Alternative Ledger Connections

by Glenn Mathewson

There's more than one way and place to hang a ledger

Over the last year there's been a lot of discussion about the new ledger bolting table and lateral load detail in the 2009 International Residential Code (IRC). I thought I would break out of the box a little bit and talk about some other ways and places a ledger can be supported and how the IRC may be able to help. Let's move away from the band joist connection and away from a black-and-white interpretation of the IRC, to add some freedom and design flexibility to your bag of tricks. And while what I'm about to cover isn't a "don't try this at home" kind of thing, make sure to get your plans approved by the local jurisdiction before building.

Can Studs Handle the Load?

So how smart do you think studs are? Will they know the difference between a vertical live load from a deck and vertical dead load from masonry? IRC section R703.7.2.1 provides criteria for attaching an angle iron lintel to wood studs for the purpose of supporting brick veneer. Why can't the same loading be used to engineer a deck ledger attachment?

A steel angle connected to double 2x4 studs at 16 inches on center with two 7/16-inch x 4-inch lag screws can carry 40 pounds per square foot (psf) of brick veneer to a height of 12 feet 8 inches. Because the doubled studs act like a single larger member, the large-diameter lag screw can get complete penetration into the wood fibers without splitting out the side.

From these criteria, the vertical loads placed at the face of double 2x4 studs can be easily determined. At 40 psf and 12 feet 8 inches of allowable height, the bolting prescribed by the IRC is supporting 480 pounds per linear foot of dead load. So, if a bolted lintel can handle 480 pounds per lineal foot, you can equate it to a deck load by dividing by 50 psf, the minimum combined live and dead load of deck. That yields a potential 10 square feet of deck supported by each foot of ledger. Because only half the load of a deck is borne by the ledger (the outer beam carries the other half), this is equivalent to a deck with a 20-foot joist span, far greater than typical.

One argument against this interpretation may be that floors supporting an occupant load would have a safety factor built in to the prescriptive criteria and that brick veneer loads would not. If that were the case, the standard 2.5 safety factor for testing of assemblies would certainly be appropriate. With that consideration, you could still have an 8-foot span between bearing points. This would be very conservative, but should be easily acceptable.

We aren't finished with the analysis though, as only the magnitude of the load has been equated. Next we have to consider the replacement of a steel angle with a 2-by wood ledger. While the fastener securing two materials together is almost always questioned by builders and inspectors, it is often the wood member in the connection that is the limiting factor. The fastener strains the internal integrity of wood members with as much force as is applied to it. In the race to failure, the wood usually loses — that is, the wood is likely to fail before the bolt.

Consider a generic bolted connection between two pieces of wood using eight bolts. The same connection made with only four bolts that were twice as strong would not necessarily be equal. The force on the wood around the bolts is doubled, increasing the likelihood of wood failure even though the four stronger bolts are capable of supporting the same load as the eight weaker ones.

You can't arbitrarily swap wood for metal without evaluating the force imposed by the fasteners on the wood, a job for an engineer. However, in this application, we know from the IRC's ledger bolting table that wood ledgers handle internal stresses just fine when secured with bolts every 16 inches. In this case, swapping wood for metal doesn't really make a difference.

Another item for consideration is the length of the lag bolt penetration into the studs. The steel angle is only about 1/4 inch to 3/16 inch thick, as opposed to the 1 1/2-inch-thick ledger, so adding about 1 1/4 inches to the length of the 4-inch bolts is in order.

The most difficult part of this connection method is the need for double studs, which are not typical in most walls. On new construction, it's easy enough to add studs. But on an existing house, you will likely find doubles only at corners and at the sides of windows and doors. So, while this solution may not work for all applications, it does provide some design freedom in others. For instance, if the deck is outside an unfinished walkout or garden-level basement, or a garage, then adding some studs may be easy.

Connection to a Foundation

In my former career as a deck builder, I bolted many decks to concrete foundations. I am sure many of you have done the same. There are lots of good reasons to do this; for one, it provides a step down to the deck, which limits the amount of snow that can build up around the door. And dropping the deck also "lowers the stage" from all the neighbors. Often just a few feet can make the difference between seeing over a privacy fence or not.

Connecting a ledger to a foundation also allows you to avoid the extra beam and footings required for a freestanding deck, simplifying the framing. A landing or a small upper deck will take care of the step at the door. Though I was never questioned about it during inspections, I wouldn't have known a way to back it up by the code. Now that we have a ledger bolting table in the IRC, equivalent methods can be submitted with little effort.

There are only a few differences between ledger connection to band joists and to concrete. The only criteria I see needing evaluation are the fastener shear strength, the fastener connection strength, and the internal strength of the concrete. Manufacturers like ITW Red Head (630/350-0370, itw-redhead.com), Simpson Strong-Tie (800/999-5099, strongtie.com), and USP (800/328-5934, uspconnectors.com) know that for their products to sell, they have to be tested so limitations of use can be provided to consumers and designers. Testing is one way to approval as an alternative to the code. Combining these tested connections with the ledger table in the code shouldn't be a problem at all.

What About Lateral Loads?

With the addition of the lateral load anchor detail to the 2009 IRC (see *Structure,* November 2009; deckmagazine.com), it's hard to say whether the bolts in the ledger table are given any credit for resisting lateral loads. While failing band joists were the reason for the detail, many folks will read the 2009 IRC and discredit all lateral restraint from ledger bolts: "Why would the lateral anchor detail be there if the ledger bolts could resist the loads?"

The history of successful bolted connections tells me lags are worth something in the battle against lateral loads. I've never heard of a deck ledger whose properly installed lag bolts pulled straight out of the fibers of the band joist. Lag screws have listed withdrawal capacities in the NDS (National Design Specification for Wood Structures, a referenced standard of the IRC and IBC) of around 400 pounds per inch of penetration in Douglas fir. The problem isn't the ledger-to-band-joist connection, but the one between the band joist and the house. If the band joist is the problem, I think bolting to the studs or using concrete anchors of comparable strength is a perfectly fine way to achieve lateral load resistance — one lag fully penetrating a 2x4 stud provides up to 1,400 pounds of withdrawal resistance. Two lags would easily handle the lateral resistance requirement. And in the case of attaching to foundations, all manufacturers make adhesive anchors tested to well over the 1,500-pound load specified in the IRC for lateral resistance.

As always, though, consult your local building official. ❖

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