Building and Installing Deck Stairs

by Mike Guertin

Traditional cut stringers combined with new hardware make a strong connection

I've been building stairs inside homes and on decks for almost 30 years. There are lots of viable methods that avoid the pitfalls that lead to uneven risers, tilted staircases, and downright collapses; in this article, I describe my practices for building a set of stairs with cut stringers (stringers notched out for treads and risers), probably the most common type of stringers used on decks. I reference the 2009 International Residential Code (IRC); your local code may differ.

Establish the Landing First

Where I work, the grade at the end of a deck staircase often slopes, which means I have to establish where the bottom step will land before I can determine the overall rise of the stair. So rather than calculate a set of stairs and try to sort out the landing afterward, I lay out the landing first and cut the stairs to fit.

I start by taking a rough measurement from the elevation of the deck's surface plumb down to where I judge the landing should go. I divide that number by $7\frac{3}{4}$ inches (the maximum permitted riser height) and round the answer to the next highest integer to determine the number of risers I'll need. For example, a total estimated rise of $52\frac{1}{2}$ inches divided by $7\frac{3}{4}$ inches equals 6.77, which rounds up to seven risers. I subtract one to get the number of treads (unless the top tread is an extension of the deck surface, there is always one less tread than there are risers). Then I multiply the number of treads by my selected tread depth (usually 10 inches, the minimum per the code) to determine precisely how far away from the edge of the deck the last riser will land.

It's not difficult to locate the landing when the grade is level or slightly sloping, but on steep grades, I sometimes have to recalculate because my first guess for the landing area or height doesn't work out.

Once you know the position of the bottom riser, you can determine the

Figure 1. After making preliminary calculations to find the location of the base of the stairs, the author pours concrete for the landing.

landing's finish grade level based on the surrounding earth. Keep in mind these often-overlooked code provisions: A solid, stable landing surface is required to extend at least 36 inches beyond the bottom step, and the landing should slope for drainage but no more than 1/4 inch per foot. Depending on how the work progresses, I may form and pour the landing before laying out and cutting the stringers (**Figure 1**). Other times, I make a mark on a grade stake indicating the top of the landing, measure to the mark, and cut the stairs.

When I form and pour a landing, I use enough concrete to make it at least 4 inches thick, and I broom-finish the top for traction. In some locales, inspectors require the landing to be on frost footings, but this isn't an issue my local building departments have raised. If you don't regularly pour concrete or set hardscape materials for a landing, consider these benefits — a level surface for a precise total rise measurement and a stable footing to rest the staircase on. And the last thing you want is for the staircase to end on bare earth or lawn, because it will only be a matter of time before the landing looks like the area under a children's swing set.

Stair stringers are laid out from finish level to finish level. With the landing elevation pinpointed, I measure the total stair rise from the landing finish level to the top of the decking. I always lay a piece of finish decking on top of the joists to measure from; otherwise — if I measure off the deck frame — I might forget to add in the width of the decking. For decks close to the ground, I place a level across the finish decking and just measure down from it to the landing. On tall decks, since my level doesn't reach out far enough, I set a laser atop the finish decking and measure up from the landing to the light beam; then from that measurement I subtract the distance between the base of the laser and its beam (**Figure 2**).

Figure 2. Use a laser level and a tape to accurately measure the total rise between the landing and the top of the finish decking.

Figure 3. Stair nuts used on a framing square can be handy for marking out risers and treads, but stringer wane and eased edges make them difficult to use accurately.

Figure 4. Rather than use stair nuts for marking out stringers, the author prefers to screw a straight 1x2 to a framing square. The 1x2 bridges any wane or other edge defects and provides a straight line that makes it easy to pinpoint riser and tread points when stepping off the stairs.

Like floor joists or rafters, stringers of a certain size and spacing can span only so far, depending on the type of stringers (cut or solid) and the species of wood. Also, because deck stairs may be exposed to water, the maximum allowable span has to be reduced because of the "wet-service" factor. Unlike joists or rafters, however, stringers don't have an IRC table for determining maximum span.

Rather than consult an engineer, I rely on the *Prescriptive Residential Wood Deck Construction Guide* (DCA 6) from the American Forest & Paper Association's American Wood Council (free at awc.org/publications/DCA/DCA6/DCA6-09.pdf). Since the AWC develops the standards for wood frame construction that the IRC is based on, most building officials will accept the DCA 6 criteria as an alternative to the IRC.

According to DCA 6, 2x12 southern-pine cut stringers are allowed a 7-foot span measured horizontally from the face of the bottom riser to the back cut at the stringer head. Other woods are limited to 6-foot spans for cut stringers. As a practical matter, that means the total rise of a cut set of southern-pine stringers is limited to about 5 feet 10 inches. Western treated wood species are limited to a total rise of about 4 feet 6 inches. That does not mean your decks can't be higher than that, only that you may need to add intermediate supports and footings for longer stringers.

Choosing and Laying Out Stringers

I'm choosey about stringer stock. The southern pine stocked at East Coast lumberyards tends to be knotty and may be warped, cupped, and twisted. I order #1 grade or hand-select 2x12 stringer stock, avoiding lumber with large knots that can crack and drop out on a cut stringer. Stock with crisp corners and no wane is hard to come by but necessary if you want to use stair nuts on a framing square to do the layout — stair nuts ride down into any wane void, and they fail to register the top edge of the board on heavily eased edges (**Figure 3**).

Rather than struggle eyeballing the alignment, though, I gave up stair nuts years ago in favor of a straight 1x2 fastened to a square at the pitch of the stair. The 1x2 rides along the stock, bridging heavy wane and any surface defects. I attach the 1x2 with 3/4-inch pan-head screws to a framing square in which I've drilled a series of holes (**Figure 4**). Alternatively, a pair of small spring or bar clamps work. Either way, align one end of the 1x2 with the rise dimension and one end with the run dimension on the outside of the square.

One nice thing about using a 1x2 straightedge is that you can easily register the square to the previous tread or riser line on the stringer stock, because the 1x2 gives you a precise cross point with the square that stair nuts don't. I generally start laying out the stringer near the top with a tread cut mark. The point where this mark trails off the edge of the stringer blank is where I start the stepping-off process with the framing square: riser, tread, riser, tread.

Even though the 1x2 works better

than stair nuts, the eased edge of the framing lumber and the presence of edge wane still make it hard to align the points by looking straight down at the square. Often you have to eyeball the tread mark on the stringer from the side to align it with the riser dimension on the square, or else run a separate straightedge (such as the blade of another square) along the tread mark to bridge the air space over the edge ease or wane.

I know the code allows us to be off a whopping 3/8 inch from the shortest riser to the tallest one along a stringer, but I don't see any benefit to being sloppy; it takes only a few extra seconds to do a perfect layout job. Along those lines, I keep the pencil lead sharp during the mark-out process, touching it up after every half-dozen strikes. I also avoid running the pencil lines long at the inside corner where tread meets riser to ward off the tendency to follow the line to the bitter end when making saw cuts.

Since the deck's rim joist serves as the top riser on most of my stairs, the stringer has no top riser cut. I count the tread marks (as opposed to the riser marks) on the stringer to keep track of how far to mark out. I've confused myself more than once when laying out stairs, by accidentally marking a top riser, only to end up cutting a stringer that's one step too tall (that is better than too short, but I hate to toss a piece of wood, especially if I've figured my stringer stock close).

Figure 5. Mark the bottom cut on the stringer so the bottom riser is shorter than the other risers by the thickness of the tread stock. Here, the dotted line indicates the full riser height as the author marks the cut line 1 1/2 inches shorter to account for the 2x12 tread stock.

The bottom riser cut on a stringer must be shorter than the rest by the thickness of the tread stock, which "drops" the entire stringer vertically by that much; once the treads are applied, the riser heights will be equal, from the bottom step to the deck (**Figure 5**). Housed stringers are laid out slightly differently (see "Housed-Stringer Exterior Stairs," January/February 2007; deckmagazine.com.)

Some carpenters like to nail a 2x12 to the very bottom of the stringer. If you do this, the stringers need to be trimmed off to account for the thickness of the board. The same is true for any mounting bracket you install. If the bracket elevates the stringer off the landing then you'll need to trim the stringer bottom — even if it's just 1/4 inch.

When you plan the stringer head cut, think about how you'll attach the stringer to the deck. Many common stringer attachment practices

Construction Calculator Makes Stringer Calcs Easy

You can use an ordinary calculator to compute the riser height, but that involves converting decimals to fractions of an inch. I've been spoiled by Construction Master calculators from Calculated Industries (800/854-8075, calculated.com). They have a stair calculation function and they display inches and fractions, so no converting is needed. The default stair riser factor is 7 1/2 inches, but that's easily adjusted to the IRC limit of 7 3/4 inches or whatever your code permits. I also set the fractional resolution to 1/16 inch to avoid a result in 64ths, which are unnecessarily fine. The calculator button sequence is easy: Just enter the total rise in feet, inches, and any fraction, then press [Rise] and [Stair]. The display instantly gives you the riser height (R-HT) measurement. Additional pressing of the [Stair] button gives you other useful information, such as the number of risers and the stringer length. This last is useful when ordering lumber so you can ensure minimal waste.

Figure 6. Mark the head cut plumb down from the back of the top tread cut.

Figure 7. The author makes the plumb head cut and level foot cut first, then positions the stringer between the deck and the landing to double-check the fit before notching for treads and risers.

Figure 8. Making all tread cuts in succession, then cutting the risers on a second pass along the stringer, helps the author repeat a consistent entry angle for the meticulous cuts.

wouldn't pass an engineer's sniff test, nor would they strictly adhere to the building code. I use a couple of attachment configurations that rely on metal connectors specifically designed and tested for mounting stringers to the deck frame (more on that later). Both of my methods mount the stringers directly to the deck rim board or to a header set just beneath the rim board. In either case, I cut the stringer head square down from the back of the tread cut (**Figure 6**).

I like to make one final check before notching out the riser and tread cuts. I cut just the head and foot of the stringer and position it against the deck frame to make sure my calculations and layout are on track (**Figure 7**). While this step won't save the stringer stock if you've cut it too short, at least it saves the time of notching a majority of the cuts. And you may be able to salvage at least some of a mis-cut stringer and repurpose it for treads.

Cutting Stringers

Cutting stringers is pretty straightforward. Still, I've refined the process to what works best for me and gives me the most accurate results. First, the saw and blade have to be up to the task. Because saw blades are sometimes out of square with the base plate by a degree or two, I double-check that angle with a framing square and, if necessary, adjust the base. A sharp saw blade is essential; the saw enters the cuts and tracks truer when the teeth are sharp. I often swap out a regular framing blade for a 24-tooth thin-kerf crosscut blade before I cut stringers.

The closer the saw blade lines up with the angles of the treads and risers when starting the cuts, the straighter the cuts will be. I find that a consistent body angle aids in this, so I make all the tread cuts first and make the riser cuts on a second pass along the stringer (**Figure 8**). The rhythm of making the same entry angle each time, rather than reorienting the saw 90 degrees, helps me keep the cuts clean. The accuracy is well worth the extra minute it takes for the second pass.

It is very important not to overcut the inside corners where tread and stringer cuts come together. Overcuts reduce the cross-section strength of the stringer and can lead to cracking. I often bore holes with a 3/4-inch bit where the riser and tread cuts meet so that each hole just touches the edges of both lines. This leaves a radius at the inside corner and an obvious visual cue to stop the cut. When I don't bore holes first, I stop the saw kerf 1/8 inch to 1/4 inch short of the intersecting lines (**Figure 9**) and finish the cut with a pull saw, being careful not to overcut the corner (**Figure 10**).

Since I use the first stringer as the pattern for marking the others, I cut it as precisely as possible. When I align the pattern stringer with the stock for the duplicates, I make sure the cut sides are flush even if the stock depth isn't equal; misaligned bottom edges won't affect the stringer match. Then I clamp or screw the pattern stringer to the duplicate stock to reduce the chance of them going out of alignment while I'm drawing the cut lines, especially on longer sets of stringers. I use a sharp pencil, and as the pencil marks are on the "waste" side of the notches, I take the line with the saw blade when cutting.

Alternatives to Cut Stringers

Not every deck builder cuts notches in stringers. There are at least two manufacturers making brackets designed to screw to stringers that are cut only at the top and bottom. The EZ Stair (EZ Stairs; 866/693-9570, ez-stairs.com) attaches to a pair of 2x6s on each side of the stair, while the Universal Stair Bracket (GoPro Construction Solutions; 877/577-4142, goproconstruction.com) attaches to a single 2x6. Both have lab reports that should satisfy most building inspectors.

Figure 9. Stop saw cuts 1/8 inch to 1/4 inch short of the opposite lines to avoid overcutting the corners.

Figure 10. Finish the inside corner cuts with a handsaw, taking care not to overcut the corner.

The number of stringers you need is a function of the width of the staircase and the tread material. Cut stringers can be spaced no more than 18 inches on center, so a 3-foot-wide staircase needs three stringers, and a set of slightly wider stairs (say 3 feet 6 inches) needs four stringers. The maximum 18-inch spacing presumes treads of 5/4-inch wood decking or 2-by stock. When using synthetic decking for treads, consult the decking manufacturer's instructions — many require stringers be spaced no farther apart than 12 inches or 10 inches, and some even require spacing as close as 8 inches. Pay attention to the manufacturer's installation instructions. They are referenced by the IRC in sections R317.4 and R317.4.1 and must be followed for code compliance.

Attaching Stringers

I've seen more than a dozen different methods used to mount stairs to the deck frame, from blocks nailed to the framing between the stringers, to toenailed stringers and stringers notched onto a joist hanger. Most would not pass muster with an engineer or a strict enforcement of the code.

I've become more conservative with age, and I worry about the long-term performance of critical attachments on decks. IRC section R311.5.1 states, "Attachment shall not be accomplished by use of toenails or nails subject to withdrawal," referring to stairs, decks, and other building elements. Because of the complex forces on a set of stairs, I consider any nails — in just about any arrangement — to be subject to withdrawal when used to mount the head of a set of stairs.

Consequently, to provide positive attachment between the stringer head and the deck frame, I like to use metal hardware. For a number of years I used variable-slope rafter hardware, but now I use LSC stair

Figure 11. Relatively new stringer mounting hardware is designed for simple and secure staircase hanging without an engineer's design.

Figure 12. Only rim joists made with 2x12s (or bigger) provide enough attachment surface for use with stringer mounting brackets.

Figure 13. The author installs a structural header and support posts for the stair. The posts continue through the deck frame to support the guardrail system.

stringer connectors (Simpson Strong-Tie Co.; 800/999-5099, strongtie.com) specifically made for the application (**Figure 11)**. To avoid any issue with nails pulling out of the deck frame, I secure the connectors with metal-connector screws made by Simpson for the purpose. At less than $2 each, these connectors are inexpensive insurance. And I believe as more building officials read the code book more carefully and learn about the hardware solutions, they'll be red-tagging a lot of old-school stair mounting practices.

I mount stair stringers directly to 2x12 rim joists or to a header set directly beneath 2x8 or 2x10 rim joists. Only a 2x12 rim joist has enough depth to fasten the stringer hardware to it and provide enough height for the last riser (**Figure 12**). The rim joist must be able to support the additional load of the stairs. Neither the IRC nor the DCA 6 provides much in the way of design guidelines for when joists or beams support point loads such as a stair. It's possible that simply doubling or tripling the joist would be adequate, but without an engineer's evaluation, you won't know for certain.

When I'm unsure of the ability of a 2x12 rim joist on a deck with 2x8 or 2x10 framing to support the load from the stairs, I provide independent support by installing a single-ply header directly beneath the rim joist. The header is screwed to 4x4 posts and bears on 2x4s that are screwed to the 4x4s below the header. Alternatively, I use notched 6x6s instead of 4x4s (**Figure 13**).

When I mount stairs to the rim joist that closes off the end of the floor joists, I use Simpson Strong-Tie DTT2Z Deck Tension Tie hardware to secure the rim to the joists near the two outside stringers. Stairs that attach to the rim joist at the outside edge of a deck will probably overload the joist. Often those joists will need to be doubled or tripled to support the additional load of the staircase.

The DTT2Z hardware can be bent at either of the two sets of side notches; choose the bend location based on whether you want the side flanges to mount to the left or right side of the stringer. The tall leg of

Figure 14. Use structural screws instead of nails to mount the stringer hardware. Screws are less likely to withdraw from the rim joist or header over time.

the hardware mounts to the rim joist or header and the short leg attaches to the bottom of the stringer. I orient the hardware so the side flanges face to the inside edge of the outside stringers — that way, no metal shows. The LSC hardware can be installed with nails, but to avoid any concern about "nails subject to withdrawal," I use #9 x $1\frac{1}{2}$-inch Simpson Strong-Drive (SD) Screws (**Figure 14**).

Know the Nose

Stair treads must have a nose projection of between $\frac{3}{4}$ inch and $1\frac{1}{4}$ inches beyond the riser face when the tread cuts are less than 11 inches deep. (Stairs with open risers are exempt from the overhang requirement.) This conveniently works out when the tread cut is the code-minimum 10 inches, and the tread is a dry 2x12 or a pair of $5\frac{1}{2}$-inch decking boards. Using either material results in an overhang of $1\frac{1}{4}$ inches.

One more "gotcha" to watch out for when finishing up a set of stairs is the riser opening. Simple sets of stairs often have open risers; that is, there is no solid riser board. Living in an area that gets an annual average of 5 feet of snow, I can attest to the advantage of open risers when shoveling snow off stairs. But the IRC limits the riser opening to less than 4 inches when the total rise from grade to the top of the deck is greater than 30 inches. When the stair is higher than the 30-inch limit and the design doesn't call for finished closed risers, I install ripped 2-by blocks between the stringers to close the riser opening down to $3\frac{3}{4}$ inches — closed enough for code compliance and still open enough for pushing snow through (**Figure 15**). ❖

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Treat Cuts to Avoid Rot

Because cutting into pressure-treated wood may expose areas that treating chemicals didn't reach, I field-coat the head, bottom, tread, and riser cuts with copper naphthenate or another wood preservative before final installation. Field-treating cuts is common practice for Western deck builders, but for those of us framing decks with pressure-treated southern pine, it's not. IRC section R317.1.1, "Field Treatment," is pretty straightforward: "Field-cut ends, notches and drilled holes of preservative-treated wood shall be treated in the field in accordance with AWPA M4." When you dig into AWPA M4, you'll find an out for common PT southern-pine framing lumber used above grade. Still, I've noticed shallow chemical penetration on PT southern pine delivered to my jobs in the past few years, so I'm making a conscious effort to field-treat all cuts, especially on stringers.

Figure 15. The open riser area must be closed down to less than 4 inches on staircases that are more than 30 inches above grade. Here the author installs ripped blocks beneath the tread above, leaving partially open risers.