What About Steel?

Despite some advantages over wood, light-gauge steel framing hasn't made the leap to residential building, and the reasons why may surprise you

BY SCOTT GIBSON

Visit just about any commercial construction site in the country and you're likely to find light-gauge steel framing. And why not? Galvanized studs are uniformly straight, lighter than wood, inedible by bugs, resistant to fire and rot, and conveniently prepunched for wiring.

The system is pretty simple, particularly on non-load-bearing partition walls where studs fit into tracks at the floor and ceiling and are held in place with a couple of screws. As builders continue to complain about the difficulty of finding quality framing material, and an ongoing trade dispute with Canadian lumber producers helps to push up prices, the time seems right for more residential builders to move to steel.

Why is it, then, that in 2016, the United States Census Bureau reported that a mere 3000 single-family houses are framed with steel, compared to the 674,000 houses framed with wood? In some regions of the country, the proportion of steel-framed houses is too low to rate more than a "Z" in Census Bureau records—less than 500 units, a statistical no-show.

Despite efforts by a few production builders to introduce steel framing, and attempts by researchers to make builders more comfortable with steel by providing performance data and construction details, steel framing is barely a blip on the home-building radar. Why aren't more residential builders using steel? It turns out they have their reasons, even if not all of them make sense.

Making the case for steel framing

A document produced by the Steel Framing Alliance (SFA), "A Builder's Guide to Steel Frame Construction," offers a number of reasons why builders should give steel framing a shot. In addition to its consistency and resistance to insects and mold, the guide says steel framing also reduces long-term maintenance costs, promotes indoor air quality because it releases no volatile organic compounds, and performs well in high-wind and seismic areas. Framing contains a minimum of 25% recycled material and is 100% recyclable.

And despite a price premium of 15% over wood when buildings are stick-framed—that is, built one piece at a time rather than assembled from panelized sections constructed off site—fewer warranty callbacks,

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less waste, and other factors lower that amount to only a 3% premium in total construction costs, SFA says. And when floors, walls, and roof sections are produced in a factory and delivered as panelized components, steel framing can cost less than or the same as wood framing in many parts of the country.

Further, one-story and two-story buildings can be designed without the need for an engineer by using the American Iron and Steel Institute's "Prescriptive Method," referenced in building codes.

On paper, steel framing makes so much sense for residential construction that at least two big production builders have taken a close look at framing with steel instead of wood, says Kurt Christy, a building executive in California who has worked for both KB Home and Lennar. Lennar went so far as to set up a steel-framing facility in Northern California with the intent of shipping panelized frames to its job sites, Christy says. But the effort never took off—which brings us to the first of several roadblocks preventing a wider use of steel.

Established trades don't like it

The construction industry, says Christy, is very slow to change, and the bottom line is that many builders who are used to wood framing aren't comfortable with steel.

"Our industry as a whole is not the most progressive. You hear guys say, 'My daddy framed homes this way, my grandpa framed homes this way, this is the way we're going to frame homes'—which means out of wood," Christy says, paraphrasing a common reaction from builders.

While Lennar saw potential benefits, other trades just saw trouble. According to Christy, "It wasn't just the framers, it was everybody. It was an uphill battle. It was banging your head against the wall: the plumbers, the electricians, the drywallers, the guys hanging stairs, the cabinet guys. Everybody."

Christy and partner David McAdam saw this firsthand as they developed a line of small houses for the weekend and rental markets with one of their companies, Homestead Modern. The specs for the prototype called for light-gauge steel framing, but the framer said he could do the same job for about $7000 less if he framed with wood, and the owners decided to take that route.

Christy is convinced the price premium was an intentional upcharge because the framer was unfamiliar with steel framing and didn't want to bother with it.

McAdam still has regrets about not adopting steel as the standard for Homestead Modern's site-built homes. "It just makes an enormous amount of sense to me," he says, "and I think eventually we'll get there."

Still, building to sell houses is about finding economies wherever you can, and moving the trades away from wood and getting them to embrace steel just wasn't paying off in the short term.

Plus, acceptance among home builders isn't the only concern. Steel has a number of other performance quirks to consider, not least of which is its thermal conductivity.

Beware of thermal bridging

Steel is a great thermal conductor, which makes it an excellent choice for a radiator or a frying pan, but also means that houses framed in steel are vulnerable to some serious heat loss. Contributing editor Joseph Lstiburek, Ph.D., P.Eng., and a principal of Building Science Corporation, put it this way in a 2008 Building Science Corp. paper called "A Bridge Too Far."

"Steel studs are designed to provide the maximum possible conductive energy transfer across a wall using the minimum amount of material—a thin web with cleverly designed heat transfer fins (flanges) on both sides to efficiently absorb heat on one side and reject it on the other."

Tests at Oak Ridge National Laboratory (ORNL) show thermal bridging in a wood-framed wall lowers the effectiveness of cavity insulation by 10%. In a wall framed with steel, that amount jumps to a whopping 55%. So pronounced is the bleeding away of heat through steel framing that if you put R-19 insulation in a wall framed with steel, you'll be lucky to get whole-wall performance of R-5 to R-6, Lstiburek says. That's a fraction of the nominal performance building codes require in many parts of the country, and a whole lot less than homeowners assume they're getting.

Another consideration: Standard fiberglass batts are designed for wood-framed walls, and the 14½-in. space between studs on 16-in. centers. In a wall framed with steel studs, the batts won't fit snugly because the studs are thinner. That's important because even very small gaps between insulation and framing lower performance.

Overcoming thermal bridging

Thermal bridging in steel-framed walls is not an insurmountable problem. In addition to a thick layer of exterior insulation (effective but not cheap), researchers at ORNL have looked for other ways of raising performance and presented their ideas in a 2002 paper, "Making Steel Framing as Thermally Efficient as Wood." They include reducing the contact area between studs and sheathing with ridges or dimples in the stud flanges, the use of wood and metal spacers as well as foam tape applied to the face of stud flanges, and the creation of holes and openings in the stud webs.

Other possibilities include replacing steel webs with a less conductive material, like wood, and wrapping steel studs in foam, an assembly ORNL calls the "Stud Snuggler."

Another route is to buy prefabricated assemblies that combine steel studs with expanded polystyrene (EPS) insulation. A Pennsylvania company, Syntheon Inc., produces just such an assembly, called the Accel-E Wall System. The foam-encased studs limit thermal bridging, and each face of the stud comes with a flat flange for installing siding and interior finishes.

It's worth noting that the SFA website also contains information about framing energy-efficient buildings with steel (visit steelframing.org and look for the guide "Thermal Design and Code Compliance for Cold-Formed Steel Walls" under the "Energy" tab).

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Steel can't store moisture

Another concern to building scientists like Lstiburek is the capacity of various building components to store moisture. When houses accumulate moisture faster than they can dry out, the risk of mold goes up (see "The Mold Explosion: Why Now?" in *FHB* #184).

"Mold can't survive and reproduce without water," Lstiburek explains, "so the ability of particular building materials to wick away, absorb, and store water (their buffer capacity) is related directly to whether mold can thrive in your house. Materials with higher buffer capacities produce fewer puddles, making it harder for mold to set up shop.

"We've made building materials into better mold food as we move down the processing stream from tree to paper, we've reduced the drying capacity of houses by adding insulation and vapor barriers, and we've reduced the storage capacity of houses by using newer materials that can't store much water (if any at all)," he wrote.

So, while steel itself doesn't provide mold the food it needs to grow, buildings that include steel framing can have higher mold risks because of a low buffering capacity.

And then there's fire

According to a report on fire and acoustical details of residential steel framing produced by what was then the NAHB Research Center (now called the Home Innovation Research Labs), buildings framed with cold-formed steel are "inherently noncombustible" and do not contribute to the spread of a fire.

That said, steel framing is thin, and it heats up quickly. It maintains its full strength until it reaches 750°F, after which its strength falls rapidly. The exact temperature at which lightweight steel will fail varies, depending on the assembly and not just the steel itself.

In a 2006 *Fire Engineering* magazine article titled "The Dangers of Lightweight Steel Construction," author Karl K. Thompson explains the post-fire inspection of a lightweight-steel-framed home in Florida. Compared with wood—which, Thompson explains, has a somewhat predictable rate of burn—lightweight steel frames seem to fail all at once, and without warning. In wood-frame construction, he explains, "the loads usually shift and form a lean-to type of

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MAKING A DENT IN RESIDENTIAL BUILDING

1 **At home in modular?** If metal framing has any footing in the world of residential building, it seems to be in factory-framed modular housing, where the consistency of the machine-formed framing components eliminate some complications from the assembly line.

2 **Comfort trumps convenience.** In spite of the inherent time-saving features of metal framing—prepunched holes for electrical, for instance—subcontractors who focus on residential construction are slow to accept a change from wood to metal.

3 **Plan to go beyond just batts.** Steel framing is an ideal conductor of heat, which means even the most carefully installed cavity insulation will be short-circuited by thermal bridging across the metal. For metal framing to be energy efficient, builders must rely on continuous exterior insulation.

collapse. When this steel structure failed, it acted more like a beer can being pressed in from both ends in a pancake-type collapse."

According to Thompson, "the steel framing clearly did not fuel the fire," but evidence suggests that the prepunched holes in the framing allowed fire to more easily move through the structure.

Fire resistance can be added by protecting the framing with layers of gypsum or cementitious material, mineral wool, or wood flooring. A ½-in. layer of gypsum drywall, for example, yields a 30-minute fire rating; a 60-minute rating is possible with multiple layers.

Robert Solomon, a professional engineer at the National Fire Protection Association, says both wood- and steel-framed buildings are vulnerable to fire during construction. In a completed building, however, gypsum board or some other fire-resistive treatment protects the steel framing, and the building may be required to have a sprinkler system.

These measures, he says in an email, "mean that steel structural members exposed to these higher temperatures is an unlikely scenario." He also points out that firefighters are likely to be concerned about any number of materials and would generally stay out of a house that was on fire unless someone was believed to be inside.

Thinking about change

As Christy points out, the building industry is very slow to change, even when better methods and better materials are readily available. Yes, builders have been complaining for years about the declining quality of framing lumber, but the truth is that wood is familiar and friendly and carpenters know how to work with it. These builders will need a compelling reason to start using a material they're not familiar with, particularly when it costs more, calls for different tools and work practices, and raises the potential for much lower energy performance. Until then, it's a good bet wood will continue to rule the roost. □

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