Is Your Deck Safely Connected to Your House?

by Frank Woeste, P.E., Loren Ross, P.E. and Paul Coats, P.E., C.B.O.

Data collected for deck failures since 2001 shows that one of the primary reasons for deck collapses is the failure of nail-only connections between the deck and the primary structure. Based on videos, photos, and descriptions in media reports, the data indicates that deck collapses most often result from the failure of deck ledger connections that were constructed with nails instead of properly installed bolts. The deck ledger is the deck floor rim board attached to the house, and it should be positively connected to the floor structure of the main building with bolts or lag screws, not nails.

The main objective of this article is to alert property owners and code officials to decks with "nailed-only" deck ledger connections. A homeowner, developer, building owner, code official, inspector, property manager, or contractor can quickly determine if an elevated deck is supported by a deck ledger that is attached to the house solely by nails—such an installation constitutes a "potentially dangerous" deck.

Background

For decades, the residential codes have specified an occupant deck live load of 40 pounds-per-square foot (psf), which is about one average-size person occupying a space of 2-ft. by 2-ft. (four square feet). For example, the code design load would anticipate a deck that is 14-ft. by 28-ft. could be safely occupied by 98 people. Additionally, every edition of the *International Residential Code* (IRC) since 2000 has required that decks be positively anchored to the structure to resist both vertical and lateral loads, and it has long prohibited the use of nails subject to withdrawal as the sole method of attachment. However, until the 2009 edition, the IRC did not prescriptively specify how the deck ledger should be fastened to the house.

Since 2009, every edition of the IRC (including the anticipated 2021 edition) requires the deck ledger to be connected to the house floor band joist with ½" bolts or lag screws as shown in Table 507.9.1.3(1) of the 2018 IRC. The American Wood Council (AWC) publishes *Design for Code Acceptance No. 6 (DCA 6): Prescriptive Residential Wood Deck Construction Guide*, which contains a similar table and is consistent with the IRC (see Figure 1).

Table 5. Fastener Spacing for a Southern Pine, Douglas Fir-Larch, or Hem-Fir Deck Ledger or Band or Rim Joist and a 2-inch Nominal Solid-Sawn Spruce-Pine-Fir Band Joist or EWP Rim Joist.[3,4,5,6,8]

(Deck Live Load = 40 psf, Deck Dead Load = 10 psf)

Joist Span	Rim Joist or Band Joist	6'-0" and less	6'-1" to 8'-0"	8'-1" to 10'-0"	10'-1" to 12'-0"	12'-1" to 14'-0"	14'-1" to 16'-0"	16'-1" to 18'-0"
Connection Details	**On-Center Spacing of Fasteners**							
½" diameter lag screw[1] with 15/32" maximum sheathing	1" EWP	24"	18"	14"	12"	10"	9"	8"
	1-1/8" EWP	28"	21"	16"	14"	12"	10"	9"
	1-½" Lumber	30"	23"	18"	15"	13"	11"	10"
½" diameter bolt with 15/32" maximum sheathing	1" EWP	24"	18"	14"	12"	10"	9"	8"
	1-1/8" EWP	28"	21"	16"	14"	12"	10"	9"
	1-½" Lumber	36"	36"	34"	29"	24"	21"	19"
½" diameter bolt with 15/32" maximum sheathing and ½" stacked washers[2,7]	1-½" Lumber	36"	36"	29"	24"	21"	18"	16"

1. The tip of the lag screw shall fully extend beyond the inside face of the band or rim joist.
2. The maximum gap between the face of the ledger board and face of the wall sheathing shall be ½".
3. Ledgers shall be flashed or caulked to prevent water from contacting the house band joist (see DCA 6, Figures 14 and 15).
4. Lag screws and bolts shall be staggered per DCA 6, Figure 19.
5. Deck ledgers shall be minimum 2x8 pressure-preservative-treated No.2 grade lumber, or other *approved* materials as established by standard engineering practice.
6. When solid-sawn pressure-preservative-treated deck ledgers are attached to engineered wood products (minimum 1" thick wood structural panel band joist or structural composite lumber including laminated veneer lumber), the ledger attachment shall be designed in accordance with accepted engineering practice. Tabulated values based on 300 lbs and 350 lbs for 1" and 1-1/8" EWP rim joist, respectively.
7. Wood structural panel sheathing, gypsum board sheathing, or foam sheathing shall be permitted between the band or rim joist and ledger. Stacked washers are permitted in combination with wood structural panel sheathing, but are not permitted in combination with gypsum board or foam sheathing. The maximum distance between the face of the ledger board and the face of the band joist shall be 1".
8. Fastener spacing also applies to southern pine, Douglas fir-larch, and hem-fir band or rim joists.

Figure 1. Table 5 from the AWC DCA 6, showing recommended lag screw and bolt installation.

The installation of bolts or lag screws, including their number and spacing, depends on the size of the deck (deck joist span) and other conditions given in the table footnotes. If bolted, the bolts must go completely through the deck ledger and house floor band joist and have nuts with washers tightly fitted. The installation of lag screws requires drilled pilot holes, correctly sized so the threads of the screw fully engage the wood and extend all the way through both the deck ledger and the house floor band joist. Of course, the latest code provisions in the IRC should be consulted for the proper installation of bolts or lag screws (See Figure 2) used as a deck ledger connection.

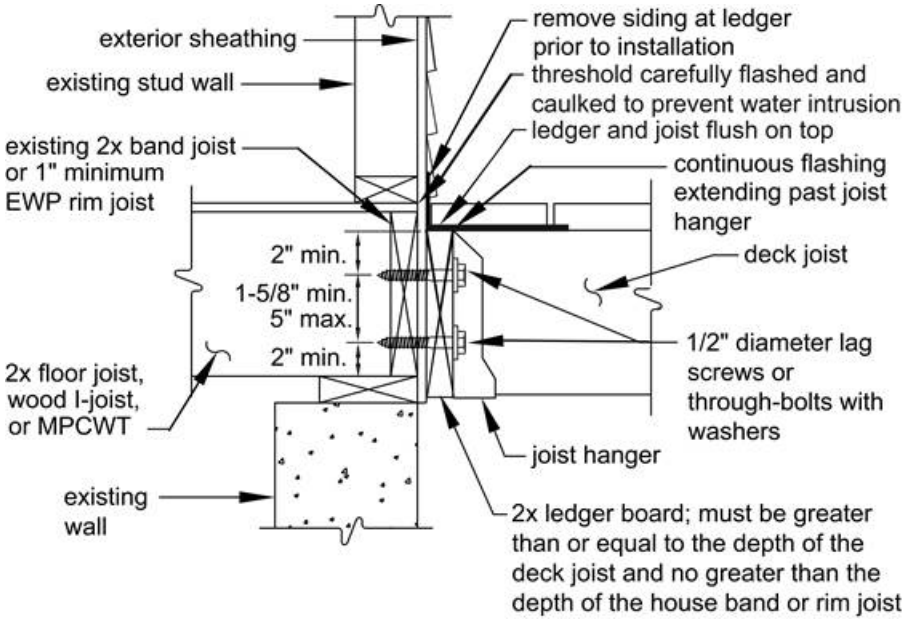

Figure 2. Figure 14 from AWC's DCA 6, showing recommended connection of the deck ledger to the house floor band joist.

Why is a nailed-only deck ledger potentially dangerous?

When decks that are simply nailed to the house are loaded by occupants, vertical and lateral loads stemming from the weight and movement of the occupants can cause the ledger nails to bend or pull out of the wood sheathing and house band joist. Decks have collapsed in this way with as few as one or two occupants present. The failed deck structure shown in Figure 3 depicts a case where the deck shifted laterally, away from the structure, and fell to the ground.

Had the deck fallen vertically, the nails would have bent over. In this case, the nails are essentially straight, indicating that the nails withdrew from the wall before total collapse. Nails used in withdrawal have limited strength, and may provide only enough support for the weight of the deck itself and not that of the occupants. Undoubtedly some nailed-only ledger decks are still standing probably because they haven't been heavily loaded to the IRC-anticipated 40 psf live-load (about one person on every 2-ft. by 2-ft. floor area).

Development of code provisions and testing

Due to the frequency of ledger connection failures constructed with nails only, it became apparent to researchers and engineers that ledger connections made with only nails could not

be relied on to perform while meeting the loading requirements of the code for a residential deck, typically 50 psf total (live plus dead) load.

Prior to 2004, an economical engineered design solution using lag screws or bolts for this application was not available. Due to recurring deck collapse cases reported in the news, Virginia Tech researchers, with input from the Journal of Light Construction, successfully tested deck ledger connections that were eventually adopted into the IRC and Virginia building code. (Visit https://www.jlconline.com/how-to/framing/practical-engineering-load-tested-deck-ledger-connections_o for testing details and background.) The test results confirmed the successful performance of connections made with ½"lag screws or bolts for the required loads.

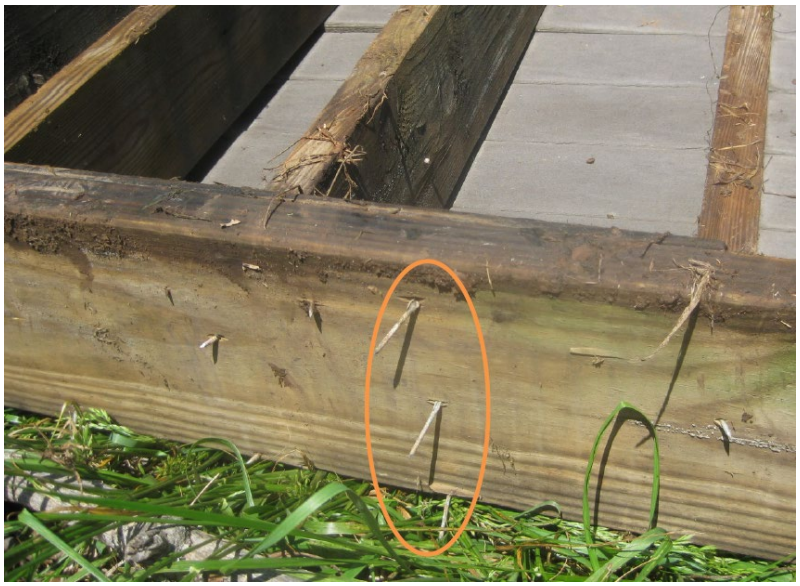

Figure 3. Close-up of deck ledger that was connected to a structure with nails only. Even though only lightly loaded by occupants, the deck shifted laterally, pulling the nails out of the supporting structure. (photo by Frank Woeste)

Do I have a nailed-only deck ledger?

This question can be answered in a few minutes. If only nail heads are visible on the surface of your deck ledger, you most likely have a nailed-only deck ledger. The deck should be identified as unsafe, its use forbidden, and immediately repaired or replaced in accordance with the recommendations of a qualified designer or construction professional.

Other potential deck ledger connection problems

Once the possibility of having a "nailed-only" deck ledger is eliminated, the work of assuring the deck's safety is not finished. Especially for decks that are elevated above ground level, a professional evaluation of an existing deck's ledger connection to the structure is strongly recommended. Even if the deck ledger is connected with bolts or lag screws, their correct installation to the house floor band joist is critical to providing a strong connection for the deck.

Example—considerations for lag screws

Lag screw installation in particular requires careful attention to detail. Some considerations are:

1. Did the contractor use ½" diameter lag screws?

The proper lag screw diameter per the IRC can be verified by the fact that ½" lag screws have a hex-head that is ¾" wide. In Figure 4 below, the contractor used ½" diameter lag screws to connect the ledger through the wall sheathing into the house floor band joist. The nail at the bottom left was likely used only to position the ledger on the wall while the lag screws were installed.

Figure 4. Section of a deck ledger with ½" diameter lag screw installed. (Photo by Frank Woeste)

2. Did the contractor install the lag screws at the correct spacing?

This question is answered by measuring the joist span and using the 2018 IRC Table 507.9.1.3(1) ledger connection table to select the required screw spacing, or the similar diagram in AWC's DCA 6. For example, for a joist span of 14 ft., the table shown in Figure 1 above requires lag screws to be spaced at 13" on-center, if the screws are attaching nominal 2-inch thick lumber. Ideally these should be staggered in two rows, one row near the top of the ledger and one row near the bottom, and not located too close to the edges (at least 2 inches from the top and side edges of the ledger and at least ¾ inch from the bottom edge, see Figure 5; see Figure 2 for recommended edge spacing in the house floor band joist).

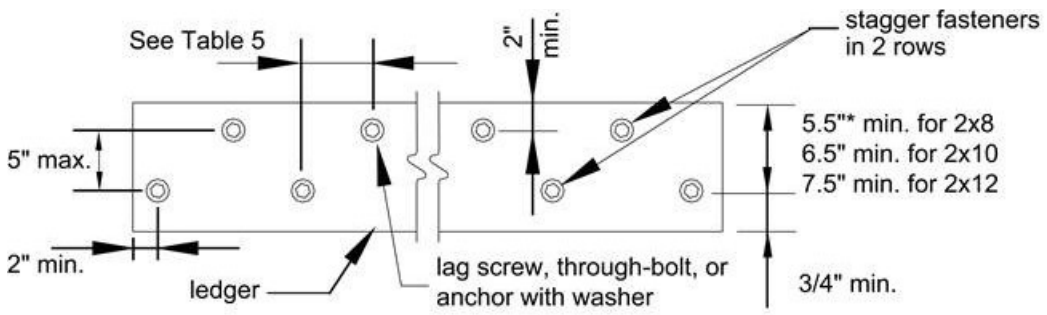

Figure 5. Figure 19 from AWC DCA 6, showing recommended lag screw or bolt edge spacing and clearances.

3. Did the contractor install lag screws of the proper length per the IRC?

In some cases, this question can be answered by viewing the inside face of the house floor band joist. As viewed in a crawl space with the insulation removed, the tip of an installed ½" lag screw connecting the deck leger to the house floor band joist should be visible as shown in Figure 6.

Figure 6. The visible tip of the lag screw as depicted indicates compliance with the IRC requirement that lag screws fully extend beyond the inside face of the house floor band joist. (Photo by Frank Woeste)

Because the tip of the screw extends beyond the inside face of the house band joist, the lag screw is clearly the proper length as required by the IRC. If the tips of the lag screws are not visible, an investigation by qualified construction professional is recommended.

Summary

To summarize, confirming that the deck ledger is correctly attached to the house floor band joist with bolts or lag screws is a critical first step. However, a poor ledger connection is only one of several possible safety deficiencies for an existing deck. For example, the structural integrity of guardrails and stairways are also critically important for ensuring the safe use of an existing deck. A complete and meaningful safety evaluation of a deck can be very challenging. For that reason, all decks, but especially elevated decks, should be inspected regularly by a qualified inspector or construction professional and evaluated in accordance with current codes and recommended practices.

Additional Resources

A practical question for property owners and code officials concerned about the safety of an existing deck is: What are the important issues for deck safety, and how do I know what constitutes a meaningful deck inspection which can ensure the continued safe use of the deck? Fortunately, there are some excellent publications which systematically address this. As previously mentioned, AWC's *Design for Code Acceptance No. 6 (DCA 6), Prescriptive Residential Wood Deck Construction Guide* has comprehensive details, figures, and recommendations which comply with the requirements for new decks up through the 2015 edition of the International Residential Code. It is available for free at https://awc.org/codes-standards/publications/dca6.

Additionally, now available is a highly illustrated booklet, *Deck Codes & Standards* by Bruce Barker of the American Society of Home Inspectors (Quarto Publishing Group USA, 2017, part of a do-it-yourself series of publications sponsored by Black + Decker). The booklet provides IRC provisions and includes many DCA 6 recommendations, featuring high-quality photos, comparisons of safe and unsafe details, a comprehensive residential deck inspection checklist, and tips for selecting a qualified contractor.*

Important reminder

This article is intended to educate homeowners on an important deck safety issue. Readers are encouraged distribute this article to friends and neighbors to help prevent deck-related injuries due to collapse. Please be aware this article is not intended for new deck construction. New deck construction is regulated by the local jurisdictions and homeowners are advised to contact the local building code official for new deck code requirements and permitting. If there is no local code or code official, the 2018 IRC and AWC's DCA 6 document may be consulted. However, neither the authors nor the American Wood Council assume any responsibility for particular designs or construction undertaken based on this article.

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* (As with any publication, the user must confirm that recommendations comply with all local codes. Mention of this book does not constitute endorsement of the content by the authors.)

About the Authors

Frank Woeste, P.E., is Professor Emeritus at Virginia Tech in Blacksburg, VA. He frequently consults with the public, contractors and building code officials on various aspects of wood construction, including decks and balconies.

Loren Ross, PE, is Manager of Engineering Research for the American Wood Council.

Paul Coats, PE, CBO, is Southeast Regional Manager for the American Wood Council.