Handling Lateral Loads

You don't need to destroy interior floors to attach a deck to the house

by Glenn Mathewson

It's been about two years since I first wrote about the lateral load anchor detail that was included in the 2009 International Residential Code (*Structure,* November 2009; deckmagazine.com). The relevant IRC section reads: *The lateral load connection required by Section R502.2.2 shall be permitted to be in accordance with Figure R502.2.2.3. Hold-down tension devices shall be provided in not less than two locations per deck and each device shall have an allowable stress design capacity of not less than 1,500 lb.*

In short, this means that decks attached to houses must be provided with a minimum of 3,000 pounds of lateral resistance to keep the deck from falling away from the house. The idea is to prevent the deck ledger from detaching from the band joist and also prevent the band joist from detaching from the house. The one detail shown in the code to achieve this — using two special tension anchors — isn't specifically required (**Figure 1**).

As a building inspector, I've worked under the 2009 IRC since it was adopted; however, no tension anchors have been installed in my jurisdiction during that time, and inspectors in other local jurisdictions say they haven't seen any either. Why aren't they being used? There are a few reasons, not the least of which is that the anchor detail isn't required — it's just one possible way to address lateral loads. Also, the 2009 IRC is a whopping huge book, with quite a few high-profile changes in it that have monopolized the attention of code professionals. (For example, residential fire sprinklers are now required for new construction, and the electrical codes call for tamper-resistant receptacles and arc fault protection.) And in truth, the mere addition of something to the code doesn't mean it'll be enforced; some things have been in the IRC for decades and still get no attention, such as treating the cut ends of pressure-treated lumber. Finally, deck failures that pull the band joist completely from a house aren't common enough in my area for regulators to push for enforcement of the lateral load requirement.

Regardless, the code is very clear that lateral load restraint must be provided.

Practicality of the Lateral Anchor Detail

Unfortunately, in all but new construction, the IRC's lateral anchor detail is often not feasible. For one, it requires access to floor framing inside. Also, the floor sheathing in the area of the anchor must be nailed 6 inches on-center. This creates an unreasonable situation when a deck is being added to an existing home, because the floor sheathing in most homes is nailed 12 inches on-center; in order for the code detail to be followed exactly as published, the floor covering will have to be removed for fasteners to be added. Assuming the deck is connected to a joist using tension anchors, would a deck failure really extract a floor joist lengthwise from a home if a few extra nails were not installed? I think not. That said, Simpson Strong-Tie (strongtie.com) does publish a detail of a way to attach an existing floor to the joists from below (**Figure 2, next page**).

There is no accepted engineering practice for determining the magnitude of lateral loads in a given deck design. Different sizes and shapes of decks have different dynamics in loading, but the anchor detail

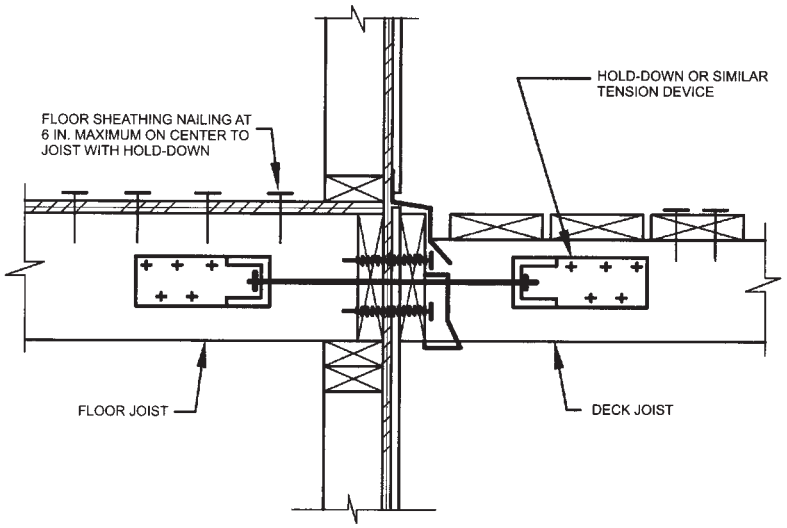

FIGURE 502.2.2.3
DECK ATTACHMENT FOR LATERAL LOADS

Figure 1. Figure R502.2.2.3 from the 2009 IRC shows one method of providing decks with resistance to lateral loads. Decks don't have to be attached to the house in this way, but building officials are likely to accept this detail without question.

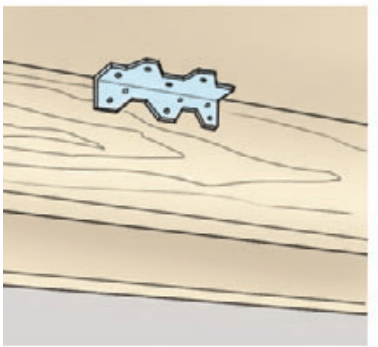

Figure 2. For situations where it's not possible to verify how well the floor above is nailed to the joist where a tension anchor is to be attached, hardware manufacturers provide an alternative method.

ILLUSTRATIONS BY CHUCK LOCKHART

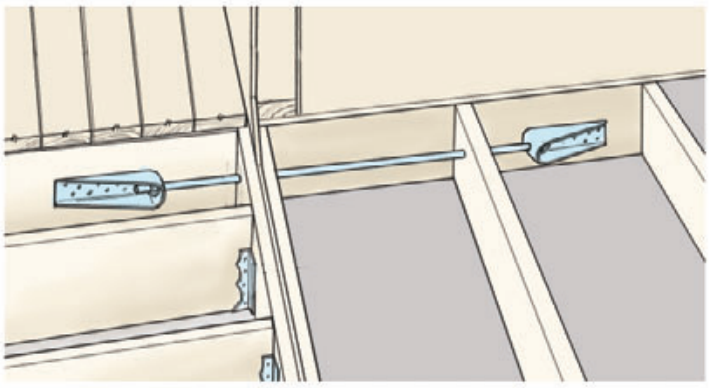

Figure 3. The IRC doesn't provide a lateral attachment detail for when the floor joists run parallel to the ledger. One commonly accepted approach is to provide blocking and use long bolts to fasten a tension tie several bays in.

made it into the code without that consideration. Consequently, the 1,500-pound restraint required at each of two anchors is empirical and essentially unfounded, as it doesn't relate at all to the structure at hand.

The code requirement does set a bar that one could attempt to reach in other ways, many of which *are* feasible on existing homes. When you're faced with the destructive nature of installing anchors inside a home, it's worth considering an alternative to what the IRC offers.

Situations Not Covered by the IRC

The IRC doesn't provide guidance about what to do for a lateral load anchor when floors aren't framed of typical dimensional lumber or when the joists run parallel to the deck ledger (**Figure 3**). For these situations, you've got to do some objective thinking. What is the goal?

The anchor detail was put in the code to address the issue that a typical band joist is not designed to resist a lateral force. It has two primary jobs (without getting too technical about horizontal diaphragms). Nailed into the ends of the floor joists, a band joist resists rotation of the joists, a natural tendency when under load. This orientation puts a shear force on the nails extended through the band joist and into the end grain of the joists — exactly the force nails are best at resisting. The other function of a band joist is to resist compression; it transfers the loads of the wall above through itself and to the plate below. The band joist's disconnection from the remainder of the

floor system is a concern; bypass it or connect to other framing elements and you may be on the right track.

When joists run parallel to the band joist, the IRC detail is insufficient. If the goal is preventing the ledger from detaching from the house, a bit of blocking and longer bolts to connect the ledger to other parts of the floor system, like the first spanning joist in from the band joist, should be sufficient.

With engineered floor systems such as I-joists or floor trusses, there are bigger issues. These systems rely solely on the manufacturer and its engineers to determine what the product can do, so the first step is to find out who the manufacturer is. I-joists are usually labeled down the length of each piece of material. A quick search on the Web will likely yield manufacturer-supplied solutions that you can confidently install (**Figures 4, 5**). These may look much like the lateral attachment detail in the IRC, but with the addition of web stiffeners between the flanges of the I-joists.

Floor trusses combine 2x4 framing lumber and steel gussets in standardized ways, and there are published load limitations for them. With that data, an engineer designs individual floors. One big difference between floor truss systems and other types of framing is that there's no band joist. Rather, the trusses bear completely on the exterior plate or mudsill and are flush to the back of the sheathing. The trusses are then either blocked or provided a 2x4 on their upper outside edge to prevent rotation.

The Structural Building Component Association (sbcindustry.com) provides guidance for bolting ledgers to floor truss systems. Instead of being bolted to a band joist (because there is none), the ledger is bolted to the end 2x4 members of each truss and to blocking installed for this purpose (**Figure 6, page 4**). While I can't speak specifically or with authority as to how well the end members of trusses are connected with regard to lateral loads, I can say that we are no longer dealing with a concentrated 1,500-pound load, as the lateral attachment requirement in the IRC posits. Rather, lateral resistance is generated uniformly by the bolted connection at each truss location. This spreads the load out over more members — a far better build in my opinion. Professionally, for the average deck, I would not be concerned

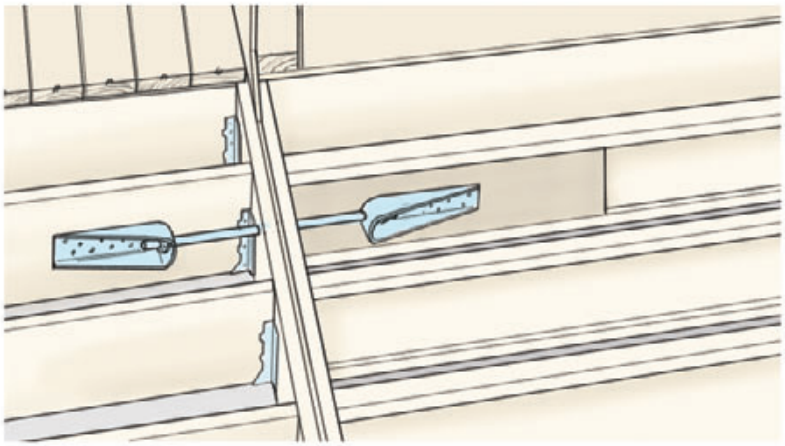

Figure 4. Typical tension-anchor details supplied by engineered-joist manufacturers look much like the IRC detail. One key difference is the addition of structural panel web stiffeners to the joists.

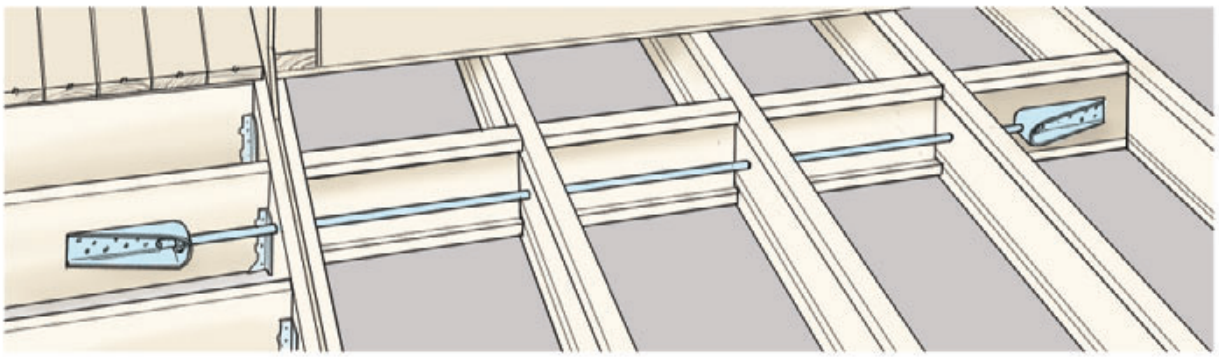

Figure 5. When engineered joists run parallel to the deck ledger, blocking, web stiffeners, and much longer bolts may be required.

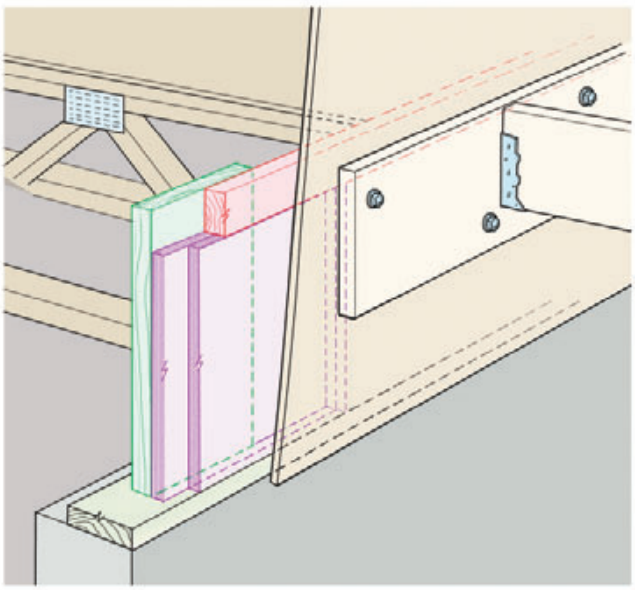

Figure 6. Solid blocking is generally required when bolting a deck ledger to floor trusses. Additionally, bolts are driven into the end of each truss.

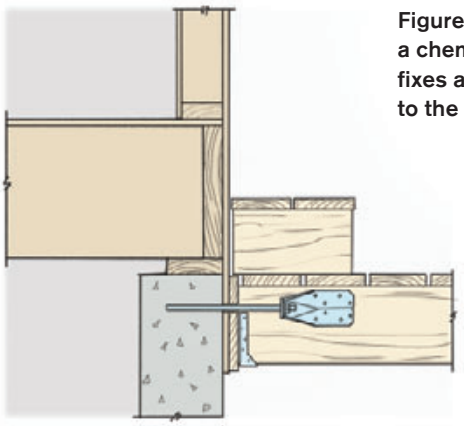

Figure 7. In this detail, a chemical anchor fixes a tension tie to the foundation.

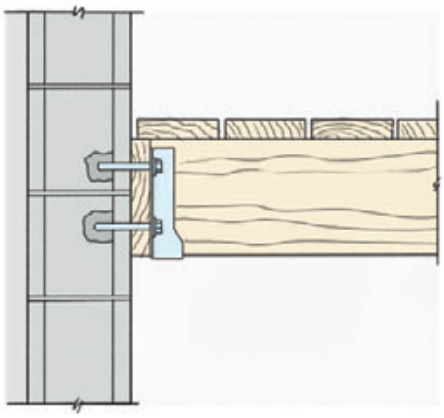

Figure 8. Deck ledgers can be attached directly to the concrete or masonry foundation of a house, using chemical or expansion anchors. The anchors alone usually generate in excess of 1,000 pounds of resistance to withdrawal.

that the loading would rip apart all the floor trusses in one catastrophic failure.

Lowest-Floor Decks

When a deck serves a floor resting directly on the foundation, my suggestion is to forget the home's wood framing entirely. Drop the ledger and attach it to the foundation (this isn't an option when the foundation has a masonry veneer); Simpson provides a detail for using its deck tension tie hardware (**Figure 7**). This approach will become more relevant going forward, as provisions in the 2012 IRC limit bolt locations in the ledger and the band joist, which will make it nearly impossible to step a deck down from the door, a popular design in snowy regions. The complicated bolting parameters in that code are a shocker and will be discussed in greater detail in a future issue of *PDB*.

Even simpler, when attaching the ledger to a concrete foundation, you can use published and tested loads for various concrete anchors for both vertical and lateral restraint (**Figure 8**). Achieving 3,000 pounds of tension resistance is easy through the use of these anchors, and resistance would be distributed more uniformly and along the entire length of the ledger, a far better construction than the two random and unspecified locations for the lateral load anchor method currently shown in the IRC. The values for tension published by manufacturers of epoxy, acrylic, and mechanical anchors are all at least 1,000 pounds for $^1/_2$-inch-diameter fasteners. Any of these anchors, spaced at 12 or 16 inches on-center, will well handle the vertical and lateral loads of any common deck.

There are several other advantages to attaching the ledger to the concrete foundation. It's likely below the exterior cladding, which therefore won't have to be removed. The deck will also be below any cantilevered floor, which avoids all the issues of that connection (**Figure 9, page 5**). Not to mention that the lower the deck, the more privacy it affords the occupants. Lowering the deck increases the distance from the adjacent windows in the home to the deck floor, and could remove them from safety glazing requirements. The only design contention to keep in mind is the additional steps from the exit door; a landing may be required if the deck is more than 15$^1/_2$ inches below the threshold.

Sinking Posts in the Piers

In the 1940s, design criteria were established for the Outdoor Advertising Association of America

for determining the lateral resistance that can be achieved at the top of a wood pole or post embedded in the ground or concrete. Just as the embedded posts of a fence or a sign can resist lateral forces imposed by wind, so should a collection of deck posts embedded in piers resist lateral deck loads. Though it seems different, it's the same; I assure you the post doesn't know where the loads come from.

Section 1807.3.2.1 of the International Building Code provides the formula for this determination, and it is unchanged in all my code volumes back to 1970. While the calculation is little more than simple mathematics, it's possible a building official would require an engineer to handle the heavy lifting. For general reference, however, I ran a few dozen calculations to see if it was even possible to derive lateral load resistance by embedding posts into the piers on a low-level deck. The variables in the calculations include the diameter of the pier, the height of the post, the soil compressive strength, and the lateral load to be withstood.

Figure 9. Attaching a deck ledger to the foundation has the added benefit of placing the ledger below any building cantilever.

For posts that extend up to 2 feet above grade, in the lowest valued soil (1,500 psf), and with 12-inch-diameter piers, six posts embedded approximately 25 inches deep would handle the required 3,000-pound lateral load (**Figure 10**). With 16-inch piers, six posts would need to be embedded only 20½ inches. The more posts sharing the load, the less deep they have to be embedded. Likewise, shorter posts require less embedment. I don't think embedding posts in the piers is the best way to build because embedded posts can't be replaced easily. However, it is a common method, and if you're already building a deck with sunken posts, they could provide the lateral load resistance you need.

Bolting to Multiple Members

The driving force behind the inclusion of the lateral load anchor in the code was that band joists are not

Embedment Depth (Inches) for Resistance of 3,000-lb. Lateral Load							
1,500 PSF soil strength		Number of Posts					
Height of post (feet)	Pier diameter (inches)	3	4	5	6	7	8
2	12	41	33	28	25	22.5	20.5
	14	36.5	30	25.5	22.5	20	18.5
	16	33	27	23	20.5	18.5	17
3	12	46	37.5	32	28.5	28	23.5
	14	41	34	29	26	23.5	21.5
	16	37.5	31	26.5	23.5	21.5	20
4	12	50	41	35.5	31.5	28.5	26
	14	45	37	32	28.5	26	24
	16	41.5	34	29.5	26	24	22
5	12	53.5	44.5	38.5	34	31	28.5
	14	48.5	40	34.5	31	28	26
	16	44.5	37	32	28.5	26	24

Figure 10. This chart provides an idea of the size, depth, and number of piers required to provide sufficient lateral load resistance to meet the IRC's 3,000-pound requirement.

designed to resist loads from a deck. Plus, even if a band joist were installed in a way designed to provide the required lateral load resistance, that could not be verified after construction. With that in mind, I asked myself if the top plates and the studs of the wall below the floor could be subject to failure from lateral loads (**Figure 11**). Considering the orientation and repetition of the fasteners and the vertical load the wall is carrying, I don't think a deck is likely to pull a wall down. Likewise with the mudsill.

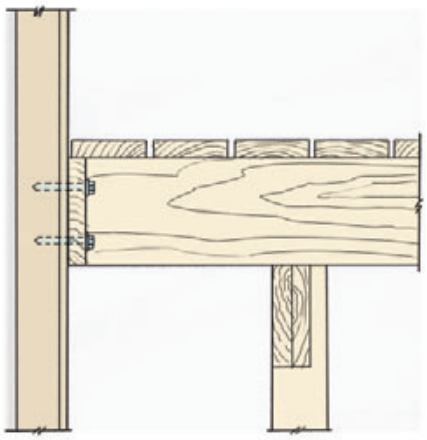

Figure 11. Bolting a ledger directly into wall studs avoids attachment to the band joist and may provide sufficient lateral resistance.

While I have no engineering or tests to back it up, I think it's worth exploring whether a 2x12 ledger installed directly against the structure one step down from a door and bolted to the rim, the top plates, and the wall studs would provide the needed lateral resistance. Connecting those parts together with a large ledger would create an assembly that isn't likely to fail. Perhaps lag bolts spaced 12 inches on-center into the band joist, followed by 5-inch structural screws below into the top plates, and finished with a third row of structural screws at 16 inches on-center into the wall studs would be a sufficient connection. With rows of fasteners into three different building components, you've got one heck of a fastened ledger, with redundancy in each connection. When fastening to the wall studs, throw in some extra fasteners where there are extra framing members, like headers over windows or king studs to their side. Using a 2x12 ledger lets you bolt to many building components, and bolts are cheap when faced with the code-provided alternative.

When bolting to the top plates or the studs, you get far more penetration into lumber due to the members' orientation, compared with the band joist. The more wood the fastener bites, the more withdrawal load it can handle. Since the structural screws will be penetrating so deep, check for electrical wire in the wall first. A good stud finder will help you avoid hitting wires and help you aim the fasteners in the center of the material.

For added lateral resistance, run a galvanized strap behind the ledger and underneath every fourth joist or so to assure the joists are laterally connected to the well-bolted ledger. No drywall repair is then necessary.

Lateral load resistance is important, but proper flashing and bolting of the ledger are also necessary. The bolts that attach the ledger to the house handle vertical loads and certainly provide some level of lateral resistance as well. Without proper flashing, the material the ledger is bolted or anchored to is subject to deterioration, ultimately making the connection useless. Rotten wood does not hold a bolt very well. A deck is made of pieces and parts that all must work together to be an effective structural system. ❖

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Deck Harness

The International Code Council's I-codes set a level of performance for buildings, but do not limit how that performance is achieved. ICC-ES is a nonprofit corporation that provides technical evaluations of building products, methods, and materials. ICC-ES does research to determine if alternatives are equivalent to the code, and shares the findings with the world. It also provides assurance to building code officials that alternatives meet the IRC's performance requirements.

In June 2011, ICC-ES released a new Acceptance Criteria, AC430, for testing a cable-method alternative to the lateral load anchor published in the IRC. Acceptance Criteria are developed through a transparent process that solicits public comments. If you're interested in this document, download it from icc-es.org/criteria/dsp.cfm?ac_code=AC430. Unfortunately, the method outlined isn't necessarily any more realistic or feasible than the lateral load anchor. It still requires the floor sheathing to be nailed to the floor joists at a maximum of 6 inches on-center and the ceiling finish material to be removed, and it's specifically limited to new construction. Currently, there are no products that have received an ES report as a deck harness.