BRACING WALLS

What Works Best?

Plywood sheathing is tops. But shear panels and let-in bracing do well, too.

by Harris Hyman, P.E.

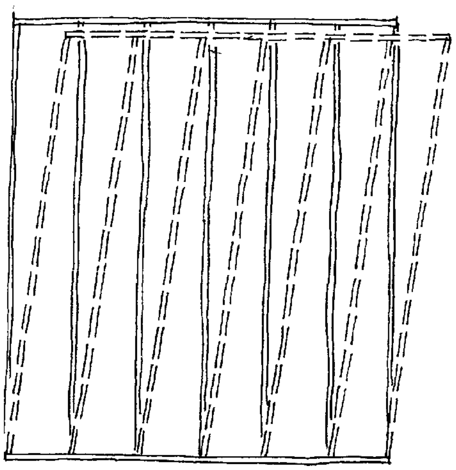
A wood-frame house is a surprisingly safe building. It is almost impossible to construct one that will fall down. Most builders instinctively work with lumber that is heavy enough to do the job. In fact, the wood is usually much, much stronger than the bare minimum that is needed to hold things up. Failures are generally water-related—rotting or leaking.

Structural problems in a house almost always relate to deflection—that is, unwanted movement of the framing. The most annoying of these unwanted movements is a bouncy floor, but the one that is most noticeable and causes the most deterioration in the house's value is racking. In this condition, walls that presumably were plumb and square shear off into parallelograms (Sketch 1).

Racking also drives carpenters crazy. They set up the job carefully, cut the studs to within 1/16 inch, measure and align everything twice, and even use a plumb bob. Then, a couple of weeks later, it's time to set the doors and windows, and the rough openings are 3/8 inch out of plumb. It's enough to drive a carpenter to toss a hammer through the window—which I've seen.

So what happened? Simple—the building moved. The upper northeast corner went a little farther northeast while the sill stayed in place. The whole thing was put together properly, but it sheared and twisted. (Unwind the plumb bob, or measure the wall diagonals, and you'll see.)

Sketch 1. *When a wall racks, what was square becomes a parallelogram.*



It's a lot worse when a building racks *after* the owner moves in. A contractor can pretty easily calm down a carpenter, but an unhappy client is another matter entirely. If the building shifts a little and the casement windows suddenly won't close and the drywall screws pop, it can take some real doing to appease the client's attorney.

Another racking problem is the building that sways in the wind. The engineer may have stamped the plans and assured the owner that nothing would happen, but every time a nor'easter blows, the house shudders—and the owner is beginning to wonder. Even *I* worry in a building that shudders. My inner ear can contradict a head full of calculations and statistics.

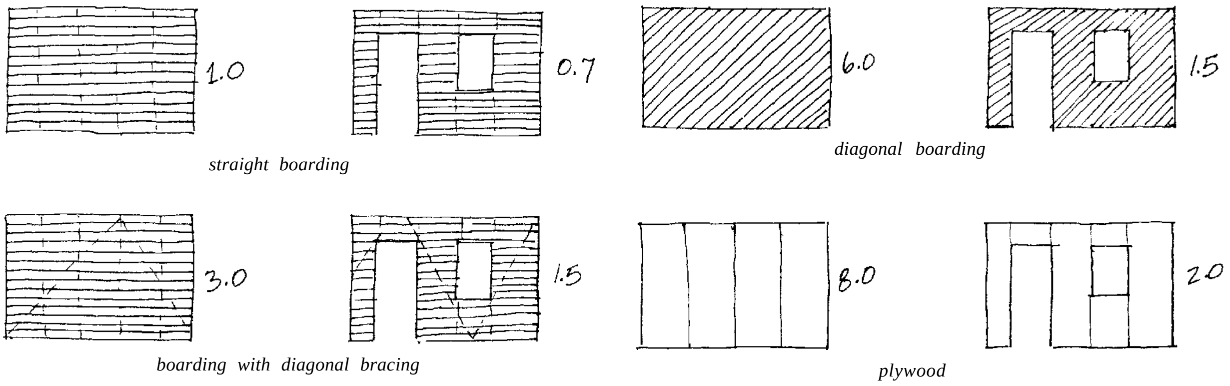
This tendency toward flimsiness and movement is going to occur more and more as exotic glazings and greenhouses become integral parts of a structure. Holes in the skin weaken a building quite a bit, but with R-6 and R-9 windows you want to cut a lot more holes. A greenhouse is *all* holes, with hardly any structure around it, and when a house is half greenhouse, a lot of the normally expected strength is gone.

There are several ways to strengthen a frame in shear and prevent racking. The traditional method is let-in diagonal bracing. Ideally, diagonal bracing should zigzag at 60 degrees or so from the sill to the top plate and back down again. Where windows and other openings interrupt the pattern, you should still try to place the braces so they go unbroken from sill to top plate.

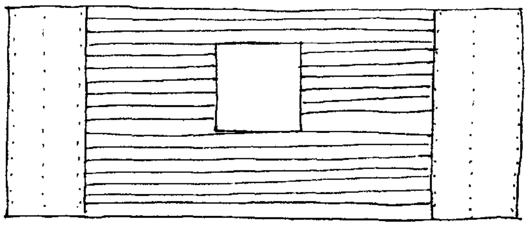
After World War II, plywood became a common skin material. It proved to be much stronger and easier to do than let-ins, which were gradually abandoned. Over the past few years, however, a number of contractors have stopped using plywood sheathing and returned to boarding.

Boarding has a couple of things going for it. It gives a generally flatter and smoother appearance than ½-inch plywood; it can be less expensive and much easier to handle than 5/8-inch plywood; and it provides a structure that is consistent with Lotz's Law, which recommends a relative permeability between the outer and inner skins of 10:1 for moisture control in the walls. But the return to boarding makes a weaker building.

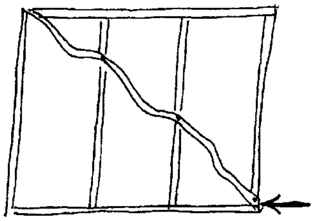
Sketch 2. *If a boarded frame wall has a strength of 1.0, diagonal bracing would have a value of 3.0, but only 1.5 with door and window openings. Plywood is tops with eight times the strength of a boarded wall.*



Sketch 3. *Plywood in the corners (shear panels) seems to have all the advantages of diagonal boarding with much less expense.*



Sketch 4. *Flat metal strapping is all right in tension, but is a wet noodle in compression. An X pattern might work.*



Another new practice is the use of a one-inch foam insulation on the exterior. The foam sheathing is placed between the framing and the skin, where it acts as both an infiltration barrier and as a thermal break for the studs. If plywood is installed on the exterior side of the foam to provide a nail base, it does little to improve the strength of the building because the plywood hangs out on one inch of unsupported nails. Additional bracing would be needed to prevent racking. (My solution is to use the foam insulation on the interior under the drywall.)

I have an old copy of Albert Dietz's classic, *Dwelling House Construction.* He gives sketches and cites NFPA strength data, which is summarized in Sketch 2. A boarded frame wall is given a baseline strength of 1.0. With diagonal bracing, it is about three times as stiff. With two door and window openings, the wall is only about three-quarters as stiff. Covering the wall with plywood makes it five times as stiff, and if the plywood is glued on, the wall has a relative stiffness of 10 to 20. With doors and windows, the plywood wall is still twice as strong as the plain boarded wall.

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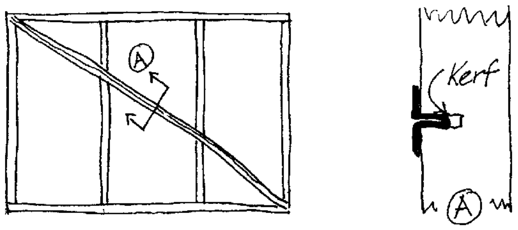
Diagonal sheathing is my personal favorite. It has the advantage of a smooth, flat skin (and the permeability) and is somewhere between diagonal bracing and plywood in strength. But it is tedious and expensive to lay up, and about 20 percent is waste.

Another anti-racking system (Sketch 3) uses a shear panel in the wall. This is basically a boarded wall construction with one or two sheets of plywood for stiffness. These are usually placed at the two corners of each wall where they provide the greatest rigidity, even with "broken" plates. This system seems to have all the advantages of diagonal boarding, but is much less expensive. I've used it and it appears to work well—the buildings feel good—but I don't have specific stiffness figures. Preliminary calculations suggest a ratio of 20 percent plywood to 80 percent boarding.

Dow Chemical, which makes Styrofoam, recommends a hybrid plywood/boarding system for use with foam on the exterior. Here, the plywood at the corner four feet of each wall is 1/4 inch, and the foam over the plywood is 3/4 inch. This system *looks* good, but may be difficult to actually put together. For one thing, the quality of the 1/4-inch, construction-grade fir plywood that is available—at least in eastern Maine—is not good, although lauan and Masonite seem like pretty inexpensive and reasonable alternatives. Furthermore, 3/4-inch foam sheeting is never available, unless you are willing to buy a full pallet.

Sketch 5. *T-section should outperform flat metal strapping.*



There are two other stiffening systems: diagonal flat metal strapping, and diagonal T-strapping. The flat metal strapping is all right in tension, but against a compressive load it's a wet noodle (Sketch 4). Using it corner-to-corner in an X pattern might work, but with nothing to go on except instinct and experience, I don't particularly like it. It seems as though it will "work" around, enlarge the nail holes, and then not provide any more stiffness.

The T-section (Sketch 5) is a little more promising since it will support compression. You install it by cutting a diagonal kerf one inch deep and nailing it up. All I've seen are the ads, and it isn't stocked by any of my local suppliers. It might be worth some experimenting, but the reviews I hear through the grapevine are mixed.

Certain types of buildings are structural horrors that are particularly susceptible to racking. Foremost is the garage-apartment, where an apartment is constructed over a garage. It's wonderful for a rural rental unit—and can make a solid contribution to the mortgage payments—but it's not physically strong. The lower walls have huge cutouts for the garage doors, the garage space must be empty of interior partitions, which would add stiffness, the apartment floor is heavily loaded, and the whole thing tends to shake. These structures often require a double, staggered skin of plywood on the garage-door wall, and careful control of the size and placement of the door openings. And even then, they shake.

Another monster is the building that has a battery of sliders or other windows. Structurally, this is similar to the garage, but not as bad. There are usually interior walls that can be stiffened with plywood sheathing to provide the rigidity that the exterior skin lacks. The bad part is that the multiple-window configuration usually occurs on an expensive house, and the owner will be especially intolerant of shaking.

So, as usual, be careful. ■

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