Installing Seismic Framing Connectors

by Jim Hart

A smooth installation demands precise planning and a thorough knowledge of seismic hardware

In the early '80s, new codes in California began calling for a variety of metal brackets and straps to help resist earthquake damage to wood-framed houses. These metal connectors work together with plywood shear walls to hold the framework of a house together at the weakest points of the structure (see "Shear Wall Basics," 1/93).

Though very much needed, metal connectors can be a nightmare for framers. Depending on the type of connector used, special nails, machine bolts, washers, and threaded rods may be needed. When nailing together and lifting walls, the last thing a framer wants to do is break the rhythm of the job to drill bolt holes and ratchet down a lot of nuts. Instead, many carpenters choose to ignore these connectors until the day before the framing inspection. I discourage this approach. Connectors that are poorly planned out require hours or even days to install properly.

I lead remodeling jobs for a general contractor in the San Francisco Bay area. On a typical 1,500-square-foot, two-story addition, we may be required to install as many as 24 foundation connectors, not to mention straps over the second-floor rim joist, ridge connectors at every rafter and scores of framing clips (see Figure 1). Even though the total material cost for each foundation connector is less than $20, the head scratching and labor it takes to get them properly installed can add up to more than $100 each.

Carpenter Craig Lauchner of Mountain View, Calif., cinches down a nut on a foundation hold-down at a bay window opening. A cripple stud has been temporarily pushed aside to make room for drilling the bolt holes in the framing.

Over the past several years, I've familiarized myself with the different manufactured connectors available. I've also learned a few tricks, the hard way, that have helped me install these connectors without interrupting the flow of the framing. While there is a wide variety of metal clips and hangers, in this article I will focus on the connectors that are most difficult to install.

Reading The Plans

The architects and engineers we work with will usually indicate on the structural page of the blueprints the metal connector location and model number. Sometimes an installation detail is included, but I've found more often that it is up to the framer to figure out how to put them in.

Before pouring the foundation, I use a colored marker to highlight on the plans all the specified metal hardware. I sometimes color-code them — red for foundation connectors, yellow for wall connectors, and blue for roof connectors. Color-coding helps remind me of things like, "The red ones go in before the pour" or "The blue ones need to be in before the roof is covered with felt." I also make a list of all the hardware we need and get everything on site as soon as possible. Even a large building supply warehouse may not stock everything, so ordering hardware well in advance of the pour will prevent slowing down the job.

I also number each of the foundation connectors on the plans. Numbering the connectors helps to make sure they aren't forgotten from the estimate and the order list. Starting at one corner of the foundation plan, I mark the first connector as (1), then move clockwise along the perimeter of the foundation, counting off all the connectors. I finish up the count by numbering the interior metal connectors.

Foundation Connectors

On a typical two-story house, there are three weak points that often require metal connectors: where the foundation meets the first-story wall, where the first-story wall meets the second-story wall, and where the second-story wall meets the roof. By far the most time-consuming and difficult to install are

Tips for Installing Hold-Downs

by Don Dunkley

About 11 years ago, I installed my first set of foundation connectors. These pieces of steel are much different than your garden-variety anchor bolts. They commonly use 1-inch-diameter or larger threaded rods and heavy-duty bolts. As a framing contractor, I wasn't used to dealing with such massive hardware. Without the right tools and experience, my early hold-down installations were less than pleasant, and rather costly. Hundreds of hold-down installations later, they are still far from fun, but I have refined my methods so at least installing this hardware doesn't cost me a fortune.

Tools. To deal efficiently with these beasts, I carry a few tools that help to make the job go smoother:

- A set of 6-inch-long high-speed metal bits 1/2 inch to 1 1/4 inch in diameter, in 1/8-inch increments
- A set of self-feeding bits 1 1/2 inches to 2 1/2 inches long
- A 1/2-inch capacity drill (a right-angle drill can be helpful)
- A ratchet with a good selection of sockets (deep sockets are helpful)
- A couple of good adjustable wrenches
- A copy of the hardware manufacturer's catalog

Working with the concrete sub. I rely on the concrete subcontractor to locate and install the anchor bolts for the hold-downs. Most of the subcontractors I deal with can read the plans well enough to place the anchor bolts in the right places. But for complex jobs, I always make a trip to the site before pour day and locate the hold-downs for them.

Unfortunately, one thing I can't control very well is how plumb the anchor bolts are and how far above the concrete they extend. There's nothing more aggravating than walking the perimeter of a newly-poured foundation viewing bolts that look more like crocodile teeth than fasteners.

If, when framing, I discover the anchor bolt is too short, I make use of a threaded-rod extender, which is a threaded sleeve that allows me to add a short piece of rod to the embedded piece without compromising the strength of the connection. If the anchor bolt ends up long, I either raise the hold-down bracket off the mudsill (which also has no impact on design load values) or cut the bolt with a Sawzall. Don't use bolts that are too long, as they prevent you from getting a socket on the nut, forcing you to use an adjustable wrench.

Installing the bracket. Depending on the size of the hold-down, between two and five bolts are needed to make the connection to the wood member. The length of the bolts depends on the dimension of the wood. As a general rule, add 1 1/2 inches to the width of the wood member to find the length of bolts needed. This added length will cover the thickness of the washer and the hold-down bracket, and leave enough thread left over to get a nut on.

My system for hold-down installation is fairly simple and works for small or large anchors. It also accommodates, with little hassle, anchor bolts that are poorly placed.

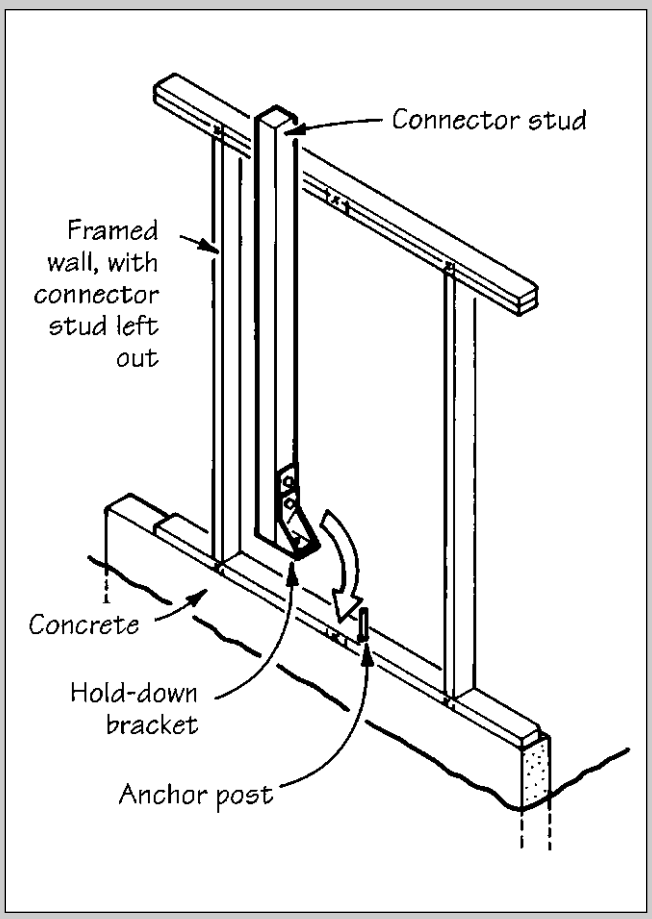
The catalog, which I use like a bible, gives me the distance between the anchor bolt and the connector stud. When I lay out the plates, I mark the stud location and drill the hole through the bottom plate for the anchor bolt, *but I leave out that stud.* After the wall is lifted in place, I come back and temporarily place the stud in its location and dry-fit the hold-down on the anchor bolt. Depending on the type of hold-down, the bracket might rest flush on the bottom plate, or it might have a built-in gauge that lifts it off the bottom plate a specific distance.

I then trace the holes for the machine bolts on the stud. This eliminates the possibility of making a measuring error and drilling my holes in the wrong place. I remove the post, comfortably drill the holes, and bolt the hold-down bracket to it. With the hold-down fastened, all I have to do is place the stud back in the wall over the anchor bolt, toenail the stud ends, and cinch down the hold-down nuts (see illustration). This method of preinstalling the bracket eliminates the aggravation of tightening the stud bolts when the anchor bolt is in the way.

At king studs and outside corners. Hold-downs are often specified at king studs of window and door openings and on outside corners. In these cases, I am forced to nail these studs in place before I lift my wall and deal with the hold-downs later. After the wall is framed, I position the hold-down bracket on the stud and drill through the holes in the bracket. Sometimes I have to Sawzall through the nails holding adjacent studs to the plate and temporarily move them out of the way to give some room to drill the holes.

On an outside corner, I recess the bolt head about 3/4 inch so it won't bulge the exterior siding or create a weak point in the stucco. But be careful: Don't count the 3/4-inch recess as part of the required stud thickness. If you need to recess for the bolts, add extra thickness to your stud. Plan for this before the concrete guys set the anchor bolts.

Before insulation, I make a point of going around and tightening all the hold-down nuts. When working with green or wet lumber, the studs and plates will shrink and I'm always surprised whenever the nuts I cinched down tight with a ratchet a couple of weeks ago can be turned by hand. ■



When framing walls, Dunkley recommends leaving out the studs that connect to hold-downs and installing them after the walls have been tipped up. This allows you to accurately attach the hold-down bracket to the stud, then place the stud and bracket over the embedded anchor bolt.

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the foundation connectors.

Hold-downs. Two types of metal anchors are commonly used to strengthen the connection between wall and foundation. The most common is a large L-shaped bracket that usually sits on the mudsill and attaches with two or more machine bolts to a wood stud or post (Figure 2). The bracket connects to an anchor bolt that is embedded in the concrete stemwall or slab.

On site we call this type of connector a *hold-down*, after Simpson Strong-Tie's brand name "holdown." Kant-Sag also markets a similar product under the brand name "anchor down." Depending on which brand an engineer is familiar with, hold-downs are referenced on plans as either HD or AD, followed by a number that indicates the size. The two brands are similar, but you should clear it with the engineer if you use the brand not referenced.

Engineers will also specify the type of anchor bolt to use with a hold-down, the rod diameter, how deep it is to be embedded, and how it terminates in the concrete (Figure 3). There are four types of anchor bolts I install regularly:

- A threaded rod with a 90-degree bend in the end, like a large J-bolt
- A threaded rod or long bolt with a nut and washer on the end
- A threaded rod with a 2- or 3-inch-square, 1/4-inch-thick steel plate bolted to the end
- A manufactured anchor bolt, such as Simpson Strong-Tie's STAB anchor

Threaded rod diameters range in size from 5/8 to 1 1/2 inches; the most common are the 5/8-, 7/8- and 1 1/8-inch sizes. STAB diameters come in either 5/8-inch or 7/8-inch diameters. The STAB anchor provides some advantages over the threaded-rod options. For one thing, it is plumb above the concrete but angles away from the outside of the foundation within the concrete, which adds strength. Also, engineers like STAB anchors because the load values have been tested, whereas threaded rod strength is based on calculations. I like them because the angle makes it easier to avoid hitting the embedded horizontal rebar.

The trick to installing a hold-down is getting the anchor bolt embedded in the concrete in the right place. This usually means coordinating with the concrete sub (see "Tips for Installing Hold-Downs"). But on additions we usually do our own concrete work, so we have to deal with placing the anchor bolts, too.

If a hold-down is located in a wall without any door or window openings, positioning the anchor bolt is usually not as critical — you

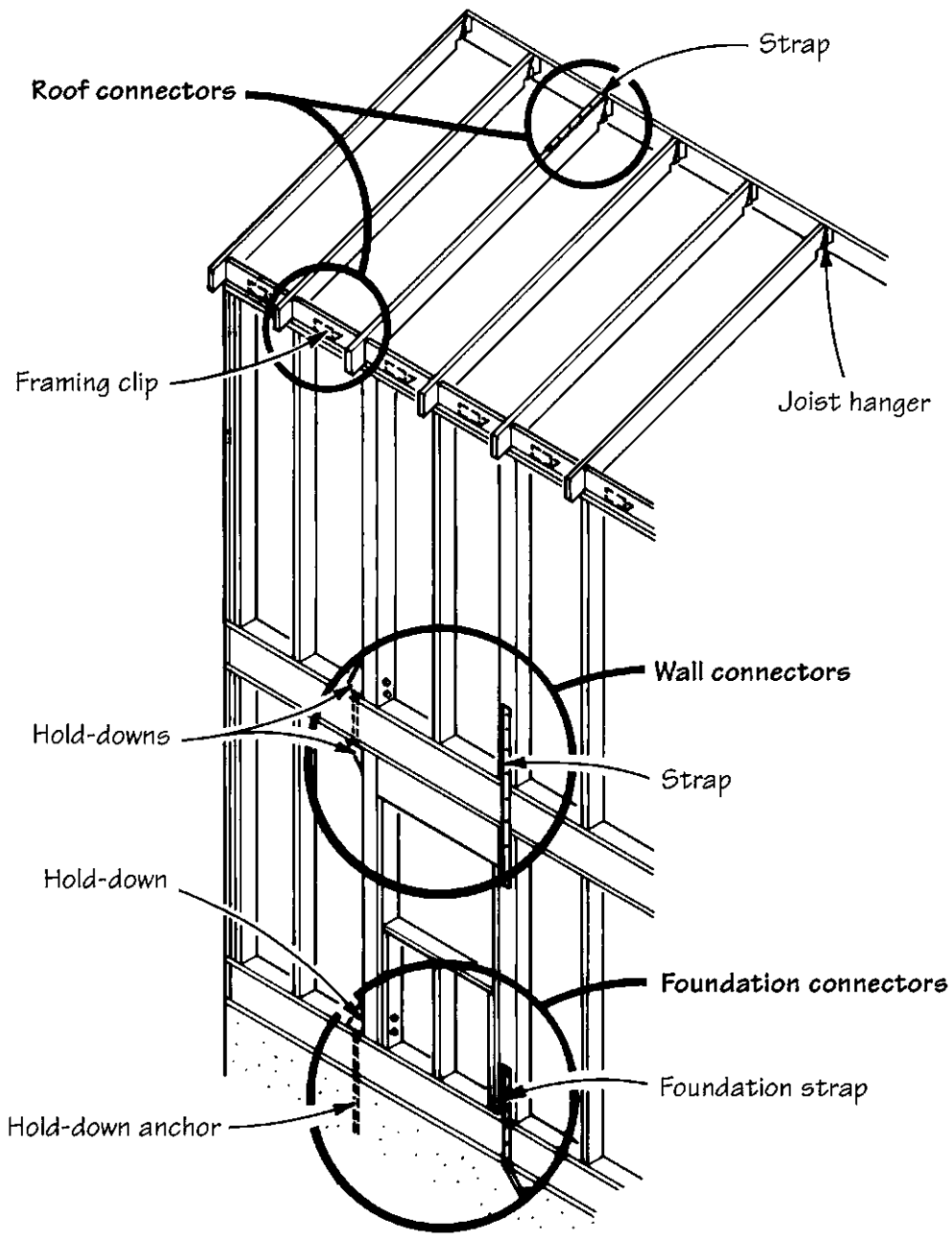

Figure 1. *On a new two-story house on the West Coast, a variety of metal connectors are used to tie the structure together and strengthen weak connections against earthquake uplift.*

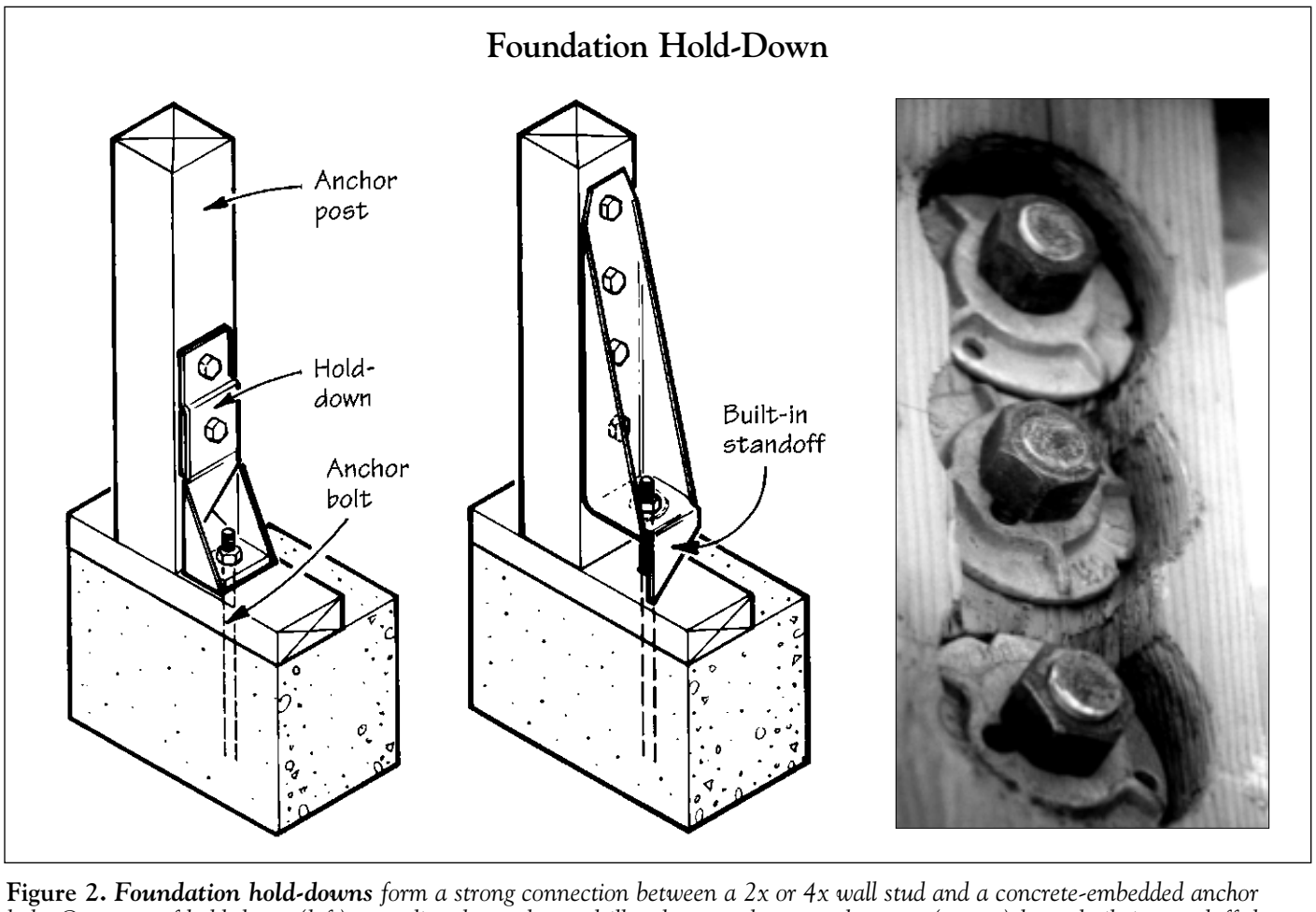

Figure 2. ***Foundation hold-downs*** *form a strong connection between a 2x or 4x wall stud and a concrete-embedded anchor bolt. One type of hold-down (left) rests directly on the mudsill or bottom plate; another type (center) has a built-in standoff that lifts it off the plate far enough so the bolt holes don't split out the end of the post. When installing a hold-down at an outside corner (right), be sure to countersink the nuts so they don't bulge the siding.*

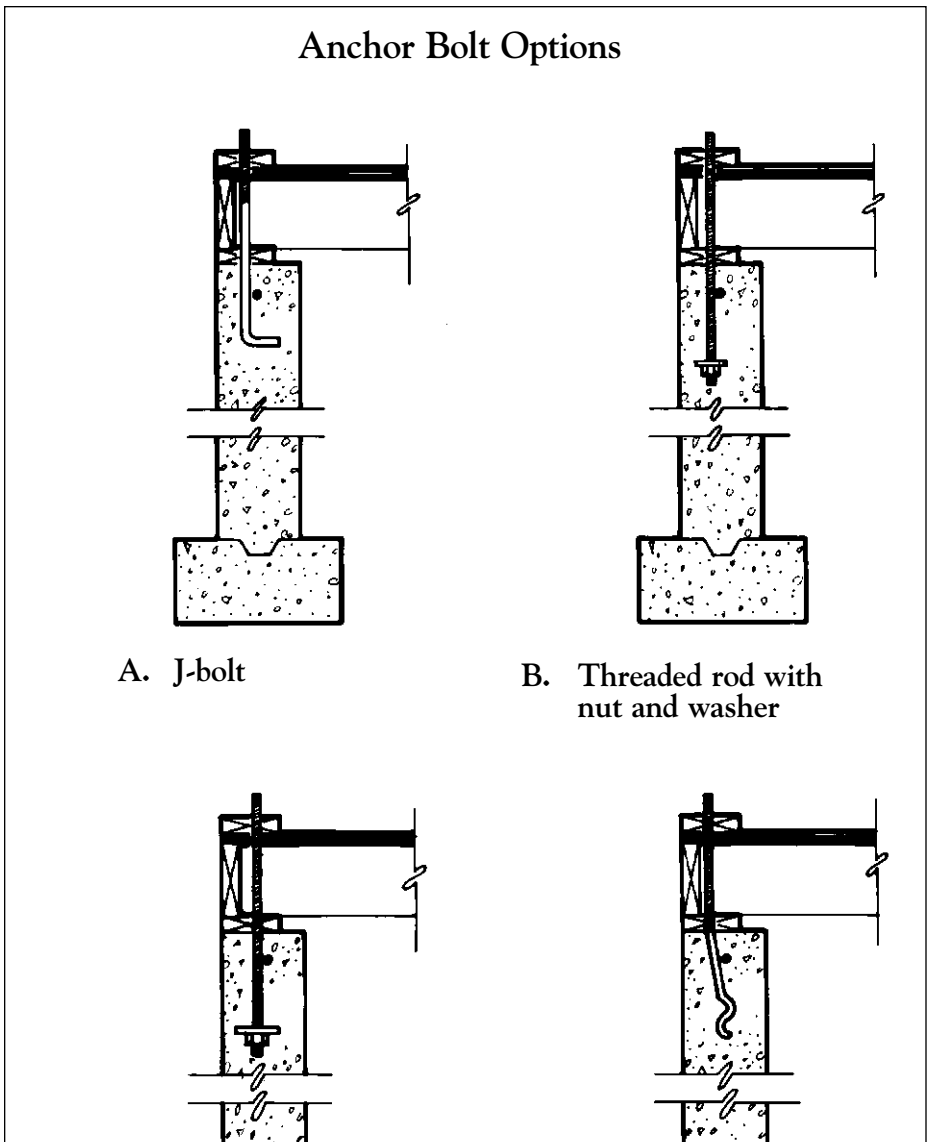

Figure 3. *Anchor bolt options.* *There are four types of anchor bolts for use with foundation hold-downs: (A) A threaded rod with a 90-degree bend in the end, like a large J bolt; (B) a threaded rod or long bolt with a nut and washer on the end; (C) a threaded rod with a 1/4-inch-thick steel plate bolted to the end; and (D) a manufactured anchor bolt, such as Simpson Strong-Tie's STAB anchor.*

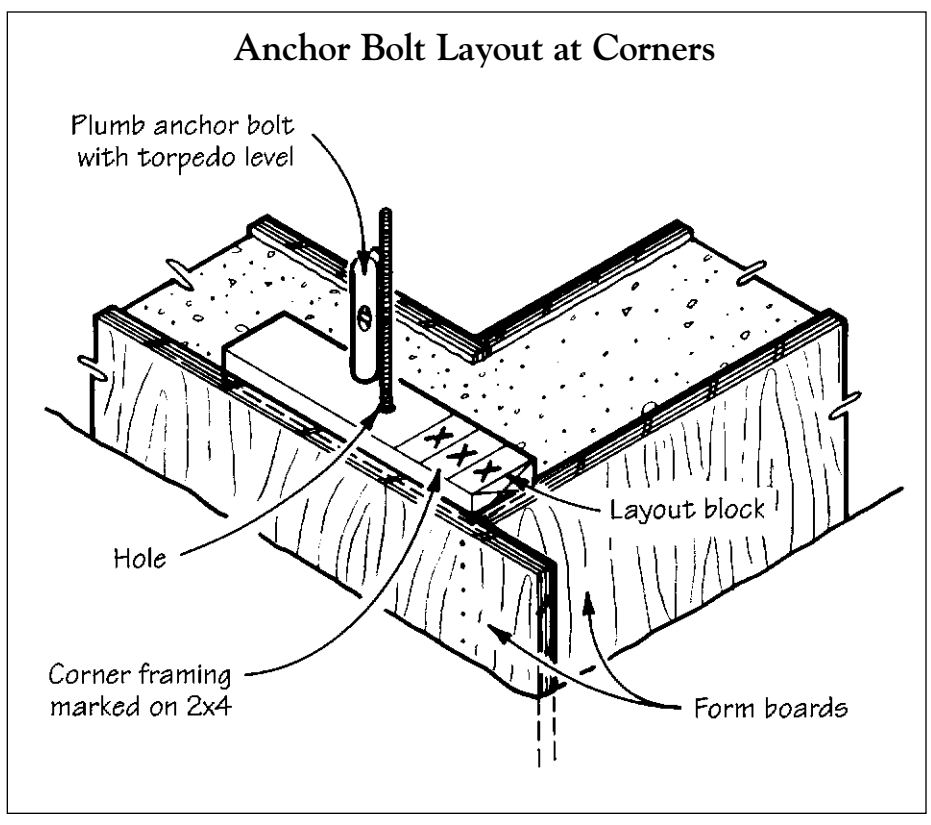

Figure 4. *To ensure the exact position of a corner anchor bolt, the author uses a layout block with a hole to hold the anchor bolt in the foundation form. The block is also useful for hold-downs at door and window openings.*

just have to make sure you position it in the center of the wall. It's when a hold-down needs to be positioned to either side of a wall opening or at a corner that proper placement becomes crucial.

I increase the chances of proper placement on a building corner by making a layout jig — a simple block with a hole to position the anchor post (Figure 4). If possible, I wire the anchor post directly to the rebar in the right position before the concrete pour. But if the rebar isn't in a workable place, I lay the anchor posts near where they are to be placed so they won't be forgotten.

Sometimes I've found it impossible to install an anchor post plumb. If the rebar happens to be in just the wrong place, you have little choice but to place the anchor slightly out of plumb. But as long as you take into consideration the hold-down's final placement, you can get away with being out of plumb. This requires picturing the framing exactly, and juggling a tape measure and blocks if necessary to mock up the location of the rod (Figure 5). You have to be fairly accurate — engineers and inspectors don't like seeing a dramatically bent anchor bolt because it weakens the metal.

Foundation straps. The other common type of foundation connection is a concrete-embedded metal strap that nails or bolts to the face of a stud member (Figure 6). We generally call these "foundation straps" on site. Simpson and Kant-Sag both refer to these as PA series anchors, and they are referenced on the plans as PAHD, MPAHD, and HPAHD.

Compared to hold-downs, the PA series anchors are easy to install. Because no drilling is usually needed, all studs can be nailed in when lifting walls.

The big advantage with PAHDs is that you don't have to deal with an anchor bolt sticking up through the subfloor. The PA series straps simply nail to the form before the pour. Also, a typical installation only requires a handful of nails. The manufacturers call for 16d common nails to get the full design loads, but you can use 16d sinkers as well — this reduces the design load values by one eighth. (A common nail has a larger-diameter shank and a larger head than a sinker.)

There are some disadvantages with foundation straps:

- Design loads for straps are significantly less than for hold-downs. The largest hold-down can handle up to 17,000 pounds of uplift, whereas the largest foundation strap in the PA series can handle less than 5,000 pounds of uplift.
- If the concrete isn't vibrated, you may leave surface voids beneath the strap. I make a point to rap the form with a hammer at each of the strap locations to make sure the concrete settles beneath each connector.
- The studs that the straps attach to can sometimes split under the heavy nailing. This will seriously reduce the design load, and you may have to replace the stud with a doubled or 4x member.

Simpson has new strap anchors — the *Fas-Tie* series — that improve the design by allowing nails or bolts to be installed on the wide face of the stud (Figure 6B). Because you have more nailing, this type of connector generally forms a stronger connection. I haven't yet used this product, but I can see a number of advantages: First, the design load value is comparable to the smaller threaded-rod hold-downs, so in some situations it can replace the more labor-intensive installation of a threaded-rod connector. Second, there's more flexibility with this strap connection because it doesn't require as much space as a threaded-rod anchor.

A disadvantage is that the Fas-Tie can interfere with the plywood sheathing. Either the plywood needs to be lumped over the strap, which might create a visual problem with the exterior siding, or the bottom plate must be notched to position the strap within the wall surface, which might cause a problem with the inspector.

Wall Connectors

There are a variety of wall connectors that are used to reinforce the connection between first- and second-story walls. The most common are hold-downs used in pairs with a large threaded rod between them (Figure 7). When installing these, remember to align the studs between floors so that the threaded rod misses a floor joist. I drill an oversized hole for the threaded rod to pass through the subfloor. Even if the studs don't perfectly align with each other, as long as the rod is not bent, the threaded rod can be installed a little out of plumb without affecting the design value.

Metal straps of different gauges, widths, and lengths are also common for strengthening the connection between stories. Both Simpson Strong-Tie and Kant-Sag offer a variety of configurations. We frequently use Simpson's MST or ST series. Strap ties require either 16d or 10d commons, but can be replaced by 16d sinkers, reducing design load by one eighth.

When laying out a wall that requires one of these larger straps, I usually use 4x4s as the connecting studs, even if the plans require only a single or double 2x4. With a 1 1/2-inch-wide strap, I have had problems with the nails splitting the 2x4 studs. And over a double 2x stud, a shift of

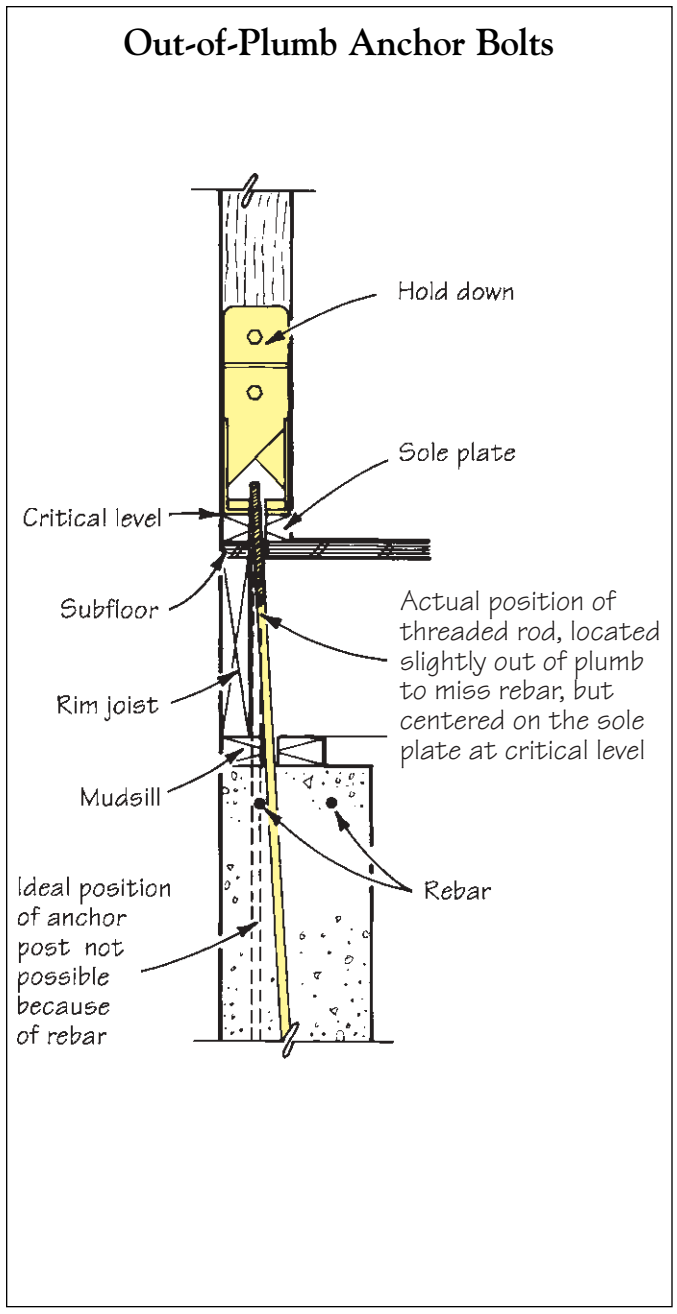

Figure 5. *You may install an anchor bolt slightly out of plumb if the rebar is in the way. This will not affect the strength of the hold-down, but you must make sure the top end of the bolt is still centered where it comes through the sole plate.*

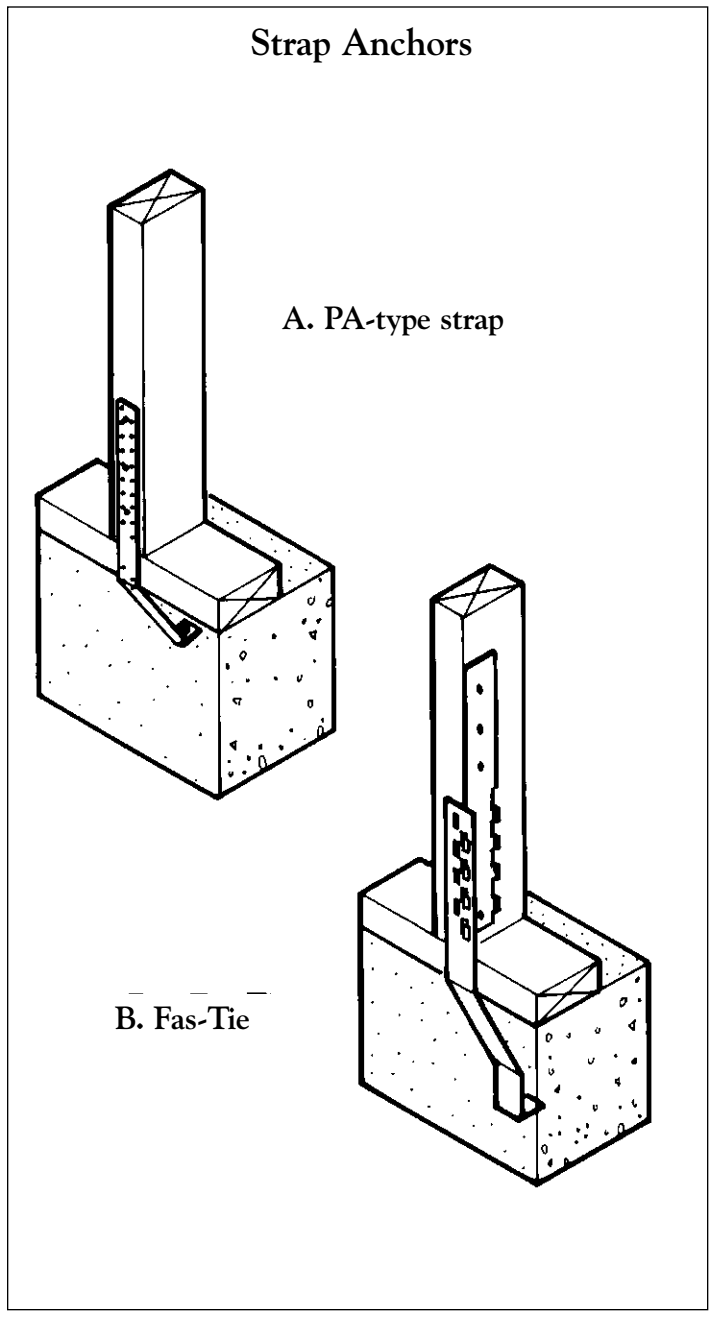

Figure 6. ***Foundation straps,*** *like the PA series (A), are nailed to the foundation forms during the pour, then nailed to the framing through the exterior sheathing once the walls are up. A new type of strap anchor, Simpson's Fas-Tie (B), has two pieces. The upper piece nails into the wide face of the stud, then interlocks with the part embedded in the concrete.*

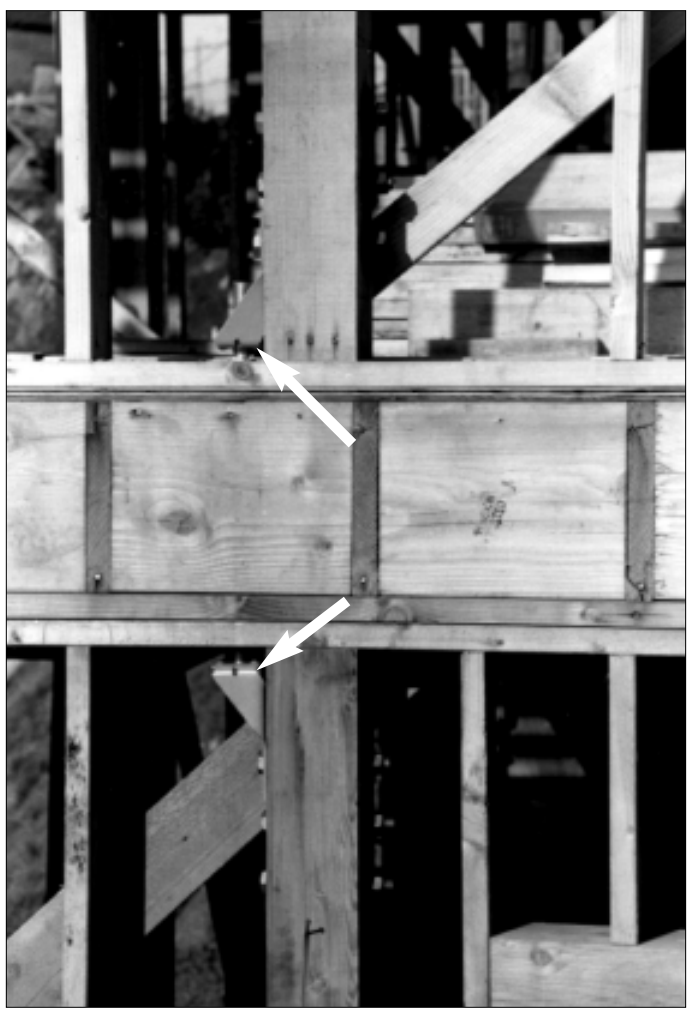

Figure 7. ***Wall connectors*** *come in two varieties. You can use hold-downs bolted together through the floor assembly (left) or nail strap ties into the studs (right).*

only 1/4 inch may mean that you nail into the crack rather than into the center of each member. Also, a 4x4 offers a little more flexibility if the studs don't line up perfectly. With 2x4s, if one stud is bowed, the strap doesn't always center over the meat of the stud.

Many strap ties are nailed onto the exterior of the plywood. To help locate the strap position, I drive a few 8d nails on either side of the upper and lower studs from inside the house. This allows me to center the strap on the studs to get the strongest attachment.

Roof Connectors

In our area of California, we don't see nearly as much roof hardware as we do foundation anchors. Nevertheless, the engineers do spec some.

Framing clips. In most cases we use metal clips (Simpson A35 or Kant-Sag MP-A1) to connect the frieze block to the double top plate. With a framing clip on every frieze block and the roof sheathing nailed to the frieze block, a strong connection is made between the wall and the roof. It's not difficult to install these. Just be sure you do it before the roof is sheathed.

Hurricane clips. Seldom do we have to install rafter ties, though occasionally we're required to strap a hip to a wall. However, rafter ties are very common in coastal wind zones. Simpson and Kant-Sag make a variety of "hurricane clips" that reinforce the connection between rafters and plates.

There is a temptation when setting rafters or trusses to just wrap the tie over the top of the rafter or top chord of a truss, bang in one nail, and move on down the line. But you must follow the manufacturer's nailing schedule, which includes nailing along the side of the rafter or top chord.

Ridge connections. While we don't see many hurricane clips, we are frequently required to strengthen the rafter connection across the ridge with either joist hangers or straps across the top of the rafters. The joist hangers force the carpenter to make a horizontal notch at the top of the rafter so that the rafter seats firmly in the hanger. Usually the straps simply nail on over the roof sheathing before the roof is felted. But these can be a real pain for a couple of reasons. The number of nails required to hold two sheets of plywood sheathing together over one rafter, plus the nails for the strap, can make mincemeat of a 2x rafter. Also, these straps can easily be forgotten in the mad rush to felt the roof against the weather. ■

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