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DP/ID/SER.A/650
1 November 1985
ENGLISH

15022

REGIONAL COCONUT WOOD TRAINING PROGRAMME

DU/RAS/81/110

# Technical report: Grading rules for coconut palm sawn wood*

Prepared for the Governments of the countries participating in the regional project by the United Nations Industrial Development Organization, associated agency of the Food and Agricultural Organization of the United Nations, which acted as executing agency for the United Nations Development Programme

Based on the work of V. K. Sulc, wood technologist

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## ABSTRACT

This paper describes how to classify coconut palm sawn wood into three density groups which is the most important part of stress grading, since primary recovery of sawn material is greatly influenced by the large basic density gradient within the stem.

The relationship between the density and stiffness of green (freshly sawn) coconut palm wood, which has nearly constant weight regardless of its density, is used as a basic principle of density group grading. The practical application of density grading by stiffness is described in detail in Part I with tabulated theoretical and experimental deflection values for sawn wood of different lengths and thicknesses under its own weight.

The second part of this paper describes the proposed permissible defects for visually stress graded coconut palm wood. The grading rules cover unseasoned and seasoned sawn wood for light frame construction material of high and medium density groups. To simplify the rules as much as possible, each density group has only one grade of a 75 per cent strength ratio.

Appearance grade is defined as material selected from each grade. In addition, cull grade is recommended. General grading rules for sawn boards are described covering materials to be used as flooring, parquetry, interior and exterior linings, roofing and siding shingles, general joinery and selection of boards intended for glue lamination of larger construction beams.

Finally, this paper contains description and proposed measurements of defects common to coconut palm wood.

ACKNOWLEDGEMENTS

The kind assistance and co-operation of the following are gratefully acknowledged:

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# PREFACE

This technical report is one of a series of reports prepared during the course of the UNDP/FAO/UNIDO project identified on the title page. The conclusions and recommendations given in the report are those considered appropriate at the time of its preparation. They may be modified in the light of further knowledge gained in this important subject, since practical use of coconut wood is still in the early stages of development.

## PART I. DENSITY GROUPS

### 1. INTRODUCTION

The purpose of grading is to maintain between sawmills standard and uniform products of similar quality regardless of regional characteristic of coconut palm stems or position of logs within the stem. Uniform grades will help the buyers and sellers of coconut wood gain confidence in the material and help determine economic uses.

Coconut palms (Cocos nucifera) are monocotyledons and form branchless stems of up to 26 metres with average breast height diameter of approximately 28 centimetres. Sawn coconut palm wood has relatively few defects; the most important characteristic is the large variation in density within the stem. The lesser problem of cross grain (cross vascular bundles) must be considered as an inherent characteristic.

Coconut palm wood nevertheless has a similar cell structure, similar chemical composition, physical and mechanical properties to conventional wood.

Coconut palm wood is similar to hardwoods and because of its large distribution in the tropical zone, could be a valuable wood of commercial significance with improved technological knowledge as sawing, strength and other properties, drying, preservation and general utilization for many end-use products where light frame construction dominates the requirements.

Individual pieces of wood, as they come from the saw, represent a wide range of densities and other characteristics such as defects, and maximum economic utilization is obtained by proper grading of the sawn wood.

Construction wood grading is based on a combination of designated mechanical properties at near minimum strength and average stiffness (Modulus of Elasticity), including sets of permissible defects.

Utility sawn wood (boards) below 38 mm thickness are not necessarily graded by mechanical properties since appearance and density are the important factors when used in construction as non-load bearing members. An exception is flooring where appearance and highest density (resistance to wear) are important factors.

Joinery grade is based on appearance, preferably defect-free and may be obtained on this basis from any designated stress grade depending on final end-use.

## 2. GRADING RULES AND METHODS OF DENSITY GROUPING

The proposed grading rules are as simple as possible, to be easy to apply and understood.

The first most important step of grading coconut palm sawn wood is to classify saw-falling material into three density groups:

| | |
|---|---|
| Basic density 600 $kg/m^3$ and above | Hard |
| Basic density 400 to 599 $kg/m^3$ | Medium |
| Basic density below 400 $kg/m^3$ | Soft |

Four methods are recognized:

(i) Density grouping by stiffness

(ii) Sawing pattern combined with log grading

(iii) Colour marking high density wood on both ends of log

(iv) Observation from which portion of log a piece of wood was sawn

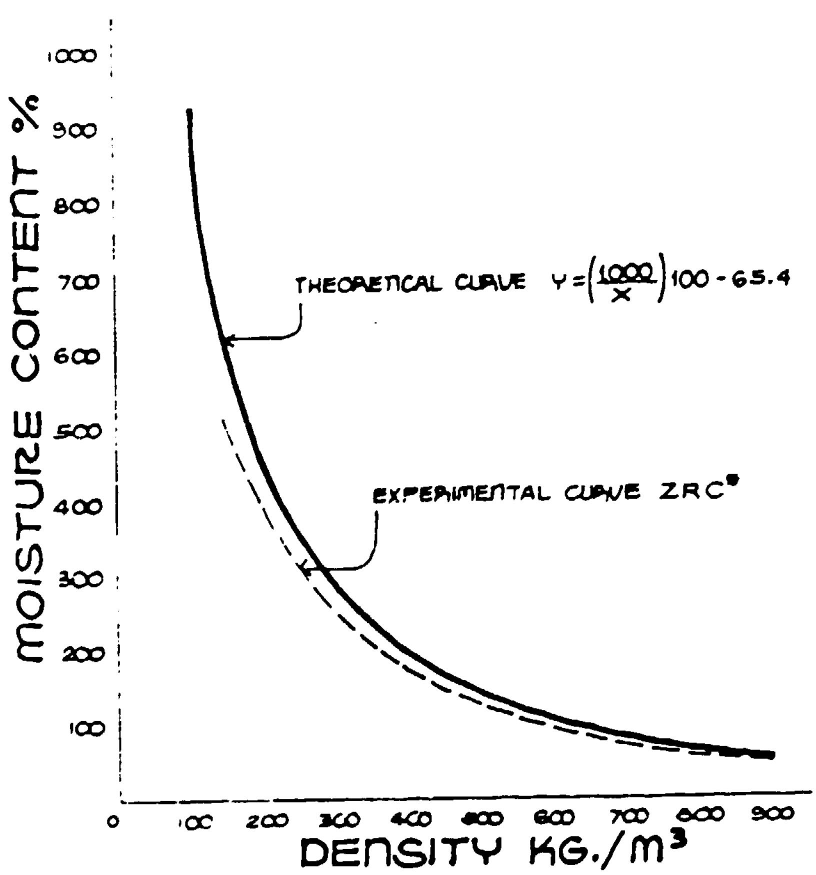
## 2.1 Density grouping by stiffness

Green coconut palm wood (directly from the saw) regardless of its density has nearly the same weight in relation to a given volume (green density) due to the varying moisture content within the stem. The situation is:

| Basic density | Green density | Moisture content |
|---|---|---|
| (800 $kg/m^3$) | - | (58 % approx.) |
| 600 $kg/m^3$ | 1,188 $kg/m^3$ | 98 % approx. |
| 400 $kg/m^3$ | 1,148 $kg/m^3$ | 187 % approx. |
| 250 $kg/m^3$ | 1,125 $kg/m^3$ | 348 % approx. |

The relationship between density and moisture content is shown in Figure 1 for fully saturated wood.

FIGURE 1



The theoretical curve is based on the density of coconut palm wood substance (approximately 1.53 g/cm$^3$) experimentally determined by Paul Jensen, Associate Expert, FAO at Rotorua Forest Research Institute, New Zealand and PCA-Zamboanga Research Center, Philippines - 1978.

The experimental curve was obtained at PCA-Zamboanga Research Center by Wulf Killman, Associate Expert, FAO - 1979. The slight deviation to the theoretical curve could be attributed to the specimens of lower density and higher moisture content which lost some moisture during laboratory processing.

The relationship of moisture content and density has no practical application to density grading of green sawn coconut palm wood.

The method of grading green sawn wood by its stiffness has been found the most accurate, simple and easily adopted to sawmill procedures.

The green weight (green density) of a piece of coconut palm saw wood, its thickness and length are the factors which with the measurement of deflection (stiffness) under own weight eventually determine the appropriate density group.

Figure 2 (page 6) shows an arrangement to measure the deflection of a piece of wood.

Theoretical deflection values could be calculated from standard deflection formula for an equally distributed load.

$$\Delta = \frac{a \times w \times l^3}{ME \times MI}$$

where: a = constant for equally distributed load - 5/384

w = load in Newton for a given volume of a piece of wood

l = length in metres

ME = Modulus of Elasticity in GPa (MPa/1,000)

MI = moment of inertia for rectangular cross section

= $b \times d^3/12$

where: b = width in mm

d = depth in mm

$\Delta$ = deflection in mm

Calculation of theoretical value of deflection for coconut palm sawn wood:

Basic density 600 kg/$m^3$ and above - Hard (based on green density 1,188 kg/$m^3$)

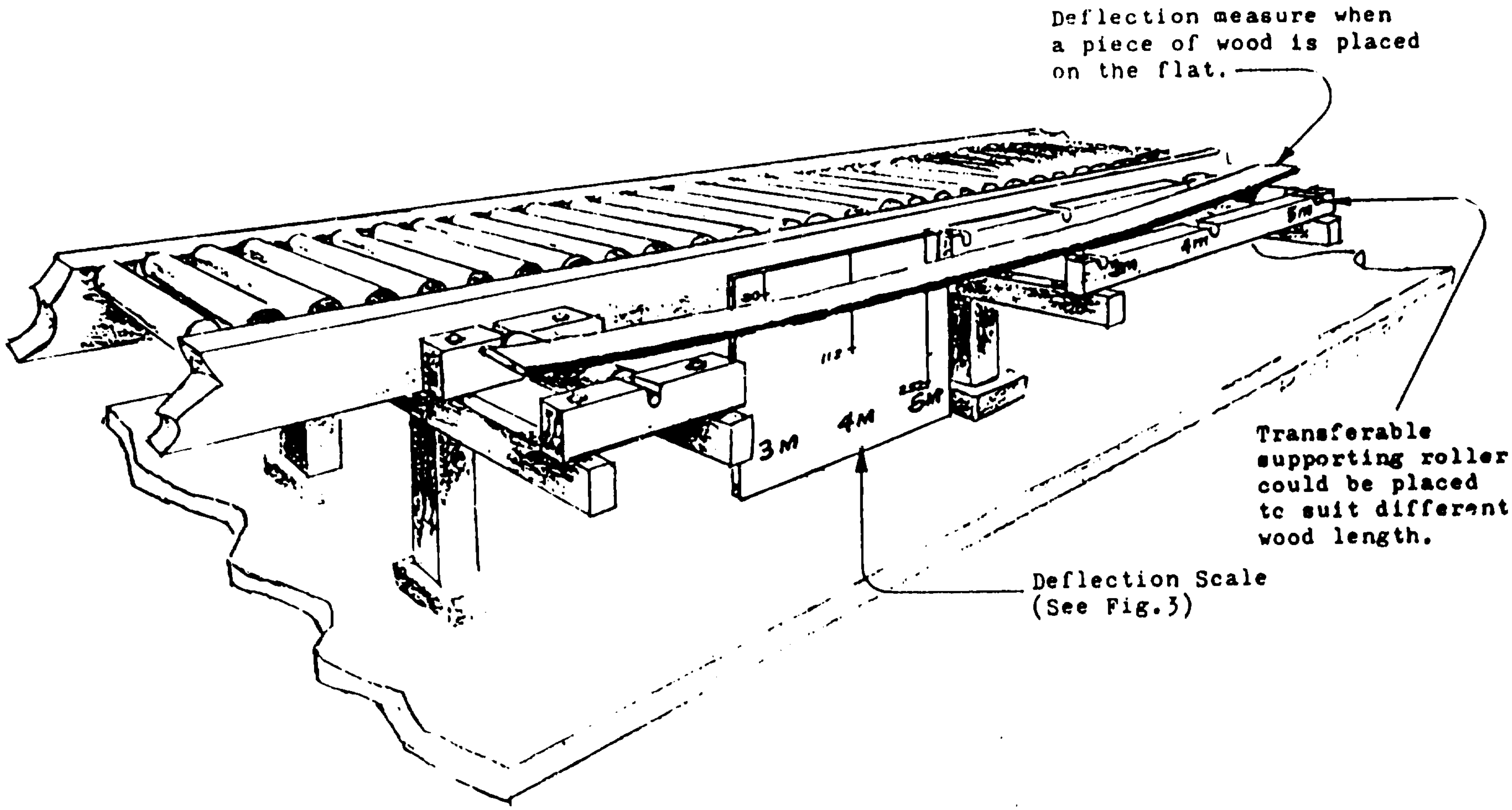



FIG. 2. Deflection "Grader" Arranged Along the Green Sawn Wood Transfer Rolls.

Deflection formula could be rearranged as follows:

$$\Delta = \frac{6.99 \times 10^5 \times 1^4}{384 \times 6.5 \times d^2} = \text{deflection in mm}$$

where: 1 = length in metres

ME = 6.5 GPa (approximate minimum value for basic density 600 $kg/m^3$)

d = thickness of wood in mm

NOTE: To change kg to Newton, multiply kg by 9.81

Basic density 400 - 599 $kg/m^3$ - Medium (based on green density 1,148 $kg/m^3$)

$$\Delta = \frac{6.76 \times 10^5 \times 1^4}{384 \times 5.0 \times d^2}$$

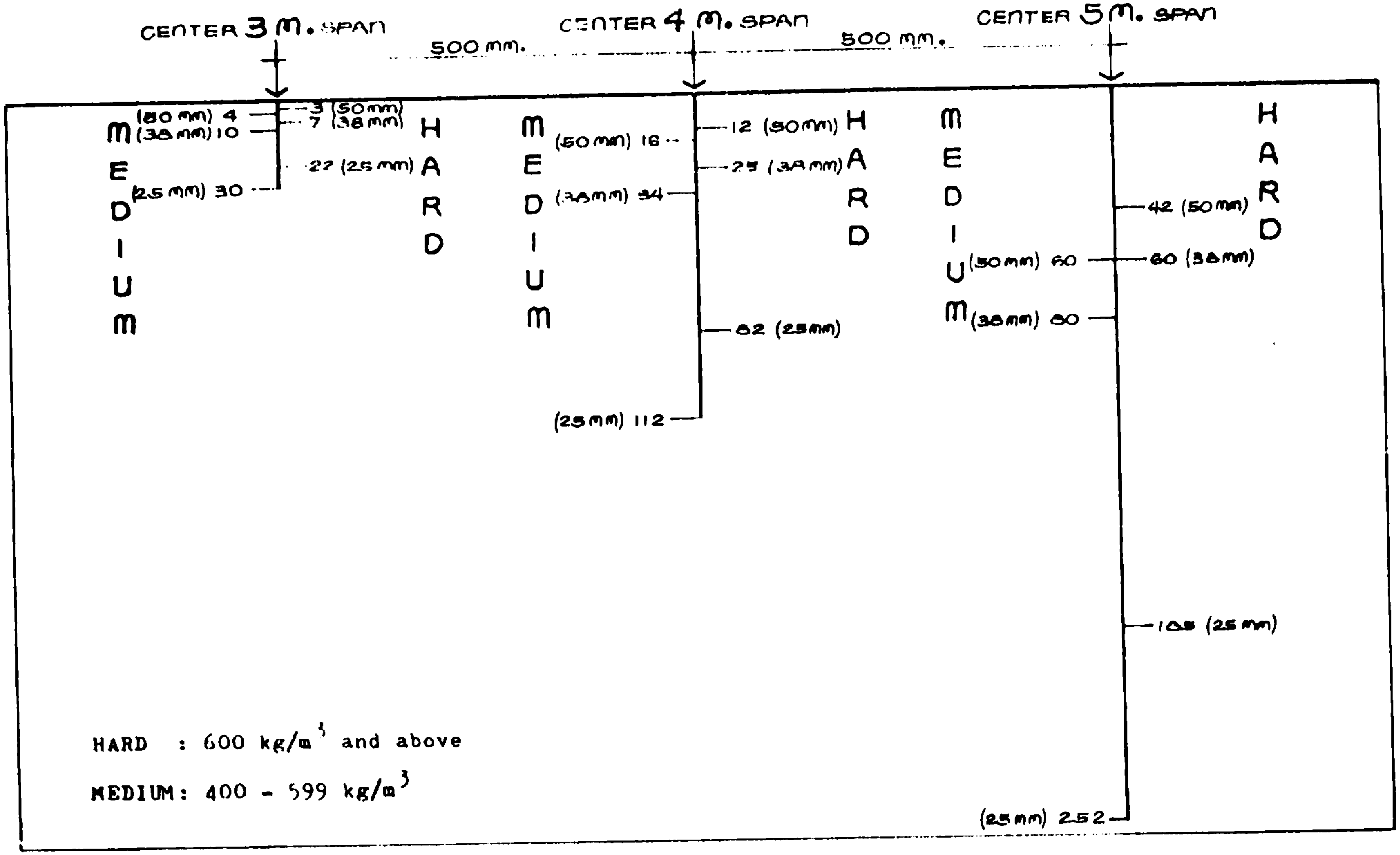
where: ME = 5.0 GPa (approximate minimum value for basic density 400 $kg/m^3$

Table 1 shows theoretical values for green wood deflection and density grouping.

**TABLE 1**

| Density group ($kg/m^3$) | Length of wood (m) | Theoretical maximum deflection in mm — Depth of wood: 25 mm | 38 mm | 50 mm |
|---|---|---|---|---|
| 600 and above | 5 | 280 | 121 | 70 |
| 400 to 599 | | 352 | 152 | 88 |
| 600 and above | 4 | 115 | 50 | 29 |
| 400 to 599 | | 144 | 62 | 36 |
| 600 and above | 3 | 36 | 16 | 9 |
| 400 to 599 | | 46 | 20 | 11 |

FIG. 3. Deflection Scale Based on Experimental Values.




Figures in parenthesis are thickness of the tested wood.

The values in millimeters in the deflection scale represent maximum deflection for a particular piece of wood thickness and length. If deflection is larger than the given values, a wood is considered "soft", e.g., average basic density below 400 kg/m$^3$ (sp. gravity .4 g/cm$^3$).

Theoretical deflection values when applied to practical application have been found too high. Therefore, by experimental testing and taking data from a considerable number of selected specimens of different lengths and thicknesses, an experimental table has been established which is recommended for use.

NOTE: The pieces of wood from which experimental deflection values were obtained were subjected to standard laboratory density test. A minimum of two samples were taken from each tested piece of wood.

Many deflection test specimens were originally 5 metres and were cross-cut to 4 metres and eventually to 3 metres to obtain values for different lengths.

Table 2 shows experimental maximum deflections for different thicknesses and lengths for green sawn wood for appropriate density grouping. Figure 3 shows these schematically as they might appear with the rig shown in Figure 2.

The attempt to find a general correction factor for the theoretical values has not been so successful. Approximate value of correction factor for the wood up to 30 mm thickness is about 0.7 and for wood between 30 mm to 50 mm, it is about 0.5. Also, the MoE value of 6.5 GPa used to calculate deflections in Table 1 is very conservative. A value of 11 GPa would have been acceptable in view of the results shown in document DP/ID/SER.A/648 Part II, Figure 9. This would give deflections of 47 per cent of the values given for F5 (400 to 599 $kg/m^3$), i.e. instead of 20, 62 and 52 mm for 38 mm wood, the deflections should be 9, 29 and 71 mm.

Deflection values for different lengths or thicknesses of wood could be calculated by linear interpolation from the given table values.

NOTE: The deflections for seasoned wood could be established if the moisture content were knwon (nominal weight). For seasoned wood to 16 per cent moisture content, the value of Modulus of Elasticity for each density group could be increased by 10 per cent.

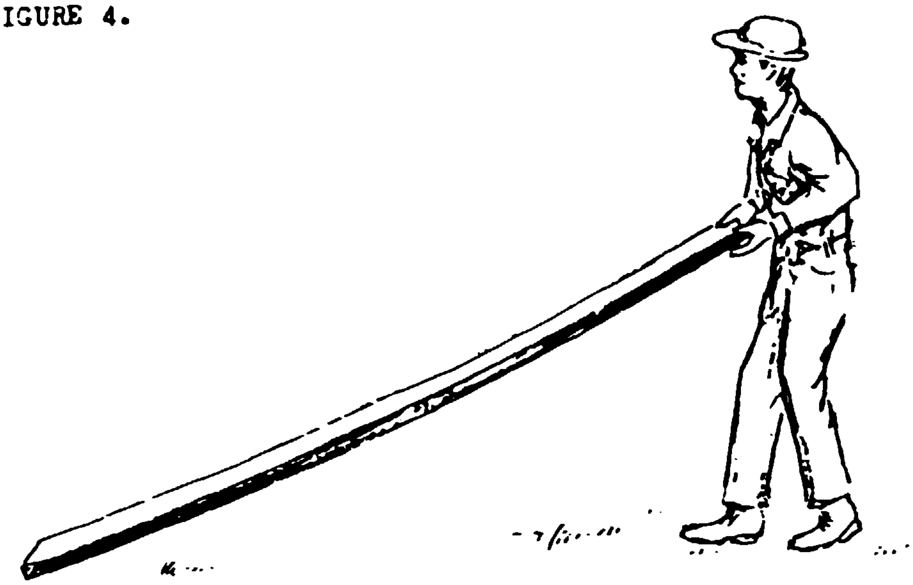
TABLE 2

| Density group ($kg/m^3$) | Length of wood (m) | Experimental maximum deflection in mm | | |
|---|---|---|---|---|
| | | Depth of wood | | |
| | | 25 mm | 38 mm | 50 mm |
| 600 and above | 5 | 185 | 60 | 42 |
| 400 to 599 | | 252 | 80 | 60 |
| 600 and above | 4 | 82 | 25 | 12 |
| 400 to 599 | | 112 | 34 | 16 |
| 600 and above | 3 | 22 | 7 | 3 |
| 400 to 599 | | 30 | 10 | 4 |

The deflection/density grader as shown in Figure 2 could be simplified to suit the sawmill layout.

NOTE: Sufficient skill may be obtained by experienced graders to estimate the size of deflection. (See Figure 4 on next page.) This method has been used with high accuracy by men who were trained for 2 to 4 months.

FIGURE 4.



Variation in any density group

In practice, up to 10 per cent (10 pieces of wood in 100) maximum variation within a density group should be acceptable. (E.g., 10 pieces in 100 may be of a lower density group than specified.)

2.2 Sawing pattern combined with log grading

The method of grading or sorting sawn coconut palm wood by sawing pattern combined with log grading could assist in density grouping.

If coconut palm logs are separated at the log yard as butt logs, No. 2 logs, No. 3 logs, etc. (e.g., in sequence as progressively cut from the stem), the logs will have different diameters and the proportion of high density wood will progressively decrease. This knowledge could be incorporated into the sawing pattern in such a way that structural wood is recovered from butt logs and No. 2 logs where the section of higher density wood is largest. Logs No. 3 or No. 4 which are cut from higher parts of the stem will rarely be able to produce sawn wood in the "hard" grade.

This, combined with the rule that the central portion of the log should not be used as load-bearing construction material and should be sawn to boards of thickness up to 30 mm, may be used as grading basis. The boards are nearly always subject to seasoning and could be regraded when moisture content is considerably reduced. This is relatively simple as the weight of wood is distinctly different for each density group.

## 2.3 Colour dye marking on ends of logs

Colour dye marking may be used to differentiate zones in the section representing density groups and their radial depth. The portion of higher density wood is distincly visible by higher concentration of lignified (darkened) vascular bundles. Scattered individual vascular bundles representing lower density wood are situated in the central portion of a cross section. Figure 5A shows a log cross-section where colour dye marks the high density wood. Figure 5B shows a sawn wood section indicating a small proportion of lower density wood.

FIGURE 5A

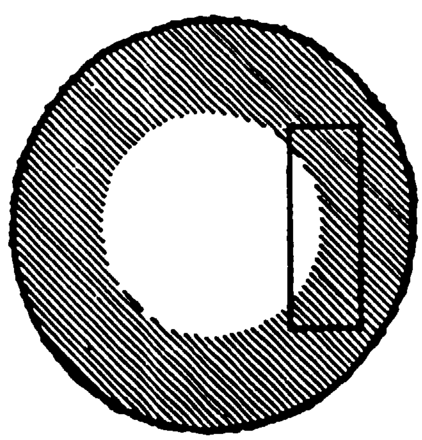
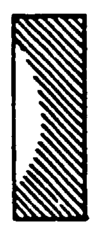


FIGURE 5B.



When logs are converted to sawn material, ends with easily visible colour mark could be used for fast estimation of the proportion of lower density in a piece of wood and be graded accordingly. Estimation of proportion of medium density material requires considerable judgement.

## 2.4 Observing from which portion of log sawn wood has been cut

The method applies to small operations where the sawing pattern could be marked by crayon or chalk on end section of the log. This is further assisted by the simple rule that construction material is always recovered from the outer portion of logs, and boards up to 30 mm thick are taken from the central portion.

NOTE (on vascular bundles):

A dark brown colour indicates cell wall thickening (lignification) which predicts higher density wood. The more concentrated the denser the wood.

A grader has to be familiar with this phenomenon as the concentration of vascular bundles is always greatest close to the stem perimeter and is the same or nearly the same along the stem height. As the stem diameter decreases, the concentration decreases.

Dense concentration of soft colourless vascular bundles indicates low density wood from higher or inner portions of the stem.

Darkened vascular bundles are a better indicator of density if the wood is dry or partly dry as the colour is more distinctive.

## PART II. VISUAL GRADING FOR DEFECTS

### 1. VISUALLY STRESS GRADED COCONUT PALM SAWN WOOD INTENDED FOR STRUCTURAL USE

Moisture condition: Unseasoned and/or partly dry.

This proposed grading rule for coconut palm sawn wood is produced with the intention of being easily understood and as simple as possible. The sawn wood first has to be classified to density groups which is probably the most important part of grading. However, a certain simplification is possible since coconut palm wood has relatively few inherent defects. To avoid too many different "grades", it is proposed that each density group will have only one stress grade:

Hard - Grade 75 classified as stress grade F11
Medium - Grade 75 classified as stress grade F5

Those pieces of wood from either density group containing defects not allowed or larger than permissible in Grade 75 should be resawn longitudinally to smaller dimensions or cross-cut to shorter length in order to remove or reduce such defects to the given "grade" permissible size.

Each density group should have a "cull or reject grade", defined as a piece of sawn wood of useful size but having non-permissible defects. This proposition has some merit as it is common in the Pacific region sawmills sawing tropical hardwood to market such "cheap" grade where the buyer or user recross-cuts the wood to useful dimension and uses it for temporary or semi-temporary light construction. The offcuts are utilized as valuable kitchen firewood.

It is not recommended to transfer a piece of wood classified to the hard density group (F11) to the medium group (F5) by the assumption that a strength-reducing defect will be acceptable in the lower density group with a lower strength classification. However, this rule may be too rigid in view of the predominate role of Modulus of Elasticity in stress grade classification. More experience should be gained in using coconut wood before relaxing such a rule.

NOTE: Graded wood resawn longtudinally should be regraded. Resawn wood in cross section should not affect original grade.

## 2. SIZES AND TOLERANCE FOR UNSEASONED WOOD

The width and thickness of any piece of sawn wood measured at any point along the length should not exceed the proposed tolerances with the exception of where a permitted defect such as harvesting step, wane, want and/or included bark is located.

Rough sawn wood

The tolerance for width:

For sawn wood up to 5 metres length and between

| | |
|---|---|
| 75 mm to 175 mm in width | ± 4 mm |
| 38 mm to 75 mm in width | ± 3 mm |

The tolerance for thickness:

For sawn wood up to 5 metres length and between

| | |
|---|---|
| 38 to 63 mm thickness | ± 3 mm |

NOTE: Sized or dressed wood*

The tolerance or finished width and thickness should be + 2 mm - 0. The length should be not less than specified.

*Coconut palm sawn wood is frequently dressed (planed) in green or semi-green condition. Maximum dressing allowance for each surface is up to 3 mm. Therefore sawn wood nominal dimension 100 mm x 38 mm should be finished 95 mm x 35 mm when dressed. Therefore, it is recommended to saw "full size" slightly larger dimension than nominal size. The same applies for the wood intended to be seasoned, e.g., shrinkage allowance.

## 3. DEFINITIONS AND MEASUREMENT OF IMPERFECTIONS (DEFECTS)

### 3.1 Definitions

A. Included bark - lengths of bark tissue appearing in concentric arcs.

B. Primary rot and diseased wood tissue* present in the living tree.

C. Wane - the presence of original underbark surface with or without bark on any face or edge of a piece of wood.

D. Want - the absence of wood, other than wane, from the corner or surface of a piece of timber.

E. Warp - any variation from a flat surface. It may consist of cup, bow, spring, twist or any combination of these.

F. Cup - a concave curvature across the grain, i.e., across the width of the face.

G. Bow - a curvature from the plane of the wide face in the direction of length.

H. Spring - a longitudinal curvature of the edge of a piece of wood, not affecting the face.

I. Twist - a spiral distortion along the length of a piece of wood.

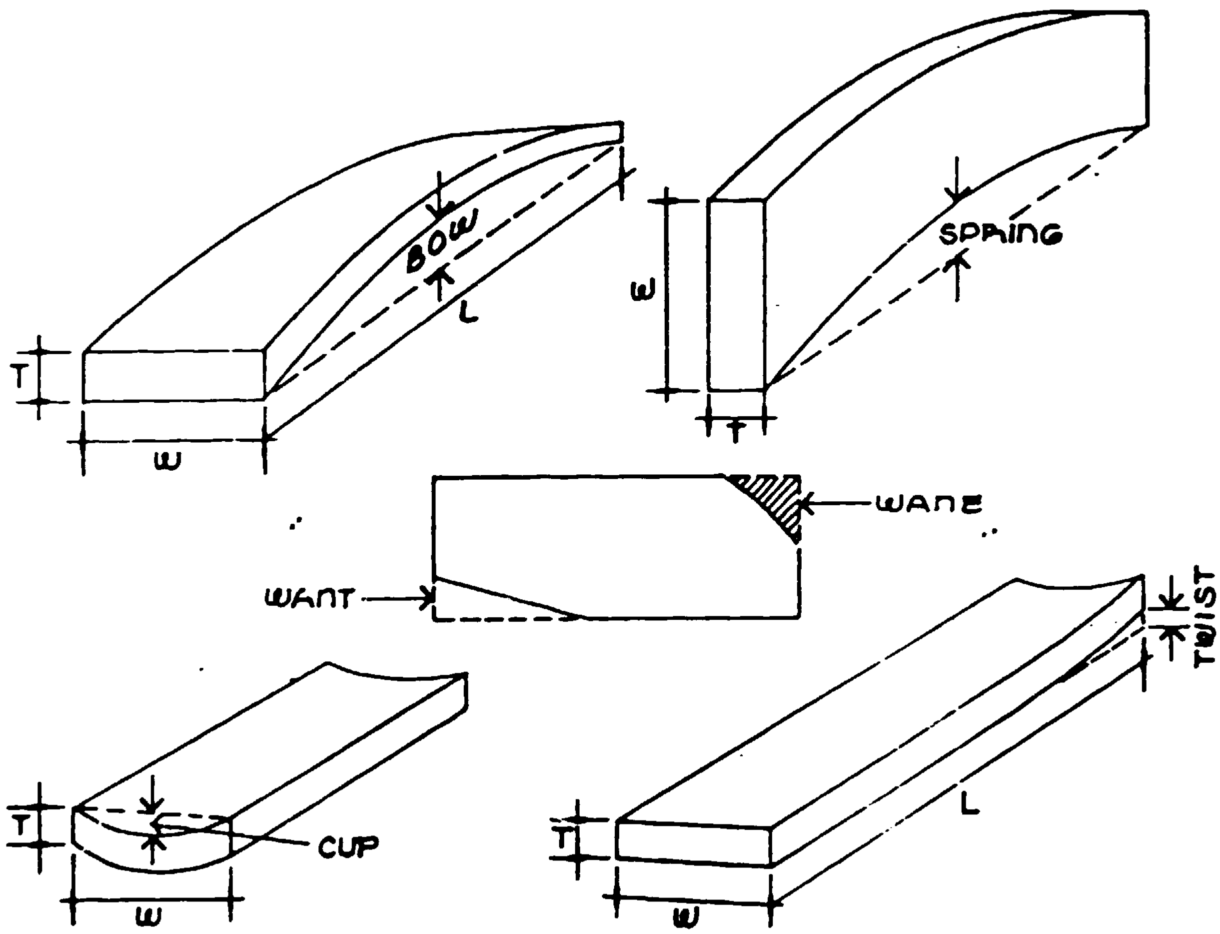
J. Sized - wood machined by sawing or dressing to a closer tolerance than "sawn wood".

K. Visual-stress grade - the classification of a piece of wood for structural purposes indicating primarily: the average basic density group and defects which in turn have predetermined (by laboratory testing) appropriate basic working stress in bending.

---

*Diseased wood tissue of the coconut palm stem is not yet correctly pathologically defined for its origin. Visible on the cross section as circular dark brown spots sometimes with missing wood tissue; on the longitudinal section as brown elongated spots in early stages of development; or as pockets (streaks) of different lengths and widths with visible loose vascular bundles, e.g., bonding tissue (parenchyma) of vascular bundles is missing. Vascular bundle cells are not visibly attacked by the disease.

DIFFERENT TYPES OF SAWN WOOD IMPERFECTIONS (DEFECTS)



## 3.2 Measurement of defects

| | |
|---|---|
| Bow and spring: | To be determined by stretching a string from an arris at each end and measuring the largest distance between string and arris. |
| Twist: | To be determined by placing the piece of wood in such a way that 3 of its corners are in contact with a plane surface and measuring the perpendicular distance from its 4th corner to the plane surface. |
| Cup: | To be measured as the greatest distance of any point on the surface from a straight line bridging the arrises. |

NOTE: If a combination of bow or spring and twist is present, they are to be measured separately.

| | |
|---|---|
| Wane and want: | To be measured as the amount by which the cross section is deficient. |
| Harvesting steps: | To be measured as a projection (width and length). |
| Surface checks: | Applies to seasoned wood permitted for structural grade - appearance grade individual checks not exceeding ½ mm width. |

NOTE: Sloping grain: The deviation of steles from straight direction is an inherent property of coconut palm wood attributed to the anatomical structure of monocotyledons. For this reason measurement of the slope of grain is omitted.

| | |
|---|---|
| Combination of imperfection: | This is based on the assumption that the effect of combined defects will not exceed the cumulative effect of a single maximum permissible imperfection. |

## 4. GRADE LIMITS

Each grade description is based on the lower limit of the grade and should be graded from four surfaces.

In general, 5 per cent variation in the parcel (e.g., 5 pieces from a bundle of 100 below limits of specified grade) is permitted.

The parcel of specified grade should represent the full quality range available in such a grade; not only pieces of the lowest permissible quality.

### 4.1 Branding or marking

It is recommended that a suitable brand mark for each density group and grade be established and backed up by a recognized institute or other authority. A training programme including certification of graders should also be set up.

### 4.2 Grade description

Moisture condition: Green or partly dry

| | |
|---|---|
| Density group 600 $kg/m^3$ and above: | "Hard" structural grade H75 classified as F11. |
| Density group 400 - 599 $kg/m^3$: | "Medium" structural grade M75 classified as F5. |

Structural grade 75 is denoted by H75 5 where "H" and "M" stand for Hard and Medium respectively. Classificat . F11 and F5 indicate that Grade H75 has minimum working stress in bending of 11 MPa (11 $N/mm^2$) and Grade M75 has minimum working stress in bending of 5 MPa (5 $N/mm^2$).

Each piece of wood with structural grade H75 and M75 should be free from:

- physical fracture
- termite galleries
- primary decay (rot)
- included bark intersecting an end

Wood should be sawn square in relation to its surface and within the recommended tolerances.

## 4.3 Permissible imperfection (defects)

Borer holes: Scattered up to 2 mm diameter and not more than 4 in any 100 mm X 100 mm area. (Produced by Ambrosia or Lyctus type borers).

Harvesting step injury: Permissible size to be measured as described in Part III "Illustrations and measurement of defects".

Warping:

Bow: Not exceeding 15 mm per 2 metre length.

Spring: Evenly distributed not exceeding 7 mm per 2 metres.

Twist: Not exceeding 1 mm per 25 mm of width in any 2 metre length.

Cup: Not exceeding 1 mm per 50 mm of width.

Surface check: Applies to seasoned wood, scattered not exceeding individually 1 mm wide.

End check: Not exceeding 2 mm wide and not exceeding ¼ of thickness of wood.

Sloping grain: As has been stated before, the deviation of vascular bundles from straight direction is an inherent characteristic of coconut palm wood and is attributed to the anatomical structure of monocotyledon. For this reason, measurement of slope of grain is omitted.

Want and wane: Permissible size to be measured as described in Part III "Illustrations and Measurement of Defects".

Included bark: Strands of bark tissue occurring in concentric arcs not intersecting an end and not 500 mm off an end. Within the middle or outside middle half of a larger surface, strands not exceeding 200 mm length and not less than 300 mm apart.

Combination of imperfection (defects): Should not exceed cumulative effect of a single maximum permissible defect.

## 5. APPEARANCE GRADE

Description:

The specification applies to wood for further machined or milled products as: Joinery in general

(a) Building joinery as door and window jambs, sills, steps, etc.

(b) Exposed beams.

Appearance grade is derived from structural grade H75 and M75 with the following restrictions on defects:

Borer holes: Scattered up to 1 mm diameter and not more than 3 in 100 mm X 100 mm area. (Usually produced by Ambrosia or Lyctus type borers.)

Harvesting step injury: Not permissible

Wane and want: Not permissible

Included bark: Not permissible

Warping: Bow: Reduced by 50 per cent of permissible size as stated in "Grade description" (page 17).

Appearance grade could include selection of wood colour (vascular bundles). Wood fungi stain is not permissible.

By careful sawing and selection of logs from the lower section of coconut palm stem, high quality material with corresponding high mechanical properties could be recovered but in somewhat limited quantity.

## 6. CULL GRADE

Definition:

A piece of sawn or partly sawn wood of useful size but with non-permissible defects.

General description:

Wood should be free from:

- termite galleries
- primary decay scattered over surface in a primary state (light brown colour)
- wane, want, harvesting step injury - should not exceed 50 per cent of a cross section area

No restriction for other imperfections.

If slabs (piece of wood sawn on only one surface, e.g., segment of log) are included, it should preferable be edged on both sides to the following requirements:

The solid wood in the centre of a cross section should be minimum 25 mm thick, edges should be half of this dimension.

Cull grade is not restricted to uniform dimension and length but preferably should contain wood from individual density group.

## 7. COCONUT PALM SAWN BOARDS

In general, sawn wood up to 32 mm thickness of different widths are called boards. Boards are usually seasoned or partly dry for further processing as machining and possible impregnation or preservative treatment before final end-use.

Exception:

(a) Structural boards usually 25 mm to 32 mm thickness are used in construction for bracing and other similar application in green or partly dry condition.

(b) Shingles are manufactured from green boatds.

Density group:

| | |
|---|---|
| Structural boards: | hard and medium |
| Shingles: | any density group |

Sawn boards are used for a number of purposes:

Flooring
Joinery
Mouldings
Roofing and siding shingles
Outside and inside wall lining

Boards are classified to all 3 density groups: hard
medium
soft

by a similar process to that of structural wood.

Density group allocation of sawn boards will determine its eventual final end-use. The boards of lower density are sawn from the inner protion of logs and are therefore subject to fewer defects.

Boards intended to be used for:

Flooring
Floor parquetry
General joinery
Roofing shingles

are sawn from the outer portion of logs to obtain higher density material.

NOTE: Flooring and floor parquetry should be sawn from highest density wood (e.g., outer part of log) to secure high wearing property.

Sawn boards intended to be used for the manufacture of shingles are obtained from all three density groups:

| | | |
|---|---|---|
| (a) | Roofing shingles (fully exposed): | hard and medium |
| (b) | Outside wall shingles (partly exposed): | medium |
| (c) | Internal wall shingles (fully protected): | soft |

Boards intended to be used for:

| | | |
|---|---|---|
| (a) | Outside lining: | hard and medium |
| (b) | Internal lining: | medium and soft |

Boards intended to be used for general milled products or joinery: hard and medium

## 7.1 Flooring (strip flooring)

| | |
|---|---|
| Density group: | Hard - above 600 kg/m$^3$ |
| Moisture condition: | Local average equilibrium moisture content $\pm$ 2 per cent |

Grade description:

Boards intended for flooring are machined:

(a) Square on all sides; or

(b) Profile type: (i) tongue and groove

(ii) shiplap

| | | |
|---|---|---|
| Flooring diemnsions: | Thickness: | 18 mm or 21 mm |
| | Width: | 70 mm up to 90 mm |
| Flooring tolerances: | Thickness: | $\frac{-}{-}$ 1 mm – zero |
| | Width: | ± 1 mm |

Quality of flooring is judged on face appearance. It should be free of any defect. Defects on the back should not prevent proper laying nor decrease the strength of the board.

Permissible defects:

| | | |
|---|---|---|
| Borers holes: | | Scattered 2 to 3 per 100 mm X 100 mm area (Ambrosia and Lyctus type borers) |
| Wane: | | Only on the back side not exceeding ¼ of the width and/or edge. Maximum length is 1/5 of the board length. |
| Harvesting step: | | Projection to back side permitted up to 2 mm depth and not more than 2 defects spaced in full length of board. |
| Warping: | Cup: | Not allowed |
| | Twist: | Not allowed |
| | Spring: | Maximum 10 mm per 3 m length |
| | Bow: | Maximum 20 mm per 2 m length |
| Checks: | | (Scattered) up to 1 mm wide and maximum 70 mm long. |

Machining defects on the face:

Raised grain: Slight

| | |
|---|---|
| Torn grain: | Less than 1 mm thick, once per 2 m length |
| Hit and miss (skip): | Less than 1 mm in depth and only 1 defect per 3 m length |

7.2 Outside wall and internal wall lining

Density group: Outside wall lining: hard and medium
Inside wall lining: medium

Graded by face appearance:

Standard dimension:

| | | |
|---|---|---|
| Outside wall lining: | Thickness: | 16 mm |
| | Width: | 70 mm - 90 mm |
| Inside wall lining: | Thickness: | 12 mm - 14 mm |
| | Width: | 70 mm - 90 mm |

NOTE: Restriction for tolerances and defects applies as for the flooring.

7.3 Moulding and/or joinery boards

Density group: Hard and medium

Graded by appearance from all four sides: Clear of any defect

Exception:

| | |
|---|---|
| Borer holes: | Scattered 1 mm diameter, 2 to 3 per 100 $mm^2$ area. (Ambrosia and Lyctus type borers.) |
| Warping: | Minimum |
| Wood fungi: | Scattered and slight |

7.4 Shingles

Moisture condition: Green

Standard sizes of shingles used in PCA-ZRC:

(a) Roofing shingles

| | | |
|---|---|---|
| Density group: | Hard and medium | |
| Length: | 400 mm | |
| Thickness: | thick end: | 12 mm - 13 mm |
| | thin end: | 6 mm |

(b) Outside wall siding shingles

| | |
|---|---|
| Density group: | Medium |
| Length: | 600 mm |
| Width: | 100 mm |
| Thickness: | 12 mm - 13 mm |

(c) Inside wall siding shingles

| | | |
|---|---|---|
| Density group: | Soft | |
| Length: | 40 mm | |
| Width: | 90 mm - 100 mm | |
| Thickness: | thick end: | 10 mm |
| | thin end: | 4 mm |

Internal wall siding shingles are visually graded for appearance and density as: First grade - wood stain should be minimum

Second grade - wood stain is permitted

where first grade shingles are fully exposed in double course application; and

second grade shingles are used for undercourse.

NOTE: Wood of basic density (specific gravity) below 300 $kg/m^3$ usually has a woolly appearance which is not necessarily removed by sanding.

Sized sawn boards of a profile dimension 400 mm X 25 mm (no tolerance) are cross cut to the desired length of shingles before the next state of manufacturing and must be free of all defects.

## 7.5 Glue lamination

Sawn boards intended to be used for lamination:

| | |
|---|---|
| Density group: | Hard and medium |
| Moisture condition: | Maximum 16 per cent moisture content |

Boards intended for glue lamination should be machined to zero tolerance and gree from all imperfection with the following exceptions:

| | |
|---|---|
| Borer holes: | Scattered, 1 mm diameter, 2 to 3 per 100 mm X 100 mm area. (Ambrosia and Lyctus type borers.) |
| Wood fungi stain: | Slight |
| Surface checks: | Not more than 1 mm wide, 70 mm long, scattered. |

Machining defects:

| | |
|---|---|
| Torn grain: | Less than 1 mm thick, one defect per 2 m length on each side |
| Hit and miss (skip): | Less than 1 mm in depth and only 1 defect per 3 m length on each side of the boards |
| Machine knife marking: | Minimum |

It is recommended that outside lamina should be chosen from the hard group. Internal lamina could be selected from the medium group.

Boards should be rough sawn slightly oversize to make allowance for seasoning and machining.

GENERAL NOTE: Sawn boards are visually graded for defects:

(a) Immediately after density group classification (e.g., green); or

(b) After seasoning when boards are dry to desired moisture content.

The same rule for non-permissible and permissible imperfection applies as for the structural wood.

Combination of defects:

Defects of maximum permissible size should be allowed if only to occur in length 3 metres or more and defects should be separated minimum 1 m apart.

A combination is permitted if combined effect of imperfection is not more than a single imperfection of maximum permissible size.

7.6 Parquetry - wood block for parquetry flooring

The following is not applicable to mosaic flooring sawn into small pieces usually 150 mm long, 25 mm wide, 6 mm thick and factory pre-assembled to square tiles (150 mm X 150 mm, sometimes called finger type parquetry).

Two types of parquetry:

(a) Domestic parquetry blocks - used in private houses, offices, etc.

(b) Industrial parquetry blocks - used in commercial and industrial buildings:

| | |
|---|---|
| Edge: | The surface of the block where depth is determined |
| End: | Cross section where the grain is cut at right angle |
| Face: | Surface of wood blocks on which grade is determined |
| Back: | Bottom surface of wood block intended to make bond with sub-floor. |

Minimum requirement for wood blocks intended to be used as parquetry flooring* to be bonded on concrete or rigid wood sub-floors:

*Flooring consisting of blocks of wood of specified size and shape arranged in a pattern.

(1) Description of grade:

The wood block shall be milled (machined) from sound wood of highest density free from defect except as follows:

(a) Domestic grade wood blocks:

(i) Face - no defects are permitted.

(ii) Back - shall be free from any defect which will impair the strength or fitting (laying) of blocks.

(b) Industrial grade blocks:

(i) Face - seasoning checks not exceeding 50 mm long.

- raised grain - slight, not more than 25 per cent of the blocks in a parcel are so affected.
- torn grain - provided it is not more than 3/4 mm
- hit and miss - very slight.
- pin holes - (Ambrosia beetle) slight, provided. that not more than 20 per cent of blocks in a parcel (not more than 4 holes per block) is affected.

(2) Manufacture:

(a) The blocks shall be finished square with opposite face and arrises sharp and parallel.

(b) Block may be machined smooth - square or tongued and grooved or ship lap.

(c) Ends are finally sawn.

(d) Back surface shall be machined along both edges to provide groove or chamfer.

(e) Dimension: standard size:

(i) Wearing thickness:

- domestic blocks: not less than 4 mm
- industrial blocks: not less than 8 mm

(ii) Thickness:

- domestic blocks: not less than 10 mm
- industrial blocks: not less than 19 mm

(iii) Width and length cover dimension:

| Type | Width | Length |
|---|---|---|
| Tongued and grooved blocks | 60 mm | 300 mm |
| Square | 62 mm | 310 mm |

If blocks of other than the standard size are manufactured, the length shall be an exact multiple of the width.

(f) Tolerance: The dimension of a block shall not differ from design dimension as follows:

(i) Thickness ± 3/10 mm

(ii) Width ± 4 mm

Measured over a distance of one metre of blocks placed edge to edge

(iii) Length ± 3/10 mm for each block

## 8. DURABILITY OF COCONUT PALM WOOD

The natural durability of coconut palm wood appears to be closely related to its density, e.g., high density wood is more resistant to decay and termites or wood borers attack. However, more experience is needed and, in any case, preservative treatment is recommended for structural used.

Coconut palm wood, as with conventional woods, will not decay if kept continuously dry. The same applies to wood permanently submerged in water or deep in the ground deprived of oxygen.

Wood fully or partly exposed to weather conditions is subject to decay depending on climatic conditions, absorption of water during the wet season, etc. In tropical climatic conditions, wood is more prone to decay.

Wood used in contact with the soil (transmission poles, fencing posts, housing foundation stumps) at ground level where moisture content fluctuates is most prone to decay.

NOTE: It is possible for fungi in infected wood to remain dormant during periods of low moisture content and become active when conditions reach suitable levels.

Flooring and structural wood under flooring depend on subfloor conditions. Sufficient ground clearance and good ventilation decreases the decay danger. Humid subfloor conditions with poor ventilation increases the hazard.

## 8.1 Natural durability rating for coconut palm wood

If the scale is used:

(a) High natural durability
(b) Durable
(c) Moderately durable
(d) Low durability
(e) Non-durable

Coconut palm wood based on density grouping could be rated as follows:

| | | |
|---|---|---|
| Hard: | Density group 600 kg/m$^3$ and above - | moderately durable |
| Medium: | Density group 400 - 599 kg/m$^3$ - | low durability |
| Soft: | Below 400 kg/m$^3$ - | non-durable |

For this reason, it is recommended that wood in contact with the soil and exposed to weather conditions should be impregnated with suitable chemicals.

## 8.2 Natural durability resistance to termite attack

Although density has less effect on termites than on decay, if the scale is used:

(a) High

(b) Moderate

(c) Low

It is suggested that:

Hard density group could be classified as high.

Medium denisty group could be classified as moderate to low.

Soft density group could be classified as low.

8.3 Resistance to mechanical wear and weathering

If high density wood of even texture is selected, wearing properties can be classified as good to very good. Lower density wood has a tendency of uneven wearing, rising grain and splintering.

When coconut palm wood is exposed to weathering, the relatively soft parenchyma tissue bonding vascular bundles deteriorates faster exposing the harder vascular bundles. This effect again is larger for the lower density group, and is similar to the effect on other woods.

8.4 Wood staining fungi (sapstain)

Wood staining fungi attack fresh sawn coconut palm wood very rapidly. Lower density wood seems more susceptible than higher density wood. Sapstain considerably affects the appearance of finished wood without altering other properties.

Prevention consists of dipping for one minute in any fungicide or 1/2 per cent sodium pentachlorophenate.

8.5 Coconut palm sawn wood preservation

It is necesary for sawn wood to be impregnated by suitable chemicals if the end-use places it:

(a) in contact with soil, or

(b) partly or fully exposed to climatic conditions.

Usually sawn wood is dried to below 25 per cent moisture content prior to impregnation unless the type of preservation process permits green condition of wood (double diffusion - hot and cold bath, etc.).

Low density wood intended for internal use (fully protected from climatic conditions) is recommended to be treated against dry wood borers and termites. The treatment process is usually done by dip diffusion (Boron based chemicals) when wood is in the green condition (freshly sawn).

# PART III. ILLUSTRATIONS AND MEASUREMENTS OF DEFECTS

## 1. FULL SIZE TEST - SPECIMENS SUBJECT TO DEFECTS

Three types of strength reducing characteristics or defects were considered during the full size static bending text:

(a) Density
(b) Harvesting steps
(c) Wane with included bark

### 1.1 Density

The influence of density on strength properties has been determined through density grouping and is shown in the tabulated results of the full-size specimen test.

### 1.2 Harvesting steps

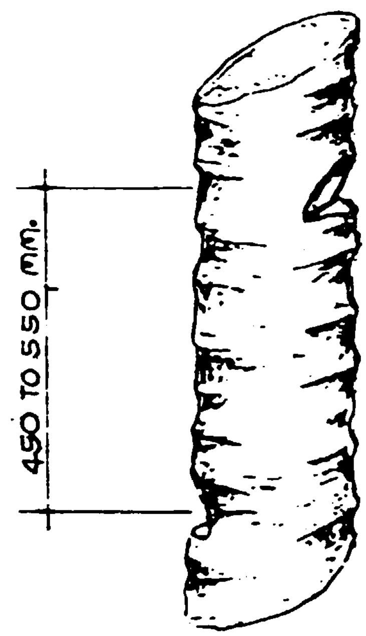
Harvesting steps are used in a number of coconut palm growing countries or particular locations as an aid to climb tail varieties during harvesting. Mature palm stems may have 40 or more steps cut progressively during the life time of the tree.

Harvesting steps are cut by bush knife alternatively on opposite sides of a stem about 450 to 550 mm apart (usually one step per year). See Figure 1 (page 36).

Coconut palm as a monocotyledon does not develop sapwood or cambium. For this reason, as palms are unable to develop a callous tissue to cover the wound, the steps stay in their original size for the whole life of the palm.

Wounds in wood tissues are subject to "bleeding" and entry of decay. Fortunately, this is not common as the cell tissues surrounding the wounds are filled by extractives which form hard layers of sclerotic zone of a high specific gravity (above 1.0) thus preventing "bleeding" or entry of disease.

FIGURE 1.




HARVESTING STEPS

Harvesting steps when projected deeper in the wood tissue reduce the recovery of high density wood. To minimize the effect of harvesting steps on sawn wood recovery, round wood with limited projection of step wound to one or both surfaces of a sawn wood is allowed. The defect could be described as "want" (e.g., absence of wood from "arris" or surface of a piece of wood). See Figures 2 and 3 (page 37).

FIGURE 2.

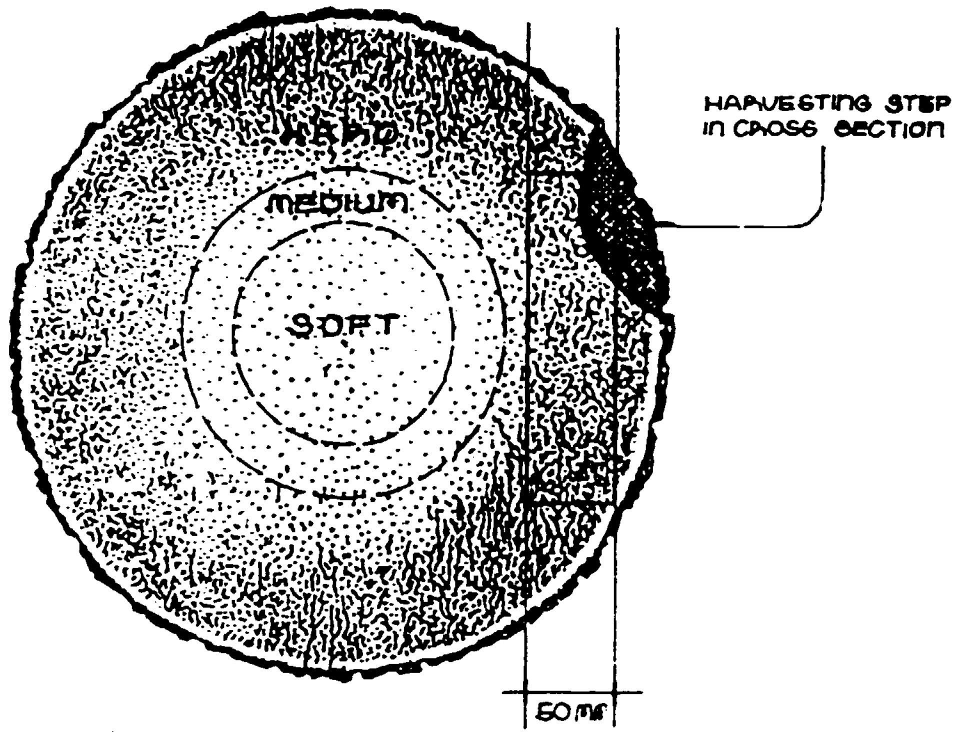
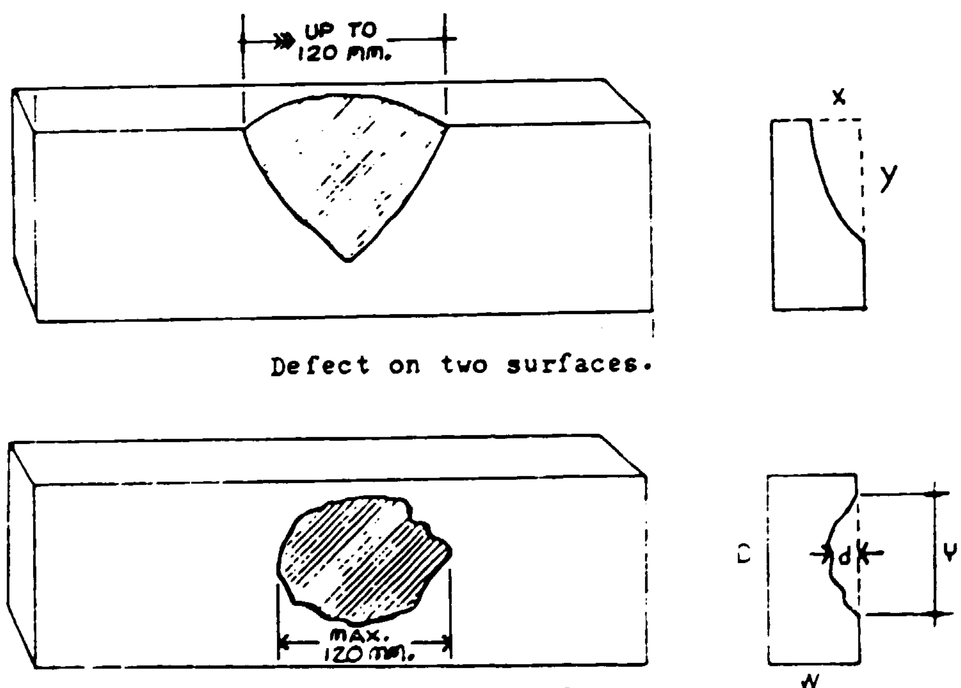



FIGURE 3.

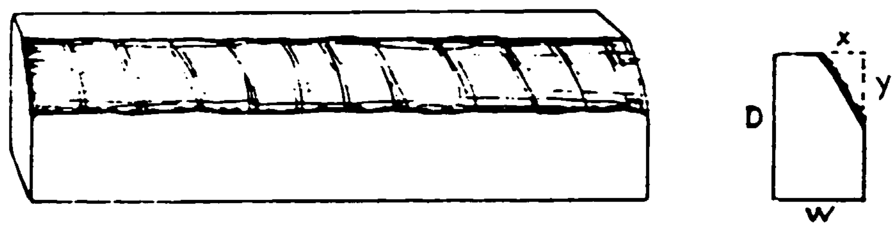



NOTE: Maximum value of y is 1/2 of D
Maximum value of d is 1/5 of W

1.3 Wane

Wane is the presence of underbark tissue with or without bark on the surface or edge of a piece of wood. See Figure 4. Wane is a strength reducing effect.

FIGURE 4.




1.4 The effect on strength properties

To determine the permissible size of defect in any location in a piece of wood classified to a particular stress grade, full size specimens containing different types and sizes of defects are placed under load with the defects in tension. Evaluation of test results confirms that the size of a defect such as harvesting steps or wane should not exceed 1/10 (10 per cent) of a nominal size cross section.

1.5 Measurement and approach to estimate maximum permissible defect

For:

(a) Harvesting steps

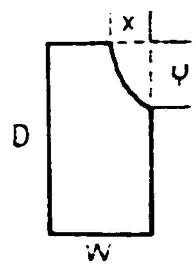
(b) Wane

(c) Want

Table 3 (page 39) illustrates standard nominal sizes of framing wood obtainable from coconut palm stem.

TABLE 3

| Nominal size in mm | Cross section area in $mm^2$ | 10 percent of cross section area in $mm^2$ | Sum of D + W in mm | 30 percent of D + W in mm | Max. value of x + y in mm |
|---|---|---|---|---|---|
| 75 x 38 | 2850 | 285 | 113 | 34 | 34 |
| 75 x 50 | 3750 | 375 | 125 | 38 | 38 |
| 100 x 38 | 3800 | 380 | 138 | 41 | 41 |
| 100 x 50 | 5000 | 500 | 150 | 45 | 45 |
| 125 x 50 | 6250 | 625 | 175 | 53 | 53 |




Where: D = depth

W = width

x = length of defect on narrow surface

y = length of defect on wide surface

30 per cent of the sum D + W is calculated as:

$$\frac{(D = W)^3}{10}$$ which represents maximum value of <u>x + y</u>

Example:

A piece of wood of a nominal cross section 75 mm x 50 mm.

Therefore, 30 per cent of (D + W) = $\frac{(75 + 50)^3}{10}$ = 375/10

= 37.5 mm (rounded to 38)

and maximum value of x + y = <u>38 mm</u>.

Since cross section 75 mm x 50 mm has maximum permissible sum of x + y = 38, therefore maximum value of x is 1/3 of width which is approximately 16 mm and maximum value of y is 1/3 of depth which is approximately 25 mm with restriction that the sum of (x + y) does <u>not exceed 38 mm</u>.

TABLE 4

Shows reduction in strength and Modulus of Elasticity in static bending test when defect excees the recommended size

| Reference number | | Dimension | Average basic density | Ave. MC 1/ | Ave. MR 2/ | Ave. SPL 3/ | Ave. ME 4/ | Defect | | | Type of defect |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Permis-sible x + y | Actual x + y | in percent of cross section | |
| | | mm | g/cm³ | % | MPa | MPa | 1000 MPa | mm | mm | | |
| 1 | Density group 600 kg/m³ and above | 38 x 38 | .762 | | 39.47 | 29.82 | 7.70 | 23 | 33 | 19.0 | wane |
| 2 | | 38 x 38 | .640 | | 32.04 | 22.48 | 5.93 | 23 | 33 | 19.0 | wane |
| 3 | | 75 x 38 | .671 | | 21.23 | 14.95 | 5.79 | 34 | 44 | 17.0 | step |
| 4 | | 75 x 50 | .733 | | 46.76 | 32.74 | 5.98 | 38 | 52 | 18.0 | wane |
| 5 | | 75 x 50 | .805 | 20 | 49.30 | 29.31 | 5.75 | 38 | 55 | 20.5 | wane |
| 6 | | 75 x 50 | .839 | | 39.47 | 29.66 | 8.85 | 38 | 49 | 16.0 | step |
| 7 | | 100 x 50 | .722 | | 37.36 | 23.35 | 8.89 | 45 | 56 | 16.0 | step |
| 8 | | 100 x 50 | .624 | | 42.18 | 31.55 | 8.86 | 45 | 55 | 15.0 | step |
| 9 | | 100 x 50 | .608 | | 39.05 | 28.86 | 7.75 | 45 | 53 | 14.0 | step |

1/ Moisture content

2/ Modulus of Rupture

3/ Stress at proportional limit

4/ Modulus of Elasticity

The maximum size of defect projected on 2 surfaces (See Figure 3) is when x = y (e.g., square).

Example:

If in nominal size 75 mm x 50 mm, the sum of x + y = 38

then x = 19 mm and y = 19 mm

$x \times y = 19 \times 19 = 361\ mm^2$ which is slightly less than 10 per cent (1/10) of nominal cross section 75 x 50 mm (1/10 is 375 $mm^2$).

The same rule applies to "wane" with or without included bark with the only restriction that x or y value should not exceed the given values in Table 3.

FIGURE 5

Illustrates included bark on end (non-permissible imperfection in stress grade).

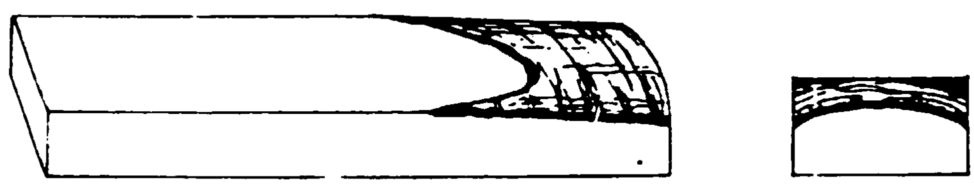


Table 4 shows the static bending test of full-size specimens where a defect of "harvesting steps" or "wane" exceed 1/10 (10 per cent of nominal cross section area).

The largest defect was placed in tension and at different locations within the test span.

The maximum effect on the strength properties occurs when a defect is located at the centre of span (maximum bending moment) and/or directly under the loading heads.

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