

# FIBRELAM GLIDER CONSTRUCTION

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## ABSTRACT

A new method of glider construction has been developed by Edgley Sailplanes Ltd in the UK based on Fibrelam - an epoxy glass composite sandwich with a Nomex honeycomb core. The glass fibre content of better than 73 % results in a laminate structure with a strength to weight ratio better even than wood and considerably better than conventional composite construction. Developed from CNC cut flat Fibrelam sheets the airframe is assembled in simple jigs thereby overcoming the need for expensive mould tools and providing a route for rapid prototyping of new designs.

## 1. Introduction

The development of a new sailplane in country always requires considerable attention to detail to ensure that airworthiness criteria are fully satisfied before a flight permit can be provided. When a new method of construction is also used then particular diligence is required.

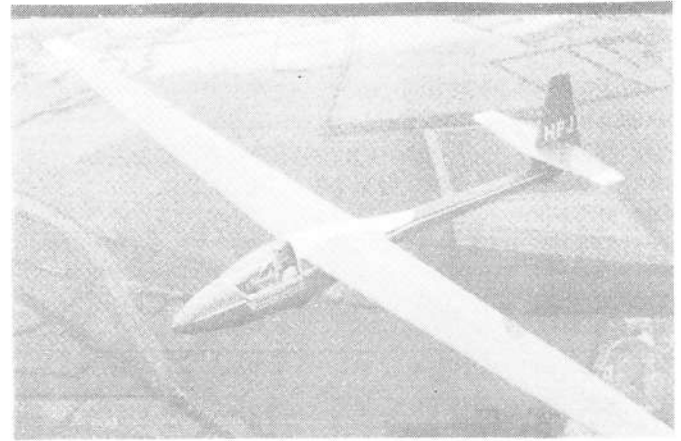
Edgley Sailplanes Ltd, based in Bideford in Devon have recently developed the EA9 Optimist constructed entirely in the composite Fibrelam material, to a design which is very similar to the successful ASK18 sailplane.

Intended essentially for club use to satisfy the requirement for first solo to gold badge flights, this glider meets the role very well, having excellent handling reminiscent of the ASK6 series whilst enjoying all the durability of a composite sailplane. The unique strength to weight properties of Fibrelam enables a lightweight airframe to be built resulting in a low wing loading similar to its wooden predecessor making it ideal for early solo pilots who can sometimes get into difficulties with more conventionally built 'higher energy' composite gliders.

In comparison with the ASK18 the 15.7 m span EA9 has a similar wing loading, whilst the use of a modern Wortmann aerofoil for the wing provides more performance at higher speeds. This makes the EA9 an excellent cross country glider well able to fly 300 km flights at reasonable speeds. A comparison of the key attributes with those of the ASK18 and ASK23 is shown below.

HOW THE EA9 'OPTIMIST' COMPARES			
	Edgley EA9 Optimist	Schleicher ASK23	Schleicher ASK18
Vne	125 kt	118 kt.	108 kt.
Best Glide Ratio	34:1 @ 41 kt	34:1 @ 43 kt.	34:1 @ 41 kt
Min. Sink	1.2 kt @ 35 kt	1.2 kt @ 35 kt.	1.25 kt @ 40 kt
Win Span	15.7 m	15 m	16m
Wing Area	13.06 sq.m.	12.90 sq.m	12.99 sq. m
Max. Wing Loading	25.6 kg/sq.m.	29.5 kg/sq. m	23.0 kg/sq. m
Aspect Ratio	18.85	17.44	19.7
Length	6.95 m	7.05 m	7.0 m
Height	1.72 m	1.48 m	1.70 m
Empty Weight	216 kg	230 kg	215 kg
Max. Weight	335 kg	380 kg	335 kg
Useful Load	120 kg	150 kg	120 kg

Although originally developed for use on airliner cabin floors, Fibrelam does have a notable airframe pedigree, being used on Concord as well as most other modern airliners flying today. Supplied by Ciba-Geigy in pre-formed 6.3mm thick flat sheet, this material needs to be cut to suitably generated shapes on a CNC routing machine, before being joined together to form the complex airframe shape required for the EA9.



## 2. Fibrelam Material Explained

Fibrelam is a proprietary product produced by Ciba-Geigy. It comprises two pre-cured laminate skins of Epoxy Glass separated by, and bonded to, a Nomex honeycomb core.

The laminate skins are 0.4 mm thick and formed by pressure impregnating unidirectional glass monofilaments laid perpendicular to one another (not woven together), with epoxy resin, to achieve a glass content of better than 73% by weight. Since the strength of the ultimate laminate is directly proportional to the glass content, this high percentage of glass results in a very high strength structure as compared to conventional wet lay-up laminates which achieve typically 60% glass content by weight.

The Fibrelam is pre-cured in a hot platten press at 160 deg. Centigrade.

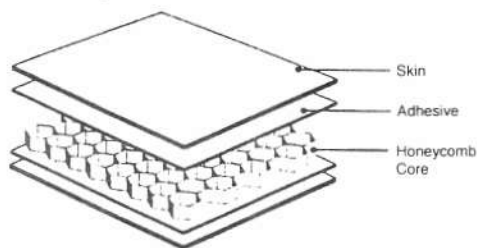
The honeycomb core is made from Nomex fabric dipped in Phenolic resin to provide rigidity. Nomex is a broadloom fabric, woven in an Aramid fibre more commonly known as Kevlar. The core diameter of the honeycomb is 4.8 mm.

This strategic and fairly expensive material is used for all the main structural elements of the EA9 except the tail empennage, the ailerons and the wing spars.

The tail empennage and the ailerons are made from a similarly formed but cheaper material in which the glass fibre element is more conventional woven glass cloth of typically 350 grams per sq.m. resulting in a lower glass to resin content which is adequate for the 'secondary' structures on which it is used.

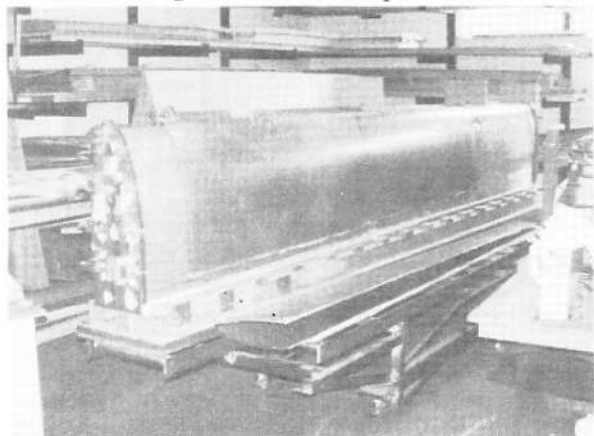
Fibrelam is generally supplied to the company in 4 ft x 12 ft sheets which are cut to the required shapes on a CNC routing machine. The only really critical curved shape which cannot be formed from flat sheet developments is the D box section of the wing, and this requires a different approach to achieve a structure similar to Fibrelam.

For this case the elements used in Fibrelam are supplied in their individual unbonded state. Skin laminates are draped over a wooden male 'D-Box' plug, sandwiching the Nomex honeycomb core.



Bonding of the skin laminates to the honeycomb core is achieved by the use of epoxy film adhesive, which is essentially pre-preg epoxy resin laid on plastic substrate to a thickness resulting in 250 kg per sq.m weight.

The sandwich of the two laminates, the film adhesive and the central honeycomb core are held firmly to the pattern by vacuum bags and then heated in an oven to 110 deg. C. At this temperature the film adhesive flows, wicks up into the honeycomb before curing to bond all the elements of the structure together into the required curved form.

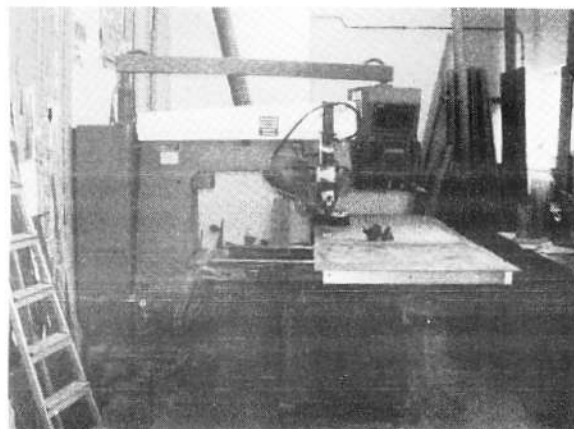


### 3. Airframe Construction

In order to generate the flat sheet shapes required to construct the airframe, a three dimensional virtual airframe is drawn in Catia, a powerful 3D CAD tool licenced by the company for the purpose.



The developed shapes required are interpreted into a second software program which generates the code needed by the Wadkin CNC milling machine to cut out the required shape.



### The Wadkin CNC Milling Machine

To prove the accuracy of these CNC programs and to avoid unnecessary scrap Fibrelam material, they are first used to direct the milling machine to cut the prescribed shape in relatively inexpensive medium density fibreboard (MDF).

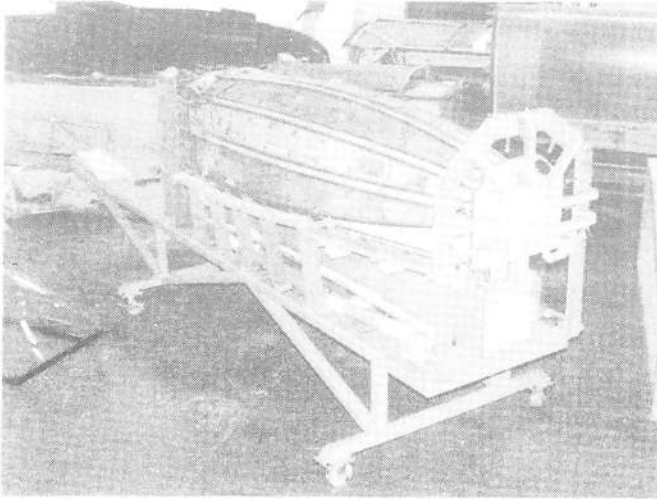


The huge dependency of this process on software tools, together with the young embryonic nature of the Edgley Sailplane business demands a young and intelligent workforce. It is not surprising therefore that the company workforce includes a number of young graduates cutting their teeth in this exciting area of new product development.



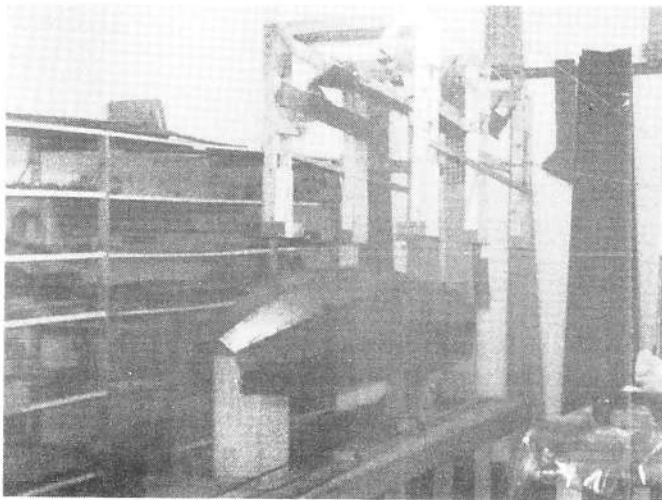
Where possible, three dimensional structures are made by machining out a flat development which is folded to the required shape. To assist the folding process an appropriate width of laminate skin is routed out along the fold line on the inner laminate.

Once the fold is complete and the inner laminates are once again in contact, a 3 M's epoxy adhesive is introduced as a fillet along the edge to rejoin the laminate and hold the folded Fibrelam to the required folded shape.

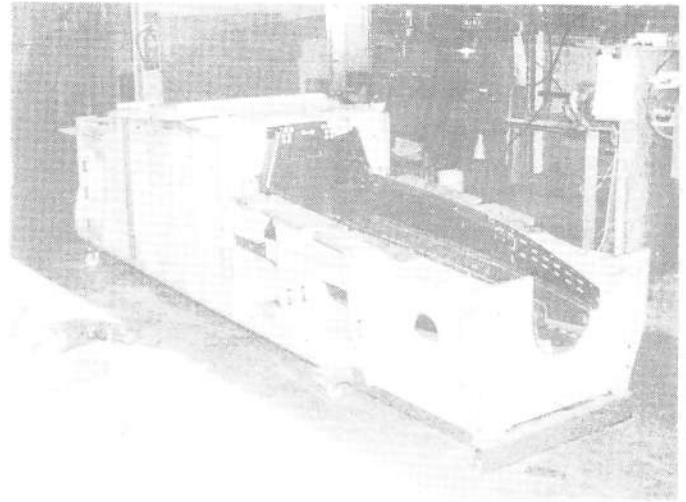


The 3 M's epoxy glue 'wicks-into' the underlying honey-comb structure providing additional integrity to the bonded joint. As a finishing measure the inner folded laminate seam can be overlain with glass woven tape bonded into position with epoxy resin although this adds little to the strength of the joint which has been proven to be adequate.

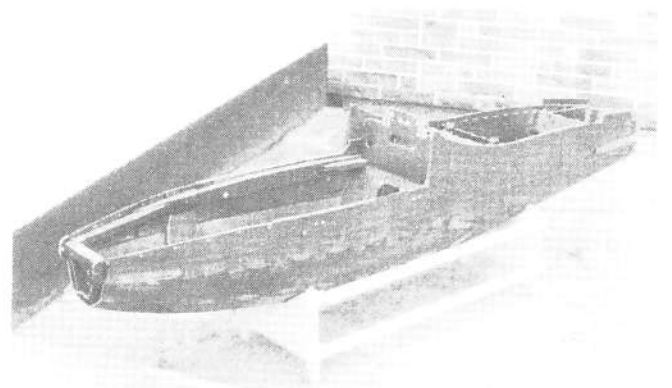
To assist with the accuracy of this folding and joining process a number of jigs are used as illustrated here. The first fuselage jig uses suction to hold the side elements to the jig until the interlocking seams are bonded and cured.



On release from this first jig the folded fuselage shell appears and is then positioned into a second fuselage jig which holds the shell securely into position whilst the bulkheads and reinforcement beams are bonded in position thereby securing the structural shape.



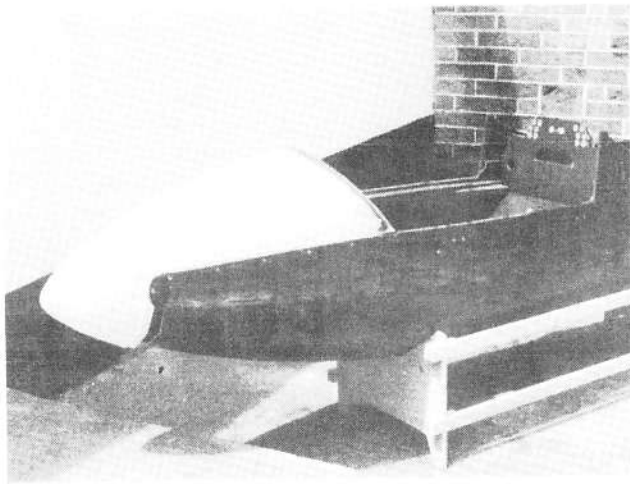
On release from this second jig the front fuselage pod is effectively structurally complete as can be seen from these two following views.



The rear fuselage is similarly constructed as a folded development of a flat sheet, bonded together at the join line. Carbon fibre tape is laid along the length of the fuselage boom to provide additional bending stiffness.

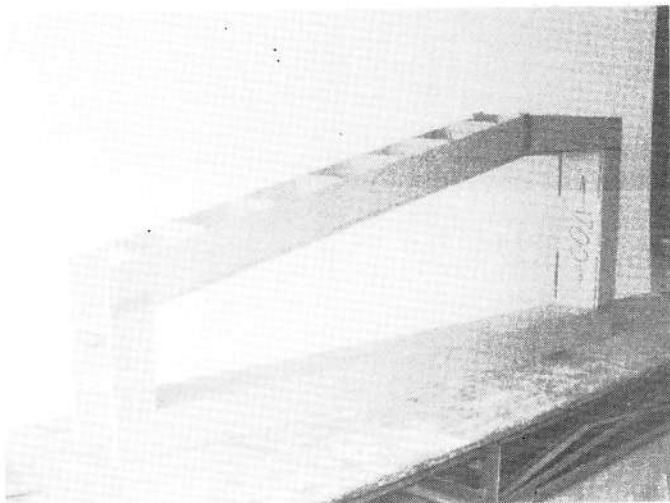


The fuselage is finished off with a conventional wet lay-up epoxy glass nose cone featuring cut outs for the nose aerotow hook and the pot pitot/ventilation intake.



Similarly, other non structural parts such as the wing centre section cover and the tailplane and fin tips are also made as wet lay-up mouldings.

The tail empennage elements are again bonded together using a jig made from the MDF packing case which is cunningly pre-cut to assist in the jig manufacture. By way of example, the jig for the tail fin is illustrated here.



Fabrication of the wing involves forming the 'D box' as previously mentioned in sections which are then bonded edgewise to one another with laminate doublers on the inner and outer laminate seams to produce adequate bond reinforcement. The laminate skins are sufficiently thin that the edges of these doublers are easily lost with filler.

The spar to which the 'D box' is bonded is a folded rectangular box section running the length of the span, with carbon fiber composite pultrusions forming the structural elements at each corner of the box. As the spar design and the tie-in of the wing root fittings is both innovative and

proprietary to the company its detail cannot be disclosed until adequate design protection is fully in place. Suffice it to say that the spar design is worthy of a paper in its own right.

#### 4. Certification Status

Edgley Sailplanes Limited is going for full certification of the EA9 in order to achieve International sales without undue difficulty. The prototype EA9 is currently flying on a UK permit after a series of initial flight trials and study of the initial structural design records.

The prototype wing is not representative of the production design since it features an aluminium spar which is soon to be replaced by the aforementioned carbon fiber composite equivalent. A significant attendant weight saving is expected. While flutter problems are not expected, full flutter verification will be undertaken on the first of the production wings to be produced.

#### 5. Conclusions

Fibrelam has been shown to be suitable for glider construction.

Fibrelam offer better strength to weight construction possibilities than wood and is better in this respect than conventional composite construction.

Use of Fibrelam is particularly suited to kit construction of composite gliders.

Use of Fibrelam offers a fast build process for new glider design construction requiring no complex moulds.