by David Frane

STURDY SITE-BUILT STAIRS

For tight treads with no squeaks, combine a conventional sawn-carriage with a housed-stringer stair

The staircase is the nicest, most expensive piece of millwork in most homes, yet it takes the most abuse. And unlike cabinets, which come and go as kitchens and bathrooms get remodeled, stairs must usually last the life of the house. I've had the opportunity to build quite a few staircases, many of them for fussy clients. Though I've tried a number of construction methods, I've finally settled on one that gives me a durable, attractive stair with minimal disruption of the work schedule. This method is a cross between a sawn-carriage stair — the most common type — and a housed-stringer stair.

Sawn-carriage stairs have 2x12 rough carriages, and 1-by finish stringers (or skirtboards). Most are open on one side and attached to a wall on the other, with treads and risers scribed and butted to the wall stringer. While the sawn-carriage stair is relatively easy to build, the butt joints are difficult to install tightly when both sides of the stair are closed, and they also tend to open up over time.

Housed-stringer stairs, by contrast, have no rough carriages; instead, the finish stringers are $1^1/4$ to $1^1/2$ inches thick — strong enough to support the stair treads. The stringers are routed to receive the treads and risers, which are held in place with tapered wedges. There's no scribing, and it's easy to get perfect joints that won't open when the frame shrinks or a stringer cups.

Housed-stringer stairs can be assembled in a shop and dropped into place as a unit, but they cost more than sawn-carriage stairs. Scheduling also gets complicated, because the walls and ceiling below the stair usually can't be framed and finished until after the stair has been installed. And if you don't want your expensive finish stair to get trashed during construction, you have to build a temporary construction stair that will be taken down later.

The hybrid. I build stairs that are a cross between the conventional sawn-carriage and the self-supporting housed-stringer stair: Rough carriages support all the weight, but the treads and risers are housed in the finish stringer (see Figure 1). Unlike a housed-stringer stair, however, the finish stringer serves no structural purpose and can be made from 1-by stock to match the rest of the home's trim. (The stair in the photos was trimmed with 1x12 poplar.) This method gives me perfect joints and a

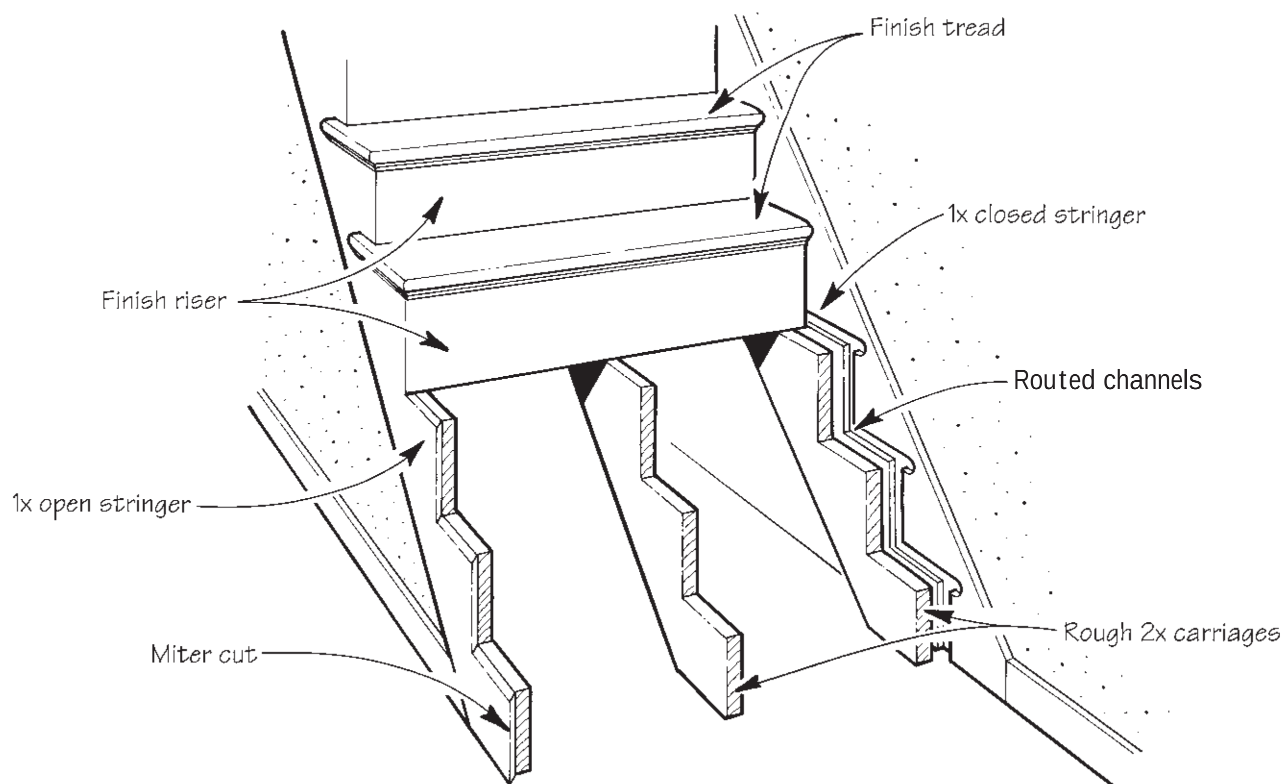


Figure 1. *Rough carriages installed during framing usually shrink before it's time to finish the staircase. The hybrid stair sidesteps the problem: The routed finished stringer determines the true rise and run; the treads and risers are then shimmed to the rough carriages for structural support.*

uniform rise and run, but lets me follow a regular construction schedule.

The first time I built a set of stairs like this, the idea of routing stringers and dadoing treads and risers seemed a bit intimidating. But I found the router jigs extremely easy to use, and only moderately difficult to make. Now that I've built stairs with housed treads and risers, I would think twice about going back to the old way.

Making and Installing Stringers

Assuming the rough carriages have already been installed, the first step is to check them for mistakes. I check for correct rise and run, paying particular attention to the top and bottom treads (see "Laying Out Stairs"). Even sawn carriages that were perfect during installation may not be that way by the time they're ready to be finished — especially if they were installed with a high moisture content (Figure 2). In fact, carriage shrinkage is one reason I build stairs the way I do; the tread and riser locations are determined by the routed channels in the closed stringer, not by the cuts in the carriage.

Making the open stringer. I use a framing square to lay out the cuts on the outer face of the open stringer. Plumb lines mark the long points of the riser miters and level lines mark the bottoms of the treads. I then cut to the lines with a circular saw or handsaw.

Routing the closed stringer. The closed stringer (the one against the wall) has 3/8-inch-deep routed channels that accept the ends of the treads and risers. (Strength isn't an issue because the sawn carriages carry the load.) Though commercially made router templates are available for this purpose, they're expensive and only work with certain tread thicknesses and nosing overhangs. It takes me 20 minutes to make a plywood template that does just as good a job.

To make the template (Figure 3) I draw one tread and riser on a piece of 3/4-inch cabinet-grade plywood. I rout the stringers with a 3/4-inch-diameter router bushing on a 1/2-inch straight bit. Because the bushing radius is 1/8 inch wider than the cutter, I draw a second set of lines 1/8 inch outside the first set. I rough-cut close to this second set of lines with a saber saw, then clean

Shrinking Stairs

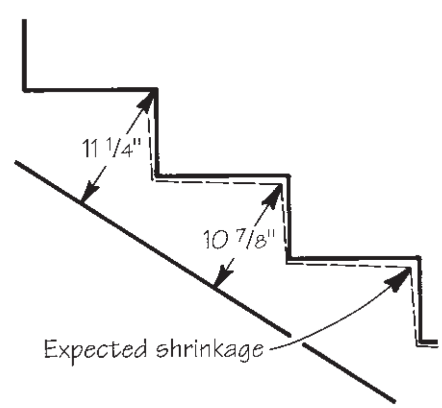


Figure 2. *When a 2x12 carriage dries, shrinkage can change the unit rise and run of the stair.*

Laying Out Stairs

Stairs are one of the few finish carpentry items where precision is required by code. Building inspectors don't care if casing reveals vary or if the kitchen counter is $\frac{1}{4}$ inch too high, but they do care if the stair treads aren't all the same width. Here are the steps to follow for a successful end result.

1. Find total rise. Measure the distance from subfloor to subfloor. If the finish flooring materials differ in thickness at the top and bottom of the stairs, use the following formula:

Total rise *equals* subfloor-to-subfloor measurement *plus* thickness of second floor finish *minus* thickness of first floor finish.

2. Find total run. Measure the horizontal distance from the upper end of the stair opening to the point where the bottom riser will meet the floor.

3. Find unit rise and run. Unit rise is the vertical distance between treads; unit run is the horizontal distance between risers. My local code requires a maximum rise of $8\frac{1}{4}$ inches and a minimum run of 9 inches. In my mind, though, the ideal stair rise-run is $7\frac{1}{4}$ by 10 inches. If you have to deviate from this, use the following rules of thumb:

- Unit rise times unit run (in inches) should equal 72 to 75.
- Two rises plus one run should equal 24 to 25 inches.

To calculate unit rise, divide the total rise by the number of risers you want to use, making sure the result falls within code requirements. A house with an 8-foot ceiling, for example, will have a total rise of, say 108 inches; using 13 risers, the unit rise will be just over $8\frac{1}{4}$ inches, not acceptable for code. Using 15 risers, however, gives a unit rise close to my ideal of $7\frac{1}{4}$ inches

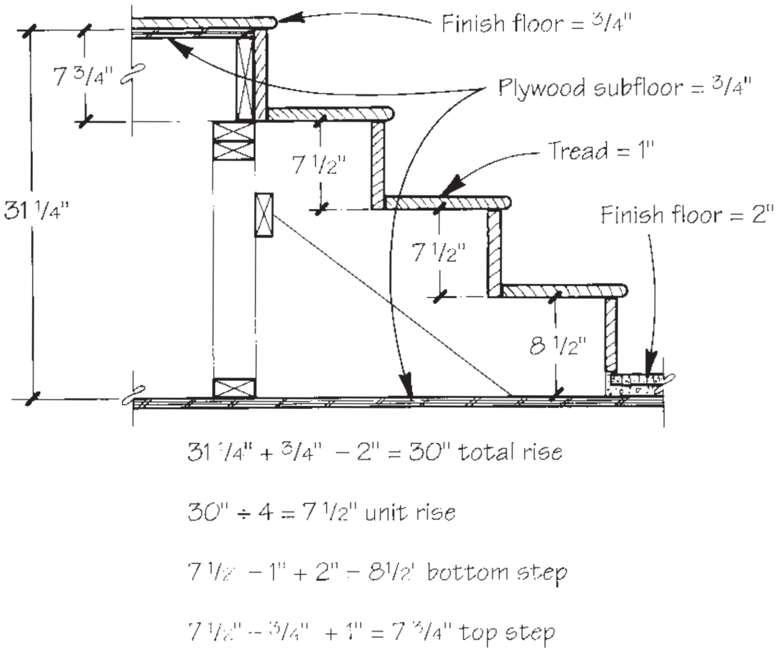
To calculate unit run, divide the total run in inches by the number of treads, which will be one less tread than the number of risers. (A stair landing counts as a tread, but should be treated as an intervening floor; the rise and run above and below the landing must match.) For instance, a stair with 15 risers and a total run of 147 inches will have a unit run of $10\frac{1}{2}$ inches.

4. Adjust top and bottom risers. If floor finishes are different thicknesses at the top and bottom of the stair, you'll need to adjust the top and bottom risers. Use the following formulas: (see illustration, above).

Bottom riser: The distance between the first-floor subfloor and the first level cut in the carriage equals unit rise minus tread thickness plus thickness of the first-floor finish.

Top riser: The distance between the top of the second-floor subfloor and the last cut on the carriage equals unit rise plus tread thickness minus thickness of second floor finish.

Adjusting Top and Bottom Risers



When treads and floor finishes differ in thicknesses, use the formulas shown to adjust the height of the top and bottom of the rough carriage.

Some Cautions

Be aware that errors in layout and construction are additive. Under my local code, the rise and run of adjacent treads may vary no more than $\frac{3}{16}$ inch and the maximum variation between any two treads over an entire set of stairs is limited to $\frac{3}{8}$ inch. So if the first 16 risers on a 17-riser stair are each $\frac{1}{32}$-inch short, the last riser will be off by $\frac{1}{2}$ inch — a code violation. I check my layout by marking the total rise on a board, setting a compass to the unit rise, and walking off the correct number of risers on the board. If the math is correct, the point of the compass will start on one mark and end on the other.

Some other code requirements I have to watch for: a minimum headroom of 6 feet 8 inches, and a maximum tread nosing overhang of $1\frac{1}{2}$ inches. Make sure you know the provisions of your own local code before you lay out stairs.

— D.F.

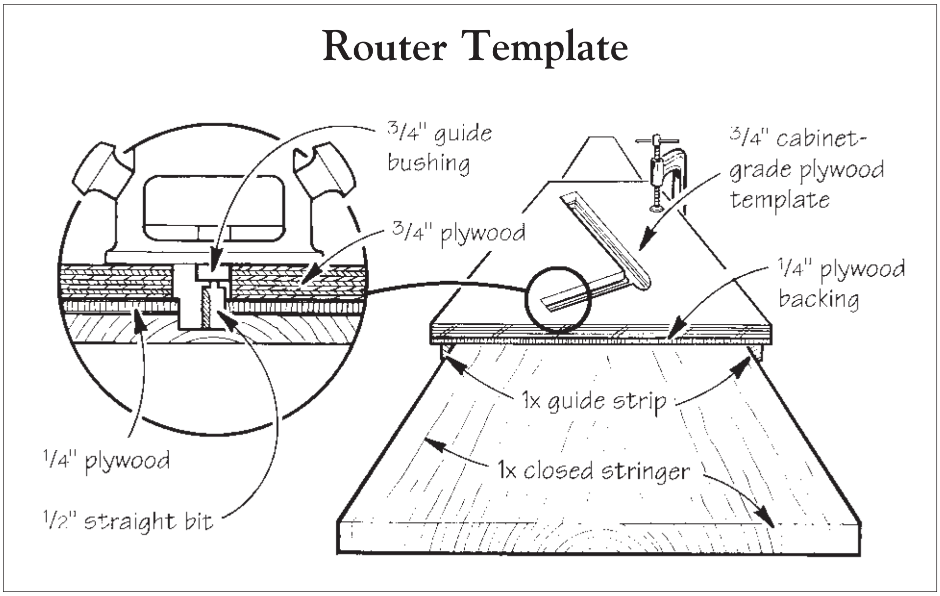


Figure 3. *Because the router's guide bushing is wider than the bit, the template must be wider than the channels to be routed in the stringer. To help with alignment, the bottom of the template is covered with 1/4-inch plywood: The cutout in the 1/4-inch plywood matches the channel in the stringer. With the treads and risers marked, the template is slid up and down the stringer (photo, right). The guide strips on the underside keep it centered.*

them up by running a flush-cut bearing bit along strips of wood tacked to the lines.

The advantage to this setback is that it keeps the cutter from accidentally nicking the edge of the template as I pull the router out. The template can be difficult to line up, however, because the opening in the template is bigger than the channels that the bit will make in the stringer. To make alignment easier, I fasten a piece of 1/4-inch plywood to the bottom of the template and cut through it with the straight bit guided by the bushing. The opening in the 1/4-inch plywood will match the shape of the channels in the stringer.

Figure 4. *To make it easy to install the risers, the author positions the finish stringers so that the plumb cuts are slightly forward of the plumb cuts in the rough carriages. He then shims the risers to the rough carriage.*

After marking the tread and riser cuts on the closed stringer, I position the template over a set of marks and clamp it in place. I then fasten guide strips to the bottom of the template to keep it aligned with the edges of the stringer. I rout one tread and riser at a time, resetting and clamping the template for each pair. The final step is to rout a short channel at the top of the stairs to house the nosing for the landing.

It takes two to three hours to lay out and rout the closed stringer for a straight run of stairs.

Installing the stringers. The cuts in the stringers determine the locations of treads and risers, not the carriages. With this in mind, I install the stringers so that the backs of the risers sit at least 1/4 inch forward of the plumb cuts in the carriages, and so the bottom of the tread will be just barely above the level cuts. The extra space makes it easy to slide the treads and risers into place, and shims can be installed later (Figure 4).

Treads and Risers

I also dado the front of the risers to receive the back edge of the treads, and the underside of the treads to receive the top of the risers (Figure 5). Housing each riser in the tread above gives me a consistent nosing overhang. Housing each tread in the riser above provides some leeway during installation, because the tread can be pushed all the way into the riser or pulled most of the way out without opening a gap. (I leave some slop in the joint for adjustment.) I've found it's best to let the back edge of the tread float in the dado rather than gluing it; that way, it can shrink and swell in width without splitting or leaving gaps.

Making and installing risers. When ripping the riser stock, I increase its width by the depth of the dado in the underside of the tread. (If the unit rise is 7 1/2 inches and the dado is 1/4 inch deep, for example, I make the riser 7 3/4 inches wide.) I then miter one end of each riser and cut them to length. It's okay if the risers are a bit short and don't hit the back of the channels in the closed stringer; I'm comfortable if the risers penetrate the stringer at least 1/8 inch. The miters fit better if they're overcut, so I make them 46 or 47 degrees.

Next, I spread yellow glue on the mitered end of a riser and position it on the stair. I wedge the riser loosely in the closed stringer, then move it up or down until the dado in the face of the riser aligns with the top of the channel for the tread. I level the riser end to end, then nail the miter joint shut, and shim behind the riser until it's wedged tightly against the channel in the closed stringer (Figure 6). I also shim and face-nail the riser at the carriages.

Figure 5. *The base of each riser is routed to receive the tread below it, while the top of the riser slips into a slot in the tread above. This strengthens the joints and prevents cracks from opening up between riser and tread.*

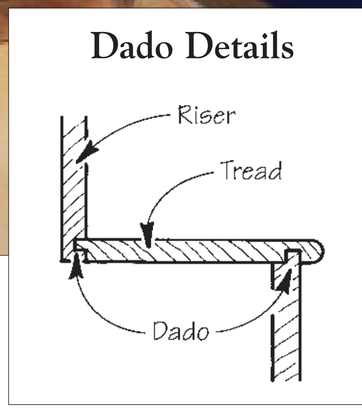


Figure 6. *With one end of the riser temporarily shimmed to the closed stringer, the riser is leveled and fastened to the open stringer.*

To ensure that any loads placed on the riser are transferred to the carriages, I place additional shims between the bottom edge of the riser and the horizontal carriage cuts.

Making and installing treads. When ripping the tread stock, I add the nosing overhang and the depth of the riser dado, less $^1/_8$ inch for expansion. (For example, if the exposed portion of the tread, including the overhang, is 10 inches wide and you have a $^3/_8$-inch-deep dado, then you need to rip the tread $10^1/_4$ inches wide.) The ends of the treads that land on the open stringer must be notched and mitered for nosing returns. I use a saw to rough-cut these treads to within $^1/_8$ inch of their finished shape, then finish them with a router and guide template. The template is a piece of cabinet-grade plywood cut to the same shape as the finish cut on the end of the tread (Figure 7). The router leaves a slightly rounded inside corner where the straight cut meets the miter, which I match by using a piece of sandpaper to round the corner of the mitered nosing.

The treads should be cut to length so that one end tucks into the channel in the closed stringer and the other lies flush to the outside of the open stringer. (If the tread is too long, the return nosing won't lie tight against the open stringer; if it's too short, the return will have to be notched around the open stringer.) Once I'm sure a tread will fit, I put yellow glue on the top edge of the riser below the tread nosing, and thick beads of construction adhesive on the horizontal carriage cuts. It's usually necessary to shim the treads off of the carriages in some spots. If the underside of the carriages haven't been covered with drywall, a helper can shim from below; if they have, I reach around the riser above. (In the latter case, the top tread has to be test-fit and preshimmed before it's installed.) The treads can be nailed to the carriages with a finish gun and 15-gauge nails, or with 10d or 16d finish nails. I typically use two or three nails at each carriage, making sure to place them in a regular pattern.

The bullnose returns for the treads extend a short distance past the face of the riser. Because treads expand and contract across their width, I don't glue the returns to the end of the tread. Instead, I glue the miter and fasten the return to the tread with three or four 8d finish nails (being careful not to nail where I'll be drilling holes for balusters). The nails have enough give to absorb any expansion or contraction. ■

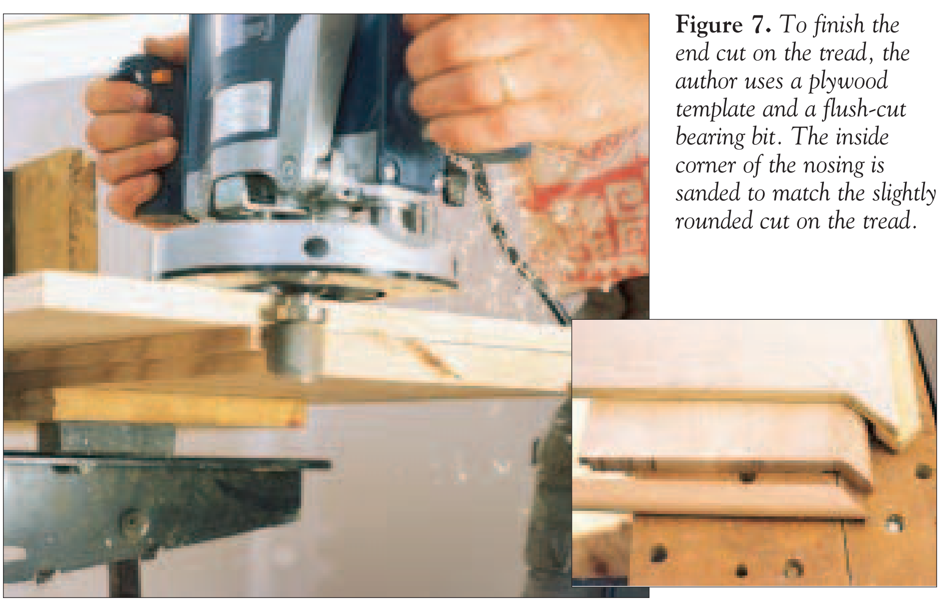


Figure 7. *To finish the end cut on the tread, the author uses a plywood template and a flush-cut bearing bit. The inside corner of the nosing is sanded to match the slightly rounded cut on the tread.*

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