Contract won by using adjustable radius forms

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Two curved walls of different radii had to be formed in the construction of St. Thomas More Worship Center in Englewood, Colorado. The outside wall of the round sanctuary was made up of two semicircles, one 60 feet in radius and one 75 feet in radius (Figure 1). Normally, a separate set of forms would have been built for each radius. To cut costs and make our bid more competitive, though, we had our form supplier custom design a set of adjustable panels which could form both radii. This enabled us to lower our bid and in the end save about $30,000 on total project costs—just about the amount by which we had underbid the next closest competitor.

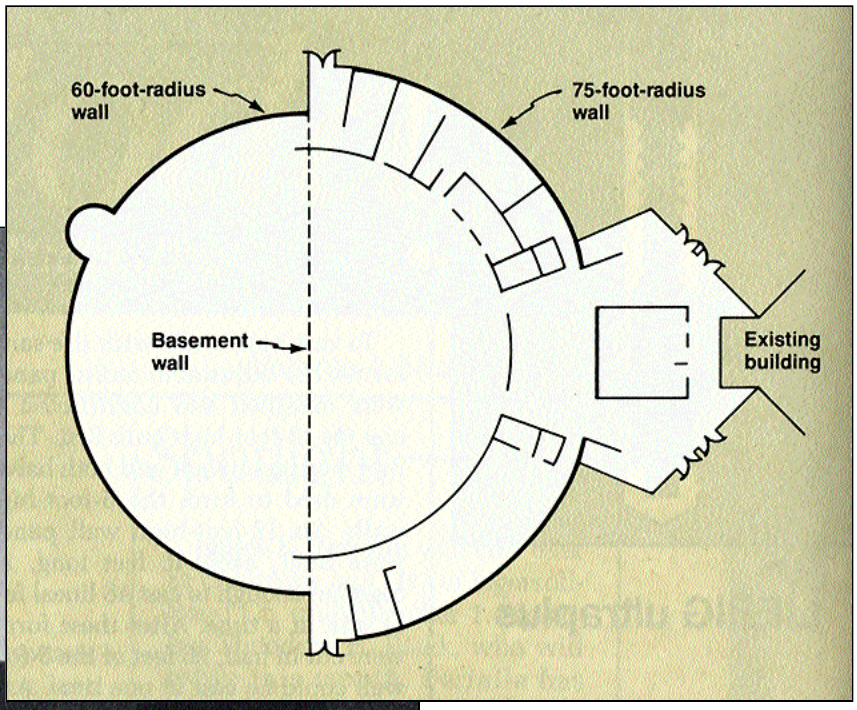

Figure 1. Curved gang form panels with adjustable steel walers formed both 60- and 75-foot-radius walls of a church in Englewood, Colorado.

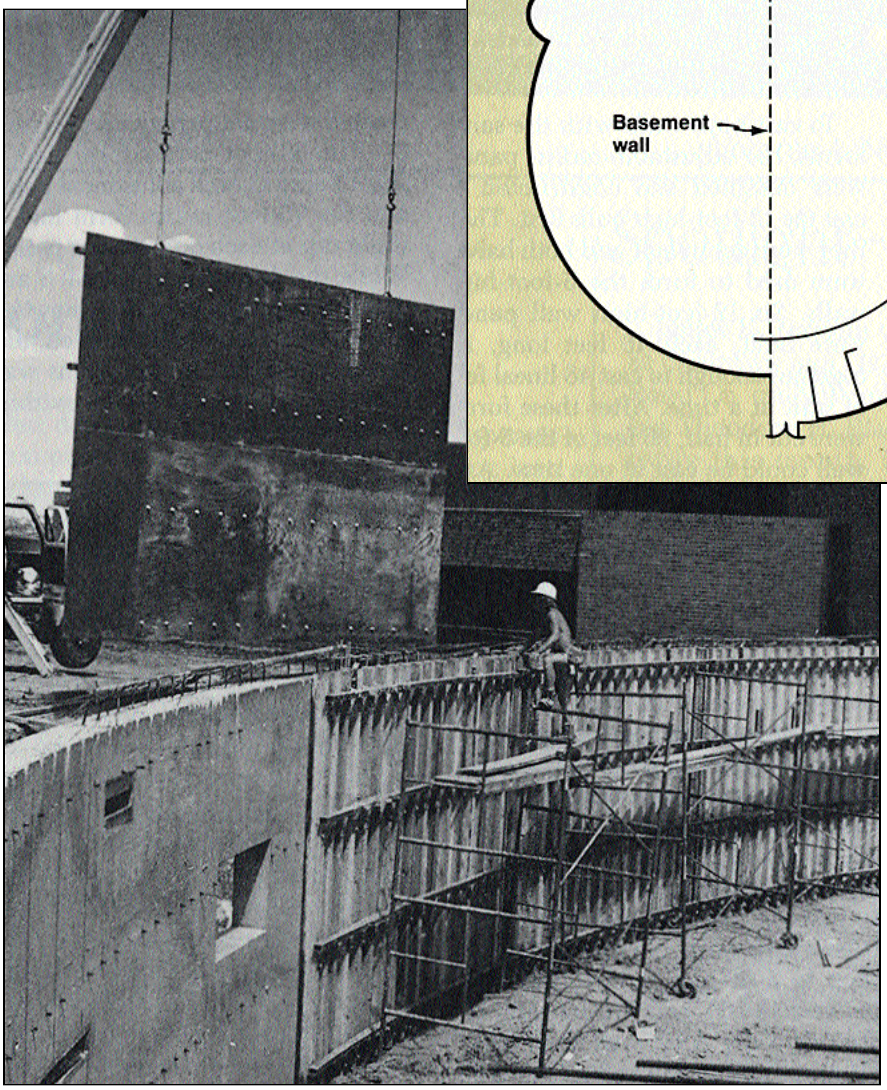

Figure 2. The adjustable 2x3-inch waler was rolled to a 68-foot radius. By tightening or loosening threaded adjustments, the steel walers could be bent in the field to form the 60- and 75-foot-radius walls.

Wall heights varied, too

The two half-circle walls differed in height as well as in radius. Because the 75-foot-radius wall extended below grade to enclose a large multipurpose basement area it had to be 12 feet high. The 60-foot-radius wall, on the other hand, was only 5 feet high. For architectural reasons, the remaining height of each wall was built as a masonry-steel stud wall.

To cast both walls with the same forms, the adjustable-radius panels were designed and constructed to cast the 12-foot-high walls first. Then they were cut in half and both halves were used to form the 5-foot-high walls. Six 12-foot-high wall panels were built, each 16 feet long, altogether enough to cast 48 lineal feet of wall at a time. After these forms were cut in half, 96 feet of the 5-foot wall could be cast at one time. As a result five concrete placements were needed to cast the 12-foot wall, but only three were needed to cast the 5-foot wall.

Adjustable walers

Adjustable curved walers made it possible to create the two different wall radii with the same forms. Two threaded adjustment devices on each waler (Figure 2) were either tightened or loosened to decrease or increase the radius of the curve. With these threaded adjustments tightened only halfway, the 2x3-inch steel box-tube walers were rolled in the metal shop to a 68-foot radius—halfway between the 60- and 75-foot-radii of the two walls. After wall form panels were built to this radius, the adjustments were loosened to create the 75-foot-radius curve. The 12-foot wall was then cast, the forms were cut in half, and the adjustments were tightened to create the 60-foot-radius curve.

Because the radius of each form was changed by making adjustments at only two points and not along the entire length of the walers, the 60- and 75-foot-radius curves that were created were not perfect arcs (Figure 3). The 60-foot-radius form had a slight bump at each adjustment point and the 75-foot-radius form had a slight dip at each adjustment point. While the drawings in Figure 3 are greatly exaggerated to show how the forms were not perfectly curved, the greatest variance in the radius was actually only ¼ inch—well within the tolerances allowed.

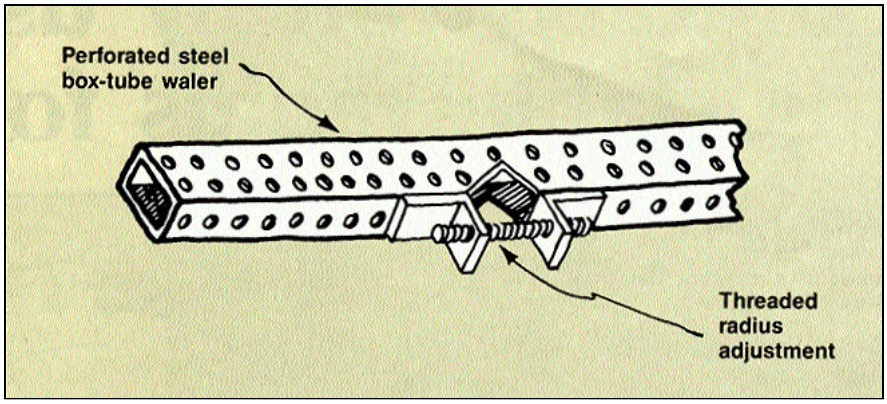

Figure 3. As rolled, the walers were a perfect arc with a 68-foot radius (middle). After they were attached to the forms, the adjustments were loosened to produce the 75-foot radius (top) or tightened to produce the 60-foot radius (bottom). Unnoticeable small humps or dips (exaggerated in the drawings) were created because the adjustments were made only at two points instead of along the entire length of each waler.

How the gang forms were built

We constructed the curved wall forms on two curved form building tables: a convex table for building inside wall panels, and a concave table for building outside wall panels. The 12x16-foot tables were built on site on truss supports. For the convex table, a 68-foot radius, convex curve was cut into the top edge of wood 2x12s. The 2x12s were then set on the trusses with the curved edge face up. Then 12-inch-thick plywood was placed over the 2x12s to create a curved plywood tabletop. The concave table was built in the same way, except the 2x12s were cut with a concave curve.

To construct a wall form panel, four box-tube steel walers were laid on one of the form tables and held in place temporarily by clips attached to the table. Prebent to the 68-foot-radius, the adjustable walers were spaced ½ feet apart, starting 8 inches above the bottom of the panel. Wood 4x4 strongbacks were placed at 12 inches on center on top of the walers, perpendicular to the 16-foot length of the panels. Then ¾-inch-thick BB form plywood was laid over the strongbacks. Carriage bolts passed through the walers, stronger backs, and plywood held the entire panel together.

Large windows created difficulties

Assembling forms was slowed by construction of many large windows, some 16 feet wide. The top and bottom bulkheads of the window blockouts had to be cut to the same radius as the wall forms, then assembled inside the forms. Although setting the wall forms and placing concrete each took only a day, constructing blockouts and installing rebar took up to 3 days.

Window blockouts made concrete placement difficult, too. Because the concrete walls were placed in one lift, concrete discharged into the top of the forms had to be worked under the blockouts without leaving voids in the window sills. To provide the vibrator the access to do this, a trapdoor was cut in the form face at the location of each blackout and a 2-inch-diameter hole was drilled in the bottom bulkhead of the blockout. During placement, we inserted a

vibrator into the concrete below the blockout by passing it through the opened trapdoor and through the hole in the bulkhead. The trapdoor was replaced afterward so the form could be reused even if there was no window at the same location in the next placement.

Snap ties didn't snap

We decided to use four rows of snap ties spaced at 12 inches horizontally, planning to break the ties first and then strip the forms. We thought this would allow us to strip a 16-foot-long form in about 30 minutes, but instead it took as long as 2 ½ hours. As the first few snap ties were broken, the curved form popped off the concrete, binding the other ties. As more and more ties were broken, the ties that were left were put in a bind even more, making them more and more difficult to break. If we had to do the project again, we'd try using taper ties instead.

$30,000 saved

The total cost of constructing the 12-foot wall and the straight wall which closed off the D-shaped basement averaged $3.66 per square foot of wall surface (1981 costs). Out of this $3.66, $1.79 was for labor and $1.87 was for materials. The total cost of the 5-foot wall came to $3.00 per square foot of wall surface, of which $2.14 was for labor and $0.86 was for materials. In both cases, stripping and cleaning cost about $0.22 per square foot of wall surface.

We estimate that using the adjustable radius forms cut the cost of the 12-foot wall by 15 percent and the 5-foot wall by 50 percent. Altogether, the saving was about $30,000, which was about 5 percent of the total project costs and 25 percent less than the cost of using two sets of wall forms, one set for each radius.

PUBLICATION #C870441