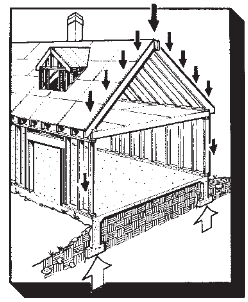

Solve It With Steel

by Harris Hyman, P.E.

From time to time, we design ourselves into a corner. The particular corner of interest this month is the situation where we just don't have room for sufficient wood to hold things up — where a second-floor girder meets a wall directly above a sliding glass door. This girder supports second-story floor joists as well as a bearing wall carrying the roof structure. All of this requires tons of support for the end of the girder. Because the girder rests above the slider, a beam is needed to carry the girder's load to solid wall framing at either side of the door. But there just isn't room for a wood header large enough to carry the point load from the girder.

So we use a piece of steel instead. A properly sized steel beam has sufficient strength to carry the load a few feet over from the head of the glass door to where the wall can provide sufficient vertical support. It may be heavy stuff, but a little steel can hold up a whole lot of building. When we don't have enough room to do it with wood, steel is an attractive option.

Wood vs. Steel

Let's compare wood and steel. One foot of 2x12 weighs about 4 pounds and costs approximately 70¢. A steel beam of the same depth (11 1/4 in.) and strength would be only about 1/10 of an inch thick — 1/15th of the volume of the 2x12. This steel beam would also weigh roughly 4 pounds per foot and would cost about $1.80. (It was a big surprise to me to find out that wood is just as strong as steel, pound for pound.) However, the steel beam is about 35% stiffer than the wood one; which means that the sag in a steel beam is only about 3/4 of the sag in an equivalent timber.

Besides the numbers, there are several other clear differences between wood and steel. Unless you have the spare time of a convict, you can't cut steel with hand tools, or even with light power tools. You can't pound nails into steel. However, welded joints in steel are quite stiff, whereas wood joints flex. Steel also doesn't warp and change dimensions with humidity, although it does expand with heat. And of course, steel doesn't rot, but then wood doesn't rust.

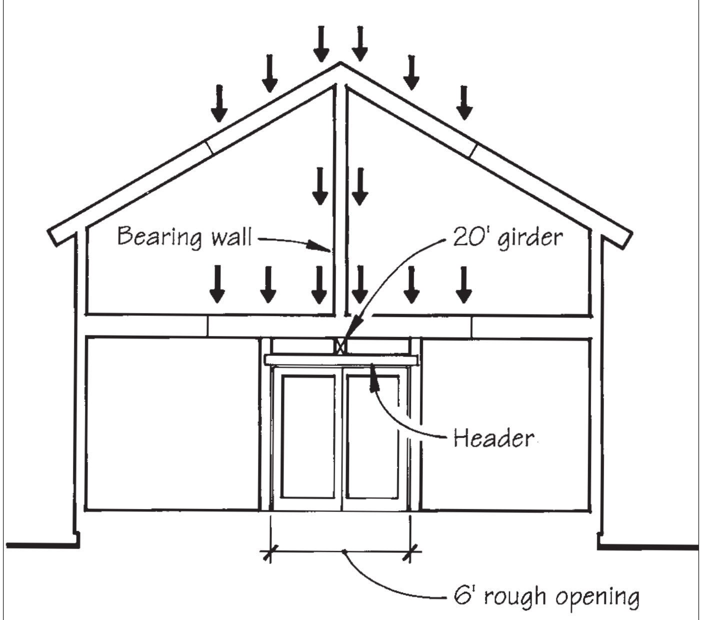

Figure 1. *In this example, a 20-foot first-floor support girder also carries a load from the roof. The resulting point load onto the window header is 12,750 pounds.*

All of this suggests the obvious: Build houses of wood and use a little steel in the tricky spots.

When Wood Won't Work

Let's look more closely at the example in Figure 1. The girder is 20 feet long. It's supported by an interior bearing wall at one end, and by the door header at the other end.

The girder supports loads from the roof and from the second floor. In my area of western Oregon, the roof design load is 35 psf — 25 pounds for snow and 10 pounds of dead load for the roof structure and covering. Since the house is 30 feet wide, the total load from the roof onto the girder is:

$$P_1 = 20 \text{ ft.} \times 15 \text{ ft.} \times 35 \text{ psf} = 10{,}500 \text{ lb.}$$

The load from the floor onto the girder is calculated in generally the same way. The floor load is 40 psf for the live load and 10 psf for the floor itself, for a total load of 50 psf. The girder carries half of the load on each side (the other half is carried by exterior walls), so the load from the floor onto the girder is:

$$P_2 = 20 \text{ ft.} \times 15 \text{ ft.} \times 50 \text{ psf} = 15{,}000 \text{ lb.}$$

So the total load on the girder is

$$P_1 + P_2 = 25{,}500 \text{ lb.}$$

Since each end of the girder carries half this load, the force on the header is 12,750 lb.

In addition to the girder point load, the header also carries some weight from the exterior wall located directly above it all the way to the roof. For an all-wood structure, this dead load — the combined weight of the wall materials — can often be safely ignored because the plywood-sheathed wall acts like a huge box beam and safely carries these vertical loads to the foundation. There are cases — with stucco or brick cladding, for example, or extra-long headers — where the weight of wall materials should be considered.

We need a header that can span 6 feet. If the header were select structural Doug fir-larch, five 2x12s would be required to support it. With a weaker lumber like No. 1 hem-fir, you would

Steel-to-Wood Connections

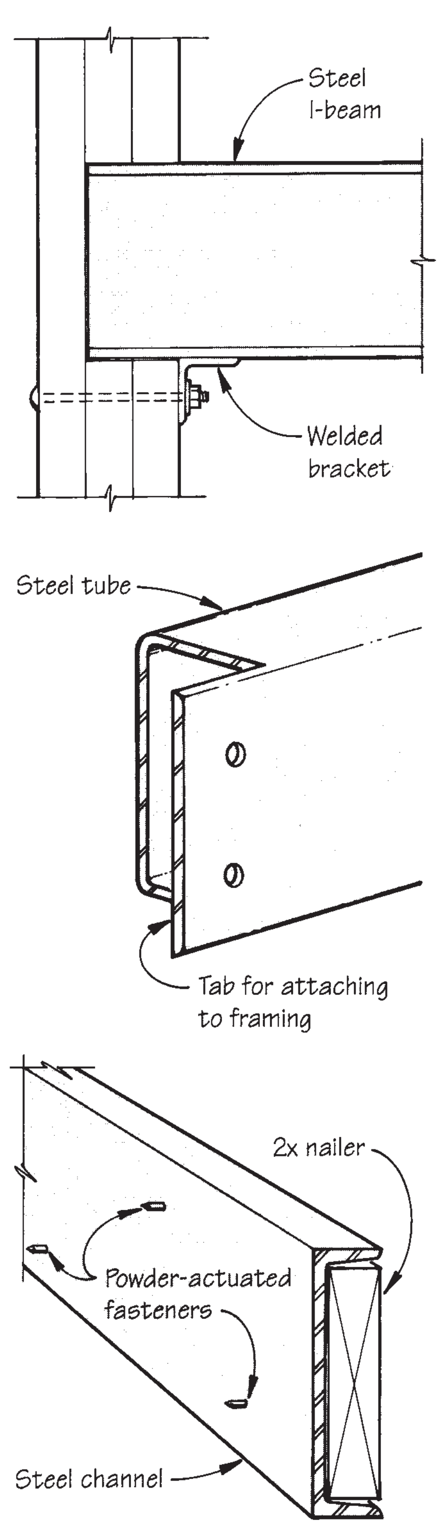

Figure 2. *A common way to attach a steel header to wood framing is to have the steel yard weld on an attachment angle bracket (top). The steel cutter can also leave an attachment tab on the ends of a piece of steel, as with the tube shown here (middle). On site, the quickest method is to fasten a 2x nailer to the steel using powder-actuated nails (bottom).*

need seven 2x12s. (Sure!) But in our example, there's no room for 2x12s. Because of the door height and the depth of the girder, there's only 8 inches of room left for the header — making steel an obvious solution.

Steel to the Rescue

For headers, there are three steel shapes that work well in 2x4 framing: tubes, channels, and 4-inch wide-flange I-beams (Figure 2). My favorite is the tube, because it can have a two-by nailed to either the wide face or the top, depending on the situation. The channel can be used this way as well and is sometimes a little lighter. Most steel yards have a variety of angles and wide-flange beams available, though these are more difficult to fit into the wood framing. Flitch plates are another common way to strengthen built-up wood headers — I'll look at those in a future column.

In our design example, a W8x15 does the job. The table below gives a range of steel options for a variety of spans and loads. The table is not meant to be used as a substitute for proper structural design — steel always requires careful engineering. The point is to show that many options exist. Much depends on what your local steel yard stocks — by substituting, you can generally find a shape and size that will work.

Installing Steel Headers

Headers should be supported by at least double 2x4 jack studs for up to a 12,000-lb. load, and triple jacks for loads above 12,000 lb. up to 18,000 lb. The header should sit directly on the end grain of the jack studs. Don't use wood shims under the header — the load is perpendicular to the grain and tends to crush the wood.

There are several ways to attach steel to wood, depending on the circumstances. I mention nailing 2x4s to tubes and channels — this is done with powder-actuated nails. The nailed-on pieces provide a tie-in point for the surrounding wood framing.

The steel can also be predrilled at the yard for tabs or L-brackets, or tabs can be welded on. For slim-profile tube headers where you don't have room to nail on lumber, ask the steel cutter to leave a tab sticking out at each end. Then notch the framing to fit and nail or lag the steel to the framing. ■

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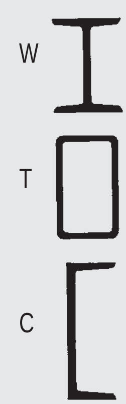
Structural Steel Headers

Point load, lb.	Span			
	3'	4'	5'	6'
5,000	T3x3x5/16 (1.88)	T4x4x3/16 (2.50)	T4x3x1/4 (3.13)	C6x8.2 (3.75)
10,000	C6x8.2 (3.75)	C6x10.5 (5.00)	W6x12 (6.25)	T6x3x3/8 (7.50)
15,000	C6x13 (5.63)	T6x3x3/8 (7.50)	T7x3x3/8 (9.38)	W8x15 (11.25)
20,000	T6x3x3/8 (7.50)	W6x16 (10.00)	W10x15 (13.00)	W10x17 (15.00)



This table gives examples of standard steel (A36) shapes and sizes that will work as headers to carry heavy point loads where height is limited. Each of these pieces of steel can be worked into a 2x4 wall, although the W beams are a full 4 inches wide and require a little work to fit. The number in parentheses is the section modulus required for the given load and span; the steel section above it is the shallowest and lightest piece of steel that will work. Substitutions may have to be made because most steel yards do not carry every size and shape.