ATTACHING Deck Ledgers

Preventing rot at the band joist is as important as using strong enough fasteners

Beginning in 2001, members of the staff at Virginia Tech's Engineering and Wood Science Departments launched a project to develop and publish an inspection manual for residential decks and balconies. To our surprise, we found that problems with deck attachment are quite common and that the issues are more complex than we had thought. In this article, we'll focus on the forces at work between the deck ledger and the band joist, and offer connection details that will safely carry the typical loads.

In addition to using the right fasteners in sufficient numbers, an important factor in designing ledger attachments is preventing moisture damage — rot — from weakening the ledger and band joist. Field observations of existing decks by Roger Robertson of the Chesterfield County, Va., Building Department revealed decay in untreated band joists where deck ledgers were attached. In some cases, the decay had spread into the interior floor joists.

Flashing between the ledger and the band joist is important for keeping water out of the interior framing. In his field studies, Robertson observed that

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aluminum flashing in contact with CCA-treated lumber had corroded within five years of construction. Our details (see Detail 1) show a flashing layer, but if you use aluminum next to CCA pressure-treated lumber, we recommend that you use a product that has been coated to prevent corrosion.

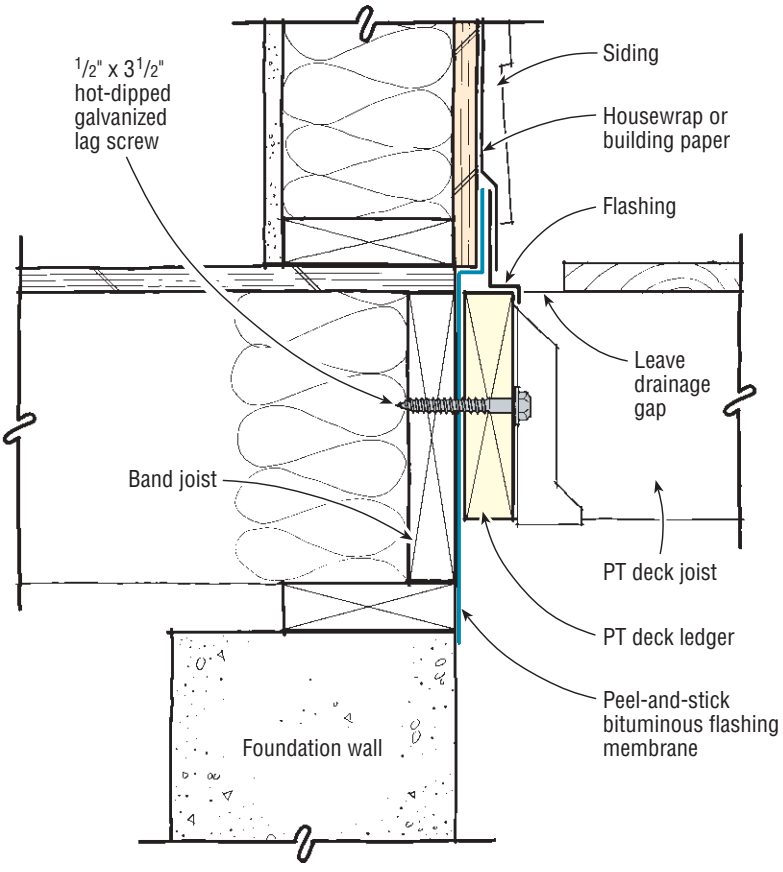
Attaching Ledger Directly to Band Joist

Builders often attach the deck ledger to the band joist after structural sheathing is already in place. But it's actually stronger if you attach the ledger right against the band. In Detail 1, the reaction force of the deck joist is transmitted directly to the band joist by lag screws acting in shear. The band joist and ledger board are in direct contact, with no sheathing in between.

Deck loads and lag screw shear values. The building code design loads for residential decks is 40-psf live load plus a dead load to account for the weight of the materials — usually about 10 psf.

When it comes to calculating how much weight a lag screw of a given size can support, the codes refer to the *National Design Specification for Wood Construction* (*NDS*). Using the *NDS* formulas, we calculated that each 1/2-inch lag screw can carry 180 pounds, assuming the ledger is 2-by southern pine and the band joist is 2-by spruce-pine-fir. We assumed that the ledger has a moisture content no higher than 19%. (If the lumber is wetter, that would theoretically reduce its strength.)

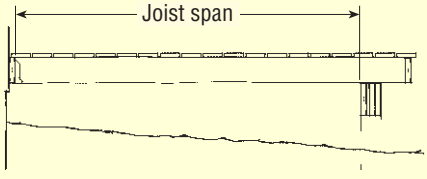
Detail 1: Attaching Ledger Directly to Band Joist



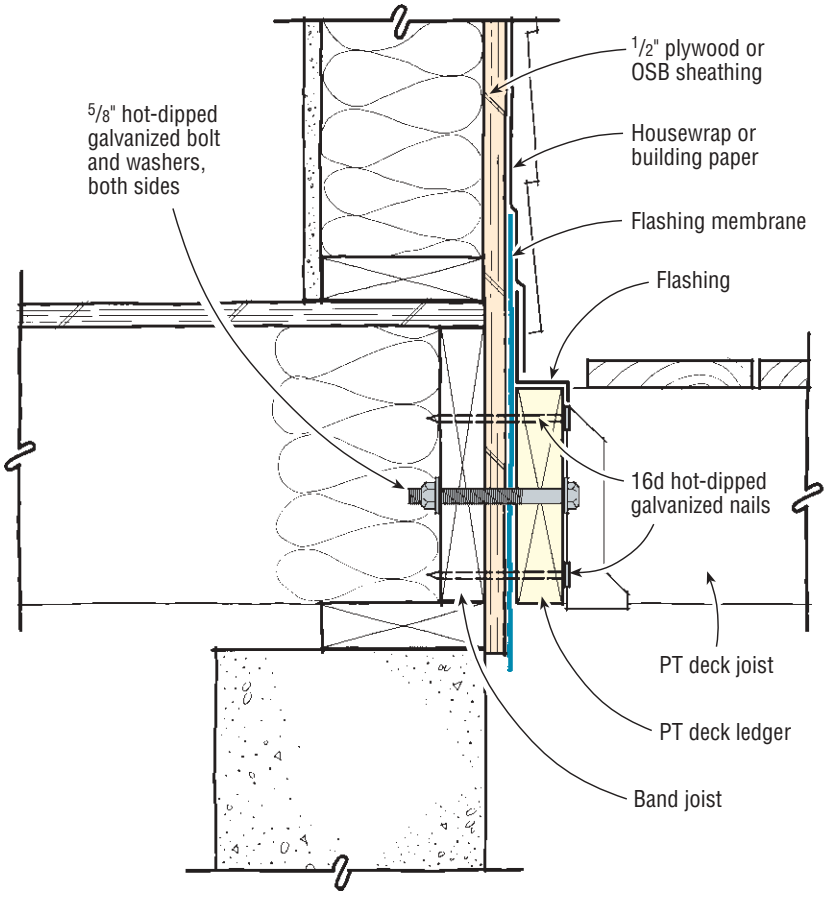
Detail 1 Fastener Schedule*

Joist span (ft.)	6	8	10	12	14	16	18
On-center fastener spacing (in.)	14.4	10.8	8.6	7.2	6.2	5.4	4.8

*Required spacing of 1/2x3 1/2-inch lag screw connecting southern pine ledger to spruce-pine-fir (SPF) band joist for residential deck joist spans. Assumes 40-psf live plus 10-psf dead load. Values are based on the root diameter of typical lag screws available at building supply stores. Attaching the ledger directly to the band joist with no sheathing in between provides the strongest mechanical connection with the fewest 1/2-inch lag screws.



Detail 2: Attaching Ledger to Band Joist Over Structural Sheathing



Detail 2 Fastener Schedule*

Fasteners	8-foot Max Joist Span	16-foot Max Joist Span
5/8-in. hot-dipped galvanized bolts and washers and 16d common hot-dipped galvanized nails	1 bolt @ 3′-6″ o.c. and 2 nails @ 8″ o.c.	1 bolt @ 1′8″ o.c. and 3 nails @ 6″ o.c.

Minimum edge distance for bolts is 2 1/2 inches. Nails must penetrate the supporting structure band a minimum of 1 1/2 inches.

*Reprinted by permission from the *North Carolina Residential Code*. The nail size in the table has been increased from 12d to 16d common (3 1/2 inches) to accommodate 1/2-inch structural sheathing, as shown in the drawing. Note that you must use 5/8-inch bolts as well as nails to make the connection.

Attaching Ledger on Top of Structural Sheathing

Because deck ledgers are often installed after the sheathing is nailed off (Detail 2), it's useful to have a fastener schedule that takes the 1/2-inch plywood or OSB into consideration. The *NDS* has no such design method, so we turned to the *North Carolina Residential Code*. Appendix M of that code includes a fastener schedule for deck ledgers that relies on 5/8-inch bolts and 16-penny common nails working together. The code specifies that no siding is permitted in the connection, but structural sheathing is okay where required if it's properly flashed. Note that the *NDS* requires bolt holes to be a minimum of 1/32 inch to a maximum of 1/16 inch larger than the bolt diameter. The purpose of this rule is to prevent the lumber from splitting if it shrinks in service.

Although the *International Residential Code* (*IRC*) specifies loads, maximum deck railing openings, and the need for lateral restraint, the *N.C. Code* is the only code we're aware of that gives design information for the ledger–band joist connection.

Attaching Ledger With Drainage Spacers

Sometimes spacers are installed between the deck ledger and the band joist to allow for drainage. While that can help prevent rot at the band joist, the spacers weaken the connection. *JLC* asked us to provide a bolting schedule for that condition, but unfortunately

we know of no design methodology that would allow us to assign any strength to the structural sheathing layer. That means that in coming up with the schedule for Detail 3, we had to assume that the ledger is separated from the band joist by a 1-inch gap. (This condition would be the same if the ledger were installed over 1-inch-thick foam insulation board, which also has no design strength.) The result is that each 1/2-inch bolt yields only about 80 pounds of shear strength, both because of the 1-inch gap and because of the "wet-use" service conditions of the ledger. It is likely that the bolt schedule in Detail 3 is overly conservative; certainly some of the spacings are ridiculously close when looked at from the carpenter's viewpoint.

For now, we have to rely on the *NDS* design methods to be safe. However, we have plans to test ledgers under actual loading conditions next year and will report our findings here as soon as we have them. Meanwhile, for those wishing to leave a space at the ledger, we strongly recommend Detail 4, page 7.

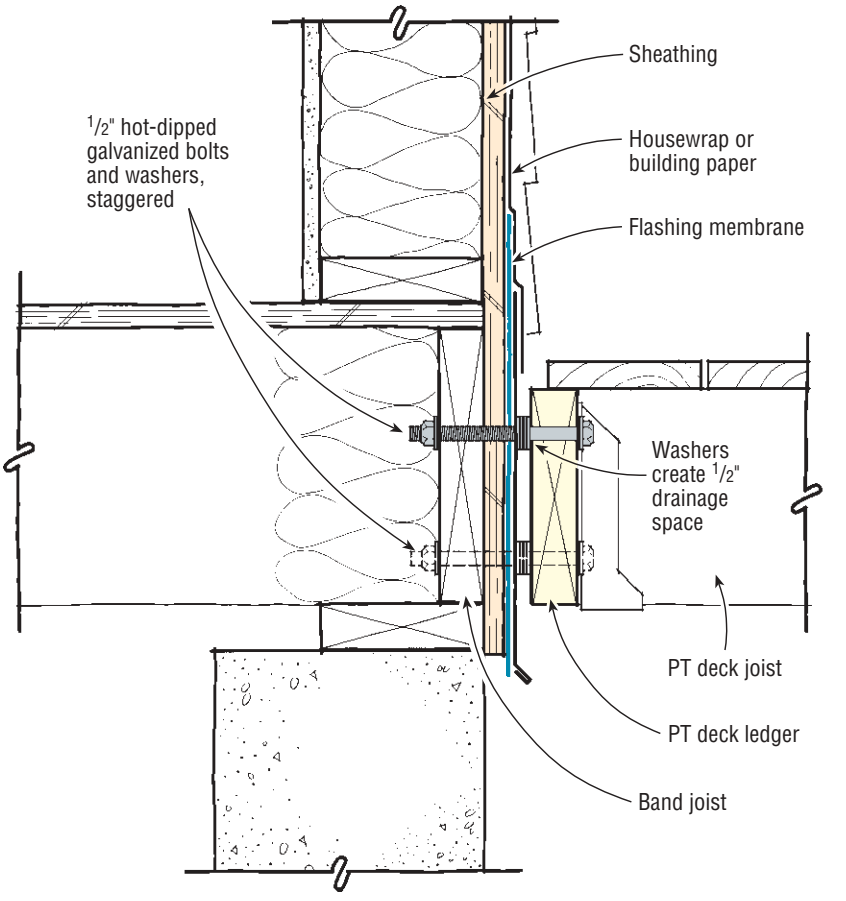
Supporting the Ledger With Posts

Attaching the ledger to the band joist may be common, but it makes it somewhat difficult for the builder — as well as the inspector — to be certain that the connection is safe and durable. In addition to the gravity loads, deck ledgers are subject to lateral, or sideways, loads, which are not addressed by the fastener schedules in the details above.

We recommend a different approach: supporting the ledger with pressure-treated posts, as shown in Detail 4. This approach has several advantages:

- It eliminates the need to penetrate the house siding, sheathing, and band joist, thus eliminating the potential for decay.

Detail 3a: Attaching Ledger With Drainage Spacers

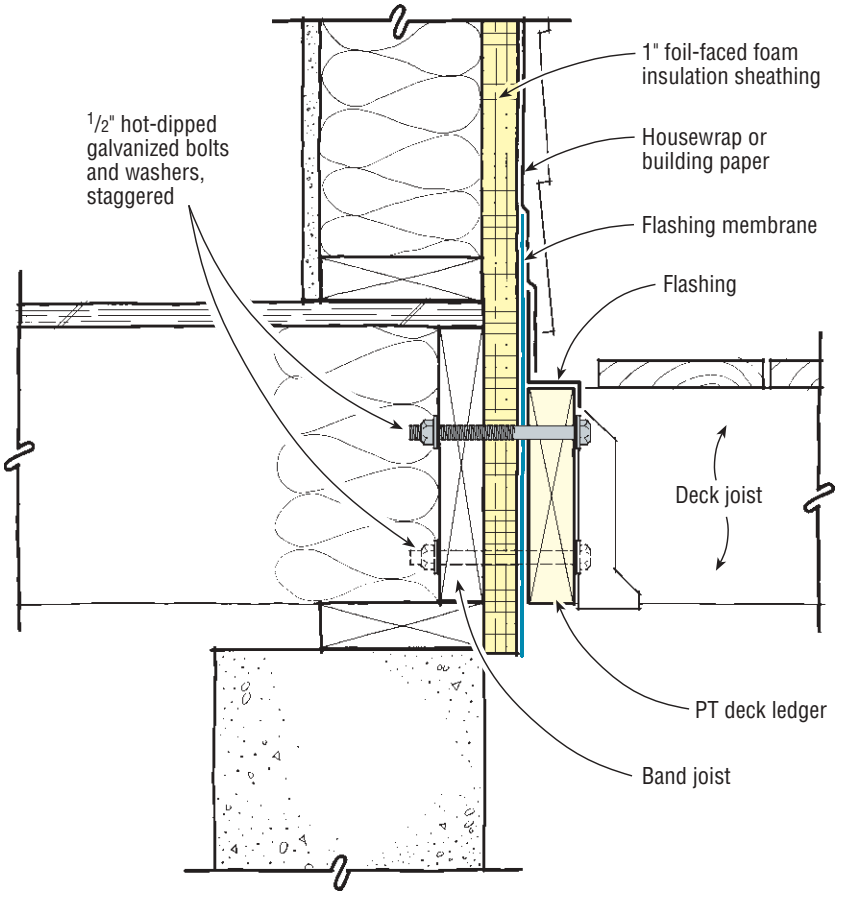


Detail 3 Fastener Schedule*

Joist span (ft.)	6	8	10	12	14	16	18
Bolt spacing (in.)	6.3	4.7	3.8	3.2	2.7	2.4	2.1

*Required spacing of 1/2-inch bolts (with washers on both sides) connecting SPF band joist (G = 0.42) to a PT ledger with the same or greater G value. Tabulated values are based on the assumption that the band and ledger are separated 1 inch due to 1/2-inch wall sheathing and a 1/2-inch spacer (washers). Assumes a residential deck load of 40-psf live plus 10-psf dead.

Detail 3b: Attaching Ledger Over Foam Sheathing



The authors used available *NDS* methods to create a fastener schedule that accounts for a drainage space behind a ledger attached over 1/2-inch sheathing (above left). Unfortunately, the sheathing provides no structural support to the bolt, resulting, from a design standpoint, in a 1-inch-wide gap between the ledger and the band. Thus, the same bolting schedule would apply to a ledger installed over 1-inch nonstructural insulating sheathing (above).

- It relies on more efficient structural connections because the ledger rests directly on the end grain of the wood post. Connections that use lag screws, bolts, or nails loaded in shear require far more attention, in both design and construction, than a simple beam-to-post connection.
- It has structural redundancy, meaning that the possible failure of one element will not automatically produce or permit collapse of the entire structure. In this detail, the through-bolt prevents sideways movement of the deck, which might occur if the outside posts were not deeply embedded in the ground. In the unlikely event that the through-bolts should fail from corrosion or any other reason, the embedded 6x6 posts at the foundation wall would still prevent a lateral collapse of the entire deck.
- From an inspection point of view, it's easier to verify that a self-supporting deck is sound, because all the elements (except the footers) are exposed.

While the 6x6 posts we've seen in retail building supply centers are treated to the 0.40 lb/ft^3 retention, we recommend using posts treated to 0.60 for longer life. The ends of the posts placed in the ground should not be cut, as that exposes untreated heartwood. Southern pine heartwood, as well as the heartwood of other softwood species, does not accept the penetration of the CCA chemical treatment; thus, only the end surface contains the chemical. Another post option is PT parallam PSL, which, according to the TrusJoist website (www.tjm.com/), is treated at least to 0.60 lb/ft^3 retention. (The specific type of treatment should be considered by the deck designer in view of the fact that CCA is scheduled to be phased out for some residential applications

Why Don't More Ledgers Fail?

At first glance, the lag screw spacings shown in the details in this article appear to be overly conservative. Builders frequently attach deck ledgers only with nails, and when they use lag screws, it wouldn't be surprising to find that the screw spacings are far greater than those shown in Detail 1 (page 2), for example.

This was noted by Christopher DeBlois, P.E., in a past *Practical Engineering* article (3/96), who went on to say: "What I am sure of, though, is that almost all the decks that I do inspect don't have enough bolts connecting the deck band joist to the house."

So, the question is, why don't residential deck-to-house connections fail on a routine basis? There are a few possible reasons.

Decks Not Often Fully Loaded

Code design loads require residential decks to be able to support a 40-psf live load plus a 10-psf dead load. Assuming a 12x18-foot deck, 40 psf would be roughly equivalent to a gathering of 58 people, based on an average weight of 150 pounds per person. In reality, however, that many people are unlikely to gather at one time on a 12x18-foot deck during its entire service life.

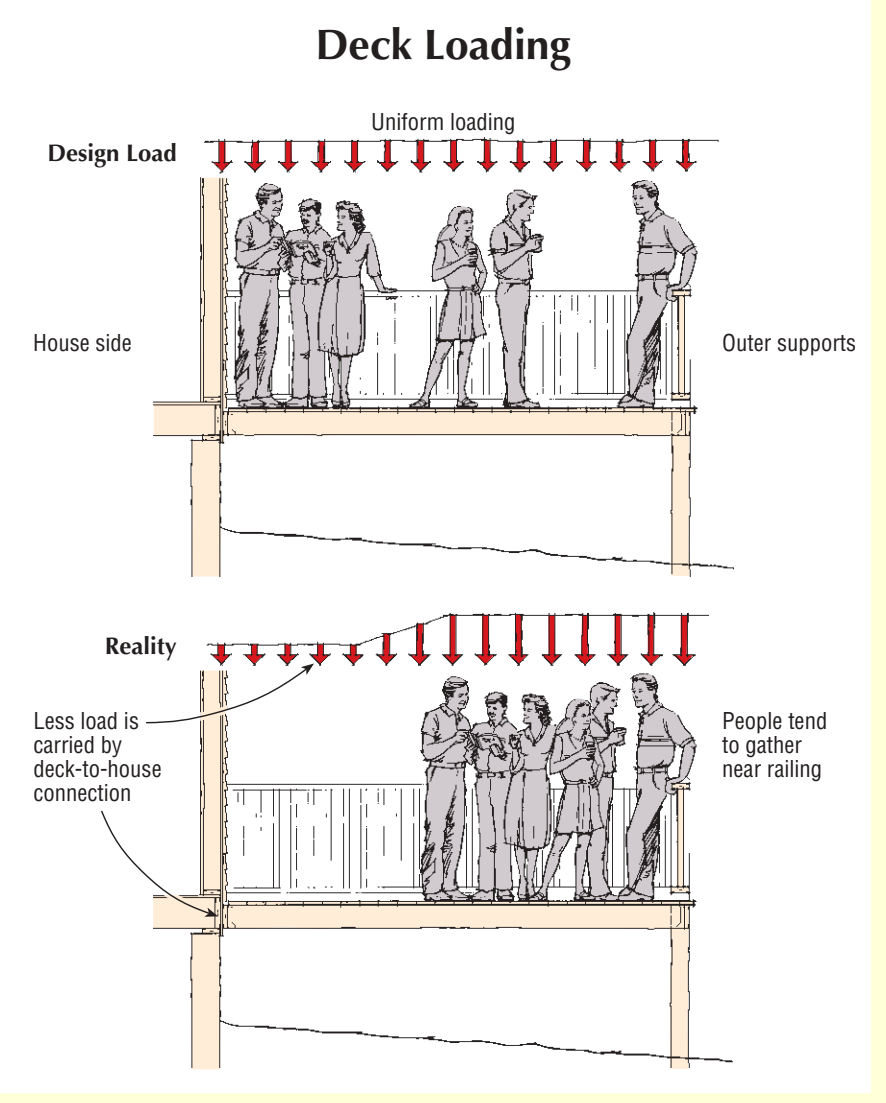
Loads Not Uniform

The fastener schedules in this article assume that the deck will be uniformly loaded, so that approximately half of the load will need to be supported by the ledger. But large groups of people don't normally sit right next to the house. Instead, more people tend to gather near the outer edges of the deck, so that live loads are typically greater on the outer supports compared with the house side (see illustration at left).

Connector Safety Factors

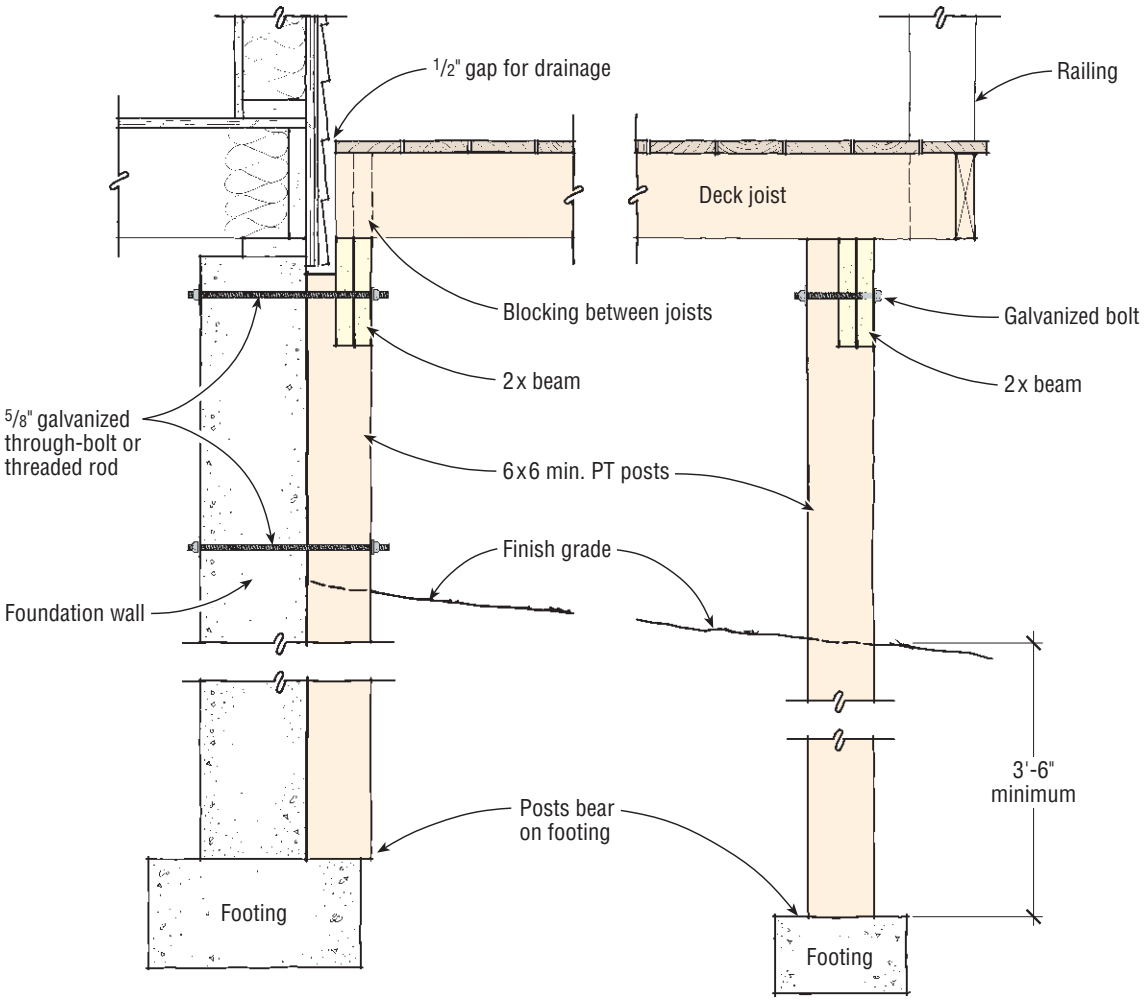
The allowable shear values for lag screws are based on code-approved engineering standards. Laboratory tests of lag screws indicate that the safety factor on the allowable design values can be as high as 5. Thus, a properly installed 1/2-inch lag screw in a band joist–ledger application will typically carry a lot more than 180 pounds of load before the connection ruptures. (Nevertheless, the safety factor should not be encroached upon: Its purpose is to account for any uncertainties of design, construction, and service conditions that may crop up. For example, a carpenter might drill too large a lead hole for the lag threads, which weakens the connection. Or a carpenter might align the lag screws in two or more rows in the wet ledger, which will increase the likelihood that the lumber will split as it dries.)

— C.A., F.W., & J.L.



Decks are designed for uniform loading (top). In reality, people tend to gather near the railings rather than next to the house, taking some of the load off the ledger (above).

Detail 4: Deck Fully Supported With Posts



The authors strongly recommend avoiding mechanical shear connections altogether and, instead, supporting residential decks with PT posts, as shown here. Use .60-retention pressure-treated lumber for greatest durability.

beginning in December 2003.)

The posts are located next to the house and notched to receive the ledger. The deck joists are then supported on the built-up beams, which further minimizes reliance on mechanical connections (joist hangers). The through-rods address lateral support, which, while not quantitatively addressed by the building codes, is extremely important.

Keep trash, vegetation, and construction debris out of the backfill around the post, as it would compromise the lateral resistance of the embedded post section. We also suggest that the post be backfilled around its base with an 80-pound bag of concrete mix, followed by 8 inches of well-compacted native soil or a sand and gravel mixture. The concrete above the footing pad will stabilize the bottom of the post in the unlikely event that the footing pad should rotate in service. The size of the post footing pad and the depth of the post embedment for a design should be determined by the deck designer and depends on local frost depth and soil strength, as well as local building codes.

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