CUNNINGHAM ON R/C

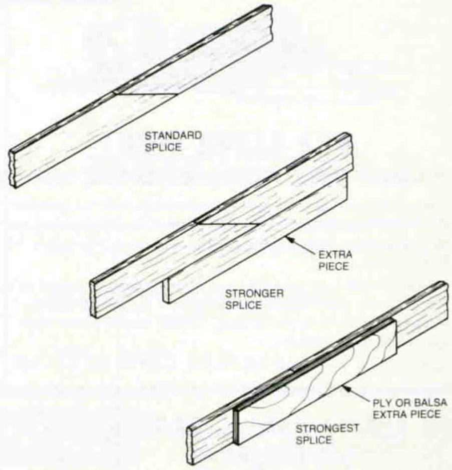

FIGURE 1

R/C DESIGN MADE EASY

PART IV

For the past several months we have presented ideas to you to make it easy for you to design your own R/C aircraft and be assured that when you completed it, your bird would be very flyable. This month we're going to go one step further in the investigation of R/C design and talk a bit about the structure of the aircraft. How to make it strong, yet not heavy; how to make it stand the rigors of flight; and how to help the structure combat our worst enemy, engine vibration.

First of all, most R/C aircraft are constructed of the very best substance possible to use, balsa wood. Sure, we also use foam, fiberglass, plastic, plywood, spruce, carbon fibers, cardboard, aluminum, wire, and whatever else can be dreamed up, but through all of the years of modeling, balsa wood is still the king. Why is balsa so great? Well, it is easy to shape and sand, easy to cut into sheets and strips, easy to cut with a razor blade, comes to us in a multitude of differing weights and strengths, accepts and adheres to a number of different adhesives, and it is truly wonderful at absorbing engine vibration. Nothing else on our list of materials above is as versatile as is balsa wood. On the other hand, it can't be used for everything. It would make a horrible firewall for engine mounting, would be terrible as a dihedral brace, would make a very bad landing gear, and so on.

Obviously, the physical size and the type of model we are going to build has a lot to do with our selection of materials we use. If, for example, you're going to design an aircraft for your own use, one that will be a "one of a kind" bird, it would be a bit impractical to construct it of fiberglass. First, let's assume that the bird that we have drawn the outline for is powered by a .61 2-stroke engine, but that we have designed it a bit larger than most .61 aircraft because we have been thinking about buying a .90 or 1.20 4-stroke and, if our aircraft turns out pretty good, we want to stick the bigger engine up front. Let's also assume, at least for the time, that we don't have a foam cutting rig, but we have the normal complement of shop tools and a good building board. What are we going to use for the primary building component, and how are we going to design the structure? Heck, the building component can't be anything else but balsa, so, let's see how we're going to use it.

Generally, balsa comes in sheets and sticks that are either three or four feet long, and three or four inches wide. We need to design our structure around these lengths and widths. (Of course, you can get wider sheets if needed.) You can also create sheets of any width by sticking two sheets together with any type CA glue. I like to use Hot Stuff, and I use the new UFO Hot Stuff for almost all of my glue joints. If we're going to design a structure that is longer than the longest sticks generally available, then we must design a splice joint into the structure, or provide some other method of making the material longer. (See Figure #1.)

Most of the kits and designs for smaller models use a method of construction whereby the sides of the fuselage are made from one piece of balsa that goes from the firewall back to the tail post, and is reinforced at the nose section by additional material (either more balsa wood or plywood) to add extra strength from the trailing edge of the wing forward. This system works very well for smaller size aircraft and has been used since the days of U-control models. The old free flight designs, needing to economize on weight, used a built-up structure with some extra sheeting in the forward end to gain additional strength. A blending of the two systems has worked out great for models that get out of the smaller class. Back in the mid seventies when I started to design seven foot span and up models, I worked out structure systems that blended balsa and spruce together in a truss system tying into a sheeted front end. This has been a very easy way to make a very strong, yet relatively light, and economical fuselage. Take a look at Figure #2 to see what I mean.

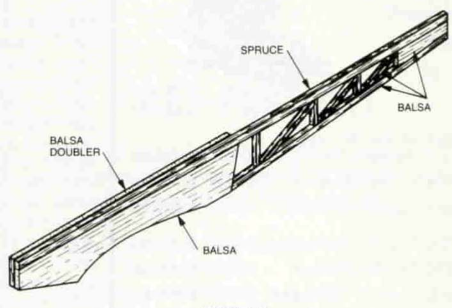

FIGURE 2

The basic idea behind any fuselage structure system is that the principle reason for the fuselage is to bring the engine, landing gear, load carrying area (radio compartment), and wing and tail structure all into one piece that will carry the required load. The total load must be carried rigidly; the structure must absorb vibration, not break up on landing, and the wing and tail must remain in the same relative position. A long, reinforced balsa sheet will do this for aircraft of .61 engines and down, and the truss system will do this for aircraft with larger engines.

Glue joints in either system must be made well, and butt glue joints should

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be reinforced with gussets or other methods of spreading the load throughout the glue joint. Back in the days when the only glue that we had was normal model airplane cement, a butt joint was pretty weak. Today, with the super glues that we have available, butt joints are better, but our ability to make that joint a really good one hasn't improved all that much unless we take a little time and care. One good example of a butt joint that doesn't have much strength is the cross pieces used to hold the fuselage sides in position. Normally, the fuselage structure from the wing aft tapers in width back to the tail post. The cross members usually are cut square with a razor saw or an X-Acto knife, wedged in place, and glued. With the old model airplane cement, these joints were terrible. With slow drying CA adhesives, the joint can be made much stronger. However, if you take the time to sand the ends of the cross pieces to match the taper of the fuselage and then stick them in place, the glue joint will be much stronger because the two wood surfaces are in total contact with each other.

The way to make the fuselage super strong is to sheet the bottom of the fuselage with balsa. Install the sheets with the grain of the wood running perpendicular to the length of the fuselage. When this type of structure is completed it is super strong and will resist the damage caused by a hard landing. No structure will resist a hard crash. You want to design a structural system that will survive the normal wear and tear of everyday flying. Trying to design a structure that will survive a head-in dive at the ground will result in a model that will never get into the air because it's too heavy. After all, what we're after is a 175 lb. wide receiver type model, not a 300 lb. nose tackle. We want something that will **fly**.

The wings present a similar problem to the designer. We want to design a structure that will carry the load and support everything that the fuselage is keeping together, yet not be too heavy or cumbersome. Again, balsa wood is the number one material, supplemented by spruce and plywood. Foam wings have been around for a long time, and we'll talk about this type of construction in a future column. Wing ribs can be made from balsa sheet, or, in the case of large models, from a material called Fome Core®. This material can be purchased in art supply stores and is a thin sheet of styrofoam coated on each side by paper.

Part of the structural integrity of the wing is to select wood for the ribs that is neither too soft nor too hard (heavy). Soft ribs often lead to weak wing structures. The principal purpose of the wing rib is to place the leading edge, the spars, and the trailing edge all in the proper position to form an airfoil shape. The airfoil that you selected for your design could be any one of several different types — flat bottom, symmetrical, etc., but the ribs must establish and keep the wing in this shape throughout the flight of the aircraft.

The spars are the main load carrying members of the wing and, as such, must be carefully sized and selected. Further, the spars must be joined together where they meet in the center section in such a manner that the load on the wing is fully transferred from one wing panel to the other. For normal sized models, the wing spars can be balsa (hard, tough balsa) while, for the larger aircraft, spruce or pine spars should be used. Actual sizing is kind of tough to do. Experience dictates more of the actual spar size than does a formula table. Since balsa can come in such a wide variety of strengths, size doesn't mean as much as does toughness. 3/8" sq. hard balsa spars are usually adequate on a 6' span bird, and 1/2" sq. hard balsa spars are fine on a 7' model ---

provided that the load on the wing isn't too great. By that I mean that I would use 1/2" sq. balsa spars on a 7' wing that was going to be pulled around by a .61 or .90 4-stroke. However, if I were designing a wing that had a 7' span and was going to be powered by an ST 3000 or a Sachs 3.1, then I would use 1/2" sq. spruce. No hard and fast rule, however, you must consider all factors when designing the wing structure.

Webbing the main wing spars is a method to further increase their strength. Webbing is material, generally balsa sheet, that is used to join the main spars together to form a structural beam, thus adding tremendous strength to the wing. The webbing material must be installed with the grain perpendicular to the spars. Balsa wood fractures very easily along its grain line but is awfully tough cross grain. The load along the wing spar beam is such that if the grain of the webbing were installed parallel to the span, the least bit of flex in the wing would fracture the webbing so the spars would not be tied into one strong structure, and would ultimately lead to the entire wing system breaking down.

The strongest system of constructing a wing is to form a "D" type system with the leading edge tied to the main spar structure with top and bottom leading edge sheeting. See Figure #3. When you couple the "D" system to spar webbing you have one very tough, rigid wing. I believe that webbing should be installed so that it has a lap glue joint with the spar, not a butt glue joint. The lap joint is considerably stronger and easier to make. The butt joint relies on a perfect butt joint, and that is almost impossible to construct (see Figure #4).

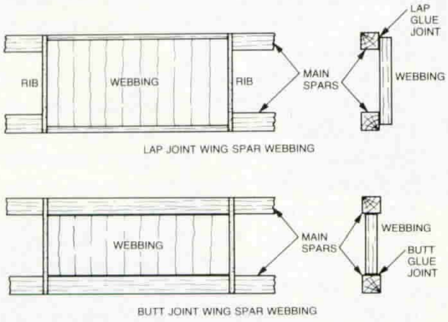

FIGURE 4

As we mentioned, the wing panels need to be joined together in such a manner that the load is transferred between the panels. The weakest part of the wing is the joint between the two panels. Dihedral braces are used to carry the load. I use aircraft plywood for the dihedral braces and like to make them long enough to extend past

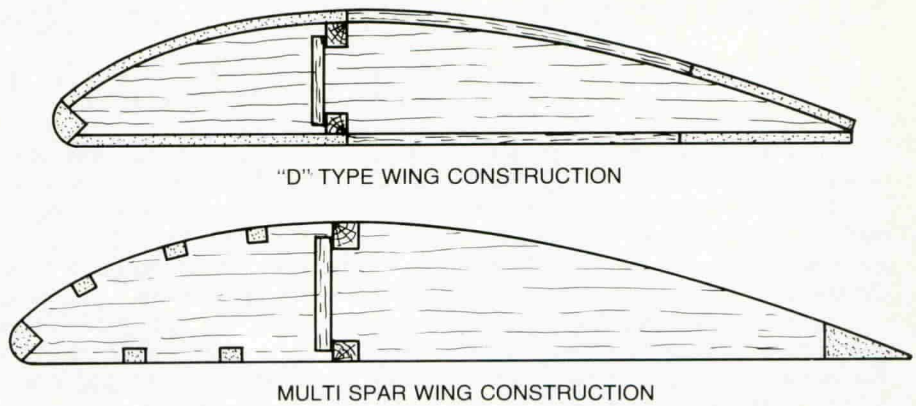

FIGURE 3

the fuselage width into each wing panel. This may seem like overkill to some, but nothing is worse than to see a wing tear apart in the air and, believe me, over the years I have seen lots of models shed their wings. I also like to install a dihedral brace at the leading edge of the wing. When a wing fails in a dive it is very similar to taking the wing in your hands and ripping it apart just as you would tear a phone book in half (if you live in a small town that is). This ripping motion will tear a wing in half easily if the joint between the leading edge is a simple butt joint with no load carrying transfer member. One of the easiest methods of ensuring a good center section joint is to wrap the joint with fiberglass cloth and resin, but nothing beats a good plywood brace, well cemented to the spars and the leading edge. A poor glue joint is just about as bad as no brace at all. Make sure that you use five ply aircraft plywood at this joint, 1/8", 3/16", or 1/4" depending upon model size. (I use 1/4" on all large models.) Do not use three ply plywood or lite ply for a dihedral brace. Lite ply has its uses, but it really isn't much stronger than balsa. Make a strength test. Cut a piece of hard balsa 1/8" thick by 1/2" wide by 12" long. Make similar size pieces of lite ply and five ply aircraft wood. Grab each piece and break it in your hands. The balsa and lite ply break equally easy, while you're still struggling to break the five ply piece.

You can construct a wing, even a large wing, using multiple spars top and bottom in place of the top and bottom leading edge sheet. This works very well, though not as strong overall as the "D" type system. It does do one thing for the wing that the sheeted leading edge does not do and that is to add a measure of turbulation to the airfoil, thus creating more lift than the smooth surface does. This is another subject to delve into at a future time. A wing constructed with multiple spars is more flexible than the "D" system wing, but by using strong central spars this can be overcome.

We really haven't covered the entire spectrum of aircraft structure. We haven't touched on the tail, or vibration dampening, or bracing, or a number of subjects. We'll cover these next month. □

Marv Reese's gigantic powered sailplane — 18' span, 2500 sq. in. wing area, 17 lbs., .61 4-stroke engine, flaps, spoilers, ailerons, elevator, and rudder. Hard to get out of the sky once it picks up a thermal.