Using Steel Sensibly

by Jamie Fisher

Structural steel doesn't play too big a role on the typical remodel job site, and for understandable reasons: You can't work steel with your usual tools, it's heavy, and using it means adding an unfamiliar supplier who may have little interest in how houses are built. Finally, wood (or its engineered by-products) is plenty strong for typical loads at typical spans.

Nevertheless, I've found myself calling for structural steel more often these days in our addition and renovation work. And it isn't always to deal with long spans or heavy loads. More often it's because of steel's compact size relative to wood of the same strength, and because it can be welded into custom shapes that retain the strength (or most of it) of the original material.

A Tricky Attic Remodel

A recent project illustrates why using steel can make sense. The owner of this small Dutch Tudor wanted to add a pair of cross-gable dormers to help expand the attic into living space (see Figure 1). The existing rafters were 2x4s (commonplace around here in pre–World War II houses), and both the new and old rafters would have to retain this depth if the renovated space was to keep its already-marginal headroom.

The ceiling would be vaulted, leaving no place for collar ties to counter the roof's lateral thrust. (Yes, I know this leaves scant room for insulation, but 2 1/2 inches of rigid fits, and that was okay with our local inspector because it doesn't get that cold here.) Nor could the floor system counter the thrust, because a short platform-framed pony wall meant that the rafters didn't go to the floor. And the Dutch hip precluded using a gable-to-gable structural ridge beam.

Obviously, we were going to have trouble keeping the roof structure together. And while the inspector will let a little insulation slide, he takes snow loads very seriously after last winter.

A look at the framing plan made it clear that the roof load would be taken to the outside walls by the four valley rafters. The spans were so tiny (the whole house is only 17 feet wide) that we could have used 2x8 LVLs for these valley rafters. But we wanted to keep their depth within the thickness of the typical rafters. And there was still the matter of countering the horizontal thrust. We needed something strong and of compact size that could transfer the horizontal thrust down through the pony wall to the floor diaphragm.

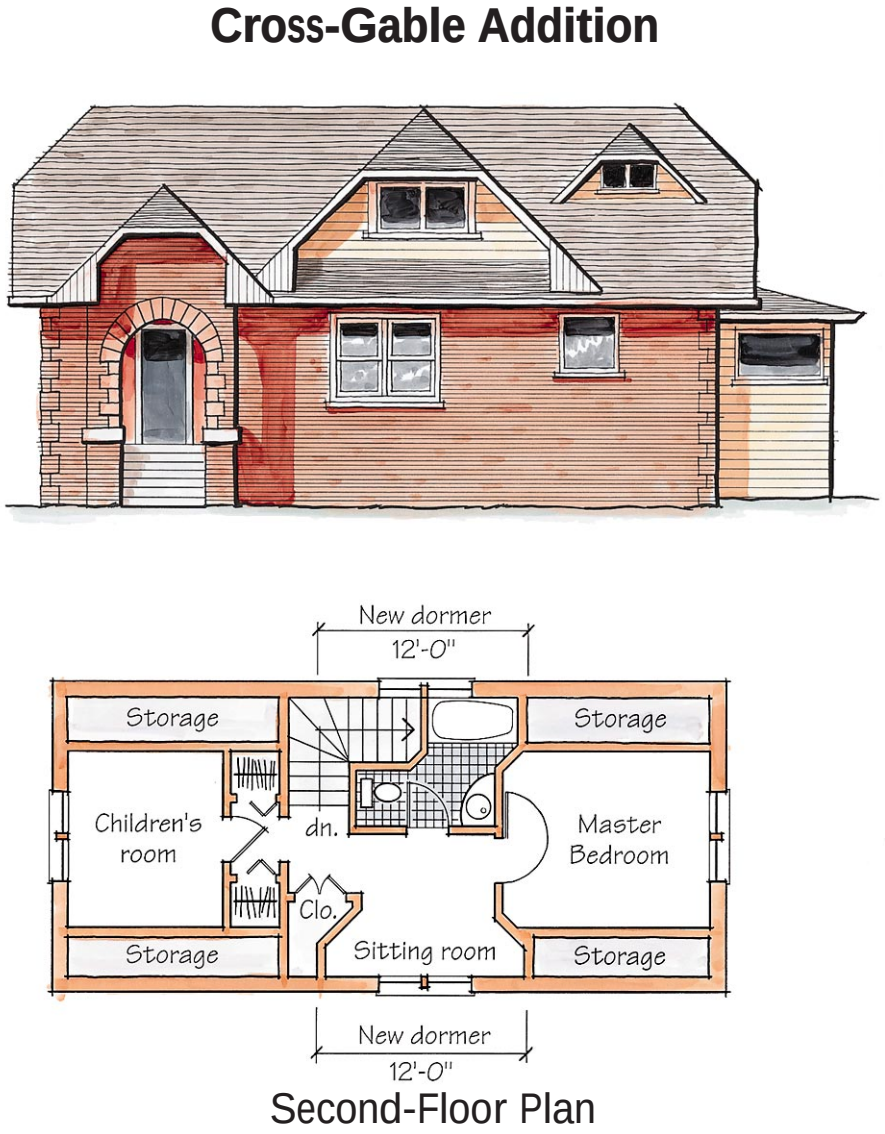

Figure 1. The roof intersection for the back-to-back dormers on this remodel required a structure that was both strong and thin, to maximize interior ceiling height. Steel was a logical choice.

Valleys of Steel

We turned to steel. We designed the valley rafter out of a 4-inch I-beam with a pair of 2x4s bolted into the web. This created a familiar-looking rectangular "wood" beam to which conventional nailed joist hangers could be attached. At the exterior wall, the I-beam was welded to and rested atop a short, 2-inch-diameter vertical steel tube. We intentionally used a tube that was narrower than the wall space inside which it would stand so that any small error in our calculation of the rafter's pitch could be taken up by a slight tilting of the tube. This tube in turn sat on and was welded to a flat nailing plate. This rigid angled connection (called a *moment connection* by engineers) restrained the horizontal thrust and carried it down into the floor diaphragm. At the other end of the valley rafter, the I-beam stopped just short of the ridge, allowing the two 2x4s of each rafter to extend up to a rather elaborate (and if I may say so, elegant) four-way bolted connector fabricated from angle stock and flat plate (Figure 2). Using this wood connection between the two shop-fabricated steel parts allowed the actual length of each of the four valleys to be precisely fitted in the field.

The owner of the house is a Boeing engineer, so I had no trouble getting him to buy into the idea of high-tech materials. (At one point, he actually floated the idea of using titanium instead of steel.) The builder, on the other hand, was pretty skeptical, and I could understand why: He was the one who was going to have to take this fancy stuff and make it work.

Fortunately for all concerned, this steel valley-rafter arrangement worked like a charm. We made sure to supply the steel fabricator with detailed drawings, and all the parts fit together like a Tinkertoy. Everything went up strong, square, and surprisingly fast, and once the steel framework was in place, the rest of the carpentry was pretty routine. In the end, the once-skeptical builder was the most enthusiastic member of the team, and he couldn't wait to use steel on his next complicated roof.

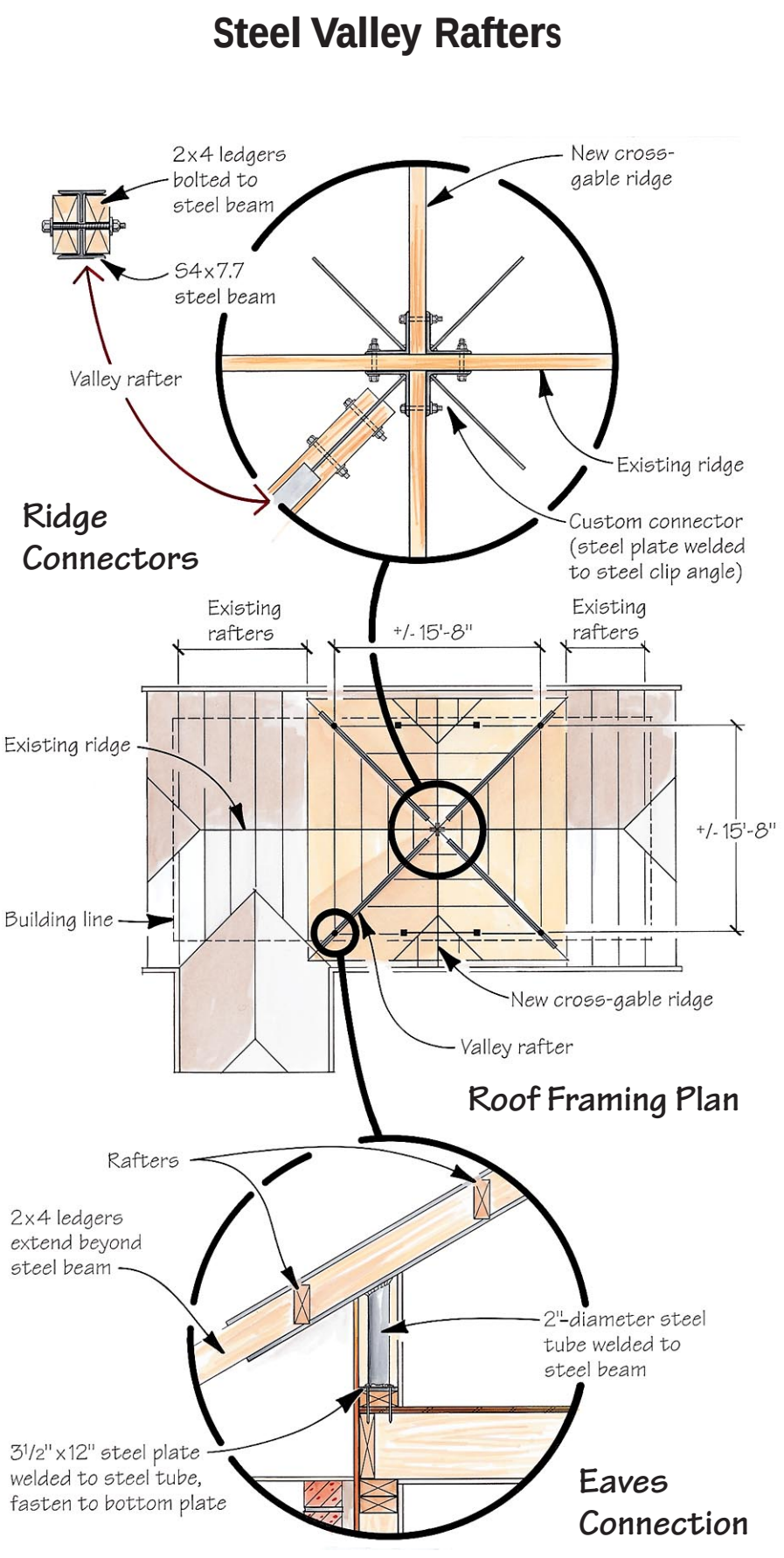

Figure 2. The framing plan called for replacing the valley rafters with 4-inch steel I-beams. Custom connectors at top and bottom were key to making the framing work.

Tips for Working with Steel

Steel isn't always the best solution, but when a design requires structural materials smaller than wood or with more rigid connections, steel can serve nicely. Using steel will go more smoothly if you take care with a few key points:

Use detailed drawings. With wood-frame construction, sketchy drawings give the carpenters enough information to do the job. But when you're speccing something unusual, your direction needs to be comprehensive and unambiguous. Use large-scale details, extensive notes, views from several angles — in short, make your directions so clear they're impossible to misunderstand. Doing so will not only make things easy to comprehend, it will also force thoroughness and accuracy on your part.

Help with the procurement. The drawings should be clear and comprehensive enough that you can hand them right to the steel fabricator. I like to fax the drawing myself right to the welding shop and put my phone number on the sketch.

Build tolerance into the design. You can trim wood to fit, but not steel. Detail the design so that if things are off by a half-inch or out of plumb or square, the whole thing doesn't have to go back to the shop and be resized.

Have the steel fabricated in the shop. Drilling a couple of small holes in the field is okay, but for the most part you should avoid field drilling and cutting, and most of all avoid field welding. Use predrilled holes and allow for all bolted connections.

Take the risk out of it. If you can, convince the owner to go time-and-materials on the steel work; that will protect you from the uncertainties of working with steel, but will probably cost less than any fixed price you would set to do the work.

Jamie Fisher *is an architect in Seattle, Wash.*