# UTILIZATION OF TREATED WOOD, STEEL, FIBREGLASS, FERROCEMENT AND ALUMINIUM IN THE CONSTRUCTION OF MODERN FISHING BOATS AND THEIR COMPARATIVE COST ANALYSIS.

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Modern fishing boats have to be built not only on perfect lines but also with sound and strong construction materials that will ensure a long lasting trouble free service commensurate with the heavy capital investment involved. Choice of construction materials for fishing boats need careful scrutiny as they have to perform too well under most aggressive environments - sea-water and marine atmosphere. A number of alternative boat-building materials are now available whose comparative merits and demerits as well as comparative costs are brought out in this paper.

## INTRODUCTION

The Fishing Industry in India today, has assumed a very great economic importance and our fishing fleet comprising of boats of different types, shapes and sizes, represent the largest single collective investment on whose efficient performance depends the economy of millions of people and the lives of an untold number of fisherman. Apart from the innumerous indigenous fishing crafts spread out all along our Indian coast line, there are nearly 8000 mechanised wooden fishing boats and about 50 steel trawlers actively engaged to-day in the exploitation of the marine fishery resources of India. Nearly 5000 wooden trawlers and 200 steel trawlers are likely to be added to the existing fleet of fishing vessels in the near future. However, of late, the progress of construction of these vessels and the programme of fleet expansion have been considerably retarded due to shortage of the required constructional materials and due to their spiraling high costs. Owning of fishing fleet now warrants heavy capital investment against uncertain returns. The fishing industry in India to-day has reached a stage where it is in need of technically, economically and socially sound propositions to develop her fishing fleet further with special reference to the programmed exploitation of the fishery resources of the deeper waters. It is not only a sound design, proper size or type of fishing vessel that is the need of the hour but also what exactly is the choice of material that is required for their construction. The need for an efficient boat to stand all the rigorous conditions of fishing in the open sea with a ma-

ximum economy in its working and maintenance under the existing operational conditions in India has to be fulfilled as much as possible in the light of the traditional construction materials available like wood and steel as also the modern materials like Aluminium-alloy, Fibreglass Reinforced Plastics (FRP) and "Ferroce ment" (steel and cement).

Before a careful selection of the proper material for the construction of the fishing vessels is made, both merits and demerits in the overall technological characteristics of each material has to be analysed in greater details and the best characteristics of that material selected, has to be taken to greater advantage before the final construction is decided. The present paper is an attempt in the above lines wherein the salient characteristics of newer construction materials are brought out in comparison with the well known wood and steel along with their comparative cost analysis (Table I, II, III & IV).

TABLE I

| Timber species | Normal service life in fishing boats. | Area where in use. | Approximat cost per $ft^3/m^3$ in long form. |
|---|---|---|---|
| Untreated Teak (Tectona grandis) | 10 to 12 years | Gujarat, Maharashtra. | Rs 14 to 16/-<br>Rs 484 to 565/- |
| " " | 10 to 12 years | Andhra Pradesh | Rs 15 to 18/-<br>Rs 530 to 635/- |
| " " | 10 to 12 years | Kerala, Mysore, Tamil Nadu. | Rs 25 to 30/-<br>Rs 883 to 1059/- |
| Untreated Aini (Artocarpus hirsuta) | 10 to 12 years | Kerala, Mysore, Tamil Nadu, Pondicherry & Laccadives. | Rs 17 to 20/-<br>Rs 600 to 705/- |
| Untreated Venteak (Lagerstroemia Lanceolata) (C.I.F.T. Finding) | 10 to 12 yerrs | Kerala, Tamil Nadu. | Rs 7 to 8/-<br>Rs 296 to 338/- |
| Seasoned and treated woods like mango (Mangifera indica) Haldu (Adina cardifolia) | About 15 years. | A recommendation for future use. | Untreated Rs 4<br>Seasoning Rs 2<br>Treatment Rs 4<br>Handing Rs 2<br>Total Rs 12/- |
| (C.I.F.T. finding) | | | Rs 424/$m^3$ |

TABLE 2 COMPARATIVE COST OF BASIC RAW MATERIALS FOR BOAT CONSTRUCTION IN INDIA,
(Based on 1971 Price Level)

| S.No. | Type of hull | Specific gravity | Average hull Thickness | Approximate cost per Ton | Remarks |
|---|---|---|---|---|---|
| 1 | Wood | 0.6-0.7 without fastenings. 0.9-0.95 with fastenings. | $1\frac{1}{2}$" - $2\frac{1}{2}$" (37.5-62.5 mm) | Boat building timber: Rs 400—1500/— Boat fastenings assorted: Galvanized iron: Rs 8000— 9000/— Copper/Brass: Rs 18,000—22,000/- | Considerable fluctuation in prices from region to regin and from species to species. Teak wood : Rs 15--30 per Cu.foot in rounds. Venteak wood; Rs 7—3 " " Aini wood : Rs 17—22 " " Seasoned & Treated Man-: Rs 12—13 " " go & Haldu Price very much depands upon the choice of metal and surface coating: Ordinary iron : Rs 2.50—3,50 per kg. Galvanised iron (Hot dip) : Rs 7—8 " Copper/Brass : Rs 18—22 " Aluminized iron : Rs 10/- " Copper/Brass : Rs 18-22 " |
| 2 | Steel | 7.9 | 4—8 mm. | Special quolity high carbon ship-building steel plates. Rs 1600—1700/— | Material has restriced supply; very high cost with retailers at Rs 2000 to 2300/— per ton. |

Contd/

| 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|
| | | | | 'A'—glass chopped strand mat as per B.S. 3496/ 1962. | |
| 3 | Fibreglass reinforced plastics. | 1.4—1.8 | 10—20 mm. | 300 g/M² 450 ,, 600 ,, 750 ,, 30 ends woven roving } 25,000/— Polyester resin Rs 20,000/— (Accelerater, Catalyst, Pigments etc) | The superior materials like 'E' variety of glass fibre and Epoxy resins are still costlier in India. Price in foreign markets: Fibreglass - Rs 14000/— per ton Resin - Rs 4000/— ,, Cost will increase considerably with the slight increase in hull thikness. |
| 4 | Ferro-cement | 2.4—2,6 | $\frac{3}{4}$"—$1\frac{1}{2}$" (18.75—37.50 mm) | Mild steel rods ; Rs 1100-1200/—per ton Cement : Rs 200—240/— ,, Galvanized iron pipe : Rs 3500/— per tons Galvanized iron chicken wire machine made webbing of 20 SWG: Rs 6500—7000/— per ton Good quality river sand extra. | Price with retailere at Rs 2000/— per ton. Steel and cement content has to be maintained at 1:4 by weight; excessive cement plastering over the reinforcement should be discouraged. |
| 5 | Aluminium -alloy | 2.5—2.7 | 4 — 8 mm. | Marine quality Aluminium -magnesium alloy plates and extrusions similar to 5086, 5052 of U.S.A. and 57S' E45S of Canada at Rs. 12,500/—per ton. | Range of magnesium content in the alloy: 2 to 5% Welding by metal Inert Gas or Tungsten Inert Gas and revtting with compatible alloys for best results. |

TABLE III CONPARATIVE COST ESTIMATION OF A 57′ OAL X 18′ X 7′—3″ (17.10 m. X 5.40 m. X 2.2 m.) FISHING TRAWLER MADE OUT OF DIFFERENT MATERIALS IN INDIA.

*(Approximate values + or - 10%)*

Note :- (1) *Hull, deck and super structure inclusive. Main engine, auxiliary deck fittings and fishing gear exclusive.*

(2) *Estimation exclusively based on cost of raw materials and Labour but not inclusive of overheads and profits.*

| S.No. | Trawler details | Price range | Normol life in tropical waters |
|---|---|---|---|
| 1 | *Steel trawler* with aluminium super structure (Indigenous) | All India Price<br>Rs 5.50 Lakhs (Ex.yard) | About 15 years |
| 2 | *Wooden trawler* (without hull sheathing)<br>(a) Conventional wooden trawler. *Teak/G.I. fastenings.* | Rs 2.25 Lakhs in Gujerat area (Ex.yard)<br>Rs 2.40 Lakhs in Andhra Pradesh (Ex.yard)<br>Rs 3.75 to 4.25 Lakhs in Kerala, Mysore, Madras & Pondicherry. | About 10 to 12 years. |
| | (b) Cheaper version of C.I.F.T' Venteak and other treated wood with G.I. fastenings (Kerala built) | Rs 2.10 Lakhs (Ex.yard)<br>*Cost of hull protection for the wooden trawler:*<br>1. Copper sheathing : Rs 38,000/—<br>2. Aluminium sheathing : Rs 12,000/—<br>3. FRP sheathing : Rs 29,000/— (2 layers) | 10 to 12 years |
| 3 | Fibreglass Reinforced Plastics (Single skin structure)<br>(a) 'E' Glass/Epoxy resin<br>(b) 'A' Glass/Polyester resin | *Calculated price*<br>Rs 12-14 Lakhs each on 5 hulls basis.<br>Rs 8.50 Lakhs " " | More than 20 years. |
| 4 | Ferro-cement | *Calculated price*<br>Rs 2.00 Lakhs | More than 20. years |

TABLE IV COMPARATIVE COST ESTIMATION FOR A STANDARD 100′ (30.3 m.) OAL COMBINATION FISHING VESSEL BUILT OUT OF DIFFERENT MATERIALS.

| S.No. | Materials | Material content for a 100'steel vessel. | To percentage of weight. | Approximate price compared in percentage. 1 Hull | 5 Hulls | 25 Hulls | Remarks | Special features: Merits | Special features: Demerits |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Steel | 106.20 Tons | 100 | 100 | 100 | 100 | Standard size for off-shore fishing | Ideal for high-seas fishing conditions. Cheaper investment & quicker construction. | Periodical maintenance is essential against marine corrosion and fouling. |
| 2 | Wood | 111.51 " | 105 | 106 | 106 | 106 | Costlier at this size range. | Treatment with preservative for a longer life is possible. | Requires heavier construction and constant hull maintenance. |
| 3 | Aluminium | 47.65 " | 45 | 135 | 135 | 135 | Lowest material weight but initial high cost | Lighter boat or greater pay load; Lesser Horse Power or greater speed. | Suffers under bimetallic contacts; requires special painting schedule for the hull against fouling |
| 4 | F.R.P. | 64.20 " | 60.5 | 143 | 100 | 90 | Progressive cost reduction under mass production, Lower premium on mould amortization. | -do- Yields to mass production. Free from decay and corrosion. | Extra lightness to be taken care of; requires painting against fouling. |
| 5 | Ferrocement. | 110.32 " | 104 | 88 | 88 | 88 | Less constlier for nearly equal weight to steel. | Strong and sturdy; easy maintenance. Cost works out to be the cheapest. | Steel reinforcement should not be exposed, quick repairs necessary; requires painting against fouling. |

## WOODEN CRAFTS

The chemical, physical and mechanical properties of some of the best Indian woods with their easy workability have won them a time honoured place in the construction of fishing boats. This material appears to be economical in boats of lengths between 30-60 feet (9 m-18 m) but not above and below. However, the greatest handicap with wood is that its strength is not uniform throughout and being an organic material, is very much susceptible for rapid deterioration under the influence of various biological agencies and under adverse weather conditions which naturally limits their normal service life to about 10 to 12 years. The under water depradation of timber structures in sea-water is so much that no wooden hull can ever remain in sea-water for long without adequate and costlier protection. Wood, has also become scarce since suitable boat-building timbers are not now easily available either in the required sizes or in adequate quantity. By 1975, it is felt, that in India there will be a gap of more than 100 percent between the demand and the actual supply of timbers for industrial uses. A durable and efficient method of hull protection has also become quite costly and time consuming. Time has thus come for the improved utilization of secondary species of timbers after careful seasoning and wood preservation as substitutes for the scarce conventional timbers like Teak, Aini and the like. Cheaper timbers like Mango and Haldu after prior seasoning and treatment can be brought to extensive use in boat building with considerable saving in cost and prolonged service life as is shown in the following tabular statement.

The Central Institute of fisheries Technology, as an experimental measure, has successfully investigated the posibility of using treated timbers for the deck beams, deck planks, railings, bulk-heads and hatch covers in a wooden trawler in lieu of the costlier untreated timbers which are now in use. It is still felt that the knowledge gained in timber technology has not been used to its fullest extent in the wooden boat building field.

## STEEL VESSELS

The versatility of steel as a construction material for fishing boats is well known. As regards ordinary iron and steel for boat construction they are highly susceptible to corrosion damages in both costal atmosphere and sea-water and yet they have by far the greatest use because of the factors of cost and their important physical properties outweigh all others. The ship building industry requires special type of steel for use. Carbon steel (mild steel) is the basic material for ships, hulls, buoys and most other large items of equipment in a marine environment. The conventional mild steel has an yield strength of 15 tonnes per square inch but with small alloying additions it can be increased to 20 to 22 t.p.s.i. some of the specially alloyed steels will have a corrosion resistance 4 to 6 times more that of ordinary mild structural steel. It is felt that so long as the displacement ships will continue to play the dominant role in sea trade, steel will remain the most commonly used ship hull material but may be high strength steels replace the present mild steel material in the coming years. However, the sea-water corrosion of steel can only be controlled by external protective measures (painting) than by the compositon of steel. Steel is ideally suited for reasons of economy and quick

fabrication if the size ranges of boats are about 60 feet overall lengths and above. To-day ship building steel is still in restricted supply and is being carefully allotted at a quoted price of Rs.1600/- per ton. In spite of an encouraging strength/weight/cost ratio of the material, steel trawlers require careful periodical maintenance particulary of the hull below water-line and the wind water zone. Under adverse tropical climatic and hydrographical conditions, the life of steel trawlers in India can be placed near about 15 to 20 years. The hull plates gradually thin out due to corrosion. By constant chipping and scraping off the rust, eventually there will be no steel left on the hull. When sea-water is of particulary virulent corrosive environment for most metals specially steel, and also has a deteriorating force and organic materials like wood, naturally the choice has to fall on a newer material which would be absolutely free from these problems.

## Fibreglass reinforced Plastics (FRP)

FRP is a proven hull material providing satisfactory service in commercial, naval and pleasure crafts all over the world. Of all the structural materials available at present Fibreglass Reinforced Plastics is probably the most suitable group especially for boat building. Reinforced plastics with the use of ideal materials like fibreglass and thermosetting resins offer a construction medium which is light, durable and astonishingly tough yielding to fabrication to any desired size and shape. The material is free from corrosion both in air and water and undergoes no deterioration at all at the hands of biological agencies specially the marine organisms. This new material and the method of construction is ideally suited for fishing boats where production is envisaged with the use of a single mould. FRP once popular for life boats, rafts and pleasure crafts, has to-day taken a firm place for smaller and medium sized trawlers also exclusively on the merits of its versatile characteristics. Considerable progress has since been made and a notable event was the publication by Lloyd's Register of shipping of provisional rules for the application of reinforced plastics to the construction of fishing craft from 20 ft. to 100 ft. (6 to 30.3 m.) long. To-day no other material is taken advantage of as much as FRP for larger sizes of trawlers and sophisticated vessels including hover-crafts and rockets. FRP boats have already become popular in U.S.A., Canada and U.K. and other developing countries. Japan is planning to modernize about 350,000 small fishing vessels with FRP as construction costs of wooden boat have gone very very much up. A 54' (16. 3m.) FRP boat "SARDINELLA" imported from Norway is already in India (Cochin) under the U.N.D.P. project. A private company has recently started manufacturing FRP boats within India.

As regards economics, FRP boats require greater initial investment and minimum expenditure on maintenance thereafter. The most essential raw materials like fibreglass and thormosetting resins are very highly priced in India when compared to world markets. The fibreglass material for the reinforcement that is now available in India is of alkali 'A' glass composition containing 10 to 15% of alkali calculated as $Na_2O$ much inferior to the 'E' glass. The lower alkali 'E' glass composition which contains less than 1% alkali will give 10% greater strength and better results under adverse conditions than the 'A' glass. The resins most widely used with glass

fibre reinforcements belong to the Polyester thermosetting group and where superior physical and chemical properties are required, epoxy resins are often preferred. The cost of parent mould because of the excellent perfection that is required, is sometimes 2 to 3 times costlier than the off-spring hull. The concept of FRP shipyard is quite elaborate and complicated besides being expensive too. The technical know-how on FRP fabrication of fishing boats is very much restricted in India at the moment. FRP boat building is not merely assembling of preformed components as is in the case of wood and steel boat construction but a new structural material with the careful combination of fibreglass and resin has to be made on the spot at the time of fabrication. FRP is a unique material and full use must be made of its inherent properties in order to obtain the best possible performance.

A 32' (9.7 m.) class of vessel in FRP made in India is now offered at Rs.76,000 for hull alone and in a ready for fishing condition at Rs.1,25,000. FRP boats require special design charactors and construction details as otherwise if built on the existing lines of wooden or steel vessels they tend to float excessively and may not prove to be a stable platform for fishing. This undue lightness should be taken to advantage in as many ways as possible such as increased speed, increased fish-hold capacity, greater endurance or lesser horse-power. A reasonable reduction in the raw material cost and mass production of the standard designs of boats in suitable size ranges will alone make FRP boats an acceptable proposition under the present economic conditions in India. No doubt FRP boats will last longer than wood and steel counterparts with minimum care on their maintenances In a developing country like India with so many problems with wooden and steel fishing boats, FRP has apparently a bright future.

FERROCEMENT

To-day 'ferrocement' fishing boats have become popular all over the world and this new construction material has been accepted and approved by Lloyds Register of shipping, Bureau of Veritas, the United Kingdom White Fish Authority and the Food and Agriculture Organisation of the United Nations.

Not only Lloyds approved ferro-cement, but in January 1967, they have produced their own standard rules for all ferro-cement crafts thus giving the new material international recognition. F.A.O. of the U.N. has studied in greater details with prototype constructions, the design and economic aspects of ferro-cement fishinig crafts. Investors from Germany and Japan are reported to have shown considerable interest in the Ceylon Project to build a large number of ferrocement fishing boats. Fishing vessels with hulls of ferrocement are gaining favour in the waters of Northern Australia and a number of repeat orders have been placed with the builders. "Pak Tak" of Hong Kong (54.5' or 16.6 m.) and "Caranx" of the West Indies (50' or 15.15 m.) are some of the outstanding ferrocement boats working most satisfactorily to-day in their respective waters.

Realising the bright future for this new material and the world-wide interest, F.A.O. of the United Nations had quite recently organised a senior on the design and construction of ferro-cement fishing vessels of Wellington in New zealand during october 1972, when many newer findings have come to light.

From an economical point of view, experiences elsewere show that a size range of 40′ to 60′ (12.12 m. to 18.2 m.) ferro-cement hulls are likely to give satisfactory service if constructed on standard sound lines using the approved materials of steel, cement and sand besides clever workmanship. It must be borne in mind that ferro-cement boat construction under reference differs very much from the conventional Reinforced Cement Concrete (RCC) with which the Civil Engineers are familiar.

Ferro-cement is a very thin $\frac{3}{4}$″ to 1″ or 18 to 25 m m. thickness), highly reinforced slab of concrete with four layers of galvanized iron chicken wire mesh (20 SWF of $\frac{1}{2}$″ hexogonal mesh) firmly fixed on either side of a preformed steel framework consisting of both vertical and horizontal rods of $\frac{1}{4}$″ (6.2 m m.) thickness placed 3" x 2" (75 mm x 50 mm) apart. The mortar is a mixture of high quality cement and sand which after careful mixing with water has to be forced through the dense layers of mesh leaving no voids anywhere. The finished structure after curing should be absolutely water proof. The steel content will work out to approximately 35 pounds per cubic foot (562 kg. per cu.m.) while the mortar density is 150 pounds per cubic foot (2.2 tons per Cu,m.). A 50′(15.15 m.) boat will have a hull thickness of not more than $\frac{3}{4}$" to 1" (19 to 25 mm.) with a density of approximately 185 (2.97 tons per Cu.m.) pounds| per cubic foot (Sp. gr.of 2.4 to 2 6). The outside hull will receive suitable paint coatings before launching as a measure of protection against water seepage as well as marine foulants.

"Ferro-cement is competetive with other materials especially in countries like United Arab Republic where wood is scarce. Ferro-cement boats are quite simple to build and maintain and repairs are easy to make. They are not prey to marine borers which makes them ideal for use in tropical climates. Hulls can be perfectly finished so that they sre virtually indistinguishable from other materials", (F·A.O.). Well finished concrete hulls do not absorb water and therefore there is no risk or contamination in fishing boats. Ferrocement structure is a very good insulator having a thermal conductivity and consequently there is little or no risk of condensation in concrete hulls. It is interesting to note that "Ferro-cement" structures become stronger and stronger with increasing age more especially under constant contact with water. Unlike FRP, ferrocement is immensely hard and shows great resistance to abrasion. Ferrocement boats if sound otherwise- will have the longest life in water since reports prove to show that experimental boats built nearly 100 years ago are still structurally sound?

Based on theoretical calculations and with the limited experience we have with this new material, ferrocement boats are likely to cost very much less than the conventional wooden hull. The construction procedures are simple requiring simple tools and ordinary unskilled manual labour. If unrestricted supply of steel rods and good quality cement are assured this new material will catch up a good market in the near future due to its low cost, high strength and durability.

## Aluminium for fishing vessels

The advancement in metallurgical science to-gether with the advancements in welding techniques have made possible the free use of aluminium magne-

sium alloy to fishing vessel construction. These special quality alloys are very light (Sp. gr· 2.7 as against 7.9 for mild steel) and have a high strength to weight ratio. The marine quality alloys containing 2 to 5% of magnessium are extremely durable and they resist sea-water corrosion without water absorption, rotting, rusting and warping. The use of this material will result in a light boat with high strength per weight, low centre of gravity for proper stability, greater speed per horse power and a minium cost of maintenance. Due to a good elastic modulus, aluminium construction has greater impact resistance than steel. Aluminium is non-sparking and non-magnetic. It is non-porous and non-peeling and provides a most desirable hygienic condition for fish handling. Aluminium has high reflectivity and as such insulation and refrigeration requirements are simpler than steel and it has thermal conductivity.

Aluminium is mostly not compatible with other Conventional metals more so in sea-water due to electrolysis. Correct welding procedures and techniques in dealing with aluminium are of great importance. Its low melting point has an adverse effect on the material and so also heat on its strength properties. Smaller crafts are already operating in the Inland waters of India. The recently introduced 57′ (17.10 m) steel trawlers have their superstructures built out of marine quality aluminium and this will improve the stability of the vessel by lessening the top heaviness. India can make the best use of this indigenous material for fishing boat construction not only for the hull but also for various other ship-board applications including fish-holds, containers etc· to a great advantage wherever other conventional materials have failed for one reason or other. The material is ideal for lighter and faster coastal boats besides for drifters, gill netters and the like in spite of high investment involved.

The table below will give a fairly good idea about the lightness of marine quality aluminium alloys where in the weights of aluminium structures as a percent of an equivalent steel structure are presented.

| | |
|---|---|
| Hull | : 45 to 50% |
| Super structure & Deckhouse | : 35 to 40% |
| Hatchcovers | : 35 to 50% |
| Lifeboats, Davits | : 35% |
| Ladders, Crattings & Floors | : 45% |

It is seen that the individual characteristics of all the boat building materials mentioned above only show that the new materials like fibreglass reinforced plastics, ferro-cement and aluminium if put to proper use can only relieve the present strain on the conventional materials like steel and wood. May be, we have to-doy a wider choice of constructional materials for fishing boats. The newer materials cannot replace the traditional ones all of a sudden but every one of them have their own place and significant role to play, either in their individual capacity or in combination with others. We must now look to materials of the future if the progress is to continue steadily. The boat-building industry like any other, is constantly looking for new materials to make better, more compete-tive and more durable fishing boats. This demand and necessity have created a new technology – "The Science of Materials."

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