SHEAR WALL BASICS

A carpenter in Mountain View, Calif., nails off a plywood shear wall with a pneumatic nailer.

For good seismic protection, shear walls require precision nailing, special connectors, and ample blocking at all edges

by Jim Hart

Ever since the 1989 Loma Prieta Earthquake, which registered 7.1 on the Richter Scale, seismic codes for new construction in California have become stricter. It's now common to see engineered seismic bracing details even on plans for a simple addition. The most common detail is the *shear wall*, a framed wall with structural sheathing, designed to resist the lateral forces that an earthquake exerts on a building (see Figure 1). Any wall properly sheathed with plywood has considerable shear strength, but the term "shear wall" is reserved for walls designed by engineers. A shear wall incorporates special construction details and materials specified by code to resist the forces that rack a building during an earthquake or high winds (see Figure 2).

In a typical newly built two-story home in California, often all the exterior walls are shear walls and there may be a few interior shear walls as well (see "Typical Shear Wall Details," page 28). Exterior shear walls are usually sheathed with plywood; interior shear wall surfaces may be either plywood or drywall. Shear walls differ from conventional framed-and-sheathed walls in several ways:

- Both interior and exterior shear walls have rigorous nailing schedules. Nail spacing may be as close as 2 to 3 inches at panel edges.
- All edges of surface panels must be fastened to solid blocking. At panel joints where edge nail spacing is 2 or 3 inches, the code typically requires a minimum 3x framing member.
- All shear walls must be mechanically attached to the foundation. The plans usually specify metal hold-downs, metal straps, closely spaced anchor bolts, or some combination of the three.
- Shear walls usually tie in at the second floor and the roof with blocking and/or metal connectors.

Shear Wall Materials

Materials for shear walls are the same as for conventional framed walls with a few exceptions.

The shear wall panel. The panel is the core element of a shear wall. Usually it is structural-grade plywood from 3/8 to 3/4 inch thick. Often you see 3/8-inch plywood on a single-story structure and 1/2-inch or thicker plywood on two-story and three-story buildings.

The specs may call for either "Structural I" or "Structural II" grade plywood. This is an important distinction, because Structural I is stronger, and more expensive, than Structural II. Other structural grades are also allowable, but make sure the grade stamp matches the specs on the plans.

Oriented strand board (OSB) can also be used in shear walls, but since it has less shear strength than plywood, it isn't often used on the West Coast for seismic bracing.

Another option for interior shear walls is drywall. Because of the cost savings, many engineers specify drywall shear walls where they can. Drywall shear walls should have their sheets running horizontally, with blocking along all edges. A 4-inch-on-center nailing schedule is typical. Drywallers can use either nails or screws, but I recommend screws because they do less damage to the board. Where the hammer fractures the drywall around the nail head, it reduces that nail's shear value.

Plywood length. Buying the right length plywood will help speed production of shear walls. In many cases, if you order 4x8-foot sheets, you may be making extra work for yourself. In California, we typically run our shear panels vertically. By using 4x9 and 4x10 plywood, we can sheathe from the mudsill to the middle of the second-floor rim joist with a single sheet.

However, if you are framing a single-story home on a slab floor, 4x8 sheets may work fine. You can also use 4x8 sheets where the plans require you to run the plywood horizontally. This gives the wall additional strength against racking because the majority of the layers in the plywood have the grain running perpendicular to the studs. But it means that you'll have to install horizontal blocking at the joints between sheets.

Framing material. Shear walls are typically framed with 2x4s or 2x6s 16 inches on-center. When framing shear walls, the main thing to keep in mind is that all plywood edges must be blocked. This is because shear forces are transferred at panel edges. The blocking and close nail spacing required along the edges ensures that the plywood remains stiff under shear loads and can resist racking. Tests conducted by the American Plywood Association show that without edge blocking, shear panels under load tend to buckle and fail.

Shear walls with especially tight nailing schedules usually require a 3x stud where two sheets meet. The wider stud can stand up to the many nails required at panel edges without splitting. Since 3x studs are not widely available, I typically use 4x4s instead. If you run your sheets horizontally, the edge blocking at joints often must be 3x or 4x material as well.

Four-by-fours (or doubled 2x4s) are also usually required for attaching the hold-downs that connect to foundation anchor bolts. These are typically located at building corners, on the sides of large door or window openings, and at the ends of a shear wall.

Nails. Using the right nails is one of the most critical aspects of shear wall construction. Tests have shown that most shear wall failures occur because the nail head rips through

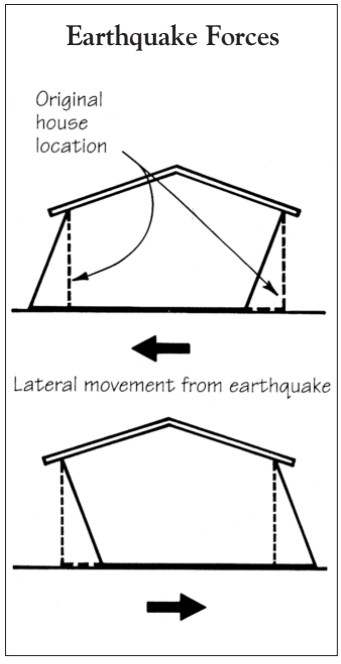

Figure 1. *An earthquake produces lateral movements in the ground that cause a building to snap back and forth. This stresses joints and connections and causes the building to shift and sometimes collapse.*

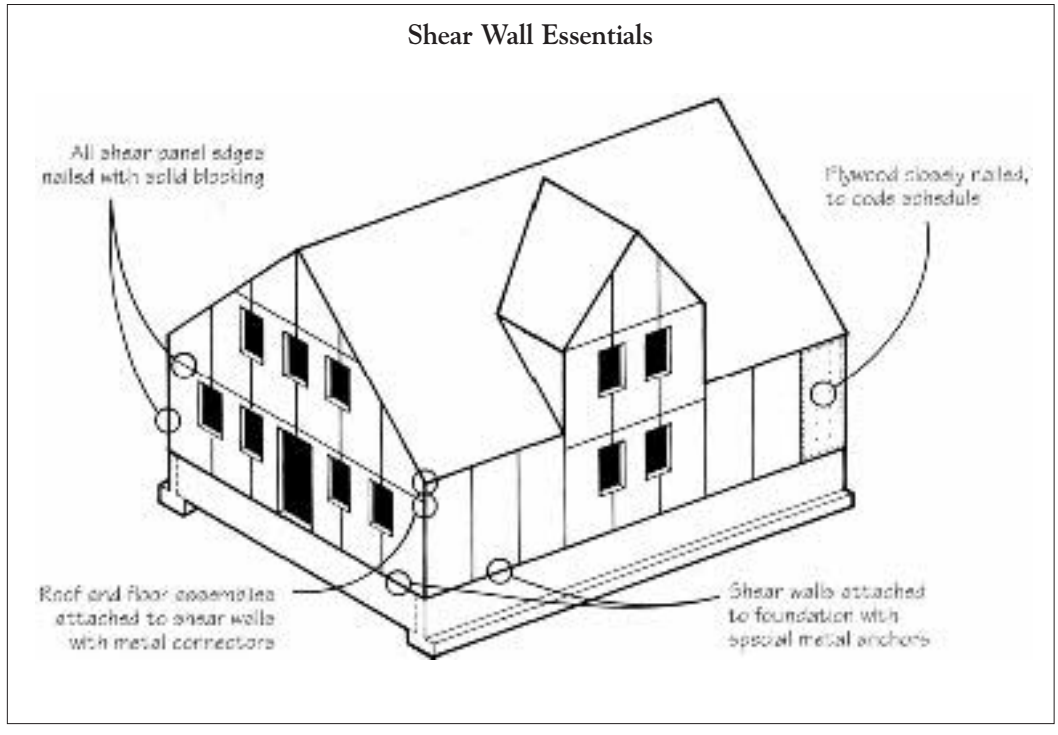

Figure 2. *Plywood shear walls resist an earthquake's lateral forces by preventing racking. Shear walls get their stiffness from close nailing patterns, solid blocking at all panel edges, and hold-downs and metal connectors at the foundation and roof.*

the plywood. The size of the nail head, as well as the nail's diameter, is therefore important in determining a nail's shear value. Engineered plans should clearly specify the type and length of nail required.

The 1988 Uniform Building Code (UBC), which we follow in California, recognizes three types of nails in its shear wall calculations: common, galvanized box, and galvanized casing. Either common nails or galvanized box nails are good for installing plywood sheathing. Though box nails have a slightly smaller diameter shank, their heads are the same diameter as common nails and both types are assigned equal shear values.

For plywood siding, where either common or box nails would be too noticeable, the UBC allows the use of galvanized casing nails. These have a smaller head and consequently lower shear values than common or box nails. If you use casing nails you may find that you have to tighten the nailing pattern to make up the needed shear resistance.

Pneumatic nails. With the widespread use of pneumatic nailers has come a whole slew of different types of fasteners, which only adds to the confusion when it's time to nail off a shear wall. Fortunately, the code organizations have addressed this situation in National Evaluation Service Committee Report No. NER-272, available from the International Conference of Building Officials (5360 South Workman Mill Rd., Whittier, CA 90601; 310/699-0541).

In addition to the three types of nails mentioned above, NER-272 gives shear values for four kinds of pneumatic fasteners: round head nails, modified round head (or "clip head") nails, T-nails, and staples (see Figure 3). The report also includes ring-shank and screw-shank nails. NER-272 is an important document for anyone having to decide what fasteners to use in a shear wall.

However, don't assume that because the code allows a nail type your inspector will approve it. For example, some inspectors will not allow clip-head nails, because of their reduced head size.

Metal framing connectors. Shear wall plans usually require a variety of metal connectors to tie the major framing members together. I usually buy these by the case at the beginning of the job. These clips, which install with several 1 1/2-inch joist hanger nails, strengthen the connections where the shear wall ties into floor and roof assemblies. Various hold-down straps and plates are also common for tying the shear wall to the foundation (see Figure 4, page 29).

Estimating Shear Walls

When estimating materials and labor for shear walls, study the blueprints meticulously. As many framing contractors have found out the hard way, you can't bid a shear wall the same way you bid sheathing. For one thing, you can trust a carpenter's helper with a sheathing job, but a shear wall needs the attention of an experienced carpenter.

But even with skilled carpenters, shear wall construction is labor intensive. Not only are there a lot of nails to drive, but the hardware for connecting shear walls to the foundation and roof takes time to install. Allow for these tasks when estimating.

When estimating interior shear walls, if the shear-wall panel is specified as plywood, and is shown as only part of the interior wall length, plan on sheathing the whole wall. This is so the interior wall treatment can be applied to a flush surface. Also remember that interior shear walls often require extra underfloor blocking that is better off completed before the subfloor goes on. Finally, it is to your advantage to nail on the plywood immediately after framing the wall so that the shear panels won't be interrupted by intersecting walls.

Construction Tips

While I prefer to nail on plywood while the wall is on the deck, this is often not possible when installing shear panels. Vertical panels have to extend from the mudsill over cripple walls, band joist, and wall framing. Also, shear panels have to tie intersecting walls and floor levels together. So, in most cases, the shear panels have to be installed after the framing is erected. This can complicate the sheathing process. Here are a few tips for an efficient job.

Measuring panels. To determine the panel length for a single-story gable wall, pull your tape from

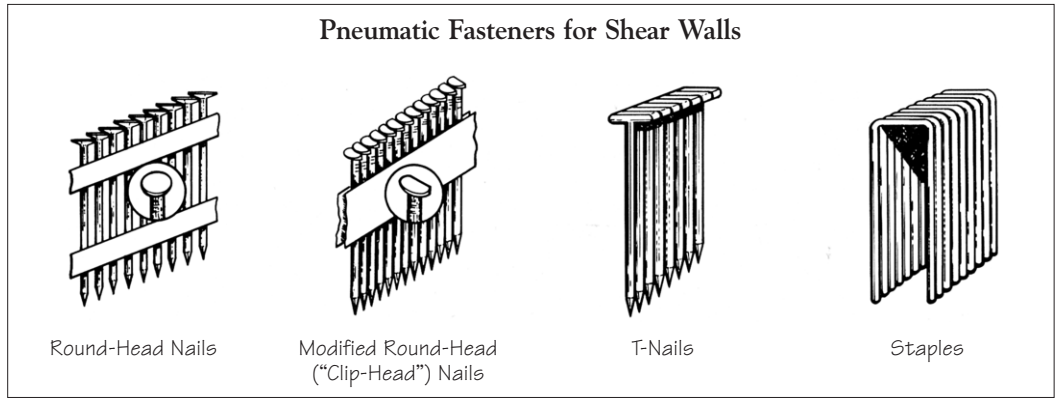

Figure 3. *The four kinds of pneumatic fasteners shown here can be used in shear wall construction, according to National Evaluation Service Committee Report No. NER-272.*

Typical Shear Wall Details

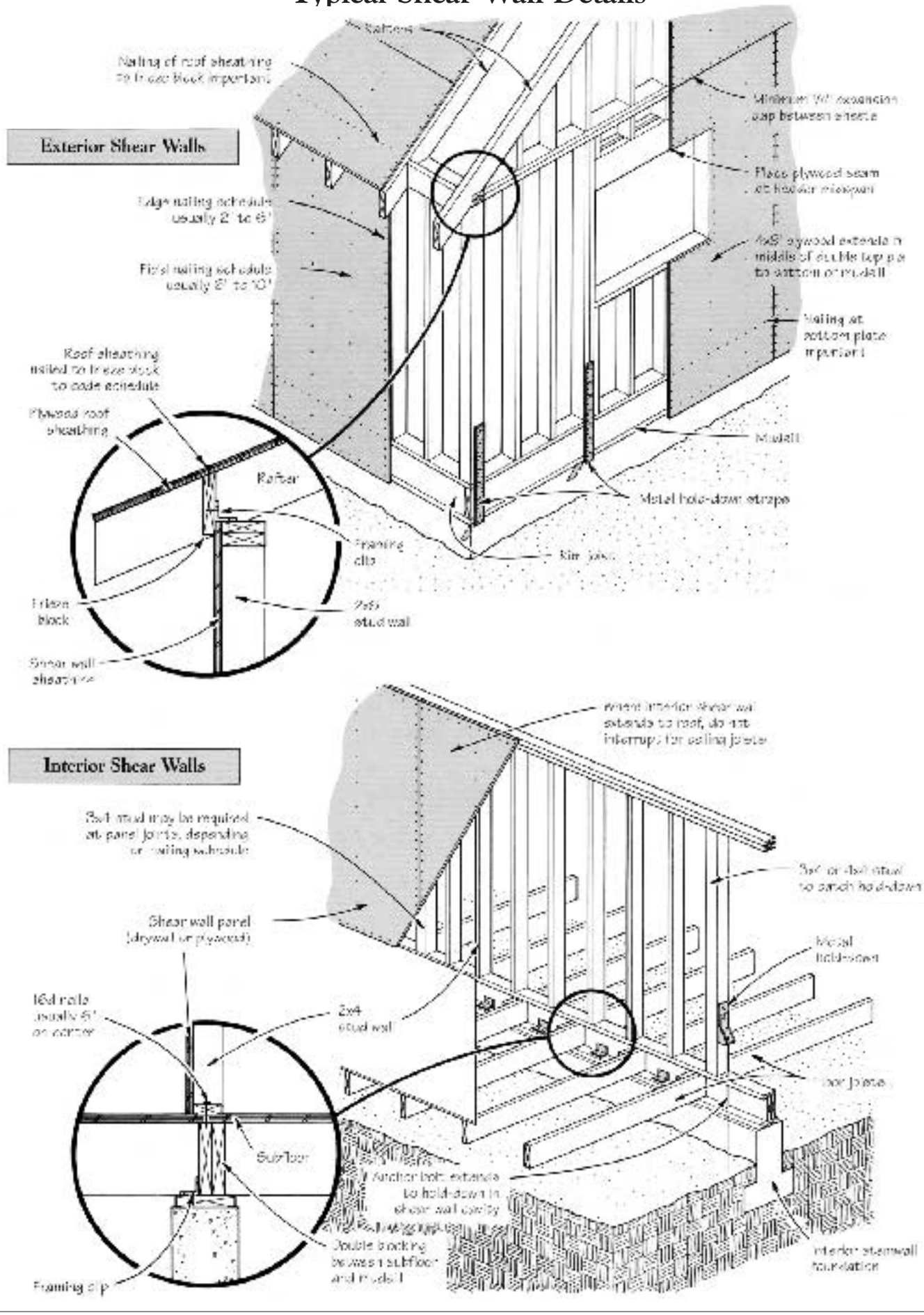

Figure 4. *Two types of metal hold-downs are common in shear wall construction. Right-angle plates (top) bolt onto threaded foundation anchors and attach to 4x4 posts in the wall. Hold-down straps (bottom) are embedded in the concrete foundation and nailed to 4x4s through the sheathing.*

the mudsill to the center of the double top plate. For the first story of a two-story platform-framed house, pull your tape from the mudsill to the center of the rim joist or joist blocking.

Cutting. Once I have determined the panel length, I gang-cut several sheets at a time. Working on a full stack of plywood, I set the depth of my circular saw blade so that it penetrates several sheets and barely scribes a cut into the last one so I can use it for the next cut.

Layout. Before I begin sheathing, I mark the stud locations on the foundation with a pencil or crayon, being careful to mark hold-down post locations, which are often placed off of the standard 16-inch on-center spacing and can be missed when nailing the plywood.

A poorly placed seam can significantly reduce the strength of a shear wall, especially at openings, which are weak points. This is most critical at large openings, like garage doors or a set of windows. Therefore, I pay close attention to where the seams end up on the wall, making sure, for instance, that seams fall at the midspan of window and door headers, not at the edge of the opening.

Placing panels. Starting at a corner of the building, I partially drive a few 16d nails in between the mudsill and the concrete. This gives me a ledge to rest the sheet on. I also use two 16d nails tacked between sheets as spacers to get the required 1/8-inch expansion gap.

I tack the sheets in place with 8d nails, making sure I work the waves out of the plywood. If you fail to work the waves out, the plywood may not make full contact with the studs, which could result in a shear wall failure.

Before nailing off the panels, I walk around the building with a crayon marking the nailing schedules of the different shear walls. This not only helps the carpenter who ends up nailing off the shear wall, it also shows the inspector that we paid attention to the plans.

Nailing off the plywood. Even though nailing off a shear wall seems mindless, doing the job right demands careful attention. To pass inspection, a shear wall must have a consistent nailing pattern, according to the code schedule. Also, by code, nails must be installed with the heads flush with the surface of the plywood. This is easier said than done, especially with pneumatic nailers, which are set at the factory to countersink the nail head by as much as 1/8 inch. Most carpenters try to control nail head depth by adjusting the air pressure, which is a finicky process. I try to adjust air pressure to leave the nail heads 1/4 to 1/2 inch above the plywood surface, then finish driving them with a hammer.

Another solution is to adjust the driver in the nail gun. Some models have a depth adjustment right on the gun. For models that don't, however, you can return the gun to the manufacturer to have the driver shortened so it drives the nail flush. This is a permanent modification, but if you nail a lot of shear walls, it's probably worth dedicating a gun for this purpose.

When using staples, the crowns must be installed parallel to the long dimension of the framing member. That means when you're stapling plywood to studs, you have to hold the stapler horizontally, not vertically.

Finally, be careful nailing at plywood edges and keep nails 3/8 inch back from the edge. If you get too close to the edge, the nail will split the edge off the sheet and undermine the strength of the shear panel. ■

Jim Hart is foreman in Mountain View, Calif., and a contributing editor to The Journal of Light Construction.