WOOD MADE PRODUCTS

A C Mathew

INTRODUCTION

Primary species of timber such as teak, rosewood and other exotic hardwoods are becoming scarce and expensive. In this context, secondary species of timber, available at lower prices, seem to be the right alternative. Plantation timbers like coconut wood, rubber wood etc. when chemically treated and seasoned to make them durable are suitable for most applications. Coconut wood & Rubberwood are now available in plenty in India, and this trend will continue.

COCONUT WOOD

Physical properties:

The physical properties of cocowood depend largely on its density, moisture content and shrinkage (Table - 1).

Table 1 : Physical properties of cocowood

PROPERTIES	COCOWOOD		
	Dermal	Sub-Dermal	Core
Moisture content (%)	87	182	356
Basic density (kg/m³)	697	473	286
Shrinkage (Green to ovendry) :			
Radial (%)	6.3	5.9	5.6
Tangential (%)	6.6	6.1	5.8

Its basic density (Oven-dry weight divided by green volume) decreases with increasing height of the stem and increases from the core to the cortex at any given height. In addition, the basic density at any particular height increases with age of the palm. Overall, the basic density ranges from 110 kg/m^3 at the top core portion to 850 kg/m^3 at bottom dermal portion of old coconut palm.

The moisture content is negatively correlated with the basic density, i.e., moisture content decreases with increasing basic density and vice versa. The amount of moisture in coconut stem increases with increasing stem height and decreases from the core to the cortex. The moisture content ranges from 50% at the bottom dermal portion to 400% at the top core portion of the stem.

The dimensional stability of the wood is determined by its shrinkage or swelling, which accompanies a change in moisture content below fibre saturation point. Shrinkage and swelling cause drying defects such as checks and split. Unlike conventional wood, where tangential shrinkage is almost twice the radial shrinkage, the tangential and radial shrinkage of cocowood are not significantly different.

Mechanical properties:

The mechanical properties of cocowood, which define its end use are positively correlated with the basic density. Accordingly cocowood has been classified in to three basic density groups as follows: High density wood (dermal), medium density wood (sub-dermal) and low density wood (core) with respective basic density as 600 kg/m^3 and above, 400 to 599 kg/m^3 and below 400 kg/m^3.

Table-2 presents the mechanical and related properties of the three density groups of cocowood based on green and dry samples. All values of the strength properties decrease with decreasing basic density. Except for impact bending, the values of other mechanical properties of cocowood at 12% moisture content are significantly higher than under green condition.

Table 2 : Mechanical and related properties of cocowood

Basic density (kg/m^3)	Moisture content (%)	Static bending			Compression parallel to grain		Compression perpendicular to grain	Impact bending (N)
		Modulus of Elasticity (MPa)	Modulus of Rupture MPa)	Stress at proportional limit (MPa)	Modulus of Elasticity (MPa)	Maximum crushing Strength (MPa)	Stress at proportional limit (MPa)	
600 and above	57	10857	86	51.6	7988	49	8.3	20.2
	12	11414	104	61.7	9747	57	9.0	20.1
400 to 599	107	6880	53	30.4	5151	31	2.8	18.3
	12	7116	63	38.4	5282	38	3.4	10.1
250 to 399	240	3100	26	13.1	2287	15	1.3	8.4
	12	3633	33	13.4	2914	19	1.7	9.0

Chemical properties:

Coconut wood is comparable to conventional hardwood/softwoods and bamboos as far as hemicellulose (62.0%), lignin (25.1%) and pentosan (22.9%) content are concerned. However, it contains higher ash than conventional woods.

SAW MILLING

Sawing pattern and grading:

In sawing coconut log, the hard dermal and the medium subdermal portion are the important and valuable materials to recover. A sawing pattern should be employed to segregate the three density groups of sawn coconut timber. The round method of sawing assures that the hard, medium and soft lumber are separately sawn. The first cut is a thin slab followed by a cut of 25mm or 50mm thick hard material depending on the diameter of the log. Then the log is either turned 90° or

180° following the same sequence of cutting until the hard portion is recovered. Similar sawing is done after each turn ensuring that the medium and soft materials are extracted separately. The optimum thickness and width of high density lumber recovered from coconut logs are 50mm and 125mm, respectively.

Grading can be done visually, based on the physical defect and colour of newly sawn timber. However, mechanical grading can also be employed by determining the basic specific gravity and/or the stiffness of the lumber immediately after sawing.

DRYING

Freshly-sawn coconut wood contains water as much as 1/3 to 1/2 of its total weight. Except for few uses, like in marine piling, green materials are not advisable to be used particularly for furniture, panels, internal woodworks and flooring. The wood has to undergo seasoning process to minimize the problems in its utilization.

Generally, different species of the wood have marked variation in their drying characteristics. Coconut wood being a monocot, exhibits varying wood structure that influence its drying behaviour. The differences in wood densities across the stem coupled with variable green moisture contents creats problems in drying. The very high moisture content of the soft central portion of the trunk is related to its susceptibility to collapse. On the other hand, the peripheral high density wood is more prone to surface checks and tends to develop twist.

The common drying methods include air drying under shed, forced-air and kiln drying.

1. Air drying:

Air drying is the simplest and economical method of moisture removal from the wood. The sawn timber are fillet-stacked under shed or exposed outside protecting the top layers from direct sunlight or rain. The drying rate mainly depends on prevailing humidity and temperature. Depending on existing weather conditions, 25 mm and 50 mm boards take 4 to 11 weeks and 16 to 21 weeks air drying, respectively, to attain equilibrium moisture content of 17% to 19%.

2. Forced-air drying:

Forced-air drying involves the use of blower where air under atmospheric or heated condition is forced to pass once or circulated through a stack of sawn timber. This process accelerates the removal of free moisture from the wood even under relatively low temperature. At an average atmospheric air temperature of 29°C and air velocity of 3.50 meters per second, 25 mm and 50 mm boards can be dried from green moisture content to equilibrium moisture content in 22 days and 40 days, respectively.

3. Kiln drying:

Kiln drying is the process of exposing green or partially air-dried sawn timber which are fillet-stacked in an enclosed chamber. The kiln is either heated by steam, electricity or the products of combustion of wood or gas. The humidity, temperature and air circulation are controlled in the drying chamber, hence the boards are dried to any desired moisture level within a short period. The 25 mm boards can be dried from green moisture content to the final moisture content of 13% in 14 days employing initial dry bulb temperature of 45°C and wet bulb temperature of 41°C to final dry bulb temperature of 50°C and wet bulb temperature of 37°C. The 50 mm boards can be dried to 16% final moisture content from green condition in 19 days with temperature range of 48°C to 50°C DBT and 39°C to 45°C WBT.

MACHINING

Cocowood furnitures and other finished wood products are gaining nation wide acceptance. However, secondary processing of cocowoood is not an easy task unless effective machining techniques are applied. Technically, the principal limiting factor is the adverse and difficult working properties of cocowood which result to rapid dulling and blunting of woodworking tools. Machining is the process of cutting and dressing wood into the desired shapes and sizes by various woodworking machineries. The process include rip and cross cutting, planing, turning, boring and sanding.

FINISHING

Finishing refers to the application of transparent or semi-transparent liquid coating to enhance the beauty of the grain, colour and figure of wood products. Good quality finish for cocowood requires the preparation of the surface by sanding to remove the knife marks and produce smooth surface. The schedules for finishing cocowood products are influenced by the kind of coating materials to be used, wood substrate which refers to the density of wood, individual skill and appropriate working methods.

Coating involves the sequential application of stain, filler, sealer and top coating materials such as lacquer, polyurethane, polyester and oil finish. Usually, two or more coats of finishes are applied to cocowood to improve the appearance and quality of wood products. Table - 3 shows the finishing schedules for cocowood.

Table 3 : Finishing schedules for cocowood.

TYPE OF WOOD FINISHES	FINISHING SCHEDULES *
Shellac	Apply non-grain-raising stain and filler as required. Sand the wood surface with the fine sand paper. Apply shellac by brushing or spraying. Sand after 2 hours drying and apply second coating. Follow the same procedure for final coating. Dry for 5 hours.
Lacquer	Apply NGR stain and filler as desired. After 2 hours drying, sand with fine sandpaper and apply sanding sealer by brushing. Sand and dust properly. Brush or spray one coat lacquer. Dry for 2 hours. Scuff with very fine sandpaper and dust. Apply second coating and after 4 hours drying, apply final coating of lacquer.
Oil finish	Apply oil finish with soft cloth by rubbing the wood surface until oil is absorbed. Allow one day interval between the first and second coats. Sand with very fine sand paper between coats. Two to 3 days interval is needed for subsequent coats. The quality of luster desired depends on the number of coats.
Polyurethane	Apply desired stain and filler, sand with fine sandpaper. Spray polyurethane finish. Dry for one hour and then sand. Apply second coating and dry for another one hour. Sand and wipe the surface clean. Apply final coating.

* Sand the wood until smooth surface is attained before applying finishes.

PRESERVATION

Cocowood belongs to the non-durable group of timber. When used in situations favourable for attack by decay fungi and wood boring insects, the hard dermal portion of the trunk will last only for one to two years. The soft inner portion will deteriorate in few months when left exposed to the weather. Its low natural durability requires preservative treatment to ensure that the wood is used within a reasonable service life. Cocowood should be properly treated to protect it against attack of wood destroying organisms especially when used in ground contact and exposed to the weather.

(1) Preparing the material for treatment

A preservative treatment can only be effective if the wood is properly prepared. Selection of defect-free cocowood prior to treatment is necessary to obtain optimum results and good performance. Machining operations like cutting in sizes appropriate to the end-use, planing the surfaces and boring should be undertaken before preservative treatment. In addition, the wood surface must be free from sawdust, paint or any other coating and there must be no sign of attack of wood destroying insects and fungi. Treatment of cocowood by diffusion process should be done in green or freshly-cut condition to permit free movement of preservative solution into the inner cavities of the wood. For other method, drying before treatment is necessary to allow adequate penetration and uniform distribution of preservative into the material. For round coconut wood, debarking should be made to minimize the atttack of insects and decay fungi during air drying. In sawn form, the lumber is easily attacked by mould and stain fungi during the air drying process leaving discoloured surfaces of wood. To prevent this problem, the newly-sawn lumber should be dipped at once into a tank containing anti-sapstain chemical before seasoning. However, the dipped timber receives only temporary protection from staining and it should be retreated with wood preservative to ensure adequate protection from wood destroying organisms.

(2) Wood preservatives

Wood preservatives fall into two types viz., oilborne such as creosote, pentachlorophenol, cuprinol and solignum; and waterbone salts which are applied as water solutions. The standard wood preservatives used in water solution include chromated copper arsenate. Another water-borne preservative applied successfully to cocowood is Disodium Octaborate Tetrahydrate.

(3) Preserving Processes

Preservative treatment of wood is generally composed of two methods viz., the pressure and non-pressure. The former, in which wood is impregnated in a close cylinder under pressure, requires high capital investment and skilled technicians to operate the plant. The latter, which varies according to procedures and equipment used, can be easily adopted in rural areas due to their simplicity in operation and low-cost capital outlay. In general, the non-pressure process provide inferior control over preservative retention and penetration than the pressure process. The treatment methods discussed below apply only to the non-pressure process since they have been found equally effective in protecting cocowood from wood destroying organisms.

3.1 Brushing or Spraying:

These methods consist of brushing or spraying preservative solution over the surface of dry wood. Oil or waterborne preservatives are used for applying two to three coatings. The preservative solution penetrates to wood due to the capillary attraction between the wood cells and the liquid flooding the surface. In most cases, the treated wood materials are used indoor.

3.2 Dipping:

This process involves immersing well-seasoned wood in a tank or container of cold or heated preservative solution for 3 to 5 minutes. This method is better than brushing or spraying because wood absorbs liquid freely and time of immersion is suited to the standard of treatment required. Wood treated in this manner is used for building construction.

3.3 Soaking/Steeping:

The soaking process involves the use of oilborne preservative while steeping involves waterborne preservative. Both methods consist of immersing dry wood in a tank of preservative solution for few days to number of weeks. The extent of preservative penetration and amount of absorption are dependent on the duration of immersion of the materials. Wood treated by this method is used for outside walling and fascia boards in house construction.

3.4 Dip Diffusion:

This process relies on movement of waterborne preservative solution into freshly-sawn wood from a higher to lower concentration. The method involves the immersion of green wood for 2-3 minutes in a tank containing preservative. The preservative coated wood are then block-stacked and stored under restricted drying condition. The stacked wood should be covered with polythene sheet, to prevent evaporation of moisture during the diffusion period. The diffusion time ranges from 4 to 6 weeks. The treated wood is generally used in building construction.

3.5 Double Diffusion:

This process involves two separate preservative solutions usually water borne preservative where freshly-cut materials are immersed first in one chemical and then in the other. The two chemicals diffuse into the wood cavities and then react to form precipitate which ultimately produce an effective preservative with high resistance to leaching. A good combination of these chemicals consists of copper sulphate and mixture of sodium dichromate and arsenic pentoxide. Treatment time is from 2 to 3 days for the first chemical and another 3 days or more for the other. The treated materials are used outdoor but not in contact with ground like sign boards and wood roof shingles.

3,6 Hot and Cold Bath:

This method involves heating of oilborne preservative with the material totally immersed during treatment. The dry wood materials are heated in an open tank for several hours and subsequently, either transferred to a cold preservative solution or allowed to cool down in the same tank. During the hot bath of about 80°C to 100°C, the air in the wood cells expands forcing some of it out of the wood. At this stage, small amount of preservative is absorbed by the wood. In the cold bath, the air in the wood contracts thereby creating partial vacuum and the preservative solution is forced into the wood by atmospheric pressure. Treatment time of each bath varies from 1 to 12 hours, depending on the condition of the material and desired retention and penetration of the preservative in the wood. The treated wood are used in ground contact like posts and poles.

3.7 *Recommended Treating Processes:*

The treatment schedules of the different processes have been established through a series of experiments, field and service tests. Table-4 presents the treating processes, preservative concentrations and target retentions in treating coconut timber for various end products.

Table 4 : Recommended treating processes for coconut timber

Service condition	Preservative and concentration	Processes & treatment schedules	Timber condition	Retention (Kg/cu.m)
Ground contact (poles/posts)	CCA:4-6%	Pressure: First vacuum, 45 min; Pressure, 120 min; Second vacuum, 10 min.	Dry	14 - 20
	Creosote - bunker oil: 70:30 mixture	Pressure: First vacuum, 1 to $1^1/_2$ hrs; Pressure, 2-3 hrs, Temp, 160-180°F; Second vacuum, 1 hr	Dry	160 - 192
	Creosote - bunker oil: 70:30 mixture	Hot and Cold Bath: 8-10 hrs. heating and overnight cooling	Dry	128 - 192
Outdoor, not in contact with ground: (sign boards, benches, roof shingles, etc.)	CCA: 2-3%	Pressure: First vacuum, 30 min; Pressure, 60 min; Second vacuum, 10 min	Dry	7 - 12
	Copper sulphate, 3% arsenic pentoxide plus sodium dichromate, 3%	Double diffusion: First soaking in 3% copper sulphate for 2-3 days and Second soaking in 3% arsenic pentoxide plus sodium dichromate for 3 days	Green	7 - 12
Indoor, not in contact with ground: (beam, rafters, jambs etc.)	PCP: 5% in oil; cuprinol or solignum: ready mixed	Dipping/Brushing: Dip for 3-5 min., or brush 3 coatings	Dry	1.8.2.0
	CCA: 2%	Steeping/Dipping/Brushing: Dip for 10-20 min. or brush 3 coatings	Dry	0.5 - 0.8
	Timber: 20-30%	Dip Diffusion: stack and cover with polyethelene sheet for 4-6 weeks.	Green	8 - 10

USES OF COCONUT WOOD

1. *Building and Housing:*

The structural application of cocowood depends mainly on its density. The high density materials should be used in building components such as posts, trusses, door and window jambs, girders, bearers, vertical studs, floors, floor joists, purlins and other load bearing structures. The medium density boards can be effectively used for walling, horizontal studs, ceiling joists and door/ window frames. As a rule, cocowood with densities below 400 kg/m^3 should not be used as a structural framing material. However, they can be utilized in internal parts of building like ceiling and wall lining in the form of boards and shingles.

2. *Furniture, Novelty and Handicraft Products:*

Cocowood can be a promising material for the manufacture of furnitures, novelties and other handicrafts due to its beautiful grain and attractive natural appearance. The hard portion, although can be used for furnitures, imposes some limitations on the density requirement for ideal furniture. This problem can be overcome by adopting a suitable design requiring small size components without sacrificing the strength requirement. The medium density wood is a good material for furniture and novelties including handicrafts as this is more or less the required density range for manufacturing furnitures.

3. *Poles, Piles and Fence Posts:*

Trunks of the coconut palm for poles, piles and fence posts are perishable in untreated condition as they are easily destroyed by termites, marine borers and decay fungi. The long usefulness of cocowood used in ground contact and exposed condition is influenced by successful preservative treatment. The recommended practice of preparing coconut trunks for poles, piles and fence posts includes (a) cutting to the desired length and debarking immediately after felling, (b) the logs should be stacked in a concrete or treated wood bearers of about 20 cm height to provide adequate movement of air through the stacks during air drying and the stacks should be covered during rainy days and (c) the materials should remain in the stack to the required drying period of 16 to 20 weeks.

RUBBER WOOD

Rubber trees have necessarily to be felled when the yield of latex decreases. Most of the timber from these trees now goes for use as fuel and cheap packing cases. If even a fraction of rubberwood available at present can be converted to useful products, a portion of the timber requirements of wood working factories can be met.

Rubberwood can be compared in physical and mechanical properties to most commonly available hard wood species. It can be used for the manufacture of joineries, furniture, parquet tiles, slatted flooring and so on. Rubber wood flooring for sports facilities such as for squash and badminton offers a reasonably priced alternative to the conventional hardwood floors. The potential use of this versatile timber is now hardly being exploited. However, rubber wood in its naturally occuring form is easily perishable.

This wood needs to be chemically treated before it can be put to use.

Chemical Treatment:

Rubber wood is easily susceptible to borer, fungi and insect attack within days of its felling. Much work has been done over the past few years to process rubber wood by impregnating the wood with preservative chemicals and drying to make it durable. Different chemical preservative treatments can be imparted with a prophylactic solution to prevent the growth of fungi. After this initial treatment, the planks are loaded into a special treatment plant where the timber goes through a prescribed cycle of vacuum and pressure, during which preservative chemicals are impregnated. The treated planks are then loaded into the seasoning kilns for drying.

Seasoning:

Artificial seasoning kilns are used to dry the rubber wood, after impregnation to moisture levels between 8 and 15 percent, depending on the end use. This is achieved by forced circulation of air over the timber under controlled conditions of humidity and temperature in a closed chamber. Moisture is drawn out from the timber until the required moisture levels (normally 10 to 12 percent) is reached. Rubber wood thus treated is durable and inexpensive.

Rubber wood properly treated and seasoned is an easily machinable timber and the surface obtained is excellent. It can be finished by painting, staining, lacquering, etc. The market for treated and seasoned rubber wood is good.

The functional uses for which the wood is currently being employed is estimated as (i) packing cases (4,70,000 m^3), (ii) veneer and plywood (1,20,000 m^3), (iii) safety matches (10,000 m^3), (iv) fuel wood (4,20,000 m^3) and (v) processed wood for building components and furniture production (30,000 m^3).

ARECANUT STEM

Arecanut stem forms a useful building material in the villages and it is widely used throughout South and South-east Asia for a variety of construction purposes. Because of its hardness and its golden yellow colour, the timber can be used for making a variety of elegant utility articles. Stationery articles like rulers, shelves, waste paper baskets etc. made of arecanut stem are both durable and attractive. In South Asia, the stem after sharpening is used for husking coconuts. Nails made of areca stem are widely used in furniture industry. Hollow stems lend themselves as drainage and irrigation pipes in the villages.