CIFT Special Bulletin No. 13

RUBBER WOOD FOR MARINE APPLICATIONS

A Success Story

Agricultural Technology Information Centre
Central Institute of Fisheries Technology
(Indian Council of Agricultural Research)
Matsyapuri P.O., Cochin - 682 029, India

2004

RUBBER WOOD FOR MARINE APPLICATIONS

A Success Story

Agricultural Technology Information Centre
Central Institute of Fisheries Technology
(Indian Council of Agricultural Research)
Matsyapuri P.O., Cochin - 682 029, India

2004

Rubber wood for marine applications - A success story

CIFT Special Bulletin No.13

Price : Rs. 40/- + Tax

Central Institute of Fisheries Technology
P.O. Matsyapuri, Cochin - 682 029, India
Phone: 91 (0)484-2666845
Fax : 91 (0)484-2668212
Telex: 0885-6440 CIFT IN
E-mail: cift@ciftmail.org
ciftaris@sancharnet.in

Published by	:	Dr. K. Devadasan, Director, CIFT, Cochin
Prepared by	:	Dr. Leela Edwin, CIFT, Cochin
Citation	:	Edwin, L (2003), Rubber wood for marine applications - A success story-CIFT Special Bulletin 13, Central Institute of Fisheries Technology, Cochin - 29
Printers	:	Bethesda Printers, Kochi - 24. Tel : 2534435

Contents

1. INTRODUCTION

The annual demand of wood in our country is 262 million m^3, while the exploitable supply is estimated to be only about 52 million m^3. India with a coastline of nearly 6000 km, uses large amount of timber for shipping and fishing activities. The requirement of timber for the marine fishing industry is not known precisely, but it is roughly estimated to be around 20,000m^3 for annual replacement alone (Kumar, 1985). The overall requirement of timber may be over 0.1 million m^3. In India, according to the latest estimates, there are 2,80,491 fishing craft. Of these, 1,81,284 are traditional craft, 44,578 are motorized craft and 53,684 are mechanised craft (Anon, 2000). The larger class of fishing vessels is made of steel while vessels belonging to the medium and lower category use wood for construction. When timber was plentifully available, the accent was on the use of very durable traditional timbers like teak. But as this timber is in short supply and the fact that timber is still the most favoured material for boat building among the rural fishing communities, there is a need for the use of preserved wood over untreated non-durable species of wood or even durable wood. Majority of the artisanal craft are made of wood and a loss of millions of rupees is incurred annually due to biodeterioration of these boats.

India has rich timber resources with nearly 5000 species of trees which are known to yield timber. Of these, only 400 species are actually used for boat building and only 200 of them are put to commercial use extensively. Teak is widely used for fishing boat construction in Gujarat, Maharashtra, Andhra Pradesh (Godavari Teak) and Orissa. The second choice is 'Aini' (jungle jack) particularly in Kerala, Tamil Nadu, Karnataka and Pondicherry. Timber for log raft should be light, have low absorption of water, rot resistance and good weathering properties. Species best suited are Siris (*Albizzia chinensis*), Semul (*Bombax ceiba*), Malabar neem (*Melia composita*), *M. dubia*, Maharukh (*Alianthus malabarica*), Murikku (*Erythrina indica*) and Rain tree (*Samanea saman*). Timbers recommended for mechanized boat construction are teak (*Tectona grandis*), Aini (*Artocarpus hirsuta*), Chaplash (*A. chaplasha*), Sal (*Shorea robusta*), Shisham (*Dalbergia sissoo*), Padauk (*Pterocarpus *dalbergioides*), Laurel (*Terminalia alata*) and Kindal (*T. paniculuta*).

Boat building timbers should be strong, moderately heavy (480-624 kg/m^3 at 12% moisture content), elastic and durable against biological agencies. They should be free from natural defects with straight grains, and should have good retention of shape, strength and stiffness as a beam, good load bearing, shock resistance and nail holding properties. They should also be compatible with metal fastenings and have good working and seasoning properties. Of the several inherent properties of timber, its buoyancy, workability, treatability, nail holding power, strength to weight ratio and poor transmittance of heat, sound and electricity makes it suitable for boat building. However, dimensional instability and susceptibility to biodeterioration are important handicaps of wood as boat building material. Proper seasoning and storage of timber bring about dimensional stability. In India, the hull below the water line area of boats is sheathed by aluminium-magnesium alloy sheets. Fibreglass reinforced plastic sheathing also is a proven method of protection. Although steel, aluminium and plastics are some of the modern alternatives, they can substitute timber only to a certain extent. It is in this context that the use of less durable, low cost and easily available species assumes importance. Treatment with chemical preservatives gives resistance to biodeterioration and extends the service life of timber. Fortifying the timber structure with chemicals, which are toxic to all the destructive biological agencies, can artificially enhance the natural resistance in wood. Protection can also be achieved by using physical and/or chemical barriers applied to the surface of the timber. Physical barriers such as metals (copper, lead, aluminium etc.), concrete and plastic have been used to achieve protection. The demand for timber can therefore be met by utilization of the less used species, social forestry products and wastes from commercial plantations.

The cost of replacement of timber in the marine industry was estimated at one million rupees/year for the state of Kerala. The increasing demand for timber can be met only through scientific processing of timber to meet the requirements. Kumar (1985) estimated that the overall requirement of timber for marine use by 2000 AD would be over 40 million m^3 and suitable preservative treatment would reduce this to 17 million m^3.

Due to its prolonged natural durability, teak was very much in use until half a century ago. The jungle jack (Aini) started to replace Teak from the 1950s.The present cost of this species of wood is about Rs.650/- c.ft. Besides, it is becoming scarcely available. The CIFT has proved the usefulness of Venteak wood (*Lagerstroemia lanceolata*) as a cheaper substitute for teak wood. Prototype fishing boats built of this wood, besides proving to be very cheap, have been giving long and good service as the counterparts built of conventional materials. It has been found that Mango wood (*Mangifera indica*) and Haldu (*Adina cordifolia*), when properly seasoned and impregnated with chemical preservatives like Creosote and Copper-Chrome-Arsenic (CCA), will not only be cheaper but will last longer than teak, aini and the like.

Certain, alternate timber species for construction of catamarans have also been identified by CIFT. These species are available in the Andaman forests and can be used as alternate species to the conventional timbers for catamaran logs. They are *Tetrameles nudiflora, Endospermum malaccense, Bombax insigne, Canarium euphyllum, Albizzia stipulata, Planchonella longipetiolata, Parisha insignes, Pterocymbium tenctorim, Alianthus triphysa* and *Artocarpus chaplasha.*

Rubber wood as an alternate timber

The invention of vulcanization by Charles Good Year in 1839 laid the basis for the modern technical use of natural latex. *Hevea brasiliensis* has since been planted in a number of tropical countries as a plantation crop. The area under rubber cultivation in the world has more than doubled since the 1950s. Rubber plantations are now found in more than 30 countries confined to the tropical and the sub-tropical regions. The existing rubber plantations have the potential to produce a total of about

39 million m^3 of wood per year and this is expected to increase gradually to an estimated 52 million m^3 in the year 2010 (Albaladejo, 2003). More than 80% of the 7.2 million ha of plantation of rubber all over the world is in south-east Asia. Indonesia is now the world's largest producer of rubber from *Hevea brasiliensis* with a rubber plantation in an area of about 3.04 million ha followed by Malaysia with a rubber cultivation of 1.83 million ha and Thailand with 1.78 million ha. About 74% of the plantation is in these countries which have overcome most of the problems in processing and utilizing the wood. According to the FAO statistics of 1999, India was the 6th largest producer of rubber wood in the world. The total area under rubber cultivation in India is 5,67,000 ha (Anon, 2002). Being naturally non- durable, rubber wood is not economically usable without preservative treatment. However, its good working properties makes it suitable for a number of applications. Since rubber wood is a plantation by-product it is available at a relatively low cost. In Malaysia, the log price of rubber wood was found to constitute only 5–6 % of the sawn timber price compared to the dark red *Shorea* spp. (Killmann & Hong, 2003). The wood in the log form costs less than one-fourth the price of conventional boat building timbers. Rubber wood, according to experts, has become established as a substitute for light tropical hardwood. The main reasons are its favourable timber and wood working properties and relatively low cost since it is an agricultural by-product. This makes it highly competitive when compared to other forest species. An additional advantage is that the rubber trees have to be removed for replanting after 25-30 years because of the declining latex yield. This makes the wood available in large quantities. The acceptance of rubber wood as a suitable, plantation grown, environment friendly timber has contributed to its universal appeal.

2. *Hevea brasiliensis* – THE WOOD

2.1 History

Hevea brasiliensis is a native of the Amazon valley of Brazil, South America. It is the source of virtually all the rubber production of the world. It comes under the family Euphorbiaceae. The classification of the *Hevea brasiliensis* in the plant kingdom is as follows.

Kingdom	Plantae	-	Plants
Subkingdom	Tracheobionta	-	Vascular plants
Super division	Spermatophyta	-	Seed plants
Division	Magnoliophyta	-	Flowering plants
Class	Magnoliopsida	-	Dicotyledons
Subclass	Rosidae	-	
Order	Euphorbiales	-	
Family	Euphorbiaceae	-	Spurge family
Genus	Hevea aublet	-	hevea
Species	*Hevea brasiliensis* (Wild. Ex Adr. Juss.) Muell. Arg. – rubber tree		

(Source: Plant Profile for *Hevea brasiliensis,* USDA Plants Profile 2003)

There are 11 species of Hevea. It is one of the youngest domesticated crops. The world rubber industry began to develop in the 1800s. The production of natural rubber is concentrated in only a few countries. The three major countries in Asia producing rubber are Malaysia, Indonesia and Thailand, accounting for 80% of the world total. Two other Asian producers are Sri Lanka and India.

A commercial rubber plantation

It was introduced in the Far East in the 1870s by the Kew Botanical Gardens, England and in India in 1879. Commercial plantation started in 1905 in Kerala in the south west coast of India. Kerala with a temperature of 22 – 32^0 C, relative humidity 75 – 90% and mean annual rainfall of 3000 mm is an ideally suitable habitat for this tree. The rubber is a large tree attaining a height of up to 30 m with a girth of up to 110 cm. The economic life of the tree is 25 – 30 years or even up to 35 years. The state of Kerala alone accounts for 3,26,710 ha of plantation and yield from them amounts to 21% of the forest supply of wood (Rajan, 1989). The Rubber Board estimates the availability of rubber wood in India as 1.25 million m^3 per year. Out of this, logs constitute 60% and branch wood 40%. So about 0.75 million m^3 of timber will be available annually. The output will be 0.62 million m^3 / yr after a loss of 15% in harvesting, storage and transportation. Utilization of rubber wood however poses a number of problems.

2.2 Utilization pattern

Rubber trees are replanted every 25 – 30 years when they are uneconomical for latex production. The world over, the current annual industrial utilization of rubber wood is only 5 million m^3 and the balance is commonly used as firewood or wasted (Albaladejo, 2003). In timber scarce countries like Sri Lanka and India, it has been used for general utility purposes. Rubber wood became an industrial raw material only about a decade ago and has become a new source of wood. But it was in the late seventies that intensive commercial utilization of the wood started in Malaysia. The credit of first utilization of rubber wood goes to India or Sri Lanka (Hong, 1995). Malaysia is the first country to export rubber wood. During the last five to ten years, the market for furniture making has been growing extremely fast. In Thailand, one million m^3 of rubber wood is reportedly used annually by the furniture industry, while a total of two million m^3 was utilized in Malaysia in 1995. A very recent development is the peeling of rubber wood for the manufacture of plywood.

The current production of rubber wood per ha in India estimated by the Rubber Board is 150 and 180 m^3 in small holdings and estates respectively. The projected availability of rubber wood for 2009-2010 is 42,36,000 m^3. The stem wood, which forms 60% of the total is used for industrial purposes and the branch goes as firewood to the brick industry (Anon, 2002). The major consumers of rubber wood are the unassembled packing cases manufacturing industry. Packing cases include low-grade plywood for tea chests, chair seats etc. The packing case sector consumes 62.5% of the stem wood and the plywood/veneer sector, 22.5%. A small quantity is used by the safety match industries (3%) and for making textile accessories. The secondary processing sector consumes 10% of the stem wood.

The wood presents an attractive colour, beautiful grain pattern and gives a smooth finish on polishing. Due to these properties, countries like Malaysia and Indonesia have started using rubber wood for furniture. In the context of declining forest resources, use of rubber wood can help in saving these resources. The present utilization pattern of rubber wood presents a dismal picture. For proper utilization, the wood has to be converted to commercial grade through processing and value addition.

2.3 Properties of rubber wood

2.3.1 Anatomical properties

Rubber wood is a light coloured timber. It has different shades depending on the clone and the site – pink, brown and yellow. Usually it is whitish yellow when freshly felled but turns light brown on drying. Sapwood and heartwood are not distinct. Heart wood is confined to the pith only. Growth rings or annual rings are not visible in rubber wood. It is a diffused, porous timber with medium texture.

The proportions of different cells are given in Table1.

Table 1-Proportion of different cells in rubber wood

	Proportion %
Vessels	8.5
Fibres	58.0
Rays	22.0
Parenchyma	11.5
Fibre dimensions	
Length (mm)	1.19
Width (microns)	17.25 – 20.56
Tension wood	
Extent	8.5 –36.1
Fibre dimensions	
Length (mm)	1.06 – 1.28
Width (microns)	24.72 – 27.43

Source: Reghu *et al.,* (1989)

The occurrence of tension wood (unlignified cellulosic gelatinous fibres) seen as white lustrous zones when freshly cut, is a characteristic feature of rubber wood (Reghu *et al.*, 1989). This tension wood formation is considered as a natural defect in wood brought about by growth irregularities and environmental conditions. The tension wood fibre is short and broad as compared to the normal wood fibre. The wood structure of *Hevea brasiliensis* varies between trees as well as between different heights (vertical variation) and at different positions (horizontal variation). The existence of this variation is reported to be due to the difference in the conditions under which a particular tree grows (Reghu *et al.*, 1989). As tension wood has considerable impact on seasoning and industrial utilization, it is necessary to establish its quantity, nature and distribution in the wood. It ranges from 8.5 % to 36.0%. The planks containing tension wood warp due to longitudinal shrinkage. The distribution of tension wood ranges from tree to tree.

2.3.2 Physical and mechanical properties

Rubber wood is a light hardwood. The wood is whitish yellow or pale cream when freshly cut and seasons to light straw or light brown. It is a diffuse porous wood with medium texture and straight grain. It is a moderately hard and 'light to moderately heavy' timber with density ranging from 435 to 626 kg/m^3 at 12% moisture content. Its medium density and low shrinkage values makes it a furniture grade timber. The shrinkage values in the radial, tangential, longitudinal and volumetric directions are 2.6-3.1, 5.7-6.5, 0.2-0.9, 10.1-12.0 % respectively (Shukla & Lal, 1985) Sapwood and heartwood are not distinct. Occurrence of tension wood, seen as white lustrous zones when freshly cut, is a characteristic feature of rubber wood. It can be dried free from surface cracking within reasonably short periods and the wood is easily treatable.

The properties of rubber wood are different and independent in all the principal directions of growth: longitudinal, radial and tangential (orthotropicity). The occurrence of latex particles and tension wood causes these variations. Factors like elevation, air temperature,solar radiation, humidity, rainfall, soil characteristics, spacing, clonal difference and age of the tree can influence to a certain degree the properties of the wood. The dynamic properties of the rubber wood are higher than the static properties under impact loads. However, the static properties of rubber wood in dry conditions are higher than those when green but in the case of dynamic properties, the reverse is the case for fibre stress at elastic limit and the modulus of elasticity (Anon, 2002)

A study conducted by Gnanaharan and Damodaran (1992) showed rubber wood from 35 year old trees grown in the central region of Kerala had a mean MOR (Modulus of Rupture) of 98.4 N / mm^2, MOE (Modulus of Elasticity) of 15.7 kN / mm^2, MCS (Max. Compressive Stress) of 52.7 N/ mm^2 and a density of 580 kg/ m^3. This study has shown that rubber wood from a 35 year old tree has strength values comparable to those of many structural timbers. When a material is under simple stress within the proportional limit, the ratio of stress to the corresponding strain is called Modulus of Elasticity (MOE). It was observed that the strength values in *Hevea brasiliensis* continued to increase up to 35 years i.e. the common felling age of the tree. Besides, the mechanical properties of rubber wood come within a comparable range of most conventionally grown trees in Kerala as can be seen from Table 2. The standard tests for determination of this suitability are the 3-point bend test and the compression test. These tests help in the determination of the suitability of timber to be used as beam and as a post during boat building.

Table 2 - Physical and mechanical properties of some conventional Kerala grown timbers

Sl. No	Species	Static bending		Compression parallel to grain	Density kg/m^3
		MOR N/mm^2	MOE KN/mm^2	MCS	
1.	*Tectona grandis* (Teak)	95.9	12.0	53.2	650
2.	*Albizzia lebbek* (Kokko)	88.7	12.3	53.4	640
3.	*Albizzia oderitisima* (Kala series)	143.8	14.5	78.7	595 -1010
4.	*Artocarpus heterophyllum* (Jack)	8.06	10.1	49.6	595
5.	*Artocarpus hirsuta* (Jungle jack, Aini)	96.9	12.2	61.6	595
6.	*Cocos nucifera* (Coconut)	92.7	15.9	57.2	761
7.	*Grevillia robusta* (Silver oak)	63.3	8.3	38.9	640
8.	*Grewia tillifilia* (Dhaman)	130.2	16.4	70.1	785
9.	*Mangifera indica* (Mango)	90.4	11.2	44.8	690
10.	*Terminalia paniculata* (Kundal)	111.8	14.3	63.9	785
11.	*Xylia xylocarpa* (Irul)	109.8	14.8	71.4	850
	Hevea brasiliensis	**98.4**	**15.7**	**52.4**	**580**

Source : Journal of Tropical Forest Science 6 (2)

2.3.3 Working qualities of rubber wood and its suitability indices ?

Rubber wood is easy to saw and machine. Dabbing of saw blade with fuel oil can easily eliminate clogging of saw with latex. For best results in sawing, narrow gauge saw blade with teeth having top clearance angle of 15° and front rake of 20° should be used. Short length of sawn planks can be overcome by finger jointing. Moderately large size pores (1 – 4 / mm^2) and presence of tension wood make rubber wood less durable. A cutting angle of 30° gives very smooth surface on planing and facilitates further smoothening of the surface. It can be finished to a very glossy look on polishing and can be given ammonia fumigation-cum-bark extract quenching treatment to obtain golden to dark brown hues and decorative figures. Rubber wood can be bent in steam or in ammonia to make curved items. It takes up stains well and being light in colour it can be stained to the shades of teak, rosewood, mahogany, beech, cherry etc. The surface is a little coarse and wooly. Planing renders a very smooth surface. Turning is slightly difficult and boring and mortising does not give a clear surface. The overall performance of rubber wood with regard to the working qualities is given a rating of 194 when compared to teak, which is given 100.

Studies conducted by the Rubber Board on the working properties of rubber wood showed that planing, boring and turning was easy and gave a smooth finish. Sawing was slightly difficult in the green condition and moderately easy in the dry condition.

Rubber wood offers good resistance to screw and nail withdrawal forces. Considering the moderately good mechanical properties and workability of rubber wood, it would be appropriate to compare the suitability indices of rubber with that of teak which has a suitability rating of 100 (Table 3).

Table 3 - Suitability indices of rubber wood

Property	Suitability index (Teak : 100)
Weight at 12 % m. c	93
Strength as a beam	62
Stiffness as a beam	77
Suitability as a post	52
Shock resisting ability	75
Retention of shape	77
Shear	92
Hardness	74
Splitting co-efficient	75

Source : Shukla and Lal (1985)

2.3.4 Seasoning of rubber wood

Rubber wood belongs to seasoning class 'B' of IS:1141-1993 with reference to refractoriness. When freshly cut, moisture content of the timber will be above 60%. For any use, the moisture content has to be reduced to the equilibrium moisture content (EMC) and this is about 12%. This is for dimensional stability and for obtaining good machining and finishing properties. Rubber wood contains tension wood and hence seasoning is carried out with utmost care at controlled conditions of temperature, humidity and air velocity so that the drying takes place uniformly throughout the entire charge. The final moisture content should be 10%. The drying time is dependent on the timber thickness. Currently two types of seasoning techniques are employed; conventional kiln drying and vacuum drying. With vacuum drying, drying time can be saved and the wood will have fewer defects with better colour.

3. BIODETERIORATION OF RUBBER WOOD AND ITS PRESERVATION

3.1 Biodeterioration

Rubber wood, which offers such a vast potential, poses an equal number of problems too. It is highly perishable when compared to other commercially used species of wood. Conversion of this perishable wood into value added products through chemical preservative treatment will surely turn it into one of the promising sources of timber. The reason for the high degree of susceptibility of the light coloured hardwood to micro-organisms is the relatively high starch content and the general lack of phenolic compounds, which are inhibitory to these organisms. It has less lignin content too.

The types of defects caused to rubber wood can be classified as borer holes and tunnels caused by insects and marine borers, stains caused by sap stain fungi and decay and rot caused by fungi and bacteria. *Botryodiplodia theobromae* attack rubber wood the most and causes a deep penetrating stain. Surface moulds such as *Aspergillus* spp. and *Pencillium* spp. has been reported to infect rubber wood (Ali *et al.*, 1980). Insects attack rubber wood while in the form of the standing tree, when felled and during and after seasoning. Wood rotting fungi such as *Lenzites palisotii* and *Ganoderma applantum* destroy rubber wood. Norhara (1981) has documented about 25 beetle species as pests associated with rubber wood. The common species are *Minthea rugicollis, Heterobostrychus aequalis, Sinoxylon anale* and *Xylothrips flavipes.*

Due to enzymatic action, the timber becomes soft and light, spongy, inflammable and emit a mucky and unpleasant odour. Eventually, fungus attacked wood gets fully soaked in water and becomes heavy and loses the nail holding properties and strength properties. In dry condition, the wood cracks and these gradually become longer and deeper resulting in the failure of such structures. Fishing crafts have to be periodically repaired or replaced and the cost of this runs to several lakhs of rupees. Dark brown or reddish brown stains are caused by change in the cell contents and the oxidation of phenolic compounds. These can be removed by planing. Proper seasoning can prevent the fungal attack. Underwater storage is the most effective method to prevent the fungal attack of rubber logs (Findlay, 1985).

Rubber wood when exposed to seawater or estuarine water is found to be destroyed within four to five months by the attack of marine borers. The marine borers that cause the greatest amount of damage are categorized into two: bivalve molluscs and crustaceans, each characteristic in its general appearance and method of attacking wood. The molluscan borers may be separated into two families - the Teredinidae or the wood - boring shipworms, and the pholadidae or rock borers.The important genera of wood boring molluscs are Teredo, Bankia, Nausitoria and Martesia of which the first three are superficially worm like in appearance and are known as 'shipworms'. The damage caused by shipworms is internal and can become quite extensive without being apparent. The larvae make very small entrance holes on the surface of the wood, but once within the wood they increase rapidly in size and develop the characteristic worm like bodies. As the animal advances into wood, it secretes a protective calcareous lining for the burrow. As a result of the continued boring, the structural strength may be greatly reduced. *Teredo elongata, T. manni, T. furcifera, T. fulleri, Bankia carinata, B. liliobankia* and *Nausitoria hedleyi* are the species important to India.The pholadidae looks very much like small clam in appearance and bore into wood, clay, soft rock, and shells and even into plastic and poor grades of concrete. Pholadidae is represented by *Pholas* and *Martesia* of which *Martesia* is of importance to India because of its widespread distribution, density of attack and rapid succession of generation. The young attack wood by boring small entrance holes and once within the wood, they continue their boring and excavate the wood sufficiently to accommodate the growth of their imprisoned bodies. *M. striata* and *M. fragilis* are common to India (Thomas, 2003).

Crustacean borers are distinct from the molluscan borers in their method of attack, general structure and appearance. They do not become imprisoned in the wood but are able to move about. The young and adult alike attack the wood making narrow galleries, which seldom reach very deep. The damage done by this group is less serious than by shipworms as this is more evident on inspection and the excavation proceeds less rapidly. The animals make extensive network of tunnels in the wood, which are eroded away by wave action, which exposes unattacked surface for fresh attack. The important crustacean borers are of two orders 'Amphipoda' and 'Isopoda' and are represented by three major genera viz. *Limnoria, Sphaeroma* and *Chelura* of which the latter is of minor importance to India. *Sphaeroma* commonly called as 'pill bugs' grow to a size of 13 mm long while *Limnoria* is much smaller growing to a size of 6 mm only. *Sphaeroma. terebrans*, *S. annandale, S. walkeri, Limnoria tripunctata, L. bombayensis, L. insulae* and *L. andamanensis* are active in Indian waters.

Another defect of rubber wood is its susceptibility to warping while seasoning. Controlled seasoning and following standard stacking procedures can overcome this threat to dimensional stability. The biodeterioration can be prevented by suitable preservative treatment through which the wood can be effectively utilized to relieve the pressure on our forests.

3.2 Preservation

Studies have shown that chemical wood preservation increases the life of wood 10-15 times. The study on the natural resistance of rubber wood to marine borers and the effect of preservative treatment on this wood by Rao *et al.* (1993) reveals the potential of preservative treatment in increasing the durability of this timber. Rubber wood would continue to remain underutilized if it is not treated with preservative chemicals for protection against fungal and insect attack (Gnanaharan & Mathew, 1985).

The highly perishable timber now finds utilization after preservation treatment with conventional chemical preservatives. Even non-conventional methods like acetylation have been attempted on rubber wood and their effect on the dimensional stability and physical and mechanical properties have been studied (Dhamodaran, 1995). This technique is found to be promising in protecting rubber wood and imparting dimensional stability to the wood.

3.2.1 Types of preservatives

Preservatives are of the following four types, each consisting of any one or more of the chemicals mentioned under it.

a) Oil type

This type comprises various forms of Creosote. The most widely used is the coal tar creosote, which is a coal tar distillation product and consists of liquid and solid aromatic hydrocarbons, tar acids and tar bases. Tar acids and tar bases are the toxic compounds and hydrocarbons act as carriers or reservoirs for them. Creosote has the advantages of being an indigenous product with high toxicity, relatively high permanence and non-corrosive. Its major disadvantage is that creosoted timber cannot be painted.

b) Organic solvent type

This group comprises organic or inorganic salts dissolved in suitable organic solvents. Copper napthanate, Zinc napthanate, Pentachlorophenol, Benzene hexachloride etc. come under this group. These are clean to handle, have high permanency and can be painted but some are inflammable.

c) Water soluble-leachable type

These are organic or inorganic salts soluble in water. Zinc chloride, Sodium fluouride, Boric acid, Sodium pentachlorophenate, Benzene hexachloride are examples of this type. These are comparatively inexpensive, easy to transport and odorless but are subjected to leaching.

d) Water soluble-fixed type

They are mixtures of various water soluble salts and a fixative salt, usually Sodium or Potassium dichromate. Treated timber should be allowed to dry for 3-6 weeks to complete fixation. Copper-chrome-arsenic compound, Copper-chrome-boric compound, acid Cupric chromate and chromated Zinc chloride come under this type.

The above chemical preservatives are sometimes used in combination also. Multiple preservative treatments have been found to be more effective than single treatments. Dual treatment is the pressure impregnation of timber with a copper based preservative followed by pressure treatment with Creosote. There is an intermittent drying stage between each preservative application. Double treatment refers to CCA treatment followed by Creosote in one complete cycle without any intermediate drying. Combination treatment is a double diffusion treatment followed by pressure creosoting.

The preservative can be incorporated into the wood in the green condition or in air-dried condition. According to Hong *et al.* (1982), the control measure against sap stain, mould, fungi and insect borers is the dip treatment using a preservative mixture of 1-2% Sodium pentaphenoxide (NaPCP) and 1.5% Borax. Synthetic pyrethroids and organic solvent-based preservatives are also used in much smaller quantities. Water borne preservatives like Copper-Chrome-Arsenic (CCA) and oil borne preservative like Creosote can be used when rubber wood is being used for marine purposes. A combination treatment using these two types of preservatives, as mentioned above, can also be used for increasing the effectiveness of preservative treatment.

3.2.2 Methods of preservative treatment

The two main methods of preservative treatment are the non pressure process and the pressure process.

3.2.2.1 Non-pressure process

Steeping or Immersion treatment

As the name implies, the treatment consists in steeping the wood in a preservative solution, usually at atmospheric temperature, for a long period. This is superior to the brush or the dip treatment but is not as effective as the pressure treatment (Anon, 1970). This process requires only a tank that is sufficiently large to permit the submersion of poles/

scantlings and a simple device to keep them submerged. The duration of the treatment depends on the species of wood, moisture content, sapwood and heartwood content and the absorption required. In the case of rubber wood, for samples of 2.5 cm thickness and around 25% moisture content, it is found that immersion in 7.5% CCA solution for 10 days yielded a retention of 8-9 kg/m^3.

Diffusion process

Diffusion process is a non - pressure method and does not require any special equipment. This process works on the principle that when wood containing free water (green wood) is placed in contact with a solution of a highly water soluble chemical, a concentration gradient is set up and the chemical moves in solution from the zone of high concentration on the surface of the wood to the zone of zero concentration at the centre till a state of equilibrium is reached. Generally, the preservative chemical is introduced on the surface of the green wood by keeping the wood immersed in the chemical solution for a specific period, which depends on the concentration of the solution and thickness of wood. Then the wood is stacked closely and covered completely (using polythene sheet or other suitable material) to eliminate air movement so as to permit diffusion.

The chemicals usually used for this process are water-soluble boron compounds (boric acid and borax) effective against fungi causing sap stain and mould formation during diffusion storage. To make 100 litres of solution for treatment, 5.0 kg boric acid, 7.5 kg borax and 0.5 kg NAPCP are to be used. The treatment solution can be used over and over but the concentration of the solution should be restored. The time for diffusion depends on the thickness of the planking.

It is calculated using the following formula

$$T = \frac{3.2\,t^2}{C} \times 60$$

Where

T = time in minutes, t = thickness in cm and C = concentration in %

The diffusion storage period ranges from 4 weeks to 16 weeks (25 mm – 100 mm thickness). Such dip treated wood should not be exposed to rain, as rainwater would remove the surface layer of protective chemicals (Findlay, 1985).

3.2.2.2 Pressure process

Vacuum – Pressure Impregnation process

This is otherwise known as the full – cell or Bethel process because it results in filling the cells of the treated zone with the liquid. It is usually employed when water borne preservatives are used. The treatment plant essentially consists of mild steel cylinder fitted with a door which is hermetically sealed, a mother tank connected to the cylinder containing the preservative, a supply of steam for raising temperature, pressure/vacuum pumps for controlling the air pressure or vacuum inside and hydraulic pump for creating liquid pressure. Air-dried specimens are used for this purpose. After an initial vacuum period, the preservative solution is introduced into the treatment cylinder containing the timber charge, with the vacuum pump working. After the cylinder is filled the vacuum pump is stopped. The charge is subjected to a pressure for a particular period after which the preservative solution is withdrawn from the cylinder. A vacuum is once again applied to free the timber from excess preservatives. The vacuum pressure treatment offers effective protection when diffusion treatment is not adequate and higher loading of chemical is required for specific end uses.

VPI treatment can be done with boron chemical and with CCA (Copper – Chrome – Arsenic). The air-dried samples are impregnated with 3% boron chemicals. Rubber wood is easy to treat by the VPI method. The initial vacuum period was found to be critical. A vacuum of 85 kpa for duration of 15 minutes was found to be optimum (Dhamodaran, 1995). Increasing the vacuum period beyond 15 minutes was found to reduce the chemical pickup. Although chemical intake increased with increase in pressure treatment time, a pressure of 1000 kpa for 15 minutes was found to give adequate loading. A dry salt retention (DSR) of 3 kg / m^3 is achieved through this. Studies conducted at the Kerala Forest Research Institute (KFRI) shows that 2% CCA gives sufficient dry salt retention in the case of air-dried and partially air-dried samples for external use. The penetration of CCA was found to be uniform.

The VPI treatment ensures greater protection for the rubber wood used for marine purposes by providing greater penetration and salt retention. For use in seawater, a higher concentration of CCA is required. Experiments conducted at CIFT have shown that a solution concentration of 7.5% gives adequate protection to timber at sea An initial vacuum of 56mm Hg was given for 30 minutes followed by a pressure of 75 psi for one hour. The preservative solution is withdrawn and a vacuum of 38mm Hg is applied for 15 minutes. This gave an average retention of 16 kg/m^3 for CCA and 160 kg/m^3 for creosote.

However, multiple treatments were found to be more effective for rubber wood. A dual preservative treatment involving the use of a water borne preservative followed by an oil borne preservative has given very encouraging results in prolonging the durability of rubber wood. Dual preservative treatment of timber is the pressure impregnation of copper based preservatives followed by pressure treatment with creosote (Edwin & Pillai, 2004). There is an intermediate drying stage between these applications. Trials carried out at CIFT showed that dual treated panels performed well under marine conditions. The performance of the panels under field conditions is dealt with in detail in the ensuing chapter.

4. PERFORMANCE OF PRESERVATIVE TREATED RUBBER WOOD UNDER FIELD CONDITIONS

4.1 Natural durability of rubber wood

Untreated rubber wood panels exposed to sea water for 6 months

A review of the literature on the durability of rubber wood shows that the work on the resistance to biodeterioration pertains mostly to terrestrial environment rather than the aquatic environment Varma & Gnanaharan, 1989. Hong *et al.*, 1982). The low lignin content of the wood makes it prone to quick and easy insect attack. The high starch content of the wood attracts numerous organisms.

Studies have shown that the easily perishable wood can be upgraded through preservative treatment (Dhamodaran & Gnanaharan, 1994, Goh *et al.*, 1983)

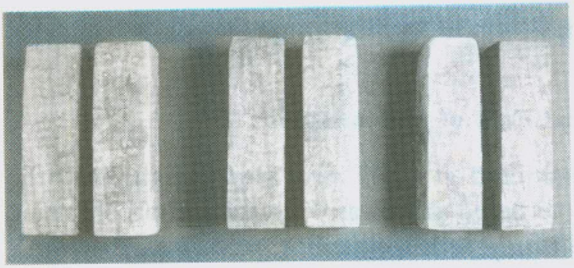
Deterioration of wood makes it less attractive and unsuitable for specific end uses in land and water. The studies on the natural resistance of rubber wood to marine borers show that the wood is highly perishable in untreated condition having been completely destroyed in 4-6 months, The natural resistance of rubber wood to marine borers and the effect of preservative treatment was first studied by Rao *et al.* (1993) from three Indian ports. In this study, panels treated with CCA and CCB showed up to 5% destruction at the end of 24 months, while control panels were destroyed completely within 6 months. Studies were conducted in CIFT on the natural durability of rubber wood. The loss in compressive and bending strength was studied under marine, soil and atmospheric conditions. Details of the observations are discussed in the following sections.

4.2 Preservative treatment of test samples

The studies conducted at CIFT provides insight into the effectiveness of creosote based preservative treatment in combating biodeterioration of the highly perishable rubber wood. Rubber wood samples were taken from a plantation-grown tree felled after 20 years. The biocides selected for evaluation of their suitability for preservation of rubber wood were arsenical Creosote, Copper creosote and a combination of Copper - chrome - arsenic (CCA) and Creosote. Copper creosote and Arsenical creosote were prepared in the laboratory through fortification of Creosote using Cuprous oxide and Arsenous trioxide (Nair *et al.,* 1972, Ravindran *et al.,* 1985). CCA of 7.5 % concentration was used for dual treatment. Creosote used in this experiment had a specific gravity of 1.06. Preservative impregnation was by the full cell process (IS : 401 - 1960) in a 400 litre pressure impregnation chamber at 75 psi pressure for 90 minutes. An initial vacuum of 56 cm Hg was given for 30 minutes and final vacuum of 38 cm Hg for 15 minutes was applied. Average preservative retention of 160 kg / m^3 for plain Creosote was obtained. There was an intermittent drying period of 15 days between CCA and Creosote treatments. A change in specific gravity was brought about due to treatment. The mean specific gravity of untreated panels was about 0.563. The increase in specific gravity was lowest in dual treated panels followed by Arsenical creosote treated panels and Copper creosote treated panels.

4.3 Resistance of rubber wood to marine borers

It is seen that rubber wood is highly perishable under marine conditions. The untreated control panels were severely damaged to the point of failure before the end of 6 months. Rapid loss of strength was noted in the case of the untreated control panels. It was observed that the average rate of loss of compression stress was 0.16 N/mm^2/day of exposure. These panels were given a grading of 0 showing complete



Treated panels after 33 months of exposure in sea

destruction of the panels. All the treated panels were graded 10. This rating indicated no more than trace attack. The number of borer holes for panels treated with arsenical creosote and copper creosote were only 2 and 3 respectively. None of the dual preservative treated panels showed even a single borer hole. Confirmation of these results through X - ray photography showed no internal damage in any of the panels. Panels treated with Arsenical creosote showed two burrows made by *Martesia* sp. and only one surface hole could be detected in Copper creosote treated panels. X - ray photographs of dual treated panels showed them to be in perfect condition. On the other hand, all control panels except one, disintegrated totally by the end of 6 months. The radiograph of the panels showed tunnels made by *Nausitora* sp., burrows of *Martesia* sp., and darker spaces indicating sphaeromatid burrows. The teredinid and pholad burrows were identified from the calcareous lining of the tunnels and holes.

The results of the mechanical strength tests conducted to show the relative extent of internal damage are given in the Table 4. The comparison of compressive stress of untreated rubber wood with treated wood shows an increase in strength due to treatment. An average increase of 18.80% was noticed. Maximum increase in strength was noticed in dual preservative treated panels ie. 20.73%. It is observed that after 33 months of exposure there has occurred an average reduction of 12.4% in compressive stress. There was 5%, 12.5% and 6% reduction for panels treated with Arsenical creosote, Copper creosote and dual preservative respectively. It is seen that the extent of compression in exposed panels was 28.5% more than in panels that were treated and not exposed and untreated control panels.

These preliminary studies point out to the need for upgradation of rubber wood through preservative treatment which is confirmed by the present study. The increased utilization of preservative treated rubber wood is feasible, primarily due to its good mechanical properties and workability (Shukla & Lal, 1985, Gnanaharan & Dhamodaran, 1992). An increase in compressive strength due to treatment and no significant difference in strength due to exposure can be attributed to the type of preservatives used. Creosote was the main component of the preservative in the three different types of treatment. Earlier studies conducted at CIFT showed that Creosote treatment did not bring about any significant difference in strength compared to untreated control panels (Thomas *et al.* 1998, Edwin & Thomas, 2000). This is because creosote does not enter into any reaction, which would affect the strength of wood, and the oils are restricted to the cell cavities only (Hunt & Garrat, 1953).

Table 4 Compression strength of panels exposed to field conditions for 5 years

Preservative	Copper creosote				Arsenical creosote				Dual treatment			
Conditions of experiment	Lab	Marine	Atmos	Soil	Lab	Marine	Atmos	Soil	Lab	Marine	Atmos	Soil
Comp. stress parallel to grain	33.60	29.40	33.35	30.02	31.44	25.61	30.85	31.74	33.67	31.59	33.58	27.13

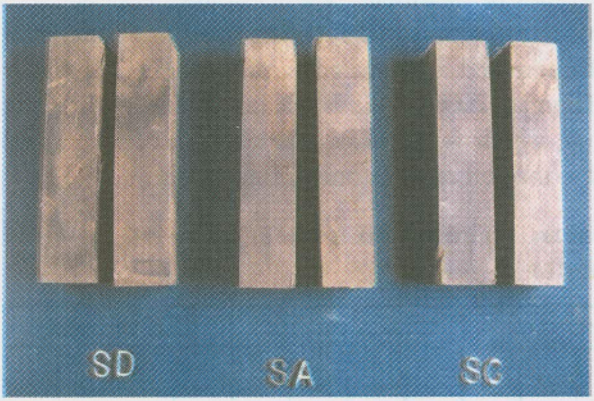
4.4 Resistance of rubber wood to terrestrial borers, fungi and bacteria

The primary purpose of any wood preservative is to extend the useful life of the treated wood. During service life, the rate and cause of deterioration may be chemical, physical, mechanical or biological which are

Soil burial test control panel

influenced by the conditions of service to which the wood is exposed. These service conditions are difficult and costly to simulate in a laboratory. The possible source of performance data for preservative treated wood is from graveyard or field exposure tests.

Small canoes used by the fishermen are of the beach landing type. After the day's fishing is over, these canoes are hauled upon the beach where they are exposed to the vagaries of nature such as scorching sunlight, the incessant rains during monsoon and attack by terrestrial borers, bacteria and fungi in the soil. Three types of preservative treatments viz. Arsenical creosote, Copper creosote and dual treated panels (CCA and Creosote) were used for this study as in the marine exposure test. The average retention of preservative was 16 kg/ m^3 of CCA and 160 kg/m^3 for Creosote treatment. According to Beesley (1985), for scientific and



Treated panels subjected to soil burial test for five years


Weathering test control panel

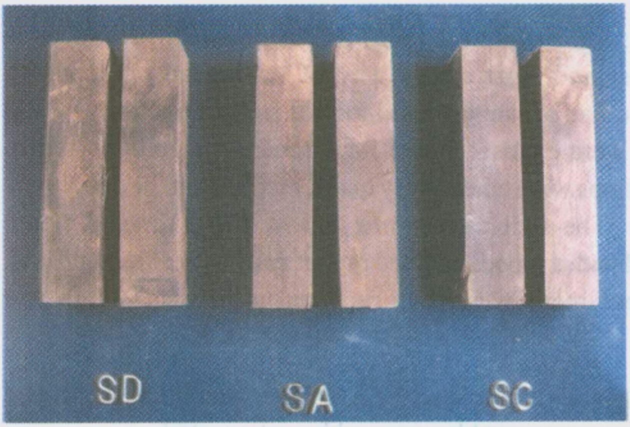
research purposes, a graveyard (or field) test using small specimens is often the simplest and least costly way of testing and comparing preservatives. The size of samples used for this study was 50 x 50 x 200 mm. The panels were exposed to the field conditions giving uniform spacing. Observations were taken every quarter to find out the conditions of the specimens. The specimens were removed and scraped clean, visually examined with a probe and rated numerically as per the standards. The inspected specimens were then replaced at original depth and orientation.

The control panels exposed to the soil were completely destroyed before the end of one year and hence could not be tested.

4.5 Resistance of rubber wood to weathering conditions

In very humid climates, test samples when used out of ground contact, will not remain free from decay. The rubber wood is especially susceptible to the attack of microorganisms as soon as it is felled. Small samples of size 50 x50 x 200 mm treated with copper creosote, arsenical creosote and dual treatment were exposed to atmospheric conditions. The test assemblies were exposed at 45^0 with longest direction parallel to the ground to enhance decay. The panels showed no sap stain or physical damage at the end of five years. At the end of 28 months, the control panels were rated 2 in a 0 - 3 rating scale and an average reduction of 48% weight was observed in the case of these panels. Studies on the changes in specific gravity of rubber wood exposed to atmospheric conditions after 52 months of exposure showed that average specific gravity reduced from 0.56 to 0.25. Changes in specific gravity of treated panels exposed to field conditions showed that maximum reduction occurred in Copper creosote treated panels (0.179) followed by Arsenical creosote treated panels (0.138) and least reduction in dual preservative treated panels.

Since traditional canoes are usually beach landed and since these wooden craft are subjected to the vagaries of the physical, chemical and



Treated panels subjected to weathering test for five years

biological factors of the sea, air and soil, the rubber wood test panels were subjected to prolonged testing for five years. Besides studying biodeterioration through visual observations, X ray analysis changes in density and mechanical strength testing were resorted to in order to study the extent of biodeterior-ation. It is concluded that the performance of treated rubber wood panels was excellent at the end of five years.

An increase in compressive stress of dual preservative treated panels coupled with the maximum resistance to biodeterioration brings into focus the importance of this type of treatment. This superiority of dual treatment over single treatment has already been reported by Johnson (1977), Edwin *et al.* (1993) and Thomas *et al.* (1998). These studies reveal the effect of preservative treatment in preventing biodeterioration of rubber wood under marine conditions. Besides, it permits an evaluation of the changes in compressive stress due to treatment and due to field exposure.

5. FISHING CANOES FROM RUBBER WOOD

5.1 Preservative treated rubber wood canoe

The encouraging results obtained from the laboratory and field trials led to the construction of two prototype canoes, for backwater fishing and for marine fishing. The canoes were constructed following the traditional design of canoes used for gill net fishing in the backwaters and in the sea. These canoes were constructed at a local boatyard at Chellanam, a fishing village in the outskirts of Cochin. A cement tank was constructed for the purpose of pre-treatment of the scantlings.

5.1.1 Construction procedure

The freshly sawn planks were given a dip treatment for 2-3 minutes with the preservative solution to prevent fungal attack. The planks were then kept for seasoning by horizontally stacking them. They were placed on crossers placed approximately 0.5m apart to prevent warping. Care was taken to keep the planks about 10 cm off the ground. Moisture content of the planks was monitored using portable moisture meter. Gaps of about 2.5 cm were left between adjoining planks in all layers to allow vertical movement of air.

Canoe under construction

The planks on reaching a moisture content of about 25% were taken and shaped as per the requirements for canoe construction. The backbone of the vessel was shaped from a single plank. Two planks attached on the fore and aft of the backbone give the characteristic curvature to the canoe. Three planks are used on either sides of the keel. Another feature of this deckless craft is the presence of cross planks for the fishermen to sit. Holes are made near the edges of the planks for tying them together. This is a prerequisite for the construction of plank built canoes of this area. This presetting and shaping of the planks ensures minimum carpentry work after preservative treatment. The planks were then dismantled for the preservative treatment.

The first stage of the treatment procedure involves treatment with the water borne preservative, which was diluted to the required concentration, based on the results of the experiments conducted earlier. A cement tank, of size 7m x 0.75m x 0.75m, was used for the preservative treatment. The treatment consists in steeping the wood in the preservative solution at atmospheric temperature. The planks were kept weighted to prevent them from floating. The duration of immersion was standardized as 10 days for the given plank thickness. This was followed by drying of the planks again. On reaching a moisture content of approximately 25%, the planks were again kept immersed in the oil borne preservative for one week until the desired retention was obtained. The planks were reset on becoming tack free. The tying of the planks was by using coir or split polypropylene ropes. Experiments conducted show that the water borne preservative affected the strength of coir drastically, whereas the oil borne preservative brings about only a slight reduction in strength. Hence coir used for tying was not given any type of preservative treatment. Caulking of the seams was done by coconut husk fibre sprinkled with coconut oil as in the traditional method of construction. However, no traditional method of treatment was used during or after construction. The construction of the canoes was completed within two months. The important dimensions of the two canoes, one for backwater fishing and the other for marine fishing, are given in Table 5.

Table 5 - Important dimensions of the canoes

Specification	Canoe for marine fishing	Canoe for back water fishing
Length (m)	6.4	6.05
Breadth (m)	0.83	0.77
Depth (m)	0.42	0.39
Plank thickness (cm)	3.18	3.18
No. of cross planks	6	5
No. of ribs	4	3

5.1.2 Cost of preservative treated rubber wood canoe

The cost of rubber wood in the log form is only one-fourth the cost of the conventionally used timber, jungle jack or aini (*Artocarpus*

Treated rubber wood canoe

hirsuta). The cost of the treated rubber wood canoe is 35-40% less than an aini canoe of the same size. The cost of construction of a treated rubber wood canoe with the conventional aini canoe is given in Table 6.

Table 6 - Construction cost of rubber wood canoe and *Aini* wood canoe

Item	Rubber wood canoe (in Rupees)	*Aini* wood canoe (in Rupees)
Cost of 15 cu.ft. wood	2250.00 (@ 150.00/cu.ft.)	9750.00 (@ 650.00/cu.ft.)
Cost of water borne preservative	350.00	Nil
Cost of oil preservative	2600.00	Nil
Cost of traditional treatment	Nil	1000.00
Labour cost	2800.00	2800.00
Total	**8000.00**	**13550.00**

5.1.3 Performance evaluation of canoes

Two prototype canoes have already been given to inland and marine fishermen through Fishermen Co-operative Societies. Periodical

Rubber wood canoe under experimental operation monitoring of the bioresistance is being carried out with reference to the decay caused by bacteria, fungi, borer holes caused by marine boring organisms, cracking due to weathering, physical damage to find out abrasion resistance, insect attack when kept on the beach, change in colour etc.. The canoe going for gill net fishing in the sea is being hauled up and kept on the beach each day after operation whereas the canoe in the backwater is tied up at the jetty. It is observed that both canoes were free from attack of organisms and any physical damage. The fishermen operating the canoes were satisfied with the performance and the construction and operation of these canoes have evoked a lot of interest among the local fishermen.

5.2. Fibreglass Reinforced Plastic (FRP) sheathed treated rubber wood canoe

As a logical sequel to the construction of canoes made of treated rubber wood, canoes were made out of rubber wood and sheathed with FRP by the institute. Here a modification was brought about by giving the scantlings a single preservative treatment. The canoes constructed earlier were received well by the artisanal fisheries sector and are now being operated successfully by fishermen in the sea and in backwaters. A further modification in the construction procedure of the treated rubber wood canoes was thought of while taking up the present programme. The rubber wood planks before construction were given a treatment with a water borne preservative. Two coats of FRP were given in the inside as well as on the outside for adequate protection of the craft.

The preservative used was Copper-Chrome-Arsenic. Planks of 2 cm width were sawn from rubber wood about 25 years old. The freshly sawn scantlings were given a dip treatment for less than 5 minutes in the water borne preservative solution. The concentration of the Copper-Chrome-Arsenic preservative solution is 2%. The planks were then kept for air seasoning by stacking them horizontally about 0.5 m apart with gaps of about 2.5 cm (Edwin *et al.,* 2003). The scantlings on attaining optimum moisture content were set and shaped as per the requirement. The planks were screwed to the hull frames with copper tacks. In the traditional method of construction of plank built canoes in the southwest coast of India, the planks are held together by stitching with coir/polypropylene strands and the joints caulked using coconut fiber and cotton. Stitching of the planking has been avoided in this method of construction. Instead, the rivetting holds the planks edge to edge tightly. The gaps between planks are sealed by cotton and putty.

Rubber wood canoe under construction

Once the setting of the scantlings is over, the surface is cleaned and prepared very carefully. It is ensured that the wood is dry. The adhesion bonding between wood and FRP is mainly by mechanical interlocking and chemical bonding. Dry wood contains 5-12 % moisture. The rough edges are smoothened and care is taken to ensure that the surface is free from moisture, dirt and grease. The holes/perforations if any on the hull are closed using a mixture of fine saw dust and activated resin. It sets and covers the hole to form a smooth and firm surface. A coating of activated resin is applied on the de-greased and cleaned surface. A layer of chopped strand mat is applied immediately on top of the resin. Skilled labourers are required for carrying out the sheathing work at the required speed to prevent setting of the resin and to avoid the formation of air bubbles.

Table 7. The type, quantity and cost of raw materials used for making FRP sheathing

Description	Quantity required	Cost in Rupees
Chopped strand mat (300g/m^2)	13 kg	1625.00
Surface mat	10m^2	400.00
Polyester resin	40kg	3480.00
Acetone	0.5 l	37.00
Brush-2"	4 nos.	80.00
Chalk powder	5kg	60.00
Colour	1 kg	310.00
Miscellaneous		500.00
Total		**6492.00**

The cost of a canoe of 6.05 m length is approximately Rs. 15, 000. This compares well with the cost of a traditional canoe of the same size made of conventional wood like aini (*Artocarpus hirsuta*) which costs Rs. 12,500/- to Rs. 13,500/-. This construction is expected to give a maintenance free service to the craft unlike the conventional canoe for which Rs. 500 –1000/- is incurred annually on maintenance using traditional preservatives like sardine oil, cashew nut shell liquid etc. Considering the long anticipated service life, this venture may prove economical in the long run.

The primary function of the FRP sheathing is to provide strength and dimensional stability to the rubber wood and also keep away moisture. Besides providing water proofing, the sheathing reduces maintenance, provides resistance to impact and abrasion, prevents attack of marine borers and other decay causing organisms, provides an extended service life and improves appearance of wooden fishing vessels. In the case of the rubber wood canoe where FRP sheathing was given, the use of preservatives was minimized. It is observed that sealants can reduce exposure to the leaching of arsenic up to 75%. The construction is simple and can be taken up by traditional boat builders once a basic training is received. Thus FRP enables the fishermen to make efficient use of the under utilized rubber wood for small canoe construction.

FRP sheathed rubber wood canoe

6. CONCLUSION

About 75% of the world's rubber plantations are small holdings owned by four million households who could increase their income substantially through sale of rubber wood. Harvesting and processing of the wood can generate rural employment. Rubber wood can be a good substitute for the wood from the natural forests. It is estimated that the economically available volume of rubber wood logs, which can be harvested in a short period, is equivalent to an annual harvesting area of 6,00,000 ha of natural tropical forests. So the utilization of this wood is considered as a logical sequence of the projected scarcity in the supply of conventional timbers from the forest.

India is now the third largest producer of rubber with over 5,30,000 ha under rubber cultivation (Rubber Board, 2003). Between the age of 22 – 29 years, latex production becomes uneconomic and the tree becomes a sources of eco – friendly timber. The present total availability of rubber wood is estimated as 1.6 million m^3 / yr and is estimated by the Rubber Board to be 2.5 times by the end of the decade. The stem wood, which forms 60% of the total, is used for industrial purposes and the branch wood is used as firewood. Packing case sector consumes 62.5% of the stem wood, plywood/veneer sector 22.5%, a negligible 3% is used for making furniture and the rest goes as firewood to the brick industry. The secondary processing sector consumes 10 % of the stem wood.

At a time when India finds itself critically short of industrial timber, the abundant availability of rubber wood from this non-conventional source is a boon to the traditional fisheries sector. The traditional sector of our fishery industry depends (to a very large extent) on timber for construction of plank built boats, dugout canoes and catamarans. There are at present about 3 lakh traditional craft operating in the country. They are usually made of teak, sal, aini etc. It is estimated that the overall requirement of timber for marine use may be over 0.1 million m^3. Studies conducted at the Central Institute of Fisheries Technology have shown that rubber wood is highly perishable in untreated condition having been completely destroyed by marine borers in 4 – 6 months. But results of the studies carried out at the Institute showed that rubber wood could be suitably upgraded with preservative treatment. The treated panels were found to be absolutely free from marine borer attack even after 33 months of exposure in seawater. There were no signs of biodeterioration in the panels exposed to atmospheric and soil conditions even at the end of 60 months. The treated panels exposed to seawater were tested for loss of compressive stress and it was found that there was no significant reduction in this mechanical property when analysed statistically.

The cost of rubber wood in the log from is only one–fourth the cost of the conventionally used timber, jungle jack or aini (*Artocarpus hirsuta*). The cost of the treated rubber wood canoe is Rs. 8000/-while that of an aini canoe with traditional treatment is Rs. 13, 550 /-. Thus there is a 35 – 40 % reduction in the cost of construction. The use of rubber wood, which comes as a by product from the rubber plantations, for marine purposes would bring in an extra income to the cultivators of rubber who are facing a crisis due to the unstable prices of latex. It is to be further noted that although the stipulated forest cover of India is 33%, the actual cover is only about 20%. Therefore there is an imminent need for lesser deforestation. The utilization of rubber wood for marine purposes and the renewed interest in the use of preservative treated rubber wood for construction, joinery and furniture may, to a modest extent, reduce deforestation and thus help in maintaining the ecological stability and in conserving our fast deteriorating environment.

Acknowledgement

The author wishes to express her sincere gratitude to Dr. K.Devadasan, Director, CIFT and Dr. B.Meenakumari, Head of Division, Fishing Technology, for the encouragement received in bringing out this publication. Thanks are also due to the staff of Material Science and Marine Pollution Section, Fishing Technology Division, for their help and cooperation in carrying out the work.

REFERENCES

Albaladejo, J.L (2003) The potential rubber wood. http: ITTO Newsletter Vol. 7 No.4

Anon (1959) The Wealth of India -Raw Materials Vol. V: H-K, Council of Scientific and Industrial Research, New Delhi : 332

Ali, S., A.G.Tan and M.Steven, (1980) Some studies on fungal deterioration of rubber wood (*Hevea brasiliensis*) International Research Group on Wood Preservation-Document No. IRG/WP/2140:6

Anon (1970) Indian Forest Utilisation. Vol. 1 Dehradun. India : 462.

Anon (2000) Handbook on Fisheries Statistics, Dept. of Animal Husbandry and Dairying, Ministry of Agriculture, New Delhi: 153.

Anon, 2002 Internet document. Rubber Board.org.in Manage.rubber woodap.rd.24k

Beesley (1985) Field testing of wood preservatives in tropical countries, in preservation of timber in the tropics, W.P.K Findlay (Ed.) Martinus Nijhoff / Dr. W. Junk Publishers, England 205 – 232

Dhamodaran, T.K (1995) Chemical modification of rubber wood by acetylation and its effect on the dimensional stability and physical and mechanical properties. Paper presented at the XX International Union of Forest Research Organisations (IUFRO) World Congress, Tampere, Finland 6-12 August 1995

Dhamodaran, T. K. and R. Gnanaharan (1994) Upgradation of rubber wood. KFRI Research Report no. 93. Kerala Forest Research Institute, Peechi

Edwin. L. and Saly N.Thomas (2000) Creosote and Copper -Chrome-Arsenic (CCA) treatment on the compressive strength of *Adina cordifolia* (Haldu) *Fishery Technology* Vol.**37** (1): 1-4

Edwin L, Saly N. Thomas, N. Unnikrishnan Nair and K. Ravindran (1993) Dual preservative treatment for small fishing vessels - Observation on the biodeterioration of Mango wood. In: Low Energy Fishing - *Fish Technol.* (Spl. Issue) SOFT (I), India: 98 - 102

Edwin, L., Saly N. Thomas and B. Meenakumari (2003) Rubber wood- can it replace hard wood in boat building ? *Infofish International* 5

Edwin, L and A.G. G.K.Pillai, (2004) Resistance of preservative treated rubber wood (*Hevea brasiliensis)* to marine borers. Holz Roh Werkst (2004) **62:** 303-306.

Findlay, W.P.K (1985) Agencies of destruction in preservation of timber in the tropics. Martinus. Nijhoff/Dr. W. Junk Publishers W.P.K. Findlay (Ed), England :15-43

Gnanaharan, R. and George Mathew (1982) Preservative treatment of rubber wood (*Hevea brasiliensis*) KFRI Research Report : 15. Kerala Forest Research Institute, Peechi

Gnanaharan R. and. T.K. Dhamodaran (1992) Mechanical properties of rubber wood from a 35 year old plantation in Central Kerala, India. *Journal of Tropical Forest Science.* **6**: 12-16

Goh, T.A, K. F. Chong and M.K. Tam (1983) Preservative treatment of green rubber wood (*Hevea brasiliensis*) by vacuum pressure impregnation. *The Malaysian Forester* **46** : 375 - 386

Hong, L.T., A.S. Mohd., A. G. Tan and K.D. Singh (1982) Preservation and protection of rubber wood against bio-deteriorating organisms for more efficient utilization. *The Malaysian Forester* **45**: 299 - 315

Hong, L.T. (1995) Rubber wood utilization. A success story. Paper presented at the XX International Union of Forest Research Organisations (IUFRO) World Congress, Tampere, Finland

Hunt, G. M. and A.G. Garrat (1953) Wood preservation. Mc Graw Hill Book Company Inc.: 417

Johnson, B.R. (1977) Performance of single and dual treated panels in a semi- tropical harbour. Progress Report No.2. *Proceedings American Wood Preservers Association.* **73** : 174 -198

Killmann, W. and L.T. Hong (2003) Internet document file: //A: Malaysia rubberwood.htm. Rubber wood – the success of an agricultural byproduct

Kumar, S. (1985) Wood preservation for marine use. In: Harvest and Post Harvest Technology of Fish. Society of Fisheries Technologists (India) : 151-159

Nair, N.U., A.G. Gopalakrishna Pillai and R. Balasubramanyan (1972) Studies on arsenical creosote as a wood preservative for marine structures. Part I. Incorporation of arsenic in creosote at various temperatures. *Fish. Technol.* **9** :76-80

Norhara, H. (1981) A preliminary assessment of the relative susceptibility of rubber wood to beetle infestations. Malay. Forester **44**(4): 482 - 487

Rajan, P.S. (1989) Rubber wood-the timber with a promise. *Rubber Asia.* September - December

Rao, K.S., L.N. Santhakumaran, M.Balaji and V.V. Srinivasan (1993) Natural resistance of rubber wood to marine borers and preliminary note on the effect of preservative treatment. *Indian Journal of Natural Rubber Research* **6**: 71-74

Ravindran, K., A.G. Gopalakrishna Pillai and N. U. Nair (1985) Copper creosote - a new preservative for marine wooden structures. In: Harvest and Post Harvest Technology of Fish. Society of Fisheries Technologists (India) : 164 - 166

Reghu, C. P., D. Premakumari and A. Panikkar (1989) Wood anatomy of *Hevea brasiliensis* (wild ex. Adr. DeJuss) Muell. Arg. 1 Distribution pattern of lesion wood and dimensional variation of wood fibres. *Indian Journal of Natural Rubber Research.* 2(1):27-37.

Shukla and M. Lal,. (1985) Physical and mechanical properties of *Hevea brasiliensis* (Rubber wood) from Kerala. *Journal of the Timber Development Association* **31:** 29-30

Thomas, S.N., Leela Edwin and K.Ravindran (1998) Effect of single and dual preservative treatments on the strength of boat building timbers. In: Advances and Priorities in Fisheries Technology. Society of Fisheries Technologists (India) : 117-120

Thomas ,S.N., (2003) Marine biodeterioration. In: ICAR Winter School Manual on Advances in Harvest Technology, Central Institute of Fisheries Technology, Cochin : 250-257

Varma, V. and R. Gnanaharan (1989) Field evaluation of preservative treated rubber wood (*Hevea brasiliensis*) against subterranean termites. *Material and organismen.* **24**:287-290