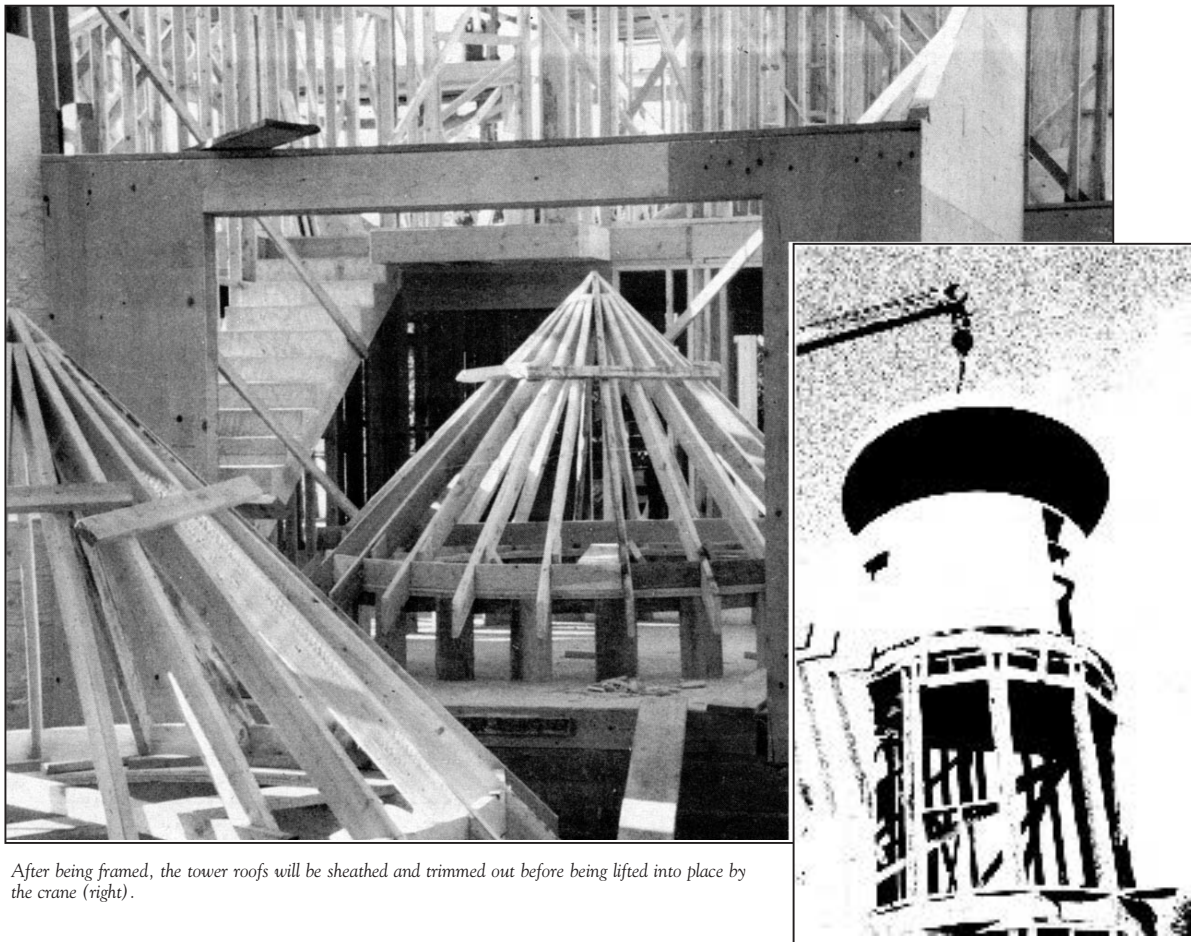




After being framed, the tower roofs will be sheathed and trimmed out before being lifted into place by the crane (right).

Framing Tower Roofs

The quickest way to construct a tower roof is to build it on the ground and lift it with a crane

by Will Holladay

I've spent most of my framing career in the high-end southern California building market, and I've often been called on to frame conical tower roofs. There are many ways to go about the job. Which framing method I choose depends most on the type of material — either beam stock or 2x — that's called for. In this article, I'll describe one method that I use with 2x lumber to form a conical roof with a vaulted interior ceiling.

Starting Out Round

The quickest way to construct any tower roof is to build it on the ground and lift it into place with a crane. But to make this work, the walls must be perfectly round and the top plates absolutely flat to receive the roof. Once built, the conical roof structure is intensely strong and rigid, and won't settle out to a bow in the wall plates. So be precise when scribing and cutting the plates for both the wall and

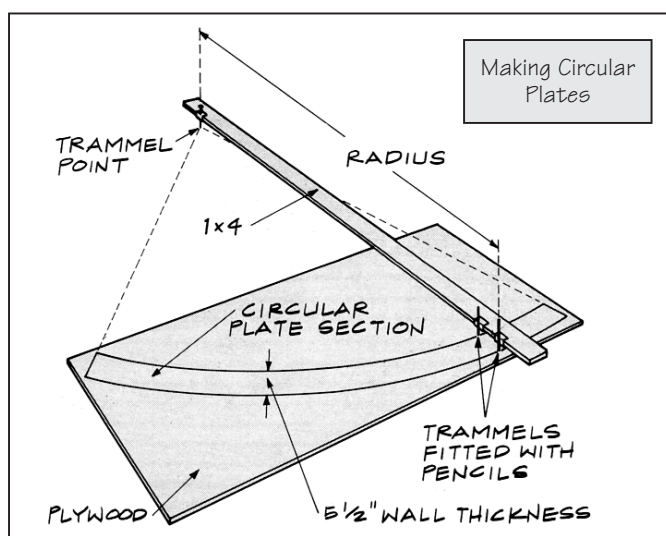


Figure 1. To lay out circular plates, the author makes a big compass from three trammel points on a piece of 1x4.

the roof.

To make the top plate, I mark the circumference on sheets of plywood with a big compass (see Figure 1). I use three Stanley trammel points on a long piece of 1x4. Two of the trammels are fitted with pencils and spaced the wall thickness apart, so I can draw the exact width of the plates in one pass.

Most large radius curves can be cut with a circular saw. Working the saw this way, the blade will get hot and warp, so I stop for a few seconds every few feet to let the blade cool off.

I usually cut wall plates out of 1 1/8-inch plywood. If the wall sits on concrete, the bottom plate can be cut out of 2x12 redwood. The walls are built in curved sections and the plates are joined together with an overlapping circular layer of 3/4-inch plywood.

To plumb the tower walls, tack a

2x4 across the diameter on the top wall plates. Measure the radius from various points along the outside circumference to locate the exact center on the 2x4. Drive a nail straight down through the point and attach a plumb bob to the nail on the underside of the board. Rack the tower around until the bob is right over the center mark on the floor below and nail up temporary sway braces on the inside. Finally, sheathe the outside with two layers of 3/8-inch plywood.

Once the walls are up, I assemble a giant "donut" to build the roof on. For this, I find a flat floor space somewhere in the house that's large enough to scribe out the tower circumference. I use this large circle as a pattern to assemble my donut from the pre-cut top plates. Like the wall plates, I construct the donut out of a layer of 1 1/8-inch plywood overlapped by a layer of 3/4-inch ply-

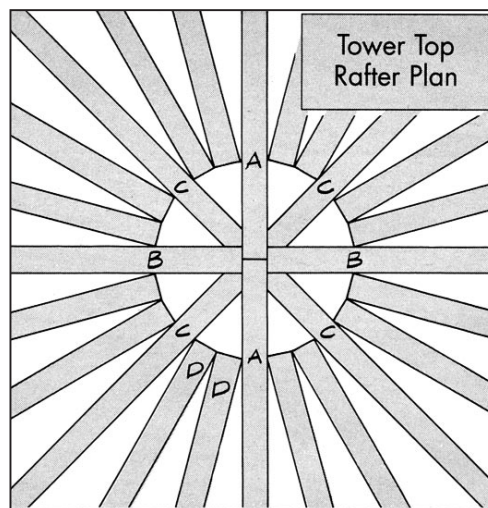


Figure 3. With 2x lumber, the author uses this framing connection at the top. Cut the rafters labeled A to the calculated rafter length, and shorten rafters B and C by 3/4 inch and about 1 inch, respectively. Rafters marked D are paired and dropped in as a unit.

wood.

Once it is nailed together, move the donut to an area outside to assemble the rafters. The donut must be positioned so the crane can move it easily later. Place the donut on a six- to eight-sided rack which is blocked up level and is high enough off the ground for the drop in the overhang.

Rafters

Since the rafters radiate from the top point of the cone, the rafter lengths are all the same. The rafter run is the radius of the tower. With the run and the pitch of the roof you can figure the length of the rafters.

While most folks use rafter tables or the Pythagorean theorem, I find it's faster to use a line length (LL) ratio (see Figure 2, previous page). The LL ratio is the unit rafter length, or hypotenuse, over the unit run (see "Production Roof Cutting," 5/90), and is figured beforehand for each roof pitch. For a 10/12 pitch, as shown in the examples, the LL ratio is 1.3017.

Figure 3 shows the rafter connection at the top of the cone. This connection works for any multiple of 8 rafters. To find the actual number of rafters needed, I first figure the circumference of the circle using the equation:

$$\text{circumference} = 2\pi r$$

(If you slept through geometry class in school, remember π equals 3.14.) I then divide the circumference by 16 (the on-center spacing of the rafters on the plates). For example, for a roof with a 5-foot radius:

$$\text{circumference} = 2 \times 3.14 \times 60 \text{ inches} = 377 \text{ inches}$$

$$377 \text{ inches} \div 16 \text{ inches} = 23.5$$

Next, choose the closest multiple of 8 (in this case 24), and divide this number back into the circumference to get the exact on-center spacing:

$$377 \text{ inches} \div 24 = 15\frac{3}{4} \text{ inches}$$

Lay out the plates using a small

scrap of lumber as a spacing pattern to measure around the circumference.

The first two rafters (labeled A in Figure 3) are cut at the calculated rafter length, but the other rafters are shortened. The next two rafters, labeled B, will butt into the A rafters at right angles, so they each need to be shortened by 3/4 inch (half the thickness of the framing material). The rafters labeled C will be nailed into the corners, so they are shortened about 1 inch (half the 45-degree thickness of the material). These shortening distances are measured perpendicular to the plumb cut.

Since not all 24 rafters can squeeze together at the top of the cone, the rafters labeled D are shortened even further. The easiest way to find this shortening distance is to find the circumference on the cone at the point where all 24 rafters can fit in a circle.

In this case, $24 \times 1\frac{1}{2} \text{ inches} = 36 \text{ inches}$. The radius of this circumference is then found from the equation:

$$\text{radius} = \text{circumference} \div 2\pi$$

$$\text{radius} = 36 \text{ inches} \div 6.28 = 5\frac{3}{4} \text{ inches}$$

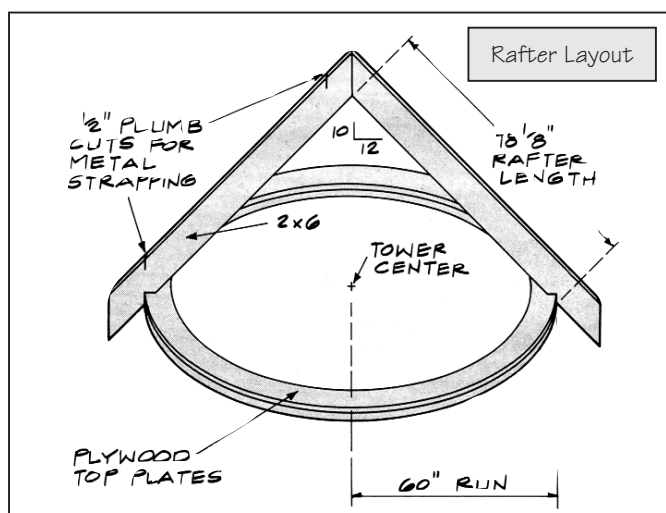
Remember that this is a radius, so it too is measured perpendicular to the plumb cut on the rafters, not along the line of the rafters.

These rafters (D) are paired and dropped in together after the other rafters are in place. I nail the two rafters together before installing them and spread their tails apart to the on-center spacing. I then put the two in as a unit, which is spiked through to the adjoining rafters with a 60d nail.

With 2x rafters, I use three toenails to secure the birdsmouths to the plates. If I'm using larger beams, I lag up through the plates into the seat cut of the birdsmouth.

Bracing

Without ties, the roof will want to flatten out under load like those paper parasols you find in exotic cocktails. To prevent this, I collar the



$$\begin{aligned} \text{run} \times \text{LL ratio} &= \text{rafter length} \\ 60 \text{ inches} \times 1.3017 &= 78.102 \text{ inches} \end{aligned}$$

Figure 2. Tower rafters are cut as commons with a run equal to the outside radius of the plates. To figure the rafter lengths, the author uses a line length (LL) ratio.

rafters with a couple of bands of 1 $\frac{1}{4}$ -inch, 16-gauge galvanized metal strapping. The bands are let in after the rafters have been put up. I set the saw table to the angle of the plumb cut and cut across the tops of the rafters. One band is positioned on the exterior plate line, and the other just below the top (see Figure 2, page 25). This second band is there mostly to support the cone when it is picked up by the crane. To tension the strapping, I hook it with my hammer claw and pull it tight before nailing.

I also put in one or two temporary cross ties to further stabilize the cone when it's lifted by the crane.

Sheathing

The trick to sheathing the tower roof is to cut the plywood into curved pieces. Here again I use a big compass that's as long as the calculated rafter length plus the tails.

I use two layers of $\frac{3}{8}$ -inch AC plywood for sheathing, and stagger the vertical seams between the layers.

If the roof diameter is under 10 feet, I cut pie-shaped pieces out of a sheet of plywood since the rafters (including the tails) are under 96 inches (see Figure 4). Between 10- and 14-foot diameters, I'll even special-order 10- and 12-foot-long sheets of plywood, since using pie-shaped pieces saves so much time. But for larger diameter roofs, you have to use two pieces along the rafter run. In these cases, I stagger the end cuts.

Since the radius of the curve is tight up near the point of the cone, you have to kerf the back side of the plywood near the point, otherwise the face will crack. I set my saw to about a $\frac{3}{16}$ -inch depth and make a series of cuts along the radius lines, about an inch or two apart. On the last project I did, we nailed the sheathing off with roofing nails, which helped hold the pieces down where the radius was small.

The roof will flatten out like a paper parasol in an exotic cocktail. To prevent this, collar the rafters with metal strapping.

screws to secure it to the rafter tails.

The style in southern California is to leave the rafter tails exposed and stucco up between them. In other parts of the country where soffits are preferred, you can cut 2x4s that tie to the rafter tails and return level into the side of the building. A $\frac{3}{8}$ -inch plywood soffit can then be scribed using the big compass with two trammel points spaced apart by the width of the overhang. This work would be done, of course, after the roof is installed.

The Crowning Touch

Lifting the roof on is the easy part. If the roof is made of heavy timbers, we hold it from at least four points, and use long, threaded eyebolts to lift from. But with a light, framed roof such as the one shown in the photos, two pickup points are sufficient.

For the pickup points, I drill through the sheathing on each side of the first two opposing rafters (marked A in Figure 3 — these two rafters are supported by a temporary cross tie) and thread a rope loop through. These loops should be positioned above the midsection of the cone, so when the roof is picked up, it will be weighted towards the bottom.

On our last project, we made two loops out of some rock climbing rope that one of the carpenters swore by. The rest of the crew took bets on whether or not the rope would break. Climbing rope is very elastic and it



Figure 4. If the rafters (including the tails) are under 96 inches, the roof can be sheathed with pie-shaped pieces cut from a sheet of plywood. The author uses two layers of $\frac{3}{8}$ -inch plywood staggered.

The toughest part of the whole job is the fascia. On the last job, which had a 5-foot radius, we used 1x10 clear redwood. After splitting one piece, one of the carpenters soaked the boards in water to make the wood more pliable. He used galvanized

stretched a lot when the crane lifted up. But it held. ■

Will Holladay is a framer from Santa Barbara, Calif. He is the author of A Roof Cutter's Secrets to Framing the Custom House, from which this article is adapted.