Safe and Durable Decks

By Frank Woeste

All deck builders should refer to the DCA6 — prescriptive guidelines for residential deck construction.

In almost any climate, heat, ultraviolet light, and elevated moisture levels take a toll on decks. The apparent degradation of materials evidenced by splintering, splitting, and rusting call attention to a deck builder's' highest priory: designing and building safe and durable decks. Fortunately, there is help at hand to guide deck builders toward code-conforming deck design and good construction practice.

Essential reference. *The Design for Code Acceptance 6: Prescriptive Residential Deck Construction Guide provides practical guidance for designing and building safe, durable decks.*

The DCA6

The reference document for safe residential construction is the International Residential Code (IRC), which has been adopted with some modifications by most states and jurisdictions. While the IRC provides comprehensive prescriptive design guidance on the foundation and structural framing of the residence from the walls inward, the available guidance on the design of an attached deck, until the advent of the DCA-6, was very limited. In recognition of this deficit of information, the American Wood Council (AWC), then called the American Forest & Paper Association (AF&PA) adapted a document developed by the Fairfax County, Virginia Dept. of Public Works, which evolved under the AWC into the Design for Code Acceptance 6 (DCA6): Prescriptive Residential Deck Construction Guide. It is available online at awc.org/codes-standards/publications/dca6. The most current edition available, which is based on the 2015 IRC, is 44 pages. The reader's attention is directed to the bottom of page 1, where the basis of the document is stated—IRC sections are bracketed when they form the basis of a section, while other sections are considered "good practice recommendations."

While every section of DCA6 is important to deck safety, the purpose of this article is to give background on sections of the DCA6 that may be of special interest to those focused on long-term durability.

Building a safe deck starts with selecting appropriate materials. The DCA6 provides builders with two options for real wood decking: naturally durable species, such as redwood or western cedars, or pressure-treated lumber. Both deserve careful study by the deck contractor who is focused on durability.

Naturally durable species. While such woods as redwood and cedar are widely considered to be naturally durable species, only the "heartwood" of redwood, cedars, black locust, and black walnut is actually considered decay resistant by the IRC. The sapwood, the outside part of a log, does not qualify. According to the USDA Wood Handbook (2010, page 315), "Untreated sapwood of substantially all species has low resistance to decay and usually has a short service life under decay-producing conditions." Only the average heartwood of species is rated in Table 14-1 of the Wood Handbook, which groups woods according to their decay resistance. Corner sapwood is permitted if 90% or more of the width of each side on which it occurs is heartwood.

Given these restrictions, it is unlikely that the typical decking lumber available will consistently meet the IRC's definition of "naturally durable wood." To ensure deck durability, the deck contractor should consider special-ordering "all heartwood" in conformance with model code definition of naturally durable wood.

Pressure-treated lumber. Pressure-treated lumber works well for both the substructure and the decking. However, contractors should pay close attention to the retention level used for lumber on all parts of the deck.

Citing the 2015 IRC R317.1.2, the DCA6 is clear: "All lumber in contact with the ground shall be approved preservative treated wood suitable for ground-contact." The difference in retention levels between "ground contact" material and "above ground" material is significant, as shown in the table below.

		RETENTION, PCF (kg/m^3)		
Preservative	**Percentages of active ingredients**	**Aboveground (UC3)**	**Ground contact (UC4A)**	**Critical structural (UC4C)**
CCA–C	19% CuO, 47% CrO_3, 34% As_2O_5	0.25 (4.0)	0.40 (6.4)	0.60 (9.6)
ACQ–B and D	67% CuO, 33% DDAC[1]	0.25 (4.0)	0.40 (6.4)	0.60 (9.6)
ACQ–C	67% CuO, 33% BAC[2]	0.25 (4.0)	0.40 (6.4)	0.60 (9.6)
CA–B	96% Cu, 4% Azole[3]	0.10 (1.7)	0.21 (3.3)	0.31 (5.0)
CBA–A	49% Cu, 2% Azole[3], 49% H_3BO_3	0.20 (3.3)	0.41 (6.5)	0.61 (9.8)
ACZA	50% CuO, 25% ZnO, 25% As_2O_5	0.25 (4.0)	0.40 (6.4)	0.60 (9.6)
Creosote	Creosote is the sole active ingredient.	8.0 (128)	10.0 (160)	12.0 (192)
Pentachlorophenol	Pentachlorophenol is the sole active ingredient.	0.40 (6.4)	0.50 (8.0)	0.50 (8.0)
Copper naphthenate	Copper naphthenate is the sole active ingredient.	0.04 (0.6)[4]	0.06 (0.96)[4]	0.075 (1.2)[4]
Oxine copper	50% Cu-8[5], 50% Nickel-2-ethylhexoate	0.02 (0.32)	Not recommended	

[1] Didecyldimethylammoniumcarbonate
[2] Alkylbenzyldimethylammoniumchloride
[3] Tebuconazole
[4] Expressed as retention of metallic copper
[5] Copper-8-quinolinolate

Treatment levels for both the "old" CCA and some of the new preservative chemicals are shown in the table above. Note that required retentions for the "above ground" treatment are substantially less than those required for "ground contact" materials.(From Preservative-Treated Wood and Alternative Products in the Forest Service [PDF])

To ensure the right treatment level, deck contractors must carefully examine the end tags on the lumber they purchase, making sure that "ground contact" material is being ordered and delivered when required. Once material with the proper retention level is purchased for the job, I recommend that contractors keep a sample of the lumber treatment tags, along with a copy of the PT lumber invoice, as part of the job file. This will help to substantiate the contractor's due diligence should a construction defect complaint related to the deck ever arise.

Even in "above ground" applications, however, there is a strong argument for using materials suited for ground contact. At this time, the adequacy of the new PT chemicals at above-ground treatment levels is still relatively unknown. CCA lumber was withdrawn from the market in late 2003 but suppliers were allowed to sell off their inventories of CCA-treated lumber. By 2005, the above-ground material came to be readily available for deck construction in the Virginia area and along the eastern seaboard. However, the durability of the new preservatives and lower treatment levels in deck applications is still not fully known, as many of the decks built after this time are still well within their service life. Moreover, there have been some reports of premature failures of above-ground treated lumber reported. Faced with uncertainty on this subject, I would strongly recommend that contractors consider using "ground contact" (minimum UC4A) lumber for all above-ground deck parts.

Solid-sawn deck posts (timbers) embedded in the ground may even require a preservative treatment level that is above UC4A. For additional information on the recommended treatment for timbers in the ground, refer to Table 3 in the Recommended Guideline section of the USDA Forest Service Technical Bulletin on Treated Wood Processes. Also keep in mind that regardless of the PT wood materials selected, decks should be inspected annually for evidence of decay and unsafe conditions.

Deck disaster? *All fasteners are subject to corrosion but coastal conditions demand even more. The photo above is not an atypical condition for decks built near the ocean, where heat, ultraviolet light, elevated moisture levels, and salt spray exact a stiff toll on wood decks in relatively short periods. A condition like this should raise safety concerns for both the deck builder and the general contractor.*

Corrosion protection of metal parts. Item 7 of the Minimum Requirements in the DCA6 covers the corrosion resistance of fasteners and metal hardware. The majority of fasteners must be hot-dipped galvanized or stainless steel. Siliconized bronze and copper are also allowed, but not typically used for structural connections and most often used for securing flashing. Coastal contractors should skip right to the fourth bullet point, which trumps the previous three bullets wherever the job site is located near the ocean: "Fasteners and connectors exposed to, and located within 300 feet of, a saltwater shoreline shall be stainless steel grade 304 or 316."

"Fasteners" include all nails, screws, lag screws, and bolts. "Connectors" are typically joist hangers and other framing hardware that is fabricated from rolled steel. In the interest of deck safety and increased durability, the provision should be considered by the contractor and owner for decks greater than 300 feet from a saltwater shoreline.

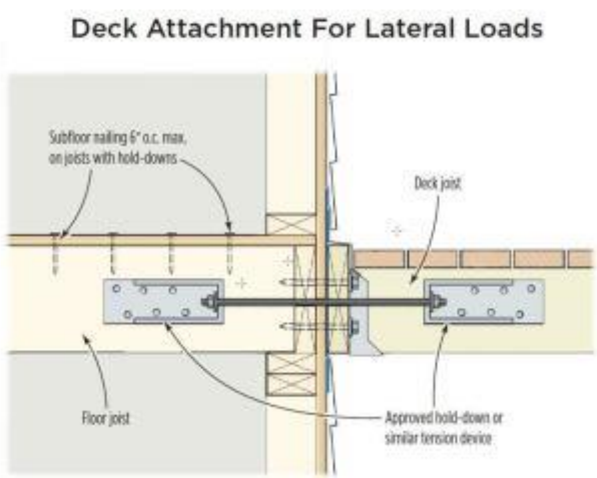
Assumed design loads. DCA6 is based on an assumed live load of 40 psf and the 10 psf dead load.

- The 40 psf live load (LL) anticipates occupants only with typical deck furniture such as lightweight tables and chairs. It does not anticipate heavy loads such as large planters, portable pools, the water in a hot tub, or any other load beyond the weight of occupants.

- Dead load (DL) is defined as the self weight of the structure and the weight of fixed objects. The use of a 10 psf DL anticipates wood framing with wood or plastic decking. It does not include the dead weight of a hot tub or any other permanently attached objects.

As a matter of good construction practice, deck contractors should formally communicate the load assumptions to the homeowner by reviewing the DCA6 Minimum Requirements [items 8 and 9, page 2]. If the customer's expectations call for loading conditions that go beyond occupant loading, you will need to get a design professional involved.

The lateral load connection. *Building codes requires hold-down tension devices. Shown here is one option allowed. This type of connector is required in at least two locations per deck, and each device must be designed for an allowable stress capacity of at least 1,500 pounds.*



Since the 2012 IRC clarified that decks must resist lateral loads, the DCA6 [page 17] began addressing lateral-load ledger connections, but limits its recommendations to the prescriptive provisions of the IRC R507.2.4, and does not address the greater lateral resistance required in high-wind and seismic zones. The illustration at left shows one example of the type of connection permitted (though not required) to resist lateral loads. At least two hold-down tensions devices of this or an equivalent type are required for all decks. Coastal decks and decks built in seismic zones may require substantially more lateral resistance, as specified by an engineer.

Joists and Beams

Maximum joist spans provided in the DCA6 [page 4] are based on No. 2 grade lumber and wet-service conditions. The tabulated spans are less than common residential floor spans because the assumed wet-service conditions reduce the strength properties of the lumber.

All carrying beams (multiple deck girders) must bear fully on supporting posts, while the joists above should fully bear on the beams. Such "wood-to-wood" bearing provides the most efficient connection possible between wood framing members. Bolting the beams to the sides of the post is not an efficient connection. In the case of a 2x beam bolted to a 6x6 post, for example, the force is applied to the beam members perpendicular-to-grain and the bolt forces are applied parallel-to-grain in the post. In this situation, the capacity of a typical 1/2-inch bolt in the perpendicular-to-grain loading is relatively low under wet-service conditions. Splitting is also likely to occur when two (or more) bolts are aligned vertically in the beam, because the shrinkage rates between the beam members and the post are dramatically different (about 40:1).

Premature decline. *On a beachfront home in Virginia, no Z-type flashing was installed over the ledger-to-house connection, which led to extensive decay.*

Ledger Attachment and Flashing

Based on deck collapses and injuries reported in media sources, the connection of the deck ledger to the house band joist is the most critical structural element of a deck. But the integrity of the connection is based on the assumption that the house band and deck ledger has no decay [DCA6 Table 5, page 15]. Therefore, flashing the connection is easily as important as the connection design (fastener size and spacing).

Ledger fastening. The fastener spacings from DCA6 Table 5 are based on tests of simulated deck-ledger to band-joist connections performed at Virginia Tech and Washington State University that form the basis of an IRC code proposal. Since the publication of the ledger fastener table in the 2007 IRC, AF&PA has added EWP rim boards to the DCA6 Table 5 based on tests at APA.

Ledger flashing. The critical role of effective ledger flashing cannot be overemphasized. The photo above underscores the result from overlooking the Z-flashing on a beachfront home. If for any reason the wall sheathing and house band joist are exposed to water, decay will follow because the typical ledger connection is "water trapping," and significant decay is the likely outcome.

Best practice calls for not only including the Z-flashing recommended by DCA6 but also providing self-adhesive flashing against the house. This type of membrane is strongly recommended in any exposed conditions to help protect against water infiltration resulting from wind-driven rain.

Destined to fail. Deck joists (framed with PT framing lumber) have been hung from a ledger that is lagged into the rim board of a cantilevered I-joist system. Even if the lag screws were to be positioned to penetrate the I-joist flanges, the connection would be dangerously weak. It is likely to collapse under very low loads, possibly the dead load of just the deck structure itself. DCA6 strictly prohibits the connection of a deck to a cantilevered overhang.

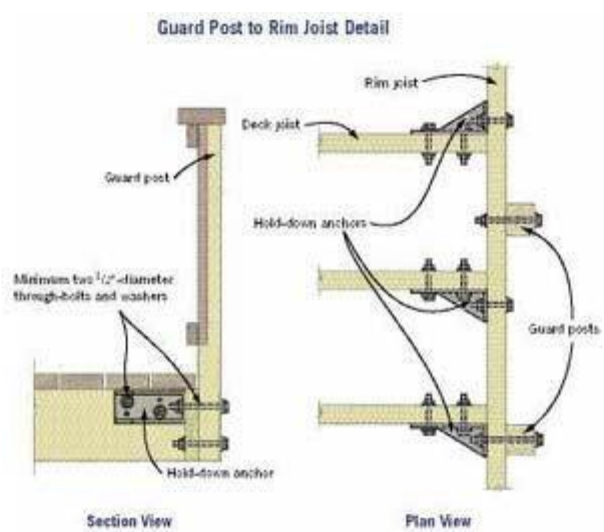
Ledger connection to cantilevers. Without a connection detail by a professional engineer, a deck ledger should never be supported off the end of a cantilevered floor [DCA6 figure 18] because the load path is not complete. It is extremely difficult to transfer the vertical load from the deck ledger to the floor joist of the house using fasteners, because the rim joist/house band is bearing on "air" instead of a plate with a high wood-to-wood bearing capacity. This situation is depicted in the photo at left. It is extremely dangerous and likely to collapse under relatively low deck loads (possibly dead load only).

Guard Requirements

In the vernacular of DCA6 [pages 15-16, 18-19], a deck's "guard" is the guardrails or handrails surrounding the deck. All deck surfaces greater than 30 inches above grade are required to have a guard. Details for a proper guard can be found in DCA6 Figure 25 and 26. At stake here is the protection of the occupants against severe injuries and fatalities. Falls through decks guards are generally grave, and among problems with decks, only deck ledger failures are reported more frequently in the media.

Deadly rail. *The photo above shows an example of a grossly deficient guardrail system that produced a fatality and another injured party. In this case, a young man died after falling through the guardrail with posts that were nailed only to joists on the end of the deck. A fatal flaw included with this rail twas notched 4x4 posts — a detail that is not permitted in the DCA6.*

DCA6 Figure 26 show one rail post construction needed to meet the intent of the IRC code (shown in the illustration "Guard Post to Rim Joist Detail", below). In all guardrail attachment methods allowed by code, the top of the rail must safely resist a 200-lb. outward force. "Safely" in this case means that a safety factor is applied to a test of a detail to prove that it can work in the field, because tests rely on virgin material and perfect fabrication that doesn't always exist on site. In an effort to determine what constitutes a safe rail post connection to the end of deck joists, we tested numerous details at Virginia Tech. All lagged and through-bolted connections failed to meet the 500-lb. test load, despite numerous attempts to reinforce the connection with blocking. Only the connection that relied on a metal hold-down anchor, such as the Simpson HD2AHDG (www.strongtie.com/products/connectors/HDA-HD.asp) or DeckLok (www.mtdecklok.com/railpost.htm), passed the test.



Hold-downs required. *To meet code, guard posts for deck guards that run perpendicular to the deck joists must be attached to the rim joist as shown at right. (Or, alternative attachment methods can be made that meet code-approved manufacturer's instructions.)*

As mentioned previously, stainless steel connectors and fasteners are recommended in DCA6 for saltwater shoreline exposure. DeckLok is one source for 304 and 316 stainless steel hold-down anchors that resisted the 500-lb. load used in the Virginia Tech guard post tests.

Landmark Step

The publication of DCA6 by the AF&PA is a landmark step in advancing the cause of safe decks in order to prevent injuries and fatalities from deck collapses. While I have only commented on a few sections with respect to deck safety and durability, the entire DCA6 is important and deserves careful study and consideration by the professional deck contractor. For decks applications and conditions that fall outside the scope of DCA6, the contractor should seek professional design input and evaluation by the local jurisdiction through the permitting and inspection program.

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