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THE FUTURE OF FRAMING
March 2014
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contents

The mission of *Structural Building Components Magazine (SBC)* is to increase the knowledge of and to promote the common interests of those engaged in manufacturing and distributing structural building components. Further, *SBC* strives to ensure growth, continuity and increased professionalism in our industry, and to be the information conduit by staying abreast of leading-edge issues. *SBC's* editorial focus is geared toward the entire structural building component industry, which includes the membership of the Structural Building Components Association (SBCA). The opinions expressed in *SBC* are those of the authors and those quoted, and are not necessarily the opinions of Truss Publications or SBCA.

editor's message

by Scott Ward

The Complete Package

SBCA Jobsite Packages are an integral part of a successful project, but often it's taking the time to connect with your customer that makes all the difference.

Our products live and die by the individuals who install them. Every page of this issue attests to the fact that the skill and knowledge of the framers handling our components can either make us heroes (Perfect Form, page 16), middlemen (Holy Truss, page 12) or goats (Long [Attention!] Span, page 22). I am convinced that the most effective way for me to be the hero more often than the goat (I hate being the goat) is to give an SBCA Jobsite Package to the general contractor (GC) and framing crew on every job.

It doesn't matter whether it's a $500 car port or a million-dollar multi-family development; I want one of those plastic bags full of industry best practices in the hands of everyone handling my products. You all know as well as I, that if those components aren't handled or installed correctly, I'm going to hear about it and I'm probably not going to be happy.

The biggest problem is that the Jobsite Package frequently gets lost on the jobsite or is simply ignored. Sometimes you can put it in their hands, and they don't bother to read it. Sometimes they can't read it. For example, I had a job recently where this was an issue. It was a big nursing home, with three-part long span trusses. The entire framing crew was Hispanic, but even though the Jobsite Package is bilingual, these guys couldn't read Spanish either.

The framing crew didn't read the documents, didn't look at the pictures, and didn't understand the need for a spreader bar. As they lifted each truss, it would deflect, causing some of the plates to pop off. I remember getting the call from the building owner, a doctor, who was furious and thought something was wrong with the quality of our trusses.

When I showed up on the jobsite and saw what was happening, I couldn't stop them fast enough. Several truss repairs later, the building owner had fired the original crew and hired a second framing crew to complete the installation. The supervisor of the second crew knew to use a spreader bar, but unfortunately, he didn't read the Jobsite Package either, and didn't put up any bracing.

As the trusses started to twist out of plane, I got another call from the building owner. They don't make Rolaids strong enough for that kind of heartburn. I got the GC and the building owner out on the jobsite and explained to them that we'd need to hire a professional engineer (PE) to inspect the building and create a bracing plan to fix the problem. After several site visits, the PE designed the plan, and the crew spent several days implementing it before the building was back on track.

If I wasn't convinced the Jobsite Package is a necessity before that project, I certainly am now. I am also convinced that simply having your driver drop it off with the component package at the jobsite isn't enough, unless you've worked with the framing crew several times in the past and totally trust they know what they're doing.

Anytime we work with a GC or an inexperienced crew for the first time, we visit with them ahead of delivery, follow the enclosed *Information for Framers* and walk them through *B1 – Guide for Handling, Installing, Restraint & Bracing of Trusses, B2 – Truss Installation & Temporary Restraint/Bracing, B3 – Web Member Permanent*

Continued on page 6

at a glance

- The most effective way to avoid recurrent issues with component installation is to give an SBCA Jobsite Package to the general contractor and framing crew on every job.
- Simply having your driver drop the Jobsite Package off with the component package at the jobsite isn't enough.
- Anytime you work with a GC or an inexperienced crew for the first time, consider visiting with them ahead of delivery and walk them through the information in the jobsite package.

Editor's Message

Continued from page 5

Bracing/Web Reinforcement, B4 – Construction Loading and *B11 – Fall Protection & Trusses.* I make sure to emphasize any of the best practices contained in those Summary Sheets that might be particularly important, given the components that will be used on that particular job, such as bracing details for long span truss installation.

Enjoy this issue. Put yourself in the shoes of the manufacturers highlighted in these stories and think about whose boots you'd prefer to be in. Then, read **Parting Shots** to find out how the National Framer's Council is going to be a game changer, and how you can get involved. SBC

SBC Magazine encourages the participation of its readers in developing content for future issues. Do you have an article idea for an upcoming issue or a topic that you would like to see covered? Email your thoughts and ideas to editor@sbcmag.info.

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SIMPSON Strong-Tie®

technical Q&A

by Daniel Lawless, MSCE, Structures

Installation & Fastening of Wood Structural Panel Wall Bracing

Understand the effects that installation methods and fastener sizes can have on the lateral resistance provided by wood structural panel (WSP) wall bracing.

In light of the recent collapse[1] of a condominium building under construction in the Briar Creek area of Raleigh, NC, a closer examination of the design/installation of sheathing for braced wall lines may be needed. There are quite a few unknowns about the stage of the construction process and how installation was implemented in the case of this collapse. However, it certainly provides an excellent example of the importance of the application of connectors because it is likely that the fastening/connections in the structure played a prominent role in the collapse. An understanding of how fastener size and installation method can affect the strength of shear walls (a.k.a., braced wall panels) is critical to providing proper wall bracing.

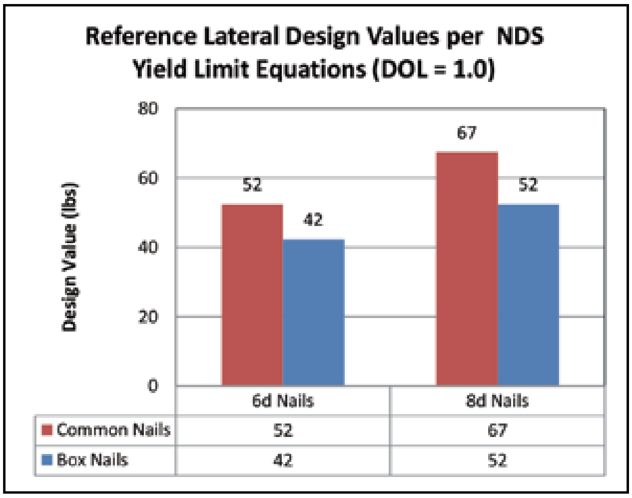


Figure 1. Comparison of 6d and 8d Box and Common Nails. (Note: Calculations were performed in accordance with the yield limit equations in *NDS* Table 11.3.1A. Yield mode III_s controls.)

Question

What effects can installation methods and fastener sizes have on the strength of wood structural panel (WSP) wall bracing?

Answer

A variety of nail sizes and spacing can be used to attach WSPs to the framing members to provide lateral resistance bracing. The construction documents for each project should clearly indicate the diameter and length of the nails to use for each shear wall, as well as the spacing of the fasteners around the perimeter and in the field of the panels (e.g., 8d [2-½" x 0.131"] @ 6" o.c. max. at all panel edges and 8d nails @ 12" o.c. max. at all intermediate studs).

Specifying only the penny weight of the nail is not sufficient because there are usually several different diameters and lengths for a given size. For instance, a 6d nail could be a 6d common (2" x 0.113"), a 6d box (2" x 0.099"), or a 6d sinker (1-7/8" x 0.092"). It is typical for a gun nail with any of these sizes to be called a 6d nail. For a building constructed in accordance with the *International Residential Code (IRC),* changing from a 6d common (2" x 0.113") nail to a 6d box (2" x 0.099") nail would require the fastener spacing to decrease from 6" o.c. along panel edges and 12" o.c. in the field to 3" o.c. along panel edges and 6" o.c. in the field. If the framer uses the 6d box (2" x 0.099") nail without reducing the fastener spacing appropriately, the building may not have sufficient lateral resistance to withstand the design wind forces.

Unlike the prescriptive fastening provisions of the *IRC* (e.g., 6d common [2" x 0.113"] at 6" o.c. edge and 12" o.c. field), the *Special Design Provisions for Wind and Seismic (SDPWS)* allows for either common or galvanized box nails to be used to fasten WSP sheathing with no change to the fastener spacing or design values. A 6d common nail has a shank diameter of 0.113", while a 6d galvanized box nail has a diameter of only 0.099". Similarly, an 8d common nail has a shank diameter of 0.131", compared to an 8d galvanized box nail that has a diameter of only 0.113". Compared to the corresponding common nail diameter, there is about a 12 percent and 14 percent reduction in the shank diameter (0.99/0.113 and 0.113/0.131) of 6d and 8d galvanized box nails, respectively.

at a glance

- ❑ Use of galvanized box nails may result in shear walls with a shear capacity significantly below the nominal unit shear capacities given in *SDPWS*.
- ❑ Thus, the majority of WSP shear walls have a shear capacity with a high degree of design value variability. This may have unintended consequences that are unknown and unappreciated by the professional engineering and/or building design community.
- ❑ Once SBCA and SBCRI were certain their testing and engineering analysis was consistent and repeatable, they were persistent in bringing all WSP shear wall performance issues to the attention of APA, AWC, ICC-ES and ICC.

[1] "OSB Sheathed/Braced Condo Collapse Video Goes Viral," SBC Industry News, January 12, 2014, sbcmag.info/news/CondoCollapse

Figure 2. Single Panel Wall Testing: The results from these two single panel wall test setups were compared to ensure they produce similar results.

Figure 3. Isolated 4x8 Wall Testing: The results from the 12' x 30' building tests were compared to the new SBCRI lateral wall station with truss framing tests to ensure they produce similar results.

Figure 4. Fully Sheathed Wall Testing: The results from the 12' x 30' full building lateral wall with a full set of roof trusses test were compared to the lateral wall station with truss framing tests to ensure they produce similar results.

Using the *National Design Specification (NDS)* yield limit equations for dowel-type fasteners, the lateral load resistance for 7/16" OSB sheathing fastened to an SPF framing member drops by 19 percent and 22 percent when 6d and 8d galvanized box nails are used instead of 6d and 8d common nails, respectively.

To help resolve this discrepancy, data from industry shear wall tests conducted by the SBC Research Institute (SBCRI) was examined to provide a better understanding of the sheathing-to-framing fastener performance.

Wall Bracing Tests

SBCRI[2] performed 49 tests of segmented shear walls sheathed with 3/8", 7/16", or 15/32" Sheathing Category OSB fastened with either 8d common (2-½" x 0.131") or 8d box (2-3/8" x 0.113") nails. The wall framing consisted of SPF studs spaced 16" o.c. because this is a common construction in light-frame buildings. The nails were spaced precisely at 6" o.c. along the panel edges and 12" o.c. in the field because SBCRI staff marked the fastener locations on the panel. The nails were installed using a minimum of a 3/8" edge distance that was chalk-lined on the panels so each nail had *SDPWS, Wood Frame Construction Manual (WFCM), IRC* and *IBC* code-compliant installation. Obviously, this type of test lab framing is more precise than field framing. Photos of the six different set-ups used to conduct the shear wall tests are shown in Figures 2 through 4.

Figures 5 and 6 (on page 10) provide a histogram that shows the distribution of the data for each of the nail sizes. Table 1 shows the variation in the shear wall capacity for the two different nail types used in the segmented shear wall tests using near perfectly installed connectors. As can be seen from Figures 5 and 6, there is a significant amount of variability in the shear resistance capacity of the tested WSP walls.

Continued on page 10

[2] This testing was funded by Qualtim, Inc. Qualtim has granted SBCA/SBCRI the exclusive right to use this data to thereby improve the SBC industry's knowledge regarding shear wall performance, to enhance the design and use of wall panels and provide a foundation for innovation within the engineered wall panel marketplace.

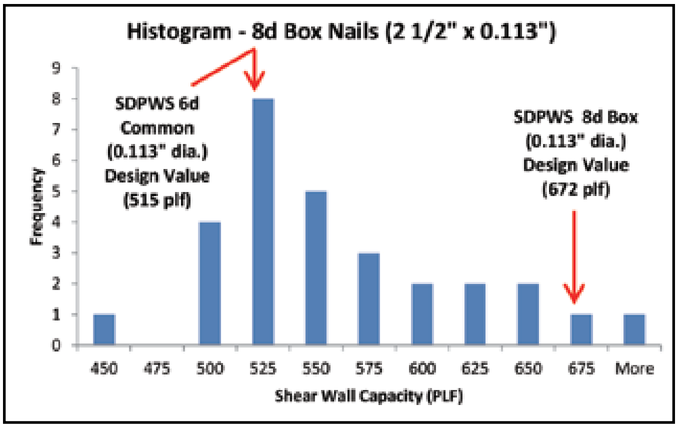


Figure 5. Histogram of Tested Shear Wall Capacity for 8d Box (2-$^3/_8$" x 0.113") Nails. (Per *SDPWS,* $^3/_8$" WSP with SPF framing 16" o.c. has a design value of 515 plf for 6d common [2" x 0.113"] nails and 672 plf for 8d box [2-½" x 0.113"] nails.)

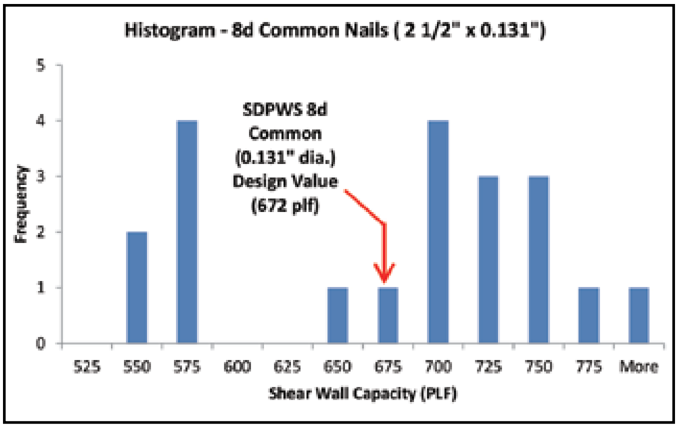


Figure 6. Histogram of Tested Shear Wall Tests for 8d Common (2-½" x 0.131") Nails. (Per *SDPWS,* $^3/_8$" to $^{15}/_{32}$" WSP with SPF framing 16" o.c. has a design value of 672 plf for 8d common [2-½" x 0.131"] nails.)

Technical Q&A

Continued from page 9

The SBCRI testing minimized the variation in the results by carefully controlling the tested materials, construction, and boundary conditions for each shear wall test set-up. SBCRI staff always chalk-lined the panel edges to ensure the sheathing fasteners were placed a minimum of $^3/_8$" from the panel edge per *SDPWS*. Any shiners (when present) were removed and a new fastener was installed. The studs were always straight and spaced precisely. In other words, these walls represented an ideal case from a construction practice perspective. It is expected that the variability in the SBCRI tests represent quality control issues with the OSB sheathing, wood framing, and nail specifications. Greater variability than is shown in Figures 5 and 6 will likely exist in real-world applications using common OSB field construction practices for shear walls.

This SBCRI testing shows that, on average, there is about a 20 percent decrease in the lateral load resistance when 8d galvanized box (2-$^3/_8$" x 0.113") nails are used instead of 8d common (2-½" x 0.131") nails. Notice that this difference is very similar to the 23 percent decrease between the design values for 6d common (2" x 0.113") nails vs. 8d common (2-½" x 0.131") nails in $^3/_8$" OSB given in *SDPWS*.

Of the 29 SBCRI shear wall tests with the 8d box (2-$^3/_8$" x 0.113") nails, only one test met the published *SDPWS* nominal unit shear capacity of 672 plf (see Figure 5).

As currently written, Table 4.3A in *SDPWS* shows that a $^3/_8$" WSP shear wall with 8d galvanized box (2-$^3/_8$" x 0.113") nails and a $^3/_8$" WSP shear wall with 8d common (2-½" x 0.131") nails both have the same nominal unit shear capacity of 672 plf (730 plf multiplied by 0.92 for DF to SPF reduction).

However, as shown in Figure 5, the nominal unit shear capacity for the 8d galvanized box (2-$^3/_8$" x 0.113") nail has a median value between 500 and 525 plf, about 150 plf less than the design value given in *SDPWS*.

Since a 6d common (2" x 0.113") nail has the same diameter as the 8d galvanized box nail (2-$^3/_8$" x 0.113"), the test results in Figure 5 were compared to the *SDPWS* design value for 6d common nails. Table 4.3A in *SDPWS* gives a nominal unit shear capacity of 515 plf (560 plf times 0.92 for DF to SPF reduction) for a $^3/_8$" WSP shear wall with 6d common (2" x 0.113") nails. This is comparable to the median shear capacity for the shear walls with 8d galvanized box (2-$^3/_8$" x 0.113") nails.

It seems that the 8d galvanized box (2-$^3/_8$" x 0.113") nail and the 6d common (2" x 0.113") nail should have the same design value as the only difference between the two fasteners is the $^3/_8$" greater fastener penetration of the 8d galvanized box nail. However, the provisions of *SDPWS* inaptly state otherwise.

It is clear that the design values used for fastening systems in OSB shear walls need to be seriously reviewed and updated. The concern is that there is a high degree of variability in both nails and OSB that may cause unintended WSP design value consequences that are typically unknown and unappreciated by the professional engineering and building design community, and further, this result occurs under ideal laboratory construction conditions. This clearly should be an issue of serious importance to APA-The Engineered Wood Association and to the *SDPWS* and *WFCM* ANSI standards developer, the American Wood Council (AWC).[3]

The lack of a reduction in strength for the smaller nail diameter of box nails is a position that APA has recognized. In the

[3] Since August 2011, when SBCA and SBCRI were certain their testing was consistent and repeatable, they have provided their findings to the market. This includes sending data and conclusions to interest groups such as APA, AWC, ICC-ES, and ICC. Since neither test data, nor an analytical response correcting these findings has ever been received, SBCA and SBCRI believe the testing/analysis presented here is precise, accurate and legitimate. This information has been provided as a public service to the professional engineering and specification community in order to be fully transparent. The goal is to provide facts, backed by empirical test data, so that wiser engineered design decisions can be made. For all past correspondence regarding OSB shear wall (a.k.a., braced wall panel) performance, visit sbcmag.info/news/OSBpast.

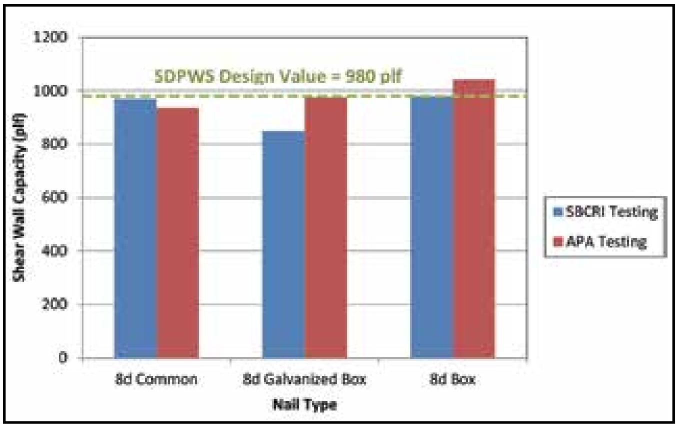


Figure 7. Bar Chart of Tested Shear Wall Capacity for 8d Common (2-½" x 0.131") and 8d Box (2-$^{3}/_{8}$" x 0.113") Nails. (Per *SDPWS*, $^{7}/_{16}$" WSP with DF framing 24" o.c. or SPF framing 16" o.c. has a design value of 980 plf.)

publication entitled "Shear Wall Test Results Comparing 8d Common and 8d Box Nails" (TT-087B), APA states the following regarding the performance of 8d box and 8d common nails:

> An 8d common nail has a shank diameter of 0.131 inch but an 8d box (or cooler, or sinker) nail has a diameter of 0.113 inch, which is approximately a 15 percent reduction in shank diameter.

Furthermore, this APA publication states:

> Using the NDS equations, a 15 percent reduction in shank diameter leads to approximately a 25 percent reduction in the lateral load resistance (assuming other variables remain equal) for typical wood-structural-panel-to-framing connections.

The referenced APA publication finally concludes that:

> Published results from 32 full-scale cycle tests show that the racking resistance of shear walls built with 8d box nails is comparable to those built with 8d common nails… The differences between the full-scale shear wall test results and the NDS analytical calculations may be attributable to less wood splitting due to smaller-diameter nail shank and/or to an assembly/group effect that overshadows the small difference in nail shank diameter (neither the splitting nor the system/group effect is accounted for in the NDS single-fastener yield equations)…. Whether or not these same results are applicable to a particular case, (e.g. variations in nail sizes and types, or whether the test cases were used in diaphragms, etc.) should be determined by the design professional and/or building official upon review of the available test results and design literature.

APA's viewpoint is that they have not observed a difference in the shear wall performance with 8d box versus 8d common nails. Hence, the same shear wall design value can be used for either nail type.

Although the results of the SBCRI shear wall tests have been provided to APA, there have been no changes made to *SDPWS*. APA's position is based on testing of common and box nails with a maximum fastener spacing of 4" o.c. around the panel edges and 6" o.c. in the field (APA Research Report T2004-14[4]).

SBCRI tested shear walls with the same fastener spacing (4" o.c. around the panel edges and 6" o.c. in the field) as the APA shear wall tests to verify the results. The bar chart in Figure 7 shows the results of the APA and SBCRI tests. The results are similar except for the 8d galvanized box nails. The 8d hot-dipped galvanized box nails used by SBCRI resulted in an average decrease of 12 percent compared to the 8d common nails.

The SBCRI test results suggest that the nominal unit shear capacity of the wall sheathing is highly dependent on the fastener type and fastener itself, when all other factors are controlled. This includes but is not limited to:

1. Fastener edge distance
2. Fastener steel yield and ultimate strengths
3. Fastener specifications, diameter tolerances, and gun nail glues
4. Specific fastener installation instructions from the WSP and/or fastener supplier or both, including number of allowable shiners
5. Field installed fastener inspections by building officials
6. Unexpected new fasteners replacing existing fastener types, while being called similar names
7. ASTM testing standard boundary conditions[5]

Concluding Thoughts

Currently, the primary nail used in the field is the 8d galvanized box (2-$^{3}/_{8}$" x 0.113") nail. In SBCRI's experience, gun-driven 8d common (2-½" x 0.131") nails can only be obtained by special order from a nail/nail gun supplier. Also, in the normal field environment, there is little or no quality control on the required minimum edge distance for fasteners, and no guidance is available on the number of allowable shiners.

This means that the majority of the WSP shear walls constructed have a shear capacity where there is a high degree of shear wall design value variability. This is due at least in part to all the items listed above, and there may be more that come to light with further testing that is more realistic with respect to actual field application conditions. All of this may lead to unintended WSP design value consequences that are typically unknown and unappreciated by the professional engineering, building design and specification community.

There is the very real potential that actual design values are significantly below the nominal unit shear capacities divided by a factor of safety of 2 as given in *SDPWS, WFCM, the IBC*

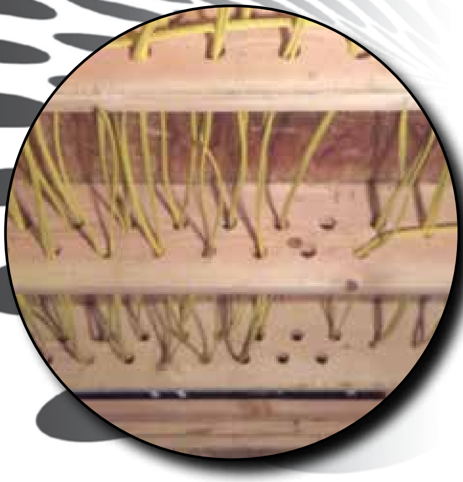
Continued on page 26

[4] This is a research report referenced by TT-087B.

[5] Some testing facilities use: (1) a steel beam to apply lateral load to the wall assembly, which does not simulate real-world framing along the top plate of the wall. This changes the top plate ductility and can affect the design values obtained and/or (2) a threaded rod to tie the leading edge of the wall top plate to the foundation. This causes a hold-down force to be applied to the top plate of the wall, increasing the lateral resistance capacity and, therefore, inadvertently increasing the design values of the shear wall being tested by an unknown amount.

the Holy Truss

by Sean D. Shields



Ever have one of those component jobs where everything went exactly to plan, only to have a hiccup at the last moment? A lot of truss repairs can fit that bill, and this one is no exception. The key is ensuring you have a strong focus on customer service when dealing with the unexpected when it comes. This is a brief look at how one component manufacturer addressed an unusual truss repair.

"The project was a light-frame commercial building located in a heavily wooded area that was part of a religious camp," said Glen Etchison, a Sales Product Manager for ProBuild in Clackamas, OR. "They specified attic trusses at either end of the building to be used for storage."

After being awarded the job, Etchison produced the layouts and truss profiles, and after a few rounds of revisions, got the green light for production. Even the production went smoothly. In fact, the only real challenge was actually delivering the trusses. "The campgrounds were located in a remote area in the foothills of the Cascade Mountains," said Etchison. "It took the driver a good hour and a half to reach the camp from the closest highway."

In the Oregon market, roof trusses are delivered above the top plate using a boom crane truck. Between the drive and the unloading process, it took the driver a full day to finish the delivery. Still, that's not so bad for a job well done. That is, until Etchison heard the building failed its final framing inspection.

"The project supervisor contacted me, letting me know an issue had come up during the walk through," said Etchison. The supervisor emailed Etchison two pictures of the source of the problem (see photos at left). He couldn't believe what he saw.

"The supervisor said that he didn't think it was a big issue," remembered Etchison. "He said they always drill holes in the bottom chords to run wiring." To give you a sense of scale, the bottom chord of each truss is made of 2x10 Doug-Fir Select Structural. "I asked them if they typically drill that many holes in their bottom chords, because, in this case, they had removed all the load bearing capacity of the trusses."

"We quickly worked with our third-party engineers to develop a repair for the trusses," said Etchison. "Unfortunately, they rejected the first repair solution." The first repair called for scabbing a 24'-long piece of 2x10 LVL to each bottom chord after removing all the wiring and plumbing. "The supervisor didn't approve the repair, citing it would cost too much to remove and reroute all the wiring and plumbing. There were also concerns they wouldn't be able to get the 24'-long LVL up into the attic." So, Etchison went back to his third-party engineers and found another solution.

"I did my best to convince the supervisor that the repair was necessary as a matter of structural integrity, and that the cost needed to be a secondary issue," said Etchison. "It was a challenging conversation."

In the end, the project supervisor approved the second repair, which called for two separate 2x10 Doug-Fir Select Structural scabs to be affixed to each bottom chord, allowing for a prescribed number of 1" holes to be drilled into the bottom chord and scab.

"We have an internal process in place to determine whether we are at fault when something goes wrong in the field," said Etchison. "In this case, it obviously wasn't our fault. Still, we worked with the customer to get a repair they found acceptable. If it had been something we had done wrong, we also would have provided the framing crew to do the repair."

Truss repairs are necessary more often than they should be. In most cases, the truss damage requiring repair is no fault of the component manufacturer. However, good service on every repair helps ensure a happy customer and a strengthened relationship that can pay dividends far into the future. SBC

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Perfect Form

The Value of Engineering & a Well-Executed Plan

by Sean D. Shields

the players:

- Pennsylvania Department of Transportation
- Butch Tyler, Outside Sales Representative from Carter Lumber
- Brian Otto, Truss Designer from Cussewago Truss LLC
- Art Hernandez, P.E. & Matt Vinson, P.E., Truss Design Engineers from Eagle Metal Products
- Russell Standard Corporation

Last summer, Superstorm Sandy caused an estimated $65 billion worth of damage in the U.S., a total surpassed only by Hurricane Katrina in American history. Sandy was the largest hurricane on record to hit the Atlantic Coast, at over 1,100 miles in diameter. So while it hit the New Jersey shores the hardest, according to the National Oceanic and Atmospheric Administration, its disastrous effects were felt as far inland as Wisconsin and Michigan.

While the chaos and destruction wrought by this powerful natural force is sobering, it's hard not to simultaneously focus on the positive stories that came out of such events. One such story is that of Cussewago Truss LLC in Cambridge Springs, PA. It's a tale of the marvels of wood, the value of engineering and the fruits of a well-executed plan.

Sandy Steals the Steel

About a mile inland from Lake Erie, Route 5 crosses Walnut Creek on an old bridge between Erie and Fairview, PA. To call it a bridge is perhaps overstating the fact a bit. It's really more of a pair of large tunnels through which the waters of the creek flow into one of the mighty Great Lakes. Last year, the Pennsylvania Department of Transportation approved lengthening the tunnels by eight feet (four feet on each side) to make future widening of the road surface possible.

Initially, the formwork for pouring the concrete to extend the tunnels was made out of heavy-gauge steel (see Photo 1). When fully constructed, the steel lattice and plywood weighed over 17,000 pounds. Due to strict environmental constraints, heavy machinery was prohibited in and around the river, so the steel needed to be hauled down into the river and assembled by hand. It was a labor-intensive and logistical nightmare.

After pouring the first tunnel extension on the Northeast side (upriver), the steel structure was painstakingly disassembled and reassembled in the adjacent tunnel. However, on October 31, before the concrete could be poured, Superstorm Sandy's torrential rains caused Walnut Creek to swell rapidly. The strong current pulled the steel structure away from the tunnels and carried it down the river (see Photo 2).

Eventually, the steel form had to be fished out of the river using heavy crane equipment. It was ruined beyond use, and state officials hoped there was a better way to finish the project. Enter Carter Lumber and Cussewago Truss LLC.

A Triangle in an Arch

"They came to me asking if we could make a round topped truss," recalled Butch Tyler, an Outside Sales Representative for Carter Lumber. "I said I thought we could, and I knew the guy to ask." That "guy" was Brian Otto, a Truss Designer at Cussewago.

"Initially, I got an email from Butch with a request for a quote. His first question was whether it could be done," said Otto. "Followed, of course, by how much it would cost." Tyler also sent Otto the layout of the steel structure for the profile and dimensions. "It was an interesting challenge trying to design each segment so the top chord profile matched as closely as possible," said Otto. Once he got the profile close, he sent it back to Tyler with the cost estimates.

"They were blown away," remembers Tyler. "They were practically falling over themselves accepting our bid." Not only was Cussewago's bid almost half the cost of the steel structure, it promised to be lighter and easier to install, not to mention more flexible to accommodate the slight differences between the three different tunnel openings where it would be used.

"I have to admit that I was initially a little nervous, given all that was at stake between the government contract and the outcome if the trusses failed once the concrete was poured on top of them," said Otto. Most of the structure would have anywhere from 18 to 24 inches of concrete poured on top of it, but there were sections along the outer edges that had as much as nine yards of concrete poured on top.

Otto worked closely with the engineers at his plate supplier, Eagle Metal Products, to get the design right. "Each truss was 28 feet long and 14 and a half feet tall," said Otto. Cussewago typically didn't design a component more than 13 feet tall, due to the constraints of its production equipment, so initially, Otto designed the trusses in two pieces with a piggyback truss to complete the profile in the center."

Art Hernandez, P.E. and Matt Vinson, P.E. at Eagle worked with Otto on the project. They pointed out there wasn't a safe way to connect the piggyback, given the forces involved, and worked to redesign the trusses as a single component. Factoring in all of the state's parameters, and even figuring in the shock loading of the concrete as it initially came out

Continued on page 18

photo.1

photo.2

1. Original formwork for the project was made out of heavy-gauge steel.
2. Torrential rain from Superstorm Sandy washed the steel form from the tunnel.

photo.4

photo.5

photo.3

3. A platform of steel jacks were an integral part of the installation

4 & 5. The jacks provided four bearing locations for the truss assembly along their 28-foot length.

Perfect Form

Continued from page 17

of the chute and hit the formwork, they designed the trusses to withstand 800 pounds per square foot. "Because of the application, we turned the wind and snow loading off in the software and calculated it as a uniform dead load," explained Otto. "The load duration was relatively brief as the weight of the concrete dissipates as it cures."

For Hernandez and Vinson, it was an enjoyable challenge and a departure from the typical residential roof profiles. They had the opportunity to combine the strength of the arch, an architectural shape perfected by the Romans, with the power of the triangle, to design a truss to withstand this unusual loading condition. The duo was also able to optimize the truss configurations through adjusting panel points and web cuts to minimize the amount of material needed in their construction.

Each truss was designed to be part of a four-ply girder, which would be fastened together in the field. Again, no heavy equipment could be used during the installation, so each truss had to be transported and put in place by hand. Overall, the formwork structure needed to be 28 feet deep, so it required 14 four-ply girders spaced two feet on center. The top and bottom chords of each truss were constructed using Southern Yellow Pine MSR 2400, and the webs were constructed of SPF No. 2. Each single-ply truss weighed in at a hefty 500 pounds, making each girder an even ton.

Install, Uninstall, Rinse & Repeat

Delivery of the 56 individual trusses was not without its challenges as well. "At 14 and a half feet tall, we needed special state permits from the transportation department," said Otto.

6. After the girders were assembled and the purlins were installed, sheets of ¾-inch plywood were affixed to the trusses using flathead Simpson screws.

"It also meant that the state determined the delivery route, which was not a straight line." For the final stretch of road, the state shut down Route 5 completely and diverted traffic. While the driver waited for law enforcement to shut the road down, an automobile accident occurred that had to be cleared away before the driver could deliver the trusses.

Cussewago uses roll-off trailers to deliver all of its component packages. However, when the driver began preparing to unload the stack of trusses off the trailer, the project supervisor objected. "Initially, he thought that the roll off process would damage the trusses," said Otto. "He preferred to use a lift and take the trusses off the trailer one at a time." Given the earlier transportation delays, the driver was concerned there wasn't enough daylight left to do what the supervisor wanted. Otto was more concerned that lifting the trusses one at a time using a lift increased the chance to damaging the trusses. "In the end, I was able to convince the supervisor it was a better idea to roll the trusses off the trailer, particularly given our driver's extensive experience doing it that way."

Once the trusses were offloaded, they had to be carried by hand down from the road and installed above the river one at a time. Before the trusses arrived, the crew installed a platform of steel jacks, which could be adjusted once the formwork was completed (see Photo 3). "Those jacks were an integral part of the installation; they made it easier to build and install the forms," said Tyler. "Really, they were what made it possible to remove the forms and move them after each pour was completed."

"They would have preferred the trusses be clearspan, but the reactions at the heels were so high already, we needed to spread the support out along the bottom chord," said Otto. "We didn't specify what they needed to provide the supports, but we did specify the bearings." The jacks provided four bearing locations for the truss assembly along their 28-foot length. "Once the assembly was completed and sheathed, they could adjust it right where they wanted it and lock it in place, it was impressive," added Tyler. (See Photos 4-5.)

Applying the sheathing was also an interesting process. After the girders were assembled and the purlins were installed, sheets of ¾-inch plywood were affixed to the trusses using flathead Simpson screws. "It took a crew of three guys who would start at the bottom of a sheet, sink the screws in unison, and then move up the sheet

Continued on page 20

photo.7

photo.8

7. Walnut Creek is typically a calm waterway.

8. Heavy rains threatened the wood form structure. The form held and work continued after the waters receded.

Perfect Form

Continued from page 19

a short ways and sink another row of screws," said Tyler. "They let the screws slowly bend the sheathing to fit the top chord profile. It was amazing to watch." (See Photo 6 on page 19.)

Once the sheathing was installed, they were ready for the concrete to be poured. "The concrete was added in sections, and there were a couple big pours they were concerned about," said Tyler. "Turns out there was nothing to worry about. All the concrete pours went really smooth." Once the concrete cured, the framing crew lowered the jacks and set about the difficult job of deconstructing the formwork and then moving it to the next tunnel opening. It isn't too often you need to construct the same truss assembly on a jobsite three times, much less have to tear it down three times, but that's exactly what they did. "They built the form in the most difficult tunnel opening first, upriver," said Tyler. "They knew that, if it worked there, it would easily work for the other two tunnel openings downriver."

In fact, the most nerve-racking moments of the entire project had nothing to do with concrete, but with water. Normally, Walnut Creek is a pretty calm waterway (see Photo 7), but heavy rains came again, raising the water level and current strength, which threatened to wash the wood structure down the river, much as it had the steel structure earlier (see Photo 8). Fortunately, the form held and work was able to continue once the waters receded.

Easy Is a Relative Term

"Russell Standard, the concrete and asphalt surfacing company that did the pours, was impressed with how easy the project went once they switched to metal plate connected wood trusses," said Tyler. "Easy being a relative term." They were so impressed, in fact, that Carter and Cussewago were quickly hired to do a similar project over 12 Mile Creek, not far away. "The tunnels are a different size, so we had to design and build a whole new set of trusses for that project," said Otto.

It's interesting to note, the trusses used on the Walnut Creek project will continue to serve a purpose, even though their formwork days are over. The surfacing crew from Russell Standard took them back to their yard, and plans to use them for the roof of a new warehouse they are building at their facility. "I went back and ran the trusses with the wind and snow loading turned on just to be sure," said Otto with a bit of humor. "Turns out, they'll do just fine." SBC

Long ATTENTION span

Trusses Over 60 Feet Present Bracing Challenges

by Sean D. Shields

"There's something wrong with your trusses!"

It's certainly not the first thing you want to hear from your customer after dropping off 60- and 80-foot trusses at his jobsite a few days earlier. But that's the message Bob Mochinski, Sales Manager of Littfin Truss Co. in Winsted, MN, heard when he showed up for work one day last summer. "I was glad they were only a few hours away, so I jumped in the car and drove up to see the jobsite for myself," said Mochinski. Fortunate, because Littfin regularly delivers trusses to the North Dakota market over 600 miles away.

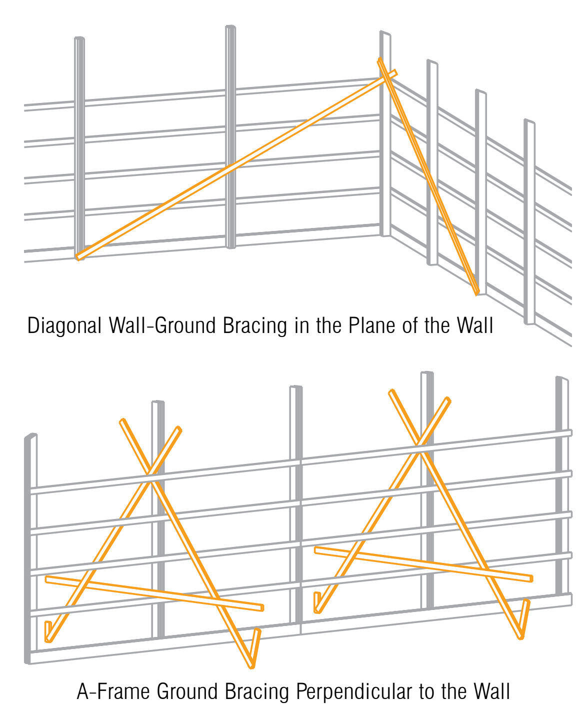

Figure 1. Ground Bracing (from Step 1 of B10)

Upon arrival, he knew immediately what the problem was: inadequate bracing. How Mochinski dealt with the situation, and what he has to say about educating framers installing long span trusses (i.e., 60 feet and over), is worth contemplation.

One Stiff Breeze

"When I got to the jobsite, I was pleasantly shocked the building was still standing," said Mochinski. "There were wires and 'come-alongs' all over the building, but nowhere bracing." Littfin supplied a Long Span Jobsite Package with the delivery of components, but its best-practice guidance hadn't been followed. The *BCSI B10 Summary Sheet, Post Frame Truss Installation, Restraint & Bracing,* outlines in a step-by-step process the bracing that needs to be put in place as long span trusses are installed.

For instance, Step 1 of B10 states, "Ensure stable side-wall and end-wall columns." It includes the illustrations shown in Figure 1, which depicts how to install diagonal wall-ground bracing in the plane of the wall and A-frame ground bracing perpendicular to the wall to ensure adequate stability. Instead, Mochinski saw walls lacking much in the way of bracing (see Photos 1 and 2).

Fortunately, for the most part, the walls were still relatively in plane. However, the roof trusses had begun to buckle (see Photos 1 and 3). When taking Photo 3, Mochinski stood directly below the truss in the middle of the picture. All he should have seen was the profile of the bottom chord; instead, he could see a good deal of the truss, as it had twisted out of plane by over a foot.

Step 3 in B10, which provides guidance on installing purlins along the top chords (see Figure 2), was followed (see Photos 3 and 4). Unfortunately, the next part of Step 3, which calls for the installation of diagonal bracing of the purlins (see Figure 3 on page 24) had not been followed. It's important to note that, while this bracing can be installed above or below the purlins, for ease of installation, the temporary diagonal bracing generally is affixed below the purlins so the diagonal bracing can remain as part of the roof system's permanent bracing and does not have to be removed during the sheathing process.

The guidance on how to install cross bracing between the trusses also went unheeded (see Figure 4 on page 24).

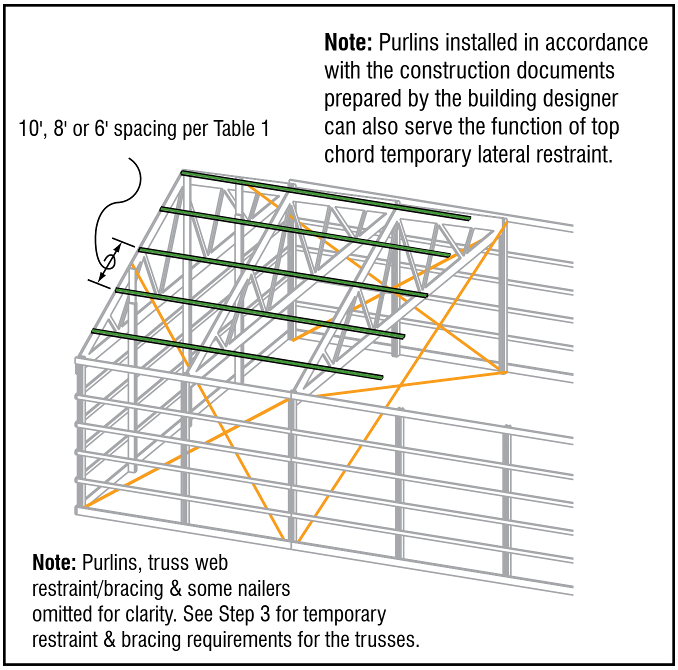

Figure 2. Top Chord Temporary Lateral Restraint (from Step 3 of B10)

"The framer told me everything had looked perfectly plumb when he went home the night before," said Mochinski, "but when he showed up the next morning, everything had shifted. He was adamant there was something wrong with the trusses we had supplied him." The lumber yard immediately asked Littfin to supply a whole new set of trusses for the job. "I knew there wasn't anything wrong with the trusses, so I offered to send a professional engineer to inspect the building and provide his analysis."

At first, they were hesitant, but eventually they agreed to abide by the determination of the P.E. Even though the analy-

Continued on page 24

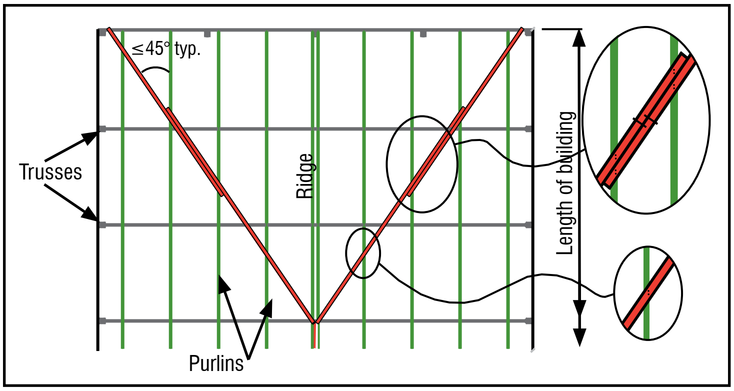

Figure 3. Top Chord Diagonal Bracing Using 2x4 Lumber (from Step 3 of B10)

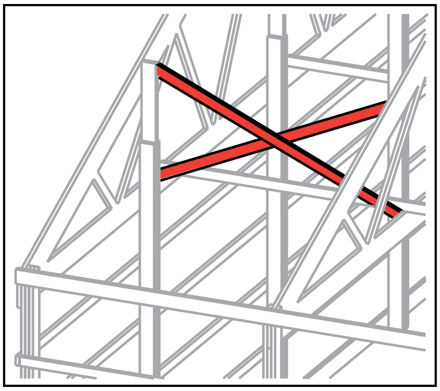
Figure 4. Cross Bracing (from Step 3 of B10)

Long (Attention!) Span

Continued from page 23

sis came with a cost, it supported his assertion that inadequate bracing was to blame.

What was truly miraculous was that the building did not actually collapse. It stood among acres and acres of alfalfa, with nothing around to protect it from the wind. Structural studies like *Lateral Movement of Unbraced Trusses During Construction* by David R. Bohnhoff, published by the American Society of Agricultural and Biological Engineers (ASABE), have determined that, prior to sheathing, a building is as vulnerable as it will ever be to wind loading. (A copy of this report can be viewed in the online version of this article.) Given the lack of bracing, one stiff breeze would have possibly been enough to blow the entire building over. Fortunately, for four days, the winds remained still.

Long Spans Require Special Consideration

The building itself wasn't unique for agricultural post-frame construction. It measured 140 feet wide by 160 feet long. "Historically, 25 percent of our production volume is this type of construction," said Mochinski. Over the 140-foot span, there was one bearing wall, so the roof profile was split into sets of roof segments—one using 60-foot clear span trusses and the other 80-foot clear span trusses. The trusses were built as a carrier truss and piggyback truss system as well, with the depth of the carrier truss 14 feet high and the piggyback truss completing the roof profile.

This type of building is being constructed throughout the farm belt as production farming and agricultural equipment gets larger and larger. "The newest farm equipment doesn't fit in the old sheds, so they need to build them bigger," said Mochinski. "It's no longer uncommon to do jobs with truss spans over 100 feet." Those long spans allow for large entryways (see Photo 5), but they also require special attention to the design of the building and the entire installation process.

This particular building makes an interesting case in point. "The 60-foot truss side of the building showed only minimal shifting," said Mochinski (see Photo 6, background).


5


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"Whereas, the 80-foot truss side showed a significant shift," (see Photo 6, foreground). This makes sense, given the ASCE report's conclusions (see sidebar), which state that, the longer and heavier the truss, the greater the forces pulling the truss further out of plane once the truss begins to move out of plane.

In its first warning to installers, the B10 Summary Sheet states,

> Trusses with clear spans 60 feet or greater are extremely dangerous to install and require more detailed safety and handling measures than shorter span trusses. Hire a registered design professional (RDP) to provide a restraint/bracing plan and to supervise the erection process.

Further, the *ANSI/TPI 1-2007* standard states in Chapter 2, Section 2.3.1.6.1, which addresses Long Span Truss Requirements,

> In all cases where a Truss clear span is 60 feet or greater, the Owner shall contract with any Registered Design Professional for the design of the Temporary Installation Restraint/Bracing and the Permanent Individual Truss Member Restraint and Diagonal Bracing.

Chapter 2 goes on to say, in Section 2.3.1.6.2,

> Special Inspection. In all cases where a Truss clear span is 60 ft. (18 m) or greater, the Owner shall Contract with any Registered Design Professional to provide special inspections to assure that the Temporary Installation Restraint/Bracing and the Permanent Individual Truss Member Restraint and Diagonal Bracing are installed properly.

Both *B10* and *TPI 1* are clear that the owner of the building is responsible for hiring an RDP, given the complexity of the design and installation process for long span trusses. It's a service component manufacturers can choose to offer their customers, to foster a good working relationship. However, it can be a costly service for the manufacturer to provide and the owner to pay. "For the jobs we ship 600 miles away, it's not practical to send an RDP all the way out to the jobsite," said Mochinski.

Knowledge Is Power

When you talk about the construction industry today, Mochinski is quick to point out that, for many young framers, long span trusses are almost like a new product. "During the recent recession, we lost a whole generation of old, experienced framers who either retired early or found jobs in other industries," said Mochinski. "With the construction industry picking up, young guys are starting framing crews, but the mentors they need for dealing with these large trusses aren't around."

As a consequence, buildings like this one get erected without the bracing they need. "The reasons the framer insisted there was something wrong with my trusses was because he had built several homes and buildings before and had never had this happen to him," said Mochinski. "But he admitted he had never built a building anywhere near as large as this one, and that made all the difference."

What's Mochinski's advice? "We all need to educate our framers, particularly the ones installing long span trusses." Don't just hand them a Long Span Jobsite Package. Take some time prior to delivery and installation to walk them through the industry best-

7

practice guidance contained in the Summary Sheets. Further, continue to remind them of the importance of hiring an RDP, and know how to implement the bracing plan once it is created.

Mochinski is quick to point out that Littfin works with several experienced framers who know what needs to be done as far as bracing, whether it's walls (see Photo 7) or truss systems (see lead photo at top of page 22). "I have never gotten a call from them saying there's something wrong with my trusses," laughs Mochinski.

The framer on this job learned the hard way. Fortunately, the building stayed upright and none of the trusses were damaged. Still, it took the framing crew four additional days to brace the trusses, get the building back to square, and sheath it properly. Littfin, wanting to preserve their relationship with their customer and the framer, provided assistance in remedying the problem. "It goes to show that being proactive and taking the time upfront to ensure they know how to install our products properly is a worthwhile investment." SBC

Trusses require careful lateral bracing during construction to prevent lateral buckling of the compression chord(s) due to the combination of axial forces induced by the truss's own dead weight, and bending forces resulting from wind forces.

The probability of failure from compression chord buckling increases as truss span increases. This is due to a combination of the following interacting factors.

1. Chord axial forces due to truss dead weight increase with span.
2. Longer span trusses exhibit greater out-of-plane movement. Note: Deflection of a simply supported beam subjected to a uniform load is directly proportional to the fourth power of the span, when cross-sectional area remains constant with length.
3. Longer span trusses have larger chords and generally larger and longer webs. This translates into increased surface area and weight per foot of span. The greater the surface area, the greater the wind force that acts to laterally bow the truss out-of-plane.
4. The more weight per unit length, the greater the gravitational force that works to overturn/collapse the truss as it bows out-of-plane.
5. Longer trusses tend to be taller. Not only may this subject the top of the truss to higher wind forces, but for trusses only fixed from out-of-plane movement at their bases (i.e., heels), the overturning moment about the base is increased.

parting shots

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

By creating national standards, based on field-tested best practices, the National Framers Council (NFC) will not only help improve the safety of each worker on the jobsite, it will aid in reducing ambiguity in everything from OSHA jobsite inspections to residential fall protection. On February 5, the NFC, a council of SBCA, met during the International Builders' Show in Las Vegas, NV (see above). Framers, builders, component manufacturers and construction industry suppliers discussed the NFC's approach toward meeting these goals.

The council's first initiative is to help framers leave the jobsite in the same health as they arrived. To that end, the NFC is working on a standardized jobsite safety program that will contain a jobsite-specific safety manual, training, and certification. In addition, the safety program will be enhanced through informal on-site trainings called "tool box talks." George Hull (Hull & Associates Framing and 2014 NFC Chairman) said, "The NFC will be able to impact change on a national level by developing standards for framing field operations and implementing best practices."

For more information on the NFC, and to become a member, go to sbcindustry.com/nfc. **SBC**

Technical Q&A

Continued from page 11

and the *IRC*. These inaccuracies reduce the expected factor of safety for structures using WSPs or, in other words, take advantage of the building system effect. Without clear installation information and realistic design values, a designer's ability to provide adequate lateral load resistance in *IRC*- or *IBC*-compliant structures could easily have unintended consequences attached to unknown and unappreciated application conditions that would affect the design value used or result in a much lower than expected overall building factor of safety. Having accurate design value knowledge and design values will allow for much better engineering judgments to be made and increase the value of engineering, engineers and innovative engineered design. **SBC**

To pose a question for this column, email technicalqa@sbcmag.info.

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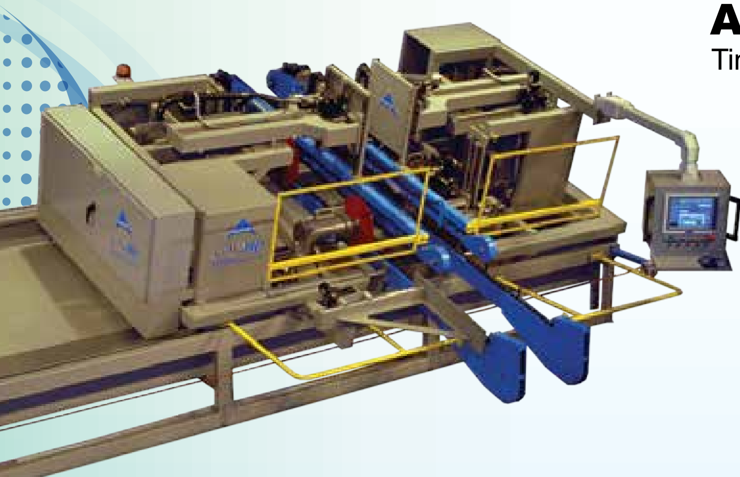

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