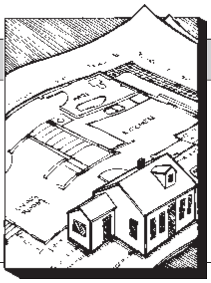


Framing Quiz

by Gordon F. Tully

Last month I discussed some common errors made in concrete foundations. For this issue on structure and framing, I will revisit my very first house design, on which I made a number of bloopers. The house is in excellent shape—although one of the mistakes had to be fixed soon after construction.

A Wall

The first drawing shows the western elevation of this seashore house, which stands about 300 feet back from the water, and up a bank about 20 feet above sea level.

The drawing shows the 2x4 wall framing. All the walls and floors are shown blackened. The floor joists run parallel to the wall, which is 33 feet wide. The ridge of the cathedral ceiling is 20 feet from the lower of the two upper levels. The ceiling is carried on a series of parallel roof beams (shown blackened in), which frame into this west wall.

Before reading further, can you figure out what I did wrong? (Ignore the creative framing at the ridge beam.)

Answer: The wall was framed up with properly sized headers, plates, and so on. But strong winds from the west are normal at the seashore. What went unnoticed was the fact that the wind load on the upper-floor windows and sliding door gets concentrated in the three or four 20-foot 2x4s in the center of the wall. These members are simply inadequate to carry such a load. This is a good example of using standard framing where special engineering is called for.

During the first winter, our sharp-eyed tenant noticed that the wall moved like a drumhead during 70-mph winds. He measured a two-inch deflection, and gave us a call.

To brace the wall, we added on the inside a carefully engineered, glued and screwed, multilayer, horizontal plywood diaphragm, which now forms an attractive soffit over the windows and doors. The diaphragm picks up the wind load and transfers it to the two outer roof beams, thereby acting as a horizontal beam.

A Porch

On the west side of the same house is a cantilevered deck, supported by a 2x12 on each side and a 4x12 in the middle. These beams are blackened in on the wall drawing, just below the upper floor.

While one beam is buried in the right-hand wall, the others run back into closets. The porch cantilevers 5 1/2 feet from the wall, and the beams are 11 feet apart and 12 feet long. Can you spot the problems with this porch?

Answer: One problem is that the beams are not long enough. Although the drawings call for the ends to be tied down to the slab, there simply is not enough weight in the structure to counterbalance the design load of the porch. (There is, unfortunately, no partition above the beams.)

A more serious problem is that the beams are undersized per the BOCA code. Why, then, hasn't the porch fallen down or seriously deflected? Simply because the building code asks you to design for a pretty large live load, and to reach that load there would have to be 51 people on the deck. However, the worst case to date has probably been 20 or 25 people, producing a load that does not over-stress the beams.

A problem that many might miss is a common one: underestimating the size of a post. The post in question occurs at the cantilever support point. The load on the post is *twice* the total load from the deck on the beam, because both the deck and the tie-down are pressing on the post with equal force.

A small post will have no trouble carrying the load. The problem, however, is that it will crush the wood fibers of the beam above and the wall sill below. The allowable compressive strength *across* the grain for most species is about one-quarter the allowable compressive strength *along* the grain. This cross-grain compression strength governs the size of the post. The end of the post must be big enough to spread the load and prevent crushing.

In this case, the post is exactly *half* the size needed, but, again, a problem hasn't arisen because the worst load on the porch so far has been about half the design load of 60 pounds per square foot.

A Porch Railing

The final conundrum involves the design of a typical porch railing, such as the one on this house. If the railing is to meet the BOCA code, it must resist 50 pounds per foot, or a single load of 200 pounds applied at the top of the railing. The railing must be at least 36 inches high.

Two alternative designs are shown. One has a pair of 2x4s bolted to each side of a 2x10 joist, with 1/2-inch bolts spaced 6 1/4 inches apart. Notice that both members run past the joint to provide enough clearance between the bolt holes and the ends and edges of the wood members. If you don't do this, the wood might split.

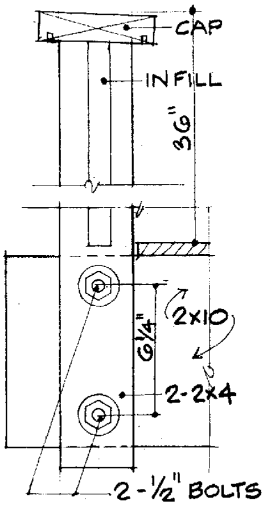
To prevent splitting in this case, the bolt must be a distance of seven bolt diameters from the ends of the 2x4 and the 2x10. And it must be four diameters from the edges of the 2x4, and 1 1/2 diameters from the edges of the 2x10 (measured from the center of the bolt). These limits are determined by whether the bolt is pushing across or along the grain.

Question: How often does this detail have to occur in a deck that runs indefinitely; that is, one that has no angles or corners to brace it?

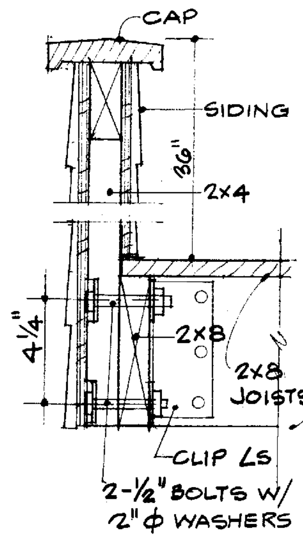
Answer: Approximately 16 inches on center (approximately, because readers should check their own railing designs and not treat this one as gospel). The calculations are based on the 50-pounds-per-foot rule. The other criterion—that the rail must resist a 200-pound point load—should be checked.

The other design shows a flat 2x4

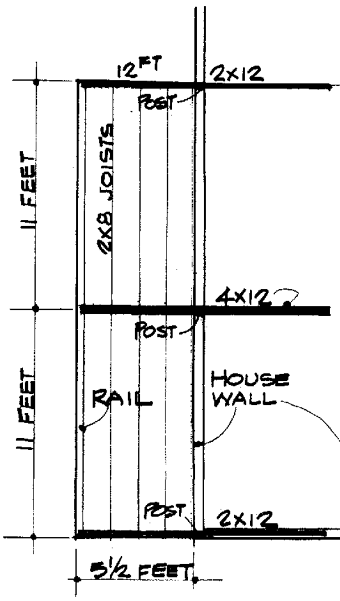
Porch Rail Detail #1



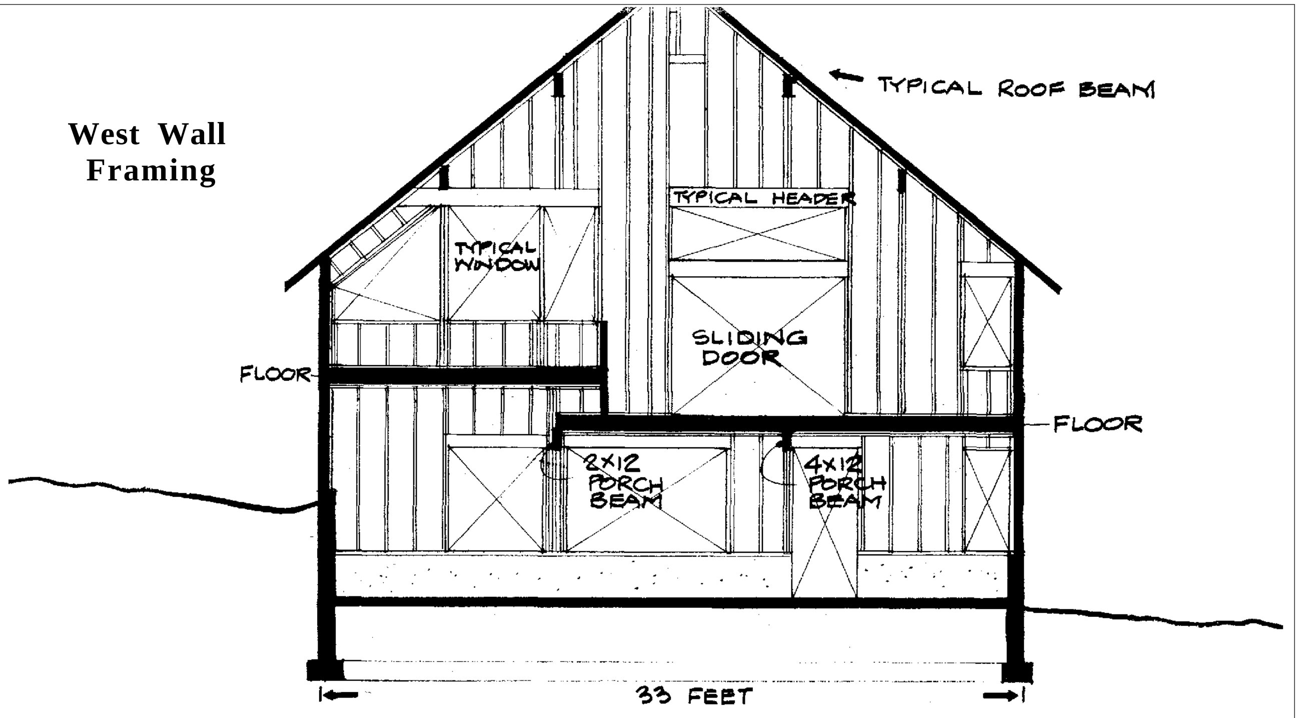
Porch Rail Detail #2



Plan of Porch



West Wall Framing



buried in a solid railing and bolted to a 2x8 running along the edge of the deck. It is bolted on with two 1/2-inch bolts equipped with heavy 2-inch-diameter washers spaced 4 1/4 inches apart. The 2x8 is, in turn, attached to the framing with steel clip angles.

Again, the question is: What must the spacing of the 2x4s be, and how often must the 2x8 be clipped back to the framing?

Answer: The 2x4s must be spaced about 18 inches apart, as limited by the size of the washers, which distribute the load to prevent crushing the members. But the real problem with this detail is how to get the torque out of the 2x8 and into the perpendicular framing.

The 2x8 will try to roll out at the top, due to the 50-pound-per-foot pressure at the top of the railing and translated into the 2x8 by the bolts. This twisting must be resisted by a clip of some kind. The nails or bolts at the top of the clip must resist a pretty substantial pull: about 350 pounds per running foot of railing.

For example, if you fasten each leg of each clip at the top with a single 16d nail, you will need a joist every 4 1/2 inches! If you double the 2x8 and use two 16d nails on each leg of each clip, you can space the joists about 12 inches on center. If you use 1/2-inch lag screws and are careful how you anchor them into the joists, you might reach a spacing of 24 inches o.c. (The clip angles are assumed to be steel plates, not 16-gauge joist clips.)

In all railing details, the fastening problem goes away if you up-size the joists from 2x8s to 2x10s or 2x12s. The fasteners then act over a longer lever arm (moment arm) and the stress drops.

Another strategy is to brace the railing with buttresses, returns, or angles, and to install a heavy top member as a horizontal beam. Now, new crucial joints occur at the corners, where the stress in the railing has to be transferred to the bracing rail.

Moral

It is hard to accept code-imposed design limits when the "normal" practice doesn't even come close to meeting code. Is the code therefore wrong? Is it ridiculous to imagine that a deck could be jammed with people, many of whom would lean on the railing?

I'm sure the code is dealing with the worst case, which seldom happens. Designing for the worst case—whether through building codes and zoning ordinances, or flood-plain and hazardous-waste-disposal regulations—always costs money.

You may feel the extra money to make a deck safe is wasteful and you may be right. As in my case, you may violate the code unintentionally by using intuition rather than engineering.

Once a code standard is set, however, any accident that occurs will be measured against that standard. Unless you have met it in your construction, you may find yourself on the losing end of a court case.

It's a tough problem, and one I haven't found a satisfactory answer to. And if you don't familiarize yourself with the code, it's especially hard to solve problems—because you won't even know about them. ■

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