Building a Curved Stairway

by Gary Striegler

Bryan Striegler

Simple framed walls support the treads and act as forms for bending the rails and stringers

I'm not a math whiz or a full-time custom stair builder, but I still like to tackle the occasional curved staircase. I enjoy the challenge of figuring out how to build it, and I like the distinctive look that custom stairs give my custom homes.

As with straight staircases, all you really need to know to build curved stairs is the rise and run. But a curved stair has two runs: The inside stringer has a tighter radius and thus a shorter run, while the outside stringer has a larger radius and a longer run.

To keep things simple, I lay out curved stairs using only the inside radius. I also do a full-scale layout — right where the stair will be built — with a story pole and a trammel arm. I frame a pair of curved stud walls to support the treads. These walls also serve as forms for both the curved stringers and the curved handrails, which I glue up on site with bending rail.

Layout

Before starting, I always check with the local building inspector about specific stair requirements; I want to make sure that the rise and tread depth meet local code. On most curved stairs, tread depth (not including the part of the tread that

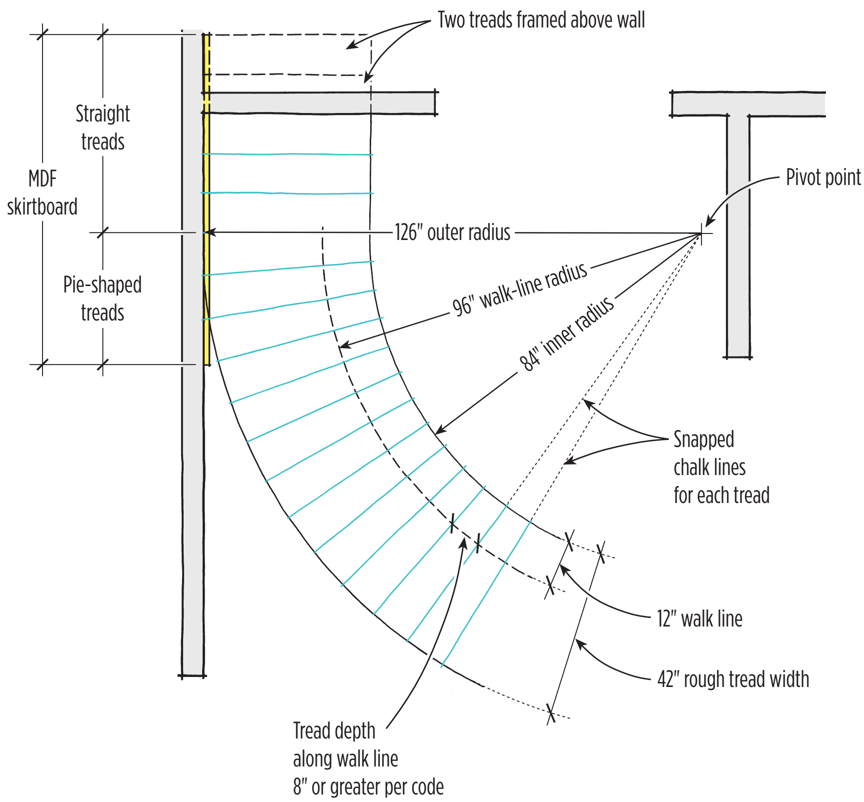
Figure 1. The author uses a trammel arm to draw three arcs on the floor representing the stair's inner and outer radii and the walk line (top left). To lay out the treads, he measures the available run along the walk line with a digital scale (top right), divides the run into equal code-compliant increments, and snaps lines from the pivot point through those increments to the outer radius (bottom left). Another mark 1 inch from each snapped line represents the face of the 2x4 pony walls that will be built to support the treads (bottom right).

overhangs the riser) is measured 12 inches in from the inside radius of the stair, along the walk line.

Rise. I begin the vertical layout on a 2x4 story pole, starting from the top and working down. To get the minimum number of treads needed, I divide the total rise between floors by the greatest rise per step allowed by code (remembering to account for finish-floor materials and thicknesses). Because this usually results in a fractional value, I round up to the next whole number to get the actual number of risers. For example, a stair with a 96-inch rise and maximum 7-inch riser height will require at least 14 $6\frac{7}{8}$-inch-high risers and 13 treads.

Run. I draw the horizontal tread layout in full scale right on the floor (**see Figure 1**). First, I use a trammel arm to draw the inside tight radius for the curved portion of the stair (the stair shown here also has a short straight run at the top). The length of this radius varies depending on how much room is available for the stairway; in this case,

Tread Layout



After drawing arcs for the inner and outer faces of the stair, the author divides a third arc — the walk line — into equal increments. Lines snapped from the pivot point through these increments represent each tread.

I used an 84-inch radius. Using the same pivot point, I then swing another arc with a 96-inch radius, which is where the measurement for tread depth along the walk line will be taken.

Finally, I swing an arc with a 126-inch radius, to create a 42-inch-wide step. I let all the lines run a couple of feet beyond the point where I think the stair will start (**see illustration, above**).

Measuring the walk line. Next I use a digital measuring device called a Scale Master (Calculated Industries, 800/854-8075, www.calculated.com) to measure the total length of available run along the 96-inch-radius walk line. I then divide this run by the total number of treads.

To meet code in my area, this dimension — the tread depth along the walk line — has to be greater than or equal to 8 inches. If it is, I mark this increment along the 96-inch radius, beginning at the stair's starting point; otherwise, I need to move the stair's starting point so that there's more available total run.

Marking out the treads is a simple matter of hooking a chalk line over the screw at the pivot point and snapping lines through these incremental marks to the 126-inch outside radius. Each line marks the face of a riser; the space between the lines is the tread size without any overhangs. Using this snapped layout for reference, I can now make a full-size tread template, remembering to account for the 1¼-inch-thick laminated stringers on each side as well as the overhang.

Building the Stringers

At this point the story pole and floor layout contain all the information I need to build the stairs. First I cut and fit an MDF skirtboard for the short straight stair section. Then I frame a pair of stepped curved walls to support the stair treads; these walls — which also provide a form for the curved stair stringers — are glued up from three layers of 5⁄16-inch-thick bending plywood and a finish layer of ¼-inch birch plywood.

Skirtboard. This stairway follows a straight wall at the top, and has three straight and three pie-shaped treads that fit into the skirtboard. I use the story pole and a level to lay out the tread locations directly on the wall, and then I tack the skirtboard in place and mark it (**Figure 2, page 4**). I dado the stair treads into the skirtboard with a router and a 1⅛-inch pattern bit. In addition to fitting tightly into the dado, each tread is supported by 2x2 cleats glued and screwed to the skirtboard.

Framed walls. Taking the dimensions from the story pole, I cut the studs and plates for each tread (**Figure 3, page 5**). I cut the top and bottom plates at a slight angle — taken from the layout on the floor — so that the support wall follows the stair's radius. I assemble the walls from the bottom up, checking for plumb as I go and adding temporary bracing as needed.

The stringers are laminated from 16-inch-wide rips of $5/16$-inch-thick bending plywood (the type that rolls up into a 4-foot-tall — not 8-foot-tall — cylinder). Even though most of the stair's strength comes from the framed walls, I glue and staple each of the three layers together and stagger the joints by at least 2 feet.

A fourth layer of $1/4$-inch birch plywood gives the stringers a smooth surface that's ready for paint. When fastening it in place, I keep the staples close to the bottom edge and near the stair cutouts so they'll be covered by moldings.

I cut out the stair-tread openings with a flush trim router bit, a process that takes only a few minutes but makes a real mess. The last few inches at the top and bottom — where the router base bumps up against a floor or wall — have to be trimmed with a handsaw.

Bending the Rail

Bending rail looks like an ordinary handrail that's been sliced up into several indexed laminations. When glued back together and sanded smooth, the laminations usually disappear, and the rail holds the shape it's been formed into.

On a straight stairway, I typically assemble the railing right on top of the treads; if everything fits there, it will fit when I lift the railing up into place. I glue up curved railings the same way. To make sure the handrails match the curve of the stairs, I form the bending rail right on the stringers (**Figure 4, page 6**).

Rail glue-up. Besides taking a lot of manpower, gluing up a long handrail usually takes about all the clamps I own; I use a combination of metal L brackets cut from angle iron and special clamps from R&R Clamp (920/863-2987, www.rrclamp.com), which I like because they tighten quickly with an impact wrench.

Once we've spread the glue and wrapped the laminations together with packing tape, we wrestle the rail into place. We start in the middle — one person bending, the other two adjusting the clamps — and work toward each end, using damp rags to wipe off as much of the glue squeeze-out as possible.

Figure 2. Where the stair runs along the flat wall, the author lays out an MDF skirtboard (above), then uses a router equipped with a pattern bit to cut dadoes for the treads (above right). The $1^1/8$-inch-diameter bit allows the tread to slide in easily and almost perfectly matches the bullnose profile cut on 1-inch-thick tread stock (right).

Because a laminated rail will spring back slightly when the clamps come off, I actually overbend it in the middle by about ½ inch. Bending rail tends to twist a little on each end, so I tweak the ends a bit beyond square with pipe clamps; it's hard to attach a handrail fitting to a twisted rail.

Glued-up rails need to stay clamped for at least 12 hours. Before unclamping, I make some indexing marks so that later I can put the rails in exactly the same place. It always takes a little work with a sharp chisel, block plane, and sandpaper to clean up the rails and prepare them for fittings.

Treads

Making the stair treads takes about as much time as building the walls and stringers, and requires at least six heavy-duty clamps and a 13-inch-wide planer.

I glue up 5⁄4-inch-thick stock for 1-inch-thick finished treads, making the glue-up wide enough to cut two treads at

Figure 3. Along the curved layout lines, the author frames a pair of stepped walls to help support the treads (above); wall heights are taken from the story-pole layout. Each curved stringer is laminated from three layers of 5/16-inch-thick bending plywood, trimmed in place with a router equipped with a flush trim bit (far left). A final lamination of 1/4-inch birch plywood gives the stringers a smooth, paint-ready surface (left).

Figure 4. In preparation for glue-up, the author lays out the handrail's centerline, notches the temporary treads (to keep them from interfering with handrail positioning), and installs adjustable clamps (above left). After spreading yellow glue on the individual laminations (above right), he binds the bending rail with packing tape and places the assembly in the clamps, which can be quickly tightened with an impact wrench (right).

once and adding several inches of length to cover any snipe from the planer (**Figure 5, page 7**). The exact size of the blank and angle of cut comes from the tread template I made during the layout stage, with enough added for the treads with mitered returns.

Since the stringers are curved, each end of the tread has a slight angle — determined, again, by the full-scale layout. I add a 2-inch-wide bullnose edging to each tread with pocket screws and glue. The miter cuts for the bullnose returns are slightly less than 90 degrees at the inside radius and slightly more than 90 degrees at the outside radius. When applying the edge nosings, I'm careful to locate the pocket screws so that they will be out of the way of the dowel screws for the balusters.

We use trim-head screws and lots of construction adhesive to attach treads, and make shims out of poplar to level them. Starting from the top and working from the inside, I use pocket screws and yellow glue to join each riser to the tread above it. This makes a really strong tread and eliminates another possible squeak.

Starting step. The radiused starting step is wide enough to accommodate the starting newels and their volutes and balusters (**Figure 6**). I use a $3/4$-inch-thick subtread on the starting step to provide a form for the curved riser. A matching nailer on the floor serves as a form for the bottom of the riser and also helps anchor the starting newels.

Balustrade Assembly

To make sure that lengths and angles are right, I measure, cut, and dry-fit the stair parts with the curved rails sitting on top of the treads (**Figure 7, page 8**). I use two pitch blocks for the angles — one for the inner radius and one for the outer radius — and a laser to align the rails with the starting newel-post locations.

This stair has a pair of starting volutes; in order for them to be level with one another at the bottom step, the rail height along the inside radius — which has the steeper pitch — needs to be about 4 inches lower than that along the outside radius. To my eye, this solution looks better than out-of-level volutes, and the rail heights still meet code.

Once I'm satisfied the assembled handrails are accurately positioned on the treads, I lay out the balusters — two per tread along the inside radius and three per tread along the outside radius. After we've installed the newel posts and raised the handrails into position (with a couple of temporary supports to keep the centers of long rails at the right height), I use the laser to transfer the baluster layout to the bottom of the handrails.

We use an adjustable jig called a Bore Buster (L.J. Smith Stair Systems, 740/269-2221, www.ljsmith.net) to hold the drill at the correct angle when we bore the baluster holes in the bottom of the handrail (**Figure 8, page 8**). To get a really

Figure 5. The author glues up blanks from $5/4$-inch stock, making them wide enough to cut two wedge-shaped treads with a tapering jig and long enough to allow for planer snipe. To make it easier to cut the mitered returns, 2-inch-wide nosings are fastened to the treads with pocket screws and glue.

Figure 6. At the first step, a radiused subtread and matching nailer provide a form for the curved riser. Here, the author uses the laser to mark the position of the starting newel and help locate the center of the starting volute.

Figure 7. Measuring and fitting components is easier with the rail clamped firmly in place on the treads (left); after the newels have been installed and the rail lifted into position, a laser is handy for transferring the baluster layout to the underside of the handrail (below).

strong balustrade, we fasten the balusters to the treads with special double-threaded dowel screws (also available from L.J. Smith, along with a special driver bit for installing them).

Labor and Cost

The first time we built a curved stair, framing and finishing it took two men two full weeks. With our second job, we were about two days faster. Today, building a curved staircase takes us about 40 hours longer than building a comparable straight one.

Two days are spent just gluing up and building the custom treads (on a straight run of stairs, we use manufactured tread stock); for this project, we used about 160 board feet of 5⁄4-inch-thick red oak lumber. We also used a lot of plywood, including three sheets of bending plywood, two sheets of 1⁄4-inch birch plywood, and three sheets of 3⁄4-inch thick birch plywood (for the risers).

At $14 per lineal foot and up, bending rail isn't cheap — though it's not as expensive as it once was. Sometimes you can find a manufacturer who supplies it in 8-foot lengths, but on this project we used two 16-foot-long sections. We also went through plenty of glue, including a gallon or two of Titebond and eight to 10 tubes of construction adhesive.

Gary Striegler is a builder in Springdale, Ark.

Figure 8. The author bores the balustrade holes with the help of a jig (left). A simple site-built box that fits snugly over the balusters allows him to screw each one tightly to the tread without damage (right).