BAY OF BENGAL PROGRAMME

DEVELOPMENT OF SMALL-SCALE FISHERIES

BOAT BUILDING MATERIALS FOR SMALL-SCALE FISHERIES IN INDIA

BOBP/WP/9

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(G CP/RAS/040/SWE)

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PREFACE

This paper summaries a study on the availability and prices of materials used to construct the hulls of fishing craft for the important small-scale fisheries of the East Coast of India. The paper should be of interest to development planners, legislators and administrators. Builders of fishing craft, suppliers of materials, and owners and prospective owners of fishing craft may also find useful the information on trends in prices and availability of boatbuilding materials and the possibilities of alternative materials.

The study covered the following boatbuilding materials: timber for kattumarams and boats; fibre-reinforced plastics; ferrocement; steel; and aluminium, which is used for sheathing wooden hulls and is also a construction material in its own right.

The study was carried out by Matsyasagar Consultancy Services Private Limited under contract to the Programme for the Development of Small-Scale Fisheries in the Bay of Bengal, GCP/ RAS/040/SWE (usually abbreviated to the Bay of Bengal Programme). The Programme is executed by the Food and Agriculture Organisation of the United Nations (FAO) and funded by the Swedish International Development Authority (SIDA).

The main aims of the Bay of Bengal Programme are to develop and demonstrate technologies by which the conditions of small-scale fishermen and the supply of fish from the small-scale sector may be improved, in five of the countries bordering the Bay of Bengal — Bangladesh, India, Malaysia, Sri Lanka and Thailand.

This document is a working paper and has not been officially cleared by the Government of India or by the FAO.

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1 INTRODUCTION

1.1 Most of the marine fish landings in India are produced by small-scale fishermen. On the East Coast alone roughly a quarter of a million men are directly engaged in catching fish, with perhaps a million direct dependents. The continuing survival of these communities depends upon many things, one of the most important being the availability of materials for constructing their fishing craft and gear, at prices they can afford. The prospects of improving their prosperity and ot increasing the supplies of food fish depend upon improving their productivity, which may be achieved by the introduction of better fishing craft, gear and methods. This, too, would depend upon the availability at economic cost, of suitable materials of construction.

1.2 In recent years some of the traditional materials of construction have become unavailable for political and economic reasons or because of depletion of the natural resources from which they are produced; other materials are scarce or in short supply. The prices of all materials are rising. Owners and builders of fishing craft have therefore resorted to the use of alternative materials. In some cases, notably in the use of man-made fibres for nets and lines, the new material is so much better than the old that the latter has been supplanted. In other cases, however, the substitute materials in current use have properties somewhat inferior to those of traditional materials, and may themselves be in short supply or becoming scarcer than they were. This is especially true of materials used for the construction of the hulls of small fishing craft: certain types of solid timber; steel; aluminium; ferro-cement; fibre-reinforced plastics; laminated timber. Of these, solid timber is the orthodox choice and by far the most widely used.

1.3 It is desirable to embark upon programmes of technical investigation into possible substitute materials and also into methods of construction that make more efficient use of the materials available.

1.4 It may also be desirable to formulate policies and plans aimed at ensuring future supplies, for example by suitable programmes of forest planting.

1.5 Meanwhile, fisheries development planners, owners and prospective owners of fishing craft, boat builders, and departments of government concerned with the prosperity and well-being of the fishing communities and with such matters as grants to assist in costs of construction of fishing craft, should be aware of the trends in availability and price of the preferred materials of construction and the existing alternatives, and the general characteristics and properties of the latter.

1.6 The Bay of Bengal Programme therefore initiated a study on these subjects. This working paper summarises the results.

2 TIMBER

2.1 Small Fishing Craft—East Coast of India

Generally these craft can be categorised into three types:

(I) Log rafts operating from open beaches

(ii) Open boats operating from beaches

(iii) Small motorised boats operating from harbours and river inlets.

Statewise Distribution of Small Craft (estimated)

	Log rafts	Open boats	Mechanised small craft
West Bengal & Orissa ..	4,000	3,000	450
Andhra Pradesh	18,000	6,000	1,500
Tamil Nadu	26,000	5,000	2,000

2.2 Log Rafts

They are found in Orissa, Andhra Pradesh and Tamil Nadu. Though they differ in shape and method of construction from place to place, they all use logs lashed together. They rely entirely on the lightness of the logs for the buoyancy. The craft vary in size from 5 to 7 metres in length and the width depends on the number and size of logs.

So far, the log raft is the best low cost craft developed to operate from surf beaten beaches. It has the advantage of being nonsinkable and dismantlable for easy handling on the beach. Present designs are limited in carrying capacity and have other disadvantages, and a programme of technical development has been undertaken. It is expected that there will continue to be large numbers of log rafts operating on the East Coast of India for the foreseeable future, probably constructed of timber.

2.2.1 *Wood for Log Rafts:* The following qualities are desired for the wood:

(a) lightness

(b) low water absorption

(c) rot resistance

(d) good weathering properties

2.2.2 *Species:* The preferred species is *Melia dub/a.* This species used to be imported from Sri Lanka and is not available anymore. Other species commonly used are *Albizzia Stipulate* and *Bombax Ma/abaricum.* These timbers too are now not freely available as there has not been a planned plantation programme. Certain alternate species like *Bombax insigne* and *Caner/urn Euphyllum* from Andamans seem suitable and they should be evaluated for use.

2.2.3 *Properties and Cost of Timber for Log Rafts:*

Species	Trade name	Density lb/fV	Density kg/m³	Shrinkage % radial	Shrinkage % tangential	Price (Rs.) 1970	Price (Rs.) 1980
Albizzia stipulata	Sins, royya	25	400			400	1600
Bombax malabaricum	Semul	23	368	2.3	5.1		800
*Bombax insigne	Semul	23	468	2.3	5.4		350
*Canarium Euphyllurn	White Dhup	26	416				350

**Andaman prices. Approximate freight and handling costs to mainland 200 Rs/m³.*

2.2.4 *Long-term Availability:* On an average requirement of 3.5 m^3 per log raft and for a probable 5000 units per year as replacement and new craft, the timber requirement is 17,500 m^3 per year. At present the quantity of alternate species from Andamans has been estimated at 10,000 m^3/year. However these timbers are being utilised for other purposes such as manufacture of matches, in accordance with policies of allocation of supplies at present in force. Thus the fisheries authorities should give consideration to whether they should press for specific allocations. Otherwise it is doubtful if these timbers will be available to the log raft builders and the cost of these craft will continue to rise if built in the scarcer mainland timbers.

2.3 Open Boats

These are found in Orissa, Andhra Pradesh and Tamil Nadu. The majority of these craft are plank built though a few dugouts are found in Tamil Nadu. The planked boats are mostly of carvel type with naturally grown crooks for frames. One particular craft called the Masula is an open boat built without any frames. Another boat called the Nava is popular in Andhra Pradesh and Orissa and is used to operate from surfbeaten beaches. The vallams of southern Tamil Nadu too operate from the beach but under mild or no-surf conditions.

The Bay of Bengal Programme includes a project for the development of improved beach landing craft and among the designs under trial are boats of timber construction. If these trials are successful and the designs are widely adopted, there will be a corresponding increase in the demand for timber suitable for constructing this size and type of boat, although the use of alternative materials and methods of construction (FRP, laminated timber) may be feasible.

2.3.1 *Wood for Open Boats:* For dugouts the wood should be available in adequate length and girth to make a fair-sized boat. Lightness, rot resistance and resistance to borers are other qualities desired. The most common timber for dugouts is *mangifera md/ca.*

Timber for planking should have good shape retention or low shrinkage. Low water absorption and resistance to marine borers are other qualities desired. The most common timber species for planking are Jeypore Teak in Andhra Pradesh, Ayni and Venteak in Tamil Nadu.

Timbers like *Terminal/a Tomentosa* (marudu) are used for keel and stem and engine bearers.

2.3.2 *Properties and Cost of Timber for Boat Construction:*

Species	Trade Name	Weight		Shrinkage		Price	
		lb/ft³	kg/m³	radial	tangential	1970	1980
Tectona grandis	Jeypore Teak	43	688	2.5	5.8	600	2200
Mangifera indica	Mango	41	656	3.0	4.9	300	1000
Artocapus hirsuta	Aini	37	592	3.4	5.3	400	2000
Lagerstroemia lancelota	Venteak	38	608	4.5	7.3	400	2000
Artocarpus chaplasha	Chaplash	32	512				1000
Terminalia Tomentosum	Chuglam	43	688	5.4	7.4		1600
Dipterocarpus Turbinatas	Gurjan	47	760	4.2	8.9		1500

2.4 Small Motorised Boats

These boats, 8 to 10 metres in length, are of planked construction. They are mainly used for shrimp trawling though the smaller sizes are used for gillnetting occasionally, and a growing proportion of this fleet may become more heavily involved in food fish production in future. They are found in Orissa, Andhra Pradesh and Tamil Nadu.

2.4.1 *Timber for Mechanized Boats:* Timber for planking is usually Aini. Venteak is used only above water in view of its poor borer resistance and shape retention. *Mangifera indica* (mango) and *Dipterocarpus turbinatus* (gurjan), if pressure treated, can be used successfully for planking.

2.4.2 *Alternate Methods of Construction:* The amount of wastage in wooden boatconstruction can be as high as 40% from the log. To utilise a higher proportion of the original log it is necessary to adopt other construction methods viz. strip planking, laminated and glued-up construction and double sawn framing; and to use smaller lengths of straight-grained timber and bent framing. Laminated construction would also allow the use of cheaper and lower grade timber of small sizes.

2.4.3 *Safety and Insurance:* It has to be borne in mind that decked, mechanically-propelled fishing vessels are in many parts of the world increasingly subject to rules regarding materials and standards of construction promulgated by insurance companies, classification societies and governments. In future, therefore, it is possible that proposals for the use of unorthodox materials and methods of construction may have to be specially approved by such authorities where they exist. In cases where the use of the material or method of construction is experimental and no adequate experience exists, the design and the methods of fabrication may be the subject of discussion between technical experts representing the owners, builders and any interested insurance, classification and safety authorities respectively; the agreed design and methods of fabrication will then become a provisional standard for ships built of this material or by this method of construction.

3. OTHER MATERIALS

Certain grades of plywood; certain grades of steel; certain aluminium alloys; ferro-cement; and certain fibre-reinforced plastics (FRP) can be considered for the construction of some or all of the types of small fishing craft discussed earlier.

In each case, there may in future be a need to take note of insurance and safety considerations as outlined in 2.4.3.

3.1 Plywood

With the availability of plywood suitable for marine use in sheet form, it is now possible to use this material in the construction of boats. However, the stiffness of the panels limits the hull shapes to those that can be 'developed' (without compound curvature). The use of large panels enables a hull to be planked easily, rapidly and with very few seams. Compared to wooden planking, plywood is lighter and stronger. It is very important, however, to seal the edges and to paint the vessel to protect the plywood from dangerous dampness. It is not advisable to fasten into the edge of the plywood. Plywood seams can be scarfed but the use of a butt block is simpler. The use of FRP to seal joints at chine and keel has solved what was formerly a difficult problem in plywood boat construction. Although it is practicable to build only one vessel to a given design, plywood construction lends itself better to series production. It is therefore all the more important that the designer and builder produce a successful and safe design.

3.1.1 *Standards for Plywood:* Marine plywood in India is manufactured to Indian Standard Specification IS 710:1976. Pressure-treated plywood is available on request. Thicknesses available are 4 mm, 6 mm, 9 mm, 12 mm, 16 mm, 19 mm and 25 mm in sheets of 2.44 mm x 1.22 m and 1.84 mx 1.22 m. These plywoods are resistant to boiling water (BWP) even after 72 hours.

3.1 .2 *Availability and Cost of Plywood:*

Thickness	Price/m^2 in Rs. 1970	Price/m^2 in Rs. 1980	Manufacturers
3 mm	20.00	35.25	(1) The Indian Plywood Manufacturing Co. Ltd. Bombay.
6 mm		47.50	(2) The Western India Plywood Ltd. Beliapatam, Kerala.
12 mm		62.80	
19mm		102.15	
25 mm	80.00	135.85	

3.2 Steel

Steel is well known as shipbuilding material. For small boat construction it is not so popular due to its higher weight. The main problem with steel boats in Indian conditions is the maintenance required due to corrosion. Though round bilge construction is possible with the use of plate bending machines, the use of single-curvature forms with single or multiple chines is more practical.

Other disadvantages of steel for small craft are, first, that it requires skilled labour (welders) second, high investment (on equipment), and third, a substantial power supply. Steel is suitable for one-off and series production.

3.2.1 *Standards for Shipbuilding Steel.* Steel for marine use is manufactured in limited quantities in India as per Indian Standard Specification No. IS 3030-1965. It is not readily available in the open market due to a general shortage. The Steel Authority of India Limited are responsible for allotment and price but very often the open market price is nearly twice the official price.

3.2.2 *Availability and Cost of Shipbuilding steel:*

Thickness	Price/tonne Rs. 1970	Price/tonne Rs. 1980	Availability
3 mm	2000	3250	From open market at rates 40 to 50% higherthan controlled prices.
5 mm		3170	
6mm		3130	
8 mm		3020	
10mm		3020	
Sections	2000	2700	

3.3 Fibreglass Reinforced Plastics

FRP uses fibre, usually glass fibre, as reinforcement in a thermosetting resin matrix. The most common resins used in boat building are polyester resins. Successive layers of reinforcement are individually impregnated with resin during lay-up in a mould. The resin is allowed to cure forming a strong rigid structural laminate. The strength of the laminate is controlled by the number of plies and the type of reinforcement within a given thickness of laminate.

FRP does not corrode, rot or otherwise deteriorate in a marine environment. It has high strength relative to its weight. FRP hulls can generalTy be fabricated as one-piece mouldings without any seams, making them leakproof, Complex shapes can be moulded.

The material has a low modulus of elasticity and is very flexible. Design is therefore governed more by requirements of rigidity than by tensile strength. Single-skin construction stiffened by frames is the most common. Sandwich construction can produce large rigid panels but is expensive and of limited application in boat-building. FR P has abrasion resistance, necessitating the use of chafing plates and fenders where abrasion might occur. FRP construction lends itself ideally to mass production. Hand lay up over a female mould is the most common method of building FRP hulls. Moulds are also usually made in FRP though wooden moulds can be used for limited production.

Investment costs on the moulds are high, and these costs can be arnortised only if a large number of boats are built. This makes it essential to ensure that the design is a good one from the operational and safety viewpoints.

Moreover, the life-potential of FRP hulls is high. It is possible that the hull will last so long that the design no longer meets the requirements of owners, because of changed conditions in the fishery.

3.3.1 *Raw Materials and Methods in FRP Construction:* It is not appropriate here to go into details of raw materials and methods of fabrication of FRP boats. For the planner and decision-maker the main characteristics of this method of construction are, first, the need for expensive moulds, noted earlier above; second, the need for various skills and close supervision of workers; third, the need for control of atmospheric temperature and humidity; and fourth, the need for supplies of various materials, all of which are the products of modern chemical and allied industries.

Materials required include glass reinforcement, in the form of a chopped strand mat or woven rovings made from a nonalkali borosilicate glass of the 'E' type; resins, normally orthopthalic and isopthalic polyesters; specially formulated resin mixes for the outer waterproof coating; fillers; catalysts (for example methylethyl ketone peroxide) and accelerators (cobalt naphthanate or cobalt octoate); styrene monomer to adjust the composition of the resin mix; solvents such as acetone; and release agents such as polyvinyl alconol. These must all be used in the correct quantities and in the correct ways if a satisfactory result is to be achieved. Apart from aircraft components, fishing boat hulls are probably the most demanding of all structures in the matter of the knowledge, skills and organization required for their successful construction in FRP.

3.3.2 *Availability and Cost of FRP Materials:* The following information is not exhaustive and intended only to give an idea of the variety of materials required, sources of supply and prices.

	Material	Specification	Manufacturer	Price per kg 1970	Price per kg 1980
1.	Chopped strand mat (CSM)	E 300, E 450 E 600 g/m²	Fibreglass Pilkington Limited	Rs. 23	Rs. 40.00
			U.P. Twiga Fibreglass Limited		Rs. 32.50
2.	Woven rovings	E 610 g/m²	Fibreglass Pilkington Limited	Rs. 25	Rs. 45.00
3		General purpose	Reichhold Chemicals Limited, Madras	Rs. 28 no duty	Rs. 27.00
			Acropolymers (P) Ltd., Gurgaon		Rs. 26.00
			Naptha Resins and Chemicals (P) Ltd., Madras		Rs. 29.00
4.	Catalyst	MKEP	Kerox Chemicals Corporation, Bangalore		Rs. 70.00
			Dura Chemicals, Bombay		Rs. 6000
5.	Accelerator	Cobalt Octoate	Dura Chemicals, Bombay		Rs. 60 00
6	Pigments		Kerox Chemicals Corporation, Bangalore		Rs. 120.00
7.	Polyvinyl alcohol		Calico Chemicals, Bombay		Rs. 30.00
8.	Polyurethrane foam		U Foam (P) Ltd. Hyderabad		Rs. 110.00

* *N.B. Polyester attracts an excise duty of 29% apart from sales tax.*

3.4 Ferro-Cement

Ferrocement consists of several layers of steel wire mesh reinforcement in a matrix consisting of a cement mortar comprising a mixture of sand and cement. The strength of ferrocement is related to the weight and distribution of the steel reinforcement.

The material has acceptable strength and stiffness, is waterproof, and the basic materials are inexpensive. It lends itself readily to fabrication without expensive equipment or facilities. Quality control is a major problem and the plastering operation requires considerable skill, but the requirements are less onerous than for FRP. Ferrocement is a relatively heavy material for small boat hulls (150-165 lbs/ft^3) unless very special reinforcement materials and sophisticated design methods are used. These have not yet been applied in shipbuilding. Corrosion resistance depends on the quality of the mortar cover and the proximity of the mesh to the surface. Ferro-cement is sensitive to local damage by impact but repairs are relatively easy to carry out.

3.4.1 *Raw Materials and Standards:*

1. Cement: Ordinary Portland cement used in the building industry is adequate for most mortar mixes. Portland cement of ASTM type 2 and 5 specifications which are sulphate resistant are ideal for use in tropical climates.

2. *Sand:* Clean river sand with a high silica content and substantially free from diatomaceous material, 100% passing through a No. 7 sieve and a maximum of 10% passing through a sieve No. 100 is suitable. Sand to cement ratio is 2: 1.

3. *Additives:* To keep the water content low, lignosuiphate additives may be used. For hot climates a retarding agent may be used to give more time for application of mortar and fairing.

4. *Steel reinforcement:* 4 mm to 6 mm rods (preferably high tensile) are used longitudinally and transversely. Square welded mesh 19 gauge 12 mm x 12 mm is laid up in layers and tied to the rods by 19 gauge mesh ties.

3.4.2 *Availability and Cost of Materials for Ferrocement:*

	Material	Specification	Manufacturer	Price 1970	Price 1980
1.	Portland cement	ASTM Type 2	The India Cements Ltd., Madras The Chettinad Cement Corporation Ltd., Madras	Rs. 350/ tonne	Rs. 500/ tonne
2.	Steel reinforcement mesh	12mm 12mm x 19g	Open Market	Rs. $11/m^2$	Rs. $22/m^2$
	MS Rods	6 mm	Open Market	Rs. 5/kg	As. 8/kg
	HT Rods	6 mm	Open Market	Rs. 12/kg	Rs. 22/kg
3.	Sand				Rs. 200/ tonne

3.5 Aluminium Alloy

Aluminium alloy has widespread application at present for sheathing timber hulls to protect them against the attack of certain marine worms (borers). Formerly copper was the preferred material but this is now too expensive.

As a boatbuilding material aluminium has some attractive properties. The alloys used in shipbuilding have a higher ratio of strength to weight than shipbuilding steels. They have good resistance to impact, punctures and cracking and satisfactory abrasion resistance. Being more ductile than steel, they are easier to form, but welding is more difficult and requires special equipment and skills.

Pure aluminium and certain of its alloys resist corrosion well in many conditions, but they are subject to electrolytic corrosion in the presence of moisture and dissimilar metals. As an engineering material, aluminium is always used in the form of an alloy with other metals, to improve strength and hardness. One of the commonest alloying metals is copper (as in the well-known alloy duralumin) but aluminum alloys for use in contact with sea water should be copper-free or otherwise have a special composition or be specially surface-treated. Among the best alloys for boat-building are the 5000 series (American specification). Aluminium alloys for marine use are not readily available in India.

Fabrication capabilities are likewise limited. As in the cases of plywood and steel, the construction of hull forms of single curvature would be most practicable for small boatyards.

3.5.1 *Availability and Cost of Aluminium Alloy:*

Item	Specification	Manufacturer	Price per tonne	
			1970	1980
1. Sheets	5000 Series IS 737-1974	INDAL Limited, Bombay HINDALCO Limited, Mirzapur	Rs. 20,000	Rs. 30,000
2. Sections		HINDALCO Limited, Mirzapur	Rs. 30,000	Rs. 40,000

N.B. Excise duty of 42% is charged extra.

3.6 Laminated Timber

By the technique of lamination with suitable glues, very strong and rot-proof structural components can be built up from comparatively thin sheets of wood; the species is not so important as in conventional timber structures. The technique is to build up the component—frame, deck-beam, etc.—in glued layers, in a manner similar tothefabrication of plywood. The planking of boats can also be done in layers. The method is economical of timber but requires, like FRP, good supervision, a fair degree of skill and some control of atmospheric conditions. The construction of a fishing boat by this method is attractive but would be entirely experimental.

4. CHOICE OF MATERIAL: SHORT AND LONG-TERM CONSIDERATIONS

4.1 The choice of material and method of construction of the hull of a small fishing craft should be governed by a number of considerations, of which the following are the most important:

4.1.1 Appropriate mechanical, chemical and biological properties in relation to the operational environment including interactions with the vessel's machinery and equipment.

4.1.2 Availability.

4.1.3 Availability of equipment and skills for fabrication and for local repair.

4.1.4 The possibility of changing conditions in the fishery, seen in terms of the expected life of the vessel.

4.1.5 Through-life costs, that is to say, first costs plus costs of maintenance and repair minus scrap value, suitably discounted.

4.2 Range of Choice

4.2.1 It will be apparent from the preceding chapters that the range of choice of materials for construction of certain types of fishing craft is not yet as wide as it appears at first sight.

For log rafts, the only practicable choice at present is timber, although the prices of different species vary widely.

For small open boats, there is theoretically a choice between timber, FRP, aluminium alloy and laminated timber. FRP is suitable only for mass-production of proven standard designs under strictly controlled conditions. Suitable aluminium alloy is scarce and so are the skills necessary for its fabrication. Laminated timber has not yet been tried for small fishing boats in India.

For decked boats of about 10 metres LOA and over, there is theoretically a choice of timber, steel, aluminum alloy, FRP, laminated timber and ferro-cement. The remarks made with regard to FRP, aluminum alloy and laminated timber for small open boats apply equally to larger decked boats. Steel is a possibility but equipment and skills are at present concentrated in a few yards organized for building and repairing much larger vessels. Apart from FRP, ferrocement seems the most attractive alternative to timber, from the technical point of view, but skills in fabrication in either of these materials are not widely dispersed, nor are skills in repairs.

4.2.2 Unless active steps are taken to acquire and disseminate the skills necessary for fabrication in alternative materials, of which ferrocement, FRP and laminated timber seem to be the most suitable choices for Indian conditions, there will continue to be an almost complete reliance upon timber. In view of the supply situation, this may well give cause for anxiety. Consideration might be given to programmes aimed at ensuring sufficient supplies of timber for the future. In the shorter term, consideration might be given to allocation of timber supplies to the small-scale fisheries sector, and to practical experiments in alternative materials and methods of construction, including laminated timber.

5. COST COMPARISONS

5.1.1 Earlier above, some prices of materials for boat-building have been quoted. These, however, were for unit weight or unit volume of the materials. The quantities of material required to build a boat to a given set of operational requirements (hold capacity, speed, etc.), for a boat of given dimensions and hull form, will vary according to the material and the form of construction chosen (leaving aside such matters as standards of construction). The useful life of boats of different materials and forms of construction may vary, and so may the costs of maintenance. In what follows, an attempt is made to compare different materials from the standpoint of people who are concerned with costs and profitability.

5.1 .2 Traditionally, owners of all kinds of boats, worldwide, have paid too much attention to first costs and not enough to costs of maintenance. In what follows, both are included, but it must be borne in mind that there can be wide variations in useful life and in maintenance costs depending upon the location, the treatment meted out to the vessel, the way it is looked after, the conditions of the fishery and so on, as well as random variations between vessel and vessel. The figures are therefore better regarded as useful for purposes of comparison of different materials rather than as statements of actual costs and earnings of any particular vessel type.

The figures for useful life of hulls constructed in different materials quoted later in this paper are to be regarded with caution. In the case of the large decked wooden vessel, the life quoted is the minimum to be expected in the Madras area. For the other materials, the useful life quoted is only an estimate; there is as yet little experience to go by, and certainly none of that is statistically sound. The figures are therefore no more than comparative indications of useful life-span that can be expected on the basis of experience elsewhere. The relative costs are of course sensitive to these assumptions. The calculations are therefore best regarded as examples of how to make comparisons of this kind, rather than as conclusive and authoritative statements; and individual boat owners should insert their own figures and estimates.

Scrap value is significant only in the case of aluminum alloy.

5.1 .3 It must be borne in mind that costs related to the hull represent only a part of the total costs. In very large, complex, modern steel-hulled fishing vessels, the capital cost of the bare hull may be only 10 or 15 per cent of the ship; in the case of the 10-metre trawlers in India, the hull costs 30 to 40 per cent of the total.

Because of savings in weight or in costs of painting (aluminum, FRP), the use of certain materials or forms of construction may result in actual or virtual savings elsewhere, for example in fuel consumption or time of maintenance. These, however, will be of comparatively small magnitude and although real, difficult to detect and evaluate in practice. They are neglected in what follows.

5.2 Cost Estimating

5.2.1 To make a preliminary cost comparison for building a boat in different materials the following have to be considered:

1. Basic price of the material in As/kg.
2. Wastage: 40% wood, 30% plywood, 10% FAP, 15% F.C.
3. Cost of fastenings, paint etc.: 20% wood, 15% plywood, 5% FRP, 10% F.C.
4. Cost labour
5. Overheads and profit.

5.2.2 For boats of similar shape, size can best be compared on the basis of volume and the simplest method is to use the cubic number or CUNO i.e. LOA x Beam x Depth moulded. The light weight of a boat excluding machinery and fittings depends on the surface area and the material used for construction. Each material due to its specific physical properties will have a specific weight per unit area to withstand the various service conditions. The total surface area and weight per unit area are dependent on size and can therefore be estimated for a given CUNO.

5.2.3 The weight estimation for boats can be made as follows:

1. Shell weight: Area of shell x basic weight per unit area.
2. Weights of strength members 40% of shell weight of wood and steel
   30% of shell weight for ferrocement
   20% of shell weight for FRP
3. Deck weight: Area of deck x basic weight per unit area.
4. Deckhouse weight =Volume of deck house x 70 kg/m3 for wood.
5. Outfit weight=CUNO x 25 kg/m^3.
6. Machinery weight: From manufacturers' leaflet.
7. Electrical: From manufacturers' leaflet.
8. Deck equipment: From manufacturers' leaflet.
9. Ballast and fishing gear: Determined by designer.

Weight per unit area

	Wood	Plywood	FRP	Ferrocement
CUNO = 15	25	19	10	—
=40	35	25	15	60

Area of hull and deck v/s CUNO

CUNO	Area of hull (m^2)	Area of Deck (m^2)ET 1 w 381 393 m 461 393 l S BT
15	20	8
40	50	20

Material costs/kg

	*Wood	Plywood	FAP	Ferrocement
As/kg	6.00	8.00	40.00	3.50

* Wood: cost/kg is for Aini species sawn to size.

Labour hours/CUNO

	Wood	Plywood	FRP	Ferrocement
CUNO = 15	1000	800	320	
*40	6000	4500	2500	3500

* manhours for CUNO=40 including machinery installation.
Based on data gathered from existing yards.
Man hour rate can be taken as 2.50 Rs/mhr for all materials.

5.3 Small Craft

5.3.1 Small craft can be divided into two groups: beachcraft and craft operating from harbours. Beachcraft have an upper limit on weight depending on handling methods on the beach. Trials and observations show that for manual handling with simple rollers, a fully loaded beach boat operating from steep beaches has an upper weight limit of 1000 kg. Cost permitting, it appears therefore that beach boats built of lighter material can be bigger in size and have a higher CUNO.

For other craft where weight is not the limiting factor, boats built in different materials will have about the same CUNO.

5.3.2 A sample calculation of capital cost estimates for a 7.2 m LOA beach boat now follows:

Dimensions: 7.20 m L.O.A. x 2.45 m B x 0.85 m D.

CUNO: 15m³.

		Wood	Plywood	FRP
1.	Shell area m²	20	20	20
2.	Deck area m²	8	8	8
3.	Total	28	28	28
4.	Kg/rn²	25	19	10
5.	Basic weight kg	700	532	280
6.	Structural kg	280	200	56
7.	Total wt kg	980	732	336
8.	Materials cost Rs/kg	6.0	8.0	40.0
9.	Basic cost Rs.	5880	5856	13440
10.	Wastage Rs.	2352	1756	1344
11.	Fastenings, paint As.	1176	878	670
12.	Labour cost Rs.	2500	2000	800
13.	Prime cost As.	11908	10490	16254
14.	Overheads As.	500	500	800*
15.	Profit Rs.	2350	2350	3250
16.	Price Re.	14758	13340	20304

* *Overheds for FRP will depend on number of hulls moulded.*

5.3.3 A sample calculation of annual costs based on the above figures now follows:

Running cost of beach boats excluding engine and fishing gear:

	Wood	Plywood	FRP
Boat cost As.	14750	13350	20300
Lifetime	5yrs.	5yrs.	lOyrs.
Interest	10%	10%	10%
Capital recovery factor	0.264	0.264	0.163
Capital recovery/year Rs.	3890	3525	3300
Maintenance/year As.	2950	2670	2030
Running cost/year As.	6840	6195	5330

It must be emphasized that the assumed figures for useful life are tentative and not based on adequate experience at this stage.

5.4 Small Trawler

5.4.1 A sample calculation of estimated capital cost is given below:

Dimensions: 9.8 m LOA x 2.97 m B x 1.43 m D.

CUNO: 40 m^3.

	Wood	Plywood	FRP	Ferrocement
1. Shell area m^2	50	50	50	50
2. Deck area m^2 ..	20	20	20	20
3. Total m^2	70	70	70	70
4. Kg/m^2	35	25	15	60
5. Basic weight kg.. ..	2450	1750	1050	4200
6. Structuralskg.	800	700	210	1260
7. Total wt. kg.	3430	2450	1260	5460
8. Material cost Rs/kg. ..	6.0	8.0	40.0	3.5
9. BasiccostRs.	20700	19600	50400	19110
10. Wastage Rs.	8280	5880	5040	2870
11. Fastening, paint Rs. ..	4140	2940	2520	1910
12. LabourcostRs.	15000	11250	6250	8750
13. Prime cost Rs.	48120	39670	64210	32640
14. Overheads Rs.	3000	3000	6250	3000
15. Profit Rs.	9500	9500	12850	9500
16. Price Rs.	60620	52170	83310	45140
17. Engine and stern gear Rs. ..	100000	100000	100000	100000
18. Winch and equipment ..	6000	6000	6000	6000
19. Total Rs.	166620	158170	189310	151140

5.4.2 A sample calculation of annual costs of the above boats now follows:

	Wood	Plywood	FRP	Ferrocement
Boat cost Rs.	60620	52170	83310	45140
Lifetime .. .	*5 yrs.	**5 yrs.	**15 yrs.	**7 yrs.
Interest	10%	10%	10%	10%
Capital recovery factor ..	0.264	0.264	0.131	0.205
Capital recovery/year Rs. ..	16000	13770	10900	9250
Maintenance cost/year Rs. ..	12120	10430	8330	6770
Running cost/year Rs. ..	18120	24200	19230	16020

* *in Madras area without sheathing.*
** *assumed; insufficient practical experience.*

Once again it must be emphasized that the results are sensitive to the figures assumed for useful life, and these are tentative estimates.

5.5 Log Raft

Only a partial comparison is possible for log rafts constructed of alternative timbers:

Size: 6 metres LOA

	Conventional timber	Alternate timber
Species	Albizzia stipulata	Bombax insigne
Weight ..	400 kg/m³	368 kg/m³
Price	1600 Rs/m³	350 Rs/m3
Freight handling		200 Rs./m³
Pressure treatment		350 Rs/m³
Basic cost ..	1600 Rs/m³	900 As/m³
Quantity/boat	2.5 m³	2.5 m³
Material cost ..	Rs. 4000	Rs. 2250
Labour charges ..	Rs. 500	Re. 500
Total cost	Rs. 4500	As. 2750
Service life ..	not known	not known

6 CONCLUSIONS AND RECOMMENDATIONS

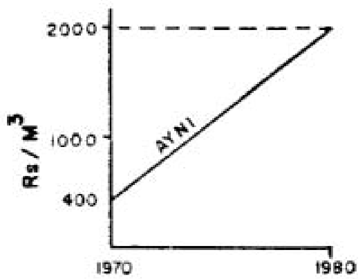
Boatbuilding materials are increasing in cost every year, and it is imperative that a lot more thought be given to better utilisation of available materials. Waste should be minimised. Alternative materials should be explored.

Traditional craft like lografts and planked canoes will continue to be built in wood. It is the cheapest material and the users cannot afford high initial cost. For small boats operating from the beach, plywood and FRP are alternatives. FRP is suited to mass production and may be found to have other adva ntages such as those that may derive from its light weight. Laminated timber may be a form of construction to which existing skills may be more easily adapted in smaller and more scattered boatyards.

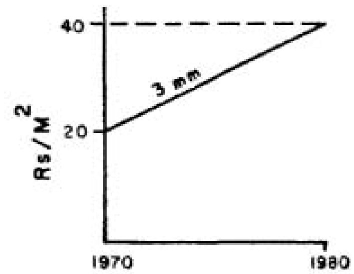
For bigger boats, ferrocement and FAP appear to be attractive if the promise of lower running costs can be realised. However, ferrocement is a heavy material and should not be considered for boats below 10 metres in length. Laminated timber is another possible form of construction attractive for Indian conditions—which is so far completely experimental in the context of fishing boat construction in India.

In view of the continuing importance of timber, and the potential of laminated timber, consideration should be given to the allocation of supplies of appropriate sizes and species of timber to the small-scale fisheries sector. Consideration shouTd also be given to securing future supplies by initiating appropriate programmes of forest planting.

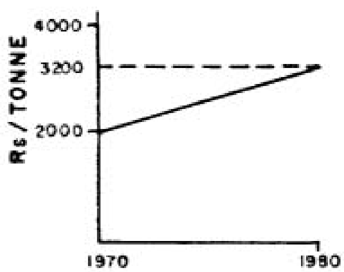
APPENDIX. COST TRENDS IN BOAT BUILDING MATERIALS



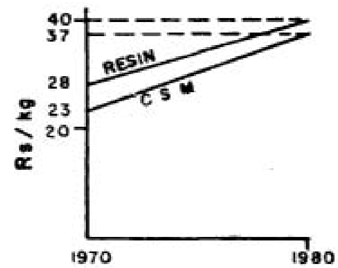
WOOD



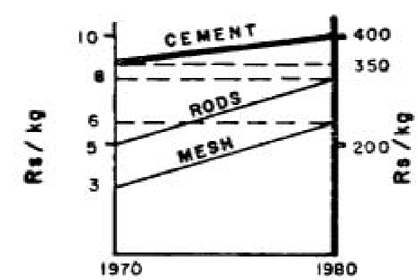
PLYWOOD



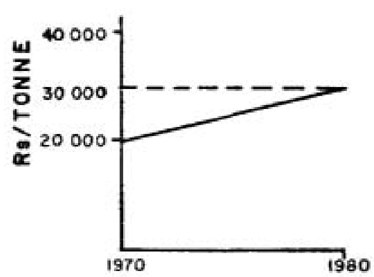
STEEL



F R P



FERROCEMENT



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