National 12 Amateur Building Guide – Foam Sandwich construction

1st revision 2004 Graham Camm
Geoff Camm
Mike Cooke

1. Introduction

Building in foam and carbon or glass is great fun and the results are spectacular, strong and light with a good surface finish if you are patient enough. The basic laminating process is easy. It is however a bit more effort as you have to create the material pretty much from scratch, compared to building in wood, where the material just needs cutting and bending to fit. The end result when building foam sandwich is excellent though and well worth the effort.

2. The laminating process

The basic laminating process is

1) Cut foam core to shape (Note: all foam should be pinholed to allow the excess epoxy and air to seep through. You can buy pre-pinholed foam or create it yourself using a 2 mm drill)

2) Cut cloth to size, along with the peel ply (a bleed layer which separates the excess epoxy), absorbent cloth (used to mop up the excess epoxy) and finally the vacuum bag

3) Mix epoxy with some micro-balloons and apply to the foam (general ratio is about 1:1 to 1.2 : 1 by weight of epoxy to cloth

4) Place on the cloth and press in using either a roller, scraper or brush, then wet out with additional clear epoxy

5) Apply the peel ply and continue to apply pressure to the peel ply: as a rule of thumb if the peel ply looks wet then you'll get a good lamination and surface finish

6) Lay over the absorbent cloth and vacuum bag (lay up shown in the diagram below), but allow the epoxy a little time to set before applying the vacuum otherwise too much epoxy can be removed, leaving the laminate too dry

7) Turn on the vacuum and apply lots of heat. 40 degrees C is good but anything above 15 degrees C will do.

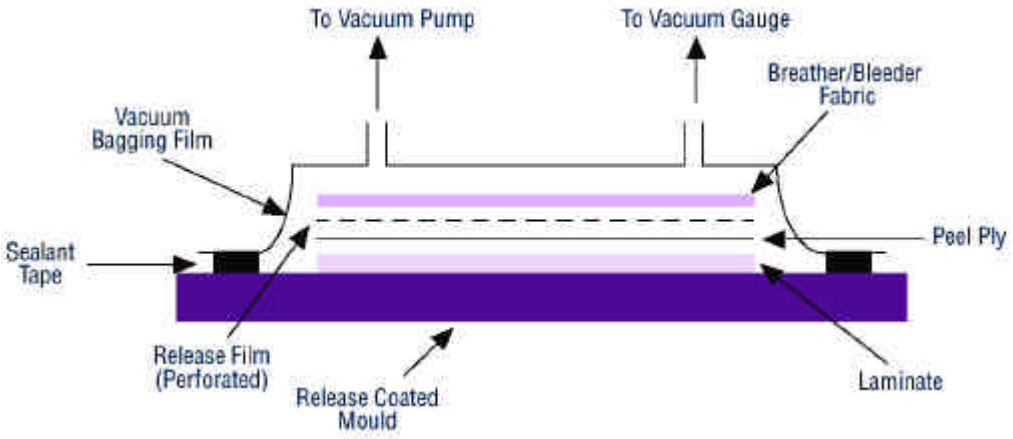
8) When set (a good trick is to leave a pot of the left over epoxy you mixed next to the job so you can test if it has set), peel off all the consumables to reveal a beautiful composite component.

Top tips

When you lay up it is important to think about where your cloth will join as these can be a bit untidy (unless you are painting).

Where fittings will be screwed or bolted on (e.g. cleats) or high loads are expected (rudder pintles of shroud plates) it is wise to use wood pads to spread the load.

Foam can be very easily shaped prior to lamination using really coarse (80 grit metallised) sandpaper. It is a bit trickier to shape after the carbon has been bonded on so best to shape prior to lamination. Post lamination it will be difficult to 3D shape but it can easily be cut using a saw or Stanley knife.



3. Materials

There is a huge range of cloths, resins, foams, honeycomb and new ones being invented all the time so the best plan if you want to do something cutting-edge is to visit the SP website and read all the material specs. The table below gives a rough idea of typical lay ups used for a National 12.

The main decision is whether to use glass or carbon. Glass is tough but not quite as stiff as carbon whereas carbon is very stiff but relatively fragile. Kevlar is not very stiff but bullet proof. A key disadvantage with Kevlar is that you cannot sand it: if you try you get a fluffy surface finish which is not so great under the waterline of your N12.

In reality the cloth densities come out similar since the main limitation is roughness rather than strength and this is down to material thickness. Glass does seem to soak up a little more epoxy though so the end result tends to be slightly heavier.

Component	Inner skin	Sandwich	Outer skin
Hull skin	200g/m2 weave	Hull bottom panel 5mm, 80Kg/m^3 Top side panels, 8mm -12mm 80kg/m^3	300g/m^2 bi-axial + 80g/m^2 glass weave protection layer or 400g/m^2 glass weave or 200g/m^2 carbon weave x 2 + 80g/m2 glass weave protection
Floor	200g/m2 weave	10mm foam, medium density (80kg/m^3)	200g/m^2 weave x 2
Bulk heads	200g/m2 weave	5 to 6 mm low density foam (40kg/m^3)	200g/m^2 weave
Side decks	200g/m2 weave (may not have an inner depending on construction method)	10mm medium density foam (80kg/m^3)	200g/m^2 weave x 2
Fore deck	200g/m2 weave	5 mm foam, medium or high density	200g/m^2 weave
Centre-board case	200g/m2 weave	5mm medium density foam, (80kg/m^3)	200g/m^2 weave x 2

4. Making the shell

4.1 Inner skin

Polish the mould with mould release agent(5-6 coats required), takes 1-2 days

Cut carbon weave to size for the whole of the inner skin

Cut foam panels to size to cover the whole of the area under the waterline / up the chine (if there is one)

Lay weave on to the mould in strips at 45 degrees to the hull, starting at the transom with an overlap of 50mm between strips.

Apply epoxy after each strip of cloth is positioned. This job takes around 4 hours so a slow hardener is essential.

Apply a micro-balloons epoxy mix to one side of the foam to fill the holes in the foam.

Place foam panels on to the mould on top of the carbon strips.

Vacuum bag.

Photo 1 (above): Hull inner skin being vacuum bagged

Photo 2 (right): Shows the result when the vacuum bag is removed. The inner black carbon weave is visible at the bottom (top sides of the hull) and at the top of the photo is the foam (covering the below water line area).

4.2 Skin Foam

Shape the edge of the bottom panel foam so that it will fit smoothly to the top side foam panel.

Cut top side foam panels, create slots to allow the foam to follow the curve of the hull with a Stanley knife or saw, e.g around the chine and near the bow. Heating gently with a hairdryer can help with the bending as well.

Coat inner surface of foam with a micro-balloon epoxy mix to fill holes.

Position and vacuum bag.

Remove excess foam using a Stanley knife

Fill foam and fair to create the exact shape you are looking for (after you apply the outer skin there is no going back!) so take time here. You could add speed bumps here if required. Allow a day for this.

Take care to get a smooth continuous chine here

Also spend time getting the nose profile right

Photo 3 (above) shows hull foam after smoothing. Take care when fairing around any epoxy hard spots (around the pin holes) as the foam will sand more easily than the epoxy and you can end up with low spots

4.3 Apply the outer skin

Option 1) If you have 1.3m wide cloth then you can do this as fore-aft runs one per side with an overlap of 75mm.

Option 2) If you have 1.0m wide cloth you will need to do this as a series of strips at 45 degrees.

Option 1 is easier as there are fewer joints and therefore less fairing.

If you want to apply a glass protective weave over the top of the carbon then apply this at the same time and vacuum bag.

Pop boat off the mould working from the transom forwards (this is quite nerve-racking).

Photo 4 (above) shows the skin removed from the mould

4.4 Make cradle

Before completely removing the skin from the mould (i.e. before the skin is sitting on your lawn) you should lay up a cradle to keep the hull in shape whilst the decks and bulk heads are being fitted. This is because as a bare skin the hull is very easy to twist.

Apply polythene or carpet over the hull then lay up chopped strand glass and polyester resin (cheap) over the top. Cut the shape out of cheap 12mm plywood and bond with more glass.

Lift boat off the mould, turn it over and put it in the cradle. Set cradle flat, square and level before putting in the boat.

5. Transom & Centre-board

5.1 Transom

Take a cardboard template of the whole transom

Cut foam to match template

Cut wood for reinforcement (.e.g. at pintles where there is high load)

Cut foam out to match wood

Glue wood in, then use filler to fair in the joint.

Laminate transom

Trim boat to length, marking up using the method from the measurement guide to make sure the boat is 12' long.

Bond transom into hull.

Position the transom 10mm inboard of the rear edge to allow a fillet both sides and also some trimming later if required to get the boat to length when the official measurer measures it.

Note 1) rough up the area you are bonding to, especially important for areas which have been in touch with a polished surface.

Note 2) It is very important to get the transom square at this stage.

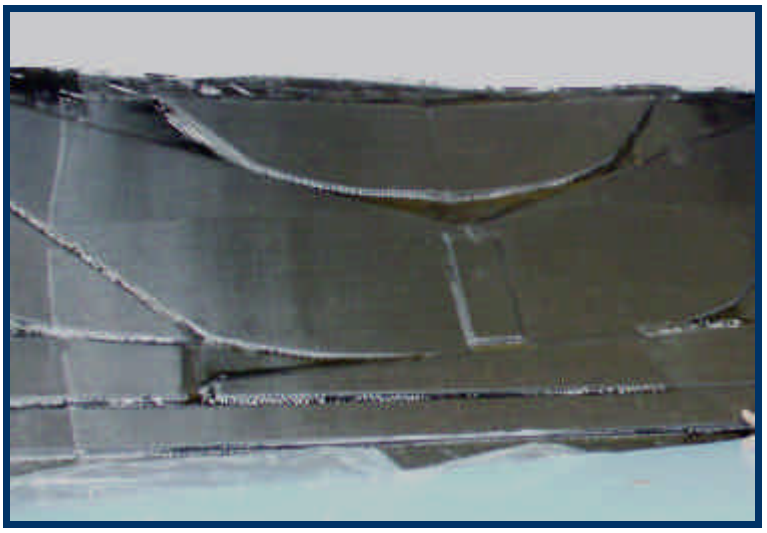


Photo 6 above shows the transom and the central spine component being laminated. The components have been cut to size and fit checked by offering up to the hull before laminating

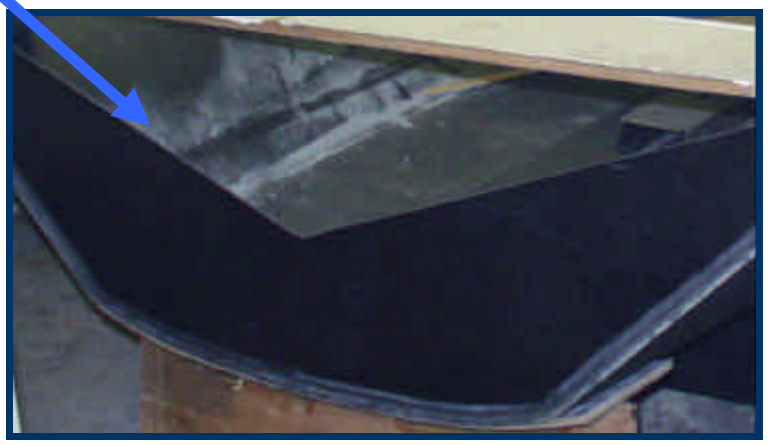


Photo 7 (above) shows the transom being bonded

5.2 Centre-board case

Make it

It is best to make the case around the board you intend to use.

Cut two pieces of foam to length

Laminate the inner surface and add an extra layer of cloth around the bearing surface where the board spends most of its time.

Bond wood around the centre-board pivot on the outer side

Bond in wood or foam spacers at the ends and then bond glass tape or cloth around the ends to prevent them parting.

Finally bond in the pivot, which is typically a 8mm

Photo 8 (above) Centre-board case made up and ready to fit, In this photo the case is tapered to match the curve of the board (rather than parallel) but this is tricky to do, parallel is easier. It also has some flanges on to make the case more rigid, this helps to keep the case in shape whilst fitting

diameter stainless steel rod or a bolt.

Test it

Test that the board rotates ok, as once it is fitted it is hard to widen the slot.

Rout a channel in the floor to take the case (optional)

Fit it

Ensure you get the case parallel to the centre-line and vertical.

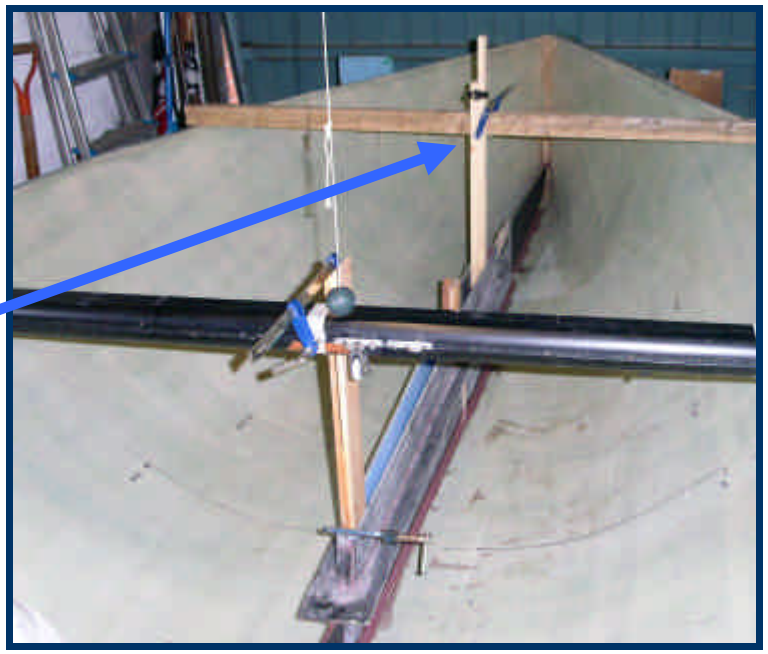
Get it vertical by clamping lengths of wood into the case and use a spirit level (or set square to horizontal beams across the boat)

Fit with some spacers in the slot to ensure the case doesn't shrink or distort.

Fillet bottom edge and reinforce with anything you've got (off cuts come in handy here) 50mm glass tape will do.

Note: You cut the slot through the outer skin later

Photo 9 (below) Shows the centre board case being fitted, note the careful alignment to centreline and vertical.



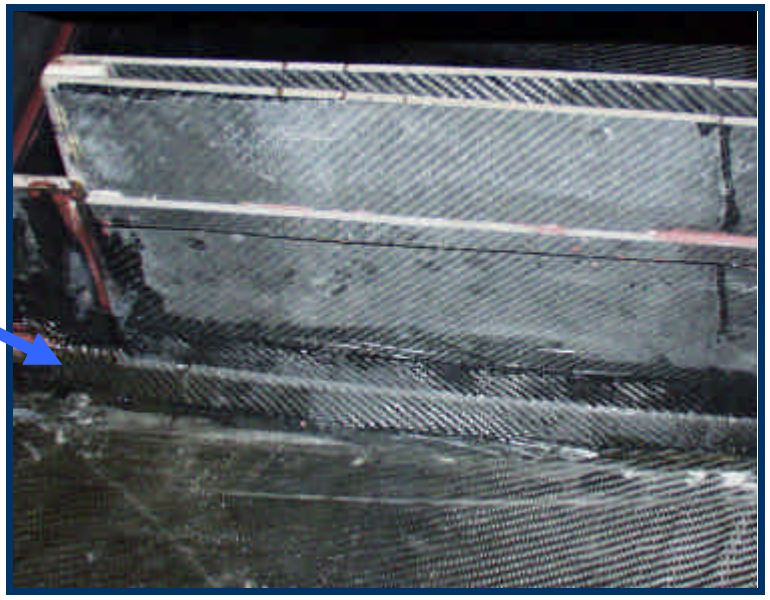


Photo 10 (below), shows reinforcing tape being applied to the joint with the hull. There is a lot of force on this joint when both crew are standing on the centre-board.

6. Bulkheads and floor

6.1 Bulkheads

These are going to support the floor and stiffen the whole boat

Aft spine:

Make out of laminated foam

Fore spine

Use 12.5mm marine plywood under the mast

Foam from the front bulk heads to the nose

Mid-ship under floor bulkheads

Position so the bulk heads cross close to your toe strap take off points, and also support the forces on the centre board case

Method is:

1) Cut cardboard template.

2) Mark floor position on the inner skin, aiming to fit to a 50mm V in the floor (this is to encourage the water to run out of the middle)

3) Mark floor position on the centre-board case, either using a laser level, a water level or a template which defines your floor angle and extrapolate from the centre spines. Alternatively fit the fore and aft bulkheads and use a trial and error method for the middle bulk heads.

4) Put a beam across and measure down to the floor

5) Translate measurements to a cardboard template and cut out

6) Check template in place

7) Apply strips to centre-board case for the floor to sit on

8) Apply strips to transom for the floor to sit on

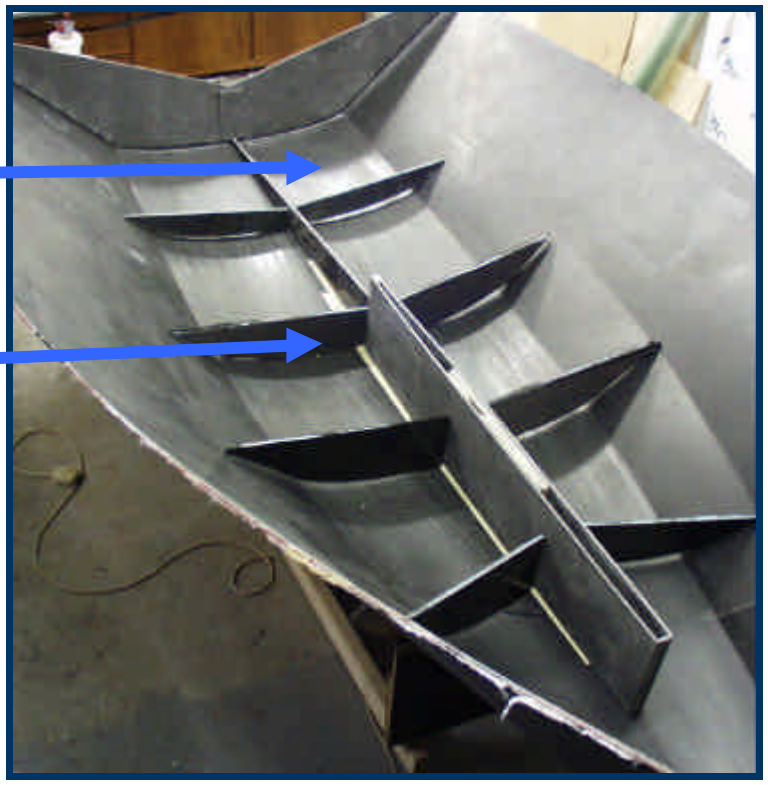


Photo 11 (above) shows a typical bulkhead layout using a combination of perpendicular and angled bulkheads. Angled bulkheads produce a stiffer boat but it is harder to shape the pieces to fit.

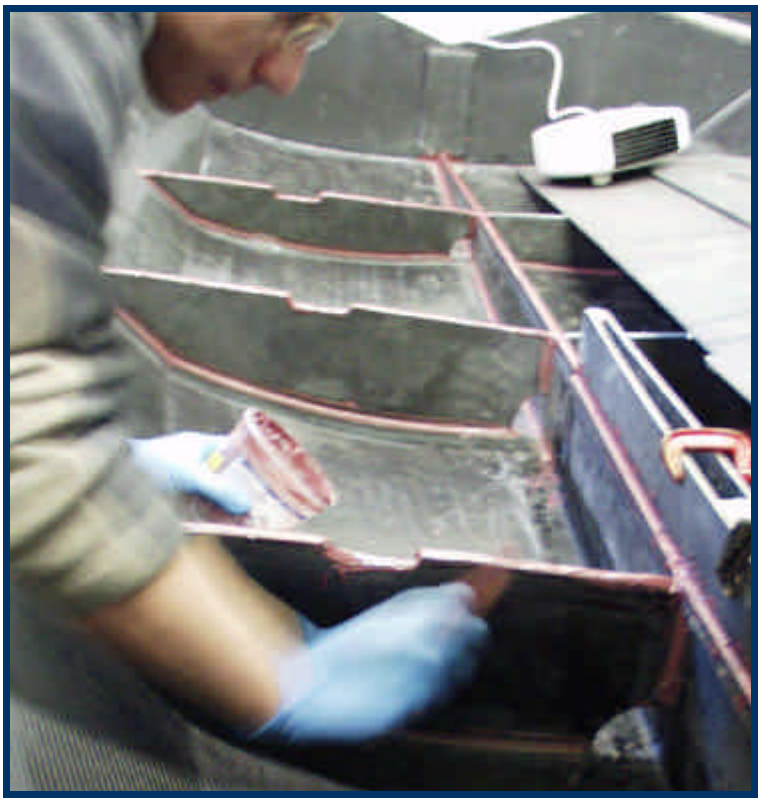


Photo 12 (right) shows the bulkheads being fitted with large epoxy fillets.

6.2 Floor

Make

One sheet of foam is not long enough for this, so you need to bond an extension to the foam to cover the area near the mast before laminating. This extension can be foam or wood. If you use wood then you can bolt fittings into it later which makes fitting out easier.

Photo 13 (right) shows the floor being cut to size and chamfered

Fit

Cut chamfers at the edge where the floor meets the skin to ensure a good bonding area

Check the alignment before bonding

Apply generous amounts of a thick epoxy bonding mixture using plenty of colloidal silica to stop the epoxy running.

Position the floor and weigh it down.

Tape joints or laminate a second layer over the whole floor. (not a bad idea as the floor gets a lot of wear)

Photo 14 (right) shows the floor being bonded in place.

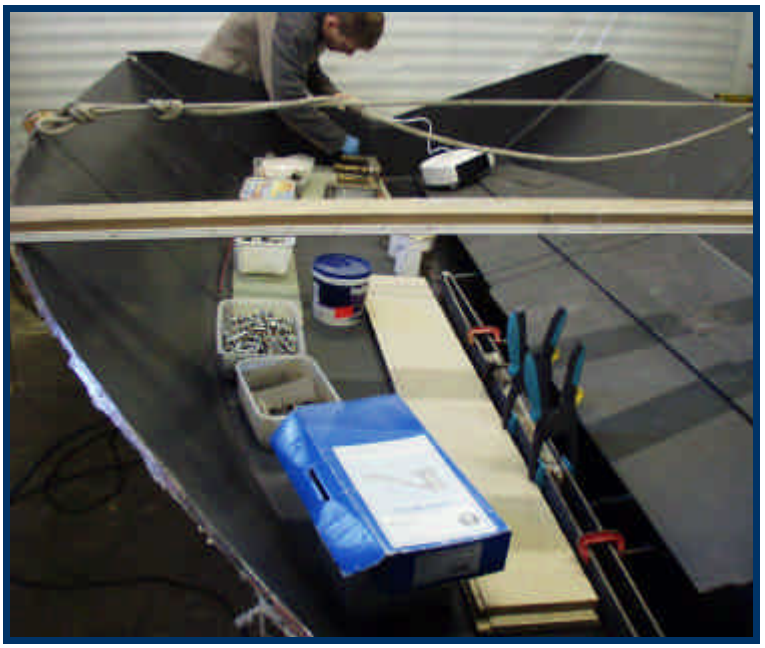
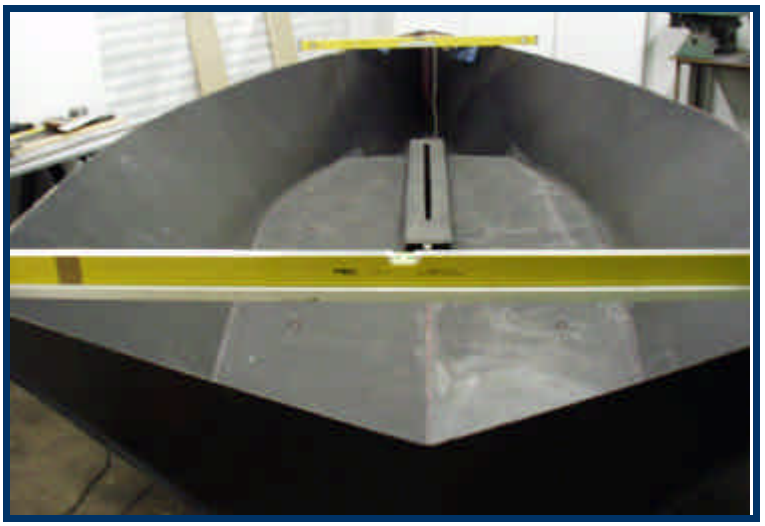


Photo 15 (right) shows the floor after the joints have been taped



6.3 Add floor mouldings

Centre-board cappings and kick bars. Generally best to make these off the boat and then bond in place once the floor is fitted

6.4 Fit front bulk heads

Cut cardboard template roughly to side, then cut and shape the foam and laminate off the boat

Bond in place with large fillets then tape the joints.

7. Decking

7.1 Cut the sheerline

If you are building on a female mould then the sheerline should be pre-defined.

If you are building on a male mould then it may be defined or you may need to mark it out. This can be done using a laser level or a water level to mark on the height along the length. The important thing is that the middle is lower than the ends and that the curve is smooth (to meet the class rules). The amount of curve should also be symmetrical for aesthetics.

7.2 Side decks

The side decks are best built up in place (unless you have a deck mould handy). The easiest method is to bond 10mm or 15mm foam strips on to the inner skin to build up the inner deck then flat this down and add foam to the top.

Bond in some plywood (at least 12.5mm good quality marine ply) where your shrouds are going to be attached as this area of the boat takes lots of load.

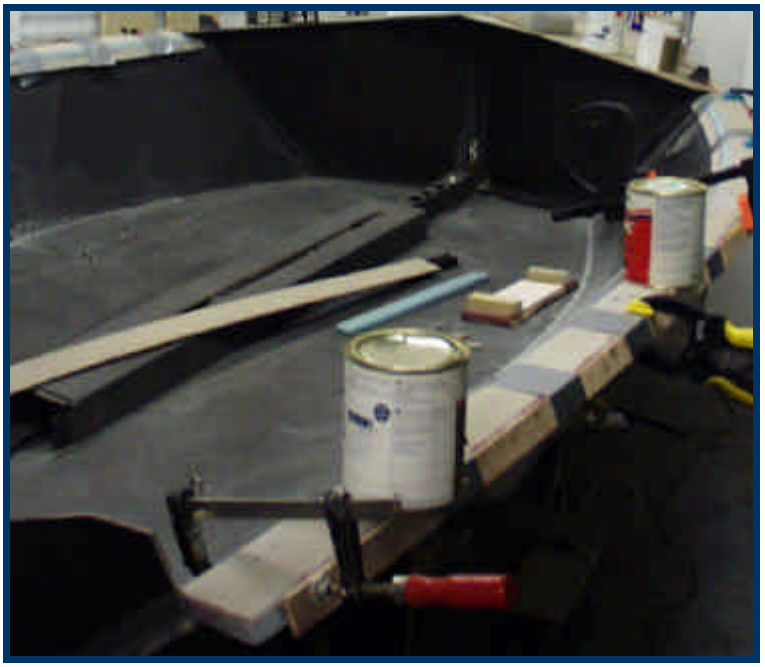
Finally consider bonding some 5mm plywood to the gunwhale edge. Foam is not ideal for the gunwhales as it crushes too easily with collisions.

Weighing down the foam can be a challenge. You will either need a lot of big clamps or planks of wood and weight across the decks (as in the photo)

It is best to use a power sander or really coarse (60 or 80 grit) sand paper . To get a flat smooth curve it is best to finish sanding manually with a long piece on sandpaper on a long block of wood (typically 60cm)

Photo 16 (above) side deck foam being bonded in place

Photo 17 (below) shows the wooden gunwhale strip being bonded and clamped in place



7.3 Foredeck

Cut the foredeck foam to shape. Consider how you are going to attach the jib to the bow of the boat: you might want to bond in wood or a metal fitting here.

Laminate the inner surface off the boat

Fit the deck and weigh it down in place

7.4 Sanding decks to shape

Take plenty of time here as it is hard to change the shape once the decks are laminated

Look along the decks from the transom and the front to check that the curves are all smooth. There are three curves to check

1) the vertical sheerline

2) the inner deck

3) the outer gunwhale

When determining the shape of your decks think about how comfortable you want them to be when you and your crew are hiking out: a gradual curve will be better than sharp changes of angle.

Photo 18 (above) the decks getting their final sand

7.5 Laminate fore-deck

Another fiddly laminating operation. Overlap the cloth on to the decks for a neat join. This has the added advantage of strengthening the shroud area. Consider reinforcing cloth over the jib attachment point.

NOTE, if there are any pin holes in the foredeck then the vacuum will start to suck the foredeck into a concave shape. It's best to drill a hole in the front bulkhead before laminating (roughly where the buoyancy hatch will go) to avoid the deck imploding!

Photo 19 (above) the foredeck being laminated and vacuum bagged

7.6 Laminate side decks and transom

This is a fiddly operation as it is a large area to laminate and vacuum bag.

Follow the normal procedure for laminating. Apply extra layers of cloth over the shroud points: it's recommended to apply 6-10 strips of cloth perpendicular to the deck over the shroud point on to the inner and outer hull.

NOTE cloth goes better around corners if the fibres are at 45 degrees to the corner.

To get the temperature up during curing you can suspend wooden planks across the decks, place a fan heater in the middle and then place polystyrene or a tarpaulin over the boat.

Photo 20 (above) the decks and transom being laminated and vacuum bagged

8. The 3 Fs “Fill, fairing and finishing”

8.1 Fill, fair and hybuild decks

The laminating process leaves a slightly pitted surface. Hybuild is great for building a thick and light weight surface which fills all the pin holes. If after one coat of hybuild you think your surface has big dents then it is time to mix up some thick epoxy filler. You can use plastic padding but this doesn’t last as well.

The other advantage of hybuild is that it is an epoxy paint and sets really quickly and overcoats can be applied within hours.

Sand flat using coarse or medium grit then repeat process until the surface is flat

Finish off with a fine grit sandpaper.

If you start to sand into carbon (i.e you start to see black dust) then stop sanding immediately and apply another coat of Hybuild.

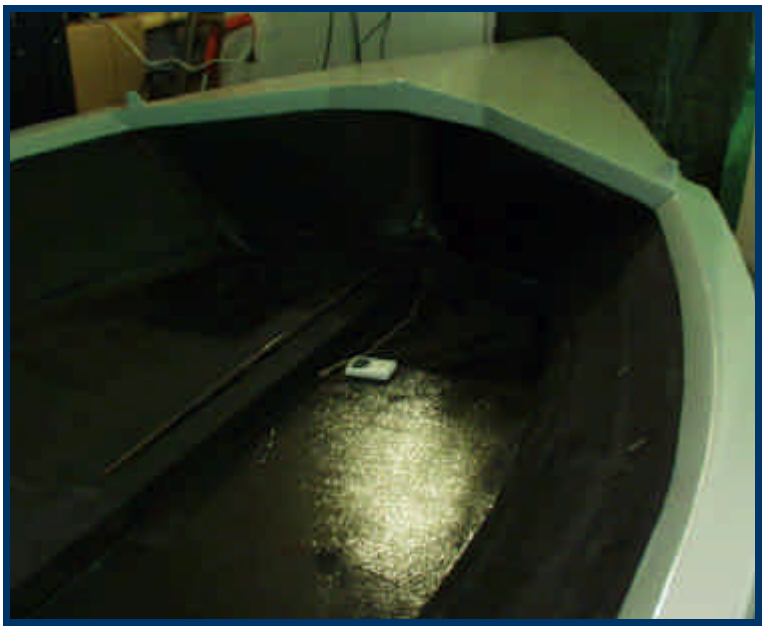


Photo 21 (above) Hybuild applied to the decks,

8.2 Fill and fair hull

Before starting the filling and fairing cut the slot for centre board case. If you have foam at the very bottom of the case then it may be wise to cut back or chamfer the foam by around 10mm on each side of the case and fill with a hard epoxy mixture. This is to stop the centre board denting the foam.

Photo 22 (above) shows the hull after a layer of filler has been scraped over the whole surface

8.3 Hybuild the hull

If you've used a male mould then the filling and fairing part will take sometime. It is probably best to start by scraping a layer of epoxy filler over the whole surface. Then coarse sand back and start applying layers of Hybuild.

8.4 The final result

Doesn't she look smart?

Ready for the top coat of paint, fitting out and then hours of fun on the water.

Well that's about it for this guide, hope it's removed some of the mystery and given you a few ideas where to start. If you want any more advice on building N12s then get in touch: the number's on the website.

Happy building