WOOD BITS

Prescriptive Requirements and Inspection of Residential Decks

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The *International Residential Code* (IRC) currently provides only limited prescriptive design requirements for decks, prompting many jurisdictions to develop their own set of design criteria and inspection procedures. The purpose of this edition of "Wood Bits" is to assist those who wish to revise their jurisdiction's deck safety program but whose limited resources inhibit them from researching and developing requirements and inspection procedures specific to local conditions.

Note that the selection of cited code sections (from the 2003 edition of the IRC) and associated commentary is not intended to represent an official ICC interpretation, but rather to provide background into practical field issues.

Live Loads

> ***R301.5 Live load.*** *The minimum uniformly distributed live load shall be as provided in Table R301.5.*

Table R301.5 of the 2003 IRC requires decks to accommodate a uniformly distributed live load of 40 pounds per square foot. Typical deck ledger to house band joist connections were recently tested at Virginia Tech University and Washington State University, and the results were reported in the December 2005 issue of *Building Safety Journal* (note: a typographical error in Table 4 was corrected on page 4 of the February 2006 issue). The Southern Pine deck ledger to house band joist connection test data are now part of the Georgia, Indiana and Virginia state residential codes.

Table R301.5 requires guardrails and handrails to safely resist a single 200-pound concentrated load applied in any direction at any point along the top of the rail and handrail, respectively. It also requires the rail infill to safely resist a horizontally applied load of 50 pounds on an area equal to 1 square foot.

Inspectors often field test the 200-pound concentrated load resistance requirement by how stiff the guardrail "feels" when a relatively low load is applied at the top of the rail. In addition to being potentially dangerous for the person conducting the test, this test is not a reliable predictor of a guardrail's ability to safely resist 200 pounds of force. For example, a seemingly "stiff" guardrail when loaded to 50 pounds outward force may collapse the next week when loaded by 55 pounds. Consider that in research conducted at Virginia Tech University, not one guardrail post to deck band joist assembly using only ½-inch bolts or lag screws successfully passed the test based on the 2.5 safety factor given in the *International Building Code* (Loferski, J.R. et al: "Strong Rail-Post Connections for Wooden Decks," *Journal of Light Construction*, February 2005, pages 65–71).

The simplest solution for deck designers and contractors is to use a single stress-rated and notch-free post that serves as both the deck support column and guardrail post. In many cases, however, the contractor or designer chooses a guardrail post spacing that does not match the spacing of the columns that support the overall deck structure. Highly unsafe deck connections can result, so inspectors should watch for deficient details—especially if the connection of the guardrail post to the deck is hidden by a covering.

The aftermath of an incident in which a young man died after falling through a guardrail that was nailed only to joists on the end of the deck.

The 4 x 4 guardrail post connection shown was completely covered by a wood-plastic sleeve and "shirt." An outward force on the top of the post or rail caused the toenails to be loaded in withdrawal: a failure mode that is typically sudden and without warning.

Stairways

R311.5.1 Width. *Stairways shall not be less than 36 inches (914 mm) in clear width at all points above the permitted handrail height and below the required headroom height. [. . .]*

R311.5.2 Headroom. *The minimum headroom in all parts of the stairway shall not be less than 6 feet 8 inches (2036 mm). [. . .]*

Bear in mind that minimum headroom can be an issue when perimeter stairs turn at a landing to terminate under the deck.

R311.5.3.1 Riser height. *The maximum riser height shall be 7¾ inches (196 mm). [. . .] The greatest riser height within any flight of stairs shall not exceed the smallest by more than ⅜ inch (9.5 mm).*

Poorly cut stringers often exceed the allowable height variance, and stairs that are built prior to patios being poured or landings being built frequently have considerably shorter first risers, which can lead to stumbling or falls when stepping off of the riser after descending the stairs.

R311.5.3.2 Tread depth. *The minimum tread depth shall be 10 inches (254 mm). [. . .] The greatest tread depth within any flight of stairs shall not exceed the smallest by more than ⅜ inch (9.5 mm). [. . .]*

R311.5.3.3 Profile. *The radius of curvature at the leading edge of the tread shall be not greater than 9/16 inch (14.3 mm). A nosing not less than ¾ inch (19 mm) but not more than 1¼ inch (32 mm) shall be provided on stairways with solid risers. The greatest nosing projection shall not exceed the smallest nosing projection by more than ⅜ inch (9.5 mm) between two stories, including the nosing at the level of floors and landings. [. . .] Open risers are permitted, provided that the opening between treads does not permit the passage of a 4-inch diameter (102 mm) sphere.*

Open risers are common with decks, and the lack of infill is a common code violation. The main purpose of the 4-inch diameter sphere provision is to prevent a small child from crawling through the opening and falling. Entrapment and possible strangulation is also a concern.

R311.5.4 Landings for stairways. *There shall be a floor or landing at the top and bottom of each stairway. [. . .] The width of each landing shall not be less than the stairway served. Every landing shall have a minimum dimension of 36 inches (944 mm) measured in the direction of travel.*

Landings are frequently concrete pads placed after the deck and stairs are built. The required 36-inch dimension in the direction of travel is measured from the nose of the lowest tread.

R311.5.6 Handrails. *Handrails shall be provided on at least one side of each continuous run of treads or flight with four or more risers.*

R311.5.6.1 Height. *Handrail height, measured vertically from the sloped plane adjoining the tread nosing, or finish surface of ramp slope, shall be not less than 34 inches (864 mm) and not more than 38 inches (65 mm).*

R311.5.6.2 Continuity. *Handrails for stairways shall be continuous for the full length of the flight, from a point directly above the top riser of the flight to a point directly above the lowest riser of the flight. Handrail ends shall be returned or shall terminate in newel posts or safety terminals. [. . .]*

R311.5.6.3 Handrail grip size. *All required*

handrails shall be one of the following types or provide equivalent graspability.

1. *Type I. Handrails with a circular cross section shall have an outside diameter of at least 1¼ inches (32 mm) and not greater than 2 inches (51 mm). If the handrail is not circular it shall have a perimeter dimension of at least 4 inches (102 mm) and not greater than 6¼ inches (160 mm) with a maximum cross section dimension of 2¼ inches (57 mm).*
2. *Type II. Handrails with a perimeter greater than 6¼ inches (160 mm) shall provide a graspable finger recess area on both sides of the profile. [. . .]*

The graspability of the typical "handrail" on decks is an important issue: regardless of how they are installed, 2 x 4s and 2 x 6s do not meet the code criteria. It is also critical that handrails for stairs begin and end as prescribed by the code. The nerves in a person's hand signal his or her mind that stairs have ended when the handrail terminates. If steps remain beyond the handrail, trips and falls are likely.

> ***R311.5.7 Illumination.*** *All stairs shall be provided with illumination in accordance with Section R303.6.*

The type and location of the stair illumination should be specified in the deck plans and inspected accordingly.

Guards

> ***R312.1 Guards required.*** *Porches, balconies or raised floor surfaces located more than 30 inches (762 mm) above the floor or grade below shall have guards not less than 36 inches (914 mm) in height. Open sides of stairs with a total rise of more than 30 inches (762 mm) above the floor or grade below shall have guards not less than 34 inches (864 mm) in height measured vertically from the nosing of the treads. [. . .]*

> ***R312.2 Guard opening limitations.*** *Required guards on open sides of stairways, raised floor areas, balconies and porches shall have intermediate rails or ornamental closures which do not allow passage of a sphere 4 inches (102 mm) or more in diameter.*
>
> ***Exceptions:***
>
> 1. *The triangular openings formed by the riser, tread and bottom rail of a guard at the open side of a stairway are permitted to be of such a size that a sphere 6 inches (152 mm) cannot pass through.*
> 2. *Openings for required guards on the sides of stair treads shall not allow a sphere 4⅜ inches (107 mm) to pass through.*

Lower decks are frequently found to be in violation of railing requirements. Benches are often installed to define the perimeter of a deck when rails are required or built next to the rails. In either case, a bench with a 36-inch back measured from the deck surface and a 19-inch seat is actually a 17-inch barrier.

The deck/bench subject is not currently addressed in the IRC and deserves careful study by local jurisdictions.

Protection Against Decay

> ***R319.1 Location required.*** *In areas subject to decay damage as established by Table R301.2(1), the following locations shall require the use of an approved species and grade of lumber, pressure treated [. . .], or decay-resistant heartwood of redwood, black locust, or cedars. [. . .]*

The operative word above regarding decay-resistant species is "heartwood." Only the heartwood—the center portion of the log—of redwood, black locust or cedars is decay-resistant. Therefore, when a local jurisdiction establishes the need for protection against decay and a decay-resistant species is offered as a code conforming product, inspectors should verify that deck materials are in fact heartwood.

Wood posts, poles, and columns embedded in concrete that is in contact with the ground or exposed to weather must be pressure preservative treated for ground contact. The inspector should verify by inspection of end tags or otherwise that all materials in contact with soil are treated to the ground contact level defined by American Wood Preservers' Association (AWPA) standards.

> ***R319.3 Fasteners.*** *Fasteners for pressure preservative and fire-retardant-treated wood shall be of hot-dipped galvanized steel, stainless steel, silicon bronze or copper.*
>
> ***Exception:*** *One-half-inch (12.7 mm) diameter or greater steel bolts.*

Traditionally, the treated wood industry has recommended hot-dipped and stainless steel fasteners and connectors. Even with treatment formulations of alkaline copper quat (ACQ) and copper azole (CA) now available, hot-dipped and stainless steel fasteners and connectors are still strongly recommended. The higher copper contents in

the newer formulations increase the likelihood of galvanic corrosion in exterior applications. Also note that we have not found an exception for larger bolts in our survey of fastener manufacturers' literature.

Deck fasteners exposed to ocean spray are currently not addressed by the IRC, but pending the findings of a study committee on Virginia code proposal RB122–06/07, we believe common sense dictates that elevated deck fasteners and connectors subject to salt spray be made of stainless steel grade 304 or 316.

Protection against Termites

> ***R320.3.1 Field treatment.*** *Field cut ends,notches and drilled holes of pressure preservatively treated wood shall be retreated in the field in accordance with AWPA M4.*

IRC Section R320.3.1 establishes the need for protection against termites in areas where damage is probable. AWPA Standard M4 recommends treating any cut, bored, drilled or adzed surfaces of treated wood with a preservative solution.

Wood Floor Framing

> ***R502.8.1 Drilling and notching in sawn lumber.*** *Notches in solid lumber joists, rafters and beams shall not exceed one-sixth of the depth of the member, shall not be longer than one-third of the depth of the member and shall not be located in the middle one-third of the span. Notches at the ends of the member shall not exceed one-fourth the depth of the member. [. . .] The diameter of holes bored or cut into members shall not exceed one-third the depth of the member. Holes shall not be closer than 2 inches (51 mm) to the top or bottom of the member, or to any hole located in the member. Where the member is also notched, the hole shall not be closer than 2 inches (51 mm) to the notch.*

Many of today's decks incorporate sinks, lights, cooking appliances and other items that may require the routing of mechanical and electrical lines through structural framing. Due to moisture cycles in the lumber from outdoor exposure, notching may be more detrimental than for the inside "dry case." Alterations beyond the provisions of R502.8.1 should be evaluated by a design professional and repaired as necessary.

> ***R502.2.1 Decks.*** *Where supported by attachment to an exterior wall, decks shall be positively anchored to the primary structure and designed for both vertical and lateral loads as applicable. Such attachment shall not be accomplished be the use of toenails or nails subject to withdrawal. Where positive connection to the primary building structure cannot be verified during inspection, decks shall be self-supporting. For decks with cantilevered framing members, connections to exterior walls or other framing members shall be designed and constructed to resist uplift resulting from the full live load specified in Table R301.5 acting on the cantilevered portion of the deck.*

Based on our analysis, this code section disallows the use of 2 x 2 ledger strips attached to ledger boards because 2 x 2s tend to rotate under load, thereby subjecting the nails to withdrawal loads. Fastening joists to the ledger with connectors (joist hangers) appears to meet the intent of this provision, but it should be noted that the code requires the design professional to account for "lateral loads" not defined in the code or other literature. In any event, the connectors must be suitable for use with the new lumber pressure treatments.

Columns

> ***R407.1 Wood column protection.*** *Wood columns shall be protected against decay as set forth in Section R319.*
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> ***R407.2 Steel column protection.*** *All surfaces (inside and outside) of steel columns shall be given a shop coat of rust-inhibitive paint, except for corrosion-resistant steel and steel treated with coatings to provide corrosion resistance.*
>
> ***R407.3 Structural requirements.*** *The columns shall be restrained to prevent lateral displacement at the bottom end. Wood columns shall not be less in nominal size than 4 inches by 4 inches (102 mm by 102 mm) and steel columns shall not be less than 3-inch-diameter (76 mm) standard pipe or approved equivalent.*

Adequately securing columns or posts can be a challenge in the field when manufactured post connectors are not used. Useful illustrations for restraining columns can be found in the *2003 International Residential Code Commentary Volume 1*. In addition, precast concrete footings typically found at building stores do not prevent displacement unless they are secured to the supporting footing.

Footings

> ***R403.1.1 Minimum size.*** *[. . .] The size of footings supporting piers and columns shall be based on the tributary load and allowable soil pressure*

in accordance with Table R401.4.1. [. . .]

R403.1.4 Minimum depth. *All footings shall be placed at least 12 inches (305 mm) below the undisturbed ground surface. Where applicable, the depth of footings shall also conform to Sections R403.1.4.1 through R403.1.4.2.*

IRC Section R403.1.4.1 deals with footings and foundation systems extending below the frost line. In areas where frost line is not an issue, the footing is still required to be a minimum of 12 inches below undisturbed ground.

Girders and Beams

Per IRC Table R602.3(1), each layer of built-up girders and beams of 2-inch lumber layers must be nailed using 10d nails 32 inches on center at top and bottom and staggered, with two nails at the ends and at each splice. (See Section R319.3 for protection of nails.)

The quantity of nails is not a typical problem in the field, but improper placement of fasteners and unsupported splices are common.

Exterior Covering

R703.8 Flashing. *Approved corrosion-resistive flashing shall be provided in the exterior wall envelope in such a manner as to prevent entry of water into the wall cavity or penetration of water to the building structural framing components. The flashing shall extend to the surface of the exterior wall finish and shall be installed to prevent water from reentering the exterior wall envelope. Approved corrosion-resistant flashings shall be installed [. . . w]here exterior porches, decks or stairs attach to a wall or floor assembly of wood-frame construction.*

As mentioned earlier, changes in the chemical makeup of the preservatives used for pressure preservatively treated wood have increased the likelihood of galvanic corrosion between fasteners, connectors and flashing. It is also worth noting that aluminum has never been recommended for use as flashing by the treated wood industry.

That said, the authority having jurisdiction should determine what materials and methods are suitable for flashing the deck connection to the house. For some ideas on deck flashing, see *www.fairfaxcounty.gov/decks/*, Sheet 7, "Siding and Flashing."

The importance of effective flashing of the deck ledger to house band area cannot be overstated. The integrity of the ledger to house band joist connection comes down to sound wood, and inadequate flashing can also cause interior water damage. The issue of flashing thereby provides strong encouragement for requiring "self-supporting" decks.

Severe water damage to the house framing can result from the lack of adequate flashing at the deck-ledger to house-band-joist connection.

Summary

Residential deck safety is a serious safety issue, and it is hoped that the preceding overview will provide a good starting point for discussions about the appropriate code requirements for a particular jurisdiction. The prescriptive deck design and inspection requirements developed by Fairfax County, Virginia, offer additional insight and direction, and are freely accessible online at *www.fairfaxcounty.gov/decks/*. ◆

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Editor's note: ICC's open, consensus-based code development process welcomes code change proposals so that all can benefit from the field experiences of peers. For more information, go to *www.iccsafe.org/cs/codes* or phone 1-888-ICC-SAFE (422-7233), extension 33810.

Questions, comments and suggestions for future "Wood Bits" are welcome and may be sent to Dr. Woeste via e-mail at fwoeste@vt.edu.