UTILIZATION OF COCONUT LUMBER FOR FURNITURE MANUFACTURE (CLASSROOM CHAIRS)

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By

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ABSTRACT

The utilization of coconut trunks for the manufacture of classroom chairs involve different stages of processing. These processes include sawmilling of trunks into lumber, drying, machining, fabrication and finishing.

Some 60 trunks of senile coconut palms measuring 25.5 cm to 30.5 cm in diameter and 3 m in length were collected from San Cristobal, San Pablo City for processing. These were sawmilled in a 54-inch bandsaw with stellite-tipped saw blade.

Specimens of coconut wood lumber were seasoned from green condition to a moisture content of about 15% to 19% by conventional air-drying. It took 112 days to dry 2.54 cm thick low density coconut lumber from an initial MC of 106.1% down to 19.81%. For 5.0 cm thick lumber of the same density, it took the same number of days to dry from 65% MC down to 15.5% MC. High density lumber. 2.54 cm thick, took 112 days to dry from 55.7% down to 16.99% MC. For 5.0 cm lumber, a drying time of 115 days reduced the MC from an initial of 53.5% to 15.81%.

Sawmilling, drying, machining, fabrication and finishing activities were done in the Forest Products Research and Development Institute (FPRDI). Some problems related to the splitting of coconut lumber (dermal portion) during nailing and assembly were overcome by pre-boring the chair components prior to nailing.

About 10 board feet of rough coconut lumber is required to fabricate one proto-type chair. The production cost per unit of one lacquer-finished chair was P45.90. Seventy classroom chairs were installed in four elementary schools in Los Banos and Calauan, Laguna, Philippines. After 1.5 years in service the experimental chairs were still in very sound condition.

INTRODUCTION

Coconut palm (*Cocos nucifera* L.), a monocotyledon is economically the most important species of the family Palmae. Though found inland, it is mainly distributed in the tropical, coastal regions of Asia, Oceania, Africa and Latin America. It thrives best in places with well-distributed rainfall between 127 to 229 centimeters and within latitude 20°North and 20° South

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of the equator. Traditionally regarded as the "Tree of Life," the coconut palm provides most of the basic requirements of man ranging from food, shelter, medicine, wine, beverage and oil to other industrial products. The trunk serves as fence posts, electric and communication poles, as short-span bridges and as housing components. Coconut lumber is also fabricated into novelty items, as tool handles and other products.

In the past, the idea of processing and utilizing coconut trunk was not given much thought by wood users. It was only when large tracts of senile coconut plantations have to be replanted with early-bearing and high yielding varieties, that the idea was given due attention. In addition, there was meager supply of cheap and easily available wooden materials for the implementation of the low-cost housing and rural electrification projects of the Philippine government. Hence, coconut utilization was favorably endorsed.

In 1980, the government started replanting some 650 hectares of old coconut palms in different regions in the country. The hectarage will eventually increase. By 1984 and onwards, the area to be replanted will be about 60,000 hectares (14)[2]. Considering that there are about 100 coconut palms in a hectare, this would total approximately 6-million cubic meters of coconut trunks, on the assumption that one whole length is equal to one cubic meter. It was estimated that the replanting program will last for 40 years or even more. Taken as a whole, with about 377 million coconut trees in the Philippines in 1978, which about 30% were 60 years old and above, there would be an enormous volume of coconut wood materials then available for processing to various end-products.

The lack or shortage of classroom chairs particularly in the remote areas has been a problem to the government's education program. As reported, out of approximately 10-million school children from grade one to high school, only about 60% are provided with comfortable chairs. It would be superfluous to state that learning comes easily with a congenial atmosphere and necessary facilities. The lack of classroom chairs can be attributed to the prohibitive cost of traditional wood materials in the market and the dwindling supply of species suitable for furniture. Hence, the need to search for possible substitute materials that are cheap and abundant is of prime importance.

This research study was proposed with the aim to recover some valuable products from felled coconuts that have to give way to the government's replanting program. From the coconut lumber, school chairs for the rural areas, may be fabricated.

This study started from the sawing of trunk into lumber, drying, machining, fabrication and finishing, to the service-testing of chairs in schools. The first five activities were conducted at FPRDI; service -testing, at four public elementary schools at Los Banos and Calauan, Laguna.

The objectives of the study are:

1. Determine the suitability of coconut lumber for fabrication of classroom chairs;

2. Help promote the utilization of coconut wood as a substitute material for conventional wood; and

3. Help alleviate the shortage of classroom chairs in the country.

[2]Underscored number in parenthesis refer to literature cited.

Coconut trunks for this study were collected at Barangay San Cristobal, San Pablo City from June 5 to 16, 1979. These were hauled to FPRDI at College, Laguna for processing.

REVIEW OF LITERATURE

Coconut (*Cocos nucifera* L.) being monocotyledon, has marked structural difference from those of traditional timbers. It has no growth rings. Gross observation of the cross-section (butt disc), reveals that the fibro-vascular bundles are congested in the dermal zone as compared to the sub-dermal and central zones. The vessels in the dermal zone are oriented towards the center (15).

The dermal and a part of the sub-dermal zones occupy the hard outer layer near the bark which on the average occupies about 47% of the trunk cross-section. The soft portion (part of the sub-dermal zone and whole of the central zone) occupy about 53% of the trunk cross-section (22).

The density of coconut wood increases from top to butt portion and from the central to the dermal zone. Similarly, the strength properties increase from central to dermal zone. These variations can be attributed to the presence of more vascular bundles which are also thick-walled in the butt and dermal zones compared to the top and central zone (18).

The moisture content (MC) of a freshly-felled round coconut wood differs considerably from butt to top-end and from core to outer portion. The MC of the core in the butt and top ends reaches up to 550% and 303%, respectively. In the outer portion, the top end has a higher MC than the butt end, while very slight variation was observed in the intermediate portion of the trunk (16).

Sawing tests conducted on standard high-speed steel blade and carbide-tipped blade showed satisfactory results. It was, however, noticed that in sawing dried lumber with standard high speed blade, burnt surfaces which were excessive indicate rapid dulling of the saw tooth. The use of carbide-tipped saw produced good to excellent sawn surfaces (5).

In the early 1970's interest in the large-scale utilization of coconut trunk or stem as an alternative to traditional wood gained momentum. It was realized that many existing plantations with overmature trees needed replanting. In the ensuing search for suitable products, attention was given to preserving sections of the trunk for use either as poles or fence posts. As reported by McQuire in 1980 (13), the earliest recorded trial in the Philippines by Mosteiro in 1971 was on treatment of pole stubs with creosote. In 1972 Little installed a test of pole stubs in Tonga. Mosteiro and Siriban in 1976 (17) reported the preservation and utilization of coconut timber. Different treatment methods, chemical preservatives, end-uses and preservative concentrations were presented for treating both seasoned and unseasoned coconut wood. The potential and present uses of coconut wood were reported by Alston in 1976 (1) and Mosteiro in 1978 (18) in which consideration is given as to how far coconut timber from the peripheral portion of the butt log meets the requirement of an ideal furniture. Reference is, likewise, made as to which portion of the coconut timber is suited for various end-products.

Studies on the anatomical structure of coconut palm wood by Kaul in 1960 (8), Meniado in 1976 (15), Richolson in 1976 (20) and Parthasarathy in 1976 (19) mentioned that the coconut trunk has no growth rings. In the cross section the trunk consists of three dstinct zones; (a) dermal zone-about 1.27 cm. wide consisting of dark brown fibrous tissue resembling the bark is the most peripheral part of the stem; (b) subdermal zone, the transitory zone between the dermal and central region is about 5.08 cm.; and (c) central region is made up of scattered bundles of vascular strands interspersed in soft or ground tissue.

The mechanical and physical properties of coconut trunk were investigated and reported by Kloot in 1952 (11), Sasondoncillo in 1971 (21), Espiloy in 1978 (6), Kininmonth in 1979 (9) and Walford in 1976 (23). Test results are promising with slight variation which could be attributed to the age, moisture content, size and density. The density increases from top to butt portion and from center to the dermal zone. Similarly, the strength increases from top to butt portion and from center to the peripheral zone. Tests conducted in the Philippines on green mature round coconut trunk with an average specific gravity of 0.500 showed an average modulus of rupture in bending of 306 kg per cm^2. Tests conducted in Australia also on round trunks showed an average value of 484 kg. per cm^2.

Research studies conducted by Decena in 1975 (4), Bergsen in 1976 (3), and Jensen in 1979 (7) showed that it is feasible to saw coconut trunks by the use of stellite or carbide-tipped saw blades. The average lumber recovery is about 40% to 49%. The three forms of lumber recovered are "wane", "half moon" and "dimension."

The MC of freshly felled coconut trunks varies widely. Test conducted by Mosteiro in 1971 (16), Mosteiro in 1976 (17) showed that the MC at the core or central region was 303% to 550%. Drying time for sawn coconut trunks was 2 to 2½ months and 4 to 5 months for round trunks without bark, under shed. Air-drying studies by Laxamana and Tamayo in 1978 (12) on 2.54 cm. coconut lumber with an average initial MC of 152% to 158% reached an MC of 18% to 19% after 10 weeks. Kiln-drying 2.54 cm coconut lumber with the same initial MC took 6 days to dry to an MC of 10.7%. Kininmonth in 1979 (10), had summarized information on the drying of sawn coconut trunks and poles.

MATERIALS AND METHODS

A. Materials

A total of 60 mature coconut trunks (3 meters long each) collected from Barangay San Cristobal at San Pablo City were hauled to FPRDI for processing. The trunks varied from 60 to 70 years. They were free from insect or beetle damage.

B. Methods

The collected trunks were bucked into 1.5 meters length prior to sawmilling. These were sawn into lumber measuring 2.54 cm x 12.7 cm x 1.5 m and 5 cm x 5 cm x 1.5 m using a 54-inch bandmill. Immediately after sawing, MC samples representing the three portions of the trunk cross-section were taken and the initial MC was determined by the oven-drying method.

The basic specific gravity of the three portions of the trunk was determined by water displacement method. Similarly, the shrinkage from green condition to oven-dry was also determined following the ASTM procedure for testing small clear specimens (D143-61).

Sawn coconut lumber from the sawmill were box-piled using 2.54 cm crossers under shed for air-drying to equilibrium moisture content (EMC about 15%-19%). Sample boards, representative of the hard and soft portions of the 2.54 cm and 5.00 cm thick materials were prepared to check the MC during the drying process.

Seasoned lumber were machined (re-sawn, planed and sanded) to desired dimension of the chair components. Some parts which required gluing were edge-glued and allowed to set for about one week. Planed and glued components were fabricated into classroom chairs. Wood putty was applied on pre-bored and nailed portions. Prior to actual service - testing, individual chairs were carefully applied with finishing materials (lacquer thinner, sanding sealer and clear gloss lacquer).

RESULTS AND DISCUSSION

Sawing

Coconut trunks were converted into lumber using a 54-inch bandmill with stellite-tipped saw blade. Sawing time for the 120 trunks, 1.5 meters long, took approximately 5.0 hours. Saw blade was changed every 1.5 hours of continuous operation (that is after converting about 36 coconut trunks into lumber) before regrinding. The lumber recovered were of low, medium and high density.

Drying

After sawing, lumber pieces were carefully stacked in a lumber shed for air drying. The 2.54-cm thick lumber were stacked or piled separately from the 5-cm thick with the use of 2.54-cm thick stickers. Standard sample boards, representative of the low and high density (soft and hard portions) were prepared and end-coated with moisture retardant material. The sample boards were properly placed within the height and length of lumber stack and were periodically weighed to determine the amount of moisture loss during the drying process.

As shown in Figure 1, the 2.54 cm thick coconut lumber showed rapid loss of moisture during the first 63 days of drying. This is evident in both the low and high density materials. The MC of the low density lumber was reduced from 106.1% to 26.5%. High density lumber was reduced from 55.7% to 21.5%. After two months of drying, moisture loss was quite gradual on both low and high density lumber. A constant MC of 19.81% for low density and 16.99% for high density were attained after 112 days of air-drying. The difference in EMC between the high and low density materials is expected. High density wood generally contains more extractives. Some of these extractives which are water-soluble contain sorption sites which are occupied with water molecules. During absorption, these sorption sites can no longer absorb water molecules thereby resulting to a decrease in moisture content.

As shown in Figure 2, the 5-cm thick coconut lumber had rapid loss of moisture during the first 49 days of drying. During this period, the MC of the low density lumber was reduced from 65.0% to 35.0%, while the MC of high density lumber decreased from 53.69% to 28.80%. After 112 to 115 days of air drying an MC of 15.5% to 15.81% was reached.

In this particular test, *collapse* was observed to be the prominent defect occurring in the soft portions of the lumber. This defect usually occurred at the start of the second and third week of drying when the MC of the

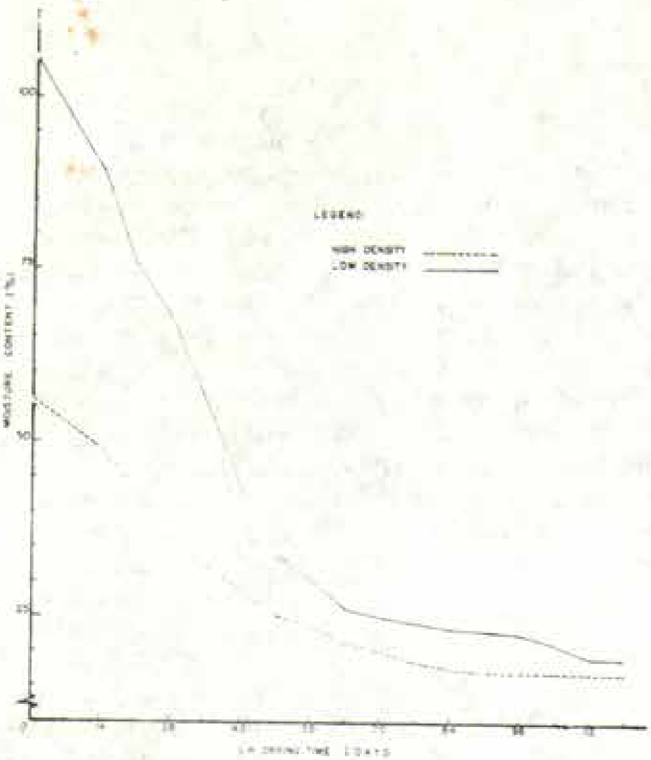

Figure 1 — Drying rate for high and low density coconut lumber 2.54 cm. thick.

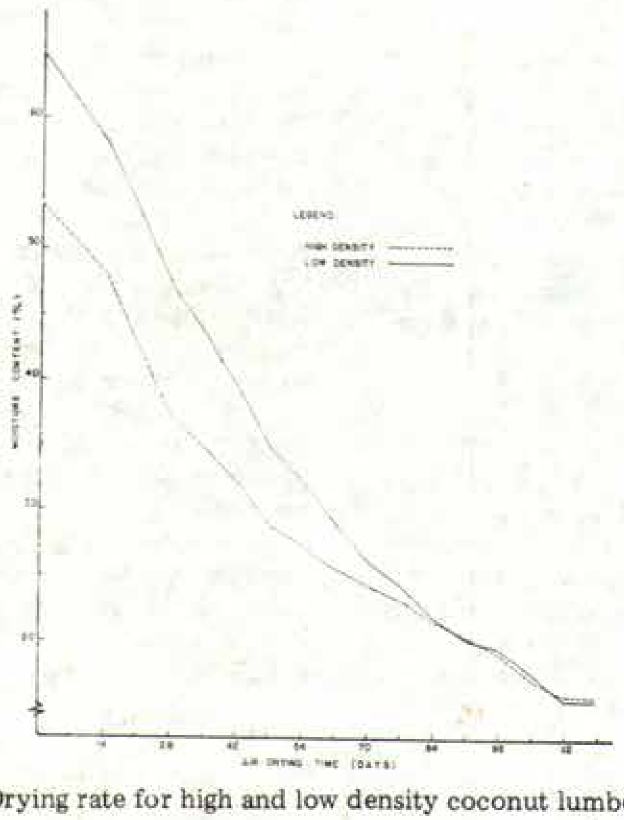

Figure 2 — Drying rate for high and low density coconut lumber 5.0 cm. thick.

lumber was between 50% to 80%. Slight *surface checks* were likewise observed on the denser portion of the coconut lumber. *Twist* was another drying defect noted in some of the coconut lumber, particularly those on the top of the stack or pile. Density variations of the coconut trunk both within the cross-section and along the height were some problems in drying and also in its utilization. Proper sorting or segregation of the high density from the low density lumber prior to drying can minimize the problem.

Specific Gravity and Shrinkage

The basic specific gravity of the dermal, sub-dermal and central zones of the coconut trunk were 0.601, 0.425 and 0.265, respectively. The shrinkage values from green to oven-dry condition in the radial direction was 6.0% for dermal zone and 6.10% for the central zone. In the tangential direction, the shrinkage was 6.71% for the dermal zone and 5.71% for the central zone. The difference in shrinkage between the radial direction or face (the surface of the block of cocowood cut from the bark toward the soft central portion) and the tangential direction or face (the surface of the block of cocowood cut tangent to the hard dermal ring or the section cut perpendicular to the radial face) was very slight.

Machining and Gluing

After drying to EMC the coconut lumber were subjected to machining operation. Individual pieces of lumber specimens were sawn and planed to desired dimensions and prebored of required holes. The lumber pieces, 1.50 m in length were then glued together to form an aggregate width of 72.6 cm. The glue was allowed to set for 1 week. Individual components of chair such as the writing board, sitting board and back board were then cut from the glued specimens by the use of a small bandsaw. Similarly, other components such as the posts, braces and supports were pre-cut to desired dimensions. All of the components were then sanded in a disc sander using grit Nos. 80 and 100.

Fabrication and Finishing

All of the sanded components were assembled into classroom chairs. These were carefully finished with the application of sanding sealer, lacquer thinner and clear gloss lacquer. Three coats of finishing (particularly to the low density portion) materials were applied to each proto-type chair. Coconut wood was observed to absorb more sealer than ordinary wood. Satisfactory finish was obtained on individual experimental chairs. It took approximately 2 hours for a carpenter to fabricate one proto-type chair (from bandsawing of glued components to complete assembly). One classroom chair can be fabricated from about 10 board feet of rough coconut wood.

Estimated Cost

The production cost of one gloss-finished coconut wood classroom chair of this type was estimated at P45.90.

Experimental chairs undergoing actual service test in public elementary schools.

PRODUCTION COST FOR ONE COCONUT WOOD CLASSROOM CHAIR

Items		Price
I.	Raw Material	
	Coconut lumber, 10 bd.ft. at P1.20/bd. ft.	P 12.00
II.	Supplies	
	1. Weldwood glue	1.80
	2. Wood putty	2.70
	3. Nails, CW	1.30
	4. Sandpaper	1.80
	5. Sanding sealer	5.10
	6. Lacquer thinner	3.70
	7. Clear gloss lacquer	7.50
III.	Labor	10.00
	Total Cost	P 45.90

Service-Testing and Inspection

Finished chairs were delivered to four public schools in Los Banos and Calauan, Laguna for service-testing. Fourth and fifth grade pupils used the experimental coconut wood chairs. Service-testing had started August 1, 1980. A total of 70 experimental chairs are undergoing service-test.

The service-testing and inspection phase will be covered by a separate study proposal and will be conducted as a regular project of FPRDI. Individual specimens will be inspected annually during the first 5 years and a semi-annual inspection during the succeeding years. A technical report on the conditions of the chairs will be prepared after every inspection.

CONCLUSION

From the foregoing study, the following conclusion can be drawn:

1. There are marked variations in the initial moisture content within the cross-section (central to dermal zone) of the coconut trunk;

2. The density of the central to the dermal portion of the coconut trunk likewise varied considerably;

3. Drying of 2.5 cm and 5.0 cm thick coconut lumber from an initial moisture content of about 200% down to equilibrium moisture content of 15% to 19% MC under shed took on the average, 2½ to 3½ months; and

4. Coconut wood is a suitable material for the manufacture of classroom chairs or desks provided that it is dried to the desired moisture content and is properly machined.

RECOMMENDATIONS

From the results obtained, the following are recommended:

1. Before stacking and air-drying sawn coconut lumber, it must be soaked momentarily in anti-stain chemicals.
2. Coconut lumber from the sawmill must be sorted properly prior to drying;
3. Sorted lumber must be properly pued or stacked in a well-ventilated shed for proper air-drying;
4. Preliminary air-drying for at least two weeks be employed prior to kiln-drying.
5. Pre-boring of chair components before nailing is advisable in processing coconut wood particularly on the dermal portion.

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