

PART 6

GRP CONSTRUCTION

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GRP CONSTRUCTION

Section 6.1 - General requirements

- 6.1.1 The Builder is to comply with the requirements and recommendations given by the raw material Manufacturer throughout the moulding and construction of the vessel.
- 6.1.2 The Surveyor will make checks and inspections as appropriate during the moulding of the hull and construction of the vessel in accordance with these Standards.
- 6.1.3 Completion of main hull framing by Owners and other Subcontractors is not allowed, and bare shell hulls without the main framing and stiffeners fitted by the original Moulders will not be accepted.
- 6.1.4 It may be acceptable for some GRP hulls to be supplied for others to complete parts of the main structure, such as decks, watertight bulkheads, or engine seatings, however catamaran bridge deck structures are to be completed by the original Moulders.
- 6.1.5 Acceptance will be conditional on the assurance that this remaining structural work will be completed by competent and experienced personnel. The work should be done in suitable conditions, strictly in accordance with the Designer's/Builder's instructions for completion and with the use of equivalent and good quality marine materials.
- 6.1.6 The Designer's acceptance and approval must be sought to complete any such work that may alter the original design concept or affect the safety of the vessel. In such cases full responsibility for the completion of those remaining items must be borne by the Owner or his Subcontractors.
- 6.1.7 In such circumstances as described above, further inspection(s) will be required, and hull certification may only then be issued after compliance and final completion of the 'intact' hull structure, as envisaged by the vessel Designer or Builder.
- 6.1.8 Hulls are to be inspected prior to any antifoul preparation (sanding) or antifoul being applied.

Section 6.2 - Definitions

In these Standards the following expressions have the following meanings:-

- 6.2.1 “**Accelerator**” means additive to the resin to speed the curing at workshop temperature.
- 6.2.2 “**Activated resin**” means resin with catalyst added.
- 6.2.3 “**Catalyst**” means an additive to the resin to induce curing with heat or with an accelerator at workshop temperature.
- 6.2.4 “**Colour pigment**” means colourant added to give colour to the gel coat resin.
- 6.2.5 “**Fire-resistant additive**” means antimony trioxide and chlorinated organic compound mixed with resin or any other Manufacturer approved additive.
- 6.2.6 “**Foam**” means closed cell polyurethane or rigid PVC foam.
- 6.2.7 “**Former**” means material used for the purpose of forming, reinforcing and stiffening members.
- 6.2.8 “**Gelation**” means the curing process of the resin liquid to a jelly-like state.
- 6.2.9 “**Gel coat**” means the outer protective and cosmetic resin coat of the hull, applied to the female mould prior to the lay-up process.
- 6.2.10 “**Gel time**” means the period from addition of the accelerator to the setting of the resin to a soft gel.
- 6.2.11 “**Glass reinforcement**” means fabric, chopped strand mat (CSM), woven rovings (WR), or combination materials stitched together and used in the lay-up for reinforcement of the laminate.
- 6.2.12 “**Green stage**” means in a soft rubbery state.
- 6.2.13 “**Hardening time**” means the time from the setting of the resin to a point when the resin is hard enough for removal from the mould.
- 6.2.14 “**Intumescent paint**” means a resin paint, which has resistance to direct flame by creating carbonaceous foam from which the inert gases formed insulate the main structure of the laminate.
- 6.2.15 “**Kiln dried timber**” means timber which has been heat treated to reduce moisture content.
- 6.2.16 “**Laminate**” means alternative layers of glass reinforcement and resin forming a moulding, applied by hand.

- 6.2.17 “**Laminate spray**” means the application of the resin and glass reinforcement by a mechanical spray method.
- 6.2.18 “**Powder bonded mat**” means a glass fibre reinforcement impregnated with high solubility polyester powder.
- 6.2.19 “**Pre-accelerated resin**” means a resin to which an accelerator has been previously added.
- 6.2.20 “**Resin**” means unsaturated polyester synthetic resin.
- 6.2.21 “**Sandwich construction**” means a method of construction comprising two laminates enclosing a core of foam, timber or other approved material.
- 6.2.22 “**Spacing**” means the distance apart of members such as stringers, frames or beams as defined in the scantling Tables.
- 6.2.23 “**Woven roving**” means a glass fibre reinforcement comprising a loose evenly woven cloth as distinct from the random woven chopped strand mat cloth.

Section 6.3 - Moulding premises

- 6.3.1 The moulding premises are to be separated from the outfit factory and are to be dust, damp, and draught free, to enable a uniform temperature and humidity to be maintained during the moulding process.
- 6.3.2 The air temperature in the moulding premises is not to be lower than 15°C, and the temperature during the moulding process should not vary by more than 10°C. The relative humidity should not exceed 70%.
- 6.3.3 The moulding premises are to be insulated or built in such a way that the indoor temperature is not significantly affected by the outdoor temperature or direct heat from the sun.
- 6.3.4 Windows enabling the mixing or moulding area to be subjected to direct radiation from sunlight should be screened or painted.
- 6.3.5 The moulding premises are to be adequately heated and ventilated, with good headroom and sufficient lighting positioned well above the mouldings.
- 6.3.6 Resins and curing agents should be stored away from the working area in a cool place, and the necessary precautions for flammable liquids and the special hazards associated with organic peroxides should be strictly observed.
- 6.3.7 Glass fibre should be stored and tailored under dry conditions.

- 6.3.8 All premises intended to be used for a new vessel construction according to these Standards will be inspected and approved by the Surveyor prior to commencement of building the vessel.

Section 6.4 - Moulding shop practice

Scope

- 6.4.1 This procedure describes the standard practices to be applied in the moulding premises. The workmanship is to be in accordance with the best marine practice and to the approval of the Surveyor.

Responsibilities

- 6.4.2 It is the responsibility of the Builders to ensure that the requirements of this procedure are complied with.

Moulding conditions

- 6.4.3 Cleanliness - cleanliness is important both for the health of the operators and for preventing contamination of resin and reinforcement. Special care is necessary for handling peroxide catalysts which can ignite spontaneously when in contact with some materials. Contaminated waste material should be removed and destroyed immediately. It is the responsibility of the Moulders to ensure that their working area is free from accumulations of foreign matter which may be transferred to the moulding surfaces. Suitable protective sheets are to be laid on the working areas of shop floors and changed at regular intervals. Cutting of mouldings by saws is only permitted in the designated assembly areas to avoid the spreading of dust to mouldings surfaces.

- 6.4.4 Humidity and temperature control - the recommended humidity and temperature ranges within which laminating is allowed are as follows:-

Temperature	15°C up to 25°C
Humidity	70%

- 6.4.5 Should the workshop atmosphere move outside these limits, then action should be taken to resolve the situation. Should the conditions continue to deteriorate, the moulding process is to cease when the following limits are reached:-

Temperature	below 13°C or above 32°C
Humidity	80%

Note: When the humidity rises above 80% there is a danger of dew precipitating on the moulding surfaces. When the temperature rises above 25°C it is necessary to reduce the amount of catalyst used. When the temperature falls below 13°C the resin cannot be worked correctly and any reduction in catalyst may result in undercure.

Humidity and temperature recorders are to be located in the moulding shop. It is the responsibility of the Builders to ensure that the equipment is monitored, and continuous and accurate records are kept for future reference. The workshop humidity and temperature should be hand recorded on at least an hourly basis or on a continuous chart and be capable of cross-referencing against moulding operations.

Laminate curing

- 6.4.6 No hull, deck or wheelhouse mouldings is to be taken outside the moulding shop environment until after seven days have elapsed from the commencement of the main lay-up procedure. If mouldings must be moved outside prior to their assembly, they should be protected against precipitation on the laminate face by the use of protective sheeting or tarpaulins.
- 6.4.7 The outer gel coat surface of hull mouldings is to reach a minimum state of cure with a Barcol hardness test reading of 30 before being transferred to the fitting out berth or yard, and should be rigidly supported to preserve hull shape until the installation of gunwales, bulkheads and decking. Any hull moulding failing to meet a minimum surface hardness test reading of 30 may be rejected. (Barcol readings stated are by use of Barcol Impressor Model GYZJ 934-1).

Catalyst use procedure

- 6.4.8 The addition of catalyst to polyester products is to be strictly controlled within the limits of 1% to 3% by weight. To enable the operators to comply with these limits, it is necessary that they know the weight of the material they are about to catalyse.
- 6.4.9 Standard catalyst percentage charts are to be provided in the workshop. The weight of resin and the volume (measured in cubic centimetres (cc)) of the catalyst to be used, is to be ascertained from the chart. Should a container be part filled only, it should be weighed in order to ascertain the correct volume of catalyst required. The catalyst level used is to be recorded on the building materials reference list.
- 6.4.10 The Moulder is responsible for ensuring that the catalyst is thoroughly dispersed in the polyester material.

Recording of materials being used

- 6.4.11 Resins and lay-up materials are supplied with batch numbers, which are to be checked against order requirements. The Builder is to maintain a record of resin and reinforcement type, batch number, quality and date received, for the particular hull under construction. These records are to be kept for future reference and to enable completion of such certification and record

of weights and content of each hull moulding, as required by the inspecting Surveyor.

Section 6.5 - Materials

- 6.5.1 The Builder is to use materials approved for marine use or alternatives permitted by MCA or Fishing Vessel Certifying Authority. Details and certification for the moulding materials are to be submitted to the inspecting Surveyor for prior consideration.
- 6.5.2 Resins are to be suitable for marine use and be in accordance with the Manufacturer's type and code number as stated in the approved specification. The mixing and use of resin is to be in accordance with the Manufacturer's recommendations, and the catalyst and accelerator should permit a maximum setting time of one hour without the use of localised heating.
- 6.5.3 Colour pigment may be added to the gel coat and initial internal finishing coat, sufficient to give a satisfactory depth of colour. The quantity of pigment paste to be added is to be strictly within the amount recommended by the resin Manufacturer. No pigment should be used in the lay-up resin of the main hull laminates. Consideration may be given to pigment being added to the first layer from the gelcoat subject to MCA or Fishing Vessel Certifying Authority approval.
- 6.5.4 It is recommended that the hull bottom below the designed load waterline should be a clear unpigmented finish for all vessels of 10m LOA and over. For vessels less than this length, pigmented finish may be used below the waterline subject to MCA or Fishing Vessel Certifying Authority approval.
- 6.5.5 Glass reinforcement is to be of the best marine quality and may be in the form of fabric, woven rovings, chopped strand mat, powder bound mat, combination mats or other approved materials.
- 6.5.6 Formers used for stiffening may be of rigid foam, timber, metal, or other approved materials. Where timber is used, it is to be kiln dried to a moisture content of not more than 15% and treated with a wood preservative of a type suitable for use with polyester resins.
- 6.5.7 Structural plywood is to be of marine standard or alternatively approved by MCA or Fishing Vessel Certifying Authority. All exposed edges are to be sealed and the plywood treated with approved preservative.
- 6.5.8 Builders are to comply with Manufacturer's recommendations concerning the storage and use dates of materials supplied.
- 6.5.9 Additives other than those required to enable the necessary thixotropic property to be achieved should not be used in resin systems.

- 6.5.10 Continuing research may produce new resin compositions and reinforcement materials, and whilst their acceptance is not discouraged, new products should be tested and proved prior to their general acceptance and recommendation for use in new vessel building according to these Standards.

Section 6.6 - Laminate lay-up

- 6.6.1 The outside surface of all laminates should have a layer of gel coat of uniform thickness, or be coated with an equivalent surface protection after completion of the moulding process.
- 6.6.2 It is recommended that the first lay-ups of the hull have at least one layer of a powder bound mat moulded by isophthalic resin next to the gel coat.
- 6.6.3 Woven rovings or heavy chopped strand mat should not be applied directly to the gel coat. It is recommended that the first layer should consist of a light mat of 300g/m² (1oz), but in no instances should this exceed 450g/m² (1½oz). The reinforcement lay-up of the laminate should then be applied in the approved sequence.
- 6.6.4 It is recommended that a suitable top coat be applied on the inside laminate surface in the keel and in bilge wells where it can be assumed water will accumulate.
- 6.6.5 A standard GRP hull will be considered to be of “single skin”, i.e. a solid laminate of glass reinforcement in resin, laid up to a glass weight as determined by Table 6.11.1.
- 6.6.6 Where the hull is of sandwich construction built on a male plug, the outer surface of the hull is to be given a coat of resin or resin-based compound prior to final painting.
- 6.6.7 The hull laminate is to be locally increased in thickness in way of fittings for rudder stocks, propeller brackets, bilge keels, etc. The increased laminate weight is to be gradually reduced to the normal laminate weight.
- 6.6.8 The exposed edges of any openings cut in the hull laminate are to be sealed with resin.
- 6.6.9 Voids are not to extend through more than one ply of laminate. The maximum size of a single void is not to exceed 15mm diameter. In any single ply of 300mm x 300mm area, the loss of area due to voids is not to exceed 260mm².

e.g.: 8 x 6mm diameter
or 12 x 5mm diameter
or 36 x 3mm diameter

Linked voids shall be assessed as a single void.

Section 6.7 - Hand lay-up method

- 6.7.1 The hull mould should be thoroughly cleaned, dried, wax polished and allowed to be conditioned to the workshop temperature prior to being treated with a suitable release agent system.
- 6.7.2 Release agents should have non-inhibiting effect on the gel coat system, and are to be properly applied over the entire surface and be allowed to dry thoroughly prior to application of the gel coat.
- 6.7.3 The gel coat may be applied by hand or by spray. Gel coats are not to be left exposed longer than necessary before the application of the first lay-ups.
- 6.7.4 The lay-up process is to be commenced within not more than 24 hours of the gelation of the gel coat. The laminations should be applied at regular intervals until completion of the total shell laminate.
- 6.7.5 The overlap of mat or woven roving is to be at least 50mm, and the shift of reinforcement overlaps is to be at least 100mm.
- 6.7.6 Reinforcement layers are to be in the approved sequence and direction, carefully positioned, and then thoroughly impregnated and consolidated to give the required glass content. The resin should be applied uniformly on each layer.
- 6.7.7 Laminates should be worked such that they are free from blisters, air gaps, delamination, excessive resin drainage and resin starved areas.
- 6.7.8 The interval between each layer of reinforcement is to be carefully timed to enable proper completion of each total laminate or complex.
- 6.7.9 The time lapse between completion of the final shell laminate and the forming and bonding of frames, stiffeners and structural members is to be kept within the limits as recommended by the resin Manufacturer, to ensure full bonding strength throughout the hull.
- 6.7.10 During rolling out over sharp edges, corners, etc., it should be ensured that the amount and thickness of the reinforcement will not be less than specified in these areas.

Section 6.8 - Spray lamination method

- 6.8.1 Due to the potential problems that could arise using this method of construction, the use of spray lay-up is limited to such parts of the structure to which access of the spray can be obtained to ensure satisfactory laminating. The Moulder is required to demonstrate the equipment and the competency of the Operator to the Surveyor's approval.

- 6.8.2 Any hull manufactured using this system of lay-up is to have at least one layer of woven roving in the laminate.
- 6.8.3 When hand lay-up adjoins spray lay-up, care should be taken to ensure continuity of strength.
- 6.8.4 Stiffeners are to be matted to the shell in accordance with Table 6.11.3 as specified for hand lay-up over laminate.
- 6.8.5 The resin control device is to be adjusted to give a resin to glass ratio of not less than 1.75 to 1, and a uniform distribution of glass and resin. The glass cutter of the spraying equipment is to be adjusted to give a minimum fibre length of at least 30mm.
- 6.8.6 The spray operator should distribute the material uniformly over the laminate surface and if necessary the glass roving is to include a colour indicator to ensure laminate thickness control. The calibration of spray equipment is to be checked periodically during operation.
- 6.8.7 The initial laminate thickness after the first rolling-out is not to be greater than 1.5mm.
- 6.8.8 Subsequent hand rolling-outs should be performed so that there is not more than a 2.5mm thickness increase between each rolling.

Section 6.9 - Hull construction

- 6.9.1 Keel and sheerstrake areas are to be laminated in accordance with Table 6.11.1 and are to have reinforcement progressively lapped to avoid any sudden change in thickness.
- 6.9.2 Hulls are to have stiffening fitted in accordance with the Tables, which may be longitudinal or transverse or a combination of both. Vessels, which have longitudinal stiffening only, should have at least two stringers on each side, in addition to the deck connection joint line or gunwale and to be to the Surveyor's approval.
- 6.9.3 Where a longitudinal stiffening system is used, partial bulkheads or frames and engine bed cross-webs are to be fitted, each in one piece from side to side. Longitudinals should extend for the whole length of the vessel and be joined at the vessel's centreline or connected to a transverse stiffening section at each end.
- 6.9.4 Transverse frames, spacing and stiffening scantlings are given in Table 6.11.3. Transverse frames are to be fitted from keel to gunwale top throughout the length of the hull and bonded as specified.
- 6.9.5 Where a weathertight deck is fitted above waterline and the main shell moulding forms the bulwark, frame stiffeners are to be fitted above deck to

the bulwark rail at every second frame position. Additional stiffeners may be required depending on the fishing method proposed.

- 6.9.6 Where through-bolting connections are required (e.g. for gunwales or beam stringers), an approved timber former is to be used. All bolt fastenings are to be of corrosion-resistant metal, galvanised or coated as required, to ensure compatibility with adjoining materials. The edges of the laminate and the fastening holes are to be sealed.
- 6.9.7 In general the framing and stiffening sections are to be built up layer by layer on to the laminate while it is still in the uncured state. Where the bonding laminate of these sections intersect, particular attention is to be given to ensure continuity of strength.
- 6.9.8 The hull surface gel coat is to be adequately protected in way of all fishing gear hauling positions by GRP sheathing, metal, hard rubber or plastic to prevent damage. Cope irons are to be fitted to the face of timber sheathing, and bulwark top rails positioned to suit each mode of fishing.
- 6.9.9 Discontinuities and hard points in the structure are to be avoided. Where the strength of a stiffener may be impaired by attachment of fittings, openings, etc., adequate compensation is to be provided.
- 6.9.10 In bonded joints, polyester or epoxy resin may be used provided that the joint is so designed that the connection is in shear. The contact area is to be as large as practicable and the surfaces are to be adequately prepared.
- 6.9.11 Where backing or insert pads are fitted in way of the attachment of fittings, the contact area is to be suitably prepared and free of contamination.
- 6.9.12 In vessels below 7m LOA where a combination of bonding of internal furniture and hull form provides adequate stiffening, the framing may be omitted at that position provided the bonding is continuous and full strength, subject to the approval of the Surveyor.
- 6.9.13 In open boats the bottom stiffening may be provided wholly or partly by the bonded-in flooring arrangement, subject to the approval of the Surveyor.
- 6.9.14 Transoms not subjected to loads from outboard engines, water-jet units or steering arrangements, etc., are to have scantlings as required for the normal shell laminate. The joint of transom and hull shell is to be increased by 100% in weight in the form of reinforcement laminates. The reinforcement should be lapped 50mm per 600g/m² weight and stiffened to the approval of the Surveyor.
- 6.9.15 Transoms which are to be used for the mounting of outboard engines, outboard pods or brackets should be constructed to the minimum requirements as indicated in Table 6.11.5. A GRP outboard pod is to be constructed with the minimum laminate equal to the hull laminate and to the

requirements of Table 6.11.5. The outboard pod fixing details are to be submitted for approval.

- 6.9.16 Where the hull shell is laid up in separate half moulds, the laminate is to be stepped back 50mm per laminate on each half. The two halves of the split mouldings are to be clamped together within 48 hours of completion of the laying-up process and the two sections bonded together. With this method, the keel lay-up weight is to be increased by 20% above the weight determined from Table 6.11.1. The stiffened keel area is to extend from the transom to the stem.
- 6.9.17 The stem is to be moulded to enable a gradual reduction from the keel weight to that required for the sheer. The lay-up should be in 50mm steps per 600g/m² from the fore foot, up to 100mm per 600g/m² at the sheer position. When moulding is in two halves, the weights in way of the joint area are to be increased by 20% above the weight obtained from the Tables.
- 6.9.18 The centre of the hull aft of the keel to the transom is to be stiffened by lay-ups as required for the keel section.
- 6.9.19 Size of frames are to be as obtained from Table 6.11.3 and constructed by moulding over formers which should be bonded to the inside hull laminate while it is still in an uncured state. Frame formers may be of top hat or rectangular section and their spacings should not be less than the minimum distance given in the Table. Where tops of frames have gunwales or bulwark stringers through-bolted, the core of the frames is to be of an approved timber.
- 6.9.20 Stringers, where fitted, are to be matted to the hull shell with spacing and scantling size obtained from Table 6.11.4. They may form a combination of other longitudinal structural members to the approval of the Surveyor.
- 6.9.21 Bilge keels, may be moulded as part of the hull, or a separate GRP moulding bonded and bolted to the hull, or of a solid hardwood or fabricated steel structure. Suitable bedding is to be fitted between the connection surfaces and bolts to be through a suitable hardwood stringer. Bolt connections to be well sealed and glassed over to prevent leakage.
- 6.9.22 Where fitted, rubbing strakes may be of hardwood, patent rubber or plastic section; securing bolts are to be non-corrodible and sealed to prevent leakage.
- 6.9.23 The height of the bulwark, guardrail, or wire is to be not less than 1m, where there is unreasonable interference with efficient operation of the vessel, this height for fixed bulwarks, rails, and wires, may be reduced, and the required height of 1m maintained by the use of portable wires and stanchions. See Section 11.12 and Figure 11.20.1.

- 6.9.24 Engine seatings are to be continuous and should be of low density or foam core, GRP sheathed, or of fabricated steel construction. Where space permits, the seating is to extend at least twice the length of the engine, i.e. from the forward holding down bolt to the face of the gearbox coupling. The seatings are to be matted to the hull and stiffened transversely with floor sections and side support brackets. A continuous flat steel plate of adequate thickness and width is to be fitted to the top of the seating in way of the engine, gearbox and front end drive arrangement, and the whole keyed and “matted in”. A typical section is shown in the Figure 6.12.8.
- 6.9.25 Hatch coamings may be separate GRP mouldings, integrally moulded as part of the deck, or of an approved timber or steel construction and fitted with weathertight covers with clips, hinges and gaskets. See Part 3 ‘Hull Integrity and Arrangement’.
- 6.9.26 Watertight bulkheads may be of GRP, steel, timber, plywood or other approved materials, suitably stiffened and fitted in accordance with Part 3, Section 3.11 ‘Watertight subdivision’.
- 6.9.27 It is recommended that bulkheads are formed and fitted to a rigid type foam core seating or frame section. When not practical to fit on a frame position, the bulkhead should be matted to the shell with double angles to a weight not less than specified in Table 6.11.10.
- 6.9.28 Watertight glands and fittings are to be fitted where bulkheads are pierced for pipework and wiring arrangements. Doors or hatches fitted in watertight bulkheads are to be of watertight construction to British Standards or equivalent requirements, and be of equivalent strength as the bulkhead.

Section 6.10 - Deck construction

- 6.10.1 Decks are to be in accordance with Tables 6.11.7 and 6.11.8, and may be either marine ply sheathed with GRP, or GRP sandwich construction with a structural core. Special consideration will be given to the construction of decks which may be GRP laminated but which must be adequately stiffened to the Surveyor’s approval. Where pre-fabricated GRP section or composite deck structures are proposed, details are to be submitted for approval.
- 6.10.2 A beam shelf or stringer arrangement is to be bonded to the hull shell to support the deck beams. A system combining through-bolting and bonding is recommended, but alternative methods, where proposed, are to be submitted for approval.
- 6.10.3 Deck beams are to be as stated in Table 6.11.7 and 6.11.8, with longitudinal stiffening provided by hatches and carlings as required.

- 6.10.4 Decks in way of gallows, warp leads, deck machinery and heavy work positions are to have additional stiffening and pillars to the approval of the Surveyor.
- 6.10.5 Main beams in accordance with Table 6.11.7 and 6.11.8 are to be fitted in way of all deck openings, machinery and deckhouse casings, and in way of masts and heavy deck machinery.
- 6.10.6 Special consideration may be given to the fitting of a steel deck beam arrangement in way of engine rooms for vessels above 10m LOA, and if required by the Owners.
- 6.10.7 Deck beams of timber, where fitted, are to be in accordance with the following:-
- (i) All main beams and beams fitted in fishrooms should be of hardwood or approved timber treated with preservative.
 - (ii) Beams should be moulded, sided and spaced in accordance with Table 6.11.8, and may be moulded 25mm less at the ends.
 - (iii) All deck beams should have a round of beam (camber) of not less than 20mm per metre of breadth unless otherwise agreed with the Surveyor.
 - (iv) Decks without camber are to be fitted with extra stiffening.
- 6.10.8 Where decks and deck beams are of GRP construction, openings in the deck may be stiffened by forming continuously moulded flanges, the weight of which should be 25% greater than the laid-up deck laminate weight. Deck openings over 500mm in length should be fitted with longitudinal stiffening comprising of wood, GRP or steel carlings or girders.
- 6.10.9 Where applicable plywood decks are to be of scantlings obtained from Table 6.11.8 and are to be bolted and bonded to the GRP/plywood beamshelf and bonded to the hull. The complete deck area is to then be sheathed with a GRP laminate. Special attention should be paid to the sheathing in way of working areas which may require extra protection.

Section 6.11 & 6.12 - Tables, figures, and illustrations

Where alternatives to the following Tables and Figures are proposed, details are to be submitted for consideration and approval prior to construction commencing.

In determining scantlings from the Tables in respect of intermediate values, the scantling applicable is to be that given for the nearest dimension/numeral, unless otherwise stated in the Table notes.

6.11 Tables for GRP construction

6.11.1 Table 1: Hull laminate (single skin construction)

Scantling numeral	Shell	Keel		Sheer	
	Weight g/m ²	Width mm	Weight g/m ²	Width mm	Weight g/m ²
10	3000	400	5400	250	3000
15	3300	450	5700	300	3600
20	3600	500	6000	350	3900
25	3900	500	6300	350	4200
30	3900	550	6600	400	4200
45	4200	550	6900	400	4500
60	4500	600	7200	450	4800
80	4500	600	7500	450	4800
100	4800	650	7800	500	5400
150	4800	700	8100	550	5400
200	5100	750	8400	600	5700
250	5400	800	9000	650	6000
300	6300	1000	9300	700	6900
350	6600	1000	9600	750	7200
400	6900	1100	9900	800	7500
450	7200	1100	10200	850	7500

Notes:-

1. Weights indicated are based on CSM at 600g/m².
2. For vessels whose design incorporates live fish wells or vivier tanks and with a scantling numeral above 45, the laminate weight of the shell is to be increased by 10%, the keel by 20%, and the sheer laminate by 10%. Details to be submitted for approval prior to commencement of moulding.

6.11 Tables for GRP construction

6.11.2 Table 2: Hull laminate (sandwich construction)

Scantling numeral	Core Thickness							
	10mm		15mm		20mm		25mm	
	Shell laminates weight g/m ²		Shell laminates weight g/m ²		Shell laminates weight g/m ²		Shell laminates weight g/m ²	
	Outer	Inner	Outer	Inner	Outer	Inner	Outer	Inner
25	3150	2550	2850	2400	-	-	-	-
30	3300	2700	3000	2550	-	-	-	-
45	3450	2850	3150	2550	-	-	-	-
60	3600	3000	3300	2700	-	-	-	-
80	3750	3150	3450	2850	3150	2550	-	-
100	3900	3300	3600	3000	3300	2700	-	-
150	3900	3300	3600	3000	3300	2700	3150	2550
200	4200	3450	3900	3300	3600	3000	3300	2700
250	4500	3600	4200	3450	3750	3150	3450	2850
300	-	-	4200	3450	4050	3300	3600	3000
350	-	-	4350	3600	4050	3300	3750	3150
400	-	-	4500	3600	4200	3450	3900	3300
450	-	-	4500	3750	4200	3600	4050	3450

Notes:-

- Weights indicated are based on CSM at 600g/m². The shell outer and inner laminates are to be faired into the keel laminate to a weight not less than that given in Table 6.11.1.

6.11 Tables for GRP construction

6.11.3 Table 3: Transverse hull framing

Scantling numeral	Frame spacing mm	Frame section		Face & web weight g/m ²
		Face Mm	Web Mm	
10	1000	60	50	1200
15	1000	65	55	1500
20	900	70	60	1500
25	800	75	70	1800
30	700	85	80	1800
45	600	95	85	1800
60	500	100	95	1800
80	510	105	100	1800
100	520	115	105	2100
150	530	130	115	2100
200	540	140	120	2400
250	550	150	125	2400
300	600	160	140	3000
350	630	165	150	3000
400	650	170	155	3300
450	700	175	160	3300

Notes:-

1. Frame spacing is centre to centre.
2. Weight is based on CSM. Where the frame spacing is required to exceed that given above, the frame scantlings are to be increased by direct proportion. Where the frame lay-up weight exceeds 1800g/m², the bonding of frame to hull is to be increased in width by 40mm per layer of 600g weight of CSM.
3. The frame spacing requirements above are based on a conventional round bilge hull form for displacement vessels. Where the hull moulding incorporates longitudinal rigidity in the form of ribs, chines or knuckles, special consideration may be given to increase the transverse frame spacings up to a maximum of 1m apart, provided that the panel modulus is equivalent to that given in this Table and increased by direct proportion where necessary.
4. Longitudinal framing will be accepted providing the modulus is equivalent to the above Table for transverse framing, and that some transverse framing is provided. Details are to be submitted and approved prior to commencement of moulding operation.

6.11 Tables for GRP construction

6.11.4 Table 4: Longitudinal hull stiffeners

Scantling numeral	Longitudinal stringers (1.5m maximum spacing)					
	Beam		Bilge		Intermediate	
	Section mm	Weight g/m ²	Section Mm	Weight g/m ²	Section mm	Weight g/m ²
10	-	-	-	-	-	-
15	-	-	-	-	-	-
20	-	-	75 x 60	1800	75 x 60	1800
25	-	-	80 x 70	1800	80 x 70	1800
30	100 x 80	1800	100 x 80	1800	100 x 80	1800
45	100 x 85	1800	100 x 85	1800	100 x 85	1800
60	125 x 95	1800	125 x 95	1800	125 x 95	1800
80	125 x 100	2100	125 x 100	2100	125 x 100	2100
100	150 x 105	2100	150 x 105	2100	125 x 105	2100
150	175 x 115	2400	175 x 115	2400	125 x 115	2400
200	175 x 120	2400	175 x 120	2400	125 x 120	2400
250	175 x 125	2400	175 x 125	2400	150 x 125	2400
300	200 x 140	3000	175 x 140	3000	150 x 140	2400
350	200 x 150	3000	175 x 150	3000	160 x 150	3000
400	200 x 155	3000	175 x 155	3000	175 x 155	3000
450	200 x 165	3000	175 x 165	3000	175 x 165	3000

Notes:-

- The Table scantlings are based on CSM and with a hull transversely framed with spacings as indicated in Table 6.11.3. The spacing of longitudinal stiffeners is not to exceed 1.5m, and may form a combination with other longitudinal structural members, such as beam shelf and engine girders at the discretion of the Surveyor. For vessels with a scantling numeral of less than 100, the stringers may be omitted providing they are substituted by other longitudinal hull stiffening either by way of hull form, chines, ribs or bondings to the inside of the hull.
- Where the over laminate weight exceeds 1800g/m², the bonding of stiffener to hull is to be increased in width by 40mm per layer of 600g/m² of CSM. See Figure 6.12.5.

6.11 Tables for GRP construction

6.11.5 Table 5: Transom construction (outboard engine mounting)

Engine power		Plywood core mm	Minimum thickness mm	Weight outer laminate g/m ²	Weight inner laminate g/m ²
Max HP	Max kW				
5	4	20 - 25	30	3000	1500
20	15	25 - 30	35	3600	1800
50	37	30 - 35	40	4200	2400
100	75	30 - 35	45	4800	3000
150	112	35 - 40	50	5400	3600
200	150	40 - 45	60	6000	4200

Notes:-

1. The inner laminate is not to be less than 60% of that required for the sheer strake lay-up, and the outer laminate is not to be less than 60% of that required for the keel area lay-ups as specified in Table 6.11.1 for the hull laminate.
2. The inner laminate is to extend to the sides and bottom of the hull moulding and be gradually tapered as required for corner reinforcements in this area.
3. Transoms not subject to loads from outboard engines or outdrive leg units are to be laid up to the same weight as required for the hull laminate, and constructed generally as detailed in Paragraph 6.9.14 and with stiffeners spaced as for frames.
4. For vessels where the scantling numeral is greater than 200, details of transom construction to be submitted for approval.

6.11 Tables for GRP construction

6.11.6 Table 6: Flanged top rails

Scantling numeral	Top rail width mm	Total flange weight g/m ²	Depth of flange at shell mm
10	70	3000	90
15	75	3300	100
20	80	3600	120
25	90	3900	140
30	100	3900	150
45	110	4200	160
60	120	4500	170
80	125	4500	180
100	130	4800	190
150	135	4800	200
200	140	5100	210
250	150	5400	220
300	160	6300	230
350	165	6600	240
400	170	6900	250
450	175	7200	260

Notes:-

1. Weight is based on CSM at 600g/m².
2. The width of top rail, laminate, and depth of flange as shown in the Table, are recommendations if the design of hull moulding enables and requires an integral flanged top rail.
3. Single piece mouldings and those with no flanged top rail are to be fitted with longitudinal stiffening for the full length of the vessel by the use of a timber gunwale and capping arrangement or deck moulding connection and rubbing bar.

6.11 Tables for GRP construction

6.11.7 Table 7: Main decks (GRP beams and sandwich core construction)

Scantling numeral	GRP beams				Sandwich				Beam shelf	
	Beam face mm	Beam web mm	Beam laminate g/m ²	Beam to hull g/m ²	Inner laminate weight g/m ²	Outer laminate weight g/m ²	Minimum core thickness mm	Deck to hull g/m ²	Cored beam shelf (CSA) cm ²	Beam shelf GRP laminate g/m ²
10	50	75	1500	1200	900	1200	15	1200	10	1200
15	75	100	1800	1800	900	1200	15	1800	15	1800
20	75	125	1800	1800	1200	1500	15	1800	20	1800
25	100	125	1800	1800	1200	1500	15	1800	25	1800
30	100	125	1800	2400	1200	1500	15	2400	30	2400
45	100	125	2400	2400	1200	1500	15	2400	35	2400
60	100	125	2400	2400	1200	1800	15	2400	35	2400
80	100	125	3000	2400	1200	1800	15	2400	40	2400
100	100	150	3000	3000	1500	1800	15	3000	40	3000
150	100	175	3000	3000	1800	2100	20	3000	45	3000
200	100	175	3000	3000	1800	2100	20	3000	50	3000
250	100	200	3000	3000	1800	2100	20	3000	55	3000
300	100	200	3000	3000	1800	2100	20	3000	60	3000
350	100	225	3000	3000	1800	2100	20	3000	65	3600
400	100	250	3000	3600	1800	2100	20	3600	70	3600
450	150	250	3300	3600	1800	2400	20	3600	75	3600

Refer to Notes on following page.

6.11 Tables for GRP construction

6.11.7 Table 7: Main decks (GRP beam and sandwich core construction) (continued)

Notes:-

1. Scantlings for deck beams are based on a spacing of 500mm centre to centre. Where the spacing exceeds 500mm, the scantlings are to be increased by direct proportion.
2. The table is based on a PVC Cross cut H Type core. The core may be any structural core material with similar sheer properties such as foam, balsa or honeycomb panels, details of which should be submitted for consideration. The core thickness should be no less than that as stated in the Tables.
3. Laminate weights are based on CSM.
4. Where surrounding structural components permit, the beam shelf may be replaced with beam knees, details of which are to be submitted for consideration.
5. The beam sections stated will be used for deep beams, ordinary beams and carlings. Where alternative beam sections are proposed, details are to be submitted for consideration.
6. Additional over-bonding may be necessary to achieve suitable impact resistance depending on the operation of the vessel.

6.11 Tables for GRP construction

6.11.8 Table 8: Main decks (sheathed plywood construction)

Scantling numeral	Deep beams face mm	Ordinary beams face mm	Web at centre mm	Plywood thickness mm	GRP sheathing g/m ²	Plywood beam shelf (CSA) cm ²	Beam shelf GRP laminate g/m ²
10	65	35	80	9	1200	10	1200
15	70	35	85	12	1200	15	1800
20	70	40	85	15	1200	20	1800
25	70	45	95	15	1800	25	1800
30	75	50	100	18	1800	30	2400
45	85	55	110	18	1800	35	2400
60	95	65	120	18	1800	35	2400
80	100	75	130	20	1800	40	2400
100	110	85	140	20	1800	40	3000
150	120	95	150	20	2400	45	3000
200	135	110	165	25	2400	50	3000
250	150	120	180	25	2400	55	3000
300	160	125	200	25	2400	60	3000
350	170	140	200	25	2400	65	3600
400	180	150	210	30	3000	70	3600
450	180	150	210	30	3000	75	3600

Note:-

- Scantlings for deck beams are based on a spacing of 500mm centre to centre and with a camber of 20mm per metre length of beam. Where the spacing exceeds the 500mm, the scantlings are to be increased by direct proportion.

6.11 Tables for GRP construction

6.11.9 Table 9: Sandwich construction watertight bulkheads

Depth of bulkhead m	Bulkhead core thickness mm						Vertical stiffeners			Horizontal stiffeners		
	10	15	20	25	30	Section	Face & web weight g/m ²	Section		Face & web weight g/m ²		
					Face mm	Web mm		Face mm	Web mm			
1.2	1800	1800	—	—	—	40	40	1200	—	—	—	
1.5	2100	1800	1800	—	—	50	40	1200	—	—	—	
1.8	2100	2100	1800	—	—	50	50	1500	50	50	1500	
2.1	2400	2100	2100	—	—	60	60	1800	60	60	1800	
2.4	—	2400	2100	2100	—	65	60	2100	65	60	2100	
2.7	—	—	2400	2100	2100	65	65	2400	65	65	2400	
3.0	—	—	2700	2400	2100	75	70	2700	75	70	2700	
3.3	—	—	2700	2700	2400	85	75	3000	85	75	3000	
3.6	—	—	3000	2700	2700	90	85	3300	90	85	3300	
3.9	—	—	3300	3000	2700	95	90	3300	95	90	3300	
4.2	—	—	3600	3300	3300	115	100	3600	115	100	3600	
4.6	—	—	3900	3600	3300	120	115	3600	120	115	3600	

Refer to Notes on following page.

6.11 Tables for GRP construction

6.11.9 Table 9: Sandwich construction watertight bulkheads (*continued*)

Notes:-

1. Depth of bulkhead is measured from top of floor/frames to underside of deck at centreline. Where depth of bulkhead is less than 2.4m, floor bearers or attached joinery connections may be incorporated as stiffeners.
2. Bulkhead scantlings are based on a stiffener spacing of 900mm. Where the spacing of stiffeners differs from 900mm the bulkhead laminate weight is to be modified at the rate of 5% per 50mm spacing difference, but in no case shall the laminates be less than 1800g/m².
3. Bulkheads with depth of 1.8m and above, are to be further strengthened by the addition of horizontal stiffeners.
4. All bulkheads are to be bonded to the shell laminate with double angles as detailed at Figure 6.12.6.
5. Non-watertight bulkheads are to have scantlings as required for watertight bulkheads.

6.11 Tables for GRP construction

6.11.10 Table 10: Plywood construction watertight bulkheads

Depth of bulkhead m	Plywood thickness mm	Vertical stiffener section		Shell bonding laminate g/m ²	Stiffener spacing mm	Horizontal stiffener section	
		Face mm	Web mm			Face mm	Web mm
0.5	9	—	—	1200	—	—	—
0.7	9	—	—	1200	—	—	—
0.9	12	—	—	1800	—	—	—
1.2	15	50	40	1800	500	—	—
1.5	18	50	40	1800	500	—	—
1.8	18	50	50	2400	500	—	—
2.1	18	60	50	2400	500	75	50
2.4	22	65	50	2400	500	75	50
2.7	22	70	50	2400	500	80	50
3	25	75	50	3000	500	85	50
3.3	25	75	50	3000	500	90	50
3.6	25	80	50	3000	500	90	50
3.9	25	85	50	3000	500	100	50
4.2	30	90	50	3600	500	100	50

Notes:-

1. Depth of bulkhead is measured from top of floor/frames to underside of deck at centreline. Where depth of bulkhead is less than 2.4m, floor bearers or attached joinery connections may be incorporated as stiffeners.
2. Bulkheads with depth of 2.1m and above, are to be further strengthened by the addition of horizontal stiffeners.
3. All bulkheads are to be bonded to the shell laminate with double angles as detailed at Figure 6.12.6.
4. Non-watertight bulkheads are to have scantlings as required for watertight bulkheads.
5. Vertical and horizontal stiffeners are to be wooden sections screw and glued in position.

6.11 Tables for GRP construction

6.11.11 Table 11: Deckhouse construction

Size of vessel	Plywood thickness (1088 WBP) mm	Single skin GRP g/m ²	Foam cored construction		
			Outer skin g/m ²	Core mm	Inner skin g/m ²
0 – 7m	10	2700	1500	10	1200
7 – 9m	12	3900	2100	12	1200
9 – 12m	18	5700	2100	12	1800
12 – 15m	25	6900	2700	15	2400

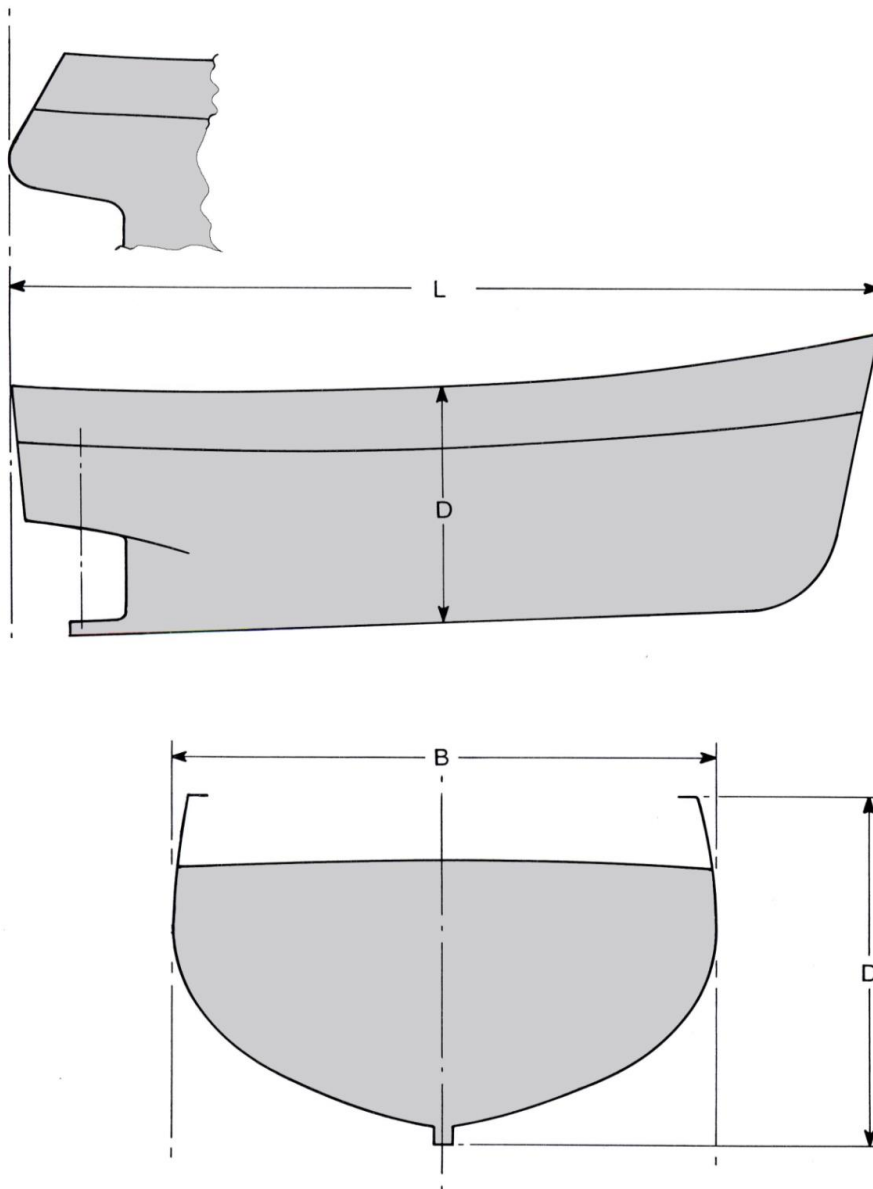
Notes:-

1. Wheelhouse and deckhouses may be of plywood with painted only finish. Plywood is to be BS 1088 WBP grade (or equivalent) and stiffeners spaced 500mm apart. If GRP sheathed, the plywood may be of B/BB quality with exterior sheathing of two layers of 600 CSM gelcoat or paint finished.
1. In deckhouses of single skin GRP construction the lay up is to be as specified above with gelcoat exterior finish.
2. In deckhouses of cored construction, the GRP inner and outer skins are to be as specified in the above Table with gelcoat or paint exterior finish.
3. This Table is for the construction of normal sized wheelhouses relevant to the size of vessel stated, for larger structures and shelter decks refer to Table 4.20.18 aluminium structures or equivalent.
4. Wheelhouses of alternative construction may be considered upon the submission of details.

6.12 Figures and illustrations

6.12.1 Scantling numeral dimensions – mono-hull

$$L \times B \times D = \text{Scantling numeral}$$



Length overall measured in a straight line from the fore side of stem at top to after side of stern/transom or fore side of the bulbous bow to after side of stern/transom if that be greater.

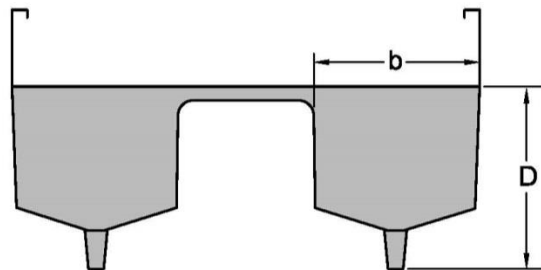
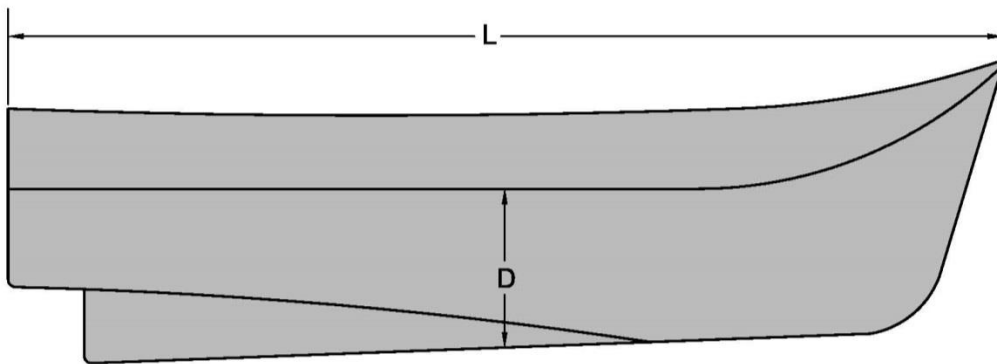
Breadth 'B' the greatest breadth of the vessel outside of the shell moulding.

Depth 'D' measured at amidships from underside of keel to top of shell moulding or gunwale.

6.12 Figures and illustrations

6.12.2 Scantling numeral dimensions – multi-hull

$$2 (L \times b \times D) = \text{Scantling numeral}$$



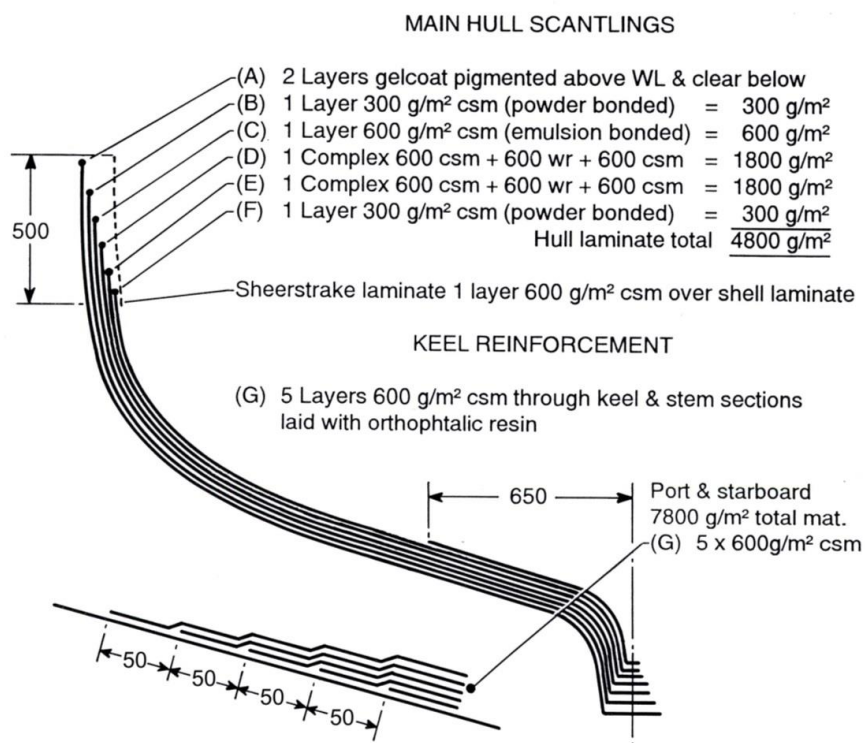
Length overall measured in a straight line from the fore side of stem at top to after side of stern/transom or fore side of the bulbous bow to after side of stern/transom if that be greater.

Breadth 'b' the greatest breadth of each hull at crossdeck level outside of the shell moulding.

Depth 'D' measured at amidships from underside of keel to underside of deck.

6.12 Figures and illustrations

6.12.3 Specimen lay-up diagram



TYPICAL HULL LAMINATE SCANTLINGS - USING SCANTLING NUMERAL 100

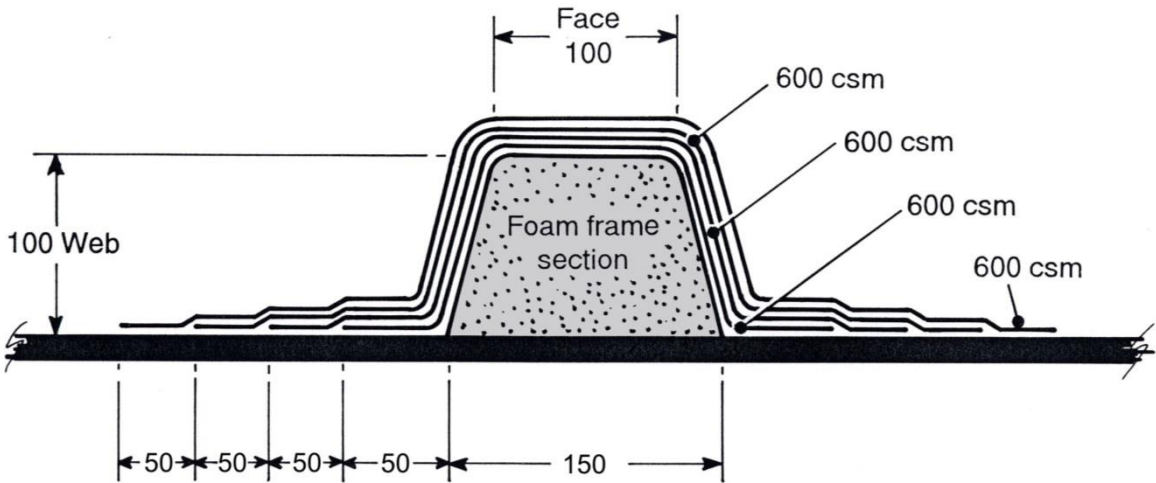
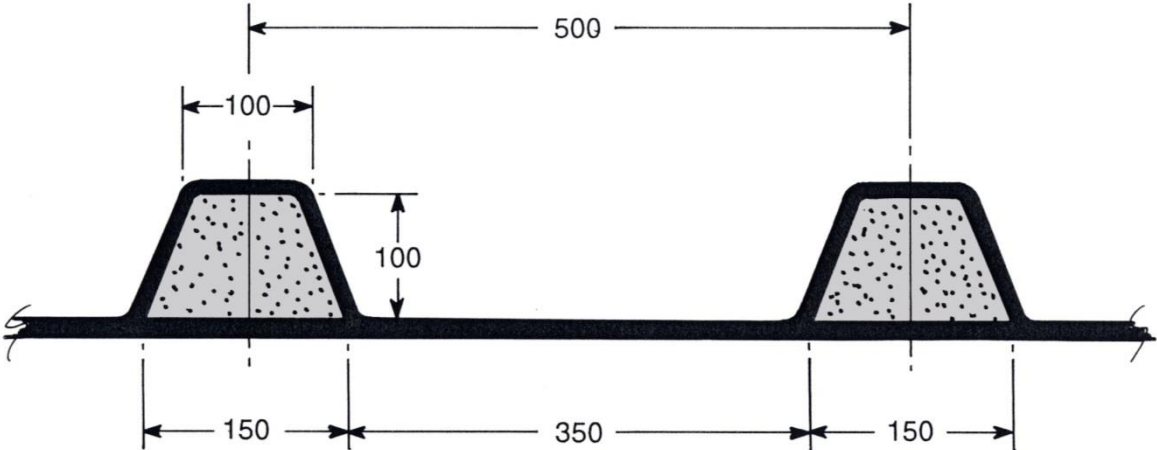
NOTES ON LAY UP PROCEDURE

- (A) Crystic 65 pa* isophtalic gelcoat laid with mohair roller. Pigmented above datum waterline to owners colour choice and clear unpigmented below.
- (B) One layer of chopped strand mat (csm) to be powder bonded and impregnated with isophtalic crystic resin No.489 pa* (csm 300 g/m² [1 oz / ft²]).
- (C) One layer of chopped strand mat (csm) to be emulsion bonded, laid vertically and overlapped at least 50mm. CSM to be impregnated with crystic orthophtalic resin No.414 pa*. Resin to be clear unpigmented.
- (D) Complex of csm + wr + csm to be laid with orthophtalic resin No.414 pa* and be overlapped at least 50mm. Overlap around transom corners and stem to be 200mm min. (* or other approved resins).

Frames to be 115mm x 105mm low density closed cell polyurethane rigid foam section spaced 520mm apart centre to centre and bonded to hull laminate with 3 layers of 600 g/m² csm & 1 layer of 300 g/m² csm. The frame bonding laminate is to be increased in width by 50mm each side per layer. Frame sections to be continuously installed and over laminated prior to longitudinal stringers.

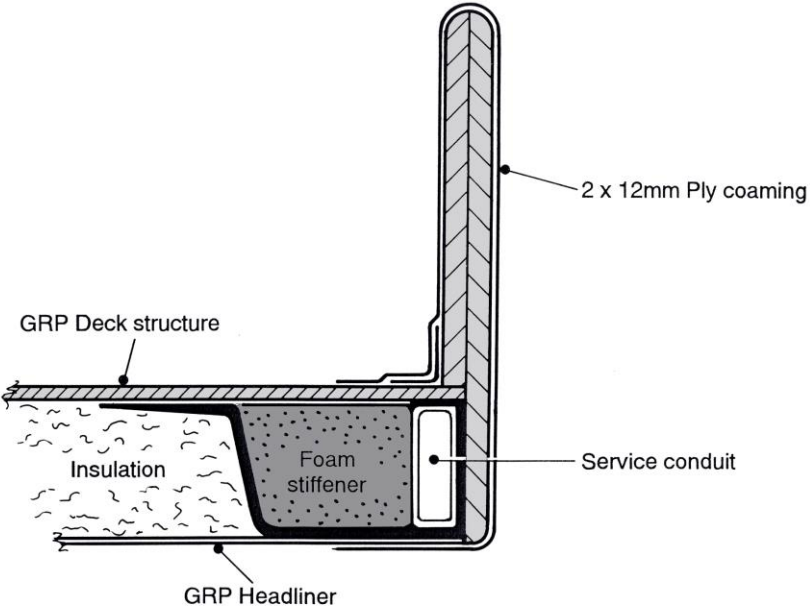
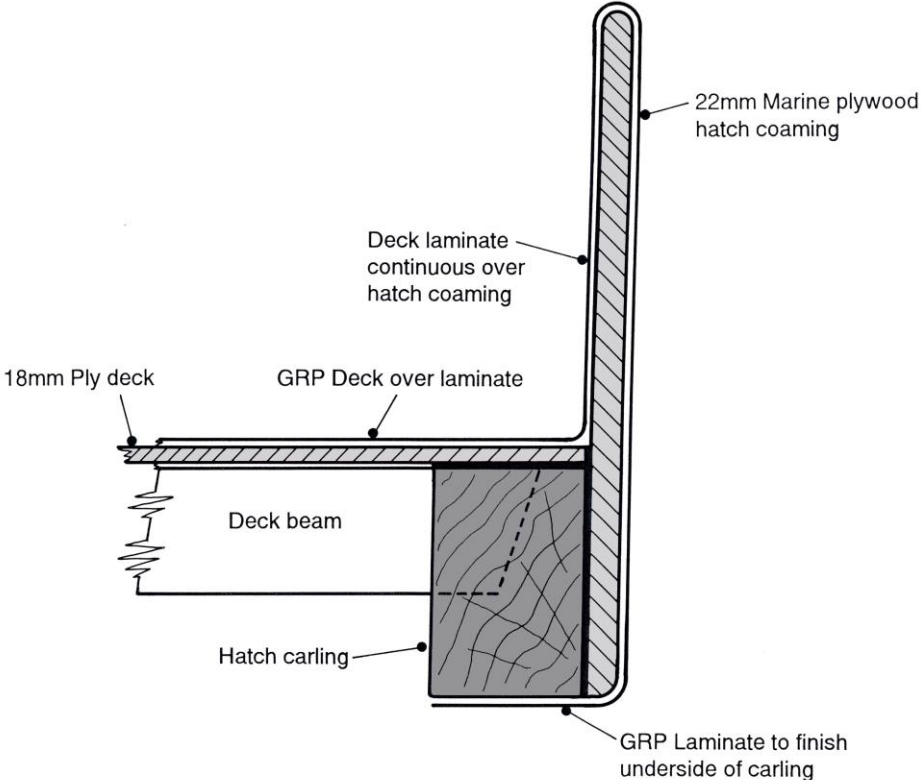
6.12 Figures and illustrations

6.12.4 Framing details



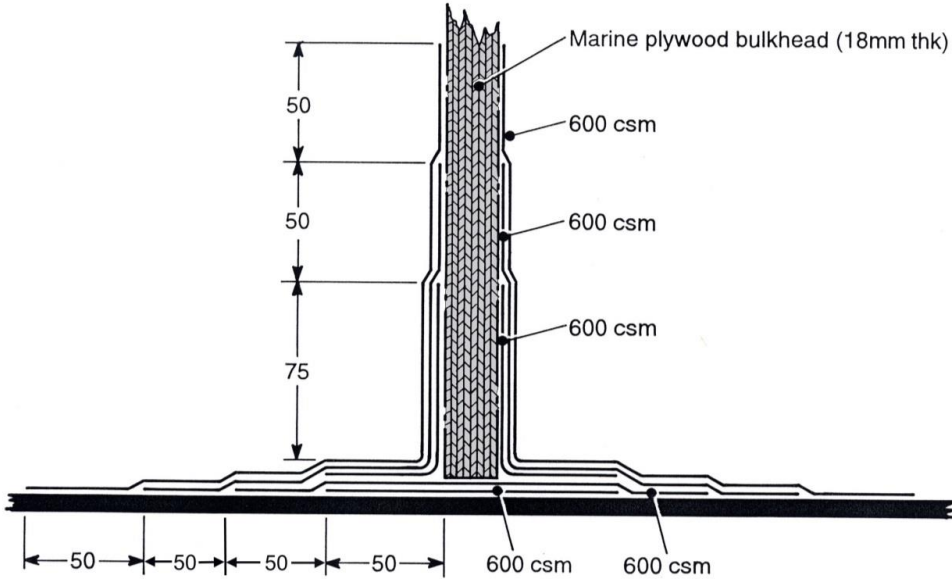
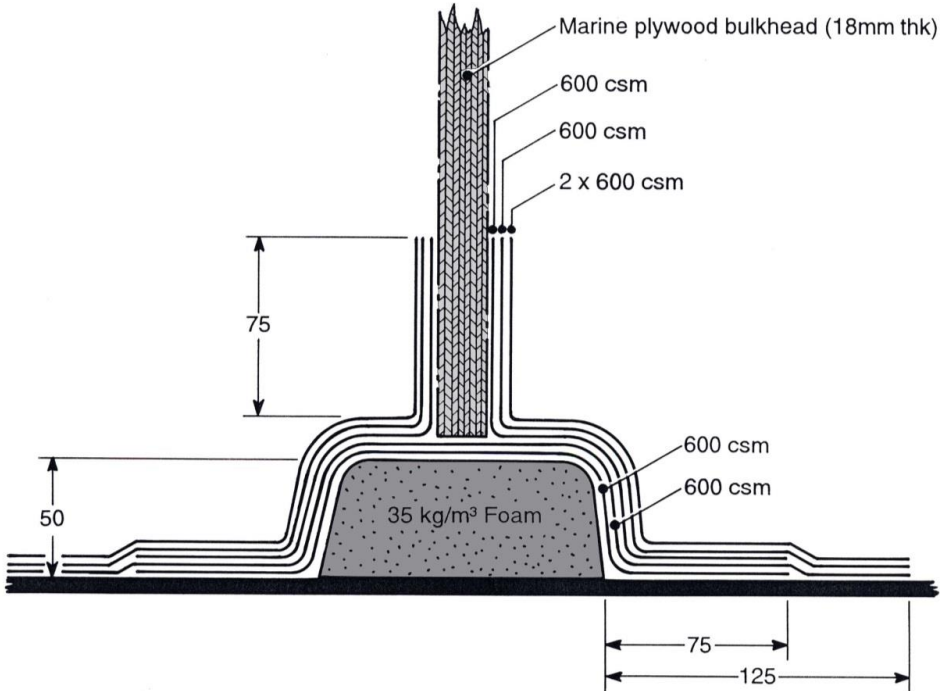
6.12 Figures and illustrations

6.12.5 Hatch coamings



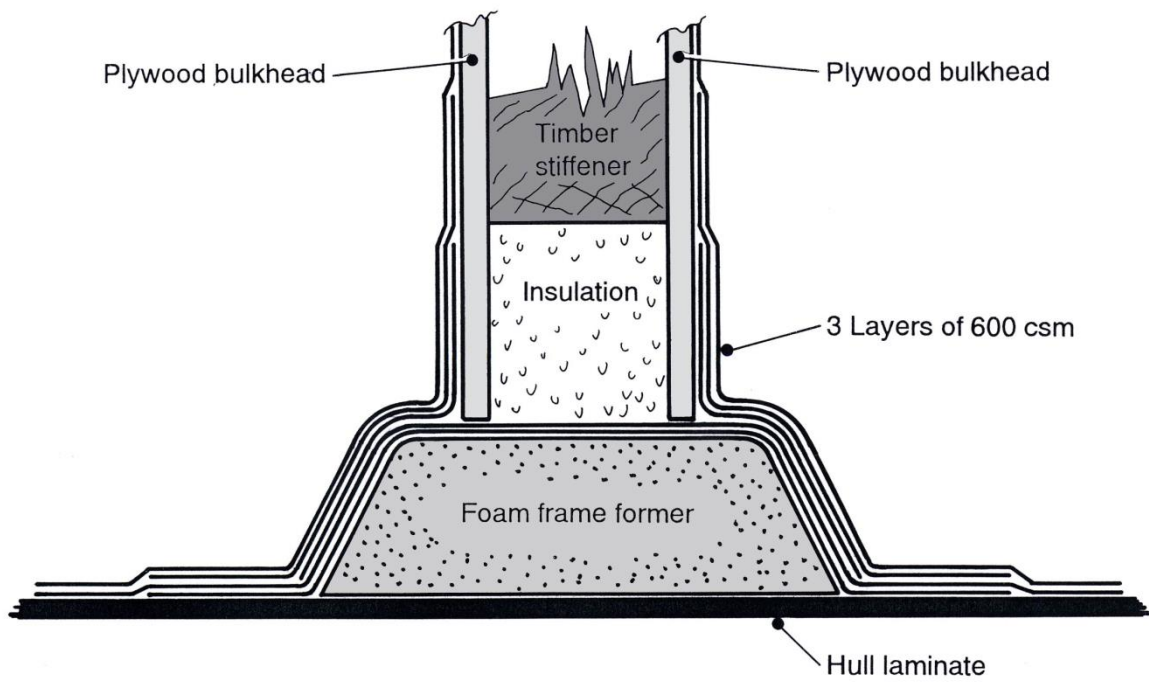
6.12 Figures and illustrations

6.12.6 Bulkhead attachments



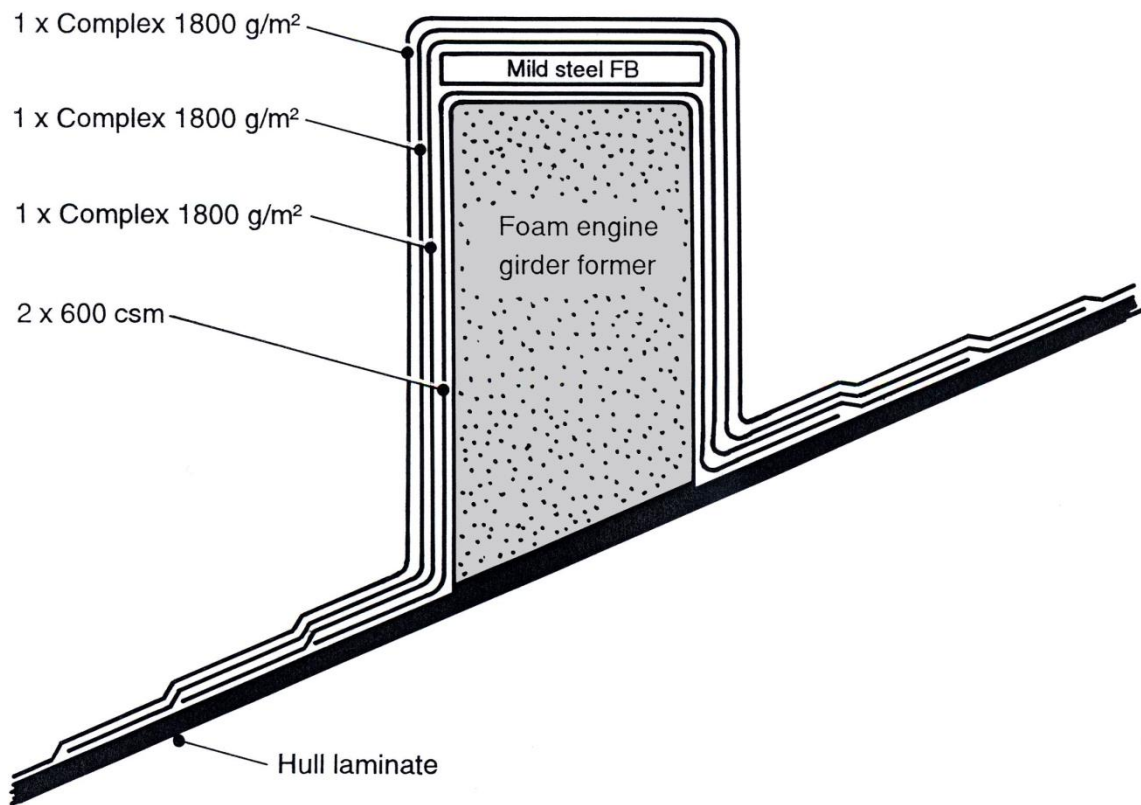
6.12 Figures and illustrations

6.12.7 Foam core bulkhead connection



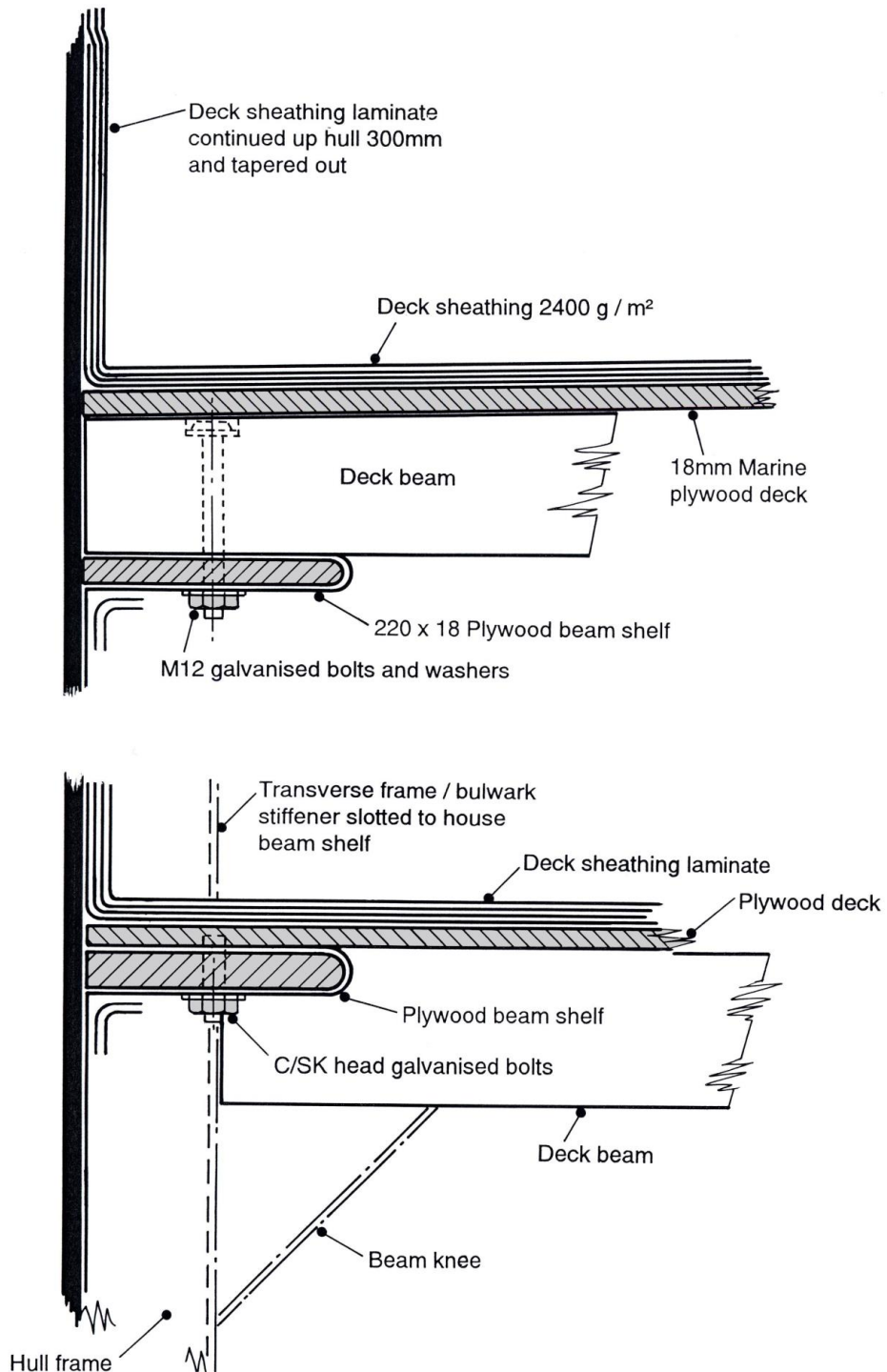
6.12 Figures and illustrations

6.12.8 Engine seats



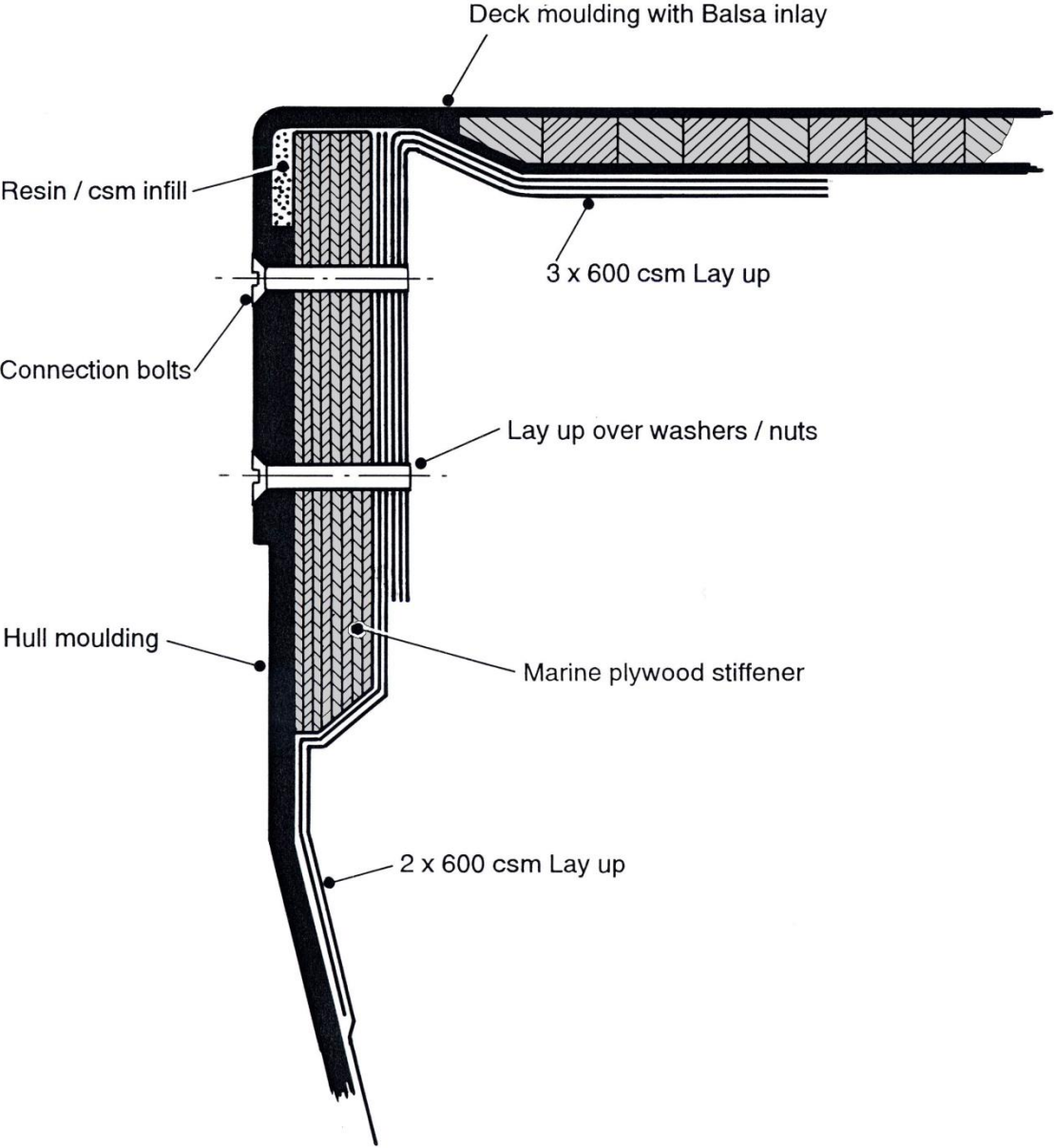
6.12 Figures and illustrations

6.12.9 Deck/beam/shelf connections



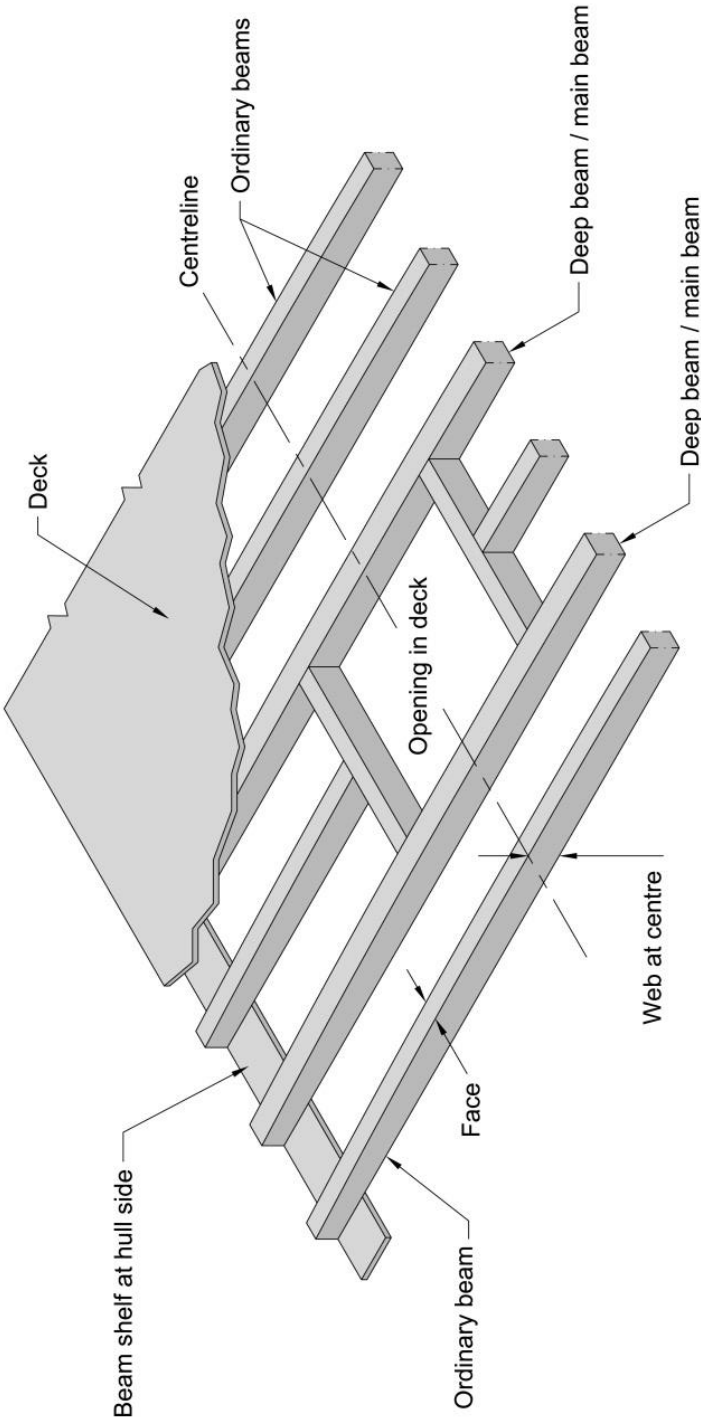
6.12 Figures and illustrations

6.12.10 Deck moulding to hull joint



6.12 Figures and illustrations

6.12.11 Deck structure



6.12 Figures and illustrations

6.12.12 Section at bulwark and beam shelf

