

FENWICK WILLIAMS CATBOAT SCANTLINGS

Please note that I have included the normal appendices supplied with my plans. There are some methods that will prove useful in terms of labour and timesaving.

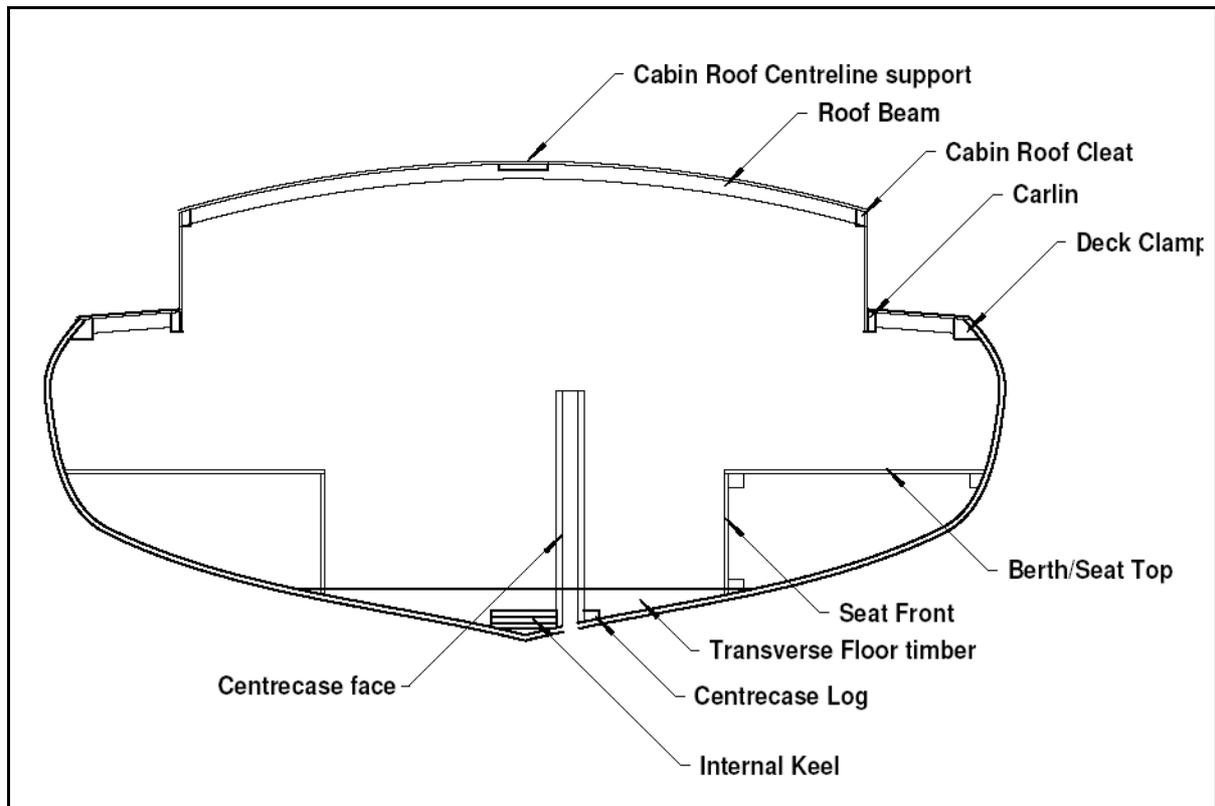
Definitions

Siding - the face parallel to the hull skin. (eg Top of Keel)

Moulding - The face perpendicular to the hull skin (eg Side of Keel)

Suggested Reading

“The Gougeon Brothers on Yacht Construction” - available Amazon, West system epoxy dealers.



SHEATHED STRIP SCANTLINGS

	IMPERIAL	METRIC
Displacement*	3763.00lb	1706.58 kg
Water Density	1.03	
Scantlings Numeral	3.94ft	

Planking thickness

0.59in 15.00mm

(to finish min 12mm – it is expected

that finished cedar strip thickness will vary from 14 to 12mm)

Species is normally Western Red Cedar for easier shaping. In Australia, Paulownia is taking over from Cedar because cedar is becoming so expensive.

Ounces of Glass Cloth (sq. yd)**14.46oz 489.60 gsm**

Method 1 - Glass is unidirectional laid perpendicular to planking - inside and outside hull

Method 2 - Alternative is +45/-45 biaxial cloth which is more commonly available and requires a little less finishing than the unidirectional which finishes quite rough.

David Wilson put a second layer of glass on the outside bottom of the boat from keel and trimmed off at 2 to 3" above waterline – this is not structurally necessary but was added to reduce the risk of damage when launching and retrieving the boat from/to the trailer.

The heavy biaxial cloths can be a little difficult to wet out. David generally precuts the biaxial to approximate size then roughly rolls it up at one end of the job. He quickly mixes an initial epoxy mix to roll or squeegee on the surface – then unrolls the glass onto the surface and applies the balance of the resin with a squeegee. He is an experienced builder.

Method 3 - It would be possible to use a standard 8 or 10oz standard woven cloth which is much easier to wet out with resin. Two layers would be needed over the outside of the hull. Peel ply could be used if wanting to do the layers in two stages. On the inside I would suggest a single layer but with an additional layer below the waterline and also in the bow section back to the bulkhead behind the mast to help take the mast loads.

Keel portion of Backbone Moulding Depth 2.76ins 70.00mm

Keel minimum siding - Widest point 5.52ins 140.00mm

Keel may be laminated if desired – it . Keep the edges parallel in way of the centrecase- the keel can act as one of the case logs. The keel is recessed into the building mould setup with the upmost face at the same level as the centreline of the moulds at each station.

Stem, sternpost, horn timber S&M 2.36ins 60.00mm

These are minimum dimensions – it is normal to laminate the stem. The knee at stem will have to be beefed up to take mast, much as existing plan. If laminating knee out of timber it may be sensible to incorporate a couple of layers of ply to resist splitting loads. It can be notched to take the front of the keel laminations.

Bilge stringers if single – square. 2.91ins 74.00mm

May be eliminated as furniture is structural - in this size fillets will not be adequate by themselves so recommend glassing over the fillets with 10oz tape - preferably cut on the bias. Or fitted externally as a bilge runner – David used three layers 45 x 25mm (1 ¾ x 1") to make up a 45 x 75 deep section. He thinks that next time he wouldn't allow the bilge runner to terminate abruptly but make it longer so it could be tapered down to nothing over 24 inches each end.

Photo below shows the bilge runner with the original blunt ends. The bilge runner was glassed over with double bias and a heavy brass strip was fitted.



Clamp Sectional Area	3.40ins²	2191.00mm²
Secondary Clamp Sectional Area	1.70ins²	1096.00mm²

Designed clamps as per plan look fine - recommend laminating.

Partner knees arranged as drawing. May be a total of 1 3/4" ply to eliminate bolts. If deck is bonded to top face of partner the partner can be reduced in thickness by the deck ply thickness.

Mast step on knee as in original.

RESPACING FLOORS (to bring them onto the building stations)

One floor is to be fitted on each mould station. Expect that floors are laminated out of two layers 12mm ply with sole cleat along top edge. Preferred if sole is glued or structurally screwed in place with hatch access to bilge. Minimum depth of floor is to be 3inches on any station - would prefer if a bit larger to make up for half strength of plywood - suggest 4 inch minimum depth on centreline. Floors to be glued, filleted and glassed to hull skin with double bias tape 75mm (3"wide).

Use these dimensions for floors – moulding is the minimum and may be adjusted upwards to support the underside of the sole at the required height.

New Floor Spacing	24.00	in
Test Siding for new Floor	1.00	in
Test Moulding for new Floor	3.00	in. (> 2 times siding)

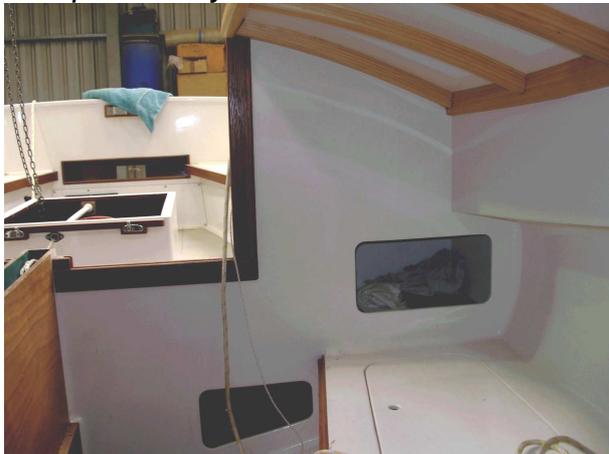
BULKHEADS AND TRANSOM

Because of the large overall beam of catboats bulkheads and transom will have to be beefed up in comparison to boats of similar length. Bulkhead behind mast (Whether the drawn one in the original plan or one fitted further forward should be approx 18mm (3/4") - can be made from 2 layers of 9mm (3/8") ply. Smaller forward bulkheads can be 12mm (1/2"). Main bulkhead (companionway) and transom can be two layers of 9mm.

Bulkheads in relation to mast support.



Companionway bulkhead



INTERNALS

Interior fitout and cockpit area can be in either 9 or 12mm as seems appropriate for the panel in question. Cabin seats/bunks are adequate in 9mm. The vertical diaphragms within the seat areas could be 12mm to support the hull sides adequately.

Much of the cockpit will need to be 12mm to give similar strength to hull panels (if it is being veneered the ply thickness can be reduced in line.

There should be a longitudinal web of ply fitted under the cockpit floor and running the length of the cockpit on either side. It should be set out the same approximate width as the settee and cockpit seat fronts (It is designed to replace the need for a bilge stringer - can be used to form the seat fronts or to provide sides of engine compartment.

CENTRECASE

Fitting case off-centre may result in limited floorspace on one side according to interior on sheet 9. check before committing yourself. David did it with his boat and it worked quite well. The problem that was not resolved was how to set up the centreboard uphaul so it was possible to pull it up from the cockpit. It interfered with the engine box and in the end we ran it through the engine box inside a conduit.

Note that the case is supported from sideways loads forward by the small cross bulkhead that forms the back of the double berth and aft by being bonded to the main bulkhead.

Case sides to be two layers 9mm. Keel forms one centreboard log. Other formed by 45mm (1 3/4") square log - depth can be chosen to match sole if desired so sole rests on top of cleat. Floors are to be connected to logs with fillets and two layers of 10oz glass tape or tapes cut from the double bias glass. (first layer 3 inches width, second 6 ins - preferably cut on bias).



CARLINS

Carlins can be as per the original plan.

DECKS

If Decks are veneered (eg teak) total thickness to be 12mm. If glassed ply can be 9mm with 10oz glass over top. It is suggested that the coaming be built of laminated plywood to a total thickness of around 25mm (1"). This is probably greater than required for structural reasons but to build it too light won't match the weight and ruggedness that one expects in a catboat. David found that 4mm ply bent fairly easily around the radii required.

The deckbeams can be laminated of 9x45mm (3/8 x 1 3/4") laminations to give an

overall depth of 54mm (2 1/8"). The spacing can be the same spacing as the stations – 2ft. Deck beams need to be glued to the tops of bulkheads where the deck is to be supported and across the front of the cabin unless it is supported directly by a bulkhead under the foredeck.

As the deck is made of plywood the ply will have to be joined at convenient locations. Plywood panels for the deck **MUST NOT BE JOINED OVER DECKBEAMS** but have to be joined between bulkheads and beams. The join can be a buttstrap under the deck cut to a width of 20 times the deck plywood thickness – if the decks are 12mm (1/2") the buttstraps will need to be 240mm (10") wide.



CABIN ROOF

The cabin sides can be 2 layers 4mm plywood. This will be bendy enough to go round the required radii. There was a lot of work involved in getting the cabin sides to look good. David made them up somewhat higher than required then clamped battens to the outside and looked from lots of angles until he found a sweet line.



The Cabin roof cleat will have to be laminated – David used 4 layers of 6mm timber to provide a cabin roof cleat that is 24mm horizontally and 55mm vertically.

Cabin roof is 9mm plywood. It is supported by Cabin Roofbeams laminated to finish 45 x 45mm ($1\frac{3}{4} \times 1\frac{3}{4}$). The cabin roof beams are set into notches in the Cabin Roof Cleat, as per the WEST reference book (and the picture right, and are glued into place.



A centreline board is inset into the tops of the roofbeams as per the photo below.

On the outside the cabin top is supported by the two longitudinals that provide the sides of the sliders for the companionway hatch. They are made from 45 x 70mm.



EXTERNAL KEEL/SKEG

If external keel is glued down over glass it should be fastened from inside of hull with large galv coach screws or similar fitted with good sized washers. Alternatively hardwood dowels (15 - 19mm diam, one in each frame bay) can be glued in from inside of hull, through the internal keel into the external keel (to within - drill holes oversize to ensure adequate bonding).

NOTES ON PLYWOOD AND BONDING.

There are some general rules for plywood bonding.

Where timber cleating is used to attach plywood to the hull the bonding area of the timber needs to be a total of 3 times the plywood thickness. So if adding a cleat on the edge of a 9mm ply to be glued to the hull the cleat has to have a bonding area of minimum of

$$3 \times 9\text{mm} = 27\text{mm}$$

The same rule applies when using epoxy fillets.

For plywood up to 9mm (3/8") the radius on the inside corners of fillets needs to be 3 times the ply thickness as well – no glass is required

For 12mm (1/2") plywood I would recommend a fillet three times the thickness of the plywood plus one layer of biaxial tape 75mm wide.

For the 18mm thick transom the most sensible alternative is to use an internal timber frame as this allows secure fastening of the cedar strips as they are added to the building jig. The timber may be as many pieces as is convenient to provide the perimeter shape. The framing will need a bonding area of a minimum of 54mm on both hull side and transom.

For the 18mm thick companionway bulkhead a pure fillet would take up too much epoxy. I would suggest using a 36mm fillet plus adding three layers of biaxial tape.

1st layer 75mm wide

2nd layer 150mm wide

3rd layer 200mm wide

They can be applied wet on wet as per the appendices to save sanding, mess and to save materials.

APPENDICES

- 1/ Cordless Battery Drill with Clutch
- 2/ Wet on Wet Epoxy Application and dewaxing cured epoxy
- 3/ One hit coating and gluing
- 4/ Gluing and filleting using snap-lock Plastic Bags
- 5/ Precoating Plywood Panels before Assembly
- 6/ Building strong lightweight boats - a note on the use of epoxy
- 7/ Fibreglass taping method – coat and tape at the same time.
- 8/ Gluing endgrain

Cordless Battery Drill with Clutch.

A marriage made in heaven. The drill can be battery (most convenient) or mains powered. It is best if it has a variable clutch. If you have a drill without a clutch, you can often buy a new chuck with inbuilt clutch.

The screws are self tapping and match a Phillip's head bit in the drill. Just hold two pieces of wood together with one hand and drive screw in with drill in other. Fast - and the screws should be removed and may be re-used.

If you want to minimize the indentation where the screw head meets the ply, use a plywood pad already placed on screw. If gluing, the pad should have some plastic packaging tape wrapped around it to stop accidental bonding to the workpiece.

I mass produce the pads by cutting a strip of ply (usually 6mm, 1/4" thick) about 19mm wide (3/4"), covering one side with packaging tape, then cutting it into 19mm (3/4") squares.

Screws should be removed when the epoxy is hard enough – usually the following day – it should feel hard when you try to indent it with a thumbnail.



If the screws ever get stuck so they can't be undone apply some heat using a cheap electric soldering iron (right). A couple of minutes and the epoxy will soften enough for them to be unscrewed.

Wet-on-Wet Coating and Dewaxing Cured Epoxy.

Great improvements have been made to Bote Cote brand epoxy in regards to this problem. It is very unlikely to occur at all. All the preparation you need for the next process is to sand the hardened epoxy surface. The wet-on-wet application method is still the best as you don't have to sand between the coats.

However other brands of epoxy may suffer from wax.

As epoxy cures some of the unreacted components migrate to the surface, leaving a waxy residue. This can reduce the adhesion of following coats, whether epoxy or paint and make them go "fish-eyed" (the surface finishes pitted).

This is why I always use a "wet-on-wet" epoxy application method (see "precoating plywood sheets" below). If the surface is allowed to cure it will have to be dewaxed (not Bote-Cote) and sanded (Bote Cote too).

Dewaxing - When the two to three coats have cured I always de-wax the surface using a plastic domestic scourer (Scotchbrite) and water with some cloudy ammonia added. Scrub very thoroughly rinsing off regularly as you go.

You can then sand the surface to key it for further painting, epoxying or gluing.

One Hit coating and gluing

An extension of wet on wet epoxying is a method for coating areas that are easy to get at now (plain plywood components) may be hard to get at a bit later when other parts are attached. A couple of examples are fitting the bottom, fitting the side decks and fitting framing to the bulkheads.

For example if gluing the bottom panel in place it is easy to coat the inside of the bottom at the same time. For major gluing processes like this it is important to make sure that everything will work smoothly – do a DRY RUN without the epoxy to make sure that you have enough screws etc to hold the bottom on OK – you can use the same holes again when you are putting the bottom on permanently.

This is the method (put on your disposable gloves!!!).

1. get all the framing that the bottom will be attached to bevelled and ready to accept glue
2. put three coats of epoxy "wet on wet" on the inside of the bottom as per the method in the appendix above.
3. immediately put glue (epoxy plus the gluing thickening powder – make up to a peanut paste thickness) on all the framing of the hull that the inside of the bottom will be glued to – spread it out ready to take the bottom.
4. drop the bottom on with its wet face in contact with the glue in the previous step and screw the bottom in place.
5. clean up any excess glue that has squeezed out of the joints about 20 minutes after the assembly. If you wait till tomorrow you will be sanding forever. Use a flat piece of timber sharpened to a chisel edge on the end with a sander.

The same method can be used when putting the framing on the bulkheads. Coat one side of the bulkhead immediately before gluing the framing on that side.

Filleting and Gluing using "Snap Lock" Plastic Bags

Most supermarkets have varieties of "snap lock" bags. They have a seal across the opening of the bag that can be pressed together with finger pressure. They make it a lot easier to keep epoxy glue away from areas on the boat where you don't want to

put it. And also areas on yourself where you don't want to put it!

Make up some epoxy, thicken it to the consistency of peanut butter. Put a "snap lock" Glad plastic bag into a tin and fold the top of bag over lip of tin (like a garbage bag in a garbage bin - trashcan). Scrape epoxy into the bag.

Take bag out of tin, seal opening and cut one corner out of bag to make a hole a few mm (approx 1/4") across - size will need to vary with consistency of mix.

By gently squeezing the bag a bead of epoxy will ooze out of hole in controlled way from the hole.

Pipe a bead of epoxy down the angle where you want the fillet. Then use a shaped piece of timber as shown right to shape the epoxy.

Use a filleting stick of a radius three times the lesser ply thickness to smooth down the fillet. Practice getting it smooth and even.



Remove excess from either side of fillet with a stirring stick that has been sharpened to a chisel point. It is possible to lay masking tape down either side of the joint in the first place so that the excess can be removed with the tape.

Precoating Plywood Panels before Assembly.

I find this the best method, where possible.

It saves the effort of sanding between coats of epoxy and prevents any waxing problems between the wet-on-wet coats.

Mask off all areas that you don't want coated. (Especially any areas you are going to glue to later – not strictly necessary with the Eureka.)

Lay surface flat where possible.

Mix resin and hardener. ***You don't need to add any powder when you are coating – they are only used when gluing one piece to another.***

Apply first coat.

NOTE - If doing large areas the epoxy will go off too quickly if left in the mixing tin. You will have much more working time if you pour most of it out over the surface first and roughly spread with a squeegee, before going back with a roller to spread properly.

Don't bother to buy a commercial squeegee – just use an offcut of ply about 200 x 75+mm (8 x 3"). Make sure the working edge is straight and that you have sanded the sharpness off the edges and corners.

When it is spread hold roller so it cannot rotate and pull gently along surface of epoxy. It slicks the surface smooth and pop any air bubbles.

When first coat has become quite tacky, roll on second coat. Slick the surface. When second coat is tacky roll on third (if required) and slick it down.

IMPORTANT - Remove masking tape when third coat is still tacky. You don't want to glue it down - forever.

When epoxy is fully cured turn the panels over, sand off any drips that have come from the other side and repeat process if required.

When the epoxy has cured sand the panels smooth using a random orbit sander (these tools are a very worthwhile investment but hand is fine too). 180 grit paper is about right. Sand enough to remove gloss.

If you have problems getting a good finish speak to your epoxy dealer.

Building strong lightweight boats - a note on the use of epoxy

Epoxy is expensive stuff, so when there is a bit left over from a process there is a temptation to use it somewhere.

Don't do it! The boat has been carefully designed to be strong enough already - all you will do is add weight and ruin the boat. Where you can use it for a legitimate step, do so - but think about it first.

Another time it is best to throw out epoxy is if it is starting to go off in the bag or tin. If it is starting to get too hot to comfortably hold it is going to be hard very shortly - you are unlikely to have enough time to put it into place.

Furthermore, hot epoxy fillets slump badly, hot coatings wax and get fish-eye pitting, and hot glue joints end up with lumps that stop clamping. Make up a smaller mix next time and get it out on the surface earlier – straight after careful mixing in the tin or bag

Fibreglass taping method

The method for fibreglassing hull seams can use the same wet-on-wet approach as above but with a small change to integrate the application of the glass tape. It makes it a very clean and tidy process once you get the idea.

Fill any screw holes, allow the epoxy to cure and sand flat. Radius the edges that the tape will be applied to. A minimum of 3mm (1/8") is just enough to allow the glass to wrap around without lifting. A bit more is better – but don't round the edges

around the transom at the stern too much – the water wraps round the corner when sailing causing drag.

Apply first coat of epoxy to hull (pic below left). Note the masking tape to prevent epoxy drips running around the corner onto the deck. The finish can be quite smooth by holding the roller so it can't turn and lightly and slowly skid it across the surface to pop bubbles and get rid of roller marks.

Put glass tape down in wet epoxy (pic below right). I should be wearing gloves.



Detail of glass along transom.(pic below left). Use the roller or a cut down disposable brush (bristles not longer than 25mm (1") to work epoxy into the glass tape – it goes clear when the epoxy has wetted it out correctly.

An example of wetting out (pic below right) – the glass along transom is now wetted out and becomes clear. Continuing with the transom sides – here cutting tape to



length.

Roller method (pic below left)

Finished taping and second coat is put on when first gets tacky (pic below) – roll the epoxy out well so as to not add too much weight – but roll a little bit extra on the tape – too much and it will run down the side.

When epoxy goes tacky apply a third thin coat and skid the roller to give a smooth finish.



If the weave pattern is still visible in the glass tape roll another coat to fill up the weave.

Leave epoxy to cure.

The next day – while the epoxy is still a little cheesy (if you leave it too long it will make this hard work) set a fine spokeshave fine and get rid of the edge of the glass tape. Keep the body of the spokeshave over the glass but set the blade with a tiny bit of depth on the edge side but no depth on the other.

Work carefully and slowly.

Then sand the glass tape using the random orbit sander and 120 grit paper. Keep the edge of the sander lined up with the edge of the glass, but keep the sander body over the tape. Angle the sander - concentrate a bit of weight on the side of the sander over the tape edge and keep the rest of the sander off the surface of the tape.

Finish off by sanding the rest of the bottom to a matte finish (no gloss) but don't go through the epoxy to the timber.

Generally I brush a couple of thin coats onto any areas where I go through to the

wood – allow that section to cure and give a light sand – making sure I blend the edges of the brushed area.

Gluing Endgrain

See drawing of endgrain right.

When gluing endgrain with epoxy it is a two stage process.

Mix enough resin and hardener to do the job. Stir well. Brush the mixed epoxy onto the endgrain.

Wait 5 minutes - brush more epoxy on the endgrain. Now add the high strength gluing powder to the epoxy in the container and apply to gluing surfaces.

And hold in place by normal methods such as clamps or packaging tape until the epoxy sets up.

