PREFAB SHEAR WALLS

New engineered components promise cost savings and guarantee compliance with strict seismic codes

by Don Dunkley

In my 30 years of framing houses on the West Coast, I've seen a steady rise in the use of techniques and materials designed to resist the powerful lateral forces imposed by earthquakes — "shear" forces, as most West Coast carpenters call them. When I first started framing in Southern California, we simply used let-in 1x6 braces and 1/2-inch-diameter foundation anchor bolts 4 feet on-center. By the end of the '70s, let-in bracing began to give way to small amounts of shear-nailed plywood. By the mid-1980s, exterior shear-ply completely covered exterior frames, and, for good measure, a few hold-down brackets were tossed into the mix.

But none of this compares to the raft of hardware and nailing schedules the house frame of the late 1990s requires. Today's frames typically include half the contents of a metal-connector catalog, and glisten in the sun like temples to the gods of engineering. New codes demand shear-plied walls riddled with 4-inch on-center 8d commons and beefy 5/8-inch-diameter anchor bolts on 32-inch centers. Heavy-duty hold-downs are now found at every corner and opening. So what's happened?

On December 14, 1993, the Northridge earthquake hit the Los Angeles area. The extensive damage taught us that previous shear wall design values were far lower than anticipated. Convinced that the old method of "monotonic," or static, testing did not accurately characterize seismic loading, engineers called for new research on the quake resistance of low-rise structures.

New Tests, New Strategies

The old method of loading a shear wall to failure exerted hydraulic pressure in a single direction on test panels. However, this method did not accurately simulate the wild mixture of

forces exerted on walls during a quake. A new testing method — called sequential phased displacement test protocol, or in plain English, cyclic testing — was developed to more closely represent the loading forces of a quake. These cyclic tests showed that shear walls, after going through an earthquake, loosened up and began to weaken. In the tests, 4-foot and 8-foot-long plywood shear walls failed at 77% of the load assigned by the *Uniform Building Code*, while 2-foot plywood shear walls failed at 56% of *UBC* loading. Cyclic testing also demonstrated that nail fatigue leads to shear wall failure. This means that each time a house experiences any seismic event, however small, its shear resistance can become less and less effective, eventually leading to the kind of massive failures seen in the Northridge quake.

Frustrated by the failures and hassles of traditional shear panel walls, builders and engineers have recently turned to manufactured shear wall systems. These consist of a prebuilt panel that can be installed inside a framed wall. Each panel structure is designed to resist large amounts of lateral force created from high winds and earthquakes. Strategically placed throughout a house frame, a handful of these panels can achieve the same resistance to lateral force as you'd get from a house covered with hold-downs and shear-ply. These new systems provide a good answer for the connector-weary builder, offering a stronger, faster, and less expensive alternative to conventional plywood shear walls.

The Problems with Shear Walls

To appreciate the new systems, I find it's important to thoroughly understand the old problems. When it comes to a standard shear wall, job-site errors can be plentiful and expensive. Some problems arise from poor workmanship, some because specific engineering details are overlooked.

Nailing. It's not uncommon for carpenters to overdrive the nails to the point where nail heads break through the top ply membrane. Overdriven nails will fail an inspection. Also, it's easy to apply the wrong diameter fastener. Engineering calcs for shear nailing often call for 8d commons with a .13-inch-diameter shank, but many carpenters use 8d coolers — a pneumatic nail with a .113-inch shank diameter. When an inspector finds this, he'll usually require the builder to resubmit the calcs to the engineer of record for an increased nailing schedule. Using more nails risks splitting the framing members, however, and adds cost because when nuts are closer than 4 inches apart, a thicker or doubled-up stud must be used where the plywood edges break.

Hold-downs are rarely installed perfectly, which can result in shear wall deflection under load. The most common problems are:

- Misaligned foundation bolts
- Oversized bolt holes
- Overtightening of the nuts on anchor bolts in an effort to compensate for lumber shrinkage
- Bolts that are too loose because of lumber shrinkage

As it turns out, nuts should be no more than finger tight plus one-third to one-half turn. Use thread adhesive or a steel-nylon locknut to prevent the nuts from spinning loose, as they are apt to do during cyclic loading.

Advantages of Prefab Shear Walls

Given the uncertainties of installation in the field, engineers keep upping the ante in shear nailing and metal connectors in hopes of getting the lateral resistance values that an earthquake-safe design requires. Here's where manufactured shear-resistant (MSR) systems offer builders several advantages over standard site-built shear walls:

Less time and money. Most MSR systems can be slipped over a couple of special foundation bolts, pushed into place in a wall cavity, and screwed or bolted to the top plate.

Crew motivation. On a large custom home, half a day spent installing a shear system — as opposed to several days of mind-numbing shear and hold-down drudgery — does wonders motivating my crew.

Friendlier inspections. Using these products, builders often get through inspections faster and with fewer red tags. This is due both to the manufactured precision of the panels, as well as there being less to inspect.

Training. Most companies claim they can offer on-site training and preconstruction meetings for subcontractors. This type of support is critical. While the advantages of MSR systems are significant, it's important that everyone on site is familiar with what they are. You need to inform the concrete contractor about using the proper bolt templates, familiarize framers with the installation process, and ensure that plumbers and electricians understand where they can and can't make holes.

Five Products Available

The innovation behind the new shear-resistant systems has sprung from all sides of the industry. For example, one manufacturer, framing contractor Gary Hardy, got his inspiration during lunch break. While looking at a 90-foot-long wood-framed wall with 23 hold-downs in it, he noticed next door a metal building with wood in-fill walls. This gave him an idea: Reverse the situation and use a metal in-fill wall to create strength in a wood wall. Two and half years later, the Hardy Frame rolled onto the job site.

Of the five systems on the market, two are wood — Shear Max and Strong-Wall — and the other three are metal. So far, I've worked with only one, Simpson's Strong-Wall. To get a sense for how the others install and perform, I talked to the manufacturers — both the company presidents and the engineers. The results of this research are summarized in the following pages.

CeeWal

CeeWal
815 Camino Ramon
Danville, CA 94526
925/743-0103
www.ceewal.com
Circle #10

Panel Construction: 3 1/4x14 3/4-inch 10-gauge galvanized steel C-channel construction. A special-order 3 1/4x9-inch unit is available for tight locations, such as garages.

Size: Tailor-made to job specifications. Any height over 22 feet is special order.

Foundation Fastening: CeeWal can be cast directly into the concrete foundation, requiring no hold-downs or anchor bolts. Typical embedment is 18 to 24 inches.

Installation: The CeeWal "column" is typically cast in place, and the walls framed around it. As an alternative, it can be dropped into a formed foundation pocket, then bonded with high-strength 7,800 psi grout. Panels attach to the top plate with 5/8-inch machine bolts. A 2 1/2x13-inch 10-gauge plate sits on the top of the wood plate, and is through-bolted to the column below. In two-story applications, CeeWal can be installed in one continuous piece, then bolt-connected to the second-floor bottom and top plates.

Penetrations: Two 13/16-inch holes on each side of the C-channel are provided for conduit. Additional holes can be made upon request.

Availability and Price: Current lead time is three to five weeks. Single-story columns are $20 per foot. Two-story columns over 18 feet in height are $18 per foot. Prices include all attachment brackets and plates.

Made of 10-gauge steel channel, CeeWal is available in one- and two-story heights (top). It is attached to angle brackets (left) and embedded in the concrete as the footings are poured. Heavy steel brackets and bolts attach to the top plates in two-story applications (right).

Hardy Frame

Simplified Structural Systems
1660 E. Main St.
Ventura, CA 93001
800/754-3030
www.hardyframe.com
Circle #11

Panel Construction: The Hardy Frame consists of 14-gauge C-studs, 16 inches o.c., and a diagonal C-stud brace, welded to 14-gauge top and bottom tracks. The Hardy Panel, designed for narrow openings such as next to garage openings, is a single 3 1/2x18-inch 12-gauge C-channel welded to 12-gauge top and bottom tracks.

Sizes: Hardy Frame is available in 32-, 48-, 64-, and 80-inch widths; Hardy Panel comes only in 18-inch width. Both are available in standard 8-, 9-, and 10-foot heights, 3 1/2 inches thick. Special-order sizes are available.

Foundation Fastening: Hardy Frame/Panel attaches to concrete with 7/8-inch-diameter all-thread bolts, using 1/2-inch-thick, 3x3-inch plate washers held by double nuts. The 3/4-inch anchor bolts and all-thread are held in place with a steel template that nails to the form and remains in place after the pour.

Installation: The Hardy Frame/Panel is set over the anchor bolts and fastened in place plumb and level with nuts and washers. The outer hold-down anchor bolts require 3 1/2x4x3/4-inch washer plates. The wall is framed and stood in place around the frame/panel. After the wood wall is plumbed and lined, the frame/panel attaches to the wood top plates using 1/4x3-inch Simpson SDS screws. Installation requirements vary, depending on application.

Penetration: The HardyFrame is open on the face, allowing multiple penetrations into the outside wall. Both frame and panel have 11/16-inch holes at one-third points on the ends; the frame has an additional 7/8-inch hole at midpoint.

Availability and Price: Minimum two-week lead-time. Prices range from $155 to $275 per unit, depending on size.

Hardy Frame is available as a narrow panel for use next to garage openings.

Shear Max Panel

Shear Transfer Systems
P.O. Box 402563
Hesperia, CA 92345
877/743-2762
www.shearmax.com
Circle #12

Panel Construction: Douglas fir lumber, with three OSB insert panels routed flush into framing members on one side, and reinforced with continuous 20-gauge steel plates. Pressure-treated bottom framing member.

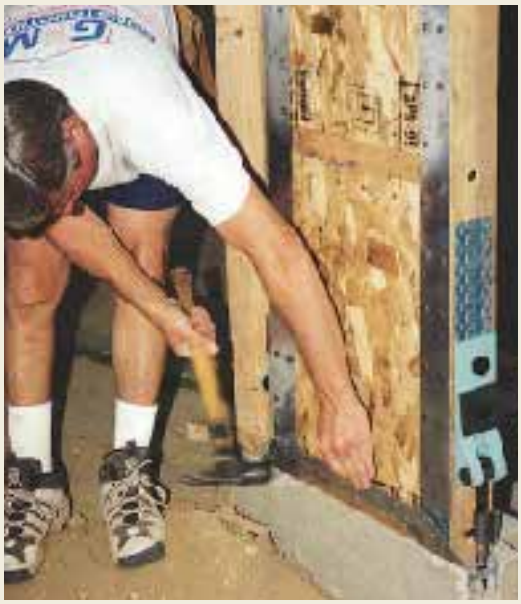
Sizes: 2 and 4 feet in width; 6 1/2, 8, 9, and 10 feet in height (special-order heights available); 3 1/2 inches thick.

Foundation Fastening: A 14-gauge metal base plate and a spacer bar with two 3/4-inch anchor bolts. Nail the base plate to the form board, then install two bolts through the base plate and into the spacer bar nailed at bottom of the form. When the foundation is poured, the base plate becomes permanently anchored in place.

Installation: Stand the panel on the base plate, either before or after the walls are up. Bend up the base-plate flange and nail with 16d sinkers or 10d commons to the Shear Max panel. Two pre-attached 7-gauge hold-down straps located on the ends of the panel connect to the two anchor bolts with reducer couplings and 5/8-inch socket head screws. Attach the panel to the top plate with metal bolts, lag screws, Simpson LTP4 framing anchors, or approved Quik Drive screws.

Penetrations: Must be centered in each panel and no larger than a 2 1/2x4-inch rectangle or 4-inch-diameter hole. Panels are predrilled for electrical conduit.

Availability and Price: 10- to 14-day lead. Basic package starts at $210, including concrete bolts, base plate, and panel with attached hold-downs.



The Shear Max Panel's anchor bolts are positioned in the footing forms with a template (left) that remains in place after the pour. After the concrete is placed, the side of the template turns up and is nailed to the bottom of the panel (below).

Strong-Wall

Simpson Strong-Tie
4637 Chabot Dr. #200
Pleasanton, CA 94588
800/999-5099
www.strongtie.com
Circle #13

Panel Construction: Wood members made of glue-laminated Southern pine timber. Pressure-treated bottom sill plate. The diaphragm is 15/32-inch Structural 1 OSB or plywood. The wood framing nails are 5 inches long and .148 inch in diameter. The panel nails are 2 1/4-inches long and .148 inch in diameter. A 20-gauge metal strip surrounds the front panel edge.

Sizes: Standard Wall comes 24, 32, and 48 inches wide; 8, 9, and 10 feet tall; 3 1/2 inches thick. Garage Portal Wall is available 16x78x4 inches, 22x78x4 inches, and 22x78x6 inches.

Foundation Fastening: A reusable template, fastened to the form board, is used to accurately position the 7/8-inch hold-down bolts and 5/8-inch anchor bolts.

Installation: Strong-Wall slips over the hold-down and mudsill bolts and is raised in place, either before or after the wood frame wall is stood up. Elongated slots in the mudsill allow for 1/2 inch adjustability. A special 2x2-inch 3-gauge anchor connector plate installs with 4 1/4x2 1/2-inch screws over 5/8-inch anchor bolts. A pre-installed 7-gauge steel hold-down bracket connects to the 7/8-inch hold-down anchor bolts with special 7/8-inch all-thread rods and coupler nuts. The panel attaches to the top plate with 1/4x6-inch screws. For easy installation, Strong-Walls are shorter than standard construction height, and full-length shims are provided to compensate. In addition to being fastened with screws, the Garage Portal Wall uses two straps fastened with 10d commons on one side; the opposite side is also nailed with 10d commons through the panel diaphragm that extends over the garage header.

Penetrations: A 1-inch-diameter hole may be drilled through the centerline of vertical members at a minimum of 12 inches above the top of the hold-down. Holes can be drilled in the center of the horizontal blocking, within 3 inches of the center of the top plates. One 4-inch-square hole in the OSB or plywood diaphragm is allowed, if located at least 14 inches above the bottom plate and 14 inches below the top plate.

Availability and Price: 24-hour lead time for standard-size panels. Price per unit runs from $150 to $250, depending on wall size.

Simpson's Strong-Wall can be set in place either before or after the frame is up.

Z-Wall

Z-Wall
P.O. Box 38096
Honolulu, HI 96837
800/735-5922
www.hawaii50.com/zwall
Circle #14

Construction: Vertical members are 3x1 1/2-inch steel channel. Welded to the two verticals are 2x1 1/2-inch 14-gauge tube steel, making a web in the form of a Z. The tops and bottoms of the verticals have flanges to receive the anchoring bolts.

Sizes: 17 1/2, 23 1/2, and 29 1/2 inches wide; 8, 9, and 10 feet tall; 3 inches thick. Special-order sizes available.

Foundation Fastening: With a reusable template, two J-shaped 7/8-inch anchor bolts are embedded in concrete.

Installation: Z-Walls are generally used in pairs, placed on each side of an opening spanned with a 4x12 header beam. The Z-Wall is stood in place and attached to the two foundation anchor bolts using two nuts per bolt, one above and one below the anchor flange. A 2-by mudsill separates the frame from the concrete slab or footing. This gets bolted to the top plates and the beam with two 7/8-inch through-bolts, with 3x5x3/8-inch plate washers. The attachment methods at the top and bottom anchoring flanges vary depending on the story height of the building.

Penetrations: Multiple openings are allowed in the face due to the open web design. A 3/4-inch-diameter hole is provided through the center of each end. The 1 1/2-inch tube steel web allows for plenty of room for wiring inside the wall cavity.

Availability and Price: Lead time is three to four weeks. The average retail cost per unit is $150, though volume discounts are available.

Don Dunkley *is a former framing contractor from Cool, Calif.*

Z-Wall is made with tube steel webs welded to channel steel sides. Typically used in pairs with a connecting header, it integrates neatly into the wood frame.