1/3rd Scale Mita Type 3 Production Notes

The third part of a multi-part series.

Norimichi Kawakami Follow
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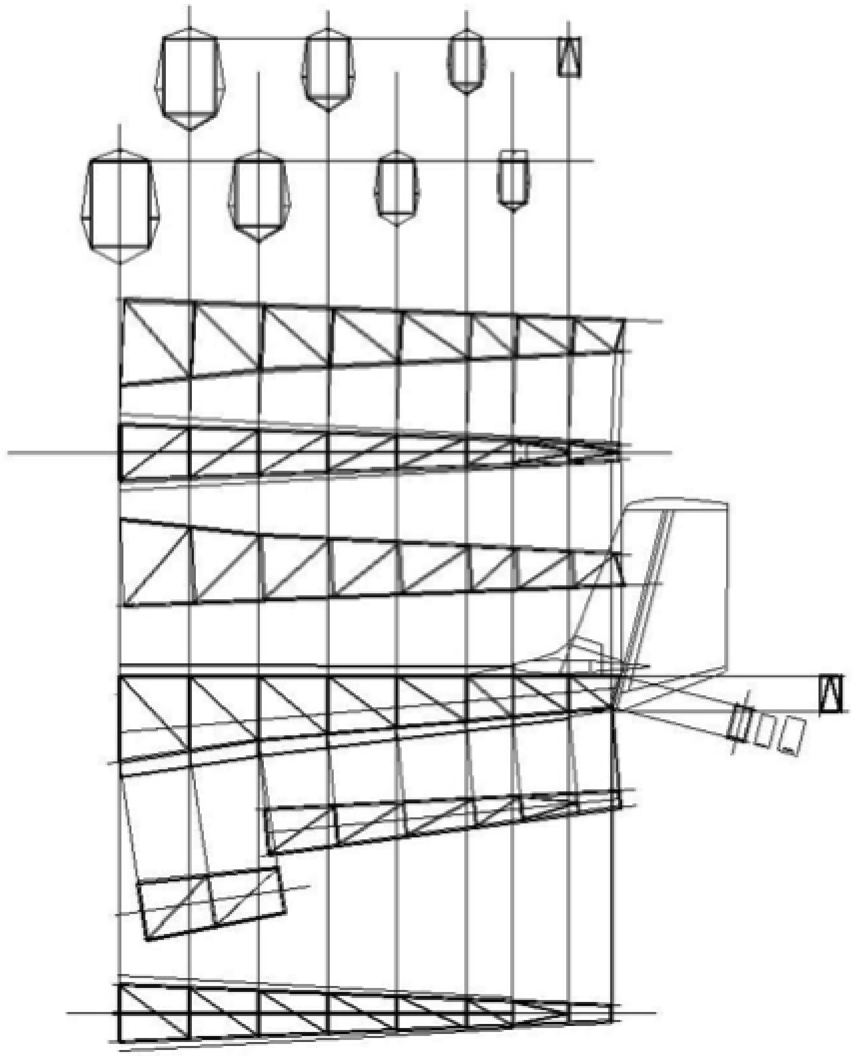
You may want to read the second part of this series before proceeding to this article. Also if you prefer, you can read this article in its original Japanese.

Fabrication Part 5: Rear Fuselage

It was time to begin the construction of the rear fuselage main truss structure made of carbon pipes.

Structure of the rear fuselage



Drawing 10: Structural drawing of the rear fuselage

Drawing 10 is the structural drawing of the rear fuselage. The rectangular shape of the cross section is the main structural truss. This part is responsible for strength and rigidity. The upper and lower trusses have one longitudinal run each. The upper truss is supported by a single support rising from the center of the upper rectangular side, and the lower truss is supported by supports extending from both lower corners of the rectangle, forming a triangular truss structure. Slightly below the center of the left and right sides of the rectangle, there are plate-like longerons one for each side. These are covered by the outer skin, resulting in an octagonal cross-sectional shape.

The side view and top and bottom views show that the four longitudinal members that form the four corners of the main structural trusses run back and forth, and the vertical and horizontal members at equal intervals connect these longitudinal members to form a ladder-like truss structure. A single diagonal member is placed between each step of the ladder to provide torsional strength and rigidity.

Material for the main structural truss of the rear body

It was decided at the time of the basic conceptualization that all main structural trusses would be made of carbon pipes. The longitudinal members, which are the strongest members, will be made of 7×5 pipes (outer diameter 7 mm, inner diameter 5 mm), the parts corresponding to the upper and lower, left and right ladder steps will be made of 5×3 pipes, and the diagonal members will be made of 3.5×2 pipes.

Cutting Carbon Pipes

This is the first time for me to work with carbon pipes. I had some doubts about how to cut it, but I found that I could cut it rather easily by attaching a diamond circular saw purchased at a hundred-yen store to a mini-router and cutting the pipe while turning it. However, as black carbon chips will fly around during cutting, it should be done outdoors.

Photo 29: Mini router for cutting carbon pipes

The cut surfaces were shaped with a round file coated with diamond powder, which I bought at a hundred-yen store, because the joint partners were circular. This was difficult to do outdoors, so I placed a vacuum cleaner nearby to suck out the chips.

Fabrication of the top panel

The first step was to make the top panel of the rear body. I spread the full-size drawing on a flat board and covered it with a thin polyethylene sheet to prevent the glue from dripping on the board. I then nailed a thin piece of cypress to the board along the outside line of the longerons. This is for positioning the longerons.

Next, the ladder rungs are cut out, and the end faces of them are individually shaped with a round file to fit perfectly the longerons. The rungs have a diameter of 5 mm and the longerons have 7 mm diameter, so thin 1mm-thick cypress bars were placed under the rungs to adjust the height.

After I finished fitting all the rungs, I checked to make sure there was no floating, then dropped thin CA on the joints. This is a temporary fix, and the real fix will be done after everything is assembled with epoxy adhesive applied to the joints.

Next, the diagonal members are attached in the same way. The diagonal members are 3.5 mm in diameter, so the thin bar underneath should be thicker. The lower panel of the rear body was made in the same way. Photo 30 shows the production status of the upper panel.

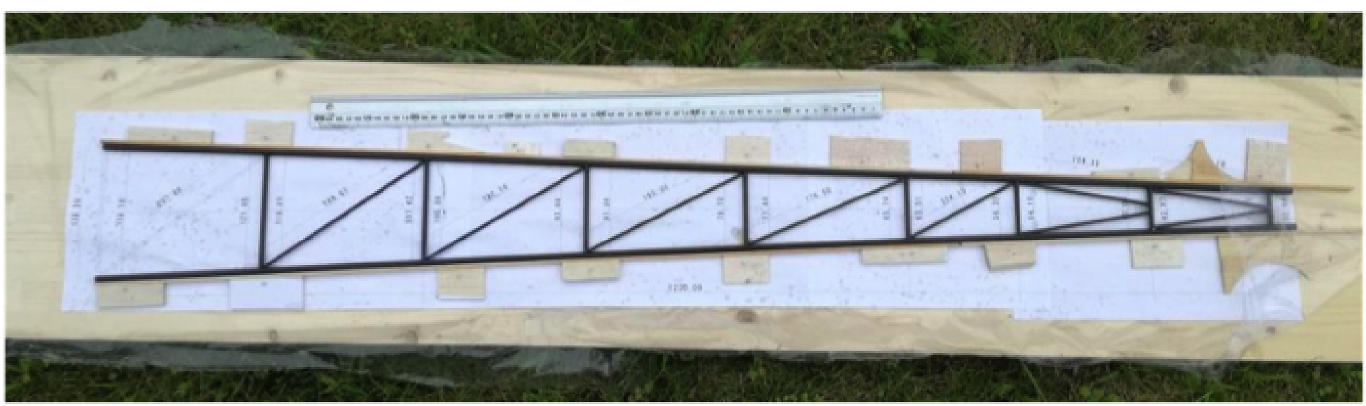


Photo 30: Production of the upper panel of the rear fuselage

> **Mistake №5:** *I was satisfied with the smooth production, but there was an unexpected pitfall. When I looked through the assembled upper panel from the rear, I found that the longeron, which should be straight, was bent!*

At first, I was puzzled as to the cause of the problem, thinking that it couldn't be because it was made by positioning a thin cypress guide. The cause was unexpected. The drawing was crooked! I only have an A4 printer. This printer can only hold 210 mm wide copy paper, but the length can be up to 1,100 mm using the user-defined function of the printer software. This upper panel has a maximum width of about 120 mm and a maximum length of 1,230 mm, so if you use long pieces of copy paper, you can get a full-size drawing in one paste. So, I cut three sheets of A3 paper into 210 mm wide and pasted them together to make a long sheet of paper about 210 x 1,200 mm, and printed a portion of just under 1,100 mm. Next I printed the rest on A4 paper, and then carefully pasted them together. This pasting was done with care, so there was no deviation, but the bend was in the area where the three A3 sheets were pasted together and printed.

When you put a long piece of paper into the printer, even if you put it in carefully, it will not go into the feed roll vertically, but will be at a slight angle. Therefore, while feeding the paper 1,100mm, the paper will come closer to the left or right and hit the edge of the paper feeder. So the paper is restricted to leaning to either side. This makes it difficult to print a straight line. At first glance, it was hard to find any problem with the 1,100 mm print, but when checked with a ruler, I found it had a waviness of 1–2 mm at maximum. Since I fixed thin bars to hold the longeron in place along this waviness, the resulting panel naturally had a waviness. The lower panel was short, so I confirmed that no such inconvenience had occurred. The upper panel is temporarily attached with CA, so it can be disassembled by impact. I took it apart, although I had taken great care in making it.

The Importance of Assembly Order

Before I started to reassemble the upper panel, I prepared the materials to make a jig to assemble the two lower panels, but then I realized that I was doing it wrong again.

The two lower panels are connected at an angle in a "V" shape, so I was thinking of making a jig with that angle and assembling them on it. Since the panels are large, I thought the jig would be quite large as well.

However, if you look closely at the drawing, you will see that the sides are on the same plane! This means that if I make the two side panels first in the same way as the top panel, I can connect them with vertical members and make the "V" shaped bend at the bottom without a jig. I felt ashamed of myself for believing, without thinking too much about it, that I had to make a total of three panels, one for the top and two for the bottom, and then assemble them on a jig.

> **Lessons Learned 3:** *The need for jigs changes depending on the assembly order. Examination of the procedure is very important.*

Photo 31: Making the rear fuselage side panels

Therefore, I decided to make the side panels instead of making the top panel again. However, since the two lower panels have already been fabricated, the fabrication of the side panels is slightly irregular this time. Photo 31 shows the production status.

The left side is the underside and the top is the right. In this photo, the right side panel has already been completed and attached to the bottom panel, and the left side panel is being made. The bottom panels are assembled by inserting jigs to make them stand vertically on a flat plate. For the printing of the drawing, this time, I cut A3 paper into 210mm widths, printed them one by one, then pasted them together. This way, the length of printing is 420mm, so the risk of printing crooked is reduced. This is the same procedure issue as *Lessons Learned 3*.

Finished rear fuselage main truss structure assembly

Finally the main truss structure of the rear fuselage was assembled after these mistakes and reflections.

Photo 32: The completed rear fuselage main truss structure

This time, the assembly was quite accurate. Photo 33 shows the front view.

Photo 33: Rear fuselage from the front

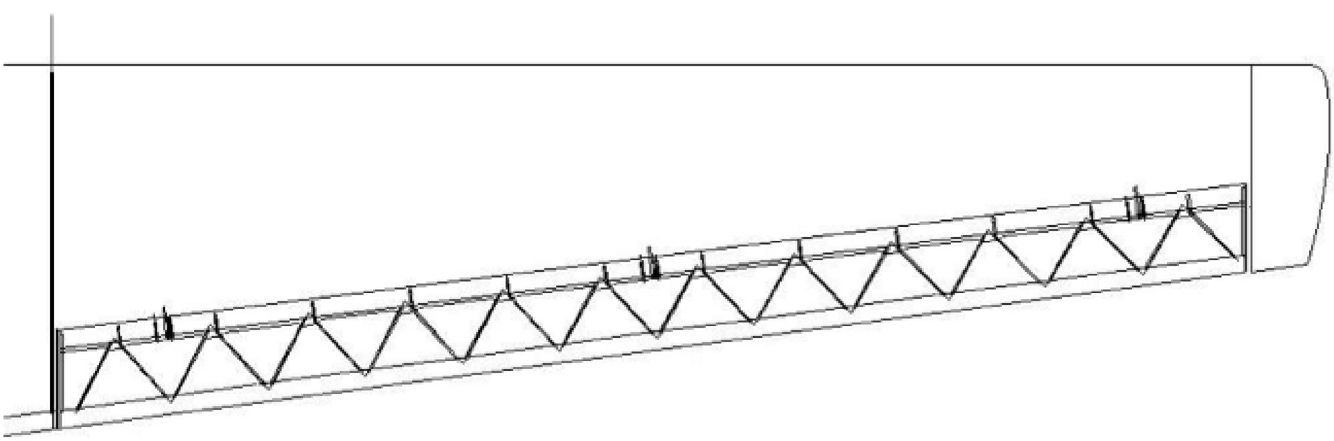
The longerons went straight through, and the upper, lower, left and right members corresponding to the steps of the ladder were assembled neatly.

Fabrication Part 6: Ailerons

Next, I started to build the ailerons.

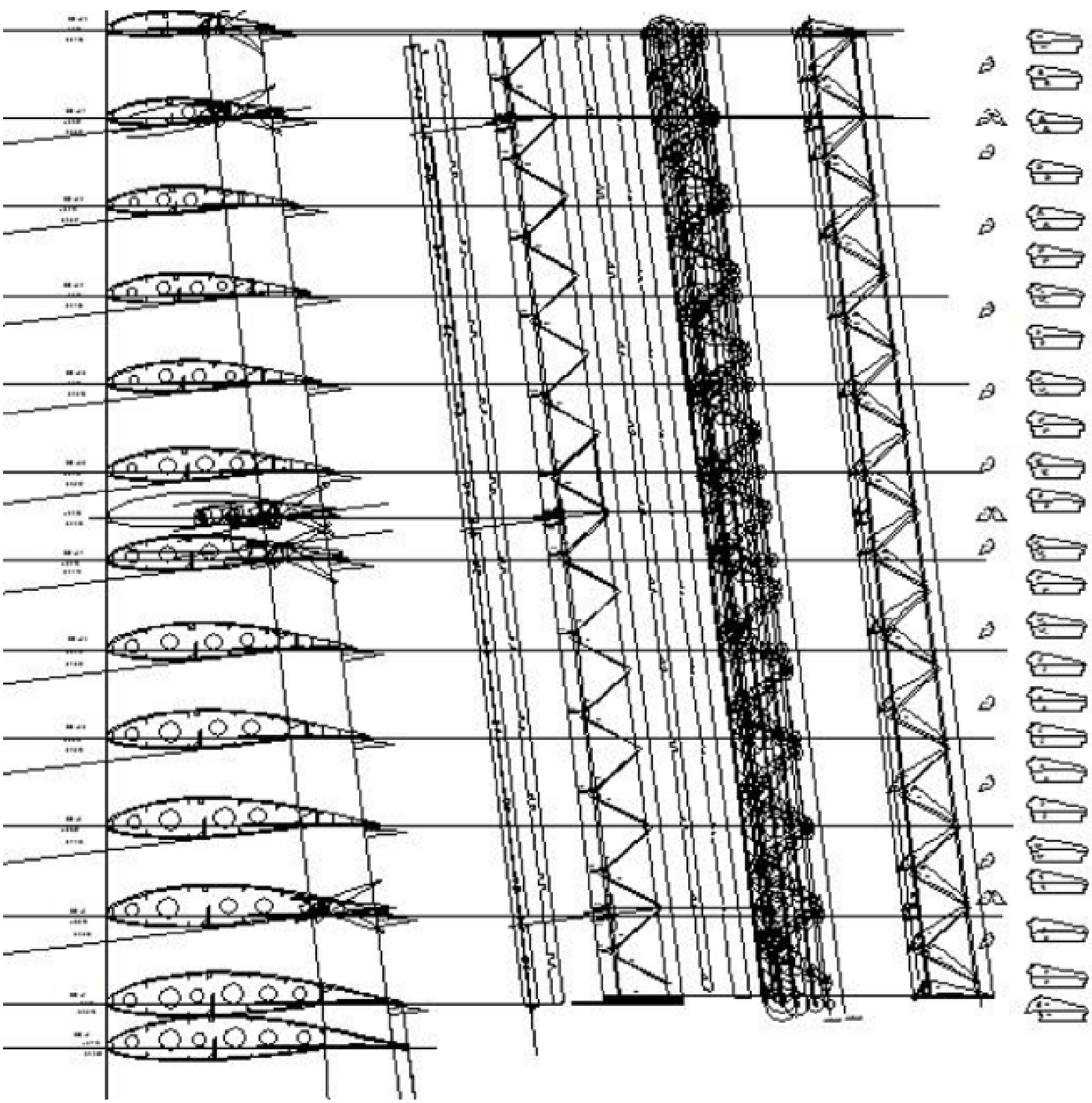
Design

Drawing 11 is for the right aileron. The length is about 1,100mm, the inner chord length is 90mm, and the outer one is 81mm, slightly tapered.



Drawing 11: Plan view of the right aileron

Although it looks simple at a first glance, the design of the ailerons was the most difficult part of the design of this plane. It is the same as the rudder and elevator in that all the ribs run diagonally, but the aileron has 26 ribs on one wing. Moreover, the innermost and outermost ribs are in the direction of the airflow. In addition, the leading edge of the aileron is parallel to the rear spar of the wing, so its cross section must be defined perpendicular to it. It was a difficult task to find this shape in 2D CAD. In the end, I spent about a month in June 2018 on this work. Drawing 12 shows the design process.



Drawing 12: Design process of aileron

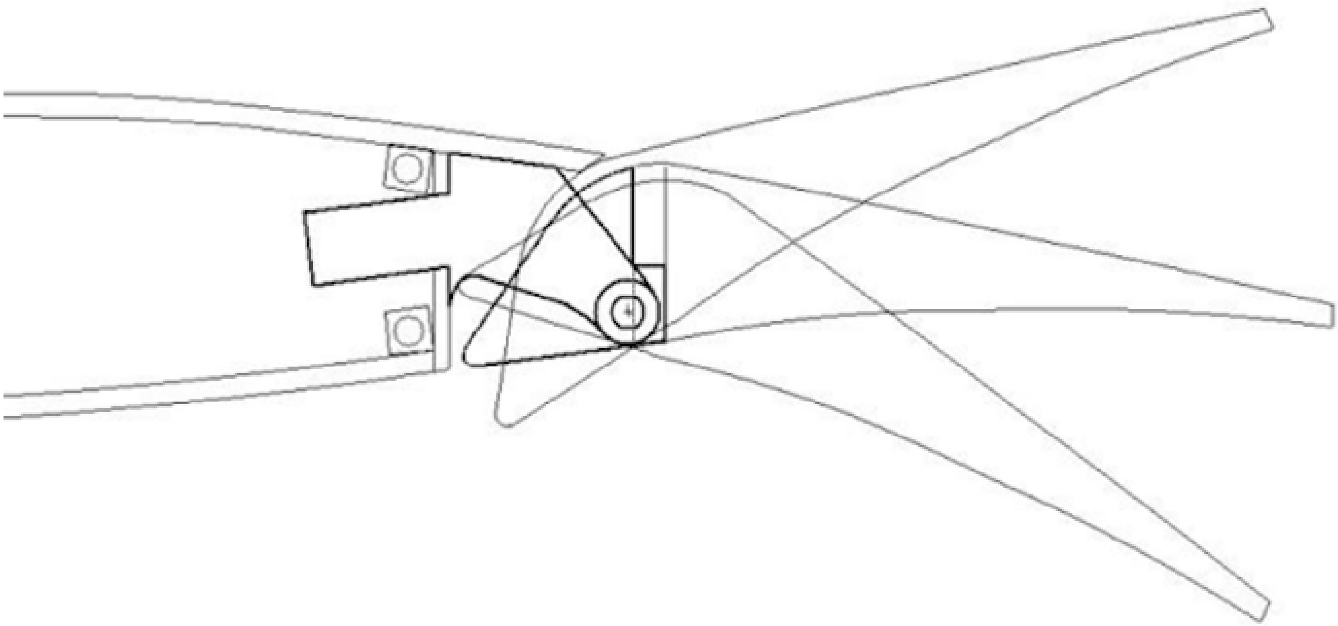
However, I cannot complain about such a thing. In the late 1960s, when the actual machine was built, there were still no CAD systems or calculators, and this work must have been done with a T ruler, triangle ruler, cloud ruler, compass, and calculation ruler. It is not hard to imagine how difficult this work must have been, and it made me keenly aware of how fortunate I am to be able to use CAD, albeit in a 2D format, and how much I respect the patience of our predecessors. Today, 3D CAD is in full swing, so my hardship may be a waste of time depending on how you look at it.

What troubled me in the design was the leading edge structure and the hinge type. Since it is a frise-type aileron, the top surface is connected to the aileron spar with a radius, but the bottom surface extends about 20 mm forward of the spar (see drawing 13 below). In other words, the cross-section of the leading edge is triangular, bounded by the spar, top and bottom surfaces. By the way, the height of the spar is only about 15 mm, even though it is 1/3 the size of a large machine. I was wondering how to make this.

There are two options. One is the method used for the elevator, which is a one-piece structure made by attaching 20 mm thick solid wood to the spar and then shaping it. The other is the method used for the rudder, which is an assembled structure with small ribs built vertically on the spar and the upper surface planked with balsa about 1.5 mm thick.

The one-piece structure is advantageous in terms of securing rigidity, but it is difficult to shape the 1,100 mm long, slightly tapered with the bottom surface not perpendicular to the spar but protruding downward with good accuracy. In the assembly structure method, the ribs are small, about 16 mm x 13 mm, and I was worried about whether the accuracy could be maintained with these ribs. In the end, I decided to use the assembly structure method without being able to find a decisive factor.

For the hinges, I had initially decided to use Robertson’s rod hinge system. This is a simple and reliable hinge, but it is difficult to ensure the accuracy of the installation position. Holes are drilled in the wing rear spar web and the aileron leading edge, and the hinge ends are inserted to fix the hinges. It was thought that the hinge mounting holes could be drilled a little larger and fixed while observing the clearance during assembly, but this would be difficult because the shape is difficult to access for gluing. In the end, I decided to make my own hinges similar to the ones used in the elevator. This hinge is relatively easy to secure the hinge position accuracy and has the advantage that the aileron can be removed. The wing tips of the main wing are removable, and the ailerons are inserted from the outside and held by the wingtips.The shape of the frise-type aileron and the hinge adopted are shown in Drawing 13.



Drawing 13: Aileron installation diagram

Fabrication

Photo 34 is the hinge I made.

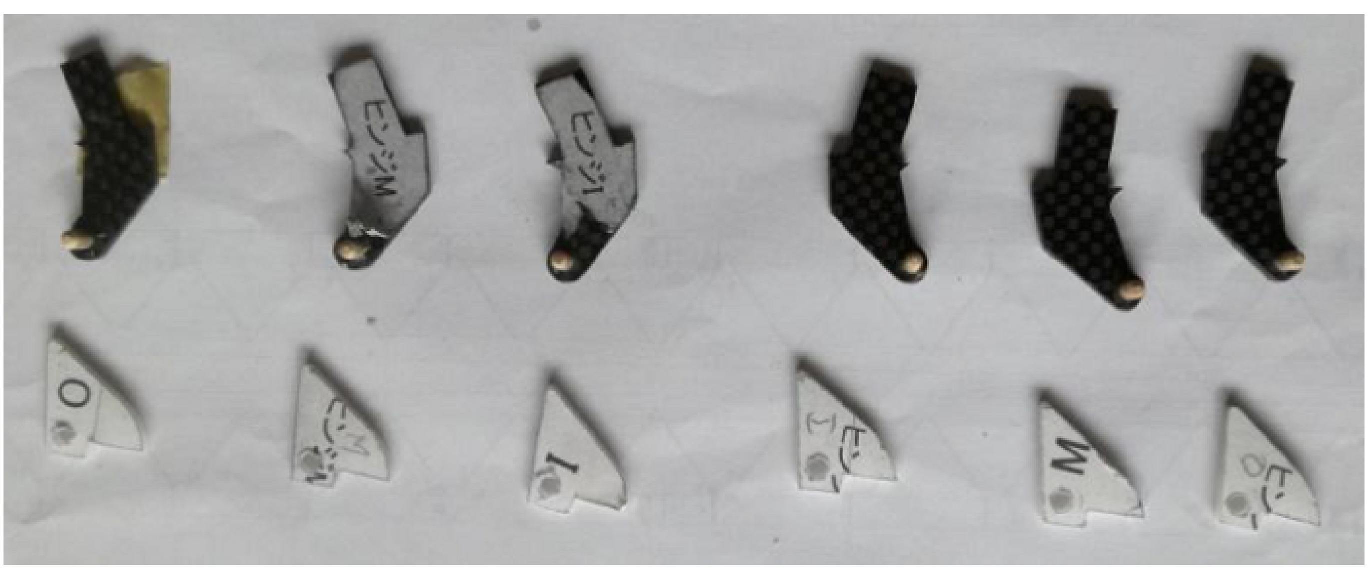


Photo 34: Aileron hinges

The hinges extending from the main wing are made of carbon and 3Φ bamboo string (upper side of Photo 34), and the hinge supports for the ailerons are made of acrylic plate (lower side of Photo 34). The elevator had two hinges on each wing, but the aileron is longer and has three hinges on each wing. The dimensions of each hinge are slightly different. In this photo, the paper patterns for cutting out the carbon are still attached, which look dirty, but if you remove it, you might make a mistake. Cutting out the carbon was so difficult that my hands turned black.

After cutting out the ribs, jig parts, spars, and trailing edges, I constructed first the assembly jigs on the full-scale drawing, as usual. Next, the ribs were sandwiched between the spar and the trailing edge on the jig. The spar and the trailing edge material have cutouts to insert the ribs into. When all the ribs were inserted, a L-shaped steel bar was placed on top to hold the ribs close to the jig and then secured with CA. Then I inserted the front edge ribs vertically into the spar and fixed them in place to attach the lower plank material. After that, the upper plank material is attached to finish the assembly of the aileron. The front edge at the hinge position was notched 12mm wide, and acrylic hinge holders were attached. The completed aileron assembly is shown in Photo 35.

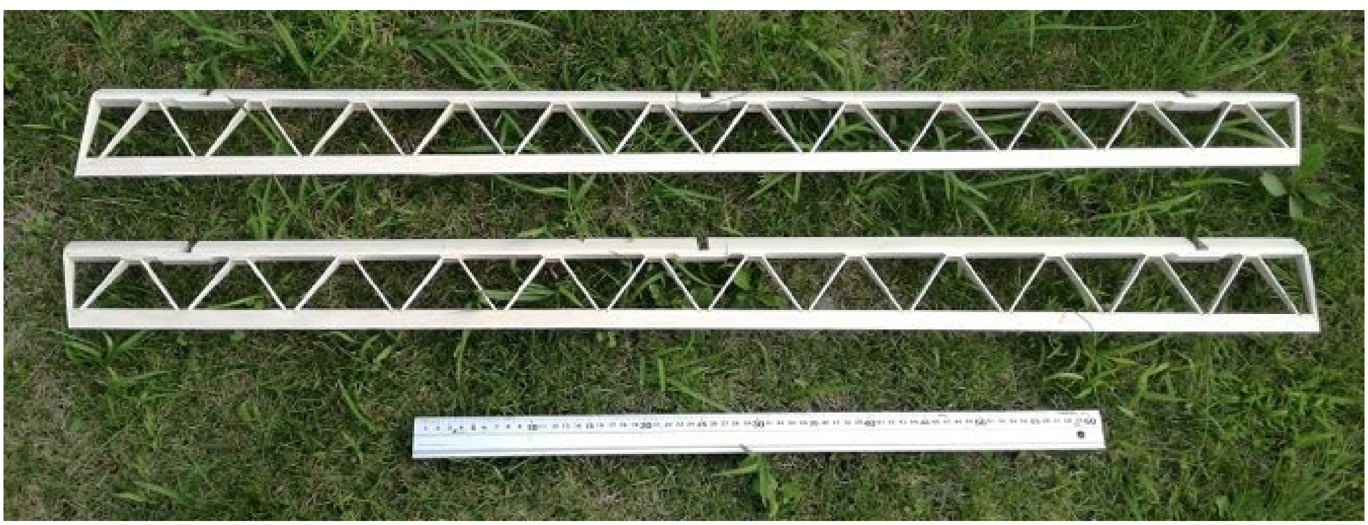


Photo 35: Finished aileron assembly

At the time of design, I was worried about the bending and torsional rigidity of the airelon, since it is only 80–90 mm wide and a little bit more than 10 mm thick, but 1,100 mm long. Initially, I had considered using two servos per wing to deal with torsion if the rigidity was insufficient, but it seems this is not necessary. Photo 36 shows the accuracy of the aileron rib assembly.

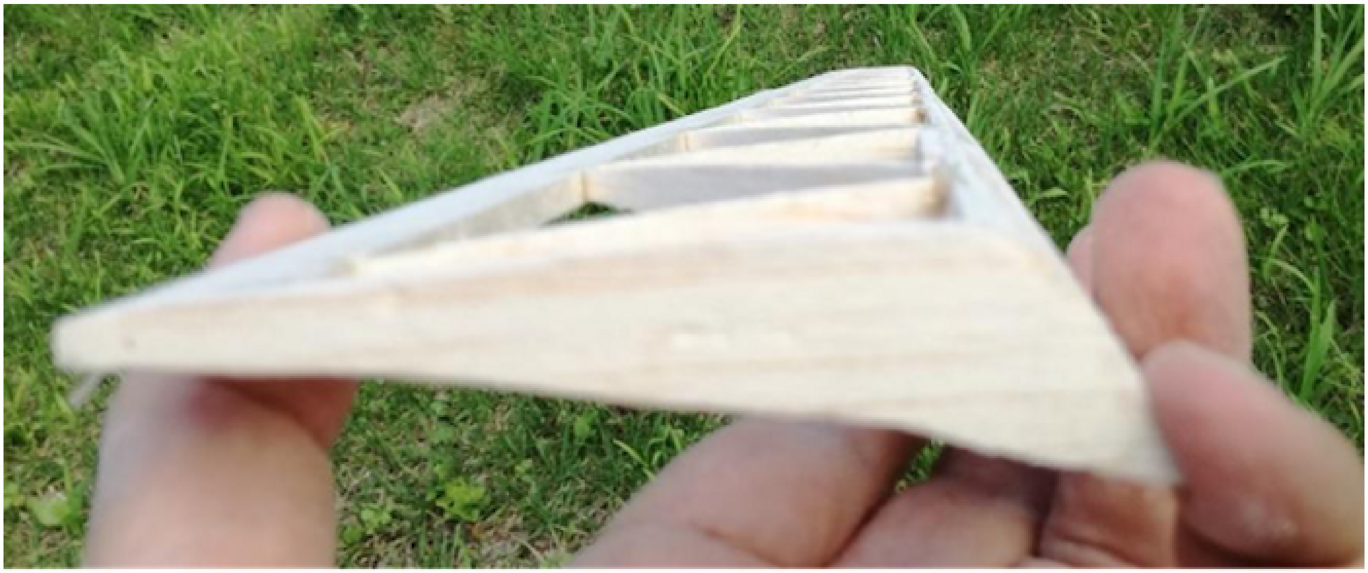


Photo 36: Accuracy check of the aileron rib assembly

There is still some shaping to be done on the trailing edge, but thanks to the assembly jig, the ribs are nicely aligned. However, there was some dissatisfaction with the accuracy of the shaping of the front edge where the small ribs were planked. Later, I shaped it with sandpaper and repaired the large distorted part with putty.

Aileron modification

Later, through Mr. Suzuki, an OB of the Tokai University glider club, I received the structural drawing of the actual aircraft. Looking at this drawing in detail, I found that there was a mistake in the aileron that I had made. The mistake was in the handling of the ribs that sandwich hinges. In Photo 35, nothing has been done, so the leading edge is notched at the hinge positions, and the strength and rigidity of that area is significantly reduced. It turns out that in the structural drawing of the actual model, triangular plywoods are planked between the ribs in this area to prevent the loss of strength and rigidity. The 1/3 model has small ribs, so it is difficult to cut and plank them. Therefore, I filled the spaces between these ribs with balsa blocks (Photo 37). This greatly improved the strength and rigidity of the hinge area.

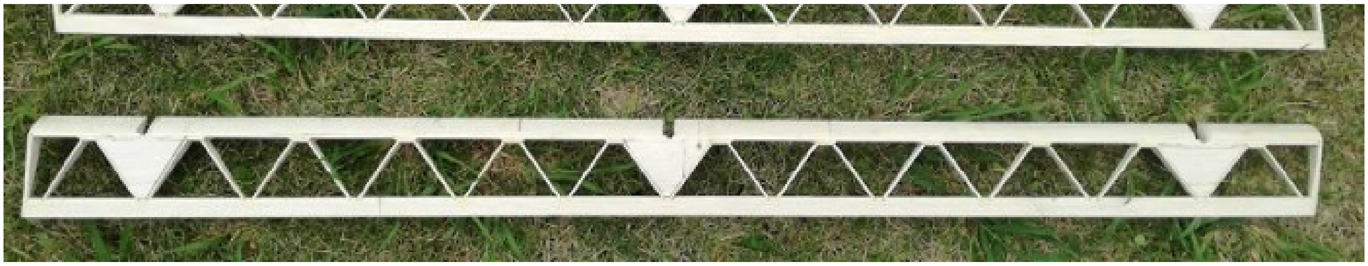


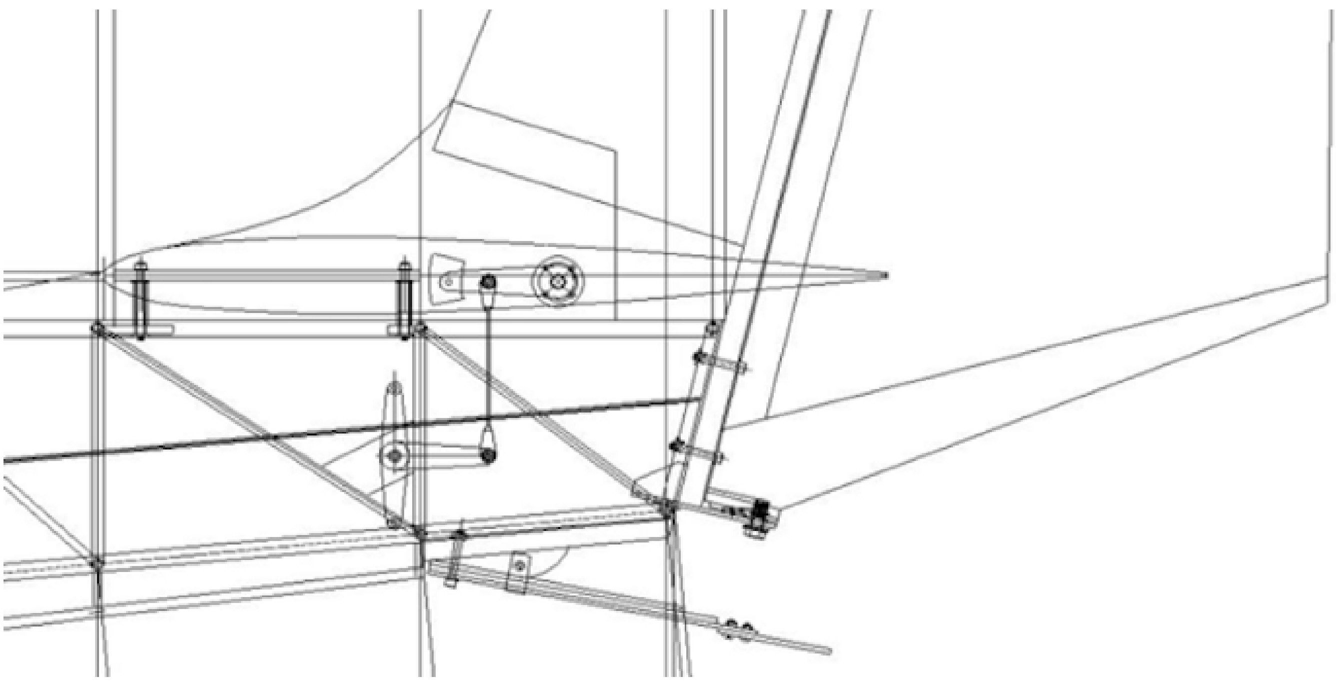
Photo 37: Ailerons after modification

Fabrication Part 7: Tail fin attachment mechanism, etc.

I started to cut out the ribs of the outer wing, but there are 36 ribs for one wing and 72 ribs for both wings. So, for a change of pace, I made the attachment mechanism of horizontal and vertical tail fins, elevator link mechanism and tail skid.

Design

First, I drew the drawing.



Drawing 14: Tail fin attachment mechanism, etc.

The horizontal tail fin has a 4mm thick plywood plate embedded in the center as a mounting point. Three posts with outer diameter of Φ7 and inner diameter of Φ3 are built on the upper surface of the rear fuselage to touch the plate. M3 bolts are inserted from the upper surface of the horizontal tail, pass through the plate and the posts, and are tightened into the claw nuts at the bottom of the posts.

Vertical tail fin is attached to the plate at the end of the body with two M3 bolts. Vertical tail must be orthogonal to the main wing, so, at this stage, only one bolt is used to fix the vertical tail fin since the main wing is not completed yet.

The tail skid has the same structure as the actual vehicle, with three 2mm-thick carbon plates for the springs and 2mm-thick aluminum plates for the ground sliding parts.

In the actual model, the bell crank for elevator operation is made by welded steel pipes. Initially, I tried to make a similar structure using carbon pipes, but I found making a hole in the pipe would cause the pipe to split longitudinally, so I decided to make it using 2mm thick carbon plates and a Φ5 carbon pipe. The elevator horn is connected to the bell crank by a link with rod ends, which are used in RC helicopter control systems.

Tail skid and elevator bell crank

Photo 38 shows the skid and bell crank fabricated per the drawing.

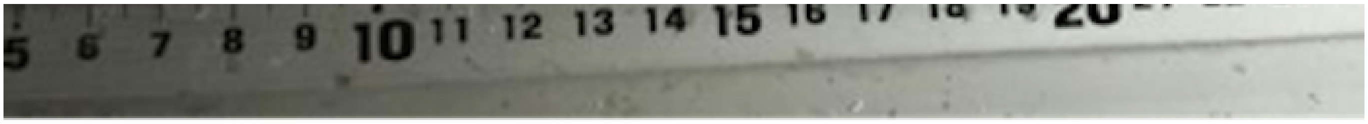


Photo 38: Tail skid and elevator bellcrank

The skid was mounted on a solid piece of pear wood. The three plate springs are fastened together by a forwardmost bolt and are only held together by the middle blacket to allow them sliding each other and creating spring effect.

Tail fins attachment strut, etc.

Photo 39 shows the tail fin attachment struts and other parts installed on the rear fuselage and the tail fin temporarily attached to it.

Photo 39: Tail fin attachment struts, etc.

The reason why the posts are long is because most of them fit inside the horizontal tail fin. In the photo, you can see the claw nuts for the vertical tail fin mounting bolts and the receiving plates for the elevator bell crank. The bell crank is fastened with a M3 bolt through the 3 mm diameter DURACON bearings inserted in the receiving plates.

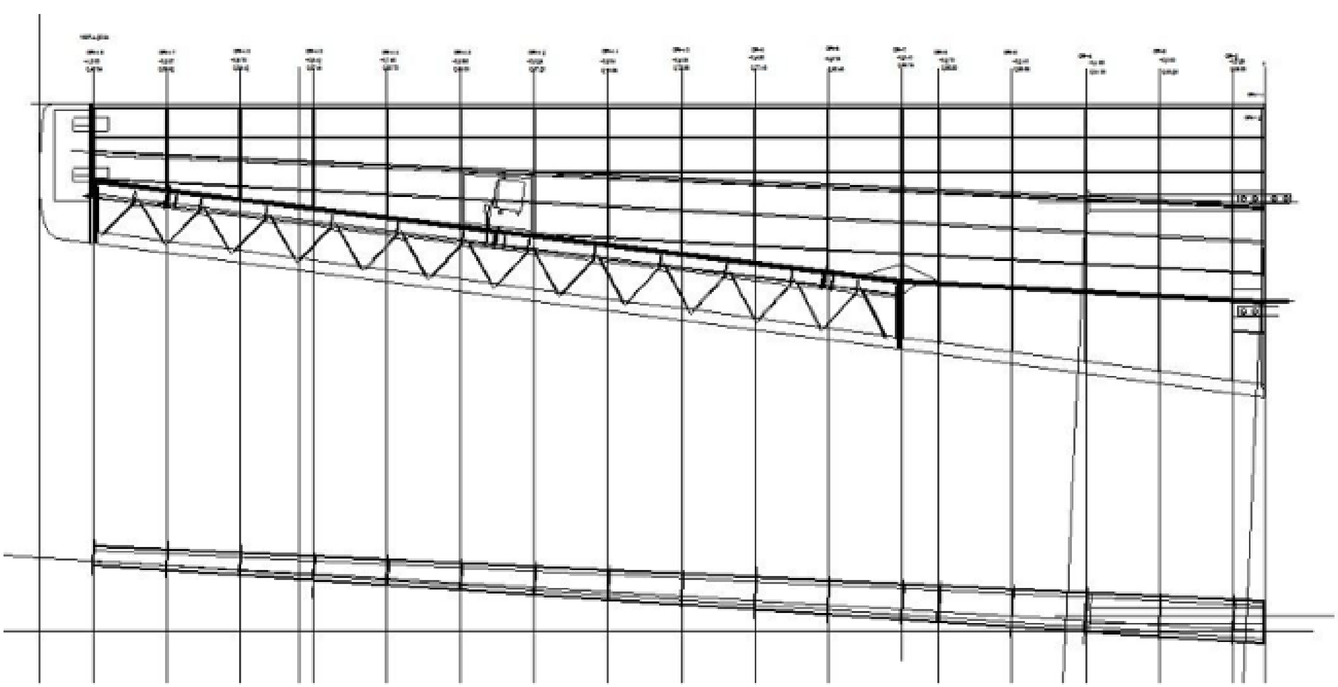
Photo 40 is the test installation of the skid and bellcrank.

Photo 40: Skid and bellcrank installed

Fabrication Part 8: Outer wing rib assembly

I finally finished cutting the outer wing ribs and assembled them.

Drawing of the outer wing



Drawing 15 is the drawing of the left outer wing.

The outer wing is tapered so that the innermost edge has the same 400 mm chord length as the center wing, but the outermost edge is 180 mm. Therefore, the taper ratio is 0.45. The length of the wing is 1,667 mm. As the tip 70 mm is the wingtip, the length of the rib assembly is a little bit under 1,600 mm. Between this span, 18 ribs are placed. The ribs are basically cut from 2.5 mm thick balsa. However, those near the root where the areas after the rear spar are not planked have 3mm thickness.

Since the wing is tapered, the spars are swept forward. The front spar flange is made of carbon pipe with 5mm square and Φ4 cavity inside, and that of the rear spar is 4mm square and Φ2.8 cavity. The spar webs are made of 1.6 mm thick plywood. There is a wing connecting pipe placed at the front spar web.

The center wing has no dihedral angle, but the outer wing has an angle of 3.45°. However, the connecting pipe should not have a dihedral angle. The front spar web is cut to insert an aluminum pipe for the pipe support. This cut must be carefully designed so that the support pipe can be inserted into the web horizontally which has forward and dihedral angles.

The area forward of the rear spar is planked with the same 2mm thick balsa sheet as the center wing.

Ribs cutted out

Photo 41 shows the ribs for one wing that have been cut out.

Photo 41: Ribs for the outer wing (for one wing)

The ribs from №1 to №7 have a full airfoil shape, but the ribs outside of №8 are only forward of the rear spar because the aileron is attached. The ribs 12 and 13 have one extra piece cut out between the front and rear spars for the aileron servo access panel between them.

Spar webs and leading and trailing edges

Photo 42 shows the cutted out spar webs, leading edge and the trailing edge.

Photo 42: Outer wing spar webs and leading and trailing edges (for one wing)

The spar webs and the front edge are about 1,600 mm long, but the materials, plywood and balsa board, are sold in 900 mm lengths. Therefore, these need to be cut out in two parts and then joined together. There are numerous cutouts in each part, where the ribs interlock. Note the cutout near the root of the front spar web. This is the area where the aforementioned support pipe shall be inserted. The diameter of the support pipe is constant at 21 mm, but because the web has a forward angle, the width of the cut is curved to become wider toward the outside.

Assembly jig components

Photo 43 shows the components of the assembly jig.

Photo 43: Outer wing assembly jig components (for one wing)

The main parts are cut out as one piece with the ribs. These are held in place by the front and rear frames, and assembled into a stair-shaped box. The front and rear frames are also cut out in two pieces and connected. The main parts have protrusions at the front and rear, and the frames have small windows.

Above photo shows the components of the left outer wing. In fact, the number of parts is double because I cut out the right wing as well. It took a little over two weeks to cut out all the parts.

The thickness of plywood and balsa, which are not industrial products, varies slightly from one sheet to another. In many cases, the lumbers are cut slightly thicker than the nominal thickness. As a result, parts that are cut to nominal dimensions may not fit together properly as they are, so they must be slid together piece by piece.

Fabrication of the outer wing assembly jig

The first step was to assemble the assembly jig. Photo 44 shows the assembly of the cut-out parts on the full-scale drawing.

Photo 44: Assembly jig of the left outer wing

This is the left outer wing assembly jig. Those parts of the jig that receive ribs have one degree of washout. If the ribs are aligned exactly with the jig and assembled, the outer wing with the correct twist will be completed.

In the process of assembling this jig, I noticed a slight problem. The length of the jig parts was different from the length of the full-size drawing. I placed the parts precisely at the innermost №1 rib position and assembled the parts sequentially toward the outside. However, the rib positions on the drawing gradually deviated from the actual positions of the parts. At the outermost №18 rib position, there is a 3–4 mm difference between the drawing and the cutout position of the part.

The cause is the stretching of the drawing. The season in which I assembled this was the height of summer in August. Because of the high temperature, the printing of the drawing was done in an air-conditioned room. The assembly of the jig had to be done in my workshop where there was no air conditioner. I used a simple hygrometer to measure the humidity in the room with and without the air conditioner, and found a difference of about 20%. I looked up data on the rate of paper expansion and contraction due to humidity on the Internet, and found that paper expands and contracts by about 0.2% at 10% humidity. The length of the outer wing jig is 1,600mm, so 0.2% is 3.2mm. I do not know the exact humidity of the paper when the drawing was printed and when the jig was assembled, but based on the above discussion, it is not surprising that there is a gap of 3–4 mm.

I understood that such a deviation was unavoidable in the current work environment and proceeded with the work as is.

Meshing of ribs and spar webs, etc.

Finally, the outer wing is assembled. First, the ribs, spar webs, leading edge and trailing edge were meshed together. Photo 45 shows the meshing of the right outer wing. The metal fitting at the right end is for attaching the wingtip, and is made from a 2mm thick aluminum plate. The plan is to insert this part into the wingtip.

Photo 45: Meshing of ribs and spar webs, etc.

In this state, no glue has been applied yet. Each part has just been engaged. The positional relationship of each part is accurate, but the angular relationship is inaccurate, because the parts are precisely cut in the interlocking position. Especially for assemblies like this outer wing, where the ribs and spars are not orthogonal, there is a large angular misalignment.

Angle adjustment and bonding of ribs and spars

Place the ribs and spar webs in this engaged state on the assembly jig and correct the angle of the ribs and spar webs to match the jig. When an almost accurate angle is achieved, embed the spar flanges and place two or three heavy steel L-shaped steel bars on top to adhere to the jig. Once it is confirmed that each part is on the jig accurately enough, drip CA adhesives on each part of the engagement and adhere them.

Photo 46: Outer wing rib assembly with angle adjustment completed

Since the outer wing attaches to the center wing with a dihedral angle of 3.45°, the №1 rib is not vertical but tilted by 93.45°. The spar web at the corresponding position was also cut out at that angle, but the angle was checked by applying a jig before gluing.

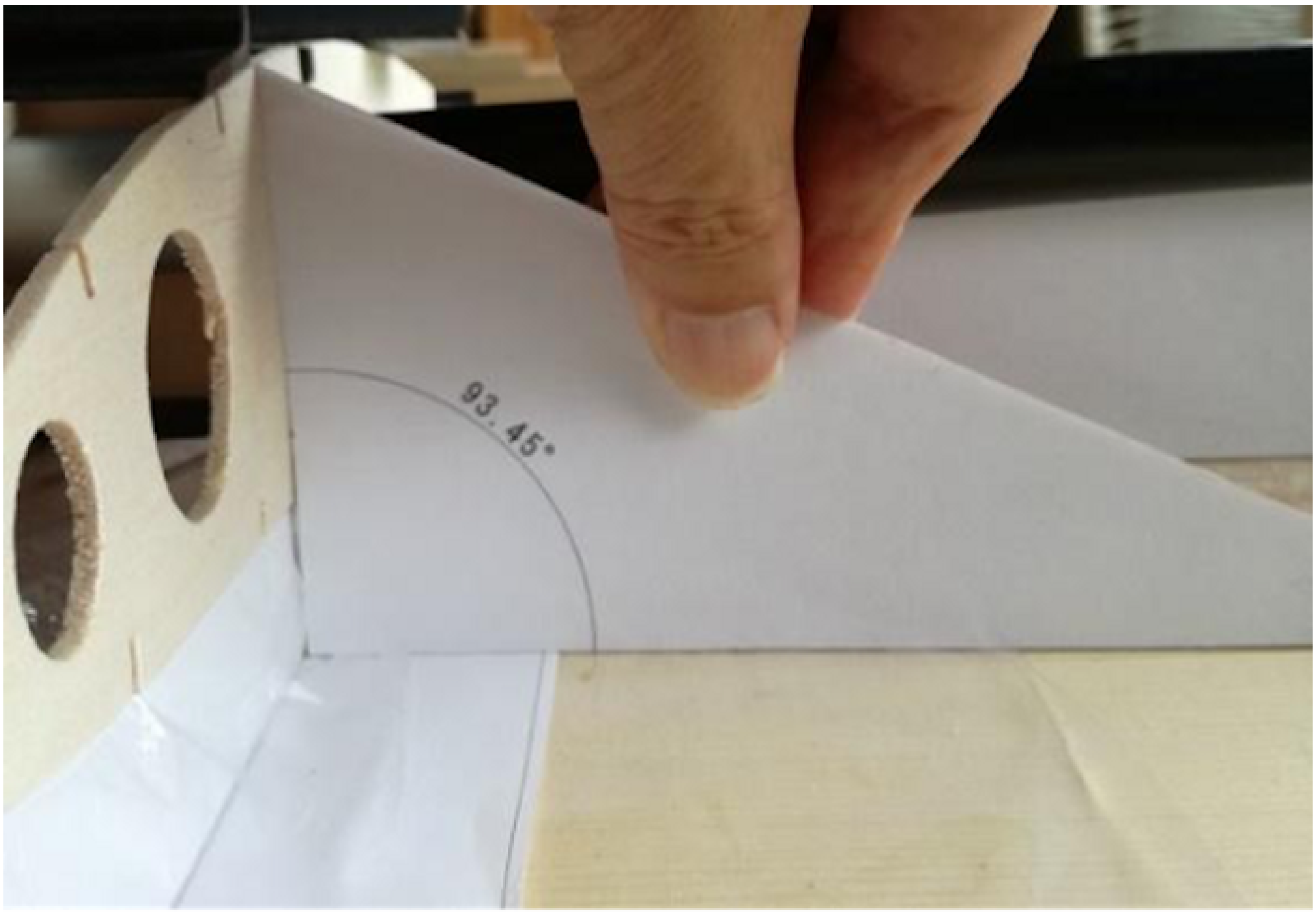


Photo 47: Adjusting the angle of №1 rib

Installation of the connecting pipe support

Next, I installed the pipe support. 21mm diameter holes are drilled in the corresponding positions on the №1 to №3 ribs. The front spar web has a slit to hold the support, so it can be attached quite accurately. However, since the connecting pipe determines the dihedral angle, I inserted the connecting pipe and applied a jig to check the angle before gluing it with epoxy adhesive.

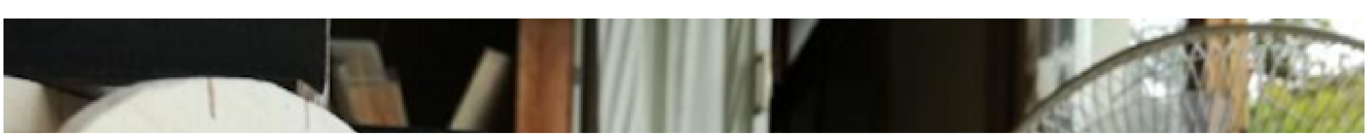


Photo 48: Checking the angle of the connecting pipe

Assembly of the outer wing skeleton completed

The assembly of the outer wing skeleton has been completed through the above process. The assembly accuracy is good, the carbon spars are straight and the rib heads are aligned.

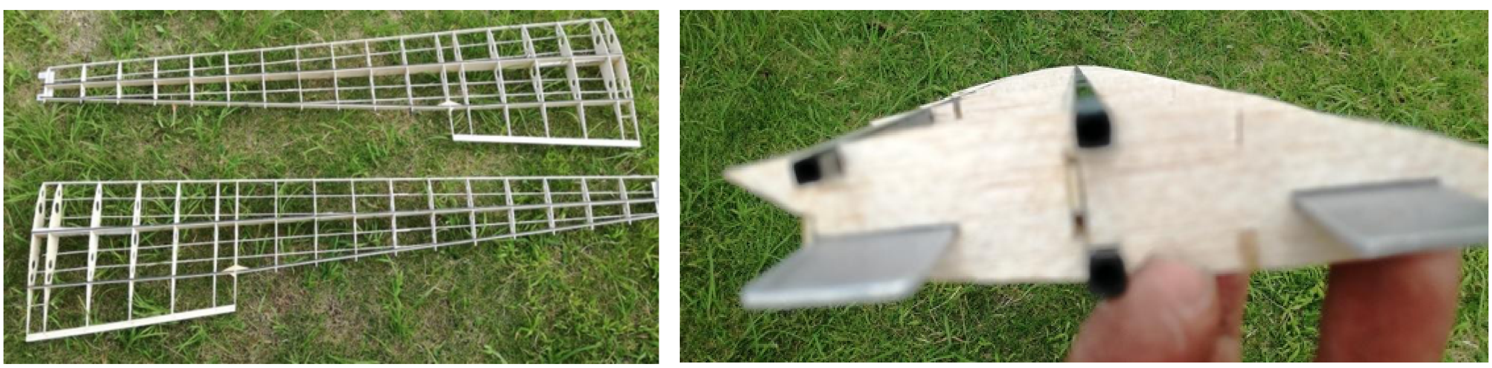


Photo 49: Completed outer wing rib assembly

I temporarily installed the aileron on the left wing (IPhoto 50). Since there are three aileron hinges, I was afraid that it would be difficult to install, but I confirmed that it could be done without much trouble. The operation of the aileron is also smooth.

Photo 50: Aileron installation check

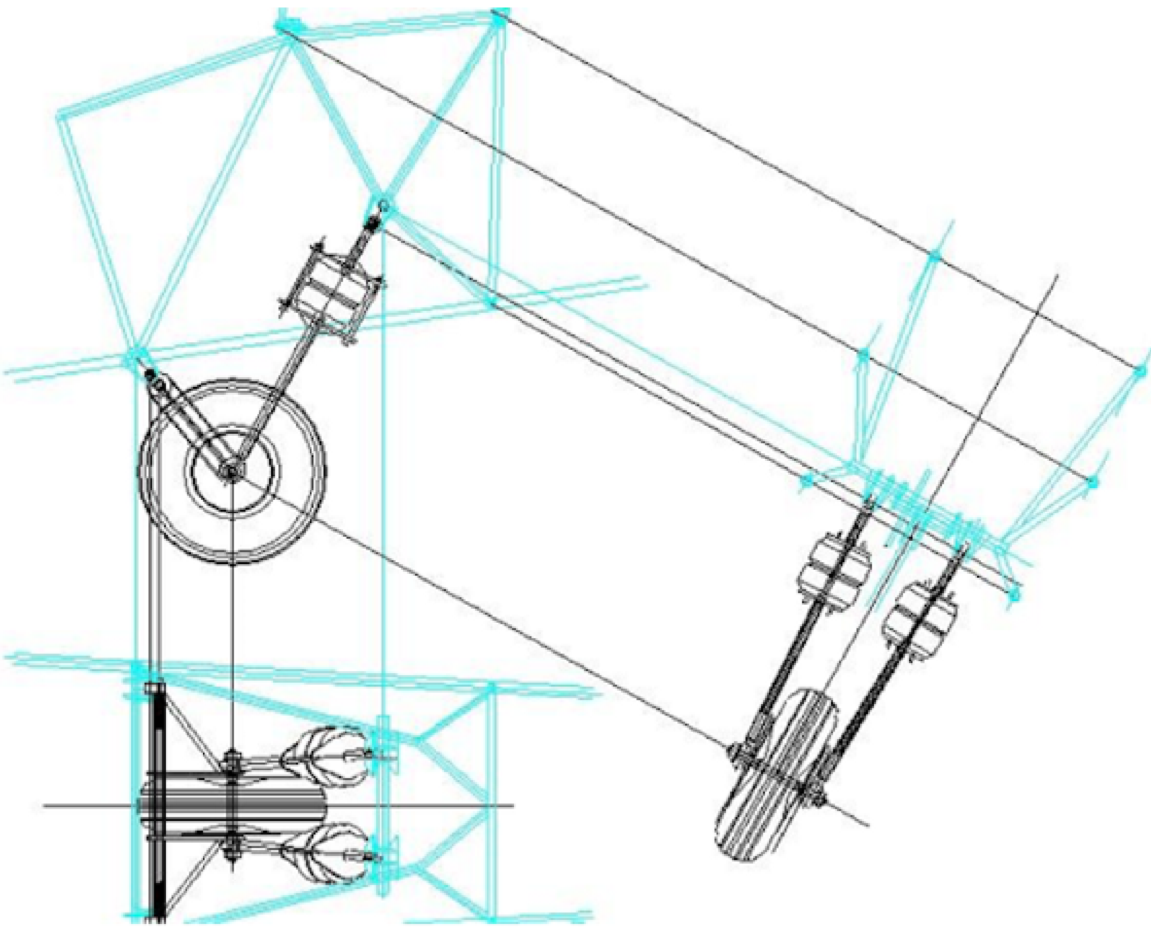
I took a commemorative photo of it alongside the center wing skeleton I had already made. It is about 140mm shorter than the finished product because there are no wingtips yet, but it is still very large.

Photo 51: Finished main wing rib assembly

Fabrication Part 9: Main Landing Gear Assembly

Drawing

This is the drawing of the main landing gear assembly.



Drawing 16: Main landing gear assembly

The main landing gear is a single-wheeled type, and its axle is supported by two support plates extending forward, and two struts extending rearward. The other end of the support plates are fixed to a horizontal axle perpendicular to the fuselage center line, and short stays are fixed to both ends of the axle. Two diagonal members are fixed between the support plates and the axle to prevent the wheel from shaking in the left-right direction.

Two large rubber shock absorbers are installed in the middle of the pillars extending aft and upward to cushion the landing impact. The pillars extending upward from the rubber dampers are attached to the trapezoidal truss structure inside the fuselage. The elevator and aileron control links are also attached to this truss structure, but in this model, the ailerons are driven by servos installed in the main wing, so only the elevator link will be attached.

Parts Fabrication

The main wheel is a 5-inch diameter wheel made by Duplo. The support plates and pillars are attached to it through the 5 mm diameter axle. The axle was made by one of my RC friends, Mr. Takamura, who is good at metal processing. The support plates and pillars are made from 2mm thick carbon plates and 5, 6, or 7mm diameter carbon piped. Rod ends with 5mm bearings are used to attach the axle, and 3mm bearings for the attachment of the rubber damper to the trapezoidal truss.

First, these parts were fabricated and purchased.

Photo 52: Main landing gear components

For the rubber damper, I bought a 40 mm diameter, 40 mm long rubber cylinder at a home center, and asked Mr. Takamura, who has a mini lathe, to drill holes and process the surface.

Assembly

Once all the parts were made, I assembled them. Since there are only a few parts, it is easy to assemble. Photo 53 shows the assembled main landing gear.

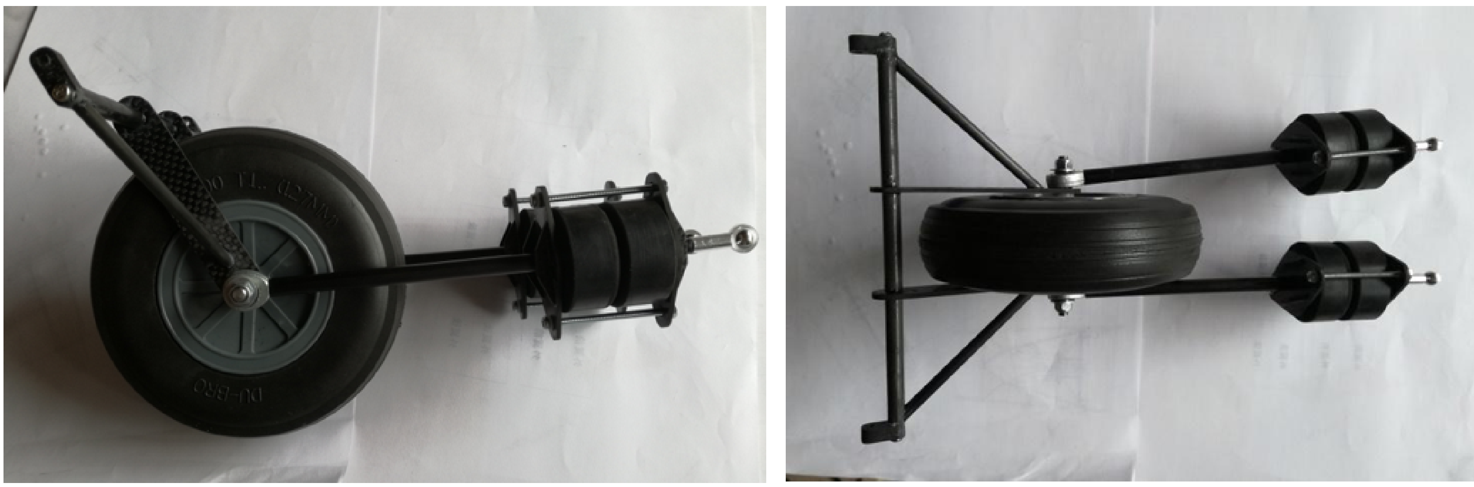


Photo 53: The completed main landing gear assembly

The outside of the damper is held in place by two M3 bolts. Between the upper and lower restraining plates and the bolts, there must be some slippage during landing, so a DURACON bushing is inserted.

I am satisfied with the completion of the main landing gear assembly, which is quite close to the real thing. The finished weight is 353g. This weight is within the target weight of the front body.

Fabrication Part 10 Aileron Counterweight

Aileron counterweights on the actual aircraft

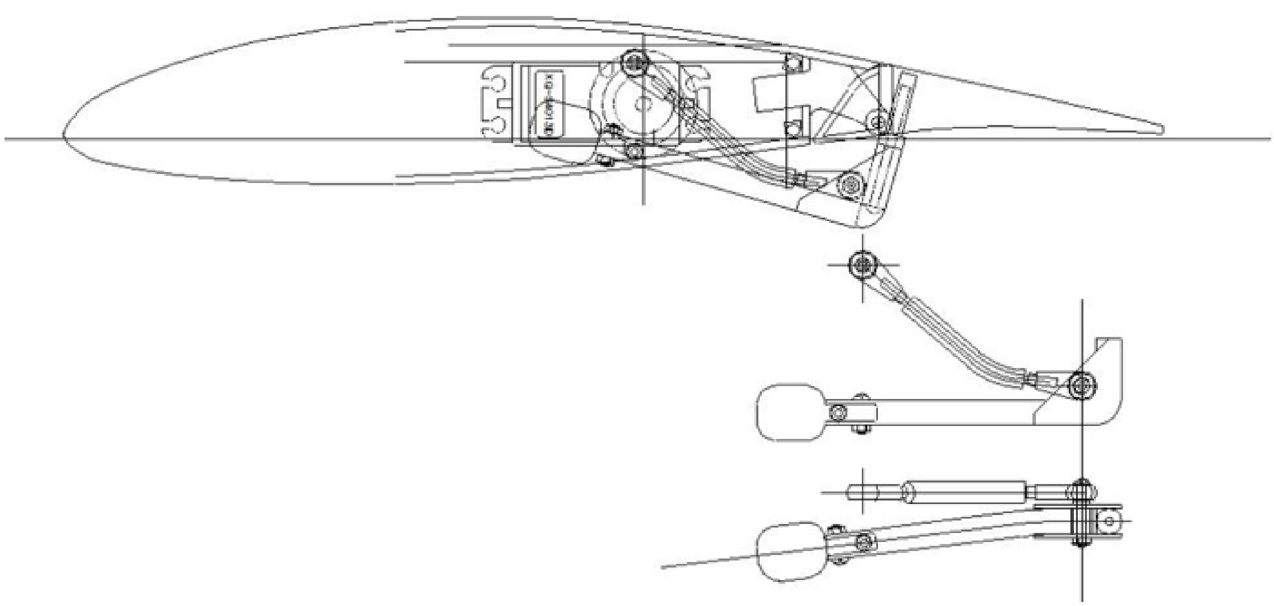
Aileron counterweights are installed on the actual aircraft to prevent fluttering of the ailerons, and they add an accent when you look at the main wings from below.

Photo 54: Aileron counterweights on the actual aircraft

The counterweight is a steel weight bolted to an arm extending from the horn where the aileron linkage is attached. This weight pops out from the underside of the wing when the aileron is raised, but is normally hidden inside the wing. For this reason, there is a hole in the underside of the wing for the weight to be stored. The photo on the right shows the weight when stowed, looking up from under the wing. The aileron control rod also sticks out from the underside of the wing, so it has a hole drilled in it as well. The purpose of this fabrication is to make a model of the counterweights, aileron horns and rods.

Drawing

First, I drew a drawing as usual.



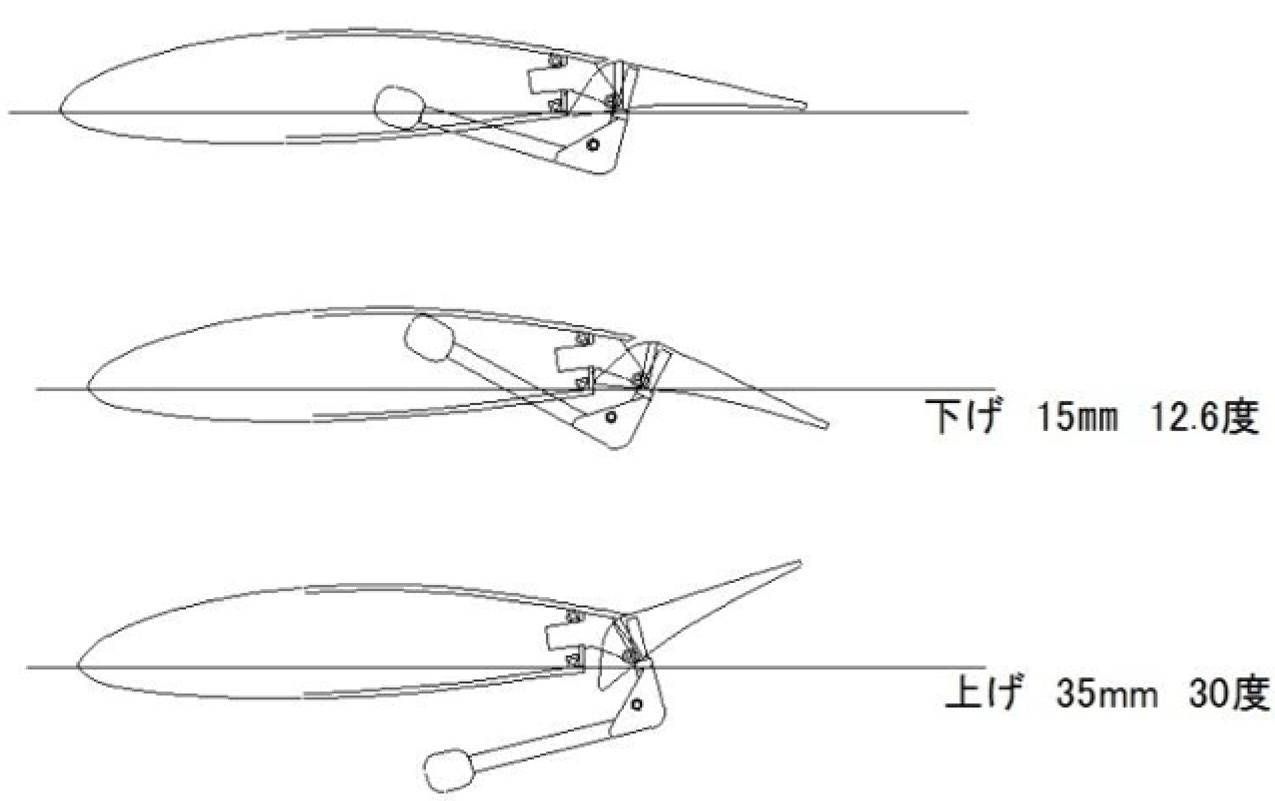
Drawing 17: Aileron counterweights and links

As I was drawing this drawing, a question arose. I had assumed that the aileron should be mounted so that it can move up and down by 20 to 30 degrees, but this would cause the counterweight to stick out on the upper surface of the wing when the aileron is lowered. Aileron differential is also often used, but its purpose is to reduce the angle of the downward aileron from that of the upward aileron in order to avoid adverse yaw caused by the higher drag of the downward aileron than that of the upward raileron. Adverse yaw is the yawing moment that causes the nose of the aircraft to point in the opposite direction of the intended turn. For example, if you want to turn right, you raise the aileron of the right wing and lower the left wing aileron to bank right. If the upper and lower aileron angles are the same, the drag of the left wing with downward aileron will be greater than that of the right wing with upward aileron. This will cause the nose to point in the opposite direction of the intended right turn, making the aircraft extremely difficult to control. In order to avoid this problem, the lower and upper angles of the ailerons are set differently, and the ailerons of my 1/5 Mita model are set in such a way.

However, the ailerons of the actual model and the 1/3 model are of the frise-type. This type of aileron was devised to eliminate the aforementioned adverse yaw, and the aileron leading edges protrude from the underside of the wing when the aileron is raised to act as resistance. I had assumed that the aileron up and down angles would be the same since the frise-type ailerons would no longer cause adverse yaw. However, the counterweight is stored in the wing, and if the angle is the same, it can only be moved by 10 or so degrees at most.

I asked the Shizuoka Aviation Museum to check the airelon angle of the actual aircraft and found that it has a differential. The downward angle was 12 to 13 degrees while the upward angle was almost 30 degrees, which was quite a differential. It is unclear whether the differential was used in combination with the frise-type aileron because it was not enough to prevent adverse yaw, or whether the differential was used as a result of avoiding the counterweight from protruding from the upper surface of the wing,but this clarified my question and allowed me to proceed the design.

Drawing 18 shows the aileron operating range of the 1/3 model. The aileron control rod is perpendicular to the leading edge of the aileron that has a forward angle due to the tapered outer wing, but the counterweight strut faces the airflow direction. Therefore, the counterweight struts are bent to open outward. The aileron control rods are also bent so that they do not hit the bottom of the wing trailing edge. The drawing 17 was made based on these factors.



Drawing 18: Aileron operating range

Parts fabrication

Photo below shows the parts manufactured based on the drawing.

Photo 55: Aileron counterweights and related parts

The counterweights are machined from a round aluminum bar and are hollow inside. Lead will be melted and embedded in them. The aileron control rods are made of a 5 mm diameter brass rod. The aileron horns to which the post and rod are attached is made of 0.5 mm thick brass. A 6 mm diameter brass spacer with a 2 mm diameter hole is attached to the rear of the horn's triangular shape, and a 4 mm diameter rod with a 2 mm thread is embedded in the aileron. A long M2 bolt is inserted from the bottom of the spacer and attached to this rod.

At both ends of the aileron control rod, attach the adjustable rod ends used for RC helicopter linkage, and fit them into the 5 mm diameter balls attached to both the servo and aileron horns.

Completed assembly

These parts are assembled and soldered.

Photo 56: Finished aileron counterweights, etc.

I still have not melted the lead into the aluminum counterweight. I was satisfied with the result, which was almost exactly what I expected, but later when I actually installed them on the aileron, I discovered a problem and had to recreate them.

> **Mistake №6:** *The problem is that the restraining force in the direction of rotation is weak and a little force will cause it to rotate.*

There are two causes.

1. The whole thing is made mainly of brass, so it is heavy and has a large inertia force.
2. Weak restraining force in rotation because it is attached with a single M2 screw.

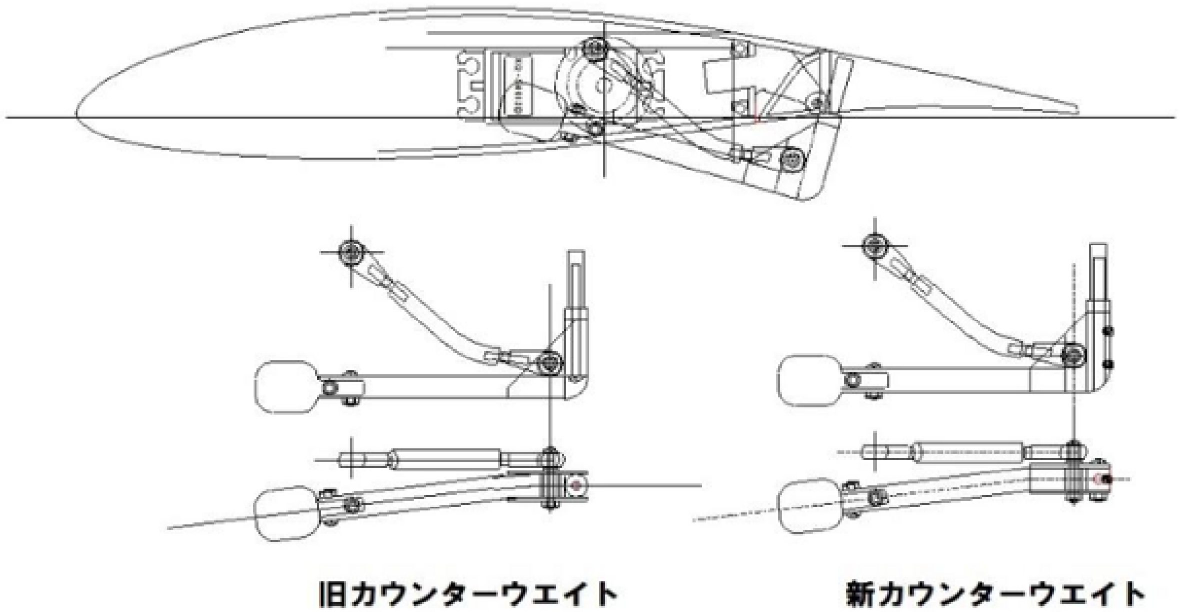
Re-worked aileron counterweights

I made an improved design with the following measures to address the two causes above.

1. Make the whole thing mainly of aluminum to reduce weight

2. Change the mounting method to inserting the counterweight into the 3mm piano wire and fixing it with two immobilizing screws.

A comparison of the old and new counterweights is shown in Drawing 19.



Drawing 19: Comparison of old and new counterweights

Photo 57 shows a counterweight that was re-made based on the new drawing.

Photo 57: Remade aileron counterweights, etc.

The brass part is embedded in the aileron. A 3mm piano wire is fixed in this part and extends downward. The piano wire passes through the aluminum prism at the rear end of the horn where the counterweight is installed. You can see two screws on the aluminum post that hold the piano wire in place. The curved rod with rod ends on both ends connects to the aileron servo, which moves the aileron together with the counterweight.

Although it is called a counterweight, I did not melt lead into it to reduce inertia. Since the speed is much slower than the actual machine, I thought there was no need to worry about fluttering, so I gave priority to reducing inertia. The holes were filled with putty. The weight of the completed new counterweights is 19g each. The old one weighed about 35g. The new counterweights are now 46% lighter.

*This is the third part in this series. Read the **next article** in this issue, return to the **previous article** in this issue or go to the **table of contents**. Downloadable PDFS: just this article or this entire issue.*