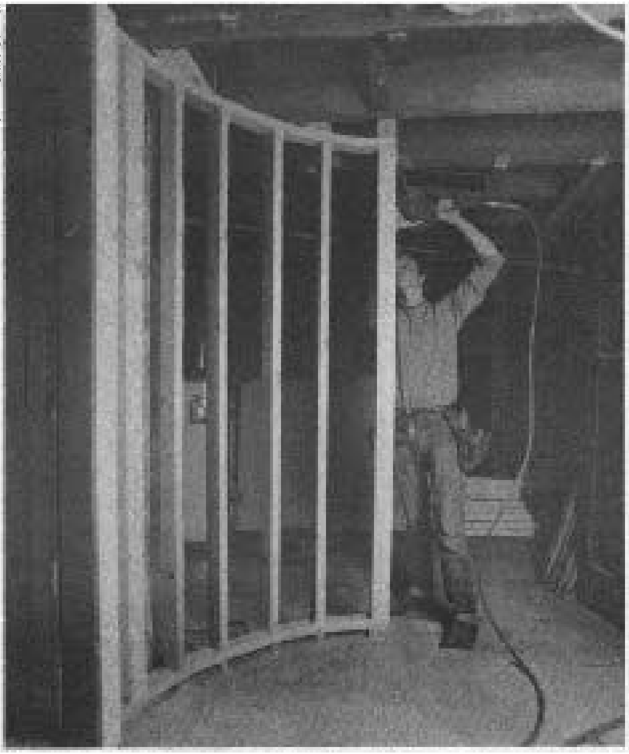
Building Curved Walls

Simple techniques can yield distinctive results

by Clayton DeKorne



Bruce Conklin

The author used plywood top and bottom plates for this non-load-bearing curved wall.

Arches, vaults, and other curved surfaces are now standard fare in many residential designs. These may add flair to the building, but for the builder, curved walls can end up being the most costly and difficult part of a project.

Many approaches rely on techniques such as steam bending, or require unusual tools such as trammel routers. This is fine for projects where money is no object. But it is also possible to build large-radius curved walls on a tight budget. Below are a few curved-construction techniques adapted from conventional building practices.

Accurate Framing

Curved partitions can be tricky to lay out. But accurate layout is critical if construction is to proceed smoothly. Fitting a curved figure into a rectangular area requires a bit of geometry (see "Geometry for Builders," last page).

To draw out the curve I prefer to use a stiff arm such as a length of strapping as a radius. It takes just a few moments more to prepare and use than a string, but it allows me to easily draw the same arc repeatedly for each component of a curved plate.

A curved plate is made easily from two layers of ¾-inch CDX plywood. I use a construction adhesive to bond the two pieces together, and stagger the joints in each layer.

Cutting curves from a 4x8 sheet has an obvious advantage over trying to cut many short lengths of the curve from wide-dimensioned framing material. But plywood plates have a slight structural disadvantage that the builder should be aware of if the wall is load-bearing.

Plywood built up to the thickness of 2x framing lumber is far inferior for carrying and transferring loads. A ¾-inch strip of CDX has at best 7/16 inch of wood running in the right direction to resist a load. A curved piece has even less. And since joists and studs will not readily line up due to the curve, the upper plate must be relied upon to bear and transfer its load to the studs.

There are three options I know of to overcome the. plywood's deficiency: (1) Additional studs can be placed beneath each joist. (2) The upper plate can be increased in size. (3) A structural header can be built to span the curve and transfer the load to solid posts at either end. Of these options, I prefer the last (see Figure 1). It is a bit more time consuming to frame but it seems to be the most direct approach to building a stable structure. Adding studs to the wall after it is erected seems haphazard. Furthermore, with the studs oriented radially along the plate, they are askew to the joists, and thus the load will not be directly transferred. Increasing the width of the plate would require at least 50-percent more plywood thickness than whatever conventional framing material would be called for. So if a doubled 2x plate is called for, at least six layers of ¾-inch CDX must be used for the top plate. This seems awkward.

Bottom plates, however, are less of a problem. Since the compressive strength of plywood is just slightly less than solid spruce, settlement of the plate itself will be negligible. Yet, care should be taken to add blocking under the floor deck—directly under the partition—if it is load-bearing.

The studs must be placed fairly close together to fully define the curve and provide adequate nailing for the skin, which will be under stress. The tighter the curve, the greater the stress will be. A loose rule of thumb states that the stud spacing in inches should equal the radius in feet multipied by three. Thus, for example, a 4-foot radius curve should have the studs 4 times 3, or 12, inches on-center. For more precise recommendations, follow U.S. Gypsum's guidelines in Table 1 below.

Steel studs and runners can also be used for framing a curved wall. To form a curved plate, a steel runner is cut every 2 inches through one leg and across its width. The other leg will then bend to any angle of curvature up to 90 degrees. A l-inch strip of 25-gauge steel is fastened to the inside of the cut leg to tie the opened 2-inch sections of the runner together (see Figure 2). Studs oriented radially along the curve are then fastened into the runner. Stud spacing is the same as with wood framing.

Covering It Up

There are a number of prefabricated curved wall coverings available for small-radius curves (see list at end of article). Using these or plastering the curve are probably the least aggravating methods to achieve a successful finished surface. For large-radius curves (over 2 feet) a drywall or plaster skin is the most economical alternative. Conventional drywall can be bent to smaller radii but rarely with satisfying results.

There are two ways I know to bend drywall: (1) by wetting the panels; and (2) by kerfing the face that is in compression. Both ways have some disadvantages. Wet drywall is delicate stuff that falls apart easily when moved. Screws can pull through if the sheet is too wet. And production time is slowed because the sheets must dry before they are taped. (More information on this subject is available in *Curved Partitions Constructed with Wetted Sheetrock Gypsum Panels*, Form WB-167, by U.S. Gypsum, 101 S. Wacker Drive, Chicago, IL 60606; 312/321-3863.)

Kerfing, on the other hand, can create quite a mess with dust, and the resulting surface is often slightly faceted rather than curved. Despite these disadvantages, however, a smooth finished curve can be produced using either method with surprisingly little trouble.

For wetting sheetrock, I prefer to bend 3/8-inch sheets; ¼-inch panels seem to fall apart more easily (even when transported dry) and often must be special ordered. I've had unsatisfactory results bending ½-inch panels. However, by following U.S. Gypsum guidelines (in Table 1), you might have better results with the various thicknesses.

With 3/8-inch panels I first bend and install strips of 3/16-inch (¼-inch nominal) lauan plywood over the framing to help define the curve. The resulting 9/16-inch thickness allows me to meet either ½-or 5/8-inch drywall on adjoining straight walls with only a little discrepancy. If a 5/8-inch minimum thickness is required for fire or sound resistance, a double layer of 3/8-inch board can be used without the lauan.

The drywall should be laid out horizontally (as with a conventional wall) at least a foot beyond the ends of the curve. Precut for size and for openings before wetting. Only the side in compression needs to be wet (that is, for a concave curve, wet the side facing out; for a convex curve, wet the inside). The amount of water is critical. If the sheet is too wet it will soak the entire thickness and dissolve in your hands. If it is too dry it will snap when bending it into

Table 1. Stud Spacing and Water Needed for Curved Sheetrock Walls (U.S. Gypsum)

Panel Thickness	Radius	No. of Studs on 90° Arc Including Those at Tangents	Maximum Stud Spacing On-Center (Outside of Arc)	Ounces of Water Required Per Panel Side
¼"	2'0"	9	6"	30
¼"	2'6"	10	6"	30
3/8"	3'0"	9	8"	35
3/8"	3'6"	11	8"	35
½"	4'0"	8	12"	45
½"	4'6"	9	12"	45

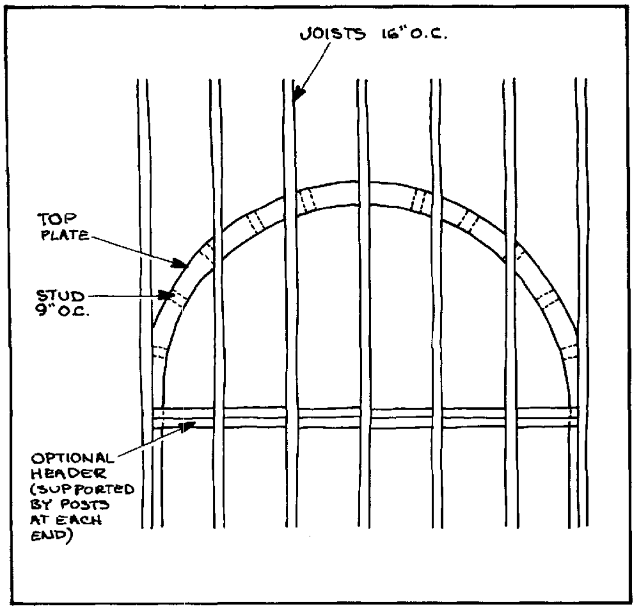


Figure 1. *On a load-bearing curved wall, the top plate must be strong enough to transfer the load to the studs. An alternative is to span the length of the curve with a header, as shown.*

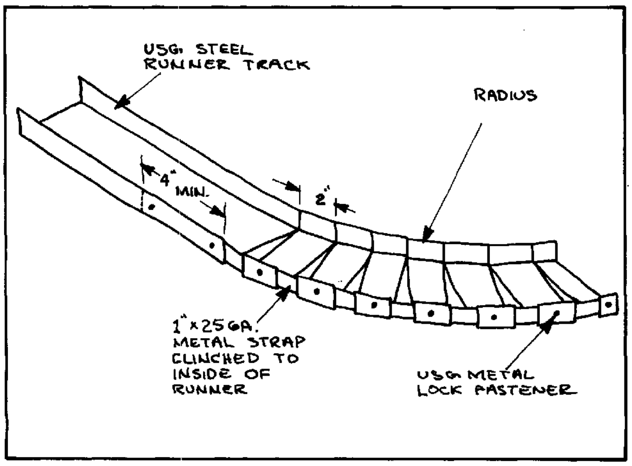


Figure 2. *With steel framing, you can create a curve by cutting the top and bottom track every 2 inches through one leg and across the width. A 1-inch strip of steel is fastened to the inside of the cut leg.*

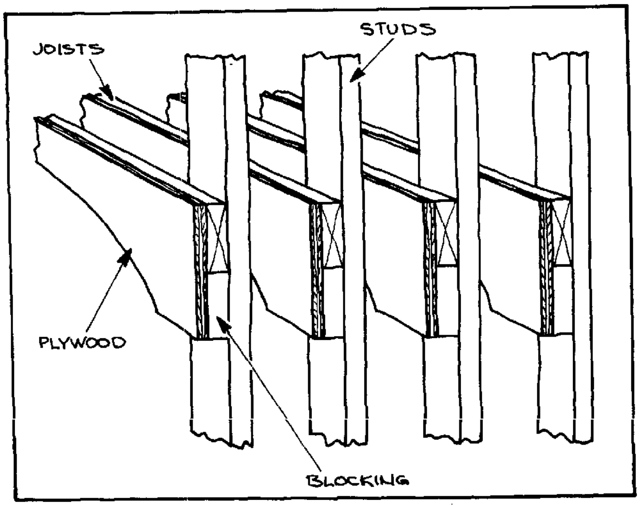


Figure 3. *To create a curved ceiling, suspend plywood forms from a sound joist structure.*

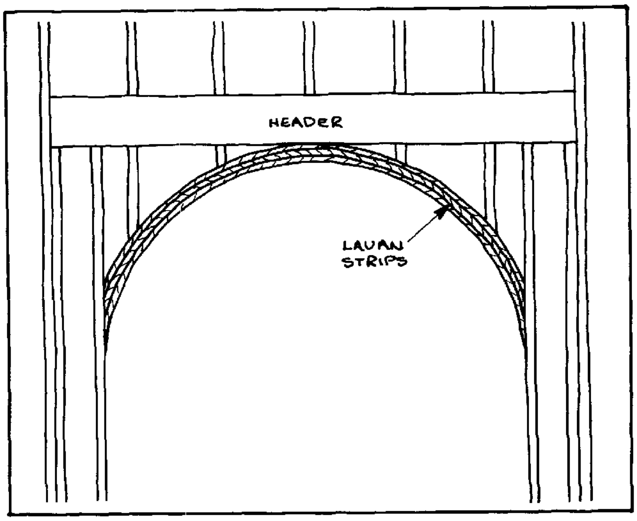


Figure 4. *Arched framing for a window can be built up from multiple lauan strips attached to short studs.*

place. Thirty-five ounces of water is sufficient to wet a 4x8 panel of ⅜-inch board. It can be easily measured and evenly applied with a garden sprayer. The amount of water required for other thicknesses is shown in the U.S. Gypsum table. The wet panels should then be stacked with the wet sides face to face and covered with poly for one hour.

You can safely move wet panels across a distance on a sheet of plywood. Slide the panels off the stack onto the plywood and then tip them up at the foot of the framing. From here they can be lifted into place with a minimum of damage.

Convex curves are a bit easier to "wrap" than concave ones. If you are doing both sides of a partition, it is probably best to start with the convex side.

On convex curves, begin by fastening one end of the panel and work your way around the framing in one direction. On concave surfaces, begin by fastening the center and work out in both directions. U.S. Gypsum recommends spacing fasteners every 12 inches on-center. For double-layer applications, fasten at 16 inches on-center for the first sheet and 12 inches on-center for the face sheet.

Standard bugle-head drywall screws tend to pull through wet panels under stress. I find that using plaster washers with screws in crucial areas-in the center of concave curves and at each end of convex curves-can help eliminate this problem. Plaster washers (The Charles St. Supply Co., 54 Charles St., Boston, MA **02114; 617/367-9046**) are quarter-sized washers perforated to accept joint compound or plaster, and indented to accept the bugle head of a drywall screw. Though designed for repairing cracks and weak portions of old plaster, they are ideal for this application.

The wet drywall must dry at least 24 hours before finishing. The moisture in joint compound is designed to be absorbed by dry panels. Unless the panels are allowed to dry, it will take much too long for your first coat of mud to dry.

Kerfing drywall is a bit faster because the drying time is eliminated. But an enormous amount of fine gypsum dust is blown around when cutting the kerfs. If you can do the cutting outside, you won't regret having to carry the sheets the extra distance.

In kerfing, the goal is to remove enough material from the side in compression that it can sufficiently shorten when the panel is bent. The two faces of a curved panel are of different length: The side in compression must he shorter than the side in tension. Kerfs ⅛-inch-wide by ¼-inch-deep, every 3 inches along the width of ½-inch drywall, is sufficient to bend a 4x8 panel horizontally around a curve with a 4-foot radius. For shallower or tighter curves, widen or reduce the kerf spacing accordingly. For curves less than 2½ feet in radius, a wider kerf (about ¼ inch) should be cut.

When cutting the kerfs, it is best to support the drywall on a stiff sheet of plywood, which can then be lifted off its horses to transport the kerfed panel. This keeps the drywall from bending backwards and snapping into a bunch of thin strips.

As with wet drywall, begin fastening at one end of a concave curve and in the middle of a convex curve. Fasten every 12 inches on-center. Not every individual section of drywall will be fastened, reducing the strength of the skin. The diagonal strength of the skin is further reduced by the kerfing. However, curved walls do not require a great deal of diagonal reinforcement. The forces that tend to rack a wall out of square are directed into the line of the curve, and are therefore resisted by the curve of the upper and lower plates.

One problem with kerfing drywall is that invariably the remaining ¼ inch of material at the kerf cuts will fail, creating a ridge in the surface of a convex wall. And concave walls, in which the face has been cut, appear-faceted. The treatment here is mud.

Smooth With Plaster

Skim coating the entire surface of the wall is often the most effective way to achieve a smooth, uniform finish. For the first coat, use a setting-type joint compound such as Durobond (U.S. Gypsum) or Goldbond Stasmooth (National Gypsum). These are recommended for any first coat thicker than ³⁄₃₂ inch, for the first taping coat, or for building up flat spots or voids. Setting joint compounds won't shrink while drying, and can be second-coated in less than an hour. But because of their durability, they do not sand easily. Therefore, use a standard drying-type joint compound for finish coats.

If you're planning to skim coat the curved wall to get a smooth, uniform finish, consider the obvious alternative: plastering. A plaster finish is durable and long-lasting, and has superior acoustic qualities as well. Whether you use a veneer plaster or a conventional three-coat plaster, the preparation for a contractor is minimal and the finished product is impeccable.

Three-coat plaster is recommended for tight curves and compound curves. A three-part system starts with a *scratch* or *bond* coat of a lime-based plaster, which is applied directly to metal lath nailed over the framing. Care must be taken with the framing to fully approximate the curve. For compound curves (for example, a cove at the top of a curved wall), use metal lath backed with tar paper.

Next, a second *ground* coat is applied. The ground coat can be applied up to ¾ inch thick to fully define the curve. A final *top* coat is applied to

Curves For Sale

Clinch-On Products
Mounds View Business Park
5201 Program Avenue
Mounds View, MN 55112
800/523-4642; 612/786-6024
"Clinch-On" galvanized steel bullnose cornerbead; "Easy Arch" galvanized steel arch framing.

Pittcon Industries, Inc.
6409 Rhode Island Ave.
Riverdale, MD 20737
301/927-1000
"Softforms" extruded aluminum and plastic bullnose drywall corners, 90- and 45-degree curved inside and outside corner panels, column covers, coves.

Roberts Plywood
Div. of Die Boards Inc.
150 Rodeo Drive
Brentwood, NY 11717
516/586-7700
Precurved poplar plywood in quarter-, half-. and full-rounds; radius-end panels with quarter-rounds; 3/4-inch and 5/8-inch thicknesses available.

Flex-Trim Moldings
7820 Boulder Ave.
Highland, CA 92346
714/864-4942
"Flex-Trim" flexible polymer moldings, wood-like appearance.

GavinAssociates
558 Dutton Road
Sudbury, MA 01776
617/443-4387
"Insta-Arch"prefabricated fiberglass arches for dry-wall construction.

Domtar Gypsum
6000 Freedom Square Drive, Suite 580
Independence, OH 44131
216/642-5700
Hi-density fiberboard, bends for curved applications.

Flannery, Inc.
13291 Paxton Street
Pacoima, CA 91331
818/899-5557
Stiff and flexible galvanized steel bullnose drywall corners; preformed arch beads; adjustable drywall reveal and expansion joints; "Fastmask" keeps adjoining surfaces mud-free.

Bending Baseboard

Small-profile moldings will readily conform to shallow curves, but larger wood trim such as baseboard will need special treatment.

The easiest approach, I find, is to use multiple layers of thin plywood. Each layer is individually bent to fit the curve. By building up several layers, you can produce a standard baseboard dimension. The exposed top edges of plywood are then capped with a molding. For a natural wood finish, you can use a hardwood plywood for the final layer.

I prefer to use lauan plywood, although data from the American Plywood Association indicates that ¼- and 5/16-inch fir plywood will bend dry to comparable radii (see table A). Lauan is cheaper and often more readily available than ¼-inch AC plywood. Take care, however, to select good lauan. Voids within the core will cause a strip to snap with only a little bending.

There are two grades of lauan sold: select and standard. The grades are based on the condition of the face veneers only. But the cores usually differ as well. Select-grade lauan tends to have a more stable and continuous core. However, your best guarantee is to inspect the material yourself. Voids often appear as light bands on the face. Also examine the edges, since these are. usually fairly representative of the core. A little time selecting your material may save you some headaches later.

Both fir and lauan plywood bend to smaller radii across the face grain than parallel to it. Therefore, it is often easier to use several short sections cut across the 4-foot dimension than to force a long run into place. Just be sure to stagger the joints from one layer to the next.

For tight curves, you will need to soak the plywood. All lauan is made for exterior use. Wetting it will not effect its strength once it has dried out, though some face checking may appear. This is true of all exterior plywoods. (Do not, however, wet hardwood plywoods, which use interior glue.)

To wet the plywood strips, stack wet towels on each strip. Use warm water and let them soak for several hours. Re-wet the towels as necessary.

Keep the area warm, especially when bending the piece into place. Wood fibers are elastic when warm but brittle when cold.

To bend a strip, begin at one end on a convex curve (for a concave curve, begin in the center) and screw the strip securely to a stud, Don't set the screws too deep or they will pull through. I use blocks attached to the stud to "clamp" the strip at the starting point (see Figure A). As I wrap the strip around, I fasten in a zigzag pattern—screwing high and low. For the next layer, I reverse the pattern—low and high. More blocks are added if the curve is very tight. Each layer is painted with glue. Wetted strips will not effect the overall strength of a water-based glue (I use aliphatic-resin "yellow carpenter's" glue). But the setting and drying times will be significantly lengthened.

Glue the finish layer, and hold it in place with nails rather than screws. Clamp it with a block on every stud. The nails will prevent this layer from slipping around while the glue is still wet.

Use stock moldings for the base cap. Stock moldings bend quite readily as anyone knows who has handled 16-foot lengths. These can be easily applied to cap the exposed top edges of the laminated strips. As with the plywood, soaking the molding with water will help for tight curves.

Sometimes, I cut a rabbett into the bottom edge of the molding (see Figure B). This keeps the plywood edge hidden if the molding moves with seasonal changes. It is likely that the baseboard and molding will move at different rates. Rabbeting is not necessary, however, and glue will go a long way toward keeping the two together over time. Also be sure to nail the molding cap into the studs, as edge-nailing into plywood is not especially secure.

— C.D.

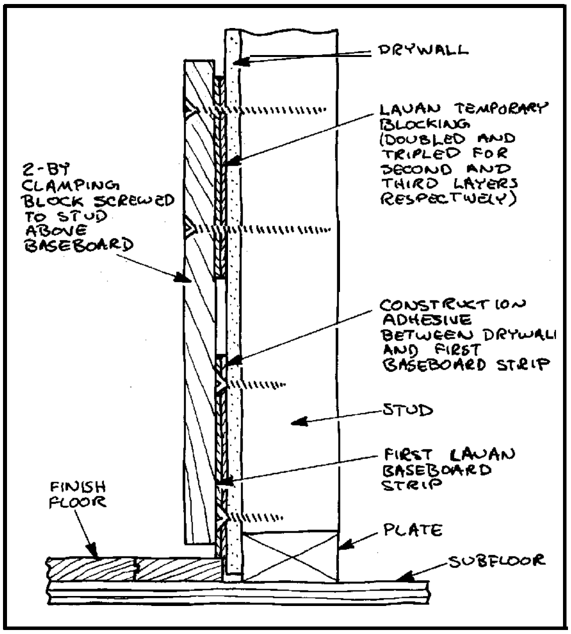


Figure A. *Since baseboard is usually applied over a finish floor, clamping blocks must be screwed into the studs above with spacers, as shown.*

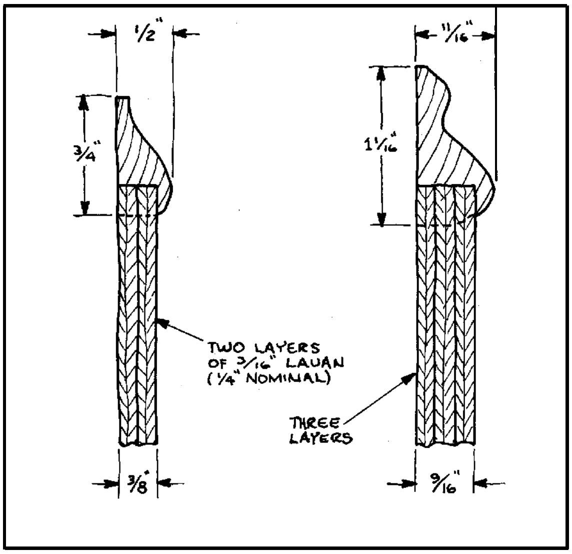


Figure B. *Stock moldings, such as the two Brosco profiles shown, work well to cap two and three layers of lauan plywood.*

Table A. Bending Radii for Dry Plywood

Panel Thickness	Bending Radii for Dry Panel: Bent Across Grain	Bent Parallel to Grain
¼"	2'	5'
5/16"	2'	6'
3/8"	3'	8'
½"	6'	12'
5/8"	8'	16'
¾"	12'	20'

The radii shown are minimums, and an occasional panel may develop localized fractures at these radii.

American Plywood Association

produce an absolutely smooth surface. The finish coat is usually a gypsum-based plaster similar to a veneer plaster.

Veneer plaster is a less expensive alternative to the three-coat system. It uses a 1/16- to ¼-inch-thick coat applied over "blue board" — a gypsum panel with a chemically treated paper designed to promote adhesion to the plaster. Blue board comes in standard thicknesses — 3/8 inch, ½ inch, and 5/8 inch-and standard lengths — 8, 10, and 12 feet. Moisture-resistant blue board is also available.

For curved walls and vaulted ceilings a two-coat veneer system is recommended, although a single coat is tine for straight walls. The two-coat system consists of a sandy scratch coat that can be built up to span slight imperfections in the curve and a smooth gypsum-based finish coat.

With veneer plaster, ½-inch blue board is used to define curves. It is applied exactly like conventional drywall. Use the wet-panel method, however, rather than kerfing it. since the board must be strong enough to carry the skim coat of plaster. In general, a blue board job can be a bit less perfect than might be required for drywall.

The result is an extremely smooth and durable surface that should be seriously considered even for straight runs. And although veneer plaster is generally more expensive than drywall, for large-radius curved surfaces it is perhaps the fastest and most faultless alternative, and may prove to be the cheapest.

Corners and Trim

In addition to the face of the wall, you will often have exposed corners to finish as well. For the outside corners of drywalled arches and the top edges of free-standing partitions, take standard corner bead and bend it as you would bend steel runners. Make closely spaced cuts through one flange (about every 1/8 inch) perpendicular to the length of the bead. These will allow the other flange to conform to the shape of the curve. Be careful to make enough cuts to allow for a gradual curve instead of a series of angles.

Trim must also be considered. While you can get quite elaborate with steam bending and curved milling, much can be done by simply laminating thin bendable sheets of lauan plywood or similar materials (see "Bending Baseboard," next page). Small profile moldings will generally conform to all but very tight curves.

Many Possibilities

These general techniques can be improvised upon to construct a wide variety of curved surfaces. Vaulted ceilings, in particular, lend themselves to similar techniques. In most cases, plywood can be cut to define the curve of the vault provided it is suspended from a sound structure (Figure 3). Arched framing for window and door openings can be constructed out of strips of lauan laminated onto studs of varying lengths, which hang from a beam (Figure 4).

Perhaps because curved surfaces are somewhat rare in American design, the impression they make is always quite surprising - they are almost always noticed and commended. Used judiciously, they can dress up many interior plans with only modest additional cost.■

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Geometry for Builders

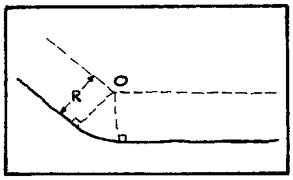

Figure a. *To draw a circular curve tangent to two lines, first draw parallel lines. Then draw the curve from the point where they intersect.*

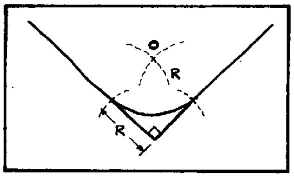

Figure b. *To round off right angles, measure back from the corner along each leg by the length of the radius. Draw two arcs. From the point where they intersect, draw the curve.*

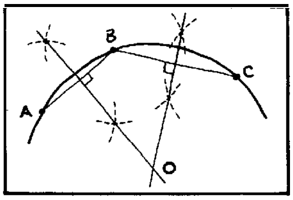

Figure c. *To draw a circular curve through three points, first connect the points, as shown. Then draw perpendicular lines through the centers of the two short lines. Where these perpendiculars intersect will be the center of the circular curve.*

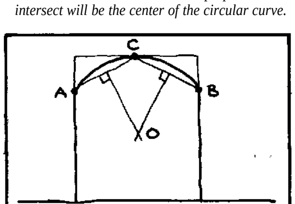

Figure d. *The three-point method shown in Figure c can also be used to lay out an arched opening.*

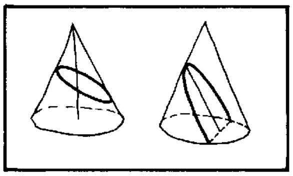

Figure e. *The ellipse and parabola can be developed by cutting sections through a cone.*

Layout is often the toughest part of building a curved surface. Particarly hard is making the curve fit accurately to an otherwise rectilinear building. A little geometry will help. The following techniques are suitable for work on paper (with compass and ruler), or on the building deck (with strapping and chalk lines).

Circular Curves

The most common curves in buildings are arcs (sections) of circles. Circular curves are usually specified by the radius of the circle and the curve's relationship to other straight lines or points in the building.

Two common situations are (1) where an arc of a circle merges with straight lines (at tangent points); and (2) where an arc must pass through three points.

For the first situation, shown in Figure *a*, one approach is to draw a parallel line in from each wall (by a distance equal to the radius of the curve you want to draw). Where the two parallel lines cross at point O, place the point of your compass or marking stick and draw the curve.

For right-angle curves, you can use a quicker method, shown in Figure *b*. From the corner where the two walls meet, measure back the length of the radius along each wall and make a mark (at D1 and D2). From those marks draw two short arcs with the radius of the circle you'll be drawing. From the point where the arcs intersect, draw the final curve.

The second situation-where a circular curve must pass through three points-is a bit more tricky. The points may represent supporting columns, door or window openings, or existing mechanical components. In Figure *c*, the points are identified as A, B, and C. First draw lines connecting A to B and B to C. Next, find the center of each of these lines, and draw a perpendicular line through the center point, as shown. Where the two perpendiculars cross (point O) will be the center of a circle passing through all three points.

Arched openings can also be laid out using this three-point method, as shown in Figure *d*. The three points you want to connect here are the midpoint of the header (C), and the two ends of the arch (A and B).

Ellipses and Parabolas

The ellipse and parabola are also common curves for building forms. Mathematically, these shapes are sections cut through a cone (see Figure *e*).

The ellipse is a common shape for gable windows and fan lights. It is also used widely in auditoriums and sound studios for its acoustic properties. Generally an ellipse must fit into an area of a known length and width, as in Figure *f*. To construct the curve, first you must locate points F1 and F2, known as the focii. The focii lie on the centerline of the rectangle, which runs from point A to point B in the drawing. To locate the focii, measure diagonally from point D to the centerline a distance equal to half the length of the rectangle.

The curve is then drawn by attaching a string to F1 and F2 that extends through point D. By maintaining tension on the string with a pencil, you can trace out a perfect ellipse.

The parabola is a curve you frequently see in satellite dishes and other electronic equipment because it will focus parallel rays at a point (Figure *g*), or transmit signals from that point in parallel.

To make a parabola, just divide two sides of a rectangle into an equal number of short segments, as shown in Figure *h*. Then connect the dots, as shown. Finally, draw a line through the intersections on the grid to produce the parabolic curve. The smaller the segments, the smoother the curve will be.

To divide the lines into even segments, you can make use of another geometrical trick, shown in Figure *i:* Hold your tape measure at one end of the line. Rotate it out as shown until the numbers line up conveniently, and mark even segments on the new diagonal line (every foot, for example). Then square down to these points to locate the divisions of the line. Once you become familiar with this method, it will prove faster than using a calculator.

Additional information on the layout of these and a variety of other curves, can be found in the old standby *Engineering Drawing,* by Thomas French (McGraw-Hill). Just substitute framing square, tape measure, and chalk line for the drafting tools used in the book.

— C. D.

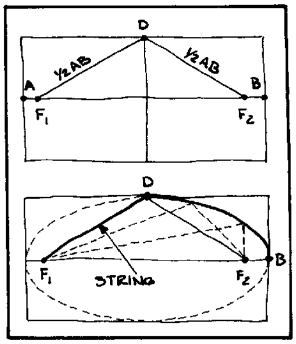

Figure f. *To construct an ellipse, tie a string to the two foccii, F1 and F2, making the string just long enough to puss through point D. Now holding the string taut with a pencil, trace out the curve, starting at point D.*

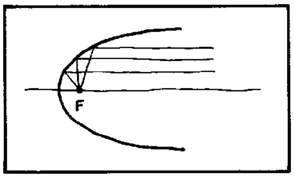

Figure g. *A parabola will focus waves at a single point, as shown, or transmit waves in parallel that are produced at that point. This property makes it useful in acoustics and electronics.*

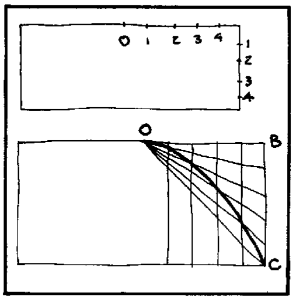

Figure h. *To construct a parabola, divide two sides of a rectangle, as shown, then connect dots 1 to 1, 2 to 2, and so on. The intersections of the grid generated will define a parabola.*

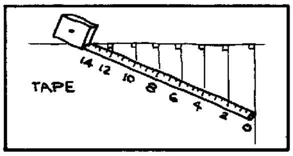

Figure i. *To divide a line into a number of equal segments (without using a calculator), draw a diagonal to that line that divides evenly into the number of segments you want. Then square down from the line, as shown.*