

Hull Protection method and construction of boat

Hull Protection method

There are different methods of hull protection is use in India.

1) Oils:

Oils like sardine oil, cod liver oil, cashew nut shell liquid oil etc., are used either singly or in combination with others to protect the hulls. This is a common practice for indigenous boats on the east and west coast of India. These oils are smeared periodically.

2) Dammar batu:

Dammar batu is a glossy organic substance extracted from certain selected trees. It differs from gum in that it is not soluble in water. Solid pieces of this resin are powdered and mixed with ground nut oil with continuous stirring. Damma batu hardens the surface of wood and retards moisture changes. The application of this resin is common in all types of boats in Sothern Gujarat and Northern Maharashtra. The fishermen in South Gujarat apply lime plaster and Maharashtra fishermen use antifouling paints over the resin to make it effective against marine borers.

3) Coal tar:

It is used for protection of indigenous boats on the eastern coast of India.

4) Copper Sheathing:

This is commonly used on mechanized boats in India.

5) Aluminium alloy sheathing:

It is becoming popular in India for protection of mechanized boats.

6) FRP sheathing:

It has been introduced in India for the protection of mechanized boats. All these methods have their own merits and demerits. The oils and Dammar batu are cheaper and are easy to apply. However, they are not effective against borers. Coal tar though easily available, cheap and effective against borers and foulers makes that boat heavy and its surface becomes sticky, creating problems in painting. Aluminum alloy is light and cheap but prone to corrosion in seawater. Hence anticorrosive paint has to be applied. FRP sheathing does not corrode, is impervious to rot and does not leak at the seams. But constant abrasion is likely to cause thinning out of sheathing. Moreover, the method of sheathing involves special techniques and the hull needs preparation in a specific way. Copper sheathing is the most ideal for protection of underwater part of the hull as anticorrosive and antifouling paints are not required. However, because of the exorbitant cost, fishermen are looking for alternative material.

Steel:

Steel as a boat building material came to general use during the period between 1845 and 1880. Steel was the first material considered to replace wood. The first steel ship was built in the year 1878. The adaptability of steel as construction material for large vessels is well known all over the world. It is one of the most remarkable materials with many advantages if used intelligently. Basically steel is an alloy of Iron and carbon. The categories of steel vary from soft and malleable, which can be easily bend and twisted, to hard and brittle as glass. The plain low – carbon steels containing from about 0.10 to 0.20% carbon are more than adequate for most of the boat construction needs. Stainless steel is not good as boat building material but it has excellent uses for rigging fittings, fastenings, propeller shafts and other applications. They are not always at their best in salt water though they are strong, tough and most corrosion resistant.

(i) General properties of steel:

The strength is the first and greatest attribute of steel. On strength weight basis steel is excellent. By alloying with metals like manganese, its strength could be increased but then they are difficult to handle due to stiffness. High tensile steel made by alloying with metals like manganese has strength of about 2.6 – 3.1 kg/cm².

However because of its stiffness, it needs special techniques of welding. These are not used extensively because of the cost factor except occasionally for the sake of speed, manoeuvrability etc., in naval vessels. A majority of steel in ship is medium steel. Although some parts of the structures may be of high tensile steel. The specific gravity of steel is 7.84. On the basis of weight alone, steel would be at a considerable disadvantage. It is heavier per cubic meter than wood, aluminum or FRP.

The mild steel is ductile, will elongate to 30-40%. Its ductibility and strength are the opposite sides of the same coin. The mild steel which is commonly used for boat construction has the advantages of cheapness, high mechanical properties and ease of cold working. However it is more prone to corrosion against which it needs efficient protections. It weighs 64-1445 Kg/m³ and has a tensile strength of 4735 kg/cm². The effect of high temperature is negligible as its melting point is around 1150 – 1200°C.

Steel is fire resistant and it can survive a fire that would be catastrophic to hulls made with other materials. Because of the relatively small frames and other structural steel members and the wider spacing possible, coupled with the feasibility of building water and fuel tanks integral within a steel hull, a considerable gain in living or working space is available in steel hulls.

(ii) Merits:

Steel is a highly versatile material. It offers significant savings in the construction of standard designs in large numbers. By adopting latest techniques in welding, larger sections of steel can be fabricated with maximum efficiency and minimum wastage of material particularly for the construction of bigger boats beyond 20 m length. Steel offers high uniform strength. It is possible to make all shapes by cutting, bending, welding and riveting. It can even be bent to double curves but this is expensive and requires special skill and time. A special advantage of steel craft is that they can be easily lengthened.

Steel is an ideal material to cope with ice afloat where other materials usually fail. Another attractive feature of steel is the ease with which they can be altered. It works out cheaper for size above 18 m. Construction of steel vessel is much faster than other materials. In comparison with wood, repair, cost is less in steel vessels. Moreover, steel is readily available in a wide variety of shapes and sizes. It is easy to fit out and easy to make strong connections.

(iii) Demerits:

The main disadvantage of steel is its corrosion because of marine environment. Hence constant maintenance is needed. As the specific gravity of metal is high, vessels constructed with steel is heavy. It is brittle adjacent to the weld. Another disadvantage with steel hulls is the difficult to getting the compass to work well. A skilled worker is necessary.

Aluminium:

Use of aluminum in construction of boats and ships is not new and in fact dates back as far as 1890. Earlier attempts did not meet with success because right type of material and method of construction were not well known. The first sea-going hull of aluminum was built in France in 1892. The advancement in metallurgical science together with latest techniques in welding has made the extensive use of aluminum possible in fishing vessels since 1930.

(i) Properties:

- Aluminum becomes harder and stronger with time
 - It's melting point is as low as 600°C
- Extremely ductile and malleable. It will bend or deflect more easily than steel.
- Alloys used in boat construction are called marine alloys like Al–magnesium alloy. Al- silicon alloys etc. Both these alloys are resistant to sea water corrosion.
- Pure aluminum is rather soft and weak and has yield strength of approximately 2,273 kg, but alloys have yield strength of about 40,000 Kg.
 - It has ultimate tensile strength of 17,273 kg/cm² and weight of 2,713 kg/m³
- Special quality alloy used is very light with specific gravity of 2.7 as against 7.8 for mild steel.
 - It is tough and resilient.
- Pure aluminum is a white metal with a bluish tinge and has good resistance to corrosion on account of formation of a protective film of oxide. However, pure metal is too soft for construction value.
 - Modulus of elasticity is more or less constant for all aluminum alloys i.e. 6960

- Kg/mm²
- Properties deteriorate at high temperature as it has low melting point (600°C)
- Easy to work with, can be formed, welded, riveted or bolted into any form.

ii) Merits:

The greatest advantage of aluminum is its light weight. The savings in weight when aluminum is used can result in an increased carrying capacity in a cargo vessel. Its use in super structures lowers the centre of gravity of a vessel. Its use in hull construction often results in the saving of fuel due to reduced displacement. It resists sea–water corrosion without water absorption. As regards its corrosion resisting properties, it is better than copper, zinc, steel etc., It is impervious to worms, rotting and rusting. Due to its good elastic modules, aluminum has a greater impact resistance than steel. It requires very little maintenance. Welding of aluminum is extraordinarily fast. The welding speed is three times that of steel though aluminum requires pre-welding preparation for cleaner surfaces.

Aluminum is non- porous and non-peeling and provides most desirable hygienic conditions for fish handling. Aluminum has a much better scrap value than steel. This is very little wastage material. Aluminum vessels have better manoeuvrability due to less weight. Greater speed is also possible. They have greater load carrying capacity if the same design is used as that for wood or steel.

iii) Demerits:

Aluminum is not compatible with other conventional metals, more so in sea – water due to electrolysis. This can be prevented by coating the surface with insulating materials as neoprene, p.v.c, rubber etc. These non-absorbent materials prevent the flow of galvanic current necessary to

sustain attacks. Zinc chromate coat also prevents galvanic corrosion in salt water. Fire near an aluminum vessel is dangerous. It will seriously reduce the strength of the boat, because of its low melting point. Aluminum requires surface preparation prior to painting. Antifouling paints have to be carefully selected for aluminium vessels because those containing mercury should not be used, as mercury destroys aluminium by forming an amalgam. The surface needs thick barrier paints like zinc chromate prior to painting. The initial cost of aluminium vessel is much higher than steel. However, about 50-60% can be saved in weight which reduces the cost difference. It lacks the stiffness of steel. The thickness of hull must be 1½ to 2 times than that of steel for the same stiffness or the same strength.

Aluminium welding is a tricky business. As the metal oxidizes rapidly, oxygen must be excluded from the weld during fusion process. This calls for skill in welding. Construction of aluminum boats requires a greater technical knowledge and skill than is required for any other vessel.

Ferro cement:

Ferro cement was first introduced as a boat–building material in 1847 in France by Joseph Louis Lambot. However it took professor Pier Luigi Nervi of Italy in 1940 to successfully develop a Ferro cement boat. Since then it is finding application as a boat building material in many countries. Ferro cement is a highly versatile form of reinforced concrete made of wire mesh, sand, water and cement which possess unique qualities of strength and serviceability. It consists of a reinforcement of a number of layers of galvanized iron chicken wire mesh over an arrangement of mild steel rods and fully plastered with a mortar mix of sand and cement combination. The American Bureau of shipping defines Ferro cement as “A thin, highly reinforced shell of concrete in which the steel reinforcement is distributed widely throughout the concrete so that the material under stress acts approximately as a homogeneous material.

(i) Properties:

- The specific gravity of Ferro cement is 2.4 to 2.6
- The steel content works out to be 22-25% (562 Kg/m³) while the mortar mix is about 70-75% (2409 Kg/m³), water is added (by weight) in the water–cement ratio 0.22 – 0.4. Water is added to give it the required plastic–like consistency. Construction involves curing after mixing one part cement in two parts of sand and then water.
- Ultimate thickness of shell after careful use of mortar mix will range between 18 mm and 38mm.
 - Like concrete, its properties are those of (i) Mortar (ii) Reinforcement (iii) Special arrangement of the reinforcement in the member (iv) Absolute dimensions of the member.

- The reinforcement averages about 385 Kg/m³ i.e., good tensile strength in all directions.
 - High steel quality and concrete gives better strength/weight ratio.
- The boat consists of layer of wire from 1.25 to 2.5cm plus 5 gauge steel rods laid fore and aft and athwart the job. These rods are the main strength. Pins made of 16 gauge U shapes are used with the arm of the U about 8 cm long. A pin has to be placed wherever rods intersect.
- FC is essentially RC but it exhibits different behavior from conventional RC in performance strength and potential application that it must be classed as completely separate material. It differs from conventional reinforced concrete in that its reinforcement consists of closely spaced multiple layers of steel mesh completely impregnated with cement mortar.
- It differs very much from the reinforced cement concrete in making greater proportional use of steel over cement.
- Ferro cement can be formed into section less than 2.5 cm thick with only fraction of an inch of cover over the outer most mesh layer. The conventional concrete is cast into sections several cm thick with about 2.5 cm of concrete cover over the outer most steel rods.

(ii) Merits:

- Easy to fabricate into complex shapes without the use of moulds.
 - It has good strength.
 - It is water proof and rust proof.
 - Has corrosion resistance.
- A unique feature of FC is that it becomes stronger with increasing age especially under constant contact with water.

- FC boats, if properly built will have the longest life in water.
 - Cost of FC boats is much less than the conventional wooden hull.
- Construction procedures are simple require simple tools and ordinary manual labour.
- Basic materials like cement, steel, sand etc., are readily available throughout the world.
- Easy to repair, repaired by cleaning the damaged part and then plastering with an epoxy binding agent.
 - Resistance to fire and marine borers.
- Hull does not need any protection; paint is given only for aesthetic reasons.
 - Highly resilient.
 - High energy–absorbing property compared to other materials.
- Only short training is required for the labour, if a skilled supervisor is present. Construction needs only unskilled labour.

(iii) Demerits:

- Not well suited for light displacement vessels less than 10 m long.
 - Low impact resistance.
 - Slightly heavy.
 - Needs more HP to propel the vessel.
- The weakest feature of FC is low resistance to penetration by a sharp object which is called punching. This is different from impact.
 - It cannot be readily adapted to mass production.

- Difficulty in making the holes after construction. Holes in the hull for water inlets are best moulded in, when the hull is constructed.
- Diesel cannot be used in FC hulls as it attacks concrete and cement mortar. To prevent this interior of tanks must be coated with epoxy or diesel-resistant tar, some time steel tanks are to be used.
 - Corrosion occurs inside, if adequate mortar is not applied inside wire mesh over the reinforcement. When mortar is forced through many layers of mesh, it is difficult to ensure complete and uniform penetration. If voids or holes are left behind, it can result in corrosion of mesh after entry of water. Special care is needed to see that steel reinforcement is not exposed. If so, quick repairs are necessary.
- As with GRP hulls it is very difficult to assess the quality of a FC hull once it has been built. Hence careful quality control and inspection is needed, if the finished hulls are to be of an acceptable standard.
 - Heat transfer into fish hold is more than wood and hence an insulation of 1½ times, the thickness used in wooden boats is needed.
- Noise transfer is more. Problem is overcome by using sound-proof insulating material in bulk heads.

Fibre glass reinforced plastics (FRP Fishing Vessels):

GRP was used for the first time in USA in 1946 in boat construction. GRP is a combination of two basic materials consisting of reinforcing agent like glass fibre in the form of thin fibre and a plastic resin capable of impregnating fibres. The resulting material is known as GRP. The term reinforcement plastic materials refers to any plastic material (Polyester resin) whose physical properties have been upgraded by the addition of some auxiliary material, fibres of glass etc., In fact reinforced plastics are analogous in several respects to reinforced concrete where the low tensile strength of concrete is upgraded with steel rods. This material is ideally suited for mass production.

The raw materials used in GRP boat building are (a) Fibre glass (b) Plastics (c) Catalyst (d) Accelerator (e) Other substances which includes (i) Thixotropic paste (ii) Fillers (iii) Pigments

There are different resins – Polyester, epoxy vinyl etc., but polyester is in common use. It is a colourless liquid which can be stored for a considerable period in a cool place. It can be activated by addition of small quantities of two other chemicals known as accelerator and catalyst. Although a number of thermosetting resins such as phenolics, melamine, silicones and epoxies are used, polyester resins have found the widest use in reinforced plastics today.

Unmixed polymer resins will have shelf life of at least three months when kept closed at 30°C but once activated it should be used within 15-60 minutes based on mixing ratio. Polyester resin when activated goes through five stages before it is regarded as fully cured. They are (i) Liquid stage (ii) Gel stage (iii) Set stage (iv) Cured stage and (v) Final cured stage.

The whole process is mainly influenced by the activators, their properties of mix and working temperature. Under tropical Indian conditions this period may be extended for 10-15 days. Preparation of polyester with glass reinforcement is in the ratio of 3:1 i.e., 67% resin by weight and 33% of glass fibre by weight. Polyester is a thermo hardener, a thermo setting plastic material

which, after the initial action of required heat and pressure cannot be changed by the application of more heat or high pressure. It is an ester formed by the reaction of an acid and an alcohol. Complex esters are known as polyesters which are cheaper, serviceable and more popular. Epoxy though stronger is tricky to handle and is more expensive.

Glass fibres are made from a basic product of “continuous filament” produced by special technique of mechanical drawing of molten glass. They are available in different forms like unidirectional, bidirectional and random directional. The most widely used fibre glass is chopped strand mat consisting of strands about 50 mm long held together in random mat form, using adhesive binders. This binding agent dissolves on contact with resin allowing the resin to penetrate the fibres to the full depth of the mat. Glass fibre serves purely for reinforcement, while the thermosetting resins help in proper binding of the material. Greater strength of laminate can be achieved by using woven glass mat called woven rovings.

The process of converting polyester resins from liquid to solid state involves chemical reaction with the addition of catalyst (methyl ethyl ketone peroxide) and an accelerator (cobalt naphenate) to polymerization at room temperature. Polymerization generates its own heat so that the lamination work with fibre glass reinforcement is cured at room temperature. Quantities of catalyst and accelerator added vary in relation to the weight of the resin, thickness of laminate and working temperature. Normally 1% accelerator and 4% catalyst are added by volume.

Other substances which can be added to the resin are thixotropic paste, fillers, pigment and release agent. Thixotropic paste is added to prevent run of resins on a vertical surface. Fillers are the powders such as china clay, chalk or alumina which make the resin opaque, reducing its cost, improving abrasion resistance surface hardness and also reducing exotherm which is the liberation of heat due to chemical reaction during manufacture. Pigment is added to the first layer on the whole layup to give the desired colour. A suitable release agent must be applied over the

working surface of the mould to prevent sticking of the resin.

(i) Properties:

- Minimum tensile strength of FRP is 1050 Kg/cm²
 - Specific gravity is 1.6
 - Weight per cubic meter 1717 Kg/m³
 - Modulus elasticity is 1.2 x10⁵ Kg/m²
- Quality and performance of GRP depend to a large extent on the skill and care employed during its manufacture. In this respect it differs from other construction materials like steel or aluminium, where the quality of the finished product depends on the nature of raw materials themselves.
 - Humidity and temperature control are essential while working with FRP. Low working temperature increases the curing time and high temperature reduces the pot life of resin. Pot life of resin is its storage period after the catalyst and accelerator are added. Normal optimum ambient temperature of FRP processing is about 28°C. The relative humidity should be as low as possible, not above 68% because the moisture carried by the glass fibre on the resin can affect the quality of the end product.

ii) Merits:

- Light weight.
- Highly durable.

- High strength to weight ratio.
 - Can be fabricated to any desired shape and size.
 - Material is free from corrosion both in air and water.
 - No deterioration due to fungi and borers.
 - Speedy construction.
- Due to light weight, it is possible to achieved greater speed; increased fish hold capacity and lesser H.P.
 - Very little surface finishing required after moulding.
 - Excellent quality control possible.
 - Impervious to moisture.
- Being homogeneous structure, there is no leakage. Hull is one piece without seams and joints
 - High chemical resistance.
 - High weathering resistance.
- In case of any accident, the damage caused will be mainly localized resulting in easy repairs.
- Smooth glossy surface finish results in minimizing frictional losses and there by resulting in fuel economy.
 - FRP lends itself ideally to mass production.
- The low modulus of elasticity of FRP is beneficial in absorbing energy from impact loads such as slamming.
- Due to the incorporation of the pigment in the gel, painting of the hull can be avoided. The plastics used to form FRP laminate can be provided with a variety of colours which eliminates the need of paint for many seasons.

- Though initial investment is high, because of minimum expenditure on maintenance and prolonged service life, FRP ultimately proves to be the most economical material for fishing boats.

(iii) Demerits:

- Higher initial cost. Moulds needed in the manufacture work out to be quite expensive, because of the utmost perfection that is required
- Unlike other yards, the concepts of FRP boat yard is elaborate and complicated besides being expensive.
 - Fabrication needs special technical knowledge.
 - Environmental controls are necessary to achieve maximum results.
- Some of the essential raw materials have low storage life and hence require storage under strict environmental control
- The resistance of FRP to abrasion is poor, considering its use in conjunction with wire ropes, otter boards etc., but this can be solved by incorporating additional weather plates wherever necessary.
 - FRP boats have significant hull deflection adversely affecting the engine and shafting.
 - Greater fire danger.
- If the defects are not seen while laminate is laid up, this will reflect at later stage of use when it is difficult to rectify. Water or oil finds their way into laminate if the edges of the laminate are not sealed.
- The material lacks stiffness as the modulus elasticity of conventional FRP is less than $1.4 \times 10^5 \text{ Kg/cm}^2$ compared to $2.1 \times 10^6 \text{ Kg/cm}^2$ for steel and $7 \times 10^5 \text{ Kg/cm}^2$ for aluminium

- Needs protection against foulers.
- Low modulus elasticity may lead to vibration.

Construction of wooden boat

1) Requirements for wooden boat construction

During construction of wooden boat the following plans are required

(i) The construction plan:

This will give the details of the plan, section and profile also relevant structural details.

(ii) Lines plan:

The lines plan is a geometric description of the hull. The sheer, body plan and half breadth plan are collectively called the LINES PLAN. This plan also gives an idea about the water lines, buttock lines, diagonals and sheer line and also showing the shape of the boat at each station with diagonals.

(iii) The table of offsets:

This is a table draws up by the designer so that the plans can be used off without inaccurate scaling of the line plan. All these lines are used to make a complete picture of the shape of a boat which the designer wishes the builder to reproduce. To assist the builder to draw the shape of a boat in full scale size, all measurements necessary to draw the various lines are gathered together in a table called the offset table. In order to obtain a fair and true shape of hull for building purpose, a full scale drawing of a boat is drawn on the boat construction yard, which is called as mold lofting. For mould lofting, offset table is necessary. This table will show the value of keel, water lines, deck, sheer from the half breadth line of boat and keel, deck and sheer from heights above from the base line for making easy drawings. The measurements on the table are normally

expressed in feet, inches and sixteenths eg. Half breadth at LWL on station 6, 8 ft 6¼ in would be appear as 8-6-4.

(iv) The sail and spar plan:

This plan is to enable these parts to be made

(v) The specification:

This is a complete schedule of all the materials etc., to be used in the construction of the boat.

2) Wooden boat construction

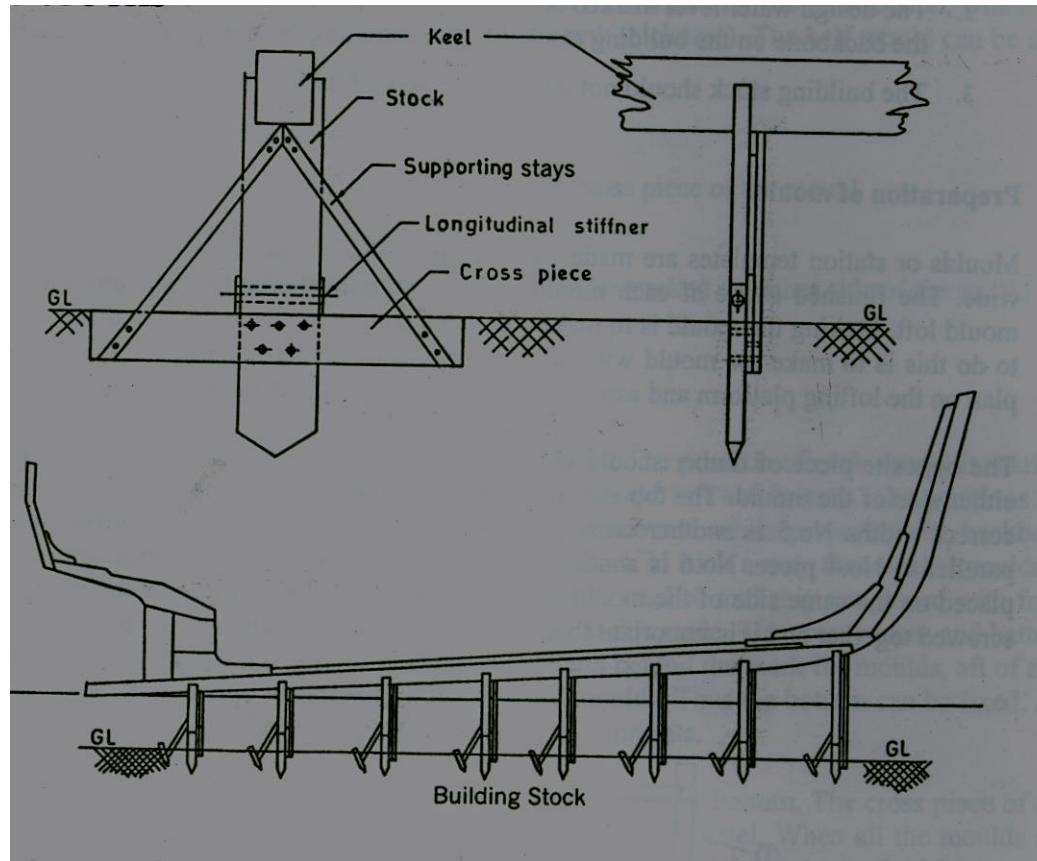
The following are the different stages of boat construction

i) Mould lofting:

This is the process of transferring the plans or blue prints into full-size interpretation on a floor or services of boards. These boards are usually painted matt black to provide a good contrast with the chalked lines. Laying out the plans to full size enables accurate patterns and templates to be made; it also shows up any discrepancy in lines thus enabling the loft man to fair them off. The first step in boat building is making the mould lofting which is the full scale drawing of construction profile and plan view and drawn in floor of construction yard. This helps the builder to see the preview details of construction before setting up the hull.

ii) Building stocks

Building stocks are the group of members arranged to provide the seating arrangement of the backbone assembly. These members should have enough strength to bare the load of the boat and its structural members and to serve till the complete construction is over.



Generally good quality, hard wood timbers are used for making the building stocks. The size normally varies from 20 to 30 cms in width, 35 to 65 mm in thick and more than 1 to 2 m in length depending upon the type of boat to be constructed. Initially at one end of the stock, a slot to the size of the keel is being cut and in the other end is made to sharp to enable the builder to drive it on the ground. This type of stocks can be erected at any uneven ground with loose soil. These

stocks are driven on the ground to the maximum possible by leaving enough height from the ground to the keel.

During the setting of the building stocks all the stocks are made ready and positioned on the ground. Since, the ground is uneven, a base line is extended by means of a string or a twine tied, at both ends of the perpendiculars erected on either ends of the boat length. This line can be checked by means of a spirit level. As per the rake indicated in the lines plan, a second line is extended from the base line to indicate the keel line. At this stage the builder can drive the stocks in their respective positions by maintaining the rake of the keel.

Preparation of mould :

Moulds or station templates are made from cheap timber about 25 to 35 mm thick and 15 to 20 cm wide. The finished shape of each mould can be got from the body plan drawn to full scale on the mould loft. Making the mould is to make a wooden pattern or shape that fits this outline. The best way to do this is to make the mould with different pieces of timber marked 1,2,3,3,4, etc., using the body plan on the lofting platform and assemble the pieces as shown in the sketch.

The opposite piece of timber should be exactly the same shape that 1,2 and 3 are the same shape of either side of the mould. The top stay (cross piece) No.4 will hold the top of the mould together at its correct widths No.5 is another cross piece of batten which helps to strengthen the mould and it is parallel to No.4 piece. No.6 is another strengthening piece at the bottom of the mould and must be placed on the same side of the mould as No.4 &5. The different piece of the mould can be nailed or screwed together and it is important that the finished mould should be true in shape and

made.

In the lofting platform, the body plan or the section lines are drawn including the thickness of hull plank. Hence, before starting to prepare the mould it is necessary that the plank thickness should be deducted. The thickness of the planking is given in the specification. The thickness is taken in a pair of dividers and arcs are drawn on each station line. All these arcs are joined together by using a batten and pencil and thus the line drawn parallel to the body plan. This is the outline for the preparation of the mould. This is done for the transom board also. The centerline of the boat should be marked on the top cross pieces which is half the width of the boat at whatever position the mould is designed. Each mould should be properly numbered. The waterline, the deck at side, and the sheer are marked on either side of the mould. In the body plan on the lofting platform only half widths of the body from the centerline are given. While passing templates or mould they are made for the half section, which has already been drawn on the platform (after deducting the plank thickness).

Mounting the mould on backbone

The moulds can now be mounted on the backbone of the boat. The position of each mould is marked as sections in the lines drawing has been transferred to the mould loft and in turn. The positions are already marked on the top of the hog keel and properly numbered while preparing the backbone assembly. The edge of the mould is placed exactly on this mark in such a way that all the moulds at the aft of midship with the back edge on the mark and the forward of midship are

placed with front edge on the mark. The position of the uprights can be fixed at this stage. The cross pieces and battens are made to the upright so that the upright is 25mm above and behind the mark for moulds, aft of midship and about 25mm above the front mark of the forward moulds. Thus the bottom can be fixed. All uprights are erected and the moulds are nailed or bolted to the uprights.

iii) Setting the backbone assembly:

The back bone consists of the stem, Apron, stem knee, keel hog, dead wood, stern post and/or transom. These parts are shaped and sided before forming together. At first, cut the solid wood from thick wooden log at desired length and lay as a keel over the keel post. Over this, place longitudinally a false keel known as hog keel. Note how the various interlocking timbers are assembled to produce the structure. Particular attention must be given to the fastening of the various components such as knees, horn timber, transom post, stern post. Stop waters should be fitted in all joints that cross rabbet lines (lines where the planking joins the backbone structure). These are round dowels of soft wood, which swell in contact with water to prevent water leaking along the line of the joint. When the rabbet (the cut-out joint into which the planks fit) has been roughed out the backbone structure is set up on convenient foundation blocking ready to receive the frames.

1) Keel: The principal fore and aft component of a vessels framing, located along the centre line of the bottom and connected to the stem and stern frames. Floor or bottom transverses are attached to the keel.

- 2) Hog keel: It is a false keel or extra keel which is in the upper part of the keel.
- 3) Stem knee: A triangular piece of wood which connects the stem and the keel.
- 4) Stern: The aft end of a vessel, the farthest distance part from the bow.
- 5) Stern knee: A triangular piece of wood which connects the stern and the keel.
- 6) Transom frame: Transom frame is the part which is connected to the horn timber. Transom planks are fixed in the transom frame.
- 7) Transom knee: A triangular piece of wood which connects the transom frame and the horn timber.
- 8) Horn timber: A timber extending aft from the stern post to the transom of a vessel and forming the central support of the stem.
- 9) Dead wood: It is a member of the backbone assembly connecting the keel with the stern post where the strong back passes over the deadwood, where great strength is required.
- 10) Shaft log: Shaft log is the member through which the propeller shaft passes.
- 11) Skeg: The extreme aft part of the keel of a vessel, the portion that supports the rudder post.

Setting up of keel:

It is usual to set the keel up on blocks of suitable building height so that the declivity is correct is so that the bulk heads would be upright and the waterline level in the position the boat is intended to assume when afloat. The top of the stem and stern post or transoms and may be the moulds, if necessary are braced by temporary fixings to a building or other convenient place. The whole backbone structure is carefully checked for being upright with level and plumb line.

iv) Preparation of mould

Setting up of moulds and bulkheads:

Moulds are built up with pieces of soft wood, joined together. Deal is a good material for this purpose. The moulds are to be set up on the keel at the number of station required. They can be held on the keel with a small block or blocks screwed on each side and screwed down. The upper side is held up by braces from any convenient part of the building and then squared up with the keel and plumbed to upright with the centre line.

The actual number of moulds will depend on the shape and type of vessel. If the vessel is to have a number of bulkheads, these can be erected in their finished condition to advantage. The moulds or bulkheads are fitted to the hog. The moulds are usually fixed by a small removable block screwed to the hog. Check each mould carefully for being upright and true.

Setting up of planking:

It is usual for the boat builder to set out the planking by eye using a true flexible batten by marking along the moulds in a fair curve. The planks will be about the same width at the stem but will vary from the gar board strake from fairly wide depending on the shape of the ends of the boat, to narrower in the turn of bilge and widening again on the flatter section of the top sides to the sheer strake. The narrowing of the turn of bilge planking is necessary to prevent distortion of the planks on the sharper curve of the mid-ship section. It is necessary to spend a good deal of time and trouble offering up the batten and sighting through before an acceptable curve is found. The sheer

and the whole of the planking must be perfectly proportion for a clincher boat of look good. The keel and hog are either glued or beaded together and can be fastened with screws, clenched rods or bolted with nuts and bolts. If the keel or hog are long and have a joint, this should be in the form of a scarf preferably of the hooked type and in a keel joint there should be a stop water fitted in the line of the rebate which will be covered by the planking this stop water is often omitted if the joint is glued. The stem having been carefully shaped will now be scarfed to the keel. There are several methods of doing this. This stem knee is now fitted having first been sided. If there is to be an apron a scarf is cut at its upper end. The stem knee is fastened right through the stem, keel and hog scarf with bolts or clenched rods arranged. Dead woods are fitted on the top of the keel is good construction. If the boat is to have a stern post it must be scarfed or half jointed to the aft end of the keel. A transom stern is jointed to the keel. This joint may run right through but it will be a neater and better job checked half way through. It is usual to build the wood keel and the structures of the boat direct into the metal keel resting on its blocks.

Template fixation:

The first stage of construction work is to make the templates for all the members from the mould loft. The templates are refer to the pattern of waste wood, arranged over the keel to give the required shape of hull.

Framing:

Frames are either sawn or laminated are then assembled and raised at the correct position on the keel structure. Once the frames are fixed then it should fastened with side planking through copper

nail. When clamped in position they are through→ bolted in place. As the frames are raised they are held in position by wooden battens. At the bow and stern there will be a number of frames that do not cross the keel but have their heels notched into the deadwood or horn timber. These are known as half frames, while the frames that cross the keel are known as square frames. In this case the heels of the frames should be notched into the deadwood, sternpost and horn timber.

Planking:

In very small craft, where for instance the planking runs the full length of the hull, it is possible to mark off and spiel planning like clincher building. If the boat is larger it more usual to steam bends the timbers into the place before planking commences. In the case of sawn or grown frames.

These are erected fully beveled and faired.

Setting up of planking:

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Construction of steel boat

Steel hulls are constructed according to one of three systems viz., Longitudinal, Transverse and Transverse-longitudinal. The longitudinal construction is characterized by member stiffening the plating in the fore and aft direction. In transverse system of construction, the main stiffening of shell and deck plating is arranged in transverse planes. The transverse elements such as floors, frames and beams are connected by brackets. Fishing vessels are constructed mostly by this method. The rigid transverse structure gives a firm and stable basis for shell plating during erection of hull section.

Bottom structure:

The bottom of a steel ship may be constructed as a single or double bottom. The latter is not required vessels over 24 m lengths. The single bottom consists of a centre line girder welded to the keel (generally a bar-keel), side girders, transverse floors (flanged at the top) interconnected by a keelson.

Side shell:

The side shell starts at the upper edge of the bilge strake and ends with the sheer strake. This shell is stiffened with frames connected to the bottom structure and deck beams by brackets.

Deck:

The deck is covered by plates running (like the shell plating) in the longitudinal direction. The deck

strake adjoining the sheer strake is called the stringer plate and both strakes form a vital structure from the point of view of longitudinal strength. Deck plating is stiffened by means of deck beams and in way of large openings (engine-room, trunks, and hatch openings) additional longitudinal supported on bulkheads are fitted.

Bulkheads:

Transverse and longitudinal - consists of flat plating with bulkhead stiffeners. The plates are mainly assembled in the transverse direction for transverse bulkheads and in the longitudinal direction for longitudinal bulkheads, as lower strakes of the bulkhead plating have greater thickness than the upper ones (due to the pressures experienced in flooding the compartment).

Keel, stem and stern: The keel of small steel vessels is usually made of a bar connected at the fore end to the stem, which is shaped in accordance with the profile of the vessel. The stern frame is important, as it has to allow the drive shaft and the rudderstock to pass through it and be able to transmit safely the forces due to action of the propeller and the rudder. Its construction may differ depending on the stern arrangement provided in the design.

Deck erections:

Deck erections may be superstructures or deck houses which have lesser breadth than the vessel and take no part in transmitting main stresses of the hull structure. Superstructures are a continuation of the main hull structure.

Engine seating:

The seating for main engine and other machinery must be of sufficient strength to transmit with appropriate safety the forces due to their action such as the propeller thrust, the winch forces at the front power take off, etc. Opening of engine room and hatch- additional longitudinal supports to bulk heads.

Construction of FRP boat

There are two types of FRP boat construction methods prevail through out the world. They are female mold and split mould technique method. Among these later method is popular in western countries. Hull moulding to be two piece structures laid up using split mould technique as follows:

- Two gel coats all over, applied by hand using “mohair” rollers and 100 mm paint brushes. Nominal thickness 0.5 mm gel type isophthalic. The whole of one side to be laid in one operation with no break, one gel after the other.
- One layer of 225 g/m² chopped strand mat emulsion bonded, laid with isophthalic resin. Resin to glass ratio 1.8:1 by weight laid by hand using “woolly rollers” and aluminium “paddles” rollers.
- Operations (a) and (b) is to be carried out in one shift of work, i.e., within 24 hours. Cure time of 30 minutes minimum between gel coats and cure time of 60 minutes for 225 g/m² layer.
- Main hull laminate has to commence not more than 24 h after application of 225 g/m² layer.
- Three layers of 600 g/m² chopped strand mat (CSM) emulsion bonded lay with resin all over. Resin to glass ratio 2:1 by weight. All three layers laid simultaneously in mat width strips transversely applied; stepped back by 50 mm steps from previous layers on the keel stem and transom join edges.
- One complex of 600 g/m² (CSM) and 600 g/m² woven roving and 600 g/m² CSM laid simultaneously in mat width strips transversely applied, stepped back by 50 mm steps from previous layer on keel, stem and transom join edges.

- Three layers of 600 g/m² CSM emulsion bonded lay with resin all over. Resin to glass ratio 2:1 by weight. All three layers laid simultaneously in mat width strips transversely applied, stepped back by 50 mm steps from previous layer on keel, stem and transom join edges.
- Bring mould halves together, bolt up all round, and arrange internal access and staging as required.
 - Apply one layer of resin proof tape to join line all round.
- Repeat operation (a) to (f) throughout length of join line ensuring 50 mm overlaps increasing by 50 mm for each layer.
 - Mark off hull with chalk or wax pencil for position of hull frames maximum spacing longitudinally 900 mm.
 - Insert frames constructed of low density closed cell polyurethane foam, trapezoidal section base size 150 mm, tapering over 100 mm to top face of 100 mm. Frames to be contact adhesive bonded to hull.
- Over laminate frames with three layers of 600 g/m² CSM with resin. Layers to lap over frame and onto hull with 50 mm, 250 mm and 400 mm laps each side.
- Frames to be extended through keel in way of bulkheads, fish hold, forefoot where practical frame to stop short in way of engine to allow fitting of engine bearers.
 - Insert hull lifting blocks/plates for release from mould.
 - Insert two main bulkheads constructed of 19 mm thick marine grade plywood vertical to datum and square to centerline. Plywood to be butt strapped on joints and glued and screwed. Bond bulkheads to frames on both sides with three layers of 600 g/m² CSM with laps as per (1).
- Hull moulding is now ready to release from mould provided lifting blocks/plates have cured for 48 hours since insertion. Section refers.

- On release from mould hull to be placed in fit out cradle or suitably chocked to prevent any distortion.
- Construction to be taken place by protected from sun, rain and in well ventilated dust-free atmosphere. All materials to be stored in similar conditions and to be suitable for use in tropical environments if appropriate and to be marine grade.
- Ballast to be located in the keel and bilge section in the form of steel punching set in resin and over laminated. Final trimming to be carried out after launch and inclining test.
 - Hull protection to be included to stem shoe, keel iron and skeg.
 - Galvanized steel strips to be fitted to bilge keels.

Deck:

The main deck to be constructed of cambered, hardwood, transverse beams nominally 150 mm x 75 mm and 60 mm as required and sheathed with 19 mm plywood over laminated with 1800 g/m² of chopped strand mat, and to incorporate a non-slip finish. The deck also incorporated an engine removal hatch and access hatches to fish hold. All hatches to be fitted on coamings of at least 300 mm. Freeing ports to be cut in the bulwarks to allow free drainage of water overboard from deck.

Bulwark height to be 610 mm minimum at side.

Gunwales:

Gunwales to be constructed in hardwood as outer section is 50x 50 mm and inner section is 150x 38 mm. Outer to be bolted to inner at approximately 900 mm centres using spacer blocks 120 mm deep x 100 mm thick.

Construction of aluminium boat

Fabrication of aluminium hulls is carried out in the same manner as for steel construction. Forming and shearing of plate are carried out with presses and sheers as for steel, while cutting is accomplished with saws in a similar manner to wood, although knife blades and saws require special setting and teeth with gullets to clear chip dust. Bend radii are higher than those for steel and for most marine applications range from 2 to 5 the thickness of the plating depending on the alloy and temper used.

The keel is made of mild steel and over this a rubber coating is needed. As per the template design, Aluminium magnesium alloy pipes are fixed over the keel as a mould station (skeleton). The space between the pipes covered with aluminium magnesium alloy sheets by using argon arc welding unit. The sheets that are attached to the framework should always overlap one another. Two welding processes are used for the joining of aluminium such as the MIG (Metal Inert Gas) process and the TIG (Tungsten Inert Gas) process. This inert gas, shielded-arc processes are used exclusively for non-ferrous metal fabrication. Small boats are usually constructed upside down over jigs with the relatively lightweight of the material facilitating the turn over process for outfitting and completion. Larger vessels are built upright and jigs can be used to facilitate the fitting and welding of hull plate:

Painting is not essential and hulls of fishing vessels are frequently left unpainted except for underwater, antifouling to prevent marine growth, aluminium to steel or wood joints for increased

resistance to electrolytic corrosion, non-slip paint on decks, and internal surfaces in accommodation for aesthetic reasons. Where painting is required, the alloy surface is etched primed and painted with zinc chromate or chromate-phosphate chemical conversion coatings as a base coat. Selection and application of antifouling paints require special care. Anti fouling paints containing mercury in any form must not be used.

Construction of Ferro-cement boat

As various methods of construction are available to the builders, no detailed construction method should be taken mandatory standards to be followed. Methods which have given satisfactory result is the use of construction of a reinforce armature of rods and mesh over mesh covered span frames (By making reinforcement using the pipes and wire mesh over this cement is applied).

- As per the loft measurement the station moulds are prepared by suitably bending the iron or GI water pipe of half to one-inch diameter.
- In the outside of the mould frames, the mild steel rods ($\frac{1}{4}$ " to $\frac{3}{8}$ ") will be attached at 2" –3" center space with help of either welding or by using 19-20 Steel Wire Gauge (SWG) iron wire.
- Attach four layer of machine woven half inch mesh size of GI chicken wire mesh (20 SWG) with a both side of frame work of reinforcement. For fastening purpose use 19 – 20 SWG GI wire.
- Plastering is done on both sides with special pozzolena cement in combination with good quality fine and sharp river sand and uncontaminated fresh water at the ratio of 1:1.5:0.4-0.5. If the pozzolena cement is not available then with the combination of ordinary Portland cement with fly ash at the ratio of 85:15 to get the required pozzolena effect at cheaper rate.
 - The finished hull thickness should be in between $\frac{3}{4}$ inch to 1 1/2 inch.
- Once a plastering is complete it should be allowed to set hard, 15-20 days are required for curing under shade condition with frequent sprinkle of coldwater. Hull must be kept fully wet condition.
- The hull must be thoroughly dry and clean before painting. Use epoxy cold tar or heavy-duty bituminous paint to fill if there is any depressed holes.

- Apply one or two coat of antifouling paints above the load water line before launching the vessel.

Deck fittings and equipments

(i) Mast and derricks:

Mast is a vertical spar primarily meant to carry sails but it is also used to carry radar, satellite aerials and navigational lights. The masts are of different types. They are made either wood or steel. Derrick is a large spar fixed to mast by goose neck and is used like a crane for hoisting heavy weights. The length of derricks should be adequate to bring the cod end aboard. It is fixed in such a way that the derrick swings through a wide area. These are commonly found in all types of fishing vessel. These are probably the oldest and most basic installation on boats. Mast or masts like structures are vital if all the necessary lifting operation is to be performed. Wooden masts are still perfectly acceptable or if available, steel pipe may be used.

(ii) Block and pulleys:

These are common in all types of fishing vessels and these are used for a variety of purpose like leading the ropes to convenient position for handling or as towing points for the warps in trawling. A block is a wooden or metal case in which one or more sheaves are fitted. Blocks and pulleys are attached to strong points on the mast and derricks. Good quality blocks are expensive but the investment is worthwhile. Cheap blocks will break or seize up or create unnecessary friction, good blocks will last for a long time. They should be made of best hard woods, nylon or steel and should have proper bearings or bushes that are self lubricated or can be lubricated. For boats with small winches or limited power –3 fall and 4 – fall blocks can enable the crew to lift heavy loads on

board provided the mast and rigging have the appropriate strength.

(iii) Power take-off and winch drives:

Power take-off is the units to take the power from the main engine for the winch drive. From the power take-off point, belt drive is preferable to chain drive as it has more flexibility. Hydraulic drive may prove cheaper than mechanical drive in the long run, provided that expertise and spare parts are locally available. On small fishing boats, the most usual power take off is for winch or Hydraulic oil pump for line hauler or power blocks in purse seiners.

(iv) Gallows and davits:

Gallows are used in trawlers and purse seiners. Trawl gallows are used in hitching up of heavy otter boards as well as for passing of towing warps. Though inverted “U” shape is the most common one for trawl gallows, other types like bipod, tripod etc., also exist. The positioning of gallows is important as they must be forward of the rudder axis to allow the vessel adequate manoeuverability but not so forward that the warps foul the stern when turned sharply. Purse seine gallows are used to lead the purse line and tow line to the winch in larger vessels. The gallows is of strong construction with three blocks. In smaller vessels, this function is carried out by davits. Davits are used in purse seiners, gill netters and pots. In smaller purse seiners, single portable davit with blocks is fitted on to mountings at the bulwark for passing of purse liners. It also supports a snatch block for tow line handling. American gill netters haul the nets by power blocks mounted on the davits.

(v) Winches:

Different types of winches are used for different fishing methods. They may be placed in the fore and after direction or athwart ship depending on the requirement. They are used commonly in trawlers, purse seiners and Danish seiners to haul the net and the catch on to the board. Trawl winches can be single drum (split type) two – drum on one shaft or two or more drums on parallel shafts. The last type is most suitable for double rig trawling and purse seining.

A winch may or may not have warping heads. When, present warping heads are used for auxiliary hauling requirements such as hauling sweep lines, wings etc., Split winches are common in large trawlers as they enable straight lead from winch drum to gallows/gantry. Winches can be driven either mechanically from the main engine or electrically or hydraulically or direct drive by a separate engine. Mechanical drive is preferred in small vessels as it is simple, reliable easy to maintain and repair and less expensive. Electric drive is confined to large vessels due to the necessity of a large capacity generating plant and auxiliary diesel. However, electric winch offers good flexibility of operation and control. Hydraulic drive is popular due to its many advantages but is used only in large vessels. Direct diesel drive has not become popular due to problems like requirements of more space fuel supply and exhaust arrangements.