Cantilevered Stairway

Steel brackets support cantilevered treads around a cylinder

by Rob Harlan

Curves make my heart sing. When I built my own house, one of the things I did was to frame a 16-ft, diameter, two-story cylindrical room. The curving wall was a great place to locate the stairway (photo below). I had a picture of a curved adobe building with slabs of wood for stair treads cantilevered out through the wall. I wanted to build a similar stair, but the problem was how to capture the adobe-house stair's light, suspended feeling, yet have it structurally sound and in compliance with the building code.

Steel solves the problem—I tried a whole bunch of wood-based designs, but the only one that worked involved extending the cantilevers through the other side of the wall, and that created space problems. Then, a friend suggested using steel to support the stair treads. Being primarily a woodworker, I had to be talked into it, but steel made for strong cantilevers that I could contain within the 2x6 wall.

I had a machinist make stair-support brackets from ¼-in. by 4-in, plate steel. Most of the brackets are two plates lapped and welded to form a T-shape. The top of the T is fastened to the studs with four ½-in. machine bolts; the base of the T protrudes through the curved wall and supports

No visible means of support. Projecting from a curved wall, this custom ash stair is supported by cantilevered steel brackets housed in the tread supports. The treads are glued and screwed to the supports, and the balustrade of bent laminations not only enhances the organic look but also helps stiffen the stair.

the treads (top photo, right). An engineer OK'd the bracket design, and the building department approved the stair.

The brackets are not all T-shaped. The bottom two are L-shaped, and the top ones are attached to the second-story floor joists, so they're straight.

One stud per tread—The cylindrical room was framed with 2x6s on 16-in. centers. In the area where the stairs project from the curved wall, I used doubled 2x6s to make 3-in, by 5½-in. studs on 9 3/16-in. centers at the outside edge. Each of these studs bears a stair bracket.

The stud spacing is based on some fairly simple math. The stairs are laid out with a 6 15/16-in. rise and an 11-in. run. Because the treads are wedge shaped, the run is longer out at the railing than at the wall. The 11-in. run is at the center of the tread, where one is most likely to walk. All I had to do was figure out the run at the wall.

I knew the radius of the circle to the outer edge of the stud wall (96 in.). I also knew the radius of the circle at the center of the treads (115¼ in.). I knew the run of the stairs at the center of the treads (11 in.). 1 determined stud spacing with a ratio: $115.25 \div 11 = 96 \div x$. The radius and the run at the center of the treads are directly proportional to the radius and the run at the wall. Putting in the numbers yielded 9 3/16-in. o. c. for the stud spacing.

The double studs were marked at the correct heights, using a builder's level and a story pole, and then drilled out for the bolts that secure the steel brackets to the studs. The lapped portions of the brackets were let into the studs so that the brackets could be bolted tight to the studs.

After walking up and down the supports a few times to verify their soundness and checking the layout for consistency of spacing, rise and levelness, I unbolted the brackets, rubbed them with stove black to prevent rust and stored them.

As construction progressed, I wrapped the outside of the curved wall with ⅜-in. CDX plywood and later with ½-in. drywall (middle photo, right). Slits were cut through these wall coverings, and eventually the steel supports were reinstalled from the back and bolted into position permanently before the drywall on the other side of the wall was installed.

Supporting the treads—I chose white ash for the entire stairway—the tread supports, the treads and the balustrade—because of its light color, durability and bendability.

Each tread support consists of three pieces of 5/4-in. by 6-in, ash sandwiched over the steel bracket. The outer section of the tread support was mortised with a router to create a pocket to house the steel (bottom photo, right). The tread support was glued with Tightbond ES747 and screwed to the steel, which had been drilled with eight ⅛-in. countersunk holes.

The remaining two sections of the tread supports were glued with Weldwood urea resin and screwed to the outer piece, covering the steel. Great care was taken to assemble the tread supports around the steel so that the joints were flush and to clean up all glue drippage with water immediately to minimize sanding after assembly.

Brackets fit in the wall. The doubled 2x6 studs were laid out on **9 3/16**-in centers—the run of the stairs at the wall—so that a welded-steel bracket could be bolted to each stud.

Drywall went on first. Slits were cut in the plywood-and-drywall sheathing materials so that the brackets could be reinstalled from inside the cylindrical room.

Tread supports sandwich the brackets. The three-piece ash tread support was mortised and fastened to the steel with Tightbond ES747 construction adhesive and screws. Weldwood urea resin glue and screws bonded the tread support, which provides bearing for the treads.

I tapered the tread supports with a bandsaw, then planed, routed, sanded and installed them. Tapering gives the suspended staircase the light look I wanted.

Although the steel brackets cantilever through the wall, the wooden tread supports were installed on top of the finished wall, which provided for easier plastering and painting. It also kept any movement of the stairs from cracking the plaster. To give the stairway its "coming out of the wall" look, I caulked where the tread supports met the wall with flexible caulk and then carefully painted it.

Making treads—The treads are ¾-in. by 12-in, pie-shaped pieces blind-splined together from 6-in, wide stock. The splines are ⅛-in. by 1½-in. pieces of white ash placed in ⅛-in. slots in the treads. Both the splines and the slots were made with a table saw.

The treads were glued and screwed to the tread supports. I left a uniform ¼-in. gap between the finished wall and the end of the tread to heighten the floating feeling.

Once again, I countersunk the screws and plugged the holes. The landing was made similarly by gluing and splining many pie-shaped pieces together.

Laminated balustrade—The balustrade I designed for this stairway preserves the light, suspended feeling of the cantilevers and weaves them together, which stiffens them. Each baluster consists of a pair of bent laminations. I made two separate bending forms, one for each baluster shape, then glued up twelve 3/32-in. wide strips of ash and clamped them in the forms.

Once the glue had cured, the bent laminations were trued up using a table saw to clean and cut the edges square, then finished with a belt sander and rounded over with a router and lots of hand sanding. Next, the balusters were glued, screwed and plugged together at their bases to form pairs.

The handrail was laminated from eight 5/16-in. by 1¼-in. by 16-ft, long strips of ash. The problem was figuring out the radius of the handrail and how to bend it.

The process turned out to be easy. I didn't have to use math; I laminated the rail in place using the outside ends of the treads as a form to hold the railing in the correct bend. The strips were clamped together with C-clamps every 3 in. It's moments such as these when you use all of your clamps and any that you can borrow.

Once the railing lamination was sanded and routed to its final shape, I set it temporarily in place. The baluster assemblies were carefully marked and cut to fit below it. I attached the balusters to the railing with ¼-in. by 2-in, dowels. The base of each baluster was mortised into the tread and glued and screwed to it.

When the balustrade was complete, the entire structure stiffened up considerably, and my dream of an organic, strong, light, curved stairway was achieved. □

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