% of the energy used to heat water ends up going down the drain with the wastewater.

But it doesn't have to be that way. With a drain water heat recovery (DWHR) system, we can recover some of the energy lost as that hot water drains away. I try to talk clients into installing DWHR systems on all of the projects I work on these days. And because DWHR systems have no pumps or moving parts, require no regular maintenance, and add very little to an overall budget—all while offering measurable energy savings—my clients are quickly on board.

A DWHR system consists of a central drain pipe, usually copper, and a series of formed-coil pipes tightly wrapped around it. This type of system is sometimes referred to as a “double-wall heat exchanger.” The double-wall design ensures that the draining greywater never mixes with any of the incoming potable cold water.

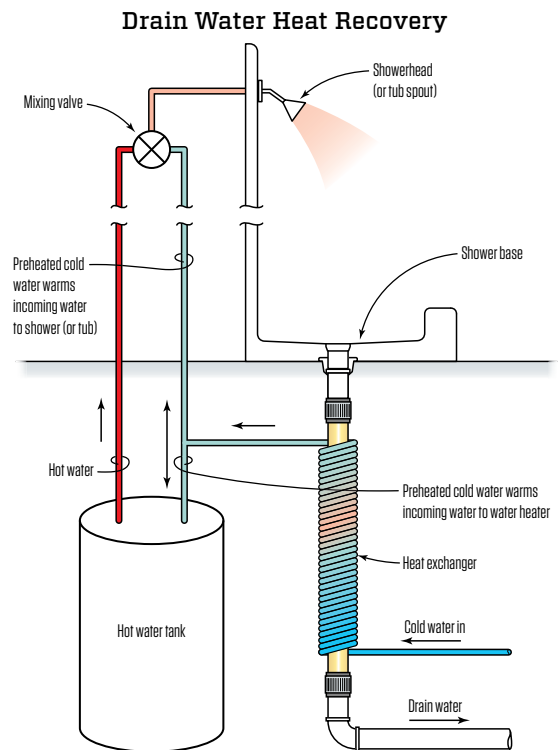
Because the system is mounted vertically, the warm greywater clings as a thin film to the inside of the drain pipe as it flows down and through. Heat from the wastewater is then recovered and transferred to the cold water coming in through the coils. Some companies boast a temperature rise as high as 25°F. While that may seem to be extreme, there is no doubt that the system does have a positive impact on the amount of energy used in heating water.

To plumb the DWHR device into a home's wastewater system, there are basically two setups. The first option runs the incoming warmed water directly to the water heater. On the drain side, the heat exchanger can be hooked up to one shower drain exclusively or possibly to a number of drains from fixtures and appliances that converge into a single drain. The perceived advantage of latter approach is having multiple drain outlets to recover heat from.

The most critical consideration to this setup is the length of drain systems before they converge into the

DWHR system. Longer pipes allow wastewater to lose more of its heat before entering the DWHR system, but continuous pipe insulation on the drain can help to counteract this loss. According to the experts, this arrangement seems to work best with at least three full-time occupants in the home.

The second configuration is more of a concentrated, or point-of-use, setup. It places a DWHR system directly downstream of the shower drain. The coiled pipes



As warm water drains from the shower, it clings to the sides of a central drain pipe. Incoming water runs through tight coils around the pipe and recovers heat from the drain water. The warmed water then feeds the water heater and the shower.



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Q&A / DWHR / Tinning Copper

from the DWHR system are then plumbed into the cold water supply for the shower. In this setup, the recovered heat is transferred directly to the cold water supply for that shower, which means that the water enters the mixing valve at a higher temperature, and less water from the water heater is required to raise the overall temperature to a comfortable showering level. The biggest advantages to this highly concentrated system are that heat losses from long lengths of drain pipe are completely eliminated, and the plumbing layout is straightforward.

There are many DWHR units on the market and costs can vary depending on the sizes of the pipes you choose. Most come in at less than \$1,000. Most companies say that you can recover the cost of a system in as little as two years depending on the energy costs in your area and on how much hot water you use. But regardless of the payback time, it's great way to save energy in a home, and the "set and forget" passive operation of the units makes them non-intimidating for your homeowner clients.

Q I enjoyed the article on copper roofing ("Installing a Flat-Seam Copper Roof," May/16). I have always "pre-tinned" copper panels before installing them. Is this necessary?

A Kyle Diamond, a partner in New Dimension Construction, in Millbrook, N.Y., responds: "Tinning" is the practice of applying solder along the edges of copper panels before bending them to create the interlocking edges that I describe in the article. Tinning helps to ensure that there are no voids in the soldered joints between the copper panels where moisture might be allowed to enter.

Tinning is essentially a way of creating a foolproof installation, and I'd recommend it as a good practice, especially for beginners.



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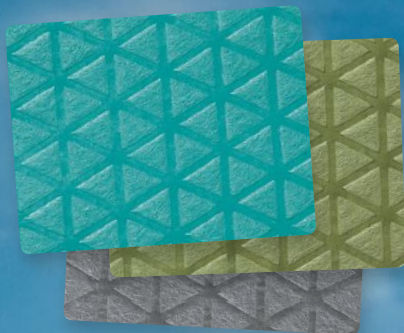
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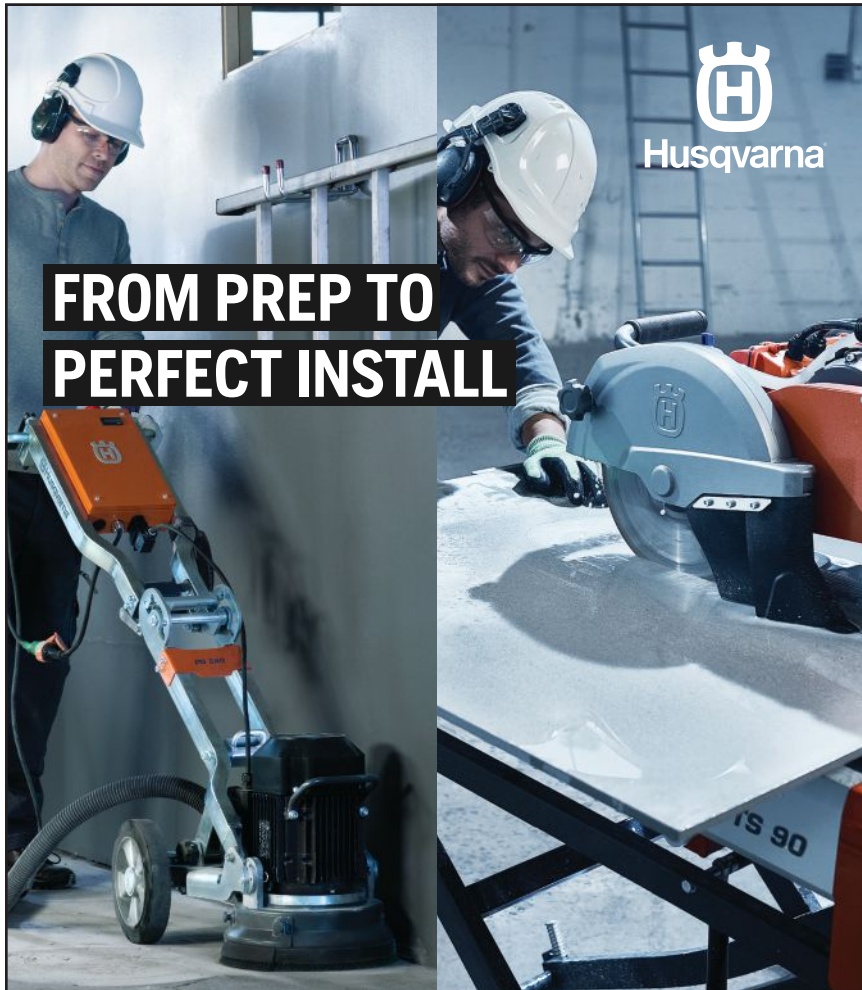


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Q&A / Tinning / In-Wall Toilet Tank

I have been soldering joints in copper roofing for years, and one of the biggest keys to creating successful and long-lasting solder joints is to control the heat of the soldering iron. I am also meticulous about cleaning the joints before applying the solder. Any contaminants in the joints, including debris such as sawdust, can be a recipe for failure.

Q I enjoyed the “Tiny Bathroom” article in the December 2015 issue. The toilet with the tank in the wall was very interesting, but was any access provided to get to the tank for future maintenance?

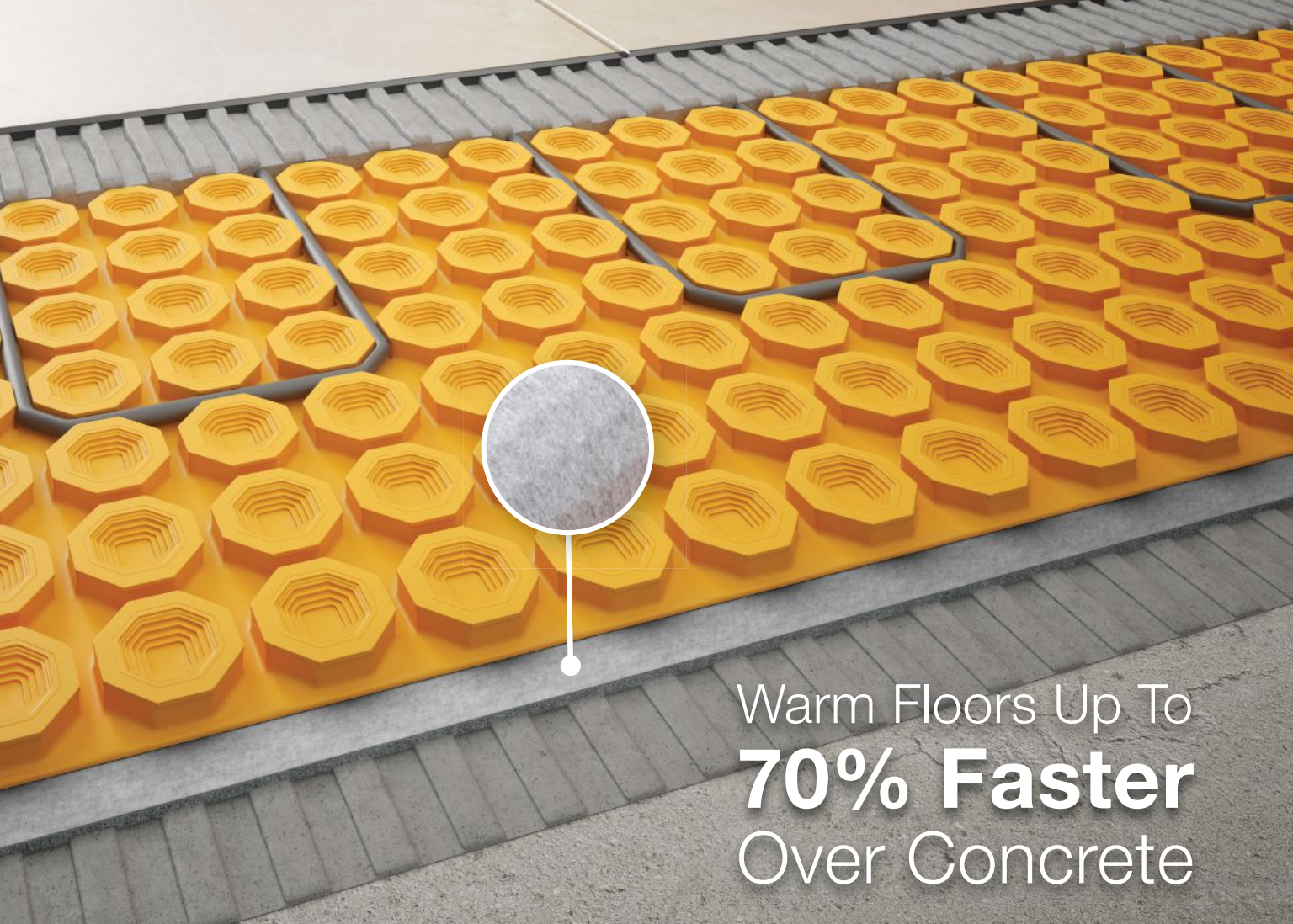
A Daniel Lewis, an architect based in Northborough and Centerville, Mass., responds: The in-wall tank for the Toto toilet was installed in a wall shared by a basement stairway. In that particular old house, the covering on the stairway side of the wall was tongue-and-groove beadboard. If a problem did develop with the plumbing connections, accessing the tank would be fairly easy and minimally invasive. But even if the tank were mounted on a wall with drywall on both sides, cutting open the wall to access the connections would still not be difficult. Plumbing connections concealed in a wall are also common with most shower valves (including the shower in the tiny bathroom).

As far as accessing the guts of the tank, that is done through the push plate where you activate the flush mechanism. The installation manual has detailed instructions for removing the plate and pulling out the flushing mechanism inside. So far, that operation has not been required; if it ever is, I would call on the plumber who installed the toilet. But the toilet has been working flawlessly, and I’m not banking on any problems for at least the next 20 years.



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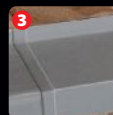
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BY GARY STRIEGLER



A New Take on Rolling Doors

I first saw options for barn-door (or rolling-door) hardware a few years ago, at a Custom Service Hardware booth at a trade show. So for my first rolling-door job, I gave them a call, and they set me up with everything from the track right down to the guides and stops. That first job led to several others, including one for which the client requested the look and function of a barn door, but without the decorative hardware. I decided to use pocket-door hardware—modifying the standard track and rollers—combined with barn-door guides.

I recently had a second chance to apply that method, to a pair of 15-light rolling doors at the entrance to a paneled study. The opening had a transom, and the mix of hardware enabled me to leave the transom completely open, without doors swinging into the adjacent hallway.

I made the opening 62 inches wide for the 32-inch door panels, which gave me an inch of overlap on each side—a prerequisite for any barn-style door. Adding the height of the door panels to that of the hardware and track, along with 1/2-inch for clearance space at the bottom gave me the height for the track. The length of the header over the doors was simply the width of the door panels times two, or 128 inches.

When I was done with the doors, the trim was painted to match the rest of the room. The exposed doors looked fantastic—it would have been a shame to have hidden them in the wall.

Gary Striegler owns Craftsman Builders, in Fayetteville, Ark., and teaches workshops at the Marc Adams School of Woodworking. His website is craftsmanbuildersnwa.com.

In preparation for mounting the track for the barn-style doors, the author drew a level line across the opening and onto the walls at the appropriate height (1). He then ripped a 2x6 in half and, using his line as a reference, centered the first piece on the opening and screwed it to the wall framing (2). Screwing the second ripped piece to the first with the bottom edges flush to each other (3) created a 3-inch-wide header to attach the track to.

Photos by Gary Striegler



Using a reciprocating saw, the author cut the track from a standard lumberyard knock-down pocket-door frame into 62³/₄-inch lengths for each side, which would leave a space for inserting rollers in the middle (4). The track sections were screwed to the split header flush with both ends and flush with the outside edge of the track (5); this positioning left enough space for the doors to clear the jamb casing when they opened and closed.

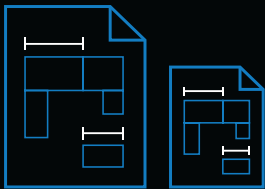
After screwing the roller hardware to the top of the door panels, the author slipped the first door panel into the track and leveled it (6). The rollers for the next panel slipped through the gap between the track pieces, allowing that panel to slide into the track on the other side (7). A tiny wrench that came with the pocket-door kit was used to adjust the height of the second panel until the two panels lined up perfectly (8). Adjusting the doors on the exposed track was much easier than adjusting a regular pocket door.

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To hide the track assembly, the author nailed trim to the header. Almost any kind of trim could be used, but for this project, a length of inverted baseboard created the first layer (9). Next, a layer of panel molding was added along the top edge (10). Wooden blocks ripped out of 1-by poplar were screwed in at both ends of the tracks as well as in the middle (11) to act as stops to prevent the rollers from dropping out of the track in the middle, and to keep the doors from hitting the trim returns at the ends.

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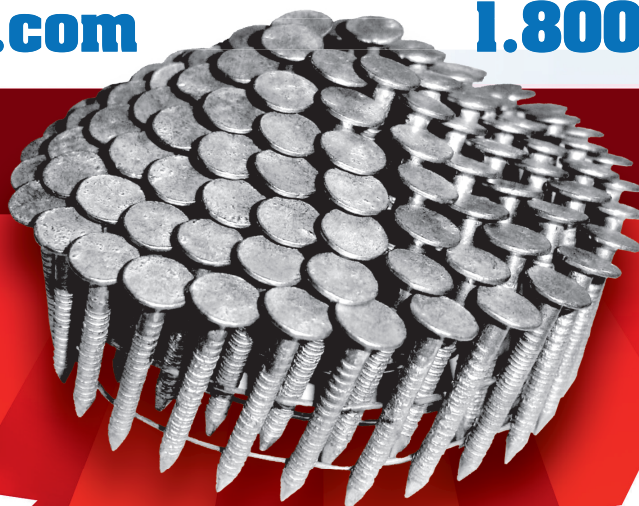
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BY MELANIE HODGDON

The Hidden Cost of Jobs That Linger

A client I met with recently expressed frustration with his cash flow. Since he'd been selling and producing jobs much more successfully than before, I was somewhat surprised, and together we started hunting for the reason.

Our first thought was that the latest job had been unprofitable. However, after I ran reports, it turned out that the job itself had been extremely profitable. In fact, because some costs had come in under budget, the job was actually among his most successful. Obviously, the problem wasn't poor pricing or cost overruns.

Then, he mentioned that the job had gone well but very slowly. Family matters had required his attention and the job dragged on well past its intended duration. As a contractor with modest sales and workforce, his jobs are done serially; that is, he finishes one job before starting the next. The job itself, taken in isolation, went great, but because its duration was longer than anticipated, the selling price that had been adequate to cover his overhead and profit for a given time period became inadequate when that time period was lengthened.

DON'T FORGET ABOUT OVERHEAD

As a simplistic example, let's assume a time period of seven units (see first chart, below). The units could be weeks, months, quarters; whatever is closest to your company's typical job length. To keep things even simpler, let's assume the following:

- estimated income for the period = \$466,667
- average achieved gross margin = 31.25%
- average overhead for the period = \$102,083

This produces an average net profit of \$6,250 per unit of time, after paying for overhead—very comfortable.

But let's see what happens when one of the jobs takes twice the estimated duration (see second chart, below). Instead of wrapping up in time period #2, this job continues into time period #3. The result is that there is twice as much overhead (\$29,166) for the same amount of gross profit (\$20,833), leading to negative net profit (-\$8,333) and the inability to cover overhead. Note that although achieved gross margins on individual jobs look fine, total revenue drops because fewer jobs are being completed in the given time period. As a result, overall profit drops and cash-flow challenges can occur. If this happened twice, or more, the results would be even more dramatic.

So beware of the hidden effects of allowing jobs to fall behind schedule. This is the reason that many contractors place an increased markup on change orders, because they know that change orders usually delay job completion, which in turn can reduce overall income. Paying attention to delays is necessary in order to maintain not only your schedule, but also a healthy cash flow.

Melanie Hodgdon is owner of Business Systems Management (melaniehodgdon.com).

	1	2	3	4	5	6	7	Total
Income	\$66,667	\$66,667	\$66,667	\$66,667	\$66,667	\$66,667	\$66,667	\$466,667
COGS	\$45,833	\$45,833	\$45,833	\$45,833	\$45,833	\$45,833	\$45,833	\$320,833
Gross Profit	\$20,833	\$20,833	\$20,833	\$20,833	\$20,833	\$20,833	\$20,833	\$145,833
Gross Margin	31.25%	31.25%	31.25%	31.25%	31.25%	31.25%	31.25%	31.25%
Overhead	\$14,583	\$14,583	\$14,583	\$14,583	\$14,583	\$14,583	\$14,583	\$102,083
Net Profit	\$6,250	\$6,250	\$6,250	\$6,250	\$6,250	\$6,250	\$6,250	\$43,750
Net Margin	9.38%	9.38%	9.38%	9.38%	9.38%	9.38%	9.38%	9.38%

	1	2	3	4	5	6	7	Total
Income	\$66,667	\$66,667		\$66,667	\$66,667	\$66,667	\$66,667	\$400,000
COGS	\$45,833	\$45,833		\$45,833	\$45,833	\$45,833	\$45,833	\$275,000
Gross Profit	\$20,833	\$20,833		\$20,833	\$20,833	\$20,833	\$20,833	\$125,000
Gross Margin	31.25%	31.25%		31.25%	31.25%	31.25%	31.25%	31.25%
Overhead	\$14,583	\$14,583	\$14,583	\$14,583	\$14,583	\$14,583	\$14,583	\$102,083
Net Profit	\$6,250	(\$8,333)		\$6,250	\$6,250	\$6,250	\$6,250	\$22,917
Net Margin	9.38%	-12.50%		9.38%	9.38%	9.38%	9.38%	4.91%

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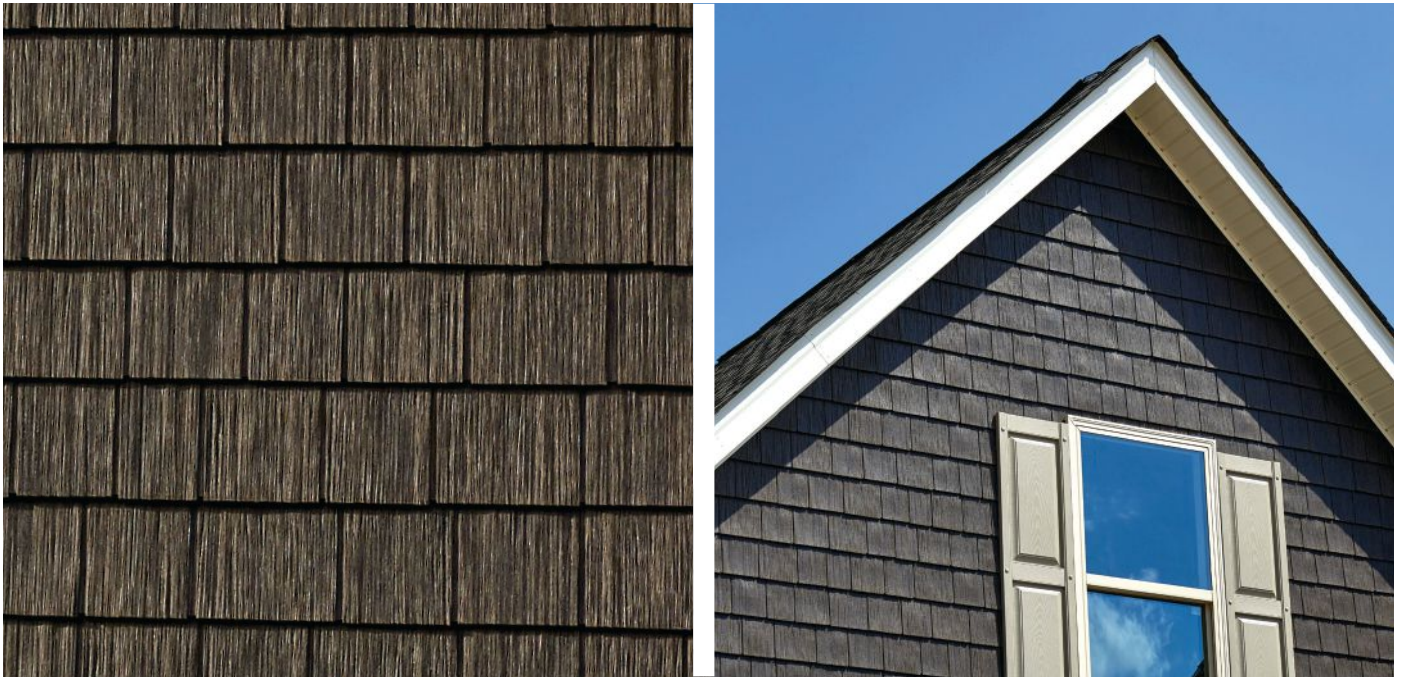


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BY GEORGE TSONGAS

Sheathing Damage From Using Wide, Impermeable Flashing



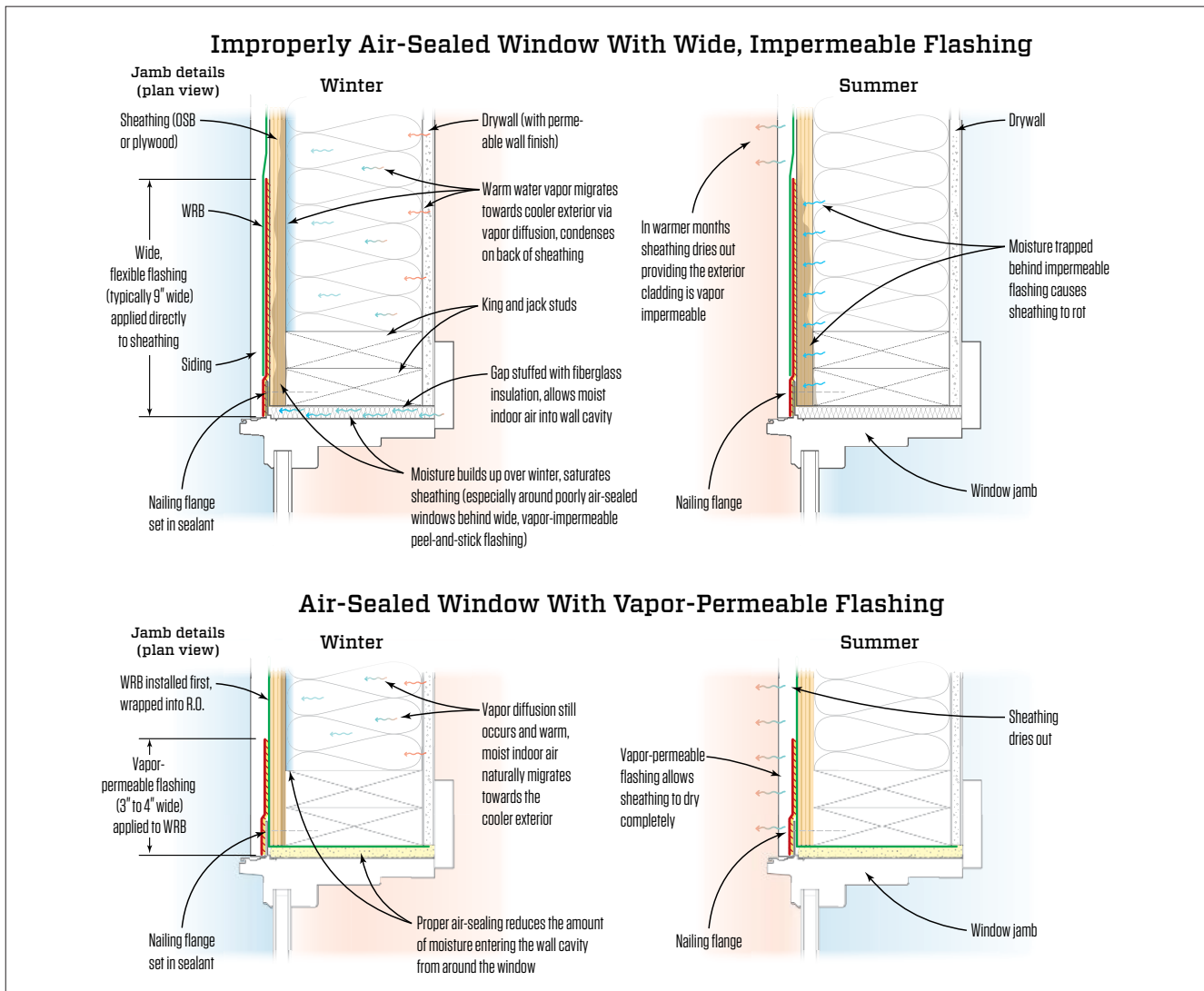
In cold climates, interior moisture can condense and saturate the sheathing from inside. Wide, impermeable flashing inhibits the drying that usually happens in the warmer months, and the wet sheathing is prone to rot. This photo shows a clear line between the rotted sheathing that was covered with flashing, and the sound sheathing that was able to dry properly.

Self-adhered, so-called “peel-and-stick,” flexible flashing materials are now used commonly throughout the country to prevent water penetration around exterior windows and doors. These flashings cover the joint between the window or door frame and the adjacent wall sheathing or WRB. For many years, non-stick, mechanically-attached flexible flashings, such as asphalt-impregnated kraft paper, have also been used. Both the non-stick and the self-adhered flashing materials are vapor-impermeable and do not allow water vapor to pass through them.

TRAPPING MOISTURE

The problem is that using any vapor-impermeable material on the outside of a wall cavity in a cold-weather climate can trap moisture in the OSB or plywood sheathing behind it and lead to serious mold and decay damage. Here's how that can happen.

During the winter months, when the air outside the house is colder than the air inside, warm water-vapor molecules move through the walls toward the cold via diffusion. In addition, interior air leaks into the wall cavity through various openings, particularly



In the top scenario, interior moisture migrates into the wall cavity and condenses on the sheathing during the winter months, especially around poorly air-sealed windows. In the summer, sheathing covered with wide, impermeable flashing cannot dry out and the sheathing rots. In the bottom scenario, proper air-sealing minimizes moisture migration in the winter, and narrow, vapor-permeable flashing allows the sheathing to dry properly in the summer.

gaps around poorly sealed windows and doors, carrying water vapor with it. The sheathing is the first cold, condensing surface that this moisture reaches, so it's where the water vapor condenses. Over the course of the winter, the moisture content of the wall sheathing slowly builds up.

Then, in the warmer months, the vapor migration stops, and the sheathing slowly dries to the outside as the sun warms the walls—if the exterior cladding is vapor-permeable. But where impermeable flashing has sealed the outside of the sheathing, it can't dry out,

and the moisture content in the sheathing continues to increase as the seasons cycle.

Winter temperatures are too cold for decay to occur (decay in wood is optimized at temperatures of 75°F to 90°F and doesn't happen below 50°F), but when the weather warms the wet sheathing behind the impermeable flashing, decay fungi can grow and damage the sheathing (see photo, previous page). Such damage occurs most often on north-facing walls, which are the coldest in winter and experience the least amount of solar drying in the summer.

Illustration: Tim Healey



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SOURCES OF MOISTURE

I've examined more than 1,500 wall openings from the outside looking for failures—during research projects that I've directed, as well as during inspections for court cases where I've been called in as an expert witness. These observations were done in 17 states as well as in Canada. In my experience, the type of damage I describe above can occur anywhere that the sheathing becomes cold enough for condensation to take place, causing the moisture content in the sheathing to build up.

Condensation of warm, moist interior air is the most common way for moisture to be introduced into the sheathing behind impermeable flashing. And in most cases, more water vapor moves into and through walls because of air leakage than diffusion, so poor air-sealing around windows and doors from the interior (which seems to be rampant in all parts of the country) definitely makes the situation worse. This is not the only source of moisture, however.

Another way that wall sheathing gets wet is from exposure to precipitation during construction. Applying impermeable flashing before the sheathing has dried completely can seal in that moisture and lead to sheathing damage behind the flashing. Self-adhered flashing should never be installed over wet sheathing, although it is often done in the name of maintaining building schedules.

Yet another source of sheathing moisture is water leaking through improperly detailed flashings and WRBs around window and doors. As with the other examples, this wet sheathing will not readily dry out if covered with impermeable flashing material. However, the primary purpose of the flashing is to prevent the sheathing from becoming wetted from the outside, so water leaks are not a common cause of moisture build-up in sheathing behind flashing.

It's also possible for more than one of these wetting scenarios to happen at one time, but again, in my experience, the biggest source of excess moisture in sheathing is from normal vapor diffusion and exfiltration of warm, moist indoor air. Any external wetting just makes it easier for the damage to occur.

MISLEADING INSTALLATION ADVICE

Wood decay typically takes many months, and often years, to become visible. And unlike decay caused by water intrusion from the outside—for which there's often visual evidence of damage within the walls—the damage behind impermeable flashing usually isn't seen unless the wall cavity is opened up, delaying detection even longer.

Many installers think that the ASTM recommendation also applies to self-adhered flashing, so it's not unusual to see wide, impermeable flashing materials used around windows and doors.

One problem is that the ASTM E 2112 *Standard Practice for Installation of Exterior Windows, Doors and Skylights* recommends the use of 9-inch-wide flexible flashing around openings. What's lost in the reading is that this recommendation is for older, mechanically attached flashings that are no longer widely used and that do not trap moisture as readily as self-adhered flashing. Many installers, however, think that the recommendation also applies to self-adhered flashing, so it's not unusual to see wide, impermeable flashing materials used around windows and doors. Ironically, the wider the flashing material, the greater the sheathing area that's not allowed to dry properly. When it comes to window flashing, bigger is not always better.

AVOIDING THE PROBLEM

To minimize the chances of damage occurring from trapped moisture around windows, you should always seal around windows with the narrowest possible self-adhered flashing. The American Architectural Manufacturers Association has released an updated voluntary standard, AAMA 711, that establishes minimum requirements for self-adhered flashing around windows and doors. AAMA 711 specifies a 4-inch minimum width, which puts just over 2 inches of the flashing on the actual sheathing (or WRB) after it is integrated with the window. Given the concerns expressed in this article, that 4-inch flashing width should never be *exceeded*, and the practice of covering entire walls with impermeable membrane is a surefire recipe for disaster. The 711 standard also specifies that the flashing not be applied to surfaces that are damp or wet, advice that is often not followed when construction occurs in wet weather.

Fortunately, there are numerous flashing products on the market that are 4 inches wide and a few that are only 3 inches wide. Using narrow-width flashing greatly reduces the potential for damage to the sheathing behind it. Furthermore, I think it is best to attach the flexible flashing to the WRB rather than directly to the sheathing, except at the head. That way, a thin air gap is maintained between the flashing and the WRB that allows some lateral drying of the sheathing behind them.

A better alternative is to seal around windows and doors with one of the vapor-permeable flashings on the market. Most manufacturers of these flashings recommend that their materials not be applied to wet surfaces. Yet another option that is gaining popularity is applying vapor-permeable fluid-applied flashing material, which is troweled onto the surface (see "Fluid-Applied Window Flashing," Jun/16). AAMA 714 covers such products and permits installation onto "damp" but not wet surfaces if the flashing material exhibits a permeability level of at least 10 perms at the recommended thickness.

Finally, regardless of what is used to seal the outside, contractors need to properly air-seal walls—especially window and door openings—from the inside. Doing so can minimize interior-moisture migration into the wall cavity and reduce the possibility of sheathing damage from trapped moisture.

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DISASTER RESISTANCE



A Practical Guide to Building in Seismic Zones Steel and framing hardware requirements demand a whole new approach to foundation and framing

BY TIM UHLER

Where I live in the Pacific Northwest, we regularly get news reports about earthquakes and the resulting tsunamis. In this seismically active region along the Cascadia Subduction Zone, which extends from northern California to British Columbia, any news of a catastrophic earthquake anywhere in the world is taken very seriously. In fact, to prepare for what many believe will be the inevitable “big one” here, some 20,000 government workers and first responders participated in the “Cascadia Rising Exercise Scenario” in June this year—a complex exercise designed to see how prepared the region is to handle a major seismic event.

Not surprisingly, builders here have to play their part, too. Each code cycle comes with more and more requirements for

keeping houses structurally safe. The majority of the seismic requirements fall on the shoulders of framers and foundation subs, whose primary role is installing a wide range of framing connectors and locating all the steel and hardware that needs to be embedded in the concrete.

In this article, I’ll walk through my experience on a recent project we completed near Seattle—a small but surprisingly complex project that I think is representative of the type of buildings increasingly in demand in our region. Its design—a two-story house that sits over a two-car garage “basement”—provides a convenient arrangement for a hillside lot. From a seismic perspective, however, the garage on the bottom floor creates a “soft story” that is prone to collapse in an earthquake unless it is reinforced

Photos by Tim Uhler

with a lot of steel—in the foundation and in the framing hardware that must be installed at every level to resist the extreme forces of seismic activity.

TAKING ON FOUNDATION WORK

On this project, the engineer designed the basement level to be formed full-height across the garage, meaning that the garage door headers would be poured concrete. The local building department was looking forward to seeing this constructed and required on-site inspections from the engineer of record (EOR), as well as from department officials.

Because so many details on this project had to be implemented correctly right off the bat at the footing and all through the poured-concrete basement-level walls, we elected to do all the foundation work on this house ourselves. We find that the more complicated the structural requirements in the foundation, the more cost-effective it is for us to do the forming. The job also runs more smoothly. In seismic country, there are more inspections, and doing the work ourselves makes it much easier to schedule them.

BLUEPRINTS AND ENGINEERING

A smooth-running job that comes in on budget starts with a good set of blueprints. If the plans are labeled and dimensioned clearly, then you won't need to pay the engineer for as much time—and he is by far the highest paid worker on the project.

On this particular job, the plans were well drawn. I once had plans on which the designer didn't dimension the walls very well—they didn't stack directly over each other, which would have resulted in hold-downs that stubbed up in the middle of a hallway. I don't recall the exact fix, but the memory of how irritated everyone became with this misdrawn detail sticks in my mind, enough so that comparing the different floor plans is the first thing I always do.

The RFI. Taking on the role of builder, as well as taking direct responsibility for the framing and foundation, we needed to be comfortable sending an RFI (request for information) to the engineer. In commercial work, an RFI is often a formal procedure. That's because any changes that come back from the engineer in response to an RFI are resubmitted to the building department, and all changes supersede the plans from that point forward.

In our case, an RFI is often a fairly informal process that goes roughly as follows: When I get the plans, I pore over them, paying close attention to which walls the engineer has designated as shear walls. I also look for what kind of hold-downs are in the walls and at how the load paths are traced all the way to the footings. Essentially,



To support the structure (1) all the footings were wider and deeper than usual **(2)**. To ensure exact placement of footings, the author tacks a nail and strings a line to mark the outside of the foundation wall **(3)**. This also allows exact positioning of the steel “verts” that are tied into the footings **(4)**.



The structural mat required two grids of steel, one sitting on rebar chairs and the other hung from 2x4s laid across the forms (5). The garage openings required a steel frame formed out of rebar within the concrete walls (6). To tie this into the footing, the rebar verts had to be positioned precisely (7).

I have to build the house in my head before we break ground. This is a crucial step.

If anything needs to be clarified with the engineer, I submit an RFI, requesting details and explaining why I need this information and when I need a response back. Often, the engineer either comes out to the job to answer my questions or sends me an email. Even if the changes do get submitted, the inspector doesn't always check on the new details—as he or she might need to on a commercial project—because the town doesn't always have time to dissect the engineering. Besides, ultimately it's on me, not the town, to get it right.

An RFI—whether as a formal procedure that supersedes the plans or as an informal clarification of details from the engineer—is critical. When details need to be verified by an engineer, and one little detail is not discovered until you are in the field, it can get incredibly time-consuming and expensive.

Our whole process has had to change as seismic requirements have gotten more complex. In the past, we weren't as concerned; we just framed the walls on the deck, sheathed them, and lifted them into place. Nowadays, we have to be very careful because we may not have the access we need to install all the required hardware, and we often have to stick-build walls in place to make sure we have enough room for the hardware. Our engineer constantly stresses to me the importance of making sure that anything to be embedded in concrete is located and placed precisely prior to the concrete being poured. Retrofitting a piece of foundation hardware becomes much more time-consuming and expensive.

FOOTINGS

The footings on this project were much more complicated to form than those we typically see. In order to support the lower level's full-height concrete walls, which were designed to support the two-story walls above the two-car garage (1), all the footings were considerably wider and deeper than usual. In fact, each run was a custom width and depth, and one area of the footings was poured as a structural slab (2). There was nothing regular about this job, which is why it worked out financially to form the footings in-house, rather than to sub the job out.

It took us about seven hours to form the footings. My process for laying out the footings was similar to that in an article I wrote a couple of years ago ("Building Stem Wall Foundations," Feb/13). But this time I used 2x12, rather than #2 1x6 pine, to form the 12-inch-deep footings. We still staked the forms every 4 feet; even though the 2x12 doesn't bow as easily as 1x6, we wanted to make sure the forms stayed in place during the pour. And we continued to work

to the same dimensional tolerances—within ¼ inch—for concrete work.

To build the footing forms, we started on a corner at the longest run. After building the corner, we marked the offset (the distance from the outside of the foundation wall to the outside of the footing) on the corner form board and tacked a 6d nail to this mark (3). We also marked the width of the foundation wall and labeled it. We then built the two runs out from this corner, squared those, and staked them straight.

When the opposite corner was built, we again measured for the offset and snapped a line between the marks at each corner across the top of the stretchers. This line (repeated for each run of footings) represented the outside of the foundation wall in all locations. Having this line minimized the math and need for constant measurement. Since all the runs had different offsets, we depended on having an easy visual reference. It also made it easy to know exactly where to run the vertical rebar when it came time to tie that in, before pouring the footings.

It took us the day to run all the footing forms. The next day, we finished staking the footing and then raised it to exact level all the way around using our Stabila LAR250 laser level.

REBAR

We had a lot of steel to tie in the footings; some runs had three #4, some had four #4 bar with shorter pieces perpendicular to the longer runs (the engineer called longer runs “longitudinal” and the shorter bar “transverse”). The following are a couple of rebar details in the footing that required special care:

Structural mat. We needed to tie two mats of steel in a structural footing that was 9 feet 3 inches wide by about 16 feet long. We had ordered our rebar precut so all we needed to do was assemble the mats, which we did using our Max rebar tying gun.

Of these two steel mats, the lower one had to be 3 inches off the ground. We first laid the longitudinal and transverse rebar within the lower mat, tied it together, and then supported the mat on chairs.

Next, we tied together the second mat and held it down 2 inches from the top of the form on 2x4s that we laid across the top of the form to span the width.

We had one hold-down bolt to locate in the structural mat. Again, having nails tacked showing the location of the stem wall made this easy. We tied in the hold-down bolt and also dug out underneath it to make sure it had proper embedment.

“Verts.” We needed to tie the shorter vertical steel—“stubs” or “verts”—into the footing at a specific spacing. Per the engineer’s notes, these needed to be placed with



After footings were poured, cleats were installed on the green concrete with “Teco” nails (8). The position of the horizontal runs was spray-painted on the rebar that would be used for the verticals (9) in the rebar gridwork for the walls (10). Before the formwork, the crew positioned the anchor bolts (11).



The forms were left off to allow inspection of the portal frame (12). To install a Simpson Strong-Wall in the front wall, a template first needs to tie into the foundation (13). The engineer specced beams under the shear walls that had to be drilled out for hold-downs (14).

the hooks alternating direction (4). Since we had snapped lines across the top of the 1x4 spreaders, we knew exactly where to place our verts in the wall. We then placed a long stick of rebar on top of the cleats, tying the verts to this, as well as into the footing steel (5). The Max rebar gun made this easy work.

Garage portal walls. The garage openings required a massive amount of steel to create a moment frame within the concrete (6). In the narrow portal walls, the vertical steel on this frame had to tie into the footing steel. I used a 2x12 cut-off to lay out the position of the steel for these verticals and drilled it out to hold the steel precisely where we needed it in the portal walls (7).

FOUNDATION WALLS

After we finished placing the footing concrete, we ran a dry line—using the same 6d nails that we'd placed in the form boards to mark out the position of our foundation walls—and set spreader cleats for the foundation wall forms (8). We used 1½-inch x .131 Teco nails to keep the cleats in place on top of the green concrete.

Before placing the forms, we had to tie full-height vertical steel onto the verts that were tied into the footings. We first took our precut bar and spray-painted the horizontal layout (9). This made it easy to get the exact spacing, and it made it easier for the engineer of record (EOR), who served as the special inspector for the town, to inspect the steel placements.

Using our rebar tying gun, we very quickly tied the vertical steel, one man scattering and holding the bar while the other man tied it off; it took only about 15 minutes to tie off the verticals for the entire foundation. After lunch, we spent a little over an hour tying the horizontals in place (10). We were able to speed up the process of tying in the horizontals by ordering full-height 30-inch-by-30-inch corners. This way, we didn't need to bend them on site—which the engineer also wanted to avoid because that can cause small cracks on the rebar. It also allowed us to plumb the corners before tying two runs together and helped us keep the rebar centered within the wall section, which was also critical from an engineering standpoint.

As a last step before setting the wall forms, we tied in the hold-down bolts (11), using the layout defined on the plans to locate the hold-downs precisely. We installed the forms around the garage portal walls and header last, keeping them open until the engineer inspected them (12).

At the garage opening, we also had to lay out the template and tie in the large bolts for the Strong-Wall wood shear walls (13). These Simpson Strong-Tie panels were specced by the engineer and were needed in the wall

frame above the garage door opening to provide shear resistance next to the cantilevered nook that would be framed in (see photo 1, page 52).

The Simpson shear walls are pretty cool. They were originally a Weyerhaeuser (I-Level) product and we used them in 2009, before Simpson acquired them. They give you more flexibility for drilling holes in them to run electrical than you would have in site-assembled shear-wall sections. They can be ordered in heights up to 141 1/4 inches and cut to length in the field (see photo on page 51).

Bracing forms. Once the formwork was erected, the last step was to brace it all off and build scaffolding for placing the concrete. I also tacked a 6d nail and strung a line for the J-bolt locations. I measured this out, too, wanting to make sure none of them landed where an I-joist would sit.

Concrete mix. The engineer specified minimum 3,000-psi concrete for the portal walls. I ordered a mix that would be 3,500 psi from the batch plant. The city where we were doing this work required that we have a special inspector on site to take samples during the pour so that the strength could be verified; the first strength test, at seven days, showed 4,200 psi.

FRAMING

As framers, we need to know the plans inside and out. When studying the plans for the first time, I like to start at the roof and work down and make sure I understand how everything will be supported. Only then can we build from the bottom up.

On this project, I had to make sure to trace the interior shear walls from the top floor all the way down. The engineer had located beams *under* the shear walls in the frame that were bolted down to the top of the foundation walls. We had to drill through the beams and run the threaded rod up through them either to a hold-down above or to a nut and washer (14). Because we went from 2x6 walls over 5 1/2-inch beams to 2x4 walls on the upper floor, I needed to make sure I kept the plane on the front wall consistent. Again, good plans helped us identify these details early on.

With the exception of the drilled beams, the floor framing on the main floor was straightforward. To simplify the foundation work, we asked the engineer if we could run the portal walls straight and eliminate the foundation jog (one that mirrored the jog in the framed wall above in the original plans). He approved that change, and we designed the front cantilever beam to hang off inverted and offset hangers (15). We then framed the cantilevered walls where the foundation originally had jogged, saving a lot of time.

After the rim was on, we had to install A23 framing



The front cantilever beam required inverted and offset hangers (15). A23 corner brackets secured the mudsill to the rim joist (16). Strapping was nailed on before the walls were lifted whenever possible (17), and hangers were fastened to the beams before they were lifted into place (18).



angles—the ubiquitous framing angle required in seismic country to maintain load paths every 16 inches from rim to mudsill (16).

On the main level, we had some special details on the cantilevered wall. This wall was full of windows, without much sheathing, so the engineer specified a lot of strapping to tie it all together. We sheathed the walls before lifting and were able to install most of the strapping before lifting (17), so we didn't need to get on ladders later.

Production framing in a seismic zone is largely a thing of the past. You can't expect to speed through the framing and then install the hardware. Instead, we typically need to install hold-downs and strapping as we are installing wall and floor sheathing. In several locations on this project, we had to leave off a panel of sheathing so the inspector could see the hold-down. We sometimes have to wait for this inspection before the next stage of framing, or we lose access to the hold-down.

It is possible to be efficient, though. For example, we think ahead as much as possible, so we left room for a positive placement gun to speed up the process of installing the hardware. On the upper floors, we installed all the hangers on beams before lifting them into place (18), which saved time. But that's not always possible. On the rear 2-foot cantilever, we had to install hangers to the rim joist upside down, and we had to do it after installing the rim (19).



On the upper floor, we framed rake walls first (20), then the rest of our exterior walls, again adding all our strapping before lifting. With the rake walls in place, we set the ridge, then balloon-framed a two-story shear wall below part of the ridge. This balloon-framed wall locked everything together and was helpful, as we could use fewer wall braces when we framed interior walls (21).



On the rear cantilever, the rim was secured with inverted hangers (19) that had to be installed after the rim was in place. On the upper floor, rake walls were installed first (20), allowing the crew to set the ridge. Then a two-story balloon-framed wall was installed below the ridge (21).

VITAL COMMUNICATION

Close communication with the engineer and the other trades is vital. Everyone involved must talk together to understand what's required and to make suggestions or clear up any misunderstandings. Sometimes, what we have to build needs to be adjusted, because of plumbing fixtures or the need to get insulation into framing cavities. Those details need to be figured out ahead of time. Constant cooperation is necessary; no one trade by itself, including the engineer, will have everything figured out ahead of time. Sometimes, there is a better way to build things, and having a good relationship with your engineer will make it easier to suggest and work out an equitable solution for all.

Tim Uhler is a lead framer for Pioneer Builders, in Port Orchard, Wash.

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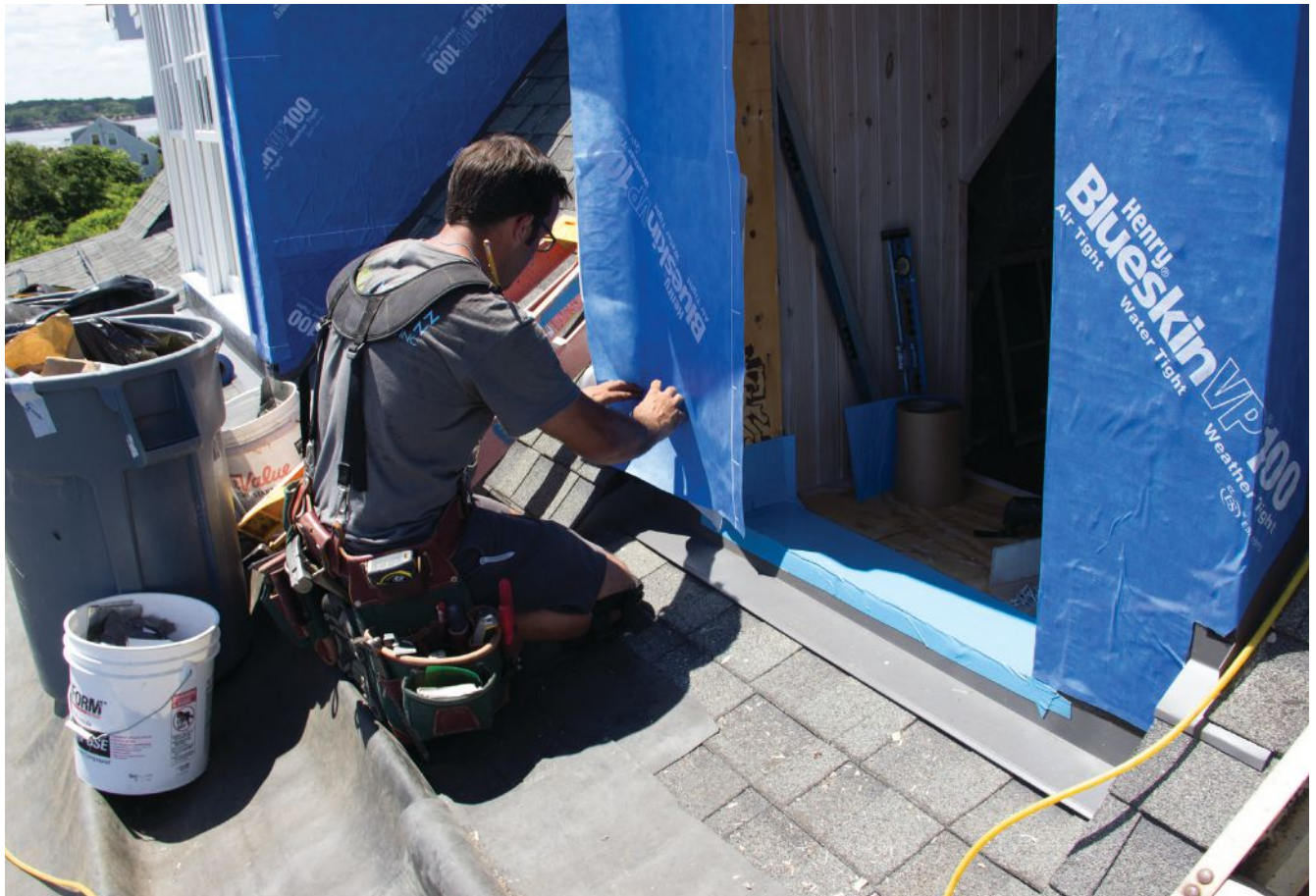
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EXTERIORS



New Skin for an Oceanfront Dormer Advanced membranes help this house face the elements

BY TED CUSHMAN

Dormers are a tricky cladding problem in the best of circumstances. If the dormers in question are facing the ocean on the shore of an island on the coast of Maine, it gets tougher. In July, *JLC's Coastal Connection* went up on the roof with Mark Pollard, lead carpenter for Thompson Johnson Woodworks, on Peaks Island, Maine, to watch Pollard deal with the dormer-flashing challenge.

The dormers shown here are exposed to rough conditions in every season: baking sun in summer, snow and ice in winter, and wind-driven sheets of rain just about year-round. These dormers were part of the Cape roof of a house built in 2001. The homeowners reported water damage to sheathing, windows, and room interiors upstairs caused by the intrusion of wind-blown rain.

When the siding was stripped, Pollard found a collection of improper construction details, including reverse-lapped housewrap and flashing. The owners approved a plan to re-clad the dormers entirely with a rainscreen system. In the next few pages, you can see how Pollard waterproofed the rough windowsills with Grace Ice and Water Shield and Zip System membrane, re-flashed the intersections between the different roof slopes using site-bent vinyl-coated aluminum flashing, and installed new flashing at the dormer-to-roof intersections and at the bottom of the window opening before applying vapor-open self-adhering Henry Blueskin weather-resistant barrier material to the wall. Over the Blueskin, he applied MortarVent rainscreen material to allow free drainage for any wind-driven rain that might penetrate behind the siding.

Photos: Ted Cushman and Mark Pollard/Thompson Johnson Woodworks

NEW SKIN FOR AN OCEANFRONT DORMER



When his crew stripped away the wood shingles, Pollard discovered that upper sheets of Tyvar were lapped behind lower pieces, which in turn were lapped behind the window head flashing (1). Flashing was also reverse-lapped at the base of the windows (2), but the bituminous membrane applied by the roofers had helped to protect the house. The windows showed clear signs of water damage at the top (3). And plywood sheathing on the dormer face, which is exposed to the worst of the wind-blown rain off the ocean, also was discolored by water intrusion (4).

REVERSE LAPS

As the photos here show, the carpenters who originally built the house had made a few classic water-management mistakes. At the window head, the Tyvar housewrap was reverse-lapped, so that any moisture penetrating the wood-shingle siding could find its way behind lower layers of housewrap and onto the top of the window—and indeed, the window showed tell-tale water stains and mildew damage.

“Whoever did the roof was the hero,” said Pollard, “because they did such a good job of sealing where the water was getting behind the shingles. It was the Grace Ice and Water Shield on the roof, lapped up onto the dormers, that saved the house.”

Eventually, the homeowners did become aware of the dormer wall leaks, said Pollard: “They knew something was up, because this

window wouldn’t close very well. And inside, where they have just a pickling stain on the window trim and the wall beadboard, it was starting to get black at the bottom of the sash. So they knew the rain was penetrating.”

In a few areas, in fact, the water did begin to make its presence known downstairs. “Under the middle dormer,” Pollard said, “they noticed damage in the first-floor ceilings.”

Pollard and his crew stripped away the original cedar shingle siding and the Tyvar housewrap, but left the Grace Ice and Water Shield in place. The Ice and Water Shield is not breathable, Pollard noted, but the plywood behind it appeared to be sound. And the water-tight, vapor-open material applied to the rest of the dormer, he hoped, would be enough to enable the whole dormer to stay in good condition going forward.



Pollard fabricates a two-piece flashing out of coated aluminum coil stock and then seals the seams from the back with tape. Holding the two pieces in place, he marks the lower piece for a cut (5). He then applies tape to the back (6). A closer view of the finished piece (7) shows how the Zip System tape applied to the back covers the entire seam of the two-part assembly. Holding the finished flashing in place on the roof (8), Pollard demonstrates how it will fit around the dormer after he nails it into position under the roofing shingles. Later, the adhesive-backed Henry weather barrier will lap down over the metal.

THREE-DIMENSIONAL FLASHING

Flashing for the intersection of a dormer and a roof is tricky. You can't make the required shapes by bending a single piece of metal, but two-piece metal-flashing buildups typically have leak points. Last year, *JLC* presented contractor Kyle Diamond's method for making a one-piece dormer corner flashing out of two pieces of bent copper soldered together (see "Best-Practice Apron Flashing," Mar/15). Mark Pollard's method uses vinyl-coated aluminum coil stock instead of copper, and he seals the seams with Zip tape.

For this job, Pollard started by snipping and bending two pieces of aluminum: one that would lie flat on the main roof below the dormer, with a bent leg extending up the dormer face, and a second piece that would lie to the side of the dormer, with a leg up the side wall and a flap bending around the dormer face. A short vertical leg

on the side flashing piece serves to direct flowing roof water past the dormer corner.

Holding the two pieces in position, Pollard temporarily stuck them together with a piece of tape across the face. Then he flipped the pair over and taped the seam on the back. In service, the hidden tape joint serves the same function as solder in a soldered copper flashing. Removing the temporary tape from the front, Pollard slid the flashing under the shingles against the dormer cheek and face, blind-nailing it to the roof (where roofing shingles would cover the nails) and to the dormer cheek (where housewrap and siding would cover the nails).

Said Pollard: "I made a bunch of these two or three years ago and I threw them out behind my shed. Just left them. Just to see if I could trust it. And they're sticking like crazy, so ..."



To prep the window opening, Pollard and Strout started by applying Grace Ice and Water Shield to the sill (9), sealing the material down onto the asphalt roofing shingles beneath the window. Next they laid a site-bent piece of aluminum coil flashing over the membrane (10), with a bead of sealant under the flashing to block wind-blown rain. Over the membrane and flashing, Strout nailed cedar shingles to create a slope for drainage (11). Then Pollard applied an additional membrane (12)—this time, using Henry WB25, a vapor-closed polyolefin membrane laminated to a modified-bitumen backing.

WATERPROOFING THE SILL

The windowsills in the dormers received a double peel-and-stick membrane and metal flashing sequence. First, Pollard applied Grace Ice and Water Shield to the rough framed sill, extending the membrane down onto the shingles that butt up to the dormer face, and using small pieces to patch gaps at the window corners. Then he installed a piece of vinyl-coated aluminum flashing, bent into the windowsill and lapping onto the roofing below the dormer. He fastened the flashing down onto the sill using stainless steel nails.

Pollard applied a bead of silicone sealant to the prepped windowsill before nailing the flashing in place, explaining: “The Ice and Water Shield and the silicone are here to stop the wind off the ocean from blowing heavy rain up under the shingles and into the wall from underneath.”

Next, Pollard (helped by carpenter Tyler Strout) attached wood shingles to create a shallow pitch on the sill, in order to direct water down and out in case the window itself leaks in a driving rain-storm. Then he applied a strip of Henry WB25 window and door flashing membrane (a polyolefin film laminated to rubberized asphalt). As with the Ice and Water Shield below the flashing, Pollard used small pieces of the membrane to patch small seams or holes at the corners.

Henry WB25 requires a proprietary primer, Blueskin Spray Prep, that comes in a rattle can. It’s applied like rubber cement: You spray the surface (in this case, the wood shingles), then let the primer tack up and dry before you peel the backing off the membrane and stick it down. WB25 has a split backing tape to make it easier to position and apply, especially in corners.



To protect the dormer walls, the crew applied Henry Blueskin VP100, a vapor-open, weather-resistive, adhesive-backed barrier membrane. Here, Pollard stuck the Blueskin to the dormer cheek after peeling back a portion of the release-paper backing (13). Using the same technique, Strout and Pollard worked together to stick the membrane to the dormer gable (14). After installing the window, they used narrow strips of Blueskin to seal the window head flashing to the wall (15). Finally, Pollard attached MortairVent rainscreen fabric over the Blueskin to create a drainage and drying cavity (16).

HOUSEWRAP AND WINDOWS

With the windowsill waterproofed, Pollard and Strout went about protecting the walls with Henry Blueskin VP100, a waterproof, vapor-open membrane that comes with a peel-and-stick adhesive backing. In the photo on page 59, Pollard is smoothing the Blueskin onto the front face of the dormer (note the small “bow-tie” patch of WB25 protecting the lower corner of the rough opening).

Compared with mechanically-fastened housewrap, Pollard pointed out, Blueskin can be easier to install. Instead of trying to hold the roll of material with one hand and nail or staple it with the other, the worker can peel off a small piece of the split-release backing and position the sheet by adhering it in a few places before peeling off the remainder of the backing. For a permanent bond, it's important to hand-roll the sheet with a rubber roller.

Pollard and Strout wrapped the Blueskin VP100 into the window opening, then set the pre-cased window in place (first laying a bead of silicone adhesive behind the side and top casings). Above the window, they applied a typical cap flashing, then taped the flashing to the wall with a 4-inch strip of VP100. Following Henry's printed instructions, they applied a bead of silicone sealant to the seam where the window-top strip lapped onto the Blueskin on the wall.

Pollard's last step before installing new wood siding on the wall was to apply a layer of MortairVent rainscreen material, an open-weave synthetic fabric that creates a $\frac{3}{8}$ -inch drainage space behind the siding.


Ted Cushman is a senior editor at JLC.



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CARPENTRY

Building Custom Doors on Site

Success comes from having a fast and easy method to join the rails and stiles and a super-flat surface for the glue-up

BY MARK LUZIO



Photos by Mark Luzio

Large sliding passage doors on guide rails—often known as barn-style doors—have become a popular detail in custom houses. Often these doors are oversized, calling for a custom door slab.

In this article, I want to demonstrate how it is possible to build large custom doors on the jobsite. I have run my own custom woodworking shop for many years and have a standard collection of industrial machines. But here I'll focus on how to build a large panel door with only the tools available on the jobsite. On many jobs, this on-site shop would be set up in the soon-to-be great room of a new house and typically includes a contractor's table saw, a small planer, and a router with a table mount. One key extra tool is essential for making the structural joint on a large wood door: a Festool Domino XL, a hand-held joiner that cuts oval mortises to fit Festool's "domino" tenons. A basic set of clamps is also required for the glue-up.

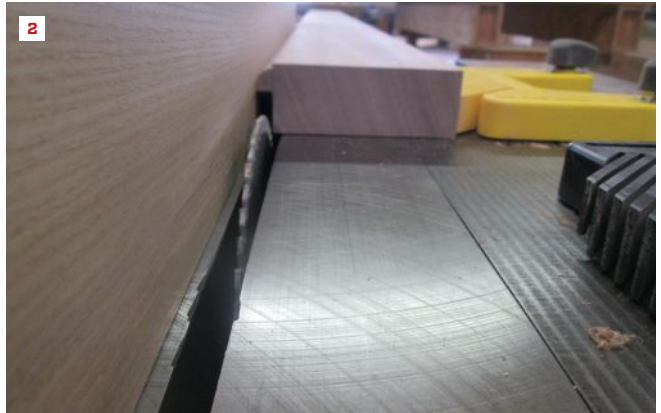
The last requirement in my jobsite shop is a set of box beams, which I make myself.

SWISS BEAMS

I learned the value of these beams 35 years ago while working in a co-op shop in Brooklyn, N.Y., with Stefan Rohner, a young Swiss cabinetmaker. He taught me the method of making them from a single sheet of 3/4-inch shop-grade plywood.

I start by ripping four sides, each 6 1/2 inches wide by 96 inches long. The pieces need to be straight and parallel. A Festool track saw would be a good option for making these rips, or a careful two-person rip on a decent jobsite table saw can work.

Using portable power tools on a simple jobsite setup, it's possible to make a custom door slab. The trick is creating a strong joint between the stiles and rails, which is done here with a Festool Domino. The author built this sliding passage door out of Utile, an African ribbon-stripe mahogany.



Starting out with dimensioned stock, the author uses a $\frac{7}{16}$ -inch quarter-round bit set to depth for a $\frac{1}{8}$ -inch step to mold one edge of each piece of the stile and rail stock (1). When you're cutting the panel rabbet in the stiles and rails, it's critical that the step in the molding and the edge of the rabbet are in the exact same plane. To accommodate small discrepancies in the cut, he leaves $\frac{1}{32}$ inch of material on the door, so he has room to adjust later when cutting his jack miters (2). Making the initial cut for the jack miters is the trickiest part. He uses a plywood sliding table to crosscut the miter, doing a test cut on a piece of poplar to get the depth exact before making a finish cut on the mahogany (3).

Next, rip four tops and bottoms, each 4 inches by 96 inches. The outside dimension of each beam will be 4 inches by 8 inches.

The beams are fairly light, which makes them easy for one person to move on and off the job. But in order to work, they must be absolutely square and stiff, and so the light, plywood sides need midspan support. I make five or six spacer blocks for each beam. These must be exactly the height of the $6\frac{1}{2}$ -inch side and $3\frac{1}{2}$ inches wide. Builders know that all plywood varies in thickness, so be very precise in measuring and cutting your blocks so the beams will finish square and true.

Before assembling the pieces, predrill all your parts, then glue them together as you assemble. The end result will be a super-straight set of beams. If both beams are the exact same dimension, you can get a perfectly flat surface. As a last step for my beams, I rip out 4-inch-wide strips of fiberboard (such as Homasote) and

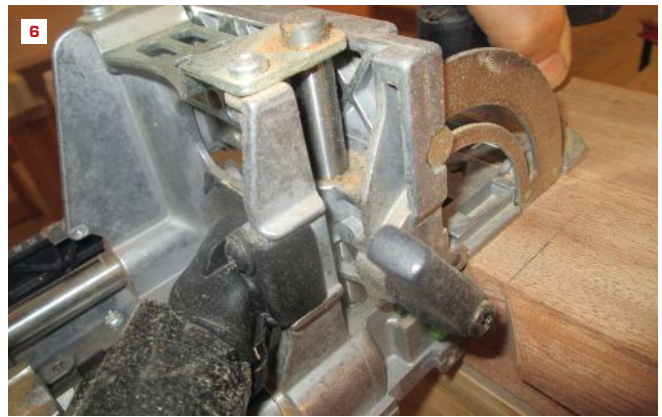
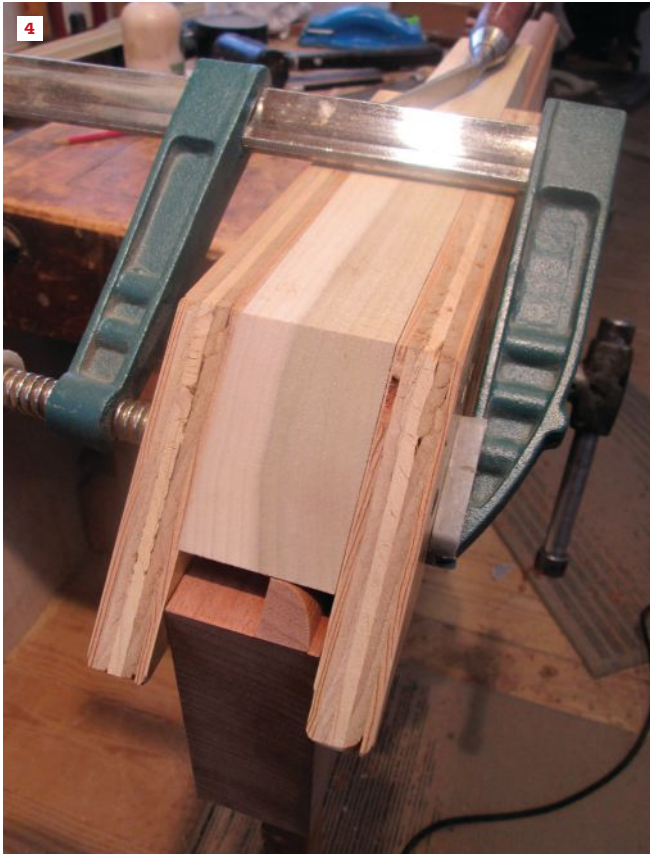
screw these to the top surface, countersinking so the screw heads are below the surface. This makes a no-slip, no-mar surface.

In my opinion, full-size tables or work benches are wasted space in any shop. If I do need a large table for a layout, I just drop a 4x8 sheet of MDF on the beams. The beams also make a great press for laminating thick stock (which I used in my article "Curved Paneling for a Circular Room," Aug/16). For this job, they are used for the layout and for cutting the mortises with the Domino. They are also set up true and flat for the glue-up of the door.

THE WORK PROCESS

I make traditional $1\frac{3}{4}$ -inch-thick doors with a $\frac{7}{16}$ quarter-round milled onto one face. I use a bead mold to hold the panels, which are applied with a brad nailer after the doors are glued up.

The key to building a door efficiently and accurately on site



To fine-tune the jack miters, the author makes a “shooting block” (4), which serves as a guide for a back bent chisel. The plywood sides of the shooting block register exactly with the very end of each rail. (On the stiles, the plywood sides register with the layout lines that mark the exact end of the shoulder). Once you shoot the miter, the whole joint closes up tight (5). Once the jack miters are cut, use the Domino joiner to cut two mortises in the end grain of all the rails and in each shoulder on the stiles. The outside mortises on the shoulders that meet the top and bottom rails are cut “normal”—that is, the joiner registers on the flat part of the shoulder (6).

comes largely from the Festool Domino. It’s easy to use, but it’s not immediately apparent that it will work on stock with molded edges. Most of the how-to videos shown online demonstrate the tool on square-edge stock. I have built hundreds of doors, most of which have been specced by architects or designers, and I can remember only very few that had no edge molding. However, with a simple jig and because the tool can make fairly deep mortises—up to 2³/₄ inches deep—it is possible to cut the tenons on doors with molded edges.

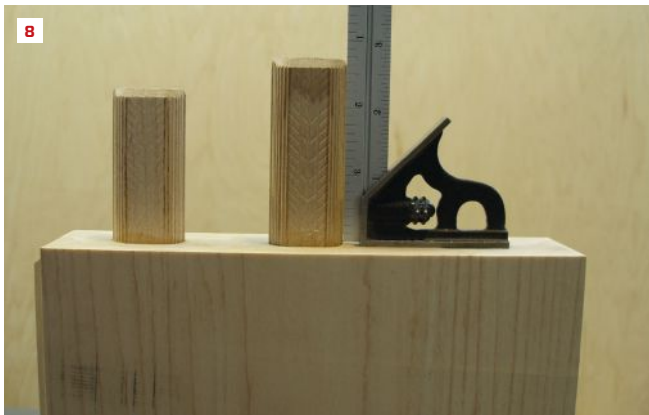
The general work process goes like this: I do all my fitting on the frame (stiles and top, bottom, and lock rails) before I use the Domino. After I cut the mortises, I dry-fit the frame, and then fit the center stiles. At that point, I glue-up the door; sand, scrape, and prefinish; then install the panels, locking them in place with an applied bead molding.

CUTTING THE PARTS

To build any door, it’s critical to start with straight and true stock, which is not easy to find in today’s world. For this job, I found some nice quarter-sawn Utile, a ribbon-stripe mahogany from Africa. I started with stiles and rails dimensioned to 5¹/₂-inches wide with a 6¹/₂-inch lock rail.

Install the 7/16 quarter-round bit in the router and adjust the depth for a 1/8-inch shoulder step. Lay out and mill the appropriate edges. To keep track of all my parts, and to mark out which edge I will mold, I use triangles. It’s the best method for marking parts; they establish top, bottom, left, and right, all with one pencil mark.

Panel rabbet. Next, cut the rabbet for the panels. It is very important that the rabbet is exactly in line with the shoulder step because at each joint, you will cut out the molded edge, and the plane of the step and the plane of the rabbet will meet. Unless this



For cutting the inside mortise on the stiles, the author makes this simple jig with a $\frac{7}{16}$ -inch block (to match the depth of the molded edge) and an extra domino tenon (7). The two mortises in the shoulder both get cut full depth, but because one is made off the block and the edge molding, the tenon needs to be cut $\frac{7}{16}$ inch shorter (8). When all the mortises are cut, the tenons get glued into place, allowing for an easier dry-fit (9).

surface is a true 90 degrees, the door will never glue up flat. It's difficult to make this rabbet perfect with a jobsite table saw, so I always aim for leaving the stock $\frac{1}{32}$ -inch fat—that is, the wood left on the door after you cut the rabbet. (If you overcut the rabbet, however, there's no way to close the joint.) This allows you to plane back to the exact layout line. I do this with a pattern bit in a router and a straightedge. More on that soon.

I cut the stiles to $\frac{1}{8}$ inch over the finished length. I cut the rails to exact length (which I can afford to do only if I am absolutely careful to allow for the removal of the round-over molding on the stiles).

In a large shop, you might want to cope all the rails, but I prefer to jack miter all the joints, and on the jobsite it's by far the easier method. Coping requires some expensive machines and tooling.

To cut a jack miter, I set the table saw blade to bevel at 45 degrees, and crosscut through the molded edge with the stile or rail on edge.

A sliding crosscut tray for your table saw is a good jig for making these cuts. (I recommend using a kit from Woodcraft or another woodworking catalog. These include plans and resin glides that are already dimensioned to fit the crosscut grooves in the table saw.) Even with the sliding table, these cuts are tough to do well. It's hard to see exactly where you are cutting. Don't rush this. I always do a test piece on a scrap board and aim to make the final cut $\frac{1}{32}$ inch fat so I have a little meat to work with. I can fine-tune the cut when I fit the door. The finish cut must extend precisely to the shoulder endpoint. I cut the miters in the stiles first and remove the excess molding with a router and a pattern bit.

The fine-tuning on the jack miter can be made with a shooting block and a back bent paring chisel. (Woodcraft sells a few nice back-bent chisels. Once you own one you will find that it is always your "go-to chisel.")



Once the frame is dry fit and clamped, the author knows the exact length for the center stiles, so these can be cut (10). After the glue-up (11) comes scraping and sanding. As most woodworkers know, it's vital to get every speck of glue off all the exposed faces of the door, otherwise the finish will be absorbed unevenly into the wood and the glue will stand out like a sore thumb.

The shooting block is an "old school jig" in that it dates back to the beginning of joining wood moldings. I start with a piece of stock that's the exact same width as the door stock and about 10 inches long. This center piece has one end cut at 45 degrees and fits between two plywood sides that are also cut at 45 degrees. These sides hang below the center piece so the jig can be slipped over the edge of the door. The 45 on the plywood extends out in front, so you can line the jig up precisely on the layout mark for the end of the shoulder, while the 45 end on the center piece serves as a guide for the chisel, allowing you to maintain a perfect 45 as you precisely shave the jack miters. When done correctly, the jack miter on the rail comes precisely to the end of each rail, and the jack miter on the stile comes precisely to the end of the shoulder.

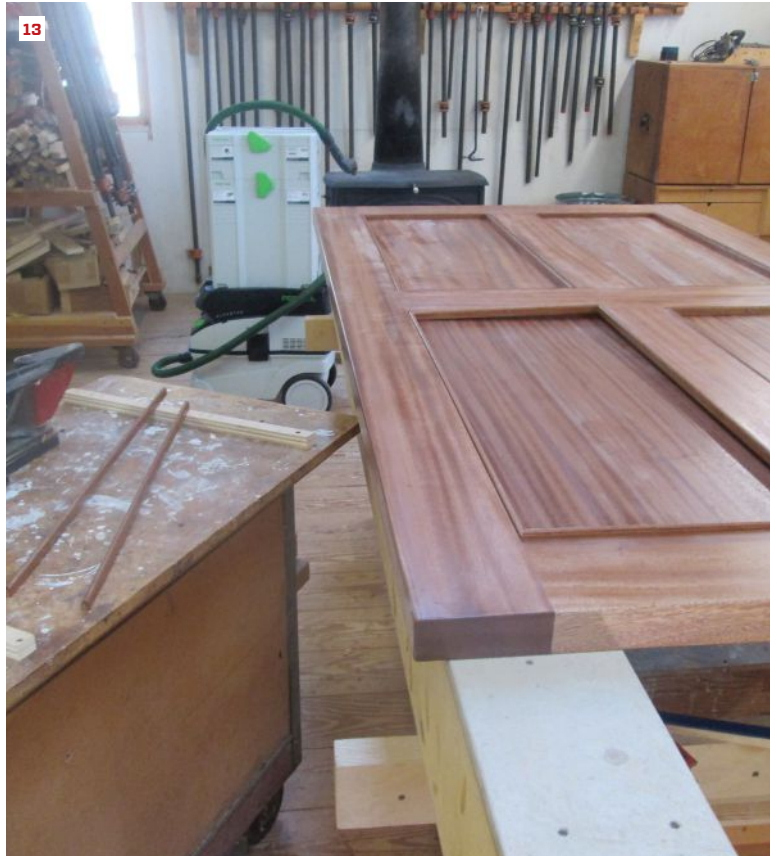
Mortising. With the jack miter trimmed exactly, you can now get out the Domino joiner. I lay out and cut the tenons in the end grain of the rails first. The Domino allows you to create two different width mortises (13.5mm and 16.5mm). I cut with the smaller size in the end grain of the rail for a tight fit, and with the larger size in the stiles to provide a little adjustment "float." This simple feature is important, as it allows for much-needed play during glue-up and accommodates wood movement over time.

At the position of the top and bottom rails, the outside mortise on the stile can be cut normally, as the machine registers on the flat part of the shoulder. But for the inside mortises, the machine runs into the moldings. I solve this by making a small block $\frac{7}{16}$ inch thick (the depth of the molded edge) and fit it on the end of an extra domino. I push this into the existing outside mortise for making the inside mortise, cutting to the full depth of $2\frac{1}{4}$ inches. When the joint is completed, one domino tenon will be $\frac{7}{16}$ inch shorter than the other.

Center stiles. I need to dry-fit and clamp the frame so I can fit the center stiles. I begin by gluing the domino tenons into the rails, then I clean up the glue and let those dry.

I set up my beams on sawhorses, checking to see they are flat and





The door is too big to be cut to its finished size on a table saw. Instead, the author uses an MDF straightedge to guide a pattern bit to square the door to its final dimension (12). He then cuts the panels and prefinishes all the pieces with an initial coat of finish before installing the panels with an applied bead molding (13).

true and that there is no twist caused by the horses sitting at odd angles on the floor.

Measuring off the assembled frame, I cut the center stile to exact length and fit the jack miters. Until the frame is assembled, there's no way to know exactly where these center pieces will end up.

GLUE-UP AND FINAL FINISH

The glue-up always goes fast so you need to be completely prepared. A complete dry-fit beforehand allows you to work out any kinks before the glue is spread. This is when you need to work out a clamp pattern, as well, so pressure gets applied evenly as you draw the pieces tight.

After the glue-up, I let the door dry overnight. In the morning, I scrape and sand. It goes without saying that getting every speck of glue off the door face is essential for a clear finish.

Squaring the door. This door is too large to square up with a jobsite table saw so there are two options: a Festool track saw or an MDF straightedge and pattern bit. I used the latter method on this project. If your pattern bit is too small, as mine is for this thickness door, make a full-depth cut, flip the door, and finish with a spiral flush trim bit.

Panels. The last step before finishing is to cut the panels. I prefinish all the pieces before installing these. I install the panels into the rabbet and secure them in place using a bead molding. I cut small molding like this using a manual miter trimmer (for example, a Lion Trimmer), which allows for a tight fit and saves me the hassle of making a special fence for my miter saw. It's also quiet, so I can enjoy my favorite Swiss jazz station on internet radio.

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



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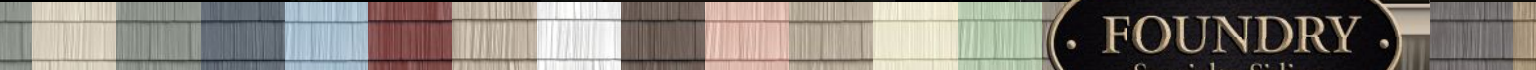


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ENERGY



A Habitat Energy Makeover Donated labor and materials made this building-science feat feasible

BY NATE ADAMS

Who knew Habitat for Humanity doesn't just build new homes? I found out early this year, when I got a call from Scott Craven, the construction manager for Habitat for Humanity of Portage County, Ohio. Scott's Habitat chapter normally builds new homes, and Scott found my website while looking for help with this rather tricky existing house. In Ohio, I learned, Habitat is bringing cutting-edge thinking to retrofit work—and proving that you don't have to be rich to do deep energy retrofits.

My company was a good match for this project. Over the last decade, I've evolved from an insulation salesman, into an insulation contractor, into a home-performance consultant. Today, my business brings current building-science thinking to the diagnosis and improvement of existing houses. Using a consultative approach, we start with a full energy audit, applying accurate energy modeling.

We then recommend and implement a complete home-performance package: high-performance envelope details, appropriate HVAC upgrades, and air-quality assurance. When we're done, we "test out" to verify the effectiveness of our work—often, as on this project, installing data-logging instruments to monitor energy performance and air quality over time. What follows is the story of the diagnosis, design, and most of the energy work on this Habitat project.

Habitat had originally acquired this home because it fit the requirements of a disabled client who wanted a small home with an open floor plan in a city full of older homes. Sadly, the client passed away suddenly—and the house sat empty while Habitat looked for another client who would be a good fit. Houses don't like to sit: They get wet. So when the project started up again, we had a few extra things to deal with. But on the plus side, we had plenty of volunteer labor, as well as some donated materials (including roofing and rigid

Photos by Nate Adams



After sitting unoccupied while Habitat for Humanity searched for an appropriate owner, this old one-story house represented a “perfect gut opportunity” for the organization’s volunteers, the author says. But moisture and energy issues were a big challenge. The home’s measured air leakage was off the charts (1). The dirt crawlspace created a huge moisture load for the interior (2). Mechanicals in the basement were fully depreciated (3), and the roof showed obvious moisture damage (4).

XPS insulation). And we had something of a blank slate: We would be able to make the most of the existing open plan, “cathedralize” the ceiling to make the small volume feel light and spacious, aim for very low air leakage, and design our HVAC solution from scratch.

DIAGNOSIS AND DECISIONS

In March, I inspected the house with Scott Craven and conducted an energy audit. The tiny cellar with its 6-foot ceiling extended under only a quarter of the house. The rest had a low dirt crawlspace. The whole thing was surprisingly wet. Steel Lally columns were rusted through. The furnace and water heater had been red-tagged by the gas company as a hazard. The ductwork was literally being held together with Saran Wrap. A perfect gut opportunity!

In his 2005 book, *Water in Buildings*, University of Illinois research architect Bill Rose noted that every home he has inspected with a

dirt crawlspace had moisture problems in the attic. This house fit the pattern: The roof sheathing was moldy, and in some locations, rotten. Our plan would have to address the moisture issues.

Next, we ran a blower-door test. This was one of the leakiest homes I’ve ever tested. As a rule of thumb, we’ve found that a blower-door number roughly equal to square footage gives us enough control to solve client problems (that is, a 1:1 ratio of leakage to square footage). This house is only 720 square feet and its blower-door result was a whopping 12,000 cubic feet per minute at 50 pascals (cfm50)—a 16:1 ratio. To be fair, the house was completely gutted, so the real ratio was likely closer to 4:1. Still, a house that leaky is a major challenge.

So here was our situation: The house had substantial moisture problems, it needed complete insulation and HVAC systems, and we had a limited budget. But we did have lots of volunteer labor. I wondered at times if I had bitten off more than I could chew.

MODELING THE ENERGY OPTIONS

Package	Blower Door Target (cfm50)	Heating Btu/hr/sf	Cooling Btu/hr/sf	Heat Load	Cooling Load	Package Cost	Annual Savings	% Savings
Baseline: Old and leaky, R-11 in attic	2,500 (actual)	33	13	23,837	9,561	\$0	\$0	0%
Package 1: Typical weatherization	700 (estimated)	15	5	10,841	3,810	\$12,965	\$388	69%
Package 2: Foam board plus spray foam, very airtight	110 (estimated)	8	6	5,634	4,480	\$14,200	\$506	72%
Package 3: Adds heat pump water heater and ventilating dehumidifier	110 (estimated)	8	6	5,634	4,480	\$19,500	\$671	77%
Package 4: Omits rigid roof foam, less airtight	400 (actual)	11	7	8,166	5,019	\$19,500	\$612	75%
Package 5: Adds triple-pane windows	110 (estimated)	7	4	5,392	3,160	\$22,000	\$690	78%

TREAT modeling software, which the author trusts based on past experience, created savings projections for several retrofit proposals. Based on costs and benefits, the author chose Package 4. The model had assumed very low air leakage (110 cfm50), but the actual Package 4 airtightness (400 cfm50) still resulted in a major improvement over the baseline.

THE DESIGN PUZZLE

We have developed what we call a “comprehensive planning process” that helps break complex problems down into small bites. Beginning with a baseline energy audit, we apply iterative energy modeling to help develop the best path to success, given client problems, objectives, and budget.

My initial thought was to tackle the house with traditional weatherization tactics: Air-seal the attic, dense-pack the walls with cellulose, and put a vapor barrier down in the basement. But the likelihood of a good leakage result with this approach was low, and it failed to address the existing attic moisture problems. We needed to dig deeper. We turned to iterative energy modeling, using TREAT energy-audit software from Performance Systems Development (psdconsulting.com). (TREAT stands for Targeted Retrofit Energy Analysis Tool.)

As we modeled various pathways, a thorough air-sealing of the whole enclosure emerged as the best option. In this case, that meant spray foam. It would cover the moisture problems and encapsulate them, thus eliminating a remediation problem we didn’t have a budget for, and at the same time, would solve the Swiss-cheese leakage problem. As long as we were sure to consistently dry the building before sealing it up, moisture issues should remain licked. Spray foam also provided 72% greater modeled energy savings compared with the standard weatherization package and allowed us to confidently use very small heating equipment. Finally, spray foam made the project drywall-ready quickly—a volunteer drywall party was breathing down our necks.

ENVELOPE

Our initial design would have treated the roof and walls the same: 1 to 2 inches of spray foam inside (primarily for the air-sealing benefit), with rigid foam outside for the insulation benefit. The rigid foam was donated by Dow and would be installed with volunteer labor. Our final implemented package increased the roof-deck spray foam and deleted the exterior foam on the roof. The additional spray foam cost more, but this approach avoided the complexity and time of applying foam board to the roof.

The spray foam was not as effective an air-sealing solution as I had hoped. But after the foam was completed and we put a cover on the basement door in the rear, the house was at about 1,500 cfm50. At that point, we did additional air-sealing with a one-part gun foam. I depressurized the house and looked for misses and low spots. That brought it down to about 1,000. Then, I used theatrical smoke and pressurized the house, observing where the fog blew out. The Habitat volunteers helped find the leak points, and I sealed them one by one.

After two rounds of touch-up air-sealing, we got the house down to 440 cfm50 before drywall. My very optimistic target of 110 cfm50 was not likely to happen. I was disappointed about that, but it was still an excellent result: This may be the tightest house in the county. These numbers also imply that the 700 cfm50 target for the non-foam weatherization package was wildly optimistic: I would have been lucky to get this house close to 1,000 cfm50 using traditional methods. Spray foam put this home’s heating and cooling load well within range of our chosen HVAC solution.



The author turned to spray foam as a one-pass insulating and air-sealing solution. The foam quickly addressed major air leaks like the big gaps between pieces of the existing board sheathing (5). Volunteers added donated rigid XPS insulation sheets to the exterior (6) to augment the R-value of the wall system. Spray foam in the basement cut the heat loss to the ground, as well as limiting the building's vapor load. A foam application sealed the ground vapor barrier to the wall (7). A fog machine (8) helped to identify remaining air leaks for point-sealing with one-part gun foam.

ENERGY AND AIR QUALITY

In a house this tight that also had previous moisture problems, we wanted to be sure that it would have sufficient dehumidification in both heating and cooling seasons. Our usual choice for managing fresh air and humidity is a ventilating dehumidifier—a device that brings in fresh air to the duct system and dehumidifies as needed, any time of year. It then distributes the air throughout the home using the duct system. (For this project, the unit was kindly donated by Ken Gehring and Thermastor.)

Combined with a media filter on a central duct system, the ventilating dehumidifier lets us control humidity and particulate matter (PM_{2.5}). Research indicates that by controlling humidity, we help to control volatile organic compounds (VOCs), as well (see, for example, Dr. Richard Corsi's work at the University of Texas). The home should have excellent indoor air quality (IAQ) by design.

In the past year or so, we have begun monitoring some of our project homes using Foobot IAQ monitors. We have noticed that VOC levels spike along with humidity—confirmation of how important good dehumidification is to comfort and IAQ.

With this fresh-air supply technique, the temperature of incoming air can be a comfort problem. Because we lost some of the tempering capability of an HRV/ERV, we ran extra-long uninsulated duct through the basement to help temper the incoming air.

Shown on the next page is the ventilating dehumidifier in the basement. On the right is a 35-foot-long intake line. Nearby is the motorized damper to open and close the intake at high and low temperatures. The "T" allows fresh air to go directly into the HVAC system and bypass the dehumidifier when dehumidification is not required. We have dampers everywhere so that we can easily adjust and balance the system during commissioning. There is also



The author's preferred HVAC solution for high-performance homes is a central heat-pump system, coupled to a fresh-air intake and dehumidifier (9). A long fresh-air-intake duct in the unconditioned basement helps to temper the incoming air for comfort. Dampers open and close the air intake in response to temperature conditions and prevent unwanted backflow through the dehumidifier. Because the roof was insulated, some ducts could also be routed through the attic (10).

a backflow damper between the dehumidifier and the air handler so that air can't short-circuit through the dehumidifier when it's not operating.

Our TREAT calculations estimated a heating load of 8,166 Btu/hour at 5°F for the insulating and air-sealing package we installed. We trusted that estimate because we've tracked actual system run-times on other homes, using Ecobee thermostats, and we've established that TREAT provides reasonably close projections (typically within 10% or 20% of actual performance).

By comparison, the industry standard Manual J, which contains a variety of "fudge factors" in order to prevent undersized systems, seems to overstate the load by 50% or 60%, particularly in high-performance homes.

The main reason we need accurate calculations is to match the equipment output to the operational requirements. We want the smallest equipment we can possibly install, while still ensuring the house can stay at 70°F on a 5°F day. Also, we want to design the equipment to be running at low stages as much as possible, because that's more efficient.

And there are other important reasons not to oversize the equipment: People are comfortable when equipment is running; fresh-air supply, filtration, and dehumidification occur when equipment is running; and cycling losses don't occur if the equipment doesn't shut off. There is also a thermal mass effect: Slowing down the addition of heating or cooling into the house allows walls, ceilings, and floors to equalize in temperature better. This leads to remarkable comfort.

If equipment is oversized, we lose those benefits. We find that oversized equipment is frequently a root cause of client comfort and moisture problems.

But right-sizing can be difficult. Typically, HVAC manufacturers don't offer equipment that matches the loads of high-performance, small homes. For example, the smallest commonly available furnace is 40,000 Btu—large enough to heat a 2,500-square-foot home. Heat pumps come with smaller outputs, but even the smallest two-stage heat pump can be way too big when operating on its high setting of 24,000 Btu/hour. Even the 14,000 Btu/hour low setting is still a bit high for this house, but it was a compromise we needed to make.

This is our fourth all-electric project, and we've been tracking the projects' usage and energy costs. We've found that air-source heat pumps have similar (and sometimes lower) energy costs compared with natural gas. Part of this is thanks to eliminating the gas meter (homeowners pay \$25 per month just to be connected); this savings alone offsets \$300 a year in electricity cost. And of course, the all-electric solution avoids the risks associated with fuel combustion inside the dwelling.

Generally, I prefer the highest-end heat pumps (we really like Carrier's GreenSpeed heat pumps). But that didn't fit this home's budget. In this case, a Habitat discount from Goodman allowed us to install a very nice 16 SEER two-stage unit for less than what a basic single stage would normally cost.

At 24,000 Btu/hour, I expect the heat pump alone will likely handle the heating, even at 0°F. Sadly, it is still substantially oversized; but the other choice was mini-splits, and there was no way to get good, fresh, filtered, and dehumidified air with mini-splits without installing a dedicated duct system for fresh air and dehumidification. And having said all that, the system we ended up with is much closer to matching the load than any furnace would have been.

WHAT WE'RE LEARNING

With this project, we are excited to continue challenging some common beliefs in the green-building world:

- *Air-source heat pumps don't work in cold climates in existing homes.* We have client feedback and system data indicating surprising success in our climate.
- *High R-values are necessary for a deep energy retrofit.* Our data and experience has indicated a range from R-17 to R-20 does an amazing job.
- *HRV/ERV is needed to temper incoming air.* We're using a ventilating dehumidifier because HRV/ERVs don't manage humidity well. In high-humidity climates, HRV/ERV equipment can introduce significant moisture loads, which then must be addressed. With long duct runs and tight equipment sizing, tempering shouldn't be an issue. The ventilating dehumidifier fits the bill 100%.
- *Balanced fresh-air strategy is best in cold climates.* With a tight house, pressurized dehumidification provides better air quality and summer drying potential than a balanced fresh-air strategy.
- *Mini-split heat pumps are good whole-house solutions.* We use central ductwork with a standard-split heat pump and provide excellent filtration, dehumidification, and central fresh-air distribution. In addition, we track air quality with Foobots. What that has told us is that the approach we recommend works very well. By contrast, our prior experiments with mini-splits have resulted in sub-par outcomes.

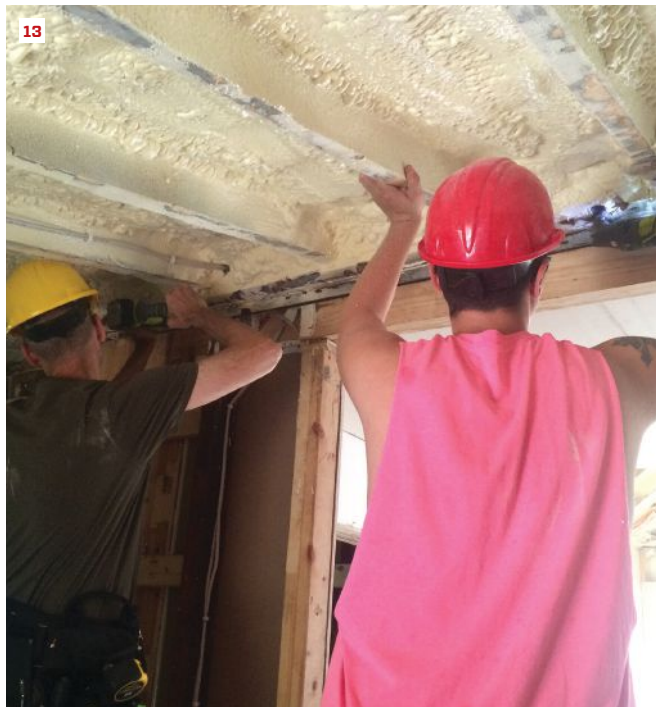
RADICAL TRANSPARENCY

If we mess this project up, the public will know it. We're going to be data-logging the house with the following tools:

- **Foobot Indoor Air Quality Monitor.** This measures temperature, relative humidity, particulates (PM2.5), and chemical pollutants, and logs the data every minute. (Thanks to Foobot for the donation.)
- **Curb Energy Monitor.** This tracks whole-house energy usage.
- **Ecobee EMS-02 Thermostat.** This controls the heat pump, the fresh-air damper, and the ventilating dehumidifier. The only data-logging thermostat on the market, the Ecobee logs runtime and stage, outdoor temperature, indoor temperature, set point, and indoor humidity.
- **NetAtMo IAQ Weatherstation.** The main unit measures barometric pressure, decibel level, carbon dioxide, temperature, and humidity. Simpler units that measure only temperature and humidity will be in the supply and return plenums, with a third being outdoors.

We firmly believe that measured outcomes and transparency will help build public confidence in home performance. It's our policy to show the good and the bad, for everyone to learn from. If we were in DOE's Building America program, we'd probably have a lot more sensors, but this substantial array cost only \$1,400, retail. As time goes on, we'll be publishing our data on the Energy Smart Blog and at JLConline.com.

Nate Adams is the founder of Energy Smart Home Performance, near Cleveland, Ohio.



Volunteer labor helped make this project possible, along with generous material donations from suppliers. Cleaning out the cluttered and dilapidated basement was a task tailor-made for volunteers (11). Volunteers also bore the brunt of the hand labor required for the extensive demolition and reconstruction that was needed to create the home's new energy-efficient exterior (12), as well as for the interior detailing (13). That helped make the most of Habitat's limited budget, freeing funds for professional tasks such as spray foam and HVAC installation.

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BY LAUREN HUNTER



1



2

1. Tile Takes Shape

Part of the Entourage glass mosaic collection, Alair offers a new shape to add a creative touch to backsplashes, bathrooms, and feature walls. The elongated hex design is a 2-by-4-inch, mesh-mounted mosaic with marble and glass elements. Choose from six colors: white-on-white cotton; golden and gray tones in honey, dove, slate, and smoke; and blue-green tinted mint. Retail pricing starts at about \$30 per square foot. americanolean.com

2. Modern Bath Vanity Finish

Oyster gray has been added as a finish for Acclaim bath vanities from Christopher Grubb. Also available in espresso and white finishes, the vanities are constructed of solid oak and come in six widths, from 30 to 80 inches. Designers can specify ivory marble or white Carrera countertops or supply their own. Matching mirrors and a coordinating linen tower with glass doors are also available. Pricing runs from \$850 for the 30-inch vanity to \$1,500 for the 80-inch dual sink. christophergrubb.com



3

3. Interior Trim for Any Style

Each of the five families in Metrie's Then & Now Finishing Collection includes wainscot molding for creating stylized wall paneling designs. The coordinated paint-grade profiles and boards are designed to ease installation. Moldings echo the design elements in each family, such as the French curves style (shown). Each molding collection includes a stile and rail board of appropriate width, a chair rail, and at least one additional molding profile. Check with dealers for pricing. metrie.com



4

4. Stately Bath Fixtures

Inspired by the pediments of New York's Manhattan Bridge, Townsend bath faucets combine urban styling, innovation, and water efficiency. Sink faucets come in one single-handle and two widespread models (one high-arc and one low spout) and deliver water at 1.2 gpm. All have brass bodies and washerless ceramic disc valves, along with Speed Connect drains and universal valves. Upgrades include a WaterSense showerhead, a 6-inch showerhead, and a 7 1/4-inch tub spout. Lavatory faucets cost from \$260 to \$535, with deck-mount tub fillers starting at \$465 and bath/shower trim kits ranging from \$260 to \$360. americanstandard.com

Products

5. Outdoor Accent Lighting

WAC Lighting has introduced a landscape lighting collection that includes wall wash, deck, and patio lights; 3-inch in-ground hardscape lighting; outdoor landscape tapes; step, area, and path lights; and more. The adjustable LED accent light (shown) can dynamically change wattage (2 to 16 watts), brightness (100 to 1,000 lumens), and color. Designers can choose from pure-white and warm-white light. The maker says it has incorporated UV- and corrosion-resistant materials throughout for a 10-year warranty on fixtures. waclighting.com

6. Smart Thermostat Adjusts to Needs

The Wisir Air Wi-Fi Smart Thermostat now features Eco IQ. Rather than entering desired temperature set points, users only need to provide feedback when they're not comfortable. Eco IQ takes over, adjusting the temperature to create an optimal environment and maximize energy savings. Using the maker's weather-forecasting service, Eco IQ also learns how long it takes to change the home's temperature in all types of weather, enabling the system to make predictive adjustments. The thermostat has an intuitive user interface, color touchscreen, and plug-and-play design, and syncs with its smartphone app. Priced at \$240. wisirair.com

7. Entryways Go Bold

Pella is making a statement with expansions in both style and color. Its new Premium Smooth Panel entry doors come in five contemporary panel designs—ranging from Craftsman to a more-modern five-panel—and two sidelite designs, and all can be finished with the maker's bold new Vibrancy Collection of colors: vivacious red, lively blue, sparkling teal, spirited orange, animated yellow, and energetic green. Pricing for the doors starts at around \$1,500. pella.com

8. Rain, Rain, Go Away

Make company vehicles safer with EnduroShield Automotive Glass Rain Repellent. One application will repel rain and improve visibility for up to one year or 12,500 miles, the maker says. Applied with a soft cloth, the non-stick, invisible coating causes rainwater to bead; reduces adhesion of grime and bugs; and eases snow and ice removal. The company also offers treatments for shower doors and other materials, making cleaning a breeze. The Automotive kit costs \$10 at Home Depot. Shower-door treatments cost \$20. enduroshield.com

5



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8



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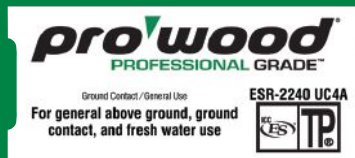
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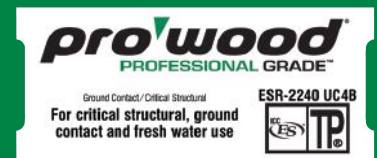
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9



9. Bright Idea for Workshops

Put light where it's needed with two new AC-powered LED work lights. Model SL-2135 has a 25-foot cord, and the SL-866 has 50 feet of cord in a retractable reel with a mounting bracket. Both models have a 1,200-lumen "high" mode and 600-lumen "low" mode. Two magnets—one in the handle and one at the light's tip—and a detachable magnetic hook provide attachment for hands-free operation. The handle's octagonal shape keeps it from rolling around when placed on its side. Look for pricing around \$60 online. baycoproducts.com

10



10. Sound-Softening Underlayment

Made from 100% latex rubber, Sound Buffer universal acoustic underlayment can be used under vinyl, laminate, engineered wood, and hardwood flooring and can be floated, nailed, stapled, or glued. Sound Buffer's IIC and STC sound tests have exceeded the standards for high-rise installations. Available in 36-inch-wide, 200-square-foot rolls with or without seam tape, the recyclable Sound Buffer is 1.2mm thick, offers density of 25 pounds per cubic foot, and has antimicrobial properties. It retails for about 50 cents a square foot. mpglobalproducts.com

11. Rustic Shower Hardware

Part of Sonoma Forge's WaterBridge collection, the Exposed Shower System can now be mounted on glass (as well as wall- or floor-mount), and new accessories conceal mounting hardware for a clean appearance. Other WaterBridge products include lavatory and bar faucets and Roman tub fillers. Optional accessories include a hand shower, tub filler, and alternative showerheads. Choose from a variety of finishes. Pricing ranges from \$2,900 to \$6,075. sonomaforge.com

11



12



12. Durable Flashing for Roof Penetrations

Eliminate the most frequent cause of roof leaks, with Ultimate Pipe Flashing. Featuring a proprietary sealing method for plumbing vent pipes and other roof penetrations, the product is made with ultra-pure silicone for UV and ozone stability and isn't prone to cracking. A compression collar prevents the rubber from relaxing away from the pipe and won't cut the silicone. Flashing with nailing slots is provided for the sides and top for a weather-tight seal without caulk. Use with roof pitches from flat to 20/12 for PVC pipes up to 2 inches, and pitches up to 18/12 for 3- or 4-inch pipes. Priced at \$50 online. lifetimetool.com

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Fiskars Hammers and Mauls

BY TIM UHLER

In February, I saw Fiskars hammers featured in *Tools of the Trade* (a sister publication to *JLC*) and was intrigued by the IsoCore grip design, so I asked to test out a couple of hammers. I also requested a 3-pound club hammer, which we use for driving stakes when we are working on foundations.

FEATURES

One of the major reasons I use a Stiletto TiBone hammer is that it transmits almost no vibration—in fact, I can't feel any when I strike a nail. Fiskars claims that the IsoCore, which consists of an insulation sleeve in the handle, absorbs the shock, resulting in four times less shock than with wood-handled hammers.

Another feature of the striking tools is an orange rubbery grip. Fiskars says that the dimples on the handles reduce blisters; I can't attest to that, as we just don't drive that many nails, and during the time of year we tested the tools, we were wearing gloves. The hammers also have a slot and magnet to hold a nail.

FRAMING HAMMER

I love the tools' grip, which provides a secure hold even in the rain. The IsoCore does dampen vibration compared with a wood-handled hammer, but I did still feel some vibration—more than with the TiBone I normally use, which has virtually no vibration.

If you want a hammer with a handle that won't break (I originally switched to the TiBone because I was tired of breaking handles—and because it was a present), has a super-comfortable grip, and dampens vibration, then I highly recommend the Fiskars IsoCore hammer. It runs about \$60 and so won't break the bank.

THREE-POUND CLUB MAUL

We always keep a mini-sledge around for moving walls or setting large beams—and especially when we are driving stakes when forming foundations. We have done plenty of those tasks lately and I can say that this maul is my favorite of all the mauls I've ever used. It has the perfect length handle for the 3-pound head. Because it was so well balanced, in fact, I used it more than I've used other mauls before. For example, I used it to tighten all the form shoes (wedge ties) on a wall. Just a tap tightened them up, whereas with a hammer, I would have needed to hit the shoes a few times. At \$40, every tradesperson should have one of these. fiskars.com

Tim Uhler is lead framer for Pioneer Builders in Port Orchard, Wash., and a contributing editor to Tools of the Trade.

The IsoCore grip reduces vibration, but doesn't eliminate it. The new Fiskars hammers feature a soft, comfortable handle design and a magnetic nail holder. The 3-pound Club Maul (below, left) is well-balanced and has the ideal length handle for the head. The author noticed a marked difference between the vibration of these hammers and mauls compared with that of traditional wood-handled versions.



Skilsaw Wormdrive Table Saw

BY MICHAEL SPRINGER

I used the new Skilsaw model SPT70WT-22 table saw for more than a month, and overall it fit my expectations of a jobsite saw built for framing and rough carpentry. It didn't quite make the cut for finer woodworking uses like glue-line rips and joinery, but Skil's framing heritage endows this saw with more of an "outside dog" pedigree anyway. With its wormdrive motor, it's more at home with its feet planted in the dirt and sawdust of the jobsite than on a workshop floor.

OUT OF THE BOX

When I first lifted the saw, I was impressed by its light weight and easy handling. At 51 pounds and with a table size of 23½ inches wide and a mere 20 inches front to back, it is compact—not as small as the "flooring" table-saw class, but somewhere between that and a standard-size jobsite saw. The Skilsaw could undoubtedly be attached to aftermarket stands, but in keeping with the saw's small and simple demeanor, I tested it on the brand's optional folding stand (model SPTA70WT-ST).

The unique thing about the Skilsaw is that it's the first table saw powered by a wormdrive motor—the same motor found on the circular saws the brand is famous for. Users unfamiliar with wormdrive motors will have to keep in mind that this saw has a gearbox filled with oil that must be checked and changed out at specified intervals.

Like most woodworking machinery—bench-top or otherwise—table saws require thorough checking and calibrating before use. I had to spend at least an hour tinkering with the Skilsaw before I could "let 'er rip." As I made my adjustments, I began to appreciate the open frame design of the saw, because it allowed me unfettered access to the working parts of the saw—unlike with a saw enclosed by a plastic body. In fact, there's barely any plastic at all on this saw, which is another aspect to admire. The open space afforded by the

tubular steel frame was put to good use with storage slots for the saw's fence, miter gauge, blade wrench, and blade-guard components, all secured within the frame.

HANDS ON

Once I calibrated it for accuracy, I put the saw to work. The Skilsaw did a respectable job cutting small, angled-tenon bridle joints, but I felt like I was reaching the limitations of the saw's finesse with this precision joinery work. In any case, more of a challenge was in order for a saw wearing a Skilsaw nameplate. Cutting sheets of OSB isn't much of a workout for most table saws, so besides doing that common job, I ripped more than a quarter-mile of 2-by-lumber (including 2x8x16s) and spent hours ripping hundreds of linear feet of 4x4s with the saw's blade fully buried in the wood.

Under those conditions, I was impressed by the Skilsaw's power and stamina. Over the many hours I ran the saw in a day—sometimes for more than an hour at a time without turning it off—I never heard the saw slow or falter, or smelled anything "hot" that would have been cause for alarm. The Skilsaw wormdrive motor is a great fit for this saw and delivers heavy-duty performance, as promised.

BOTTOM LINE

The Skilsaw SPT70WT-22 offers powerful performance in a compact table saw. I wouldn't say it's just a framer's saw, but rough carpentry is where its true strengths lie. You can rev it up and feed 4x4s through it all day without any problems as long it remains in good adjustment. A trim carpenter or woodworker might be put off by the play in the arbor, motor-raising assembly, or rear trunnion connection—all of which could create an obstacle for setting up and achieving the finest work.

Michael Springer is a former executive editor of Tools of the Trade.

Lightweight and portable. A padded handle built into the saw's side allows for one-handed carrying. The "-22" version of the saw tested comes with an upgraded 30-tooth Diablo ripping blade, versus the "-01" model, which ships with a Skil blade.

SPT70WT-22 Specs

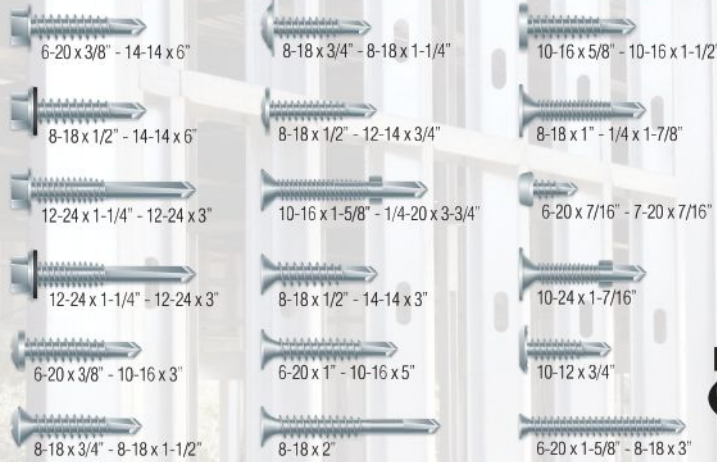
Motor: 15 amps; 5,300 rpm; worm drive
Table: 23½ inches wide; 20 inches front to back
Weight: 51 pounds
Max. depth of cut: 3½+ (almost 3⁹/₁₆) inches
Max. bevel angle: 45 degrees
Max. fence setting: 25 inches
Price: \$380; optional folding stand, \$80



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An Affordable Dustless Drywall Sander

BY MYRON FERGUSON

Over the course of my drywall-contracting career, I have tried a lot of tools, and often I end up asking myself, “What were they thinking?” Sometimes, however, I appreciate a manufacturer’s knowledge of the drywall industry, and that’s the case with Full Circle, which has been in the drywall-sanding business for a long time.

VERSATILE SYSTEM

I’ve been using Full Circle’s Radius 360 sanding system for many years and I like it for its versatility. So when I saw that Full Circle had developed a dust-control version of this system, I wanted to try it out. The Radius 360 Air is very similar to the regular Radius 360 sander, which is the only pole sander I used for years. The hub of the sander where the handle attaches is detachable so that a different hub can be attached. Changing the hub converts the pole sander into a hand sander. The hose, which has a flexible end, attaches to the handle of the hand-sander hub and easily rotates 360 degrees. The hose connects to any shop vacuum and didn’t get in the way when I was sanding.

Other features of the Radius 360 Air include the use of regular Radius 360 sanding discs—no need for holes in the paper or for sanding screen. The brushes around the disc contain the dust, which is directed to the edges of the disc where it is then sucked away. This base moves independently of the shroud for even greater smoothness of movement and the best dust-controlled sanded finish.

The other sander included in the kit is called a Flex Air Sander and can be used as a pole or hand sander using the interchangeable hubs. This rectangular-shaped sander is great for general sanding but is designed for smaller jobs, detail sanding, and getting into tight places, such as inside corner edges. The Flex Air is the perfect tool for corner and detail sanding. The “no flip” pole swivel is designed to keep the Flex Air in a working position for ease of use and uninterrupted sanding. It uses specially made sandpaper and pads, which are available in a variety of grits.

VERDICT

This dustless version is incredibly versatile and durable. I like the ability to change sanding heads, and I like the improved mechanism for holding the sandpaper. The brushes around the circular head do a good job containing dust and don’t leave marks on the drywall. All in all, each of the heads did a nice job containing and capturing dust. I would recommend this system to anyone who sands drywall regularly—either by hand or with a pole.

Myron Ferguson is a drywall contractor in Middle Grove, N.Y.



Manual sanding with dust collection.

The Radius 360 Air converts from a pole sander to a hand sander. The circular head accepts standard Radius 360 sanding discs. When attached to the pole, the heads pivot and rotate for full range of motion.

The kit includes:

- Radius 360° Air Dustless Sanding Tool
 - Flex Air Dustless Sanding Tool
 - Two-piece pole assembly
 - Orbiting adapter handle
 - Hose assembly with assorted fittings for vacuum connections
 - Set of Radius 360 sanding discs: 150, 180, and 220 grit
 - Set of Flex Air sanding paper: 150, 180, and 220 grit
 - Pair of Flex Air Foam Abrasives: fine and medium
- Price:** about \$180

Photos: Chris Emides

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BY TIM HEALEY

When Bulldozers Roamed the Earth

Next month marks the 50th anniversary of the creation of the National Historic Preservation Act (NHPA). This act, along with other regulations passed from the mid-1960s to the early 1970s, helped end an era of large-scale, federally funded construction projects that followed World War II. A new book by Francesca Russello Ammon examines this period of unbridled demolition and construction through the lens of the machine that came to symbolize it—the bulldozer. In *Bulldozer: Demolition and Clearance of the Postwar Landscape* (Yale University Press), Ammon explains how the dozer transformed from a heroic weapon in the “arsenal of democracy” into a tool for urban planning, suburban development, and the creation of the interstate highway system.

A dirt-moving war. “Victory seems to favor the side with the greater ability to move dirt,” Major General Eugene Reybold, the head of Army Corps of Engineers, declared in 1944. The Army Corps used the bulldozer in Europe to crush barriers to forward advancement and, after the war, to help clear millions of cubic yards of rubble from bomb-damaged cities. While their counterparts in the Pacific, the newly formed Seabees, cleared enough jungle “to build more than 400 bases, 100 air strips, 235,000 roads, 700 acres of warehouses, housing for 1.5 million men, and storage tanks for 100 million gallons of gasoline,” the Allies would deploy more than 100,000 tractors—many with bulldozer blades—during World War II. This photo (1) from 1944 shows International Harvester tractors lined up and ready to be shipped to the Pacific.

“Culture of clearance.” Earth-clearing skills honed overseas were put to use when these land-altering machines and their highly trained operators returned home “to wage war on the American landscape.” Urban planners made a correlation between blighted American cities and bomb-damaged European ones, recommending clearance and rebuilding for both. For instance, in this photo (2), circa 1952, a dozer works on the Cross Bronx Expressway, part of a massive development scheme for New York City.

In addition, Eisenhower, the former Supreme Allied Commander, pushed for the Federal-Aid Highway Act, after witnessing the creation of the German autobahn. The bill passed in 1956, authorizing a 41,000-mile, 10-year building program—with 90% of construction costs paid for by Uncle Sam. In this photo (3) from 1960, road builders queue up to work on a section of interstate.

All told, 7.5 million dwelling units were torn down from 1950 to 1980 in the name of urban renewal and highway planning, and 42 billion cubic yards of earth were moved to create the interstate system. The excavations displaced a vast number of people—hence the bulldozer became a symbol of protest as angry citizens began to push back against what Ammon calls “a culture of clearance.”

Tim Healey is a senior editor at JLC.

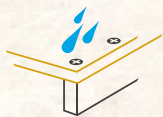


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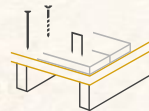
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