June 2021 $4.95

JLC

THE JOURNAL OF LIGHT CONSTRUCTION

Builder's Guide to Breathable Indoor Air

Light-Commercial Rehab

Troubleshooting a Failed TPO Roof

jlconline.com

JLCONLINE.COM

Contents


35


41

On the cover: Eric Hartman of Harvestar, in Lincoln, Vt., installs an ERV heat-recovery ventilation unit—the current standard for providing healthy indoor air without wasting too much energy. See the story on page 35. Photo by Tim Healey.

FEATURES

DEPARTMENTS

THE JOURNAL OF LIGHT CONSTRUCTION (ISSN 1056-828X), Volume 39, Number 8, is published 10 times per year (January, February, March, April, May, June, July/August, September, October, November/December) by Hanley Wood, 1152 15th St. NW, Suite 750, Washington, DC 20005. Annual subscription rate for qualified readers in the construction trades: $39.95; nonqualified annual subscription rate: $59.95. Frequency of all magazines subject to change without notice. Double issues may be published, which count as 2 issues. Publisher reserves the right to determine recipient qualification. Canada Post Registration #40612608/G.S.T. number: R-120931738. Canadian return address: IMEX, PO Box 25542, London, ON N6C 6B2. Periodicals postage paid at Washington, DC, and at additional mailing offices. POSTMASTER: Send address changes to JLC, Box 3530 Northbrook IL 60065-3530.

JLC

JLCONLINE.COM

Chief Editor, JLC Group Clayton DeKorne, cdekorne@zondahome.com
Executive Editor, JLC Group Andrew Wormer, awormer@zondahome.com
Managing Editor Laurie Elden, lelden@zondahome.com
Senior Editor Tim Healey, thealey@zondahome.com
Associate Editor, Products Vincent Salandro, vsalandro@zondahome.com
Freelance Designer Melissa Krochmal, mkrochmal@zondahome.com

Contributing Editors Mark Clement, Ted Cushman, Dave Holbrook, Tom Meehan, Roe Osborn, Matt Risinger, Emanuel Silva, Gary Striegler, Tim Uhler

Senior Director, Print Production Cathy Underwood
Senior Director, Print Production Margaret M. Coulter
Ad Production Coordinator Bernadette Couture
Production Manager, Inside Sales Stephanie Fischer
Group Director, Audience Marketing & Circulation Christina Lustan

HANLEY WOOD MEDIA

Chief Operating Officer Andrew Reid
Executive V.P., Chief Content Officer Jennifer Pearce
V.P., Digital Strategy and Operations Bridget Forbes
V.P., Marketing Lillian Spio
Senior Director, SEO and Analytics Jennifer Malkasian
Senior Design Director Tina Tabibi

PUBLISHED BY HANLEY WOOD

Chief Executive Officer Jeff Meyers
Chief Financial Officer Melissa Billiter
Chief Operating Officer Andrew Reid
Group V.P., Talent Strategy Kurt Nelson
Executive V.P., National Sales Amy Dudley
Senior Managing Principal, Advisory Group Tim Sullivan

Editorial & Advertising Offices:
The Journal of Light Construction,
Hanley Wood LLC
1152 15th St. NW, Suite 750
Washington, DC 20005
202.452.0800

INFORMATION DIRECTORY

CONTACT INFORMATION

jlconline.com
JLC
Hanley Wood LLC
1152 15th St. NW, Suite 750
Washington, DC 20005

EDITORIAL

We welcome letters and article submissions from our readers. Contact us by mail at the address above, **Attn:** Editorial Dept., or via email at jlc-editorial@zondahome.com. Keep copies of all original materials.

SUBSCRIPTION SERVICES

For help with your **JLC** subscription, contact us:
Online: jlconline.com/cs
Email: jlc@omeda.com
Phone: 888.269.8410
Mail: JLC, PO Box 3530, Northbrook IL 60065-3530
You can subscribe online at:
jlconline.com/subscribe
Subscription rates for qualified readers:
1 year/ $39.95; 2 years/$64.95.
Canada, International: add $15/ year for surface delivery.
Sales tax will be added to total due if required by your state law.
Frequency of all magazines subject to change without notice. Double issues may be published, which count as 2 issues.

JLC BACK ISSUES

JLC subscribers have free access to every issue of **JLC** since 1986. Enable your free access at jlconline.com/register. Copies of individual back issues can be purchased for $4.95 each, plus $5 shipping per order. Call 888.269.8410 for availability.

ARTICLE REPRINTS

For custom reprints of **JLC** articles, call Wright's Media, 877.652.5295; zonda@wrightsmedia.com

JLC UPDATE EMAIL NEWSLETTER

JLC Update, our email newsletter, is free to **JLC** readers. Each issue contains industry news and the latest tips on building materials, techniques, tools, and technology. Subscribe online at jlcupdate.jlconline.com

For list rentals: The Information Refinery, Brian Clotworthy, 800.529.9020, brian@inforefinery.com

Privacy of mailing list: We rent our subscriber list to reputable companies. If you do not wish to receive promotional materials from other companies, please call us, toll-free, at 888.269.8410.

JLC

ADVERTISING SALES OFFICES

Paul Tourbaf
Executive Vice President
847.778.9863
ptourbaf@zondahome.com

Kay Ross-Baker
Vice President
630.707.0811
krossbaker@zondahome.com

John Tatusko
Vice President
617.359.8619
jtatusko@zondahome.com

Deb Capone
Strategic Account Director
646.455.8589
dcapone@zondahome.com

Mark Rosenbaum
Strategic Account Director
312.802.7002
mrosenbaum@zondahome.com

Carol Weinman
Strategic Account Director
847.778.9861
cweinman@zondahome.com

Brandy Weiss
Strategic Account Director
310.591.7770
bweiss@zondahome.com

Patrick Zazzara
Strategic Account Director
571.488.5324
pzazzara@zondahome.com

Rita Hicks
Strategic Account Manager
484.467.1187
rhicks@zondahome.com

CANADA

John Magner
York Media Services
416.598.0101
jmagner@yorkmedia.net

"EURO LUMBER CREATES GRADING CONFUSION," BY TED CUSHMAN (MAY/21)

Back in "the good old days," every sawmill produced lumber and, in attempting to cater to its buyers' needs, sorted it into some form of top, middle, and lower grades. This worked well enough as long as each person knew what the other was talking about. But how could a faraway designer know that the client's sawmill would produce lumber of the strength his plans called for? The sawmill near him might be selling a much stronger grade of framing lumber than the mill his client was talking to. That was the beginning of the call for uniform lumber grading standards. In 1924, the American Lumber Standard was first published, and now Canada and the U.S. operate jointly under the oversight and grading rules of the National Lumber Grades Authority and the American Lumber Standard Committee.

Base design values—the eight strength, stiffness, and density properties engineers use—are tied to strength-limiting defects and species. Pieces of #2 lumber of two different species may have the same limiting defects, but because of the differing strength properties unique to each species, they will be assigned different design values. This is why the various span tables have different allowable spans for the same grade of different species of lumber. For instance, a 2x12 floor joist in #2 Doug fir-larch can span 18 feet 1 inch while the same 2x12 in #2 SYP is limited to a 16-foot-6-inch span.

The grading rules allow grouping some species of similar range and strength together, but limit the design values based on the weakest species in that group. Some species or species combinations carry different design values based on where they are grown. For example, northern "SPF" (spruce-pine-fir) carries higher design values than "SPF(s)"—the same species group from the south.

When European lumber began to be imported, country of origin led to much more variation in design values for each of the imported species. For instance, #2 Norway spruce in current tables of design values has six different sets of design values based on country of origin when stamped as a stand-alone species. When it's grouped into various species combinations, that adds 28 possible sets of design values for one grade. You read that right: A stamp containing some form of "#2 NSpr" has 34 possible sets of design strength values. The variability is considerable: Fb 575 E1.1 in combinations to Fb 875 E1.3 in single species, based on species combination and country of origin. I have picked just one example species, but there are several.

The well-understood and widely distributed species combination "SPF" of Canadian origin now may also be easily confused with a grade stamp "SPF/SPF(s)" containing lumber that originated in Canada, U.S., Europe, or South America. The basic design properties range from Fb 875 E1.4 to Fb 575 E1.1. If the designer is working from an optimistic viewpoint and the supplier delivers from the lower end of the spectrum, there is potentially a serious strength or serviceability problem. Using the 2x12 floor joist example from above and the design values just mentioned, the maximum allowable spans would be 17 feet 10 inches versus 14 feet 4 inches, respectively. Misinterpreting those easily confused grade stamps could be a real problem.

Remember where all this began. There was a need for the designer of a building to know that the builder would use wood of the same, or better, strength as what was called for in the design. I can think of a couple of examples where I wandered around looking at the stamps. One house contained lumber from nine different countries; another contained lumber from five. The suppliers do not know which countries their lumber is going to come from; thus, the builder does not know what strength lumber is going to arrive on the job. In other words, we've lost sight of the original goal and are back where all this began. This is not working.

There are a couple of ways of addressing the problem. The first is to design very conservatively and use the lowest possible design properties that are listed. If European wood might be used on a job, scan the tables and use the lowest design values. You'll never be wrong, but you will be limiting spans and driving up costs.

Another solution: The designer can specify the minimum design values required rather than a species or species combination, grade, and country of origin.

Lumber would need to be stamped with a species and grade but also with the design values, similar to the stamp on LVL lumber. Then the builder would order those design values from the supplier. The supplier would simply send out stock that is stamped with those design values or better.

If the builder doesn't care for the working characteristics of a particular species and the supplier has what is needed in several different species, the builder can request the order be filled with the species of preference. Either meets the strength requirement, but each has unique characteristics as well. This is the reason to retain the species stamp. *—Don Pridgen, Elk Creek, Va.*


"FROM TALLAHASSEE TO KEY WEST,
GRABBER HAS
MADE OUR
WORK EASIER."
PROFESSIONAL GRADE
Grabber fasteners are made with the highest standards, which means they drive in faster, seat better, and are less likely to cam or spin out.
"For over 15 years, Grabber has provided our team with the best quality fasteners, solutions, and support. From Tallahassee to Key West, Grabber has made our work easier. Using Grabber products allows our team to give the absolute best quality work to our customers."
— Narvaez Family, Owners
Spanish American Interiors, Royal Palm Beach, FL
With less waste, faster installation times, and an experienced support team, Grabber will save you money, project after project.
GRABBER CONSTRUCTION PRODUCTS
"The Professional's Choice"™
grabberpro.com/professional-grade

BY CLAYTON DEKORNE

Buying Hardwood

In this column, we recently covered softwood lumber—both framing and finish material that you get from a standard lumberyard or retail building material outlet (see "A Trip to the Lumberyard," Apr/21). While you can find a limited selection of hardwood at the big box stores, you're better off buying hardwood lumber and moldings from a specialty hardwood and millwork dealer. Even a small dealer will usually have a larger selection of hardwood species and molding profiles, and you have a lot more control over the quality.

Buying hardwood is usually a completely different process from running to the lumberyard. For one thing, the largest selection of woods is usually rough-surfaced material. Often, the hardwood dealer will receive bundles from a mill that include boards ripped from the same tree, and these remain stacked together so you have a better chance to match the grain and tone of the boards. This rough material is often sold by the board foot, which gets tallied up first, and then if you want the shop to dimension any of it, you pay for that as a separate charge. We'll come back to that, but first let's cover some basics.

1

2

In addition to selling rough-sawn lumber, some dealers provide S4S (surfaced four sides) material, sorted into even widths with the lengths marked on the ends **(1)**. When rough hardwood is purchased, it is typically priced by the board foot, with an upcharge for finishing. To sort out pricing and finishing, be sure you are clear on the terminology for board dimensions and surfaces **(2)**.

Adobe Stock

ROUGH LUMBER SIZING

Rough-cut lumber is sized by thickness in 1/4-inch increments: 4/4 (called out as "four quarter") stock is one inch thick, 5/4 is 1 1/4 inches thick, 6/4 is 1 1/2 inches thick, 8/4 is 2 inches thick, and so on. It's an odd convention established by the National Hardwood Lumber Association (NHLA), which has been using the system since the organization was founded in 1898. But there was good reason for it then: In an old sawmill, the sawyer could control the bed of the saw with a lever that ratcheted the log ahead of the blade between each pass. Four clicks on the ratchet equaled 1 inch; five clicks, 1 1/4; six clicks, 1 1/2; and so on.

While the thickness of most rough lumber is given in quarter sizes, it can also apply to dressed sizes. Rough-cut boards are typically surfaced (run through a thickness planer) by shaving off about 3/32 inch per side, making the dressed thickness a total of 3/16 inch thinner. So the "dimensioned," or "dressed," thickness for 4/4 lumber at the time of milling is 13/16 inches; for 5/4 surfaces, it's 1 1/16 inches; for 6/4, 1 5/16 inches; for 8/4, 1 13/16 inches; and so on. Most carpenters will refer to dressed 5/4 material as "five quarter" but usually call dressed 4/4 "1-by" material. Also remember that the dressed thickness stated here is at the time of milling and that the lumber can shrink as it dries or swell as it absorbs moisture. So, for example, a dressed 5/4 board might be 1 1/8 inches thick or 1 inch thick, depending on site conditions. When using the material on site, always check your actual dimensions.

BOARD FOOT PRICING

Unlike softwood lumber, which is sold by the stick, hardwood is often sold by volume measured in board feet, and the prices vary by thickness. The price of lumber is

The majority of lumber at a hardwood dealer is rough sawn. Here are three rough, live-sawn logs **(3)**. When available, having them stacked like this makes it easy to match grain. Dealers may also bundle S2S material **(4)**, with two sides surfaced to an even thickness but both edges left rough, so the boards will be of varying width.

also affected by grade and by the cut (visible in the orientation of growth rings).

A board foot is not a measure you'll likely use for anything other than pricing; it's not something you use for building. One board foot is the equivalent of a chunk of wood 1 foot long by 1 foot wide by 1 inch thick. I use "equivalent" because not all the stock you buy will be 1 inch (or 4/4). An 8/4-by-6-inch-wide-by-1-foot-long board is also one board foot. So is a 6/4-by-8-inch-wide-by-1-foot-long board. To calculate board feet, use the equation Thickness x Width x Length / 12 = Board Feet. Remember to keep the units the same, so if your board dimensions are in inches, you need to divide the answer by 12 to get the number of board feet.

HARDWOOD LUMBER GRADES

The NHLA grading rules for hardwood are different from those for softwood lumber. These are the grades, ranked from most expensive to least:

FAS. "First And Seconds" is used for hardwood lumber boards that have a minimum size of 6 inches wide by 8 feet long. To qualify as grade FAS, both sides of the board must have at least 83.33% (10/12) clear wood (that is, wood with no knots or other appearance defects). Also, the clear areas must be a minimum size of 3 inches wide by 7 feet long, or 4 inches wide by 5 feet long. (In other words, you can't have a board with a bunch of small knots distributed over the face. Large swaths of the board need to be completely clear.) FAS material is often used to mill large solid-wood moldings.

F1F is nearly always shipped with FAS. The boards must have one "better" face that meets all FAS criteria, while the poor face must meet all the requirements of the Number 1 Common grade (see below).

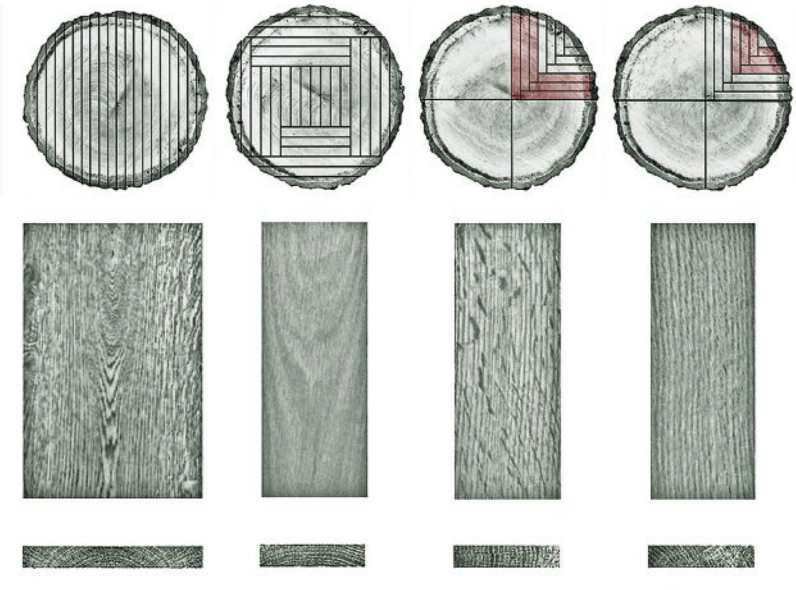
Select. This grade is virtually the same as F1F (one face mostly clear) except for the minimum board size required: Selects can be as small as (but no smaller than) 4 inches wide by 6 feet long.

Number 1 Common (**No. 1C**) is sometimes called "cabinet grade" because the board sizes work well for cabinet doors. No. 1-grade boards must be a minimum of 3 inches wide by 4 feet long, and both faces must have 66.66% (8/12) clear wood. The smallest clear area allowed is 3 inches by 3 feet or 4 inches by 2 feet.

Number 2A Common (**No. 2AC**) is often referred to as "economy grade" because of its price. It is also the grade of choice for the U.S. hardwood flooring industry. Number 2A Common-grade material must be at least 3 inches wide and 4 feet long; one face must have at least 50% (6/12) clear wood; and the clear area must be at least 3 inches by 2 feet. A board is graded as 2AC if the poorer face meets these requirements, even if the other face is better.

Number 2B Common (**No. 2BC**) has the same requirements as

5



Hardwood pricing will vary by how the boards are milled from a log. On the less expensive end are live sawn and plainsawn material. The grain pattern on the face of live-sawn boards will vary. Plainsawn material (also called "flatsawn") will mostly have characteristic "cathedral" bands on the face. Quartersawn and rift-sawn material is at the higher end of the price spectrum. Quartersawn material is usually the most expensive, and the most stable. Bear in mind that NHLA rules require only 80% of the grain to be 60 to 90 degrees to the face for quartersawn, and 30 to 60 degrees for rift sawn. This means some boards may have some grain that is pitched at a shallower angle.

Number 2A Common material, but there are no restrictions on the size of the clear area as long as all the areas of the board are sound.

Number 2 Common is a combination of 2A Common and 2B Common, with no percentage of either grade required.

LUMBER CUT

How a board is cut from a log will have a notable effect on the grain pattern of the face, as well as on how dimensionally stable a board is—that is, how likely it is to warp with changes in moisture content. The hardwood dealer knows the cut from the mill and will sort and price the lumber accordingly, but for most of us, it is difficult to see the grain on a rough board. If you want to see and evaluate the grain pattern for yourself, you can carry a low-angle block plane with you. Most dealers will not mind if you smooth a corner of a board face to reveal and verify the grain.

Live sawn is the easiest way to mill a log. The log is sliced up from one side to the other, so you get a variety of grain patterns, depending on which way the growth rings are oriented at any particular point. A few of the boards near the center will have mostly vertical grain, but on either side of center are a variety of boards that will react differently as the wood absorbs moisture or dries. Live-sawn lumber is the easiest material to use if you are trying to match grain.

Plainsawn lumber is milled to maximize the yield from the log. Most of the boards will be flatsawn, revealing the classic "cathedral" grain pattern (see photo illustration, above). The end grain of these boards will mostly have an arc shape, and these boards are the most likely to cup (the grain swells on the face at the top of the arc if the moisture level is higher on that side of the board than on the other).

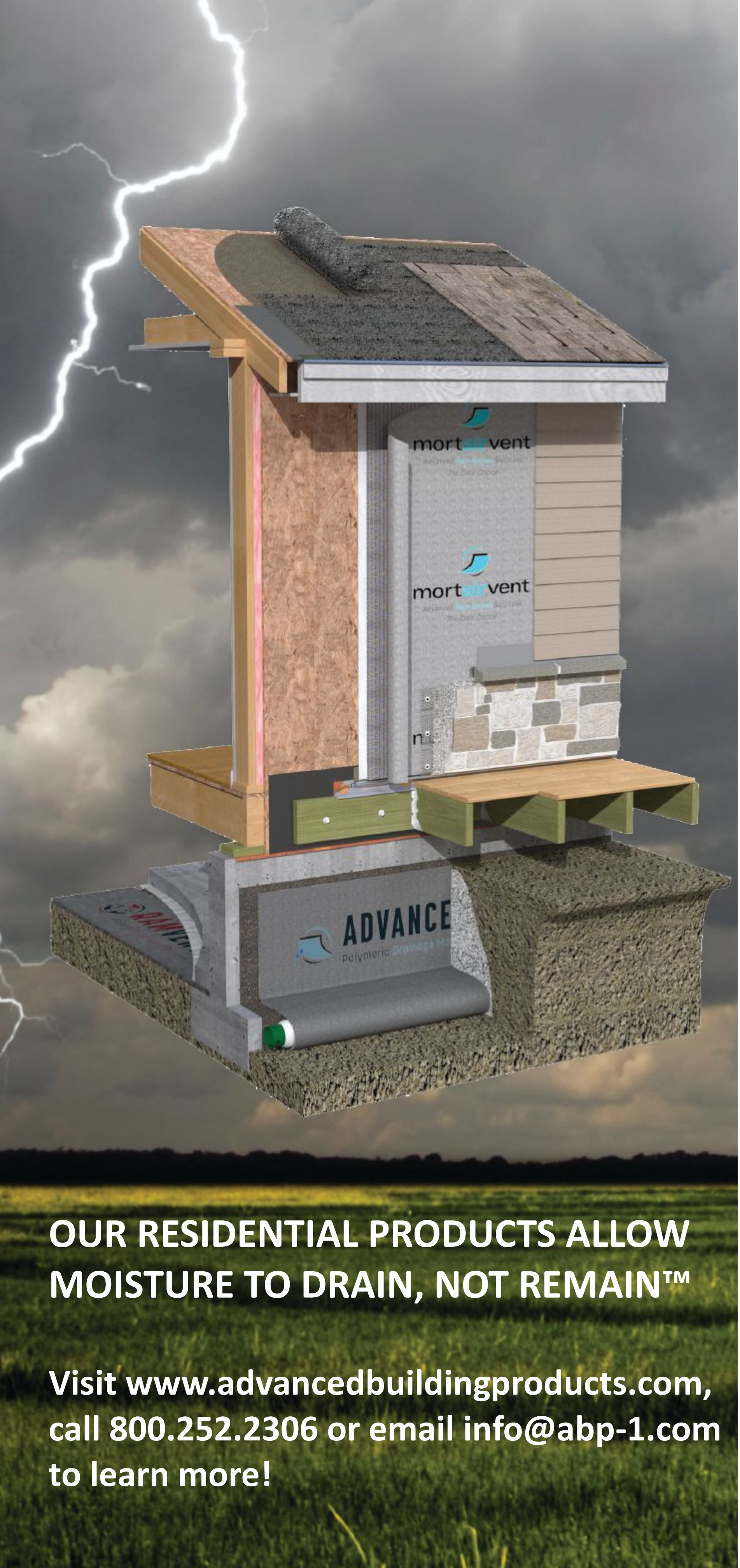
Quartersawn lumber is usually the most expensive per board foot. It is cut from logs that are first quartered. Each quarter is then milled to keep the grain orientation as vertical as possible through the thickness of the board. Technically, a board with at least 80% of the grain at 60 to 90 degrees from the face of the board qualifies as quartersawn; the material closest to the center has the most "vertical grain" (closest to 90). Quartersawn material is very dimensionally stable, and in woods with strong medullary rays will have a "flecked" grain pattern that is especially prized.

Rift sawn material is cut from the outer portion of quartered logs. In this region of the log, the grain is not as vertical, but the face of the boards will still mostly show the characteristic parallel bands, though not as many flecks as in woods with strong medullary rays. Boards with grain from 30 to 60 degrees from the face qualify as rift-sawn material.

SURFACING OPTIONS

When buying hardwood, I will often select rough-cut lumber and then have the dealer surface both sides and rip and plane one edge, a finish known as "S3S" (surfaced three sides). For this, I am charged for the material by the board foot plus a milling charge of roughly 10 cents per pass (about 40 cents total per board, which includes two passes for the edge—one through the table saw and one through the joiner).

A lot of dealers will also have pre-surfaced material in stock. "S4S" material is surfaced all four sides, and S2S has both faces surfaced to an even thickness but both edges left rough. Next to rough-sawn lumber, most material in many hardwood outlets will be S2S material, stacked in bundles of even thickness but of varying width.


mortairvent
mortairvent
ADVANCE
OUR RESIDENTIAL PRODUCTS ALLOW MOISTURE TO DRAIN, NOT REMAIN™
Visit www.advancedbuildingproducts.com, call 800.252.2306 or email info@abp-1.com to learn more!

Q Can deflection of a low-slope roof cause ponding? How can this be avoided?

A *Frank Woeste, P.E., professor emeritus at Virginia Tech, responds:* Historically, structural designers and builders have assumed that a design slope of 1/4 inch per foot (1:48) is sufficient to prevent ponding action, thinking that the installed roofing system will maintain at least a 1:48 slope in-service as required by some roof covering systems. However, in many cases and for different reasons, ponding on limited areas of low-slope roofs is common. That's due to roof deflection, which over time can cause water to collect in some areas of a roof where the design slope for drainage is not adequate, and in fact changes from a "positive" drainage slope to a "negative" slope **(1)**.

A study case. To demonstrate how a 2018 IRC/IBC-compliant design can result in roof ponding, I modeled a 20-foot roof span with a design slope of 1/4 inch per foot framed with 2x10s (No. 2 grade, KD19, modulus of elasticity of 1.5 million psi) at 16 inches on-center. Loading was 20 psf live load and 20 psf dead load, with a ceiling attached to the joists, and live-load deflection of less than L/240 (L is the span).

As shown on the vertical axis of the graph on the following page, the 1/4-inch-per-foot design slope results in the left bearing being 5 inches above the right bearing. The span of 240 inches is depicted along the horizontal axis of the graph. The straight black line represents the slope (1:48) of the 2x10s prior to any type of loading. This slope matches the "design slope," which is normally communicated to the joist or truss designer by the construction drawings or a specification.

Depicted by the orange curve, the Design Total Deflection was calculated based on 20-psf live load plus 20-psf dead load, for total load of 40 psf. The range of the vertical axis is minus 1 inch to plus 5 inches. If any part of the joist deflection curve goes below zero (or minus in the graph), pooling or ponding is the natural outcome during a rain event.

For the study case and 40-psf total load, the slope of the framing provides "positive drainage" along the entire span. However, when the roof experiences design loads, the actual roof slope is greater than a 1/4 inch per foot on the left bearing and less than 1/4 inch per foot on the right bearing location. This graphic demonstration shows that the "design slope" communicated on drawings or specifications is different from the "actual slope" of a constructed roof assembly that experiences in-service loads.

The Design Total Deflection plus Creep Deflection is depicted by the red curve to represent the potential total deflection in-service. The deflection values were calculated by adding the estimated in-service creep deflection to the Design Total Deflection values. Note that for the span between about 160 and 240 inches, the red deflection curve collects water, having a negative slope from the right bearing for about 4 feet.

The term "creep" requires some explanation. A good example of creep is the familiar sag of a heavily loaded book shelf after several years in-service. By definition, creep deflection is the additional deflection of a structural element over time. The amount of creep deflection in wood is largely dependent on the initial moisture content of the lumber and stress level due to sustained loads, typically dead loads. The extent of yearly moisture content cycles, driven by seasonal weather changes (heating verses cooling conditions), also contributes to creep deflection.

For design purposes, a "creep factor" is defined as the deflection of a member in-service divided by the initial deflection due to the applied dead load. For solid-sawn lumber, a creep factor of 1.5 is recommended by the National Design Specification (NDS) for Wood Construction for dry lumber (KD19 or SDRY)—meaning moisture content (MC) of less than 19% at time of manufacture. For lumber

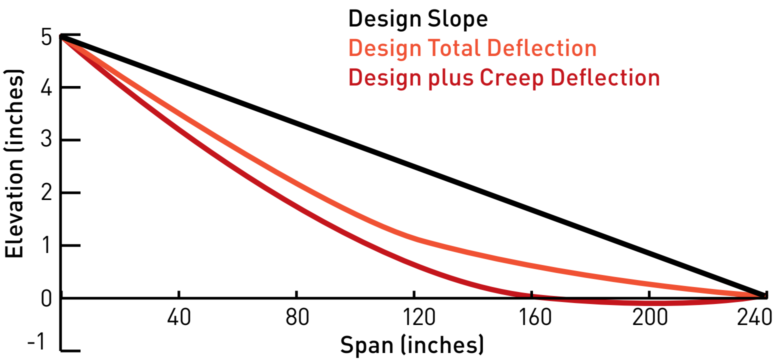
1 As shown on this exterior deck over habitable space, inadequate drainage caused by the deflection of a low-slope roof can lead to ponding.

Photos by Scott D. Coffman/courtesy Construction Science and Engineering with an MC greater than 19%, a creep factor of 2.0 is recommended.

Limited long-term testing of engineered components revealed a creep factor above 2.0. Given the uncertainty of the initial and in-service MC cycles of the lumber as well as actual stress levels in-service, I believe a factor of 2.0 is a reasonable creep factor to use for assessing the ponding potential of low-slope roof framing. The Design plus Creep Deflection curve (red) was based on a creep factor of 2.0, meaning the initial dead load deflection was doubled.

Steps to address ponding potential. A first thought of a builder or contractor might be to ask the component supplier or design professional to address the low-slope ponding issue. This may not be the best option, however, as the supplier or designer may default to building-code deflection ratios in the IRC or IBC, which do not include consideration of potential in-service ponding behavior. For example, Table 1604.3 in the 2018 IBC lists deflection limits for roof members, such as L/120, L/180, L/240, and L/360, for different combinations of live load, snow or wind, and dead plus live load. As in many cases, the footnotes to the table are extremely important (but often neglected); footnote "e" for roof members reads:

"The preceding deflections do not ensure against ponding. Roofs that do not have sufficient slope or camber to ensure adequate drainage shall be investigated for ponding. See Chapter 8 of ASCE 7."



Modeling predicts that design loads plus creep deflection will cause 2x10 joists with a 1/4-inch slope per foot over 20 feet to have a negative slope within the last 4 feet of the lower bearing point (graph, above).

Roof deflection caused by the weight of mechanical equipment that wasn't accounted for in the original design can lead to ponding.

A more reliable approach for builders, contractors, and design professionals to address the potential for roof ponding is to specify a 3/8-inch- or 1/2-inch-per-foot roof slope in lieu of the commonly used 1/4-inch-per-foot specification. For the study case discussed previously, a 3/8-inch-per-foot roof slope provided a positive drainage slope for the entire span.

In addition to the design slope specification, it is critically important for builders, contractors, and design professionals to include the position and footprint of the HVAC equipment on the roof in the construction plans, including the weight of each unit **(2)**. Being that some component suppliers may not use an ample "creep factor" in their deflection analysis, an alternative might be for the specifier to artificially increase the weight of the HVAC units by a selected creep factor, at least 1.5 or 2.0, and to specify the larger HVAC weight on the plans. This approach would reduce the in-service stress level for the impacted framing, thus automatically reducing the amount of expected creep deflection in-service. A point to remember is that it's the "sustained load," or dead load, that drives creep deflection.

Another concern is the actual MC of joists or wood truss lumber at the time of construction. Roof framing lumber, as well as FRT lumber when used, should be well dried to guard against increased creep deflection during the drying period before reaching the equilibrium MC. Well-dried KD19 lumber should have an average MC of about 15% with a maximum of 19%. The industry standard for "dry lumber" is less than 19%; it does not specify an average MC that is relevant to the concern for creep deflection.

A good resource for design professionals interested in addressing creep deflection by in-depth structural design methods is "Low-slope Roofs," a comprehensive article by Scott Coffman and Thomas Williamson in the March 2019 issue of *Civil+Structural Engineer* (csengineermag.com/low-slope-roofs/).

Color-Coding the Jobsite

BY RICK MILLS

As a project manager, I am responsible for distributing information about a project to other team members in the most effective way possible to bring the job to a successful conclusion. A big part of that is going to each team member or trade individually to find out what is needed to meet that goal. When compromises have to be made along the way, a good project manager can assess the situation and determine the direction that's needed to keep everyone on track. The key to this process is good communication.

Keeping in mind the old saying "a picture is worth a thousand words," a good project manager takes advantage of marked-up plans, spec sheets, and mock-ups to create a "picture" to get everyone on the same page. Sometimes that picture becomes muddied when notes are added to a set of plans, so to distinguish my notes, I use a color that most trades don't carry, such as magenta or teal. When someone sees a note or marking in that distinctive color on a set of marked-up plans or on site, they know it was from me.

Questions always arise and there may be times I am unavailable to answer them because I'm not on site or I'm in a meeting. The markings and information that I've added to the jobsite documentation are often enough to answer those questions without my involvement, or at least keep the job moving until I become available. But information can get buried in the plans or be misinterpreted, so I like to take the color-coding strategy a step further and mark the jobsite too.

At the start of each job, I assign each trade a color, typically one that corresponds to those used by Miss Utility or Dig Safe **(1)**. That way, if someone sees a red marking on a subfloor or ceiling joist, for instance, they know that it relates to the electrical trade. I use dark blue markings to indicate water lines, and green ones to mark DWV lines. Not all of the colors I use correspond to Dig Safe, though. For example, I use light blue paint to mark HVAC-related items, and a unique color—like magenta—for anything else that doesn't involve a trade (like door swings).

Typically, I am the only one marking with colors, unless a sub is proposing a penetration through the exterior envelope for me to approve, in which case they can mark that.

FOUNDATION

I start at the foundation; the less that's left to chance or to someone else's interpretation, the better, even when the situation may seem straightforward. I often think that I'm talking about one thing with a trade, but when we go to the specific location to discuss the detail, we find that we've been talking about two different things. Mistakes or misinterpretations are much less likely to happen when there's a visual reference that indicates exactly

1

Photos by Rick Mills

APWA Uniform Color Code

RED	ELECTRIC
YELLOW	GAS, OIL, STEAM
ORANGE	COMMUNICATIONS
BLUE	POTABLE WATER
PURPLE	RECLAIMED WATER
GREEN	SEWER/DRAINAGE
PINK	SURVEY MARKS
WHITE	PROPOSED EXCAVATION

Using a color scheme based on a typical utility locating service chart (above) and a unique and distinctive color for his own notes, the author marks up plans as well as other elements on the jobsite so that each trade can quickly identify who is responsible for what **(1)**.

2

3

4

5

The author cuts appropriately sized PVC pipe sleeves to route utilities through the foundation wall and marks them with paint **(2)**; coordinating marks on the wall indicate to the masons the courses where the sleeves should be installed **(3)**. After the footings for the steel columns have been poured, the author marks them with a stenciled number that the fabricator uses to identify each member. The plywood template is marked with bolt hole locations and other information, and is also given to the steel fabricator **(4)**. To help differentiate the elements in a complex fireplace installation, the author marked up the block foundation with several different colors prior to installation of the firebox (in the area outlined in red) **(5)**.

where a pipe, a footing, or something else needs to be installed.

For example, we like to place PVC sleeves through the foundation wall for the trades to use later for rough-in. I typically review the details with the different trades on site to determine the best locations (unless it is obvious). Then, when the masons are working on a section near any of those locations, I provide the color-marked sleeves and stay close by to make sure the masons put the sleeves where I want them **(2, 3)**.

FRAMING

During the framing stage, I use stencils to clearly label steel locations so that when the fabricator delivers the steel, everyone knows exactly where it is supposed to go. This simple step can pay huge dividends throughout a build **(4, 5)**.

Also during the framing phase—before the first-floor ceiling joists are installed, especially if they are truss joists or TJI for a second floor above—I like to have a good sense of the lighting layout, whether that comes from a lighting manufacturer or an interior designer, or we provide our own. Once I have a layout, I mark all the recessed can lighting locations on the subfloor below with spray paint and a stencil (using red to indicate it's an electrical item).

The framers know to reference this subfloor layout when installing the floor joists above. Sometimes, joists need to be shifted to accommodate the lighting; most subfloors, depending on type and thickness, can be supported by joists spaced wider than 16 inches on-center, if necessary (we always consult a structural engineer before making any changes). Moving joists later or telling clients that they can't have a light where they wanted it because it's not feasible to move the framing is something we want to avoid whenever possible.

As the interior walls go up, the author marks duct path locations on the top plates that coordinate with holes in the steel beams to ensure that joists do not get installed in those locations **(6)**. A simple way to make sure that floor and ceiling joists are installed in their proper orientation is to mark the ends with a single color (in this case, the color doesn't represent a utility) **(7)**. Marking the location of a linear HVAC diffuser (in blue) and pockets for window shades (in yellow) on the subfloor helps the homeowners visualize their positions overhead **(8)**.

During this phase, it's also helpful to know the duct layout as well as supply and return locations, especially if ducts will be run though the floor system. Marking the duct layout helps alert the framers where joists cannot be located, and where they will need to make adjustments to the layout **(6, 7)**.

Of course, we all know (and expect) that clients and designers will change their minds, so some re-work or adjustment is inevitable down the road.

ROUGH-IN

Before we shift into full rough-in, I mark on the subfloor any additional elements in the ceiling that other trades need to know (think of the subfloor as the reflected ceiling plan). These can include can lights, decorative lights, HVAC grills, shade pockets and shade locations against the windows, as well as all door swings (helpful when you're placing switch boxes). I also like to mark shower drains **(8, 9)**.

Visual aids. It can be helpful to provide a physical representation as a stand-in for a future architectural detail. This can be as simple as a 1x4 fastened to the wall framing to represent a countertop height. For a free-standing tub, a mock-up can quickly be fabricated out of scrap plywood to help properly position it as well as items that surround it **(11)**.

To represent cabinet locations, I often cut leftover 1x4 or 2x4 stock to the length of the cabinet run (with countertop overhang accounted for) and screw it to the wall at finished counter height off the finished floor. Then I mark it with the cabinet layout, including sink centers and appliance locations.

I know most cabinet suppliers are willing to come in and lay everything out on the floor, but their marks tend to become hard

In this shower area, the green paint marked on the subfloor indicates the location for a linear drain; it overlaps the yellow marking for a shade pocket that was later eliminated from the plans **(9)**. In the kitchen, a 2x4 fastened to the wall at countertop height and marked with the cabinet layout provides a convenient visual reference for clients and a precise layout reference for tradespeople **(10)**. A free-standing full-scale mockup of the planned tub was built to help the homeowners visualize different locations for the tub within the bathroom space prior to plumbing rough-in **(11)**.

to see or disappear altogether. Plus, no one likes to lay out cabinets working from their hands and knees. Most important, working from the physical set point established by the stock screwed to the wall allows for the accurate placement of fixtures such as backsplash outlets, pot fillers, wall sconces, and under-cabinet lighting, instead of leaving it to the trades to guess where they should go **(10)**.

Labeling with stencils—I buy inexpensive sets on Amazon—is a great way to provide clarity on a project. I use them to match up window numbers with rough openings. On a recent project with a ducted mini-split HVAC system, I also used stencils to mark and label all the indoor and outdoor systems so the electricians would know which unit needed which size wires pulled to it and the associated breaker sizes.

CLIENT COMFORT

Taking these steps brings clarity to the project, not only for the trades that will be installing these items, but especially for the client. Clients like to walk through projects on the weekend, and color-coding the jobsite helps them to see where things will be located (which saves on texts and emails with questions).

My system also helps acquaint clients with the project as a whole, allowing them to get comfortable with the decisions they've made about things like lighting layout and door swings. If they see something they didn't notice on the plans, they can let you know of changes they want to make before doors are ordered or wires have been connected to light fixtures. It makes for an easier and more expedited rough-in process.

On our projects, we don't like to leave much to chance and try to think through as many details as possible. Bringing those details to life is key, and this is where a marking system can really pay off. It's the key to a project turning out well and to limiting painful changes at crunch time when you are trying to complete a job.

Rick Mills is a senior project manager for Jackson Andrews Building + Design, in Virginia Beach, Va. Follow Rick and his company on Instagram @rick.jacksonandrewsbuilding and @jacksonandrewsbuilding.

THE WORK. THE TUNES.

3M™ WORKTUNES™ CONNECT WIRELESS HEARING PROTECTOR

Now you can enjoy the workday like never before. Entertains and connects while helping to protect your hearing. Stream your favorite music in high-fidelity audio. Make and take phone calls without missing a beat. No cords. No hassle.

BUILT TO PERFORM

3M

3M.com/WorkTunes

Installing a Residential Elevator

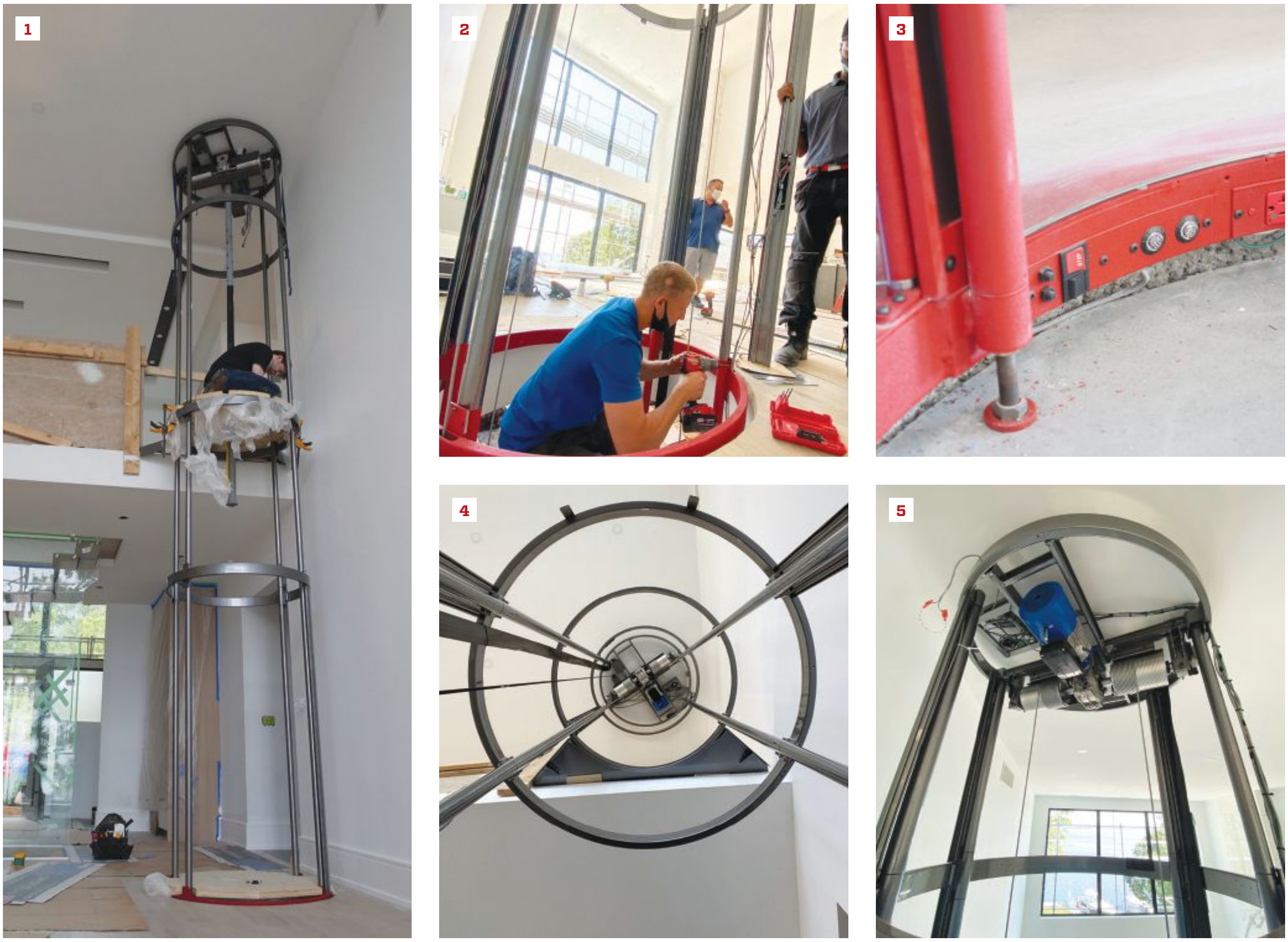
BY BRAD REEVE

We recently completed a lakefront project near Burlington, Ontario, which included a glass elevator made by Savaria. It's not the first residential elevator we have had installed on a project, and from a general contractor's viewpoint, this installation went very smoothly. The project was a new home, and my team provided the support necessary to prep the site and oversee the installation, but the owner worked directly with the Savaria to buy the unit and have it installed. I preferred that the transaction be managed directly with Savaria, as it freed me from any maintenance obligations or potential liability.

PREP WORK

This elevator serves three floors—the basement level, the main living area, and an upstairs, with the top level opening onto a balcony that overlooks the living room and the lake beyond. At the basement level, we needed to a form a "pit" that dropped 3 inches below the slab surface so the elevator cab would land flush with the basement finish floor.

We have had a number of residential elevators installed in the past, but none of them have been as simple as this one to prep for. We didn't need to provide electrical and data lines in the slab, as we



Photos courtesy Savaria Vuelift

All the wiring comes from the attic through the frame of the elevator shaft **(1)**. As the GC, we needed to provide the correctly dimensioned hole through the floor **(2)** and provide a "pit" at the bottom as a base for the frame **(3)**. The cab is driven by a motorized hoist, located at the top of the shaftway **(4, 5)**, with all the wiring coming from the attic above.

The shaftway frame is installed and secured to the basement **(6)** and first-floor framing **(7)** before the cab is wired up **(8)**. The installation was managed by Savaria, the manufacturer, freeing the author from the delivery and long-term service of the unit. On this install, it helped that the jobsite had ample room to lay out the curved glass panels for the walls of the shaftway **(9)**.

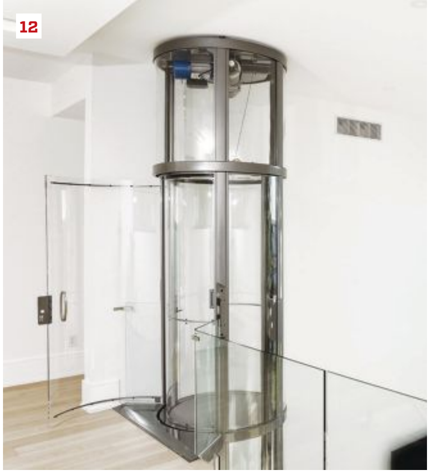
have with other units. We did have to provide 30-amp, 230-volt single-phase service for powering the motor, a 115-volt line for lighting in the cab, and a telephone jack, but the nice thing with the Savaria unit is that all this came from the attic at the top of the shaft and ran down the frame of the elevator.

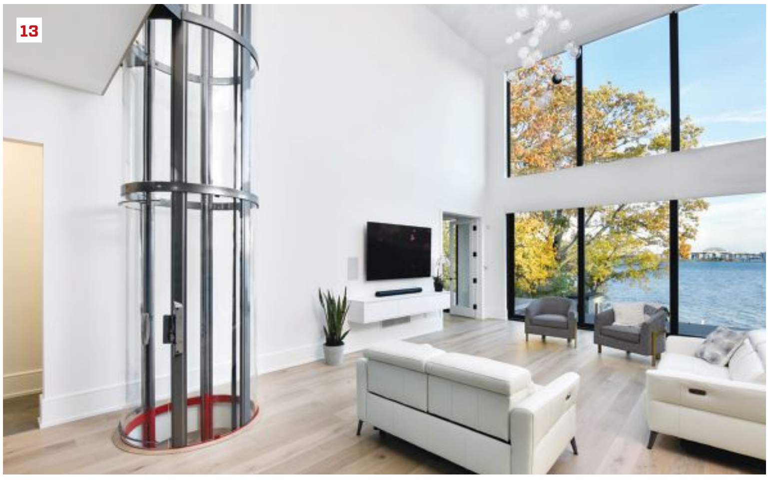
We did form a 6-inch-deep footing at the base when we poured the slab, but the manufacturer did not technically require one, as the load is not that significant. We also headed off a few joists with LVLs and framed in a 50-inch opening in the first floor. We sheathed over this opening, and then used a line laser in the center of the pit below, drilled a hole through the sheathing so the laser projected up to the ceiling, and verified that everything was in alignment. Then we laid out the circle in the floor sheathing and cut the hole for the shaftway.

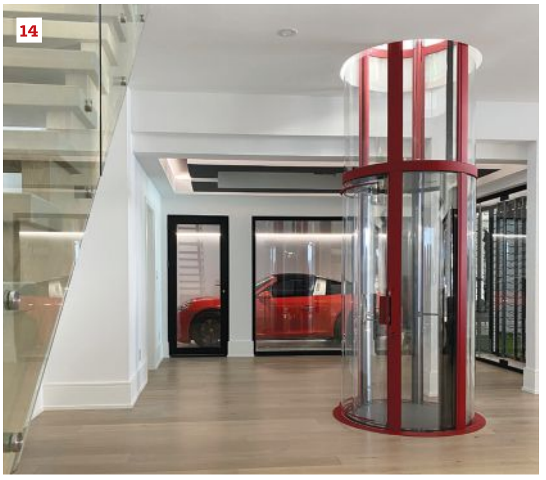
In the ceiling at the very top, we provided blocking to secure the frame. However, this didn't need to be that rugged; the elevator is not hanging from the ceiling. Rather, the steel elevator frame is the main structure and is secured at each floor level by heavy-gauge metal rings screwed into the floors.

At the top floor level, a glass railing angled out to meet the elevator. The specs for everything we needed to prep were provided on architectural drawings from the manufacturer, so they were clear to all the trades involved. But we waited until after the elevator was finished to order and install the last glass rail panel.

Finally, before the elevator crew came on site, we had all the finished flooring in place and the wall adjacent to the shaftway taped and painted out. We also drywalled and finished the inside of the hole through the first floor, since you see this as the elevator rises







As the general contractor, the author helped oversee the installation, making sure that finish flooring was protected from the scaffolding needed to install the glass panels **(10)** and that balcony glass aligned with the elevator door **(11)**. All glass surfaces were protected until the end of job. The last three photos show the finished job at the top **(12)**, living area **(13)**, and basement **(14)**.

up through the floor. Blocking this out and bending the drywall into this curve was probably the trickiest part of the job. But the result looks great. The only thing we needed to do afterward was cut and finish curved sections of hardwood to cover the gap where the elevator came to the first floor.

INSTALLATION

The elevator crew handled the delivery of all the components. All of those parts fit through a 30-inch door, so no special access was needed. The bulkiest parts were the curved glass panels. We kept the living-room area clear so the crew had plenty of floor space to unpack and prep the panels, and we made sure that none of the other trades entered this area while we had the curved glass laid out. The last thing I wanted was to have to replace any of those panels, as that would have delayed the completion of the house. The Savaria crew also handled the installation of all the components. The frame and the hoist went up fast. The cab was installed at the bottom of the shaftway, and the part that took the most time was wiring in the cab and getting it all hooked up and running properly.

The glass panels were the last parts to be installed. We helped with the scaffolding for this, as we wanted to ensure the finish floor was well protected during this setup. And we protected the doors at each level from being accidentally scratched while we finished up the house.

Brad Reeve owns Rosedale Properties, a custom homebuilding and renovation company based in Burlington, Ontario.

BY ROB CORBO

Trade-offs: Making Retirement Savings Work

In the two previous articles in this series, I established the importance of saving for retirement. I identified traditional and Roth IRAs as viable investment vehicles for retirement savings, and exchange traded stock index funds as providing the best returns on investment for IRAs. I highlighted the importance of compounding, dollar cost averaging, and low investment fees in maximizing retirement savings. But I didn't address how we are going to get the money to make the necessary regular, uninterrupted contributions of up to $6,000 a year, year in and year out for our construction careers. That's $500 a month. That's substantial money for self-employed folks and small businesses.

The best way to generate money for retirement is from the fruits of your labor. If your market will bear it, add $3 to your hourly rate (assuming 2,000 work hours a year) to generate $6,000 a year to fund your annual IRA contribution. If $3 is too much, then try $2, or $1. If you can't raise your rate, though, or you can, but want additional funds to open a spousal IRA (see "The Future Is Now: Making Retirement Savings Work," Mar/21), you may need to make trade-offs to find the cash—give up something to accomplish something else.

In business, there are always choices to make, priorities to establish, decisions to make, and goals to achieve. You don't choose to run a construction business unless you are strong and capable, used to sacrifices and trade-offs. In this article, we will examine how to fund retirement contributions by finding dollar trade-offs in business and household expenses. I will emphasize the need to spend wisely to achieve your retirement goals while remembering that a dollar not invested in retirement today is many more dollars lost in the future.

SETTING PRIORITIES

Finding money for retirement contributions from business or household funds means examining spending and establishing priorities. For this article, retirement is our number one priority, but in reality, growing your business and providing a solid family life are just as important. So, I am not going to suggest taking the kids' milk money to finance retirement, but how about your own milk money? Does carrying your lunch to work every day make you a tightwad? Not if it's a trade-off; to free up dollars to spend elsewhere, eat dinner leftovers instead of buying lunch. By carrying your lunch to work, you can save $8 a day or $160 a month. Over 30 years, if you compound a monthly contribution of $160 annually at 5%, you accrue $127,563. Hello! Lucky for me, I like leftovers.

In spite of the impressive amount of money $8 a day can become in retirement, I have spent many years' worth of lunch savings on traveling with my daughter to various national parks. A week's vacation with her is as important to me as a well-financed retirement. What isn't a priority for me is a store-bought lunch every day. Find your "store-bought lunch" and trade it off to achieve your retirement goal (or take your kids on a vacation, or buy them a drum set).

Every now and then, I punch up the company's accounting program and look at the profit and loss statement for the previous 20 years. Seeing that we spent $83,000 to rent a 10x25-foot storage facility to house business supplies and equipment prompts me to consider sacrificing the personal use of my two-car garage to save $350 a month. Gasoline costs amounting to $86,000 might lead me to consider a more fuel-efficient vehicle. For many small construction companies, vehicles are the largest capital expenditure. Trade off a new truck with all the bells and whistles but low fuel efficiency for one that's more modest with high fuel efficiency, or for a modest pre-owned truck that will cost you less for fuel and loan interest. (Paying loan interest, often a necessary evil, is the opposite of compounding savings interest; it subtracts from rather than adds to your future savings.)

> How are we going to get the money to make the necessary regular, uninterrupted contributions of up to $6,000 a year, year in and year out for our construction careers?

One beauty of many pre-owned pickups is that they were leased by folks not in the trades and therefore haven't seen heavy use. One trade-off my business made was buying a used five-year-old F550 super duty diesel dump truck from Hertz Equipment Rentals. Concerned the F550 might have been beaten up, we first rented it for a week to see how it performed. To improve the deal, Hertz gave us the truck's maintenance and repair records and agreed to take a credit card. We had the money, less than half of the truck's original purchase price, but used a credit card with a 0% interest rate promotion for 12 months to pay for the truck. We got a great truck for a good price and had money to apply to other areas of the business.

Examples of trade-offs are endless. The "carry your lunch" example shows how much a small amount of money, pocket change, can compound. Small trade-offs and sacrifices at work or at home can help you achieve your retirement goal. Larger trade-offs, like buying a used truck instead of a new one, can get you there faster.

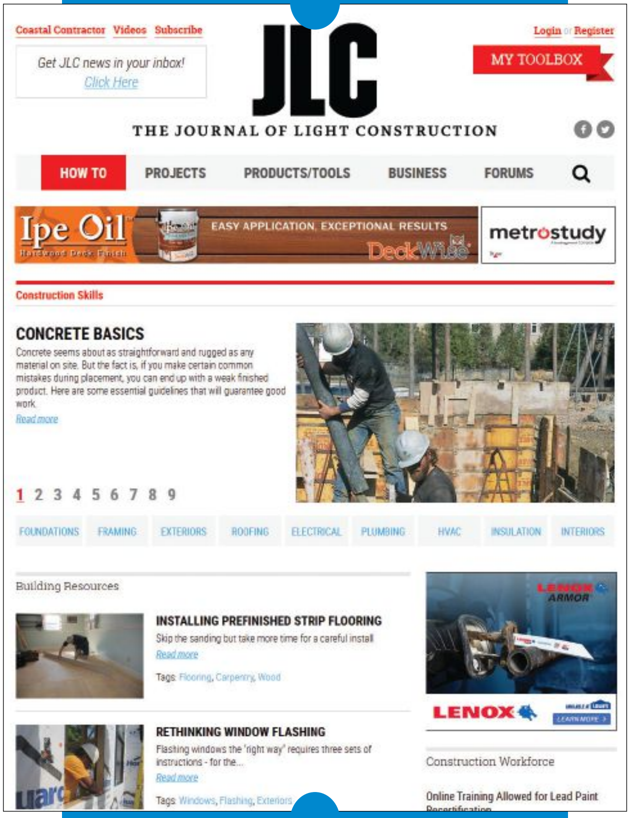
It's for you to decide what trade-offs are worth pursuing to achieve your goals. Two useful online tools for determining the worth of a trade-off are the compounding interest calculator at investor.gov, which shows you the potential reward of dollars saved from a trade-off, and the loan interest calculator at calculator.net, which shows the true cost of a purchase made with a loan. Quoting Einstein again (as I did in the two previous articles), "Compounding interest is the eighth wonder of the universe. He who understands it, earns it; he who doesn't, pays it." Use the compounding interest calculator to see "who earns it" and use the loan interest calculator to see "who pays it."

If you have extra money and want to supercharge your children's retirement, you can put them on the payroll, teach them the value of work, and establish a Roth IRA in their name. The federal government allows children of any age to work in businesses owned by their parents (except mining, manufacturing, or hazardous jobs). To be clear, I am suggesting office work. Start them at age 10 emptying the office trash and vacuuming the office floor. Keep them on the company payroll until they are 17 and have them end their construction career working with an accounting program or even working in the field, if it's safe (and allowed in your state). The more skills they can master, the better life will be. Just $40 a week will earn them $2,000 a year, which they can contribute to an IRA for eight years, for a total of $16,000. There are no federal income taxes on $2,000 of earnings in a year. Get out your compounding interest calculators and figure a $16,000 investment at 5% compounded annually for 50 years ($183,478 when they turn 67). That's in addition to their own retirement savings from age 18 to 67.

So, pocket change can become a pot of gold. A few trade-offs and you can change the course of your family's fortunes. But once you make sure you will have money to finance your retirement, you also have to make sure you'll be around to spend it. In this age of COVID-19, I would be remiss not to say that building up your immune system should be a priority. Trade off the pack of smokes a day ($8) and the case of beer a week ($24) and add years to your retirement—as well as the money to pay for the extra years. (Cue up Adam Ant: "Don't drink, don't smoke, what do you do?")

Rob Corbo, a frequent contributor to JLC, *is a building contractor based in Elizabeth, N.J.*

JLC

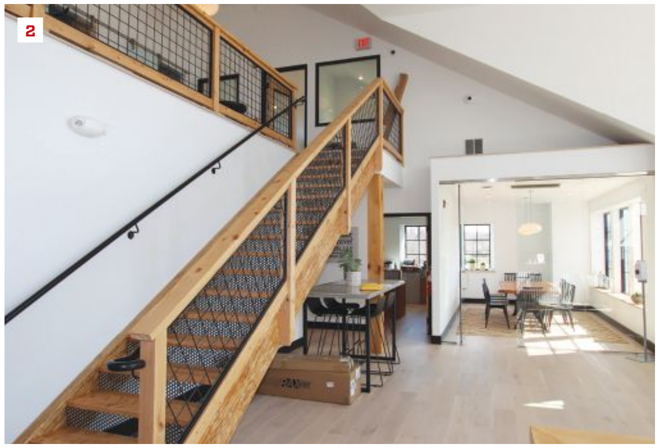


JLConline.com
offers sound technical advice, practical how-to articles, expert hosted forums, as well as networking opportunities.

Zonda Media

BY NATE HAYWARD

Heating and Cooling Office Space With a VRF-HR Heat Pump



In the second-floor entry, which is open to a third-floor mezzanine, wall-mounted units heat and cool the reception area **(1)**, while a ceiling "cassette" conditions air in a second-floor conference room, seen in the background **(2)**. A Daikin VRV Aurora HR outdoor unit **(3)** (see inset photo) supplies heat and cooling simultaneously to 17 indoor units located in offices and work areas on the 3,200-square-foot second floor and 1,000-square-foot third floor. Two smaller multi-split units supply heating and cooling to the first-floor tenants, one of which is a catering business.

Photos and illustration by Tim Healey

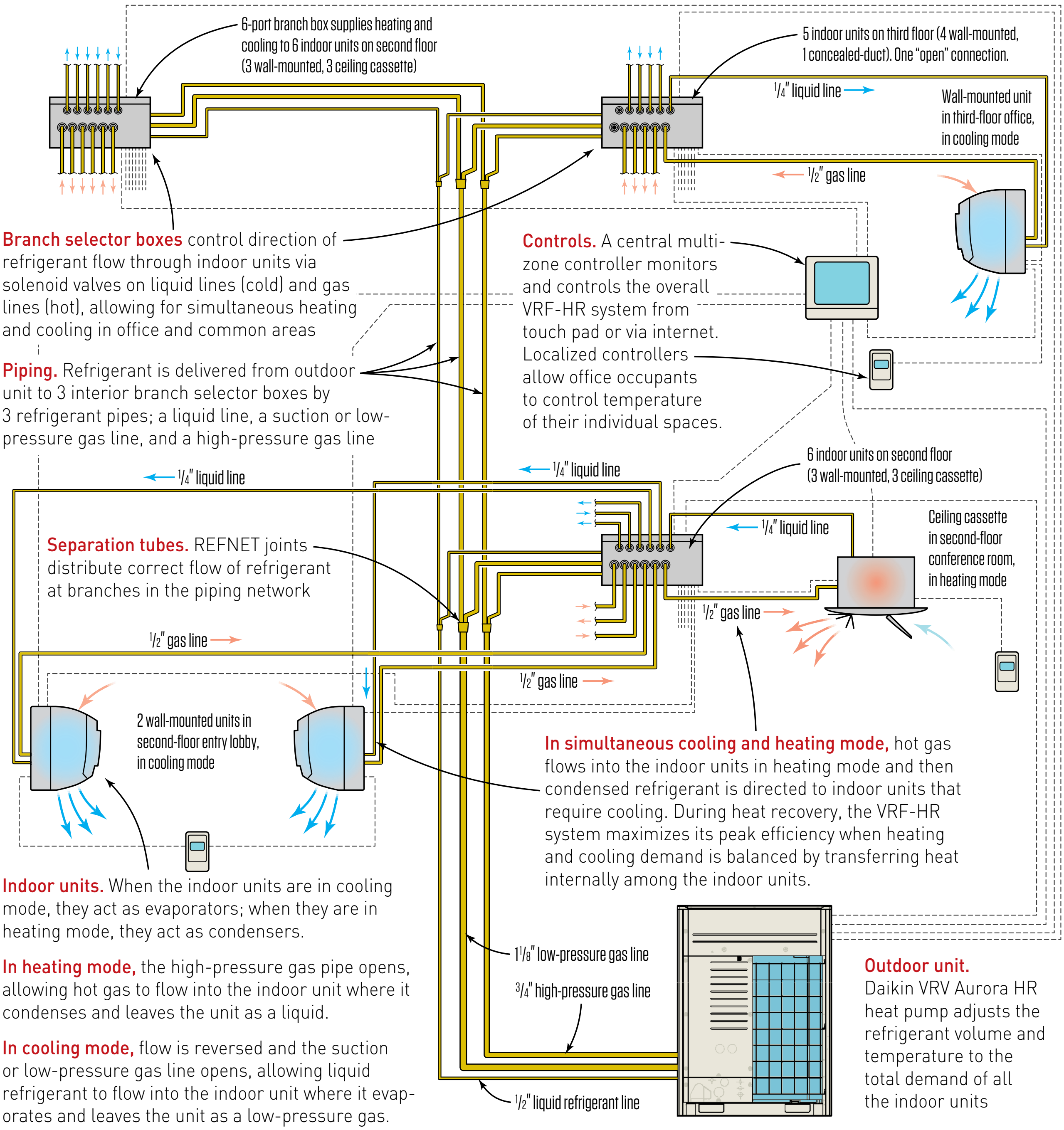
In a previous article ("Building a High-Performance Window Wall," Mar/21), I reviewed some of the high-performance features of a new 7,300-square-foot office building my company, Hayward Design Build, built in northern Vermont. While the story mainly focused on the installation of large, triple-glazed window units, it briefly touched upon the building's mechanical systems that enabled us to install mostly fixed windows throughout the building.

In this follow-up piece, I'll explain in more detail the variable refrigerant flow system with heat recovery (VRF-HR) capability we installed to supply heating and cooling simultaneously to offices and common areas in order to meet individual comfort levels of building occupants. Teamed with two large-capacity ERV units to provide a balanced air supply throughout the building, the VRF-HR multi-split system has localized programmable thermostats that allow occupants to control the temperature of their individual spaces.

Outdoor heat pump. At the center of the system is the heat pump–heat recovery unit. VRF air conditioning, where only the minimum amount of refrigerant needed is circulated at any one time, enabling individual climate control of air-conditioning zones, has been around since the early 1980s in commercial buildings. We installed a Daikin VRV Aurora HR heat pump with heat-recovery capability. (Daikin refers to variable refrigerant flow (VRF) as "variable refrigerant volume (VRV)"—which is a copyrighted term by Daikin—but "VRF" and "VRV" are the same.)

As variable-speed compressor technology has advanced in heat pumps, their ability to pull heat from colder and colder air has improved to the point where they are now able to heat a fairly large space in climate zone 6 without worries. The 10-ton Daikin VRV Aurora HR unit we installed can deliver heating down to -22°F at

VRF-HR System With Multiple Indoor Units



VRF systems with heat-recovery capability (HR) can operate simultaneously in heating and cooling mode, enabling heat pulled out from the surrounding air by the indoor "evaporator" units during cooling mode to be used rather than being expelled to the outdoors (as it would be in traditional heat pump systems). VRFs work best when there is a need for some spaces to be cooled and some heated during the same period (as often occurs in north and south sides of a building).

100% (with a diminishing performance curve at lower temperatures) and is capable of servicing up to 64 indoor units. Each individual indoor unit determines the capacity it needs based on the current indoor temperature and requested temperature from the localized thermostat. The outdoor VRF-HR unit adjusts the refrigerant volume and temperature according to the total demand of all the indoor units. For auxiliary heat in extreme cold or when there is a power outage, the building has a separate gas-fired unit in the lobby.

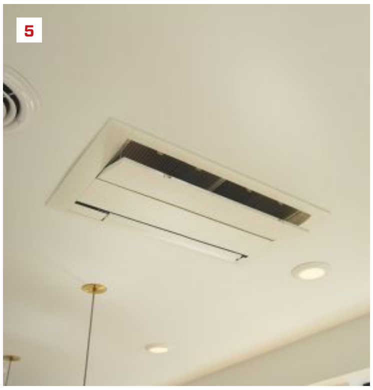
Branch selector boxes. In this case, the VRF-HR unit needed to supply heat and cooling to only 17 indoor units. Refrigerant is delivered from the outdoor unit to three interior branch selector boxes (which in turn deliver refrigerant to the 17 indoor units) via three refrigerant pipes: a liquid line, a suction or low-pressure gas line, and a high-pressure gas line. The branch selection box controls the direction of the refrigerant flow through the indoor units via solenoid valves on two refrigerant pipes—a liquid line and a gas line. (For information on system components, piping, and simultaneous cooling and heating operational modes, see the illustration "VRF-HR System With Multiple Indoor Units" on the facing page.)

Indoor units. We employed three types of indoor units to meet our heating and cooling needs: ten wall-mounted units, six ceiling cassette units, and one concealed-duct unit. The ceiling cassettes were placed in offices that had a floor system above them, while wall-mounted units were installed in hard-to-access areas, such as below insulated roof trusses. When the indoor units are in cooling mode, they act as evaporators; when they are in heating mode, they act as condensers.

Controls. The overall Daikin VRV (VRF-HR) system is controlled by an advanced multi-zone controller, the "intelligent Touch Manager (iTM)" located in a third-floor office. From the controller's touch pad (or via the internet), the "iTM" can monitor and control individual cooling and heating set points, range limitations, setbacks, and auto changeovers. Localized Daikin Simplified Remote Controllers (thermostats) allow office occupants to control the temperature of their individual spaces.

Ventilation. Critical to the high-performance office building with fixed glazing was supplying fresh air to the occupants. Two Zehnder ComfoAir Q600 ERV units were installed to supply air to the two-story office areas. Supply heads were run to each office, while each unit had a central return (door undercuts in offices work as the return paths). Traditional bath fans with occupancy sensors were used to vent the bathroom areas.

Nate Hayward is the owner and principal of Hayward Design Build, in South Hero, Vt.



Ten wall-mounted units **(4)**, six ceiling cassette units **(5)**, and one concealed-duct unit supply conditioned air to the offices. An "intelligent Touch Manager" **(6)** controls the overall VRF multi-split system, while thermostats **(7)** in each office allow for localized control.

A 12-foot-diameter ceiling fan (bigassfans.com) eliminates any temperature stratification in the large volume entry lobby **(8)**.

JLC INTEL

THERMA TRU® DOORS

BUILD BETTER ENTRYWAYS WITH A COMPLETE DOOR SYSTEM

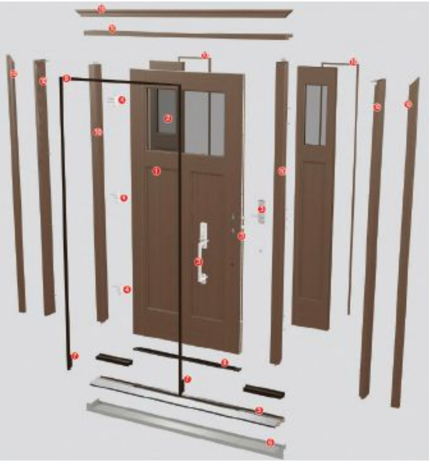
For long-term weather resistance and energy efficiency, it's all in the details.

The hinges, weatherstrip, bottom sweep and other door components aren't the first things your customers think about when designing a new entry, but they matter when it comes to the long-term durability and reliability of the door system.

With a complete door system, all of the components work together at the most critical points where an ordinary door's performance can fail, letting in air and moisture. By forming a tight seal against drafts and leaks, these components can help protect the door system and home against costly damage and deterioration. They also keep warm and cool air sealed in the house so homeowners can save on energy costs.

When the door components perform as one system, they lay the foundation for exceptional strength, security, energy efficiency, and long-term building performance.

ANATOMY OF A COMPLETE DOOR SYSTEM



1. **Fiberglass door panel** delivers years of low-maintenance durability. Unlike wood, fiberglass won't warp or rot. Unlike steel, it will not dent or rust.
2. **Glass** should balance the amount of privacy and natural light homeowners prefer. Options with triple-pane construction will provide thermal efficiency and an easy-to-clean surface.
3. **Multi-point locking system** engages the door and frame at three points from top to bottom for enhanced sealing and security, even under wind pressure.
4. **Hinges** position the door to properly compress the weatherstrip, helping form a tight, even seal against air and moisture infiltration when the door closes.
5. **Sills** provide a solid stepping surface and form a tight seal at the bottom of the door system to help channel moisture away from the home.
6. A **sill pan** gathers leak water and drains it away from the structure, adding an extra layer of protection to help keep water away from the floor system.
7. **Corner seal pads** (inswing only) fit securely behind the weatherstrip to help block potential pathways where wind-driven water can infiltrate the bottom corner of the door system.
8. **Bottom sweeps** (inswing only) feature a dual-bulb, dual-fin design to help maintain tight contact with adjustable sill caps and create added barriers against water and air.
9. **Weatherstrip** helps deliver a precise seal between the door and frame. Look for a variety of profiles to provide the best possible fit with the door system.
10. **Composite door frame** provides a rot-free solution that delivers extra protection from the damaging effects of moisture.

When you pay close attention to every detail that goes into a complete door system, you can stand behind all of its parts, ensuring long-term performance. However, proper installation is just as important for long-lasting durability as having the best components.

Whether it's just you or your entire crew on site, you want consistent, high-quality installations every time. Completing a certified installer training program can help build your knowledge, skills and confidence—and it shows customers you're serious about providing an entry door solution they can trust to perform year after year.

Visit **ThermaTru.com** for more information on Therma-Tru premium fiberglass door systems to bring exceptional style and performance to any home's front entry. Plus, open up more opportunities to grow your business with the Therma-Tru Certified Door System Installer Program.

Produced by Hanley Wood Strategic Marketing Services Group

BY DOUG HORGAN

Using a seam probe on a recently installed roof, the author found multiple voids along welded seams and patches **(1)**. In addition, required sealant along cut edges of TPO had been omitted. Dirt and moss built up at drip-edge seams, indicating water intrusion **(2)**.

When the TPO was cut back from the edges **(3)**, it was discovered that the drip edge and gravel stop edge metal had been installed on top of the protection board. The manufacturer's rigorous flashing detailing had not been followed, resulting in leaks where metal flashing overlapped **(4)**. A "leak path" had occurred from the outside corner back to the substrate; water had bypassed sealant at overlapped pieces of drip edge **(5)**.

Photos by Doug Horgan

Troubleshooting a Failed TPO Roof

With our reputation as a quality-focused contractor, we are regularly asked to take on "rescue" projects when another builder has failed to the point of being removed from the job. On a recent project, a brand-new TPO low-slope roof had been installed by a previous builder and we were asked to evaluate it as part of our work to take the partially finished project to completion and help the clients close their contract with the first builder.

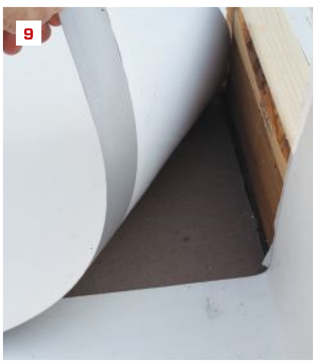
Low-slope roofs are always challenging. With most types, there is no redundancy, so a single flaw can cause large problems. Over the years, we've found that some parts are more likely than others to fail, so we checked those areas carefully.

Signs of poor construction. Evaluating the 16-by-29-foot roof, we first checked the TPO seams using a seam probe. Running the awl-like tool along the edge of the seams, we quickly found multiple voids. In addition, heat-welded patches were missing at numerous seam intersections, so it didn't take us long to determine that the roof's seam and patch work would have to be carefully checked and heat welded as needed. We also noticed that seam sealant hadn't been applied to the field-cut edges of the TPO membrane and patches. Some brands have factory edges on all sides, but once cut, the membrane's fabric reinforcing layer becomes exposed and vulnerable to weather damage.

Edge metal installed first. The most common failure point we come across on low-slope roofs is the edge. In the area where we work, the drip edge and gravel stop edge metal are often installed first, with the TPO membrane run on top of the edge metal. Edges built this way often leak, and the usual culprit is a failure to apply heat-welded flashing tape and extra layers of TPO flashing at vulnerable locations—any joints in the edge metal or the TPO membrane—per the manufacturer's specifications. In my opinion, installing the TPO membrane first, then attaching the metal on top of the membrane later is a much better flashing detail (see "Low-Slope Roofing Details That Work," Nov/19, for information about drip-edge detailing).

On visual inspection, we found areas where the membrane was not attached to the metal at all. Special coated metal per the manufacturer's specifications is to be used and the membrane heat welded to it, but on this

In addition to the leaky edges, application of the roof-to-wall and skylight curb flashing had been subpar. It was deemed preferable to remove the roof down to the decking rather than repair its many deficiencies **(6)**.



After the new protection board was installed, the TPO membrane was dry fit to the roof **(7)**. The membrane comes with an adhesive backing; here, the release paper was removed from the TPO sheet in preparation for adhering it to the roof **(8)**. Factory overlaps come without adhesive, ready for heat welding **(9)**. At cut edges, the adhesive was removed by hand to make a clean area for heat welding **(10)**.

roof, the membrane was glued to the edge metal—and poorly at that. There were lots of voids in the adhesive, and dirt from rain had collected between the metal and the roofing within a short period of time.

When we cut back the membrane along the edges, we found that five of the six edge-metal joints had leaked. The leaks were mainly from water getting between the two overlapped pieces of metal; the manufacturer calls for the edge metal flashing to be "butted" end to end with a 1/4-inch gap to account for expansion and contraction. It also calls for multiple layers of heat-welded TPO flashing to seal the joint, but these were not installed. Instead, copious amounts of sealant were "smooshed" between the overlapped metal pieces in hopes of keeping water out.

Other trouble spots included unfinished roof-to-wall flashing (the termination bar and counterflashing hadn't been installed) and the skylight TPO flashing (the curbs had been flashed and heat welded in a hodgepodge manner). Because the edges needed to be redone and the difference in cost for a total reroof was not huge, the clients decided to replace the months-old TPO roof completely.

INSTALLING A NEW SELF-ADHERING TPO ROOF

Our roofing sub's crew started the tear-off at the edges, and we immediately found leaks all along the perimeter, not just at the seams. The crew pulled the adhered TPO membrane off the protection board's facing, then unscrewed the plate fasteners and removed the foam board from the roof deck. The Zip System sheathing deck was blown dry with leaf blowers, then holes in the deck from the removed plate fasteners were hit with sealant. The roof's perimeter fascia trim was rebuilt and Zip tape was added along the deck's edge as needed to seal seams and nail holes.

New 1-inch-thick polyiso protection board was mechanically fastened to the deck, then the new self-adhering TPO roof was laid out. The Firestone UltraPly TPO SA 60-mil membrane (firestonebpco.com) was installed in two pieces, with the first, roughly 10-by-29-foot sheet trimmed and dry fit around the skylight. The membrane was overcut so it could be turned down at the edge and its vertical leg nailed off at the fascia. Crew members removed the release paper from the back of the membrane and pressed the TPO onto the protection board by hand, then rolled it with a heavy roller to set the adhesive. The second, roughly 8-by-29-foot sheet was installed similarly, with 8 inches run vertically up the adjacent masonry wall.

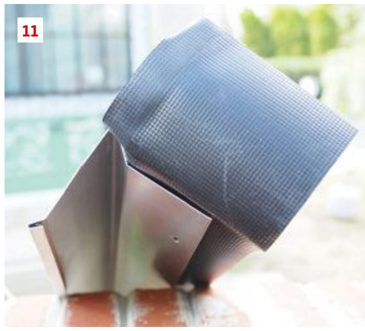
Factory overlaps do not have adhesive on them, so they're ready for heat welding. On field-cut edges, the adhesive has to be removed to make a clean area for heat welding. The crew carefully cut off the release paper and rubbed the adhesive off by hand, which bunched up and peeled off readily. Seams were heat welded and patches applied where two seams intersected, per the manufacturer's specifications.

Edge metal installed on top. Our roofing sub installs an aftermarket drip edge and gravel stop made with Firestone's coated metal and UltraPly TPO membrane. The "TPO metal" comes assembled with a strip of TPO already heat welded to it. The TPO flashing flips up to allow fastening of the edge metal, then it is heat welded down onto the membrane. At seams, the TPO metal is butted end to end and a 6-inch-wide TPO patch is applied over the joint and run down the vertical leg of the TPO metal profile an inch or so. This is faster than hand-assembling on site, and the result is superior, with an inherently less risky detail at joints in the metal.

Finishing up. At the roof-to-wall intersection, a bead of waterblock sealant was installed at the vertical leg of the membrane, then the termination bar and copper counterflashing were installed. At the ganged skylights, the TPO membrane was run up and over the existing curbs, the seams were flashed with TPO patches per the manufacturer's detailing, and cut edges were sealed with approved sealant.

Had the edge flashing not been so poorly installed, this probably would have been a "TPO roof rescue"—instead, we were left with having to reroof it.

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



The author's roofing sub uses edge metal that comes with a strip of TPO heat welded to it **(11)**. The TPO is flipped up to allow fastening of the edge metal **(12)**, then it's heat welded down onto the membrane **(13)**. The seam between lengths of "TPO metal" edge is patched with TPO membrane, and the cut edges are sealed with sealant **(14)**.

After the TPO membrane was run up the wall 8 inches, waterblock sealant was applied **(15)**. A termination bar and copper counterflashing saw-cut into the solid masonry wall were later installed. At the ganged skylights, the TPO membrane was run up and over the existing curbs, the seams were flashed with TPO patches per the manufacturer's detailing, and the cut edges were sealed with an approved sealant **(16)**. The finished reroof **(17)**.

PREMIUM TRIM AND SIDING IS ONE WAY THIS FOREVER HOME LIVES UP TO ITS NAME

Harsh Pacific Ocean salt, wind, and moisture put this coastal dream home to the test.

For the owner of a beachfront home in Pismo Beach, Calif., home maintenance and repair headaches, especially the kind you expect from living next to the Pacific Ocean, is a constant concern.

That helps explain the lengths (or better, depths) the team at Crizer Construction, led by veteran project manager Dahlan Richenberg, went to make sure this forever home lives up to its name.

"The home is right on the sand in Pismo Beach," explains Richenberg. "The home is built with 20 steel caissons embedded 80 feet deep, with a steel I-beam structure set on top to secure the wood frame home to the platform."

The owner, Richenberg explained, was adamant that the home must be as weatherproof as possible, and every detail of the craftsman-style exterior had to be considered

EASY DECISION

Richenberg recommended engineered polymer (cellular PVC) trim to the owner and cited the reasons why. Intrigued, the owner went online to research the material. His verdict was quick and decisive: The entire exterior would be finished with siding and trim from AZEK Exteriors products.

"He likes the low maintenance, durability, and authentic look. It had been such a long, arduous process getting the home to this point. He wants a home that stands up to harsh coastal conditions," Richenberg said. AZEK material is moisture resistant and won't rot, warp, or swell like wood.

BETTER WORKABILITY

Richenberg and his crew like working with AZEK's engineered polymer across a variety of products, including soffits, facia, shingle siding, board-and-batten siding, and column wraps. "The guys like AZEK because it's light and you can work with it just like wood. We're painting the shingles and siding. Everything else we're leaving white."

The workability of AZEK Exterior products proved instrumental in several tricky conditions:

- **Stilt Connections.** "There are a lot of connections that are different than a house on a regular foundation. It was a huge advantage ordering AZEK sheets in various thicknesses and widths. We could easily mill it down to create custom pieces."
- **Porch Columns.** "There are pony wall caps—these are 2x10 material and so much more durable with AZEK than wood or any other product. They were not well illustrated on the plans, so had to improvise some column wrap detailing. The AZEK material makes that easy because it's dimensioned so well. It doesn't split or crack and seams can be easily glued together."
- **Window Frames.** "We used a biscuit joiner to give the AZEK window trim really strong corners. We're using some of the same details for the siding and trim too."

For the owner, the lifetime limited warranty on siding, trim and molding is just the right touch for a forever home.

To learn more about AZEK Exteriors for your next project, visit **AZEKexteriors.com**.

Produced by Hanley Wood Strategic Marketing Services Group

Photo: Tim Healey

A Builder's Guide to Breathable Indoor Air

Homes need more ventilation than U.S. building codes require

This spring, I met up virtually with Bill Hayward, CEO of Hayward Lumber and the founder and originator of the Hayward Score (see "The Hayward Score: A Rating of Home and Human Health," page 37). Earlier this year during a conference, Bill had characterized the COVID-19 pandemic as a "trigger point," much like the energy crisis of the 1970s had been for energy-efficient housing. This new crisis has triggered a growing interest in indoor air quality and occupant health. As we all have learned a great deal more than we ever thought we would about respirable droplets, air circulation, and the spread of airborne contaminants, homeowner awareness of health, air quality, and ventilation has caught fire and is beginning to ignite a new set of demands. Advanced ventilation systems and home performance may finally be getting equal, if not greater, attention from homebuyers than granite countertops and luxury appliances.

And perhaps this is the time we will finally align ventilation codes with building science. Since 2012, we have seen strong alignment between building science and the air-sealing and insulation requirements of model building codes. But ventilation requirements feel like the poor relations nobody wants to invite for dinner. The Chapter 15 ventilation requirements of the International Residential Code are not clear to all builders, and certainly not well understood by code officials, so they aren't enforced and education is sparse. Exceptions to this do exist in multifamily construction where there tends to be a higher concern for the potential liability surrounding occupant health among developers and municipalities. There are also exceptions among a core segment of the JLC *readership that serves a very demanding clientele. But in most single-family new construction and whole-house remodeling, we seem to be mostly building tight but not ventilating right.*

Change will likely only happen when it is driven by customer demand, and that is precisely what Bill's "trigger point" is all about. To dig into the implications of this for builders, we brought Mark LaLiberte, co-founder of Construction Instruction and a frequent speaker on building science–based building practice, into the conversation to begin to formulate some clear, health-driven best-building principles. —Clay DeKorne

Bill Hayward: The pandemic certainly raised awareness of the health dimensions of our homes, and indoor ventilation especially. The lack of ventilation in homes is something that has developed gradually, and the amount of ventilation in homes is perhaps at an all-time low, since homes have gotten tighter without enough attention to controlled ventilation. A big part of the problem is that the ventilation standards referenced in the building codes are not health-based.

The first ASHRAE ventilation standard came out in 1973 and called for significantly lower airflow rates than we had seen in ventilation codes earlier last century when recommendations were based primarily on health concerns. The justification for the lower ventilation rates was driven by energy concerns [1973 also brought the OAPEC oil embargoes] and by research on controlling odors. Because of some of the justifications used in the development of the standard, you often hear it called an "odor-based" standard (see "A Short History of Established Home Ventilation Standards," page 38). This continues today: The required ventilation rate in the U.S. building code is not a health-based number.

It's time for that to change. We didn't know anything about aerosols in the country a year ago. And it took until early this year for the EPA to get more specific about ventilation guidance. Ventilation is evolving in schools that are reopening … and in restaurants. As things are opening up, people are concerned about going back in, about what's in our air, and the last place it will spill to is a deeper discussion of the air in residential housing.

BREATHABLE AIR

BH: In the past, we have heard a lot about IAQ. But I think right now, for most of us, it's not that complicated. It's more just "I need fresh air." IAQ tends to get associated with all kinds of technical specs, but right now people are saying simply, "I just need to breathe fresh air."

This focus on breathable air is propelling healthy homes into mainstream building. A good example of how builders are starting to change the paradigm is provided by Randy Noel, a homebuilder in the Greater New Orleans area. Randy, a former CEO of the NAHB, responded in his local market to customers asking about healthier indoor air, for home offices, for bigger spaces with families at home, and last year he entered the Parade of Homes with a home certified by Wellness Within Your Walls. It's still a long shot for a lot of production builders to ask what's in the indoor air. High-end custom builders have been having these conversations for years, but seldom with anything near the immediacy that they are now. Everywhere people are concerned. So the question is: Do we need to come at these discussions with a lot of technical recommendations or with just "I want to breathe good air"?

It's not complicated: Start with a tight building shell and a stand-alone ventilation system with energy recovery. When you have airtightness combined with energy-recovery ventilation, the house doesn't fill up with dust and dirt. If you are a production builder, could you sell that? Yes. And it's peacefully quiet inside. Can you sell that? Definitely. Builders can't sell airtightness. They probably can't sell IAQ. But we can show a customer 1) no dust and dirt; 2) it's quieter; and 3) oh, by the way, it's better for your health—you don't feel your allergies, and it affects health and longevity and mental alertness (see "Health Effects Tied to Buildings," left). When you show all that, the customer is likely to respond with, "Yes. I'd like all three of those."

A tight shell and balanced energy-recovery ventilation is a simple equation to get you there, but success from a builder's perspective requires one person to take charge of optimizing the heating/cooling systems with balanced ventilation, airtightness, and the thermal boundary, including windows.

Health Effects Tied to Buildings

	Percentage of Respondents
Trouble Sleeping	30%
Disturbed Sleep	32%
Allergies/Sneezing	41%
Dry Eyes	22%
Moodiness/Agitation	25%
Depression	27%
Cough/Shortness of Breath	47%
Extreme Fatigue	32%
Foggy Thinking	24%
Memory Loss	17%

Source: Hayward Score Data

This table shows the percentage of all 80,000+ respondents to the Hayward Score self-reporting health symptoms that may be connected to their homes. Shown is only a selection of the 23 medical symptoms covered by Hayward Score data. Note that among the selected symptoms, a number demonstrate a clear connection to cognitive functions.

STAND-ALONE VS. INTEGRATED SYSTEMS

Mark LaLiberte: Agreed. This may be simpler than we think if we can boil it down to some basic systems. A balance between energy use and health is found when we combine a tight, high-performance shell, so we gain control over thermal gains and losses, with stand-alone ventilation—a system that delivers balanced supply and exhaust air streams with energy recovery, and that runs continuously. When this is the default, everything gets a lot simpler.

Integrated systems, particularly in hot, humid climates, are problematic. We have huge problems right now in the Southeast with houses being ventilated with conventional supply-side or exhaust-only ventilation raising indoor relative humidity in buildings that can't properly dehumidify. So we've got condensation on clothes dryer vents and bath fan ducts and on recessed lighting fixtures. This argues for a stand-alone energy-recovery system that can help pull out some of that moisture. The basic system starts with being able to run a fan continuously to move air throughout the house. And with energy recovery, you're able to at least extract the moisture from the incoming air in hot, humid climates and reintroduce that to the outdoors.

In the work we just finished at CI [Construction Instruction], we kicked the ventilation rates up, validated fan performance, and showed that you can ventilate at 140 cfm and consume only 23 watts of electricity, recover about 85% of the energy in whichever stream you want, and reject 40% of the moisture from incoming air.

Builders need to know that the cost of ventilation with energy recovery is substantially lower than it has ever been. And I think that's the prime choice. And it's often the simpler choice. The project that we're working on in the Southeast is with a large national builder. They were running a supply-only ventilation system, taking in 60 to 100 cfm of outdoor air and running it through 500-watt, 70-pint dehumidifiers, and then introducing that air to the return side of the furnace on the air-conditioning side. This uses additional electricity and dumps dry air into the system before it hits the evaporative coil, wasting the potential of the coil to take out any of the moisture. If the builder chooses to run an energy recovery system instead, they will have a reduced need for dehumidification. In a lot of climates, dehumidification may not be needed at all. But in regions with high summer dew points, an ERV and a dehumidifier may be needed if you are selecting a higher ventilation rate.

BH: Getting the right amount of air in the house starts with putting in a stand-alone ERV that runs continuously. We breathe constantly so you want to deliver constant airflow throughout the house. An integrated system with a variable-speed fan that is turned down to low and is pumping 150 cfm so the air is mixing throughout the house *might* be OK. To my knowledge, no one has done a careful study comparing the air delivery of integrated vs. stand-alone systems, so I can only give my best WAG, but I'd wager an integrated system can deliver just 40% of what a stand-alone system can deliver. Why would you go with 40% when you can deliver fresh air everywhere in the house?

My preference is always a dedicated, stand-alone ERV. We have units that run at 80% to 90+% efficiencies. These can recover up to 90% of the heat and up to 60% of the humidity. This humidity control makes sense in most parts of the country to keep indoor humidity levels comfortable. Most of the industry is still saying that HRVs are generally needed everywhere except in hot, humid zones, but we are finding that ERVs make much more sense for most of the U.S. These units are a little more expensive, but you can eliminate the bath fans, saving some money and eliminating the extra penetrations through the roof. You now have 24/7 air moving with no cycling on and off, so you're getting the air needed for good health. And it's cheaper to run because you aren't relying on a higher wattage fan in an air handler to move fresh air throughout the house.

CONTROLLING AIRFLOW

ML: ASHRAE Standard 62-2013 provides the minimum performance criteria we should all be starting from. This is a little better than code (see "Ventilation Code Simplified," page 39). But it is still a minimum. More ventilation is good for human occupancy and the best way to provide a baseline *plus* more ventilation is to use a strategy that provides adequate flow, is quiet and efficient, and allows homeowners to engage with it as ventilation needs arise.

An example of when occupants need to control the system is when there are more people in the house, or when they get new furniture or new rugs, paint rooms, that sort of thing. If we can have ancillary support from an IAQ monitor that says "you need more air today because the PM2.5 counts are high," or that otherwise tells the occupants that they should be concerned about the VOC mix, that will certainly improve the ventilation. This level of

THE HAYWARD SCORE: A RATING OF HOME AND HUMAN HEALTH

Bill Hayward developed the Hayward Score to, as he puts it, "harness the power of consumer demand" to improve housing. It's a simple questionnaire that anyone can take for free. You log in at haywardscore.com and answer 50 questions about your house. It takes about 10 minutes.

The survey starts with questions about the materials and configuration of the home to assess its general characteristics and systems, its location, and its proximity to environmental hazards like busy roads and gas stations or dry cleaners and such. There are questions about moisture, including ones about the presence and use of ventilation fans, and indoor conditions, such as where occupants store cleaning and personal care products and other household chemicals. And then there are a range of questions about health symptoms that occupants feel may be related to their homes. These can't provide an absolute causal link between symptoms and the home, but when matched up with the presence of pests and environmental factors inside and outside the home, as well the use habits around bath fans and range hoods (or the lack thereof), Hayward Score can draw correlations and suggest improvements to indoor conditions that could alleviate the health symptoms if those conditions are in fact the cause. This all gets rolled up into an overall score and presented with a customized five-page report that gives clear action items, so participants can take steps to improve conditions aimed at transforming the indoor air quality and ultimately their health.

Hayward Score keeps in touch with participants, sending them periodic emails to help them keep up their progress and improve their score. In the process, Hayward Score gets feedback not only on how houses are improving but also on how occupant health may be improving. From this, Hayward Score is able to capture a lot of data on the link between homes and the health of occupants. It tracks 23 medical symptoms and is now the largest study on health and housing ever created, assessing more than 80,000 homes and counting. While the Hayward Score is provided to the homeowner, it proves to be a good tool for building professionals to point their clients to, as many of the improvements suggested by the report (such as installing whole-house or point-source ventilation and addressing leaks, mold, or other building failures) are often beyond the scope of DIY. —*C.D.*

A SHORT HISTORY OF ESTABLISHED HOME VENTILATION RATES

Source	Minimum Airflow
ASHVE[1] Recommendation-1895[2]	30 cfm (14 L/s) per person
ASHVE Guide and Handbook-1925[3]	10 cfm (4.7 L/s) per person
Yaglou, Riley, Coggins-1936[4]	17 cfm (8 L/s) per person
ASHRAE[5] Standard 62-1973[6]	5 cfm (2.5 L/s) per person in non-smoking spaces; 10.6 cfm (5 L/s) per person in smoking spaces
ASHRAE Standard 62-1989	15 cfm (7.5 L/s) per person
ASHRAE Standard 62.2[7]-2003[8]	7.5 cfm (3.5 L/s) per person + .01 cfm/sq ft (.05 L/s/m2) of occupiable area
CEN[9] Standard 13779 -2007	Lowest class: 10.6 cfm (5 L/s) per person; highest class: 42 cfm (20 L/s) per person
ASHRAE Standard 62.2-2013[10]	7.5 cfm (3.5 L/s) per person + 0.03 cfm/sq ft. (.15 L/s/m2) of occupiable area

1. American Society of Heating and Ventilation Engineers
2. Cf. "The History of Ventilation and Temperature Control," by John E. Janssen (ASHRAE Journal, Sep/1999). These ASHVE recommendations were based on studies by J. Billings, author of Ventilation and Heating (1893) and a physician concerned with reducing the transmission of disease, especially tuberculosis, in enclosed spaces.
3. According to Janssen, by 1925, 22 US states had ventilation codes that required a minimum of 30 cfm (14 L/s) per occupant of outdoor air. However, many heating engineers were either concerned by the energy impacts of reconditioning so much incoming outdoor air, or were inclined to view ventilation as more of a comfort concern than a health issue. Both concerns argued for reducing ventilation rates, and in response, ASHVE published "A Code of Minimum Requirements for Heating and Ventilation of Buildings" in the 1925 ASHVE Handbook and Guide.
4. Yaglou, et. al. was a more comprehensive study of work begun by Lemberg, Brandt and Morse who studied ventilation rates needed to control odors in buildings. The Yaglou study correlated minimum ventilation rate with net air space per occupant, setting the stage for ventilation codes based on occupant response, and underpinning the push to base ventilation rates on comfort control rather than health concerns. Cf. "Challenges in Developing Ventilation and Indoor Air Quality Standards: The Story of ASHRAE Standard 62" by Andrew Persily (Build Environ 2015, National Institute of Building Standards).
5. American Society of Heating, Refrigerating, and Air Conditioning Engineers (the name changed following the 1959 merger of the ASHVE with ASRE, the American Society of Refrigerating Engineers).
6. In addition to requiring this minimum flow rate, the Standard recommended from 7.5 cfm (3.5 L/s) to 21.2 (10 L/s) per person ventilation air flow.
7. ASHRAE split the Standard to address commercial requirements (62.1) separately from residential requirements (62.2).
8. "Per person" is defined in the Standard here by the number of occupants expressed as the number of bedrooms plus one (assuming two people in the master bedroom and one in others).
9. European Committee for Standardization
10. This rate remains in the most current iteration, ASHRAE 62.2-2019

occupant engagement must be based on knowledge of what is in their environment. But for the most part, the system should be set to run continuously at the baseline without occupant intervention.

BH: Ventilation, in my opinion, is the builder's best friend because it is helping them reduce risk. When I talk to production builders in particular, and we mention risk management, the light goes on. One thing you taught me years ago, Mark, is that you can't control occupant behavior. They don't run the bath fans, they don't run the range hood. They fill the place up with moisture and then the builder gets claims for humidity condensing on surfaces.

Occupants don't know what they're doing, especially with a sophisticated system like an ERV. Most people, including people that we train, don't pay attention to their ERV. So when somebody hits the "boost" button, it stays on boost for too long. Or they say, "I want to save a little energy, so I'm going to turn it off at night." But that is exactly the time you need it! On the other hand, if I put in a system that runs 24/7, I don't run into problems because I forgot to turn it back on. I'm mitigating elevated chemical exposure from new construction (ventilation is about the only way to cost-effectively remove concentrations of harmful chemical off gassing from materials, and it's virtually impossible to eliminate all chemicals from building materials), I'm mitigating moisture problems, and I've got a healthier indoor environment—all that just totally makes sense for the homeowner *and* for the builder.

Occupants have their needs—to breathe fresh air—but the house also has needs: To remain stable and to age well, a house needs a consistent source of fresh air, as well as consistent levels of temperature and humidity. Of all the ways to provide ventilation, I'd rather put in a dedicated system that delivers the right amount of fresh air throughout the entire house and leave it running. I want to give occupants some control. But from a builder's standpoint, you don't want occupants to be able to turn it off for periods of time and then have them come back to the builder and say, "Well, my daughter's having trouble breathing at night."

We also know that once you set the building up, someone may drill a hole to install cable or some other future modification, and now it's not working. An instrument can help you manage those changes. In my experience, once you give somebody an IAQ monitor on their phone, they quickly become knowledgeable about it.

ML: We want to have both the system running at a baseline and homeowner engagement. You can't smell most of the harmful contaminants—an odor-based standard is not going to provide good health. So we have to count on something to tell me that my particulate count is too high. If you look at cooking, for example, you will go from a count of zero to 100 in a matter of 20 minutes. The average consumer probably has no idea that turning on the stove had that big of an impact. But if they watch a gauge all of a sudden go into the red zone, then they're going to turn the hood on.

I remember when Whirlpool did a study where it installed a wall control that showed energy consumption in real time. When people would walk out the door, they would look at it and ask, "Why is it in the red?" And they'd run downstairs and find all the lights were on, that sort of thing. The wall control was a way to activate awareness.

For us to become activated around ventilation, we need to pay attention to several practical things about an ERV system: proper equipment selection; proper sizing; envelope performance (insulation, air-sealing, windows with a low U-value); system controls that maintain a health-based ventilation rate; and education that allows occupants to rationally engage with that system. But none of this is Fifth Element stuff. This is right now. And we can do it affordably.

A good example is what Gord Cooke is doing with 16 builders in the Toronto greater metro area, all building to net zero. Gord has been able to demonstrate that the increased cost, including ventilation and energy recovery in every house, has been between 5% and 10% at the most, and in some cases finding neutral cost. This group is working to specific outcomes—net zero—and so they are able to work with clients to say "take this out and add this here" to arrive at the outcome. When a builder can do that over and over, always aiming at their modeled benchmark, who would make a choice to go back to the other way? No one; otherwise, they lose the edge of what allows them to demonstrate to customers what makes them different and better.

Gord's example aims at an energy outcome. It includes ventilation because that is critical to building performance. But I think the work you are doing, Bill, comes at it from health, and as you say, that creates urgency that is going to move the industry faster toward a higher building standard. We need a solid health-based outcome.

A HEALTH-BASED VENTILATION STANDARD

BH: The advantage of coming from the perspective of personal health is that we're much more engaged with it than we are with energy. We naturally tend to be more concerned about health than energy because the impacts seem so much more serious for ourselves, and for children. The trigger event of 2020 began to draw a bright line around health and home. If home is our safe haven, it better be safe. Is it? Maybe not, if our ventilation standards are based on comfort and energy control instead of health factors.

Jillian Pritchard Cooke, of Wellness Within Your Walls, brings the dichotomy into sharp focus: In a recent workshop, she compared the annual savings generated by EnergyStar—about $17 billion per year on average—to the estimated cost of environmental diseases in children, which was in excess of $76 billion in 2008. The vast difference in social cost between $17 billion and $76 billion is an impact that should help reframe priorities around a ventilation standard.

For me, the current standards are not high enough if we are to address health as a primary concern. I run my home at about 30 cfm per person. That's around what old health-based codes called for, but I do it because I'm reading the instruments and want to keep the air in my home below the World Health Organization's maximum, which is 500 TVOC [total volatile organic compounds] parts per billion. The ventilation rate in my home is a lot higher than the baseline of ASHRAE 62.2-2013, but it's not as high as the recommendations in a Harvard University cognition study that found that people think clearer, sleep better, and have higher workplace productivity rates when the ventilation rate is closer to 40 cfm per person in office buildings. For homes, the correct number is between 20 to 30 cfm per person. Really, once you have a tight, well-insulated shell and a stand-alone continuous system with energy recovery, you can set it at any level that is appropriate to the customers' needs. We can do this with dedicated ERVs without having an outsized effect on energy use in the home. The energy impact has been driving ventilation rates down for the last 48 years. But that is no longer relevant with the efficiency of today's ERVs. We are ready for a complete shift in how we ventilate homes.

Health does create urgency. Everyone wants to be healthier, live longer, spend less money on health care, and be free to make life decisions that aren't encumbered by health restrictions. This is something builders can sell, not just to make money but to do the right thing. If you make homes healthy, you make them energy efficient as well because you can't control the air inside until you control the envelope. Usually the line for the last 20 years among energy-conscious builders has been the opposite: "If you make it energy efficient, you will see all these other benefits like better indoor air." But building owners don't care enough about energy to spend the money needed. If we come at it from the direction of health, we create an urgency to make that investment. And then your company is in the business of making people healthier and happy, even improving conditions for everyone on the planet by driving a lower impact on resources and energy, and driving a market for less toxic materials, less industrial pollution. The impacts go out like ripples in a pond from the simple act of making better homes.

VENTILATION CODE SIMPLIFIED

For installing a stand-alone, continuous whole-house ventilation system, the International Residential Code (IRC) follows ASHRAE Standard 62.2-2010 and offers two methods to determine the required airflow in cubic feet per minute (cfm). Note that the IRC does allow whole-house ventilation systems to operate intermittently according to rate factors defined in Table M1507.3.3(2), but if you are following the arguments put forward in this article, continuous ventilation offers the best performance for both the building and the health of the occupants.

Formula. The required flow rate for whole-building ventilation can be calculated as follows:

Ventilation rate in cfm =
floor area / 100 + (number of bedrooms + 1) x 7.5

Prescriptive table. Another way to determine the baseline airflow rate is to use the prescriptive table (right).

Minimum Continuous Whole-House Ventilation (cfm)

Floor Area (sq ft)	Number of Bedrooms				
	0 to 1	2 to 3	4 to 5	6 to 7	> 7
< 1,500	30	45	60	75	90
1,501 to 3,000	45	60	75	90	105
3,001 to 4,500	60	75	90	105	120
4,501 to 6,000	75	90	105	120	135
6,001 to 7,500	90	105	120	135	150
> 7,500	105	120	135	150	165

Table M1507.3.3(1) of the International Mechanical Code is referenced in Chapter 15-Exhaust Systems of the International Residential Code.

JLC INTEL

CONTRACTOR REWARDS

THE SECRET OF WORKER RETENTION

Attracting and retaining workers may be easier and at no extra cost to you.

Scarcely a day goes by without news about construction labor shortages. The National Association of Home Builders recently reported the largest monthly jump in construction job openings since the Fall of 2019.

Any thoughts that COVID-19 would diminish hiring needs have largely disappeared. Associated Builders and Contractors, an industry trade group, reports overall construction spending rose 4.8 percent in 2020. If the construction industry's projected growth rate tops 2021 projections, as some predict, it "… could boost the number of additional construction workers needed this year to nearly one million."

It's a huge challenge. JLC periodically publishes stories on the topic, many offering contractors ideas on how to improve worker recruitment and retention.

You've probably seen many approaches, most aimed at attracting younger workers, such as Millennial and Generation Z employees. The strategies often take the form of personal and career development, such as:

- Ongoing training
- Voice in company decisions
- Regular goal setting and development path
- Promotion from within

Then there's employee recognition rewards.

SURPRISING RESULTS

You may already use rewards for team building. A recognition reward is a powerful way to reinforce productive behavior, say for beating a deadline, coming up with a money-saving idea, referring a job candidate, celebrating a birthday or start date, helping meet a performance goal, upselling a customer, really any occasion.

The concept works. Consider multifamily owners and operators, for example. Many multifamily pros are under constant pressure to keep occupancy rates high in their properties. They face nearly similar recruitment and retention pressures with Millennials and Gen Z'ers as you do. Over the years multifamily property experts have learned with scientific precision how recognition, reward, and engagement acts like an emotional glue to minimize renter churn. That's a big deal with a $25,000 lease renewal at stake.

So, how much should you budget for your rewards program?

How does $0 sound?

INNOVATIVE IDEA

That sounded good to Elizabeth Ringer, co-owner of Ringer Construction, a 27-year-old remodeling and home addition specialist in Bayport, N.Y. Their workforce of 10 are "… extremely busy. We're in growth mode," Ringer says.

Ringer learned about a way to generate reward items almost by chance. "A window representative told my husband, George, years ago. He said there's a way to earn points for purchasing building materials we were already buying. You just submit an invoice as proof of purchase," she explains. "It snowballed from there." Among other things, she hands the staff a company-branded sweatshirt each year, courtesy of the points.

Contractors looking to add a no-cost way to obtain rewards for employees or other key partners, should check out Contractor Rewards. There's no enrollment fee and the 11-year-old service offers a wide selection of rewards from an online catalog of over 350,000 items.

Learn more about a no-cost way to earn high-value rewards for team building and other goals at **contractorrewards.com**.

Animal Hospital Rehab

Workflow and planning were critical in keeping this emergency care facility running 24/7

BY DAN WATSON

Photos by Dan Watson

One of the tricks of commercial construction is the ability to renovate office space without shutting the business down. We have a lot of experience with that, but none of our previous projects were as challenging or unique as the project described in this article, the renovation of a busy traditional veterinary practice that included an emergency room for the animals. At the time of this project, the clinic employed more than 20 doctors and 100 full-time staff members to provide both routine and urgent 24/7 veterinary care.

The core of the project was adding offices to unused space directly above the most active area of the hospital, the "treatment room." This area served as the emergency room, where many of the practice's patients were brought during the day; at any one time, there could be 10 or more animals and many more staff using the area. Also being renovated were existing offices that could not be shut down during normal business hours and attic space (filled with sprinkler lines, ductwork, plumbing, electrical wiring, network and camera wires, and suspended ceiling support wires) that was located above several other rooms and active kennels.

The actual work to renovate the space and build new offices was fairly straightforward; when we bid the job, we knew that profitability would be won or lost based on our planning and management of the logistics of the construction. Because we had experience with renovating businesses while they were open and would be self-performing much of the most invasive work, we were confident we would be able to work during normal business hours and keep the client happy. To do the job as economically as possible, we had to work closely with the client, our trade partners, the architect, and the local building department.

ACCESS, DUST, AND NOISE CONTROL

During our pre-bid planning, we had investigated the existing construction and site conditions, which we were able to compare to the original building plans. We discovered that there were load-bearing walls immediately adjacent to the proposed perimeter of the new second-floor spaces, and that the gridwork above the treatment area was able to accommodate a moderate floor load. It appeared as though the original plan for the building included a second floor, but it was never built. We had taken advantage of this in our bid and made our proposal contingent on the architect approving our means and methods and amending his plans to reflect our new plan and design.

Temporary floor. The existing gridwork above the ceiling of the treatment room made a perfect support for a new, temporary floor system below the elevation of the new second-floor framing **(1)**. Once built, the new floor would provide a noise and dust barrier between the client's space below and the active construction above.

The best option for the temporary floor was a modular platform system, which would allow us to install the panels quickly with little impact on the staff, and to remove them easily at the end of the project. We prebuilt the modular panels at our shop using 2x4 joists and 3/4-inch plywood decking and then delivered them to the jobsite, carefully measuring all the openings prior to ordering materials so we could calculate the spans and tolerances of the design.

Our goal was to install the panels quickly and safely above the treatment room, so size and weight were huge concerns. We were able to limit the total weight of each panel to about 120 pounds, which meant that two or three people could easily move and lift them into place. Most of the openings in the gridwork could be filled with a single panel, which we framed with joists 16 inches on-center **(2)**. The largest opening required two panels, which we framed with joists 12 inches on-center.

We built 2x6 frames for each panel, fitting the frames with steel angles to create a ledge for the panel to drop into **(3)**. We sized the steel so we could make the panels even and square even though the openings were inconsistent. Because we planned to remove the panels at the end of the project, all of the fasteners in the frames were installed so they could be removed from below. As we installed the panels, we also had to modify the existing ductwork so the new space below would have the required supplies and returns. Once the panels were installed, we sealed the seams with tape to prevent any dust and debris from demolition and framing from falling into the space below **(4, 5)**.

New door. Whenever we worked in occupied spaces, we took measures to completely separate our work from the staff and provide adequate safety and dust control measures. So we waited until the floor panels were in place and the second floor sealed off from

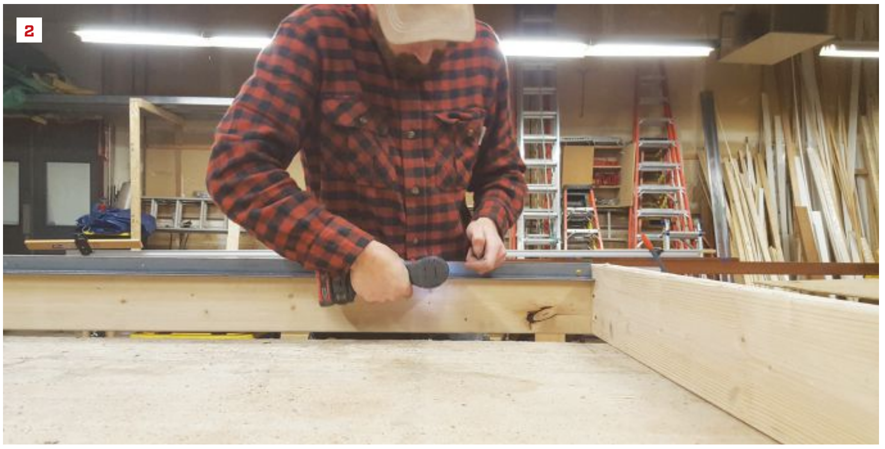
1

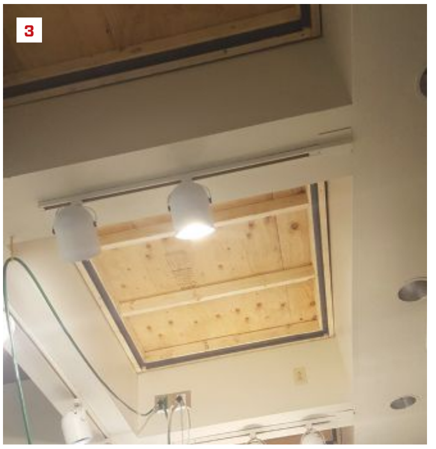
To minimize disturbance from the second-floor construction, the author added a temporary floor system to the vaulted ceiling's gridwork above this treatment area, which needed to be available to staff and patients 24 hours a day **(1)**.

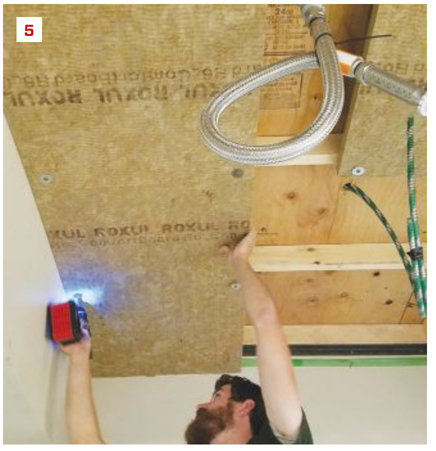
the first before removing a glass partition wall between the existing second-floor offices and the new construction area. We left all of the debris on top of the panels to be removed later, once we had better egress from the building.

A single set of stairs led up to the second-floor offices, which were located in the front of the building; to access the stairs, you had to walk through busy hallways and congested work areas on the first floor. Those offices would eventually be moved to the back of the building, so to avoid traveling through the hospital, we created a new second-floor entrance directly into the attic. This kept the construction and the practice separate, allowing us to work when we needed to and bring in larger materials without issues **(6)**.

Our new access into the building was adjacent to a new parking lot, created to address concerns about parking and on-site exterior storage. The existing parking lot was already beyond capacity, and the clinic struggled to accommodate the required client parking. Early in the project, it was decided that a new stone parking area







Panels for the gridwork were designed to be removable, and were prefabricated off-site **(2)**. Framed with 2x4s, the panels rest on steel angles fastened to 2x6 frames that are fastened to the gridwork **(3)**. The panels were taped to the gridwork from above to keep dust and debris from dropping down into the treatment room **(4)**. After the decision was made to leave the panels permanently in place, Rockwool mineral-wool insulation was added to the assembly for both fire resistance and for soundproofing **(5)**.

with dedicated delivery areas would be provided. This created a landing zone for lumber drops and easy truck access, and we were able to put our jobsite storage container in a location that was convenient for us and out of the way for the client.

Once the majority of the construction was completed, we planned to replace the new staircase and door with permanent finishes. But using pressure treated treads and temporary finishes in the meantime meant less care had to be taken when we moved supplies and materials in and out of the work zone.

We regularly use helical piers to support deck and porch framing, and this project was another example of their many benefits. The new landing and staircase were built above the existing air-conditioning condensers, so we had limited access and small spaces to work with. Instead of using large, traditional concrete footings, we were able to quickly install the helical piers without impacting the condensers and immediately begin to frame the landing.

While the finished stairs were to be built parallel to the back of the building, we built the temporary stairs so that they were perpendicular. This allowed us not only to bring long joists straight into the building but also to build the second permanent stairs at any point without having to remove our utility stairs.

FRAMING

One of our main concerns with performing the proposed work around the staff and animals was their safety. Loud noises—specifically from nail guns, compressors, and impact drivers—would add to the already hectic and loud environment below us and unnecessarily add to the stress the animals were already under.

A new entry was framed on helical piles to provide outside access to the second floor **(6)**. In a connecting hallway, a temporary ceiling allowed occupants continued use of offices and the treatment room while work proceeded in the dropped ceiling above **(7)**. A new floor framed with I-joists and engineered beams extends in one level across the existing attic and above the old ceiling gridwork **(8)**. The attic was filled with ductwork and other mechanicals that had to be moved as the framing progressed **(9)**.

Coupled with that, sometimes there would be little physical barrier between us and the activities below, so we decided that we would use no air-powered tools during construction unless absolutely necessary. That meant using structural screws instead of pneumatic nails to fasten almost all of the framing together, requiring coordination between us, the architect, and the building department to get approval.

The renovation of the second floor was phase one of a two-phase project, which would later include a large addition to the building. Part of the planning for the second phase included creating access to the addition from the renovated space. Because we had to raise the floor elevation over the ceiling gridwork, a step down to the original office floor elevation was required here, and in the front office where a restroom and stairs to the first floor were located.

An existing beam ended short of the proposed floor system. Unfortunately, this was also over the only hallway between the bullpen—a combination break room and place where workstations for the doctors and staff were located—and the rest of the hospital. It was a busy travel route, with entrances into the two staff restrooms also located in this short hallway. In order to work safely and efficiently while reframing the floor system, we built a temporary platform above the hallway and below the existing suspended ceiling, allowing us to work over the active hallway without interfering with the foot traffic **(7)**.

The new floor framing was primarily composed of 22-foot-long TJI joists installed 12 inches on-center, with a few LVL and PSL beams thrown into the mix. Because load-bearing CMU walls were already located close to where the architect had proposed the joists were to end in the original, unvaulted second-floor design, it was easy to spec and install slightly longer joists that could bear on these walls **(8)**.

First, though, we had to extend the height of the existing walls to make the floor for the entire second floor one level. We also needed to accommodate existing sprinkler lines, as well as I-joist and roof truss rafters that were already bearing on the walls. To achieve the necessary elevation, we installed short LVL beams padded out with 3/4-inch plywood sized to fit between the trusses on top of the 2-by plates capping the CMU walls.

MECHANICALS

The existing attic space looked like a typical commercial attic, filled with mechanicals that had been modified year after year, with no expectation of the space being used for anything else **(9)**. In order to safely work in the attic and move the mechanicals without shutdowns, we performed the work in phases. We would build several feet of new floor framing, and then mechanical trade partners would install new work or move existing mechanicals. We also had to work around the wires that supported the suspended ceiling over the first floor (there was no existing floor system

With the subfloor complete on the upper level and new ceiling joists installed **(10)**, work could begin on framing partition walls to define new spaces and for the closets where mechanicals and panels for electrical and network equipment could be located **(11)**. During the job, multiple BuildClean air cleaners were employed to manage dust. A new multi-head mini-split HVAC system was installed to heat the new break room and open and private office spaces on the second floor **(12)**. In the treatment room, the gridwork ceiling was fitted with the framework for a suspended ceiling after the various lines for oxygen, suction, and the sprinkler system had been extended or reconfigured **(13)**.

for the attic space). Once all the work that could be efficiently performed was completed and we had moved the suspended ceiling wiring for one section, the cycle would start over again with additional framing being installed.

Because we did not have access from below, all of the MEP work had to be done after the new floor was framed but before the subfloor was installed. At this time, we also installed the sprinkler, oxygen, vacuum, and electrical wiring that would be needed for the treatment room below. Once this work was completed, we installed Rockwool mineral wool insulation between the floor joists to help with sound control and fire protection prior to screwing down the subfloor sheathing.

Where the new rear entrance was located, we had constraints with existing electrical, plumbing, and HVAC systems. It was not cost effective to move those mechanicals, so we installed a beam to carry one end of the new joists, while the other end of the joists bears on the existing wall. This created a hallway with closets that would be used by the office staff. We were also able to house the new network equipment in one of the closets **(10, 11)**.

It was decided early that a new subpanel for the second floor made the most sense. This allowed us to limit shutdowns of the existing system and it kept us out of the first-floor bullpen where the existing panels were located.

A new mini-split HVAC system was installed for the second floor, giving the break room, open offices, and private offices temperature control and eliminating the need for the additional ductwork in already overcrowded wall and floor spaces. We framed a shelf on the side of the rear stairs to support the exterior components of the system **(12)**.

The most time-consuming and invasive mechanical work

As the project wrapped up, the construction access was transformed into a permanent second-floor entry with a new set of finished stairs **(14)** and a porch roof **(15)**. In the office at the other end of the building, the floor level steps down to the original floor level for access to an existing staircase (at left) and to a restroom (at right) **(16)**. The new second-floor break room and workspace above the existing first-floor treatment room is lit by the building's original skylights **(17)**.

involved the sprinkler system, which was a wet design in unconditioned space. The pipes were filled with 165 gallons of an antifreeze liquid that had to be drained and then pumped back into the system every time work was performed. Also, when the sprinkler system was being worked on, we had to maintain a fire watch: We had to notify the local fire department whenever the system was down, and both a staff member and someone from our company had to be on watch for any potential emergencies.

FINISH LINE

Because the second-floor offices could not be shut down, we had to complete the new offices before we could move the staff out of their old rooms. Once they moved, our rear construction entrance would become their primary entrance—and we would be walking through the new offices to continue the project **(14, 15)**—so we decided to load the majority of our materials into the space between the new and the old to limit our impact on the staff. This again required some night work and a lot of coordination between our team, the client, and the staff **(16, 17)**.

For fire safety reasons, we had originally planned on removing our temporary floor panels before finishing the gridwork ceiling of the treatment room. The plan was to support the panels from below, remove the fasteners, and then drop the panels down to dispose of them. But in the end, the fire inspector provided us with a few limited options that would allow us to leave them in place. Because the wood framing could not be left exposed, one option was to cover it with drywall, but that was not possible because of the time and mess associated with installing and taping. Another option, installing stone wool insulation, satisfied all of the inspector's requirements, as well as our own. We were able to install the Rockwool batts quickly from below and then move right on to the new suspended ceiling work in the treatment room **(13)**.

Dan Watson is a remodeling contractor based in Glendora, N.J.


Discover What Others Already Know!™
3x The Strength
3 Colors To Choose
Stainless Steel Insert
Ipe Clip®
Hidden Deck Fasteners
THE DECKWISE®
HIDDEN
DECK FASTENER!
Scratch Here!
(Just Kidding!)
DeckWise®.com
The Ipe Clip® Fastener Company, LLC
Manufacturers of Hidden Deck Fasteners & Accessories
MADE IN THE USA
HIDDEN DECK FASTENERS
It's a hidden deck fastener. You're not supposed to see it.
To see our hidden deck fasteners up close go to www.DeckWise.com.
Let us help you build the deck of your dreams!
Call 866.427.2547 or Chat Online

Products

BY VINCENT SALANDRO

2

3

1. Ladder Safety Enhancement
Mounted to any roof pitch or mounted vertically, the Ladder Safety Rest helps protect shingles and gutters from damage typically associated with ladder use. The device is secured to a roof with a plate held by four screws; the ladder is then held in place between the two hand grips with a safety chain tested for strength and durability to prevent shifting or slipping. Ladder Safety Rests are available for $300 on the manufacturer's website. laddersafetyrest.com

2. Condensing Tankless Water Heater
The Navien NPE-2 series condensing tankless water heaters feature a turndown ratio up to 15:1 and multi-line control with built-in software. They also offer increased 2-inch PVC venting length up to 75 feet, a vent installation detector, expanded cascade capability, and expanded common venting capability. Like the heaters in the NPE series, these heaters have dual stainless steel heat exchangers and 1/2-inch gas-pipe capability up to 24 feet. The NPE-2 series is available in four standard models (NPE-S2) and three advanced models (NPE-A2). Contact a distributor for pricing information. navieninc.com

3. High Performance Antimicrobial Coating
ICP Building Solutions Group reformulated its mold-resistant and fungicidal coatings line, Fiberlock IAQ 6000 Mold Resistant Coating. According to ICP, the coating, which is made with a zinc complex of active ingredients, delivers high levels of antimicrobial performance with a single coat, is ultra-low VOC and low odor, and satisfies California's Proposition 65 criteria. It can be used on a range of materials, including wood, plaster, drywall, concrete, masonry, and primed metal. Pricing varies by vendor in the $300 range for 5 gallons. fiberlock.com

4. Custom Mosaic Tile Surfaces
Artaic's Quad Collection mosaic tiles provide homeowners with a wide variety of color and pattern options. According to Artaic, the tiles do not peel or fade in the sun and have a life span of 75 years. Artaic also says the tiles are easy to clean and have low carbon footprints. They come in standard 12-inch-square sheets; pricing starts at $19 per square foot. artaic.com

5. Installation Support Tool
Designed to ease the installation of kitchen cabinets, drywall ceilings, and tub surrounds, the T-Jak support tool can support objects weighing up to 400 pounds. A quick-release knob engages the tool's threaded rod to lock it into place; twisting the knob allows users to fine-tune the height from 53 inches to 84 inches. The Original Cabinet Jack costs $126 on the company's website; 1-, 2-, and 3-foot extensions are sold separately, starting at $26. tjak.com

6. High-Tech, PM-Monitoring IAQ
The View Plus IAQ Monitor from Airthings includes sensors for monitoring particulate matter (PM), radon, carbon dioxide, humidity, airborne chemicals, temperature, air pressure, and outdoor air quality. The monitor provides users with continuous access to data and notifications about changes in air quality. The View Plus adapts to its surroundings, displaying the most relevant data based on its location, according to Airthings. Users can also customize it to prioritize the air quality data that is most important to them. The View Plus, available for pre-order for $300, can be integrated into an existing smart home system. airthings.com

7. Optimal Drain Protection
Oatey's updated Drain Seal promises to block unwanted odors, sewer gases, and insects from entering a home through a drain. The product is engineered with a drainage system that prevents water from evaporating in the P-trap and allows for continuous water flow, which inhibits ponding or pooling around a drain, according to Oatey. The non-chemical product requires no special tools for installation and is available in 2- or 3-inch sizes for approximately $30. oatey.com

8. Hands-Free Kitchen Faucets
Speakman added three touchless kitchen faucets to its portfolio, including the Neo Sensor Spring Kitchen Faucet (pictured). The faucets are activated when users hold dishes or hands in front of a sensor, and built-in technology stops water flow after two minutes. The brass faucets are ADA compliant and offer single-hole drop-in installation in decks up to 2 13/16 inches thick. Faucets are available in up to four finishes (chrome, brushed brass, stainless steel, and matte black); pricing ranges from $290 to $415, depending on style and finish. speakman.com

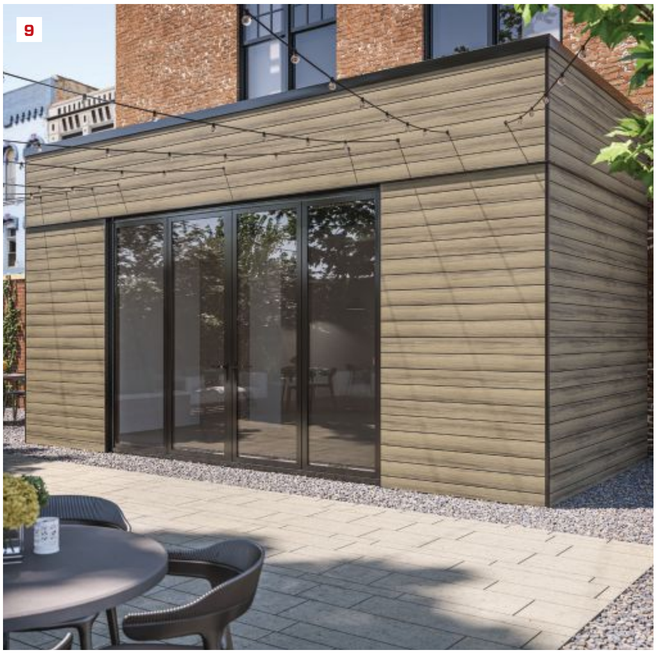
5


6


7


8


9



10

11

12

9. Mineral-Based Composite Cladding

Deckorators' mineral-based composite (MBC) decking is now approved for use as cladding in horizontal, vertical, and angled applications. The decking is 35% lighter than traditional composites and similar in weight to PVC, Deckorators says. MBC is composed of a mix of polypropylene and calcium carbonate to prevent moisture absorption and minimize thermal movement. Decking widths of 3 1/2 inches, 5 1/2 inches, and 7 1/2 inches can be installed as cladding in 12-, 16-, and 20-foot lengths. Pricing starts at $3.25 to $4.75 per linear foot for 5 1/2-inch boards in the four MBC collections. deckorators.com

10. Vapor Permeable Flashing Tape

Huber Engineered Woods added Vapor Permeable (VP) Tape, designed for use in panel seam sealing and flashing applications, to the Zip System line. The tape has an acrylic adhesive and offers a higher permeance (3 perms) than standard Zip System flashing tape (less than 1 perm) to fit the requirements of particular environments and high-performance assemblies. According to the manufacturer, Zip System panels sealed with VP Tape create a weather-resistive barrier and a rigid air barrier. VP tape is sold in 3 3/4-inch-by-90-inch rolls at lumberyards and on Amazon. ziprevolution.com

11. Premium Architectural Asphalt Shingles

TAMKO Building Products introduced Titan XT (pictured) and StormFighter IR shingles as part of its Heritage Proline series. The shingles feature an expanded nailing zone, sealants designed to be sticky even in cooler climates, and a top weathering layer that increases the thickness of the shingle. The shingles also have a poly-fabric reinforcement that the manufacturer claims delivers enhanced wind performance. Pricing varies by region. tamko.com

12. Whole-House, Two-Stage Filtration System

Fantech says its Hero HS300 whole-house HEPA filtration unit removes up to 99.97% of particles 0.3 microns and larger from the air circulating within a home. The unit has two-stage filtration—a pre-filter with carbon and a HEPA filter—to remove pollutants, allergens, odors, and viruses, according to Fantech. It can be installed on the return air plenum of a forced air system or as part of a standalone ventilation system. Suggested retail price is $570. fantech.net

Classifieds

Advertising Index

*Advertising appears in regional editions

Lamello Zeta P2 Profile Biscuit Joiner

BY MIKE SLOGGATT

I've owned some form of biscuit joiner for over 30 years. I recall the first job I needed it for, a book-matched teak wall panel for the library of a boating enthusiast. I still remember taking the client to a specialty lumberyard to pick out the panels. With 20 sheets of 4x8 teak lined up against the lumber racks to choose from, my client had the poor yard man moving them around like playing cards as he matched up each panel's grain patterns.

The assembly on that job required me to install the 4x8 panels vertically and stitch them seamlessly together on the wall. Using a biscuit joiner was the only way to align the panel faces, and both the homeowner and I were very happy with the results.

Fast forward some years to the Domino, Festool's mortise-and-tenon joiner, which works similarly to a biscuit joiner. This was a great advancement in technology, and I've used my Domino to build countless projects.

Then last year, I discovered the Lamello Zeta P2 **(1)**, the great-great-grandchild of the original biscuit joiner, which was invented by a Swiss engineer and amateur cabinetmaker named Herman Steiner in 1956. In 1968, Steiner built the first portable biscuit joiner, called the Lamello, and variants of this design are now manufactured by many tool companies.

The new Lamello—the Zeta P2—is a biscuit joiner on steroids. What makes it so special is its ability to oscillate and cut a kerf at the end of the plunge cut **(2, 3)**. This kerf allows the user to slide in half of a mechanical "biscuit" made of plastic in one of several configurations. When you join the two mating sides of a P-System biscuit together, you get alignment and a built-in clamp as well.

1

The Lamello Zeta P2 **(1)** features a unique vertical mechanical drive on the cutting spindle that creates a profiled groove. This function can be deactivated for standard biscuit installation.

2

3

A 7-mm carbide-tipped cutter **(2)** is used to cut the grooves needed for P-System connectors **(3)**. For installation of wooden biscuits, the 7-mm cutter is replaced with a 4-mm groove cutter.

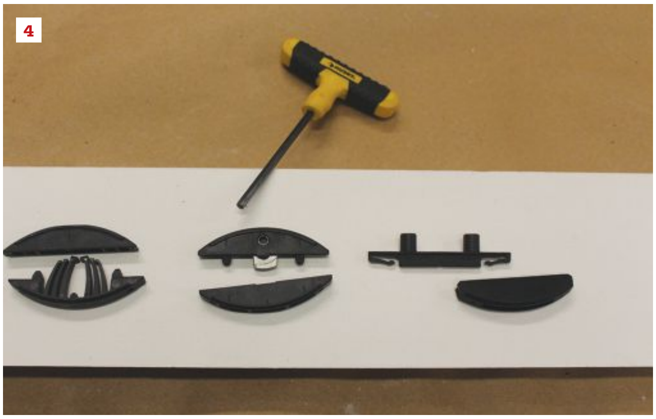
Photos by Mike Sloggatt

P-SYSTEM CONNECTORS

This tool is a game changer because the P-System connectors allow for the temporary alignment and assembly of joinery, with the ability to disassemble, assemble, and then permanently glue the pieces together when you are ready to finish the project. Or, if desired, you can have a joint that can be disabled and reassembled at any time.

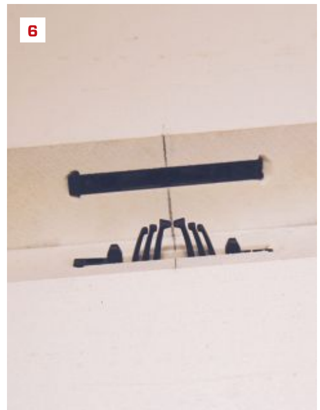
One connector, called the Tenso, is self-clamping, an incredibly useful feature when I'm working with exterior PVC trim. With the Tenso connector, I find it easy to align and clamp butt joints, miter joints, and compound miter joints with incredible precision; not having to nail or screw pieces together results in cleaner looks and almost one-handed assembly in the field. It allows me to field fit a joint and make sure it looks good before committing to the final glue-up **(4, 5, 6)**.

4



5

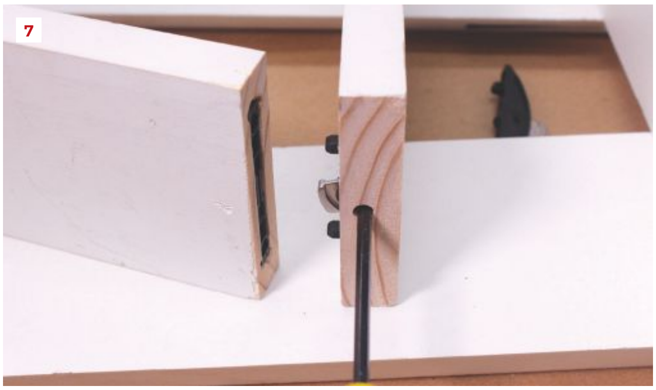
6



Available connectors for the P-System include (left to right) the self-clamping Tenso, the Clamex detachable furniture connector, and the Divario sliding connector for shelving **(4)**.

The Tenso and other P-System connectors are inserted by hand **(5)** into the T-shaped slot, which locks them into place without glue or screws **(6)**.

7



8

Available in a couple of sizes, the Clamex connector has a lever that is operated with a hex key, which allows the joint to be disassembled if desired **(7)**. A small, 6-mm hole is required for access to the lever mechanism **(8)**.

For example, when fitting 90-degree outside corners with PVC trim, I typically would hand-align the outside miter after applying PVC glue, then pin the joint together. Now, it's literally a "snap." Any angle joinery can be quickly conquered by the versatile options for setup.

For cabinetmakers who need a knock-down assembly, the Clamex is a clamped, two-part mechanical joint that's assembled and disassembled with a small Allen key. It comes in different sizes for different applications **(7, 8)**.

Another interesting fastener, the Divario, is self-clamping and allows for slide-in fastening for blind applications, such as shelving.

VERSATILE APPLICATION

I initially envisioned that this tool would find a home in a cabinetmaker's shop, where it would be used for joining fine trim and cabinetry. However, once I brought the Zeta P2 to the jobsite, I found all sorts of uses for it, including outside trim. That's partly because the Zeta P2 offers the ability to change the blade to a standard biscuit blade and use it as a traditional joiner.

The Zeta P2 is well-built, and the versatility of the available attachments, such as positioning pins, spacers, and a stop square, makes for precise placement of joinery. The only negative thing I can say about it is the learning curve. It took me a while to figure out how to set it up for the various applications. The instruction book is a generic, multilanguage, illustrated paperback, but once I discovered the videos on the company's website (csaw.com/lamello), I buried the manual in the bottom of the Systainer it came in. If you are into high-end trim and cabinetry work, this is a solid investment ($1,550) you won't regret.

Mike Sloggatt has been remodeling old homes on Long Island for 42 years and is a member of the JLC Live construction demonstration team.

Senco F-35XP Cordless Framing Nailer

BY TONY BLUE

"Senco makes cordless tools?!" That was my response when *JLC* asked me to review the Senco F-35XP, the latest battery-operated framing nailer to hit the market. I was interested in trying it out; my company does a lot of remodeling work, and we rarely sub anything out, which means we might be rewiring or tiling on one job, then framing an entire garage or outdoor deck the next. Especially on the smaller jobs, setting up a compressor for one hour for a pneumatic framing nailer isn't efficient, so we were eager to see how this battery-powered alternative would compare. I provide a monthly tool allowance to my employees, which means they own a lot of quality tools, so I put this nailer in their hands as well to get their opinions.

Overall, we found the F-35XP to be a powerful nailer capable of sinking 34-degree paper-taped nails into anything we used. Unlike the flywheel-style drive mechanism found in many other battery-powered nailers, Senco employs a brushless motor to set the piston within a pressurized cylinder filled with nitrogen (Senco calls it "Fusion air-power technology"). Pulling the trigger releases the piston, which drives the nail. This results in no ramp-up time and the power to shoot into engineered lumber with ease.

While we haven't had this nailer long enough to speak to the longevity of the company's battery-operated lineup, this nailer feels well put together, without any cheap plastic parts that might break off. We worked it hard, nailing into both dimensional and engineered lumber, and it never jammed or overheated. As fast as we were able to bump the tool along, it always kept up.

The nailer has a handy, bright-green indicator light that informs you if the tool is on and shows you what mode it is in. Another nice feature is the easy, no-tool depth adjustment.

At 11.37 pounds with a battery, this nailer is hefty, though comparable to other battery-operated framing nailers. One of my employees owns a Milwaukee M18 Fuel framing gun, which is similar in size and power and weighs in at 11.3 pounds, while another crew member owns a gas-powered Paslode, which weighs less than 8 pounds (without the fuel). Because of that weight difference, I don't see this—or any battery-operated framing nailer—replacing a pneumatic on a full-fledged framing job yet.

Initially I thought to myself, why does this nailer come with a bag and not a hard case? But with the way we use this tool, performing many small tasks in different hands and on different sites, the additional bag space was convenient, allowing us to have a handful of sheathing and framing nails at the ready, along with the nailer. The F-35XP runs on an 18-volt battery, and the kit comes with a charger. The weight and $550 price tag may scare off those who are on another battery platform and are shopping bare tool only. But if you are thinking about going mobile with your next framing nailer, you should give the F-35XP a look. The quality, power, and features are there. senco.com

Tony Blue owns @SquaredAwayContracting in Greenwich, N.Y. He is a general contractor who enjoys nerdy energy efficiency and moisture management details.

Comparable in size to other cordless nailers, Senco's 18-volt F-35XP has a 60-nail magazine that accommodates nails up to 3 1/2 inches long and 0.148 inch in diameter (top). The kit includes two 3.0-Ah batteries, a 5-amp quick charger, and a carrying bag.

Photos by Tony Blue

BY ANDREW WORMER

The compact design has a 7.6-kilowatt solar array **(1)**. Students prefabricated the wall and roof panels off-site **(2)**, then assembled the shell on-site with the help of a set crew **(3)**. The R-42 walls are insulated with natural wool batts **(4)**. The CU team monitors the completed home's energy performance **(5)**.

A Practical Solar Home for a Cold Climate

Both in distance and in climate, it's a long way from the hot and humid National Mall in Washington, D.C., to Fraser, Colo., which takes some pride in being the coldest incorporated town in the lower 48 states. Perched at an elevation of 8,574 feet, a freeze has been recorded there on every date of the year. But as the crow flies, it's less than 30 miles from Fraser to Boulder, home of Colorado University, where back in 2017, students Gabriella Abello and Hannah Blake began assembling a team to compete in the U.S. Department of Energy's Solar Decathlon 2020 Build Challenge. They had just visited the 2017 event, held in Denver, and were inspired to design and build their own solar-powered model home to be assembled and displayed on the Mall during a future competition.

COVID-19 changed the trajectory of the Build Challenge, however. Instead of figuring out the logistics of transporting their projects to Washington, teams had to refocus their efforts on building in their own communities and measuring and monitoring for the competition there instead of on the Mall. Fortunately, during the Denver event, Abello and Blake had connected with a couple who owned land in Fraser and were interested in building a sustainable home. With a few modifications, the CU team's SPARC house—for Sustainability, Performance, Attainability, Resilience, and Community—would be a perfect fit for their site.

A rotating team of more than 30 students and faculty members worked on the project in the pre-fab facilities of Denver-based Simple Homes where construction began. There, the team learned about the panelization process as they assembled the R-42 wall panels and R-60 roof panels for the 1,176-square-foot, two-story home. After the panels were trucked up to the building site, the setting crew from Simple Homes, the homeowners, and the CU team spent a couple of days assembling the shell. After that, it was a race to complete the project by the competition deadline, with small groups of students commuting up the mountain to Fraser regularly (it's a two-hour drive) to work on the house alongside the homeowners and local trade partners, all while dealing with COVID-19 restrictions.

Housing costs are high in Fraser, so the home was designed with a 300-square-foot rental unit to help provide an affordable option for seasonal workers at the local ski resort. It's insulated with Havelock natural wool batts, powered by a 7.6-kilowatt grid-tied array, and heated with three cold-climate heat pumps. Along with cold and snow, Fraser also gets a lot of sun—over 300 days per year—so most of the time, the home is selling excess electricity back to the grid. Solar Decathlon judges were so impressed with the results that they awarded the CU team first place in three Build Challenge categories and first overall. —*Andrew Wormer is executive editor of the* JLC *Group.*

Photos courtesy University of Colorado Boulder


GIVE YOUR BUSINESS MORE HORSEPOWER.
Get the most powerful training tool in the business.
JLC's Digital Field Guide is the most comprehensive, trusted skill training and best practices resource for pros in the residential and light construction industry. Give your business the boost it needs—more projects. More profit. Add the JLC Digital Field Guide to your toolbox today. Subscribe to the JLC Digital Field Guide today. jlconline.com/how-to
JLC
FIELD GUIDE