

Building a Better Profile

Part 6 - Built Up Wing Construction



Early Mo'Best version, with straight wing section

Built-Up Wings

The classical method of wing construction is "built-up", featuring one of more spars plus ribs, leading and trailing edges, and sheet planking. Open bays of built-up wings can be covered with various materials: silkspan, iron-on plastic or Mylar, even silk or nylon.

The methods described here are common. Variations on built-up wing construction usually involve the number and types of spars, ribs and/or planked areas. Other methods include "geodesic" (featuring interlocking diagonal ribs) plus an exotic method called "I-Beam" which involves hundreds (it seems..) of identical half-ribs on a single spar. Structural complexity, precision, and finish are all evident in the completed wing, and contribute greatly to its beauty.

C-Tube and D-Tube Wings

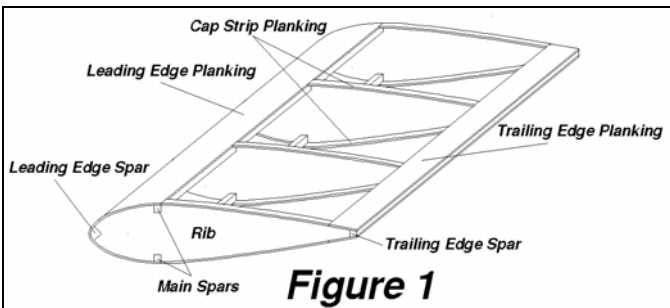


Figure 1

C-tube is a simple construction method (Figure 1) using small (often 1/4" square) spars on both the top and bottom of the wing near its high point.

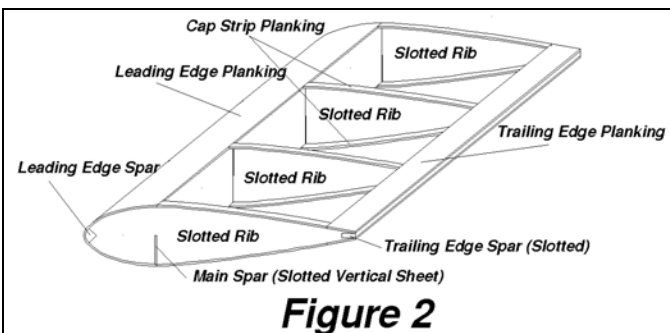


Figure 2

A common variation known as D-Tube uses a single spar with a vertical sheet; ribs and spar sheet slotted alternately to interlock (Figure 2).

Leading and trailing edges are balsa strips or sticks and the spar assembly is populated with ribs. The center section is planked with balsa sheet, as are front and back edges of the wing. Exposed edges of ribs are usually planked with balsa cap strips.

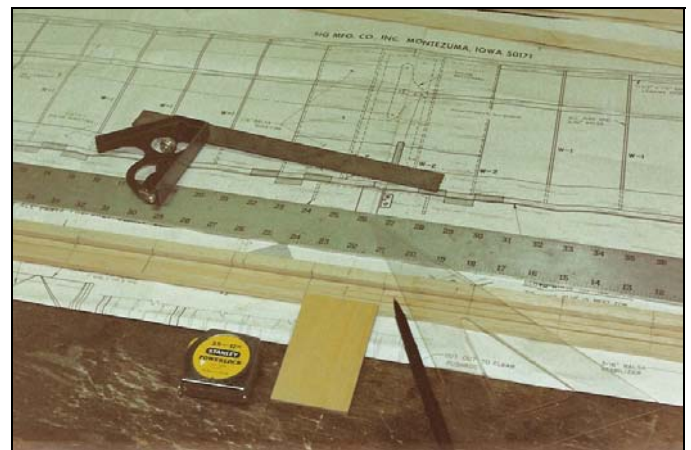
Built-up wings gain much of their strength from a monocoque (stressed skin) construction, both from the balsa planking and final covering. The finished structure is extremely light and strong, but has a tendency to develop unwanted warps and twists.

Wood Selection

Lightness has been emphasized in wood selection, but for wing spars straightness is at least as critical. Building a straight wing is difficult enough: crooked spars virtually guarantee crooked wings!

Here I am reminded of a friend who asked his wife to pick up some **very straight** 1/4" square sticks for wing spars at the hobby shop. She did precisely as asked and brought home beautiful, straight and true 48" **SPRUCE** sticks. Although spruce is about three times heavier (and three times stronger) than balsa, he used them in the wing anyway. The result was a very straight and light (under 38 oz.) *Miss BJ*, easily one of the finest profile ships I've flown.

That said, I still advise that you weigh balsa sticks. Measure and mark centers and balance each piece to determine heavy ends. Try to use heavier sticks on the outboard wing, orient heavy ends toward the outboard wing tip, and cut off the heavier ends as excess.



Marking rib locations on wing spars

Align leading edge, trailing edge and top and bottom spar pieces against a long straight edge and use a square to mark all rib locations. Note that even on wings with swept leading edges, this technique is accurate enough for locating ribs.

Ribs and planking use sheet balsa. Straightness is of minor concern here if the wood is soft. Reserve the softer, more pliable A-grain wood for leading edge planking, where the wood has to curve around a blunt airfoil. Extremely soft wood can be a poor choice for planking the center section of the wing where the ship is handled. If your thumb easily punctures the center section, the planking wood is too soft!

Considerable interior material can be cut away on ribs, especially when cap strips are used. Soft, super-light ribs are particularly

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susceptible to damage during construction; slightly heavier, harder (stronger) wood is often a good tradeoff on rib sheet stock.



Rib selection and layout

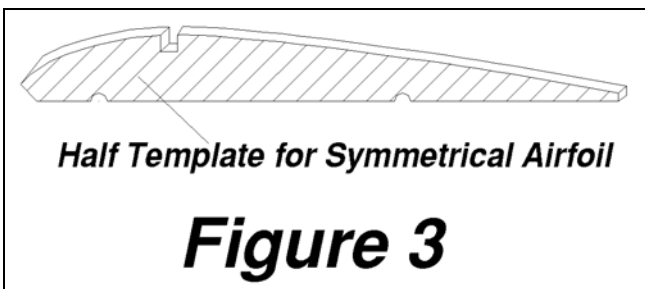
Thicker and/or harder ribs are used at critical points, such as center ribs supporting the bellcrank platform or on either side of a wing-mounted gear. Plywood ribs may be used for the same purpose.

When you are cutting your own ribs, there may be a strong temptation to get maximum utilization of your wood by cocking the angle of rib layouts on the sheet. The result is that wood grain is not parallel to the chord of the rib, which may ultimately contribute to twisting and distortion of the finished wing.

Rib Template Construction

One convenience of building a kit is NOT having to cut ribs. But with a little patience the task is not difficult. Start with a pair of precision plywood templates for root and tip sections. Lite Ply is poor choice for templates. Quality birch plywood resists sanding much better..

Getting accurate root and tip patterns onto plywood blanks is important. With high quality, accurate plans, a direct approach simply glues rib sections from the plan [or, if you insist on being civil, an accurate **photocopy**] to the plywood with rubber cement.



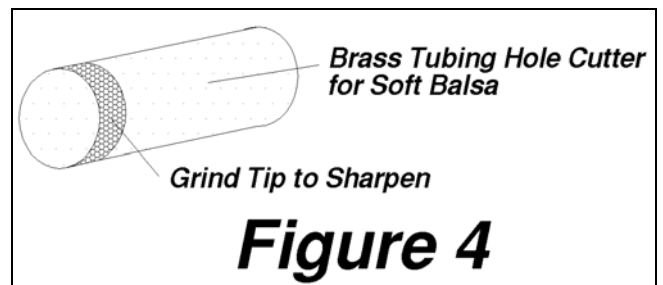
Virtually all modern stunters use a symmetrical airfoil. An alternate approach is to cut out a rib half section template from thin, stiff cardboard (Figure 3). Gently sand it to perfection. Draw a centerline on the plywood and accurately trace around the cardboard template for both halves of the symmetrical airfoil. Viola! Accurate symmetry.

Templates and Ribs for Straight Wings

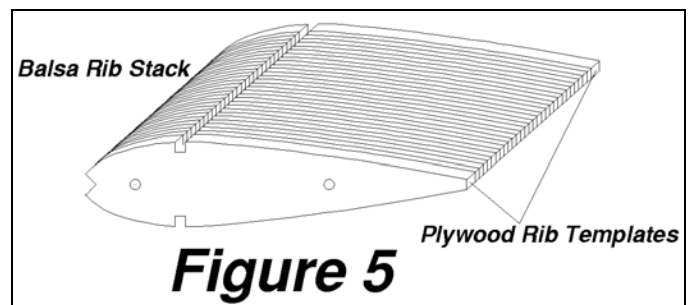
Simple "straight" built-up wings use the same rib airfoil section throughout. There is no leading edge sweep or taper from root to tip. Making a set of identical ribs for straight wings is a snap.

After cutting a pair of identical plywood templates, tack glue them together with **tiny** drops of thick CA at their leading and trailing edges. Carefully sand both to shape, then cut notches for spars and leading/trailing edges. Cut notches slightly undersized and sand them to final shape with an emery board nail file. Drill two small pilot holes along the centerline and enlarge them for long bolts, 1/8" to 1/4" diameter. Gently separate finished templates with razor blade.

Construct a stack of oversized rib blanks (add a spare rib or two for good measure), and apply drops of thin CA to their extreme edges to tack glue the stack together. Align and glue one of the plywood rib templates to one end of the stack using rubber cement.



You need bolt holes through the rib stack, of course. Unfortunately, a standard drill of any but the smallest diameter tends to tear soft balsa badly. So, improvise: get a section of brass tubing the same diameter as the desired hole and "sharpen" one end as shown in Figure 4. Tubing makes an excellent drill for cutting soft balsa.

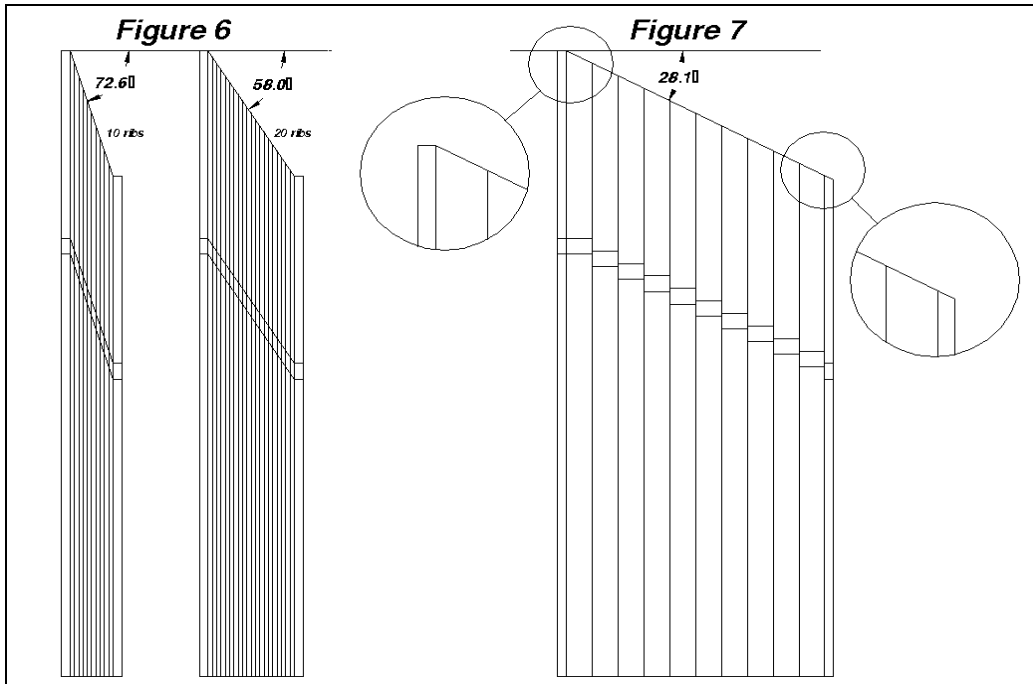


Insert long bolts with washers through the template and rib blanks; complete this sandwich with the other template, washers, and nuts (Figure 5). Tighten bolts and precisely shape the airfoil for the entire stack with a coarse, flat sanding block.

Use a fine razor saw to mark and cut out notches in the stack for spars and leading edges. Mark the top of your stack of perfect ribs, unbolt and carefully cut the ribs apart. Select and mark the hardest and strongest ribs for the center section and tips of the wing. Some prefer to cut interior holes in ribs after they have been glued into the wing. I usually pre-cut them, even though they will be very fragile.

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Rib Templates for Swept/Tapered Wings

I heard somewhere that both straight and tapered wing rib sets can be made the same way. That is, simply bolt a stack of rib blanks between root and tip rib templates and sand them to shape. Well, that might be an EASY way, friends, but it's not the *Cowboy Way*!

Figure 6 shows why. Suppose you had a typical wing with 20 ribs and a 2" sweep in the leading edge. If you use 1/16" sheet for the ribs, a stack of 10 ribs (for each wing panel) is only 5/8" thick. Your sandwich of ribs and templates has its leading edge swept at a ridiculous angle of over 72 degrees, and the front edges of all the ribs as well as the plywood root template, including the leading edge notch, must somehow be sanded to that angle.

Increasing the stack to 20 ribs offers little improvement. It is still only 1-1/4" thick, with a leading edge sweep of about 58 degrees. And pairs of adjacent ribs (supposedly the **same rib** in each panel) will come out considerably different sizes around their leading edge!

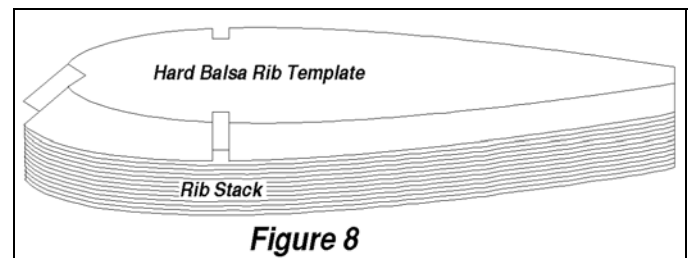
There is a better, more accurate and practical method: make a set of **TEMPLATES** first! For a wing panel with N ribs, bolt a stack of (N-1) 3/8" (thick!) hard balsa template blanks between the plywood wing root and tip templates (Figure 7). Sand these to shape and cut out notches for the leading edge. If top and bottom spars are parallel to the trailing edge (not swept back), their notches can also be cut out. Otherwise draw lines across the top and bottom of the template stack connecting edges of the spar notches. These will serve to locate the notches when they are individually cut out later.

You now have a stack of thick rib **templates**: the airfoil surface of each have been sanded on a slight taper. To sand the stack properly, the plywood template for the tip rib also has to get sanded to the same taper, while the plywood root template should NOT get sanded (enlargements, Figure 7). This scheme ends up using the plywood tip template as template for tip ribs, while the plywood root template is unused (or a "spare" root rib template).

With the rib templates still in the stack, seal their finished airfoil edges with several coats of clear dope. Then cut the stack apart with a razor blade. Each thick balsa template will always used with the larger of its two flat surfaces **down**: its outline is a very accurate template for that rib. (As a side benefit, the tapered edges of each template make them much easier to trace around.)

On the larger flat surface of each template carefully mark the top and bottom spar notches, using the straight lines drawn across the stack surface earlier. Patiently mark and cut these individual notches out with a jigsaw: their cuts should end up nice and perpendicular to the flat surfaces of the template.

All this effort yields (N-1) 3/8" thick rib templates plus one thin plywood template for the tip rib. Using these templates, it is easy to make up pairs (or a whole stack of ribs) of each type. Simply draw around each template, cut out each pair or stack of ribs very slightly oversized, and gently sand them to shape. Even making up three "kits" at a time with six ribs in the stack, cutting and sanding is extremely easy (Figure 8).



Hold the template against the rib stack with your hand for a final, gentle precision sanding to shape. Avoid sanding into your templates and they will be useable again and again!

-Larry Cunningham