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THE FUTURE OF FRAMING

August 2015

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# A Good Partnership

True House & Apex Technology Find the Right Fit for Trusses & HVAC

**Inside this Issue:** The New FAD • Wall Panel Design & much more!

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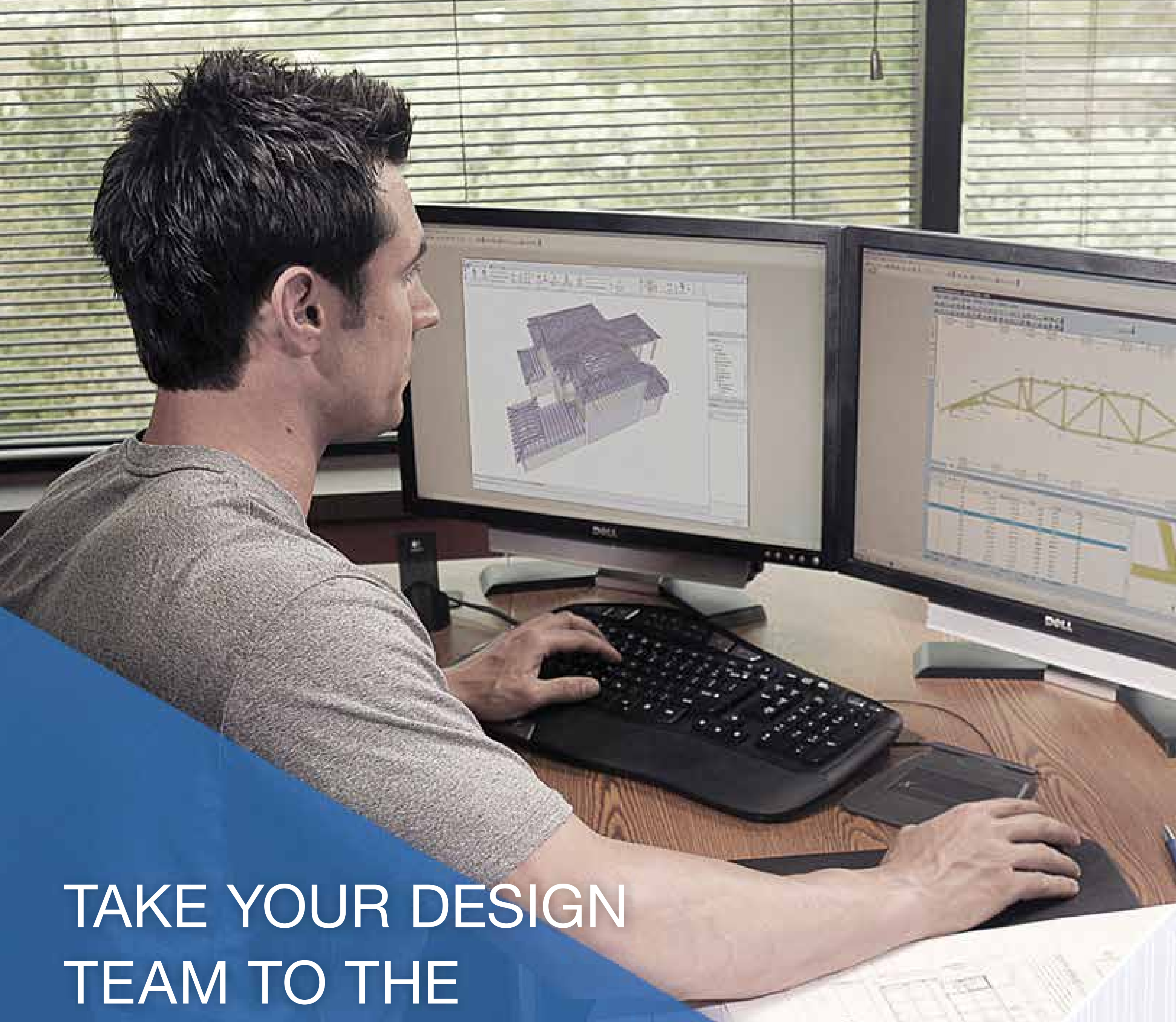

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**Publisher**
Truss Publications, Inc.
6300 Enterprise Lane • Suite 200
Madison, WI 53719
Phone: 608-310-6706 • Fax: 608-271-7006
trusspubs@sbcmag.info • www.sbcmag.info

**Editor**
Rick Parrino
Plum Building Systems • editor@sbcmag.info

**Managing Editor**
Sean Shields
608-310-6728 • sshields@sbcmag.info

**Art Director**
Melinda Caldwell
608-310-6729 • mcaldwell@sbcmag.info

**Editorial Review**
Kirk Grundahl
608-274-2345 • kgrundahl@sbcmag.info

Suzi Grundahl
608-310-6710 • sgrundahl@sbcmag.info

**Advertising Sales & Marketing**
Melinda Caldwell
608-310-6729 • mcaldwell@sbcmag.info

Sean Shields
608-310-6728 • sshields@sbcmag.info

**Staff Writers for August**
Daniel Lawless, E.I.T. • Emily Patterson •
Matt Tanger

**Accountant**
Mike Younglove
608-310-6714 • myounglove@sbcmag.info

**Computer Systems Administrator**
Jay Edgar
608-310-6712 • jedgar@sbcmag.info

**Send all ad materials, insertion orders, contracts & payments to:**
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6300 Enterprise Lane • Suite 200
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Phone: 608-310-6706 • Fax: 608-271-7006
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# contents

# editor's message

by Rick Parrino

## The Benefits of Acquisition

**A partnership mindset can have positive results with or without an actual merger.**

Over the last month, there have been a number of headlines in our weekly ***SBC* Industry News** devoted to mergers and acquisitions. While there appears to be a lot of speculation on how these transactions will impact the market in the near and long term, everyone seems to think the changes will be significant. This got me thinking about my own experience of working for an independent component manufacturer (CM) that was acquired by another company, and how that changed how we do business. There are several benefits that I think other CMs could realize, whether or not they remain independent.

I started working for Plum Building Systems in 1997. Even back then, our owner was approached about selling the company, but he decided to stay independent. In Central Iowa, the market is primarily a two-step process, with CMs selling to lumber yards, as opposed to selling directly to builders. As a consequence, our largest client was Gilcrest/Jewett Lumber Company, which started in 1856 and is one of the oldest companies in Iowa.

We sold to other lumberyards as well; it was a business model that worked well for us. Lumberyards were good about paying invoices on time, and they also provided a more consistent demand by pooling builders together. Instead of having to sell to 75-100 builders, we could concentrate on keeping 10-15 lumberyards happy. However, we did so much business with Gilcrest/Jewett that we had a salesperson who designated almost all of his time to handling their business. We developed a great working relationship with them over the years, so it wasn't a big surprise when, during the downturn, they approached the owner with an offer to purchase the company.

**Fortunately, both Plum and Gilcrest/Jewett shared strong, complementary service-oriented goals. Together, we have leveraged our existing relationships with builders, building officials and lawmakers and have even more influence in our market.**

Gilcrest/Jewett bought Plum in 2008, but they still, for the most part, treat us as a separate company. When we fill orders, we invoice Gilcrest/Jewett directly. Since they still run us independently, we continue to sell to smaller, rural lumberyards that were customers of ours before the purchase. One of the biggest changes that occurred when we were acquired was the immediate increase in communication. Our staff started attending the company's weekly meetings with their sales staff, so we were much better informed about potential orders coming into the pipeline.

Once our office lease was up, our sales and design offices moved into the same building as their sales staff. This close proximity has made a world of difference for our sales team and designers. Now, when a builder customer comes into the lumberyard with a set of plans, they can bring them right into our sales office where our team can go through the plans with them immediately and navigate potential issues. Having an opportunity to work through problems face-to-face in the office at the front end of the process saves us what used to be hours, or even days, of sending plans back

### at a glance

- Being purchased by their biggest customer allowed Plum Building Systems to forge an even more positive relationship with closer, more effective communication.
- Building partnerships with other complementary organization can benefit everyone in the supply chain.
- A collective commitment to service can produce a greater impact in the community when companies join forces.

Continued on page 6

**A CM doesn't have to be part of a lumberyard to take advantage of many of these benefits. For the independent CM, it's really about building a close relationship with a lumberyard or other partner that fits well and complements your business.**

## Editor's Message

Continued from page 5

and forth and working through multiple iterations.

This approach bolstered the design services side of our business, which also increased because of the heightened knowledge and understanding of the lumberyard sales staff, especially when it comes to products that best fit a customer's needs, like a better set of plans. The sales staff does a great job promoting everything from our design services, to the benefit of all the component products we manufacture.

While Gilcrest/Jewett increases our sales, it also helps lower the cost to produce our products. Even before the acquisition, Plum and Gilcrest/Jewett would buy material together; now it is something we work on consistently. Through them, we also became part of the Lumbermens Merchandising Corporation (LMC) to enhance our purchasing power. In addition, we now have access to the lumberyard's rail spur, which lowers our transportation costs.

Fortunately, both Plum and Gilcrest/Jewett shared strong, complementary service-oriented goals. Together, we have leveraged our existing relationships with builders, building officials and lawmakers and have even more influence in our market.

Finally, our collective commitment to service has proven very rewarding. Both of our companies were dedicated to organizations like Habitat for Humanity and military veteran support organizations. Together, we have been able to do even more for these organizations and make a significant impact on the lives of several deserving people here in Iowa.

I don't think a CM has to be part of a lumberyard to take advantage of many of these benefits. For the independent CM, it's really about building a close relationship with a lumberyard or other partner that fits well and complements your business. I believe we have both benefited each other's businesses. I'd encourage you to consider who you could partner with that would enhance both companies. The opportunity to improve your business practices shouldn't be overlooked, and it certainly doesn't have to be a purchase! We were great partners before we were acquired; we are just that much more collaborative now. SBC

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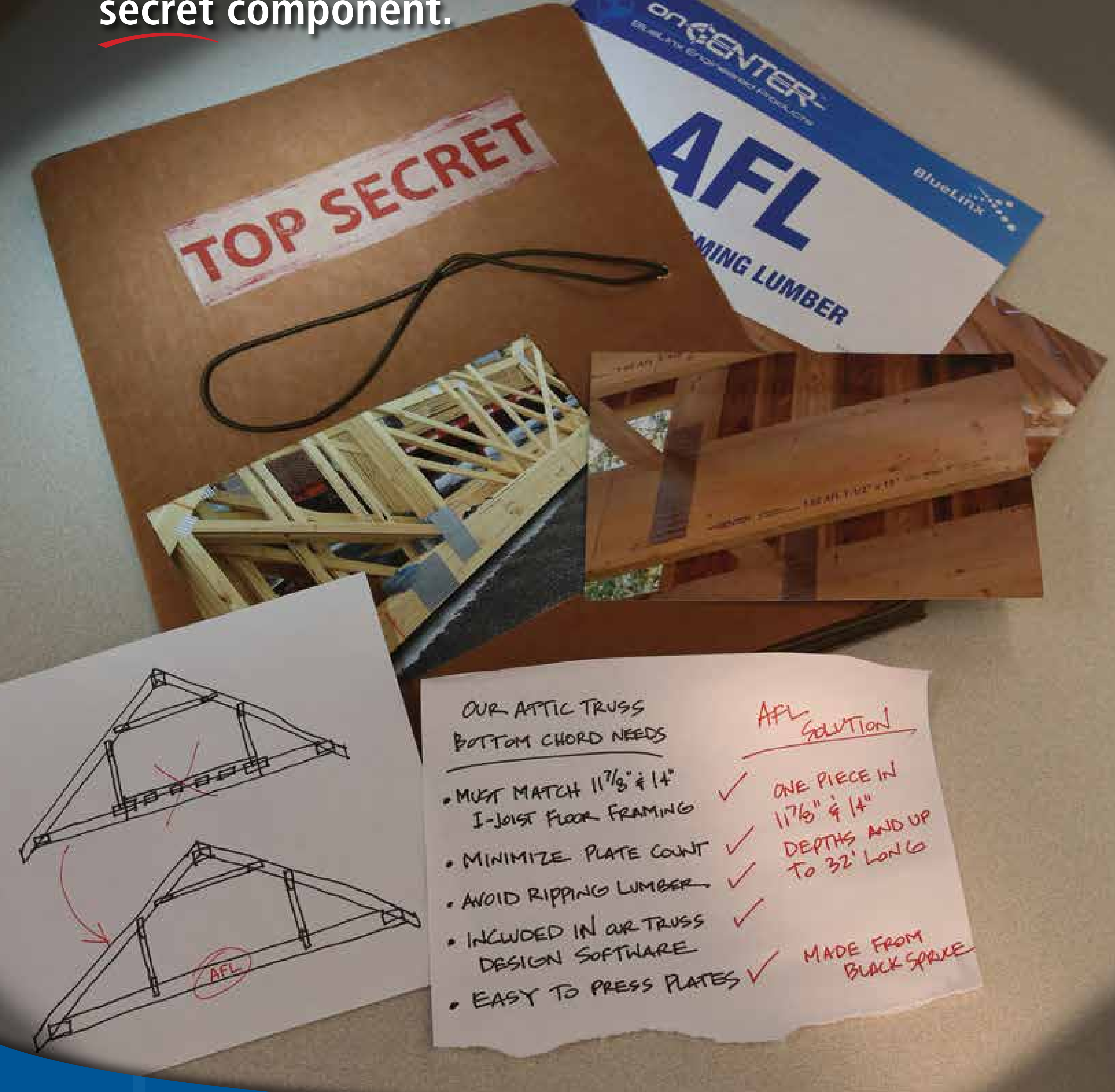


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# framer viewpoint

by George Hull & Kenny Shifflett

## Better, Faster, Smarter: Componentized Rough Openings Are Making a Difference for Framers

**Some framers are having great success with a hybrid component and conventional wall framing approach.**

Material efficiency is an important aspect of the framing business and one that's a concern for many general contractors and framing crews. It's a simple fact in the construction industry that using less material means spending less money in both labor and material. This is clearly a broad brush and just one way through which to view material efficiently. We view material efficiency as a new method or an idea for performing the same process in a smarter way.

Innovative framing, the industry's tag for what some folks call advanced framing, component framing or engineered framing, is the smarter way. Over the years, our framing businesses have become smarter and have started using component-manufactured truss openings on our jobsites. They've allowed us to increase our material efficiency on the jobsite while maintaining structural integrity and uniformity.

First, and possibly one of the largest advantages of using trussed openings (TO) (i.e., structural components that use truss technology to create window and door openings), is that site accuracy increases. Whether we're framing window or door openings, we know component TOs were built in a controlled environment and perhaps even from a template. Using fixed machinery in a controlled setting results in lengths cut to exact specifications. This allows assembly to be carried out in exactly the same manner every time. On a jobsite, there could be 10 different crewmen cutting and assembling headers and rough opening members, and each one will cut studs and assemble the rough opening a bit differently than the other. TOs take that margin of error out of the building installation equation and ensure consistency for every one of the jobsite's rough openings.

Second, TOs reduce field assembly production time. The old adage of "time is money" rings true on every jobsite, and when framing walls, the most time-consuming steps are those associated with framing openings. There are five different pieces that need to be cut and assembled to complete the design and framing of a rough opening: header lumber, fillers, jack studs, sill studs and cripple studs.

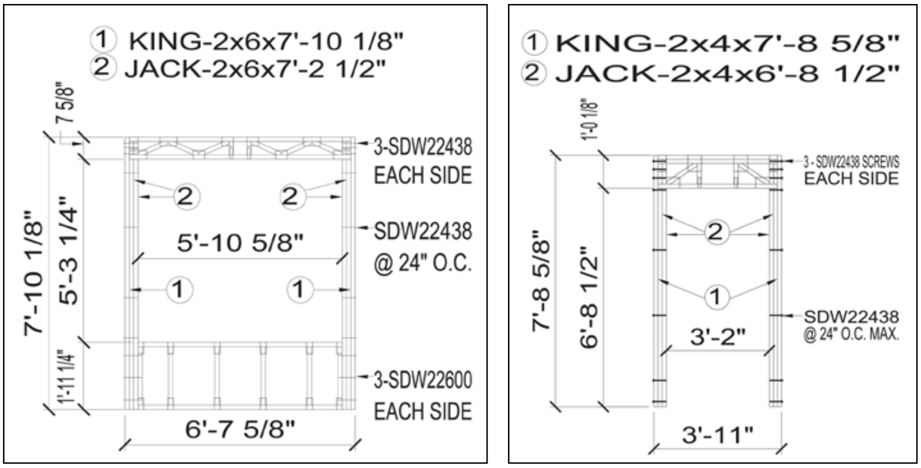
By eliminating the need for workers to make all those cuts, wall erection time is drastically reduced. TOs arrive ready for installation, and your crew is able to frame around them and move on to the next wall section. Further, if you have a rough opening design that's complex or just out of the ordinary, TOs take the complexity off the jobsite and allow the component manufacturer (CM) to do it in the factory, which is generally much easier.

An added bonus in reducing site-cut studs is there are fewer scraps for the framers to spend time cleaning up and less waste going into the dumpster. It's always imperative the floor is clear of any obstacles, whether it be tools, power cords or materials. Header and rough opening creation produces the most off-cuts and scrap wood of any of the steps in the wall assembly framing process. Obviously, taking time to clean up takes away from assembly time. Further, using TOs reduces lumber waste, which is all part of our material efficiency objective.

Third, innovatively framed TOs do away with conventional heavy timbers for header

### at a glance

- ❑ Manufacturing rough openings in a plant improves site placement accuracy efficiency dues to consistent framing every time.
- ❑ Componentized wall sections also significantly reduce jobsite waste and allow for the use of alternative header approaches and materials.
- ❑ Having the ability to deliver components just in time to urban jobsites alleviates the need for hard-to-find storage and staging areas.



Standard details for window and door rough openings using components.

material. The second largest expense of building walls is 2x10 or 2x12 header lumber. With TOs, headers are designed much the same as an open web floor truss. 2x4 and 2x6 studs, which are much cheaper to buy, make up the header. Due to this, most TOs feature gusset plates (a.k.a. metal connector plates or truss plates), which add more stability to the header than conventional nailing used on site. Additionally, gusset plate connections are easier for third-party inspectors to see than nailing patterns.

A few indirect ways TOs can positively impact a jobsite include jobsite space and loads on walls. Consider the lack of storage space on many inner-city projects. How many jobs have we encountered with continual storage, movement space and installation efficiency issues? There's no room for supplies; there's no room for extra machinery, etc. TOs solve this problem since they're delivered to the site pre-assembled and ready for immediate installation. There's no waiting for assembly, there are less studs needed on site, and delivery is just in time.

Another potential feature that can be incorporated into TO designs is the ability to incorporate hold-down assemblies directly into the wall to counter uplift loads and provide more cost-effective shear wall designs for most wind and seismic loads. New products already in use allow framers to install wall systems that resist live and dead loads called for by the building designer. Most of these products are in the form of engineered wall panels, proprietary shear walls (a.k.a. braced wall panels) and portal frames with hold-downs. The possibility of using the same types of concepts and designs in TOs is easy to extrapolate. Greater innovation in the shear wall realm with TOs is just around the corner, and framers will be pleased to see these advancements.

Building a stronger structure at a faster rate with TOs is going to change the way we build. The possibilities for expansion of innovative designs are many and the time is now. Material efficiency is not a lofty ambition because it's already happening. Innovative framing is the way of the future. Component TOs are just one of many ways we can rely on innovative designs to make framing better, faster and less expensive. Engineering and testing can go a long way in developing these systems, and the industry has a responsibility to demand it. The challenge is ahead of us; who's willing to accept it? SBC

*George Hull is President of Hull Associates, LLC in Arlington, TX. He brings more than 35 years of framing experience as the first Chairman of the National Framers Council. Kenny Shifflett owns Ace Carpentry in Manassas, VA, and has been in the framing industry for more than 40 years. He serves on NFC's Steering Committee and chairs the Council's Safety Subcommittee. For more information about the NFC, visit framerscouncil.org.*

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# RENEWING THE DREAM

## How BCMC Build Will Help CMs Grow Market Share

by Sean D. Shields

This fall, two houses will be built on adjacent lots in the community of Jackson, WI, a suburb just north of Milwaukee. While the neighborhood is unassuming, and the homes themselves are of average size (2,200 sq. ft.), their impact on the structural building component (SBC) industry will be significant.

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Why? Because these homes will be the next chapter in Framing the American Dream (FAD), an initiative that started more than 20 years ago. To fully understand the impact of this project, and what it may mean for component manufacturers (CMs) across the country, it's important to explore where this project started and then look at today's residential construction market and what FAD can potentially accomplish within that market.

### The First FAD

FAD was initiated in 1995 with the idea that building two identical homes side by side would provide a good comparison of stick-frame and SBC framing methods. In January of 1996, two homes were built in the parking lot of the Astroarena in Houston, TX, as part of the International Builders Show (see below). This project provided a real-world comparison of framing techniques that show attendees could tour.

It was quickly apparent, however, that the process of constructing the two homes in this manner could yield an even more beneficial outcome. During construction, time, labor, material and cost comparison data was collected to finally have a true apples-to-apples comparison between the two framing methods of these identical projects.

The data collected in 1996 has been used by CMs since then to successfully market the many advantages of engineered and componentized framing, with the focus on reduced labor costs for installation. While the resulting marketing materials have aided many CMs to convince their builder customers to switch from conventional framing to components, several SBCA members recognized that much has changed in the industry over the past 19 years in terms of design, manufacturing, component costing and installation techniques.

## Renewing the Dream

Over the past few years, the SBCA Board of Directors has considered a few proposals to collect new FAD data. These efforts culminated in a discussion during the CM & Supplier Roundtable in Madison, WI, in August of 2014. The roundtable discussed a proposal to frame homes at the SBC Research Institute (SBCRI) to collect FAD information, but also conduct structural testing on the two framing methods. Ultimately, the Board decided that it was not the right time to conduct testing of this type, given the current need and value of FAD data was time and materials based. The SBCRI-based FAD testing project was ultimately tabled for a later date.

During the initial planning stages of BCMC Build 2015, it became clear there was the potential to collect new FAD data in a relatively economical way. BCMC Build has proven to be a successful annual charity build project for the SBC industry, allowing BCMC attendees the opportunity to come together and help construct a home for a deserving individual in the city hosting the trade show.

In preparation for the BCMC Build project in Milwaukee, two local homebuilders, Tim O'Brien of Tim O'Brien Homes and David Belman of Belman Homes, enthusiastically stepped forward to participate in the project. Almost as fortuitous, a regional real estate developer, Mark Neumann of Neumann Communities, donated two side-by-side lots in a development in Jackson.

Jason Blenker, 2015 BCMC Chair; Steve Szymanski, 2015 BCMC Build Chair; and Rick Parrino, 2015 SBCA President, proposed the idea of using this year's BCMC Build to renew the FAD project to the SBCA Executive Committee and Board of Directors. The Board agreed this year's BCMC Build offered a cost-effective way to accomplish both the goal of the charity build as well as FAD data collection.

## Why Now?

The housing downturn that started in 2006 and lasted through 2012 had several impacts on the residential construction industry. One that is starting to get a lot of attention in the media today is how it limited the availability of framing labor. Indeed, according to a recent MetroStudy report,[1] framing labor is the contractor position builders find the most challenging to fill. There are also reports that some builders are finding subcontractors recruiting in highly creative and increasingly aggressive ways.[2]

As the housing market continues to grow, the constraint caused by a shortage of labor will get worse. One of the most logical solutions is to reduce the amount of time individuals need to be on a jobsite to frame a building. It follows that, the less time it takes to frame a building, the more buildings a builder can construct using the same amount of people. This solution is exactly what components offer to builders who are currently relying on framers to conventionally frame homes one board at a time.

Thanks to advancements in digital photography, video, Internet-based tools and mobile devices, the new FAD data collected through this effort will be more complete and comprehensive than what was captured in 1996. Further, with all the design and production advancements that have occurred within the industry over the past 20 years, the comparison data will paint a starker and more accurate picture of the labor and material savings that can be achieved through componentized framing.

## Points of Comparison

The two homes built by Belman Homes and Tim O'Brien Homes are virtually identical, with small aesthetic changes to the exterior facade to differentiate the two (see page 14). Again, the homes are modest in size, but there are plenty of framing challenges to highlight the differences between the two framing methods.

For one, there will be tray ceilings in the master bedroom and the front study/bedroom. While not difficult to incorporate into truss designs, these ceiling details, which are common in many markets today, may provide a challenge to conventional framing methods. Second, storage was added above the garage. With a walk-out basement that may be fully finished and utilized by its occupants, storage space may be at a premium. Attic trusses will provide a competitive alternative to rafter-framed storage in this case. Third, the span and vaulted ceiling in the great room will present a significant challenge. Incorporating both the hip-end roof and the vaulted ceiling into the construction will provide an excellent contrast in structural capabilities of trussed and rafter systems.

Finally, the floor system in the component-framed house will be built using 16" floor truss panels, preassembled in the manufacturing plant. Not only will the floor truss panels install quickly, but the CM is working with the other trades to incorporate ductwork and plumbing into the design of the chase openings for easier installation of conditioned air and water distribution systems.

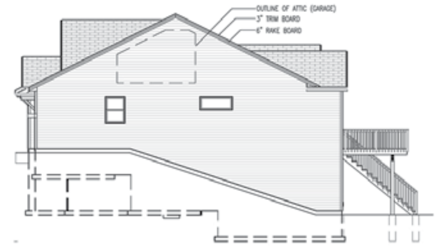
Continued on page 14

[1] www.builderonline.com/building/trades-subcontractors/labors-love-lost_o

[2] www.builderonline.com/building/trade-wars-the-fight-for-labor-grows-ugly-pitting-builder-against-builder_o

LEFT ELEVATION
SCALE: 1/8" = 1'-0"

REAR ELEVATION
SCALE: 1/8" = 1'-0"



RIGHT ELEVATION
SCALE: 1/8" = 1'-0"

## Renewing the Dream

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### Conclusion

The value of updating the FAD data cannot be overstated. Builders in many markets are scrambling for solutions to the lack of adequate framing labor. Having the ability to offer proof on how much labor and materials componentized framing can save a builder will be an incredibly powerful tool for CMs looking to grow their market share.

Through the help of Operation FINALLY HOME, these two homes will go to wounded veterans, individuals who have given so much in service to our country. That outcome provides even greater value to the project. Indeed, the homes BCMC Build has built in the past have proven to be transformational in the recipients' lives. SBC

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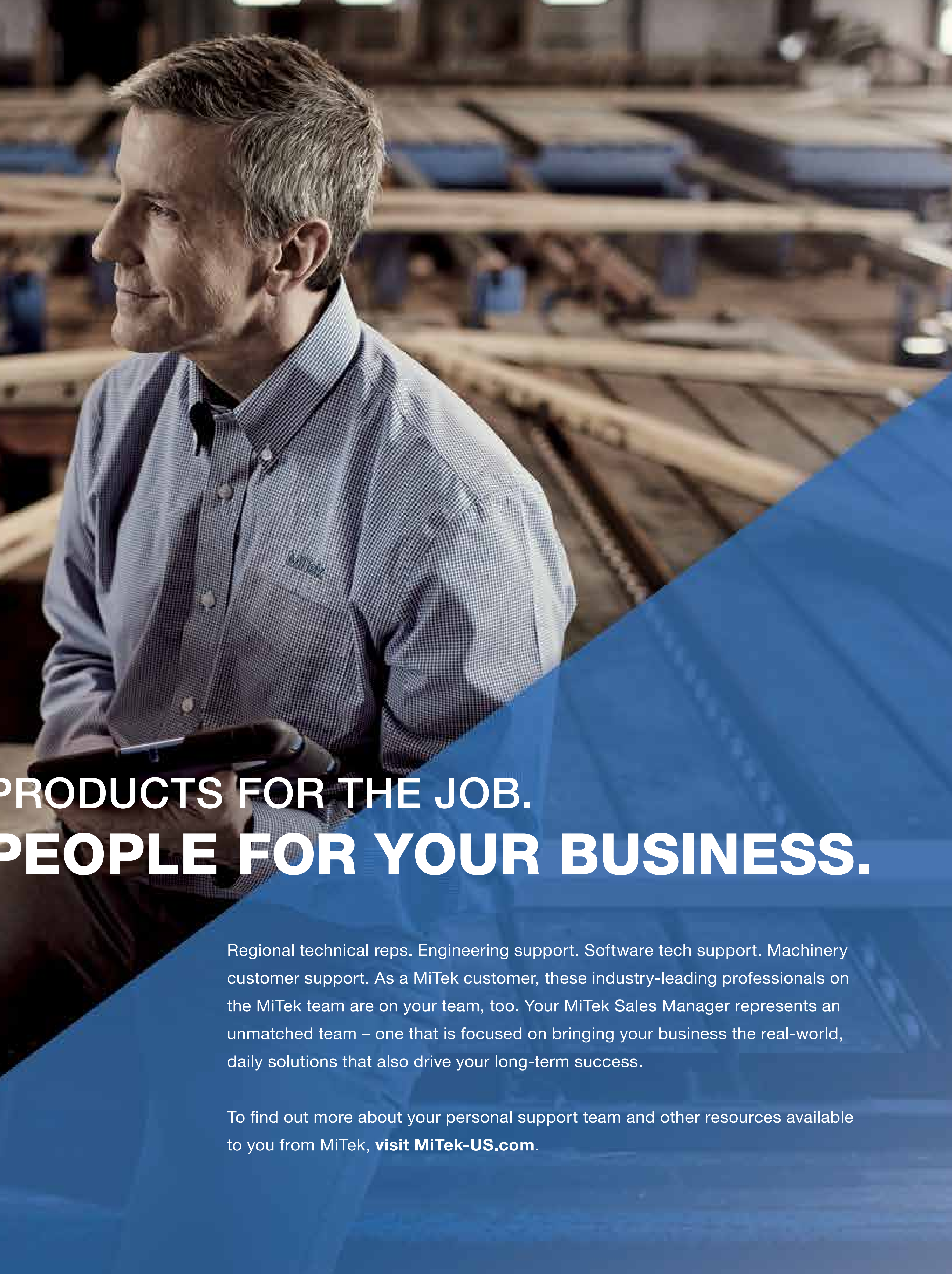
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# A Good Partnership

## True House & Apex Technology Find the Right Fit for Trusses & HVAC

by Emily Patterson

One could argue that truss and HVAC design do not have the best history. Many component manufacturers (CMs) have stories about truss webs damaged to accommodate an HVAC system, or the dreaded call from the jobsite saying that the HVAC system simply doesn't fit with or within the trusses. Much of this discord is due to deferred submittals, and how the people who design trusses and HVAC systems rarely communicate, or if they do, it's during the later stages of a project.

Apex Technology, a building design company based in Jacksonville, FL, along with CM parent company True House, looked at this problem and asked, "What if we did things differently?"

Apex Technology and True House set out to work with builders and mechanical engineers to integrate all HVAC design into master plan sets. Through this collaboration, Apex can provide both an HVAC plan and a truss plan with duct layout overlay (see Figure 1), where both systems fit together and complement each other.

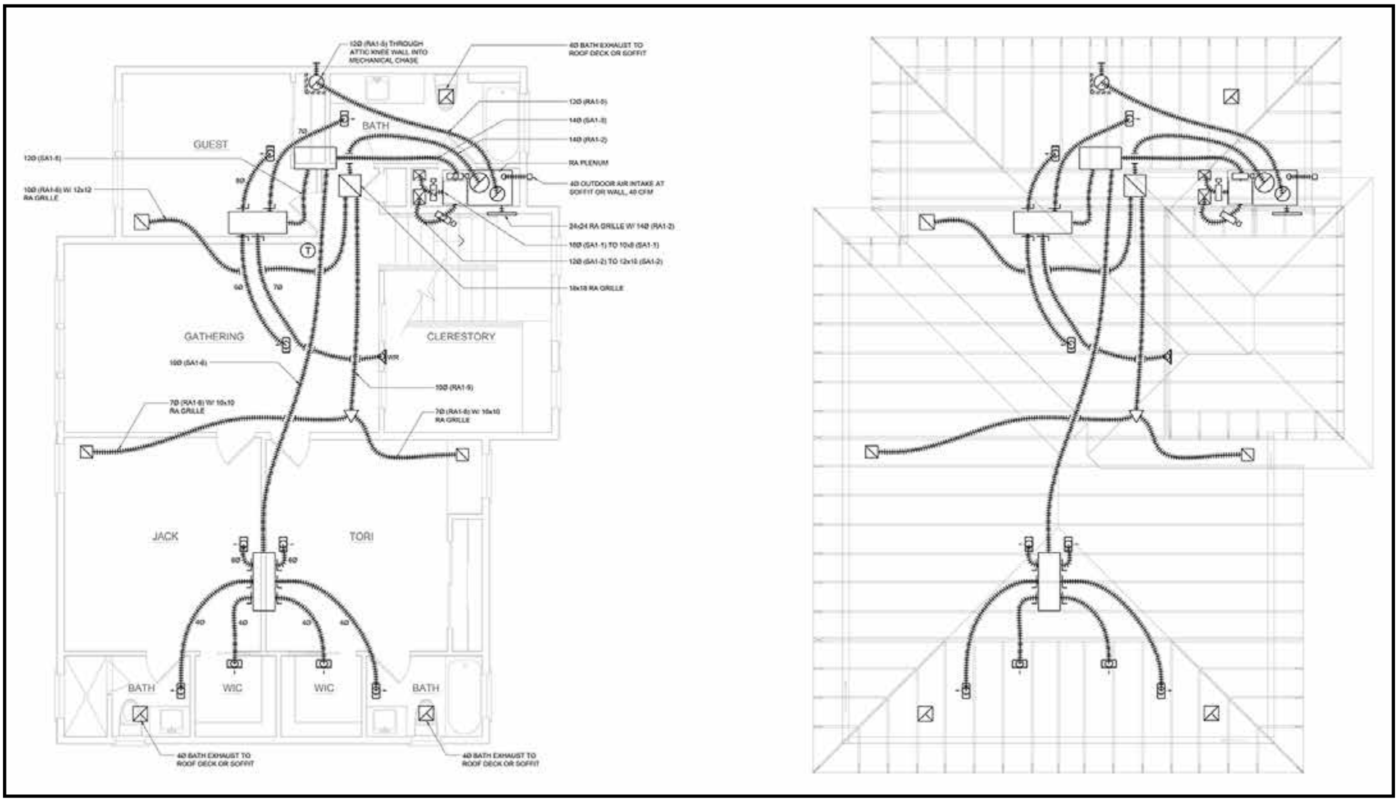


Figure 1. By working with the HVAC engineer on the front end, Apex and True House can provide both an HVAC plan (L) and a truss plan with duct layout overlay (R).

**Incorporating the truss and HVAC design into the master plan addresses issues, such as allowable openings in floor trusses, early in the project.**

## "We knew it would be cool"

While communication between the building trades has traditionally been fragmented, True House and Apex had a hunch that the market would benefit from this added coordination. "We knew everything was leaning toward Energy Star," said Mike Kozlowski, P.E., President, noting that working with the mechanical engineer was a good step toward increased energy efficiency because the building envelop design has great influence over the demands placed on the HVAC system.

To test the waters, Apex and True House tried the process with a customer who specifically asked that mechanical layouts be incorporated into the master plans. "They were running into problems in the field with not being able to get ducts the way they wanted them done. They wanted to limit or eliminate those issues," explained Dan Morris, Truss Design Manager. The early collaboration between truss design and HVAC went well, and True House and Apex knew they were on to something. Much like the initial test case, when other builders saw plans that included both the truss and mechanical design, they responded positively. "It started to fall into place," said Kozlowski. "It fits together really well. We knew it would be cool."

The early collaboration between truss design and mechanical engineering worked especially well for a client who wanted to use rigid ducts. After seeing instances where the webs of installed trusses were knocked out and removed to make room for the ducts, Apex and True House devised a solution that didn't require fitting the ducts in the trusses. "We designed the entire floor system around the mechanical chases. We designed it so the rigid duct fits next to the trusses, without having to feed it through the trusses," said Morris. "That worked out extremely well."

## "We eliminated a lot of the back and forth"

That first project and subsequent projects gave everyone involved a chance to learn and make adjustments to the process. One notable lesson learned along the way was the order of who should work on the plans. On the initial project, the mechanical engineer worked on the plans first. When the truss designer got the plans, there were HVAC issues that didn't work with the component design. The team wondered if the process might work better if the truss designer worked on the plans before the mechanical engineer.

"As the truss designers got used to working with the mechanical engineer, they got to know what the mechanical engineer was looking for," said Morris. The team fine-turned the workflow based on what they learned. "The process evolved, and now plans go to the truss designer first, and the mechanical engineer can usually work with what the truss designer develops. We eliminated a lot of the back and forth," said Morris.

While truss designers and mechanical engineers may not have a long history of working together, Morris said mechanical engineers have been very open to working with them. "Once you start to explain to them why you can't do what they want to do or how there's a more cost-effective way, they're very open to it."

Continued on page 20

**Designing the truss and HVAC systems together on the front end can lead to a much smoother installation process.**

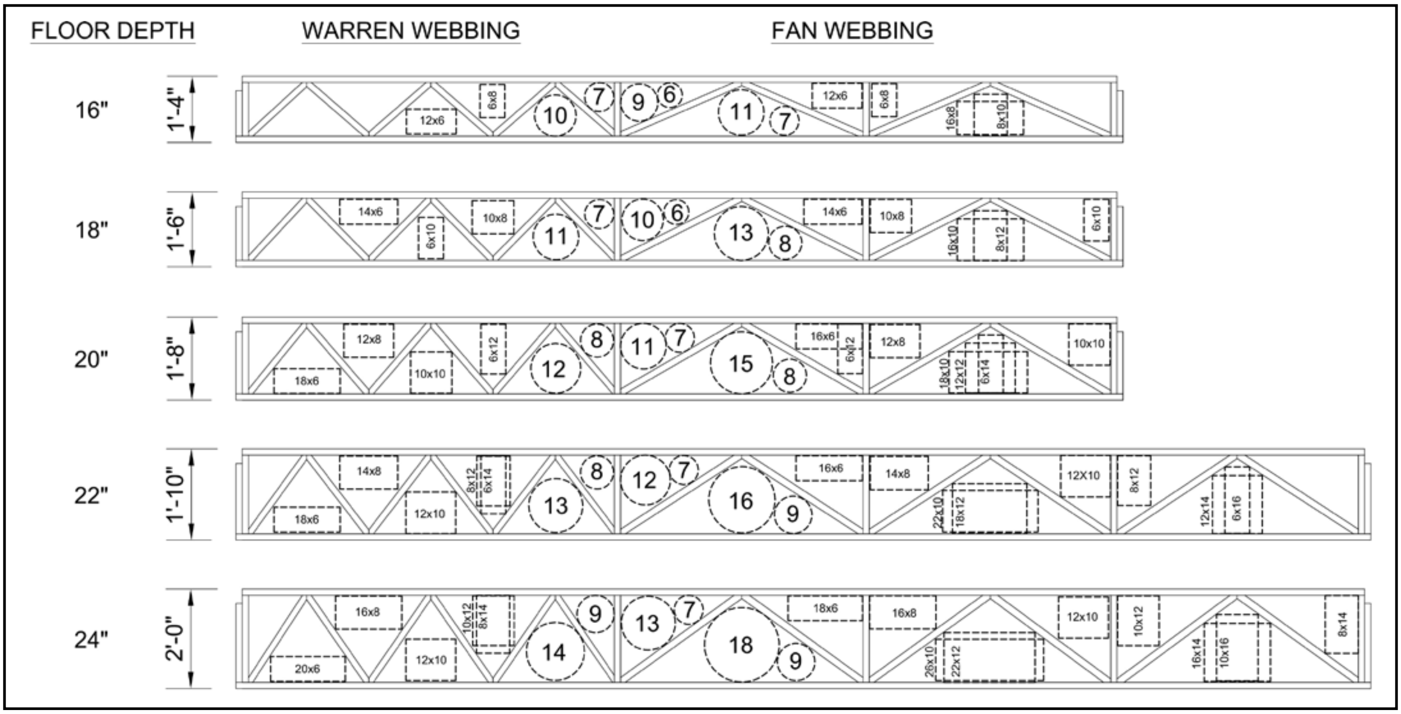


Figure 2. To help the process run smoothly on projects, Apex and True House drafted a document showing the allowable openings in floor trusses of various depths with warren webbing and fan webbing.

## A Good Partnership

Continued from page 19

Truss designers soon learned that, while component and HVAC design didn't go hand in hand under the old process, the two trades actually have quite a bit in common. "Mechanical layouts are not much different than trusses," said Morris. "There are about ten ways to do something. None of them are wrong, but it's a matter of finding what's best for a project. It makes for a good partnership."

To help in the collaboration with HVAC engineers, Mike Berry, P.E., Mechanical Design and Building Science Lead, drafted a document showing the allowable openings in floor trusses of various depths with warren webbing and fan webbing (see Figure 2).

Incorporating the truss design and HVAC into the master plan didn't just make the lives of the truss designers and mechanical engineers easier—it also helped builders. "When Mike [Berry] does the energy calculations and sizes the system, [the builders] can then bid that out to multiple contractors and make sure they're getting the system they want," said Bryan Tebbe, VP of Customer Development.

**While component and HVAC design didn't go hand in hand under the old process, the two trades actually have quite a bit in common.**

Simply put, more information gives builders more power to get the structure they truly want. "Builders gain more control of the system and its performance. Some find great value with that," added Tebbe.

## "You don't have to sell at all"

For Tebbe, it isn't so much a matter of selling this new process than finding where it meets customers' already existing needs. "It's really client specific. You don't have to sell at all. If they realize the need, it falls in line," he said. Depending on a customer's preferences, True House and Apex can adapt to provide the services to meet their project requirements. "Some larger companies, they have all of these master plans and they really understand and see a value in getting the plans complete all the way through. Others prefer to work things out in the field. The trick is knowing which clients have which philosophy," said Tebbe.

Figuring out what clients want and meeting that need has definitely paid off for Truss House and Apex, and it may also be a preview of what's to come in terms of the working relationship between truss designers and mechanical engineers. "The drum that I keep beating in the industry is for the truss design group to be part of the building design team instead of deferred submittals," said Kozlowski. "This is a good thing for the industry. Everybody we talk to is wishing this was going on in their market." SBC

# The Process in Action

For this two-story, 2,642 sq. ft. single-family home, the truss and HVAC systems were optimized together on the front end. Collaborating with the HVAC engineer early on led to some changes in the truss design that helped make installation easier and provided greater cost control.

"The floor truss depth was increased to 20 in. versus the traditional 16 in. depth in our market to accommodate duct work," Berry explained. "Also atypical, and sometimes more expensive, floor layouts were designed to ease installation and performance of the HVAC system."

As it turned out, optimizing the truss and HVAC systems on the front end saved money on the project. "The builder was presented with design options ahead of time, and made decisions that met both the truss and HVAC performance goals, which led to the lowest cost of the truss and HVAC combined—not separately as is traditionally done," said Berry.

**For this two-story, 2,642 sq. ft. single-family home, the floor truss depth was increased to 20 in. to accommodate duct work, and floor layouts were designed to ease installation and performance of the HVAC system.**

# Engineered vs. Prescriptive Wall Panel Design

by Daniel Lawless, EIT & Kirk Grundahl, P.E.
Commentary by Sean D. Shields

## commentary

For this article, we thought it would be helpful to provide the following commentary in blue. This extended sidebar will run throughout the article and is intended to put the more technical aspects of the piece in layman's terms, as well as to provide additional perspective on various issues.

This article explores the two different methods used to calculate a wall panel's capacity to resist applied lateral loads (think wind and seismic): a code-adopted prescriptive method (*IRC*), and a science-based engineered approach (*IBC*).

When a component manufacturer (CM) endeavors to provide an innovative framing solution to a customer's lateral resistance problem using a shear wall, they must use engineering principles found in the *IBC* and/or generally accepted engineering practice to design it.

This article explores how the prescriptive *IRC* method essentially stacks the deck against CMs who use these innovative framing solutions by implicitly devaluing engineered design and accepted engineering practice.

Why it does this is straightforward: the *IRC* provides a built-in competitive advantage for wood structural panels and, therefore, the wood products industry. This advantage has been strategically codified over time to protect traditional construction methods.

How it does this is a bit more complicated. The code development process is political in nature, and the science and reasoning used to develop the building code is not transparent to the marketplace.

Understanding this issue in detail can help CMs who want to provide innovative wall framing solutions to their customers. Conversely, not understanding this issue hinders CMs by keeping them bound to products that have a built-in competitive advantage.

Very few elements of a light-frame residence have as much engineering analysis behind their design as metal plate connected wood trusses. Typically, trusses in a residential structure are analyzed by a powerful design software program and reviewed by a structural engineer to insure their design is adequate. An extensive knowledge base developed through decades of testing and structural analysis has been used to develop the design procedures and manufacturing process for metal plate connected wood trusses. Given their engineering advantage, it is unsurprising that truss components provide far more efficient and cost-effective designs than conventional framing.

To better meet the needs of their customers, some CMs have added wall panels to their product lines. One would expect, given the advantages of the design software available to create wall panel configurations, wall panels manufactured by a CM would be more efficient than a stick-framed wall built in accordance with the *International Residential Code (IRC)*. However, if one compares the conventional methods for wall panel bracing with those required for an engineered approach, an entirely different story unfolds.

The two main approaches for constructing light-frame shear walls are the prescriptive provisions, as found in the *IRC, International Building Code (IBC),* and *Wood Frame Construction Manual (WFCM),* and engineered design methods, as found in the American Wood Council's *Special Design Provisions for Wind and Seismic (SDPWS)* referenced by the *IBC*. The prescriptive provisions of the *IRC* specify the minimum construction requirements (sheathing thickness, fastener type and spacing, anchorage, etc.) and the length of wall bracing that are intended to result in a structure that is able to resist the applicable wind and seismic loads. The amount of bracing required by this approach was originally based on historic practice for light-frame construction. In 2009, the prescriptive provisions for wind loads in the *IRC* were revised to "have a consistent and logical framework to ensure wall bracing capacity meets wind load demand".[1] However, this revision was still calibrated to "align with past successful wall bracing practice" by using an adjustment factor to increase the design values by 20 percent to account for partial overturning restraint and the contribution of the whole building system.[1] The prescriptive design approach has the advantage of being simple to apply, but it can only be used for buildings that meet the height, plan dimensions and loading conditions given in the *IRC*.

## commentary

The *IRC* establishes a "box" that defines the maximum size and loading conditions of a residential building (see Table 1 below, which outlines the limits of the box). As long as the building being constructed fits inside that box, the building can be built using the prescriptive method. However, just because a building doesn't fall down doesn't mean we have a good understanding of why it doesn't fall down, or even how well it resists the loads exerted on its individual framing elements. So, for good measure, the building code developers initially established what amounts to a "rule of thumb" to follow based on historical evidence and single-element testing, and then added 20 percent as an educated guess on what the additional strength the entire system added to the resistance capacity of a given wall panel.

On the other hand, engineered design methods are based on the principles of engineering mechanics and/or experimental tests of shear wall assemblies. This approach provides a method for calculating the resistance of a shear wall system, which is then compared to the applied wind and/or seismic loads specified by the building code. The resistance has to be greater than the applied load for the design to be adequate. Most commercial buildings and multi-family residences require an engineered design. Compared to the prescriptive approach, engineering design methods require more complex computations.

It would be expected that the simplifications necessary to develop a prescriptive approach would result in a more conservative solution than a detailed engineered design, which could take into account the unique features of a structure. However, it can be shown that many prescriptive designs are much less conservative than an engineered solution. This is because the *IRC* is not based on fundamental engineering, but rather is calibrated to "historical acceptable performance," which has no engineering definition. Since the *IRC* does not state the fundamental engineering properties or the factors applied to those engineering properties, the reasoning behind the code provisions can be easily misinterpreted, resulting in engineering-related unintended consequences. Greater transparency with respect to the use of generally accepted engineering mechanics and associated test data calibrations used in the *IRC* need to be provided, so that designers can make good engineering judgments.

Fortunately, SBCA members have full access to proprietary SBCRI shear wall testing that provides insight into the true behavior of shear walls. To better understand shear wall performance and the competitive advantage of the *IRC* provisions, this article will examine three different concepts of shear wall design: overturning anchorage, shear wall openings (i.e., perforated shear walls) and the wall aspect ratio.

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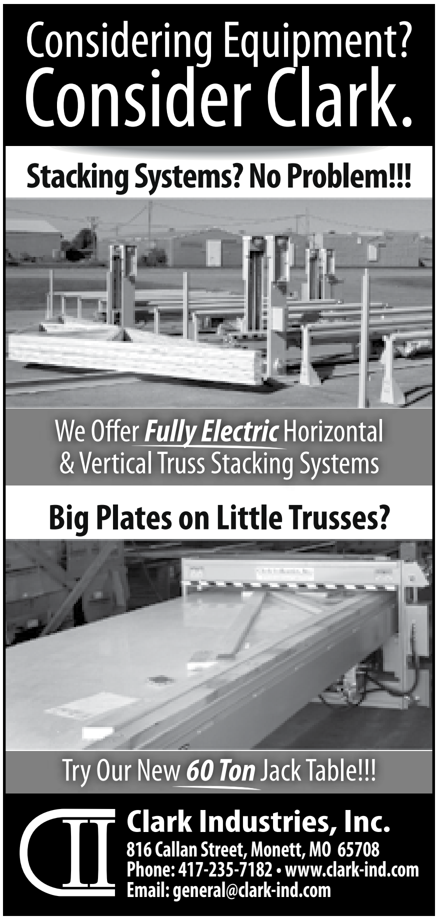
# Table 1

## The Limits of the *IRC*

| Description | Maximum Allowed | Code Section |
|---|---|---|
| **Roof Live Load** | 20 psf | R301.6/Table R301.6 |
| **Ceiling/Floor Live Load** | 10, 20, 30 or 40 psf | R301.5/Table R301.5 |
| **Snow Load** | 70 psf | R301.2.3 |
| **Wind Speed (2012)** | 110 mph | R301.2.1.1/Figure R301.2(4)A |
| **Wind Speed (2006/9)** | 110 mph<br>100 mph hurricane-prone regions | R301.2.1.1 |
| **Seismic – Townhouses** | SDC: C, $D_0$, $D_1$, & $D_2$ | R301.2.2 (SDC: A & B exempt) |
| **Seismic – 1- & 2-family** | SDC: $D_0$, $D_1$, & $D_2$ | R301.2.2 (SDC: A, B & C exempt) |
| **Story Height** | 10' (laterally unsupported) plus floor framing not to exceed 16" or 12' as allowed by exception | R302.3/Table R602.3(5) |
| **Number of Stories** | 3 above grade plane | R101.2 |
| **Building Width (perpendicular to ridge)** | 36' | footnote to Tables R502.5(1) & R802.5(2) |
| **Building Length (parallel to ridge)** | Not specified for wood | [CFS & ICF limited to 60'] |
| **Mean Roof Height** | Up to 60' with application of adjustment factors | Table R602.3(1), Table R602.10.3(1) & Section R802.11 |
| **Building Width (perpendicular to ridge)** | 40' (36' building plus max 24" overhang each side) | footnote to Tables R502.5(1), R802.5(2) & R802.7.1.1 |
| **Rafter Span** | Maximum tabulated or 26' | Footnote b Table R802.5(1)-(8) |
| **Ceiling Joist Span** | Maximum tabulated or 26' | Footnote b Table R802.4(1) & (2) |
| **Rafter/Ceiling Joist Spacing** | 24" o.c. | Table R802.5(1)-(8) & Table R802.4(1) & (2) |
| **Roof Pitch** | 3/12 to 12/12 or greater | Table R301.6 & R802.3 |





# Wall Panel Design

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## commentary

Overturning anchorage is relatively straightforward. The prescriptive code, which again is based on historical performance, requires traditional anchor bolts set in concrete or affixed to the foundation as the means for a wall segment to resist lateral loads. The development of innovative shear wall hold-down hardware has taken off over the past decade (Figure 1 is a photo of just one example). The good news is a CM can take advantage of the innovative hold-down hardware and, as a result, have a great deal of flexibility to design a value-added wall panel system to meet a customer's needs. This is an area where a CM's creativity and skill can produce significant innovation. For instance, if a CM knows the precise loads flowing into the hold-down connection, it's easy to provide the proper resistance.

Testing shows that there are many times where the uplift load is far less in the building than what the prescriptive or engineered design process suggests is needed. For example, the *SDPWS* design method predicts a need to resist 4,200 lbs., but the uplift load at a load cell during structural testing indicates the actual load is half of that. It should be possible for a CM to use a less costly anchor, if this is a consistent result and can be quantified and justified.

## Overturning Anchorage

The prescriptive provisions for wall construction in the *IRC* do not require hold-downs to prevent braced wall panels from displacing or overturning under shear and uplift loads.[2] Instead, braced walls are anchored by bolts spaced 6' o.c. for walls supported by concrete foundations or by three (3) 10d box (3½" x 0.135") nails at 16" o.c. when supported by rim joists, band joists or blocking. For two-story buildings in Seismic Design Categories $D_0$, $D_1$ and $D_2$, and two-story townhouses in Seismic Design Category C, the maximum anchor bolt spacing is reduced to 4' o.c.

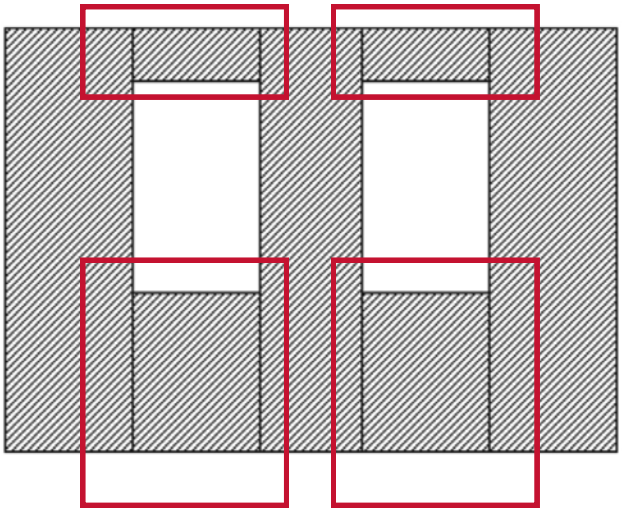
In contrast, engineered shear walls constructed in accordance with *SDPWS* require the use of hold-down hardware to anchor each end of a shear wall (also known as a segmented shear wall) unless the dead load is sufficient to prevent the wall from overturning.[3]

Currently, there are no codified engineering procedures to design a shear wall that is restrained by anchor bolts only. This is unfortunate given that this assembly has good performance and would provide an economical engineered solution, albeit at lower capacities than a segmented shear wall design using hold-down hardware.

# Figure 1


Example of Typical Hold-Down Required by *SDPWS*

# Figure 2



Example of a Perforated Shear Wall

## Perforated Shear Walls

The presence of openings (e.g., windows and doors), called perforations, in a shear wall must be considered in its design. The perforated shear wall (PSW) method contained in *SDPWS* provides one way to design shear walls with window and door openings. This method only requires a hold-down at each end of the wall instead of placing a hold-down on either end of each wall segment between the openings.

In the PSW method, an empirical adjustment factor is used to reduce the perforated shear wall capacity to account for the loss of resistance due to the openings and the reduced overturning restraint due to the use of fewer hold-downs. The shear capacity adjustment factor is a function of the area of the openings and the length of the full-height sheathing segments.[4] These two variables are combined into a single factor called the sheathing area ratio, *r*, which can be calculated as shown in the equation below.

$$r = \frac{1}{1 + \frac{A_o}{h \sum L_i}}$$

where:

$A_o$ = total area of openings in the perforated shear wall

$\sum L_i$ = sum of the perforated shear wall segment lengths

$h$ = height of the perforated shear wall

Using the results of experimental shear wall tests, the following regression equation was derived to relate the sheathing area ratio, *r*, to the shear capacity adjustment factor, $C_0$.

$$C_o = \left(\frac{r}{3 - 2r}\right)\frac{L_{tot}}{\sum L_i}$$

where:

$L_{tot}$ = total length of a perforated shear wall including the lengths of perforated shear wall segments and the lengths of segments containing openings

As shown in *SDPWS* Section 4.3.3.5, the equation for calculating the shear capacity of a perforated shear wall is as shown in the equation below.

$$V = C_o * v * \Sigma L_i$$

where:

$V$ = shear capacity of the perforated shear wall in lbs.

$C_O$ = shear capacity adjustment factor

$v$ = nominal unit shear capacity from *SDPWS* Table A4.3

Although the PSW design method was originally calibrated to shear wall test results, recent research has shown the PSW method to predict shear wall capacities significantly below the measured shear wall capacities.[5,6] The adjustment factor for the PSW method needs to be calibrated to better fit the test data in order to result in more economical designs.

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## commentary

While it intuitively makes sense to reduce the lateral load resistance capacity of a wall segment because of the presence of window and door openings, the degree of reduction the formulas in *SDPWS* require appears from testing to be far from precise.

What doesn't make sense is that wood structural panel resistance performance is overstated in the *IRC* and *SDPWS* methods, making the use of engineering not very competitive. Meanwhile, calculating resistance capacity is quite conservative when perforations (window and door openings) are added to the wall configuration.

The *SPDWS* formulas effectively render any wall segments above or below windows and doors (see areas in red boxes in Figure 2), not to mention the doors and windows themselves, as providing little to no resistance. Extensive perforated shear wall testing conducted in SBCRI provides great insight into the error of this assumption.

SBCA's goal is to use this data to create a wall panel design and QC methodology that will help SBCA members interested in manufacturing walls gain a competitive advantage over stick-built walls.

Being able to take advantage of an increased resistance capacity will make engineered perforated shear walls more competitive against prescriptively built walls. The biggest challenge is developing an approach that is as easy to implement as the prescriptive method in the *IRC*.

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## commentary

The consideration of what is called "aspect ratio" further highlights the disparity between the prescriptive method and a CM's ability to design a value-added wall framing solution. The aspect ratio is the relationship between the height of the wall and the width of a wall segment, either between the hold-down and an opening, the corner and an opening, or between two openings. The article points out the *IRC* limits the wall height to 8', and the allowable wall segment can be at least 24" (2'), hence a ratio of 4 to 1. In practical terms, the prescriptive method allows a window to be placed as close as 24" from the end of a wall or 24" from a door or window without reducing the wall's resistance capacity.

For a CM using the *SDPWS* method, the aspect ratio is decreased to 3.5 to 1, meaning the window has to be at least 30" from the end of a wall or 30" from a door or window to avoid reducing its resistance capacity. Further, if anything less than 4' separates an opening from the end of the wall or another opening, the resistance capacity of the wall needs to be reduced further.

Think about all the houses you have contributed product to and try to count on two hands how many of them have their openings more than 4' from the end of a wall or between openings.

So what does all of this mean in practical terms? This article now provides a discrete example of how the prescriptive method arrives at a very different assumed resistance capacity versus the *SDPWS* engineered method.

### Aspect Ratio

The *IRC* allows wall segments as small as 24" in width to count as part of the braced wall length if they are adjacent to openings less than 64" in height and are part of a continuously sheathed wall. Since the wall height for this provision is limited to 8', a 24" braced wall segment results in a height to width aspect ratio of 4:1. In many cases, the *IRC* does not require these segments to be restrained by hold-downs. Their only resistance to overturning forces comes from anchor bolts and the surrounding framing members. Unlike the provisions for engineered design, there is no reduction factor applied to these 4:1 aspect ratio segments, regardless of whether they are resisting wind or seismic forces. On the other hand, *SDPWS* limits the aspect ratio of light-frame shear walls to 3.5:1.

For perforated shear walls, aspect ratios exceeding 2:1 are only allowed if a reduction factor equal to *2bs/h* is applied to that segment, where *bs* and *h* are the shear wall segment length and height, respectively.

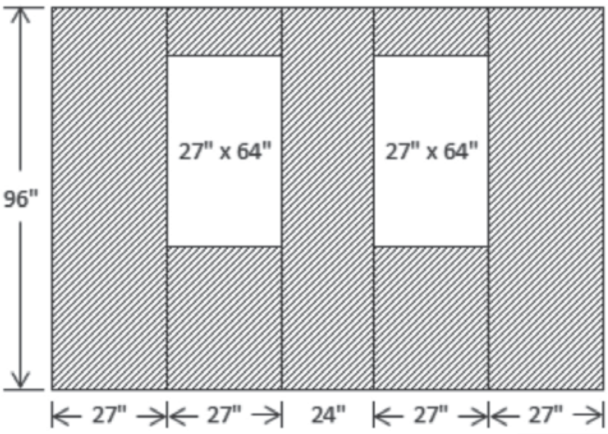
## Design Comparison

To illustrate the differences between a prescriptive *IRC* design and the engineered PSW design method, consider the shear wall shown in Figure 3. The wall is 11' long, 8' high, and has two 27" by 64" openings. It is sheathed with $^3/_8$" OSB fastened to Spruce-Pine-Fir (SPF) studs spaced 16" o.c. The fasteners are 6d common (2.0" x 0.113") nails spaced 6" o.c. along panel edges and 12" o.c. along intermediate framing members. This shear wall construction is in accordance with the minimum requirements of the *IRC*. The nominal unit shear capacity for wind loads according to *SDPWS* is 560 plf x 0.92 = 515 plf, where the reduction factor of 0.92 accounts for the use of SPF framing members.

Following the procedures used to develop the *IRC* wall bracing requirements, the shear capacity of the example wall can be calculated as the fully restrained shear wall design values from *SDPWS* (rounded down to 500 plf) times a net adjustment factor of 1.2 to account for the combination of partial restraint and the whole building system contributions to the overall wall bracing performance.[1] In addition, a 15 percent increase of this design value can be taken when the walls are continuously sheathed with wood structural panels (CS-WSP) to account for the effect of sheathing above and below window openings and sheathing segments not meeting the minimum length requirements.[1] Since the wall height is 8' and the height of the openings adjacent to the segment is equal to or less than 64", the total length of bracing for this wall is 6.5'. Thus, the shear capacity according to the provisions of the *IRC* is (500 plf x 1.2 x 1.15) x 6.5' = 4,485 lbs. The design capacity is 4,485 divided by 2, or 2,242 lbs. of design lateral load resistance. (See Table 2.)

On the other hand, a shear wall designed using the PSW method in *SDPWS* requires a reduction in the shear capacity due to the presence of openings, as discussed previously. For the shear wall shown in Figure 3, the shear strength is reduced by a shear capacity adjustment factor, $C_O$, of 0.81. Since the center pier of the wall has an aspect ratio of 4:1, it is not counted as part of the sum of the perforated shear wall segment lengths. According to the equation for the capacity of a perforated shear wall given above, the shear capacity is 0.81 x 515 plf x 4.5' = 1,877 lbs. The design capacity is 1,877 divided by 2, or 938 lbs. of design lateral load resistance. (See Table 2.)

# Figure 3




Example Shear Wall

# Table 2

**Comparison of *IRC* & *SDPWS* Design Capacities**

| Code Provisions | Shear Capacity (plf) | x | Factor for Continuous Structural Sheathing (IRC) or Shear Capacity Adjustment Factor, C0 (SDPWS) | x | Combined partial restraint and whole building factor (for IRC only) | x | Shear Wall Length (ft) | / | Factor of Safety | = | Design Lateral Load Resistance (lbs) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| IRC | 500 | x | 1.15 | x | 1.2 | x | 6.5 | / | 2.0 | = | 2243 |
| SDPWS | 515 | x | 0.81 | x | 1.0 | x | 4.5 | / | 2.0 | = | 938 |
| Ratio of IRC to SDPWS Design Lateral Load Resistance | | | | | | | | | | = | 2.4 |

## commentary

This example makes clear there are serious economic ramifications to the disparity between the two methods used to calculate a perforated shear wall's resistance capacity.

Using the exact same wall, the *IRC* states that the wall in the Figure 3 example, held down by anchor bolts set 6' apart, has a resistance of 2,242 plf.

In contrast, the *SDPWS* method would tell a CM that, if they designed this wall using today's innovative hold-down hardware at the corners, its resistance capacity is reduced to 938 plf, 2.4 times less capacity.

This doesn't make sense. The *IRC* significantly reduces the value of the engineered solution. The CM is forced to use more hardware in the hold-downs, but ends up with 2.4 times less capacity.

Based on this example, it becomes clear that, through this disparity, conventional framing methods and products, such as OSB sheathing, have an *IRC* protected position in the market.

The CM's ability to provide a cost-effective and innovative solution to their customer is, needless to say, severely restrained.

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## commentary

The test standards referenced in the *SDPWS* method provide an additional illustration of how conventional framing methods are given a competitive advantage in the market. *ASTM E72* is a standardized index test for wood structural panels. The *ASTM E72* test setup favors wood structural panel performance and its typical failure modes.

In practice, *ASTM E72* causes severe stress on the corner connectors of a wall by forcing a rectangle to essentially become a parallelogram through the use of a steel bar that eliminates normal building ductility (you can see the effects of this test in Figure 5 below).

It's easy to appreciate why the wood structural panel industry worked hard to get the *ASTM E72* standard adopted into the *IRC*. It provides a built-in competitive advantage for wood structural panels and, therefore, the wood products industry.

## Shear Capacities & Installation Methods

There are also engineering concerns over the development of the shear capacities that form the basis of the engineering found in *SDPWS/IRC*. *ASTM E72 – Test Methods of Conducting Strength Tests of Panels for Building Construction* contains the following notes regarding the evaluation of sheathing materials:

> **14. Racking Load—Evaluation of Sheathing Materials on a Standard Wood Frame**
> NOTE 2—These test methods have been used to evaluate design shear resistance of wall assemblies without the involvement of anchorage details. If the test objective is to measure the performance of the complete wall, Practice E564 is recommended.
>
> NOTE 5—Differences in edge distance, angle of fastener, and amount of fastener head penetration into the sheathing may impact the results of the tests and should be consistently installed in accordance with the manufacturer's installation instructions.

However, *ASTM E72* was used to define the nominal unit shear strength of wood structural panels in both the *IRC* and *SDPWS* instead of *ASTM E564* as clearly recommended above. The ***SBC Magazine*** article "Installation & Fastening of Wood Structural Panel Wall Bracing" (March 2014) provides test data that defines the *ASTM E564* tested ultimate strengths and goes into greater detail on the fastening-related considerations discussed in Note 5 of *ASTM E72*.

## Figure 5

In practice, *ASTM E72* causes severe stress on the corner connectors of a wall.

## references


1 Crandell J. and Z. Martin. The Story Behind the 2009 IRC Wall Bracing Provisions (Part 2: New Wind Bracing Requirements). *Forest Products Society,* 19(1), 2009.

2 *International Residential Code (IRC)*. International Code Council. Falls Church, VA. 2012.

3 *Special Design Provisions for Wind and Seismic (SDPWS)*. ANSI AF&PA SDPWS - 2008. American Forest & Paper Association. Washington, DC. 2008.

4 Douglas, B. K. and H. Sugiyama: Perforated Shearwall Design Approach. American Forest and Paper Association, Washington, DC, 1994.

5 Dolan, D. J. and A. C. Johnson. Monotonic Tests of Long Shear Walls with Openings. Virginia Polytechnic Institute and State University Timber Engineering Report TE-1996-001. 1996.

6 The Performance of Perforated Shear Walls with Narrow Wall Segments Reduced Base Restraint, and Alternative Framing Methods. NAHB Research Center, Inc. Upper Marlboro, MD. 1998.

## Conclusions

The Ad Hoc Wall Bracing Committee that developed the prescriptive wall bracing provision in the *2009 IRC* spent nearly two years studying the extensive amount of testing on shear walls and whole buildings that has been conducted in previous years. Based on that research, several increases in wall braced resistance capacity have been included in the residential code. Some adjustments, such as the 15 percent increase for continuous sheathing and the use of 4:1 aspect ratio segments, were based on the results of test programs, while other adjustments, like the 1.2 adjustment factor to the design strength, were based on committee member judgments.

One of the driving factors in the 20 percent increase to the design values was a desire to better reconcile the current *IRC* wall bracing lengths with past wall bracing practices. According to Crandell and Martin, the, "net adjustment factor could be grossly characterized as a 'calibration factor' to bring results in line with historic bracing requirements for 1950s or 1960s era 1,500 sq. ft. or less, two story or less, conventionally constructed houses." [1]

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SBCRI has conducted extensive research on perforated and segmented shear walls, with both partial and full restraint. Future articles in ***SBC*** will discuss the findings from this testing. **SBC**

## commentary

The bottom line is the *IRC* uses factors to define a shear wall's capacity to resist lateral loads that are not transparent in the marketplace.

This lack of transparency is a significant problem because engineers are prohibited from understanding the fundamental properties of the design process used by the *IRC*, making it impossible for engineered solutions to be competitive.

Unfortunately, the wood structural panel industry, led by APA and AWC, and an *IRC* process dominated by NAHB, have opposed SBCA's past code change proposals to provide greater clarity on how these adjustment factors were derived and how they should be used. SBCA continues to advocate that providing a transparent understanding of these design properties will lead to better understanding, better design and, ultimately, greater innovation in the market.

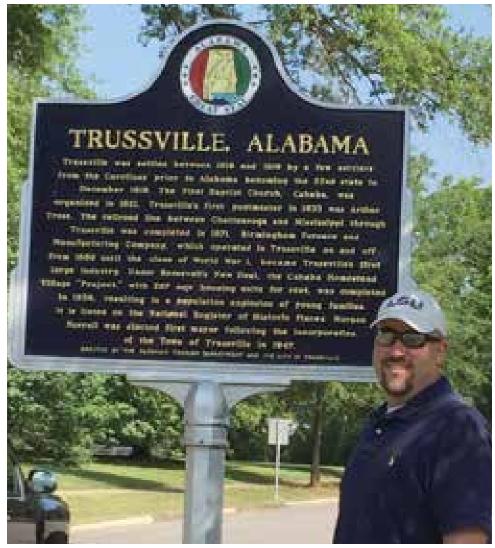
When the same wall has a calculated resistance capacity of 2,242 plf using *IRC* design and framing methods, but only 938 plf using a fully engineered solution, it is clear that innovation in the market is being stifled.

Fortunately, there is hope for CMs. With the extensive shear wall performance data collected through testing at SBCRI, there is empirical evidence on how shear walls actually perform in real-world buildings.

SBCA's goal is to take that data and work with CMs to develop more accurate engineering design procedures for shear walls. The aim will be to develop design and QC procedures that give CMs a distinct advantage over field framing methods. A transparent, science-based methodology for calculating shear wall resistance capacity will enable more creativity and innovation than the current, non-transparent *IRC* prescriptive approach.

# parting shots

Share your stories and photos with us! Send submissions to partingshots@sbcmag.info.




On his drive to SBCA's July Open Quarterly Meeting in Nashville, TN, Past President Scott Ward (Southern Components) stopped in Trussville, AL. While not the legendary birthplace of today's modern metal plate connected wood truss, might it be the perfect place to host a future BCMC? SBC




I BUILD COMPONENTS.
I NEED A PARTNER
TO HELP ME
DO IT BETTER, SMARTER
AND FASTER.