On The Use Of Douglas Fir As A Substitute For Spruce

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HAVE YOU looked into the going price for spruce lately? Scandalous. And have you tried to find it in your local lumber yard? Impossible. You have to send away for it. And sometimes you don't get what you asked for.

Why not forget about spruce and use vertical grain Douglas fir instead? A lot of us do. Fir costs only about one-fifth as much as spruce, is beautifully straight grained, can be procured in unusually long lengths and best of all, can be purchased at most sizable lumber yards right there in your own town.

Why isn't fir more widely used among the experimental aircraft builders? For two reasons, I believe. One is that spruce is the traditional wood for aircraft and tradition, being what it is, is difficult to break with. People think spruce, so spruce it is.

Another reason is that few people take the trouble to compare other woods with spruce on an engineering basis and thus information about them is not as widespread as it ought to be.

Before developing a case for fir, let's look a bit closer at spruce. Why does it cost so much? For one thing, the same small stand of spruce growing in a narrow band along the northern Pacific coast has been supplying the needs of U.S. aircraft builders since the days of the Wright Brothers. In addition, spruce finds considerable use in the construction of pleasure boats. As anybody knows, any time you have a limited supply and a heavy demand, you have high prices. This is one reason spruce is uncommonly expensive in comparison to other suitable woods.

A third reason is that we aircraft builders insist on the best spruce we can find. It has to be stamped "certified aircraft" or we turn up our noses. This stamp is put on there by an inspector who selects the best pieces from the lot — and adds his pay to your bill.

By the time the spruce is inspected and stamped, shipped to a jobber (the man **you** deal with), wrapped or crated and shipped across the country to your home via train and truck, you have a sizeable bill on your hands.

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However, as one advertiser for spruce put it, you "deserve only the best." You also deserve a new Cadillac, but I doubt if you have one.

Your new aircraft may deserve the best, but it likely doesn't need it. Any professional airplane designer who uses the highest quality material available, regardless of cost or real need, soon finds himself out of a job. And I think there is a lesson here.

If your aircraft really **needs** spruce and you are willing to go to the trouble of finding it and paying for it, by all means use it. But do you really need it? Before you decide, let's look at some trade-offs between spruce and vertical grain Douglas fir. It may be an eye-opener. We've already talked about availability and touched upon cost, so let's look now at the physical characteristics of the two woods. This is summarized in the following table. You won't need the whole table to help you make up your mind but I've put it all there for the sake of completeness and because the data are readily available; it comes right out of ANC-18, "Design of Wood Aircraft Structures."

Let me emphasize that we are talking here about **Douglas fir,** not other kinds of fir such as California red fir, Noble fir, Pacific silver fir and white fir. Don't make a mistake and get the wrong kind. And be sure the Douglas fir is **vertical grain**. If you don't know what this is, your lumberman will.

Let's look at selected elements in the table in a bit more detail. All comparisons are based on identically sized members.

a. **Modulus of Rupture** — This refers to the bending strength of the wood, useful in considering spars and other structures that take the loads in bending. Observe that fir is 23 percent stronger than spruce under this heading.

b. **Modulus of Elasticity** — This refers to the material's stiffness. Observe that fir is a bit stiffer than spruce. An aircraft with a very high aspect ratio wing, such as are common to sailplanes, would ride a little less smoothly in rough air if it had a fir wing than if it had one of spruce; it wouldn't bend as much for the same load. However, pilots of the little, stubby-winged airplanes would hardly notice the difference since the wings on these aircraft are very stiff anyway.

c. **Compressive Strengths, Parallel and Perpendicular to Grain** —Observe that the compressive strength of fir, parallel to the grain, is 39 percent higher than spruce and the compressive strength perpendicular to the grain is higher by 55 percent. Aside from the obvious conclusion that a fir spar is stronger than a spruce spar of the same size there is an additional one; the bearing strengths of bolts in fir are higher by the same percentages. If you are concerned about bolts tearing out of a spruce member you can improve things by making the part of fir.

d. **Weight** — Since the table shows fir to be about 23 percent stronger than spruce (using the Modulus of Rupture as the basis for comparison) you would certainly expect it to be heavier. It is. In fact, it's more than 23 percent heavier — by 3 percent. It isn't as "efficient" as spruce on a pound for pound basis but it is very, very close.

If you're designing your own ship this small difference is quite meaningful in terms of saving money because, although fir is heavier than spruce it doesn't require **as much of it** to do the same job. Consequently the 3 percent value is good.

On the other hand, if you're building from plans you don't want to use "less of it." You certainly don't want to reduce the size of the spars and other critical structure so as to hold the weight increase to only 3 percent.

This is foolishness. Besides making the designer mad you will have all kinds of problems with this approach, trying to make things fit. You'd best leave everything just as it is and accept, as the table shows, an increased strength of 23 percent and an increased weight of 26 percent.

Obviously, although fir is 26 percent heavier than spruce your whole ship won't be that much heavier. You'll pick up that 26 percent only where you have used fir instead of spruce.

If your (spruce) ship weighs, say, 800 lbs. empty you have probably around 100 to 150 lbs. of wood in it. With fir your ship would pick up 25 to 35 lbs. more, which isn't very much, all things considered.

e. **Cost** — 150 lbs. of spruce (which is an interesting way to measure it, isn't it?) will cost at the very least $100.00, based on $1.50/board foot (the lowest price I've seen anywhere).

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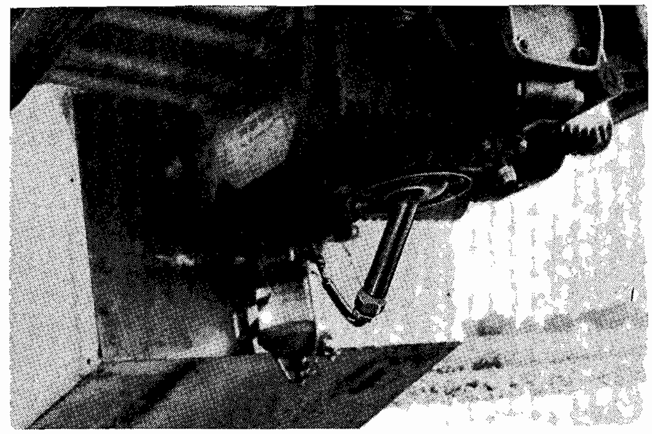
From The Designee File

RICHARD GLEASON, EAA Designee No. 10, has two hints for builders of homebuilts. First, a word on control rigging. Control cable tensions should range from 30 to 40 lbs. Champion uses 30 lbs. on their Citabria, and Cessna uses 40 lbs. (plus or minus 10 lbs.). Properly tensioned cables eliminate sloppy controls and control flutter.

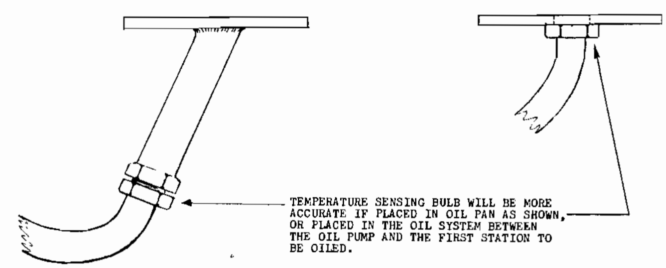
Secondly, Designee Gleason would like to bring to your attention a common mistake made by many . . . even licensed mechanics. This is the placement of drain grommets on a fabric covered plane. Each grommet should be placed on the outboard side of the rib with the drain hole as near the junction of the rib and trailing edge as possible. Inboard of the rib, 1 to 2 in. from the rib or trailing edge, the drain grommet is of no value. The purpose is to drain accumulated moisture from the wing structure, so if grommets are not placed properly, the presence of water in a wing, aileron, elevator, or even the rear of a fuselage can affect the flight characteristics of an aircraft. Failure to eliminate moisture accumulation from any part of an aircraft can eventually lead to dangerous deterioration.

EAA Designee No. 39, Donald Berndt, of Coon Rapids, Minn., observed a potential trouble spot for builders of VW powered aircraft while reading the December, 1965 issue of *SPORT AVIATION*. To quote Designee Berndt:

"This letter is in reference to the article entitled 'The Brown Volkswagen Installation' in the December *SPORT AVIATION* on page 12. Mr. Brown mentioned that the oil temperature had never exceeded 100 deg. F. This indicated that he either had a defective gauge or was not picking up the temperature correctly. The fact that the latter was the problem was very clearly shown by the picture. The temperature sensing bulb is too far from any moving or circulating oil to give the correct temperature; i.e., the oil is cooled considerably by the time it reaches the bulb. The bulb should either be placed in the oil pan itself or preferably in the oil system between the oil pump and the first station that is to be oiled. This would give the temperature of the oil going into the engine, and this is what is desired. Of course, it is not always possible, so directly in the oil pan is about the next best bet. Also the installation as shown would be subject to cracks at the base of the tube where it fastens to the oil pan. A small brace out near the end of the tube up to the oil pan would be advisable."



Bill Brown did a remarkable job in the construction of his folding-wing Jodel D-9, and his VW engine conversion is a very good one. However, we feel that this small problem concerning oil temperature readings should be pointed out, so that more accurate readings can be obtained by all VW aircraft owners.



USE OF DOUGLAS FIR . . .

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The same number of board feet of fir, figured at about 30 cents/board foot (fairly representative) will cost about $20.00, for a saving of $80.00. If you insist on using spruce anyway, in spite of the added cost, you will be paying $80.00 to save 35 lbs., or about $2.30 per lb., **plus** shipping costs.

If you build your 800 lb. airplane out of spruce, and if it is powered by a 65 hp engine which pulls it at 90 mph, 35 lbs. of added weight would reduce the top speed by about 2 mph. Your stubbornness in using spruce, or whatever you choose to call it, will cost you $40.00 per mph.

TABLE 1
Some Comparisons, Spruce vs. Douglas Fir

	Characteristic	Spruce (psi)*	Fir (psi)*	Compared with Spruce, Fir is:
Static	(Fiber stress at prop limit (F_{br})	6200	8000	29% stronger
Bending	(Modulus of rupture (F_{bu})	9400	11500	23% stronger
	(Modulus of elasticity (E_l)	1300x10³	1700x10³	31% stiffer
Compression parallel to grain	(Fiber stress at prop limit (F_{cp})	4000	5600	39% stronger
	(Max. crushing strength (F_{cu})	5000	7000	39% stronger
	Compressive str. 90° to grain ($F_{cu}T$)	840	1300	55% stronger
	Shear strength parallel to grain (F_{su})	850	920	8% stronger
	Weight, (W) lbs. per cu. ft.	27	34	26% heavier
	Ratio, "Strength" to weight (F_{bu}/W)	347	338	3% "weaker"/lb.

*unless specified otherwise

f. **Workability** — Fir is a little harder to work with than spruce. However, few woods are as nice to work with as spruce, so you'd expect it. Fir splits a little easier than spruce and since it is a harder material it doesn't sand quite as well. You also have to be a bit more careful in planing, watching the grain direction a little more attentively so you won't gouge out a piece by planing against the grain.

In conclusion, vertical grain Douglas fir is a fine material for use on aircraft. Although it is a shade heavier and stiffer than spruce and harder to work with, it is both cheaper and stronger — and you can get it. Use the same criteria in picking out the right pieces as you do with spruce; vertical grain, about 8 to 14 grains per in. and grain runout not to exceed 1 in. in 15. And use that $80.00 plus for other purchases you need for that dream ship of yours.