# MECHANICAL PROPERTIES OF TIMBERS COMMONLY USED IN WESTERN AUSTRALIA

By P.N.Shedley & D.J.Challis



FORESTS DEPARTMENT OF WESTERN AUSTRALIA

TECHNICAL PAPER 7

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**Forests Department of W.A.**
**P.J.McNamara**
**Acting Conservator of Forests**
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# INTRODUCTION

This publication has been prepared to provide a convenient reference of theoretical mechanical or physical properties of timber for those working with wood in Western Australia. The properties of timbers indigenous to Western Australia are given in Table 1 and those of some commercially imported timbers are given in Table 2. Incorporated in the Tables are sections summarizing current Australian Standards information on the various species.

The information presented here has been derived from various published sources, all of which are listed in the references. It is not intended that this publication should replace the detailed information available in other publications; it merely collects and summarizes relevant information available for the convenience of Western Australian users.

# EXPLANATION OF THE TABLES AND DEFINITION OF TERMS USED

## REFERENCES

The numerals in parenthesis throughout the tables refer to published references, listed on pages 11 and 12, from which more detailed information may be available.

## NOMENCLATURE

The timber species or groups of species are presented individually in alphabetical order of the *Trade Name*. The name listed as the Trade Name is that most commonly used in Western Australian timber industry and commerce. Where the term 'combined group' is used, it refers to the accepted marketing practice which has been developed to cater for a number of species that have similar properties and are difficult to identify separately.

*Botanical Names* are also given.

Where additional or alternative common or local names are used they are listed under the heading *Common Name*, together with the locality (in brackets) of its common usage, where applicable.

Appendix I lists all Trade, Botanical and Common Names, in alphabetical order, showing all synonyms, for each name.

## PLACE OF ORIGIN

The column giving the place of origin of species indicates the location where the species is indigenous, not necessarily where timber available in Western Australia may have actually been harvested. For example, the place of origin of *Pinus pinaster* is Portugal but the timber of this species available in W.A. may have been harvested from local plantations. Differences in properties can occur within the same species of timber, whether or not harvested from different localities. Thus the figures given should be considered as species' means rather than absolutes.

## MOISTURE CONDITION

Properties are given for wood samples with both green, and 12 per cent moisture content. The term *Green* is applied to unseasoned wood. Expressions of green wood properties relate to testing at the moisture contents normally occurring in freshly sawn wood.

The amount of water present in a wood sample is expressed as a percentage of the oven dry weight of the wood. The equilibrium moisture content is reached when the moisture content of wood samples reach equilibrium with atmospheric moisture. Twelve per cent moisture content is the accepted mean used internationally when testing the properties of this dried wood.

The mechanical properties of wood are considerably influenced by the moisture condition. Depending on the species, there is an increase in all strength properties of the wood (except shock resistance) below 25 to 30 per cent moisture content. The strength properties of the wood continue to increase as moisture content diminishes.

## DENSITY

Density, is the weight per unit volume of wood. Within species it is influenced by rate of growth, proportions of early wood and late wood and by inherited characteristics. The strength, toughness, hardness, durability and resistance to cleavage usually increase with increased density (Corkhill).

There are various ways to express the density of wood. For the purposes of this publication green and air dry density are given.

*Green density* is the ratio of the weight of green or unseasoned wood to green volume, expressed in $kg.m^3$.

*Air-dry density* is the ratio of the weight of air-dry wood to the air-dry volume in equilibrium with atmospheric conditions (12 per cent moisture content) expressed in $kg.m^3$

## BASIC DENSITY

Basic density is the ratio of the oven dry weight of wood to green or maximum volume, expressed as $kg.m^3$.

## STATIC BENDING

*Modulus of elasticity* is a measure of stiffness or resistance to deflection in bending. It is expressed in megapascals (MPa).

*The modulus of rupture* is a direct measure of the strength of wood in bending, expressed in megapascals (MPa).

## MAXIMUM CRUSHING STRENGTH

*Maximum Crushing Strength* is a measure of the resistance of timber to compression loading, parallel to the grain. It is expressed in megapascals (MPa).

## STRENGTH GROUP

The strength group to which a timber or group of timbers is assigned is based on the mechanical and/or density determinations of the defect-free material of the species. There are seven groups in descending order from S1 to S7 for unseasoned timber (green) and eight groups from SD1 to SD8 for seasoned timber (12 per cent jarrah).

Classification into the groups is based on the nature and amount of data available. The primary grouping is 'Positive' and only when insufficient data are available is the 'Provisional' grouping used. Provisional strength groups are indicated by brackets.

The following is an outline of each class:

(1) 'Positive' strength class is the class to which a timber is assigned based on mechanical test data for five or more correctly sampled trees. Mechanical properties used are modulus of rupture, modulus of elasticity and maximum crushing strength.

(2) Provisional strength class is the class to which a timber is assigned based on density and/or limited mechanical properties data.

Strength properties are expressed in megapascals.

## DURABILITY CLASS

Durability is the natural resistance against decay and insect attack of heartwood in ground contact.

Durability varies from tree to tree within a species and even between species from the same tree. Consequently it is possible to express durability only in average terms. For this reason, timbers are grouped into four broad classes, namely:

1 = highly durable
2 = durable
3 = moderately durable
4 = non-durable.

This classification does not refer to sapwood which is non-durable.

## LYCTUS SUSCEPTIBILITY

The powder-post beetles (Lyctus spp.) attack only the sapwood of certain hardwoods. The two conditions that most commonly limit the susceptibility of a species are pore size and starch content. In only a few hardwood species are the pores too small to permit attack, hence susceptibility is usually governed by starch content. *Lyctus* attack does not occur in softwoods.

The susceptibility to *Lyctus* borer attack is designated as either 'S' meaning susceptible or 'R' meaning resistant (AS. 1604-1980). (Standards Association of Australia - 1980).

## SHRINKAGE

Shrinkage refers to the reduction in dimensions, due to lowering of the moisture content from green to 12 per cent moisture content. It is expressed as radial or tangential percentage reduction in dimensions.

## SHRINKAGE GROUP

Values are for tangential shrinkage from green to 12 per cent moisture content

H = high shrinkage (over 8%)
M = medium shrinkage (5 to 8%)
L = low shrinkage (less than 5%)

(AS. 2082-1979 "Visually stress graded hardwood for structural purposes")

## SHRINKAGE - RADIAL AND TANGENTIAL (Before and After Reconditioning)

Separate figures are given for before reconditioning and after reconditioning. Reconditioning is a steaming treatment which restores some of the reduced dimensions.

## AVAILABILITY

This refers to commercially available timbers in Western Australia at the time of publication.

TABLE 1

# MECHANICAL AND PHYSICAL PROPERTIES OF

| NOMENCLATURE | | | MOISTURE CONTENT | DENSITY (kg m³) | BASIC DENSITY (kg m³) | STATIC BENDING | |
|---|---|---|---|---|---|---|---|
| TRADE NAME | BOTANICAL NAME | COMMON NAME | | | | MODULUS OF ELASTICITY (MPa) | MODULUS OF RUPTURE (MPa) |
| Banksia, river | *Banksia Littoralis* var. *seminuda* | | Green | 945(a) (8) | 392 (9) | - | - |
| | | | 12% | 560 (15) | | 7920 (8) | 71 (8) |
| | | | | (a) Green 100% moisture content | | | |
| Blackbutt, W.A. | *Eucalyptus patens* | yarri | Green | 1120 (11) | 689 (9) | 11523 (2) | 66 (2) |
| | | | 12% | 850 (15) | | 12765 (2) | 99 (2) |
| Jam, Raspberry | *Acacia acuminata* | raspberry jam | Green | 1170(b) (8) | 899 (9) | - | - |
| | | | 12% | 993 (15) | | 16249 (8) | 105 (8) |
| | | | | (b) Green 25% moisture content | | | |
| Jarrah | *Eucalyptus marginata* | | Green | 1120 (11) | 658 (9) | 10210 (2) | 68 (2) |
| | | | 12% | 820 (15) | | 12970 (2) | 112 (2) |
| Karri | *Eucalyptus diversicolor* | | Green | 1200 (11) | 695 (9) | 14283 (2) | 73 (2) |
| | | | 12% | 900 (15) | | 19044 (2) | 133 (2) |
| Mallet, brown | *Eucalyptus astringens* | | Green | 1120 (8) | 770 (9) | 15387 (2) | 113 (2) |
| | | | 12% | 1014 (15) | | 18492 (2) | 179 (2) |
| Marri | *Eucalyptus calophylla* | red gum | Green | 1200 (11) | 663 (9) | 13524 (2) | 77 (2) |
| | | | 12% | 850 (15) | | 16629 (2) | 126 (2) |
| Salmon gum | *Eucalyptus Salmonophloia* | | Green | 1120(c) (8) | 895 (9) | - | - |
| | | | 12% | 1057 (15) | | 17250 (8) | 134 (8) |
| | | | | (c) Green 25% moisture content | | | |
| Sheoak | *Casuarina fraserana* | | Green | 960(d) (8) | 622 (9) | - | - |
| | | | 12% | 833 (15) | | 9356 (8) | 83 (8) |
| | | | | (d) Green 33% moisture content | | | |
| Tingle, red | *Eucalyptus jacksonii* | | Green | - | 589 (9) | - | - |
| | | | 12% | 700 (15) | | 13448 (5) | 98 (8) |
| Tingle, yellow | *Eucalyptus guilfoylei* | | Green | 1200(e) | - | - | - |
| | | | 12% | 900 (11) | | 19448 (5) | 134 (8) |
| | | | | (e) Unpublished F.D. data | | | |
| Tuart | *Eucalyptus gomphocephala* | | Green | 1280 (11) | 836 (9) | 12282 (2) | 81 (2) |
| | | | 12% | 1040 (11) | | 16353 (2) | 125 (2) |
| Wandoo | *Eucalyptus wandoo* syn. *E. redunca* var. *elata* | white gum | Green | 1280 (11) | 921 (9) | 13731 (2) | 101 (2) |
| | | | 12% | 1100 (11) | | 16698 (2) | 142 (2) |
| Yate | *Eucalpytus cornuta* | | Green | 1265(f) (8) | 860 (9) | - | - |
| | | | 12% | 1137 (11) | | 19320 (8) | 148 (8) |
| | | | | (f) Green 32% moisture content | | | |
| York gum | *Eucalyptus loxophleba* | | Green | 1233(g) (8) | - | - | - |
| | | | 12% | 1073 (11) | | 12420 (8) | 97 (8) |
| | | | | (g) Green 30% moisture content | | | |

# TIMBERS INDIGENOUS TO WESTERN AUSTRALIA

| MAXIMUM CRUSHING STRENGTH (MPa) | STRENGTH GROUP | DURABILITY CLASS | LYCTUS SUSCEPT-IBILITY | SHRINKAGE GROUP | SHRINKAGE | | | | AVAILABILITY IN W.A. |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | Before Recon. | | After Recon. | | |
| | | | | | Rad. (%) | Tan. (%) | Rad. (%) | Tan. (%) | |
| -<br>- | ( S7) (16)<br>(SD8) (16) | - | - | - | 2.2 (9) | 7.4 (9) | 1.9 (9) | 5.6 (9) | Not commercially available. |
| 37 (2)<br>65 (2) | S4 (16)<br>SD5 (16) | 2 (15) | S (15) | H (15) | - | - | - | - | Limited availability in building, structural and flooring sizes. |
| -<br>- | (S2) (16)<br>(SD2) (16) | - | - | - | 1.1 (9) | 1.8 (9) | 1.1 (9) | 1.2 (9) | Not commercially available. |
| 36<br>61 | S4 (16)<br>SD4 (16) | 2 (15) | R (15) | M (15) | 4.8 (9) | 7.4 (9) | 4.6 (9) | 6.7 (9) | Readily available in most structural sizes up to 200mm x 100mm x 5.4m. |
| 36 (2)<br>72 (2) | S3 (16)<br>SD2 (16) | 3 (15) | R (15) | H (15) | 4.3 (9) | 9.9 (9) | 4.0 (9) | 8.5 (9) | Readily available in most structural sizes up to 2500mm² x 6m. |
| 53 (2)<br>94 (2) | S1 (16)<br>SD2 (16) | - | - | - | 4.4 (9) | 7.1 (9) | 3.6 (9) | 5.5 (9) | Not commercially available. |
| 41 (2)<br>66 (2) | S3 (16)<br>SD3 (16) | 3 (15) | S (15) | M (15) | 3.7 (9) | 6.6 (9) | 3.4 (9) | 5.6 (9) | Limited availability, mainly in domestic structural sizes. |
| -<br>- | (S2) (16)<br>(SD3) (16) | - | - | - | - | - | - | - | Not commercially available. |
| -<br>- | (S6) (16)<br>(SD6) (16) | - | - | - | 1.2 (9) | 4.5 (9) | 1.0 (9) | 1.7 (9) | Not commercially available. |
| -<br>- | S4 (16)<br>SD4 (16) | 2 (15) | S (15) | H (15) | 5.7 (9) | 9.9 (9) | 3.1 (9) | 5.0 (9) | Very limited availability in building and structural sizes. |
| 69[2]<br>- | S2 (16)<br>SD2 (16) | 2 (15) | R (15) | - | - | - | - | - | Very limited availability in building and structural sizes. |
| 46 (2)<br>72 (2) | S3 (16)<br>SD3 (16) | 2 (15) | S (15) | M (15) | 3.0 (9) | 6.9 (9) | 2.6 (9) | 5.8 (9) | Very limited availability. Used principally for wagon construction, some flooring, and uses where high abrasion qualities are sought. |
| 55 (2)<br>82 (2) | S2 (16)<br>SD3 (16) | 1 (15) | R (15) | L (15) | 2.6 (9) | 4.2 (9) | 2.3 (9) | 3.3 (9) | Very limited availability in most sizes with length restrictions. |
| -<br>- | S2 (16)<br>SD2 (16) | - | - | - | - | - | - | - | Not commercially available. |
| -<br>- | S2 (16)<br>(SD2) (16) | - | - | - | - | - | - | - | Not commercially available. |

[2] Unpublished F.D. data

TABLE 2

# MECHANICAL AND PHYSICAL PROPERTIES OF

| NOMENCLATURE | | | PLACE OF ORIGIN | MOISTURE CONTENT | DENSITY (kg m³) | BASIC DENSITY (kg m³) | STATIC BENDING | |
|---|---|---|---|---|---|---|---|---|
| TRADE NAME | BOTANICAL NAME | Common Name(s) | | | | | MODULUS OF ELASTICITY (MPa) | MODULUS OF RUPTURE (MPa) |
| Ash, mountain | *Eucalyptus regnans* | Australian oak, string gum, swamp gum, Tasmanian oak, Victorian ash, white mountain ash | Tasmanian Victoria | Green<br>12% | 1041 (11)<br>673 (11) | 500 (9) | 12970 (2)<br>16420 (10) | 63 (2)<br>110 (2) |
| Cedar, western red | *Thuja plicata* | British Columbia red cedar, canoe cedar | North America | Green<br>12% | -<br>380 (10) | - | 6500 (10)<br>7700 (10) | 36 (10)<br>52 (10) |
| Douglas fir | *Pseudotsuga menziesii* | Blue Douglas fir Columbian pine, common Douglas, green Douglas fir, oregon, oregon pine | North America | Green<br>12% | 641 (11)<br>561 (11) | 372 (9) | 10350 (10)<br>13150 (5) | 52 (10)<br>82 (10) |
| Hickory, shagbark (true hickory) | *Carya ovata* | | North America | Green<br>12% | -<br>760 (10) | - | 10800 (18)<br>14900 (18) | 76 (10)<br>139 (10) |
| Jelutong | *Dyera costulata D. lowii* | djelutong (Indonesia) | South east Asia | Green<br>12% | -<br>465 (7) | 384 (9) | 8000 (18)<br>8100 (18) | 39 (10)<br>50 (10) |
| Kapur | *Dryobalanops* spp. *prinicpally D. aromatica* | comphorwood (Sabah), kapoer (Indonesia), kapor (Borneo), keladan (Sarawak) | South east Asia | Green<br>12% | -<br>770 (15) | - | 16350 (10)<br>20550 (10) | 82 (10)<br>132 (10) |
| Keriung (combined group) | *Dipterocarpus* | | South east Asia India | Green<br>12% | -<br>720-800(15) | - | 20550 (10)<br>21800 (10) | 73 (10)<br>118 (10) |
| Mengakulang | *Heritiera simplicifolia* | lumbayau | South east Asia | Green<br>12% | -<br>730 (15) | - | 14650 (10)<br>14650 (10) | 82 (10)<br>132 (10) |
| Meranti, red (combined group) | *Shorea* spp. | | South east Asia | Green<br>12% | -<br>400-770(15) | 392 (3) | 10350 (10)<br>- | 52 (10)<br>- |
| Nyatoh | Most species of family *sapotaceae* | balam (Sumatra), betis (Philippines), bitis (Indonesia), bubunga (solomon Is.), ketiau (Borneo, Sabah, Sarawak), keya (Burma), nato (Philippines), njatoh (Sumatra) | South east Asia | Green<br>12% | -<br>- | - | 11775 (10)<br>14650 (10) | 66 (10)<br>103 (10) |
| Pine, pinaster | *Pinus pinaster* | cluster pine maritime pine pinaster pine | Mediter-ranean | Green<br>12% | -<br>577 (1) | - | -<br>12986 (1) | -<br>94 (1) |
| Pine, radiata | *Pinus radiata* | monterey pine radiata pine | California | Green<br>12% | 889 (4)<br>530 (4) | 485 (9) | -<br>11480 (4) | -<br>87 (4) |
| Pine, western yellow | *Pinus ponderosa* | ponderosa pine | North America | Green<br>12% | -<br>405-450(10) | 376 (9) | 7800 (18)<br>9500 (18) | 39 (10)<br>73 (10) |
| Ramin | *Gonystylus macrophyllus* | ainunura (Solomon Is.), baygo (Philippines) gaharu buaja (Indonesia), lanutan (Phillippines), marota (Fiji), melaweis (Malaysia), ramin telur (Sarawak) | South east Asia | Green<br>12% | -<br>650 (15) | 474 (3) | 13150 (10)<br>16350 (10) | 66 (10)<br>118 (10) |
| Redwood | *Sequoia sempervirens* | California redwood, sequoia | North America | Green<br>12% | -<br>428 (10) | - | 8175 (10)<br>9150 (10) | 52 (10)<br>66 (10) |
| Teak | *Tectona grandis* | djati (Java), kyun (Burma), teck (Thailand) | South east Asia | Green<br>12% | -<br>683 (10) | - | 11775 (10)<br>13150 (10) | 76 (10)<br>90 (10) |

# TIMBERS IMPORTED TO WESTERN AUSTRALIA

| MAXIMUM CRUSHING STRENGTH (MPa) | STRENGTH GROUP | DURABILITY CLASS | LYCTUS SUSCEPT-IBILITY | SHRINKAGE GROUP | SHRINKAGE | | | | AVAILABILITY IN W.A. |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | Before Recon. | | After Recon. | | |
| | | | | | Rad. (%) | Tan. (%) | Rad. (%) | Tan. (%) | |
| 30 (2)<br>63 (2) | S4 (16)<br>SD3 (16) | 4 (15) | R (15) | H (15) | 6.6 (9) | 13.3 (9) | 3.7 (9) | 7.1 (9) | Limited: not usually stocked. Sizes 50x25mm to 100x50m in lengths up to 4.2m. |
| 19 (10)<br>31 (10) | S7 (16)<br>SD8 (16) | 2 (17) | R (10) | Very L (10) | - | - | - | - | Limited availability. Sizes up to 150x50mm in lengths up to 4.2m. |
| 26 (10)<br>52 (10) | S5 (16)<br>SD5 (16) | - | R (10) | M (10) | 1.7 (9) | 3.4 (9) | 1.9 (9) | 3.9 (9) | Readily available. Sizes 75x50mm to 300x 150mm in lengths up to 6.0m, occasionally up to 7.2m |
| 32 (10)<br>64 (10) | S4 (10)<br>SD4 (10) | - | - | - | - | - | - | - | Not commercially available. |
| 21 (10)<br>27 (10) | -<br>- | - | - | - | 1.3 (9) | 3.6 (9) | 1.0 (9) | 3.1 (9) | Limited availability. Sizes 50x25mm to 150x25mm in lengths up to 3.0m. |
| 46 (10)<br>73 (10) | S3 (16)<br>SD4 (16) | 2 (15) | R (15) | M (15) | - | - | - | - | Readily available. Sizes up to 300x50mm in lengths up to 6.0m. |
| 41 (10)<br>66 (10) | S3 (16)<br>SD3 (16) | 3 (15) | S (15) | H (15) | - | - | - | - | Not normally stocked in WA. Sizes 50x25mm up to 100x50mm in lengths from 1.8m up to 6.0m. |
| 41 (10)<br>52 (10) | S5 (16)<br>SD5 (16) | 4 (15) | S (15) | M (15) | - | - | - | - | Limited availability. Sizes up to 200x38mm in lengths up to 6.0m. |
| 29 (10)<br>- | S5* SD6¶ (16)<br>S6* SD7¶ (16) | 3* 4¶ (17) | S (15) | M (15) | 2.5¶ (3) | 5.2¶ (3) | 2.0¶ (3) | 4.2¶(3) | Readily available. Sizes 75x25mm up to 200x50mm in lengths from 1.8m up to 6.0m |
| | * meranti, dark red | | ¶ meranti, light red | | | | | | |
| 33 (10)<br>59 (10) | S4 (10)<br>SD4 (10) | - | S (10) | L (10) | - | - | - | - | Readily available. Sizes 50x25mm up to 250x50mm in lengths up to 6.0m. |
| -<br>57 (1) | (S7) (16)<br>(SD7) (16) | - | - | - | - | - | - | - | Limited availability. |
| -<br>48.3 (4) | S6 (16)<br>SD6 (16) | - | R (15) | L (10) | 1.6 (9) | 3.9 (9) | 1.8 (9) | 4.0 (9) | Increasing availa-bility. Currently limited but expected to be readily available by mid 1980s. |
| 20 (10)<br>42 (10) | S7 (16)<br>SD7 (16) | - | R (10) | - | 2.5 (9) | 3.8 (9) | 2.5 (9) | 3.6 (9) | Readily available. Sizes 25, 38, 50x150mm in lengths from 2.4 up to 4.8m. |
| 37 (10)<br>66 (10) | S4 (16)<br>SD4 (16) | 4 (15) | S (15) | M (15) | 2.4 (9) | 6.2 (9) | 2.4 (9) | 6.4 (9) | Limited availability. Sizes 75x25mm up to 200x50mm in lengths up to 6.0m. |
| 29 (10)<br>41 (10) | S6 (16)<br>SD7 (16) | 2 (17) | R (15) | L (10) | - | - | - | - | Limited availability. Sizes 25x25mm up to 150x150mm in lengths up to 6.0m. |
| 38 (10)<br>48 (10) | S4 (10)<br>SD5 (10) | - | S (15) | L (10) | - | - | - | - | Available from a limited nubmer of suppliers. Sizes 100x 25mm up to 200x50mm in lengths from 1.8m up to 3.6m. |

# REFERENCES


(1) BANKS, C.H. (1954). The mechanical properties of timbers with particular reference to those grown in the Union of South Africa. *Journal of the South African Forestry Association* No. 24, 44-65.

(2) BOLZA, E. and KLOOT, N.H. (1963). The mechanical properties of 174 Australian timbers. *CSIRO Division of Forest Products Technological Paper* No. 25.

(3) BUDGEN, B. (1981). Shrinkage and density of some Australian and South-east Asian timbers. *CSIRO Division of Building Research Technical Paper* (Second Series) No. 38.

(4) DITCHBURNE, N., KLOOT, N.H. and RUMBALL, B. (1975). The mechanical properties of Australian-grown *Pinus radiata* D. Don. *CSIRO Division of Building Research Technical Paper* (Second Series) No. 9.

(5) FORESTS DEPARTMENT OF WESTERN AUSTRALIA (1971). *Forestry in Western Australia.*

(6) FOREST PRODUCTS ASSOCIATION (W.A.) (1980). *Availability, sizes and properties of Western Australian timbers.*

(7) FOREST PRODUCTS ASSOCIATION (W.A.) (1980). *Availability, sizes and properties of timbers imported into Western Australia.*

(8) JULIUS, G.A. (1906). *Western Australian timber tests 1906: The physical characteristics of the hardwoods of Western Australia.* Pub. by Government of Western Australia.

(9) KINGSTON, R.S.T. and RISDON, C.J.E. (1961). Shrinkage and density of Australian and other south-west Pacific woods. *CSIRO Division of Forest Products Technological Paper* No. 13.

(10) KLOOT, N.H. and BOLZA, E. (1977). Properties of timbers imported into Australia. *CSIRO Division of Building Research Technical Paper* (Second Series) No. 17.

(11) PEARSON, R.G., KLOOT, N.H. and BOYD, J.D. (1962). *Timber engineering design hand book.* (Second ed.) Published by Jacaranda Press and CSIRO.

(12) STANDARDS ASSOCIATION OF AUSTRALIA (1970). *Australian Standard 02-1970: Nomenclature of Australian timbers.*

(13) STANDARDS ASSOCIATION OF AUSTRALIA (1971). *Australian Standard 1148-1971: Nomenclature of commercial timbers imported into Australia.*

REFERENCES

(14) STANDARDS ASSOCIATION OF AUSTRALIA (1975). *Australian Standard 1720-1975: SAA Timber Engineering Code.*

(15) STANDARDS ASSOCIATION OF AUSTRALIA (1979). *Australian Standard 2082-1979. Visually stress-graded hardwood for structural purposes.*

(16) STANDARDS ASSOCIATION OF AUSTRALIA (1979). *SAA Miscellaneous Publication 45-1979: Report on strength grouping of timbers.*

(17) STANDARDS ASSOCIATION OF AUSTRALIA (1980). *Australian Standard 1604-1980: Preservative treatment for sawn timber, veneer and plywood.*

(18) UNITED STATES FOREST PRODUCTS LABORATORY (1974). *Wood handbook: wood as an engineering material.* U.S. Department of Agriculture, Agriculture Handbook No. 72.

# APPENDIX 1

Index of trade, common, local and botanical names used in this publication, listed alphabetically. The Trade Name, by which the species is identified in the Tables, is given in capitals.

*Acacia acuminata* : JAM, RASPBERRY.

ainunura (Solomon Islands); bagyo (Philippines); gaharu buaja (Indonesia); *Gonystylus macrophyllus*; lanutan (Philippines); mavota (Fiji); melaweis (Malaysia); RAMIN; ramin telur (Sarawak).

ASH, MOUNTAIN: Australian oak; *Eucalyptus regnans*; string gum; swamp gum; Tasmanian oak; Victorian ash, white mountain ash.

Australian oak: ASH, MOUNTAIN: *Eucalyptus regnans*; string gum; swamp gum; Tasmanian oak; Victorian ash; white mountain ash.

bagyo (Philippines): ainunura (Solomon Islands); gaharu buaja (Indonesia); *Gonystylus macrophyllus*; lanutan (Philippines); mavota (Fiji); melaweis (Malaysia); RAMIN; ramin telur (Sarawak).

balam (Sumatra): betis (Philippines); bitis (Indonesia); bubungu (Solomon Islands); ketiau (Borneo, Sabah, Sarawak); keya (Burma); nato (Philippines); njatoh (Sumatra); NYATOH; Sapotaceae family.

*Banksia littoralis* var. seminuda: BANKSIA, RIVER.

BANKSIA, RIVER: *Banksia littoralis* var. seminuda.

betis (Philippines): balam (Sumatra); bitis (Indonesia); bubungu (Solomon Islands); ketiau (Borneo, Sabah, Sarawak); keya (Burma); nato (Philippines); njatoh (Sumatra); NYATOH, Sapotaceae family.

bitis (Indonesia): balam (Sumatra); betis (Philippines); bubungu (Solomon Islands); ketiau (Borneo, Sabah, Sarawak); keya (Burma); nato (Philippines); njatoh (Sumatra); NYATOH, Sapotaceae family.

BLACKBUTT, W.A.: *Eucalyptus patens*; yarri.

blue Douglas fir: Columbian pine; common Douglas; DOUGLAS FIR; green Douglas fir; oregon; oregon pine; *Pseudotsuga menziesii*.

British Columbia red cedar: canoe cedar; CEDAR, WESTERN RED; *Thuja plicata*.

bubungu (Solomon Islands): balam (Sumatra); betis (Philippines); bitis (Indonesia); ketiau (Borneo, Sabah, Sarawak); keya (Burma); nato (Philippines); njatoh (Sumatra); NYATOH; Sapotaceae family.

California redwood: REDWOOD; sequoia; *Sequoia sempervirens*.

camphorwood (Sabah): *Dryobalanops* spp. principally *D. aromatica*; kapoer (Indonesia); kapor (Borneo); KAPUR; keladan (Sarawak).

canoe cedar: British Columbia red cedar; CEDAR, WESTERN RED; *Thuja plicata*.

*Carya ovata*: HICKORY, SHAGBARK (True hickory).

*Casuarina fraserana*: SHEOAK.

CEDAR, WESTERN RED: British Columbia red cedar; canoe cedar; *Thuja plicata*.

cluster pine: maritime pine; PINE, PINASTER; *Pinus pinaster*.

Columbian pine: blue Douglas fir; common Douglas; DOUGLAS FIR; green Douglas fir; oregon; oregon pine; *Pseudotsuga menziesii*.

common Douglas: blue Douglas fir; Columbian pine; DOUGLAS FIR; green Douglas fir; oregon; oregon pine; *Pseudotsuga menziesii*.

*Dipterocarpus*: KERUING (combined group).

djati (Java): kyun (Burma); TEAK; teck (Thailand); *Tectona grandis*.

djelutong (Indonesia): *Dyera costulata*; *D. lowii*; JELUTONG.

DOUGLAS FIR: blue Douglas fir; Columbian pine; common Douglas; green Douglas fir; oregon; oregon pine; *Pseudotsuga menziesii*.

*Dryobalanops* spp. principally *D. aromatica*: camphorwood (Sabah); kapoer (Indonesia); kapor (Borneo); KAPUR; keladan (Sarawak).

*Dyera costulata*: djelutong (Indonesia); *Dyera lowii*; JELUTONG.

*Dyera lowii* : djelutong (Indonesia); *Dyera costulata*; JELUTONG.

*Eucalyptus astringèns*: MALLET, BROWN.

*Eucalyptus calophylla*: MARRI; redgum.

*Eucalyptus cornuta*: YATE.

*Eucalyptus diversicolor*: KARRI.

*Eucalyptus gomphocephala*: TUART.

*Eucalyptus guilfoylei*: TINGLE, YELLOW.

*Eucalyptus jacksonnii:* TINGLE, RED.

*Eucalyptus loxophleba:* YORKGUM.

*Eucalyptus marginata:* JARRAH.

*Eucalyptus patens:* BLACKBUTT, W.A.; yarri.

*Eucalyptus regnans:* ASH, MOUNTAIN; Australian oak; string gum; swamp gum; Tasmanian oak; Victorian ash; white mountain ash.

*Eucalyptus salmonophloia*: SALMON GUM.

*Eucalyptus wandoo* syn. *E. redunca* var. elata: WANDOO; white gum.

gaharu buaja (Indonesia): ainunura (Solomon Islands); bagyo (Philippines); *Gonystylus macrophyllus*; lanutan (Philippines); mavota (Fiji); melaweis (Malaysia); RAMIN; ramin telur (Sarawak).

*Gonystylus macrophyllus*: ainunura (Solomon Islands); bagyo (Philippines); gaharu buaja (Indonesia); lanutan (Philippines); mavota (Fiji); melaweis (Malaysia); RAMIN; ramin telur (Sarawak).

green Douglas fir: blue Douglas fir; Columbian pine; common Douglas; DOUGLAS FIR; oregon; oregon pine; *Pseudotsuga mensiesii*.

*Heritiera simplicifolia*: lumbayau; MENGKULANG.

HICKORY, SHAGBARK (True hickory): *Carya ovata*.

JAM, RASPBERRY: *Acacia acuminta*.

JARRAH: *Eucalyptus marginata*.

JELUTONG: Djelutong (Indonesia); *Dyera lowii; Dyera costulata*.

kapoer (Indonesia): camphorwood (Sabah); *Dryobalanops* spp. principally *D. aromatica;* kapor (Borneo); KAPUR; keladan (Sarawak).

kapor (Borneo): camphorwood (Sabah); *Dryobalanops* spp. principally *D. aromatica;* kapoer (Indonesia); KAPUR: Keladan (Sarawak).

KAPUR: camphorwood (Sabah); *Dryobalanops* spp. principally *D. aromatica;* kapoer (Indonesia); kapor (Borneo), keladan (Sarawak).

KARRI: *Eucalyptus diversicolor*.

keladan (Sarawak): camphorwood (Sabah); *Dryobalanops* spp. principally *D. aromatica*; kapoer (Indonesia); kapor (Borneo); KAPUR.

KERUING (combined group): *Dipterocarpus*.

ketiau (Borneo, Sabah, Sarawak): balam (Sumatra); betis (Philippines); bitis (Indonesia); bubungu (Solomon Islands); keya (Burma); nato (Philippines); njatoh (Sumatra); NYATOH; Sapotaceae family.

keya (Burma): balam (Sumatra); betis (Philippines); bitis (Indonesia); bubungu (Solomon Islands); ketiau (Borneo, Sabah, Sarawak); nato (Philippines); njatoh (Sumatra); NYATOH; Sapotaceae family.

kyun (Burma): djati (Java); TEAK; teck (Thailand); *Tectona grandis*.

lanutan: ainunura (Solomon Islands); bagyo (Philippines); gaharu buaja (Indonesia); *Gonystylus macrophyllus*; mavota (Fiji); melaweis (Malaysia); RAMIN; ramin telur (Sarawak).

lumbayau: *Heritiera simplicifolia*; MENGKULANG.

MALLET, BROWN: *Eucalyptus astringens*.

maritime pine: cluster pine; PINE, PINASTER; *Pinus pinaster*.

MARRI: *Eucalyptus calophylla*; redgum.

mavato (Fiji): ainunura (Solomon Islands); bagyo (Philippines); gaharu buaja (Indonesia); *Gonystylus macrophyllus*; lanutan (Philippines); melaweis (Malaysia); RAMIN; ramin telur (Sarawak).

melaweis (Malaysia): ainunura (Solomon Islands); bagyo (Philippines); gaharu buaja (Indonesia); *Gonystylus macrophyllus*; lanutan (Philippines); mavota (Fiji); RAMIN; ramin telur (Sarawak).

MENGKULANG: *Heritiera simplicifolia*; lumbayau.

MERANTI, RED (combined group): *Shorea* spp.

monterey pine: PINE, RADIATA; *Pinus radiata*.

nato: balam (Sumatra); betis (Philippines); bitis (Indonesia); bubungu ( Solomon Islands); ketiau (Borneo, Sabah, Sarawak); keya (Burma); njatoh (Sumatra); NYATOH; Sapotaceae family.

njatoh: balam (Sumatra); betis (Philippines); bitis (Indonesia); bubungu (Solomon Islands); ketiau (Borneo, Sabah, Sarawak); keya (Burma); nato (Philippines); NYATOH (Sumatra); Sapotaceae family.

NYATOH: balam (Sumatra); betis (Philippines); bitis (Indonesia); bubungu (Solomon Islands); ketiau (Borneo, Sabah, Sarawak); keya (Burma); nato (Philippines); njatoh (Sumatra); Sapotaceae family.

oregon: blue Douglas fir; Columbian pine; common Douglas; DOUGLAS FIR; green Douglas fir; oregon pine; *Pseudotsuga menziesii*.

oregon pine: blue Douglas fir; Columbian pine; common Douglas; DOUGLAS FIR; green Douglas fir; oregon; *Pseudotsuga menziesii*.

PINE, PINASTER: cluster pine; maritime pine; *Pinus pinaster*.

PINE RADIATA: monterey pine; *Pinus radiata*.

PINE, WESTERN YELLOW: *Pinus ponderosa*; ponderosa pine.

*Pinus pinaster*: cluster pine; maritime pine; PINE, PINASTER.

*Pinus ponderosa*: PINE, WESTERN YELLOW; ponderosa pine.

*Pinus radiata*: monterey pine; PINE, RADIATA.

*Pseudotsuga menziesii*: blue Douglas fir; Columbian pine; common Douglas; DOUGLAS FIR; green Douglas fir; oregon; oregon pine.

radiata pine: monterey pine; PINE, RADIATA; *Pinus radiata*.

RAMIN: ainunura (Solomon Islands); bagyo (Philippines); gaharu buaja (Indonesia); *Gonystylus macrophyllus*; lanutan (Philippines); mavota (Fiji); melaweis (Malaysia); ramin telur (Sarawak).

ramin telur (Sarawak): ainunura (Solomon Islands); bagyo (Philippines); gaharu buaja (Indonesia); *Gonystylus macrophyllus*; lanutan (Philippines); mavota (Fiji); melaweis (Malaysia); RAMIN.

redgum: *Eucalyptus calophylla*; MARRI.

REDWOOD: California redwood; sequoia; *Sequoia sempervirens*.

SALMON GUM: *Eucalyptus salmonophloia*.

Sapotaceae family: balam (Sumatra); betis (Philippines); bitis (Indonesia); bubungu (Solomon Islands); ketiau (Borneo, Sabah, Sarawak); keya (Burma); nato (Philippines); njatoh (Sumatra); NYATOH.

sequoia: California redwood; REDWOOD; *Sequoia sempervirens*.

*sequoia sempervirens*: California redwood; REDWOOD; sequoia.

SHEOAK: *Casuarina fraserana*.

*Shorea* spp: MERANTI, RED (combined group).

string gum: ASH, MOUNTAIN; Australian oak; *Eucalyptus regnans*; swamp gum; Tasmanian oak; Victorian ash; white mountain ash.

swamp gum: ASH, MOUNTAIN; Australian oak; *Eucalytus regnans*; string gum; Tasmanian oak; Victorian ash; white mountain ash.

Tasmanian oak: ASH, MOUNTAIN; Australian oak; *Eucalyptus regnans*; string gum; swamp gum; Victorian ash; white mountain ash.

TEAK: djati (Java); kyun (Burma); teck (Thailand); *Tectona grandis*.

teck (Thailand): djati (Java); kyun (Burma); TEAK; *Tectona grandis*.

*Tectona grandis*: djati (Java); kyun (Burma); TEAK; teck (Thailand).

*thuja plicata*: British Columbia red cedar; canoe cedar ; CEDAR, WESTERN RED.

TINGLE, RED: *Eucalyptus jacksonii*.

TINGLE, YELLOW: *Eucalyptus guilfoylei*.

TUART: *Eucalyptus gomphocephala*.

Victorian ash: ASH, MOUNTAIN ; Australian oak; *Eucalyptus regnans*; string gum; swamp gum; Tasmanian oak; white mountain ash.

WANDOO: *Eucalyptus wandoo* syn. *E. redunca* var. elata; white gum.

western red cedar: British Columbia red cedar; canoe cedar; CEDAR, WESTERN RED; *Thuja plicata*.

white gum: *Eucalyptus wandoo* syn. *E. redunca* var. *elata*; WANDOO.

white mountain ash: ASH, MOUNTAIN ; Australian oak; *Eucalyptus regnans*; string gum; swamp gum; Tasmanian oak; Victorian ash.

yarri: BLACKBUTT, W.A.; *Eucalyptus patens*.

YATE: *Eucalyptus cornuta*.

YORKGUM: *Eucalyptus loxophleba*.