Wood Basics
*Products, Properties, Terminology, & Specification*

Greg Nolan & Jon Shanks

*Centre for Sustainable Architecture with Wood, School of Architecture and Design, University of Tasmania*

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**Learning Objectives**

- Participants completing this activity will be able to:
  - Describe the essential timber and wood product types
  - Describe the essential properties of timber and wood products
  - Specify timber and wood products

- For architects - AACA Competencies:
  - Design
  - Documentation
This presentation

• Timber’s primary characteristics
• Product types
• Sizes
• Grade & grading
  – Structural
  – Appearance
• Specification

Vertical board cladding

Timber as a material for design - Basics
The forest yields logs

... that are converted by various techniques...

- Harvested log
- Solid wood products
  - Sawn boards
  - Peeled veneers
- Rounds and poles
  - Chip and flake boards
  - Mulches
- Short grained elements
- Fuel
  - Fiber boards
  - Paper & cardboards
- Fiberal elements
  - Chemicals
  - Various compounds
... into products ready for fabrication...

... into imaginative elements or..
...utilitarian applications of varying scale.

Material Properties - Basics
Timber is a natural material

**Natural:** existing in or caused by nature; not man-made

- Timber is a natural material, drawn from the wood in trees.
- The tree determines the timber’s character.
  - Its species.
  - Form and growth of the wood in the tree over time.

Major timber species

**Hardwoods**
- NSW/Qld – blackbutts, ironbarks, spotted gum, stringybarks,
- Victorian/Tasmanian – Tassie oak, ash species
- WA – jarrah, karri
- Imported – oak, merbau/kwila, belian

**Softwoods**
- Australia plantation pines – radiata, hoop, slash
- Australian native - cypress
- Imported – radiata, baltic pine, spruce, Douglas fir, SPF, western red cedar
**Major timber species**

**Plantation timbers**
- Radiata pine is most commonly used plantation grown timber for wood products in Australia
- Advantages:
  - light-weight
  - easy to handle and cut
  - can be finished with a variety of coatings and stains
  - easily treated to extend durability
  - high strength to weight ratio
  - reliable supply and low cost
- Other plantation pines: Slash, Caribbean
- Plantation hardwoods: Supply of quality material is limited.

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**Timber is hygroscopic**

*Hygroscopic:* the ability to lose or gain moisture content with fluctuations in environmental humidity.
- When harvested, timber holds a significant volume of water.
- After seasoning, timber absorbs or loses moisture to remain in equilibrium with the surrounding atmosphere
  - As it absorbs moisture, *it expands.*
  - As it loses moisture, *it shrinks.*
- The timber’s moisture content (MC) is critical for structural and appearance applications.
Moisture content: structural

Seasoned (S) timber
• Also called kiln-dried (KD), the timber’s MC is between 10% and 15%
• Minimal additional shrinkage - dimensionally stable
• Remain straight - little twisting, cupping or bowing
• Well suited for painting.

Unseasoned timber
• Also called “green”, the timber’s MC is greater than 15%.
• Prone to shrinkage and movement.

Moisture content: appearance

The recommended MC varies for each product but generally:
• Interior:
  – between 9% and not more than 14%
• Exterior:
  – between 10% and not more than 18%

Unseasoned timber is generally unsuitable for appearance applications.
Timber is variable (anisotropic)

Anisotropic: having physical properties that have different values when measured in different directions.

- It also varies with its original location in the tree, and the tree’s age, source, and species.

Zones of wood

Bark
- A protection layer. New bark is made continually with portions falling off each year.

Pith / heart
- cells from the original sapling or growing tip

Cambium
- growth cells that created wood cells on the inside face and bark cells on the outside

Sapwood
- newest wood on the outside areas of the stem that transports nutrients between the root and the leaves

Heartwood
- older wood cells filled with extractives and other material to increase durability and support for the tree.
Zones of wood

- Bark
- Pith / heart
- Cambium
- Sapwood
- Heartwood

Timber is biodegradable

**Biodegradable:** capable of being decomposed by bacteria or other living organisms

Wood can be broken down by:

- weathering
- fungi (or decay).
- insects and termites.
- marine organisms.

The impact of these mechanisms vary with:

- exposure to hazard.
- the nature of the wood.

Lyctid borer attack in sapwood
Timber’s weathering

- The greying and minor cracking of timber due to *mechanical* or *chemical* breakdown of the surface by:
  - light,
  - the action of dust and sand,
  - Shrinkage and swelling due to moisture content changes.
- The breakdown rate is slow with effects often limited to the surface.
  - ~ 0.1 mm per year depending on species and board orientation.
- Weathering affects appearance, the performance of finishes; and eventually, decay rate.

Timber’s decay

- Decay is the decomposition of wood by fungi.
  Decay rates vary with:
  - The wood’s character
  - Its moisture content (20% MC and above)
  - The ambient temperature (~ 5° to 60°C).
- It can occur most readily in timber kept regularly moist.
  - It tends to attack the moisture-permeable end-grain most vigorously.
- Decay hazard is often assessed *above ground* and *in-ground contact*. 
Timber’s resistance to hazards

- Timber resists hazards by
  - its natural durability and
  - any applied treatment.
- Natural durability:
  - varies with species and
  - is rated in durability classes in-ground contact and above-ground

Timber’s natural durability

<table>
<thead>
<tr>
<th>Class</th>
<th>Probable in-ground life expectancy (years)</th>
<th>Probable above-ground life expectancy (years)</th>
<th>Example species</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Greater than 25</td>
<td>Greater than 40</td>
<td>Ironbark, Tallowwood</td>
</tr>
<tr>
<td>2</td>
<td>15 to 25</td>
<td>15 to 40</td>
<td>Spotted gum, Blackbutt, WRC</td>
</tr>
<tr>
<td>3</td>
<td>5 to 15</td>
<td>7 to 15</td>
<td>Brush box, Southern blue gum, Messmate</td>
</tr>
<tr>
<td>4</td>
<td>0 to 5</td>
<td>0 to 7</td>
<td>Vic ash, Radiata pine, Douglas fir</td>
</tr>
</tbody>
</table>

All sapwood is rated Class 4.

The ratings in this table are based on expert opinions and the performance of the following test specimens:
(a) In-ground: 50 × 50 mm test specimens at four sites around Australia.
(b) Above-ground: 35 × 35 mm test specimens at eleven sites around Australia.
Durability: Protection from weather

AS 1684: Protected from weather

- Material susceptible to biodegradation can be treated with preservative chemicals to provide a reliable service life.
  - The toxicity and amount of chemicals retained governs the protection level.
- The target chemical retention is set for the intended Hazard Level.
- As the chemicals are carried in a liquid, wood’s permeability limits the effectiveness of treatments.
  - It is very hard to reliably achieve the target retentions in heartwood.

Treatment extends the product suite
### Treatment classes

<table>
<thead>
<tr>
<th>Class</th>
<th>Suitability</th>
<th>Biological hazard</th>
</tr>
</thead>
<tbody>
<tr>
<td>H1</td>
<td>suitable for H1 hazard environments – <em>indoors, protected</em></td>
<td>Borers Only</td>
</tr>
<tr>
<td>H2</td>
<td>suitable for H2 hazard environments – <em>suitable for all internal use</em></td>
<td>Borers and termites</td>
</tr>
<tr>
<td>H3</td>
<td>suitable for H3 hazard environments – up to <em>above ground external use</em></td>
<td>Decay borers &amp; termites</td>
</tr>
<tr>
<td>H4</td>
<td>suitable for H4 hazard environments – up to in <em>contact with dry ground</em></td>
<td>Severe decay, borers &amp; termites</td>
</tr>
<tr>
<td>H5</td>
<td>suitable for H5 hazard environments – up to all <em>in-ground uses</em></td>
<td>Very severe decay, borers and termites</td>
</tr>
<tr>
<td>H6</td>
<td>suitable for H6 hazard environments – up to <em>marine uses</em></td>
<td>Marine wood borers and decay</td>
</tr>
</tbody>
</table>

### Major conventional treatment

<table>
<thead>
<tr>
<th>TYPE</th>
<th>HAZARD LEVEL</th>
<th>H1</th>
<th>H2</th>
<th>H3</th>
<th>H4</th>
<th>H5</th>
<th>H6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>Boron</td>
<td>😞</td>
<td>😞</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CCA</td>
<td>😞</td>
<td>😞</td>
<td>😞</td>
<td>😞</td>
<td>😞</td>
<td>😞</td>
</tr>
<tr>
<td></td>
<td>Copper Azole</td>
<td>😞</td>
<td>😞</td>
<td>😞</td>
<td>😞</td>
<td>😞</td>
<td>😞</td>
</tr>
<tr>
<td></td>
<td>ACQ</td>
<td>😞</td>
<td>😞</td>
<td>😞</td>
<td>😞</td>
<td>😞</td>
<td>😞</td>
</tr>
<tr>
<td>Solvent</td>
<td>LOSP</td>
<td>😞</td>
<td>😞</td>
<td>😞</td>
<td>😞</td>
<td>😞</td>
<td>😞</td>
</tr>
<tr>
<td>Double</td>
<td>CCA + Creosote</td>
<td>😞</td>
<td>😞</td>
<td>😞</td>
<td></td>
<td></td>
<td>😞</td>
</tr>
</tbody>
</table>

(1) Southern waters only
Preservative treatment

• For hazard levels H1 – H6 preservative must penetrate:
  – 100% of the sapwood
  – 0 – 20mm of the heartwood
• The exception is for timber framing South of Tropic of Capricorn - Hazard level H2F

Penetration after treatment

Treated round log

Treated sawn section
The wood’s permeability limits treatment retention.

- Heartwood in hardwood is very hard to treat reliably.
- Heartwood in softwood may retain treatment but below the levels required for standard compliance.

Key product types
Limits on timber products

- Timber products are limited by:
  - The form and size of the log
    - Size constraints impose on recovered pieces
  - The directionality of its key properties
  - Its structural consistency (or variability)

Primary reduction process

- The log is broken down into a hierarchy of elements, governed by value.
- Solid wood processing can only convert a portion of logs to the most valuable elements.
- The remainder is channeled into other, less valuable element streams.
Timber rounds - poles

- Natural or shaved round timber used with or without preservative treatment.
- A valuable market for forest thinnings.

Sawn timber & scantling

- Hard or softwood boards cut from logs and usually dried.
- This is a versatile material used for moulding, frames and exposed structures.
- Board size is restricted by log size and required cutting patterns.
Laminated Veneer Lumber (LVL)

Small section timbers can be glued together into large structural elements that may be used in architectural structures.

Glulam made to AS 1328 Glued-laminated structural timber
Other wood products

I-beams

- Multiple layers of solid section timber glued together into panels with the grain direction alternating between layers.
- The panels are custom-made to the panel’s intended function.
- Currently, imported into Australia but not produced here.

Cross laminated timber

- Multiple layers of solid section timber glued together into panels with the grain direction alternating between layers.
- The panels are custom-made to the panel’s intended function.
- Currently, imported into Australia but not produced here.
Wood panels

Panel products
- Plywood
- Hardboard
- Particleboard
- MDF
- Veneer

Fabrication: Doors and windows

Appearance timbers can be fabricated into external or internal joinery elements.
Steel nail-plates can convert sawn boards into versatile truss elements designed for specific projects.
Product sizing

Sizing: Terminology

Timber is ordered by actual or nominal dimensions
• Nominal dimensions
  – approximate size of timber based on its unseasoned condition and rough dimension that it was originally cut to.
  • e.g. a sleeper of nominal size of 200 x 50 mm will have actual dimensions less than this. This is to account for shrinkage and any machining that may have occurred
• Actual dimensions
  – are actual timber size
Generally:
- Seasoned timber - uses **actual** dimensions
- Unseasoned (green) timber – uses **nominal** dimensions

**Sizing: Terminology**

- **Timber dimensions**
  - Usually nominate the depth first followed by breadth
  - “Depth by breadth”
    - Studs and joists – 90 x 35 mm
    - Wall plate and battens – 45 x 70 mm
    - Joist – 190 x 35 mm
  - In North America it’s reversed
Sizing: Availability

Availability

• Seasoned structural timber usually only available in 35 mm and 45 mm breadth for both hardwood and softwood

• Check with local suppliers before specification, especially outside metro area

Sizing: Pine Sizes

<table>
<thead>
<tr>
<th>Width (mm)</th>
<th>Thickness (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>35</td>
<td>45 70 90</td>
</tr>
<tr>
<td>35</td>
<td>- 45 70 90</td>
</tr>
<tr>
<td>45</td>
<td>- - 70 90</td>
</tr>
<tr>
<td>70</td>
<td>35 45 70 -</td>
</tr>
<tr>
<td>90</td>
<td>35 45 70 90</td>
</tr>
<tr>
<td>120</td>
<td>35 45 - -</td>
</tr>
<tr>
<td>140</td>
<td>35 45 - -</td>
</tr>
<tr>
<td>170</td>
<td>35 45 - -</td>
</tr>
<tr>
<td>190</td>
<td>35 45 - -</td>
</tr>
<tr>
<td>220</td>
<td>35 45 - -</td>
</tr>
<tr>
<td>240</td>
<td>35 45 - -</td>
</tr>
</tbody>
</table>
### Sizing: Hardwood (seasoned) sizes

<table>
<thead>
<tr>
<th>Width (mm)</th>
<th>Thickness (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>70</td>
<td>35 45</td>
</tr>
<tr>
<td>90</td>
<td>35 45</td>
</tr>
<tr>
<td>120</td>
<td>35 45</td>
</tr>
<tr>
<td>140</td>
<td>35 45</td>
</tr>
<tr>
<td>170</td>
<td>35 45</td>
</tr>
<tr>
<td>190</td>
<td>35 45</td>
</tr>
<tr>
<td>220</td>
<td>35 45</td>
</tr>
<tr>
<td>240</td>
<td>35 45</td>
</tr>
</tbody>
</table>

### Sizing: Hardwood (unseasoned)

<table>
<thead>
<tr>
<th>Width (mm)</th>
<th>Thickness (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>38 50 75 100</td>
</tr>
<tr>
<td>50</td>
<td>x 38 50 75 100</td>
</tr>
<tr>
<td>75</td>
<td>x 38 50 75 100</td>
</tr>
<tr>
<td>100</td>
<td>x 38 50 75 100</td>
</tr>
<tr>
<td>125</td>
<td>x 38 50 75 100</td>
</tr>
<tr>
<td>150</td>
<td>x 38 50 75 100</td>
</tr>
<tr>
<td>175</td>
<td>25 38 50 75 x</td>
</tr>
<tr>
<td>200</td>
<td>x 38 50 75 x</td>
</tr>
<tr>
<td>250</td>
<td>25 38 50 x x</td>
</tr>
</tbody>
</table>
Product strength performance and grading

Cell structure and directionality

- Wood is anisotropic. Its properties vary radially, tangentially, and longitudinally.
- The cell structure is primarily longitudinally arranged tubes.

Vessels and fibers in birch
Source: http://www.swed.org/teach/1st2/struct1.html
Timber’s strength is related to:
• Properties of the cell structure
• Cell size and direction

**Strong parallel to grain & stiff parallel to grain**

**Weak perpendicular to grain**

**Relative strength**

*Tension & compression along the grain: 10 units*

*Tension & compression across the grain: >1 units*
Key structural properties

- **Strength (when it breaks)** and **stiffness (how much it bends)** values are influenced by:
  - moisture content,
  - grain structure of the species,
  - slope of grain in the piece,
  - other features in the piece.

Wood variation with age

- Zone of unchanging wood properties
- Age of deposited wood – years
- Age of log – years
Strength-reducing characteristic

- Knots: part of a branch;
- Grain direction: sloping or irregular;
- Check and shakes: small surface cracks or splits;
- Bark and heart or pith
- Gum vein, resin pockets
- Insect attack; and
- Others.

Grade & Grading

- In practice, grading involves separate assessment of:
  - The properties of the timber in the piece against grade criteria
  - The quality of the piece’s form as a board or sheet against specific tolerances for warp, wood quality, etc.
Grade & Grading

Structural stress grades
• F Grades
  • e.g. F5, F7, F8, F17, F27
  • Visual and/or mechanical testing process
  • Applies to all softwood, hardwood, plywood and rounds
• MGP (Machine graded pine) Grades
  • e.g. MGP 10, MGP 12, MGP 15
  • Machine tests stiffness of timber
  • Applies only to radiata, slash, hoop, Caribbean pine. Some spruce is available
• GL grades – Glulam grades
• LVL and I-beams,
  • unique properties to each manufacturer – manufacturers grade

Grade & Grading

Non-structural grades
• Merchant (merch) “grade”
• Merch was a structural grade in 60’s / 70’s
• No longer recognised as a grade
Grade & Grading

Structural stress grades

- Characteristics that affect stress grade:
  - Sloping grain
  - Knots
  - Fractures

- Some companies also sort on appearance after stress grading (e.g. for pergola framing timbers)
Grade & Grading

**Structural stress grades**

Lesser stress grade limiting characteristics

Core wood – pith – weaker wood – lower load capacity

Surface checks / fractures – only a problem if they become splits

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Grade & Grading

**Structural stress grades**

Lesser stress grade limiting characteristics

Wane – absence of underbark timber
Want – absence of timber other than wane

Bow – curvature along the face Spring – curvature along the edge
Grade & Grading

- **Structural stress grades Identification**
- MGP stress grade is marked with either ink marks, stamp, end tag or sticker
  - Ink marks may occur every 1.2 m
- Do not rely on the mill colour marks for grade identification
- Rely on actual grade marking or grade on delivery docket
- If there is more than one grade mark on the timber, ALWAYS go with lowest grade

Grade & Grading

**Structural stress grades - Important**

- Grading applies at time of grading
- So if:
  - Forklift splits / tears a chunk out of timber; or
  - Timber is re-sawn into smaller dimensions
- Member no longer has any stress grade
- Timber needs to be regraded or considered as non-structural
Grade & Grading: Appearance

Appearance grade products

- Flooring and light decking
- Lining / panelling
- Handrails, balusters, balustrades, stringers, and treads
- Dressed boards, joinery and trim: mouldings, architraves, skirting boards, shelves, door and window frames
- Cabinets: built in cupboards, benches, furniture
- Cladding, fascia

Grade & Grading: Appearance

Appearance grades

- Many common descriptions are meaningless unless it is accompanied by a grade description
- e.g. in Australian Standard for softwood (AS 4785) and hardwood have appearance grades
  - Softwood (AS 4785)
    - clear, appearance, select, standard or utility
  - Hardwood (AS 2796)
    - select, medium feature, high feature
Grade & Grading: Appearance

Hardwood appearance grades (AS2796):

- select
- medium feature
- high feature

High Feature:
Distinct with a rich, lively & vibrant surface.

Medium Feature Standard:
Increased feature providing a surface with distinct natural appeal.

Low Feature Select:
Straight & even grain with uniform texture.

Specification

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Example of Key Words</th>
</tr>
</thead>
<tbody>
<tr>
<td>Application or Product</td>
<td>Cladding, flooring, rather, beam, joint, hand rail, etc.</td>
</tr>
<tr>
<td>Size</td>
<td></td>
</tr>
<tr>
<td>Species or Species group</td>
<td>Mixed hardwood, blackbutt, spotted gum, New England group</td>
</tr>
<tr>
<td>Surface Finish</td>
<td>Sawn, dressed, sized, gauged, D.A.R., needled finish, etc.</td>
</tr>
<tr>
<td>Profile</td>
<td>Tongue and Groove (T&amp;G), End matched</td>
</tr>
<tr>
<td>Moisture Content</td>
<td>Seasoned or unseasoned</td>
</tr>
<tr>
<td>Treatment</td>
<td>Treated H1, H2, H3, H4, H5, H6 or untreated</td>
</tr>
<tr>
<td>Durability Class</td>
<td>In-ground / Above Ground Durability Class 1, 2, 3 or 4</td>
</tr>
<tr>
<td>Structural Grade</td>
<td>F5, F7, F8, F14, F17, F22, F27, F32</td>
</tr>
<tr>
<td>Appearance Grade</td>
<td>Pine: Clear, Appearance, Utility</td>
</tr>
<tr>
<td>Appearance</td>
<td></td>
</tr>
<tr>
<td>Special Features</td>
<td>E.g. density between 600 and 700 kg/m³</td>
</tr>
<tr>
<td>Fixing</td>
<td>Fixed with 2/75 x 3.15mm diameter galvanised nails</td>
</tr>
<tr>
<td>Fabrication details</td>
<td>To specific requirements</td>
</tr>
<tr>
<td>Finishing details</td>
<td>One flood coat of water repellent preservative</td>
</tr>
</tbody>
</table>
Wood Basics: Specification

Specifying wood products

- **Application** – framing, flooring, pergola, kitchen, fascia, cladding, formwork?

- **Performance** – appearance, structural performance, service life, cost?

- **Environment** – inside/outside, exposure to decay and/or termites, exposure to weathering, marine, poolside?
More Information

Wood Solutions
design and build
www.woodsolutions.com.au

Questions?

Greg Nolan & Jon Shanks

Centre for Sustainable Architecture with Wood,
School of Architecture and Design,
University of Tasmania