FRAMING A Cross-Vault Ceiling

Trial and error can't equal a calculator for laying out the arches

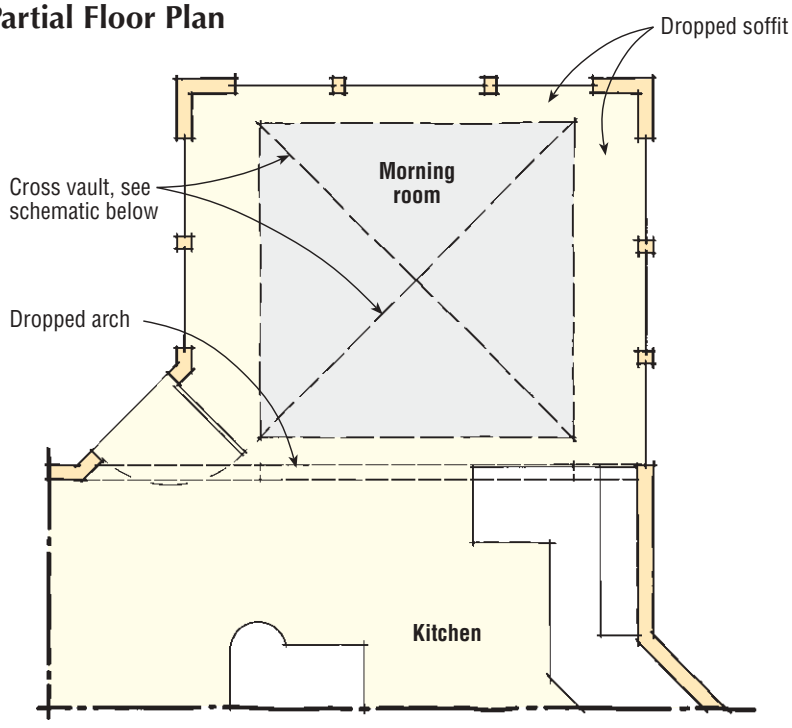
by Jeff Davis

As a custom framer, I welcome the challenge to do something a little out of the ordinary. A recent job called for a recessed cross-vault ceiling in a rectangular morning room off the kitchen. In that section of the house, we'd framed the basic ceiling flat at a height of 10 feet. The recess would be built as a nonstructural assembly beneath the ceiling consisting of two equal barrel vaults intersecting at right angles.

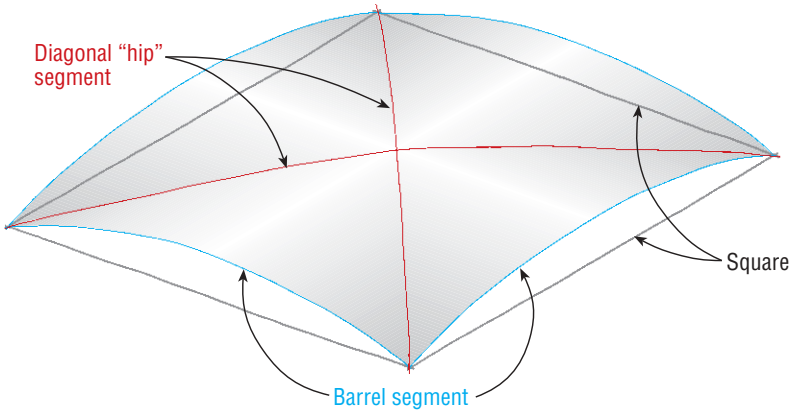
Classically, this configuration is called a groin vault. When framed within rectangular confines, the barrel segments intersect in diagonal "hips" that form a pair of diagonal segmental arches. While it may sound like a difficult piece of framing, in fact, the process was relatively simple.

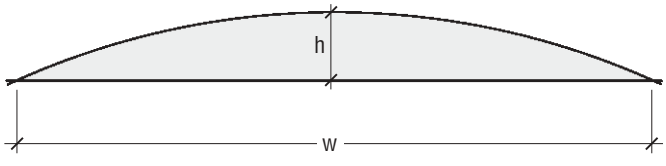
Cross Vault Ceiling

Partial Floor Plan



Schematic





$$r = \frac{w^2 + 4h^2}{8h}$$

It seems that every builder I've framed for — and I work with some great builders — has at some point attempted to fit an arch into an opening by bending a skinny stick from point to point or fooling around with a loop of string, then stepping back to appraise the line with an artful eye. To me, the trial-and-error approach is crude and inefficient. In a nutshell, the problem is to find an accurate, geometric, and repeatable radius for any predetermined arch height and span. I carry the formula printed on a wallet-size card that I can pull out when I want it to remind me what to do with my scientific calculator.

Layout

The idea for the ceiling treatment came from the clients, who'd seen the design in a California home and had shot a few Polaroids. In lieu of construction drawings, the builder, Mark Reilly, gave me the photos and asked me to figure out how to build it.

Mark left it to me to decide where the

Figure 1. A dropped soffit beneath the 10-foot ceiling of the breakfast room formed the boundaries of the cross vault (plan, top). A dropped arch on the open side of the room helped further define the space. The vault is formed by the intersection of two barrel vaults. Both the arches needing to be framed — the barrels and the intersecting diagonals — can be quickly found with the simple formula shown.

limit of the vault area would be, a somewhat tricky decision. The breakfast nook measured roughly 10x12 feet, with window walls on three sides; the fourth "side" opened onto the kitchen area (see Figure 1, previous page).

The nook was in an ell off the main structure, with an inside corner that was chamfered at 45 degrees to accommodate an egress door. The general ceiling area was rectangular, not square, so I created an 8-foot-square "recess" in the nook's ceiling by building 12-inch-high soffits along the three window walls and a fourth soffit across the open end. I used 2x4s, ladder style, on 16-inch centers for the underside of the soffit and paneled the vertical faces with 3/4-inch cdx plywood. In effect, I'd installed a dropped ceiling in the nook, with a coffered center (Figure 2).

Figure 2. By dropping a perimeter soffit from the furred ceiling joists, the author created a visual division between living spaces and established a recess for the vault. Plywood backing on the vertical soffit faces provides solid nailing for the barrel arch construction.

Building Barrels

With the recess defined, I concentrated on forming the barrel arches. Each of the four barrel ends spanned 8 feet, point to point. The diagonal of

Figure 3. The plywood diagonal arches were cut with a circular saw, which can make faster cuts than a jig saw, down to a 4-foot radius, before binding. Here, a carpenter adds a block to support a center light fixture.

Figure 4. At the top of the groin, the ceiling blocks are square-cut at double 45-degree angles, but as the hip descends to the spring line, the cuts become progressively beveled. The author used a flexible story pole to space the blocking equally and divided the bevel angles incrementally between the top and bottom blocks.

an 8-foot square measures 11 feet 3 3/4 inches. The barrel spans and the diagonal hip spans shared a common height — 12 inches — so I calculated the two radiuses needed, made a trammel stick, and drew the respective arches on 3/4-inch plywood (Figure 3, previous page). For the record, the two radiuses were 6 feet 8 inches and 7 feet 4 inches. I carefully cut the arches with a circular saw — I've found that you can effectively cut curves as tight as a 4-foot radius using that tool. The diagonal arches exceeded the capacity of a 4x8 plywood sheet, so I cut them in four separate pieces that met in the center of the ceiling. We had previously nailed 1x3 furring to all the ceilings in the house, a standard framing procedure in this region. The furring provided good general backing to attach the arch components. We added a piece of 3/4-inch plywood to back up the center arch junction and provide support for a chandelier. With the diagonals installed, we nailed the barrel cutouts directly to the plywood facing on the

Figure 5. The bevel for the starter block — 26 1/2 degrees — was the simplest to establish, using a bevel gauge and a miter saw. The rest of the bevels were deduced from that angle.

four soffits. Those two plywood patterns established all the necessary framing lines to complete the converging barrel shapes. I used flat 2x4 blocking to define the contours of the barrels, starting at the top of each vault. Each of these longest blocks fit at the center groin with a double 45-degree square end cut. (The opposite ends were all square, 90-degree cuts.) But as the blocking carried along down the hip to the spring line, the hip cuts became progressively compound (Figure 4, previous page).

Quick calculation for compound cuts. I took a practical route to calculating these bevels. First, I found the bevel angle for the short triangular piece of blocking at the bottom end using a bevel gauge and a sliding compound miter saw (Figure 5, previous page). Next, I stepped off six equal blocking intervals on a thin flexible strip of wood, bent along the underside of one of the single hips. Then all I had to do was progressively step the bevels down by a sixth of the total bevel angle, one

Figure 6. Although produced quickly, the vault framing is accurate, uniform, and almost too nice to cover up with drywall. The front soffit awaits a box-beam arch to complete the framing.

Figure 7. Roughed out on sawhorses and nailed up in two pieces, the box beam's arch had to remain shallow to clear windows at both ends (left). The arch effectively echoes the barrel vault arches and helps to delineate the open but separate living spaces.

Figure 8. Thin 3/8-inch drywall flexed without buckling over the concave barrel framing. To crisply highlight the lines of the cross-vault, the plastering contractor used expanded-metal plaster bead.

block at a time, from 26 1/2 degrees to 0 degrees. The 45-degree hip angle cuts remained constant. For efficiency, I cut eight of every piece in mirrored pairs, as each vaulted quadrant was identically proportioned. With me cutting and a helper nailing the pieces up, installing the barrels only took us a couple of hours. The resulting geometric framing pattern looked almost too good to cover up (Figure 6, previous page).

Arched Header

To further distinguish the nook, I added an arched box header under the front soffit. I laid it out and cut it on sawhorses, using 2x4s and a 1/2-inch plywood skin, then nailed it up in two pieces (Figure 7, previous page). I had to keep the dropped shoulders, and hence the arch itself, shallow — only about 4 inches below the soffit level — because the header had to clear a transom window above a door in the angled wall. The arch spanned 8 feet, centered on the vault, and provided a subtle introduction to the curving ceiling lines.

The plastering contractor, Michel Tanguay, used 3/8-inch drywall board and skim-coat plaster to finish the barrels, and did a beautiful job (Figure 8). He used metal plaster corners, the type with expanded mesh flanges, which flexed smoothly along the easy curves and gave the groin joints sharp definition. The diagonal arcs finish crisply at the recess corners and meet in the center at the chandelier's electrical box. Maybe someone will come along, take a few snapshots, and the process will begin all over again somewhere else. But you'll be ready for it.

***Jeff Davis** is a framing contractor in Harwich, Mass.*