PHOTOS BY ANNE DAWSON

Better Stair Stringer Layout

This calculated approach guarantees uniform risers and treads

by Mark Dawson

When you're building stairs, the most important thing is to make sure they are as safe as possible. Why focus on safety? Because each year, according to the National Safety Council, more than 1,000,000 people are treated at a hospital for stair-related injuries, and 12,000 stair-related deaths are reported.

Safe stairs depend on factors including good design, appropriate materials, firm attachments, adequate lighting, and code-approved handrails where required. One way I endeavor to build safer stairs is to ensure the layout is as accurate as possible. While building codes typically allow for up to 3/8-inch variance in the dimensions of the rises and runs on a stair, if I find more than 1/8-inch difference, I'll correct it. With the method described in this article, however, that rarely happens.

Total Rise

Start by determining the total rise, which is the vertical distance from a finished surface to a finished surface. For a deck, this would typically be the distance from the top of the decking down to a landing slab; note that it's important to measure down to the elevation where the stairs will land, which is not necessarily straight down from the deck.

For example, the ground may be sloped away from the edge of the deck; 12 feet out, the ground may be several inches lower. That difference in elevation will affect the total rise of the stairs. It may be necessary to use a laser level or some other method to establish the height of the deck above the actual landing spot.

Unit rise. Code says the maximum allowable unit rise—the vertical distance from one step to the next—is 7.75 inches. Assume, for example, that the total rise is 8 feet 6 1/2 inches, or 102.5 inches. To determine the unit rise, first divide 102.5 by 7.75, which equals 13.22 units of rise. Since there can't be a partial rise, I divide 102.5 by 14, yielding a unit rise of 7.3214 inches, or just over 7 5/16 inches. That's less than the code maximum and acceptable. If I divide the total rise by 13, the unit rise would be 7.88 inches, or 7 7/8 inches, which exceeds the code maximum.

Depending upon how much horizontal room there is, a stair could have more than 14 risers. Going to 15 risers yields a comfortable unit rise of 6.8333 inches, or 6 13/16 inches (102.5 divided by 15 = 6.8333). Going to 16 risers yields a unit rise of 6.4062 inches, or 6 3/8 inches

Determining Stringer Layout

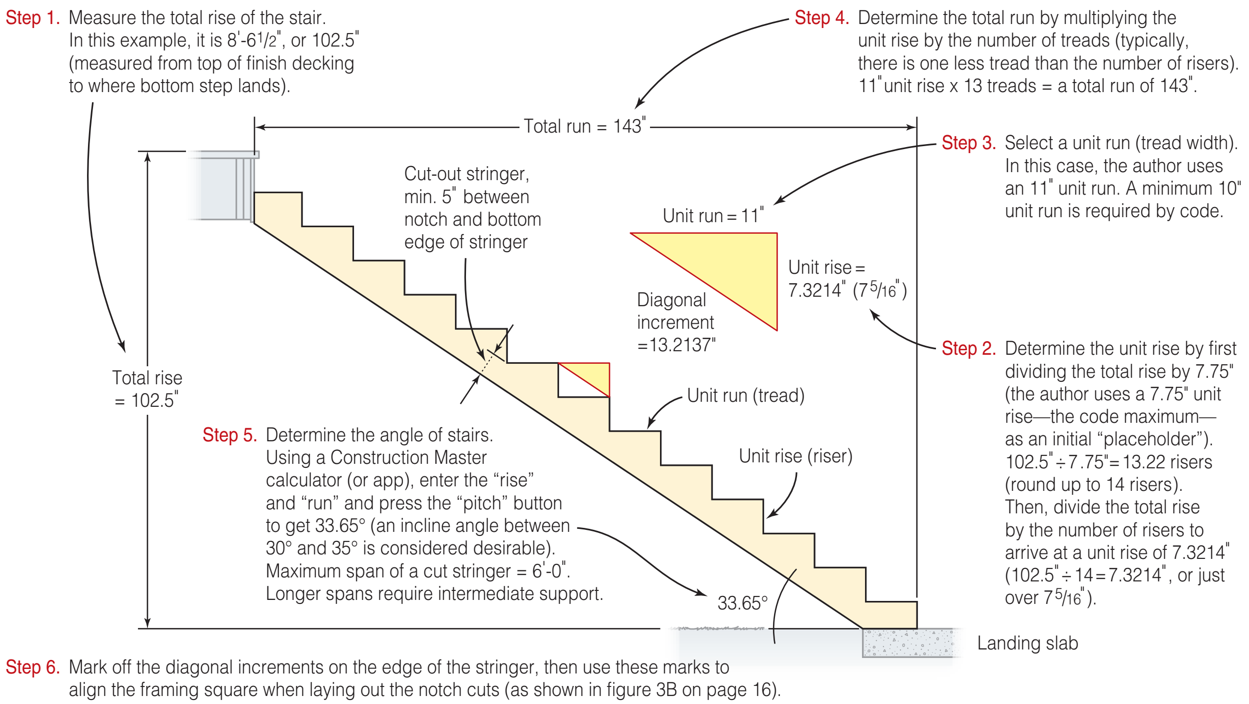

Figure 1. The author determines the stair's total and unit rise and run following the steps above, then calculates the diagonal increment using the Pythagorean theorem. In this example, the increment is 13.2137 inches. He makes a pencil mark every 13.2137 inches along the edge of the stringer stock to guide the placement of the notched cuts.

"strong"—a little shallow but still perfectly acceptable. Unless circumstances dictate otherwise, I try to avoid rises less than 6 inches because they make a stair feel choppy and so create a bit of a hazard.

Total Run

If no obstacles limit the horizontal length of the stairs, the unit run can be determined somewhat arbitrarily (note that the actual depth of a tread, which typically includes a nosing/overhang, is almost always greater than the unit run). This measurement yields a stair's total run, which is determined by multiplying the unit run by the number of treads.

Code specifies a minimum unit run of 10 inches; in terms of functionality, I consider that too short and would use it only if I had no other way to fit the stairs in a given space. A long run, on the other hand, can feel unnatural and awkward and therefore be a hazard. In this example, there is room for an 11-inch unit run, which I consider safe and comfortable and is the minimum unit run for commercial stairs.

With a unit rise of 7.3214 inches and unit run of 11 inches, you can determine the angle of the stairs. Many carpenters—myself included—enter the rise and run into a Construction Master calculator (or app) and press the "pitch" button to get 33.65°. An angle between 30°and 35° is desirable, so we are right in that sweet spot. Another way to determine this angle is by using the inverse tangent function on a scientific calculator (I use a TI-30Xa): First, divide the rise (7.3214) by the run (11) to get 0.6655. On my calculator, I'd press the "2nd" button followed by the TAN key to get 33.64°.

Diagonal increment. Because of the Pythagorean theorem ($a^2 + b^2 = c^2$), we know that the diagonal (hypotenuse) of a right triangle with a 7.3214-inch rise and 11-inch run is 13.2137 inches, or 13 1/4 inches light. This basic formula is the key to figuring rise and run angles for stairs, rafters, and whatever else you build that involves an angle other than 90°. And this diagonal increment is my key to accurate stair stringer layout.

Stringer Layout

A 2x12 cut-out stringer with 14 risers will have 13 treads, as stairs almost always start one riser down from the deck surface. So, the total horizontal run of our stair is 13 feet 11 inches, or 143 inches. Keep in mind that the horizontal span of an unsupported cut stringer is limited to 6 feet, so stairs with 13 treads will typically require one or two intermediate supports or other structural reinforcement.

ILLUSTRATION BY TIM HEALEY

Figure 2. After calculating the unit rise and run following the steps shown in the drawing on the facing page, the author lays out a few treads and risers on scrap plywood ripped to the width of the stringer stock (A). He uses this template to check the fit at the top (B) and bottom (C) of the stairs prior to laying out and cutting expensive stringer stock (D).

Using the pitch of the stairs, I use the COS function on my calculator to find the mathematical length of the stair along the angle—and thus the length of the 2x12 stock needed for the stringers. This is a relatively simple rake length calculation, which can be done using trigonometry. On a TI=30Xa calculator, I find the angle as described above (33.64°), then push the COS button followed by 1/x to find the rake length multiplier of 1.2012. Multiplying the 143-inch run by 1.2012 equals 171.7716 inches.

Alternatively, I can multiply the length of the diagonal of one riser/tread combination (13.2137 inches) by the number of tread/riser combinations in the stair (13) and find a diagonal length of 171.7781 inches. This is the mathematical diagonal length; the actual stringer will be a bit longer than that and will need to be cut from a 16-foot-long 2x12.

Template. Before I begin laying out and cutting stringers, I like to make a template so I can check the calculated plumb cut at the top and the level cut at the bottom. I rarely have a scrap piece of 2x12, so I make the template out of plywood ripped to the width of my stringers, typically $11^{1}/_{2}$ inches. I then make the top and bottom cuts (instructions to follow) to check that my math is correct (**Figure 2**).

When I started as a carpenter, I was taught to set the stair gauges on a framing square to the rise and run—in this case, $7^{5}/_{16}$ inches and 11 inches—and mark the layout with a utility knife rather than a pencil as I slid the square down the board. This was because a pencil line was considered inaccurate and could cause an accumulation of errors. While a utility knife is better than a pencil, this method can still cause errors. By using a calculator and its plus/equals function, as described below, I eliminate any possibility of an accumulation of errors. In the “old days,” you would also use one stringer as a template for the other(s), which could also cause minor layout errors. But laying out the diagonal increments on each stringer with a calculator eliminates the possibility of an error creeping in to the transfer of the layout.

Start by making a mark on the edge of a 2x12 near one end, with the crown up. Pull a tape from that mark and make another mark 13.2137 inches—or $13^{1}/_{4}$ inches light—along the board. Using a calculator that does plus/equals, add 13.2137 and 13.2137 to get 26.4274 (or $26^{7}/_{16}$) inches, and make another

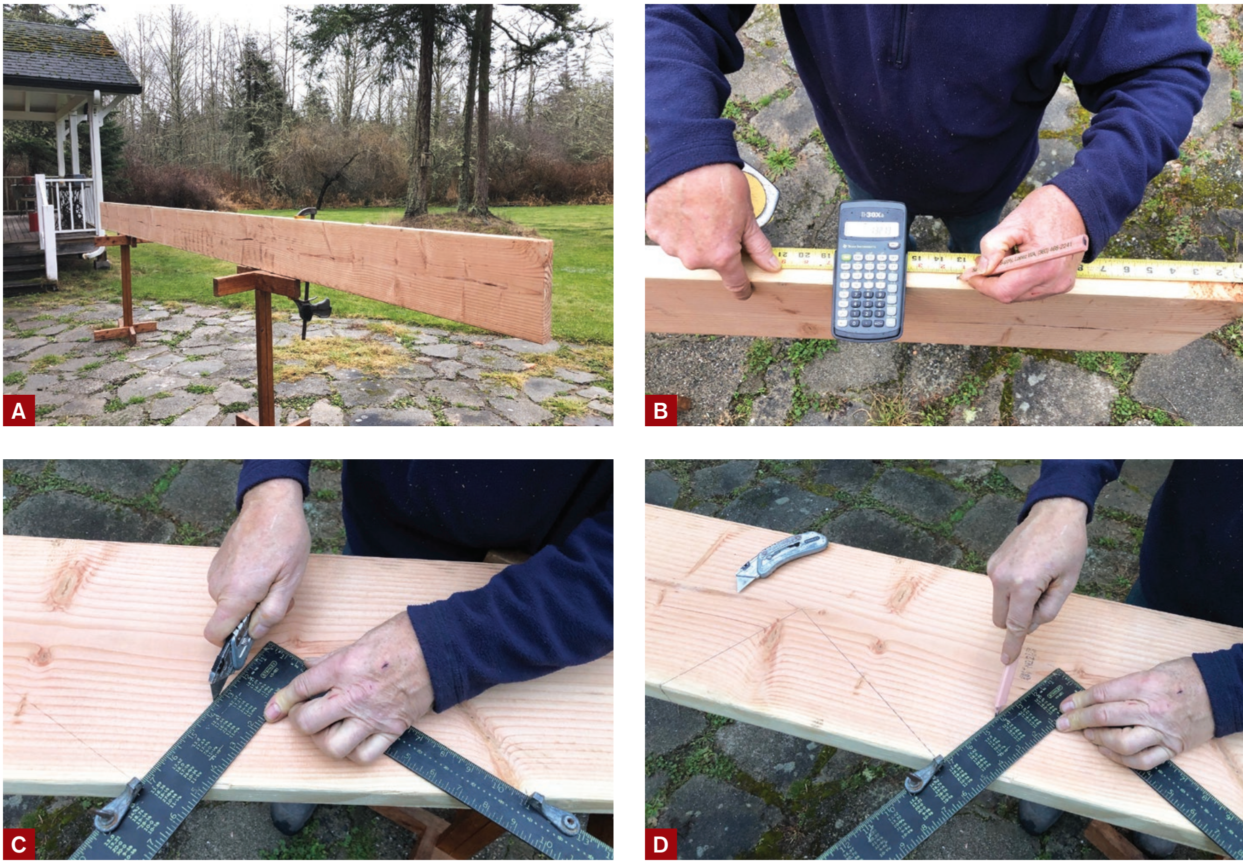

Figure 3. The author places his stringer stock on edge with the crown up (A) to mark the diagonal increments, using the plus/equals function on his calculator to determine the exact distance of each increment from his starting point (B). The increments guide the placement of the framing square as he marks the notches with a utility knife (C). Highlighting the layout lines with a pencil makes them easier to see when cutting the notches (D).

mark there. Keep hitting equals and we get the following:

- 39.6411 ($39\frac{5}{8}$ inches strong),
- 52.8548 ($52\frac{13}{16}$ inches strong),
- 66.0685 ($66\frac{1}{16}$ inches),
- 79.2822 ($79\frac{1}{4}$ inches strong),
- 92.4959 ($92\frac{1}{2}$ inches),
- 105.7096 ($105\frac{11}{16}$ inches strong),
- 118.9233 ($118\frac{15}{16}$ inches),
- 132.137 ($132\frac{1}{8}$ inches),
- 145.3507 ($145\frac{3}{8}$ inches light), and
- 158.5644 ($158\frac{9}{16}$ inches).

We now turn the board on its side, set the stair gauges (I prefer ones made by L.S. Starrett) on a framing square at $7\frac{5}{16}$ inches strong and 11 inches, and mark the notch cuts with a utility knife, using the pencil marks to guide the placement of the framing square. The stringer layout will be perfect, with no accumulation of errors (**Figure 3**).

Cutting the Stringers

I cut the notches in stringers with a circular saw, stopping at the crotch of the cut and finishing with a jigsaw so as not to weaken the stringer by overcutting.

The stringer's bottom cut is determined by the thickness of the tread material. If it's 2-by stock, I cut $1\frac{1}{2}$ inches off the bottom of the stringer. In other words, measure the thickness of the tread material and cut off that amount from the stringer. If the bottom of the stringer were not cut, then once the treads were added, the top step would be too short—$5\frac{13}{16}$ inches—and the bottom step would be too tall—$8\frac{13}{16}$ inches.

The connection detail at the top determines the top cut. If the stringer is attaching directly to a finished top riser, and the last deck board or boards project 1 inch over that riser, then we want the first tread nose to be 11 inches away, measured horizontally, from the nose of that deck board.

Making the vertical cut at the top of the stringer at $10\frac{1}{4}$ inches from the cut for the first riser allows for $\frac{3}{4}$-inch-thick risers. Since code doesn't allow any opening larger than 4 inches on the stairs at the treads, risers are required on cut-out stringers. I typically make these using $\frac{3}{4}$-inch-thick stock. They need not be the full height of $7\frac{5}{16}$ inches, but they must not allow a sphere greater than 4 inches through the space under the tread.

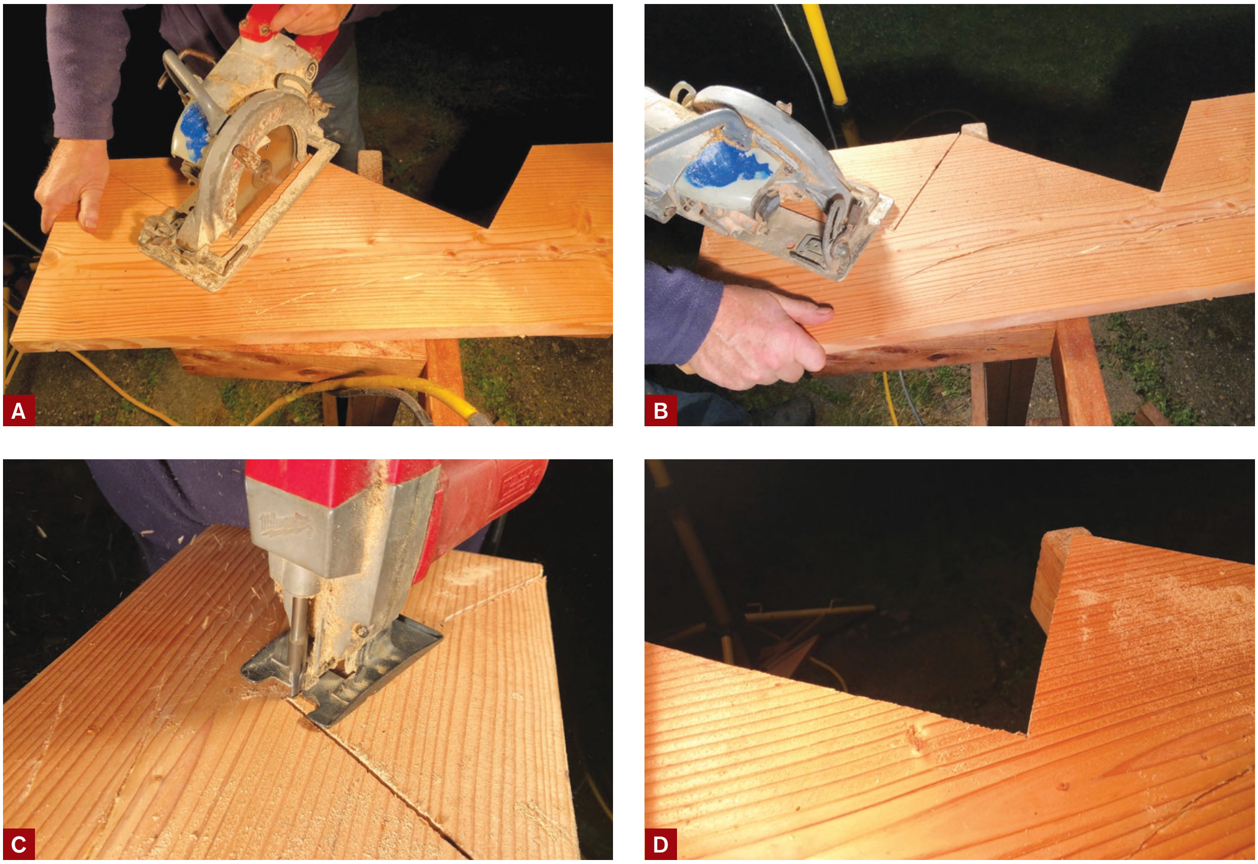

Figure 4. To avoid overcutting the notches, which would weaken the stringer, the author starts the cuts with a circular saw (A, B), and finishes the cuts with either a handsaw or a jigsaw (C). Marking the diagonal increments on the stringer before laying out and cutting the notches ensures that tread and riser dimensions vary by no more than 1/8 inch (D).

A typical nosing projection, or the distance the tread overhangs the front of a riser, is 1 inch. If we use two 2x6s for the tread, we can space the rear 2x6 1/2 inch from the riser above, leaving a 1/2-inch gap between the two 2x6s and allowing the front 2x6 to overhang the riser below by 1 inch. The spaces between the riser and the back tread and between tread boards allow for drainage.

Code says the nosing shall be between 3/4 inch and 1 1/4 inches. If the nosing is 3/4 inch, then the space between the boards and the space at the back riser will be 3/8 inch. If the nosing is 1 1/4 inches, those spaces would grow to 5/8 inch; for smaller gaps, a 2x8 ripped to width could be used for one of the treads instead of a 2x6. A nosing is not required on stairs with a run of 11 inches or greater. I prefer using two 2x6s rather than a single 2x12 tread because not only do they provide for better drainage, but the narrower boards are less likely to cup over time. ❖

Converting Decimals to Fractions

Using a scientific rather than a construction calculator requires converting hundredths into fractions, which can feel unwieldy at first but eventually becomes easier. We all should know the halves and quarters; e.g., 0.5=½ inch, 0.75=¾ inch, etc. The eighths should also come pretty quickly; e.g., 0.375=3/8 inch, 0.625=5/8 inch, etc. Once you have those down, it's a logical progression to learning the sixteenths, and the beauty of no accumulation of errors is even if you miss a sixteenth measurement slightly, it probably will barely be noticeable, and it won't affect the next layout mark. —*M.D.*

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