TIMBER TECHNOLOGY BULLETIN

Published by Forest Research Institute Malaysia, 52109 Kepong, Selangor Darul Ehsan No. 35, 2005 ISSN:139-258

Characteristics and utilisation of oil palm stem

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Introduction

The oil palm (*Elaeis guineensis* Jacq.) was introduced to Malaysia in the early 1900's. However, extensive cultivation was not carried out until the 1960's. Today, the total area under oil palm cultivation in Malaysia is well over 3 million hectares and about 80% of which are in Peninsular Malaysia.

Oil palms are usually felled after the age of 25 years, either due to their decreasing yield or because they have grown too tall which makes harvesting very difficult. For the disposal of oil palm stems, they are normally left to rot or are burnt in the field. However, freshly felled stems with their high moisture content cannot be easily burnt in the field. Leaving the stems in the field without further processing will physically hinder the process of planting new crops as the stem can take about five years to decompose completely. Meanwhile, they serve as the breeding grounds for insect pests such as rhinoceros beetles (*Oryetes rhinoceros*) and stem rotting fungi *Ganoderma* spp. The practice of disposing oil palm stems by burning is now considered unacceptable as it creates air pollution and affects the environment. Thus, with the expected large volume of oil palm stem available annually due to replanting, the task of finding ways to utilise this enormous amount of lignocellulosic material is great.

General characteristics

The oil palm, being a monocotyledon, has marked structural differences from our commercial timbers. The most remarkable features of woody monocotyledons are that most of them achieve their stature without secondary thickening. Thus, unlike the wood of most other tree species, which is mostly secondary xylem, the wood of oil palm consists of primary vascular bundles embedded in parenchymatous tissue (Figure 1). There is usually a very hard peripheral rind surrounding the soft central region. The wood of palm is not homogenous.

Anatomically, the hard peripheral zone composed of a narrow layer of parenchyma and congested vascular bundles giving rise to a sclerotic zone, which formed the main mechanical support of the palm stem. The central zone consists of larger and widely scattered vascular bundles embedded in the thin-walled parenchymatous tissue. Each vascular bundle consists of a fibrous sheath, phloem cells, xylem, and parenchyma cells and surrounded by spherical, druse-like silica bodies (Figure 2). The xylem is always sheathed with parenchyma cells and usually consists of one or two wide vessels.

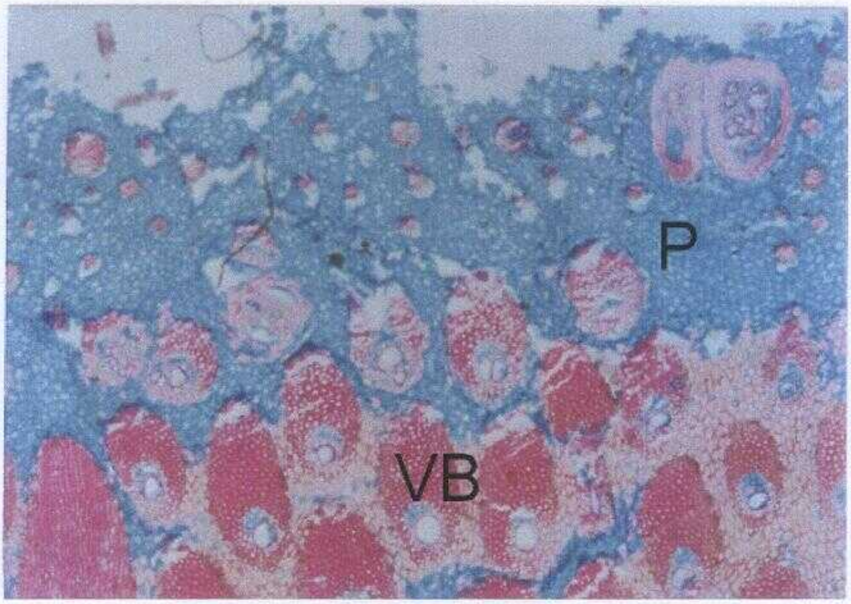

Figure 1 Cross section of oil palm stem showing vascular bundles (VB) embedded in parenchymatous tissue (P)

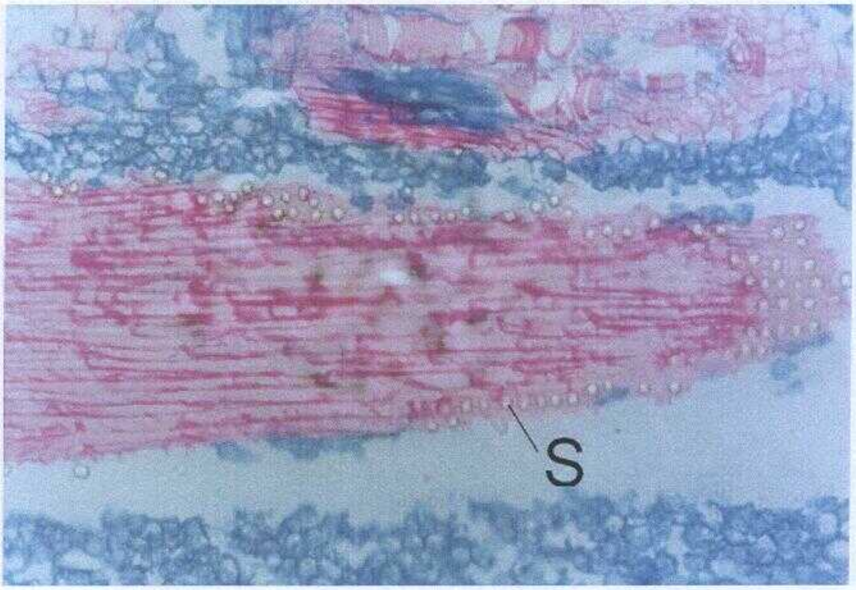

Figure 2 Longitudinal section of oil palm stem showing fibrous tissues surrounded by silica bodies (S)

Density

As with other monocotyledons, the density of oil palm stem shows considerable variability over the stem, both radially and vertically (Lim & Khoo 1986) (Figure 3). Generally, the density at the peripheral region is over twice the values of the central region. At any height level, the density decreased towards the centre of the trunk. The mean density ranges from 485–575 kg m^{-3} (average 530 kg m^{-3}) and 190–280 kg m^{-3} (average 235 kg m^{-3}) at the peripheral and central regions respectively. The density of oil palm stem is generally low. For example, the average density of oil palm stem at the peripheral region (530 kg m^{-3}) is very similar to sesendok (*Endospermum diadenum*) (average 530 kg m^{-3}) but lower than Malaysian oak (*Hevea brasiliensis*) (average 640 kg m^{-3}). The density of the central region, which is 190–280 kg m^{-3}, is about half of that of some common light weight timbers like damar minyak (*Agathis borneensis*) (465 kg m^{-3}) and jelutong (*Dyera costulata*) (465 kg m^{-3}). Recent study by Gan *et al.* (2001) on 30-year-old oil palm stem reported a range of 140.9 to 635.1 kg m^{-3}.

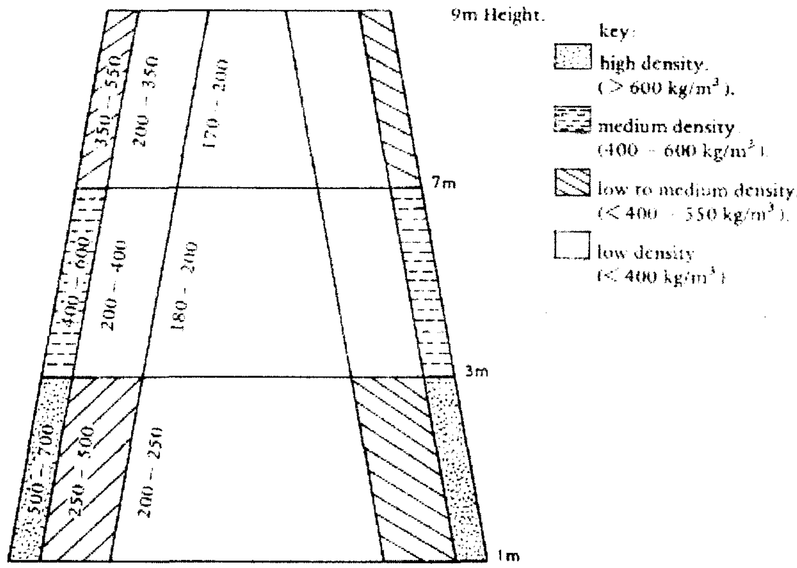

Figure 3 Schematic diagram of density variation in oil palm stem (Source: Lim & Khoo 1986)

Moisture content

The stem of oil palm contains a large amount of water. Lim & Khoo (1986) reported that the moisture content of the stem could range from 120% to more than 500%. The peripheral region contains the lowest moisture content and increases progressively from the peripheral region to the pith or central region. A separate study by Gan *et al.* (2001) on five 30-year-old oil palm stems revealed that the moisture content varies from 76.5% to 575.4% with a mean of 326.2 ± 115.7% (Figure 4). The moisture content variation can possibly be explained by the relative amount of vascular bundles and parenchymatous tissue within the oil palm. The latter is known to retain more moisture than the former.

The high moisture content gradient as found in the oil palm stem is likely to cause a lot of problems in the drying process.

Drying of oil palm boards

Drying of oil palm wood is expected to be problematic due to the high moisture and density gradients and variations mentioned above. As such, it is advisable to dry boards of oil palm stem separately according to the range of density and moisture content. For example, boards from the peripheral region having higher density but lower moisture content should be dried separately from the middle and the inner regions.

Experiments carried out at FRIM (Ho *et al.* 1985) discovered that oil palm boards of 25 mm thick required 60 days to dry from an average moisture content of 128.0% to 15.7%. Collapse was the main drying defect especially those from the central and inner regions of the stem. Other defects observed by the authors include cupping and wavy formation (Figures 5 & 6).

Kiln drying was able to reduce the drying time for the boards by less than half depending on the drying schedule used. When a mild schedule was used (Schedule B), it took about

15 and 24 days to dry boards of 25 mm and 50 mm respectively. When a faster kiln drying schedule was used (Schedule E), 25 mm boards took about 4 to 9 days to dry. Main drying defects reported include collapse and 'raised grain' (Ho *et al.* 1985).

A recent study by Anon (2002) on the kiln drying properties of 20 and 30-y-old oil palm boards found that 70% of 20-y-old boards had severe drying defects such as deformation, surface and internal checks whereas the remaining 30% which were from the peripheral region had mild or no defect. The drying period for the 20-year-old oil palm boards was 14 days using the schedule as shown in Table 1. For the drying of the 30-year-old oil palm, drying schedule for the 20-year-old oil palm was modified as shown in Table 2. The recovery rates of dried boards were between 75 to 80%. The main defects were deep surface checks and collapses. It is therefore, advisable to sort the materials by density or green moisture content before drying to avoid excessive drying defects.

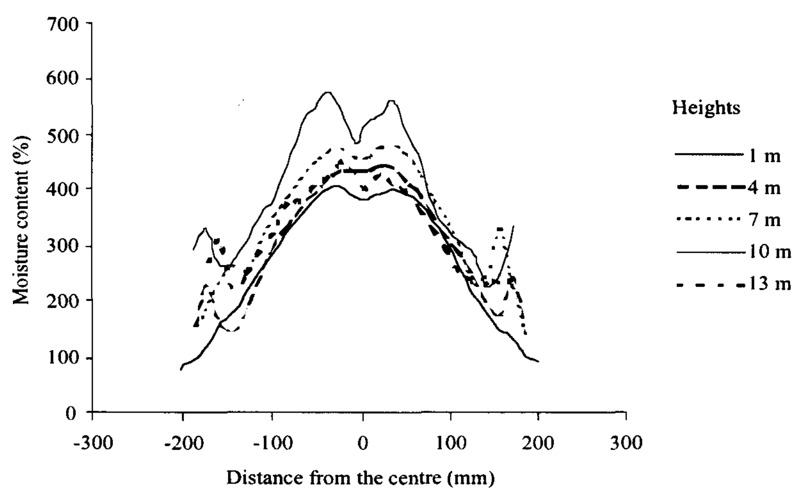

Figure 4 Moisture content variation of oil palm stem (Source: Gan *et al.* 2001)

Table 1 Drying schedule for 20-y-old oil palm boards

Moisture content	Dry bulb temperature (°C)	Wet bulb temperature (°C)	Duration (hours)
Conditioning – average moisture content 227%	41	41	6
Drying commence – average moisture content 213%	43	41	48
130%	44	41	72
80%	47	41	24
42%	48	40	24
23%	50	41	24

Table 2 Drying schedule for 30-y-old oil palm boards

Moisture content	Dry bulb temperature (°C)	Wet bulb temperature (°C)	Duration (hours)
Conditioning – average moisture content 242%	40	40	8
Drying commence – average moisture content 214%	43	41	24
171%	44	41	24
136%	46	41	24
88%	50	42	24
52%	52	42	24
30%	56	44	24
14%	56	47	24
Equalization treatment moisture content 9–10%	56	47	20

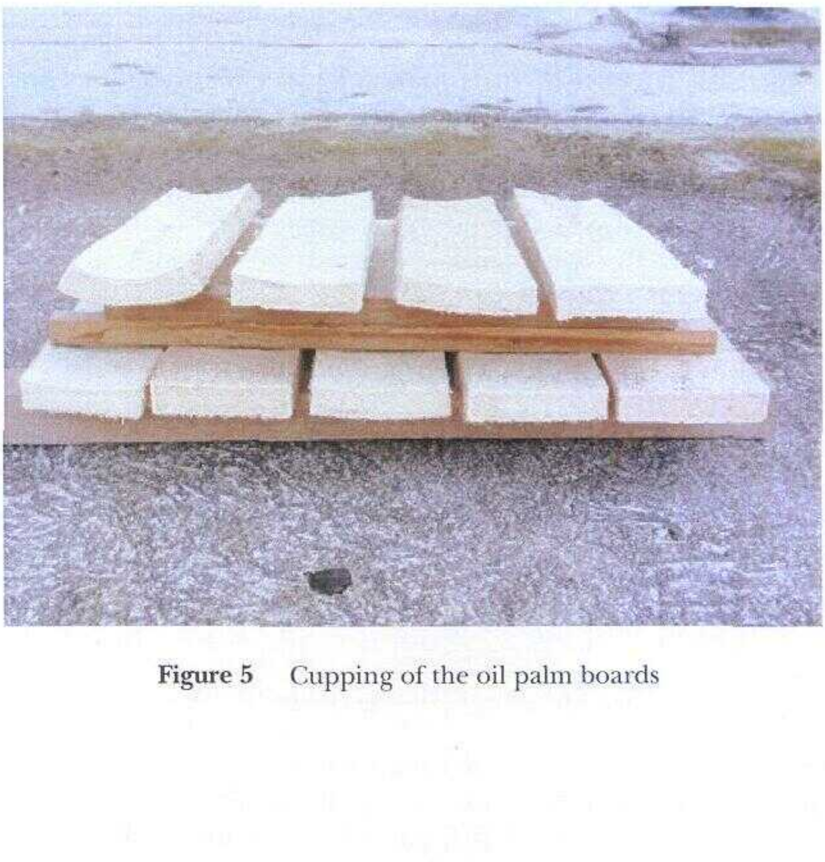

Figure 5 Cupping of the oil palm boards

Figure 6 Wavy formation of oil palm boards

Preservative treatment of oil palm boards

Oil palm logs or oil palm boards attract infestation of both insects (beetles) and fungi fairly quickly (some even happened overnight) when they are left in the field or even under cover (personal observations by the authors). The high susceptibility of oil palm stem and boards to infestation by both fungi and insects are due to the presence of high sugar and starch in the parenchyma cells.

Experiments carried out at FRIM on the effectiveness of preservative on fungi and insects indicated that by applying a mixture of 2% Sodium Pentachlorophenate and 2% Borax, it was only 89% effective up to 21 days and 55% effective at the end of 42 days. To achieve a higher level of control, it was suggested that either the strength of the preservative be increased or alternative preservatives used (Ho & Hong 1991). However, the use of Sodium Pentachlorophenate has been banned in Malaysia since 1993 and as such, alternative preservatives such as Methylene-bis-thiocynate (MBT) and 2-thiocyanomethylthio benzothiazole (TCMBT) could now be used as the substitutes for Sodium Pentachlorophenate (Tang 2005).

Machining properties

The sawing and machining of oil palm stems have been reported to be difficult and the quality of finish was rough (Ho *et al.* 1985) (Figures 7 & 8). The rough surfaces were either due to raised vascular bundles strands or tearing of the cells. The difficulty in the sawing and machining of oil palm is expected as it has been shown anatomically that all the vascular bundle strands are surrounded by silica bodies (Figure 2) which will blunt the cutter knife easily.

Strength properties of oil palm wood

The high density variation within the oil palm stem has a significant effect on its strength properties. Based on a joint study conducted by University of Malaya and FRIM (Anon 2002), the modulus of elasticity (MOE), modulus of rupture (MOR) and compressive strength along the grain are found to be linearly correlated to the density. Table 3 shows the comparison of basic strength properties of oil palm wood and coconut wood. At the higher density (> 500 kg m^{-3}) range, oil palm wood can be classified under the Strength Grouping 7 together with timbers like geronggang, sesendok, pulai and terentang. Generally, the wood is weak, but with proper design, oil palm wood may have some uses in the construction industry.

Table 3 Comparison of basic strength properties of oil palm wood and coconut wood

Density (kg m^{-3})	MOE (N mm^{-2})		MOR (N mm^{-2})		Compressive strength (N mm^{-2})	
	Coconut	Oil palm	Coconut	Oil palm	Coconut	Oil palm
> 500	8600	6744	12.9	68.7	10.2	38.1
350 – 500	4400	5094	7.5	52.5	6.4	31.4
< 350	2200	1712	2.5	18.1	3.0	13.0

Utilisation of oil palm stem

Oil palm wood has the potential to be used for various applications as enjoyed by coconut wood popularized in the Philippines. With proper treatment against bio-deteriorating agents, oil palm wood could be used for various light construction applications. It can be also used as core material for the production of blockboard and plywood, which in turn, can be used as framing material for the manufacture of upholstery furniture. Selected materials from the stem may also be used for the manufacture of furniture. Veneers obtained from stem are used for the manufacture of formed plywood for furniture components.

Beside the uses mentioned above, other possible usage of oil palm stem is in the form of composite panel products such as particleboard, wood-cement board, gypsum-bonded particleboard and medium density fibreboard (MDF) (Chew *et al.* 1991). Research also indicates that the kraft pulp from oil palm stems can be used as reinforcing material for cellulose fibre reinforced cement boards (CFRC) (Abraham *et al.* 1998). Other uses investigated include the briquetting of oil palm stem with empty fruit bunches and pressed fruit fibres into solid fuel pellets. Apparently, the calorific value of the fuel pellets produced is very similar to that of most tropical hardwoods (about 17.8 MJ kg^{-1}). Under controlled conditions, it is also possible to convert oil palm stem through enzymatic activity into fermentable sugars to produce alcohol fuels (Hoi & Putri 1991). There is also the possibility of using oil palm stem as a roughage and energy source in ruminant feeds for cattle (Ismail & Hoi 1991). Other possible uses of oil palm stem may be in the form of novelty items such as ash trays, lamp shades, paper weights, pencil and calling card holders and cigar boxes. Treated materials of oil palm stem may also be used as insulating material. In view of the overall low density, the use of the stem, even the harder portion, for load bearing properties is not advisable. The compositions of the structure and the presence of a large amount of parenchyma cells is likely to make the 'wood' of the palm less rigid resulting in excessive creep (long term deformation) or sudden failure if an excessive load is applied.

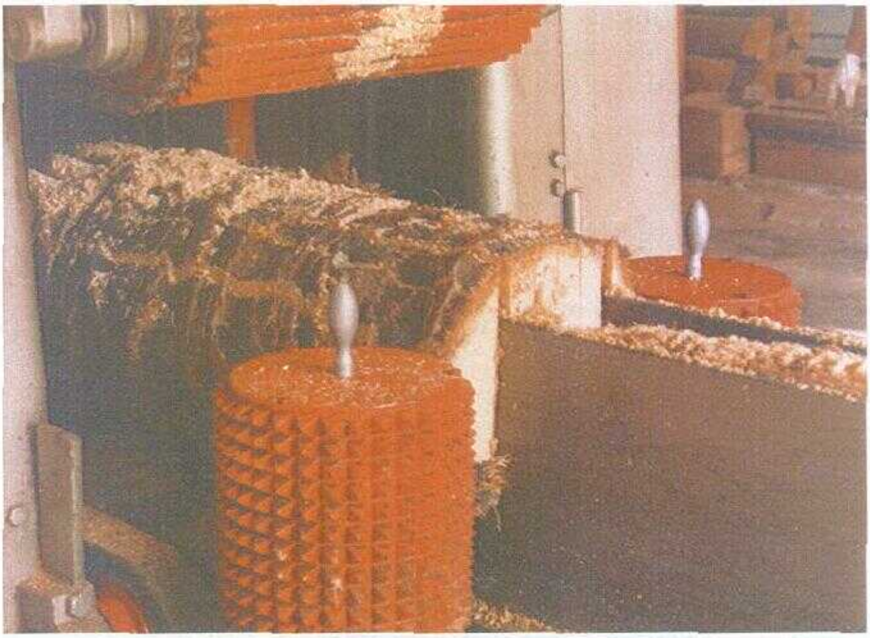

Figure 7 *Sawing of oil palm stem using gang-saw*

Figure 8 Sawn surface of oil palm board

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Series Editor: Y. E. Tan
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