Cold-Formed Steel Framing: Engineering the Details of Your Next Project

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Cold-Formed Steel Framing Resource Center for Building Professionals

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The success of any construction project often comes down to the details. Beyond the major driving factors, such as budget and timeline, building professionals must address the technical specifications that allow them to construct a building that's safe, durable, structurally sound, and aesthetically appealing.

Material choice makes a significant difference in how these details are addressed. This eBook explores several technical aspects of designing and engineering cold-formed steel framing to help you complete your project successfully.

In it, you'll learn how to engineer CFS subfloors for better sound attenuation, how exterior continuous insulation requirements affect CFS field integrations, and how to address seemingly minor construction details that can have a significant impact on your project.

Tip: If you are new to CFS framing or haven't used it in a while, get up to speed by downloading "A Beginner's Guide to Cold-Formed Steel Framing."

How to Engineer Cold-Formed Steel Subfloors for a Little Peace and Quiet

The occupants of a building want peace and quiet. How can you engineer the cold-formed steel (CFS) subfloors and flooring joists to meet that demand?

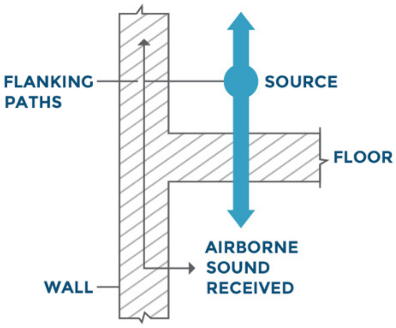
The answer involves designing CFS floors with greater mass. You must also take into account joist spacing, resilient channels, vibration breaks, and a few other factors.

But first, you must understand the basics of sound transmission.

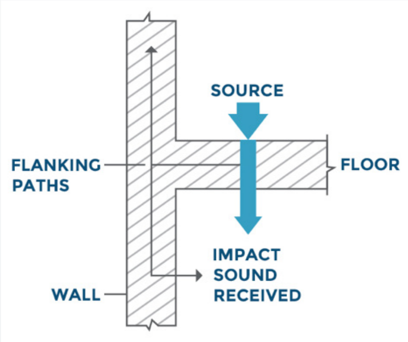
SOUND 101

Sound is vibration. It's transmitted as a wave motion through air, liquids, and solid materials, including plywood, gypsum board, and CFS framing. Acoustics specialist Christoph Hoeller, research officer at the National Research Council Canada (NRCC), noted two types of building sound:

1. Airborne sound travels through the air. It can pass through walls and floors and reemerge in surrounding spaces, as shown in the adjacent diagram.



2. Impact sound (or structural-born sound) involves the mechanical excitation of partitions, even though some of this sound is eventually conducted by the air. Impact sound can originate as footsteps, a treadmill, or furniture dragged across the floor, as just a few examples.



As noted in these diagrams, airborne sound and impact sound are transmitted in two ways:

1. Direct sound transmission travels through separating partitions.

2. Flanking sound transmission travels through other pathways, such as common floors or ceilings and their junctions.

It's important to understand how building sounds are transmitted. The methods used to lesson sound transmission vary. How can engineers minimize sound transmission in designing CFS flooring?

MASS IS THE KEY

According to Hoeller, subfloor mass matters more than anything else in controlling building noise. The heavier the mass separating floors and walls, the better the sound insulation between units. And so, it's ideal to include as much mass as possible on either side of the joists.

- **Above the joists, two layers of OSB or plywood subfloor provides better sound attenuation than one layer.**
- **Below the joists, a double-layered gypsum board ceiling reduces sound transmission better than one sheet of drywall.**

DECOUPLING FACTORS

1. Joist spacing. Increase the joist spacing as far as structural requirements allow. "Twenty-four inches is better than 16 inches for sound attenuation," Hoeller said. Partitioned within the joist cavity, air acts as a sound buffer. The wider the cavity, the greater the buffer, and the greater the decoupling effect. This is especially true if fibrous insulation fills the joist cavity.

2. Resilient channels. Resilient channels are cross-furring members. They attach to a gypsum board ceiling (or wall) and add springiness to a second board layer that isolates sound transmissions. "It's difficult to achieve good sound insulation with floor and ceiling assemblies without using resilient metal channels," Hoeller said.

Double-leg resilient channel, Image Courtesy of ClarkDietrich

Resilient channels are often installed incorrectly. Contractors may use long screws that drill through the entire resilient channel. That creates a rigid connection — coupling the system and facilitating sound transmission, rather than impeding it.

VIBRATION BREAKS

Sound can travel between adjacent rooms via flanking paths, such as a common floor or ceiling. For this reason, the 2015 edition of the National Building Code of Canada changed. Instead of requiring Sound Transmission Class ratings, it mandates system performance using Apparent STC ratings. (The 2015 International Building Code has only STC rating requirements.)

"[Canadian] designers, architects, and engineers can no longer just look at the separating assembly," Hoeller said. "They also have to look at the flanking assembly."

An NRCC study, “Apparent Sound Insulation in Cold-Formed Steel-Framed Buildings” (RR-337), sponsored by the Canadian Sheet Steel Building Institute (CSSBI), focused largely on flanking sound transmissions. It looked at different configurations for attaching CFS floor joists to CFS-framed walls and how sound travels between spaces by direct paths and by flanking paths. The biggest finding involved subfloors that are continuous across junctions. To prevent flanking sound transmission, engineers should include vibration breaks in both the joists and the subfloor.

“Cutting the joists at the junctions is much better for sound insulation than having a continuous joist,” Hoeller said.

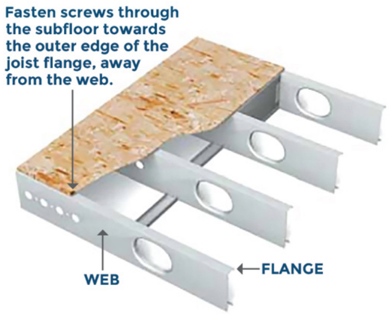
DEEP JOISTS

A variety of CFS profiles, depths, widths, and thicknesses exist in the marketplace. Some profiles have lips, some don’t. Some have proprietary knockout areas. The factor relevant to sound attenuation is web depth, according to Hoeller.

“The deeper the joists, generally the better the sound insulation,” Hoeller said. Joist thickness bears little on noise impedance, he said, so you should focus primarily on the joists’ depth and spacing.

SCREWS AWAY FROM THE WEB

What about fasteners? Where should you place the screws in a joist? Answer: Screw the subfloor into the joist flange as far from the web as you can. Fastening the subfloor away from the stiff part of the joist allows the flange to act as a decoupling element. It can help attenuate some noise.



OTHER SOUND ATTENUATION FACTORS

Other factors go beyond the purview of the CFS flooring assembly, but are worth noting:

- **Finish flooring.** Heavy finish flooring adds mass. But a lighter material, such as carpeting, can soften the impact of footsteps and reduce the mechanical power injected into a floor.
- **Sound mats.** Resilient floor interlayers reduce impact noise. They can also reduce some airborne sound.

With this knowledge, you can meet your goal of engineering CFS floors for peaceful and quiet interiors.

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Energy Codes: How Exterior Continuous Insulation Requirements Affect Cold-Formed Steel

Big changes in energy code requirements occurred with the 2009 and 2012 International Energy Conservation Code® (IECC) and the ASHRAE Standard 90.1-2013 that followed. The newest versions of IECC and ASHRAE Standard 90.1 call for one to four inches of exterior continuous insulation depending on the building location by climate zone, even in warmer zones where foam board insulation had not previously been required.

Here's what these requirements mean for cold-formed steel (CFS) assembly design and field integrations.

CFS FRAMING ASSEMBLY DESIGN

Architects, engineers, and contractors need to understand how to apply foam board insulation products as well as address the installation of cladding through the insulation, extensions for window and door openings, and other installations related to wall assemblies containing exterior insulation. Here's what to do:

Don't be quick to change

While the national model energy codes require greater thicknesses of continuous insulation (e.g. solid foam insulation), it may be tempting to choose a framing system that requires less continuous insulation than a CFS system.

But why give up the strength, durability, and other benefits of CFS framing when a variety of CFS wall assemblies meet IECC and ASHRAE 90.1 requirements?

Designers have a range of options. CFS walls vary in terms of claddings, the number of CFS members used in the framing, the thickness of CFS members, and other characteristics. And, a variety of methods to determine a wall assembly's thermal performance — including new modeling software — exist and are approved for use.

According to the Steel Framing Industry Association (SFIA), many architects and large corporations (e.g. Target, Walmart, etc.) are moving toward conducting building simulations to comply with the energy code. This approach, known as the simulated compliance or performance path, allows trade-offs of one component of the energy system for other parts.

Understand how to calculate thermal performance

In general, energy codes and standards call for three ways to determine a wall assembly's thermal properties:

- **Prescriptive R-value.** When a code specifies a prescriptive R-value, you compare the R-values of the wall cavity insulation and the exterior continuous insulation. The wall insulation R-value total must be equal to or greater than the R-values listed in the code.
- **Prescriptive U-factor.** Some energy codes specify a U-factor for the entire wall assembly, rather than an R-value just for the insulation. In this case, the designer could check published tables of U-factors for common CFS wall assemblies with a variety of combinations of insulation. The Steel Framing Alliance guide, "Thermal Design and Code Compliance for Cold-Formed Steel Walls, 2015 Edition," includes U-factor tables for a variety of CFS wall assemblies.

- Performance pathways. IECC and ASHRAE 90.1 include performance pathways that require building simulations. These new pathways include the total building performance option, energy cost budget method, and the Standard 90.1 Appendix G performance rating method. COMcheck software from the U.S. Department of Energy can help determine if a design meets the IECC and ASHRAE 90.1 requirements.

FIELD INTEGRATIONS

Energy code compliance will generally require adjustments in how CFS assemblies are installed. This could include the application of energy efficient framing methods such as a two-stud corner versus a three-stud corner, different framing methods for window and door openings, and the framing factor (e.g., 24 inches on center framing versus 19.2 or 16 inches on center).

Attaching continuous insulation materials

Attaching foam board insulation to an exterior brings the surface of those materials further from the face of the framing. The fasteners used will have to resist greater bending forces, since they must cantilever farther to support the exterior cladding, and the soft nonstructural continuous insulation provides little to no support of the fastener or cladding.

The SFIA paper, "Impact of Energy Code Changes," indicates that this is a critical design issue with heavy cladding materials on multi-story buildings that could threaten occupants or visitors walking below if not designed and installed properly.

Attaching exterior items

Whereas windows, doors, and light fixtures would normally attach to CFS framing, attachment points may not be directly accessible with foam insulation in place.

Therefore, pay extra attention to certain issues: the corners when attaching cladding, jamb extensions for exterior doors, supplemental framing to attach window flanges, and possible changes to the fastening system.

Adjusting the interior space

The requirements to add foam board insulation to CFS and wood-framed assemblies can reduce a building's interior square footage. The exterior walls may be thicker than other types of framing systems. If there's no room to expand the envelope footprint, then any added wall depth will have to come from the interior space.

What do the new energy code requirements mean for CFS assembly design and field integrations? They mean doing some thermal calculations and modifying some installation procedures. Of course, what you decide to do in the end depends on your specific state or jurisdiction's energy code requirements.

Designing With Cold-Formed Steel? Don't Overlook These 2 Costly Details

Everyone involved in a construction project knows that details are important — but some can have a more significant impact than others.

"Some construction details cause major conflicts," said Don Allen, P.E., Director of Engineering, Super Stud Building Products, Inc. Here are two construction details Allen recommends you look out for — and their solutions.

DETAIL #1: REQUIRING STUDS AND DECK FLUTES TO LINE UP

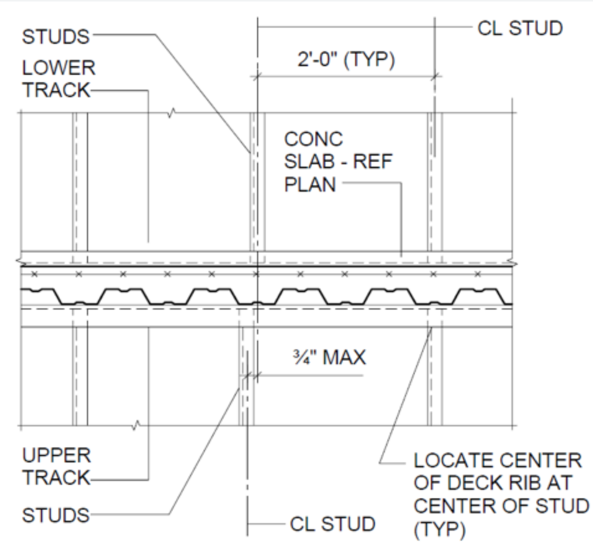
Most building codes require CFS load-bearing studs on different floors to line up with each other. Many structures use poured concrete over fluted metal decks. And so, engineers often write in what they feel is a typical detail: "Locate center of deck rib at center of stud."

Should the studs between floors and respective metal deck ribs all line up?

"This is unnecessary and costly to do," Allen said. "Not only do you have to line up the studs below with the deck flutes on top of them, but you have to line up the studs above."

Engineers understand the studs on lower floors hold up the studs above them. They know that if a stud pushes up into a metal deck flute, then the deck itself could push back down and crimp the track around the supporting stud.

So, engineers often do what comes easily — they add stud/flute alignment to their specifications, even though doing so adds cost. In most cases, the installer would have to cut some of the metal deck to get them to align. This detail is hard to execute in the field and may be impractical.



The note at bottom right calls for alignment of the wall studs and deck flutes, which can be unnecessary and costly.

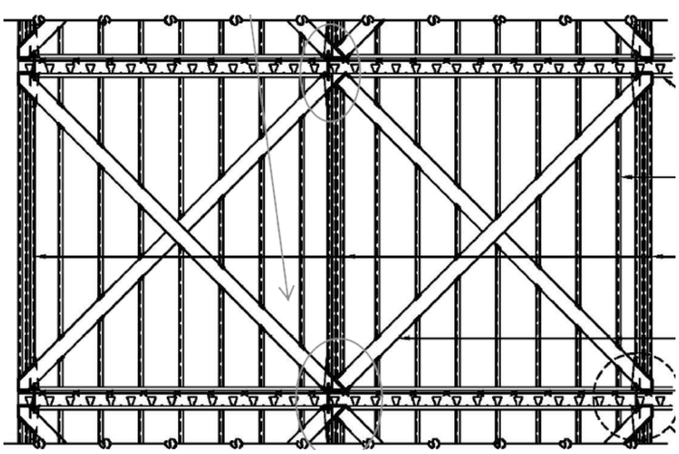
Solution: Load distribution members

The solution is to add a load distribution member (LDM) to the track. Load distribution can involve adding a single stud or a boxed set of studs to the top of the track or adding deep leg deflection tracks to the assembly. Structural steel LDMs may be used with heavy loads.

"LDMs get rid of having to line up the studs and flutes," Allen said. "They allow loads to spread out over the system."

Most building codes require CFS studs to line up between floors, unless an engineer designs an alternate system. But LDMs are a great solution.

DETAIL #2: UNNECESSARY HOLD-DOWNS



The engineer requires hold-downs at the outer posts and at the center post (oval circles), raising costs.

Engineers add bracing straps to CFS framing assemblies to handle loads caused by wind and seismic forces. But are strap hold-downs needed at every post in the system? No.

"Hold-downs are needed at the right post and at the left," said Allen about the wall assembly shown in the diagram. "But nothing is gained by adding hold-downs to the center post — just extra costs."

In this example, the system requires only four hold-downs. But, the designer specified two additional hold-downs at the center post. This raises the cost of materials by 50 percent, not counting the extra labor needed to install them.

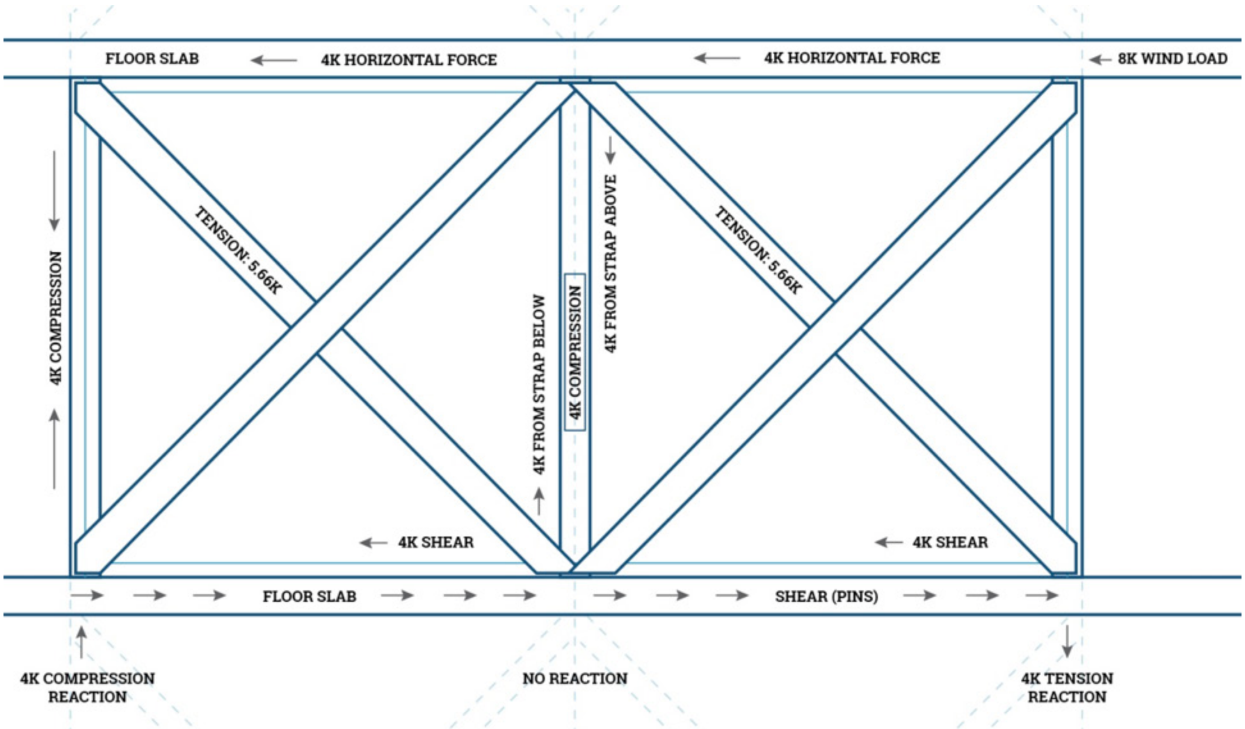
Solution: Understand how lateral forces act on your systems

Look at the entire double-braced wall as a single, free body. Imagine hurricane-force winds acting on the above assembly from the top right, pushing the upper level to the left. According to Allen, such lateral load would tend to turn the wall into a trapezoid.

The straps running from top left to bottom right would help resist the wind. One strap would handle half the lateral load, while the other strap bears the remaining load. (The two straps running down to the lower left have no function in this example of wind forces originating from the right.)

Wind pushing horizontal from the right creates load along the straps and down into the floor. This creates compression on the left post and center post. It also creates lift on the right post, which is why the right post needs hold-downs.

“Hold-downs are needed at the right post and at the left,” said Allen about the wall assembly shown in the diagram. “But nothing is gained by adding hold-downs to the center post — just extra costs.”

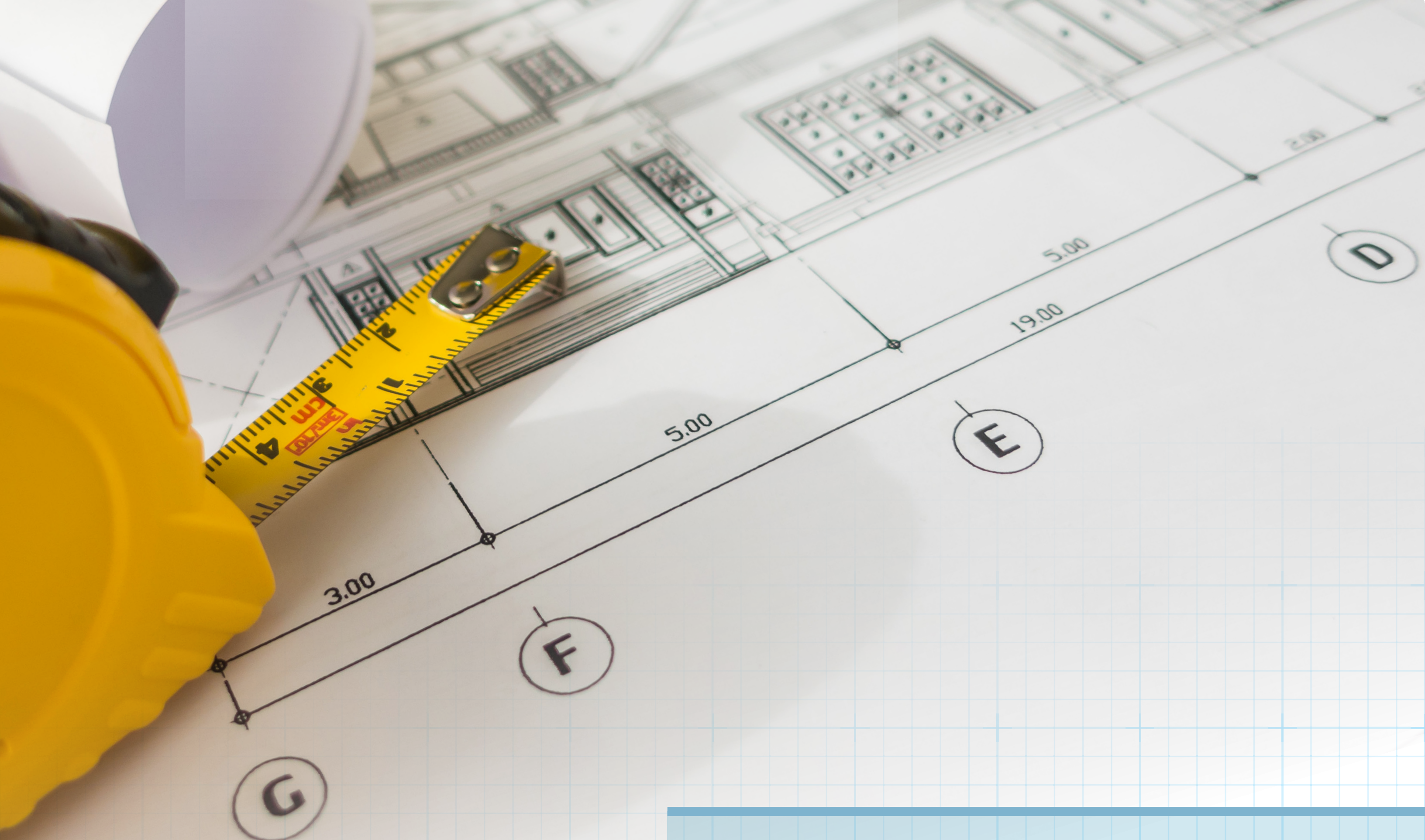


This figure shows why hold-downs for the cross-bracing at the center post are unnecessary.

Hold-downs are not needed for the center posts. The opposite but equal forces from the two straps cancel out, so no lift at the center exists.

One design solution is to run the straps the full length of the shear wall, from end-post to end-post, eliminating the center post. While installation and fabrication issues exist with a longer-strap design, Allen explained that such designs can work.

Every structure is unique and requires understanding of the lateral load requirements for a given area. But, you can likely reduce the hold-downs used on your next project.



As you continue to construct CFS-framed buildings, you'll likely encounter additional technical details that need to be addressed to bring your project to completion.

If you have questions, we can help. Whether you encounter challenges in the design or planning process, the BuildSteel team of experts can address your concerns. We offer complimentary project assistance for new or existing cold-formed steel framed projects. Request assistance now.

Images in eBook courtesy of Steel Framing Industry Association and SuperStud Building Products.

About **BuildSteel**

BuildSteel provides valuable resources, education, and complimentary project assistance related to the use of cold-formed steel framing in low and mid-rise and multi-family construction projects.

As a centralized source for information, BuildSteel offers resources to help move your next cold-formed steel framing project forward efficiently and effectively.

@buildsteel
@buildsteelorg
/company/buildsteel
@buildsteel_cfsteel
buildsteel.org/feed/
info@buildsteel.org

513 W. Broad Street
Suite 210
Falls Church, VA 22046
703.538.1613

BUILDSTEEL.ORG