

ALL THINGS WOOD

Anatomy of an Inherently Dangerous Deck

By Frank Woeste

Over the period of nine days starting on June 9, 2017, five deck collapses in five states (MT, VA, OH, MI, and WI) were reported in the news media. Using the injury data from the media, the five collapses resulted in a total of 57 injuries. In one case, WAVY.com reported that, after an inspection by code enforcement inspectors, "Officials say it appears the deck failed at the ledger board—where the deck attaches to the main building." In another case, covered by <http://abc6onyourside.com/>, a [photo gallery shows only nails](#) were used to connect the deck ledger to the condo.

Deck collapses caused by failure of a nailed deck-ledger-connection to the structure or house have been followed since 2002, when researchers at Virginia Tech began to investigate and test critical structural elements of a residential/multi-family deck. After several years of tracking deck collapses, it became apparent that the primary cause of deck collapses was the connection of the deck ledger to the house made with nails only. In fact, I believe 90% of all deck collapses result from the failure of the deck ledger-to-house connection, and of the 90% most are caused by nailed-only ledgers.

The focus of this article is existing decks with a "nailed-only" ledger connection. As will be demonstrated, a homeowner, home inspector, property manager, or other professional can quickly determine if the deck is dangerous—nails only in a deck ledger constitutes a "dangerous deck."

Background

For decades, the residential codes have specified an occupant deck load of 40 pounds-per-square foot (psf), which translates into about one average-size person locating a space of 2-ft. by 2-ft. In addition, 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. Assuming a deck that is 14-ft by 28-ft, the code design load would anticipate the deck could be safely occupied by 98 people. However, until 2007, the IRC did not prescriptively specify how contractors should fasten or connect the deck ledger to the house.

A "2007 Supplement to the IRC," added to the code as Table R502.2.2.1, states the following:

TABLE R502.2.2.1
FASTENER SPACING FOR A SOUTHERN PINE OR HEM-FIR DECK LEDGER
AND A 2-INCH NOMINAL SOLID-SAWN SPRUCE-PINE-FIR BAND JOIST^{c,f,g}
(Deck Live Load = 40 psf, Deck Dead Load = 10 psf)

Joist Span	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 ^{d,e}						
1/2" diameter lag screw with 15/32" maximum sheathing ^a	30	23	18	15	13	11	10
1/2" diameter bolt with 15/32" maximum sheathing	36	36	34	29	24	21	19
1/2" diameter bolt with 15/32" maximum sheathing and 1/2" stacked washers ^{b,h}	36	36	29	24	21	18	16



Depending upon deck joist span and assumed conditions given in the footnotes (not shown here), the requirement for ½" diameter lag screws or bolts is established for connecting deck ledgers to the band joist. The requirement for ½" bolts or lag screws has appeared in every edition of the IRC since 2009.

Why is a Nailed Ledger Dangerous?

When decks are loaded by occupants, the weight of deck occupants causes the ledger nails to simply bend and pull out of the wood sheathing and house band joist, or more simply to pull straight out of the wall by the lateral movement of the deck floor. For example, I am aware of deck collapse cases where, with only one person on the deck and another person walking onto the deck and stopping, the entire deck shifted away from the house and collapsed.

The deck remains shown in Figure 1 depict a case where the deck shifted laterally, away from the structure, and fell to the ground.

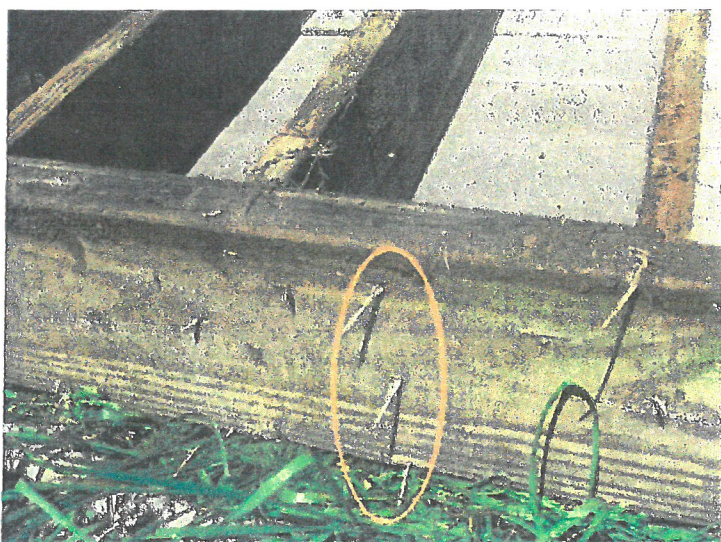


Figure 1. Close-up of deck ledger that was connected to a structure with nails only. When lightly loaded by occupants, the deck shifted laterally, pulling the nails out of the supporting structure.

Had the deck fallen vertically at the ledger side of the deck before shifting away from the house, 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 of the deck floor. Nails used in this application have negligible strength, providing only support for the weight of the deck without sufficient reserve capacity for in-service loading by occupants.

Why are Some Nailed Ledger Decks Still Standing?

The primary reason nailed ledger decks survive for some time is simply because they haven't been heavily loaded to the IRC-anticipated 40 psf or about one person on every 2-ft. by 2-ft. floor area. A secondary reason that some decks survive for a while is that the new wood materials and nails are typically free of decay and red rust, respectively, and thus the connection has peak strength when installed. Due to rain water or salt water exposure, galvanized nails have a limited life, and wood fibers around the nails experience decay that causes the nail connections to weaken as time passes. When considering the occupant load issue coupled with the impact of water (or salt water) exposure on the nail connection strength, nailed ledger decks continue to fail, especially during special family events (birthdays, graduations, weddings, family reunions, and so on).

Do I have a Nailed-only Deck Ledger?

This question can be answered in a few minutes—if *only* nail heads are present on the surface of your deck ledger, you have a nailed-only deck ledger. The deck should be tagged as unsafe, not occupied, and immediately repaired or replaced.

Did my Contractor use ½" Lag Screws or Bolts as Required by the IRC?

Once passing the "nailed-only ledger" question, other deck safety issues are more difficult to assess and a professional evaluation of the ledger connection to the structure is strongly recommended. In terms of the original installation of the lag screws, a sample of questions follows.

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

A deck ledger, metal flashing, and the bottom of a deck board are shown in Figure 2.



Figure 2. Section of a deck ledger with a nail head and ½" diameter lag screw installed.



The proper lag screw diameter per the IRC can be verified by the fact that $\frac{1}{2}$ " lag screws have a hex-head that is $\frac{3}{4}$ " wide. In this case, the contractor used $\frac{1}{2}$ " diameter lag screws to connect the ledger to the wall sheathing and house band. (The nail (bottom left) was likely used to position the ledger on the wall while the lag screws were installed.)

Issue 2. Did the contractor install the lag screws (or bolts) at the correct spacing?

This question is answered by measuring the joist span and using the 2007 IRC Table R502.2.2.1 ledger table (Table R507.2 in the 2015 IRC) and by selecting the required screw spacing. For example, for a joist span of 14 ft., the required lag screw spacing is 13" on-center.

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

In some cases, the resolution to this question can be answered entering a space that does not have a fixed ceiling installed (crawl space or basement) and viewing the face of the band joist. When $\frac{1}{2}$ " lag screws are used, observing the inside face of the house band joist is a critically important step in verifying the proper lag-screw length was installed. As viewed in a crawl space with the insulation removed, the tip of an installed $\frac{1}{2}$ " lag screw connecting the deck ledger to the house-band joist is shown in Figure 3.

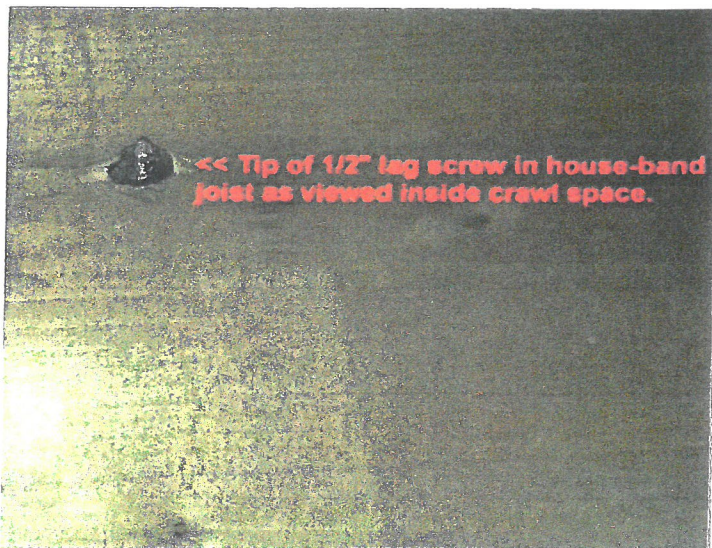


Figure 3. The tip of the lag screw depicted meets the IRC requirement for fully extending beyond the inside face of the band joist.

Because the tip of the screw extends beyond the inside face of the house-band joist, the installed $\frac{1}{2}$ " lag screw is clearly the proper length as required by the IRC. Assuming the tips of the lag screws are not present, the installation is not

IRC compliant and thus the deck may be unsafe, requiring an investigation by a design professional.

Note that, for the connection depicted with *wall sheathing only*, a 4" lag screw is required. For example, if $\frac{1}{2}$ " insulation board were added to the 15/32" wall sheathing, a $\frac{1}{2}$ " through-bolt with washers and nut would be required. Based on the 2007 IRC Supplement provisions (last row of Table 502.2.2.1 above), footnote h, states: "Wood structural panel sheathing, gypsum board sheathing or foam sheathing not exceeding 1 inch in thickness shall be permitted. The maximum distance between the face of the ledger board and face of the band joist shall be 1 inch."

Summary

Except for the "nailed-only ledger issue" that can be accomplished in a couple of minutes, a meaningful safety evaluation of a deck is both complicated and difficult. In this article, only some of the issues related to the installation of $\frac{1}{2}$ " lag screws in a deck ledger connection to the house are discussed. *For an existing deck, the difficulty of inspecting the ledger connection and other (structural) deck components is magnified by a factor of 10 because of the potential for wood decay and corrosion of fasteners (nails, lag screws, bolts, hangers).* All safety issues should be addressed before any deck is occupied.



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