

FLOOR FRAMING WITH STEEL

Steel framing has so many advantages over wood — including dimensional stability, consistent pricing, and resistance to rot and

by Jon Henderlong

termites — that I'm convinced it will claim more and more of wood's market share in the years ahead. But for builders who have never used anything but wood, the prospect of diving into steel framing all at once can present a big mental barrier (see "Making the Switch to Steel," 6/00).

One alternative is to start at the bottom, and begin the transition to steel with the floor framing system. As the former project manager of a family-owned company that has been framing entirely with steel for years, I found that the material's benefits were especially attractive for floor framing.

Advantages of Steel Floor Framing

As you can see from the table at right, at 24 inches on-center, a 10-inch-deep 54-mil steel C-joist can span 15 feet 11 inches at 40 psf live load (see Figure 1). To get the same span from wood joists of the same depth, you'd have to go to a 12-inch spacing. If you go to a 12-inch spacing with the same steel joist, you can span up to 20 feet. That's a nice option if you want to build a bonus room over a garage without having to add a beam. You can span even farther with heavier-gauge joists, but I've found that if you go beyond 16 gauge, it gets difficult to drive screws into the material.

Although steel is usually referred to by gauge on the job site, current tables reference it by mils of thickness. Sixteen-gauge steel is 54 mils thick, 18 gauge is 43 mils, and 20 gauge is 33 mils. For easy

Allowable Spans for Cold-Formed Steel Floor Joists^{1,2,3,4}

Single Span
33 ksi Steel

Nominal Size	30 psf Live Load Spacing (inches)			40 psf Live Load Spacing (inches)		
	12	16	24	12	16	24
2x6x33	11'-7"	10'-7"	9'-1"	10'-7"	9'-7"	8'-1"
2x6x43	12'-8"	11'-6"	10'-0"	11'-6"	10'-5"	9'-1"
2x6x54	13'-7"	12'-4"	10'-9"	12'-4"	11'-2"	9'-9"
2x6x68	14'-6"	13'-2"	11'-6"	13'-2"	12'-0"	10'-6"
2x6x97	16'-1"	14'-7"	12'-9"	14'-7"	13'-3"	11'-7"
2x8x33	15'-8"	13'-3"	8'-10"	14'-0"	10'-7"	7'-1"
2x8x43	17'-1"	15'-6"	13'-7"	15'-6"	14'-1"	12'-3"
2x8x54	18'-4"	16'-8"	14'-7"	16'-8"	15'-2"	13'-3"
2x8x68	19'-8"	17'-11"	15'-7"	17'-11"	16'-3"	14'-2"
2x8x97	21'-10"	19'-10"	17'-4"	19'-10"	18'-0"	15'-9"
2x10x43	20'-6"	18'-8"	15'-3"	18'-8"	16'-8"	13'-1"
2x10x54	22'-1"	20'-1"	17'-6"	20'-1"	18'-3"	15'-11"
2x10x68	23'-8"	21'-6"	18'-10"	21'-6"	19'-7"	17'-1"
2x10x97	26'-4"	23'-11"	20'-11"	23'-11"	21'-9"	19'-0"
2x12x43	23'-5"	20'-3"	14'-1"	20'-11"	16'-10"	11'-3"
2x12x54	25'-9"	23'-4"	19'-7"	23'-4"	21'-3"	17'-6"
2x12x68	27'-8"	25'-1"	21'-11"	25'-1"	22'-10"	19'-11"
2x12x97	30'-9"	27'-11"	24'-5"	27'-11"	25'-4"	22'-2"

For SI: 1 inch = 25.4 mm, 1 psf = 0.0479 kN/m², 1 foot = 0.3 m

1. Table provides the maximum clear span in feet and inches.
2. Bearing stiffeners shall be installed at all support points and concentrated loads.
3. Deflection criteria: L/480 for live loads; L/240 for total loads.
4. Floor dead load = 10 psf (0.479 kN/m²)

Courtesy of the NAHB Research Center

Figure 1. Steel joists permit unsupported spans of well over 20 feet. By varying the gauge of the material, it's possible to increase the allowable span without increasing the depth of the joist.



Figure 2. A conventional wormdrive saw with an abrasive blade (left) is the preferred tool for most cuts made on site. The 14-inch chop saw (right) can cut several stacked pieces of material at once, speeding repetitive cuts.

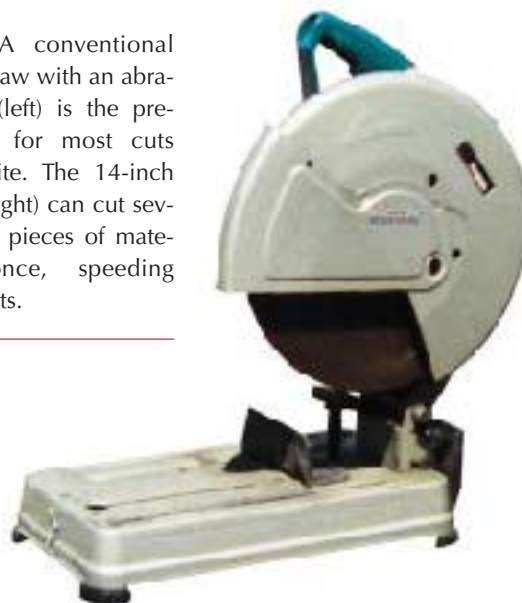


Figure 3. Lapping joists at a central beam eliminates the need to cut joists precisely to length, making it possible to order material before the exact dimensions of the foundation are known. Web stiffeners are not required at the laps.



reference, steel framing is also color coded, with 16 gauge being green, 18 yellow, and 20 white.

Unlike wood I-joists, steel joists also allow you to vary the gauge of the material to suit the span, without increasing the depth of the joist. That's useful when you have two spans of different lengths that lap over a beam. With I-joists you'd have to frame the shorter span with an unnecessarily deep joist, or go to a shallower joist and face the problem of getting the floor surfaces to line up at the beam. With steel, you can use a 16-gauge joist on the longer span and go to 18 gauge for the shorter one — maintaining a constant depth without throwing away material.

Working With Steel

The steel framer's tool kit is pretty simple. For cutting joists and tracks, we use a standard 7¹/₄-inch wormdrive saw equipped with cheap abrasive blades that we buy from a local supplier for about \$3 apiece, or a 14-inch chop saw with the same type of blade (Figure 2). We tried a new carbide-toothed blade from Tenryu that lasted longer and provided a nicer cut, but the results didn't seem to justify the \$40-per-blade price tag. Also, we found that any vibration in the blade had a tendency to cause the teeth to chip.

All steel-to-steel connections are screwed together with self-tapping screws. Our crews like the Quik-Drive

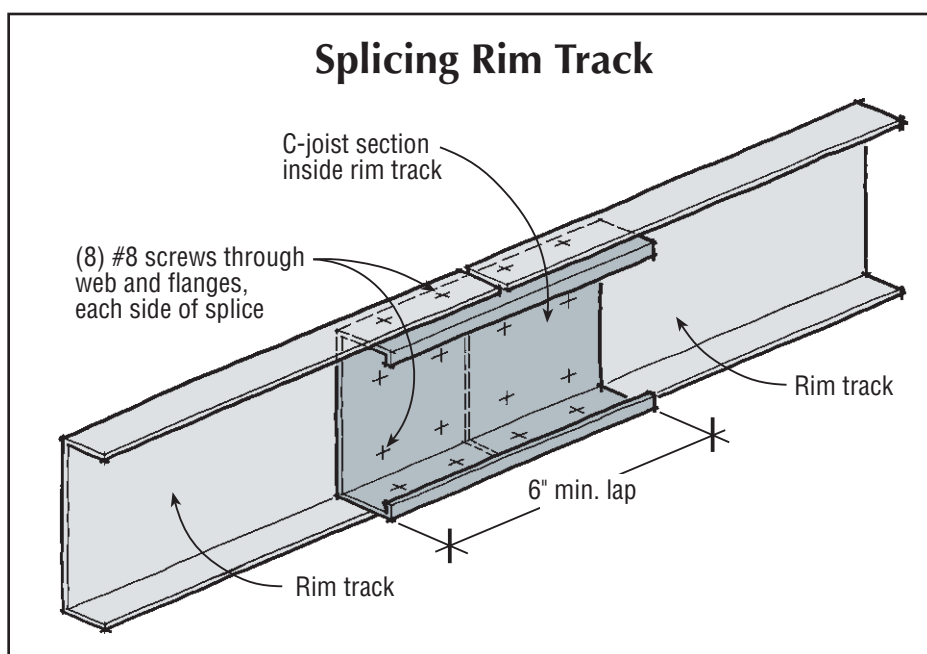


Figure 4. Lengths of rim track are easily spliced with a short section of C-joist fastened with screws.

QD2000MT housing for strip screws, mounted on a DeWalt screwgun. Whatever gun you prefer, stick with a 2,500 rpm model; screws driven at 4,000 rpm tend to burn at the tip and are therefore more difficult to set.

In addition to the power tools, each framer also needs self-locking clamps (usually one large and one small will do the trick) to temporarily hold joists and tracks in place until they can be screwed together. A pair of aviation snips can also come in handy at times.

Planning and Layout

When you're framing with steel, you need to spend extra time previewing plans and doing takeoffs, because you can't just make a run to the local lumberyard for material you forget. While many contractors and subs view this as an extra burden, our company found it to be a blessing in disguise.

By spending a few extra hours in the office detailing and laying out the plans, we save twice that much time in the field. Our crews aren't left standing around waiting for missing material to be delivered, and the detailed plans show them exactly where each piece of steel is to be used. Finally, most of the material is ordered precut, which eliminates the need for cutting and saves time and material.

Dealing with foundation irregularities. It can be risky to order precut full-length joists, because you don't really know the exact dimensions of the foundation until the forms are stripped. Unless the foundation is dead on, the joists won't fit. Ordering them a little long and cutting them down is a waste of time and material, but if you wait for the actual foundation measurement to place your order, you may not get the material by the time you need it.

To avoid these kinds of problems, we plan the floor layout with a central I-beam where we can lap the joists (Figure 3). That lets us adjust the joist length as needed without any cutting. The joists are still ordered to length, with an additional 6 inches to allow for the lap. This also saves time, because screwing the joists together

Trade Ready Floor System

We use conventional C-joists and track sections in our floors, but another option is the Trade Ready floor system from Dietrich Industries (500 Grant St., Suite 2226, Pittsburgh, PA; 412/281-2805; www.dietrichindustries.com).

The biggest selling point for this system is its ease of assembly. In place of a conventional rim track, the Trade Ready system uses a track that contains prepunched joist tabs at 12, 16, and 24 inches on-center. No web stiffeners are required at the rim track. When doubled with a length of joist, the rim track material can also be used as a header at floor openings, greatly reducing the need for clip angles.

Another advantage of the Dietrich system is that the joists contain flanged 6¹/₄x9-inch mechanical punch outs, which are large enough to accommodate some hvac ducts. Dietrich also manufactures structural blocking, precut to the appropriate on-center spacing, which is easily screwed to the bottom flanges of the joists.

Inevitably, the system also has a few drawbacks. It costs somewhat more than framing with conventional steel joists. While the larger mechanical



The Dietrich Trade Ready floor system eliminates the need for web stiffeners at joist ends, and incorporates large openings for plumbing and hvac lines.

punch outs are useful, they don't eliminate the problem of larger-diameter hvac trunk lines and returns, which still must be suspended from the joists. The rim track also demands extra care where it must be spliced or where there is an offset in the floor joist. Unless the track is cut to length perfectly, the floor layout will be wrong. Finally, the Trade Ready joists are available only in even 2-foot lengths, much like dimension lumber. This not only eliminates the cost savings of ordering joists to length, but could create work by making it necessary to cut joists to length on site.

—J.H.

Figure 5. Because steel joists can fail by buckling under point loads, joist ends are reinforced with web stiffeners beneath bearing walls. Foam floor gasketing beneath the OSB decking helps deaden floor noise.



back-to-back at the lap eliminates the need for web stiffeners over the beam.

Span Tables and Approved Details

Until just a few years ago, all steel framing had to be approved by an engineer. But now, steel framers can draw on span tables and approved details from the *Prescriptive Method for Residential Cold-Formed Steel Framing*, developed by HUD, the American Iron and Steel Institute, and the NAHB Research Center (available from the NAHB Research Center, 400 Prince George's Blvd., Upper Marlboro, MD 20774-8731). The prescriptive method is recognized by the 2000 International Building Code and 2000 Residential Building Code, and we've had no problems with the building inspectors here in Indiana. But as we all know, each municipality and local building official is different, so I would suggest opening a line of communication early on. The North American Steel Framing Alliance (NASFA, 1726 M St. NW, Suite 601, Washington DC 20036-4523; 202/785-2022; www.steel framing-alliance.com) is an excellent source for both information and assistance in educating your local officials.

Engineered details. In several areas, we've developed fastening and framing details that depart from the prescriptive method. (Eliminating web stiffeners at lapped joists, as described above, is one example.) To avoid having to get an engineer's okay for each of these details on every house we build, we've pulled them together into a framing detail book that we had stamped by an engineer. Now, whenever we use one of these methods, we can present the book to the building inspector for approval.

Rim Track and Floor Openings

The first step in framing a steel floor is to bolt a pressure-treated sill plate 1¹/₄ inches in from the concrete, all around the perimeter of the foundation. The rim track — the equivalent of the rim joist in wood framing — is screwed to the plate with 1/2 inch #8 panhead screws. These are also available as Quik-Drive strip screws. The ends of the joists are inserted

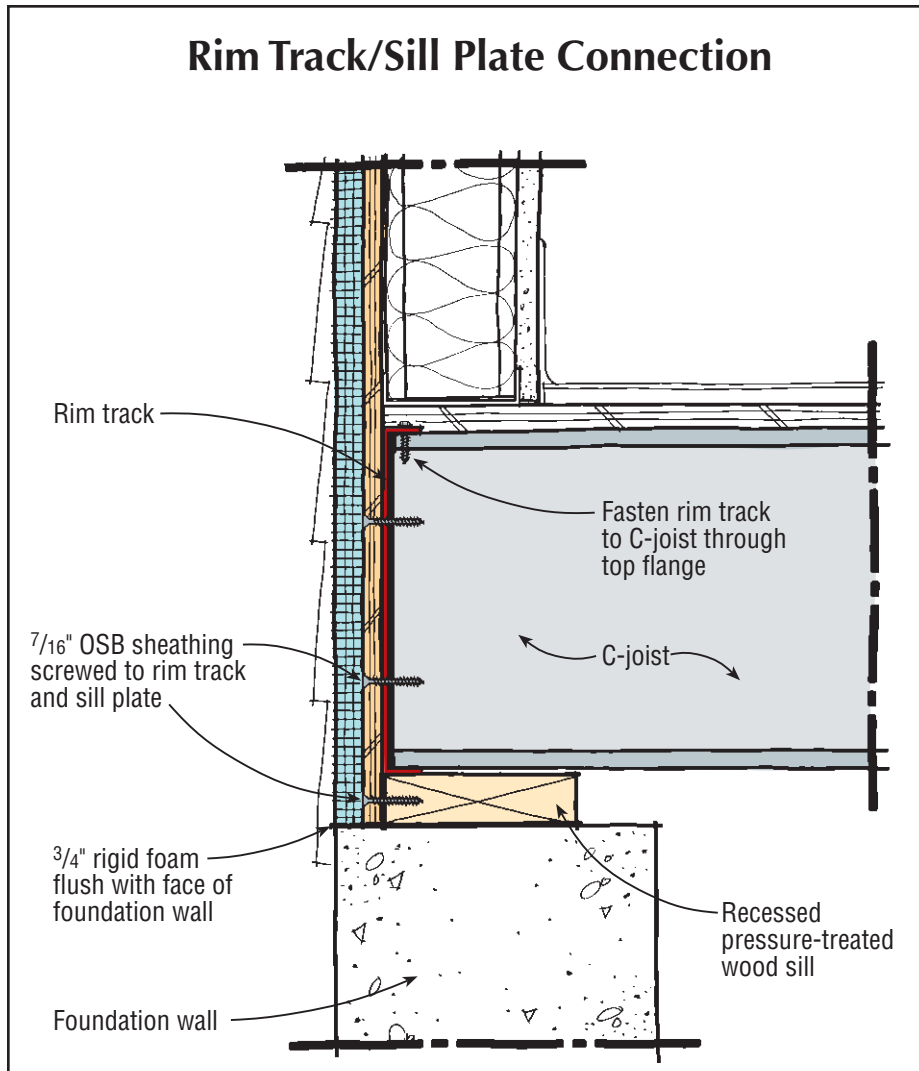


Figure 6. A treated-wood sill plate is recessed from the foundation wall to accommodate OSB sheathing and a layer of rigid foam. The OSB is screwed to both plate and rim track, providing a strong, continuous connection between the foundation and floor structure.

in the track and secured with screws driven through the top flange of the track and into the joists. Layout markings are generally made with a permanent marker. Where necessary, sections of rim track can be spliced with a short section of C-joist (Figure 4, page 2).

Web stiffeners and connections. To prevent the ends of the floor joists from buckling under the concentrated load of the exterior walls, the end of each joist is reinforced with a web stiffener — essentially a short length of C-stud material that is screwed to both the joist and rim track (Figure 5). Web stiffeners are also used beneath interior bearing walls.

Once the wall framing is up, we tie everything solidly to the foundation by running the $7/16$ -inch OSB sheathing all the way to the concrete and fastening it to the studs, rim track, and plate. This is another of our engineered details, which we prefer to the spaced 3x4-inch steel plates that the prescriptive method specifies for the connection between rim track and plate. A layer of $3/4$ -inch polyiso board goes on over the OSB, bringing the wall flush with the concrete and providing a thermal barrier for the rim track (Figure 6).

Framing a second floor. If the second-floor steel joists are supported by a wood-framed wall, the procedure is almost the same: The rim track is screwed to the top plate and the joists are screwed to the track. On a steel-framed wall, the rim track is screwed to the top track (the steel equivalent of the top plate) of the supporting wall, and the bottom flanges of the joists are also screwed to the top track (Figure 7). Web stiffeners are usually required at the joist ends, as for the first floor. Cantilevered joists also require a web stiffener where they pass over the supporting wall (Figure 8).

Regardless of whether the walls are framed with wood or steel, the upper edge of the OSB will fall about one foot below the rim track, provided that the first course of OSB starts at foundation level, as described earlier. The next sheet of OSB ties the second-floor rim joist solidly to the studs and plate beneath.



Figure 7. Second-floor joists are fastened to the top track of a steel-framed wall with screws driven through the joist flanges. OSB sheathing will be screwed to both studs and rim track for a secure connection between floor and wall framing.



Figure 8. A framer clamps the cantilevered floor joist to the top track before screwing it in place. Additional web stiffeners will be added where the joists bear on the plate. Floor cantilevers of up to 2 feet are permitted by the prescriptive method.

Framing Floor Openings

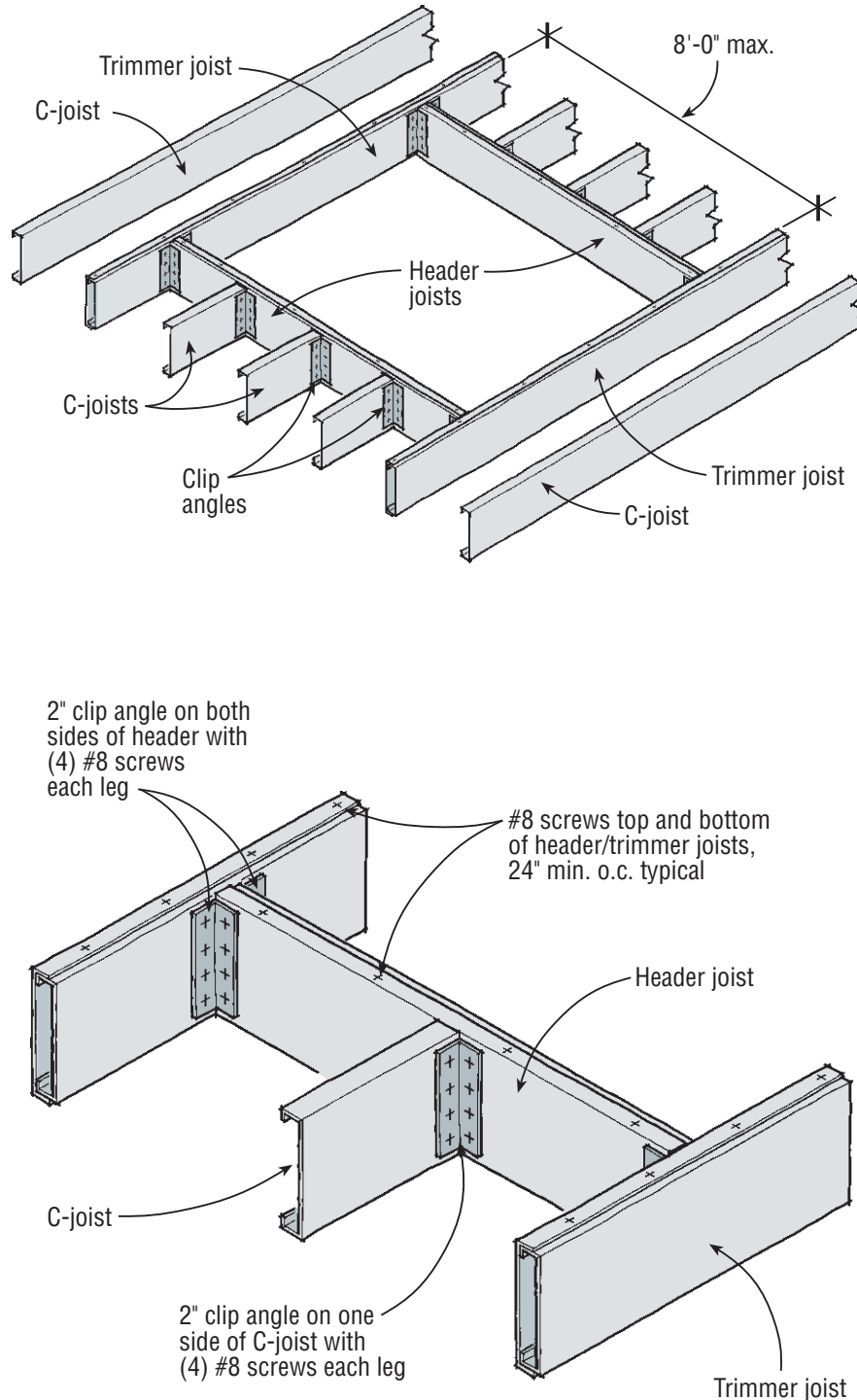


Figure 9. Floor openings are simple if you think of nested track and joist sections as double trimmers or headers, and clip angles as joist hangers.

Clip angles and nested assemblies.

Framing openings in a steel floor is similar to framing openings with wood. In place of the traditional double trimmer at each side of the opening, a nested assembly consisting of a C-joist and a track section is used (Figure 9). Steel headers are assembled the same way. Connections are made with screws and clip angles, which are the steel framer's equivalent of joist hangers.

Bridging, Blocking, and Decking

The decking applied to the top flanges of the joists acts as bracing to prevent the joists from rolling; spans of over 12 feet must also be braced at the bottom flange. A drywall ceiling makes acceptable lower-flange bracing, but in a basement, the usual approach is to run a strip of 1½-inch steel strapping at the center of the joist span for the entire length of the floor section, securing it at each joist with one screw (Figure 10). This is the equivalent of metal or wood bridging in a wood joist. In addition, blocking is required between joists at intervals of no more than 12 feet. The blocking can be up to 2 inches narrower than the joists themselves, and is fastened with clip angles.

Dampening floor noise. A steel floor is naturally stiffer than one framed with wood or I-joists, which translates to a slightly harsher feel underfoot. Carpeting takes care of most of this, but to provide some additional cushioning, we also use a 1½-inch-wide foam material that is manufactured for use with I-joists (Integrity Floor Gasket, Weyerhaeuser Advanced Building Components). It's a self-adhesive material that's pressed onto the top flange of each joist before it's set in place.

For decking, we use ¾-inch Advantech. We tack the decking in place with a few 1¼-inch knurled pin fasteners from a model 500 ET & F pneumatic gun — the same gun and fasteners we use for wall sheathing — then screw them down with 1¼-inch self-drilling collated strip screws. The air fasteners keep the decking from rising as the first few screws go in.



Figure 10. Joists are braced with 1 1/2 inch steel strapping at mid span, and spaced blocking fastened to the joists with clip angles.

Plumbing, wiring, and HVAC. Steel joists have punch outs for water lines, gas pipe, and wiring, so these are not a problem to install. However, ductwork and PVC drain lines do require some thought. More often than not, the home can be designed to allow the ductwork and drain piping to run parallel to the joists. Where this isn't possible, they're suspended below the joists and enclosed in a soffit or dropped ceiling.

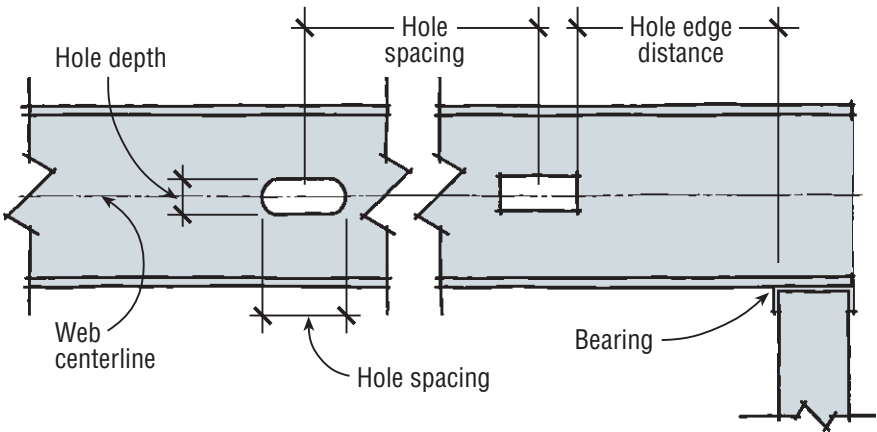
In practice, this is rarely a problem, because you're usually down in the basement, where the main trunk line from the furnace has to drop below the joists no matter what. We try to run the trunk line right next to the beam at mid-span, and run the main waste line right next to it. It's easy to enclose both in the same soffit if the basement is finished later.

If absolutely necessary, the prescriptive method makes allowances for joist penetrations (Figure 11), but I have never had a case where a plumber or HVAC contractor had to cut through a joist.



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C-joist Web Holes



Maximum Hole Dimensions and Spacing in Floor & Ceiling Joist Webs

Nominal Member Size	2x6x33						
	2x6x43		2x8x43				
	2x6x54		2x8x54		2x10x54		
	2x6x68		2x8x68		2x10x68	2x12x43	2x12x68
	2x6x97	2x8x33	2x8x97	2x10x43	2x10x97	2x12x54	2x12x97
Maximum Hole Depth ¹ (inches)	2	1.5	3	1.5	4	1.5	4.75
Maximum Hole Length ^{2,3,4} (inches)	5.3	4	8	4	10	4	12
Maximum Hole Spacing ⁵ (inches)	16.5	24	24	24	24	24	24
Minimum Edge Distance ⁶ (inches)	3	10	3.5	10	3.5	10	3.5

For SI: 1 inch = 25.4 mm

1. The dimension of the hole measured across the depth of the joist web.
2. The dimension of the hole measured along the length of the joist.
3. Holes shall not be located at mid-span $\pm$ 2 feet (610 mm).
4. Circular holes shall have a maximum diameter of 6 inches (127 mm).
5. Spacing is the center-to-center distance between holes.
6. Edge distance is measured from the edge of the hole to the edge of bearing support.

Courtesy of the NAHB Research Center

Figure 11. The prescriptive method permits limited holes in steel joists, but with careful planning, holes can be reduced or eliminated.