PART III

BUILDING AN FRP BEACH LANDING BOAT

10 - BUILDING AN FRP BEACH LANDING BOAT

10.1 PREPARATION

The following is a practical guide to building an FRP boat, using an IND 30 8-m BLC as an example.

A beach landing boat operating from surf-beaten beaches is subject to a much harsher environment than a boat operating from a creek or harbour. It is subject to tremendous impact forces when crossing breakers and landing on the beach. In addition to impact, a BLC is also subject to severe abrasion when it is hauled up on to the beach each day. These operating conditions must be taken into account when deciding hull lay-up and structural arrangements.

Figure 68

Before starting, study the drawings thoroughly to understand the details of the lay-up schedule and structural details.

Typical drawings required are given in Annex 3.

Recommendations for determining FRP scantlings are given in Annex 4. These are the recommended guidelines for FRP fishing boats and form Annex III of the draft FAO/ILO/IMO *Safety recommendations for decked fishing vessels of less than 12 m in length and undecked fishing vessels*, which are under development.

On the IND 30 hull, we are using two layers of woven roving in the bottom, combined with CSM. The CSM builds thickness and the WR is good for impact strength.

On impact, the forces will be spread over a wider area if WR is used. WR layers are put as close to the laminate surfaces as practical. If it is too close to the gelcoat, the pattern of the WR will be visible.

The structure of the IND 30 is designed by an engineer to a formula for good strength to weight. The boat has four longitudinal stiffeners, two chines and two top-hat sections in the bottom. These longitudinals allow us to use less frames or bulkheads. The bulkheads also support the deck.

Figure 69

Finished internal structure. Note the bulkhead stiffeners to keep the bulkheads from buckling. The gunwale will also be reinforced.

10.2 A TYPICAL LAMINATING SCHEDULE

A typical laminating schedule is given below for the IND-30A.

Layer	Material	Area to be covered
1)	Gelcoat	Full cover
2)	Gelcoat	Full cover
	FIRST LAMINATION	
3)	300 g/m^2 (CSM)	Full cover
	SECOND LAMINATION	
4)	Fill keels with sand / resin slurry	
5)	300 g/m^2 (CSM)	Local, to cover slurry
	THIRD LAMINATION	
6)	300 g/m^2 (CSM) surface mat (optional)	Bottom only
7)	and 610 g/m^2 (WR)	Bottom only
8)	and 450 g/m^2 (CSM)	Full cover
	FOURTH LAMINATION	
9)	450 g/m^2 (CSM)	Keel reinforcement (see drawings)
10)	450 g/m^2 (CSM)	Keel reinforcement (see drawings)
	FIFTH LAMINATION	
11)	600 g/m^2 (CSM)	Full cover
12)	610 g/m^2 (WR)	Full cover
13)	300 g/m^2 (CSM)	Full cover

10.3 MOULD PREPARATIONS

Ensure that the mould sits level and flat in the workshop to avoid building a twisted boat or the hull from pre-releasing.

Wax the mould 3 times (10 times for a new mould): wax on, wax off approximately half a square metre at time.

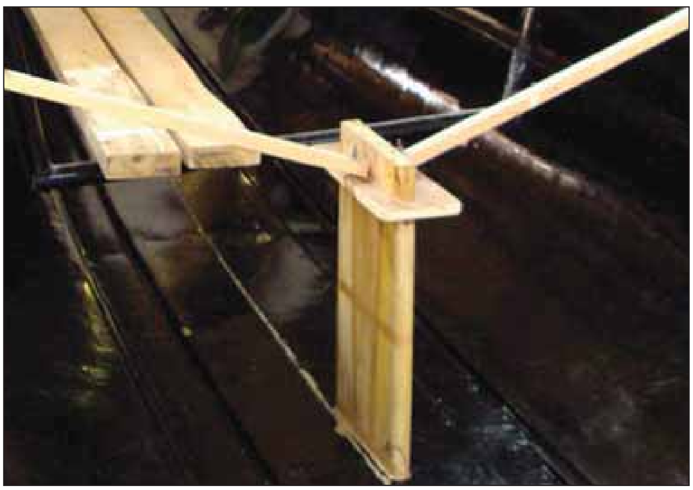

Figure 70

Before applying PVA, fit the centreboard case and drive tunnel moulds. Ensure that the centreboard case goes in straight or the boat will go around in circles.

Figure 71

Modelling clay is used to fill the joins of the parts of the moulds before the PVA is applied.

Read the instructions from the manufacturer.

Figure 72

Apply the PVA by hand with a sponge. Thin the PVA with water to give a consistency that gives an even coating.

Although a high gloss finish and wax application may be sufficient for small boats, it is always safer to use PVA when complex curvature is involved.

Read the instructions on the can.

10.4 TESTING

Figure 73

It is a good idea to build a smaller part first before beginning the hull in order to understand the performance of the resin.

10.5 APPLYING THE GELCOAT

Use only **iso-gelcoat** to improve the waterproofing and reduce osmosis.

Check that the PVA has cured by scraping with your fingernail. If it scrapes like cellophane tape, it has cured.

MAKE SURE THAT THE PVA FILM IS TOTALLY DRY BEFORE APPLYING THE GELCOAT!

Figure 74

Mix the pigment and accelerator well into the gelcoat with an electric drill or mixer, if possible. Let it stand for some time to let the air bubbles in the gelcoat escape. Mix small batches and keep a wet edge when applying the gelcoat. Brush horizontally and then vertically to help avoid runs.

Figure 75

For the first coat, apply the gelcoat at 500–700 g/m^2 and around 300–500 g/m^2 for the second coat.

Brush horizontally then vertically to avoid runs.

Mix small batches and work keeping a wet edge.

THE FIRST COAT MUST BE THICKER THAN THE SECOND COAT.

HAVE A RELIABLE PERSON
DO THE MIXING AND RECORDING

Ratios for gelcoating	
Pigment	6 to 10%
Accelerator	1.5 to 2%
Catalyst	Max. 2%
Gelcoat coverage	500–700 g/m^2 first coat. Wait a minimum of three to four hours between coats. Apply 300–500 g/m^2 for the second coat when the first coat has set but is tacky when touched.

The variables for setting time are the ratios of catalyst and accelerator to gelcoat, as well as air temperature and working time needed. Consider working at the coolest time of day and resting when it is hottest. Make sure that you have a plan for a laminating sequence that all workers are aware of and that the person mixing the resin is reliable and works in a consistent manner. Recording the use of resin accelerator and catalyst is a good practice.

After the second coat has also cured to a tacky film, you can start to laminate. To test the cure, drag your finger over the gelcoat in a low part of the mould. If no gel sticks to your finger but it is tacky to the touch, you can start to laminate. If in doubt, wait a little longer. If you laminate too soon, the styrene in the resin will attack the partly cured gelcoat and wrinkle it like an alligator's skin.

10.6 MIXING OF THE RESIN

The most commonly used polyester resin is a general purpose (GP) **ortho-polyester.** This resin, when mixed with 1% of MEKP catalyst, typically has a gel time of 8–15 minutes at 30 °C.

Figure 76

If a drill with a proper mixing attachment is not available, the second best alternative is to roll the drum.

However, if the drum has been standing upright for some time, polyester resin near the bottom may already be of higher viscosity and rolling the drum for a full 10 minutes might not be enough to fully mix the heavier and lighter resin. If not fully mixed, the first resin drawn from the drum tap may be of a different viscosity that that drawn later.

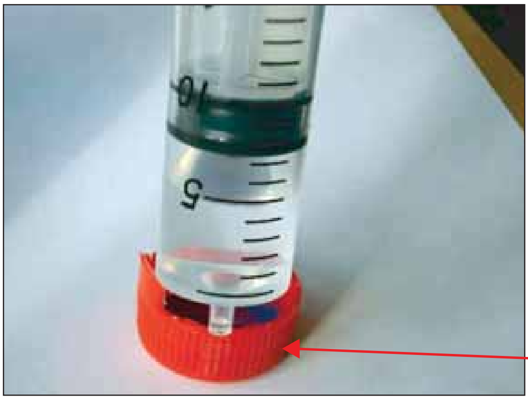

Figure 77

A variety of syringes can be used for correctly measuring very small amounts of hardener.

A typical cap from a soda bottle can usually hold around 5 ml of hardener.

Figure 78

In the case that there is no scale for measuring polyester resin, one may assume that one kilogram equals almost one litre. For either measure, there will be no significant loss of quality when working with these materials on a sturdy structure such as the IND-30 boat.

Follow the initial steps set out in the section Material Description and Handling and make sure you use the correct amount of hardener for a good cure.

Iso-polyester with superior resistance to sea water should be used for the backup layer. Cheaper **ortho-polyester** may be used for the main lay-up.

Maximum and minimum ratios		
Catalyst	Min. 0.8%	Max. 2%
Catalyst for gelcoat	Min. 1.5%	Max. 2%
Accelerator	Min. 1.5%	Max. 2%

Keep the catalyst level above the minimum so you can easily adjust the working time as the day gets hotter.

Be careful!
Catalyst levels 0.8 to 2% MAX!

10.7 APPLYING THE BACKUP LAYER

The gelcoat must be backed by a layer of E 300 CSM mat. Catalyse this layer quickly to avoid alligatoring. Be careful to work out all air bubbles from this layer as this is the layer most affected by osmosis. Avoid a buildup of extra resin or fibre on this layer. A uniform layer of 300 g/m^2 CSM is required.

For the backup layer it is especially important that the fibreglass mat be torn (section 5.3). Always use **iso-polyester** for the backup layer.

Figure 79

The backup layer is a non-structural lightweight laminate.

Tilting the mould would make this job easier and release the styrene fumes, which slow the cure of polyester.

The chine will be used to ground the edge of the deck.

A coat of polyester resin should always be applied before laying on the fibreglass mat. The metal roller is effective for working out any air bubbles and for compacting the resin and fibreglass layers together.

10.8 SUBSEQUENT LAYERS

Follow the laminating schedule and be thorough; roll all layers with a metal roller. Continue to laminate, not leaving the open laminate for more than 24 hours.

In the tropics, be aware of weather changes. You may need to stop laminating and cover the job if it rains.

Figure 80

Tilting the mould is a good way to obtain access to all parts of the mould and also to avoid contamination with dirt.

The tilting mould releases the styrene, which is heavier than air. Styrene fumes slow the cure of polyester resin. On thin laminates or gelcoat, lower areas of the job may cure more slowly than higher areas.

Figures 64 and 65 (see page 40) shows how the framing of a mould could be constructed in order to make the titling of the mould possible.

As mentioned earlier, it is wise to have a WR close to the surface. A surface mat can be used to help fill the weave of the roving and prevent the resin draining out of the laminate immediately before gelling. The resin gets warm just before gelling, thins and runs. Using a filler up to 5 percent of resin weight to thicken the resin has the same effect as a surface mat. Surface mat is the stronger alternative, as fillers tend to weaken the bond between layers.

The below chine area actually starts 50 mm above the chine to give an overlap to the topsides and add strength. Overlap all layers a minimum of 50 mm except the backup layer, as this layer is not considered structural. Staggering of overlaps should ensure that there is no buildup of thickness at panel joints.

Figure 81

All corners must be reinforced and any sharp corners filleted with roving strands after the gelcoat to prevent voids or resin-rich areas that will be brittle. Build up a double laminate at the corner of the hull/transom and the stem.

10.9 BONDING IN STIFFENERS AND BULKHEADS

The internal structure is built before it is needed and laminated into the hull before the hull is released to guarantee that the hull shape is kept.

Figure 82

Longitudinals are in position ready to be tabbed in place, then laminated over. Longitudinal stiffener formers must be shaped to fit fairly over the hull laminate. Use a hacksaw and file to obtain satisfactory seating.

Use weights and resin putty to hold them in place. Laminate over the formers and on to the hull after proper surface preparation to ensure a good secondary bond.

Figure 83

Longitudinals are finished with a web bracket on to the transom.

Reinforcement patches are for the rudder and towing eye connections.

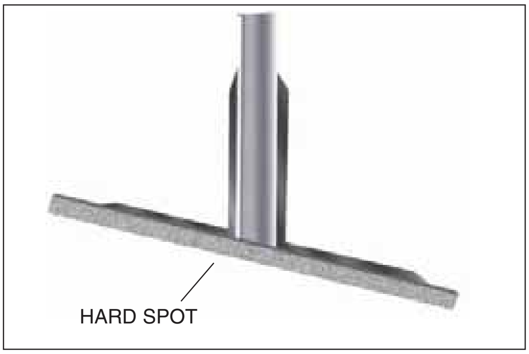

Figure 84

Bulkheads should not fit tightly against the hull.

See Figure 85 and Annex 4, Appendix 2, section 4.4.19 for recommended practice.

Hard spots cause stress concentration and subsequent laminate failure caused by fatigue.

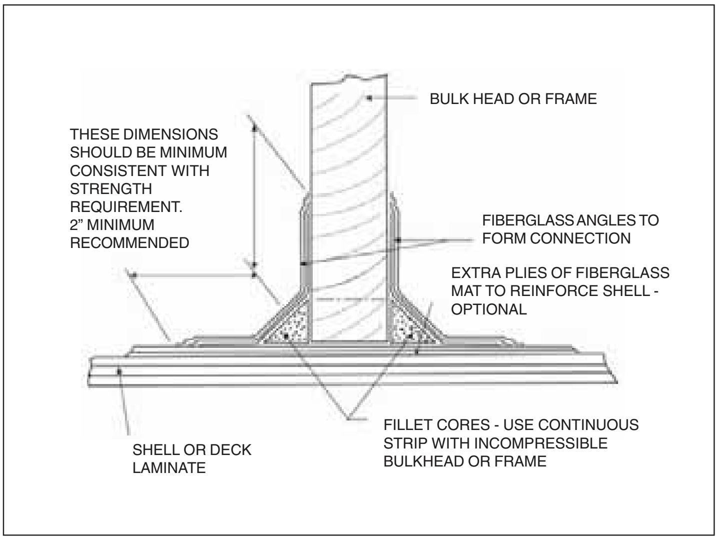

Figure 85

Apply a polyester filler fillet before laminating as has been done here.

Fit a foam fillet so that the frame will not print through on the hull.

Figure 86

Bulkheads are filleted into place before laminating.

A clamp ensures the correct height of the bulkhead, which is vital for a good hull to deck bond later.

Note that the fitting of the bulkhead to the hull could have been better; having accurate moulds or templates for the bulkheads will help this.

Figure 87

Tabbing of the bulkheads and floors to the hull should be as specified. Prior to bonding bulkheads and stringers, the area should be well ground to ensure a good secondary bond.

Figure 88

The bottom longitudinals are pre-moulded in one piece with 1 x 450 g/m² CSM, fitted and laminated over with 2 x 450 g/m² CSM from each side, giving a total of 5 x 450 g/m² on top to give best effect and 3 x 450 g/m² on the sides. Limberholes are fitted before laminating the frame into the hull.

Stiffeners are added to the bulkhead to stop them buckling.

Figure 89

This is an example of a bad fit and should be rectified.

Figure 90

An example of a poorly designed and built framing system.

Well thought-out use of longitudinal stiffeners and transverse framing will result in a better and cheaper structure.

See Figure 91 below.

Figure 91

Example of well-designed framing system.

10.10 RELEASE

Release the hull as gently as possible. The use of many small wedges around the mould edges is better than a few big wedges that will stress the product locally.

PVA release agent can be dissolved if water is used to release the piece.

Use a rubber mallet if necessary.

Remember that the mould is an investment that should be treated gently.

Figure 92

The starboard half of the mould after the release.

Don't release the part too soon!
Make sure it has cured!
Avoid the risk for print through or pulls from post-curing as polyester shrinks 2% as it cures.
24 hours at 40^{0} C is good for post-curing parts.

10.11 DETAILS

Plywood is an excellent structural material. If plywood frames are used instead of the specified FRP frames, be sure that they are marine-grade plywood. Seal the edges properly.

Figure 93

If you decide to use plywood instead of FRP for the bulkheads, then keep the fibreglass longitudinals as they are.

Keep the hull skin as designed.

See scantling tables for details.

Figure 94

Tunnel for a liftable propulsion system (the BOB drive).

Figure 95

Gelcoat on the centreboard slot plug.

Ensure that the centreboard slot plug goes in straight or the boat will go around in circles.

Figure 96

Mats being applied.

Figure 97

Plug being removed.

Figure 98

Mixing of sand and resin for the abrasion layer.

Figure 99

A 10-mm abrasion layer applied with a sliding mould after removal from the mould.

Note: It is easier to apply the abrasion layer in the mould after the first layer of CSM 300, as shown in construction drawing no. 4 (Annex 3).

Figure 100

Resin being applied on top of an abrasion layer that consists of sand and resin.

Figure 101

While the resin is still wet, a CSM mat is applied.

Figure 102

Finally, the abrasion layer is covered with two layers of topcoat.

10.12 DECK PLUG, MOULDING AND ASSEMBLY

Decks for FRP boats can be built either by using FRP-sheathed marine plywood or as an FRP moulding suitably stiffened. Compared with the hull moulding, an FRP deck is simpler. However, the deck to hull joint is crucial. The deck needs to be seated on a shelf attached to the hull at sheer.

In the IND 30, the outward flange at sheer and the flat of chine provide seating of the deck. The deck assembly is of three separate pieces: the fore and aft decks at sheer level and the lower cockpit deck in between.

Deck to hull connection may be of the bolted type or by bonding to the hull with FRP angles. Prior to assembly, the seating surface and underside of the deck edge must be well ground and cleaned. The deck should be set in place over at least two layers of wet mat of E 450 g/m^2 to ensure a leakproof joint.

Figure 103

Building of the deck plug (inside the hull of the first boat).

Figure 104

Hatch coamings attached to the plug.

Figure 105

Application of modelling clay.

Figure 106

Topcoat being applied.

Figure 107

Note the metal plates on the deck to prevent a slippery surface.

Figure 108

Cockpit deck mould complete.

Figure 109

The cockpit deck in front and the mould behind.

Figure 110

Stiffeners being attached to the underside of the deck.

Some good tips for hull to deck bonding:

- Use a slurry of premixed resin and waste CSM pieces as glue. Make it thick enough to stay where put and wet enough to bond properly.
- It is important to do a “dry fit” to check that the hull and deck fit.
- The IND 30 has deck hatches so the interior of the boat can be easily checked and worked on, which is a good feature in any boat.
- Mount any fittings that will be difficult to mount after the deck is on.
- Use fibreglass tapes to bond the deck to the hull and bulkheads wherever possible.
- Bond the deck to hull outside with 3 x 450 g/m^2 CSM 120 mm wide. Stagger the layers.
- Hatches must be properly secured to the boat for safety.

Figure 111

Cockpit deck seated on chine flat. Using temporary thwarts and vertical struts to exert pressure, the deck is bonded over wet mat.

Figure 112

The deck edge is also connected with FRP tabbing to the hull after the seating has set.

Figure 113

Note the proper seating of the deck over the transverse bulkhead.

Figure 114

The plugs for the fore and aft decks under construction.

Figure 115

Antiskid plates on the fore deck plug.

Note the mast step.

Figure 116

The mast step.

Figure 117

The engine hatch coaming on the aft deck plug.

Figure 118

The first layer of gelcoat being applied on the deck plug.

Figure 119

Final stage of the making of the mould for the aft deck.

Figure 120

Detail of the rudder for the BOB-drive.

Figure 121

Detail of the emergency rudder to be used with sail.

10.13 FITTING OF BUOYANCY MATERIAL AND FENDERS

Wooden blocks may be laminated to the hull or deck to fix the strapping for securing the buoyancy in place. Strap the buoyancy blocks in securely. Sealing these foam blocks by painting them with water-based paint or bagging them in plastic will make them more effective and stop them from getting mouldy.

Figure 122

The fore and aft decks are assembled the same way by seating the decks on the hull flange after placing the required polystyrene buoyancy blocks under the deck.

Figure 123

Polystyrene buoyancy blocks under the aft deck.

Figure 124

The deck is stiffened with top-hat stiffeners and doubling pads moulded in to take deck fittings.

Figure 125

The sheer rail is bonded with a former to take a PVC pipe fender.

Figure 126

PVC pipe fender.

Figure 127

PVC pipe fender being put in place

Figure 128

The finished boat.

Figure 129

The deck layout of the finished boat.

Figure 130

The BoB-drive in a lower position to the left and in a upper position to the right.

Figure 131

Sea trials should be carried out together with the buyer before the delivery of the boat.

Figure 132

Sea trials to test the stability in surf crossing.