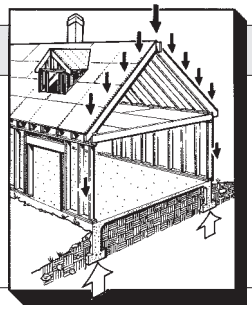


Holding It Together

by Harris Hyman, P.E.

Typical porch deck construction is joists running perpendicular to the side of the house. The joists are then supported by a ledger strip nailed to the side of the house. Is this strong enough? Let's see.

Suppose our deck is 6 feet deep by 12 feet wide, with joists placed 16 inches on-center. The inside ends of the joists sit on the ledger or in joist hangers attached to the ledger. A box joist is nailed into the outboard ends, and this box joist is supported by posts. Building codes specify a working design load of 60 pounds per square foot on small exterior residential balconies. Because the joists are placed 16 inches (1.33 feet) on-center, the load per running foot on each joist is:

w = 1.33 sq ft/ft x 60 lb/sq ft = 80 lb/ft

The total load on each 6-foot joist is:

P = 6 ft x 80 lb/ft = 480 lb

This load is shared, half held up by the ledger, and half held up by the box joist. The force of the half load that is felt by the ledger is called the "end reaction," which is:

$$R = \frac{P}{2} = \frac{480\ lb}{2} = 240\ lb$$

Therefore, each 16-inch section of the ledger must have sufficient nails to support a lateral load of 240 pounds.

The Humble Nail

It is almost too obvious to say that nails are the basic fasteners in wood frame construction. However, few engineers and fewer builders have considered the strength of nails. We just bang 'em in, and where we get worried, we bang in a few extra ones, running pretty much on feel and experience. Meanwhile, a lot of research has actually been done on nailing. The holding power of a nail depends on the diameter of the nail, the distance it penetrates into the wood and the type of wood used. The research also looks at two different loading situations: *lateral loading* and *withdrawal*.

Lateral loading is a load that is perpendicular to the nail; the ledger nails are laterally loaded. Most builders *never* use nails loaded in withdrawal situations, where the load tends to pull the nail out. It just isn't done, except for nailing up ceiling drywall or the like. (At least, most builders *think* they never do — more on this in a later column.)

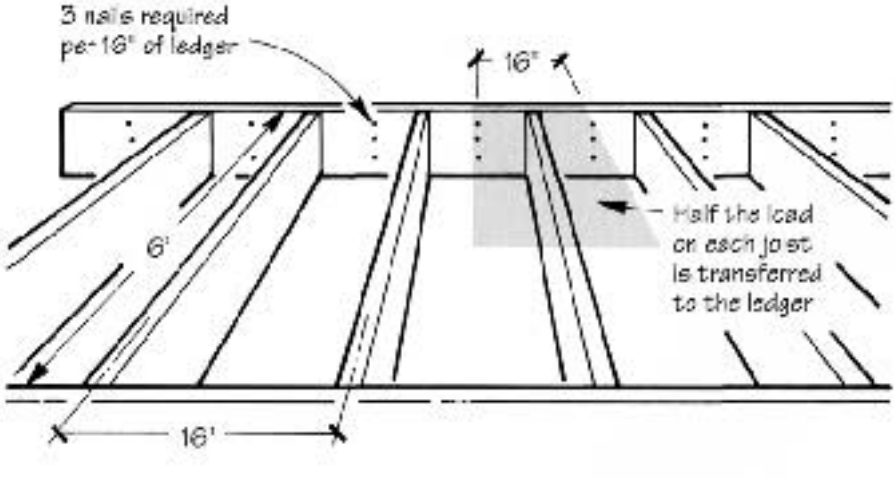
The research has come up with nailing tables and rules. The table shown below, for example, is from the Uniform Building Code.

Let's get back to the deck ledger. Each 16 inches of ledger supports 240 pounds. Here in the West, most of the framing is Doug fir, so we need three 10d or 12d nails for each 16-inch section of ledger. I have never seen nailing tables for eastern spruce, but I have seen research reports. These suggest working values of about 2/3 the safe loads of nails driven into Doug fir. So in New England, you'll need *four* nails in each 16 inches of ledger. At the other end of the joist, three nails are needed to support the (Doug fir) joists into the box joist; 4 nails in spruce.

Now take a closer look at the table:

Strength of Nails

Nail Size	6d	8d	10d	12d	16d
Safe lateral load, Doug fir, So. pine	63lb	78lb	94lb	94lb	107lb
Safe withdrawal load, Doug fir	29lb	34lb	38lb	38lb	42lb
Safe withdrawal load, So. pine	42lb	48lb	55lb	55lb	60lb



For a 6-foot-wide deck with a 60 lb./sq. ft. design load, each joist framed 16 in. on-center must carry 480 lb. Half the load is transferred to the ledger, so each 16-in. section of ledger must support a 240-lb. lateral load. According to the chart, for Doug fir or Southern pine lumber, you'll need at least three 10d nails for every 16 inches of ledger (three 10d nails x 94 lb. = 282 lb.).

There really isn't any difference in holding strength between 10d and 12d nails. This is because they both have a diameter of 0.148 inch, but the 12d nails are 1/4 inch longer. And there really isn't too much decrease in strength by dropping to 8d nails. Also, you don't gain much of an increase in strength by using 16d nails. The sharper carpenters have known this for some time and a lot of excellent framing is done with 8d nails.

I'll suggest a rule of thumb: 80 pounds per nail — any nail — in Doug fir, 60 pounds per nail for spruce, and *never* use nails in withdrawal situations. This is pretty workable, and if strength is really a serious consideration, use some fastener other than a nail — like a screw or lag bolt. Screws are about twice as strong in lateral loading and about four times as strong in withdrawal.

There are some suggested rules for nailing.

- Never rely on a single nail — use a minimum of two. Wood is not homogeneous and a single nail could be driven into a soft spot.
- Space nails no closer than half their length, and do not place nails closer than 1/4 of their length to the edge of the wood — this avoids the risk of splitting. For example, 10d nails are 3 inches long. By this rule, don't drive them into the ledger within 3/4 inch of the edge and don't place them any closer than 1 1/2 inches apart.
- Nails need 11 diameters of penetration to hold at full strength. This is about 1 1/2 inches for 8d to 16d nails. If the penetration is less than 4 diameters, about 1/2 inch, just forget about any possible contribution of *that* nail. So when you nail a two-by ledger onto framing through 1/2-inch sheathing, the ledger and the sheathing take up 2 inches of the nail. To penetrate 1 1/2 inches, you'll need a nail at least 3 1/2 inches long — a 16d. But there's a problem: The 16d nail is a little fatter (0.162 inches) and 11 diameters is about 1 3/4 inches. So instead, use a 20d nail — it's 4 inches long and has a diameter of 0.192 inches. Even this is a little shy of the 11 diameters needed, but it's close enough.
- In unseasoned wood, nails have only about 3/4 of the holding power.
- Metal side plates increase the holding power of nails by about 25%, if they are used according to the manufacturer's instructions. Joist hangers are typical holding plates, attached with lots of small nails. Keep a Teco or Simpson catalog on hand to help with messy framing situations.
- Do not toenail for strength. Toenailing should be used *only* to hold things in place until stronger fastenings can be applied. The bottom of a toenailed stud is a model of this — the stud is really held in place with sheathing nails.
- In exterior applications, galvanized nails usually have the zinc pounded off the head during driving, so that they rust and stain the wood. Their real value is increased holding power from the rougher shank. If staining is a problem, spring for stainless steel nails.

In rural areas, spiral-shank, or "pole barn," nails are used a lot. These nails are rated for the same strength as common nails, but they maintain full rated strength in unseasoned wood. (Personally, I do not agree with this rating. I have done some measured tests and found that pole barn nails have 1/3 to 1/2 more holding power. This is speculative on my part, as my tests were not extensive and systematic.)

There are other types of nails that are *very* strong, particularly ring-shank nails used in marine applications. For strength values, look up the manufacturer.

In the past few years, air nailers have become very popular. They are extremely quick and effective, as any user well knows. Air-driven nails have been tested and do have the same strength as hammer-driven nails even though the nail magazine manufacturers are using lighter wire for the nails.

Back to the porch where we started. The joists that rest on the nailed up ledger will certainly keep from falling, but the ledger will not keep the joists from *pulling away* from the building (that's one advantage of joist hangers). Each particular design should be examined for this possibility and appropriate measures should be taken.

Subtle creatures, these nails. ■

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