

If you follow the news, it may seem like there has been a rash of deck failures in the past few years. Typing “residential deck failures” into my search engine yields thousands of results. There are several reasons we might be seeing more deck failures than ever before. One is that decks have simply become more popular. Back in the 1960s and ’70s, people built patios. The living space outside the home was on the ground. When treated lumber became readily available, patios in large part were replaced by raised wood decks, and more decks mean more opportunities for deck failures.

Another reason is related to the growth in size and complexity of residential decks over the years. It’s common now to see heavy loads from hot tubs and large grills placed on decks, and many decks have multiple levels as well as angles and curves. Prescriptive codes and common references don’t typically cover decks of such design. Instead, they provide guidelines for building decks that are basically rectangular in shape and that meet certain size requirements. The American Wood Council’s *Prescriptive Residential Wood Deck Construction Guide* (DCA 6-12), which many jurisdictions accept as an alternative to the IRC for deck construction, states, “The overall deck length shall be equal to or less than the overall deck width.” Decks with concentrated loads or shapes that don’t fit into the prescriptive guidelines may require an engineered design, and this engineering doesn’t always happen.

Still another reason for the preponderance of deck failures is time. Wood rots and steel rusts—even treated wood and galvanized steel. And many older decks were not built to the standards of today’s code. Time is particularly unkind to structures built with substandard materials and poor methods. Contractors may say that modern code requirements are overkill, that the design loads building codes specify are extremes that rarely occur. It may be decades before circumstances prove those contractors wrong. With time comes not only deterioration but the increased likelihood that a deck will see a load that approaches or exceeds its maximum design load. It might be a big graduation party or the placement of a kiddie pool on the deck.

As a structural engineer, I’ve investigated a number of deck failures. I tend to see the same problems over and over. Usually the question I ask isn’t “Why did it fall down?”; it’s “Why didn’t it fall down sooner?” Each component of a deck can be at risk if not properly designed and constructed. In my experience, most structural failures occur when more than one problem exists.

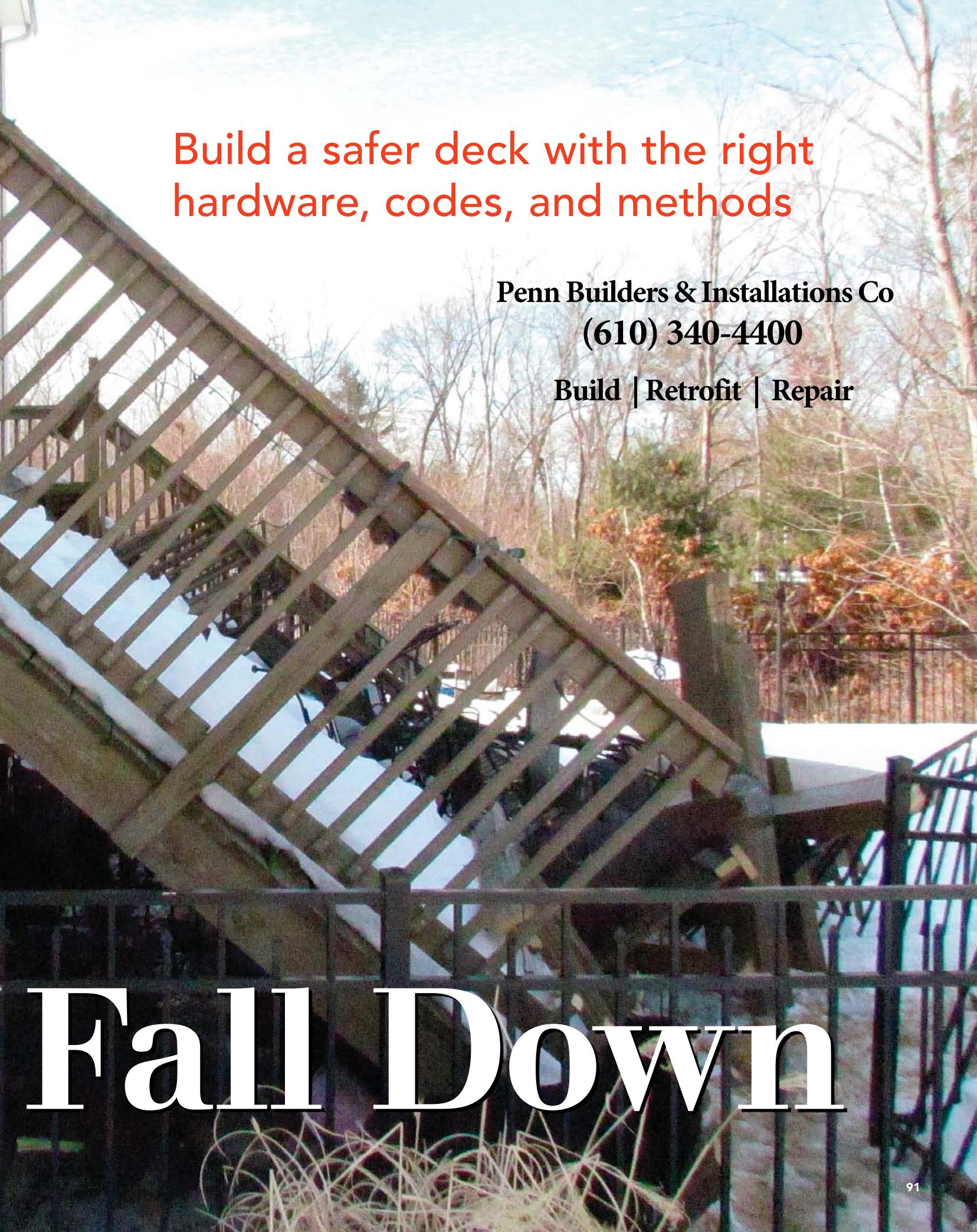
I hope that showing what can happen to decks that are built poorly helps you to understand why the building-code provisions exist and encourages you to identify the specific requirements for your project. Anyone building a deck needs to understand the basis for deck design and the codes, and to follow the manufacturers’ instructions for the material and hardware used. Even if you hire a contractor, you still need to make sure that he or she obtains building permits and calls for inspections. “The Fix” drawings shown here are based on the DCA 6-12, which you should refer to for complete details.

David Grandpré, P.E., is a structural engineer in Cranston, R.I. Photos by the author, except where noted.



Snow collapsed this deck. Here, the posts and beam had not been properly braced. The snow load on the deck created unbalanced forces on the posts that caused them to rotate and tip over.

Why Decks



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Fall Down

WHY DECKS FALL DOWN

FAILURE

1 The deck-ledger attachment

Improper installation of the ledger to the house is probably the most common reason for deck failure. Since the 1980s, codes have required that the deck ledger be bolted to the house, but it's still common to see nailed connections in older decks and in decks built without permits. In some cases, sudden failure at the ledger has resulted in injury and even death. This is a widely discussed topic, and recent editions of the building codes have done a good job of providing prescriptive requirements for fastening deck ledgers.

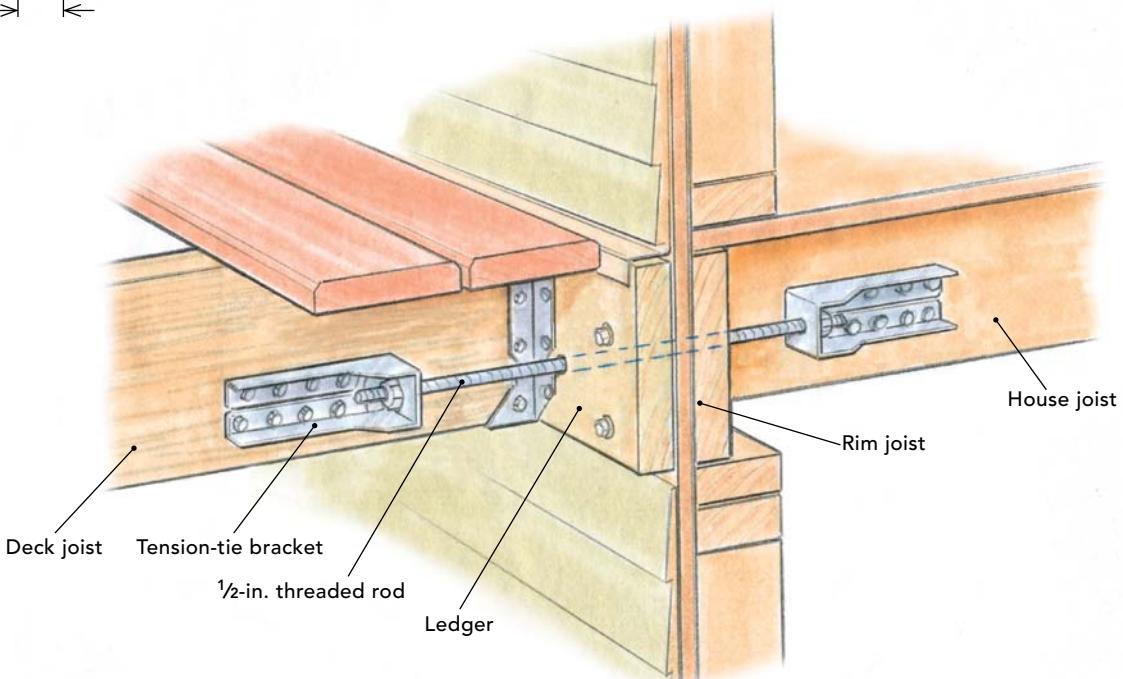
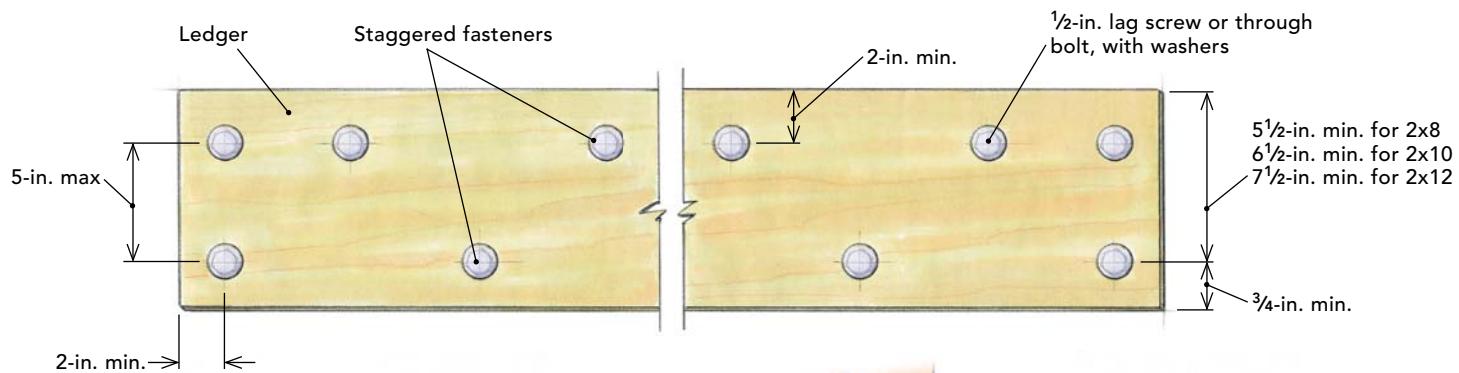
THE
FIX

Bolt the ledger and the house together

Code now requires decks to be attached to the rim joist of a house with a minimum of either $\frac{1}{2}$ -in. machine bolts or $\frac{1}{2}$ -in. lag screws; in both cases, the fasteners must be made of hot-dipped-galvanized or stainless steel. Bolt location and spacing is spelled out in both the IRC and the DCA 6-12 and depends on the span of the joists. Additionally, code now requires a lateral-load anchor capable of resisting a 1500-lb. outward pull in two places on each deck. One common method uses threaded rods and tension-tie brackets screwed to the joists in the house and the deck. The details here are for houses with solid-lumber joists. A house with engineered joists or floor trusses requires different details acceptable to the manufacturer.



Detaching ledger. In this case, the homeowner noticed the failure of the nailed connection before the deck gave way. In other cases, decks have given way suddenly, often when they've been loaded with people.



FAILURE

2

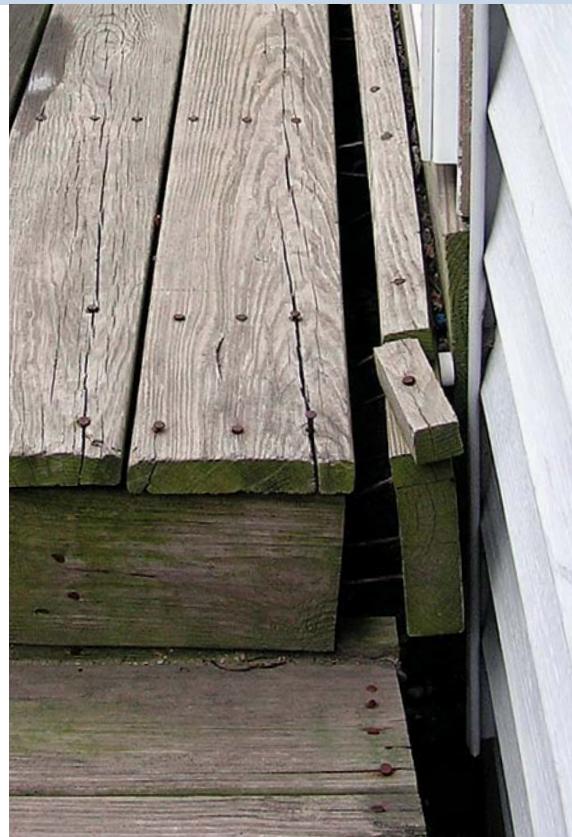
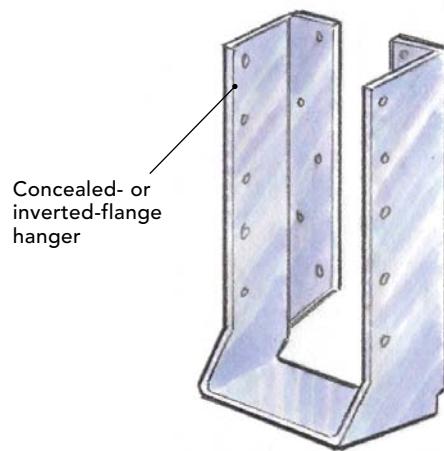
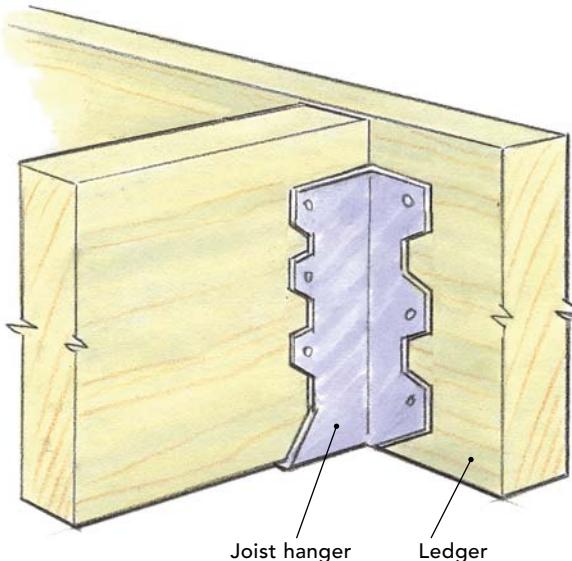
Joist-to-ledger connections

The use of metal joist hangers in joist-to-ledger connections has become an industry standard. Previously, joists were usually toenailed to the ledger. Alternatively, nails were driven through the ledger into the end grain of the joists, with the entire assembly then put in place and the ledger secured. Nails used in these ways don't provide either the shear connection or the withdrawal resistance needed. Any hardware or structural fasteners used on a deck must be stainless steel or galvanized to the G180 standard (which is stamped on the hardware).

THE
FIX

Tie the joists to the ledger with joist hangers

Properly sized joist hangers support vertical loads and help to prevent joists from pulling away from the ledger. Joist hangers with concealed or inverted flanges should be used for joists at the ends of a ledger. They are nailed to the ledger first, and then the joist is placed in the hanger and nailed home. Stainless-steel hardware should be used near the ocean.



Nails alone don't do the job. This small deck was assembled by driving nails through the back of the ledger into the joists' end grain prior to installation. Toenailed joist-to-ledger connections are more common but also likely to fail.



Use the right joist hangers. Although galvanized, the hangers on this seaside deck are rusty and nearing failure. Regular inspection of hardware is a good idea.

FAILURE

3

Bad ledger flashing

Deterioration of components due to water exposure is a leading cause of deck failures. Decayed deck boards and joists often can be seen and repaired before a deck has a disastrous failure. However, the decay of wood or of fasteners that are not easily observable leads to some of the most dramatic deck failures. The most likely place for hidden decay is at the interface with the house. Not only can ledgers and ends of joists decay, but missing or poor flashing can lead to severe decay of the house's sheathing, rim joist, and mudsill, leaving little for the ledger fasteners to grab.

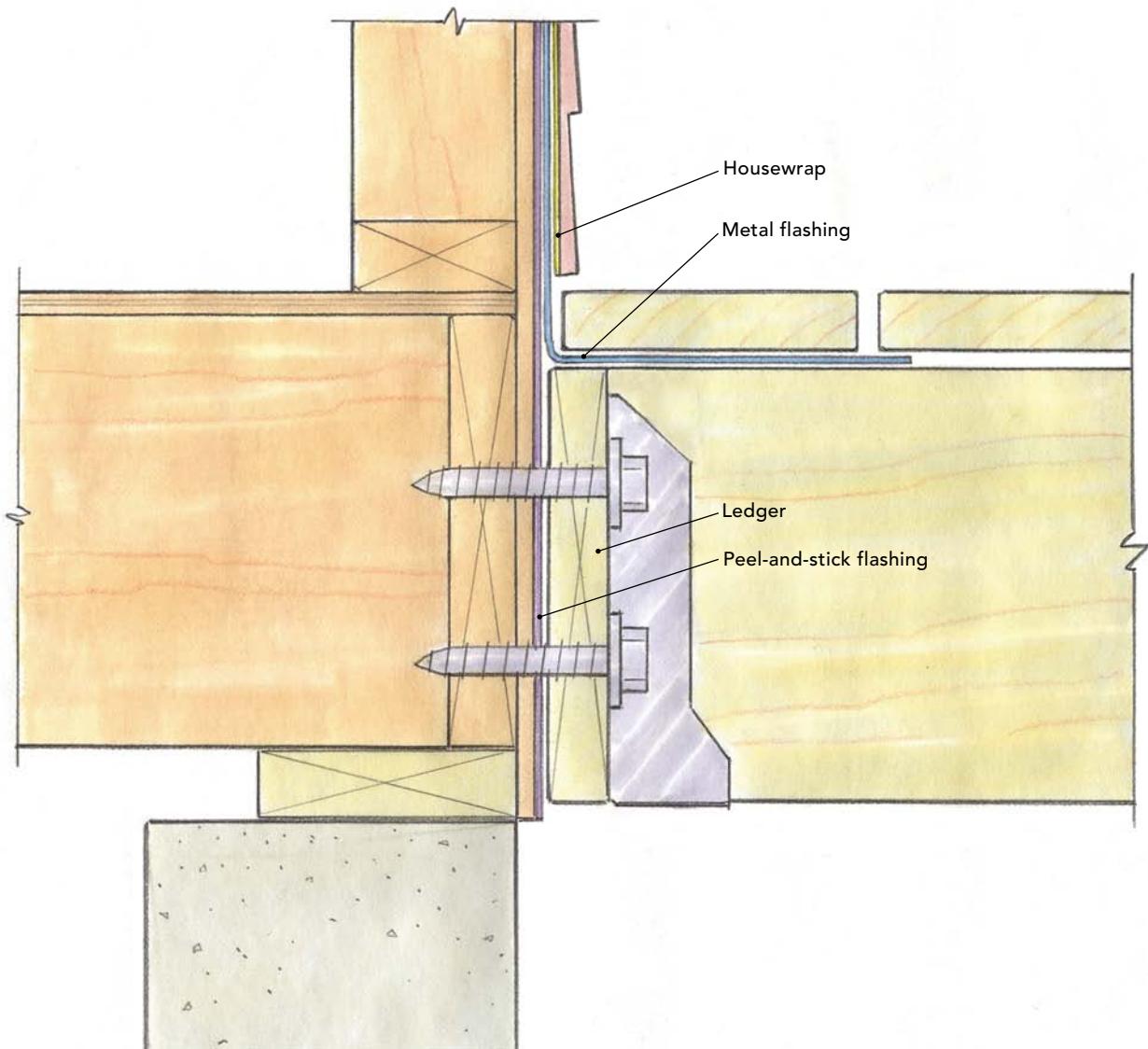
THE
FIX

Integrate ledger flashing with housewrap

Keeping water out of the joint between the deck and the house calls for multiple layers of flashing. Self-sealing flashing (peel-and-stick) should be applied to the wall sheathing before installing the ledger. The flashing should run below the ledger and at least 6 in. higher up the wall than the top of the ledger. L-shaped metal flashing goes over the top of the ledger and up the wall as high as the peel-and-stick. A narrow band of peel-and-stick over the top of the metal prevents water that gets behind the housewrap from getting behind the ledger. At the least, the housewrap must extend several inches down the face of the metal flashing.



Poor flashing leads to a rotted house.
Although this deck ledger had flashing, it was not properly integrated with the housewrap or building paper behind the siding. Water found its way to the house framing, rotting the rim joist and mudsill.



FAILURE**4**

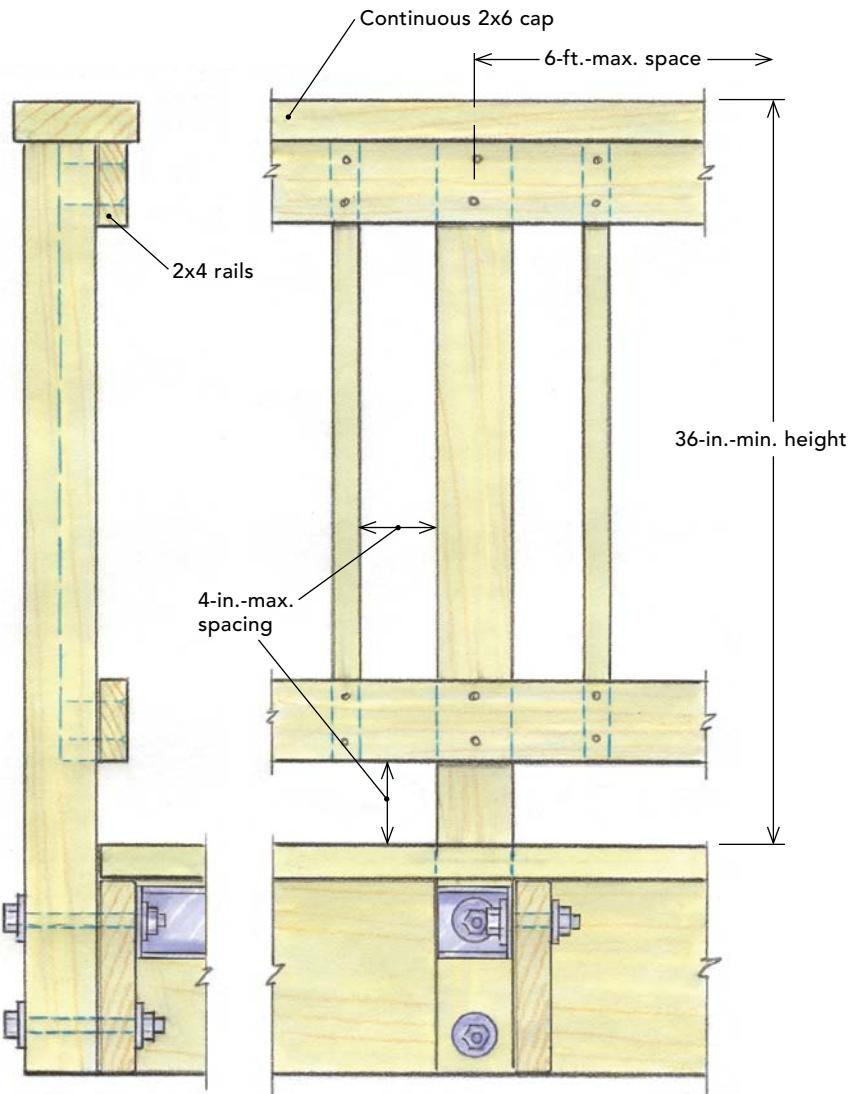
Weak railing attachment

In my experience, very few residential wood railing systems are built to endure code-designed loads. A rail is supposed to be able to withstand a 200-lb. force pushing out on the top. It is a challenge to accomplish this with wood, and in my opinion, the ideal railing is made from welded, hot-dipped galvanized steel. The DCA 6-12 shows details (below) for a wood railing, but I would be more comfortable with 6x6 posts, 2x8 top rails, and 2x6 rails.

**THE
FIX**

Screw rails to the inside of posts

A robust and code-compliant wood railing can be built if you rely on corrosion-resistant screws and place the railing inside the posts. Capping the posts and railing sections with a continuous 2x6 makes the assembly more rigid.



Toenailed railing-to-post connection fails.
Over time, the wood decayed and the nails rusted. The weakened railing fell to the ground when someone leaned on it.



Don't rely on nails. This railing was just nailed to the outside of the posts. The nails eventually withdrew, and the railing pulled away.

FAILURE

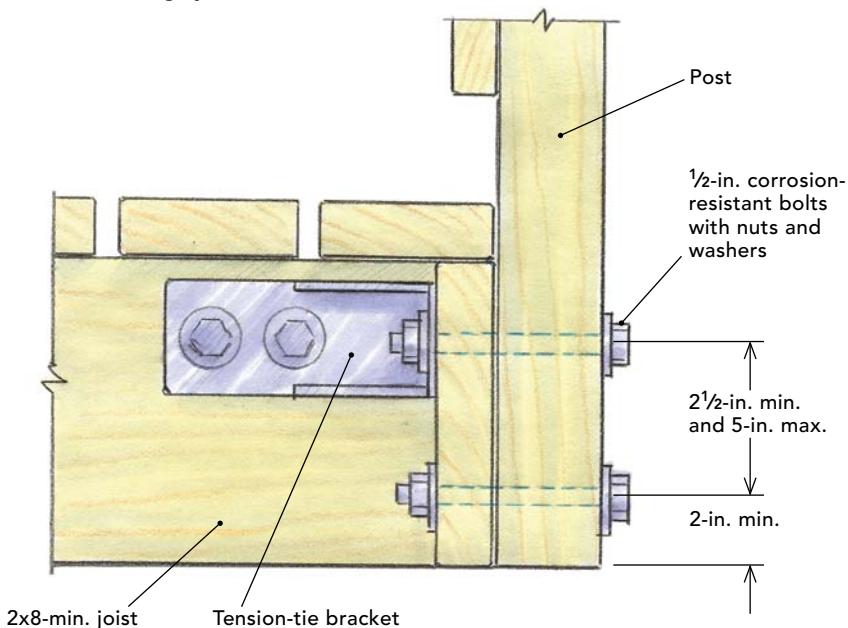
5 Shaky railing posts

No matter how well a railing is attached to a post, it is bound to fail if the post isn't firmly anchored to the deck framing. This connection hadn't been studied or addressed in the code until recently, so it's common to find loose and shaky railing posts. Although the DCA 6-12 allows 4x4 posts, I prefer 6x6s.

THE
FIX

Fasten wood posts with metal hardware

One way to achieve the code-required load capabilities is with a combination of bolts and metal tension-tie brackets, although this can only work with joists that are 2x8 or larger. That's because the top of the joist acts as a fulcrum for the post, and 2x6 joists don't provide enough depth for the fasteners to resist the leverage. Shallower, 2x6 joists would require a manufactured surface-mount railing system.



Scabbed-on bracing points to trouble. The post is notched around the joists and nailed into place, but this joint won't meet the code's load requirement. The untreated wood bracing is a poor attempt to address the problem.



FAILURE

6 Unbraced outer beam

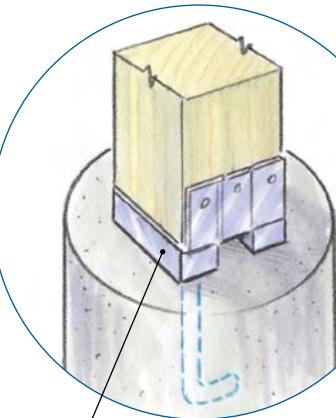
While the bolts and tension ties at the ledger keep a deck from pulling away from the house, they do little to prevent lateral motion at the outer beam. If the beam moves far enough laterally, the posts can topple over sideways, causing the deck to collapse. Bracing between the posts and the outer beam is crucial whenever the posts exceed 2 ft. in height, and the taller the posts supporting the outer beam of a deck, the more important bracing becomes.



**THE
FIX**

Brace and fasten the posts

Posts should be at least 6x6 and should join to the beam either by being notched and bolted to two-ply beams, or with an approved metal connector to either two-ply or three-ply beams. Posts must fasten to footings with approved post bases. When the outer posts of a deck are taller than 2 ft., they require diagonal bracing between them and the beam.



Manufactured post base and anchor

