

COCONUT STEM UTILIZATION IN SRI LANKA

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INTRODUCTION

In the plantation agriculture in Sri Lanka, coconut occupies the highest area of nearly 420,000 ha. It is distributed in all 24 districts. The estate sector (8 ha or more) comprises 104,000 ha (24.7%) of the area while the balance, 316,000 ha (75.3%) is categorized as small holdings (Table 1).

Table 1: Distribution of Coconut Holdings and Estates

District	SMALL HOLDINGS			ESTATE			TOTAL		
	No of Holdings	Area (Ha)	% -	No of Estates	Area (ha)	% -	No. of Holdings	Area (Ha)	% -
Colombo	29,360	8,668	2.7	101	1,069	1.0	29,461	9,737	2.3
Gampaha	113,230	52,302	16.6	703	11,862	11.5	113,933	64,164	15.3
Kalutara	49,400	11,408	3.6	140	919	0.9	49,540	12,327	2.3
Kandy	13,010	4,670	1.5	97	1,578	1.5	13,107	6,248	1.5
Matale	14,200	6,552	2.1	160	2,416	2.3	14,360	8,968	2.1
Muara-Eliya	2,010	886	0.3	05	6*	0.0	2,015	892	0.2
Galle	44,360	11,311	3.6	229	1,575	1.5	44,589	12,886	3.1
Matara	46,560	14,075	4.4	251	2,430	2.4	46,811	16,505	3.9
Hambantota	31,840	18,652	5.9	157	2,157	2.1	32,997	20,809	5.0
Jaffna	13,260	4,913	1.6	204	3,956	3.8	13,464	8,869	2.1
Mannar	940	1,137	0.4	13	205	0.2	953	1,342	0.3
Vavuniya	750	469	0.1	4	18*	0.0	754	487	0.1
Mulativu	2,110	1,509	0.5	58	907	0.9	2,168	2,417	0.6
Batticaloa	8,150	2,460	0.8	104	1,583	1.5	8,254	4,044	1.0
Ampara	11,550	2,428	0.8	27	739	0.7	11,557	3,167	0.8
Trincomalee	4,240	1,732	0.5	19	204	0.2	4,259	1,936	0.5
Kurunegala	157,270	101,686	32.2	2,319	45,876	44.5	159,589	147,551	35.2
Puttalam	48,550	30,586	9.7	1,235	22,586	21.9	48,785	53,182	12.7
Anuradhapura	14,100	4,144	1.3	20	160	0.2	14,120	4,304	1.0
Polonnaruwa	7,320	2,380	0.7	8	74	0.1	7,328	2,454	0.6
Badulla	1,090	571	0.2	18	38	0.1	1,108	609	0.1
Moneragala	11,800	3,662	1.1	10	32	0.1	11,810	3,694	0.9
Ratnapura	34,500	10,809	3.4	175	973	0.9	34,675	11,782	2.8
Kegalle	49,320	19,057	6.0	223	1,764	1.7	49,543	20,820	5.0
SRI LANKA	708,920	316,068	100.0	6,280	103,127	100	715,200	419,195	100

*) Coconut may be a component in other estates (Coconut Research Institute, Lunuwila, Sri Lanka)

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Coconut is a very important commodity in Sri Lanka. It is used traditionally as a component in food, and about 70% of the production is consumed locally. About 9% of the total expenditure on food of an average household is spent on coconut, which is the principal source of edible oil and fat. Coconut provides about 22% of the total intake of calories of an average consumer in Sri Lanka and is only second to rice insofar as intake of calories is concerned (Tillakeratne and Perera, 1981). These data amply demonstrate the importance of coconut in Sri Lanka.

Cultivation Aspects

About 44% of the total estate sector coconut area lies in the Kurunegala district, 22% in Puttalam district and 11.5% in Gampaha district. The area covered by these three districts forms the basis of the "coconut triangle", which has nearly 78% of the coconut estate sector area. As indicated in Table 1, coconut is primarily a small holder crop in Sri Lanka. Of the total area of 316,000 ha, 32.2% are in the Kurunegala district, 16.6% in Gampaha district and 9.7% in Puttalam district. The average size of a small holding is 1 acre. According to a census carried out by the Department of Census and Statistics in 1982, about 90,000 ha (225,000 ac) or 29% of the area under smallholdings is made up of holdings less than 0.8 ha (2 ac.)

In order to formulate a strategy for the use of coconut wood, it is necessary to examine the varieties grown and the general age structure of the holdings. In Sri Lanka, there are three main varieties of coconut, namely tall (*typica*), dwarf (*nana*) and thambili (king coconut - *aurantiaca*). There are numerous forms of these varieties, which have been described by Wickramaratne (1987).

The commonest commercially grown variety - is the tall variety, *typica*. During the past 20 years or so, a limited amount of the dwarf x tall (CRIC 65) hybrid has been planted, and the area under this hybrid has been estimated to be about 4,000 ha.

Age Structure, Plant Density and Rotation

The age structure of coconut plantations is important in determining the availability of wood for utilization. The actual economic life of a coconut palm is also an important consideration. It is often thought that the economic life span of a coconut tree is about 60 years. In Sri Lanka, high yielding palms much older than 60 years are not uncommon.

A study in 1980 indicated that in the coconut estate sector, 79.4% of the palms are under 60 years of age. About 18.5% are 60 years and over. However, when the small holder sector is also considered, the overall pattern changes, and only 8.0% of the coconut are over 60 years old. The age structure of coconut is given in Table 2 (Perera, 1980).

The government operates a popular subsidy scheme for underplanting, where the new plants are planted about 6-8 years before the older trees are to be uprooted. In the estate sector 19.5% of the area is presently underplanted. Underplanting provides a regular output of trees. However, recent experience has shown that the small holders are reluctant to uproot the older palms in a systematic manner. The underplanting subsidy is paid in four instalments, and the final instalment (38% of the total subsidy) is paid only if the specified number of older trees have been removed. This condition has been imposed in order to ensure that the growth of the underplantation is not adversely affected by shading from older trees. Consequently, only a very few small holders apply for the final subsidy instalment (Coconut Development Authority, 1981). As a result of the underplanting subsidy scheme, there is a gradual overcrowding of older palms thereby increasing the proportion of palms of 60 years and more. Any change, in the operation of the subsidy scheme is likely to influence the small holders in their perception of economies of prolonging the life of coconut trees and thereby influencing the availability of palms in the market.

Table 2: Age Structure of Coconut in Sri Lanka

Age Class (years)	% Palms Population	Estimated Palm (X 10 ⁶)
0 – 5	7.56	6.39
5 - 15	24.89	21.03
16 - 30	21.47	18.14
31 - 45	20.10	16.99
46 - 60	17.93	15.15
Over 60	8.05	6.80
	100.00	84.50

A comprehensive sample survey has been undertaken in Sri Lanka recently to assess the availability of timber and biomass fuel from coconut (see Goonatilake, 1985). In this survey, it was revealed that 98.5% of the trees belonged to the *typica* (tall) group and the balance either *nana* (dwarf) or CRIC 65 hybrids. All dwarf and hybrid plants were less than 30 years old. This survey also showed that the average density in the holdings was 57.4 palms/ac. In underplanted areas, the density of old trees was 49.8/ac whilst those of the young palms was 56.6/ac. From these data, it has been concluded that the average density of Sri Lankan coconut plantations is 57 trees/ac (141 trees/ha) which is slightly lower than the hitherto accepted density of 64 palms/ac (160 palms/ha). The rotation period ranged from 57 to 71 years, and 65 years appear to be a more representative age. This compares well with the annual replanting rate of 1.5% to 2.0% suggested for the industry (Liyanage, 1982).

AVAILABILITY AND DEMAND OF WOOD IN SRI LANKA AND THE POSITION OF COCONUT

In 1983, forestry contributed 1.7% to the Gross Domestic Product, or Rs 1.9 billion. The non-forest wood resources are primarily made up of tea, rubber, coconut, homestead gardens and areas classified as mixed trees and other perennial crops. If all resources are put together, the total value of wood production, harvesting and transport is around Rs 4.5 billion. The total area of non-forest wood and biomass resources is about 3.0 million ha or about 45% of the total area of Sri Lanka.

The present demand for industrial logs is 980,000 m³ sub per year. This is expected to increase upto about 1.4 million m³ during the period 1996-2000 and to 2.1 million m³ sub in 2011-2020 (Poyry, 1986).

It is reported that only about 20% of the available coconut wood of sawlog quality is used. This is mainly used for hand-hewn rafters. Considering the available quantity of coconut wood, there is currently a large surplus of between 250,000 m³ to 300,000 m³ coconut wood per year. It is most likely that this surplus is used as fuel wood.

The availability and demand for industrial logs for the period 1986-2020 is given in Table 3. It would be seen that upto about 1990, Sri Lanka has surplus wood and need not depend on coconut wood. However, as demand increases with time, she would be obliged to increase the use of coconut wood. From Table 3, it would also be clear that Sri Lanka would face a shortage of industrial logs if not for coconut wood.

Table 3: Availability and Demand for Industrial Logs (m³ sub/year) 1986-2020

	1986-90	1991-95	1996-2000	2001-10	2011-20
Natural forests Planted forest Non-forest logs	1,343	1,266	1,148	1,372	1,362
Coconut	351	326	338	343	367
Total availability	1,704	1,592	1,486	1,715	1,729
Demand	1,050	1,230	1,390	1,680	2,050
Surplus (+) / Deficit (-) if coconut is not used	+ 293	+ 36	- 242	- 308	- 688

Source: Poyry, 1986

A recent study has very clearly shown that the diminishing supply and increasing demand of wood can only be met by increasing the use of rubber and coconut wood. By the year 2000, the coconut wood use has to be increased by about 140% (from 3 the present level of 75,000 m³ sub/year to 191,000 m³ sub/year). If the use of coconut wood is not increased, the shortage of sawn timber will increase as follows (Poyry, 1986):

- 1990 by 15,000 m³ sub
- 1995 by 32,000 m³ sub
- 2000 by 43,000 m³ sub

Unless the use of coconut wood is developed, these deficits in the market will have to be met by imported wood. The projected development of coconut log use is given in Table 4.

Table 4: Development in the Utilization of Coconut Logs

Period	Coconut log use ('000 m ³ sub/year)
1986 - 1990	102
1991 - 1995	145
1996 - 2000	174
2001 - 2010	215
2011 - 2020	235

Source: Poyry, 1986

The demand development of wood upto the year 2020 has been projected by Poyry (1986). The demand for coconut logs for rafters has been estimated at a steady 60,000 m³ sub/year. The future supply of logs and sawn timber from coconut upto the year 2000 is given in Table 5. It is envisaged that the present level of supply of these two items will be increased by about 150% by the year 2000.

Table 5: Supply of Logs and Sawn Timber from Coconut Up to the Year 2000

	Logs (‘000 m ³ sub/year)	Sawn Timber (‘000 m ³ /Year)
1985	70	20
1990	115	33
1995	157	51
2000	181	61

IMPORTANCE OF COCONUT AS A WOOD RESOURCE

Historical Aspects

Timber has been traditionally used in construction work in Sri Lanka. For example, the Kandyan wooden architecture (circa 15th century) has a distinct character of its own due to the wonderful timber architecture used. Insofar as Sri Lanka is concerned, coconut has been a 'traditional' wood and has been used extensively in building construction from ancient times. Coomaraswamy (1956) and Karunaratne (1971, 1975) have given accounts on the dominant position of timber in construction in ancient Sri Lanka.

The use of coconut wood in medieval period in Sri Lanka is amply evident. "Sandesa" gives reference to coconut in the 15th century. The coconut palm in homesteads, is depicted in Degaldoruwa paintings (circa 18th century). It is also well known that master carpenters in the 18th and 19th centuries used adze as the main tool for debarking, cutting and shaping wood. Currently, the adze is widely used for the preparation of coconut wood rafters, and this is an indication of the evolution of the practice of preparing adze-hewn coconut wood.

Coconut wood has been extensively used in building construction in ancient Sri Lanka. For example, the "Star Court" at Matara in the coastal belt of Southern Sri Lanka, built during the early dutch period (circa 1760's) has a considerable amount Of coconut timber (Karunaratne, 1988).

In recent times, coconut is used almost exclusively for rafters. Architecturally, it is a very decorative, timber for balustrades and other decorative, work (Perera, 1985).

Availability of Coconut Wood

As indicated earlier, coconut can be classified as a "traditional" wood in the "non-forest wood resources" group. Coconut is a very important component of non-forest wood resources.

The results of a sample survey reported by Goonatilake (1985) show that about 75% of the coconut wood harvested by growers are sold while 21.4% are used by themselves (Table 6). However, about 78% of the coconut stumps are left unused (Table 7). In the estate sector, the stumps are normally removed when a tree is felled as a phytosanitary measure to prevent the breeding of the rhinoceros beetle (*Oryctes rhinoceros*). However, additional expenditure, will have to be incurred for this operation, and as a result, it is not a common practice in the small holder sector.

Goonatilake (1985) has also reported the yield of timber and fuel wood from coconut plantations (Table 8). It is seen that about 50 m³ sub of sawlogs could be extracted from a hectare, of mature plantation.

Table 6: Use of Coconut Wood in 1984

Use	No of Palms	%
Own use as fuelwood	86	3.3
Own use as timber	555	21.4
Given free	18	0.7
Sold to local people	836	32.2
Sold to outsider	1,099	42.4
Felled and left unused	0	0.0
Burnt	0	0.0
Other	0	0.0
Total	2,594	100.0

Table 7: Use of Coconut Stump

Own use as fuelwood :	3.2
Given free to others :	0.8
Lef unused :	77.7
Burnt :	18.3
Sold :	0.0
(Sample response 80)	

**Table 8: Estimated Average Yield of Timber and Fuelwood from Coconut
(Volume in m³ sub)**

	Per Hectrare	Per Palm
Stocking rate	158.0	1.0
Total wood volume	101.1	0.634
Stem volume	82.0	0.516
- saw log volume first 5 m above stump	49.4	0.313
- fuelwood volume	32.6	0.203
Stump volume	19.6	0.124
Total fuelwood volume	51.6	0.327
(stump + stem fuelwood) Adapted from Goonatilake, 1985		

The availability of coconut wood largely depends on the rotation period. Goonatilake (1985) computed the removal rates of coconut palms upto the year 2020. These removal rates have been computed assuming a rotfition period of 70 years and using the data from the sample survey on the age structure of the coconut plantations. The area over 65 years has been estimated at 8% of the total area. About 2% is thought to be already removed, leaving only 6% of the total area for future removal. This area will be removed gradually at the following rates: 2% in 1988-1990, 1% each in 1991-1995 and 1996-2000. During the 36 year period between, 1985-2020, 51.2% of the coconut area

will be uprooted. This rate compares very favourably with the theoretical removal rate of about 1.5% suggested for the industry. Based on these assumptions, the coconut area to be uprooted up to 2020 is given in Table 9.

Table 9: Coconut Areas to be Uprooted: 1985-2020

Age Class (Year)	(%) -	Area (Ha)	Removal Period	(%) to be Removed	Area to be Removed (ha)
Over 65	8.0	33,520	1985	2.0	380
61-65	6.0	25,140	1986-1990	8.0	33,520
56-60	6.0	25,140	1991-1995	7.0	29,330
51-55	6.0	25,140	1996-2000	7.0	29,330
41-50	13.3	55,725	2001-2010	13.0	55,725
31-40	13.9	58,240	2011-2020	13.9	58,240

Adapted from Goonatike, 1985

The district-wise annual production potential of timber and fuelwood from coconut plantations for the period 1985-1990 is given in Table 10. Similar computations have been made for different periods upto 2020 (Table 11). On an average, about 600,000 m³ of coconut wood are available annually.

Table 10:- Annual Production Potential of Timber and Fuelwood from Coconut Plantations

District	Total Area (ha)	Removal (ha)	Sawlogs (m ³)	Fuelwood (m ³)	Total (m ³)
Colombo	9,737	162	7,985	8,340	16,325
Gampaha	64,164	1,065	52,617	54,960	107,577
Kalutara	12,327	205	10,109	10,559	20,668
Kandy	6,248	104	5,124	5,352	10,476
Matale	8,968	149	7,354	7,682	15,036
Nuwara Eliya	892	15	732	764	1,496
Galle	12,886	214	10,567	11,038	21,605
Matara	16,505	274	13,535	14,138	27,672
Hambantota	20,809	345	17,064	17,824	34,888
Jaffna	8,869	147	7,273	7,597	14,870
Mannar	1,342	22	1,100	1,150	2,250
Vavuniya	487	8	399	417	817
Mulativu	2,417	40	1,982	2,070	4,052
Batticaloa	4,044	67	3,316	3,464	6,780
Ampara	3,167	53	2,597	2,713	5,310

Trincomalee	1,936	32	1,588	1,658	3,246
Kurunegala	147,551	2,449	120,998	126,386	247,384
Puttalam	53,182	883	43,611	45,554	89,165
Anuradhapura	4,304	71	3,529	3,687	7,216
Polonnaruwa	2,454	41	2,012	2,102	4,114
Badulla	609	10	499	522	1,021
Moneragala	3,694	61	3,029	3,164	6,193
Ratnapura	11,782	196	9,662	10,092	19,754
Kegalle	20,820	346	17,073	17,834	34,907
T o t a l	419,195	6,959	343,755	359,067	702,822

Table 11:- Production Potential of Timber and Fuelwood From Coconut Plantations 1985-2020

Period	Removal (ha)	Sawlogs ('000 m ³)	Fuelwood ('000 m ³)	Total ('000 m ³)
1986-1990	33,520	1,655.9	1,929.6	3,385.5
1991-1995	29,330	1,448.9	1,513.4	2,962.3
1996-2010	29,330	1,448.9	1,513.4	2,962.3
2001-2010	55,725	2,752.8	2,875.4	5,628.2
2011-2020	58,240	2,877.0	3,005.2	5,882.2
	206,145	10,183.5	10,637.0	20,820.5

CONSTRAINTS IN THE DEVELOPMENT OF COCONUT WOOD-BASED INDUSTRIES

The peculiar characteristics of coconut wood restrict its large scale industrial use. The density variation within a palm is very wide. The pith in the palm stem is unsuitable for timber. These drawbacks do not allow the production of large dimension timber of uniform density range.

The peripheral areas of mature trunk is very hard. The tracheids too are extremely hard, and the parenchymatous cells contain above-normal quantities of silica. These special characteristics warrant the use of special cutting blades. Normally, saw-teeth have to be specially hardened using tungsten carbide or stellite, both of which are expensive. The immense heat produced in the process of using machine-driven saws often make saw teeth blunt, needing regular attention. Work carried out in Sri Lanka has shown that for every sharpening given to tungsten carbide tipped saw, a stellite-tipped saw will be sharpened five times and retipped and ground once (Francis and Bergseng, 1984 a).

The problems associated with curing high-moisture containing coconut wood are also common. The common defects are bow (in low-density badly stacked wood), cup (again in low-density wood) and stain (Embogama, 1987). However, these are not insurmountable, and it requires only education, training and experience to learn proper drying methods.

Francis and Bergseng (1984 a) carried out a study Sri Lanka and recommended a design for a coconut sawmill. Their financial analysis indicated that the cost of the mill could be recovered within a few years. However, the initial capital required at that time for the machinery alone was about US\$ 500,000, and is beyond the means of most entrepreneurs. In view of this high capital requirement, establishment of coconut sawmills has not attracted much attention. However, a recent study of Poyry (1986) indicates that investment in new coconut sawmills may not be financially viable, considering the cost and price relations existed at that time in Sri Lanka. Under the circumstances, it is likely that, at least in the immediate future, manual methods will continue to be used for converting coconut wood into the item of most demand, namely rafters.

CURRENT TRENDS IN COCONUT WOOD UTILIZATION IN SRI LANKA

The development of coconut wood-based industries in Sri Lanka has been slow owing to numerous constraints, some of which are described elsewhere. Traditionally, coconut wood has been used in the construction of buildings, particularly dwelling houses. The most common uses of coconut are roof trusses (medium density), rafters (high density) and roof shingles (medium high density). In addition, a considerable amount of flooring (high density) and wall panelling (medium and high density) are also made. Coconut wood is also used on a very limited scale for the manufacture of furniture and artifacts.

Timber

Until about the early 1980's, almost the entire coconut wood processing was manual. Large scale hand-hewn rafter manufacture is not uncommon in the main coconut growing areas.

Mechanized Wood Processing

As indicated earlier, previous attempts to install sawmills for coconut wood were unsuccessful, primarily owing to the heavy capital outlay required. In the early 1980's the United Nations Industrial Development Organization (UNIDO) carried out a study in Sri Lanka and recommended that a new sawmill be installed to complement the facilities of Borwood Ltd, which was operating on treated rubber wood, to enable them to undertake coconut wood utilization. The UNIDO also provided assistance with a saw doctor and other technical inputs (see Bergseng, 1984). However, these proposals have not been implemented.

In the mid 80's, the State Timber Corporation of Sri Lanka (STC) began mechanized processing of coconut wood using a sawmill gifted to the Government of Sri Lanka for processing the cyclone-felled palms in Eastern Province. After the operations in the Eastern Province were completed by the Coconut Development Authority of Sri Lanka, the sawmill was relocated at Nattandiya in the North Western Province in the heart of the coconut growing area. The STC also encouraged several private entrepreneurs to commence mechanized processing of coconut wood. Assistance was provided to these mills for stellite-tipping their saw teeth, and the sawn timber was taken by the STC. In addition to the STC sawmill, currently there are about 10 other mills engaged in coconut wood processing. However, at the present moment, the work is disrupted owing to the sudden increase in the cost of stellite-tipping. Hopefully, the STC will absorb at least a part of this increase so that the private mills could continue the operations.

Presently, the STC annually processes about 1,200 m³ of coconut logs. About 70% of this is used for the manufacture of mechanical-sawn rafters. The balance is used for the manufacture of wall-panelling, balustrades and furniture. Coconut wood also offers the possibility of reasonably long lengths of scantling, say 5 meters, which allow construction of trusses. Coconut has an

estimated stress rating of F8 for outerwood, thereby allowing the designs as per British Standards 5,268 to be used for tiled roofs (Francis and Bergseng, 1984 b).

Mechanically-sawn rafters and other roof members have become popular in the construction industry. The uniform thickness of the rafters enables easier handling, and the carpenters prefer them to hand-hewn rafters.

Facilities for curing and treating coconut wood are available with the STC.

Drying and Preservation of Coconut Wood:

Coconut timber contains more moisture than most other woods. Often 400% moisture has been encountered. The presence of high moisture content requires careful drying. Work done in Sri Lanka has indicated that coconut wood has fibre saturation point at approximately 21-23% moisture content. Low density coconut wood, which has a high moisture content, tends to collapse during early stages of drying (Mohanadas and Ratnayake, 1984).

The STC has a solar drier for sawn coconut timber, but the timber has to be stacked properly to avoid warping etc. Drying in a steam kiln appears to be the most, acceptable method to avoid defects. In a steam kiln, a week's curing is adequate (Embogama, 1988).

Several preservatives, both water-based and oil-based, are available for treating coconut wood. At the STC, the choice of the preserving agent depends on the ultimate use of the timber. For example, copperchrome-arsenate (CCA) cannot be used on sawn timber if they are to be used for wood panelling as CCA gives a colour to the wood, rendering it unsatisfactory for final polishing. Wood consigned for poles and fence posts is treated with creosote. Timber for purlins, trusses, joists and other structural members can be treated with boron. In Sri Lanka, the treatment of wood is carried out using nonpressure processes such as dipping and soaking and steeping.

Development of Coconut Wood Promming:

The income generated by the STC on coconut wood processing has been increasing gradually. The income derived in 1986 has been about SLRs 2 million and in 1987 about SLRs 4.0 million. The projected income for 1988 is SLRs 5 million (US \$ 1= Sri Lanka Rs 30).

Coconut wood processing by the private sector too is on the increase. Although accurate statistics are not available, the number of carpentry shops dealing with coconut wood has increased appreciably during the past few years.

Furniture

Coconut wood has been used as a source of timber for furniture for a long time in Sri Lanka. It is not uncommon to see coconut wood in antique furniture items. However, its use has been rather limited, perhaps due to the high cost of processing.

In the recent times, the State Timber Corporation pioneered the use of coconut wood in general furniture manufacture. The publicity given to this venture, and the availability of coconut-based furniture at affordable prices have created an awareness and interest in the general public, who have hitherto generally not considered coconut as a possible candidate for furniture manufacture. The interest generated, and the availability of mechanized processing have resulted in several small to mediumsized furniture manufacturing concerns using coconut wood. The private

sector now produces a range of coconut wood-based furniture, both for the regular and luxury markets, and the increasing demand for these products augurs well for the prospects of increasing the use of coconut wood in this sector.

Coconut Wood in the Construction Industry

A novel technique of using coconut timber for reinforcement in concrete has been described by Kulasinghe (1984). This reinforcement can either be in the form of strips of small sections embedded in the concrete or larger sections, banded to the top and the bottom of a concrete section. Rafters and reepers of sizes varying from 4" x 2", 5' x 2" and 6" x 2" have been made by this method using 2" x 1" coconut timber. Figs. 1 (a) and 1 (b) show the cross sections of such coconut/concrete members. These members allow economical construction of roofs and also give a neat and attractive appearance.

Kulasinghe (1984) has also shown that coconut timber can be embedded in concrete to reinforce the latter. A cross section of a lintel reinforced using two pieces of coconut timber of 1" x ½" is given in Fig. 1(c). However, when coconut timber is embedd steps should be taken to avoid the normal shrinkage of wood and the consequent loss of bond. This can be conveniently avoided by coating the timber first with water-proofing material.

At the National Engineering Research and Development Centre in Sri Lanka, large span (40 feet) roof trusses made of coconut wood have been tested and found to be economical. Two methods of construction suggested are (a) ordinary Howe type roof trusses, and (b) Vierendeel type roof trusses (Kulasinge, 1984).

In the recent past, use of coconut wood in house construction has increased (Samarasekera, 1988). Coconut makes the construction attractive and natural, and being an uncommon wood for purposes other than rafters, enhances the value of construction. In addition to the rafters and purlins, wall plates, ridge plates and ventilating grills made of coconut timber are not uncommon. Demand for such items is on the increase.

A notable departure from the traditional use of coconut wood is its use in supporting columns. The debarked logs are thoroughly dried and iron rods driven through the pith, which is then impregnated with wood preservative. Colourless wood preservative is used externally. Such columns should be kept off the floor with a concretepad to avoid termite damage. An alternative way of construction of column is to use coconut timber to encase concrete columns. After drying the log, it is split in two, pith removed and the two halves are thoroughly impregnated with wood preservatives. The two halves are then bolted together around the concrete column and the bolt holes plugged with same timber.

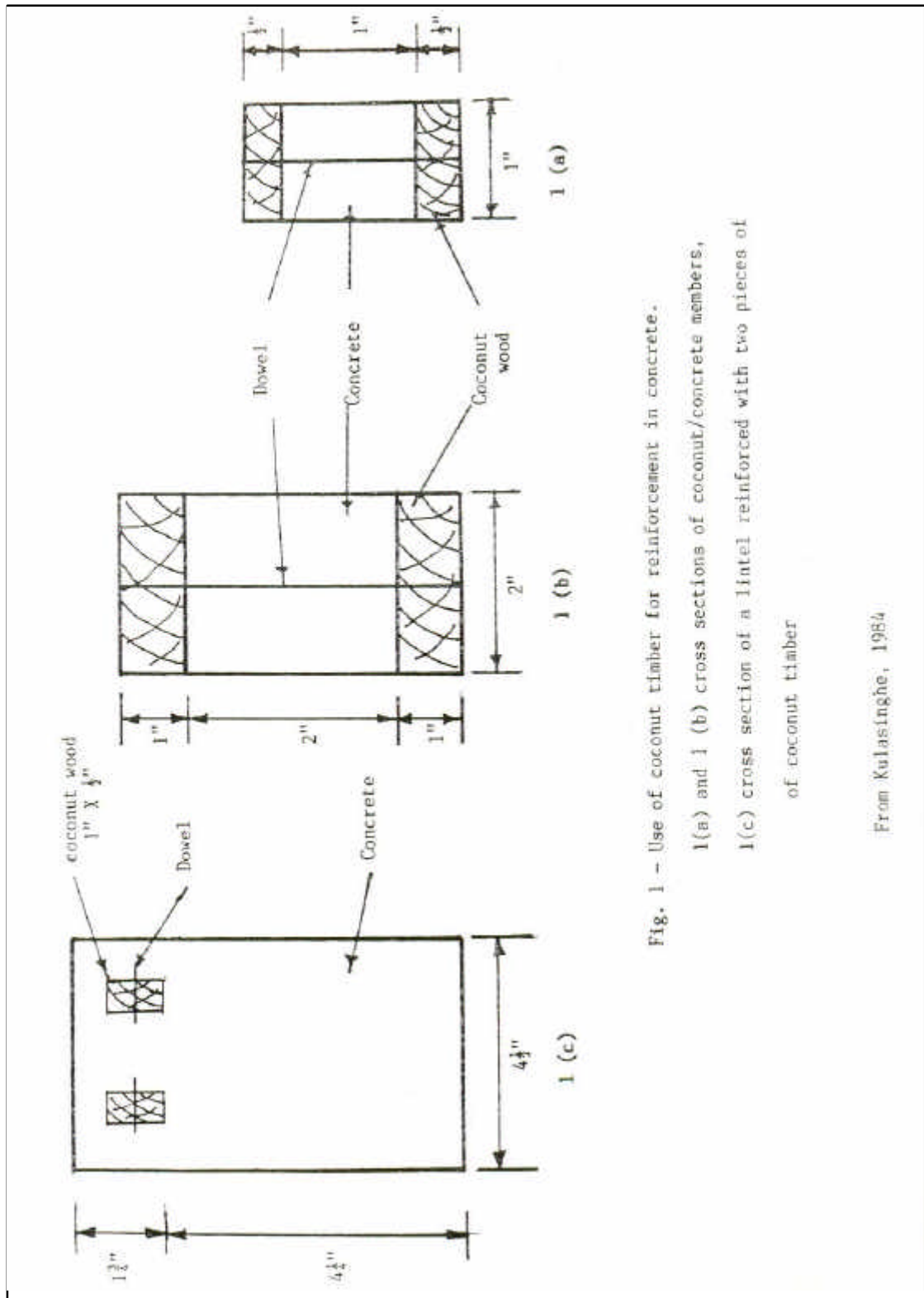


Fig. 1 - Use of coconut timber for reinforcement in concrete.

1(a) and 1 (b) cross sections of coconut/concrete members,
 1(c) cross section of a lintel reinforced with two pieces of
 of coconut timber

From Kulasinghe, 1984

Coconut Wood as a Source of Fuel

Coconut wood is well known as a fuelwood. In fact, much of the available coconut wood in Sri Lanka is yet used as fuelwood, particularly in brick and tile kilns.

The chemical composition of coconut wood is similar to other woods, with 50% carbon, 6.2% hydrogen and 43.8% oxygen. Thus thermal value is also similar to other woods, and averages 8,500 BTU/lb (oven dry basis). Coconut wood has been identified as a possible source of fuel for small-scale power generation (Groom and Associates, 1982).

In Sri Lanka, coconut logs are used extensively in both brick and tile kilns. In the manufacture of bricks, an *ad hoc* kiln is made everytime when bricks are to be cured, using the clay blocks that are to be cured as bricks. However, tile kilns are permanent ones. The use of coconut wood in tile kilns is less than that in brick kilns because of the difficulties encountered in handling coconut logs, in tile kilns.

Traditionally, coconut logs are cut into pieces of about 1 metre in length and costs about US\$ 0.50 per piece delivered to the kiln. Presently, it appears to be cheaper than other fuelwood. About 7 to 8 pieces are required to cure 1,000 bricks.

As a fuelwood, coconut wood has several attractions for brick and tile industries. Firstly, it is relatively cheap. Secondly, it is available in areas where brick and tile industries are concentrated. Thirdly, coconut wood does not generate intense heat as does some other hard wood types. In fact, the moderate heat generated by Coconut wood is ideal for curing clay. It is perhaps because burning fuel of high moisture content moderates temperature.

The National Engineering Research of Sri Lanka has manufactured a range of gasifiers, some of which could be used in copra and desiccated coconut manufacture. These gasifiers are designed to use coconut stem effectively (Kulasinghe, 1988).

Other Uses of Coconut Stem

Coconut timber can be sawn into planks varying in thickness from about ¼” to 1 The hardwood portions can be separated and laminated to produce structural members of various sizes. This process reduces the waste involved in sawing larger rectangular sections from the log itself (Kulasinghe, 1984). Manufacture of "ligno-plasticized" wood from coconut wood has already been demonstrated (Silva, 1971).

In Sri Lanka, wall panelling and balustrades made of coconut wood are becoming increasingly popular. The output of these products by the State Timber Corporation of Sri Lanka is gradually increasing (Embogama 1985).

The Ceylon Institute of Scientific and Industrial Research (CISIR) conducted research and demonstrated the feasibility of manufacture of paper board, fibre board and particle board from the softer portions of the coconut stem (Silva, 1971). However, the technoeconomic aspects of these processes need further study.

With the increasing mechanical sawing of coconut logs, the demand for coconut wood saw dust by the rural populace for cooking stoves is increasing. It is claimed that coconut wood saw dust gives ideal heat for cooking. This aspects needs further investigation. Coconut wood saw dust is also in demand for tile and brick kilns.

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