Companion Guide: "Building Fly Baby"
Article 3: Fuselage

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and the Fly Baby Community

This Companion Guide is written to accompany the third of Pete Bowers' Fly Baby construction articles in EAA SPORT AVIATION magazine. The first article two articles involved construction of the wings.

You will need to download these articles from the EAA Archives to actually build the wings. This Companion Guide merely supplies additional background information and some helpful hints on the actual construction. A full Table of Contents is included on the next page.

There are two kinds of figure references in this Companion Guide. If the reference is "Figure 1-1" (with a hyphen), it's a figure in the original EAA articles. Figures without a hyphen are contained in this document and should closely follow the text which refers to them.

For specific assistance in building the components described, see the Workmanship and Hardware articles on the PB100 Web Page.

Many thanks to Matt Wise, Jim Katz, Jim Hann, and the others of the Fly Baby community for providing some great pictures to illustrate the points in this Guide.

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1 OVERVIEW

In Part 3 of the "Building Fly Baby" series, the majority of the fuselage will be constructed. Additional fuselage details are contained in Part 4, "Fuselage Secondary Structure."

While the fuselage is addressed in Part 3 of the magazine series, there are some advantages to building the fuselage first. As addressed in Part 2, Pete recommends installing the last rib and closing out the wing-walk area with the wings temporarily attached to the fuselage.

Figure 1 illustrates a fuselage under construction. Note, though, that the builder in this case has opted to save some weight by routing-out the plywood on the fuselage sides (See Section 5.1). This is optional.

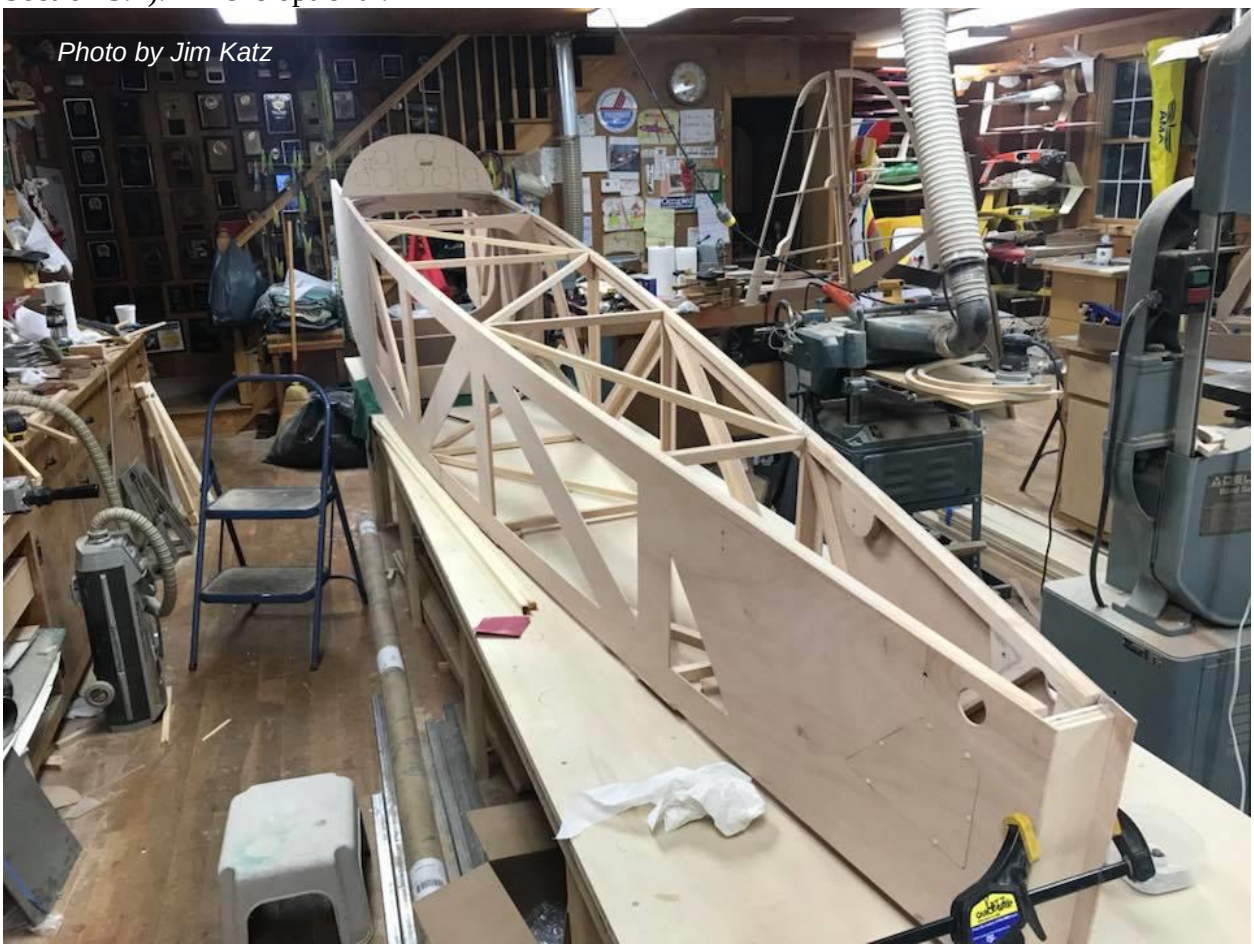


Figure 1: Fly Baby Fuselage Under Construction

While the wing can be completed before the fuselage, for the best fit, certain finishing tasks should be left until the fuselage is available.

1.1 Fuselage Truss Structure

Stop me if you've heard this before, but the fuselage is built very similarly to a balsa model.

Like most wooden or steel-tube airplanes (and most balsa models), the Fly Baby's fuselage is a "truss" structure. "Beams" (in this case, 3/4" square pieces of spruce) are glued together to form a series of triangles.

Figure 2 shows the basic truss structure for the sides of the Fly Baby fuselage. The reference for the Fly Baby fuselage is the upper longeron at the firewall; all dimensions are measured aft and down from that point.

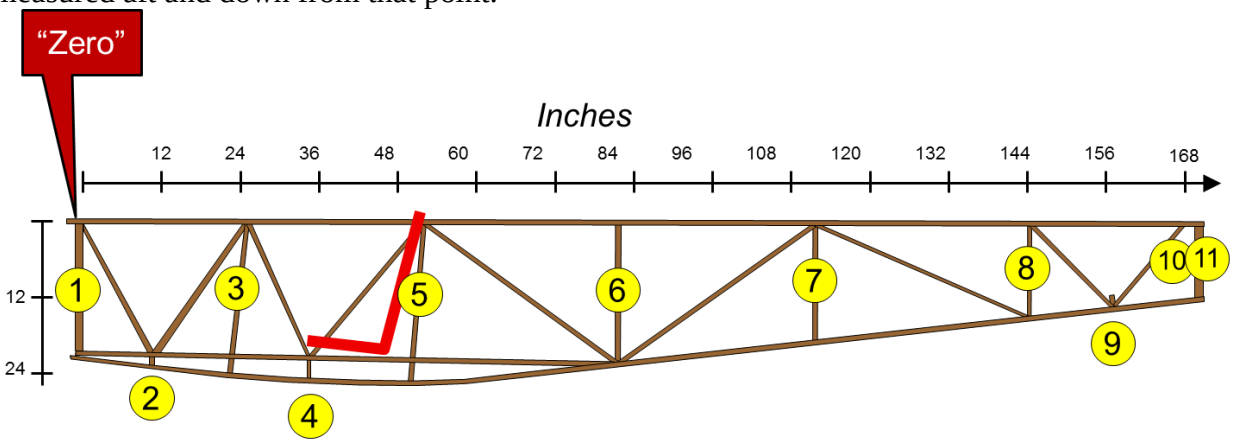


Figure 2: Fly Baby Fuselage Truss

The positions of the various components are defined by their distance from the upper longeron at the firewall, but key vertical truss elements are designated by the "Station" number shown in the yellow circles in the above diagram. These are usually abbreviated as "STA" ("STA 3," "STA 5," etc.). This makes it a lot easier to refer to key locations, as shown in Figure 3.

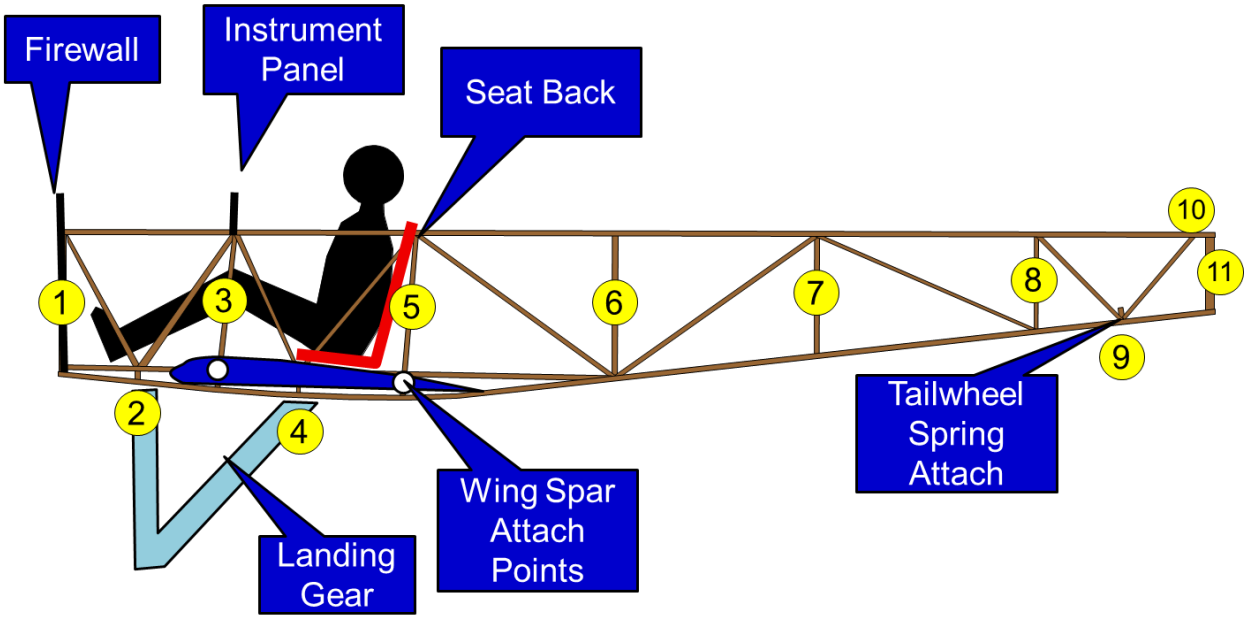


Figure 3: Fuselage Stations

Two identical trusses are built, and covered with 1/8" plywood. The plywood-covered trusses are positioned the proper distances apart at Station 1 and Station 5, then are allowed to gradually merge by the time they reach Station 10. A steel bracket is used to solidly hold the two

sides together, and to act as a base for the spar of the vertical stabilizer. Spruce sticks are glued between the fuselage sides to complete the forming of Sta. 6-11.

1.2 Top and Bottom Diagonal Bracing

Once the fuselage sides are attached, additional diagonals are placed between the two sides on the tops and bottom. This is shown really well in Figure 1-8 of Article 3, on page 6.

Ideally, each "bay" (the area between Stations) would be reinforced by a diagonal brace on the top and bottom and left and right, but this isn't possible… the pilot has to fit in the Station 3-5 bay, his or her legs through the Station 1-3 bay, and the fuel tank gets installed in the Station 1-3 bay as well.

While most of the Stations are rectangular boxes, Stations 3 and 5 are actually oval in shape. In addition, as Figure 4 shows, the TOP of the opening in the cockpit is oval as well. The bulkheads at Station 3 and 5 are made by the same 3/4" square spruce pieces as the other bulkheads, but curved pieces are used to join them to substitute for diagonal braces. These two bulkheads are then covered with 1/8" plywood on both sides. The bulkheads are depicted in Figure 1-9 on page 6 of Article 3, and an example is shown below.

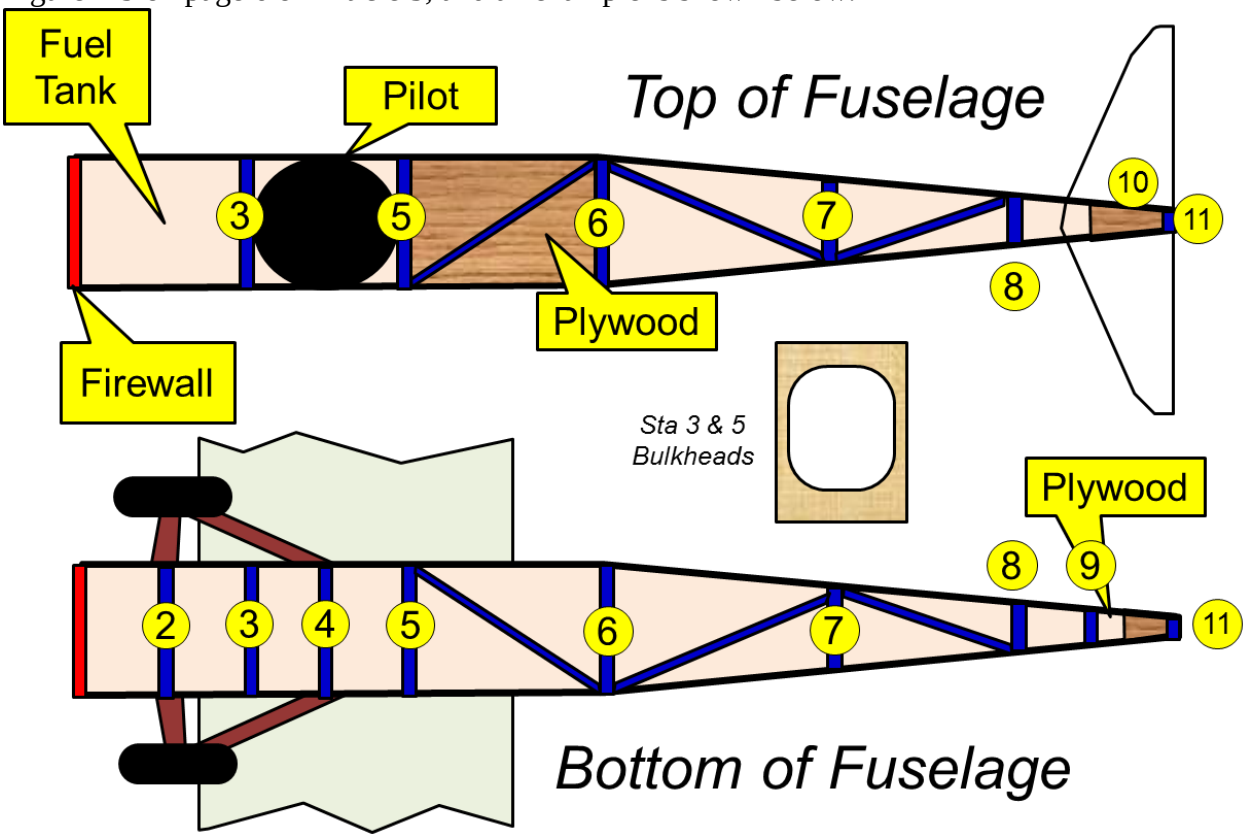


Figure 4: Top and Bottom Diagonal Bracing

A diagonal is installed between the top longerons in the Station 5 to 6 Bay, but plywood is installed over this area as well. This forms the floor of the baggage compartment in the turtledeck. Additional plywood is installed in the tail.

Stations 1, 3, and 5 are major players in the Fly Baby fuselage, and will probably occupy the majority of your time. Station 1 is the firewall, where the engine bolts to the fuselage. In addition to the normal woodwork, Station 1 will be covered with stainless steel, and will be

reinforced by bolting big aluminum angles to the fuselage sides. The engine mount will be bolted through the firewall into those angles, so you know things have to be hefty.

Stations 3 and 5 are where the wing spars attach. Obviously, accuracy here is important.

1.3 Other Structure

In addition to the plywood and curved pieces mentioned above, additional reinforcement will be added at some Stations to handle the local loads. Typical is a quarter- or half-circle of 3/4" plywood glued in to handle the landing gear loads.

1.4 Note about Illustrations

To make things clearer, I have drawn up a lot of sketches to illustrate some of the aspects of the assembly. Peripheral details on these sketches are just there to complete the drawing—they may not, exactly, match the original Pete Bowers figures. My sketches always are in color; Pete's are black and white.

Where there is a difference between my sketches and those from the Pete Bowers article, assume the original article sketches are correct.

This is especially true when looking at the sketches of the fuselage trusses. There are subtleties that Pete includes that may not be reflected in this document.

If two pieces in my sketches are supposed to be the same size but look different, just assume that was an error.

1.5 Workmanship

This would be a good time to review the Basic Workmanship rules for building Fly Babies. Key notes:

- Do not varnish any areas which will subsequently be glued
- Varnish any closed areas (double-plywooded forward section, etc.) before they are closed up.
- Drill holes in wood directly to size, using a brad-point drill bit
- Varnish all bolt holes
- Varnish all areas where metal parts will be in contact with the wood
- All metal components should be painted or otherwise protected.

2 ERRATA

Article 3 had probably the most errors.

2.1 Fuselage Dimension Errors

Pete had a bad day when he specified some key fuselage dimensions. He corrected them in Part 11 of the series, but by that time (nearly a year later) some folks had built fuselages to the incorrect dimensions. You can get the corrected values from Part 11, but I've summarized them below.

2.1.1 Figure 1-1

Figure 1 shows the dimensional corrections at the heart of the error. Basically, the "slant" of the vertical sides of Stations 3 and 5 are wrong. This affected the wing angle of incidence. In Part 11, Pete shows special wing spar fittings to correct the problem, but these won't be needed if the plane is built per Figure 5 below,

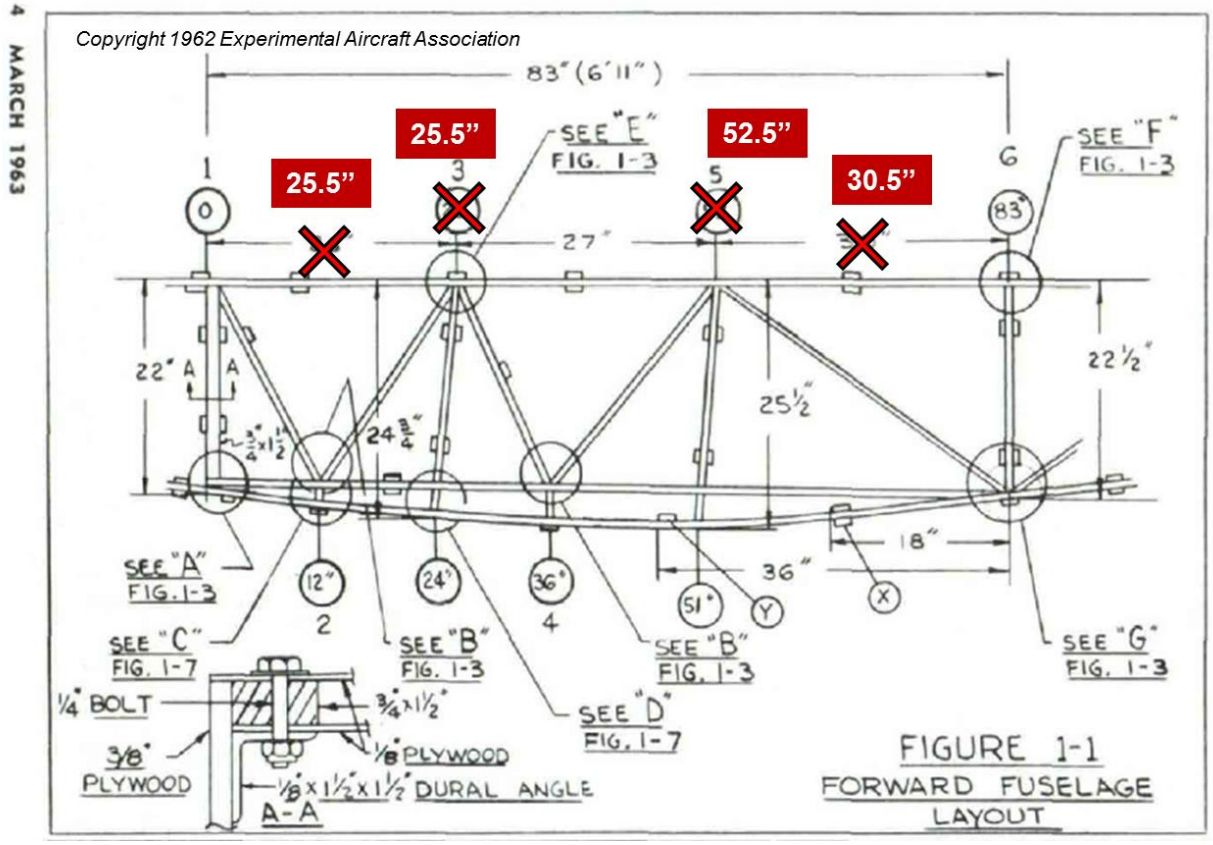


Figure 5: Figure 1-1 Corrections

2.1.2 Figure 1-8

Figure 1-8 has to reflect the same changes; the 26" shown at Station 3 of the top truss only is actually 25.5", and the 53" at station 5 is actually 52.5"

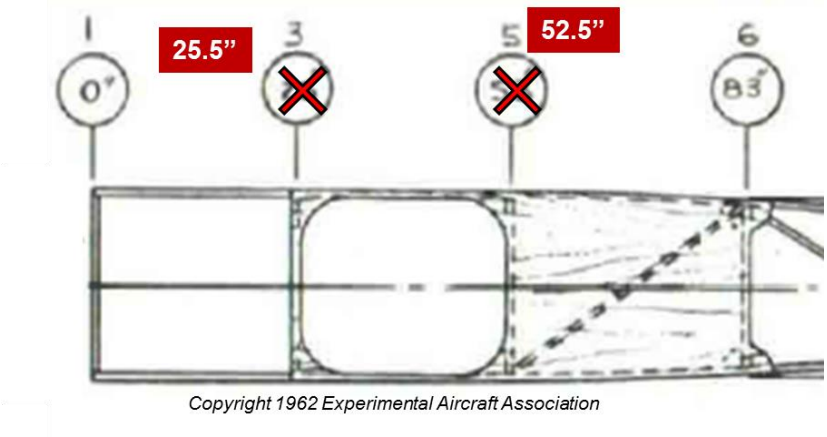


Figure 6: Figure 1-8 Corrections

While we're at it, a bit of clarification to Figure 1-8, as well. It seems to show a lateral brace at Station 1 (front of the fuselage). There actually isn't one; the depiction on the drawing is the firewall, which is installed as part of the next Article.

2.2 Understanding Figure 1-7

Figure 1-7 shows the lower portions of four of the fuselage stations: 2, 3, 4, and 5. The top illustration ("Detail C") is Stations 2, 4, and 5, and the lower one ("Detail D") is Station 3. The Details show how the bulkheads are slightly inclined from the vertical, with Detail D more inclined than Detail C.

However, Detail C is a bit deceptive, when it comes down to Station 5. Station 5 inclines the same as Station 3 (in Detail D). So don't be worried if it doesn't match Figure 1-7 Detail C.

The main point Pete wanted to make here is that the filler blocks for Station 5 did not have holes in them, like the ones for Station 3 (Detail D). So do the smaller filler blocks (no holes) for Station 5, and don't worry about any apparent angle difference in the Figure.

2.3 Figure 1-2 and Figure 1-11 Discrepancy.

Detail B-B in Figure 1-2 shows the cross section of the tail, and the bracket that allows the rudder post to be bolted in place. Figure 1-11 shows how this bracket works. However, in Figure 1-2, this bracket is listed as built from 0.064" steel, while Figure 1-11 says it's 0.032".

General consensus in the Fly Baby community says 0.032" is adequate.

2.4 Horizontal Stabilizer Attach Point

On Figure 1-2, the Aft Fuselage Layout, there's a half-circular block installed forward of the tail post, aft of Station 8. The diagram shows the distance to the tail post to be 21 inches. Change this to 19.25 inches.

Part 7 of the series (July 1963) added a Figure 3-9 to the Tail surfaces section, showing a change to a block location in Figures 1-2 and 1-3 for stabilizer installation.

Figure 1-12 shows this area as well. It's labeled 21 inches, and should be 19.25 inches.

2.5 Figure 1-3

Figure 1-3 is on Page 5. In the upper left corner of Figure 1-3 is Detail "A". It shows a 2-inch dimension; this should be 2.75" instead.

For Detail "H" of this figure, also see Figure 1-12 and Figure 1-13.

2.6 Figure 1-10 Rudder Post Assembly

Figure 1-10 shows the area in the rudder post "sandwich" that need reinforcement for attachment of the rudder hinges. The second reinforcement block up from the bottom block shows its centerpoint as being 17" from the bottom of the post (the line marked "cl block").

Bowers later said the "centerline" of the block as shown should be the TOP of the block…so the actual centerline of the 1¼" block should be 5/8ths of an inch lower (Figure 7). Or just make the block 5/8" longer to cover the same area.

Also, make the top block on the rudder post an inch or two wider. This block is for the top hinge, which gets installed near an internal diagonal support for the vertical stabilizer (which is described in Part 6 of the articles). The diagonal (seen in Figure 3-1 in Article 6) may actually interfere with bolting the hinge in place, and you may wish to move the hinge down a bit. Making the top block longer will make this easier.

Both these changes are shown in Figure 7. However, they may be moot if a solid rudder post is used, as described in Section 3.1.

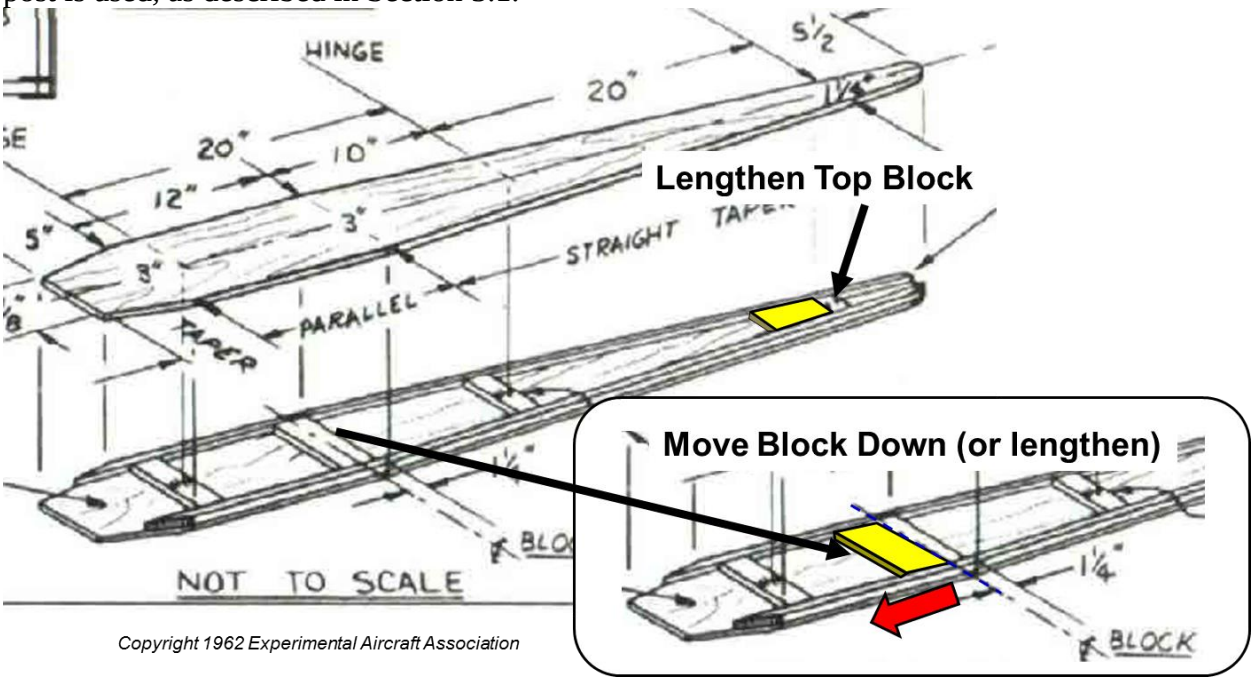


Figure 7: Rudder Post Block Correction

2.7 On Plywood Thickness

Throughout the design, Pete uses 1/8" (0.125") plywood. Some dimensions are based on the use of 1/8" plywood PLUS some other dimension. For instance, a piece of 1/8" plywood is added to a 5/8" thick upright to equal the 3/4" thick longerons.

However, it's hard to find true 1/8" plywood these days. Most of it is sold in metric sizes, either 3mm (0.11811") or 4mm (0.15748"). If you're using the metric plywood, some dimensions will need to be altered slightly when the plywood is being combined with cut pieces of wood. Basically, ensure the same final thickness is achieved.

The height difference between 3mm and 1/8" is slight, and will result in negligible strength differences. For the fuselage-side plywood, Pete actually stated 1/16" would be adequate. So a direct substitution of 3mm for the 1/8" should be OK.

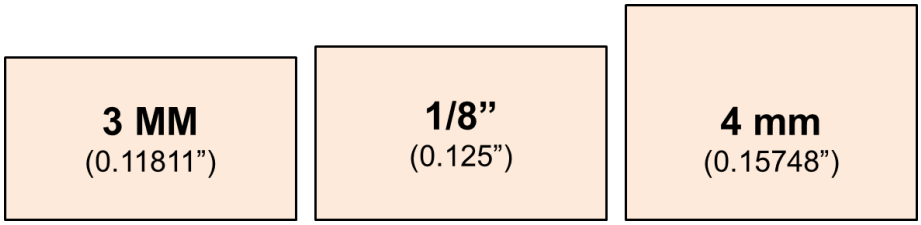


Figure 8: Relative Thicknesses of Metric Plywood vs. 1/8 inch Plywood

If it bothers you to use a slightly thinner plywood, use the 3mm for the fuselage sides, and the 4mm for gussets. But note how close 3mm is to 1/8"…just seven thousands of an inch less. That's about 1/128th of an inch. Ain't been a Fly Baby made to that degree of accuracy….

2.8 "Hardwood"

Several components are made from what Pete calls "Hardwood." This is denser wood used for higher-stress locations. The tailwheel mount is one example, as is the uprights where the firewall attaches.

The definition of "hardwood" varies, but generally this means oak, ash, teak, mahogany, maple, or beech.

Red oak can be bought at the "big box" hardware stores. When wood is bought from non-aviation sources, it is possible it has not yet been completely dried. Use a moisture meter, if you have one, to verify its internal moisture level is around 12%. Otherwise, I'd suggest buying it early and letting it sit for a while to stabilize.

However, one piece of required hardwood is the tail spring support lateral (See Figure 1-11 on Page 6 of Article 3), and it's one inch wide. This will have to be obtained from a specialty lumber shop. There are several online that sell hardwood 1" thick or greater.

2.9 Elevator Cable Interference

The fuselage cross-diagonal at Station 8 has a potential interference issue with the elevator cables. One solution for this involves carving out a clearance area and gluing reinforcement to the diagonal. For this reason, I'd recommend NOT varnishing the Station 8 diagonal during fuselage assembly. Put a note on it along the lines of "Remember to varnish this piece," and wait until control installation (Article 8) to determine if it's necessary. The Companion Guide for Article 8 has more information.

3 SAFETY ISSUES

There are no significant safety issues related to the fuselage design. However, there's a small issue with the rudder post.

3.1 Rudder Post Sealing

The basic construction of the Rudder Post (which is, basically the spar for the vertical stabilizer) is shown in Figure 9. A long, tapered wooden box is created, with 1/8" plywood on either side around fitted side pieces. Four blocks inside the box accept the crush loads from the rudder hinges.

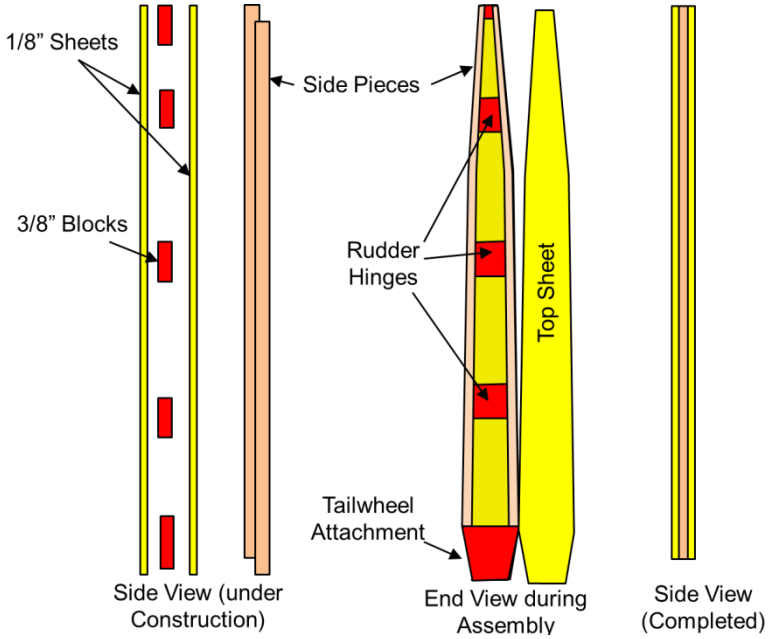
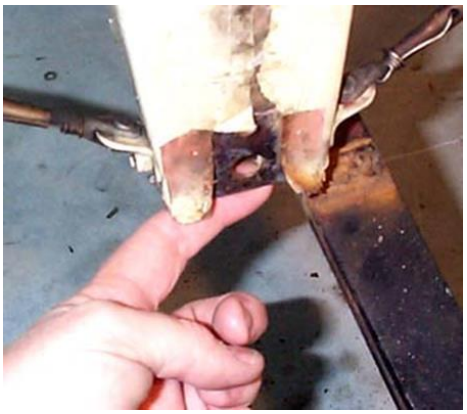


Figure 9: Rudder Post Construction



However, in a wood airplane, we do not *want* a sealed box. Sealed wooden structures are breeding grounds for wood rot; all wooden structures need ventilation holes to keep moisture from condensing inside and staying in constant contact with the wood. This is what killed Knute Rockne…the airliner he was a passenger on had a sealed box spar that let moisture in and let the spar rot from the inside.

If you've read the wing construction Guides, you've seen several notices about the need to include ventilation in box structures so rot cannot take hold.

This is not just an idle risk. My own airplane, less than 20 years after construction, had the tail post rot out from the inside. The picture to the right shows how the lower plug in my rudder post rotted away completely…that's my finger inside the "sandwich" of the rudder post, where the lower block just rotted away.

So, make sure you adequately varnish the inside of the rudder post prior to closing it up.

4 CONSTRUCTION DETAILS

There are two main materials needed for building a Fly Baby fuselage.

The first is a LOT of 3/4" square spruce. About 125 linear feet, and it'd be a good idea to pick up extra. It'll go into making longerons, uprights, and diagonals as seen in Figure 10, as well as the lateral components between the fuselage sides and the diagonals on the top and bottom.

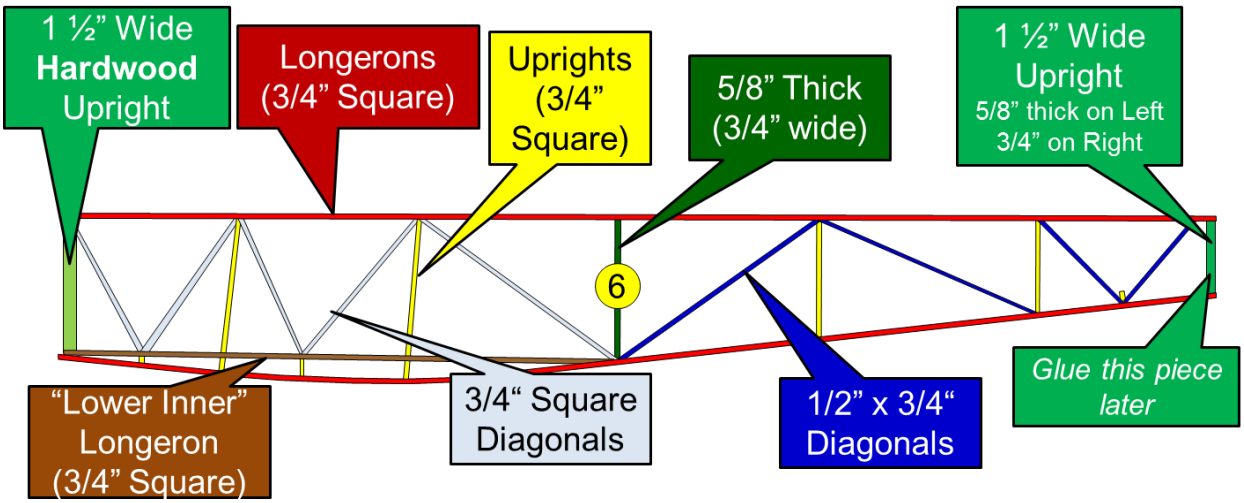


Figure 10: Fuselage Components

The classic way of producing these pieces is to buy a wide plank of 3/4" spruce and cut 3/4" wide pieces out of it. You can actually buy pre-cut 3/4" square cap strips, which would cost a bit more (~50 cents a linear foot, or about $65 for the whole batch). The problem is, the cap strips may not be the right quality. When spruce stock doesn't meet the quality standards of AC-43-13, they make cap strips out of it.

Not everything is 3/4" square. The Station 6 upright is slightly thinner: It's 5/8", rather than 3/4". Aft of Station 6, as the figure shows, the diagonals are 1/2" x 3/4".

The uprights at the extreme nose and tail are an inch and a half wide; these are where the firewall and the rudder post attach. The Station 1 upright is not spruce; Pete specifies, "Hardwood." The definition varies, but generally this means oak, ash, teak, mahogany, maple, or beech. Red oak can be bought at the "big box" hardware stores.

The upright at the tail on the LEFT side of the fuselage only is 5/8" thick, vs. the usual three-quarters. This is to accommodate a 1/8" plywood doubler. (Adjust the upright thickness if using metric plywood, see Section 2.7)

So tune up your table saw, you're going to be ripping a lot of planks.

4.1 Making the Fuselage Trusses

All the drawings show the truss layout for the left side. So start with the left side, first.

4.1.1 Longeron Preparation

The key fuselage components are the longerons. These are the usual 3/4" wide, but are 15 feet long each. You can cut the four pieces you'll need from a four-inch-wide spruce plank (remember, the plank loses 1/8" extra per cut from the blade). *Look at the pricing* before

ordering. Aircraft Spruce sells 4" wide spruce spar stock for the same price as 4.75" wide stock. So it makes no sense to order the four-inch-wide stuff.

It'd be a good idea to order the spruce spar stock for the fuselage at the same time as the wing spars. The shipping cost will be much less than two individual orders.

Another option would be to buy shorter stock, and scarf it together to get the required fifteen-foot length. The PB100 Workmanship Guide covers scarfing.

4.1.2 Longeron Layout

To start with, the work table should be as flat as possible and free of twists. The table needs to be at least sixteen feet long, and at least 30 inches wide.

Jim Katz generated an AutoCAD file that includes the layouts for all fuselage components. Download the Zip file, and get the "Fly Baby Fuselage Building Layout.dwg" printed out at exact size. Use a rule to verify the size is right.

However, all the required dimensions are in Figures 1-1 and 1-2 of Article 3.

Start with the top longeron. Lay it out on the work table parallel, and close to, the edge of the table.

Nail temporary blocks to the table to lock the longeron solidly in place. These blocks are made from scrap wood 1/2" thick, 1 inch wide, and about three inches long. Figure 1-1 in Article 3 shows these blocks, and some recommended locations. Two ordinary nails hold them in place. Pound the nails completely into the wood so that nothing sticks out past the longerons.

Get the top longeron solidly anchored to the table. It's the most important—it's the longest straight line in the fuselage, and all other pieces are installed relative to it.

Take the measurements from Figures 1-1, 1-2 and 1-3, and draw out the lower longeron shape, the inner longeron, and the locations of the uprights. Place the lower longeron and the inner longeron on the drawn shapes, and lock them in place with blocks (Figure 11).

Figure 11: Longerons in Place

Don't leave the back of the lower longeron square. Cut it at an angle to match a vertical drawn from the upper longeron (Figure 12)

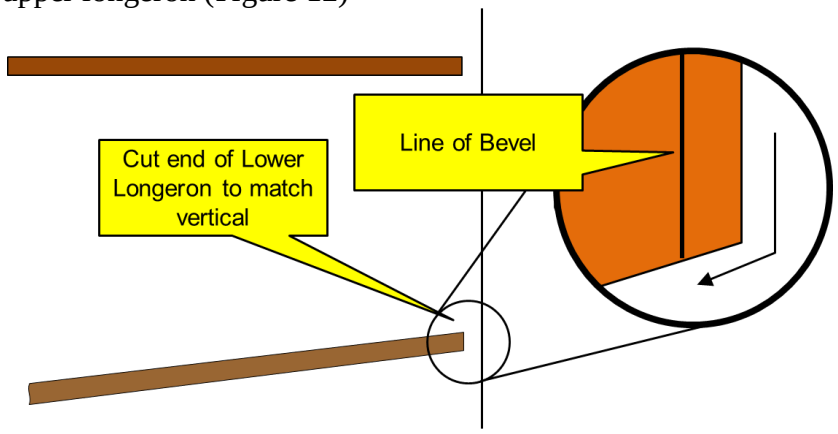


Figure 12: Trimming Back End of Lower Longeron

The back of the longerons will also, eventually, need to be beveled to fit together properly. It's actually easier to do this now, but extreme care must be taken to make the bevel in the proper direction. See Section 4.6.3.1. Jim Katz' CAD program found the proper angle to be 7.65° (Figure 13), though you're probably not going to be able to reach that level of precision!

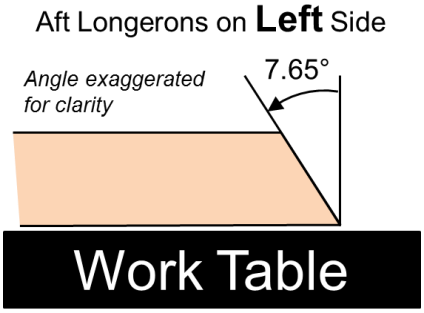


Figure 13: Aft Longeron Bevel on LEFT side of Fuselage

For the lower longeron, the bevel has to be parallel to the vertical line, not the end of the longeron itself. See the "Line of Bevel" back on Figure 12.

When the longerons are laid out, the fronts of the two longerons should project a bit further out than the fuselage requires; this is to support gluing the firewall in place in Article 4.

Use temporary blocks to hold all components in their exact locations.

There is a classic builders' adage: "Measure twice, cut once." Cut each piece a bit longer than needed, then gradually cut it down until it fits snugly. Modern epoxies fill gaps very well, but you're always better off with a tight joint.

4.1.3 Uprights

Cut the upright for station 6, and place it into position. See Detail "F" in Figure 1-3 on page 5 of Article 3; the upright at station 6 is only 5/8" thick, rather than the stock 3/4". This leaves space for a backing plate for the plywood splice at Station 6.

However, this 5/8" assumes that 1/8" plywood is in use. If you're using 3mm or 4mm plywood, select the thickness for Station 6 so that it's either 3 mm or 4 mm less than 3/4".

Follow the instructions in Article 3 for completing the fuselage truss (Figure 14). As the article says, don't permanently install the Station 11 upright yet.

Figure 14: Completed Fuselage Truss

The uprights and diagonals can be cut using any convenient tool. Personally, I prefer saws that use circular blades rather than bandsaws. The bandsaw blade can flex a bit.

If I were building today, I'd use a power miter saw for cutting out the uprights and diagonals. They give you a solid hold on the pieces, and are designed for cutting very precise angles. Mine even has a laser that marks across the wood. It's great, once one understands that the laser line is actually a bit off from where the saw is going to cut.

Miter saws are pretty cheap… $100 to $200. For a bit more, you can get a radial arm saw. These are similar to miter saws, but the cutting blade is on an arm that slides in and out. That's great if one is cutting wide wood at steeper angles, but the ordinary Miter saw will probably be enough for a Fly Baby.

And of course, there's always the good ol' table saw.

Reference Figure 1-3 on Page 5 of Article 3 often. The inset diagrams show how to manage the components at specific locations.

4.1.3.1 STATION 1 UPRIGHT

The Station 1 upright is not made from spruce. Bowers specifies "Hardwood" for the upright at the very front of the fuselage. For good reason, Station 1 will include the engine firewall, and the engine mount will be attached here.

Hardwood includes oak, ash, teak, mahogany, maple, or beech. This upright is 1½" wide, and the usual 3/4" thick.

4.1.3.2 TWO-PART STATION 3 AND 5 UPRIGHTS

If you look closely at Figure 1-1, you'll see that the Lower Inner Longeron actually crosses over the uprights at Stations 3 and 5. A small section of upright will need to be installed between the bottom of Lower Inner Longeron and the bottom longeron. This section of upright MUST be in-line with the rest of the upright.

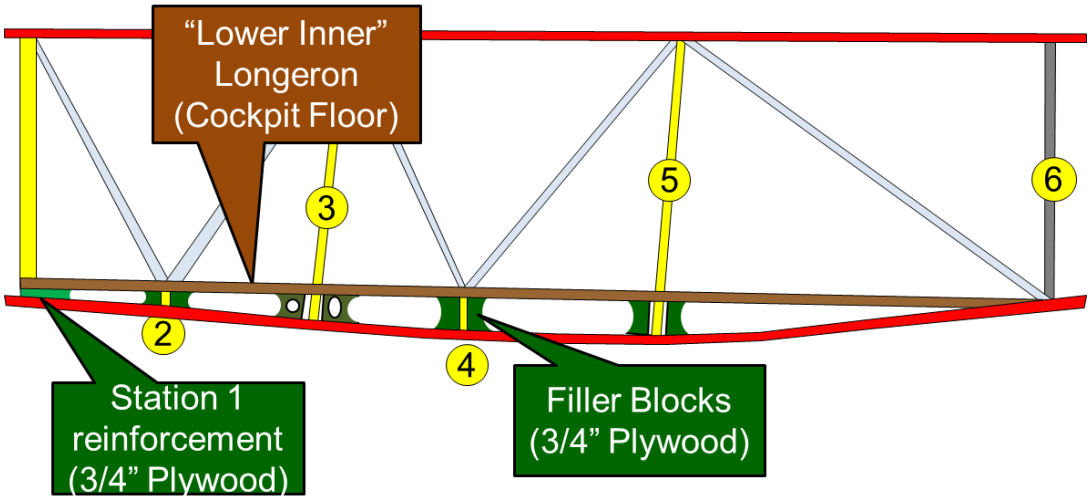


Figure 15: Two-Part Station 3 and 5 Uprights

4.1.3.3 STATION 11 UPRIGHT

The upright for Station 11 (the extreme rear of the fuselage) is unusual, as the two fuselage sides have different thickness. On both the left and right sides, this piece is 1½" wide. However, on the left side, it is 5/8" thick, vs. the right side, which has the standard 3/4".

Why? Because the plywood on the left side of the fuselage is going to get a 1/8" plywood doubler added at the extreme tail.

Those end uprights (and the very ends of the longerons) are going to be slightly beveled, at some point, to match the tapering fuselage to the flat rudder post. So they don't actually get glued into place until the fuselage is being assembled.

4.1.4 Diagonals

The diagonal pieces in the fuselage trusses must intersect properly with the uprights and the longerons. If you look at the truss intersections on Figures 1-1 and 1-2, nearly every intersection references a specific Detail in Figure 1-3.

This is going to take some work, since the ends will need to be cut at an arbitrary angle that matches whatever intersection is being worked on. Generally, start with a diagonal piece a bit too long, lay it down across the longerons in the proper position, and draw a line at the cut locations. Cut the first end to the line, and the second end at the marked angle but a bit longer. Then trim gradually to fit.

You can use the miter guide on your table saw, or a power miter saw. For the most part, the cuts will be by eyeball.

The temptation is there to adjust angles slightly using a benchtop sander. This tends to put a "glaze" on the wood, and the glue won't soak into the grain. For fine adjustments, use a rasp or file.

4.1.4.1 DIAGONALS AFT OF STATION 6

The diagonals in the forward fuselage (up to Station 6) are 3/4" square, just like the uprights and the longerons.

The diagonals aft of Station 6 are 3/4" wide (like the other fuselage components) but only 1/2" thick. As Figure 16 shows, the 3/4" side is positioned to match the longeron and upright widths, and the narrow side is vertical.

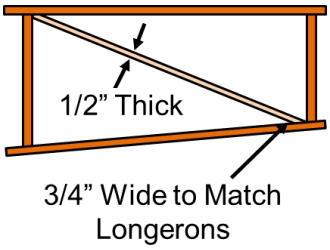


Figure 16: Diagonal Measurements Aft of Station 6

4.1.4.2 STATION 9

Station 9 is a bit different. Figure 1-2 shows a short stub of vertical there, but THIS IS TEMPORARY. Look at Detail "H" on Figure 1-3.

The short stub is a temporary holding block, one inch wide. It's place 14 inches forward of the end of the longerons. The block is "standing in" for the tail spring support cross-piece, letting things get glued in place while reserving room for the tailwheel spring anchor. You can see the cross-piece on Page 6 of Article 3, in Figure 1-11.

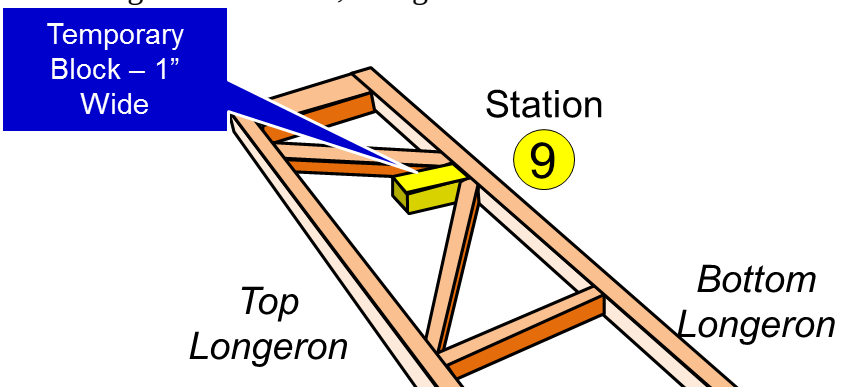


Figure 17: Temporary Block at Station 9

Examine Detail "H" of Figure 1-3 carefully when fitting these diagonals. Unlike most of the diagonals, the ends at the temporary block are carved back on BOTH sides, not just one side (like an arrow, rather than like a wedge).

Figure 18 gives a close-up view of the orientation at Station 9. Note how the centerline of the temporary blocks and the two diagonals should intersect at the same point on the bottom of the lower longeron.

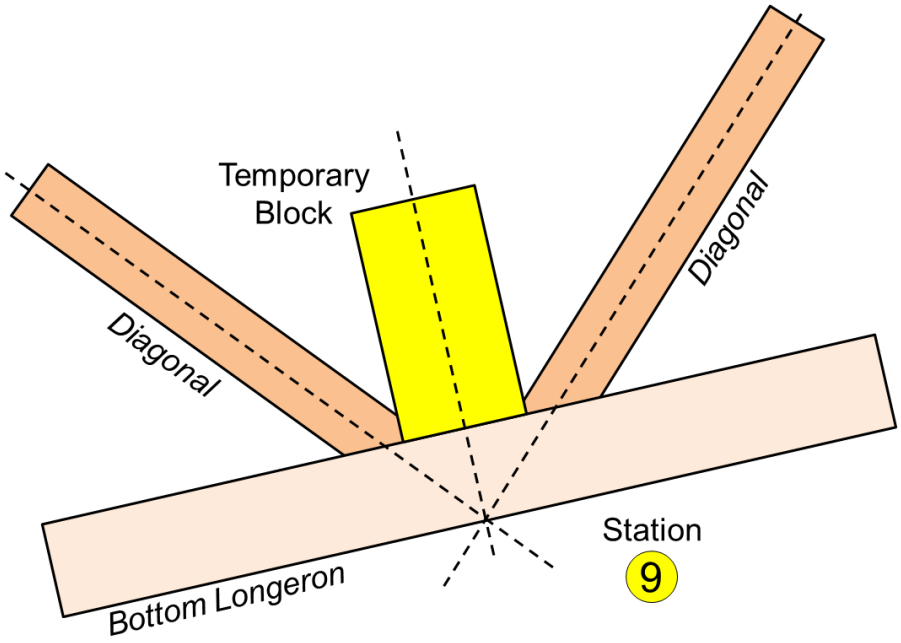


Figure 18: Station 9 Diagonal Positioning

When gluing the two diagonals at Station 9, slip a piece of wax paper on either side of the temporary block so it REMAINS temporary.

4.1.5 Gluing the Truss

The truss can be glued as it is being assembled, or it can be laid out, dry, first, and then individual pieces can be removed to be glued and replaced. DON'T STINT THE GLUE. There should be enough glue in each joint that it oozes out equally over the entire circumference of the joint. Another recommendation is to dab some glue onto the cut end of the piece being glued, waiting a couple of minutes for some of that glue to soak in, and add a bit more.

IMPORTANT NOTE:
There is a risk of gluing your fuselage to the work table at this point. You don't want that! Before gluing, make sure there's a generous piece of wax paper under the joint. It can be peeled off once the glue is cured.

After the glued point is in place, wipe the excess glue off the top of the joint. This is to minimize the amount of cured glue that will have to be scraped out of the way when adding plywood or the lateral braces to the fuselage.

Once the glue is cured on the fuselage truss, sand or file away any excess glue on the exposed side.

As mentioned, don't glue the Station 11 upright in, yet. That has to be shaped to match the rudder post after the fuselage sides are joined.

4.1.6 Horizontal Stabilizer Attach Points

Two hard points are glued to the aft fuselage to accept the bolts from the horizontal stabilizer.

Per Figure 1-2, a half-circle of 3/4" plywood is glued underneath the top longeron. Article 3 actually has the wrong measurement, Figure 19 shows the correct measurement (19.25 inches aft of the tail post).

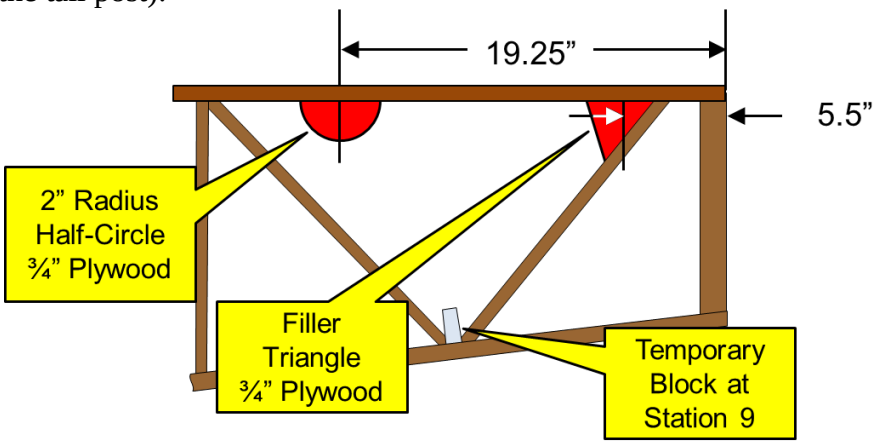


Figure 19: Horizontal Stabilizer Attach Points

A second hard point is necessary as well. It's a triangular block, again 3/4" plywood, that fits just forward of the top of the aftmost diagonal. The shape and size aren't critical, but the mounting hole will be drilled through it five and a half inches forward of the aft side of the tailpost (as shown in the previous figure). According to Figure 1-11, the front edge of this block should be two inches forward of the point where the diagonal intersects the top longeron.

When all the glue is cured, remove the temporary block located at Station 9.

4.1.7 Trimming the Lower Inner Longeron

Before moving on, there's one little bit of additional trimming necessary.

The Lower Inner Longeron, the Lower Longeron, and the front upright all intersect at the front bottom of the fuselage sides. The firewall is going to be glued and bolted to the wide front lateral.

Very likely, the Lower Inner Longeron and the filler block between it and the Lower Longeron is going to extend slightly beyond that front edge of the upright. It's important to trim back the Lower Inner Longeron and the filler block to match the upright.

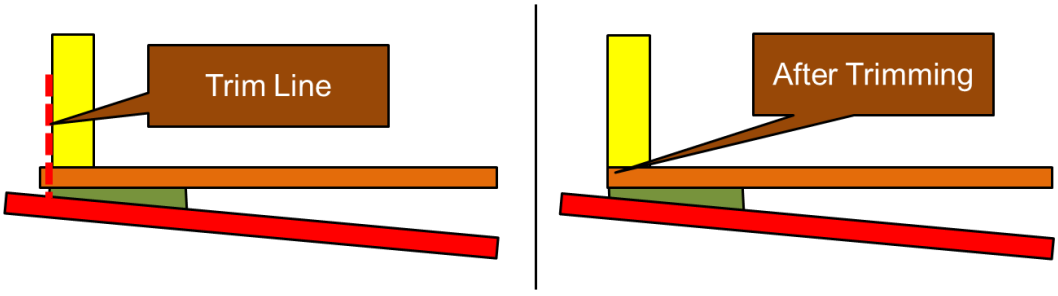


Figure 20: Trimming Above the Lower Longeron

Don't trim the lower longeron itself! It has to extend beyond the upright to help support the firewall.

4.2 Adding the Plywood

Many small wooden airplanes with wooden truss structures use small gussets at the intersection of the pieces. The Fly Baby effectively does the same thing, only it covers the entire truss with a sheet of thin plywood, instead of small pieces of plywood at intersections. The Fly Baby system is slightly heavier, but it provides a lot of support for the fuselage structure.

The gusset system is more labor, but is less complex to install. The additional complexity on Fly Baby covering is because plywood only comes in eight-foot sheets. Two separate pieces cover the front and back of each side of the fuselage with a reinforced scarf joint at Station 6, as seen in Figure 21. This intersection is also depicted on Page 5 of Article 3, in Detail "F" of Figure 1-13.

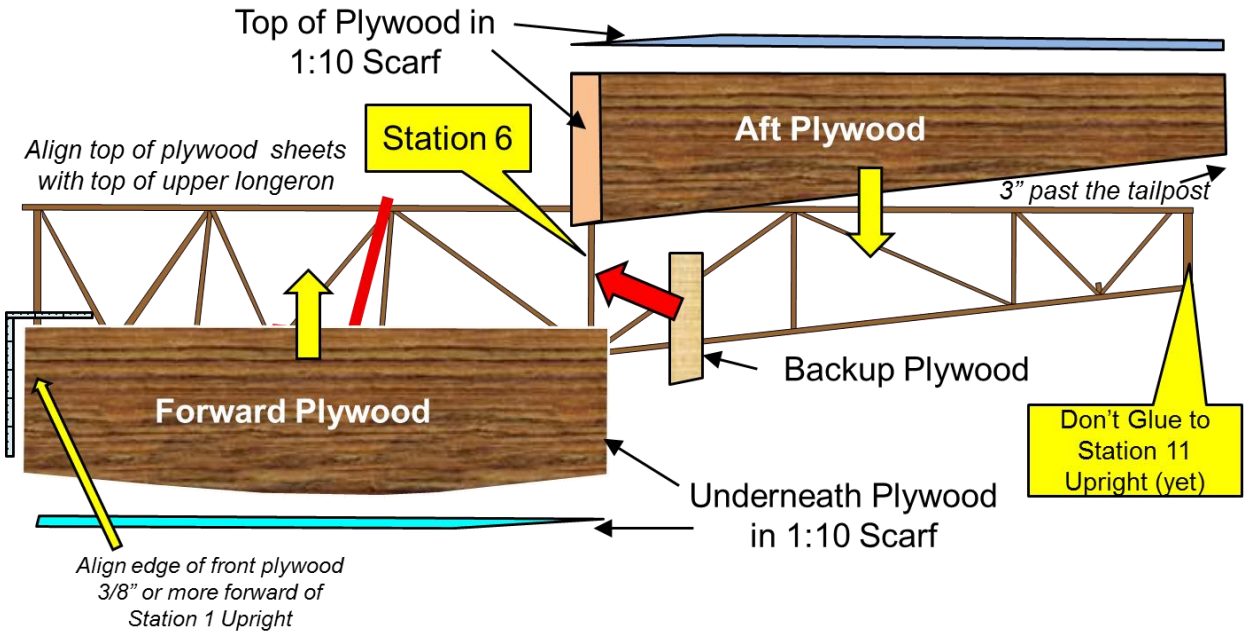


Figure 21: Fuselage Plywood

The two pieces don't have to be cut to fit the outside shape fuselage truss exactly, as they can be trimmed away as needed once the plywood is glued down. But the top longeron is straight, for its entire 15-foot run, so the plywood should be lined up so one of the manufactured edges is aligned with the top. When the plywood is cut to length, all the vertical lines should be perpendicular to that top edge. Note that both ends of the plywood go past the verticals at the nose and tail. In the front, the plywood should be at least 3/8" longer than the front upright, and in back, it should run 3" past the tail post.

To lay down the plywood, cover the structure thoroughly with glue, then line up the top edges with the top of the upper longeron and place the plywood. The front upright is perpendicular to the upper longeron, so the upper plywood should be aligned with it, too. Note that there are still short stubs on the longerons; these poke out beyond the plywood.

Use nails or stapes to hold the plywood in place while the glue cures; these nails and stapes can remain in place or can be (laboriously) removed later.

As a reminder, Pete says to run the aft piece of plywood three inches past the tailpost, as shown in the above figure. Also, don't glue the plywood to the Station 11 upright, which isn't even glued in to the truss, yet.

. The PB100 Workmanship Guide describes how the 1/8" plywood is scarfed. Figure 22 depicts the process used to join the two pieces of plywood at Station 6. The Upright at Station 6 is 1/8" (or the thickness of the plywood in use) thinner than the other uprights to leave space for a piece of plywood to be laid under the scarf joint for reinforcement.

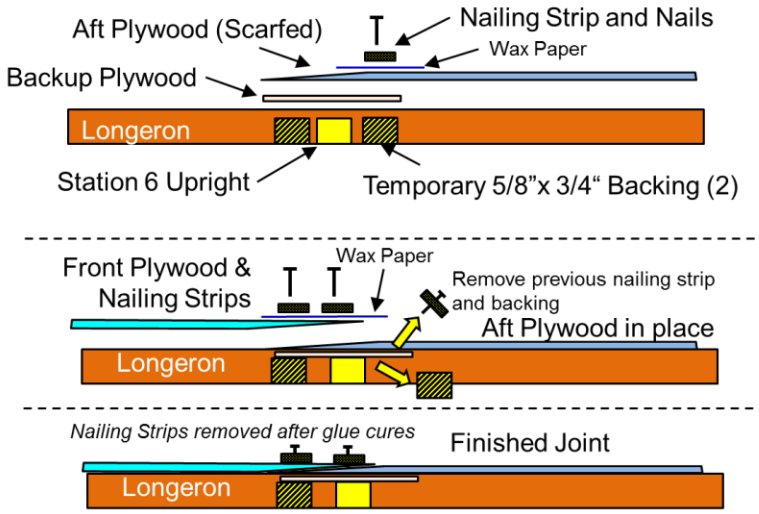


Figure 22: Cross-Sectional View of Station 6 Plywood Scarf

Once the glue is cured and the nailing strips are removed, there's likely to be a bit of discontinuity along the scarf line. Feel free to sand this down as necessary.

Once the plywood glue has cured, you can trim the plywood back to match the curve of the bottom longeron. Several ways would work; a router with a pattern bit might be a good pick (Figure 23). Don't forget to leave the extra three inches at the tail—that will be worked as part of fairing the fuselage side in with the rudder post.

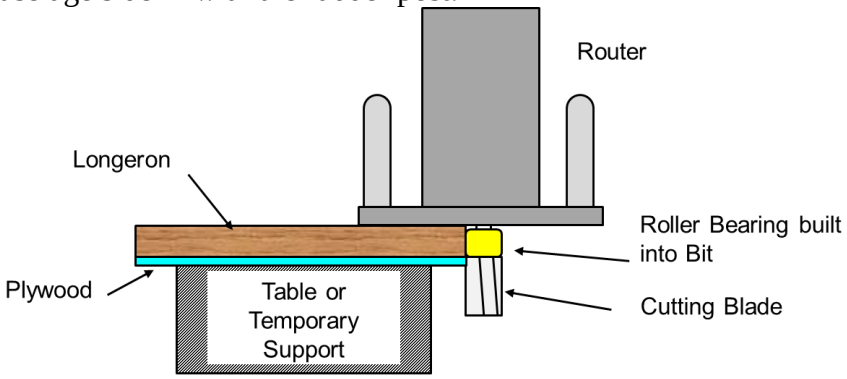


Figure 23: Trimming Plywood with a Router

4.3 Building the Right Side Truss

At this point you've got a single fuselage truss, for the left side. Next step is to build the right truss.

Pete designed the two sides identically—so it's important not to disturb the temporary blocks when you remove the left side from the table. Lay the other set of longerons in place, and start laying up the right-side truss.

Notice that the Station 6 upright has to be handled a bit differently this time. It's the one that's only 5/8" wide, rather than the normal three-quarter. Place a piece of 1/8" plywood down before laying the Station 6 upright in place (Figure 24).

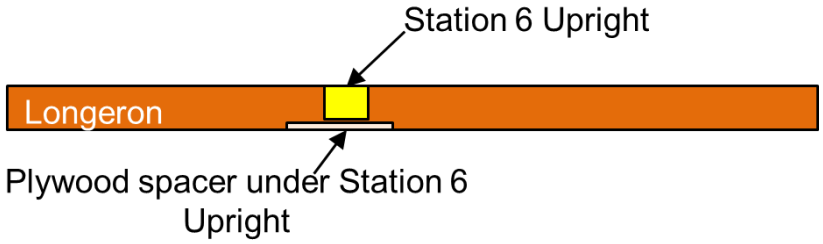


Figure 24: 1/8" thick spacer under the Station 6 Upright

Don't forget the wax paper! Also, remember to trim the Lower Inner Longeron and the filler block at the front lower corner of the fuselage truss, as described in Section 4.1.7.

4.3.1 Beveling the Right Side

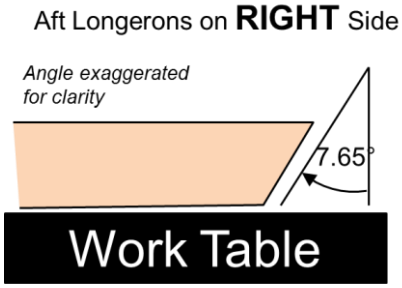


Figure 25: Aft Longeron Beveling on Right Side of Fuselage

As mentioned in Section 4.1.2, the aft end of the longerons will need to be beveled. Pete leaves this off until final tail section assembly (Section 4.6.3.1), but it would be easier to do this with the pieces on the table.

However, since the right side of the fuselage is being built in the same blocks as the left side, the beveling has to be in the opposite direction! See Figure 25. And, again, remember that the bevel for the bottom (slanting) longeron is not directly crosswise to the longeron, but vertical. This is shown in Figure 12.

4.3.2 Installing the Plywood

Since the plywood has to be installed to what is the lower surface of the truss, the truss has to be removed from the blocks without the plywood. It's, frankly, not strong enough without the plywood.

After the glue on the truss is cured, install temporary gussets made from scrap 1/8 plywood at each intersection. Hold them down with aircraft nails, as shown in Figure 26. Hammer the nails all the way in, since the truss will be turned over to rest on that side on the table.

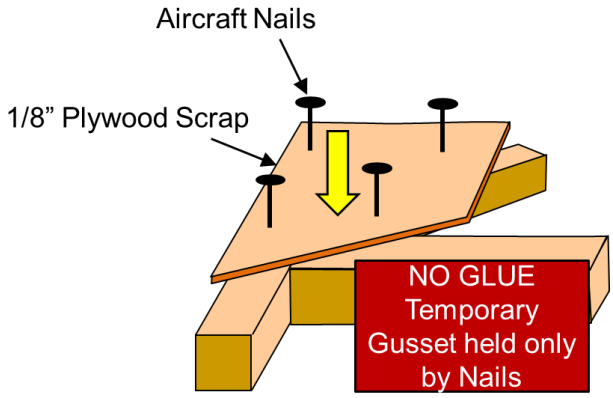


Figure 26: Temporary Gussets

When the temporary gussets are in place, remove the truss from the blocks turn and it over so the other side is up. Place it on the work table, and install the 1/8 plywood in the same fashion as the first side…with one exception.

The exception is the temporary backing put in place to support the nailing/gluing of the scarf ends to the backup plywood. On the left side, these temporary pieces were 5/8" thick; the 5/8" plus the 1/8" backup plywood equaled the 3/4" thickness of the fuselage truss.

But the right side is now sitting on the work table, and it has 1/8" thick temporary gussets at each component intersection. It sits 1/8" higher… so the temporary backing has to be a full 3/4", rather than 5/8". See Figure 27.

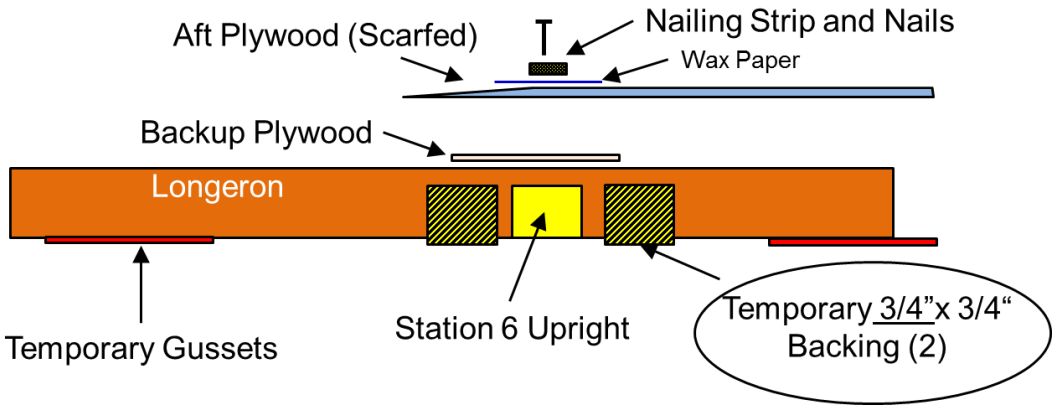


Figure 27: Station 6 Temporary Backing on the Right Side Truss

Once the glue is cured, trim off the excess plywood and remove the temporary gussets. With that, you're ready to start assembling the fuselage.

Figure 28: Fuselage Trusses

4.4 Initial Fuselage Assembly

Fuselage assembly starts with Figure 1-4 on Page 5 of Article 3. The fuselage will be needing gussets to hold the laterals to the fuselage sides. Cut out 26 of the 3.125" radius half-circles from 1/8" plywood. Use a fly cutter or other method to cut out full 6.25" diameter circles, then cut them in half.

Similarly, 16 quarter-circles with 3" radius are needed, again from 1/8" plywood.

The use of these are shown clearly in Detail A and Detail B on Figure 1-4.

Finally, note Detail "C" on Figure 1-4. Twelve corner reinforcements of the indicated shape are needed; these are of 3/4" plywood. Pete doesn't seem to have a name for these. Let's call them "Bulkhead Arcs."

Figure 29 shows a simplified version of how they're used. At a given station, laterals are attached between the top longerons and between the bottom longerons. The Corner Bows are glued into the corners. Then each side of the bulkhead is covered with 1/8" plywood in four separate pieces.

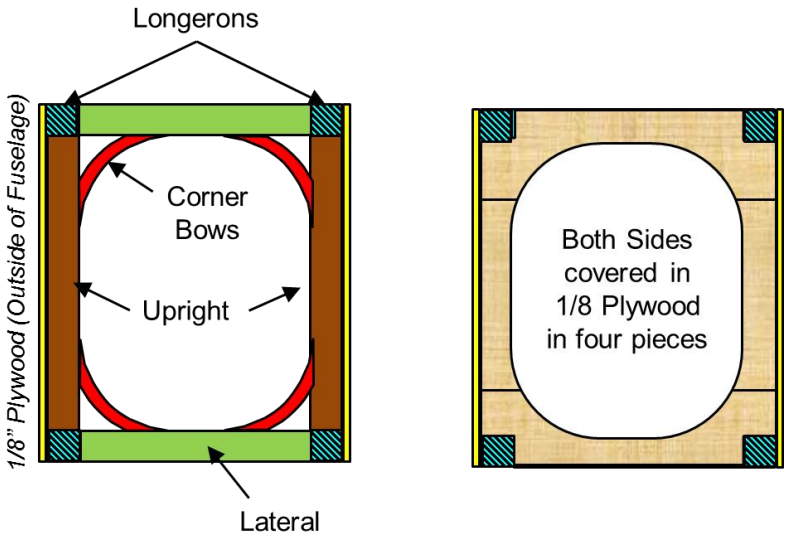


Figure 29: Bulkhead Construction

The result is a strong, fairly light panel that, frankly, looks pretty cool. Good thing, because all of these panels are in the cockpit area, for others to see and admire (Figure 30).

Figure 30: Completed Bulkheads

The figure above shows a bulkhead where the laterals are the same sizes as the uprights; this isn't usually the case. For both Stations 3 and 5, the lateral elements are a bit wider. Figure 1-9 on page 6 of Article 3 shows the actual dimensions of the bulkheads. It also provides view of the "non bulkhead" stations, which run a diagonal across the middle of the fuselage to strengthen the structure.

4.4.1 Spacer Bars

Key to assembling the fuselage are the Spreader Bars, shown as Detail D in Figure 1-4 (on page 5 of Article 3). These can be pieces of scrap wood (2x4, for instance), but the top and bottom need to be true—not warped, and perfectly parallel with each other.

Dimensions are shown in Figure 1-4, Detail D, on page 5 of Article 3, and in Figure 31 below. The reason for the particular dimensions is easy discerned. The "24.25" inches between the OUTSIDE edges of the notches = 24 inch longeron separation, plus two pieces of 1/8" plywood. The 7/8" width of the notches= 3/4" wide longerons, plus a single sheet of 1/8" plywood[1]. The one-inch depth allows the longerons to seat well.

The key point is that the distance from the bottom of each notch to the bottom of the spacer bars must be the same for all notches, on all bars.

[1] If you're using 3mm plywood, DON'T adjust this measurement…use the full 24.25", and luxuriate in the extra 1/64" of fuselage width you'll get.

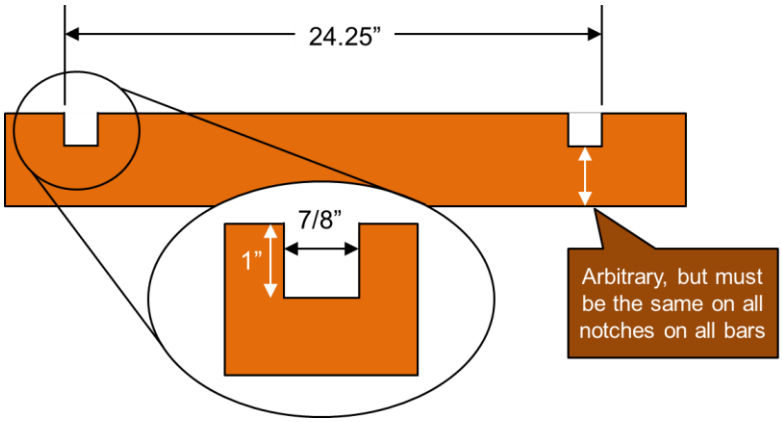


Figure 31: Fuselage Spacer Bars

The spacer bars’ use is shown in Figure 1-5 on page 5 of Article 3. The fuselage rests inverted, with the top longerons in the spacer bars. A carpenter’s square is used to ensure the two sides of the fuselage are exactly aligned. Measure to the UPRIGHT at Station 1, not to the stub ends of the longerons. Remember, we were not controlling the length of the longerons at this end, as long as the back ends were lined up.

In addition, use a second carpenter’s square to ensure the fuselage slides are exactly vertical, in relation to the work table. If you can lay hands on a THIRD square, check both sides at the same time.

When the fuselage is absolutely as straight as you can make it, nail in a couple of temporary supports across the aft section of the fuselage. They’ll be “on top,” from this frame of reference, but they’re actually on the bottom of the fuselage.

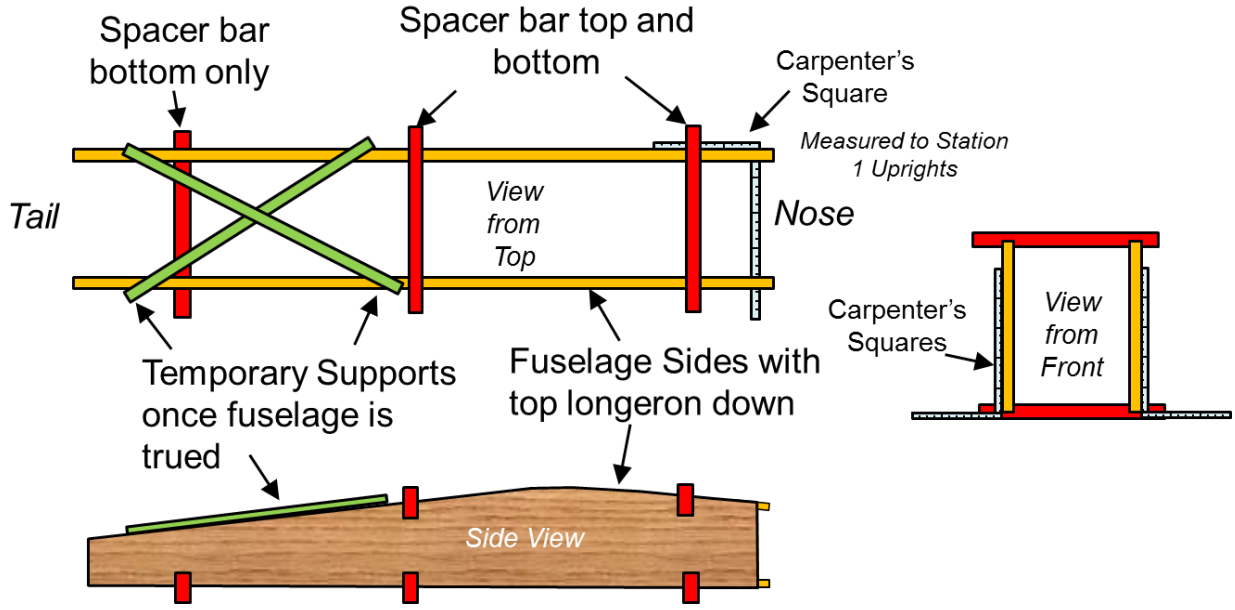


Figure 32: Aligning the Fuselage Sides

As of this stage, you’re readying to start internal assembly.

4.4.2 Station 3

The bulkheads at Stations 3 and 5 are the central portion of the fuselage structure. Either can be built first. Let’s start with Station 3, first.

Figure 33 shows the initial steps: Installing the laterals (cross-pieces) across the top and bottom. Cut these to size, but they should be around 22.5 inches (plus or minus a little bit, if you're using 3mm or 4mm plywood). Use pieces of 1/8" plywood as temporary gussets to hold them while the glue cures. Make sure the temporary gussets aren't glued down!

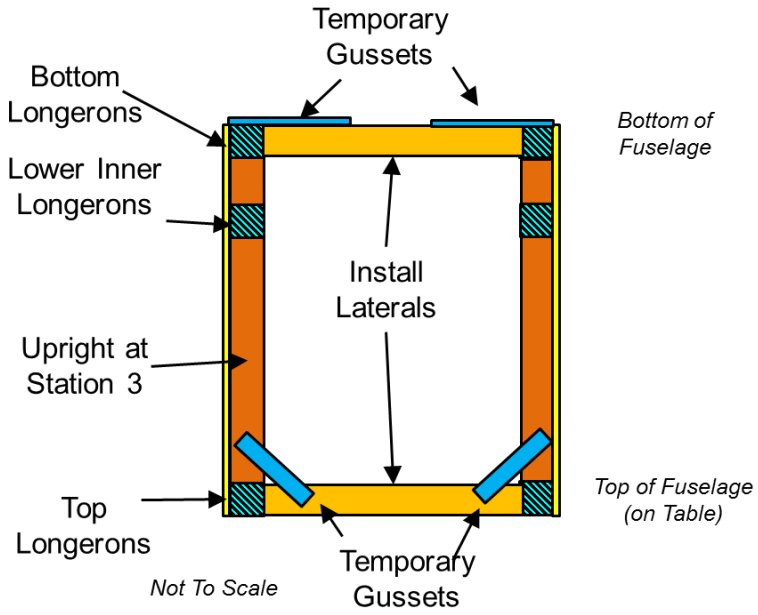


Figure 33: Installing Laterals at Station 3

(Note that these drawings are for reference only; the dimensions are not necessarily to scale)

Next step is to install two cross-pieces on the bulkhead. As Figure 34 shows, the cross piece at the top of the build (actually, bottom of the fuselage) is five inches deep, and the one at the bottom of the build (top of the fuselage) is 1¾". Temporary holding blocks should be installed to keep the top cross-piece in place while the glue cures. Again, try not to glue these in place.

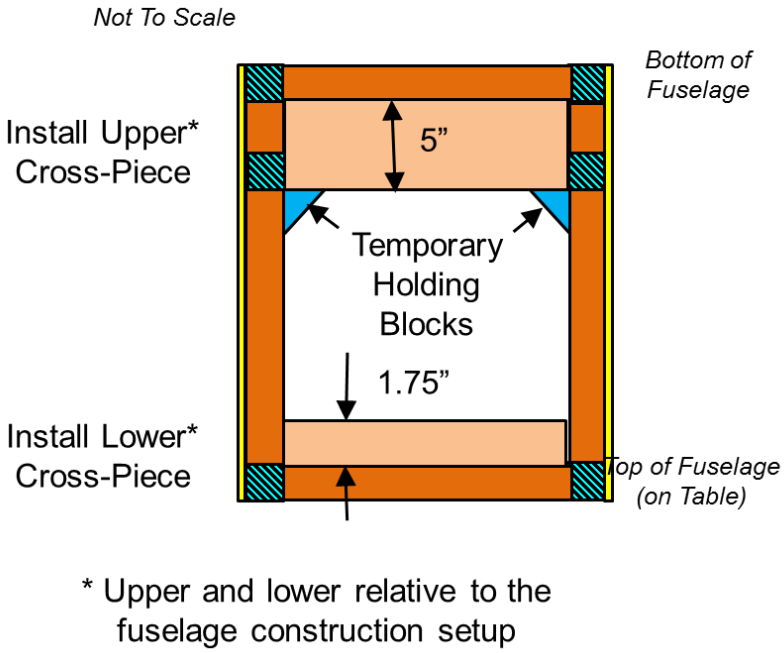


Figure 34: Station 3 Cross-Pieces

Next, install the corner bows on the corners of the center opening. Apply the glue, then nail them in position.

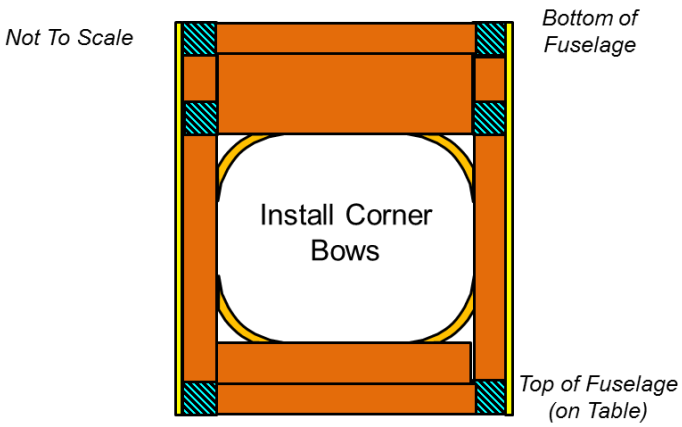


Figure 35: Install Bulkhead Arcs

Figure 1-9 on page 6 of Article 3 (Detail “A”) shows additional reinforcement that needs to be added inside the corner bows on the top of Station 3. Of course, with the fuselage upside down, it’s the side closest to the tabletop.

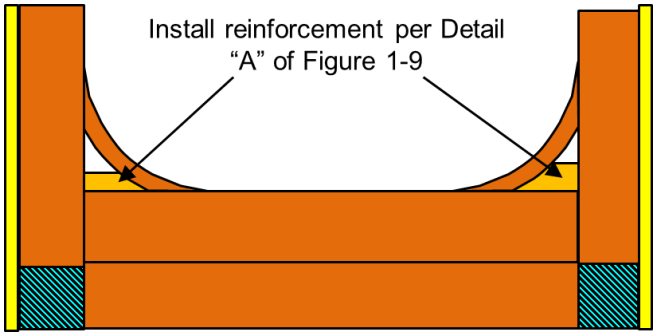


Figure 36: Station 3 Reinforcement

Finally, both sides of the bulkhead are covered with 1/8" plywood.

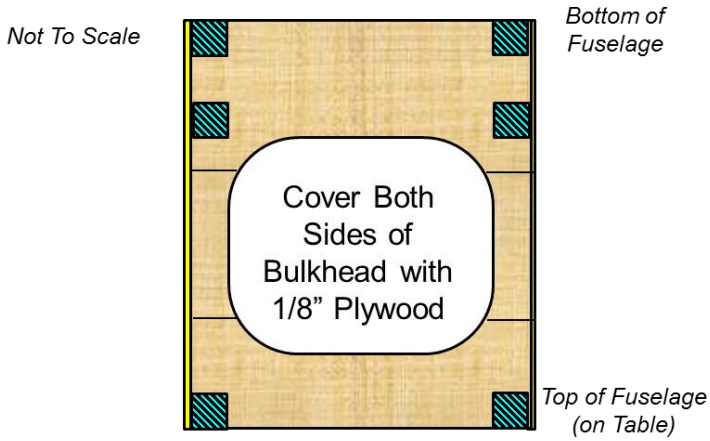


Figure 37: Completing the Bulkhead

Two points: First, don't forget to varnish the inside of the area inside the corner bows (Figure 38). It's the only open area in the assembly. Make sure the areas which will be glued are clear of varnish.

Figure 38: Varnish inside the Corner Bows

Second, no one expect this to be a once-piece sheet of plywood. Bowers' drawings show one piece at the top, one at the bottom, and two short connecting strips of 1/8" ply on the uprights on either side. Cut out pieces of cardboard for test fits.

Figure 39 shows the plywood being applied to the top side one of the bulkheads. Note the binder clips used as clamps.

Figure 39: Bulkhead Plywood Gluing

Again, note that Figure 1-6 on page 5 of Article 3 describes this process.

One thing Figure 1-6 shows is the drilling of the holes for the spar pins from the wings (the hole for the 7/16" ID bushing). I'd leave this for now, and drill it when you can test fit it with the wing. The other hole is the pass-through for the rudder cable, and cam be drilled.

Normally, I'd recommend coating the whole thing with varnish when complete. However, there's other stuff to be glued in place…let's wait a bit.

4.4.3 Station 5

The bulkhead at Station 5 is built almost identically to that at Station 3. The only major difference is the size of the lower cross-piece. It was 1.5" for Station 3, but is a standard 3/4" piece on Station 5.

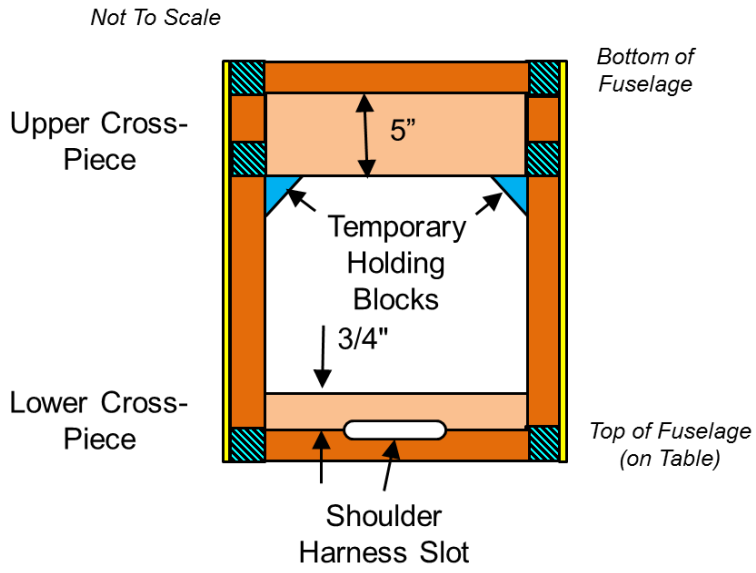


Figure 40: Station 5 Bulkhead

However, there is a major difference: Where the lateral and the lower cross-piece meet, there's a ~1/4" x 6 inch slot for the shoulder harness. It's basically centered on the two 3/4" pieces that are attached cross this area.

The stock shoulder harness setup is less than optimal. See Section 5.2 for a discussion of the alternatives.

4.4.4 Station 4

Station 4 is built similarly to Stations 3 and 5, except there is no upper portion of the bulkhead and there are no corner bows. This bulkhead is pretty busy, though. It's part of the landing gear structure (the aft portion of the gear bolts to the bottom of the fuselage at Station 4, it holds the aft end of the control stick torque tube, and it's a support for the pilot seat. As usual, it receives the 1/8" plywood on both sides, as shown in Figure 41.

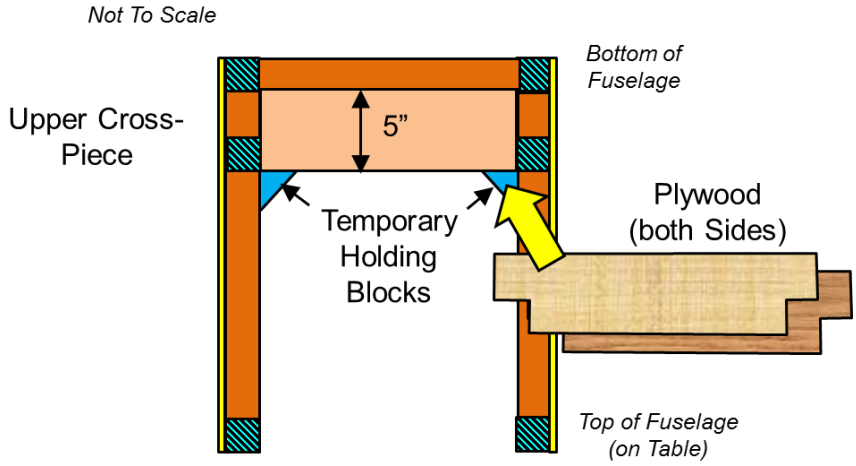


Figure 41: Station 4 Construction

4.4.5 Station 2

Station 2 is built the same as Station 4, but Pete says to wait until the firewall is installed. That happens in Article 4.

4.4.6 Station 1, 2, 3, 4, and 5 Lower Reinforcement

The "Lower Inner Longeron" referenced earlier is, basically, the cockpit floor. It runs straight aft, while the bottom longeron describes the graceful arc of the lower fuselage.

The area between the Lower Inner and Bottom Longerons is a critical one; it is where the wings and the landing gear attach to the fuselage. As described in Figure 1-7 on page 5 of Article 3, and depicted in Figure 42 below, the arced-shaped gap between the longerons is filled with four filler blocks. In addition, Figure 1-3 on Page 5, Detail "A", shows how the very front is reinforced.

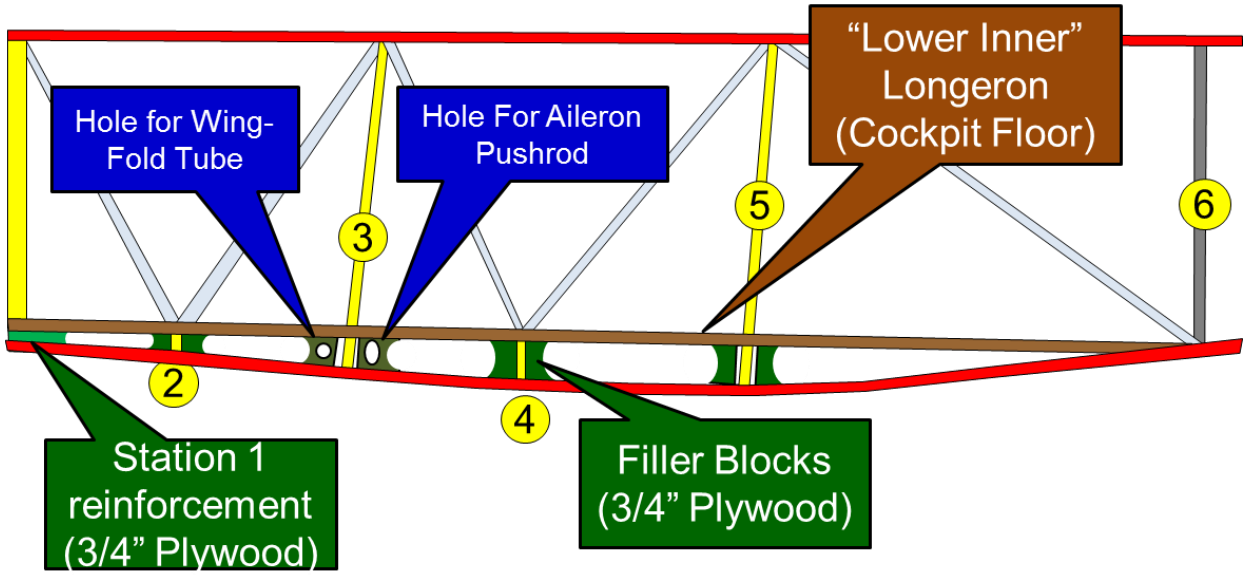


Figure 42: Lower Longeron Reinforcement

These filler blocks are just 3/4" plywood. They are installed at the locations where Stations 1, 2, 3, 4, and 5 intersect the lower inner longeron. Their shape is similar, but they are all differently sized. The Stations 3 and 5 blocks have holes sliced in them to allow the spar plates on the wings to pass. Station 3 also has additional holes for the wing-fold tube and the aileron pushrods.

Also, some builders install the filler blocks at the aft end of the lower inner longeron, right where it intersects with the bottom longeron. An example of this can be seen in Figure 39.

4.4.7 Closing the Lower Longerons

The lower inner longeron and the bottom longeron have a lot of reinforcement installed between them. Bowers caps this off (literally) by applying plywood to the area of the inside of the fuselage to make this a closed, strong, box structure

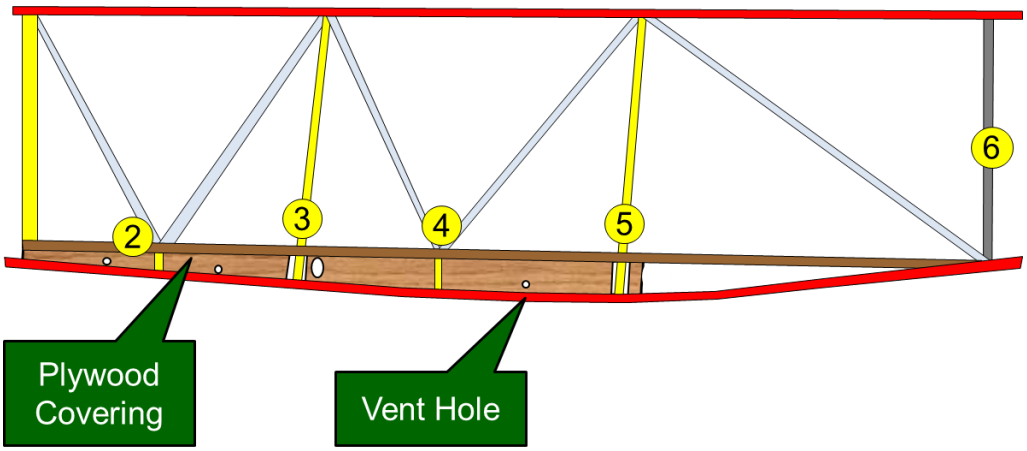


Figure 43: Lower Fuselage Box Structure

The only thing is, the Station 2 bulkhead has not yet been constructed…we're waiting until the firewall is installed, and that happens in Article 4.

The plywood between Stations 3 and 5 can be installed, though. Remember to varnish inside, and each of the areas must have a small hole near the bottom to allow ventilation. The area between Station 3 and 4 should be good, as it needs a hole to allow the aileron pushrod to go into the wing. Technically, the area between Station 4 and 5 should be OK as well (since the spar plates go through at Station 5), but if the gap left for the spar plates is small, the ventilation may not be as good.

4.5 Final Fuselage Assembly

Glue cured? Loins girded?

Time to bite the bullet and turn those two parallel fences into an airplane fuselage. The laterals and diagonals for the front section of the fuselage are in place; now it becomes time to pinch the tail section together and taper the body from the cockpit to the tail

First step is to remove the fuselage from the spreader blocks. Shouldn't need them anymore. Lay the fuselage on its top longeron directly onto the work table. Add temporary braces if you like, but the fuselage is going to flipped a lot during the final assembly phase. Remove the temporary "X"-braces installed on the aft fuselage.

The primary reference for closing the tail is Figure 1-8 on page 6 of Article 3. This figure shows how the diagonal braces run, and the width of the fuselage at each Station.

The Fly Baby fuselage is 24.25 inches wide from Station 1 to Station 5, and starts after Station 5. Here are the fuselage widths:

Station	Outside Width (Figure 1-8)	Computed Length of Lateral
1	24.25"	22.5
2	24.25"	22.5
3	24.25"	22.5
4	24.25"	22.5
5	24.25"	22.5
6	22"	20.25
7	17.75"	16.00
8	10.375	8.625

9	See Below	
10	See Below	
11	3.25	1.5

For Stations 6 aft, the "Computed Length of Lateral" in the above table is at the center of the lateral. The lateral itself will need to be beveled to match the closing fuselage (Figure 44).

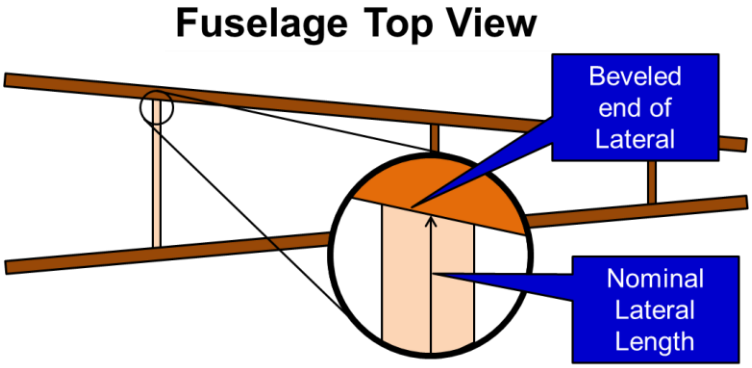


Figure 44: Beveled Ends of Lateral Braces

The fuselage width of Stations 9 and 10 is going to be set by the Stations on either side (Station 8 and Station 11). Station 9's lateral is on the bottom only, and it's a hardwood cross-piece for the tailwheel spring. Station 10 doesn't even get its own lateral, but one is attached a few inches forward of it.

The "Computed Length of Lateral" takes the outside dimensions, subtracts two 3/4" thick longerons, and two pieces of 1/8" plywood. All told, the laterals should be 1.75" shorter than the outside fuselage width.

4.5.1 Overall Guidance

4.5.1.1 INTERFACING THE LONGERONS, LATERALS, AND DIAGONALS

There are a lot of ways to join the pieces, where longerons, laterals, and diagonals join at the fuselage stations.

Figure 45 shows an idealized standard. The extended centerlines of the lateral and diagonal pieces intersect at a common point in the middle of the Longeron (Figure 45).

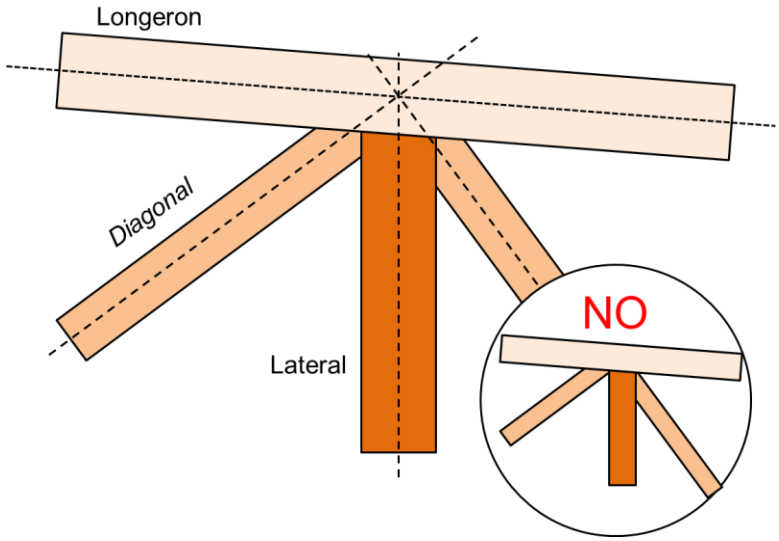


Figure 45: An Ideal Joint

The point is that the pressure from the diagonals should go, as equally as possible, to both of the components it joins. That means, roughly, about the same surface area should be touching the longeron as it does the lateral.

The Inset "No" figure shows what we're trying to avoid. Both the diagonals in this case are mostly touching either the longeron or the lateral. Depending on the direction of the loading, it might be resisted by only the thin "shovel end" of the diagonal.

Make the ends of the diagonals look like the front end of a boat, not a wedge, and you're probably doing well enough.

4.5.1.2 GUSSETS

When the laterals and any diagonals are glued, most of the Stations receive the Type A or Type B gussets defined in Figure 1-4 on page 5 of Article 3 and in Figure 46. Type A gussets are a quarter of a 6" diameter circle, and Type B gussets are half of a 6.25" diameter circle. Sixteen Type A and 26 Type B are needed.

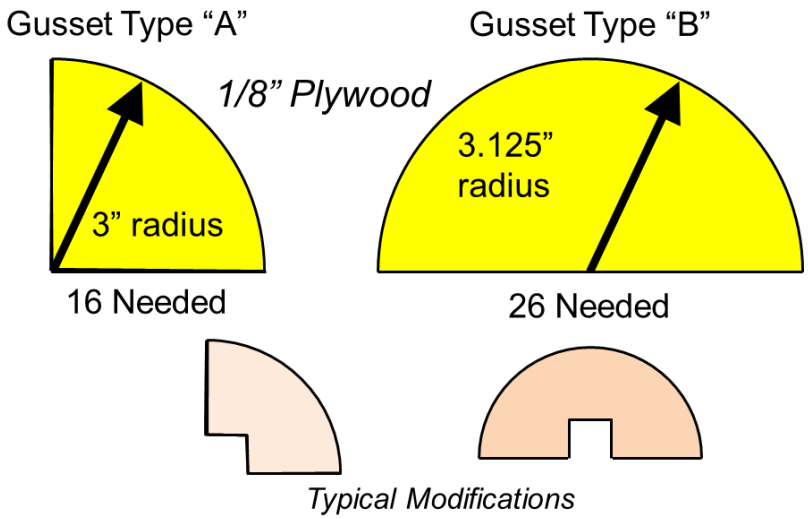


Figure 46: Gussets for Fuselage Assembly

These are usually installed out the outside of the longeron, and glued to the longeron, the lateral, and any diagonals at that intersection. Use nails to clamp down on the gusset. However, there are a few that get put in around an upright, and a 3/4" square notch (such as shown in the figure) will be needed.

Figure 47 shows an installation in process. Bar clamps are across the fuselage forward and aft of the lateral, to hold the joint firmly together. Jim Katz, the builder in this case, added the routed holes in the fuselage sides (See Section 5.1) which gave purchase for a set of clamps holding the gusset down. If the fuselage isn't routed (and most aren't), nailing the gusset into place should be sufficient.

Figure 47: Gluing the Gussets

4.5.1.3 CHECKING ALIGNMENT

Now, Pete doesn't say anything, in either the EAA articles or the plans, about verifying that the fuselage is aligned as the aft portion is coming together.

Probably, the way the front fuselage is assembled, there's really very little that can go wrong, alignment-wise, as the aft Stations are closed up.

But…if you would prefer something that can be checked, here's a suggestion: Mark the centerline of the Station 3, 4, and 5 laterals, and to each newly-made lateral. Use a string or a long straightedge to check alignment per Figure 48 prior to gluing up each joint.

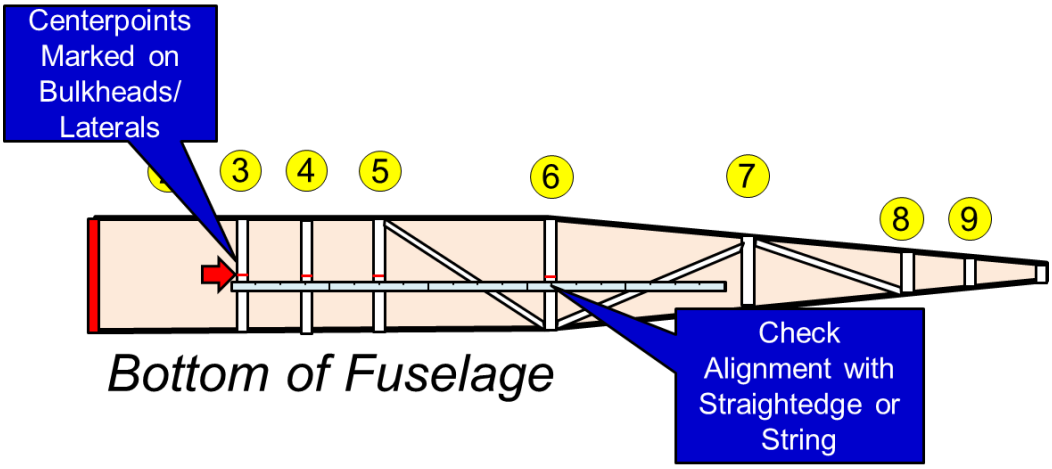


Figure 48: Suggested Alignment Check

A string will probably work best, especially over the curving lower fuselage. Mark the center on each new lateral, clamp it and its diagonals in place, and check the alignment. If the alignment seems to be diverging, adjust the diagonals. There are also systems that use low-cost lasers to provide an alignment reference.

4.5.2 Install Gussets on Stations 4 and 5

First, some unfinished business from earlier. Figure 1-8 shows that the half-circle gussets should be installed on the bottom of the bulkheads at Station 4 and 5 (remember, the fuselage is upside down, so the bottom is on top). Having them in place when the plywood was being applied would have complicated things, so go ahead and install the Type B gussets now, on the bottom only.

4.5.3 Closing Station 6

Start the fuselage-tapering process by installing the lateral on the bottom of Station 6, along with the diagonal between Station 5 and Station 6. Use bar clamps to hold the joint, and install the gussets using glue and nails.

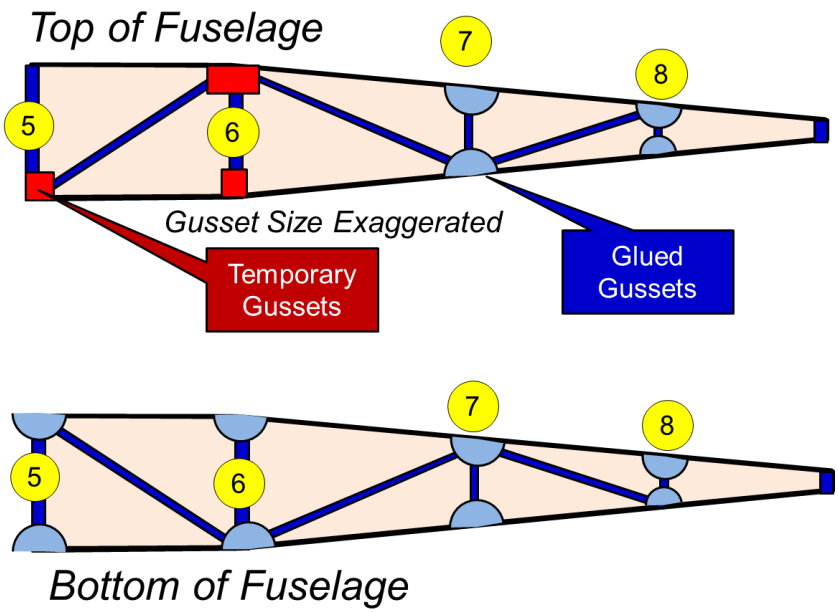


Figure 49: Gusseting the Aft Fuselage

Once the gussets are nailed down, the fuselage can be flipped over to install the lateral and install using temporary gussets as shown in Figure 49. Use nails to attach the temporary gussets, but not glue. Put some wax paper under the gusset so the squeeze-out from gluing the lateral and diagonal don't lock the temporary gusset.

Why temporary gussets on top of the fuselage at Stations 5 and 6? Because a big piece of plywood will be glued down to the top of the fuselage in this area, to provide a floor for the baggage area.

4.5.4 Stations 7 and 8

Repeat the above process with Stations 7 and 8, except no temporary gussets…glue them all.

4.5.5 Cross-Diagonals

Diagonals are also installed across the inside of the fuselage. Figure 1-9 on Page 6 of Article 3 describes the shape of the cross-diagonals at Stations 6, 7, and 8.

Note how they go in different directions…the cross-diagonal at Station 6 goes from the upper right longeron to the lower left, but at Station 7, it's from the LOWER right to the UPPER left. And Station 8, it's back to the same way as Station 6.

The joints with cross-diagonals get a PAIR of Type A gussets (the ones that a quarter-circle), with a notch cut to fit around the longeron. Detail A in Figure 1-4 on page 5 of Article 3 illustrates how this is done.

Note: The cross-diagonal at Station 8 has a potential interference issue with the elevator cables. One solution for this involves carving out a clearance area and gluing reinforcement to the diagonal. For this reason, I'd recommend NOT varnishing the Station 8 diagonal during fuselage assembly. Put a note on it along the lines of "Remember to varnish this piece," and wait until control installation (Article 8) to determine if it's necessary. The Companion Guide for Article 8 has more information.

4.5.6 Additional Type B Gussets

In fact, most of the joints behind Station 5 get double Type B gussets (the half-circle kind), with the second inside the fuselage rather than outside. See Detail B in Figure 1-4 on page 5 of Article 3. A notch has to be cut to fit the gusset on the inside the joint.

These could (and probably should) be installed at the same time as the external gussets. However, not every joint gets them…the joints with a cross-diagonal do not, and if you inadvertently install the inside gusset, it'll mess you up to no end.

4.6 Rudder Post

The Rudder Post in a Fly Baby (sometimes called the Tail Post) is a key element in the fuselage design (Figure 50). The Rudder post not only supports the hinges for the rudder, but it is the main structural element for the vertical tail and holds the tailwheel on the aircraft. It also is the main structural element bolting the two sides of the fuselage together, and supports the brace wires for the horizontal stabilizers.

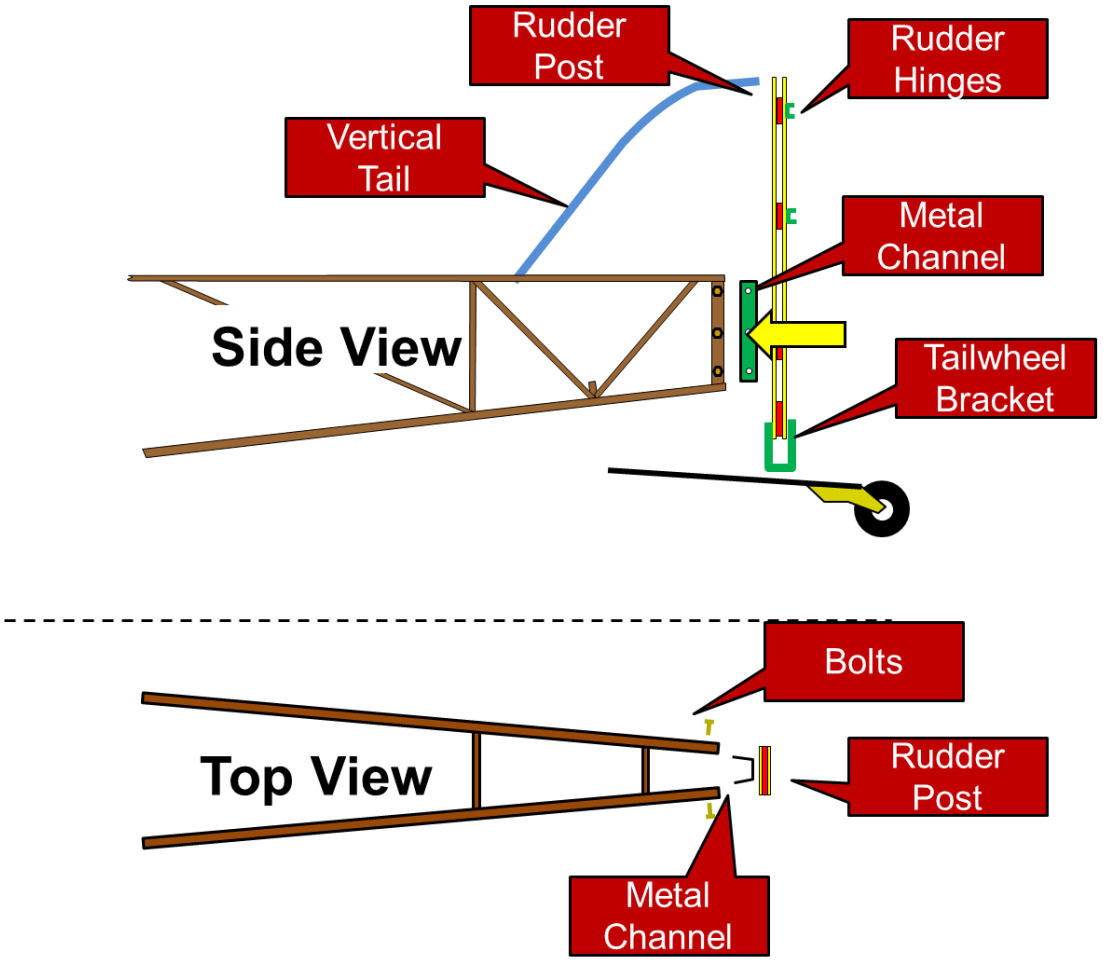


Figure 50: Rear Fuselage Joining

The rudder post is depicted in Figure 1-10, and its basic construction is shown in Figure 51. It consists of a sandwich; 1/8" plywood sheets on the outside, with 3/8" square spruce along the sides and 3/8" thick blocks inside. The top two blocks provide the hard points to attach the

rudder hinges, the next one down is a "hard point" for bolting the bracket to the post, and the next one is used for both a hard point for the bracket and a hinge. At the bottom is the solid hard point for attaching the tailwheel spring. When it's all glued together, you get a nice, compact, sealed box.

It's bolted to the airframe using a 0.032" steel channel, shown in Detail B-B in Figure 1-2). The bracket bolts to the upright at the extreme end of the fuselage, and the rudder post is glued to the main components in the extreme tail.

Figure 50 above showed how the two sides of the fuselage are joined at the extreme tail of the aircraft. A U-Shaped metal channel is bolted to the ends of the fuselage sides. The tail post is then bolted to the channel as well.

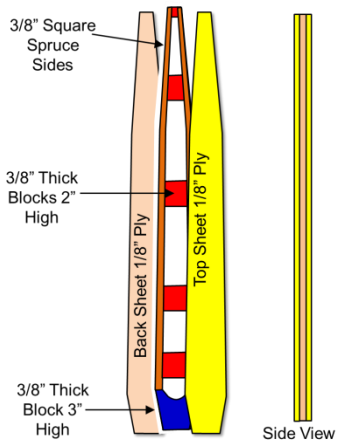


Figure 51: Stock Rudder Post Construction

4.6.1.1 BASIC DESIGN

The stock design of the rudder post is a closed wooden box, with reinforcements inside to allow bolting the rudder hinges to the post.

While Figure 1-10 in Article 3 depicts the dimensions of the rudder post, it's not all that clear. In addition, as mentioned in the Errata section, Pete made a mistake as to the positioning of one of the blocks. Figure 52 provides the external dimensions and the block locations separately.

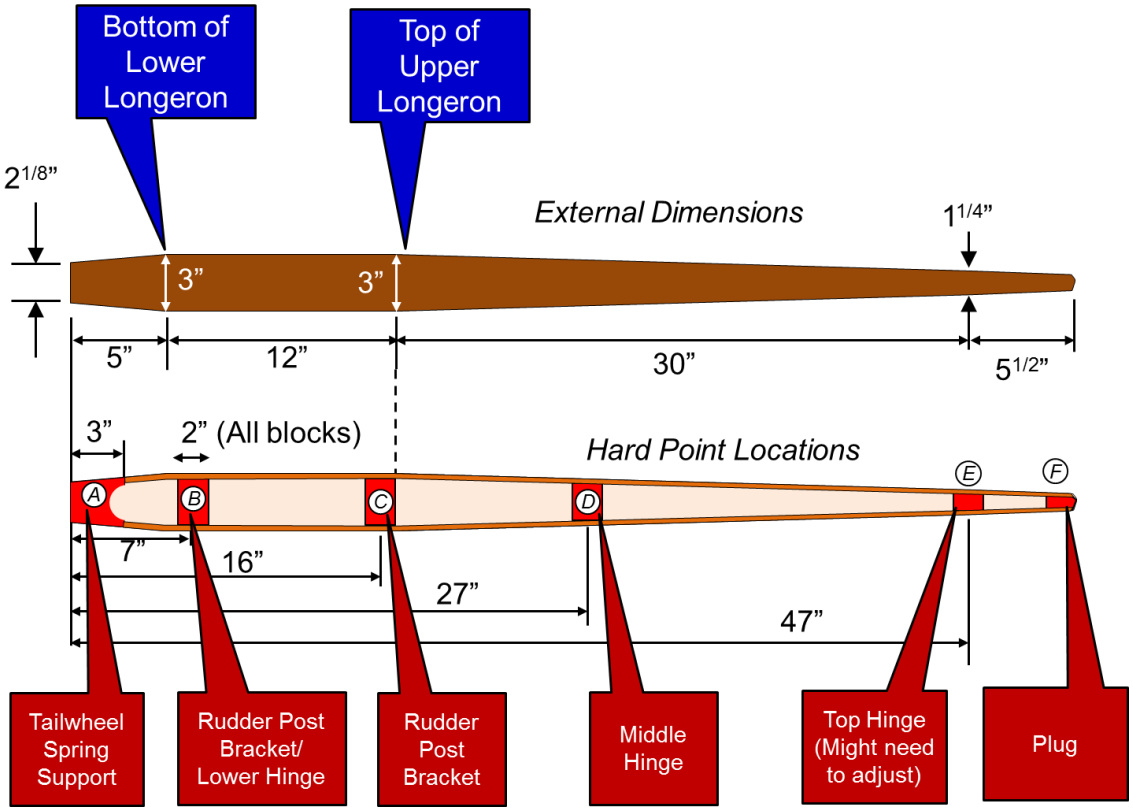


Figure 52: Rudder Post Dimensions and Uses

The block inserts in the design are labeled by circles with A through F inside. The blocks are used as follows:

A: The tailwheel support bracket bolts to this hard point.

B: This block supports the lower bolt that holds the bracket to the rudder post. The lowest rudder hinge attaches here as well.
C: The upper bolt that holds the rudder post to the bracket goes through here.
D: Middle hinge for the rudder
E: Top hinge for the rudder
F: A "Plug" at the top of the structure to close it up.

The bolts in the tail are installed with the heads aft (contrary to normal practice), so that nut plates can be installed on the front of the rudder post for the hinges. This will allow removal of the hinges without having to cut open the tail fabric to access that end of the bolt.

4.6.1.2 HARD POINT LOCATION ISSUES

Figure 53 shows how the rudder post is installed at the back of the fuselage, and how the various other components that attach to it.

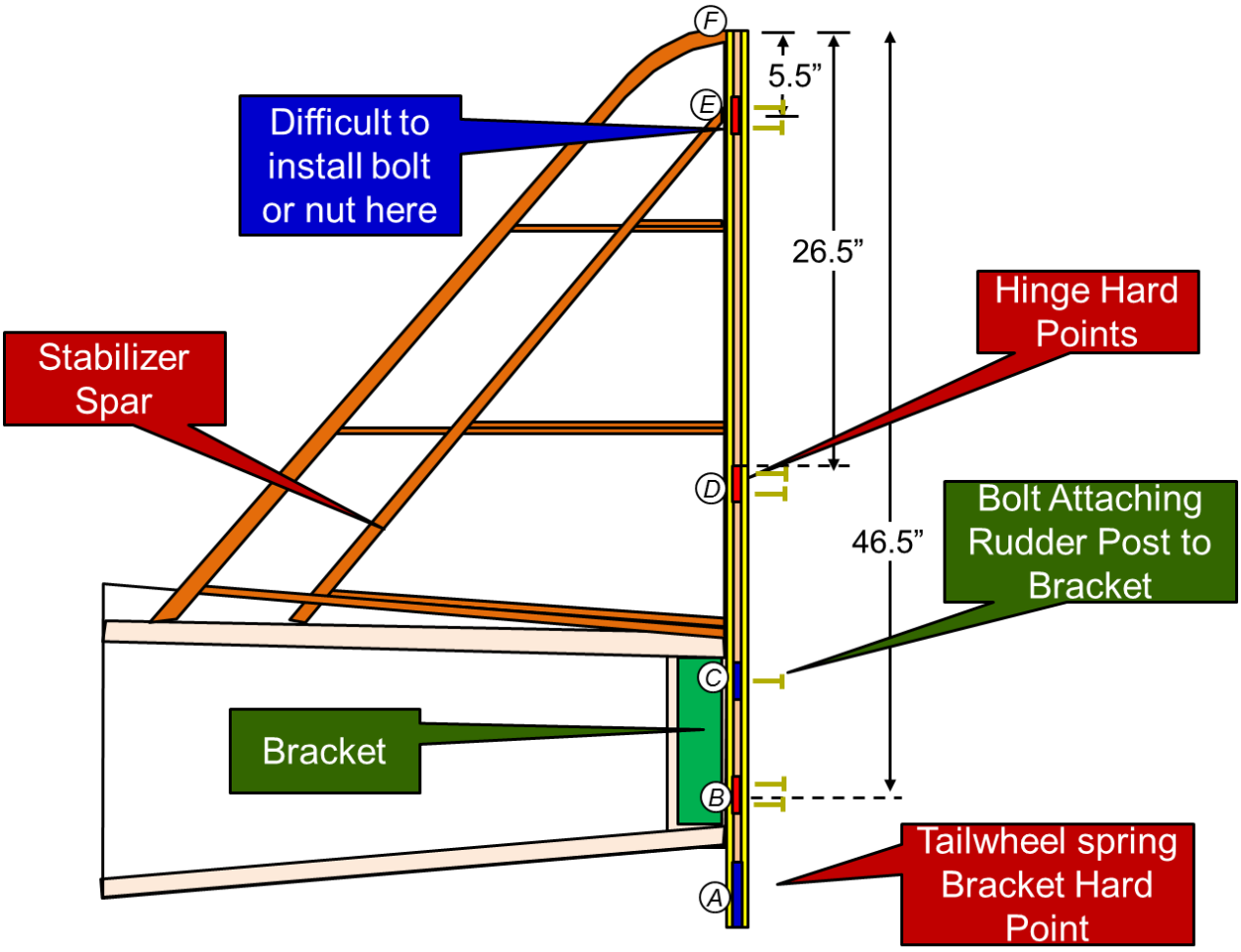


Figure 53: Interference Issue with Upper Hinge Point

As mentioned in Section 2.6, Block "C" is depicted in the wrong position in the EAA article. It should be about ~1 inch lower. As the above diagram shows, the block would have been partially above the location of the bracket.

Builders have reported problems with Block "E" as well. As the above picture shows, it is located near the main spar for the vertical stabilizer. That's an excellent location, load-wise, but the presence of the diagonal spar makes it difficult to install the bolts in the hinge. Consider

making this block ~4 wide rather than two inches, to give some leeway later if necessary. One builder just moves this block higher to clear the diagonal.

Block "A" is A ~3" long hard point is included at the bottom of the rudder post, to accept the tailwheel spring attach bracket (Figure 54).

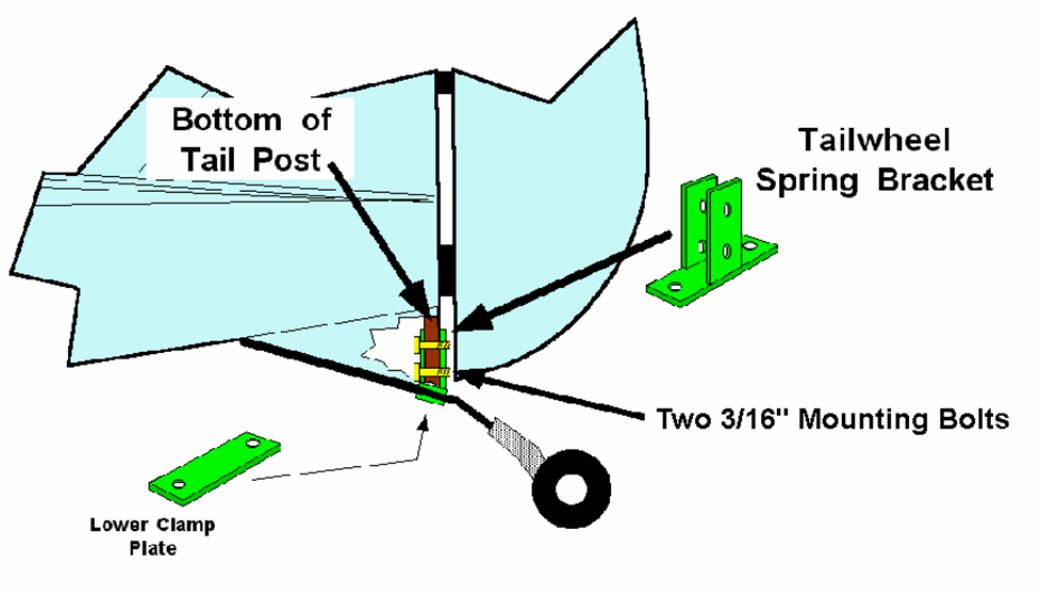


Figure 54: Tailwheel Spring Support Bracket

However, my own experience with this bracket indicates it should be a bit longer; long enough to accept three bolts through the lower hard point instead of two (Figure 55). And in that case, Block "A" must be longer.

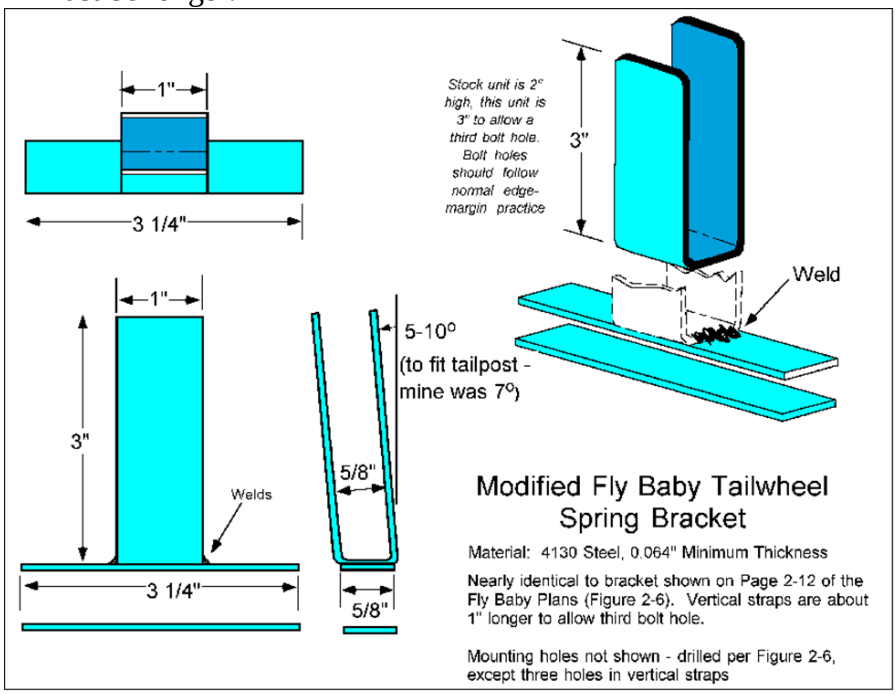


Figure 55: Modified Tailwheel Spring Bracket

4.6.1.3 SOLIDIFYING THE RUDDER POST

As mentioned in Section 3.1, the sealed box of the rudder post can trap moisture and encourage dry rot. And as mentioned earlier in this section, the blocks for several of the hard points need to be adjusted a bit and/or made a little larger.

One option here is to replace all the blocks, and the 3/8" square spruce around the periphery, with a solid piece of 3/8" spruce (Figure 56). One could use a solid piece of 5/8 spruce instead, but there are strength advantages to retaining the plywood face pieces.

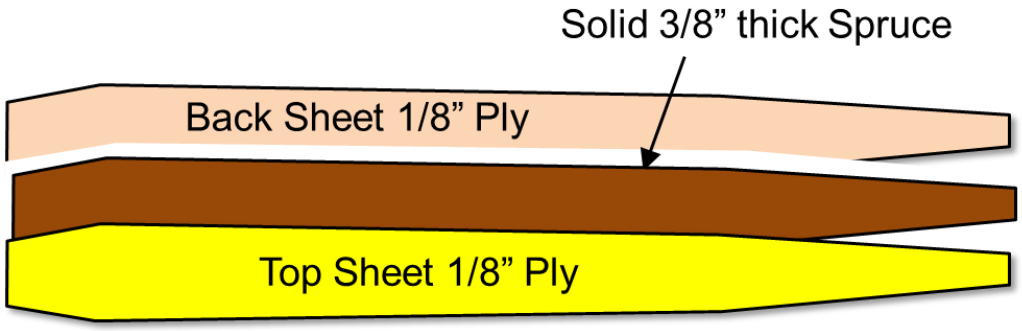


Figure 56: Solid-Core Rudder Post

This eliminates the potential for dry rots in the voids, it provides hard points for the bracket bolts, and it allows shifting the rudder hinges to handle any installation contingency.

The downside is weight. This "solid core" rudder post will weigh about 1.4 pounds more than the stock rudder post.

Another option would be to use solid spruce from the tail spring bracket end to the upper bolt for the tail post bracket.

In any case, make sure the internal area of the built-up rudder post is thoroughly varnished before closing it up.

4.6.2 Rudder Post Bracket

The rudder post bracket (or "Channel") is made from 0.032" type 4130 steel. Figure 1-11 calls for 0.064", but 0.032" is listed in both Figure 1-2 and the materials list for the plans.

The piece is a slightly-flatted "U" section, with each leg 1.5 inches long. The bends should be with a minimum radius of about 1/8ths of an inch. The overall length of the bracket is 10.5 inches, and each arm has three 3/16" holes along each leg's centerline for bolting it to the structure. The bracket is defined in Figure 1-11 on Page 6 of Article 3, The "B-B" detail in Figure 1-2 on Page 4, and in Figure 57 of this document.

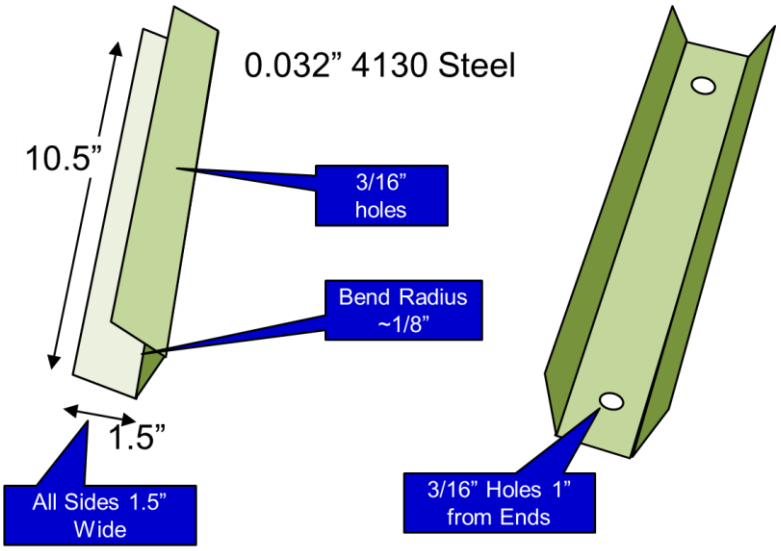


Figure 57: Rudder Post Bracket

Two 3/16" holes are drilled in the center section, one inch from the ends. These are for the bolts that attach it to the rudder post, and correspond with blocks "B" and "C".

Of course, the steel bracket must be painted before installation.

The rudder post bracket is installed after the rudder post is glued to the aft fuselage. Figure 58 illustrates how the front side of the rudder post should be prepared for installation. The lines corresponding to the top and bottom longerons should be marked, and the area where the bracket will be installed should be varnished. Don't varnish outside the bracket area, since most of that will be glued to the tail of the fuselage.

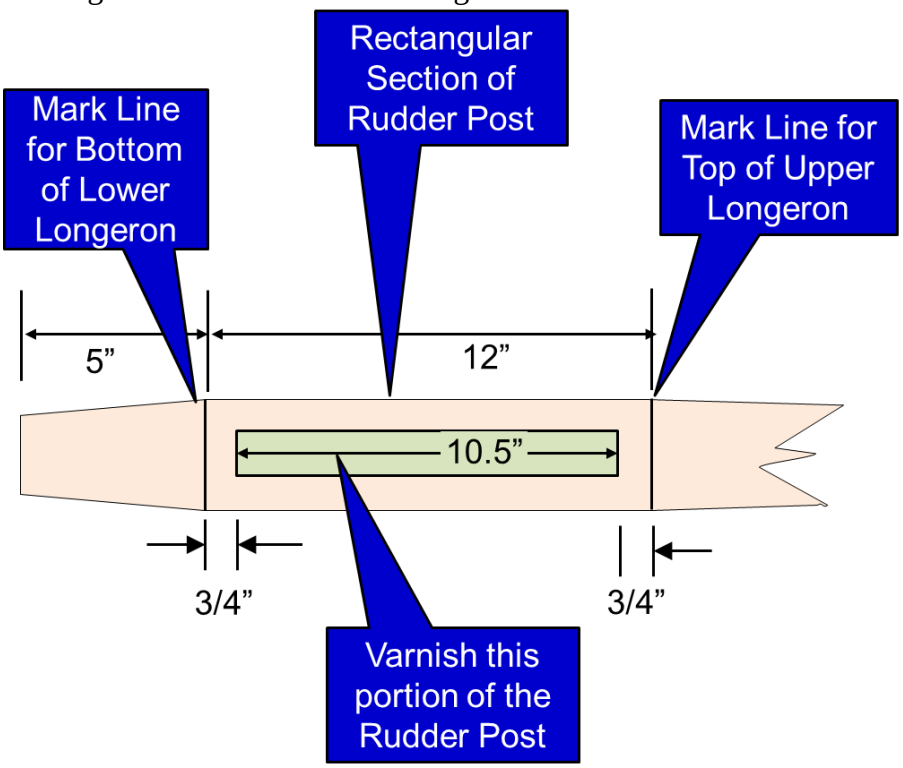


Figure 58: Rudder Post Preparation

Once the rudder post has been glued to the fuselage, the bracket will be installed on the centerline of the rudder post, with the bottom end (on the left) 3/4" past where the bottom taper ends, and the top 3/4" before the rectangular section ends.

Note that the bracket is exactly 1.5 inches shorter than the top-to-bottom measurement of the aft longerons at the tail. This is because small spruce laterals will be installed above and below the bracket, between the fuselage sides.

4.6.3 Final Beveling Before Rudder Post Installation

Before bolting the rudder post to the aircraft, some final beveling must be performed. The tail uprights, the ends of the longerons, and the tail post itself must be beveled so that everything fits snugly. The basic goal is that the uprights, and the longerons, will need to present a flat surface for solid joining of the rudder post.

At the (beveled) ends of the longerons, measured to the outside of the plywood, the fuselage should be 3.25” inches across, as shown in Figure 59. A pair of temporary braces and some bar clamps can be used to get the proper spacing.

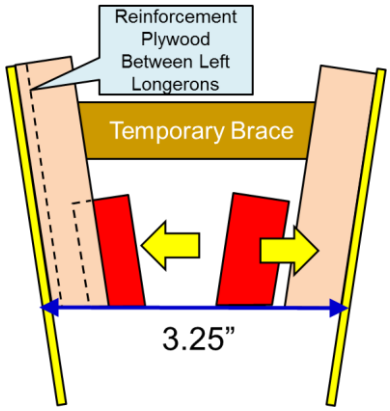


Figure 59: Setting the Tail Spacing

Note the reference to “Reinforcement Plywood” in Figure 59. This is the tail doubler, and is applied on only the left side. Its installation is described in Section 4.6.4

4.6.3.1 LONGERON BEVELING

When the rectangular longerons are bent together to meet at the ends, the square-cut faces are not flat in relation to the rudder post, either, as shown in Figure 60. So in addition to beveling the uprights, the ends of the longerons must be shaped, without disturbing the plywood. Jim Katz reports the angle is 7.65°.

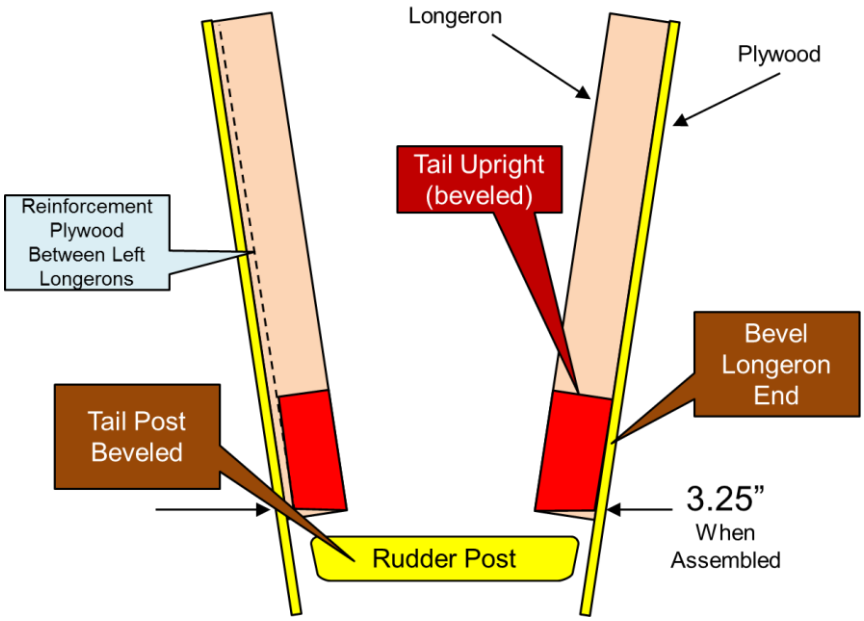


Figure 60: Beveling Needed at End of Tail

Frankly, beveling the longerons would have been easier before the plywood had been applied…or even easier to bevel the longerons before gluing the fuselage truss.

The problem is, this is kind of an "eyeball" thing. Plus beveling the two fuselage sides will have to be done differently, since the "cut back" section is on top for the left fuselage side, and on the bottom for the right side (Figure 61).

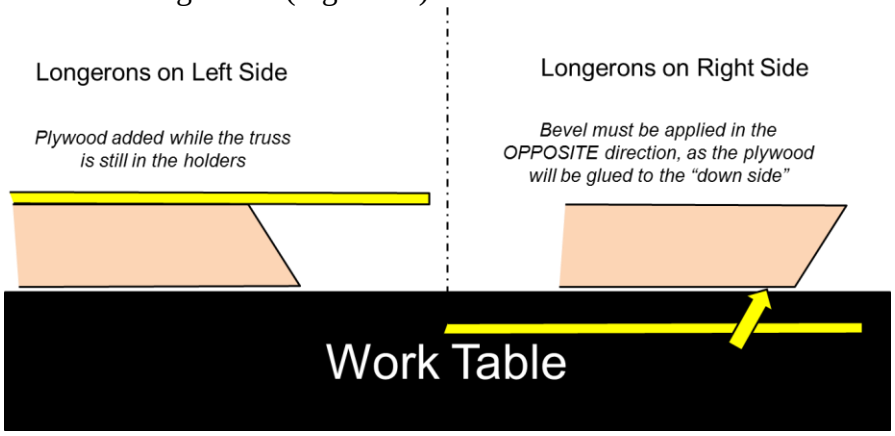


Figure 61: Applying the Tail Beveling During Assembly Has to be Done Carefully

The figure illustrates the potential for confusion. It's probably easier, mentally, to bevel the longerons. Leave the 1/8" plywood alone, for reasons that will soon become apparent.

4.6.3.2 STATION 11 UPRIGHT BEVELING/GLUING

The Station 11 uprights haven't been glued in to this point, specifically because of the needed beveling. Since they're still not glued it, this can be done on the table saw. I'd recommend cutting some scrap wood first to ensure the angle is right.

When the angle is right, line up the beveled edges with that longerons and glue the Station 11 uprights into place.

Remember, the two Station 11 uprights are of different thickness—don't switch them!

4.6.3.3 RUDDER POST BEVELING

As Figure 60 illustrates, the tail post itself will need to have its sides beveled. The distance inside the plywood at the tail is three inches, which is the same width as the rudder post. So the rudder post needs to be beveled back to match the plywood on the sides.

It's probably best to install the rudder post bracket before performing this work, as the beveling will tend to obscure the definition of the rectangular area defined in the earlier figure. Strictly speaking, the beveling is only needed in the area near the fuselage plywood. But running it across the entire length on both sides will make the vertical stabilizer look better when completed.

4.6.4 Tail Doubler

Per Pete's instructions, install a 1/8" plywood doubler on the inside of the LEFT fuselage only, as shown in Figure 62. Note that this piece of plywood is a doubler, glued directly to the inside of the plywood covering the fuselage side. It does not form a box structure, hence do not varnish inside.

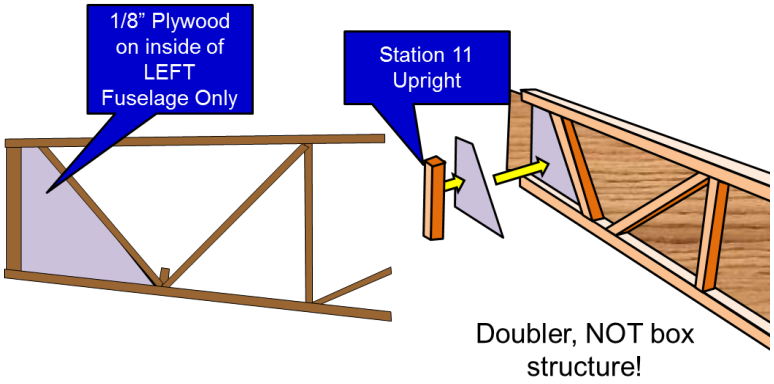


Figure 62: Aft Fuselage Doubler (Left Side Only)

The doubler goes from the Station 10 diagonal all the way to the ends of the longerons. The Station 11 upright should not have been glued yet, so remove it, glue in the doubler, then set the upright back in place. The upright goes on top of the doubler, that's why the upright at Station 11 on the left side is only 5/8" thick.

Bevel the plywood to match the upright and longerons.

4.6.5 Installing the Rudder Post

At this point, actually installing the rudder post is actually anti-climactic. The major effort is to ensure the rudder post—which is the main spar for the vertical stabilizer—vertical, and at 90 degrees to the fuselage axis. Keep the temporary braces and bar clamps holding the fuselage sides (Figure 59) in place.

The rudder post will need to be slid between the plywood sheets on the fuselage side from below or above. Make sure the fuselage is sitting level on the work table, and use squares, plumb bobs, laser levels or what have you to get the rudder post as close to vertical as possible.

Once you're sure of the fit, remove the rudder post and liberally apply glue to the interface areas. Slide the tail post back into place, check that it's properly aligned, and clamp it in position.

Make sure the fuselage-side plywood is glued to the side of the tail post, as well. When the glue has cured, cut back the excess plywood and shape it to the rudder post.

4.6.6 Mounting the Bracket

The rudder post mounting bracket is installed once the glue holding the rudder post to the fuselage has cured. Slide it into position, then bolt it to the rudder post by two AN3 (3/16") bolts

Each side of the bracket is held to the Station 11 upright with three bolts (Figure 63). Start with the upper bolt on the right side. Select a spot that will go through the bracket about an inch down from the top—that'll be two or so inches from the top of the longeron—and in the center of the arm of the bracket.

Figure 63: Rudder Post Attachment Bolts

Then drill a 1/8" hole through the fuselage plywood and through the Station 11 uprights into the center of the bracket "arm". Change to a 3/16" bit, and drill the hole to final size.

Slip a bolt into that hole (with an AN970 wide washer at the head), add a washer and nut to the inside, and snug it up.

Switch to the opposite side of the fuselage, and find a good spot for the lowermost of the bolts. Again, it needs to go through the center of the arm about an inch from the bottom.

Drill the 1/8" pilot hole, followed by the 3/16" final size. Install another bolt, washers, and nut.

Complete the other four bolt holes in the same fashion. Insert a bolt, but don't bother with the nuts and washers.

4.7 Aft Fuselage Cross-Pieces

Attach two cross pieces between the top and bottom longerons all the way in the back of the fuselage, as depicted in Figure 64. These should be jammed hard against the rudder post and glued.

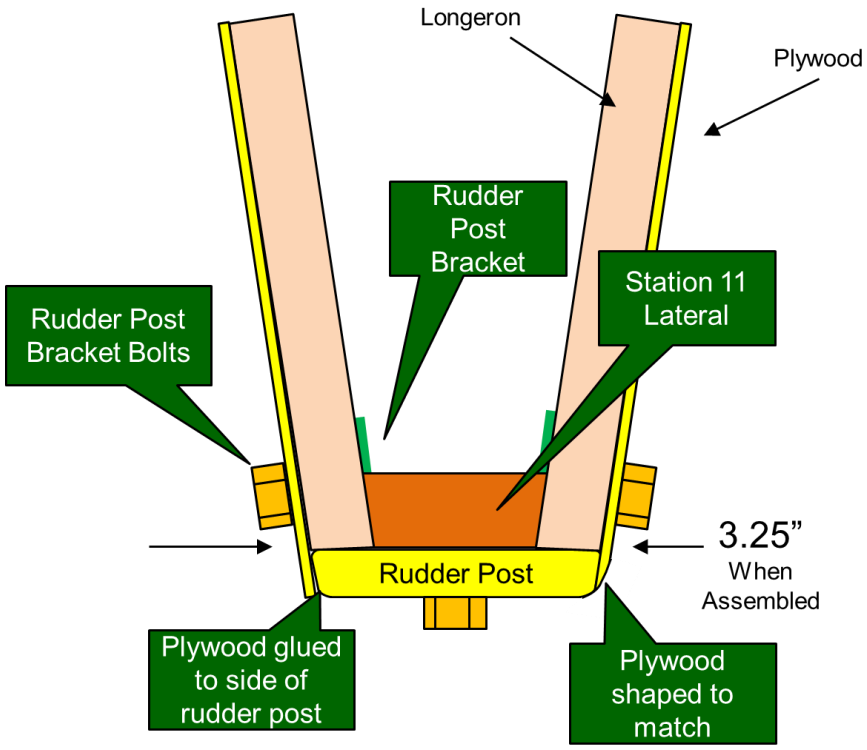


Figure 64: Laterals at Station 11

Because the lower longeron slopes upward, the lateral between the lower longerons has to be (shudder) beveled. See Figure 65. The figure shows the top of the lateral level rather than beveled to match the top of the longeron. Since this is glued to the Station 11 upright, too, it doesn't much matter…and is easier to make.

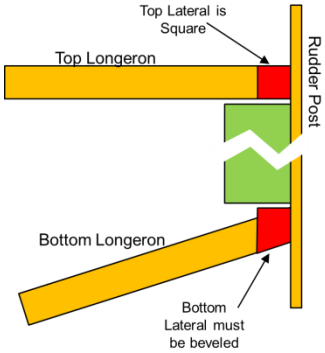


Figure 65: Bevel in Lower Lateral

4.8 Station 9 Tail Spring Support Lateral

Back when the fuselage trusses were being built, a temporary block was placed in the Station 9 location on the bottom of the fuselage truss. Time to replace this with a hardwood tail spring support lateral.

Figure 1-11 on Page 6 of Article 3 shows this very clearly. Not only is the notched hardwood glued into position, but support anchors (3/4” plywood) are glued over it and to the inside of the fuselage plywood.

This lateral is one inch thick. The “big box” stores don't normally sell red oak in widths greater than 3/4", so this piece of hardwood will need to be purchased from a specialty lumber outlet. The prices aren't too bad, and you just need a piece 1” thick, 2” high, and about 18 inches long.

When it's in place, mark the centerline of the fuselage on the top of it and drill a 5/16” hole vertically through it, as seen in Figure 1-11.

4.9 Tail Plywood

Part of the extreme tail, on both the top and bottom, are covered with plywood to facilitate several functions.

4.9.1 Top-Longeron Plywood in the Tail

Start with adding two additional 3/4" square laterals as shown on Figure 1-11 on Page 5 of Article 3. The first is between the centers of the half-round supports for the horizontal stabilizers. The centerline of the second is 7 inches forward of the rudder post

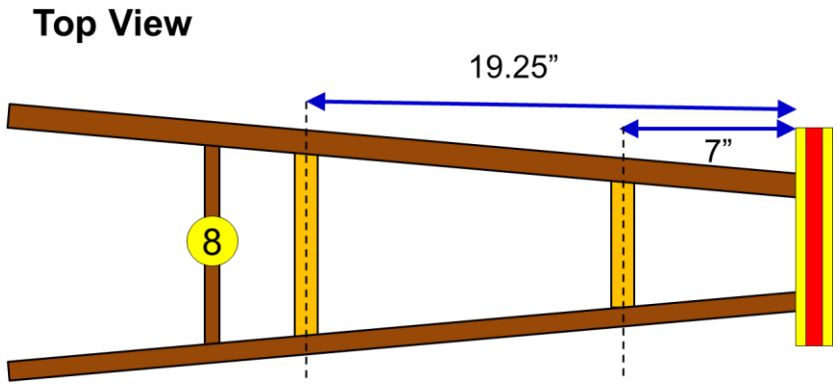


Figure 66: Additional Laterals

Two pieces of plywood are installed on the top of the fuselage over these laterals. They’re shown in Figure 1-12, just below the figure showing the laterals.

The 21” dimension in Figure 1-12 is wrong; it should be 19.25 inches, the same as the lateral in the above figure. The plywood actually goes over the lateral and swoops a bit forward, as Figure 1-12 shows.

If you look very carefully on Figure 1-12, you’ll see that the lateral added 7” forward of the tail actually has a notch in it. This is half the thickness of the lateral, and it provides clearance for the top elevator control cable.

4.9.2 Bottom-Longeron Plywood

Figure 1-13 on Page 6 of Article 3 shows the plywood going on the bottom of the fuselage. It’s from the hardwood lateral at Station 9 all the way to the end of the fuselage.

4.10 Tail Skeg Construction

Yes, it’s a real word. Look it up. A “Skeg” is defined as, “…a tapering or projecting stern section of a vessel's keel, which protects the propeller and supports the rudder.”

Aviation stole a lot of terms from the nautical folks (rudder, spar, rigging, etc.), and “skeg” is one of them. In aviation, the skeg is a structural support for the tail skid or tail wheel, or, in some cases, a projection that is strong enough to drag on the ground if someone pitches a tricycle-gear plane too far during takeoff or landing.

On the Fly Baby, the tail skeg is the projection below the tail. It’s actually a rather strange item; the plywood on it take a weird slant.

Basically, two 1/4" squares are glued to the bottom of the lower-longeron plywood that was just installed. They’re even with the lower portion of the rudder post at the point to comes

out from beneath the fuselage, but narrow down to a 2” gap by the time they reach the Station 9 cross-piece (Figure 67).

Figure 67: Starting the Skeg

A sort of wooden channel is constructed, as shown in the inset on Figure 1-13, using 1/4" squares and 1/8” plywood. This is the diagonal piece at the bottom of the skeg (Figure 68). The front is slanted to join the underfuselage plywood, while stretching back to the bottom of the rudder post (Figure 69).

Figure 68: Skeg Bottom Piece

Figure 69: Tail Skeg Under Construction

Plywood is attached on the sides, to the 1/4" square strips, to close out the area. Figure 70 shows what it looks like when completed.

Figure 70: Completed Tail Skeg

Varnish the inside before installing the plywood. If you note the drawing for the center channel, there's a big U-shaped hole. This is the part that installs to the rudder post; the hole gives access to the tailwheel spring bracket bolts as well as ventilating the area.

5 ALTERNATE APPROACHES

The following topics have been discussed within the Fly Baby community. They may provide advantages to the builder, but have not been verified as viable.

5.1 Routing Out the Fuselage Plywood

Weight is the enemy for aircraft, and one way some Fly Baby builders try to save weight is to route out the plywood in the aft fuselage, between Stations 6 and 9 (Figure 71). Pete used 1/8" plywood for the fuselage side because it was cheaper than the 1/16" ply that would have been adequate. Many wooden homebuilts merely gusset the intersections with 1/8" plywood. So cutting away the excess plywood shouldn't affect the strength and may save

Figure 71: Routed Fuselage

Do the routing before the fuselage sides are attached to each other. Leave a generous allocation around each joint and along each component. Drill a generous hole at each corner (~1/2"-1") and cut out the panels between.

The 1/8" plywood on the Fly Baby weighs about 20 pounds for both sides (11 lbs. per 4x8 sheet, each fuselage side is roughly 2 ft. x 15 feet). An eyeball estimate of the above fuselage shows about ~1/3rd of the plywood has been removed, for an estimated weight loss of roughly six to seven pounds.

One advantage of the routing is that it gives better access to the inside of the fuselage while gluing the laterals and diagonals. The downside is the effort required.

5.2 Shoulder Harness Alternatives

I'm not sure when EAA added its "Shoulder Harness Pledge," but N500F included a provision for a shoulder harness from the very start.

However, the design is not ideal. The stock harness attaches to the Station 6 area and is routed forward underneath the baggage shelf. It then emerges from the slot on the top of the Station 5 bulkhead and wraps over the pilot's shoulders (Figure 72).

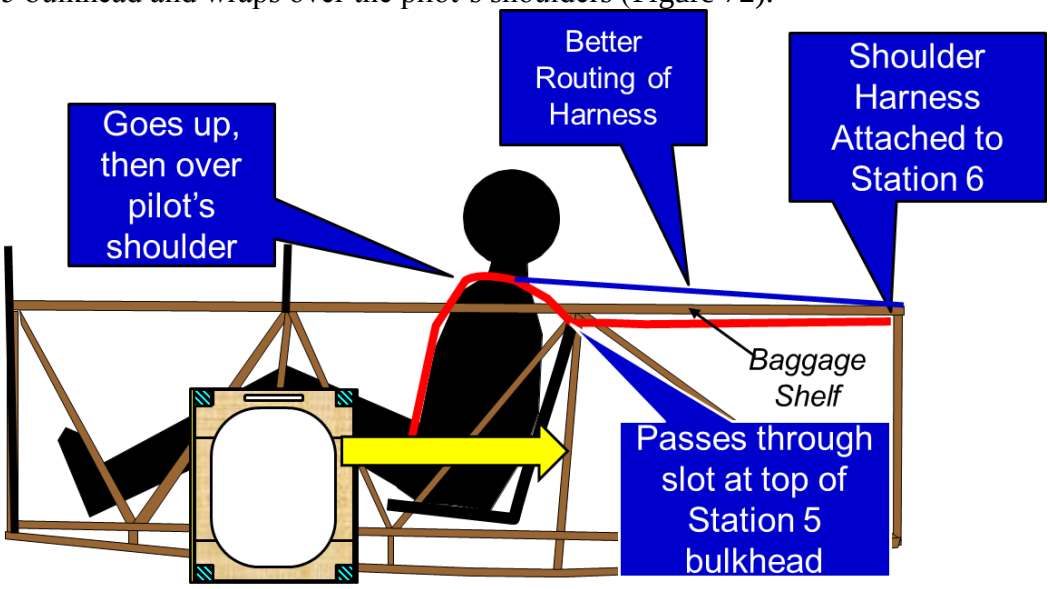


Figure 72: Shoulder Harness Routing

The problem is the upward curve in the shoulder harness applies downward pressure in a crash. This is not the ideal situation.

Ideally, the shoulder harness would run ATOP the baggage shelf, as shown by the blue line in the above illustration. This does tend to make use of the baggage shelf awkward, and the baggage compartment door will need to include provision for feeding the seat belt through.

END OF COMPANION GUIDE FOR ARTICLE 3