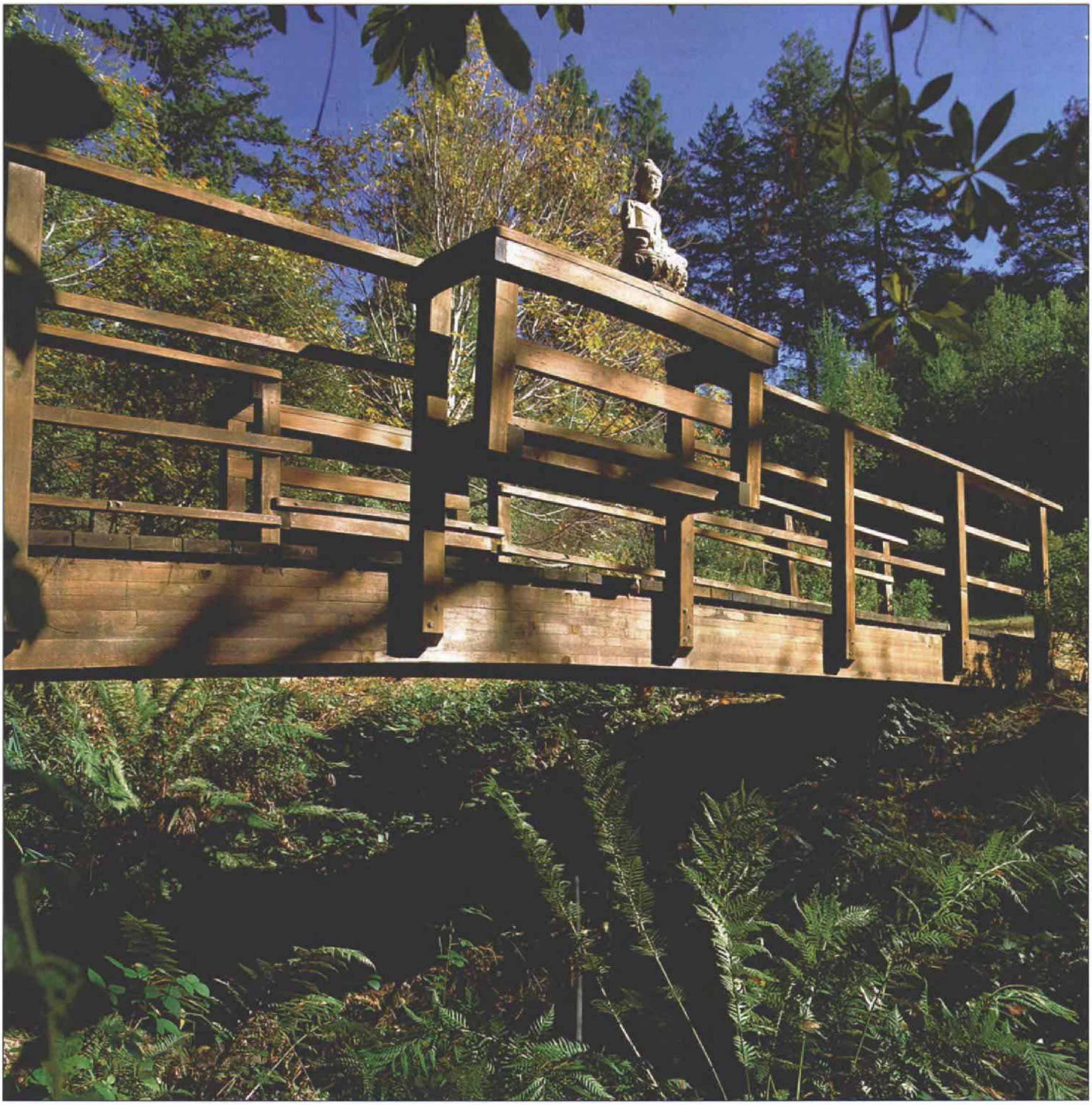
Site-Built Footbridge

Using backcountry lamination techniques to span a creek in style

by Henry Smith



An arched bridge with benches. A pair of laminated redwood girders traverse this little ravine. At center span, a pair of built-in benches cantilever off the railing posts by way of half-lapped 4x4s.

Photo: Charles Miller

There's nothing like a big event to focus your attention on some long-neglected job around the house. Maybe the new neighbors are dropping by for coffee, or the bank's appraiser is about to pass judgment on the home-equity loan. For me, it was a wedding day. In a couple of months, some friends were going to be married in the meadow below our house. To get to the meadow, the hundred or so guests would have to cross a small creek on our decaying, poorly constructed footbridge. The thought of launching a marriage with a bridge disaster was enough to get me in gear.

Trailside technology—On hiking trips in the Santa Cruz mountains near our home in northern California, I had admired the many small, finely crafted footbridges. Their decks were supported by laminated redwood girders that were built in place. The local park ranger sent me a drawing of one of their basic bridges. The drawing included the footing design and assembly techniques that I put to use building our bridge. I did change a couple of things, however.

I like the look of the arching footbridges that are often centerpieces of Japanese gardens. So I modified the straight girder the Park Service uses in its bridges by putting some curve into our bridge girders. Also, I decided to incorporate a pair of built-in benches in the railing (photo facing page). Located midspan, the benches provide a contemplative alcove to enjoy the creek, the natural setting and the company of friends.

Put the footings back from the bank—Our creek isn't very wide. But the banks are sandy clay held together by roots, and you can watch the bank erode before your eyes during a heavy downpour. So I chose to place the bridge footings about 8 ft. back from the erosion line. That put the two footings about 30 ft. apart.

The footings are 42 in. long and L-shaped in cross section (top drawing right). Both the vertical and the horizontal legs of the footings are 6 in. thick and 16 in. wide. The ends of the girders bear against the vertical legs, which oppose the horizontal thrust exerted by the arched girders. I placed three horizontal lengths of ½-in. rebar as well as vertical rebar Ls 6 in. o. c. to reinforce the concrete. Steel post bases cast into the footings anchor the ends of the girders. While building the footing forms, I made sure the footings ended up square and level to one another.

Overbuild the girder—I admit that I didn't have an engineer on this job. Instead, I made the girders so big that they *had* to be strong enough. Like the Park Service, I used green construction-heart redwood for the girders, but I used 2x8s instead of 2x6s. It's important to stagger the joints in a glued-up beam, so I made a chart on graph paper that served as a guideline for the glue up (bottom drawing right).

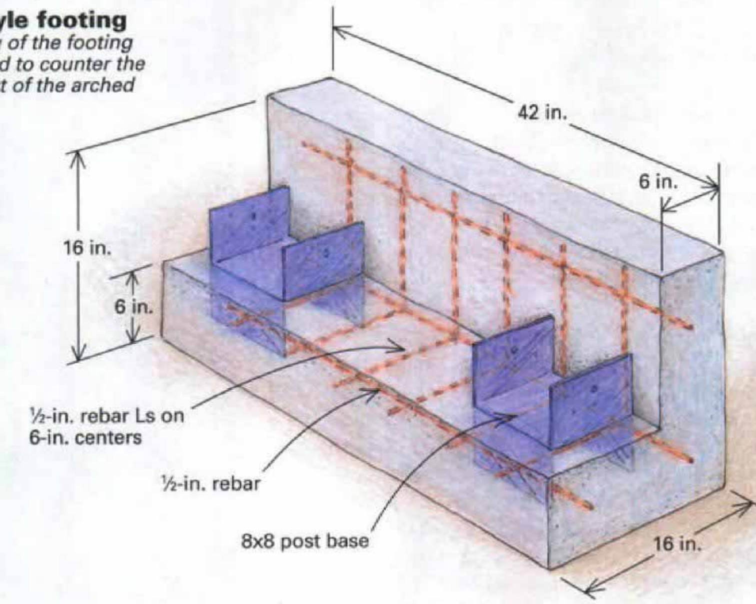
In my workshop I constructed a series of clamping stations to build up the beams with 8 in. of camber (top photo above). The two outboard stations were 28 ft. apart. Between them,

Girders under construction. The author shaped the girders by bending them across 2x4 clamping stations affixed to the shop walls. The outboard stations were weighted down with pier blocks to keep the 2x8s from lifting the stations.

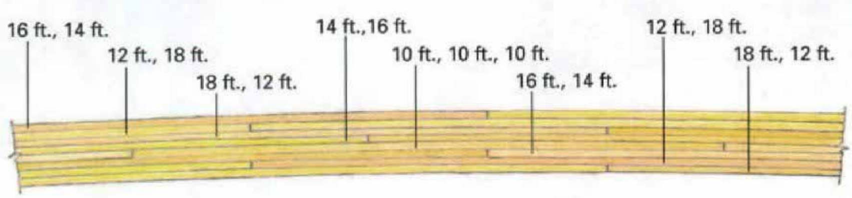
A girder heads for home. Once the girders were cut to length, they were fitted with temporary handles and carried to their footings.

A bench-style footing

The vertical leg of the footing extends upward to counter the sideways thrust of the arched girders.



Lamination layout. *The author arranged the eight layers of 2x8s that make up the 30-ft. arched beams in the sequence below to separate the butt joints.*



Drawings: Christopher Clapp

the center station was 8 in. taller. A couple of intermediate stations supported the stock at mid-curve. The stations consisted of 2x4s attached to the shop wall at a convenient working height and well-braced to allow for a considerable amount of weight and clamping force.

I joined the first two boards from underneath with a plywood splice plate to keep them aligned. Then I rolled Weldwood powdered resin glue onto the mating 2x8s, and pipe-clamped the 2x8s together beginning in the middle. I used the Weldwood glue because it's got a waterproof rating and because it has a long pot life.

I had to remove the clamps each time I added a new layer of boards. So before removing the clamps, I screwed the top board to the one below it with 2½-in. galvanized drywall screws on staggered 16-in. centers. The screws ensured that the glue joints would remain stationary as subsequent layers of 2x8s were added. Just to make sure the laminations stay put over the long haul, I ran ½-in. carriage bolts through the girders on staggered 2-ft. centers. Each girder took two people about four hours to build.

Cutting and setting the girders—As any builder knows, making an irreversible cut on an expensive beam can be a nerve-racking experience. And with a curved beam, "measure twice, cut once" doesn't apply. On the advice of a friend, I made a full-size pattern out of ½-in. plywood to mimic the shape of the girder. I stiffened the pattern with some 2x4s to keep it from being too floppy. Then, with the help of two assistants, I scribed the pattern in place to get the precise plumb and horizontal cuts.

The girders weighed about 700 lb. apiece, and they required eight men to move them into place. What's more, an arched girder wants to roll over as it is carried, so we nailed and clamped temporary handles to the girders (bottom photo, p. 65). The first girder dropped sweetly into place, with a gap of about 1/16 in. The second girder required a few passes with a power planer, and then it too fit.

Decking, posts and railings—I decked the bridge with redwood 2x6s by starting at the ends and working toward the middle. The ½-in. gaps between the boards promote quick drainage and keep leaves from clogging the gaps. When I neared the middle of the bridge, I ripped a few boards down to make sure that the deck boards fit comfortably and that the gaps stayed uniform.

I lag bolted 4x4 posts to the sides of the girders on 4-ft. centers. Then I clamped a flexible 2x ripping to the posts and adjusted the ripping to match the curve of the bridge at the right height for a railing. With the ripping as my guide, I marked the posts and cut them to length on the appropriate angle to receive the 2x6 railing.

With a lot of help from my friends, I finished the bridge the day before the wedding. We decorated the railings with balloons, crepe paper and flowers, and the wedding went off without a bridge collapse. □

Henry Smith lives in Santa Cruz, California. Photos by the author except where noted.

Another Way to Make an Arched Bridge

by Geoffrey Cole

As my 3-year-old son toddled onto the bridge, he shouted, "The bridge is falling." He was right. Rising water in our backyard creek had eroded the footings under the aging footbridge that connected our yard with our neighbors' yard. The bridge had sunk 18 in. Our neighbors and my family all wanted a new bridge, and I liked the idea of building it myself.

I began the bridge-building project by studying a book called *Bridges and Cupolas* (Janet and Richard Strombeck, 1981, $12.45, Sun Designs, P. O. Box 6, Oconomowoc, Wis. 53066; 414-567-4255). The book contains sketches of 21 footbridges, eight covered bridges and 36 cupolas. I was immediately attracted to one of the covered bridges, but my grandiose plans never made it past the oversight committee: my wife and the neighbors. We finally decided on the 20-ft. arched wooden bridge that was called the "Potomac" in *Bridges and Cupolas.*

Arched-beam bending form. Using a curved chalk mark on a concrete slab as his guide, the author made this bending form out of 2x4s. A strip of ¼-in. hardboard tacked to the tops of the risers defines the curve. The ¼-in. thick laminations were glued up in groups of five.

Stabilize the creek bank—Before investing the time and money to build a new bridge, I had to shore up the bank of the creek. To that end, I stacked unopened bags of premixed concrete in layers along the portion of the eroded bank. The bags were made of permeable paper, which allowed water to seep into the concrete. The concrete hardened, and in time, the bags ripped away, leaving a solid, durable wall that looks like a stack of concrete pillows.

The high cost of big, curved beams—The plan called for two 20-ft. arched beams, $3\frac{1}{8}$-in. thick by $7\frac{1}{2}$-in. deep. My local building-supply store had a source for the beams, but it wanted $980 apiece. That seemed like a lot of money, so I asked a woodworker friend if he was interested hi the job. No thanks. So I made the beams myself and learned firsthand why a professional woodworker might not want to take on this tough job. It's a labor-intensive process.

I began by drawing the 22-fl. radius of the bottom of the beam on my garage floor. Then I made a bending form that matched the curve (photo facing page). The form consisted of a doubled 2x4 base with 2x4 risers spaced 6 in. o. c. The risers fit into $\frac{3}{4}$-in. deep dadoes in the base. I cut the top of each riser to match the angle of the full-size drawing. Then I screwed a strip of $\frac{1}{4}$-in. hardboard to the risers, and I waxed the hardboard to keep any misplaced glue from sticking to it.

I had a stack of clear pine siding left over from work on our house. Even though it isn't the most rot-resistant wood available, I decided to use the pine to fabricate my beams, reasoning that a good paint job and some annual maintenance would ensure a long and useful life span for the bridge.

The $\frac{3}{4}$-in. thick boards weren't easily bent with my low-tech tools. So I used my table saw and planer to rip them into supple, $\frac{1}{4}$-in. thick strips that were $3\frac{1}{4}$-in. wide by various lengths. In addition to being easier to bend, thin stock is less likely to spring back when the clamps have been removed.

Using a paint roller, I spread water-resistant yellow glue on the strips and then clamped them together in groups of five. I arranged the strips so that any butt joints in adjacent layers were separated by at least 3 ft. I let the strips cure overnight before removing the clamps. Then I added another five strips, and so on, until 28 strips were glued together.

I cut the finished beams to length and smoothed their sides with a hand-held power planer. After letting the glue cure for a couple of days, I finished the beams with a coat of primer and two coats of glossy white paint. Each beam weighed approximately 150 lb., and each beam required 672 linear ft. of pine, a half-gallon of glue and more than 20 hours of labor.

Twin arches span the creek. Held steady by bolts through steel brackets, the arches perch above the defunct bridge. The beam brackets, which are made of $\frac{1}{4}$-in. steel plate, were custom-made for the job.

A garden centerpiece. Painted white with a lattice border on the arched beams, the finished bridge unites neighboring yards. Pressure-treated 2x6s and 2xl2s comprise the bridge decking and the treads at each end. The handrails were laminated in place from four layers of $\frac{1}{4}$-in. thick pine.

Steel brackets anchor the beams—The arched beams bear on concrete footings on each side of the creek. The footings, which are level to one another, are 6 ft. long, 2 ft. wide and nearly 4 ft. deep. A local welder fabricated the beam brackets out of $\frac{1}{4}$-in. steel. The brackets are connected to the footings by way of 18-in. anchor bolts welded to the bottoms of the brackets. U-shaped pockets in the brackets cradle the ends of the beams (photo top left), and $\frac{3}{4}$-in. bolts hold them in place.

I finished the bridge by adding a deck of pressure-treated 2x6s and stair treads of pressure-treated 2x12s. The treads sit atop stringers affixed to the inside faces of the arched beams. I got out the clamps again for the handrails. They're anchored to 4x4 posts bolted to the sides of the beams. I laminated the handrails in place out of four layers of $\frac{1}{4}$-in. thick pine.

I calculate the cost of the bridge's raw materials at a little more than $1,400 (that includes the wood for the beams), and I spent more than 100 hours putting the parts together. That's a lot of weekends for a project that isn't an essential piece of shelter. But the satisfaction of seeing the bridge each morning when my wife and I get up is payback enough (photo bottom left).

—When he isn't building structures in his garden, Geoffrey Cole is a neurosurgeon in Athens, Georgia. Photos by the author.