No. 180 JUNE 2001

T.W.I.T.T. NEWSLETTER

Here is a little different "flying wing", the Mignet "Flying Flea". These are two variations of the design, on with an open cockpit, strut mounted engine and, the gear mounted directly to the fuselage. The other is a more modern version with a higher positioned enclosed cockpit and more traditional engine mount. This upper wing was sort of like the more recently promoted "freewing" aircraft that have been explored by experimental builders.

T.W.I.T.T.
The Wing Is The Thing
P.O. Box 20430
El Cajon, CA 92021

The number after your name indicates the ending year and month of your current subscription, i.e., **0106** means this is your last issue unless renewed.

Next TWITT meeting: Saturday, July 21, 2001, beginning at 1:30 pm at hanger A-4, Gillespie Field, El Cajon, CA (first hanger row on Joe Crosson Drive – Southeast side of Gillespie).

THE WING IS THE THING
(T.W.I.T.T.)

T.W.I.T.T. is a non-profit organization whose membership seeks to promote the research and development of flying wings and other tailless aircraft by providing a forum for the exchange of ideas and experiences on an international basis. T.W.I.T.T. is affiliated with The Hunsaker Foundation which is dedicated to furthering education and research in a variety of disciplines.

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1oz/1	1.75	1.75	1.00
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Meetings are held on the third Saturday of every other month (beginning with January), at 1:30 PM, at Hanger A-4, Gillespie Field, El Cajon, California (first row of hangers on the south end of Joe Crosson Drive, east side of Gillespie).

TABLE OF CONTENTS

PRESIDENT'S CORNER

If you didn't make the May meeting you missed a good opportunity to ask an expert about composite materials and construction. Alex Kozloff covered a lot of ground in an hour talking about aircraft and boat composite construction, fiber structures and, how to use the various types of fibers depending on the application. He makes it all sound so easy, other than the toxic nature of the resins, it just wants to make you want to go out and start building that dream machine.

The program for July is shaping up nicely. We have Stefanie Brochocki giving us an update on the latest information she has been able to gather on the true story of the BKB-1. This will also be our anniversary, so make sure to at least show up for the cake and ice cream.

Not a lot of mail again this month, so I used some of the material that has been coming through the guestbook section of the web page. We continue to receive nice comments about the website and its contents. I have also found that we are included in the links sections of a great many other websites, both professional and amateur. This is very heartening since it gives us the additional exposure necessary to continue our work of getting the word out on flying wings. I have added some of them to our links pages as a reciprocal so those finding our site first, will also find the others.

For those of you who have been building over the winter months, let us know how your flying season is going as we progress through the summer. If you have photos of your bird, that would be a welcome addition.

Andy

JULY 21, 2001 PROGRAM

As of publication date the July program was firming up around a return visit by **Stefanie Brochocki** to up date us on the latest developments surrounding the **BKB-1**. She has some new material on vortex lift and a video with enlarged images that may answer the tumbling question once and for all.

Since there has been a big demand for copies of the PBS program featuring Paul MacCready and his unusual "toys", we plan on showing it as the concluding part of the day's program.

The video will be a nice way to spend your time eating cake and ice cream as part of our **15th Anniversary** serving members with information on flying wings.

So make sure to mark your calendar for July 21st and come join us for a good program and lots of camaraderie with your fellow flying wing nuts.

MINUTES OF THE MAY 19,2001 MEETING

The meeting was opened at our usual 15-minutes late with Andy welcoming everyone and taking care of the housekeeping announcements. Andy told the group that Ruth Bowlus, Hawley's wife, had passed away recently. He asked if anyone had any aviation oriented announcements to offer the group but there being none Andy proceeded to introduce Alex Kozloff, our speaker for today. Alex's program would be covering the use of composite materials in the construction of aircraft and a few applications for the boaters in the audience.

Alex opened his presentation with an introduction of the basics on composite construction to put everyone on an even keel with the subject matter. He started with a listing of definitions that would help as he continued.

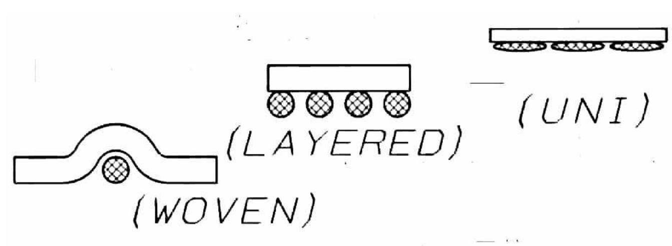
1. Composite is something made up of disparate or separate parts or elements.
2. Fiber is a general term used to refer to filamentary materials and is often used synonymously with filament. A filament of finite length is at least 100 times its diameter that is typically .004-.005 inches.
3. Lamina is a single ply or layer of a laminate and, laminate is a product of uniting laminae with a bonding material.
4. Matrix is a homogeneous resin or polymer in which the fiber system is imbedded.
5. Polymer is a high molecular weight organic compound, natural or synthetic, whose structure can be represented by a repeated small unit – the mer.
6. Resin is a solid or pseudosolid organic material, usually of high molecular weight that exhibits a tendency to flow when subjected to stress. It usually has a softening or melting range and, in reinforced plastics the material used to bind together the reinforcement material – the matrix.

A composite can be made up of a filament and a matrix. A matrix can be anything that is organic or inorganic, aluminum, ceramic, etc. In the case of fiber reinforced plastics a resin, or polymer, is a chemical compound made up of similar items, so we talk about long chain polymers.

The pros of composites are: conform to complex shapes so much desired in aircraft; chemical resistance; ease to shape; fatigue resistant; lighter, and; non-corrosive.

The down side to composites are: anisotropic – strength properties directional with alignment of the fibers; subject to heat and UV damage; limited choice of colors to light ones; creeps under load; can't be threaded or riveted, and; material is hazardous to the environment.

The fiber is the strong part of the matrix, andthere are four types of material to consider: S-Glass; E-Glass; Kevlar, and; carbon. One of the considerations is how much fiber you are putting in the matrix, the more fiber the stronger and stiffer the structure. Formatting of the fibers is also important in that if all the fibers are aligned in the direction of the load you have the most efficient structure. Formatting includes: unidirectional; layered; woven; knitted, and; chopped. Since the fibers are anisotropic you need to be very careful with orientation in relation to the load, since just a few degrees off will affect performance properties.



The important properties to consider are the modulus of elasticity in compression and tension. Most literature talks about tensile strength since it is the strongest factor and is easy to measure. However, most failures occur in the compression mode so this factor has to be considered.

The ideal composite structure has fibers that are oriented in the direction of the load, have a minimum of resin about each fiber and, has no crimps, twists or waviness. This is harder to achieve with woven or knitted clothes since the bends in fiber direction to create these materials weakens the fiber's strength.

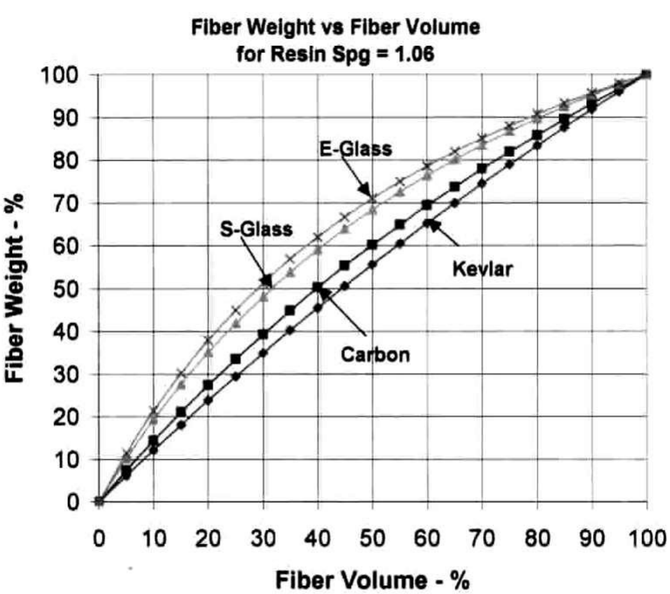
Elongation is an important consideration when picking a fiber material, since this controls how stiff & brittle or flexible & resilient your structure will be. If you match the resin, fiber and core elongation factors properly you achieve the best strength. S-Glass gives the best elongation factor, 5%, before it breaks and carbon has the least, 1.5%, with E-Glass and Kevlar the 4% area.

Alex commented on the bulletproof nature of Kevlar that is so widely publicized. However, Kevlar with this absorbing characteristic is really Kevlar 29 and not the

Kevlar 49 used in building structural pieces. Kevlar 29 a lower modulus of elasticity and higher strength, therefore more elongation, but is not suitable for aircraft use. If you kink or weave carbon the elongation factor goes down at the micro level because you have increased the number of failure areas.

Alex then talked about the tensile strength of materials. There are three fiber format technologies, high, medium and low. The chart he presented showed that the woven style could achieve about 10-15 thousand-PSI for a zero-90 degree material at 30% fiber volume. The layered is better because the fibers are not crimped, but there is a problem with gaps in-between the fibers so you don't get as efficient wet-out. In the unidirectionals, like used for pre-pregs, the fibers are spread out as much as possible so the highest fiber volume if achieved in the wet-out.

Since fiber volume is so important in a design you need to determine what the weight trade-off is when putting in extra resin. With hand layup on unidirectional material you can get about 30% fiber volume and, that's with squeegeeing really nicely. Using a vacuum assist you might get to about 40% fiber volume. Some tests at Wright Patterson found that the highest volume that can be practically achieved is 68-70% with unidirectional, under vacuum and in an autoclave. If you get any higher than this then there isn't enough resin to wet-out all the fibers so you don't get the desired strength. So for the homebuilder there really isn't a problem with not getting enough resin into the fibers. The formulas Alex provided demonstrated that there is a straight-line relationship between fabric weight and thickness. So as you double the fiber weight the thickness also doubles.

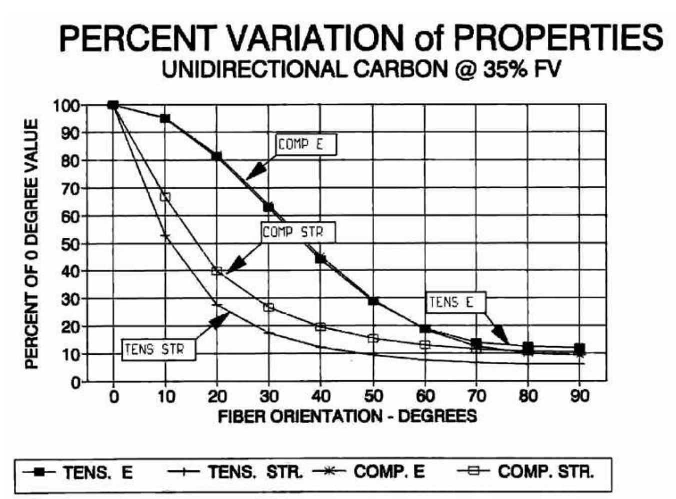


Alex put up a chart comparing fiber weight to fiber volume for the four types of fabrics being discussed. It turns out that E-Glass at 30% volume is very close to 50% fiber weight. As you get to the more exotic fibers that are lighter you find that the ratio lines almost become straight. Another example is carbon at 30% volume has nearly 40% weight, so there is not a large difference in the factors.

He noted a couple of differences between E-Glass and S-Glass. The E- stands for electrical since the fiber was originally used to make circuit boards during WWII. After the war a man named Fal decided to make boats with the material and they turned out relatively well. In 1965, Wright Patterson Field got interested in making the glass more efficient so they developed S-Glass, which has fiber filaments that are half the diameter of E-Glass. Its modulus of elasticity is about 25% more than E-Glass and its strength is really good at 660,000 psi versus 500,000 for E-Glass. More importantly is that since it has twice as many fibers per square inch its impact resistance is about 40% greater. So in his opinion he would use S-Glass even though it cost twice as much since you really get more bang for the buck.

Alex went through a series of graphs that show the tensile strength versus the angle off the axis of the fibers. The further off angle the fiber alignment the weaker the material becomes in tension. This also occurs to a similar degree in the compression mode.

The next graph was a comparison of compression and tensile strengths by orientation for carbon at 35% fiber volume. It shows that compression and tensile modulus lines are almost the same, with the strength lines only showing a slight variation from each other. But what it does demonstrate is that modulus is less dependent on the angle of orientation, whereas, strength



is much more sensitive to the angle. In the real world this means is that structures prone to fail in compression (buckling) are not as affected by fiber angle variations as are structures depending on tension. He indicated that for something like a wing you would want the fibers oriented along the spar line, but for torsional strength you would want them at 45 degrees to the torque line. So when you build a laminate it should have fibers running in the direction of tension and compression loads, circular to retain the structure's shape and, biased to handle the torsional loads.

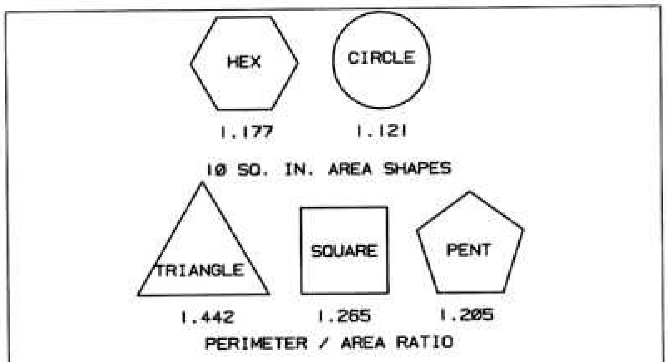


FIGURE 1.

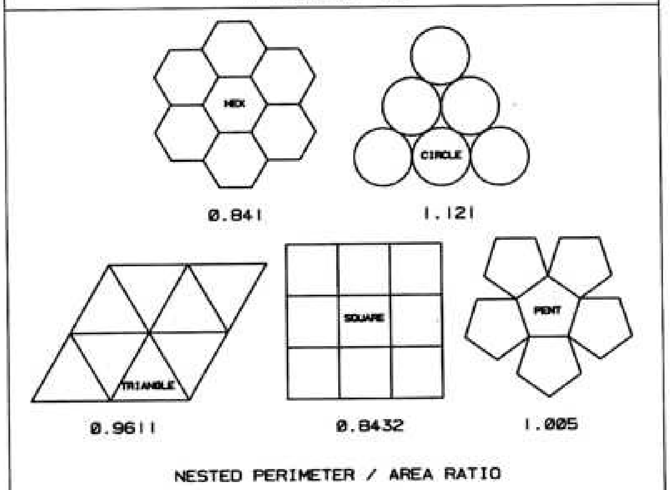


FIGURE 2.

Since lightweight is so important in building aircraft, sandwich construction techniques have been developed. The advantages sandwiches have are: light; stiff; strong; impact resistant; insulative for sound, thermal and vibration; damage resistant, and; water proof. With that introduction to sandwiches, Alex elected to take a short break for some coffee and donuts before continuing.

We began the second part with a slide stating, "Now, the Lord made the bee, and the bee made the honey, and the honeybee's lookin' for a home and he called it Honeycomb (J. Rogers, 1957)." A scientific analysis of why bees make honeycombs started out with five shapes: hexagon; circle; triangle, square, and; pentagon. These were all made in ten square inch areas, then the perimeter to area ratio was determined and, then they were nested to find which was the most efficient. The hexagon had a relative volume of .841, where the nested circles, triangles and pentagons had higher volumes. It was noted that the pentagon never really got together, which was construed as a political commentary of the times. The square nest was the close at .8342 and Alex offered some further analysis to show why the hexagon was the ultimate winner.

Aluminum honeycomb has been found to be have the greatest shear strength per density of any of the other core types evaluated. These included Herex Rigid PVC, Aramid, superlite balsa, and core-cell linear SAN. Alex noted that the core material should have some resiliency, like the core-cell, when using brittle fibers like carbon. When the carbon surface is impacted the core helps absorb some of the pressure and spread it out over a wider area. In a test of sandwiches built from the various types, it was found that the Aramid and balsa cores were the weakest, with the rigid type running close behind. However, the core-cell foam out performed all but the aluminum honeycomb.

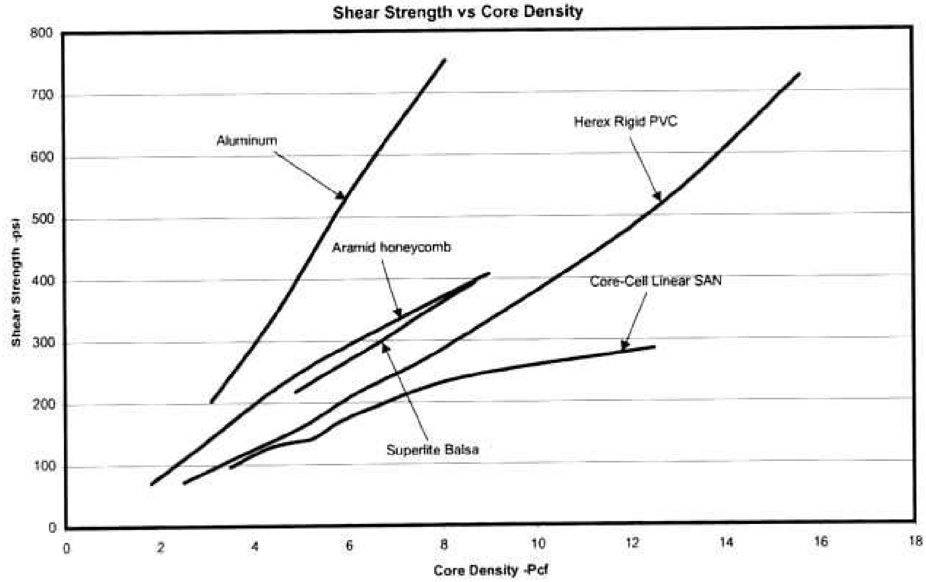
The question was asked about the qualities of Ballteck's Duracore. Alex explained that this product is really a double sandwich consisting of end-grain balsa which has good compressive qualities, with layers of luan, a kind of wood laminate, on either side. It has some flexibility so strips can be shaped and then glassed on the top and bottom. He noted that the extra layers of luan really don't add to the shear strength properties of the core. If your plan calls for using planking for shaping the structure, Alex noted that the core-cell came in a form called bead-and-cove that bends around much easier. This is then covered with the glass on the outside and inside to create the necessary sandwich.

Alex spent a little time talking about composite construction in boats, especially those that run at high speeds in high seas. These boats need to be much stronger than an aircraft since seawater is much denser than air and causes excessive loads on the hull structures. For instance, an aircraft traveling Mach 2 has about the same dynamic pressure on it as a boat doing 40 knots in seawater. So you can see that although the speeds are much different the need for super strong structures is necessary.

This led Alex into a discussion on the tensile strength to weight ratio of the materials he has been describing. If you

Figure 4.

Shear Strength vs Core Density

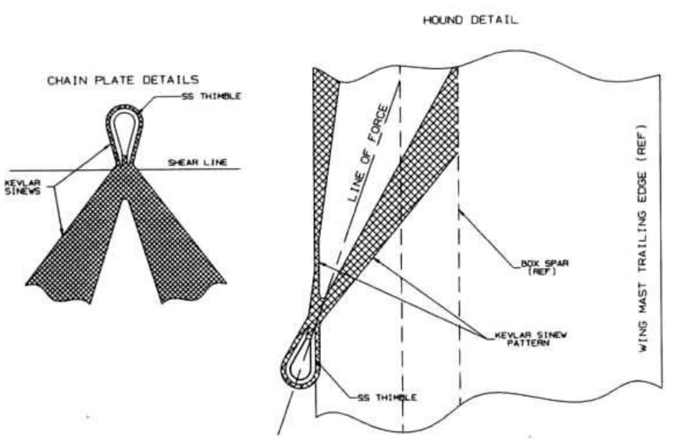


took a piece of E-Glass then stretched it until it broke at a value of its own weight, the strand would be 43 miles long. By comparison, stainless steel would only achieve 4.79 miles and T6 aluminum 6.76 miles before breaking, so the composites have a ten-to-one strength-to-weight ratio. Plus the composites have better fatigue properties.

The next table showed the relationship between the various fiber types in tensile strength per weight of cloth. An example was double bias E-Glass with a tensile strength of 110 pounds at a weight of 12.11 oz per sq. yard, compared to 1554 pounds for 4.43 oz. of unidirectional Kevlar because it is not twisted or crimped.

All these fibers are made up of tows or sinews. If you take one of these sinews for E-Glass that weighs one pound for 450 yards of material it has a tensile strength of 219 pounds. S-Glass at 250 yards per pound has a tensile strength of 821 pounds. The higher the number of yards per pound the thinner the fiber, so you can see there is a tradeoff between thickness and weight when it comes to tensile strengths and where it is being used.

Sinews can be used to mount items that will take bolts or be under heavy shear loads. Each square inch of facing of the sinews on the structures surface gives you 1000 pounds of shear strength. So if you use a ten-to-one safety factor in an 8 x 8 square you get a lot of shear strength for only about half a pound of weight.

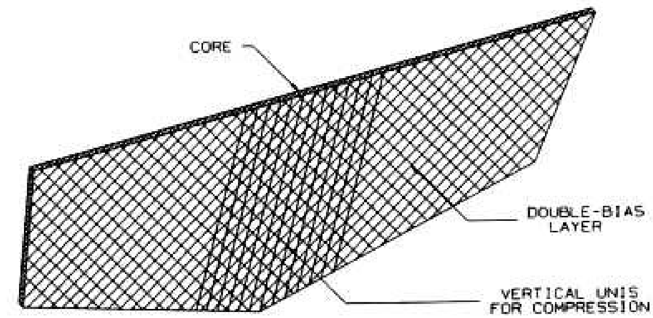


There was a short discussion on the shape of boom type structures and whether or not a square/rectangle was better than a round tube. According to Alex's analysis it would appear that the rectangular shape would handle the loads much better than the tube.

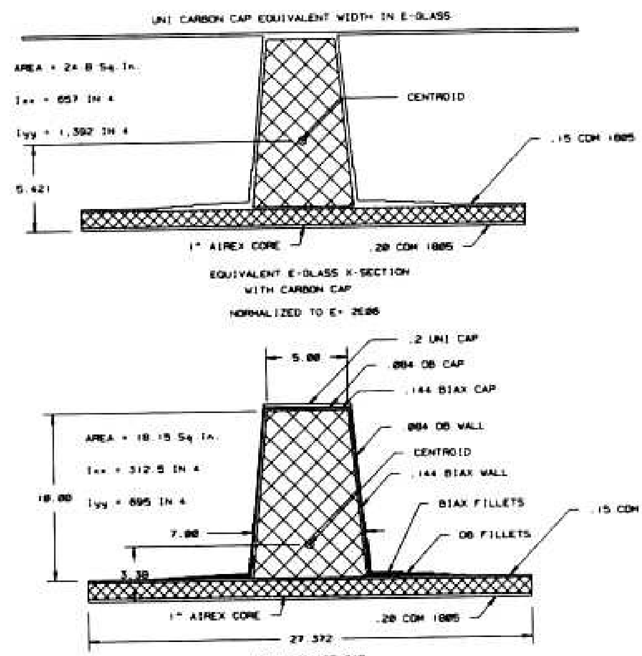
The next table showed the reduction in tensile strength when more resin is added to achieve thickness without the addition of new fibers. In an example using Style 118 E-Glass (4 oz./sq.yd.) the tensile strength was 38,000 psi at a laminate thickness of .005 inches which is a 42% fiber by volume. Using extra resin and not getting as good a wetout reduces the tensile strength to 19,000 psi at .010 thickness, so the weight has been increased and the specific strength lowered.

One of the questions from the floor queued Alex to explain a little about the compressive strengths of the four fibers. Carbon has 75% of its tensile strength in compression, whereas, E- & S-Glass have only 50% in compression and Kevlar about 33%.

Carbon is also helpful in applications like spars and stringers, which you want stiff and strong. By using a carbon cap strip, which has three to four times the stiffness, you can enhance the structure with a thinner layer of fiber. So it becomes cost effective to use carbon in these types of areas.



BULKHEAD SKIN ORIENTATION



STRINGER DESIGN

He also talked a little about hybrid clothes like carbon and Kevlar put together. But Alex feels this is not a good compromise since each fiber type has its unique uses and actually provides better performance if layered properly. He also noted that Kevlar is very hard to work with in terms of using it in molds or making complete structures. However, it is good as sinews for those types of applications. One other thing with Kevlar is the fact that it doesn't really bond the resin well, but rather floats within the resin.

At this point Alex took any more questions from the audience. The first question was about carbon rods. Alex described carbon rods as strands of carbon wetted out, stretched tight and then magically cured. This gets it close to the ideal structure since the fibers all lined up, its pre-stressed, has great stiffness, plus the fact that it is compliant so will work around some shapes.

The next question was how do you insulate a carbon skin from an aluminum honeycomb. Alex noted that this is done with a layer of E-Glass.

Asked what was the best value per dollar for cloth, Alex indicated it was E-Glass.

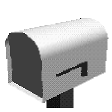
A question was asked about brown-paper honeycomb. Alex noted that the paper absorbs moisture and looses its strength, which is why most honeycomb is made of aramid paper.

Alex was asked about the aircraft he was building. It is a Pulsar, which is a two-place, side-by-side, 470 lb. empty weight, 900 lb. all-up weight with a 2-cycle 66 hp Rotax 582. It should have performance equivalent to a Cessna 150. It has a composite spar versus the wooden one and he will be putting on composite skins. The spar will be an I-beam shape with aluminum inserts in it to accommodate the wing pins. He was asked if he was staying within other parts of the plans, which it turns out he is not. He is using carbon where glass is called for and has reduced it down to one radiator for the cooling instead of two.

Asked about making hardpoints for attachment points, Alex noted that the structure needs to be built so the composites transitions to them in an even way.

In response to a question, Alex commented that carbon was a very good material but the builder needs to take some precautions when working with it. You have to wear gloves and masks when sanding it to prevent getting really nasty splinters and, you have to be careful the dust doesn't get into any of your power tools.

After some discussion about various types of "boats", we adjourned the meeting. Andy noted the July meeting would be our anniversary so we would be having cake and ice cream instead of donuts, so everyone needed to make plans for attending.



LETTERS TO THE EDITOR

(ed. – From the Guestbook.)

May 22, 2001

Subject: Plans of Horten Flying Wing

I want to make a Homebuilders Association with my friends, (they have already built a seaplane motor-glider ultra light experimental, and a French homebuilt "pou du ciel " adapted as a seaplane to have the benefit of ours lagoon), to realize a third experimental seaplane.

We want to work on a Horten wing to experiment with some building ideas for reducing to less than hundred hours the building time. But even if we have some ideas we don't have then Horten brother's experience, that's why we need Horten's plans like the P.U.L 9 and P.U.L 10. Because we don't want to take stupid risks on test flying, that is the reason why I search for information to buy Horten's wing plans.

I hope your help may help us to built a popular aircraft.

Yours faithfully.

David

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(ed. - Reply from Reinhold Stadler after a request from me.)

May 29, 2001

Hi David,

Andy Kecskes informed me that you are looking for information on the PUL 10. That's no easy question.

I was involved in the PUL 10 a little bit. Unfortunately I have no contact with the present owner of the PUL 10 design, Mr. Mattlener at the moment. So I can not check with him what is open data and what is proprietary.

But maybe I can give you some information anyway. The PUL 10 was designed by Reimar HORTEN. It has a span of 10 m and a tapered wing (basic wing data is 2.5 m airfoil at root, 0.5 m at tip, the real wing has an enlarged section of 2.875 m at the root). The airfoil is original Horten. Wing twist is designed for Horten-bell shaped lift distribution (calculated without sweep).

The PUL 10 design is under redesign at present. The original layout with its huge pilot fairing allows only small CG-migration, which is not well suited for a simple airplane. So a smaller pilot fairing would be preferable (tandem seat position). Flight handling is different in some respects. The nose-gear strut can be changed in length to get a high A-o-A for takeoff, this is necessary on flying wings of Horten-design. The PUL 10 uses only single flaps on each side. An additional drag rudder would be helpful for cross-wind landing.

The PUL 10 is built in molds with a type of stiff laminate. That gives a relatively heavy airplane but has the advantage of an extremely stiff skin. Due to this the design has a single spar and only few ribs for shaping. Mass of the airplane may be close to the limits of Ultralights.

Construction of the flying wing is as complex as a conventional design due to the complex wing shape. So you may expect a similar building time. The shape has be duplicated carefully, because there is no way to easy Design changes when finished.

Greetings,

Reinhold

(ed. – David wrote back with some additional information on his plans, apparently without seeing the information from Reinhold.)

June 2, 2001

TWITT & Reinhold:

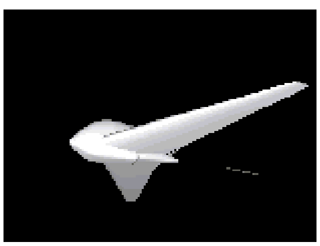
I'm happy about your help. I know it's a lot of work to build a prototype (between 600 or 800 hours). but my idea to build it in less than 100 hours is: - use only one monolithic pressure molding built in two parts: -one for the extrados of the wing, the cockpit, and the engine support -- the second for the intrados and the pontoon .

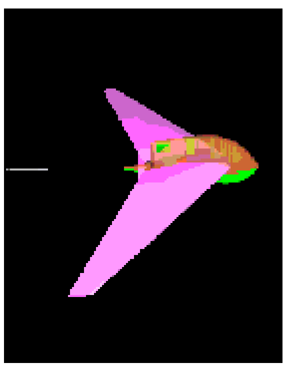
The most important building operations are: -cutting the carbon tissue, -make the skin, -dry it, -put the elevons and engine conduit, -close the molds, -inject the foam, -finish the elevons-, -fix the stick command system, -fix the engine- and test everything.

Even if that idea look's crazy, and things don't progress with the general idea, it is the thing turning in my head since so long time that's why I have to do it. If I can find the plans I'm ready to give in exchange the plans of my future prototype and the flying test result. Would you send me the Reinhold email and the Mattlener email .

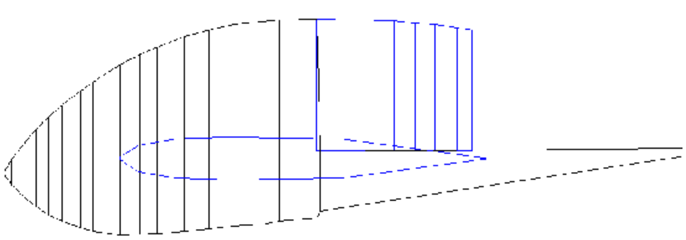
Yours faithfully,

DAVID





(ed. – This will be interesting to see what happens. It is also nice to see that even in the outer reaches of world there a people who are interested in flying wings. Just before publication, David sent along several graphics to show what his team is considering, so I have included a couple here.)



(ed. – From e-mails.)

May 30, 2001

TWITT:

Here-under you will find a copy of different articles concerning flying wing models of Horten powered flying wings. These were taken out of the German periodical FMT. There was also a test of the HoV model in the April issue of this periodical. If you wish a copy of this article, I can send it to you. The internet addresses of the 2 model suppliers are in the copies of the articles. (Hobby und Modellbauversand, W. Steinhardt, Postfach 900 211, 32532, Bad Oeynhausen, Tel und Fax: 05731/53369, e-mail: wshmv@t-online.de , www.modellbau-steinhardt.de)

With best regards.

Eric (du Trieu de Terdonck)

(ed. – Above and below are a couple of the pictures from the articles Eric referred to. I also added the addresses from the article. It is obvious that this is an electric powered model and looks like it is relatively easy to build for the average modeler. The instructions are probably in German, so will either need a good means of translation or take your chances at interpreting the drawings. I have done this in the past with Japanese plans with some luck.)

March 27, 2001

TWITT:

This is a shot in the dark, but would anyone there know of the Davis Wing? It was manufactured [?] about 1988 in Boise, ID. This was a kit designed after the Northrup Aircraft Company's N-1M, a modified flying wing.

I am trying to find specs on this aircraft. Thanks.

Patrick Sullivan
drps484@siouxvalley.net

(ed. – Speaking of the devil, we received the following after I had provided Pat with the mailing address for Gilbert Davis.)

May 28, 2001

TWITT:

I was just looking on the internet for information on flying wing aircraft and came across your page. My father is Gilbert Davis, the designer/builder of the Davis Wing, which is featured on your site. If you would like more information or pictures of his planes please let me know and I will see what I can get (he was on the cover of Popular Mechanics in the late 80's, I can provide you with a copy of the article if you would like). The planes never made it into production but I think were a great idea.

Anyway if you would like any more info just email me, or you can call me at 310-625-0846.

Best Regards,

Mike Davis

(ed. – I wrote back to Mike and got the following, which seems rather promising. Hopefully we will have something new for the July or August newsletter.)

May 29, 2001

TWITT:

I am currently living in Los Angeles, but will be travelling home to Boise this weekend and will see my father so I can get some copies of articles and such, and maybe some pictures that I can scan and send to you. Sometime next week after I return I'll give you a call so that I can let you know what material I've gotten and so that I can tell you the whole story of what happened to the Davis Wing. Anyway thanks for the interest.

Best Regards,

Mike Davis

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